GROUND-WATER RESOURCES OF THE COOSA RIVER BASIN IN GEORGIA AND ALABAMA—*SUBAREA 6* OF THE APALACHICOLA-CHATTAHOOCHEE-FLINT AND ALABAMA-COOSA-TALLAPOOSA RIVER BASINS

U.S. GEOLOGICAL SURVEY

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NORTHWEST FLORIDA WATER MANAGEMENT DISTRICT

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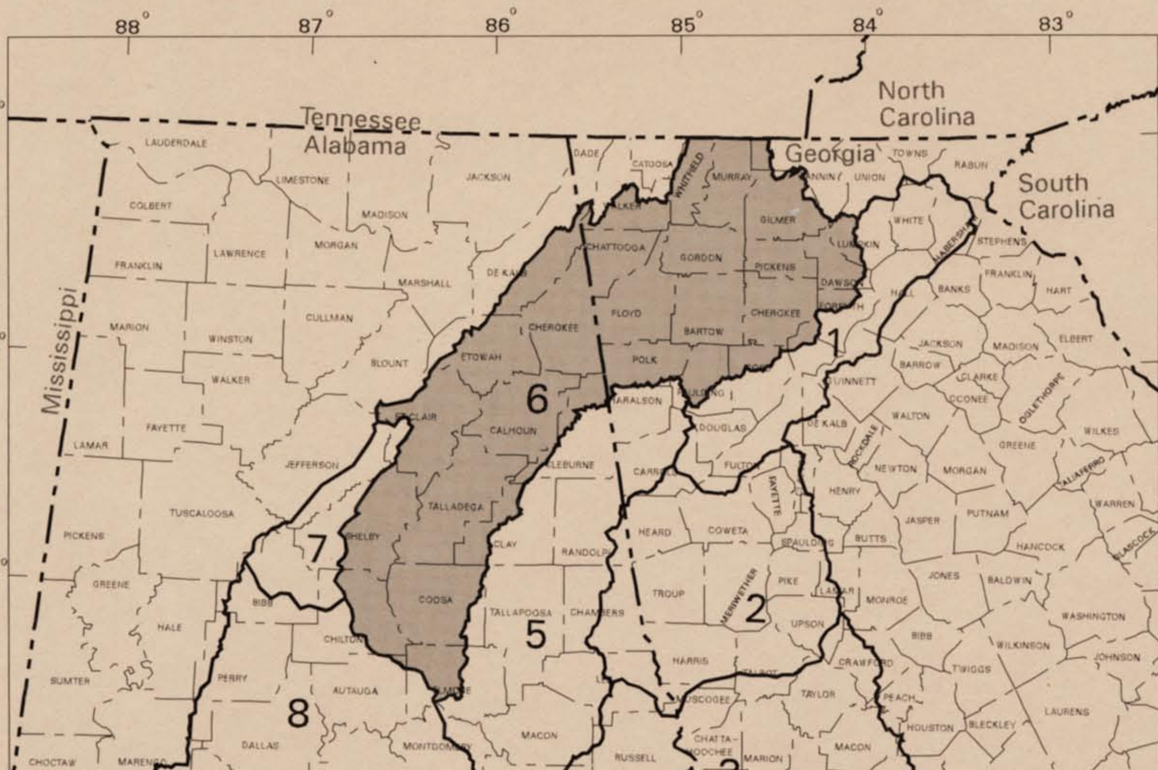

Location of subareas in the Apalachicola–Chattahoochee–Flint and Alabama–Coosa–Tallapoosa River basins. Subarea described in this report is shaded.

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CONVERSION FACTORS, ABBREVIATIONS AND ACRONYMS, AND VERTICAL DATUM

CONVERSION FACTORS

Multiply	by	to obtain
Length		
inch (in.)	25.4	millimeter
inch per year (in/yr)	25.4	millimeter per year
foot (ft)	0.3048	meter
square foot (ft^2)	0.0929	square meter
mile (mi)	1.609	kilometer
feet per mile (ft/mi)	0.1894	meter per kilometer
Area		
acre	4,047	square meter
square mile (mi^2)	2.59	square kilometer
Volumetric rate and volume		
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
	448.831	gallon per minute
	0.6463	million gallons per day
cubic foot per second per square mile ($ft^3/s/mi^2$)	0.01093	cubic meter per second per square kilometer
gallon per minute (gal/min)	6.309×10^{-5}	cubic meter per second
	2.228×10^{-3}	cubic foot per second
	0.06308	liter per second
	1,440	gallon per day
gallon per day (gal/d)	3.785×10^{-3}	cubic meters per day
million gallons per day (Mgal/d)	1.547	cubic foot per second
	63.09	cubic meter per second
	694.44	gallons per minute
gallon per minute per foot of drawdown (gal/min/ft)	1.24×10^{-2}	cubic meters per minute per minute per meter of drawdown
acre-foot	325,900	gallon
Transmissivity		
foot squared per day (ft^2/d)	0.0929	meter squared per day

Temperature

Temperature in degrees Fahrenheit (° F) can be converted to degrees Celsius as follows:

× C = 5/9 x (° F - 32)

ABBREVIATIONS AND ACRONYMS

7Q2	7-day, 2-year low flow
ACF	Apalachicola-Chattahoochee-Flint River basin
ACT	Alabama-Coosa-Tallapoosa River basin
ADAPS	Automated Data Processing System
Corps	U.S. Army Corps of Engineers
MOA	Memorandum of Agreement
GWSI	Ground Water Site Inventory database
MOVE.1	Maintenance of Variance Extension, Type 1; computer program (Hirsch, 1982)
RORA	Computer program (Rutledge, 1993)
SWGW	Surface Water-Ground Water; computer program (Mayer and Jones, 1996)
USGS	U.S. Geological Survey

VERTICAL DATUM

Sea Level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NVGD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

GLOSSARY

7Q2—Minimum average stream discharge for 7 consecutive days for a 2-year recurrence interval.

Alluvium—Sediment transported and deposited by flowing water.

Altitude—As used in this report, refers to the distance above sea level.

Anisotropic—Condition having varying hydraulic properties of an aquifer according to flow direction.

Annual—As used in this report, refers to a water year.

Aquifer—A 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.

Baseflow—That part of the stream discharge that is not attributable to direct runoff from precipitation or melting snow; it is usually sustained by ground-water discharge.

Bedrock—A general term for the consolidated rock that underlies soils or other unconsolidated surficial material.

Clastics—Rocks composed of fragments of older rocks, for example, sandstone.

Colluvium—Heterogeneous aggregates of rock detritus resulting from the transporting action of gravity.

Cone of depression—A depression of the potentiometric surface, often in the shape of an inverted cone, that develops around a well which is being pumped.

Confined aquifer—An aquifer bounded above and below by impermeable beds or by beds of distinctly lower permeability than that of the aquifer itself; ground water in the aquifer is under pressure significantly greater than that of the atmosphere.

Continuous-record gaging station—Complete records of discharge obtained using a continuous stage-recording device through which either instantaneous or mean-daily discharge may be computed for any time, or any period of time, during the period of record.

Crystalline rock—A general term for igneous and metamorphic rocks.

Darcian flow—Flow that is laminar and in which inertia can be neglected.

Dendritic drainage—A branching stream pattern that resembles the branching of trees.

Drought—There is no accepted definition of drought. As used in this report, a period of deficient rainfall extending long enough to cause streamflow to fall to unusually low levels for the period of record.

Evapotranspiration—The combined evaporation of water from the soil surface and transpiration from plants.

Faults—Fractures in the Earth along which there has been displacement parallel to the fault plane.

Foliation—A planar or layered structure in metamorphic rocks that is caused by parallel orientation of minerals or bands of minerals.

Fluvial—Pertaining to the actions of rivers.

Fracture—Breaks in rocks due to intense folding or faulting.

Geologic contact—The boundary surface between one body of rock or sediment and another.

Ground-water recharge—The process of water addition to the saturated zone or the volume of water added by this process.

Head, static—The height above a standard datum of the surface of a column of water (or other liquid) that can be supported by the static pressure at a given point. The static head is the sum of the elevation head and the pressure head.

Head, total—The total head of a liquid at a given point is the sum of three components: (a) the elevation head, which is equal to the elevation of the point above a datum, (b) the pressure head, which is the height of a column of static water that can be supported by the static pressure at the point, and (c) the velocity head, which is the height to which the kinetic energy of the liquid is capable of lifting the liquid.

Heterogeneous—Pertaining to a substance having different characteristics in differing locations.

Hydraulic conductivity—The capacity of a rock to transmit water. It is expressed as the volume of water that will move through a medium in a unit of time under a unit hydraulic gradient through a unit area measured perpendicular to the direction of flow.

Hydraulic gradient—A change in the static pressure of ground water, expressed in terms of the height of water above a datum, per unit of distance in a given direction.

Hydrograph separation—Division of the stream hydrograph into components of aquifer discharge and surface runoff.

Igneous rock—Rocks which have solidified or crystallized from a hot fluid mass called magma.

Intergranular porosity—Porosity resulting from space between grains.

Intrusive igneous rocks—Masses of igneous rock formed by magma cooling beneath the surface.

Isotropic—Condition in which hydraulic properties of an aquifer are equal in all directions.

Joints—Fractures in rocks, often across bedding planes, along which little or no movement has taken place.

Mafic—Applied to the ferromagnesian minerals or to igneous rocks relatively rich in such minerals.

Mean annual—As used in this report, refers to the average of the annual values for a specified period of record.

Metamorphic rock—Rocks derived from pre-existing rocks by mineralogical, chemical, and structural alterations due to endogenetic processes.

Partial-record gaging station—Is a particular site where limited streamflow and/or water-quality data are collected systematically over a period of years.

Permeability—The property of a porous medium to transmit fluids under an hydraulic gradient.

Porosity—The amount of pore space and fracture openings, expressed as the ratio of the volume of pores and openings to the volume of rock.

Potentiometric surface—An imaginary surface representing the static head of ground water and defined by the level to which water will rise in a tightly cased well.

Primary porosity—Porosity due to the soil or rock matrix; the original interstices created when a rock was formed.

Recession index—The number of days required for discharge to decline one complete log cycle.

Regolith—Loose, unconsolidated and weathered rock and soil covering bedrock.

Residuum—The material resulting from the decomposition of rocks in place and consisting of the nearly insoluble material left after all the more readily soluble constituents of the rocks have been removed.

Rock—Any naturally formed consolidated material consisting of two or more minerals.

Run-off—Precipitation that flows from the surface of the land and into streams and rivers.

Saprolite—Surficial deposits produced by the decay of rocks and remaining as residuals.

Secondary openings—Voids produced in rocks subsequent to their formation through processes such as solution, weathering, or movement.

GLOSSARY—Continued

Secondary porosity—Porosity due to such phenomena as dissolution or structurally controlled fracturing.

Soil—The layer of unconsolidated material at the land surface that supports plant growth.

Specific capacity—The rate of discharge of water from the well divided by the related drawdown of the water level within the well.

Specific yield—The ratio of the volume of water which the porous medium after being saturated, will yield by gravity to the volume of the porous medium.

Storage coefficient—The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head (virtually equal to the specific yield in an unconfined aquifer).

Stream discharge—The volume of water flowing past a given point in a stream channel in a given period of time.

Transmissivity—The rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It equals the hydraulic conductivity multiplied by the aquifer thickness.

Trellis drainage—A river system resembling a trellis or rectangular pattern and characteristic of areas of folded sedimentary rocks where tributaries cut channels through less resistant beds.

Unconfined aquifer—An aquifer in which the water table is a free surface at atmospheric pressure.

Unit-area discharge—Stream or ground-water discharge divided by the drainage area.

Water table—Upper surface of a zone of saturation under atmospheric pressure.

Water year—The standard water-year used by the U.S. Geological Survey is from October 1 to September 30 of the second calendar year.

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By James L. Robinson, Celeste A. Journey, and J.B. Atkins

ABSTRACT

Drought conditions in the 1980's focused attention on the multiple uses of the surface- and ground-water resources in the Apalachicola-Chattahoochee-Flint (ACF) and Alabama-Coosa-Tallapoosa (ACT) River basins in Georgia, Alabama, and Florida. State and Federal agencies also have proposed projects that would require additional water resources and revise operating practices within the river basins. The existing and proposed water projects create conflicting demands for water by the States and emphasize the problem of water-resource allocation. This study was initiated to describe ground-water availability in the Coosa River basin of Georgia and Alabama, Subarea 6 of the ACF and ACT River basins, and to estimate the possible effects of increased ground-water use within the basin.

Subarea 6 encompasses about 10,060 square miles in Georgia and Alabama, totaling all but about 100 mi^2 of the total area of the Coosa River basin; the remainder of the basin is in Tennessee. Subarea 6 encompasses parts of the Piedmont, Blue Ridge, Cumberland Plateau, Valley and Ridge, and Coastal Plain physiographic provinces. The major rivers of the subarea are the Oostanaula, Etowah, and Coosa. The Etowah and Oostanaula join in Floyd County, Ga., to form the Coosa River. The Coosa River flows southwestward and joins with the Tallapoosa River near Wetumpka, Ala., to form the Alabama River.

The Piedmont and Blue Ridge Provinces are underlain by a two-component aquifer system that is composed of a fractured, crystalline-rock aquifer characterized by little or no primary porosity or permeability; and the overlying regolith, which generally behaves as a porous-media aquifer. The Valley and Ridge and Cumberland Plateau Provinces are underlain by fracture- and solution-conduit aquifer systems, similar in some ways to those in the Piedmont and Blue Ridge Provinces. Fracture-conduit aquifers predominate in the well-consolidated sandstones and shales of Paleozoic age; solution-conduit aquifers predominate in the carbonate rocks of Paleozoic age. The Coastal Plain is underlain by southward-dipping, poorly consolidated deposits of sand, gravel, and clay of fluvial and marine origin.

The conceptual model described for this study qualitatively subdivides the ground-water flow system into local (shallow), intermediate, and regional (deep) flow regimes. Ground-water discharge to tributaries mainly is from local and intermediate flow regimes and varies seasonally. The regional flow regime probably approximates steady-state conditions and discharges chiefly to major drains such as the Coosa River, and in upstream areas, to the Etowah and Oostanaula Rivers. Ground-water discharge to major drains originates from all flow regimes. Mean-annual ground-water discharge to streams (baseflow) is considered to approximate the long-term, average recharge to ground water. The mean-annual baseflow was estimated using an automated hydrograph-separation method, and represents discharge from the local, intermediate, and regional flow regimes of the ground-water flow system. Mean-annual baseflow in Georgia was estimated to be about 4,600 cubic feet per second (ft^3/s) (from the headwaters to the Georgia-Alabama State line), 5,360 ft^3/s in Alabama, and 9,960 ft^3/s for all of Subarea 6 (at the Subarea 6-Subarea 8 boundary). Mean-annual baseflow represented about 60 percent of total mean-annual stream discharge for the period of record.

Stream discharge for selected sites on the Coosa River and its tributaries were compiled for the years 1941, 1954, and 1986, during which sustained droughts occurred throughout most of the ACF-ACT area. Stream discharges were assumed to be sustained entirely by baseflow during the latter periods of these droughts. Estimated baseflow near the end of the individual drought years ranged from about 11 to 27 percent of the estimated mean-annual baseflow in Subarea 6.

The potential exists for the development of ground-water resources on a regional scale throughout Subarea 6. Estimated ground-water use in 1990 was 1.1 to 1.6 percent of the estimated mean-annual baseflow, and ranged from about 4.3 to 9.9 percent of the average baseflow near the end of the droughts of 1941, 1954, and 1986. Because ground-water use in Subarea 6 represents a relatively minor percentage of ground-water recharge, even a large increase in ground-water use in Subarea 6 in one State is likely to have little effect on ground-water and surface-water occurrence in the other. Indications of long-term ground-water level declines were not observed; however, the number and distribution of observation wells for which long-term water-level measurements are available in Subarea 6 are insufficient to draw conclusions.

INTRODUCTION

Increased and competing demands for water and the droughts of 1980-81, 1986, and 1988 in the Apalachicola-Chattahoochee-Flint (ACF) and Alabama-Coosa-Tallapoosa (ACT) River basins have focused the attention of water managers and users in Alabama, Florida, and Georgia, on the water resources in the two basins. The ACF-ACT River basins encompass about 42,400 square miles (mi^2) and extend from near the Georgia-Tennessee State line, through most of central and southern Alabama and Georgia and part of the Florida panhandle to the Gulf of Mexico (fig. 1). Ground- and surface-water systems of the ACF-ACT River basins behave as an integrated, dynamic flow system comprised of an interconnected network of aquifers, streams, reservoirs, control structures, floodplains, and estuaries. The degree of hydrologic interaction between ground water and surface water suggests that the water resources be investigated and managed as a single hydrologic entity, to account for the climatic and anthropogenic factors that influence the flow systems.

Recent water projects and resource allocations, and other actions proposed by Federal, State, and local agencies, have resulted in conflicts among the States of Alabama, Florida, and Georgia, and the U.S. Army Corps of Engineers (Corps). The Corps has been given the authority to regulate the Nation’s surface waters through the Rivers and Harbors Act of 1927, in accordance with the U.S. House of Representatives Document Number 308, 69th U.S. Congress. Proposed projects designed to increase development and to re-allocate surface-water supplies in Georgia, based on revised operating practices of control structures for flood control, navigation, and hydropower generation, and a proposal to construct a dam and reservoir have met with opposition from Alabama and Florida. As a result, in 1991, the U.S. Congress authorized the Corps to initiate a Comprehensive Study of the ACF-ACT River basins that would “develop the needed basin and water-resources data and recommend an interstate mechanism for resolving issues” (Draft Plan of Study, Comprehensive Study, Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River basins, prepared by: The Comprehensive Study Technical Coordination Group, July 1991, U.S. Army Corps of Engineers, Mobile District).

In 1992, the Governors of Alabama, Florida, and Georgia; and the U.S. Army, Assistant Secretary for Civil Works, signed a Memorandum of Agreement (MOA) establishing a partnership to address interstate water-resource issues and promote coordinated systemwide management of water resources. An important part of this process is the Comprehensive Study of the ACF and ACT River basins. Since this signing, the Study Partners defined scopes of work to develop relevant technical information, strategies, and plans, and to recommend a formal coordination mechanism for the long-term, basinwide management and use of water resources needed to meet environmental, public health, and economic needs (U.S. Army Corps of Engineers, written commun., 1993). The U.S. Geological Survey (USGS) was requested to assist in the development of a scope of work for the ground-water-supply element of the Comprehensive Study, and in June 1993, was asked to conduct that study element.

Eight subareas of the ACF-ACT River basins were identified by the Study Partners and the USGS on the basis of hydrologic and physiographic boundaries. Addressing the study at the smaller, subarea scale within the ACF-ACT River basins facilitated evaluation of the ground-water resources on a more detailed scale. This report is one of a series of eight reports that present results of ground-water studies of the ACF-ACT subareas.

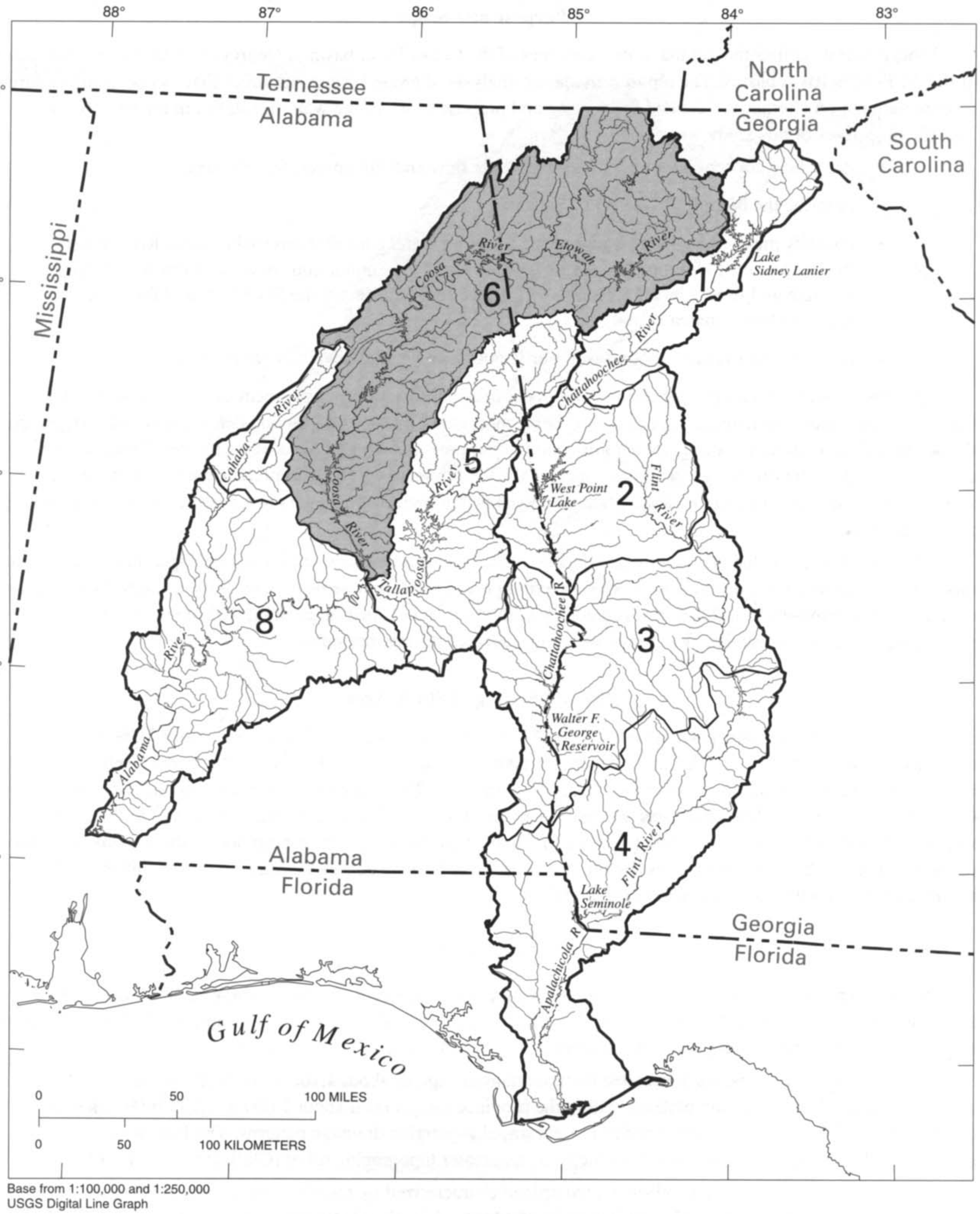

Figure 1. Subareas and major streams in the Apalachicola–Chattahoochee–Flint and Alabama–Coosa–Tallapoosa River basins.

Purpose and Scope

This report describes the ground-water resources of the Coosa River basin of Georgia and Alabama—Subarea 6 of the ACF-ACT River basins. The report provides an analysis of ground-water resources that can be used to address resource-allocation alternatives created by existing and proposed uses of the water resources in the river basins. Specific objectives of this study were to:

- describe a conceptual model of ground-water flow and stream-aquifer relations;
- describe the hydrologic setting of Subarea 6;
- quantify mean-annual and drought period ground-water contributions to the Coosa River from the headwaters to Wetumpka, Ala., including separate computations of the contributions from Georgia and from Alabama; from Georgia into Alabama across the State line; and the ground water exiting Subarea 6; and
- describe and evaluate ground-water utilization and general development potential.

Findings contained herein are but one component of a multidiscipline assessment of issues related to the basinwide utilization and management of water. This report is not intended to provide definitive answers regarding the acceptability of ground-water-resource utilization or the potential for additional resource development. Such answers are dependent on the synthesis of results from all components of the Comprehensive Study and on subsequent consideration by the Federal, State, and local water-resource managers responsible for decision making within the basin.

The report scope includes literature and data searches and an assessment of existing geologic data. A conceptual model that describes the hydrologic processes governing the ground- and surface-water flow was developed, and an evaluation of ground-water utilization was made by compiling and evaluating existing hydrologic, geologic, climatologic, and water-use data. Field data were not collected during this study.

Physical Setting of Study Area

The Subarea 6 study area encompasses about 4,700 mi^2 in northwestern Georgia and about 5,360 mi^2 in northeastern Alabama (fig. 1). The Coosa River basin also includes about 100 mi^2 in southeastern Tennessee; however, that part of the basin is not in the Subarea 6 study area. The study area is bounded to the north by the Georgia-Tennessee State line, to the east by the upper Chattahoochee River basin (Subarea 1) and to the south-southeast by the Tallapoosa River basin (Subarea 5). To the west, the study area is bounded by the Cahaba River basin (Subarea 7), and to the south-southwest by the Alabama River basin (Subarea 8). Major rivers of Subarea 6 flow southwestward into the Alabama River (Subarea 8) (fig. 1).

Physiography

Fifty-two percent of Subarea 6 lies within the Valley and Ridge Province and 34 percent lies within the Piedmont Province. The Cumberland Plateau, Blue Ridge, and Coastal Plain Provinces comprise 8, 4, and 2 percent, respectively, of Subarea 6 (Sapp and Emplaincourt, 1975; Clark and Zisa, 1976) (fig. 2).

The Blue Ridge Province is dominated by mountains as high as about 4,100 feet (ft) above sea level. Land-surface altitude of intermountain plateaus within the province ranges from about 1,600 to 1,700 ft (Brackett and others, 1991). Most streams are characterized by rectangular or trellis drainage patterns. The Blue Ridge is distinguished from the Piedmont Province chiefly by its greater topographic relief (Clark and Zisa, 1976).

The Piedmont Province is a well-dissected upland characterized by rounded interstream areas to the north and rolling topography, indicating a dissected peneplain of advanced erosional maturity to the south (Chandler and Lines, 1974). Prominent topographic features generally reflect the erosional and weathering resistance of quartzites, amphibolites, and mafic/ultramafic plutonic rocks. Stream patterns predominantly are dendritic; however, a modified trellis pattern is associated with divides separating linear ridges underlain by quartzite in the southern part of the Piedmont. Altitude ranges from about 500 to 1,500 ft.

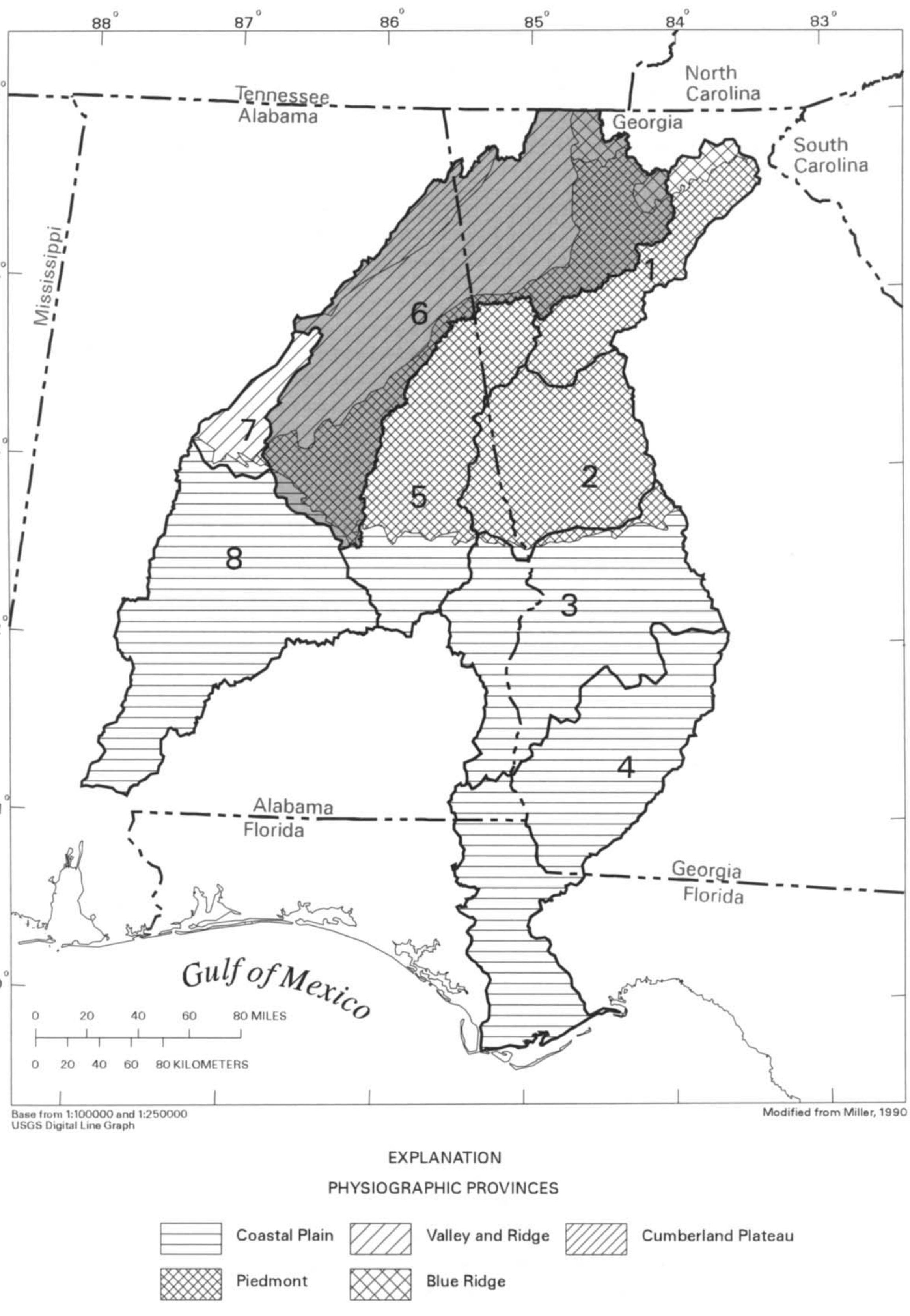

Figure 2. Physiographic provinces and subareas in the Apalachicola–Chattahoochee–Flint and Alabama–Coosa–Tallapoosa River basins.

The Valley and Ridge Province consists of relatively narrow, northeast-trending linear ridges at altitudes ranging from about 600 to 1,600 ft. Intervening streams drain relatively wide valleys that range in altitude from 400 to 900 ft (Scott, Cobb, and Castleberry, 1987; and Cressler and others, 1976). In contrast, the Cumberland Plateau is dominated by relatively flat plateaus ranging in altitude from 1,500 to 1,800 ft that bound narrow, northeast-southwest-trending linear valleys. Stream patterns both in the Valley and Ridge and Cumberland Plateau Provinces predominantly are trellis or rectangular.

The Coastal Plain Province is characterized by relatively flat to gently rolling uplands and broad, gently sloping valleys that range in altitude from about 130 to 850 ft above sea level (Scott, Cobb, and Castleberry, 1987). Stream patterns generally are dendritic. For a more complete discussion of the Coastal Plain Province, the reader is referred to Miller (1990).

Climate

The climate in Subarea 6 is moist and temperate. Mean-annual precipitation ranges from 52 to 64 inches (in.) (Harkins and others, 1982; Cressler and others, 1976; Carter and Stiles, 1983; Miller, 1990). Precipitation chiefly occurs as rainfall, and to a lesser extent, as snowfall. Rainfall is fairly evenly distributed throughout the year, but a distinct dry season usually occurs from mid-summer to late fall. Winter is the wettest season and March the wettest month (Harkins and others, 1982). The mean-annual temperature is about 60 degrees Fahrenheit.

Ground-Water Use

The estimated ground-water use in Subarea 6 during 1990 was about 87 million gallons per day (Mgal/d) or about 134 cubic feet per second (ft^3/s) (Baker and Mooty, 1993; Fanning and others, 1992). Of this total, about 59 percent was for public water supply, about 16 percent for domestic water supply, 16 percent for self-supplied industrial and commercial activities, and 9 percent for agricultural use. The largest ground-water use in Georgia is for self-supplied industrial and commercial supply, and in Alabama is for public water supply (table 1).

Table 1. Estimated ground-water use, by category, Subarea 6, 1990
[Mgal/d, million gallons per day; ft^3/s, cubic feet per second]

State	Public water supply		Self-supplied industrial and commercial		Agricultural		Domestic		Total	
	(Mgal/d)	(ft^3/s)	(Mgal/d)	(ft^3/s)	(Mgal/d)	(ft^3/s)	(Mgal/d)	(ft^3/s)	(Mgal/d)	(ft^3/s)
Georgia[1/]	8.3	12.8	12.4	19.2	2.2	3.4	9.2	14.2	32.1	49.6
Alabama[2/]	43.3	67.0	1.4	2.2	5.4	8.4	4.5	7.0	54.6	84.5
Subarea total	**51.6**	**79.8**	**13.8**	**21.4**	**7.6**	**11.8**	**13.7**	**21.2**	**86.7**	**134.1**

[1/]Fanning and others (1992).
[2/]Baker and Mooty (1993).

Ground-water use reported by Baker and Mooty (1993) and Fanning and others (1992) is by county; ground-water use in those counties that are partially in Subarea 6 are reported herein for Subarea 6 only. Ground-water use for public water supply, and self-supplied industrial and commercial uses were determined by using site-specific data. Ground-water pumpage for domestic purposes was determined by subtracting the population served by public supply facilities from the total population of the county or hydrologic unit, then multiplying that number by a water-use coefficient of 75 gallons per day (gal/d) per person. Agricultural ground-water use was estimated by multiplying the reported county use by the percentage of the land area of the county in Subarea 2.

Previous Investigations

Investigations of the geology of the general area of Subarea 6 began in the 19th century. Reports published before 1900 by the Geological Survey of Alabama and the Georgia Geologic Survey described the mineral deposits of the region, and concentrated on the precious metal deposits in the Piedmont Province. Smith (1907) conducted a study of the ground-water resources of Alabama, and McCallie (1908) described ground-water resources in the Piedmont and Blue Ridge Provinces of Georgia. Brackett and others (1991) described the ground-water resources of the Piedmont and Blue Ridge Provinces in Alabama and Georgia. Subsequent studies of the geology of the Piedmont and Blue Ridge Provinces were completed by Crickmay (1952), and Baker (1957), Sever (1964), Joiner and others (1967), Scarbrough and others (1969), and Guthrie and DeJarnette (1989).

Early studies of the Valley and Ridge Province included those by Hayes (1892), who described the geology of northeastern Alabama and adjacent parts of Georgia and Tennessee, and by McCalley (1897) who studied the Paleozoic strata of the Coosa Valley of Alabama. As early as 1933, ground water in the Paleozoic rocks of northern Alabama was a subject of study by Johnston (1933). More recent geologic studies include Butts and Gildersleeve (1948), on the Paleozoic strata of northwestern Georgia; Allen and Lester (1957), on zonation of the Middle and Upper Ordovician strata in northwestern Georgia; McLemore and Hurst (1970), on the carbonate rocks in the Coosa Valley of Georgia; Thomas (1972), who correlated Mississippian strata in Alabama; and Chowns (1972, 1977, 1983, 1989), on the geology and stratigraphy of the Paleozoic strata of northwestern Georgia. Additional studies of the geology and water resources of counties that lie wholly or partially within the Coosa River basin, published by the Georgia Geologic Survey and the Geological Survey of Alabama, are listed in the “Selected References” section of this report.

Well inventories and discussions of the water resources were presented in water-resources and water-availability reports that were prepared for county and larger areas in Alabama and Georgia: (Cressler and others, 1976; Scott, Cobb, and Castleberry, 1987; Scott, Harris, and Cobb, 1987; Bossong, 1989; Kidd, 1989; Planert and Pritchett, 1989; and Peck and Cressler, 1993).

One of the earliest reports discussing the surface-water resources of the ACF-ACT River basin area was “Water Powers of Alabama” (Hall and Hall, 1916). This report contains information on the dry-weather flow of streams in Alabama, and includes flow data for the Coosa River at Rome, Ga. Carter and others (1949) described the water resources and hydrology of southeastern Alabama. Peirce (1955) described the hydrology and surface-water resources of the ACT River basin area in Alabama to the mouth of the Cahaba River, and also included data for tributaries in the Piedmont Province of Alabama. Thompson and Carter (1955) described the effects of the drought of 1954 on streamflow in Georgia. Hale and others (1989) described the effects of the drought of 1986 on streamflow in Alabama, Georgia, North Carolina, South Carolina, Tennessee, and Virginia. Faye and Mayer (1990) described ground-water flow and stream-aquifer relations in the northern Coastal Plain part of the ACF River basin area.

Reports describing methods of estimating streamflow and ground-water discharge to streamflow include Bingham (1982), Hirsch (1982), Hoos (1990), Rorabaugh (1960, 1964), Rutledge (1991, 1992, 1993), and Mayer and Jones (1996). Data collected as part of the ongoing surface-water monitoring program of the USGS are published annually in the reports “Water-Resources Data, Alabama” (or Georgia, respectively). Other reports containing information about the surface- and ground-water resources of the ACF-ACT River basin area are listed in the “Selected References” section of this report.

Well and Surface-Water Station Numbering Systems

Wells in Georgia are numbered by a system based on the U.S. Geological Survey topographic maps. Each 7 1/2-minute topographic quadrangle map in Georgia has been assigned a number and letter designation beginning at the southwest corner of the State. Numbers increase sequentially eastward through 39; letters advance northward through “Z,” then double-letter designations “AA” through “PP” are used. The letters “I,” “O,” “II,” and “OO” are not used. Wells inventoried in each quadrangle are numbered sequentially beginning with “1.” Thus, the second well inventoried in the Zebulon quadrangle (designated 11Y) is designated 11Y002.

The well-numbering system in Alabama is based on the Federal system of subdivision of public lands into townships and ranges. Each township is divided into 36 sections numbered from one in the northeast corner to 36 in the southeast corner. Each township is assigned a letter in the same order that sections are numbered from “A” through “X,” with “A” being assigned to the northeasternmost equal subdivision of the section and “X” to the southeasternmost subdivision. Letter designations are doubled or tripled as needed. Wells in each subdivision are numbered consecutively such as A-1, A-2.

Wells in the USGS Ground-Water Site Inventory (GWSI) data base are assigned a 15-digit identification number based on the latitude and longitude grid system. The first six digits denote the degrees, minutes, and seconds of latitude. The next seven digits the degrees, minutes, and seconds of longitude. The last two digits (assigned sequentially) identify wells within a one-second grid.

The USGS established a standard identification numbering system for all surface-water stations in 1950. Stations are numbered according to downstream order. Stations on a tributary entering upstream of a main-stream station are numbered before and listed before the main-stream station. No distinction is made between continuous-record and partial-record stations. Each station has a unique eight-digit number that includes a two-digit part number (02 refers to natural drainage into the Eastern Gulf of Mexico) and a six digit downstream order number. Gaps are left in the series of numbers to allow for new stations that may be established; hence, the numbers are not consecutive. The complete number for each station includes a two-digit part number “02” plus the downstream-order number, which can be from 6 to 12 digits. All records for a drainage basin, encompassing more than one State, can easily be correlated by part number and arranged in downstream order.

Approach and Methods of Study

This study included several work elements used to appraise the ground-water resources of Subarea 6, including the description of a conceptual model of ground-water flow and stream-aquifer relations, and an assessment of ground-water availability. The approach and methods used to accomplish these tasks included:

- compilation of information and data from pertinent literature, including geologic, ground-water, streamflow, and ground-water use data;
- separation of streamflow hydrographs to estimate mean-annual ground-water contribution to the Coosa River and its tributaries;
- evaluation of streamflow records and periodic discharge measurements during drought periods to estimate “worst-case” streamflow conditions; and
- comparison of 1990 ground-water use with mean-annual and drought-flow conditions to evaluate ground-water availability.

Literature and data reviews provided information necessary to describe a conceptual model of ground-water/surface-water relations. Much of the conceptual model is based on results of previous investigations by Toth (1962, 1963), Freeze (1966), Freeze and Witherspoon (1966, 1967, 1968), Winter (1976), Faye and Mayer (1990), Heath (1984, 1989), and Miller (1990). These studies suggest that large rivers, such as the Coosa, and their tributaries function as hydraulic drains for ground-water flow, and that during significant droughts, most of the discharge in these streams is contributed by ground water.

Streamflow data were compiled from the USGS Automated Data Processing System (ADAPS) database. Streamflow records from continuous-record and miscellaneous discharge-measurement stations were used for hydrograph-separation analyses and drought streamflow evaluation.

Stream-aquifer relations were quantified using two approaches: (1) the hydrograph-separation method of Rorabaugh (1960, 1964) and Daniel (1976), called the recession-curve-displacement method; and (2) a drought-flow mass-balance analysis of streamflow. The hydrograph-separation method was used to estimate the mean-annual discharge of ground water (baseflow) to the basin. The mean-annual baseflow was used as a base or reference with which to compare and evaluate droughts under “worst-case” conditions. An estimate also was made of the mean-annual volume of ground water discharged to Alabama from Georgia as baseflow at the State line and from Subarea 6 to Subarea 8 as baseflow in the Coosa River at it’s mouth. The mass-balance analysis was used to estimate the minimum baseflow contributions to the surface-water system during historically significant droughts and the ground water delivered as baseflow to Alabama from Georgia, and from Subarea 6 to Subarea 8 in Alabama at the end of these droughts.

Mean-Annual Baseflow Analysis

Discharge data from continuous-record gaging stations along the Coosa River and its tributaries were selected for baseflow analysis based on the period of record of unregulated flow. Streamflow representative of low, average, and high years of stream discharge were evaluated by hydrograph-separation methods to estimate annual baseflow. The mean-annual baseflow was then computed as the average baseflow of the three representative flow years.

The selection process for the most representative year of low, average, and high stream discharge involved objective statistical examination of the discharge data, followed by some subjectivity in the final choice of the water year selected. Hydrographs acceptable for separation were characterized by relatively normal distributions of daily stream discharge, small ranges of discharge, and the absence of extremely high, isolated peak stream discharge. For each station, the mean annual stream discharge was computed for the period of record of unregulated flow and used as a reference mean for low-, average-, and high-flow conditions for that station. The mean- and median-annual stream discharge for those water years identified as acceptable were compared to the reference mean. Because extremely high discharge during a water year could greatly influence the mean but not the median (which is similar to the geometric mean for positively skewed data sets, such as discharge), the process of selecting representative water years for low-, average-, and high-flow conditions considered the position of the mean discharge for the selected year relative to the median and the reference mean. The hydrographs for these representative water years were examined and separated. True subjectivity in the selection process entered only at this point, such that, if acceptable hydrographs were available for several years, one year arbitrarily was chosen over the others.

The separation analyses were conducted using the computer program SWGW (Mayer and Jones, 1996) which is an automated version of the recession-curve-displacement method, often referred to as the Rorabaugh or Rorabaugh-Daniel method. The SWGW program was applied to a water-year period of streamflow data. SWGW utilizes daily mean discharge data collected at unregulated stream-gaging sites and requires at least 10 years of record to accurately estimate a recession index necessary for hydrograph-separation analysis.

The hydrograph-separation method estimates the ground-water component of total streamflow. In general, the streamflow hydrograph can be separated into two components—surface runoff and baseflow (ground-water discharge to streams). Figure 3 shows the graphical output from the SWGW program. Surface runoff is the quick response (peaks) of stream stage to precipitation and nearby overland flow.

Application of the recession-curve-displacement method requires the use of the streamflow recession index. The streamflow recession index is defined as the number of days required for baseflow to decline one order of magnitude (one log cycle), assuming no other additional recharge to the ground-water system. The streamflow recession index is a complex number that reflects the loss of ground water to evapotranspiration (Daniel, 1976) or leakage, and the influence of geologic heterogeneities in the basin (Horton, 1933; Riggs, 1963). The slope of the streamflow recession is affected by evapotranspiration, such that the streamflow recession index varies from a maximum during the major rise period to a minimum during the major recession period (fig. 3). The major rise period of streamflow generally occurs from November through March or April, when precipitation is greatest and evapotranspiration is least. The major recession period occurs during late spring through fall and coincides with a period of lesser precipitation, higher temperature, and greater evapotranspiration (fig. 3). Two recession indices were estimated for streamflow observed at each continuous-record gaging station used in the mean-annual baseflow analysis; one index for the major rise period and one for the major recession period.

Available ground-water-level data indicate that long-term changes in ground-water storage are minimal in Subarea 6. Because long-term storage changes are minimal, mean-annual ground-water discharge, estimated using the hydrograph-separation method, is considered an estimate of minimum mean-annual recharge. Also, aquifers at a regional scale in Subarea 6 are considered, for purposes of analysis, to respond as homogeneous and isotropic media.

Results of the mean-annual baseflow analysis are based on measured and estimated data, and the analytical methods to which they are applied. Drainage areas were measured using the most accurate maps available at the time of delineation (Novak, 1985), and are reported in units of square miles. Drainage areas are reported to the nearest square mile for areas greater than 100 mi^2; to the nearest tenth of a square mile for areas between 10 and 100 mi^2; and to the nearest hundredth of a square mile for areas less than 10 mi^2, if the maps and methods used justify this degree of accuracy (Novak, 1985). Annual stream discharge, the sum of the daily mean stream discharges for a given water year, is reported in units of cubic feet per second, to the nearest cubic foot per second. Daily mean discharge is reported to the nearest tenth of a cubic foot per second for discharge between 1.0 and 9.9 ft^3/s; to the nearest unit for discharge between 10 and 100 ft^3/s; and is reported using three significant figures for discharge equal to or greater than 100 ft^3/s (Novak, 1985).

The accuracy of stream-discharge records depends primarily on: (1) the stability of the stage-discharge relation or, if the control is unstable, the frequency of discharge measurements; and (2) the accuracy of measurements of stage and discharge, and the interpretation of records. Accuracy of records of streamflow data used in this report can be found in annually published USGS data reports, for example, Pearman and others (1994). The accuracy attributed to the records is indicated under “REMARKS” in the annual data reports for each station. “Excellent” means that about 95 percent of the daily discharges are within 5 percent of the true discharge; “good,” within 10 percent; and “fair,” within 15 percent. Records that do not meet these criteria are rated “poor.” The accuracy of streamflow records at a station may vary from year to year. In addition, different accuracies may be attributed to different parts of a given record during a single year (Novak, 1985).

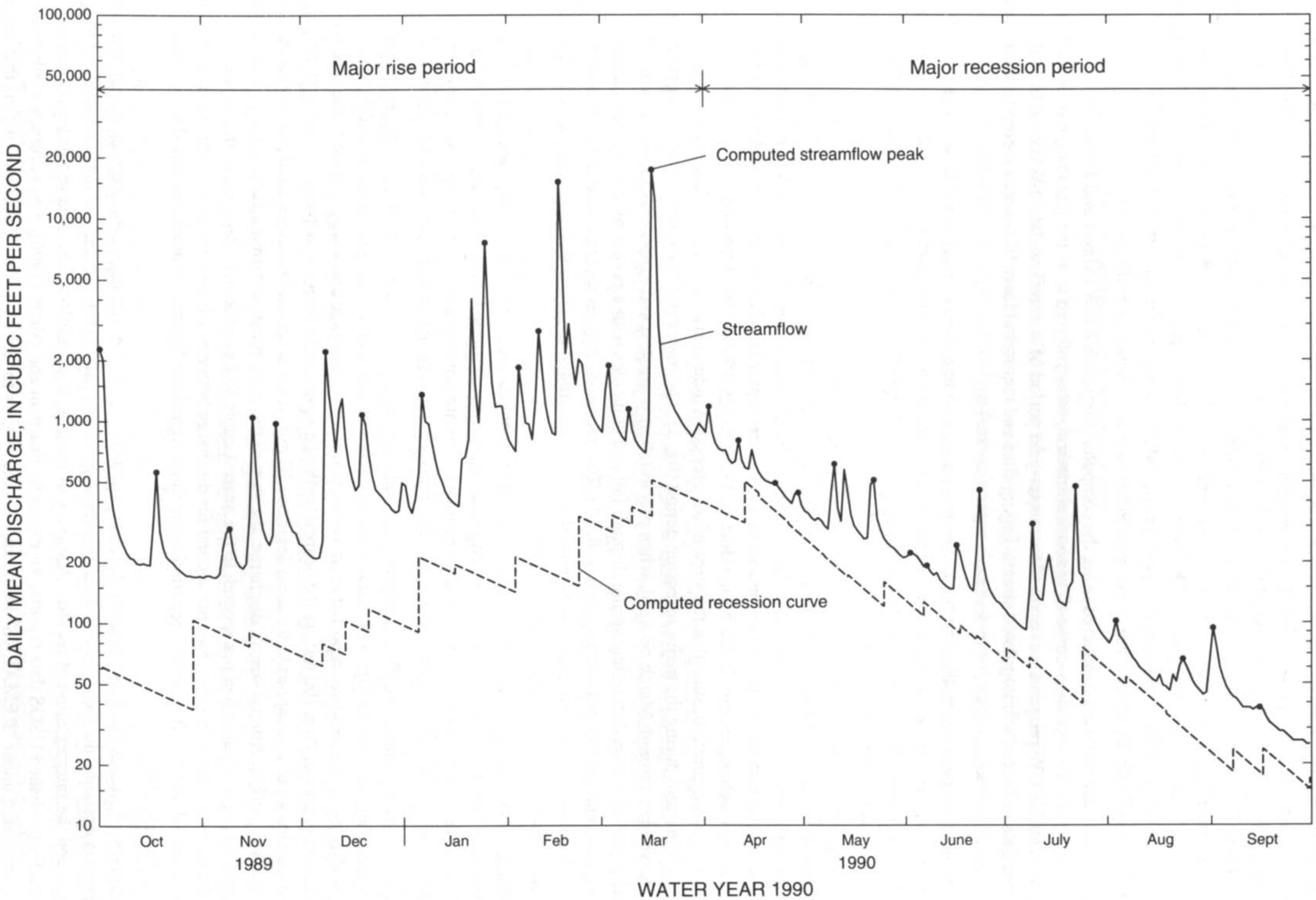

Figure 3. Streamflow hydrograph, separated by program SWGW.

Results of the mean-annual baseflow analyses are inherently uncertain. The hydrograph-separation method of analysis is partly subjective, relying on the input of several user-selected variables. As such, the results of the analyses derived and reported herein, are difficult to independently confirm and are presented as estimates of unknown quality and confidence. However, because the values in this report are used in several water budgets, not only within Subarea 6 but also from subarea to subarea, hydrograph-separation results may be reported to a greater significance than the data and analyses warrant to maintain the numerical balance of the water budget; implication of accuracy to the extent shown is not intended.

Drought-Flow Analysis

Daily mean streamflow data collected at gaging stations during periods of low flow and corresponding periodic measurements of stream discharge collected at partial-record stations were compiled for the drought years 1941, 1954, and 1986. These data included nearly concurrent daily measurements of streamflow in the Coosa River and periodic measurements of tributary discharge.

Standard periods of analyses for drought studies were selected for all ACF-ACT subareas. The period of analysis selected for compiling 1954 drought data was September 15 through November 1, 1954. The selected period for the 1986 drought was July 1 through August 14, 1986. Streamflow during these periods was considered to represent the “worst case” of ground-water storage and availability throughout the ACF-ACT study area. Discharge data were sparse during the 1941 drought; therefore, a standard period of analysis was not selected for the entire ACF-ACT study area.

The period of “worst-case” conditions may not include the minimum streamflow that occurred during a drought at a streamflow measurement site. Minimum drought flows typically occur at different times at different stations within large watersheds, such as the Coosa River basin. Rather, the “worst-case” evaluation was designed to describe streamflow during the advanced stages of each drought; thus, providing a near-contemporaneous summary of streamflow conditions during periods of low flow throughout the ACF-ACT study area.

The estimated “worst-case” distribution of Coosa River streamflow during the 1941, 1954, and 1986 drought periods was determined by balancing mass in the stream network in a general downstream direction during a relatively short interval of time. The tributary discharge to the Coosa River during drought periods was calculated using a unit-area discharge extrapolated to the entire drainage area of the tributary. Unit-area discharges are based on streamflow measurements that generally are inclusive of only part of the tributary drainage, and may not be representative of an average unit-area discharge for the entire tributary drainage. Therefore, most unit-area discharges used to estimate discharge at ungaged and unmeasured tributaries were based on streamflow data measured near the mouths of tributaries to better represent the entire tributary contributing area.

Because daily discharge or periodic discharge measurements did not exist for some sites during all or some of the three drought periods, estimates of the daily discharge at those sites during the drought periods were based on correlation methods that use relations of available discharge data from other periods. The logarithms of these discharge data were correlated with the logarithms of concurrent daily discharges at selected continuous-record gaging stations (index stations). The relation was defined by a line of correlation determined by a technique known as MOVE.1—Maintenance of Variance Extension, Type 1 (Hirsch, 1982)—or by a graphically determined best-fit line (Riggs, 1972). The MOVE.1 technique was used instead of ordinary least-squares regression to develop these relations because it produces an estimate that is less biased than the ordinary least-squares regression.

Drought streamflow daily discharges were estimated for 1941, 1954, and 1986 for partial-record and continuous-record stations where at least 10 discharge measurements were available, using the MOVE.1 line and the concurrent daily discharge for the index station. This estimating technique transfers a selected daily discharge from the index station using the MOVE.1 line of correlation to determine the corresponding daily discharge for the partial-record station or continuous-record station (dependent station). This technique assumes that daily discharges will occur concurrently at the dependent station and the index station and that the two stations drain hydrologically and geologically similar basins in close geographical proximity. Partial-record stations having fewer than 10 discharge measurements, or where relations between dependent stations and index stations were not linear, were correlated with index stations by a graphical technique. A graphically determined best-fit line through an x-y plot of concurrent daily discharge for the index station and discharge data for the dependent station was used for estimating daily discharges (Riggs, 1972).

CONCEPTUAL MODEL OF GROUND-WATER FLOW AND STREAM-AQUIFER RELATIONS

The conceptual model of the ground-water flow and stream-aquifer relations in Subarea 6 is based on previous work done in other areas by Toth (1962, 1963), Freeze (1966), Freeze and Witherspoon (1966, 1967, 1968), Winter (1976), and Faye and Mayer (1990). These studies suggest that recharge originates from precipitation that infiltrates the land surface, chiefly in upland areas, and percolates directly, or leaks downward to the water table. Ground water subsequently flows through the aquifer down the hydraulic gradient and either discharges to a surface-water body or continues downgradient into confined parts of an aquifer. Major elements of this conceptual model include descriptions of flow regimes, stream-aquifer relations, recharge to ground water, and ground-water discharge to streams.

Toth (1963) observed that most ground-water flow systems could be qualitatively subdivided into paths of local (shallow), intermediate, and regional (deep) flow. Local flow regimes are characterized by relatively shallow and short flow paths that extend from a topographic high to an adjacent topographic low. Intermediate flow paths are longer and somewhat deeper than local flow paths and contain at least one local flow path. Regional flow paths (fig. 4) begin at or near the major topographic (drainage) divide and terminate at regional drains, which is the Coosa River in Subarea 6. Depending on local hydrogeologic conditions, all three flow regimes may not be present everywhere within the subarea.

The water table in Subarea 6 probably is a subdued replica of the land-surface topography but generally has less relief. The presence of ground-water flow regimes depends largely on the configuration of the water table, such that recharge occurs in highland areas and discharge occurs in lowland areas. Quantities of recharge to the water table and ground-water discharge to streams are variably distributed throughout the local, intermediate, and regional flow regimes. Local regimes receive the greatest ground-water recharge from the water table and provide the most ground-water discharge to streams. Ground-water discharge to tributary drainages primarily is from local and intermediate flow regimes; ground-water discharge to regional drains, such as the Coosa River includes contributions from the regional as well as local and intermediate regimes.

Seasonal variation in rainfall affects the local ground-water flow regime most significantly, and affects the regional flow regime least significantly. Generally, regional flow probably approximates steady-state conditions, and long-term recharge to and discharge from this regime will not vary significantly.

Continuum methods of analysis of ground-water flow, such as hydrograph separation, are based on assumptions of laminar flow through a medium characterized by systematic changes in primary porosity and permeability. Such media generally are classified as porous media. Ground-water flow through porous media is commonly termed Darcian flow. Fractured rock media in the Valley and Ridge, Cumberland Plateau, Piedmont, and Blue Ridge Provinces contain virtually no primary porosity or permeability and virtually all ground-water flow occurs through secondary openings. For purposes of analysis, continuum methods based on assumptions of Darcian flow are applied to ground-water flow through fractured rock media. Such approaches commonly are justified on a regional scale because fracture systems typically are ubiquitous and intersecting. Further support for the assumption of Darcian flow is provided by regional scale maps of potentiometric surfaces, which demonstrate the continuity of ground-water flow through fractured rocks at a county or multi-county scale. Examples of regional scale maps of potentiometric surfaces in fractured rock aquifers are shown by Bossong (1989) and Planert and Pritchett (1989).

Results of smaller-scale studies also demonstrate the continuity of ground-water flow through fractured media. For example, long-term ground-water pumping operations near Ridgeway, S.C., began in the fall of 1988 to dewater fractured Piedmont rocks to accommodate open-pit mining of gold-bearing ore (Glenn and others, 1989). Detailed ground-water monitoring around and within the mined areas indicated that after less than one year of pumping, drawdown extended in an oblong distribution for more than 1 mi beyond the center of pumping. Drawdown decreased uniformly with distance from pumped wells. Nelson (1989) used water-level data from numerous monitoring wells at a 120-acre study site constructed in fractured Piedmont rocks to describe stream-aquifer relations (non-pumping conditions) near the Rocky River in North Carolina. Nelson (1989) concluded that the Rocky River was a drain for ground water discharged from Piedmont rocks, and that observed hydraulic relations between the fractured-rock aquifer and the river and within the aquifer at various depths, were consistent with porous-media concepts of ground-water flow, as described by Toth (1962, 1963).

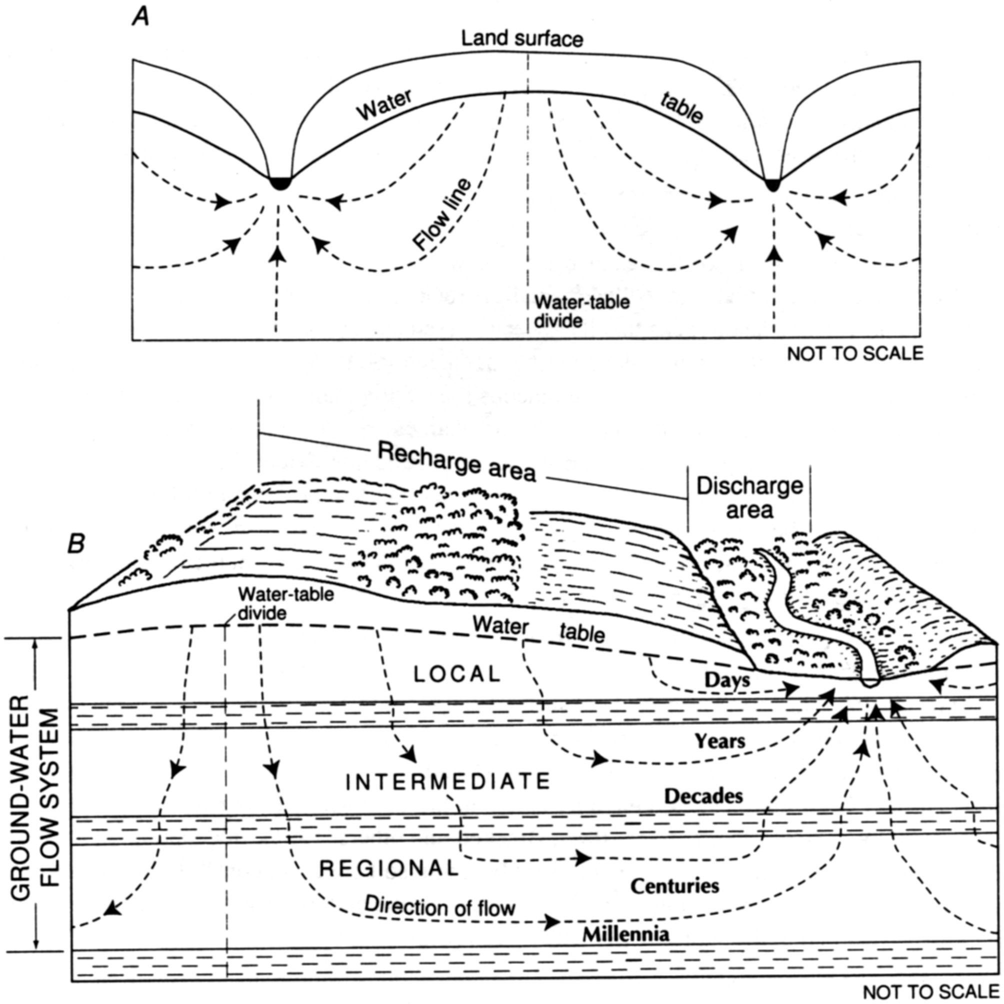

Figure 4. (*A*) Distribution of ground-water flow in an areally extensive, isotropic, homogeneous aquifer system (modified from Hubbert, 1940, and Heath, 1984) and (*B*) example of local, intermediate, and regional ground-water flow (modified from Heath, 1984).

HYDROLOGIC SETTING

The hydrologic framework of Subarea 6 contains dynamic hydrologic systems consisting of aquifers, streams, reservoirs, and floodplains. These systems are interconnected and form a single hydrologic entity that is stressed by natural hydrologic and climatic factors and by anthropogenic factors. For this discussion, the hydrologic framework is separated into two systems: the ground-water system and surface-water system.

Ground-Water System

The ground-water system forms as geology and climate interact. Geology primarily determines the aquifer types present, as well as the natural quality and quantity of ground water. Climate primarily influences the quantity of ground water.

Geology

A detailed description of the diverse and complex geology of Subarea 6 is beyond the scope of this study; however, a brief description of the geology of the subarea is presented, based on selected published descriptions of various geologic investigations (see the section “Selected References”). The geology in each physiographic province of Subarea 6 (fig. 2) generally is unique to each province; therefore, geology is discussed by province.

The Blue Ridge and Piedmont Provinces are characterized by complex sequences of igneous rocks of Precambrian to Paleozoic age, and metamorphic rocks of late Precambrian to Permian age (Miller, 1990); in the Piedmont, isolated igneous rocks of Mesozoic age also are present (D.C. Prowell, U.S. Geological Survey, oral commun., 1996). Collectively, these rocks are called crystalline rocks. The metamorphic rocks originally were sedimentary, volcanic, and volcaniclastic rocks that have been altered by several stages of regional metamorphism to slate, phyllite, schist, gneiss, quartzite, and marble; a variety of cataclastic rocks also are present. The metamorphic rocks are extensively folded and faulted. The intrusive igneous rocks, dominantly granites and lesser amounts of diorite and gabbro, occur as widespread plutons. The rocks are characterized by a complex outcrop and subsurface distribution pattern, as shown on geologic maps of various scales (Szabo and others, 1988). Because rock characteristics can vary significantly on the scale of a few tens of feet within the same lithologic unit, detailed geologic-unit differentiation can be accomplished only on the scale of a topographic quadrangle, or larger. The Piedmont contains major fault zones that generally trend northeast-southwest and form the boundaries between major rock groups (Georgia Geologic Survey, 1976).

The crystalline igneous and metamorphic rocks largely are covered by a layer of weathered rock and soil known as regolith. The regolith ranges in thickness from a few to more than 150 ft, depending upon the type of parent rock, topography, and hydrogeologic history. From the land surface, the regolith consists of a porous and permeable soil zone that grades downward into a clay-rich, relatively impermeable zone that overlies and grades into porous and permeable saprolite, generally referred to as a transition zone (Heath, 1989). The transition zone grades downward into unweathered bedrock. Regolith thickness generally is less in the Blue Ridge Province than in the Piedmont because of the steeper slopes (Schmitt and others, 1989; Brackett and others, 1991). In general, the massive granite and gabbro rocks are poorly fractured and are characterized by a thin soil cover; in contrast, the schists and gneisses are moderately to highly fractured. The weathering of the rocks is erratic and usually deep; remnants of the original texture and foliation are retained in the saprolite in many places (Clarke, 1963).

Rocks of Paleozoic age characterize the Valley and Ridge and Cumberland Plateau Provinces. These rocks are folded, faulted, and thrusted clastic and carbonate rocks of fluvial and marine origin that have been only locally metamorphosed. The deformation of rocks in the Cumberland Plateau is less intense than those in the Valley and Ridge. Fold axes trend northeast to southwest. Typical rock types include shale, siltstone, sandstone, limestone, and dolostone. Lenticular, discontinuous quartz sand and gravel beds of Cenozoic age have been deposited in the valley floor of the Coosa River. Significant deposits have been noted in Calhoun (Warman and Causey, 1962), Cherokee (Causey, 1965a), Elmore (Lines, 1975), Etowah (Causey 1961a), and St. Clair (Johnston, 1933) Counties, Ala.

Sediments of Cretaceous age in the Coastal Plain Province mostly are undeformed, poorly consolidated, clastic deposits of estuarine, deltaic, and shallow marine origin and form a southward-thickening wedge that overlies rocks of the Piedmont and Valley and Ridge Provinces. These sediments dip gently to the south and southeast. Typical sediment types are clay, sand, and gravel. The outcrops of Cretaceous sediments, which contain sand and gravel aquifers in limited use in Subarea 6, form narrow bands across Chilton, Autauga, and Elmore Counties, Ala.

Aquifers

Aquifers in Subarea 6 (fig. 5) vary widely in their lithologic and water-bearing characteristics (table 2). Three types of aquifers are present in the Subarea, identified on the basis of their ability to store and yield water: (1) porous-media; (2) solution-conduit; and (3) fracture-conduit aquifers (table 2). These aquifer types differ fundamentally in origin and water-supply potential. Aquifers are not hydraulically isolated within physiographic provinces, which also could be considered “hydrogeologic provinces.” Ground water flows from one hydrogeologic unit to another; for example, where the units are juxtaposed, ground water can flow from the fracture-conduit aquifers of the Piedmont to the porous-media aquifers of the Coastal Plain.

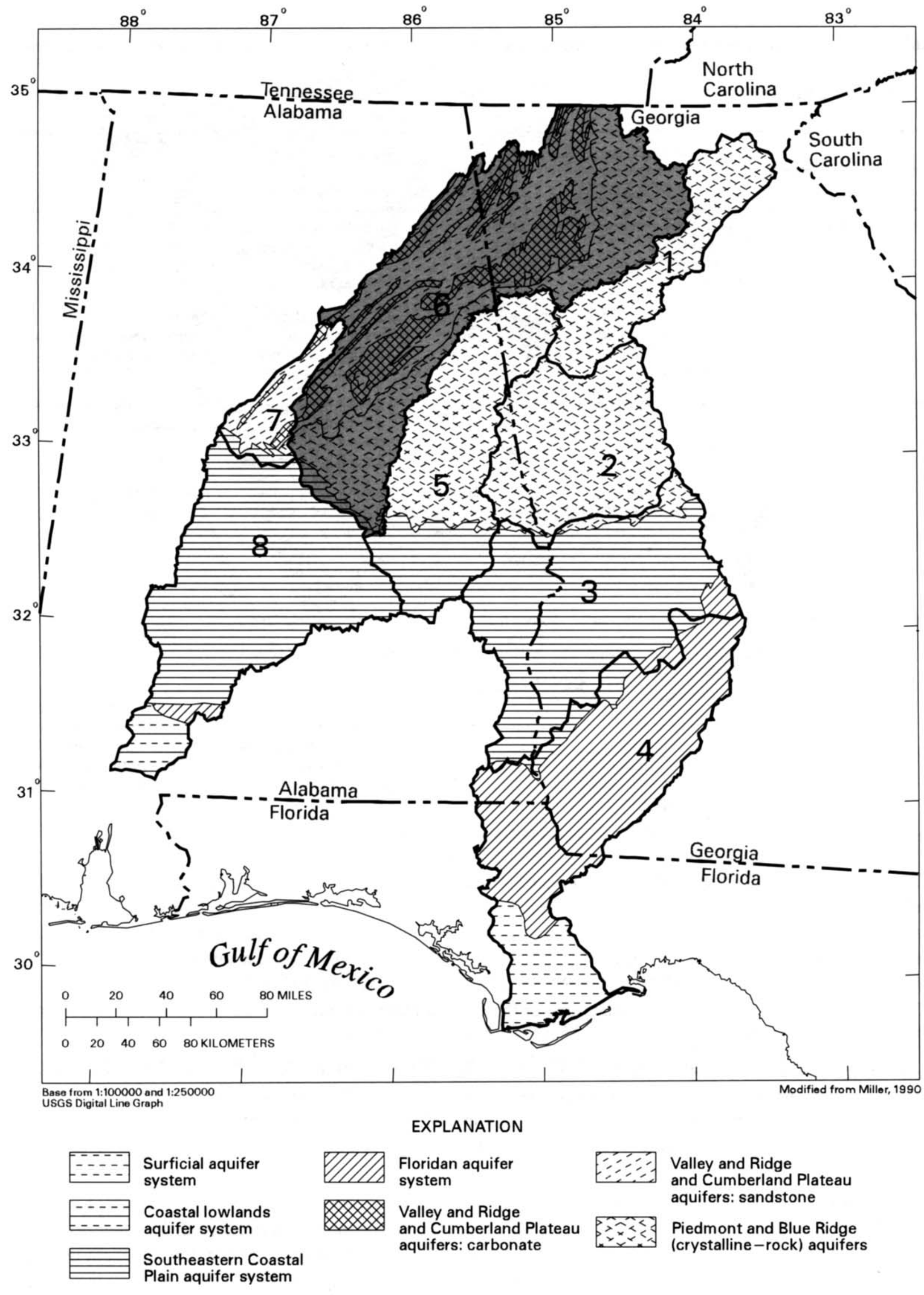

Figure 5. Major aquifers and subareas in the Apalachicola–Chattahoochee–Flint and Alabama–Coosa–Tallapoosa River basins.

Table 2. Generalized geologic units in Subarea 6, and water-bearing properties, chemical characteristics, and well yields
[—, no available data]

Physiographic province	Geologic age and lithology	Aquifer type	Water-bearing properties and chemical characteristics	Well yield
Valley and Ridge	Cenozoic—sand and gravel	porous-media	generally adequate only for domestic use, may have high iron concentrations	10 gallons per minute typical
Coastal Plain	Cretaceous—sand and gravel beds of the Coker and Gordo Formations	porous-media	used for limited public water supply in Chilton and Elmore Counties, Alabama	100 to 200 gallons per minute (Scott, Cobb, and Castleberry, 1987)
Valley and Ridge and Cumberland Plateau	Paleozoic—sandstone, shale, and siltstone	fracture-conduit	yield highly variable, may have high iron content, in limited use for public-water supply	10 to 200 gallons per minute (Bossong, 1989)
	Paleozoic—limestone, dolostone, chert	solution-conduit	widely used for public water supply, water may have high concentrations of calcium and bicarbonate	10 to 2,000 gallons per minute (Bossong, 1989)
Piedmont and Blue Ridge	regolith, soil, alluvium, colluvium, and saprolite derived from various-aged rocks	porous-media; preferential flow	generally suitable for domestic use only	—
	Precambrian to Paleozoic—quartzite, slate, gneiss, schist, marble, phyllite, granite	fracture-conduit	local, discontinuous properties, well yields variable, water quality generally good	1 to 25 gallons per minute typical; may exceed 500 gallons per minute (Kidd, 1989; Guthrie and others, 1994)

Porous-media aquifers typically consist of unconsolidated or poorly consolidated sediments. In these aquifers, ground water moves through interconnected pore spaces between sediment grains. The space between sediment grains is termed voids or interstices, and the interconnection of these spaces allows water to flow through the sediments. Such flow is said to be the result of primary permeability. The porous-media aquifers occur in sand and gravel deposits in the valley floor of the Coosa River and in clastic deposits in the southeastern Coastal Plain (figs. 1 and 2). For a more complete discussion of aquifers of the Coastal Plain Province, the reader is referred to Miller (1990).

Lenticular, discontinuous sand and gravel deposits in the valley floor of the Coosa River are limited in thickness and extent and form local aquifers. Ground-water flow generally is toward the river, but may be reversed temporarily near the river during periods of high streamflow. Wells completed in these sediments generally yield small quantities of water. These aquifers are hydraulically connected to the Coosa River and area not major sources of ground water in Subarea 6.

The Coosa River flows across the outcrop area of the Cretaceous sediments in northwestern Elmore County, Ala. Aquifers in these sediments are of the porous-media type (fig. 6), and the Coosa River receives water discharged from these aquifers. Water not intercepted by the river or by ground-water withdrawal flows downgradient through the aquifers beyond Subarea 6. These aquifers have limited thickness and extent and are not major sources of ground water in Subarea 6. Ground water flows southward and eastward away from the area of outcrop towards major pumping centers in Montgomery and Autauga Counties, Ala. (Scott, Cobb, and Castleberry, 1987).

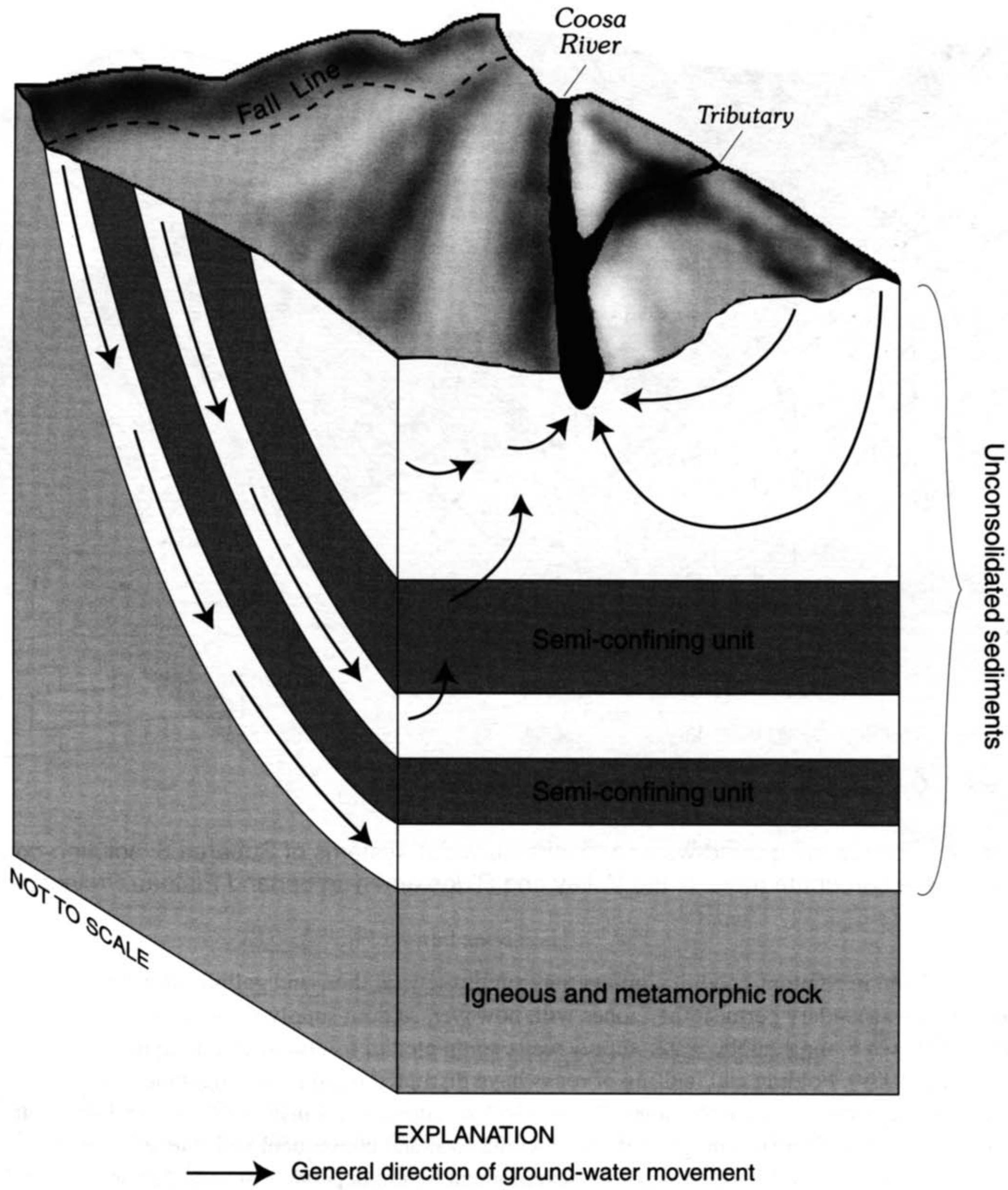

Figure 6. Conceptual ground-water and surface-water systems in Subarea 6: porous-media aquifer in unconsolidated sediments of the Coastal Plain Province.

Solution-conduit aquifers of Subarea 6 (fig. 7) occur in well-cemented carbonate rocks of the Valley and Ridge and Cumberland Plateau Provinces. The study of the occurrence and development of ground water in solution-conduit aquifers is an area of specialization and is only briefly explained here. The carbonate rocks of Subarea 6 are characterized by little primary porosity or permeability. Secondary porosity features, such as solution-enlarged fractures and bedding planes, form a system of interconnected conduits through which water moves (Bossong, 1989). The weathered zone above many of the carbonate-rock aquifers contains a layer of chert rubble that stores and transmits water slowly to the underlying fractured-rock aquifer. The carbonate-rock aquifers are anisotropic and heterogeneous because of the local and directional nature of water-bearing units in the bedrock.

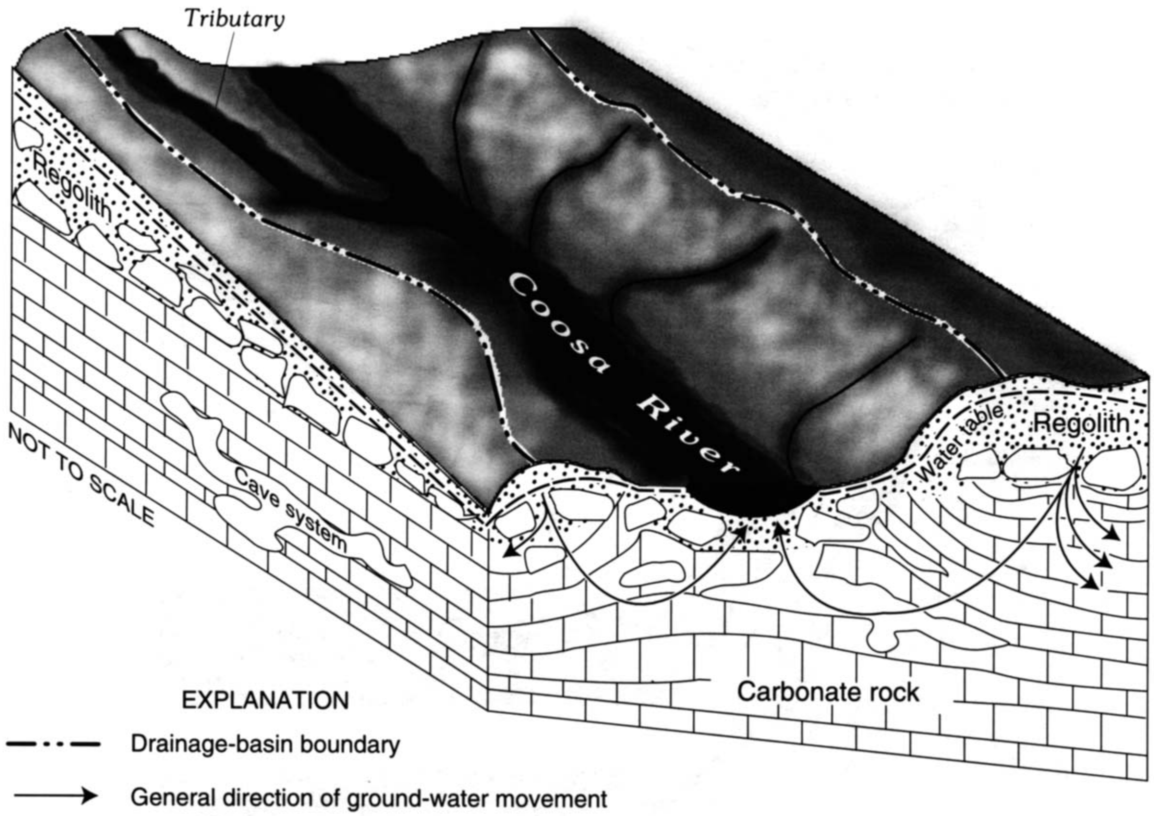

Figure 7. Conceptual ground-water and surface-water systems of Subarea 6: solution-conduit aquifer in the carbonate rocks of the Valley and Ridge and Cumberland Plateau Provinces.

Wells completed in solution-conduit aquifers may supply several thousand gallons of water per minute. Wells that do not intercept secondary permeability zones will, however, seldom supply more than 10 gallons per minute or may be dry. In Subarea 6, most public water-supply wells completed in solution-conduit aquifers yield 350 to 700 gal/min (Bossong, 1989). Folding and faulting of rocks have disrupted regional stratigraphic continuity so that the same aquifer unit may occur in adjacent valleys but not be hydraulically connected (Planert and Pritchett, 1989). As in any solution-conduit aquifer system, ground-water withdrawal and consequent water-level declines could induce sinkhole development. The likelihood of sinkhole development would depend on several factors—including, but not limited to—quantity of water withdrawn, amount of water-level decline, proximity of solution conduits to the land surface, and land-surface loading.

In Subarea 6, fracture-conduit aquifers occur in shale, siltstone, and sandstone (fig. 8) of the Valley and Ridge and Cumberland Plateau Provinces, and in igneous and metamorphic rocks (fig. 9) of the Blue Ridge and Piedmont Provinces. Two general water-bearing zones comprise the ground-water flow system in fracture-conduit aquifers: (1) the shallow regolith, composed of saprolite, soil, colluvium, and alluvium; and (2) the deeper, fractured bedrock. The soil and alluvium of the regolith is characteristic of a porous-media aquifer and bedrock is characteristic of a fracture-conduit aquifer. In general, the regolith consists of porous, permeable soil at land surface, grading downward into a highly weathered, clay-rich, relatively impermeable zone that overlies a less-weathered and more permeable transition zone (Heath, 1989). In some instances, ground water in the regolith is similar to that in porous media, where intergranular porosity is present in the soil or alluvium, or where rocks have been deeply weathered, and retain few structural characteristics. Porosity of the regolith can range from 20 to 30 percent (Heath, 1984). The transition zone between saprolite and bedrock contains weathered material and boulders, and along structural features, such as foliation and jointing, generally is more permeable than the saprolite. Ground-water flow can be preferential in saprolite, where weathered rock retains relict structural features (Stewart, 1964; Stewart and others, 1964).

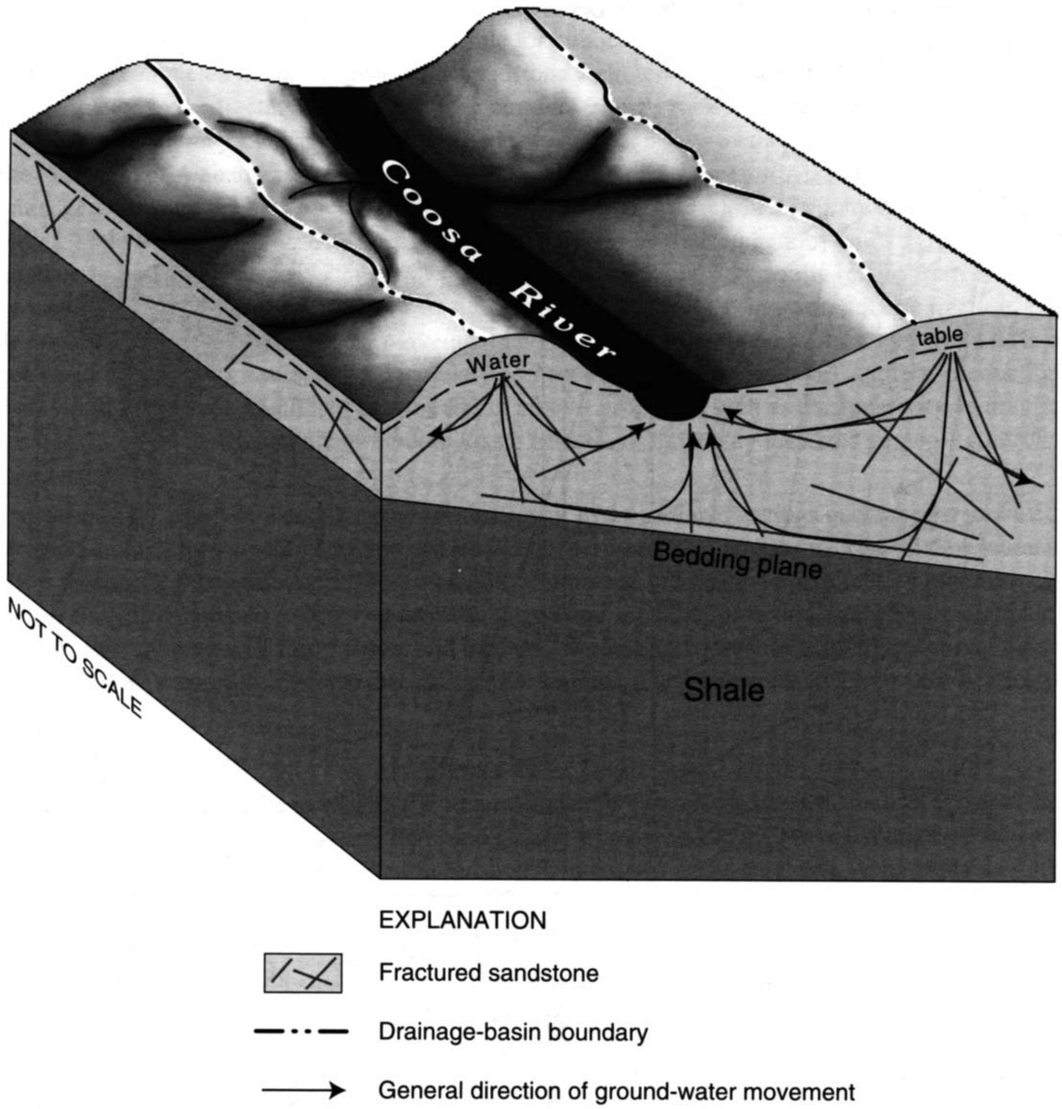

Figure 8. Conceptual ground-water and surface-water systems in Subarea 6: fracture-conduit aquifer in the clastic sedimentary rocks of the Valley and Ridge and Cumberland Plateau Provinces.

In fracture-conduit aquifers, nearly all ground-water movement is through fractured or broken rock and through openings between cleavage planes. Secondary porosity is created by faulting and fracturing and is enhanced by weathering along these openings. The bedrock below the weathered zone and beyond fractures typically has little or no porosity or primary permeability. Ground-water storage primarily is in the overlying weathered rock (regolith or saprolite, which behaves like a porous-media aquifer). The volume of water in storage is controlled by the porosity and thickness of the regolith, which is thicker in marble, schist, and gneiss, and in valleys (Kidd, 1989); to a lesser degree, the volume of water in storage is controlled by the amount of fracturing of the rock. Because of the limited storage in fractures, water levels in fracture-conduit aquifers respond rapidly to pumping and to seasonal changes in rainfall.

The fracture-conduit aquifers are anisotropic and heterogenous because of the highly complex and locally variable geologic characteristics controlling the presence of the water-bearing units in the bedrock and regolith. Rock type, structural features, and regolith thickness vary locally and affect the storage capacity and hydraulic conductivity of an aquifer (LeGrand, 1967, 1989; Daniel, 1987; Guthrie and DeJarnette, 1989; Schmitt and others, 1989; Chapman and others, 1993; Guthrie and others, 1994).

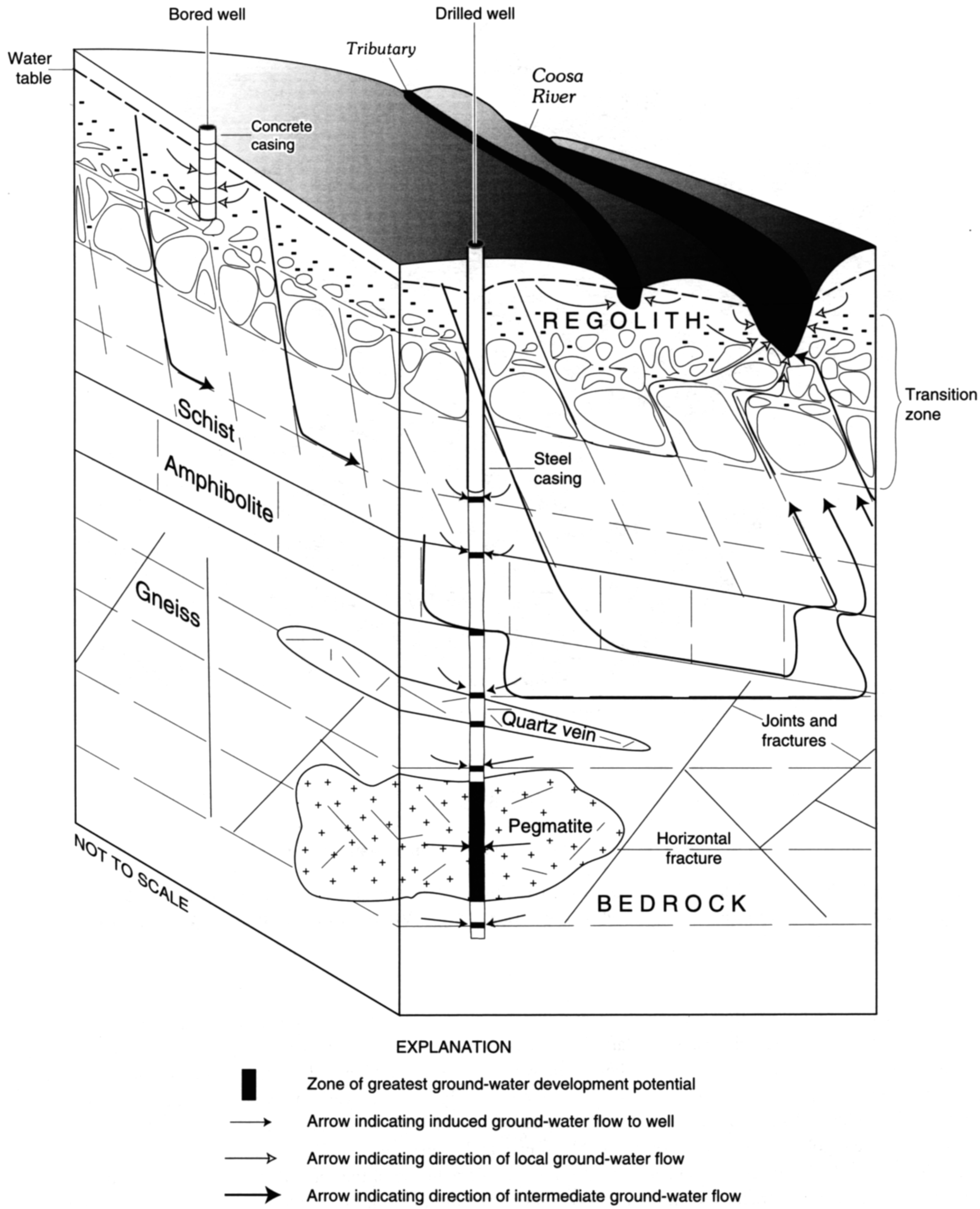

Figure 9. Conceptual ground-water and surface-water systems in Subarea 6: fracture-conduit aquifer in the igneous and metamorphic rocks of the Blue Ridge and Piedmont Provinces.

Fracture-conduit aquifers formed in shale, siltstone, and sandstone of the Valley and Ridge and Cumberland Plateau Provinces may yield quantities of water suitable for public or industrial supply. In Subarea 6, most public water-supply wells completed in shale, siltstone, or sandstone yield less than 100 gal/min (Bossong, 1989). Yields from wells completed in the fractured crystalline-rock aquifers (schist, gneiss, quartzite, and granite) generally range from 1 to 25 gal/min, but may exceed 500 gal/min (Kidd, 1989). Guthrie and others (1994) reported that yields of wells in the Piedmont of Alabama range from 0 to 700 gal/min. In the Piedmont of Alabama, yields from wells drilled in mica schist generally are the highest (Baker, 1957); and yield from wells drilled in granite and other igneous rocks are the lowest. Yield from wells in valleys, where the regolith is thickest, average four times as much as that from wells located on hilltops where the regolith is thin (Baker, 1957). Well depth generally ranges from 100 to 500 ft. Wells may yield water from several fractures throughout a borehole or from a single productive fracture. Conversely, a borehole may not intersect a fracture, or the fracture may not be water bearing, and thus, may yield little or no water. Because of the complex nature of the secondary permeability in fracture-conduit aquifers, production zones generally are of limited extent. Quantitative estimates of aquifer properties such as transmissivity, hydraulic conductivity, and storage coefficient are difficult to assess because of the highly localized geologic controls on secondary permeability.

Recent studies have shown that a thorough evaluation of hydrogeologic settings in areas characterized by solution-conduit and fracture-conduit aquifers can lead to an increased likelihood of successful development of ground-water resources. Most municipal, industrial, and commercial ground-water exploration plans now include consultation with hydrogeologists, who evaluate surficial geology, including structural features, topographic relations to geologic features, existing well information, and land use. Surface and borehole geophysical surveys also may be conducted to delineate subsurface features that indicate the sources of water to wells and the water-bearing properties of the rocks.

Ground-Water Levels

Ground-water levels fluctuate in response to natural and anthropogenic processes, such as seasonal changes in rainfall, interaction with the surface-water system, and ground-water withdrawal. These fluctuations indicate changes in the amount of water in storage in an aquifer. In Subarea 6, long-term water-level data were available for 8 wells in fracture-conduit aquifers for the period 1968-94; 18 wells in solution-conduit aquifers for the period 1959-94; and 4 wells in the porous-media aquifers of the Coastal Plain for the period 1972-94.

The hydrograph of well O3PP01 (just north of Subarea 6) (fig. 10) completed in a solution-conduit aquifer in Walker County, Ga., shows a seasonal water-level fluctuation that probably is typical of such wells in Subarea 6. Annual low water levels occur in the fall after the dry summer; and annual high water levels occur in the early spring because of recharge following rainfall during the winter. Although the water level fluctuates seasonally, significant year-to-year or long-term change in the average water level in the aquifer has not occurred. This suggests that mean-annual recharge and discharge are approximately equal, and during the period November 1977 to 1995, permanent changes in storage in the aquifer have not occurred.

Ground-water levels in observation wells in Subarea 6 ranged from about 2 ft above land surface (a flowing well) to 60 ft below land surface in the fracture-conduit aquifers, from 2 to 150 ft below land surface in the solution-conduit aquifers, and from 13 to 226 ft below land surface in the porous-media aquifers. Water levels fluctuated 5 to 45 ft seasonally over the period of record. Water-level trends and long-term changes were not observed. However, the number and distribution of wells having long-term water-level records in Subarea 6 is insufficient to make any conclusions. In general, shallow, bored wells that are completed in regolith are more susceptible to water-level decline during droughts. Wells that are completed in bedrock often are more capable of sustaining yields during droughts.

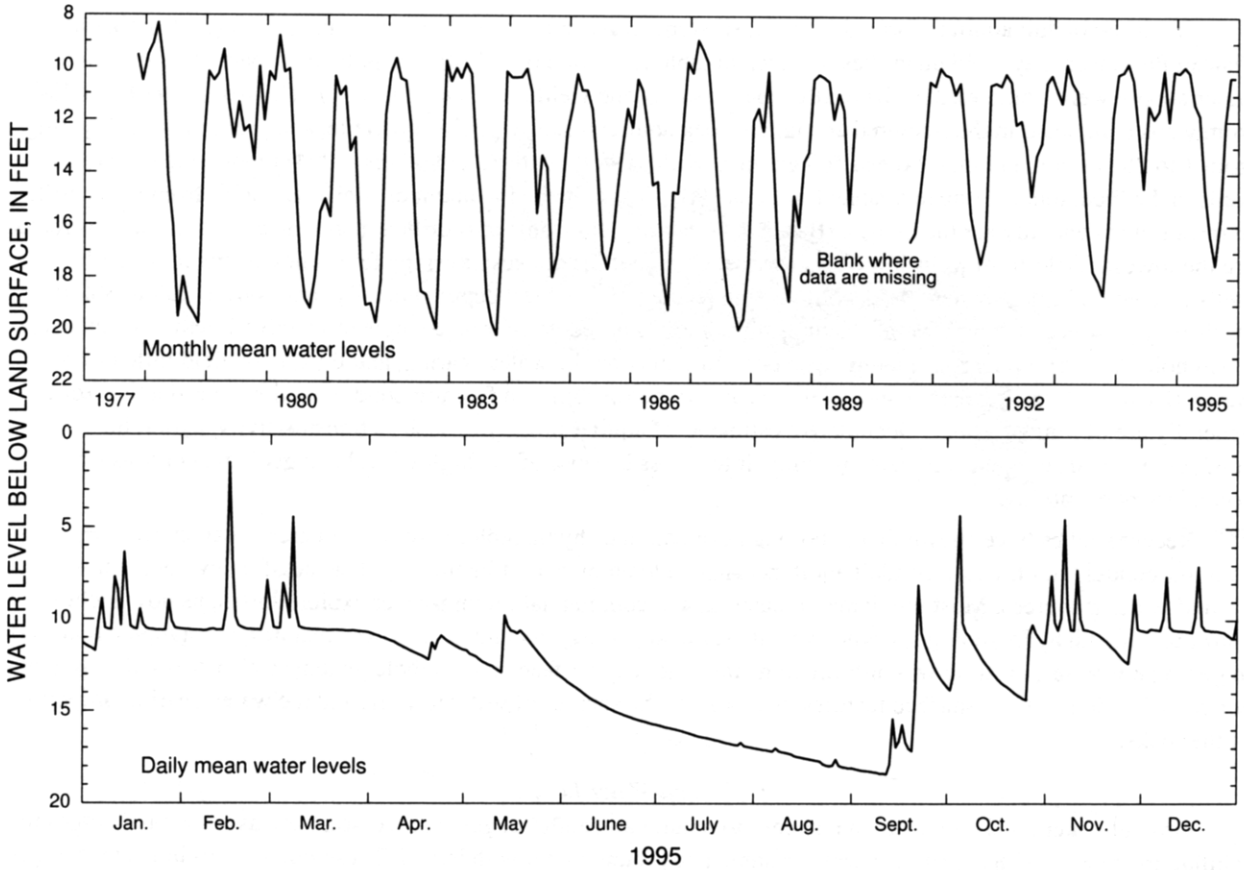

Figure 10. Water-level fluctuations in observation well 03PP01, Walker County, Georgia, 1977–95.

Surface-Water System

The surface-water system in Subarea 6 includes the Coosa River and its tributaries. The drainage area of the Coosa River basin encompasses about 5,360 mi^2 in Alabama (U.S. Army Corps of Engineers, 1985a,b); about 4,700 mi^2 in Georgia; and about 100 mi^2 in Tennessee (not included in Subarea 6). The confluence of the Etowah and Oostanaula Rivers near Rome, Ga., forms the Coosa River. The drainage area of the Coosa River near Rome, Ga. (02397000), is about 4,040 mi^2. From Rome, Ga., the Coosa River flows southwest into Weiss Reservoir in Cherokee County, Ala. From Weiss Reservoir, the Coosa River flows southwest across the Valley and Ridge and Piedmont Provinces. The major tributaries of the Coosa River include the Etowah, Oostanaula, and Chattooga Rivers in Georgia; and the Little River, Terrapin, Big Wills, Big Canoe, Tallaseehatchee, Cane, Choccolocco, Talladega, Kelly, Yellowleaf, and Hatchet Creeks in Alabama. The Coosa River joins the Alabama River near Wetumpka, Ala.

For this report, the mean-annual stream discharge of a surface-water drainage measured at a gaging station is defined as the arithmetic average of all reported annual discharges for the period of record. Note that, by definition, the stream discharge includes both surface runoff and baseflow.

The estimated mean-annual contribution of stream discharge of the Coosa River from Georgia into Alabama is between about 6,700 and 8,200 ft^3/s, using values based on mean-annual stream discharge data collected at Coosa River near Rome, Ga. (02397000), and Coosa River at Leesburg, Ala. (02399500), respectively (table 3; fig. 11). The estimated mean-annual stream discharge of the Coosa River to the Alabama River (into Subarea 8) is about 16,000 ft^3/s (table 3); this value is based on data for the continuous-record stream-gaging station—Coosa River at Jordan Dam near Wetumpka, Ala. (02411000)—which is representative of essentially the entire Coosa River basin.

Table 3. Selected active and discontinued continuous-record stream-gaging stations in the Coosa River basin, Subarea 6

[I, fracture-conduit aquifer in igneous or metamorphic rocks; F, fracture-conduit aquifer in clastic rocks; S, solution-conduit aquifer]

Station number	Station name	Drainage area (square miles)	Type of stream	Major aquifer drained	Period of record of unregulated flow	Mean-annual stream discharge (cubic feet per second)
02379500	Cartecay River near Ellijay, Ga.	134	tributary	I	1937-1977	[1]289
02380500	Coosawattee River near Ellijay, Ga.	236	do.	I	1938-1949 1963-1994	[2]515
02382500	Coosawattee River at Carters, Ga.	521	do.	I	1896-1908 1918-1923 1961-1972	[2]1,184
02383500	Coosawattee River near Pine Chapel, Ga.	831	do.	I	1938-1974	[2]1,502
02384500	Conasauga River near Eton, Ga.	252	do.	I,S	1981-1994	[2]482
02388500	Oostanaula River near Rome, Ga.	2,120	regional	I,S,F	1939-1974	[2]3,627
02389000	Etowah River near Dawsonville, Ga.	107	do.	I	1940-1976	[3]270
02392000	Etowah River at Canton, Ga.	613	do.	I	1896-1905 1936-1949	[2]1,239
02394000	Etowah River at Allatoona Dam, above Cartersville, Ga.	1,120	do.	I	1938-1949	[2]1,910
02396000	Etowah River at Rome, Ga.	1,820	do.	I,S	1904-1921 1938-1949	[2]2,955
02397000	Coosa River near Rome, Ga.	4,040	do.	I,S,F	1896-1903 1928-1931 1937-1949	[2]6,711
02397500	Cedar Creek near Cedartown, Ga.	115	tributary	S	1942-1973	[4]160
02398000	Chattooga River at Summerville, Ga.	192	do.	S	1937-1994	[2]359
02398300	Chattooga River above Gaylesville, Ala.	366	do.	S	1959-1967 1984-1994	[5]640
02398500	Chattooga River at Gaylesville, Ala.	379	do.	S	1937-1960	[6]649
02399000	Little River near Jamestown, Ala.	125	do.	F	1922-1932 1935-1949	[6]260
02399200	Little River near Blue Pond, Ala.	199	do.	F	1958-1967 1970-1994	[5]491
02399500	Coosa River at Leesburg, Ala.	5,270	regional	I,S,F	1937-1949	[5]8,161
02400100	Terrapin Creek at Ellisville, Ala.	252	tributary	S,F	1962-1967 1980-1994	[5]390
02400500	Coosa River at Gadsden, Ala.	5,805	regional	I,S,F	1926-1949	[5]9,468
02401000	Big Wills Creek near Reece City, Ala.	182	tributary	S	1943-1970 1986-1994	[5]302
02401500	Big Canoe Creek near Gadsden, Ala.	253	do.	S	1938-1965	[6]431
02402500	Coosa River at Riverside, Ala.	7,070	regional	I,S,F	1896-1916	[6]11,740
02404400	Choccolocco Creek at Jackson Shoal near Lincoln, Ala.	481	tributary	I,S	1960-1967 1984-1994	[5]713
02404500	Choccolocco Creek near Lincoln, Ala.	496	do.	I,S	1938-1953	[6]709
02405000	Coosa River near Cropwell, Ala.	7,663	regional	I,S,F	[1]1941-1949	[6]12,570
02405500	Kelly Creek near Vincent, Ala.	193	tributary	F	1951-1970 1986-1994	[5]323
02406500	Talladega Creek at Alpine, Ala.	150	do.	I,S	1900-1904 1938-1951 1987-1994	[5]240
02407000	Coosa River at Childersburg, Ala.	8,390	regional	I,S,F	1913-1949	[6]13,860
02407500	Yellowleaf Creek near Wilsonville, Ala.	96.5	tributary	F	1951-1967	[6]148
02408500	Hatchet Creek near Rockford, Ala.	233	do.	I	1944-1979	[6]386
02408540	Hatchet Creek below Rockford, Ala.	263	do.	I	1980-1994	[5]404
02411000	Coosa River at Jordan Dam near Wetumpka, Ala.	10,102	regional	I,S,F	[1]1912-1914	[5]16,360

[1]U.S. Geological Survey (1978).
[2]Stokes and McFarlane (1994).
[3]U.S. Geological Survey (1977).
[4]U.S. Geological Survey (1974).
[5]Pearman and others (1994).
[6]Atkins and Pearman (1994).

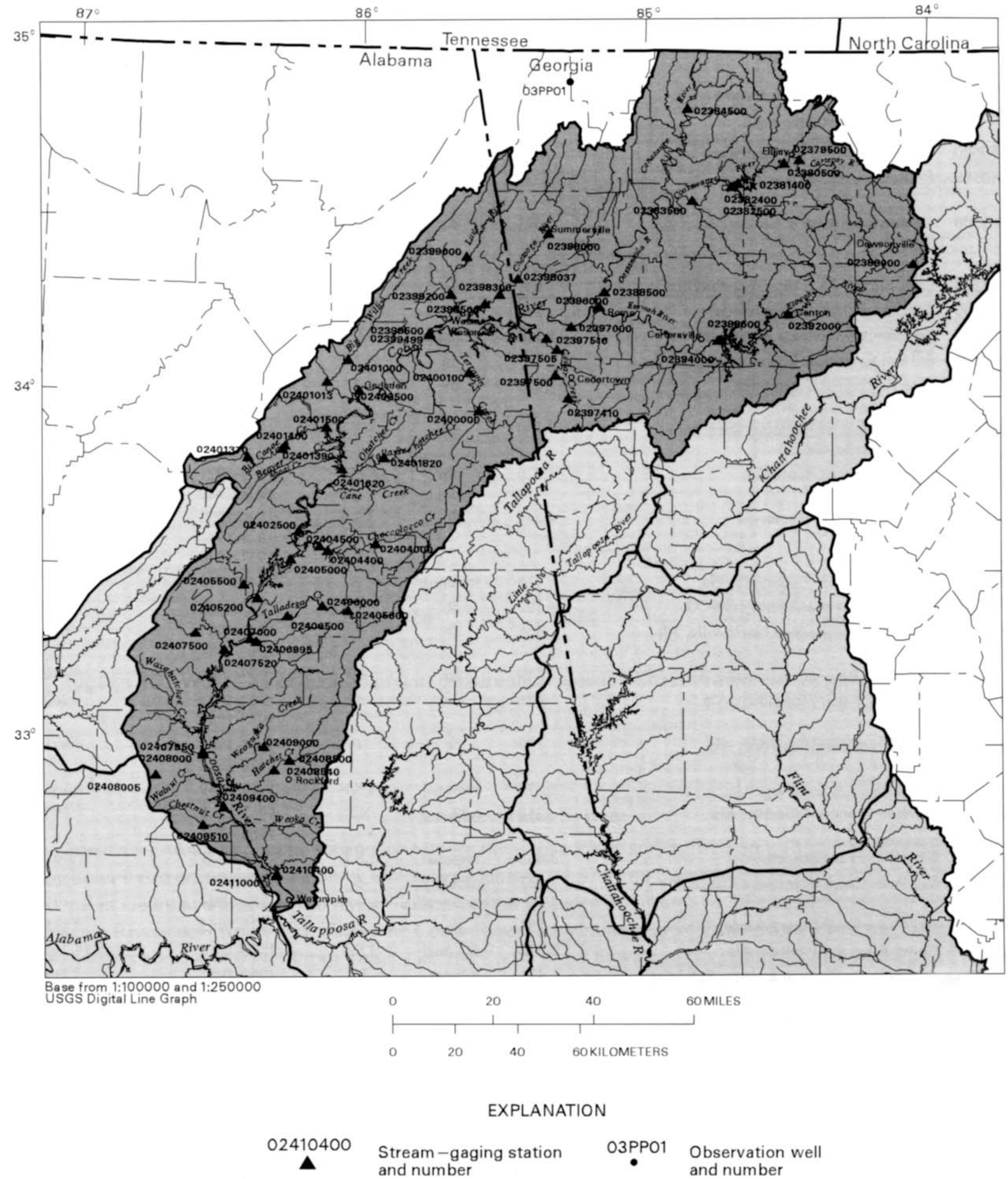

Figure 11. Selected stream-gaging stations, Subarea 6, and observation well 03PP01, Walker County, Georgia.

Streamflow characteristics of the tributaries of the Coosa River in Subarea 6 vary with geology. Seven-day two-year low flows (7Q2) in tributaries draining terranes underlain by igneous and metamorphic rocks in Georgia range from about 0.4 to 0.8 cubic foot per second per square mile ($ft^3/s/mi^2$). These corresponding low flows in tributaries draining igneous and metamorphic rocks in Alabama range from about 0.1 to 0.3 $ft^3/s/mi^2$. The range of estimated 7Q2 for tributaries draining carbonate rocks in both Georgia and Alabama is about 0.2 to 0.4 $ft^3/s/mi^2$. In general, the lowest 7Q2, about 0.005 to 0.02 $ft^3/s/mi^2$, occurs in tributaries that drain sandstone and shale of the Valley and Ridge and Cumberland Plateau Provinces of Alabama.

The largest drainage system in Subarea 6 is the Coosa River, which integrates and is influenced by the streamflow characteristics of its tributaries. Estimated 7Q2 for the Coosa River ranges from about 0.3 to 0.4 $ft^3/s/mi^2$. The greatest value (0.4 $ft^3/s/mi^2$) is near Rome, Ga. (02397000), because of the influence of the relatively higher low flows maintained by the igneous and metamorphic rocks of Georgia. As more and more of the drainage basin is integrated, downstream 7Q2 in the Coosa River varies less than 15 percent, from about 0.3 to 0.35 $ft^3/s/mi^2$.

The Coosa River basin has three major impoundments in the Piedmont Province in Georgia, one in the Piedmont Province in Alabama, and five in the Valley and Ridge Province in Alabama (figs. 2 and 11; table 4). The impoundments mainly are used for power generation, flood control, and recreation. The first was completed in 1914 near Clanton, Ala., and the last in 1975 in Murray County, Ga. Total reservoir storage is 1,160,400 acre-feet in Georgia, and 1,425,524 acre-feet in Alabama.

Table 4. Major impoundments in the Coosa River basin, Subarea 6

Impoundment structure	Station number	Location	Installation date	Major uses	Total storage capacity (acre-feet)
Carters Dam	02381400	Murray County, Ga.	1974	power generation, flood control, recreation	1/472,800
Carters re-regulation Dam	02382400	Murray County, Ga.	1975	do.	1/17,600
Allatoona Dam	02393500	Bartow County, Ga.	1949	do.	1/670,000
Weiss Dam	02399499	Cherokee County, Ala.	1961	do.	2/360,400
H. Neely Henry Dam	02401620	Calhoun County, Ala.	1966	do.	2/120,850
Logan Martin Dam	02405200	St. Clair County, Ala.	1964	do.	2/273,300
Lay Dam	02407950	Chilton County, Ala.	1914	power generation, recreation	2/144,994
			1968		3/262,774
Mitchell Dam	02409400	Chilton County, Ala.	1923	do.	2/172,000
Jordan Dam	02410400	Elmore County, Ala.	1929	do.	2/236,200

1/Stokes and McFarlane (1994).
2/Pearman and others (1994).
3/Storage capacity of Lay Lake was increased from 144,994 to 262,774 acre-feet in 1968 (Pearman and others, 1994).

GROUND-WATER DISCHARGE TO STREAMS

Streamflow is comprised of two major components—a typical hydrograph integrates these components as:

- overland or surface runoff, represented by peaks, indicating rapid response to precipitation; and
- baseflow, represented by the slope of the streamflow recession, indicating ground-water discharge to the stream.

In relation to the conceptual model, baseflow in streams is comprised of contributions from the local, intermediate, or regional ground-water flow regimes. Estimates of recharge to the ground-water system are minimum estimates because the budgets were developed as ground-water discharge to streams, and do not include ground water discharged as evapotranspiration, to wells, or ground water that flows downgradient into other aquifers beyond the topographic boundary defining Subarea 6. Local flow regimes likely are the most affected by droughts. Discharge measured in unregulated streams and rivers near the end of a drought should be relatively steady and composed largely of baseflow.

Mean-Annual Baseflow

Mean-annual baseflow was determined by estimating mean-annual ground-water discharge to the Coosa River and its major tributaries. Streamflow data used to determine mean-annual ground-water discharge at continuous-record gaging stations were selected according to periods of record when flow was unregulated. The modified hydrograph-separation program SWGW (Mayer and Jones, 1996) was applied to estimate mean-annual baseflow at 25 continuous-record gaging stations in the Coosa River basin (table 5), including one station in Georgia and five stations in Alabama on the Coosa River. For each gaging station, two recession indices are listed in table 5; one represents the rate of streamflow recession during the major rise period, generally in winter, and the other during the major recession period, generally in summer. Some variables that are supplied by the user to SWGW for each hydrograph separation are not listed in table 5, but can be obtained from the U.S. Geological Survey, Alabama District Office, Montgomery, Ala. These variables include the time-base (in days) from the peak to the cessation of surface runoff, the time period (the beginning and ending months) for application of the summer recession index, and the adjustment factor for the displacement of the recession curve. See Rutledge (1993) for a discussion of time-base, and Mayer and Jones (1996) for a discussion of the other user-supplied variables.

The mean-annual baseflow, in cubic feet per second; and the related unit-area baseflow, in cubic feet per second per square mile, were computed for each station. Mean unit-area baseflow estimated for four stations representing discharge from igneous and metamorphic rocks was 1.19 $ft^3/s/mi^2$; for six stations representing discharge from carbonate rocks, was 0.886 $ft^3/s/mi^2$; and for three stations representing discharge from fractured clastic rocks, 0.640 $ft^3/s/mi^2$. Mean unit-area baseflow was not estimated at continuous-record gaging stations in unconsolidated clastic sediments of the Coastal Plain Province of Subarea 6.

Mean-annual baseflow in the Coosa River and tributaries at the Georgia-Alabama State line and at the mouth of the Coosa River was estimated using representative unit-area mean-annual baseflow derived from the hydrograph-separation analyses to estimate discharge from ungaged drainages. Baseflow estimates based on mean-annual unit-area stream discharges were checked using a mass-balance approach. For example, the estimated mean-annual baseflow at the Georgia-Alabama State line should approximate, but be less than, the estimated mean-annual baseflow in the Coosa River at Leesburg, Ala. Because of the lack of unregulated flow data for the Coosa River near its mouth, the unit-area mean-annual baseflow for Subarea 6 probably is best represented by the results of hydrograph separation using streamflow data for the Coosa River at Childersburg, Ala. (table 5). The unit-area mean-annual baseflow determined for the Coosa River at Childersburg, Ala., was used, together with the unit-area mean-annual baseflow of major tributaries, to estimate the mean-annual baseflow at the mouth of the Coosa River (table 6).

The mean-annual baseflow in the Coosa River and tributaries in Georgia at the Georgia-Alabama State line is estimated to be about 4,600 ft^3/s (table 6). The estimated cumulative contribution of mean-annual baseflow at the mouth of the Coosa River entering the Alabama River (at the boundary with Subarea 8) is 9,960 ft^3/s (table 6). The difference of 5,360 ft^3/s is the estimated mean-annual baseflow in the Coosa River tributaries in Alabama. Mean-annual baseflow of the Coosa River and drainage area is shown in figure 12 and summarized in table 6. Estimated mean-annual baseflow in the Coosa River ranges from about 58 to 64 percent of mean-annual stream discharge and is estimated to be about 60 percent of the mean-annual stream discharge at the mouth of the Coosa River.

Table 5. Mean-annual stream discharge, estimated annual and mean-annual baseflow, and unit-area mean-annual baseflow at selected gaged streams in the Coosa River basin, Subarea 6

[I, fracture-conduit aquifer in igneous and metamorphic rocks; F, fracture-conduit aquifer in clastic rocks; S, solution-conduit aquifer in carbonate rocks]

Station number	Station name	Type of stream	Drainage area (square miles)	Major aquifer type	Recession index: Winter (days)	Recession index: Summer (days)	Water year	Flow conditions	Mean-annual stream discharge[1/] (cubic feet per second)	Annual baseflow[2/,3/] (cubic feet per second)	Mean-annual baseflow[3/,4/] (cubic feet per second)	Unit-area mean-annual baseflow[3/,5/] (cubic feet per second per square mile)
02383500	Coosawattee River near Pine Chapel, Ga.	tributary	831	I	130	80	1941	Low	717	569		
							1966	Average	1,423	984	958	1.15
							1964	High	2,065	1,320		
02388500	Oostanaula River near Rome, Ga.	regional	2,120	I,S	136	80	1941	Low	1,626	1,030		
							1972	Average	3,457	1,950	1,780	.840
							1964	High	5,096	2,360		
02392000	Etowah River at Canton, Ga.	do.	613	I	145	85	1986	Low	510	413		
							1977	Average	1,188	898	897	1.46
							1946	High	1,868	1,380		
02396000	Etowah River at Rome, Ga.	do.	1,820	I,S	110	65	1941	Low	1,550	1,190		
							1948	Average	2,818	1,980	1,990	1.09
							1946	High	4,355	2,810		
02397000	Coosa River near Rome, Ga.	do.	4,040	I,S	124	75	1941	Low	3,236	2,360		
							1948	Average	6,031	3,880	3,930	.973
							1946	High	9,943	5,560		
02397500	Cedar Creek near Cedartown, Ga.	tributary	115	S	114	70	1956	Low	105	69.6		
							1963	Average	163	87.6	89.1	.775
							1964	High	220	110		
02398000	Chattooga River at Summerville, Ga.	do.	192	S	120	65	1986	Low	133	107		
							1991	Average	340	208	185	.964
							1984	High	506	241		
02398300	Chattooga River above Gaylesville, Ala.	do.	366	S	117	70	1986	Low	249	220		
							1965	Average	633	396	362	.989
							1990	High	1,147	471		
02398500	Chattooga River at Gaylesville, Ala.	do.	379	S	117	65	1959	Low	436	281		
							1953	Average	724	391	373	.984
							1949	High	1,122	446		

Table 5. Mean-annual stream discharge, estimated annual and mean-annual baseflow, and unit-area mean-annual baseflow at selected gaged streams in the Coosa River basin, Subarea 6—Continued

[I, fracture-conduit aquifer in igneous and metamorphic rocks; F, fracture-conduit aquifer in clastic rocks; S, solution-conduit aquifer in carbonate rocks]

Station number	Station name	Type of stream	Drainage area (square miles)	Major aquifer type	Recession index		Water year	Flow conditions	Mean-annual stream discharge[1/] (cubic feet per second)	Annual baseflow[2/,3/] (cubic feet per second)	Mean-annual baseflow[3/,4/] (cubic feet per second)	Unit-area mean-annual baseflow[3/,5/] (cubic feet per second per square mile)
					Winter (days)	Summer (days)						
02399000	Little River near Jamestown, Ala.	tributary	125	F	35	19	1941	Low	136	51.9		
							1947	Average	275	80.7	76.3	.610
							1946	High	396	96.2		
02399200	Little River near Blue Pond, Ala.	tributary	199	F	52	20	1986	Low	192	58.6		
							1987	Average	492	145	132	.663
							1973	High	696	193		
02399500	Coosa River at Leesburg, Ala.	regional	5,270	I,S,F	124	70	1941	Low	4,460	3,320		
							1948	Average	7,863	4,930	5,260	.998
							1946	High	12,630	7,540		
02400100	Terrapin Creek at Ellisville, Ala.	tributary	252	S,F	120	70	1986	Low	147	129		
							1991	Average	365	243	212	.841
							1964	High	488	265		
02400500	Coosa River at Gadsden, Ala.	regional	5,805	I,S,F	124	70	1941	Low	4,673	3,350		
							1947	Average	9,081	5,430	5,750	.990
							1946	High	14,310	8,460		
02401000	Big Wills Creek near Reece City, Ala.	tributary	182	S	125	170	1988	Low	112	81.7		
							1961	Average	299	192	165	.906
							1990	High	450	222		
02401500	Big Canoe Creek near Gadsden, Ala.	regional	253	S	67	30	1956	Low	302	136		
							1951	Average	438	172	176	.696
							1961	High	605	221		
02402500	Coosa River at Riverside, Ala.	regional	7,070	I,S,F	120	70	1904	Low	5,024	3,990		
							1908	Average	11,490	6,840	6,560	.928
							1901	High	15,870	8,850		
02404400	Choccolocco Creek at Jackson Shoal near Lincoln, Ala.	tributary	481	I,S	120	70	1986	Low	221	189		
							1989	Average	781	464	417	.867
							1990	High	1,109	598		
02404500	Choccolocco Creek near Lincoln, Ala.	tributary	496	I,S	120	70	1941	Low	437	331		
							1952	Average	722	448	468	.944
							1949	High	1,172	626		

Table 5. Mean-annual stream discharge, estimated annual and mean-annual baseflow, and unit-area mean-annual baseflow at selected gaged streams in the Coosa River basin, Subarea 6—Continued

[I, fracture-conduit aquifer in igneous and metamorphic rocks; F, fracture-conduit aquifer in clastic rocks; S, solution-conduit aquifer in carbonate rocks]

Station number	Station name	Type of stream	Drainage area (square miles)	Major aquifer type	Recession index		Water year	Flow conditions	Mean-annual stream discharge[1/] (cubic feet per second)	Annual baseflow[2/,3/] (cubic feet per second)	Mean-annual baseflow[3/,4/] (cubic feet per second)	Unit-area mean-annual baseflow[3/,5/] (cubic feet per second per square mile)
					Winter (days)	Summer (days)						
02405000	Coosa River near Cropwell, Ala.	regional	7,663	I,S,F	120	70	1945	Low	9,400	5,380		
							1943	Average	14,090	7,360	7,500	.979
							1946	High	19,350	9,760		
02405500	Kelly Creek near Vincent, Ala.	tributary	193	F	40	20	1988	Low	112	61.4		
							1966	Average	305	126	125	.648
							1968	High	493	187		
02406500	Talladega Creek at Alpine, Ala.	tributary	150	I,S	130	70	1941	Low	156	111		
							1947	Average	260	174	170	1.13
							1949	High	373	224		
02407000	Coosa River at Childersburg, Ala.	regional	8,390	I,S,F	122	70	1931	Low	8,262	5,160		
							1943	Average	14,510	8,400	8,220	.980
							1946	High	20,300	11,100		
02408500	Hatchet Creek near Rockford, Ala.	tributary	233	I	130	70	1959	Low	268	183		
							1968	Average	398	250	255	1.09
							1976	High	612	332		
02408540	Hatchet Creek below Rockford, Ala.	tributary	263	I	130	70	1985	Low	245	176		
							1987	Average	403	255	278	1.06
							1990	High	657	402		

[1/]From annually published U.S. Geological Survey data reports, for example: Pearman and others (1994) or Stokes and McFarlane (1994).
[2/]Estimated using the SWGW program (Mayer and Jones, 1996).
[3/]Values are reported to three significant digits to maintain the numerical balance of the water budget; implication of accuracy to the degree shown is not intended.
[4/]Estimated by averaging discharges for low, average, and high flow years for the period of unregulated flow.
[5/]Discharge divided by drainage area.

Table 6. Estimated mean-annual baseflow at selected gaged streams, estimation sites, the Georgia-Alabama State line, and exiting Subarea 6
[—, not applicable]

Station number or estimation site	Station name	Drainage area (square miles)	Mean-annual stream discharge (cubic feet per second)	Mean-annual baseflow[1/] (cubic feet per second)	Unit-area mean-annual baseflow[1/] (cubic feet per second per square mile)
02397000	Coosa River near Rome, Ga.	4,040	[2/]6,711	[3/]3,930	[4/]0.973
02397500	Cedar Creek near Cedartown, Ga.	115	[2/]160	[3/]89.1	[4/].775
02398000	Chattooga River at Summerville, Ga.	192	[2/]359	[3/]185	[4/].964
Estimation site	Chattooga River at Georgia-Alabama State line	[5/]286	—	[6/]276	—
Estimation site	Little River at Georgia-Alabama State line	[5/]43.8	—	[6/]26.7	—
Estimation site	Coosa River at Georgia-Alabama State line	[5/]4,362	—	[6/]4,300	—
Cumulative drainage area and baseflow in the Coosa River and tributaries at Georgia–Alabama State line		**[5/]4,692**	**—**	**[7/]4,600**	**—**
02399500	Coosa River at Leesburg, Ala.	5,270	[2/]8,161	[3/]5,260	[4/].998
02407000	Coosa River at Childersburg, Ala.	8,390	[2/]13,860	[3/]8,220	[4/].980
02408500	Hatchet Creek near Rockford, Ala.	233	[2/]386	[3/]255	[4/]1.09
02408540	Hatchet Creek below Rockford, Ala.	263	[2/]404	[3/]278	[4/]1.06
02411000	Coosa River at Jordan Dam near Wetumpka, Ala.	10,102	[2/]16,360	—	—
Drainage area and estimated baseflow in the Coosa River in Subarea 6		**[5/]10,161**	**—**	**[6/]9,960**	**—**

[1/]Values are reported to three significant digits to maintain the numerical balance of the water budget; implication of accuracy to the degree shown is not intended.
[2/]From table 3.
[3/]From table 5.
[4/]Discharge divided by the drainage area—termed the unit-area discharge.
[5/]Drainage areas in the Coosa River basin, Ala. (James L. Pearman, U.S. Geological Survey, written commun., 1980).
[6/]Estimate based on unit-area discharge of station(s) for the same reaches listed in table 5.
[7/]Sum of measured and estimated mean-annual baseflow.

Drought Flow for 1941, 1954, and 1986

Regional drought periods of 1938-45, 1950-63, and 1984-88 were marked by severe droughts in the years of 1941, 1954, and 1986 in the ACF and ACT River basins. Typically, the lowest mean-annual streamflow for the period of record occurred during one of these years. Streamflow was assumed to be sustained entirely by baseflow near the end of these droughts. Near-synchronous discharge measurements at partial-record gaging stations or daily mean streamflow at continuous-record gaging stations during these periods were assumed to provide a quantitative estimate of minimum baseflow across the Georgia-Alabama State line and from Subarea 6 into Subarea 8. Where available, streamflow data for an interval of a few days were compiled; and where not available, streamflow was estimated using various techniques.

Estimated and measured streamflow near the end of the 1941, 1954, and 1986 drought years at selected sites on the Coosa River and its tributaries are shown in tables 7, 8, and 9, respectively, and summarized in table 10. Streamflow near the end of the drought of 1941 represented the minimum baseflow in the Coosa River in Georgia; however, streamflow in Subarea 6 in Alabama was lowest during the drought of 1986. Estimated streamflow at the Georgia-Alabama State line near the end of the 1941, 1954, and 1986 drought years was 1,060, 1,170, and 1,230 ft^3/s, respectively (tables 7, 8, and 9); streamflow range was 170 ft^3/s, and the average streamflow (table 11) was 1,150 ft^3/s. Estimated streamflows at the mouth of the Coosa River near the end of the 1941, 1954, and 1986 droughts were 2,070, 1,780, and 2,170 ft^3/s, respectively (tables 7, 8, and 9); streamflow range was 390 ft^3/s, and the average streamflow (table 11) was 2,010 ft^3/s.

Table 7. Stream discharge during the months of October and November of the drought of 1941, Subarea 6
[—, not applicable]

Station number or estimation site	Station name	Type of stream	Drainage area (square miles)	Date	Stream discharge (cubic feet per second)	Unit-area discharge (cubic feet per second per square mile)
02388500	Oostanaula River near Rome, Ga.	tributary	2,120	10/25/41	[1]441	[2]0.208
02396000	Etowah River at Rome, Ga.	tributary	1,820	10/25/41	[1]520	[2]286
02397000	Coosa River near Rome, Ga.	regional	4,040	10/24/41	[1]972	[2].241
02398000	Chattooga River at Summerville, Ga.	do.	192	10/23/41	[1]50	[2].260
Estimation site	Chattooga River at Georgia-Alabama State line	do.	[3]286	—	[4]74	—
02398500	Chattooga River at Gaylesville, Ala.	do.	379	10/24/41	[1]98	[2].259
Estimation site	Chattooga River at mouth below Gaylesville, Ala.	do.	[3]380	—	[5]98	—
Estimation site	Little River at Georgia-Alabama State line	do.	[3]43.8	—	[5]0.2	—
02399000	Little River near Jamestown, Ala.	do.	125	10/24/41	[1].5	[2].004
Estimation site	Little River at edge of backwater of Weiss Lake near Little River, Ala.	do.	[3]208	—	[5]1	—
Estimation site	Coosa River at Georgia-Alabama State line	regional	[3]4,362	—	[5]990	—
Cumulative drainage area and stream discharge, Coosa River basin at Georgia-Alabama State line			**[3]4,692**	**—**	**[6]1,060**	**—**
02399500	Coosa River at Leesburg, Ala.	regional	5,270	10/24/41	[1]1,130	[2].214
Estimation site	Terrapin Creek at mouth near Centre, Ala.	tributary	[3]284	—	[7]68	—
02400500	Coosa River at Gadsden, Ala.	regional	5,805	10/24/41	[1]1,220	[2].210
02401013	Big Wills Creek near Attalla, Ala.	tributary	218	11/13/41	[8]56	[2].257
Estimation site	Big Wills Creek at U.S.Highway 411, 1/4-mile above mouth near Gadsden, Ala.	do.	[3]366	—	[5]94	—
02401400	Big Canoe Creek near Ashville, Ala.	do.	145	11/13/41	[8]18	[2].124
02401500	Big Canoe Creek near Gadsden, Ala.	do.	253	10/25/41	[1]19	[2].075
Estimation site	Big Canoe Creek at mouth above Greensport, Ala.	do.	[3]277	—	[5]21	—
Estimation site	Beaver Creek at edge of backwater of H. Neely Henry Lake	do.	[3]35.7	—	[9]3	—
Estimation site	Shoal Creek at edge of backwater of H. Neely Henry Lake	do.	[3]28.9	—	[9]2	—
Estimation site	Tallasseehatchee Creek at confluence with Ohatchee Creek near Ohatchee, Ala.	do.	[3]136	—	[7]49	—
Estimation site	Ohatchee Creek at mouth but excluding Tallasseehatchee Creek	do.	[3]87.0	—	[7]3	—
Estimation site	Cane Creek at edge of backwater of Logan Martin Lake near Ragland, Ala.	do.	[3]96.5	—	[7]25	—
Estimation site	Trout Creek at edge of backwater of Logan Martin Lake near Ragland, Ala.	do.	[3]28.2	—	[10]1	—
02404000	Choccolocco Creek near Jenifer, Ala.	do.	277	10/25/41	[1]69	[2].249
02404500	Choccolocco Creek near Lincoln, Ala.	do.	496	10/25/41	[1]159	[2].321
Estimation site	Choccolocco Creek at mouth above Cropwell, Ala.	do.	[3]502	—	[5]161	—
Estimation site	Kelly Creek at mouth above Vincent, Ala.	do.	[3]208	—	[11]8	—
02406500	Talladega Creek at Alpine, Ala.	do.	150	10/25/41	[1]55	[2].367
Estimation site	Talladega Creek at Alabama Highway 235, 1/4-mile above mouth near Childersburg, Ala.	do.	[3]175	—	[5]64	—
02406995	Tallasseehatchee Creek at Childersburg, Ala.	do.	184	11/12/41	[8]30	[2].163

Table 7. Stream discharge during the months of October and November of the drought of 1941, Subarea 6—Continued
[—, not applicable]

Station number or estimation site	Station name	Type of stream	Drainage area (square miles)	Date	Stream discharge (cubic feet per second)	Unit-area discharge (cubic feet per second per square mile)
Estimation site	Tallasseehatchee Creek at Alabama Highway 235, 1/4-mile above mouth near Childersburg, Ala.	do.	[3]199	—	[5]33	—
02407000	Coosa River at Childersburg, Ala.	regional	8,390	10/25/41	[1]1,840	[2].219
02407520	Yellowleaf Creek at Wilsonville, Ala.	tributary	164	11/17/41	[8]6.6	[2].040
Estimation site	Yellowleaf Creek at mouth above Wilsonville, Ala.	do.	[3]184	—	[5]7	—
Estimation site	Waxahatchee Creek at Alabama Highway 145 at edge of backwater of Lay Lake	do.	[3]180	—	[12]30	—
Estimation site	Yellowleaf Creek at County Road, 1/2-mile above mouth	do.	[3]77.9	—	[13]18	—
Estimation site	Walnut Creek at mouth above Mitchell Dam, Ala.	do.	[3]53.2	—	[13]6	—
Estimation site	Hatchet Creek at mouth above Mitchell Dam, Ala.	do.	[3]357	—	[14]51	—
Estimation site	Weogufka Creek at mouth above Mitchell Dam, Ala.	do.	[3]128	—	[12]21	—
02409510	Chestnut Creek at Verbena, Ala.	do.	38.7	10/23/41	[8]2.4	[2].062
Estimation site	Chestnut Creek at mouth near Mountain Creek, Ala.	do.	[3]74.9	—	[5]5	—
Estimation site	Weoka Creek at mouth near Titus, Ala.	do.	[3]78.7	—	[15]5	—
02411000	Coosa River at Jordan Dam near Wetumpka, Ala.	regional	10,102	—	[16]2,060	[2].204
Drainage area and stream discharge at the mouth of the Coosa River			**[3]10,161**	**—**	**[17]2,070**	**—**

[1]Daily mean discharge.
[2]Discharge divided by the drainage area.
[3]Drainage areas in the Coosa River basin, Ala. (James L. Pearman, U.S. Geological Survey, written commun., 1980).
[4]Estimate based on unit-area discharge of the Chattooga River at Summerville, Ga.
[5]Estimate based on unit-area discharge(s) of station(s) on the same reach.
[6]Sum of measured and estimated ground-water discharge to the Coosa River and tributaries in Georgia.
[7]Estimate based on the correlation to the discharge of Choccolocco Creek near Jenifer, Ala., using the Maintenance-of-Variance Extension Technique.
[8]Discharge measurement.
[9]Estimate based on unit-area discharge of Big Canoe Creek near Gadsden, Ala.
[10]Estimate based on unit-area discharge of Big Canoe Creek near Gadsden, Ala., using the Maintenance-of-Variance Extension Technique.
[11]Estimate based on unit-area discharge of Yellowleaf Creek at Wilsonville, Ala.
[12]Estimate based on correlation to the discharge of Mulberry Creek near Jones, Ala., using the Maintenance-of-Variance Extension Technique.
[13]Estimate based on correlation to the discharge of Mulberry Creek near Jones, Ala., using the Maintenance-of-Variance Extension Technique.
[14]Estimate based on correlation to the discharge of Talladega Creek at Alpine, Ala., using the Maintenance-of-Variance Extension Technique.
[15]/Estimate based on unit-area discharge of Chestnut Creek at Verbena, Ala.
[16]Estimate based on unit-area discharge computed using the sum of tributary discharges and respective drainage areas intermediate to this station and the nearest upstream Coosa River station.
[17]Estimate based on unit-area discharge computed using the sum of tributary discharges and respective drainage areas intermediate to the Coosa River at Jordan Dam near Wetumpka, Ala., and the Coosa River at Childersburg, Ala., station.

Table 8. Stream discharge during the months of September and October of the drought of 1954, Subarea 6
[—, not applicable]

Station number or estimation site	State name	Type of stream	Drainage area (square miles)	Date	Stream discharge (cubic feet per second)	Unit-area discharge (cubic feet per second per square mile)
02388500	Oostanaula River near Rome, Ga.	tributary	2,120	09/27/54	1/432	2/0.204
02396000	Etowah River at Rome, Ga.	do.	1,820	09/—/54	3/453	2/.249
02397000	Coosa River near Rome, Ga.	regional	4,040	09/—/54	3/961	2/.238
02397500	Cedar Creek near Cedartown, Ga.	tributary	115	09/30/54	1/35	2/.304
02397505	Cedar Creek near Cave Springs, Ga.	do.	169	10/07/54	4/62	2/.367
Estimation site	Big Cedar Creek at mouth below Fosters Mills, Ga., near Georgia-Alabama State line	do.	5/211	—	6/77	—
02398000	Chattooga River at Summerville, Ga.	do.	192	09/30/54	1/62	2/.323
Estimation site	Chattooga River at Georgia-Alabama State line	do.	5/286	—	6/92	—
02398500	Chattooga River at Gaylesville, Ala.	do.	379	09/30/54	1/102	2/.269
Estimation site	Chattooga River at mouth below Gaylesville, Ala.	do.	5/380	—	6/102	—
Estimation site	Little River at Georgia-Alabama State line	do.	5/43.8	—	7/0.2	—
Estimation site	Little River at edge of backwater of Weiss Lake near Little River, Ala.	do.	5/208	—	7/1	—
Estimation site	Coosa River at Georgia-Alabama State line	regional	5/4,362	—	8/1,080	—
Cumulative drainage area and stream discharge, Coosa River basin at Georgia-Alabama State line			**4,692**	—	9/**1,170**	—
02399500	Coosa River at Leesburg, Ala.	regional	5,270	09/—/54	3/1,239	2/.235
02400000	Terrapin Creek near Piedmont, Ala.	tributary	116	09/30/54	1/2.8	2/.024
Estimation site	Terrapin Creek at mouth near Centre, Ala.	do.	5/284	—	6/7	—
02400500	Coosa River at Gadsden, Ala.	regional	5,805	09/—/54	3/1,270	2/.219
02401000	Big Wills Creek near Reece City, Ala.	tributary	182	09/30/54	1/37	2/.203
Estimation site	Big Wills Creek at U.S. Highway 411, 1/4-mile above mouth near Gadsden, Ala.	do.	5/366	—	6/74	—
02401500	Big Canoe Creek near Gadsden, Ala.	do.	253	09/30/54	1/12	2/.047
Estimation site	Big Canoe Creek at mouth above Greensport, Ala.	tributary	5/277	—	6/13	—
Estimation site	Beaver Creek at edge of backwater of H. Neely Henry Lake	do.	5/35.7	—	10/2	—
Estimation site	Shoal Creek at edge of backwater of H. Neely Henry Lake	do.	5/28.9	—	10/1	—
02401820	Tallasseehatchee Creek below Wellington, Ala.	do.	100	09/29/54	4/32	2/.32
Estimation site	Tallasseehatchee Creek at confluence with Ohatchee Creek near Ohatchee, Ala.	do.	5/136	—	6/44	—
Estimation site	Ohatchee Creek at mouth—excluding Tallasseehatchee Creek	do.	5/87.0	—	11/0.3	—
Estimation site	Cane Creek at edge of backwater of Logan Martin Lake near Ragland, Ala.	do.	5/96.5	—	11/22	—
Estimation site	Trout Creek at edge of backwater of Logan Martin Lake near Ragland, Ala.	do.	5/28.2	—	12/0.4	—
02404000	Choccolocco Creek near Jenifer, Ala.	do.	277	09/29/54	1/57	2/.206
Estimation site	Choccolocco Creek at mouth above Cropwell, Ala.	do.	5/502	—	6/103	—
02405000	Coosa River near Cropwell, Ala.	regional	7,663	09/—/54	3/1,650	2/.215
02405500	Kelly Creek near Vincent, Ala.	tributary	193	09/29/54	1/1.7	2/.009
Estimation site	Kelly Creek at mouth above Vincent, Ala.	tributary	5/208	—	6/2	—

Table 8. Stream discharge during the months of September and October of the drought of 1954, Subarea 6—Continued
[—, not applicable]

Station number or estimation site	State name	Type of stream	Drainage area (square miles)	Date	Stream discharge (cubic feet per second)	Unit-area discharge (cubic feet per second per square mile)
02406000	Talladega Creek near Talladega, Ala.	do.	101	09/30/54	[1/]1.9	[2/].019
02406500	Talladega Creek at Alpine, Ala.	do.	150	09/28/54	[4/]42	[2/].28
Estimation site	Talladega Creek at Alabama Highway 235, 1/4-mile above mouth near Childersburg, Ala.	do.	[5/]175	—	[6/]49	—
Estimation site	Tallasseehatchee Creek at Alabama Highway 235, 1/4-mile above mouth near Childersburg, Ala.	do.	[5/]199	—	[13/]1	—
02407000	Coosa River at Childersburg, Ala.	regional	8,390	—	[8/]1,720	[2/].205
02407500	Yellowleaf Creek near Wilsonville, Ala.	tributary	96.5	09/30/54	[1/]0.5	[2/].005
Estimation site	Yellowleaf Creek at mouth above Wilsonville, Ala.	do.	[5/]184	—	[6/]1	—
Estimation site	Waxahatchee Creek at Alabama Highway 145 at edge of backwater of Lay Lake	do.	[5/]180	—	[13/]6	—
02408005	Yellowleaf Creek near Thorsby, Ala.	do.	17.0	09/30/54	[4/]1.9	[2/].112
Estimation site	Yellowleaf Creek at County Road, 1/2-mile above mouth	do.	[5/]77.9	—	[6/]9	—
Estimation site	Walnut Creek at mouth above Mitchell Dam, Ala.	do.	[5/]53.2	—	[14/]1	—
02408500	Hatchet Creek near Rockford, Ala.	do.	233	10/03/54	[1/]8	[2/].034
Estimation site	Hatchet Creek at mouth above Mitchell Dam, Ala.	do.	[5/]357	—	[6/]12	—
02409000	Weogufka Creek near Weogufka, Ala.	do.	73.4	09/28/54	[1/]0.1	[2/].001
Estimation site	Weogufka Creek at mouth above Mitchell Dam, Ala.	do.	[5/]128	—	[6/].1	—
Estimation site	Chestnut Creek at mouth near Mountain Creek, Ala.	do.	[5/]74.9	—	[13/]1	—
Estimation site	Weoka Creek at mouth near Titus, Ala.	do.	[5/]78.7	—	[13/]1	—
02411000	Coosa River at Jordan Dam near Wetumpka, Ala.	regional	10,102	—	[8/]1,770	[2/].175
Drainage area and stream discharge at the mouth of the Coosa River			[5/]**10,161**	—	[15/]**1,780**	—

[1/]Daily mean discharge.
[2/]Discharge divided by the drainage area.
[3/]Mean discharge for September 1954, adjusted for change in upstream reservoir storage.
[4/]Discharge measurement.
[5/]Drainage areas in the Coosa River basin, Ala. (James L. Pearman, U.S. Geological Survey, written commun., 1980).
[6/]Estimate based on unit-area discharge of station(s) on the same reach.
[7/]Estimate based on unit-area discharge of the Little River near Jamestown, Ala., which was 0.004 on October 26, 1941.
[8/]Estimate based on unit-area discharge computed using the sum of tributary discharges and respective drainage areas intermediate to this station and the nearest upstream Coosa River station.
[9/]Sum of all measured and estimated ground-water discharge to the Coosa River and tributaries in Georgia.
[10/]Estimate based on unit-area discharge of Big Canoe Creek near Gadsden, Ala.
[11/]Estimate based on correlation to discharge of Choccolocco Creek near Jenifer, Ala., using the Maintenance-of-Variance Extension Technique.
[12/]Estimate based on correlation to discharge of Big Canoe Creek near Gadsden, Ala., using the Maintenance-of-Variance Extension Technique.
[13/]Estimate based on unit-area discharge of Hatchet Creek near Rockford, Ala.
[14/]Estimate based on correlation to discharge of Mulberry Creek near Jones, Ala., using the Maintenance-of-Variance Extension Technique.
[15/]Estimate based on unit-area discharge computed using the sum of tributary discharges and respective drainage areas intermediate to the Coosa River at Jordan Dam near Wetumpka, Ala., and the Coosa River at Childersburg, Ala., stations.

Table 9. Stream discharge during the month of July of the drought of 1986, Subarea 6
[—, not applicable]

Station number or estimation site	Station name	Type of stream	Drainage area (square miles)	Date	Stream discharge (cubic feet per second)	Unit-area discharge (cubic feet per second per square mile)
02388500	Oostanaula River near Rome, Ga.	tributary	2,120	07/—/86	[1]512	[2]0.242
02396000	Etowah River at Rome, Ga.	do.	1,820	07/—/86	[1]455	[2].250
02397000	Coosa River near Rome, Ga.	regional	4,040	07/—/86	[1]1,010	[2].250
02397410	Cedar Creek at Cedartown, Ga.	tributary	66.9	07/08/86	[3]13	[2].194
02397500	Cedar Creek near Cedartown, Ga.	do.	115	07/10/86	[4]31	[2].270
02397516	Big Cedar Creek at Fosters Mills, Ga.	do.	200	07/08/86	[4]84	[2].420
Estimation site	Big Cedar Creek at mouth below Fosters Mills, Ga., near Georgia-Alabama State line	do.	[5]211	—	[6]89	—
02398000	Chattooga River at Summerville, Ga.	do.	192	07/15/86	[3]63	[2].328
02398037	Chattooga River at Chattoogaville, Ga.	do.	281	07/15/86	[4]91	[2].324
Estimation site	Chattooga River at Georgia-Alabama State line	do.	[5]286	—	[6]93	—
02398300	Chattooga River above Gaylesville, Ala.	do.	366	07/15/86	[3]109	[2].298
Estimation site	Chattooga River at mouth below Gaylesville, Ga.	do.	[5]380	—	[6]113	—
Estimation site	Little River at Georgia-Alabama State line	do.	[5]43.8	—	[6]0.6	—
02399000	Little River near Jamestown, Ala.	do.	125	07/10/86	[4]1.8	[2].014
02399200	Little River near Blue Pond, Ala.	do.	199	07/10/86	[3]6.6	[2].033
Estimation site	Little River at edge of backwater of Weiss Lake near Little River, Ala.	do.	[5]208	—	[6]7	—
Estimation site	Coosa River at Georgia-Alabama State line	regional	[5]4,362	—	[7]1,140	—
Cumulative drainage area and stream discharge, Coosa River basin at Georgia-Alabama State line			[5]**4,692**	—	[8]**1,230**	—
02400000	Terrapin Creek near Piedmont, Ala.	tributary	116	07/08/86	[4]5.3	[2].046
02400100	Terrapin Creek at Ellisville, Ala.	do.	252	07/08/86	[3]75	[2].298
Estimation site	Terrapin Creek at mouth near Centre, Ala.	do.	[5]284	—	[6]85	—
02401000	Big Wills Creek near Reece City, Ala.	do.	182	07/10/86	[4]43	[2].236
Estimation site	Big Wills Creek at U.S. Highway 411, 1/4-mile above mouth near Gadsden, Ala.	do.	[5]366	—	[6]86	—
02401370	Big Canoe Creek near Springville, Ala.	do.	45.0	07/08/86	[3]11	[2].244
02401390	Big Canoe Creek at Ashville, Ala.	do.	141	07/08/86	[3]22	[2].156
Estimation site	Big Canoe Creek at mouth above Greensport, Ala.	do.	[5]277	—	[6]43	—
Estimation site	Beaver Creek at edge of backwater of H. Neely Henry Lake	do.	[5]35.7	—	[9]6	—
Estimation site	Shoal Creek at edge of backwater of H. Neely Henry Lake	do.	[5]28.9	—	[10]2	—
Estimation site	Tallasseehatchee Creek at confluence with Ohatchee Creek near Ohatchee, Ala.	do.	[5]136	—	[11]41	—
Estimation site	Ohatchee Creek at mouth but excluding Tallasseehatchee Creek	do.	[5]87.0	—	[11]2	—
02401905	Cane Creek near Alexandria, Ala.	do.	[5]28.2	07/08/86	[4]2.6	[2].093
Estimation site	Cane Creek at edge of backwater of Logan Martin Lake near Ragland, Ala.	do.	[5]96.5	—	[11]22	—
Estimation site	Trout Creek at edge of backwater of Logan Martin Lake near Ragland, Ala.	do.	[5]28.2	—	[8]4	—
02404000	Choccolocco Creek near Jenifer, Ala.	do.	277	07/09/86	[4]57	[2].206
02404400	Choccolocco Creek at Jackson Shoal near Lincoln, Ala.	do.	481	07/09/86	[3]125	[2].260
Estimation site	Choccolocco Creek at mouth above Cropwell, Ala.	do.	[5]502	—	[6]130	—
Estimation site	Kelly Creek at mouth above Vincent, Ala.	tributary	[5]208	—	[12]1	—

Table 9. Stream discharge during the month of July of the drought of 1986, Subarea 6—Continued
[—, not applicable]

Station number or estimation site	Station name	Type of stream	Drainage area (square miles)	Date	Stream discharge (cubic feet per second)	Unit-area discharge (cubic feet per second per square mile)
02405800	Talladega Creek above Talladega, Ala.	do.	69.6	07/09/86	[4]6.3	[2].091
02406000	Talladega Creek near Talladega, Ala.	do.	101	07/09/86	[4]12	[2].119
02406500	Talladega Creek at Alpine, Ala.	do.	150	07/08/86	[4]36	[2].240
Estimation site	Talladega Creek at Alabama Highway 235, 1/4-mile above mouth near Childersburg, Ala.	do.	[5]175	—	[6]42	—
Estimation site	Tallasseehatchee Creek at Alabama Highway 235, 1/4-mile above mouth near Childersburg, Ala.	do.	[5]199	—	[13]48	—
02407500	Yellowleaf Creek near Wilsonville, Ala.	do.	96.5	07/11/86	[4].37	[2].004
Estimation site	Yellowleaf Creek at mouth above Wilsonville, Ala.	do.	[5]184	—	[6]1	—
Estimation site	Waxahatchee Creek at Alabama Highway 145 at edge of backwater of Lay Lake	do.	[5]180	—	[14]21	—
Estimation site	Yellowleaf Creek at County Road, 1/2-mile above mouth	do.	[5]77.9	—	[15]10	—
Estimation site	Walnut Creek at mouth above Mitchell Dam, Ala.	do.	[5]53.2	—	[15]5	—
02408500	Hatchet Creek near Rockford, Ala.	do.	233	07/08/86	[4]28	[2].120
02408540	Hatchet Creek below Rockford, Ala.	do.	263	07/08/86	[3]38	[2].144
Estimation site	Hatchet Creek at mouth above Mitchell Dam, Ala.	do.	[5]357	—	[6]51	—
Estimation site	Weogufka Creek at mouth above Mitchell Dam, Ala.	do.	[5]128	—	[16]3	—
Estimation site	Chestnut Creek at mouth near Mountain Creek, Ala.	do.	[5]74.9	—	[15]2	—
Estimation site	Weoka Creek at mouth near Titus, Ala.	do.	[5]78.7	—	[14]9	—
02411000	Coosa River at Jordan Dam near Wetumpka, Ala.	regional	10,102	—	[7]2,160	[2].214
Drainage area and stream discharge at the mouth of the Coosa River		—	[5]**10,610**	—	[7]**2,170**	—

[1/]Mean discharge for July 1986, adjusted for change in upstream reservoir storage.
[2/]Discharge divided by drainage area.
[3/]Daily mean discharge.
[4/]Discharge measurement.
[5/]Drainage areas in the Coosa River basin (James L. Pearman, U.S. Geological Survey, written commun., 1980).
[6/]Estimate based on unit-area discharge of stations on the same reach.
[7/]Estimate based on unit-area discharge computed using the sum of tributary discharges and respective drainage areas intermediate to the Coosa River at Jordan Dam near Wetumpka, Ala., station and the Coosa River at the Georgia-Alabama State line.
[8/]Sum of all measured and estimated ground-water discharge to the Coosa River and tributaries in Georgia.
[9/]Estimate based on unit-area discharge of Big Canoe Creek at Ashville, Ala.
[10/]Estimate based on unit-area discharge of Big Canoe Creek at Ashville, Ala., using the Maintenance-of-Variance Extension Technique.
[11/]Estimate based on correlation to discharge of Choccolocco Creek near Jenifer, Ala., using the Maintenance-of-Variance Extension Technique.
[12/]Estimate based on correlation to discharge of Talladega Creek at Alpine, Ala., using the Maintenance-of-Variance Extension Technique.
[13/]Estimate based on unit-area discharge of Talladega Creek at Alpine, Ala.
[14/]Estimate based on unit-area discharge of Hatchet Creek near Rockford, Ala.
[15/]Estimate based on correlation to Mulberry Creek discharge near Jones, Ala., using Maintenance-of-Variance Extension Technique.
[16/]Estimate based on correlation to discharge of Hatchet Creek near Rockford, Ala., using Maintenance-of-Variance Extension Technique.

Table 10. Relations among mean-annual stream discharge, estimated mean-annual baseflow, and drought flow in the Coosa River, Subarea 6
[Mean-annual stream discharge is mean for the period of record; —, not applicable or no available data]

Station number or estimation site	Station name	Drainage area (square miles)	Stream discharge, in cubic feet per second				
			Mean-annual stream discharge[1/]	Estimated mean-annual baseflow[2/]	Drought of 1941[3/]	Drought of 1954[4/]	Drought of 1986[5/]
02397000	Coosa River near Rome, Ga.	4,040	6,711	3,930	972	961	1,010
Estimation site	Coosa River at Georgia-Alabama State line	4,362	—	4,300	990	1,080	1,140
02399500	Coosa River at Leesburg, Ala.	5,270	8,161	5,260	1,130	1,239	—
02400500	Coosa River at Gadsden, Ala.	5,805	9,468	5,750	1,220	1,270	—
02402500	Coosa River at Riverside, Ala.	7,070	11,740	6,560	—	—	—
02405000	Coosa River near Cropwell, Ala.	7,663	12,570	7,500	—	1,650	—
02407000	Coosa River at Childersburg, Ala.	8,390	13,860	8,220	1,840	1,720	—
02411000	Coosa River at Jordan Dam near Wetumpka, Ala.	10,102	16,360	—	2,060	1,770	2,160
Estimation site	**Coosa River at mouth**	**10,161**	**—**	**9,960**	**2,070**	**1,780**	**2,170**

[1/]From table 3
[2/]From tables 5 and 6.
[3/]From table 7.
[4/]From table 8.
[5/]From table 9.

Table 11. Estimated drought flows and mean-annual baseflow in the Coosa River and tributaries; and ratio of average drought flow to mean-annual baseflow, Subarea 6

	Drought flows, in cubic feet per second				Mean-ann[1/] (in cubic feet per second)	Ratio of average drought flow to mean-annual baseflow (percent)
	1941[2/]	1954[3/]	1986[4/]	Average drought flow		
Georgia	1,060	1,170	1,230	1,150	4,600	25
Alabama	1,010	610	940	853	5,360	16
Exiting Subarea 6	**2,070**	**1,780**	**2,170**	[5/]**2,010**	**9,960**	**20**

[1/]From tables 6 and 10.
[2/]From tables 7.
[3/]From tables 8.
[4/]From tables 9.
[5/]Average drought flow exiting Subarea 6, 1941, 1954, and 1986.

Baseflow near the end of these droughts averaged about 25 percent of the estimated mean-annual baseflow to the surface-water system in Georgia (ranged from about 23 to 27 percent for individual drought years); about 16 percent of the estimated mean-annual baseflow in Alabama (ranged from about 11 to 19 percent for individual drought years); and about 20 percent (ranged from about 18 to 22 percent for individual drought years) of the estimated mean-annual baseflow at the mouth of the Coosa River (Subarea 6-Subarea 8 boundary). Streamflow profiles for the Coosa River were plotted from estimated and measured streamflow at selected stations for the 1941, 1954, and 1986 drought years (fig. 12). In relation to the conceptual model of ground-water flow and stream-aquifer relations, the mean-annual baseflow estimated for the Coosa River represents ground-water discharge from the local, intermediate, and regional flow regimes. Baseflow during droughts indicates greatly reduced contributions from the local and intermediate flow regimes. Drainage areas, drought flows, and baseflows in the Coosa River basin near the end of the 1941, 1954, and 1986 droughts are plotted in figure 12 and summarized in tables 10 and 11.

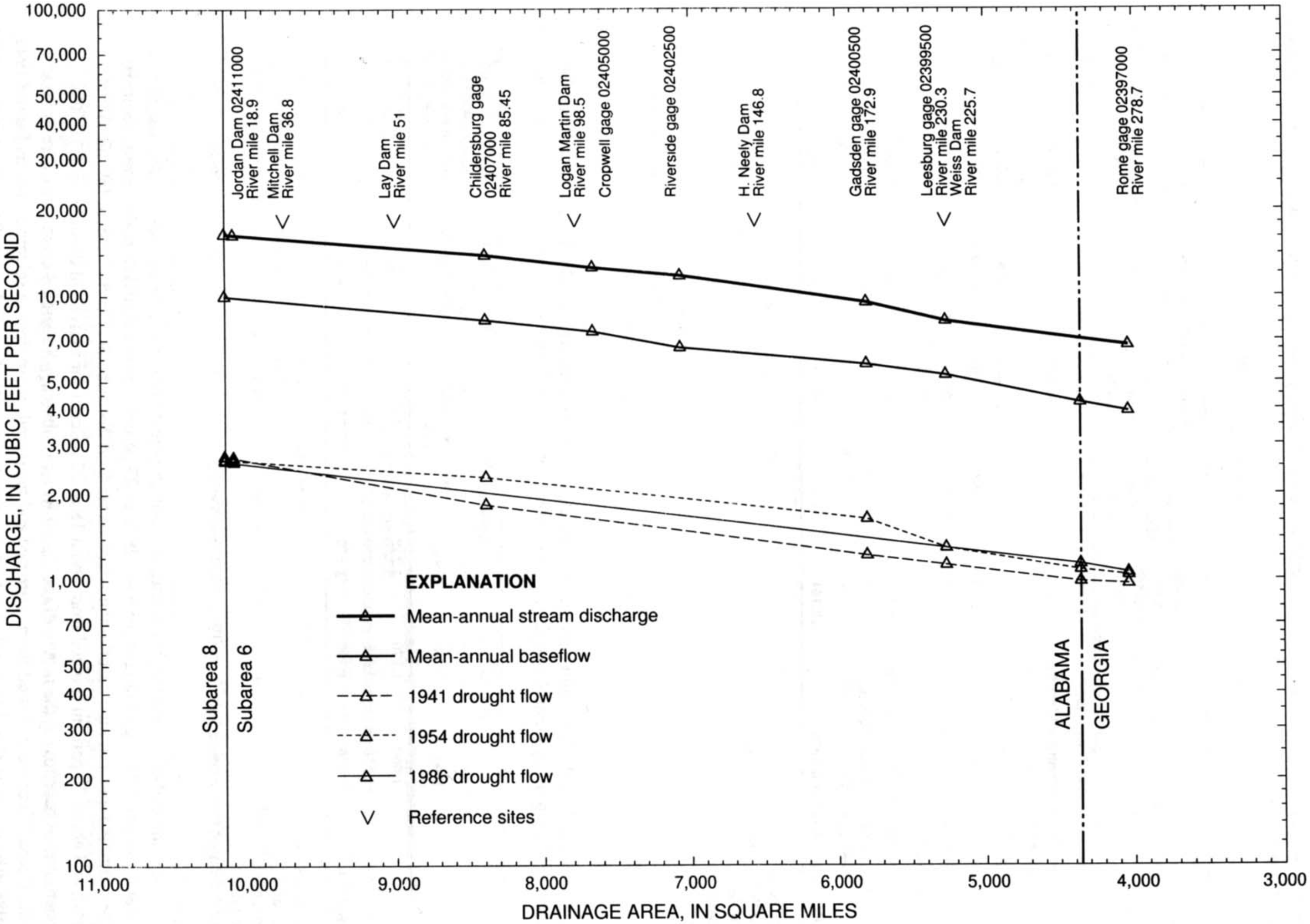

Figure 12. Relations among mean-annual stream discharge, mean-annual baseflow, and drought flow, Coosa River, Subarea 6. [Note: Triangles represent estimated or measured discharges; lines connecting triangles represent interpolated discharge. River mile is measured upstream from the mouth of the Coosa River.]

GROUND-WATER UTILIZATION AND GENERAL DEVELOPMENT POTENTIAL

Ground-water utilization is defined as the ratio of ground-water use in 1990 to mean-annual ground-water recharge. The degree of ground-water utilization is scale dependent. For example, local ground-water pumping may result in substantial storage change and water-level declines near a center of pumping; whereas, such pumping relative to the entire Subarea would be small compared to mean-annual recharge. Because ground-water use in Subarea 6 represents a relatively minor percentage of ground-water recharge, even a large increase in ground-water use in Subarea 6 in one State is likely to have little effect on ground-water and surface-water occurrence in the other.

Ground-water use of about 134 ft^3/s in 1990 in Subarea 6 represented 1.1 to 1.6 percent of the mean-annual baseflow in the surface-water system and 4.3 to 9.9 percent of the average drought flow near the end of the droughts of 1941, 1954, and 1986 (table 12). For the worst-case scenario, in which flow decreased to the minimum during the period of analysis, 1990 ground-water use represented 4.7 to 13.9 percent of the minimum drought flows. Local problems of ground-water overuse were not identified. However, long-term water-level data at wells in Subarea 6 are few in number and poorly distributed areally; and conclusions regarding regional water-level declines or storage change cannot be reasonably drawn.

Table 12. Relation between 1990 ground-water use and ground-water discharge during mean-annual baseflow, average drought flow, and minimum drought flow, Subarea 6

	Ground-water use, 1990 (cubic feet per second)	Baseflow to the Coosa River and tributaries (cubic feet per second)			Ratio of ground-water use to baseflow (percent)		
		Mean-annual baseflow	Average drought baseflow	Minimum drought baseflow	Mean-annual baseflow	Average drought baseflow	Minimum drought baseflow
Georgia	1/49.6	4,600	1,150	2/1,060	1.1	4.3	4.7
Alabama	3/84.5	5,360	853	4/610	1.6	9.9	13.9
Exiting Subarea 6	**134.1**	**9,960**	5/**2,010**	4/**1,780**	**1.4**	**6.7**	**7.5**

1/From Fanning and others (1992).
2/Minimum stream discharge during 1941 drought.
3/From Baker and Mooty (1993).
4/Minimum stream discharge during 1954 drought.
5/Average drought flow exiting Subarea 6, 1941, 1954, and 1986.

In general, ground-water resources are underutilized throughout the study area. The rural population relies on ground water as their principal source of water supply; whereas, more densely populated areas rely on surface-water resources. However, wells supplied water to many communities prior to the development of large surface-water reservoirs. In recent years, suburban communities have developed ground-water supplies in response to curtailed surface-water supplies.

A general assessment of ground-water development potential in Subarea 6 would reflect, in part, the cumulative effects of current and anticipated future hydrologic stresses imposed on the ground-water resources, and to a lesser extent, the current availability of surface-water supplies. The nature of such an assessment is necessarily limited by a lack of knowledge of current hydrologic conditions and the lack of agreed upon standards by which Federal, State, or local water-resource managers evaluate the effects of additional stress and future development. Current pumpage and streamflow conditions might be unknown in some areas, making the results of an evaluation of development potential highly uncertain. Future stresses also might be linked to water-management practices that have yet to be formulated, or to water-management decisions that have yet to be made. Therefore, an assessment of ground-water development potential provides insight only into one aspect of the broader question of how water-management decisions affect ground-water availability; specifically, whether existing hydrologic data document flow-system behavior adequately to allow the potential effects of future development on the flow system to be adequately evaluated and understood. Further, an assessment of ground-water development potential does not account for the suitability of existing ground-water resource management approaches or the effects of future approaches on further resource development. Such answers partly are dependent on the synthesis of results from the various Comprehensive Study components and subsequent consideration by the Federal, State, or local water managers responsible for decision-making within the basin.

The identification of areas that could be developed for ground-water supply to replace or supplement surface-water sources could not be determined from available data for Subarea 6. Because geologic controls affecting ground-water availability are highly variable, even on a local scale, regional evaluations are inherently characterized by a high degree of uncertainty. Ground-water availability may be a constraint in areas underlain by Piedmont crystalline-rock and Paleozoic-rock terranes more because of the difficulty in locating water-bearing voids in the rocks, rather than because of a lack of water. Ground-water resources probably could provide supplemental supplies during peak demand periods throughout most suburban areas of Subarea 6. In more rural areas, ground-water supplies could serve as a primary resource depending upon demands. Generally, wells need only supply about 5 gal/min for domestic users, and may not be drilled to a depth that taps the available ground-water supply at a site. Most municipal or industrial users generally require well yields of at least 50 to 100 gal/min or more, and wells for such supplies likely are drilled to a depth sufficient to intersect as many water-bearing zones as feasible. Municipal and industrial users also tend to drill multiple wells to obtain the required ground-water supply.

SUMMARY

Drought conditions in the 1980's have focused attention on the multiple uses of the surface- and ground-water resources in the Apalachicola-Chattahoochee-Flint (ACF) and Alabama-Coosa-Tallapoosa (ACT) River basins in Alabama, Florida, and Georgia. Federal, State, and local agencies also have proposed projects that are likely to result in additional water use and revisions of reservoir operating practices within the river basins. The existing and proposed water projects have created conflicting demands for water and emphasized the problem of allocation of the resource. This study was initiated to describe ground-water availability in the Coosa River basin in Georgia and Alabama, Subarea 6 of the ACF-ACT River basins, and to estimate the possible effects of increased ground-water use in the basin.

Subarea 6 encompasses about 4,700 square miles (mi^2) in northwestern Georgia and about 5,360 mi^2 in northeastern Alabama. The Coosa River basin also includes about 100 mi^2 in southeastern Tennessee; however, that part of the basin is not in the study area. Subarea 6 is bounded to the north by the Georgia-Tennessee State line, to the east by the upper Chattahoochee River basin (Subarea 1) and to the south-southeast by the Tallapoosa River basin (Subarea 5). To the west, the study area is bounded by the Cahaba River basin (Subarea 7), and to the south-southwest by the Alabama River basin (Subarea 8). Major rivers of Subarea 6 flow southwestward into the Alabama River (Subarea 8).

The Piedmont and Blue Ridge Provinces are characterized by a two-component aquifer system composed of a fractured crystalline-rock aquifer characterized by little or no primary porosity or permeability; the overlying weathered regolith, composed of soil alluvium, colluvium, and saprolite, that responds hydraulically as a porous-media aquifer. The Valley and Ridge and Cumberland Plateau Provinces are characterized by fracture- and solution-conduit aquifers, similar in some ways to aquifers in the Piedmont and Blue Ridge Provinces. Fracture-conduit aquifers are predominant in the well-consolidated sandstone and shale of Paleozoic age; and solution-conduit aquifers are predominant in the carbonate rocks of Paleozoic age. The Coastal Plain is characterized by southward-dipping, poorly consolidated Cretaceous-age sand, gravel, and clay deposits of fluvial and marine origin.

The conceptual model of ground-water flow and stream-aquifer relations subdivides the ground-water flow system into local (shallow), intermediate, and regional (deep) flow regimes. The regional flow regime probably approximates steady-state conditions and water discharges chiefly to the Coosa River, and downstream reaches of the Etowah and Oostanaula Rivers. Ground-water discharge to tributaries primarily is from the local and intermediate flow regimes. Ground water that discharges to regional drains is composed of local, intermediate, and regional flow regimes. Mean-annual ground-water discharge to streams (baseflow) is considered to approximate the long-term, average recharge to ground water.

Mean-annual baseflow in Subarea 6 was estimated using an automated hydrograph-separation method. Mean-annual baseflow to the Coosa River and tributaries was estimated to be about 4,600 cubic feet per second (ft^3/s) in Georgia (from the headwaters to the Georgia-Alabama State line); about 5,360 ft^3/s in Alabama; and about 9,960 ft^3/s at the mouth of the Coosa River (at the Subarea 6-Subarea 8 boundary). Mean-annual baseflow represents about 60 percent of the mean-annual stream discharge at the mouth of the Coosa River.

Stream discharges for selected sites on the Coosa River and tributaries were compiled for the years 1941, 1954, and 1986, during which historically significant droughts occurred throughout most of the ACF-ACT River basins. Stream discharge was assumed to be sustained entirely by baseflow during the latter periods of these droughts.

Estimated baseflow near the end of the individual drought years ranged from about 11 to 27 percent of the estimated mean-annual baseflow in Subarea 6.

The limited scope, lack of field-data collection, and the short duration of the ACF-ACT River basin study has resulted in incomplete descriptions of ground- and surface-water-flow systems, which may affect the future management of water resources in the basins. For example, the extent and continuity of local and regional flow systems and their relation to geology is largely unknown. Similarly, quantitative descriptions of stream-aquifer relations, ground-water flow across State lines, water quality, drought flows, and ground-water withdrawal and subsequent effects on the flow systems (the availability and utilization issue) are highly interpretive; therefore, the descriptions should be used accordingly.

Estimates of water-use and ground-water discharge to streams are dependent on methodologies employed during data collection, computation, and analyses. Results reported herein are limited by a lack of recent data, particularly water-use data, and the non-contemporaneity of all data. Analyses using limited data may not adequately describe stream-aquifer relations. Most importantly, analyses in this report describe only two hydrologic conditions—(1) mean-annual baseflow and (2) drought-flow conditions during 1941, 1954, and 1986. Analyses derived from extrapolation to other hydrologic conditions, such as much longer drought periods or increased ground-water withdrawal, should be used with caution. Special concern also should be directed to the effects of increased post-1990 withdrawal on ground-water discharge to streams in Subarea 6.

The potential exists for the development of ground-water resources on a regional scale throughout Subarea 6. Ground-water use in 1990 represented about 1.1 to 1.6 percent of the estimated mean-annual baseflow, and about 4.3 to 9.9 percent of the average drought flow during the droughts of 1941, 1954, and 1986. Because ground-water use in Subarea 6 represents a relatively minor percentage of ground-water recharge, even a large increase in ground-water use in Subarea 6 in one State probably would have little effect on the quantity of ground-water and surface-water occurrence in the other. Long-term ground-water level declines were not observed; however, long-term water-level data at wells in Subarea 6 are few in number and poorly distributed areally, and conclusions regarding regional water-level declines or storage changes cannot be reasonably drawn.

SUGGESTIONS FOR FURTHER STUDY

This report presents a discussion of ground-water resources and interaction of ground- and surface-water systems in the Coosa River basin, Subarea 6, of the ACF-ACT River basins. In Subarea 6, ground-water availability is addressed only from a regional perspective using historical data. Data collection was not a part of this study; therefore, lack of streamflow and ground-water data necessitated that estimation methods be used extensively to describe stream-aquifer relations. Additional data, particularly data describing surface- and ground-water conditions on a local scale, are needed to further refine and quantify the interaction of ground- and surface-water systems in the Subarea. Analyses of these data could better describe stream-aquifer relations, as well as ground-water availability and development potential in Subarea 6.

Although the overall objectives of this study were to evaluate the ground-water resources and supply, the data used to accomplish these objectives were stream-discharge data. Stream-discharge data were sufficient to meet study objectives; however, such data either were not totally adequate or were not available at critical sites. Future stream-discharge data collection to support resource management should emphasize (1) continuous-record data at critical hydrologic and political boundaries for a period of years; and (2) concurrent stream-discharge measurements at critical sites during drought periods.

Continuous stream-discharge data collected over a period of years at critical locations provide the basic information essential to basinwide water-resource planning and management. Current data coverage is incomplete. For example, stream-gaging stations located at State lines and subarea boundaries would have eliminated or reduced the need to extrapolate and interpolate data from stations distant from these boundaries, and consequently, would have improved the accuracy of estimates of ground-water contributions from subarea to subarea and from State to State.

The collection of drought-flow data obviously is contingent on the occurrence of a drought; thus, collection of drought data is not routine and is not easily planned. A contingency plan to collect drought data should be in place. The plan could consider, but not be limited to, logistics, manpower needs, and the preselection of stream data-collection locations. For more rigorous planning, field reconnaissance of preselected stream sites could be conducted.

Data-base development also is critical to resource management. Data elements, such as well construction and yield; hydraulic characteristics of aquifers; water quality; and ground-water withdrawals—both areally and by aquifer—are particularly important. Seepage runs (detailed streamflow measurements of drainage systems made concurrently during baseflow conditions) can be used to identify individual ground-water flow systems and improve the understanding of stream-aquifer relations, especially in crystalline and mixed-rock terranes. Once identified, a flow system can be studied in detail to define its extent, recharge and discharge areas, movement of water, chemical quality, and the amount of water that can be withdrawn with inconsequential or minimal effects. These detailed studies might include test drilling, borehole geophysical logging, applications of surface geophysics, aquifer testing, a thorough water-withdrawal inventory, and chemical analyses of ground water to delineate the extent of the ground-water-flow system and evaluate its potential as a water supply. Evaluation of several such flow systems would greatly improve the understanding of ground-water resources throughout the subarea. Because aquifer properties vary substantially on a local scale and data are sparse, field studies are needed to obtain quantitative definitions of the hydraulic interactions of aquifers and streams in Subarea 6.

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