FLORIDA GEOLOGICAL SURVEY

BULLETIN
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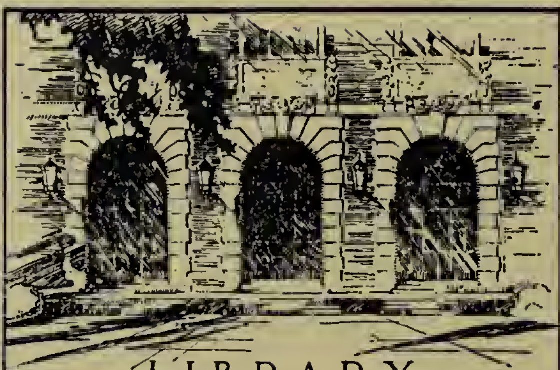

Rock *Springs* near Apopka, Orange County

Juniper Springs east of Ocala, Marion County

Spring of *Ichatucknee Springs* group, northeast of Hildreth, Columbia County

STATE OF FLORIDA
DEPARTMENT OF CONSERVATION
J. T. Hurst, *Supervisor*

Florida Geological Survey
Herman Gunter, *Director*

GEOLOGICAL BULLETIN No. 31

SPRINGS OF FLORIDA

By
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S. K. LOVE, and R. O. VERNON

Prepared by the
United States Geological Survey
in cooperation with the
Florida Geological Survey

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CONTENTS

ILLUSTRATIONS

LETTER OF TRANSMITTAL

HONORABLE J. T. HURST, *Supervisor*
Florida State Board of Conservation

Sir:

I have the honor to transmit a report entitled "Springs of Florida." This paper was prepared by members of the Federal and State Geological Surveys from information obtained through cooperative activities and investigations and from the records contained in the files of both surveys.

The subject is one of considerable economic importance and of more than passing interest to visitors and citizens alike. The report should fill a long felt need to properly answer questions on Florida springs and should allow these springs to be more correctly evaluated.

This paper will be published as Geological Bulletin No. 31 and it is anticipated that this report will be one of the most popular of the Survey bulletins.

Very respectfully,

HERMAN GUNTER, *Director*
Florida Geological Survey

Tallahassee, Florida
May 20, 1947

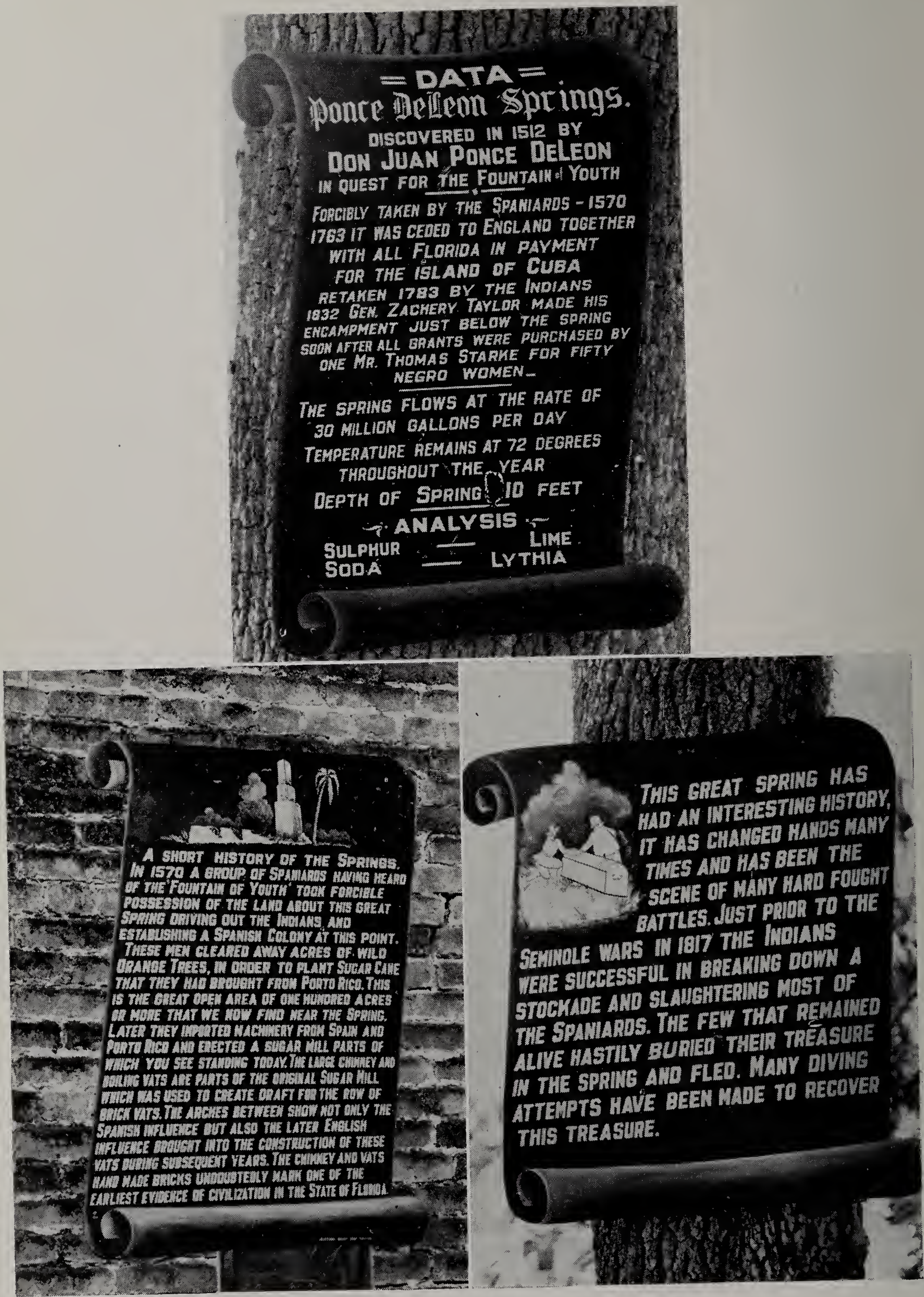

FIGURE 1. Ancient history associated with *Ponce De Leon Springs*, Volusia County.

PREFACE

Since one of the primary functions of the State and Federal Geological Surveys is to gather information on natural resources and make it available to the public, this report on springs of Florida was prepared as a cooperative project.

The springs of Florida are a perennial source of water that contribute to most of our streams, so necessary for human activity. Some are used as a source of supply for municipal water, sanitariums have been constructed at a few, and many are a source of supply for stock. The sportsman and woodsman are interested in the springs as a breeding place for birds and fish, and many resort hotels have been constructed at spring sites for the sportsman and visitor.

Many interesting historical battles, settlements, and details are closely associated with Florida springs, and this background combined with the intrinsic beauty of the water and surroundings and with the facilities for recreation, exercise, and health creates an attraction that appeals to all who have the opportunity to visit or live in Florida.

G. E. Ferguson, C. W. Lingham,
S. K. Love, and R. O. Vernon

Tallahassee, Florida
May 20, 1947

SPRINGS OF FLORIDA

PART I

A. INTRODUCTION

By G. E. Ferguson

District Engineer, Surface Water Division, U.S.G.S.

A Glance at Florida's Springs

Florida's springs hold the fascination of the millions who have visited them. The tourist is delighted as he views through glass-bottomed boats the beautiful and strange world beneath the surface of the crystal clear waters of the spring pools. He is equally pleased with the scenic channels through which the waters issuing from the springs pass tranquilly toward the ocean. The waters remain at uniformly cool temperatures throughout the mild winters and long summers. Local residents have long enjoyed the springs as highly satisfactory recreational centers and swimming pools.

These springs, and especially the deep and readily navigable waterways they form, have played an important part in the development of the State. The channels were the highways of the early settlers. The hulks of some of the early river boats can still be seen clearly beneath the spring waters. Along the banks, not far distant, the ruins of long-abandoned wharves and warehouses are visible.

The springs of Florida constitute one of the State's most important natural resources. As commercialized tourist attractions, they are the bases of business enterprises of considerable magnitude. The waters of some of the springs are bottled and sold for domestic consumption and the water supplies of several Florida municipalities are piped from nearby spring pools. Sanatoriums have been established at some of the more highly mineralized springs. Private and public agencies have provided hotels, motor courts, cottages, dance pavilions, restaurants, boating, swimming, and fishing facilities. At certain springs, the discharged waters have been harnessed to provide electric power in greatly varying amounts from commercial hydroelectric plants with modern large turbines and generators to scenic water wheels turning small dynamos. The rivers throughout a large part of Florida are beneficially affected by the comparatively uniform amounts of spring water they receive and their navigability is usually improved.

The major springs are noted for their outstandingly large rates of discharge. The magnitude of these flows has created an interest and popularity which has attracted tourist, local resident and scientist alike. The word "spring" is generally associated with a relatively small amount of water issuing from the ground and trickling into a nearby stream. In Florida, however, the larger springs issue from the ground as rivers, some of which are large enough for commercial navigation. Either of Florida's two largest springs has sufficient water to supply a city of over 3,000,000 population, and any one of 20 of the major springs would serve a city of over 500,000 population.

The Purpose and Scope of this Report

This report on Florida's major springs contains both a story of the springs and a collection of facts about them. For the casual reader it provides a picture of the natural processes by which the springs were formed, the sources of the spring waters and the individual locations and descriptions of many of the larger springs. For the student, it presents the general geography, geology and hydrology of the springs, and the chemistry of the spring waters, and by references directs him to other published reports. Finally, for the practicing professional engineer, geologist, hydrologist, chemist and naturalist it contains a considerable amount of factual data that have been systematically collected on many of Florida's springs and are proving highly valuable in the development of the State.

The report covers only a part of the many springs of Florida. The program for the investigation of Florida's springs was for many years directed toward the systematic measurement of discharge of a few of the large springs in order to define their characteristics and place among the water resources of the State. More recently this program was expanded to include inspections of many more of the larger springs during which discharge measurements were made, samples taken for chemical analyses, and physical descriptions of the spring pools prepared. The springs were selected on the basis of rates of discharge and the degree of utilization. It is realized that future development and increased utilization of certain springs not included herein may place them among the major or important springs of Florida. In certain areas where large springs are common, such as in Marion County and along the spring-fed streams such as the Suwannee River and its tributary Santa Fe River, many of the little known and relatively inaccessible springs have not been included. Some of these springs discharge directly into the river beds often through numerous small caverns or fissures. These conditions may make direct measurement and study impracticable.

It is suggested that those who desire all available data on any particular spring communicate with the Director of the Florida Geological Survey in Tallahassee, or the District Engineer of the United States Geological Survey in Ocala, Florida. This report contains only the most pertinent of the data collected as space does not permit nor general usage require publication of all field sketches, measurements, soundings and highly technical interpretations and comparisons. Data collected subsequent to the preparation of this report are also available as the spring investigational program is of a continuing nature. For instance, as additional discharge measurements are made, they will, when used with the earlier measurements, give a more reliable value of average flow for any individual spring than shown in this report. Maximum and minimum rates of discharge presented may also be superseded in the light of later records. It is planned to begin periodic discharge measurements on an additional group of the larger springs and decrease the frequency of measurements on those for which annual and seasonal flow rates are now well defined.

Cooperation and Acknowledgements

The preparation of this report is a joint undertaking by the Florida Geological Survey and the United States Geological Survey. The portions relating to hydrology and geology were prepared by Dr. R. O. Vernon, Associate State Geologist of the former, and the balance by the latter in financial cooperation as shown below.

Measurements and estimates of the flow of Florida's springs have been made for many years by various individuals and agencies. Systematic measurements of the discharge of a representative number of the major springs of the State were begun early in 1931 and have continued to date, the work being accomplished

by the United States Geological Survey in cooperation with the Florida Geological Survey during 1931-32 and since 1946, and with the Florida State Road Department during 1933-45. In 1941, the Federal Survey in cooperation with the Florida Geological Survey began special hydraulic investigations of the more prominent individual springs preparatory to this report and in 1945 the program of measurements was expanded and the chemical analysis of spring waters was added.

Geologic data used in the report have come largely from the files and publications of the Florida Geological Survey.

The work of the Federal Survey in preparing the report was under the general supervision of Carl G. Paulsen, chief hydraulic engineer of the Water Resources Branch; Joseph V. B. Wells, chief of the division of surface waters; S. K. Love, chief of the division of quality of waters; and G. E. Ferguson, district engineer of the division of surface waters in Florida. Numerous members of the Federal Survey rendered valuable assistance in the collection, compilation and analysis of the data, notably D. S. Wallace, district engineer for Florida during 1930-41, and C. C. Yonker, who since 1941, has supervised the collection of spring discharge data and their compilation and analysis.

The work of the Florida Geological Survey was accomplished under the direction and guidance of Dr. Herman Gunter, State Geologist, whose long interest in Florida's springs and foresight in arranging for the collection of spring data has made the report possible.

The authors are also indebted to the various spring owners and operators for their continuing interest and cooperation in the collection of the data on spring flows. Credit should be accorded Messers Lewis J. Marchand, Ira Burtis, Dean B. Bogart, The Tampa Tribune and officials of Crystal, Homosassa, Kissengen, Poe, Sanlando, Silver, Wakulla, Warm Salt, and Weekiwachee Springs for certain photographs which have been used in the report.

Mr. H. H. Cooper, Jr., District Engineer for Florida, and Mr. V. T. Stringfield, Senior Geologist, Washington, D. C., U. S. Geological Survey, Ground Water Division, have been especially helpful in reviewing the section on geology and hydrology of spring areas. Dr. A. G. Unklesbay, formerly of the Ground Water Division, U. S. Geological Survey, compiled some of the early data used in this report.

B. THE HYDROLOGY and GEOLOGY of FLORIDA SPRINGS

By Robert O. Vernon
Associate State Geologist, Florida Geological Survey

Introduction

A spring is a natural fountain or supply of water issuing at the surface of the earth, and its flow may range from a wet seep to a sizeable stream. The source is the water which falls or condenses from the atmosphere and passes down into the pores and interstices of the underlying rock through which the water flows to the spring opening. Meinzer[1] has given an excellent discussion of Florida springs and on the basis of discharge rates classified springs into eight magnitudes. However, considering only the movement of water through the formations, two general types of springs occur in Florida. In one, water that has fallen as rain percolates down through permeable formations until it reaches a relatively impervious bed, after which it flows more or less parallel with this bed to a place on an intersecting land surface where it issues as a spring. In the other type of spring the rainwater enters directly into porous bedrock or passes through surface formations and through more impervious beds by means of sinks and caverns into bedrock. The water is here confined in the aquifer under hydrostatic pressure. Springs issue from this aquifer at some lower elevation where the bedrock lies near or is exposed at the land surface, whether this elevation lies above or below sea level. Where the aquifer crops out below sea level a fresh water submarine spring, such as that offshore from Crescent Beach, may occur, see figure 2.

The openings through which the ground water flows in the rock must be large, and sizeable caverns must extend from the spring vent well back into the aquifer to enable such large quantities of water to be delivered at the spring opening. The aquifer, filled with water, acts as a large reservoir which equalizes the discharge of water flowing through it over periods of heavy rainfall and drought. The flow from most Florida springs is thus perennial and relatively uniform. Because of the active circulation of the large volume contained in these formations the water is relatively soft and remarkably clear even during heavy rain-

[1] Meinzer, O. E., Large Springs in the United States, U.S.G.S. Water Supply Paper 557, 94 pp.

fall, except where the spring is connected through caverns directly to a surface stream. Although spring water is relatively soft, ground water is nevertheless stratified and in older and deeper rocks heavily mineralized and saltier waters occur. This heavily mineralized and salty water is generally encountered under all of Florida in deep wells, but in the southern peninsular area and at some places along the coasts salt water occurs relatively near the ground surface. In general, where hydrostatic pressure is low, see figure 4, salt water occurs at shallow depths. Vigorous circulation of the ground water through rapid natural flow or by heavy pumping of wells may flush salt water out of the formation.

FIGURE 2. "Slick" and "boil" of artesian submarine spring in the Atlantic Ocean about three miles east of Crescent Beach, Florida. The slick is about 70 feet in diameter.

Several of the springs discussed in this report are salty. Salt Springs in Marion County with a chloride content of 2,800 parts per million, Little Salt Spring and Warm Salt Springs of Sarasota County with 1,430 and 9,350 parts per million respectively are notably salty. The salt contained in spring water results from either the flushing of salt trapped in formations as they were deposited or from salt water trapped in Pliocene and older beds during the Pleistocene epoch when sea level stood at higher levels than at present. It is generally believed that the pressure of artesian water prevents the infiltration of sea water to shallow depths along present shore lines, except where the artesian head has been reduced by heavy use or drainage of water.

The rate of flow of water through the caverns in the aquifers is regulated partially by hydraulic gradient, which in Florida is controlled almost entirely by the altitudes of the spring vent in relation to the height of the water table. This relation of altitudes in turn, is governed by relief in topography and, although Florida has low surface elevations, it does have a fair relief. The altitude of the land surface ranges from sea level to slightly less than 400 feet above sea level. The highest land is in western and northern Florida near the Alabama and Georgia lines and along a high erosional sand remnant known as "Trail Ridge" and "The Central Highlands," which extends almost down the center of the peninsula of Florida. These high areas are underlain by Pleistocene clastic deposits, largely sand, and much of the water that falls upon these deposits is absorbed and is stored in the formations to maintain a high column of water that merges with the water table near the land surface. However, in addition to the hydraulic gradient, the amount of flow of water from each spring also depends on the permeability of the formation, which in turn depends on the size and relation of the openings in the formation delivering water into the spring vent. The large connected caverns below the top of the zone of saturation or water table permit a large discharge to springs.

Discharge of the springs varies also with atmospheric conditions and changes in barometric pressure. Heavy rain may cause some springs to become turbid with sediment and organic acids which were washed into the spring by surface water locally and temporarily emptying into the underground reservoir. This local drainage from heavy rainfall may also cause large increases in discharge, and prolonged periods of dry weather may cause decreases in discharge. However, the flow is perennial and none of the springs reported on have ever gone dry. Large perennial flows indicate a large storage capacity in the limestone aquifer, the formation acting as a large reservoir from which the water flows at a rate governed by the hydrostatic head. During wet periods the amount and head of water in the formation are greater than during dry periods. The water table is consequently higher during wet weather and produces a high rate of flow and large discharge. The water table and hydraulic pressure declines during dry weather and the rates of flow and discharge decrease accordingly.

A large part of the water falling on Florida drains underground, but where impervious beds lie at the ground surface the surplus rain water, as it drains off, carves valleys emptying into local drainage basins or the sea. Valleys are also formed by the run off of spring water, and as the larger part of Florida surface streams are spring fed many of the valleys owe their origin to spring development.

Structure

Structure is not necessarily a factor in the control of artesian water flow, except where this structure has established differ-

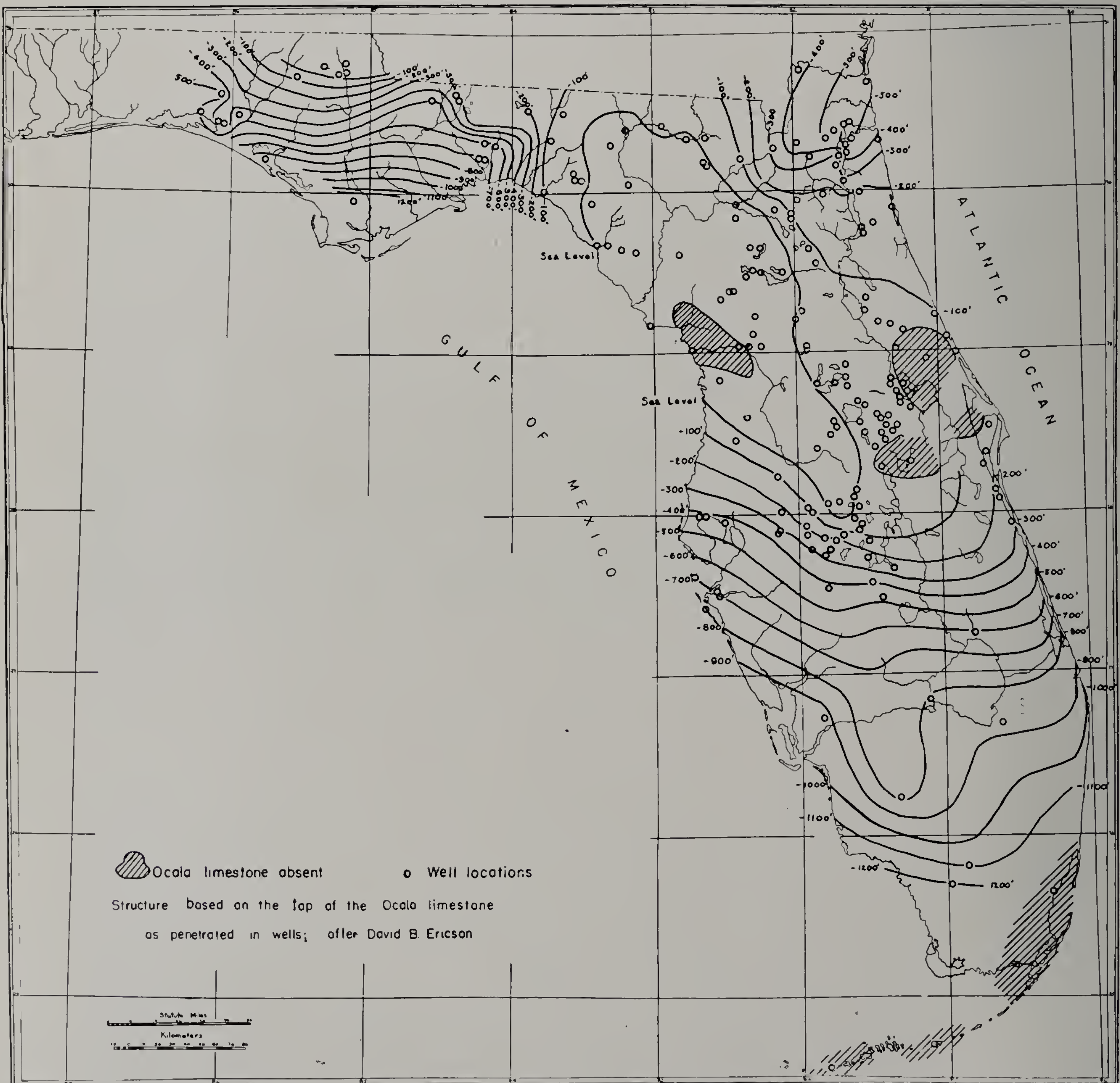

FIGURE 3. Structural map of Florida based on the top of Ocala limestone as penetrated in wells.

entials in head in controlling the location of areas of discharge and recharge. As an illustration, Stringfield[2] has shown that in Florida the water generally flows down dip in western and the

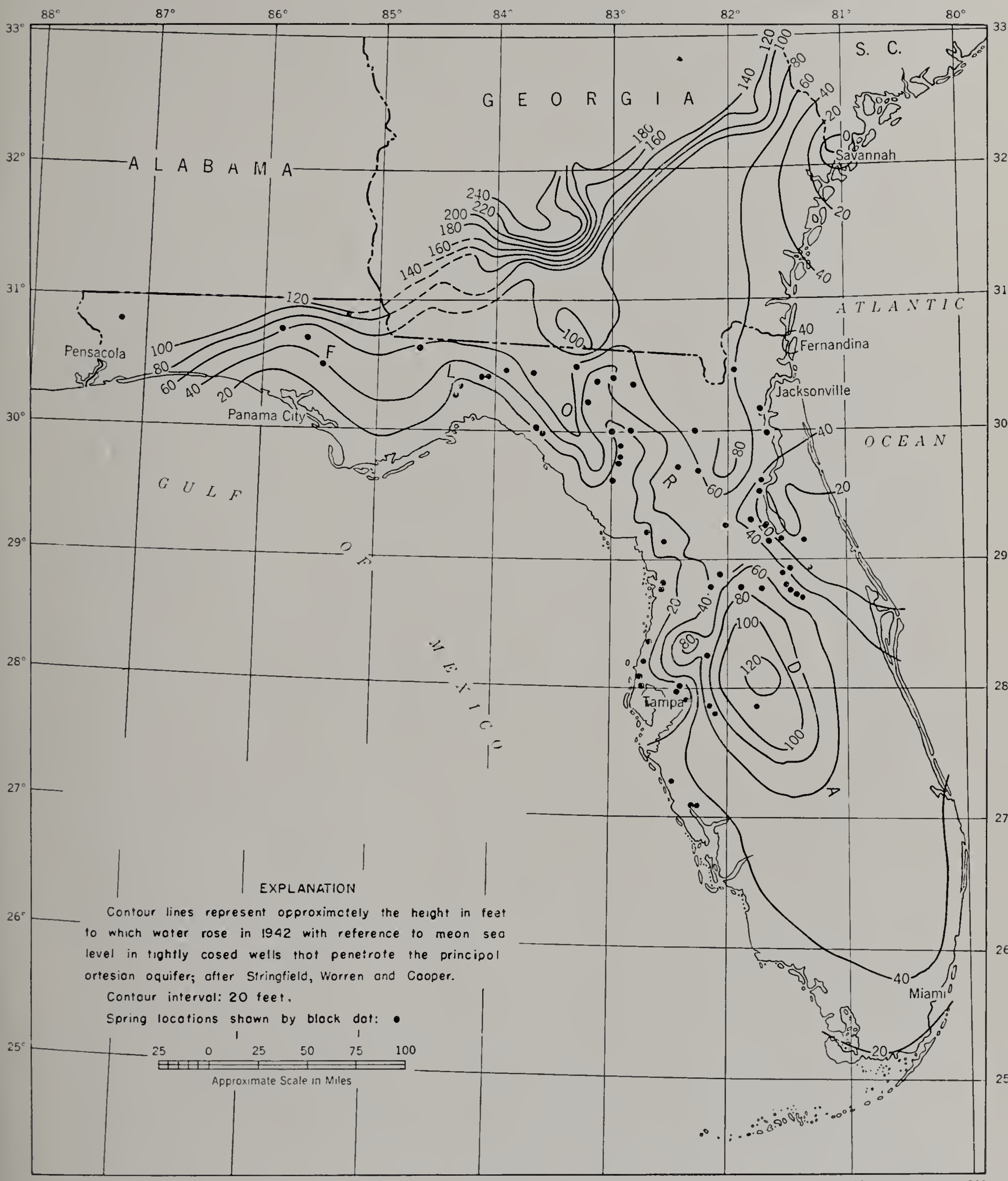

FIGURE 4. Piezometric map of Florida.

[2] Stringfield, V. T., Artesian Water in the Florida Peninsula, U.S.G.S. Water Supply Paper 773-C, 195 pp.

southern peninsular Florida, but in the middle Peninsula the water flows up dip from Polk County to Marion County. This relationship of water flow to structure may be visualized by comparing the structure map of figure 3 with the map of the piezometric surface as shown in figure 4. A structure map represents a specific geologic horizon, whereas in Florida the piezometric surface represents an artesian head that transgresses formation boundaries and which exists in wells penetrating an aquifer composed of several formations. Because the high contours of the two maps do not coincide it is believed that in Florida ground water flow is controlled largely by topographic relief rather than structure, principal recharge areas being located on topographic highs and discharge areas in topographic lows.

The high erosional remnant of Pleistocene deposits, largely sand, extending down the middle of the peninsula is filled with water which mingles freely with the underlying limestone beds to maintain a high column of water. This column of water crosses formation boundaries in that the water table feeds directly through outcrops and sink holes into a section made up of several beds of limestone, the fluids of which mingle through cavities and caverns. The aquifer is thus greatly expanded through these higher and younger beds in the vicinity of Polk County and elsewhere along this ridge and thus the head forces the water to move laterally from this area in all directions, even up the "Ocala uplift," to points where erosion has exposed the aquifer and its many caverns.

Figure 3, is a structural map, the contours of which connect points of equal elevation on the top of the Ocala limestone, as penetrated in wells. Since the Ocala has been extensively eroded and younger beds have been deposited on this eroded surface, the structure can be considered only as reflected and highs and lows may have been higher or lower than represented by this map. In general, the major axial crest of what has been termed the "Ocala uplift" trends in a roughly northwest-southeast direction along the west side and somewhat parallels the axis of the peninsular portion of Florida. A minor synclinal flexure parallels this uplift to the east in the vicinity of Jacksonville and extends south to about Titusville.

The structure in western Florida is a gentle southerly slope of about 25 feet per mile which is modified by two troughs centered in Gadsden and Jefferson counties and a nose centered in Leon County.

Shallow structures contribute directly to the control of flow of artesian water and to the development of Florida's large springs by the elevation of portions of Florida which were subsequently eroded to develop considerable topographic relief. The deeply buried structures associated with the Cretaceous deposits are not considered to bear directly on the control of artesian flow except where they have modified the younger structures.

Hydrology

Most general textbooks on geology, hydraulics and hydrology discuss the conditions required for the occurrence of artesian water. Unfortunately only the simple and ideal conditions are usually considered so that conceptions of the conditions necessary for artesian flow are established and can not be sustained in the field. The ideal basin structure is present in Florida but it as well as the equally ideal sloping and covering impervious beds are not essential. In fact, in some areas in Florida all these textbooks conditions are absent, and artesian water travels up dip in a porous limestone aquifer covered by nothing more impervious than unconsolidated sand or dense limestone matrix. This is illustrated in figure 5.

In order to clarify the use of the term "artesian," in this chapter, it is considered that any water confined or partly confined in an aquifer under hydrostatic head is artesian regardless of the physical character and structure of the rock or of the direction of movement of the water. In general, all large springs in Florida are artesian springs that are fed by underground streams running through caverns. Falmouth Springs, a tributary to the Suwannee River exposed by partial collapse of the cavern roofs, is similar to one of these streams although it probably is not artesian except perhaps after heavy rains or when the Suwannee is in flood stage. The water in the cavities of the limestone beds of an aquifer in any selected area is so connected that for practical purposes the vent of each spring may be considered the mouth of an underground stream and the head of a surface stream. Like surface streams, the mouth of the subsurface stream may be made up of many distributaries so that some springs have several vents from which the water issues. In Florida the flow of artesian water through the cavities and caverns of permeable rock is largely controlled by the relationship which exists between the locations of areas of large discharge and large recharge. This can be stated more simply as the distribution of hydrostatic

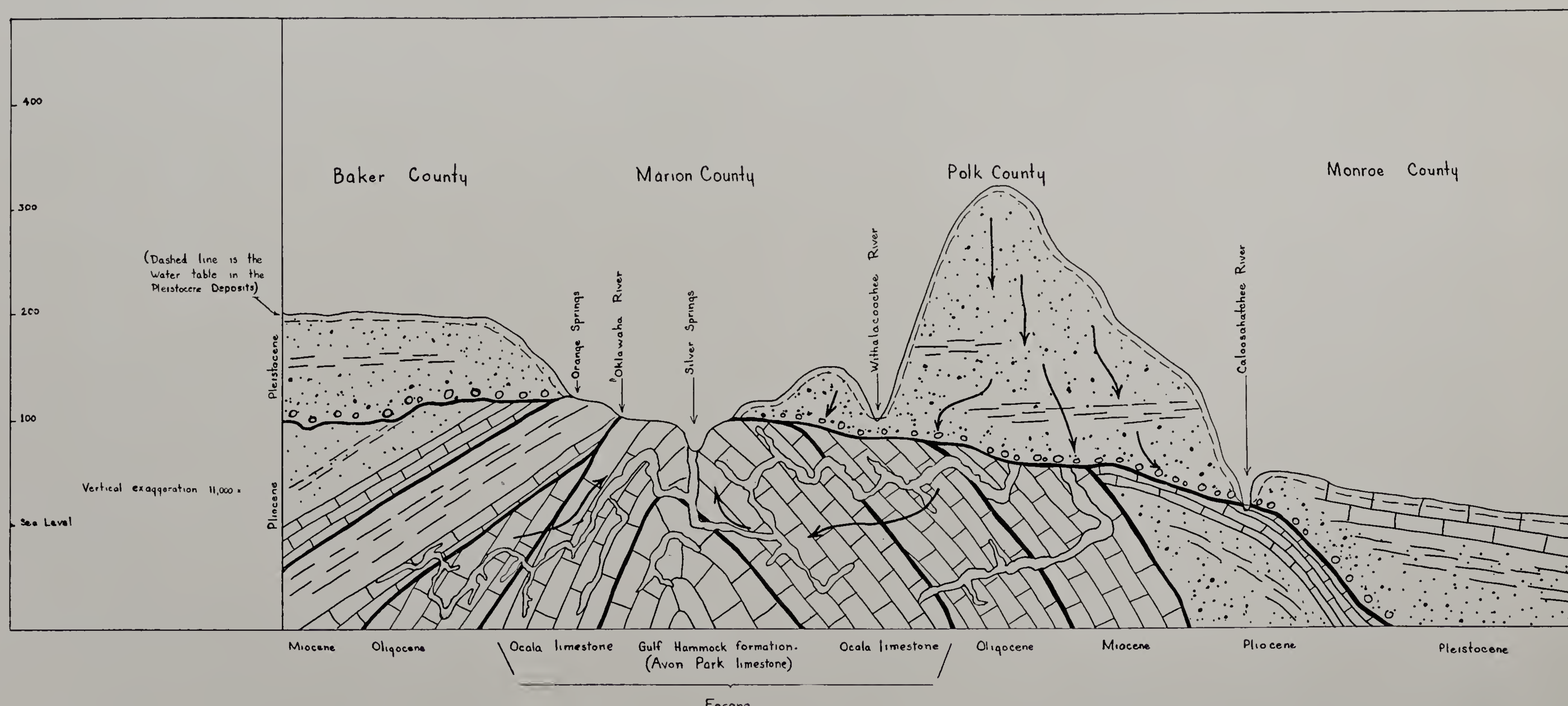

FIGURE 5. Generalized and diagrammatic cross section through the peninsula of Florida, greatly foreshortened. Horizontal scale: 1″ to 220 miles, vertical scale: as indicated.

head. A water gradient or slope exists between a discharge area or low head and a recharge area or high head, down which the ground-water flows. The limestone aquifers are covered in some areas by less permeable beds so that water is retained and conducted through cavities in the limestone under pressure of a column of water much like water in a pipe.

Figure 4, is a graphic representation of the height above sea level at which artesian ground-water stood in 1942 in tightly cased wells which penetrated the principal water-bearing beds. This imaginary surface is known as a piezometric surface, and the one illustrated does not differ materially from that of the present time. Principal recharge areas are located on Latitude 28 degrees, two places on Latitude 30 degrees and in Southern Georgia, but recharge areas exist also wherever the land area is higher than the piezometric surface, if there is no impervious cover to prevent the water from entering the artesian aquifer. In fact, because the aquifer is near the surface and sink holes are usually well developed in discharge areas, ideal conditions for recharge also exist in these areas, but this water is discharged rather rapidly and locally from the artesian aquifer.

Principal discharge areas occur along coastal areas and along the trough shown in figure 1, extending down the St. Johns River Valley crossing the Peninsula between Latitudes 29 and 30 degrees and fanning out on the western coast of peninsular Florida. Another trough in the piezometric surface running along Longitude 83 degrees marks the course of the Suwannee River, the bed of which is marked by an almost continuous line of springs. This is proved by the increase in minimum discharge progressively down the Suwannee River which is not accounted for by measured inflow from known springs and streams tributary to the Suwannee. The Suwannee River minimum flow above White Springs is 4.8 second-feet whereas at Ellaville the minimum discharge is 1,000 second-feet. The total discharge from tributary springs and streams is less than 400 second-feet which leaves about 595 second-feet that must be discharged from springs into the river along its channel, see figure 6. Similar comparisons can be made along other sections further down the stream, but complete data are not available. In the discharge areas discussed above are located the majority of our large springs, as shown in figure 4.

It is considered that water enters an aquifer through sink

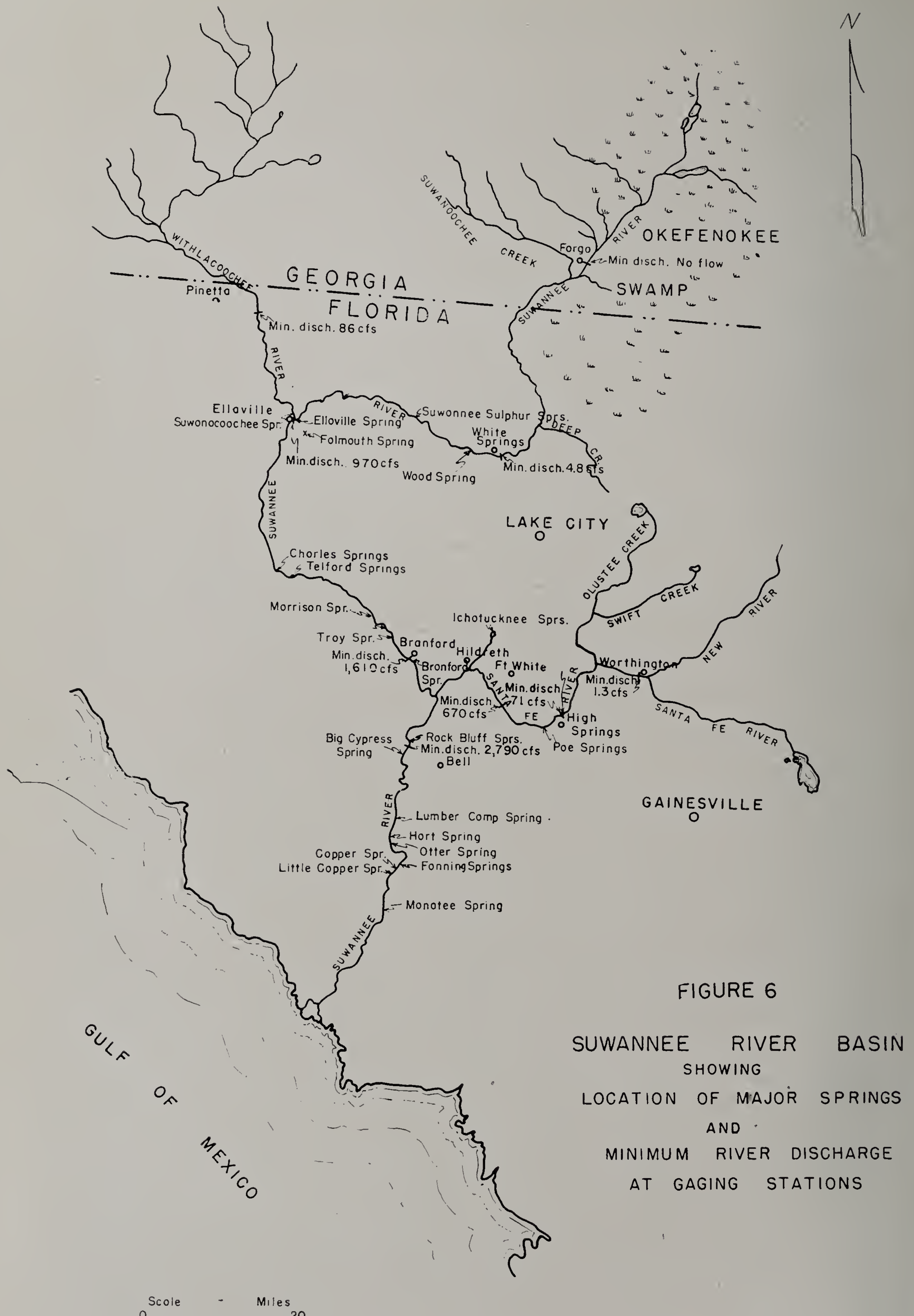

FIGURE 6. Map of the Suwannee River and its tributaries, illustrating increase in discharge down the River as a result of sub-channel springs.

holes, through overlying pervious beds, or directly through cavities in the aquifer at its outcrop. Where openings in this aquifer reach the ground surface at lower elevations water issues out or rises in the opening to the height of the piezometric surface. If this vent to the surface is a natural opening from which water flows it is called a spring, if a pool is formed with no overflow it is called a lake or sink and if artificially made it is called a well.

Formation of large solution features

The mechanics of the formation of the large caverns and cavities in these limestone beds are of some interest to the observer of these large springs, since they control the flow of water.

It has been proved in laboratory practice and by observation of bedded rock that limestone and dolomite are soluble in water, and where these rocks are saturated the ground water, containing natural acids, acts as a slow solvent, moving through open spaces, connecting crevices or cavities and increasing the permeability of the rock by dissolving the carbonate rocks. In this manner large caverns, fissures and cavities are slowly formed and become a connective system of channels, through which streams, partially or completely filling the cavity, may run.

The generally accepted theses covering the physical and chemical aspects of the solution of limestone and of sink hole formation rarely include a conception of the effect of artesian water upon soluble aquifers such as limestone. It has generally been accepted that sinks and caverns are formed above the ground water table as the result of the localized solution of limestone, and that the effectiveness of water as a solvent decreased as the water table was approached. However, in 1930 Davis[3] advanced the thesis that caves are formed in rock saturated with water and Bretz[4] presented evidence in 1942 to support Davis. Since water in an artesian aquifer is under pressure any solution of this aquifer must necessarily be carried on while the rock is saturated.

Waters that contain free carbon dioxide, oxygen and hydrogen sulphide are capable of dissolving large amounts of lime-

[3] Davis, W. M., Origin of limestone caverns, Geol. Soc. America Bull. vol. 41, No. 3, pp. 475-628, September 30, 1930.

[4] Bretz, J. Harlan, Vadose and phreatic features of limestone caverns: Jour. Geology, vol. 50, No. 6, part 2, pp. 675-811, August-September, 1942.

stone[5], and water under pressure will dissolve and hold larger amounts of these gases than free water. The heavy rainfall, prolific decaying vegetation in Florida and the low evaporation and agitation in these confined reservoirs cause the artesian waters to be heavily charged with organic acids and acid forming gases[6]. The solution of limestone aquifers in Florida is therefore active and rapid, and the cumulative effect of this solution probably runs the length of the aquifer as many cavities have been encountered far from the recharge areas at great depths in the drilling of artesian and oil test wells. In fact, the gentle dip of the beds, the high purity and inherent porosity of the carbonate rocks, the flat sand-covered divides between relatively few surface streams, the dense vegetation and humid climate, the relatively high relief and the active circulation of artesian waters all combine to create in Florida the most favorable conditions for the active solution of carbonate rock by water.

Because of greater porosity toward the surface the solution by artesian water under hydrostatic head would tend to expand upward along joints and more soluble rock to an overlying impervious bed. In areas where this bed is near the surface the unsupported roof may collapse, but in areas where there is no definite impervious bed the artesian water may dissolve the limestone to a position near the surface where roof collapse follows, or the artesian solution cavities may merge with those formed under water table conditions. Sinks with rims that lie above the piezometric surface generally contribute surface and rain water to the underlying aquifer.

If there were no open cavities in an artesian aquifer through which the water could escape it eventually would become saturated with soluble salts and become stagnated. However, the porous nature of limestone aquifers in Florida provides many outlets, as evidenced by the many artesian springs and clear-water streams, and circulation is assured.

In the study of the caves of Florida that lie above and below

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[5] Carbon dioxide dissolved in water is carbonic acid, the most common natural solvent of limestone, and free oxygen may combine with hydrogen sulphide to form sulphurous acid, which in converting calcium carbonate to calcium bi-sulphide liberates carbonic acid.

[6] Dr. A. P. Black, consulting Chemical Engineer, Gainesville, Florida (personal communication, November 11, 1942) analyzed the water from 26 selected wells that penetrated the Ocala limestone reservoir in Baker, Duval, Clay and St. Johns counties, all well away from recharge areas. The total CO_2 content in these waters ranged between 3.0 and 25.0 parts per million, and 17 waters analyzed 10.0 p.p.m. or more. The total H_2S content ranged up to 2.5 parts per million and 19 of the waters analyzed 1.0 p.p.m. or more.

the present ground water table it is well to remind the student of geomorphology that the preponderance of evidence in Florida indicates that sea level, and correspondingly the ground water levels, occupied positions during the Pleistocene epoch considerably higher and considerably lower than at present and has occupied positions between these levels since the Pleistocene epoch was initiated. But cavities have been penetrated at depths up to 8,000 feet in oil test wells and circulation of mud in the well has been lost at lower depths. Since the maximum change of sea level is believed by most glacialogists to have been in the nature of 300 feet below and above the present sea level, these eustatic sea-level changes during Pleistocene time could have had little effect on the formation of these deep cavities and artesian gas-charged waters logically can be assumed to have played an important part in the formation of these cavities.

Geology

As indicated in the previous discussion, the springs of Florida are intimately associated with carbonate rocks, which are the aquifers, and, as would be expected, the larger number of springs occur in the peninsular region where the rocks are predominantly limestones and dolomites. In western Florida where the rocks are predominantly sands and clays the springs are less frequent and are as a rule smaller. The Ocala limestone is considered to be the principal water-bearing bed, but is connected by cavities and caverns to other limestones that differ in faunal content and lithology. In some areas the Ocala limestone is the only artesian aquifer. In other areas the Chipola, Hawthorn, Tampa, Suwannee, Byram and Marianna formations are added to the underlying Ocala limestone to make a thick aquifer, see Table 1. In general, the artesian aquifer can be considered to consist of the complete limestone section older than the Pliocene beds. The clay, dense marl and limestone beds of the Hawthorn formation of Miocene age are the important impervious beds covering the aquifer, but the clays and marls of other Miocene formations and of the Pliocene and Pleistocene deposits may be locally important. In fact, the caverns of the limestone aquifers may provide such a proficient aqueduct that a non-cavernous part of the aquifer may be sufficiently tight to provide the necessary impervious cover.

Throughout the Pleistocene epoch Florida was covered intermittently by sea water, and thick continental and marine deposits of sand, gravel, shell marl and clay were deposited. These porous and pervious deposits have accumulated as a mantle over both the upland areas and in stream valleys, and they serve as a large initial reservoir which decreases run-off and through which rain water percolates without difficulty down to the underlying bedrock.

The most abundant and widespread bedrocks in Florida are limestone and dolomite. The beds generally are of consistently high purity, but the younger limestones are high in phosphate and sand and are generally more indurated and less pervious. The geologic section of the bedrock in western Florida is largely composed of clastic fragments of other rocks which were mechanically transported by streams and oceans and deposited in Florida as sands, clays and gravel. The few beds of limestone in the western Florida section were deposited as beach shell accumulations and chemical precipitates in deeper water. The geologic section of the Tertiary bedrock in peninsular Florida is composed almost entirely of chemically precipitated limestone and beach accumulated shells. The transition between the two sections occurs along the northwestern part of peninsular Florida.

The geologic formations present at the surface of Florida probably are 1,300 to 1,500 feet thick and include rocks of the Eocene, Oligocene, Miocene, Pliocene (?), Pleistocene and Recent. The primary aquifers are the Gulf Hammock formation (Avon Park limestone) and the Ocala limestone of Eocene age; the Suwannee limestone of Oligocene age; the Tampa and Hawthorn formations of Miocene age.

The Gulf Hammock formation (Avon Park limestone) underlies most of peninsular Florida and crops out in Citrus and Levy counties. It is essentially dolomite and limestone and has a maximum thickness of 700 feet. It is represented in the subsurface of western Florida by sands, clays and marls of probable Lisbon age. The formation is locally important as a source of water in Citrus and Levy counties on the western peninsular coast and in Seminole, Volusia, Orange, Brevard and Osceola counties where it lies relatively near the ground surface. From well records the formation is known to be absent in parts of Columbia, Hamilton and Suwannee counties. The water from this formation is generally very mineralized and hard. The beds older than the Gulf Hammock formation, while saturated with water, are usually highly mineralized and contribute directly to

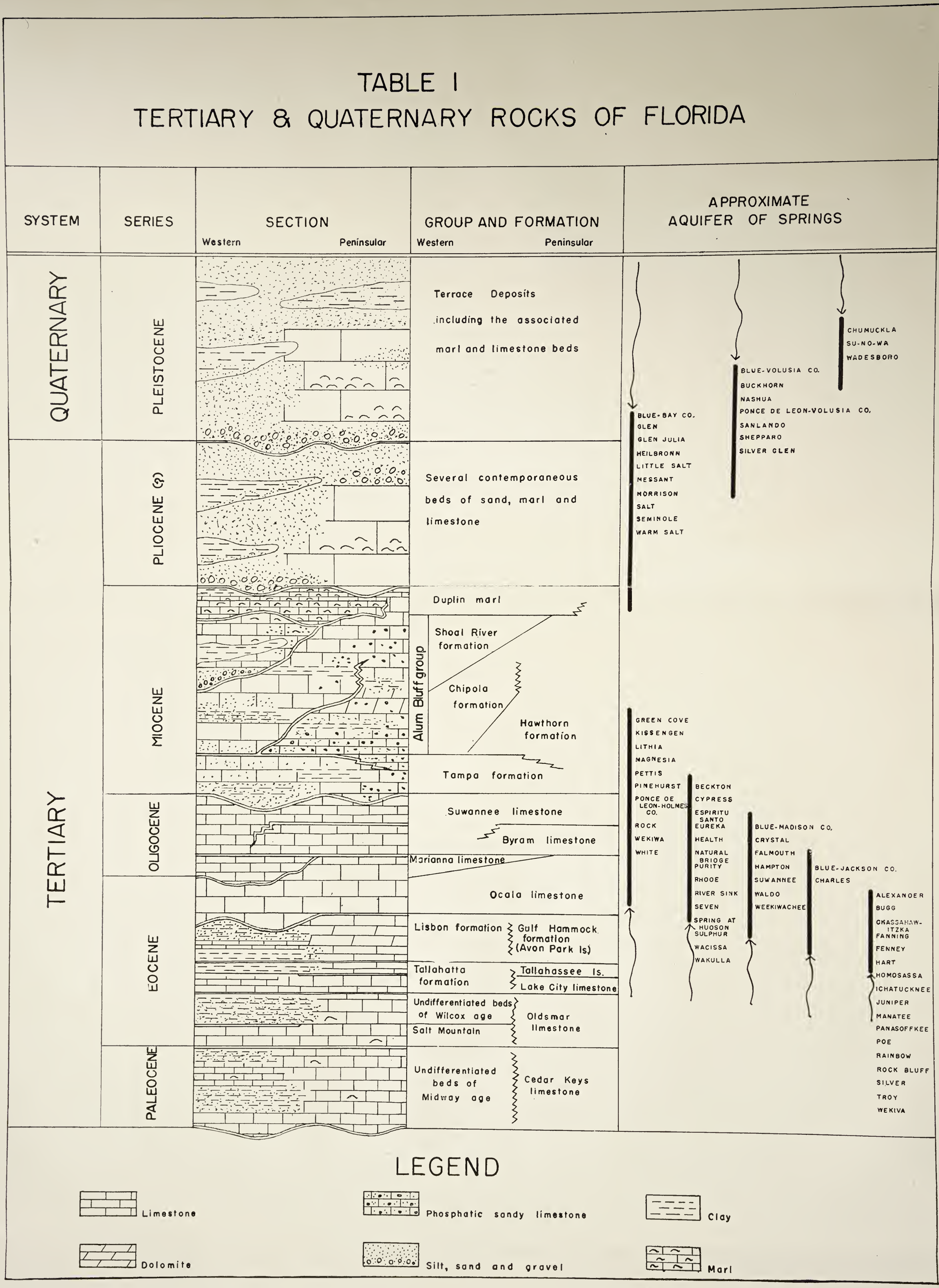

Table 1. Chart of the Tertiary and Quaternary formations of Florida, showing the approximate aquifer of selected springs.

the artesian water in springs and domestic water wells only where the stratification equilibrium existing normally in the underground waters is upset.

The Ocala limestone lies at or near the surface in the west central part of the peninsula and in the middle and northern part of western Florida. This is the principal artesian aquifer and source of Florida's drinking water. The formation is a massive, chalky, porous limestone of high purity and is very variable in thickness. It is known to be at least 300 feet thick in the central peninsular Florida but it thins toward the north and is known from well records to be absent in parts of Brevard, Lake, Orange, and in Citrus and Levy counties where the Gulf Hammock crops out.

The Marianna limestone has been mapped in only Holmes and Jackson counties. There it has a maximum thickness of 30 feet and is a soft, white, chalky limestone, locally indurated and slightly glauconitic at the base. The Marianna limestone rests directly on the Ocala limestone and is overlain by the Byram limestone or, where it is not recognized, by the Suwannee limestone. It is important only locally as an aquifer.

The Byram limestone has been recognized at the surface in Jackson County in western Florida and along the Suwannee River in peninsular Florida. The base of the Suwannee limestone in Holmes and Washington counties, western Florida, show faunal similarities to the Byram and may represent it in this area. The Byram limestone is generally cream-colored, sandy, soft, porous and granular. Locally it is indurated and contains beds of argillaceous limestone. The Byram rests directly on the Ocala limestone and is overlain by the Suwannee limestone in peninsular Florida. In western Florida it rests on the Marianna limestone and is overlain by the Suwannee limestone, except in the area where it may be represented in the base of the Suwannee. The limestone is from 10 to 40 feet thick and is not important as an aquifer.

The Suwannee limestone overlies the Ocala limestone and crops out in the northwestern and east central parts of the peninsular and as an arcuate band extending across Holmes, Washington and Jackson counties in western Florida. It is a soft, porous, granular limestone of high purity and as an aquifer approaches the Ocala limestone in importance. It has a maximum thickness of 450 feet but well records indicate that it is absent in northern Jackson County and in the central and eastern parts of the Peninsula.

The Tampa limestone overlies the Suwannee limestone and crops out in the west-central and northwestern part of the Peninsula and in scattered areas in western Florida. In the eastern part of western Florida and the northern part of peninsular Florida where the Tampa is not present it may be represented in the base of the Hawthorn formation which overlies the Suwannee. In the Peninsula the Tampa formation is largely limestone but in the northern part of the Peninsula and in parts of western Florida the formation consists of siltstone, silt, clay and phosphatic limestone. It ranges from 100 to 200 feet in thickness.

The Hawthorn formation in the eastern part of western Florida and in peninsular Florida overlies the Tampa formation but rests directly on older formations where the Tampa can not be separated as a unit or where erosion has removed part of the section. The Pliocene and Pleistocene sands and marls generally overlie the formation but it lies not far below the surface in most of Florida except in the outcrop areas of the older beds. The Hawthorn may represent the complete Miocene section in some areas of the northern Peninsula and western Florida, but several divisions of the Miocene are recognized in other parts of western and peninsular Florida, where the Hawthorn has not been recognized, see Table 1. Thin bedded clay, fuller's earth, dense marl, phosphatic limestone make up the formation which may be up to 500 feet in thickness.

C. THE DISCHARGE of FLORIDA SPRINGS

By G. E. Ferguson

District Engineer, Surface Water Division, U. S. Geological Survey

Why are spring flows measured?

Knowledge of the quantities of water discharged by the major springs of Florida is necessary to the wise utilization and conservation of the water resources of the State. These springs furnish many Florida streams their only substantial supplies of water during dry periods. The successful use of these spring-fed streams, whether for industry, navigation, agriculture or recreation, is made possible largely through accurate records of the amounts of water available.

The amounts of spring discharge reveal also the quantities of water stored in the huge natural underground reservoirs with which many parts of Florida are blessed. The water we see emerging from springs is either the overflow or leakage from these underground basins. A relatively large flow indicates a large supply in the basin; and in general a small discharge reveals a small supply.

For these reasons the investigational work on Florida's springs has been devoted largely to the periodic measurement of discharge of the major springs. Other physical data can be collected at any time but valuable knowledge of the trends and characteristics of the discharge can be had only through the long continuance of careful measurements.

What is a "second-foot"?

The discharge of a spring is the rate at which known unit quantities of water emerge from underground channels through the spring's natural outlet orifices into the surface channels. In the measurement of the flow of water several different units have been adopted. The hydraulic engineer most often uses the term "cubic foot per second". A discharge (or flow) of one cubic foot per second (also referred to as a "second-foot") is equivalent to a stream one foot wide, one foot deep, and moving at the average rate of one foot per second. If the stream is two feet wide or if the water is moving at the average rate of two feet per second, the discharge is then *two* cubic feet per second (or two "second-feet"). The discharge of a spring is thus the product of the area, in square feet, of the cross-section of the outlet channel or orifice and the average velocity of the water, in feet per second, at that section of the channel. Since a discharge measurement is usually first calculated in "second-feet" and since the "second-foot" is adopted for river measurements, that unit is given prominence in this report. The reader may find it helpful to consider a flow of one second-foot as that which would (1) fill a one-acre area to a depth of about two feet in 24 hours or (2) satisfy the water requirements of an average type American city of about 6,000 population or (3) fill a typical 35 by 20 foot swimming pool in about one hour.

The discharge of large springs is also frequntly expressed in "millions of gallons per day." One "million gallons per day" is equal to 1.54+ second-feet. One second-foot equals 0.646 million gallons per day (or 646,000 gallons per day).

For the smaller Florida springs the unit "gallons per minute" is used and is perhaps the most satisfactory of the flow units for the non-technical reader to visualize. One second-foot equals 448 gallons per minute.

The measurement of spring flows

Over many parts of the country spring flows are measured simply by determining the length of time required for the discharged water to fill a vessel of known capacity. This volumetric method is only rarely applicable to the measurement of Florida springs because the flows are ordinarily far too large. Moreover, the spring orifices are usually well submerged and the rates of flow are best determined by river measurement methods in some straight and uniform reach of the run or channel downstream from the spring pool.

These measurements[7] require the use of an instrument called a "Current-meter" which measures the speed of the water in the selected cross-section of channel. The depths of the water and the area of the particular section are measured by sounding lines and tapes.

The discharge values covered in this report are nearly all the results of current-meter measurements. Many are accurate within 5 percent or less and almost all within 10 percent except for the measurements prior to about 1920. The accuracy of these few earliest measurements is unknown but adequate measuring equipment was not always available and rough estimates of flow may, at times, have been necessary.

Clean and straight reaches of channel suitable for measurements are sometimes found only at some distance downstream from the springhead. Any appreciable inflow between the spring pool and this measuring section has, when possible, been measured and deducted. During storms or very wet periods some surface water drainage may have been inadvertently included since it often cannot be effectively segregated. Such

[7] For complete description of the methods used in making current meter measurements refer to U. S. Geological Survey Water Supply Paper No. 888, Stream Gauging Procedure, pp. 13-76, 1943.

surface drainage, however, is usually small as compared to the spring discharge. For this reason, the discharge, as measured at the selected section of the channel downstream, is considered as the discharge of the particular spring. Once a measuring section has been carefully selected, it is usually used indefinitely. This permits more effective comparisons between measurements.

How the discharge of a spring varies

As the visitor views one of the Florida springs he is usually impressed by the apparent stability of the flow. Yet systematic observations and measurements reveal spring flow as ever changing. As the rainfall, filtering downward through the sand and rock fills the contributing underground basins, greater quantities of this water are discharged by the spring. Conversely, as the ground-water table lowers, the spring flow decreases. This responsiveness to rainfall gives the discharge of Florida springs particular characteristics which are illustrated in figure 7. On this plate are plotted in cubic feet per second the discharge of several of the largest Florida springs.

Perhaps the most noticeable characteristic of discharge is its seasonal variations. The Florida peninsula often receives about one-half of its annual rainfall in the summer months. This usually results in well-replenished ground-water basins and consequently greater spring flows by early fall. Discharge then slowly recedes, broken only by occasional individual heavy rainfall, until the next summer wet season.

Response to storm rainfall is often pronounced and rapid. For instance, the discharge of both Silver Springs and Rainbow Springs increased greatly following the outstanding storms during September 1933 and October 1941. Conversely, the extremely low discharges of these springs occurred during the extreme drought conditions of 1932.

A third characteristic is evidenced by the degree to which a spring varies above and below its average value. For example, this range in fluctuation is seen to be somewhat greater for Silver Springs as compared to that for Rainbow Springs.

Comparison of discharge of Florida springs

The size of a spring is often evaluated on the basis of its discharge. The average discharge seems to be the best value for this purpose. The minimum discharge might also be considered since this represents the quantity of water that is available at all times. The comparison of peak or maximum flows, however, is to be avoided, because during or following the storm periods in which these maximum flows occur, storm surface waters and subsurface ground waters flow into the channel above the measuring section and may be included in the measured spring discharge. For this reason the maximum storm discharge as shown on figure 7 may not always represent true spring discharge to the same degree of accuracy as the other measurements.

A single or relatively few discharge measurements of a spring do not always accurately indicate its average flow. If such measurements were made during or following a drought the measured discharge was probably somewhat less than normal. If the spring was measured following heavy rainfall and substantial recharge to the underground basin, the value obtained was likely greater than normal. The hydrographs of discharge shown on figure 7 show clearly the times and amounts of fluctuations for the springs indicated. The times and rates of changes in discharge of other springs in the general area would be expected to have similar patterns of variations. The greater number of discharge measurements, made during all seasons of the year, the better defined is the average spring discharge.

The table below shows the number of springs of first magnitude, or springs with a probable average flow of 100 second-feet (64.6 m.g.d.) or more, in the various regions of large springs in the United States. The information has been extracted from a table in the volume entitled "The Large Springs of Missouri" by H. C. Beckman and N. A. Hinchey, published by the Missouri Geological Survey and Water Resources in 1944. The number of springs shown for Florida has been revised by the writers on the basis of more recent information.

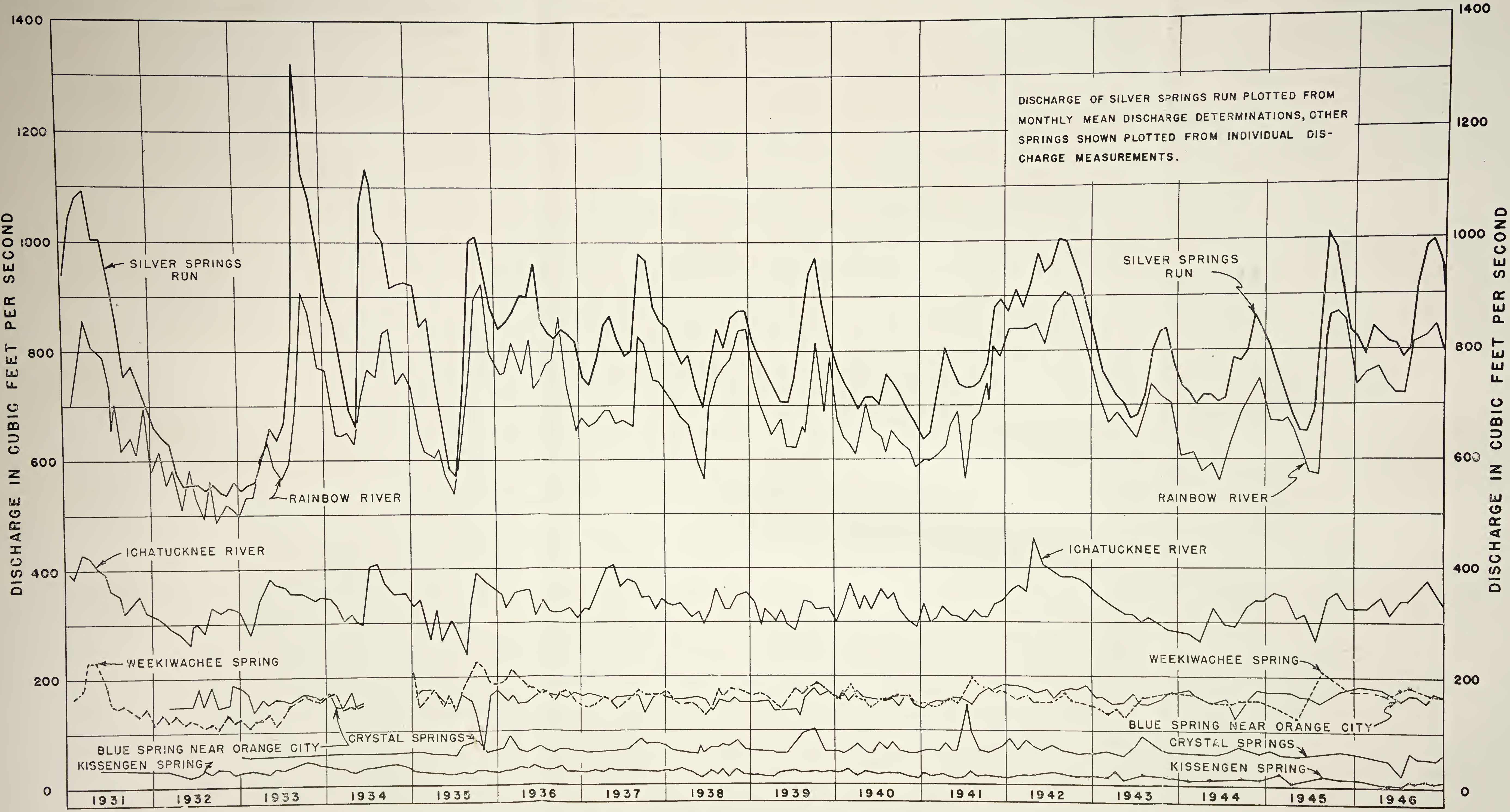

FIG. 7 GRAPHS COMPARING FLOWS OF SPRINGS OF FLORIDA HAVING LONGER RECORDS DURING THE PERIOD 1931-46.

NUMBER OF SPRINGS OF FIRST MAGNITUDE IN THE UNITED STATES

(Average flow of 100 second-feet or more)

REGION	NUMBER OF SPRINGS
Florida	17
Snake River Basin in Idaho	15
Ozark region of Missouri (including Mammoth Spring just south of Missouri-Arkansas State line)	12
Deschutes River Basin, Oregon	8
Sacramento River Basin, California	7
Willamette and Umpqua River Basin, Oregon	5
Balcones fault belt in Texas	4
Montana	3
Klamath River Basin, Oregon	2
Northern Alabama and adjacent areas	1
Interior basins of Oregon	1
Total in the United States	75

Based on this tabulation, Florida has the greatest number of first magnitude springs in the United States. It also has approximately 49 springs of second magnitude, or springs having an average flow of 10 to 100 second-feet.

The primary vents of both Silver and Rainbow Springs are believed to have larger average flows than any limestone spring in the United States and possibly in the world. Certainly the total average flows down Silver Springs Run and Rainbow River, 808 and 699 second-feet respectively, will rank these springs among the largest in the world.

Significant trends in discharge

Spring flow reflects conditions of water supply in the underground basins and changes in spring flow over a considerable number of years usually reveals significant changes in water supplies from these basins. A study of figure 7 shows only one spring with a significant change in flow. Kissengen Spring in Polk County has, since periodic measurements were begun during 1932, shown a gradual reduction in flow. This is consistent with reports that ground water supplies are decreasing in this area in which there are heavy demands for water for irrigation.

D. QUALITY of FLORIDA SPRING WATERS

By S. K. Love
Chief, Quality of Water Division, U. S. Geological Survey

Introduction

All natural waters contain dissolved minerals. The minerals are derived from soil, rocks, and vegetative matter with which the water comes in contact. The quantity of dissolved minerals in a water depend primarily on the type of soil or rock material through which the water has passed and the length of time that contact is maintained.

In general, ground water contains more dissolved minerals than surface streams. This is largely the result of a longer contact period between ground water and the surrounding rocks and soils. Since spring water is usually considered to be ground water, spring water should be expected to contain more dissolved minerals than surface waters. This is generally true, although some springs yield water containing less minerals than nearby surface streams.

Chemical analyses were made on samples collected between April and July 1946 from 38 springs described in this report. Analyses of 18 of these springs were made in 1923 and 1924 and are published in the Federal Survey's Water-Supply Paper 596-G, "Chemical Character of Water of Florida." Analyses are also given in Water-Supply Paper 596-G for 5 springs included in this report but from which samples were not collected in 1946. In order that all of the available analytical data may be presented, analyses given in Water-Supply Paper 596-G are repeated in this report.

The minerals in solution

The characteristics and dissolved mineral constituents of spring waters discussed in the following paragraphs include those found in quantities sufficient to have practical effect on the value of the waters for ordinary use.

Color.—The term "color" refers to the appearance of water free from suspended solids. Natural color in water is caused almost entirely by organic matter extracted from leaves, roots, and other substances in the ground. A color less than 20, based on a graduated scale of standard colored-glass disks, usually passes unnoticed. Some swamp waters have natural color of 200 or more. Surface waters usually are more highly colored than ground waters. In passing through rock materials color in water is partly or completely removed. Florida springs ordinarily are not highly colored.

Exceptionally clear water free from color due to organic matter appears blue when viewed through a depth of several feet. This natural blue color of clear water is caused largely by a scattering of sunlight by the water molecules. Since most of the scattering occurs in the short wave lengths of light which are located toward the blue end of the visible spectrum, the result is that the water appears to be blue. Thus, the deeper the water is penetrated by sunlight the more scattering that will take place and hence the bluer the water will appear. Because many springs in Florida are exceptionally clear and relatively deep, it is natural that they should have a blue color.

Hydrogen-ion concentration (pH).—The intensity of acidity or alkalinity of a water, as indicated by the hydrogen-ion concentration, is of importance with reference to corrosive properties of water, and to proper treatment for coagulation at water-treatment plants. The symbol pH is commonly used to indicate the hydrogen-ion concentration. For practical purposes, the pH scale may be used with reference to acidity and alkalinity, as a temperature scale is used with reference to heat conditions. A neutral water has a pH of 7.0. The pH of most natural waters varies between 6.0 and 8.0. Some alkaline waters have pH values greater than 8.0 and waters containing free mineral acid have values less than 4.5.

Specific conductance.—The specific conductance of a water is a measure of its ability to conduct a current of electricity. It varies with the concentration and the degree of ionization of the different minerals in solution. For spring and ground waters that have fairly uniform composition, the specific conductance bears a fairly definite relation to the total concentration of dissolved minerals.

Silica (SiO_2).—Silica is dissolved from practically all rocks. A few natural waters contain less than 3 parts per million of silica and some contain more than 50 parts, but most of them contain from 10 to 30 parts per million. Silica affects the usefulness of a water because it contributes to the formation of boiler scale. Otherwise silica is of little practical importance.

Iron (Fe).—Iron is dissolved from many rock materials. On exposure to air water that contains more than 1 part per million of iron soon becomes turbid with the insoluble compound produced by oxidation; surface waters therefore rarely contain as much as 1 part per million of dissolved iron. Ground waters and certain spring waters, however, frequently contain several parts per million of dissolved iron until they are brought in contact with air.

Calcium (Ca).—Calcium is dissolved from practically all rocks, but particularly from limestone, dolomite, and gypsum. Calcium and magnesium make water hard and are the active agents in forming boiler scale. Most waters from granite contain less than 10 parts per million of calcium; many waters from limestone contain from 30 to 70 parts; and waters that leach deposits of gypsum may contain more than 100. Since limestone, which is essentially calcium carbonate, is widely distributed throughout Florida and is the principal rock material in which large springs are found, relatively high concentrations of calcium are found in most Florida spring waters.

Magnesium (Mg).—Magnesium is dissolved from many rocks but particularly from dolomite. Its effects are similar to those of calcium, but waters that contain much magnesium and chloride are likely to be corrosive, especially in steam boilers. The magnesium in soft waters may amount to only 1 or 2 parts per million, but water in areas that contain large quantities of dolomite may contain 20 to 50 parts per million of magnesium. Except in coastal areas where the ground water is contaminated with sea water and in those areas where saline residues from earlier invasions of the sea still remain, the concentration of magnesium in Florida ground and spring waters is usually relatively low.

Sodium and potassium (Na and K).—Sodium and potassium are dissolved from practically all rocks, but they make up only a small part of the dissolved mineral matter in most waters in humid regions. Natural waters that contain only 3 or 4 parts per million of the two together are likely to carry about equal quantities of sodium and potassium. As the total quantity of these constituents increases the proportion of sodium becomes greater. Moderate quantities of these constituents have little effect, but waters that carry more than 50 or 100 parts per million of the two may require careful operation of steam boilers to prevent foaming. Waters that contain large quantities of sodium salts injure crops and some waters contain so much sodium that they are unfit for nearly all uses. With few exceptions the amount of sodium in Florida spring waters is relatively small. Where there is a large amount of chloride present, such as Salt Springs in Marion County and other saline springs, the amount of sodium present will usually be approximately equivalent to the chloride.

Carbonate and bicarbonate (CO_3 and HCO_3).—Carbonate and bicarbonate occur in waters largely through the action of carbon dioxide, which enables the water to dissolve carbonates of calcium and magnesium. Carbonate is not present in appreciable quantities in many natural waters. The bicarbonate in waters that come from relatively insoluble rocks may amount to less than 10 parts per million; many waters from limestone contain from 200 to 400 parts per million. The solution of limestone rock by natural waters in the presence of carbon dioxide is probably the largest single factor responsible for the existence of large springs in Florida.

Sulfate (SO_4).—Sulfate is dissolved in large quantities from gypsum and from deposits of sodium sulfate. It is also formed by the oxidation of sulfides of iron and is therefore present in considerable quantities in waters from mines and from many beds of shale. Sulfate in waters that contain much calcium and magnesium causes the formation of hard scale in steam boilers and may increase the cost of softening the water.

Chloride (Cl).—Chloride is dissolved in small quantities from rock materials in most parts of the country. The chloride in waters has little effect on their use unless it is present in excessive quantities, as in brines. Although most springs in Florida contain relatively small amounts of chloride, a few spring waters range from moderately to strongly saline. Presumably, the source of the salty water is saline residues remaining from earlier invasions of the sea.

Fluoride (F).—Fluoride has been reported as present in rocks to about the same extent as chloride. However, the quantity present in natural waters is usually much less than that of chloride. Fluoride in water is known to be associated with the dental effect known as mottled enamel, if the water is used for drinking by young children during calcification or formation of the teeth. This condition becomes more noticeable as the quantity of fluoride in water increases above 1 part per million. It is reported that the incidence of dental caries (decay of teeth) is decreased or prevented by quantities of fluoride that are not sufficient to cause permanent disfigurement from mottled enamel. Those springs for which analyses are given in this report contain less fluoride than is normally considered necessary to cause mottled enamel.

Nitrate (NO_3).—Nitrate in water is considered a final oxidation product of nitrogenous material, and may indicate previous contamination by sewage or other organic matter. The quantities of nitrate usually present have no effect on the value of water for ordinary uses.

Dissolved solids.—The quantity reported as dissolved solids (the residue on evaporation) consists mainly of the dissolved mineral constituents in the water. It may also contain some organic matter and water crystallization. Waters with less than 500 parts per million of dissolved solids are usually satisfactory for domestic and most industrial uses. Waters with more than 1,000 parts per million of dissolved solids are likely to be unsuitable for most domestic and industrial uses.

Hardness.—Hardness is the characteristic of water that receives most attention with reference to industrial and domestic use. It is usually recognized by the increased quantity of soap required to produce lather and by the deposits of insoluble salts formed when a water is heated or evaporated. Hardness is caused almost entirely by calcium and magnesium.

Hardness is usually expressed as the quantity of calcium carbonate ($CaCO_3$) equivalent to the calcium and magnesium present. Water that has less than 60 parts per million of hardness is usually rated as soft and its treatment for removal of hardness is seldom justified. Hardness between 61 and 120 parts per million does not seriously interfere with the use of water for many purposes, but its removal by softening processes may be profitable for laundries and other industries. Water with hardness between 121 and 180 parts per million may have to be treated for many industrial purposes but is usually satisfactory for domestic use. Considerable savings in soap consumption can be effected by softening water in this range of hardness. Water with hardness beyond 180 parts per million can profitably be softened for most purposes although that with hardness of 200 to 300 parts per million is extensively used for domestic purposes.

Carbon dioxide (CO_2).—Carbon dioxide is one of the gases in the atmosphere. It dissolves in water to form carbonic acid, H_2CO_3. It is this acid which reacts with rocks in the ground to form bicarbonates of calcium, magnesium, and other metals. Carbon dioxide in dissolved form is present in most natural waters, especially those in which the pH is less than 7. Ground waters usually contain more dissolved carbon dioxide than surface waters. Decaying organic matter in the ground gives off carbon dioxide which is dissolved in the surrounding ground water, a large part of which is retained in solution, unless the carbonic acid thus formed reacts with surrounding rock material or unless the water is exposed to the atmosphere.

Chemical characteristics

Most of the spring waters described in this report, for which chemical analyses are available, are not remarkable as to their content of ordinary mineral constituents. Many of them have about the same composition as water used for public supplies of several of the larger cities and towns in Florida. While most spring waters are characteristicly calcium carbonate waters, a few of the springs, however, do contain rather large amounts of dissolved minerals, composed mainly of sodium chloride (common salt). There are indications that the high concentrations result either from the admixture of ground water and sea water, or from ground water passing through saline residues remaining from ancient invasions of the sea.

For those springs for which analyses were made in 1923-24 and again in 1946, it will be observed that the concentration of dissolved minerals in most of them was about the same at both times. For a few springs, however, the concentration was somewhat different in 1946 from what it was in 1923-24.

The lowest concentration of dissolved mineral solids determined in the analyses made in 1946 was 15 parts per million for Glen Julia Springs in Gadsden County, and the highest concentration determined was 5,850 parts per million for Salt Springs in Marion County.

PART II

DESCRIPTIONS of INDIVIDUAL SPRINGS

By C. W. Lingham
Assistant Engineer
and Others
of the Surface Water Division, U. S. Geological Survey

Explanation of descriptive data

A uniform system of headings is used to include information relating to location, description, discharge, quality of water, and utilization for each spring. This grouping of compiled data makes the report suitable as a reference. The manner of presentation of data under each heading is as follows:

Location.—Practically all of the springs described in this report can be reached by automobile, hence directions are given to enable one to reach the springs by highway and road. The distances in miles and tenths of a mile which can be read from an automobile odometer are given from post offices or highway junctions to the springs. Land-line locations for the springs have been used when satisfactory driving directions are difficult. The State highway numbers shown are those of the new system recently adopted and shown on the official State Highway Map of Florida for 1946.

Plate 1, a map of the State of Florida, will be found in the pocket inside of the back cover of this report. The locations of selected springs, investigated during the preparation of this report, are shown on this map. It contains also a list of these springs, by counties, with the reference number assisting in its location on the map.

Description.—Under this heading are given the setting and topographic background, drainage pattern, pool characteristics, turbidity, water level and temperature data, and the general characteristics of the spring applicable to its natural state.

The depths of various parts of the spring pools and cavities were determined by soundings usually made with a 15-pound bronze weight on a light aeroplane-type steel cable and are ordinarily accurate to the nearest tenth of a foot. The date of soundings are given for certain springs because of fluctuating water levels in the pool.

The temperatures of the water were measured with Fahrenheit mercury column type thermometers that were accurate to the nearest one-half degree or less. The rates of discharge of the Florida springs are sufficiently great that temperatures taken near the pool surface accurately indicate the temperatures of the water as it emerges from the submerged cavities.

The temperatures of the waters of a spring usually vary but little with the season. These temperatures vary from 68°F to 71°F for the more northerly springs to about 75°F to 86°F for those near the southern edge of the spring area.

Definitions of various terms used in the description of the springs are as follows:

Bank:

Left bank: The bank on the left when facing downstream.

Right bank: The bank on the right when facing downstream.

Boil: An agitated surface disturbance of a spring pool caused by the velocity of spring outflow and suggestive of the boiling of water.

Slick: A smooth surface on the water due to stilling of wave action by spring outflow.

Cavern: An enlarged cavity.

Cavity: A place hollowed out in the rock, generally by solution.

Crevice: A crack or split in the rock, a fissure.

Chimney: A vertical tubular opening in the rock.

Pool: A small and rather deep body of (usually) fresh water.

Head or springhead: The point of origin of the spring, a fountain or source.

Run: A small freely-flowing watercourse.

Sink: A depression in the ground, commonly funnel-shaped, formed by solution and erosion of carbonate rock by surface and ground water.

Spring: A point of emergence of ground water at the land surface, an issue of water from the earth.

Turbidity: The extent to which the clearness of a liquid is obscured due to the suspended sediment.

Discharge.—Under the heading of discharge the measurement of spring flows are given in second-feet or cubic feet per second and the equivalent flow in million gallons per day, or in some cases where flows are relatively small the unit "gallons per minute" has been used. The date and discharges are listed in chronological order. When measurements at a spring are numerous the average only of all of the measurements is given together with the dates and values of the maximum and minimum flows during the period of record. For a few of the springs having more comprehensive coverage annual mean flows and monthly mean flows have been computed.

In interpreting data from the springs one should be mindful that at many locations cross sections with excessive aquatic vegetation, fallen trees, and rocky stream-beds make flow measurements difficult. Also many springs are located along the banks of the larger rivers and because of backwater are subject to reduction of flow if not actual reversal in flow at higher stages of the rivers.

Quality of water.—The source and significance of the mineral constituents are described earlier in this report. A short general statement relating to the chemical composition of the water of the individual spring precedes the tabulated results of analyses.

Utilization.—This section describes present and past uses of the spring. As one visits various springs in the state he is impressed by the varying stages of development and use. For example in Hillsborough County Lithia Springs is in its undeveloped natural state, Sulphur Springs and Purity Springs are highly developed for their specific purposes, while Palma Ceia Spring shows evidence of the abandonment of much early development work doubtless done in the "boom" days of the 1920's.

At the end of the individual spring descriptions for each county are brief references to certain other and usually smaller springs which are known but have not yet been included as a part of the spring investigational program. The list is not complete.

ALACHUA COUNTY

GLEN SPRINGS *near* GAINESVILLE

Location.—About two miles northwest of Gainesville. Reached by driving 1.5 miles north of Gainesville on U.S. Highway 441, turning west on a paved road and driving 0.5 mile to the springs.

Description.—The springs are in a wooded ravine at the edge of the plateau northwest of the city and their outflow is tributary to Hogtown Creek which is in the St. Johns River basin. The springs form an irregular-shaped pool about 20 feet long which is enclosed by concrete walls. The water, which is very clear, emerges from several small submerged horizontal caverns and flows into two adjoining swimming pools. The temperature, taken one foot below the surface of the water in the springhead on April 16, 1946, was 72°F.

Discharge.—A flow of 0.32 second-foot (0.21 m.g.d.) was measured on December 10, 1941; and 0.33 c.f.s. (0.21 m.g.d.) on April 16, 1946.

Quality of water.—The water in Glen Springs as represented by the following analysis is intermediate between soft and hard. The dissolved constituents consist primarily of calcium, magnesium, and bicarbonate, which is typical of many springs in Florida.

ANALYSIS

Date of collection April 16, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	10	—
Iron (Fe)	.04	—
Calcium (Ca)	15	.75
Magnesium (Mg)	6.7	.55
Sodium (Na)	3.2	.14
Potassium (K)	.6	.02
Bicarbonate (HCO_3)	74	1.21
Sulfate (SO_4)	2.6	.05
Chloride (Cl)	3.4	.10
Fluoride (F)	.4	.02
Nitrate (NO_3)	1.8	.03
Dissolved Solids	76	—
Total Hardness as $CaCO_3$	65	—
Carbon Dioxide (CO_2)	12	—
Color	0	—
pH	7.0	—
Specific Conductance ($K \times 10^5$ at 25°C.)	14.3	—

Utilization.—The springs are used for swimming. Great care was taken to keep side hill drainage out of the swimming pools. Convenient bathhouses and a dance floor are available. The two swimming pools built end to end are approximately 30 x 100 feet and 30 x 150 feet, respectively, and are chlorinated.

MAGNESIA SPRING *near* HAWTHORN

Location.—About 4 miles west of Hawthorn. Reached by turning west from State Highway 200 at drugstore in Hawthorn and driving 3.7 miles on graded road, then turning south at gate marked "Magnesia Spring" on sand road and driving 0.4 mile to the spring. It can also be reached from Grove Park on State Highway 20.

Description.—The spring lies at the base of the sandy pine wooded hills on the east side of the Lochloosa Creek valley. It is tributary to Lochloosa Creek, which flows into Lochloosa Lake, and is in the St. Johns River basin. The spring forms a semicircular pool being enclosed by a concrete wall whose diameter is about 40 feet. The discharging water comes from an artesian flow through sand in the bottom of the pool. The pool has been sounded with an iron pipe to a depth of 30 feet from the water surface to a sand bottom and is said to have been pushed to a depth of 30 feet more through the soft sand. The temperature of the water, taken one foot below the surface of the water near the flume outlet on April 16, 1946, was 75°F. The water is piped to a swimming pool which can also be by-passed.

Discharge.—A slight change in flow is reported during the wet and dry seasons. The by-pass pipe outflow only, measured on December 10, 1941, was 1.8 second-feet (1.2 m.g.d.). Total discharge measured below the point where the swimming pool outflow and by-pass pipe outflow join was 0.65 c.f.s. (0.42 m.g.d.) and the flow into the swimming pool was 0.46 c.f.s. (0.30 m.g.d.) on April 16, 1946.

Quality of water.—Analysis of a sample of water collected from Magnesia Spring shows that it is hard and typical of many Florida springs. It contains moderate concentrations of calcium, magnesium, and bicarbonate.

ANALYSIS

Date of collection April 16, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	28	—
Iron (Fe) - - - -	.02	—
Calcium (Ca) - -	40	2.00
Magnesium (Mg) -	13	1.07
Sodium (Na) - - -	5.6	.24
Potassium (K) - -	.8	.02
Bicarbonate (HCO_3)	181	2.97
Sulfate (SO_4) - -	4.9	.10
Chloride (Cl) - -	8.2	.23
Fluoride (F) - - -	.3	.02
Nitrate (NO_3) - -	.1	.00
Dissolved Solids - -	184	—
Total Hardness as $CaCO_3$ - - - -	154	—
Carbon Dioxide (CO_2)	9	—
Color - - - - -	5	—
pH - - - - - -	7.5	—
Specific Conductance ($K \times 10^5$ at 25°C.) -	31.5	—

Utilization.—The water is bottled and sold. A distilling plant is on the grounds and some of the water is distilled and sold for use in automobile batteries. Bathhouses and tables and chairs under shelter are available for picnics. The swimming pool is about 30 x 150 feet and varies from 3 to 9 feet in depth.

POE SPRINGS *near* HIGH SPRINGS

Location.—About 3 miles west of High Springs. Drive 0.6 mile south on U.S. Highway 41 from the U.S. Highway 441 junction in High Springs, turn west on a graded road and drive 2.5 miles to the "Poe Springs" sign, then turn north and drive 0.6 mile to the springs.

Description.—(See figure 8). These springs are on the wooded south bank of the Santa Fe River. The springs form a circular pool about 75 feet in diameter with most of the flow emerging from a horizontal cavern covered at the cavern mouth by 16.6 feet of water. The pool was reported to be 36 feet in depth some 20 years ago. The springs have gradually filled up with sand and debris. The pool is enclosed on the south and west side by a board and sheet-metal wall. The water is quite clear and flows 200 feet north before entering the Santa Fe River. The temperature of the water was 73°F on July 22, 1946.

FIGURE 8. Headpool of *Poe Springs*, looking down the run emptying into the Sante Fe River.

Discharge.—The average flow determined from the five discharge measurements listed below is 70.4 second-feet (45 m.g.d.).

DATE	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
Feb. 19, 1917 - - -	86.5	56
Jan. 31, 1929 - - -	75.1	48
Mar. 14, 1932 - - -	31.2	20
Dec. 13, 1941 - - -	84.0	54
July 22, 1946 - - -	75.3	49

Quality of water.—The following analyses of water from Poe Springs show that it is hard and that the dissolved mineral matter consists almost entirely of calcium and bicarbonate. The two analyses made 22 years apart are practically identical.

ANALYSIS

Date of collection:	Oct. 31, 1924		July 22, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	8.7	—	7.8	—
Iron (Fe)	.05	—	.07	—
Calcium (Ca)	64	3.19	65	3.24
Magnesium (Mg)	4.7	.39	6.4	.53
Sodium (Na) } Potassium (K) }	5.7	.25		
Sodium (Na)			4.4	.19
Potassium (K)			0.9	.02
Bicarbonate (HCO_3)	201	3.29	204	3.34
Sulfate (SO_4)	10	.21	17	.35
Chloride (Cl)	7.0	.20	6.8	.19
Fluoride (F)	—	—	.1	.01
Nitrate (NO_3)	—	—	.5	.01
Dissolved Solids	204	—	210	—
Total Hardness as $CaCO_3$	179	—	188	—
Carbon Dioxide (CO_2)	—	—	16	—
Color	—	—	5	—
pH	—	—	7.3	—
Specific conductance ($K \times 10^5$ at 25°C.)	—	—	36.8	—

Utilization.—They are used as a swimming pool and picnic grounds. A bathhouse is available. A dance floor covered with a roof has recently been erected on the grounds.

OTHER SPRINGS

Other springs reported in Alachua County are: Blue Springs, Boulware Spring (2 miles southeast of Gainesville), Ford Spring (0.5 mile southeast of Melrose), Hornsby Springs (1 mile east of High Springs), Iron Spring (at Hawthorn), July Spring, Lilly Spring, Sulphur Spring (at Hawthorn), and two small springs near High Springs.

BAY COUNTY

BLUE SPRINGS *near* BENNETT

Location.—This group of three springs is located in or near Sec. 4, R. 13 W., T. 1 S., 2 to 3 miles north of Bennett. To reach springs, drive east from bridge on State Road 388 over Econfina Creek and turn north on first graded road that intersects State Road 388. Follow this road 2.5 miles and turn left on sand road, which winds through woods to reach Econfina Creek, into which the springs flow. The springs are approximately 0.5 mile downstream from this point and may be reached by boat.

Description.—Because they have no individual names the springs will be designated herein as Nos. 1, 2, and 3. No. 1 is on the left bank and Nos. 2 and 3 are on the right bank (No. 3 is the most upstream spring). All are located within several hundred feet of each other and discharge through short channels into Econfina Creek.

Spring No. 1: The pool is circular in shape with a diameter of about 20 feet with a cavity in the center about 6 feet deep. Another cavity 100 feet below the head is 12.5 feet deep. The run is from 1 to 3 feet deep, 40 feet wide, and 800 feet long. It winds through a swamp and is choked in places with fallen tree trunks. The water temperature on May 22, 1942, was 71°F.

Spring No. 2: The discharge comes out of a submerged cavity in a vertical limestone bank. This bank is about 25 feet above the water surface. The run is about 100 feet long, 10 feet wide at the head and 50 feet wide at the mouth. The bottom slopes sharply from 1 to 4 feet and then drops off to 8 feet at the head. Soundings indicate a maximum depth of 10.5 feet and 50 feet below the top of the bank. All were made on May 22, 1942, on which day the water temperature was 71°F.

Spring No. 3: The run is choked with tall grass and fallen trees and is not navigable. The bottom of the run is carpeted with sub-aquatic growth in places where there is no tall grass.

Discharge.—Spring No. 1: 20.2 second-feet (13 m.g.d.) on November 14, 1941, and 4.7 c.f.s. (3 m.g.d.) on May 22, 1942.

Spring No. 3: 44.5 second-feet (29 m.g.d.) on November 14, 1941.

Utilization.—They are totally undeveloped.

BRADFORD COUNTY

HEILBRONN SPRING *near* STARKE

Location.—About 6 miles northwest from Starke. Reached by driving northwest from Starke on State Road 16 for 5.6

miles, then turning south on graded road and driving 0.1 mile to the spring.

Description.—The spring is on the swampy, wooded south bank of Water Oak Creek, one of the headwater tributaries of the Suwannee River. The surrounding flat lands have been cleared for farming except for occasional stands of mostly pine timber. The spring is enclosed by a circular concrete wall about 10 feet in diameter. A 3-inch outlet pipe is on the south side about 2.5 feet from the top of the wall. Three other outlet pipes are plugged. Maximum depth was 16 feet from the water surface on May 8, 1946, and the water temperature was 70°F.

Discharge.—The flow of this spring is as follows:

100 gallons per minute (0.22 c.f.s.) in 1903, WSP 102, p. 267.
250 gallons per minute (0.56 c.f.s.) in 1913, WSP 319, p. 272.
36 gallons per minute (0.08 c.f.s.) as measured with pygmy current meter on May 8, 1946.

Quality of water.—Heilbronn Spring water is hard as shown by the following analysis made in 1924. The dissolved mineral matter consists largely of calcium, magnesium, and bicarbonate. No sample was collected for analysis in 1946.

ANALYSIS

Date of collection: November 7, 1924

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	23	—
Iron (Fe)	.03	—
Calcium (Ca)	38	1.90
Magnesium (Mg)	19	1.56
Sodium (Na) / Potassium (K)	8.7	.38
Bicarbonate (HCO_3)	206	3.38
Sulfate (SO_4)	2.5	.05
Chloride (Cl)	14	.39
Fluoride (F)	—	—
Nitrate (NO_3)	—	—
Dissolved Solids	197	—
Total Hardness as $CaCO_3$	173	—
Carbon Dioxide (CO_2)	—	—
Color	—	—
pH	—	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—

Utilization.—Local residents use the water for drinking, and the water is also bottled and sold.

CALHOUN COUNTY

Abes Spring, located in Calhoun County in T. 1 S., R. 9 W., is listed here for the record.

CITRUS COUNTY

CHASSAHOWITZKA SPRINGS *near* HOMOSASSA SPRINGS

Location.—About 7.7 miles by highway from the town of Homosassa Springs. Reached by driving 6.0 miles south from the town of Homosassa Springs on U.S. Highway 19, then turning west on graded road at sign reading "Chassahowitzka" and driving 1.7 miles to the springs.

Description.—These springs are situated topographically much the same as Homosassa Springs and form the head of the broad shallow tidal Chassahowitzka River which meanders through the thick jungle lowlands to finally reach the Gulf of Mexico. Higher rolling lands lie to the east, and to the southeast is found the Devil's Punch Bowl, one of the larger sinks in the state. The headspring forms a rather circular pool about 150 feet in diameter with most of the water emerging from a sand-filled crevice about 25 feet long and 1.5 feet wide at the bottom of the steeply sloping southwest side, covered by a maximum depth of 23.9 feet of water on July 25, 1946. A measurement on October 9, 1930, shows a depth of 35 feet. The temperature of the water was 75°F on July 25, 1946, and 74°F on February 14, 1933. About 500 feet downstream, more springs originate some 300 feet from the right bank of the river. The run from these springs is known as Crab Creek. The water from these springs emerges with a noticeable surface disturbance from two horizontal caverns or crevices and three chimney-shaped holes in the limestone. The deepest of the chimney-shaped holes was 16.7 feet. The water is quite clear.

Discharge.—All of the following measurements were made approximately 300 feet below the point where Crab Creek flows into the river. Their average is 81.4 second-feet (53 m.g.d.).

DATE	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
Oct. 9, 1930 - - -	101	65
Mar. 15, 1932 - - -	98.1	63
Feb. 14, 1933 - - -	66.6	43
Nov. 8, 1935 - - -	54.6	35
July 25, 1946 - - -	86.9	56

Quality of water.—The water represented by the following analysis is hard and in most other respects typical of many Florida springs. The dissolved mineral matter consists largely of calcium, magnesium, and bicarbonate, but contains somewhat larger amounts of sodium and chloride than some springs in the State.

ANALYSIS

Date of collection July 25, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	8.6	—
Iron (Fe) - - - -	.04	—
Calcium (Ca) - -	49	2.45
Magnesium (Mg) -	13	1.07
Sodium (Na) - - -	29	1.26
Potassium (K) - -	1.5	.04
Bicarbonate (HCO_3)	178	2.92
Sulfate (SO_4) - -	13	.27
Chloride (Cl) - - -	53	1.49
Fluoride (F) - - -	.1	.01
Nitrate (NO_3) - -	.3	.00
Dissolved Solids - -	261	—
Total Hardness as $CaCO_3$ - - - -	176	—
Carbon Dioxide (CO_2)	9	—
Color - - - - - -	8	—
pH - - - - - - -	7.5	—
Specific Conductance ($K \times 10^5$ at 25°C.)	47.0	—

Utilization.—The river is used as a small boat harbor by commercial fishermen. Water for domestic use is pumped from the headspring by some local residents. Boats are available for fishermen. Many different species of fish are noticeable in the run and numerous blue crabs were seen in Crab Creek. There is a hotel for fishermen on the north side of the springs.

HOMOSASSA SPRINGS *at* Homosassa Springs

Location.—One mile west of the town of Homosassa Springs. Reached by turning west from U.S. Highway 19 at the town of Homosassa Springs and driving 0.6 mile, then turning south and driving 0.4 mile to the springs.

Description.—These springs and numerous others in the area form the headwaters of the Homosassa River which finds its way to the Gulf of Mexico through the flat, thick, jungle coastal lowlands of this section of the west coast of Florida. The head of the main spring, see figures 9 and 10, called Nature's Fish Bowl, forms a circular pool about 80 feet in diameter with spring flow issuing from a number of vertical holes and fissures in the limerock. The maximum depth measured in a crevice was 43.8 feet on April 3, 1946. Soundings were made at 20 to 25 points to insure that the maximum depth was reached. Average depth of the bottom was about 30 feet. The pool attracts many and various species of fish. The temperature of the water one foot below the surface of Nature's Fish Bowl on April 3, 1946, was 75°F.

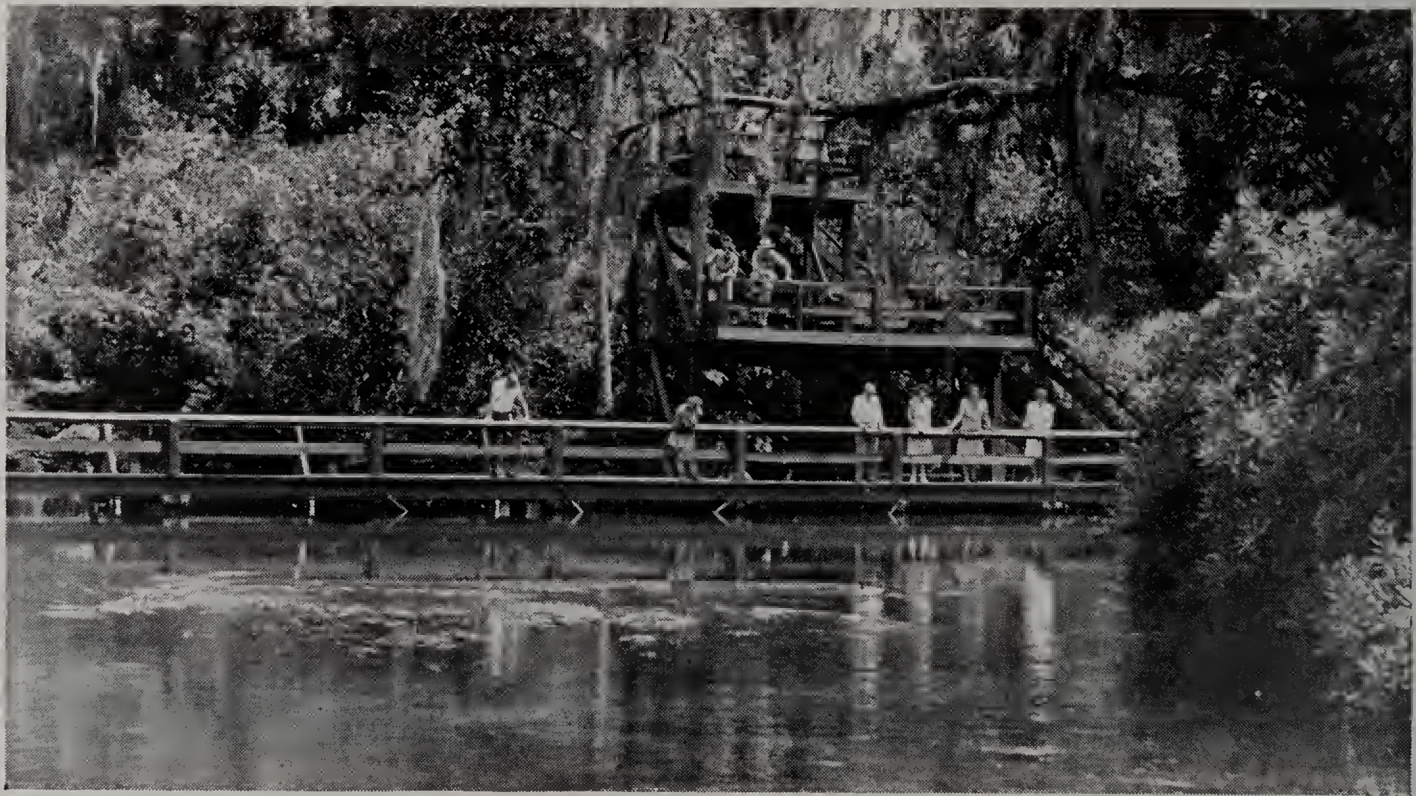

Figure 9. View of the headpool of *Homosassa Springs*, showing platforms from which the underwater scenery can be seen.

FIGURE 10. Fish in *Homosassa Springs*, showing sheepshead, mangrove snappers, catfish, bream and others.

Discharge.—

DATE		CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
Mar. 7, 1936	Maximum	222	143
Feb. 14, 1933	Minimum	141	91
	Mean	185	120

The mean flow was computed from 8 measurements made during the period March 15, 1932 to April 3, 1946.

Quality of water.—Homosassa Springs water is mineralized and decidedly hard. The dissolved mineral matter contains a large proportion of sodium chloride (common salt) which may have had its origin in the Gulf of Mexico or in saline residues remaining from ancient invasions of the sea.

ANALYSIS

Date of collection April 3, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	9.0	—
Iron (Fe) - - - -	.12	—
Calcium (Ca) - -	50	2.50
Magnesium (Mg) -	45	3.70
Sodium (Na) - - -	308	13.39
Potassium (K) - -	9.6	.25
Bicarbonate (HCO_3)	136	2.23
Sulfate (SO_4) - - -	87	1.81
Chloride (Cl) - - -	570	16.08
Fluoride (F) - - -	.0	.00
Nitrate (NO_3) - -	.9	.01
Dissolved Solids - -	1200	—
Total Hardness as $CaCO_3$ - - - - -	310	—
Carbon Dioxide (CO_2)	—	—
Color - - - - - -	0	—
pH - - - - - - -	7.4	—
Specific Conductance ($K \times 10^5$ at 25°C.)	224	—

Utilization.—A main attraction is the feeding of the fishes from the bridge around the main springhead, and there is a "nature trail" for sightseeing. A brick pavilion houses the coffee shop, office, and entrance to the nature trail. Rowboats are available for fishing in Homosassa River.

OTHER SPRINGS

Other springs in Citrus County are Cedar Hill Spring, Hunter Spring and other springs at the head of Crystal River, see figure 11.

FIGURE 11. One of the springs forming the head of Crystal River, Citrus County. Water hyacinths in bloom are visible in the foreground. After Cooke, 1939.

CLAY COUNTY

GREEN COVE SPRING *at* GREEN COVE SPRINGS

Location.—In Green Cove Springs opposite the Qui-Si-Sana Hotel on U.S. Highway 17.

Description.—The spring is in the heart of the city of Green Cove Springs in a park amid oak and palm trees on the west bank of the St. Johns River whose water's edge is about 250 feet to the east. The spring forms a circular pool, being enclosed by a concrete wall 16 feet in diameter. The water appears to discharge from one horizontal cavern, at whose mouth was measured a maximum depth of 27.7 feet on April 18, 1946. The water has an odor of hydrogen sulfide and flows into a swimming pool, which can be bypassed if necessary. On April 18, 1946, the water temperature was 77°F and 70°F on February 16, 1924.

Discharge.—The flow on February 12, 1929 was 5.4 cubic feet per second (3.5 m.g.d.), and on April 18, 1946 it was 4.42 cubic feet per second (2.9 m.g.d.).

Quality of water.—The water from Green Cove Spring, as represented by the two analyses below, is moderately hard. The dissolved matter consists largely of calcium and magnesium bicarbonates with an appreciable amount of sulfate. The analyses are almost identical, which shows that the composition of the water was the same in 1946 as it was in 1924.

ANALYSIS

Date of collection	February 16, 1924		April 18, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	15	—	13	—
Iron (Fe)	.03	—	.06	—
Calcium (Ca)	28	1.40	28	1.40
Magnesium (Mg)	16	1.32	15	1.23
Sodium (Na)	2.4	.10	4.6	.20
Potassium (K)	1.8	.05	1.2	.03
Bicarbonate (HCO_3)	100	1.64	102	1.67
Sulfate (SO_4)	49	1.02	51	1.06
Chloride (Cl)	5.7	.16	6.1	.17
Fluoride (F)	—	—	.2	.01
Nitrate (NO_3)	—	—	.1	.00
Dissolved Solids	170	—	171	—
Total Hardness as $CaCO_3$	136	—	132	—
Carbon Dioxide (CO_2)	—	—	8	—
Color	—	—	0	—
pH	—	—	7.3	—
Specific Conductance ($Kx10^5$ at 25°C.)	—	—	28.9	—

Utilization.—The spring is used for swimming and drinking. A bathhouse and swimming pool are available.

WADESBORO SPRING *at* ORANGE PARK

Location.—Reached by driving 0.9 mile southwest from Orange Park on the Doctors Inlet highway to the Atlantic Coast Line railroad crossing. The spring is 300 feet southeast of the railroad crossing.

Description.—The spring is at the head of a ravine which opens upon Doctors Lake about 0.3 mile to the southeast. The spring run is tributary to Doctors Lake which is a branch of the St. Johns River. The springhead is in a pool enclosed by a square concrete wall about 20 x 20 feet. Almost all of the water emerges from two horizontal caverns and white sand boils from each. The average depth is 3.5 feet.

Discharge.—1.40 cubic feet per second (0.90 m.g.d.) was the total outflow measured on April 18, 1946.

Quality of water.—The hardness of Wadesboro Spring is less than the average for Florida springs, although it would not ordinarily be classed as a soft water. The dissolved mineral matter consists primarily of calcium and bicarbonate.

ANALYSIS

Date of collection February 16, 1924

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	6.3	—
Iron (Fe)	—	—
Calcium (Ca)	33	1.65
Magnesium (Mg)	1.7	.14
Sodium (Na)	5.0	.22
Potassium (K)	.7	.02
Bicarbonate (HCO_3)	104	1.70
Sulfate (SO_4)	3.6	.08
Chloride (Cl)	11	.31
Fluoride (F)	—	—
Nitrate (NO_3)	—	—
Dissolved Solids	110	—
Total Hardness as $CaCO_3$	89	—
Carbon Dioxide (CO_2)	—	—
Color	—	—
pH	—	—
Specific Conductance ($Kx10^5$ at 25°C.)	—	—

Utilization.—None. It is reported that the water was once bottled for sale. The improvements were in an abandoned condition on April 18, 1946.

OTHER SPRINGS

Magnolia Springs in Clay County are located just north of the city of Green Cove Springs. The area to the north was occupied in earlier years by a famous resort hotel, later a military academy, which was destroyed by fire. The springs had no flow in 1947, but are reported to flow whenever a nearby flowing well is turned off. Pecks Mineral Spring, 6 miles east of Starke, is a source of drinking water.

COLUMBIA COUNTY

ICHATUCKNEE SPRINGS *near* HILDRETH

Location.—The point at which the total outflow of this group of springs is measured is at the State Highway 20 crossing of Ichatucknee River 1 mile east of Hildreth. The group of seven or more springs which contribute to the flow of the river are located on both thickly wooded banks and their runs issue between the highway and the head spring a little over 3 miles to the northeast.

Description.—(See the frontispiece.) The Ichatucknee River system is similar to that of the Wakulla River. A large part of its flow undoubtedly originates in two surface streams, Alligator Lake outlet whose head is Alligator Lake at Lake City and whose terminus is a sink 0.7 mile east of Bass, and Rose Creek roughly parallel to the first stream and 2 to 2.5 miles to the south. The elevation of the headlands of the Rose Creek basin is 160 to 170 feet above mean sea level and the creek terminates in a sinkhole at Columbia City. Here it becomes a subterranean stream and a study of the contour map of the area indicates it finds its way into the Ichatucknee River.

The Ichatucknee headspring forms a somewhat circular pool about 100 feet in diameter with the water emerging from a horizontal cavern beneath the north bank where the maximum depth to the cave floor was 13.6 feet on May 17, 1946. The entrance to the cavern is approximately 35 feet wide, north to south, and 60 feet long, east to west. The temperature of the water on this same day was 72°F. The measured outflow of the headspring on February 18, 1917 was 44.4 cubic feet per second (20 m.g.d.).

On the east bank of the river, 0.3 mile downstream from the headspring, is another spring of about the same pool size. The cavity of the spring is unique, however, in that its shape resembles that of a huge jug. The maximum depth to the cavity floor was 36.8 feet on May 17, 1946, and the water temperature was 71°F. There was a cross-current in the lower part of the cavity flowing to the northwest and toward the headspring. On May 17, 1946 a measurement of the flow of the headspring and the jug-shaped spring runs, a short distance below the point where they merge, indicated a rate of flow of 126 cubic feet per second (81 m.g.d.). About two-thirds of this flow issues from the jug-shaped spring.

About 0.6 mile downstream from the headspring on the left bank the run from Spring No. 3 (the springs are numbered herein to facilitate description) enters the river. The flow from this spring as measured on May 17, 1946 was found to be 49.4 c.f.s. (32 m.g.d.). The headwaters of this spring made up of a group of eight small springs are separated from those of Spring No. 4 by only a low divide of broken rock. Spring No. 5 is located downstream from Springs Nos. 3 and 4 but on the opposite bank about 100 feet east of the river. Its springhead forms a circular pool about 60 feet in diameter with the flow emerging from horizontal caverns. The deepest of the two was 14.0 feet and the depth to the rock ledge surrounding this cavern was 6.0 feet. The temperature of the water of this pool was 72°F on May 17, 1946. Just a short distance below Spring No. 5 the river broadens considerably with widths up to 200 feet and shallow depths. These shallow depths promote the luxuriant growth of many varieties of aquatic vegetation. Near the lower end of this broad section of the river, which extends for about 0.7 mile, a small spring on the left bank (Spring No. 6) joins the river. The river a short distance below this point narrows to a width of about 100 feet.

Mill Spring is situated on the same side of the river about 0.3 mile south of Spring No. 6. Water power from this spring was once used to operate a grist mill of which no trace now remains except the earthworks which formed the raceway for the waterwheel. The discharge of this spring, measured 125 feet below the head on May 17, 1946, was 21.8 cubic feet per second (14 m.g.d.). The run was navigable for a canoe up to the point the measurement was made but the rocky stream bed prohibits further navigation to the springhead.

Discharge.—Flow measurements of Ichatucknee River as representative of the collective flow of the entire group of Ichatucknee Springs have been made at approximately monthly intervals since January, 1931. Four earlier flow measurements have been made as listed below:

DATE	FLOW IN CUBIC FEET PER SECOND
December 23, 1898 - - -	403
February 19, 1917 - - -	342
January 30, 1929 - - -	467
August 20, 1930 - - - -	416

A graph of the measurements made since January, 1931 appears in figure 7. The maximum discharge measured was 467 second-feet (302 m.g.d.) on January 30, 1929. The minimum discharge measured was 243 c.f.s. (157 m.g.d.) on August 20, 1935. The average flow of 168 measurements made from February 19, 1917 to April 16, 1946 is 335 c.f.s. (216 m.g.d.), thereby indicating that the flow of the Ichatucknee Springs group ranks third in order of magnitude of average flow for springs in Florida.

Quality of water.—Water in Ichatucknee Springs is hard as indicated by the following analysis. The dissolved mineral matter consists almost entirely of calcium and bicarbonate, which is typical of many Florida springs.

ANALYSIS

Date of collection May 17, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	9.1	—
Iron (Fe)	.03	—
Calcium (Ca)	58	2.89
Magnesium (Mg)	6.6	.54
Sodium (Na)	3.1	.13
Potassium (K)	0.3	.01
Bicarbonate (HCO_3)	200	3.28
Sulfate (SO_4)	8.4	.17
Chloride (Cl)	3.6	.10
Fluoride (F)	.1	.01
Nitrate (NO_3)	1.0	.02
Dissolved Solids	188	—
Total Hardness as $CaCO_3$	172	—
Carbon Dioxide (CO_2)	6	—
Color	0	—
pH	7.7	—
Specific Conductance ($K \times 10^5$ at 25°C.)	32.9	—

Utilization.—The springs area is undeveloped. The head-spring is used for swimming and picnicking by local residents and for watering stock. Fishing, hunting, and boating are other locally popular means of recreation. Botanists, zoologists, geologists and hydrologists find much of interest in the area. As mentioned in a previous paragraph Mill Creek spring once furnished water power for a grist mill. The entire area could be developed into a fine state park.

DADE COUNTY

Springs in Dade County, such as Mangrove Spring at Coconut Grove, Miami Springs, and various bayside springs which were reported to flow in earlier years, no longer flow owing to lowered water tables in the area. Mangrove Spring which supplied water for the United States fleet off Havana in 1898, was reported to flow at a rate of 100 gallons per minute in 1903.

DE SOTO COUNTY

A spring at Owens in De Soto County is located in Sec. 16, T. 38 S., R. 24 E., and yields sulphur water.

DIXIE COUNTY

Fletcher Springs in Dixie County are reported to be about 13 miles downstream from Branford on the right bank of the Suwannee River. Some data on Big Cypress Spring (2 miles below Rock Bluff ferry), Copper Spring and Little Copper Spring (near Oldtown) are given in Table 4.

DUVAL COUNTY

St. Nicolas Spring in South Jacksonville, Duval County, has a tiny flow, and may be the only flowing spring remaining in the county, the others having ceased to flow because of decreased water levels.

ESCAMBIA COUNTY

Bay Springs, Bluff Springs and Jackson's Springs are located in Escambia County.

GADSDEN COUNTY

GLEN JULIA SPRINGS *at* MOUNT PLEASANT

Location.—One mile southwest of Mount Pleasant. The springs are reached by turning west off U.S. Highway 90 on a graded road at Howell's Service Station in Mount Pleasant and driving 0.3 mile, turning south at the railroad for 0.2 mile, then turning west for 0.2 mile, turning south at school and driving 0.1 mile, turning west at the "Glen Julia Park" sign and driving 0.4 mile to a cattle guard, then turning north to the springs.

Description.—These 8 or 9 small springs emerge from fissures in the rock along the bottom of a large ravine about 50 feet deep and are tributary to a small stream that flows northwesterly. They are spread out over a distance of 200 feet downstream from the head of the first spring in the ravine, and are tributary to South Mosquito Creek which empties into the Apalachicola River. The temperature of the water was 69°F on May 16, 1946.

Discharge.—The flow was 0.78 second-foot (0.50 m.g.d.) as measured by pygmy current meter May 16, 1946.

Quality of water.—The water represented by the following analysis is exceptionally soft and in this respect is unlike most of the springs in Florida. It contains almost no dissolved mineral matter. Very soft water is frequently corrosive to plumbing.

ANALYSIS

Date of collection May 16, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	4.6	—
Iron (Fe) - - - -	.08	—
Calcium (Ca) - -	.5	.02
Magnesium (Mg) -	.4	.03
Sodium (Na) - - -	1.9	.08
Potassium (K) - -	.5	.01
Bicarbonate (HCO_3) -	3.0	.05
Sulfate (So_4) - - -	.2	.00
Chloride (Cl) - -	3.1	.09
Fluoride (F) - - -	.1	.00
Nitrate (NO_3) - -	.7	.01
Dissolved Solids - -	15	—
Total Hardness as $CaCO_3$ - - - -	2.9	—
Carbon Dioxide (CO_2)	14	—
Color - - - - -	10	—
pH - - - - - - -	5.7	—
Specific Conductance ($Kx10^5$ at 25°C.) -	1.66	—

Utilization.—The springs are used as a park and owned by the county. Tables and benches under a covered pavilion are available for picnics. The paths around the bottom of the ravine are scenic.

SPRING *at* CHATTAHOOCHEE

Location.—The spring is in the NW¼ of Sec. 33, T. 4 N., R. 6 W., and is in the town of Chattahoochee.

Description.—It issues in a small rivulet from the side of a steep head.

Discharge.—The flow was estimated at 13 gallons per minute on April 1, 1924, and 16 gallons per minute was measured volumetrically on May 6, 1946.

Quality of water.—Water in this spring is exceptionally soft and contains only a very small amount of dissolved mineral matter. Water having this composition is not typical of Florida springs.

ANALYSIS

Date of collection: April 1, 1924

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	4.0	—
Iron (Fe) - - - -	.07	—
Calcium (Ca) - -	4.2	.21
Magnesium (Mg) -	1.3	.11
Sodium (Na) - - - / Potassium (K) - -	1.5	.07
Bicarbonate (HCO_3)	2.4	.04
Sulfate (SO_4) - - -	1.7	.04
Chloride (Cl) - -	3.8	.11
Nitrate (NO_3) - -	14	.23
Dissolved Solids - -	34	—
Total Hardness as $CaCO_3$ - - - -	16	—
Carbon Dioxide (CO_2)	—	—
Color - - - - -	—	—
pH - - - - - - -	—	—
Specific Conductance ($K \times 10^5$ at 25°C.) -	—	—

Utilization.—It was once used to furnish water for a swimming pool, but these improvements were in an abandoned condition in July, 1946.

GILCHRIST COUNTY

HART SPRING *near* WILCOX

Location.—Reached by turning left off State Highway 26 on sand graded road at Wilcox post office and driving 4.2 miles, then turning west and driving 2.0 miles to the spring.

Description.—This is another of the many springs near the banks of the Suwannee River, and it forms a rather irregular circular pool about 100 feet in diameter with water emerging somewhat horizontally from two limerock cavities, one circular and the other V-shaped. Maximum depth to the floor of the latter was 32 feet on July 24, 1946. On this day the water was very clear and its temperature was 73°F. The run is about 500 feet long, varies from 30 to 75 feet in width, and flows north, curves to the southwest and empties into the Suwannee River.

Discharge.—The flow was measured at 62.1 second-feet (40 m.g.d.) on May 12, 1932; and 58.6 c.f.s. (38 m.g.d.) on July 24, 1946.

Quality of water.—This is a typically hard water such as found in many of the Florida springs. The dissolved mineral matter consists primarily of calcium and bicarbonate.

ANALYSIS

Date of collection July 24, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	5.2	—
Iron (Fe) - - - -	.05	—
Calcium (Ca) - -	67	3.34
Magnesium (Mg) -	4.8	.39
Sodium (Na) - - -	2.0	.09
Potassium (K) - -	0.6	.02
Bicarbonate (HCO_3)	208	3.41
Sulfate (SO_4) - - -	12	.25
Chloride (Cl) - - -	3.8	.11
Fluoride (F) - - -	.0	.00
Nitrate (NO_3) - -	2.3	.04
Dissolved Solids - -	200	—
Total Hardness as $CaCO_3$ - - - - -	186	—
Carbon Dioxide (CO_2)	17	—
Color - - - - - -	5	—
pH - - - - - - -	7.3	—
Specific Conductance ($K \times 10^5$ at 25°C.) -	35.5	—

Utilization.—The spring is in its natural state and is used as a swimming pool and picnic grounds by local residents. It is also used by fishermen as a place to launch small boats for access to the Suwannee River.

ROCK BLUFF SPRINGS *near* BELL

Location.—On the left bank of the Suwannee River about

500 feet above Rock Bluff Ferry, 5 miles northwest of Bell, and approximately 9 miles south of the point the Santa Fe River flows into the Suwannee River.

Description.—The springs are intact in their natural surroundings, and the banks of the run are lined with immense cypress trees, see figure 12, some measuring 10 to 15 feet in diameter at their base. The springs are a rich blue color. The main spring cavity is ellipsoidal in shape, having a length of approximately 30 feet by a width of 6 feet and a maximum sounded depth of 30.2

FIGURE 12. Scene showing large cypress trees at *Rock Bluff Springs* near Bell, Florida. Recent high water marks are visible.

feet on December 8, 1942. The east wall appeared to be cavernous near the bottom. The cavity formation is of limestone with almost straight vertical walls. The run is approximately 0.2 mile long and flows west into the Suwannee River, the outflow of the main spring being joined by that of two smaller springs about 100 feet below the main springhead. One of the two smaller springs measured 10 feet in depth in a pool of about 12 feet in diameter.

Discharge.—A flow of 42.1 second-feet (27 m.g.d.) was measured on December 8, 1942, and this was comprised of 21 m.g.d. from the main spring and 6 m.g.d. from the two smaller springs.

Utilization.—The springs are used by local residents for swimming, although there are no bathhouse facilities. "Gigging", or spearing of fish at night is a favorite sport of some local people as the spring pool is a rendezvous for many types of fish.

OTHER SPRINGS

Bell Spring, located on the left bank of the Suwannee River about 0.8 mile upstream from Fanning Spring, Lumber Camp Springs, one mile south of Wannee, and Otter Spring, two miles north of Oldtown, are also in Gilchrist County.

GULF COUNTY

Small springs are located in Gulf County at Dalkeith, in Sec. 23, T. 5 S., R. 9 W.

HAMILTON COUNTY

WHITE SPRINGS *at* WHITE SPRINGS

Location.—In the town of White Springs. The "White Springs" sign is plainly visible from U.S. Highway 41.

Description.—(See figure 13.) The springs form an oblong pool 50 x 90 feet, being enclosed by a concrete swimming-pool

FIGURE 13. View of discharge vent at *White Springs,* which is located inside the building shown to the right of the picture.

wall located on the north bank of Suwannee River. The water emerges seemingly from two horizontal caverns and one, which is tapped by a pipe to a hand-lift pump for drinking water, is reported by the manager to have three steps of ledges forming a cavern under the north side of the pool. The depth of the third step is about 39 feet. The entire pool is enclosed by a four-story, open type patio with porches. The water has a distinct sulphur odor and its temperature was 72°F on September 3, 1923 and 70°F on May 6, 1946. The springs empty immediately into Suwannee River through a weir regulated by wooden stop gates on the south side of the pool. The gates are used to prevent river water from flooding the pool at medium and high river stages.

Discharge.—The average flow computed from the seven discharge measurements listed below is 55.2 second-feet (36 m.g.d.).

DATE	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
February 13, 1907 - -	72	46
May 8, 1927 - - -	67.2	43
May 17, 1927 - - -	58.5	38
Nov. 4, 1931 - - -	36.2	23
Mar. 17, 1932 - - -	46.4	30
Apr. 2, 1932 - - -	43.1	28
May 7, 1946 - - -	62.7	40

Quality of water.—The water in White Springs is hard and in most respects is typical of many springs in Florida. The dissolved mineral matter consists essentially of calcium and magnesium bicarbonates. The two analyses made 23 years apart are very similar. The color of this water, as shown by the 1946 analysis, is the highest found in spring waters analyzed for this report, but is much lower than found in many surface waters.

ANALYSIS

Date of collection	September 3, 1923		May 6, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - - -	17	—	17	—
Iron (Fe) - - - - -	.21	—	.16	—
Calcium (Ca) - -	43	2.15	45	2.25
Magnesium (Mg) -	13	1.07	11	.90
Sodium (Na) - - - } Potassium (K) - - }	5.6	.24	6.5	.28
			.8	.02
Bicarbonate (HCO_3)	171	2.80	167	2.74
Sulfate (SO_4) - - -	19	.40	16	.33
Chloride (Cl) - -	7.7	.22	8.5	.24
Fluoride (F) - - -	—	—	.5	.03
Nitrate (NO_3) - -	—	—	1.3	.02
Dissolved Solids - -	203	—	196	—
Total Hardness as $CaCO_3$ - - - - -	161	—	158	—
Carbon Dioxide (CO_2)	—	—	17	—
Color - - - - - -	—	—	75	—
pH - - - - - - -	—	—	7.2	—
Specific Conductance ($K \times 10^5$ at 25°C.) -	—	—	31.7	—

Utilization.—A hotel and health resort, which has been operated in conjunction with the springs for many years, uses the springs for bathing, swimming, and drinking. The four-story, open patio-type building around the pool houses dressing rooms for bathers. Water is piped from the main boil for drinking purposes.

OTHER SPRINGS

Another spring in Hamilton County is Wesson's Iron Springs, although its exact location has not been determined.

HARDEE COUNTY

Zolfo, formerly called Aquavita Springs, and Fort Green Springs are situated in Hardee County. These springs are located in or near towns bearing the same name.

HERNANDO COUNTY

WEEKIWACHEE SPRING *near* Brooksville

Location.—This spring is about 12 miles southwest of Brooksville on U.S. Highway 19 at its junction with State Highway 50. It can be reached by following State Highway 50 west and south from Brooksville.

Description.—(See figure 14.) Weekiwachee Spring is the head of the Weekiwachee River which flows into the Gulf of Mexico,

Figure 14. *Weekiwachee Spring*, looking down the run from the headpool.

some 10 miles to the west. The pool water level is at an approximate elevation of 50 feet above mean sea level. Higher flat, sandy, scrub lands on the east rise to elevations of 100 feet above mean sea level, and one knoll towards Brooksville reaches an elevation of 160 feet. The springhead pool is circular and about 150 feet in diameter with the spring flow leaving the spring pool on the northwest side in a channel about 100 feet in width. The bottom of the pool slopes from the edge of the water to a 12 foot depth at the edge of the cavity at which point it drops abruptly to 50 feet in depth. Soundings on March 3, 1947 indicate an average cavity depth of 50 feet. The submerged cavity is approximately 50 feet in diameter and the water emerges with sufficient force to produce a turbulent "boil" which rises approximately a tenth of a foot above the surrounding water level in the pool. The spring water is very clear.

Temperatures of the water have been observed as listed below:

DATE	WATER TEMPERATURE
	°F
March 18, 1931 - - - -	77
August 7, 1931 - - - -	74
October 7, 1931 - - - -	74
February 12, 1932 - - - -	74
March 12, 1932 - - - -	74
February 14, 1933 - - - -	74
October 4, 1933 - - - -	72
January 11, 1936 - - - -	74
April 18, 1936 - - - - -	74
September 9, 1944 - - - -	74
July 5, 1946 - - - - -	75

Discharge.—A graphical picture of the time-discharge relation plotted from the flow measurements that have been made at Weekiwachee Spring since February 6, 1931 is presented in figure 7. A tabulation of its discharge in million gallons per day giving average monthly discharge, annual means, and monthly and annual percentages of the mean flow for the period of record is shown in Table 2. Measurements of the spring flow made prior to 1931 are as follows:

DATE	FLOW IN CUBIC FEET PER SECOND
February 23, 1917 - - -	145
February 4, 1929 - - - -	163
August 21, 1930 - - - -	178

The maximum flow measured is 231 second-feet (149 m.g.d.) on May 6, 1931. The minimum flow measured is 106 c.f.s. (68 m.g.d.) on February 14, 1933. The mean monthly flow computed graphically from discharge measurements made about monthly near the spring outlet from January 1931 to December 1946 is 158 c.f.s. (102 m.g.d.).

TABLE 2. Discharge, in million gallons per day, of WEEKIWACHEE SPRING *near* BROOKSVILLE, FLORIDA

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	CALENDAR YEAR ANNUAL MEAN	CALENDAR YEAR ANNUAL RUNOFF % OF MEAN
1931	108	108	120	146	143	125	101	94	94	88	87	86	108	104.9
1932	77	82	78	80	73	77	73	71	73	74	82	76	76.3	74.1
1933	75	71	77	81	79	74	87	98	103	104	101	102	87.7	85.1
1934	106	108	95	92	93	96	101	106	111	116	122	127	106	102.9
1935	125	97	104	108	98	103	95	113	133	143	135	121	115	111.7
1936	120	125	133	124	117	112	109	109	104	110	109	99	114	110.7
1937	95	94	98	101	98	93	97	104	111	106	106	107	101	98.1
1938	108	100	96	96	93	85	92	109	107	112	111	109	102	99.0
1939	107	109	104	98	92	102	112	111	116	119	115	110	108	104.9
1940	105	111	116	104	98	94	100	102	105	105	105	98	104	101.0
1941	96	94	93	98	101	100	114	125	118	115	111	112	106	102.9
1942	108	103	106	103	99	99	99	103	106	100	98	95	102	99.0
1943	93	88	86	89	83	87	97	104	106	107	108	109	96.4	93.6
1944	109	108	105	102	98	97	97	98	100	100	101	99	101	98.1
1945	97	93	89	84	82	95	110	126	129	123	117	112	105	101.9
1946	112	112	111	108	107	112	116	116	113	111	109	108	111	107.8
1931-46 Mean	103	100	101	101	97.1	96.9	100	106	108	108	107	104	103	100.0
% of Annual	100.0	97.1	98.1	98.1	94.3	94.1	97.1	102.9	104.9	104.9	103.9	101.0	100.0	

Minimum discharge measured, 68 m.g.d. Feb. 14, 1933.
Minimum average monthly discharge, 71 m.g.d. August 1932 and February 1933.
NOTE: Monthly values are averages computed graphically from discharge measurements made about monthly at outlet of pool. Records collected in cooperation with Florida Geological Survey and Florida State Road Department.

Quality of water.—This is a typically hard calcium bicarbonate water and similar to many other limestone springs in Florida. The two analyses made 13 years apart are very similar.

ANALYSIS

Date of collection	October 4, 1933		July 5, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	14	—	8.9	—
Iron (Fe) - - - -	.14	—	.05	—
Calcium (Ca) - -	49	2.45	48	2.40
Magnesium (Mg) -	7.8	.64	5.8	.48
Sodium (Na) - - -	3.7	.16	4.0	.17
Potassium (K) - -		—	.7	.02
Bicarbonate (HCO_3)	178	2.92	168	2.75
Sulfate (SO_4) - - -	7.5	.16	6.4	.13
Chloride (Cl) - - -	4.7	.13	4.8	.14
Fluoride (F) - - -	—	—	.1	.01
Nitrate (NO_3) - -	—	—	0	.00
Dissolved Solids - -	173	—	161	—
Total Hardness as $CaCO_3$ - - - -	154	—	144	—
Carbon Dioxide (CO_2)	—	—	5	—
Color - - - - -	—	—	13	—
pH - - - - - - -	—	—	7.7	—
Specific Conductance ($K \times 10^5$ at 25°C.) -	—	—	28.7	—

Utilization.—The spring and river have served as a recreational area for swimming, boating, fishing and hunting for many years.

It was purchased by the City of St. Petersburg for possible use as a reserve water supply for that city; however a newspaper article in July, 1946 reported that the city negotiated a 30-year lease of the spring to a syndicate of businessmen and sportsmen who intend to make extensive improvements to develop the spring as a playground and resort center.

OTHER SPRINGS

Other springs in Hernando County are Bobhill Spring about 1.5 miles southeast of Aripeka, and Sulphur or Mud Spring, 2 miles northeast of Bayport at the head of Mud River.

HILLSBOROUGH COUNTY

BUCKHORN SPRING *near* RIVERVIEW

Location.—2.8 miles northeast of Riverview. Reached by driving 2 miles north from Riverview on U.S. Highway 41, turning east at junction with a paved road and driving 2.2 miles east, then turning south on a graded road and driving 0.2 mile to the spring.

Description.—The spring lies in the wooded Buckhorn Creek valley 0.4 mile upstream from the point the creek enters the Alafia River. The springhead forms a circular pool about 30 feet in diameter with spring flow emerging from a horizontal cavern and flowing immediately into Buckhorn Creek. The temperature of the water was 76°F on May 1, 1946. There are several other small springs reported in the vicinity.

Discharge.—The flow was 11.0 second-feet (7.1 m.g.d.) as measured by current meter on May 1, 1946.

Quality of water.—No samples taken.

Utilization.—The spring is a private swimming and picnicking area.

EUREKA SPRINGS *near* TAMPA

Location.—About 3 miles east of Tampa. Reached by driving about 3 miles east from Tampa on U.S. Highway 92, turning north at "Eureka Springs" sign opposite a service station and driving 0.7 mile to the springs.

Description.—These springs are situated in the rather flat headwaters area of the Six Mile Creek basin. The springs consist of 4 or 5 small springs, the discharge channels of which join to form one small run. The temperature of the water was 74°F on May 1, 1946. The water is very clear and small particles of shells can be seen boiling up in each separate spring.

Discharge.—A flow of 3.9 second-feet (2.5 m.g.d.) was measured by pygmy current meter on May 1, 1946.

Quality of water.—No samples were collected.

Utilization.—The springs are operated as a private park open to the public. Tropical fish are raised in pools on the well developed grounds, on which a swamp area was drained, an artificial lake made and an undershot water wheel 6-feet in diameter placed in the springs run to add a picturesque touch.

LITHIA SPRINGS *near* LITHIA

Location.—About three miles west of Lithia. Reached by driving southeast from the Alafia River bridge for 0.6 mile on the paved road between Bloomingdale and Lithia, turning southwest on graded road and driving 1.4 miles to the springs.

Description.—The springs are near the south bank of the Alafia River in an area of sandy wooded hills amid a setting of much natural beauty. The springs form a circular pool about 75 feet in diameter with the water emerging from one large and one small horizontal cavern. These caverns are under a rock ledge on the west side of the springhead. The maximum depth sounded by wading to the edge of the ledge was 16.5 feet on April 30, 1946. The run is U-shaped and flows for about 400 yards before entering the Alafia River. The temperature of the water was 70°F on July 19, 1923 and 76°F on April 30, 1946.

Discharge.—Five discharge measurements of the flow of these springs have been made and are listed below. The average flow is 50.2 second-feet (32 m.g.d.).

DATE	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
January 8, 1934 - -	48.8	32
April 9, 1935 - - -	47.4	31
November 18, 1941 -	51.5	33
April 13, 1943 - -	39.2	25
April 30, 1946 - -	64.2	41

Quality of water.—The water analyzed from Lithia Springs is hard and moderately mineralized. The dissolved mineral matter contains a large proportion of calcium and magnesium bicarbonates, and also moderate amounts of other constituents normally found in ground waters. The two analyses made 23 years apart are very similar, showing that the spring water had essentially the same composition on the two dates on which it was sampled.

ANALYSIS

Date of collection	July 19, 1923		April 30, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	19	—	15	—
Iron (Fe)	.15	—	.04	—
Calcium (Ca)	65	3.24	62	3.09
Magnesium (Mg)	14	1.15	10	.82
Sodium (Na)	14	.61	14	.61
Potassium (K)		—	.9	.02
Bicarbonate (HCO_3)	135	2.21	129	2.11
Sulfate (SO_4)	93	1.94	86	1.79
Chloride (Cl)	23	.65	21	.59
Fluoride (F)	—	—	.3	.02
Nitrate (NO_3)	.76	.01	.7	.01
Dissolved Solids	331	—	285	—
Total Hardness as $CaCO_3$	220	—	196	—
Carbon Dioxide (CO_2)	—	—	6	—
Color	—	—	5	—
pH	—	—	7.5	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—	46.9	—

Utilization.—The springs are not developed but have good possibilities if the access road were paved and if precautions were taken against the flood hazard, the frequency of which could be determined from the nearby river gaging station. They are used for swimming and picnicking by local residents.

PALMA CEIA SPRINGS

Analysis of a water sample collected from Palma Ceia Springs on Bayshore Boulevard at Barcelona Street, Tampa in 1923 indicates that it is a hard water containing moderately large concentration of calcium, sodium, bicarbonate, and chloride. The sodium chloride (common salt) may have its origin in saline residues remaining from ancient invasions of the sea, or in sea water remaining in the formation from the time it was deposited, or both. No sample was collected for analysis in 1946 but a flow determination of 42 gallons per minute was made on May

1, 1946. The temperature of the water was 70°F on August 26, 1923.

ANALYSIS

Date of collection: August 26, 1923

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	17	—
Iron (Fe) - - - -	.19	—
Calcium (Ca) - -	109	5.44
Magnesium (Mg) -	15	1.23
Sodium (Na) - - - / Potassium (K) - -	100	4.35
Bicarbonate (HCO_3)	249	4.08
Sulfate (SO_4) - -	29	.60
Chloride (Cl) - -	231	6.52
Fluoride (F) - - -	—	—
Nitrate (NO_3) - -	.6	.01
Dissolved Solids - -	692	—
Total Hardness as $CaCO_3$ - - - -	334	—
Carbon Dioxide (CO_2)	70	—
Color - - - - -	—	—
pH - - - - - -	—	—
Specific Conductance ($K \times 10^5$ at 25°C.) -	—	—

PURITY SPRING *at* TAMPA

Location.—Near Sulphur Springs. Reached by turning west off Florida Ave. (U.S. Highway 541) onto first graded road north of the Hillsborough River crossing and driving 0.1 mile to the spring.

Description.—The spring is on the north bank of the Hillsborough River about 150 feet north of the river's edge and near the base of the sandy hills to the north. The water level is not many feet above that of the tidal river level. The spring is an irregularly shaped pool about 20 x 30 feet, enclosed by a concrete wall with almost all of the flow emerging from one horizontal cavern. It is completely covered by a springhouse. A 6-inch diameter steel pump intake pipe is at the entrance to the cavern, and an 8-inch diameter pipe enters near the bottom on the south side of the pool. These pipes are connected to pumps of 350 and 500 gallons-per-minute rated capacity. The water level varies due to the amount of water being pumped from the spring. The temperature of the water was 70°F on July 20, 1923.

Discharge.—The small pump is used almost continuously but withdrawal at the combined capacities of both pumps is said to be rare.

Quality of water.—This is typical spring water of moderate hardness and similar to many other spring waters in Florida. The dissolved constituents consist largely of calcium and bicarbonate.

ANALYSIS

Date of collection July 20, 1923

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	8.9	—
Iron (Fe)	.07	—
Calcium (Ca)	45	2.25
Magnesium (Mg)	3.4	.28
Sodium (Na)	6.0	.26
Potassium (K)		—
Bicarbonate (HCO_3)	142	2.33
Sulfate (SO_4)	3.6	.07
Chloride (Cl)	11	.31
Fluoride (F)	—	—
Nitrate (NO_3)	.26	.00
Dissolved Solids	157	—
Total Hardness as $CaCO_3$	126	—
Carbon Dioxide (CO_2)	—	—
Color	—	—
pH	—	—
Specific Conductance ($Kx10^5$ at 25°C.)	—	—

Utilization.—For public supply. It is piped to about 4,000 customers in the Sulphur Springs area by the Purity Springs Water Co. They are also the principal water bottling company in Tampa.

SULPHUR SPRINGS *at* SULPHUR SPRINGS

Location.—The springs are clearly visible to motorists and lie about 100 feet west of U.S. Highway 41 and 100 feet north of the Hillsboro River at Sulphur Springs, 7 miles north of downtown Tampa.

Description.—Situated in the heart of the Sulphur Springs business district, these springs are responsible for much of the urban growth surrounding it. The springs' pool is enclosed by a circular concrete retaining wall about 50 feet in diameter which forms the swimming pool. On May 9, 1930 a maximum depth of 30.3 feet was measured in the main boil in a crevice which was about 5 feet deeper than the cavity floor. The water level of the pool is regulated by two control toboggan flumes with fixed crest elevations placed on each side of the large moveable steel stop-gate at the pool outlet. When the pool level is lowered to permit cleaning portions of the pool bottom, water levels of wells in the vicinity and of the sink at Waters Avenue and 10th street are also lowered. The north side of the discharge channel below the control is used as a bathing beach, and the channel flows west and south for about 500 feet to the point where it joins the Hillsboro River.

Water temperatures of the spring pool have been observed as shown on the dates listed below:

DATE	WATER TEMPERATURE	DATE	WATER TEMPERATURE
	°F		°F
July, 1923 - - -	70	April 7, 1932 - -	75
April 6, 1931 - -	78	June 8, 1932 - - -	77
June 24, 1931 - -	73	August 4, 1932 - -	77
August 8, 1931 - -	75	February 15, 1933 -	76
February 12, 1932 -	75	May 2, 1946 - - -	76
March 10, 1932 - -	74		

Discharge.—The maximum and minimum flows are as follows:

DATE		CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
Aug. 3, 1945	maximum	163	105
Feb. 12, 1934	minimum	12.9	8.3

The average flow determined from 49 discharge measurements made during the period February 24, 1917 to November 8, 1946 is 52.6 c.f.s. (34 m.g.d.).

Quality of water.—The composition of this spring water appears to change from time to time as indicated from the two analyses given below and also by the results of a few partial analyses not listed. It is a hard water containing a relatively large amount of sodium chloride (common salt).

ANALYSIS

Date of collection	July 1923		November 8, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	15	—	6.6	—
Iron (Fe)	.21	—	.02	—
Calcium (Ca)	63	3.14	64	3.19
Magnesium (Mg)	15	1.23	12	.99
Sodium (Na)	110	4.78	86	3.74
Potassium (K)		—	3.4	.09
Bicarbonate (HCO_3)	103	1.69	130	2.13
Sulfate (SO_4)	77	1.60	60	1.25
Chloride (Cl)	209	5.90	164	4.62
Fluoride (F)	—	—	.1	.00
Nitrate (NO_3)	—	—	1.5	.02
Dissolved Solids	619	—	487	—
Total Hardness as $CaCO_3$	219	—	209	—
Carbon Dioxide (CO_2)	—	—	7	—
Color	—	—	10	—
pH	—	—	7.5	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—	25.9	—

Utilization.—The springs have been a recreational area for many years and are developed principally as a park and as a swimming and bathing resort with bathhouse facilities. During the period that the Tampa electric street railways were in operation the springs were the terminus of their northmost line.

OTHER SPRINGS

Messer Spring located 3 miles northeast of Riverview, and two springs with no names near Buckhorn Spring are located in Hillsborough County and some data on each are given in Table 4.

HOLMES COUNTY

PONCE DE LEON SPRINGS *at* PONCE DE LEON

Location.—One mile southeast of the town of Ponce de Leon.

Description.—The head of the springs is surrounded by a timber retaining wall. This pool has a rock and sand bottom which is kept clean by the operator of the springs. A horizontal cavity is located in the approximate center of the pool and soundings of May 20, 1942 indicate a maximum pool depth of 16 feet. The roof of the cavity is 7 feet below the water surface. The temperature of the water was 68°F on May 20, 1942 and on December 9, 1946. The operators of the springs state that they check the temperature several times during each year and find it to be always about 68°F. A second cavity is located near the north side of the pool just above the run, and causes the bottom of the pool to slope from one foot at the shore to 10 feet at the edge of the cavity. The water emerges from a circular chimney 6 to 8 feet in diameter, the bottom of which is 18 or 19 feet below the water surface. There is a third cavity a short distance down the run but observations indicate that it is not active as a spring or sink. The run is approximately 350 feet long, and flows into Sandy Creek, a tributary of the Choctawhatchee River.

Discharge.—The flow was 20.7 second-feet (13 m.g.d.) on May 20, 1942 and 18.1 c.f.s. (12 m.g.d.) on December 9, 1946.

Quality of water.—Water in Ponce de Leon Springs is moderately hard. The dissolved solids consist primarily of calcium and bicarbonate. No sample was collected for analysis in 1946.

ANALYSIS

Date of collection February 21, 1927

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	8.8	—
Iron (Fe)	.27	—
Calcium (Ca)	30	1.50
Magnesium (Mg)	9.2	.76
Sodium (Na)	1.9	.08
Potassium (K)	.4	.01
Bicarbonate (HCO_3)	123	2.01
Sulfate (SO_4)	3.8	.08
Chloride (Cl)	2.6	.07
Fluoride (F)	—	—
Nitrate (NO_3)	.25	.00
Dissolved Solids	113	—
Total Hardness as $CaCO_3$	113	—
Carbon Dioxide (CO_2)	—	—
Color	—	—
pH	—	—
Specific Conductance ($Kx10^5$ at 25°C.)	—	—

Utilization.—Facilities include a privately operated swimming pool, bathhouses, showers, and locker rooms which are open to the public.

OTHER SPRINGS

Other springs in Holmes County are Blue Springs, Turner Spring, two springs at Miller Cross Roads, and a sulphur spring at Prosperity.

JACKSON COUNTY

BLUE SPRINGS *near* MARIANNA

Location.—At the head of an elongated power reservoir about 5 miles northeast of Marianna. Reached by driving east from Marianna for about 1 mile on U.S. Highway 90, then north for about 1 mile on State Highway 71, then northeast on the unpaved Dellwood road for 4 miles to the head of the reservoir and springs.

Description.—The springs rise in the hilly red clay farmlands and woodlands northeast of Marianna. A wooded high bluff forms the northwest bank of the reservoir below the springhead and shifts to the opposite bank about 0.5 mile downstream. The water's edge of the reservoir is lined with cypress trees which spread out over the lower land areas. The springs are tributary to the Chipola River and are in the Apalachicola River basin.

The head of the springs is a circular pool about 200 feet in diameter with all or almost all of the water emerging from a nearly horizontal cavern having a maximum pool depth of 17.1 feet at its entrance on May 20, 1942. The maximum velocity of the water emerging from the cavern on this date was 1.73 feet per second, and the temperature of the water at the entrance to the cavern was 70°F on May 20, 1942 and on May 15, 1946. The general depth of the pool away from the cavern varies from 3 to 7 feet. Another spring issues from the right bank about 300 feet below the headpool.

About 0.2 mile downstream from the head of the springs at a diving platform on the right, 20 feet offshore, and opposite a military reservation warning sign on the left side of the run, is located a funnel-shaped sinkhole with an oval opening with diameters of about 15 and 20 feet. The maximum depth measured in this chimney was 23.0 feet on May 15, 1946. The bottom was irregular, having 0.1 to 0.2 foot of sludge between hard spots of rock. The sinkhole is also known as Spring No. 3 but there was no visible outflow. There are believed to be six other smaller springs in the vicinity, all in the reservoir. Sinkholes also are said to be present beneath the lake of the reservoir.

Discharge.—Measured flows are as follows:

DATE	CUBIC FEET PER SECOND		MILLION GALLONS PER DAY	
	U.S. HIGHWAY 90	BELOW HEAD	U.S. HIGHWAY 90	BELOW HEAD
August 2, 1927	185		120	
January 24, 1929		134		87
January 24, 1929	100		65	
September 24, 1930	200		129	
December 14, 1932	152		98	
April 11, 1934	109		70	
December 22, 1934		56.4		36
October 14, 1941	86.4		56	
May 20, 1942		265		171
April 11, 1946	277		179	
November 15, 1946		178		115
December 16, 1946		166		107
January 30, 1947		178		115
Averages	158	163	102	105

Quality of water.—This spring water is moderately hard. The dissolved mineral matter consists largely of calcium and bicarbonate. The two analyses made on samples collected 22 years apart are very similar, indicating that the composition of the water is probably fairly constant.

ANALYSIS

Date of collection	April 2, 1924		May 15, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	12	—	5.6	—
Iron (Fe)	.09	—	.04	—
Calcium (Ca)	43	2.15	38	1.90
Magnesium (Mg)	1.0	.08	2.1	.17
Sodium (Na)	2.3 (Na + K)	.10 (Na + K)	1.7	.07
Potassium (K)			.4	.01
Bicarbonate (HCO_3)	126	2.07	118	1.93
Sulfate (SO_4)	2.4	.05	.9	.02
Chloride (Cl)	2.0	.06	2.5	.07

	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Fluoride (F) - - -	—	—	.0	.00
Nitrate (NO_3) - -	1.6	.03	5.7	.09
Dissolved Solids - -	125	—	115	—
Total Hardness as $CaCO_3$ - - - -	112	—	103	—
Carbon Dioxide (CO_2)	—	—	6	—
Color - - - - -	—	—	8	—
pH - - - - - -	—	—	7.5	—
Specific Conductance ($Kx10^5$ at 25°C.) -	—	—	20.5	—

Utilization.—The springhead is used extensively for swimming, and is equipped with dressing rooms and a diving board.

The U. S. Department of the Interior, Fish and Wildlife Service, removes quantities of young bass from the head of the spring each year for fisheries at Marianna.

Water from the reservoir is used in hydro-electric power production for the manufacture of ice.

OTHER SPRINGS

Some of the other springs in Jackson County are Blue Hole Spring and Sugar Mill Spring at the Florida Caverns State Park, Hayes Spring west of Greenwood, Waddells Spring, and a number of springs along Dry Creek. There are many small springs in Jackson County in addition to these.

JEFFERSON COUNTY

WACISSA SPRINGS *at* WACISSA

Location.—The group of springs known as Wacissa Springs are located 1 mile south of the town of Wacissa.

Description.—These springs comprise the headwaters of Wacissa River and are located within 0.8 mile of the head of the Wacissa River.

Wacissa Springs are composed of the following springs: Big Spring, Garner Springs, Blue Spring, Buzzard Log Springs, Minnow Spring, Cassidy Spring, two apparently unnamed springs herein designated as No. 1 and No. 2, Thomas Spring, and Log Springs.

Big Spring, sometimes known as Big Blue Spring, consists of a circular pool approximately 90 feet in diameter, having a cavity about 70 feet in diameter whose side walls drop almost vertically to a depth of about 40 feet. The cavity is in limestone which appears to be cavernous on both the east and west sides. Soundings indicate a maximum depth of 45 feet. The bottom of the pool is covered with a layer of silt approximately one foot in depth. The average depth of the pool away from the cavity varies from 2 to 5 feet. The spring flow discharges into two runs, one flowing southwest and the other flowing northwest, both entering the Wacissa River within 0.2 mile of each other. The runs are full of eel grass and measurements of the discharge are made very difficult. The run flowing northwest is approximately 0.2 mile in length and 80 feet in width, the dimensions of the other were not determined.

Garner Springs consists of two headpools. In the smaller a limestone cavity, 8 feet in diameter, has a maximum depth of 6.3 feet. It was impracticable to get to the larger of the springheads because its outlet channel was obstructed by fallen trees. This spring run is approximately 800 feet long and 50 feet in width and is full of eel grass and other aquatic growth.

Blue Spring consists of a circular pool with a limestone cavity about 40 feet in diameter, which has a maximum depth of 19.0 feet. The spring run is about 900 feet long and approximately 50 feet in width. The run is full of eel grass and aquatic vegetation and the surface has a scum of "duck seed".

Buzzard Log Springs consists of four springheads, two being at the confluence of the run with the Wacissa River and the other two at the head of the run which is approximately 0.2 mile in length. The maximum depth of the two spring cavities at the mouth of the run was 8.1 feet and the flow emerges from limestone in one and apparently from a sand boil in the other. It was impracticable to get to the head of the run due to the stream being obstructed by logs. The run is covered with "duck seed" and is full of aquatic growth.

Minnow Spring consists of a circular pool with a limestone cavity about 15 feet in diameter in the bottom at a maximum depth of 8.1 feet. The water in the boil of the spring is filled with sand particles flushed out of the cave. The run is approximately 100 feet in length and flows in an easterly direction.

Cassidy Spring consists of a pool with a limestone cavity at the bottom, 8 feet in diameter and in a maximum of 28.0 feet of water. The run is approximately 70 feet long and discharges into the Wacissa River.

Spring No. 1 consists of a cavity in a limestone outcrop within the Wacissa River. The maximum depth of the pool cavity was 24.7 feet.

Spring No. 2 discharges from a circular cavity in a limestone outcrop beneath a maximum of 18.9 feet of water in the Wacissa River.

Thomas Spring discharges from a limestone cavity approximately 8 feet in diameter under the Wacissa River at a maximum depth of 28.2 feet.

Log Springs discharge from two cavities within a limestone pool 40 feet in length by 15 feet in width. The maximum depths to the floors of the cavities are 28.2 feet and 24.0 feet, respectively.

Sand spring boils are visible at many points along the stretch of the river from Teate's fish camp to the head of the Wacissa River. There are believed to be additional springs upstream from Thomas Spring, downstream from mouth of Big Spring Run and also in Little River. These were not investigated.

Discharge.—The following measurements of discharges were made on July 16, 1942:

Big Spring—The total discharge was found to be 69.4 second-feet (45 m.g.d.), which was comprised of a discharge of 22.7 c.f.s. (15 m.g.d.) in the southwest run, and 46.7 c.f.s. (30 m.g.d.) in the northwest run.

Garner Spring—17 c.f.s. (11 m.g.d.) measured 200 feet below the head of the smaller spring.

Blue Spring—9.43 c.f.s. (6 m.g.d.) measured 300 feet below the head of the spring.

Minnow Spring—5 c.f.s. (3 m.g.d.), estimated.

Big Spring, Garner Springs, Blue Spring, Buzzard Log Springs, Minnow Spring, Cassidy Spring and Log Springs discharge into the Wacissa River. Thomas Spring, Spring No. 1 and Spring No. 2 are within the Wacissa River channel and therefore their flow would be difficult to measure.

Quality of water.—The water in *Big Spring* is hard and contains moderate concentrations of calcium and bicarbonate. It is typical of many spring waters in Florida.

ANALYSIS

Date of collection July 23, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	12	—
Iron (Fe)	.08	—
Calcium (Ca)	52	2.59
Magnesium (Mg)	8.6	.71
Sodium (Na)	3.1	.13
Potassium (K)	.8	.02
Bicarbonate (HCO_3)	191	3.13
Sulfate (SO_4)	6.7	.14
Chloride (Cl)	5.1	.14
Fluoride (F)	.1	.01
Nitrate (NO_3)	.3	.00
Dissolved Solids	181	—
Total Hardness as $CaCO_3$	165	—
Carbon Dioxide (CO_2)	12	—
Color	2	—
pH	7.4	—
Specific Conductance ($K \times 10^5$ at 25°C.)	32.0	—

Utilization.—The springs are intact in their natural surroundings. A group of men at one time were said to have been interested in developing the springs as an attraction for tourists but the plan never materialized. The river in the vicinity of Springs No. 1 and No. 2 is used for swimming. The runs of the various springs are frequented by fishermen, owing to the abundance of fish.

OTHER SPRINGS

Walker Spring, also in Jefferson County, is 8 miles southeast of Lamont.

LAFAYETTE COUNTY

TROY SPRING *near* BRANFORD

Location.—About six miles northwest of Branford on the southwest side of the Suwannee River. The spring can be reached by driving northwest on State Highway 20 from Branford for a distance of 4.8 miles to a filling station, then turning right and driving 1.2 miles on a sand road to another sand road going to the right; thence 0.6 mile to the head of the spring.

Description.—(See figure 15.) The head of the spring is an ellipsoidal cavity approximately 70 feet by 50 feet, existing in a pool about 100 feet in diameter, that has been carved out of the comparatively flat wooded southwest river bank. The side walls of the cavity drop almost vertically downward to an average depth of about 50 feet and a maximum depth on July 17, 1942, of 68.5 feet measured very close to the north side of the cavity. The cavity appears to have tributary horizontal caverns on the north and west sides. The water in the pool was so clear that a few submerged logs lying on the bottom were clearly seen. The general depth of the pool away from the cavity varies from 2 to 8 feet. The spring run enters the Suwannee River about 200 feet below the head of the spring after flowing in an almost easterly direction. The spring run has an average width of about 100 feet, and its bed is lined almost entirely with

FIGURE 15. Headpool and run of *Troy Spring*, Lafayette County.

limestone, having long deep transverse cracks and a few longitudinal openings.

A short distance below the main head of the spring there is another pool and cavity on the right which has a maximum depth of 15.0 feet.

Discharge.—The flow was 55.2 second-feet (36 m.g.d.) on May 15, 1927 and 149 c.f.s. (96 m.g.d.) on July 17, 1942.

Mr. William Milford of Branford stated that he had been told by the "old timers" in the vicinity that on a few occasions when the stage of the Suwannee River was exceedingly low the run from Troy Spring was dry and no visible flow from the spring could be detected.

Utilization.—The spring is as nature has made it. It is used extensively for swimming by people in the nearby vicinity, but no facilities for dressing are provided.

Historical note.—The submerged hull of an old steamboat, its bow pointing towards the head of the spring, is clearly visible at a point near where the spring joins the Suwannee River. Mr. William Milford of Branford stated that the steamboat was an old gun boat of the Confederate Army during the war between the States. The story is told that the Union Army had trapped the gun boat on the Suwannee River. In order that the boat would not fall into the hands of the Union forces, the captain ran it into the run and scuttled it there.

OTHER SPRINGS

Two other springs are reported in Lafayette County. These are Morrison Spring ten miles northwest of Branford and Steinhatchee Spring, reported to be near the head of the Steinhatchee River near Cooks Hammock.

LAKE COUNTY

ALEXANDER SPRINGS *near* ASTOR

Location.—About 6 miles southwest of Astor Park. Reached by driving southwest from Astor Park for 6 miles on State Highway 445, turning northwest off the highway upon a sand road and following it about 0.1 mile to the springhead.

Description.—(See figure 16.) Situated at the foot of the sandy, pine-wooded hills on the north and east which face the swampy hammock area of Nine Mile Branch to the northwest, Alexander Springs is one of the relatively lesser known of the major springs in the state due to its distance from the larger populated centers. The head of the springs forms a circular pool about 200 feet in diameter with almost all of the flow emerging vigorously from one large cavern which was covered by a maximum depth of 25.5 feet of water, measured at its entrance on April 2, 1946. The temperature of the water was 74°F one foot below the surface at the main boil on April 2, 1946. The force of the issuing flow of water flushes shell and sand particles from the cavern and also causes a well defined "hump" on the water surface at the boil.

FIGURE 16. *Alexander Springs* near Astor, looking down run from the head-pool. The "boil" is near the end of the springboard.

Discharge.—The average of 6 measurements made during the period from February 12, 1931 to April 2, 1946 is 117 second-feet (76 m.g.d.).

Quality of water.—The water represented by this analysis is hard and moderately concentrated. Sodium and chloride are the chief constituents, but it also contains appreciable quantities of calcium, magnesium, bicarbonate, and sulfate.

ANALYSIS

Date of collection April 2, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	8.8	—
Iron (Fe)	.03	—
Calcium (Ca)	41	2.05
Magnesium (Mg)	18	1.48
Sodium (Na)	103	4.48
Potassium (K)	2.3	.06
Bicarbonate (HCO_3)	98	1.61
Sulfate (SO_4)	56	1.17
Chloride (Cl)	192	5.42
Fluoride (F)	.1	.01
Nitrate (NO_3)	.9	.01
Dissolved Solids	508	—
Total Hardness as $CaCO_3$	176	—
Carbon Dioxide (CO_2)	20	—
Color	0	—
pH	6.9	—
Specific Conductance ($Kx10^5$ at 25°C.)	92.0	—

Utilization.—The springs are undeveloped but are occasionally used for swimming and picnicking. A dock and diving board are available but there is no bathhouse. The springs are inside the boundary of the Ocala National Forest and are under the supervision of the U. S. Forest Service. They were known to the early Spaniards and are located near the center of a Spanish land grant.

BUGG SPRING *at* OKAHUMPKA

Location.—About 0.5 mile northwest of the town of Okahumpka and approximately 4 miles southwest of the city of Leesburg. Reached by driving west 0.2 mile on road from Okahumpka to Sumterville, thence north 0.2 mile on a sand farm road to the head of the spring.

Description.—(See figure 17.) The run from Bugg Spring flows north from the high citrus lands lying southwest of Lake Harris then east through Helena Run into Lake Harris. It then goes through a chain of lakes comprising the headwaters of the Oklawaha River, a tributary of the St. Johns River. The head of the spring is a elliptical shaped cavity approximately 200 feet by 100 feet submerged in a nearly circular pool of about 400 feet in diameter. The pool bottom slopes gradually from the banks to the rim of the cavity which is approximately 55 feet below the water surface. The side walls of the cavity drop

FIGURE 17. *Bugg Spring* at Okahumpka. Headpool shown in foreground.

almost vertically downward to a depth of approximately 165 feet with a maximum depth of 176 feet near the center of the cavity, as shown by the soundings of March 16, 1943. The bottom of the cavity is soft as though covered with a "sludge" deposit. Due to the murky color of the water and the extreme depth of the spring it was impossible to see the spring bottom but visibility extended to a depth of about 40 feet. Figure 18 shows contours of depth as defined by 237 soundings taken along six radial lines. The temperature of the water on April 19, 1946 was 74°F.

Old residents at Okahumpka on March 16, 1943, stated that the stage of Bugg Spring was at the lowest ever remembered in the past 60 years. Information on the maximum stage was vague but it may have been as much as five or six feet higher than the stage on that date.

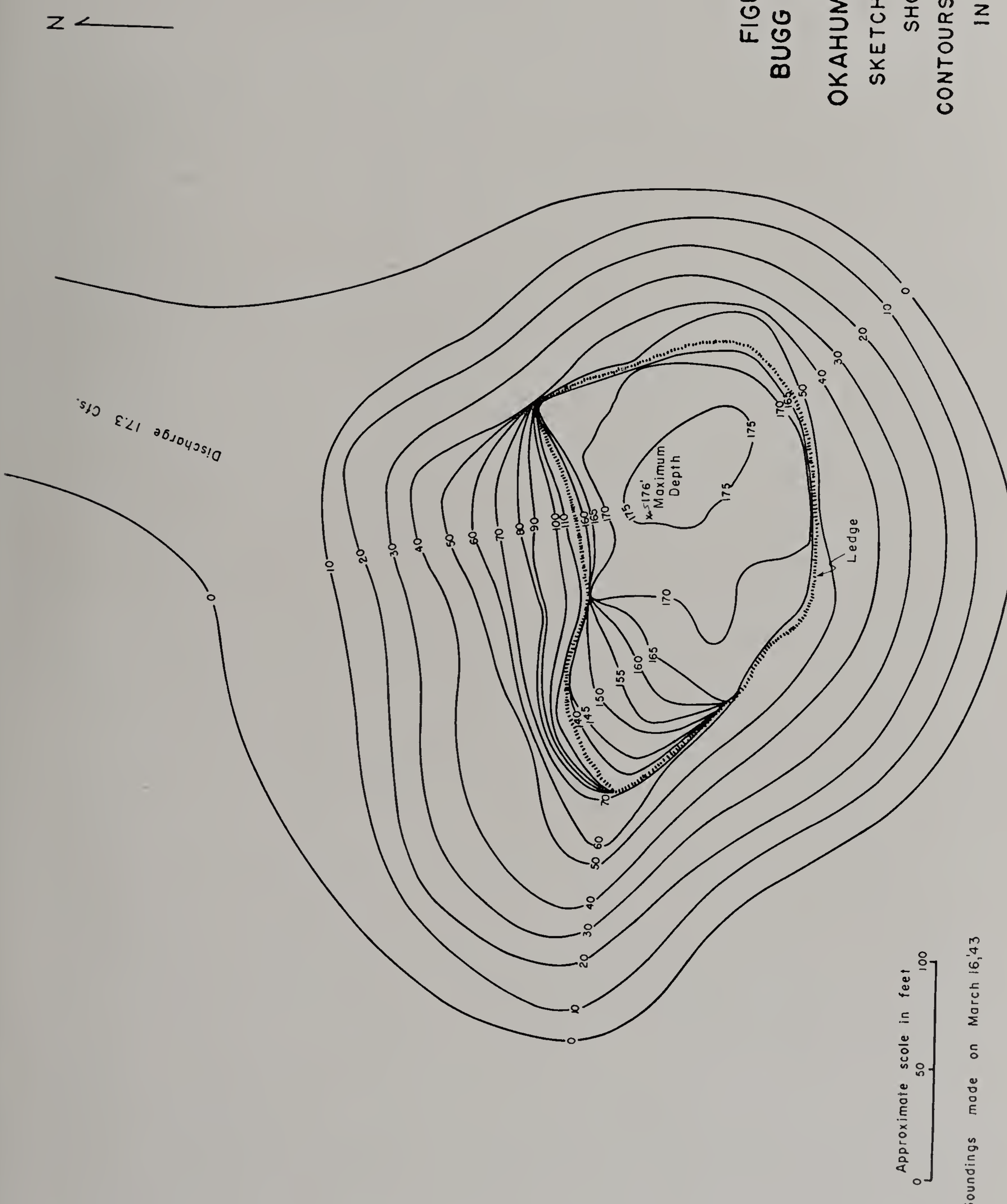

FIGURE 18
BUGG SPRING
AT
OKAHUMPKA, FLA.
SKETCH OF POOL
SHOWING
CONTOURS OF DEPTH
IN FEET

On April 19, 1946, the water surface was 1.24 feet higher than on March 16, 1943.

Discharge.—A flow of 17.3 second-feet (11 m.g.d.) was measured below the head of the spring on March 16, 1943. The shallow stream bed at the measuring section is covered with a soft "sludge" deposit emitted from the spring. A discharge of 17.6 c.f.s. (11 m.g.d.) was measured on April 19, 1946.

Quality of water.—Water in Bugg Spring is moderately hard and in all respects typical of many springs in Florida. The dissolved mineral matter consists primarily of calcium and bicarbonate.

ANALYSIS

Date of collection April 19, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	9.0	—
Iron (Fe)	.08	—
Calcium (Ca)	44	2.20
Magnesium (Mg)	2.9	.24
Sodium (Na)	4.4	.19
Potassium (K)	.2	.01
Bicarbonate (HCO_3)	146	2.39
Sulfate (SO_4)	2.0	.04
Chloride (Cl)	6.6	.19
Fluoride (F)	.0	.00
Nitrate (NO_3)	.3	.00
Dissolved Solids	140	—
Total Hardness as $CaCO_3$	122	—
Carbon Dioxide (CO_2)	9	—
Color	5	—
pH	7.4	—
Specific Conductance ($K \times 10^5$ at 25°C.)	25.9	—

Utilization.—The spring is intact in its natural surroundings and is privately owned. It is used for swimming by local residents, although there are no facilities for dressing at the spring. It is a well known fishing place for the local people. On the south side of the spring there is a large citrus grove. The two farm homes at the spring utilize its water for household and gardening needs, having a direct pipe line from the spring to their pump. The water has a pleasing taste.

MESSANT SPRING *near* SORRENTO

Location.—About 7.4 miles northeast of Sorrento. Reached by driving east from Sorrento on State Road 46 for 0.5 mile, turning north on a paved road and driving 3.0 miles, then turning east and driving 1.6 miles on a graded road, turning north and driving 1.6 miles on a road which curves east, then turning east and driving 1.1 miles to the spring at an abandoned lumber camp.

Description.—Situated on relatively flat land, the spring is tributary to Blackwater Creek, thence to the Wekiva River and into the St. Johns River. It was impossible to view the springhead due to heavy underbrush. Portions of the run are too deep for wading and there is too much aquatic vegetation on the surface to navigate a boat. The temperature of the water was 79°F on May 10, 1946.

Discharge.—The flow was 18.4 second-feet (12 m.g.d.) on May 10, 1946.

Quality of water.—The water has a slight odor of hydrogen sulfide. No samples were collected for analysis.

Utilization.—A wide place in the run, 6 to 8 feet deep, was once used by employees of the Wilson Cypress Company as a swimming pool and steps and a diving tower still remain.

SEMINOLE SPRINGS *near* SORRENTO

Location.—About 3.4 miles northeast of Sorrento. Reached by driving east from Sorrento on State Road 46 for 0.5 mile, turning north on an asphalt road and driving 3.0 miles, turning east on a graded road and driving 1.6 miles, then turning south and driving 0.7 mile to the springs.

Description.—Located in two deep ravines the springs are the headwaters of Seminole Creek which flows into Black Creek, a tributary of the Wekiva River. Each uppermost spring forms a kidney-shaped head with pools 6 to 10 feet in diameter. The spring flow emerges from rocks and horizontal caverns at the water surface. The deepest water covering these caverns on May 10, 1946, was 4.5 feet. The north head joins the west head about 100 feet downstream and flows east as one run. There are about 100 boils reported in the run within 0.3 mile of the head. The water is clear and has no taste of sulphur.

Discharge and temperature.—An average flow of 22.0 second-feet (14 m.g.d.) has been computed from the four discharge measurements given below.

DATE	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY	WATER TEMPERATURE
			°F
February 5, 1931 - - -	27.1	18	80
March 8, 1932 - - - -	10.2	6.6	76
February 10, 1933 - - -	35.8	23	74
May 10, 1946 - - - -	14.7	9.5	76

Quality of water.—No samples were collected.

Utilization.—About 1936 the Wilson Cypress Company camp at Cassia used the springs as a source of water supply and also dammed the springs to form a swimming pool. Remnants of the timber dam and flumes remain but they no longer perform the functions for which they were built and the springs area has partially reverted to its natural setting. Vines and matted vegetation, fallen trees and brush, make it a difficult section to traverse.

SPRING (NO NAME) *at* ECHO GLEN *at* YALAHA

Location.—The spring is 0.3 mile north of Yalaha and may be reached by turning north off State Highway 48 at the railroad station on a graded road, driving 0.3 mile to the edge of Lake Harris, then turning west and driving about 0.1 mile to the spring run.

Description.—The spring lies between the edge of Lake Harris and its bordering hills to the south. It forms a small crooked run about 10 feet wide which flows north about 100 feet into Lake Harris and the Oklawaha River, a tributary of the St. Johns River.

Discharge.—The flow was 4.6 second-feet (3 m.g.d.) on April 19, 1946.

Quality of water.—No samples were collected.

Utilization.—The spring is not developed.

OTHER SPRINGS

Some of the other springs in Lake County are Bear Spring, Blue Spring near Yalaha, and Apopka Springs or Minniebohoo Springs, 3 miles east of Oakland in the "gourdneck" section of Lake Apopka.

LEON COUNTY

NATURAL BRIDGE SPRING *at* NATURAL BRIDGE, *South of* TALLAHASSEE

Location.—Approximately 6.5 miles east of Woodville, the spring can be reached by driving 6.2 miles east along State Highway 259 from Woodville. The headpool is 300 feet south of the first fork in the road east of the natural bridge over the St. Marks River.

Description.—(See figure 19.) The head of the spring is a pool that is roughly circular with a diameter of about 40 feet and is located within the wooded river valley depression. Soundings made on May 19, 1942, indicate a maximum depth of 43 feet at a point 5 feet from shore at the extreme head. The bottom of the pool is rather soft. The temperature of the water was 68°F on May 19, 1942, and 69° on May 14, 1946. There is no noticeable boil. The water flows into a channel having a width of about 40 feet and depths of 4 to 6 feet in straight portions and as great as 15 feet at bends. The channel meanders for about 0.3 mile ending in a sink. This sink is about the same size and shape as the head of the spring with a center depth of 36 feet. This sink is located along the side of State Highway 259 about 300 feet east of St. Marks River at Natural Bridge, and is probably tributary to the St. Mark River.

Both pool and channel are obstructed by submerged tree trunks and lined with heavy growth of large trees and underbrush.

Discharge.—The flow was 115 second-feet (74 m.g.d.) on May 19, 1942, 200 feet below head, and 132 c.f.s. (85 m.g.d.) on May 14, 1946.

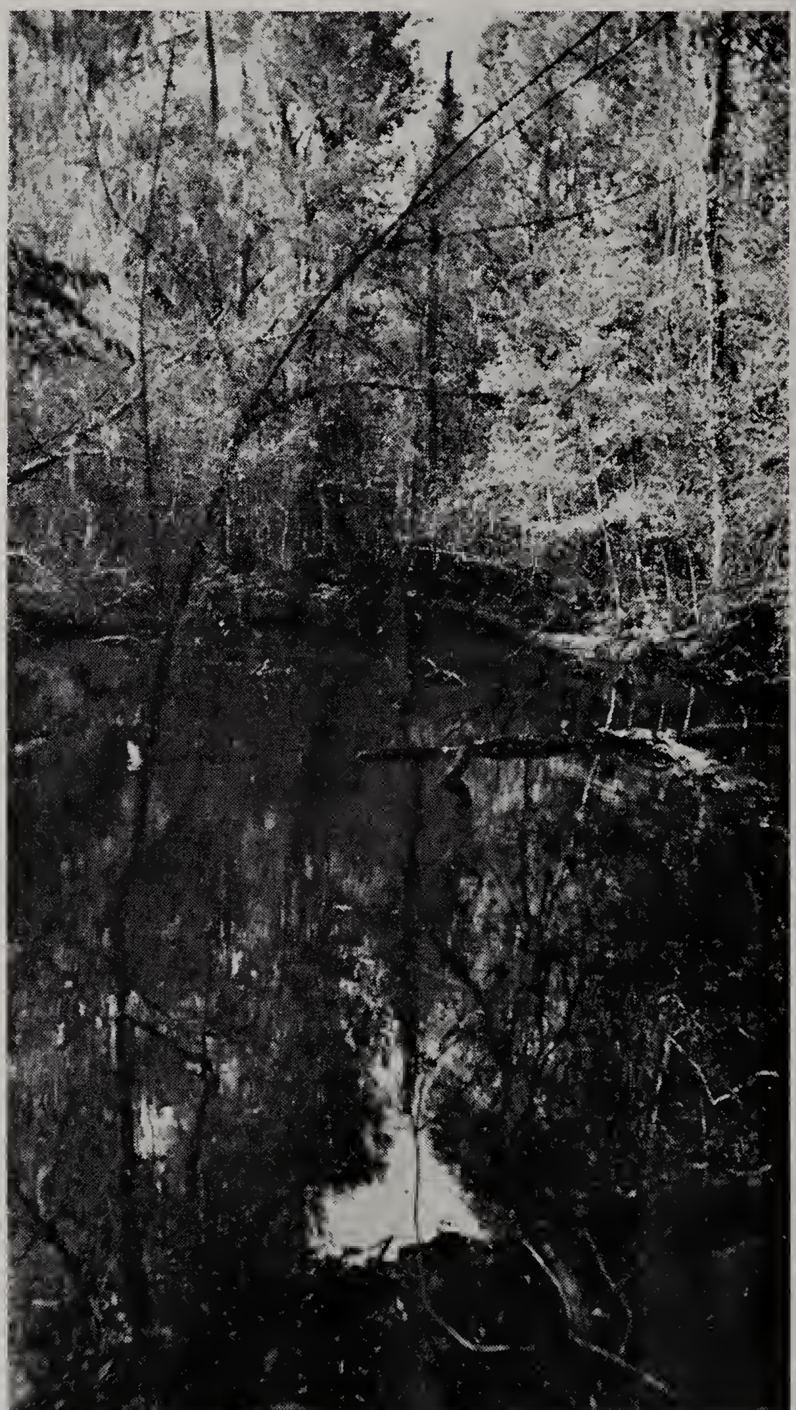

FIGURE 19. *Natural Bridge Spring.* Photograph taken at springhead looking southwest down the run.

Quality of water.—Water in Natural Bridge Spring is moderately hard, containing an appreciable amount of calcium and bicarbonate. It is typical of many spring waters in Florida.

ANALYSIS

Date of collection May 14, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	11	—
Iron (Fe) - - - -	.05	—
Calcium (Ca) - -	35	1.75
Magnesium (Mg) -	6.5	.54
Sodium (Na) - - -	3.3	.14
Potassium (K) - -	.5	.01
Bicarbonate (HCO_3)	128	2.10
Sulfate (SO_4) - -	7.1	.15
Chloride (Cl) - -	5.0	.14
Fluoride (F) - - -	.3	.02
Nitrate (NO_3) - -	1.2	.02
Dissolved Solids - -	137	—
Total Hardness as $CaCO_3$ - - - -	114	—
Carbon Dioxide (CO_2)	8	—
Color - - - - - -	40	—
pH - - - - - - -	7.4	—
Specific Conductance ($K \times 10^5$ at 25°C.) -	22.6	—

Utilization.—The spring is undeveloped.

RHODES SPRINGS, *South of* TALLAHASSEE

Location.—This is a group of four or more springs about 13 miles southeast of Tallahassee and between Woodville and Fanlew near the St. Marks River at Natural Bridge in Leon County.

The springs are located within an area of less than two square miles and are all known locally as Rhodes Springs. They are designated herein as Spring No. 1, No. 2, No. 3, and No. 4, and are referred in location to the Natural Bridge on State Road 354 which crosses the St. Marks River 6.5 miles east of Woodville or to the Natural Bridge monument several hundred feet east of Natural Bridge.

Head of No. 1 is located about 0.5 mile south of Natural Bridge Monument.

Head of No. 2 is south of State Road 354 between Woodville and Natural Bridge and 0.8 mile from the latter.

Head of No. 3 is 200 feet southeast of an abandoned but standing brick chimney at old house site about 0.5 mile east of Natural Bridge Monument.

Head of No. 4 is reached by driving southwest 0.4 mile from Natural Bridge Monument on sand road diverging from State Road 354 at monument and turning left on trail and driving 0.1 mile to the spring.

Description.—No. 1 consists of a circular head, about 50 feet in diameter, and a channel that meanders generally northeast for about 100 feet into another pool where it makes a ninety degree turn to the right and flows 50 feet into a sink about the same size and shape as the head. Soundings indicate a maximum depth of 31 feet in the headpool which has a fairly uniform sandy bottom with the greatest depth located at the center. There are some submerged tree trunks in the head. Water passes from the pool over a lip about 3 feet deep and 25 feet wide to a channel about 30 feet wide. The pool at the bend in the run is 10 feet deep, and the sink, into which the run discharges, has a depth of 46.5 feet in the center of the pool, which is believed to be the maximum depth of the group. The temperature of the water from Spring No. 1 on May 19, 1942, was 69°F.

Spring No. 2 consists of two heads, each about 25 feet in diameter. Water from one head flows south for about 75 feet and joins the easterly flow of the second head 50 feet downstream from that head. The combined flow passes through a constriction of logs and planking, losing about a foot of head, and continues to flow east for about 100 feet in an old wood flume, 15 feet wide, to a sink about the same size and shape as the headpools.

The head of Spring No. 3 is a pool contained in part of an eroded ravine overgrown with vegetation. A small falls drops about 2 or 3 feet into the pool, which widens from 8 feet across to about 15 feet across at a point 20 feet downstream from the falls. The run flows southeast, is about 25 feet wide and probably discharges into the St. Marks River an unknown distance below the head. Soundings indicate a maximum depth of 22 feet in the head of the springs.

Spring No. 4 consists of a circular head that is 40 feet in diameter and about 16 feet deep, a run that is 25 to 30 feet wide and about 200 feet long, and a sink into which the run discharges with the same size and shape as the head and a probable maximum depth of 25 feet. The water temperature of Spring No. 4 on October 14, 1941, was 69°F.

Discharge.—The flow from Spring No. 1 was 22.4 second-feet (14 m.g.d.) measured at a point immediately below the bend of the run.

The flow of Spring No. 2 was 13.8 c.f.s. (8.9 m.g.d.) measured in the flume of the spring.

The flow in Spring No. 3 was not measured but is believed less than the others of this group.

Spring No. 4 has a flow of 21.1 c.f.s. (14 m.g.d.) measured at a point midway between the head and the sink.

The preceding discharge measurements were made on May 19, 1942.

Utilization.—A partially-rotted wood flume built in the connecting channel between the heads and sink of Spring No. 2 indicates an early development of an undisclosed type.

This group of springs is in a recreational area and is likely used for picnicking and swimming.

OTHER SPRINGS

Levy's Spring, another spring in Leon County, is located north of Tallahassee.

LEVY COUNTY

FANNING SPRING *near* WILCOX

Location.—On the wooded left bank of the Suwannee River, 0.2 mile south of U.S. Highway 19 bridge, 2.2 miles south and 0.8 mile west of Wilcox. It can be reached by turning south on the marked road which is about 300 feet east of the highway bridge.

Description.—As viewed from the top of the high east bank this spring pool and run are somewhat suggestive of Rainbow Springs. The cavity of the spring pool is about 30 feet in diameter and its maximum depth on December 17, 1942 was sounded as 13.3 feet. Besides the flow from the cavity of the spring boil, the spring is also fed by six small hillside springs. The spring is in limestone, and has a rich blue color in contrast to the white sand of the bottom. There are many colored types of aquatic growth in the spring run. The boil of the spring shows a constant eruption of sand particles from the cavity opening. The temperature of the water was 72°F on March 14, 1932 and

January 2, 1946 and 73°F on July 24, 1946. The spring run is approximately 60 feet wide and flows west 500 feet into the Suwannee River.

Discharge.—The flow was 109 second-feet (70 m.g.d.) on October 25, 1930; 79.2 c.f.s. (51 m.g.d.) on March 14, 1932; and 137 c.f.s. (88 m.g.d.) on December 17, 1942.

Quality of water.—The water represented by the following analysis is hard and is typical of water found in limestone aquifers in Florida. The dissolved mineral matter consists largely of calcium and bicarbonate.

ANALYSIS

Date of collection July 24, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	6.1	—
Iron (Fe) - - - -	.08	—
Calcium (Ca) - -	66	3.29
Magnesium (Mg) -	4.8	.39
Sodium (Na) - - -	2.6	.11
Potassium (K) - -	.6	.02
Bicarbonate (HCO_3)	210	3.44
Sulfate (SO_4) - -	9.9	.21
Chloride (Cl) - - -	4.0	.11
Fluoride (F) - - -	.0	.00
Nitrate (NO_3) - -	2.0	.03
Dissolved Solids - -	199	—
Total Hardness as $CaCO_3$ - - - - -	184	—
Carbon Dioxide (CO_2)	17	—
Color - - - - - -	2	—
pH - - - - - - -	7.3	—
Specific Conductance ($K \times 10^5$ at 25°C.) -	35.7	—

Utilization.—The spring has been privately developed. There is a dancing and skating pavilion, bathhouse, diving tower, and boat house. The grounds surrounding the spring have been cleared and are frequented by picnickers and campers.

MANATEE SPRING *near* CHIEFLAND

Location.—It is 7 miles west of Chiefland and can be reached by auto by traveling west on the sand road just south of Hardeetown.

Description.—The spring lies on the densely wooded east bank of the Suwannee River near the foot of the gradual slope from the highlands to the east. The springhead is approximately 70 feet in diameter with a maximum sounded depth of 30.8 feet, as measured on December 17, 1942. Although numerous soundings were taken, it is possible that the maximum depth was not included, as visibility of the spring bottom was impaired by "duck seed" and the turbulence of the spring. Fine sand particles were emitted from the spring cavity. Manatee Run flows southwest approximately 0.2 mile to the Suwannee River. The temperature of the water was 72°F on March 14, 1932, and 73°F on July 24, 1946.

Discharge.—The flow was 149 second-feet (96 m.g.d.) on March 14, 1932; 218 c.f.s. (141 m.g.d.) on December 17, 1942; and 137 c.f.s. (88 m.g.d.) on July 24, 1946.

Quality of water.—Manatee Spring water is hard and typical of many springs in Florida. The dissolved mineral matter consists largely of calcium and bicarbonate.

ANALYSIS

Date of collection July 24, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	5.8	—
Iron (Fe)	.06	—
Calcium (Ca)	75	3.74
Magnesium (Mg)	6.3	.52
Sodium (Na)	2.9	.13
Potassium (K)	.4	.01
Bicarbonate (HCO_3)	223	3.65
Sulfate (SO_4)	23	.48
Chloride (Cl)	5.1	.14
Fluoride (F)	.0	.00
Nitrate (NO_3)	1.7	.03
Dissolved Solids	231	—
Total Hardness as $CaCO_3$	213	—
Carbon Dioxide (CO_2)	14	—
Color	0	—
pH	7.4	—
Specific Conductance ($K \times 10^5$ at 25°C.)	40.2	—

Utilization.—The spring is intact in its natural surroundings. There is a fish camp 200 feet below the head of the spring. A few new cabins have been built. A sign posted on a tree reads: "Notice: This spring for free public use. No additional fences or buildings permitted. Patterson-McInnis Lbr. Co. (owners)."

WEKIVA SPRINGS *near* GULF HAMMOCK

Location.—About 6.3 miles east of Gulf Hammock. The springs are reached by turning northeast off U.S. Highway 19 at Gulf Hammock A. C. L. Railroad station on a graded road for 6.0 miles, turning left at the high tension electric power line and driving for 0.2 mile, then driving left 0.1 mile to the springs. The last 2 miles of the sand road are very bad and automobile travel during dry weather is difficult.

Description.—The springs are near the head of Gulf Hammock and are tributary to the Waccasassa River which flows into the Gulf of Mexico. They present an interesting picture. The head spring is a collapsed limestone cavern that forms a rather irregularly shaped pool about 20 feet in diameter and heavily surrounded by brush and undergrowth. The spring run flows a short distance, disappears, and comes up again a few feet away, forming a small natural bridge. The run winds about 50 feet more with several boils coming up through the limestone. This run disappears again and comes up again about five feet away, thereby forming another natural bridge. The run winds a few feet farther into another circular pool about 20 feet in diameter, from which the largest flow issues. Its maximum depth was 21.3 feet on July 25, 1946. The temperature of the water was 78°F on February 9, 1931, and 74°F on July 25, 1946.

Discharge.—The average, computed from the six flow determinations given below, is 72.9 second-feet (47 m.g.d.), and includes the flow of all springs.

DATE	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
February 21, 1917 - -	64.7	42
February 1, 1929 - -	100	65
October 25, 1930 - -	75.2	49
February 9, 1931 - -	81.3	52
March 16, 1932 - - -	55.1	36
July 25, 1946 - - -	60.9	39

Quality of water.—No samples were collected.

Utilization.—The springs are intact in their natural surroundings and are used as a swimming pool by local residents and as a watering place for stock.

OTHER SPRINGS

Other springs in Levy County are Blue Spring near Bronson, several small springs near Cedar Keys, King Spring near Lebanon, and Sulphur Spring near Otter Creek.

MADISON COUNTY

BLUE SPRING *near* MADISON

Location.—About 10 miles east of Madison. It is reached by driving east from Madison 2.3 miles on U.S. Highway 90, continuing east on State Road 6, a graded sand road, for 8.0 miles, then turning south and driving 0.1 mile to the spring.

Description.—The spring is on the southwest bank of the Withlacoochee River and flows 100 feet northeast into the river, thence into the Suwannee River and the Gulf of Mexico. The water is blue and very clear so that the bottom is clearly visible. The temperature of the water was 70°F on March 16, 1932 and 71°F on July 23, 1946. The side of the pool, as well as the floor of the run, is lined almost entirely with limestone. On the south bank of the pool a rock and sand bluff rises to a height of 25 feet above the water level. The spring forms a rather circular pool about 50 feet in diameter with all of the flow emerging from a near-horizontal cavern of limestone having an opening of about 20 x 35 feet. The maximum depth in the pool was 30.9 feet on July 23, 1946.

Discharge.—A flow of 145 second-feet (94 m.g.d.) was measured on July 23, 1946.

Quality of water.—Water represented by this analysis is moderately hard and free from color. The dissolved mineral matter consists primarily of calcium and bicarbonate.

ANALYSIS

Date of collection July 23, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	9.2	—
Iron (Fe) - - - -	.04	—
Calcium (Ca) - -	39	1.95
Magnesium (Mg) -	8.7	.72
Sodium (Na) - - -	2.4	.10
Potassium (K) - -	.7	.02
Bicarbonate (HCO_3)	148	2.43
Sulfate (SO_4) - -	10	.21
Chloride (Cl) - - -	3.6	.10
Fluoride (F) - - -	.1	.01
Nitrate (NO_3) - -	1.5	.02
Dissolved Solids - -	147	—
Total Hardness as $CaCO_3$ - - - - -	134	—
Carbon Dioxide (CO_2)	6	—
Color - - - - - -	0	—
pH - - - - - - -	7.6	—
Specific Conductance ($K x 10^5$ at 25°C.) -	26.2	—

Utilization.—It is used by local residents as a swimming pool. One local resident claims that 80 years ago when wells were not numerous people came here in ox-carts from miles around to bathe, wash clothes, and secure fresh water for drinking. The spring is in its natural state and is privately owned but open to public use.

PETTIS SPRING *near* GREENVILLE

Location.—About 5 miles west of Greenville. Reached by driving 4.3 miles west from Greenville on U.S. Highway 90, turning south on graded road and driving 2.4 miles to the spring.

Description.—This small spring is tributary to the Aucilla River which is 0.2 mile downstream from the source of the spring. The flow is artesian and the spring is enclosed by concrete walls and top and a wooden springhouse. A 3-inch diameter iron outlet pipe is on the west side of the springhouse. Water is pumped to a swimming pool and residence of the owners. The temperature of the water was 68°F on May 16, 1946.

Discharge.—The flow was 71 gallons per minute, measured volumetrically, on May 16, 1946.

Quality of water.—No samples were collected on May 16, 1946. The water has a slight iron taste. An analysis by Dr. Edgar Everhart, State Capitol, Atlanta, Georgia, was furnished by one of the owners, and it shows that the spring water is hard and the dissolved mineral matter consists almost entirely of calcium and bicarbonate. Its composition is typical of many springs in Florida. The analysis, after recalculating from grains per gallon to parts per million, is as follows:

ANALYSIS

Date of collection:

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	9.4	—
Iron (Fe) - - - -	.6	—
Calcium (Ca) - -	56	2.79
Magnesium (Mg) -	9.2	.76
Sodium (Na) - - -	5.1	.22
Potassium (K) - -	.4	.01
Bicarbonate (HCO_3)	217	3.56
Sulfate (SO_4) - - -	.5	.01
Chloride (Cl) - - -	8.5	.24
Dissolved Solids - -	187	—
Total Hardness $CaCO_3$	178	—
Carbon Dioxide (CO_2)	—	—
Color - - - - -	—	—
pH - - - - - -	—	—
Specific Conductance ($Kx10^5$ at 25°C.) -	—	—

Utilization.—It is used for drinking and for filling the swimming pool which serves several neighboring towns. It is open to the public by the courtesy of the owners, rather than as a business. The water was once bottled and sold.

OTHER SPRINGS

Cherry Lake Springs, situated 3.5 miles west of Pinetta, and

Swanacoochee Spring at Ellaville also are located in Madison County.

MANATEE COUNTY

Several springs, on which little information is available, are located in Manatee County. These are Brack Spring, 2 miles west of Bradenton; Manatee Spring at Manatee; Indian Spring, located in the Manatee River; and Sulphur Spring.

MARION COUNTY

JUNIPER SPRINGS *near* OCALA

Location.—About 27 miles east of Ocala. The springs are reached by driving for 27 miles east from Ocala on State Highway 40, then turning north on a paved road plainly marked with a large sign and following this road for 0.2 mile to the head of the springs.

Description.—(See frontispiece.) Situated in a well developed forest park, these springs are one of the popular recreational spots of central Florida. They form the headwaters of Juniper Creek which flows into Lake George in the St. Johns River basin. The head of the springs forms a circular pool about 100 feet in diameter with discharge emerging from three caverns, the floors of which were covered by maximum depths of 16.1, 16.6, and 17.8 feet of water on April 4, 1946. Other than in the boils, the average depth of the pool was about 12 feet. The water is quite clear and its temperature was 72°F on April 4, 1946.

Discharge.—The average of 11 measurements made during the period February 11, 1929 to April 4, 1946 is 12.8 second-feet (8.3 m.g.d.).

Quality of water.—No samples were collected.

Utilization.—The springs have been well developed by the U. S. Forest Service. Nominal charges to cover maintenance costs of the facilities are made, and they are used for swimming and picnicking. The grounds include a trailer park, winding nature paths, and a bathhouse. The run operates a small hydroelectric power plant with an undershot water wheel operating under a head of water of about 5 feet which supplies electricity for the buildings and grounds.

RAINBOW SPRINGS *near* DUNNELLON

Location.—The springs are 4 miles northeast of Dunnellon. Large signs along U.S. Highway 41 indicate the paved side road leading to the spring pool.

Description.—(See figure 20.) These springs, rising among the wooded, rolling highlands in the southwest corner of Marion County, form the headwaters of Rainbow River which winds its way south for 5 miles to the point it joins the Withlacoochee River. The headpool is semicircular in shape with a diameter of about 400 feet. The principal improvements surround this pool, while 1 mile to the east other springs form a second pool whose outflowing waterway joining Rainbow River gives the headwaters area of the river the shape of a huge, rounded Y.

There are four relatively deep spring cavities in the headpool, and four cavities of lesser depth in the pool to the east. Maximum depths in these headpool cavities on February 18, 1947 were 11.6 and 14.2 feet, these being in the first and second narrow reaches of the pool respectively. The cavities in the east pool and the run near their southeast shores were sounded on the same date and found to have depths of 4.5 and 7.0 feet, respectively. A spring one mile downstream from the headpool, which boils from a crevice in the limerock, known as Garfish Hole, was found to have a maximum depth of 24 feet on January 8, 1947. Numerous small springs and "sand boils" may be noticed in both pools and the river. The aquatic vegetation is very luxuriant at these springs.

The water surface elevation of the headpool varies seasonally with the amount of rainfall in the area. The maximum stage that has been observed during the period October 8, 1930 to February 18, 1947 is 33.09 feet above mean sea level on July 5, 1934. The minimum stage that has been observed during the same period is 30.07 feet above mean sea level on February 8, 1941. An average annual range based on monthly observations in this same period is from 31.2 feet to 31.8 feet above mean sea level.

Temperatures have been observed at the springs as follows:

DATE	WATER TEMPERATURE	AIR TEMPERATURE
	°F	°F
February 9, 1931	72	75
March 16, 1931	72	69
April 6, 1931	72	63
May 6, 1931	79	74
June 26, 1931	74	86
May 21, 1938	75	
June 20, 1938	72	
June 2, 1945	76	
June 18, 1946	76	87

Discharge.—The flow of Rainbow Springs has been measured at about monthly intervals since February 9, 1931, and the graphical plotting of these measurements in relation to time and discharge is given in figure 7. It will be noticed that the trends of discharge of Rainbow Springs follow those of Silver Springs Run fairly well. A tabulation of monthly and annual mean discharge values is presented in Table 3. The annual mean flow for the period 1932-46 is 699 second-feet (452 m.g.d.).

FIGURE 20. *Rainbow Springs.* Photograph taken looking south down the river from the porch of Rainbow Lodge.

TABLE 3. Discharge, in cubic feet per second, of RAINBOW SPRINGS *near* DUNNELLON, FLORIDA

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL MEAN
1931			793	838	806	791	718	672	626	632	631	646	
1932	588	600	566	558	528	564	517	511	540	497	517	509	541
1933	511	533	556	612	618	581	574	639	768	894	840	776	658
1934	749	666	647	647	650	731	764	775	836	804	748	750	731
1935	703	638	612	608	600	560	561	657	800	906	895	791	694
1936	765	775	810	776	796	745	762	782	820	819	725	668	770
1937	675	666	673	689	685	672	671	680	809	797	751	740	709
1938	721	700	678	658	609	578	682	748	772	796	835	839	718
1939	775	706	671	655	669	628	625	656	708	790	719	750	696
1940	669	641	627	625	683	661	644	628	647	631	620	594	639
1941	598	602	610	623	665	665	593	667	692	733	795	800	670
1942	833	840	840	843	839	820	862	892	904	890	848	805	851
1943	752	698	673	681	669	652	650	693	733	722	710	679	693
1944	616	611	602	583	590	570	597	642	682	707	731	733	639
1945	685	670	681	671	629	592	572	650	840	866	851	788	708
1946	743	758	766	760	740	725	727	781	817	826	839	808	774
MEAN 1932-46	692	674	675	677	674	658	657	692	758	779	762	735	699

NOTE: Monthly values are averages computed graphically from discharge measurements made about monthly at gaging station on Rainbow River at bridge about 5 miles downstream from head of springs. Surface inflow between springs and measuring section believed negligible except after heavy rains. Records collected by U. S. Geological Survey in cooperation with Florida Geological Survey (1931 to 1932) and Corps of Engineers, U. S. Army (1933 to date).

The maximum discharge measured during the period 1931-46 was 927 c.f.s. (599 m.g.d.) on November 9, 1935, and the minimum discharge 487 c.f.s. (315 m.g.d.) on October 3, 1932. Miscellaneous measurements of the flow of the springs made in earlier years and which are among the earliest recorded in the state are listed below:

DATE	FLOW IN CUBIC FEET PER SECOND
December 22, 1898 - - -	778
December 24, 1904 - - -	716
February 8, 1907 - - - -	847
February 21, 1917 - - -	738
February 1, 1929 - - - -	838
October 8, 1930 - - - -	837

Quality of water.—Water in Rainbow Springs is not as hard as most of the springs in Florida for which analyses are available. The dissolved mineral matter consists essentially of calcium and bicarbonate. The two analyses made 19 years apart are almost identical except for the sulfate concentration.

ANALYSIS

Date of collection	March 4, 1927		June 18, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	9.4	—	7.7	—
Iron (Fe) - - - -	.15	—	.08	—
Calcium (Ca) - -	21	1.05	21	1.05
Magnesium (Mg) -	5.1	.42	4.0	.33
Sodium (Na) - - -	1.4	.06	2.9	.13
Potassium (K) - -	.5	.01	.4	.01
Bicarbonate (HCO_3)	72	1.18	78	1.28
Sulfate (SO_4) - - -	16	.33	4.7	.10
Chloride (Cl) - -	3.0	.08	3.5	.10
Fluoride (F) - - -	—	—	.0	.00
Nitrate (NO_3) - -	.34	.01	.8	.01
Dissolved Solids - -	83	—	81	—
Total Hardness as $CaCO_3$ - - - -	73	—	69	—
Carbon Dioxide (CO_2)	—	—	2	—
Color - - - - -	—	—	2	—
pH - - - - - -	—	—	7.9	—
Specific Conductance ($K \times 10^5$ at 25°C.) -	—	—	14.5	—

Utilization.—The springs have been highly developed to provide comfortable lodging and recreational facilities for visitors. Boats of special design having submerged viewing ports and windows cruise the waters of the springs affording views of underwater plant and animal life, and interesting rock formations. Swimming and bathing in the headpool may also be enjoyed. The lodge, restaurant, and cottages offer accommodations to persons wishing to stop for a meal or overnight lodging or to spend a longer time at the springs.

SALT SPRINGS *at* LAKE KERR

Location.—Twenty-eight miles northeast of Ocala. Reached by driving east from Ocala on State Highway 40 for 10 miles, turning north 0.5 mile east of the Ocklawaha River, at the intersection with State Highway 314 and driving 17.5 miles to the springs.

Description.—(See figure 21.) Situated at the edge of the St. Johns River lowlands the springs form a somewhat circular pool approximately 107 feet in diameter into which the flows emerging from 7 large and 2 small vertical holes and fissures in the rock discharge. The maximum depth of the largest fissure was 19.5 feet on April 4, 1946. There is a heavy covering of grass on the bottom. The temperature of the water was 75°F

FIGURE 21. *Salt Springs,* Marion County. An artesian spring whose water is made salty by passing through rock containing salt or salty water. After Cooke, 1939.

in the boil near the northwest shore of the pool on April 4, 1946. The run flows about 4 miles before entering Lake George, in the St. Johns River basin.

Discharge.—The following maximum and minimum flows are listed:

DATE		CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
May 5, 1931	Maximum	105	68
Oct. 15, 1935	Minimum	54.0	35
Period Feb. 9, 1929 to Apr. 4, 1946	Average of 13 measurements	81.1	52

Quality of water.—Water in Salt Springs is very hard in which mineral solids are highly concentrated. The dissolved mineral matter is probably derived from saline residues remaining from ancient invasions of the sea. The differences between the concentrations of the constituents reported in the two analyses made 22 years apart may reflect actual changes in composition or may be the result of sampling at different locations in the spring area.

ANALYSIS

Date of collection	August 19, 1924		April 4, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	—	—	11	—
Iron (Fe)	—	—	.10	—
Calcium (Ca)	218	10.88	240	11.98
Magnesium (Mg)	138	11.35	167	13.74
Sodium (Na)	1362 (Na + K)	59.23 (Na + K)	1540	66.97
Potassium (K)			38	.97
Bicarbonate (HCO_3)	84	1.38	87	1.43
Sulfate (SO_4)	542	11.28	613	12.76
Chloride (Cl)	2439	68.80	2800	78.97
Fluoride (F)	—	—	.0	.00
Nitrate (NO_3)	—	—	—	—
Dissolved Solids	5210	—	5850	—
Total Hardness as $CaCO_3$	1111	—	1290	—
Carbon Dioxide (CO_2)	—	—	—	—
Color	—	—	0	—
pH	—	—	7.1	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—	933	—

Utilization.—The springs are used for swimming, fishing, and boating and rowboats are available for fishing. Many people drink the water believing it to be beneficial to their health. Numerous private cottages are located in the area. The springs were known to the early Spaniards and they are recorded on an old Spanish land grant, probably selected with the purpose of insuring a good supply of water.

SILVER GLEN SPRINGS *near* ASTOR

Location.—These springs are 9 miles northwest of Astor and are reached by driving west from Astor on State Highway 40 for about 8 miles, turning north just inside the Marion County line and driving 6 miles to the head of the springs.

Description.—(See figure 22.) These springs of first magnitude flow are at the head of a navigable stream which empties into Lake George 0.6 mile to the northeast. Nestled against the

FIGURE 22. Headpool of *Silver Glen Springs,* Marion County. After Cooke, 1939.

undulant sandy hills of the Ocala National Forest to the west, the head of the springs forms a circular pool of about 150 feet in diameter with most of the springs flow emerging from a horizontal cavern at the main boil. A fissure in the limerock called the "Natural Well", which is a tributary of the main boil, has a maximum depth of 24.0 feet as sounded on April 1, 1946.

It is about 100 feet in length and contributes almost one-third of the total flow of the springs. The temperature of the water was 73°F in the "Natural Well" on the day listed above.

Discharge.—The average, minimum, and maximum flow are as follows:

DATE		CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
Apr. 12, 1935	Maximum	129	83
Feb. 7, 1933	Minimum	89.9	58
Period Mar. 17, 1931 to Apr. 1, 1946	Average of 8 measurements	111	72

Quality of water.—This is a hard, mineralized water containing a relatively large amount of sodium chloride (common salt). Its composition indicates that the dissolved mineral matter may have originated at least in part from saline residues remaining from ancient invasions of the sea.

ANALYSIS

Date of collection April 1, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	9.0	—
Iron (Fe)	.08	—
Calcium (Ca)	87	4.34
Magnesium (Mg)	46	3.78
Sodium (Na)	334	14.52
Potassium (K)	10	.26
Bicarbonate (HCO_3)	85	1.39
Sulfate (SO_4)	205	4.27
Chloride (Cl)	610	17.20
Fluoride (F)	.0	.00
Nitrate (NO_3)	.8	.01
Dissolved Solids	1400	—
Total Hardness as $CaCO_3$	406	—
Carbon Dioxide (CO_2)	—	—
Color	0	—
pH	7.4	—
Specific Conductance ($K \times 10^5$ at 25°C.)	248	—

Utilization.—Bathing, swimming, and fishing are the chief recreations. Cabins for rent, bathhouse and small store, as well as rowboats for fishing, are available. The "Natural Well" is used as a source of drinking water for several private dwellings and cottages surrounding the springs. A large amount of the shell from the Indian mounds which surround the spring has been removed by barges for use as a road building material.

SILVER SPRINGS *near* OCALA

Location.—Five miles northeast of Ocala. Reached by driving east from Ocala on State Highway 40 to Silver Springs Post-office and springs.

Description.—(See figure 23.) Silver Springs lies at the western edge of an extensive cypress swamp which forms a portion of the Oklawaha River Valley and borders the higher sandy pine land to the west. Its somewhat circular main pool is about 250 feet in diameter and forms the head of Silver Springs Run, the channel of which winds easterly through the densely wooded swamp for about 5 miles into the Oklawaha River, a tributary of the St. Johns River. Several smaller spring cavities lie on both sides of the run immediately downstream from the head pool.

The water is delivered to the springs through subterranean channels, the cavern-like ends of which can be clearly seen at the bottom of the spring cavities. The largest, which lies at the bottom about 36 feet below the surface of the main pool and which is said to be about 65 feet wide and 12 feet high at the mouth, discharges in a roughly southerly direction with such force as to form a gentle "boil" at the surface. The pool bottom slopes gradually upward from the cavern floor near the north side to the shallowly inundated southeastern rim over which the water passes in a short reach of shallow channel where it gains a velocity sufficient to keep the luxuriant aquatic growth from the upper half of the channel. The lower reaches of the run have depths of from 6 to over 30 feet, the deeper areas occurring where the sandy bottom has been scoured from turbulent currents caused by bends and natural channel obstructives. The flow is usually tranquil, averaging 0.7 feet per second (0.5 mile per hour) over the entire cross-section at a representative section.

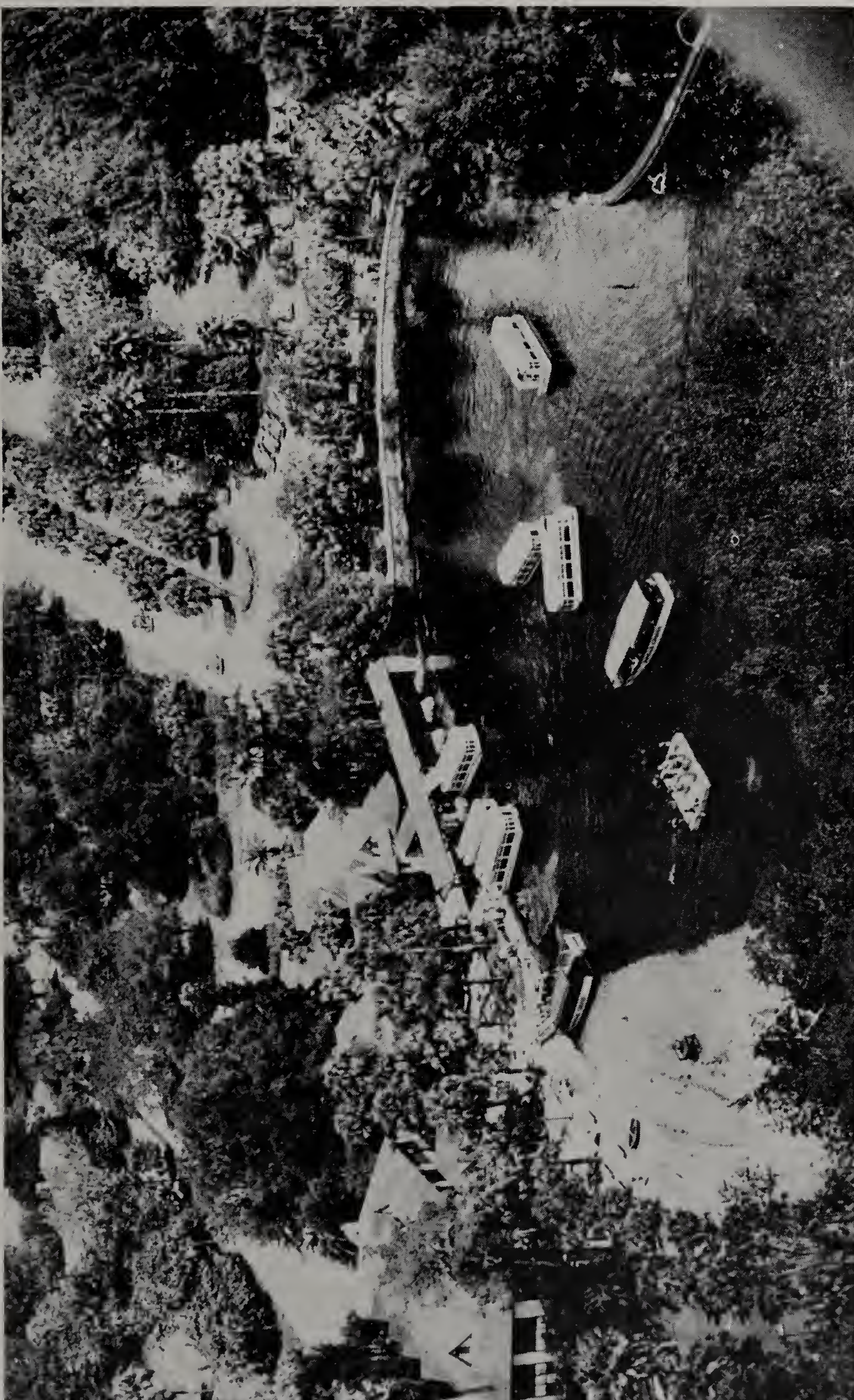

FIGURE 23. Aerial view of *Silver Springs*, Marion County.

The bottoms and sides of the headpool and small contributing cavities are partially covered by aquatic growth and have precipitous and oddly shaped exposures of limestone. Numerous fountains of white sand are visible, being activated by the jets of water discharged by the underlying spring fissures and caverns. The low turbidity and color of the spring water, the predominately white bottom and the direct exposure to sunlight combine to make the under water visibility excellent even at the greater depths.

The elevation of the water surface in the headpool usually varies seasonally with the discharge from about 39.3 feet to 42.0 feet above mean sea level. The maximum stage recorded was 44.5 feet, m.s.l., measured during the hurricane of September 1933, although a higher stage is reported in the Ocala Evening Star of Thursday, September 7, 1933 by John Pasteur as having occurred during a storm in 1871. The maximum stages are largely the result of excessive movement of waters into the spring pools and the run from the storm flooded adjacent areas.

The temperature of the water issuing from the spring has been measured in degrees Fahrenheit, as follows:

March 2, 1945 - - -	74°	January 3, 1946 - - -	73°
March 30, 1945 - - -	74°	January 31, 1946 - -	73°
April 28, 1945 - - -	74°	March 1, 1946 - - -	73°
June 1, 1945 - - - -	74°	April 1, 1946 - - -	73°
June 22, 1945 - - -	74°	May 1, 1946 - - - -	73°
August 3, 1945 - - -	74°	May 31, 1946 - - -	74°
September 1, 1945 - -	73°	June 27, 1946 - - -	74°
September 26, 1945 - -	74°	July 31, 1946 - - -	72°
November 1, 1945 - -	74°	August 31, 1946 - - -	72°
November 29, 1945 - -	73°		

The average temperature computed from the readings made during the period March 2, 1945 to August 31, 1946 is 73.4°F.

Discharge.—An analysis of the numerous discharge measurements made, over a period of many years, at the outlet of the headpool and at various locations on Silver Springs Run has revealed many of the discharge characteristics of the springs, see figure 7. The total average annual discharge of the springs has been calculated as approximately 500 million gallons per day of which about one half is discharged by the large cavern in the head pool. The minimum total flow measured was 649 second-feet (419 m.g.d.) on June 22, 1945; the maximum 1,170 c.f.s. (756 m.g.d.) on August 4, 1930. Numerous measurements made within a short period of time at different locations downstream from the head along the run indicate that no measurable increase in flow occurs below a point about 3,500 feet from the head-pool. This effectively defines the spring area.

Comparisons of the discharge of Silver Springs with that for other large springs in the United States are interesting. Beckman and Hinchey[8] state:

> "The available records indicate that the average flow of Big Spring in Missouri is about equal to that from the upper pool of Silver Springs in Florida and that these two share the distinction of being the largest single-outlet springs in the United States, although the total flow of the Silver Springs group is considerably larger than that of Big Spring."

Data available at the present time indicate that Rainbow Springs should be included in this classification, and probably the portion of its flow from a single-outlet is larger than any other known spring. Of the large springs existing principally in California, Florida, Idaho, Missouri, Montana and Oregon, the average annual discharge of Silver Springs is apparently the greatest. The writers are reluctant to make such a comparison on an international scale because of the possible presence of springs of unknown discharge in relatively unsettled regions. However no group of springs within such a small area and having a comparable discharge are known to them.

Figure 24 is a graphical presentation of the relation of the daily flow of Silver Springs to the cumulative daily rainfall at Ocala and the weekly ground water level observations at the Sharpes Ferry well near Ocala. The period from June 1 to November 30, 1945 was selected for study as it follows a very dry period when ground water tables were quite low, and covers an unusually wide range in flow in a short period of time. The trend of the flow graph follows the rainfall cumulative curve trend quite closely up to a rate of discharge of 1,000 c.f.s. At this point the porous limestone in its saturated condition was unable to absorb the heavy rainfall of September 15, 1945, and as evidenced by the sharp rise of the flow graph, the peak flow of 1,150 c.f.s. is due partially to direct surface runoff and runoff from the ground water table nearest the surface. It will be

[8] Beckman, H. C. and Hinchey, N. S., The Large Springs of Missouri, p. 17, Missouri Geological Survey and Water Resources, Vol. XXIX, Second Series, 1944.

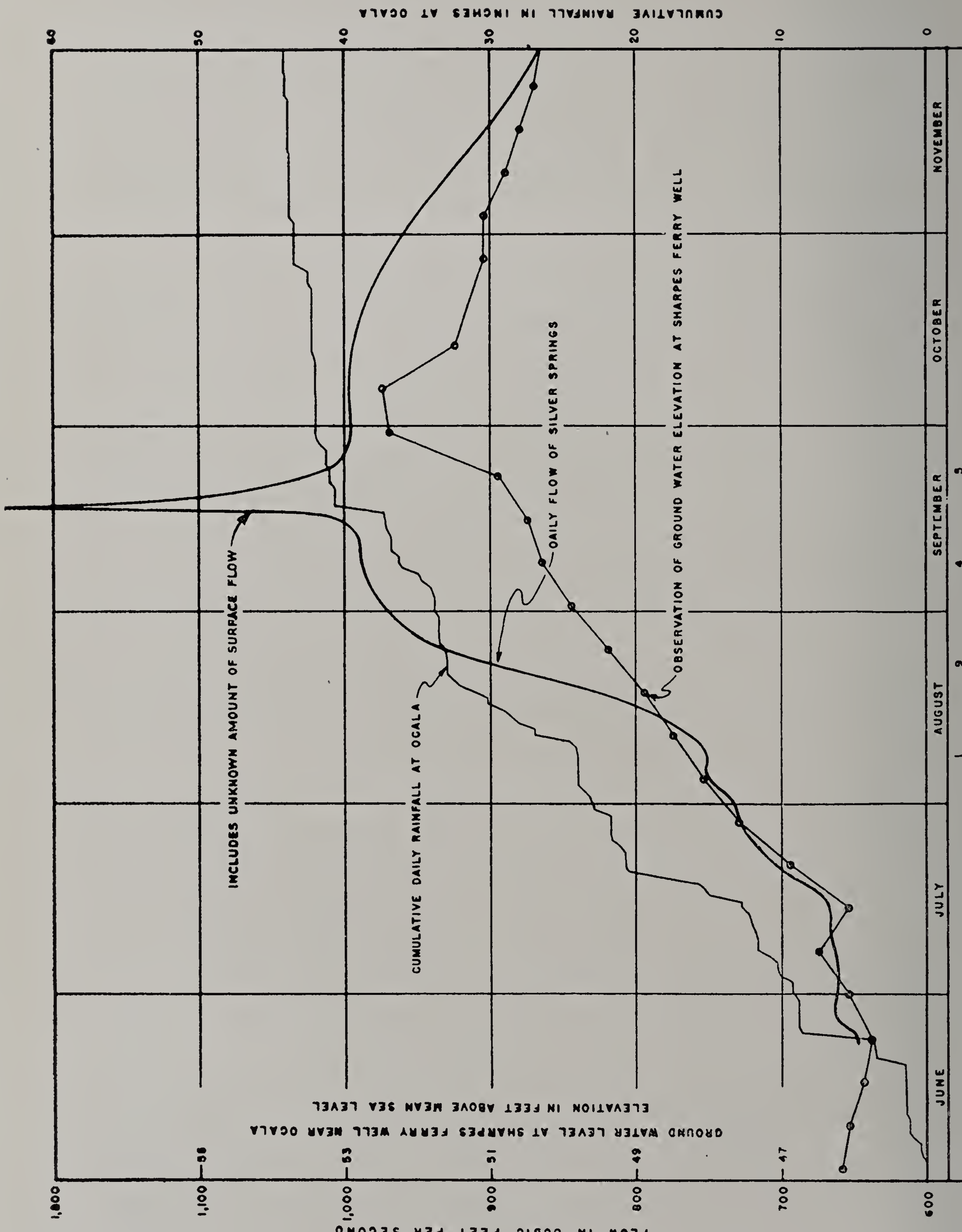

FIGURE 24. Graph showing the relation of rainfall at Ocala, flow at Silver Springs, and ground water elevation at Sharpes Ferry.

noticed that the highest ground water levels at the Sharpes Ferry well did not occur until 12 to 19 days after the peak flow, and produced the sustained flow of the springs from September 21 to October 24, 1945.

Quality of water.—Water from Silver Springs is hard and typical of many limestone springs in Florida. The dissolved mineral matter, consisting largely of calcium and bicarbonate and a moderate amount of sulfate, issues from the spring at the calculated rate of approximately a ton every 3 minutes. The two analyses made 39 years apart show that the composition at the times the samples were collected was practically the same. Another sample collected in 1923 had essentially the same composition.

ANALYSIS

Date of collection	December 16, 1907		October 21, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	13	—	9.2	—
Iron (Fe)	—	—	.04	—
Calcium (Ca)	73	3.64	68	3.39
Magnesium (Mg)	9.2	.76	9.6	.79
Sodium (Na)	9.8 (Na + K)	.43 (Na + K)	4.0	.17
Potassium (K)			1.1	.03
Bicarbonate (HCO_3)	219	3.59	201	3.29
Sulfate (SO_4)	44	.92	34	.71
Chloride (Cl)	7.7	.22	7.8	.22
Fluoride (F)	—	—	.1	.01
Nitrate (NO_3)	.20	.00	1.3	.07
Dissolved Solids	274	—	237	—
Total Hardness as $CaCO_3$	220	—	209	—
Carbon Dioxide (CO_2)	—	—	5	—
Color	—	—	4	—
pH	—	—	7.8	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—	40.1	—

Utilization.—The springs and adjacent areas are highly developed and comprise a commercial tourist attraction of the first magnitude. The traveler will find a wide choice of lodging and eating establishments. Recreational facilities include glass-bottomed and other underwater viewing boats, cruise launches and dressing rooms and diving equipment for swimming. Among the several concessions that operate in the grounds are a snake farm, a zoo, a Seminole Indian village and refreshment and souvenir establishments. A colony of monkeys released several years ago on the banks of scenic Silver Run a distance below the springs have in their almost native surroundings multiplied and remain immediately available for "handouts" by the river-boat-cruise attendants.

OTHER SPRINGS

Orange Spring, another Marion County spring, is described on page 96 of Florida Geological Survey Bulletin 17, by C. Wythe Cooke. The following description is quoted from the publication:

> "Orange Spring, from which the village of Orange Springs at the north edge of Marion County is named, is much smaller than the other springs herein described. It differs from them, too, in that its water contains sulphur. No chemical analysis is necessary to attest this fact, for the odor of hydrogen sulphide is plainly evident. The spring flows through sand into the bottom of a circular pool enclosed within concrete walls, which raises its level about 3 feet. It is surrounded by tall pines and cabbage palmettos. The water presumably is derived from the Hawthorn formation, which yields sulphur water at a number of places."

In addition some data are given in Table 4 on a small spring known as The Aquarium, 27 miles east of Ocala, and on Blue Spring, 4.5 miles east of Orange Spring.

NASSAU COUNTY

SU-NO-WA SPRING *near* VERDIE

Location.—Reached by driving south from Verdie 0.3 mile on State Highway 200, turning east on graded road and driving 3.6 miles, then turning north and driving 0.1 mile to the spring.

Description.—Situated at the edge of the east bank swamp which follows Thomas Creek, the spring is probably a side hill seepage, and is piped from its head at a depth of about six feet. Reservoir tanks and a hand pump are enclosed in a springhouse and the intake pipe extends to the side of a hill some 100 feet away. Water is reported to have come up through the sand even before the time it was piped. The springhouse is in a run-down and abandoned condition. The temperature of the water, taken immediately in a gallon can full of water drawn from the spring on April 17, 1946, was 70°F.

Discharge.—A flow of 12 gallons per minute was measured volumetrically on April 17, 1946. Nearby residents reported the flow to be constant.

Quality of water.—This spring water is unusual for Florida in that it is very soft, and contains only a relatively small amount of dissolved mineral matter. Waters of this type are apt to be corrosive to plumbing, especially in hot water lines and tanks. The two analyses made 22 years apart show that the water had practically the same composition at the times the samples were collected.

ANALYSIS

Date of collection	January 12, 1924		April 17, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	6.4	—	4.7	—
Iron (Fe)	.38	—	.6	—
Calcium (Ca)	7.6	.38	7.2	.36
Magnesium (Mg)	4.0	.33	2.9	.24
Sodium (Na)	2.7	.12	3.2	.14
Potassium (K)	.9	.02	.4	.01
Bicarbonate (HCO_3)	35	.57	36	.59
Sulfate (SO_4)	3.4	.07	1.4	.03
Chloride (Cl)	6.5	.18	6.5	.18
Fluoride (F)	—	—	.1	.00
Nitrate (NO_3)	—	—	.1	.00
Dissolved Solids	49	—	48	—
Total Hardness as $CaCO_3$	35	—	30	—
Carbon Dioxide (CO_2)	—	—	151	—
Color	—	—	9	—
pH	—	—	5.8	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—	8.28	—

Utilization.—The water is used for drinking.

ORANGE COUNTY

ROCK SPRINGS *near* APOPKA

Location.—About 6.5 miles north of Apopka. Reached by driving 6.1 miles north on State Highway 435 from the U.S. Highway 441 junction at Apopka, then turning east on a paved road and driving 0.5 mile to the springs.

Description.—(See frontispiece and figure 25.) These springs are peculiar to those of peninsular Florida by the absence of the usual well-defined deep pool and the fact that the principal discharge is out of a partially submerged horizontal cavern at the base of a 17-foot high overhanging bluff. The water is discharged with considerable turbulence from the 3-foot throat of the cavern into a channel about 20 feet in width. About 10

FIGURE 25. View of *Rock Springs* as seen at the spring outlet at the base of the rock cliff, which gives the spring its name.

feet down stream from the head, additional water is discharged through a submerged opening in the channel bottom with sufficient force to create a boil at the surface. The temperature of the water was 74°F on May 20, 1933, and 75°F on May 9, 1946. The springs flow into the Wekiva River, a tributary of the St. Johns River.

Discharge.—The following data are based on the nine discharge measurements made since February 1931:

DATE		CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
Jan. 30, 1935 / Dec. 6, 1935	Maximum	62.8	41
Mar. 8, 1932	Minimum	51.9	34
	Mean	57.2	37

Quality of water.—Water from Rock Springs is moderately hard. The dissolved mineral matter is composed largely of calcium and bicarbonate, which is typical of most of the spring waters in Florida.

ANALYSIS

Date of collection May 9, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	9.6	—
Iron (Fe) - - - -	.07	—
Calcium (Ca) - -	29	1.45
Magnesium (Mg) -	8.4	.69
Sodium (Na) - - -	4.3	.19
Potassium (K) - -	.6	.02
Bicarbonate (HCO_3)	105	1.72
Sulfate (SO_4) - - -	17	.35
Chloride (Cl) - -	6.1	.17
Fluoride (F) - - -	.1	.00
Nitrate (NO_3) - -	.3	.00
Dissolved Solids - -	128	—
Total Hardness as $CaCO_3$ - - - -	107	—
Carbon Dioxide (CO_2)	8	—
Color - - - - -	4	—
pH - - - - - -	7.3	—
Specific Conductance ($K \times 10^5$ at 25°C.) -	22.2	—

Utilization.—The springs which are used for swimming, bathing and picnicking are being developed by Orange County as a park. They are also a game, bird, and fish sanctuary. Dressing rooms and diving boards are available as well as picnic grounds. About 700 feet down stream from the springhead a concrete weir wall has been built almost all the way across the run, and both sides of the run have a concrete retaining wall which form an oval-shaped swimming pool.

WEKIWA SPRINGS *near* APOPKA

Location.—About 5 miles northeast of Apopka. Reached by driving east one mile from Apopka post office on U.S. Highway 441, taking State Highway 436 for 1.5 miles, then turning north on a paved road which curves east and driving 2.9 miles, turning north on graded road at "Wekiwa Springs" sign and driving 0.2 mile to the springs.

Description.—(See figure 26.) The springs are one of the principal headwaters of the Wekiva River which is in the St. Johns River basin. The springs form a kidney-shaped pool about 120 feet in diameter with the discharge emerging from 5 horizontal caverns covered by a maximum depth of 14.7 feet of water on May 9, 1946. The water has a slight sulphur odor. The average depth of pool is 6 feet. The temperature of the water was 75°F on May 9, 1946.

FIGURE 26. *Wekiwa Springs,* looking northwest at head and run of spring.

Discharge.—

DATE	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
March 8, 1932 - - -	63.9	41
February 10, 1933 - -	66.9	43
November 7, 1935 - -	72.5	47
May 9, 1946 - - -	67.5	44

Quality of water.—This spring water is moderately hard. The dissolved mineral matter consists primarily of calcium and bicarbonate, which is typical of most of the springs in Florida. No sample was collected for analysis in 1946.

ANALYSIS

Date of collection August 8, 1924

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	8.0	—
Iron (Fe)	.06	—
Calcium (Ca)	28	1.40
Magnesium (Mg)	7.1	.58
Sodium (Na) / Potassium (K)	4.0	.17
Bicarbonate (HCO_3)	117	1.92
Sulfate (SO_4)	5.3	.11
Chloride (Cl)	8.0	.22
Fluoride (F)	—	—
Nitrate (NO_3)	—	—
Dissolved Solids	122	—
Total Hardness as $CaCO_3$	99	—
Carbon Dioxide (CO_2)	—	—
Color	—	—
pH	—	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—

Utilization.—The springs are used for swimming, fishing, boating, and picnicking, and are fairly well developed. A concrete bathhouse for swimmers was closed when the springs were visited in 1946.

OTHER SPRINGS

Miami Springs, 5 miles northeast of, and Mill Creek Springs 4 miles northeast of Apopka also are located in Orange County. Some data on these are available in Table 4.

PASCO COUNTY

CRYSTAL SPRINGS *near* ZEPHYRHILLS

Location.—The springs are 1.5 miles west of the village of Crystal Springs and are visible from State Highway 39.

Description.—(See figure 27.) The springhead, situated in the flat upper Hillsboro River basin, is an oval-shaped pool about 1,000 feet in length bent in the center almost to an L-shape. The west end of the pool connects with the Hillsboro

FIGURE 27. Headpool of *Crystal Springs*, Pasco County.

River. The maximum depth to the largest spring cavern furnishing water to the pool was 7.2 feet on December 27, 1946, and the average depth of the floor of the pool was 3.0 feet. A number of smaller boils may be seen in the pool. In 1945 a timber and earth dam having a variable control weir was placed across the springhead below the main boil. The discharge of the springs decreases whenever the pool is held at a higher level because the head of water in the pool more nearly balances the artesian head that produces the flow. Prior to the construction of the control the pool level elevation varied from about 50 to 54 feet above mean sea level. A head of from 1 to 3 feet is maintained between the pool and the river levels. The following water temperatures have been observed:

DATE	WATER TEMPERATURE
	°F
February 17, 1933	74
January 14, 1946	75
July 1, 1946	75
December 27, 1946	75

Discharge.—The data below are based upon 125 discharge measurements, plotted in figure 7, made since January 1933:

DATE		CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
July 19, 1941	Maximum	147	95
July 1, 1946	Minimum	20.3	13
	Mean	64.7	42

Quality of water.—Crystal Springs water is a typical hard, limestone water in which the dissolved mineral matter consists primarily of calcium and bicarbonate.

ANALYSIS

Date of collection	July 19, 1923		July 1, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	14	—	10	—
Iron (Fe)	—	—	.07	—
Calcium (Ca)	53	2.65	52	2.59
Magnesium (Mg)	5.0	.41	4.0	.33
Sodium (Na)	3.8 (Na + K)	.19	4.0	.17
Potassium (K)		—	.4	.01
Bicarbonate (HCO_3)	168	2.75	170	2.79
Sulfate (SO_4)	9.3	.19	7.8	.16
Chloride (Cl)	5.5	.16	5.4	.15
Fluoride (F)	—	—	.1	.01
Nitrate (NO_3)	.42	.01	.8	.01
Dissolved Solids	177	—	166	—
Total Hardness as $CaCO_3$	153	—	146	—
Carbon Dioxide (CO_2)	—	—	5	—
Color	—	—	5	—
pH	—	—	7.7	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—	28.9	—

Utilization.—The flow from Crystal Springs constitutes the basic flow of the Hillsboro River which is the source of water supply for the City of Tampa. The springs as developed include a picnic ground, a bathhouse, and refreshment stand. The pool has been adapted for swimming.

SEVEN SPRINGS *near* ELFERS

Location.—About 4 miles from Elfers. Reached by turning east at Elfers on State Road 54 and driving 3.7 miles to the Anclote River bridge. The main spring is 200 feet south of the bridge and about 50 feet east of the highway.

Description.—The main spring is near the top of the flat wooded south river bank. It is enclosed by an 18-inch concrete pipe sunk vertically around the spring and the depth of water was about 12 feet on May 3, 1946. Water flows into the Anclote River from a 1-inch horizontal pipe inserted in the west side of the concrete pipe. The temperature of the water was 76°F on May 3, 1946. R. L. Taylor, U.S.G.S. engineer, reports that the spring almost stopped flowing during the dry season in May 1945. Several other small springs are reported in the vicinity, most of which have ceased to flow.

Discharge.—A flow of 13 gallons per minute was measured volumetrically on May 3, 1946.

Quality of water.—No samples were collected but the water has a pronounced sulphur taste.

SPRING (NO NAME) *at* HUDSON

Location.—At Hudson at the head of the small boat harbor.

Description.—The spring is a circular pool about 25 feet in diameter at the head of a small boat harbor inlet from the Gulf of Mexico. It was not possible to determine how the water emerges because of discoloration. There is, however, a noticeable surface disturbance from the outflow and the stage and discharge of the spring are affected by tide. The maximum depth was 12.5 feet on May 3, 1946, and the temperature of the water was 77°F. About 50 feet east of the spring is a sink, 25 feet in diameter, enclosed by a rock wall. The water is slightly discolored and is tide affected. There is no outflow. Its maximum depth was 17 feet on May 3, 1946.

Utilization.—The spring is apparently used only for watering and docking small boats, and perhaps for fishing.

PINELLAS COUNTY

ESPIRITU SANTO SPRINGS *at* SAFETY HARBOR

Location.—The springs are located on the waterfront in Safety Harbor on State Highway 590.

Description.—The springs lie near the base of the low bluff which looks east on Old Tampa Bay. The four springs which comprise the Espiritu Santo Springs group are now housed in the large springs pavilion adjacent to the Safety Harbor Sanatorium and the Safety Harbor Hotel. On the ground floor of the pavilion each spring has been cased with a tile-faced, concrete wall about three feet in diameter with a moveable glass cover. Water from each spring is pumped by an individual electric pump to the bottling department. The temperature of the water was 72°F on October 16, 1923.

Discharge.—At present there is no outflow from any of the springs. The operators report the yield from pumping is adequate for the demand of the sanitorium, the bottling plant, and the public for drinking. U. S. Geological Survey Water Supply Paper 102, p. 267 reports a flow of 24,000 gallons per minute in 1903 for this spring, while Water Supply Paper 596-G shows Spring No. 2 to be a flowing spring on October 16, 1923. This indicates that water tables in the recharge area have been lowered.

Quality of water.—Water from Espiritu Santo Springs is very hard and highly mineralized. The dissolved mineral matter may be derived from saline residues resulting from ancient invasions of the sea or from salt water originating in the Gulf of Mexico or Tampa Bay, or both. The two analyses made 23 years apart show that the concentration of dissolved solids was different at the two sampling periods. This may represent an actual difference or it may be the result of sampling at slightly different locations inasmuch as there is more than one opening in the spring area.

ANALYSIS

Date of collection	October 16, 1923		May 2, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	14	—	12	—
Iron (Fe)	.09	—	2.1	—
Calcium (Ca)	176	8.78	157	7.83
Magnesium (Mg)	108	8.88	80	6.58
Sodium (Na)	960 (Na + K)	41.74 (Na + K)	715	31.09
Potassium (K)			15	.38
Bicarbonate (HCO_3)	261	4.28	255	4.18
Sulfate (SO_4)	232	4.83	172	3.58
Chloride (Cl)	1775	50.07	1340	37.79
Fluoride (F)	—	—	.0	.00
Nitrate (NO_3)	—	—	1.2	.02
Dissolved Solids	3473	—	2880	—
Total Hardness as $CaCO_3$	883	—	721	—
Carbon Dioxide (CO_2)	—	—	—	—
Color	—	—	15	—
pH	—	—	7.3	—
Specific Conductance ($Kx10^5$ at 25°C.)	—	—	474	—

Utilization.—The springs form the nucleus for Florida's first spa. They were discovered by Hernando de Soto on May 18, 1539 and given their present name by him. The modern sanitorium has 25 rooms and the hotel 58 rooms for the accommodation of patients, guests, and visitors.

HEALTH SPRING (FORMERLY WALL SPRINGS) *at* WALL SPRINGS

Location.—At Wall Springs. Reached by turning west off U.S. Highway 19 at "Wall Springs" sign and driving 0.2 mile to the spring.

Description.—The spring lies at the east shore of Boggy Bayou on a narrow coastal strip of land which is flanked by sandy hills to the east. It forms a circular pool, being enclosed by a concrete wall about 30 feet in diameter. The water emerges from an irregular sloped cavern 6 x 10 feet. The maximum depth at the entrance of the cavern was 10 feet on May 3, 1946.

The springhead is separated from a 40 x 90 foot swimming pool by a concrete weir wall. The temperature of the water on May 3, 1946, was 77°F.

Discharge.—There is no outflow during high tide. A salt water check gate prevents large quantities of salt water from entering the swimming pool.

Quality of water.—Water from Health Spring is moderately hard and contains appreciable amounts of calcium, sodium, bicarbonate, and chloride. Because of the proximity of the springs to the Gulf of Mexico, it is possible that some of the sodium chloride (common salt) is derived from the sea. Except for the larger amount of sodium chloride in the sample collected in 1946, the two analyses made 23 years apart show that the spring water had about the same composition at the times of collection.

ANALYSIS

Date of collection	September 1, 1923		May 3, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	6.1	—	7.4	—
Iron (Fe)	.06	—	.04	—
Calcium (Ca)	33	1.65	32	1.60
Magnesium (Mg)	15	1.23	10	.82
Sodium (Na)	148 (Na + K)	6.43 (Na + K)	68	2.96
Potassium (K)			2.5	.06
Bicarbonate (HCO_3)	107	1.75	96	1.57
Sulfate (SO_4)	38	.79	28	.58
Chloride (Cl)	252	7.11	114	3.22
Fluoride (F)	—	—	.1	.00
Nitrate (NO_3)	—	—	4.1	.07
Dissolved Solids	564	—	323	—
Total Hardness as $CaCO_3$	144	—	121	—
Carbon Dioxide (CO_2)	—	—	2	—
Color	—	—	5	—
pH	—	—	7.9	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—	59.1	—

Utilization.—The spring is used for drinking, swimming and bathing.

POLK COUNTY

KISSENGEN SPRINGS *near* BARTOW

Location.—The springs are 4 miles southeast of Bartow, and may be reached by driving 3.2 miles south of the city on U.S. Highway 17 and turning east on a side road marked with a large sign directing the public to the springs.

Description.—(See figure 28.) These springs are located 0.3 mile west of Peace Creek at the edge of the wooded swamp which follows the river. A grove of Oak trees almost surrounds the springhead and provides shade during the summer months. The

FIGURE 28. General view of recreational developments at *Kissengen Springs.*

springhead has been partially walled in with a low earth embankment leaving an opening at the control weir outlet. The pool forms nearly a perfect circle about 200 feet in diameter and the spring flow issues from a submerged cavern near the center. The maximum pool depth which is located at the entrance of this cavern was 17.6 feet on December 27, 1946. The sand covered pool bottom slopes from the water's edge to an average depth of 6.0 feet. The water level of the springs is controlled by changing the stop-log elevations in the control-weir on the east side of the pool and all stop-logs are removed periodically to permit cleaning of portions of the pool bottom. This regulation of pool levels has been observed to vary the flow of a nearby artesian well. The following account of this well from the original field notes of P. R. Speer made at the time of the flow measurement on February 5, 1929 explains the relation between the well and the spring:

> "An oil test well about 300 feet east of spring was started drilling in July 1927 and at the 220 foot depth tapped the spring flow practically draining it. It was cased and continued to 4,700 feet striking a strong sulphur artesian flow the entire way. The casing is so arranged that it drains this flow back into the spring cavity and at the time this was accomplished a noticeable increase in the spring flow was reported by raising its elevation. This probably accounts for some of the increase over the measurement of 1917."

The well water has a more pronounced odor of hydrogen sulfide than the water at the spring. Under normal conditions the discharge flow drops 3 to 4 feet at the pool weir but at times it is affected by backwater from flood stages of Peace Creek.

The water is distinctly sulphur and has a greenish-blue color which is intensified at the boil by the deeper water. Pool water temperatures have been observed as listed below:

DATE	WATER TEMPERATURE
	°F
August 24, 1923	72
March 10, 1932	77
June 11, 1932	75
February 17, 1933	76
July 1, 1946	76
December 27, 1946	76

Discharge.—Periodic flow measurements of Kissengen Springs have been made since March 10, 1932. A graph showing the time-discharge relation is shown in figure 7 for comparison with the flows of other springs during the same period. Four earlier measurements have been made and the date and flow measured for each of these is listed below:

DATE	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
December 21, 1898 -	31	20
February 25, 1917 - -	21.3	14
February 5, 1929 - -	34.7	22
September 14, 1930 -	30.5	20
May 28, 1931 - - -	34.0	22

The maximum flow which has been measured since February 25, 1917 is 43.6 second-feet (28 m.g.d.) on October 11, 1933; the minimum measured is 3.48 c.f.s. (2 m.g.d.) on July 1, 1946. The mean annual flow of the springs as obtained from graphical averages of the plotted measurements during each year are given in the following table:

	MEAN ANNUAL DISCHARGE	
YEAR	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
1932 - - - - - -	26	17
1933 - - - - - -	33	21
1934 - - - - - -	33	21
1935 - - - - - -	23	15
1936 - - - - - -	28	18
1937 - - - - - -	24	16
1938 - - - - - -	22	14
1939 - - - - - -	20	13
1940 - - - - - -	20	13
1941 - - - - - -	17	11
1942 - - - - - -	18	12
1943 - - - - - -	15	10
1944 - - - - - -	12	8
1945 - - - - - -	15	10
1946 - - - - - -	9	6

The mean annual flow of the springs for the 15 year period 1932-46, computed from the table above is 21 c.f.s. (14 m.g.d.).

Quality of water.—The two analyses of water from Kissengen Springs made about 23 years apart show that the concentration of dissolved mineral matter was somewhat different at the times the samples were collected. Most of the difference is accounted for by changes in concentration of calcium and sulfate. The concentrations of sodium and chloride were essentially the same, indicating that there was no contamination with salt water. The water in both samples was hard.

ANALYSIS

Date of collection	August 24, 1923		July 1, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	17	—	15	—
Iron (Fe)	.06	—	.11	—
Calcium (Ca)	45	2.25	36	1.80
Magnesium (Mg)	17	1.40	13	1.07
Sodium (Na)	4.2	.18	5.7	.25
Potassium (K)			.5	.01
Bicarbonate (HCO_3)	131	2.15	130	2.13
Sulfate (SO_4)	65	1.35	34	.71
Chloride (Cl)	7.6	.21	7.6	.21
Fluoride (F)	—	—	.4	.02
Nitrate (NO_3)	.85	.01	2.3	.04
Dissolved Solids	232	—	180	—
Total Hardness as $CaCO_3$	182	—	144	—
Carbon Dioxide (CO_2)	—	—	3	—
Color	—	—	0	—
pH	—	—	7.8	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—	29.7	—

Utilization.—The springs have been used as a bathing and swimming pool for many years, in fact at the time of the measurement made in 1917 it was noted that such was its use at that time. A bathhouse and a refreshment stand are located at the spring.

PUTNAM COUNTY

NASHUA SPRING (FORMERLY CRANE SPRING) *near* SATSUMA

Location.—At Nashua just off State Road 309, and 2.5 miles south of Satsuma.

Description.—The spring lies near the foot of the east bank of the St. Johns River and its water level is very little higher than that of the river. The spring forms a circular pool about

8 feet in diameter, being enclosed by a cypress board wall with all of the spring flow emerging from apparently one horizontal cavern, covered by a maximum depth of 6.7 feet of water at the entrance on May 8, 1946. A 1-inch pipe extends almost to the entrance of the horizontal cavern from which water is pumped, and the temperature of the water was 74°F on May 8, 1946. There was a reddish clay sediment on spring and run bottom.

Discharge.—The flow was 0.30 million gallons per day (0.46 c.f.s.), measured May 8, 1946.

Utilization.—The spring is used for drinking by the owner, who also bottles and sells water on a small scale.

SPRING (NO NAME) *at* NASHUA (NEAR SATSUMA)

Location.—The spring is 0.2 mile north of Nashua Spring (formerly Crane Spring). Reached by turning west at the first graded road north of Nashua Spring road just off State Road 309 in Nashua, and about 2.5 miles south of Satsuma.

Description.—This spring also lies toward the foot of the east bank of the St. Johns River but the water level is not normally affected by the stage of the river. The spring forms a circular pool about 20 feet in diameter with all of the flow emerging from one horizontal cavern where the maximum pool depth was 6.0 feet on May 8, 1946. The temperature of the water was 76°F on the same date. The water has a saline taste and a hydrogen sulfide odor. There is a reddish clay sediment on the spring bottom.

Discharge.—The flow was 1.14 million gallons per day (1.77 c.f.s.) on May 8, 1946.

Quality of water.—No samples collected.

Utilization.—The water is used for swimming and drinking by local residents.

OTHER SPRINGS

Other springs in Putnam County are Beacher Springs, 3 miles south of Nashua Spring, and Welaka Spring, 1.5 miles south of Nashua Spring.

Whitewater Springs in the Ravine Gardens at Palatka are composed of innumerable hillside springs in the ravine. The flow from the springs has been dammed and is sufficient to meet the water-supply requirements of the City of Palatka during most of the year. In 1947 the consumption of water by the city was about 1 m.g.d.

SANTA ROSA COUNTY

CHUMUCKLA OR MINERAL SPRINGS *near* BOGIA

Location.—1.8 miles southeast of Bogia.

Description.—The springs lie to the east of the edge of the low Escambia River swamplands and flow into Diamond Creek which enters the Escambia River 0.5 mile downstream. The springs are cased by a concrete house and well 12 feet by 12 feet. On May 21, 1942, they were flowing through a 3½-inch variable head pipe into the creek.

The springs flow may be discharged through other outlets or pumped to the bottling house.

Discharge.—The flow was estimated to be less than 49 gallons per minute on May 21, 1942.

Utilization.—The water is bottled and sold as mineral water.

OTHER SPRINGS

Another spring at Berrydale in Santa Rosa County is listed in U. S. Geological Survey Water Supply Paper 102, p. 268, 1903.

SARASOTA COUNTY

LITTLE SALT SPRING *near* MURDOCK

Location.—About 2 miles northeast of Warm Salt Springs and 8 miles northwest of Murdock. Reached by driving southeast on graded road from Warm Salt Springs 0.4 mile, then turning northeast and following rough graded road 2.2 miles to the springhead.

Description.—The area surrounding the spring is flat, sandy, prairie-grazing land with occasional palmetto and cabbage palm hammocks dotting the landscape. The spring run is tributary to Big Slough Canal, thence into the Miakka River which flows into Charlotte Harbor. The spring forms a circular pool about 250 feet in diameter and is a submerged sink. The water has a slight salt taste but not as pronounced as Warm Salt Springs. It also has a clear appearance. The temperature of the water was 77°F on April 29, 1946, and 82°F on May 29, 1946.

Discharge.—The flow is as follows: 75 gallons per minute (0.17 c.f.s.) as estimated January 1943 (Florida Geological Survey Bulletin 27, pp. 33, 34); 150 gallons per minute (0.33 c.f.s.) as estimated August 1943 (F.G.S. Bulletin 27, pp. 33, 34); and 669 gallons per minute (1.49 c.f.s.) as measured April 29, 1946.

Quality of water.—Water represented by this analysis is very hard and contains a relatively large amount of dissolved mineral matter. The chief mineral constituents are sodium and chloride (common salt). The dissolved minerals may have their origin in saline residues remaining from earlier geologic invasions of the sea.

ANALYSIS

Date of collection May 29, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	17	—
Iron (Fe)	.05	—
Calcium (Ca)	194	9.68
Magnesium (Mg)	136	11.18
Sodium (Na)	758	32.96
Potassium (K)	24	.61
Bicarbonate (HCO_3)	171	2.80
Sulfate (SO_4)	534	11.12
Chloride (Cl)	1430	40.33
Fluoride (F)	1.6	.08
Nitrate (NO_3)	1.8	.03
Dissolved Solids	3480	—
Total Hardness as $CaCO_3$	1040	—
Carbon Dioxide (CO_2)	—	—
Color	12	—
pH	7.3	—
Specific Conductance ($K \times 10^5$ at 25°C.)	534	—

Utilization.—Apparently the spring is not used unless as watering place for stock or for fishing. A tarpon is reported to inhabit the pool.

PINEHURST SPRING *near* SARASOTA

Location.—About 7 miles south of Sarasota. Reached by driving 6.8 miles south on U.S. Highway 41 from the Terrace Hotel at Sarasota, turning west at a trailer house and a small "Pinehurst Spring" sign, and driving 200 yards to the spring.

Description.—The spring issues through the sand on the north bank of a small bayou of Sarasota Bay and is enclosed by a 4-inch thick concrete retaining wall, 4.5 feet in diameter, which extends to a depth of 11 feet. The spring has been probed to depth of 20 feet through sand to strike rock. The outlet is a ¾-inch pipe on the lower west side of concrete wall. It is reported that at one time the spring came up in the center of this small bayou and that a small horizontal tube in the limerock was open as far back as the shore line. The present concrete well intercepts this tube. The temperature of the water was 73°F on April 30, 1946.

Discharge.—A flow of 2.9 gallons per minute on April 30, 1946 was measured volumetrically. The maximum flow reported is 50 gallons per minute. A rate of 10 gallons per minute was estimated in May 1931 (Florida Geological Survey 23rd and 24th Annual Report, p. 145).

Quality of water.—No samples were collected. A copy of the Pinehurst Spring Water Company analysis, in parts per million, which appears on their bottle labels, is given below:

ANALYSIS

Total solids at 105°C.	432	Calcium (Ca)	82.1
Hardness, total	354	Magnesium (Mg)	36.4
Loss on ignition	42	Sodium, Potassium (Na+K)	16.0
Silica (SiO_2)	6.4	Bicarbonate (HCO_3)	404.1
Ferric oxide (Fe_2O_3)	0.3	Sulfate (SO_4)	9.4
Iron (Fe)	0.2	Chloride (Cl)	34.0
Alumina (Al_2O_3)	2.8	Nitrate (NO_3)	trace

Utilization.—The water is bottled and sold for drinking purposes by Pinehurst Spring Water Company.

WARM SALT SPRING *near* MURDOCK

Location.—About 8 miles northwest of Murdock. Reached by driving 8.1 miles northwest from Murdock on U.S. Highway 41, then turning on gravel surfaced road and driving 1.0 mile to the spring.

Description.—(See figure 29.) The head of the spring is almost circular, about 250 feet in diameter, and is the source of Salt Creek which flows into the Miakka River. The spring surface was about 3 feet below the level of the surrounding flat, sandy prairie land in October 1942. There are small stands of pine timber to the northeast and the Salt Creek outlet is bordered with a salt marsh which supports a growth of mangrove. In general the spring location is quite open and exposed. The maximum depth is 167 feet as determined from numerous soundings made on October 1 and 29, 1942. The temperature of the water taken 0.5 foot below water surface 5 feet upstream from upstream side of the bridge across the outlet on April 29, 1946, was 86°F.

FIGURE 29. *Warm Salt Springs,* Sarasota County.

Discharge.—Current meter measurements are listed below:

DATE	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
October 1, 1942 - - -	11.0	7.1
April 29, 1946 - - -	10.8	9.0

Quality of water.—A sulphurous odor is noticeable in the vicinity of the pool. The water has a brackish sulphurous taste. Analysis made by U. S. Geological Survey of sample collected on February 10, 1927 shows the following chemical character:

ANALYSIS

	PARTS PER MILLION
Silica (SiO_2) - - - - -	18
Iron (Fe) - - - - -	.12
Calcium (Ca) - - - -	766
Magnesium (Mg) - - -	471
Sodium, Potassium (Na+K)	5,124
Bicarbonate (HCO_3) - -	167
Sulfate (SO_4) - - - -	1,704
Chloride (Cl) - - - -	9,350
Nitrate (NO_3) - - - -	—
Total Hardness as $CaCO_3$ -	3,846
Dissolved Solids - - - -	17,812

Analyses of samples collected in 1927, 1930, and 1943 are reported in Florida Geological Survey Bulletin No. 27, page 34.

Utilization.—The spring has recently been developed. The grounds have been cleared, a bathhouse built, a gasoline water pump installed, an electric power line brought in, and a trailer park built. The water in the springhead is used for swimming and drinking.

SEMINOLE COUNTY

PALM SPRINGS *near* LONGWOOD

Location.—About 3 miles west of Longwood and 0.3 mile north of Sanlando Springs.

Description.—(See figure 30.) They are situated at the base of a hill adjacent to the Little Wekiva River. Sanlando Springs are located on the opposite side of this hill. A rectangular spring pool is formed by a concrete retaining wall which has a 6-foot width spillway opening on the river side. The outflow can be regulated with stop-logs.

FIGURE 30. Pool basin at *Palm Springs*, Seminole County. Photograph taken 1935.

Discharge.—The flow of the springs as measured on Nov. 12, 1941 was found to be 9.7 second-feet (6.3 m.g.d.).

Utilization.—There is a bathhouse for swimmers and bathers at the springs.

SANLANDO SPRINGS *near* LONGWOOD

Location.—About 9 miles north of Orlando. Reached by driving north from Orlando on U.S. Highway 17 and 92 for 9 miles, turning west and driving 1.1 miles to Longwood. Continue on the same road and drive 3.1 miles to the springhead.

Description.—(See figure 31.) The springs are situated on the east bank of the Little Wekiva River in a wooded semi-tropical setting with rolling sandy hills to the east and the flat Wekiva River valley swamplands a short distance to the north. The springhead forms an irregular kidney-shaped pool about 50 feet in diameter, being enclosed on the east side by a concrete retaining wall. From the pool the springs branch into two small runs that empty individually, about 200 feet west of the pool, into the Little Wekiva River in its course northward. A concrete wall dam with a 4-foot width weir of stop-logs crosses the north run about 70 feet from the springhead and a similar dam crosses the south run about 120 feet from the springhead. All of the water appears to emerge from one horizontal cavern. The maximum depth at the cave entrance was 13.2 feet on April 23, 1946, and the temperature of the water was 74°F.

FIGURE 31. *Sanlando Springs* near Longwood, Seminole County.

Discharge.—Measurements of flow made between the dams and the Little Wekiva River are as follows:

DATE	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
November 12, 1941 -	22.4	14
April 23, 1946 - - -	21.7	14

Quality of water.—Water in Sanlando Springs is moderately hard and is typical of many spring waters in Florida. The dissolved mineral matter consists essentially of calcium and bicarbonate.

ANALYSIS

Date of collection April 23, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	13	—
Iron (Fe) - - - -	.09	—
Calcium (Ca) - -	29	1.45
Magnesium (Mg) -	7.9	.65
Sodium (Na) - - -	5.8	.25
Potassium (K) - -	.6	.02
Bicarbonate (HCO_3)	125	2.05
Sulfate (SO_4) - - -	3.3	.07
Chloride (Cl) - - -	7.8	.22
Fluoride (F) - - -	.2	.01
Nitrate (NO_3) - -	.1	.00
Dissolved Solids - -	123	—
Total Hardness as $CaCO_3$ - - - -	105	—
Carbon Dioxide (CO_2)	13	—
Color - - - - -	6	—
pH - - - - - - -	7.2	—
Specific Conductance ($Kx10^5$ at 25°C.) -	22.8	—

Utilization.—The springs and adjacent grounds are well landscaped and developed, and facilities are present for swimming, picnicking, and dancing. A restaurant and club house are located on the grounds which are interwoven with paths and foot walks. The springs are privately owned and developed and a charge is made for admission to the grounds.

SHEPPARD SPRING *near* LONGWOOD

Location.—About 3 miles west of Longwood and approximately 0.2 mile north of Sanlando Springs. The spring can be reached by driving 0.4 mile west from Sanlando Springs, at which point a woods road leads off right to the spring, approximately 0.5 mile northwest from this turnoff.

Description.—The spring lies at the base of a rather high slope, the pool being 70 to 80 feet in circumference, with a strong boil in its center. The temperature of the water was 74°F on July

25, 1944. There is no run; the outlet opens directly into the Little Wekiva River. On the date measured, July 25, 1944, there was a temporary weak dam structure at the opening into the river with a hardly perceptible drop in water surface.

Discharge.—The flow was 16.7 second-feet (11 m.g.d.) as measured on July 25, 1944.

Quality of water.—Results of a partial analysis made in 1944 of a sample collected from Sheppard Spring indicate that it is moderately hard and in other respects typical of many Florida springs.

ANALYSIS

Date of collection: July 25, 1944

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	—	—
Iron (Fe)	—	—
Calcium (Ca)	—	—
Magnesium (Mg)	—	—
Sodium (Na)	—	—
Potassium (K)	—	—
Bicarbonate (HCO_3)	141	2.31
Sulfate (SO_4)	12	.34
Chloride (Cl)	12	.25
Fluoride (F)	—	—
Nitrate (NO_3)	—	—
Dissolved Solids	—	—
Total Hardness as $CaCO_3$	126	—
Carbon Dioxide (CO_2)	—	—
Color	—	—
pH	—	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—

Utilization.—It is used as a private swimming pool by the owner, who has improved the spring by diverting a creek which ran a few feet from the spring to a new bypass channel a distance 50 or 60 feet farther to the west. An earth fill was placed around the spring to a height of 2 or 3 feet.

OTHER SPRINGS

Other springs in Seminole County are Altamonte Springs; Clifton Spring on the south side of Lake Jessup; Elder or Robinson Springs, 5.5 miles south of Sanford; Massin Spring; and Seminole Spring.

SUMTER COUNTY

FENNEY SPRINGS *near* COLEMAN

Location.—About 2.3 miles east of Coleman. Reached by driving 2.0 miles east from Coleman on State Highways 35 and 468, turning south on sand road through a cattle guard and driving 0.3 mile to the springs.

Description.—The springs are in the headwaters of the Panasoffkee River which flows into Lake Panasoffkee and thence to the Withlacoochee River. The surrounding land is fairly flat with numerous depressions and, near the spring, an elevation of about 60 feet above mean sea level. The springhead forms a nearly circular pool about 50 feet in diameter which had a maximum depth of 25.7 feet on July 26, 1946. The water was discolored and dark on that day, due to surface water from a nearby swamp, so the bottom of the springs was not visible. However, a rock ledge was visible on the west side of the pool just a few feet underneath the surface of the water. Less than 10 feet south of the springs is a sink hole about 30 feet in diameter having a maximum depth of 30.1 feet. The small outflow was estimated to be 0.5 c.f.s. Small gar fish are numerous. The temperature of the water was 76°F on July 26, 1946.

Discharge.—The flow was 21.6 second-feet (14 m.g.d.) as measured on July 26, 1946.

Quality of water.—No samples collected.

Utilization.—The springs are not developed. They are used as a swimming pool and picnic grounds by local residents, and as a watering place for stock.

PANASOFFKEE RIVER *near* COLEMAN
(FORMERLY BRANCH MILL SPRING GROUP)

Location.—At highway bridge on State Highway 35, two miles south of the Seaboard Railroad station at Coleman.

Description.—The river discharge consists of the total base flow of three or more springs including Fenney, Matahonka, and Warm Springs and an appreciable amount of surface flow during the wet season. It is tributary to Lake Panasoffkee thence into the Withlacoochee River. The temperature of the water was 74°F on February 17, 1933, and 76°F on July 26, 1946.

Discharge.—Flow measurements are listed as follows:

DATE	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
March 14, 1932 - -	18.7	12
February 17, 1933 - -	8.6	5.6
July 26, 1946 - - -	40.2	26

Quality of water.—No samples collected.

Utilization.—Apparently none unless as a watering place for stock. In earlier days a water wheel downstream from the highway furnished power for a grist mill.

OTHER SPRINGS

Another spring, Gum Slough Spring, is located in Sumter County and some data on it are given in Table 4.

SUWANNEE COUNTY

CHARLES SPRINGS *near* LURAVILLE

Location.—The springs are located on the northeast bank of the Suwannee River 3 miles north and 3 miles west of Luraville.

Description.—The steep banks around the head of the springs and run are approximately 30 feet above the water surface and the head of the springs is an oblong pool about 25 feet long, varying from 4 to 10 feet in depth. There are numerous sinks and pot-holes shoreward of the springs. Some are dry and some are filled with water. The temperature of the water in the head-pool was 69°F on May 29, 1942. The discharge of water from this pool flows under a natural rock bridge into a second pool which is about 20 feet by 10 feet in size and varies from 6 to 8 feet in depth. The water then flows under another natural bridge into a large shallow circular pool about 40 feet in diameter, the outlet of which flows into the Suwannee River through a run about 200 feet long and 15 to 25 feet in width. Depths were obtained May 29, 1942.

Discharge.—The flow was 17.9 second-feet (12 m.g.d.) on May 15, 1927; 9.4 c.f.s. (6.1 m.g.d.) on December 12, 1941; and 36.8 c.f.s. (24 m.g.d.) on May 29, 1942, measured at the downstream end of the large shallow pool.

Utilization.—They are undeveloped, but are used for swimming and fishing by local residents.

FALMOUTH SPRING *at* FALMOUTH (FORMERLY NEWLAND'S SPRING)

Location.—The spring is 0.2 mile west of Falmouth and 3.5 miles southeast of the Suwannee River at Ellaville. It can be reached by driving 0.2 mile on the road on the east side of a store building located on the south side of U.S. Highway 90, 0.2 mile west of the Falmouth railway station.

Description.—This depression, whose shape somewhat resembles a dumbbell split end to end, is surrounded by rolling wooded lands of pine and oak. The water normally emerges from a spring at one end of the depression and then flows northwest 400 feet into a sink hole at the other end. When the Suwannee River is in flood stage, this flow has been known to reverse in direction; that is, to flow from what is normally the "sink" hole southeast into the spring cavity and then disappear underground.

The springhead consists of a semicircular pool about 70 feet in diameter which is connected by a channel about 35 feet in width and 400 feet in length to the sink, which is approximately the same size as the springhead.

A series of soundings in the spring and sink made March 30, 1943 indicate a maximum depth of 45 feet in the springhead and 36 feet in the sink. It was not possible to see the bottom of the pools as both the springhead and sink were covered with a mat of grass 2 to 3 feet in thickness and were also filled with branches, logs, and fallen trees. The "feel" of the sounding-line indicated a rock formation which was jagged and creviced. The spring and sink cavities, together with connecting channel, are in a depression bounded by a steep limestone and sand bank, the foot of which lies from 10 to 20 feet from the shoreline of the pools and channel. The temperature of the water was 71°F on July 22, 1946.

Discharge.—The flow was 365 second-feet (236 m.g.d.) on February 10, 1933. The measurement was made from the upstream side of the former walkway over the spring and the flow was opposite to the direction of normal flow due to flood stages in the Suwannee River at that time. Normal flow is toward the river.

On December 9, 1942, the flow was in the normal direction and was measured as 59.6 c.f.s. (39 m.g.d.).

On July 22, 1946, the flow was in the normal direction and was measured from a boat as 157 c.f.s. (101 m.g.d.).

Quality of water.—This is a hard water, typical of many Florida springs. The dissolved mineral matter consists almost entirely of calcium and bicarbonate. No sample was collected for analysis in 1946.

ANALYSIS

Date of collection February 26, 1924

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	6.1	—
Iron (Fe)	.04	—
Calcium (Ca)	65	3.24
Magnesium (Mg)	9.2	.76
Sodium (Na)	3.1	.13
Potassium (K)	.4	.01
Bicarbonate (HCO_3)	228	3.74
Sulfate (SO_4)	9.5	.20
Chloride (Cl)	4.0	.11
Fluoride (F)	—	—
Nitrate (NO_3)	—	—
Dissolved Solids	218	—
Total Hardness as $CaCO_3$	200	—
Carbon Dioxide (CO_2)	—	—
Color	—	—
pH	—	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—

Utilization.—The spring is used for bathing and swimming by local residents. There are no bathhouse facilities, however. In earlier years this was a well known watering place and resort.

SUWANNEE SPRINGS *near* LIVE OAK

Location.—The springs can be reached by driving about 7 miles north from Live Oak on State Road 51, turning east at the graded road just south of the Suwannee River highway bridge and driving about 500 feet to the springs.

Description.—(See figure 32.) Located in a hollow of the high bank of the Suwannee River, the springs form a rather rectangular-shaped pool, enclosed by a concrete rock wall 15 feet high with dimensions of about 45 x 85 feet. All of the flow emerges from three horizontal caverns covered by a maximum depth of 13.6 feet of water on May 16, 1946. The pool outlet is a concrete culvert with a 6 x 7 foot cross-sectional opening at the northwest corner of the pool which empties immediately into the Suwannee River. There are three control openings in the north wall which are closed with stop gates when the river is at high stages. The temperature of the water was 70°F on March 16, 1932, December 27, 1945 and May 16, 1946.

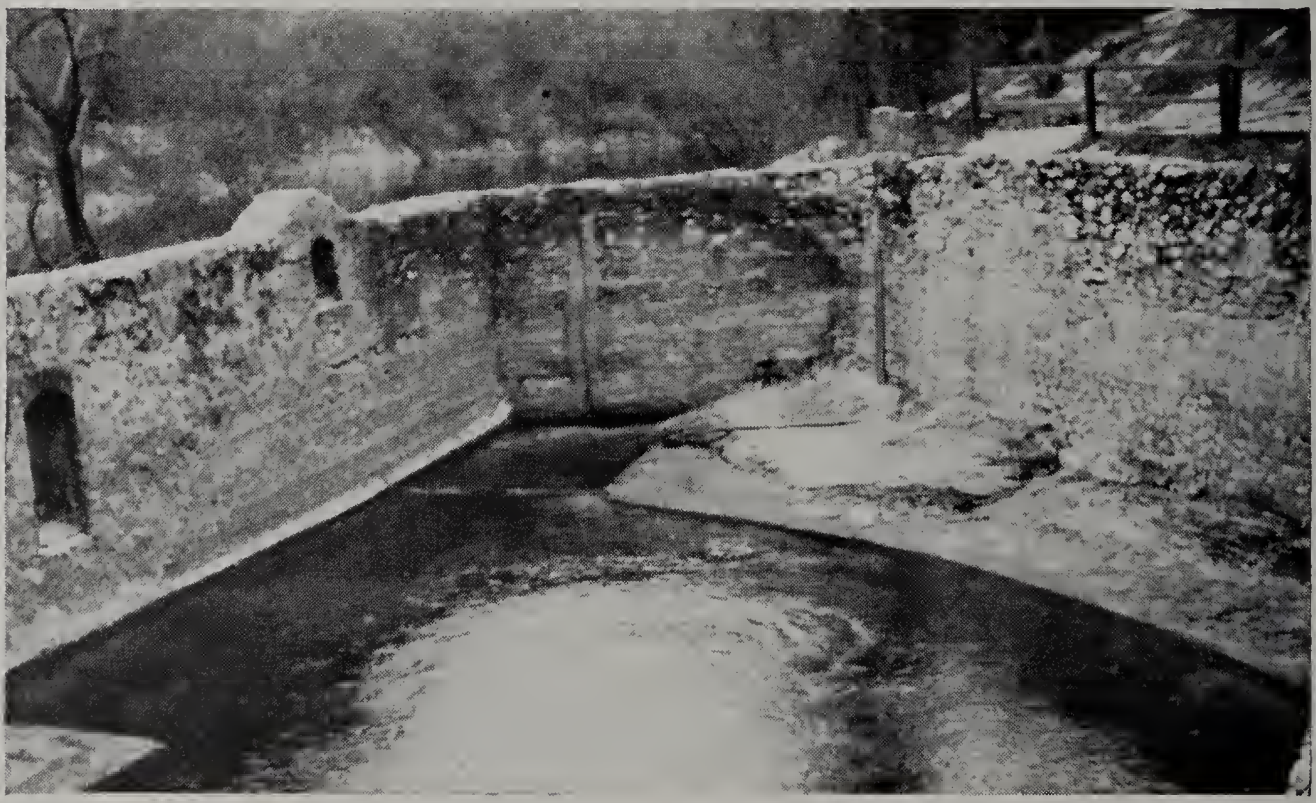

FIGURE 32. *Suwannee Springs,* photograph taken looking northeast into headpool surrounded by a flood wall.

Discharge.—The flow of Suwannee Springs has been measured as follows:

DATE	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
May 17, 1906	44	28
March 16, 1932	6.1	3.9
May 16, 1946	37.9	25

Quality of water.—Analyses of two samples collected 22 years apart show that the water is hard and had essentially the same composition at the time the samples were collected. The dissolved mineral matter consists largely of calcium and bicarbonate.

ANALYSIS

Date of collection	February 26, 1924		May 16, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	14	—	12	—
Iron (Fe)	.16	—	.13	—
Calcium (Ca)	53	2.65	54	2.69
Magnesium (Mg)	12	.99	8.7	.72
Sodium (Na)	5.5	.24	4.7	.20
Potassium (K)	.6	.02	.6	.02
Bicarbonate (HCO_3)	185	3.03	179	2.93
Sulfate (SO_4)	27	.56	21	.44
Chloride (Cl)	7.0	.20	6.2	.18
Fluoride (F)	—	—	.2	.01
Nitrate (NO_3)	—	—	.4	.01
Dissolved Solids	220	—	198	—
Total Hardness as $CaCO_3$	182	—	171	—
Carbon Dioxide (CO_2)	—	—	11	—
Color	—	—	25	—
pH	—	—	7.4	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—	35.0	—

Utilization.—The springs are developed for swimming, bathing, and as a health resort. A bathhouse is available as well as cottages for rent. The flood wall around the springs has been there 60 or more years.

OTHER SPRINGS

Partial data on Branford Springs at Branford, Ellaville Spring at Ellaville and Telford Springs at Luraville are given in Table 4.

TAYLOR COUNTY

HAMPTON SPRINGS *near* PERRY

Location.—About 4.8 miles west of Perry. The springs are reached by turning west off U.S. Highway 19 at "Hampton Springs" sign and driving on State Road 30 a distance of 4.8 miles to the hotel and springs.

Description.—The springs are sheltered by a house on the west side of the hotel and flow into a swimming pool, which is also covered, then empty into Rocky Creek, a tributary to Fenholloway River. The springs have been cased with a 3-inch thick vertical concrete pipe 2.5 feet in diameter, and have a maximum depth of 11.3 feet. The temperature of the water was 70°F on November 21, 1923 and 73°F on July 23, 1946.

Discharge.—The flow is as follows: 223 gallons per minute (0.50 c.f.s.) in 1913 (W.S.P. 319, p. 415); 260 gallons per minute (0.58 c.f.s.) on November 21, 1923 (W.S.P. 596-G, p. 230); 67 gallons per minute (0.15 c.f.s.) on January 25, 1929; and 202 gallons per minute (0.45 c.f.s.) on July 23, 1946.

Quality of water.—The two analyses of water collected from Hampton Springs show that it is very hard and contains relatively large amounts of dissolved mineral matter. The sample analyzed in 1946 contained appreciably more dissolved solids than the sample analyzed in 1923. This water is unusual in that approximately half of the dissolved matter consists of sulfate. The contents of sodium and chloride are unusually low for a water containing so much dissolved mineral matter. No other spring water in Florida analyzed by the Geological Survey has been found which has a similar composition.

ANALYSIS

Date of collection	November 21, 1923		July 23, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	15	—	10	—
Iron (Fe)	.10	—	.13	—
Calcium (Ca)	162	8.09	189	9.43
Magnesium (Mg)	72	5.92	85	6.99
Sodium (Na) } Potassium (K) }	6.6	.29	7.0	.30
			2.0	.05
Bicarbonate (HCO_3)	294	4.82	288	4.72
Sulfate (SO_4)	440	9.16	557	11.60
Chloride (Cl)	10	.28	8.8	.25
Fluoride (F)	—	—	.7	.04
Nitrate (NO_3)	—	—	.0	.00
Dissolved Solids	914	—	1080	—
Total Hardness as $CaCO_3$	700	—	821	—
Carbon Dioxide (CO_2)	—	—	—	—
Color	—	—	30	—
pH	—	—	6.9	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—	132	—

Utilization.—The development of the springs as a winter resort began in 1910 at the time the hotel was built. The hotel was being renovated in July 1946.

WALDO SPRINGS *near* PERRY

Location.—About 7.5 miles along road south and west of Perry. The springs are reached by driving 1.4 miles south on U.S. Highway 19 from the A. C. L. Railroad tracks and turning south at the junction with State Road 55. Drive 3.2 miles, turn west and drive 0.4 mile, then turn into the right fork and drive 1.5 miles to the springs. The last 1.5 miles of the road are very sandy and travel in dry weather is difficult.

Description.—Situated in the flat lowlands, surrounded with palmetto and pine vegetation, the springs form a rather circular shaped pool about 60 feet in diameter with the springs flow apparently coming from crevices in the floor of the limestone exposed on the north side of the pool. There was no noticeable surface disturbance. The water has a slight sulphur odor. The maximum depth sounded was 9.2 feet on July 24, 1946, and the temperature of the water was 71°F. The run is tributary to the Fenholloway River which flows into the Gulf of Mexico.

Discharge.—A flow of 26.5 second-feet (17 m.g.d.) was reported in Water Supply Paper 319, p. 415, published in 1913, and 3.3 c.f.s. (2.1 m.g.d.) was measured 50 feet below the spring head on July 24, 1946.

Quality of water.—No samples were collected.

Utilization.—The springs are intact in their natural surroundings. They are used by local residents as a swimming pool and picnic grounds and are probably used by stock as a watering place. A timber flume has been placed in the springs run about 50 feet downstream from the outlet. Backfilling around the flume has not been completed, however, and there are no stoplogs in place.

OTHER SPRINGS

Other springs in Taylor County are Adams Spring, Blue Springs, Econfenee Spring, Emmerson Spring, Ewing Spring, Fenholloway Springs, Iron Spring, and Union Spring.

UNION COUNTY

WORTHINGTON SPRING *at* WORTHINGTON

Location.—The spring is in the town of Worthington and is about 300 feet west of State Highway 23 near the north bank of the Santa Fe River.

Description.—The spring has been cased in a square pool by concrete walls about 6x6 feet and from this pool the water flows into an adjoining swimming pool which is partially enclosed by a recreation hall and bathhouse.

Discharge.—The flow of this spring has not been measured but is relatively small. The pool and spring are subject to flooding of the nearby Santa Fe River.

Quality of water.—An analysis of Worthington Spring made in 1924 indicates that it is moderately hard and that the dissolved mineral matter consists largely of calcium and bicarbonate. No sample was collected for analysis in 1946.

ANALYSIS

Date of collection August 13, 1924

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	24	—
Iron (Fe)	.04	—
Calcium (Ca)	40	2.00
Magnesium (Mg)	7.9	.65
Sodium (Na), Potassium (K)	12	.52
Bicarbonate (HCO_3)	166	2.72
Sulfate (SO_4)	8.8	.18
Chloride (Cl)	10	.28
Fluoride (F)	—	—
Nitrate (NO_3)	—	—
Dissolved Solids	189	—
Total Hardness as $CaCO_3$	132	—
Carbon Dioxide (CO_2)	—	—
Color	—	—
pH	—	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—

Utilization.—The spring is used to furnish water for the swimming pool.

VOLUSIA COUNTY

BLUE SPRING *near* ORANGE CITY

Location.—The spring is 2.5 miles west of Orange City. It may be reached by turning west from U.S. Highways 17 and 92, 0.4 mile south of the point it crosses the Florida East Coast Railway.

Description.—The springhead forms a fairly circular pool about 85 feet in diameter. The bottom of the pool is somewhat funnel-shaped sloping from the shore to a depth of 9.0 feet at the edge of a ledge where the depth increases precipitately to 40 feet. The maximum depth in this deepest cavity was 41.7 feet on January 3, 1947. The milky-colored sulfurous water emerging from this main cavity produces a decided disturbance rising as much as 0.3 foot above the pool surface. Fallen trees in the run 50 feet downstream from the boil create a slight break in the profile of the stream. The run varies from 70 to 100 feet in width. It flows south from the head for 0.2 mile then turns southwest and flows 0.2 mile to join the St. Johns River. High stages in the river force backwater into the spring, hence there is lower flow from the spring at certain periods for this reason. Temperatures of the spring water have been observed as follows:

DATE	WATER TEMPERATURE
	°F
March 7, 1932 - - - - -	73
February 8, 1933 - - - -	73
January 3, 1945 - - - -	74
July 8, 1946 - - - - -	73
January 3, 1947 - - - -	74

Discharge.—This spring has the largest flow of any in the St. Johns River basin. Flow measurements have been made at about monthly intervals since March 7, 1932. A graph showing the trends in discharge appears in figure 7. The maximum discharge measured during the period was 188 second-feet (121 m.g.d.) on December 5, 1932, and the minimum discharge was 62.7 c.f.s. (40 m.g.d.) on November 6, 1935. This latter discharge figure may be somewhat in error due to adverse measuring conditions and backwater effect from the St. Johns River. The average flow of 150 measurements made from March 7, 1932 to November 26, 1946 is 161 c.f.s. (104 m.g.d.).

Quality of water.—Water in Blue Spring is hard and contains a relatively large amount of dissolved mineral matter. Sodium and chloride are the predominant mineral constituents. The dissolved minerals may have their origin in saline residues remaining from earlier geologic invasions of the sea.

ANALYSIS

Date of collection July 8, 1946

	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2) - - -	6.0	—
Iron (Fe) - - - -	.07	—
Calcium (Ca) - -	76	3.79
Magnesium (Mg) -	51	4.19
Sodium (Na) - - -	419	18.22
Potassium (K) - -	13	.33
Bicarbonate (HCO_3)	148	2.43
Sulfate (SO_4) - - -	113	2.35
Chloride (Cl) - - -	775	21.86
Fluoride (F) - - -	.0	.00
Nitrate (NO_3) - -	2.0	.03
Dissolved Solids - -	1660	—
Total Hardness as $CaCO_3$ - - - -	399	—
Carbon Dioxide (CO_2)	5.9	—
Color - - - - -	5	—
pH - - - - - -	7.6	—
Specific Conductance ($K \times 10^5$ at 25°C.) -	284	—

Utilization.—A number of boathouses are located along the east bank of the run which are used to shelter the small craft of boat owners in the vicinity. There is also a bathing beach upstream from the boathouses at the end of the road from Orange City. Rowboats for rent are available from the spring operators, as well as cabins and barbeque pits. There is a refreshment stand on the grounds.

PONCE DE LEON SPRINGS *near* DeLand

Location.—About 8.5 miles north of DeLand. Reached by driving north from DeLand on U.S. Highway 17 for 6.6 miles, turning west on paved road at a sign that reads "Ponce de Leon Springs" and driving 1.9 miles to the springhead.

Description.—(See figure 33.) The springs form a semi-circular pool nestled between high rolling sandy hills to the north, south and east. The pool is enclosed by a concrete wall about

170 feet in diameter. There are two weir outlets on the west side of the pool and one flume outlet on the southwest side of the pool, which are tributary to Lake Woodruff, thence to the St. Johns River. The temperature of the water on October 26, 1923 was 79°F, on April 23, 1946 was 74°F and on November 27, 1946 it was 73°F. All of the springs flow appears to come from one cavern and chimney whose maximum sounded depth was 35.4 feet on April 23, 1946. The resident owner reports a wooden plank across the opening where the water emerges so there may be some question as to the present sounded depth, since this had earlier been used as a place to dump numerous objects. All the sugar mill machinery displayed at the springs was recovered from the springs but a Spanish treasure said to be buried there in 1817 is still unrecovered.

FIGURE 33. General view of *Ponce De Leon Springs*. Photograph taken looking west.

Discharge.—The average flow computed from the four measurements listed below is 30 second-feet (19 m.g.d.).

DATE	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
February 11, 1929 - -	22.0	14
March 7, 1932 - - -	20.4	13
April 23, 1946 - - -	41.8	27
November 27, 1946 -	36.0	23

Quality of water.—The composition of water in Ponce de Leon Springs was quite different in a sample collected in 1946 from the composition found in a sample collected in 1923. The 1946 sample contained less than half the amount of dissolved solids found in the 1923 sample. Both samples were hard and moderately mineralized. Sodium and chloride are the predominant constituents.

ANALYSIS

Date of collection	October 26, 1923		April 23, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	19	—	6.6	—
Iron (Fe)	.15	—	0.06	—
Calcium (Ca)	64	3.19	44	2.20
Magnesium (Mg)	44	3.62	17	1.40
Sodium (Na)	332 (Na + K)	14.43 (Na + K)	124	5.39
Potassium (K)			4.0	.10
Bicarbonate (HCO_3)	130	2.13	122	2.00
Sulfate (SO_4)	93	1.94	35	.73
Chloride (Cl)	622	17.55	231	6.52
Fluoride (F)	—	—	.0	.00
Nitrate (NO_3)	1.1	.02	.8	.01
Dissolved Solids	1256	—	541	—
Total Hardness as $CaCO_3$	340	—	180	—
Carbon Dioxide (CO_2)	—	—	8	—
Color	—	—	0	—
pH	—	—	7.4	—
Specific Conductance ($Kx10^5$ at 25°C.)	—	—	103	—

Utilization.—The springs are well developed for swimming, boating, picnicking, and fishing. There is a hotel on the northeast side of the pool (open from December through March), a gift shop and bathhouses, also a diving tower and diving boards. Rowboats are available for fishing in the run. On the southeast side of the pool there are spacious picnic grounds surrounded by shade trees. Water from the flume on the southwest side of the pool drives the antique 34-foot diameter undershot wheel which now operates a water pump furnishing running water for all buildings around the springs. The present age of the wheel is

78 years, and in earlier days it was used to grind sugar cane, corn and grains, and ran three cotton gins.

History.—The springs were discovered in 1512 by Don Juan Ponce de Leon in quest of the Fountain of Youth and were forcibly taken by the Spaniards in 1570. In 1763 it was ceded to England together with all Florida in payment for Cuba, and retaken in 1783 by the Indians. In 1832 Gen. Zachary Taylor made his encampment just below the springs and soon afterward all grants were purchased by one Mr. Thomas Starke for 50 negro women, see figure 1.

OTHER SPRINGS

Some data on Green Springs, also located in Volusia County, are given in Table 4.

WAKULLA COUNTY

RIVER SINK *in* RIVER SINK PRECINCT *South of* TALLAHASSEE

Location.—Approximately 12 miles southwest of Tallahassee, in sec. 28, T. 2 S., R. 1 W., in the area known as "River Sink Precinct" in Wakulla County. To reach the spring drive south 12 miles from Tallahassee on State Highway 359 and take left fork. Continue 0.2 mile to a house and turn east through a tree-lined lane. Follow this road 0.8 mile east and then 0.2 mile north to pool and sink.

Description.—The following description by Sellards[9] explains the origin and character of River Sink as a part of the Wakulla River system:

> "The Wakulla River system originates in small surface streams which reach north-west to within one or two miles of the Ocklocknee River in Leon County. These tributaries flow as surface streams in a general south-east direction until they reach the limestone area, when they become subterranean streams entering the limestone through sinks. After entering the limestone they may occasionally be seen owing to the caving of the roof above them. One such view of the stream making its way underground is to be had at what is known as the River Sinks

[9] Sellards, E. H., Geology between the Ochlockonee and Aucilla Rivers in Florida: Florida Geological Survey Ninth Ann. Rept. pp. 136, 137, 1917.

> in Wakulla County. These underground streams make their way, as we may believe, in a general southeast direction and re-emerge, in part at least, to form the great Wakulla Spring, and from that place continue as an open surface stream to the Gulf."

River Sink springhead consists of a semi-circular pool about 65 feet in diameter connected by a channel about 65 feet in width and 300 feet in length to a sink approximately the same size as the springhead.

A series of soundings in the spring and sink made May 19, 1942 indicate a maximum depth of 30 feet in the springhead and 31 feet in the sink, the bottoms of both being fairly uniform. The depth of the connecting channel was generally between 5 and 6 feet at the midpoint between the head and the sink on May 19, 1942. The water on the above date was not sufficiently clear to see the bottom of the pools, probably due to recent local rainfall. The surrounding ground surface is 8 to 10 feet above the pools with a 45 degree slope at the banks. The temperature of the water on October 14, 1941 was 72°F.

Discharge.—The flow was 178 second-feet (115 m.g.d.) at a section in the channel midway between head and sink on May 19, 1942.

Utilization.—The spring is undeveloped.

WAKULLA SPRING *near* CRAWFORDVILLE

Location.—This large spring is 6 miles northeast of Crawfordville and 14 miles south of Tallahassee. It is reached by driving south from Tallahassee on U.S. Highway 319. Prominently displayed signs guide the visitor to the spring.

Description.—(See figure 34.) Wakulla Spring is situated on the relatively flat coastal lowlands approximately midway between Tallahassee and Apalachee Bay. The woodlands of cypress, live-oak, magnolia and pine in the surrounding area rise to elevations of 20 to 30 feet above mean sea level. The semi-circular shaped head of the spring is approximately 400 feet in diameter, covering an area of about 5 acres. Fifty feet south of the end of the high diving platform on the north side of the spring the gently sloping bottom of the pool drops abruptly from a depth

FIGURE 34. General view of *Wakulla Spring* as seen looking over the headpool down Wakulla River.

of 25 feet to a water depth of 103 feet, as measured by a vertical sounding line on October 7, 1942. The water issuing from the cavern mouth at this point of maximum measured depth is the source of the broad Wakulla River which flows through Apalachee Bay into the Gulf of Mexico. At medium and low stages a slight daily stage fluctuation due to tide effect occurs in the springhead as shown in figure 35. The large head of fresh water in the aquifer feeding the spring prevents salt water from entering the pool whose bottom is far below mean sea level.

The direct influence of rainfall upon the water surface fluctuation of the spring is shown in the lower graph of figure 35 for the period December 27, 1931 to January 4, 1932. This relation for a longer period is shown in figure 36.

The low color and turbidity of the spring water (except during and after heavy rainfall) in combination with the white bottom and bright sunlight make under water visibility excellent.

Many mastodon skeletons have been recovered from the spring. One of these, completely mounted, is exhibited in the Florida Geological Survey Museum at Tallahassee.

The temperature of the spring water measured on April 22, 1931 was 77°F, on September 15, 1931, 74°F, and on June 18, 1946, 73°F.

Discharge.—Flow measurements have been made about monthly during 1931, 1932, and since July 1941, with one measurement made during each of the years 1907, 1917, 1929 and 1930. These gagings were made on Wakulla River at a point about 3 miles downstream from the springhead. The series subsequent to August 1941 have been corrected for major intervening inflow and studies indicate that such net values generally represent the flow of Wakulla Spring. The average of this series of 49 measurements from August 12, 1941 to January 9, 1947 is 283 second-feet (183 m.g.d.).

Quality of water.—Water from Wakulla Spring is moderately hard and typical of many Florida springs. The dissolved mineral matter consists essentially of calcium and bicarbonate. The two analyses made about 22 years apart are almost identical, which indicates that the composition is probably nearly constant.

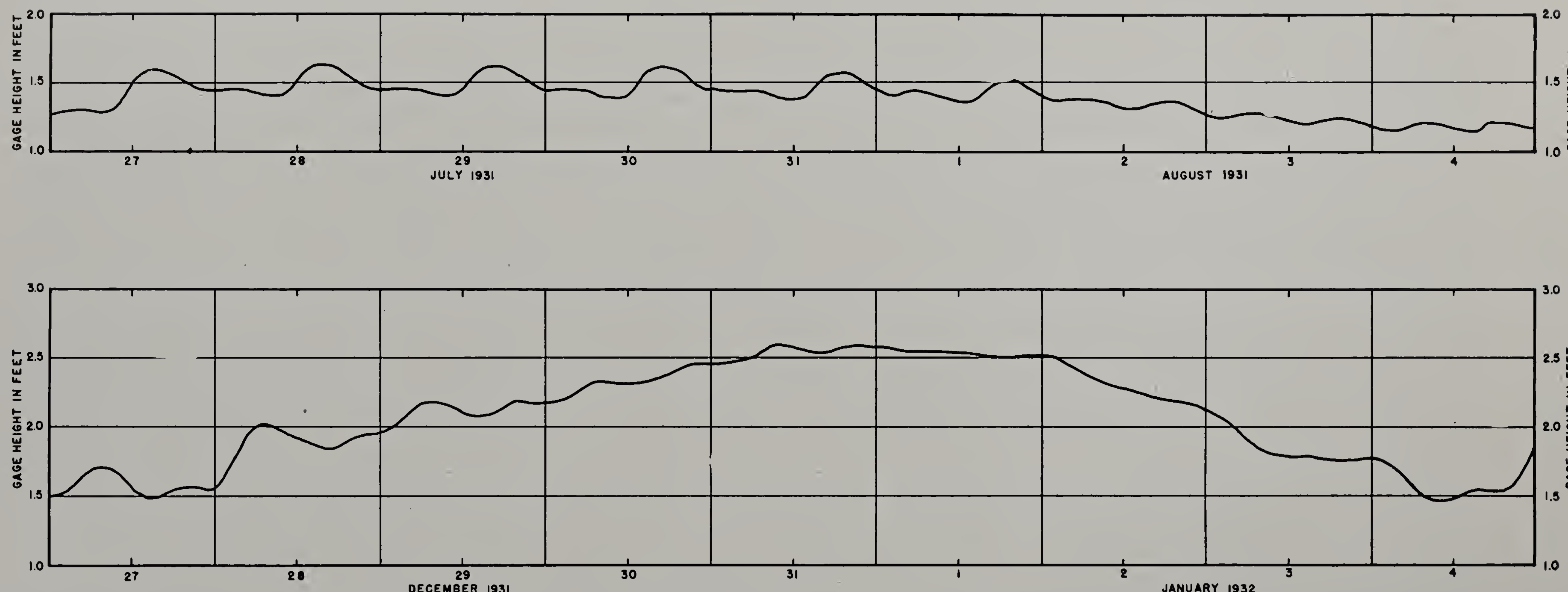

FIGURE 35. Selected graphs showing daily stage fluctuations of *Wakulla Spring*.

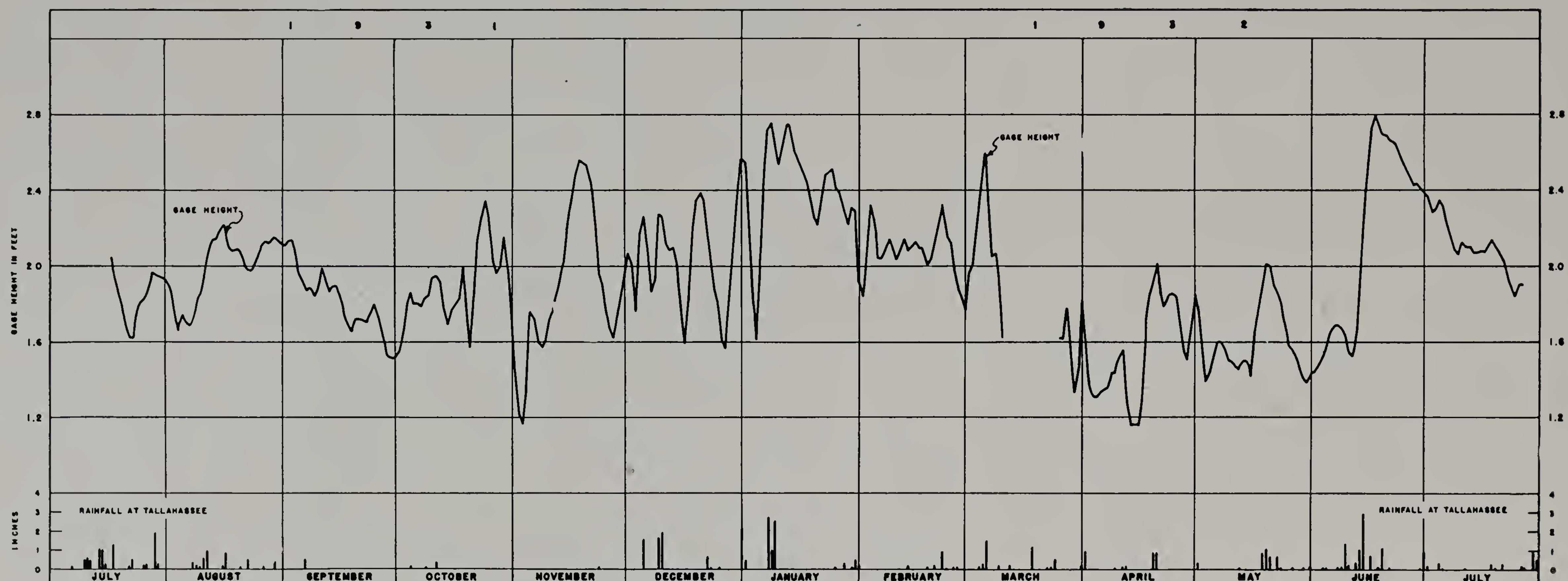

FIGURE 36. Graph showing *Wakulla Spring* water surface fluctuations in relation to rainfall at Tallahassee during the period July 1931 to July 1932.

ANALYSIS

Date of collection	February 28, 1924		June 18, 1946	
	PARTS PER MILLION	EQUIVALENTS PER MILLION	PARTS PER MILLION	EQUIVALENTS PER MILLION
Silica (SiO_2)	16	—	12	—
Iron (Fe)	—	—	.09	—
Calcium (Ca)	39	1.95	38	1.90
Magnesium (Mg)	9.6	.79	9.5	.78
Sodium (Na)	5.7	.25	4.0	.17
Potassium (K)			.5	.01
Bicarbonate (HCO_3)	154	2.52	152	2.49
Sulfate (SO_4)	11	.23	9.3	.19
Chloride (Cl)	8.0	.23	5.1	.14
Fluoride (F)	—	—	.1	.01
Nitrate (NO_3)	—	—	1.0	.02
Dissolved Solids	167	—	155	—
Total Hardness as $CaCO_3$	137	—	134	—
Carbon Dioxide (CO_2)	—	—	3	—
Color	—	—	0	—
pH	—	—	7.9	—
Specific Conductance ($K \times 10^5$ at 25°C.)	—	—	27.7	—

Utilization.—The spring is developed as a public resort. A modern lodge is located on the grounds which is open throughout the year and offers comfortable accommodations for travelers and vacationists. Bathing, swimming and diving are leading sports and the clear waters of the spring lend themselves to under water photography. Glass-bottomed boats ply the surface of the spring and small cruisers are available for jungle cruises down the river. The grounds are landscaped and are gradually being enlarged.

OTHER SPRINGS

Newport Springs and Panacea Springs, famous watering resorts in earlier years, and Spring Creek are among the other springs located in Wakulla County.

WALTON COUNTY

MORRISON SPRING *near* PONCE DE LEON

Location.—The spring is reached by driving south from Ponce de Leon for 4.4 miles on State Highway 81, east on a graded road 1.6 miles, then south 0.7 mile to the head of the spring.

Description.—(See figure 37.) This large spring is situated in a depression among the sandy wooded rolling hills adjacent to the Choctawhatchee River basin. The head of the spring is a circular pool which at low water stage is about 250 feet in diameter, and is bordered by majestic cypress trees which take root in the surrounding swamp, bordering the run on each side. Soundings made May 23, 1942 indicate the floor of the pool to be 20 to 25 feet deep with a large cavity 30 feet in diameter having a maximum depth of 52 feet. Water discharging from the cavity causes no noticeable surface disturbance. The temperature of the water in the pool was 69°F on May 23, 1942 and 67°F on December 9, 1946.

The run is about 150 feet wide and 1 mile long, and the upper end has a sand bottom varying from 5 to 15 feet deep which is covered by a small amount of vegetation. The flow is very slug-

FIGURE 37. *Morrison Spring,* photograph taken looking east northeast at head-pool from the end of the road to the spring.

gish but at high stages the spring overflows into the adjoining swamp. Stages in the run and pool are directly affected by the stage of the Choctawhatchee River. The spring water is frequently discolored by the muddy river water.

Discharge.—The flow was measured as follows:

DATE	CUBIC FEET PER SECOND	MILLION GALLONS PER DAY
May 27, 1942 - - -	121	78
December 9, 1946 - -	89	57

Quality of water.—Samples were not collected.

Utilization.—The spring is undeveloped. Boats are available for rent from the caretaker for hunting and fishing.

WASHINGTON COUNTY

BECKTON SPRINGS *near* VERNON

Location.—The springs are approximately 1.5 miles north of Vernon. They are reached by driving northeast from Vernon on State Highway 79 for 1.9 miles, turning right on a sand road and following it for 0.5 mile to the springs.

Description.—These springs lie along the northwest edge of the Holmes Creek valley and are subject to frequent flooding by rises of the creek. The northwest bank of the headpool is sandy pine land rising about 15 feet above the elevation of the pool surface. The balance of the shoreline is low swampland supporting mixed timber, principally cypress. The pool is roughly circular with a diameter of about 175 feet. Numerous soundings made on December 10, 1946 indicate the pool to be a funnel-shaped sinkhole with a somewhat irregular bottom and a maximum depth of 25.5 feet. Several channels and sloughs containing much aquatic vegetation connect the head with Holmes Creek. Pool temperatures ranging from 66°F to 73°F have been observed.

Discharge.—The net flow of 49.0 second-feet (32 m.g.d.) on May 26, 1942 was obtained by subtracting inflow to the spring from outflow of the spring.

Quality of water.—Samples were not collected.

Utilization.—The springs are undeveloped, and are used by local residents for swimming and fishing.

BLUE SPRINGS *near* REDHEAD

Location.—The springs can be reached by driving 1.8 miles north from Redhead on State Highway 79 and turning west through a gate on a sand road for 0.4 mile to the springs and run.

Description.—The springhead and run are surrounded by a swamp area and lined with cypress and willow trees while the higher sandy hills adjacent to the springs support a varied growth of timber with pine predominant. The head of the springs is roughly circular with a diameter of approximately 100 feet. A series of soundings on May 22, 1942 indicated a maximum depth of 28.5 feet in the boil which creates a pronounced surface disturbance at its point of issue. The run flows into Holmes Creek, a tributary of the Choctawhatchee River. The run is normally about 40 feet in width, but during flood stages of Holmes Creek it widens to 100 to 150 feet. Depths vary from 8 to 12 feet, and the run makes a ninety degree turn to the left about 250 feet below the head. The temperature of the water was 71°F on May 22, 1942.

Discharge.—A flow of 31.6 second-feet (20 m.g.d.) was measured on May 26, 1942, and 52.5 c.f.s. (34 m.g.d.) was measured on December 10, 1946.

Quality of water.—Samples were not collected.

Utilization.—The springs are in their natural state and are probably frequented by hunters, swimmers and fishermen.

CYPRESS SPRING *at* VERNON

Location.—Approximately 3 miles northeast of Vernon. Reached by driving north from Vernon 3 miles on State Highway 79, turning right on sand road at the southwest end of a concrete bridge, and following this road west and south to the head of Piney Wood Spring. Follow road east along right bank of Piney Wood run 0.4 mile from its head to where the road makes a sharp left turn. Follow the foot path from this point 300 feet east and 200 feet northeast to the head of Cypress Spring. (Use of local guide recommended.)

Description.—The pool is surrounded by low swampland and the run flows through this low land into Holmes Creek, a tributary of the Choctawhatchee River. The run varies from about 150 to 200 feet in width. The head is semicircular in shape and approximately 125 feet in diameter. It has a sand bottom covered with some aquatic growth and a few logs. The floor of the main cavity varies from 14 to 17.5 feet in depth and the small cavity along the left side of the pool was 14 feet deep on May 26, 1942. The flow from cavities created no apparent boil or surface disturbances on that date.

Discharge.—The flow was 84.9 second-feet (55 m.g.d.) on May 26, 1942 at a point 400 feet below the head of the spring. This discharge figure excludes an estimated flow of about 5 million gallons per day entering the springhead from the run fed by Piney Wood Spring.

Utilization.—The spring is undeveloped and is used at times by local residents for pleasure fishing.

OTHER SPRINGS

Hightower Spring, 5 miles southwest of Vernon, and Piney Wood Spring, 3 miles northeast of Vernon, are also in Washington County.

SUMMARY TABULATION OF SPRING DATA BY COUNTIES

EXPLANATION OF TABULATED DATA

Table 4 contains an alphabetical list by counties and springs of all springs shown on the map, Plate 1, in the pocket, and data for many springs which appear no other place in this report. The names given are those in general use in 1947. Locations are given in airline distances from the nearest post office or large city. The highest and lowest observed temperatures of the water are given wherever available. Single temperature readings are generally for the date given for the determination of flow, with a few exceptions. The numbers and letters shown in the data column refer to the month, day and year, year shown, or the footnote references.

Data given are those available in the reports of the Florida Geological Survey, and the files and reports of the U. S. Geological Survey. It should be kept in mind that conditions noted in the development or use column vary somewhat from year to year. Occasionally a developed spring is abandoned and undeveloped springs are improved for use as resorts or other purposes. This list, together with the other springs listed with the individual reports by counties is the most extensive compilation on springs of Florida published to date.

TABLE 4

NAME	LOCATION	APPROXIMATE WATER TEMPERATURE °F	DETERMINATION OF FLOW DATE	C.F.S.	M.G.D.	G.P.M.	FACILITIES AVAILABLE, 1947 DEVELOPMENT OR USE, 1947
ALACHUA COUNTY							
Boulware Spring	2 mi. S.E. of Gainesville	72	1898-1913			175-1,000	Formerly one of sources of municipal water supply, City of Gainesville
Glen Springs	2 mi. N.W. of Gainesville	72	ab	0.32	0.21		Swimming pool, dancing
Hornsby Springs-c	1 mi. E. of High Springs			Flow reverses			Undeveloped, bathing
Magnesia Spring	4 mi. W. of Hawthorne	75	4-16-46	.65	.42		Swimming pool, water bottled
Poe Springs	3 mi. W. of High Springs	73	ab	70.4	45		Resort, swimming, dancing
BAY COUNTY							
Blue Springs, No. 1	2 or 3 mi. N. of Bennett	71	ab	12.4	8.0		Undeveloped
No. 2	2 or 3 mi. N. of Bennett	71	a				Undeveloped
No. 3	2 or 3 mi. N. of Bennett		11-14-41	44.5	29		Undeveloped
BRADFORD COUNTY							
Heilbronn Spring	6 mi. N.W. of Starke	70	a			36-250	Water bottled
CITRUS COUNTY							
Chassahawitzka Sps.	6 mi. S. of Homosassa Spgs.	74-75	ab	81.4	53		Fishing, boating
Homosassa Springs	1 mi. W. of Homosassa Spgs.	75	ab	185	120		Resort, coffee shop, boating
Hunter Spring	At Crystal River	76	b	62.9	41		Fishing, boating, tidal

CLAY COUNTY							
Green Cove Spring	At Green Cove Springs	77	ab	4.9	3.2		Drinking, swimming pool
Peck Mineral Spgs.	6 mi. E. of Starke	71				20	Drinking
Wadesboro Spring-a	0.9 mi. S.W. of Orange Park		4-18-46	1.40	.90		Small aband. bathing pool
COLUMBIA COUNTY							
Ichatucknee Springs	5 mi. N.E. of Hildreth	71-74	ab	335	216		Undeveloped, livestock water.
DIXIE COUNTY							
Big Cypress Spring	2 mi. below Rock Bluff ferry		5-12-32	12.4	8.0		Livestock watering
Copper Spring	Near Oldtown		5-12-32	18.8	12		Livestock watering
Little Copper Spring	Near Oldtown		5-12-32	2.0	1.3		Livestock watering
GADSDEN COUNTY							
Glen Julia Spring	1 mi. S.W. of Mt. Pleasant	69	5-16-46	.78	.50		County park area
Spring	At Chattahoochee	68	5-16-46			16	Abandoned swimming pool
GILCHRIST COUNTY							
Hart Spring	5 mi. N. of Wilcox	73	ab	60.4	39		Undeveloped, bathing
Lumber Camp Spgs.	1 mi. S. of Wannee		5-12-32	3.0	1.9		Undeveloped, drinking
Otter Spring	2 mi. N. of Oldtown		5-12-32	5.4	3.5		Undeveloped
Rock Bluff Springs	5 mi. N.W. of Bell		12- 8-42	42.1	27		Swimming, fishing
HAMILTON COUNTY							
White Springs	At White Springs	70-72	ab	55.2	36		Resort, hotel, drinking
HERNANDO COUNTY							
Weekiwachee Spring	12 mi. S.W. of Brooksville	74-77	ab	160	103		Being developed as a resort

a - Refer to individual spring descriptions in Chapter III
b - Average of measurements available
c - Former names were Homsley Spring and Traxler Springs

SUMMARY TABULATION OF SPRING DATA BY COUNTIES (Cont.)

NAME	LOCATION	APPROXIMATE WATER TEMPERATURE °F	DETERMINATION OF FLOW DATE	C.F.S.	M.G.D.	G P.M.	FACILITIES AVAILABLE, 1947 DEVELOPMENT OR USE, 1947
HILLSBOROUGH COUNTY							
Buckhorn Spring	2.8 mi. N.E. of Riverview	76	a	11.0	7.1		Swimming, private
Eureka Springs	3 mi. E. of Tampa	74	a	3.9	2.5		Aquarium of tropical fish
Lithia Springs	3 mi. W. of Lithia	76	a	50.2	32.4		Undeveloped, swimming
Messer Spring	3 mi. N.E. of Riverview	77	5- 1-46	.32	.21		House supply, hydraulic ram
Palma Ceia Springs	Bayshore Blvd., Barcelona St.		5- 1-46			42	Abandoned swimming pool
Purity Spring	0.5 mi. W. of Sulphur Spgs.		a			350-850	Public supply, bottled
Spring (no name)	0.1 mi. E. of Buckhorn Spg.		5- 1-46	1.27	.82		Water for stock
Spring (no name)	0.5 mi. W. of Buckhorn Spg.	75	5- 1-46	.09	.06		Water for stock
Sulphur Springs	At Sulphur Springs		ab	52.6	34		Resort, swimming
HOLMES COUNTY							
Ponce de Leon Spgs.	1 mi. S. of Ponce de Leon	68	ab	19.4	13		Resort, bath houses
JACKSON COUNTY							
Blue Springs	5 mi. N.E. of Marianna	70	ab	163	105		Resort, swimming, fishing
JEFFERSON COUNTY							
Wacissa Spgs. group	1 mi. S. of Wacissa		a				Fishing, boating, hunting
Big Spring			7-16-42	69.4	45		
Blue Spring			7-16-42	9.4	6.1		
Garner Spring			7-16-42	17.0	11		

LAFAYETTE COUNTY							
Morrison Spring	10 mi. N.W. of Branford		5-14-27	51.6	33		Fishing, boating, hunting
Troy Springs	6 mi. N.W. of Branford		ab	102	66		Fishing, boating, hunting
LAKE COUNTY							
Alexander Springs	6.4 mi. S.W. of Astor	74	ab	117	76		Undevel., swimm'g, picnick'g
Bugg Spring	0.5 mi. N.W. of Okahumpka	76	ab	17.4	11		Private swimming and boat'g
Messant Spring	7.4 mi. N.E. of Sorrento	79	5-10-46	18.4	12		Aband. lumber camp, swim'g
Seminole Springs	3.4 mi. N.E. of Sorrento	74-80	ab	22.0	14		Undeveloped
Spring (no name)	0.3 mi. N. of Yalaha		4-19-46	4.6	3.0		Undeveloped
LEON COUNTY							
Natural Bridge Spg.	6.5 mi. E. of Woodville	68-69	ab	124	80		Undeveloped, hunting, fishing
Rhode Spgs. group	6.5 mi. E. of Woodville		a				
Spring No. 1	(a)	69	5-19-42	22.4	14		Undeveloped, hunting, fishing
Spring No. 2	(a)	69	5-19-42	13.8	8.9		Undeveloped, hunting, fishing
Spring No. 4	(a)	69	5-19-42	21.1	14		Undeveloped, hunting, fishing
LEVY COUNTY							
Fanning Spring	2.3 mi. S.W. of Wilcox	72-73	ab	108	70		Swimming, picnic'g, dancing
Manatee Spring	7 mi. W. of Chiefland	72-73	ab	168	109		Swimming, camping, fishing
Wekiva Springs	6.3 mi. E. of Gulf Hammock	74-78	ab	72.9	47		Undeveloped, swimming
MADISON COUNTY							
Blue Spring-a	10 mi. E. of Madison	70-71	7-23-46	145	94		Undeveloped, swimming
Pettis Spring-a	5 mi. W. of Greenville	68	5-16-46			.71	Water supply, swimming pool
Swanacoochee Spg.	At Ellaville	70-76	b	29.6	19		State park, swimming pool
MARION COUNTY							
Blue Spring	4.5 mi. E. of Orange Springs		10- 8-35	10.6	6.8		Undeveloped, fishing

SUMMARY TABULATION OF SPRING DATA BY COUNTIES (Cont.)

NAME	LOCATION	APPROXIMATE WATER TEMPERATURE °F	DETERMINATION OF FLOW DATE	C.F.S.	M.G.D.	G.P.M.	FACILITIES AVAILABLE, 1947 DEVELOPMENT OR USE, 1947
Juniper Springs	27 mi. E. of Ocala	72	ab	12.8	8.3		Park, swimming, trailer park
Rainbow Springs	4 mi. N.E. of Dunnellon		ab	699	452		Resort, cottages, underwater boats
Salt Springs	28 mi. N.E. of Ocala	75	ab	81.1	52		Drinking, swimming, fishing
Silver Glen Springs	9 mi. N.W. of Astor	73	ab	111	72		Resort, cottages, swim., fish.
Silver Springs	5.5 mi. N.E. of Ocala	72-77	ab	808	522		Resort, glass-bottom boats, swimming
The Aquarium	27 mi. E. of Ocala		b	16.6	11		Park, trailer park, nature trails
NASSAU COUNTY							
Su-no-wa Spring	3.6 mi. E. of Verdie	70	4-17-46			12	Abandoned, drinking
ORANGE COUNTY							
Miami Springs	5 mi. N.E. of Apopka		8- 8-45	5.8	3.7		Undeveloped
Mill Creek Springs	4 mi. N.E. of Apopka		8- 8-45	4.7	3.0		Undeveloped
Rock Springs	6.5 mi. N. of Apopka	74-75	ab	57.2	37		County park, swim'g, picnic'g
Wekiwa Springs	5 mi. N.E. of Apopka	75	ab	67.7	44		Swimming, boating, fishing
PASCO COUNTY							
Crystal Springs	At Crystal Springs	74-75	ab	64.7	41.8		Swimming, picnicking
Seven Springs	4 mi. E. of Elfers	76	5- 3-46			13	Drinking, sulphur water
Spring (no name)	At Hudson	77	5- 3-46	a			Boating, tidal

PINELLAS COUNTY							
Espiritu Santo	At Safety Harbor		5- 2-46	No outflow			Sanatorium, swimming pool
Health Spring	At Wall Springs	77	5- 3-46	No outflow			Swimming pool, drinking
POLK COUNTY							
Kissengen Springs	4 mi. S.E. of Bartow	75-77	ab	21	14		Resort, swimming, bathing
PUTNAM COUNTY							
Nashua Spring (*formerly* Crane Spring)	2.5 mi. S. of Satsuma	74	5- 8-46	0.46	0.30		Drinking, bottled
Spring (no name)	2.3 mi. S. of Satsuma	76	5- 8-46	1.77	1.1		Drinking, bathing
ST. JOHNS COUNTY							
Fountain of Youth	St. Augustine			No flow			Historic point
SANTA ROSA COUNTY							
Chumuckla Springs	near Bogia					49	Bottled
SARASOTA COUNTY							
Little Salt Spring	8 mi. N.W. of Murdock	77	4-29-46 a	1.49	.96	671	Undeveloped, water for stock
Pinehurst Spring	7 mi. S. of Sarasota	73	4-30-46 a			3	Drinking, bottled
Warm Salt Spring	8 mi. N.W. of Murdock	86	ab	10.9	7.0		Resort, drinking, bathing, trailer camp
SEMINOLE COUNTY							
Palm Springs	3 mi. W. of Longwood		11-12-41	9.7	6.3		Drinking, bathing
Sanlando Springs	3.1 mi. W. of Longwood	74	ab	22.0	14		Resort, swim., danc., picnick.
Sheppard Spring	3 mi. W. of Longwood	74	7-25-44 a	16.7	11		Private, swimming

SUMMARY TABULATION OF SPRING DATA BY COUNTIES (Cont.)

NAME	LOCATION	APPROXIMATE WATER TEMPERATURE °F	DETERMINATION OF FLOW DATE	C.F.S.	M.G.D.	G.P.M.	FACILITIES AVAILABLE, 1947 DEVELOPMENT OR USE, 1947
SUMTER COUNTY							
Fenney Springs	2.3 mi. E. of Coleman	76	7-26-46	21.6	14		Undeveloped, water for stock
Gum Slough Spring	7 mi. N. of Rutland		3-15-32	11.1	7.2		Undeveloped, water for stock
Panasoffkee Riv. grp. (*formerly* Branch Mill Spring group)	2.0 mi. S. of Coleman	74-76	ab	22.5	15		Undeveloped, water for stock
SUWANNEE COUNTY							
Branford Springs	At Branford	72	b	10.6	6.8		Bathing, swimming
Charles Springs	4 mi. N.W. of Luraville	69	ab	21.4	14		Undeveloped, swim'g, fishing
Ellaville Spring	At Ellaville		12- 9-42	41.2	27		Undeveloped, flow reverses
Falmouth Spring	0.2 mi. W. of Falmouth	71	a	Flow	reverses		Bathing, swimming
Suwannee Springs	7 mi. N. of Live Oak	70	ab	29.3	19		Resort, cottages, swim., drink.
Telford Springs	At Luraville	70	b	37.0	24		Swimming, bathing
TAYLOR COUNTY							
Hampton Springs	4.8 mi. W. of Perry	72-73	a			67-260	Hotel resort, drinking, swimming pool
Union Spring	3 mi. S.W. of Perry		1903			335	Undeveloped
Waldo Springs	5 mi. S.W. of Perry	71-72	ab	14.9	9.6		Undeveloped, water for stock
UNION COUNTY							
Worthington Spring	At Worthington	71	1913			1,000	Swimming pool

VOLUSIA COUNTY						
Blue Spring	2.5 mi. W. of Orange City	73-74	ab	161	104	Boat'g, swim'g, fish'g resort
Green Springs	Near Benson		3- 7-32	1.0	.65	Drinking
Ponce de Leon Spgs.	8.5 mi. N. of DeLand	73-74	ab	30.0	19	Resort, hotel, swim'g, boat'g
WAKULLA COUNTY						
River Sink	12 mi. S.W. of Tallahassee	72	5-19-42	178	115	Undeveloped, swimming
Wakulla Spring	14 mi. S. of Tallahassee	73-77	ab	283	183	Resort, hotel, glass-bot. boats
WALTON COUNTY						
Morrison Spring	5 mi. S.E. of Ponce de Leon	67-69	ab	105	68	Undeveloped, fishing, hunting
WASHINGTON COUNTY						
Beckton Springs	1.5 mi. N. of Vernon	66-73	5-26-42	49.0	32	Undevel., swimming, fishing
Blue Springs	1.8 mi. N. of Vernon	71	ab	42.0	27	Undevel., swimming, fishing
Cypress Spring	3 mi. N.E. of Vernon		5-26-42	84.9	55	Undevel., swimming, fishing

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Figures in boldface indicate illustrations

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SPRINGS OF FLORIDA
Prepared by the U. S. Geological Survey
in cooperation with the Florida Geological Survey
MAP OF FLORIDA SHOWING
LOCATIONS OF SELECTED SPRINGS
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