QUALITY AND AVAILABILITY OF GROUND WATER IN GEORGIA

by

John L. Sonderegger, Lin D. Pollard, and Charles W. Cressler

STATE OF GEORGIA
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PREPARED IN COOPERATION WITH THE U. S. GEOLOGICAL SURVEY

ATLANTA
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INFORMATION CIRCULAR 48

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

Multiply English Units	By	To Obtain SI Units
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
gallons (gal)	3.785	liters (L)
gallons per minute (gal/min)	0.06309	liters per second (L/s)

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ABSTRACT

Ground-water quality and availability data for Georgia are summarized, and the ranges of concentrations of major chemical constituents and physical properties are shown on areal distribution maps. The distribution and yield of major ground-water reservoirs are summarized by physiographic province and rock type.

Most water is of good quality and is suitable for agricultural, industrial, and public supplies, in accordance with published recommended water quality criteria, particularly those of the U.S. Public Health Service and the Committee on Water Quality Criteria of the National Academy of Sciences. Areal distribution of the water-quality characteristics shows that the variation in water quality over the State is related to the lithologic characteristics of the ground-water reservoirs.

*Prepared in cooperation with the U. S. Geological Survey

INTRODUCTION

The purpose of this report is to make available general information on quality and availability of ground water for those planning to develop public, industrial, or agricultural water supplies. This information is presented on areal distribution maps and tables, which show the areas of Georgia where specific water-quality needs can be met. Recommended limits for each water-quality characteristic are given where the published limits apply to particular industrial, agricultural, or public supply uses.

Concentration ranges of silica, alkalinity, sulfate, dissolved solids, and hardness and ranges of specific conductance and pH are shown on the areal distribution maps. Concentration ranges of chloride, fluoride, and nitrate show too small a variation areally to be included on the distribution maps. Also excluded from these generalized maps are the concentrations of constituents and the properties that represent isolated points of excessively high values.

The water-quality data were taken from Grantham and Stokes (1976), records in the Georgia Department of Natural Resources, and published reports on specific areas in Georgia listed in Selected References.

CHARACTERISTICS OF GROUND-WATER RESERVOIRS

Ground-water quality and the quantity available for development are related to the composition and character of the ground-water reservoirs and the nature of the material through which the ground water has moved. The three rock types — igneous, metamorphic, and sedimentary — compose the rock framework for the ground-water reservoirs in Georgia (fig. 1).

The Valley and Ridge Province and the Cumberland Plateau in northwest Georgia are underlain by sinuous bands of sedimentary rocks, including sandstone, shale, limestone, dolomite, and chert, that have been folded and faulted. The complexity and close proximity of different lithologic units result in an extremely complicated map pattern of ground-water quality values. To facilitate the use of this report, a lithologic map of the Valley and Ridge Province and the Cumberland Plateau is shown in figure 2. Drilled wells in these sedimentary rocks normally range from 50 feet to 300 feet in depth. Wells less than 50 feet deep commonly obtain water directly from the soil or weathered rock.

The Blue Ridge and Piedmont Provinces are underlain by bands of metamorphic and igneous rocks. These rocks contain water primarily in fractures, which are more abundant in the upper 50 feet of rock and at the transition zone between layers of different rock types. However, most of the available water is stored near the surface.

The Coastal Plain Province includes three major subdivisions of water-producing sedimentary rocks (fig. 1). The first consists of limestone and dolomite and underlies the major portion of the Coastal Plain. The second is primarily limestone and sand and is limited to the southwestern part of the Coastal Plain. The third consists mainly of sand and some gravel and is located south of the Fall Line adjacent to the Piedmont Province.

In contrast to the folded sedimentary rocks of the Valley and Ridge Province and the Cumberland Plateau, these Coastal Plain rock units are nearly flat-lying and dip gently to the southeast. Regional flow of ground water generally follows this dip, and single wells can produce water from one or more of these layered, ground-water reservoirs. The altitude map of the ground-water reservoirs (fig. 3) is a composite map showing the depth to the top of the first major reservoir for specific areas in the Coastal Plain. In central Georgia it would represent the top of reservoir 3, while in coastal Georgia it would be for reservoir 1. To obtain depth from land surface to the top of reservoir add negative map values to land surface altitude, subtract positive map values from land surface altitude.

GROUND-WATER QUALITY AND AVAILABILITY

Ground-water quality and availability are summarized in table 1. Areal distribution maps of the ranges of concentrations of the constituents and properties used in this report are shown in figures 4 through 10. The corresponding recommended limits for several water-quality constituents and characteristics are given in tables 2 through 9.

The recommended limits for industry, agriculture, and general home use were taken from the Committee on Water Quality Criteria (1973) and McKee and Wolf (1963). The recommended limits for drinking water standards were taken from the Georgia Water Quality Board (1970), which based its standards on the U. S. Public Health Service Drinking Water Standards (1962).

The following definitions are for the properties of water used in this study:

Alkalinity—measurement of the capacity of water to neutralize acid to a pH of 4.5.

Dissolved solids—constituents in water not removed by simple filtration.

Hardness—property attributable to the presence of alkaline earths, primarily calcium and magnesium. Hardness is also a measurement of soap consumption of water. In the commonly used hardness scale, having units given in milligrams per liter as calcium carbonate: 0 to 60 is classified as soft, 61 to 120 as moderately hard, 121 to 180 as hard, and greater than 180 as very hard.

pH—measurement of the hydrogen ion activity. Water with a pH of 7.0 is neutral; with a pH less than 7.0, acidic; and with a pH greater than 7.0, basic.

Specific conductance—measurement of the water's ability to conduct an electric current @ 25°C.

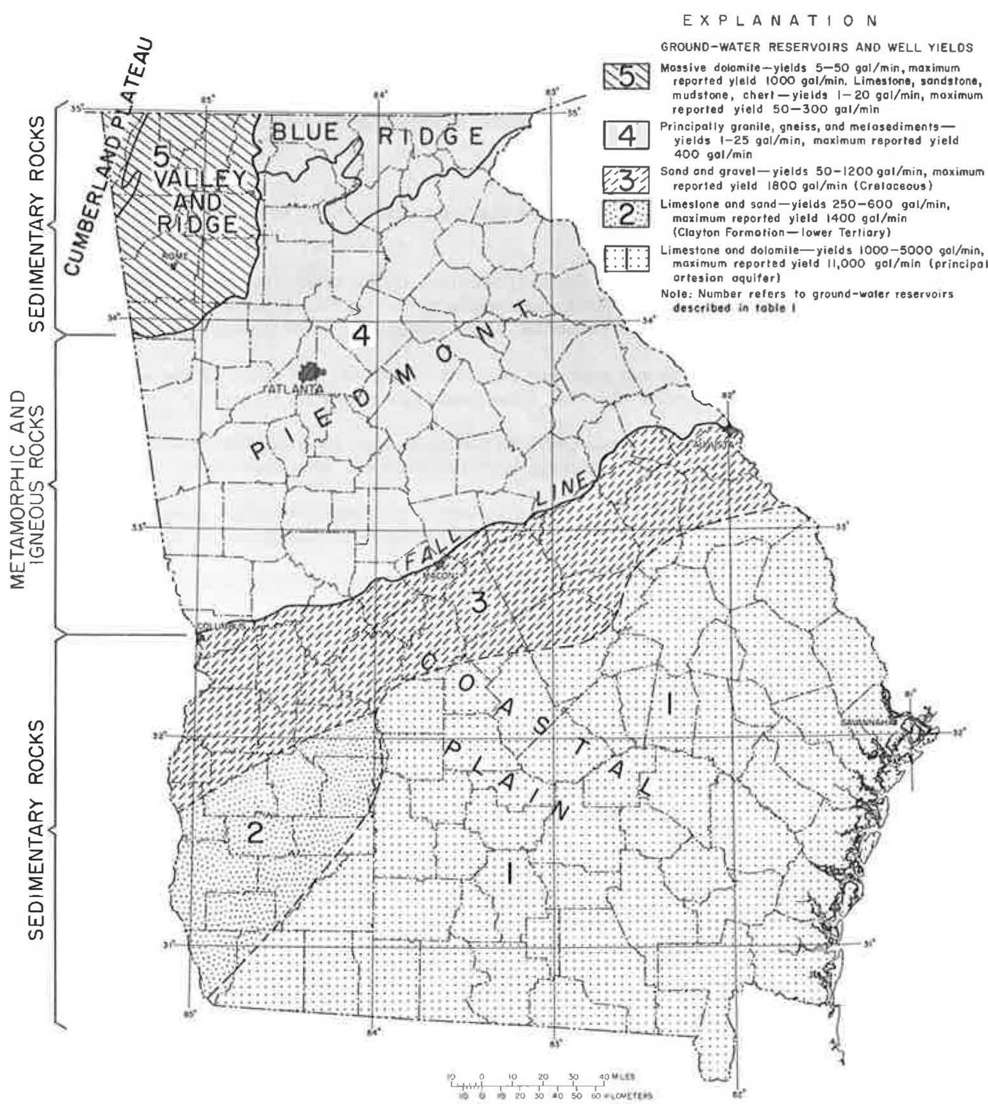

Figure 1. Physiographic provinces and major ground-water reservoirs.

E X P L A N A T I O N

Thick- to massive-bedded sandstone and conglomeratic quartzite interlayered with shale and coal; shale interbedded with siltstone and sandstone. Underlies broad, rolling mountain tops and forms cliffs along the mountain sides.

Includes: Rockcastle Sandstone, Vandever Shale, Bonair Sandstone, Whitwell Shale, Sewanee and Gizzard Members of Lookout Sandstone (Pennsylvanian age); Pennington Shale and Hartselle Sandstone (Mississippian age); Frog Mountain Sandstone (Devonian age); and Chilhowee Group (Cambrian age).

Thick- to massive-bedded limestone. Generally occupies steep slopes on the flanks of high ridges; locally underlies valleys.

Includes: Bangor Limestone and major limestone units of the Floyd Shale (Mississippian age); Chota Formation, Lenoir Limestone, and Holston Formation (Ordovician age); limestone units in the Conasauga Formation (Cambrian age).

Siliceous dolomite and limestone that weathers leaving medium-bedded chert. Generally underlies steep slopes along the flanks of high ridges.

Includes: Fort Payne Chert (Mississippian age) and Armuchee Chert (Devonian age).

Interlayered shale, siltstone, and thin- to thick-bedded sandstone, commonly of reddish color. Forms high, steep-sided ridges.

Includes: Red Mountain Formation (Silurian age).

Thin- to thick-bedded clayey limestone with red and yellow, limey mudstone in the lower part. Underlies broad valleys.

Includes: Chickamauga Limestone (Ordovician age).

Thick- to massive-bedded brown and gray siliceous dolomite that weathers to a thick cherty soil; and thick- to massive-bedded fairly pure limestone and dolomite. Forms broad low ridges.

Includes: Newala Limestone (Ordovician age); Knox Group (Cambrian and Ordovician age); lower dolomite unit of the Conasauga Formation in Bartow County, upper dolomite unit of the Conasauga Formation in Floyd County, the dolomite and limestone facies of the Maynardville Limestone Member of the Conasauga Formation, and the Shady Dolomite (Cambrian age).

Maroon and gray limey mudstone and siltstone, gray and yellowish limestone, and minor white, reddish, and rust-colored sandstone. Underlies valleys or forms ridges of low to moderate relief, depending on the sandstone content.

Includes: Lavender Shale Member of the Fort Payne Chert (Mississippian age); Bays and Moccasin Formations (Ordovician age); and the unit of the Conasauga Formation (Cambrian age), composed mainly of limestone, with shale layers.

Dark-gray to tan shale and thin-bedded siltstone, with minor sandstone and limestone-pebble conglomerate. Underlies broad undulating valleys and rolling upland areas. Forms ridges of moderate relief where siltstone and sandstone are abundant.

Includes: Floyd Shale (Mississippian age); Red Mountain Formation in Dade County (Silurian age); Rockmart Slate and Athens Shale (Ordovician age).

Limestone and dolomite in thick to massive beds. Underlies broad valleys.

Includes: Newala Limestone (Ordovician age).

Shale and thin-bedded siltstone with minor thick-bedded blue-gray limestone. Forms rolling uplands and broad valleys.

Includes: Conasauga Formation undivided and units of the Conasauga Formation that consist of shale and siltstone that contain some limestone units (Cambrian age).

Maroon, purple, yellow, green, and rust-colored shale and siltstone interlayered with white to rust-colored thin to massive layers of sandstone. The thick layers of sandstone occur mainly in the upper part. Forms moderate ridges having very uneven topography.

Includes: Rome Formation (Cambrian age).

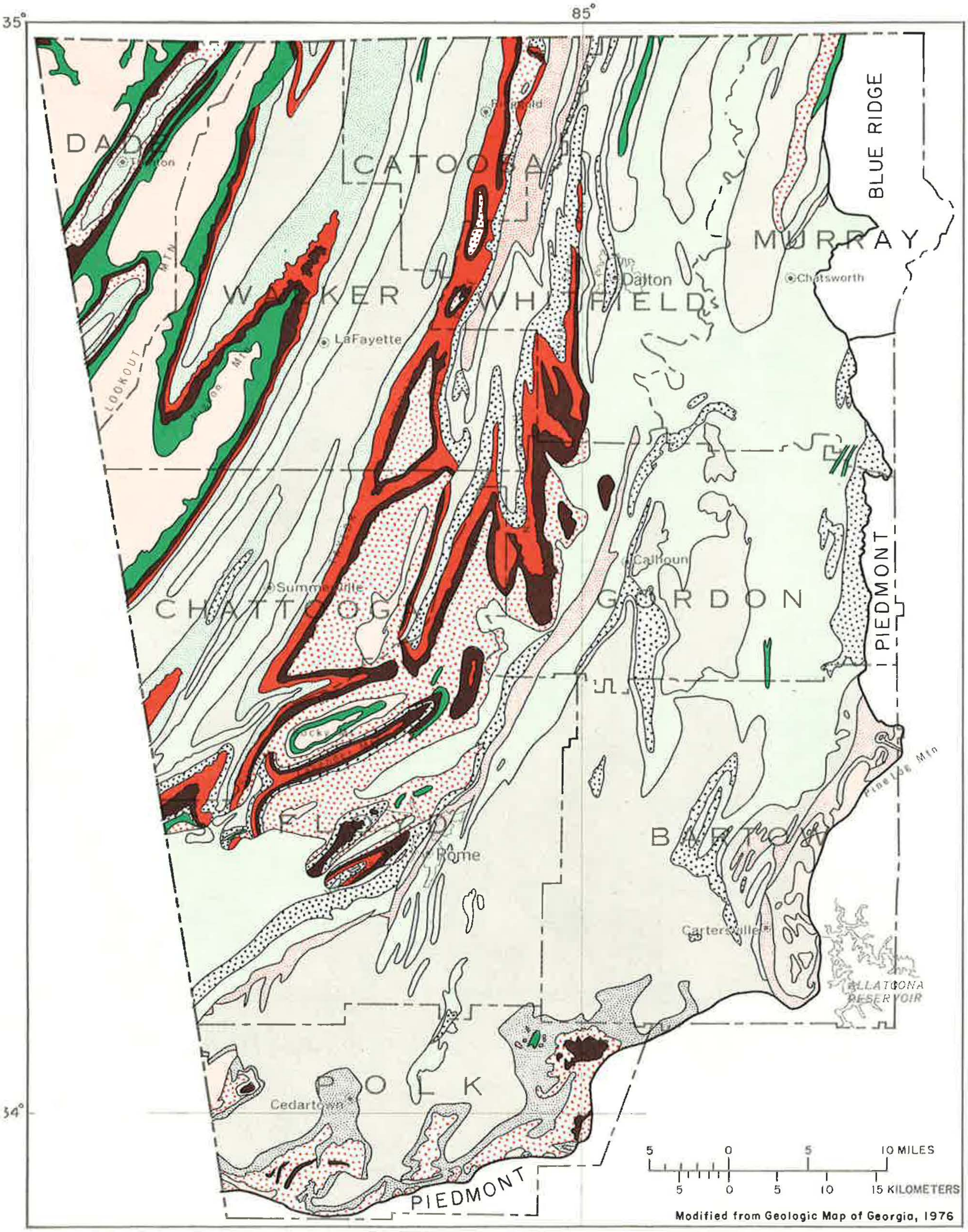

Figure 2. Generalized lithology of the Valley and Ridge Province and the Cumberland Plateau.

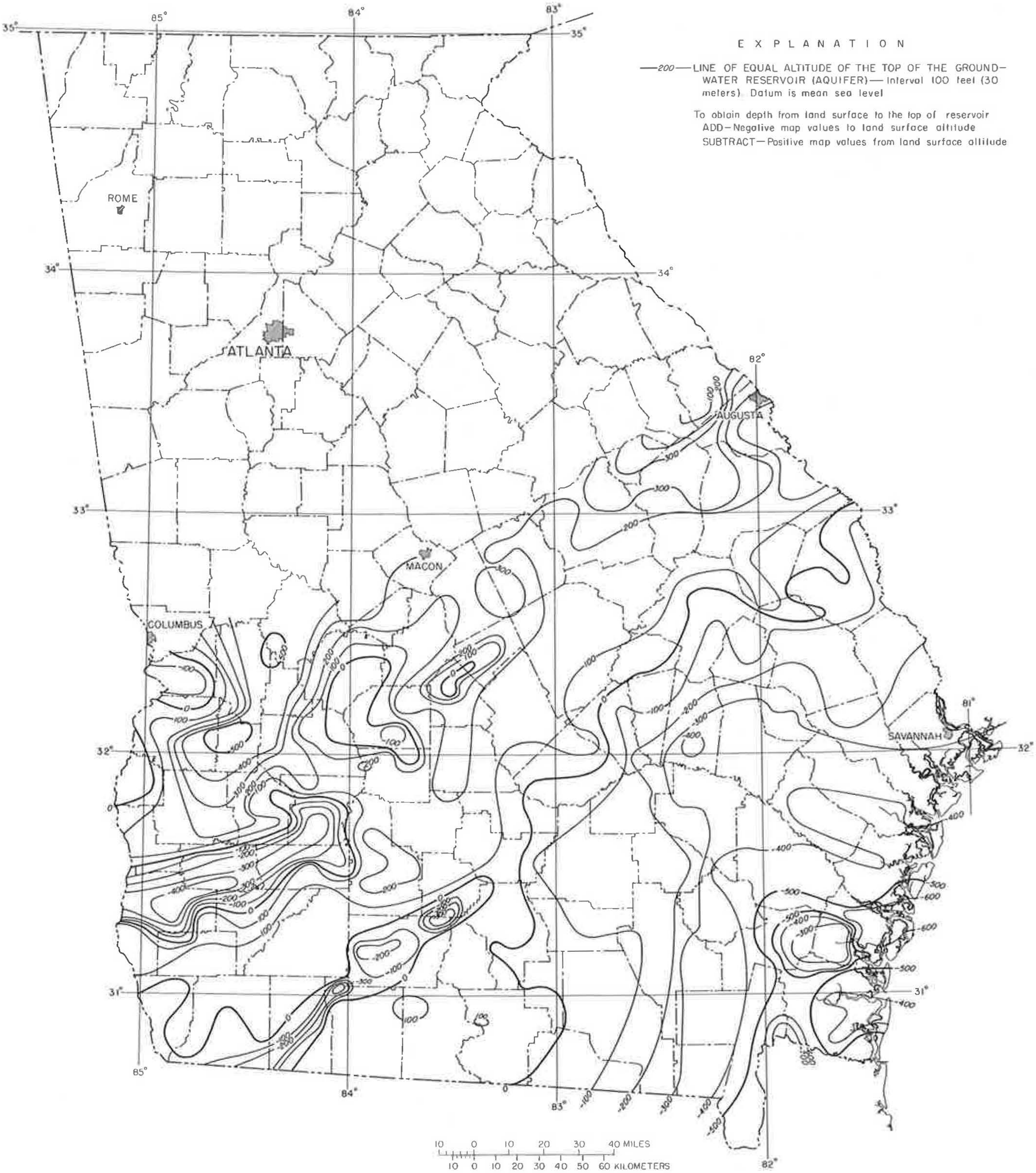

Figure 3. Altitude of the top of the first major ground-water reservoir for specific areas in the Coastal Plain.

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TABLE 1.--SUMMARY OF GROUND-WATER QUALITY AND AVAILABILITY IN GEORGIA.

Area (See fig. 1)	Ground-water reservoirs	Yield (gallons per minute)		Usual depths to water-bearing unit (feet)	Constituents and Properties										Comments
					Milligrams per liter								Specific conductance (micromhos per centimeter @25°C)	pH	
		Usual range	Maximum reported		Silica (SiO)	Alkalinity as calcium carbonate ($CaCO_3$) at 25°C	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as calcium carbonate ($CaCO_3$) @25°C			
Valley and Ridge Province and Cumberland Plateau	Sedimentary rocks including sandstones, shales, limestones, dolomites, cherts, and residuum. Comparison of the lithologic map (fig. 2) with the constituent areal distribution maps shows the relationship between rock type and ground-water quality (5).	5 - 50 in massive dolomite 1 - 20 in limestone, sandstone, mudstone, and chert.	1,000 50 to 300	50 to 300	5 to 20	26 to <350	0 to 250	0 to 10 Concentrations are uniformly low.	0 to 0.6 Concentrations are uniformly low.	0 to 4 Higher concentrations are associated with fertilizers, sewage plants, and animal wastes.	51 to 850 Higher concentrations are in water from thin-bedded limestones in the Pigeon Mountain Syncline.	0 to 500 Sandstones and shales generally yield soft to moderately hard water. Limestones and dolomites (carbonate rocks) generally yield hard to very hard water.	51 to 1,000 Higher concentrations are in water from thin-bedded limestones in the Pigeon Mountain Syncline.	4.5 to <7.5 Massive sandstones generally yield water of low pH (acidic). Limestones and dolomites yield water of high pH (alkaline).	Ground water from the residuum (weathered rock) or rock in the Knox Group (fig. 2) is softer, lower in dissolved solids and slightly more acidic than ground water from the unweathered rock. Ground water from the Rome Formation, Knox Group, Bays Formation, Rockmart Slate, Frog Mountain Sandstone, and Floyd Shale and from rocks of Pennsylvanian age contain enough iron to cause staining.
Blue Ridge Province and Piedmont Province	Fractured metamorphic and igneous rocks and overlying loose, weathered material (4).	1 - 25	400	10 to 250	5 to 60	0 to 100 Lower concentrations are characteristic of Blue Ridge ground water.	0 to 10 Concentrations ranging from 11 to 50 are limited in extent. Higher sulfate concentrations are caused by the dissolution of sulfur-bearing minerals.	0 to 10 Concentrations are uniformly low.	0 to 0.6 Concentrations are uniformly low.	0 to 4 Higher concentrations are associated with fertilizers, sewage plants, and animal wastes.	0 to 50 in Blue Ridge. 51 to 250 in Piedmont.	0 to 120 Higher concentrations are limited in extent to mineralized zones.	0 to 300 Higher concentrations are limited in extent of mineralized zones.	3.8 to 7.5 More acidic water is present in the Blue Ridge.	Ground water can contain enough iron to cause staining. Iron may occasionally cause reduced yields by forming a crust in the rock fractures through which the water moves toward the well.
Coastal Plain Province	Sedimentary rocks forming three major units: 1) limestone and dolomite (carbonates), 2) limestone and sandy limestone, and 3) sand and gravel. The carbonate-rock unit is the principal artesian aquifer in Georgia.	1,000-5,000 in carbonates. 250 - 600 in limestone and sandy limestone. 50-1,200 in sand and gravel.	11,000 1,400 1,800	50 to 500 (See fig. 3.)	5 to 80	0 to 200 Alkalinity is greater than 150 mg/L in areas of limited extent and in the southeastern corner of Georgia.	0 to 250 Concentrations greater than 50 mg/L are in water from the southeastern corner of Georgia and a belt through south-central Georgia.	0 to 60 Higher concentrations are in the southeastern corner of Georgia. Excessive pumping has caused an increase in the chloride concentration in the Brunswick area, Glynn County.	0 to 0.6 Concentrations are uniformly low.	0 to 4 Higher concentrations are associated with fertilizers, sewage plants, and animal wastes.	0 to 850 Very low concentrations are in water from the sands. Carbonate rocks in the southeastern corner of Georgia yield water having the highest concentrations.	0 to 500 Water from the sands in the northern Coastal Plain and from some water-bearing units associated with a specific kind of clay is soft to moderately hard. Water from limestone and dolomite is hard to very hard.	0 to 1,000 Very low concentrations are in water from the sands. Carbonates in the southeastern corner of Georgia yield water having the highest concentrations.	3.8 to >7.5 Sands yield water of low pH (acidic) and the carbonate rocks yield water of higher pH (alkaline).	Ground water from the sands can contain enough iron to cause staining. Ground water is produced from multiple zones in the carbonate-rock water-bearing unit. The uppermost major water-bearing zone was selected for this summary. The lower zones may yield water with higher concentrations of dissolved solids, chloride, and sulfate than are shown in the areal distribution maps for the uppermost zone. A water-bearing sand above the carbonate-rock water-bearing unit yields water in adequate quantities for domestic wells in southeastern Georgia.
					See table 2 for recommended limits and figure 4 for areal distribution.	See table 3 for recommended limits and figure 5 for areal distribtuion.	See table 4 for recommended limits and figure 6 for areal distribution.	See table 9 for recommended limits.	The recommended range for fluoride varies with temperature. The Georgia Department of Natural Resources gives the following limits: below 70.7°F, 0.7 to 1.2 mg/L fluoride; above 70.6°F, 0.7 to 1.0 mg/L fluoride. The recommended range for food and drink processing is 0 to 1 mg/L fluoride. The suggested limit for livestock is 2.0 mg/L fluoride.	The recommended limit in drinking water is 45 mg/L nitrate and 400 mg/L nitrate for livestock. High nitrate concentration are undesirable for brewing and textile dyeing, but are beneficial for most irrigation uses.	See table 5 for recommended limits and figure 7 for areal distribution.	See table 6 for recommended limits and figure 8 for areal distribution.	See table 7 for recommended limits and figure 9 for areal distribution.	See table 8 for recommended limits and figure 10 for areal distribution.	

Table 2.—Recommended limits for silica in water
(In milligrams per liter)

Industry		Agriculture	Home
Boiler feedwater		No published recommended limits	No published recommended limits
Industrial			
0 to 150 psig	30		
150 to 700 psig	10		
700 to 1,500 psig	0.7		
Electric utilities			
1,500 to 5,000 psig	0.01		
Brewing	50		
Cooling water			
Once through, fresh	50		
Makeup for recirculation, fresh	50		
Food processing	50		
Paper manufacturing			
Fine paper	20		
Kraft paper, bleached	50		
Kraft paper, unbleached	100		
Groundwood papers	50		
Soda and sulfite pulp	20		
Rayon pulp production	less than 25		
Textiles	25		

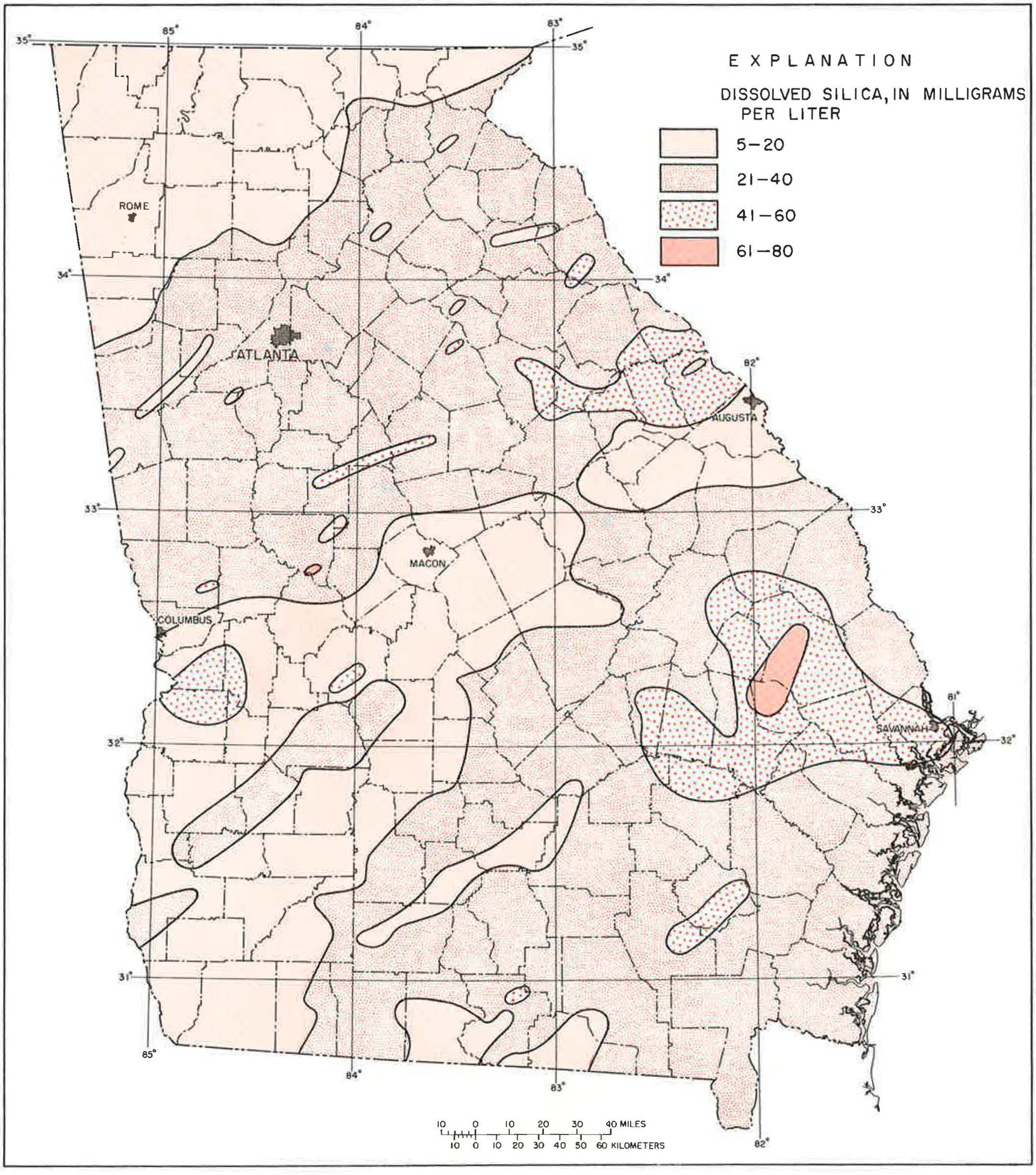

Figure 4. Concentration ranges of dissolved silica in ground water.

Table 3.—Recommended limits for alkalinity in water
(In milligrams per liter of $CaCO_3$ at 25°C)

Industry		Agriculture	Home
Boiler feedwater		No recommended limits for agriculture and home use because of the dependence on other properties such as pH and hardness.	
Industrial			
0 to 150 psig	350		
150 to 700 psig	100		
700 to 1,500 psig	40		
Electric utilities			
1,500 to 5,000 psig	1		
Brewing			
Light beer	75-80		
Dark beer	80-150		
Cooling water			
Once through, fresh	850		
Makeup for recirculation, fresh	650		
Food processing	250		
Laundering	60		
Paper manufacturing			
Fine paper	75		
Kraft paper, bleached	75		
Kraft paper, unbleached	150		
Groundwood paper	150		
Soda and sulfite pulp	75		
Rayon pulp production	50-75		
Soft drinks	85		
Textiles	50-200		

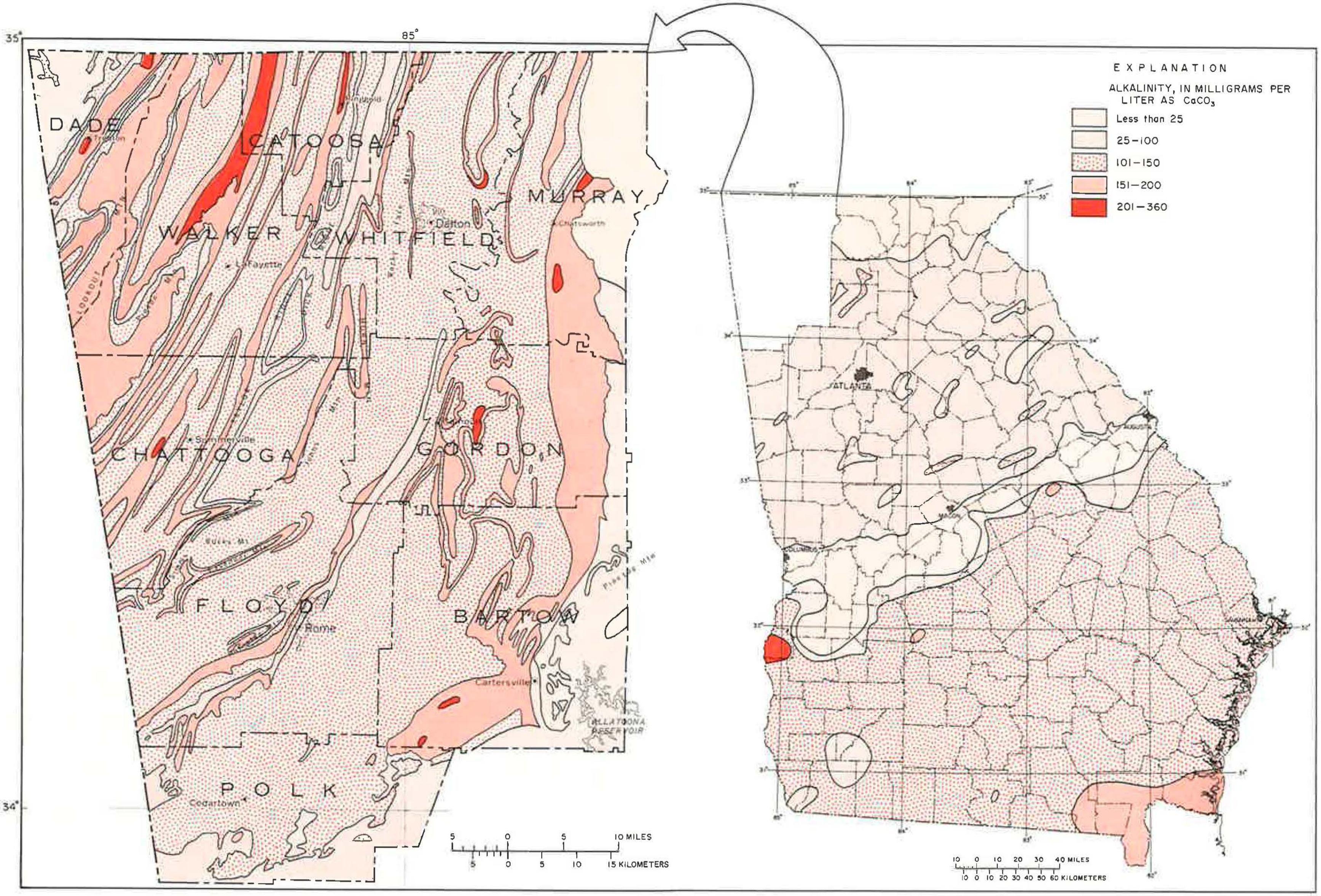

Figure 5. Concentration ranges of alkalinity as calcium carbonate in ground water.

Table 4.—Recommended limits for sulfate in water
(In milligrams per liter)

Industry		Agriculture		Home	
Brewing	70-350	Irrigation	0 to 200 good 200 to 500 acceptable	Drinking	250
Chemical and allied products industries	850	Livestock	0 to 500 good 500 to 1,000 acceptable		
Dairy industry	less than 60				
Food processing	250				
Photographic processes	70				
Soft drinks	500				
Tanning processes and finishing	250				
Textiles	100				

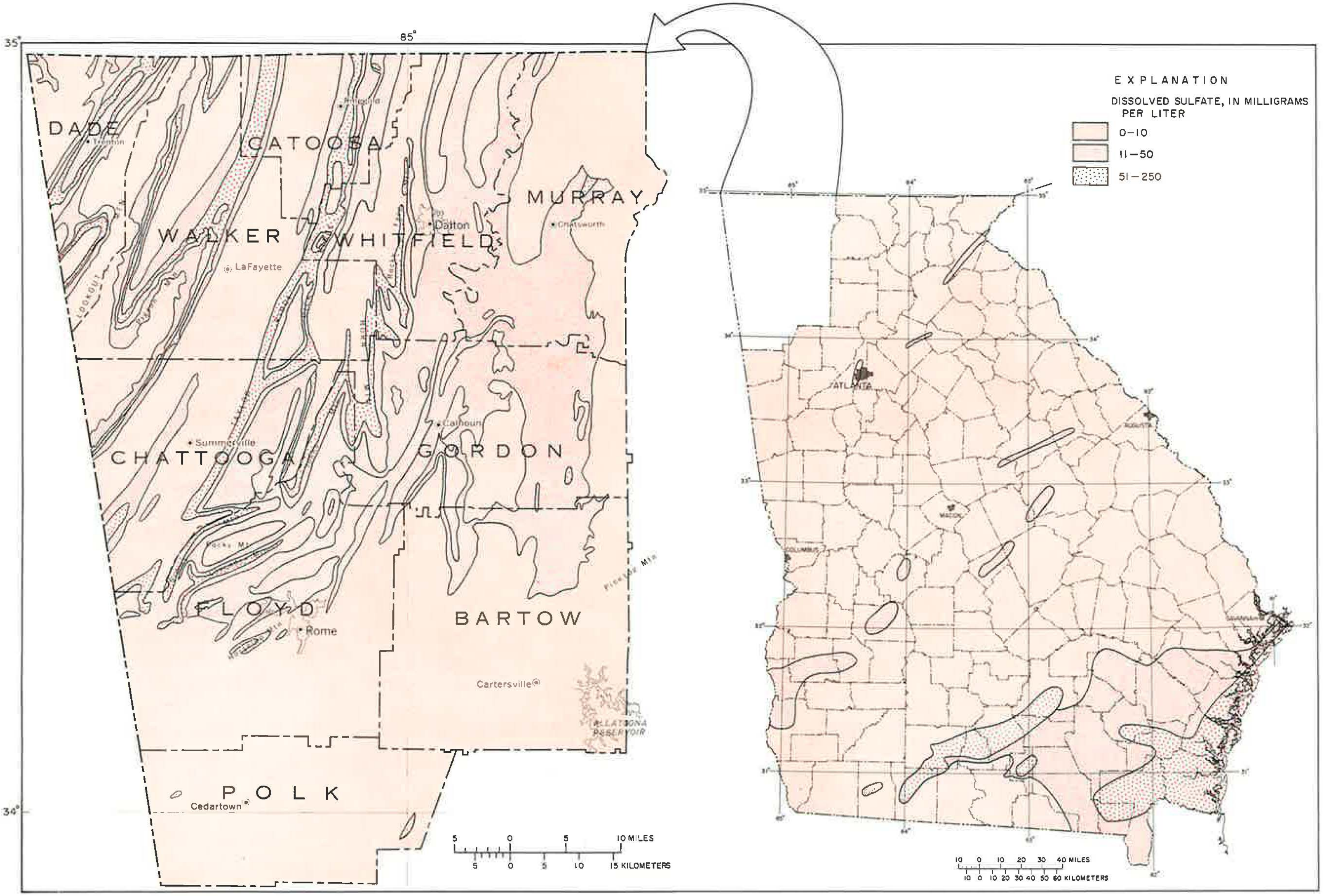

Figure 6. Concentration ranges of dissolved sulfate in ground water.

Table 5.—Recommended limits for dissolved solids in water
(In milligrams per liter)

Industry

Boiler feedwater	
Industrial	
0 to 150 psig	700
150 to 700 psig	500
500 to 1,500 psig	200
Electric utilities	
1,500 to 5,000 psig	0.5
Brewing and distilling	500-1,500
Canning and freezing	850
Chemical and allied products industries	2,500
Cooling water	
Once through, fresh	1,000
Makeup for recirculation, fresh	500
Food equipment washing	850
Food processing	500
Ice manufacturing	170-1,300
Paper manufacturing	
Fine Paper	200
Kraft paper, bleached	300
Kraft paper, unbleached	500
Groundwood papers	500
Soda and sulfite pulp	250
Soft drinks	controlled by treatment for other constituents
Textiles	100-200

Agriculture

Irrigation	500
500 to 5,000 can be used if water quality and soil characteristics are considered in choosing crops.	
Livestock	3,000

Home

Drinking water	500
500 to 2,000 can be used without physiological damage where alternate supplies are not available.	

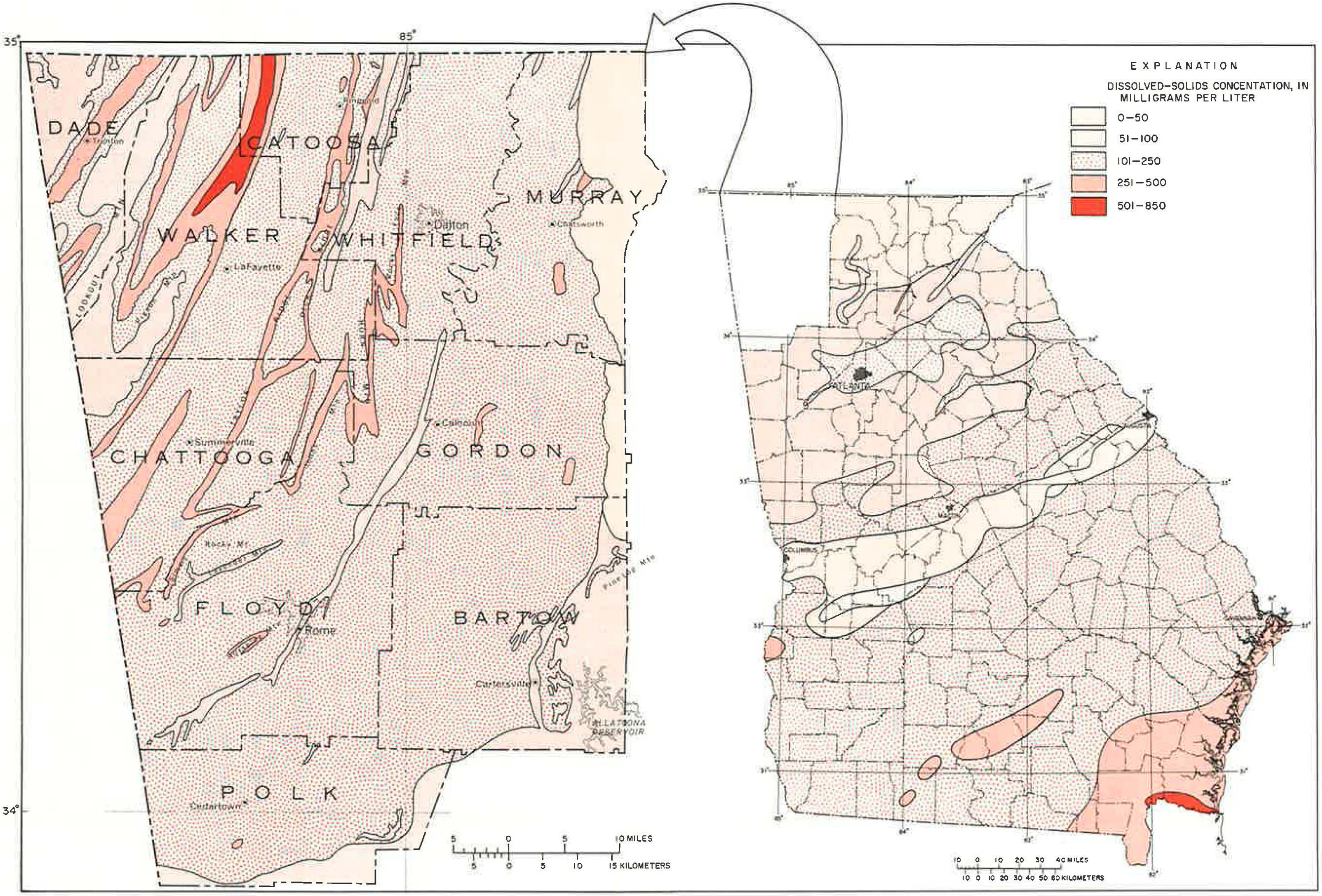

Figure 7. Concentration ranges of dissolved solids in ground water.

Table 6.—Recommended limits for hardness in water
(In milligrams per liter as $CaCO_3$ at 25°C)

Industry		Agriculture	Home
Boiler feedwater		Irrigation . . . less than 61	General use depends upon pH, alkalinity, and dissolved oxygen.
Industrial			
0 to 150 psig	350		
150 to 700 psig	1.0		
700 to 1,500 psig	0.07		
Electric utilities			
1,500 to 5,000 psig	0.07		
Chemical and allied products industries	1,000		
Cooling water			
Once through, fresh	850		
Makeup for recirculation, fresh	650		
Dairy industry	less than 180		
Food equipment washing	10		
Food processing	250		
Laundering	0-50		
Paper manufacturing			
Fine paper	100		
Kraft paper, bleached	100		
Groundwood paper	200		
Soda and sulfite pulp	100		
Photographic processes	200		
Rayon			
Pulp production	8		
Cloth manufacturing	55		
Soft drinks	controlled by treatment for other constituents		
Steel manufacturing	50		
Synthetic rubber	50		
Tanning processes	150		
Textiles	0-50		

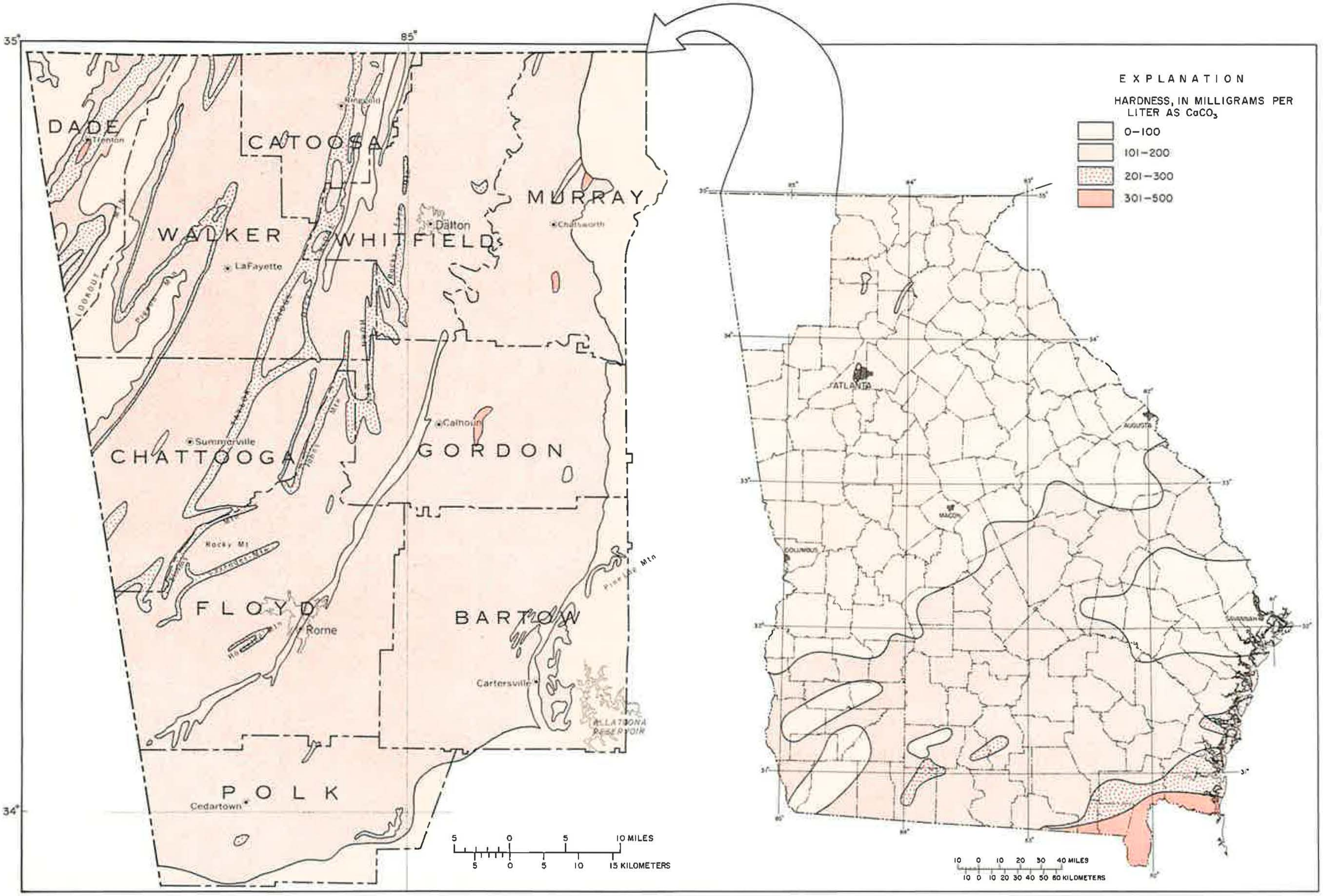

Figure 8. Concentration ranges of hardness as calcium carbonate in ground water.

Table 7.—Recommended limits for specific conductance in water
(In micromhos per centimeter at 25°C)

There are no recommended limits for specific conductance. Values vary with dissolved-solids, hardness, chloride, and sulfate concentrations.

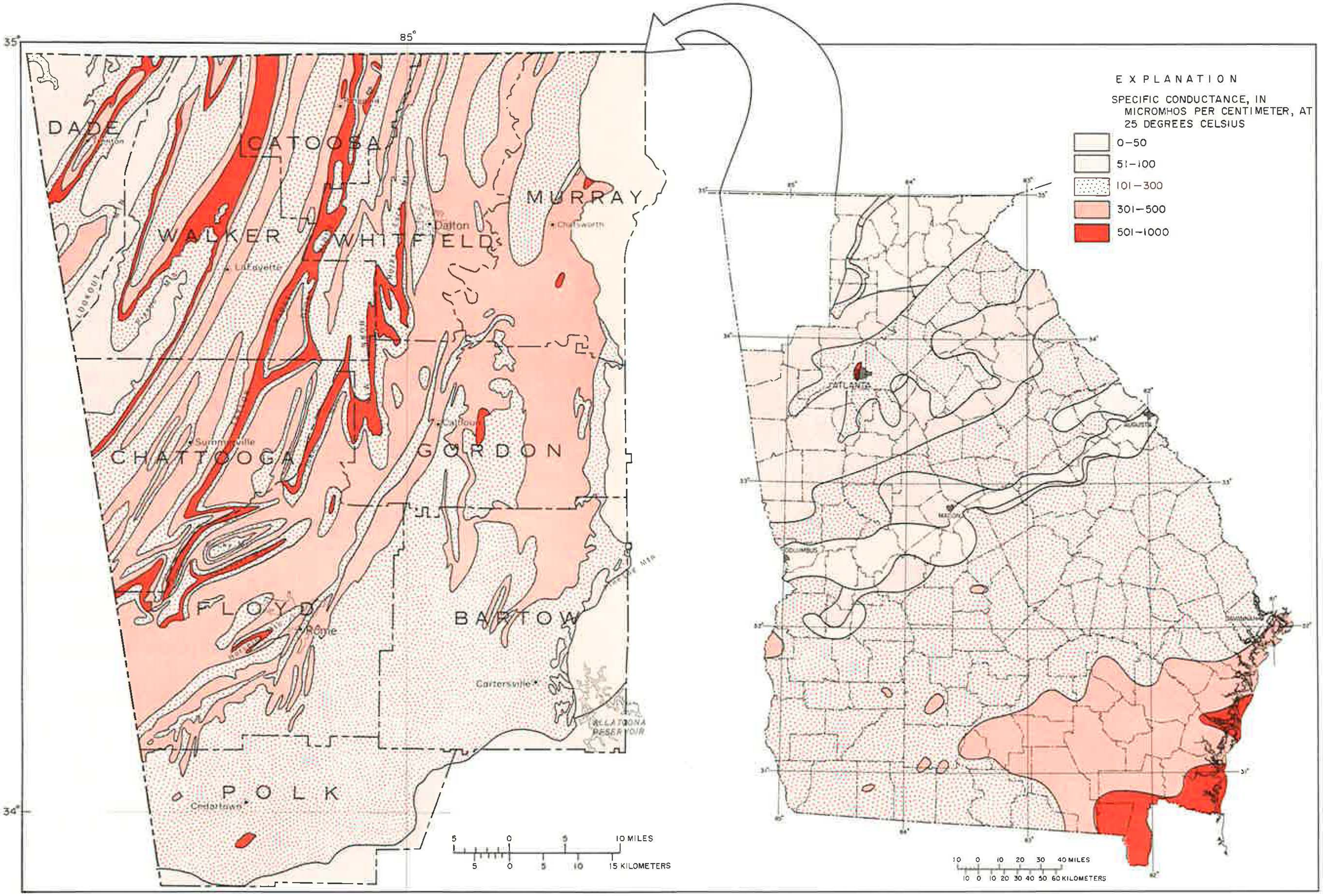

Figure 9. Ranges of specific conductance in ground water.

Table 8.—Recommended limits for pH in water

Industry		Agriculture		Home	
Boiler feedwater		Irrigation	3.8-9.5	General use	5.0–9.0
Industrial					
0 to 150 psig	7.0-10.0				
150 to 700 psig	8.2-10.0				
700 to 1,500 psig	8.2-9.0				
Electric utilities					
1,500 to 5,000 psig	8.8-9.4				
Brewing	4.6-5.7				
Chemical and allied products industries	5.5-9.0				
Confectionery	greater than 7.0				
Cooling water					
Once through, fresh	5.0-8.3				
Makeup for recirculation, fresh	Accepted as received				
Food processing	6.5-8.5				
Laundering	6.0-6.8				
Oil well flooding	7.0				
Rayon manufacturing	7.8-8.3				
Steel making	6.8-7.0				
Tanning processes	6.0-8.0				

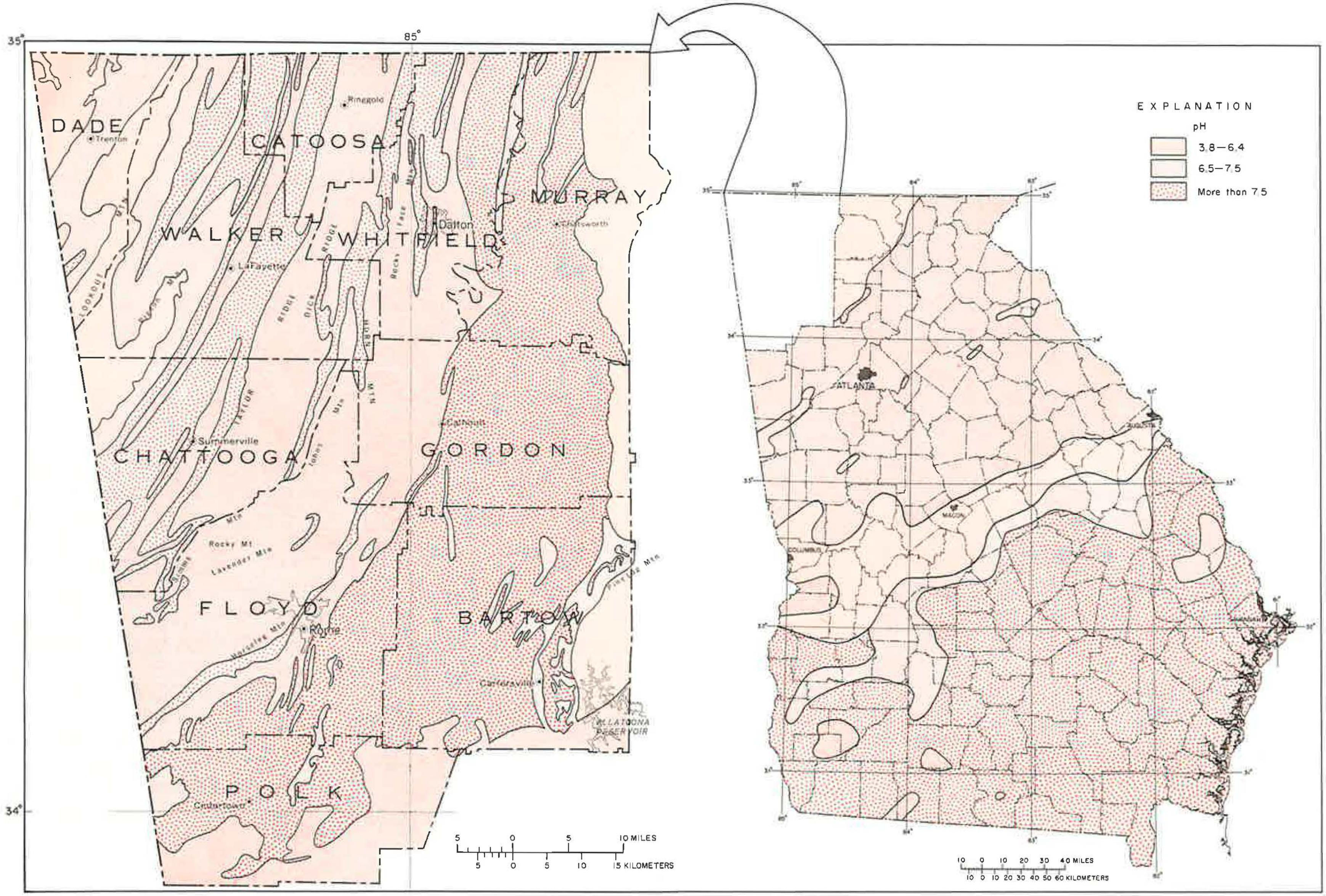

Figure 10. Ranges of pH in ground water.

Table 9.—Recommended limits for chloride in water
(In milligrams per liter)

Industry		Agriculture		Home	
Brewing	60-100	Irrigation	250	Drinking water	250
Chemical and allied products industries	500	The amount of chloride that can be tolerated is very crop-specific.			
Cooling water					
Once through, fresh	600				
Makeup for recirculation, fresh	500				
Dairy industry	less than 30				
Food equipment washing	250				
Paper manufacturing					
Kraft paper	200				
Groundwood papers	75				
Soda and sulfite pulp	75				
Soft drinks	500				
Sugar making	20				
Tanning and finishing industry	250				
Textiles	100				

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