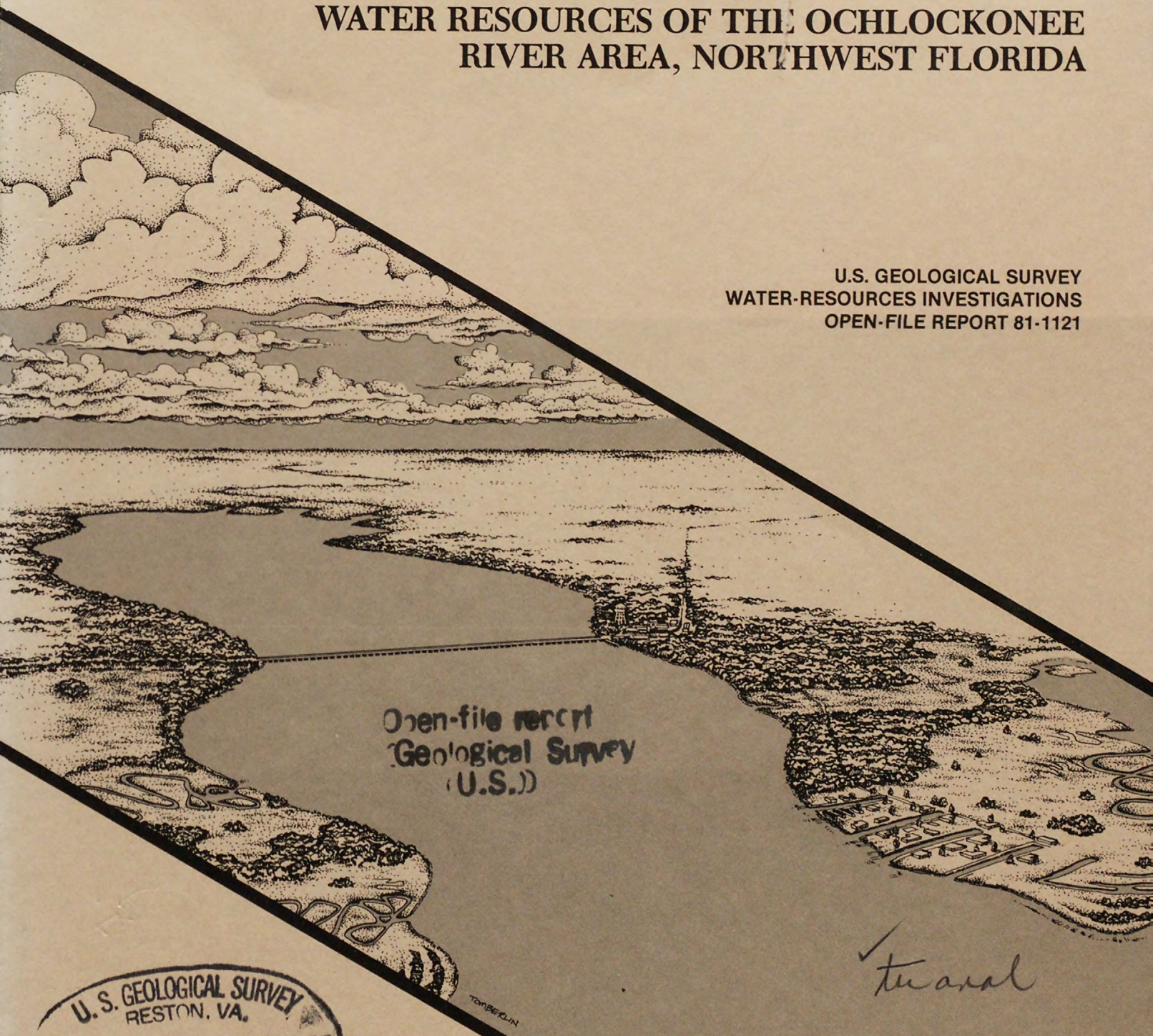
(200)
R290
no. 81-1121

WATER RESOURCES OF THE OCHLOCKONEE RIVER AREA, NORTHWEST FLORIDA

U.S. GEOLOGICAL SURVEY
WATER-RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 81-1121



Open-file report
Geological Survey
(U.S.)

U.S. GEOLOGICAL SURVEY
RESTON, VA.
MAR 19 1982
LIBRARY

Prepared in cooperation with the

NORTHWEST FLORIDA WATER MANAGEMENT DISTRICT,
GADSDEN COUNTY, and the
CITY OF QUINCY

USGS LIBRARY-RESTON
3 1818 00072133 0

WATER RESOURCES OF THE OCHLOCKONEE RIVER AREA, NORTHWEST FLORIDA

By Charles A. Pascale and Jeffry R. Wagner

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations

Open-File Report 81-1121

Prepared in cooperation with the

NORTHWEST FLORIDA WATER MANAGEMENT DISTRICT,
GADSDEN COUNTY, and the
CITY OF QUINCY

1982

321587

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

U.S. Geological Survey
325 John Knox Road, Suite F-240
Tallahassee, Florida 32303

CONTENTS

	Page
Abstract	1
Introduction	2
Purpose and scope	2
Location and extent of area	3
Data collection	3
Acknowledgments	5
Previous investigations	6
Hydrologic setting	7
Climate	7
Physiography	10
Geology	12
Eocene Series--Ocala Limestone	23
Oligocene Series--Suwannee Limestone	23
Miocene Series--Tampa Limestone, Hawthorn Formation, Miccosukee Formation	26
Pliocene Series--Jackson Bluff Formation	29
Pleistocene and Holocene Series--surfical sands and terrace deposits	30
Water resources	30
Ground water	30
Occurrence and movement	30
Aquifers	33
Surficial sand aquifer	33
Water-level fluctuations	33
Quality of water	33
Water-bearing zone of the upper confining unit	33
Water-level fluctuations	48
Quality of water	48
Floridan aquifer	48
Discharge from the Floridan aquifer	51
Water-level fluctuations	51
Aquifer characteristics	53
Quality of water	56
Surface water	68
Occurrence of streamflow	68
Streamflow characteristics	68
Flow duration	75
Low-flow frequency	80
Flooding and flood frequency	80
Lakes	89
Lake Iamonia	89
Lake Jackson	91
Lake Talquin	91
Quality of water	91
Streams	91
Lakes	101

CONTENTS--Continued

Page

Water resources--Continued
Water use---------- 105
Water availability---------- 105
Suggestions for further study---------- 109
Summary and conclusions---------- 109
Selected references---------- 112

ILLUSTRATIONS

Page

Figure 1. Map showing location of Ochlockonee River basin, Florida; the area of investigation, and hydrologic data-collection sites---------- 4
2. Graph showing average monthly temperature and rainfall, and annual rainfall at Quincy, 1917-77---------- 8
3. Map showing physiographic divisions and terraces of Ochlockonee River basin, Florida---------- 11
4. Map showing location of wells and geohydrologic sections referred to in other illustrations and text of report---------- 15
5-11. Geohydrologic sections through the Ochlockonee River area:
5. A-A'---------- 16
6. B-B'---------- 17
7. C-C'---------- 18
8. D-D'---------- 19
9. E-E'---------- 20
10. F-F'---------- 21
11. G-G'---------- 22
12. Map showing altitude of the top of the Ocala Limestone in the Ochlockonee River area---------- 24
13. Map showing altitude of the top of the Suwannee Limestone in the Ochlockonee River area---------- 25
14. Map showing altitude of the top of the Tampa Limestone and Floridan aquifer in the Ochlockonee River area---------- 28
15. Map showing potentiometric surface of the Floridan aquifer, September 26-30, 1977---------- 32
16. Hydrographs showing water levels of wells 336, 257, and 166 (Floridan aquifer); well 167 (water-bearing zone of the upper confining unit; and monthly rainfall at Quincy, 1967-77, in northern part of study area---------- 49

Page

Figure 17. Hydrographs showing water levels of wells 130, 63, 53, and 23 (Floridan aquifer) in southern part of study area and monthly rainfall at Quincy, 1967-77---------- 52
18. Map showing specific capacities of wells in the Ochlockonee River area---------- 55
19. Map showing dissolved-solids concentration in water from the Floridan aquifer---------- 57
20. Map showing chloride concentration in water from the Floridan aquifer---------- 58
21. Map showing sulfate concentration in water from the Floridan aquifer---------- 59
22. Map showing fluoride concentration in water from the Floridan aquifer---------- 60
23. Chemical analyses illustrated by Stiff diagrams for principal ions in water from wells tapping the Floridan aquifer---------- 61
24. Map showing stream discharge and dissolved-solids concentrations, September 17-23, 1976----- 78
25. Flow-duration curves for eight streams in the Ochlockonee River area---------- 79
26. Low-flow frequency curves for Sopchoppy River near Sopchoppy, 1964-77---------- 81
27. Low-flow frequency curves for Ochlockonee River near Havana, 1926-77---------- 82
28. Low-flow frequency curves for Little River near Quincy, 1950-77---------- 83
29. Low-flow frequency curves for Quincy Creek at S-267 at Quincy, 1975-77---------- 84
30. Low-flow frequency curves for Rocky Comfort Creek near Quincy, 1965-77---------- 85
31. Low-flow frequency curves for Ochlockonee River near Bloxham, 1926-77---------- 86
32. Low-flow frequency curves for Telogia Creek near Bristol, 1950-71, 1975-77---------- 87
33. Regionalized flood-frequency curves for the Ochlockonee River area---------- 90
34. Hydrograph showing levels of Lake Jackson near Tallahassee, calendar years 1949-77--------- 92
35. Graph showing variation in chloride concentration and discharge of Ochlockonee and Sopchoppy Rivers---------- 96

TABLES

			Page
Table	1.	Records of rainfall	9
	2.	Stratigraphic units and their water-bearing properties in the Ochlockonee River area	13
	3.	Selected ground-water data-collection sites	34
	4.	Chemical analyses of water from selected wells that tap the Floridan aquifer	44
	5.	Chemical analyses of water from selected wells that tap the water-bearing zone of the upper confining unit	50
	6.	Summary of aquifer tests	54
	7.	Chemical analyses of water collected at various depths from selected wells	63
	8.	Selected surface-water data-collection sites	69
	9.	Summary of streamflow data at gaging sites	76
	10.	Summary of flood heights at selected streams	88
	11.	Selected chemical constituents of surface water in the Ochlockonee River area	93
	12.	Selected physical properties of surface water in the Ochlockonee River area	97
	13.	Pesticide analyses of bottom sediments of streams	100
	14.	Selected nutrient constituents of surface water in the Ochlockonee River area	102
	15.	Bacteriological analyses of surface water	104
	16.	Water used in the Ochlockonee River area during 1975	106

CONVERSION FACTORS

For use of those readers who may prefer to use metric units (SI) rather than U.S. inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply U.S. inch-pound	By	To obtain SI units
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
foot squared per day (ft^2/d)	0.0929	meter squared per day (m^2/d)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot (ft^3)	0.283	cubic meter (m^3)
cubic foot per second (ft^3/s)	28.32	liter per second (L/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]
acre-foot (acre-ft)	1,233	cubic meter (m^3)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
gallon per minute per foot [(gal/min)/ft]	0.000207	cubic meter per second per meter [$(m^3/s)/m$]
gallon per day (gal/d)	0.00004381	liter per second (L/s)
million gallon per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
degree Fahrenheit (°F)	0.446 x (°F-32)	degree Celsius (°C)

* * * *

WATER RESOURCES OF THE OCHLOCKONEE RIVER AREA, NORTHWEST FLORIDA

By Charles A. Pascale and Jeffry R. Wagner

ABSTRACT

The Ochlockonee River area comprises about 1,420 square miles in the panhandle of northwest Florida. In 1975, the population of the area was about 48,000. Water use averaged 11.4 million gallons per day; about half was pumped from wells and half from streams.

The area receives 57 inches of precipitation per year on the average. Much of this water enters the surficial sand aquifer, seeps to streams, or enters the underlying water-bearing zone of the upper confining unit and the Floridan aquifer.

The water-bearing zone of the upper confining unit is used for rural domestic supplies and is also important because the water it stores is a source of recharge to the underlying Floridan aquifer.

The Floridan aquifer underlies all of the Ochlockonee River area and, except for the city of Quincy, is the principal source of municipal water supply. Well yields range from as little as 20 gallons per minute in Gadsden County to as much as 4,500 gallons per minute in Leon County. The transmissivity of the Floridan aquifer ranges from about 170 feet squared per day in the southern part of the area to 5,100 feet squared per day in the northern part. Storage coefficients calculated from two aquifer tests are 2×10^{-4} and 2.6×10^{-4}. At Tallahassee, directly east of the Ochlockonee River, transmissivity is as high as 130,000 feet squared per day. The Floridan aquifer is recharged by downward leakage of water from the surficial sand aquifer and from the water-bearing zone of the upper confining unit. The Floridan aquifer is also recharged directly by rainfall in northern Leon County and in southern Georgia where it is near or at land surface. Ground water moves toward the southeast from the potentiometric high in southwestern Gadsden County and south from Leon County toward Wakulla Springs, located about 10 miles south of Tallahassee. The potentiometric surface of the upper part of the Floridan aquifer ranges from about 50 feet higher than that of the middle and lower part of the Floridan aquifer in southwestern Gadsden County to about 10 feet higher near Midway in eastern Gadsden County. The aquifer discharge in the basin area is by wells and by natural discharge through seeps and springs along the Ochlockonee River and at Ochlockonee Bay.

Water levels in the Floridan aquifer fluctuate in response to seasonal and long-term variations in rainfall. Hydrographs do not show evidence of any long-term water-level declining trend.

Saline water (more than 1,000 milligrams per liter of dissolved solids) occurs naturally within the Floridan aquifer throughout the Ochlockonee River area at depths ranging from 200 to 600 feet below sea level. The depth below which dissolved solids in water exceed 500 milligrams per liter in the Havana area ranges from 200 to 250 feet below sea level; in the Quincy area, from 400 to 450 feet below; and in the Greensboro area, from 200 to 250 feet below.

Concentrations of dissolved solids in water pumped from wells tapping the Floridan aquifer in the Ochlockonee River area range from 60 to 1,370 milligrams per liter; chloride from 0 to 630 milligrams per liter; sulfate from 0.0 to 280 milligrams per liter; and fluoride from 0.0 to 1.3 milligrams per liter.

Streamflow originating in the Ochlockonee River area in Florida averages about 1,000 million gallons per day; minimum discharge during dry periods is about 285 million gallons per day. Stream yields range from 0.90 to 2.62 cubic feet per second per square mile. Quincy Creek, at State Highway 267 at Quincy, the primary source of water for the city of Quincy, yields an average flow of 19 million gallons per day, has a 7-day 10-year low flow of 2.8 million gallons per day, and contains water of acceptable quality. The chemical quality of most streams in the basin is acceptable for most uses. Dissolved-solids concentration is generally less than 135 milligrams per liter; pH ranges from 5.3 to 7.3 units; color from 20 to 90 platinum-cobalt units; and turbidity from 3 to 85 Jackson turbidity units. Variations in chloride concentration in water from the Ochlockonee River (5.2 to 140 milligrams per liter) are influenced by discharge of food processing waste and municipal sewage plant effluent to the river.

The three large lakes in the basin range from 4,000 to 7,000 acres in surface area. All are now used primarily for recreation. Dissolved-solids concentrations of water from the lakes range from less than 20 to 50 milligrams per liter. A major flood occurred in 1975 when the Ochlockonee River near Havana reached the third highest stage of record and the peak flood at the Sopchoppy River exceeded that for the period of record (11 years in 1975); no significant damage occurred.

INTRODUCTION

Purpose and Scope

Readily available potable water has been limited in the Ochlockonee River area, especially near Quincy in central Gadsden County. By the early 1970's, awareness of a limited supply was accentuated by continually increasing withdrawals. Wells drilled for water supply either had low yields, or highly mineralized water sometimes unsuitable for consumption or irrigation. Also, area water planners were concerned that Quincy Creek,

the primary source of water supply in Quincy, could not meet the growth demands of the city. All of the problems mentioned above, together with the lack of hydrologic information in the area, indicated the need for a comprehensive hydrologic investigation. Consequently, the Northwest Florida Water Management District, Gadsden County and the city of Quincy entered into a cooperative agreement with the U.S. Geological Survey to investigate the hydrology of the Ochlockonee River area.

This report evaluates the water resources of the Ochlockonee River area and provides information that will aid in the development of ground and surface water for current and future needs. The report also delineates areas favorable or unfavorable for water-supply development.

Field investigation began in October 1974 and continued through September 1977 and involved the establishment of a hydrologic monitoring network, water-quality sampling, aquifer tests, and geophysical logging. Major emphasis was concentrated in the northern part of the Ochlockonee River basin (Gadsden County) during the first 2 years and was shifted to the southern part of the Ochlockonee River basin during the third year.

Location and Extent of Area

The Ochlockonee River basin in the panhandle of northwest Florida extends from Georgia to the Gulf of Mexico and comprises about 1,420 mi^2. It includes all of Gadsden County and parts of Liberty, Wakulla, Leon, and Franklin Counties, as shown in figure 1. The area of investigation includes all of the Ochlockonee River basin in Florida and part of the Apalachicola River basin.

In 1970, Quincy and Chattahoochee, the two largest cities in the area, had populations of 8,334 and 7,944, respectively. In 1975, the estimated population of the area was about 48,000.

Agriculture is the principal industry in the area. Tobacco has been replaced by tomatoes, corn, ornamental plants, and pines as the principal crops. Much of the southern part of the Ochlockonee River basin is included in the Apalachicola National Forest--about 350 mi^2. The St. Marks National Wildlife Refuge also extends into the basin, comprising about 25 mi^2.

Data Collection

An observation-well network established during October through December 1974 was operated for 3 years. Water-level recorders were established on 7 wells to complement 3 long-term continuous stations, and an additional 50 wells were measured at 6- to 8-week intervals. Water samples from selected wells were analyzed for various constituents. Supplemental water-level and quality data were collected from more than 300 wells tapping various water-bearing zones.

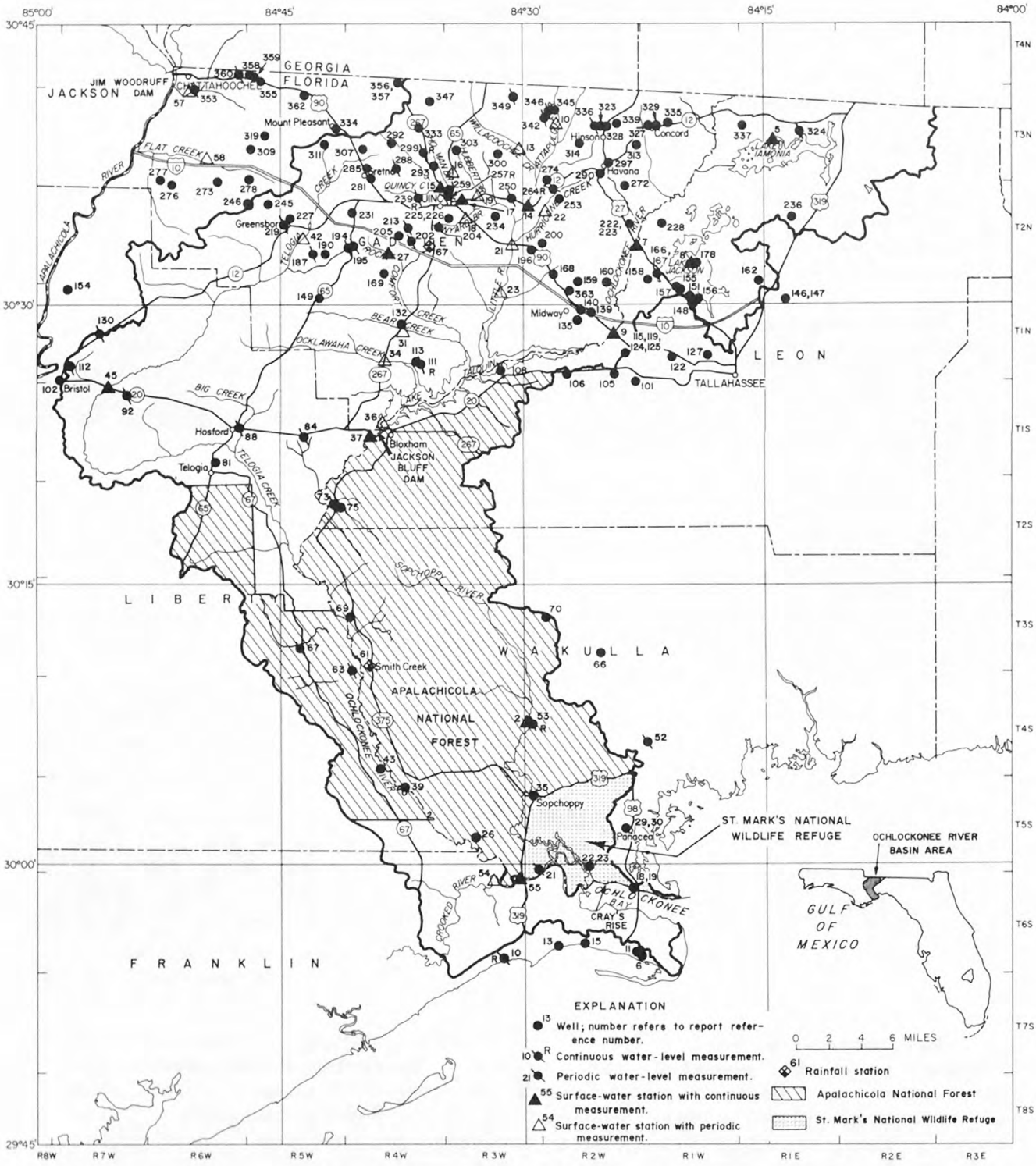


Figure 1.--Location of Ochlockonee River basin, Florida; the area of investigation, and hydrologic data-collection sites.

Geophysical logs were run in 50 wells throughout the area to: (1) determine physical well characteristics (depth of casing, bore-hole diameter, and depth of well); (2) aid in correlating geologic units; and (3) delineate zones of highly mineralized water. Detailed lithologic descriptions were made of cuttings from 100 wells. The well cuttings were either on file at the Florida Bureau of Geology or were collected from wells that were drilled during the investigation. Lithologic logs of 58 wells and cores were also made available by the Florida Bureau of Geology. Electric logs of oil test wells were used to determine the approximate depth to the base of freshwater. Aquifer tests were conducted at 10 wells.

Twelve surface-water gaging stations (4 continuous and 8 monthly) were established October 1974 to complement 6 long-term continuous gaging stations located within the basin. Annual mean discharges were estimated from monthly discharge measurements made at the 12 monthly gaging stations using a method by Riggs (1969). The average flows for the daily discharge station were adjusted to a common base period (1926-77) using correlation methods described by Searcy (1960). Streamflow measurements were also made annually at miscellaneous sites. Water samples were collected intermittently from streams at gaging stations for analysis of chemical and bacteriological content. To monitor the effects of agricultural development in the area, Quincy Creek, Little River, and Ocklawaha Creek were sampled annually for pesticides.

The suitability of water for public supply and domestic use can be judged by standards that have been recommended for drinking water by the U.S. Environmental Protection Agency (1977). The following maximum levels of common inorganic chemical and physical constituents for which data were collected are: chlorides, 250 mg/L; sulfate, 250 mg/L; dissolved solids, 500 mg/L; color, 15 platinum-cobalt units; and pH, 6.5-8.5. The maximum level for nitrate (NO_3-N) is 10.0 mg/L, U.S. Environmental Protection Agency (1975), and fluoride should not exceed a concentration that is determined by the annual average of maximum daily air temperature in the area considered. For the Ochlockonee River area (70.7 to 79.2°F), the recommended maximum fluoride concentration is 1.6 mg/L.

Acknowledgments

Appreciation is extended to the many individuals who furnished information on their wells and gave access to their land and equipment for measurements and tests. Special acknowledgment is made to the cities of Quincy, Havana, and Panacea, and to Talquin Electric Coop., Inc., and Coastal Lumber Co. for the use of their wells for geophysical logging and water-level measurements and also for the use of their pumping equipment during aquifer tests. Talquin Electric Coop., Inc., and Rowe Drilling Co. also supplied chemical analyses of water from their wells.

Special thanks are in order for the Florida Bureau of Geology and Northwest Florida Water Management District. Their excellent lithologic descriptions of cores and cuttings from 58 wells in the Ochlockonee River area were invaluable in mapping the geology of the area.

The courtesies extended by the following persons are most appreciated: Raymond Hurst and Carl Ferguson, city of Quincy; Cecil Tripp and Oliver Hunt, city of Havana; Lamar Rowe, Richard Rowe, and Edith Rowe, Rowe Drilling Co.; Robert Cooper, Talquin Electric Coop., Inc.; and members of the Board of Commissioners, Gadsden County: Ben S. Duncan, Lamar Massey, Jim Henry Slappey, Murray Spooner, Earl W. Lodge, and Joe M. Butler.

Previous Investigations

Earlier reports on the geology of the Ochlockonee River area include a description of the fuller's earth deposits of Gadsden County by Sellards and Gunter (1909). Sellards (1917) also described the geology between the Ochlockonee and Aucilla Rivers in Florida, and Sellards and Gunter (1918) described the geology between the Apalachicola and Ochlockonee Rivers. Cooke and Mossom (1928) and Cooke (1945) included descriptions of the stratigraphy of the area in reports on the geology of Florida. Hendry and Yon (1958) described the geology of the area in and around the Jim Woodruff Reservoir near Chattahoochee, Florida. A geologic and ground-water resources investigation in Leon County by Hendry and Sproul (1966) includes part of the Ochlockonee River area. Hughes (1967) investigated the water-level fluctuations of Lake Jackson, and Bridges and Davis (1972) described the record flood of September 1969 in the Gadsden County area. Patterson (1974) described the geology and in particular the fuller's earth and industrial mineral resources of a district that included the Quincy area. Harriss (1974) described the water quality of Lake Talquin. Rumenik and others (1975) provided a generalized map delineating flood-prone areas of Gadsden County. Cameron and Mory (1977) described the mineral resources of the Bradwell Bay and Sopchoppy River area in the southern Ochlockonee River basin.

Continuous discharge records have been collected at Ochlockonee River near Havana and Ochlockonee River near Bloxham since 1926, Little River near Quincy and Telogia Creek near Bristol since 1950, Sopchoppy River near Sopchoppy since 1964, and Rocky Comfort Creek near Quincy since 1964. Daily discharge for these streams are published by the U.S. Geological Survey in the annual series of Water-Supply Papers through 1970 and in the "Water Resources Data for Florida, Part 1, Surface-Water Records of Florida, Volume 1, Streams," 1971-74.

Chemical analyses of surface water and ground water have been published in a series of Water-Supply Papers through 1974, and in the "Water Resources Data for Florida, Part 2, Water Quality Records," 1971-74.

Ground-water levels have been measured in the Ochlockonee River basin since 1935. The measurement records have been published in the Water-Supply Paper series of the U.S. Geological Survey.

Lake elevations have been published in the series of Water-Supply Papers through 1970 and in the "Water Resources Data for Florida, Part 1, Surface-Water Records, Volume 3, Lakes," 1971-74.

Water-resources data for the area have been published in the Water Resources Data for Florida series, Volume 1 for 1975 and Volume 4 for 1976-77.

Pascale and others (1978) list data collected within the Ochlockonee River area on streamflow, ground-water levels, quality of ground and surface water, and lithology.

HYDROLOGIC SETTING

Climate, physiography, and geology control the availability of water. Of the climatic elements--temperature, wind, and rainfall--rainfall has the greatest and most important effect on the amount of freshwater that reaches the land surface as available water. Once the freshwater has reached land surface, physiography and geology govern the amount and rate of runoff and infiltration of water not evaporated or transpired. Rainfall that is not lost to evapotranspiration either is stored temporarily in lakes or ponds, flows overland in streams, or percolates through the soil and eventually replenishes the aquifers.

Climate

The Ochlockonee River area has a warm, humid climate, typical of the Gulf Coast. Summers are long, warm, and relatively humid; winters are mild and relatively short, although cold spells occur periodically. The average annual air temperature at the National Weather Service (NWS) station in Quincy is 67°F. The average monthly air temperature ranges from 53°F in January to 80°F in July and August (fig. 2). Average monthly rainfall ranges from 2.6 inches in November to 7.7 inches in July (fig. 2). Nearly half the yearly rainfall occurs between June and September as a result of frequent short-duration afternoon and evening thunderstorms.

Annual rainfall at Quincy from 1917 to 1977 averaged 57 inches and ranged from 30 inches in 1954 to 84 inches in 1964 (fig. 2). An annual rainfall of 57 inches uniformly distributed over the Ochlockonee River area is equivalent to 3.9 billion gallons per day. From 1975 to 1977, when most of the hydrologic data for the investigation were collected, the cumulative rainfall was very close to the long-term average.

During the investigation, monthly rainfall was as much as 9 inches greater at the National Weather Service station at Smith Creek than at Quincy (table 1). Annual rainfall at Smith Creek ranged from 16 inches greater than that at Quincy in 1975 to 6 inches greater in 1977. This suggests that rainfall in the southern part of the Ochlockonee River basin is appreciably greater than indicated by the rainfall station at Quincy.

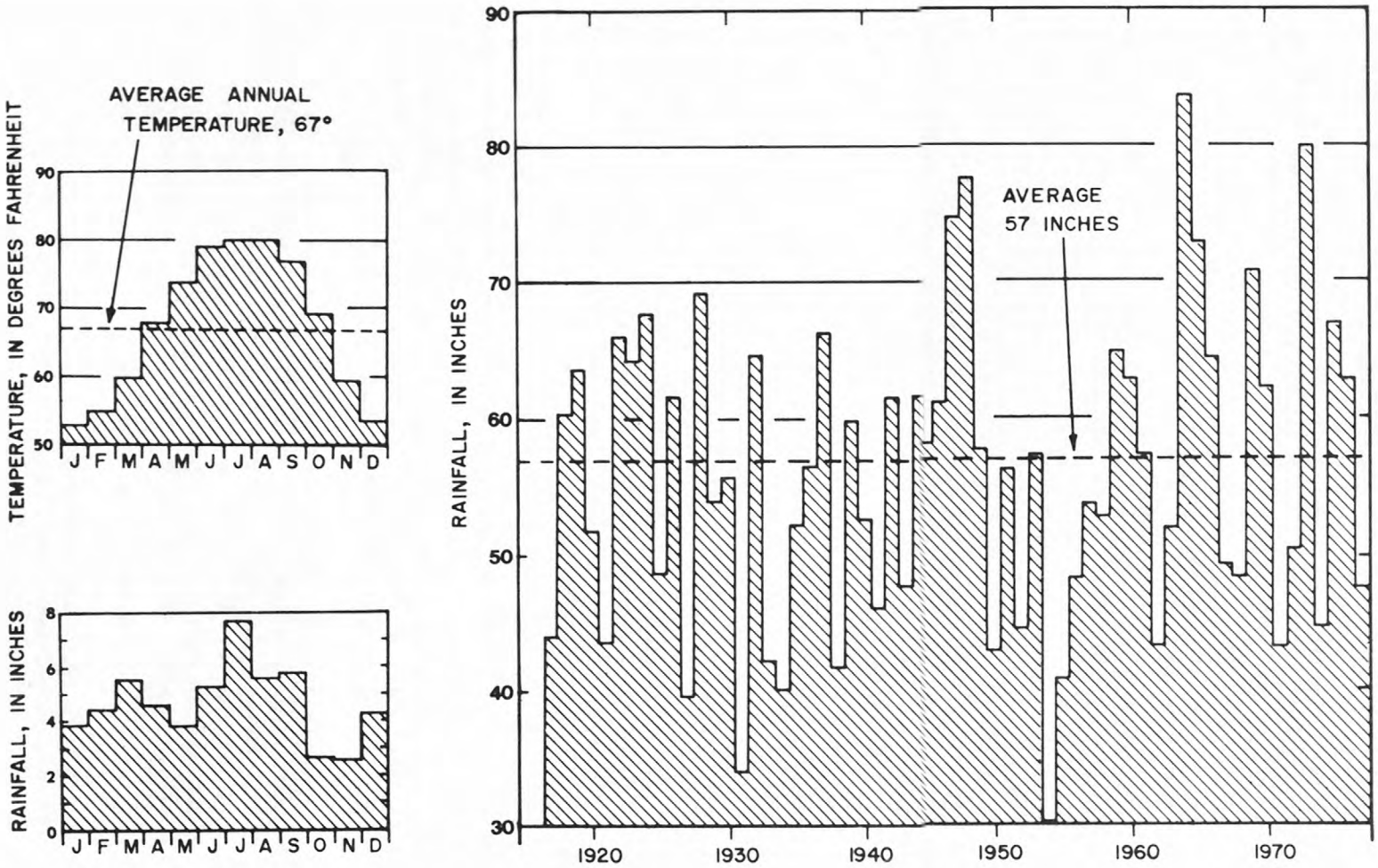


Figure 2.--Average monthly temperature and rainfall, and annual rainfall at Quincy, Florida, 1917-77 (Data from Davis and Mickelson, 1969, and unpublished data from files of Quincy Experimental Station, Florida).

Water from well 43 (fig. 1), located near the Ochlockonee River south of Smith Creek, contained the highest concentration of dissolved solids of any well sampled in the southern Ochlockonee River area. A pumped sample contained 762 mg/L dissolved solids. Samples collected with a deep-well sampler indicated that there was no change in dissolved solids with sample depth. The well, bottom altitude 240 feet below sea level, has 6-inch casing to 152 feet below sea level. Water samples collected at 164 and 229 feet below sea level had dissolved-solids concentrations of 900 and 918 mg/L, respectively. The well is in the Apalachicola Forest and is equipped with a low-capacity pump (5 gal/min) and is used only sparingly by campers and hunters. The high dissolved-solids concentration may reflect upward movement of saltwater. The configuration of the potentiometric surface in the southern part of the study area and its position above the Ochlockonee River indicates that the Floridan aquifer discharges to the river. Natural upward discharge flow in the vicinity of the river tends to move deeper salty water into the upper zone of the aquifer.

Surface Water

Occurrence of Streamflow

Streamflow consists of direct runoff during and immediately following rains, and ground-water runoff. Ground-water runoff supplies the base flow of a stream and sustains streamflow during periods of fair weather. In the northern part of the area, the base runoff of most small streams comes from seepage from deposits of sand and clay of the upper confining unit; in the central part from thick sand beds of the surficial aquifer; and in the southern part from shell beds and limestone of the upper part of the Floridan aquifer. A small portion of the base runoff to the Sopchoppy River comes from ground-water discharge from rocks of the Floridan aquifer that crop out in the river channel.

Streamflow Characteristics

Streamflow originating in the Ochlockonee River area in Florida averages about 1,500 ft^3/s or about 1 billion gallons per day; this is based on discharge from gaged areas and estimates from ungaged areas. Estimated discharges were obtained by correlation with streams in nearby basins whose physical characteristics are similar and for which the stream discharge is known.

Surface-water data-collection sites identified in figure 1 are listed in table 8. The tabulation includes station names, numbers, drainage areas, type and frequency of records, and period of record collection. For other hydrologic data see Pascale and others (1978).

Table 8.--Selected surface-water data-collection sites

Type of record: A, standard chemical analysis; B, bacteriological; D, discharge and stage; K, conductivity; N, nutrient analysis; P, pesticide analysis; S, stage.
Frequency of record: d, daily; i, intermittent; p, periodic; r, continuous; (25), total number if analyses of samples or measurements of streamflow.

Station number in figures	Station name	Drainage area (mi^2)	Type and frequency of record	Period of record (water years)
1	Sopchoppy River near Arran	48.2	Di(10),A(3), K(4)	1965-67 1969-71 1975-76
2	Sopchoppy River near Sopchoppy	102	Dr,A(146), B(21),N(33), P(8)	1961-77
3	Ochlockonee River near Concord	1,002	Di(6),A(1), K(5),N(2)	1921 1975-77
4	Shaw Creek near Concord	11.4	Di(1),K(1)	1976
5	Lake Iamonia near Bradfordville	101	Sr,A(1), N(1)	1976-77
6	Lewis Creek near Havana	2.65	Di(3),K(2)	1976
7	Ochlockonee River near Havana	1,140	Dr,A(108), B(20),N(33), P(10)	1926-77
8	Lake Jackson near Tallahassee	43.2	Sr,A(21) N(9)	1926-29 1958-77
9	Ochlockonee River at Ochlockonee	1,390	Di(4),K(1) N(1)	1958-59 1975

Table 8.--Selected surface-water data-collection sites--Continued

Station number in figures	Station name	Drainage area (mi^2)	Type and frequency of record	Period of record (water years)
10	Attapulgus Creek at Jamieson	95.6	Dp(23),A(30, B(4),K(9), N(8)	1969 1975-77
11	Swamp Creek at Jamieson	53.0	Di(2),K(2), N(1)	1975-76
12	Willacoochee Creek near Dogtown	36.5	Di(3),K(3), N(1)	1975-76
13	Willacoochee Creek near Quincy	64.9	Dp(24),A(3), B(4),N(8)	1975-77
14	Little River near Quincy	237	Dr,A(5), N(2)	1950-77
15	Quincy Creek at S-267 at Quincy	16.8	Dr,A(5), B(4),K(17), N(8),P(3)	1975-77
16	Holman Branch near Quincy	3.09	Dp(36),A(3), B(4),K(17), N(8)	1969 1975-77
17	Quincy Creek at Quincy	21.9	Dr,A(5),B(4), K(15),N(8)	1956,1965-67 1973,1975-77
18	Tanyard Branch near Quincy	4.91	Dp(31),A(3), B(4),K(14), N(8)	1969 1975-77
19	Hubbert Branch near Quincy	4.68	Dp(36),A(3), B(4),K(17), N(8)	1969 1975-77
20	Winkley Branch near Quincy	1.64	Di(3),K(2), N(1)	1969, 1975-76

Table 8.--Selected surface-water data-collection sites--Continued

Station number in figures	Station name	Drainage area (mi^2)	Type and frequency of record	Period of record (water years)
21	Little River near Littman	279	Di(10),A(2), B(2),K(7), N(4),P(3)	1926, 1939, 1969, 1975-77
22	Hurricane Creek near Havana	8.31	Dp(37),A(3), B(4),K(16), N(7)	1969 1975-77
23	Little River near Midway	305	Di(14),A(7), B(4),K(14), N(8)	1965-71 1975-77
24	Monroe Creek near Midway	6.80	Di(4),K(1)	1958-59 1976
25	Richlander Creek near Quincy	5.80	Di(5),K(1), N(1)	1958-59 1975-76
26	Polk Creek near Bloxham	3.64	Di(3),K(1)	1958,1976
27	Rocky Comfort Creek near Quincy	9.46	Dr,A(5), N(1)	1956 1965-76
28	Vote Creek near Quincy	1.06	Di(1),K(1)	1976
29	Rocky Comfort Creek near Wetumpka	34.1	Di(6),K(3), N(1)	1958-59 1975-76
30	Turkey Creek near Quincy	4.78	Di(4),K(1)	1958-59, 1976
31	Bear Creek near Wetumpka	10.2	Di(4),K(1), N(1)	1958-59 1975
32	Harvey Creek near Bloxham	8.11	Di(3),K(1)	1958, 1976

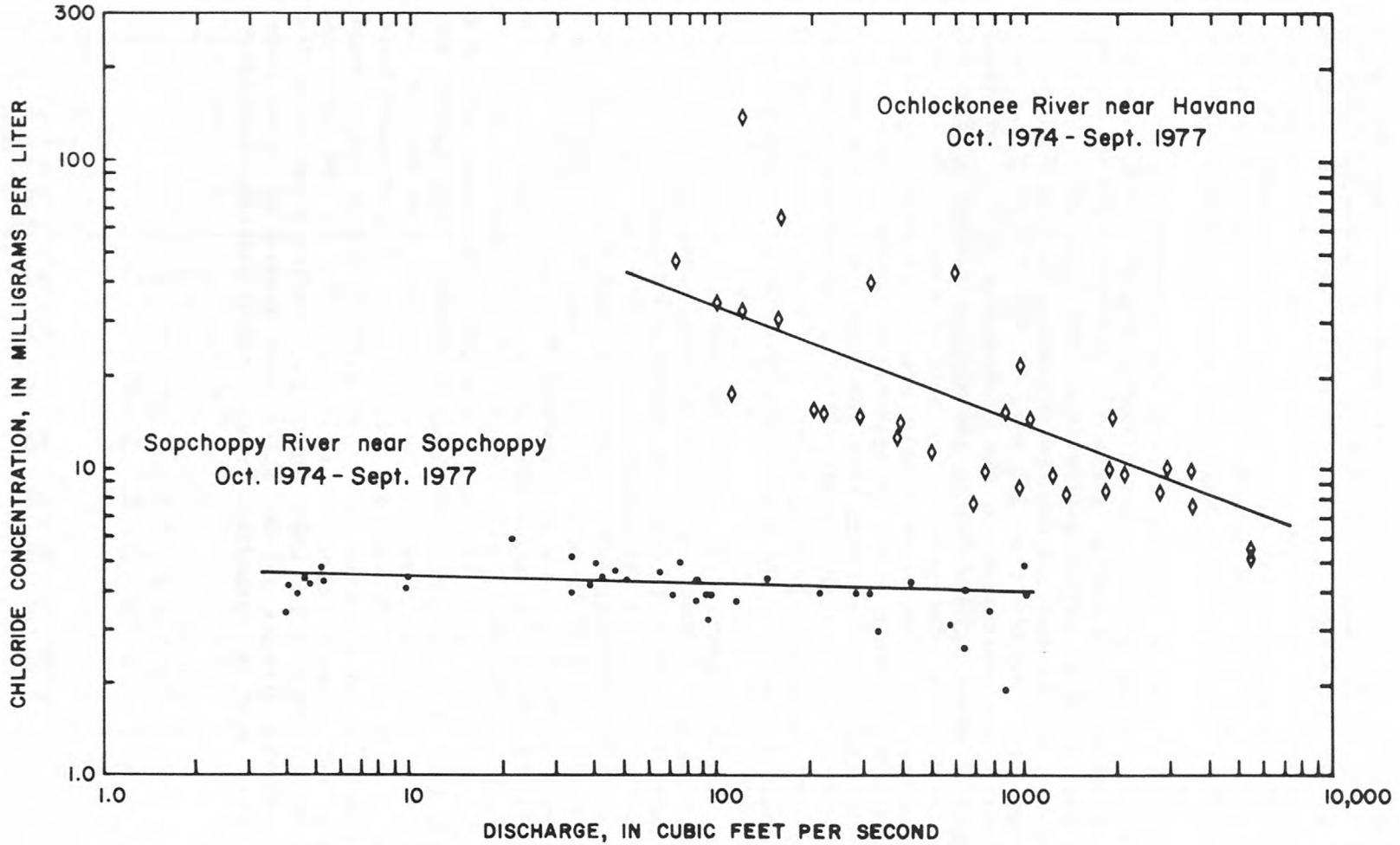


Figure 35.--Variation in chloride concentration and discharge of Ochlockonee and Sopchoppy Rivers.

Table 12.--Selected physical properties of surface water in the Ochlockonee River area

Station number in fig. 1	Name	Date	Temperature (°C)	Discharge (ft^3/s)	pH	Specific conductance (umho/cm at 25°C)	Color (PCU)	Turbidity (JTU)	Hardness (Ca, mg)
2	Sopchoppy River near Sopchoppy	11/20/74	10	4.5	7.2	202	50	3	120
5	Lake Iamonia near Bradfordville	06/03/77	26	(1)	5.0	20	20	3	5
7	Ochlockonee River near Havana	11/01/74	20	119	7.0	178	55	7	44
8	Lake Jackson near Tallahassee	09/14/77	29	(2)	6.4	29	10	1	6
10	Attapulgus Creek at Jamieson	11/19/74	15	21	6.5	116	40	7	31
13	Willacoochee Creek near Quincy	11/19/74	17	23	7.3	38	70	9	15
14	Little River near Quincy	11/21/74	15	83	6.7	80	30	8	28
15	Quincy Creek at S-267 at Quincy	11/19/74	19	12	5.7	50	50	85	20
16	Holman Branch near Quincy	11/20/74	18	.82	7.0	42	60	10	15
17	Quincy Creek at Quincy	11/20/74	18	9.7	6.4	55	20	7	17

[1]Altitude: 99.27 ft above sea level.
[2]Altitude: 84.02 ft above sea level.

Table 12.--Selected physical properties of surface water in the Ochlockonee River area--Continued

Station number in fig. 1	Name	Date	Temperature (°C)	Discharge (ft^3/s)	pH	Specific conductance (umho/cm at 25°C)	Color (PCU)	Turbidity (JTU)	Hardness (Ca, mg)
18	Tanyard Branch near Quincy	11/20/74	19	19	6.9	111	90	70	31
19	Hubbert Branch near Quincy	11/19/74	18	1.4	7.0	54	30	6	17
22	Hurricane Creek near Havana	11/19/74	16	.04	6.9	142	20	7	65
34	Ocklawaha Creek near Havana	11/21/74	14	47	5.3	16	80	3	4
36	Lake Talquin near Bloxham	09/15/77	26	(3)	6.6	75	30	6	5
42	Telogia Creek near Greensboro	11/21/74	15	20	6.3	46	70	6	11
55	Ochlockonee River near McIntyre	11/26/74	16	--	7.0	83	50	6	22
58	Flat Creek near Chattahoochee	11/21/74	15	22	6.7	43	30	4	15

[3]Altitude: 88.25 ft above sea level.

The chemical quality of water in Quincy Creek, the principal source of water for municipal supply for the city of Quincy, is acceptable for raw surface water for public supply before treatment. (Treatment is necessary to remove the color and turbidity.) Dissolved solids of water samples collected there ranged from 28 to 44 mg/L with a mean concentration of 38 mg/L, well below the proposed Secondary Drinking Water Limit (U.S. Environmental Protection Agency, 1977) of 500 mg/L. Color ranged from 35 to 140 platinum-cobalt color units; turbidity from 10 to 85 Jackson turbidity units. The water contained no detectable amounts of pesticides but bottom sediments collected from May 1975 to May 1977 showed detectable concentrations of chlordane, DDD, DDE, DDT, and PCB (table 13). Pesticides accumulate and are absorbed on stream-bottom sediments. These pesticides could have reached Quincy Creek by direct surface runoff or by wind drift from adjacent treated farm areas.

Other streams sampled during the period of investigation showing detectable amounts of pesticides on bottom sediments included the Ochlockonee River, Little River, and Ocklawaha Creek (table 13). No detectable amounts of pesticides were found in bottom sediments collected at the Sopchoppy River.

Nutrient concentrations in streamflow in the area in the form of nitrogen and phosphorus (table 14) generally averaged less than 3.0 mg/L and 0.5 mg/L, respectively, well below any maximum contaminant level specified for a public supply by the Florida Department of State (1978). Water receiving sewage effluent or agricultural drainage commonly contains appreciable nitrogen (ammonia, nitrate, nitrite, and organic) and phosphorus (ortho and total). The maximum nitrate concentration, as N, of streams shown in table 14 was 2.0 mg/L at Little River; the minimum was 0.00 mg/L at Ochlawaha Creek and Sopchoppy River. Nitrate concentration at Quincy Creek (station 15) was 0.25 mg/L.

The presence of fecal coliform bacteria and fecal streptococci bacteria in water can be used as indications of possible sewage pollution and of the sanitary quality of the water. The degree of pollution is indicated by the number of coliform colonies present. Their concentrations are expressed as number of colonies per 100 mL of sample. Standards are not yet available for streptococci bacteria; but for a surface-water supply to be acceptable, the Florida Department of State (1978) suggests that fecal coliforms should not exceed 2,000 colonies per 100 mL at any given time. With this limitation, water-treatment plants are considered capable of producing water meeting drinking-water standards of 1 coliform colony per 100 mL. Coliform tests of 14 streams in the area during September 1975 and March 1977, shown in table 15, indicate that at the time of sampling, Willacoochee Creek (Sept. 1975), and Tanyard Branch (March 1977) did not meet the foregoing standards.

Table 13.--Pesticide analyses of bottom sediments of streams

[Concentration in micrograms per kilogram]

Date	Discharge (ft^3/s)	Chlordane	DDD	DDE	DDT	Dieldrin	Endrin	Heptachlor	Heptachlor epoxide	Lindane	Toxaphene	PCB	Aldrin
Station 2, Sopchoppy River near Sopchoppy													
06/01/76	285	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0.0
04/14/77	1.7	0	.0	.0	.0	.0	.0	.0	.0	.0	0	0	.0
Station 7, Ochlockonee River near Havana													
05/20/75	2,620	22	ND[1]	ND	ND	ND	ND	ND	ND	ND	ND	(2)	ND
11/13/75	393	ND	ND	ND	ND	.0	ND	ND	ND	ND	ND	--	ND
11/02/76	587	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	ND
05/09/77	205	3	--	--	--	.4	ND	ND	ND	ND	ND	--	ND
Station 15, Quincy Creek at S-267 at Quincy													
05/20/75	32	3	.7	.7	.0	.0	.0	.0	.0	.0	0	1	.0
04/23/76	11	0	.0	.0	.0	.0	.0	.0	.0	.0	0	0	.0
05/18/77	5.9	2	1.0	.0	.3	.0	.0	.0	.0	.0	0	0	.0

[1]ND: analyzed for but not detected.
[2]No data.

Table 13.--Pesticide analyses of bottom sediments of streams--Continued

Date	Discharge (ft^3/s)	Chlordane	DDD	DDE	DDT	Dieldrin	Endrin	Heptachlor	Heptachlor epoxide	Lindane	Toxaphene	PCB	Aldrin
Station 21, Little River near Littman													
05/23/75	269	0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0.0
04/23/76	119	0	.0	.0	.0	.0	.0	.0	.0	.0	0	0	.0
05/19/77	56	0	.6	.0	.0	.0	.0	.0	.0	.0	--	0	.0
Station 34, Ocklawaha Creek near Wetumpka													
05/22/75	56	0	.0	.0	.0	.0	.0	.0	.0	.0	0	0	.0
04/23/76	37	0	.0	.0	.0	.0	.0	.0	.0	.0	0	0	.0
05/19/77	33	2	1.0	.0	.3	.0	.0	.0	.0	.0	0	0	.0

Table 14.--Selected nutrient constituents of surface water in the Ochlockonee River area

[Constituents in milligrams per liter]

Station number in fig. 1	Name	Date	Total organic carbon (TOC)	Nitrate (N)	Nitrite (N)	Organic nitrogen (N)	Ammonia nitrogen (N)	Phosphorus total ortho (P)	Phosphorus total (P)
2	Sopchoppy River near Sopchoppy	11/20/74	6.0	0.00	0.00	0.13	0.03	0.06	0.07
5	Lake Iamonia near Bradfordville	06/03/77	--	.00	.00	.01	.44	.01	.02
7	Ochlockonee River near Havana	11/01/74	8.0	.87	.01	.33	.04	.30	.31
8	Lake Jackson near Tallahassee	09/14/77	6.0	.00	.00	.48	.01	.01	.03
10	Attapulgus Creek at Jamieson	11/19/74	4.0	.49	.09	.54	.63	.02	.04
13	Willacoochee Creek near Quincy	11/19/74	5.0	.01	.01	.26	.02	.03	.04
14	Little River near Quincy	11/21/74	9.0	2.0	.03	.48	.04	.14	.19
15	Quincy Creek at S-267 at Quincy	11/19/74	7.0	.25	.02	1.8	.02	.05	.20
16	Holman Branch near Quincy	11/20/74	6.0	.04	.01	.35	.01	.11	.20
17	Quincy Creek at Quincy	11/20/74	4.0	.31	.01	.19	.07	.03	.09

Table 14.--Selected nutrient constituents of surface water in the Ochlockonee River area--Continued

Station number in fig. 1	Name	Date	Total organic carbon (TOC)	Nitrate (N)	Nitrite (N)	Organic nitrogen (N)	Ammonia nitrogen (N)	Phosphorus total ortho (P)	Phosphorus total (P)
18	Tanyard Branch near Quincy	11/20/74	14	0.51	0.04	1.0	0.03	0.14	0.17
19	Hubbert Branch near Quincy	11/19/74	6.0	.21	.01	.15	.03	.03	.05
22	Hurricane Creek near Havana	11/19/74	4.0	.11	.00	.31	.02	.03	.06
34	Ocklawaha Creek near Wetumpka	11/21/74	11	.00	.01	.22	.01	.01	.01
36	Lake Talquin near Bloxham	09/15/77	--	.11	.01	.47	.08	.21	.22
42	Telogia Creek near Greensboro	11/21/74	7.0	.44	.01	.34	.03	.04	.06
55	Ochlockonee River near McIntyre	11/26/74	7.0	.10	.01	.29	.03	.03	.04
58	Flat Creek near Chattahoochee	11/21/74	7.0	.51	.01	.22	.01	.13	.16

Table 15.--Bacteriological analyses of surface water

Station number in fig. 1	Name	Date	Discharge (ft^3/s)	Fecal coliform (colonies per 100 mL)	Streptococci (colonies per 100 mL)
2	Sopchoppy River near Sopchoppy	09/18/75	145	260	150
7	Ochlockonee River near Havana	09/11/75	385	40	220
10	Attapulgus Creek at Jamieson	09/17/75	52	143	600
		03/16/77	206	200	430
13	Willacoochee Creek near Quincy	09/18/75	131	3,200	8,000
		03/16/77	110	180	1,365
14	Little River near Quincy	09/25/75	171	410	208
		03/18/77	516	110	188
15	Quincy Creek at S-267 at Quincy	09/18/75	41	767	1,720
		03/16/77	33	140	700
16	Holman Branch near Quincy	09/25/75	1.4	1,020	1,720
		03/18/77	4.8	280	1,660
17	Quincy Creek at Quincy	09/18/75	43	833	1,680
		03/16/77	43	230	730
18	Tanyard Branch near Quincy	09/25/75	3.0	140	440
		03/18/77	6.1	2,760	1,520
19	Hubbert Branch near Quincy	09/18/75	6.6	1,070	3,000
		03/16/77	9.3	440	1,070
22	Hurricane Creek near Havana	09/17/75	0.98	800	1,600
		03/16/77	22	190	1,200
34	Ocklawaha Creek near Wetumpka	09/25/75	71	220	124
		03/17/77	69	210	188
42	Telogia Creek near Greensboro	09/29/75	20	90	280
		03/17/77	34	60	196
58	Flat Creek near Chattahoochee	09/29/75	52	690	1,600
		03/17/77	56	1,865	2,600

Lakes

Chemical analyses shown in tables 11, 12, and 14 indicate that Lakes Iamonia, Jackson, and Talquin contain water of excellent chemical quality. The dissolved-solids concentration of water from Lake Talquin is 50 mg/L, and chloride and sodium concentrations 11 and 7.4 mg/L, respectively, reflecting the quality of the Ochlockonee River. Water in Lakes Iamonia and Jackson contains less than 20 mg/L dissolved solids, and is similar to the quality of rainwater. Analyses of 24 water samples taken at Lake Jackson from 1965 to 1977 showed little change in chemical quality. Dissolved-solids concentrations ranged from 13 to 24 mg/L; chloride from 2.1 to 8.5 mg/L; nitrate from 0.00 to 0.1; total nitrogen from 0.01 to 0.71 mg/L; ortho-phosphorus, 0.00 to 0.02; and total phosphorus from 0.01 to 0.06.

Water Use

In 1975, 11.4 Mgal/d of water was withdrawn for all uses in the Ochlockonee River area, as shown in table 16. About half of the water withdrawn was from wells and half was from streams.

Pumpage for the cities of Quincy and Chattahoochee, the two largest municipal water suppliers in the area, averaged 1.5 and 0.4 Mgal/d, respectively, during 1977, a slight increase over that of 1975 (table 16). Since 1964, pumpage at Quincy has averaged 1.3 Mgal/d, ranging from 1.1 Mgal/d in 1964 to 1.5 Mgal/d in 1971 and 1977. The primary source of water for the city of Quincy is Quincy Creek. Ground water is used occasionally as a supplemental source during prolonged dry periods when Quincy Creek approaches its minimum flow. During 1977, for example, the city's one supply well was used intermittently for 40 days from April through August, pumping an average of 0.4 Mgal/d.

Other water uses throughout the area in 1975 included 2.4 Mgal/d withdrawn from streams to irrigate tobacco, vegetables, and nursery plants; 1.7 Mgal/d from the Floridan aquifer and 1.9 Mgal/d from streams for self-supplied industries; and 2.6 Mgal/d from wells and streams for rural-domestic and livestock.

Surface water is the principal source of water for irrigation because of low well yields and high chloride content of ground-water in the area. The few farms that use ground water use it in conjunction with surface water. Most streams in the area have highly variable flow, and more than 50 dams and ponds have been constructed on small streams and branches in Gadsden County to store water for irrigation or to water livestock.

Water Availability

Although surface water in most of the area is acceptable for most uses, how much pumpage can streams near Quincy sustain during minimum flows without storage? Will the streams near Quincy supply the anticipated future water needs of the city?

Table 16.--Water used in the Ochlockonee River area during 1975

Water supply	Number of people served	Number of wells	Capacity (gal/min)	Water used (Mgal/d) Ground water	Water used (Mgal/d) Surface water
Municipal					
Quincy	10,870	1	320	--	1/1.180
Chattahoochee	3,000	2	510	0.340	--
Havana	2,995	2/3	300-700	0.370	--
Hinson	65	1	50	0.004	--
Greensboro	1,100	2	220-300	0.088	--
Bristol	1,530	3/4	45-220	0.094	--
Sopchoppy	720	1	280	0.035	--
Panacea	1,530	4/3	150-370	0.080	--
Alligator Point	78	3	90	0.078	--
Talquin Electric Coop., Inc.5/	3,859	20	20-600	0.339	--
Industrial self supplied				6/1.716	7/1.940
Rural				2.163	0.402
Irrigation				--	2.43
Totals of ground water and surface water used				5.407	5.592
Combined totals				11.359	

[1]Primary source - Quincy Creek.
[2]One well non-operational.
[3]Only 3 wells operating.
[4]Only 2 wells operating.
[5]Includes 14 systems within the basin area.
[6]Includes 1.213 Mgal/d from Arvah B. Hopkins Generating Station, Leon County.
[7]Includes 1.83 Mgal/d from Florida State Hospital, Gadsden County, source - North Mosquito Creek.

The average flow of Quincy Creek at State Highway 267 is about 31 ft^3/s (20 Mgal/d). Its 7-day 10-year low flow is 4.2 ft^3/s (2.7 Mgal/d). During 1977, the average pumpage at Quincy was 2.0 ft^3/s (1.3 Mgal/d). If pumpage increases much above that of 1977, it can soon exceed water available in the creek during periods of extreme low flow.

Of all the streams measured at or near Quincy, Little River is considered the best alternate source of surface-water supply without storage. It contains water of acceptable chemical quality and its 7-day 10-year low flow is 14 ft^3/s (9 Mgal/d). Little River and Quincy Creek together would yield about 18 ft^3/s (12 Mgal/d). At the present per capita water usage at Quincy (110 gallons per day), 12 Mgal/d would be sufficient to supply a population of about 109,000.

Another alternative for future water supply at Quincy would be to develop a ground-water supply. The volume of potable ground water available for use from the Floridan aquifer in Gadsden County is substantial. For example, based upon an estimated aquifer thickness of 200 feet and storage coefficient (volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head) of 2×10^{-4}, the estimated volume of ground water stored in the upper part of the Floridan aquifer in Gadsden County is about 13,000 acre-ft.

Potential for development of the upper part of the Floridan aquifer without deleterious effect is good throughout the area except near the coast. The potential is especially good where the upper part is separated from the middle and lower parts of the Floridan aquifer by a leaky confining bed in the western two-thirds of Gadsden County. The leaky confining unit will help retard upward movement of the more mineralized water contained in the middle and lower parts of the Floridan aquifer.

The upper part of the Floridan aquifer will have to be developed with proper planning because of its low transmissivity in the area of investigation. For example, by using low-capacity wells, (75 gal/min or less) widely spaced, drawdowns likely will not be great enough to cause upward movement of poorer quality water. For example, if a well were to pump 75 gal/min (0.11 Mgal/d) for 10 years from an aquifer whose transmissivity is 1,000 ft^2/d and whose storage coefficient is 2.0×10^{-4}, the drawdown at a point 1,000 feet distant after 10 years would be 12 feet (assuming no recharge or leakage) according to Theis nonequilibrium formula (Theis, 1935); the drawdown at a point 10,000 feet distant after 10 years would be 7 feet. Thus, well spacing is very important not only to reduce the drawdown effect on other wells but to reduce the overall decline in head within the aquifer.

If water does leak to the Floridan aquifer through the overlying semiconfining bed from the water-bearing zone of the upper confining unit, a condition that is highly probable, the actual drawdown by pumping would be less than that calculated by Theis formula. For example, the leakage, or volume of water moving vertically to the Floridan aquifer may be calculated using the following form of Darcy's Law (Lohman, 1972):

where: $$Q = \frac{K^1}{B^1} (A) (h) \frac{(7.48)}{1,440}$$

where: Q = Leakage, in gallons per minute

K^1 = Vertical hydraulic conductivity of confining bed, in ft/day. The vertical hydraulic conductivity is assumed to be 0.001 foot per day [estimated from laboratory values of vertical hydraulic conductivity of 6 cores collected at Osceola National Forest by Miller and others (1978, table 17)].

B^1 = Thickness of confining bed, in feet. Thickness of clay is assumed to be 15 feet.

A = Area of confining bed through which leakage occurs, in square feet. The area in this example is assumed to be that enclosed by a circular area having a radius of 1,000 feet.

h = Average head difference between the potentiometric surfaces, in feet. The average difference in head within a radius of 1,000 feet between the potentiometric surfaces of two water-bearing zones is 10 feet.

The leakage to the Floridan aquifer would be about 11 gal/min under steady-state conditions. Under these conditions, of the 75 gal/min pumped, 11 gal/min should be supplied by leakage and 64 gal/min would come from storage within the Floridan aquifer. Increased leakage due to large-scale pumping would eventually cause the potentiometric surface of the water-bearing zone of the upper confining unit to decline. However, this in turn would cause some increase in leakage into the water-bearing zone of the upper confining unit from the overlying surficial aquifer.

One other consideration in the successful development of a ground-water supply in the upper part of the Floridan aquifer is well construction. Construction of wells in the poorly transmissive upper part of the Floridan aquifer may present problems for well drillers when the uncased limestone section contains lenses of clay and sand. If the wells are overpumped, the velocity of ground water entering the open-hole section may be great enough to erode the clay and sand in the walls of the bore hole and cause these materials to be carried in suspension in the ground water. Thus, the water would be cloudy or milky. A reportedly successful method is to screen and gravel pack a well in the water-producing interval rather than complete the well open-hole. One well recently constructed in this manner southwest of Havana produces 125 gal/min of excellent quality water.

Because of low base flow of the Sopchoppy River and the lack of potential surface-water supply sources in the Sopchoppy and Panacea areas, ground water will continue to be developed in the southern part of the Ochlockonee basin. Increased development of ground water in the immediate vicinity of the coast will increase the potential for lateral movement of saltwater into the freshwater zone of the aquifer from the Gulf and vertical upconing from depth. The potentiometric surface of the Floridan aquifer along the coast is less than 10 feet above sea level (fig. 15). As long as that surface is above sea level, ground water will continue to discharge to the gulf and thus prevent landward movement of seawater into the aquifer. However, if the potentiometric surface declines near the coast, the saltwater at 300 feet below sea level in the aquifer will tend to move upward. According to the Ghyben-Herzberg relation (Walton, 1970), saltwater at depth in the aquifer will move upward and theoretically displace 40 feet of freshwater in the aquifer for each 1-foot decline in the potentiometric surface. In other words, if the potentiometric surface were lowered 3 feet by pumping at Panacea, saltwater could theoretically move upward from 300 feet below sea level to 180 feet below sea level, displacing 120 feet of freshwater in the aquifer. The Ghyben-Herzberg relation is modified by local hydrologic conditions in many coastal areas. If it were desirable to develop new water supplies for the coastal area, the potential for serious saltwater intrusion could be reduced by developing ground-water sources inland where the potentiometric surface of the Floridan aquifer is higher than at the coast.

Suggestions for Further Study

Increased ground-water use, especially in Gadsden County and along the coast, may induce upward movement of the saltwater that occurs at relatively shallow depths throughout the study area. Because of this potential for saltwater contamination, a ground-water-quality monitoring program would be worthwhile. The program would be useful to alert users to any onset of saltwater intrusion by including the collection of samples from observation wells located near the center of heavy pumping and along the coast. Also, it would be worthwhile to continue the collection of discharge data at Quincy Creek to improve the long-term low-flow frequency data and also to continue to monitor the stream's water quality.

SUMMARY AND CONCLUSIONS

The Ochlockonee River area has three ground-water reservoirs, the surficial sand aquifer, the water-bearing zone of the upper confining unit, and the Floridan aquifer. The Floridan aquifer is the most important of these, the surficial sand aquifer and the water-bearing zone of the upper confining layer being of secondary importance.

The Floridan aquifer underlies all of the Ochlockonee River area and, except for the city of Quincy which uses surface water, is the principal source of municipal water supply. The aquifer is composed primarily of limestone ranging in age from Eocene to middle Miocene. It is confined by dense clay at the base of the Hawthorn Formation in the northern area and by Hawthorn-type sediments in the south. The top of the Floridan aquifer is about 120 feet above sea level in the northwest and northeast parts of the area, sloping southward to more than 100 feet below sea level in the center of the area. Further south near the coast, the top of the aquifer is 30 or fewer feet below sea level. Specific capacities of wells are low in Gadsden County, ranging from less than 1 to 5 (gal/min)/ft in wells penetrating the upper part of the Floridan aquifer, to 5 to 160 (gal/min)/ft in wells penetrating both the upper part and middle and lower parts of the Floridan aquifer. Wells generally produce from 25 to 100 gal/min in Gadsden County and 25 to 250 gal/min near the coast. The measured transmissivity of the aquifer is highly variable and ranges from 170 ft^2/d in the south to 5,100 ft^2/d at Quincy; calculated storage coefficients from two aquifer tests are 2×10^{-4} and 2.6×10^{-4}.

In the Ochlockonee River area the Floridan aquifer is recharged by downward leakage of water from the surficial sand aquifer and from the water-bearing zone of the upper confining unit and directly by rainfall in northern Leon County and in southern Georgia where it is near or at land surface.

Water levels in the Floridan aquifer fluctuate with rainfall, and there is no evidence of long-term water-level decline.

Floridan-aquifer water is generally of acceptable chemical quality, but quality declines with depth throughout the area. Water from wells tapping the upper part of the Floridan aquifer is usually a calcium bicarbonate type water of excellent chemical quality. Wells penetrating the deeper middle and lower parts of the Floridan aquifer usually produce a sodium chloride type water, high in dissolved solids. The depth below which dissolved solids in water exceed 500 mg/L in the Havana area varies between 200 and 250 feet below sea level; in the Quincy area, between 400 and 450 feet below; and in the Greensboro area, between 200 and 250 feet below. Along the coast, saltwater occurs in the aquifer below about 160 feet below sea level.

The surficial sand aquifer underlies most of the area; the water-bearing zone of the upper confining unit underlies most of Gadsden County. The surficial sand aquifer does not constitute a primary source of water supply but it is important because it stores water, maintains streamflow, and supplies recharge to underlying aquifers. The water-bearing zone of the upper confining unit is important because it is used for rural domestic supplies, and it also stores water and supplies recharge to the underlying Floridan aquifer. Water from the surficial sand aquifer and the water-bearing zone of the upper confining unit is of good quality. Dissolved solids in water from the surficial sand aquifer ranged from 20 to 40 mg/L; and 134 to 199 mg/L from the water-bearing zone of the upper confining unit.

Total water use in the Ochlockonee River area in 1975 averaged 11.4 Mgal/d, of which 5.4 Mgal/d was from wells and 6.0 Mgal/d was from streams. Surface water used for irrigation was 2.4 Mgal/d. Quincy and Chattahoochee, the two largest municipal water suppliers in the area, averaged 1.2 and 0.3 Mgal/d, respectively.

An alternative to surface water for future water supply at Quincy would be to develop a ground-water supply from the upper part of the Floridan aquifer. The upper 200 feet of the Floridan aquifer in Gadsden County contains about 13,000 acre-ft of water and has the potential for yielding greater quantities than are presently being withdrawn. Because of its low transmissivity, wells will generally have low yields (75 gal/min or less) and should be spaced properly to limit interference between wells. Potential water supplies for the coastal area exist further inland, where the potentiometric surface of the Floridan aquifer is higher. Continued lowering of the potentiometric surface along the coast will cause saltwater to gradually displace freshwater in the aquifer.

Streamflow originating in the Ochlockonee River area in Florida averages about 1,000 Mgal/d; minimum discharge during dry periods is about 285 Mgal/d. Streams draining areas overlain with thick permeable sands have the highest yields [as much as 2.62 $(ft^3/s)/mi^2$] while streams draining swamps and recharge areas have the lowest [less than 1.0 $(ft^3/s)/mi^2$]. Little River is considered the best alternative as a surface-water source for the city of Quincy to supplement the Quincy Creek supply.

The chemical quality of streams in the Ochlockonee River area is acceptable for most uses. Dissolved-solids concentrations are generally less than 135 mg/L. Color and turbidity are generally high, and treatment of the water is necessary for municipal supply. Large variations in chloride concentrations of water from the Ochlockonee River are caused by commercial and municipal waste discharged to the stream. Water in streams sampled contained no detectable amounts of pesticides, but bottom sediments collected at Quincy and Ocklawaha Creeks and at Little and Ochlockonee Rivers indicated the presence of pesticides. Nutrient concentrations of surface water in the area indicated little pollution, but bacteriological analyses of water from two streams near Quincy exceeded 2,000 colonies per 100 mL.

Three large lakes are in the area of investigation, two natural and one manmade. The natural lakes leak water to the Floridan aquifer through sinks. Lake Talquin, once used to generate hydroelectric power, is now used for recreation. The lakes contain water low in dissolved solids and nutrients.

SELECTED REFERENCES

Bridges, W. C., and Davis, D. R., 1972, Floods of September 20-23, 1969, in the Gadsden County area, Florida: Florida Bureau of Geology Information Circular no. 79, 37 p.

Cameron, C. C., and Mory, P. C., 1977, Mineral resources of the Bradwell Bay Wilderness and Sopchoppy River study area, Wakulla County, Florida: U.S. Geological Survey Bulletin 1431, 37 p.

Cooke, C. W., 1939, Scenery of Florida interpreted by a geologist: Florida Geological Survey Bulletin 17, 118 p.

_____1945, Geology of Florida: Florida Geological Survey Bulletin 29, 339 p.

Cooke, C. W., and Mossom, Stuart, 1928, Geology of Florida: Florida Geological Survey 20th Annual Report, p. 29-227.

Davis, D. R., and Mickelson, J. E., 1969, Climatological summary for the north Florida experimental station, Quincy, Florida: North Florida Station Memorandum Report NFS 69-1.

Florida Department of State, 1979, Rules of the Department of Environmental Regulation, water-quality standards, Chapter 17-3, in Florida Administrative Code: Tallahassee (in hearing).

Harriss, R. C.,1974, Lake Talquin investigations: completion report to the Florida Game and Fresh Water Fish Commission Project F-12-15: Florida State University, 112 p.

Healy, H. G., 1975, Terraces and shorelines of Florida: Florida Bureau of Geology Map Series no. 71.

Hendry, C. W., Jr., and Sproul, C. R., 1966, Geology and ground-water resources of Leon County, Florida: Florida Division of Geology Bulletin 47, 178 p.

Hendry, C. W., Jr., and Yon, J. W., Jr., 1958, Geology of the area in and around the Jim Woodruff Reservoir: Florida Geological Survey Report of Investigation no. 16, 52 p.

_____1967, Stratigraphy of upper Miocene Miccosukee Formation, Leon and Jefferson Counties, Florida: American Association of Petroleum Geologists Bulletin, v. 51, no. 2, p. 150-256.

Herrick, S. M., and Vorhis, R. C., 1963, Subsurface geology of the Georgia coastal plain: Georgia Geological Survey Information Circular no. 25, 79 p.

Hughes, G. H., 1967, Analysis of the water-level fluctuations of Lake Jackson near Tallahasseem Florida: Florida Division of Geology Report of Investigation no. 48, 25 p.

Johnson, L. C., 1892, The Chattahoochee embayment: Geological Society of America Bulletin, v. 3, p. 128-132.

Kohler, M. A., Nordenson, F. J., and Baker, D. R., 1959, Evaporation maps for the United States: Technical Paper no. 37, U.S. Weather Bureau.

Lohman, S. W., 1972, Ground-water hydraulics: U.S. Geological Survey Professional Paper 708, 70 p.

MacNeil, F. S., 1950, Pleistocene shorelines in Florida and Georgia: U.S. Geological Survey Professional Paper 221-F, p. 95-107.

Miller, J. A., Hughes, G. H., Hull, R. W., Vecchioli, and Seaber, P. R., 1978, Impact of potential phosphate mining on the hydrology of Osceola National Forest, Florida: U.S. Geological Survey Water-Resources Investigations 78-6, 159 p.

Parker, G. G., Ferguson, G. E., Love, S. K., and others, 1955, Water resources of southeastern Florida: U.S. Geological Survey Water-Supply Paper 1255, 965 p.

Pascale, C. A., Wagner, J. R., and Sohm, J. E., 1978, Hydrologic, geologic, and water-quality data, Ochlockonee River basin area, Florida: U.S. Geological Survey Water-Resources Investigations 78-97, 515 p.

Patterson, S. H., 1974, Fuller's earth and other industrial mineral resources of the Meigs-Attapulgus-Quincy district, Georgia and Florida: U.S. Geological Survey Professional Paper 828, 45 p.

Patterson, S. H., and Herrick, S. M., 1971, Chattahoochee Anticline, Apalachicola Embayment, Gulf Trough, and related structural features, southwestern Georgia, fact or fiction: Georgia Geological Survey Information Circular no. 41, 16 p.

Puri, H. S., 1953, Contributions to the study of the Miocene of the Florida panhandle: Florida Geological Survey Bulletin 36, 345 p.

_____1957, Stratigraphy and zonation of the Ocala Group: Florida Geological Survey Bulletin 38, 248 p.

Puri, H. S., and Vernon, R. O., 1964, Summary of the geology of Florida and a guidebook to the classic exposures: Florida Division of Geology Special Publication no. 5, 312 p.

Riggs, H. C., 1969, Mean streamflow from discharge measurements: Bulletin of the International Association of Scientific Hydrology, XIV, d, 12/1969, p. 95-110.

Rosenau, J. C., Faulkner, G. L., Hendry, C. W., Jr., and Hull, R. W., 1977, Springs of Florida: Florida Bureau of Geology Bulletin no. 31 revised, 461 p.

Rumenik, R. P., Pascale, C. A., and Tucker, D. F., 1975, Flood-prone areas of Gadsden County, Florida: U.S. Geological Survey Water-Resources Investigations 31-75.

Searcy, J. K., 1960, Graphical correlation of gaging-station records: U.S. Geological Survey Water-Supply Paper 1541-C.

Sellards, E. H., 1910, Some Florida lakes and lake basins: Florida Geological Survey Annual Report no. 3, p. 34-77.

_____1914, Some Florida lakes and lake basins: Florida Geological Survey Annual Report no. 6, p. 115-159.

_____1917, Geology between the Ochlockonee and Aucilla Rivers in Florida: Florida Geological Survey Annual Report no. 9, p. 85-139.

Sellards, E. H., and Gunter, Herman, 1909, The fuller's earth deposits of Gadsden County, Florida: Florida Geological Survey Annual Report no. 2, p. 253-291.

_____1918, Geology between the Apalachicola and Ochlockonee Rivers in Florida: Florida Geological Survey Annual Reports no. 10-11, p. 9-56.

Stiff, H. A., Jr., 1951, The interpretation of chemical water analysis by means of patterns: Journal of Petroleum Technology, v. 3, no. 10, p. 15-17.

Theis, C. V., 1935, The relation between the lowering of the Piezometric Surface and the rate and duration of discharge of a well using ground-water storage: Transactions of the American Geophysical Union, v. 16, pt. II, p. 519-524, August 1935.

U.S. Environmental Protection Agency, 1975, National interim primary drinking water regulations: Federal Register, v. 40, no. 248, Wednesday, December 24, 1975, pt IV, p. 59566-59587.

_____1976 (1977), Quality criteria for water: U.S. Government Printing Office, 256 p.

_____1977, National secondary drinking water regulations: Federal Register, v. 42, no. 62, Thursday, March 31, 1977, pt. I, p. 17143-17147.

U.S. Water Resources Council, 1976, Guidelines for determining flood flow frequency, Bulletin no. 17, Hydrology Committee, March 1976.

Vernon, R. O., 1942, Geology of Holmes and Washington Counties, Florida: Florida Geological Survey Bulletin 21, 161 p.

Walton, W. C., 1970, Ground-water resource evaluation: New York, McGraw Hill, p. 164.

USGS LIBRARY-RESTON
3 1818 00072133 0

ED STATES DEPARTMENT OF THE INTERIOR
GICAL SURVEY
ohn Knox Rd--Suite F240
hassee, Florida 32303

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF THE INTERIOR
INT. 413

U.S. MAIL