

STATE OF FLORIDA
DEPARTMENT OF NATURAL RESOURCES
Harmon Shields, Executive Director

DIVISION OF INTERIOR RESOURCES
Charles M. Sanders, Director

BUREAU OF GEOLOGY
Charles W. Hendry, Jr., Chief

REPORT OF INVESTIGATIONS NO. 76

WATER RESOURCES OF WALTON COUNTY, FLORIDA

By
Charles A. Pascale

Prepared by
UNITED STATES GEOLOGICAL SURVEY
in cooperation with
BUREAU OF GEOLOGY
FLORIDA DEPARTMENT OF NATURAL RESOURCES
and
WALTON COUNTY BOARD OF COUNTY COMMISSIONERS

TALLAHASSEE, FLORIDA
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OF
NATURAL RESOURCES**

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Bureau of Geology
Tallahassee
December 5, 1974

Honorable Reubin O'D. Askew, *Chairman*
Department of Natural Resources
Tallahassee, Florida

Dear Governor Askew:

We are pleased to make available the report "Water Resources of Walton County, Florida" by Charles A. Pascale. This report should add substantially to the regional hydrologic picture in the panhandle of Florida. This type of regional descriptive hydrologic report is most important in providing a general overview of the water resources capability of an area and is one which is badly needed for other counties in north Florida. This type of report provides the necessary background data to be able to evaluate specific problems as they arise, or to avoid specific problems by proper planning.

Respectfully yours,

Charles W. Hendry, Jr., *Chief*
Bureau of Geology

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Bureau of Geology

Tallahassee
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WATER RESOURCES OF WALTON COUNTY, FLORIDA

By
Charles A. Pascale

ABSTRACT

Walton County is an area of about 1,140 square miles in northwestern Florida. In 1970 the population of the county was 16,087. Ground-water use averaged about 13.2 mgd (million gallons per day) and most of it was used for irrigation—10 mgd or about 11,000 acre-feet per year. Surface water is not a significant supply.

The county receives abundant rainfall, 65 inches per year on the average, at DeFuniak Springs. Much of this water enters the sand-and-gravel aquifer, then seeps to streams, or enters the underlying artesian Floridan aquifer.

The two major aquifers in Walton County are the sand-and-gravel aquifer and the Floridan aquifer. The sand-and-gravel aquifer supplies some water for rural domestic use. It is an important aquifer because it stores water, maintains streamflow, and is a source of recharge to the Floridan aquifer. Water from the sand-and-gravel aquifer ranges in dissolved solids from 20 to 120 mg/l (milligrams per liter), in pH from 5.3 to 6.9, and in iron content from 0.1 to 5.0 mg/l.

The Floridan aquifer underlies all of Walton County and is the primary source of water supply. Wells generally yield 500 to 1,000 gpm (gallons per minute) except along the gulf coast where the yield is less because the permeability of the aquifer is low. The transmissivity of the Floridan aquifer is highly variable and ranges from 4,000 gpd (gallons per day) per foot along the gulf coast to 180,000 gpd per foot in southeastern Walton County; the coefficient of storage ranges from 1.6×10^{-4} to 5.6×10^{-4} . The aquifer is recharged by downward leakage of water from the sand-and-gravel aquifer where the water table in the sand-and-gravel aquifer is higher than the potentiometric surface of the Floridan aquifer; and where the clay confining beds that separate the two aquifers are permeable, thin, or breached. In southern Alabama the Floridan is recharged directly by rainfall. There the Floridan is exposed or is near land surface. Ground-water moves southward and away from the potentiometric high in northwestern Walton County. The aquifer discharges through springs and seeps along Choctawhatchee River, by leakage to the bay and gulf, and by wells.

In southern Walton County water levels in the Floridan aquifer declined about 0.25 foot per year from 1948 to 1968 because of increased water use. In 1968 levels declined sharply owing to a lack of recharge to the aquifer and heavy seasonal pumpage for irrigation. Pumpage for irrigation in 1970, from farm wells in southeastern Walton County, caused water levels there to decline more than 80 feet. The cone of influence generated by this large seasonal pumpage extended outward for more than 10 miles and increased natural recharge to the Floridan aquifer. Water levels remained above sea level in the coastal areas and all water levels recovered to about normal after the irrigation season.

Saline water (more than 1,000 mg/l of dissolved solids) occurs naturally at depth within the Floridan aquifer throughout all of Walton County. The elevation of the fresh-water-saline-water interface in the aquifer ranges from about 650 feet below sea level in the northeastern part of the county to 1,200 feet below in the southwestern part. Saline water at relatively shallow depths along the coast limits useful well-bottom elevations to about 500 feet below sea level.

Dissolved solids in water from wells tapping the Floridan aquifer in Walton County range from 70 to 3,500 mg/l and chloride, from 1 to 2,000 mg/l. In water from north of Choctawhatchee Bay, dissolved solids is less than 150 mg/l and chloride, less than 10 mg/l. In water adjacent to Choctawhatchee Bay, dissolved solids range from 500 to 3,500 mg/l and chloride, from 150 to 2,000 mg/l; both constituents increase in amount with well depth. Along the central gulf coast, wells drilled to less than 500 feet below sea level generally contain water whose chloride content is less than 250 mg/l. Water of excellent quality is available from the Floridan aquifer along the coast in a little used zone about 100 feet thick and generally less than 100 feet below land surface.

Streams originating in Walton County discharge on the average about 1,000 mgd; minimum discharge during dry spells is about 300 mgd. Although most streams yield copious amounts of water of good quality, none are used for water supply. Mineral content is relatively low, averaging 20 mg/l; pH ranges from 4.7 to 7.9, color, from 4 to 50 platinum-cobalt units, and turbidity, from 3.1 to 25 Jackson turbidity units. Dissolved-solids content of Magnolia and Seven Runs Creeks increased by about 45 mg/l due to return flow of irrigation water.

There are about 25 named lakes in Walton County that range from 10 to 400 acres in surface area. Most are used primarily for recreation. Lakes along the coast are brackish and those inland contain water with dissolved-solids content usually less than 20 mg/l.

INTRODUCTION

In 1968, northwestern Florida experienced a record-breaking drought which caused record-low surface-water discharge. The drought caused increased ground-water use which resulted in record-low water levels in wells tapping the Floridan aquifer. In southern Walton County artesian wells ceased to flow, some wells went dry, and intakes of many pumps had to be lowered.

Ground-water use has increased rapidly during the last few years. In southeastern Walton County, 27,000 acres of land were developed for agriculture during 1968 and more than 80 large-capacity wells were drilled into the Floridan aquifer to irrigate this land. Recent increase in commercial and domestic demand for water along the gulf coast is hastening the development of ground-water supplies.

The problems caused by the increased water use brought to the attention of area water planners the need for water-resource information. They needed to know whether the low water levels were permanent, where to obtain more water, and what effect increased water use would have on salt-water encroachment of the Floridan aquifer along the coast.

LOCATION AND EXTENT OF AREA

Walton County is in northwestern Florida (fig. 1). The county extends from the gulf to Alabama and is bordered on the west by Okaloosa County, and on the east by Holmes, Washington, and Bay counties.

The area of Walton County is 1,140 square miles, including 85-square-mile Choctawhatchee Bay. Eglin Air Force Base includes about 240 square miles in southwestern Walton County. In 1970 the population of the county was 16,087. DeFuniak Springs, the county seat and largest city in the county, had a population of 4,966.

Agriculture is the principal industry in the area. Corn, soybeans, grain sorghum, and wheat are the principal crops. Much of the county is covered with commercial pine forests. Tourism is important along the coast.

PURPOSE AND SCOPE

Recognizing the need for water-resources information, the Walton County Board of County Commissioners and the Florida Department of Natural Resources, Bureau of Geology, entered into a cooperative agreement with the U.S. Geological Survey to investigate and report on the hydrology of Walton County, Florida.

BUREAU OF GEOLOGY

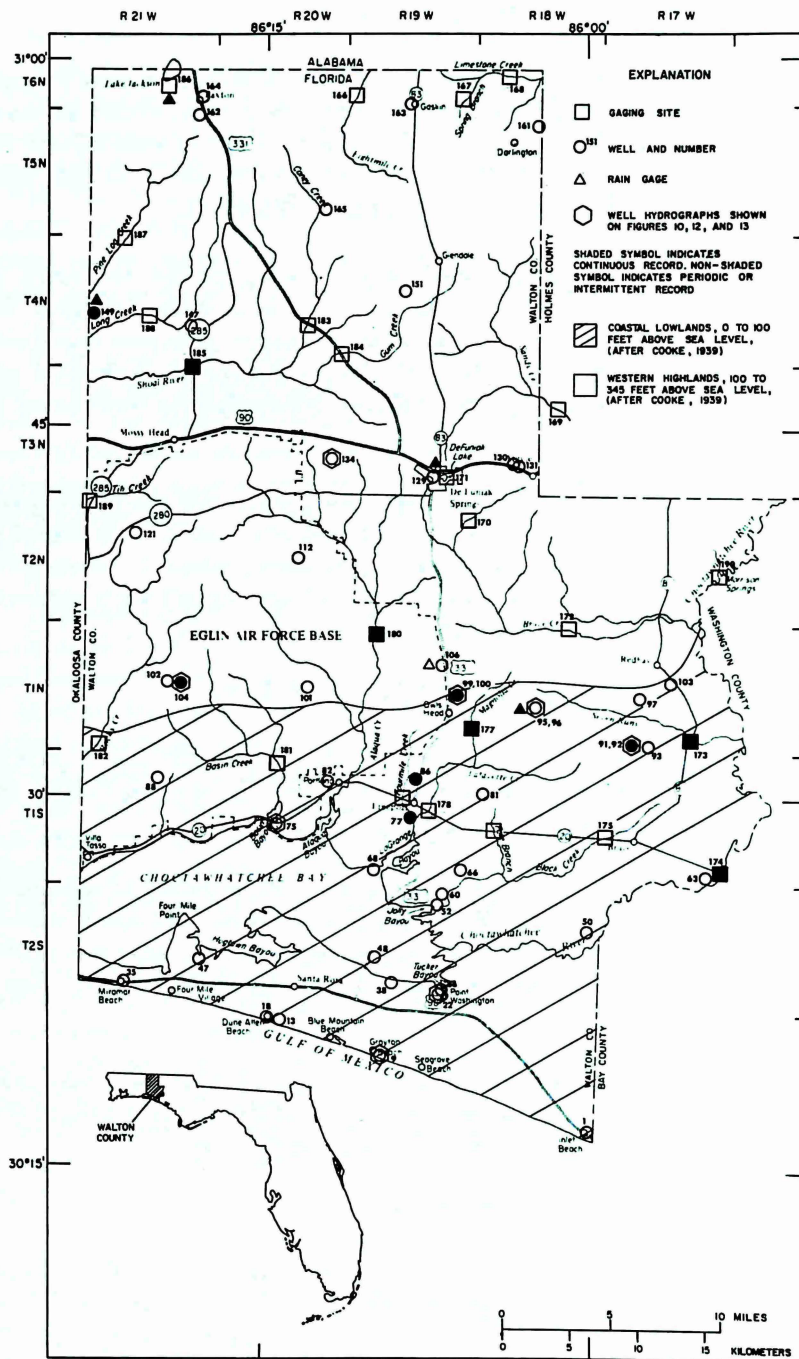


Figure 1. Map showing locations of hydrologic data-collection sites and generalized physiographic divisions of Walton County.

This report evaluates the water resources of the county and provides information that will aid in the development and use of ground and surface water for current and future needs. It also provides information concerning the potential for salt-water encroachment of the Floridan aquifer.

The field studies began in the summer of 1968 and continued through September 1970. Some records of streamflow, ground-water levels, and water quality had been collected for Walton County as part of the statewide data-collection program. Other records were collected as part of this project. Figure 1 shows the sites where hydrologic data were collected and tables 6 and 7 (Appendix) describe the sites, the types of data, and periods of record. The long-term streamflow records and chemical analyses of surface water are published by the U.S. Geological Survey in an annual series of Water-Supply Papers. Other data collected during the investigation have been published (Pascale, Essig, and Herring, 1972).

DATA COLLECTION

An observation-well network, established July 1968, was operated for 2 years. Recording water-level gages were maintained on six wells. Water levels in an additional 30 wells were measured at 4- to 8-week intervals. Water from selected wells was analyzed for chemical content. Supplemental data were collected from more than 160 wells which tap either the sand-and-gravel or Floridan aquifer.

Five surface-water gaging stations (two daily and three monthly) were established September 1968 to complement three long-term daily gaging stations located in the county. Annual mean discharges were estimated from monthly discharge measurements made at the three monthly gaging stations (Riggs, written commun., 1968). The average flows for the daily discharge stations were adjusted to a common base period (1931-70). Streamflow measurements were also made annually at miscellaneous sites. Water samples were collected semiannually from streams at gaging station sites for analysis of chemical content and monthly for temperature and specific conductance. Water samples from streams at all the project gaging station sites in October 1969 and September 1970 were analyzed for total coliform bacteria. Pesticide analyses were run on samples taken from Magnolia Creek twice during the study.

Three rainfall gages were established within the county to extend the rainfall-data coverage already available.

Aquifer tests were made at 10 wells. Selected wells were logged to determine the physical well characteristics (depth of casing, bore-hole diameter,

depth of well, and lithology), and to try to delineate a zone of saline water known to occur within the aquifer. Geologic logs of selected core holes and wells made available by the Florida Bureau of Geology were used to map the top of the Floridan aquifer. Logs of oil test wells were used to determine the depth to the fresh-water-saline-water interface.

ACKNOWLEDGEMENTS

Appreciation is extended to the many individuals who furnished information on their wells and who gave access to their land and equipment for measurements and tests. First American Farms, Inc. made their irrigation equipment and wells available for aquifer tests and their wells for ground-water-level measurements.

Mr. C.W. Hendry, Jr., Florida Department of Natural Resources, Bureau of Geology, made available the descriptions of more than 25 well cores taken in Walton County. They were invaluable in mapping the geology of the study area.

The cooperation and courtesies extended by the following persons were outstanding: Gus Hatch, Leonard Perkins, Terrance Williams, and Lewis Miller. Thanks are also extended to Conley Martin and the other members of the Walton County Board of Commissioners who cooperated in all aspects of the investigation.

The author is indebted to his colleague, Carl F. Essig, Jr., for his assistance in the collection of hydrologic data.

HYDROLOGIC SETTING

Climate, physiography, and geology control the availability of water. Climate determines the amount of fresh water that reaches the land surface as rainfall while physiography and geology govern the amount and rate of runoff and infiltration. Rainfall in Walton County that is not lost to evapotranspiration is absorbed by porous soils and eventually replenishes the aquifers; or it is stored in lakes or ponds, or flows overland in streams as surface water. Rain which falls outside the county may enter the county as ground or surface water.

CLIMATE

Walton County has a warm humid climate. The average annual air temperature at the NWS (National Weather Service) station in DeFuniak Springs is 69°F. The average monthly air temperature ranges from 55°F in December and January to 82°F in July and August (fig. 2). Average monthly rainfall ranges

from 3.2 inches in October to 8.8 inches in July (fig. 2). Nearly half the yearly rainfall occurs between June and September as a result of thunderstorms and tropical depressions.

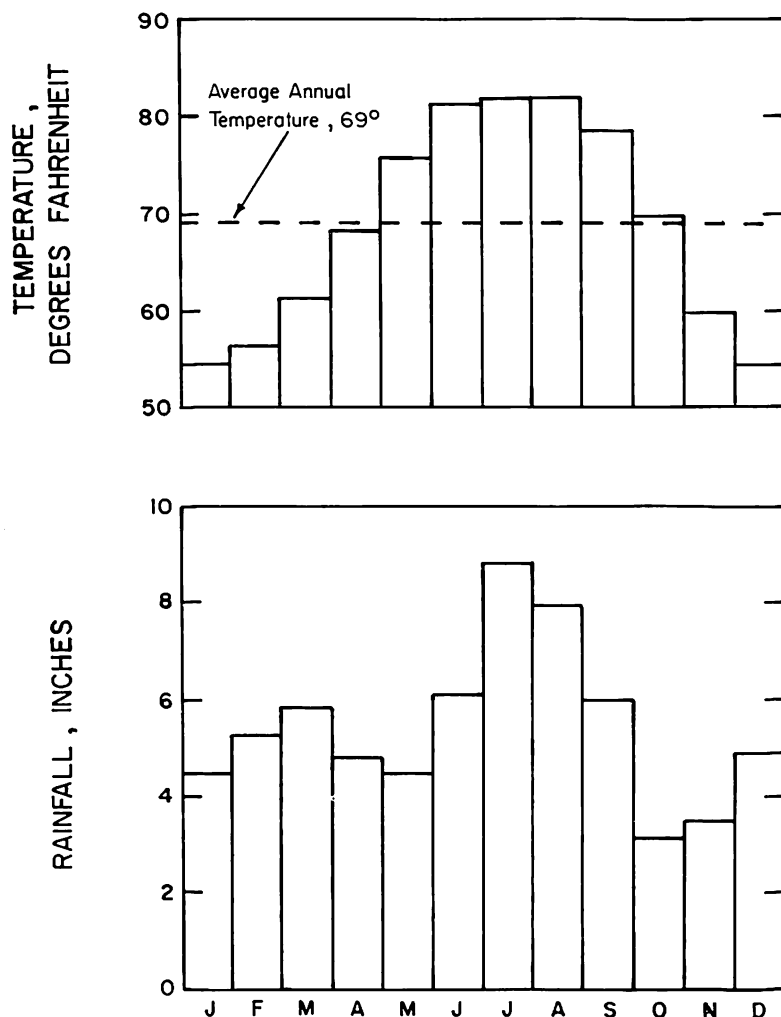


Figure 2. Graphs showing average monthly rainfall and temperature at DeFuniak Springs, 1897-1970.

Annual rainfall at DeFuniak Springs from 1897 to 1970 averaged 65 inches and ranged from 38 inches in 1954 to 94 inches in 1947 (fig. 3). An annual rainfall of 65 inches uniformly distributed throughout Walton County is

equivalent to 3.3 bgd (billion gallons per day). During 1968 and 1969 when most of the hydrologic data for the investigation were collected, the 2-year cumulative rainfall was 99.41 inches or about 30 inches below average.

During the investigation annual rainfall was as much as 10 inches greater at some places in the county than it was at DeFuniak Springs. This difference was due to isolated storms—a data variation which is equalized in long-term records.

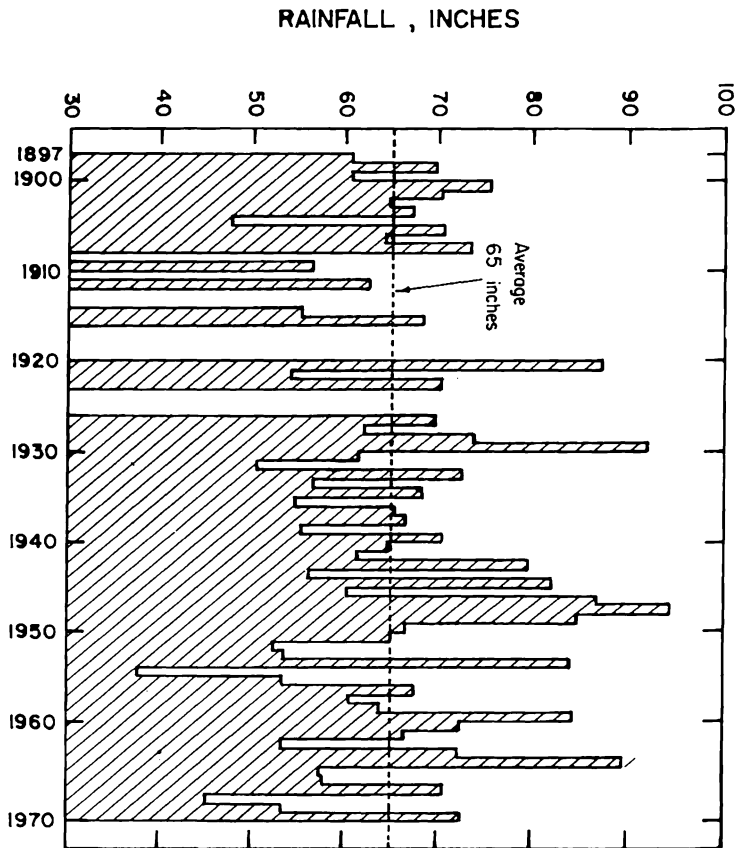


Figure 3. Graph showing annual rainfall at DeFuniak Springs, 1897-1970.

PHYSIOGRAPHY

Walton County is included in two of Cooke's (1939, p. 14) topographic

divisions of Florida, the Coastal Lowlands and the Western Highlands (fig. 1).

The Coastal Lowlands include the white-sand beaches and sand-dune ridges along the coast and the swamps and flatwoods that extend inland 10-15 miles. The Lowlands generally range in elevation from sea level to 100 feet. The sand ridges, formed by wind and wave action, rise sharply from the beach and extend inland from one-half to 1 mile and then slope gradually toward Choctawhatchee Bay. At Blue Mountain Beach, dunes are more than 70 feet high. Numerous creeks and lakes along the ridges connect with the gulf. Most of the lakes are brackish because water from the gulf moves into them during severe storms. According to Martens (1931, p. 112), they were at one time bays or inlets of which the mouths have been nearly closed by sand bars.

The swamps and flatwoods are in an area adjacent to Choctawhatchee Bay and River that extends approximately 15 miles north from the coast. The swamps include the low, poorly drained areas south of Choctawhatchee Bay and the flood plain of the Choctawhatchee River, usually less than 30 feet above sea level. The flatwoods forest area north of the bay is generally well drained by small streams which discharge into the bay.

The Western Highlands extend northward from the Coastal Lowlands into Alabama. The southern part includes the gently rolling sandhills which range in elevation from 100 to 250 feet above sea level. The northern part includes the swampy bays in the north-central and the hilly section along the Alabama line where elevations are as much as 345 feet above sea level.

The sandhill area is characterized by the steepness of the heads of many streams that drain the area. According to Sellards (1918, p. 27), "These steepheads are due to the fact that indurated sands and sandy clays overlie slightly indurated sands and clays and shell marls. The surface waters pass into the earth and, upon reaching the underlying clay or marl beds, emerge as springs. The indurated sandy clays near the surface stand up vertically, while the softer sands, at a greater depth where the springs emerge wash easily. The result is the formation of a nearly vertical bluff, at the base of which springs emerge, supplying small streams. This bluff or streamhead assumes in time a semicircular form, which is the 'steephead'." Due to this active undermining at the base of the "steepheads," bluffs eventually collapse and the streams move headward.

A characteristic of the Western Highlands is the nearly circular lakes of central Walton County. Cooke (1939, p. 17) suggested that these lakes were originally sinks formed when the ground-water level was much lower than present and the downward movement of rainwater was more active. As water levels rose to their present positions, ground water flooded the deep sinks and converted them into lakes and ponds.

In the northern part of the county, bay sinks developed in depressions formed by the collapse of the underlying limestone. The sandy clay and marl which filled the depressions are low in permeability; the depressions remain wet most of the time. That part of the county north of the bay sinks is hilly: Florida's highest land elevation, 345 feet above sea level, is near Paxton.

The county is drained by several large rivers and by many small streams. Shoal River heads in the northern part of the county and drains south and southwest into Yellow River in Okaloosa County which empties into Blackwater Bay in Santa Rosa County. Eightmile Creek also heads in northern Walton County; it flows north into Alabama where it discharges into Pea River, a tributary to Choctawhatchee River. Alaqua Creek, Lafayette Creek, Black Creek, Basin Creek, and Rocky Creek drain most of the sandhill area south of DeFuniak Springs and discharge into Choctawhatchee Bay. Sandy Creek, Seven Runs Creek, and Bruce Creek drain most of the eastern half of the county to Choctawhatchee River.

GEOLOGY

Walton County is underlain by two major hydrogeologic units. The upper unit is the sand-and-gravel or unconfined aquifer (Musgrove, Barraclough, and Marsh, 1961, p 11). Below the sand-and-gravel aquifer, and for the most part separated from it by layers of clay and marl, are the limestones of the Floridan aquifer.

SAND-AND-GRAVEL AQUIFER

The sand-and-gravel aquifer consists primarily of quartz sand of Miocene age that ranges in color from white to brown and in size from fine to very coarse. Lenses of coarse to very coarse pea gravel mixed with sand are found throughout the aquifer. Usually a small quantity of clay is also present in the sand and acts as a coloring and cementing agent, adhering to the sand grains. Stringers of white to purple clay are scattered throughout the aquifer.

The sand-and-gravel aquifer extends throughout the county, as shown by the generalized geologic sections in figures 4 through 7. It is thickest in the west-central part of the county and gradually thins to the north and east. In the north, the aquifer is divided into an upper and lower section by a layer of clay and marl which pinches out south of U.S. Highway 90.

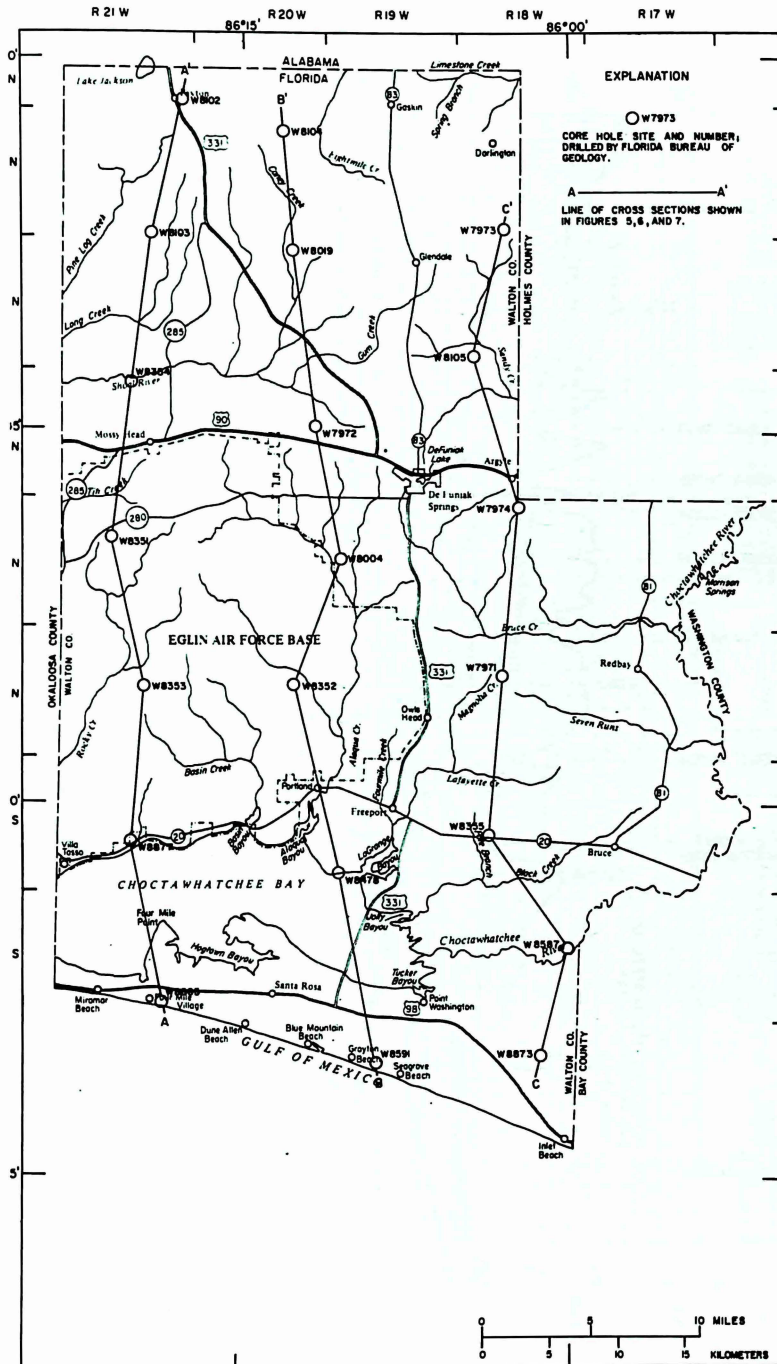


Figure 4. Map showing locations of core holes and cross sections referred to in other illustrations and text of report.

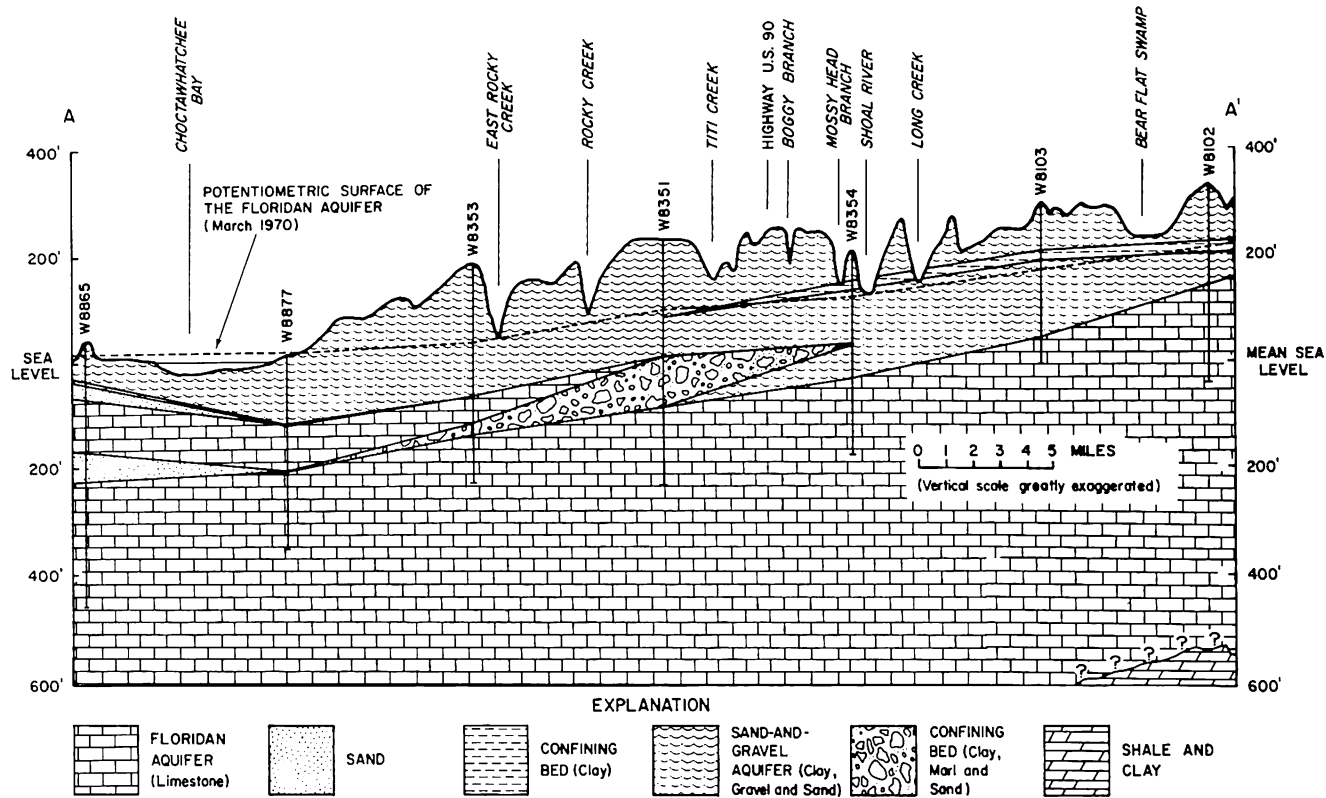


Figure 5. Hydrogeologic section A-A' through western Walton County.

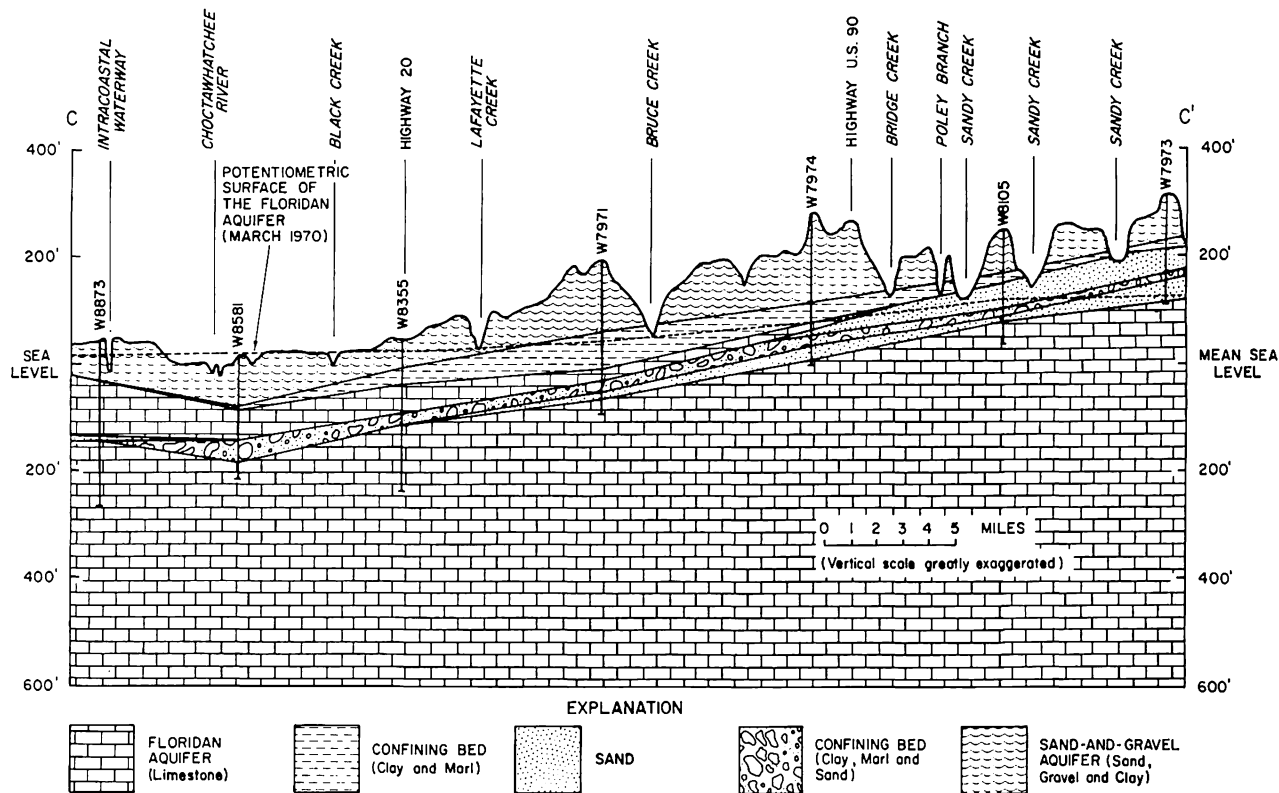


Figure 6. Hydrogeologic section B-B' through central Walton County.

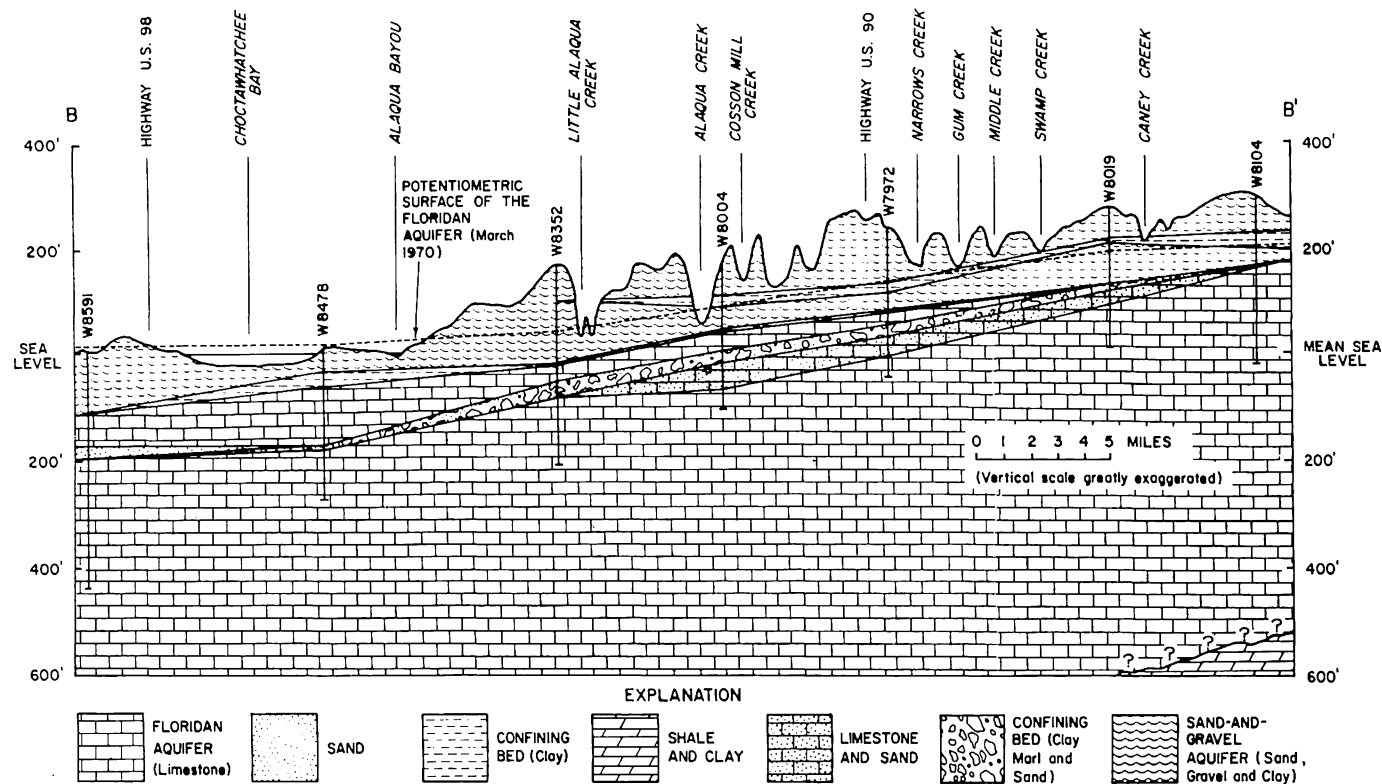


Figure 7. Hydrogeologic section C-C' through eastern Walton County.

FLORIDAN AQUIFER

The Floridan aquifer is the principal source of ground water in Walton County. It was first described by Stringfield (1936) and later named the Floridan aquifer by Parker and others (1955, p. 189). The Floridan aquifer underlies all of Florida and parts of the adjacent States of Georgia and Alabama, and it ranges in age from middle Miocene to upper Eocene.

In south-central Walton County two sequences of limestone, separated by layers of clay and marl (figs. 5-7), are present. The upper sequence is thickest in the south and gradually pinches out to the north. C. W. Hendry, Jr. (written commun., 1968) described the upper limestone sequence as yellowish gray, very finely crystalline, sandy, and microfossiliferous with lenses of clay and marl commonly intermixed throughout. He identified it as a part of the Chipola Formation of the lower Miocene Series.

Below the Chipola Formation, separated by Miocene clay, is the Suwannee Limestone which underlies all of Walton County. Hendry (written commun., 1969), identifies the Suwannee Limestone as composed of yellowish brown to brown dolomitic limestone, hard, and with varying porosity. The Suwannee Limestone is part of the Oligocene Series.

Below the Suwannee Limestone is limestone of the Ocala Group which underlies all northwest Florida. The Ocala Group is part of the upper Eocene Series; its limestone is white to grayish cream and rather soft and chalky. It contains lenses of hard, light-gray shale (Musgrove, Barraclough, and Marsh, 1961, p. 18).

The Suwannee Limestone is separated from the overlying Chipola Formation by sand and clay. It grades into the limestone of the underlying Ocala Group; the contact between the Suwannee Limestone and Ocala Group has not been determined. In this report the Floridan aquifer is considered to include the Chipola Formation, the Suwannee Limestone, and the Ocala Group.

The Floridan aquifer is underlain by shale and clay of middle Eocene age (Musgrove, Barraclough, and Marsh, 1961, p. 18) which dips generally southwestward—it ranges in depth from about 600 feet below sea level at the Alabama State line to about 1,000 feet below sea level at the coast.

CONFINING BEDS

Layers of relatively impermeable clay and marl occur throughout the aquifers (figs. 5, 6, and 7) and reduce average permeability of the aquifer. Where they occur as confining beds, they retard the movement of water between

aquifers and develop an artesian head in the confined aquifer. The clay and marl beds range in thickness from a few inches to more than a hundred feet. The clay varies from dark olive gray to brownish black and from firm plastic to medium sandy. The marl is yellowish gray to olive gray and is soft to firm.

WATER RESOURCES

GROUND WATER

OCCURRENCE AND MOVEMENT

Ground water that is not returned to the atmosphere by evaporation and transpiration moves from areas of recharge (high, relatively flat, sandy ground) to areas of discharge (streams, wells, the gulf); the moving force is gravity.

Ground water in the sand-and-gravel aquifer is not confined—that is, its potentiometric surface or water table is said to be under nonartesian conditions. Water in the Floridan aquifer is confined and its water level or potentiometric surface rises above the top of the aquifer in a well and in some cases above land surface (a flowing artesian well).

The sand-and-gravel aquifer is recharged directly by rainfall and the shape of the water table is related to topography. Water that reaches the aquifer moves toward areas of lower elevation. Ground water is discharged from the aquifer through seeps and springs to streams, to evapotranspiration, by leakage to the underlying Floridan aquifer and by pumping of wells.

In Walton County the Floridan aquifer is recharged by downward leakage of water from the sand-and-gravel aquifer where the water table in the sand-and-gravel aquifer is higher than the potentiometric surface of the Floridan aquifer; and where the clay confining beds that separate the two aquifers are permeable, thin, or breached. In southern Alabama it is recharged directly by rainfall where the Floridan is exposed or is near land surface.

The shape of the potentiometric surface of the Floridan aquifer varies during the year. In the spring the potentiometric surface of the Floridan slopes smoothly, mostly toward the south (fig. 8). In the summer, when discharge from the aquifer is at a maximum, the potentiometric surface slopes sharply toward the area of heavy withdrawal (fig. 9).



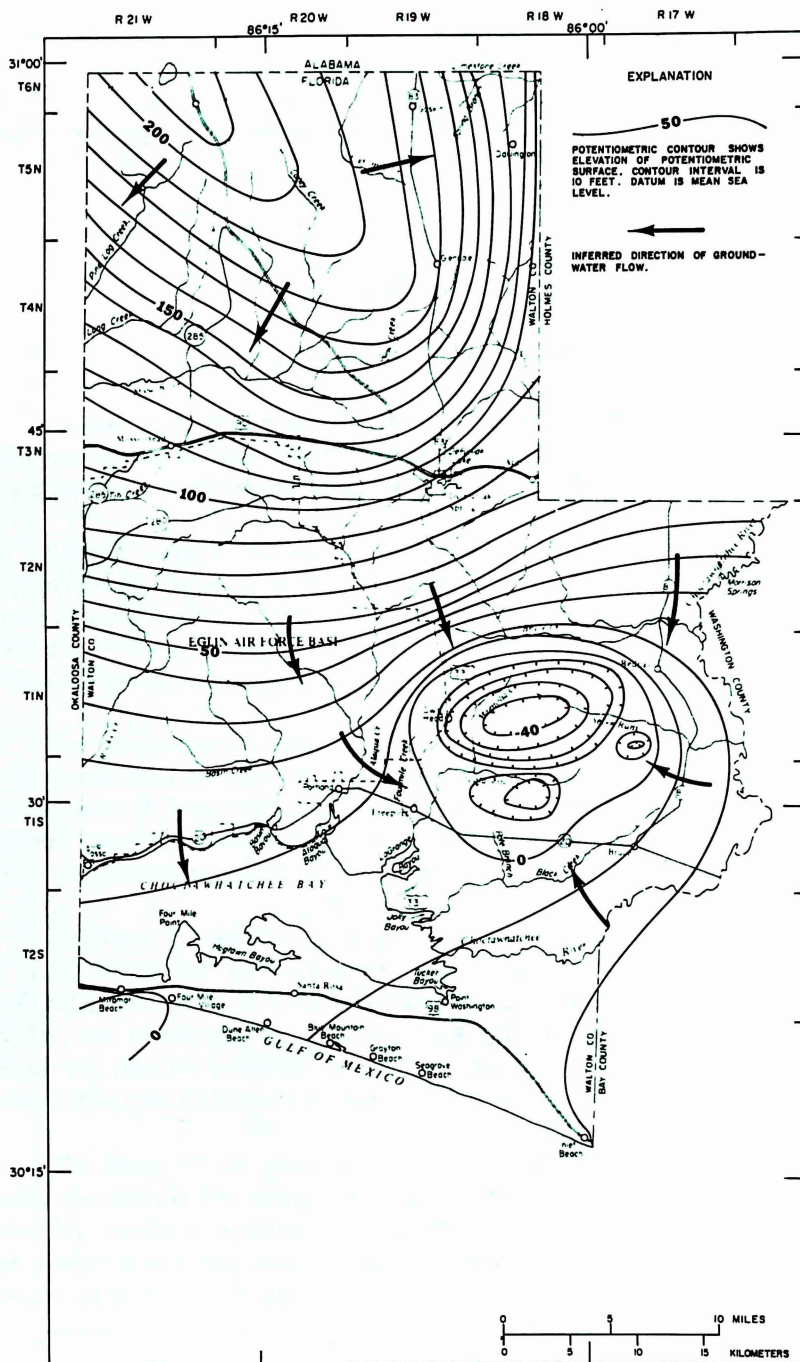


Figure 9. Map of the potentiometric surface of the Floridan aquifer, June 22-26, 1970.

The potentiometric surface of the Floridan aquifer normally ranges from more than 190 feet below land surface in northern Walton County, in areas where land elevations exceed 300 feet, to 20 feet above land surface in southern Walton County, where land elevations are less than 10 feet above sea level (figs. 5, 6, and 7). Where the potentiometric surface is above land surface, wells that tap the aquifer flow. Wells flow in most areas near Choctawhatchee Bay and the gulf coast, and also in low areas along the Choctawhatchee River. When use of ground water is high, the potentiometric surface declines below land surface and wells stop flowing.

Ground water moves downgradient away from the potentiometric high in northwestern Walton County (fig. 8). The rather flat gradient in the southeastern part of the county probably reflects the higher permeability of the limestone in that area (fig. 16) where, on the basis of individual aquifer tests, transmissibility is as high as 180,000 gpd per foot.

The Floridan aquifer discharges naturally by leakage to the bay and gulf, to the Choctawhatchee River, and through seeps and springs in areas where the potentiometric surface is above the land surface and the aquifer's confining bed is breached or missing. The aquifer is discharged also through pumping or flowing wells. The depressions in the potentiometric surface shown in figure 9 for June 1970 are a result of large withdrawals of ground water from the aquifer for irrigation.

AQUIFERS

SAND-AND-GRAVEL AQUIFER

The sand-and-gravel aquifer is used mostly for rural-domestic supplies. It does not now constitute a primary source of water supply in Walton County. Its importance will begin to grow as supplies from the Floridan aquifer diminish or become more expensive. The sand-and-gravel aquifer is highly permeable except where it contains clay. Wells that tap this aquifer range in depth from 25 feet to 165 feet and yield from 5 to 30 gpm (gallons per minute), which is generally sufficient for domestic uses. The present importance of the sand-and-gravel aquifer stems from its capacity to store water, to maintain streamflow, and to supply water to shallow wells and to the Floridan aquifer. The sand-and-gravel aquifer is a tremendous reservoir that, in Walton County, contains about 20,000,000 acre-feet of potable water.

Water-level Fluctuation

Water levels in the sand-and-gravel aquifer rise when rainfall is sufficient to recharge the aquifer. Water levels decline when recharge is less than leakage.

Hydrographs of sand-and-gravel wells 92, 96, 100, and 104 (fig. 1) and monthly rainfall at DeFuniak Springs are shown in figure 10. Well 104, which is not affected by pumping, reflects natural fluctuations of the water level and shows the influence of rainfall on water levels in the aquifer. The minimum water level at year end 1968 represents the culmination of a 2-year drought. From January 1969 to September 1969, when rainfall was about average, the water level rose about 14 feet. From April to September 1969 wells 92, 96, and 100 were affected by the pumping of nearby Floridan aquifer irrigation wells. Pumping from individual wells in the Floridan varied according to the need for water by the various crops. The water level rose in sand-and-gravel aquifer well 100 from April through July 1969 due to irrigation of a corn field surrounding well 100. The high-water level in June 1970 at wells 92 and 100 was caused by application of excess water to irrigate crops near these two wells, and from above average rainfall during June. During 1970, pumping for irrigation did not begin near well 96 until August.

Quality of Water

The water in the sand-and-gravel aquifer is generally of good quality and in most respects meets standards for drinking water. Concentrations of dissolved solids and chloride are usually less than 25 mg/l; some wells produce water with excessive amounts of iron in solution. A map showing some selected chemical constituents of water from wells penetrating the sand-and-gravel aquifer,

Both chloride and dissolved-solids concentration are used as an index of water mineralization. Chloride is in all natural waters; usually the concentrations are low (Hem, 1970, p. 172). U.S. Public Health Service (1962) recommends that water for domestic use should not exceed 250 mg/l of chloride or 500 mg/l of dissolved solids. Hem (1970, p. 323) reports, however, that for the lack of better water, some people have used water whose chloride or dissolved-solids concentration is substantially in excess of the limits recommended by the U.S. Public Health Service with no apparent detrimental effects to the users.

Because the unconsolidated quartz materials which make up the sand-and-gravel aquifer are insoluble, the dissolved-solids concentration in the water from that aquifer is usually low. In water from wells along the coast, the dissolved-solids concentration ranges from 20 to 128 mg/l.

Chloride concentrations range from 0.8 to 26 mg/l and are highest in water from wells adjacent to the coast, probably because of saltwater contamination in the lower part of the aquifer. Coastal rain also contains small amounts of chloride acquired over the Gulf.

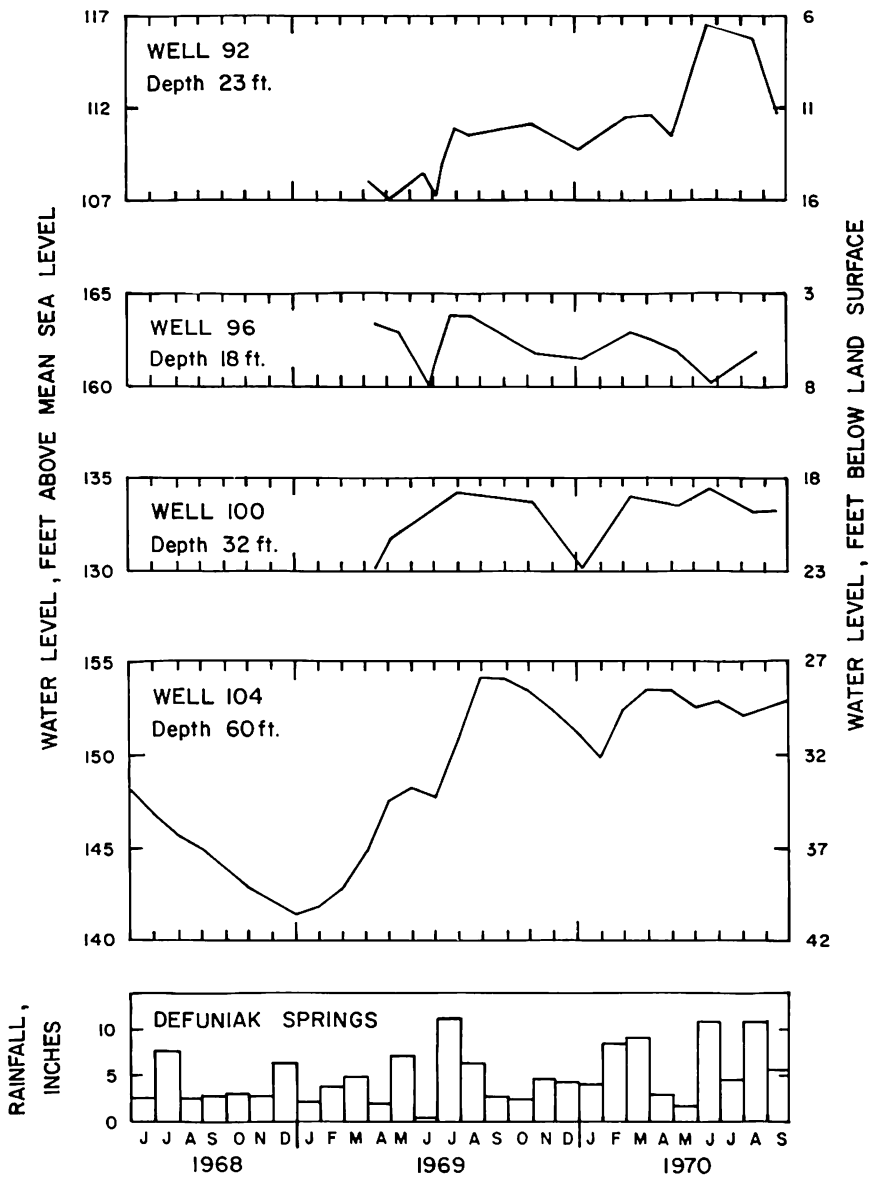


Figure 10. Hydrographs showing water levels in selected wells that tap the sand-and-gravel aquifer and graph of monthly rainfall at Defuniak Springs.

The iron concentration in the water ranges from less than 0.1 to 5 mg/l. According to the U.S. Public Health Service (1962), more than 0.3 mg/l of iron is undesirable as it stains plumbing fixtures, clothing, and imparts an unpleasant taste and color to the water. The reaction of iron oxide in limonite clay interbedded in the aquifer, with the acidic water (pH, 5.3 to 6.9) is probably responsible for the high iron concentration of the water. Other possible sources of iron in water from wells that tap the aquifer are iron pipe, storage tanks, and fittings that are in constant contact with the water. The low pH of the water makes it corrosive and the iron readily dissolves.

FLORIDAN AQUIFER

The Floridan aquifer underlies all of Walton County and is the primary source of water in the county. It is composed of permeable and porous limestone which contains large quantities of ground water. Wells tapping this aquifer commonly yield 500 gpm to as much as 1,000 gpm.

The top of the aquifer ranges from 50 feet below land surface in the northeast part of Walton County to 300 feet below in the midwest part. The aquifer ranges in thickness from about 700 feet in the north to about 1,000 feet in the south.

Discharge from the Floridan Aquifer

A significant quantity of ground water discharges naturally along Choctawhatchee River where the aquifer is exposed by erosion. The potentiometric level of the Floridan aquifer is usually greater than the elevation of the water surface along the entire reach of the river.

A channel-bottom profile was made with a fathometer near the mouth of the Choctawhatchee River. Many large and deep depressions were detected in the channel bottom, some of which were 40 feet or more below the normal channel profile. That these depressions remain unfilled near the mouth of the river, where stream velocities are low and in a river whose storm runoff is heavily laden with sediment, suggests that groundwater discharge is great enough to keep the depressions open.

Morrison Spring, on the west bank of the Choctawhatchee River (fig. 1), is another example of natural discharge from the Floridan aquifer. The spring normally discharges through numerous channels into a swamp and then into Choctawhatchee River, but at low flow the discharge is confined to one channel and thus measurable. During the drought of the summer of 1968 the level of the Choctawhatchee River was near its record low and Morrison Spring discharge

was measured at 83 cfs (cubic feet per second) or 54 mgd (million gallons per day).

Until 1968, withdrawals from wells by pumping and by artesian flow increased gradually, mostly along the gulf coast and for domestic use. In 1968, large-scale farming began and ground-water withdrawals for irrigation immediately exceeded the total withdrawals for domestic uses up to that time. More than 80 high-capacity (800-1,000 gpm) wells were constructed in the Floridan aquifer to irrigate about half of the 27,000 acre Owl's Head Farm located 5 miles north of Freeport and east of U.S. Highway 331. In 1969, six 800-gpm wells were drilled to irrigate about 1,000 acres of the 3,000-acre Mossy Head Farm, 5 miles north of Mossy Head.

The irrigation wells on the Owl's Head Farm range in depth from 400 to 550 feet; most have 190-220 feet of 12-inch casing then open hole into the Floridan aquifer. On Mossy Head Farm the wells average about 700 feet deep; most have 300-350 feet of 12-inch casing and open hole into the Floridan aquifer. Most of the wells are arranged in a network of four wells per square mile and each well is equipped with an automatic circular self-propelled sprinkler system which requires between 60 to 70 hours of continuous discharge (800-1,000 gpm) to apply a 1-inch depth of water on 140 acres in one rotation.

During the growing season, each well is pumped intermittently, depending on the soil moisture available for the crops. During dry spells, however, more than half the wells are pumped simultaneously.

Water-level Fluctuations

Development of ground water was gradual until 1968, when development increased rapidly. Development rate since 1968 has had a pronounced effect on water levels. Until 1968, for example, the levels in Floridan aquifer wells 9, 22, 75, and 134 (location on fig. 1) fluctuated chiefly in response to above- or below-normal rainfall as shown in figures 12 and 13. After 1968, response to local irrigation pumpage overshadowed the response to rainfall.

Figure 13 is a hydrograph of well 22 which illustrates the water-level changes that occurred from 1948 through 1968. Periods of high-water levels (caused by above-normal rainfall) were averaged with periods of low-water levels (caused by below-normal rainfall) and a trend line or rate of decline was developed on the hydrograph. This trend line indicates that from 1948 to 1968 the water level declined 0.25 foot per year on the average; a similar trend is also evident on the hydrograph in figure 12. This long-term decline was probably caused by increased ground-water use in southern Walton County.

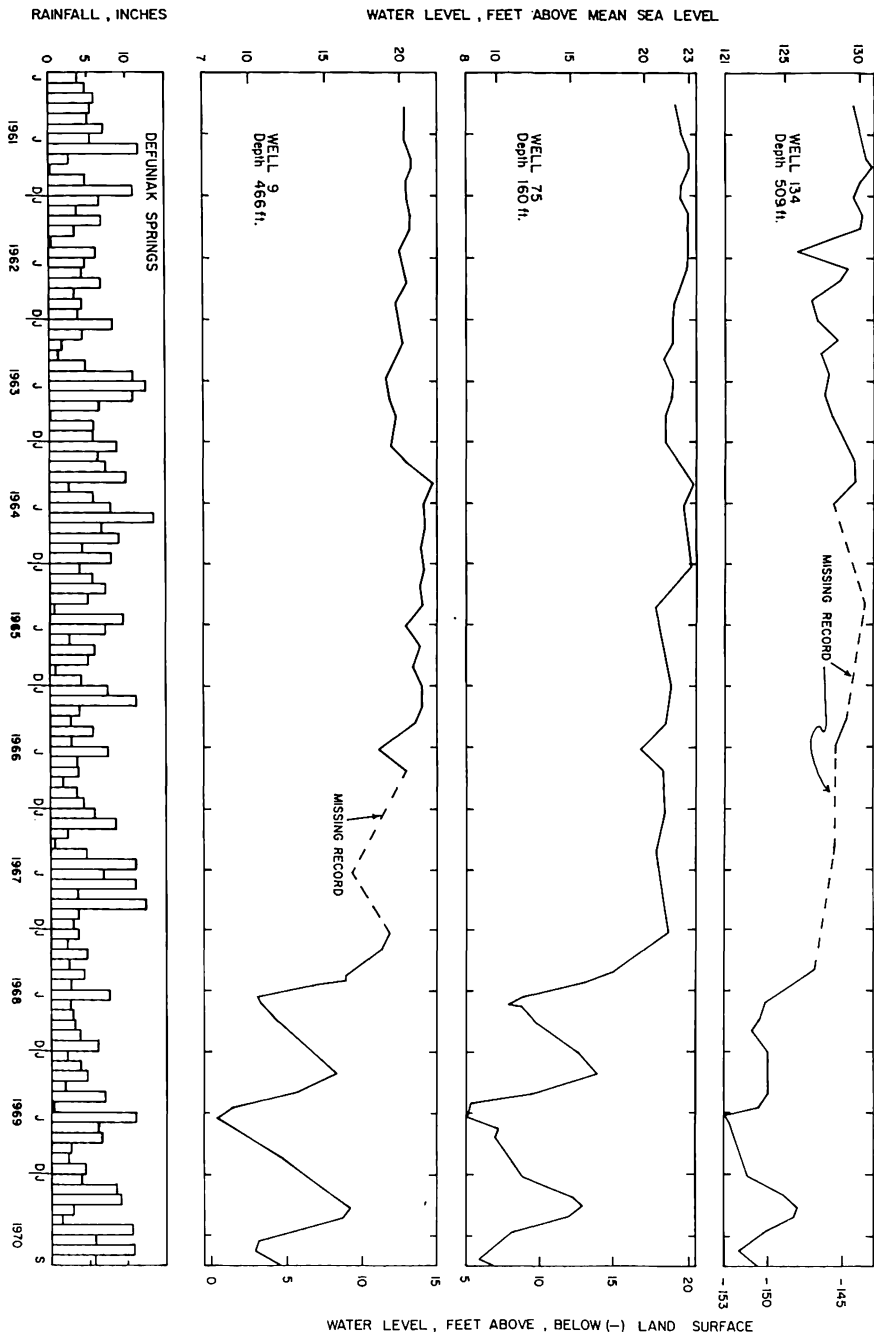


Figure 12. Hydrographs showing water levels in wells that tap the Floridan aquifer and graph of monthly rainfall at DeFuniak Springs.

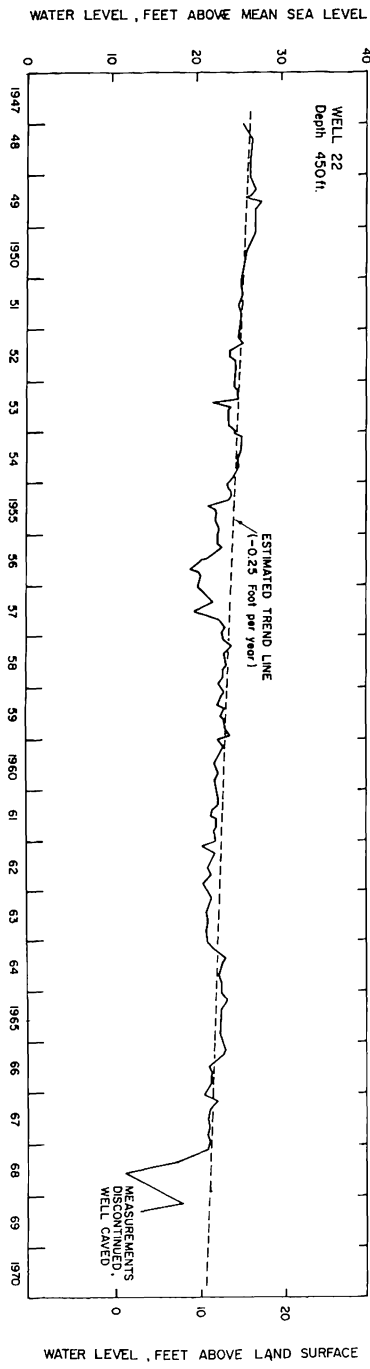


Figure 13. Hydrograph showing water level in well 22 that taps the Floridan aquifer.

In 1968, water levels declined sharply from January through April 1968—a decline (figs. 12 and 13) caused by a lack of recharge to the aquifer brought about by a severe drought. From May through July 1968 water levels declined even faster, showing the added effect of pumping for irrigation in southern Walton County.

Pumping for irrigation at the Owl's Head Farm during the spring and summer of 1969 and 1970 (fig. 14), caused a sharp decline in levels in observation wells 91 and 99 which are about 8 miles apart (fig. 1). Because the wells are not pumped, their fluctuation in level represents the effect of pumping from nearby wells. Pumping for irrigation stopped in July 1969 and by mid-May 1970 recovery of levels was virtually complete.

The amount of water-level decline varies directly with pumping which in turn varies with weather conditions and with the water requirements of the different types of crops planted. Soybeans and sorghum generally require less water than corn. The maximum observed decline in water level—about 80 feet at well 99—resulted from heavy pumping to irrigate corn during the unusually dry weather of June 1969. At well 91 pumping was less intensive because the area was planted in soybeans and sorghum. Hence, its low-water level of June 1969 was not outstanding.

In 1970 ground-water levels were low in the summer and again in the early fall. The fall decline resulted from pumping for an early crop of corn and a later crop of soybeans.

By June 1970, after 60 wells had been pumped intermittently at 800-1,000 gpm during April-June, water levels had declined more than 80 feet at the Owl's Head Farm north of Freeport (fig. 15); limited pumping of 6 wells at the Mossy Head Farm caused levels there to decline about 10 feet. The effects of pumping extended outward more than 10 miles from the center of pumping at the Owl's Head Farm (fig. 9). The extensive decline in levels from March 1970 to June 1970 temporarily changed the direction of ground-water movement. A comparison of figure 8 with figure 9 will show in detail the nature of this change in direction. Ground water that moved toward Choctawhatchee River, Choctawhatchee Bay, and the gulf generally was captured in the areas of heavy withdrawals. The lowering of the head in the Floridan aquifer caused an increase in head difference between the Floridan and the sand-and-gravel aquifers and, consequently, recharge was increased.

Aquifer Characteristics

Transmissivity is a measure of the ability of an aquifer to transmit water.

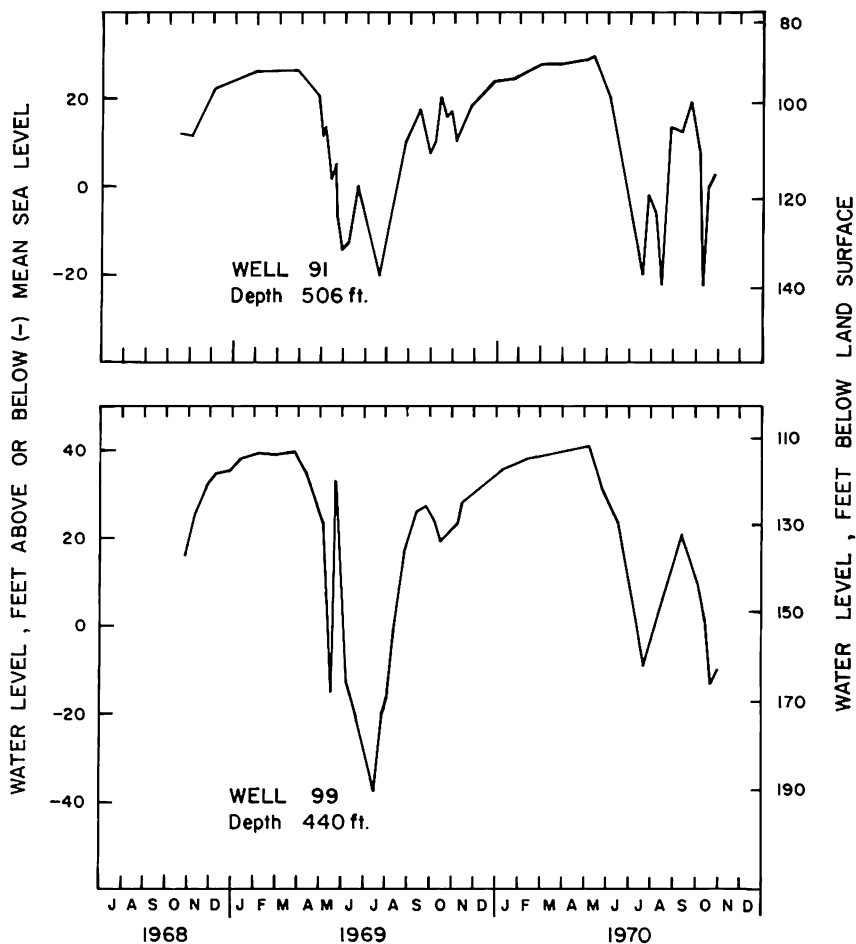


Figure 14. Hydrographs showing water levels in wells that tap the Floridan aquifer at Owl's Head Farm.

It represents the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient. In this report transmissivity is given in units of gallons per day per foot.

In Walton County, the transmissivity is highly variable ranging from 4,000 gpd/ft (gallons per day per foot) along the central and eastern gulf coast to 100,000 gpd/ft along the western gulf coast as shown in figure 16. Transmissivity is 180,000 gpd/ft at a point 10 miles south of DeFuniak Springs and as low as 24,000 gpd/ft to the northwest, near Argyle. In general, transmissivity is relatively high in the southcentral part of the county.

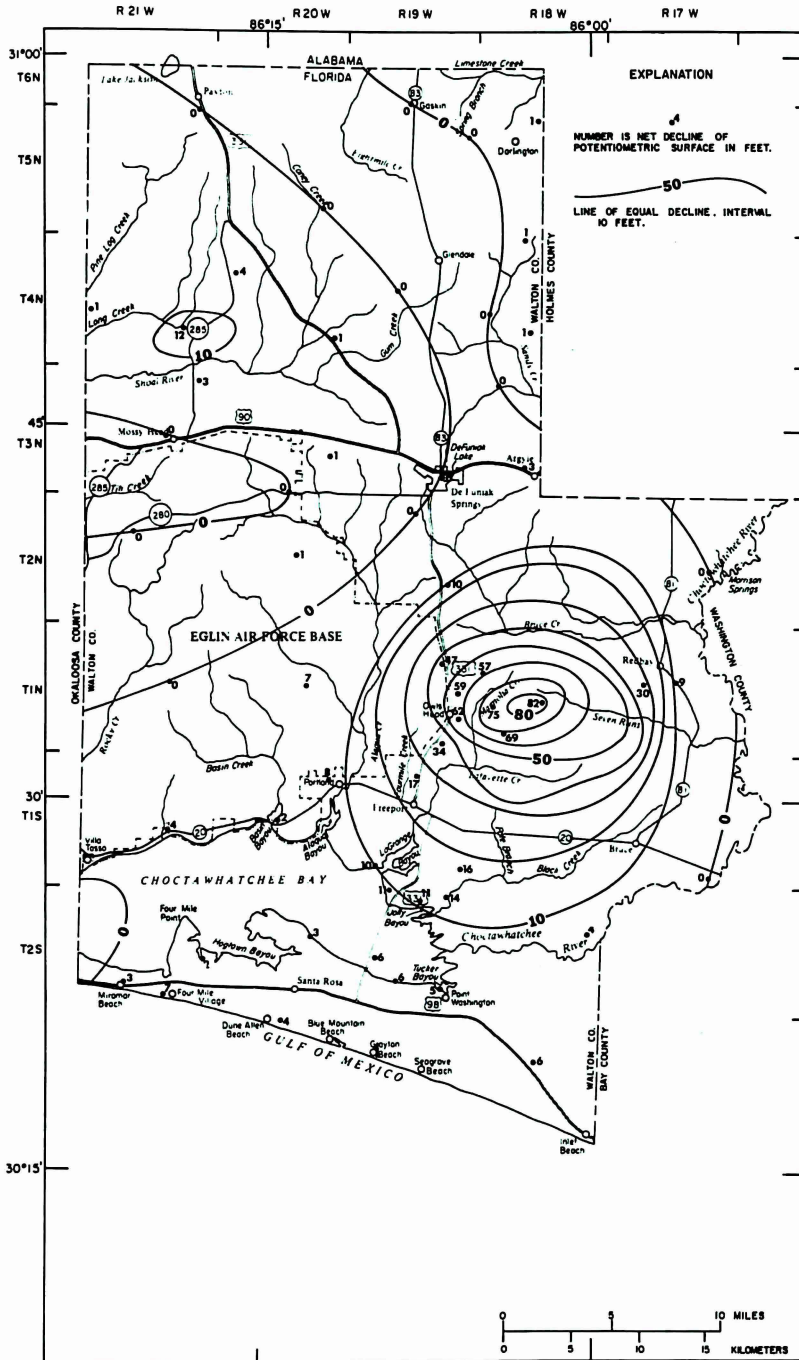


Figure 15. Map of the net decline of potentiometric surface of the Floridan aquifer from March 9-13 to June 22-26, 1970.

Variation in transmissivity is the result of local differences in the composition of the aquifer and its thickness. Along the gulf coast much limey clay and marl are interbedded with the limestone of the aquifer; and in northern Walton County, large amounts of clay and sand occur throughout the aquifer, especially in the upper section. The presence of these materials accounts for its lower transmissibility in those places.

The storage coefficient is the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. In Walton County storage coefficient ranges from 1.6×10^{-4} to 5.6×10^{-4} (fig. 16).

Quality of Water

Water from wells tapping the Floridan aquifer is of acceptable chemical quality except in an area in southeastern Walton County adjacent to Choctawhatchee Bay, where the water is highly mineralized. Table 1 lists chemical analysis of water from selected Floridan aquifer wells that range in depth from 80 to 506 feet.

Water from Floridan wells north of Choctawhatchee Bay is of calcium bicarbonate type and is low in dissolved solids. The low dissolved solids reflects the quality of recharge from the sand-and-gravel aquifer. Water from Floridan wells adjacent to Choctawhatchee Bay is of sodium chloride type and is high in dissolved solids, reflecting the quality of water that occurs at depth within the Floridan aquifer.

Dissolved-solids concentration in water from the Floridan aquifer ranges from less than 70 to 3,500 mg/l (fig. 17); and chloride concentration is as much as 2,000 mg/l (fig. 18). Water from Floridan wells north of Choctawhatchee Bay usually contains less than 5 and 150 mg/l of chloride and dissolved solids, respectively. Adjacent to Choctawhatchee Bay, however, both chloride and dissolved solids increase with depth in most wells. The chloride concentration of water from Floridan wells adjacent to the bay is shown in figure 18.

In area A of figure 18, water from the Floridan ranges in chloride concentration from 61 to 790 mg/l; bottom elevation of wells range from 206 to 470 feet below sea level. Chloride is highest in water from wells along the south side of the bay increasingly westwardly from Tucker Bayou to Hogtown Bayou.

In area B, water from the Floridan ranges in chloride concentration from 10 to 600 mg/l; bottom elevations of wells range from 80 to 533 feet below sea level though most are below 350 feet. The safe useful well depth in area B is about 500 feet below sea level. Wells with bottom elevations more than 500 feet below sea level usually contain water with chloride greater than 250 mg/l.

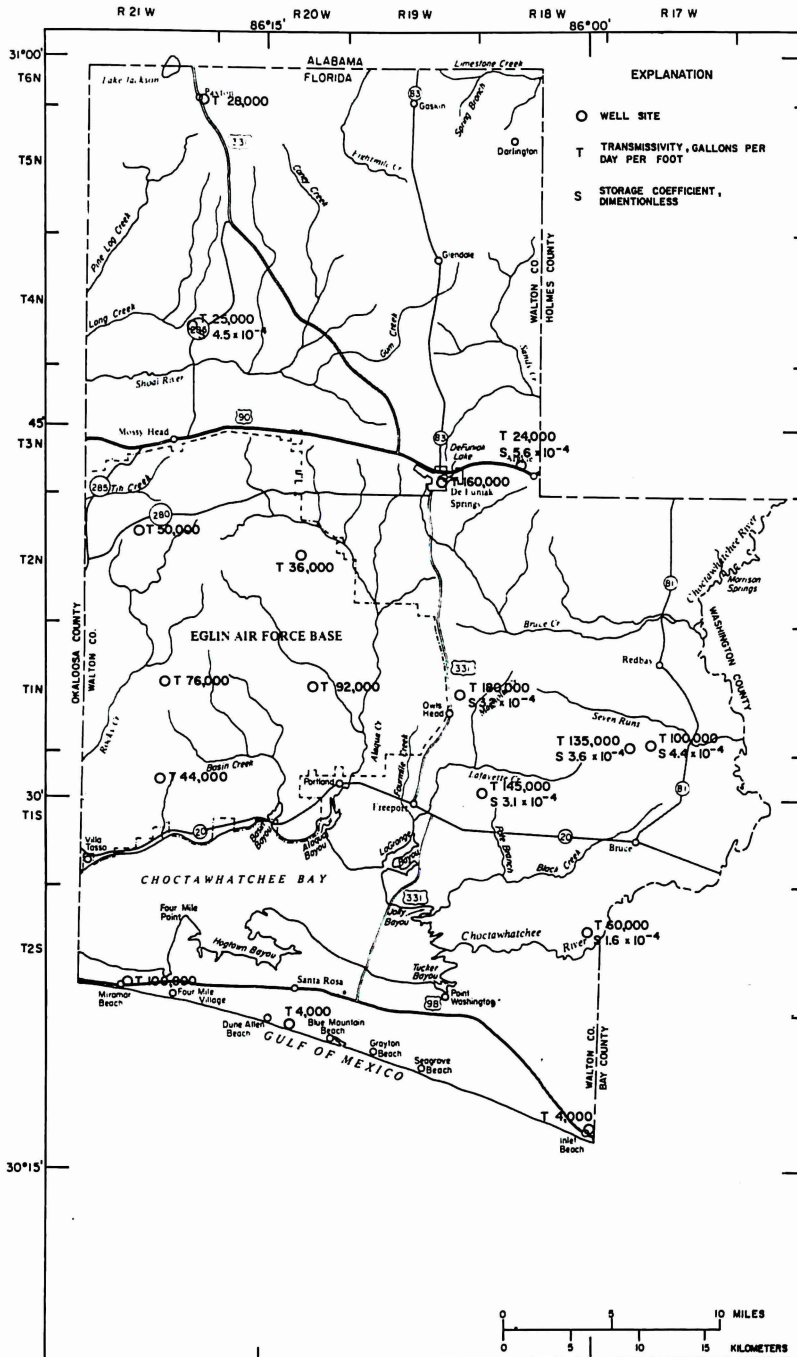


Figure 16. Map showing transmissivities and storage coefficients at wells that tap the Floridan aquifer.

TABLE 1
QUALITY OF FLORIDAN AQUIFER WELLS IN WALTON COUNTY
(Chemical analyses, milligrams per liter)

Site number on figure 1	Well number*	Well depth (feet)	Date of collec- tion	Specific conduct- ance (micro- mhos at 25°C)	Dissolved solids (calcu- lated)	Chlo- ride (Cl)	pH	Total iron (Fe)	Fluo- ride (F)	Hardness (Ca-Mg)	Cal- cium (Ca)	Mag- ne- sium (Mg)	Sodium (Na)	Ni- trate (NO ₃)	Alkalin- ity (as (CaCO ₃))	Bicar- bonate (HCO ₃)	Tem- per- ature (°C)
13	302058N0861432.1	340	06-19-68	276	172	16	7.6	-	0.2	132	41	6.7	6.2	0.1	125	152	23.5
18	302112N0861501.1	455	05-07-70	2,200	1,300	564	7.9	0.02	6	280	49	37	311	.0	157	191	21.0
38	302243N0860917.1	389	05-05-70	1,350	771	362	8.1	.02	6	139	26	18	250	.0	98	120	20.0
47	302346N0861812.1	400	09-25-69	330	176	47	8.1	0	.7	123	21	17	23	-	120	-	20.0
50	302444N0860010.1	229	09-24-69	150	71	7.0	7.9	0	.3	68	15	7.3	5.7	-	66	80	22.0
52	302549N0860717.1	240	09-25-69	2,300	1,220	680	8.1	.01	8	171	32	22	400	-	131	160	22.0
91	303214N0855804.1	506	06-12-70	174	102	2.2	7.5	.01	.2	83	19	8.6	2.7	.0	70	96	23.8
99	303426N0860611.1	440	06-12-70	160	91	1.2	8.1	0	.2	83	19	8.5	2.1	.0	75	92	23.6
151	305043N0860833.1	320	05-04-70	225	136	2.0	7.9	0	.2	113	27	11	1.8	.0	108	132	21.0
161	305732N0860208.1	120	05-04-70	192	111	1.5	7.6	0	.2	96	34	2.5	1.6	.5	94	115	20.5
163	305816N0860815.1	80	05-04-70	232	143	4.0	8.0	0.2	.2	121	40	5.0	2.4	6.8	111	135	19.0

*Well number is latitude and longitude of the well site. Example: Site 13 is at Lat. 30°20'58"N., Long. 086°14'32"W., and there is 1 well.

Generally, wells with bottom elevations less than 400 feet below sea level contain water low in chloride. Several relatively shallow wells in area B yield water of excellent chemical quality; they tap a little used part of the Floridan aquifer along the coast that lies less than 100 feet below land surface and that varies in thickness from 90 to 100 feet (figs. 5, 6, and 7).

In area C, water from wells tapping the Floridan ranges in chloride content from 10 to 32 mg/l; bottom elevations of wells range from 397 to 496 feet below mean sea level.

In area D, water from the Floridan ranges in chloride content from 422 to 2,040 mg/l; bottom elevations of wells range from 172 to 303 feet below sea level. Chloride content increases with well depth. This was substantiated by samples from well 60 (fig. 1), northeast of Jolly Bayou. The well, bottom elevation 303 feet below sea level, contained 106 feet of 4-inch casing and flowed about 25 gpm for 45 minutes before sampling was begun. Water samples were field analyzed for temperature, pH, specific conductance, and chloride. The results are as follows:

Sampling Depth (feet below msl)	Temperature (°C)	pH	Specific	Chloride (mg/l)
			Conductance (micromhos at 25°C)	
130	22.0	7.9	6,100	2,040
200	22.0	7.8	7,000	2,480
280	22.5	7.5	8,600	3,000
303	22.0	7.7	11,000	4,200

Water from this well contained the most chloride of any well sampled. The high chloride content of water from the Floridan in area D may be the result of upward movement of salt water from depth. Salt-water encroachment of the aquifer from the bay or gulf is not possible because the potentiometric surface is above sea level (fig. 8).

Electric logs indicate that saline water (dissolved solids in excess of 1,000 mg/l) occurs in the Floridan aquifer throughout Walton County. The fresh-water-saline-water interface is about 750 feet below sea level near Bruce in the southeastern part of the county, about 1,200 feet below near Miramar Beach in the southwestern part, about 650 feet below near Glendale in the northeastern part, and about 950 feet below near Paxton in the northwestern part. For the most part, fresh and salt water are not in direct contact but are separated by a "zone of diffusion," an area where mixing takes place. In southwestern Walton County, the Floridan aquifer contains a wedge of clay which thins eastward and gradually pinches out about 8 miles east of the Okaloosa County line (Marsh, p. 45, 1966). The top of the clay is about 650 feet below sea level—it prevents

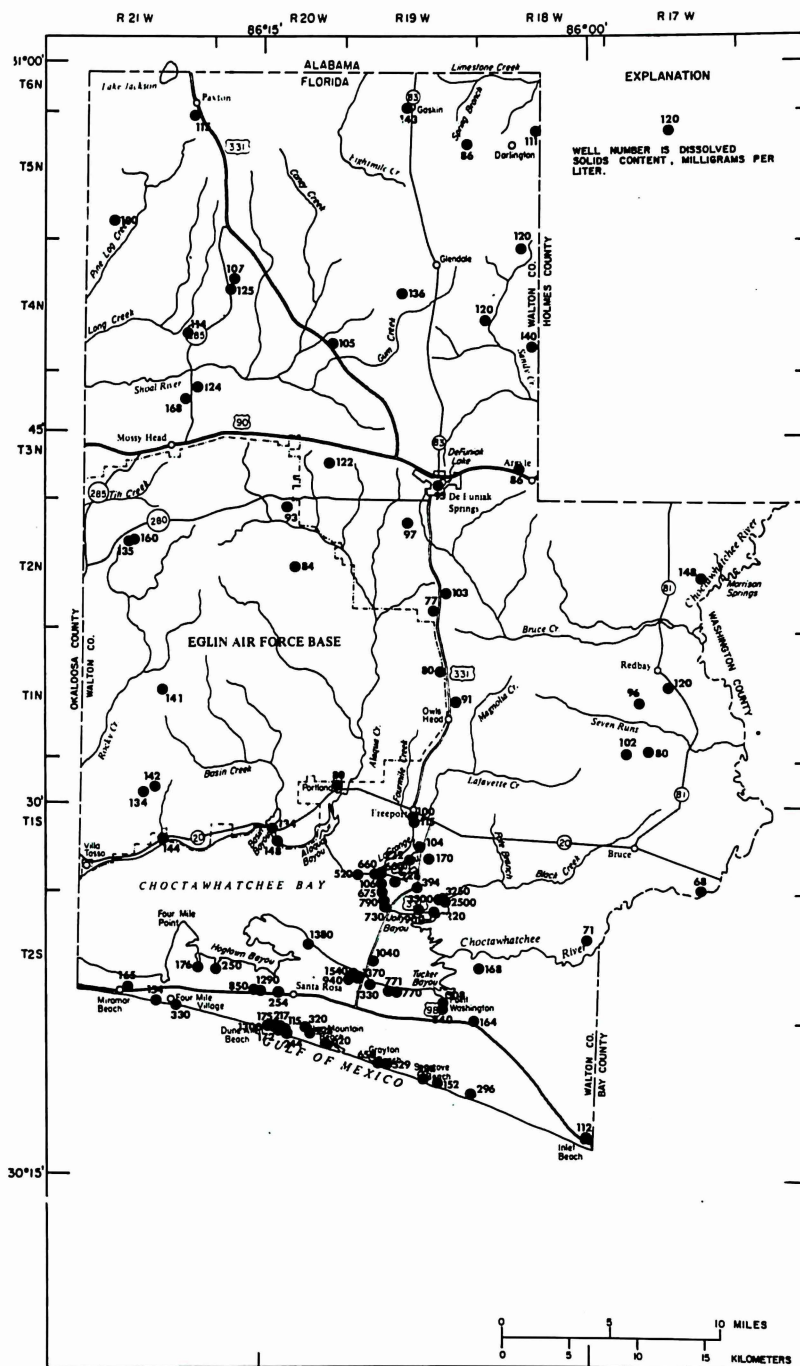


Figure 17. Map showing dissolved solids in water from wells that tap the Floridan aquifer.

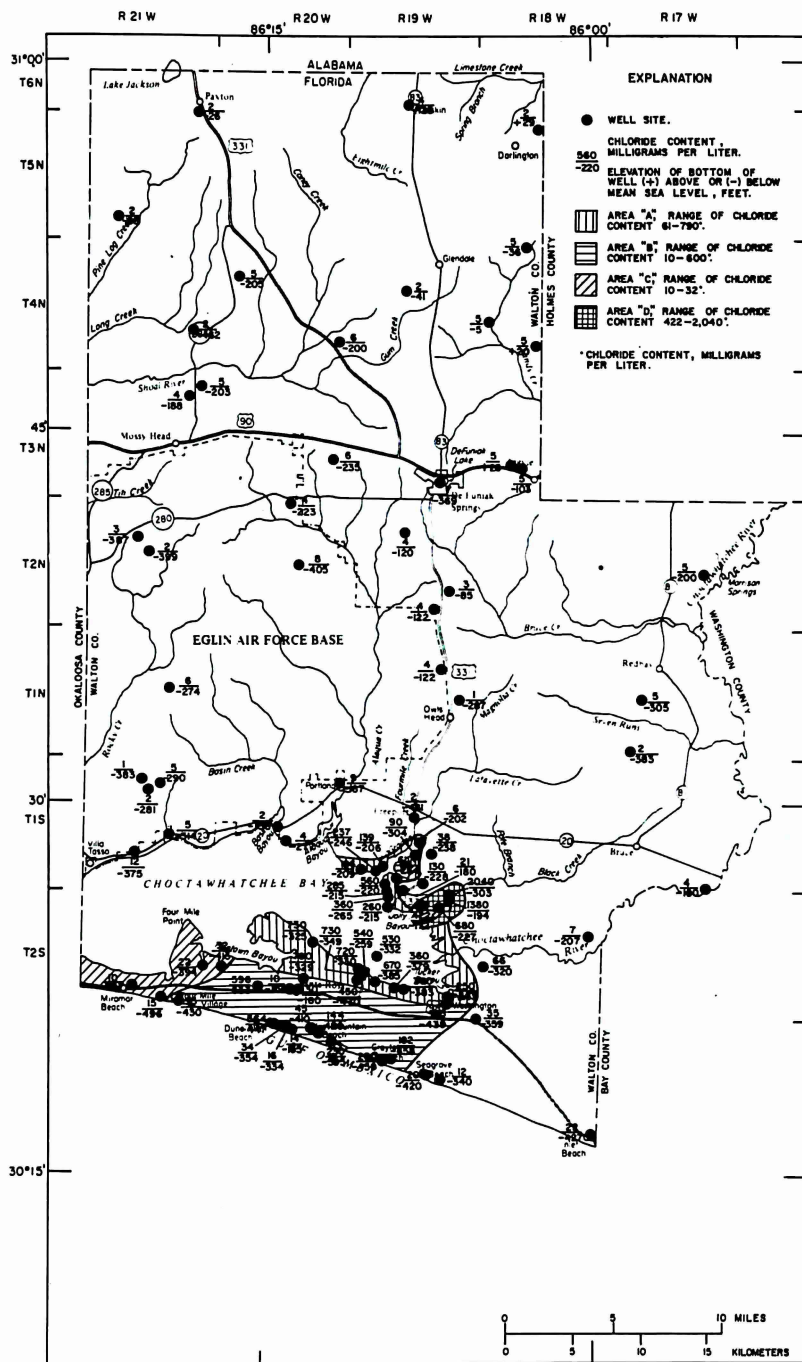


Figure 18. Map showing chloride content of water from wells that tap the Floridan aquifer.

upward movement of the underlying salt water and accounts for the low dissolved solids and chloride concentrations in water from wells in area C (fig. 18).

The configuration of the potentiometric surface of the Floridan aquifer in the vicinity of Choctawhatchee Bay and above the mouth of the Choctawhatchee River (fig. 8) and its position above the water surface (fig. 7) indicate that the Floridan aquifer leaks to the bay and river. In area D (fig. 18) this leakage may consist of salt water moving up through permeable faulted zones, possibly mixed with fresh water in the upper part of the aquifer and now evidenced by the poor quality of the ground water in the area.

The chloride concentration of water from wells in the Floridan aquifer has not changed appreciably during the last 10 years. Graphs in figure 19 show that chloride varies but with no specific upward trend in water from coastal area wells. The potential for salt-water contamination does exist, however, in the coastal area. Increasing ground-water withdrawals with attendant declining water levels could cause an upward and landward displacement of fresh ground water with salty water.

SURFACE WATER

OCCURRENCE OF STREAMFLOW

Streamflow, water flowing overland in natural channels, is derived from rainfall, from lakes or swamps, and from ground-water runoff. Ground-water runoff constitutes the base flow of a stream and sustains streamflow during periods of drought. In Walton County, the base flow of most streams comes entirely from the sand-and-gravel aquifer.

STREAMS

Streamflow originating in Walton County averages about 1,600 cfs (cubic feet per second) or 1.0 bgd (billion gallons per day); this is based on discharge from gaged areas and estimates of ungaged areas. Estimated discharges were obtained by correlation with known yields from similar drainage basins.

Table 2 shows that streams of Walton County have high yields (rate of discharge per square mile of drainage area). Shoal River, Alaqua Creek, and Magnolia Creek discharge, on the average, 1.85, 2.38, and 3.24 cfs/m (cubic feet per second per square mile), respectively. The highest yields are from drainage basins in the southern part of the county.

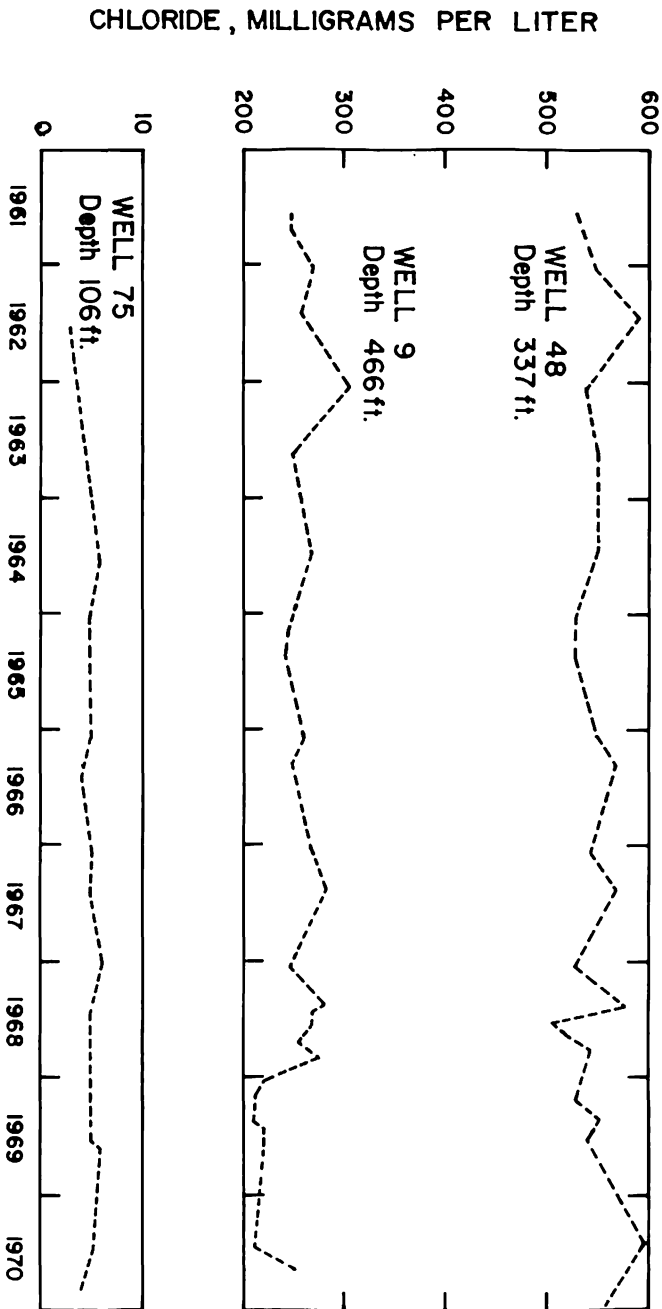


Figure 19. Graphs showing chloride content of water from Floridan aquifer wells in Walton County.

TABLE 2
SUMMARY OF STREAMFLOW DATA AT GAGING SITES IN WALTON COUNTY

Site number on figure 1	Gaging Station	Drainage area (sq. mi.)	Period of Record	Years of Record	Average flow			Minimum flow for period of record	
					Recorded (cfs)	(cfsm)	Estimated, 1931-70 (cfs)	(cfs)	Date
166	Eightmile Creek near Gaskin	24.9	1968-70	2	34.5 ^e	1.39	—	6.24	10-24-68
169	Sandy Creek near Argyle	51.8	1968-70	2	55.7 ^e	1.08	—	5.07	10-24-68
170	Bruce Creek near Redbay	51.4	1968-70	2	106 ^e	2.06	—	5.10	10-24-68
173	Seven Runs Creek near Redbay ^d	2.58	1968-70	2	85.6	3.32	96.0	26	10-23-68
174	Choctawhatchee River near Bruce ^d	4,384	1930-70	40	6,830	1.56	6,830	1,290	10-27-68
177	Magnolia Creek near Freeport ^d	11.2	1968-70	2	36.3	3.24	44.0	19	10-23-68
180	Alaqua Creek near DeFuniak Springs ^d	65.6	1951-70	19	156	2.38	170	27	1955*
185	Shoal River near Mossy Head ^d	123	1951-70	19	227	1.85	230	42	06-09-56

^d Daily discharge station

^e Estimated

*June 9, 21, 22, 30, and July 1

The base flow of most streams in the county is high. Base flow can be estimated from stream-discharge hydrographs by separating the base flow from that part of the storm or overland runoff that causes the sharp increase (flood peaks) in stream discharge. An approximation of base flow can be made graphically by drawing a smooth curve on the hydrograph tangent to the low points at each end of the flood peaks. For example, an analysis of the hydrographs in figure 20 indicates that during March, April, and May 1970, a period of normal rainfall, the base flow from Shoal River, Alaqua Creek, and Magnolia Creek averaged 75, 80, and 90 percent of the total flow, respectively. The effect of subsurface return flow of irrigation water may account for the higher base flow of Magnolia Creek.

The minimum flows measured during 1968-70 (table 2) resulted from a severe drought that ended about November 1968. Although 2 years is too brief a time in which to establish the limits of extreme hydrologic events, analysis of long-term records for streams in or near Walton County showed that the minimum streamflows measured during 1968 were representative of the minimum flows likely to occur over a much longer time. At Shoal River near Mossy Head, for example, the minimum for 1968-70 was 46 cfs, compared to the 42-cfs minimum of record since 1951. At Choctawhatchee River near Bruce, the 1,290-cfs minimum for 1968-70 was the lowest discharge since 1930. At Alaqua Creek near DeFuniak Springs, a 46-cfs minimum for October 1968 was the fifth lowest discharge since the 1955 record low of 27 cfs; the streamflow records for this station began in April 1951.

Flow-duration curves for Shoal and Choctawhatchee Rivers and Alaqua, Magnolia, and Seven Runs Creeks are similar—their relatively flat slopes, particularly at the lower end, indicate that these basins have large ground-water storage (fig. 21). The relatively flat slope at the upper end of the flow-duration curve for Choctawhatchee River suggests that stream has large flood-plain storage. Seven Runs Creek has the highest yield per square mile and Choctawhatchee River the lowest.

Information on the recurrence of low flows is particularly important in designing surface-water supply systems because the lowest discharge usually establishes the limits of supply without storage. Low flow frequency curves for Alaqua Creek, Shoal River, and Choctawhatchee River are shown in figures 22-24. Based on minimum 7-day flows for 10-year recurrence intervals (commonly used as a basis for design of water-supply systems), and assuming that flow conditions in the future will be comparable to those experienced during the period of record, 35, 48, and 1,550 cfs are the minimum quantities of water available from Alaqua Creek, Shoal River, and Choctawhatchee River, respectively.

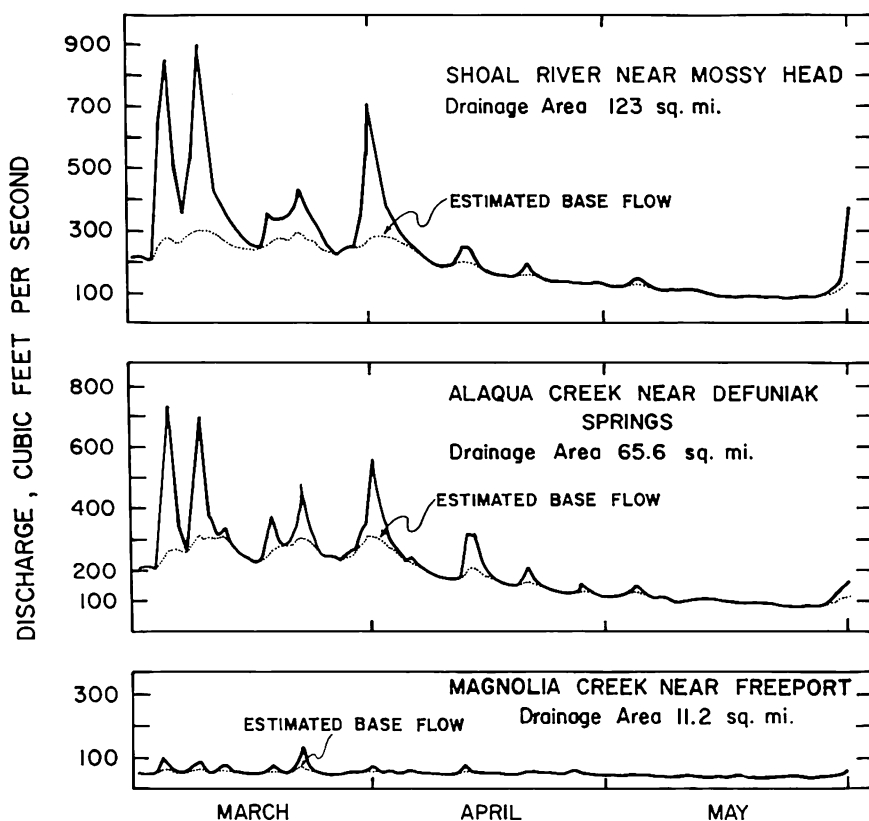


Figure 20. Hydrographs showing daily flow of three streams in Walton County, March-May 1970.

Measurements of 22 of Walton County streams on May 14-26, during a period of low flow suggest the streams may be perennial (fig. 25). The flows were about the same in May 1969 as in May 1970.

Industrial or residential encroachment onto the flood plain of the county has been slight and, therefore, flood damage has been minimal. Stream flood plains in the county are generally flat swampy areas inundated to some degree almost every year. During a record flood of 1953 at Alaqua Creek near DeFuniak Springs (fig. 1) when the peak discharge was 5,160 cfs, the stage was about 5 feet above bank-full stage (38.1 feet above sea level) and the creek inundated more than a one-quarter-mile-wide section of flood plain at the gage site. Two days after the flood peak, the stage receded and the creek was within its banks. In 1964, Shoal River near Mossy Head (fig. 1) reached a record-peak discharge of 10,500 cfs at an elevation of 129.2 feet above sea level. Peak stage

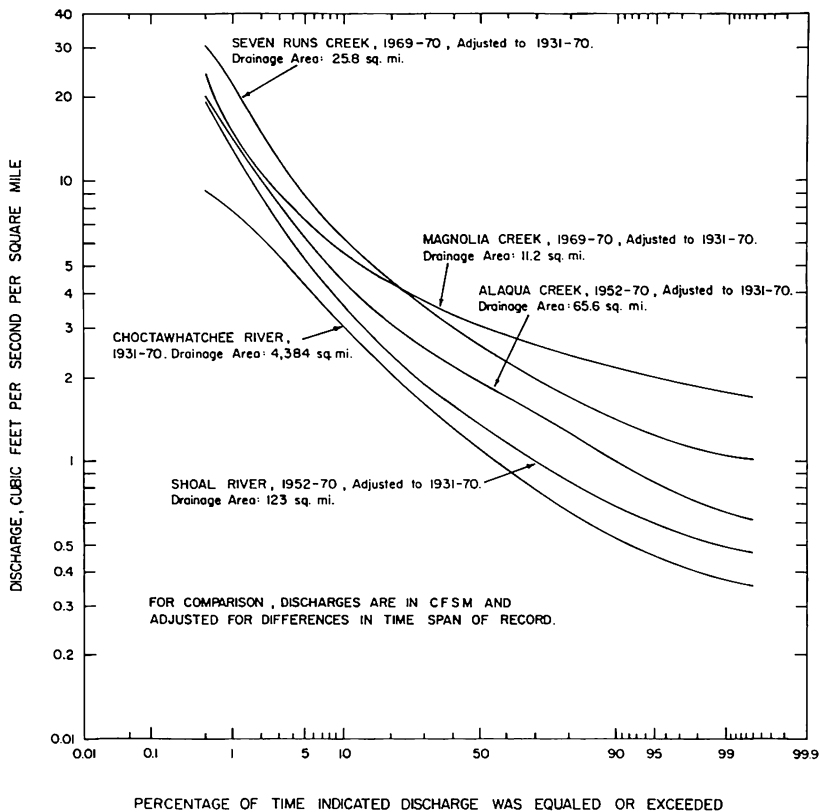


Figure 21. Flow-duration curves for major streams in Walton County.

was about 10 feet above bank-full stage and the river inundated a section of flood plain at the gage site more than a half mile wide. Two days after the flood peak, the stage receded. The Alaqua Creek flood described above had a recurrence interval greater than 20 years; the Shoal River flood, greater than 50 years.

Regionalized flood-frequency curves shown in figure 26 apply to Shoal River and its tributaries, to tributaries of Choctawhatchee River, and to streams draining south into Choctawhatchee Bay. These flood-frequency curves may be used at ungaged streams to estimate the probable magnitude of floods having recurrence intervals of 2.33 (mean annual), 5, 10, 20, and 50 years. A stream with a drainage area of 50 square miles, for example, experiencing a flood having a recurrence interval of 10 years, will have a discharge of 3,400 cfs.

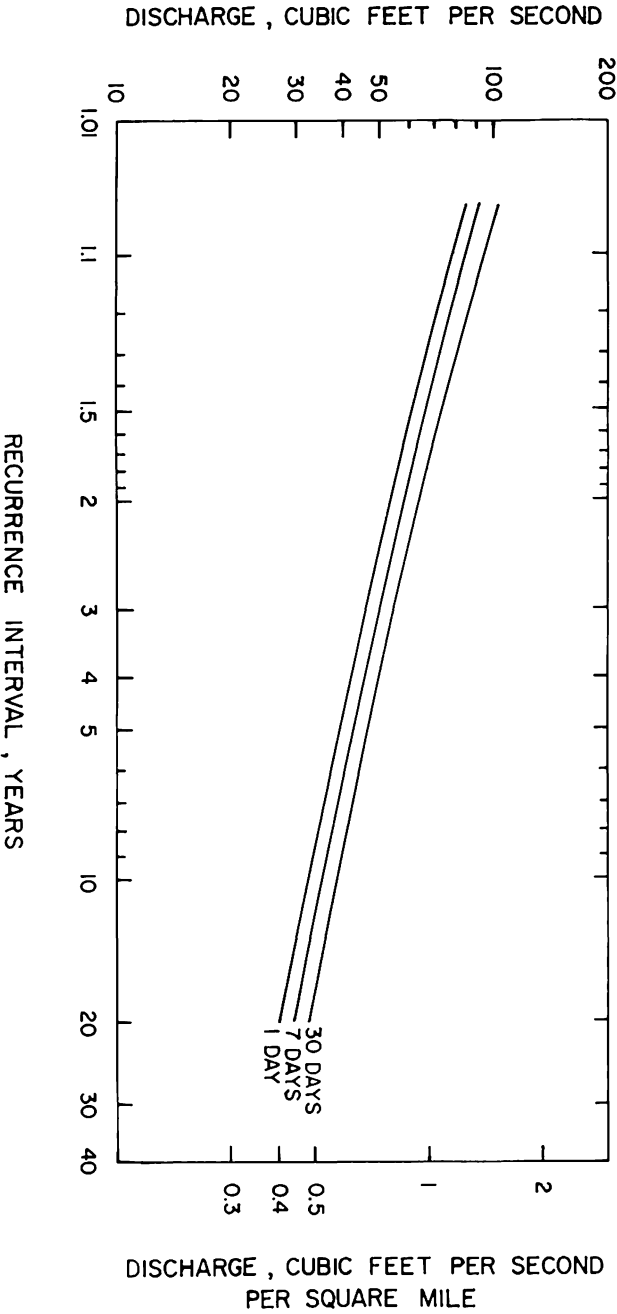


Figure 22. Graph showing magnitude and frequency of low flow at Alaqu Creek near DeFuniak Springs, 1952-70.

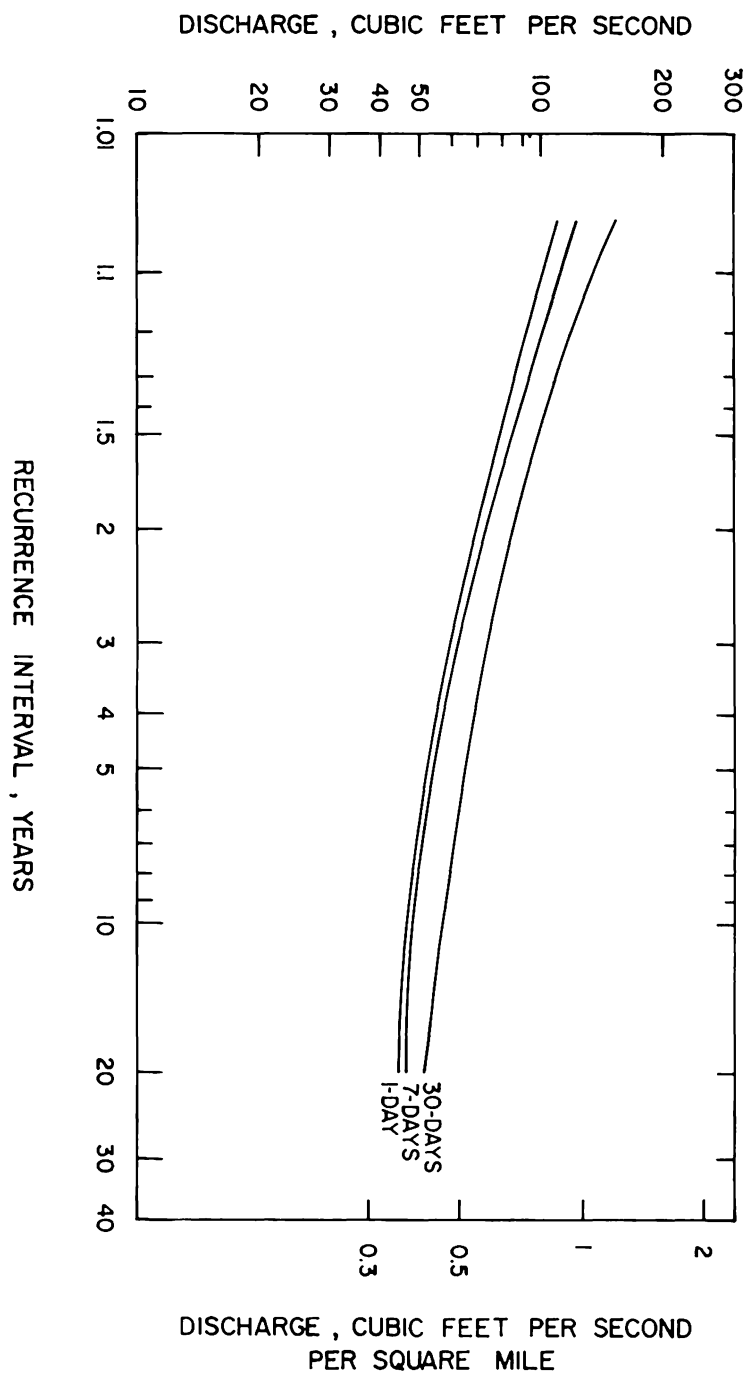


Figure 23. Graph showing magnitude and frequency of low flow at Shoal River near Mossy Head, 1952-70.

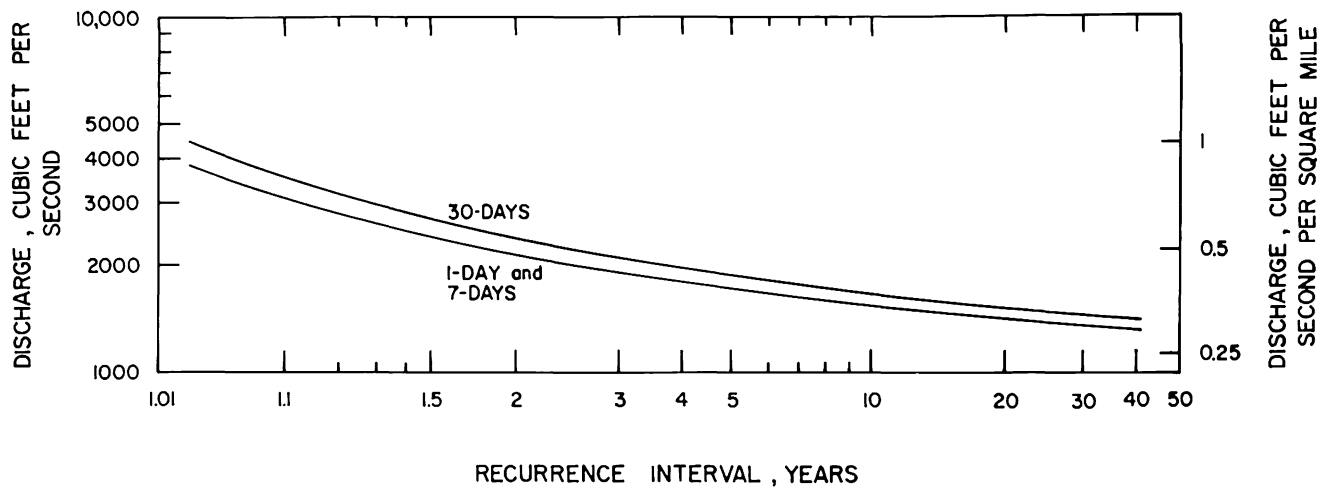


Figure 24. Graph showing magnitude and frequency of low flow at Choctawhatchee River near Bruce, 1931-70.

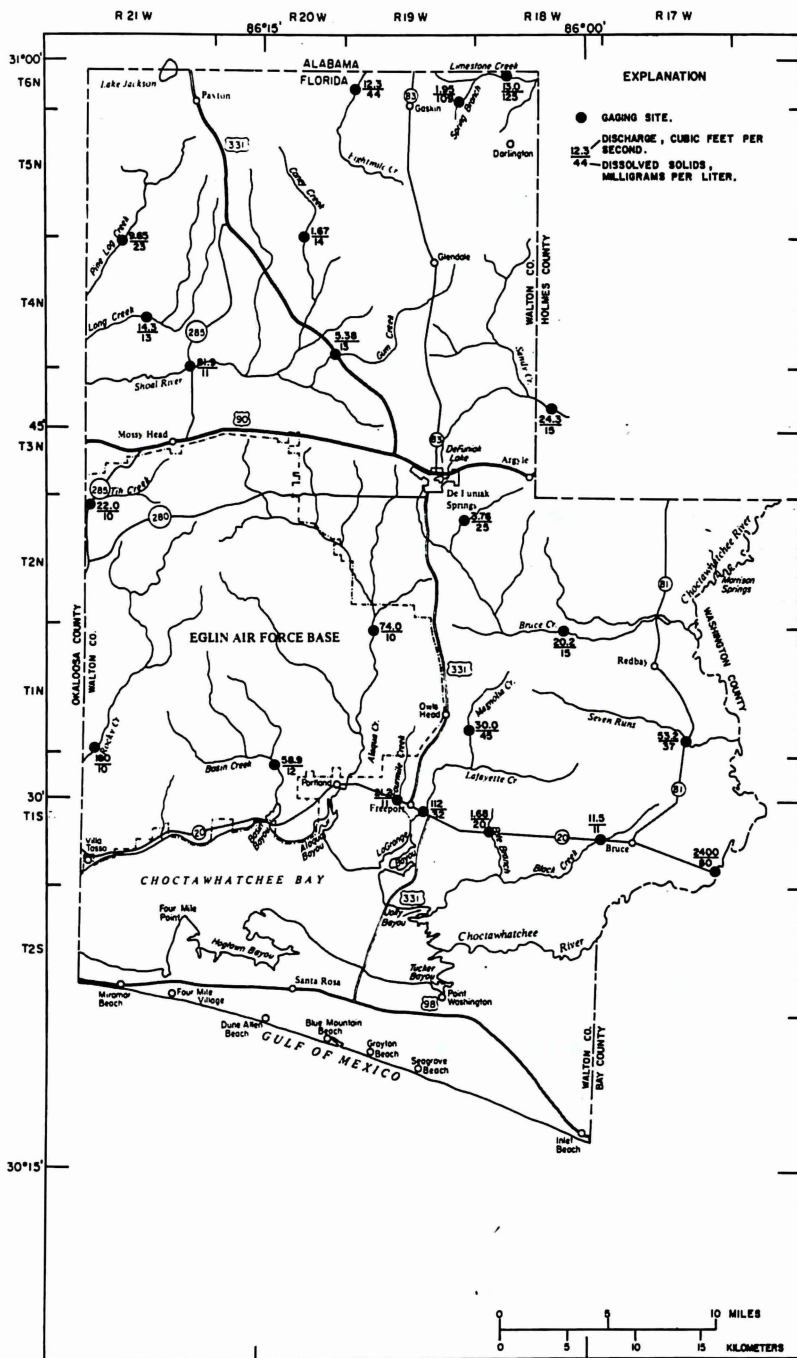


Figure 25. Map showing stream discharge and dissolved solids, May 14-26, 1970.

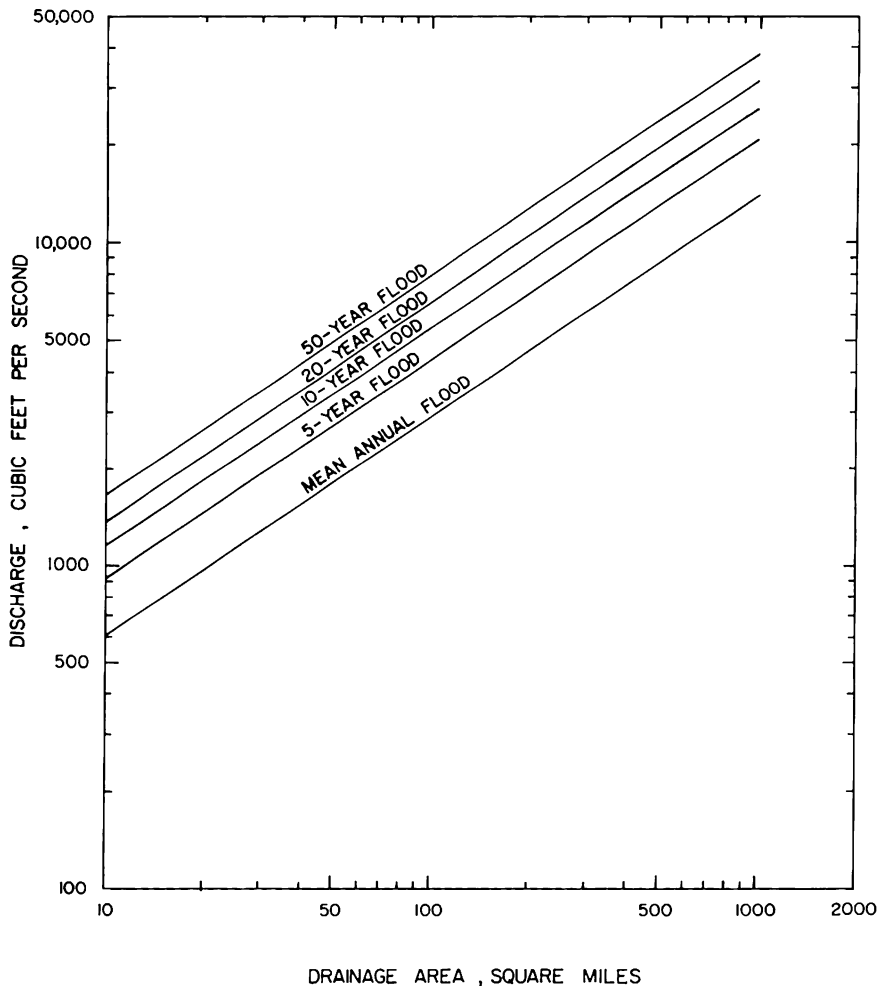


Figure 26. Graph showing regionalized flood-frequency curves for Shoal River Basin and basins between Choctawhatchee River and Yellow River.

LAKES

Walton County has about 25 named lakes; they range in size from 10 to 400 acres. Most of them are primarily recreational. Fifteen of the lakes are near the coast and are brackish most of the time; the others are fresh-water lakes in the northern part of the county. Lake Jackson is the largest lake in the county, with a surface area of about 400 acres. DeFuniak Lake, measuring 40 acres, is one of the smaller.

Lake Jackson, in common with most lakes and ponds in northern Walton County, was formed by solution and eventual collapse of the underlying limestone to form a sink. It is a water-table lake fed by the sand-and-gravel aquifer, by rainfall, and by a small amount of surface runoff. The level of the lake rises when it rains, partly because of rainfall on the lake and partly from increased inflow from the sand-and-gravel aquifer. Depressions detected in the lake bottom by a fathometer indicate that a hydraulic connection probably exists between the lake and the Floridan aquifer. The level of the lake generally stands from 30 to 35 feet above the potentiometric surface of the Floridan aquifer and the lake most likely loses some water to the Floridan aquifer. At high stages, Lake Jackson overflows through a culvert into a tributary of Pond Creek. The almost steady decline in lake level from January to November 1968 reflects a drought. The level declined sharply in June 1970 after the culvert outlet (fig. 27) was cleaned.

Chemical analyses shown in table 3 indicate that Lake Jackson and DeFuniak Lake contain water of excellent chemical quality. The water contains dissolved solids less than 20 mg/l and is similar to the quality of rainwater.

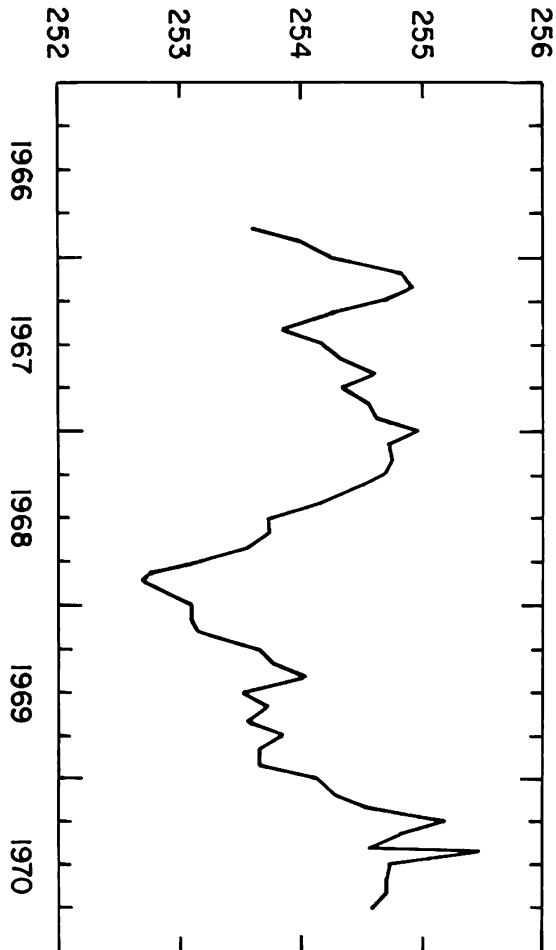
QUALITY OF WATER

Walton County has an abundant supply of surface water whose chemical quality is acceptable for most uses. Dissolved-solids concentration of stream water ranged from 10 to 125 mg/l, chloride from 2.0 to 10 mg/l (fig. 25, table 3). A large percentage of the total flow of most streams in the county is base flow from the sand-and-gravel aquifer and, because of the relatively insoluble nature of the aquifer, is low in dissolved solids. During peak flow, the major difference in water quality is an increase in color and turbidity. The base flow of a few streams such as Eightmile Creek, Spring Branch, Limestone Creek, and Choctawhatchee River, is from the Floridan aquifer. During low flow, water in these streams is high in dissolved solids primarily because of the calcium and carbonate dissolved from the limestone as the ground water passes through that aquifer.

The color and turbidity of the water of Walton County is objectionable but not injurious. Most of the color comes from leaching of organic material in the soil and turbidity is the result of the colloidal suspension of sediment and other nonsettleable particles in the water. Drinking Water Standards proposed by the U.S. Public Health Service (1962) suggest that domestic water not exceed 15 color units or 5 turbidity units—water from streams in Walton County varies from 5 to 50 platinum-cobalt color units and from 3.1 to 25 Jackson turbidity units.

TABLE 3
QUALITY OF WATER IN WALTON COUNTY STREAMS

Station name	Site number on figure 1	Date of collection	Discharge (cfs)	Specific conductance (microhmohms at 25°C)	pH	Temperature (°C)	Color	Turbidity	Chemical analyses, milligrams per liter																				
									Silica (SiO ₂)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Phosphate, Ortho (PO ₄)	Phosphate, Total (PO ₄)	Alkalinity as (CaCO ₃)	Hardness (Ca-Mg)	Noncar bonate Hardness	Dissolved Solids (calculated)	Dissolved Oxygen (DO)	Ammonia Nitrogen as (NH ₄)	Organic Nitrogen as (N)	Nitrite (NO ₂)
Fightmile Creek	166	05-14-70	12.3	90	6.8	22	30	10	6.0	12	2.0	1.7	0.3	37	0.0	0.3	3.3	0.1	0.4	0.02	0.10	30	38	8	44	-	0.03	0.28	0.01
Spring Branch	167	05-19-70	19.5	195	7.8	22	5	4.6	7.4	35	3.1	1.4	0.3	118	.0	8	2.5	.1	.2	.02	.09	97	101	4	109	5.0	.04	.07	.01
Limestone Creek	168	05-19-70	13.0	190	7.9	21	5	10	7.4	35	3.1	2.0	.3	115	.0	.1	2.0	.1	.4	.02	.10	94	101	7	125	7.0	.31	.32	.01
Sandy Creek	169	05-14-70	39.1	22	6.3	22	40	7.4	3.3	0.9	0.4	2.4	.5	.5	.0	.3	3.5	.1	.6	.37	.51	4.0	4.0	0	15	-	.08	.50	.01
Bruce Creek	170	05-20-70	3.8	58	5.5	21	50	20	5.0	2.5	.9	4.4	2.1	1	.0	8	5.7	.1	1.0	1.90	2.30	1.0	10	9	25	4.9	4.90	1.20	.10
DeFuniak Lake	171	05-20-70		27	6.7	27	5	3.3	0.5	2.2	.4	1.6	0.9	7	.0	1.9	2.8	.0	0.0	0.01	0.08	6.0	7.0	2	14	7.0	0.07	0.52	.00
Bruce Creek	172	05-14-70	20.2	23	5.9	21	30	9.4	4.2	1.1	.4	2.2	.6	.3	.0	0.6	3.4	.1	.9	.15	.25	2.0	4.0	2	15	-	.80	.36	.10
Seven Runs Creek	173	05-14-70	53.2	70	4.7	25	5	6.9	3.2	2.7	1.8	2.9	3.6	0	.0	4	9.3	.0	13.0	.00	.08	0.0	12	14	59	-	.11	.28	.01
Choctawhatchee River	174	05-26-70	2,400	143	7.2	26	5	25	7.6	21	2.8	4.9	0.7	72	.0	6	6.3	.2	1.2	.03	.09	59	64	5	80	6.3	.11	.16	.02
Black Creek	175	05-18-70	11.5	17	6.5	20	40	6.4	3.9	1.0	0.3	1.4	.2	2	.0	.6	2.5	.1	0.0	.02	.06	2.0	4.0	2	11	7.9	.32	.22	.01
Pate Branch	176	05-26-70	1.68	42	6.2	26	5	4.9	3.8	2.5	1.2	2.1	1.5	3	-	.3	5.8	.1	.7	.00	.02	2.0	11	9	20	6.5	.05	.22	.01
Magnolia Creek	177	05-14-70	30.0	90	4.7	20	5	5.8	3.4	3.5	2.6	2.0	4.2	0	0.0	.2	10.0	1	19.0	.00	.08	0.0	19	19	58	-	.58	.60	.01
Lafayette Creek	178	05-18-70	11.2	60	5.4	26	5	3.4	3.0	2.6	1.8	1.9	2.9	1	.0	6	8.1	.0	11.0	.00	.06	1.0	14	13	32	6.6	.04	.30	.01
Fourmile Creek	179	05-20-70	21.2	19	5.6	21	20	4.3	3.3	0.6	0.4	1.4	0.3	1	.0	2	3.0	.0	1.5	.01	.05	1.0	3.0	2	11	7.0	.05	.16	.01
Alaqua Creek	180	05-25-70	74.0	12	6.2	22	10	10	3.7	.6	.3	1.2	2	3	.0	.0	2.0	.1	0.2	.02	.10	2.0	3.0	0	10	7.5	.01	1.10	.01
Basin Creek	181	05-20-70	58.9	19	5.5	21	30	4.0	3.2	1.1	.4	1.9	.2	2	.0	8	3.2	.0	1	.00	.02	2.0	4.0	3	12	6.8	.05	.16	.01
Rocky Creek	182	05-14-70	180	13	6.2	21	10	3.1	3.8	0.4	.2	1.5	.3	2	.0	.2	2.7	.1	2	.00	.06	2.0	2.0	1	10	-	.01	.10	.01
Caney Creek	183	05-19-70	1.67	16	6.2	20	40	6.9	5.5	.9	.3	2.1	2	2	.0	6	3.4	.0	.3	.05	.12	2.0	3.0	2	14	5.0	.05	.23	.01
Gum Creek	184	05-20-70	5.38	16	5.8	19	40	6.6	4.8	.5	.3	1.7	2	2	.0	6	3.1	.0	4	.04	.10	2.0	2.0	1	13	6.6	.07	.24	.01
Shoal River	185	05-25-70	81.9	16	6.2	24	10	6.1	3.6	.6	.4	1.4	.3	2	.0	4	2.7	.1	.7	.02	.08	2.0	3.0	2	11	7.6	.07	.17	.01
Lake Jackson	186	05-13-70		32	6.2	27	5	10	0.5	1.8	.6	2.3	.9	4	.0	4.6	3.6	.1	.0	.03	.06	3.0	7.0	4	16	-	.01	.35	.01
Pine Log Creek	187	05-19-70	9.65	34	7.1	22	20	6.4	6.2	3.2	1.3	1.6	.2	14	.0	0.8	2.5	.1	.2	.03	.08	11	14	2	23	7.5	.02	.24	.01
Long Creek	188	05-19-70	14.3	16	6.4	21	20	6.3	5.0	0.9	0.4	1.3	.3	3	.0	.5	3.0	.0	.5	.02	.08	2.0	3.0	1	13	6.5	.05	.20	.01
Titu Creek	189	05-19-70	22.0	13	6.3	20	10	7.6	3.3	.9	.3	1.1	.2	2	.0	6	2.2	.0	.3	.02	.07	2.0	3.0	2	10	7.6	.05	.15	.01

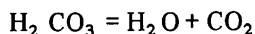
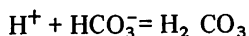
WATER LEVEL , FEET ABOVE
MEAN SEA LEVEL

The water in Magnolia and Seven Runs Creeks increased in specific conductance (a value directly related to dissolved solids content of water) between October 1968 and May 1970 because of increased concentrations of potassium, nitrate, and chloride. Bicarbonate and pH (hydrogen-ion concentration) decreased; this is shown in the following tabulation:

Stream	Date	Discharge	K	NO ₃	Cl	HCO ₃	Specific Conductance	pH
		(cfs)	(mg/l)				(micromhos at 25°C)	
Magnolia Creek	10/23/68	22.2	1.0	1.2	5.0	3	25	5.7
	05/14/70	30.0	4.2	19	10	0	90	4.7
Seven Runs Creek	10/23/68	24.8	0.0	0	4.0	5	20	5.6
	05/14/70	53.2	3.6	13	9.3	0	70	4.7

Ninety-five and 75 percent of their drainage basins, respectively, are farm land treated with fertilizers and irrigated with water from the Floridan aquifer. Fertilizer constituents generally applied are nitrogen, phosphoric acid, and potash in ratios of 5, 10 and 15 percent, respectively. The application rate ranges from 600 to 800 pounds per acre per crop per year. Nitrogen solutions are also applied as a side dressing at a rate of 200 pounds per acre per crop per year.

The pH, and bicarbonate concentration, of irrigation water from the Floridan aquifer range from 7.8 to 8.1 and 90 to 100 mg/l, respectively; and from the sand-and-gravel aquifer and streams they range from 5.5 to 6.0 and 1 to 5 mg/l, respectively. Most fertilizers are acid-forming (Volk, p. 14) and when added to the soil apparently act as proton (H⁺) donors which react with the Floridan aquifer irrigation water and the sand-and-gravel aquifer water to lower the pH and eliminate bicarbonate from Magnolia and Seven Runs Creeks water by the reactions:



Specific conductance of water in Magnolia and Seven Runs Creeks increased as discharge approached base flow conditions (fig. 28). Most fertilizer constituents and irrigation water, therefore, reached these streams by infiltration to the water table and lateral movement through the sand-and-gravel aquifer. Bruce and Sandy Creeks also receive base flow from the sand-and-gravel aquifer but specific conductance did not change during the same period—their drainage basins are agriculturally undeveloped.

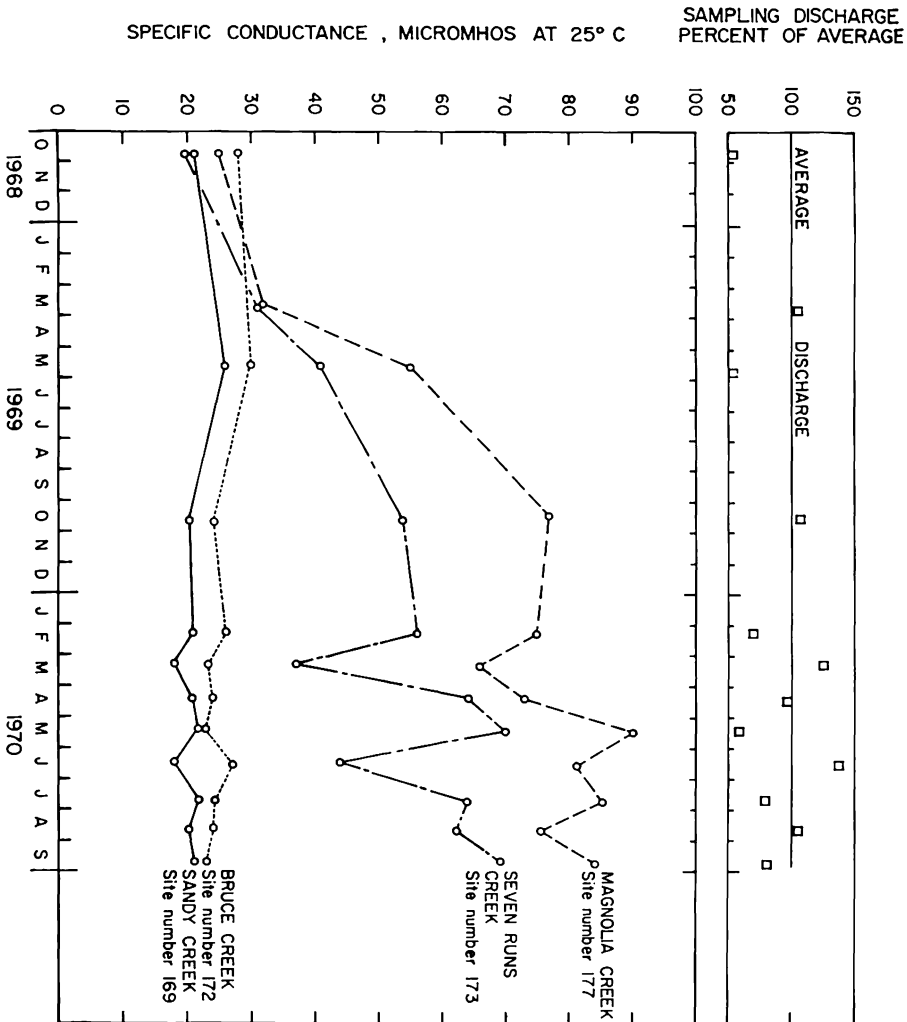


Figure 28. Graph showing variation in specific conductance of selected streams and discharge of Magnolia and Seven Runs Creeks.

To develop background information regarding the possible existence of stream pollution in the county, streams were sampled for nutrients—nitrogen (ammonia, nitrite, nitrate, and organic), and phosphate (ortho- and total). Water receiving raw or treated sewage, or agricultural drainage, normally contains appreciable concentrations of nutrients. Except Bruce Creek most streams tested have concentrations of nitrogen and phosphate below 0.50 mg/l (table 3). The higher concentrations of nutrients of Bruce Creek indicate some pollution upstream from the sampling site.

TABLE 4
DIFFERENCES IN SIGNIFICANT CHARACTERISTICS OF SELECTED STREAMS,
OCTOBER 1969-SEPTEMBER 1970

Station Name	Site number on figure 1	Date of collection	Discharge (cfs)	Specific conductance (micromhos at 25°C)	pH	Temperature (°C)	Dissolved Oxygen mg/l	Coliforms per 100 ml
Eightmile Creek	166	10-15-69	17	59	6.5	19	6.5	1,800
		09-28-70	119	26	5.6	22	5.6	5,400
Sandy Creek	169	10-15-69	37	19	5.3	18	8.2	3,400
		09-28-70	153	21	4.8	22	7.3	8,800
Bruce Creek	172	10-15-69	44	25	5.3	19	8.0	2,000
		09-28-70	49	22	5.5	23	7.2	750
Seven Runs Creek	173	10-15-69	72	60	4.7	20	7.8	1,650
		09-28-70	88	62	4.5	24	7.6	4,400
Choctawhatchee River	174	10-15-69	3,820	110	7.0	21	6.6	450
		09-28-70	3,050	136	7.2	26	6.7	250
Magnolia Creek	177	10-15-69	41	77	4.3	20	8.0	3,200
		09-28-70	32	78	4.6	22	8.0	2,000
Fourmile Creek*	179	09-28-70	—	21	4.6	23	7.4	2,950
Alaqua Creek	180	10-15-69	105	13	5.6	18	8.0	4,600
		09-28-70	208	18	5.6	22	7.5	4,600
Rocky Creek	182	10-15-69	95	15	5.2	18	8.2	2,000
		09-28-70	173	13	4.9	22	7.4	1,850
Shoal River	185	10-15-69	153	19	5.4	19	8.6	3,500
		09-28-70	313	20	5.1	22	7.6	7,400

The presence of coliform bacteria in water can also be used as evidence of pollution. Coliforms originate from excreta of warm-blooded animals and are found in sewage, soils, and vegetation. The degree of pollution is indicated by the number of coliforms present. For a surface-water supply to be acceptable the Federal Water Pollution Control Administration suggests (1969) that coliforms should not exceed 10,000 colonies per 100 ml (milliliters). With this limitation, water-treatment plants are considered capable of producing water meeting drinking water standards of 2.2 coliform colonies per 100 ml. Coliform tests of 10 streams in Walton County, shown in table 4, indicate that, at the time of sampling, the streams all met the limitation described above.

In 1969 neither the water nor bottom sediments from Magnolia Creek contained detectable amounts of pesticides but in 1970 the bottom sediments contained DDD, DDE, and DDT (table 5). Pesticides accumulate and adsorb on stream-bottom sediments. These pesticides could have reached Magnolia Creek by direct surface runoff, by wind drift from adjacent treated areas, or through ground-water discharge to the stream. Either separately or in combination, the first two routes are the most likely because the pesticides would be adsorbed by the soil and underlying sediments of the sand-and-gravel aquifer before reaching Magnolia Creek.

WATER USE AND AVAILABILITY

Most of the water used in Walton County comes from the Floridan aquifer. The sand-and-gravel aquifer supplies some small, mostly rural, domestic uses. In 1970 13.2 mgd was withdrawn for all uses, of which 12.7 mgd was from the Floridan.

Since 1968, more water has been withdrawn for irrigation than for all other uses. Of the 13.2 mgd pumped during 1970, for example, 10 mgd (11,000 acre-feet) on the average was used for irrigation. Water withdrawn for industrial use averaged about 1.5 mgd for the same period; and pumpage for DeFuniak Springs, which has the largest municipal water supply in the county, averaged only 0.6 mgd. The towns of Argyle, Freeport, Mirmar Beach, Paxton, and a few other small communities had a combined average pumpage of about 0.1 mgd. Water withdrawn for rural domestic use is estimated to be 1.0 mgd, half of which is from the sand-and-gravel aquifer.

Surface water is used primarily for recreation. Choctawhatchee River and Choctawhatchee Bay are the main water bodies and are used for boating, fishing, and swimming. A few farm ponds are used to water livestock. Most streams in the county are overlooked as potential sources of water supply even though they have high base flows and the quality is acceptable for domestic use. For

TABLE 5
PESTICIDE ANALYSES FOR WATER AND BOTTOM SEDIMENT FROM MAGNOLIA CREEK

Site number on figure 1	Date of collection	Discharge (cfs)	Temperature (°C)	Insecticides								Herbicides		
				Aldrin	DDD	DDE	DDT	Dieldrin	Endrin	Heptachlor	Lindane	2,4-D	2,4,5-T	Silvex
Water Samples (µg/l)														
177	06-26-69	22.2	26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
177	06-18-70	38.6	24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bottom Sediments (µg/kg)														
177	06-26-69	22.2	26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
177	06-18-70	38.6	24	0.0	0.2	1.0	0.9	0.0	0.0	0.0	0.0			

example, Seven Runs and Magnolia Creeks have a combined average discharge equivalent to 88,250 acre-feet per year—more than eight times greater than the volume of ground water used for irrigation during 1970—and neither stream is used for irrigation. Even during drought, streamflow originating in Walton County is about 300 mgd—or more than 20 times greater than the quantity used in 1970.

The quantity of ground water available for use from the Floridan aquifer is substantial. For example, the Floridan aquifer contains an estimated 150,000 acre-feet of fresh water in Walton County. The volume of water withdrawn from the aquifer during 1970 was less than 15,000 acre-feet. Wells tapping the aquifer yield from 500 to 1,000 gpm except along the coast where yields are generally less than 100 gpm.

Except from an area adjacent to Choctawhatchee River and Bay, ground water is of acceptable chemical quality. Because along the coast, aquifer transmissivity is low and saline water occurs at relatively shallow depths within the aquifer, care and judgment are required in developing wells. With proper planning and development, the coastal ground water may be utilized without deleterious effects. For example, by using widely spaced, low capacity wells (100 gpm or less) drawdowns likely will not be great enough to cause upward migration of salt water in the aquifer.

Can the Floridan aquifer sustain a large seasonal irrigation pumpage in southern Walton County without salt-water contamination of the aquifer?

In 1970 before pumping for irrigation began in the southeastern part of the county, the potentiometric surface of the Floridan aquifer along the bay and gulf ranged between 10 and 20 feet above sea level (fig. 8). As long as that surface is above sea level, ground water will continue to discharge to the gulf and to the bay where hydraulic continuity exists and thus prevent landward movement of sea water into the aquifer. The amount of water that can be safely pumped, therefore, is at most that volume that can be removed until the potentiometric surface of the Floridan declines to sea level along the coast.

Ground-water pumpage for irrigation in southern Walton County during that part of the April-June 1970 pumping season when pumping was most intensive averaged about 20 mgd. Net decline in the potentiometric surface of the Floridan aquifer south of Freeport averaged about 10 feet (fig. 14), bring it to near sea level along the bay and gulf in June 1970. According to the Theis nonequilibrium formula (Theis, 1935), pumping at a rate of 26 mgd over a 3-month period would lower the potentiometric surface to sea level or to the point where salt-water encroachment could occur along the coast. Consequently,

if ground-water withdrawals in the south part of Walton County are increased much above those of 1970, the potentiometric surface of the Floridan aquifer should be expected to go below sea level along the coast.

Although there is no evidence of saline water moving upward near Owl's Head Farm, where the cone of depression is below sea level during periods of heavy pumping (fig. 9), that possibility exists.

SUGGESTIONS FOR FURTHER STUDY

In view of the large withdrawal of water from the Floridan aquifer in southern Walton County and the potential for salt-water movement into the upper aquifer from the lower part of the aquifer and from the coast, continuing the water resources monitoring program now in effect would be worthwhile. This program includes: the collection of quality samples from observation wells near the center of heavy pumpage and along the coast, for indications of saline-water movement; the periodic measurement of water levels in selected wells to detect changes in level; and the collection of discharge and water-quality data at Magnolia Creek to determine the long-term effects of irrigation water on the stream.

SUMMARY AND CONCLUSIONS

The two ground-water reservoirs of Walton County are the sand-and-gravel aquifer and the Floridan aquifer. The former is thickest in westcentral Walton County. It is important because it stores water, maintains streamflow and is a source of recharge for the underlying Floridan aquifer in those parts of the county where the water table is higher than the potentiometric surface of the Floridan aquifer and where the confining bed is permeable, thin or breached. Although water of the sand-and-gravel aquifer is low in dissolved solids, it is acidic and therefore corrosive; it also contains high concentrations of iron which may make it undesirable as a domestic or industrial water supply.

The Floridan aquifer underlies all of the county and is the principle source of water supply. It is composed primarily of limestone ranging in age from lower Miocene to upper Eocene. The aquifer varies in thickness from 700 to 1,000 feet and is confined by clay and marl of varying thickness. The top of the aquifer ranges from 50 feet below land surface in northeastern Walton County to 300 feet below in the midwestern part. The transmissivity ranges from 4,000 gpd/ft along the coast to 180,000 gpd/ft in southeastern Walton County, the storage coefficient ranges from 1.6×10^{-4} to 5.6×10^{-4} .

In Walton County the Floridan aquifer is recharged by downward leakage

of water from the sand-and-gravel aquifer. In southern Alabama it is recharged directly by rainfall where the aquifer is exposed or is near land surface. The potentiometric surface of the Floridan is highest in northwest Walton County, a limestone area of low transmissivity. Discharge from the Floridan aquifer is by leakage to the bay, gulf, and Choctawhatchee River, and by pumping or flowing wells.

In June 1970 water levels in the Floridan declined more than 80 feet in southeastern Walton County but remained stable in the northern part of the county. Recovery to normal levels occurred during the subsequent nonirrigation season. Floridan aquifer water levels in southern Walton County have declined 0.25 foot per year on the average since 1948 due to increased ground-water use.

Floridan aquifer water in Walton County is of acceptable chemical quality except in an area adjacent to Choctawhatchee Bay where the water is highly mineralized. The water becomes more mineralized with depth and along the coast, from Fourmile Village to Seagrove Beach, the safe useful well depth is about 500 feet below sea level. A little used zone of the Floridan aquifer along the coast contains fresh water. Its top is less than 100 feet below land surface and the aquifer varies in thickness from 90 to 100 feet.

The fresh-saline-water interface in the Floridan aquifer ranges in elevation from about 650 feet below sea level in the northeastern part of the county to about 1,200 feet below in the southwestern part. Chloride concentration of water from wells in the Floridan aquifer has not changed significantly during the last 10 years.

Total water use in Walton County in 1970 averaged 13.2 mgd of which 12.7 mgd was from the Floridan aquifer. Water used for irrigation averaged 10 mgd and exceeded all other uses. Recreation is the principal use of the lakes and streams of the county.

Pumpage from the Floridan aquifer did not exceed the safe aquifer yield during 1970. However, if irrigation pumpage in southern Walton County exceeds that of 1970, the potentiometric surface should be expected to fall below sea level in the coastal area.

The inland water-table lakes were formed by the solution and collapse of the underlying limestone. They contain water low in dissolved solids. During storms the coastal lakes are subjected to inflow of water from the gulf and are usually brackish. Streams originating in the county discharge on the average, 1.0 bgd. Minimum streamflow is approximately 300 mgd. Seepage from the sand-and-gravel aquifer accounts for their high base flow. Surface water in

Walton County is low in dissolved solids but is objectionable in that it is corrosive, colored, and turbid. Nutrient and bacteriological analyses of water from selected streams indicate little pollution. Irrigation return water that reached Magnolia and Seven Runs Creeks changed their chemical quality. Specific conductance increased from 25 to 90 micromhos at Magnolia Creek and from 20 to 70 micromhos at Seven Runs Creek. Samples of stream-bottom sediments collected at Magnolia Creek indicated the presence of pesticides in 1970 where there had been none in 1969.

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APPENDIX

The following tables list all surface-water sites and primary ground-water sites where hydrologic data were collected. In table 6, surface-water sites are listed in downstream order; and the drainage area, type, frequency and period of record are given. Table 7 shows the well locations, depths, yields, and the type, frequency, and period of record for each. The well location number refers to latitude and longitude (301637N0860002.1 is lat. 30°16'37" north, long. 86°00'02", well number 1.).

Information Circular 78, "Records of hydrologic data, Walton County, Florida" (Pascale and others, 1972), contains the hydrologic data collected in Walton County.

For the convenience of those who prefer the use of metric units, table 8 lists conversion factors for computing metric units from the English units used throughout the text.

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TABLE 6
SURFACE-WATER DATA-COLLECTION SITES IN WALTON COUNTY

Type of record: A, Standard chemical analysis; D, Discharge and stage; I, Insecticide and Herbicide analysis; K, Conductivity; S, Stage; T, Total coliform.

Frequency of record: d, Daily; p, Periodic; c, Continuous; (25) Total number of samples or measurements of streamflow.

Site number on figure 1	Location (in downstream order)	Drainage area (sq. mi.)	Type and frequency of record	Period of record
12A CHOCTAWHATCHEE RIVER BASIN (12A3 PL A RIVER)				
166	Eightmile Creek near Gaskin	24.9	Dp(25) A(4), T(2), K(8)	1968-70
167	Spring Branch near Gaskin		Dp(2) A(2)	1968-70
168	Limestone Creek near Gaskin		Dp(2) A(2)	1969-70
12A CHOCTAWHATCHEE RIVER BASIN (12A4 BL LOW PL A RIVER)				
190	Morrison Springs near Redbay		Dp(5) A(1)	1946-68 1968
169	Sandy Creek near Argyle	51.8	Dp(24) A(3), T(2), K(8)	1968-70
170	Bruce Creek near DeFuniak Springs		Dp(2) A(2)	1969-70
171	DeFuniak Lake at DeFuniak Springs		Sp(2) A(2)	1968-70
172	Bruce Creek near Redbay	51.4	Dp(26) A(3), T(2), K(8)	1968-70
173	Seven Runs Creek near Redbay	25.8	Dd A(3), T(2), K(8)	1968-70
174	Choctawhatchee River near Bruce	4,384	Dr A(3), T(2), K(3)	1930-70
12B COASTAL RIA BETWEEN CHOCTAWHATCHEE RIVER AND YELLOW RIVER				
175	Black Creek near Bruce		Dp(2) A(2)	1969-70
176	Pate Branch near Freeport		Dr A(2)	1968-70
177	Magnolia Creek near Freeport	11.2	Dr A(5), T(2), K(8) I(2)	1968-70
178	Lafayette Creek near Freeport		Dp(2) A(2)	1969-70
179	Fourmile Creek near Freeport		Dp(1) A(1), T(1)	1970
180	Alaqua Creek near DeFuniak Springs	65.6	Dr A(3), T(2)	1951-70
181	Basin Creek near Portland		Dp(2) A(2)	1969-70
182	Rocky Creek near Niceville	67.0	Dr Dp(10) A(3), T(2)	1966-68 1968-70
YELLOW RIVER BASIN				
183	Caney Creek near Glendale		Dp(4) A(2)	1967-70
184	Gum Creek near DeFuniak Springs		Dp(5) A(2)	1966-70
185	Shoal River near Mossy Head	123	Dr A(6), T(2)	1951-70
186	Lake Jackson near Payton	2	Sd A(2)	1966-70
187	Pine Log Creek near Lowersville		Dp(2) A(2)	1969-70
188	Long Creek near Mossy Head		Dp(2) A(2)	1969-70
189	Titt Creek near Mossy Head		Dp(2) A(2)	1969-70

TABLE 7
GROUND-WATER DATA-COLLECTION SITES IN WALTON COUNTY

Type of record: A, Standard chemical analysis; C, Chloride; P, Partial chemical analysis; S, Stage.

Frequency of record: i, Intermittently; p, Periodic; r, Continuous; (15), Total number of samples.

Site number on figure 1	Location	Depth (feet)	Yield (gpm)	Type and frequency of record	Period of record
1	301637N0860002.1	455	210	Si A(1)	1968
9	301946N0860957.1	466	360	Sp A(1), Cp	1961-70
13	302058N0861432.1	340	—	Sp A(1), Cp	1968-70
18	302112N0861501.1	455	15	Si A(1), Pi	1970
22	302214N0860652.1	450	—	Sp A(1), Cp	1946-69
26	302221N0860652.1	365	—	Sp Cp	1970
35	302231N0862143.1	420	—	Sp A(1), Cp	1968-70
38	302243N0860917.1	389	—	Si A(1)	1970
47	302346N0861812.1	400	—	Si A(1), Pi	1969-70
48	302357N0861007.1	337	50	Sp A(1), Cp	1961-70
50	302444N0860010.1	229	—	Si A(1), Pi	1969-70
52	302549N0860717.1	240	—	Si, Ci A(1), Pi	1969-70
60	302619N0860642.1	310	—	Si Pi	1969-70
63	302637N0855433.1	196	—	Sp Cp	1968-70
66	302708N0860557.1	932	—	Sp Cp	1968-70
68	302721N0861014.1	250	1,700	Sp Cp	1968-70
75	302912N0861458.1	160	—	Sp Cp, Pi	1961-70
77	302929N0860818.1	125	—	Sr Pi	1968-70
81	303027N0860513.1	393	975	Si Pi	1969-70
82	303040N0861202.1	230	—	Sp —	1968-70
86	303053N0860753.1	207	—	Sr —	1968-70
88	303103N0862010.2	382	100	Si A(3)	1965-67

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91	303214N0855804.1	506	965	Sr A(1)	1968-70
92	303214N0855804.2	23	—	Sp	1969-70
93	303223N0855704.1	585	1,050	— Si Pi	1968-70
95	303348N0860224.1	440	900	Sp Pi	1968-70
96	303348N0860224.2	18	—	Sp	1969-70
97	303417N0855731.1	440	—	— Sp Pi	1968-70
99	303426N0860611.1	440	1,100	Sr A(1), Pi	1968-70
100	303426N0860611.2	32	—	Sp	1969-70
101	303434N0861303.1	440	278	— Sp Pi	1968-70
102	303443N0861939.1	452	150	Si A(7)	1960-70
103	303454N0855606.1	300	—	Sp Pi	1968-70
104	303456N0861916.1	60	5	Sr A(1)	1967-70
106	303545N0860646.1	440	27	Sp A(1)	1968-70
112	303937N0861257.1	620	125	Sp A(1)	1968-70
121	304044N0862116.1	630	250	Sp A(15)	1947-51, 1966-70
129	304310N0860706.1	621	640	Si A(1)	1969-70
130	304334N0860324.1	236	—	Sp Pi	1968-70
131	304335N0860319.1	372	380	Si Pi	1970
134	304358N0861208.1	509	—	Sp A(1)	1961-70
147	304914N0861842.1	700	1,200	Si Pi	1970
149	304950N0862322.1	455	—	Sr —	1968-70
151	305043N0860833.1	320	—	Sp A(1)	1968-70
161	305732N0860208.1	120	—	Si A(1)	1969-70
162	305804N0861809.1	350	50	Sp A(1)	1968-70
163	305816N0860815.1	80	—	Si A(1)	1969-70
164	305828N0861809.1	420	430	Si —	1969
165	305359N0861226.1	250	—	Sp —	1968-70

TABLE 8
FACTORS FOR CONVERTING ENGLISH UNITS
TO INTERNATIONAL SYSTEM (SI) UNITS

The following factors may be used to convert the English units published herein to the International System of Units (SI).

Multiply English units	By	To obtain SI units
Length		
inches (in)	25.4 .0254	millimeters (mm) meters (m)
feet (ft)	.3048	meters (m)
miles (mi)	1.609	kilometers (km)
Area		
acres	4047 .4047 .4047 .004047	square meters (m ²) hectares (ha) square hectometers (hm ²) square kilometers (km ²)
square miles (mi ²)	2.590	square kilometers (km ²)
Volume		
gallons (gal)	3.785 3.785 3.785×10 ⁻³	liters (l) cubic decimeters (dm ³) cubic meters (m ³)
million gallons (10 ⁶ gal)	3785 3.785×10 ⁻³	cubic meters (m ³) cubic hectometers (hm ³)
cubic feet (ft ³)	28.32 .02832	cubic decimeters (dm ³) cubic meters (m ³)
acre-feet (acre-ft)	1233 1.233×10 ⁻³ 1.233×10 ⁻⁶	cubic meters (m ³) cubic hectometers (hm ³) cubic kilometers (km ³)
Flow		
cubic feet per second (ft ³ /s)	28.32 28.32 .02832	liters per second (l/s) cubic decimeters per second (dm ³ /s) cubic meters per second (m ³ /s)
gallons per minute (gpm)	.06309 .06309 6.309×10 ⁻⁵	liters per second (l/s) cubic decimeters per second (dm ³ /s) cubic meters per second (m ³ /s)
million gallons per day (mgd)	43.81 .04381	cubic decimeters per second (dm ³ /s) cubic meters per second (m ³ /s)
Flow per Unit Area		
cubic feet per second per square mile (cfs/m)	.01093	cubic meters per second per square kilometer (m ³ /s/km ²)
Specific Capacity		
gallons per minute per foot (gpm/ft)	2.07×10 ⁻⁴	cubic meters per second per meter (m ³ /s/m)
Transmissivity		
gallons per minute per foot (gpd/ft)	.0124	square meters per day (m ² /day)

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