PRELIMINARY EVALUATION OF THE WATER-SUPPLY POTENTIAL OF THE SPRING-RIVER SYSTEM IN THE WEEKI WACHEE AREA AND THE LOWER WITHLACOOCHEE RIVER, WEST-CENTRAL FLORIDA

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U.S. Geological Survey

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CONVERSION FACTORS

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

U.S. customary	Multiply by	Metric
in (inch)	2.54	mm (millimeter)
ft (foot)	.3048	m (meter)
mi (mile)	1.609	km (kilometer)
ft/mi (foot per mile)	.1894	m/km (meter per kilometer)
mi^2 (square mile)	2.59	km^2 (square kilometer)
gal (gallon)	.00378	m^3 (cubic meter)
ft^3 (cubic foot)	.02832	m^3 (cubic meter)
ft^2/d (foot squared per day)	.09291	m^2/d (meter squared per day)

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ABSTRACT

Coastal springs and seeps, including Rainbow Springs, a tributary of Withlacoochee River, discharge as much as a billion gallons of water per day to low-lying coastal swamps and estuarine marshes along the Gulf Coast of Citrus and Hernando Counties. The springs discharge water from a part of the Floridan aquifer which underlies about 3,400 square miles of west-central Florida.

Although Weeki Wachee Spring has long been regarded as an obvious source of freshwater supply, long-term diversion of large volumes of water from Weeki Wachee River will cause encroachment of brackish water throughout the residential canals in the lower reach of the river to about 4.4 miles below Weeki Wachee Spring. Short-term diversions in excess of 50 cubic feet per second are feasible during periods when spring discharge is above 200 cubic feet per second.

Weeki Wachee Spring is analogous to a flowing well tapping an artesian aquifer. Analysis of ground-water flow in the vicinity of the spring suggests a transmissivity of about 2.1 million feet squared per day. Other solution cavities near Weeki Wachee may have equally large potential for ground-water development with minor effects on Weeki Wachee Spring and River. Withdrawal of 50 cubic feet per second from Eagle's Nest Sink, for example, would diminish the flow from Weeki Wachee Spring by about 15 cubic feet per second.

Flow characteristics of Withlacoochee River and Rainbow Springs indicate that about 600 cubic feet per second is available on a perennial basis, disregarding the downstream requirements for control of saltwater encroachment. About 500 cubic feet per second is sufficient to maintain the freshwater-saltwater interface within its present range in the Lower Withlacoochee River. An additional 23 cubic feet per second is necessary to offset evaporation loss from Lake Rousseau. Allowing 523 cubic feet per second for the above, low-flow analysis of the discharge records indicates that, with a 25-year recurrence interval, during a 90-day low-flow period, the flow available for diversion would average about 200 cubic feet per second.

INTRODUCTION

Increasing competition for municipal, industrial and irrigation water supplies in the Southwest Florida Water Management District (SWFWMD) necessitates an evaluation of additional potential sources. Such potential sources include the coastal springs of west-central Florida. Of interest to water managers is a determination of how much coastal-spring water might be diverted and the effects of such diversion on the hydrologic system.

The five largest springs investigated discharge more than a billion gallons of water per day from the Floridan aquifer to coastal salt marshes along the Gulf of Mexico (fig. 1). The average discharge of these large springs is summarized below:

Spring	Average discharge ft^3/s	Number of measurements	Range of discharge ft^3/s	Period of record 1/
Rainbow	748	395	487-1,230	1899-75
Crystal River	916 2/	continuous	0-4,340	1964-75
Homosassa	192 2/	75	125- 257	1932-72
Chassahowitzka	139 2/	81	32- 208	1930-72
Weeki Wachee	176	370	101- 275	1917-75

Data from Rosenau and Faulkner, 1974, updated by the U.S. Geological Survey Water-data report FL-75-3.

1/ Includes miscellaneous measurements.
2/ Measurements include an undetermined amount of surface runoff and are influenced by tidal effects.

In addition to the flow from the known and measured springs, an unknown volume of water issues from the aquifer through a myriad of smaller solution cavities and seeps directly to the coastal swamps and marshes where cavernous limestone is exposed or occurs near land surface.

Purpose and Scope

The purpose of this report is to describe the water-supply potential of two hydrologic systems: the Weeki Wachee Spring and River system, and the lower Withlacoochee River-Rainbow Spring-Lake Rousseau system. These systems were selected for study from among the five major springs along the coast because they seemed to offer the greatest potential for development. The Crystal River, Homosassa and Chassahowitzka springs are topographically low, tidally affected, and are located near or in the zone of diffusion between coastward-moving freshwater and inland-moving saltwater

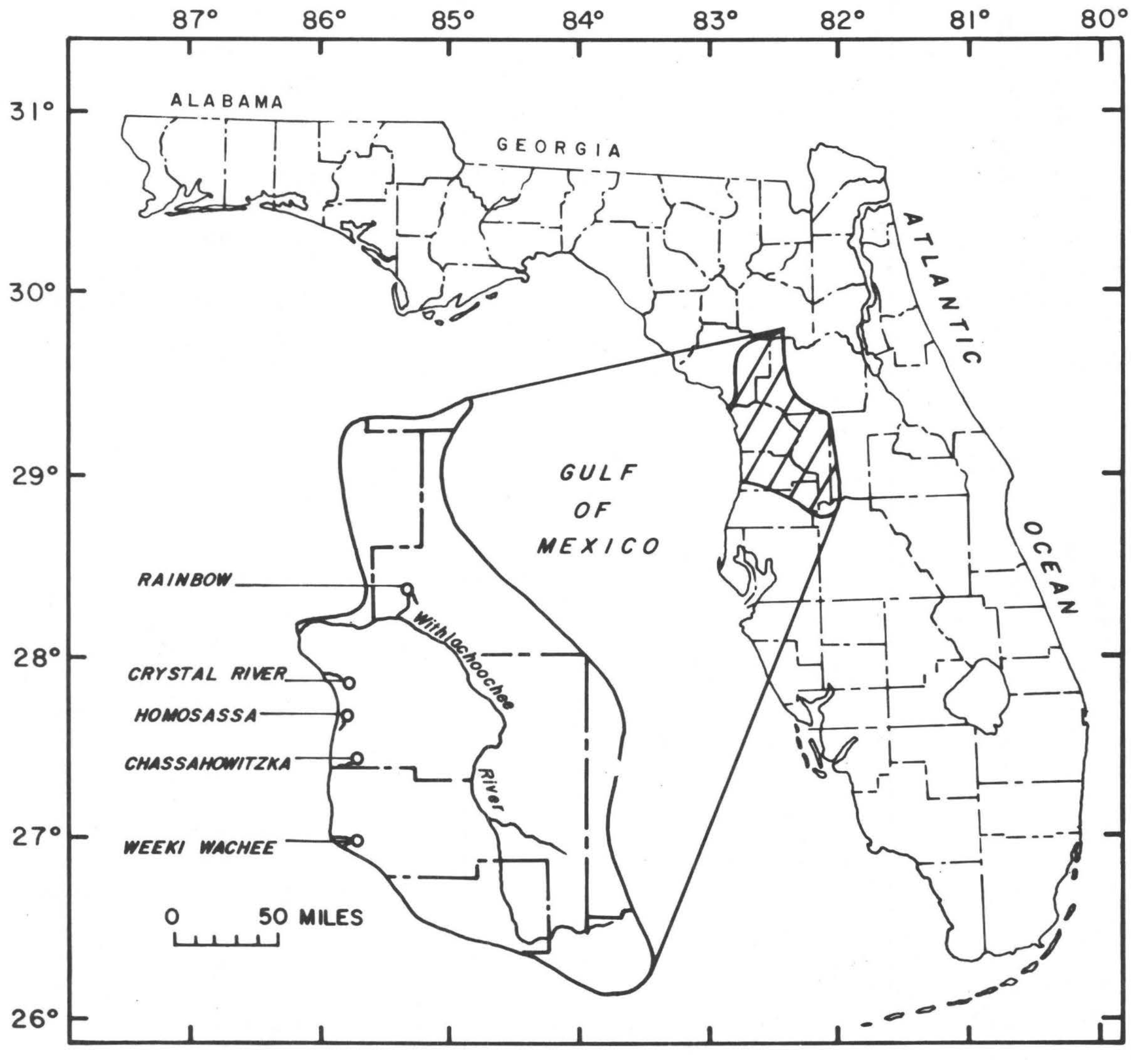

Figure 1. --Location of five major coastal springs

from the Gulf of Mexico. The spring pools at Weeki Wachee and Rainbow, on the other hand, stand well above tidal effects, and the spring water is relatively low in total dissolved solids and has negligible amounts of chloride.

The possible effects of water withdrawal or diversion on flow from springs and streams, on the level of the potentiometric surface, and on the position of the saltwater-freshwater interface in the Weeki Wachee and Withlacoochee Rivers are discussed. The report includes descriptions of the springs, the ground-water flow system, aquifer characteristics, streamflow characteristics, and the chemical quality of the water.

This is a preliminary evaluation of water-supply potential. More detailed hydrologic studies, as well as investigations of the social, economic, and environmental effects of withdrawing water from these sources are necessary prior to development for water supply. The investigation was made by the U.S. Geological Survey in cooperation with the Southwest Florida Water Management District as part of a continuing study of water resources in west-central Florida.

Previous Investigations

Measurements of flow of some of the principal springs and rivers of Florida were made as early as the latter part of the last century, but a systematic collection of data on the discharge, stage and quality of the springs and streams was not begun until the early 1930's. Discharge measurements of "Weekiwachee Springs near Brooksville", Rainbow Springs, and several stations of the Withlacoochee River are summarized in the annual report entitled "Water resources data for Florida" (U.S. Geological Survey, 1975).

Weeki Wachee and Rainbow Springs were described by Ferguson (1947). Wetterhall (1965b) described them and a number of lesser-known springs and sinks and listed discharge measurements and chemical analyses of the water for many. Mann and Cherry (1969) briefly described the relationship of spring discharge to precipitation and the importance of the springflow in maintaining the freshwater-saltwater balance along the coast. Reichenbaugh (1972) mapped the extent of saltwater encroachment along the Gulf Coast of Pasco County, south of Weeki Wachee Spring, and Mills (written commun., 1977) has continued the saltwater-encroachment study northward through Hernando and Citrus Counties. The general hydrology of the Middle Gulf Area was described by Cherry and others (1970), and Vernon's (1951) study of the geology of Citrus and Levy Counties provided an understanding of the geologic framework essential to interpretation of the hydrology of the coastal spring area.

Faulkner's study (1973b) of the geohydrology of the Cross-Florida Barge Canal area was the first to include a detailed analysis of the ground-water flow in the vicinity of a large spring (Silver Spring).

Physiographic Setting

The area tributary to the coastal springs, as determined from the potentiometric surface in figure 2, is about 3,400 mi^2. A well-defined ancient shoreline 24 to 30 ft above present sea level trends roughly parallel to the present shore, 2 to 3 mi inland near Weeki Wachee and about 15 mi from the coast along the lower Withlacoochee River (fig. 2). The area west of this shoreline, called the Pamlico Beach, is largely swamp and salt marsh. Limestone bedrock is at or near the surface in this coastal zone, dipping westward at about 1 ft/mi. Subdued undulations in the bedrock surface provide only slight relief. The springs which form Chassahowitzka, Homosassa, and Crystal Rivers issue from cavities in the limestone, which underlies the coastal swamp and rises but a few feet above sea level.

Inland from the Pamlico Beach (fig. 2), a mantle of sand and clayey sand 30 to 50 ft thick overlies the limestone. This sandy plain is pitted with internally drained depressions, sinkholes, and sinkhole lakes formed by subsidence of the surficial sand into solution cavities in the underlying limestone. The plain rises gently to the east and abuts the steeper slope of the north-trending Brooksville Ridge shown in figure 2 (Puri and Vernon, 1964). Although mantled by surficial sand and clay, the Brooksville Ridge is an area where the limestone stands 100 ft or more above the lowlands which lie both to the west and east. The flanks of the ridge were apparently cut by wave action of an ancient sea which stood 95-100 ft higher than present sea level. Short, intermittent streams draining to sinkholes and sinkhole lakes, in conjunction with land subsidence and collapse created a topography of relatively high relief compared with that in much of Florida. Local relief in the Brooksville area commonly exceeds 50 ft from sinkhole to hillcrest.

East of Brooksville Ridge lies the flat, north-trending valley of the Withlacoochee River. Its eastern margin is bounded by a series of topographic highs rising more than 100 ft above sea level, whereas its central part, less than 50 ft above sea level, is occupied by the chain of lakes and marshes which comprise Tsala Apopka Lake (fig. 2).

HYDROGEOLOGIC SETTING

Underlying the coastal springs area at depth is a sequence of limestone strata that extends beneath virtually all the Florida Peninsula. Table 1 summarizes the stratigraphic section most important to the hydrology of the coastal springs area. The Lake City Limestone of middle Eocene age is the oldest formation shown and it is probably the lowermost geologic unit along the coast with any potential for freshwater. The Eocene-Oligocene sequence of limestone strata shown in table 1 constitutes the Floridan aquifer in the coastal springs area.

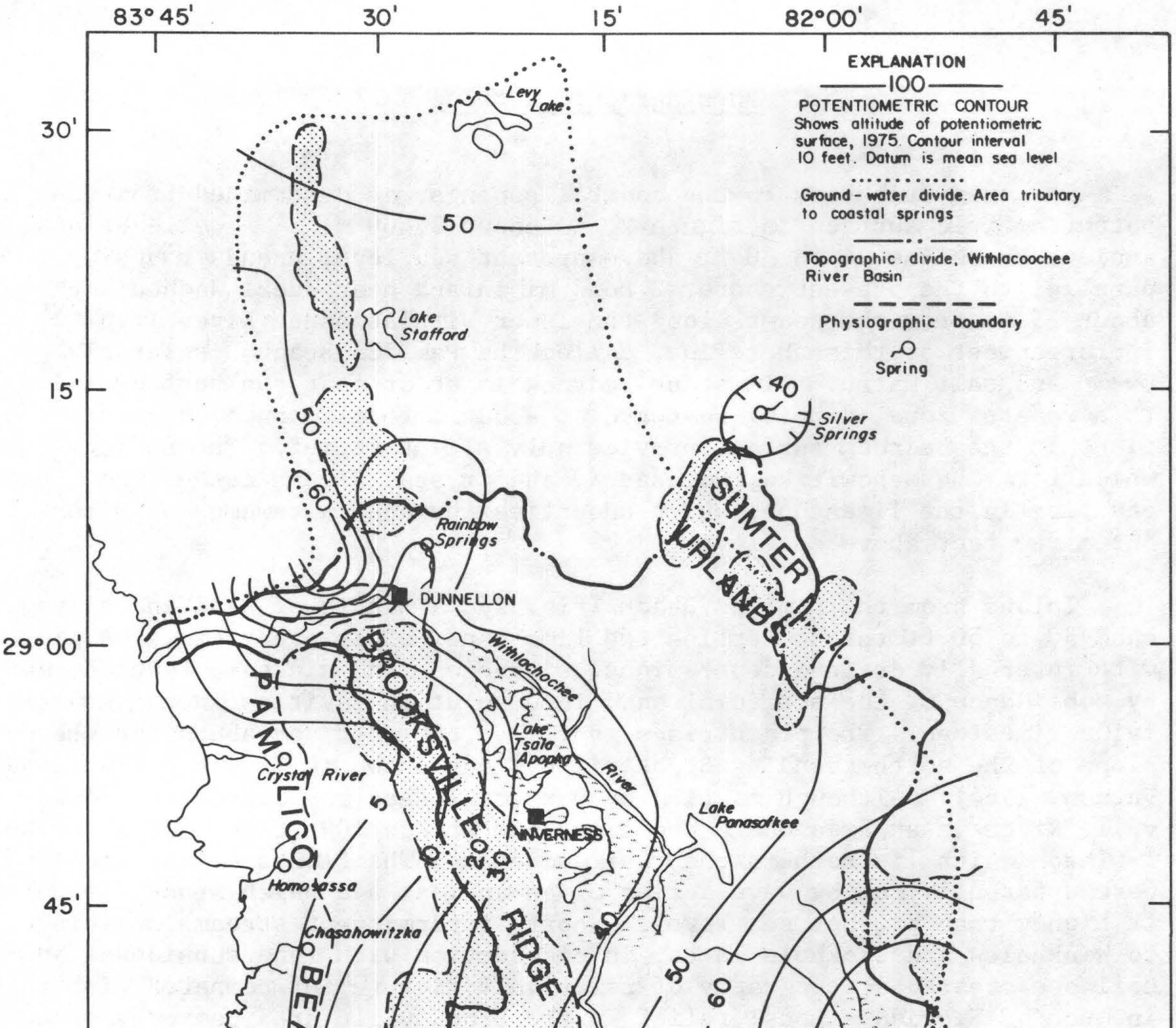

Figure 2. --Location of the coastal springs and associated tributary area, including potentiometric surface of the Floridan aquifer in September 1975, and watershed of the Withlacoochee River

Table 1.--Description of stratigraphic section of the coastal springs area

System	Series	Stratigraphic Unit	Thickness (ft)	Lithology
Quaternary	Pleistocene	Pamlico Formation and other unnamed features	0 - 100	SAND, SANDY CLAY, and CLAY. Marine and estuarine terraces, alluvial, lake, and windblown deposits.
Tertiary	Pliocene	Alachua Formation	0 - 100	Interbedded deposits of CLAY, SAND, and SANDY CLAY. Base is a rubble of phosphate rock and silicified limestone residuum in a greenish-gray phosphatic clay matrix.
	Oligocene	Suwannee Limestone	0 - 100	LIMESTONE, cream-colored, granular to lithographic, detrital, porous, thin-bedded to massive, generally with some sand and abundant fossils.
	Eocene (upper)	Ocala Limestone[1]	0 - 180	Upper member[2]: LIMESTONE, white to cream, soft, massive, friable coquina. Porous, almost entirely composed of fossils in places. Lower member[3]: LIMESTONE, cream to tan, granular to detrital, rarely pasty, fairly hard, porous. Lower part may be DOLOMITE, tan to brown, very porous but poorly permeable.

Table 1.--Description of stratigraphic section of the coastal springs area - continued

System	Series	Stratigraphic Unit	Thickness (ft)	Lithology
Tertiary	Eocene (middle)	Avon Park Limestone	200 - 400	LIMESTONE: light to dark brown, highly fossiliferous, variable porosity. DOLOMITE below 150 ft. Gray to dark brown, very fine to finely crystalline, porous.
		Lake City Limestone	1,000$\pm$	DOLOMITE: dark to light brown, gypsiferous below -760 ft msl, very fine to microcrystalline, porous, with fossil molds. Thin beds of carbonaceous material and peat fragments.

1 Ocala Group of Bureau of Geology, Florida Department of Natural Resources.

2 Crystal River Formation of Ocala Group.

3 Inglis Formation and Williston Formation (older to younger) of Ocala Group.

Much of the water falling on the coastal springs area penetrates the surficial deposits through streambeds, sinkholes, or sinkhole lakes to recharge the limestone (Floridan) aquifer. The water recharged moves generally coastward and much of it reappears as discharge from springs that issue from the solution cavities in the limestone near the coast. These cavities often are large, and are connected with one another by conduits, some large enough to accomodate extremely large flows.

The networks of solution cavities in Florida have not developed entirely under the hydrologic conditions that exist today. Many periods of erosion evident in the geologic record were also periods of subsurface solution development. The land surface of the Floridan Plateau has stood at various elevations with respect to sea level and the ground-water regimen has adjusted to sea level. Many caves along Florida's west coast are plugged by silt, suggesting that they are segments of former, more extensive flow systems whose circulation has stagnated owing to the rise of sea level to its present position.

Along the coast a dynamic balance exists between freshwater and saltwater in the limestone aquifer, producing a zone of diffusion between the two. This zone moves laterally, responding to head differences between the freshwater and saltwater.

Surface-Water Hydrology

Surface drainage throughout much of the coastal springs area is internal. That is, the rainfall percolates through the surficial sand and clay to the limestone. Small intermittent streams are common, often carrying runoff, after heavy rains, to open sinkholes or sediment-filled sinkhole depressions, where the water either percolates quickly to the Floridan aquifer or is temporarily ponded.

The watershed of Withlacoochee River comprises about 2,100 mi^2, as shown in figure 2. Along much of its course, the Withlacoochee River is in hydrologic contact with the aquifer; at times augmented by springflow and at times recharging the aquifer, depending on the relative stage of the river and the potentiometric surface of the aquifer. In its middle reach, the Withlacoochee intermittently spills into the southern end of the Tsala Apopka chain of shallow lakes. The river channel continues around the eastern side of Tsala Apopka Lake for about 25 river miles and receives overflow from the northern end of the lake through a canal and control structure operated by Southwest Florida Water Management District. The river continues northwestward, through a gap in the Brooksville Ridge near Dunnellon, to the Gulf of Mexico. The flow from Rainbow Springs enters Withlacoochee River near Dunnellon, about 5 mi downstream from the main springs.

The only other perennial streams are those fed by springflow in the area of ground-water discharge along the coast: Weeki Wachee, Chassahowitzka, Homosassa, and Crystal Rivers.

Ground-Water Hydrology

Based on the potentiometric surface of September 1975, the ground-water basin of the coastal springs-Withlacoochee River area comprises about 3,400 mi^2. Figure 2 shows contours on the potentiometric surface of the Floridan aquifer for September 1975 and the ground-water drainage area tributary to the coastal springs. The position of the ground-water divide shifts slightly with fluctuations in the potentiometric surface, but not enough to significantly affect the size and shape of the ground-water basin for the purpose of this investigation.

Ground-water flow in the area is generally from topographic highs in the southeast, northwestward to the coastal discharge area. Most ground-water flow is in the Floridan aquifer. The surficial deposits are generally too thin or clayey to comprise an important aquifer. Infiltration from rainfall or from surface runoff percolates through the surficial mantle into the permeable limestone of the Floridan aquifer.

The large flow from many of the coastal springs is the result of highly localized development of flow passages by solution of the limestone in areas of ground-water discharge. As a flow passage becomes enlarged by solution of the rock, additional flow is induced from adjacent, incipient conduits with sub-parallel courses which then become tributary to the largest conduit which has least resistance to flow. This tributary water then accelerates development of the principal conduit at the expense of nearby solution channels. In this manner an integrated underground drainage system develops, similar to a surface stream, with tributaries diminishing in size as they increase in number upgradient toward the recharge area. Development of a solution network is common at, or just below, the water table where the water is chemically most aggressive in dissolving limestone, and where circulation of ground water is vigorous.

In contrast to solution development beneath the water table, most of the sinkholes in the area are vertical shafts which formed above the water table at a time when sea level and ground-water levels were lower than at present. Vertical shafts ideally are of cylindrical shape with hemispherical apex and base. They are commonly called dome-pits in central Kentucky where they have been studied in detail (Pohl, 1955). The cylindrical shape developed as water initially entered the rocks along joint planes--vertical cracks in the rock--and moved downward most readily at the intersection of two joints. The dome-cylinder-pit configuration evolved as water dripped from the apex of the upper end of the shaft, flowed and fell downward along the walls, enlarging the shaft and smoothing any projections by dissolving them. Water dripping or flowing down the walls of the shaft would lose velocity and chemical aggressiveness as it moved to the bottom and the splash of free-falling water would excavate the pit. A mantle of insoluble, poorly permeable material, which provides a slow or intermittent supply of water percolating downward into more permeable soluble rock, is essential to the development of vertical shafts.

Under these conditions, vertical shafts will develop upward until stopped by insoluble soil or rock strata. Downward development is limited by impermeable strata or the water table. Shafts may continue to expand in diameter after the vertical limits have been reached, until the roof collapses. Where carbonate rock is exposed at the surface, or overlain by more permeable material, vertical shafts are not likely to form.

Vertical shafts do not necessarily have open connections with lateral cave systems. The potential of vertical shafts for water supply is similar to that of a large-diameter well at the same location. Should a vertical shaft or a well intercept passages which may be part of an integrated cave system, its potential for water supply would be greatly increased.

Freshwater-Saltwater Relationship

Ocean water is about 2.5 percent heavier than freshwater. Hence, in a coastal aquifer in contact with the sea, the saltwater tends to enter the lower part of the aquifer while the upper part is occupied by freshwater. The extent of the saltwater intrusion varies with the freshwater head. When head differences permit, saltwater moves inland and, because of density difference, wedges beneath the coastward-moving freshwater. The freshwater-saltwater interface in the Weeki Wachee area is located in figure 3 in accordance with the Ghyben-Herzberg principle, which states that seawater will be depressed 40 ft for each foot of freshwater head above sea level. Generally, a zone of diffusion exists along the interface because of fluctuations in freshwater head and tide in the Gulf. For example, samples taken from Salt Spring at low tide on December 21, 1975, showed a chloride concentration of 450 mg/L at the surface, 760 mg/L at a depth of 110 ft, and 1,200 mg/L at a depth of 130 ft. At high tide on December 11, 1975, chloride concentration at the surface of Salt Spring was 1,800 mg/L. Salt Spring appears to lie within the zone of diffusion. Chloride concentrations of other water samples taken from the zone of diffusion are shown in figure 3.

The freshwater-saltwater relation is greatly complicated by the presence of cave passages such as Salt Spring because water moves rapidly through them in response to tidal effects or drawdown resulting from pumpage. Any substantial diversion of water from the springs, spring runs, or spring-fed streams would alter the hydrologic system, and might induce saltwater to move inland and upward in the aquifer. This possibility must be considered in any decision concerning water diversion.

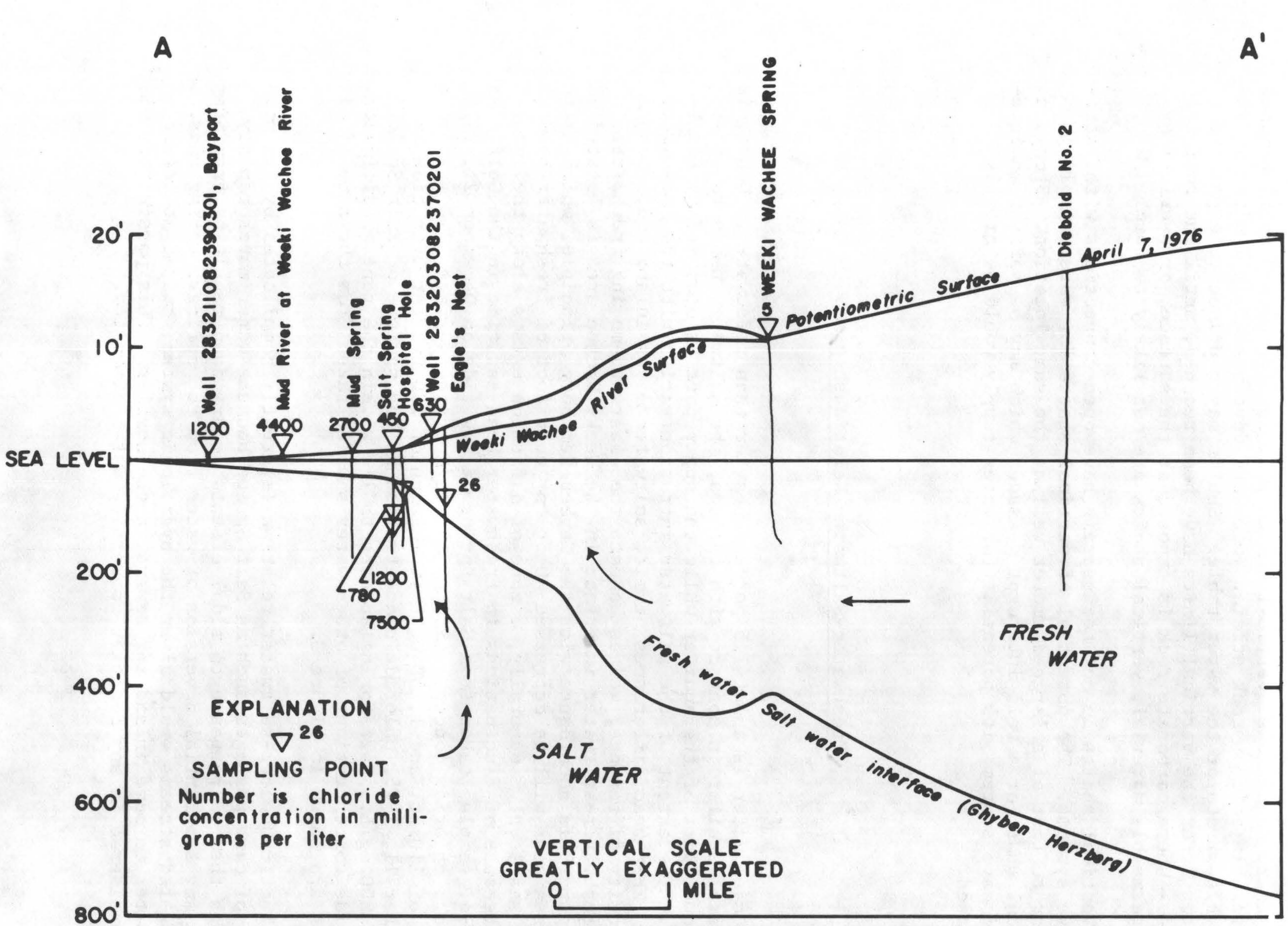

Figure 3. --Geohydrologic section A-A', showing the Floridan aquifer from the Gulf of Mexico eastward through Weeki Wachee Spring

WATER-SUPPLY POTENTIAL OF THE WEEKI WACHEE SPRING AND RIVER SYSTEM

Weeki Wachee Spring is located about 12 mi west of Brooksville in Hernando County, Florida, near the intersection of U.S. Highway 19 and State Road 50 at the head of the Weeki Wachee River. The spring pool is about 150 ft wide and 250 ft long and the bottom slopes gently to a ledge about 10 ft below the surface. The opening in the rock is about 50 by 100 ft with steeply sloping sides forming an elongate funnel-shaped hole, which narrows downward to a single orifice at a depth of about 80 ft. The orifice narrows to a north-trending slot which slopes steeply to the east and is about 20 ft long by 4 ft wide at the center. The slot appears to bottom at about 150 ft where it apparently enters a horizontal passage. Below about 80 ft, the walls of the spring-vent are deeply scalloped by solution activity of the turbulent discharging water. On the basis of known discharge and estimated cross-sectional area, the velocity at the orifice probably exceeds 3 ft/s.

Ground water moves in a generally northwesterly direction from the potentiometric high southwest of Dade City toward Weeki Wachee Spring (fig. 2). The potentiometric map (fig. 4) is based on measurements of water levels in wells of various depths which tap different parts of the aquifer. The map, therefore, gives a generalized picture of the potentiometric surface associated with the entire flow system. Precise delineation of the area tributary to Weeki Wachee Spring cannot be made with the data available. It probably is 100 to 150 mi^2. The configuration of the potentiometric surface of the Floridan aquifer in the vicinity of Weeki Wachee Spring on December 11, 1975, is based on measurements of water levels in the 25 wells and sinkholes shown on figure 4 and in an additional 20 wells in the surrounding area.

Potentiometric contours are lines of equal head on the potentiometric surface of the aquifer. The flow pattern may be represented by construction of a set of flow lines whose spacing is equivalent to the interval between contours as shown in figure 4. Water flows from areas of higher to lower head; the flow lines cross the contours at right angles if the aquifer is isotropic; equally transmissive in all directions. The result, under the assumed conditions, is an orthogonal net of contours and flow lines. In practice, however, the assumed conditions are seldom met. In the Weeki Wachee area, the data points may be too sparse to define the complexity of the flow system. The flow field, about 1 mi upgradient from the spring, appears relatively uniform so the flow lines were drawn normal to the 14- and 15-ft contours and spaced so that cells 1 through 12 are as nearly square as possible. The extent to which the flow cells diverge from this ideal shape is an indication of the extent to which the aquifer departs from the assumed conditions. The volume of water moving in any flow tube (between two flow lines) remains constant, assuming no recharge or discharge along the tube; thus a steepening or flattening of the potentiometric surface must indicate a decrease or increase, respectively, in

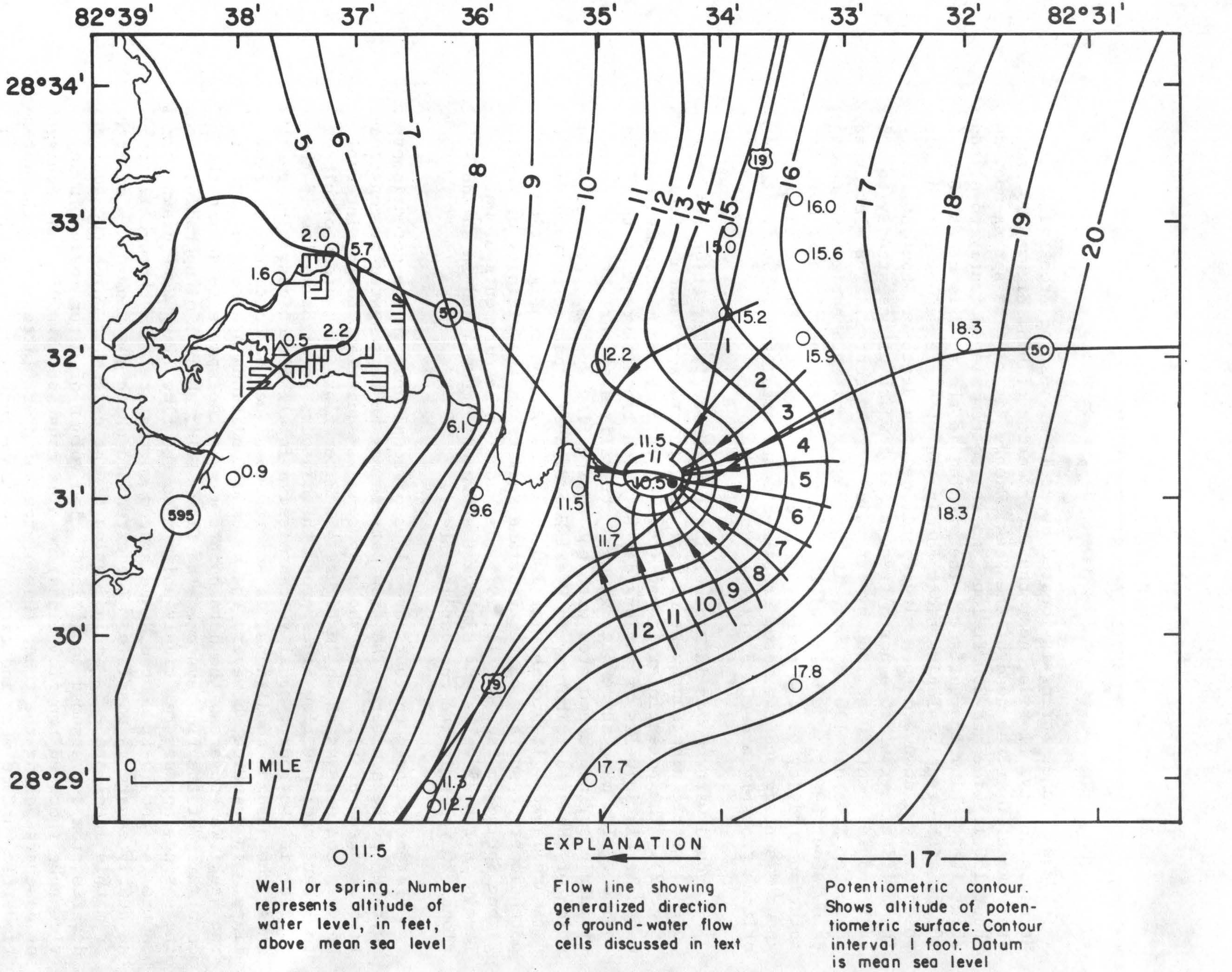

Figure 4. --Potentiometric surface of Floridan aquifer in the vicinity of Weeki Wachee Spring showing generalized flow lines, 12-11-75

transmissivity of the aquifer. The configuration of the potentiometric surface shown in figure 4 is highly generalized; many additional data points would be required to define more closely the flow pattern in the aquifer and to delineate the conduits.

Weeki Wachee Spring as a Water Supply

The stage of the spring pool ranges from 8.7 to 12.0 ft above mean sea level. Based on 357 discharge measurements, made about 1 mi downstream, the average discharge for the 45-year period of record is 176 ft^3/s. Measured discharge has ranged from 101 ft^3/s on July 24, 1956, to 275 ft^3/s on October 19, 1964. Discharge of "Weekiwachee Springs near Brooksville" (measured about 1 mi downstream) for the 10-year period 1966 to 1975 is shown in figure 5 along with monthly precipitation at Brooksville (Chinsegut Hill) and cumulative departure from normal monthly precipitation.

Springflow responds to rainfall but, as figure 5 shows, in a somewhat subdued manner--much less, for example, than that of streamflow draining a surface watershed. The response is sluggish because of the large storage capacity of the aquifer.

The flow measured on December 11, 1975, was 161 ft^3/s when tidal fluctuation was near minimal. Water levels in six wells equipped with continuous water-level recorders, and all within 8 mi of the Gulf, showed no appreciable tidal influence, on that day.

In order to analyze the flow system at Weeki Wachee Spring--as a way of determining the effects of any large-scale withdrawals of water from the aquifer--equations were used that require knowledge of the transmissivity of the aquifer. These equations are based on the assumption that the aquifer is isotropic, homogeneous, and of infinite areal extent. Although this assumption is not entirely valid for the Floridan aquifer in the Weeki Wachee area, the method is useful in determining a reasonable, though qualified, estimate of aquifer characteristics in the vicinity of the spring.

Transmissivity was calculated from the flow net of figure 4 by the equation:

$$T = \frac{Q}{(n_f/n_d)\ \Delta h}$$

Where: T = Transmissivity (ft^2/d),
Q = discharge at Weeki Wachee Spring (ft^3/d) = 1.39×10^7,
n_f = number of flow tubes = 12,
n_d = number of potential drops (contours) = 4,
Δh = total potential drop between the 15- and 11-ft contours (ft) = 4.

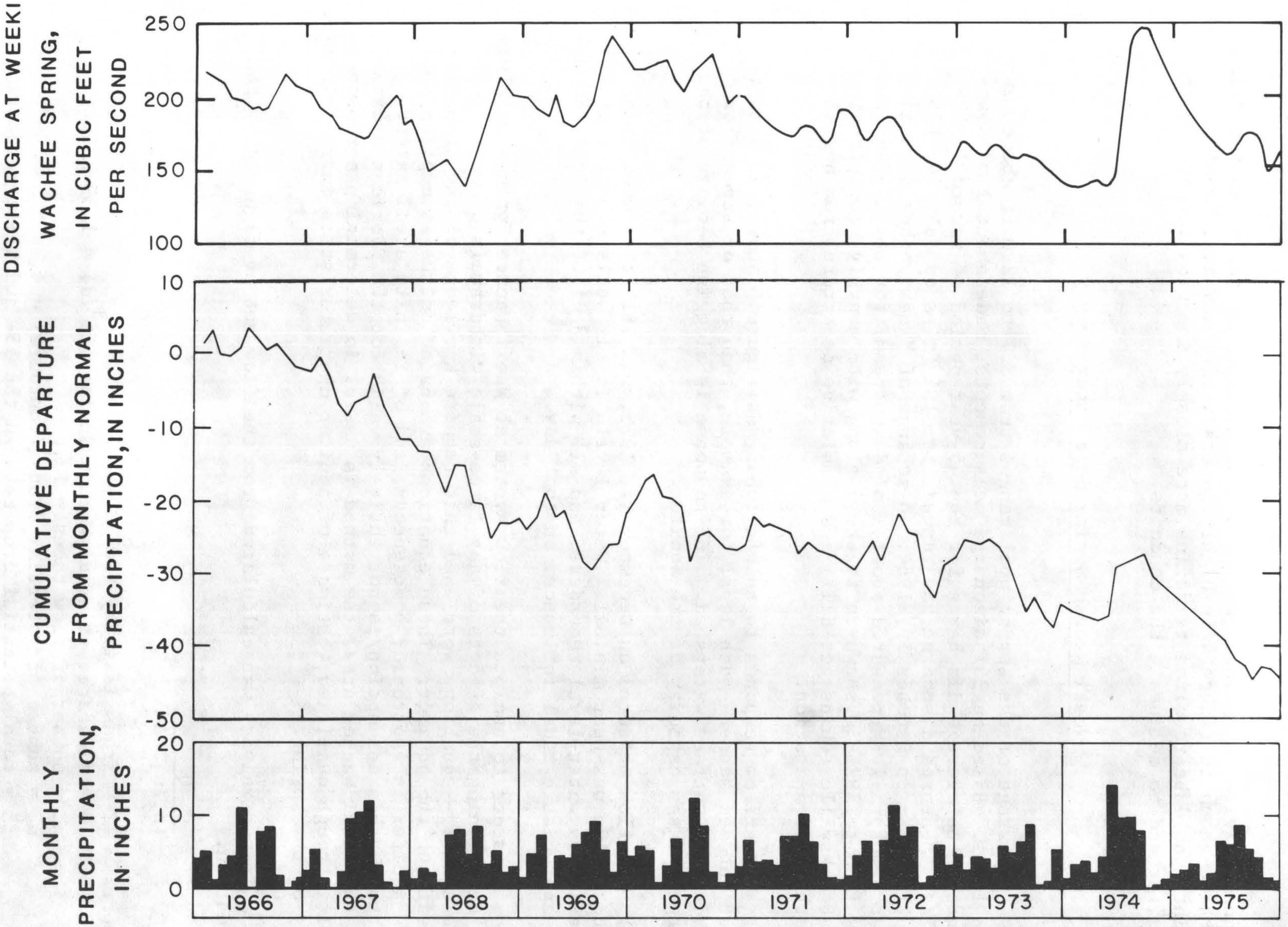

Figure 5. --Precipitation and cumulative departure from monthly normal precipitation at Brooksville and discharge at "Weekiwachee Springs near Brooksville"for the period 1966 to 1975

Thus: $T = \frac{1.39 \times 10^7}{12} = 1.2 \times 10^6 \text{ ft}^2/\text{d}.$

A second equation was used (Lohman, 1972, p. 47) for calculating transmissivity when two or more closed contours surround a point of discharge. According to this approach:

$$T = \frac{2Q}{(L_1 + L_2)\ \Delta h/\Delta r}$$

where: L_1 is the perimeter of the outer (11.5-ft) contour in ft: 10,560
L_2 is the perimeter of the inner (11-ft) contour in ft: 7,100
Δh is the head difference between contours in ft: 0.5
Δr is the average distance between contours in ft: 660.

Referring again to figure 4,

$$T = \frac{2 \times 1.39 \times 10^7 \text{ ft}^3 \text{ day}^{-1}}{(10{,}560 \text{ ft} + 7{,}100 \text{ ft})\ (-0.5 \text{ ft}/660)}$$

$$T = 2.1 \times 10^6 \text{ ft}^2/\text{d}.$$

The two transmissivities are within the same order of magnitude and are probably representative for the areas covered. That is, the transmissivity of the aquifer may be as much as 2.1×10^6 ft^2/d at the spring then decrease to about 1.2×10^6 ft^2/d 1 mi upgradient away from the spring and, presumably be even less still further away as the conduits tributary to the spring diminish in size in the manner of tributaries to a surface stream. An aquifer test using wells in the vicinity of the spring would not yield such high values of transmissivity unless the wells happened to penetrate the system of solution cavities tributary to the spring.

Weeki Wachee Spring is analogous to a flowing artesian well tapping an aquifer with a transmissivity of 2.1×10^6 ft^2/d. Diversion of the average discharge of 176 ft^3/s from the spring would cause no long-term effect on the potentiometric surface of the Floridan aquifer as long as the level of the spring pool was not lowered. Any diversion would have a direct effect on the flow of Weeki Wachee River, however, as will be discussed in a later section.

Other Solution Cavities

Several large solution cavities other than the spring itself occur in the Weeki Wachee area. Some of the large solution cavities shown on figure 6 and described in table 2 might well be developed as water supplies.

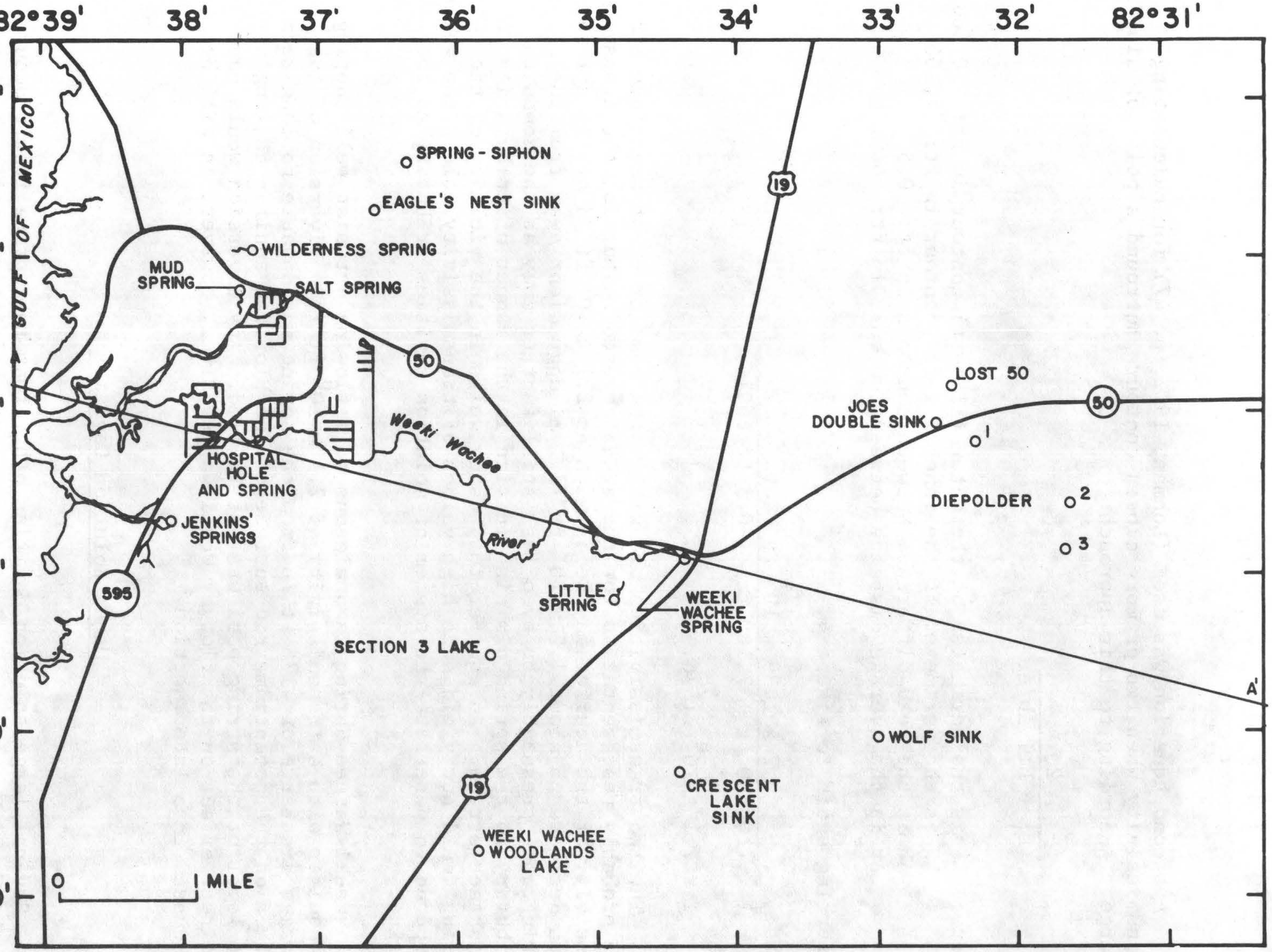

Figure 6. --Location of selected springs and sinks in the Weeki Wachee area

Table 2.--Description of selected springs, sinks, and caves in the Weeki Wachee Area

NAME	DESCRIPTION
Diepolder 1	Vertical shaft 60-ft diameter, 50 ft deep. No leads.
Diepolder 2	Vertical north-trending slot 10 by 60 ft, 230 ft deep. Cave passage at bottom trends northwest for 600 ft.
Diepolder 3	Vertical shaft about 30-ft diameter enlarges to about 30 by 150 ft at 170-ft depth. Passage 200 ft wide by 30 ft high trends westward about 450 ft.
Lost 50	Shallow canyon in lake bottom at 50-ft depth leads into easterly-trending cave passage about 3- to 4-ft diameter. Depth 80 ft at 80-ft penetration. Passage continues; silty.
Joe's Double Sink	Two vertical shafts, 50 ft and 65 ft deep, 30- to 40-ft diameter. Water temperature reported 60° F at depth implies poor connection with aquifer; silty.
Wolf Sink (Lake Azora)	Sinkhole lake; low water level implies good hydraulic connection with aquifer.
Crescent Lake Sink	Vertical shaft in Crescent Lake, 20-ft diameter.
Weeki Wachee Woodlands	Sinkhole lake; low water level implies good hydraulic connection with aquifer.
Sec 3 Lake	Sinkhole lake; low water level implies good hydraulic connection with aquifer.
Little Spring (Twin D's)	Two 3-ft diameter shafts descend to about 50 ft into a lateral passage that reportedly descends to about 200 ft and trends in a northerly direction.
Weeki Wachee Spring	Elongate, funnel-shaped, narrows downward to near-vertical slot at 80 ft. Vertical slot, 20 ft (N-S) by 4 ft maximum, appears to enter horizontal conduit at about 150-ft depth.

Table 2.--Description of selected springs, sinks, and caves in the Weeki Wachee Area - continued

NAME	DESCRIPTION
Spring-siphon	Small sand boil in spring flows about 300 ft into vertical shaft about 35 ft deep.
Eagle's Nest (Eagle Hole)	Three vertical shafts, 3- to 6-ft diameter, (at 40-ft depth) in bottom of small lake open into large room at 80-ft depth. Passages ranging from 50 to 150 ft wide, which bottom generally from 250 to 300 ft below surface, have been penetrated 1,100 ft in a southwesterly then northwesterly direction, and 450 ft northeasterly then about 350 ft southeasterly. Several leads below 300 ft have not been explored. Saltwater at 290 ft.
Salt Spring	Vertical shaft, 6-ft diameter, enters maze at 55-ft depth. Many deep winding passages and rooms to 170-ft depth.
Wilderness Spring	No description available.
Mud Spring (Sulphur Spring)	West wall of spring pool open to 185-ft depth. West-flowing current reported at 50-ft depth.
Hospital Hole (Fish Hospital)	Hole in Weeki Wachee River bottom about 50-ft diameter breaches dome which may be 200-ft diameter at depth. Layer of opaque hydrogen sulfide water, 10 to 20 ft thick varies from 80- to 100-ft depth. Total depth 150 ft.
Hospital Spring	Vertical shaft 3 ft in diameter, 40 ft deep.
Jenkins' Spring (Palm Springs #1 and #2)	Two spring openings, no description available.

The water-supply potential of Eagle's Nest Sink (fig. 6) is limited only by its proximity to the Gulf (2 mi) and to Salt Spring (0.8 mi) to which it may be connected. The freshwater-saltwater interface in Eagle's Nest Sink is reportedly very abrupt as suggested by changes in appearance and taste of the water at depths within the range of 240 to 290 ft. It would probably be possible to skim large volumes of freshwater from the 2,000 ft of passages known to exist in Eagle's Nest cave system.

Assuming that the transmissivity of the Floridan aquifer at Eagle's Nest Sink is similar to that estimated for Weeki Wachee Spring, that is, 2.1×10^6 ft^2/d, and that 50 ft^3/s were to be pumped from Eagle's Nest Sink, then the effect of the diversion would be to lower the altitude of the spring pool at Weeki Wachee Spring from 10.2 to 9.8 ft, diminishing the flow of the spring by 15 ft^3/s or less. The effect at Eagle's Nest would be to lower the water level 3.7 ft, causing the freshwater-saltwater interface to rise to a depth of about 100 ft below land surface. This means that withdrawing 50 ft^3/s from Eagle's Nest Sink would have much less effect on the river than would the removal of that quantity from Weeki Wachee Spring. The additional 35 ft^3/s would be induced from the surrounding aquifer and by increased leakage from the surface due to lower head in the aquifer. Calculations of drawdown were based on the Hantush-Jacob (1955) leaky aquifer method using an assumed leakance of 5×10^{-3} day^{-1}. If the leakance were greater than estimated, the effect at Weeki Wachee Spring would be less. Conversely, if the leakance is less than estimated, or if transmissivity is less than 2.1×10^6 ft^2/d, then the drawdown at Weeki Wachee Spring would be more than calculated above, with a greater loss of springflow.

A similar analysis was made for a presumed yield of 50 ft^3/s from Diepolder vertical shaft 3, which is 170 ft deep, about 2.7 mi east of Weeki Wachee Spring. None of the three natural "wells" penetrates a cave system as extensive as Eagle's Nest, so a smaller transmissivity of 1.2×10^6 ft^2/d was assumed, but with the same leakance.

Pumpage of 50 ft^3/s from Diepolder 3 would cause a decline in stage at Weeki Wachee Spring of 0.7 ft, using the same method of calculation as before, and would diminish the discharge by about 31 ft^3/s. Again, the difference--19 ft^3/s in this instance--would be induced from the aquifer by the steepened gradients in the potentiometric surface surrounding the point of discharge and, to some extent, by an increase in downward leakage from the surficial sand.

Between the Diepolder sinks and Weeki Wachee Spring is an undulating sandy plain characterized by relatively permeable surficial material. Some permanent lakes occupy the area, but many lakes and marshes are ephemeral, suggesting a relatively high rate of infiltration to the underlying limestone. The assumed leakance value is probably low for this area.

Little Spring (table 2) issues from two small vertical shafts about 2,800 ft southwest of Weeki Wachee Spring. Discharge from Little Spring contributes 7 to 14 percent of the flow of Weeki Wachee River. This volume of water (18 to 38 ft^3/s) could be diverted with little effect on the ground-water system, but as emphasized in the section on diversion of water from Weeki Wachee River, the river flow would be diminished by that amount. The natural drawdown of the potentiometric surface at Little Spring would be increased only if water were diverted at a rate greater than the natural flow rate. The effect on Weeki Wachee Spring of diversion from Little Spring is difficult to predict without an actual test.

In summary, the solution cavities in the aquifer offer the potential for large withdrawals of ground water. The effects of such withdrawals on Weeki Wachee Spring or River would be far smaller than if the withdrawals were made directly from the Spring or River. Ground water in the vicinity of Eagle's Nest Sink is moving generally westward beneath the Chassahowitzka Swamp (fig. 7) toward the Gulf of Mexico. Diversion of this water to beneficial use would have a minimal effect on the freshwater resources of the area. The calculations discussed above are based on tentative or assumed values for aquifer characteristics. Whether or how the known solution cavities are connected to one another could have an overriding influence on the effects of ground-water withdrawals throughout the area. Further studies, including cave mapping, tracer, and pumping tests would be valuable to a better understanding of the ground-water system.

Existing Water Wells

In 1975, annual withdrawal of ground water through large-capacity wells in the Weeki Wachee area was slightly less than 400 Mgal, about 1 percent of the average flow of Weeki Wachee Spring. The wells are few and are widely spaced, as shown in figure 7. The withdrawals tabulated in table 3 serve as many as 4,500 homes. Many small-capacity wells, not included within the major developments, serve other homes and vacation cottages throughout the area. Although population increases have continued steadily for the past few years, hydrologic effects of the resulting increase in withdrawal of water from the Floridan aquifer have been negligible in comparison to the available resource.

Weeki Wachee River as a Water Supply

The Weeki Wachee River flows westward from the spring to its confluence with Mud River, an estuary 7 river miles downstream (fig. 8). The estuary continues three-quarters of a mile to the Gulf of Mexico at Bayport. The flow of Weeki Wachee River is measured about 1 mi downstream from Weeki Wachee Spring; below the confluence with the run from Little Spring. Discharge at Little Spring has ranged from 17.6 to 38.2 ft^3/s (7.3 to 14.1 percent of the total flow of Weeki Wachee River) on the basis of seven flow measurements. The average of 357 flow measurements of "Weekiwachee Springs near Brooksville" is 176 ft^3/s. The lowest flow measured was 101 ft^3/s on July 24, 1956, and the highest was 275 ft^3/s on October 19, 1964. The average of the lowest measured flow in each of the 24 years, 1951-75, is 111 ft^3/s.

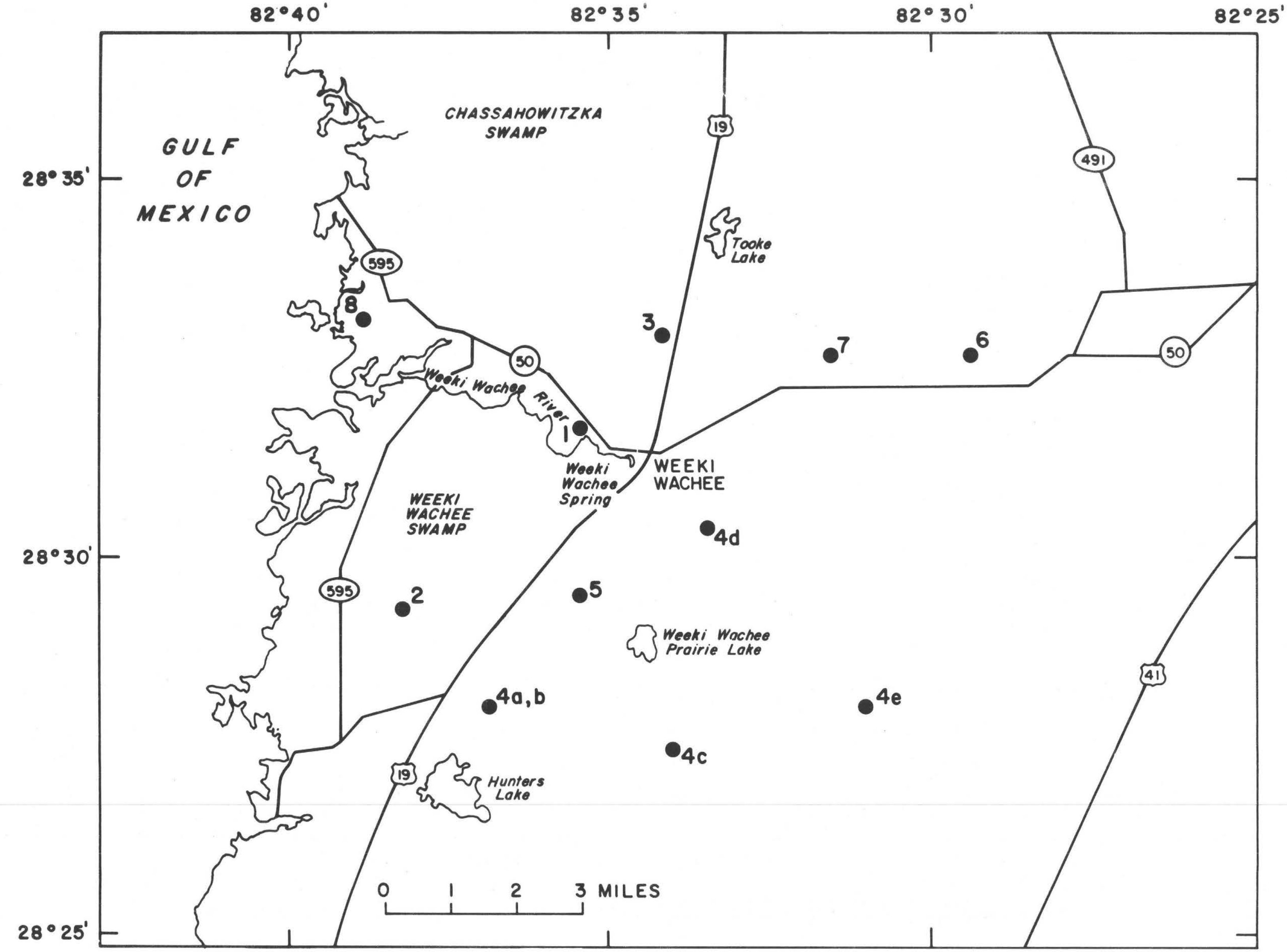

Figure 7. --Location of public-supply wells in the Weeki Wachee area

Table 3.--Large-capacity ground-water supplies in the Weeki Wachee Area

[For locations see figure 8.]

Location on figure 8	Owner	Well		Consumptive use (Mgal)		Number of subscribers
		Depth (ft)	Capacity (gal/min)	Daily	Annual	
1	Weeki Wachee Water Company	205	250			
		260	250			
		265	250	0.142	52 (1974)	760
2	Hernando Beach Water Supply	265	-	.105	38.4 (1974)	350
3	Royal Highlands	190	300 (est.)	-	.36 (est.)	15
4	Spring Hill	a 373	300			
		b 315	350			
		c 320	575			
		d 418	400			
		e 395	400	.621	226.8	2,315
5	Weeki Wachee Woodlands	200	450			
		180	325	.054	19.5 (1975)	196
6	Brookridge	500	750	.014	5 (est.)	202

Table 3.--Large-capacity ground-water supplies in the Weeki Wachee Area - continued

Location on figure 8	Owner	Well		Consumptive use (Mgal)		Number of subscribers
		Depth (ft)	Capacity (gal/min)	Daily	Annual	
7	High Point	260	500	.167	61.03 (1975)	600
8	Pine Island Water Company (brackish water not for drinking)	56	7-8 (est.)	.011	4.08	45

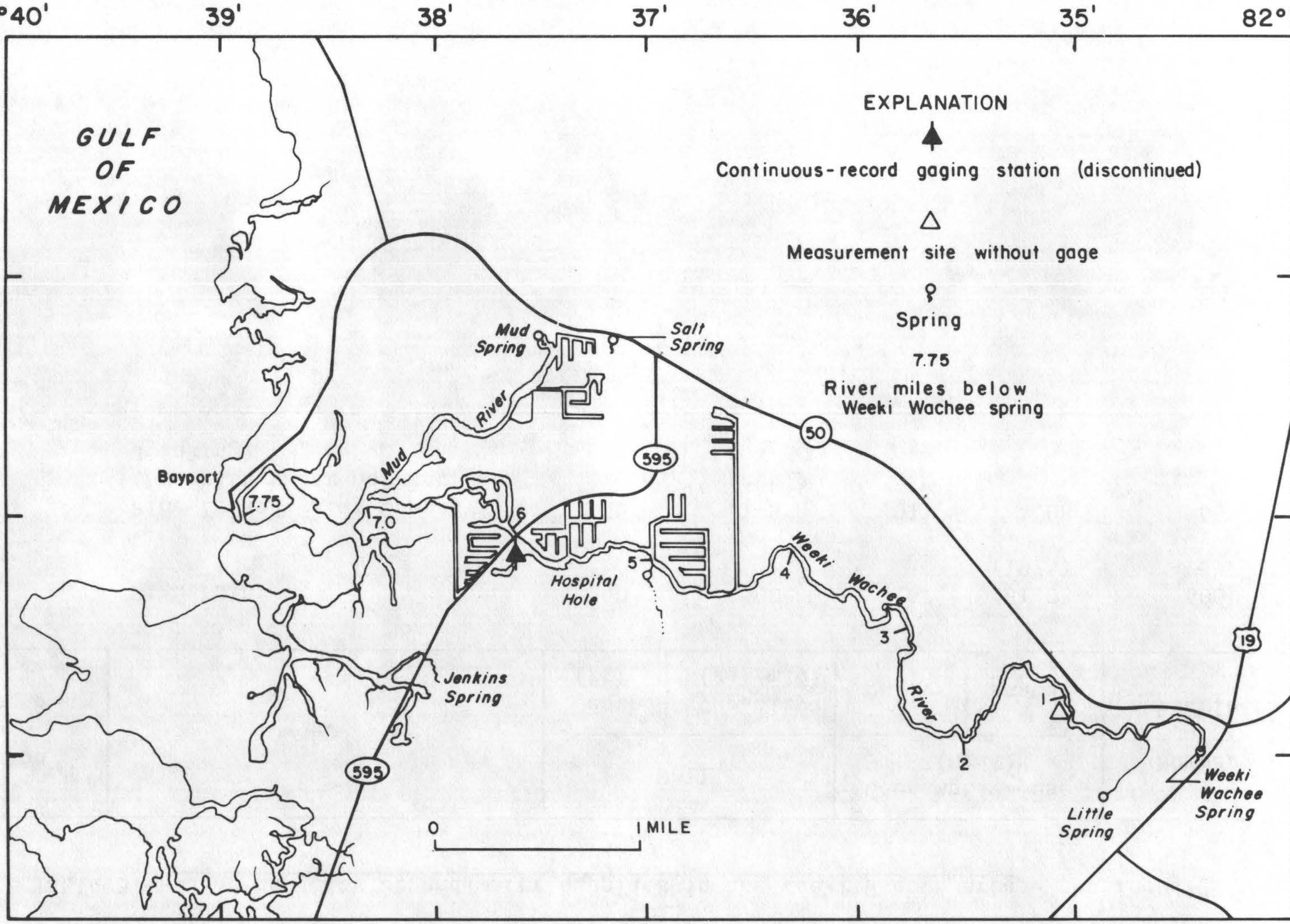

Figure 8. --Weeki Wachee River area

In each of the last 20 years, about 9 measurements of Weeki Wachee River have been made. Because springflow varies gradually, the lowest of the several discharges measured each year provides a reliable estimate of the annual minimum daily flow. The magnitude and frequency of the estimated annual minimum daily flow of "Weekiwachee Springs near Brooksville" is shown in figure 9.

The plot shows that at least once every 2 years daily discharge is expected to decline below about 165 ft^3/s. Or, looking at it another way, there is a fifty-percent chance that in any year, daily discharge will be less than 165 ft^3/s. On the average, daily discharge will decline to about 100 ft^3/s once every 20 years, or there is a five-percent chance daily discharge will decline to about 100 ft^3/s in any year.

Figure 5 shows the discharge of "Weekiwachee Springs near Brooksville", and monthly precipitation and cumulative departure from monthly normal precipitation at Brooksville for the 10-year period 1966-75. In spite of a cumulative deficiency of about 45 in of rainfall for the 10-year period, the spring discharged from 150 to 200 ft^3/s throughout most of the period. The discharge hydrograph of "Weekiwachee Springs near Brooksville" generally reflects the recession of cumulative departure from monthly normal precipitation. Although rainfall at Brooksville was below normal, June-September 1968 and 1969, the regional rainfall was apparently adequate to recharge the aquifer and to increase discharge from the springs by about 50 ft^3/s in both of those 4-month periods. Although figure 9 shows that statistically the discharge should fall below 110 ft^3/s at least once in 10 years, this did not happen during 1966-75, a drought period of 10-years duration.

Discharge measurements have been made at the gaging station at State Road 595 (fig. 8) for several years, but interpretation of these measurements is difficult because of tidal effects. For December 11, 1975, tidal fluctuations were predicted to be near minimal and so, on that day, discharge measurements were made of the flow of Weeki Wachee Spring at the measurement site 1 mi downstream of the springs, and also at State Road 595, 5.7 mi downstream below Weeki Wachee Spring (fig. 8). The discharge of Little, Mud, Salt, and Jenkins Springs also were measured. Measurements of water level in six wells on which automatic recorders were in operation indicated no significant tidal effects in the aquifer. The average of two measurements of the flow at State Road 595 on December 11, 1975, was 192 ft^3/s. The discharge at the Weeki Wachee Spring measurement site was 161 ft^3/s.

The 31 ft^3/s gain through the 5.7-mi reach of river is due, in part, to the gain of water by upward leakage from the Floridan aquifer, from bank seepage of water moving through the surficial sand aquifer, and from the few minor tributaries that drain neighboring swamps. A traverse of the river was made from Weeki Wachee Spring to State Road 595 to measure dissolved-oxygen content and temperature of the water. These two parameters are constant in Floridan-aquifer water and a large resurgence of

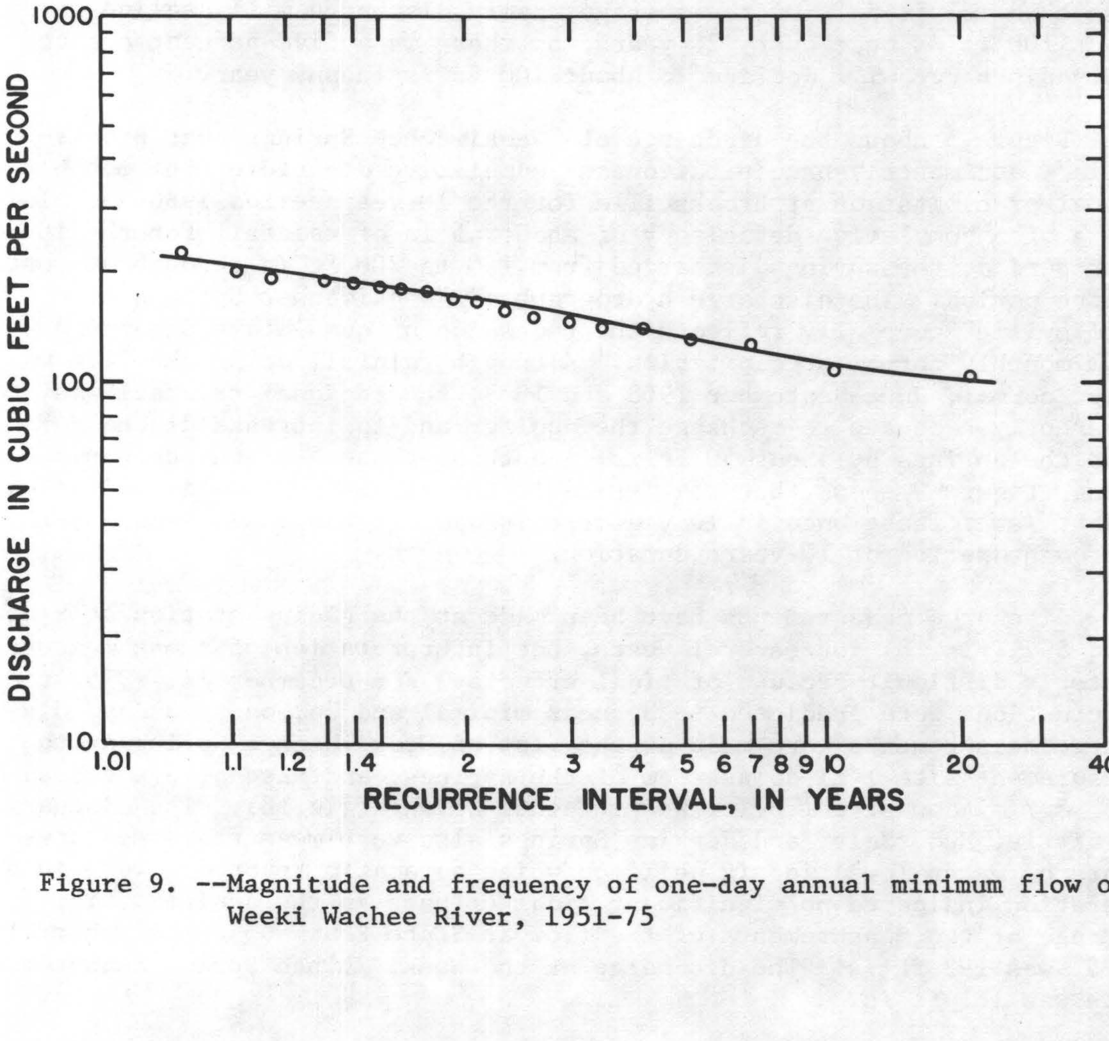

Figure 9. --Magnitude and frequency of one-day annual minimum flow of Weeki Wachee River, 1951-75

ground water in the river would have been apparent. No anomalies were noted from Weeki Wachee Spring to Hospital Hole at mile 5.5. Hospital Hole is a large dome-shaped cavity which extends to a depth of about 150 ft below the river bed. A flow of 2 ft^3/s was measured in a horizontal passage which enters Hospital Hole at a depth of about 70 ft. The measured flow is only a small part of the discharge from Hospital Hole to the river.

The channel of Weeki Wachee River is naturally narrow and sinuous and flow is relatively rapid, on the order of 1 ft/s from the spring to mile 4.4. Mean sea level intercepts the river bottom at mile 3. The effects of tidal fluctuations reach upstream to mile 1.1 where a sand bag control has been installed. Upstream from the control the gradient is extremely flat.

Downstream from mile 4.4 much of the river has been widened and deepened so that the current is sluggish and affords little resistance to saltwater invasion. In addition, about 4.7 mi of canals have been dredged tributary to the river. Movement of water in the canals is slight, and occurs mainly because of tidal effects.

Water Salinity versus Discharge Rate

Simultaneous determinations of discharge of "Weekiwachee Springs near Brooksville" and of specific conductance of the Weeki Wachee River at State Road 595 suggest that they are inversely related, as shown by figure 10. Specific conductance is an indicator of dissolved solids in water and usually increases as the dissolved solids content increases.

Specific conductance of water sampled at the surface and bottom of the river shows that brackish water extends in a tongue along the bottom of the river to mile 6.5 at high tide, and retreats to the confluence with Mud River at mile 7 at low tide. The samples on which this statement is based were taken during a "normal" tide cycle when the river was flowing about 210 ft^3/s. Saltwater from the Gulf of Mexico, therefore, does not normally contribute to the high specific conductance measured at State Road 595. Brackish water from Hospital Hole, which penetrates the zone of diffusion, discharges at a greater rate when the river stage is low, resulting in the relationship shown in figure 10.

Development Potential

In the section of Weeki Wachee River that has been dredged, from mile 4.4 to mile 6.5, water velocity is much lower than it is in the natural channel and circulation through the canals is poor. During periods of extreme low flow, saltwater may invade this reach of the river

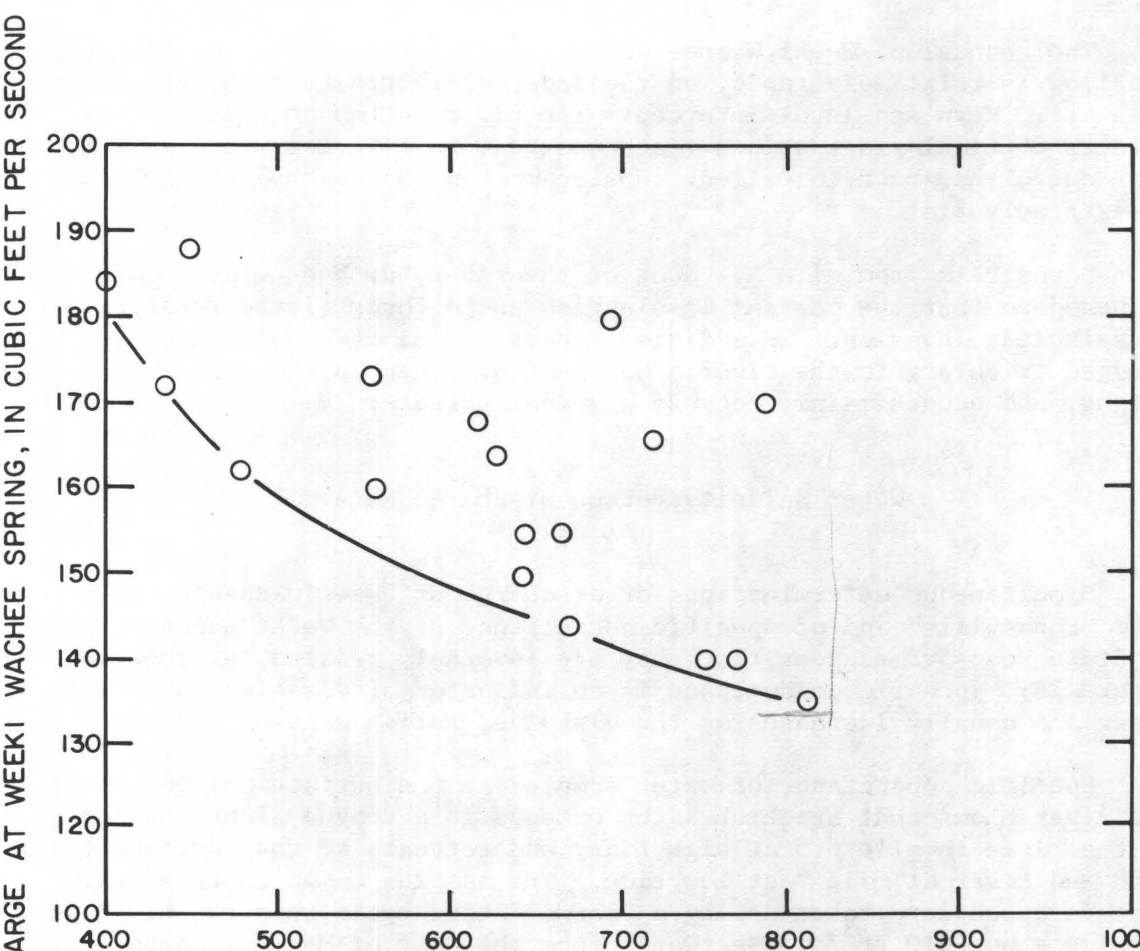

Figure 10. --Specific conductance of Weeki Wachee River water at State Road 595 compared with discharge of Weeki Wachee Spring

and any significant diversion of water from the river would increase the probability of saltwater reaching as far upstream as mile 4.4. Diversion of water for public supply would have to be upstream from mile 4.4.

Most of the flow of Weeki Wachee River is from Weeki Wachee Spring, as previously explained. Hence, fluctuations in discharge of the river tend to be reduced because of the immense storage capacity of the aquifer. There is little channel and bank storage along the river. This is relevant only to the extent that, in view of the high velocity of the river, channel storage is probably equivalent to no more than one day's flow; 9×10^6 ft^3 at 101 ft^3/s, based on the low flow of record. Thus, any plans for diversion would have to be made on a run-of-the-river basis and the daily values of minimum flow in figure 9 may be the best management tool available.

WATER-SUPPLY POTENTIAL OF THE LOWER WITHLACOOCHEE RIVER

The Withlacoochee River has a drainage area of 2,100 mi^2; its largest tributary is Blue Run which carries the discharge from Rainbow Springs near Dunnellon (fig. 11). Rainbow Springs is the major source of water in the Withlacoochee River during periods of low flow. The average discharge of Rainbow Springs is 748 ft^3/s. The minimum discharge was 487 ft^3/s and the maximum was 1,230 ft^3/s. The maximum discharge of record for the Withlacoochee River near Holder, upstream from Blue Run from 1931 to 1975 was 8,660 ft^3/s on April 5, 1960; minimum was 112 ft^3/s on June 18, 1956; average for the period of record is 1,132 ft^3/s. The discharge of Rainbow Springs has been measured on a regular basis only since 1965. In figure 12, the discharge of the Withlacoochee River near Holder is plotted against the combined discharge of the river near Holder plus Rainbow Springs. The reasonably consistent relationship (fig. 12) indicates that the 44 years of record near Holder can be used to compute the total discharge of Withlacoochee River downstream from Blue Run. Additional inflow, other than that from Rainbow Springs, may amount to as much as 5 percent of base flow to 15 percent for flood flows, as estimated by Rabon (1966).

Downstream from the confluence with Blue Run, the Withlacoochee River enters Lake Rousseau which was created by Florida Power Company's dam and is presently maintained by structures designed for the Cross-Florida Barge Canal. Discharge from Lake Rousseau is controlled by Inglis Dam (fig. 11), which spills into a short reach of the natural channel before being diverted by the Gulf-Coastal reach of the canal, and by a spillway which controls discharge through the Inglis Bypass Channel into the lower Withlacoochee River. Capacity of the bypass channel is about 1,600 ft^3/s.

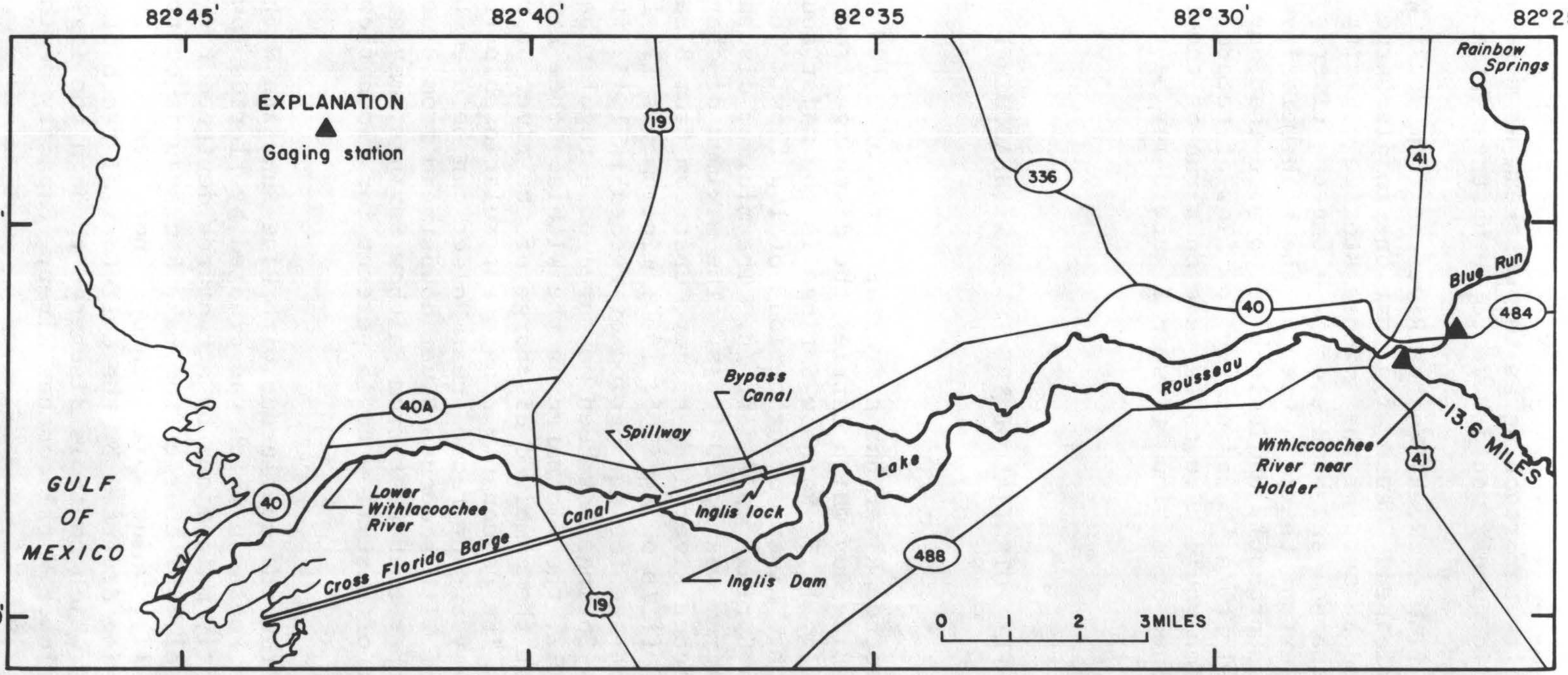

Figure 11. --Lower Withlacoochee River/Cross-Florida Barge Canal complex

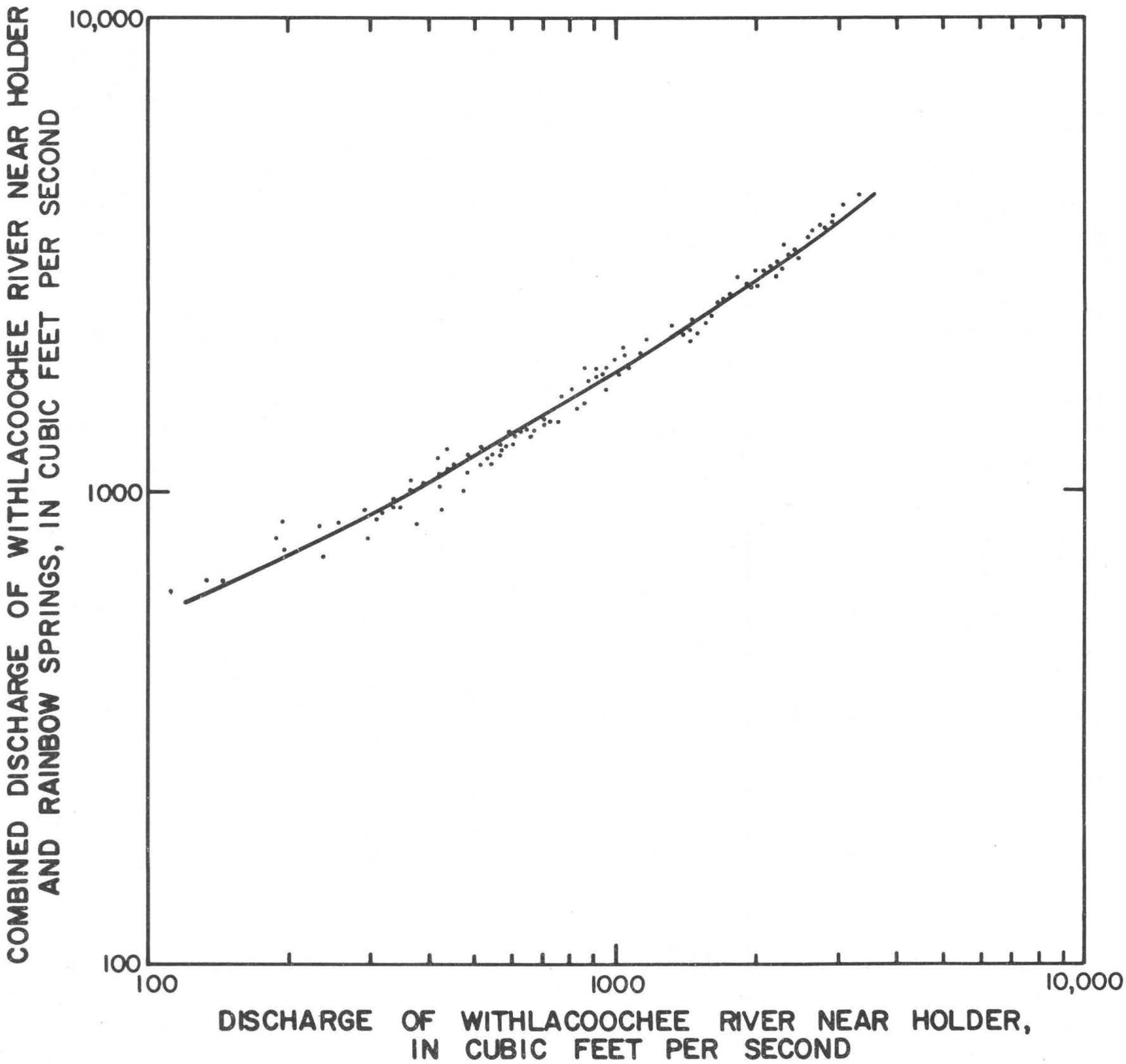

Figure 12. --Relation of discharge of Withlacoochee River near Holder to combined discharge of Withlacoochee River and Rainbow Springs

Saltwater Encroachment in Lower Withlacoochee River

The quantity of water per unit time that might be diverted from Lake Rousseau depends on the flow characteristics of the river and whether or not its lower reach is to be maintained fresh or permitted to become saline by encroachment from the Gulf of Mexico.

In his study of saltwater movement in the Lower Withlacoochee River, Bush (1973) suggested that under low-flow conditions tidal effects have more influence on the upstream movement of saltwater than does the rate of freshwater discharge. According to Bush (1973, p. 20) " - - - the farthest upstream movement of the salt front during the investigation (4.8 mi upstream from river entrance) apparently did not occur during the period when discharge was about 500 cfs, but instead, when the discharge was about 1,320 cfs. This indicates that tides have a stronger influence on the upstream movement of the salt front than freshwater discharge in the 500-1,500 cfs range - - -."

Saltwater in the channel would probably not pose a threat to the Yankeetown well field except under conditions of extremely high tide, coupled with sustained low head in the aquifer. Faulkner (1973a) depicts "low-water conditions" in a potentiometric map that shows the 2.5-ft potentiometric contour passing nearly through the well field and about one-quarter mile from the river. Ground-water flow therefore is toward the river, even under "low-water conditions."

Water-Supply Potential of Lake Rousseau

The following analysis of the potential for diversion from Lake Rousseau (the Withlacoochee River backwater) is based on the assumption that downstream release of water to the lower Withlacoochee River will not be less than 500 ft^3/s. Lake evaporation in the area is about 48 in/yr according to Kohler and others (1959). The surface area of Lake Rousseau is about 6.5 mi^2. Thus, average evaporation of about 23 ft^3/s must also be subtracted from any calculations of proposed withdrawals.

Precipitation at Inverness averages about 56 in/yr. This is more than enough to balance evaporation from the lake surface on the average. During periods of low flow, however, when water-supply potential may be critical, it is likely that precipitation will be below normal and evaporation will be an important factor. For the purposes of the following discussion, therefore, precipitation will be ignored.

Table 4.--Annual minimum discharge of the Withlacoochee River below Blue Run for indicated periods of consecutive days

[Discharge, in cubic feet per second]

Recurrence interval, in years	PERIOD - CONSECUTIVE DAYS								
	7	14	30	60	90	120	183	274	365
2	960	1000	1040	1080	1150	1230	1540	--	1880
5	775	805	840	860	910	980	1170	1320	1420
10	700	740	750	765	810	880	1010	--	1240
25	630	660	670	685	725	780	885	980	1050
50	590[a]	615	620	635	675	730	805	887	940
100	550	580	585	600	640	700	750	--	885

a At least once in 50 years, the average minimum discharge will be 590 ft^3/s or less for 7 consecutive days.

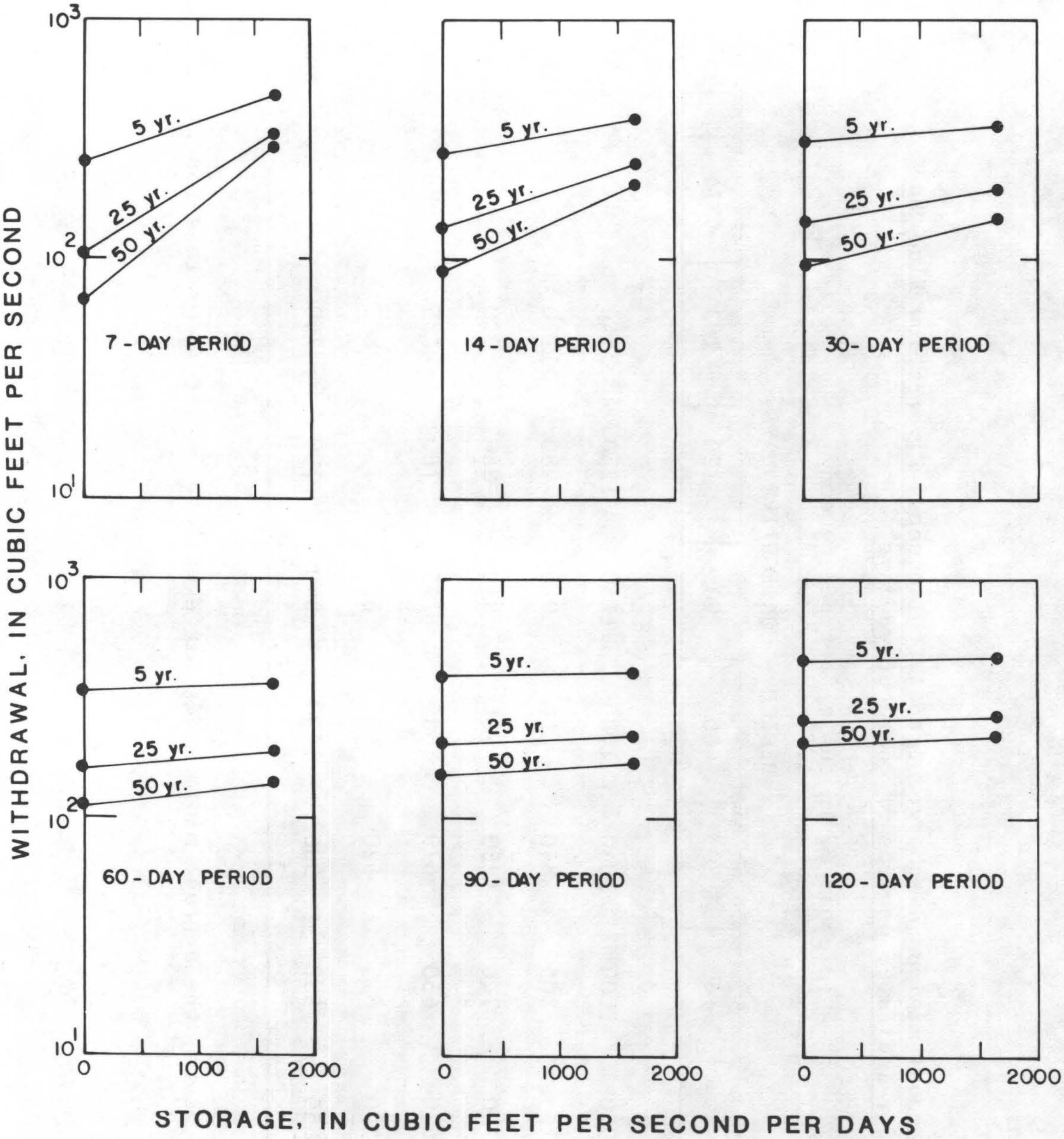

Figure 13. --Volume of water available from Withlacoochee River backwater for various periods of consecutive days at recurrence intervals of 5, 25, and 50 years with usable storage ranging from 0 to 1,610 cubic feet per second per day.

Magnitude and Frequency of Annual Low Flows

Table 4 summarizes the low-flow frequency analysis of Withlacoochee River downstream from Rainbow Springs. The annual minimum average discharge shown is for periods of from 7 to 365 consecutive days, and for recurrence intervals of from 2 to 100 years. The table shows, that on the average over a long period, the average minimum discharge will be 960 ft^3/s or less for 7 consecutive days at least once in 2 years. Not until a recurrence interval of 50 years is reached does the 7-day average minimum discharge decline below 600 ft^3/s.

Draft-Storage Analysis

The permissible draft from Lake Rousseau is assumed to be the discharge into the lake minus 500 ft^3/s for release downstream to combat saltwater encroachment and 23 ft^3/s to offset evaporation.

According to Rabon (1966), usable storage in Lake Rousseau is about 1,610 $(ft^3/s)/d$. Figure 13, based on the values in table 4 minus 523 ft^3/s, illustrates the draft available for various lengths of withdrawal periods at recurrence intervals of 5, 25, and 50 years, depending on the volume in storage at the beginning of the withdrawal period.

For example, during a 7-day low-flow period with a recurrence interval of 25 years, the average discharge available for diversion would range from about 100 ft^3/s with no storage, to about 300 ft^3/s with full storage at the beginning of the period. Over a 90-day low-flow period with a recurrence interval of 25 years, the average discharge available would be about 200 ft^3/s regardless of the volume of water in storage.

Consequently it would seem more accurate to say that unless the flow distribution is optimum during a 90-day low-flow period, the limitation on storage capacity might make it necessary to reduce the draft rate to less than 200 ft^3/s during part of the period.

SUMMARY AND CONCLUSIONS

1. Of the five large spring-river systems evaluated, two have major potential as sources of freshwater supply: (1) the Weeki Wachee Spring and River system, and (2) the Withlacoochee River system, including Rainbow Springs and Lake Rousseau. Withdrawal of ground water from large caverns in the Weeki Wachee area appears to offer good potential for water supply with minimal effect on the Weeki Wachee Spring and River.

2. The average annual discharge at the measurement site "Weekiwachee Springs near Brooksville" is 176 ft^3/s. The minimum recorded discharge was 101 ft^3/s and the maximum was 275 ft^3/s. Any diversion of water from the spring or river that would reduce the discharge to less than 100 ft^3/s might cause brackish water to move upstream at least to within 4.4 mi of Weeki Wachee Spring.

3. Under natural conditions, the flow of Weeki Wachee Spring will fall below the minimum discharge of 101 ft^3/s at least once every 20 years. Discharge can be expected to drop below 165 ft^3/s at least once every 2 years. Short-term diversions in excess of 50 ft^3/s are feasible during periods when spring discharge is average or greater, but predictions of low flow cannot be made with the available data.

4. Development of ground water from large caverns in the Weeki Wachee area is feasible, and may be preferable to diversion from Weeki Wachee Spring or Weeki Wachee River. Withdrawal of 50 ft^3/s from Eagle's Nest Sink, for example, would diminish the flow from Weeki Wachee Spring by only about 15 ft^3/s.

5. The average discharge of the Withlacoochee River at Holder is 1,132 ft^3/s. The minimum discharge was 112 ft^3/s and the maximum was 8,660 ft^3/s. The discharge from Rainbow Springs comprises the major component of base flow of the lower Withlacoochee River. The average discharge of Rainbow Springs is 748 ft^3/s. The minimum measured discharge was 487 ft^3/s and the maximum was 1,230 ft^3/s. On the basis of previous studies, it is assumed that a minimum release of 500 ft^3/s from Lake Rousseau would be required to maintain the farthest upstream movement of the freshwater-saltwater interface at or near its natural position, 4.8 mi upstream from the mouth of the lower Withlacoochee River. About 23 ft^3/s would be required to offset evaporation losses from Lake Rousseau.

6. Estimates of the availability of water from the Withlacoochee River were made for several periods of withdrawal of different recurrence intervals based on the flow duration analysis of the inflow to Lake Rousseau, subtracting the sum of the low-flow release and evaporation loss. For example, with a recurrence interval of 25 years the following conditions would be expected:

a. During a 7-day low-flow period, the volume of water available for diversion would range from about 100 ft^3/s with no storage, to about 300 ft^3/s with full storage in Lake Rousseau at the beginning of the period;

b. During a 90-day low-flow period, the average discharge available would be about 200 ft^3/s regardless of the volume of water in storage.

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