UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HYDROLOGIC ALMANAC OF FLORIDA

By Richard C. Heath and Clyde S. Conover

Open-File Report 81-1107

Prepared in cooperation with the

FLORIDA DEPARTMENT OF
ENVIRONMENTAL REGULATION
and other
STATE, LOCAL, AND FEDERAL AGENCIES

Tallahassee, Florida

1981

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Doyle G. Frederick, Acting Director

Suggestions for improving the usefulness of any future editions of this almanac will be appreciated. Write:

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

PREFACE

This first edition of the U.S. Geological Survey "Hydrologic Almanac of Florida" is a compilation of selected hydrologic facts that have been collected for over a century. Early field observations and measurements and many reports on the water resources of the State provided much of the information presented in this almanac.

"Hydrologic Almanac of Florida" was prepared by the U.S. Geological Survey in cooperation with the Florida Department of Environmental Regulation and with other State, local, and Federal agencies. Envisioned as a ready reference or source of information on various facts and features about water in Florida, it is primarily aimed to help busy politicians, writers, agency officials, water managers, planners, consultants, educators, hydrologists, engineers, scientists, and the general public answer questions that arise on comparative and statistical information on the hydrology of Florida. This almanac provides a useful supplement to the statewide Florida Water Atlas consisting of nearly 50 maps prepared in cooperation with the Florida Department of Environmental Regulation and with the Bureau of Geology, Florida Department of Natural Resources.

Reports referred to in the text of this almanac are cited by author and date of publication. The complete references are listed in the "Selected Bibliography." U.S. Geological Survey reports constitute the major source for most information in the almanac. Specific references to Survey reports have been restricted for the most part to tables and diagrams. However, information from other sources has been specifically referenced in the text as well as in the tables and diagrams. Much of the statistical comparative data was especially prepared for this almanac to further its utility. Also, a glossary of technical terms and conversion tables that go beyond terms used in this almanac have been added for easy reference.

The almanac should not be considered a treatise on the hydrology of Florida. Though many facts are presented, many are missing. Some facts were omitted inadvertently, but others were omitted in an effort to reduce the volume of material and keep the almanac manageable. An attempt will be made to correct errors, rectify serious omissions, and to update material in future editions of the almanac.

R.C.H.

C.S.C.

ACKNOWLEDGMENTS

Appreciation is expressed to the many cooperators who, over the years, have supported the hydrologic program in Florida that made compilation of the water facts for this almanac possible. Special appreciation is expressed to the many individuals in the Survey who encouraged and supported the preparation of this first edition of the almanac.

Particular acknowledgments are extended to Donald F. Foose, hydrologic technician with the U.S. Geological Survey, who researched and compiled facts pertaining to unpublished data on lakes and streams and assisted in resolving problems on conflicting data. James Tomberlin and Ronald Spencer reviewed and prepared the illustrations for the almanac. Maude Claiborne, Letitia Faircloth, Mildred Glenn, Elizabeth Pearce, Deborah Weldon, and Twila Wilson typed and edited texts and tables at various stages of preparation and Lougenia Nierstheimer formatted the tables, prepared final copy, and proofread the almanac. Additional editing was provided by the Reports Section in the Florida headquarters office of the Survey. Many other Survey personnel of the various Hydrologic Records Sections throughout the State were also of immeasurable assistance in the compilation of data from their files. Advice, assistance, and discussions about technical matter came from many staff members of the Survey. This first edition reflects a team effort and the authors thank all who helped bring the almanac to fruition.

CONTENTS

CONTENTS

ILLUSTRATIONS

CONTENTS

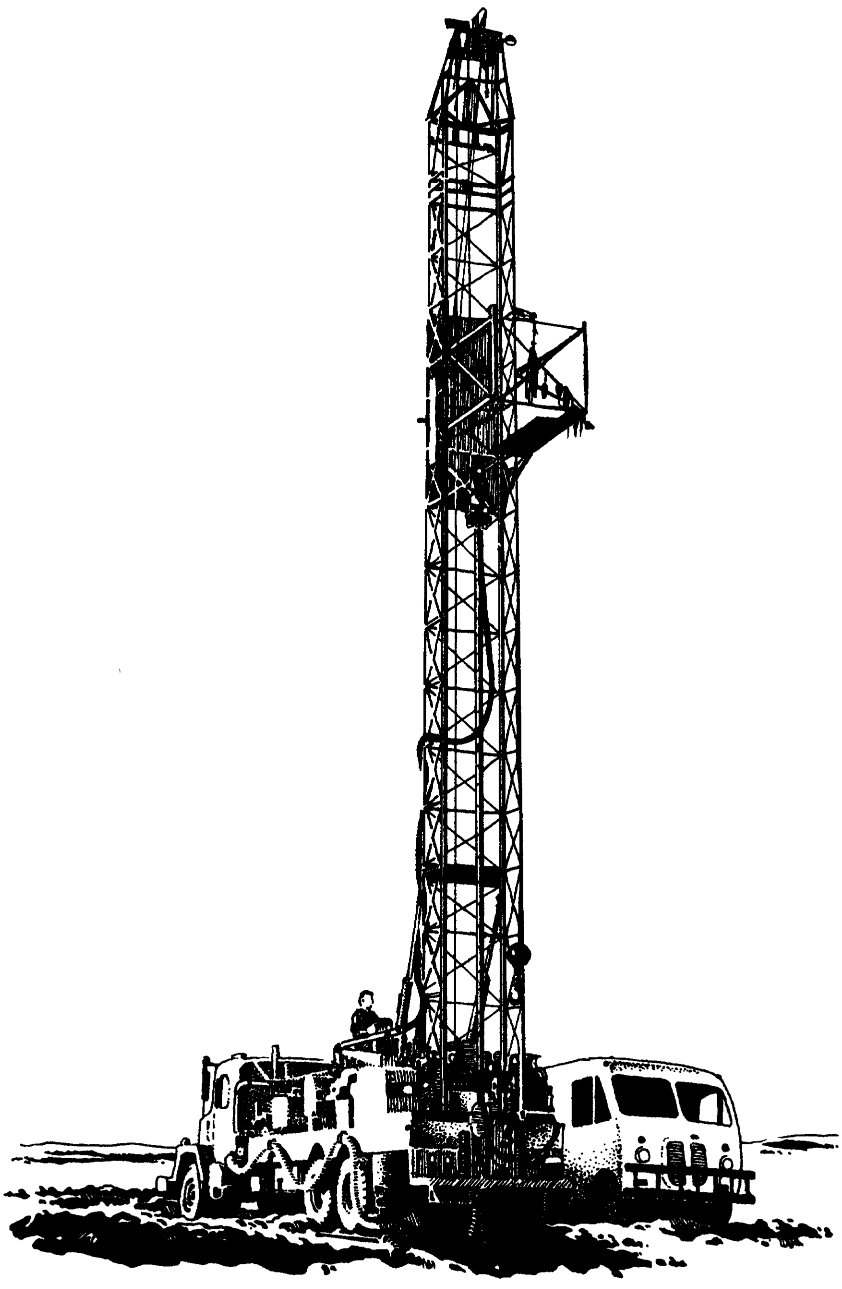
CONTENTS

CONTENTS

TABLES

CONTENTS

CONTENTS



HYDROLOGIC ALMANAC OF FLORIDA

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SOURCES OF INFORMATION

Publications

The U.S. Geological Survey in Florida has collected hydrologic information as part of a broad, national program to appraise the water resources of the United States. Appraisals of water resources in Florida by the Survey are highly diversified, ranging from hydrologic records networks to interpretive investigations of water resources, including applied research for developing investigative techniques. Much of the program is in cooperation with various State, regional, district, county, and local agencies and with various Federal agencies. The results of water resources investigations are released by the Survey and usually published in one of its own series or published outside the agency.

The following lists various publications series which contain water resource information prepared by the Survey and the offices to contact for information about availability and price of U.S. Geological Survey and Florida Bureau of Geology publications.

U.S. Geological Survey

Series	Office to contact
Professional Papers Bulletins Water-Supply Papers Journal of Research Techniques of Water-Resources Investigations Hydrologic Investigations Atlases Miscellaneous Investigations Series maps Circulars	Branch of Distribution U.S. Geological Survey 1200 South Eads Street Arlington, VA 22202
Open-File Reports Water-Resources Investigations Water-Data Reports	Florida District Office U.S. Geological Survey Suite F-240 325 John Knox Road Tallahassee, FL 32303

Florida Bureau Of Geology

Series	Office to contact
Information Circulars Map Series Report of Investigations	Bureau of Geology Florida Department of Natural Resources 903 West Tennessee Street Tallahassee, FL 32304

The U.S. Geological Survey issues a monthly list of "New Publications of the Geological Survey." For free subscriptions to this nationwide listing of new reports, write to:

U.S. Geological Survey
329 National Center
Reston, VA 22092

Circular 777 "A Guide to Obtaining Information from the USGS, 1981" can be obtained free from:

Branch of Distribution
U.S. Geological Survey
1200 South Eads Street
Arlington, VA 22202

Most reports by the Survey on the water resources of Florida may be inspected in the District office of the Survey in Tallahassee, at its suboffices in Jacksonville, Miami, Orlando, Tallahassee, Tampa, and Fort Myers; at headquarters offices of the Water Management Districts in Florida at Brooksville, Havana, Live Oak, Palatka, and West Palm Beach; and at libraries of the State University System in Boca Raton, Gainesville, Jacksonville, Miami, Orlando, Pensacola, Tallahassee (2), and Tampa.

Addresses of the Survey offices in Florida and of the Water Management Districts are listed below. Areas of program responsibility and location of headquarters are shown in figures 1 and 2 for the Survey and Water Management Districts, respectively.

U.S. Geological Survey

U.S. Geological Survey
District Office
Suite F-240
325 John Knox Road
Tallahassee, FL 32303
Telephone: (904) 386-7145

U. S. Geological Survey
Suite 106
4415 Beach Boulevard
Jacksonville, FL 32207
Telephone: (904) 791-2934

U. S. Geological Survey
Suite 110
7815 Coral Way
Miami, FL 33155
Telephone: (305) 350-5382

U. S. Geological Survey
Suite 216
80 North Hughey Avenue
Orlando, FL 32801
Telephone: (305) 420-6191

U. S. Geological Survey
Suite L-103
325 John Knox Road
Tallahassee, FL 32303
Telephone: (904) 386-2180

U.S. Geological Survey
Suite B-5
4710 Eisenhower Boulevard
Tampa, FL 33614
Telephone: (813) 228-2124

U. S. Geological Survey
Room 307, Federal Building
First Street
Fort Myers, FL 33901
Telephone: (813) 334-7787

U. S. Geological Survey
Suite 10, Federal Building
308 Tequesta Drive
Jupiter, FL 33458
Telephone: (305) 116-7680

U. S. Geological Survey
Room 242, Federal Building
207 NW 2d Street
Ocala, FL 32670
Telephone: (904) 629-8931

U. S. Geological Survey
Suite 108, Federal Building
111 South Orange Avenue
Sarasota, FL 33577
Telephone: (813) 955-9388

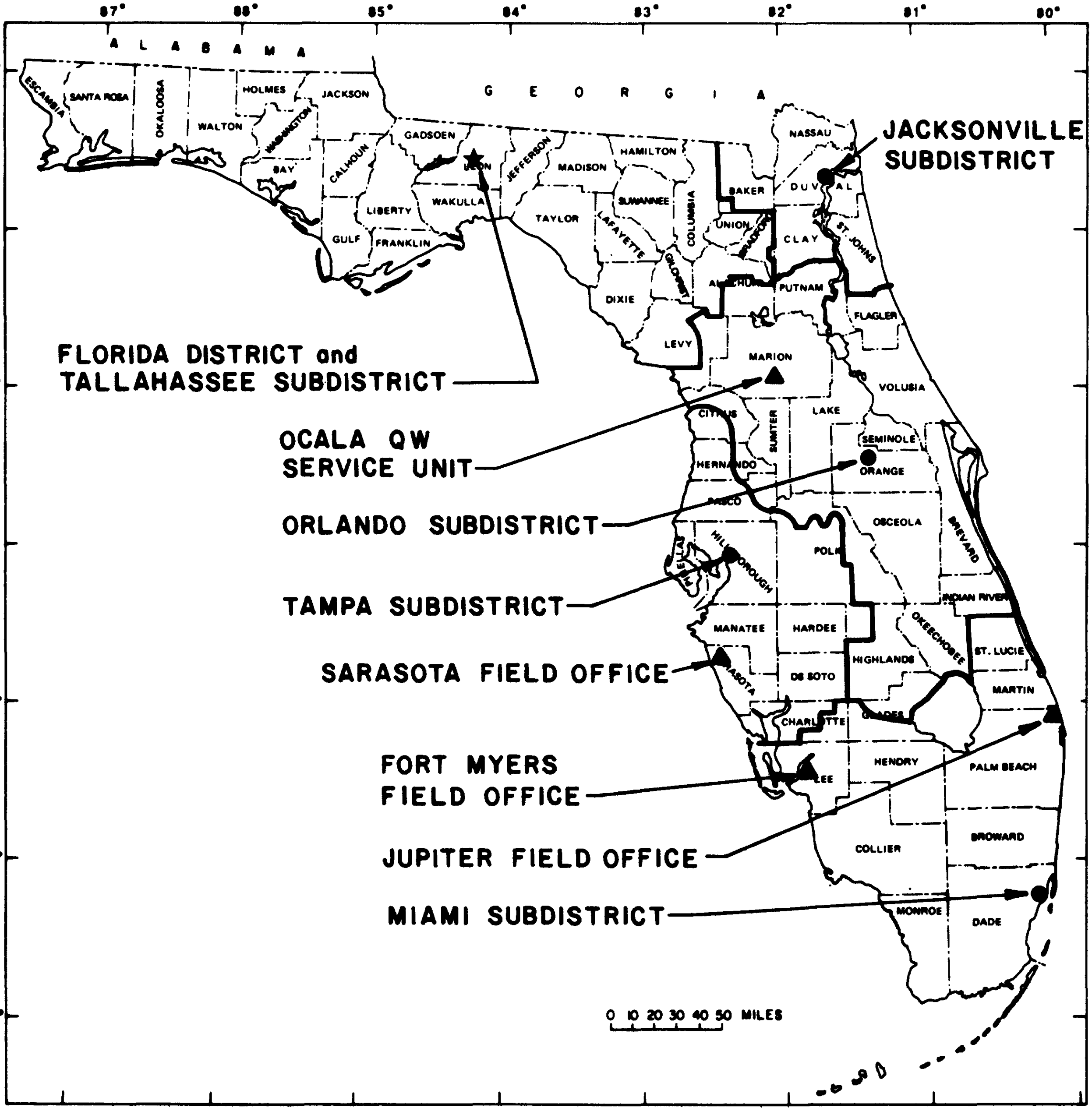

Figure 1.--U.S. Geological Survey office locations in Florida.

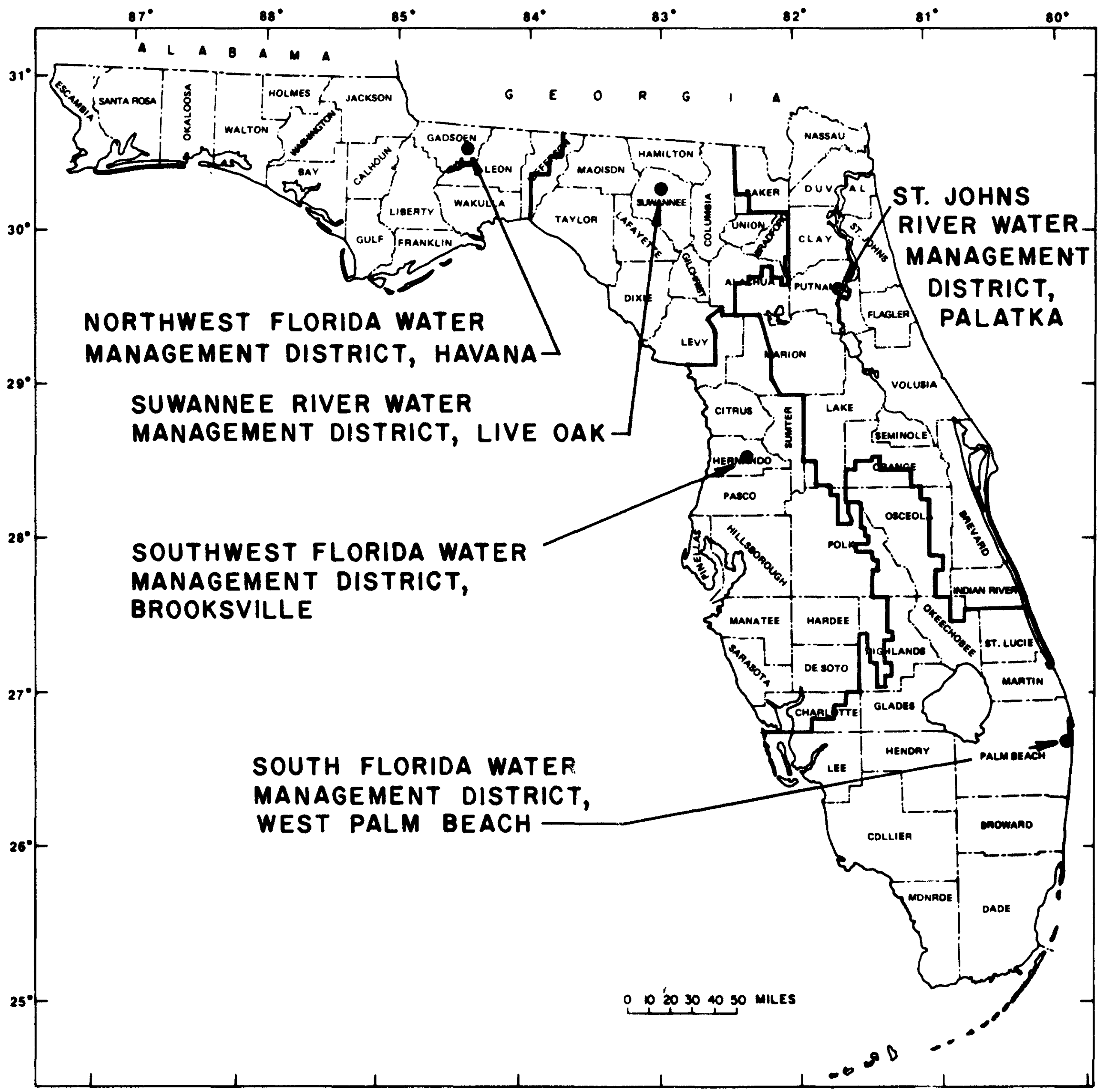

Figure 2.--Boundaries and locations of Florida's five Water Management Districts.

Water Management Districts

Northwest Florida Water
Management District
Route 1, Box 3100
Havana, FL 32333
Telephone: (904) 487-1770

South Florida Water
Management District
P. O. Bov V
West Palm Beach, FL 33402
Telephone: (305) 686-8800

St. Johns River Water
Management District
P. O. Box 1429
Palatka, FL 32077
Telephone: (904) 325-5383

Southwest Florida Water
Management District
5060 U.S. Highway 41, South
Brooksville, FL 33512
Telephone: (813) 933-7881

Suwannee River Water
Management District
Route 3, Box 64
Live Oak, FL 32060
Telephone: (904) 362-1001

Certain Survey reports, including many of the Water Resources Investigations (WRI) series and many compilations of data, can be purchased in paper copy or microfiche only from National Technical Information Service (NTIS). Beginning with 1975 issues, "Water Resources Data for Florida for ____(Year)" can also be purchased from NTIS. The price of each new WRI/NTIS report is listed in the monthly catalog, "New Publications of the Geological Survey."

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Telephone: (202) 557-4650

Data

All water-resources data collected by the Survey are entered into the National Water Data Storage and Retrieval System (WATSTORE). Data are grouped and stored on the basis of common characteristics and data-collection frequencies. At present, these data are organized into five files and contain nationally: (1) Station Header File--an index file for more than 220,000 sites for which data are stored; (2) Daily Values File--over 200 million data entries for 65 water-data parameters, including data for ground-water levels, reservoir contents, river stages, sediment concentrations, specific conductance, streamflow and water temperatures; (3) Peak Flow File--400,000 entries related to annual maximum streamflow and gage-height values at surface-water sites; (4) Water Quality File--1.4 million analyses of biological, chemical, physical, and radiochemical characteristics of 185 different constituents in surface and ground waters; and (5) Ground-Water Site Inventory File (independent but cross-referenced to Daily Values and Water Quality Files)--contains data on 700,000 sites, listing geohydrologic characteristics, one-time field measurements such as water temperature, site location and identification, physical characteristics for wells, springs, and other sources of ground water.

All types of water data can be retrieved through the central computer facilities in Reston, Va., and from a number of localities nationwide. The requester is charged a minimal fee plus the actual computer cost incurred in retrieving the data. Cost estimates and information about the availability and acquisition of specific types of data can be obtained from the District and Subdistrict offices of the U.S. Geological Survey in Florida. (See fig. 1 and p. 3.)

The National Water Data Exchange (NAWDEX) is a computerized data system that identifies sources of water data and that indexes the types of water data collected by various Federal, State, and other participating agencies. The primary purpose of the system is to facilitate the exchange of data between the organizations that gather water data and the organizations that need the data. A variety of services is provided by the NAWDEX Program Office of the U.S. Geological Survey in Reston, Va. and by local Assistance Centers.

Information available includes identification of organizations that collect water data, specific locations within the organizations that provide the data, alternate sources for the data, the geographic area in which the organization collects data, and types and availability of data collected. Also available are identification and locations of sites at which water data are being collected, the organization using the site, the types of data available, the parameters for which data are available, the frequency of measurement of these parameters, and the media in which the data are stored.

For services or additional information, contact:

National Water Data Exchange
U.S. Geological Survey
421 National Center
Reston, VA 22092
Telephone: (703) 860-6031

GLOSSARY

Definition of Hydrologic Terms

[Modified for the most part from U.S. Geological Survey Water Resources Data for Florida, 1978; Langbein and Iseri, 1960; and Lohman and others, 1972]

Acre-foot (acre-ft). The quantity of water required to cover 1 acre to a depth of 1 foot and is equivalent to 43,560 cubic feet or about 326,000 gallons.

Algae. Mostly aquatic single-celled, colonial, or multicelled plants, containing chlorophyll and lacking roots, stems, and leaves.

Aquifer. A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Artesian. Synonymous with confined. Artesian water and artesian water body are equivalent, respectively, to confined ground water and confined water body.

Artesian well. A well that derives its water from an artesian or confined water body. The water level in an artesian well stands above the top of the artesian water body it taps. If the water level in an artesian well stands above the land surface, the well is a flowing artesian well.

Bacteria. Microscopic unicellular organisms, typically spherical, rod-like, or spiral and thread-like in shape, often clumped into colonies. Some bacteria cause disease; others perform an essential role in nature in the recycling of materials, for example, by decomposing organic matter into a form available for reuse by plants.

Fecal coliform. Bacteria that are present in the intestines or feces of warm-blooded animals. They are often used as indicators of the sanitary quality of the water. In the laboratory they are defined as all organisms which produce blue colonies within 24 hours when incubated at 44.5°C ± 0.2°C on M-FC medium (nutrient medium for bacterial growth). Their concentrations are expressed as number of colonies per 100 milliliters (mL) of sample.

Fecal streptococcal. Bacteria found in the intestines of warm-blooded animals. Their presence in water is considered to verify fecal pollution. They are characterized as gram-positive cocci bacteria which are capable of growth in brain-heart infusion broth. In the laboratory, they are defined as all the organisms which produce red or pink colonies within 48 hours at 35°C ± 1.0°C on M-enterococcus medium (nutrient medium for bacterial growth). Their concentrations are expressed as number of colonies per 100 milliliters of sample.

Bacteria.--Continued

Total coliform. A particular group of bacteria that are used as indicators of possible sewage pollution. They are characterized as aerobic or facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C. In the laboratory, these bacteria are defined as all the organisms which produce colonies with a golden-green metallic sheen within 24 hours when incubated at 44.5°C ± 0.2°C on M-FC medium (nutrient medium for bacterial growth). Their concentrations are expressed as number of colonies per 100 milliters of sample.

Biochemical oxygen demand (BOD). A measure of the quantity of dissolved oxygen, in milligrams per liter, necessary for the decomposition of organic matter by microorganisms, such as bacteria.

Biomass. The amount of living matter present at any given time, expressed as the weight per unit area or volume of habitat.

Ash weight. The weight or amount of residue present after the residue from the dry weight determination has been ashed in a muffle furnace at a temperature of 500°C for 1 hour. The ash weight values of zooplankton and phytoplankton are expressed in grams per cubic meter (g/m^3), and periphyton and benthic organisms in grams per square meter (g/m^2).

Dry weight. Refers to the weight of residue present after drying in an oven at 60°C for zooplankton and 105°C for periphyton, until the weight remains unchanged. This weight represents the total organic matter, ash, and sediment in the sample. Dry weight values are expressed in the same units as ash weight.

Organic weight. (or volatile weight of the living substance). The difference between the dry weight and the ash weight; represents the actual weight of the living matter. Organic weight is expressed in the same units as ash and dry weights.

Wet weight. The weight of living matter plus contained water.

Chemical oxygen demand (COD). A measure of the chemically oxidizable material in the water; furnishes an approximation of the amount of organic and reducing material present. The determined value may correlate with natural water color or with carbonaceous organic pollution from sewage or industrial wastes.

Chlorophyll. Refers to the green pigments of plants. Chlorophyll a and b are the most common green pigments in plants.

Confining bed. A body of relatively "impermeable" material stratigraphically adjacent to one or more aquifers. In nature, however, its "hydraulic conductivity" may range from nearly zero to some value distinctly lower than that of the aquifer.

Consumptive use. The difference between the quantity of water withdrawn from a source and the quantity returned to the source. The quantity of water discharged to the atmosphere or incorporated in the products of vegetative growth, food processing, or an industrial process.

Contents. The volume of water in a reservoir or lake. Unless otherwise indicated, volume is computed on the basis of a level pool and does not include bank storage.

Control. Designates a feature downstream from the gage that determines the stage-discharge relation at the gage. This feature may be a natural constriction of the channel, an artificial structure, or a uniform cross section over a long reach of the channel.

Control structure. As used in this report, a structure on a stream or canal that is used to regulate the flow or stage of the stream or to prevent the intrusion of saltwater.

Cubic foot per second (ft^3/s). The rate of discharge representing a volume of 1 cubic foot passing a given point during 1 second and is equivalent to 7.48 gallons per second or 448.8 gallons per minute.

Cubic foot per second per day ($ft^3/s/d$). The volume of water represented by a flow of 1 cubic foot per second for 24 hours. It is equivalent to 86,400 cubic feet, 1.9835 acre-feet, or approximately 646,000 gallons and represents a runoff of approximately 0.0372 inch from 1 square mile.

Cubic feet per second per square mile ($ft^3/s/mi^2$). The average number of cubic feet of water flowing per second from each square mile of area drained, assuming that the runoff is distributed uniformly in time and area.

Discharge. Conceptually discharge means outflow; therefore, the use of this term is not restricted as to course or location, and it can be applied to describe the flow of water from a pipe, from a drainage basin, or from an aquifer. If the discharge occurs in some course or channel, it is correct to speak of the discharge of a canal or of a river. It is also correct to speak of the discharge of a canal, a stream, or a spring into a lake, a stream, or an ocean.

Data in reports of the Geological Survey on surface water represent the total fluids measured. Thus, the terms discharge, streamflow, and runoff represent water with the solids dissolved in it and the sediment mixed with it. Of these terms, discharge is the most comprehensive. Generally discharge is taken to mean the volume of water (or more broadly, total fluids) that passes a given point within a given period of time.

Instantaneous discharge. The discharge at a particular instant of time.

Mean discharge. The arithmetic mean of individual daily mean discharges during a specific period.

Dissolved. Refers to the amount of a substance present in true chemical solution. In practice, however, the term includes all forms of the substance that will pass through a 0.45-micrometer membrane filter and, thus, may include some very small (colloidal) suspended particles. This is a convenient operational definition used by Federal agencies that collect water data. Chemical analyses are performed on filtered samples.

Drainage area. Refers to that area of a stream measured in a horizontal plane, enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into the river upstream of a specific location. Drainage areas given herein include all closed basins, or noncontributing areas, unless otherwise noted.

Drainage basin. A part of the surface of the earth that is occupied by a drainage system which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water. A catchment area.

Drainage divide. The boundary of a drainage basin. A topographic ridge dividing one drainage basin from another.

Evaporation. The process by which water is changed from the liquid to the vapor state. In hydrology, evaporation is vaporization that takes place at a temperature below the boiling point, such as from a stream or lake or moist soil.

Evapotranspiration. Water withdrawn from a land area by evaporation from water surfaces and moist soil and by transpiration from plants.

Gage height. The water-surface elevation referred to some arbitrary gage datum. Gage height is often used interchangeably with the more general term "stage," although gage height is more appropriate when used with a reading on a gage.

Gaging station. A particular site on a stream, canal, lake, or reservoir where systematic observations of gage height or discharge are obtained. When used in connection with a discharge record, the term is generally applied only to those gaging stations where a continuous record of discharge is computed.

Ground water, confined. Water under pressure significantly greater than atmospheric, and its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the material in which the confined water occurs.

Ground water, perched. Unconfined ground water separated from an underlying body of ground water by an unsaturated zone. Its water table is a perched water table. It is held up by a perching bed whose permeability is so low that water percolating downward through it is not able to bring water in the underlying unsaturated zone above atmospheric pressure.

Ground water, unconfined. Water in an aquifer that has a water table.

Hydrologic Unit. A geographic area that forms a national system for cataloging hydrologic and other information. The boundaries of hydrologic units coincide with those of drainage basins but also include areas such as intervening segments of drainage areas and islands, estuaries, coastal lands, and other similar areas not part of drainage basins.

Micrograms per liter (μg/L). A unit expressing the concentration of chemical constituents in solution as weight (micrograms) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter.

Milligrams per liter (mg/L). A unit for expressing the concentration of chemical constituents in solution. Milligrams per liter represents the weight of solute per unit volume of water. Concentration of suspended sediment can also be exposed in mg/L based on the mass of sediment per liter of sample.

National Geodetic Vertical Datum of 1929 (NGVD of 1929). A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "mean sea level."

Noncontributing area. An area having no perennial surface outlet where water commonly drains internally underground, generally into cavernous formations, and reappears as seepage or spring flow in downgradient areas, possibly in basins other than the area where it entered. Noncontributing areas are common in areas of karst terrane and are generally characterized by sinkholes.

Organism. Any living entity, such as an insect, phytoplankton, or zooplankton.

Cells/volume. Refers to the number of cells of any organism which is counted by using a microscope and grid or counting cell. Many planktonic organisms are multicelled and are counted according to the number of contained cells per sample, usually milliliters (mL) or liters (L).

Organism count/area. Refers to the number of organisms collected and enumerated in a sample and adjusted to the number per area habitat, usually square meters (m^2), acres, or hectares. Periphyton, benthic organisms, and macrophytes are expressed in these terms.

Partial-record station. A particular site where limited streamflow data are collected systematically over a period of years for use in hydrologic analyses.

Periphyton. The assemblage of microorganisms attached to and growing upon solid surfaces. While primarily consisting of algae, they also include bacteria, fungi, protozoa, rotifers, and other small organisms. Periphyton is a useful indicator of water quality.

Pesticides. Chemical compounds used to control the growth of undesirable plants and animals. Major categories of pesticides include insecticides, miticides, fungicides, herbicides, and rodenticides. Since the first application of DDT as an insecticide in the early 1930's, there have been almost 60,000 pesticide formulations registered, each containing at least one of the approximately 800 different basic pesticide compounds (Goerlitz and Brown, 1972). The United States annually produces about one billion pounds of these compounds. Although efforts are being made to substitute many of the chlorinated hydrocarbon pesticides with more specific, fast-acting, and easily degradable compounds, chlorinated hydrocarbon pesticides are still commonly used in many areas of the country.

Phytoplankton. The plant part of the plankton. They are usually microscopic and their movement is subject to the water currents. Phytoplankton growth depends upon solar radiation and nutrient substances. Because they are able to incorporate as well as to release materials to the surrounding water, the phytoplankton have a profound effect upon the quality of the water. They are primary food producers in the aquatic environment and are commonly known as algae.

Blue-green algae. A group of phytoplankton organisms having a blue pigment, in addition to the green pigment called chlorophyll. Blue-green algae often cause nuisance conditions in water.

Diatoms. The unicellular or colonial algae having a siliceous shell. Their concentrations are expressed as number of cells per 100 milliliters of sample.

Green algae. Have chlorophyll pigments similar in color to those of higher green plants. Some forms produce algae mats or floating "moss" in lakes. Their concentrations are expressed as number of cells per 100 milliliters of sample.

Picocurie (pCi). One-millionth of the amount of radioactivity represented by a microcurie, which is the quantity of radiation represented by one-millionth of a gram of radium-226. A picocurie of radium results in 2.22 disintegrations per minute.

Plankton. The community of suspended, floating, or weakly-swimming organisms that live in the open water of lakes and rivers.

Potentiometric surface. A surface which represents the static head in an aquifer, defined by the levels to which water will rise in tightly cased wells. The water table is a particular potentiometric surface.

Radioisotopes. A radioactive isotope of an element. Isotopes are species of a chemical element that differ in atomic weight, having the same number of protons but a different number of neutrons. They are very nearly alike in chemical properties. For example: Ordinary chlorine is a mixture of isotopes having atomic weights 33 and 27, with the natural mixture having an atomic weight of 35.453. Most elements exist as mixtures of isotopes, and a great many new isotopes have been

Radioisotopes.--Continued

produced in the operation of nuclear devices such as the cyclotron (Rose and Rose, 1966). There are 275 isotopes of the 81 stable elements in addition to over 800 radioactive isotopes.

Riparian. Pertaining to the banks of a stream, of a lake, or of a tidewater.

River mile. The distance upstream from the mouth of a stream. Mileage figures are determined from the best maps available and are generally determined according to instructions in Bulletin 14 of the federal Water Resources Council.

Runoff. That part of precipitation that appears in surface streams. Includes water that flows directly into gullies, creeks, lakes, and rivers, and also includes water that infiltrates to ground-water bodies and subsequently emerges in surface streams within the area under consideration. The quantity of runoff from an area is commonly expressed in terms of inches of water uniformly distributed over the area that contributes the water. In other words, an inch of runoff represents a 1-inch layer of water over a given time period covering the drainage basin or area that contributed the water.

Sea level. General term for "National Geodetic Vertical Datum of 1929," which see.

Sediment. Fragmental material that originates from weathering of rocks and is transported by, suspended in, or deposited from water or air or accumulated in beds by other natural forces. It includes chemical and biochemical precipitates and decomposed organic material such as humus. The quantity, characteristics, and cause of the occurrence of sediment in streams are influenced by environmental factors. Some major factors are degree of slope, soil characteristics, land usage, and quantity and intensity of precipitation.

Sediment discharge. The rate at which suspended sediment passes a section of a stream or the quantity of sediment, as measured by dry weight, or by volume, that is discharged in a given time.

Suspended sediment. The sediment that at any given time is maintained in suspension by the upward components of turbulent currents or that exists in suspension as a colloid.

Sinkhole lake. A lake occupying a sinkhole which has been formed, in general, by solution of surficial limestone and by collapse of the roof of underground channels or caverns. Commonly, circular shaped lakes in Florida are loosely referred to as sinkhole lakes. Other discrete lakes or lake complexes likewise formed by solution are not generally referred to as sinkhole lakes.

Solute. Any substance derived from the atmosphere, vegetation, soil, or rocks and dissolved in water.

Specific capacity (of a well). The rate of discharge of water from a well divided by the drawdown of water level within the well. It varies slowly with duration of discharge and is approximately proportional to the transmissivity of the aquifer.

Specific conductance. A measure of the ability of a water to conduct an electrical current and is expressed in micromhos per centimeter at 25°C. Specific conductance is related to the type and concentration of ions in solution and can be used for approximating the dissolved-solids content of the water. Commonly, the concentration of dissolved solids (in milligrams per liter) is about 65 percent of the specific conductance (in micromhos). This relation is not constant from stream to stream, and it may even vary in the same source with changes in the composition of the water.

Stage-discharge relation. The relation between gage height and the volume of water per unit of time, flowing in a channel.

Streamflow. The discharge that occurs in a natural channel. Although "streamflow" can be applied to the flow of a canal, "streamflow" uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than "runoff," as streamflow may be applied to discharge whether it is affected by diversion or regulation.

Stream, gaining. A stream or reach of a stream whose flow is increasing by inflow of ground water.

Stream, losing. A stream or reach of a stream that is losing water to the ground.

Surface area. That area of a lake outlined on the latest U.S. Geological Survey topographic map as the boundary of the lake and measured by a planimeter. In localities not covered by topographic maps, the areas are computed from the best maps available. All areas shown are those for stages when the various maps were made.

Thermograph. A thermometer that continuously and automatically records on a chart the variations in temperature of a substance. "Temperature recorder" is the term used in hydrology to indicate the location of the thermograph or a digital mechanism that automatically records water temperature on paper tape.

Tons per day. The quantity of a substance in solution or suspension that passes a stream section during a 24-hour period.

Total (as used in table of chemical analyses). The total amount of a given constituent in a representative water-suspended sediment sample, regardless of the constituent's physical or chemical form. This term is used only when the analytical procedure assures measurement of at least 95 percent of the constituent present in both the dissolved and suspended phases of the sample. A knowledge of the expected forms of the constituent in the sample, as well as the analytical methodology

Total.--Continued

used, is required to judge when the results should be reported as "total." (Note that the word "total" does double duty here, indicating both that the sample consists of a water-suspended sediment mixture and that the analytical method determines all of the constituent in the sample.)

Total organic carbon (TOC). A measure of the organically-related carbonaceous content of water. It includes all natural and manmade organic compounds which are combustible at a temperature of 950°C.

Transmissivity. The rate at which water, of the prevailing kinematic viscosity, in the aquifer is transmitted through a unit width of the aquifer under a unit hydraulic gradient.

Transpiration. Water absorbed and transpired and used directly in the building of plant tissue.

Water table. That surface in an unconfined ground-water body at which the pressure is atmospheric; defined by the levels at which water stands in wells that penetrate the water body far enough to hold standing water. The water table is a particular potentiometric surface.

Water year. In Geological Survey reports dealing with surface-water supply, the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends. Thus, the 1980 water year begins October 1, 1979 and ends September 30, 1980.

Zone, saturated. That part of the water-bearing material in which all voids, large and small, are ideally filled with water under pressure greater than atmospheric. The top of the saturated zone is the water table.

Zone, unsaturated. The zone between the land surface and the water table.

Significance of Dissolved and Particulate Mineral and Organic Constituents and Properties of Water

Virtually all natural waters contain dissolved and particulate mineral and organic matter. Natural processes influence the chemical, physical, and biological characteristics of water which vary by location, time, and climate. Rainfall contains small amounts of dissolved minerals and gases carried by wind from the oceans and the land. The quantity of dissolved and particulate mineral matter in natural water depends primarily on the type of rocks or soils with which the water has been in contact and the length of time of contact. Ground water is generally more highly mineralized than surface runoff because it remains in contact with the rocks and soils for much longer periods; however, the mineral content of ground water is usually less variable than that of surface water. Many streams are fed by surface runoff and by ground water from seepage or from direct spring inflow. Such streams reflect the character of the more mineralized ground water during dry (low-flow) periods and are diluted by surface runoff during wet (high-flow) periods.

Water quality is relative; it must be associated with intended use. It is influenced by natural factors and by activities of man.

The quality of water can be classified in many ways, such as for intended use and by character and chemical constituents. Classifications by degree of salinity and by hardness, in milligrams per liter, are as follows:

Classification of water by degree of salinity in terms of dissolved-solids concentration

[Modified from Swenson and Baldwin, 1965]

Description		Dissolved solids (mg/L)
Nonsaline-fresh		Less than 1,000
Slightly saline	brackish	1,000-3,000
Moderately saline	brackish	3,000-10,000
Very saline	brackish	10,000-35,000
Brine		More than 35,000

Classification of water by hardness in terms of calcium carbonate

[Modified from Durfor and Becker, 1964]

Description	Calcium carbonate hardness (mg/L)
Soft	0-60
Moderately hard	60-120
Hard	120-180
Very hard	More than 180

Hardness concentrations recommended for various industrial uses of water are given in table 1.

Table 1.--Hardness concentrations recommended for various industrial water uses

[Modified from Shampine, 1965c]

Industry and process	Recommended hardness (milligrams per liter)
Boiler feed water (pounds per square inch)	
At 0-150	80
At 150-250	40
At 250-400	10
Over 400	2
Brewing	200-300
Carbonated beverages	200-250
Cooling	50
Food canning and freezing:	
General	50-85
Legumes	25-75
Fruits and vegetables	100-200
Peas	200-400
Food equipment, washing	10
Food processing, general	10-250
Ice manufacturing	70-72
Laundering	0-50
Pulp and paper making:	
Ground-wood pulp	200
Soda pulp	100
Kraft pulp, bleached	100
Kraft pulp, unbleached	200
Fine paper pulp	100
Rayon:	
Pulp production	8
Cloth manufacture	55
Steel manufacturing	50
Synthetic rubber	50
Tanning:	
Beam house	513
Tan house	50-135
Textile manufacture	0-50

Mineral constituents and physical properties of waters presented in water-resources data reports include those that have a practical bearing on water use. Routine mineral analyses generally include determinations for silica, iron, calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulfate, chloride, fluoride, nitrate, pH, dissolved solids, and specific conductance. Aluminum, manganese, color, dissolved oxygen, and other dissolved constituents and physical properties are also determined at times. Microbiologic and organic components (pesticides, total organic carbon, and coliform bacteria) and minor elements (arsenic, cobalt, cadmium, copper, lead, mercury, nickel, strontium, zinc, etc.) are determined occasionally in connection with specific studies. The source and significance of a number of mineral constitutents and properties of waters are discussed in table 2.

HYDROLOGIC RECORDS

Hydrologic records collected by the U.S. Geological Survey consist of stage, discharge, and water quality of streams and canals; elevation and water quality of lakes and reservoirs; water levels and water quality of ground water and physical information on wells; discharge and water quality of springs; and related information on other water features. Information is collected as part of investigations and from monitoring networks. The hydrologic records collected in Florida represent part of the National Water Data System operated by the U.S. Geological Survey in cooperation with State, local, and Federal agencies in Florida which are entered into the WATSTORE computer and published annually in Survey reports on a state boundary basis.

Water-resources data collected in Florida are published annually in a series of reports entitled "Water Resources Data for Florida for ________ (Year)" covering surface water, ground water, and quality of water. These can be inspected in offices of the Survey in Florida, in offices of the Water Management Districts and in various State university libraries. They can be purchased from the National Technical Information Service, U.S. Department of Commerce, Springfield, Va. They are not sold by the U.S. Geological Survey. In 1978, the annual report for Florida contained discharge records of 295 streams and canals, stage only records for 206 streams, levels of 216 lakes, water levels for 1,134 wells and crest stage partial records for 54 streams. The current annual data report for Florida consists of 8 volumes covering Northeast, South, Southwest, and Northwest Florida. In Florida, surface-water records have been published on a state boundary basis annually since 1961; water-quality data since 1964; and ground-water data since 1975.

All data are identified and cataloged by site number, name, location, county, site type, and Hydrologic Unit; and geologic unit if the site is an observation well. The site number for most surface-water gaging stations is assigned in accordance with the national system of downstream order numbers used by the U.S. Geological Survey. The name and location of each

Table 2.--Source and significance of mineral constituents and properties of water

[Units of measurement: milligrams per liter (mg/L); micrograms per liter (μg/L)]

Alkalinity

Source or cause.--Caused primarily by bicarbonate, carbonate, and hydroxide. Other weak acid radicals like borate, phosphate, and silicate may contribute to alkalinity.

Significance.--Ability of water to neutralize strong acid. High alkalinity itself not detrimental but usually associated with high pH, hardness, and dissolved solids which can be detrimental.

Aluminum (Al)

Source or cause.--Usually present only in negligible quantities in natural waters except waters that have been in contact with the more soluble rocks of high aluminum content. Acid waters often contain large amounts.

Significance.--May be troublesome in feed waters forming scale on boiler tubes. High concentrations usually indicate the presence of acid mine drainage or industrial waste.

Arsenic (As)

Source or cause.--Natural arsenic-bearing minerals. Found in some ground waters, in wastes from industry and mining activity, and residues from some insecticides and herbicides.

Significance.--National Interim Primary Drinking Water Regulations (U.S. Environmental Protection Agency, 1975a) give a limit of 50 μg/L for potable waters. Lethal doses for animals is believed to be about 20 milligrams per animal pound. Small concentrations in drinking water can accumulate in man and other animals until lethal dosage is reached.

Barium (Ba)

Source or cause.--Barium occurs in nature chiefly as barite, $BaSO_4$, and witherite, $BaCO_3$, both of which are highly insoluble salts. The metal is stable in dry air, but is readily oxidized by humid air or by water. Many barium salts are reported to be poisonous. However, barium ions generally are thought to be rapidly precipitated or removed from solution by adsorption and sedimentation. In most natural waters there is sufficient sulfate or carbonate to precipitate the barium present in the water as a virtually insoluble, nontoxic compound.

Table 2.--Source and significance of mineral constituents and properties of waters--Continued

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Barium (Ba)--Continued

Source or cause.--Continued

The major commercial value of barium is in its compounds which are used in a variety of applications including medicinal purposes. (U.S. Environmental Protection Agency, 1976b.)

Significance.--Barium enters the body primarily through air and water, as appreciable amounts are not in foods. Ingestion of soluble barium compounds may result in effects on the gastrointestinal tract, causing vomiting and diarrhea, and on the central nervous system, causing violent tonic and clonic spasms followed in some cases by paralysis. Barium salts are considered to be muscle stimulants, especially for the heart muscle. As barium is readily excreted, it is not likely to accumulate in the bone, muscle, kidney, or other tissues. As barium is not removed by conventional water-treatment processes and because of the effect on the heart and blood vessels, The National Primary Drinking Water Regulations (U.S. Environmental Protection Agency, 1975a) give a limit of 1 mg/L for domestic water supplies. As the physical and chemical properties of barium generally preclude the existence of the toxic soluble form under usual marine and freshwater conditions, a restrictive limit of barium for aquatic life appears unwarranted. (U.S. Environmental Protection Agency, 1976b.)

Bicarbonate (HCO_3) and carbonate (CO_3)

Source or cause.--Produced by reaction of atmospheric carbon dioxide with water. Dissolved from carbonate rocks such as limestone and dolomite.

Significance.--Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot water facilities to precipitate as scale and release corrosive carbon dioxide gas. In combination with calcium and magnesium cause carbonate hardness.

Cadmium (Cd)

Source or cause.--Found in wastes from pigment works, textile printing, lead mines, and chemical industries.

Significance.--The results of animal studies suggest that very small amounts of cadmium can produce nephrotoxic and cardiovascular effects. The reproductive organs of animals are specifically affected after parenteral administration of very small amounts of cadmium salts. National Interim Primary

Cadmium (Cd)--Continued

Significance.--Continued

Drinking Water Regulations (U.S. Environmental Protection Agency, 1975a) state that cadmium in excess of 10 µg/L is cause for rejection of the water supply. Cadmium is also toxic to fish and aquatic life in varying concentrations.

Calcium (Ca) and magnesium (Mg)

Source or cause.--Dissolved from practically all soils and rocks, but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in seawater.

Significance.--Causes most of the hardness and scale-forming properties of water; consumes soap (see hardness). Waters low in calcium and magnesium are desired in electroplating, tanning, dyeing, and in textile manufacturing.

Chloride (Cl)

Source or cause.--Dissolved from rocks and soils. Present in sewage and found in large amounts in ancient brines, seawater, and industrial brines.

Significance.--About 300 mg/L in combination with sodium gives salty taste to water. Increases the corrosiveness of water. Proposed National Secondary Drinking Water Regulations (U.S. Environmental Protection Agency, 1977) recommends that the chloride content not exceed 250 mg/L.

Chromium (Cr)

Source or cause.--Few if any waters contain chromium from natural sources. Natural waters can probably contain only traces of chromium as a cation unless the pH is very low. When chromium is present in water, it is usually the result of pollution by industrial wastes such as metal pickling, plating, manufacturing of paints, dyes, explosives, ceramics, paper, glass, and photography processing.

Significance.--National Interim Primary Drinking Water Regulations (U.S. Environmental Protection Agency, 1975a) limit the maximum concentration of hexavalent chromium to 50 µg/L. Toxicity to aquatic life varies widely with the species, temperature, pH, and other factors.

Table 2.--Source and significance of mineral constituents and properties of waters--Continued

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Cobalt (Co)

Source or cause.--Cobalt occurs in nature in the minerals, smaltite, $(Co,Ni)As_2$, and cobaltite, (CoAsS). Alluvial deposits and soils derived from shales often contain cobalt in the form of phosphate or sulfate, but other soil types may be markedly deficient in cobalt in any form. Biological activity may aid in the solution of small amounts of cobalt. May also be present in industrial wastes especially those from manufacture of ceramics, inks, electric heating units, and cobalt pigments.

Significance.--Usually suggests pollution. Relatively low toxicity to man. Fish and aquatic life tolerance varies widely from less than 3 mg/L to more than 10 mg/L. Essential in trace quantities for plant growth.

Color

Source or cause.--Yellow-to-brown color of some water is usually caused by organic matter extracted from leaves, roots, and other organic substances. Objectionable color in water also results from industrial wastes and sewage.

Significance.--Water for domestic and some industrial uses should be free from perceptible color. The National Secondary Drinking Water Regulations (U.S. Environmental Protection Agency, 1977) proposes a limit of 15 Platinum Cobalt (Pt-Co) units. Color in water is objectionable in food and beverage processing and many manufacturing processes. Limits light penetration in water, thus preventing growth of some organisms.

Copper (Cu)

Source or cause.--Copper is a fairly common trace constituent of natural water. Small amounts may be introduced into water by solution of copper and brass water pipes and other copper-bearing equipment in contact with the water or from copper salts added to control algae in open reservoirs. Copper salts such as the sulfate and chloride are highly soluble in waters with a low pH but in water of normal alkalinity the salts hydrolyze and copper may be precipitated. In the normal pH range of natural water containing carbon dioxide, copper might be precipitated as carbonate.

Table 2.--Source and significance of mineral constituents and properties of waters--Continued

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Copper (Cu)--Continued

Significance.--Copper imparts a disagreeable metallic taste to water. As little as 1.5 mg/L can usually be detected, and 5 mg/L can render the water unpalatable. Copper is not considered to be a cumulative systemic poison like arsenic, lead, and mercury; most copper ingested is excreted by the body and very little is retained. The pathological effects of copper are controversial, but it is generally believed very unlikely that humans could unknowingly ingest toxic quantities from palatable drinking water. Proposed National Secondary Drinking Water Regulations (U.S. Environmental Protection Agency, 1977) recommend that copper should not exceed 1 mg/L in drinking and culinary water. Copper is essential in trace amounts for plant growth but becomes toxic in large amounts.

Dissolved oxygen (DO)

Source or cause.--Dissolved in water from air and from oxygen given off in the process of photosynthesis by aquatic plants.

Significance.--Dissolved oxygen increases the palatability of water. The amount necessary to support fish life varies with species and age, with temperature, and concentration of other constituents in the water. Under average stream conditions, 5 mg/L is usually necessary to maintain a varied fish fauna in good condition. For many industrial uses, zero dissolved oxygen is desirable to inhibit corrosion.

Dissolved solids

Source or cause.--Chiefly mineral constituents dissolved from weathering of rocks and soils.

Significance.--The Proposed National Secondary Drinking Water Regulations (U.S. Environmental Protection Agency, 1977) recommend that the dissolved solids should not exceed 500 mg/L; however, 1,000 mg/L is permitted under certain circumstances. Waters containing more than 1,000 mg/L of dissolved solids are unsuitable for many purposes.

Table 2.--Source and significance of mineral constituents and properties of waters--Continued

Fluoride (F)

Source or cause.--Dissolved in small to minute quantities from most rocks and soils. Enters many waters from fluoridation of municipal supplies.

Significance.--Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth depending on the concentration of fluoride, the age of the child, amount of drinking water consumed, and susceptibility of the individual (Maier, 1950). National Interim Primary Drinking Water Regulations (U.S. Environmental Protection Agency, 1975a) set the following maximum contaminate levels (MCL) for fluoride in drinking water:

Annual average of maximum daily air temperature		Maximum contaminate level (MCL)
Degrees Fahrenheit (°F)	Degrees Celsius (°C)	Milligrams per liter (mg/L)
Below 53.8	Below 12.1	2.4
53.8 to 58.3	12.1 to 14.6	2.2
58.4 to 63.8	14.7 to 17.6	2.0
63.9 to 70.6	17.7 to 21.4	1.8
70.7 to 79.2	21.5 to 26.2	1.6
79.3 to 90.5	26.3 to 32.5	1.4

Hardness (as $CaCO_3$)

Source or cause.--In most waters, nearly all the hardness is due to calcium and magnesium. All of the metallic cations other than the alkali metals also cause hardness.

Significance.--Consumes soap before a lather will form. Deposits soap curd on bathtubs. Hard water forms scale in boilers, water heaters, and pipes. Hardness equivalent to the bicarbonate and carbonate is called carbonate hardness. Any hardness in excess of this is called noncarbonate hardness.

Iron (Fe)

Source or cause.--Iron is dissolved from many rocks and soils. On exposure to air, normal basic waters that contain more than 1 mg/L of iron soon become turbid with the insoluble reddish ferric compounds produced by oxidation. Surface waters, therefore, seldom contain as much as 1 mg/L of dissolved iron, although some acid waters carry large quantities of iron in solution.

Significance.--On exposure to air, iron in ground water oxidizes to reddish-brown sediment. More than about 300 µg/L may stain laundry and utensils reddish-brown. Objectionable for food processing, textile processing, beverages, ice manufacture, brewing and other processes. Proposed National Secondary Drinking Water Regulations (U.S. Environmental Protection Agency, 1977) for esthetic reasons, recommend that iron should not exceed 300 µg/L. Larger quantities cause unpleasant taste and favor growth of iron bacteria.

Lead (Pb)

Source or cause.--Lead seldom occurs in most natural waters, but industrial mine and smelter effluents may contain relatively large amounts of lead that contaminate streams. Also, atmospheric contamination, produced from several type of engine exhausts, has considerably increased the availability of this element for solution in rainfall (and as aerosols and particulates in the atmosphere), resulting in lead contamination in streams (Hem, 1970). Lead in the form of sulfate is reported to be soluble in water to the extent of 31 mg/L at 25°C (Seidell, 1940). In natural water, this concentration would not be approached, however, as a pH of less than 4.5 would probably be required to prevent formation of lead hydroxide and carbonate Pleissner (1907) reported that at 18°C water free of carbon dioxide will dissolve the equivalent of 1.4 mg/L of lead and the solubility is increased nearly fourfold by the presence of 2.8 mg/L of carbon dioxide in the solution. Presence of other ions may increase the solubility of lead.

Significance.--National Interim Primary Drinking Water Regulations (U.S. Environmental Protection Agency, 1975a) state that lead shall not exceed 50 µg/L in drinking and culinary water on carriers subject to Federal quarantine regulations. Maximum safe concentrations for animal watering is reported to be 500 µg/L. Toxicity of lead to fish decreases with increasing water hardness.

Table 2.--Source and significance of mineral constituents and properties of waters--Continued

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Manganese (Mn)

Source or cause.--Dissolved from some rocks and soils. Not as common as iron. Large quantities often associated with high iron content and with acid waters.

Significance.--Same objectionable features as iron. Causes dark brown or black stain. Proposed National Secondary Drinking Water Regulations (U.S. Environmental Protection Agency, 1977) recommend that manganese not exceed 0.05 mg/L.

Mercury (Hg)

Source or cause.--Though mercury is distributed throughout the environment, most natural waters generally contain mercury concentrations of less than 0.1 μ/L. However, as a result of industrial and agricultural applications, large increases above natural levels in water, as well as soil and air, may occur in localized areas around chlor-alkali manufacturing plants and industrial processes involving reuse of mercurial catalysts, and from use of slimicides primarily in the paper-pulp industry and mercurial seed treatment. (U.S. Environmental Protection Agency, 1975b.)

Significance.--Alkyl compounds of mercury are the most toxic to man, producing illness from the ingestion of only a few milligrams. Outside of occupational exposure, food, particularly fish, is the greatest contributor to body burden of mercury. Mercury in bottom sediments can be converted by micro-organisms to the alkyl form, enter the food chain and accumulate in the higher members of the chain. Alkyl mercury can cross the blood-brain barrier more easily than other mercurials, so that blood-brain levels are much higher after a dose of alkyl mercury than after a corresponding dose of any other mercurial. Fortunately, as only a small fraction of the mercury in drinking water is in the alkyl form, the risk to health from waterborne mercury is not nearly so great as is the risk from mercury in fish. Also, fortunately, mercury in drinking water seldom exceeds 2 μg/l, the maximum limit established by the National Interim Primary Drinking Water Regulations. (U.S. Environmental Protection Agency, 1975b.)

Table 2.--Source and significance of mineral constituents and properties of waters--Continued

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Nickel (Ni)

Source or cause.--Chiefly from metal-plating works, manufacturing of ceramic colors, and inks.

Significance.--Presence of nickel in water may suggest pollution. Federal drinking water standards do not place a limit on nickel. In the Soviet Union, the maximum permissible concentration is 1.0 mg/L (Kirkor, 1951).

Nitrogen, ammonia (NH_4, as N)

Source or cause.--Includes nitrogen in the form of NH_3 and NH_4^+. Found in many waters but usually only in trace amounts. Waters from hot springs may contain high concentrations. Found also in waters polluted with sewage and other organic waste.

Significance.--Usually indicates organic pollution. Toxicity to fish depends on the pH of the water; 2.5 mg/L ammonia nitrogen can be harmful in the 7.4 to 8.5 pH range (Ellis, M. M., et. al., 1946). Ammonium salts are destructive to concrete made from portland cement.

Nitrogen, organic (N)

Source or cause.--Amino acids, proteins, and polypeptides. Derived from living organisms and their life processes and from wastes and sewage.

Significance.--Sometimes indicates pollution. Increases nutrient content of water through decomposition and formation of other nitrogen forms.

Nitrogen, nitrate (NO_3, as N)

Source or cause.--Decaying organic matter, sewage, fertilizers, and nitrates in soil.

Significance.--Concentrations much greater than the local average may suggest pollution. The National Interim Primary Drinking Water Regulations (U.S. Environmental Protection Agency, 1975a) have established a 10 mg/L maximum contamination level. More than about 10 mg/L of nitrate (N) may cause a type of methemoglobinemia in infants, sometimes fatal. Water of high nitrate content should not be used in baby feeding (Maxcy, K. F., 1950). Nitrate has shown to be helpful in reducing intercrystalline cracking of boiler steel. It encourages growth of algae and other organisms which produce undesirable tastes and odors.

Table 2.--Source and significance of mineral constituents and properties of waters--Continued

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Nitrogen, nitrite (NO_2, as N)

Source or cause.--Unstable in the presence of oxygen and is present in only small amounts in most waters. Found in sewage and other organic wastes.

Significance.--Presence of nitrite is usually an indication of recent organic pollution. Undesirable in waters for some dyeing and brewing processes.

Nitrogen, total Kjeldahl (N)

Source or cause.--Includes ammonia nitrogen and organic nitrogen.

Significance.--See nitrogen, ammonia and nitrogen, organic.

Nitrogen, total (N)

Source or cause.--All forms of nitrogen--inorganic and organic.

Significance.--See nitrogen: ammonia, nitrate, nitrite, and organic.

pH, hydrogen ion concentration

Source or cause.--Hydrogen ions derived from ionization of weak and strong acids. Hydrogen ion concentration is expressed in terms of pH where pH = -log (H+). Acid generating salts and dissolved gases such as SO_2 and CO_2 increase the number of hydrogen ions. Carbonates, bicarbonates, hydroxides, phosphates, silicates, and borates reduce the number of hydrogen ions.

Significance.--pH ranges between 0 and 14. A pH of 7.0 indicates a neutral solution having equal numbers of hydrogen and hydroxide ions. pH higher than 7.0 denotes predominance of hydroxide ions; values lower than 7.0 indicate predominance of hydrogen ions. The National Secondary Drinking Water Regulations (U.S. Environmental Protection Agency, 1977) recommend a pH range of 6.5-8.5. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals.

Table 2.--Source and significance of mineral constituents and properties of waters--Continued

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Selenium (Se)

Source or cause.--Selenium appears in the soil as basic ferric selenite, calcium selenate, and as elemental selenium. Elemental Selenium must be oxidized to selenite or selenate before it has appreciable solubility in water. The level of selenium in water is proportional to the selenium in the soil. In low selenium areas the content of water may be significantly below 1 µg/L. (U.S. Environmental Protection Agency, 1976b.)

Significance.--Biologically, selinium is an essential beneficial element in trace amounts for animals but toxic to them when ingested in amounts ranging from about 0.1 to 10 mg/kg of food. Selenium is considered toxic to man. Symptoms appear similar to those of arsenic poisoning. The toxicity of selenium to man must take into account the dietary requirements for the element in amounts estimated to be 0.04 to 0.10 mg/kg of food. Considerable difficulty is involved in determining the required level and toxic levels of selenium in humans. Taking account of the average daily intake of selenium in food of about 200 µg/L, the U.S. Environmental Protection Agency (1975a) established a maximum safe level of selenium in drinking water of 10 µg/L under the National Primary Drinking Water Regulation. (U.S. Environmental Protection Agency, 1975a.)

Silver (Ag)

Source or cause.--The need to set a water standard for silver arises from its intentional addition to waters as a disinfectant (U.S. Environmental Protection Agency, 1975a). The solubility of silver oxide is low enough to prevent high concentrations of silver at high pH, and silver chloride has a low enough solubility to exert a major control where chloride concentration exceeds 35 mg/L (Hem, 1970).

Significance.--The chief effect of silver in the body is cosmetic. It consists of a permanent blue-grey discoloration of the skin, eyes, and mucous membranes (argyria) which is unsightly and disturbing to the observer as well as to the victim. Most common silver salts produce argyria when injected or ingested in sufficient doses. There is a long-delayed appearance of discoloration. Evidence is lacking that gradual disposition of silver in the body produces any significant alteration in physiological functions (U.S. Environmental Protection Agency, 1975a).

Table 2.--Source and significance of mineral constituents and properties of waters--Continued

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Silver (Ag)--Continued

Significance.--Continued

Because of evidence that silver, once absorbed, is held indefinitely in tissues, particularly the skin, and because of the probable high absorbability of silver bound to sulfur components of food cooked in silver-containing waters, The National Interim Primary Drinking Water Regulations (U.S. Envi-romental Protection Agency, 1975a) give a limit of 50 µg/L of silver in drinking water.

Strontium (Sr)

Source or cause.--Dissolved from rocks and soils. Found in seawater and many brines. Present in waters of local areas where strontium minerals such as celestite and stronianite are present.

Significance.--Naturally occurring strontium is similar chemically to calcium and only adds to the hardness of water.

Sulfate (SO_4)

Source or cause.--Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Usually present in mine waters and in some industrial waters.

Significance.--Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts, sulfate in combination with other ions gives bitter taste to water. Some calcium sulfate is considered beneficial in the brewing process. Proposed National Secondary Drinking Water Regulations (U.S. Environmental Protection Agency, 1977) recommend that the sulfate content should not exceed 250 mg/L.

Temperature

Source or cause.--Solar energy, thermal pollution from waste outfalls and heat from Earth's core.

Significance.--Affects usefulness of water for many purposes. For most uses, a water of uniformly low temperature is desired. Shallow wells show some seasonal fluctuations in water temperature. Ground waters from moderate depths usually are nearly constant in temperature, which is near the mean annual air temperature of the area. In very deep wells, the water temperature generally increases on the average about 1°C with each 100-foot increment of depth. Seasonal fluctuations in temperatures of surface waters are comparatively large, depending on the depth of water, but do not reach the extremes of air temperature.

Table 2.--Source and significance of mineral constituents and properties of waters--Continued

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Turbidity

Source or cause.--Colloidal suspensions of sediment, precipitates, and other small particles.

Significance.--The National Interim Primary Drinking Water Regulations (U.S. Environmental Protection Agency, 1975a) has established a maximum contaminant level as a monthly average of 1 NTU (nephelometric turbidity unit) or 5 NTU with State approval, provided it does not interfere with disinfection, maintenance of chlorine residue, or bacteriological testing). Interferes with light penetration and limits growth of organisms. Also directly lethal to some life forms.

Zinc (Zn)

Source or cause.--Dissolved from some rocks and soils. Found in high concentrations in some mine waters having a low pH. Zinc is widely used in many commercial products and industrial wastes may contain large amounts. May be derived from zinc plated or galvanized metal products.

Significance.--High concentrations may be toxic to aquatic plants and animals. Zinc may have a toxic action on purifying bacterial flora of streams such as to present serious sewage pollution problems. Zinc is an essential and beneficial element in human metabolism. Proposed National Secondary Drinking Water Regulations (U.S. Environmental Protection Agency, 1977) recommend that zinc not exceed 5,000 μg/L (5 mg/L).

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site are determined from the best available maps. Table 3 lists abbreviations normally used for water courses, branches and forks, location and direction, and other aspects in hydrologic records. The county in which the site is located is represented by a numerical code that conforms with the national system of county codes, "Political Subdivision Code," (National Bureau of Standards, 1972) which provides a basis for cataloging and retrieving hydrologic and other data by political units as well as by Hydrologic Units. The political subdivision code for the 67 counties for Florida is given in table 4.

A Hydrologic Unit is a geographic area that forms a national system for cataloging hydrologic and other information. The boundaries of hydrologic units coincide with those of drainage basins but also delineate areas such as intervening segments of drainage areas and islands, estuaries, coastal lands, and other similar areas not part of drainage basins. The total area of Florida included in the Hydrologic Units, table 5, is 60,477 square miles. This includes estuaries and bays such as Florida Bay and is based upon a 1:500,000 scale map of Florida. The total area of Florida, exclusive of Florida Bay, based on 1:250,000 scale maps, determined in 1977, is 59,300 square miles. The total area of Florida determined in 1960 by the U.S. Department of Commerce (1970) is 58,560 square miles based on various maps then available and excluding areas of oceans, bays, sounds, etc., not defined as inland water. Based upon that determination, Florida is 21st in ranking of total area for the 48 conterminous states and second in water area with 4,424 square miles compared to Minnesota with 4,779 square miles. Alaska, the largest state with 586,412 square miles, has 19,980 square miles of water area (U.S. Geological Survey, 1970). Florida has the greatest percentage, 7.6 percent, of water area of all states except for Rhode Island. Rhode Island has 13.6 percent water area of a total area of 1,214 square miles. Although Alaska and Minnesota exceed Florida in water area, percentage-wise they are smaller, being 3.4 and 5.7 percent respectively.

The Hydrologic Unit Code consists of an eight-digit code representing the Region, Subregion, Accounting, and Cataloging Units. The Regions and Subregions are used by the U.S. Water Resources Council for water and related land-resources planning. The Accounting and Cataloging Units are used by the U.S. Geological Survey for managing the National Water Data Network. The boundaries of the Hydrologic Units in Florida (fig. 3), have been adopted by Florida and provide a cataloging system for the five Water Management Districts whose boundaries are hydrologic in nature. The names and areas of the Hydrologic Units in Florida are given in table 5.

The Hydrologic Units drainage basins for the South Atlantic slope and eastern Gulf of Mexico basins are cataloged in a clockwise direction--beginning in Florida in the northeast (and southeast Georgia) with the St. Marys River Basin and continuing southward for the Atlantic coastal and southern Florida systems, thence northward along western peninsula Florida, and thence westward to the Perdido River Basin and Perdido inflow and coastal area in northwest Florida (and southwest Alabama).

Table 3.--Abbreviations normally used for hydrologic records

Water Courses

B	Branch	O	Outlet	SL	Slough
BK	Brook	OV	Overflow	TR	Tributary
C	Creek	P	Pond	WW	Waterways
CA	Canal	PR	Prong		
D	Ditch	R	River		
DI	Distributary	RE	Reservoir		
ES	Estuary	RN	Run		
F	Fork	SD	Sound		
LA	Lateral	SG	Spring		
LK	Lake	SGS	Springs		

Branches and Forks

EB	East Branch	MP	Middle Prong	SF	South Fork
EF	East Fork	NB	North Branch	SP	South Prong
EP	East Prong	NF	North Fork	WB	West Branch
MB	Middle Branch	NP	North Prong	WF	West Fork
MF	Middle Fork	SB	South Branch	WP	West Prong

Location and Direction

AB	Above	N	North	SE	Southeast
BL	Below	NE	Northeast	SW	Southwest
E	East	NR	Near	W	West
M	Middle	NW	Northwest		
MTH	Mouth	S	South		

Other

AR	Area	CON	Conservation	LV	Levee
AV	Avenue	COT	Cottage Road	RD	Road
BHAM	Buckingham	CT	Control	SFL RD	South Fence Line Road
CNF	Confluence	HWY	Highway	SPWY	Spillway
COMP	Complex	L	Little		
		STR	Structure		
		USNAS	U.S. Naval Air Station		
		WPB	West Palm Beach		

Table 4.--Political subdivision codes for the 67 counties of Florida

[Modified from National Bureau of Standards, 1972]

CODE	COUNTY	CODE	COUNTY
001	Alachua	071	Lee
003	Baker	073	Leon
005	Bay	075	Levy
007	Bradford	077	Liberty
009	Brevard	079	Madison
011	Broward	081	Manatee
013	Calhoun	083	Marion
015	Charlotte	085	Martin
017	Citrus	087	Monroe
019	Clay	089	Nassau
021	Collier	091	Okaloosa
023	Columbia	093	Okeechobee
025	Dade	095	Orange
027	De Soto	097	Osceola
029	Dixie	099	Palm Beach
031	Duval	101	Pasco
033	Escambia	103	Pinellas
035	Flagler	105	Polk
037	Franklin	107	Putnam
039	Gadsden	109	St. Johns
041	Gilchrist	111	St. Lucie
043	Glades	113	Santa Rosa
045	Gulf	115	Sarasota
047	Hamilton	117	Seminole
049	Hardee	119	Sumter
051	Hendry	121	Suwannee
053	Hernando	123	Taylor
055	Highlands	125	Union
057	Hillsborough	127	Volusia
059	Holmes	129	Wakulla
061	Indian River	131	Walton
063	Jackson	133	Washington
065	Jefferson		
067	Lafayette		
069	Lake		

Table 5.--Designation, names, and areas of Hydrologic Units in Florida

[Modified from Conover and Leach, 1975 and Foose, 1981]

[Florida is in South-Atlantic Gulf Region 03]

Sub region no.	Accounting unit	Cataloging unit	Name of Hydrologic Unit	Square miles: Drainage basin[1]	Square miles: Sub-region[2]	Square miles: Accounting unit[2]	Square miles: Cataloging unit[2]
07			ALTAMAHA - ST. MARYS RIVERS		1,375		
	02		St. Marys - Satilla Rivers			1,375	
		04	St. Marys River Basin	1,480			940
		05	Coastal area between St. Marys and St. Johns River				435
08			ST. JOHNS RIVER		11,358		
	01		St. Johns River Basin	9,168		9,168	
		01	St. Johns River Basin above Oklawaha River	3,753			3,753
		02	Oklawaha River Basin	2,769			2,769
		03	St. Johns River Basin below Oklawaha River	2,646			2,646
	02		East Florida Coastal			2,190	
		01	Coastal area between St. Johns River and Ponce de Leon Inlet				798
		02	Coastal area between Ponce de Leon Inlet and Sebastian Inlet				905
		03	Coastal area Sebastian Inlet to St. Lucie River				487
09			SOUTHERN FLORIDA		18,212		
	01		Lake Okeechobee inflow			4,086	
		01	Kissimmee River Basin	2,933			2,933
		02	Taylor Creek Basin and inflow to Lake Okeechobee from North				273
		03	Fisheating Creek Basin and inflow to Lake Okeechobee from Northwest				880
	02		Lake Okeechobee			14,126	
		01	Lake Okeechobee				696
		02	Everglades and southeastern coastal area				8,028
		03	Florida Bay and the Florida Keys				1,375
		04	Big Cypress Swamp and sonthwestern coastal area				2,649
		05	Caloosahatchee River				1,378
10			PEACE, WITHLACOOCHEE, HILLSBOROUGH RIVERS AND WESTERN COASTAL AREA		9,881		
	01		Peace River			3,630	
		01	Peace River Basin	2,403			2,403
		02	Myakka River Basin	602			602
		03	Charlotte Harbor and coastal area				625
	02		Tampa Bay			6,251	
		01	Coastal area between Myakka and Manatee Rivers				425
		02	Manatee River Basin	357			357
		03	Little Manatee River Basin	222			222
		04	Alafia River Basin	420			420
		05	Hillsborough River Basin	690			690
		06	Tampa Bay and Coastal areas				877
		07	Coastal area from Tampa Bay to Withlacoochee River				1,201
		08	Withlacoochee River Basin	2,059			2,059
11			SUWANNEE AND AUCILLA RIVERS		7,781		
	01		Aucilla River and Coastal area			3,551	
			Waccasassa River and coastal area between Withlacoochee and Suwannee Rivers				924
		02	Coastal area between Suwannee and Aucilla Rivers				1,892
		03	Aucilla River Basin	952			735
	02		Suwannee River	9,950		4,230	
		01	Suwannee River Basin above Withlacoochee River excluding Alapaha River Basin	2,770			866
		02	Alapaha River Basin	1,840			110
		03	Withlacoochee River Basin	2,360			270
		05	Suwannee River Basin below Withlacoochee River excluding Santa Fe River Basin				1,600
		06	Santa Fe River Basin	1,380			1,380
12			OCHLOCKONEE RIVER		2,299		
	00		Ochlockonee River			2,299	
		01	St. Marks and Wakulla Rivers and coastal area between Aucilla and Ochlockonee Rivers				1,047
		03	Ochlockonee River Basin	2,250			1,252
13			APALACHICOLA, CHATTAHOOCHEE, AND FLINT RIVERS		3,080		
	00		Apalachicola River			3,080	
		04	Lower Chattahoochee	17,200			190
		11	Apalachicola River				1,163
		12	Chipola River Basin	1,237			1,020
		13	Coastal area between Ochlockonee and Apalachicola Rivers				557
		14	Apalachicola Bay coastal area and offshore islands				252
14			CHOCTAWHATCHEE, YELLOW, AND ESCAMBIA RIVERS		6,491		
	01		Florida Panhandle Coastal			4,528	
		01	St. Andrew Bay, inflow and coastal area				1,351
		02	Choctawhatchee Bay, inflow and coastal area				692
		03	Yellow River Basin	1,365			858
		04	Blackwater River Basin	860			700
		05	Escambia Bay, inflow and coastal area				542
		06	Perdido River Basin	925			252
		07	Perdido Bay, inflow and coastal area				133
	02		Choctawhatchee River Basin	4,646		1,538	
		02	Pea River	1,100			108
		03	Choctawhatchee River below Pea River	3,546			1,430
	03		Escambia River Basin	4,233		425	
		04	Lower Conecuh River	2,900			8
		05	Escambia River	1,333			417

[1] Includes area (sq. miles) in adjacent states.
[2] Includes area (sq. miles) in Florida only.

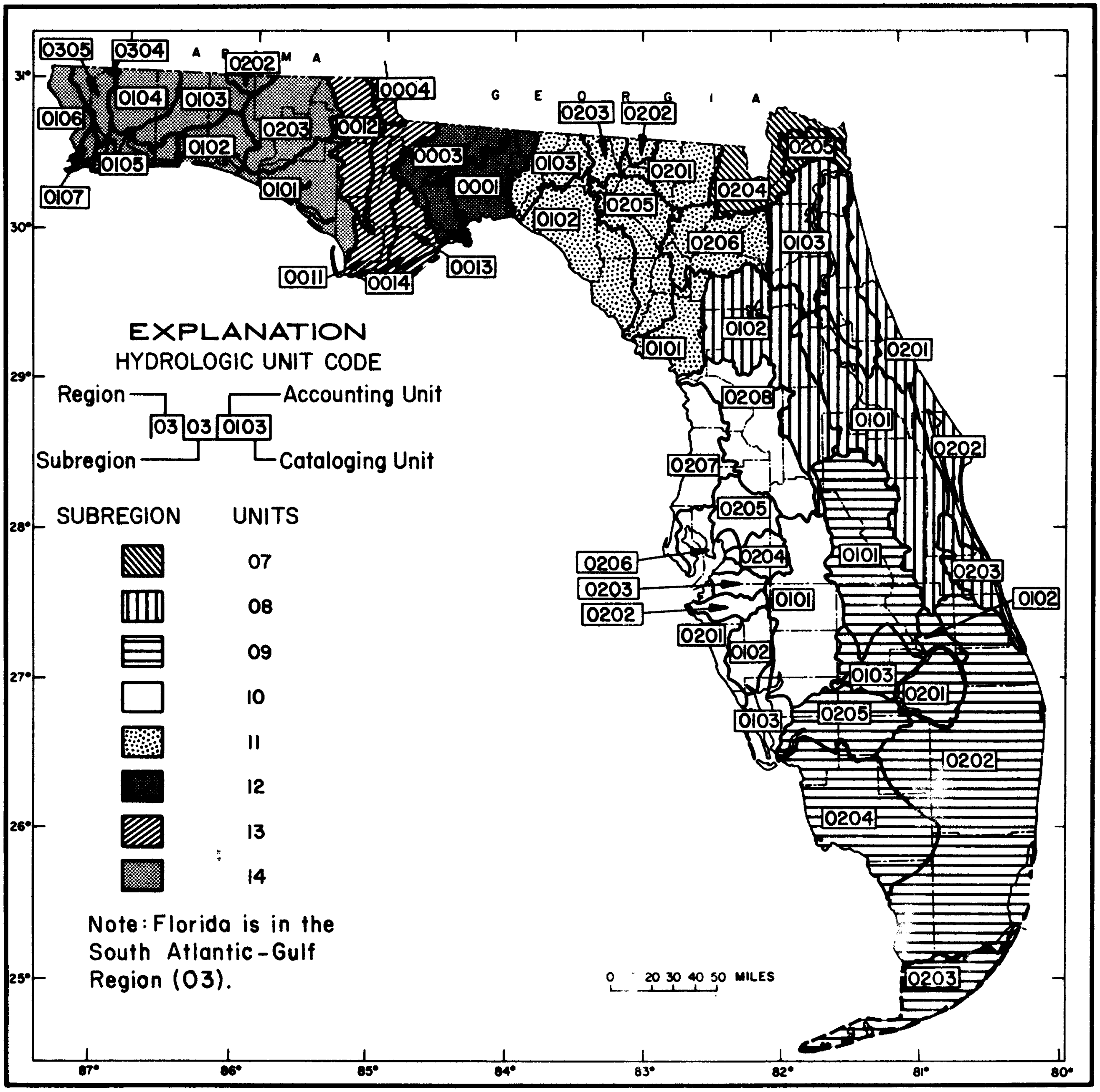


Figure 3.--Hydrologic Unit map of Florida (modified from Conover and Leach, 1975).

Surface-water record sites are listed in the annual data reports in a downstream direction for each river basin along the main stem of a stream. All stations on a tributary that enter above a main-stem station are listed before that station. If a tributary enters between two main-stem stations, it is listed between them. A similar order is followed listing stations on first rank, second rank, and other ranks of tributaries. To indicate the rank of any tributary on which a gaging station is situated and the stream to which it is immediately tributary, each indention in the listing of gaging stations represents one rank (U.S. Geological Survey, 1972).

Downstream order station numbers are not assigned to wells or miscellaneous surface-water sites where only random water-quality samples or discharge measurements are taken. A grid system based on latitude and longitude provides each well and miscellaneous site with a unique number consisting of 15 digits. The first 6 digits denote the degrees, minutes, and seconds of latitude; the next 7 digits denote degrees, minutes, and seconds of longitude; and the last 2 digits are a sequential number for sites within a 1-second grid. In the event that the latitude-longitude coordinates for two sites are the same, sequential numbers "01," "02," are assigned.

HYDROLOGY

Hydrology is the science of the behavior and properties of water in the atmosphere, and on and under the surface of the Earth. The exchange of water between Earth and atmosphere is called the hydrologic cycle.

Two distinguished hydrologists of the U.S. Geological Survey, Luna B. Leopold and Walter B. Langbein (1960), best describe in a few words the basic history of water knowledge:

"In the Middle Ages people believed that the water in rivers flowed magically from the center of the Earth. Late in the 17th century Halley, the famous English astronomer, added up the amount of water flowing in rivers to the Mediterranean Sea and found that their flow is about equal to the water falling as rain and snow on the area drained by the rivers. At nearly the same time, two Frenchmen, Perrault and Marriotte, made measurements of the flow of rivers and also found their flow about equal to the amount of water falling as rain and snow. These are the earliest known instances of anyone having correctly reasoned that precipitation feeds lakes, rivers, and springs. This idea was very much advanced for the time. Now there are enough river-measuring stations to permit that kind of comparison accurately for many parts of the world." Thus, we now know that the flow of rivers equals only a part of the precipitation falling on a drainage basin or contributing area. For example, the annual runoff in Florida averages about 14 inches, less than 30 percent of the average statewide precipitation of 53 inches.

"Water is being exchanged between the Earth and the atmosphere all the time. This exchange is accomplished by the heat of the Sun and the pull of gravity. Water evaporates from wet ground, from the leaves of growing plants, and from lakes and reservoirs. It is carried in the air as water vapor, a gas. When water vapor condenses it changes from a gas to a liquid and falls as rain. The rain feeds the rivers and lakes. Rivers carry water to the ocean. Evaporation from land and ocean puts water back in the atmosphere, and this exchange goes on continually. Water goes from Earth to atmosphere to Earth, around and around."--referred to as the hydrologic cycle (fig. 4).

In this system, there is no water lost or gained, but the amount of water available to the user may fluctuate because of variations at the source, or more usually, in the delivering agent.

Selected facts compiled by the U.S. Geological Survey on the world's water supply are as follows:

"Every second, millions of Sun-heated molecules are evaporated into the air to help supply the water for the hydrologic cycle.

"Only about 3,100 cubic miles of water, chiefly in the form of invisible vapor, are contained in the atmosphere at any given time. If it were to fall all at once, the Earth would be covered with only about 1 inch of water.

"Of the 102,000 cubic miles of water that pass into the atmosphere annually, 78,000 cubic miles fall directly back into the oceans. Streams and rivers collect and return to the oceans some 9,000 cubic miles of water, including a large quantity of water which has soaked down into the ground and which, as "ground water," has moved slowly to natural outlets in the beds and banks of streams. The remaining 15,000 cubic miles of water maintain life processes, principally as soil moisture which provides water necessary to vegetation. This water reaches the atmosphere again by the process of evapotranspiration.

"Once fallen, water may run swiftly to the sea in rivers, or may be held in a glacier for 40 years, in a lake for 100 years, or in the ground for thousands of years. Or, it may evaporate immediately. Regardless of how long the water may be delayed, it is eventually released to enter the cycle once more.

"The total water supply of the world is 326 million cubic miles (1 cubic mile of water equals more than 1 trillion gallons). At any instant, only about 5 gallons of every 100,000 gallons is in motion. Most of the water is stored in the oceans, frozen in glaciers, held in lakes, or detained underground.

"More than 2 million cubic miles of freshwater are stored in the Earth, about half within a half mile of the surface. This is more than 35 times the amount held on the surface in lakes, rivers, and inland seas, but in turn, is relatively small compared to the 7 million cubic miles stored in glaciers and icecaps.

"The 317 million cubic miles of water held by the oceans constitute 97.3 percent of the Earth's supply.

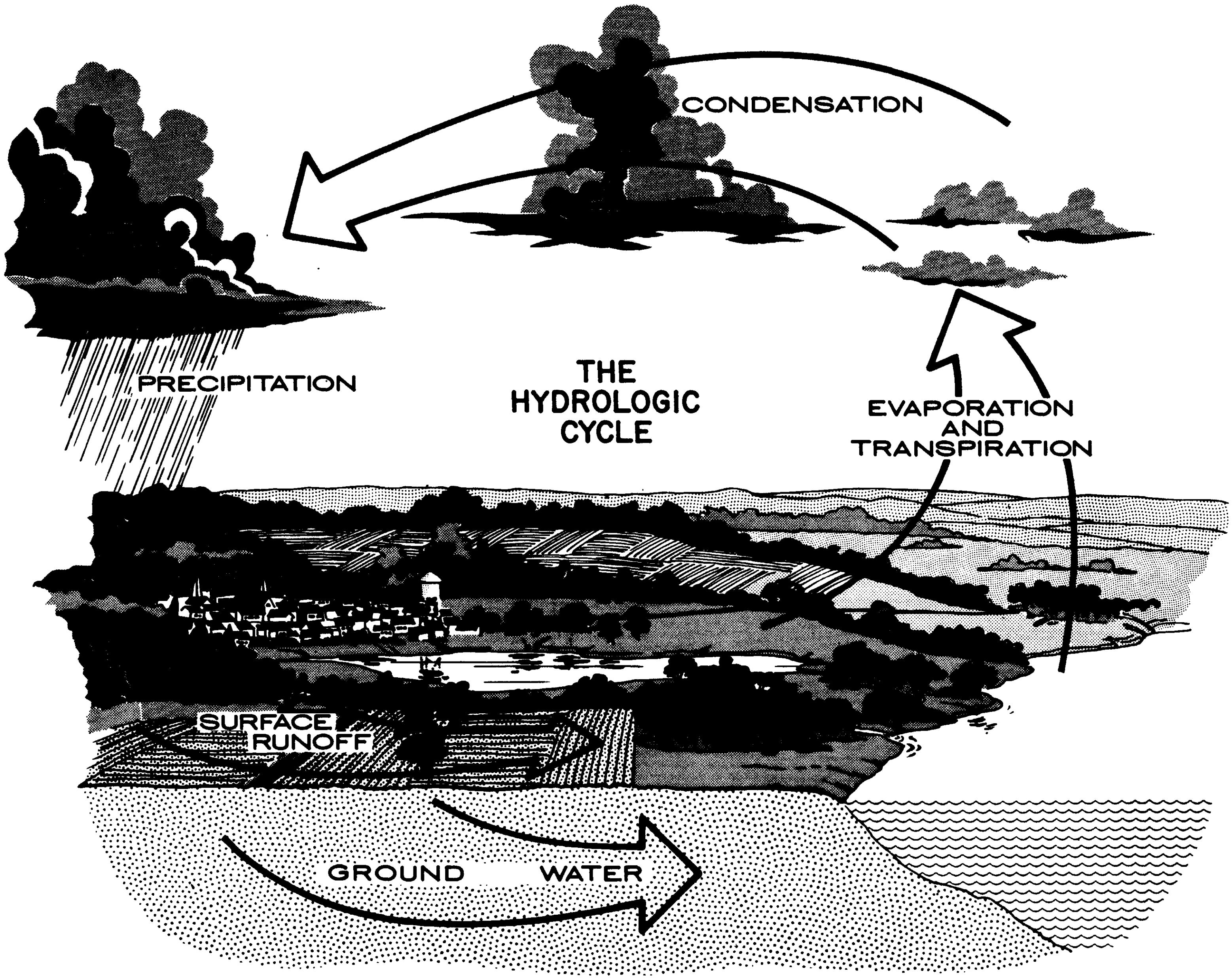


Figure 4.--The hydrologic cycle.

"If the world's total supply of water was poured upon the 50 United States, the land surfaces would be submerged to a depth of 90 miles.

"The conterminous United States receives a total volume of about 1,430 cubic miles of precipitation each year."

CLIMATE

Much of the information on climate in this section is adapted from "Climate of Florida" and other records and reports of the National Oceanic and Atmospheric Administration, National Weather Service (formerly U.S. Weather Bureau).

Climatic conditions in Florida range from a zone of transition between temperate and subtropical in the extreme northern interior to tropical in the Florida Keys. The climate is affected by the southerly latitude (25° to 31°N), the Atlantic Ocean, the Gulf of Mexico, and by the many lakes located throughout the peninsula.

A temperate, or variable, zone (climate) is defined as being situated between the tropical and frigid zones, from latitude 23½°N to 66½°N. A tropical climate (defined by the National Oceanic and Atmospheric Administration, National Weather Service) is one in which the average temperature of the coldest month is 64.4° Fahrenheit (18.1° Celsius) or higher.

Temperature

Florida summers are usually long with periods of very warm, humid air (50-95 percent relative humidity) throughout the State. Winters are generally mild except for short periods when cold fronts move southeastward from the northwestern section of the continent. Coastal areas are generally cooler in summer and slightly warmer in winter than inland areas at the same latitude.

Maximum temperatures in the State average about 90°F (32°C). Temperatures of 100°F (38°C) and higher are infrequent in most of the State and practically unknown in parts of southern Florida. June, July, and August are the hottest months on the average, exceeding 80°F throughout the State. The mean monthly maximum temperatures exceed 90°F for most of the State, except for much of the coastal areas.

Mean annual temperatures range from upper 60°F (16°C) in the northern part to middle 70°F (21°C) in the south, except for the Keys, which reach a mean annual temperature of nearly 78°F (26°C) (table 6). Overall, Florida is the hottest state and has the least seasonal range of temperature--about 30°F on the average. Some notable temperature extremes as of 1972 are: highest, 109°F at Monticello on June 29, 1931, and lowest, 2°F at Tallahassee on February 13, 1899.

No place in Florida is safe from frost or freezing, but it is rare for temperatures to remain below freezing throughout the day at any place in Florida. Very cold periods seldom last more than 2 or 3 days at a time.

Table 6.--Temperature data for selected long-term climatological stations in Florida listed alphabetically by counties

[Modified from National Oceanic and Atmospheric Administration, 1978a]

County and station	Extreme temperature (°F)[1]				Normal or average temperature (°F)[2]													Reference years of record and ending year	
	Max	Date	Min	Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Year		
Alachua, Gainesville 3 WSW	102	1957	12	1962	57.2	58.6	63.6	70.0	75.8	80.0	81.1	81.2	79.1	71.8	63.3	57.8	69.9	(25)	1978
Baker, Glen St. Mary 1 W	103	1945	9	1962	54.2	56.3	61.3	68.0	73.9	78.9	80.6	80.6	77.8	69.6	60.6	54.7	68.0	(83)	1978
Bay, Panama City 2	105	9/--/25	9	12/--/62	55.2	56.9	61.3	67.9	75.1	80.7	82.0	82.0	79.1	71.0	60.8	55.6	69.0	(62)	1960
Bradford, Starke	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	(21)	1978
Brevard, Melbourne	102	--	18	--	61.8	62.7	66.5	71.5	75.6	79.4	81.2	81.5	80.3	75.1	67.9	63.1	72.2	(41)	1978
Broward, Fort Lauderdale	99	9/--/35	29	12/--/34	66.8	67.7	70.7	74.6	77.5	80.5	82.2	82.7	81.5	77.6	72.2	67.9	75.2	(65)	1978
Calhoun, Blountstown	105	--	12	--	51.4	54.1	59.8	67.9	74.6	79.9	81.1	81.1	77.7	68.6	58.3	52.1	67.2	(66)	1978
Charlotte, Punta Gorda	103	7/--/52	25	12/--/62	64.8	66.1	69.1	73.7	78.1	80.9	82.0	82.3	81.3	76.9	70.2	65.9	74.3	(29)	1960
Citrus, Inverness	105	1965	18	1905	59.8	61.8	65.3	70.6	76.4	80.5	81.6	81.9	80.1	73.3	65.0	60.2	71.4	(61)	1960
Clay, Middleburg	107	--	12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	(28)	1938
Collier, Everglades	99+	9/02/72	28	1/21/71	65.6	66.6	69.9	74.1	77.5	80.8	82.3	82.9	82.0	77.9	71.7	66.8	74.8	(52)	1978
Columbia, Lake City 2 E	105	6/10/54	10	12/13/62	54.6	56.7	62.0	68.9	75.0	79.5	80.8	80.9	78.0	70.2	61.4	55.8	68.7	(95)	1978
Dade, Miami WSMO AP	96	4/--/71	34	12/--/68	67.2	67.8	71.3	75.0	78.0	81.0	82.3	82.9	81.7	77.8	72.2	68.3	75.5	(40)	1978
De Soto, Arcadia	103	1927	18	1962	62.1	63.5	67.6	72.2	76.7	80.0	81.2	81.7	80.3	74.7	67.0	63.0	72.6	(75)	1978
Dixie, Cross City 2 WNW	103	7/--/50	17	2/--/43	54.4	56.2	61.6	68.5	74.7	79.5	80.8	79.8	78.9	70.6	61.1	55.2	68.6	(19)	1978
Duval, Jacksonville WSO AP	105	7/--/42	12	12/--/62	54.6	56.3	61.2	68.1	74.3	79.2	81.0	81.0	78.2	70.5	61.2	55.4	68.4	(42)	1978
Escambia, Pensacola FAA AP	100	7/--/72	11	1/--/66	52.1	54.8	59.9	68.1	75.2	80.6	81.8	81.8	78.3	70.0	59.5	53.8	68.0	(34)	1978
Flagler, Marineland	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1978
Franklin, Apalachicola WSO AP	102	7/--/32	13	12/--/62	53.7	55.8	60.7	68.3	74.9	80.0	81.4	81.5	78.6	70.8	61.1	55.2	68.5	(76)	1978
Gadsden, Quincy 3 SSW	105	--	12	--	52.8	55.0	60.2	67.6	74.1	79.1	80.1	80.2	77.1	68.9	59.4	53.5	67.3	(11)	1978
Gilchrist	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Glades, Moore Haven Lock 1	99	9/01/72	24	12/13/62	62.7	63.9	68.0	72.7	76.6	80.1	81.4	81.9	80.8	76.0	69.0	64.1	73.1	(60)	1978
Gulf, Wewahitchka	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	(23)	1978
Hamilton, Jasper 3 SE	103	--	5	--	52.7	56.8	60.5	67.1	73.3	78.6	80.0	80.5	77.3	68.2	59.7	53.0	67.3	(9)	1960
Hardee, Wauchula 2 N	--	--	--	--	61.8	63.1	67.1	72.1	76.6	80.2	81.3	81.6	80.2	74.7	67.4	62.7	72.4	(46)	1978
Hendry, La Belle	--	--	--	--	63.4	64.7	68.5	73.1	76.9	80.4	81.5	81.9	80.6	75.6	68.5	64.3	73.3	(48)	1978
Hernando, Brooksville Chin Hill	100	5/28/62	15	12/13/62	60.2	61.6	66.1	71.7	76.6	80.2	80.8	81.0	79.6	73.7	66.0	61.3	71.6	(86)	1978
Highlands, Avon Park 2 W	103	7/31/61	20	12/13/62	62.9	64.2	68.4	73.5	77.9	81.3	82.4	82.3	81.3	75.8	68.8	64.1	73.6	(86)	1978
Hillsborough, Tampa WSMO R	98	8/--/75	23	1/--/71	60.4	61.8	66.0	72.0	77.2	81.0	81.9	82.2	80.8	74.7	66.8	61.6	72.2	(89)	1978
Holmes, Bonifay	107	--	13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	(26)	1938
Indian River, Fellsmere 7 SSW	102	1958	21	1976	63.2	64.5	67.4	71.9	76.3	80.3	81.8	82.0	80.5	75.6	68.8	64.4	73.1	--	1960
Jackson, Marianna Sch for Boys	106	--	13	--	54.4	56.3	61.1	67.7	74.7	80.0	81.0	80.8	77.6	69.0	59.2	54.4	68.0	--	1960
Jefferson, Monticello 3 W	106	5/28/62	7	12/13/62	52.7	54.8	60.4	68.0	74.5	79.4	80.6	80.5	77.2	68.9	59.2	53.3	67.5	(75)	1978
Lafayette, Mayo 5 NW	--	--	--	--	55.3	58.0	61.6	68.1	75.2	80.2	81.4	81.3	78.4	70.3	60.0	54.7	68.7	(11)	1960
Lake, Clermont 6 SSW	101	7/31/61	19	12/13/62	60.0	61.7	66.3	72.2	77.3	80.9	81.7	82.2	80.5	74.3	66.3	60.9	72.0	(86)	1978
Lee, Fort Myers WSO AP	98	6/--/75	26	12/--/62	63.5	64.7	68.5	73.3	77.7	81.1	82.5	82.8	81.6	76.4	69.4	64.8	73.9	(87)	1978
Leon, Tallahassee WSO AP	100	8/--/72	10	12/--/62	52.8	54.8	60.3	67.9	74.8	80.0	81.1	81.1	78.1	69.3	58.9	53.2	67.7	(92)	1978
Levy, Cedar Key 1 WSW	103	1942	15	1962	58.3	60.0	64.0	70.5	77.4	81.9	82.5	82.7	81.1	74.5	65.6	59.8	71.5	--	1960
Liberty, Bristol	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1978
Madison, Madison 4 N	103	5/27/53	7	12/13/62	53.9	56.0	61.6	69.3	75.8	80.3	81.3	81.3	77.9	69.7	60.2	54.4	68.5	(75)	1978
Manatee, Bradenton Exp Sta	100	6/--/98	19	12/--/94	61.9	63.2	66.1	71.0	76.2	79.9	81.0	81.3	80.3	74.8	67.6	63.0	72.2	(75)	1960
Marion, Ocala	105	1933	16	1962	58.8	61.9	65.8	71.2	77.8	81.5	82.2	82.6	80.3	73.0	65.4	59.7	71.7	(58)	1960
Martin, Stuart 1 N	105	1942	26	1962	65.4	66.2	69.7	74.1	77.5	80.9	82.2	82.7	81.6	77.3	71.4	66.7	74.6	(43)	1978
Monroe, Tavernier	98+	9/03/63	38+	12/14/62	69.5	70.2	73.3	76.7	79.3	82.0	83.3	83.8	82.3	78.8	74.3	70.6	77.0	(42)	1978
Nassau, Fernandina Beach	102+	8/08/51	16	12/13/62	56.6	58.0	62.1	68.6	75.3	80.	82.0	82.3	79.6	72.0	63.2	57.1	69.8	(82)	1978
Okaloosa, Niceville	103	1968	8	1962	50.4	52.7	58.0	66.1	73.0	78.9	80.7	80.7	77.0	68.1	57.8	51.7	65.3	(52)	1978
Okeechobee, Okeechobee Hrcn Gate 6	99	--	23	--	62.9	64.7	67.8	72.5	77.2	79.8	80.7	81.4	80.3	76.0	70.0	63.8	73.1	(13)	1960
Orange, Orlando WSO McCoy	99	5/--/73	24	1/--/66	56.8	61.5	65.9	71.3	76.4	80.2	81.4	81.8	80.1	74.3	66.6	61.5	71.8	(5)	1978
Osceola, Kissimmee 2	102	6/--/52	19	2/--/95	60.9	62.6	66.2	71.2	76.4	80.2	81.4	81.8	80.0	74.2	66.7	61.9	72.0	--	1960
Palm Beach, Belle Glade Exp Sta	97+	6/13/52	25	1/18/65	62.8	63.7	67.3	71.3	75.1	78.8	80.3	80.7	79.7	75.1	68.6	64.0	72.3	(54)	1978
Pasco, Saint Leo	100+	5/28/62	18	12/13/62	60.5	62.0	66.5	72.2	77.3	80.8	81.7	82.0	80.4	74.2	66.6	61.7	72.2	(84)	1978
Pinellas, Tarpon Spgs Sewage Pl	98	7/02/57	19+	12/14/62	60.0	61.5	65.6	71.2	76.5	80.5	81.8	82.0	80.6	74.4	66.5	61.2	71.8	(93)	1978
Polk, Lakeland 3 SE	101	7/--/42	20	12/--/62	60.8	62.1	66.3	72.0	77.0	80.5	81.6	81.9	80.2	74.3	66.8	62.0	72.1	(63)	1978
Putnam, Palatka	105	1950	16	1962	59.2	61.0	65.0	70.6	76.8	81.2	82.5	82.5	80.3	73.2	64.8	59.4	71.4	(53)	1978
St. Johns, St. Augustine	102+	8/19/72	16	12/13/62	57.8	59.4	63.1	69.0	75.1	79.7	81.0	81.1	79.4	72.8	64.2	58.6	70.1	(--)	1960
St. Lucie, Fort Pierce	99	9/26/59	24	12/13/62	63.5	64.3	68.0	72.5	76.3	79.7	81.2	81.6	80.6	76.1	69.6	65.0	73.2	(78)	1978
Santa Rosa, Milton Exp Sta	--	--	--	--	54.0	55.9	59.1	66.3	74.1	78.9	80.5	80.7	76.6	67.8	57.6	53.1	67.1	(12)	1960
Sarasota, Sarasota	--	--	--	--	62.2	64.9	67.0	71.3	76.7	80.2	81.3	82.0	80.9	76.0	68.6	63.7	72.9	(12)	1960
Seminole, Sanford Exp Sta	102	--	21	--	60.2	61.4	65.8	71.3	76.4	80.4	81.8	81.9	80.0	74.2	66.5	61.5	69.0	(23)	1978
Sumter, Bushuell 2 E	100+	6/16/64	15	12/13/62	59.0	60.7	65.3	70.9	75.9	79.9	81.0	81.2	79.6	73.0	64.8	59.9	70.9	(42)	1978
Suwannee, Live Oak	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	(82)	1978
Taylor, Perry	103	--	15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	(56)	1978
Union, Raiford State Prison	104	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1978
Volusia, Daytona Bch WSO APR	102	6/--/44	21	12/--/62	58.4	59.6	63.9	69.7	75.0	79.4	81.0	81.1	79.5	73.3	65.1	59.6	70.5	(65)	1978
Wakulla, St. Marks 6 SE	103	6/27/52	11	12/13/62	54.5	57.1	61.3	68.2	75.4	80.6	81.7	81.8	78.8	70.9	60.8	54.2	68.8	(18)	1960
Walton, DeFuniak Springs	105+	7/24/52	5	12/13/62	52.3	55.0	60.4	68.8	75.2	80.2	81.4	81.3	77.5	68.9	58.8	53.2	67.8	(80)	1978
Washington, Chipley 3 E	103	6/28/54	8	12/13/62	53.0	55.4	60.6	68.2	74.4	79.6	80.9	80.8	77.6	68.7	59.0	53.7	67.7	(40)	1978

[1] Extreme temperature.--Maximum and minimum figures for each county identified without dates are from U.S. Department of Agriculture, 1941, which may or may not be for same location as current station.

[2] Normal temperature.--Climatological normals are usually based on 30 years of record for periods 1931 through 1960, or 1941 through 1970, or earlier periods. Normals are not available for a few stations with 30 or more years of record through 1970 (as indicated by number of years of record through 1978).

Average temperature.--Long-term means (averages) are used in place of normals for varied periods of record of less than 30 years. Averages have been computed only through 1960 for some selected stations (as noted by ending year), even though stations may be currently in operation.

Average minimum winter temperatures range from the middle 40°F (4°C) in the north to the middle 50°F (10°C) in the south. Available records indicate that the February 1835 freeze was probably the most severe experienced to date in Florida during some two dozen outstanding recorded cold spells. The more recent freeze of the 20th century, December 1962, was as severe as those in the late 1890's (table 7).

Rainfall

Rainfall in Florida is generally abundant (fig. 5), but it is quite varied both in annual amount and in seasonal distributions (figs. 6-12; table 8). Mean annual rainfall varies from about 40 inches in the Florida Keys to more than 64 inches in southeast and northwest Florida and averages about 53 inches for the State. Many areas have received more than 80 inches in a calendar year; and in a few cases, more than 100 inches have been measured in a year at some sites. Almost all areas of the State have experienced a dry year of less than 40 inches. Averages show October as the driest month in northwest Florida but, in general, it is among the wettest months on the southeast coast and Florida Keys. The greatest 24-hour rainfall of 38.7 inches was recorded at Yankeetown, September 5-6, 1950.

Summer rainfall comes mostly from thunderstorms. Florida has the greatest number of thunderstorms of any state, averaging more than 70 days per year with parts of central Florida averaging more than 100 per year. Practically every part of Florida occasionally has very heavy rains, nearly always associated with tropical disturbances (U.S. Department of Agriculture, 1941).

Much of the rainfall in Florida is returned to the atmosphere by evaporation from land and water and by evapotranspiration from plants. Yearly potential evaporation from lake surfaces in Florida ranges from about 45 inches in northeast Florida to about 55 inches in the Keys (fig. 13). On an average day, as much as 1.6 billion gallons of water evaporate from Lake Okeechobee. Evaluation of the amount and areal variation of rainfall in excess of all evaporative losses is necessary to appraise the outflow of water from an area. Outflow is the total surface and ground-water flow from an area and is equal to the difference between rainfall in an area and actual evaporation and transpiration from an area.

Figure 13 depicts the difference between rainfall and potential evaporation in Florida. Potential evaporation essentially represents the amount of evaporation that would occur yearly if an area were perennially wet. The map thus portrays the minimum outflow to be expected from an area; however, actual outflow cannot be determined from the map. Actual outflow will almost always exceed the minimum because actual evaporation is almost always less than potential evaporation.

Table 7.--Dates of severe freezes of the 19th century and noteworthy cold spells of the 20th century in Florida

[Modified from National Oceanic and Atmospheric Administration, 1972]

19th century	20th century
February 1835[1]	January 1905
January 1857	December 1906
December 1870	December 1909
December 1880	February 1917
January 1886	January 1928
December 1894	December 1934
February 1895	January 1940
January 1898	February 1947
February 1899	December 1957
	January 1958
	December 1962[2]
	November 1970[3]
	January 1971[4]

[1] Most severe known.
[2] Severe as those freezes in late 1890's.
[3] Historic early freeze.
[4] Long-duration freeze.

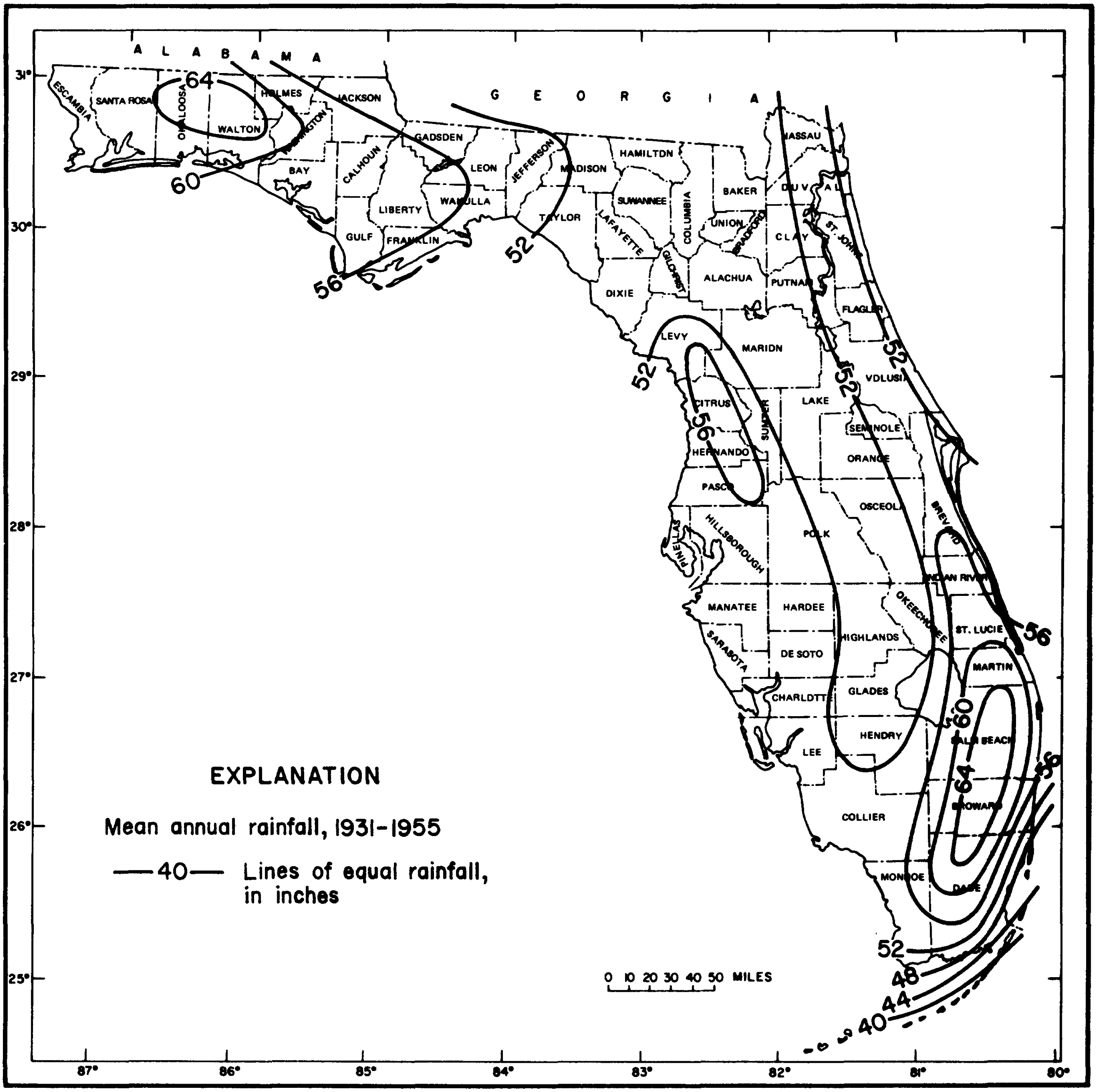


Figure 5.--Mean annual rainfall (January-December) in Florida (modified from Hughes and others, 1971).

Figure 6.--Mean seasonal rainfall for spring (March-May) in Florida (modified from Hughes and others, 1971).

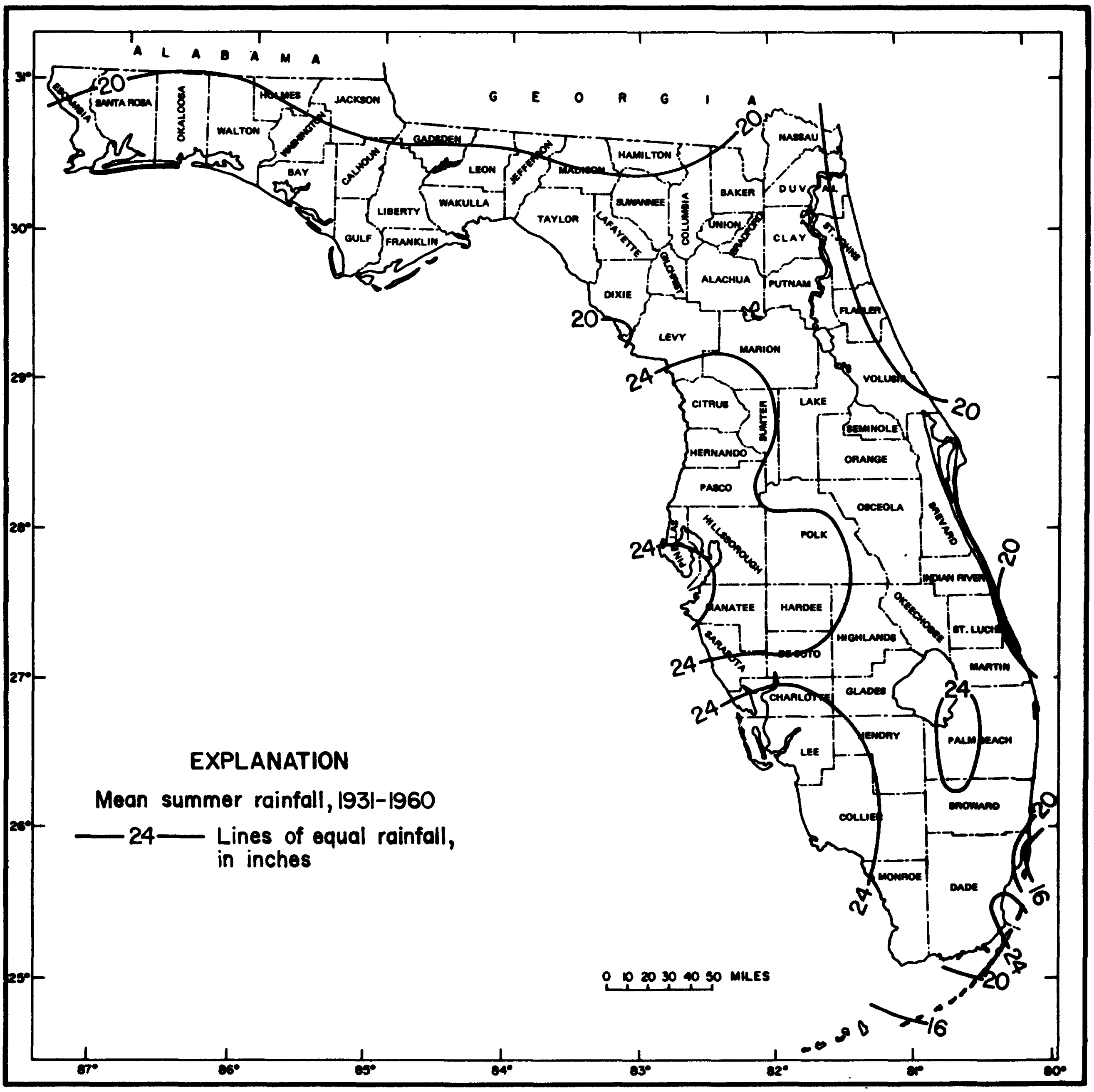


Figure 7.--Mean seasonal rainfall for summer (June-August) in Florida (modified from Hughes and others, 1971).

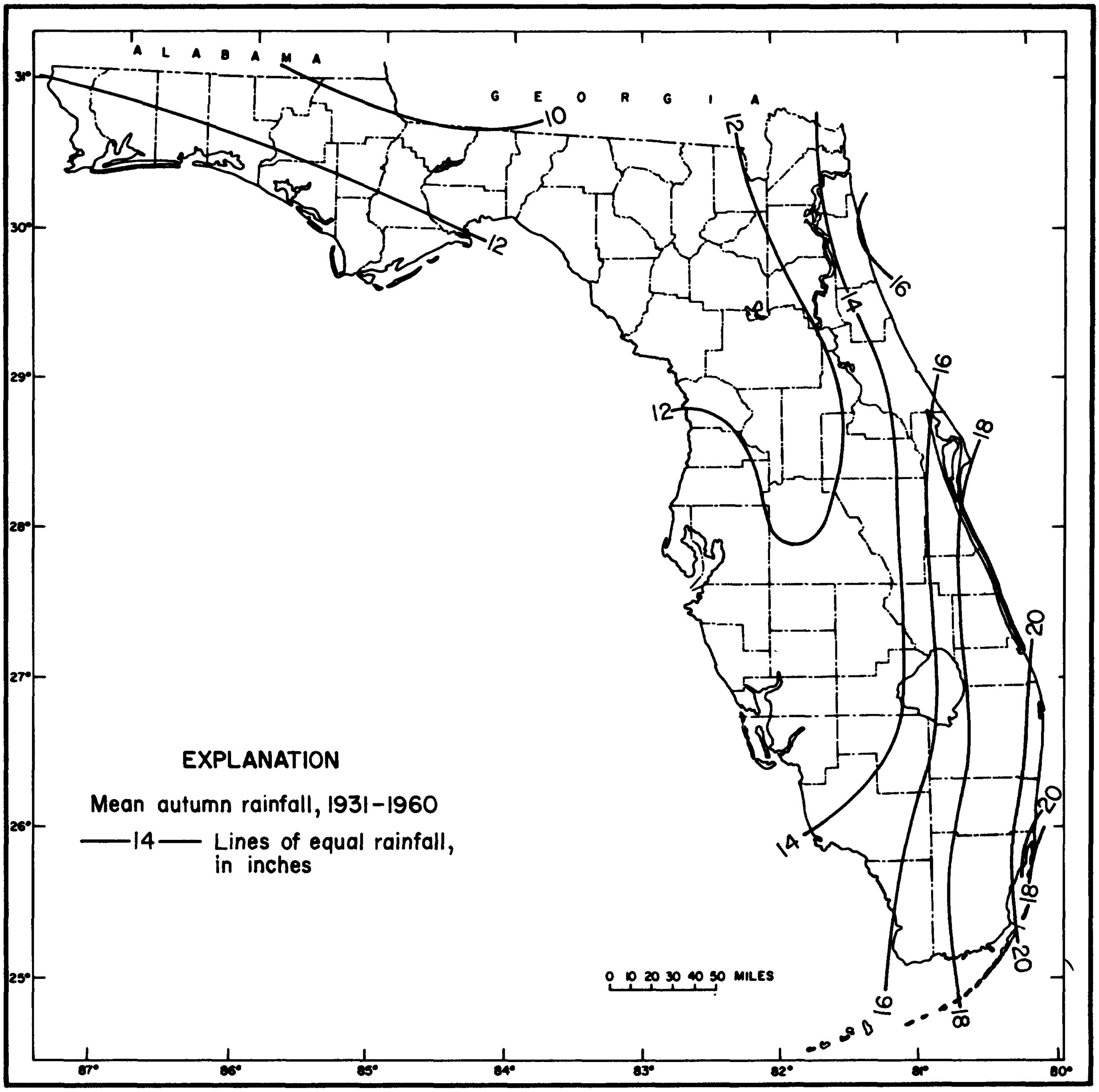


Figure 8.--Mean seasonal rainfall for autumn (September-November) in Florida (modified from Hughes and others, 1971).

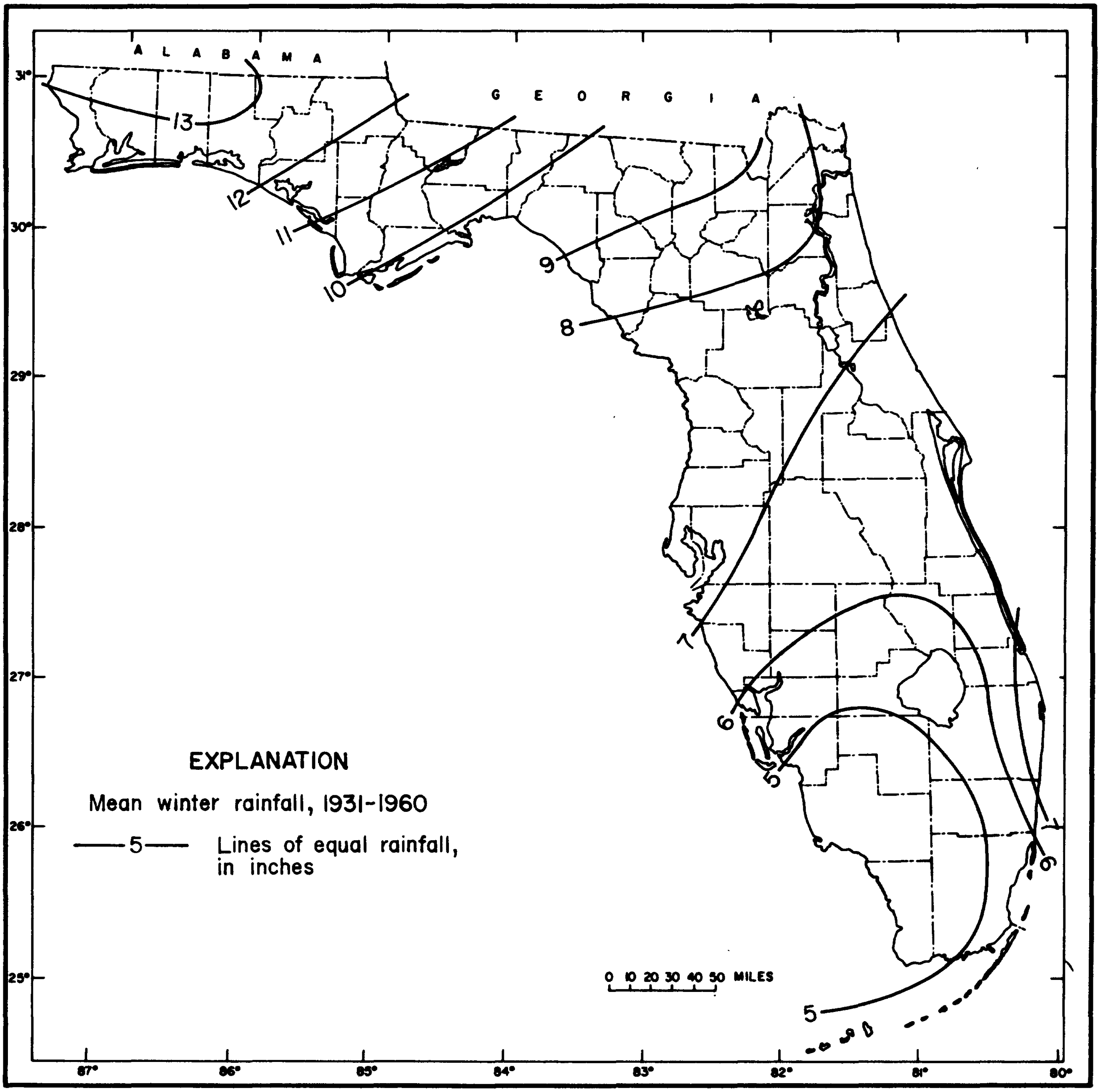


Figure 9.--Mean seasonal rainfall for winter (December-February) in Florida (modified from Hughes and others, 1971).

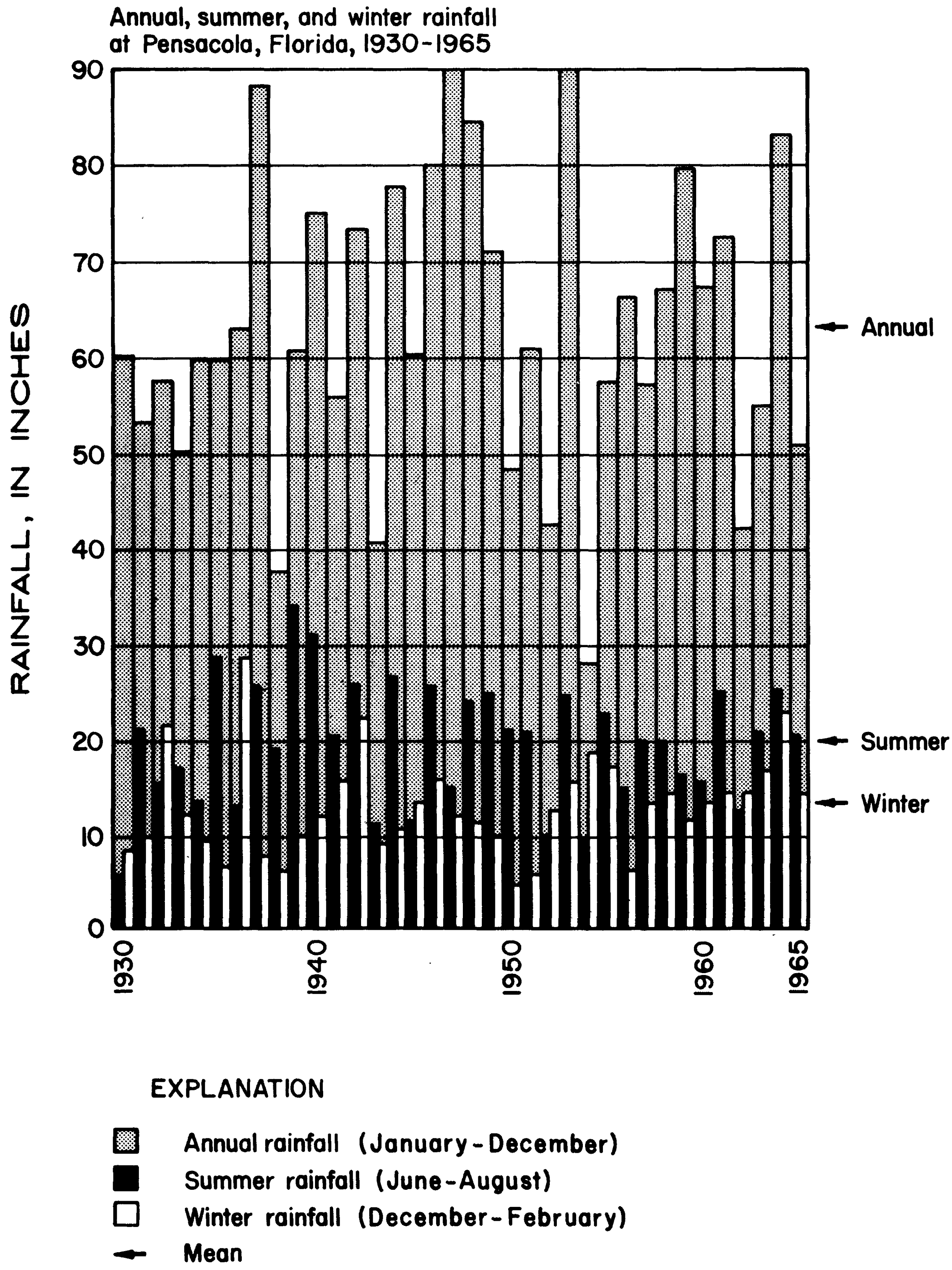


Figure 10.--Variation of rainfall during period 1930-65 at Pensacola, Florida (modified from Hughes and others, 1971).

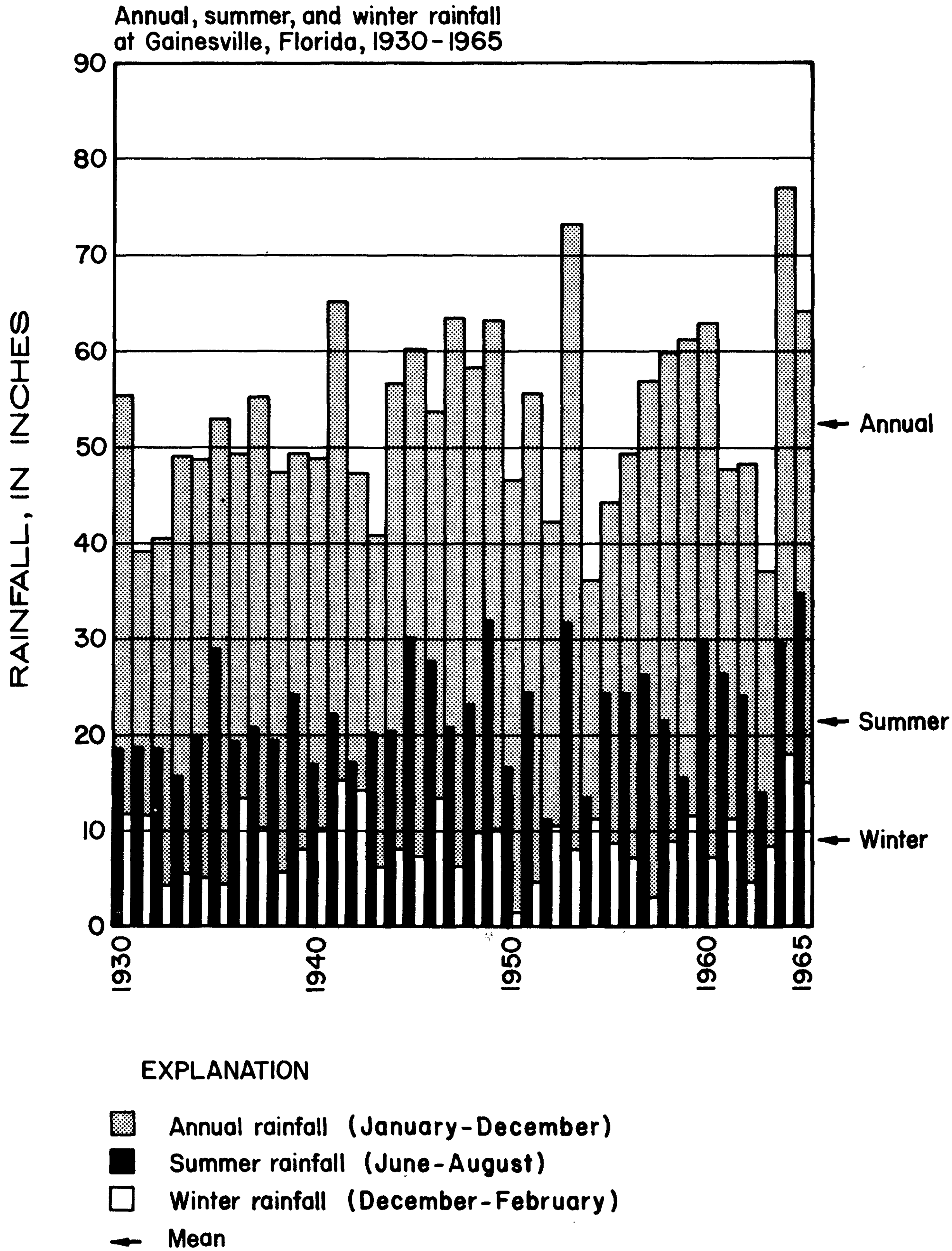


Figure 11.--Variation of rainfall during period 1930-65 at Gainesville, Florida (modified from Hughes and others, 1971).

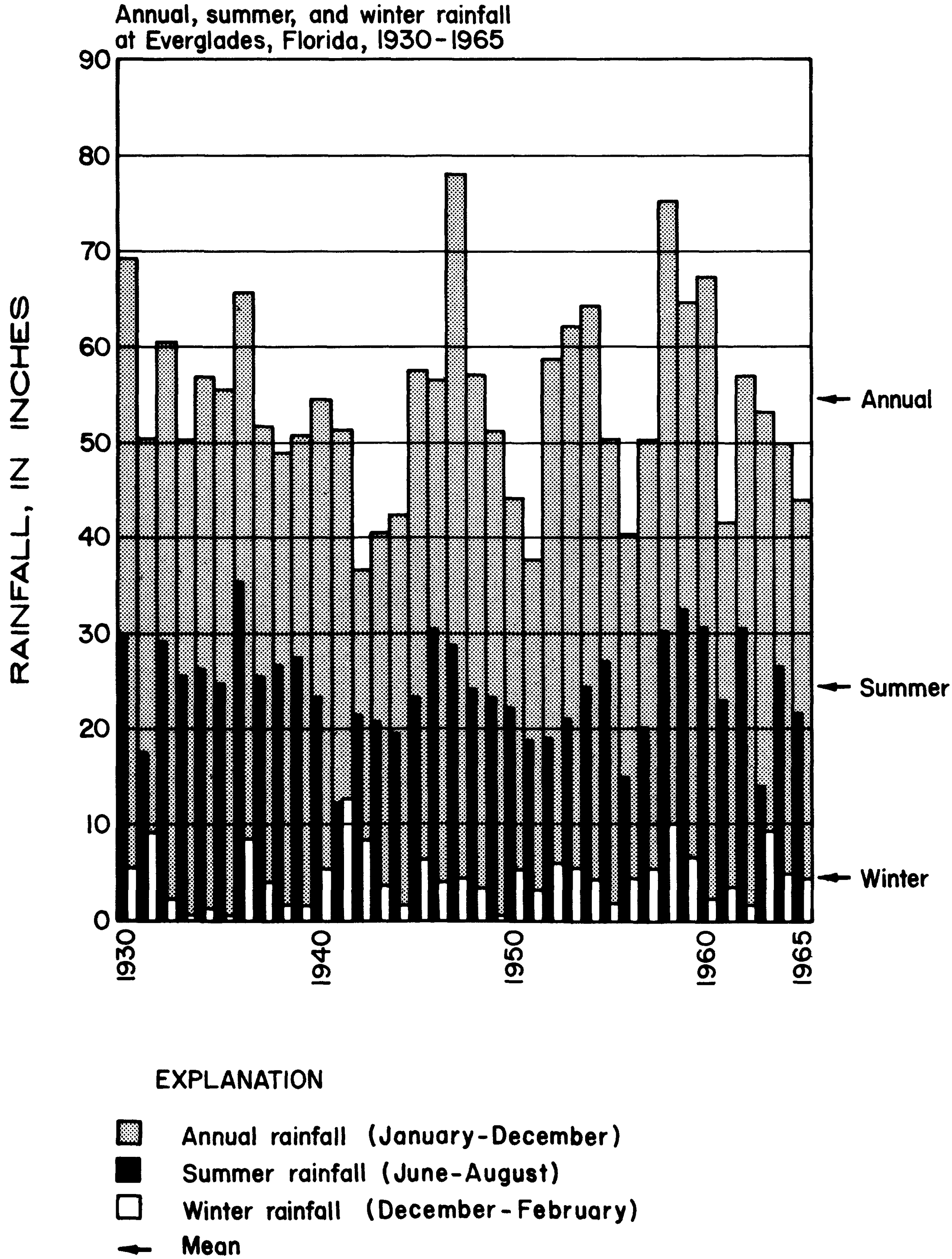


Figure 12.--Variation of rainfall during period 1930-65 at Everglades, Florida (modified from Hughes and others, 1971).

Table 8.--Rainfall data for selected long-term climatological stations in Florida listed alphabetically by counties

[Modified from National Oceanic and Atmospheric Administration, 1978a]

County and station	Maximum rainfall (inches)				Normal or average rainfall (inches)[1]													Reference years of record and ending year	
	Month	Date	Day	Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Year		
Alachua, Gainesville 3 WSW	20.19	6/92	9.93	10/--/41	2.84	3.70	4.26	3.02	3.54	6.81	8.03	8.25	5.67	3.67	1.92	2.88	54.59	(25)	1978
Baker, Glen St. Mary 1 W	--	--	--	--	3.17	4.04	4.37	2.94	4.13	6.60	8.82	7.97	7.14	3.79	2.31	3.47	58.75	(83)	1978
Bay, Panama City 2	--	--	10.50	8/--/32	3.56	4.08	5.32	4.65	3.02	4.46	8.21	7.90	6.67	2.70	3.30	4.14	58.01	(64)	1960
Bradford, Starke	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	(21)	1978
Brevard, Melbourne	--	--	--	--	2.20	2.81	3.68	2.36	3.57	6.54	6.05	5.63	8.19	5.55	2.60	1.61	50.79	(41)	1978
Broward, Ft. Lauderdale	--	--	10.85	10/--/47	2.27	2.30	2.46	3.44	5.51	8.17	5.92	6.91	8.61	8.93	2.93	2.63	60.08	(65)	1978
Calhoun, Blountstown	--	--	--	--	4.15	4.09	5.10	4.70	4.53	5.56	7.96	6.54	5.74	3.02	3.02	3.87	58.67	(66)	1978
Charlotte, Punta Gorda 4 ESE	--	--	9.00	9/--/62	1.91	2.30	2.79	2.37	3.64	9.12	7.39	7.20	8.02	4.06	1.34	1.65	51.79	(14)	1978
Citrus, Inverness	--	--	--	--	2.64	3.39	4.30	2.50	3.48	7.07	9.53	9.81	6.40	3.23	1.54	2.40	56.29	(79)	1978
Clay, Camp Blanding	--	--	--	--	2.16	2.38	3.37	3.30	3.05	5.78	7.90	6.87	6.38	4.99	1.79	2.50	50.47	(16)	1957
Collier, Everglades	23.47	6/69	10.09	6/30/66	1.67	1.79	1.96	2.43	4.66	9.49	8.60	6.79	9.60	4.76	1.42	1.23	54.40	(52)	1978
Columbia, Lake City 2 E	15.31	6/65	7.01	9/29/63	3.45	3.87	4.06	3.27	3.84	6.48	7.37	6.85	5.88	3.52	2.29	3.26	54.14	(95)	1978
Dade, Miami WSMO AP	24.40	9/60	9.95	10/--/48	2.15	1.95	2.07	3.60	6.12	9.00	6.91	6.72	8.74	8.18	2.72	1.64	59.80	(40)	1978
De Soto, Arcadia	--	--	--	--	2.16	2.55	2.95	2.51	4.10	9.07	8.84	7.79	7.57	4.07	1.84	1.98	55.43	(78)	1978
Dixie, Cross City 2 WNW	18.76	7/41	7.04	7/--/41	2.95	3.77	4.48	2.85	3.67	7.04	10.38	7.88	6.81	2.99	2.25	2.84	57.91	(19)	1978
Duval, Jacksonville WSO AP	19.36	9/49	10.17	9/--/50	2.78	3.58	3.56	3.07	3.22	6.27	7.35	7.89	7.83	4.54	1.79	2.59	54.47	(42)	1978
Escambia, Pensacola FAA Ap	16.03	7/75	10.02	9/--/67	4.37	4.69	6.31	4.99	4.25	6.30	7.33	6.67	8.15	3.13	3.37	4.66	64.22	(34)	1978
Flagler, Marineland	--	--	--	--	1.69	3.01	4.47	2.05	2.26	3.46	4.77	5.67	8.75	6.32	2.34	2.10	46.89	(9)	1960
Franklin, Apalachicola WSO AP	22.55	9/46	11.71	9/--/32	3.07	3.78	4.70	3.61	2.78	5.30	8.02	8.07	9.00	2.88	2.68	3.32	57.21	(76)	1978
Gadsden, Quincy 3 SSW	--	--	--	--	3.90	4.46	5.61	4.62	3.98	5.38	7.74	5.62	5.74	2.75	2.62	4.30	56.72	(11)	1978
Gilchrist,	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Glades, Moore Haven Lock 1	18.56	7/74	6.00	6/12/55	1.76	2.06	2.88	2.67	4.43	8.05	7.16	6.57	7.49	4.48	1.14	1.53	50.22	(60)	1978
Gulf, Wewahitchka	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	(23)	1978
Hamilton, Jasper 3 SE	--	--	--	--	2.89	4.51	4.93	4.41	3.59	5.61	7.00	5.03	6.40	3.01	2.23	2.37	51.98	(10)	1960
Hardee, Wauchula 2 N	--	--	--	--	2.28	2.79	3.39	2.85	3.99	8.66	9.04	7.48	7.88	3.05	1.63	1.70	54.66	(46)	1978
Hendry, La Belle	--	--	--	--	1.76	2.23	3.25	2.54	4.52	9.65	8.52	7.70	7.49	4.20	1.25	1.51	54.62	(48)	1978
Hernando, Brooksville Chin Hill	17.70	3/60	8.58	7/29/60	2.69	3.37	4.44	2.70	3.50	7.65	9.02	9.60	7.29	3.09	1.76	2.53	57.64	(86)	1978
Highlands, Avon Park 2 W	18.95	6/54	6.32	11/25/53	2.14	2.77	3.36	3.08	3.93	9.13	8.75	7.25	7.72	3.87	1.64	1.70	55.34	(81)	1978
Hillsborough, Tampa WSMO R	20.59	7/60	12.11	7/--/60	2.33	2.86	3.89	2.10	2.41	6.49	8.43	8.00	6.35	2.54	1.79	2.19	49.38	(89)	1978
Holmes, Bonifay	--	--	--	--	4.82	4.91	4.20	4.92	3.76	5.05	7.69	5.14	4.72	2.96	3.33	4.65	56.15	(25)	1931
Indian River, Fellsmere 7 SSW	--	--	--	--	2.08	2.29	3.54	2.63	3.86	7.41	6.79	7.99	8.66	6.85	2.07	1.71	55.88	(66)	1978
Jackson, Marianna Ind School	--	--	--	--	3.78	4.34	5.70	5.02	4.30	4.82	7.67	6.47	4.81	2.08	3.27	4.07	56.33	(70)	1960
Jefferson, Monticello 3 W	23.35	9/57	7.41	9/16/57	3.76	4.26	5.60	4.23	3.62	5.89	7.42	5.32	5.63	2.70	2.42	3.71	54.56	(75)	1978
Lafayette, May 5 NW	--	--	--	--	2.39	3.51	4.62	4.69	3.92	6.36	8.33	6.11	6.43	4.30	2.42	2.34	55.42	(11)	1960
Lake, Clermont 6 SSW	16.23	8/67	5.62	10/16/56	2.34	2.93	3.89	2.95	2.91	7.00	8.62	7.24	6.56	3.16	1.66	2.14	51.40	(86)	1978
Lee, Fort Myers WSO AP	20.10	6/74	10.85	10/--/51	1.64	2.03	3.06	2.03	3.99	8.89	8.90	7.72	8.71	4.37	1.31	1.30	53.95	(87)	1978
Leon, Tallahassee WSO AP	20.12	7/64	9.47	9/--/69	3.74	4.77	5.93	4.07	4.04	6.62	8.92	6.89	6.64	2.93	2.81	4.22	61.58	(94)	1978
Levy, Cedar Key	--	--	--	--	2.47	2.81	3.62	2.95	2.02	4.19	8.08	7.40	6.38	3.07	1.38	2.19	46.56	(82)	1960
Liberty, Bristol	--	--	--	--	2.77	4.18	4.62	5.48	5.01	5.82	5.94	4.80	5.46	3.72	2.84	3.46	54.10	(10)	1960
Madison, Madison 4 N	20.44	9/57	8.90	3/31/62	3.43	3.94	5.36	3.88	3.34	5.61	7.19	6.03	5.48	2.61	2.39	[illegible]	52.63	(78)	1978
Manatee, Bradenton 5 ESE	25.62	6/12	10.80	6/--/45	2.68	2.87	3.65	2.43	2.60	7.63	8.94	9.55	8.68	3.24	1.91	[illegible]	56.35	(14)	1978
Marion, Ocala	16.26	9/50	8.00	9/--/50	2.38	3.01	3.55	3.04	3.98	7.30	8.40	7.82	6.77	3.27	1.75	[illegible]	53.95	(65)	1960
Martin, Stuart 1 N	--	--	6.50	4/--/37	2.43	2.52	3.46	2.83	4.48	7.16	6.55	6.19	8.46	7.48	2.17	2.26	55.99	(43)	1978
Monroe, Tavernier	21.83	6/67	8.51	10/30/62	2.00	1.92	1.87	2.28	4.37	6.61	4.75	4.88	7.45	8.35	2.36	2.05	48.89	(42)	1978
Nassau, Fernandina Beach	23.80	11/69	22.02	11/01/69	2.65	3.35	3.82	2.68	3.41	5.27	6.65	6.99	8.09	4.71	2.59	2.67	52.88	(82)	1978
Okaloosa, Niceville	--	--	--	--	4.35	4.47	5.61	4.91	[illegible]	6.18	8.35	7.52	7.48	3.17	3.48	4.90	64.14	(52)	1978
Okeechobee, Okeechobee Hrcn Gate 6	--	--	--	--	1.80	2.10	2.93	2.71	3.70	7.61	5.89	6.26	6.84	4.88	1.25	1.47	47.44	(56)	1978
Orange, Orlando WSO McCoy	19.57	7/60	9.67	9/--/45	2.28	2.95	3.46	2.72	2.94	7.11	8.29	6.73	7.20	4.07	[illegible]	1.90	51.21	(5)	1978
Osceola, Kissimmee 2	17.13	6/45	9.50	10/--/99	1.91	2.44	4.03	3.34	3.61	7.75	8.03	6.83	7.25	3.97	[illegible]	1.90	52.80	(70)	1960
Palm Beach, Belle Glade Exp Sta	19.50	9/60	6.29	10/02/51	1.99	1.97	3.21	2.96	[illegible]	9.08	8.58	8.21	8.82	5.65	1.74	1.80	58.75	(54)	1978
Pasco, Saint Leo	19.08	6/74	9.17	4/13/53	2.55	3.13	4.53	3.10	3.79	8.02	8.68	8.55	7.08	2.93	1.87	2.36	56.59	(86)	1978
Pinellas, Tarpon Spgs Sewage Pl	20.76	7/60	8.70	7/29/60	2.69	2.82	4.36	2.68	2.52	5.58	9.10	9.32	7.37	2.78	1.91	2.54	53.67	(88)	1978
Polk, Lakeland 3 SE	15.67	7/60	10.12	6/--/45	2.32	2.52	4.02	2.57	3.44	6.70	8.09	7.18	6.06	2.84	1.60	[illegible]	49.43	(63)	1978
Putnam, Palatka	--	--	8.56	10/--/51	2.54	3.42	4.05	3.00	3.32	6.49	7.74	7.56	7.58	4.88	1.85	2.41	54.84	(53)	1978
St. Johns, St. Augustine	21.80	9/63	9.52	9/18/63	2.35	3.06	4.05	3.25	2.85	5.35	6.21	5.88	7.77	6.56	2.48	2.57	52.38	(92)	1960
St. Lucie, Fort Pierce	19.90	9/63	6.62	9/24/63	2.10	2.77	3.50	3.33	4.15	6.11	5.53	6.35	8.69	7.87	2.36	2.24	54.91	(78)	1978
Santa Rosa, Milton Exp Sta	--	--	--	--	3.85	4.16	5.81	6.43	3.81	6.99	8.52	4.91	8.40	3.02	3.57	5.30	64.77	(12)	1960
Sarasota, Sarasota	--	--	--	--	2.24	2.65	3.53	3.57	2.84	5.11	8.03	8.60	9.96	3.92	2.17	2.51	55.13	(13)	1960
Seminole, Sanford Exp Sta	--	--	--	--	2.31	2.84	3.90	2.69	2.83	7.19	8.35	6.99	7.76	4.56	1.75	2.15	53.32	(23)	1978
Sumter, Bushnell 2 E	16.85	6/74	6.90	6/25/74	2.46	3.22	4.34	3.12	3.64	6.97	8.97	7.43	6.65	3.25	1.51	2.18	53.74	(42)	1978
Suwannee, Live Oak 2 ESE	--	--	--	--	3.01	3.38	4.64	4.62	3.60	7.11	9.17	4.81	5.81	3.30	1.89	2.15	53.49	(8)	1960
Taylor, Perry[2]	--	--	--	--	2.85	3.56	4.20	2.86	3.74	6.46	9.55	7.43	6.66	2.46	3.65	2.20	55.32	(9)	1938
Union, Raiford St Prison	--	--	--	--	2.68	3.40	3.39	3.06	3.84	6.38	7.64	6.82	5.39	3.41	1.63	3.21	50.85	(58)	1956
Volusia, Daytona Bch WSO APR	19.89	8/53	9.29	10/--/53	2.05	2.92	3.37	2.39	2.65	6.60	6.69	6.84	7.10	5.52	2.13	1.96	50.22	(65)	1978
Wakulla, St. Marks 5 SSE	28.55	9/57	8.36	4/28/64	3.57	4.03	4.86	3.78	3.33	6.15	7.87	6.22	6.41	2.87	2.58	3.45	55.12	(51)	1978
Walton, DeFuniak Springs	16.14	12/53	7.01	10/30/67	4.70	4.72	6.81	5.01	4.37	6.36	8.82	7.66	6.78	3.21	3.52	4.97	66.92	(80)	1978
Washington, Chipley 3 E	16.43	12/53	7.35	4/02/60	4.22	4.32	5.94	4.59	3.97	5.07	6.51	5.75	5.14	2.68	3.12	4.52	55.83	(40)	1978

[1] Normal rainfall.--Climatological normals are usually based on 30 years of record for periods 1931 through 1960, or 1941 through 1970, or earlier period. Normals are not available for a few stations with 30 or more years of record through 1970 (as indicated by number of years of record through 1978).

Average rainfall.--Long-term means (averages) are used in place of normals for varied periods of record of less than 30 years. Averages have been computed only through 1960 for some selected stations (as noted by ending year), even though stations may be currently in operation.

[2] U.S. Department of Agriculture, 1941.

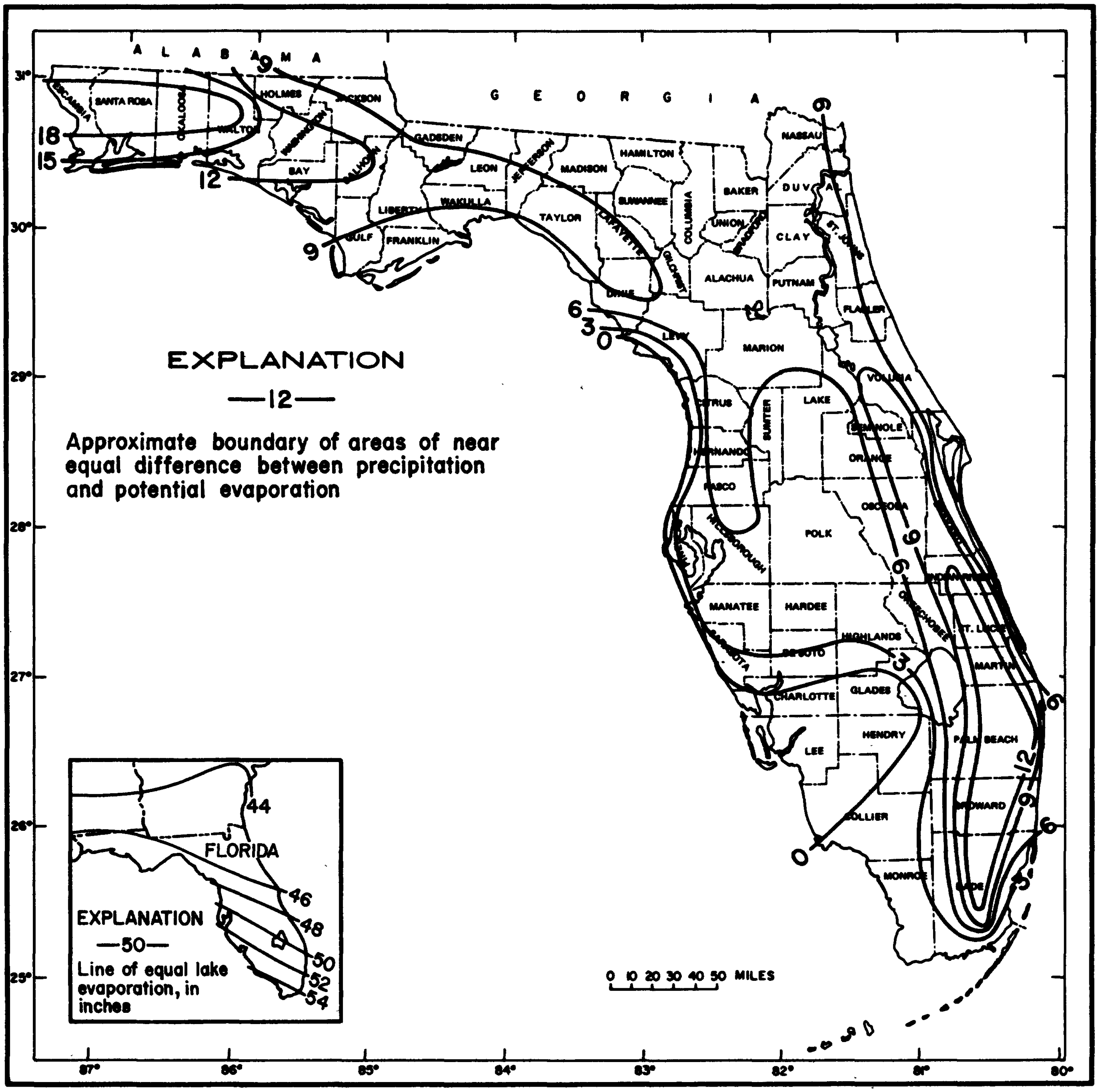


Figure 13.--The difference between rainfall and potential evaporation in Florida (modified from Visher and Hughes, 1969).

HURRICANES

Hurricanes are tropical cyclones with sustained winds of 75 or more miles per hour. Florida, of all the states, is most exposed to these types of storms. The hurricane season extends from June through October with most hurricanes and tropical cyclones occurring during September (fig. 14). The average number in September has been nearly three per year, but may vary from none to five. About two thirds of the tropical cyclones in September reach hurricane force although the ratio in other months is usually higher.

Day-long rains are usually associated with tropical disturbances (cyclones). Some of the world's heaviest rainfalls have occurred within tropical cyclones--more than 20 inches in 24 hours is not uncommon. A storm that entered the west coast of Florida in October 1941 was never of hurricane intensity, but over a 3-day period about 35 inches of rainfall was measured of which about 30 inches occurred in 24 hours.

Extensive damage and flooding in north Florida in September 1969 resulted from a minimum tropical disturbance that was nearly stationary for 48 hours in the Quincy-Havana area. Rainfall associated with the tropical disturbance exceeded 20 inches over a part of Gadsden County, Fla., during September 20-23, 1969, and the maximum rainfall of record occurred at Quincy with 10.87 inches during a 6-hour period on September 21. The 48-hour maximum of 17.71 inches exceeded the 1 in 100-year probability of 16 inches for a 7-day period. The previous maximum rainfall of record at Quincy (more than 12 inches) was on September 14-15, 1924. The characteristics of this historical storm were similar in path and effect to the September 1969 tropical disturbance (Bridges and Davis, 1972; Davis and Bridges, 1972).

Hurricanes produce storm surges when they approach the coasts or enter inland. Storm-surge heights are added to the normal astronomical tides to form storm tides. For example, a storm surge of 15 feet which produces a storm tide of 17 feet, typical of those produced by a hurricane approaching the Atlantic or Gulf coastal areas of Florida, is described in figure 15. Storm-surge heights for Florida, calculated by NOAA (National Oceanic and Atmospheric Administration), range from 16 to 32 feet as shown in figure 16. These storm-surge heights were calculated for storms Camille of 1969 and the Florida Keys hurricane of 1935, both considered to be the most severe hurricanes of record for the United States. Storm-surge heights, based on the highest tide to be expected on the average of once every century, the 100-year storm tide, have been calculated by National Oceanic and Atmospheric Administration for the entire coast of Florida. These 100-year storm surges range from 7.5 feet just north of Pompano Beach to 16.5 on the coast at the Collier-Monroe County boundary (National Oceanic and Atmospheric Administration, 1978c; 1980).

The paths of hurricanes are erratic as illustrated by figure 17. The chances of hurricane-force winds reaching a particular locality in Florida in any given year varies from 1 in 100 at Jacksonville to 1 in 7 at Key West and Miami. Only 10 or 11 storms of hurricane intensity in 87 years have passed inland on the west coast of Florida in the area from Cedar Key to Fort Myers (National Oceanic Atmospheric Administration, 1978c).

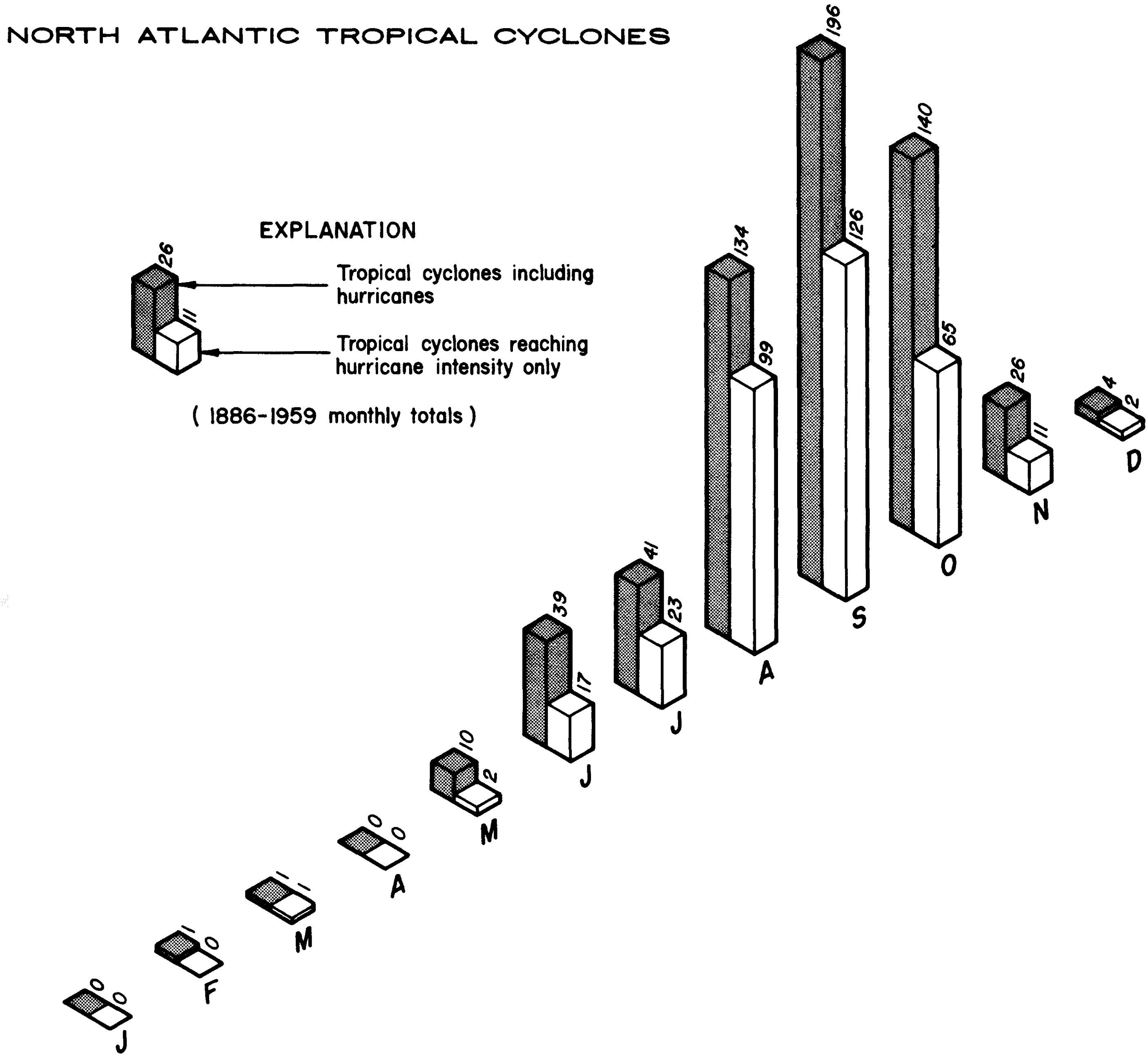


Figure 14.--Number of North Atlantic tropical cyclones and hurricanes by months of period 1886-1959 (modified from unpublished illustration by Kenner, 1960).

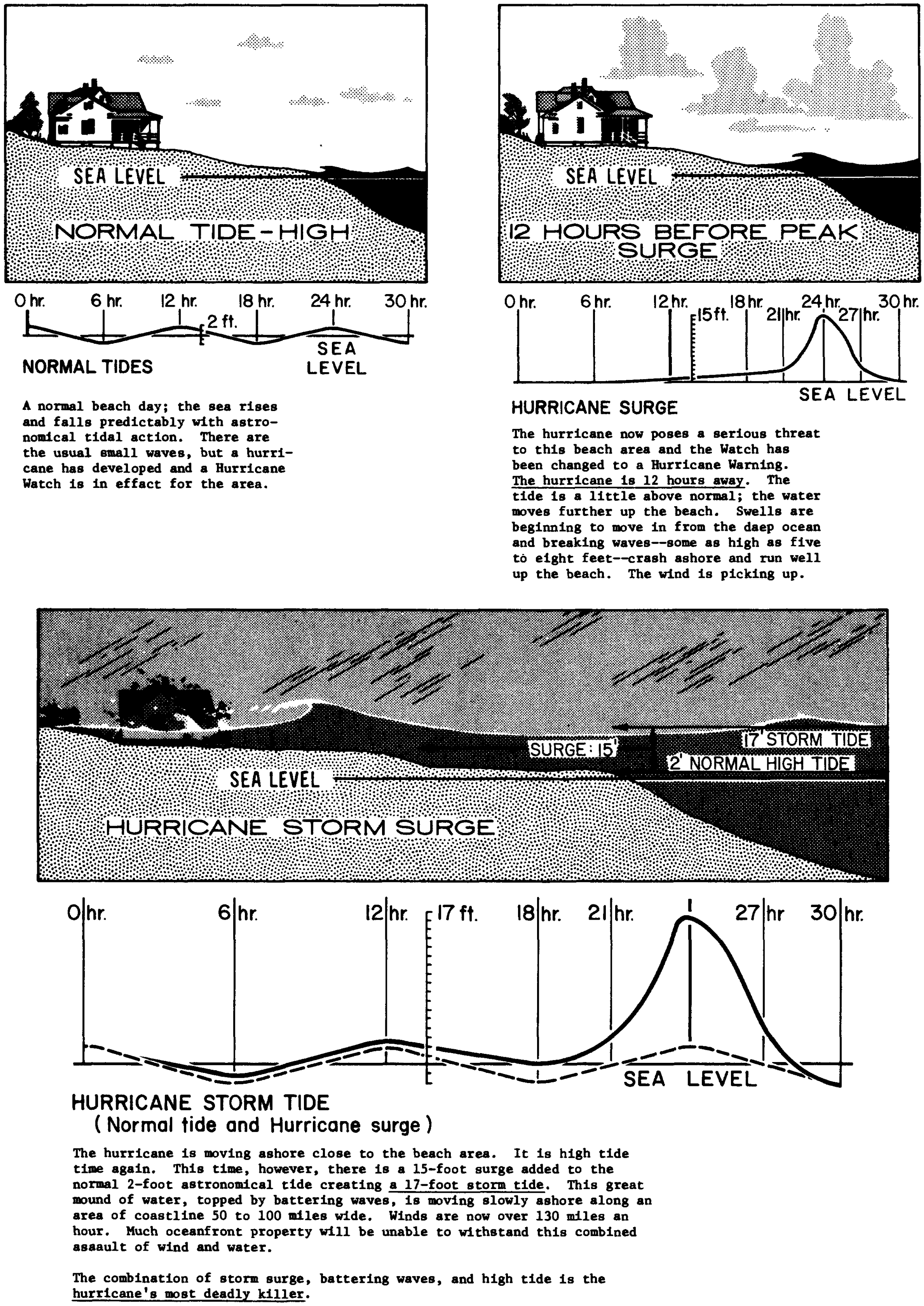


Figure 15.--Typical storm surge produced by a hurricane approaching the Atlantic or Gulf Coastal areas of Florida (modified from National Oceanic and Atmospheric Administration, 1978c).

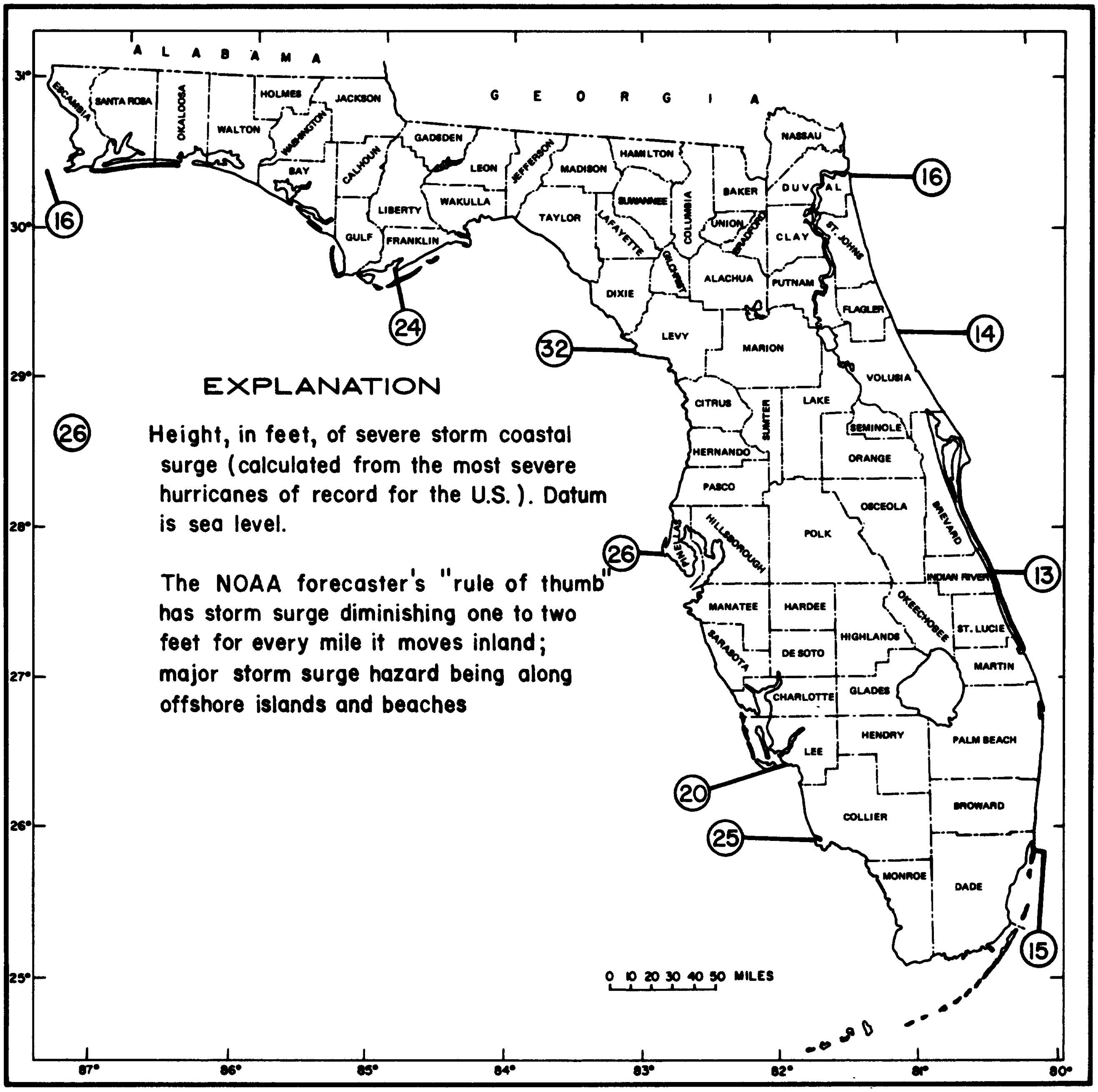


Figure 16.--Calculated storm-surge heights for Florida (modified from National Oceanic and Atmospheric Administration, 1978c and 1980).

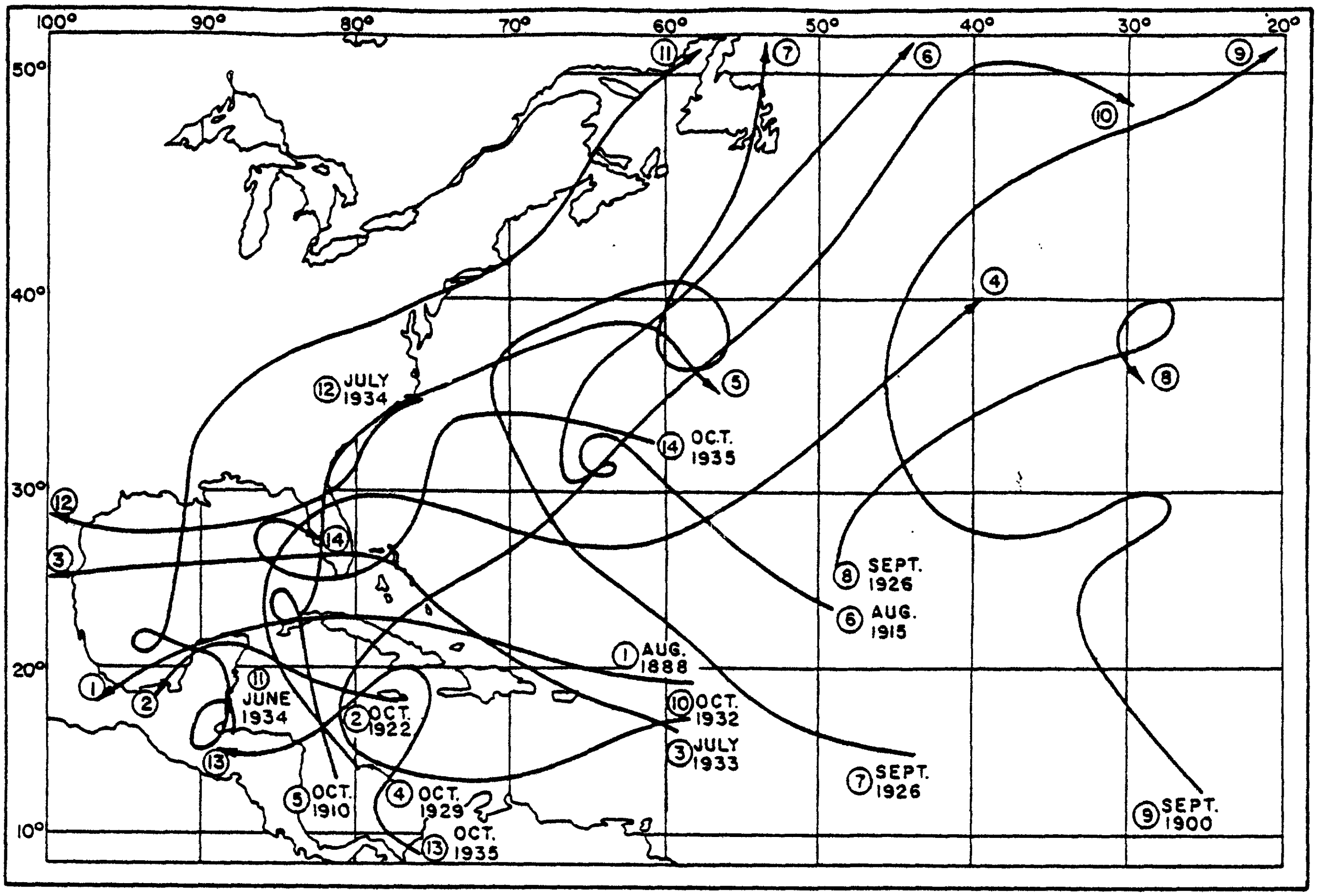


Figure 17.--Irregular movements of selected hurricane tracks over the Atlantic Ocean and the Gulf of Mexico (modified from U.S. Weather Bureau, 1939).

Atlantic and Gulf hurricane tracks near, or through, Florida and other eastern states are plotted on maps (figs. 18-23) for 6 selected periods from 1919 through 1975 (modified from National Oceanic and Atmospheric Administration, 1978c). Generalized tracks of hurricanes "David" and "Frederic" in 1979 are shown in figure 24.

LAKES

In recent years there has been a greatly increased awareness that Florida's lakes have contributed much to the development of the State and that they have a direct influence on its future growth. Along with the increased awareness has come an increased need for information on lakes.

The many lakes and extensive areas of wetlands of Florida are depicted by the Earth Resources Observation System (EROS) image map at a scale of 1:500,000 (shown reduced in fig. 25). It was prepared by the U.S. Geological Survey in cooperation with the National Aeronautics and Space Administration (U.S. Geological Survey, 1973).

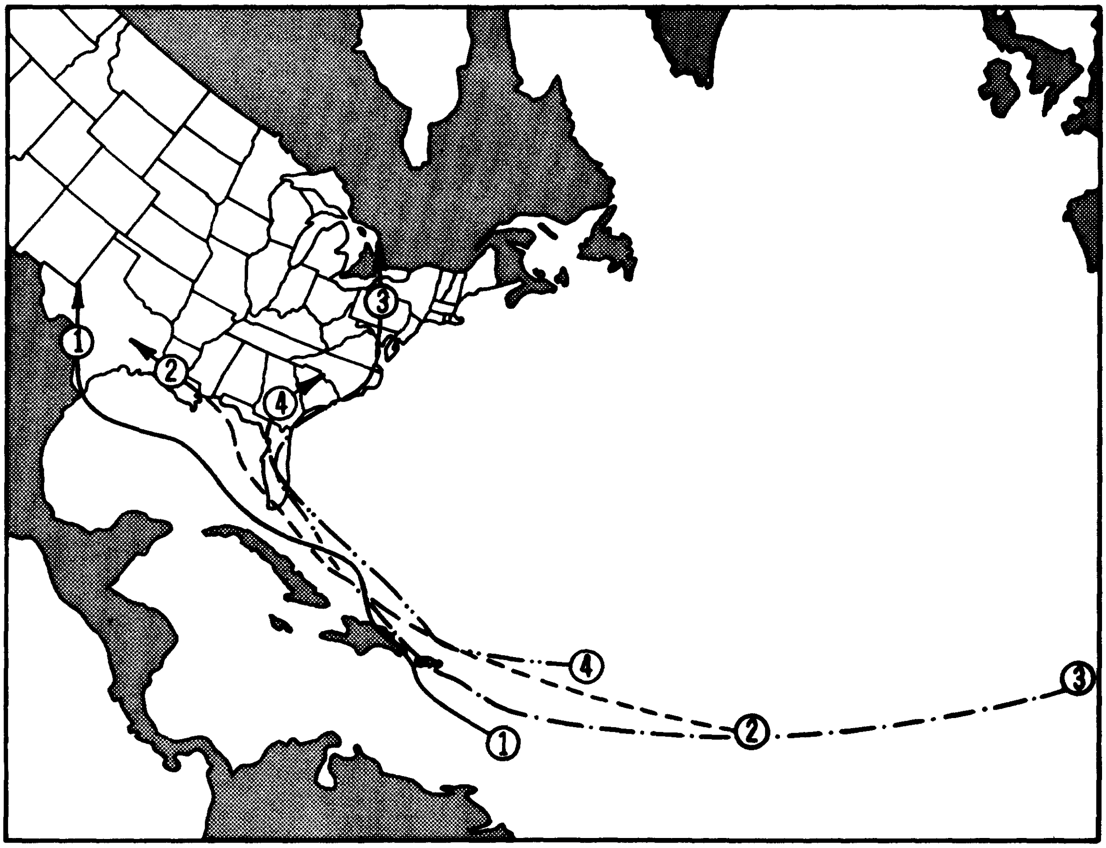
Location and Number

Of the 7,783 freshwater lakes and reservoirs in Florida, about 35 percent are in 4 counties--Lake, Orange, Osceola, and Polk. The principal lakes in these four counties, those having surface areas of 1,000 acres or more, are named in figures 26-29. Twelve counties each have more than 200 lakes and only 19 counties have fewer than 30 lakes (table 9).

Nearly 3,500 of the freshwater lakes in Florida are named. The named lakes range in size from approximately 1 acre, such as Heath Pond in Jackson County, to the largest, Lake Okeechobee in south Florida, which measures 436,000 acres. The 7,783 lakes in Florida cover 2,290,000 acres, nearly 3,600 square miles or essentially 6 percent of the State. Unnamed lakes of 10 acres or more in size that have been identified in the State total 4,300. Although not a lake, water Conservation Area 3, a manmade impoundment or reservoir in the Everglades is worth mentioning here because of its size. The largest water body in the State, it contains 585,280 acres.

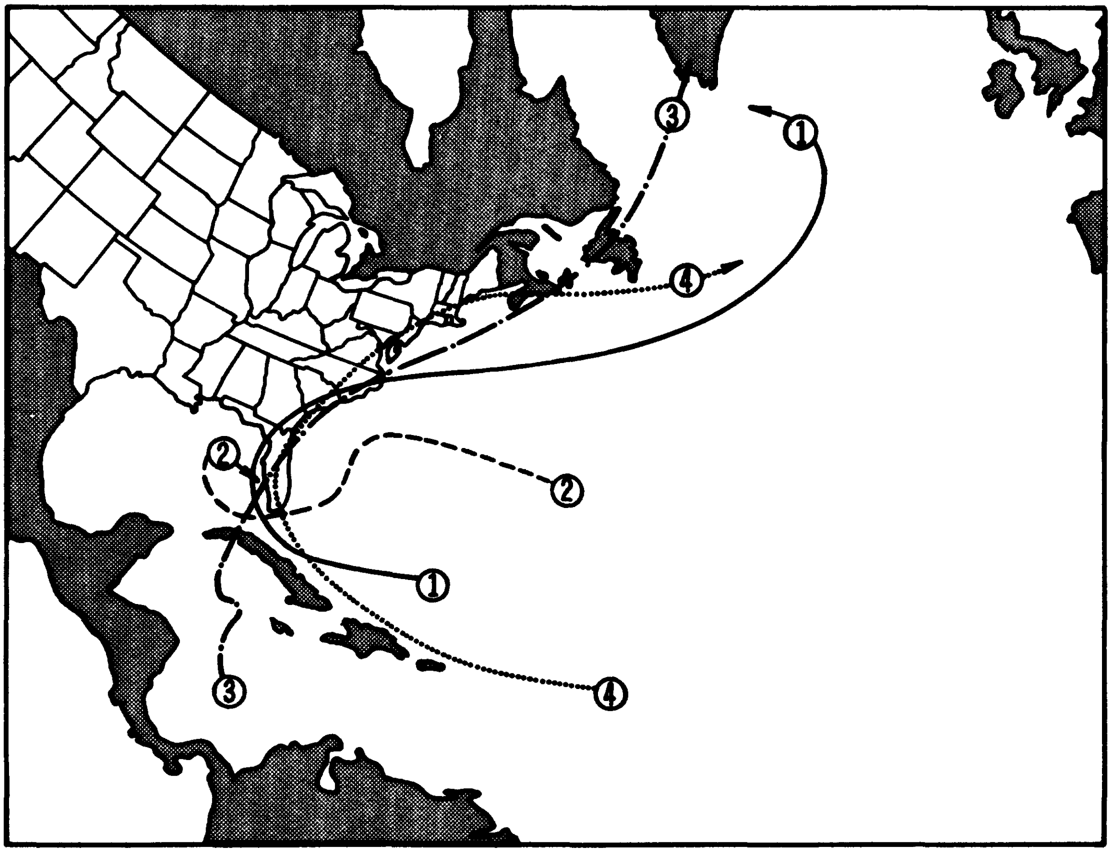
Stage (lake level) data have been collected from a network of more than 300 lakes in Florida. Stages are determined by recording instruments and from daily or periodic observations. Lake Okeechobee has the longest stage record in Florida, beginning in 1912.

A large number of lake and pond names in Florida are repeated at least twice and many are repeated a dozen or more times. The most repeated lake names are "Sand/Sandy" (33), "Long" (30), "Bonnet/Bonnett" (26), "Mud/Mudd/Muddy" (25), "Grass/Grassy" (22), "Blue" (19), and "Silver" (19). "Little" is the first word of lake or pond names 63 times.



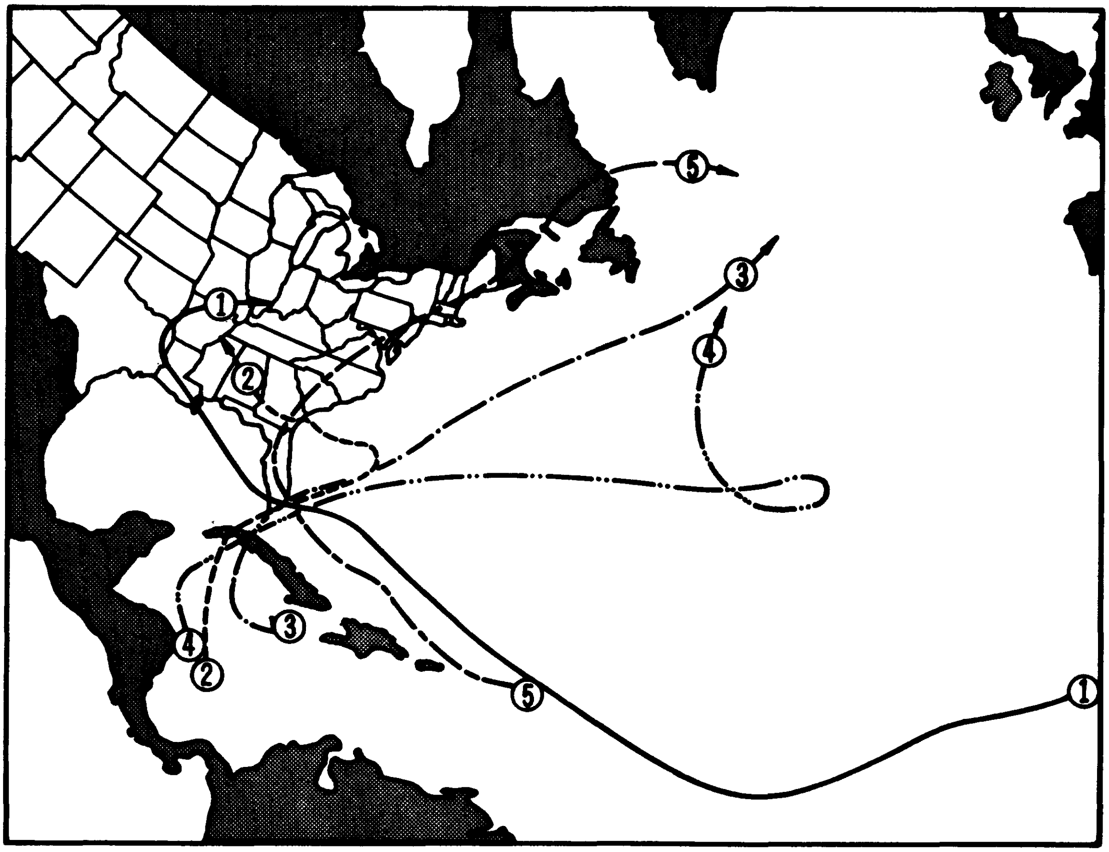
Dates of hurricane	Areas most affected	Land station with highest wind speed	Damage
1. 1919, September 2-15	Florida, Louisiana and Texas	Sand Key, Fla., 72 mph.	Hurricane was severe both in Florida and in Texas. Over 500 casualties in ships lost at sea.
2. 1926, September 11-22	Florida and Alabama	Miami, Fla., 96 mph. Miami Beach, Fla., gust, 132 mph.	Very severe in the Miami area and from Pensacola into southern Alabama.
3. 1928, September 6-20	Southern Florida	Lake Okeechobee, Fla., 75 mph.	Wind-driven waters of Lake Okeechobee overflowed into populated areas, causing most of the casualties.
4. 1933, August 31 - September 7	Florida	Jupiter Inlet, 125 mph.	Much property damage on the coast from Vero Beach; property damage inland was minor; citrus loss nearly complete near the coast.

Figure 18.--Selected Atlantic and Gulf hurricane tracks near, or through, Florida and other Eastern States during 1919-33 (modified from National Oceanic and Atmospheric Administration, 1977).



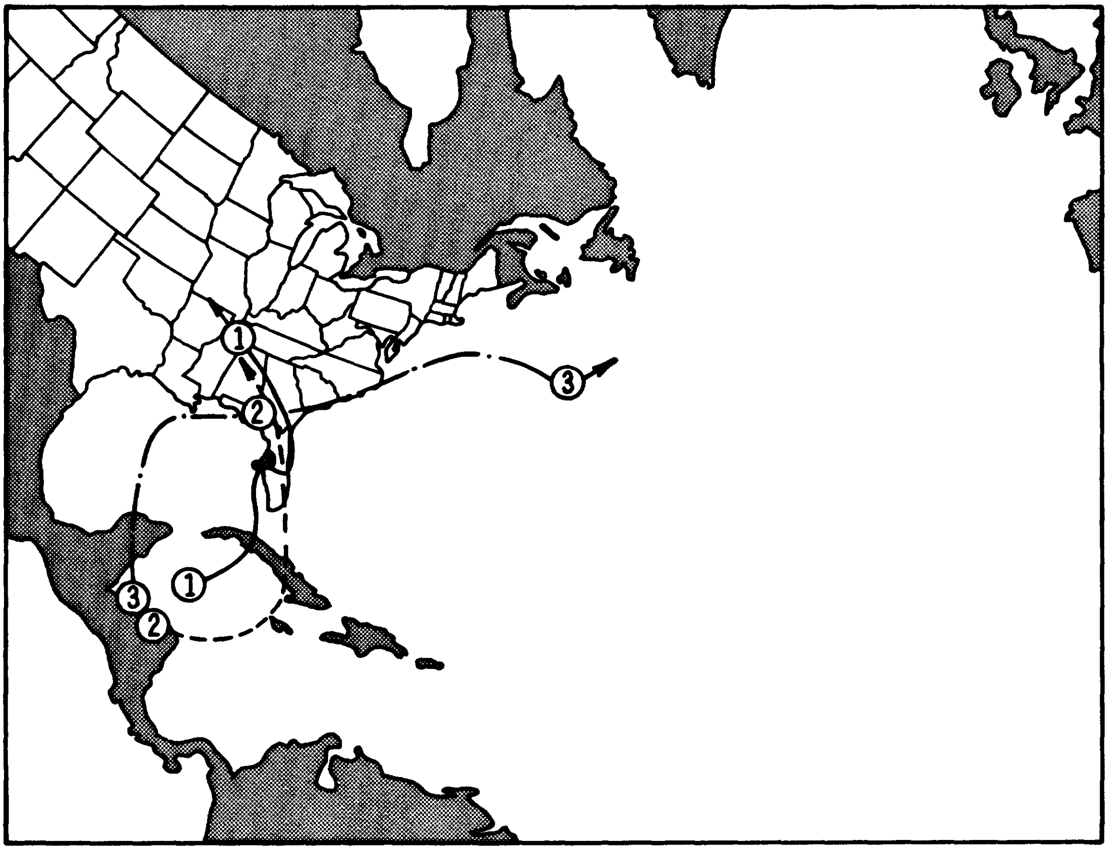
Dates of hurricane	Areas most affected	Land station with highest wind speed	Damage
1. 1935, August 29-September 10	Southern Florida	Tampa, Fla., 86 mph.	"Labor Day Storm"--barometer reading of 26.35 inches on Long Key is lowest of record in the Western Hemisphere. Peak winds were estimated 150-200 mph on some Keys.
2. 1935, October 30-November 8	Southern Florida	Miami, Fla., 94 mph.	"Yankee Storm"--so-called because it moved into the Miami area from the northeast. It was quite small--destructive winds covered only a narrow path.
3. 1944, October 12-23	Florida	Dry Tortugas, Fla., 120 mph.	Warnings and evacuation prevented heavier casualties.
4. 1945, September 11-20	Florida, Georgia and South Carolina	Carysfort Reef Light, 138 mph.	Damage very heavy in Dade County (Miami), Fla. Evacuation of exposed locations prevented heavy loss of life.

Figure 19.--Selected Atlantic and Gulf hurricane tracks near, or through, Florida and other Eastern States during 1935-45 (modified from National Oceanic and Atmospheric Administration, 1977).



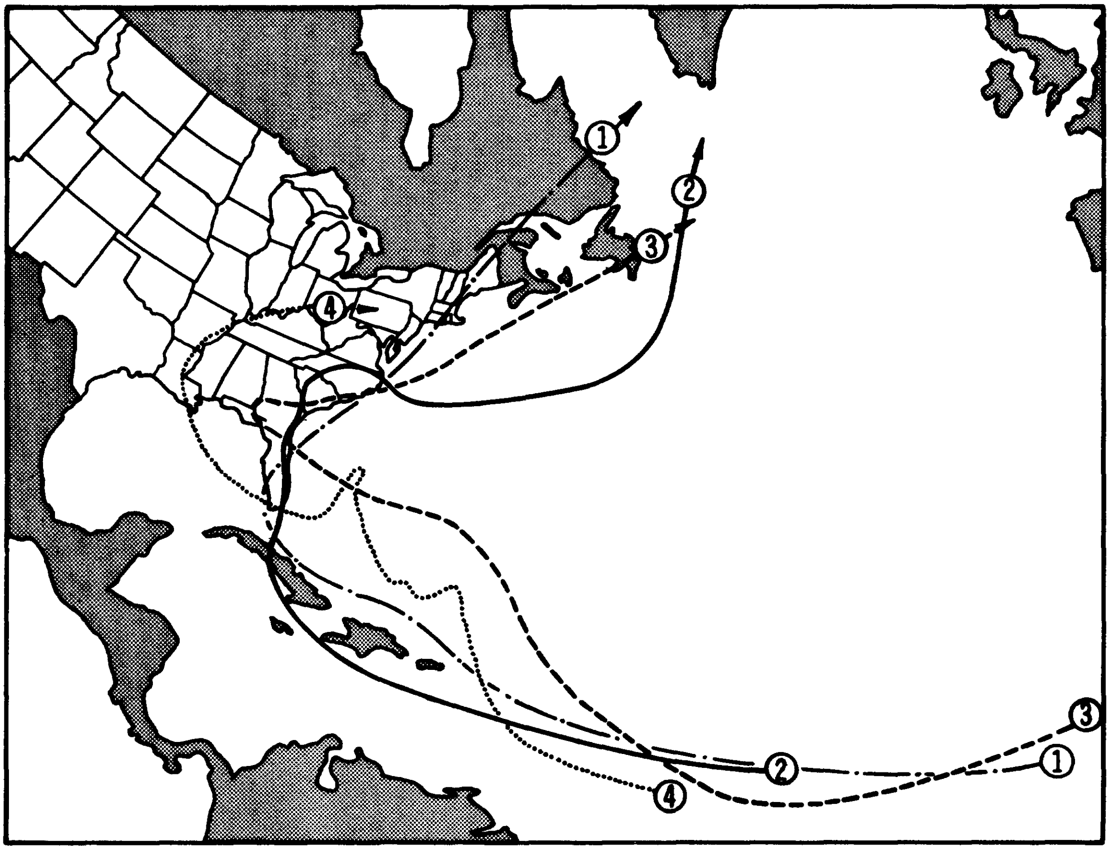
Dates of hurricane	Areas most affected	Land station with highest wind speed	Damage
1. 1947, September 4-21	Florida and Middle Gulf Coast	Hillsboro Light, Fla., 121 mph; gust, 155 mph.	Very large and intense storm. Wind and water damage heavy on Florida east coast and in Louisiana and Mississippi.
2. 1947, October 9-16	Southern Florida, Georgia and South Carolina	Hillsboro Light, Fla., 92 mph.	Heavy to excessive rains in Florida climaxed a very wet season. Heavy damage also occurred in the Savannah, Ga. area from wind and along the South Carolina-Georgia coast from high tides.
3. 1948, September 18-25	Southern Florida	Key West, Fla., 78 mph.	Many lulls and calms reported from widely separated points simultaneously; two lulls at some places near Okeechobee several hours apart.
4. 1948, October 3-15	Southern Florida	Sombrero Key, Fla., 100 mph.	Damage not as great as could be expected, since much of area had been hit by September storm.
5. 1949, August 23-31	Florida to the Carolinas	West Palm Beach, Fla., 110 mph. Juniper, Fla., gust, 153 mph.	Storm center passed over Lake Okeechobee. Levees built since 1928 prevented overflow and casualties.

Figure 20.--Selected Atlantic and Gulf hurricane tracks near, or through, Florida and other Eastern States during 1947-49 (modified from National Oceanic and Atmospheric Administration, 1977).



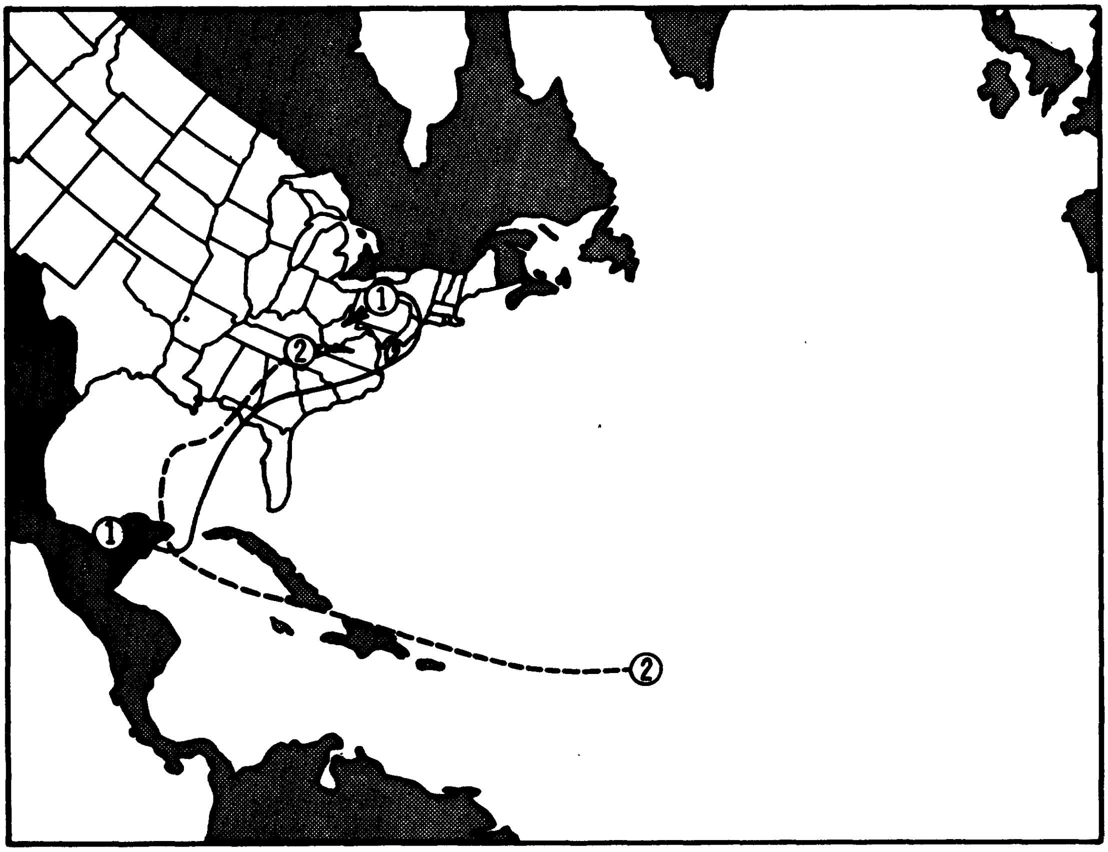
Dates of hurricane	Areas most affected	Land station with highest wind speed	Damage
1. 1950, September 1-9	Florida	Cedar Keys, Fla., gust, 125 mph.	Unusual double loop in storm track in the Cedar Keys area. Coast from Sarasota northward suffered extensive wind and tide damage.
2. 1950, October 13-19 KING	Florida	Miami, Fla., 120 mph.	A small violent storm which passed directly over Miami, then up the entire Florida peninsula.
3. 1956, September 21-30 FLOSSY	Louisiana to northern Florida	Burrwood, La., 88 mph; gust, 110 mph.	Damage over area from New Orleans and mouth of Mississippi eastward to western Florida.

Figure 21.--Selected Atlantic and Gulf hurricane tracks near, or through, Florida and other Eastern States during 1950-56 (modified from National Oceanic and Atmospheric Administration, 1977).



Dates of hurricane	Areas most affected	Land station with highest wind speed	Damage
1. 1960, August 29-September 13 DONNA	Florida to New England	Block Island, R.I., 95 mph; gust, 130 mph. Ft. Myers, Fla., 92 mph. Cape Henry, Va., 80 mph.	Record amount of damage in Florida. First storm with hurricane force winds in Florida. Middle Atlantic States, and New England in 75-year record. Winds estimated near 140 mph, with gusts 175-180 mph on central Florida Keys.
2. 1964, August 20-September 5 CLEO	Southern Florida, Eastern Virginia	Miami, Fla., 110 mph.	First hurricane in Miami area since 1950. Moderate wind damage extensive along Florida lower east coast. Record rainfall and widespread flooding from Hampton Roads area southward in Virginia. Tornadoes in southeast Florida and the Carolinas.
3. 1964, August 28-September 16 DORA	Northeastern Florida, Southern Georgia	St. Augustine, Fla., 125 mph.	First storm of full hurricane force on record to move inland from the east over Northeastern Florida.
4. 1965, August 27-September 12 BETSY	Southern Florida, Louisiana	Port Sulphur, La., 136 mph.	Much of the damage was caused by flooding, particularly in Louisiana.

Figure 22.--Selected Atlantic and Gulf hurricane tracks near, or through, Florida and other Eastern States during 1960-65 (modified from National Oceanic and Atmospheric Administration, 1977).



Dates of hurricane	Areas most affected	Land station with highest wind speed	Damage
1. 1972, June 14-23 AGNES	Florida to New York	Key West, Fla., 43 mph; Jacksonville, Fla., gusts, 56 mph. Storm tide 6.4 ft. above normal at Apalachicola, Fla.	One of the costliest natural disasters in U.S. history--$2.0 billion. Devastating floods from North Carolina to New York with many recordbreaking river crests. Tornadoes--15 in Florida and 2 in Georgia.
2. 1975, September 13-24 ELOISE	Florida Panhandle and eastern Alabama	5 miles northwest of Ozark, Ala., 104 mph.	Major (almost total) storm surge and wind damage to structures along beach strip from Fort Walton Beach to Panama City, Fla. High winds destroyed property and crops over eastern Alabama. Flooding and miscellaneous damage from heavy rains over northeastern U.S.

Figure 23.--Selected Atlantic and Gulf hurricane tracks near, or through, Florida and other Eastern States during 1972-75 (modified from National Oceanic and Atmospheric Administration, 1977).

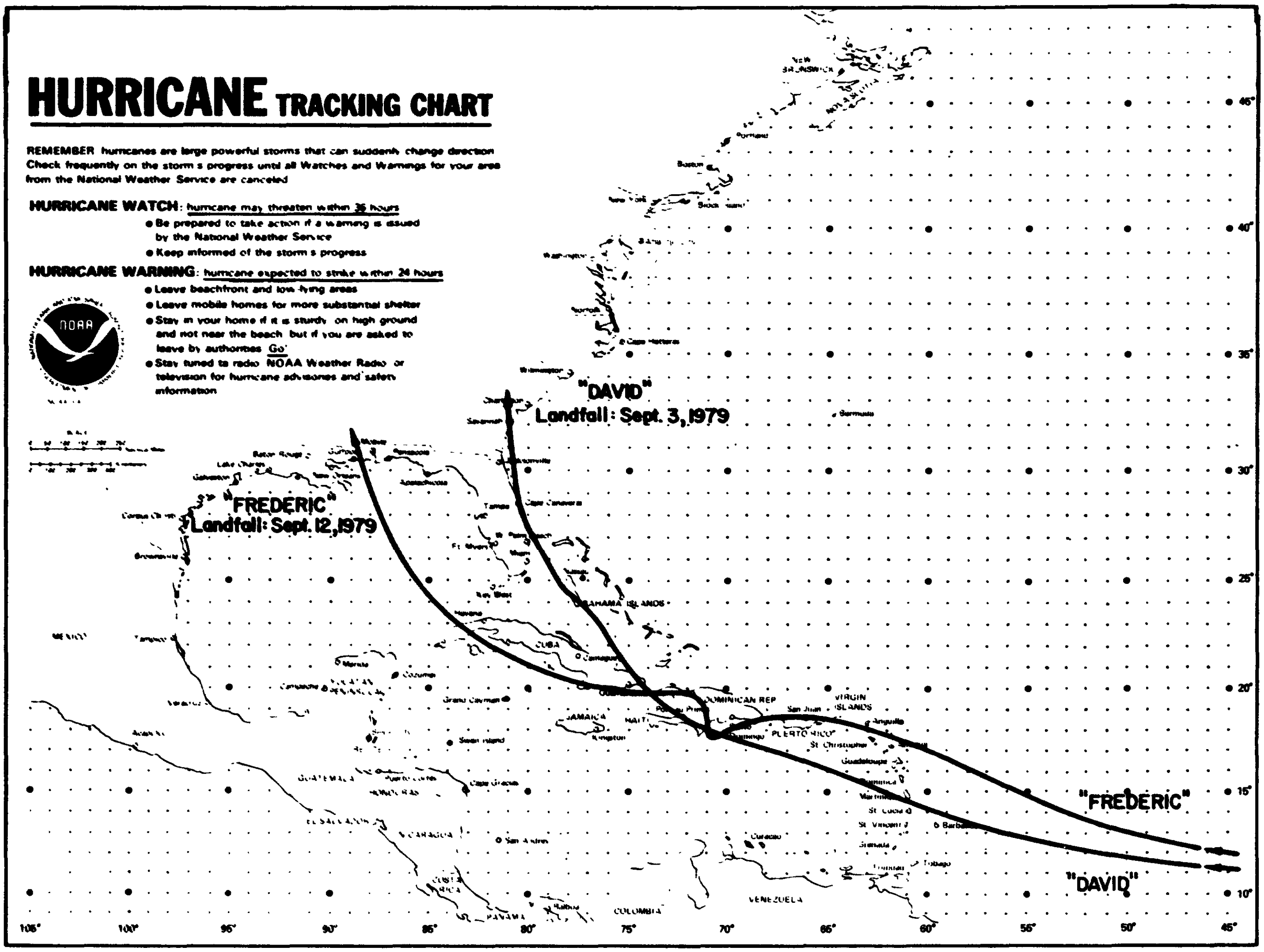


Figure 24.--Generalized tracks of 1979 hurricanes "David" and "Frederic" plotted on National Oceanic and Atmospheric Administration chart.

Figure 25.--Satellite photograph of Florida (from U.S. Geological Survey, 1973).

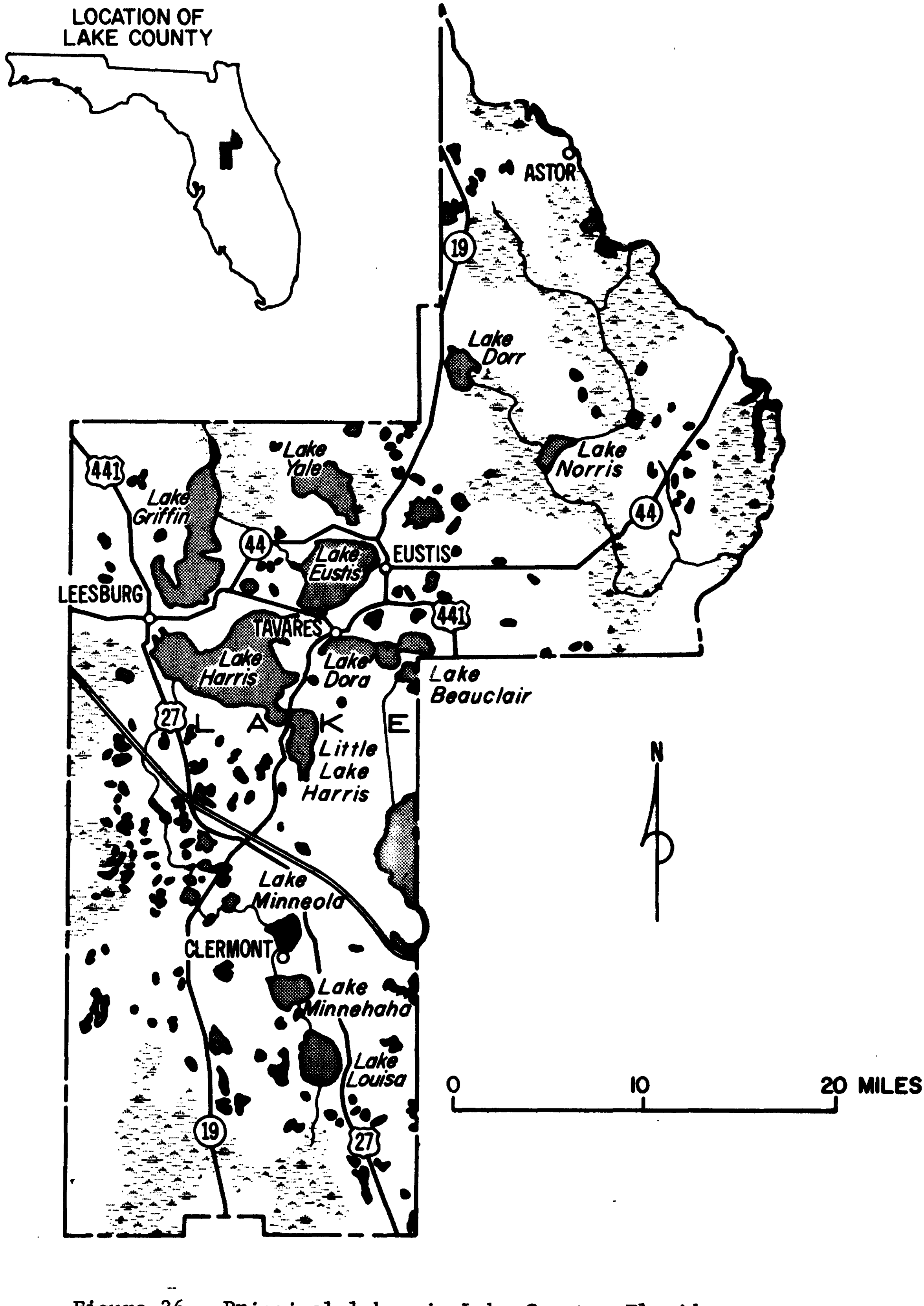


Figure 26.--Principal lakes in Lake County, Florida.

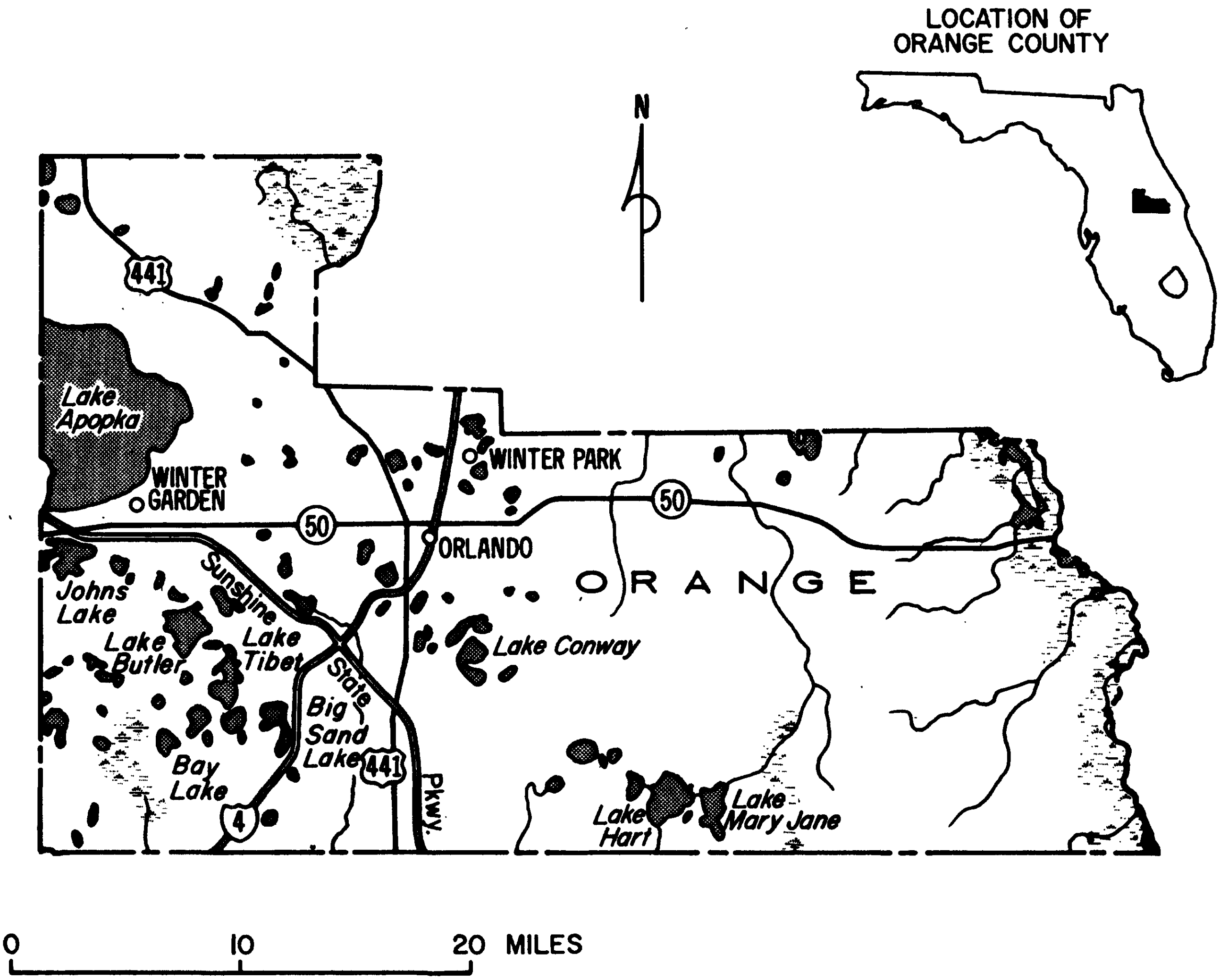


Figure 27.--Principal lakes in Orange County, Florida.

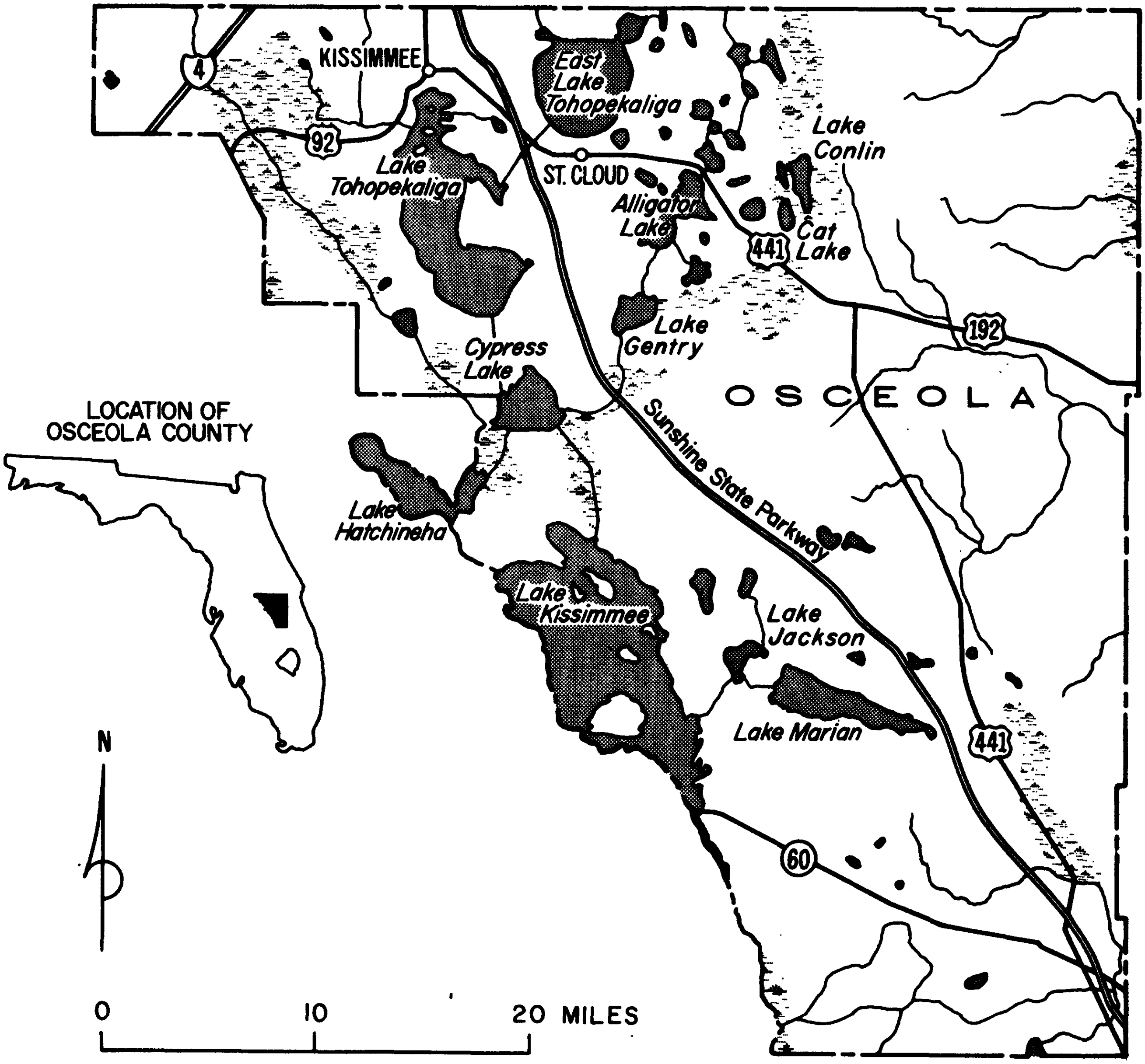


Figure 28.--Principal lakes in Osceola County, Florida.

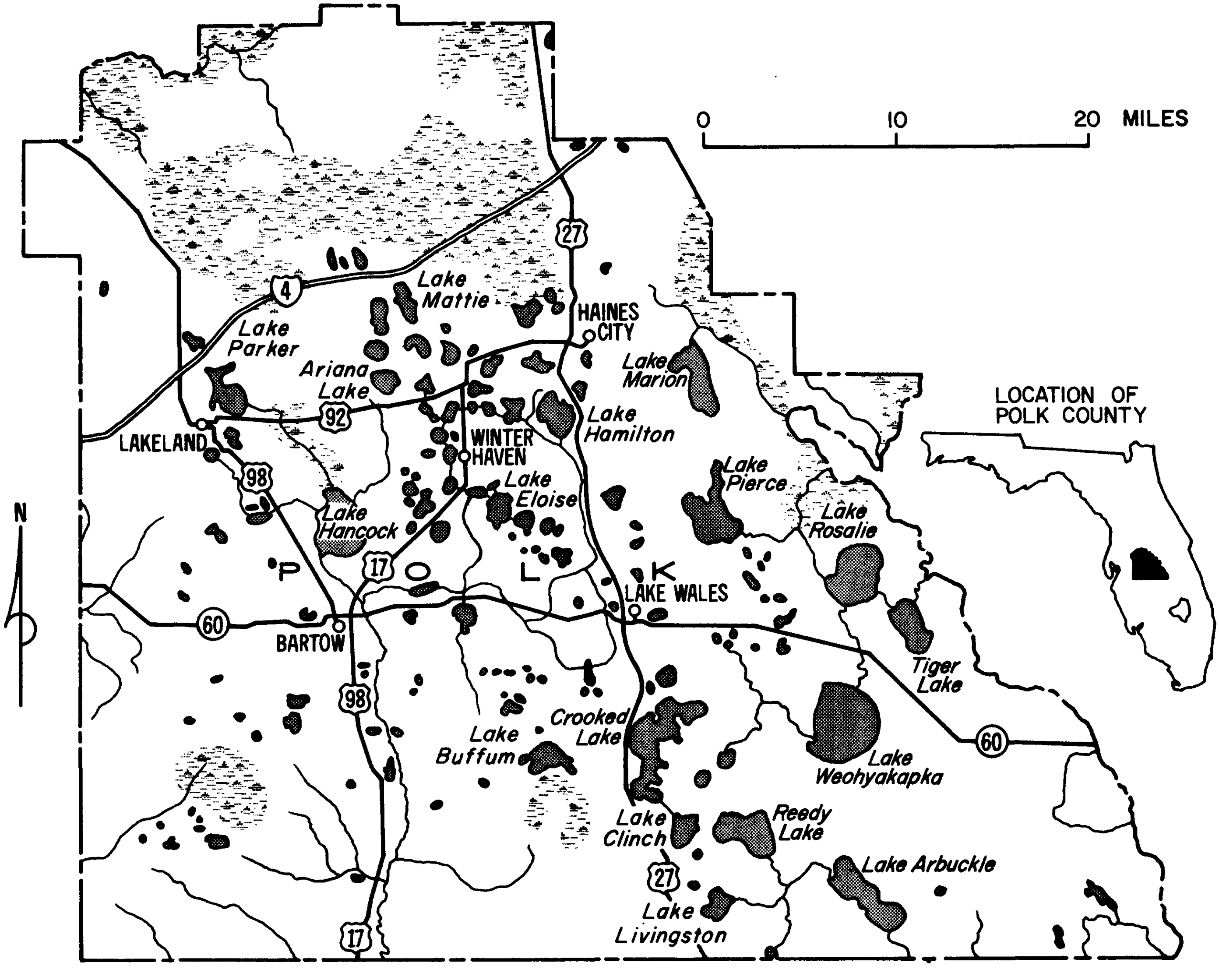


Figure 29.--Principal lakes in Polk County, Florida.

Table 9.--Number and area (in acres) of lakes by counties in Florida

[Modified from Florida Board of Conservation, Division of Water Resources, 1969]
[Type of lake: 1. Streams flowing in, 2. Streams flowing out, 3. Streams flowing both in and out, 4. Landlocked]
[Includes manmade lakes or reservoirs]

County	Named										Unnamed[1]										Total for state	
	Type								Total for county		Type								Total for county			
	1		2		3		4				1		2		3		4					
	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Alachua	5	886	5	314	20	50,196	28	3,378	58	54,774	10	790	16	634	18	982	67	1,946	111	4,352	169	59,126
Baker	0	0	0	0	0	0	2	1,817	2	1,817	0	0	0	0	0	0	0	0	0	0	2	1,817
Bay	2	481	4	60	7	5,669	24	871	37	7,081	1	16	1	15	0	0	10	162	12	193	49	7,274
Bradford	2	732	0	0	4	3,687	1	46	7	4,465	0	0	0	0	1	41	6	151	7	192	14	4,657
Brevard	0	0	2	117	18	14,108	2	84	22	14,309	0	0	4	56	25	759	38	1,089	67	1,904	89	16,213
Broward	0	0	2	22	0	0	22	719,855	24	719,977	0	0	4	243	0	0	49	1,178	53	1,421	77	721,398
Calhoun	0	0	9	111	8	482	14	293	31	886	0	0	0	0	1	10	4	113	5	123	36	1,009
Charlotte	0	0	2	62	3	154	0	0	5	216	1	23	7	115	7	142	126	2,348	141	2,628	146	2,844
Citrus	0	0	2	696	3	19,189	18	847	23	20,730	0	0	0	0	0	0	14	273	14	273	37	21,003
Clay	2	884	1	201	10	9,558	14	2,515	27	13,158	2	103	1	56	0	0	29	2,084	32	2,243	59	15,401
Collier	1	32	2	26	1	1,479	25	236	29	1,773	1	32	2	26	0	0	14	207	17	265	46	2,038
Columbia	6	484	5	211	3	31	24	689	38	1,415	2	55	1	25	2	22	9	154	14	256	52	1,671
Dade	0	0	3	60	4	303	31	474	38	837	0	0	7	216	3	214	33	1,167	43	1,597	81	2,434
DeSoto	1	28	1	4	3	53	2	53	7	138	0	0	4	119	3	42	27	517	34	678	41	816
Dixie	2	52	2	12	5	37	18	558	27	659	2	52	1	15	3	46	43	833	49	946	76	1,605
Duval	0	0	3	50	1	22	6	22	10	94	0	0	3	122	1	19	9	235	13	376	23	470
Escambia	0	0	6	91	14	273	2	35	22	399	0	0	2	44	2	30	0	0	4	74	26	473
Flagler	0	0	0	0	2	2,242	10	306	12	2,548	0	0	0	0	1	35	3	86	4	121	16	2,669
Franklin	0	0	5	39	6	281	12	278	23	598	0	0	1	17	0	0	5	88	6	105	29	703
Gadsden	0	0	0	0	23	8,077	0	0	23	8,077	0	0	0	0	11	283	0	0	11	283	34	8,360
Gilchrist	1	83	2	118	0	0	3	206	6	407	0	0	0	0	0	0	5	220	5	220	11	627
Glades	0	0	0	0	3	333	6	82	9	415	0	0	0	0	0	0	4	92	4	92	13	507
Gulf	1	16	2	21	2	10,775	4	50	9	10,862	0	0	0	0	0	0	0	0	0	0	9	10,862
Hamilton	0	0	1	1	1	3	14	414	16	418	0	0	0	0	0	0	11	241	11	241	27	659
Hardee	0	0	0	0	1	162	1	6	2	168	0	0	0	0	1	12	0	0	1	12	3	180
Hendry	0	0	0	0	1	3	1	6	2	9	3	49	4	61	1	17	56	878	64	1,005	66	1,014
Hernando	3	590	3	376	5	419	70	3,162	81	4,547	2	28	2	32	2	63	43	1,025	49	1,148	130	5,695
Highlands	6	425	14	8,291	23	36,807	41	2,883	84	48,406	0	0	0	0	0	0	11	195	11	195	95	48,601
Hillsborough	5	377	13	325	23	2,504	104	3,261	145	6,467	1	22	3	64	6	219	83	1,988	93	2,293	238	8,760
Holmes	2	333	22	649	14	554	21	285	59	1,821	0	0	1	10	2	49	0	0	3	59	62	1,880
Indian River	0	0	0	0	1	6,522	4	95	5	6,617	1	16	2	309	3	87	13	202	19	614	24	7,231
Jackson	9	351	13	1,091	29	41,715	102	2,758	153	45,915	8	180	39	1,585	40	1,802	84	1,680	171	5,247	324	51,162
Jefferson	3	140	6	227	13	6,710	16	693	38	7,770	2	50	1	15	4	70	10	233	17	368	55	8,138
Lafayette	0	0	0	0	5	58	28	865	33	923	0	0	0	0	1	11	31	627	32	638	65	1,561
Lake	11	944	19	2,352	47	69,540	197	9,569	274	82,405	13	635	18	457	17	1,719	250	9,095	298	11,906	572	94,311
Lee	0	1	5	627	3	13	3	13	11	653	2	46	11	253	6	109	58	979	77	1,387	88	2,040
Leon	10	10,147	10	376	25	2,349	29	508	74	13,380	2	29	10	243	10	276	15	314	37	862	111	14,242
Levy	2	285	0	0	2	4,813	26	528	30	5,626	1	40	2	49	3	103	65	1,626	71	1,818	101	7,444
Liberty	0	0	5	26	11	89	13	218	29	333	0	0	0	0	1	13	0	0	1	13	30	346
Madison	10	10,281	8	256	6	171	46	2,517	70	13,225	1	12	5	375	3	95	34	803	43	1,285	113	14,510
Manatee	0	0	0	0	2	60	3	71	5	131	2	25	1	16	2	23	9	101	14	165	19	296
Marion	10	5,328	13	2,299	11	8,199	54	3,678	88	19,504	0	0	6	161	5	220	185	5,847	196	6,228	284	25,732
Martin	0	0	0	0	0	0	2	46	2	46	0	0	0	0	1	50	9	227	10	277	12	323
Nassau	0	0	0	0	0	0	2	118	2	118	0	0	0	0	0	0	0	0	0	0	2	118
Okaloosa	2	74	8	70	26	470	14	130	50	744	0	0	1	20	4	71	3	49	8	140	58	884
Okeechobee	0	0	0	0	0	0	1	40	1	40	0	0	3	67	2	141	64	1,890	69	2,098	70	2,138
Orange	33	2,465	24	2,051	59	49,508	229	11,358	345	65,382	11	457	22	1,251	21	843	312	10,362	366	12,913	711	78,295
Osceola	3	420	8	2,321	37	107,397	30	4,202	78	114,340	35	2,288	102	4,140	70	7,989	592	18,826	799	33,243	877	147,583
Palm Beach	0	0	1	540	5	578,356	6	85	12	578,981	0	0	0	0	0	0	3	116	3	116	15	579,097
Pasco	4	413	7	269	12	1,245	118	5,803	141	7,730	3	89	10	228	8	170	138	3,557	159	4,044	300	11,774
Pinellas	1	91	2	24	10	3,772	13	148	26	4,035	0	0	4	91	1	11	7	126	12	228	38	4,263
Polk	17	7,312	37	5,604	54	53,511	192	20,365	300	86,792	10	320	25	733	16	445	199	4,904	250	6,402	550	93,194
Putnam	5	278	10	1,392	20	33,305	82	8,249	117	43,224	0	0	7	155	3	238	137	3,602	147	3,995	264	47,219
St. Johns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	136	6	136	6	136
St. Lucie	0	0	0	0	0	0	2	40	2	40	1	40	1	107	5	323	22	856	29	1,326	31	1,366
Santa Rosa	0	0	8	53	25	412	14	116	47	581	0	0	1	10	0	0	4	49	5	59	52	640
Sarasota	0	0	0	0	3	1,406	0	0	3	1,406	1	12	2	31	2	31	7	106	12	180	15	1,586
Seminole	12	356	16	631	31	14,155	82	2,355	141	17,497	1	13	4	136	3	52	36	1,019	44	1,220	185	18,717
Sumter	4	825	3	84	19	7,691	34	1,628	60	10,228	3	39	16	421	30	2,609	144	3,762	193	6,831	253	17,059
Suwannee	1	3	2	173	3	54	13	153	19	383	1	60	1	67	1	16	12	525	15	668	34	1,051
Taylor	0	0	0	0	3	110	22	840	25	950	2	67	2	33	7	344	60	1,275	71	1,719	96	2,669
Union	1	437	0	0	0	0	2	1,479	3	1,916	0	0	0	0	0	0	0	0	0	0	3	1,916
Volusia	2	272	5	225	29	71,865	47	1,661	83	74,023	8	335	10	227	10	525	129	4,685	157	5,772	240	79,795
Wakulla	2	283	4	40	8	626	10	164	24	1,113	0	0	1	25	1	12	18	322	20	359	44	1,472
Walton	1	22	11	543	20	1,638	38	594	70	2,797	0	0	5	66	1	12	14	222	20	300	90	3,097
Washington	21	2,976	26	1,085	44	6,866	153	5,395	244	16,322	3	57	5	94	18	439	25	481	51	1,071	295	17,393
Total	203	49,106	362	34,216	771	1,240,025	2,147	829,294	3,483	2,152,641	136	5,980	381	13,235	389	21,834	3,394	95,874	4,300	136,923	7,783	2,289,564

[1] 10 acres or more in size.

Meandered Lakes

Following the acquisition of Florida by the United States, the Federal Government began to determine which water bodies were federally navigable and which were nonnavigable. If a water body was navigable, under Federal law at the time statehood was granted, title to the bed was vested in the State (as "sovereignty lands"). Determination of navigability was accomplished by the process of surveying called meandering. The survey line or meander, as it is called, consists of a series of straight lines, of various lengths and bearings, forming an irregular polygon encompassing the lake and conforming roughly to the shape of the lake. The Florida Supreme Court has held that meandering on the original State survey is evidence of navigability, although the final test is whether the watercourse is in fact navigable (Maloney and others, 1968).

Spain, by the treaty of 1819, ceded the Floridas to the United States. By 1824, the Federal Government was sending surveyors into the territory to subdivide and record the newly acquired lands. During the next 60 years, dozens of surveyors, under contract with the U.S. Surveyor General, participated in the methodical subdivision of the State. Each surveyor was left largely to his own discretion in deciding which lakes were navigable and, therefore, should be meandered (Landrum, 1959). Simply, a meandered water body is evidence of navigability and establishes State sovereignty. However, the fact that a water body was not meandered (surveyed) does not determine navigability or State sovereignty. The meander line is not a boundary. The boundary of a lake, the dividing line between State-owned lake bottom and Federally-owned upland, is the ordinary high-water mark which existed on March 3, 1845 when Florida acquired these lakes incident to statehood (Landrum, 1959).

There are 236 meandered lakes in Florida (table 10). They range in size from Mirror Lake in Lake County with a surface area of 2 acres to Lake Okeechobee in Palm Beach County with a surface area of 436,000 acres. Twenty-nine counties in Florida have meandered lakes (table 10, fig. 30). Polk County with 58 meandered lakes has the largest number; Highlands County is second with 44 lakes, which is twice as many as other counties. The total for Polk and Highlands County represents more than 40 percent of all meandered lakes in the State.

Size

Lake Okeechobee is the largest natural freshwater lake in the conterminous United States that is entirely within one state (681 square miles at a stage of 14 feet above sea level). It is also the second largest natural freshwater lake within the conterminous 48 states. The largest natural freshwater lake in the United States that is entirely within one state is Lake Iliamna in Alaska (1,150 square miles at lake elevation 150 feet above sea level--one and a half times the area of Lake Okeechobee). Lake Michigan is the largest (22,400 square miles at lake stage 579 feet above sea level), but it is not entirely within one state (table 11).

Table 10.--Meandered lakes of Florida listed alphabetically by counties

[Modified from Kenner, 1961]

Lake	Location: Township	Location: Range	Surface area: Acres	Surface area: Sq. mi.	Drainage area sq. mi.	Elevation approx. above sea level	Type of lake[1]
			Alachua County				
Altho	8S	21,22E	555	0.87	3.39	141	3
Ledwith (also in Marion County)	11,12S	19,20E	1,785	2.79	-	66	3
Levy	11S	19,20E	4,556	7.12	-	63	3
Little Santa Fe (also in Bradford County)	8S	22E	1,135	1.77	-	141	3
Lochloosa (Lockloosa)	11S	21,22E	8,800	13.8	88.0	58	3
Newnans	9,10S	21E	7,350	11.5	114	68	3
Orange (also in Marion County)	11,12S	21,22E	13,160	20.6	1,012	58	3
Santa Fe (includes Little Santa Fe) (also in Bradford County)	8,9S	22E	5,299	8.28	24.3	141	2
			Baker County				
Ocean Pond	3S	19E	1,793	2.80	13.1	154	4
			Bay County				
Powell	2,3S	17,18W	657	1.03	-	2	3
			Bradford County				
Crosby (Little Sampson Pond)	6S	21E	536	0.84	-	131	3
Hampton (Little Santa Fe, Santa Fe Pond)	7S	21E	823	1.29	-	138	3
Little Santa Fe (see Alachua County)							
Rowell (Alligator Pond)	6,7S	21E	364	0.57	-	131	3
Sampson (Sampson Pond)	6,7S	21E	2,071	3.24	59.3	131	3
Santa Fe (see Alachua County)							
			Brevard County				
Poinsett (also in Orange and Osceola Counties)	24,25S	35E	4,293	6.71	1,272	12	3
Washington	26,27S	36E	2,665	4.16	1,025	17	3
Winder (also in Osceola County)	25,26S	34,35E	1,496	2.34	-	12	3
			Calhoun County				
Ammonia	2S	8W	126	0.20	-	28	3
Dead (see Gulf County)							

See footnote at end of table.

Table 10.--Meandered lakes of Florida listed alphabetically by counties--Continued

Lake	Location		Surface area		Drainage area sq. mi.	Elevation approx. above sea level	Type of lake[1]
	Township	Range	Acres	Sq. mi.			
			Citrus County				
Bradley	20S	20E	590	0.92	-	41	2
Tsala Apopka	17-20S	19-21E	19,000	30	-	39	3
			Clay County				
Doctors	4S	25,26E	3,397	5.31	22.4	1	3
Geneva	8S	23E	1,746	2.73	35.5	108	3
			Flagler County				
Crescent (see Putnam County)							
Dead	12,13S	28E	398	0.62	-	-	3
Disston	14S	29E	1,844	2.88	-	-	3
			Glades County				
Okeechobee (see Palm Beach County)							
			Gulf County				
Dead (Chipola) (also in Calhoun County)	3,4S	9,10W	6,700	10.5	1,205	18	3
Wimico	7,8S	9W	4,055	6.34	-	3	3
			Highlands County				
Adelaide	33S	28E	96	0.15	-	100	1
Angelo	33S	28,29E	60	0.09	-	92	4
Annie	37,38S	30E	85	0.13	5.7	111	2
Apthorpe	36S	29,30E	215	0.34	15.3	69	3
Blue	36S	30E	14	0.02	-	78	4
Buck	37S	30E	7	0.01	-	94	4
Carrie (Bear)	36S	29E	65	0.10	-	76	2
Charlotte	35S	29E	204	0.32	-	91	2
Clay	36S	30E	361	0.56	11.7	78	3
Crews	36,37S	29E	62	0.10	-	119	4
Damon	33S	28E	278	0.44	4.4	102	4
Dinner	34S	29E	380	0.59	2.0	101	4
Francis (Jack)	36S	29E	530	0.83	49.1	70	3
Grassy	37S	30E	510	0.80	5.39	90	4
Henry	36S	29E	64	0.10	-	74	4
Hill	36S	29E	70	0.11	-	99	1
Huntley	36,37S	30E	676	1.06	9.5	83	3
Istokpoga	35,36S	30,31E	27,500	43.0	607	38	3
Jackson (Rex Beach)	34,35S	28,29E	3,244	5.07	14.0	102	2
Josephine	35S	29E	1,240	1.94	46.3	71	3

See footnote at end of table.

Table 10.--Meandered lakes of Florida listed alphabetically by counties--Continued

Lake	Location		Surface area		Drainage area sq. mi.	Elevation approx. above sea level	Type of lake[1]
	Township	Range	Acres	Sq. mi.			
			Highlands County--Continued				
June-in-Winter (Stearns)	36,37S	29,30E	3,662	5.72	44.0	73	2
Lelia	33S	28E	165	0.26	-	112	4
Letta	33,34S	28,29E	471	0.74	15.6	99	3
Little Red Water	34S	28,29E	329	0.52	9.6	104	3
Little Red Water (Allie)	36S	29E	21	0.03	-	70	2
Lotela	33S	28E	795	1.24	12.2	106	3
McCoy	37S	30E	54	0.08	0.3	86	4
Mirror	37S	30E	96	0.15	0.6	92	2
Nellie, Center	36S	29E	43	0.07	-	71	3
Nellie, Northwest	36S	29E			-	71	2
Nellie, Southeast	36S	29E	29	0.05	-	71	1
Pearl	37S	30E	67	0.10	0.2	86	2
Persimmon	36S	29E	30	0.05	-	68	2
Placid (Childs)	37S	29,30E	3,381	5.28	20.2	92	3
Pythias	33S	28E	318	0.50	-	101	2
Red Beach	35S	29E	335	0.52	-	76	2
Red Water	36S	29E	66	0.10	-	70	3
Ruth	35S	29E	83	0.13	-	91	4
Saddlebags	36,37S	30E	23	0.04	-	83	4
Sebring	34S	28E	465	0.73	6.1	107	3
Simmons	36S	29E	22	0.03	-	72	4
Sirena	37S	29E	149	0.23	1.4	86	1
Trout (see Polk County)							
Tulane	33S	28E	89	0.14	-	117	4
Viola (Vigo)	33S	28E	73	0.11	-	112	4
			Hillsborough County				
Keystone (Distress)	27S	17E	388	0.61	10	41	3
Thonotosassa (Flints)	28S	20E	824	1.29	60.0	30	3
			Jackson County				
Ocheesee Pond (Cypress)	3,4N	7,8W	2,230	3.5	24.2	111	3
			Jefferson County				
Miccosukee (also in Leon County)	2,3N	3,4E	6,312	9.86	240	80	3
			Lake County				
Apopka (see Orange County)							
Beauclair (also in Orange County)	20S	26,27E	1,111	1.74	-	63	3

See footnote at end of table.

Table 10.--Meandered lakes of Florida listed alphabetically by counties--Continued

Lake	Location		Surface area		Drainage area sq. mi.	Elevation approx. above sea level	Type of lake[1]
	Township	Range	Acres	Sq. mi.			
			Lake County--Continued				
Carlton (see Orange County)							
Dexter (see Volusia County)							
Dora	19,20S	26,27E	4,437	6.93	236	63	3
Dorr	17S	27E	1,712	2.68	26.5	34	3
Eustis	19S	25,26E	7,806	12.2	646	63	3
George (see Volusia County)							
Gertrude	19S	26,27E	250	0.39	-	69	4
Grassy	22S	26E	156	0.24	-	83	4
Griffin	18,19S	24,25E	10,660	16.7	775	59	3
Harris (includes Little Harris)	19-21S	24-26E	17,650	27.6	357	63	3
Joanna	19S	27E	302	0.47	-	154	3
Johns (see Orange County)							
Junietta	19S	26E	40	0.06	-	63	4
Little Harris	20,21S	25,26E	2,739	4.28	-	63	3
Louisa (Louise)	23S	26E	3,660	5.72	121	94	3
Minnehaha	22,23S	25,26E	2,410	3.77	131	96	3
Minneola	22S	25,26E	1,892	2.96	158	96	3
Mirror	17S	28E	2	0.003	-	44	4
Norris	18S	28E	1,131	1.77	-	31	3
Saunders	19S	26E	420	0.66	-	74	4
Silver	19S	25E	388	0.61	-	66	4
Tracy	17,18S	28E	-	-	-	-	3
Yale	18S	25,26E	4,030	6.30	67.6	59	3
Unnamed Lakes.--							
Sections 13,14	18,19S	26,27E	-	-	-	-	-
Sections 18,19	18S	27E	-	-	-	-	-
Sections 24,25	19S	26E	-	-	-	-	-
			Leon County				
Iamonia	2,3N	1,2E,1W	5,680	8.9	101	98	1
Jackson	1,2N	1W	4,001	6.25	43.1	87	1
Miccosukee (see Jefferson County)							
			Madison County				
A Deep Pond	3N	8E	-	-	-	-	1

See footnote at end of table.

Table 10.--Meandered lakes of Florida listed alphabetically by counties--Continued

Lake	Location		Surface area		Drainage area sq. mi.	Elevation approx. above sea level	Type of lake[1]
	Township	Range	Acres	Sq. mi.			
			Marion County				
Bryant	15S	24,25E	1,260	2.04	9.86	54	3
Kerr (Ker) (includes Warner)	13S	25,26E	4,484	7.01	102	25	1
Ledwith (see Alachua County)							
Little Weir	17S	23E	320	0.50	-	57	2
Mill Dam	15S	25E	346	0.54	39.4	-	4
Nicotoon	17S	26E	328	0.51	19.2	55	4
Orange (see Alachua County)							
Smith	16S	23E	482	0.75	5.01	55	2
Weir (includes Little Weir)	17S	23,24E	5,760	9.0	53.8	57	3
			Orange County				
Apopka (and Lake County)	21,22S	26-28E	30,630	47.9	128	66	3
Beauclair (see Lake County)							
Butler	23S	27,28E	1,665	2.60	14.5	98	3
Carlton (Sam's) (also in Lake County)	20S	26,27E	382	0.60	-	63	3
Conway	23S	29,30E	1,079	1.69	12.7	86	3
Hart	24S	31E	1,841	2.88	166	58	3
Johns (also in Lake County)	22,23S	26,27E	2,411	3.77	40.1	94	3
Ola	20S	27E	442	0.69	-	72	2
Pickett (Pickle) (also in Seminole County)	21,22S	32E	742	1.16	-	56	3
Poinsett (see Brevard County)							
Tibet	23S	28E	1,205	1.88	24.2	98	3
			Osceola County				
Alligator	26S	31E	3,401	5.31	26.6	64	3
Cypress (also in Polk County)	27,28S	30E	4,085	6.38	1,162	52	3
East Tohopekaliga	25S	30,31E	11,950	18.7	308	57	3
Gentry	27S	31E	1,797	2.81	44.6	62	3
Hatchineha	28S	29,30E	6,636	10.4	1,162	52	3
Jackson	29,30S	31,32E	1,020	1.59	-	51	3
Kissimmee	29-31S	30,31E	34,760	54.3	1,607	49	3
Lizzie	26S	31E	792	1.24	-	63	2
Marian	30S	32,33E	5,727	8.95	49.6	59	3
Poinsett (see Brevard County)							

See footnote at end of table.

Table 10.--Meandered lakes of Florida listed alphabetically by counties--Continued

Lake	Location		Surface area		Drainage area sq. mi.	Elevation approx. above sea level	Type of lake[1]
	Township	Range	Acres	Sq. mi.			
			Osceola County--Continued				
Preston	25S	32E	690	1.08	-	61	3
Runnymede	25,26S	30,31E	300	0.47	-	57	3
Tohopekaliga	25,27S	29,30E	18,790	29.4	620	53	3
Trout	25,26S	31E	273	0.43	-	63	3
Winder (see Brevard County)							
			Palm Beach County				
Clarke	44S	43E	33	0.05	-	9	4
Mangonia	43S	43E	540	0.84	-	13	2
Okeechobee (also in Glades County)	37-43S	32-37E	436,000	681	5,650	14	3
Osborne	44,45S	43E	356	0.56	-	9	3
Webster	45S	43E	-	-	-	-	-
			Pinellas County				
Tarpon (Butler)	27,28S	16E	2,534	3.96	60	2	3
			Polk County				
Annie	28,29E	27E	534	0.83	4.06	119	3
Arbuckle	32S	29,30E	3,787	5.92	170	53	3
Ariana	27,28S	25E	1,019	1.59	7.86	130	3
Aurora	30S	28,29E	176	0.28	-	101	4
Banana (Mud)	29S	24E	343	0.54	14.3	105	3
Bess	29S	27E	148	0.23	-	125	1
Blue	30S	27E	118	0.18	-	117	4
Bonny (Bony)	28S	24E	346	0.54	2.89	130	2
Buffum	31S	26,27E	1,544	2.41	11.0	132	1
Cannon	28S	26E	333	0.52	10.1	131	3
Clinch (Belmon, Crooked, Locha-popka, Turtle Eating)	31,32S	28E	1,194	1.87	42.0	103	3
Conine	28S	26E	237	0.37	17.2	128	3
Crooked (Caloosa)	30,31S	27,28E	5,533	8.65	31.3	118	3
Crystal (part of Hamilton)	28S	26,27E	33	0.50	0.40	1.31	2
Cypress (see Osceola County)							
Eagle (Bourke)	28,29S	25,26E	659	1.03	2.52	131	2
Easy	30S	27,28E	419	0.65	-	112	1
Eloise	28,29S	26E	1,172	1.83	5.62	131	3
Fannie (Fanny)	28S	26E	833	1.30	24.7	125	3
Garfield	29,30S	26E	664	1.04	18.0	100	3

See footnote at end of table.

Table 10.--Meandered lakes of Florida listed alphabetically by counties--Continued

Lake	Location		Surface area		Drainage area sq. mi.	Elevation approx. above sea level	Type of lake[1]
	Township	Range	Acres	Sq. mi.			
			Polk County--Continued				
Gator	30S	26E	114	0.18	-	130	4
Gibson	27S	23,24E	477	0.75	4.31	145	3
Gordon	30S	27E	213	0.33	-	114	3
Hamilton	28S	26,27E	2,170	3.39	46.8	120	3
Hancock	28,29S	24,25E	4,541	7.10	131	97	3
Hartridge	28S	26E	437	0.68	1.33	131	3
Hatchineha (see Osceola County)							
Hickory	32S	28E	100	0.16	-	98	4
Hollingsworth	28S	24E	356	0.56	1.92	133	2
Howard	28S	26E	634	0.99	12.8	131	3
Kissimmee (see Osceola County)							
Lee	29S	27E	40	0.06	-	119	2
Lenore (Patrick)	31S	28E	393	0.61	-	86	2
Little Hamilton (part of Hamilton)	28S	27E	367	0.57	-	120	3
Livingston	32S	28E	1,192	1.86	28.9	87	2
Lulu (part of Eloise)	28,29S	26E	307	0.48	22.7	131	3
Marion	27,28S	27,28E	2,968	4.64	35.7	67	3
McLeod	29S	25,26E	488	0.76	1.50	133	4
Middle Hamilton (part of Hamilton)	28E	26,27E	106	0.17	-	120	3
Moody	31S	28E	391	0.61	-	-	4
Myrtle	29S	27E	416	0.65	4.98	118	3
Parker	27,28S	24E	2,291	3.58	23.6	128	3
Pierce	28,29S	28E	3,736	5.84	58.9	76	1
Polecat	30S	26E	40	0.06	-	140	4
Reedy (Istokpogayksa, Head of Deadman's)	31,32S	28E	3,454	5.40	60.9	78	3
Rochelle	28S	26E	581	0.91	15.6	128	3
Rosalie	29,30S	29E	4,592	7.18	133	53	3
Ruby	29S	26,27E	253	0.40	0.93	125	1
Sarah (part of Hamilton)	28S	27E	41	-	-	121	2
Scott	29S	24E	287	0.45	2.11	168	3
Shipp	28S	26E	284	0.44	14.9	131	3
Silver	32S	28E	130	0.20	-	102	4
Smart	28S	26E	279	0.44	17.9	128	3
Streety	32S	27E	321	0.50	-	105	3
Surveyors	30S	26E	293	0.46	-	131	4
Tiger (Kotsa)	29,30S	29,30E	2,200	3.44	-	.50	3
Trask	28S	27E	163	0.25	-	109	4

See footnote at end of table.

Table 10.--Meandered lakes of Florida listed alphabetically by counties--Continued

Lake	Location: Township	Location: Range	Surface area: Acres	Surface area: Sq. mi.	Drainage area sq. mi.	Elevation approx. above sea level	Type of lake[1]
			Polk County--Continued				
Trout (also in Highlands County)	32S	28E	143	0.22	-	102	4
Wales	30S	27E	330	0.52	2.4	112	4
Weohyakapka (Walk-in-The Water)	30,31S	29E	7,555	11.8	93.5	62	3
Winterset	29S	26E	551	0.86	2.19	131	1
			Putnam County				
Adaho	9S	23E	106	0.17	-	98	2
Ashley (Ashley Prairie)	9S	23E	85	0.13	-	95	2
Boyds	9S	24E	59	0.09	-	85	3
Brantley	9S	23,24E	324	0.51	-	86	4
Broward	11S	27E	480	0.75	-	-	4
Clearwater	9S	24E	37	0.06	-	87	4
Cowpen (Water Pen)	10S	23E	584	0.91	-	95	4
Crescent (Dunn's) (also in Flagler County)	11-13S	27,28E	17,140	27.0	456	1	3
Georges	8S	24,25E	816	1.28	-	99	3
Goose	9S	23E	199	0.31	-	95	3
Grandin	9S	24E	354	0.55	3.71	82	4
Levys Prairie	10S	23E	1,938	3.03	-	90	3
Long Pond	9S	24E	35	0.05	-	86	4
Orange Grove	9S	24E	4	0.006	-	89	4
Stella	12S	27,28E	308	0.48	-	-	4
Suggs	9S	23E	181	0.28	-	98	3
Swan	9S	23E	554	0.87	-	96	4
Wall	9S	23E	53	0.08	-	95	4
Unnamed Lakes.--							
Section 27	9S	24E	-	-	-	-	-
Section 21	9S	24E	-	-	-	-	-
Section 16	9S	24E	-	-	-	-	-
			Seminole County				
Harney (see Volusia County)							
Jessup	20S	30,31E	7,792	12.2	156	5	3
Mills (Mill)	21S	32E	233	0.36	10.6	42	3
Monroe (also in Volusia County)	19S	30,31E	8,840	13.8	2,582	5	3
Mullet	19,20S	32E	631	0.99	-	3	3
Pickett (see Orange County)							

See footnote at end of table.

Table 10.--Meandered lakes of Florida listed alphabetically by counties--Continued

Lake	Location		Surface area		Drainage area sq. mi.	Elevation approx. above sea level	Type of lake[1]
	Township	Range	Acres	Sq. mi.			
			Sumter County				
Sarah Jane	18S	23E	-	-	-	-	-
Panasoffkee	19,20S	22E	4,821	7.53	420	41	3
			Volusia County				
Ashby	18S	32E	1,077	1.68	-	11	3
Beresford	17S	29,30E	800	1.25	-	1	3
Bethel	19S	31E	213	0.33	-	-	3
Dexter (Pond) (also in Lake County)	16S	27,28E	1,902	2.97	-	1	3
George (also in Lake County)	13-15S	26,27E	46,780	73.1	3,721	4	3
Harney (also in Seminole County)	19,20S	32,33E	6,058	9.47	-	2	3
Lower Louise (Long Pond)	13S	28E	257	0.40	-	-	1
Monroe (see Seminole County)							
Spring Garden (Mud)	16S	29E	521	0.81	-	1	3
Unnamed Lakes.--							
Sections 20,29	15S	30E	-	-	-	-	-
Sections 28-33	15S	30E	-	-	-	-	-
Sections 19,20,24	15S	29E					
			Walton County				
Deer	3S	18W	40	0.06	-	2	3
Eastern	3S	18,19W	90	0.14	-	2	3
Jackson (Jackson's Pond) (also in Covington County, Ala.)	6N	21W	210	0.33	2.0	253	2
Oyster	3S	20W	22	0.03	-	2	1
Stalworth	3S	20W	16	0.02	-	6	4

[1] Type of lakes: 1. Streams flowing in, 2. Streams flowing out, 3. Streams flowing both in and out, 4. Landlocked.

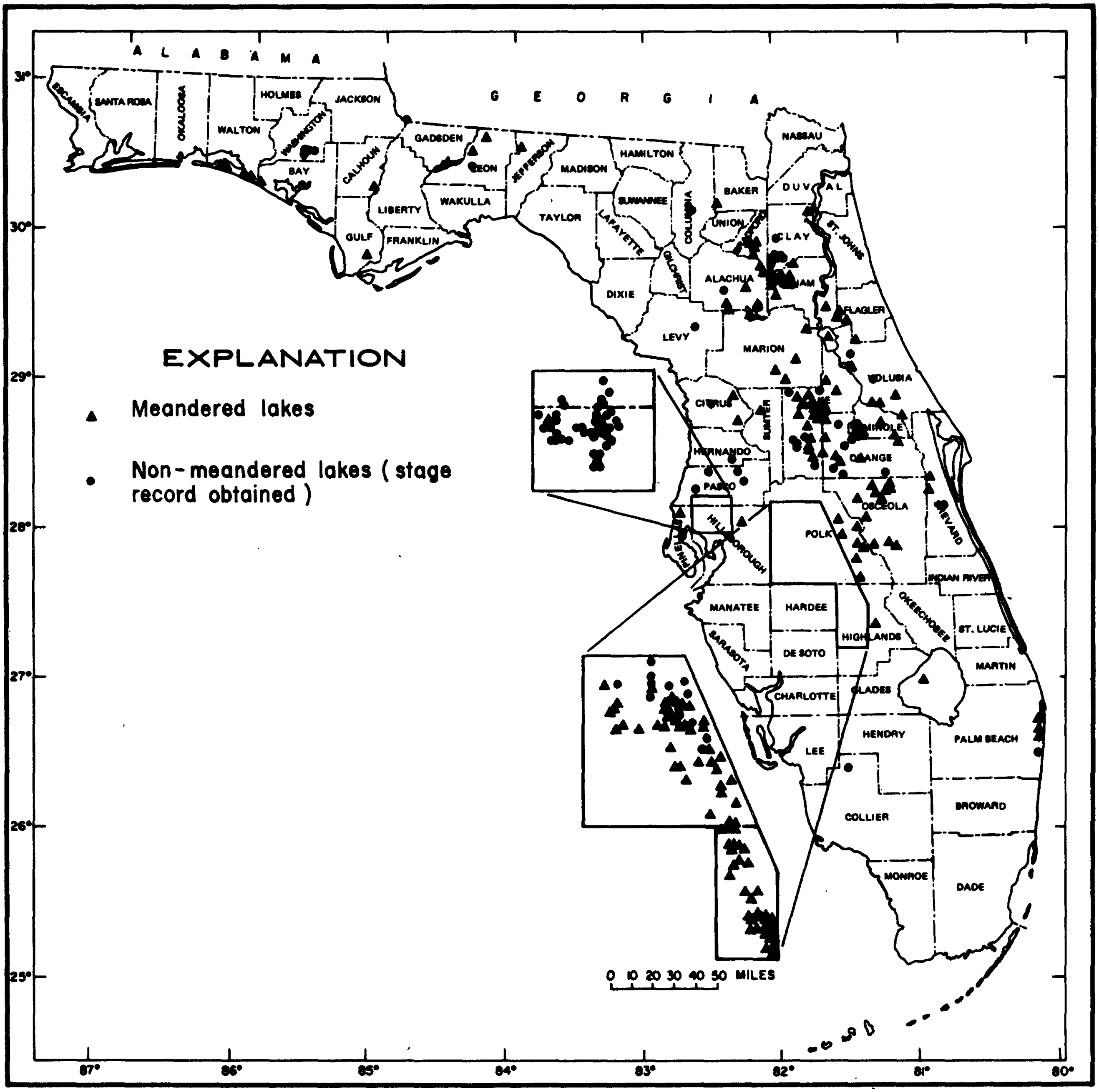


Figure 30.--Location of meandered lakes and nonmeandered lakes having stage records in Florida (modified from Hughes, 1974).

Table 11.--Comparison of large natural lakes of the United States ranked according to surface area

[Modified from Bue, 1963]

Lake	Surface area (square miles)
Superior, U.S. and Canada	31,820
Huron, U.S. and Canada	23,010
Michigan, U.S.	22,400
Erie, U.S. and Canada	9,940
Ontario, U.S. and Canada	7,540
Lake of the Woods, Minnesota and Ontario	1,485
Iliamna, Alaska	1,150
Great Salt Lake[1], Utah	1,000
Okeechobee, Florida	681
Pontchartrain[1], Louisiana	625
Champlain, New York, Vermont, and Quebec	490
St. Clair, Michigan and Ontario	460
Becharof, Alaska	458
Red Lake, Minnesota	451
Salton Sea[1], California	350
Rainy, Minnesota and Ontario	345
Teshekpuk, Alaska	315
Naknek, Alaska	242
Winnebago, Wisconsin	215
Mille Lacs, Minnesota	207

[1] Saline lakes.

Florida has 20 natural freshwater lakes with areas of 10 square miles or more (table 12); in the United States, only Alaska and Minnesota have more. The 20 largest lakes in Florida range in size from 681 square miles, Lake Okeechobee, to 10.2 square miles, Blue Cypress. Lake Okeechobee is nearly 10 times the size of Lake George, the second largest lake in Florida with an area of 73 square miles.

Worldwide, Lake Superior is the largest body of freshwater (31,820 square miles); Lake Victoria in Africa is second (26,800 square miles); Lakes Huron and Michigan rank third and fourth. Though not freshwater, the largest lake in the world is considered to be the Caspian Sea (143,550 square miles of surface area) in Asia-Europe (Bue, 1963).

Level and Fluctuation

Lake Jackson near Paxton in Walton County has the highest known water level of any lake in Florida with a range in stage between about 253 to 256 feet above sea level. Many lakes in or near coastal areas of the State are less than 5 feet above sea level.

Between significant wet and dry spells, the range of fluctuation in stage (lake level) varies greatly among lakes (fig. 31) in Florida. Stages vary as little as 2 feet for some lakes, but more than 30 feet for others. About 80 percent fluctuate 5 feet or more as indicated in figure 32 (Hughes, 1974). Fluctuations in stage of lakes are the result of a number of hydrological and geological factors and in many cases are influenced by man's activities. An understanding of the hydrologic system is needed to determine the cause and magnitude of fluctuations of a particular lake. As fluctuations in lake level are mainly the result of rainfall and lack of rainfall, levels of lakes in the same general area tend to fluctuate together; however, the range of fluctuation may differ significantly. Pebble Lake and Kingsley Lake in Clay County are only about 10 miles apart in what appears to be similar terrane. Yet, since 1945, the range of fluctuation in level of Pebble Lake is about 10 times greater than the range for Kingsley Lake, as indicated in figure 33 (Hughes, 1974).

Lake levels are influenced by the level of the water table in the adjoining aquifer and by the level of the potentiometric surface in the underlying artesian aquifer. The relation of the various levels is complex and variable, depending upon the degree of interconnection of the lake with the aquifers and the relative elevation of the levels. The relation between the potentiometric surface at Bay Lake in Orange County from below lake level in dry periods to above lake level in wet periods and the level of the lake under natural conditions prior to lake level control is shown in figure 34 (from Hughes, 1974).

Lake levels for closed lakes that remain above the potentiometric surface, in the underlying limestone aquifer, fluctuate in response to precipitation on the lake, surface and ground-water runoff to the lake, evaporation from the lake, and downward leakage from the lake. Thus, the level of closed lakes is the net result of the balance between long-term inflow and outflow as illustrated by Lake Jackson near Tallahassee (fig. 35).

Table 12.--Natural freshwater lakes in Florida of 10 square miles or more in area ranked according to size

Name	County(ies)	Surface area	
		Acres	Square miles
Okeechobee	Glades, Hendry, Martin, Okeechobee, Palm Beach	436,000	681
George	Lake, Marion, Putnam, Volusia	46,780	73.0
Kissimmee	Osceola, Polk	34,710	54.2
Apopka	Orange	30,630	47.9
Istokpoga	Highlands	27,500	43.0
Tsala Apopka	Citrus	19,000	30.0
Tohopekaliga	Osceola	18,790	29.4
Harris	Lake	17,650	27.6
Crescent	Flagler, Putnam	17,140	26.8
Orange	Alachua, Marion	13,160	20.6
East Tohopekaliga	Osceola	11,950	18.7
Griffin	Lake	10,660	16.7
Monroe	Seminole, Volusia	8,840	13.8
Lochloosa	Alachua	8,800	13.7
Eustes	Lake	7,806	12.2
Jessup	Seminole	7,790	12.2
Weohyakapka	Polk	7,555	11.8
Newnans	Alachua	7,350	11.5
Hatchineha	Osceola	6,636	10.4
Blue Cypress	Indian River, Osceola	6,522	10.2

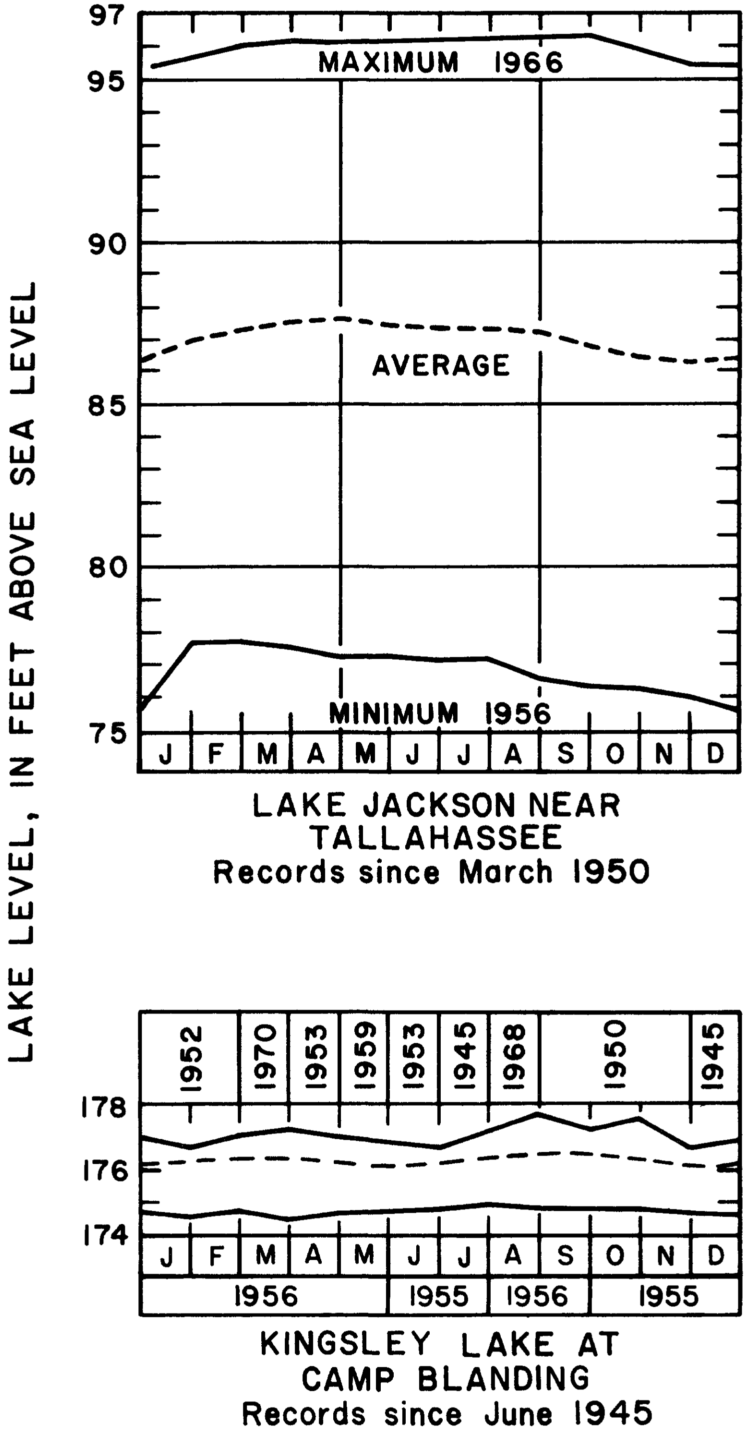


Figure 31.--Maximum, minimum, average and years of extremes of month-end lake levels for Lake Jackson near Tallahassee and Kingsley Lake at Camp Blanding, Florida.

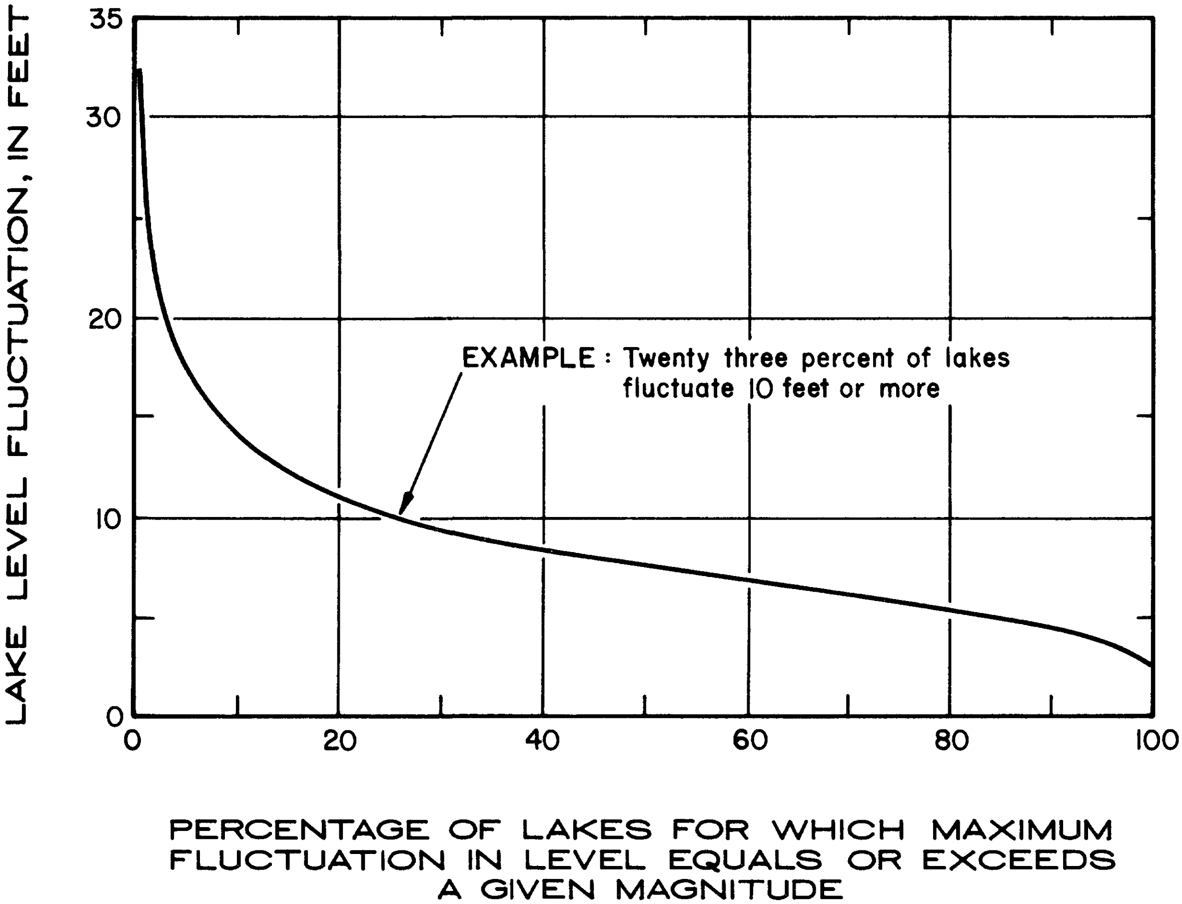


Figure 32.--Cumulative frequency distribution of maximum fluctuation in level of 110 Florida lakes having stage records of 10 years or more (from Hughes, 1974).

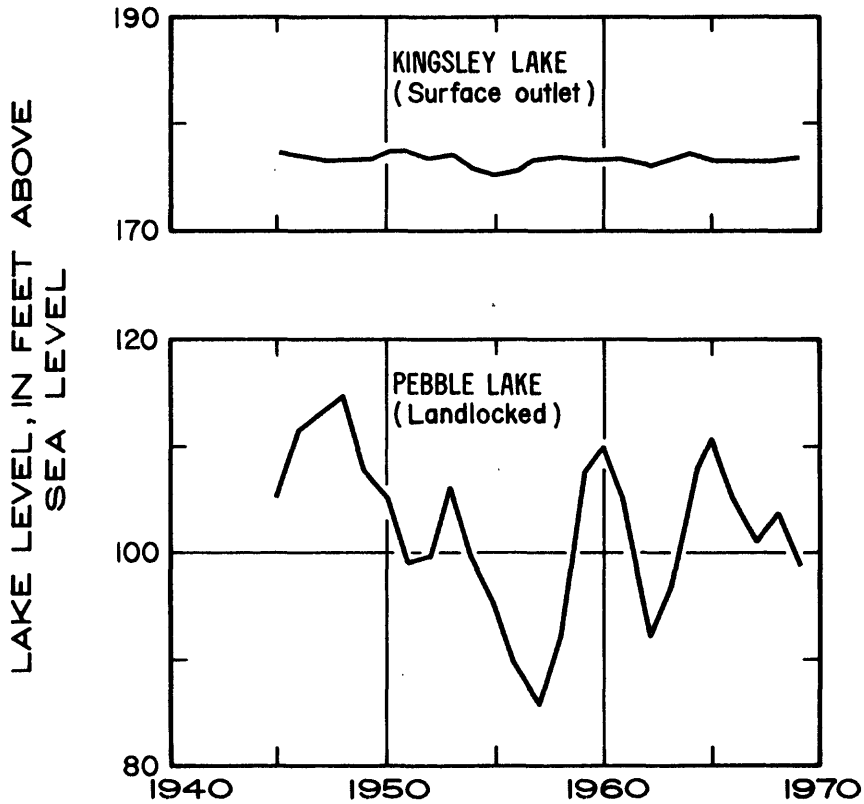


Figure 33.--Contrasting hydrographs of two lakes, Clay County, Florida (from Hughes, 1974).

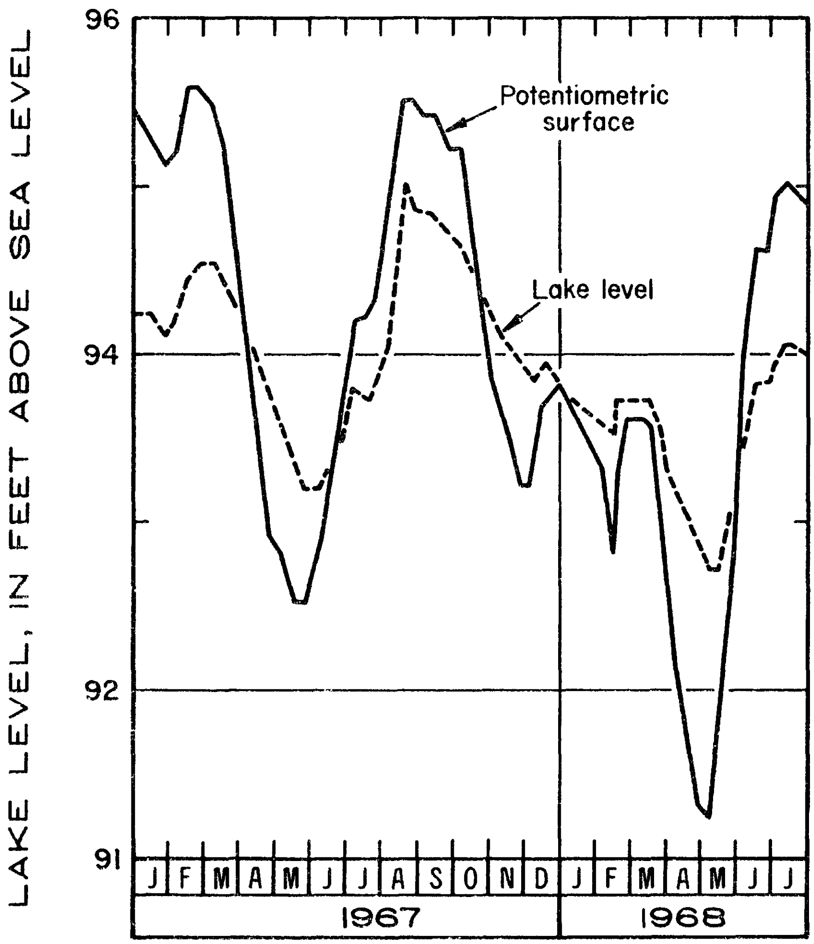


Figure 34.--Seasonal fluctuation in levels of Bay Lake, Orange County, Florida, prior to lake level control, and potentiometric surface of confined aquifer (Floridan) underlying Bay Lake (modified from Hughes, 1974).

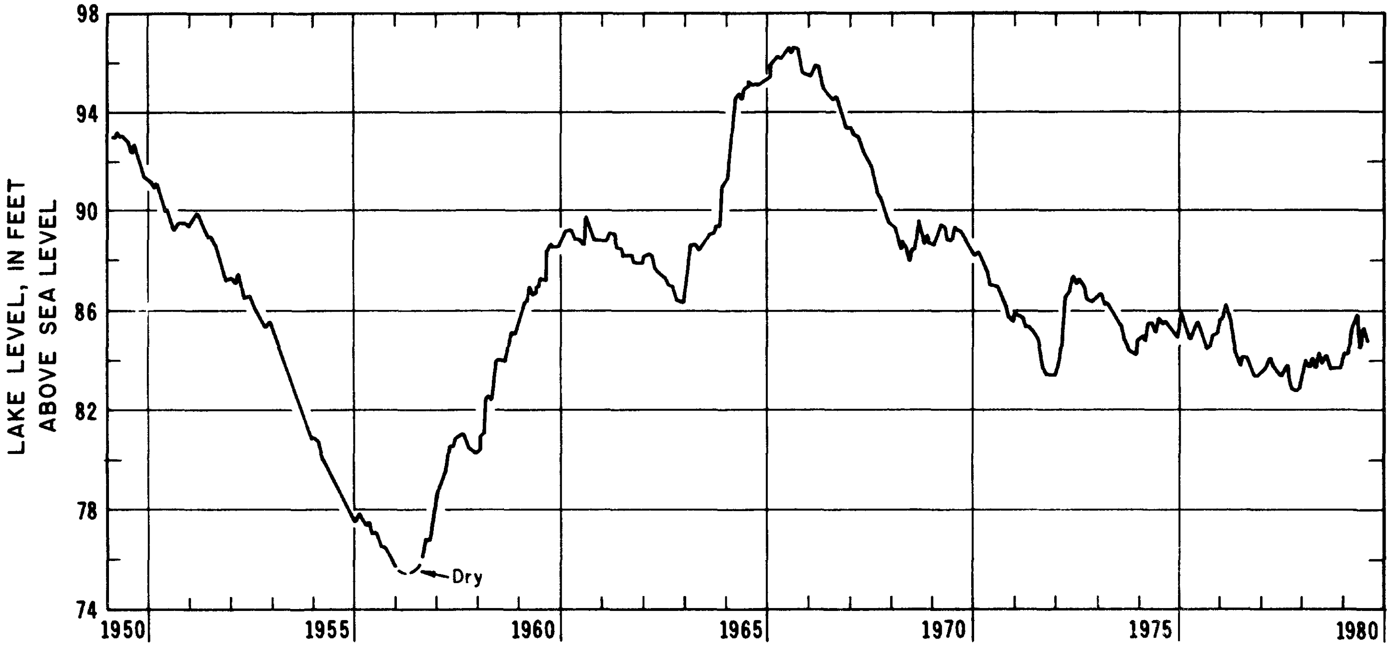


Figure 35.--Month-end water level of Lake Jackson near Tallahassee, Florida (modified from Hughes, 1969).

Levels of lakes interconnected by a stream tend to fluctuate together but the range of fluctuation may differ significantly. Since 1935, the fluctuation in level of a group of large regulated lakes on the Oklawaha River has ranged from 4 feet at Lake Griffin to 6 feet at Lake Eustis. Since 1942, the maximum fluctuation in level of uncontrolled lakes on the St. Johns River has ranged from 10.5 feet at Lake Washington to 9.0 feet at Lake Monroe. The difference in the magnitude of lake-level fluctuations is marked in a chain of lakes in the upper Etonia Creek, a small basin in Clay County, where since 1957 the fluctuation in level has ranged from only 2 feet at Sand Hill Lake to 10.2 feet at Brooklyn Lake.

Depth

Generally, lakes in Florida range in average depth from about 7 feet (such as Lake Tohopekaliga--fig. 36) to 20 feet. The deepest lake in Florida is not known but likely is Emerald Spring, a sinkhole lake, near Orlando. In 1950, it was 390 feet deep when the water level was 56 feet below land surface. The sinkhole is about 20 feet in diameter from the surface down to 20 feet below sea level where it connects to a large cavern that bottoms at 280 feet below sea level (Stringfield, 1966). Another deep sinkhole lake is Still Lake, about 16 miles east and slightly south of Fort Myers in Lee County. In 1943, it had a maximum depth of 208 feet below water surface. The area of Still Lake is about 6.5 acres and the maximum depth occurs in a narrow funnel about 20 to 40 feet in diameter (Parker and Cooke, 1944).

Some lakes have small, deeper areas that extend a number of feet down from the water surface such as 34 feet in Lake Weir (fig. 37). Kingsley Lake at Camp Blanding in Clay County has a bottom contour that is characteristic in shape of a circular sinkhole (fig. 38). One part of the lake has an 85-foot depth (Clark and others, 1962). Kingsley Lake is one of the deepest lakes in Florida.

Lake Tarpon Sink, a sinkhole on the west side of Lake Tarpon near Tarpon Springs in Pinellas County, is 115 feet deep (fig. 39). The maximum depth of the lake proper is less than 15 feet. Because of frequent inflow of saline water to the lake through Lake Tarpon Sink, an earthen dike with four gated culverts was constructed around the sinkhole in May 1969. Levels of the lake have ranged from slightly more than 7 feet to less than 1 foot above sea level (Hunn, 1974).

Although Lake Okeechobee has a large surface area (681 square miles nearly 30 miles in diameter), it is a very shallow lake; the deepest parts of the lake are approximately at sea level (Parker and others, 1955). The lake levels have ranged from a maximum of 24 to a minimum of about 10 feet above sea level. At an average lake level of 14 feet above sea level (and at maximum natural depth of about 14 feet), the capacity of the 30-mile diameter lake is 3,530,000 acre-feet (U.S. Army Corps of Engineers, undated); or about 1 cubic mile of water.

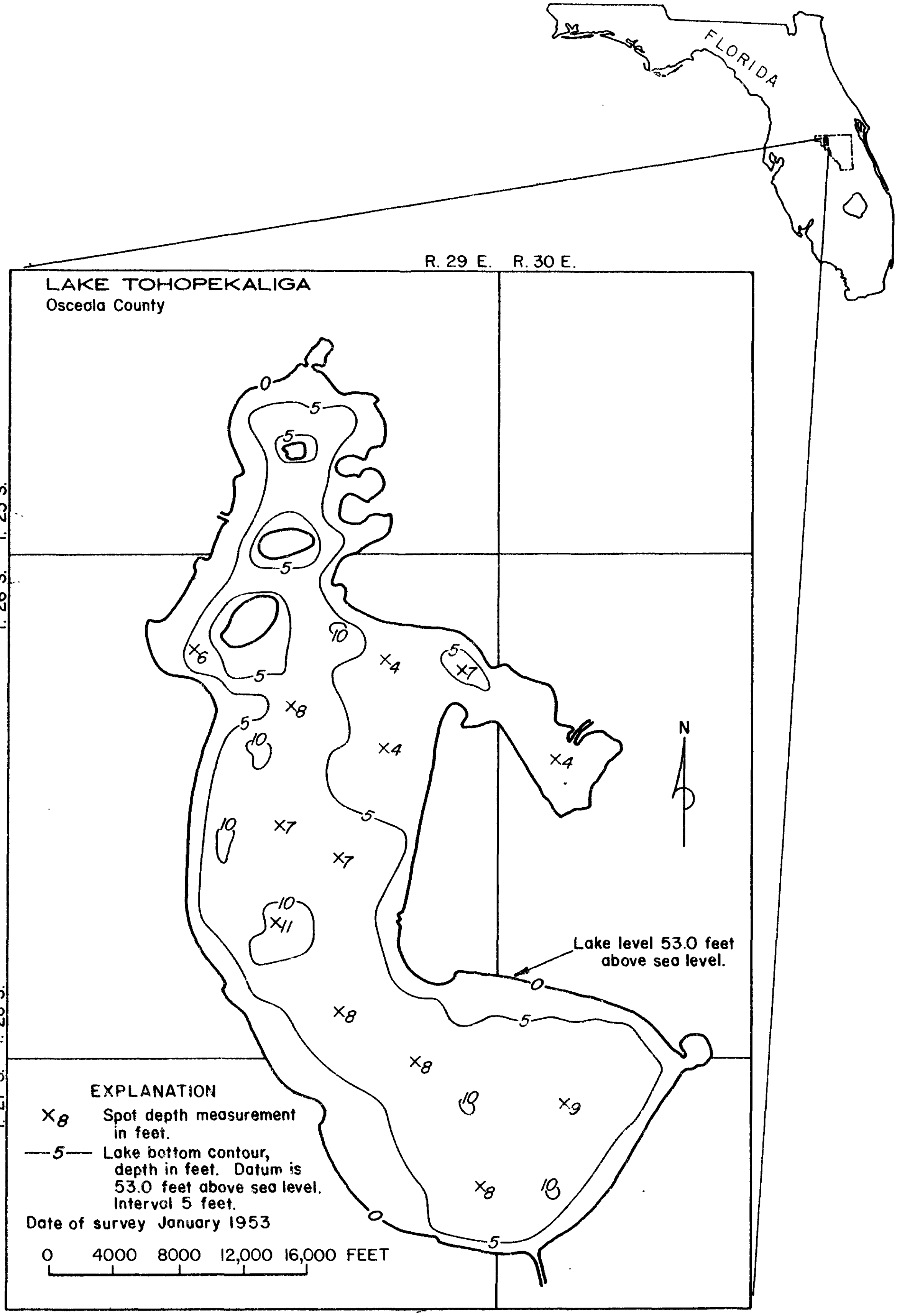


Figure 36.--Lake bottom contours of Lake Tohopekaliga at Kissimmee, Florida (modified from Kenner, 1964).

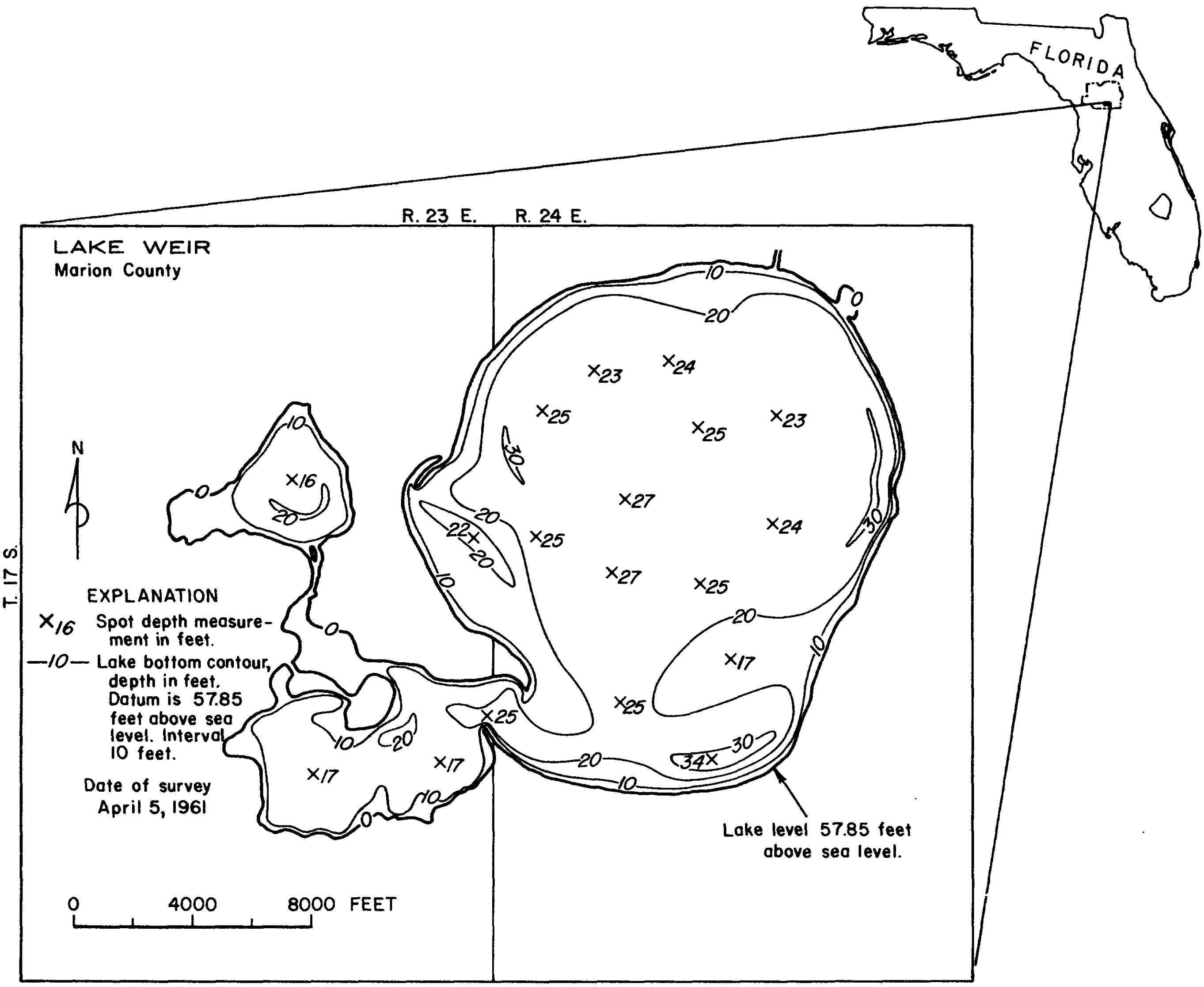
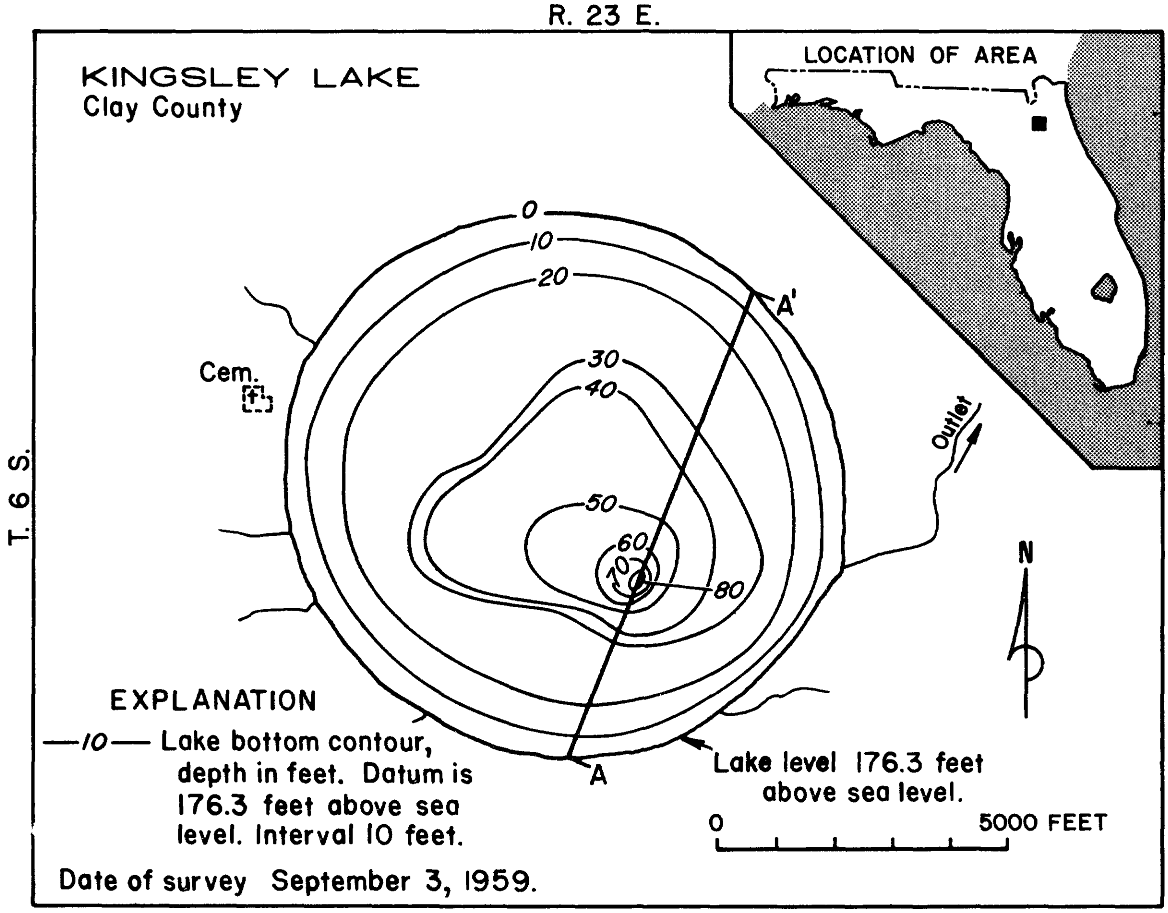


Figure 37.--Lake bottom contours of Lake Weir at Oklawaha, Florida (modified from Kenner, 1964).



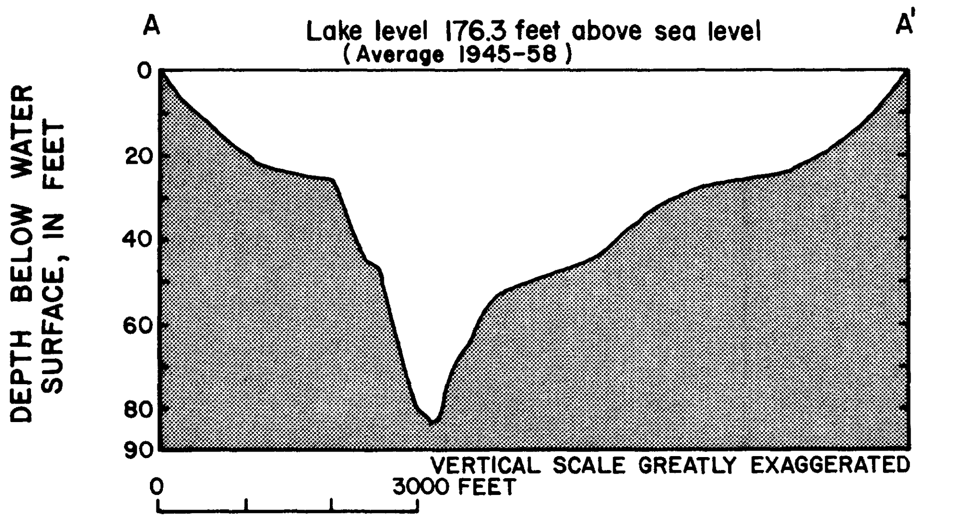


Figure 38.--Lake bottom contours and cross section of Kingsley Lake near Camp Blanding, Florida (modified from Clark and others, 1962).

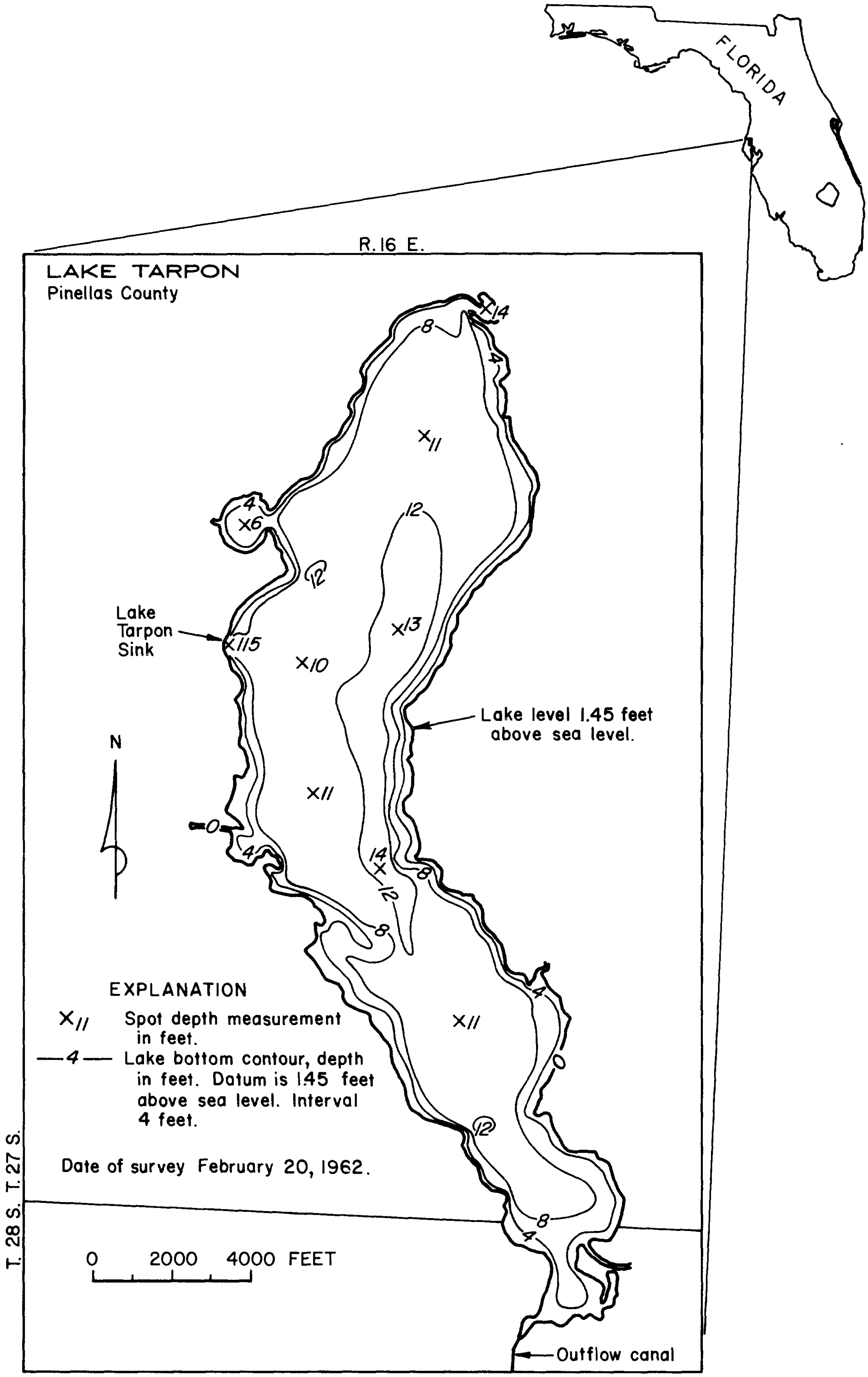


Figure 39.--Lake bottom contours of Lake Tarpon near Tarpon Springs, Florida, and location of Lake Tarpon Sink (modified from Kenner, 1964).

Pumpage

The effect on stage of pumping water from an individual lake is conjectural unless an intensive study is made of a lake. Large amounts of water are lost to evaporation every month, and for lakes of substantial size it is likely that more water is lost by this process than is pumped by riparian owners.

The effect of pumping on the level of a lake is illustrated by a family of curves showing 30-day changes in elevation for selected rates of pumping from lakes with surface areas up to 14 square miles (fig. 40). For instance, pumping 2,000 gal/min continuously for 30 days from a lake with an area of 4 square miles will lower the lake level about 0.1 foot.

Reservoirs

Reservoirs are manmade lakes or impoundments as distinguished from controlled natural lakes. For example, Lake Okeechobee is a controlled natural lake though it, like other controlled lakes, is at times referred to as a reservoir. Likewise, most reservoirs are referred to as lakes and are so named. Reservoirs are constructed for many of the same purposes for which natural lakes are controlled.

Florida has nine freshwater reservoirs with surface areas of 6 square miles or more (table 13). Three of these reservoirs, Lake Seminole, Lake Talquin, and Lake Rousseau, were constructed primarily for hydroelectric power generation. Lake Ocklawaha was constructed to be a regulating reservoir for the Cross Florida Barge Canal. Deer Point Lake is the only large reservoir in Florida constructed primarily for water supply. The four Conservation Areas in south Florida were constructed as water regulating reservoirs.

Lake Seminole, with a surface area of about 60 square miles, mostly in Georgia, is the largest reservoir constructed for hydroelectric power. It was created by construction of Jim Woodruff Dam on the Chattahoochee River at Chattahoochee, Fla. The gates of Jim Woodruff Dam were closed May 20, 1954, and filling of Lake Seminole was accomplished in several stages through February 4, 1957, when the pool first reached normal operating level of 77 feet above sea level. The reservoir is used for power generation, navigation, and flood control.

Lake Talquin, with a surface area of 6,850 acres, more than 10 square miles, at minimum operating level is the second oldest (after Lake Rousseau) large manmade lake in Florida. Lake Talquin was formed for power generation. Storage at Jackson Bluff Dam on the Ochlockonee River near Bloxham, Fla., began in June 1929. The minimum operating level of 60 feet above sea level in the lake was reached in January 1930. Power generation ceased December 15, 1970. At present (1981), the City of Tallahassee plans to reactivate power generation at Lake Talquin.

Lake Rousseau (Inglis Pool) is the oldest large manmade lake in Florida and the first reservoir constructed in Florida for hydroelectric power generation. Inglis Dam was constructed in 1909 on the Withlacoochee River along the Levy-Citrus and Marion-Citrus County boundaries. Power generation ceased in 1965. Lake Rousseau is 11 miles long and covers

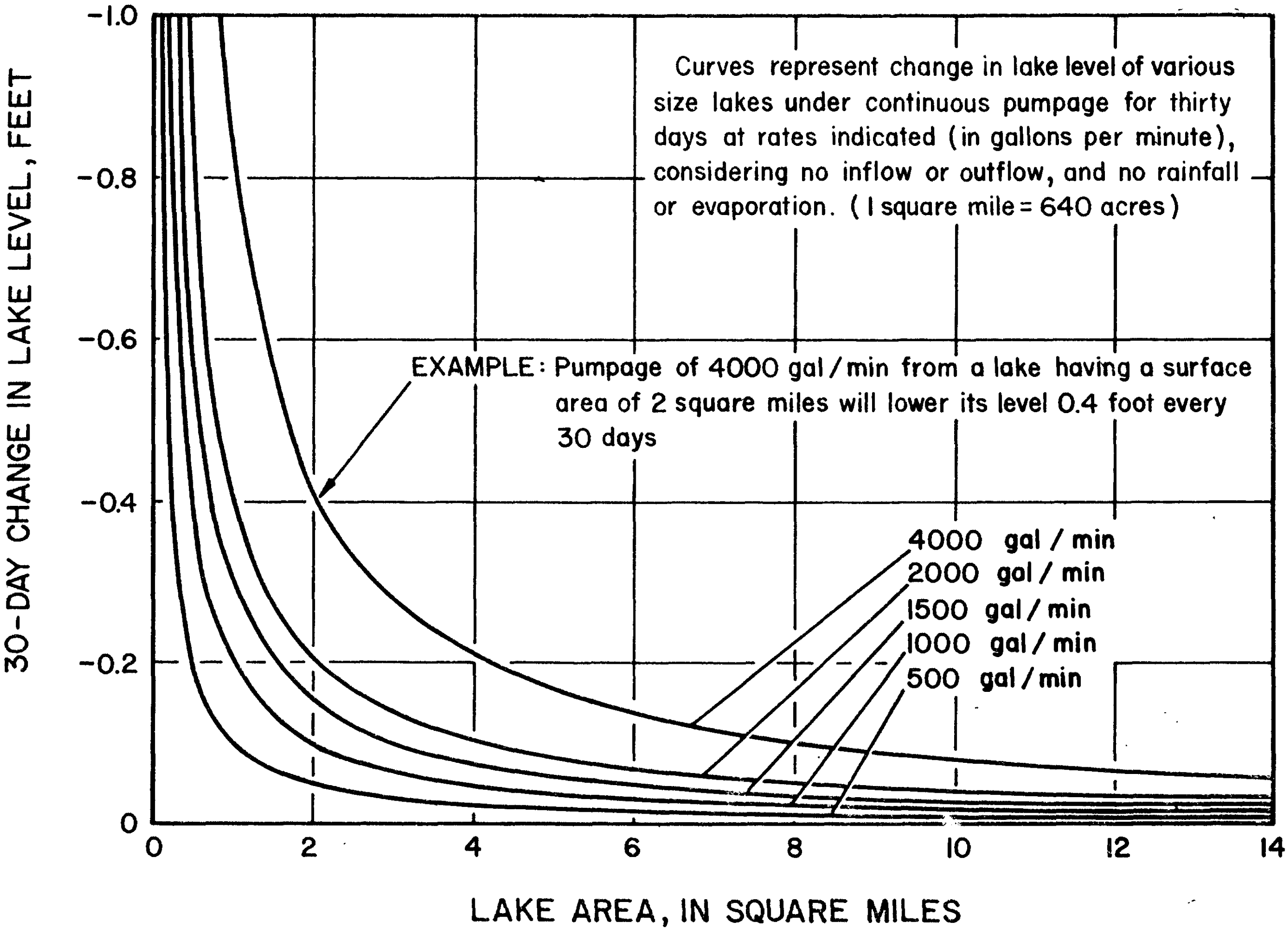


Figure 40.--Effect of pumpage from lakes (Heath, 1961).

Table 13.--Freshwater reservoirs in Florida of six square miles or more in area

Lake name and year	County(ies)	Elevation[1]	Surface area Acres	Surface area Square miles
Conservation Areas 3A, 3B 1962-67	Broward, Dade	7-8	585,280	914
Conservation Area 1 (1950's)	Palm Beach	14	141,440	221
Conservation Area 2 (1950's)	Broward	8	134,400	210
Seminole (Jim Woodruff Reservoir) 1954	Gadsden and Jackson, Fla.; Decatur and Seminole, Ga.	77	37,500	58.6
Ocklawaha (Rodman Pool) 1968	Marion, Putnam	20	10,800	16.9
Talquin (Ochlockonee Reservoir) 1929	Gadsden, Leon	60	6,850	10.7
Dead (Chipola Reservoir) 1968	Calhoun, Gulf	18.2	6,700	10.5
Deer Point (Econfina Reservoir) 1961	Bay	4.5	4,698	7.3
Rousseau (Withlacoochee Backwater, Inglis Pool) 1909	Citrus, Levy, and Marion	27.5	4,163	6.5

[1] Reservoir height in feet above sea level used for surface area computation.

4,163 acres, about 6.5 square miles, at normal lake level of 27.5 feet above sea level. Lake Rousseau was planned to be part of the Cross Florida Barge Canal, construction of which was stopped January 1971. Inglis Lock and the Withlacoochee River Bypass Channel outlets from Lake Rousseau were constructed from 1965-69 (fig. 48).

Lake Ocklawaha was formed by construction of Rodman Dam on the Oklawaha River (note different spelling for lake and river) near Orange Springs, Fla. Lake Ocklawaha (Rodman Pool) storage began September 30, 1968, and after an interim period at about 16 feet above sea level in November 1968, an operating or design pool elevation of 20 feet above sea level was first reached in July 1969. The surface area at this elevation is about 17 square miles. The reservoir was to be a part of the Cross Florida Barge Canal, construction of which began February 1964 and was stopped January 1971 (fig. 48).

Deer Point Lake was formed in 1961 by construction of a low-level causeway dam across the northern part of North Bay at Deer Point about 8 miles north of Panama City. The lake, with an area of 7.3 square miles at elevation 4.3 feet above sea level, provides a water supply for the Panama City area and adds to the water-oriented recreational facilities for tourists and residents of the area. Deer Point impounds part of the flow of four creeks--Econfina, Bear, Bayou George, and Big Cedar. Impoundment of freshwater began November 1961.

Water Conservation Areas 1, 2, 3A, and 3B within the Everglades are an integral part of the water management system in South Florida (fig. 47). They are enclosed by levees, and together occupy 1,345 square miles--nearly twice the area of Lake Okeechobee. Conservation Areas 1 and 2 were enclosed by levees during the 1950's. Conservation Area 3 was enclosed on the south side by the end of 1962 and fully enclosed by July 1967, except for 7.1 miles of the western levee system. Water in Conservation Area 1 that is in excess of regulation level can be diverted to Conservation Area 2 and the excess there can be moved to Conservation Area 3. The prime functions of the Conservation Areas are to detain and store excess water to reduce flooding of areas east of the levee system during wet periods and to release water during dry periods. Although the areas are shallow reservoirs, large volumes of water can be stored temporarily. (Leach and others, 1972.)

STREAMS

Factors influencing the surface-water features of Florida are: the State's location between the Atlantic Ocean and the Gulf of Mexico, the subtropical climate, the average rainfall of 53 inches, the relatively flat terrane, and the nature of its soils and underlying rocks. The surface-water features include extensive wetlands and swamps, many streams, lakes, and ponds in certain parts of the State, few streams in the Central Highlands, and the extensive network of ditches and canals--particularly in the southeastern part (Snell and Kenner, 1974).

The great swamps, such as the Everglades, Big Cypress Swamp, St. Johns Marsh, coastal marshes, wooded flatlands, and other wetlands along with the numerous lakes throughout the State are typical and outstanding surface-water features. Before man began to drain and develop the wetlands, they covered about half the State and exceeded the area of combined total wetlands of 37 other conterminous 48 States (Snell and Kenner, 1974, fig. 41). Wetlands are the habitat of subtropical and tropical wildlife in Florida. They are continually being altered by the works of man through vast networks of ditches and canals for the development of land for citrus and other crops and for residential and recreational uses.

Many of the streams in Florida are intrastate in character, that is, they originate in Florida and do not cross a state boundary. However, 92 named streams in Florida are interstate in character and originate in Alabama or Georgia. Figure 42 depicts less than half of the interstate streams. Some of the interstate streams are well known and discharge to the Gulf of Mexico, such as the Apalachicola-Chattahoochee River and the Suwannee River, or discharge to the Atlantic Ocean, such as the St. Marys River. Many of the interstate streams are relatively unknown and are tributary to the coastal interstate streams. Three of the interstate streams form part of the boundary between Alabama and Florida and Georgia and Florida, to wit, the Perdido River with Alabama and the Chattahoochee and St. Marys Rivers with Georgia.

Runoff

Runoff is that part of precipitation that appears in surface streams. It includes water that flows directly into gullies, creeks, lakes, and rivers, and also includes water that infiltrates to ground-water bodies and subsequently emerges as springs or as seepage to maintain base flow in streams within the area under consideration. Runoff is commonly expressed in terms of inches of water uniformly distributed over the area that contributes the water. Runoff is a measure of the water-yielding characteristics of drainage basins or areas if due allowance or recognition is made of the differing hydrogeologic characteristics of the drainage basins or areas.

The size and characteristics of the drainage basins are factors for consideration. In Florida, drainage basins may encompass many square miles, such as the Suwannee River Basin, or less than a square mile, such as a small basin tributary to a tributary of the Suwannee River. Some basins may have large land slopes while others may have essentially flat slopes. Some basins may be characterized by karst topography and internal or closed drainage while others are not.

Determining drainage divides is somewhat difficult in Florida, which for the most part has little topographic relief and also encompasses many areas of internally drained karst topography. Drainage divides frequently can be hydrologically misleading. For instance, where the ridge between basins is indistinct, such as the one between the upper part of St. Johns River Basin and the Kissimmee River Basin, and is low enough to be topped by floodwaters, it functions as a basin boundary only part of the time. During floods, water in one basin can move to an adjacent basin and run off through the stream system of the adjacent basin. Where the ridges between basins are particularly low, for example, south of Lake Okeechobee, natural drainage divides are indeterminate.

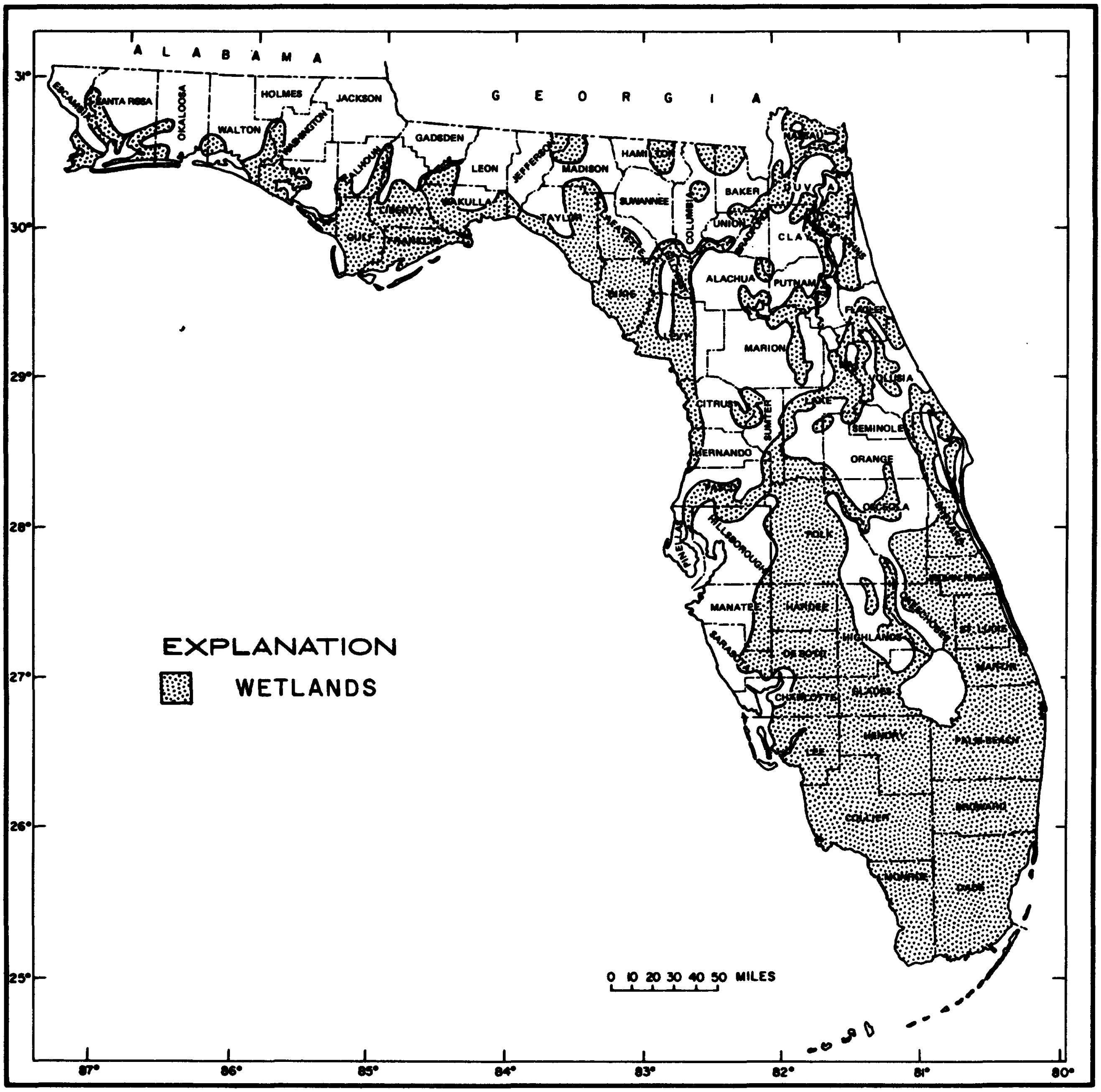


Figure 41.--Florida wetlands prior to development (modified from Snell and Kenner, 1974).

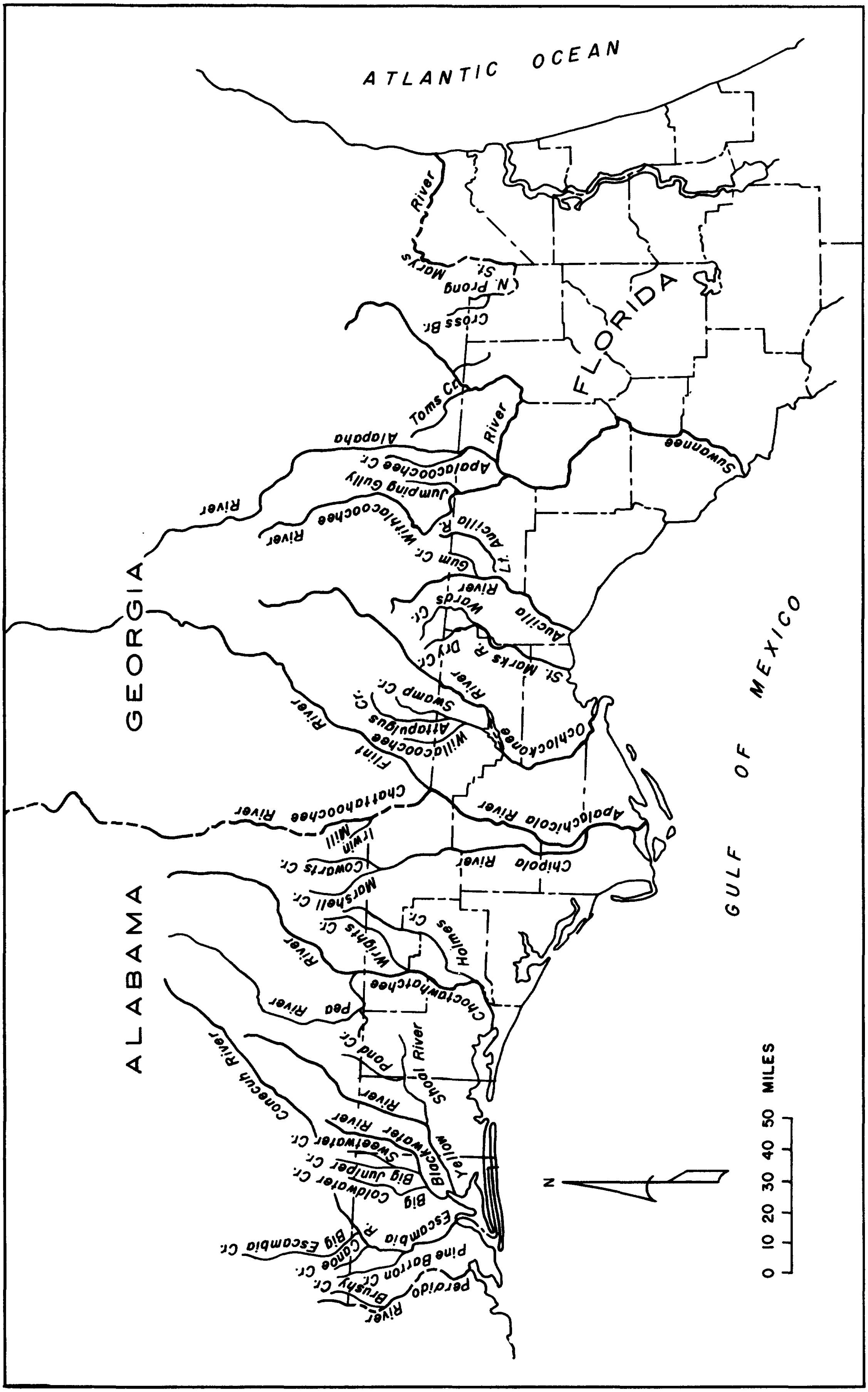


Figure 42.--Selected interstate streams of Florida.

Drainage areas over much of southeast Florida are meaningless where water is controlled by canals, dikes, impoundments, and other manmade control devices so that natural divides do not apply. The drainage pattern of some streams such as the Caloosahatchee and Kissimmee Rivers and Reedy and Shingle Creeks have been so changed by man that the drainage areas are now "indeterminate." Canals do not ordinarily have a meaningful drainage area. Some canals are "improved" streams and retain some stream characteristics. A good example is Sumter Creek Canal in west-central Florida. Drainage areas, with appropriate qualifiers, can be determined for these canals.

In areas of karst terrane, water commonly drains internally underground into cavernous formations and reappears as seepage or spring flow in downgradient areas, possibly in basins other than the one where it entered. These are referred to as noncontributing areas. For example, a large karst area in Marion County drains internally and provides water for Silver Springs which discharges to the Oklawaha River and thence to the St. Johns River and the Atlantic Ocean. It also provides water for Rainbow Springs which discharges to the Withlacoochee River and thence to the Gulf of Mexico.

Florida has many noncontributing areas; that is, areas that do not contribute directly to surface runoff. They range in size from small isolated sinkholes to many square miles. Of significance is one of approximately 50 square miles near Bennett in northern Florida called the Deadenings and one of approximately 650 square miles of drainage area for Paynes Prairie near Gainesville. Many lakes and ponds have no perennial outlets and have either noncontributing or partially noncontributing areas (Foose, 1980).

Several streams in Florida disappear underground. The Aucilla River in Jefferson County, Lost Creek and the St. Marks River in Wakulla County, Little River in Suwannee County, Falling Creek and Rose Creek in Columbia County, the Alapaha River in Madison County, the Little Alapaha River in Hamilton County, Norton Creek in Madison County, and the Santa Fe River in Alachua County among others. The drainage area for these streams is sometimes considered a closed basin and noncontributing to any other streams, but is sometimes considered to be contributing to another stream, based on the analysis of the situation for that stream.

Many Florida river systems have their headwaters in swamps. The St. Johns River, for example, flows out of the St. Johns Marsh which extends into St. Lucie County. The St. Marys and Suwannee Rivers originate in the extensive Okefenokee Swamp of southern Georgia. The Econfina, Fenholloway, and Steinhatchee Rivers, and Spring Warrior Creek originate in San Pedro Bay. The Green Swamp is the headwaters of three major systems: the Withlacoochee, the Oklawaha, and the Hillsborough. When more than one stream originates in a swamp, the drainage area for the swamp, in the absence of field data to the contrary, is split midway between the channels of the affected streams.

Areal variations in runoff are also caused by regional differences in rainfall, by the evaporation potential of the atmosphere, by the extent to which water remains on or near the land surface to sustain evaporation from the land and water surfaces and transpiration by plants, by man's activities in constructing drainage canals, reservoirs, and impervious areas, by developing irrigated cropland, and by diverting water from one basin to another.

Long-term streamflow records show that the statewide annual runoff from Florida averages about 14 inches. Locally it averages from less than 5 inches to more than 30 inches. Runoff also varies greatly from year to year. Because of variations in yearly runoff, comparisons of runoff from different areas are more meaningful if made for a number of years of the same time period. Figure 43 was prepared using runoff data for 1951-74 for all parts of the State except for those drainage basins south of Lake Okeechobee, where data for 1965-74 were used.

Annual runoff from a stream basin can vary several fold between wet and dry years. For example, as shown in figure 43, runoff from the Santa Fe River Basin in northeast Florida during the 48 years when data were available ranged from about 39 inches in 1948 to about 9 inches in 1956. Runoff of 30.3 square miles of drainage area for Cypress Creek near Vineland ranged from 18 inches in 1960 to 0.4 inch in 1977 during 33 years of record. Small basins tend to have a wider range in runoff than large basins. Also within each year the runoff rate of a basin varies widely, because of the seasonal variation in rainfall.

Length

Florida has more than 1,700 streams which range in length from less than one-half mile to about 500 miles.

The Apalachicola River, located in the "Panhandle," with its source the Caloosahatchee River in Georgia, is the longest river of Florida--524 miles. Actually, the Apalachicola River is relatively short, being only about 107 miles in length from its confluence with the Chattahoochee River, Flint River, Spring Creek, and Fishpond Drain which discharge into Lake Seminole at the Florida-Georgia boundary near Chattahoochee.

The St. Johns River, which drains the eastern part of the peninsula, is the longest north-flowing river in the United States, and is the longest river entirely within the State--273 miles. Its drainage basin, 9,168 square miles, represents about one-sixth of the total area of Florida.

Table 14 provides a comparison of the length of selected principal coastal rivers of the United States with the Apalachicola, Suwannee, and St. Johns Rivers. Coastal rivers are those that discharge directly to the ocean or gulf. They are independent, in contrast, to tributary rivers that discharge to other rivers. First-order tributaries discharge to coastal rivers while second-order tributaries discharge to first-order tributaries (U.S. Geological Survey, 1949).

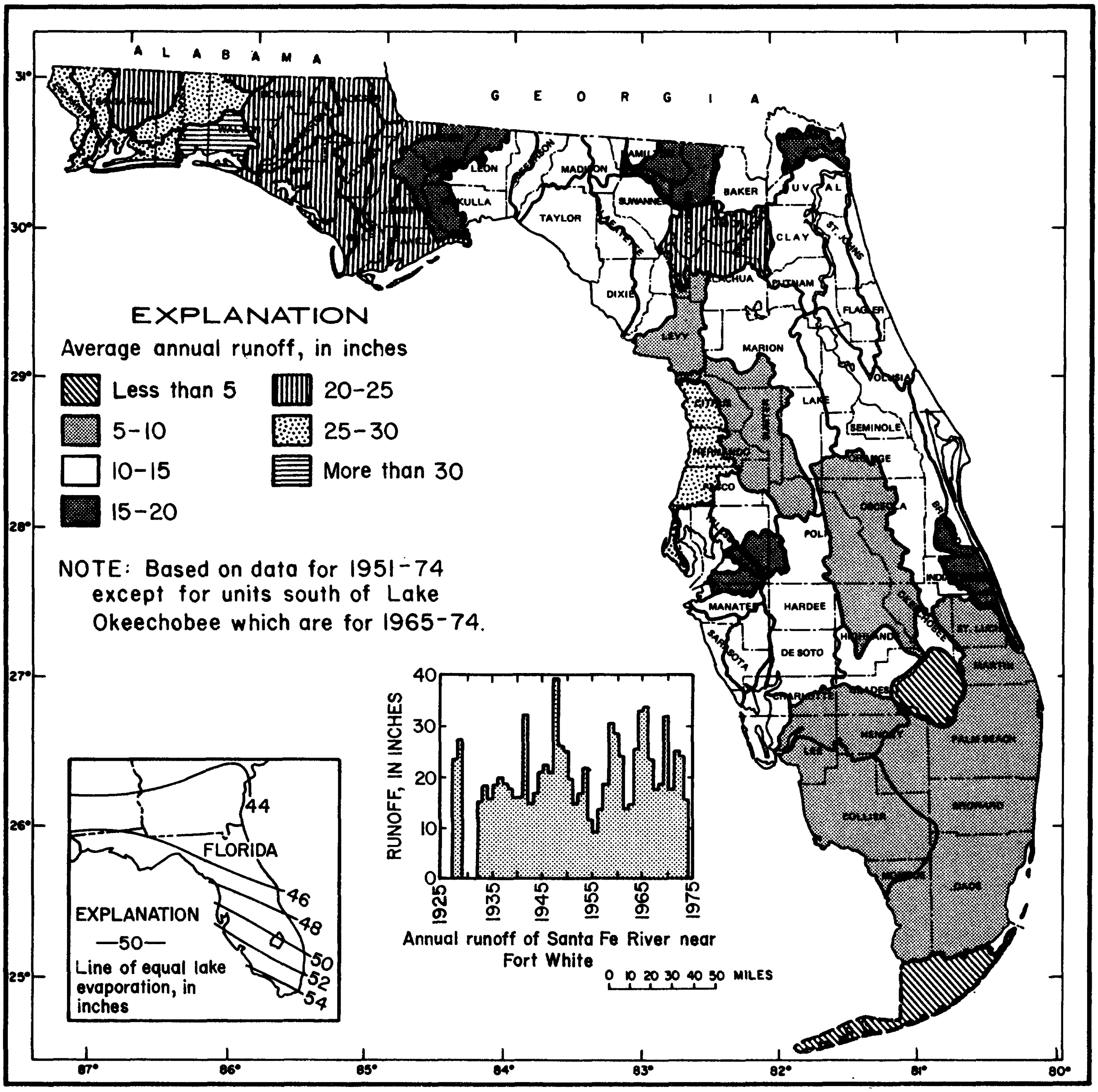


Figure 43.--Average annual runoff in inches from hydrologic units in Florida (modified from Hughes, 1978).

Table 14.--Selected principal coastal rivers of the United States ranked according to length

[Modified from U.S. Geological Survey, 1949; 1970]

River	Source	Outflow	Miles
Mississippi-Missouri-Red Rock	Source of Red Rock River, Mont.	Gulf of Mexico (mouth of Southwest Pass)	3,741
Mississippi	Lake Itasca, Minn.	Gulf of Mexico (mouth of Southwest Pass)	2,348
Rio Grande	San Juan County, Colo.	Gulf of Mexico	1,885
Yukon	British Columbia, Canada	Pacific Ocean (Bering Sea)	1,875
Colorado (U.S.-Mexico)	Rocky Mountain National Park, Colo.	Pacific Ocean (Gulf of California, Mexico)	1,450
Columbia	Columbia Lake, British Columbia, Canada	Pacific Ocean	1,243
Brazos	Roosevelt County, N. Mex.	Gulf of Mexico	1,210
Colorado	Dawson County, Tex.	Gulf of Mexico (Matagorda Bay)	894
Mobile-Alabama-Coosa	Gilmer County, Ga.	Gulf of Mexico (Mobile Bay)	780
Trinity	Cooke County, Tex.	Gulf of Mexico (Trinity Bay)	715
Apalachicola-Chattahoochee	Towns County, Ga.	Gulf of Mexico (Apalachicola Bay)	524
Pearl	Winston County, Miss.	Gulf of Mexico	490
Susquehanna	Ostego Lake, Ostego County, N.Y.	Atlantic Ocean (Chesapeake Bay)	444
Delaware	Schoharie, Green and Delaware County, N.Y.	Atlantic Ocean (Delaware Bay)	420
Sacramento	Siskiyou County, Calif.	Pacific Ocean (Suisan Bay)	382
Hudson	Lake Tear of the Clouds Essex County, N.Y.	Atlantic Ocean (Upper New York Bay)	306
Suwannee	Big Alligator Creek, Ga.	Gulf of Mexico	280
St. Johns	Upstream end of perennial water in St. Johns Marsh, Fla.	Atlantic Ocean	273

Velocity

Most streams in Florida have low gradients because of the relatively flat terrane and low land-surface elevations characteristic of the State. The average velocity of Florida streams is about 1½ feet per second (1-mile per hour), based on average annual discharge and cross sectional areas at gaging stations.

The St. Johns River has an average fall of about 0.1 foot per mile in its 273-mile length to the beginning of perennial flow in St. Johns Marsh (fig. 44). The average velocity of the St. Johns River at State Highway 44, located 142 miles upstream from the mouth, is only 0.3 mile per hour--the lowest average velocity at measuring sites of the 13 major coastal rivers along Florida's shoreline (table 15).

Discharge

Florida has 13 major coastal rivers based upon estimated average discharge at the mouth (table 15). Major rivers are those that have an average discharge at the mouth of 1,000 ft^3/s (cubic feet per second), or 646 Mgal/d (million gallons per day), or more--equivalent to at least an average of 1,983 acre-ft/d (Kenner and others, 1969). The 13 major coastal rivers discharge more than 38,604 Mgal/d to the ocean. All except the Peace River are in the northern part of Florida. In general, the 13 major coastal rivers each have a basin drainage area in excess of 500 square miles at their mouth (table 16 and fig. 45). The Hillsborough River with a drainage area of 690 square miles has an estimated average discharge at the mouth of about 430 Mgal/d (Kenner and others, 1969).

Seven tributary rivers in Florida are classified as major (fig. 46 and tables 15 and 16); all are located in the northern half of the State except for the Kissimmee River. Three of these rivers, Withlacoochee, Alapaha, and Santa Fe Rivers, flow into the Suwanee River.

The Santa Fe River as a major tributary is unique in that it disappears into a sinkhole at O'Leno State Park and then emerges after being underground for a distance of about three miles (N. D. Hoy, oral commun., 1976). During periods of low stream flow, about 50 percent of the discharge is temporarily diverted to ground water, later to emerge as spring flow.

The largest of the major tributaries ranked according to drainage area is the Oklawaha River, another north-flowing river. The Oklawaha is one of three rivers that headwater in Green Swamp in the central part of Florida. Silver Springs accounts for more than 50 percent of the average flow of the Oklawaha River downstream of the mouth of Silver River (Silver Springs Run) at State Highway 40 in the central part of Marion County near Ocala. The average velocity of the Oklawaha at this bridge site is more than 2½ times that of the St. Johns but about half the average velocity of most Florida streams (table 15).

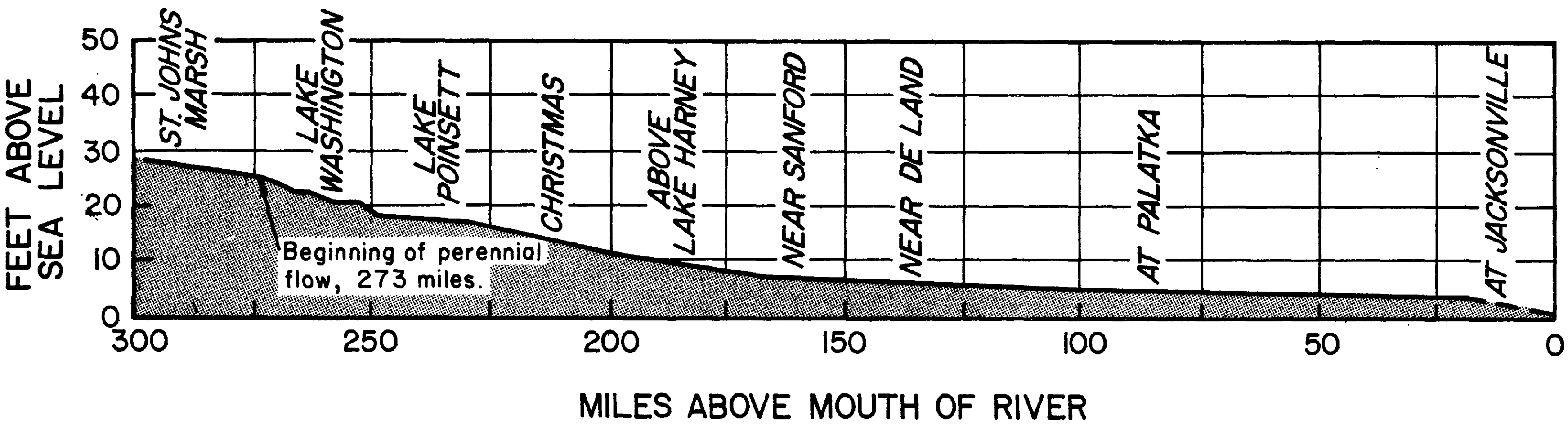


Figure 44.--Profile of St. Johns River for 1960 high water from the headwaters marsh north to the mouth at the Atlantic Ocean (modified from Snell and Kenner, 1974).

Table 15.--Major coastal and tributary rivers of Florida ranked according to average discharge at gaging sites

[Note: Major rivers of Florida are those with an average discharge at the mouth of 1,000 ft^3/s, or 646 Mgal/d, or more, Kenner and others, 1969]

River	County location of site	Highway bridge or structure site	Miles upstream from mouth	Average discharge in million gallons per day at site	Drainage area in square miles above site	Average yearly runoff in inches above site	Average velocity in miles per hour at site
Coastal rivers							
Apalachicola nr. Blountstown	Calhoun and Liberty	State-20	78	16,000	17,600	19.11	1.5
Suwannee nr. Wilcox	Levy and Dixie	US-19	33	6,870	9,640	14.98	1.1
Choctawhatchee nr. Bruce	Walton and Washington	State-20	21	4,650	4,384	22.29	1.1
Escambia nr. Century	Santa Rosa and Escambia	State-4	52	4,070	3,817	22.43	1.4
St. Johns nr. De Land	Lake and Volusia	State-44	142	2,040	3,066	14.00	0.3
Ochlockonee nr. Bloxham	Liberty and Leon	State-20	65	1,160	1,700	14.36	0.5
Yellow at Milligan	Okaloosa	US-90	40	763	624	25.68	1.0
Peace at Arcadia	DeSoto	State-70	36	756	1,367	11.61	0.9
Withlacoochee nr. Holder	Marion and Citrus	State-200	38	714	1,825	8.22	0.8
Perdido at Barrineau Park	Escambia and Baldwin, Ala.	Barrineau Park	27	[1]487	394	25.99	1.3
St. Marys nr. Macclenny	Baker and Charlton, Ga.	(Former "Stokes" Bridge)	100	[1]441	700	13.25	0.5
St. Marks nr. Newport	Wakulla	(Near US-98)	14	[1]432	535	16.96	0.7
Blackwater nr. Baker	Okaloosa	State-4	35	[1]221	205	22.66	1.0
Tributary rivers							
Alapaha nr. Jennings	Hamilton	State-150	21	1,210	1,680	15.14	1.5
Withlacoochee nr. Pinetta	Madison and Hamilton	(Pinetta-Bellville)	22	1,080	2,120	10.72	0.8
Santa Fe nr. Fort White	Gilchrist and Columbia	(Near State-47)	18	1,050	1,017	21.79	1.4
Chipola nr. Altha	Calhoun	State-274	54	966	781	25.98	1.6
Kissimmee[2] nr. Okeechobee at S-65E	Okeechobee and Highlands	S-65E	8.2	[3]910	[4]2,300	8	-
Oklawaha nr. Conner	Marion	State-40	51	766	1,196	13.46	0.8
Shoal nr. Crestview	Okaloosa	State-85	7.0	713	474	31.60	1.2

[1] Discharge at mouth estimated to exceed 646 Mgal/d based on ratio of drainage area of basin versus drainage area above gaging site or based on hydrologic knowledge of tributary or spring discharge to river downstream of gaging site.

[2] Also see table 17.

[3] Does not include 180 Mgal/d diversion since July 1962 from Lake Istokpoga, through canal structure 68, Canal 41A.

[4] Approximate, does not include drainage area of Lake Istokpoga of about 600 square miles.

Table 16.--Major coastal and tributary rivers of Florida ranked according to basin drainage area

River	County(ies) at river mouth	Location of river mouth	Most distant source	Mouth to source in miles	Basin drainage area in square miles above mouth
Coastal rivers					
Apalachicola	Franklin	Apalachicola Bay	Towns County, Ga.	524	19,600
Suwannee	Dixie and Levy	Gulf of Mexico	Big Alligator Creek, Ga.	280	9,950
St. Johns	Duval	Atlantic Ocean	Upstream end of perennial water in St. Johns Marsh Fla.	273	9,168
Choctawhatchee	Walton	Choctawhatchee	Bluff Creek/Pea River Headwaters, Ala.	230	4,646
Escambia	Escambia and Santa Rosa	Escambia Bay	Conecuh River Headwaters near Union Springs, Ala.	240	4,233
Peace	Charlotte	Charlotte Harbor	Gum Lake Marsh, Fla.	133	2,403
Ochlockonee	Franklin and Wakulla	Ochlockonee Bay	Ochlockonee River Headwaters at Gordy, Ga.	206	2,250
Withlacoochee	Citrus and Levy	Withlacoochee Bay	Lake Mattie, Fla.	138	2,035
St. Marys	Nassau and Camden, Ga.	Cumberland Sound	North Prong St. Marys River Headwaters, Ga.	127	1,480
Yellow	Santa Rosa	Blackwater Bay	Yellow River Headwaters (Lightwood Knot Creek, Ala.)	110	1,365
Perdido	Escambia and Baldwin, Ala.	Perdido Bay	Perdido River Headwaters, Ala.	68	925
St. Marks	Wakulla	Apalachee Bay	St. Marks River Headwaters, Fla.	37	871
Blackwater	Santa Rosa	Blackwater Bay	Blackwater River Headwaters, Ala.	62	860
Tributary rivers					
Oklawaha	Putnam	St. Johns River	Lake Lowery, Fla.	148	2,718
Kissimmee[1] (Canal 38)	Okeechobee	Lake Okeechobee	Alligator Lake, Fla.	170±	[2]2,300
Withlacoochee	Madison and Hamilton	Suwannee River	Withlacoochee River Headwaters (5 miles east of Tifton, Ga.)	120	2,290
Alapaha	Hamilton	Suwannee River	Alapaha tributary (near Pitts, Ga.)	130	1,840
Santa Fe	Gilchrist and Suwannee	Suwannee River	Santa Fe Lake, Fla.	87	1,384
Chipola	Gulf	Apalachicola River	Chipola River Headwaters, Ala.	115	1,237
Shoal	Okaloosa	Yellow River	Gum Creek Headwaters, Fla.	50	499

[1] Also see table 17.
[2] Does not include drainage area of Lake Istokpoga of 600 square miles, diverted July 1962.

Figure 45.--Major coastal rivers of Florida ranked according to basin drainage area.

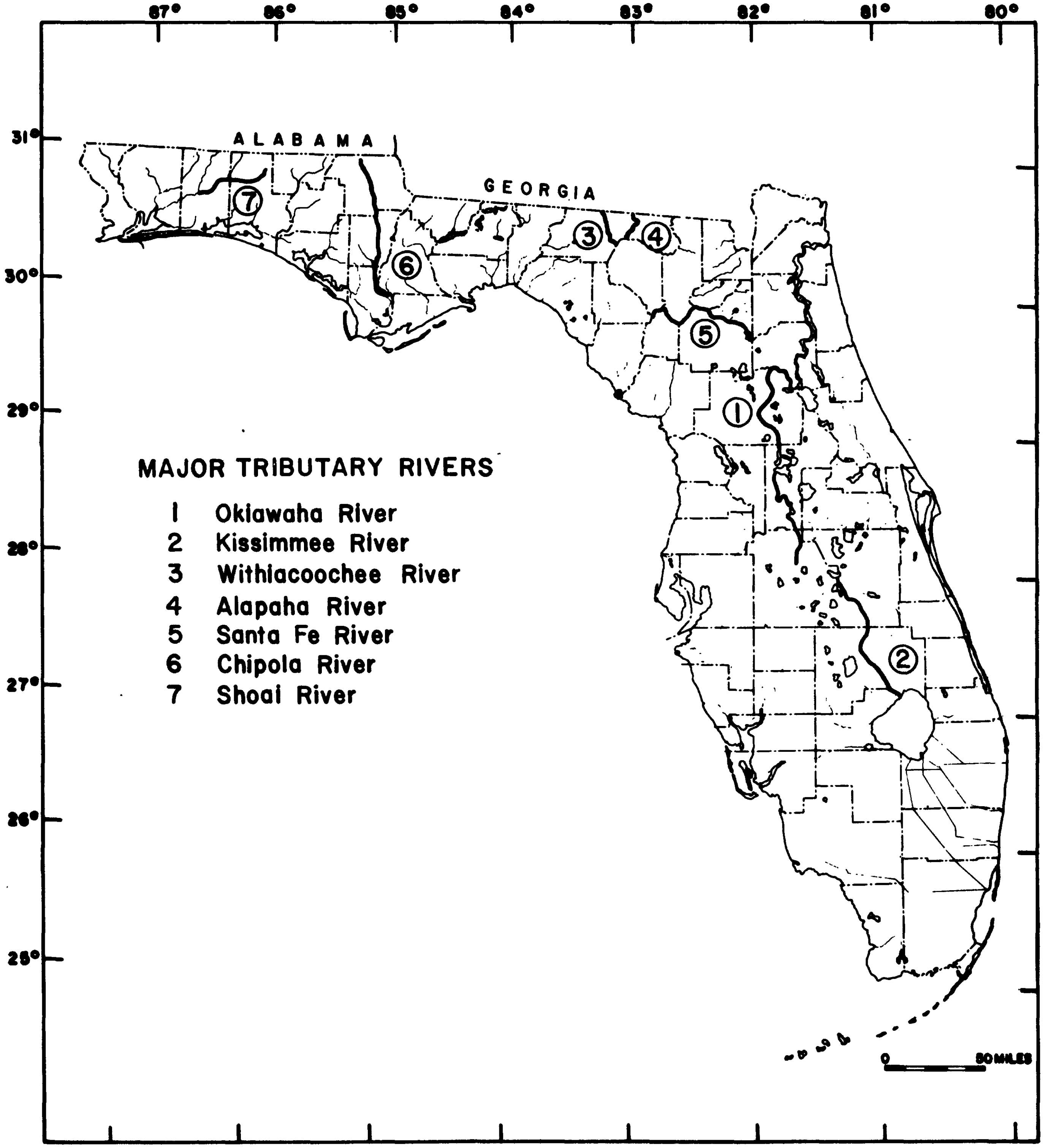


Figure 46.--Major tributary rivers of Florida ranked according to basin drainage area.

Twenty-two selected primary coastal canals discharge an average of about 4,000 million gallons of water per day to the Gulf of Mexico and the Atlantic Ocean (table 17). Twenty-five of the twenty-nine selected primary coastal and tributary canals are in south Florida (fig. 47). Three of the remaining canals are part of the uncompleted Cross-Florida Barge Canal (table 17 and fig. 48). Only three canals in Florida are classified as major, based on average discharge of 1,000 ft^3/s (cubic feet per second), or 646 Mgal/d (million gallons per day), or more at the mouth or outlet of the canal. The primary coastal canals have salinity control or lock structures at or near their mouths. The control structures are closed during low discharge to control upstream movement of saltwater and over-drainage of freshwater.

The Kissimmee River (Canal-38), in south-central Florida, which was extensively modified with canals, levees, and control structures from 1961 to 1971, is the largest tributary to Lake Okeeochobee. Its source (headwater) is Alligator Lake in Osceola County.

The Caloosahatchee River (Canal-43) and St. Lucie Canal (Canal 44) discharge water from Lake Okeechobee to the Gulf of Mexico and to the Atlantic Ocean, respectively. These two canals with a system of locks and spillways and a navigational channel across Lake Okeechobee comprise an operational "Cross-Florida" inland waterway.

Average discharge of freshwater into the oceans by all the world's rivers is about 26 trillion gallons per day or about 40,220,000 ft^3/s (fig. 49). In comparison, the average discharge of freshwater to the ocean from Florida rivers is 40 billion gallons per day, or about 62,000 ft^3/s.

The Amazon, the largest river of the world, has an average discharge of 4 trillion gallons per day, or about 6,200,000 ft^3/s (table 18). This represents about 15 percent of the total average discharge of all rivers of the world and 100 times the discharge of the rivers of Florida.

In comparison with Florida's largest river, the Amazon has 230 times the average discharge of the Apalachicola River (fig. 50). The St. Johns River, the largest coastal river with the entire drainage basin within the State, has an average discharge of less than 0.001 of the Amazon River's average.

The discharges of rivers relate directly to long-term variations in precipitation, from wet periods to droughts, and short term daily and seasonal variations caused by storm events. Consequently, over a period of years, large variations occur in discharge of rivers. Also, the smaller the drainage area, the greater the ratio of maximum to minimum discharge. These variations are illustrated in table 19 for the periods of record for the major coastal and tributary rivers of Florida.

Monthly mean discharge of Florida streams vary considerably from month to month throughout the State. Also, there is a wide range in flow from the maximum to the minimum for each month over long periods of time as shown for the Shoal River and Econfina Creek in figure 51.

Table 17.--Selected primary coastal and tributary canals of Florida ranked according to average discharge at downstream structures

Canal	Location of canal mouth	County(ies) at canal mouth	Most distant source	Downstream structure	Discharge at downstream structure: Average annual, Million gallons per day	Average annual, Years of record to 1978	Minimum annual, Million gallons per day	Minimum annual, Water year	Maximum annual, Million gallons per day	Maximum annual, Water year
Coastal canals										
Caloosahatchee River (Canal 43)	San Carlos Bay (Gulf of Mexico)	Lee	Lake Okeechobee	W. P. Franklin Lock and Dam S-79 near Olga	863	12	249	1972	3,361	1970
St. Lucie Canal (Canal 44)	South Fork St. Lucie River (Atlantic Ocean)	Martin	Lake Okeechobee	St. Lucie Lock S-80 near Stuart	614	26	6	1962	2,682	1954
West Palm Beach Canal (Canal 51)	Intracoastal Waterway (Atlantic Ocean)	Palm Beach	Lake Okeechobee	S-155 near West Palm Beach	486	38	135	1971	996	1947
North New River Canal	Intracoastal Waterway (Atlantic Ocean)	Broward	Lake Okeechobee	Sewell Lock near Ft. Lauderdale	269	38	39	1971	773	1948
Snake Creek Canal (Canal 9)	Intracoastal Waterway (Atlantic Ocean)	Dade	Everglades	S-29 N. Miami Beach	248	19	127	1962	441	1966
Hillsboro Canal	Intracoastal Waterway (Atlantic Ocean)	Broward	Lake Okeechobee	Deerfield Lock near Deerfield Beach	205	38	37	1956	567	1954
Miami Canal (Canal 6)	Miami River (Biscayne Bay - Atlantic Ocean)	Dade	Lake Okeechobee	S-26 36th Street	187	19	70	1925	545	1960
Fahka Union Canal	Fahka Union Bay (Gulf of Mexico)	Collier	Big Cypress Swamp	Near Copeland	160	8	104	1977	216	1974
Snapper Creek Canal (Canal 2)	Biscayne Bay (Atlantic Ocean)	Dade	Tamiami Canal (C-4)	S-22 near South Miami	143	19	43	1971	371	1960
Mowry Canal (Canal 103)	Biscayne Bay (Atlantic Ocean)	Dade	Canal 111	S-20F near Homestead	129	8	60	1971	217	1978
Little River Canal (Canal 7)	Biscayne Bay (Atlantic Ocean)	Dade	Miami Canal (C-6)	S-27 at Miami	104	14	28	1962	196	1968
Fellsmere Canal (Sebastian Canal, C-54)	Sebastian Creek (Atlantic Ocean)	Indian River and Brevard	St. Johns Headwaters (marsh)	S-157 near Fellsmere	88	12	57	1956	144	1960
Tamiami Canal (Canal 4)	Miami River (Biscayne Bay - Atlantic Ocean)	Dade	Everglades	S-25 near Coral Gables	84	19	47	1975	186	1960
Black Creek Canal (Canal 1)	Biscayne Bay (Atlantic Ocean)	Dade	Tamiami Canal	S-21 near Goulds	73	7	37	1974	120	1947
Biscayne Canal (Canal 8)	Biscayne Bay (Atlantic Ocean)	Dade	Everglades	S-28 near Miami	67	16	25	1971	125	1966

See footnotes at end of table.

Table 17.--Selected primary coastal and tributary canals of Florida ranked according to average discharge at downstream structures--Continued

Canal	Location of canal mouth	County(ies) at canal mouth	Most distant source	Downstream structure	Discharge at downstream structure: Average annual		Minimum annual		Maximum annual	
					Million gallons per day	Years of record to 1978	Million gallons per day	Water year	Million gallons per day	Water year
Coastal canals--Continued										
Barron River Canal	Chokoloskee Bay (Gulf of Mexico)	Collier	Big Cypress Swamp	Near Everglades	65	26	26	1956	122	1958
Main Canal	Indian River (Atlantic Ocean)	Indian River	St. Johns Headwaters (marsh)	At Vero Beach	65	29	27	1950	89	1960
Canal 111	Barnes Sound (Atlantic Ocean)	Dade	Tamiami Canal (C-4)	S-197 near Florida City	48	10	3	1974	185	1969
Tampa Bypass Canal	McKay Bay (Gulf of Mexico)	Hillsborough	Hillsborough River	S-160 at Tampa	36	4	32	1977	41	1978
South Canal	Indian River (Atlantic Ocean)	Indian River	St. Johns Headwaters (marsh)	Near Vero Beach	25	28	10	1962	40	1960
North Canal	Indian River (Atlantic Ocean)	Indian River	St. Johns Headwaters (marsh)	Near Vero Beach	19	27	8	1961	34	1960
Cross-Florida Barge Canal (West)	Withlacoochee Bay (Gulf of Mexico)	Citrus and Levy	Lake Rousseau	Inglis Lock near Inglis	8	8	3	1973	13	1978
Tributary canals										
Kissimmee River[1] (Canal-38)	Lake Okeechobee	Okeechobee and Glades	Alligator Lake	S-65E near Okeechobee	910 [2](1,303)	14 (48)	380 (211)	1972 (1956)	1,733 (3,607)	1970 (1960)
Withlacoochee River Bypass Channel	Withlacoochee River	Levy	Lake Rousseau	Near Inglis	772	8	636	1975	772	1978
Canal 41A	Kissimmee River	Highlands	Lake Istokpoga	S-84 near Okeechobee	127	14	2	1977	327	1970
Harney Pond Canal (C-41)	Lake Okeechobee	Glades	Lake Istokpoga	S-71 near Lakeport	127	16	31	1965	303	1966
South New River Canal (C-11)	North New River Canal	Broward	Everglades	S-13 near Davie	113	21	39	1971	207	1960
Indian Prairie Canal (C-39A)	Lake Okeechobee	Glades	Lake Istokpoga	S-72 near Okeechobee	31	16	7	1977	74	1978
Cross-Florida Barge Canal (East)	St. Johns River	Putnam	Lake Ocklawaha (Rodman Pool)	Buckman Lock near Palatka	26	8	14	1972	38	1977

[1] Also see tables 15 and 16.
[2] Data in parenthesis include flow from Lake Istopoga by Canal 41A at structure 68 which was diverted from Kissimmee River July 1962.

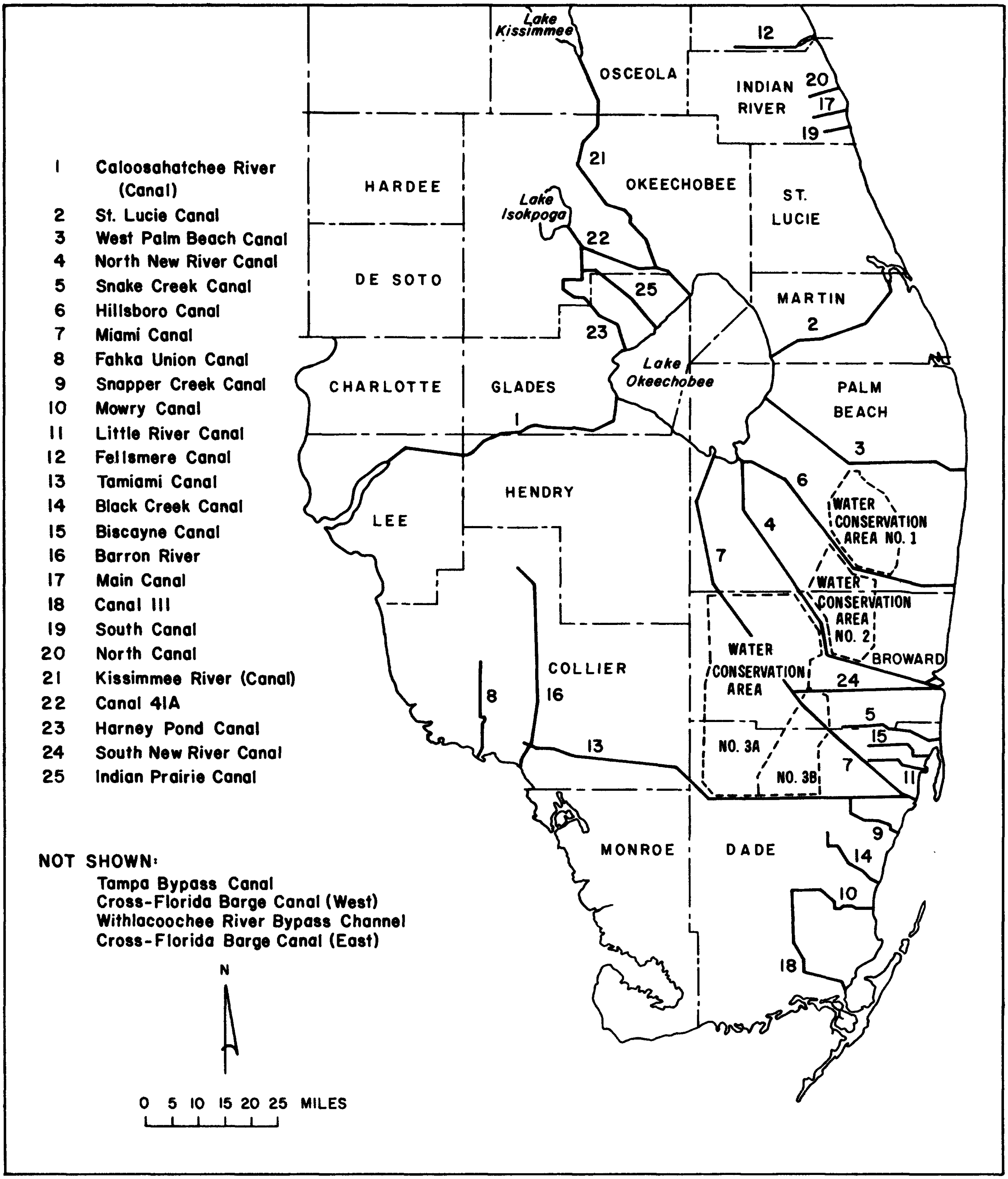


Figure 47.--Primary coastal and tributary canals of south Florida (modified from U.S. Army, 1975).

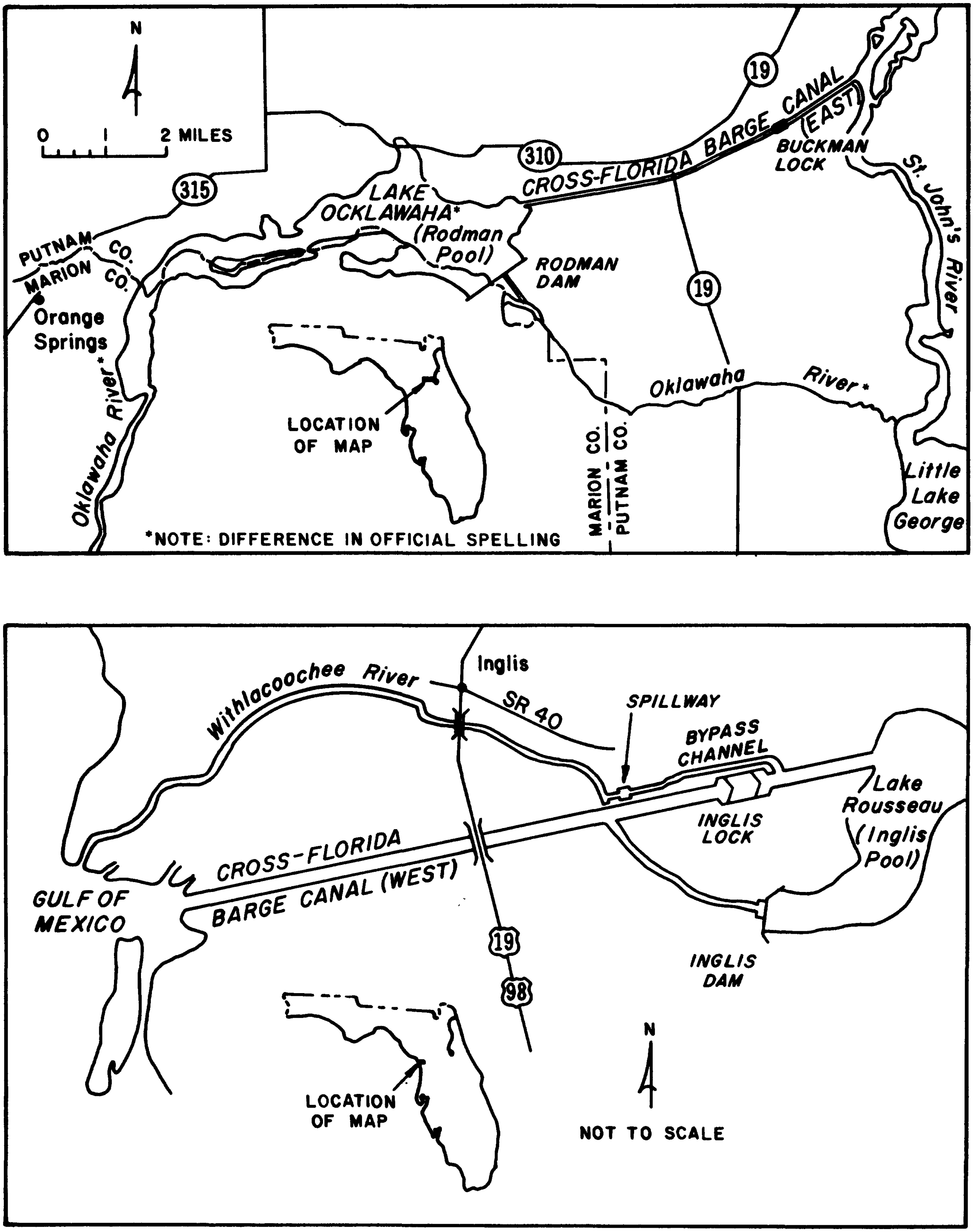


Figure 48.--Cross-Florida Barge Canal segments (east and west) and Withlacoochee River Bypass Channel (modified from U.S. Army, 1966, U.S. Department of Agriculture, 1979, and Faulkner, 1973a).

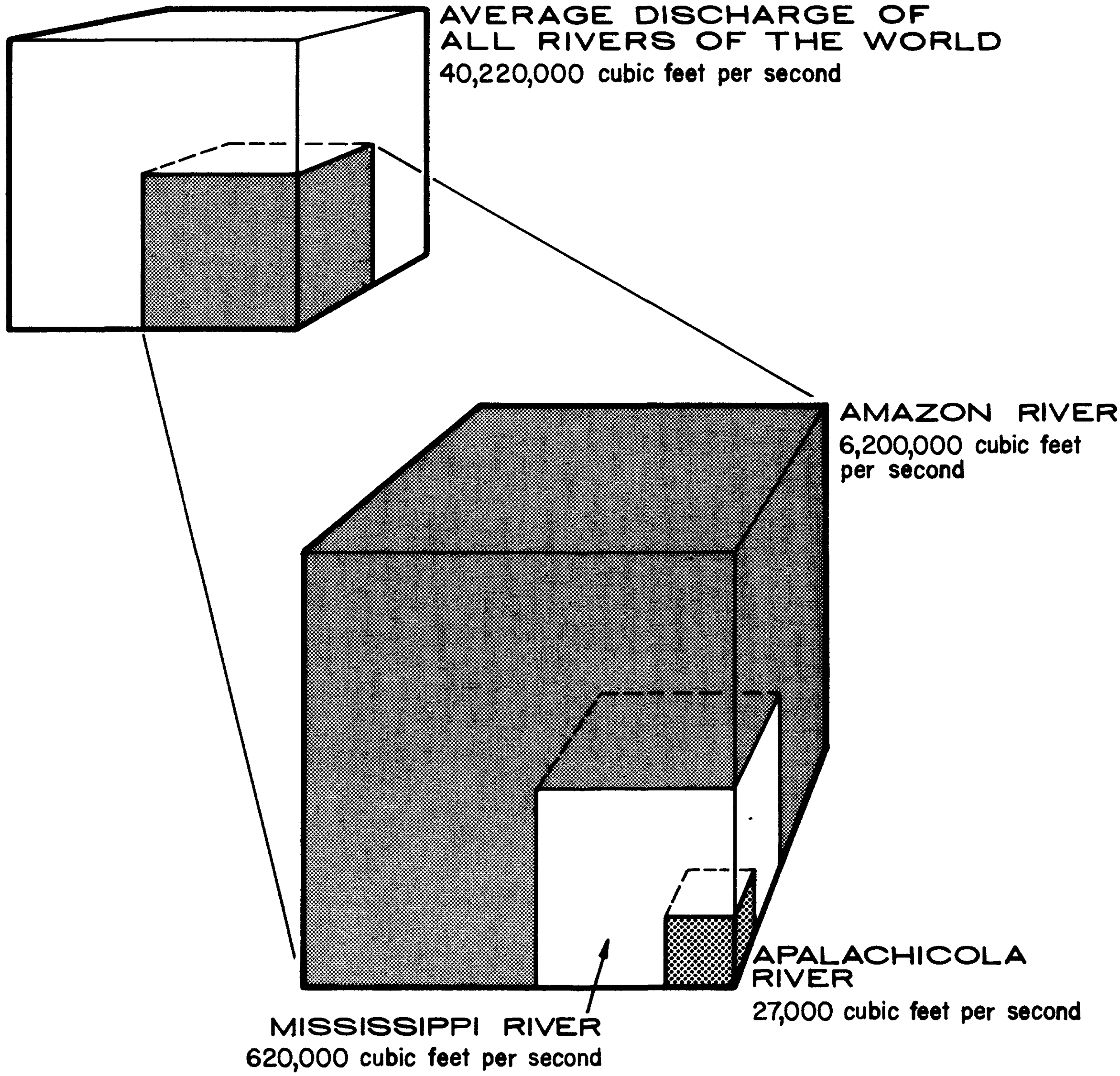


Figure 49.--Freshwater discharged into the oceans by all the world's rivers.

Table 18.--Comparison of selected major coastal rivers of Florida with large rivers of the world ranked according to discharge

River	Outflow to sea	Length in miles	Drainage area in square miles	Average discharge: Cubic feet per second	Average discharge: Million gallons per day
Amazon[1]	Atlantic Ocean	4,000	2,300,000	6,200,000	4,000,000
Congo[2]	Atlantic Ocean	2,718	1,550,000	1,400,000	900,000
Mississippi[3]	Gulf of Mexico	2,348	1,243,700	620,000	400,000
Apalachicola[4]	Gulf of Mexico	524	19,600	27,000	17,000
Suwannee[5]	Gulf of Mexico	280	9,950	11,000	7,100
St. Johns[5]	Atlantic Ocean	273	9,168	6,000	3,900

[1] Brazil, South America; ranked No. 1 with large rivers of the world.
[2] Congo, Africa; ranked No. 2. with large rivers of the world.
[3] United States, North America; ranked No. 7. with large rivers of the world ranked No. 1 with large rivers of the U.S.
[4] United States, North America; ranked No. 21 with large rivers of the U.S.
[5] United States, North America.

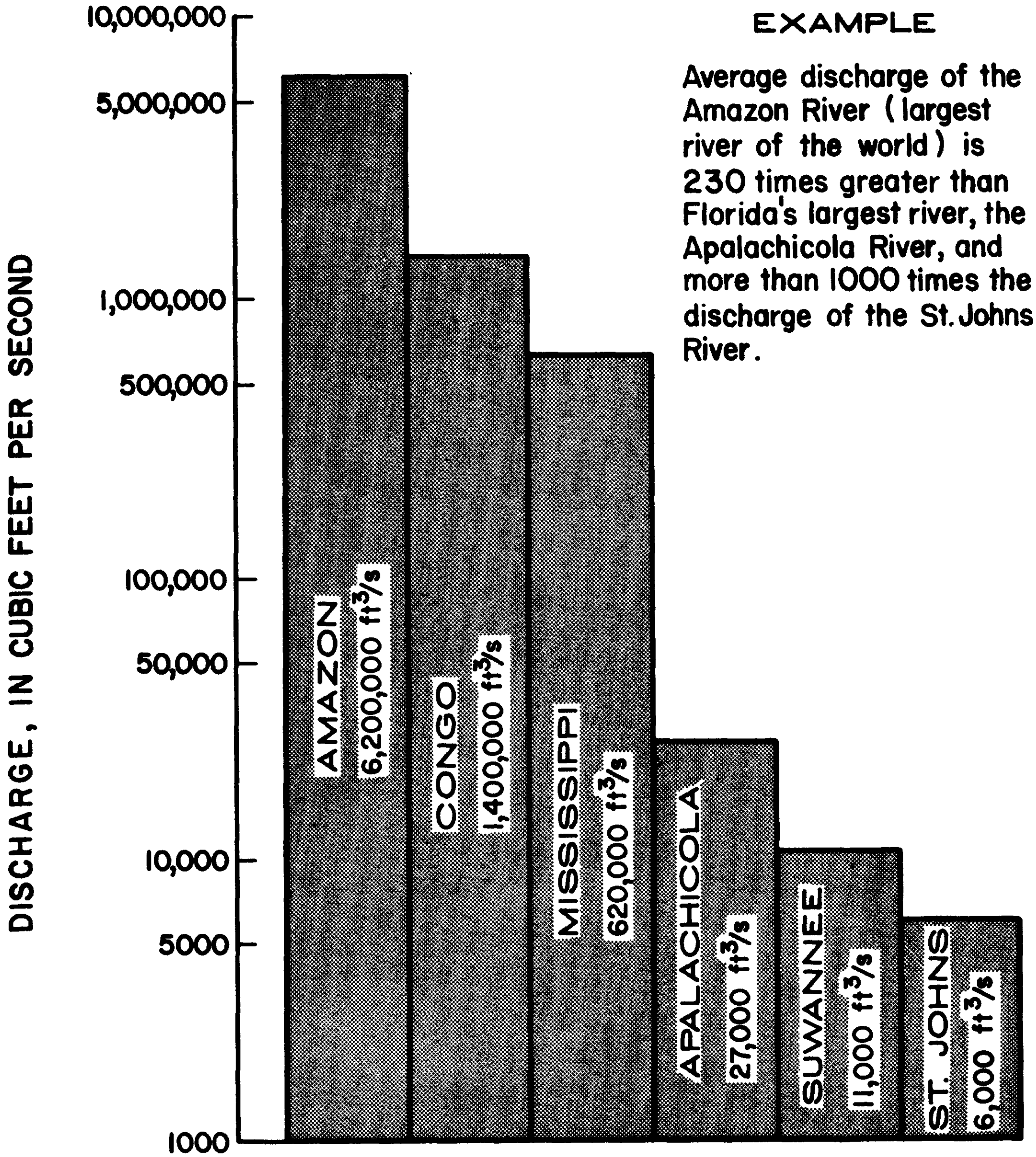


Figure 50.--Comparison of the discharge of selected major coastal rivers of Florida with large rivers of the world.

Table 19.--Maximum and minimum discharges of major coastal and tributary rivers of Florida

[Million gallons per day]

River	Years of record (as of 1978)	Annual discharge				Monthly discharge				Extremes			
		Max.	Water yr.	Min.	Water yr.	Max.	Calendar mo./yr.	Min.	Calendar mo./yr.	Max.	Date	Min.	Date
Coastal rivers													
Apalachicola nr. Blountstown	54	25,607	1949	7,248	1955	108,851	3/29	3,339	10/54	184,756	3/21/29	3,089	10/30/54
Suwannee nr. Wilcox	38	15,866	1948	2,772	1955	36,990	4/48	2,309	12/55	54,716	4/14/48	[1]2,112	2/24/57
Choctawhatchee nr. Bruce	48	7,507	1948	2,231	1956	18,992	1/36	904	10/68	50,000	4/15/75	833	10/27/68
Escambia nr. Century	44	7,552	1975	1,866	1968	20,368	1/36	418	10/68	59,626	4/12/75	373	10/23/68
St. Johns nr. DeLand	45	4,156	1960	745	1971	10,207	10/53	40	5/62	11,047	10/15/53		([2])
Ochlockonee nr. Bloxham	28	2,917	1948	203	1955	8,553	4/48	32	10/54	57,752	9/23/69	[3]2	11/1-2/57
Yellow at Milligan	40	1,425	1975	393	1955	4,026	12/53	99	10/54	24,936	4/12/75	85	6/23-24/67
Peace at Arcadia	47	1,661	1960	253	1956	6,380	9/33	39	5/45	23,385	9/9/33	24	5/28/49
Withlacoochee nr. Holder	47	2,180	1960	216	1956	4,584	4/60	85	6/56	5,594	4/5/60	72	6/18/56
Perdido at Barrineau Park	37	716	1947	240	1968	1,898	8/75	127	10/68	25,194	4/15/55	121	10/12-18/73
St. Marys nr. Macclenny	52	1,476	1948	58	1955	4,240	4/73	10	11/31	18,153	9/25/47	8	5/22/32
St. Marks nr. Newport	22	727	1965	260	1968	1,783	4/73	216	2/57	3,069	4/7/73	200	4/25/64
Blackwater nr. Baker	28	477	1975	96	1968	1,311	12/53	41	10/54	16,925	6/4/70	39	9/7-8/54

See footnote at end of table.

Table 19.--Maximum and minimum discharges of major coastal and tributary rivers of Florida--Continued

[Million gallons per day]

River	Years of record (as of 1978)	Annual discharge				Monthly discharge				Extremes			
		Max.	Water yr.	Min.	Water yr.	Max.	Calendar mo./yr.	Min.	Calendar mo./yr.	Max.	Date	Min.	Date
Tributary rivers													
Alapaha nr. Jennings	2	1,282	1977	1,136	1978	4,567	2/78	54	6/77	9,044	2/9/78	40	9/4/77
Withlacoochee nr. Pinetta	47	3,465	1948	152	1955	11,189	4/48	50	11/54	51,292	4/5/48	45	8/23/55
Santa Fe nr. Fort White	48	2,010	1948	483	1956	4,098	9/64	411	5/57	10,982	9/16/64	393	5/22/57
Chipola nr. Altha	43	1,923	1948	396	1955	4,937	9/26	245	10/68	16,150	9/20/26	213	10/31-11/1,2/68
Kissimmee nr.[4] Okeechobee at S-65E	48	3,607	1960	211	1956	7,429	10/48	1	5/77	16,667	10/3/69		([5])
Oklawaha nr. Conner	17	1,013	1931	547	1933	1,319	4/31	419	11/77	2,390	9/6/33	408	2/1/33
Shoal nr. Crestview	40	1,151	1978	356	1955	2,833	8/75	194	9/72	16,279	8/1/75	155	10/17-18/72

[1] Since January 1951.
[2] Maximum daily reverse flow 1,957 Mgal/d August 23, 1957.
[3] Caused by a closure of breaks in embankment of Jackson Bluff Dam.
[4] Does not include diversion since July 1962 from Lake Istokpoga, through structure 68, Canal 41A.
[5] No flow many days in some years after 1965.

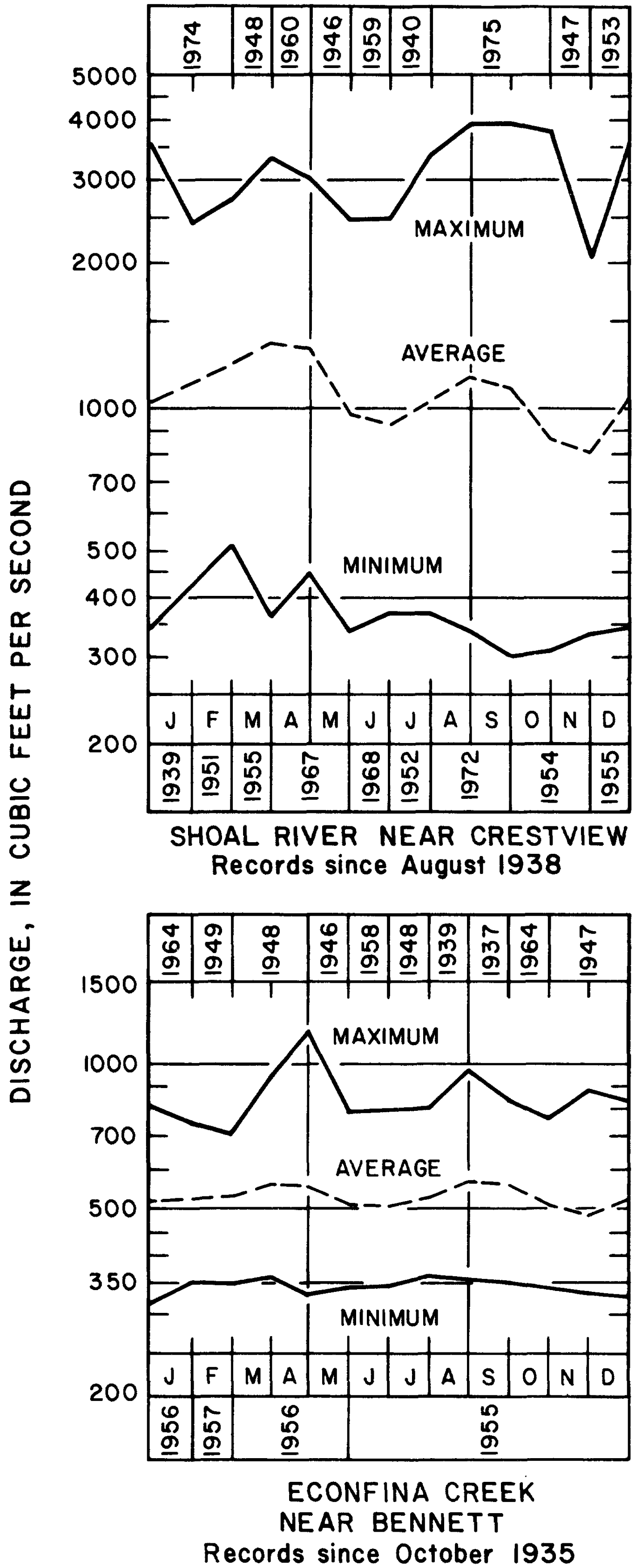


Figure 51.--Maximum, minimum, and average monthly mean discharge and years of extremes for Shoal River and Econfina Creek, Florida.

Low streamflow results from prolonged periods of deficient rainfall. Such minimums (or base flow) vary throughout the State depending upon the amount of ground water contributed to a stream.

Selected years of significant high-water periods in Florida between 1926 and 1973 are given in table 20 with names of river basins and coastal areas that were affected. Major areas and selected years of high-water periods are noted in figure 52.

Comparison of seasonal variations in discharge for streams in north-northwest Florida and south Florida are indicated by hydrographs of two representative gaging stations in figure 53. As shown, streams in the south have high discharges in late summer and early fall whereas those in the north are higher in the late winter and early spring months. Conversely, low water generally occurs in late spring in the south and late spring and early winter in the north.

A generalized divide between these contrasting water conditions is shown in figure 54. North-northwest Florida is most representative of an October 1 to September 30 climatic year with usual peak high stage and discharge months being in March-April and low stage and discharge being in October-November. A secondary low water period usually occurs in north-northwest Florida in May-June. For the Florida peninsula south of the outlined climatic-river basin divide, the climatic year is considered to be the same as the calendar year--January 1 to December 31; with months of high stage and discharge being in September-October and months of low stage and discharge being in May-June. A climatic year for hydrologic purposes represents a 12-month period which includes a complete period of high stage and discharge and low stage and discharge. Defining the climatic year facilitates preparation of statistical summaries in enumerating consecutive days of high or low stage or discharge for each class interval. The normal climatic year, called the "water year," October 1 to September 30, used for water accounting in the United States, is based on the premise that low-water conditions generally occur in August and September. This condition does not hold for most of Florida. Accordingly, a "hydrologic year," from July 1 to June 30, is more appropriate for Florida. This permits an annual statewide synoptic assessment of water conditions in May and June, normally low-water months.

Temperature

Stream temperatures fluctuate daily and seasonally over a smaller range than air temperatures. The long-term average temperature of a natural stream is normally about the same as the long-term average air temperature in the vicinity of the stream.

In general, the range in observed temperatures of streams throughout Florida is from about 40°F (4.4°C) to 98°F (36.7°C). The lowest stream temperature observed since 1956 was 34°F (1.1°C) on Ochlockonee River near Havana in northwest Florida, Leon County. The highest observed was 100°F (37.8°C) on Fisheating Creek near Venus in south-central Florida, Glades County, (Anderson, 1971).

Table 20.--Selected years of significant high-water periods in Florida, 1926-73

Year and Month	River basins and coastal areas affected
1926 September	Lake Okeechobee and lake shore perimeter area in southern Florida.
1928 September	Caloosahatchee River and southwestern Lake Okeechobee shore area in southern Florida.
1929 March	Coastal area between Ochlockonee and Apalachicola Rivers excluding Lighthouse Point coastal area in northwest Florida. Lower Chattachoochee. Apalachicola River. Chipola River basin. Apalachicola Bay coastal area and offshore islands. St. Andrews Bay, inflow and coastal area. Pea River. Choctawhatchee River below Pea River. Choctawhatchee Bay, inflow and coastal area. Yellow River basin. Blackwater River basin. Lower Conecuh River. Escambia River. Perdido River basin. Perdido Bay, inflow and coastal area in northwest Florida.
1933 September	Peace River basin in west-central Florida. Charlotte Harbor and coastal area. Myakka River basin. Coastal area between Myakka River and Manatee River basin. Little Manatee River basin. Tampa Bay and coastal areas including Pinellas County Gulf coastal area. Alafia River basin. Hillsborough River basin in west-central Florida.
1935 September	Florida Bay and Florida Keys in southern Florida.
1936 June	Big Cypress Swamp and southwestern coastal area in southern Florida.
1947 October	Everglades and southeastern coastal area in southern Florida.
1948 April	Alapaha River basin in north Florida. Withlacoochee River basin (tributary to Suwannee River). Suwannee River basin below Withlacoochee River excluding Santa Fe River basin. Coastal area between Suwannee and Aucilla Rivers. Aucilla River basin. St. Marks and Wakulla Rivers and coastal area between Aucilla and Ochlockonee Rivers. Ochlockonee River basin including Lighthouse Point coastal area in north Florida.
1951 October	Fisheating Creek basin and inflow to Lake Okeechobee from northwest in southern Florida.
1953 October	St. Johns River basin above Oklawaha River excluding area between Fort Drum Creek and Taylor Creek in east-central Florida.
1956 October	Coastal area between Ponce de Leon Inlet and Sebastian Inlet in east-central Florida. Coastal area Sebastian Inlet to St. Lucie River and area between Fort Drum Creek and Taylor Creek. Taylor Creek basin and inflow from north in east-central Florida.
1960 March/ September	Oklawaha River basin in central Florida. Kissimmee River basin. Coastal area from Tampa Bay to Withlacoochee River excluding Pinellas County Gulf coastal area. Withlacoochee River basin. Waccasassa River and coastal area between Withlacoochee River basin and Suwannee River basin.
1964 September	St. Johns River basin below Oklawaha River in northeast Florida. Coastal area between St. Johns River and Ponce de Leon Inlet. Santa Fe River basin (tributary to Suwannee River).
1973 April	St. Marys River basin in north Florida. Coastal area between St. Marys and St. Johns Rivers. Suwannee River basin above Withlacoochee River excluding Alapaha River basin.

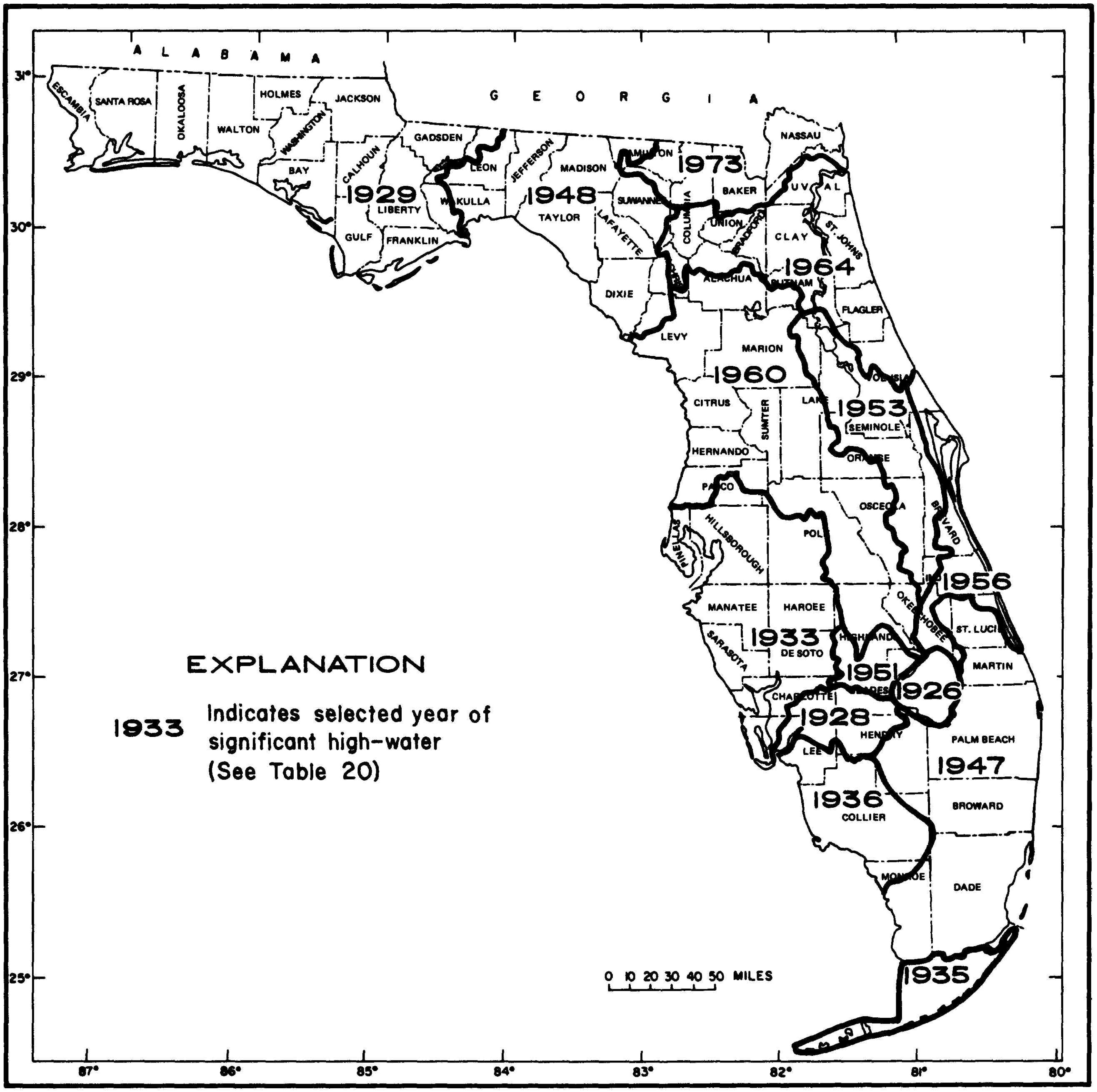


Figure 52.--Major areas and selected years of significant high water in Florida, 1926-73.

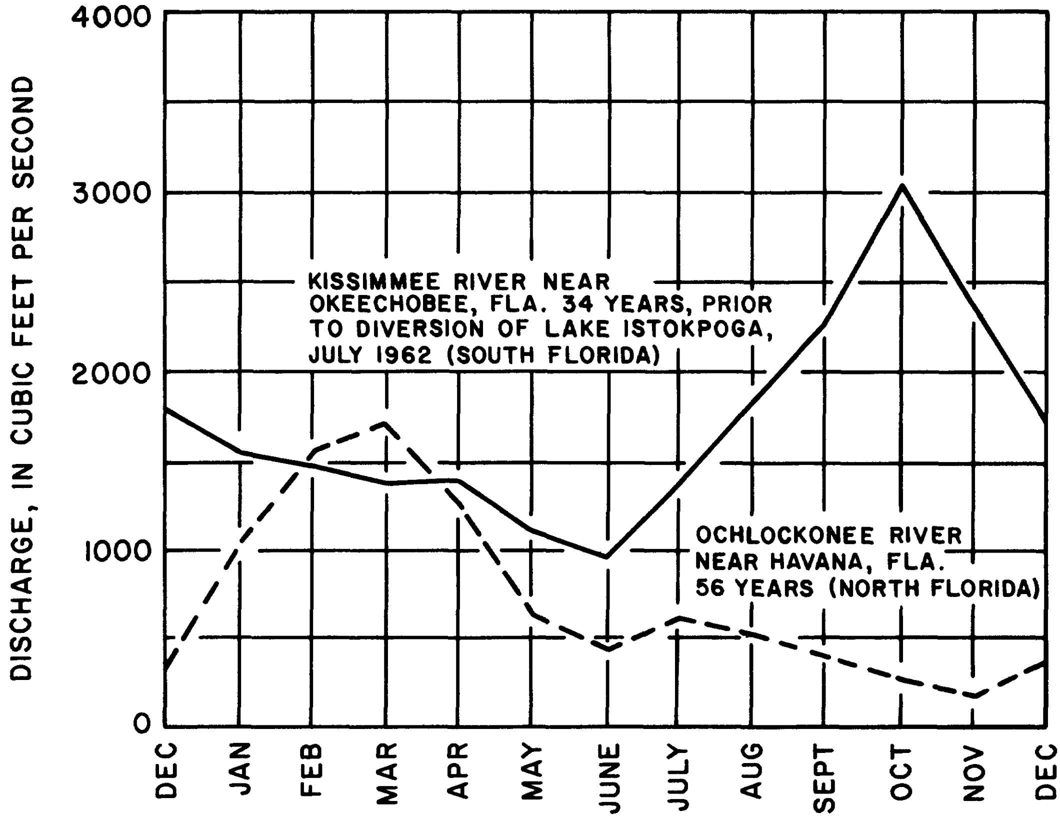


Figure 53.--Comparison of monthly median discharges at a representative gaging station in north Florida and in south Florida (modified from Heath and Wimberly, 1971).

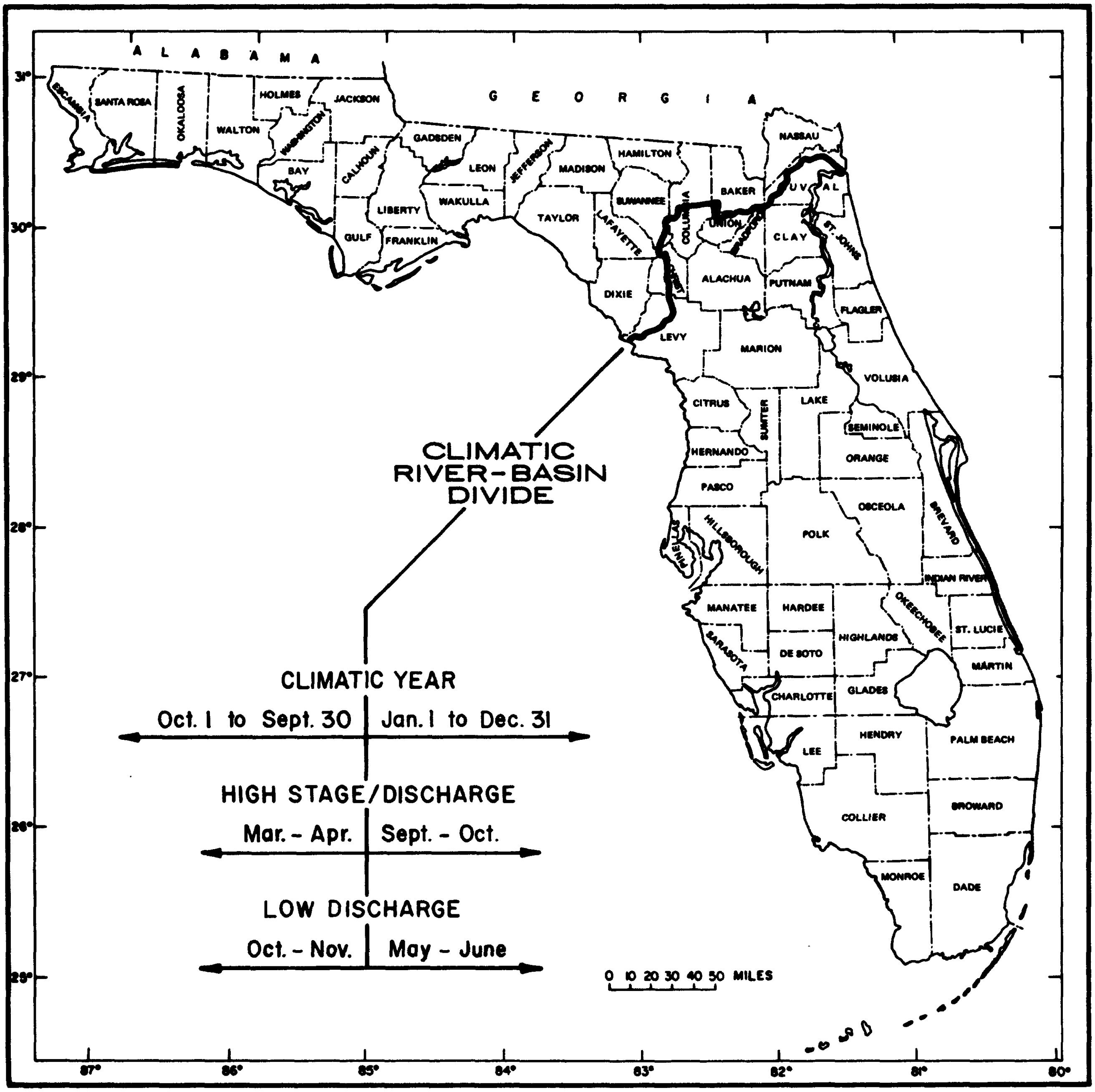


Figure 54.--Climatic-river basins divide between north-northwest Florida and south Florida (modified from Heath and Wimberly, 1971).

The average annual temperatures of streams in Florida are about 64° to 68°F (17.8° to 20.0°C) in northwest and north Florida increasing to more than 76°F (24.4°C) in southeast Florida (table 21).

SPRINGS

Discharges from Florida's springs are natural overflow from the ground-water storage and circulation system. Springs were classified with respect to average discharge (flow) by Meinzer (1927) in "Large Springs in the United States." Table 22 shows the classification of springs into eight orders of magnitude according to average discharge.

Location and Number

As shown in table 23, the total number of known springs in Florida is about 320 (Rosenau and others, 1977). The better known natural springs total more than 200, most of which are shown in figure 55. Most springs in Florida are in the northern half of the State, north of latitude 28°, and are concentrated along major streams. Only a few springs are known south of the 28th parallel and most of these are pseudo springs (flowing artesian wells) that are commonly, and incorrectly, identified as springs (table 24).

Florida has 27 first-magnitude springs (fig. 56 and table 25), which is more than any other state in the nation. The entire United States has a total of only about 78 first-magnitude springs. Florida has about 70 second-magnitude springs.

Discharge

Combined discharge from Florida's springs is estimated at 12,600 ft^3/s or more than 8 Bgal/d (billion gallons per day). The combined discharge of all springs is more than 20 percent of the discharge of the 13 major coastal rivers in Florida and exceeds total freshwater (both ground and surface water) withdrawn for all uses in Florida in 1975 by 1 Bgal/d.

Total average discharge of only the 27 first-magnitude springs is more than 9,600 ft^3/s, or slightly more than 6.2 Bgal/d (table 25), and nearly twice the total fresh ground water used in 1975 of 3.3 Bgal/d. The 70 second-magnitude springs discharge 2,700 ft^3/s, 1,744 Mgal/d, or about 21 percent of the total spring discharge.

Cessation

The only known large spring (second-magnitude) in Florida to cease flowing completely is Kissengen Spring. It was near the Peace River in Polk County about 4 miles southeast of Bartow. Prior to 1937, the beginning of a progressive decline in discharge, the average discharge of Kissengen Spring was about 30 ft^3/s or about 19 Mgal/d. Withdrawals from wells located in the area were increasing, and the resultant decline of the potentiometric surface caused the discharge of the spring to decrease until

Table 21.--Average annual temperature range of streams in Florida

[Modified from Anderson, 1971]

General areas of Florida	Approximate range (°F)	(°C)
Northwest and north	64-68	17.8-20.0
North-central and west-central	68-72	20.0-22.2
South-central and southwest	72-76	22.2-24.4
Southeast	76-"+"	24.4-"+"

Table 22.--Classification of springs according to average discharge

[Modified from Meinzer, 1927]

Magnitude	Average discharge		
	Cubic feet per second (ft^3/s)	Million gallons per day (Mgal/d)	Gallons per minute (gal/min)
1	100 (or more)	64.6 (or more)	
2	10 to 100	6.46 to 64.6	
3	1 to 10	0.646 to 6.46	
4			100 to 448.8
5			10 to 100
6			1 to 10
7			0.125 to 1
8			<0.125

Table 23.--Number of recorded springs in Florida, by counties

[Modified from Rosenau and others, 1977]
[Includes separately identified springs in spring groups]

Alachua	10	Hernando	22	Orange	6
Bay	7	Hillsborough	25	Pasco	12
Bradford	1	Holmes	4	Pinellas	1
Broward	[1]1	Jackson	16	Putnam	8
Charlotte	[1]1	Jefferson	13	Santa Rosa	1
Citrus	15	Lafayette	12	Sarasota	2
Clay	5	Lake	8	Seminole	11
Columbia	18	Lee	[1]2	Sumter	9
Dade	[1]2	Leon	8	Suwannee	24
Dixie	4	Levy	7	Taylor	12
Escambia	1	Liberty	1	Union	1
Gadsden	3	Madison	2	Volusia	5
Gilchrist	12	Marion	11	Wakulla	7
Gulf	1	Monroe	[1]1	Walton	2
Hamilton	7	Nassau	1	Washington	6

[1] Pseudo spring.

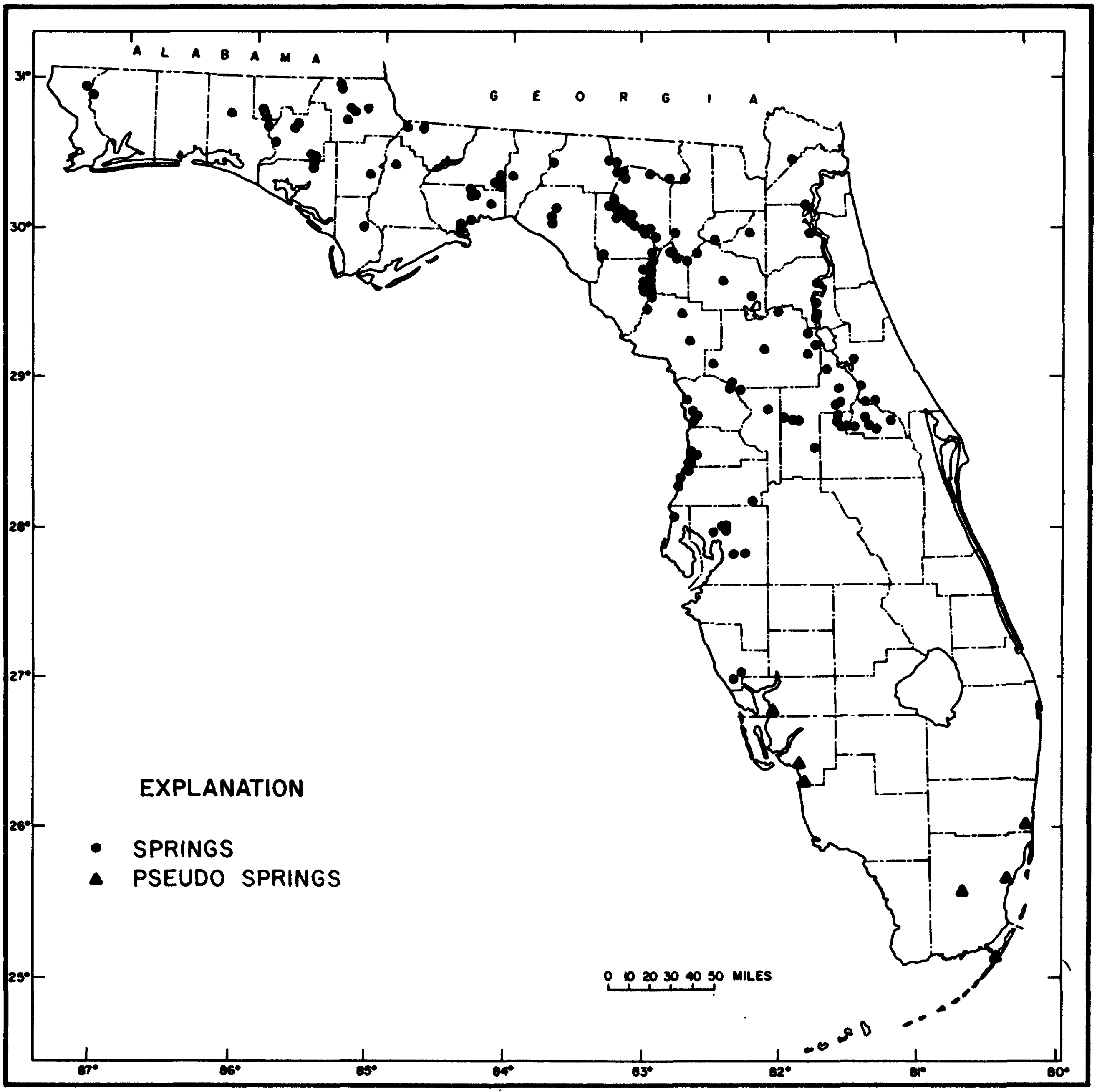


Figure 55.--Locations of Florida's better known springs (modified from Rosenau and Faulkner, 1974).

Table 24.--Selected Florida pseudo springs (artesian wells)

[Modified from Rosenau and others, 1977]

Name	County	Discharge (gal/min)	Discharge (Mgal/d)
Carlsbad Spa Villas at Hollywood Beach---	Broward	115	0.2
Hot Springs near Punta Gorda-------------	Charlotte	2,750	4.0
Hurricane Lodge Motel at Miami-----------	Dade	400	0.6
Mineral Springs at Chekika (Grossman) State Park, The Everglades-------------	Dade	1,000	1.4
Pennekamp Spring at John Pennekamp State Park, Key Largo------------------	Monroe	150	0.2
Shangri La Motel Health Resort at Bonita Springs-------------------------	Lee	700	1.0
Warm Springs Spa near Fort Myers---------	Lee	--	--

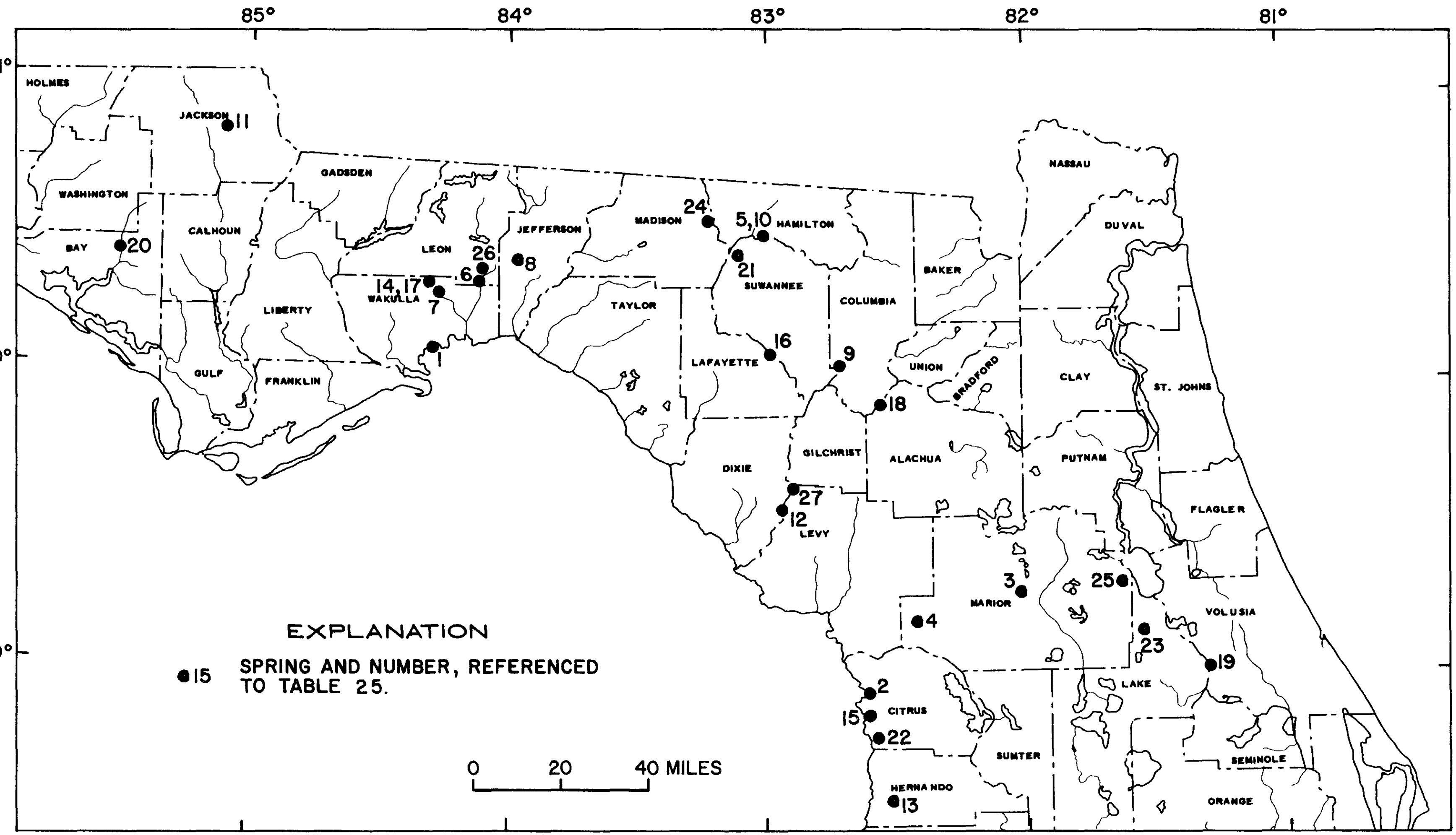


Figure 56.--Locations of Florida's 27 first magnitude springs (modified from Rosenau and others, 1977).

Table 25.--Hydrologic data for the 27 first-magnitude springs and spring groups of Florida, in order of average discharge--known through December 1976

[Modified from Rosenau and others, 1977]

Number	County and spring	Period of record	Discharge Average (Mgal/d)	Discharge Range (Mgal/d)	Number of measurements	Average Water temperature °F	Average Water temperature °C	Average Dissolved solids (mg/L)
1.	Wakulla County Spring Creek Springs	1972-74	[1]1,294	([2])	1	67	19.5	2,400
2.	Citrus County Crystal River Springs group	1964-75	[3]592	([2])	([4])	75	25.0	144
3.	Marion County Silver Springs	1906-74	530	348-833	155	73	23.0	245
4.	Marion County Rainbow Springs	1898-1974	493	315-795	402	73	23.0	93
5.	Hamilton County Alapaha Rise	1975-76	393	328-452	4	66	19.0	130
6.	Leon County St. Marks Spring	1956-73	335	200-614	130	69	20.5	154
7.	Wakulla County Wakulla Springs	1907-74	252	16-1,234	276	70	21.0	153
8.	Jefferson County Wacissa Springs Group	1971-74	251	181-391	20	69	20.5	150
9.	Columbia County Ichetucknee Springs	1917-74	233	156-373	375	73	22.5	170
10.	Hamilton County Holton Spring	1976	186	45-311	3	-	-	-
11.	Jackson County Blue Springs	1929-73	123	36-185	10	70	21.0	116
12	Levy County Manatee Spring	1932-73	117	71-154	9	72	22.0	215

See footnotes at end of table.

Table 25.--Hydrologic data for the 27 first-magnitude springs and spring groups of Florida, in order of average discharge--known through December 1976--Continued

Number	County and spring	Period of record	Discharge: Average (Mgal/d)	Discharge: Range (Mgal/d)	Number of measurements	Average: Water temperature °F	Average: Water temperature °C	Average: Dissolved solids (mg/L)
	Hernando County							
13.	Weeki Wachee Springs	1917-74	114	65-178	364	74	23.5	150
	Wakulla County							
14.	Kini Springs	1972	114	-	1	68	20.0	110
	Citrus County							
15.	Homosassa Springs	1932-74	113	81-166	90	73	23.0	1,800
	Lafayette County							
16.	Troy Spring	1942-73	107	96-132	4	72	22.0	171
	Wakulla County							
17.	River Sink Spring	1942-73	106	66-139	6	68	20.0	110
	Alachua County							
18	Hornsby Spring	1972-75	105	49-161	2	73	22.5	230
	Volusia County							
19.	Blue Spring	1932-74	105	41-138	360	73	23.0	826
	Bay County							
20.	Gainer Springs	1941-72	103	85-120	7	72	22.0	60
	Suwannee County							
21.	Falmouth Spring	1908-73	102	[5]39-142	8	70	21.0	190
	Citrus County							
22.	Chassahowitzka Springs	1930-72	90	21-127	81	74	23.5	740
	Lake County							
23.	Alexander Springs	1931-72	78	48-105	13	74	23.5	512
	Madison County							
24.	Blue Spring	1932-73	74	48-94	6	70	21.0	146

See footnotes at end of table.

Table 25.--Hydrologic data for the 27 first-magnitude springs and spring groups of Florida, in order of average discharge--known through December 1976--Continued

Number	County and spring	Period of record	Discharge: Average (Mgal/d)	Discharge: Range (Mgal/d)	Number of measurements	Average: Water temperature °F	Average: Water temperature °C	Average: Dissolved solids (mg/L)
	Marion County							
25.	Silver Glen Springs	1931-72	72	58-83	11	73	23.0	1,200
	Leon County							
26.	Natural Bridge Spring	1942-73	68	51-85	5	68	20.0	138
	Levy County							
27.	Fannin Springs	1930-73	67	41-90	8	72	22.0	194

[1] From group of 8 known springs.
[2] Tidal affected.
[3] From group of 30 known springs.
[4] Continuous record, vane gage.
[5] Reverse flow of 236 Mgal/d measured on February 10, 1933.

it finally ceased in February 1950 (Peek, 1951). Health Spring (formerly Wall Springs), a former third-magnitude spring on the Gulf Coast in Pinellas County, has also ceased flowing (Rosenau and others, 1977). Some small springs cease to flow at times of dry weather and some may have ceased flowing due to lowerings of artesian pressure in areas of heavy pumping.

Size

The two largest measured springs in Florida are Spring Creek Springs in Wakulla County and Crystal River Springs Group in Citrus County. The discharge of Springs Creek Springs is about 2,000 ft^3/s, about 1,300 Mgal/d, from a known group of eight springs. The discharge of Crystal River Springs Group is 916 ft^3/s, 592 Mgal/d, from 30 known springs. Both of these spring groups are coastal springs; they are at the shoreline. They are affected by tides and have higher average discharges than the noncoastal or inland springs.

The discharge of Silver Springs since 1906 averaged about 820 ft^3/s, 530 Mgal/d. This is the same as the earliest reported measured flow of Silver Springs of 531 Mgal/d on December 20, 1898 (Meinzer, 1927). The discharge has ranged from about 348 to 833 Mgal/d. This inland spring in Marion County, about 5 miles northeast of Ocala, is the largest noncoastal spring in Florida. The average discharge of Rainbow Springs is 763 ft^3/s, 493 Mgal/d, which is essentially the same as the earliest reported measured flow of 503 Mgal/d on December 22, 1898 (Meinzer, 1927).

Wakulla Springs, about 15 miles north of the Gulf Coast and about 14 miles south of Tallahassee, has the greatest range in discharge of from 16 to 1,234 Mgal/d. The peak is about 50 percent greater than the maximum discharge from Silver Springs. However, its average discharge is less than half that of Silver Springs.

Average discharge of each of the three largest springs in Florida, more than 500 Mgal/d, is believed to be greater than any other perennial spring in the United States and possibly in the northern hemisphere.

According to Linsley and others (1949) the largest known spring in the world (based on maximum discharge) is the Fontaine de Vaucluse in France, which has a discharge often exceeding 4,000 ft^3/s, 2,600 Mgal/d. However, the average discharge of this spring is only 517 Mgal/d, which is less than Silver Springs with 530 Mgal/d. The Fontaine de Vaucluse, which drains limestone terrane, is estimated to discharge 60 percent of the precipitation in the area. Silver Springs discharges an average of about 15 inches from the catchment area of 730 square miles, equivalent to about 28 percent of the average precipitation over the catchment area (Faulkner, 1973b).

Quality

The quality of water from most of Florida's 100 first- and second-magnitude springs falls into four prevalent chemical types: (1) calcium-magnesium bicarbonate, (2) sodium chloride, (3) mixed (no dominant cations or anions), and (4) calcium sulfate. Seventy-five percent of the springs contain type 1 (calcium-magnesium bicarbonate) water. As most of the springs discharge from the Floridan aquifer, this reflects solution of the carbonate rocks (limestones and dolomites) of the Floridan aquifer. Water from Wakulla Springs is typical of type 1 (calcium-magnesium bicarbonate) water (table 26). Ten percent of the springs contain sodium chloride type water. Water from Blue Springs in Volusia County is typical of type 2 (sodium chloride) water (table 26).

Less than 10 percent of the springs discharge water of the third (mixed) type. This type of water is a mixture of two or more sources having different types. Beecher Springs in Putnam County represents type 3 water and is a mixture of about 99 percent type 1 and 1 percent seawater. Messant Spring in Lake County is the only large spring that discharges the fourth (calcium sulfate) type of water (table 26).

The water quality of Florida springs is relatively constant. For example, the water quality of Wakulla Springs (table 27) is essentially the same as it was a half century ago. However, a few saline springs, such as Salt Springs in Marion County (table 27), have concentrations that fluctuate over a wide range. This is because of variations in the mixing of freshwater and saline water that contribute to the springs.

The long-term dissolution and transport of minerals by water discharged by the large springs is significant. Silver Springs (as an example) carries each day to the ocean about 540 tons of material that was dissolved from subsurface rocks. This is about 210,000 tons per year. At this rate, it takes essentially 10,000 years to remove one foot of limestone over the contributary area.

Temperature

The temperature of spring water ranges only about 7.2°F or 4°C throughout each year in Florida. The difference in average temperatures, though, between springs located in north Florida and those in the south is about 14.4°F or 8°C (table 28).

Submarine Springs

Submarine springs in Florida are offshore springs that discharge below sea level in a coastal saltwater environment.

Sixteen submarine springs have been identified in Florida. The known submarine springs are most numerous along the Gulf Coast from near Tampa northward and westward as far as the Choctawhatchee River, in the State's western "Panhandle" (fig. 57). The discharge of most submarine springs is

Table 26.--Comparison of chemical types of spring water to seawater

[Modified from Slack and Rosenau, 1979]
[Reporting units: µmho/cm, micromhos per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter]

Parameter	Reporting units	Beecher Springs (Putnam County)	Blue Spring (Volusia County)	Messant Spring (Lake County)	Wakulla Springs (Wakulla County)	Seawater[1]
Specific conductance	µmho/cm at 25°C	446	1,800	650	279	-
pH	units	7.9	7.8	7.9	7.3	-
Calcium (Ca)	mg/L	33	30	94	39	400
Magnesium (Mg)	mg/L	8.3	4.9	20	8.7	1,350
Sodium (Na)	mg/L	41	4.5	7.4	3.7	10,500
Bicarbonate (HCO_3)	mg/L	110	110	120	150	142
Sulfate (SO_4)	mg/L	11	4.4	230	17	2,700
Chloride (Cl)	mg/L	74	7	10	3.4	19,000
Total nitrogen (N)	mg/L	-	-	-	.39	.50
Total phosphorus (P)	mg/L	-	.07	-	.04	.07
Strontium (Sr)	µg/L	280	1,100	-	110	8,000
Arsenic (As)	µg/L	-	0	-	0	3
Cadmium (Cd)	µg/L	-	2	-	.00	.11
Copper (Cn)	µg/L	-	20	-	0	3
Lead (Pb)	µg/L	-	1	-	3	.03
Zinc	µg/L	-	20	-	20	10
Iron (Fe)	µg/L	-	70	-	10	10
Mercury (Hg)	µg/L	-	-	-	.00	.03
PCB[2]	µg/L	-	.00	-	.00	-
I&H[3]	µg/L	-	.00	-	.00	-
Type of water	-	Mixed	Sodium chloride.	Calcium sulfate.	Calcium-magnesium bicarbonate.	-
Date sampled	-	5-26-72	5-2-72	4-7-72	4-25-72	-

[1] Hem, 1970.
[2] Polychlorinated biphenyls.
[3] Insecticides and herbicides.

Table 27.--Variation of water quality of Wakulla Springs and Salt Springs with time

[Modified from Slack and Rosenau, 1979]
[Milligrams per liter unless otherwise noted]

Constituent	Wakulla Springs, Wakulla County				Salt Springs, Marion County			
	Date of collection				Date of collection			
	Feb. 28 1924	June 18 1946	Apr. 25 1972	Apr. 28 1977	Aug. 19 1924	Apr. 4 1946	Apr. 24 1956	May 31 1972
Calcium (Ca)	39	38	39	38	220	240	154	200
Magnesium (Mg)	9.6	9.5	8.7	9.3	140	170	98	120
Sodium (Na)	15.7	4.0	3.7	4.2	11,400	1,500	878	1,100
Potassium (K)	--	.5	.3	.5		38	24	30
Silica (SiO_2)	16	12	10	11	---	11	12	3.2
Bicarbonate(HCO_3)	150	150	150	160	84	87	67	80
Carbonate (CO_3)	--	0	0	0	---	0	0	0
Sulfate (SO_4)	11	9.3	17	8.4	540	610	375	440
Chloride (Cl)	8.0	5.1	3.4	5.5	2,400	2,800	1,600	1,900
Fluoride (F)	--	.1	.3	.2	---	.0	.1	.2
Dissolved solids	[2]167	[2]155	[2]160	[2]154	[3]5,210	[3]5,850		
Hardness as $CaCO_3$	140	130	130	130	1,100	1,300	787	1,000
Specific conductance (micromhos per centimeter at 25°C)	--	277	279	290	---	9,330	5,520	6,500
pH(units)	--	7.9	7.3	7.4	---	7.1	7.6	7.8
Color (platinum-cobalt units)	--	0	0	0	---	0	5	10

[1] Sodium and potassium.
[2] Calculated.
[3] Residue on evaporation at 180°C.

Table 28.--Range and variation of temperature of springs in Florida

[From Rosenau and others, 1977]

Section of Florida	Approximate range (in °C)	Average temperature (°F)	Average temperature (°C)
North	19 to 23	70	21
Central	22 to 26	75	24
South	27 to 31	84	29

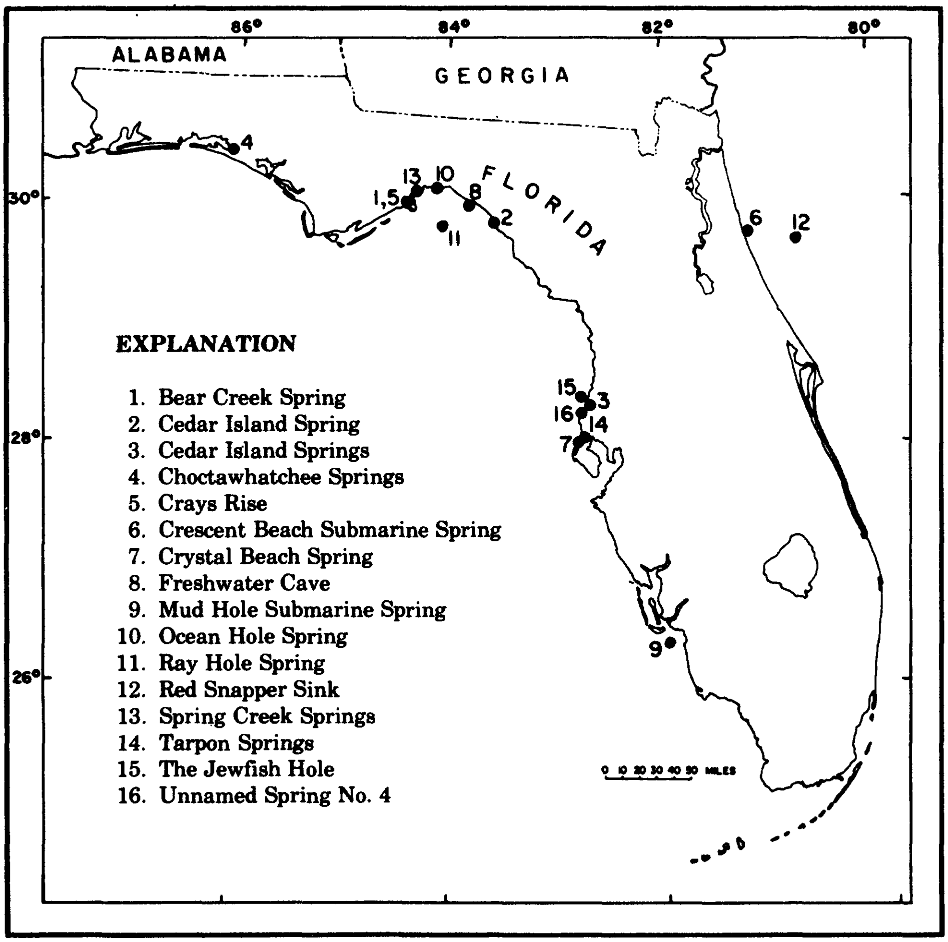


Figure 57.--Locations of Florida's known submarine springs (from Rosenau and others, 1977).

unknown. Spring Creek Springs, table 25, with a discharge of about 2,000 ft^3/s, is the largest known submarine spring in Florida. Some submarine springs reverse discharge as a result of tidal action. Tarpon Springs, prior to May 1969 when a dam was constructed around Tarpon Sink, was well known in this respect and its reversals in discharge were sporadic. Measured discharge of Tarpon Springs ranged from 1,000 ft^3/s in 1950 to a reverse discharge of 146 ft^3/s in 1946 (Rosenau and others, 1977).

GROUND WATER

Ground water in Florida is abundant. On an areal basis, Florida has more ground water available in large quantities than any other state (McGuinness, 1963). Potable supplies of ground water can be obtained in most areas of Florida except in certain areas near the coast. Saline ground waters underlie potable water at various depths under all of Florida.

The principal statewide source of potable ground water in most of Florida is the Floridan aquifer. Two other large aquifers are the Biscayne aquifer of southeastern Florida and the sand-and-gravel aquifer of northwestern Florida. Other important aquifers are the numerous nonartesian and artesian aquifers that contain potable water and overlie the Floridan over much of the State. The general description and areal extent of these aquifers has been shown by Hyde (1965). The approximate areas where these aquifers are the main source of public water supply are shown in figure 78.

Floridan Aquifer

The Floridan aquifer is one of the most productive aquifers in the world and is one of the most valuable natural resources in Florida. It is part of an artesian aquifer system that extends over 82,000 square miles in Florida, southern Alabama, southeastern Georgia, and part of South Carolina, and is a principal source of ground-water supplies in these areas (Healy 1975a).

The Floridan aquifer consists of the limestones and dolomites of Eocene, Oligocene, and Miocene age. As defined by Parker and others (1955), the Floridan aquifer included parts or all of the middle Eocene (Avon Park and Lake City Limestones), upper Eocene (Ocala Limestone), Oligocene (Suwannee Limestone), and Miocene (Tampa Limestone and permeable parts of the Hawthorn Formation that are in hydraulic contact with the rest of the aquifer). Presently (1981), it is considered to include the Oldsmar Limestone of lower Eocene age.

Figure 58 depicts the approximate altitude of the top of the rock or sediment that composes the Floridan aquifer. In some areas such as middle gulf counties and northwestern counties--Holmes, Jackson, Washington, and Walton--rock is exposed at or near the land surface. In the western part of the Panhandle of Florida, the aquifer is as much as 2,000 feet below sea level while in southwestern Monroe County it is 1,000 feet below sea level.

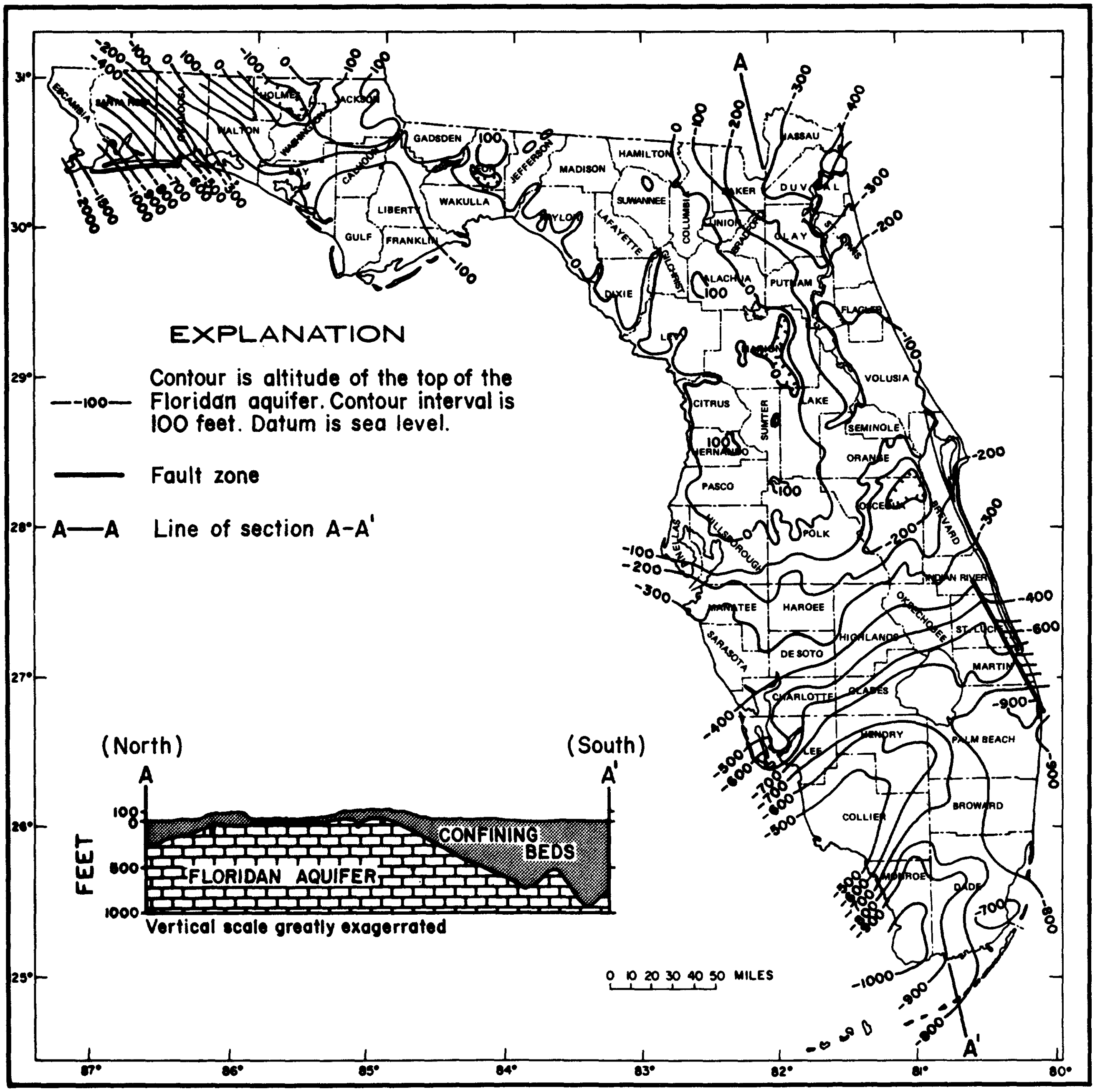


Figure 58.--Top of the Floridan aquifer (modified from Vernon, 1973).

Recharge

The Floridan aquifer is recharged in areas where the potentiometric surface of the Floridan is lower than the water table. The areas of recharge are essentially those areas of nonartesian flow (fig. 60). The areas of natural recharge to the Floridan aquifer are classified into four types: (1) areas of generally no recharge, (2) areas of very low recharge, (3) areas of very low to moderate recharge, and (4) area of high recharge. The recharge areas, shown by figure 59, are generalized. The areas of generally no recharge, under natural conditions, are mostly where the potentiometric surface of the Floridan aquifer is above land surface much of the time, that is, in areas of artesian flow. About 45 percent of the State falls within this classification. The areas of very low recharge are where the Floridan is known to be overlain by relatively impermeable confining beds generally more than 25 feet thick. In these areas recharge rates are estimated to be less than 2 inches per year. The areas of very low to moderate recharge are where the confining beds are generally less than 25 feet thick or breached. They include areas where the confining bed is absent but where the water table and potentiometric surface of the Floridan aquifer are both close to the land surface so that little recharge occurs. Recharge rates of very low to moderate recharge are estimated to range from less than 2 inches to as much as 10 inches per year. The areas of high recharge represent about 15 percent of the State, and recharge rates in these areas are estimated to range from 10 to 20 inches per year. (Stewart, 1980.)

Potentiometric Surface

The configuration of the potentiometric surface and the areas of artesian flow of the Floridan aquifer in Florida as of May 1974 are shown in figure 60 (Healy, 1975a). The position of the potentiometric surface for May 1974 is based on water levels measured in 670 selected wells in Florida. The altitude of the potentiometric surface is the level, referenced to sea level, to which water will rise in tightly-cased wells that tap the Floridan aquifer. The area of artesian flow is where the water level in artesian wells generally is above land surface so that the well will flow at the ground surface.

The approximate maximum depth below land surface of potable water in the Floridan aquifer is shown in figure 61.

Biscayne Aquifer

The nonartesian Biscayne aquifer underlies an area of about 3,000 square miles in Dade, Broward, and southern Palm Beach counties. The wedge-shaped aquifer is 100 to 400 feet thick in coastal Dade and Broward counties but thins to a few feet near the western boundary of the counties. The areal extent of the aquifer, where used as a source of public water supply, is given in figure 78.

The Biscayne aquifer is composed of rock ranging in age from late Miocene through Pleistocene. The rocks, from oldest to youngest, are the Tamiami Formation of Miocene age, the Caloosahatchee Marl of Pliocene age, and the Fort Thompson Formation, Key Largo Limestone, Anastasia Formation, Miami Oolite, and Pamlico Sand of Pleistocene age.

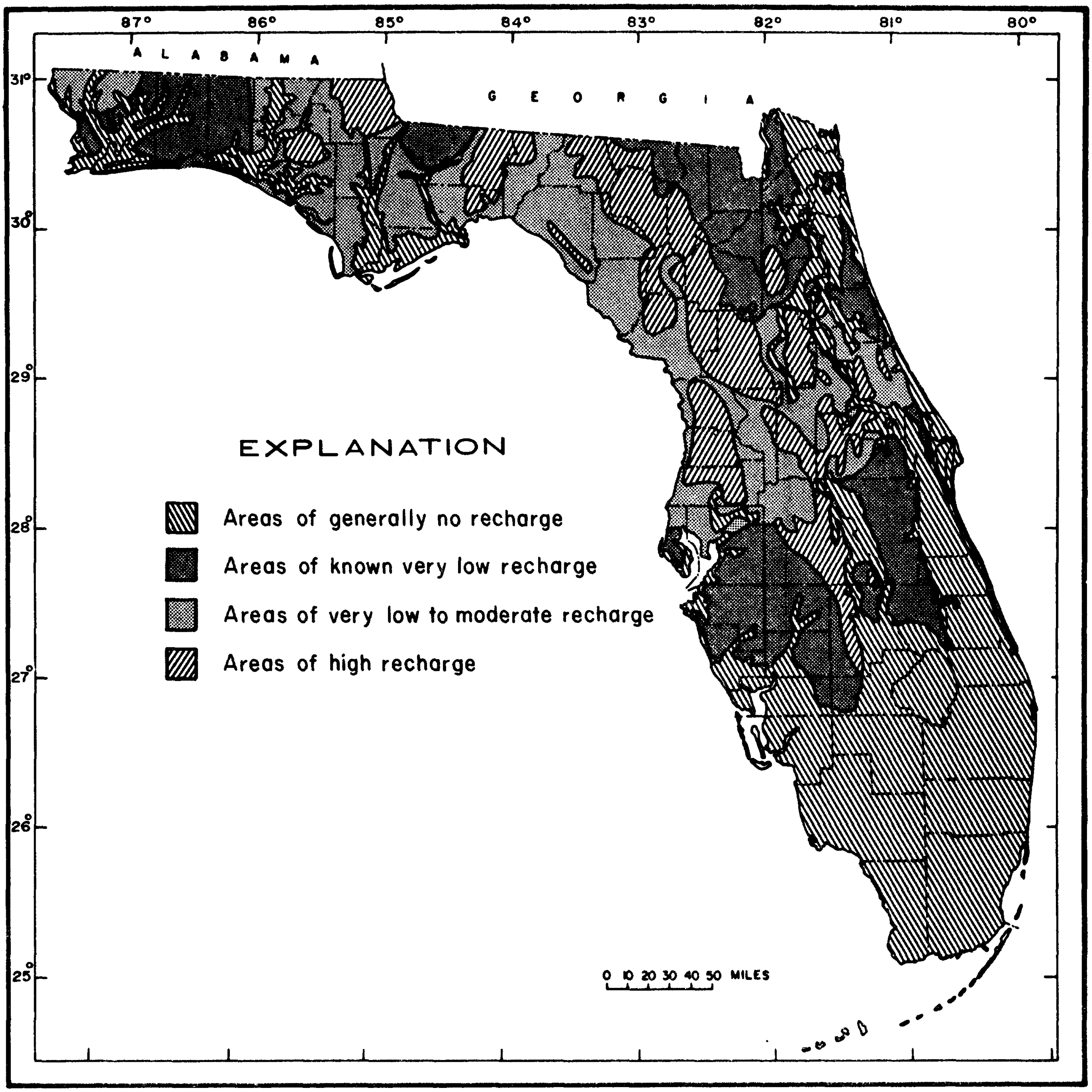


Figure 59.--Areas of natural recharge to the Floridan aquifer in Florida (modified from Stewart, 1980).

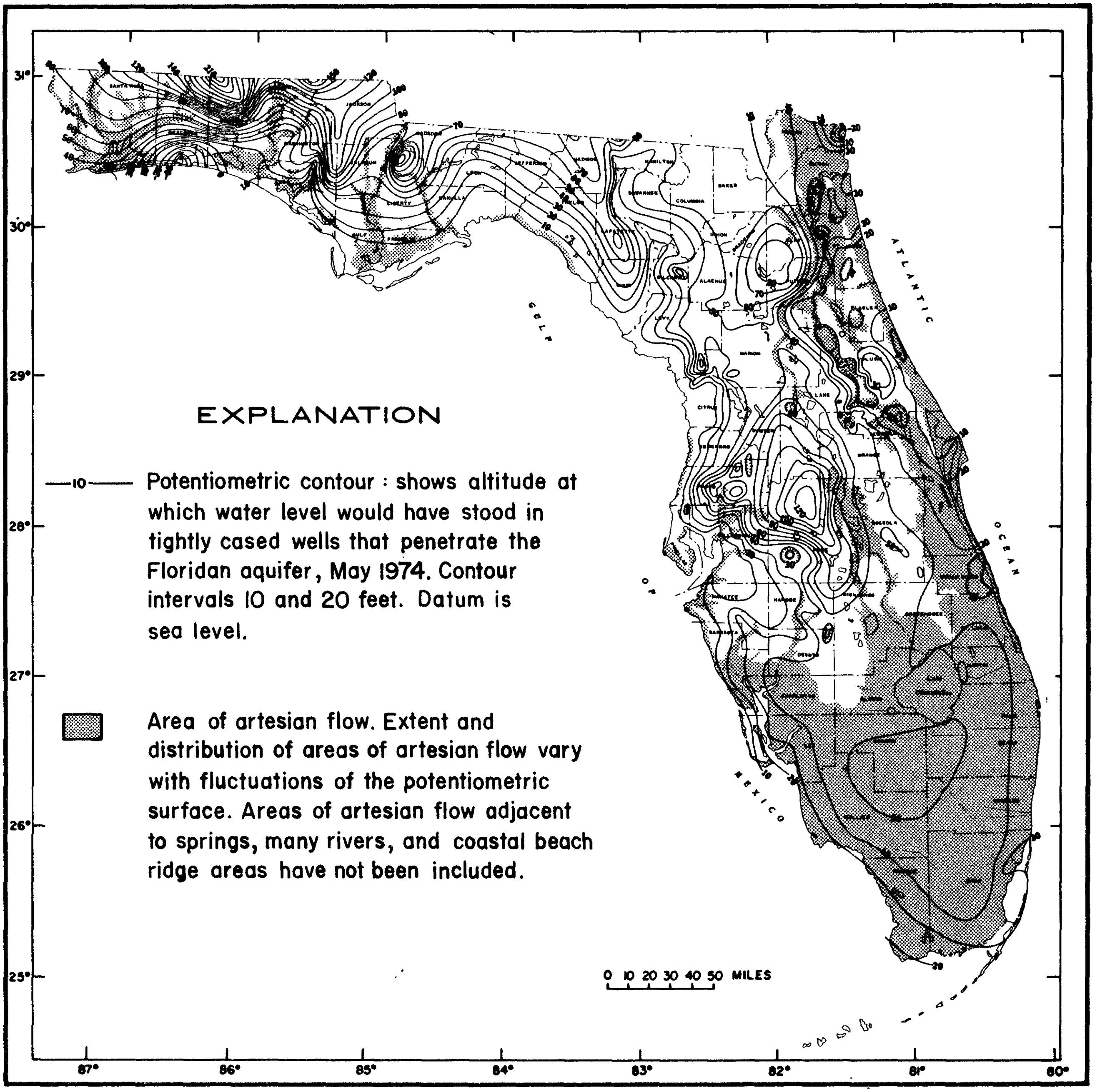


Figure 60.--Potentiometric surface and areas of artesian flow of the Floridan aquifer in Florida, May 1974 (modified from Healy, 1975a).

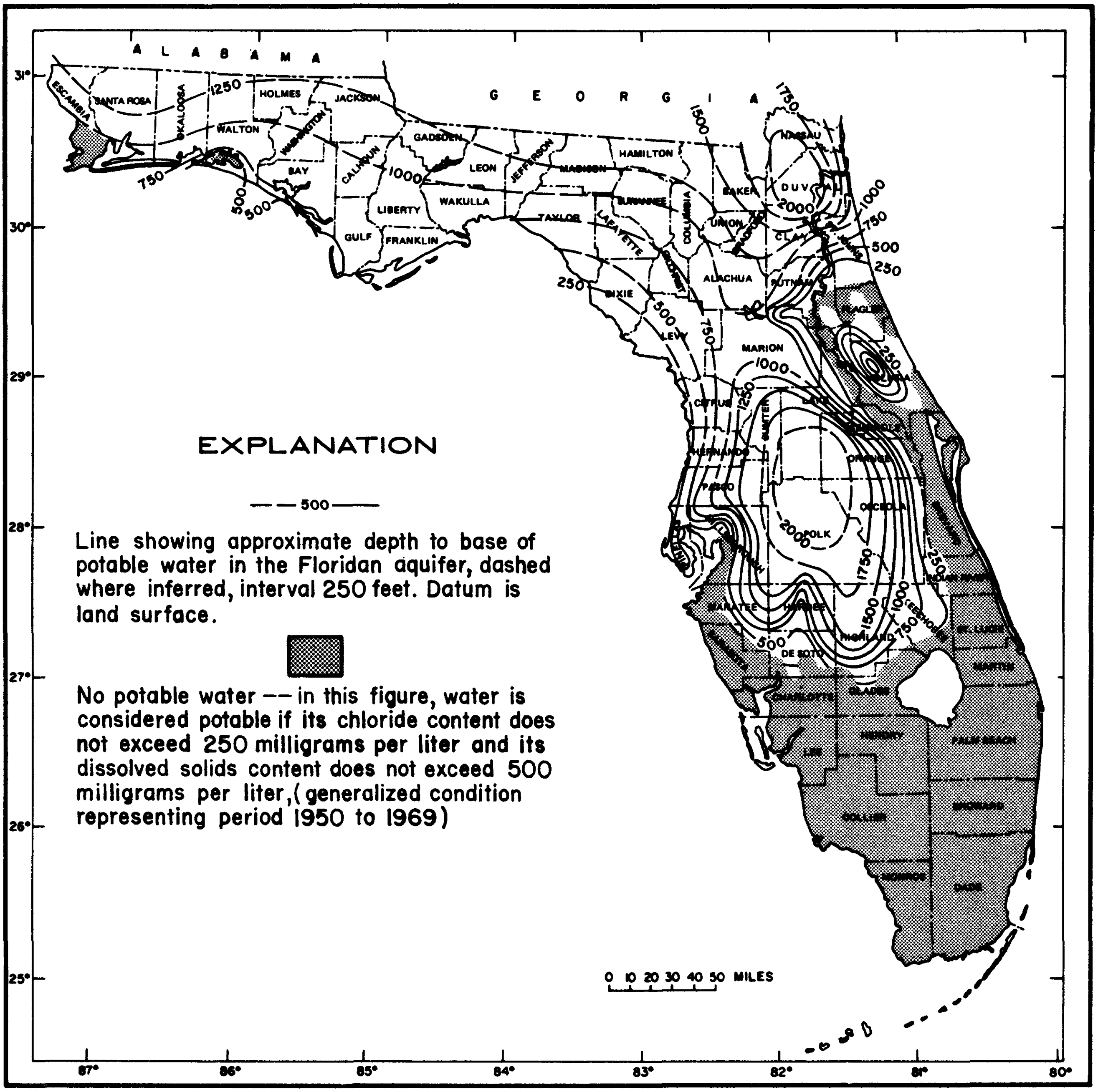


Figure 61.--Depth to base of potable water in the Floridan aquifer in Florida (modified from Klein, 1971).

The aquifer is an interconnected hydrologic unit of permeable materials whose boundaries are set by differences in the hydrologic properties. The permeable limestone of the aquifer is shielded against upward intrusion of saline water from the underlying Floridan aquifer by relatively impermeable beds of clay and marl. However, there is no shield against lateral encroachment of seawater, the major problem in the area served by the Biscayne aquifer. Encroachment can result from overdrainage by canals. However, proper control of drainage canals and proper water management have greatly reduced the threat of seawater encroachment.

Water in the Biscayne aquifer is derived chiefly from local rainfall and during dry periods from canals connected to conservation areas.

The ground water from uncontaminated parts of the aquifer is fairly uniform in quality. The hardness generally ranges from 200 to 300 mg/L (milligrams per liter) and the chloride from about 15 to 30 mg/L. Nearly all the water is colored either with organic material or iron, or both; the color is usually greatest in the upper part of the aquifer. Excessive amounts of iron are encountered in some parts of the aquifer. The quality of water from the Biscayne aquifer, based on public water supplies, is given in tables 43 and 44.

The Biscayne aquifer is highly productive everywhere along the coastal ridge and for a considerable distance to the west; however, its productivity varies considerable from place to place. Wells developed in the aquifer are as large as 36 inches in diameter. A typical well is 6 inches in diameter, 50 to 75 feet deep, and finished with 3 to 10 feet of open hole in highly permeable limestone. In the northern part of the area, wells may be as deep as 200 feet. Yield from 6-inch wells ranges from 1,000 to 1,500 gal/min with less than 4 feet of drawdown.

Sand-and-Gravel Aquifer

The nonartesian sand-and-gravel aquifer is the major source of ground water in extreme western Florida. It is a wedge-shaped deposit extending northward into Alabama. It generally thickens to the west and southwest from its thin outcrop along the Walton-Washington County line. In southeastern Escambia County, the aquifer is 400 to 500 feet thick. The areal extent of the aquifer where used as a source of public water supply, is given in figure 78.

The sand-and-gravel aquifer is composed of sediments ranging in age from Miocene to Pleistocene. The sediments are chiefly very fine to very coarse quartz sand which in places is mixed with granules and small pebbles of quartz and chert. Lenses and stringers of gravel and clay occur throughout the aquifer.

Water in the sand-and-gravel aquifer is derived chiefly from local rainfall and is low in dissolved solids which generally range from 15 to 40 mg/L; hardness ranges from 4 to 30 mg/L, chloride from 2 to 30 mg/L, iron less than 0.25 mg/L, and fluoride less than 0.2 mg/L. The water is usually acidic. The quality of water from the sand-and-gravel aquifer, based on public water supplies, is given in tables 43 and 44.

Wells in the sand-and-gravel aquifer furnish all of the ground water used in Escambia, most of that used in Santa Rosa, and a substantial part of the smaller supplies in Okaloosa County. Wells may be as large as 30 inches in diameter, the depth varies from 30 to 500 feet, and the yield ranges from 50 to 2,000 gal/min.

Other Aquifers

Other aquifers are present over much of the State, but they are an important source of ground water only where a better supply is not available from the Floridan, Biscayne, or sand-and-gravel aquifers. For example, numerous shallow, near-surface, aquifers are used for public supplies (fig. 78) in much of the south-central, the central-east coast, and the southwest coastal parts of Florida, where water in the Floridan aquifers is of poor quality. Also, in most rural areas where water requirements are small, the shallow, near-surface, aquifers are tapped by shallow wells.

The lithology, thickness, and hydrologic characteristics of the shallow, near-surface, aquifers differ from place to place. In southern Florida, the aquifers range in age from Miocene to Recent and are composed of sands of the Pamlico or older terrace deposits, beds of shell and sand of the Anastasia Formation, beds of shell and limestone in the Tamiami Formation, or limestones in the upper part, and in some places the lower part, of the Hawthorn Formation. Northward along the coast the aquifer is composed primarily of Pleistocene and Holocene deposits of sand and shells, but in some areas it extends downward to include deposits of Miocene or Pliocene age. The shallow, near-surface, aquifers used for public supply in 21 counties range in depth from essentially the surface to 250 feet (table 37).

The water in the shallow, near-surface, aquifers is derived chiefly from local rainfall and generally is of good chemical quality. The water is usually low in chlorides except where contaminated by adjacent saltwater bodies. It ranges from soft to very hard, and it is commonly high in color and in iron. The quality of water from shallow, near-surface, aquifers used for public supply is given in tables 43 and 44.

Water-level Fluctuations

Water levels are measured periodically in a network of about 5,000 wells in Florida to evaluate the status of the ground-water resources and to determine the response of the aquifer systems to natural and developmental effects.

Ground-water levels rise in response to recharge from precipitation, and likewise decline in its absence. Long-term fluctuation in water levels due to natural variations in recharge is illustrated by the artesian well, Marion 5, in Marion County (fig. 62). The artesian pressures in Marion 5 are used to compute the discharge of Silver Springs which is about 4 miles northwest of the well.

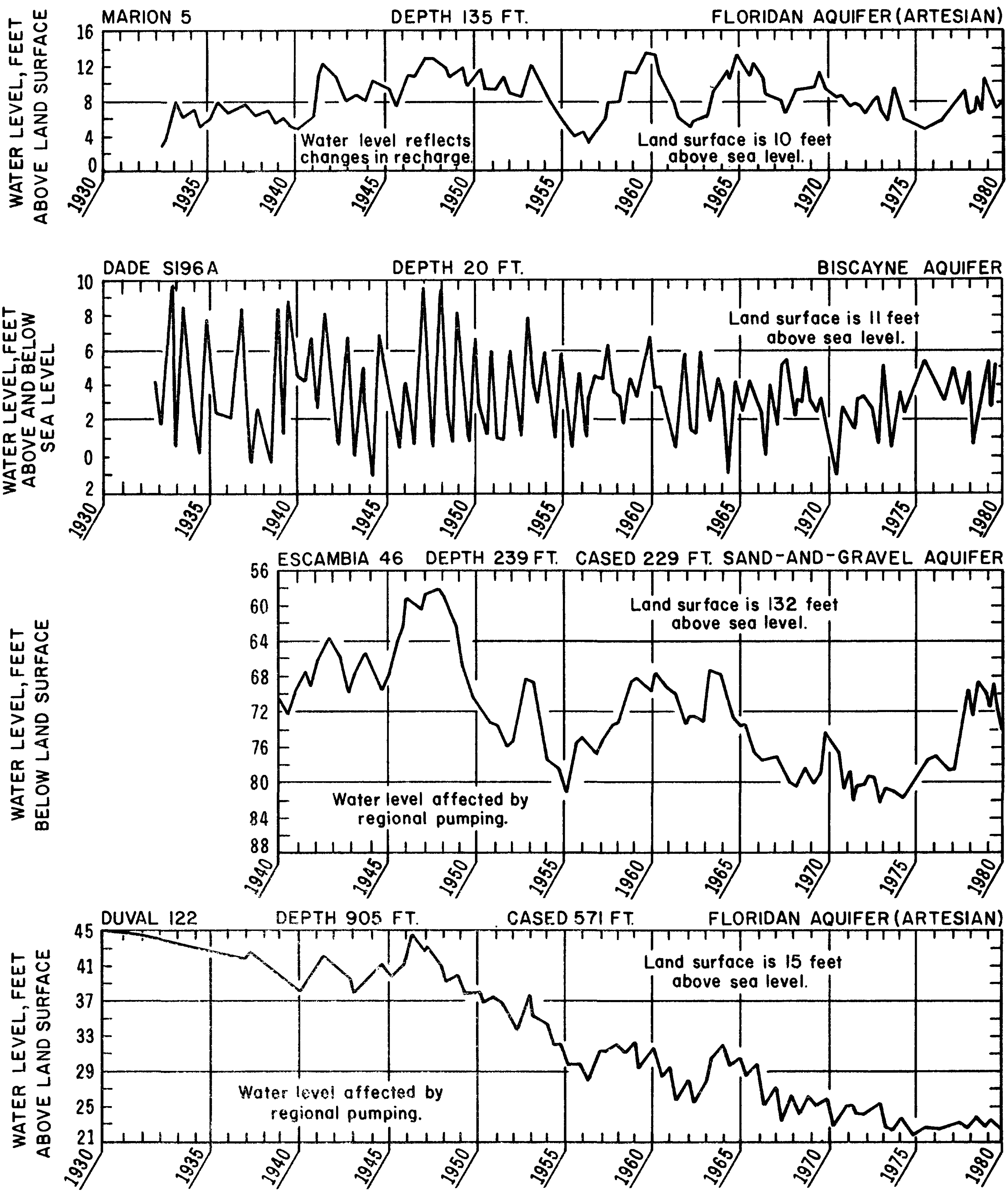


Figure 62.--Fluctuation of water levels in observation wells in Marion, Dade, Escambia, and Duval Counties, Florida, 1930-80 (modified from Healy, 1980).

Ground-water levels also fluctuate in response to water management activities such as control of the discharge in canals in southeast Florida. The water levels in observation well Dade S196A in the Biscayne aquifer near Homestead, Dade County, show seasonal changes of as much as 8 feet in the early years of record before water management control was fully effective whereas in recent years, seasonal changes have been about 4 feet. The high seasonal levels have been lowered while the low seasonal levels have tended to be raised (fig. 62).

Ground-water levels decline when wells are pumped and rise when pumping is reduced or stopped. Pumping contributes to seasonal variations in water levels and also to long-term trends in water levels. The seasonal variations relate to irrigation, public supply, and industrial demands for water. The long-term trends and variations in seasonal fluctuations are illustrated in figures 62 and 63.

The water level in observation well Escambia 46 (fig. 62), in Escambia County, reflects a combination of changes in recharge and pumpage in the sand-and-gravel aquifer over a 40-year period. Though water levels have fluctuated from a high level of about 58 feet below land surface in 1948 to a low of about 82 feet in 1956, the level in 1980 was essentially the same as in 1940.

The water level in observation well Duval 122 (fig. 62), Duval County, reflects long-term effects of pumping from the Floridan aquifer in northeastern Florida as represented primarily by municipal and industrial use. The water levels exhibit a long-term decline of about 25 feet interrupted by relatively short periods of rise associated with recharge and related reduction in pumpage.

The water level in observation well Sarasota 9 (fig. 63), Sarasota County, reflects the long-term effects of pumping from the Floridan aquifer in southwest Florida. The increase in seasonal fluctuations in the last few years reflects the increase in seasonal pumping, especially for irrigation. Seasonal high levels in 1980 were about 12 feet below those in 1931 while seasonal low levels were about 19 feet lower.

Wells

The yield, or pumping rate of wells, depends upon many factors including permeability of the aquifer, diameter of the well, thickness of the aquifer penetrated by the well, size of pump, construction of the well, and length of time the well is pumped. The map, figure 64, portrays the geographical variation of yields of wells for the major aquifers used to supply potable water in Florida (fig. 78). The yield of wells portrayed was based on a specific set of conditions: a well of 12-inch diameter tapping the full thickness of the aquifer, a 24-hour period of pumping, a 10-foot drawdown, and a minimal well loss. A larger or smaller well yield can be obtained by larger or smaller pumps. For instance, pumping at a rate that would double the 10-foot drawdown of a well would nearly double its yield.

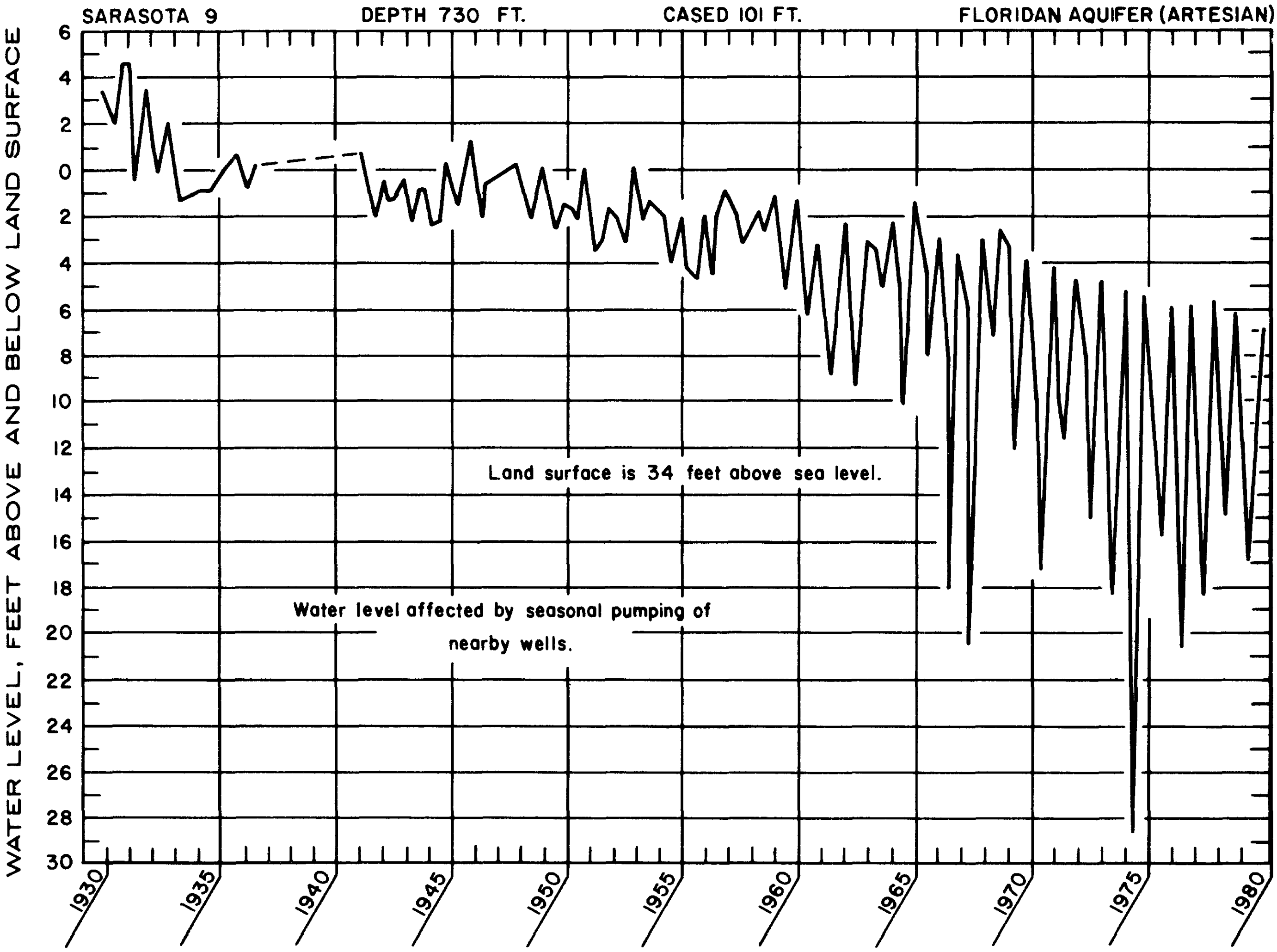


Figure 63.--Fluctuation of water level in observation well 9, Sarasota County, 1930-80 (modified from Healy, 1980).

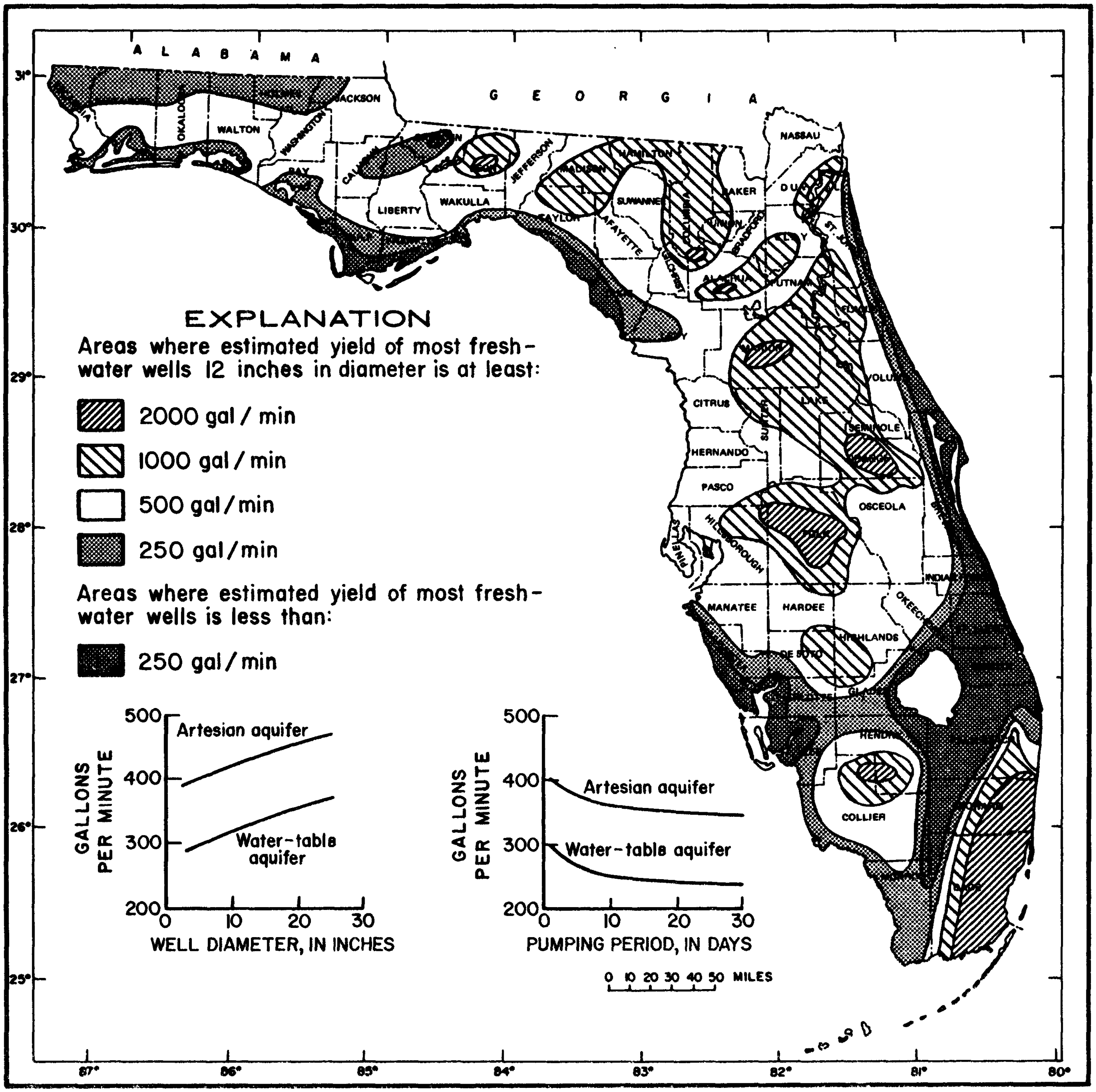


Figure 64.--Estimated yield of freshwater wells in Florida (modified from Pascale, 1975).

Two of the largest natural-flowing wells in the world are in Florida. One well near Palatka in Putnam County discharges 17 Mgal/d. Another artesian well (24-inch diameter) near Sanford in Lake County discharges 29 Mgal/d. Wells which discharge several million gallons per day are common in coastal areas, stream valleys, and in the southern part of Florida.

The maps, figures 58, 60, and 61, showing the top of the Floridan aquifer, the potentiometric surface of the aquifer, and the depth to the base of potable water, coupled with knowing the surface altitude at any point where a well is to be drilled into the Floridan aquifer, can be used to obtain a meaningful estimate of (a) the length of casing required; (b) the ability of the well to flow, or of the water level below land surface; and (c) the thickness of the freshwater column.

EARTHQUAKES

Most earthquakes throughout the world occur along the contact of the shifting plate-like segments of the Earth's crust. Florida, being somewhat distant from the contact boundaries of the North American Plate, is one of the relatively earthquake-free areas in the country. Local earthquakes of any consequence are a rarity in Florida. Much of the information in this section is adapted from the "Seismicity map of Florida," (Stover and others, 1979).

"Florida is one of the more earthquake-free areas in the country: its residents have only experienced about two dozen confirmed earthquakes in the past 200 years. Some distant earthquakes have been felt in Florida, notably from Cuba in 1880 and from Charleston, South Carolina, in 1886...." (Stover and others, 1979). The effects of the "Good Friday" earthquake in Alaska in 1964 (table 29) were observed at gaging stations on streams and lakes, and on water-level recorders on observation wells in Florida. Recorders on some wells showed water-level fluctuations of several feet. Double amplitude of water-level fluctuations (highest recorded water-level fluctuation minus lowest) on March 28, 1964, at artesian observation wells throughout Florida, ranged from an estimated maximum of 17.0 feet in Taylor County to a minimum of 0.28 feet in Duval County. The average water-level fluctuations caused by the Alaskan earthquake in these selected wells was about 4.0 feet. The Alaskan earthquake was the first to have hydrologic data from a major earthquake compiled on a worldwide basis.

Most earthquakes in Florida are reported in terms of their intensity on the Modified Mercalli (MM) scale, which is a measure of an earthquake's effects in a given area and is based on human observation of damage and other effects. On this scale, the maximum intensity of XII would produce total destruction. The open-ended Richter magnitude scale (table 29) is based on instrument readings of the amount of energy released by an earthquake. The 1906 San Francisco earthquake had a maximum intensity (MM) of XI and an estimated Richter magnitude of 8.3.

Table 29.--Magnitude of a few of the world's major earthquakes

Date	Location	Magnitude (Richter scale)[1]
1897	India	8.7
1906	San Francisco	8.3
1923	Japan	8.3
1960	Chile	8.5
1964	Alaska	8.4

[1] The Richter scale, named for Dr. Charles F. Richter is the best known scale for measuring magnitude of earthquakes. A quake of magnitude 2 is the smallest quake normally felt by humans. Earthquakes with a Richter value of 6 or more are commonly considered major in magnitude.

The two strongest earthquakes centered and recorded in Florida occurred near Pensacola in Escambia County in 1780 and about 50 miles southwest of St. Augustine in Marion-Putnam Counties in 1879. Both quakes were assigned an intensity of VI based on the Modified Mercalli intensity scale. Shaking during the 1879 earthquake knocked plaster from walls and objects off shelves in St. Augustine and produced similar effects at least as far as Daytona Beach, 50 miles south (fig. 65). The most recent earthquake shown in figure 65 occurred on December 4, 1975, near Daytona Beach in Volusia County, and registered 2.9 on the Richter Scale and IV on the MM scale.

Fifty-five seismic events have been reported in Florida. Thirty-one of the events are considered to be nontectonic in origin, such as from an explosion, and are not plotted in figure 65. Twenty of the events occurred on January 19, 1942 (table 30). The ground shaking in 1942 was centered in the Everglades northwest of Miami and is not considered to be of tectonic origin (pertaining to structural deformation in the Earth's crust).

WATER QUALITY

Surface-Water Quality

Quality is a measure of the surface-water resources of Florida. The quality of surface water, however, is complex as it encompasses such considerations as its particular suitability for drinking, agriculture, industry, fish and wildlife propagation, and esthetic value. Once the beneficial uses and quality standards of a water resource have been established, generally by statute, it must be monitored. For example, the National Stream Quality Accounting Network (NASQAN) of the U.S. Geological Survey is a data-collecting network established to monitor regional and nationwide quality of water in streams at about 500 sites in the United States. The locations of 30 NASQAN sites in Florida in 1980 are given in figure 66.

The primary objectives of NASQAN are: (a) account for the quantity and quality of water moving within and from the United States; (b) depict areal variability; (c) detect changes in stream quality; and (d) lay the groundwork for future assessments of changes in stream quality.

In addition to NASQAN stations, many other streams are sampled regularly throughout Florida and analyses are made to define the quality characteristics and changes in the surface waters of the State.

More than 350 analyses of water samples collected during low flow from 1940 through 1967 were used by Kaufman (1972) in compiling data on prevalent chemical types of water in Florida streams and canals (fig. 67) and on relations among chemical composition, concentration, and discharge for selected sites during low versus high streamflow (fig. 68).

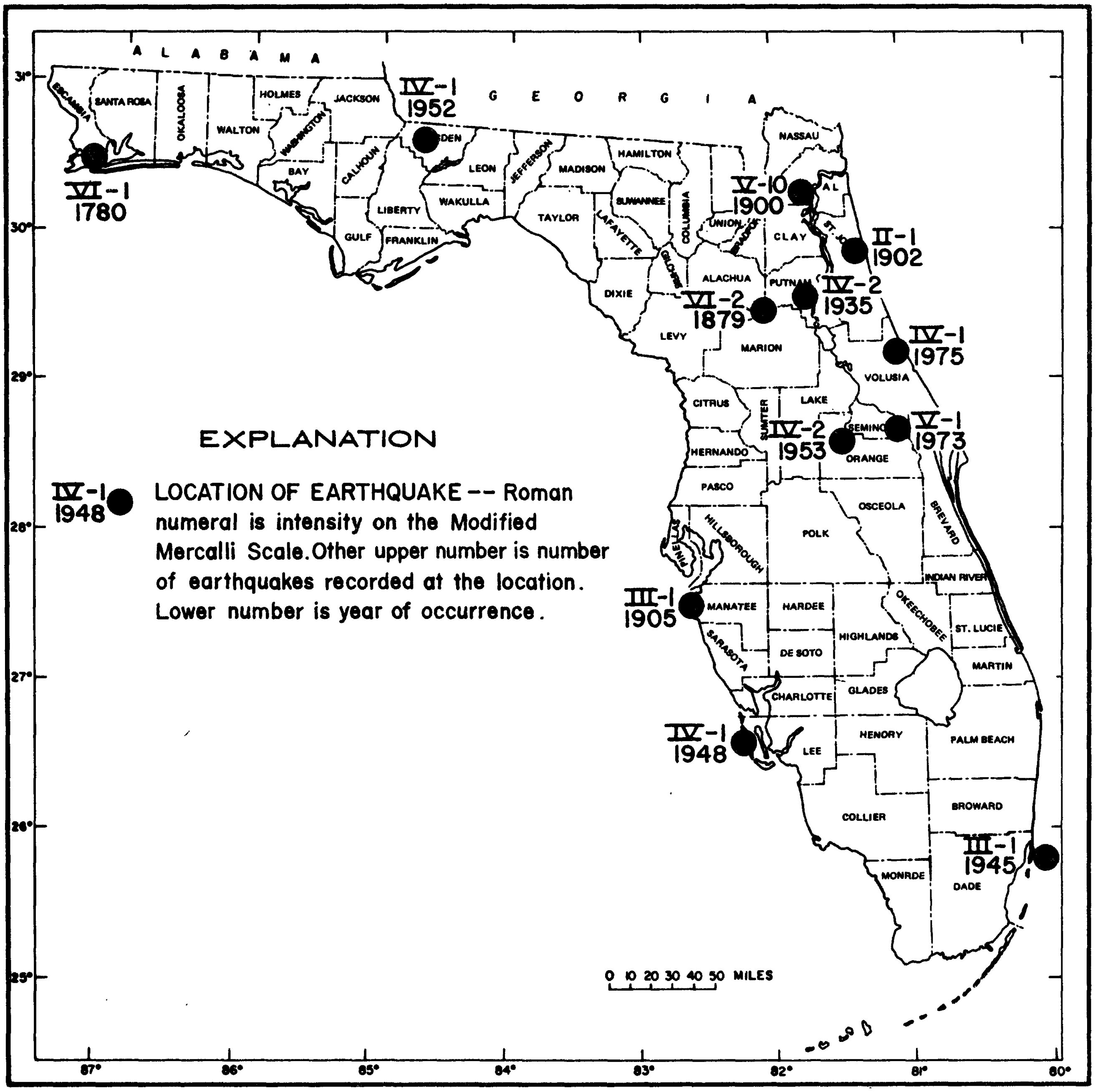


Figure 65.--Location of selected earthquakes in Florida (modified from Stover and others, 1979).

Table 30.--Chronological listing of earthquakes in Florida

[Modified from Stover and others, 1979]

An explanation of the symbols and codes used in the table follows:

Date-day, (7) indicates number of aftershocks reported same day.

Latitude and longitude are listed to a hundredth of a degree if they have been published with that degree of accuracy, or greater; however, most historical events have been published only to the nearest degree or tenth of a degree and are therefore listed at that accuracy in the table. An asterisk (*) to the right of the longitude indicates that the latitude and longitude were not given in the source reference, but were assigned by the compilers of the data file. An (x) to the right of the longitude indicates that the event is an explosion, a suspected explosion, or a nontectonic event.

The letter code in the Hypocenter, Qual column is defined as follows: Determination of noninstrumental epicenters from felt data are estimated to be accurate within the ranges of latitude and longitude listed below. Each range is letter coded as indicated:

F 0.0°-0.5°
G 0.5°-1.0°
H 1.0°-2.0°
I 2.0° or larger

An asterisk (*) in the Intensity column indicate that the intensity was assigned by the compiler on the basis of the available data at the time the catalog was compiled.

Date			Lat.	Long.	County	Hypocenter	Intensity
Year	Month	Day	(N.)	(W.)		(Qual)	Modified Mercalli (MM)
1780	Feb	06	30.4	87.2*	Escambia	G	VI*
1879	Jan	13(1)	29.5	82.0	Marion/ Putnam	H	VI
1886	Jan	08	30.4	81.7	Duval	H	..
1886	Sep	01	30.4	81.7*	Duval	H	IV
1886	Sep	03	30.4	81.7*	Duval	H	IV
1886	Sep	04	30.4	81.7	Duval	H	IV
1886	Sep	05	30.4	81.7*	Duval	H	IV
1886	Sep	08	30.4	81.7*	Duval	H	IV
1886	Sep	09	30.4	81.7	Duval	H	IV
1893	June	21	30.4	81.7*	Duval	H	IV
1900	Oct	10(7)	30.3	81.7x	Duval	H	V
1900	Oct	31	30.4	81.7	Duval	H	V
1902	May	21(1)	29.9	81.3*	St. Johns	H	II
1905	Sep	04	27.5	82.6*	Manatee	H	III
1930	July	19	25.8	81.4x	Collier/ Monroe	H	V
1935	Nov	14(1)	29.6	81.7*	Putnam	H	IV
1940	Dec	27	28.0	82.5x	Hillsborough	H	..
1942	Jan	19(19)	26.5	81.0x	Hendry	I	IV*
1945	Dec	22	25.8	80.0*	Dade	H	III*
1948	Nov	08	26.5	82.2*	Lee	H	IV*
1952	Nov	18	30.6	84.6	Gadsden	H	IV
1953	Mar	26(1)	28.6	81.4	Orange	H	IV*
1973	Oct	27	28.7	81.0	Seminole/ Volusia	F	V
1973	Dec	05	30.5	86.5x	Okaloosa	I	III*
1975	Dec	04	29.2	81.0*	Volusia	I	IV

Note.--The data have some basic limitations in terms of the size (magnitude or intensity) of the earthquakes listed. Prior to 1965 all recorded felt earthquakes are listed, after 1965 only published earthquakes having magnitudes above the 2.5-3.0 range are listed; the lower magnitude levels apply mostly to the eastern United States. The low magnitude events located in recent years with dense seismograph networks have not been included.

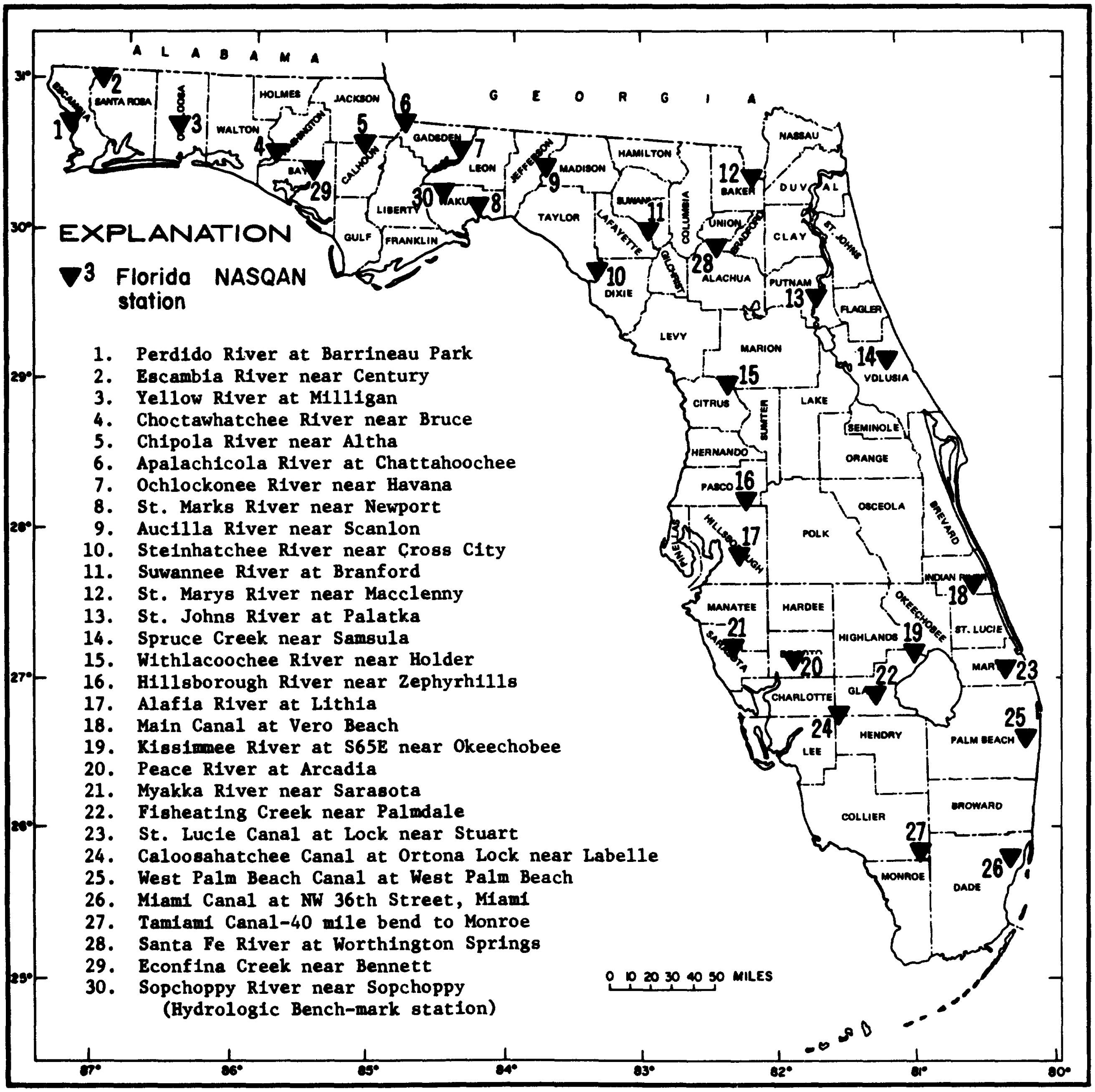


Figure 66.--National Stream Quality Accounting Network (NASQAN) stations in Florida, 1980.

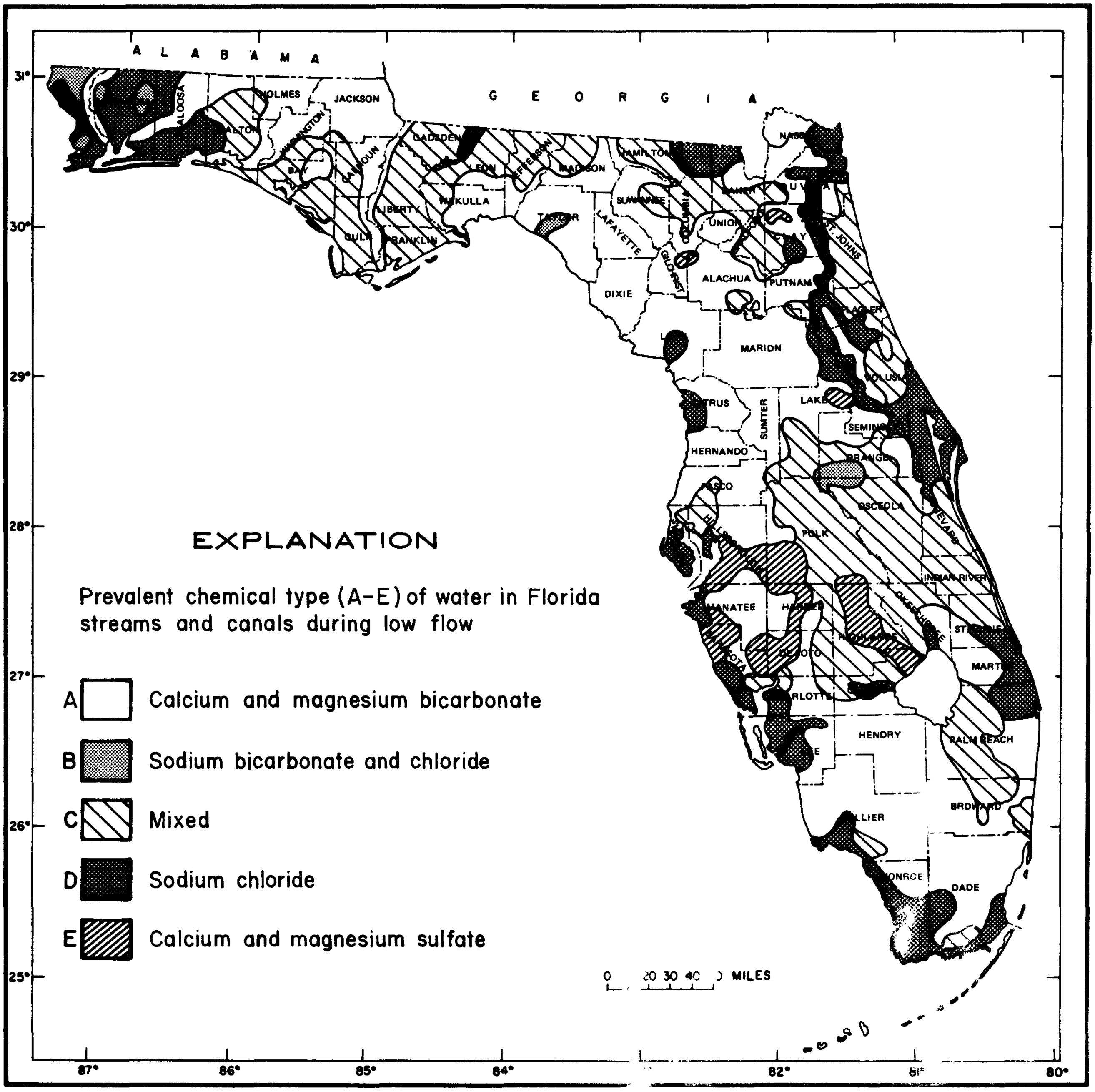


Figure 67.--Chemical types of water in Florida streams (modified from Kaufman, 1971).

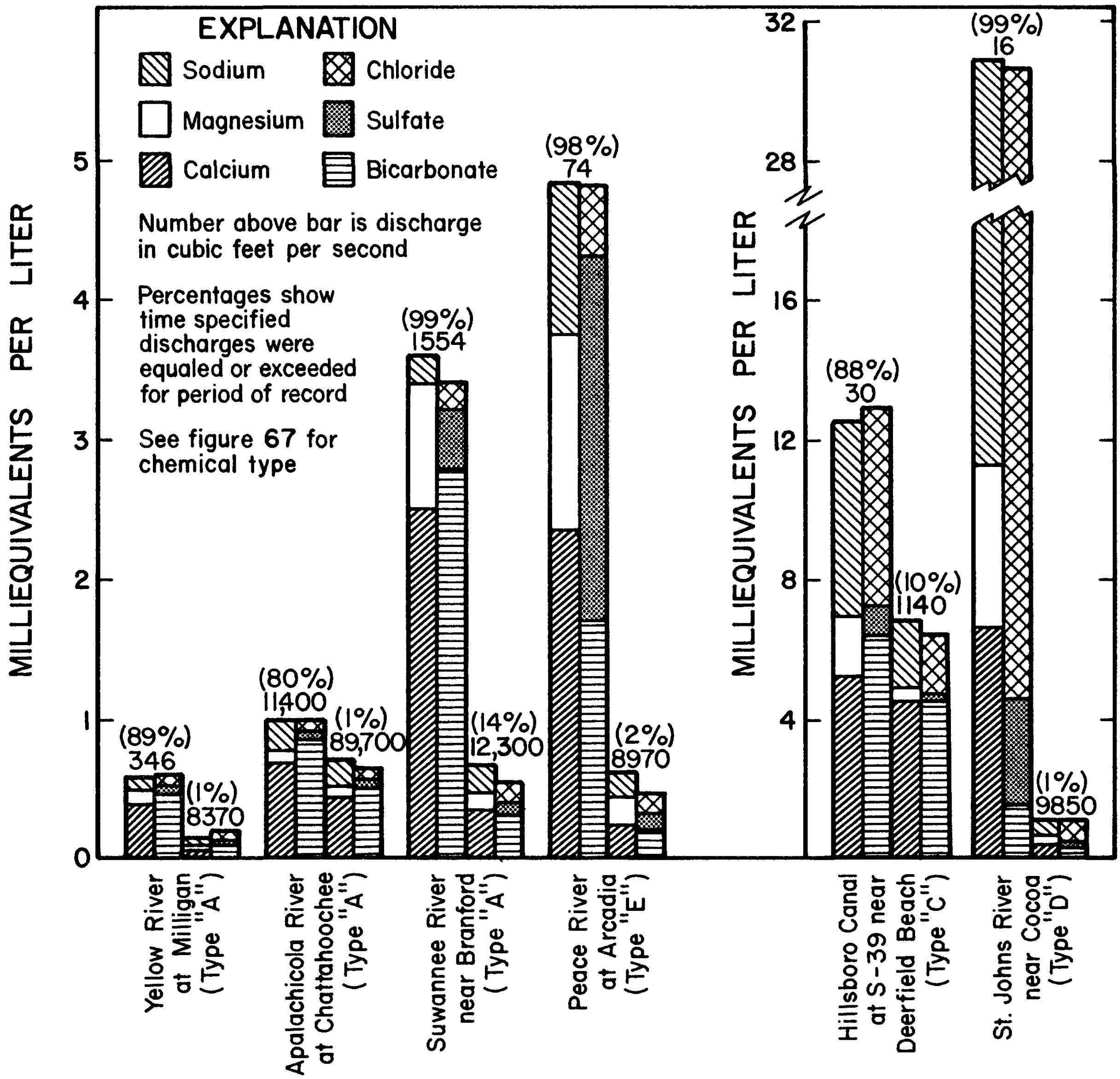


Figure 68.--Relations among chemical composition, constituent concentration, and discharge for six Florida streams and canals during low versus high streamflow (modified from Kaufman, 1971).

A knowledge of the occurrence of phosphorus in surface waters, from natural sources as well as sources influenced by man, is essential to the understanding and management of the quality aspects of Florida's surface-water resources. Figure 69 (Kaufman, 1969a) outlines the generalized distributions and concentrations of orthophosphate. Table 31 lists orthophosphate concentrations and loads of selected streams and springs in the State.

Phosphates are one of the end products of decomposition of organic matter and, in addition, may be derived from leaching of naturally occurring phosphatic minerals such as fluorapatite ($Ca_5(PO_4)_3F$), an important constituent of phosphatic sediments in Florida. Phosphates are contributed to water in significant quantities from several manmade and natural sources, including: (1) industrial wastes; (2) water-treatment plant effluent (human and other wastes); (3) agricultural drainage, including farm-animal wastes and fertilizers; (4) urban drainage, including municipal water-treatment discharges; (5) drainage from natural phosphatic terranes; (6) rural runoff; and (7) rainfall. Evaluation of the various sources of phosphorus suggests that the greatest contribution of phosphorus to water is directly or indirectly a result of the activities of man (Task Group 2610P Report, 1967).

The concentration of dissolved solids is a measure of the amount of inorganic and organic material in solution and, therefore, is one of the most common and useful measurements of water quality. Dissolved-solids data have been analyzed to evaluate their areal distribution and to compute the loads transported by rivers, canals, and springs in the State. Dysart and Goolsby (1977) mapped the dissolved-solids concentrations and loads in Florida surface waters (fig. 70) which consist mainly of bicarbonate, chloride, and sulfate of calcium, magnesium, sodium, and, in lesser amounts, potassium.

Dissolved solids load, discharge, concentrations, and annual load per square mile of drainage area for 20 selected rivers, canals, and springs in Florida determined at gaging stations, are given in table 32. Load is a function of discharge and dissolved-solids concentration and changes in either are reflected in load calculation. The St. Johns River transports the greatest load of dissolved solids in Florida. The concentration is more than 10 times that of the Apalachicola River even though the discharge is only about one-eighth that of the Apalachicola.

Rates of dissolution of basins of different size show that dissolution ranges from about 60 to 140 tons per square mile per year for representative rivers and canals in Florida. The St. Johns River is atypical--the 4-to 10-fold larger yields are probably due to the dissolved-solids contributions of Silver Springs and to leakage to the river of highly mineralized water from the aquifers underlying the basin (Dysart and Goolsby, 1977).

Annual loads carried by springs are given in table 32 for those that contribute substantially to rivers. Of such springs, Blue Springs adds about 135,000 tons to the annual load of the St. Johns River, Silver Springs about 210,000 tons to the Oklawaha River, Ichatucknee Springs about 140,000 tons to the Suwannee River, and Wakulla Springs about 60,000 tons to the St. Marks River.

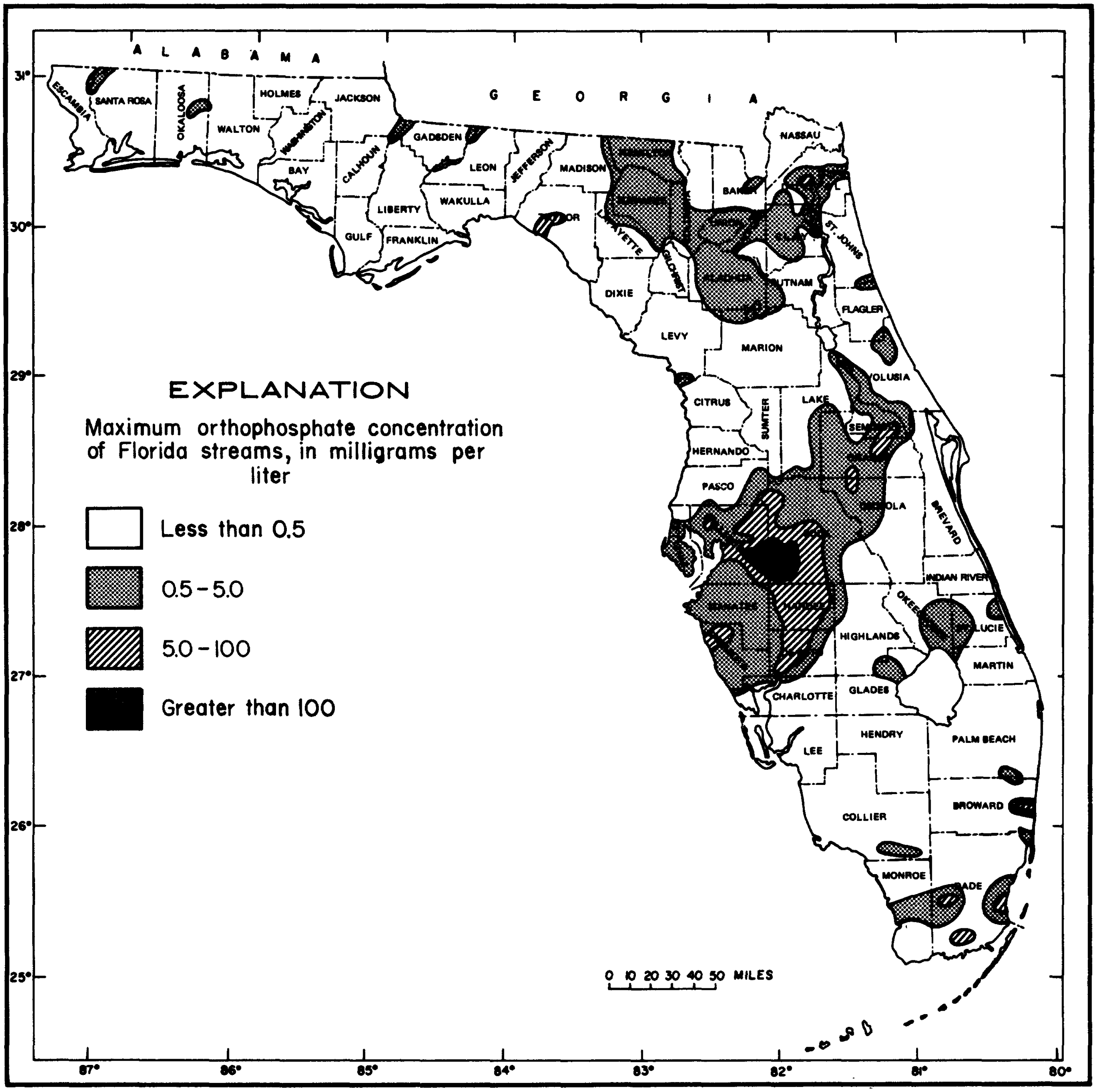


Figure 69.--Generalized distribution and concentration of orthophosphate in Florida streams (modified from Kaufman, 1971).

Table 31.--Orthophosphate concentrations and loads of selected streams and springs

[Modified from Kaufman, 1969a]

Stream/Spring county	Drainage area (mi^2)	Principal source	Date	Discharge (Mgal/d)	Orthophosphate as PO_4 concentration (mg/L)	Orthophosphate as PO_4 load			
						lbs./day	lbs./day/mi^2	lbs./yr/mi^2	tons/yr
Alafia R. at Lithia, Hillsborough County.	335	Ind. waste	1957-58	[1]268	57	127,800	382	141,020	23,600
Peace R. at Arcadia, De Soto County.	1,367	Ind. waste	1964-65	[1]545	[1]6.8	31,000	22	8,277	5,600
Fenholloway R. at Foley, Taylor County.	110	Ind. waste	5/16/66	89	46	34,200	312	113,482	6,250
Econlockhatchee R. nr Chuluota, Seminole County.	241	Sewage effluent	5/9/66	65	7.7	4,200	18	6,570	800
New R. nr Lake Butler, Union and Bradford Counties.	212	Agric. drainage	5/10/66	1,143	0.36	3,400	16	5,854	600
Manatee R. nr Bradenton, Manatee County.	80	Natural PO_4 terrane.	1964-65	[1]72	[1]1.4	840	10	3,760	150
Yellow R. nr Holt, Okaloosa County.	1,210	Natural, non-PO_4 terrane.	6/2/66	995	0.08	660	<2	200	100
Withlacoochee R. nr Holder, Citrus and Marion County.	1,710	Natural, non-PO_4 terrane.	5/26/66	614	0.06	300	<2	64	50
Blue Spr nr Orange City, Volusia County.	--	Floridan aquifer	5/26/66	101	0.39	320	--	--	50
Silver Spr nr Ocala, Marion County.	730	Floridan aquifer	5/11/67	552	0.13	600	<1	300	100
Lithia Spr nr Lithia, Hillsborough County.	--	Floridan aquifer	5/18/67	13	0.13	20	--	--	4
Wakulla Spr nr Crawfordville, Wakulla County.	--	Floridan aquifer	5/19/66	245	0.07	140	--	--	25

[1] Time weighted average.

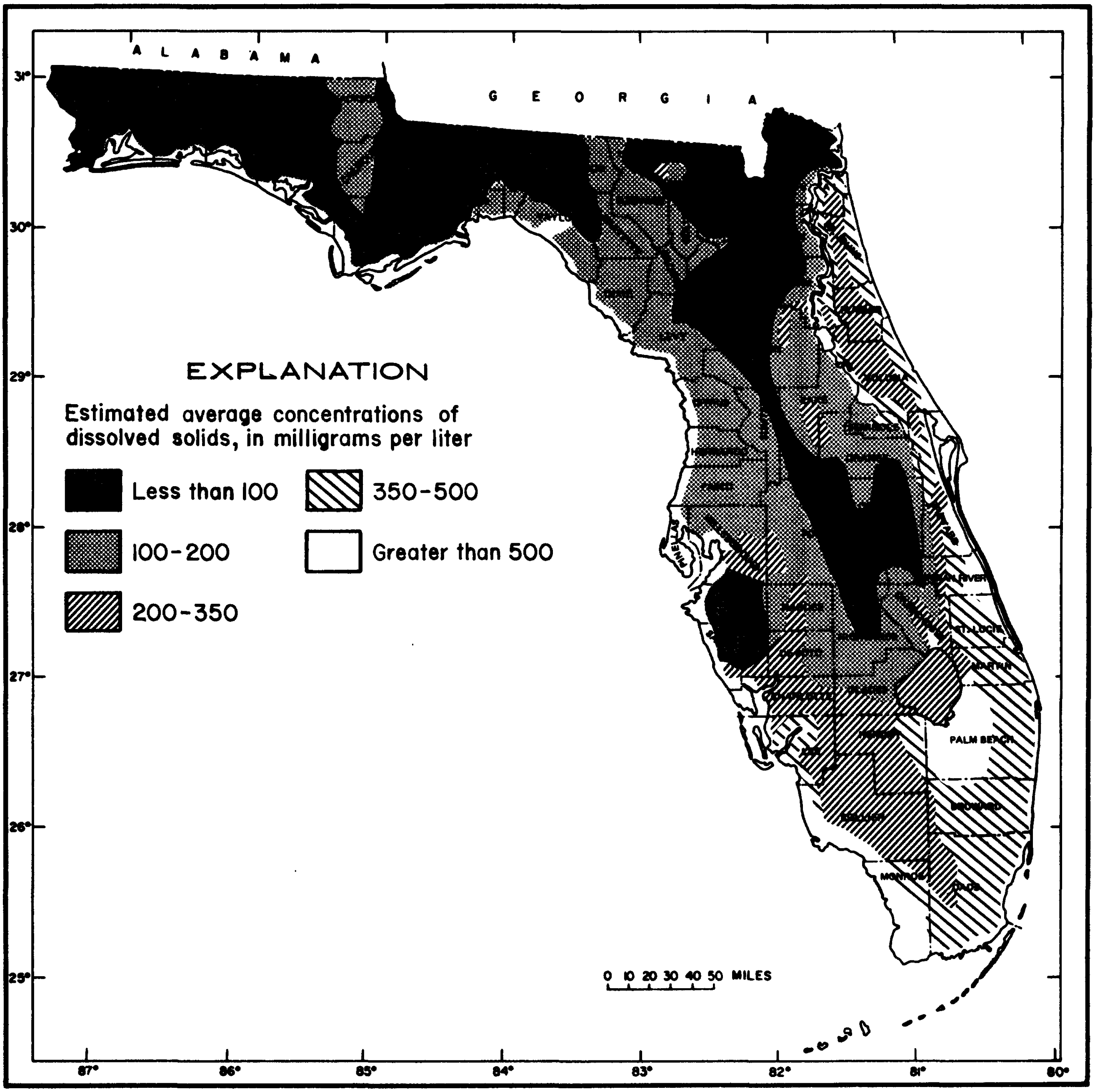


Figure 70.--Dissolved-solids concentrations in Florida surface waters (modified from Dysart and Goolsby, 1977).

Table 32.--Dissolved-solids concentrations and loads for selected rivers, canals, and springs in Florida

[Modified from Dysart and Goolsby, 1977]

Station	County(ies)	Average load, tons per year	Average discharge (Mgal/d)	Average concentration (mg/L)	Yield tons per square mile per year[1]
St. Johns River near De Land.	Lake and Volusia.	1,900,000	2,075	643	614 (583)
Apalachicola River at Chattahoochee.	Gadsden and Jacksonville.	1,200,000	14,277	58	70 (64)
Suwannee River at Branford.	Layfayette and Suwannee.	980,000	4,470	161	126
St. Lucie Canal near Stuart.	Martin	470,000	714	439	Indeterminate.
Escambia River near Century.	Escambia and Santa Rosa.	370,000	3,897	66	96 (104)
Choctawhatchee River at Caryville.	Holmes and Washington.	270,000	3,442	54	76
Silver Springs near Ocala.	Marion	210,000	530	263	288
Withlacoochee River near Holder.	Citrus and Marion.	190,000	740	181	104
Peace River at Arcadia.	De Soto	190,000	783	208	138
Homosassa Springs at Homosassa Springs.	Citrus	175,000	[2]68	1,490	--
Kissimmee River near Okeechobee.	Okeechobee	150,000	1,413	92	[3]50
Ichetucknee Springs near Hildreth.	Columbia	140,000	233	175	--
Blue Springs near Orange City.	Volusia	135,000	105	827	--
Withlacoochee River near Pinetta.	Hamilton and Madison.	130,000	1,063	139	61
Rainbow Springs near Dunnellon.	Marion	80,000	493	91	--
Wakulla Springs near Crawfordville.	Wakulla	60,000	252	158	--
Tamiami Canal near Miami.	Dade	50,000	163	238	Indeterminate.
St. Marys River near Macclenny.	Baker and Charlton.	40,000	445	69	64
Weeki Wachee Springs near Brooksville.	Hernando	30,000	114	169	--
Myakka River near Sarasota.	Sarasota	20,000	168	93	93

[1] Data in parentheses computed from Liefeste (1974).
[2] Computed discharge for main springs only.
[3] Approximate, based on 2,900 square mile drainage area, including Lake Istokpoga drainage.

The primary coastal canals are the main conduits for dissolved-solids discharge for south Florida. The total load discharged by the canals to the ocean and the gulf is estimated to be 2.2 million tons per year or 17 percent of the statewide annual load. The St. Lucie Canal of Martin County and the Caloosahatchee River in Lee County discharge about 470,000 and 550,000 tons respectively. The Caloosahatchee River is a controlled river and its drainage area has been extensively modified. In this report, the Caloosahatchee River is considered to be a canal.

The average annual load, computed by Dysart and Goolsby (1977), that discharges into the Atlantic Ocean and Gulf of Mexico is about 13 million tons; of this, 7 million tons are discharged to the ocean and 6 million tons to the gulf. The bulk of the total load (43 percent) is discharged by the St. Johns River (5.6 million tons). The Apalachicola River's average annual load is 1.6 million tons, about 12 percent, and the Suwannee River's is 1.4 million tons, about 11 percent. The combined annual load of all other rivers discharging from Florida of 2.2 million tons, represents 17 percent. The balance of the annual load to the ocean and the gulf, (2.2 million tons; 17 percent) is by the canals in south Florida.

Ground-Water Quality

The chemical quality of ground water in Florida ranges widely depending upon location, aquifer, and depth at which the water is obtained. Ground-water quality ranges from fresh, less than 1,000 mg/L dissolved solids, to brine, more than 35,000 mg/L at depth. The best quality of ground water in terms of dissolved solids and hardness is in the sand-and-gravel aquifer in northwest Florida where dissolved solids average only 42 milligrams per liter (mg/L) and hardness averages 10 mg/L. Water in the deeper part of the Floridan aquifer in the so-called "boulder zone" at depths ranging from 2,600 to 4,300 feet in the coastal areas of southeast Florida has a composition equivalent to seawater (Kaufman, 1973).

The quality of waters in the aquifer systems in Florida is represented, in general, by the quality of raw (untreated) ground waters used for public supplies. Table 33 summarizes, by aquifers, the quality of raw waters used for selected public supplies in August-September 1976. The information is based on statewide sampling. The median and range of constituents are based on 69 samples of water from the Floridan aquifer, 12 samples from the Biscayne aquifer, 2 samples from the sand-and-gravel aquifer, 15 samples from the shallow aquifer, and 4 samples from aquifers in the Hawthorn and Tampa Formations in south and south-coastal Florida. Table 34 summarizes the trace element analyses of the same supplies (Irwin and Healy, 1978).

The Floridan aquifer is the principal source of ground water in Florida. Accordingly, much information on the quality of water in the Floridan has been obtained and is depicted in areal maps. Figure 71 depicts the areal variation in chloride in water from the upper part of the aquifer. The Floridan aquifer contains water high in chloride in the southern part of the State and along most of the east coast. In most of the remainder of the State, chloride concentration in water from the upper part of the Floridan aquifer is less than 50 mg/L.

Table 33.--Summary of chemical and physical analyses of ground water by aquifers in Florida, based on raw waters used for selected public supplies, August-September 1976

[Modified from Irwin and Healy, 1978]

Chemical constituent or physical property	Dissolved concentrations in milligrams per liter, except as indicated									
	Floridan aquifer		Biscayne aquifer		Sand-and-gravel		Shallow aquifer		Hawthorn and Tampa[1]	
	Median	Range	Median	Range	Median[2]	Range	Median	Range	Median	Range
Silica (SiO_2)	12	4.1-33	7.0	3.1-9.1	7.2	6.4-8.0	12	5.4-50	38	23-54
Calcium (Ca)	47	6.2-120	96	82-100	1.6	.8-2.5	110	61-280	61	47-120
Magnesium (Mg)	9.0	1.5-68	3.1	1.7-8.0	1.2	.5-2.0	5.8	2.2-22	34	24-56
Sodium (Na)	6.7	2.6-80	18	11-47	5.2	2.3-8.2	33	9.6-120	42	15-61
Potassium (K)	1.1	.2-8.4	1.8	1.3-5.9	.4	.4-0.5	1.6	.8-8.6	3.6	2.2-11
Strontium (Sr)	.29	.00-32	.82	.65-1.2	.07	.03-0.10	.74	.23-2.2	11	1.2-20
Bicarbonate (HCO_3)	164	54-380	278	215-304	2	2	316	168-373	278	248-360
Sulfate (SO_4)	8.6	.0-310	26	14-65	1.6	1.2-2.0	34	4.2-370	25	13-360
Chloride (Cl)	9.3	2.7-190	31	16-82	6.4	2.7-10	55	19-190	69	21-170
Fluoride (Fl)	.2	.1-1.2	.2	.2-0.3	.0	.0	.2	.1-0.7	1.3	1.0-2.3
Nitrate (NO_3-N)	.01	.00-3.7	.01	.00-0.43	2.1	.50-3.6	.00	.00-0.47	.01	.00-0.28
Dissolved-solids (residue at 180°C)	220	86-745	358	262-444	42	25-58	470	228-1,350	478	372-766
Hardness as $CaCO_3$ (Ca, Mg)	160	35-490	260	210-270	10	4-15	290	160-770	290	250-550
Noncarbonate hardness as $CaCO_3$	9	0-300	25	14-84	8	2-13	34	0-410	72	22-400
Percent sodium	9	2-80	14	10-27	53	52-54	20	3-37	26	6-31
Alkalinity as $CaCO_3$	135	44-312	232	176-249	2	2	262	138-300	213	157-233
Specific conductance (micromhos/cm at 25°C)	300	114-1,130	592	470-760	46	20-71	738	465-1,820	835	596-1,010
pH (units)	7.3	7.0-8.0	7.4	7.2-7.7	-	5.1	7.3	7.1-7.7	7.6	7.6
Temperature (°C)	24.0	21.5-28.0	26	25.5-29.1	23.5	23.5	25.5	23.0-28.0	25.5	25.0-26.0
Color (Pt-Co units)	5	0-30	30	5-80	5	5	30	5-100	5	0-10
Turbidity (NTU)	1	0-10	2	1-5	1	1	1	1-2	1	1

1 South and south-coastal Florida.
2 Mean of two samples.

Table 34.--Summary of trace element analyses of ground water by aquifers in Florida, based on raw waters used for selected public supplies, August-September 1976

[Modified from Irwin and Healy, 1978]

Chemical constituent or physical property	Total concentrations in micrograms per liter, except as indicated									
	Floridan aquifer		Biscayne aquifer		Sand-and-gravel		Shallow aquifer		Hawthorn and Tampa[1]	
	Median	Range	Median	Range	Median[2]	Range	Median	Range	Median	Range
Arsenic (As)	0	0-15	1	0-4	0	0	0	0-7	0	0
Barium (Ba)	0	0-200	0	0-100	0	0	0	0-100	0	0-100
Cadmium (Cd)	1	0-4	1	0-7	2	0-14	0	0-3	0	0-1
Chromium (Cr)	20	<10-50	10	<10-20	([3])	<10-10	10	<10-40	20	10-30
Lead (Pb)	7	0-30	12	4-45	11	8-14	7	2-42	1	0-5
Mercury (Hg)	.0	.0-0.9	.1	.0-0.2	.2	.1-0.2	.2	.0-0.3	.2	.1-0.3
Selenium (Se)	0	0-1	0	0	0	0	0	0-1	0	0
Silver (Ag)	0	0-1	0	0-7	0	0	0	0-9	0	0

[1] South and south-coastal Florida.
[2] Mean of two samples.
[3] Some concentrations below the analytical detection limit.

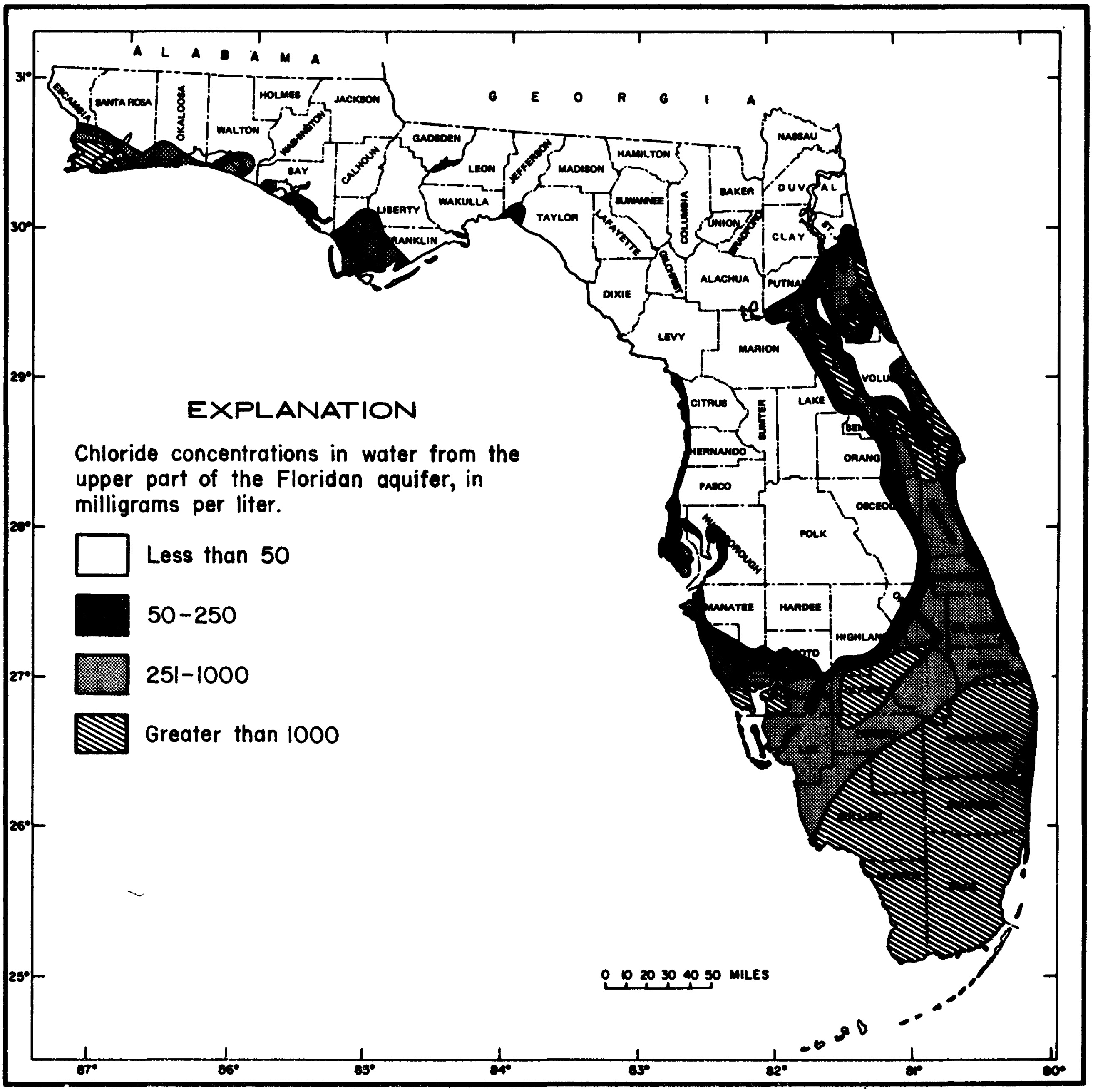


Figure 71.--Chloride concentrations in water from the upper part of the Floridan aquifer in Florida (modified from Shampine, 1965a).

At depth, ground water high in chloride can be found everywhere in the State. In the center of Florida, as shown in figure 72, freshwater may extend downward 2,000 feet in the center of the peninsula but may not be any deeper than 200 feet along the coast.

Sulfate concentrations in water from the upper part of the Floridan aquifer in the State are shown in figure 73. Sulfate concentrations throughout most of the State are less than 50 mg/L. In the southern part of Florida, the sulfate concentration generally exceeds 100 mg/L and is as much as 1,700 in some cases--tending to be higher in the deeper zones of the aquifer.

In Florida, the hardness of water refers mostly to carbonate hardness. The upper part of the Floridan aquifer yields water with hardness of less than 180 mg/L in the northwestern part and in much of the center of Florida (Shampine, 1965c). For most of the remainder of the State, the aquifer yields water having hardness greater than 180 mg/L (fig. 74) and in some cases as much as 1,900 mg/L.

The predominant dissolved constituents in water from the upper part of the Floridan aquifer are calcium carbonate, sodium carbonate, sodium chloride, and calcium and magnesium sulfate. In most of the State where the Floridan is the principal source of water, calcium and bicarbonate are the predominant constituents in the water. In the southern part of Florida, calcium, magnesium, and sulfate predominate (fig. 75).

In the northwestern part and throughout much of the center of the State, the upper part of the Floridan aquifer yields water containing less than 250 mg/L of dissolved solids (fig. 76). In the southern part and along most of the east coast of Florida, dissolved solids in the ground water exceed 1,000 mg/L and are as high as 23,000 mg/L.

WATER FOR PUBLIC SUPPLY

In 1975, information on water use for public supply in Florida was collected as part of a periodic 5-year national and statewide survey of water use by the U.S. Geological Survey. The information was collected by the U.S. Geological Survey and the five Water Management Districts. The inventory was made by personal contact with water-plant superintendents, water managers, and city officials. Water-use information was obtained for (1) all cities whose population in 1972 was 5,000 or more, (2) all municipalities and communities whose populations in 1975 were generally less than 5,000, and (3) all county seats. Also included was information for three large unincorporated communities having an aggregate population served of 16,300 and three municipalities that use water for public supply derived partly or wholly from some type of desalination process. Public-supply records were included for selected municipalities for 1945, 1947, 1956, 1965, and 1970-74 (Healy, 1977).

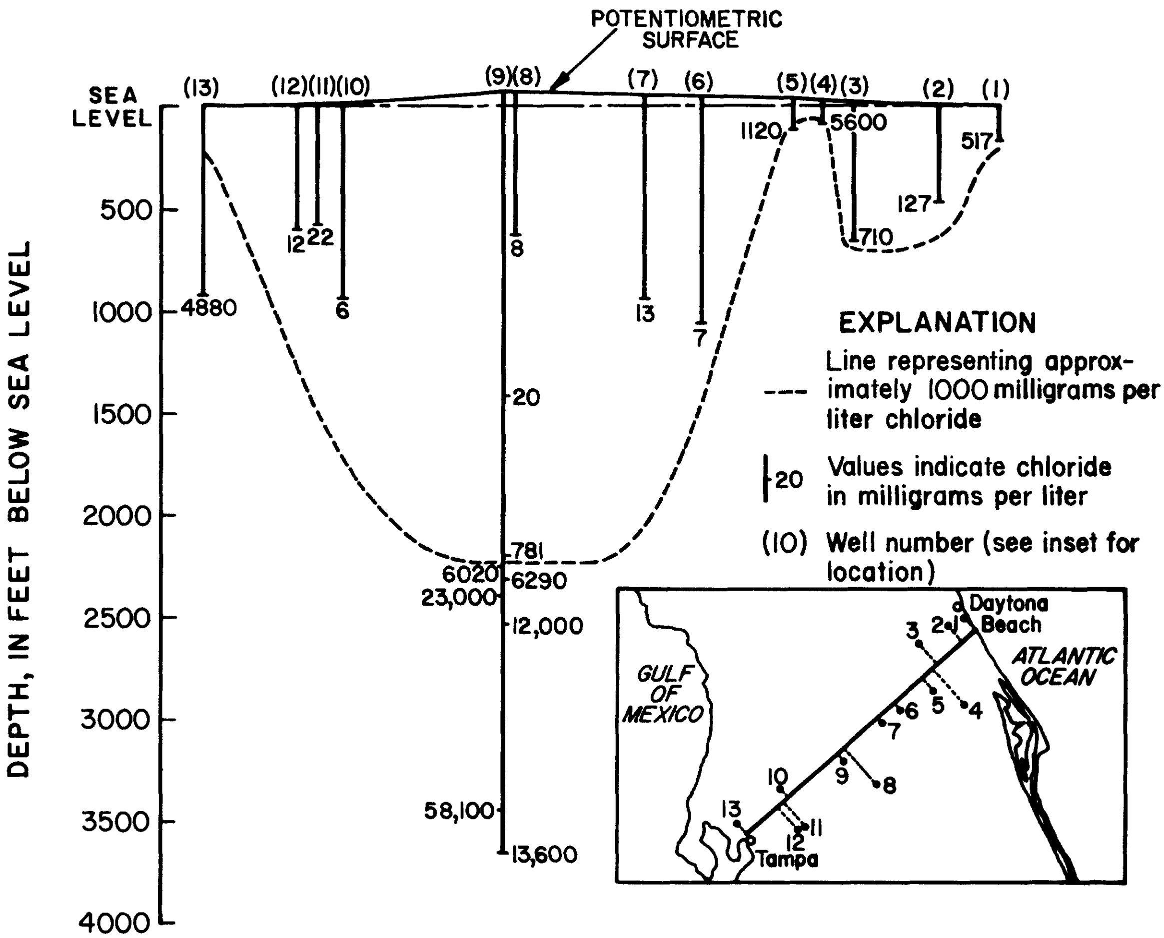


Figure 72.--Vertical distribution of chloride concentrations of water in wells across central Florida (modified from Shampine, 1965a).

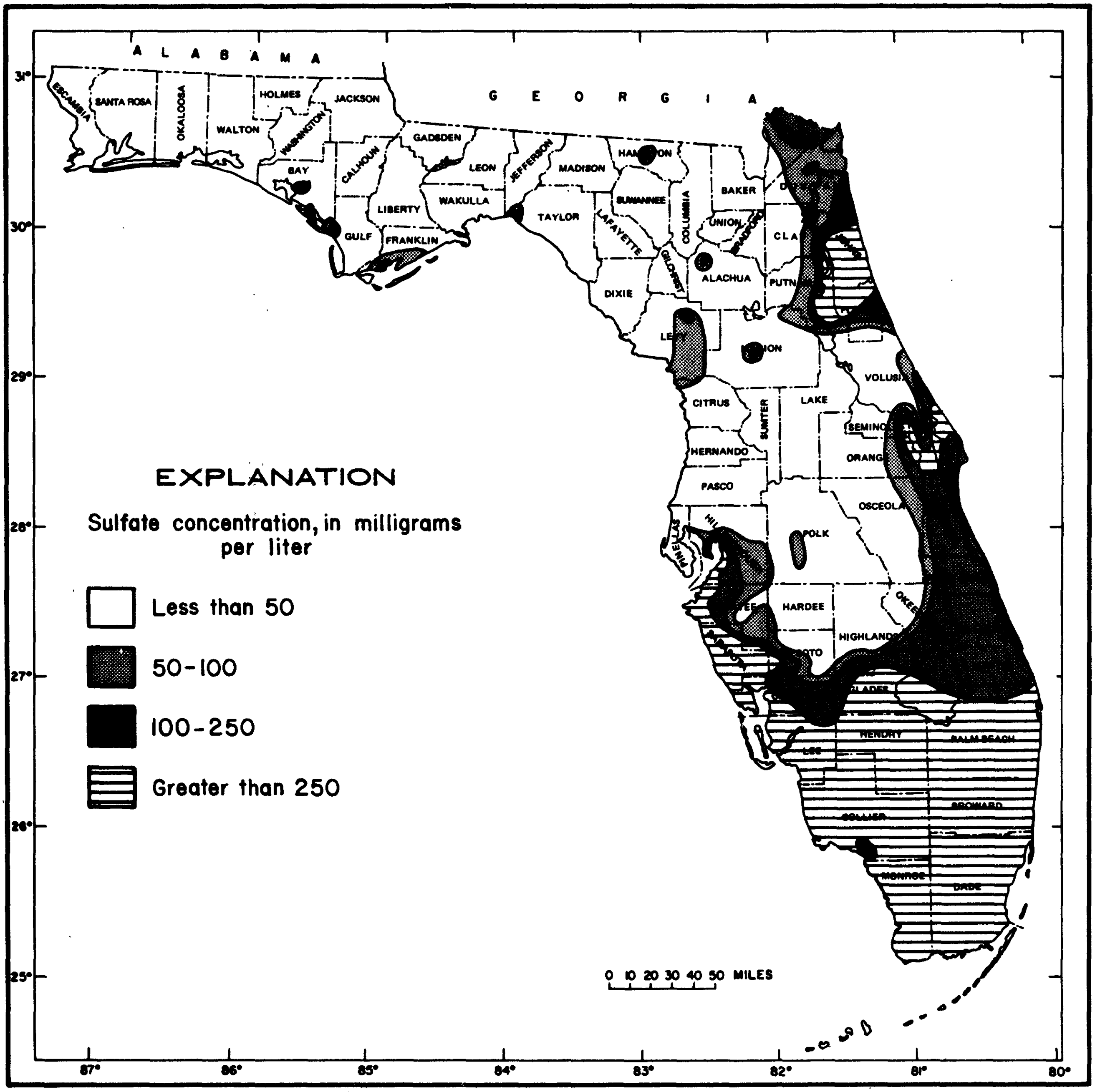


Figure 73.--Sulfate concentrations in water from the upper part of the Floridan aquifer in Florida (modified from Shampine, 1965e).

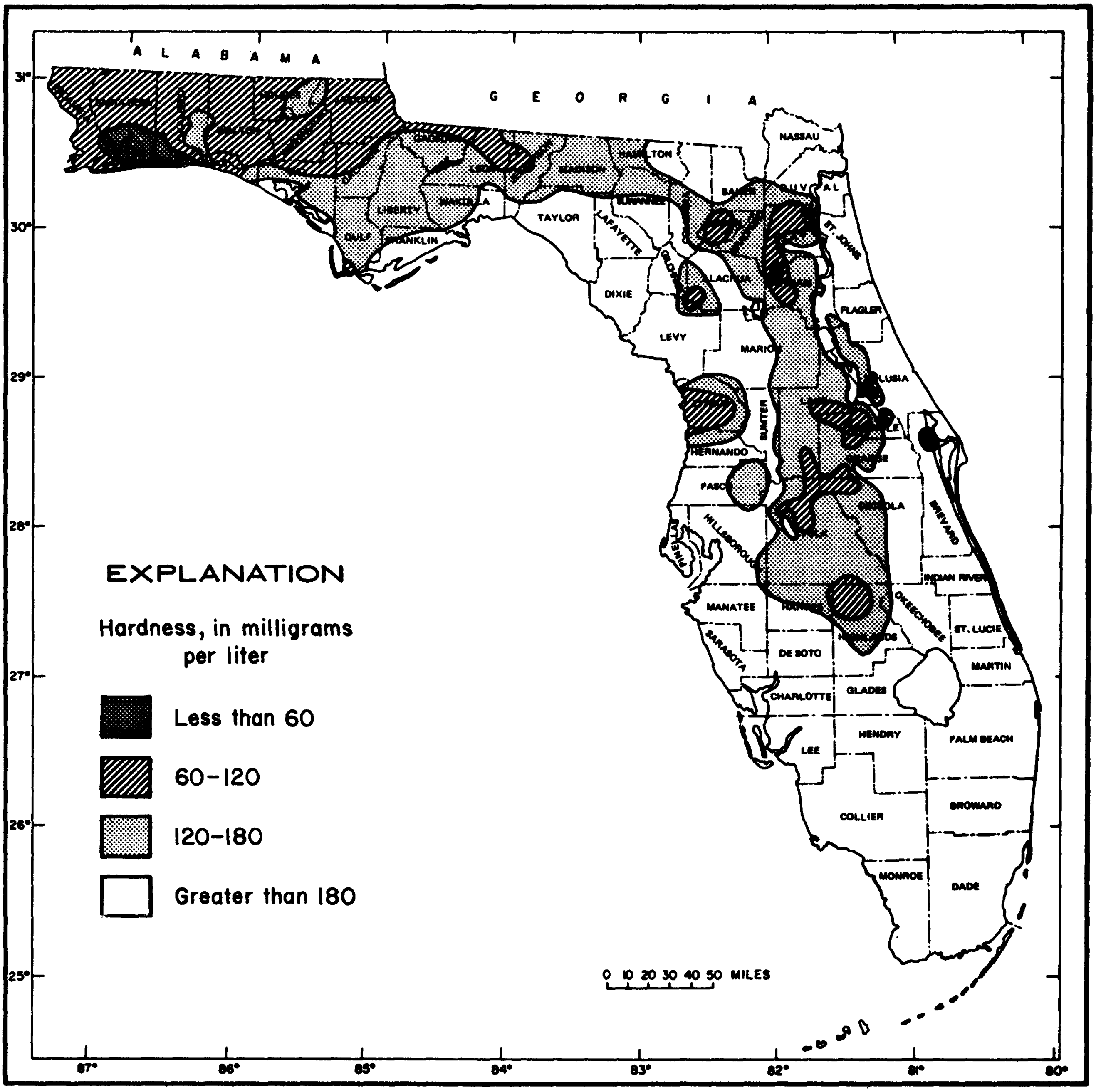


Figure 74.--Hardness of water from the upper part of the Floridan aquifer in Florida (modified from Shampine, 1965c).

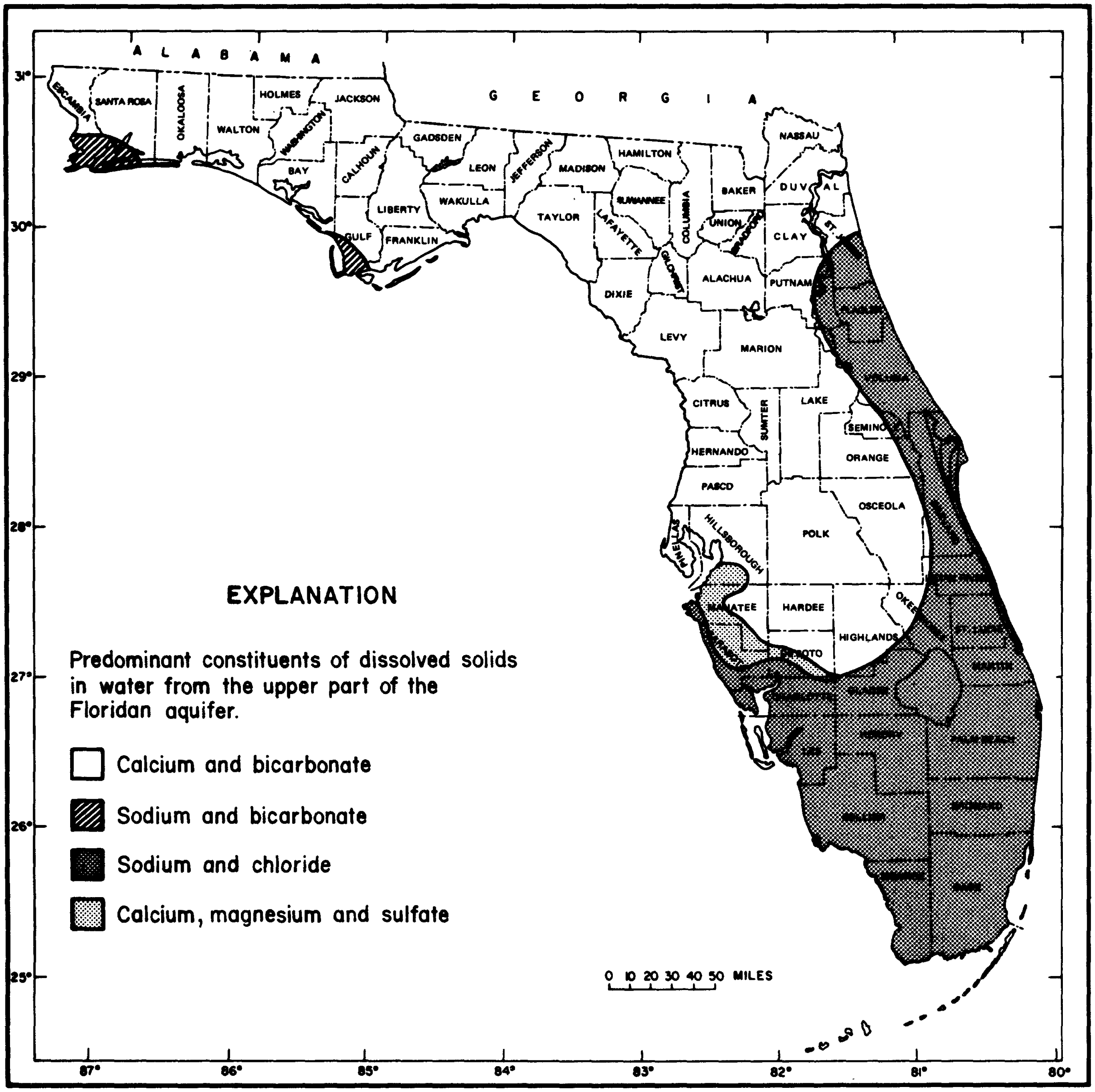


Figure 75.--Predominant constituents of dissolved solids in water from the upper part of the Floridan aquifer in Florida (modified from Shampine, 1965b).

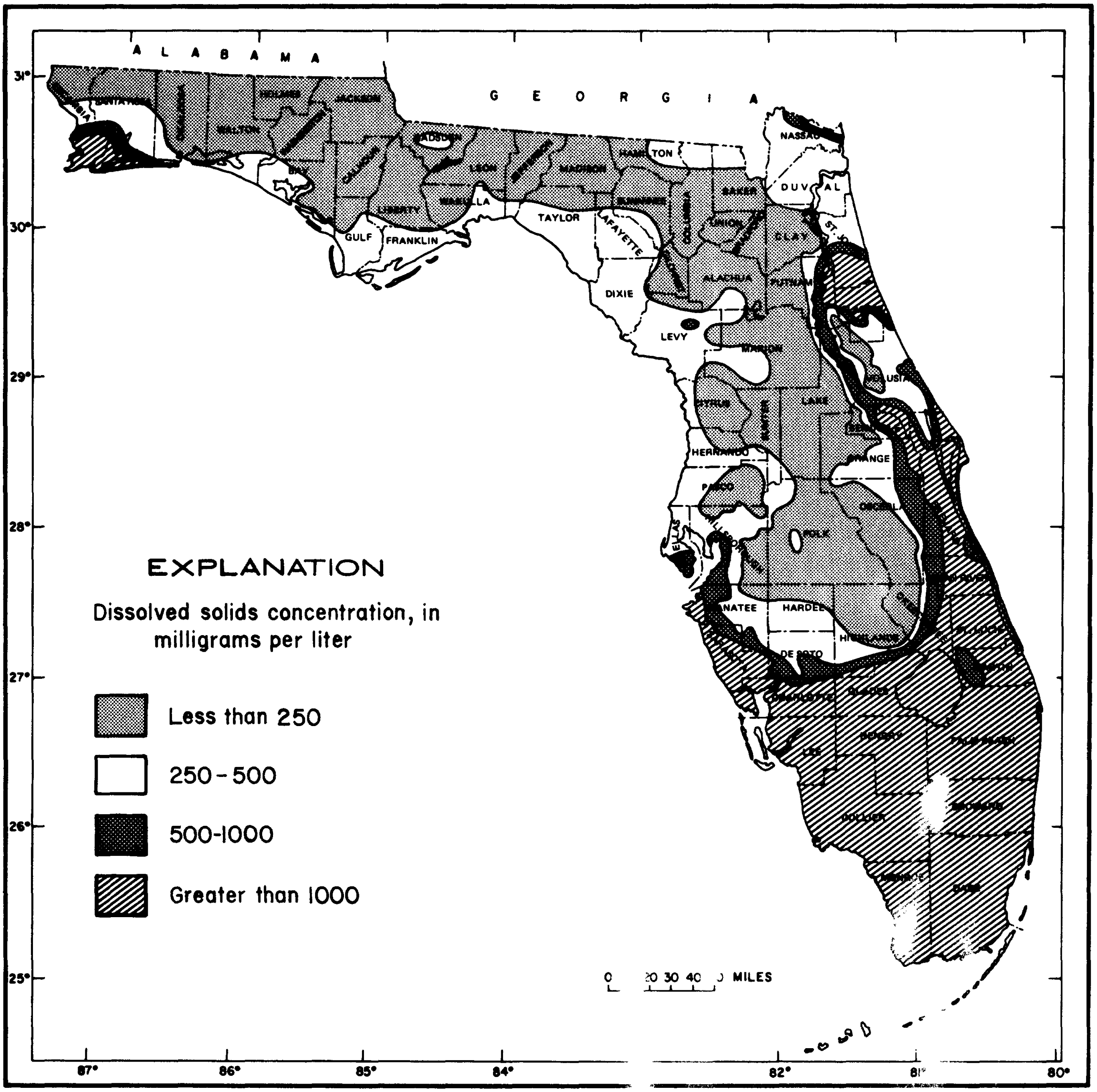


Figure 76.--Dissolved solids in water from the upper part of the Floridan aquifer in Florida (modified from Shampine, 1965b).

The data for public-supply systems in 1975 were furnished by water department officials. Most utility systems maintain adequate records of water pumped from the source or delivered to customers. Some of the smaller utility companies do not maintain pumpage records. For these systems the amount of water used during 1975 was estimated on the basis of the number of customers served. In all, water-use information was obtained from 710 county, municipal, and private utilities systems of which the largest was Miami-Dade Water and Sewer Authority serving more than 1.21 million people, and the smallest were private systems that serve fewer than 100 people. The total public supply water use for each county is shown in table 35 and figure 77. The per capita use in some counties, such as Bay and Nassau, is high because water for industrial use supplied from a municipal source is included in the total municipal pumpage.

A municipal water supply or a water utility that serves the public is classed as a "public supply." If public supply either is not available to individual families and small communities or if available but not used by them, the water used is classed as self-supplied and categorized as "rural" or "rural supply," regardless of whether the users live within the city limits.

Source of Water

Ground water is the predominant source for public supply in Florida. In 1975, 985 Mgal/d of ground water, 86 percent of a total of 1,146 Mgal/d, was withdrawn for public supply. The remaining 14 percent, 161 Mgal/d was surface water, from lakes, streams, and reservoirs.

Of the surface water used for public supply in 1975, 53 percent was from rivers, 27 percent was from lakes, and 20 percent was from reservoirs (table 38). The largest source of surface water for public supply is the Hillsborough River which furnishes water for Tampa (table 36). Surface water is the sole source for public supply in two counties, Manatee and Okeechobee (table 35). In 1975, 22 municipalities derived all or part of their water supply from surface-water sources. Eighteen of the municipalities were supplied entirely from surface-water sources and four were supplied from both surface and ground-water sources (table 36). Of the four supplied by both, the surface-water supply ranged from 16 percent of total supply (Panama City Beach) to 92 percent of total supply (Port Charlotte).

Ground water for public supplies in Florida is derived from three principal aquifers. These are, in order of total use, with percentage of ground water supplied, in 1975: (1) the Biscayne aquifer, 45 percent; (2) the Floridan aquifer, 43 percent; and (3) the sand-and-gravel aquifer, 3 percent. The remaining 9 percent is derived from other aquifers (table 38 and fig. 78).

Table 35.--Public supply water use in Florida by counties, 1975

[Modified from Leach, 1978b]

County	Population (thousands) Total	Population (thousands) Municipal	Population (thousands) Rural	Population served (thousands) Ground water	Population served (thousands) Surface water	Population served (thousands) All water	Water withdrawn (Mgal/d) Ground water	Water withdrawn (Mgal/d) Surface water	Water withdrawn (Mgal/d) Total	Per capita (gal/d)	Water delivered (Mgal/d) by uses Public supply	Agric-ulture	Indu-stry	Comm-ercial	Air cndtng	Water consumed (Mgal/d)
Alachua	130.8	86.3	44.5	90.7	0.0	90.7	14.90	0.0	14.90	164	14.90	0.0	0.0	0.0	0.0	5.82
Baker	12.3	4.0	8.3	4.1	0.0	4.1	0.54	0.0	0.54	132	0.46	0.0	0.0	0.08	0.0	0.49
Bay	91.6	65.3	26.3	17.7	65.0	82.7	1.95	32.59	34.54	418	7.84	0.0	25.56	1.14	0.0	12.49
Bradford	16.3	6.7	9.6	8.3	0.0	8.3	0.83	0.0	0.83	100	0.67	0.0	0.0	0.16	0.0	0.0
Brevard	252.0	157.1	94.9	134.9	90.0	224.9	[1]18.22	8.90	[1]27.12	121	27.12	0.0	0.0	0.0	0.0	8.85
Broward	876.3	730.8	145.5	812.0	0.0	812.0	139.78	0.0	139.78	172	102.66	20.71	5.12	8.70	2.58	80.91
Calhoun	8.3	3.0	5.3	3.0	0.0	3.0	0.28	0.0	0.28	93	0.21	0.0	0.0	0.07	0.0	0.05
Charlotte	42.2	6.1	36.1	1.7	30.3	32.0	0.18	3.90	4.08	128	3.63	0.0	0.0	0.45	0.0	2.15
Citrus	35.3	5.7	29.6	5.5	0.0	5.5	0.59	0.0	0.59	107	0.40	0.0	0.0	0.19	0.0	0.14
Clay	47.7	16.7	31.0	29.7	0.0	29.7	5.01	0.0	5.01	169	4.65	0.0	0.06	0.22	0.08	0.81
Collier	62.7	17.7	45.0	52.4	0.0	52.4	11.93	0.0	11.93	228	9.35	2.28	0.10	0.10	0.10	7.43
Columbia	28.8	11.5	17.3	15.9	0.0	15.9	1.70	0.0	1.70	107	1.04	0.0	0.17	0.41	0.08	0.67
Dade	[2]1,638.0	803.5	834.5	1,546.4	0.0	1,546.4	[3]264.55	0.0	[3]264.55	171	221.28	0.0	12.44	20.96	9.87	155.89
DeSoto	18.2	6.1	12.1	7.0	0.0	7.0	0.76	0.0	0.76	109	0.68	0.0	0.05	0.03	0.0	0.38
Dixie	6.6	2.5	4.1	3.8	0.0	3.8	0.42	0.0	0.42	111	0.40	0.0	0.0	0.02	0.0	0.07
Duval	578.3	578.3	0.0	523.7	0.0	523.7	95.42	0.0	95.42	182	69.46	0.0	7.54	13.20	5.22	29.90
Escambia	224.9	67.2	157.7	192.1	0.0	192.1	27.80	0.0	27.80	145	19.43	0.06	0.0	8.31	0.0	5.51
Flagler	6.6	3.5	3.1	6.0	0.0	6.0	0.62	0.0	0.62	103	0.62	0.0	0.0	0.0	0.0	0.26
Franklin	7.9	4.3	3.6	6.7	0.0	6.7	0.99	0.0	0.99	148	0.72	0.0	0.06	0.22	0.0	0.69
Gadsden	39.1	18.6	20.5	8.5	10.9	19.4	0.96	1.18	2.14	110	1.97	0.0	0.0	0.17	0.0	1.09
Gilchrist	5.1	1.7	3.4	1.5	0.0	1.5	0.38	0.0	0.38	253	0.38	0.0	0.0	0.0	0.0	0.09
Glades	5.1	1.2	3.9	1.2	0.0	1.2	0.20	0.0	0.20	167	0.18	0.0	0.0	0.02	0.0	0.04
Gulf	10.9	6.7	4.2	1.9	4.7	6.6	0.11	0.64	0.75	114	0.47	0.0	0.26	0.01	0.0	0.15
Hamilton	8.6	3.8	4.8	5.9	0.0	5.9	0.60	0.0	0.60	102	0.53	0.0	0.02	0.05	0.0	0.13
Hardee	18.5	7.0	11.5	6.9	0.0	6.9	1.20	0.0	1.20	174	1.20	0.0	0.0	0.0	0.0	0.20
Hendry	15.9	7.3	8.6	3.2	6.9	10.1	0.25	1.80	2.05	203	1.42	0.0	0.63	0.0	0.0	1.83
Hernando	28.5	4.8	23.7	5.0	0.0	5.0	0.75	0.0	0.75	150	0.75	0.0	0.0	0.0	0.0	0.19
Highlands	42.8	17.1	25.7	24.4	0.0	24.4	4.26	0.0	4.26	175	3.84	0.0	0.05	0.36	0.0	2.50
Hillsborough	605.6	318.6	287.0	53.6	350.0	403.6	[4]7.17	52.70	[4]59.87	148	55.14	0.0	3.61	0.80	0.32	8.55
Holmes	12.5	3.4	9.1	4.0	0.0	4.0	0.20	0.0	0.20	50	0.14	0.0	0.03	0.03	0.0	0.14
Indian River	46.3	18.1	28.2	18.6	0.0	18.6	4.49	0.0	4.49	241	3.81	0.0	0.28	0.40	0.0	1.79
Jackson	41.2	16.3	24.9	16.8	0.0	16.8	1.77	0.01	1.78	106	1.30	0.0	0.16	0.31	0.01	0.75
Jefferson	9.4	2.5	6.9	3.0	0.0	3.0	0.44	0.0	0.44	147	0.38	0.02	0.0	0.04	0.0	0.14
Lafayette	3.1	0.8	2.3	1.0	0.0	1.0	0.14	0.0	0.14	140	0.08	0.0	0.0	0.03	0.03	0.03
Lake	86.7	45.8	40.9	50.5	0.0	50.5	9.85	0.0	9.85	195	7.09	0.0	0.36	2.39	0.0	4.00
Lee	156.5	58.2	98.3	112.8	35.0	147.8	9.97	6.85	16.82	114	14.60	0.0	1.08	1.14	0.0	3.44
Leon	133.2	86.4	46.8	101.2	0.4	101.6	15.83	0.0	15.83	156	12.96	0.0	0.0	2.87	0.0	3.89
Levy	15.6	7.6	8.0	7.0	0.0	7.0	0.98	0.0	0.98	140	0.98	0.0	0.0	0.0	0.0	0.23
Liberty	3.9	0.7	3.2	1.5	0.0	1.5	0.09	0.0	0.09	60	0.07	0.01	0.0	0.01	0.0	0.02
Madison	14.4	5.4	9.0	7.0	0.0	7.0	1.09	0.0	1.09	156	0.74	0.0	0.30	0.05	0.0	0.67
Manatee	123.5	45.0	78.5	0.0	80.0	80.0	0.0	18.91	18.91	236	12.91	0.0	6.00	0.0	0.0	11.92
Marion	93.5	5.9	87.6	37.6	0.0	37.6	6.23	0.0	6.23	166	6.11	0.0	0.09	0.02	0.0	2.99
Martin	47.7	10.8	36.9	23.8	0.0	23.8	5.72	0.0	5.72	240	5.42	0.0	0.15	0.15	0.0	2.60
Monroe	55.7	30.3	25.4	43.5	12.2	55.7	[5]7.67	0.0	7.67	138	6.60	0.0	0.0	0.77	0.31	7.67
Nassau	29.1	10.3	18.8	5.8	0.0	5.8	2.40	0.0	2.40	414	1.24	0.18	0.70	0.27	0.0	0.61
Okaloosa	102.0	48.9	53.1	79.8	0.0	79.8	9.31	0.0	9.31	117	8.53	0.12	0.0	0.66	0.0	4.16
Okeechobee	17.0	4.2	12.8	0.0	8.2	8.2	0.0	1.04	1.04	127	0.94	0.0	0.0	0.10	0.0	0.42
Orange	424.6	174.6	250.0	339.1	0.0	339.1	[6]63.35	0.0	[6]63.35	187	58.97	0.0	2.19	2.19	0.0	30.07
Osceola	36.7	18.2	18.5	19.0	0.0	19.0	3.65	0.0	3.65	192	3.30	0.0	0.34	0.0	0.0	0.79
Palm Beach	477.8	337.8	140.0	282.2	109.7	391.9	62.98	31.43	94.41	241	74.93	0.0	6.61	6.73	6.14	43.51
Pasco	130.2	20.6	109.6	26.3	0.0	26.3	[7]2.96	0.0	[7]2.96	113	2.85	0.0	0.0	0.10	0.0	1.73
Pinellas	666.6	500.4	166.2	604.6	0.0	604.6	[8]76.97	0.0	[8]76.97	127	62.98	0.22	3.19	4.00	6.58	68.44
Polk	276.0	125.9	150.1	183.0	0.0	183.0	31.23	0.0	31.23	171	28.62	1.02	0.62	0.97	0.0	18.71
Putnam	43.5	13.6	29.9	14.9	0.0	14.9	2.58	0.0	2.58	173	2.58	0.0	0.0	0.0	0.0	0.87
St. Johns	40.2	14.3	25.9	21.2	0.0	21.2	2.67	0.0	2.67	126	2.49	0.0	0.18	0.0	0.0	0.17
St. Lucie	69.1	37.1	32.0	42.5	0.0	42.5	6.14	0.0	6.14	144	5.70	0.0	0.11	0.27	0.05	2.43
Santa Rosa	46.9	14.7	32.2	37.9	0.0	37.9	3.40	0.0	3.40	90	2.99	0.06	0.0	0.35	0.0	1.04
Sarasota	163.2	67.7	95.5	87.0	2.9	89.9	9.33	0.98	10.31	115	7.93	0.0	0.71	0.48	1.19	2.02
Seminole	136.4	68.9	67.5	63.1	0.0	63.1	10.45	0.0	10.45	166	9.40	0.0	0.0	0.92	0.13	3.13
Sumter	20.6	6.1	14.5	7.3	0.0	7.3	0.61	0.0	0.61	84	0.53	0.0	0.0	0.08	0.0	0.12
Suwannee	18.9	8.1	10.8	9.1	0.0	9.1	1.13	0.0	1.13	124	0.86	0.03	0.04	0.21	0.0	0.67
Taylor	14.6	8.0	6.6	10.4	0.0	10.4	1.37	0.0	1.37	132	1.03	0.0	0.0	0.30	0.04	0.54
Union	10.4	2.2	8.2	1.7	0.0	1.7	0.55	0.0	0.55	324	0.20	0.0	0.30	0.05	0.0	0.27
Volusia	212.4	137.0	75.4	147.7	0.0	147.7	25.06	0.0	25.06	170	21.22	0.0	1.76	1.83	0.25	12.07
Wakulla	8.8	0.7	8.1	4.5	0.0	4.5	0.26	0.0	0.26	58	0.26	0.0	0.0	0.0	0.0	0.06
Walton	18.0	6.5	11.5	10.6	0.0	10.6	1.08	0.0	1.08	102	0.86	0.0	0.02	0.18	0.02	0.52
Washington	14.1	6.0	8.1	6.4	0.4	6.8	0.59	0.0	0.59	87	0.58	0.0	0.0	0.01	0.0	0.07
State total	[2]8,685.1	4,932.1	3,753.1	6,006.1	806.6	6,812.6	984.88	160.93	1,145.81	168	923.58	24.71	80.90	83.62	33.00	559.97

[1] Includes 14.4 Mgal/d imported from Orange County.
[2] Includes an estimated 200,000 tourists in Dade County.
[3] Does not include 5.96 Mgal/d exported to Monroe County.
[4] Does not include 24.27 Mgal/d exported to Pinellas County.
[5] Includes 5.96 Mgal/d imported from Dade County and 1.71 Mgal/d pumped from Key Largo Limestone, used by Stock Island desalination plant, Key West.
[6] Does not include 14.4 Mgal/d exported to Brevard County.
[7] Does not include 15.7 Mgal/d exported to Pinellas County.
[8] Includes 24.27 Mgal/d exported from Hillsborough County and 15.7 Mgal/d exported from Pasco County.

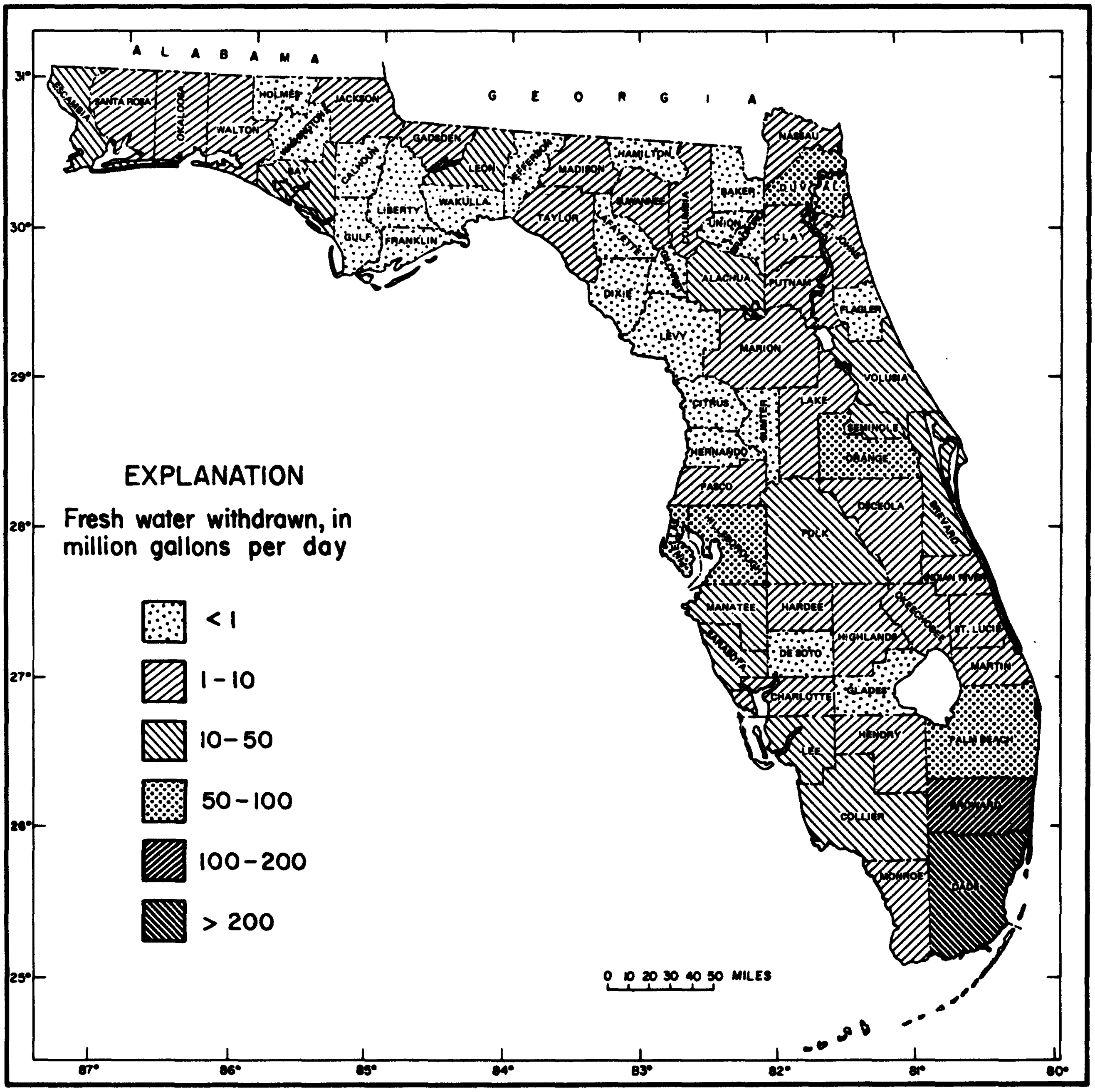


Figure 77.--Water withdrawn for public supplies in Florida by counties, 1975 (from Leach, 1978b).

Table 36.--Source and quantity of surface water supplied to 22 municipalities, 1975

[Modified from Healy, 1977]

Municipality	Source	Percentage supplied from source cited	Water supplied (Mgal)
Callaway	Deer Point Reservoir	100	105
Panama City	do	100	1,737
Panama City Beach	do	16	87
Springfield	do	100	188
Port Saint Joe	Chipola River	100	235
Quincy	Quincy Creek	100	432
Tampa	Hillsborough River	100	19,238
Melbourne[1]	Lake Washington	100	3,249
Palmetto	Manatee River	100	197
Bradenton	Braden River	100	1,397
Lake Placid	Lake Sirena	50	36
Punta Gorda	Shell Creek	100	666
Belle Glade	Lake Okeechobee	100	1,467
Clewiston	do	100	424
Okeechobee	do	100	380
Pahokee	do	100	304
Fort Myers	Caloosahatchee River	50	1,044
Fort Myers (suburban)		100	1,463
West Palm Beach[1]	Lake Mangonia and Clear Lake	100	7,760
N. Port Charlotte	Myakka-Hatchee River	100	359
Port Charlotte	Fordham Waterway	92	761
Saint Augustine	Infiltration gallery	50	466
			41,995

[1] Includes other municipalities.

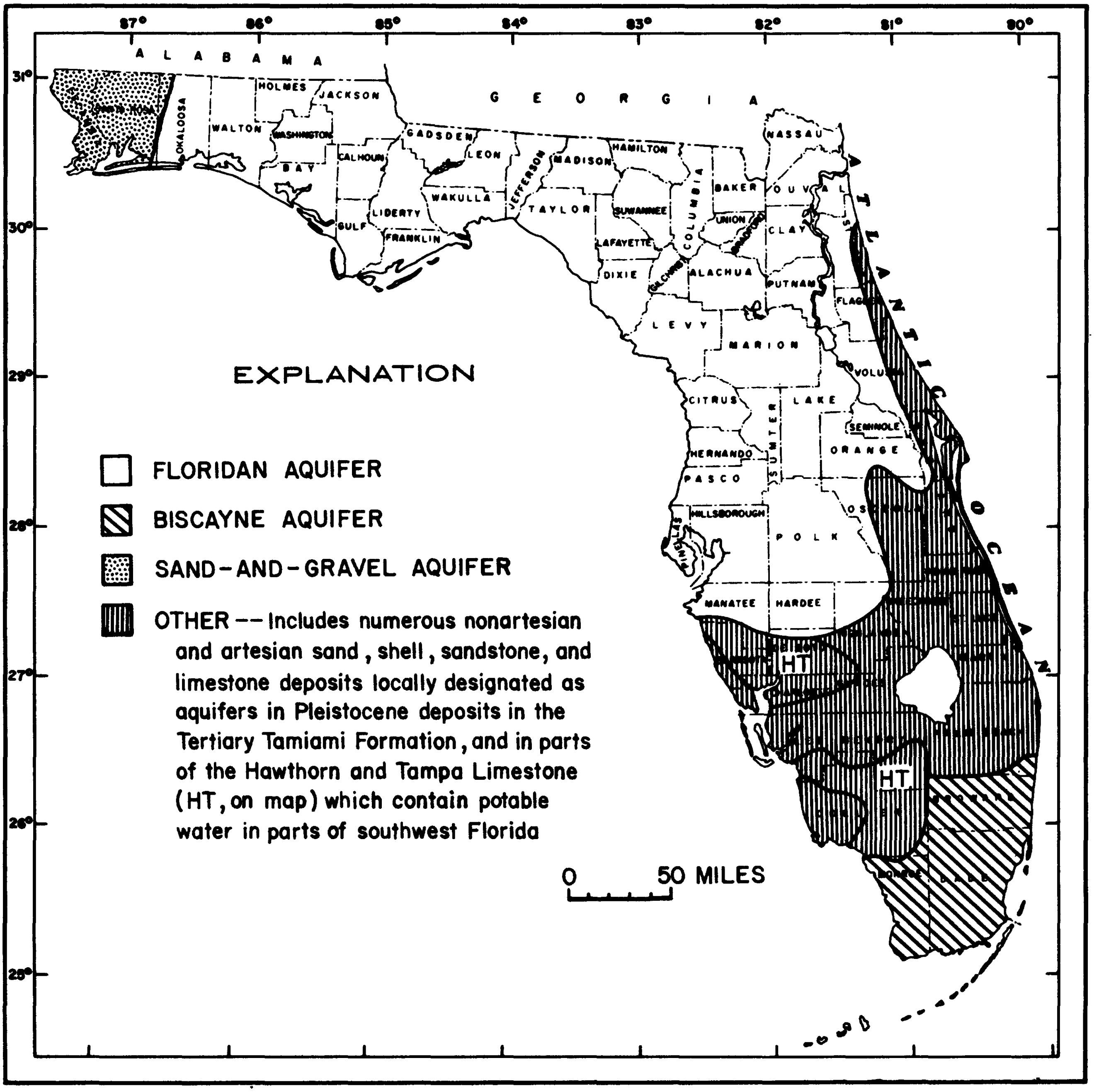


Figure 78.--Sources of ground water for public supply in Florida (modified from Irwin and Healy, 1978).

In many parts of the State, small to large quantities of water are pumped for public supply from shallow (near-surface) aquifers consisting of clastic materials including sand, shell beds, and sandstone, in addition to limestone. These aquifers, not everywhere continuous, have various names depending on the location. For convenience, all are grouped together in figure 78 under "other" aquifers. The shallow aquifers as a source of municipal water supply are particularly important in those areas where water in the underlying Floridan aquifer is too highly mineralized for municipal use. In such areas as Palm Beach, Martin, and St. Lucie Counties, the principal sources of water for municipal supply are the shallow aquifers. Table 37 gives the names of the shallow aquifers that are of sufficient thickness and areal extent to supply quantities of water suitable for public supply.

Water Used

In 1975, 169 municipalities and five county water systems supplied 1,037 million gallons (Mgal) of water each day, on the average, to 77 percent of the population of Florida (table 38). The quantity of water supplied represented 90 percent of the State's public water-supply demand. Of the 169 municipalities and five county systems, 150 supplied 887 Mgal of ground water and 24 supplied 150 Mgal of surface water each day. Of the total demand of the 174 water systems, 85 percent was ground water and 15 percent was surface water.

In 1975, five county water systems provided, on the average, 96.6 Mgal/d of public-supply water to a population of 595,980. Three of the five systems provided, in the aggregate, 54.4 Mgal/d of ground water, and two supplied 42.2 Mgal/d of surface water. Table 39 lists quantities of water supplied by all five.

In 1975, three of the 150 municipal ground-water suppliers reportedly processed about 3.2 Mgal of water each day by desalination.

The 20 largest cities in the State have an aggregate population of 3.72 million--44 percent of the population of the State and 57 percent of the population of the 169 municipalities. The 20 largest cities used an average of 638 million gallons of water per day. This represents 56 percent of the entire public supply in the State and 72 percent of the total municipal water supply of the 169 municipalities (tables 38 and 40).

The average quantity of water withdrawn each day in Florida by public supplies in 1975 was estimated to be 1,146 Mgal/d, an increase of 262 Mgal/d since 1970. Of this quantity, 86 percent was ground water while the remaining 14 percent was surface water (lakes, streams, and reservoirs). Statewide ground-water use for municipal supply increased from 759 Mgal/d in 1970 (Pride, 1973) to 985 Mgal/d in 1975 and surface-water use increased from 125 Mgal/d in 1970 (Pride, 1973) to 161 Mgal/d in 1975. The 29 percent increase in ground-water and in surface-water use reflects the continuing rapid population growth and the accompanying expanding economic activity in the State. The increase in population and the total yearly water use for selected municipalities are shown in figure 79.

Table 37.--Depth of shallow aquifers used for municipal supply in various counties in Florida

[Modified from Irwin and Healy, 1978]

County	Name of shallow aquifer	Depth range (feet)	Number of municipalities supplied, statewide
Brevard	Shallow sand aquifer	--	1
Collier	Shallow aquifer	60-100	1
Flagler	Nonartesian aquifer	100-115	1
Glades	Shallow aquifer in the Tamiami Formation.	85-100	1
Hendry	Shallow aquifer in the Tamiami Formation.	16-40	1
Indian River	Shallow aquifer	90-100	1
Lee	Water-table aquifer in Pleistocene sand.	16-44	1
	Sandstone aquifer in the Tamiami Formation.	57-86	2
	Water-table aquifer	20-49	1
Martin	Shallow aquifer	60-140	1
Palm Beach	Shallow aquifer	60-250	8
	Shallow aquifer in Pleistocene sand.	60-110	1
Sarasota	Nonartesian aquifer	--	1
	Nonartesian sand aquifer	40-90	1
St. Johns	Shallow sand aquifer	45-96	1
St. Lucie	Shallow sand-and-gravel aquifer.	80-120	1

Table 38.--Public water supply used in Florida and water delivered to users by 169 municipalities and 5 county water systems, by source, 1975

[Modified from Healy, 1977]

Source	State (Mgal/d)	Total for 169 municipalities and 5 county systems: Average daily (Mgal)	For 1975 (Mgal)	Percentage of water supplied (by source)	Percentage ground and surface-water supplied
Surface water[1]					
Rivers	85	80	29,210	53.0	7.8
Lakes	43	37	13,620	24.7	3.6
Reservoir	32	32	11,806	21.4	3.1
Infiltration gallery	1	1	466	.9	.1
Total, surface water	161	150	55,102	100.1	14.6
Ground water (aquifers)					
Biscayne	[2]439	[2]405	147,878	45.8	39.0
Floridan	427	367	133,864	41.4	35.3
Sand-and-gravel	31	27	9,733	3.0	2.6
Other	88	88	32,129	9.8	8.5
Total, ground water	985	887	323,604	100	85.4
Total, ground and surface water	1,146	1,037	[3]378,706		100

[1] Leach, 1978a.
[2] Includes 2 Mgal/d from Key Largo Limestone supplied to Stock Island desalination plant at Key West.
[3] Constitutes 90.7 percent of the 418,290 Mgal supplied to a statewide user population of 6,820,600.

Table 39.--Water supplied by five county water systems in Florida, 1975

[From Healy, 1977]

County water system	Population served	Water supplied: For 1975 (Mgal)	Water supplied: Average daily (Mgal)	Source
Bay County	65,000	11,806.21	[1]32.35	Deer Point Reservoir.
Broward County Utilities Dept.	136,000	7,081.0	19.40	Biscayne aquifer.
Manatee County	55,000	3,613.5	9.90	Manatee River.
Okaloosa County	20,870	716.64	1.96	Floridan and sand-and-gravel aquifers.
Pinellas County	319,110	12,055.91	33.05	Floridan aquifer.
Total	595,980	35,273.26	96.60	

[1] Includes 25.39 Mgal/d for industrial use.

Table 40.--Quantity of public-supply water delivered to users by the 20 largest municipalities in Florida, 1975

[From Healy, 1977]

Municipality	Source[1]	Water supplied: For 1975 (Mgal)	Water supplied: Average daily (Mgal)	Population served	Average daily per capita use (gal)
Miami	GW	68,876	188	1,210,000	156
Jacksonville	GW	21,333	58	250,000	152
Tampa	SW	19,238	53	350,000	150
Fort Lauderdale	GW	16,798	46	226,430	203
Orlando	GW	14,881	41	196,000	208
Saint Petersburg	GW	12,796	35	253,000	209
North Miami Beach	GW	9,176	25	165,000	152
Pensacola	GW	8,318	23	144,435	102
West Palm Beach	SW	7,760	21	79,950	266
Boca Raton	GW	6,254	17	46,200	371
Lakeland	GW	6,224	17	82,000	208
Pompano Beach	GW	5,475	15	63,000	238
Hollywood	GW	5,293	15	100,000	145
Cocoa	GW	5,263	14	100,000	144
Tallahassee	GW	5,229	14	92,789	124
Gainesville	GW	5,048	14	80,000	173
Winter Park	GW	4,133	11	60,000	189
North Miami	GW	4,131	11	65,000	174
Daytona Beach	GW	4,062	11	62,300	179
Melbourne	SW	3,249	9	90,000	99
Total		233,537	638	3,716,104	

[1] GW, ground water.
SW, surface water.

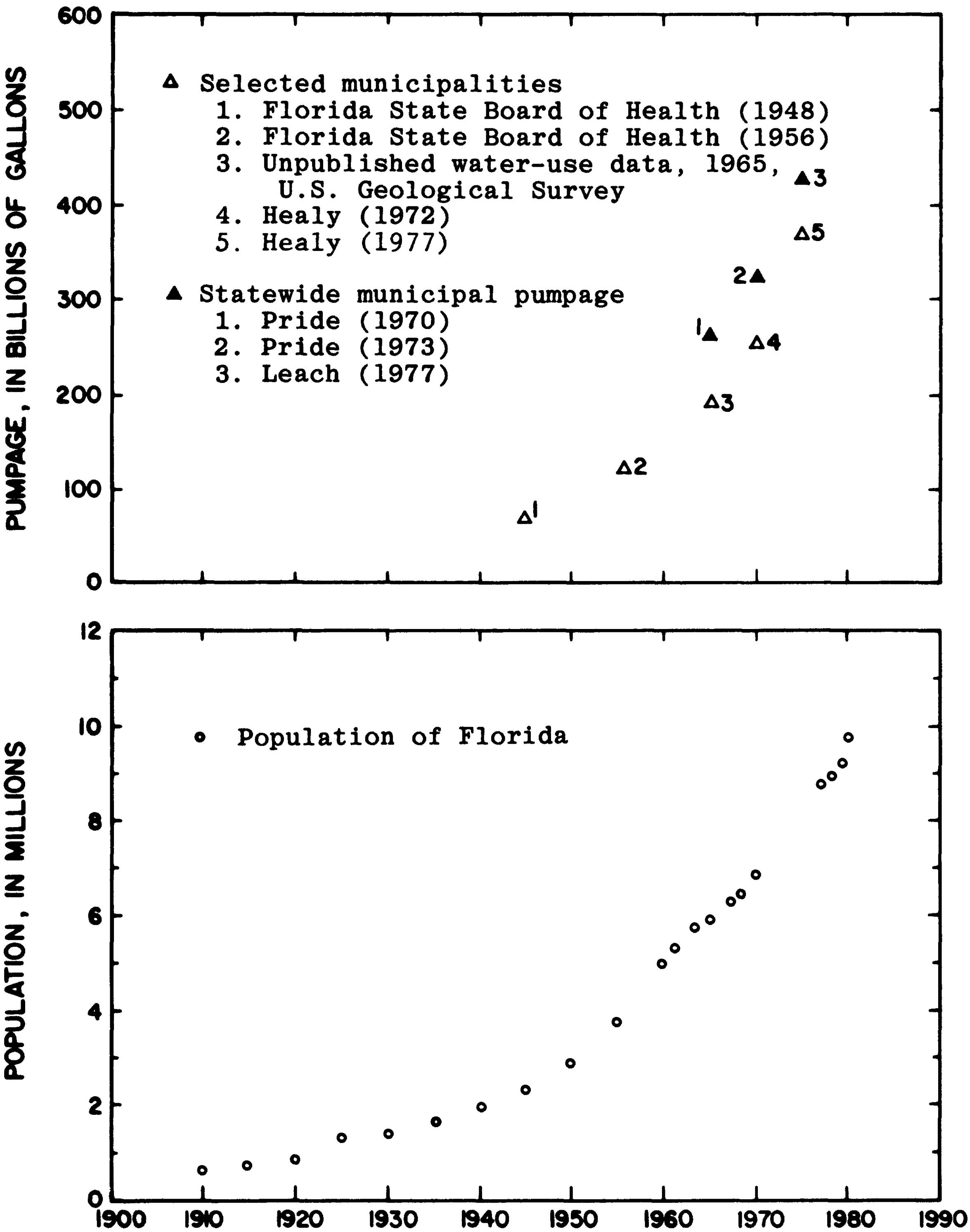


Figure 79.--Population of Florida, 1900-80, quantity of public-supply water delivered by selected municipalities, 1947, 1956, 1965, 1970, and 1975, and by all municipalities in Florida, 1965, 1970, and 1975 (modified from Healy, 1977).

The average per capita use of water by public supply systems in 1975 was 168 gal/d. Considering only that part of public supply water that was used for domestic purposes, the average per capita use was 135 gal/d--only a 3 gal/d increase over the per capita use in 1970. The population served by the 169 municipalities and five county systems is 6,537,913 or 77 percent of the total 1975 population of 8,485,230. Average per capita use of public water supplied ranged from 35 gal/d at Crawfordville in Wakulla County to 530 gal/d at Palm Beach in Palm Beach County. The average per capita use of the water supplied by the 174 systems was 158 gal/d, compared to an average per capita use of 168 gal/d based on total statewide daily municipal water use of 1,146 Mgal/d (table 38).

Consumptive Use

The amount of public supply water consumed is considered to be the difference between the amount of water withdrawn from the source and the amount of effluent discharged from sewage treatment plants. This relation is true if there are no leaks into or out of the sewers, no industries discharging self-supplied water to the sewers, and no extensive use of septic tanks in the areas served by the public supply. Only a few cities measure the effluent from their sewage treatment plants and generally sewage discharge must be estimated to determine the water consumption. These estimates are based on data from similar systems serving about the same number of people and other commercial uses.

The percentage of withdrawn water consumed varies from city to city because of the type of waste discharge and the percentage of public supply used for commercial purposes. Some industries incorporate almost 100 percent of the water in their products, whereas other industries return almost all the water to the system for reuse.

Average daily use of public supply water in 1975 exceeded the daily sewage discharge for 72 percent of the 169 municipalities reported. The daily use exceeded daily sewage discharge by less than 50 percent in 39 municipalities, between 50 to 100 percent in 27 municipalities, and between 100 to 200 percent in 31 municipalities. Of the remaining 25 municipalities, daily use exceeded daily sewage discharge between 200 to 350 percent in 12, and was greater than 350 percent in 13 municipalities.

Quality of public water supplies

Chemical analyses of public supply waters in Florida waters have been made since the 1890's. The earlier water analyses were made only by a few of the larger public-suppliers, by the Florida Board of Health, and to a lesser extent by commercial laboratories. Because most of the smaller water-supply facilities did not have extensive analytical capabilities, chemical analyses were not made regularly.

Data on the chemical quality of public supply waters from about 1941 through 1976 are available in selected publications of the Florida State Board of Health, Bureau of Sanitary Engineering; the Florida Department of Natural Resources, Bureau of Geology; and the U.S. Geological Survey. Though most of the agencies have published documents that in part dealt with the quality of public water supplies, perhaps the first statewide summary specifically addressing the chemical quality of water used for public supplies was released in 1960 by the Florida State Board of Health, Bureau of Sanitary Engineering. Three subsequent reports, published by the Bureau of Sanitary Engineering during 1965-69, summarize the major inorganic chemical composition of raw supply water for about 230 municipalities, 400 subdivisions, and 80 mobile home parks.

In mid-1960, the U.S. Geological Survey began a statwide water-use investigation which included sampling and analyses of selected public water supplies. A report, published by the Florida Bureau of Geology lists, for 1970, 160 chemical analyses of untreated ground and surface water for 138 municipalities (Healy, 1972). In 1975, the U.S. Geological Survey, as part of a 5-year statewide inventory of public water use, collected selected chemical data on water from 169 municipalities and 5 county water systems (Healy, 1977).

On December 16, 1974, Public Law 93-523, commonly referred to as the "Safe Drinking Water Act" was passed by the U.S. Congress (1974). Subsequently, the U.S. Environmental Protection Agency (1975a,b) established the National Interim Primary Drinking Water Regulations which went into effect June 24, 1977. These regulations supersede, but closely parallel, the 1962 drinking water standards by the U.S. Public Health Service.

Supplementary regulations released July 9, 1976 added maximum contaminant levels for selected natural and manmade radioactivity. The effective date for the radioactivity regulations coincides with the date for the initial primary regulations.

On March 31, 1977, the U.S. Environmental Protection Agency (1977) released the proposed National Secondary Drinking Water Regulations. The secondary regulations complement the primary regulations. They are not Federally enforceable and are intended as guidelines for State policy. The secondary regulations mainly pertain to esthetic qualities of drinking water.

The maximum contaminant levels (MCL) for constituents established by the primary drinking water regulations or proposed by the secondary drinking water regulations are as follows (also see Glossary):

National Primary Drinking Water Regulations

Constituent	Maximum contaminant level (MCL)	
	Milligrams per liter	Micrograms per liter
Arsenic (As)	0.05	50
Barium (Ba)	1.	1,000
Cadmium (Cd)	.010	10
Chromium (Cr)	.05	50
Lead (Pb)	.05	50
Mercury (Hg)	.002	2
Selenium (Se)	.01	10
Silver (Ag)	.05	50
Endrin	.0002	2
Lindane	.004	4
Methoxychlor	.1	100
Toxaphene	.005	5
2,4-D	.1	100
2,4,5-TP (Silvex)	.01	10
Fluoride (F)	[1]1.6-1.8	[1]1,600-1,800
Nitrate (NO_3-N)	10	10,000
Turbidity (NTU)	([2])	([2])
Radionuclides	([3])	([3])

[1] Fluoride: The maximum contaminant level for fluoride is a function of the annual average daily air temperature for the location in which the water supply is located. In Florida, where mean annual temperatures range from the upper 60's in the north to as high as 78°F at Key West, the appropriate standards for fluoride are:

Temperature, in degrees Fahrenheit	Temperature, in degrees Celsius	Maximum contaminant level (MCL)	
		Milligrams per liter	Micrograms per liter
63.9 to 70.6	17.7 to 21.4	1.8	1,800
70.7 to 79.2	21.5 to 26.2	1.6	1,600

When increasing fluoride concentrations by the addition of fluoride containing compounds, State recommendations should be followed.

[2] Turbidity: The maximum contaminant level is a monthly average of 1 nephelometric turbidity unit (NTU). With State approval, 5 turbidity units are allowed when it does not interfere with disinfection, maintenance of chlorine residual, or bacteriological testing.

[3] Radionuclides: The maximum contaminant levels for gross alpha particle activity and gross beta particle activity are as follows: (U.S. Environmental Protection Agency, 1976a, Section 141.15):

Gross alpha particle activity (including radium-226, but excluding radon and uranium)--15 picocuries per liter (pCi/L). It should be noted that this MCL excludes alpha particle activity due to uranium, which is normally measured as part of the gross alpha activity. If the MCL is exceeded, Federal regulations require that further analyses be run to determine the source of the radiation--radium, uranium, radon, or yet another radionuclide. If uranium is determined, its contribution to alpha activity should be subtracted from gross alpha activity for a direct comparison with the suggested MCL. If radium is measured, the applicable standard is:

Combined radium-226 and radium-228; 5 pCi/L.

The average annual concentration of beta particle and photon radioactivity from manmade radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem per year (Rem, roentgen equivalent, man). In order to compare the measured value for gross beta particle activity (in pCi/L) to the recommended MCL (in Rem units), the average annual concentration should not exceed 50 pCi/L. If this MCL is exceeded, Federal regulations require that further analyses be run to determine the major beta particle contaminants.

Selected Proposed Secondary Drinking Water Regulations

Constituent	Maximum contaminant level (MCL) Milligrams per liter	Micrograms per liter
	(except as indicated)	
Chloride (Cl)	250	250,000
Color (Pt-Co units)	15	15
Copper (Cu)	1.	1,000
Iron (Fe)	.3	300
Manganese (Mn)	.05	50
pH (units)	6.5-8.5	6.5-8.5
Sulfate (SO4)	250	250,000
Dissolved solids	500	500,000
Zinc (Zn)	5.	5,000

The objective of the Safe Drinking Water Act is to encourage public water-supply agencies to provide water of high quality to users by establishing and maintaining national standards. This goal is to be achieved primarily by expanding the scope and level of water utility service, thus improving the quality and dependability of the nation's drinking water.

Public Law 93-523 is a Federal Act; however, primacy under the Act becomes the responsibility of individual states upon their request to, and approval by, the U.S. Environmental Protection Agency. The State of Florida, having assumed primacy, designated the Department of Environmental Regulation, Bureau of Drinking Water and Special Programs, as the agency responsible for coordinating all public drinking water supply activities in the State.

In July 1976, the Florida Department of Environmental Regulation and the U.S. Geological Survey entered into a cooperative hydrologic investigation to evaluate the water quality of selected public water supplies in Florida. As an initial endeavor during August-September 1976, untreated (raw) and treated (after processing by treatment plant) waters from 127 public supplies were sampled throughout the State (Irwin and Healy, 1978). The sampling emphasis was on the chemical parameters designated in the National Interim Primary Drinking Water Regulations. The reconnaissance had two objectives. The first objective was to determine the quality of the treated water distributed to users by selected public supply agencies. The second objective was to evaluate the quality of untreated or source waters used by those agencies.

A second sampling reconnaissance of 129 public water supplies was conducted during November 1977-February 1978 (Irwin and Hull, 1979). The scope of the reconnaissance for 1977-78 was essentially the same as for the 1976 sampling, except for a significant increase in the water quality parameter coverage. Additional analytical coverage for 1977-78 included selected secondary drinking water regulation parameters at all sites and gross radioactivity at 90 selected sites.

A third reconnaissance sampling of 131 public water supplies was made during January-May 1979. Of this total, 110 were treated ground-water supplies and 21 were surface-water supplies (both raw and treated waters were sampled at these sites). Chemical analyses of samples collected at each site included all major inorganic constituents, as well as selected physical properties, trace elements, pesticide compounds, and gross alpha and beta radioactivity (Franks and Irwin, 1980).

Presentation of the analytical results of the three reconnaissance samplings of nearly 350 public water supplies with a discussion of results as compared with the National Interim Primary Drinking Water Regulations and the National Secondary Drinking Water Regulations are presented in the three reports mentioned above.

During the January-May 1979 reconnaissance most of the 110 ground-water supplies sampled were treated waters. A majority of the sites can be characterized as communities of small population density and noncommunity facilities such as utility companies and small corporations. Also during the January-May 1979 reconnaissance, most of the principal public surface-water supplies in the State were analyzed for parameters included in the primary and secondary drinking water regulations. Analyses were also made for additional selected major inorganic chemical and physical parameters. For each supply, samples of raw and treated water were collected and analyzed (tables 41 and 42).

Summaries of analyses of the 1976, 1978, and 1979 samplings of the treated public ground-water supplies are given in tables 43-46. With few exceptions, sampling of the treated ground water public supplies were not repeated each year and public supplies were sampled in each county. The analyses therefore provide a composite sampling of treated public ground-water supplies in Florida. The summary of analyses for selected radiochemical data for raw and treated surface and ground waters from selected public drinking waters for the 1979 sampling is given in table 47.

Table 41.--Summary of analyses of major inorganic chemical constituents and physical properties for selected public surface-water supplies in Florida, January-May 1979

[Modified from Franks and Irwin, 1980]

[Concentrations in milligrams per liter, except as indicated]

Chemical constituent or physical property	Raw Sample				Treated Sample			
	Number of samples	Minimum concentration	Maximum concentration	Median	Number of samples	Minimum concentration	Maximum concentration	Median
Silica (SiO_2)	21	1.9	15	5.7	21	2.7	18	5.0
Calcium (Ca)	21	2.9	130	33	21	12	73	36
Magnesium (Mg)	21	1.4	22	5.7	21	.8	19	6.0
Sodium (Na)	21	2.3	86	28	21	2.4	84	46
Potassium (K)	21	.4	6.0	3.1	21	.4	5.9	3.2
Bicarbonate (HCO_3)	21	11	320	99	21	0	94	40
Carbonate (CO_3)	21	0	0	0	21	0	36	1
Sulfate (SO_4)	21	1.4	110	42	21	7.5	170	68
Chloride (Cl)	21	4.1	160	48	21	8.5	170	72
Fluoride (F)	21	0	.4	.2	21	0	.9	.3
Nitrate (NO_3-N)	20	0	.5	.14	21	.03	.65	.13
Nitrite (NO_2-N)	20	0	.04	.01	21	0	.06	.01
Dissolved solids (residue at 180°C)	21	40	644	255	21	64	576	322
Hardness, as $CaCO_3$	21	13	340	130	21	33	240	120
Hardness, noncarbonate (as $CaCO_3$)	21	4	120	48	21	14	210	66
Alkalinity (as $CaCO_3$)	21	9	260	81	21	18	77	43
Specific conductance (µmho/cm at 25°C)	21	26	840	385	21	70	935	490
pH (units)	19	5.7	9.2	7.0	18	7.4	10.3	8.6
Termperature (°C)	21	7.5	28.5	21.0	21	11.5	27.5	21.5
Color (Pt-Co units)	21	10	200	50	20	0	10	0
Turbidity (NTU)	21	1	14	4	21	1	4	1

Table 42.--Summary of trace element analyses for selected public surface-water supplies in Florida, January-May 1979

[Modified from Franks and Irwin, 1980]

[Total concentrations in micrograms per liter, except as indicated]

Chemical constituent or physical property	Raw Sample				Treated Sample			
	Number of samples	Minimum concen-tration	Maximum concen-tration	Median	Number of samples	Minimum concen-tration	Maximum concen-tration	Median
Arsenic (As)	21	0	5	1	21	0	3	1
Barium (Ba)	21	0	100	0	21	0	200	0
Cadmium (Cd)	18	0	3	0	18	0	1	0
Chromium (Cr)	21	10	30	10	21	10	20	10
Copper (Cu)	21	0	320	3	21	0	22	2
Iron (Fe)	21	50	1300	170	21	10	270	70
Lead (Pb)	18	0	6	3	18	0	10	1
Manganese (Mn)	21	0	40	10	21	0	20	0
Mercury (Hg)	21	.5	2.1	.5	21	.5	.8	.5
Selenium (Se)	21	0	0	0	21	0	0	0
Silver (Ag)	21	0	1	0	21	0	0	0
Strontium (Sr)	21	20	2400	660	21	30	2700	600
Zinc (Zn)	21	0	150	10	21	0	150	20

Table 43.--Summary of chemical and physical analyses for selected treated public ground-water supplies in Florida, August-September 1976

[Modified from Irwin and Healy, 1978]

[Dissolved concentrations in milligrams per liter, except as indicated]

Chemical constituent or physical property	Floridan aquifer		Biscayne aquifer		Sand-and-gravel		Other aquifers			
							Shallow sand		Hawthorn and Tampa	
	Median	Range	Median	Range	Median[1]	Range	Median	Range	Median	Range
Fluoride (F)	0.2	0.1-1.1	0.5	0.2-1.1	-	-	0.3	0.1-1.0	1.0	0.8-1.8
Nitrate (NO_3-N)	.03	.00-3.7	.02	.00-0.44	1.9	0.62-3.2	.04	.00-1.5	.04	.02-0.29
Dissolved solids (residue at 180°C)	203	94-560	214	130-328	-	-	344	162-658	502	280-796
Specific conductance (micromhos/cm at 25°C)	385	146-1,150	335	185-550	76	26-125	520	220-988	772	435-1,180
pH (units)	7.4	6.7-7.8	8.7	7.2-9.7	-	5.5-7.2	7.9	7.4-9.6	-	7.2-8.3
Temperature (°C)	28.0	22.5-33.0	27.0	25.5-30.5	30.0	28.5-31.0	28.0	25.5-30.5	-	25.0-29.0
Turbidity (NTU)	1	0-3	1	1-45	-	-	1	0-2	1	1

[1] Mean of two samples.

Table 44.--Summary of trace element analyses for selected treated public ground-water supplies in Florida, August-September 1976

[Modified from Irwin and Healy, 1978]

[Total concentrations in micrograms per liter, except as indicated]

Chemical constituent or physical property	Floridan aquifer		Biscayne aquifer		Sand-and-gravel		Other aquifers			
							Shallow sand		Hawthorn and Tampa	
	Median	Range	Median	Range	Median[1]	Range	Median	Range	Median	Range
Arsenic (As)	0	0-14	0	0-6	0	0	0	0-1	0	0-1
Barium (Ba)	0	0-200	0	0-100	0	0	0	0-100	0	0-100
Cadmium (Cd)	1	0-5	1	0-3	4	3-5	0	0-6	0	0
Chromium (Cr)	20	<10-40	10	<10-20	([2])	<10	20	<10-30	20	10-20
Lead (Pb)	7	0-61	11	3-34	14	12-15	8	1-22	4	2-7
Mercury (Hg)	.1	.0-0.7	.2	.0-0.2	.0	.0	.1	.0-0.3	.2	.1-0.3
Selenium (Se)	0	0-1	0	0-1	0	0	0	0-1	0	0
Silver (Ag)	0	0-1	0	0-5	0	0	0	0-9	0	0

[1] Mean of two samples.
[2] Some concentrations below the analytical detection limit.

Table 45.--Summary of analyses of major inorganic chemical constituents and physical properties for selected treated public ground-water supplies in Florida, November 1977-February 1978 and January-May 1979

[Modified from Irwin and Hull, 1979 and Franks and Irwin, 1980]
[Total concentrations in milligrams per liter, except as indicated]

Chemical constituent or physical property	November 1977-February 1978			January-May 1979		
	Number of samples	Range	Median	Number of samples	Range	Median
Silica (SiO_2)				105	1.7-51	11
Calcium (Ca)				106	.6-130	44
Magnesium (Mg)				106	.5-98	7.1
Sodium (Na)				106	1.6-320	12
Potassium (K)				106	.1-28	1.2
Bicarbonate (HCO_3)				107	3-420	160
Carbonate (CO_3)				107	0-17	0
Sulfate (SO_4)	98	.1-300	11	107	.1-210	11
Chloride (Cl)	98	2.5-310	21	107	1.8-590	22
Fluoride (F)	97	.0-3.3	.1	106	0-1.5	.1
Nitrate (NO_3-N)	97	.00-5.8	.04	104	0-5.9	.05
Nitrite (NO_2-N)				104	0-.19	0
Dissolved solids, (residue at 180°C)	98	42-999	225	106	18-1410	250
Hardness, as $CaCO_3$				106	4-600	160
Hardness, noncarbonate (as $CaCO_3$)				106	0-430	23
Alkalinity (as $CaCO_3$)				107	2-340	130
Specific conductance (µmho/cm at 25°C)				107	17-2200	405
pH (units)	104	5.5-9.3	7.5	103	5.3-9.8	7.6
Temperature (°C)				107	10-29.5	20
Color (Pt-Co units)	98	0-42	2	107	0-50	5
Turbidity (NTU)	95	0-6	1	106	0-6	1

Table 46.--Summary of trace element analyses for selected treated public ground-water supplies in Florida, November 1977-February 1978 and January-May 1979

[Modified from Irwin and Hull, 1979 and Franks and Irwin, 1980]

[Total concentrations in micrograms per liter, except as indicated]

Chemical constituent or physical property	November 1977-February 1978			January-May 1979		
	Number of samples	Range	Median	Number of samples	Range	Median
Arsenic (As)	97	0-10	1	107	0-6	1
Barium (Ba)	43	0-100	0	107	0-200	0
Cadmium (Cd)	99	0-8	0	93	0-2	0
Chromium (Cr)	99	<10-40	10	107	10-40	10
Copper (Cu)	99	0.001-0.160	.007	107	0-420	5
Iron (Fe)	99	.000-2.40	.050	107	0-2000	70
Lead (Pb)	99	.000-2.40	.050	107	0-19	1
Manganese (Mn)	99	.000-0.050	.000	107	0-80	10
Mercury (Hg)	98	<0.5-1.8	<.5	107	.5-2.0	.5
Selenium (Se)	96	0-15	0	107	0-3	0
Silver (Ag)	98	0-2	0	107	0-0	0
Strontium (Sr)	--	-	-	106	6-15000	260
Zinc (Zn)	98	.000-0.830	.020	107	0-1000	40

Table 47.--Summary of analyses for radiochemical data from selected public drinking-water supplies in Florida, January-May 1979

[Modified from Franks and Irwin, 1980]

[Concentration in picocuries per liter]

Chemical constituent or physical property	Raw Sample				Treated Sample			
	Number of samples	Minimum concen-tration	Maximum concen-tration	Median	Number of samples	Minimum concen-tration	Maximum concen-tration	Median
				Surface Water				
Gross alpha particle activity	20	<0.7	8.2	4.8	21	0.9	<6.8	3.4
Gross beta particle activity	20	1.6	9.7	5.4	21	1.3	11	4.8
				Ground Water				
Gross alpha particle activity	3	<3.7	<19.0	<3.9	100	<0.3	59	3.7
Gross beta particle activity	3	<1.0	<8.0	5.5	100	0.5	27	2.4

WATER USE

The U.S. Geological Survey in 1950 started a series of nationwide reports compiling water-use data every five years. The results are contained in reports by MacKichan (1951; 1957); MacKichan and Kammerer (1961); Murray (1968); and Murray and Reeves (1972, 1977). These reports contain estimates of water use by categories for each state but do not contain information for smaller subareas such as counties.

In Florida the earliest documentation of water use on a county-by-county basis was made in 1956 by the Florida Water Resources Study Commission (1956). The results of the investigation were forwarded to the Governor of Florida and the 1957 Legislature. A water-use inventory of southwest Florida was made in 1962 by the Florida Board of Conservation (1966) and was published in their report on land and water resources. Snell and Anderson (1970) compiled water-use data for northeast Florida for 1965. These data were included in the water and related land resources report of the St. Johns River basin by the Florida Department of Natural Resources (1970). Additional Florida water-use data reports by the U.S. Geological Survey include: 1965 water-use data for Florida, a map report, (Pride, 1970); Estimated use of water in Florida, 1970 (Pride, 1973); Public water supplies of selected municipalities in Florida, 1970 (Healy, 1972); Public water supplies of selected municipalities in Florida 1975 (Healy, 1977); Source, use, and disposition of water in Florida, 1975 (Leach, 1978b); and Estimated water use in Florida, 1977 (Leach and Healy, 1980).

The 1975 Florida water assessment was made as part of a statewide cooperative program with the Florida Department of Environmental Regulation, Northwest Florida Water Management District, South Florida Water Management District, Southwest Florida Water Management District, St. Johns River Water Management District, and the Suwannee River Water Management District. In 1977 a cooperative program among the aforementioned agencies was initiated in Florida to annually assess water use in Florida, to improve techniques for determining water use and to evaluate uses of water. A continuing inventory and knowledge of water use is a prerequisite for quantitative hydrology, for development of water resources and for water management.

Water-use data--the quantity of water diverted for use and consumed--are presented by the following categories: Public supply, rural domestic and livestock, self-supplied industrial, irrigation, and thermoelectric power generation. Water use is also categorized as to source: ground or surface water, and as to quality: fresh and saline.

In 1975, Florida ranked fifth nationally in terms of total water use, fresh and saline, exclusive of water used for hydroelectric power (table 48). The relatively large use of water in Florida is the result of the large use of saline water for thermoelectric power generation; saline water use in Florida being second and nearly equal to that of New York. Florida is seventh in use of fresh ground water even though Florida ranked eighth in population in 1975.

Table 48.--Summary of water withdrawn, except for hydroelectric power, in Florida compared with other larger use states, 1975, listed in order of water withdrawn

[Modified from Murray and Reeves, 1977]

[Partial figures may not add to totals because of independent rounding]

State	Population (thousands)	Freshwater per capita use (gal/d)	Water withdrawn including irrigation conveyance losses (million gallons per day): Ground water			Surface water			Reclaimed sewage	All sources			Conveyance losses	Freshwater consumed
			Fresh	Saline	Fresh and saline	Fresh	Saline	Fresh and saline		Fresh	Saline	Fresh and saline		
California	21,113	1,900	19,000	240	19,000	21,000	9,700	31,000	160	41,000	9,900	51,000	5,300	23,000
Texas	12,236	1,900	11,000	0	11,000	13,000	5,100	18,000	62	23,000	5,100	29,000	430	13,000
New York	19,530	610	1,000	3.4	1,000	11,000	12,000	23,000	0	12,000	12,000	24,000	0	740
Pennsylvania	11,828	1,500	880	0	880	17,000	200	17,000	0	18,000	200	18,000	0	830
Florida	8,485	810	3,300	48	3,300	3,600	11,000	15,000	0	6,900	11,000	18,000	220	2,300
United States[1]	217,482	1,600	82,000	980	83,000	260,000	69,000	330,000	530	350,000	70,000	420,000	23,000	96,000

[1] Including Puerto Rico and Virgin Islands.

Irrigation in Florida has expanded at such a rate that in 1975 Florida ranked ninth in acreage irrigated, 15th in total water used for irrigation, and 10th in ground water used for irrigation (table 49). The 14 states using more water for irrigation than Florida are all west of the Mississippi River. Water used for irrigation in Florida is greater than many of the drier states west of the Mississippi River and nearly five times greater than the next largest user east of the Mississippi River. Florida uses twice as much water for irrigation as all the remaining states east of the Mississippi River.

Florida is second in the use of water for thermoelectric power in the United States; New York being first (table 50). Florida is fortunate in having saline waters available for thermoelectric power cooling. Saline water constitutes 85 percent of thermoelectric power use in Florida as compared with 63 percent for New York.

Florida in 1975 ranked eighth in water used for public supplies (table 51). Florida is second to California in use of ground water for public supplies. However, of those furnished public supply, 88 percent of the population in Florida use ground water as compared with 43 percent in California. Only Hawaii, Idaho, and New Mexico exceed Florida in the percentage of population (95, 92, and 92 percent, respectively) furnished ground water for public supply (Murray and Reeves, 1977). Ground water furnished 86 percent of the water used for public supply in Florida in 1975 (table 35).

The use of water in Florida has increased by more than 21 times as compared with an increase in population from 1950 to 1977 of less than four times (table 52). The trends in population and withdrawals of water in Florida from 1950 to 1977 are shown in figure 80.

The source of freshwater used statewide, both surface and ground, the water used for municipal, rural, industrial, irrigation, and thermoelectric power, and the disposition of freshwater withdrawn in Florida in 1975, are given in figure 81. This figure effectively portrays the source, use, and disposition of freshwater. For example, follow one of the sources through use to disposition. First, surface-water represents 52 percent of the statewide use, of which 45.3 percent is pumped for irrigation. Surface water furnishes 56.6 percent of freshwater used for irrigation. Irrigation represents 42 percent of the statewide use and 46.4 percent of irrigation water is consumed. About 8 percent of the water used for irrigation is lost to conveyance (about one half of conveyance is evaporated) and the remainder is returned to the system for reuse. Irrigation contributes 30.1 percent of the freshwater that is returned for reuse and represents 57.9 percent of the water consumed in Florida.

Table 49.--Water used for irrigation in Florida compared with other larger use states, 1975, listed in order of all water withdrawn for irrigation

[Modified from Murray and Reeves, 1977]

[Partial figures may not add to totals because of independent rounding]

State	Acres irrigated (1,000 acres)	Total water withdrawn (1,000 acre-feet per year)				Fresh-water consumed (1,000 ac-ft/yr)	Convey-ance loss (1,000 ac-ft/yr)	Total water withdrawn (million gallons per day)				Freshwater consumed (Mgal/d)	Convey-ance loss (Mgal/d)
		Ground water	Surface water	Re-claimed sewage	All water			Ground water	Surface water	Re-claimed sewage	All water		
California	9,000	18,000	20,000	180	39,000	23,000	5,900	17,000	18,000	160	35,000	21,000	5,300
Idaho	3,800	3,900	13,000	6.2	17,000	5,300	4,800	3,500	12,000	5.6	15,000	4,700	4,300
Texas	8,600	10,000	2,600	60	13,000	12,000	480	9,400	2,300	53	12,000	11,000	430
Montana	2,400	120	12,000	0	12,000	3,000	2,800	110	11,000	0	11,000	2,700	2,500
Colorado	3,100	2,800	7,500	90	10,000	5,700	1,200	2,500	6,700	80	9,300	5,100	1,000
Nebraska	5,600	5,900	2,300	0	8,200	6,400	1,700	5,200	2,100	0	7,300	5,800	1,600
Arizona	1,400	4,700	3,100	60	7,900	6,000	280	4,200	2,800	54	7,000	5,400	250
Wyoming	1,700	300	7,300	0	7,600	2,200	1,800	270	6,500	0	6,800	2,000	1,600
Oregon	2,100	1,000	5,700	4.0	6,700	3,400	1,900	920	5,100	3.6	6,000	3,000	1,700
Washington	1,600	260	5,900	0	6,200	2,500	1,200	230	5,300	0	5,500	2,200	1,000
Kansas	3,000	5,200	370	0	5,600	4,300	120	4,600	330	0	5,000	3,800	110
Utah	1,700	540	3,300	1.0	3,900	2,400	430	480	3,000	.9	3,500	2,200	390
Nevada	860	590	2,900	3.7	3,500	1,700	800	530	2,600	3.3	3,100	1,500	720
New Mexico	1,100	1,500	1,800	0	3,200	1,600	24	1,300	1,600	0	2,900	1,400	21
Florida	2,000	1,400	1,800	0	3,200	1,400	240	1,200	1,600	0	2,900	1,300	220
United States[1]	54,000	63,000	94,000	410	160,000	89,000	25,000	57,000	84,000	360	140,000	80,000	23,000

[1] Including Puerto Rico and Virgin Islands.

Table 50.--Water used for electric utility generation of thermoelectric power in Florida and the 10 largest use states, 1975, listed in order of water used

[Modified from Murray and Reeves, 1977]

[Partial figures may not add to totals because of independent rounding]

[Million gallons per day]

State	Condenser and reactor cooling					Other thermoelectric uses					Water consumed	
	Self-supplied			Public supplies	Self-supplied and public supplies	Self-supplied			Public supplies	Self-supplied and public supplies		
	Fresh ground water	Surface water				Fresh ground water	Surface water					
		Fresh	Saline				Fresh	Saline			Fresh	Saline
New York	0	6,800	12,000	36	19,000	190	370	0	6.0	570	15	24
Florida	52	1,600	11,000	1.5	13,000	8.5	2.3	0	1.6	12	36	91
Ohio	17	12,000	0	42	12,000	5.9	130	0	1.3	140	78	0
Michigan	0	12,000	0	0	12,000	0	58	0	0	58	0	0
Texas	37	8,900	2,800	4.9	12,000	1.3	2.8	.3	.1	4.5	390	28
California	380	1,100	9,200	0	11,000	0	0	0	0	0	32	60
Pennsylvania	1.3	11,000	160	0	11,000	2.5	96	0	0	98	230	1.0
Illinois	.7	8,800	0	1.0	8,800	7.0	320	0	3.0	320	5.0	0
Massachusetts	0	880	6,400	0	7,200	0	0	0	0	0	0	0
Indiana	1.2	7,200	0	1.0	7,200	.4	110	0	0	110	65	0
United States[1]	1,100	130,000	64,000	200	190,000	290	2,000	41	35	2,400	1,900	260

[1] Including Puerto Rico and Virgin Islands.

Table 51.--Water used for public supplies in Florida compared with larger use states, 1975, listed in order of all water withdrawn for public supply

[Modified from Murray and Reeves, 1977]

[Partial figures may not add to totals because of independent rounding]

State	Total population (thousands)	Population served (thousands)			Water withdrawn (million gallons per day)				Water delivered (million gallons per day)		
		Ground water	Surface water	All water	Ground water	Surface water	All water	Per capita	Industrial and commercial uses	Domestic use and losses[1]	Fresh-water consumed
California	21,113	8,540	11,300	19,900	1,700	2,000	3,700	185	720	3,000	1,500
New York	19,530	4,030	13,600	17,700	560	2,200	2,700	154	1,300	1,400	520
Illinois	10,692	3,690	7,000	10,700	700	1,400	2,100	199	630	1,500	21
Texas	12,236	4,370	5,190	9,560	840	840	1,700	176	550	1,100	730
Pennsylvania	11,828	1,860	7,540	9,400	350	1,300	1,700	178	480	1,200	170
Ohio	10,751	2,740	5,770	8,510	400	1,000	1,400	167	210	1,200	210
Michigan	9,141	1,400	5,670	7,070	240	950	1,200	168	650	530	98
Florida	8,485	6,010	807	6,820	980	170	1,100	168	210	930	590
United States[2]	217,482	64,700	110,000	175,000	11,000	19,000	29,000	168	9,100	20,000	6,700

[1] Includes public use.
[2] Including Puerto Rico and Virgin Islands.

Table 52.--Population and estimated water use in Florida, 1950-77

[Modified from Leach and Healy, 1980]

Year of inventory	Total population (thousands)	Total water withdrawn (Mgal/d)									Per capita use (gal/d)		Total water consumed (Mgal/d)
					Industrial uses			All uses					
		Public supplied	Rural domestic and livestock	Irrigation	Thermoelectric power production	Other industry	All industrial uses	Fresh	Saline	All water	Freshwater only	All water	
1950	2,771	170	55	410	(1)	(1)	286	(1)	(1)	921	(1)	332	(1)
1955	3,670	319	38	510	(1)	(1)	1,945	2,167	645	2,812	590	766	(1)
1956	3,941	390	(1)	1,182	(1)	(1)	2,227	(1)	(1)	3,799	(1)	964	(1)
1960	4,951	530	110	660	4,800	1,020	5,820	3,760	3,360	7,120	759	1,438	1,210
1965	5,805	710	142	3,200	8,100	961	9,061	6,852	6,261	13,113	1,180	2,259	1,639
1970	6,789	884	195	2,099	11,076	1,059	12,135	5,768	9,545	15,313	849	2,255	1,934
1975	8,485	1,146	266	2,867	13,135	1,003	14,138	6,915	11,502	18,417	815	2,170	(2) 2,393
1977	8,717	1,236	257	2,873	16,108	996	17,104	6,654	14,812	21,466	763	2,463	(2) 2,329

1 Data not available.
2 Does not include that portion of conveyance loss that is consumed.

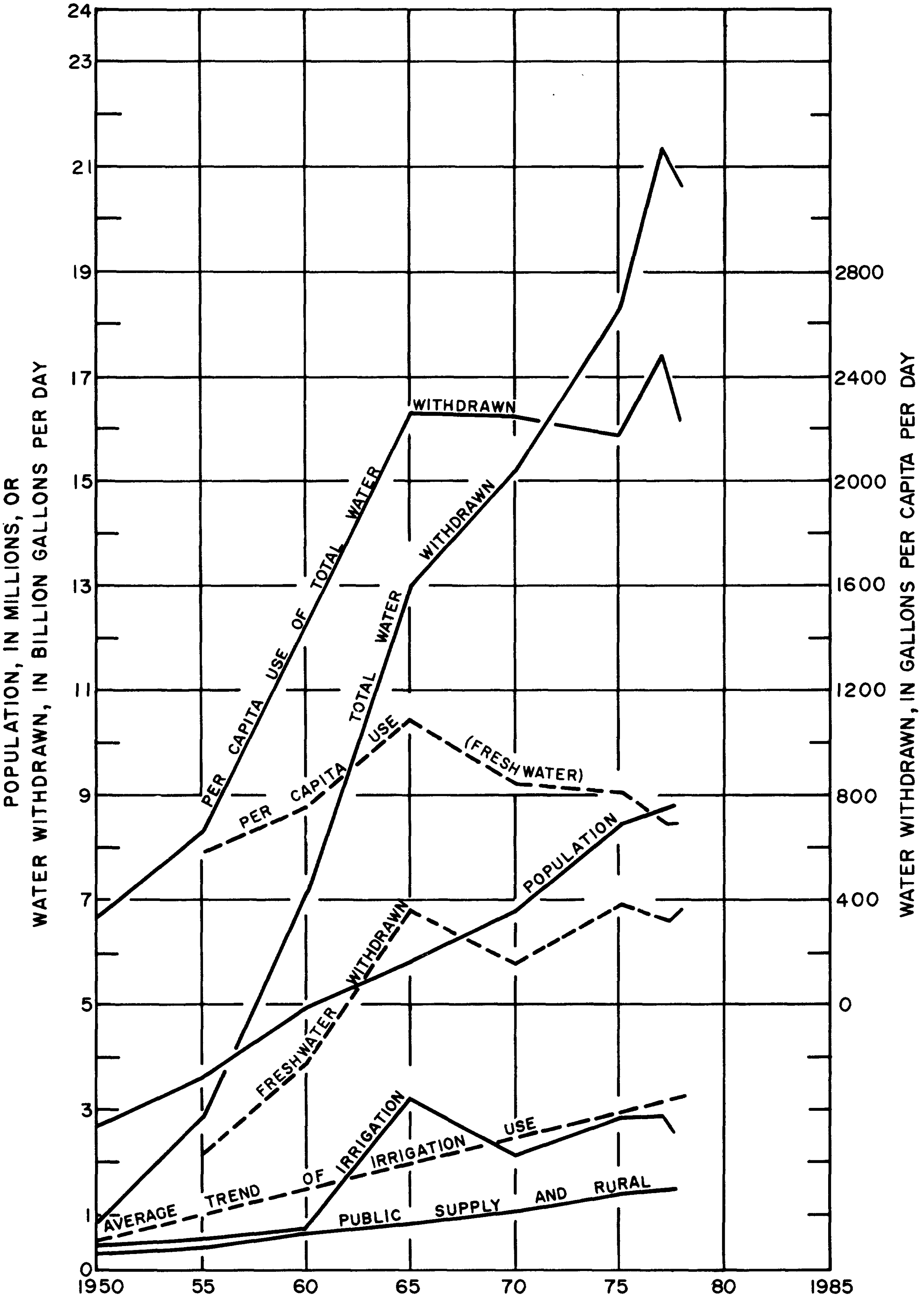


Figure 80.--Trends in population and withdrawals of water in Florida, 1950-78 (modified from Leach and Healy, 1980).

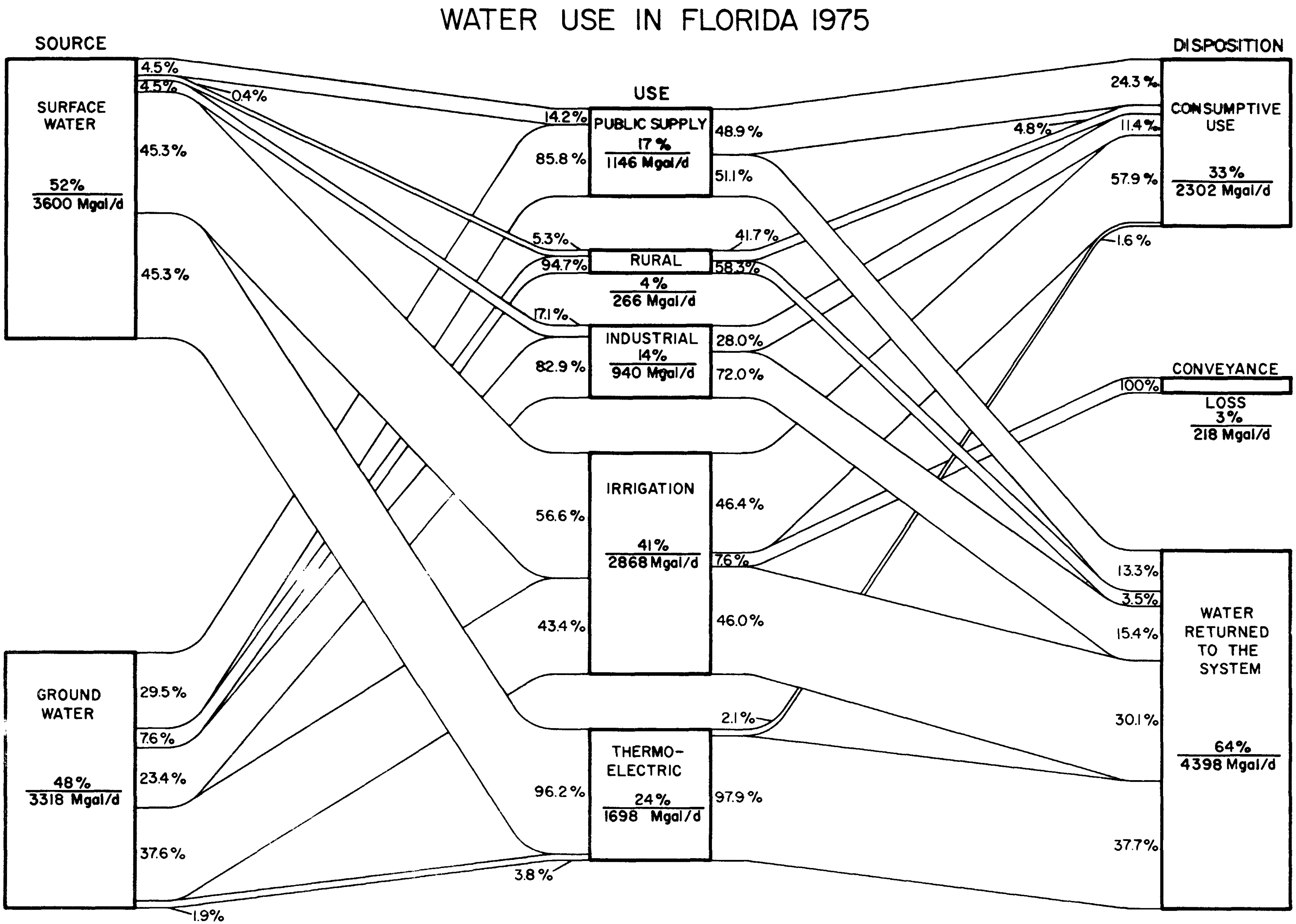


Figure 81.--Source, use, and disposition of freshwater withdrawn in Florida, 1975 (from Leach, 1978b).

The total water withdrawn in Florida in 1975 is listed by counties in table 53 and the freshwater use is portrayed in figure 82. The counties with the largest use of freshwater are those with combinations of large populations, industry, thermoelectric power, and irrigation. Polk County is the largest user of freshwater, more than 700 million gallons a day. This use is 1,000 times greater than the 0.7 million gallons a day used in Liberty County. Ten counties use more than 200 million gallons of freshwater a day and together account for 57 percent of the freshwater used in the State.

Water used for irrigation in Florida in 1975 constituted 41 percent of freshwater use. Use of water for irrigation and acreage irrigated by type of crops are given by counties in tables 54 and 55. Ground water furnished 43 percent of the irrigation water in Florida. Twelve counties relied entirely on ground water for irrigation. Citrus constituted 30 percent of the acreage irrigated. Palm Beach had the largest irrigated acreage, about one fourth that for the State, with sugar cane representing more than half the acreage irrigated. On the average, approximately 21 inches of water was applied for irrigation in Florida in 1975. The four counties with the largest use of water for irrigation, each using more than 200 million gallons a day in 1975, were Palm Beach, St. Lucie, Indian River, and Hendry (fig. 83). Irrigation use by these four counties was primarily from surface water and represented nearly 90 percent of irrigation water use in Florida in 1975.

Table 53.--Total water withdrawn in Florida for all uses by counties, 1975

[Modified from Leach, 1978b]

[Million gallons per day]

County	Municipal	Rural	Industrial		Irrigation	Thermoelectric		Total	
	Fresh	Fresh	Fresh	Saline	Fresh	Fresh	Saline	Fresh	Saline
Alachua	14.90	5.01	6.53	-	5.97	1.40	-	33.81	0.0
Baker	0.54	1.75	0.32	-	0.67	-	-	3.28	-
Bay	34.54	1.12	1.35	-	0.0	0.68	228.7	37.69	228.7
Bradford	0.83	1.08	3.96	-	0.06	-	-	5.93	-
Brevard	27.12	6.10	0.45	-	58.49	0.53	1,612.0	92.69	1,612.0
Broward	139.78	8.61	3.50	-	77.42	0.53	1,678.0	229.84	1,678.0
Calhoun	0.28	0.65	0.36	-	2.58	-	-	3.87	-
Charlotte	4.08	1.51	0.10	-	34.31	-	-	40.00	-
Citrus	9.59	3.38	1.32	-	0.47	0.63	919.0	6.39	919.0
Clay	5.01	2.28	10.92	-	0.04	-	-	18.25	-
Collier	11.93	1.40	0.0	-	69.52	-	-	82.85	-
Columbia	1.70	1.77	0.12	-	1.14	-	-	4.73	-
Dade	264.55	9.65	3.38	-	90.42	0.09	504.0	368.09	504.0
DeSoto	0.76	4.05	0.59	-	63.79	-	-	69.19	-
Dixie	0.42	0.64	3.54	-	0.15	-	-	4.75	-
Duval	95.42	7.80	48.77	-	2.02	42.12	653.8	196.13	653.8
Escambia	27.80	6.47	76.45	3.04	0.90	267.92	-	379.54	3.0
Flagler	0.62	0.38	0.0	-	8.39	-	-	9.39	-
Franklin	0.99	0.13	0.01	-	0.0	-	-	1.13	-
Gadsden	2.14	2.40	2.03	-	2.43	-	-	9.00	-
Gilchrist	0.38	0.54	0.03	-	0.18	-	-	1.13	-
Glades	0.20	1.10	0.0	-	52.78	-	-	54.08	-
Gulf	0.75	0.55	33.72	13.00	0.22	-	-	35.24	13.0
Hamilton	0.60	0.76	30.30	-	1.49	-	-	33.15	-
Hardee	1.20	3.95	1.45	-	90.51	0.23	-	97.34	-
Hendry	2.05	5.30	0.82	-	289.06	-	-	297.23	-
Hernando	0.75	5.14	61.68	-	0.69	-	-	68.26	-
Highlands	4.26	3.04	0.70	-	144.40	95.23	-	247.63	-
Hillsborough	59.87	26.13	16.12	45.00	45.90	2.41	3,031.0	150.43	3,076.0
Holmes	0.20	1.25	0.02	-	0.07	-	-	1.54	-
Indian River	4.49	3.14	0.44	-	297.82	4.30	60.0	306.32	60.0
Jackson	1.78	2.88	0.80	-	6.01	120.72	-	132.19	-
Jefferson	0.44	1.37	0.02	-	0.69	-	-	2.52	-
Lafayette	0.14	1.46	0.0	-	1.52	-	-	3.12	-
Lake	9.85	4.70	20.65	-	57.32	-	-	92.52	-

Table 53.--Total water withdrawn in Florida for all uses by counties, 1975--Continued

[Modified from Leach, 1978b]

[Million gallons per day]

County	Municipal	Rural	Industrial		Irrigation	Thermoelectric		Total	
	Fresh	Fresh	Fresh	Saline	Fresh	Fresh	Saline	Fresh	Saline
Lee	16.82	2.33	8.40	-	64.06	0.11	568.0	91.72	568.0
Leon	15.83	3.38	33.61	-	0.59	1.18	-	54.59	-
Levy	0.98	1.49	0.0	-	1.29	-	-	3.76	-
Liberty	0.09	0.25	0.33	-	0.0	-	-	0.67	-
Madison	1.09	1.05	0.03	-	1.84	-	-	4.01	-
Manatee	18.91	6.23	1.99	-	23.98	25.02	-	76.13	-
Marion	6.23	8.58	0.30	-	16.92	-	-	32.03	-
Martin	5.72	2.95	0.08	-	83.50	-	-	92.25	-
Monroe	7.67	0.0	0.0	-	0.0	0.10	47.5	7.77	47.5
Nassau	2.40	2.24	57.93	2.00	0.52	45.00	-	108.09	2.0
Okaloosa	9.31	2.39	6.05	-	0.72	-	-	18.47	-
Okeechobee	1.04	3.00	0.0	-	82.87	-	-	86.91	-
Orange	63.35	8.88	14.78	-	32.68	77.48	-	197.17	-
Osceola	3.65	2.72	0.70	-	12.14	0.50	-	19.26	-
Palm Beach	94.41	15.40	46.54	-	503.29	0.69	657.0	660.33	657.0
Pasco	2.96	13.60	25.01	-	47.19	0.23	670.0	88.99	670.0
Pinellas	76.97	6.98	1.30	-	33.77	0.14	794.0	119.16	794.0
Polk	31.23	11.94	272.23	-	99.35	298.80	-	713.55	-
Putnam	2.58	6.15	37.20	-	15.80	120.06	-	181.79	-
St. Johns	2.67	2.49	2.00	-	28.78	-	-	35.94	-
St. Lucie	6.14	4.78	0.19	-	368.09	-	-	379.20	-
Santa Rosa	3.40	1.29	17.67	-	0.33	-	-	22.69	-
Sarasota	10.31	8.03	2.99	-	19.99	-	-	41.32	-
Seminole	10.45	8.05	2.59	-	10.98	-	-	32.07	-
Sumter	0.61	2.11	16.06	-	3.39	-	-	22.17	-
Suwannee	1.13	1.54	2.39	-	1.42	172.91	-	179.39	-
Taylor	1.37	0.65	57.02	-	0.19	-	-	59.23	-
Union	0.55	0.92	0.0	-	0.20	-	-	1.67	-
Volusia	25.06	6.70	0.14	-	5.36	314.03	16.0	351.29	16.0
Wakulla	0.26	0.46	1.23	-	0.0	105.58	-	107.53	-
Walton	1.08	0.96	0.41	-	0.78	-	-	3.23	-
Washington	0.59	0.97	0.0	-	0.0	-	-	1.56	-
Total	1,146	266	940	63	2,867	1,696	11,439	6,915	11,502

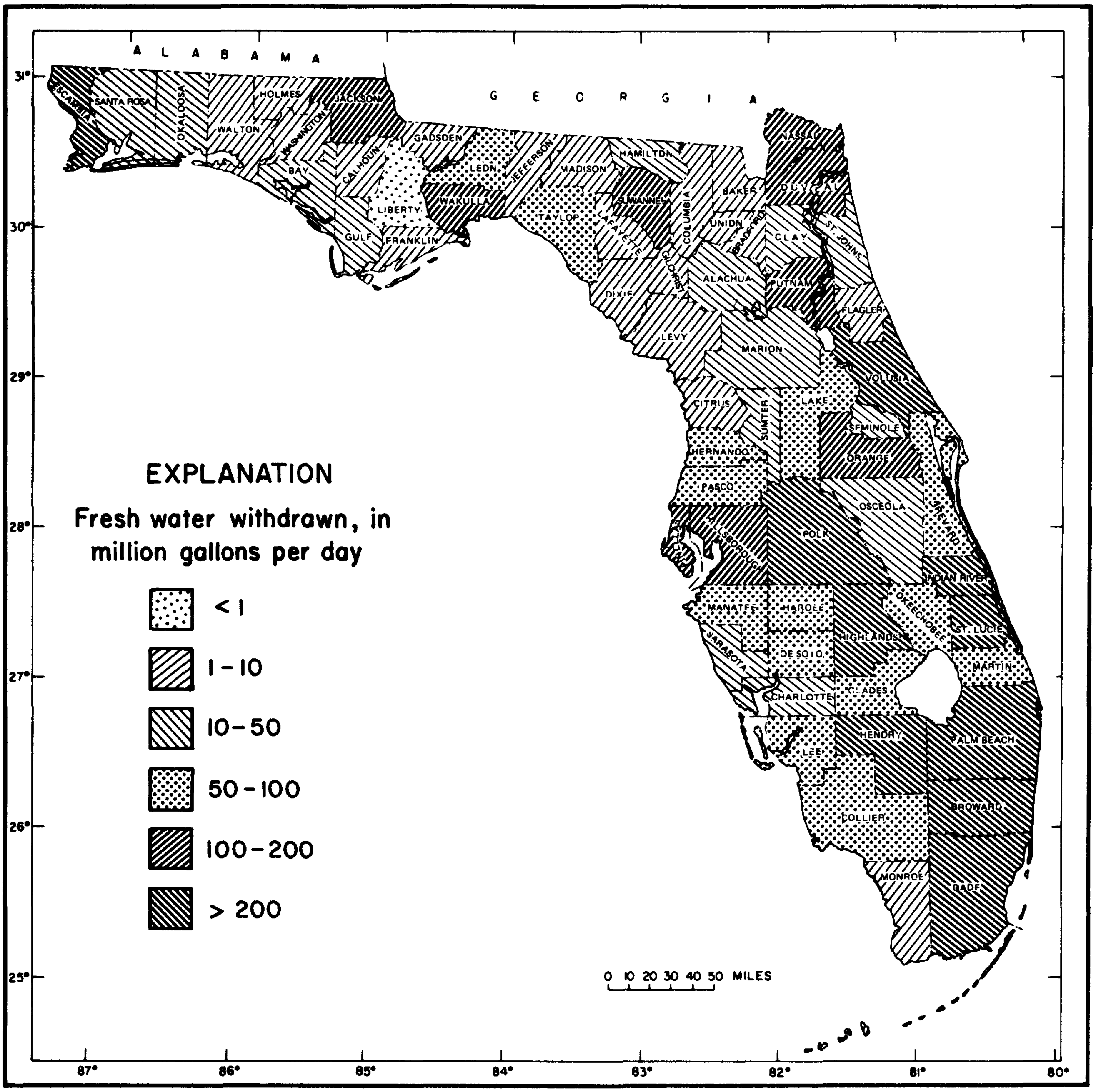


Figure 82.--Total freshwater withdrawn for all uses in Florida by counties, 1975 (from Leach, 1978b).

Table 54.--Water used for irrigation in Florida, by counties, 1975

[From Leach, 1978b]

		Total water withdrawn (ac-ft/yr)					Total water withdrawn (Mgal/d)				
County	Acres irrigated	Surface water	Ground water	All water	Convey loss	Consump use	Surface water	Ground water	All water	Convey loss	Consump use
Alachua	7,354	1,671	5,011	6,682	0	4,678	1.49	4.47	5.97	0.0	4.18
Baker	60	750	5	755	0	250	0.67	0.0	0.67	0.0	0.22
Bay	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Bradford	290	7	59	66	0	33	0.01	0.05	0.06	0.0	0.03
Brevard	29,685	24,100	41,400	65,500	3,100	13,600	21.52	36.97	58.49	2.77	12.14
Broward	10,800	66,700	20,000	86,700	8,700	16,400	59.56	17.86	77.42	7.77	14.65
Calhoun	372	1,575	1,317	2,892	0	578	1.41	1.18	2.58	0.0	0.52
Charlotte	11,300	0	38,420	38,420	0	14,507	0.0	34.31	34.31	0.0	12.95
Citrus	3,786	265	265	530	0	424	0.24	0.24	0.47	0.0	0.38
Clay	1,110	40	10	50	0	10	0.04	0.01	0.04	0.0	0.01
Collier	39,490	5,600	72,250	77,850	16,130	39,100	5.00	64.52	69.52	14.40	34.92
Columbia	1,815	127	1,146	1,273	0	891	0.11	1.02	1.14	0.0	0.80
Dade	51,554	3,250	98,000	101,250	0	37,200	2.90	87.51	90.42	0.0	33.22
Desoto	42,660	2,240	69,195	71,435	0	47,933	2.00	61.79	63.79	0.0	42.80
Dixie	411	52	119	171	0	34	0.05	0.11	0.15	0.0	0.03
Duval	2,338	251	2,015	2,266	0	1,133	0.22	1.80	2.02	0.0	1.01
Escambia	428	302	704	1,006	0	201	0.27	0.63	0.90	0.0	0.18
Flagler	6,900	0	9,400	9,400	0	0	0.0	8.39	8.39	0.0	0.0
Franklin	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Gadsden	3,350	2,724	0	2,724	0	545	2.43	0.0	2.43	0.0	0.49
Gilchrist	660	20	185	205	0	41	0.02	0.17	0.18	0.0	0.04
Glades	45,400	46,600	12,500	59,100	6,100	41,900	41.61	11.16	52.78	5.45	37.42
Gulf	300	0	250	250	0	100	0.0	0.22	0.22	0.0	0.09
Hamilton	3,580	167	1,506	1,673	0	335	0.15	1.34	1.49	0.0	0.30
Hardee	51,516	0	101,357	101,357	0	70,291	0.0	90.51	90.51	0.0	62.77
Hendry	155,000	237,600	86,100	323,700	31,000	189,300	212.18	76.89	289.06	27.68	169.04
Hernando	1,240	114	660	774	0	608	0.10	0.59	0.69	0.0	0.54
Highlands	139,650	64,500	97,200	161,700	8,400	49,800	57.60	86.80	144.40	7.50	44.47
Hillsborough	36,590	2,540	48,859	51,399	0	36,400	2.27	43.63	45.90	0.0	32.51
Holmes	150	83	0	83	0	0	0.07	0.0	0.07	0.0	0.0
Indian River	84,230	289,100	44,400	333,500	37,700	59,100	258.17	39.65	297.82	33.67	52.78
Jackson	17,250	673	6,053	6,726	0	1,681	0.60	5.41	6.01	0.0	1.50
Jefferson	1,188	86	692	778	0	194	0.08	0.62	0.69	0.0	0.17
Lafayette	3,056	168	1,530	1,698	0	424	0.15	1.37	1.52	0.0	0.38
Lake	65,550	21,247	42,936	64,183	0	47,997	18.97	38.34	57.32	0.0	42.86
Lee	42,200	17,390	54,350	71,740	970	42,200	15.53	48.53	64.06	0.87	37.68
Leon	503	173	487	660	0	0	0.15	0.43	0.59	0.0	0.0
Levy	2,880	144	1,296	1,440	0	288	0.13	1.16	1.29	0.0	0.26
Liberty	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Madison	5,610	206	1,857	2,063	0	518	0.18	1.66	1.84	0.0	0.46
Manatee	26,348	1,343	25,514	26,857	0	3,064	1.20	22.78	23.98	0.0	2.74
Marion	43,228	952	18,000	18,952	0	15,160	0.85	16.07	16.92	0.0	13.54
Martin	53,400	85,900	7,600	93,500	11,200	46,000	76.71	6.79	83.50	10.00	41.08
Monroe	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Nassau	175	0	580	580	0	400	0.0	0.52	0.52	0.0	0.36
Okaloosa	830	385	425	810	0	162	0.34	0.38	0.72	0.0	0.14
Okeechobee	45,100	17,600	75,200	92,800	2,300	18,400	15.72	67.15	82.87	2.05	16.43
Orange	30,700	22,100	14,500	36,600	2,900	22,000	19.74	12.95	32.68	2.59	19.65
Osceola	9,300	4,200	9,400	13,600	500	6,800	3.75	8.39	12.14	0.45	6.07
Palm Beach	444,000	524,500	39,100	563,600	68,400	367,800	468.38	34.92	503.29	61.08	328.45
Pasco	27,800	10,563	42,276	52,839	0	32,676	9.43	37.75	47.19	0.0	29.18
Pinellas	10,000	0	37,818	37,818	0	11,200	0.0	33.77	33.77	0.0	10.00
Polk	101,765	5,563	105,692	111,255	0	106,600	4.97	94.38	99.35	0.0	95.19
Putnam	11,380	0	17,691	17,691	0	3,538	0.0	15.80	15.80	0.0	3.16
St. Johns	20,300	0	32,225	32,225	0	25,780	0.0	28.78	28.78	0.0	23.02
St. Lucie	97,200	357,400	54,800	412,200	46,600	78,200	319.16	48.94	368.09	41.61	69.83
Santa Rosa	2,002	0	366	366	0	73	0.0	0.33	0.33	0.0	0.07
Sarasota	14,475	2,238	20,145	22,383	0	18,674	2.00	17.99	19.99	0.0	16.68
Seminole	9,630	0	12,300	12,300	240	8,300	0.0	10.98	10.98	0.21	7.41
Sumter	6,580	190	3,604	3,794	0	2,883	0.17	3.22	3.39	0.0	2.57
Suwannee	3,990	0	1,592	1,592	0	318	0.0	1.42	1.42	0.0	0.28
Taylor	326	18	195	213	0	43	0.02	0.17	0.19	0.0	0.04
Union	500	25	200	225	0	45	0.02	0.18	0.20	0.0	0.04
Volusia	5,020	0	6,000	6,000	0	4,500	0.0	5.36	5.36	0.0	4.02
Wakulla	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Walton	7,028	210	665	875	0	144	0.19	0.59	0.78	0.0	0.13
Washington	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Total:	1,841,333	1,823,652	1,387,422	3,211,074	244,240	1,491,454	1,628.52	1,238.96	2,867.48	218.11	1,331.86

Table 55.--Acres irrigated by crop type in Florida, by counties, 1975

[From Leach, 1978b]

County	Citrus	Truck farming	Pasture	Sugar cane	Tobacco	Corn	Water-melons	Other	Total
Alachua	0	655	1,080	0	1,479	1,440	0	2,700	7,354
Baker	0	0	0	0	10	0	0	50	60
Bay	0	0	0	0	0	0	0	0	0
Bradford	0	100	0	0	50	0	0	140	290
Brevard	6,000	0	23,200	0	0	0	0	485	29,685
Broward	0	5,000	0	0	0	0	0	5,800	10,800
Calhoun	0	0	0	0	0	120	0	252	372
Charlotte	4,450	1,080	4,640	0	0	0	1,000	130	11,300
Citrus	3,500	5	0	0	0	80	200	1	3,786
Clay	0	50	1,000	0	0	0	0	60	1,110
Collier	7,000	22,500	5,000	0	0	1,000	3,500	490	39,490
Columbia	0	0	100	0	935	480	220	80	1,815
Dade	3,719	34,185	750	0	0	0	0	12,900	51,554
DeSoto	30,000	1,000	8,000	0	0	160	3,500	0	42,660
Dixie	0	33	80	0	73	0	225	0	411
Duval	0	0	0	0	0	0	0	2,338	2,338
Escambia	0	0	0	0	0	0	0	428	428
Flagler	0	4,500	2,400	0	0	0	0	0	6,900
Franklin	0	0	0	0	0	0	0	0	0
Gadsden	0	1,500	0	0	1,000	500	0	350	3,350
Gilchrist	0	60	100	0	200	200	100	0	660
Glades	2,200	1,200	26,000	16,000	0	0	0	0	45,400
Gulf	0	0	0	0	0	0	0	300	300
Hamilton	0	200	1,000	0	1,600	500	200	80	3,580
Hardee	23,000	2,500	25,000	0	0	0	1,000	16	51,516

Table 55.--Acres irrigated by crop type in Florida, by counties, 1975--Continued

[From Leach, 1978b]

County	Citrus	Truck farming	Pasture	Sugar cane	Tobacco	Corn	Water-melons	Other	Total
Hendry	30,000	12,000	88,000	25,000	0	0	0	0	155,000
Hernando	650	30	60	0	0	0	100	400	1,240
Highlands	35,000	3,000	100,000	0	0	0	250	1,400	139,650
Hillsborough	20,000	9,250	5,000	0	0	0	0	2,340	36,590
Holmes	0	100	0	0	0	0	0	50	150
Indian River	50,000	0	34,000	0	0	0	0	230	84,230
Jackson	0	12,500	1,000	0	100	2,500	800	350	17,250
Jefferson	0	200	510	0	50	0	100	328	1,188
Lafayette	0	100	200	0	700	50	2,000	6	3,056
Lake	52,000	9,800	2,500	0	0	0	750	500	65,550
Lee	7,000	5,700	25,000	0	0	0	1,500	3,000	42,200
Leon	0	0	0	0	0	280	0	223	503
Levy	0	200	160	0	120	1,000	1,000	400	2,880
Liberty	0	0	0	0	0	0	0	0	0
Madison	0	760	100	0	1,130	1,200	200	2,220	5,610
Manatee	7,000	7,000	8,000	0	0	600	1,000	2,748	26,348
Marion	6,000	6,000	20,000	0	18	5,000	5,000	1,210	43,228
Martin	41,000	3,000	5,000	3,000	0	0	0	1,400	53,400
Monroe	0	0	0	0	0	0	0	0	0
Nassau	0	0	0	0	0	0	0	175	175
Okaloosa	0	0	520	0	0	0	0	310	830
Okeechobee	4,200	800	40,000	0	0	0	100	0	45,100
Orange	19,000	4,500	0	0	0	4,500	0	2,700	30,700
Osceola	8,000	0	200	0	500	0	300	300	9,300
Palm Beach	13,000	119,000	60,000	245,000	0	0	0	7,000	444,000

Table 55.--Acres irrigated by crop type in Florida, by counties, 1975--Continued

County	Citrus	Truck farming	Pasture	Sugar cane	Tobacco	Corn	Water-melons	Other	Total
Pasco	18,000	800	5,000	0	0	0	0	4,000	27,800
Pinellas	1,000	0	1,000	0	0	0	0	8,000	10,000
Polk	91,650	2,000	7,000	0	0	0	0	1,115	101,765
Putnam	800	4,780	3,000	0	0	2,500	0	300	11,380
St. Johns	60	19,910	0	0	0	0	0	330	20,300
St. Lucie	73,000	1,200	22,000	0	0	0	200	800	97,200
Santa Rosa	0	1,900	0	0	0	0	0	102	2,002
Sarasota	1,500	2,000	10,000	0	0	850	0	125	14,475
Seminole	5,000	4,170	0	0	0	0	0	460	9,630
Sumter	500	2,500	1,000	0	15	100	2,200	265	6,580
Suwannee	0	50	0	0	3,000	500	400	40	3,990
Taylor	0	20	0	0	200	25	0	81	326
Union	0	0	0	0	250	0	0	250	500
Volusia	600	3,000	0	0	0	0	0	1,420	5,020
Wakulla	0	0	0	0	0	0	0	0	0
Walton	0	6,878	0	0	0	0	0	150	7,028
Washington	0	0	0	0	0	0	0	0	0
Total	564,829	317,716	537,600	289,000	11,430	23,585	25,845	71,328	1,841,333

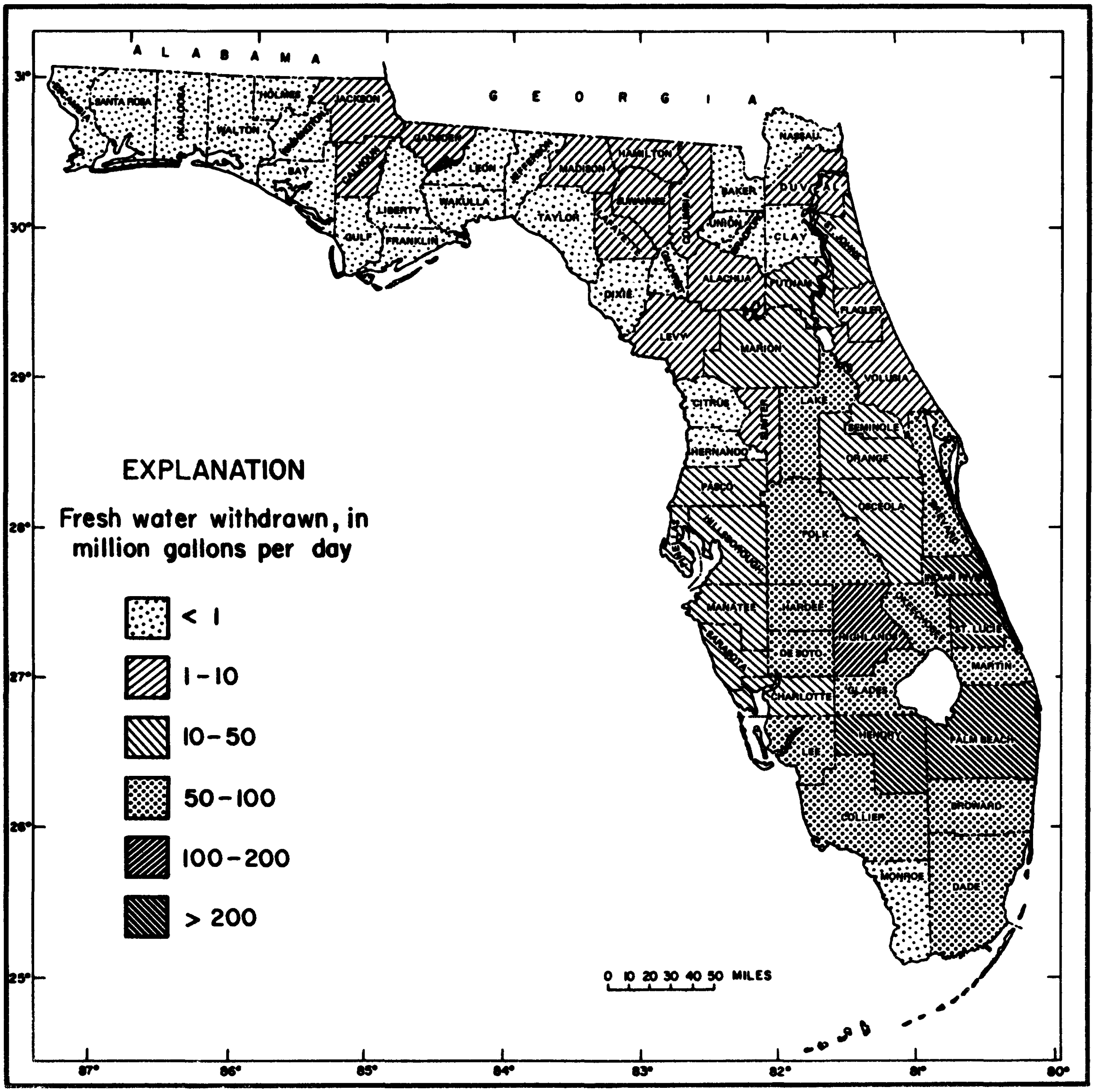


Figure 83.--Water withdrawn for irrigation (including conveyance losses) in Florida, by counties, 1975 (from Leach, 1978b).

CONVERSION FACTORS

Tables of inch-pound equivalents

Length

1 inch = 0.083333 foot = 0.027778 yard

1 foot = 12 inches = 0.33333 yard = 0.00018939 mile

1 yard = 36 inches = 3 feet = 0.00056818 mile

1 mile = 63,360 inches = 5,280 feet = 1,760 yards

1 fathom = 6 feet

Surface

1 square inch = 0.06944 square foot = 0.0007716 square yard

1 square foot = 144 square inches = 0.11111 square yard = 0.000022957 acre

1 square yard = 1,296 square inches = 9 square feet = 0.0002066 acre

1 acre = 6,272,640 square inches = 43,560 square feet = 4,840 square yards = 0.0015625 square mile

1 square mile = 27,878,400 square feet = 3,097,600 square yards = 640 acres

Volume

1 cubic inch = 0.004329 U.S. gallon = 0.0005787 cubic foot

1 U.S. gallon = 231 cubic inches = 0.13368 cubic foot = 0.00000307 acre-foot

1 cubic foot = 1,728 cubic inches = 7.4805 U.S. gallons = 0.037037 cubic yard = 0.000022957 acre-foot

1 cubic yard = 46,656 cubic inches = 27 cubic feet = 0.00061983 acre-foot

1 acre-foot = 325,851 U.S. gallons = 43,560 cubic feet = 1,613.33 cubic yards

Velocity

1 foot per second = 0.6818 miles per hour

1 mile per hour = 1.467 feet per second = 0.869 knot

1 knot = 1.151 miles per hour

Hydraulics

1 U.S. gallon of water = 8.34 pounds avoirdupois

1 cubic foot of water = 62.5 pounds avoirdupois

1 cubic foot per second = 7.48 U.S. gallons per second = 448.8 U.S. gallons per minute = 26,928 U.S. gallons per hour = 646,317 U.S. gallons per day (0.646 million gallons per day) = 60 cubic feet per minute = 3,600 cubic feet per hour = 86,400 cubic feet per day = 31,536,000 cubic feet per year = 0.9917 acre-inch per hour = 1.983471 acre-feet per day = 723.966942 acre-feet per year

1 million gallons per day = 694 gallons per minute = 1.55 cubic feet per second = 3.07 acre-feet per day = 1,121 acre-feet per year

1 acre-foot per day = 226.3 gallons per minute = 0.32544 million gallons per day = 0.50417 cubic feet per second

1 billion cubic feet = 11,574 cubic feet per second for one day = 413 cubic feet per second for 28-day month = 399 cubic feet per second for 29-day month = 386 cubic feet per second for 30-day month = 373 cubic feet per second for 31-day month

100 gallons per minute = 0.223 cubic feet per second = 0.442 acre-foot in one day

1 cubic foot per second for 1 year (365 days) = 1 square mile 1.1312 feet (13.5744 inches) deep

1 square mile one inch deep = 2,323,200 cubic feet = 0.0737 cubic feet per second for one year

Miscellaneous

Acceleration of gravity, g, = 32.174 ft/s^2

1 atmosphere (mean) = 14.697 pounds per square inch = 1.0582 tons per square foot = 33.95 feet of water at 62°F = 760 mm. of mercury at 32°F at sea level

1 foot deep (head of 1 foot) = 0.434 pound pressure on 1 square inch

1 horsepower = 5,694,120 foot-gallons per day = 550 foot-pounds per second = 33,000 foot-pounds per minute = 1,980,000 foot-pounds per hour

1 cubic foot per second falling 8.81 feet = 1 horsepower

1 cubic foot per second falling 10 feet = 1.135 horsepower

1 cubic foot per second falling 11 feet = 1 horsepower, 80 percent efficiency

1 avoirdupois pound = 7,000 grains = 0.4436 kilogram

1 kilogram = 1,000 grams = 0.001 tonne = 15,432 grains = 2.2046 pounds avoirdupois

1 milligram per liter = 1 part per million = 0.058 gram per gallon

1 grain per gallon = 17.12 milligrams per liter

Table of Inch-Pound/Metric Equivalents

Factors for Converting Inch-Pound Units to International System Units (SI)

Multiply inch-pound units	By	To obtain SI units
	Length	
inches (in)	2.54×10^{1}	millimeters (mm)
	2.54×10^{0}	centimeters (cm)
	2.54×10^{-2}	meters (m)
feet (ft)	3.048×10^{-1}	meters (m)
miles (mi)	1.609×10^{0}	kilometers (km)
	Area	
acres	4.047×10^{3}	square meters (m^2)
	4.047×10^{-1}	square hectometers (hm^2)
	4.047×10^{-3}	square kilometers (km^2)
square miles (mi^2)	2.590×10^{0}	square kilometers (km^2)
	Volume	
gallons (gal)	3.785×10^{0}	liters (L)
	3.785×10^{0}	cubic decimeters (dm^3)
	3.785×10^{-3}	cubic meters (m^3)
million gallons (Mgal)	3.785×10^{3}	cubic meters (m^3)
	3.785×10^{-3}	cubic hectometers (hm^3)
cubic feet (ft^3)	2.832×10^{1}	cubic decimeters (dm^3)
	2.832×10^{-2}	cubic meters (m^3)
cubic feet per second days	2.447×10^{3}	cubic meters (m^3)
	2.447×10^{-3}	cubic hectometers (hm^3)
acre-feet (acre-ft)	1.233×10^{3}	cubic meters (m^3)
	1.233×10^{-3}	cubic hectometers (hm^3)
	1.233×10^{-6}	cubic kilometers (km^3)
	Flow	
cubic feet per second (ft^3/s)	2.832×10^{1}	liters per second (L/s)
	2.832×10^{1}	cubic decimeters per second (dm^3/s)
	2.832×10^{-2}	cubic meters per second (m^3/s)
gallons per minute (gal/min)	6.309×10^{-2}	liters per second (L/s)
	6.309×10^{-2}	cubic decimeters per second (dm^3/s)
	6.309×10^{-5}	cubic meters per second (m^3/s)
million gallons per day (Mgal/d)	4.381×10^{1}	cubic decimeters per second (dm^3/s)
	4.381×10^{-2}	cubic meters per second (m^3/s)
	Mass	
tons (short)	9.072×10^{-1}	megagrams (mg) or metric tons

Table of map series scale equivalents

Series	Scale	Inches/mile (centimeters/ kilometer)	Miles/inch (kilometers/ centimeter)	Distance on map/ distance on ground
7½ minute	1:20,000	(5.0)	(0.20)	1 centimeter/200 meters
	1:24,000	2.64000	0.378787	1 inch/2,000 feet
	1:25,000	(4.0)	(0.25)	1 centimeter/250 meters
	1:30,000	2.11200	0.47349	1 inch/2,500 feet
	1:31,680	2.00000	0.50000	1 inch/0.5 mile
	1:45,000	1.40800	0.71023	1 inch/approx. .07 miles
15-minute	1:50,000	(2.0)	(0.5)	1 centimeter/500 meters
	1:62,500	1.01376	0.98642	1 inch/approx. 1 mile
	1:63,360	1.00000	1.00000	1 inch/1 mile
	1:90,000	0.70400	1.42046	1 inch/approx. 1.4 miles
Intermediate	1:100,000	(1.0)	(1.0)	1 centimeter/1 kilometer
	1:125,000	0.50688	1.97285	1 inch/approx. 2 miles
	1:126,720	0.50000	2.00000	1 inch/2 miles
1:250,000	1:250,000	0.25344	3.94570	1 inch/approx. 4 miles
		(0.4)	(2.5)	1 centimeter/2.5 kilometers
State base	1:500,000	0.12672	7.89141	1 inch/approx. 8 miles
		(0.2)	(5.0)	1 centimeter/5 kilometers
International maps of the world (IMW)	1:1,000,000	0.06336	15.78282	1 inch/approx. 16 miles
		(0.1)	(10.0)	1 centimeter/10 kilometers
U.S. bases	1:2,000,000	0.03168	31.56566	1 inch/approx. 32 miles
		(0.05)	(20.0)	1 centimeter/20 kilometers
	1:2,500,000	0.025344	39.4570	1 inch/approx. 40 miles
		(0.04)	(25.0)	1 centimeter/25 kilometers
	1:3,168,000	0.020000	50.00000	1 inch/50 miles
	1:5,000,000	0.012672	78.9141	1 inch/approx. 80 miles
		(0.02)	(50.0)	1 centimeter/50 kilometers
	1:6,336,000	0.010000	100.00000	1 inch/100 miles
	1:10,000,000	0.006336	157.8282	1 inch/approx. 158 miles
		(0.01)	(100.0)	1 centimeter/100 kilometers

Table of Chemical Equivalents

[Conversion of milligrams per liter to milliequivalents per liter]

Ion	Multiply by	Ion	Multiply by
Aluminum (Al^{+3})	0.11119	Iodide (I^{-1})	0.00788
Ammonia as NH^{+1}	.05544	Iron (Fe^{+3})	.05372
Arsenic (As^{+3})	.04004	Lead (Pb^{+2})	.00965
Barium (Ba^{+2})	.01456	Lithium (Li^{+1})	.14411
Bicarbonate (HCO_3^{-1})	.01639	Magnesium (Mg^{+2})	.08226
Bromide (Br^{-1})	.01251	Manganese (Mn^{+2})	.03640
Cadmium (Cd^{+2})	.01779	Mercury (Hg^{+2})	.00997
Calcium (Ca^{+2})	.04990	Nickel (Ni^{+2})	.03406
Carbonate (CO_3^{-2})	.03333	Nitrate (NO_3^{-1})	.01613
Chloride (Cl^{-1})	.02821	Nitrite (NO_2^{-1})	.02174
Chromium (Cr^{+6})	.11539	Phosphate (PO_4^{-3})	.03159
Cobalt (Co^{+2})	.03394	Potassium (K^{+1})	.02557
Copper (Cu^{+2})	.03148	Sodium (Na^{+1})	.04350
Cyanide (CN^{-1})	.03844	Strontium (Sr^{+2})	.02283
Fluoride (F^{-1})	.05264	Sulfate (SO_4^{-2})	.02082
Hydrogen (H^{+1})	.99209	Sulfide (S^{-2})	.06238
Hydroxide (OH^{-1})	.05880	Zinc (Zn^{+2})	.03060

Tables of Temperature Equivalents

Fahrenheit to Celsius

$$°C = 0.5555(°F - 32)$$
$$= 5/9(°F - 32)$$

°F	°C	°F	°C	°F	°C
5	-15.00	42	5.56	78	25.56
6	-14.44	43	6.11	79	26.11
7	-13.89	44	6.67	80	26.67
8	-13.33	45	7.22	81	27.22
9	-12.78	46	7.78	82	27.78
10	-12.22	47	8.33	83	28.33
11	-11.67	48	8.89	84	28.89
12	-11.11	49	9.44	85	29.44
13	-10.56	50	10.00	86	30.00
14	-10.00	51	10.56	87	30.56
15	- 9.44	52	11.11	88	31.11
16	- 8.89	53	11.67	89	31.67
17	- 8.33	54	12.22	90	32.22
18	- 7.78	55	12.78	91	32.78
19	- 7.22	56	13.33	92	33.33
20	- 6.67	57	13.89	93	33.89
21	- 6.11	58	14.44	94	34.44
22	- 5.56	59	15.00	95	35.00
23	- 5.00	60	15.56	96	35.56
24	- 4.44	61	16.11	97	36.11
25	- 3.89	62	16.67	98	36.67
26	- 3.33	63	17.22	99	37.[illegible]
27	- 2.78	64	17.78	100	37.78
28	- 2.22	65	18.3[illegible]	101	38.33
29	- 1.67	66	18.89	102	38.89
30	- 1.11	67	19.44	103	39.44
31	- 0.56	68	20.00	104	40.00
32	0.00	69	20.56	105	40.56
33	0.56	70	21.11	106	41.11
34	1.11	71	21.67	107	41.67
35	1.67	72	22.22	108	42.22
36	2.22	73	22.78	109	42.78
37	2.78	74	23.33	110	43.33
38	3.33	75	23.89	111	43.89
39	3.89	76	24.44	112	44.44
40	4.44	77	25.00	113	45.00
41	5.00				

Tables of Temperature Equivalents--Cont.

Celsius to Fahrenheit

$$^{\circ}F=1.800(^{\circ}C)+32$$
$$=5/9(^{\circ}F-32)$$

°C	°F	°C	°F	°C	°F
-15	5.0	5	41.0	25	77.0
-14	6.8	6	42.8	26	78.8
-13	8.6	7	44.6	27	80.6
-12	10.4	8	46.4	28	82.4
-11	12.2	9	48.2	29	84.2
-10	14.0	10	50.0	30	86.0
- 9	15.8	11	51.8	31	87.8
- 8	17.6	12	53.6	32	89.6
- 7	19.4	13	55.4	33	91.4
- 6	21.2	14	57.2	34	93.2
- 5	23.0	15	59.0	35	95.0
- 4	24.8	16	60.8	36	96.8
- 3	26.6	17	62.6	37	98.6
- 2	28.4	18	64.4	38	100.4
- 1	30.2	19	66.2	39	102.2
0	32.0	20	68.0	40	104.0
1	33.8	21	69.8	41	105.8
2	35.6	22	71.6	42	107.6
3	37.4	23	73.4	43	109.4
4	39.2	24	75.2	44	112.2

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U.S. GOVERNMENT PRINTING OFFICE: 1981-740-127 35