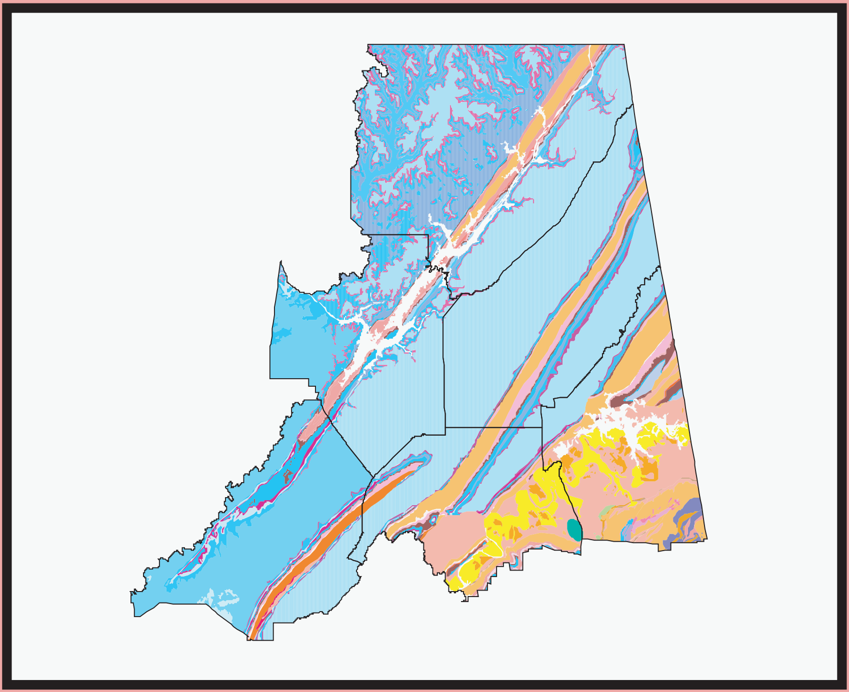
HYDROGEOLOGY AND VULNERABILITY TO CONTAMINATION OF MAJOR AQUIFERS IN ALABAMA: AREA 2



GEOLOGICAL SURVEY OF ALABAMA
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GEOLOGICAL SURVEY OF ALABAMA

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State Geologist

WATER INVESTIGATIONS PROGRAM

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HYDROGEOLOGY AND VULNERABILITY TO CONTAMINATION OF MAJOR AQUIFERS IN ALABAMA: AREA 2

By
David C. Kopaska-Merkel, Lewis S. Dean,
and James D. Moore

Prepared by the Geological Survey of Alabama in cooperation with the
Alabama Department of Environmental Management

Tuscaloosa, Alabama
2008

GEOLOGICAL SURVEY OF ALABAMA

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February 28, 2008

The Honorable Bob Riley
Governor of Alabama
Montgomery, Alabama

Dear Governor Riley:

It is with pleasure that I make available to you and the citizens of Alabama the publication "Hydrogeology and Vulnerability to Contamination of Major Aquifers in Alabama: Area 2," by David C. Kopaska-Merkel, Lewis Dean, and James D. Moore. It is published as Circular 199 F of the Geological Survey of Alabama and is the result of a cooperative effort between the Survey and the Alabama Department of Environmental Management.

The publication contains information on the geology, characteristics of the major aquifers, and public water supply wells in Blount, Cherokee, DeKalb, Etowah, Jackson, and Marshall Counties. This report is the fourth in a 13-part series that will ultimately cover the entire state. These studies will provide vital information to engineers, geologists, resource managers, city planners, and others regarding the ground water resources of Alabama.

Respectfully,

Berry H. (Nick) Tew, Jr.
State Geologist

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HYDROGEOLOGY AND VULNERABILITY TO CONTAMINATION OF MAJOR AQUIFERS IN ALABAMA: AREA 2

By
David C. Kopaska-Merkel, Lewis Dean, and James D. Moore

ABSTRACT

The Geological Survey of Alabama (GSA), in cooperation with the Alabama Department of Environmental Management (ADEM), is revising and expanding a series of hydrogeologic studies to delineate the major aquifers in Alabama and their vulnerability to contamination. The U.S. Geological Survey in cooperation with ADEM prepared the original reports. The state is divided into 13 areas that are addressed in separate reports. The hydrogeology and vulnerability to contamination of the major aquifers in Area 2, which includes Blount, Cherokee, DeKalb, Etowah, Jackson, and Marshall Counties, are described in this report. The reports for Area 13 (Mobile and Baldwin Counties), Area 10 (Clarke, Choctaw, and Washington Counties), and Area 5 (Chambers, Clay, Cleburne, Coosa, Lee, Randolph, and Tallapoosa Counties) have been published (Gillett and others, 2000; Raymond and others, 2001; Kopaska-Merkel and others, 2001).

The major aquifers in Area 2 are the Valley and Ridge aquifer system; the Mississippian aquifer system, which includes the Hartselle aquifer, the Bangor aquifer, the Fort Payne-Tuscumbia aquifer, and the Monteagle aquifer; and the Pottsville aquifer. Minor aquifers are the Nashville-Stones River aquifer, which is stratigraphically equivalent to part of the Valley and Ridge aquifer system; metasedimentary and metavolcanic aquifers of the Piedmont; and the watercourse aquifer. The recharge area of the Nashville-Stones River aquifer in Area 2 is restricted to small, elongate areas in the vicinity of Guntersville Lake. The metasedimentary and metavolcanic aquifers crop out in fault slices in southern Cherokee County. The watercourse aquifer crops out in Area 2 in the Coosa River valley. Highest yields from aquifers are associated with solution openings in carbonate rocks, which dominate the Valley and Ridge aquifer system and the three carbonate aquifers of the Mississippian aquifer system (the Bangor aquifer, the Monteagle aquifer, and the Fort Payne-Tuscumbia aquifer). Most public-supply wells in the study area are completed in the carbonate aquifers and tap water contained in secondary voids that have been enlarged by dissolution processes. Public water-supply wells completed in the carbonate aquifers commonly produce between 0.5 and 1.0 million gallons per day (mgd). Wells completed in the Pottsville aquifer generally produce less water than wells completed in the carbonate aquifers. Water-level measurements made in nearly 500 wells indicate that the potentiometric surface for each aquifer is a subdued reflection of topography and that ground water moves toward streams (Bossong, 1989).

All aquifer recharge areas in Area 2 are vulnerable to contamination from the land surface. The recharge areas of the Valley and Ridge and Mississippian aquifer

systems and the watercourse aquifer are highly vulnerable to contamination from the surface, whereas the recharge areas of the Pottsville and Nashville-Stones River aquifers are moderately vulnerable to contamination from the surface. The recharge areas of the metasedimentary and metavolcanic aquifers are only slightly vulnerable to contamination from the surface. Three conditions exist in the study area that locally may increase vulnerability of aquifers to contamination. First, fracturing of rock materials caused by faulting may create planar zones of high permeability. Second, the production of a porous cherty soil via weathering may facilitate passage of water from the surface into the ground water system. Third, where sinkholes are present the land surface may be directly connected to the underlying aquifer. Areas with sinkholes are extremely vulnerable to contamination. Aquifers become less vulnerable to contamination from the surface with an increasing degree of confinement by impermeable layers (such as shale) and increasing distance from conduits such as sinkholes and fault zones. However, even deep aquifers can be vulnerable to natural sources of contamination such as mineralized ground water.

Pumping of public water supply wells and irrigation wells can increase the potential for contamination of aquifers if not properly planned, managed, and monitored. Pumping of large quantities of ground water creates cones of depression, increases flow gradients, and draws ground water and any associated contaminants toward pumping wells. Available data do not indicate the existence of large cones of depression in Area 2.

INTRODUCTION

The U.S. Geological Survey, in cooperation with ADEM, conducted a series of hydrogeologic studies in Alabama to delineate the major aquifers and their recharge areas and to define areas vulnerable to contamination from the surface. Different investigators studied each of the 13 areas of the state. Bossong (1989) summarized the characteristics of aquifers in Area 2, which includes Blount, Cherokee, DeKalb, Etowah, Jackson, and Marshall Counties. The GSA, in cooperation with ADEM, is updating and expanding the scope of the past study and is publishing the information online. The new online format will include a pdf format report, GIS databases used in the plates, metadata, and a website driven interactive map that user will be able to create their own maps with. The Readme file contains information on how to obtain a copy of GIS software, ARC Reader, from ESRI, Inc.

The extent to which Area 7 is dependent on ground water is not fully addresses iin this report, which discusses only public water supply wells. The numerous domestic wells that are present in the area are not discussed.

ACKNOWLEDGMENTS

The authors thank the well drillers and managers and operators of water-supply systems in Area 2 for providing information about wells. In addition, Sonja Massey, the late Fred Mason, Lynn Ford, David Lovoy, and Enid Probst of ADEM provided assistance and suggestions in the preparation of this report. Ruth T. Collier of the GSA provided geographic information systems (GIS) support. Her efforts are greatly appreciated.

PURPOSE AND SCOPE

The purposes of this report are to (1) describe the hydrogeology of the study area; (2) delineate, redefine, and describe the major aquifers and their recharge areas; (3) delineate areas within the recharge areas that are vulnerable to contamination; (4) compile the Source Water Assessment Areas or Wellhead Protection Areas as defined under section 335-7-5 and section 335-7-12 of ADEM's administrative code and as currently identified in the study area; (5) identify the locations of public supply wells and springs in the study area; and (6) provide all hydrogeologic data in GIS format that can be readily accessed.

The revised Geologic Map of Alabama (Osborne and others, 1988; Szabo, Osborne, and Copeland, 1988; Szabo, Osborne, Copeland, and Neathery, 1988) at a scale of 1:250,000 provides new geologic data from which to update the previous aquifer susceptibility map (Bossong, 1989) (pl. 1). Plate 2 shows geographic and stratigraphic relationships among the geologic units mapped on plate 1. Plate 3 shows geographic and stratigraphic relationships among the major aquifers of Area 2. A hydrogeologic cross section of Area 2 is shown on plate 4. Areas susceptible to surface contamination were delineated from topographic maps, geologic maps, and field investigations. Aquifer recharge areas, areas of aquifer vulnerability, and locations of selected water supply wells and springs in Area 2 are shown on plate 5. All active and inactive public water supply wells and springs as well as other water supply wells and springs are shown on plate 5. In the study by Bossong (1989) all wells used for municipal and rural public water supplies were inventoried, and water levels were measured in these wells where possible. Data on water use were compiled during the inventory. In this study, water-level data were used to prepare generalized potentiometric surface maps of the major aquifers (pls. 6 through 8). In addition, ground water-quality data were used to prepare a generalized map of the concentration of iron in shallow ground water in Area 2 (pl. 9). For this study, delineations of wellhead protection areas were derived from maps submitted to ADEM by public water systems that have completed wellhead protection projects (pl. 10). Wellhead protection areas are shown on plate 10 exactly as they appear on maps submitted to and approved by ADEM.

LOCATION AND EXTENT OF THE STUDY AREA

The study area comprises about 4,600 square miles in northeastern Alabama. About 56 percent of the area is forested, 38 percent is agricultural, and the remainder is mostly urban or wetland. The 1995 population was reported to be 292,490 (Mooty and Richardson, 1998). The largest urban centers are Gadsden, Fort Payne, Guntersville, Oneonta, and Scottsboro.

PREVIOUS INVESTIGATIONS

Several published reports on the structure, stratigraphy, and lithology of the study area are of interest. Adams and others (1926) provided the descriptive base of most geologic studies in Alabama. Johnston (1933) presented a comprehensive account of the ground water resources in the Paleozoic rocks of northern Alabama. Neathery and Drahovzal (1985) updated and revised descriptions of the Upper Ordovician stratigraphy of the Alabama Appalachians. Thomas (1972) published a comprehensive description of the Mississippian stratigraphy of Alabama.

Reports on ground water resources, which include geologic mapping and well inventories, have been published for each of the counties in Area 2. These reports include Causey (1961, 1965); Sanford (1966); Faust and Harkins (1980); Baker (1989); Baker and Moser (1989); and Mann and Baker (1995). Baker and Osborne (1994) reported on geologic and hydrologic investigations in the Valley Head area, DeKalb County, in support of a wellhead protection program, and Smith and Baker (1997) reported on geologic and hydrologic investigations in the Douglas area, Blount and Marshall Counties, in support of a wellhead protection program. These reports provide a broad and useful base of geologic and hydrologic information.

In 1988, GSA published a revised geologic map for the state at a scale of 1:250,000, which provides the most up-to-date geologic mapping of the study area (Osborne and others, 1988; Szabo, Osborne, and Copeland, 1988; Szabo, Osborne, Copeland, and Neathery, 1988).

PHYSICAL FEATURES

The study area includes parts of two physiographic sections: the Cumberland Plateau section of the Appalachian Plateaus province and the Alabama Valley and Ridge section of the Valley and Ridge Province. Figure 1 shows the locations of these two sections as well as the districts within each of them (Sapp and Emplaincourt, 1975).

The northwestern part of Area 2 in Blount, DeKalb, Jackson, and Marshall Counties and part of Etowah County lies in the Cumberland Plateau section. Relatively flat plateaus, especially south of the Tennessee River in the Blount, Lookout, and Sand Mountain districts, dominate the terrain. The plateau surface is about 1,500 to 1,800 feet above mean sea level. In the Murphrees, Sequatchie, and Wills Valley districts, streams have cut narrow linear valleys into the plateau surface resulting in base altitudes of about 500 to 600 feet. North of the Tennessee River in the Jackson County Mountains district, drainage patterns are dendritic. Drainage is to the Tennessee River and its tributaries in all of Jackson and parts of DeKalb and Marshall Counties. Drainage in the remainder of the Cumberland Plateau section is to the Locust and Mulberry Forks of the Black Warrior River.

The southeastern part of Area 2 in Cherokee, DeKalb, and Etowah Counties lies in the Alabama Valley and Ridge section. Topography is controlled by bedrock geology and is characterized by a series of relatively narrow, linear ridges that have been classified as the Armuchee and Weisner Ridge districts. These ridges trend northeastward and have altitudes of about 1,500 to 1,600 feet. Streams drain relatively wide valleys in the Birmingham-Big Canoe, Cahaba, and Coosa Valley districts. The altitudes of the valley floors generally range from 500 to 600 feet. Most drainage in the area is to the Coosa River and its tributaries.

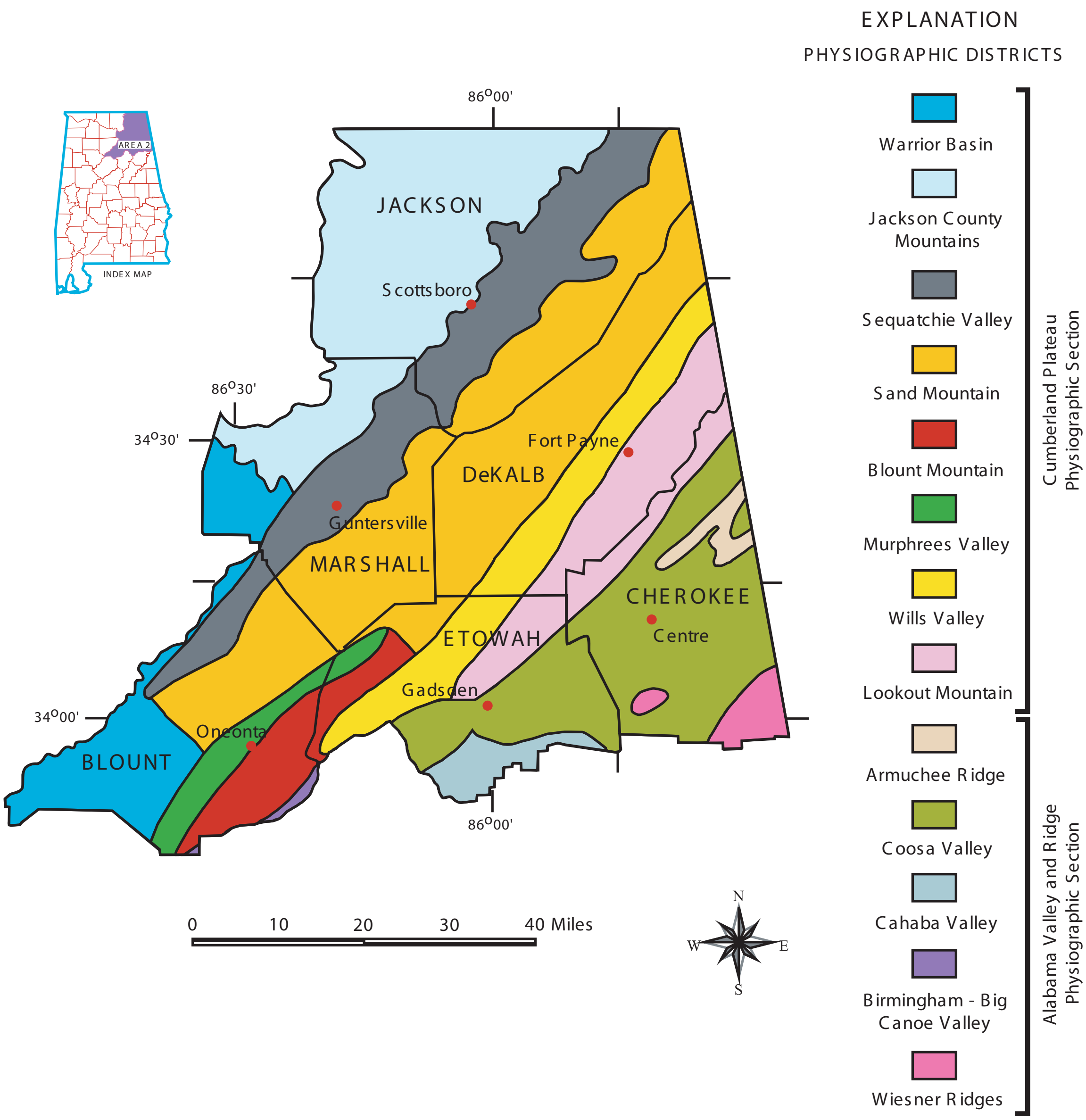

Figure 1.–Physiography of Area 2. Modified from Bossong (1989).

STRUCTURE

The structural geology and physiography of Area 2 are quite complex because the region was strongly affected by large-scale tectonic activity, most of which took place during the Alleghanian orogeny. Most of the study area is in the Appalachian fold and thrust belt, which consists of shallow marine to deltaic Paleozoic sedimentary strata that were deposited on a continental platform (Thomas, 1985). Paleozoic metasedimentary rocks crop out along the southeastern border of Area 2 in Cherokee County and are structurally controlled by imbricate thrust faults (Cloud, 1968).

Strata throughout the study area generally maintain a northeast-southwest strike; strata are relatively flat lying in the northwestern part of Area 2, and in the southeastern part of the area, dips trend to the southeast (fig. 2; pl. 4). Across strike, the fold and thrust belt is characterized by broad flat-bottomed synclines and narrow asymmetric anticlines to the northwest (fig. 2), major thrust faults in the central area (fig. 2), and low-angle, broad, multiple-level thrust sheets to the southeast (Thomas, 1985). Most of Area 2 is included in the northwestern or central areas. The southeastern area is represented in Area 2 by a small region consisting of numerous thrust slices and sheets.

STRATIGRAPHY

Area 2 contains Paleozoic sedimentary rocks and Quaternary sediments. Paleozoic stratigraphy is summarized in plate 2. Metasedimentary rocks of the Piedmont crop out in Area 2 only in very small thrust slices. These rocks were described by Kopaska-Merkel and others (2001).

Thomas (1985) divided the Paleozoic sedimentary succession above the Precambrian basement into four major components: a basal Cambrian siliciclastic sequence, a Cambrian-Ordovician carbonate shelf facies, a thin and laterally variable Middle Ordovician to Lower Mississippian succession of shallow-marine shelf siliciclastic and carbonate rocks, and parts of two Mississippian-Pennsylvanian siliciclastic wedges that prograded over the carbonate shelf. Each of these four components formed under relatively stable conditions and consists of genetically related rock units, but the four components are separated by major discontinuities. Major unconformities separate the basal Cambrian siliciclastic, Cambro-Ordovician carbonates, and Middle Ordovician to Lower Mississippian sequences in most or all of Area 2. Deposition of the Mississippian-Pennsylvanian clastic wedges did not follow a significant period of nondeposition or erosion, but these strata record a dramatic change in the style of deposition and the sources of sediment (Thomas, 1972; Pashin, 1993).

Alleghenian thrust faults and associated folds have displaced and deformed the youngest preserved Paleozoic strata. Quaternary sediments overlie older deposits in stream valleys, chiefly in the Coosa River valley.

SEDIMENTARY DEPOSITS OF PALEOZOIC AGE

The Cambrian System is represented in Area 2 by the Chilhowee Group, Shady Dolomite, Rome Formation, and Conasauga Formation (pl. 2). The Chilhowee Group

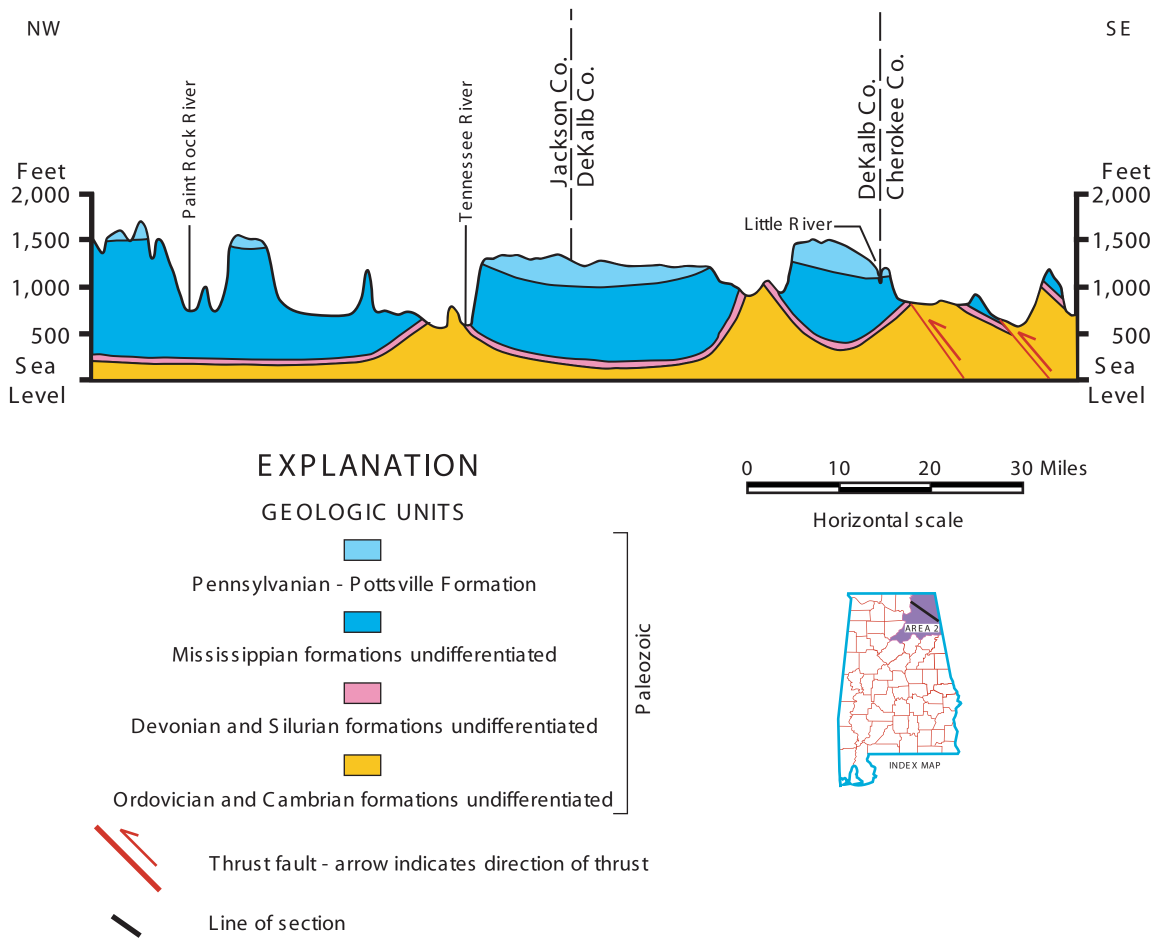

Figure 2.–Generalized geologic section through Jackson, DeKalb, and Cherokee Counties in northeastern part of Area 2. Modified from Bossong (1989).

includes the Cochran Formation, Nichols Formation, Wilson Ridge Formation, and Weisner Quartzite (Szabo, Osborne, Copeland, and Neathery, 1988). The Chilhowee crops out in the Weisner Ridges and the Coosa Valley (fig. 1). It consists of more than 1,300 feet of fluvial to shallow-marine sandstone, conglomerate, and mudstone (Thomas, 1985). The Cochran Formation is dominated by sandstone and conglomerate with minor silty mudstone (Mack, 1980). The Nichols Formation consists of mudstone with minor siltstone and very fine sandstone (Mack, 1980). The Wilson Ridge Formation consists of sandstone and silty mudstone (Mack, 1980). The Weisner Quartzite consists of sandstone, conglomerate, and lesser amounts of mudstone (Butts, in Adams and others, 1926; Johnston, 1933) and tends to support ridges where it crops out. The Shady Dolomite overlies the Chilhowee Group and generally forms valleys adjacent to, or occurs low on, Weisner-capped ridges. The Shady Dolomite reaches thicknesses of 500 to 1,000 feet and consists of sandy dolomite and dolomitic limestone. The Shady crops out in valleys of the Weisner Ridge district in Cherokee County. The Rome Formation overlies and crops out in proximity to the Shady Dolomite. Interbedded sandstones, siltstones, and shales make up the Rome, which is about 1,000 feet thick in Area 2. The Conasauga Formation, which overlies the Rome, grades from shale with thin interbeds of limestone and dolomite in the west to shale with relatively thick interbeds of limestone and dolomite in the east. The Conasauga is highly variable within Area 2. It crops out extensively in Etowah and Cherokee Counties and has a well developed regolith.

The Knox Group of Cambrian and Ordovician age overlies the Conasauga Formation and includes the Copper Ridge Dolomite, Chepultepec Dolomite, Longview Limestone, Newala Limestone, and Odenville Limestone (pl. 2). (The Odenville is included in the Newala on the 1988 state geologic map.) These formations crop out in Cahaba and Wills Valleys and southeastern Cherokee County. The maximum thickness of the unit is about 3,900 feet (Thomas, 1985) but it thins westward to 2,600 feet (Szabo and others, 1988b). The lithology ranges from siliceous (cherty) dolomite in the lower part to fine- to coarse-grained limestone in the upper part. The four lower formations assigned to the Knox Group were described by Butts (in Adams and others, 1926). The Odenville was described by Osborne (1992).

The Middle-Upper Ordovician succession in Area 2 is divided into a dominantly carbonate western facies and a largely siliciclastic eastern facies (pls. 1, 2). The western facies in turn is divided into western and eastern parts. In ascending order, the western part of the western facies in Area 2 is composed of the Stones River Group, Nashville Group, Inman Formation, Leipers Limestone, and Sequatchie Formation. This succession passes eastward into the Chickamauga Limestone. The Stones River Group is dominated by argillaceous and silty limestone containing abundant fossils. Bentonite beds and bentonitic shales occur near the top. The lower part contains sucrosic dolomite, cryptocrystalline chert, and limestone. Locally, sandy zones occur near the base and middle of the unit. Thickness ranges from 500 feet in northwestern Alabama to 1,150 feet in Jackson County (Drahovzal and Neathery, 1971; Kidd, 1976). The Nashville Group consists of limestone that is argillaceous and silty in its lower part and contains minor amounts of gray shale. Locally, it contains dolomitic limestone, dolomite, bentonitic shale, and brown chert. Thickness ranges from 50 feet near Gadsden, Etowah County, to 250 feet in Jackson County (Drahovzal and Neathery, 1971; Kidd, 1976). The Inman Formation consists of calcareous laminated shale, argillaceous limestone, shale, and limestone, with small amounts of dolomite. Thickness ranges from 0 to 50 feet (Neathery and Drahovzal, 1985). The Leipers Limestone consists of limestone interbedded with thin argillaceous limestone layers. Thickness ranges up to 60 feet (Drahovzal and Neathery, 1971; Kidd, 1976; Neathery and Drahovzal, 1985). The Inman Formation and Leipers Limestone are thin and crop out in very narrow belts along flanks of anticlines. The western facies of the Sequatchie Formation consists of calcareous laminated mudstone and limestone, which may be glauconitic, arenaceous, and silty. The unit is up to 200 feet thick (Drahovzal and Neathery, 1971). Eastward, the Stones River-Leipers succession is replaced in the eastern part of the western facies by the stratigraphically equivalent Chickamauga Limestone, which is composed mainly of fine- to coarse-grained, medium- to thick-bedded, pure to argillaceous limestone, locally containing abundantly fossiliferous layers. The Chickamauga ranges in thickness from 260 to 1,100 feet (Butts, in Adams, 1926; Drahovzal and Neathery, 1971; Benson and Stock, 1986). The eastern facies of the Middle-Upper Ordovician is composed, in ascending order, of the Lenoir Limestone, Little Oak Limestone, Athens Shale, Greensport Formation, Colvin Mountain Sandstone, and Sequatchie Formation. The upper units are dominantly siliciclastic, whereas the Lenoir and Little Oak Limestones are generally fine- to medium-grained, medium- to thick-bedded limestone. The Lenoir and Little Oak correlate in part to each other and to the lower Chickamauga Limestone. The Athens Shale is a black, graptolitic fissile shale, which contains argillaceous limestone in its lower part. The maximum thickness of the Athens is about 300 feet. The Greensport Formation consists of variegated siltstone, microcrystalline limestone, and shale and contains irregular lenses of fine sandstone. The Greensport is found in the eastern Valley and Ridge in Etowah and Cherokee Counties and ranges from 200 to 250 feet thick. The Colvin Mountain Sandstone is a light colored well-sorted sandstone containing local concentrations of small pebbles. The Colvin Mountain Sandstone is found in the northern part of the eastern Valley and Ridge in Etowah and Cherokee Counties. The Sequatchie Formation, a largely siliciclastic unit, is the youngest Ordovician unit and thins to the southwest and northwest. The Sequatchie grades westward from siltstone, sandstone and shale overlain by calcareous siltstone and dolomite to calcareous mudstone with intercalated limestone beds that are locally fossiliferous (Butts, in Adams, 1926; Drahovzal and Neathery, 1971; Neathery and Drahovzal, 1985; Raymond and others, 1988; Szabo, Osborne, Copeland, and Neathery, 1988). The Sequatchie is found in the northern part of the eastern Valley and Ridge in Etowah and Cherokee Counties and along the flanks of the Sequatchie anticline in Jackson and Marshall Counties.

Silurian and Devonian outcrops within the study area are limited to a narrow zone along the Sequatchie and Wills Valley anticlines. The Silurian Red Mountain Formation is primarily a siliciclastic unit of interbedded sandstone, siltstone, shale, and hematite with thin interbeds of bioclastic limestone. The maximum thickness of Silurian rocks is more than 500 feet. The Frog Mountain Sandstone of Devonian age is characteristically a medium- to very coarse-grained sandstone, generally thinner than 200 feet. The Chattanooga Shale is a widespread black shale of Devonian age and is generally less than 30 feet thick.

The Mississippian System in Area 2 is dominated by shallow-marine carbonate facies that are bordered on the southeast by a prograding wedge of terrigenous deltaic to shallow-marine sandstone and shale (Thomas, 1972; Thomas, 1985; Mars and Thomas, 1999). The Lower Mississippian Maury Shale, which unconformably overlies the Chattanooga Shale, is a greenish clay shale and ranges from a few inches to about 3 feet in thickness. Upper Lower and Upper Mississippian strata include the Fort Payne Chert, Tuscumbia Limestone, Pride Mountain Formation, Hartselle Sandstone, Bangor Limestone, Floyd Shale, Monteagle Limestone, Pennington Formation, and Parkwood Formation. Some of these units thin or grade laterally into each other. The complex stratigraphy of the Mississippian of northeast Alabama has been described by Thomas (1972) and Pashin (1993).

The Mississippian carbonate facies includes the Fort Payne Chert, which is primarily thin-bedded fossiliferous chert and limestone, and the overlying Tuscumbia Limestone, which is a thin-bedded limestone and chert. These units generally crop out on the flanks of structures. The Tuscumbia and Fort Payne vary in thickness but tend to thin southwestward in the Warrior basin and southeastward across the fold and thrust belt. The Fort Payne ranges up to about 200 feet in thickness, and the Tuscumbia to about 250 feet in thickness. The Fort Payne and Tuscumbia in northeast Alabama were deposited on the proximal part of a carbonate ramp (Ahr, 1973) and are lithologically more homogeneous than overlying Mississippian units (Pashin, 1993). Lenses of the siliciclastic Pride Mountain Formation (dominated by fine-grained rocks) and Hartselle Sandstone overlie the carbonate facies and, through facies changes, have general equivalents in the lower part of the fine-grained siliciclastic Floyd-Parkwood succession and (to the east) in the Monteagle Limestone. In the Black Warrior basin to the southwest and in the Coosa syncline to the east, the upper part of the Floyd-Parkwood siliciclastic succession passes laterally into a shallow-marine carbonate platform facies (Bangor Limestone). This unit is best developed in central northern Alabama where it contains small carbonate mounds dominated by bryozoans, rugose corals, and microbes in Lawrence, Morgan, and Blount Counties (Areas 1 and 2) (Kopaska-Merkel and Haywick, 1999, 2001; Kopaska-Merkel and others, 1998). Bangor limestone deposits are widespread in northeast Alabama but grade into fine-grained siliciclastic strata of the Floyd-Parkwood succession in the Coosa syncline and into siliciclastic strata of the Pennington Formation to the northeast (Thomas, 1972). Thicknesses of Mississippian strata generally increase southwestward in the Warrior Basin and southeastward across the Appalachians, but areas of maximum thickness of the Floyd-Parkwood interval (3,500 feet in the Coosa syncline) appear to coincide with structural troughs.

The Pennsylvanian System, which crops out in the Warrior basin and on the Cahaba and Coosa ridges, includes the uppermost part of the Parkwood Formation and the Pottsville Formation, and comprises the youngest Paleozoic rocks in the state. The Pottsville, primarily a ridge-forming succession of sandstone, shale, and coal beds, overlies the Mississippian Bangor Limestone and the Mississippian and Pennsylvanian Parkwood Formation. The thickness of the unit increases southward to a known maximum of about 9,000 feet at the southern end of the Cahaba and Coosa synclines (Thomas, 1972).

SEDIMENTARY DEPOSITS OF QUATERNARY AGE

Quaternary alluvial deposits overlie older formations along major streams throughout the study area (pl. 1). The alluvium is irregularly stratified, locally derived fluvial sediments consisting of clay, silt, sand and pebbles with locally abundant cobbles, boulders, and heavy minerals (Szabo, Osborne, Copeland, and Neathery, 1988).

HYDROGEOLOGY

The geologic formations of Area 2 can be grouped into three major aquifers: the Valley and Ridge aquifer system, the Mississippian aquifer system (consisting of the Hartselle, Bangor, Monteagle and Fort Payne-Tuscumbia aquifers), and the Pottsville aquifer (pl. 3). Three minor aquifers are the Nashville-Stones River aquifer, metasedimentary and metavolcanic aquifers, and the watercourse aquifer (pl. 5). Except where noted, aquifers are defined in this report using the classification of Moore (1998).

Individual aquifers are associated with major physiographic divisions in Area 2 (fig. 1; pl. 5), whereas aquifer systems are more widely distributed. The complex geologic structure of Area 2 has disrupted the regional continuity of rock units so that major aquifers or aquifer systems exhibit disjunctive distributions. Aquifers consisting of limestone, sandstone, and fractured rock are exposed in valleys; intervening ridges are commonly underlain by sandstone. A given major aquifer may be present in adjacent valleys but the two valleys may not be hydraulically connected because of faulting or folding (fig. 2). In general, aquifers yield more water in topographically low locations than in high areas.

Most high-yield aquifers are carbonates, and the highest yields are from wells that penetrate interconnected dissolution cavities. Individual rock units and their water-bearing properties are described in table 1. A mantle of residuum covers most bedrock within valleys, which is the product of in situ weathering of the underlying parent material. Residuum may or may not be permeable. Where the mantle of residuum is permeable, underlying shallow ground water tends to be capped by a free water table. By contrast, where the mantle of residuum is relatively impermeable, artesian conditions may exist within the underlying shallow aquifer. Most carbonate aquifers are productive not because of primary porosity but because they contain networks of fractures that have been enlarged by dissolution. Waters undersaturated with calcium carbonate typically enter rock units from the surface, which means that, in general, porosity and permeability decrease downward. Johnston (1933) recommended that wells drilled in lithified carbonates be abandoned if an adequate supply of water is not encountered within the first 200 feet of depth. The ridges dividing the valleys (figs. 1, 2) are capped or held up by siliciclastic strata that are highly resistant to chemical weathering, are unaffected by faulting, and are relatively impermeable. The Weisner Ridges are capped by quartzite, whereas Sand Mountain and Lookout Mountain are capped by sandstone and conglomerate. The ridges generally have steep slopes and little soil, which facilitates rapid runoff of rainfall to the edges of the flatter valleys. The Weisner Quartzite predominantly forms ridges in the southeastern part of Area 2; however, in

Table 1.–Generalized section of geologic units and their water-bearing properties (modified from Osborne and others, 1988; Bossong, 1989)

System	Stratigraphic unit	Lithology	Aquifer	Water-bearing properties
Quaternary	Alluvial and low terrace deposits	Sand, gravel, clay	Watercourse	Exposed along Coosa River; less than 50 feet thick; water bearing; variable quality
	High terrace deposits	Sand, gravel, clay	Watercourse	
Pennsylvanian	Pottsville Formation	Sandstone, shale, conglomerate, coal	Pottsville	Sandstone yields moderate amounts of water, quality variable, frequently with high iron
Pennsylvanian-Mississippian	Parkwood Formation and Pennington Formations undifferentiated	Shale, sandstone, conglomerate, mudstone	Confining units	Small amounts of water sufficient for domestic use, often high in iron
	Parkwood Formation and Floyd Shale undifferentiated	Shale	Confining units	
Mississippian	Pennington Formation	Shale	Confining units	Minor amounts of water sufficient for domestic use
	Bangor Limestone	Limestone	Bangor	Abundantly water bearing where solution channels are developed. Calcium bicarbonate waters
	Bangor and Monteagle Limestones undifferentiated	Limestone	Bangor	
	Paleozoic Shale undifferentiated	Shale, mudstone	Confining units	Relatively impermeable and not an aquifer
	Floyd Shale	Shale	Confining units	Minor amounts of water sufficient for domestic use
	Hartselle Sandstone	Sandstone	Hartselle	Yields moderate amounts of water; variable quality
	Monteagle Limestone	Limestone, dolomite	Valley and Ridge	Does not crop out in study area
	Pride Mountain Formation	Shale	Confining units	Yields moderate amounts of water; variable quality
	Tuscumbia Limestone	Limestone	Fort Payne-Tuscumbia	Solution channels feed many large springs and yield adequate water to

Table 1.−Generalized section of geologic units and their water-bearing properties (modified from Osborne and others, 1988; Bossong, 1989)—Continued

System	Stratigraphic unit	Lithology	Aquifer	Water-bearing properties
Mississippian continued	Fort Payne Chert	Limestone, chert	Fort Payne-Tuscumbia	bicarbonate waters
Devonian	Chattanooga Shale	Shale	Confining units	Relatively impermeable and not an aquifer
	Frog Mountain Sandstone	Sandstone	Valley and Ridge	Little water; variable quality
Silurian	Red Mountain Formation	Sandstone, siltstone, shale	Valley and Ridge	Yields sufficient for domestic use; commonly high in iron content
Ordovician	Sequatchie Formation	Shale, limestone	Valley and Ridge	Relatively impermeable and not an aquifer
	Sequatchie Formation, Colvin Mountain Sandstone, Greensport Formation undifferentiated	Shale, mudstone, dolomite, limestone	Valley and Ridge	Yields calcium bicarbonate waters, shale and argillaceous limestone yield little water
	Leipers Limestone	Limestone	Valley and Ridge	
	Inman Formation	Shale, limestone	Valley and Ridge	
	Chickamauga Limestone	Limestone	Valley and Ridge	Yields sufficient for domestic use
	Attalla Chert Conglomerate Member of the Chickamauga Limestone	Conglomerate	Valley and Ridge	
	Colvin Mountain Sandstone	Sandstone	Valley and Ridge	Little water; variable quality
	Greensport Formation	Shale, mudstone, limestone	Confining units	Relatively impermeable and not an aquifer
	Athens Shale	Shale	Confining units	
	Little Oak and Lenoir Limestones undifferentiated	Limestone	Valley and Ridge	Locally abundant water bearing. Hard bicarbonate waters but otherwise of quality suitable for most uses
	Little Oak and Newala Limestones undifferentiated	Limestone	Valley and Ridge	
	Nashville Group	Limestone	Valley and Ridge	Yields calcium bicarbonate waters, shale and argillaceous limestone yield little water
	Nashville Group and Stones River Groups undifferentiated	Limestone, shale	Valley and Ridge	

Table 1.–Generalized section of geologic units and their water-bearing properties (modified from Osborne and others, 1988; Bossong, 1989) —Continued

System	Stratigraphic unit	Lithology	Aquifer	Water-bearing properties
Ordovician continued	Stones River Group undifferentiated	Limestone, shale	Valley and Ridge	Yields calcium bicarbonate waters, shale and argillaceous limestone yield little water
	Chepultepec and Copper Ridge Dolomites undifferentiated	Dolomite, limestone	Valley and Ridge	
Cambrian	Ketona Dolomite	Dolomite	Valley and Ridge	Cherty subsoil forms an excellent ground water reservoir; excessive iron
	Conasauga Formation	Dolomite and chert	Valley and Ridge	Interbedded limestone and sandstone may be highly productive whereas the dolomite and shale yield little water
	Lower unnamed shale facies of Conasauga Formation	Shale	Confining units	Relatively impermeable and not an aquifer
	Rome Formation	Mudstone, shale, siltstone, and limestone	Valley and Ridge	Yields moderate amounts of water of variable quality
	Shady Dolomite	Dolomite and chert	Valley and Ridge	Aquifer yields abundant calcium and magnesium bicarbonate waters of moderate hardness
	Chilhowee Group undifferentiated	Conglomerate, mudstone and sandstone	Valley and Ridge	Yields moderate amounts of water of variable quality
	Weisner and Wilson Ridge Formations undifferentiated	Sandstone, conglomerate and mudstone	Valley and Ridge	Yields moderate amounts of water of variable quality, dependent upon fractures which may yield abundant supplies for domestic use
	Nichols Formation	Mudstone	Confining units	Relatively impermeable and not an aquifer

parts of adjacent counties the quartzite is poorly cemented and the Weisner is water-bearing (Johnston, 1933; Kopaska-Merkel and others, in press). A dramatic example is provided by Coldwater Spring in adjacent Calhoun County, which discharges on average about 31.2 mgd (Scott and others, 1987). Coldwater Spring is sourced in part by the Weisner Quartzite and in part by limestone and dolomite units of the Valley and Ridge aquifer system (Johnston, 1933; Scott and others, 1987).

METASEDIMENTARY AND METAVOLCANIC AQUIFERS

The metasedimentary and metavolcanic aquifers, which are important in the Piedmont hydrogeologic province (Area 5; Kopaska-Merkel and others, 2001), crop out in Area 2 only in isolated thrust slices in southern Cherokee County. Because of their limited recharge area and low productivity, the description of the metasedimentary and metavolcanic aquifers in this report is brief.

The metasedimentary and metavolcanic aquifers occupy about three-quarters of the Piedmont (Area 5; Kopaska-Merkel and others, 2001) and are geologically diverse. Metasedimentary and metavolcanic aquifers were classified by Guthrie and others (1994) as “phyllite + quartzite + slate,” “schist,” “metagraywacke,” “dolomite marble,” and “mylonite” hydrogeologic units. Lithologic and hydrogeologic characteristics of formal rock units classified as metasedimentary and metavolcanic aquifers are summarized in Kopaska-Merkel and others (2001).

No public water supply wells or springs tap the metasedimentary and metavolcanic aquifers in Area 2.

VALLEY AND RIDGE AQUIFER SYSTEM

The Valley and Ridge aquifer system is found in Wills Valley, Coosa Valley, Sequatchie Valley, Murphrees Valley, and Birmingham-Big Canoe Valley. Formations included in this aquifer are the Weisner Quartzite; Shady Dolomite; Conasauga Formation; Ketona Dolomite; Copper Ridge and Chepultepec Dolomites; and the Longview, Newala, Lenoir, and Little Oak Limestones. In some areas the Copper Ridge, Chepultepec, Longview, and Newala are mapped as the Knox Group undifferentiated. Most other rock units of Cambrian to Devonian age (pl. 2) are included within the Valley and Ridge aquifer system (pl. 3) because they do not form effective barriers to ground water movement among permeable units of the Valley and Ridge aquifer system. However, these other units also are not regionally significant sources of ground water. The Valley and Ridge aquifer system is the Knox-Shady aquifer of Bossong (1989) and the Valley and Ridge aquifer system of Moore (1998). However, outcrops of the Weisner and Wilson Ridge Formations in southeastern Cherokee County were classified by Moore (1998) as metasedimentary and metavolcanic aquifers. In this report these strata are included in the Valley and Ridge aquifer system (following Raymond and others, 1988, and Bossong, 1989) for two reasons. First, the genesis, location, and stratigraphic and geographic associations of the Weisner and Wilson Ridge Formations unite them with the Paleozoic sedimentary strata of the Valley and Ridge aquifer system. Second, the Weisner Quartzite changes character from south to north and is locally a permeable aquifer in Area 2. In the report on Area 5 (Kopaska-

Merkel and others, 2001) the Weisner and Wilson Ridge Formations were classified with the metasedimentary and metavolcanic aquifers (following Moore, 1998) because in Area 5 these units are very poor aquifers. The south-to-north appearance of permeable units in the Weisner Quartzite is gradational and not mapped in detail. For convenience the division between low-quality and low-to-high quality aquifers in this unit is drawn at the area boundary. In order to preserve consistency of maps between areas, the outline of the Weisner and Wilson Ridge Formations is defined by a colored line on plate 5. Plate 6 shows a map of the potentiometric surface of the Valley and Ridge aquifer system. The Valley and Ridge aquifer system is lithologically diverse, and ground water quality and quantity vary greatly from place to place.

The Weisner Quartzite forms ridges in which the unit is tightly cemented and impermeable. Where the Weisner underlies valleys it locally contains poorly cemented sandstone that is both porous and permeable (Johnston, 1933). In addition, the Weisner weathers to a sandy porous subsoil that holds and transmits water effectively (Johnston, 1933). The Weisner yields as much as 0.07 mgd of water to springs in Cherokee County (Causey, 1965).

The Shady Dolomite is characteristic of the calcareous rocks in Area 2, which dissolve along fractures to create enlarged channels that can yield substantial amounts of water to wells. Wells that do not encounter cavity systems produce only small amounts of water from the Shady. The Shady contributes to the discharge of Coldwater Spring and also feeds numerous small springs in adjacent Calhoun County (Johnston, 1933).

Limestone of the Conasauga Formation in the Birmingham-Big Canoe Valley yields substantial amounts of water where the dominantly calcareous and steeply dipping strata contain well-developed dissolution channels. In the Coosa Valley where the formation is shaly, the Conasauga is a minor aquifer and is used only for domestic supplies (generally yielding less than 0.1 mgd to wells) (Johnston, 1933; Causey, 1961; 1965; Mann and Baker, 1995). The unit yields about 1.2 mgd to a spring in Cherokee County where fracturing has enhanced permeability (Johnston, 1933) and more than 0.3 mgd to a spring in Etowah County northeast of Gadsden, also located in a fractured zone (Causey, 1961). The water-bearing areas are usually associated with valleys rather than ridges.

The Copper Ridge and Chepultepec Dolomites are similar in their water-bearing characteristics. Both are cherty dolostones containing elaborate systems of closely spaced and interconnected dissolution channels. Weathering results in a cherty soil that is porous and allows rapid infiltration of rainfall (Butts, in Adams, 1926; Johnston, 1933). The Copper Ridge yields as much as 1.4 mgd to springs in Cherokee and DeKalb Counties and up to about 0.7 mgd in Etowah County (Johnston, 1933). The Copper Ridge and Chepultepec undifferentiated yield a maximum of nearly 5 mgd to springs in Cherokee County (Causey, 1965).

Water-bearing properties of the Longview, Newala, Lenoir, and Little Oak Limestones are similar to those of other carbonate units in Area 2 in which most water is derived from dissolution channels. However, in contrast to older units, only the Longview has appreciable chert in its weathered subsoil, which is less cherty and hence not as permeable as subsoils developed on dolostone of the underlying Copper Ridge and Chepultepec Dolomites. Subsoils developed on the Newala, Lenoir, and Little Oak Limestones are poor aquifers because of the paucity of chert (Johnston, 1933). A well completed in the Longview and/or Newala in Etowah County yielded about 0.4 mgd of water (Causey, 1961).

The Knox Group undifferentiated (Copper Ridge, Chepultepec, Longview, and Newala) in Etowah County yields as much as 2.0 mgd of water to springs in Etowah County, but more commonly, yields are less than 0.5 mgd (Mann and Baker, 1995). The Knox Group undifferentiated may yield as much as 1.4 mgd of water to wells in DeKalb County, but 0.15 mgd is more typical (Baker and Moser, 1989).

The hydrogeologic properties of the Odenville Limestone are not discussed in this report because the Odenville is a thin unit of limited distribution and its pore system is poorly known.

The Ketona Dolomite, unlike most other carbonate units assigned to the Valley and Ridge aquifer system, is remarkably free of chert (Butts, 1926). As a result, subsoils that develop on the Ketona are relatively impermeable. Nevertheless, fractured Ketona contains networks of dissolution channels as do most Valley and Ridge aquifer system carbonates, and the unit can produce substantial quantities of water (Johnston, 1933).

Other rock units assigned to the Valley and Ridge aquifer system are locally important sources of ground water. The Chickamauga Limestone yields as much as 0.5 mgd of water to springs in Etowah County (Mann and Baker, 1995).

Most public water-supply wells completed in the carbonate aquifers of the Valley and Ridge aquifer system yield 0.5 to 1.0 mgd of water (Bossong, 1989).

NASHVILLE-STONES RIVER AQUIFER

The Nashville-Stones River aquifer in Area 2 consists of porous and permeable strata of the Ordovician Inman Formation, Leipers Limestone, Nashville Group, and Stones River Group. The Nashville-Stones River aquifer also includes strata assigned to the relatively impermeable Sequatchie Formation (Ordovician) where the strata are in contact with other rocks of the Nashville-Stones River aquifer. The recharge area of the Nashville-Stones River aquifer in Area 2 is restricted to small, elongate areas in the vicinity of Guntersville Lake. Because of the limited recharge area and low productivity of the aquifer, the description of the Nashville-Stones River aquifer in this report is brief.

The Stones River and Nashville Groups, Inman Formation, and Leipers Limestone yield small amounts of calcium bicarbonate water. The Sequatchie Formation is relatively impermeable and yields little water.

MISSISSIPPIAN AQUIFER SYSTEM

The Mississippian aquifer system is roughly equivalent to the Tuscumbia-Fort Payne aquifer of Bossong (1989) and to the combined Bangor, Hartselle, Monteagle, and Fort Payne-Tuscumbia aquifers of Moore (1998). The Mississippian aquifer system is found in the Cahaba, Birmingham-Big Canoe, Murphrees, and Coosa Valleys.

Formations in the Mississippian aquifer system include the Fort Payne Chert, Tuscumbia Limestone, Hartselle Sandstone, Bangor Limestone, and Monteagle Limestone of Mississippian age. The five formations listed are considered a single aquifer system for two reasons. First, they are not separated by impermeable strata; on lithologic grounds they are inferred to contain a single freely interconnected ground water system. Second, ground water level measurements for the Mississippian aquifer system define a single potentiometric surface in Area 2 (pl. 7). The Mississippian aquifer system is lithologically variable, and its secondary pore system is also highly variable in development. Consequently, well yields and spring discharges vary greatly from place to place.

The Fort Payne Chert owes its water-bearing capacity to the dissolution of limestone from cherty beds, leaving a porous reservoir. Where the beds have been folded, incipient cracks in the chert have opened, enhancing the porosity of the aquifer. On the gentler slopes of the formation broken chert fragments have accumulated, creating a highly permeable soil. The Fort Payne Chert is an important aquifer in Areas 1, 2, and 4.

The Tuscumbia Limestone, like the underlying Fort Payne Chert, is an important aquifer in Areas 1, 2, and 4. The Tuscumbia produces water from dissolution channels like those characterizing many of the carbonate units of the Valley and Ridge aquifer system. However, the Tuscumbia is noteworthy because the unit contains a well-developed network of dissolution channels almost everywhere it has been tested (Johnston, 1933). Two of the three largest springs in Alabama, Brahan (Huntsville Big) Spring in Madison County and Tuscumbia Spring in Colbert County (both in Area 1) are sourced in the Tuscumbia Limestone. The Fort Payne and Tuscumbia are commonly considered one unit because they occur together and there is no barrier to water movement between them (Barksdale and Moore, 1976). In Blount County, wells yield between 0.4 and 0.7 mgd from the combined Fort Payne and Tuscumbia; wells in DeKalb and Jackson Counties yield up to about 0.7 mgd (Barksdale and Moore, 1976). Springs in Cherokee County yield up to about 0.6 mgd from the combined units according to Johnston (1933), but Causey (1965) reported a maximum spring discharge of about 2.4 mgd from the combined Fort Payne and Tuscumbia in that county. Springs in Etowah County yield up to about 0.7 mgd from the combined Tuscumbia and Fort Payne (Mann and Baker, 1995). Ground water supplies adequate for domestic use are available in the Fort Payne and Tuscumbia wherever these units are found in Area 2.

The Monteagle Limestone is a relatively pure limestone and a reasonably productive aquifer in Area 2 (Barksdale and Moore, 1976). The Monteagle grades westward into siliciclastic strata that are not productive sources of ground water. In Jackson County the Monteagle yields less than 0.1 mgd of water in rugged terrain, but 0.2 to 1.0 mgd in low areas (Barksdale and Moore, 1976); according to Baker (1989), the Monteagle may yield 1.5 mgd or more to springs in Jackson County. The Monteagle has yielded up to 0.7 mgd in low areas of DeKalb County, but steeply dipping strata in that county typically yield no more than 0.1 mgd. In Etowah County, the Monteagle yields sufficient ground water for domestic use. However, a spring in Etowah County produces up to about 0.7 mgd from the combined Monteagle and Hartselle (Mann and

Baker, 1995). The Monteagle is not known to yield ground water in Cherokee County (Causey, 1965).

The Hartselle Sandstone is well cemented and has only fair porosity throughout most of its outcrop where it yields moderate amounts of water to wells. Locally in Area 2 (for example, in parts of Blount County) the Hartselle is unusually friable and yields as much as 0.7 mgd of water to wells (Barksdale and Moore, 1976).

The Bangor Limestone, like the other carbonate rocks assigned to the Mississippian aquifer system, contains a network of dissolution channels that are interconnected and can yield large quantities of water. In addition, the formation contains sufficient chert to allow the development of a fairly permeable soil (Johnston, 1933). In Blount, Jackson, and DeKalb Counties, the Bangor yields less than 0.1 mgd in rugged areas but up to 1.0 mgd in low areas. A spring in Etowah County produces as much as 2.5 mgd from the Bangor (Mann and Baker, 1995). The Bangor is expected to yield adequate water for domestic use wherever it is found in Area 2 except in Cherokee County (Barksdale and Moore, 1976).

Most public water-supply wells completed in the carbonate aquifers of the Mississippian aquifer system yield 0.5 to 1.0 mgd of water (Bossong, 1989).

POTTSVILLE AQUIFER

The youngest Paleozoic aquifer in Area 2 is the Pottsville aquifer, which consists of the Pottsville Formation (pls. 2, 3). The Pottsville Formation is not a reliable source of large amounts of ground water, but for much of Areas 3 and 4, and parts of Areas 1 and 2, it is the only aquifer available. Ground water in the Pottsville aquifer is found primarily in fractures and weathered zones; primary porosity is not important in this aquifer (Stricklin, 1989). In addition, ground water in the Pottsville aquifer is commonly confined because of sharp permeability contrasts within the aquifer (Stricklin, 1989). Most public water supply wells completed in the Pottsville aquifer yield less than 0.15 mgd (Johnston, 1933; Bossong, 1989). However, yields of as much as 0.3 mgd of water may be achievable from wells completed in the Pottsville in DeKalb County (Baker and Moser, 1989).

WATERCOURSE AQUIFER

The watercourse aquifer occupies a small part of Area 2 in Etowah and Cherokee Counties along the Coosa River but is not tapped by any public-supply wells in Area 2. The watercourse aquifer consists of sand, gravel, and clay deposits located along modern and ancient watercourses. Reported yields of water from the watercourse aquifer in Cherokee County range up to about 1.4 mgd (Johnston, 1933; Causey, 1965).

RECHARGE AND MOVEMENT OF GROUND WATER

The source of recharge to aquifers in Alabama is precipitation, mostly rain supplemented by occasional snow. Shallow wells commonly respond quickly to changes in amounts of precipitation, demonstrating the relatively direct connection between the aquifer in the vicinity of the well bore and precipitation falling on the land surface (fig. 3). Average annual precipitation in Area 2 is about 55 inches per year, but 20 to 30 inches or more runs off during and directly after rainstorms. Most of the remainder is returned to the atmosphere by evaporation and transpiration by plants. A relatively small part of the total rainfall infiltrates to the water table and recharges aquifers. The only aquifer recharge that can be measured is that which is discharged to streams. A conservative estimate of recharge can be obtained by examining the base (dry weather) flow of streams. This estimate is reasonably accurate if there is no net long-term recharge or depletion of the aquifers (the system is in a steady state). There is no evidence for long-term recharge or depletion of aquifers in Area 2. Bossong (1989) estimated recharge to the Pottsville aquifer at about 2 to 3 inches per year and recharge to the carbonate aquifers at up to 10 inches per year using data from Kidd and Bossong (1987) and Zurawski (1978). Average recharge to aquifers in Area 2 is estimated herein at 5 inches per year. This is comparable to estimated recharge rates for neighboring areas (6 inches per year for Area 5 and 5 inches per year for Area 4; Kopaska-Merkel and others, 2001; in press). Recharge in Area 13 is substantially greater (8.1 inches per year according to Gillett and others, 2000), because of greater precipitation, lower slopes, and more permeable surficial deposits in the southern part of the Coastal Plain.

The amount of water that infiltrates the soil depends on the hydraulic conductivity and permeability of the soil, the amount of water present in the soil during rainfall, and the slope of the land surface. Infiltration is greater in flat areas underlain by gravel and coarse sand sediments than in sloping areas or areas underlain by shale or tightly cemented sandstone.

Ground water movement can be illustrated by plotting the water levels in wells on a map and contouring the water levels. Ground water flow paths can be determined for the resulting map, called a potentiometric surface map, by lines drawn perpendicular to the contours from higher to lower elevations of the potentiometric surface. Streams are the most common natural low points on a potentiometric surface map, but in Area 2 numerous springs are found where the water table (or potentiometric surface) intersects the land surface.

The potentiometric surface map of the Valley and Ridge aquifer system (pl. 6) was constructed from data collected over several decades. Natural annual fluctuations in this aquifer system generally are less than 10 feet (Bossong, 1989), and no long-term trends are evident in data from monitored wells, therefore the potentiometric surface should represent average conditions within the aquifer system. Movement of ground water in the Valley and Ridge aquifer system is primarily from the higher altitudes adjacent to the ridges to the center of the valleys; there is also "down-valley" movement in the direction of stream flow.

The potentiometric surface of the Mississippian aquifer system (pl. 7) is less useful because data are almost entirely restricted to narrow belts corresponding to montane recharge areas. However, this map illustrates a general “down-valley” movement of ground water in the direction of streamflow, like that shown by the potentiometric surface of the Valley and Ridge aquifer system (pl. 6). The Mississippian aquifer system, like the Valley and Ridge aquifer system, is characterized by annual fluctuations of less than 10 feet; and, based on water-level data collected from monitored wells, this system does not experience any long-term trends. Elevations on

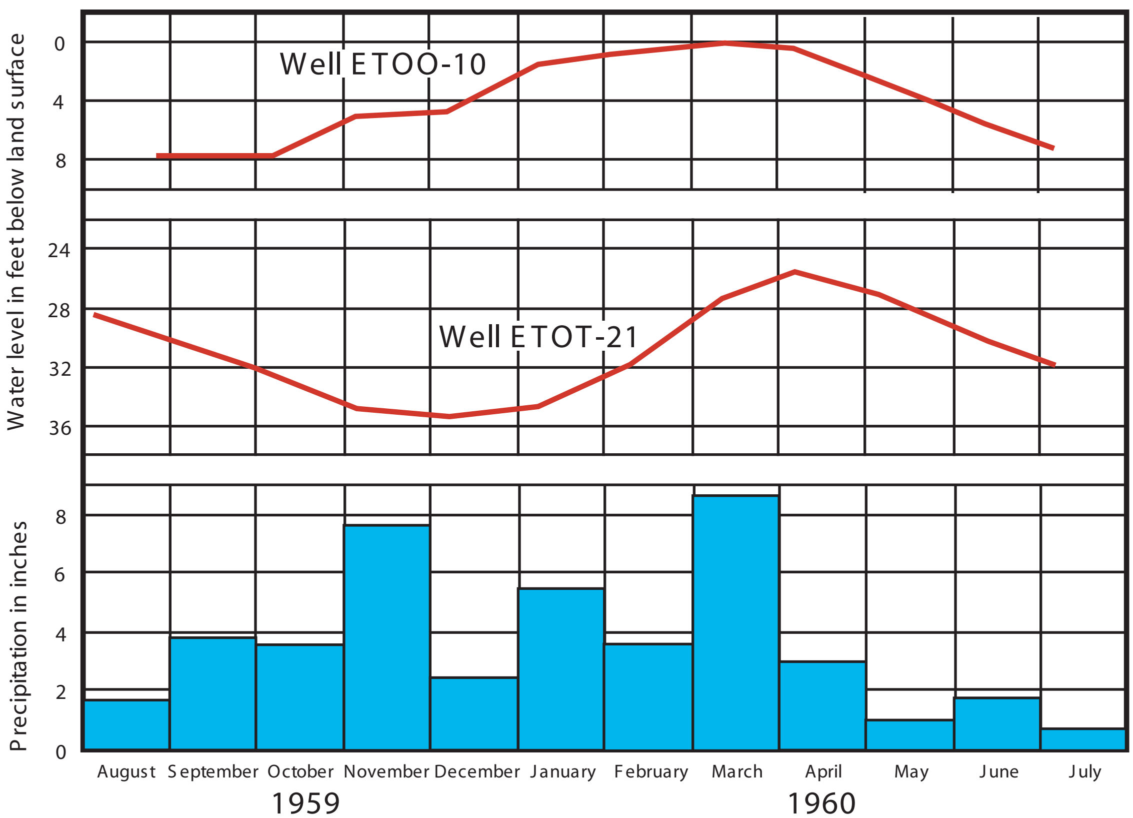

Figure 3.−Changes in water levels in wells ETOO-10 and ETOT-21 and precipitation at Gadsden in Etowah County. Modified from Causey (1961).

the Mississippian aquifer system potentiometric surface are roughly comparable to those on the Valley and Ridge aquifer system, but the two surfaces are not congruent.

The Pottsville aquifer is the youngest important aquifer in Area 2 (pl. 8). The potentiometric surface of the Pottsville aquifer is much higher than those of the Valley and Ridge and Mississippian aquifer systems and exhibits a pronounced slope off of ridges and "down-valley" in the direction of streamflow within major valleys.

Several processes can cause depressions to form on aquifer potentiometric surfaces. Incised streams may gain water from the aquifers they penetrate, and this probably is a factor in Area 2. Pumping from a well also can cause a depression to form on the potentiometric surface of an aquifer. However, no cones of depression in Area 2 are large enough to be visible at the scale of plates 6 through 8.

Faulting is another important factor to be considered when discussing ground water flow in Area 2. Faults are not simply cracks, but are zones of crushed and disturbed rock that can transmit ground water through otherwise impermeable strata at significant rates (Johnston, 1933) and for long distances. Some wells and springs in Area 2 that are noted for producing large amounts of water are located in fault zones. Examples include wells and springs near Gadsden associated with the Gadsden fault and a spring associated with a fault plane in Cherokee County (Johnston, 1933).

NATURAL DISCHARGE AND GROUND WATER WITHDRAWALS

A large part of aquifer recharge is discharged to streams through seeps and springs. At the driest time of the year, most streamflow is aquifer discharge. Five inches or more of water per year is discharged to the streams in Area 2 from carbonate aquifers, compared with about 2 inches per year from the Pottsville aquifer (Bingham, 1982). Average dry-season discharge in Area 2 is estimated at 5 inches per year. Pumpage from wells accounts for any other measurable discharge from the aquifer system. For the study area, estimated withdrawals from ground water for 1995 were as follows: public supply, 11.45 mgd; self-supplied industry, 1.64 mgd; agriculture, 2.50 mgd; and self-supplied domestic, 4.27 mgd (fig. 4a). Ground water withdrawals for public water systems in the study area during 1995 by county were as follows: Blount, 2.38 mgd; Cherokee, 0.16 mgd; DeKalb, 1.22 mgd; Etowah, 4.25 mgd; Jackson, 0.92 mgd; and Marshall, 2.52 mgd (fig. 4b) (Mooty and Richardson, 1998). The estimated total withdrawal in the study area of 19.87 mgd is equivalent to 0.09 inches per year of recharge. This figure is about 50 percent higher than a similarly derived estimate of 0.06 inches per year in the late 1980s (Baker and Mooty, 1987; Bossong, 1989). However, 1995 ground water withdrawals were only about 2 percent of the estimated recharge of 5 inches per year. By contrast, in Area 4, which is underlain by similar aquifers, about 5 percent of the estimated recharge was withdrawn in 1995, reflecting the higher population density and consequent higher rates of ground water use in that region (Kopaska-Merkel and others, 2006). The largest ground water users in the study area are Attalla, Guntersville, and Oneonta. Locations of all active public-supply wells and springs are shown on plate 1; pertinent data concerning the wells and springs, including well construction, water levels, and spring flows, are presented in appendix A. Appendix B presents similar data for inactive public-supply wells and springs and selected other wells and springs in Area 2.

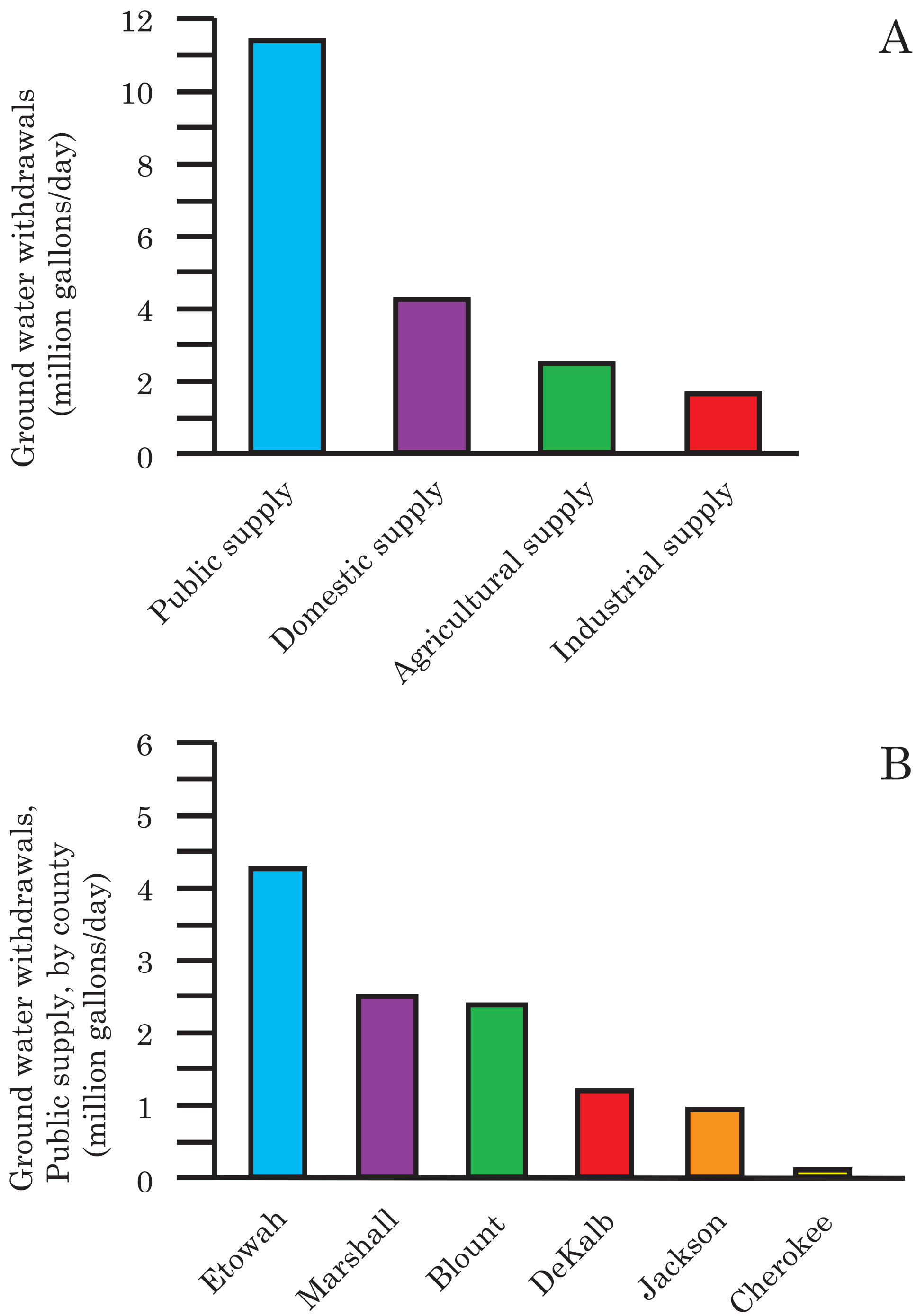

Figure 4.–Water use in Area 2 in 1995 (data from Mooty and Richardson, 1998). (A) Ground water withdrawals by kind of use. (B) Ground water withdrawals for public supply, by county.

EFFECTS OF WITHDRAWALS FROM THE AQUIFERS

Large long-term withdrawals of water from the aquifers may result in the formation of depressions on the potentiometric surfaces of the aquifers. The extent of the depression depends on the amount of water withdrawn and the water-bearing characteristics of the sediments. However, there are no known extensive depressions on the potentiometric surfaces of the aquifers in Area 2. Depressions on the water surfaces in aquifers caused by pumpage could induce recharge by vertical leakage from overlying saturated zones. Recharge could also be induced by pumpage in areas along major rivers where aquifers are hydraulically connected to streams. Depressions on potentiometric surfaces also create steepened hydraulic gradients in the vicinity of pumping centers and increase the rate of movement of water and any potential contaminants to points of ground water withdrawal.

GROUND WATER QUALITY

The mineral content of water changes as it passes through the different phases of the hydrologic cycle. As precipitation comes in contact with soil and rock, minerals are dissolved. The amount of mineral matter dissolved in water depends on the resistance of the minerals to chemical and physical attack, the length of time the minerals are in contact with the water, and the chemical composition, temperature, and pressure of the water. In general, deeper ground water has been in the ground longer and is more mineralized.

Ground water in Area 2 is suitable for most uses, but some ground water quality problems have been noted. Ground water from siliciclastic reservoirs tends to contain excessive quantities of dissolved iron (pl. 9), whereas ground water from carbonate reservoirs is hard to very hard (Baker, 1989; Baker and Moser, 1989). No long-term changes in ground water quality in Area 2 have been observed (Mann and Baker, 1995).

Ground water in the Valley and Ridge aquifer system is generally of high quality, though it ranges from moderately hard to very hard (Causey, 1961, 1965; Faust and Harkins, 1980), reflecting the preponderance of limestone and dolostone reservoir rock in this aquifer system.

Ground water in the Mississippian aquifer system is generally of high quality, though some samples are moderately hard or hard (Baker and Moser, 1989). The Bangor aquifer, part of the Mississippian aquifer system, is sometimes associated with problems such as turbidity, subsidence, contamination, and drilling difficulties. These problems may result, at least in part, from the highly weathered nature of the upper part of the formation (Causey, 1961, 1965).

Ground water in the Pottsville Formation tends to contain excess iron and manganese, and some Pottsville ground water is moderately hard (Baker, 1989; Baker and Moser, 1989). Water with iron concentrations in excess of 0.3 mg/L is considered objectionable because it stains plumbing fixtures. The U.S. Environmental Protection Agency (EPA) has defined 0.3 mg/L of dissolved iron as a secondary maximum contaminant level allowed in drinking water, which is not enforceable by federal law.

However, the State of Alabama has adopted this value as part of its regulations for public water supplies. Many wells completed in the Pottsville aquifer produce ground water containing greater than 0.3 mg/L of dissolved iron (plate 9). Excess manganese (greater than the maximum contaminant level of 0.05 mg/L) has the same effect as excess iron.

The dissolved iron concentration in shallow ground water is controlled by large-scale geologic structure (pls. 1,9). Ground water with high iron concentrations is found in the Pottsville aquifer in the Valley and Ridge geologic province, whereas ground water in Mississippian and lower Paleozoic carbonate aquifers in the same region is relatively low in iron. Regional faults and folds control the distribution of these aquifers at the surface and hence also control the distribution of dissolved iron in shallow ground water in the Valley and Ridge. Iron concentrations do not show pronounced linear patterns in the flat-lying strata of the Cumberland Plateau. Most wells in the Cumberland Plateau are completed in the Pottsville aquifer, and iron concentrations are variable but commonly high.

Water hardness is caused by the presence of the divalent metallic cations calcium and magnesium. These cations react with soap to form a precipitate, thereby causing an increase in soap usage and reducing its cleansing action. Hardness is expressed as a concentration of $CaCO_3$ and is classified as follows: soft, 0 to 60 mg/L; moderately hard, 61 to 120 mg/L; hard, 121 to 180 mg/L; and very hard, greater than 180 mg/L (Mann and Baker, 1995). Because carbonate rocks (limestone and dolomite) are composed chiefly of $CaCO_3$ and (Ca, Mg) CO_3, areas underlain by carbonates typically yield hard water to wells. Most sandstone units are poor in calcium and magnesium ions and therefore yield relatively soft water. The Pottsville aquifer is the most widespread siliciclastic aquifer in Area 2, and areas underlain by the Pottsville contain softer ground water than areas underlain by the dominantly carbonate formations of the Mississippian and Valley and Ridge aquifer systems (pl. 5).

VULNERABILITY OF THE AQUIFERS TO CONTAMINATION

Aquifer vulnerability is a difficult concept to evaluate owing to the complexity and variability of the geology and aquifers involved. Aquifers are vulnerable to contaminants from both surface and subsurface sources.

Surface sources of potential contamination are numerous, and include point sources such as gasoline tanks, chemical spills, pipeline and sewer leaks, treatment lagoons, and industrial sites. Potential nonpoint sources of pollution include chemicals applied to agricultural fields, confined animal feeding operations, onsite sewage system discharges, chemicals applied to lawns and gardens, and urban runoff.

Contaminants such as petroleum products are lighter than water and float on the water table. These are referred to as light nonaqueous phased liquids (LNAPLs). Other chemicals such as chlorinated hydrocarbons are denser than water and can sink through the aquifer and accumulate and migrate on subsurface confining units. These chemical contaminants are referred to as dense nonaqueous phased liquids (DNAPLs). Some contaminants dissolve in or mix with water and neither float nor sink but move with the ground water. Also, naturally occurring contamination such as saline ground water may encroach into freshwater aquifers from downdip or from other water-bearing units.

Outcrops of all aquifers in Alabama are vulnerable to contamination from surface sources of pollution. The extent to which an aquifer can become contaminated depends on the nature of the contaminant and on the hydrogeologic characteristics of the aquifer. These hydrogeologic characteristics are highly variable from aquifer to aquifer and even within individual aquifers and are largely controlled by the permeability of the units comprising an aquifer. For instance, the amount of cementation of the Hartselle Sandstone controls its porosity and permeability, and the unit ranges from tightly cemented and impermeable to weakly cemented and highly permeable. Unconfined aquifers with high permeability values have high recharge rates (typically more than 6 inches per year) and contaminants from the surface may not be adequately filtered out as water moves toward the water table. The most vulnerable aquifers in Alabama are either unconsolidated sand and gravel, or carbonate rocks that contain numerous joints and fractures enlarged by dissolution. Only the latter kind of highly vulnerable aquifer is important in Area 2. Aquifers least vulnerable to contamination are typically overlain by thick (50 feet or more) relatively impermeable units such as clay or chalk. These impermeable units are either aquicludes or aquitards.

Aquifers are most vulnerable in their outcrops where water table conditions exist. Where aquifers are buried beneath other units and become confined, their vulnerability to surface contamination decreases. This is because aquifers are protected by aquicludes or aquitards that retard the vertical downward movement of contaminants. Although this confinement affords some protection to the aquifer, no aquifer is immune to contamination from poorly constructed wells and bad management practices. Pumping of large quantities of ground water from public supply wells, industrial supply wells, or irrigation wells creates cones of depression, increases flow gradients, and draws ground water and any associated contamination, where present, toward the pumping wells.

General guidelines (shown below) have been established to assist in identifying aquifers that have a high vulnerability, moderate vulnerability, or low vulnerability to contamination. Most of the factors listed below apply particularly to the vulnerability of the aquifer in the outcrop area. Not all factors are required for any one aquifer to be assigned to a particular vulnerability category. A few factors pertain only to possible contamination from natural sources of contamination at depth or downdip.

<u>High vulnerability to contamination</u>

- Aquifer is unconfined, unconsolidated, highly permeable, and has high recharge rates (typically greater than 6 inches per year)
- Aquifer is not confined by thick homogeneous impermeable units or is semiconfined
- Aquifer is comprised of rocks that contain solution cavities and/or fractures that allow rapid ground water movement and high recharge rates
- Aquifer has a freshwater/salt-water interface in close proximity to the area of concern

- Aquifer is penetrated by faults that provide an avenue for entrance of contaminated water from the surface or from another aquifer

Moderate vulnerability to contamination

- Aquifer is unconfined, is consolidated rock, has low permeability, and has low to moderate recharge rates (typically 1 to 6 inches per year)
- Aquifer has no solution cavity development
- Aquifer is overlain by thick, cumulatively impermeable, or discontinuous impermeable units sufficient to provide some protection to the aquifer
- Aquifer is comprised of fractured rock but fractures are of limited extent and connectivity and are not enlarged
- Aquifer is confined by aquitards that transmit water, but not in quantities sufficient for development

Low vulnerability to contamination

- Aquifer is well confined by aquicludes that are laterally continuous, are thick, lack connected fracture networks, have low recharge rates (less than 1 inch per year), and are incapable of transmitting significant quantities of water
- Aquifer is well confined by aquicludes that are incapable of transmitting significant quantities of water
- Area of concern is a significant distance from the freshwater/salt-water interface of the aquifer

Detailed site-specific hydrogeologic investigations should be undertaken to accurately determine an aquifer's vulnerability to contamination. Long-term aquifer testing is needed to determine the aquifer's hydrologic characteristics and the hydraulic properties of confining beds.

Much of the central and eastern portions of Area 2 are underlain by aquifers of the Valley and Ridge aquifer system (pls. 5, 6). Most of these aquifers are cherty carbonates that are susceptible to dissolution; contain systems of dissolution channels, and weather to form highly porous soils. The recharge area of the Valley and Ridge aquifer system is highly vulnerable to contamination from the surface. A few of the lower Paleozoic units associated with the Valley and Ridge aquifer system are relatively impermeable and are mapped as confining units (pl. 5); the recharge areas of these units are of low vulnerability to contamination from the surface. However, aquifers that underlie confining units that are less than 50 feet thick are moderately or even highly vulnerable to contamination from the surface. Confining units in Area 2 have relatively small outcrop areas.

Parts of Area 2 are underlain by aquifers of the Mississippian aquifer system (pls. 5, 7). All but one of the Mississippian aquifers are carbonate units that are susceptible to dissolution and sinkhole formation. The Mississippian carbonates contain systems of dissolution channels and are extremely permeable. In addition, the Bangor aquifer and especially the Fort Payne aquifer are cherty and hence are prone to developing highly permeable soils. The recharge area of the Mississippian aquifer system is considered highly vulnerable to contamination from the surface (pls. 5, 7). The Mississippian Pride Mountain Formation and Floyd Shale are relatively impermeable and are mapped as confining units on plate 5. The outcrop areas of these two units are of low vulnerability to contamination from the surface. In addition, the Mississippian-Pennsylvanian Parkwood and Pennington Formations, which in places separate the Mississippian aquifer system from the Pottsville aquifer, are mapped as confining units and are of low vulnerability to contamination from the surface (pls. 1, 5). Mississippian aquifers that are confined by the Mississippian and Pennsylvanian Pride Mountain, Parkwood, and Pennington Formations and Floyd Shale are substantially less vulnerable to contamination from the surface than where the aquifers crop out. Where the Pride Mountain Formation, Floyd Shale, and Parkwood and Pennington Formations are less than 50 feet thick (as a result of limited deposition, erosion, or faulting) underlying aquifers are moderately or even highly vulnerable to contamination from the surface. However, detailed geologic mapping would be needed to define areas underlain by thin confining units.

Much of Area 2 is underlain by the Pottsville aquifer (pls. 5, 8), which is a lithified sandstone unit that produces ground water chiefly from fractures and weathered zones. Long-distance ground water flow in the Pottsville is inhibited by sharp permeability contrasts and by typically low matrix permeability values within the aquifer (Stricklin, 1989). Consequently, the recharge area of the Pottsville aquifer is considered moderately vulnerable to contamination from the surface (pls. 5, 8).

The three minor aquifers in Area 2 are the watercourse aquifer, the Nashville-Stones River aquifer, and the metasedimentary and metavolcanic aquifers. The recharge area of the watercourse aquifer is considered highly vulnerable to contamination from the surface because it is permeable and porous and because the recharge area in Area 2 is relatively continuous and large enough to permit infiltration of substantial amounts of water. The Nashville-Stones River aquifer is considered moderately vulnerable to contamination from the surface because its recharge areas are very small and isolated, and because the aquifer is only moderately productive, consisting of intercalated permeable and relatively impermeable strata. The metasedimentary and metavolcanic aquifers are only slightly vulnerable to contamination from the surface because the recharge areas are very small and the aquifer is not very productive.

In addition to the large-scale characteristics of the major aquifers, several modifying factors can increase aquifer vulnerability in Area 2. Chief among these are faulting, formation of cherty soils, and sinkholes (fig. 5).

Faulted areas have potential to be highly vulnerable to contamination from the surface. Fault zones or faults may be extremely transmissive and, where they crop out, may be sites of increased recharge. The increased permeability in fault zones also represents an increase in the potential for surface contamination to enter the aquifer; these areas are designated as highly vulnerable to contamination. Most of the major faults in Area 2 have been mapped and are shown on plate 1. It is likely, however, that many additional unmapped minor faults are present in the study area.

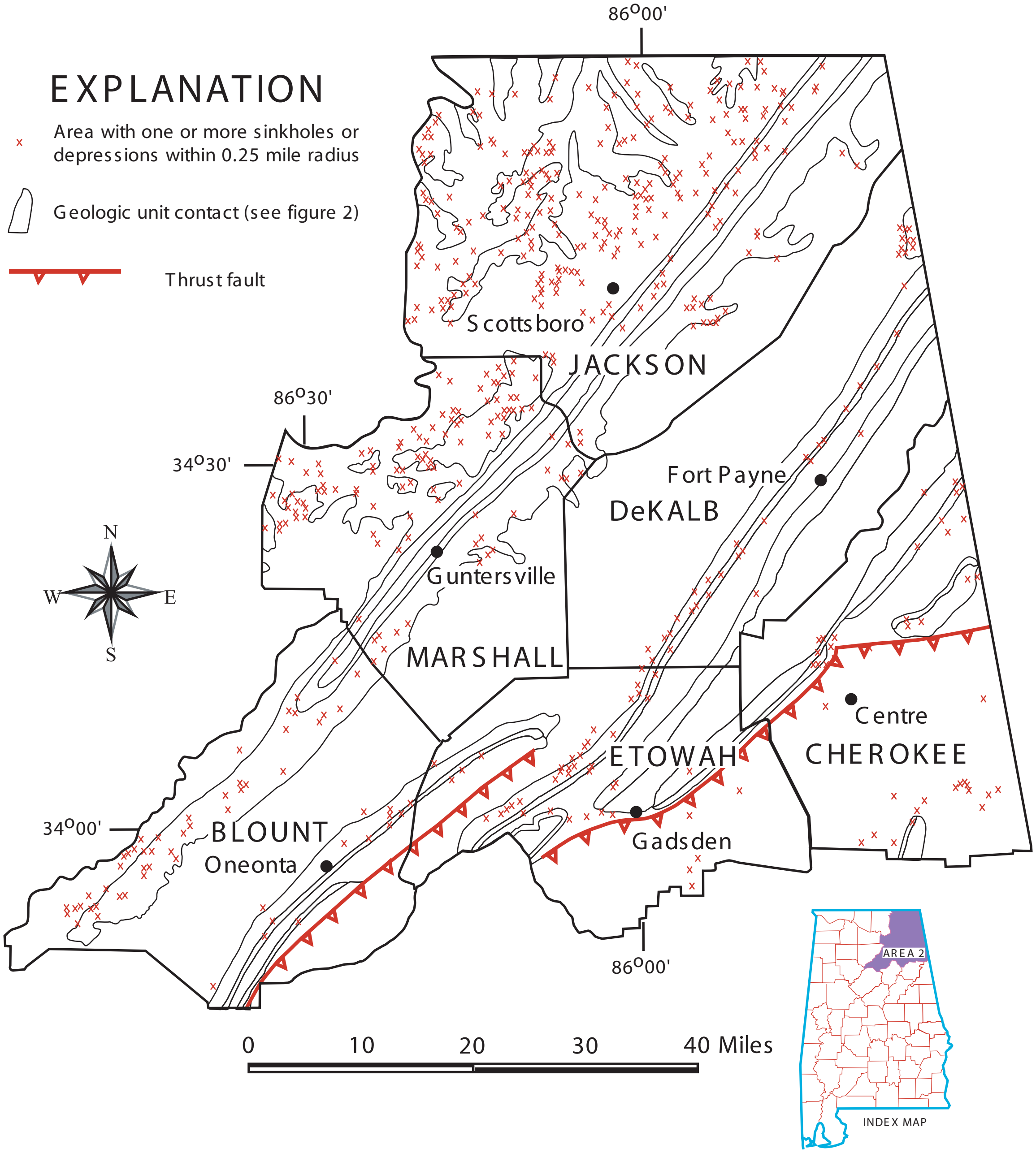

Figure 5.–Locations of sinkholes in Area 2. Modified from Bossong (1989).

Weathering of rocks that have a high chert content leaves the chert unaltered, creating a residual soil that is fairly porous and allows rapid recharge. Areas underlain by these soils tend to be more susceptible to surface contamination, but a detailed geologic map or possibly a soils map showing the particular formations or soils of interest would be needed to identify these localized areas.

Some areas within Area 2 can be classified as extremely vulnerable to contamination because they coincide with the locations of sinkholes (U.S. Geological Survey, 1977a-f; Bossong, 1989). Sinkholes are depressions in the land surface caused by the collapse of rock materials into a solution cavity. Sinkholes can provide a direct link to the aquifer system that could allow immediate contamination of the aquifer (Newton, 1987). Locations of mapped sinkholes are shown on figure 5. Formation of sinkholes is controlled by bedrock characteristics and ground water hydrology, so sinkhole distribution is related both to aquifer recharge areas and physiographic areas. Sinkholes in Area 2 are most common in the recharge areas of the Mississippian aquifer system, especially near the edges of these regions (fig. 5).

PUBLIC-SUPPLY WELLS AND SPRINGS

In the study area, 29 public ground water supply wells and 8 public supply springs provide water for 23 water systems (app B; pl. 1). Roughly equal numbers of these wells and springs derive water from the Valley and Ridge and Mississippian aquifer systems and the Pottsville aquifer. Public water supply wells in Area 2 average about 200 feet in depth; nearly all are shallower than 350 feet.

WELLHEAD PROTECTION AREAS

Public water supply systems that use ground water provide water to about one-third of the population of Alabama (Mooty and Richardson, 1998). Programs that protect ground water sources from potential contamination are known as Wellhead Protection Programs (WHPPs). Alabama's WHPP is the result of 1986 amendments to the Safe Drinking Water Act originally enacted by Congress in 1974. The 1986 amendments directed the EPA to oversee the states' development of plans and programs to protect areas providing ground water to public water supply wells or springs. The 1996 amendments established Source Water Assessment requirements for public water supply systems using either ground water or surface water sources. The Source Water Assessment Program (SWAP) requires a Source Water Assessment Area (SWAA) delineation, a contaminant source inventory within each SWAA, a susceptibility analysis of each contaminant source in the inventory, and public notification of the condition of raw water supplies, including their susceptibility to contamination. The SWAAs are identified surface areas where potential contaminants that migrate into the ground are most likely to cause contamination of public water supply wells or springs. SWAAs are delineated using hydrogeologic conditions or time-of-travel criteria. The revised WHPP is a voluntary program that builds on the SWAP by providing guidance for developing protection strategies in the delineated areas. Protection strategies include building a local team of concerned citizens, developing an education and outreach program and developing management and contingency strategies. The terms SWAA and WHPA can be used to identify the same area around a public water supply well or spring and are used synonymously in this report. Baker and Osborne (1994) reported on geologic and hydrologic investigations in the Valley Head area, DeKalb County, in support of a Wellhead Protection Program, and Smith and Baker (1997) reported on geologic and hydrologic investigations in the Douglas area, Blount and Marshall Counties, in support of a Wellhead Protection Program. Locations of established WHPAs are shown on plate 10.

SUMMARY AND CONCLUSIONS

The geology of the study area, along with the diverse physiography, is quite complex owing to past large-scale tectonic activity. Most of the study area is in the Appalachian fold and thrust belt, which consists of Paleozoic sedimentary strata. Paleozoic metasedimentary rocks crop out along the southeastern section of Cherokee County.

The geologic formations in Area 2 can be grouped into three major aquifers—the Valley and Ridge aquifer system, the Mississippian aquifer system (including the Hartselle aquifer, the Bangor aquifer, the Fort Payne-Tuscumbia aquifer, and the Monteagle aquifer), and the Pottsville aquifer, as well as three minor aquifers—the watercourse aquifer, the Nashville-Stones River aquifer, and the metasedimentary and metavolcanic aquifers. The complex structure in the area has disrupted the regional continuity of the formations so that individual aquifers are associated with the major valleys in the study area and the same major aquifer type may be present in adjacent valleys but may not be hydraulically connected because of faulting or folding.

Aquifers coincide with the physiographic districts of the Wills Valley, Coosa Valley, Murphrees Valley, Sequatchie Valley, and Birmingham-Big Canoe Valleys. These aquifers are tapped within their outcrop areas where they are also recharged. A mantle of residuum covers most rocks, which is a product of the underlying parent material. Water may occur in either water-table or artesian conditions within the aquifers. Highest yields from aquifers are associated with solution openings in carbonate rocks.

For the study area, estimated withdrawals from ground water are as follows: public supply, 11.45 mgd; self-supplied industry, 1.64 mgd; agriculture, 2.50 mgd; and self-supplied domestic, 4.27 mgd (Mooty and Richardson, 1998). The estimated total withdrawal of 19.87 mgd is equivalent to 0.09 inch per year of recharge. The largest ground water users in the study area are Attalla, Guntersville, and Oneonta.

All the recharge areas for the aquifers are susceptible to contamination from the surface. However, the recharge areas of the metasedimentary and metavolcanic aquifers are only slightly susceptible to contamination from the surface. Three conditions exist in the study area that may cause the aquifers to be highly susceptible to contamination on a local scale: rock materials are fractured in places due to faulting and weathering, cherty soils tend to be porous. Where sinkholes are present, there may be a direct connection between the surface and the aquifer; these areas are considered to be extremely susceptible to contamination.

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RELATED LINKS

http://www.adem.state.al.us/
Alabama Department of Environmental Management (ADEM)
ADEM administers all major federal environmental laws, including the Clean Air, Clean Water and Safe Drinking Water acts and federal solid and hazardous waste laws. Information regarding ADEM news, regulations, funded programs, and status of filings are available on this site.

http://www.epa.gov/OW
United States Environmental Protection Agency (EPA)
This is the home page of the EPA Office of Water. Information includes America's water resources, environmental programs and partnerships, monitoring, data, and tools, you and clean water, regulations and legislation, information resources, etc. Pages for EPA Water are maintained as well: Wetlands, Oceans, and Watersheds, Science and Technology, Wastewater Management, Groundwater and Drinking Water, etc. The various regional programs are also covered as well as EMAP Estuaries.

http://www.nrcs.usda.gov/
United Stat Department of Agriculture (USDA)
The Natural Resources Conservation Service (NRCS) is the USDA agency that works at the local level to help people conserve all natural resources on private lands. USDA provides soil information and other agricultural information, including maps of soil types.

http://www.ngwa.org/
National Ground Water Association (NGWA)
NGWA operates the National Ground Water Information Center ®, the largest non-governmental clearinghouse on ground water science and well technology in the world, with more than 40,000 volumes. Ground Water On-Line ®, a nearly 80,000 citation bibliographic database of ground water literature is available at no cost to NGWA members. A database of standards, guidelines, criteria, practices and procedures is also available at the Web site.

http://www.gsa.state.al.us
Geological Survey of Alabama (GSA)
The Geological Survey of Alabama, established in 1848, is a data gathering and research agency that explores and evaluates the mineral, water, energy, biological, and other natural resources of the State of Alabama and conducts basic and applied research in these fields as a public service to citizens of the State.

http://water.usgs.gov/
United States Geological Survey (USGS)
This site is the http server Water Division home page. It contains links to information from the water, geologic, and mapping divisions. USGS fact sheets, information releases, publications, data products, etc. are available. Information on GIS and the National Spatial Data Infrastructure is also included. Contact information for USGS resources (maps, etc.) Is given as well as the USGS telephone book. Links to other USGS sites on-line are available.

http://www.ucowr.siu.edu/
Universities Council on Water Resources (UCOWR)
UCOWR maintains several databases for providing water information. Over 100 different water related links are listed by categories.

http://www.gwpc.org/
Ground Water Protection Council (GWPC)
The Ground Water Protection Council is a nonprofit (501(c)3) organization whose members consist of state and federal ground water agencies, industry representatives, environmentalists and concerned citizens, all of whom come together within the GWPC organization to mutually work toward the protection of the nation's ground water supplies.

http://www.fws.gov/
U.S. Fish & Wildlife Service (FWS)
This site has general information, news releases, and employment information for the Fish and Wildlife Services. Pages on FWS activities such as Conservation Programs, Endangered Species, Contaminants, Federal Aid to States, Fire Management, Fisheries, Migratory Birds and Waterfowl, National Wildlife Refuge System, Wetlands, Wildlife Law, and Wildlife Species are included. Pages for the various FWS Regions are also incorporated.

www.nal.usda.gov/wqic/
National Extension Water Quality Database
This site allows for searches in a database that has 2,500 abstracts and 1,500 documents on all aspects of water quality. The documents are full text and list available contacts. Also available are Quick Time Movies.

http://www.TheHydrogeologist.com/
This page is a collection of hundreds of links to hydrogeological organizations, software and data repositories, publications, and other resources of potential use to hydrogeologists.

http://www.nws.noaa.gov/oh/

The Office of Hydrology serves as a primary link between the National Weather Service Headquarters and the hydrologic field service programs. Activities include development of hydrologic models, hydrologic data for rivers and flood forecasts, warnings, and water supply forecasts. Current and Historical Data include floods, hydrologic conditions, and water supply outlooks. Data systems available online are HADS (a real time hydrological and meteorological data acquisition and distribution system) and INFLOWS (Integrated Flood Observing and Warning System). Full text handbooks, reports, and user manuals are available. Information on forecast systems is also available.

APPENDIX A

Records of public water-supply wells and springs in Area 2

SYSTEM, Water system name.
PWS ID, Public water system identification number as assigned by the Alabama Department of Environmental Management.
SE ID, Source identification number as assigned by the Alabama Department of Environmental Management.
GSA ID, Well identification number assigned by the Geological Survey of Alabama (GSA).
DEPTH, Total depth of well in feet.
YEAR DRILLED, Year the well was completed and ready for operation.
DRILLING CONTRACTOR, Name of driller.
ALTITUDE, Elevation of land surface in feet above mean sea level.
AQUIFER: Mb, Bangor Limestone; Mm, Monteagle Limestone; Mt, Tuscumbia Limestone; Mfp, Fort Payne Chert; Mtfp, Tuscumbia-Fort Payne Formations; Ppv, Pottsville Formation; OCk, Knox Group; CO, Cambrian and Ordovician rocks undifferentiated; Oc, Chickamauga Limestone; VR, Valley and Ridge aquifer system. Formation names identify parts of the Valley and Ridge aquifer system that correspond to the named geologic units.
WATER LEVEL, Water level in feet below land surface. For springs, measured flows are given in gallons per minute (gpm).
DATE MEASURED, Date of water-level measurement.
WELL CONSTRUCTION, YIELD, REMARKS, gpm is gallons per minute.

Appendix A.--Records of public water-supply wells and springs in Area 2

BLOUNT COUNTY

System	PWS ID	SE ID	GSA ID	Depth	Year drilled	Drilling contractor	Altitude	Aquifer	Water level or spring discharge	Date measured	Well construction, yield, remarks
Allgood	98	1	BLOT-2				760	VR (OЄk)	190	3/14/67	Allgood Spring. Average production 0.04-0.06 mgd. USGS No. 75.
Altoona	571	1	BLO-02	105	1958	H. W. Peerson	923	OЄk	15	2/1/57	Casing 8 in. 0-77 ft., 6 in. slotted 63-105 ft. Drawdown 57 ft. Pump rated at 300 gpm. USGS No. 53.
Blountsville	100	1	BLOJ-2	128	1964	H. W. Peerson		Mfp	62	1/23/64	Well no. 1. Drawdown 15 ft. Yield 300 gpm when pumped for 6 hours. Pump rated at 200 gpm. Average production 0.2 mgd.
Blountsville	100	2	BLON-04	143 or 170-180							Casing 12 in. 0-102 ft. Pumping at 700 gpm, pumping level about 80 ft. Average production 0.5 mgd. Well no. 2; Putman Well.

EXPLANATION

Appendix A.--Records of public water-supply wells and springs in Area 2--Continued

BLOUNT COUNTY

System	PWS ID	SE ID	GSA ID	Depth	Year drilled	Drilling contractor	Altitude	Aquifer	Water level or spring discharge	Date measured	Well construction, yield, remarks
Cleveland	101	1	BLOO-6	200	1968	Campbell	507	Ppv	8	12/14/67	Casing 8 in. 0-62 ft. Well no. 1. Drawdown 9.5 ft after 20 hrs pumping 154 gpm on 3/14/68. Pump rated at 120 gpm. Average production 0.09 mgd. USGS No. 61.
Cleveland	101	2	BLOO-01	270	1977	Graves Well Drilling Co.	560	Ppv	65.88	12/2/76	Casing 12 in. 0-14 ft. Tested at 100 gpm in 1976. Well no. 2. Drawdown 15 ft. Pump rated at 420 gpm. Average production 0.2 mgd. USGS No. 60.
Nectar	122	1	BLON-02	145	1979	Interstate Drillers	445	Ppv	14.08	11/18/79	Casing 10 in. Well no. 1. Tested at 500 gpm in 1979. Drawdown 2 ft. in 1982. Pump rated at 250 gpm. Average production 0.15 mgd. USGS No. 65.

Appendix A.--Records of public water-supply wells and springs in Area 2--Continued

BLOUNTY COUNTY

System	PWS ID	SE ID	GSA ID	Depth	Year drilled	Drilling contractor	Altitude	Aquifer	Water level or spring discharge	Date measured	Well construction, yield, remarks
Oneonta	103	2	BLOS-1	196	1947	H. W. Peerson	875	VR (OЄk)	130	1954	Casing 10 in. +1 to 175 ft; basal 66 ft. slotted. Tested at 303 gpm with 57 ft. drawdown (specific yield 5.3 gpm/ft of drawdown) in 1947. Tested at 220 gpm in 1954. Pump rated at 450 gpm. Average production 0.5 mgd. Well no. 1. USGS No. 67. Located on Jefferson Ave. When drilled it was well no. 2.

Appendix A.--Records of public water-supply wells and springs in Area 2--Continued

BLOUNT COUNTY

System	PWS ID	SE ID	GSA ID	Depth	Year drilled	Drilling contractor	Altitude	Aquifer	Water level or spring discharge	Date measured	Well construction, yield, remarks
Oneonta	103	3	BLOP-03	335	1985	Graves Well Drilling Co.	839.7	Mtfp	88	8/19/86	Casing 12 in. 0 to 300 ft.; screen 8 in. 300 to 323 ft. Drawdown 25 ft. in 1987. Tested in 1986 at 900 gpm with 24.5 ft. of drawdown. Pump rated at 600 gpm. Average production 0.8 mgd. Well no. 2. Located at Heritage Green. Also called Quail Valley Well.
Oneonta	103	4	BLOP-05	315	1991	Miller Drilling Co.	772.33	Ppv	4.5	8/19/91	Casing 10 in. 0 to 184 ft., 4 in. slotted screen 184 to 249 1/3 ft. Tested at 403 gpm with 157 ft of drawdown for 56 hours beginning 8/19/91. Pump rated at 400 gpm. Average production 0.6 mgd. Well No. 3. Located on County Road 39.

EXPLANATION

Appendix A.--Records of public water-supply wells and springs in Area 2--Continued

BLOUNT COUNTY

System	PWS ID	SE ID	GSA ID	Depth	Year drilled	Drilling contractor	Altitude	Aquifer	Water level or spring discharge	Date measured	Well construction, yield, remarks
Snead	108	1	BLOH-01	200	1971	Graves Well Drilling Co.	840	Ppv			Well no. 1. Pump rated at 250 gpm. USGS No. 50.

EXPLANATION

Appendix A.--Records of public water-supply wells and springs in Area 2--Continued

CHEROKEE COUNTY

System	PWS ID	SE ID	GSA ID	Depth	Year drilled	Drilling contractor	Altitude	Aquifer	Water level or spring discharge	Date measured	Well construction, yield, remarks
Cherokee County	189	1	CHEO-3				612	Mtfp	210	5/10/55	Bristow Spring. Pump rated at 180 gpm.

Appendix A.--Records of public water-supply wells and springs in Area 2--Continued

DEKALB COUNTY

System	PWS ID	SE ID	GSA ID	Depth	Year drilled	Drilling contractor	Altitude	Aquifer	Water level or spring discharge	Date measured	Well construction, yield, remarks
Crossville	508	1	DEKFF-1	307	1965	C. B. Dalrymple	1,080	Ppv	35	5/18/05	Casing 8 in. 0-43 ft. Pumped 24 hrs. at 225 gpm with drawdown of 19 ft. USGS No. 31.
Valley Head	523	1	DEKJ-4				958	OЄk	500	9/21/28	Dixie Brown Spring. USGS No. 19.

EXPLANATION

Appendix A.--Records of public water-supply wells and springs in Area 2--Continued

ETOWAH COUNTY

System	PWS ID	SE ID	GSA ID	Depth	Year drilled	Drilling contractor	Altitude	Aquifer	Water level or spring discharge	Date measured	Well construction, yield, remarks
Altoona	571	1									See under Blount County.
Attalla	572	1	ETOP-01	338	1986	Miller Drilling Co.	660	OЄk	11.7	2/2/87	Casing 8 in. 0 to 120 ft. Yield 250+ gpm. Pump rated at 700 gpm. Producing zone 151 to 156 ft. Well 18.
Attalla	572	2	ETOP-02	427	1987	Miller Drilling Co.	660	Ppv	14	4/29/87	Casing 10 in. 0 to 340 ft. Yield 200+ gpm. Pump rated at 700 gpm. Producing zone 368 to 370 ft. Well 24.
Attalla	572	3	ETOP-05								Well 3. Pump rated at 225 gpm.
Glencoe	578	1	ETON-01	264	1966	Adams-Massey	575	OЄk	23	2/9/66	Casing 8 in. 0-135 ft. Drawdown 120 ft. Well 1.
Glencoe	578	2	ETON-02	287	1969	Adams-Massey	580	OЄk	76	2/3/88	Casing 6 in. 0-247 ft. Well 2. Pump rated at 285 gpm. USGS No. 69.

EXPLANATION

Appendix A.--Records of public water-supply wells and springs in Area 2--Continued

ETOWAH COUNTY

System	PWS ID	SE ID	GSA ID	Depth	Year drilled	Drilling contractor	Altitude	Aquifer	Water level or spring discharge	Date measured	Well construction, yield, remarks
Glencoe	578	3	ETON-25				543	OЄk	1600	5/23/60	Glencoe or Big Spring. Pump rated at 185 gpm. USGS No. 68.
Hokes Bluff	581	1	ETON-16				570	OЄk	1690	11/26/85	Tawana (Hokes Bluff) Spring. Pump rated at 550 gpm. USGS No. 63.
Ridgeville	590	1	ETOI-03	185	1971	Dinglers Drilling Co.	598	OЄk	26.11	2/4/88	Casing 6 in. 0-49 ft. Flowed 20 gpm when drilled. Pumped at 75 gpm 1/9/72 for 24 hrs with 12 ft. of drawdown.
Southside	591	1	ETOT-04	278	1976	Graves Well Drilling Co.	535	Mtfp	9.5	12/23/76	Casing 16 in. 0-50 ft., 10 in. 0-150 ft., 6 in. casing and perf. Pipe 150-278 ft. Drawdown 33 ft. when pumped 48 hrs. at 151 gpm. In 1976. Well 1, Green Valley. USGS No. 79.

EXPLANATION

Appendix A.--Records of public water-supply wells and springs in Area 2--Continued

ETOWAH COUNTY

System	PWS ID	SE ID	GSA ID	Depth	Year drilled	Drilling contractor	Altitude	Aquifer	Water level or spring discharge	Date measured	Well construction, yield, remarks
Southside	591	2	CALE-03	170	1979	Graves Well Drilling Co.	640	Mtfp	58.58	12/12/79	Casing 8 in. Pumped 450 gpm on test. Drawdown 32 ft. Well 2, Calhoun. USGS No. 80. This well is located in Calhoun County but is listed here to keep records for the City of Southside together.
Walnut Grove	592	1	ETOG-03	252	1961	Adams-Massey	860		18.84	1962	Casing 6 in. 0-252 ft. Pumped 200 gpm in 1961 on test. Drawdown 15 ft. USGS No. 51.
West Etowah	582	1	ETOH-25				855	Mb	691	11/9/76	Cove Spring. Pump rated at 450 gpm.

EXPLANATION

Appendix A.--Records of public water-supply wells and springs in Area 2--Continued

JACKSON COUNTY

System	PWS ID	SE ID	GSA ID	Depth	Year drilled	Drilling contractor	Altitude	Aquifer	Water level or spring discharge	Date measured	Well construction, yield, remarks
Bridgeport	713	1	JACC-4				880	Mb	200	9/17/28	Bridgeport Spring. Pump rated at 700 gpm. No. 56 in Johnston (1933, pt. 2, table 2). GSA water quality station. USGS No. 2.
Hollywood	719	1	JACAA-2	160	1962	Campbell Drilling	660	Mm	36.5	12/3/62	Casing 8 in. 0 to 70 ft., 6 in. 0 to 91 ft. Drawdown 28 ft. after 24 hrs pumping 80 gpm on 12/3/62. Well No. 1. USGS No. 10.
Hollywood	719	2	JACAA-01	163	1975	Campbell Drilling	660	VR (ЄO, Oc)	46	7/30/75	Casing 8 in. 0 to 68 ft. Drawdown 13 ft. when tested at 70 gpm for 72 hrs on 7/30/75 - 8/2/75. Well No. 2. USGS No. 11.
Pisgah	726	1	JACCC-4	62	1961	Campbell Drilling	1350	Ppv	+5.3	3/16/71	Casing 10 in. 0 to 15 ft., drawdown 8 ft. when pumped 22 hrs. at 300 gpm in 1961. USGS No. 15.

Appendix A.--Records of public water-supply wells and springs in Area 2--Continued

JACKSON COUNTY

System	PWS ID	SE ID	GSA ID	Depth	Year drilled	Drilling contractor	Altitude	Aquifer	Water level or spring discharge	Date measured	Well construction, yield, remarks
Stevenson	732	1	JACN-01								Well No. 1. Pump rated at 400 gpm.
Stevenson	732	2	JACN-02								

EXPLANATION

Appendix A.--Records of public water-supply wells and springs in Area 2--Continued

BLOUNT COUNTY

System	PWS ID	SE ID	GSA ID	Depth	Year drilled	Drilling contractor	Altitude	Aquifer	Water level or spring discharge	Date measured	Well construction, yield, remarks
Douglas	940	3	MALU-11				650	Mt	300	8/24/28	Big Spring. Produced at 1,000 gpm in 1995. No. 46 in Johnston (1933, pt. 2, table 34).
Douglas	940	2	BLOA-02	290	1982	Graves Well Drilling Co.	635	Mt	11.02	1/27/87	Surface casing 12 in., 6 in. casing 0 to 33 ft. Drawdown 35 ft. when pumped 40 hrs at 220 gpm. Produced at 600 gpm in 1995. Well No. 1 (test well no. 3). USGS No. 41.
Douglas	940	5	BLOA-09	171	1997	Miller Drilling Co.	685	Mt	9	10/8/97	Casing 18 in. 0 to 11 ft; 14 in., 0 to 100 ft. Test hole 9.
Douglas	940	6	BLOA-010	190	1997	Miller Drilling Co.	680	Mt			Casing 18 in. 0 to 15 ft.; 14 in. 0 to 104 ft. Test hole 10.
Guntersville	943	4	MALO-05	150	1986	Graves Well Drilling Co.	601	Mb	10	1986	Casing 6 in. to 133 ft.; 5 in. slotted pipe from 133 to 154 ft. Test pumped at 300 gpm in 1986. Well No. 1.

EXPLANATION

APPENDIX B

Records of selected wells and springs for Area 2

EXPLANATION FOR TABLE 3

SYSTEM, Water system name
PWS ID, Public water system identification number as assigned by the Alabama Department of Environmental Management (ADEM).
SE ID, Source identification number assigned by the ADEM.
GSA ID, Well identification number assigned by the Geological Survey of Alabama (GSA).
DEPTH, Total depth of well in feet.
YEAR DRILLED, Year the well was completed, and ready for operation.
DRILLING CONTRACTOR, Name of driller.
ALTITUDE, Elevation of land surface in feet above mean sea level.
AQUIFER: Mb, Bangor Limestone; Mm, Monteagle Limestone; Mt, Tuscumbia Limestone; Mfp, Fort Payne Chert; Mtfp, Tuscumbia-Fort Payne Formations; Ppv, Pottsville Formation; OЄk, Knox Group; ЄO, Cambrian and Ordivician rocks undifferentiated; Oc, Chickamauga Limestone; VR, Valley and Ridge aquifer system. Formation names identify parts of the Valley and Ridge aquifer system that correspond to the named geologic units.
WATER LEVEL, Water level in feet below land surface. For springs, measured discharge is given in gallons per minute (gpm).
DATE MEASURED, The date the water level or discharge measurement were made.
WELL CONSTRUCTION, YIELD, REMARKS, gpm is gallons per minute

Appendix B.—Records of selected wells and springs in Area 2 (modified from Bossong, 1989)

Well Owner	Well Number	GSA ID	Depth (feet)	Year drilled	Drilling contractor	Altitude	Aquifer	Water level	Date measured	Well construction, yield, remarks
Russell Cave National Monument	1	JACC-3	180	1962	Dodson	710	Mtfp	47.12	1-28-87	System capacity 0.2 mgd.
Stevenson Utilities	3		n.a.	n.a.	n.a.	1,050	Mb	--	--	Periwinkle Spring.
North Jackson Hospital	4		120	1958	Campbell Drilling	630	CO	--	--	System capacity 0.1 mgd. Test pumped 80 gpm.
Stevenson Utilities	5	JACN-3	n.a.	n.a.	n.a.	800	Mtfp	30	9/27/29	Sabe Spring. Also known as Balm Spring or Mountain Spring.
Stevenson Utilities	6		163	1971	Campbell Drilling	640	CO	42.75	2-15-71	System capacity 0.9 mgd. Test pumped 300 gpm.
Stevenson Utilities	7		301	1948	Adams-Massey	630	CO	22	9-48	System capacity 0.9 mgd.
Mead Paper Board	8	JACN-02	83	1973	Miller Drilling Co.	630	CO,Oc	--	--	Casing 6 in. 0 to 63 ft. Yield 200 gpm.
Cumberland Mountain Water Authority	9	JACZ-01	161	1976	Graves Well Drilling Co.	640	Mb	20.00	6/22/76	Test pumped 330 gpm.

Appendix B.—Records of selected wells and springs in Area 2 (modified from Bossong, 1989) —Continued

Well Owner	Well Number	GSA ID	Depth (feet)	Year drilled	Drilling contractor	Altitude	Aquifer	Water level	Date measured	Well construction, yield, remarks
Paint Rock Water System	12	JACX-03	160	1977	Graves Well Drilling Co.	610	Mtfp	12.08	1-17-77	Casing 6 in. 0 to 65 ft. System capacity <0.1 mgd.
Scottsboro	13	JACZ-4	522	1954	Virginia Supply and Well	625	Mtfp	14	1954	Casing 12 in. 0 to 44 ft., open below. Test pumped 250 gpm.
Scottsboro	14	JACAA-10	463	1947	H. W. Peerson Drilling	630	Mtfp	--	--	Casing 8 in. 0 to 92 ft. Sealed. Test pumped 130 gpm.
Woodville Water	16		136	1969	Dodson Drilling	605	Mtfp	9.42	11-17-69	System capacity 0.3 mgd. Test pumped 350 gpm.
Woodville Water	17	JACJJ-4	163	1963	Dalrymple Drilling	590	Mb	12	2-1963	Casing 8 in. 0 to 83.5 ft. System capacity 0.3 mgd. Test pumped 300 gpm in 1963 for 80 hours, drawdown 22 ft.
Skyline Shores Water	18		250	1958	Campbell Drilling	610	Oc	--	--	System capacity <0.1 mgd.

Appendix B.—Records of selected wells and springs in Area 2 (modified from Bossong, 1989) —Continued

Well Owner	Well Number	GSA ID	Depth (feet)	Year drilled	Drilling contractor	Altitude	Aquifer	Water level	Date measured	Well construction, yield, remarks
Mentone	20	DEKJ-04	51	1954	R. M. Crowe	1,700	Ppv	--	--	Casing 6 in. 0 to 23 ft. Test pumped 12 gpm. Well no. 1.
Mentone	21	DEKJ-05	50	1954	R. M. Crowe	1,700	Ppv	--	--	Casing 6 in. 0 to 22 ft. Test pumped 5 gpm. Well no. 2.
South Sauty Camp	22		--	--	--	615	Oc	--	--	--
Bucks Pocket State Park	23		190	1970	Sand Mtn Drillers	670	Ppv	70	6-18-70	--
Canyon Land Park	24		225	1967	--	1,150	Ppv	--	--	--
Canyon Land Park	25		165	1965	Owens	1,150	Ppv	40	3-87	--
Arab Water Works	26	MALM-13	325	1951	Campbell Drilling	1,057	Ppv	80	1951	Test pumped 120 gpm.
Arab Water Works	27		337	1935	H. W. Peerson Drilling	1,100	Ppv	--	--	--

Appendix B.—Records of selected wells and springs in Area 2 (modified from Bossong, 1989) —Continued

Well Owner	Well Number	GSA ID	Depth (feet)	Year drilled	Drilling contractor	Altitude	Aquifer	Water level	Date measured	Well construction, yield, remarks
Arab Water Works	28	MALM-10	302	1954	Virginia Well Supply	1,095	Ppv	40.5	6-28-54	Casing 10 in. 0 to 51 ft. Test pumped 320 gpm.
Arab Water Works	29	MALM-01	350	1950	Campbell Drilling	1,100	Ppv	45	1952	Test pumped 120 gpm.
Arab Water Works	30	MALM-15	385	1952	Campbell Drilling	1,095	Ppv	--	--	Casing 8 in. 0 to 100 ft. Test pumped 85 gpm.
Collinsville	32	DEKGG-02	358	1980	Graves Well Drilling Co.	710	CO	15.5	1-06-81	Casing 6 in. 0 to 85.5 ft. System capacity 0.4 mgd. Welded cap. Test pumped 85 gpm.
Collinsville	33		275	1984	Graves Well Drilling Co.	710	CO	10.5	1-27-84	System capacity 0.4 mgd. Private test pumped 50 gpm.
Little River Canyon Mouth Park	34		180	1967	Graves Well Drilling Co.	620	Mtfp	34	1-22-87	--
Collinsville	35		n.a.	n.a.	n.a.	725	Mtfp	--	--	--

Appendix B.—Records of selected wells and springs in Area 2 (modified from Bossong, 1989) —Continued

Well Owner	Well Number	GSA ID	Depth (feet)	Year drilled	Drilling contractor	Altitude	Aquifer	Water level	Date measured	Well construction, yield, remarks
Collinsville	36	DEKBB-5	120	1966	Interstate Drillers	725	Mtfp	30	3-04-66	Casing 8 in. 0 to 27 ft. System capacity 0.4 mgd. Filled w/ rocks. Test pumped 600 gpm.
Gaylesville	37	CHEJ-01	150	1966	Sand Mountain Drilling	530	Cc	109	3-22-66	Casing 6 in. 0 to 91 ft. Test pumped 30 gpm for 24 hours in 1966, drawdown 9 ft.
Collinsville	38	DEKBB-02	450	1982	Graves Well Drilling Co.	820	Mb	2.16	10-15-82	Casing 6 in. 0 to 72 ft. System capacity 0.4 mgd. Test pumped 85 gpm.
Cedar Bluffs	39	CHEJ-12	300	1951	H. W. Peerson Drilling	580	Cc	10	8-31-53	Casing 8 in. 0 to 44 ft. Test pumped 60 gpm for 24 hours in 1952, drawdown 85 ft.
Douglas	40		300	1982	Graves Well Drilling Co.	785	Mb	40.36	1-27-87	Reported yield 300 gpm.
Douglas	41		290	1982	Graves Well Drilling Co.	635	Mb	11.02	1-27-87	Reported yield 300 gpm.

Appendix B.—Records of selected wells and springs in Area 2 (modified from Bossong, 1989) —Continued

Well Owner	Well Number	GSA ID	Depth (feet)	Year drilled	Drilling contractor	Altitude	Aquifer	Water level	Date measured	Well construction, yield, remarks
Douglas	42		365	1982	Graves Well Drilling Co.	785	Mb	--	--	Reported yield 300 gpm.
Boaz	43		295	1965	--	1,040	Ppv	--	--	Test pumped 350 gpm.
Boaz	44	MALS-01	230	1955	Adams-Massey	1,040	Ppv	--	--	Casing 8 in. 0 to 27 ft. Test pumped 300 gpm.
Boaz	45	MALS-46	200	1948	Adams-Massey	1,040	Ppv	--	--	Casing 8 in. 0 to 28 ft. Test pumped 200 gpm.
Boaz	46			1927	--	1,065	Ppv	--	--	--
Blountsville	47		150	1972	Miller Drilling Co.	690	Mtfp	51.15	1-13-87	--
Blountsville	48		150	--	--	690	Mtfp	--	--	--
Blountsville	49		143	1972	Miller Drilling Co.	680	Mtfp	89	1-13-87	Test pumped 300 gpm.

Appendix B.—Records of selected wells and springs in Area 2 (modified from Bossong, 1989)—Continued

Well Owner	Well Number	GSA ID	Depth (feet)	Year drilled	Drilling contractor	Altitude	Aquifer	Water level	Date measured	Well construction, yield, remarks
Altoona Water and Sewer	52	ETOG-3	140	1967	Interstate Drillers	870	CO	9.23	4-23-77	--
Altoona Water and Sewer	54	ETOG-9	252	1958	H. W. Peerson	955	CO	15	1958	Cased 8 in. 0 to 64 ft. System capacity 0.5 mgd. Test pumped 104 gpm for 27 hours with 57 ft. drawdown.
Ridgeville	55		--	--	--	585	CO	7.21	1-21-87	System capacity 0.1 mgd.
Reece City	56	ETOJ-01	150	1962	Adams-Massey	580	Mtfp	7.31	1-21-87	Casing 6 in. 0 to 88 ft. System capacity 0.2 mgd.
Northeast Etowah Water	57		--	--	Graves Well Drilling Co.	570	CO	--	--	System capacity 0.6 mgd.
Northeast Etowah Water	58		--	--	--	545	CO	--	--	--
Mt. Zion Water	59		150	1962	Adams-Massey	650	CO	--	--	--

Appendix B.—Records of selected wells and springs in Area 2 (modified from Bossong, 1989)—Continued

Well Owner	Well Number	GSA ID	Depth (feet)	Year drilled	Drilling contractor	Altitude	Aquifer	Water level	Date measured	Well construction, yield, remarks
Oneonta Utilities Board	62		325	1977	Graves Well Drilling Co.	790	CO	--	--	Not on line in 1987. Has top welded.
Nectar Water System	64	BLON-01	380	1979	Interstate Drillers	480	Ppv	41.49	1-03-79	System capacity 0.4 mgd. Test pumped 130 gpm.
Oneonta Utilities Board	66		173	1947	J. J. Hart	870	CO	70	1947	System capacity 1.3 mgd.
Glencoe	70		230	1972	Adams-Massey	580	CO	60	--	System capacity 0.1 mgd. Test pumped 350 gpm.
Hayden Water Works	71	BLOV-01	139	1973	H. W. Peerson	510	Mtf	32	11-08-74	Casing 6 in. 0 to 15 ft. System capacity 0.1 mgd. Test pumped 350 gpm.
Pine Bluff Water and Fire	72		--	--	--	525	Ppv	--	--	System capacity 0.5 mgd.
Pine Bluff Water and Fire	73		170	1979	Interstate Drillers	450	Ppv	39.6	2-02-81	System capacity 0.5 mgd. Test pumped 300 gpm.

Appendix B.—Records of selected wells and springs in Area 2 (modified from Bossong, 1989) —Continued

Well Owner	Well Number	GSA ID	Depth (feet)	Year drilled	Drilling contractor	Altitude	Aquifer	Water level	Date measured	Well construction, yield, remarks
Pine Bluff Water and Fire	74		103	1969	H. W. Peerson	500	Ppv	--	--	System capacity 0.5 mgd. Test pumped 200 gpm.
Rickwood Caverns	76		n.a.	n.a.	n.a.	760	Mb	--	--	
Mt. High Rock Springs Water Authority	77		143	1979	Graves Well Drilling Co.	640	Mb	8.58	1-13-87	System capacity 0.5 mgd.
Southside	78		100	1976	Dodson Drilling	530	CO	3.30	4-20-76	System capacity 1.2 mgd. Test pumped 400 gpm.

GEOLOGICAL SURVEY OF ALABAMA

CIRCULAR 199F PLATE 1

EXPLANATION

BLOS-1 Public water supply well or spring number

● Public water supply well

Public water supply spring

4 Selected or inactive public water supply well or spring number

○ Selected or inactive public water supply well

Selected or inactive public water supply spring

SYSTEM	SERIES	GEOLOGIC UNIT
Quaternary	Holocene	Alluvial and low terrace deposits
	Pleistocene	High terrace deposits

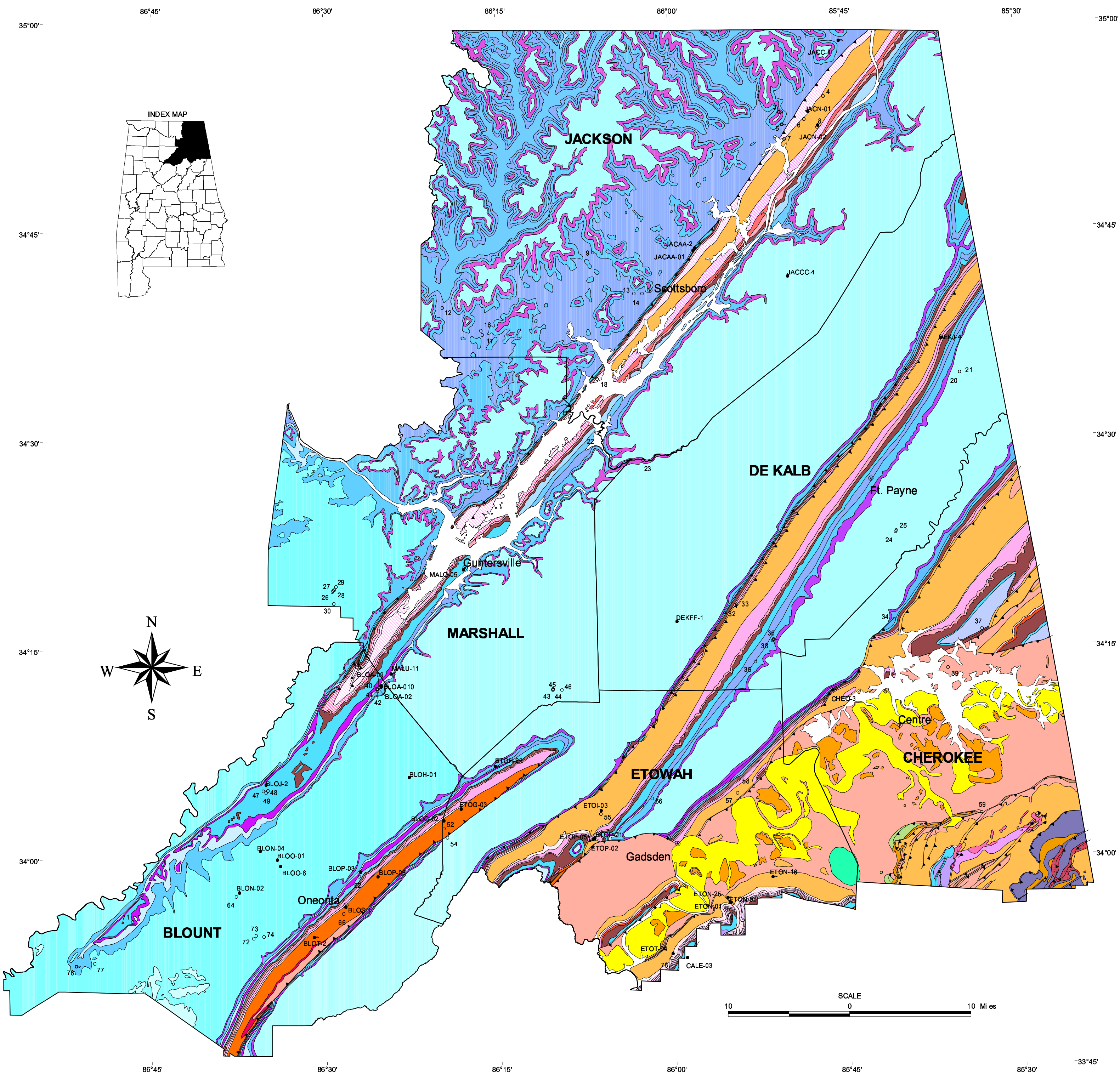
VALLEY AND RIDGE AND APPALACHIAN PLATEAUS PROVINCE

SYSTEM	GEOLOGIC UNIT
Pennsylvanian	Pottsville Formation
	Pottsville Formation (upper part) Appalachian Plateaus Province
	Pottsville Formation (lower part) Appalachian Plateaus Province
Pennsylvanian-Mississippian	Parkwood Formation and Pennington Formations undifferentiated
	Parkwood Formation and Floyd Shale undifferentiated
Mississippian	Pennington Formation
	Bangor Limestone
	Bangor and Monteagle Limestones undifferentiated
	Paleozoic shale undifferentiated
	Floyd Shale
	Hartselle Sandstone
	Monteagle Limestone
	Pride Mountain Formation
	Tuscumbia Limestone
	Tuscumbia Limestone and Fort Payne Chert undifferentiated
	Fort Payne Chert
Devonian	Chattanooga Shale
	Frog Mountain Sandstone
Silurian	Red Mountain Formation
Ordovician	Sequatchie Formation
	Sequatchie Formation, Colvin Mountain Sandstone, Greensport Formation undifferentiated
	Leipers Limestone
	Inman Formation
	Chickamauga Limestone
	Attalla Chert Conglomerate Member of the Chickamauga Limestone
	Colvin Mountain Sandstone
	Greensport Formation
	Athens Shale
	Little Oak and Lenoir Limestones undifferentiated
	Little Oak and Newala Limestones undifferentiated
	Nashville Group
	Nashville and Stones River Groups undifferentiated
	Stones River Group undifferentiated
	Newala Limestone
Ordovician-Cambrian	Knox Group undifferentiated
	Chepultepec and Copper Ridge Dolomites undifferentiated
Cambrian	Ketona Dolomite
	Conasauga Formation
	Lower unnamed shale facies of Conasauga Formation
	Rome Formation
	Shady Dolomite
	Chilhowee Group undifferentiated
	Weisner and Wilson Ridge Formations undifferentiated
	Nichols Formation

Thrust or reverse fault, sawteeth on upper plate, dashed where inferred

Fault for which sense of movement is unknown

⊙ County Seat



GEOLOGY, LOCATIONS OF SELECTED WATER SUPPLY WELLS AND SPRINGS IN AREA 2

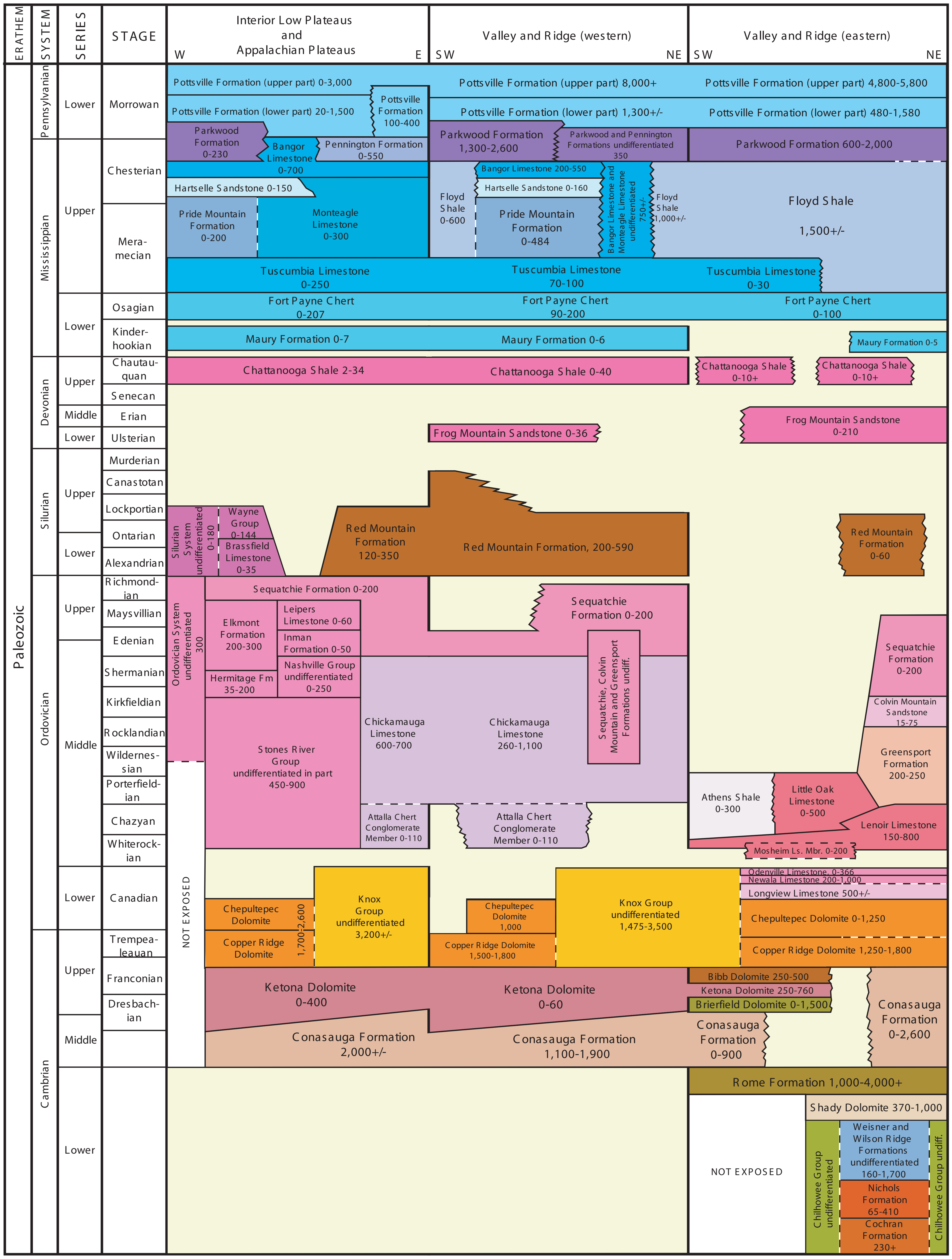
Geology modified from Szabo, Osborne, Copeland and Neathery (1988)

By Lewis S. Dean and David C. Kopaska-Merkel

2003

BERRY H. (NICK) TEW, JR.
State Geologist

GIS by Ruth T. Collier and Douglas R. Taylor



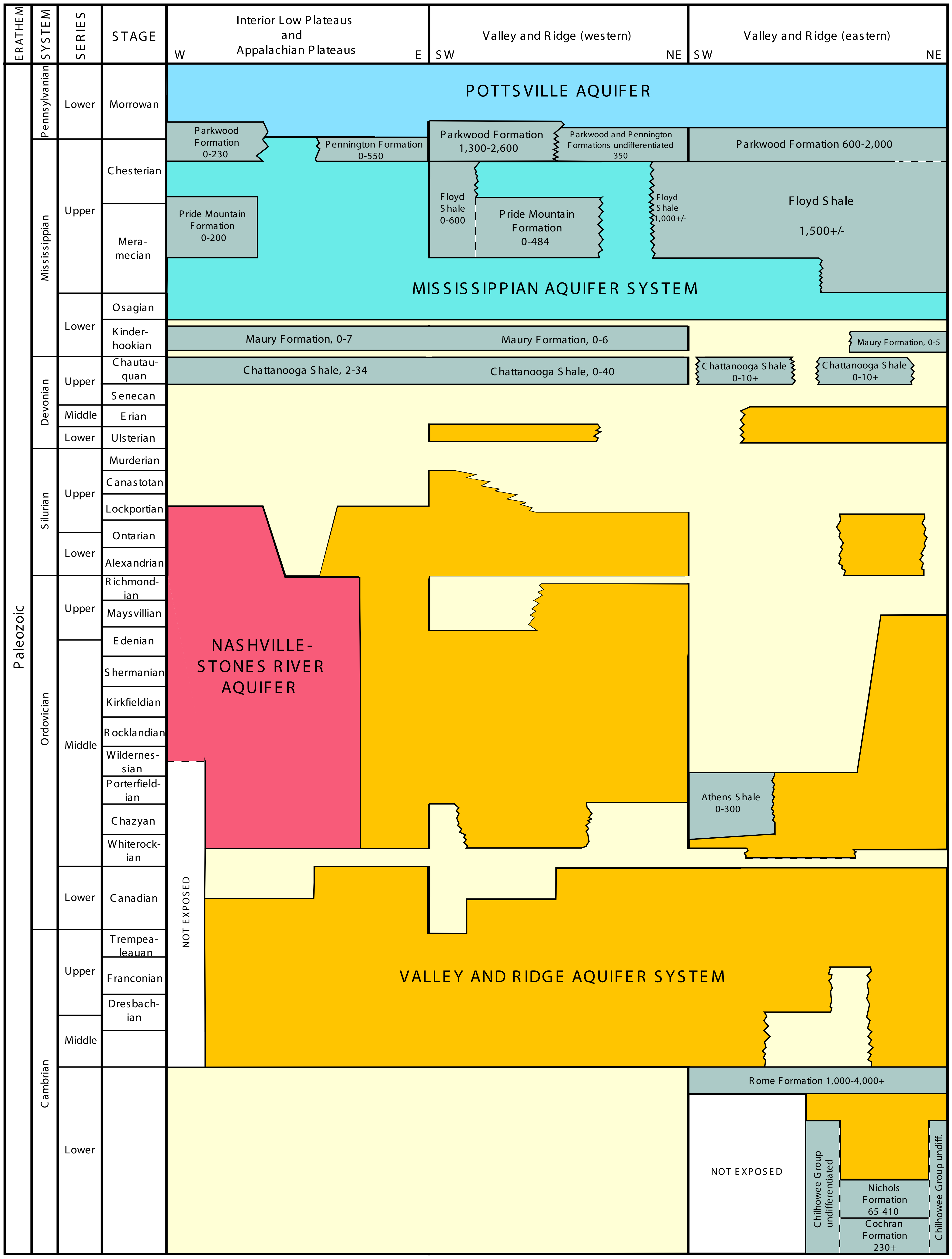
Interval of erosion or nondeposition.

Thicknesses of geologic units given in feet.

STRATIGRAPHIC RELATIONSHIPS AMONG EXPOSED PALEOZOIC UNITS IN THE APPALACHIAN PLATEAUS AND VALLEY AND RIDGE PROVINCES

Geology modified from Szabo, Osborne, Copeland, and Neathery(1988)
By David C. Kopaska-Merkel 2007

BERRY H. (NICK) TEW, JR.
State Geologist



Interval of erosion or nondeposition.

Aquitard or other non-aquifer interval (including range of thickness in feet).

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION OF MAJOR AQUIFERS IN THE PLATEAUS AND VALLEY AND RIDGE PROVINCES

Modified from Szabo, Osborne, Copeland, and Neathery (1988)
By David C. Kopaska-Merkel 2007

GEOLOGICAL SURVEY OF ALABAMA • Founded 1848

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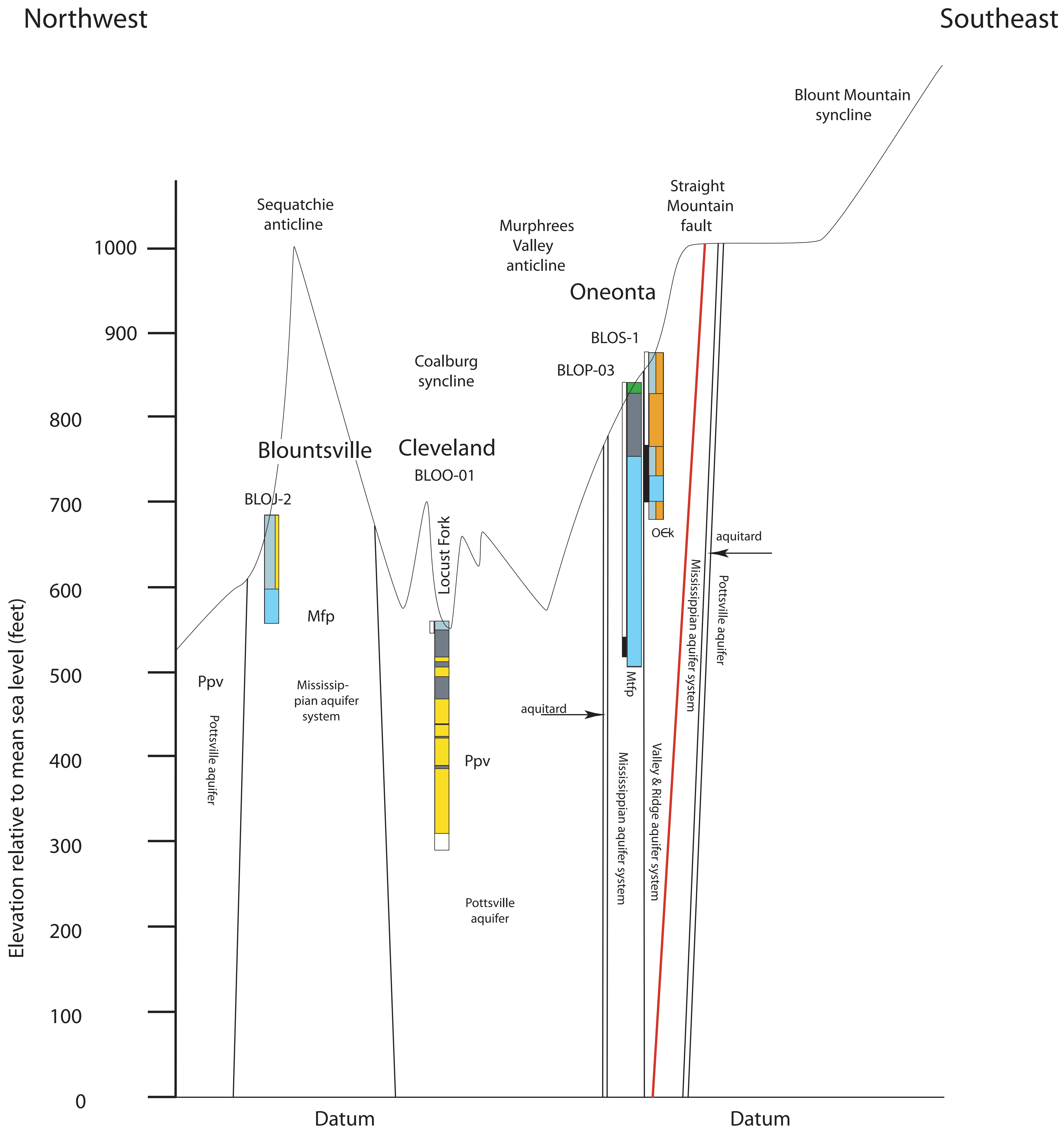

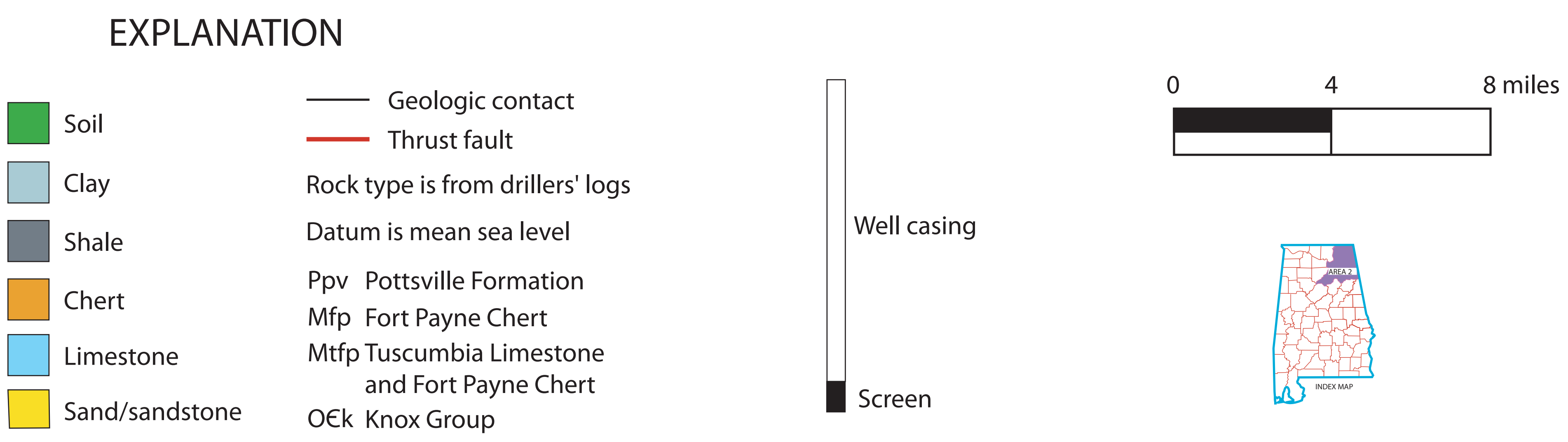

HYDROGEOLOGIC CROSS SECTION OF APPALACHIAN PLATEAU AND VALLEY AND RIDGE GEOLOGIC PROVINCE IN AREA 2

By
David C. Kopaska-Merkel
2007

BERRY H. (NICK) TEW, JR.
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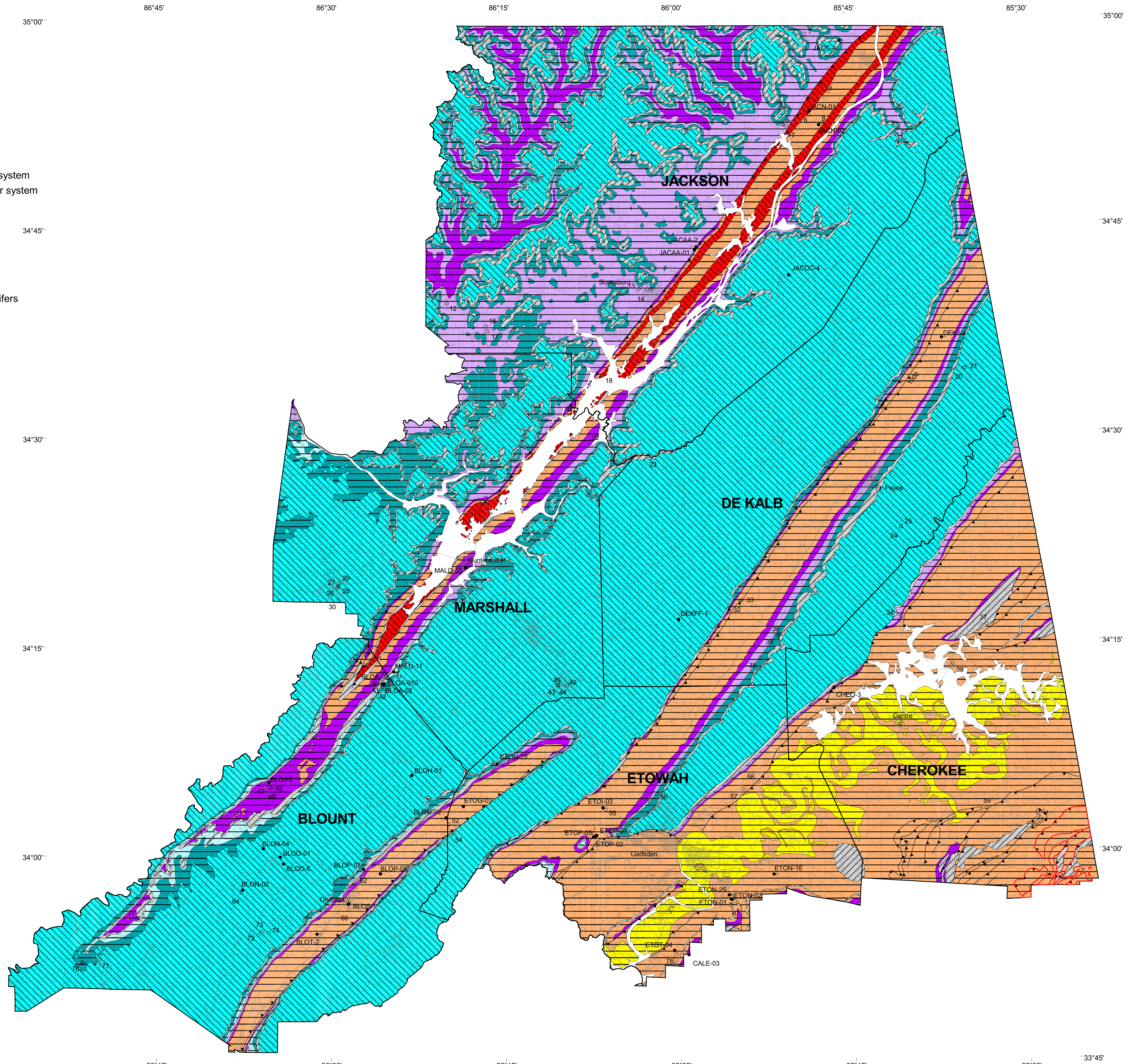
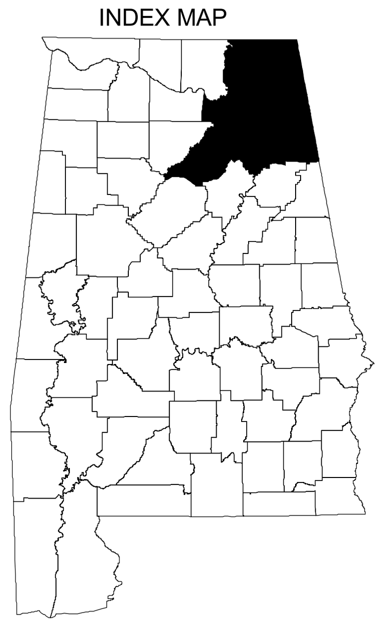
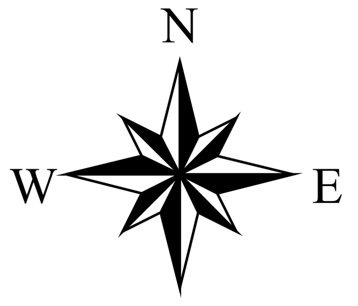
EXPLANATION

BLOA-02 Public water supply well or spring number
- • Public water supply well
- Public water supply spring
- 4 Selected or inactive public water supply well or spring number
- ○ Selected or inactive public water supply well
- Selected or inactive public water supply spring
- Recharge area of the watercourse aquifer
- Recharge area of the Pottsville aquifer
- Recharge area of the Bangor aquifer of Mississippian aquifer system
- Recharge area of the Hartselle aquifer of Mississippian aquifer system
- Recharge area of the Monteagle aquifer
- Recharge area of the Fort Payne-Tuscumbia aquifer of Mississippian aquifer system
- Recharge area of the Nashville-Stones River aquifer
- Recharge area of the Valley and Ridge aquifer system
- Recharge area of the Weisner and Wilson Ridge Formations undifferentiated, assigned to Valley and Ridge aquifer system
- Recharge area of the metasedimentary and metavolcanic aquifers
- aquiclude
- Thrust or reverse fault, sawteeth on upper plate, dashed where inferred
- Fault for which sense of movement is unknown
- High vulnerability to contamination from the surface
- Moderate vulnerability to contamination from the surface
- Low vulnerability to contamination from the surface
- Roads
- County Seat



INDEX MAP





SCALE

10 0 10 Miles

AQUIFER RECHARGE AREAS, AREAS OF VULNERABILITY, AND LOCATIONS OF PUBLIC WATER SUPPLY WELLS AND SPRINGS IN AREA 2

By David C. Kopaska-Merkel

2003

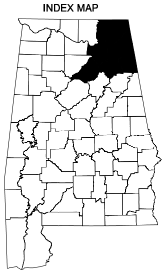
BERRY H. (NICK) TEW, JR.
State Geologist

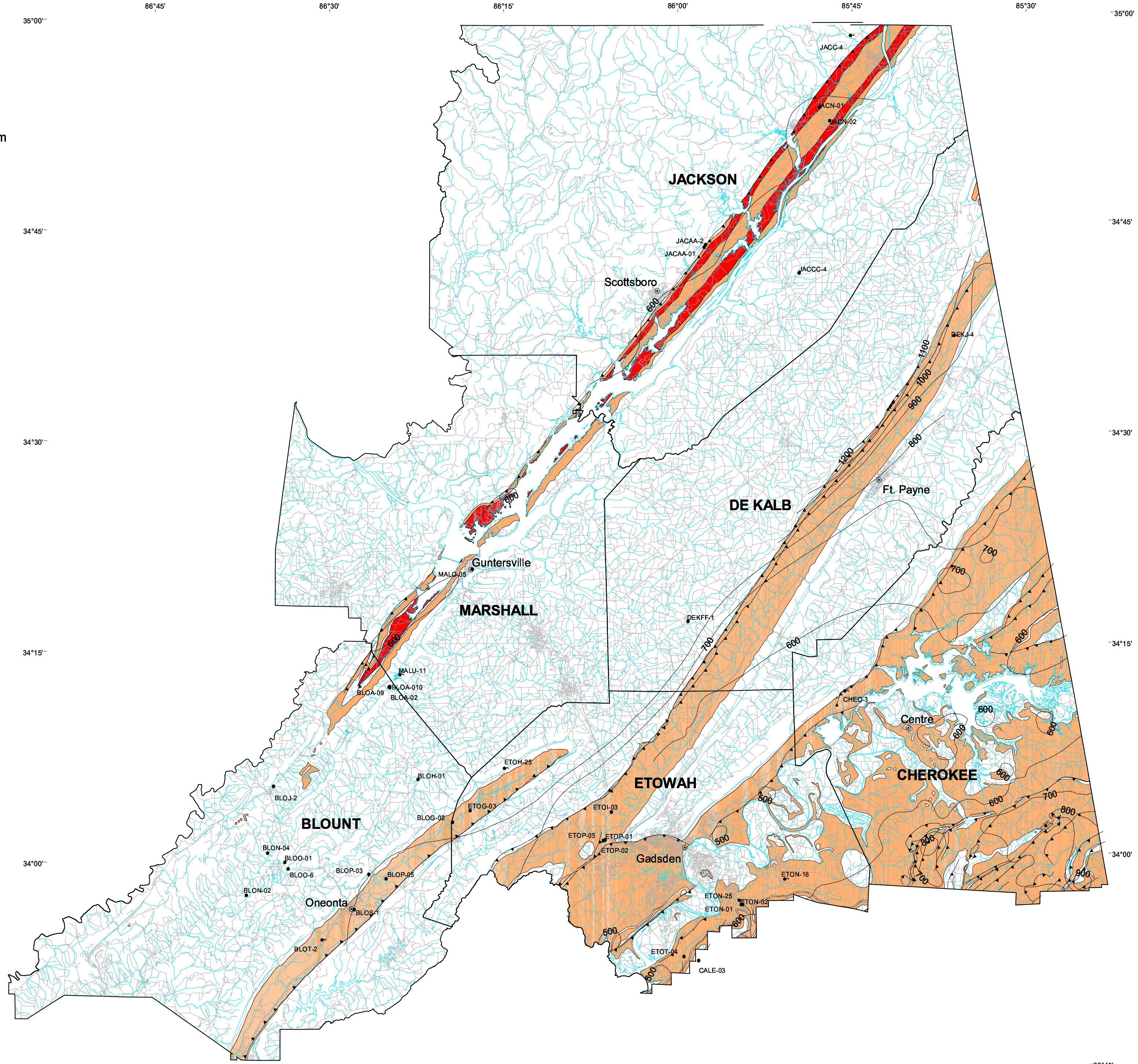
GIS by Ruth T. Collier and Douglas R. Taylor

EXPLANATION

- BLOS-1 Public water supply well or spring number
- • Public water supply well
- Public water supply spring
- Recharge area of the Valley and Ridge aquifer system
- Recharge area of the Nashville-Stones River aquifer
- 500 Potentiometric contours. Datum is mean sea level. Contour interval is 100 feet.
- Thrust or reverse fault, sawteeth on upper plate, dashed where inferred
- Fault for which sense of movement is unknown
- Roads
- Streams
- ⊙ County Seat

INDEX MAP





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SCALE

10 0 10 Miles

POTENTIOMETRIC SURFACE AND RECHARGE AREAS OF THE VALLEY AND RIDGE AQUIFER SYSTEM AND THE NASHVILLE-STONES RIVER AQUIFER IN AREA 2

By David C. Kopaska-Merkel

2003

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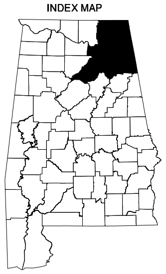
State Geologist

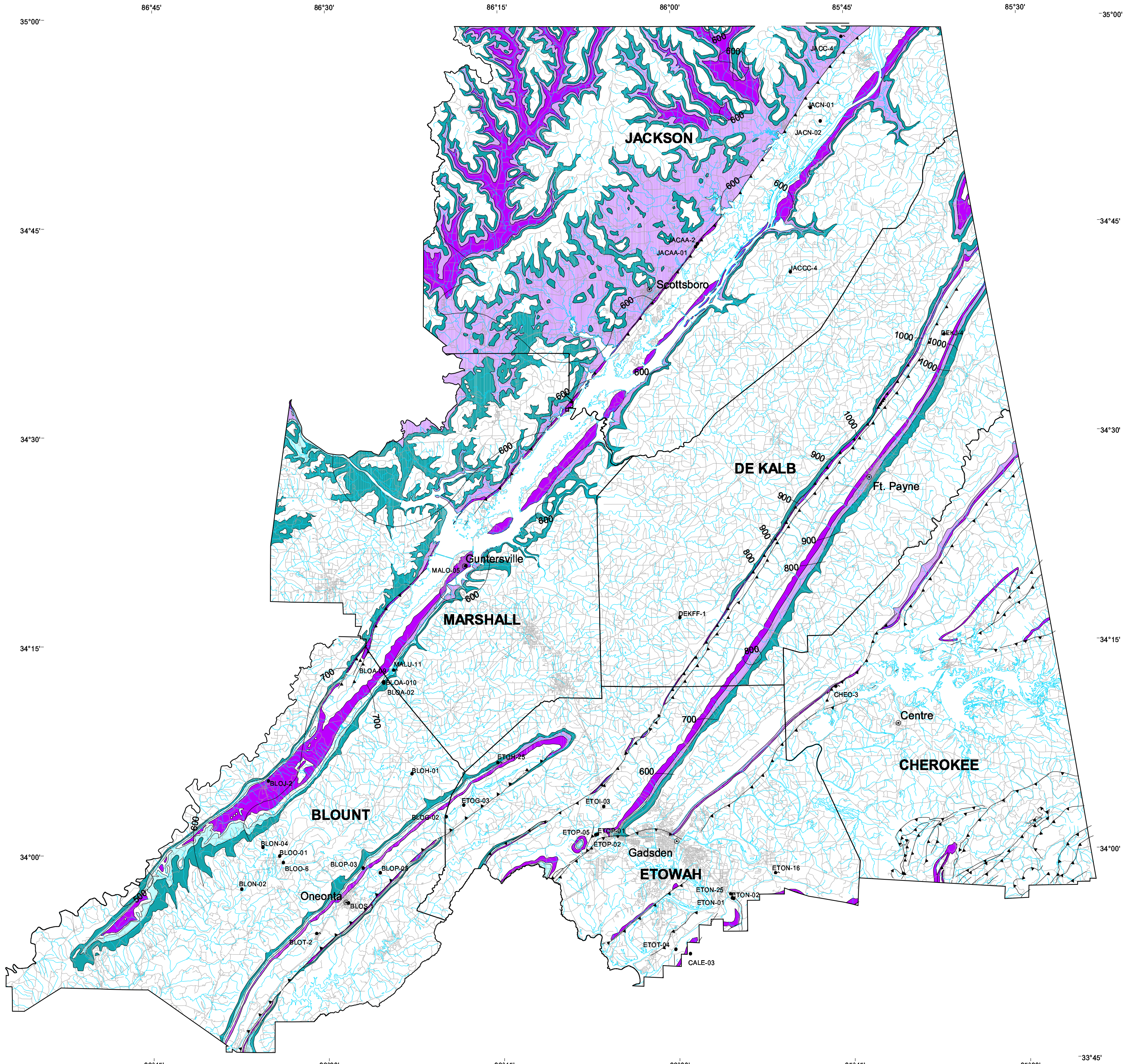
GIS by Ruth T. Collier and Douglas R. Taylor

EXPLANATION

- BLOS-1 Public water supply well or spring number
- Public water supply well
- Public water supply spring
- Recharge area of the Bangor aquifer
- Recharge area of the Hartselle aquifer
- Recharge area of the Monteagle aquifer
- Recharge area of the Fort Payne-Tuscumbia aquifer
- 500 Potentiometric contours. Datum is mean sea level. Contour interval is 100 feet.
- Thrust or reverse fault, sawteeth on upper plate, dashed where inferred
- Fault for which sense of movement is unknown
- Roads
- Streams
- County Seat

INDEX MAP





SCALE
10 0 10 Miles

POTENTIOMETRIC SURFACE AND RECHARGE AREA OF MISSISSIPPIAN AQUIFER SYSTEM (HARTSELLE, BANGOR, AND FORT-PAYNE-TUSCUMBIA AQUIFERS) IN AREA 2

By David C. Kopaska-Merkel

2003

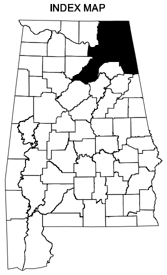
BERRY H. (NICK) TEW, JR.
State Geologist

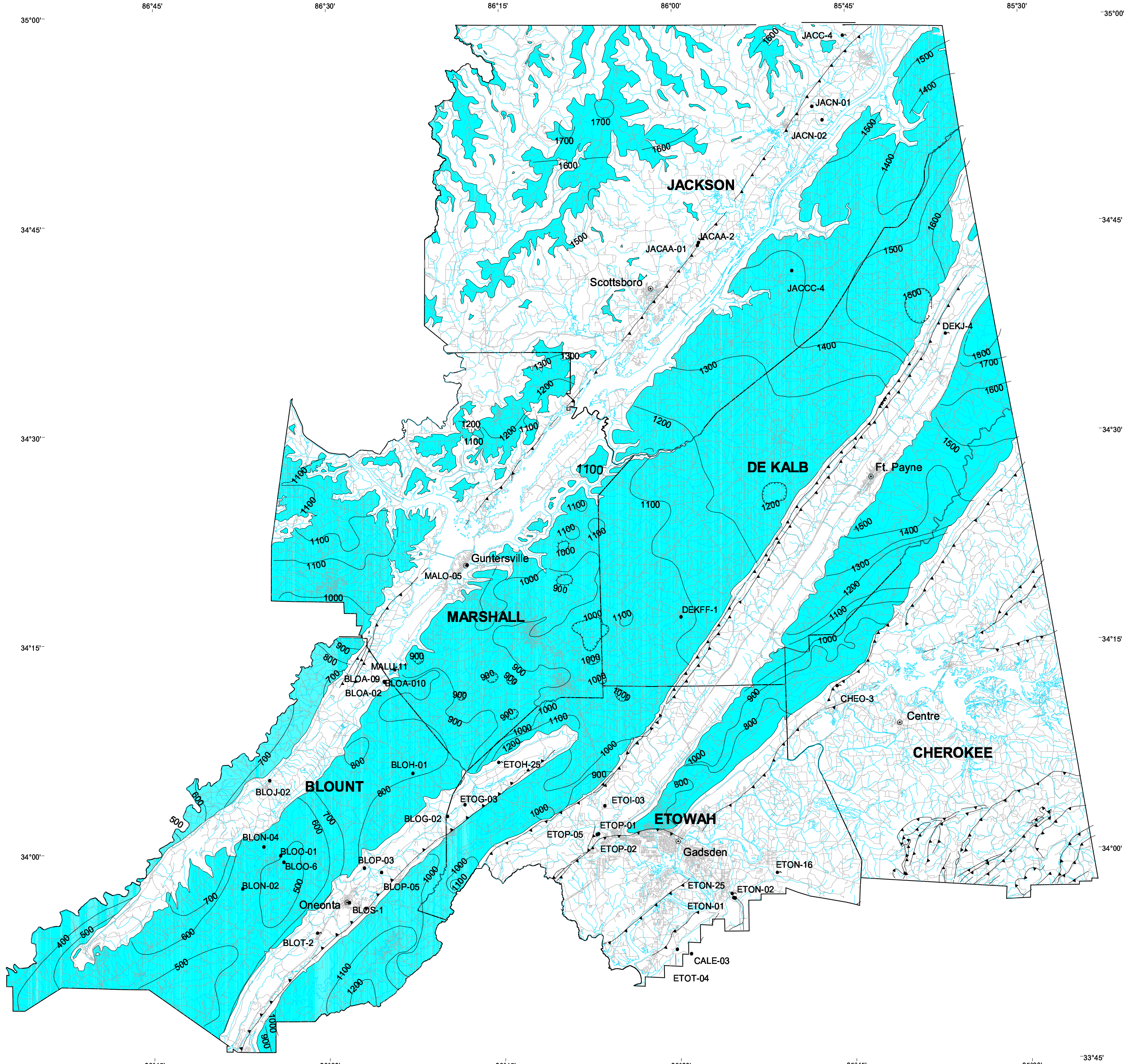
GIS by Ruth T. Collier and Douglas R. Taylor

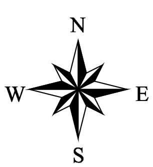
EXPLANATION

- BLOS-1 Public water supply well or spring number
- Public water supply well
- Public water supply spring
- Recharge area of the Pottsville aquifer system
- 500 Potentiometric contours. Datum is mean sea level. Contour interval is 100 feet.
- Thrust or reverse fault, sawteeth on upper plate, dashed where inferred
- Fault for which sense of movement is unknown
- Roads
- Streams
- County Seat

INDEX MAP







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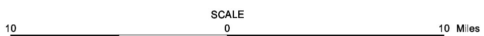


POTENTIOMETRIC SURFACE AND RECHARGE AREA OF POTTSVILLE AQUIFER SYSTEM IN AREA 2

By David C. Kopaska-Merkel

2003

BERRY H. (NICK) TEW, JR.
State Geologist

GIS by Ruth T. Collier and Douglas R. Taylor

EXPLANATION

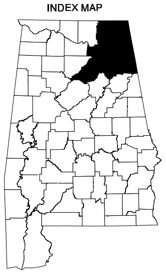
- BLOJ-02 Public water supply well or spring number
- Public water supply well
- Public water supply spring

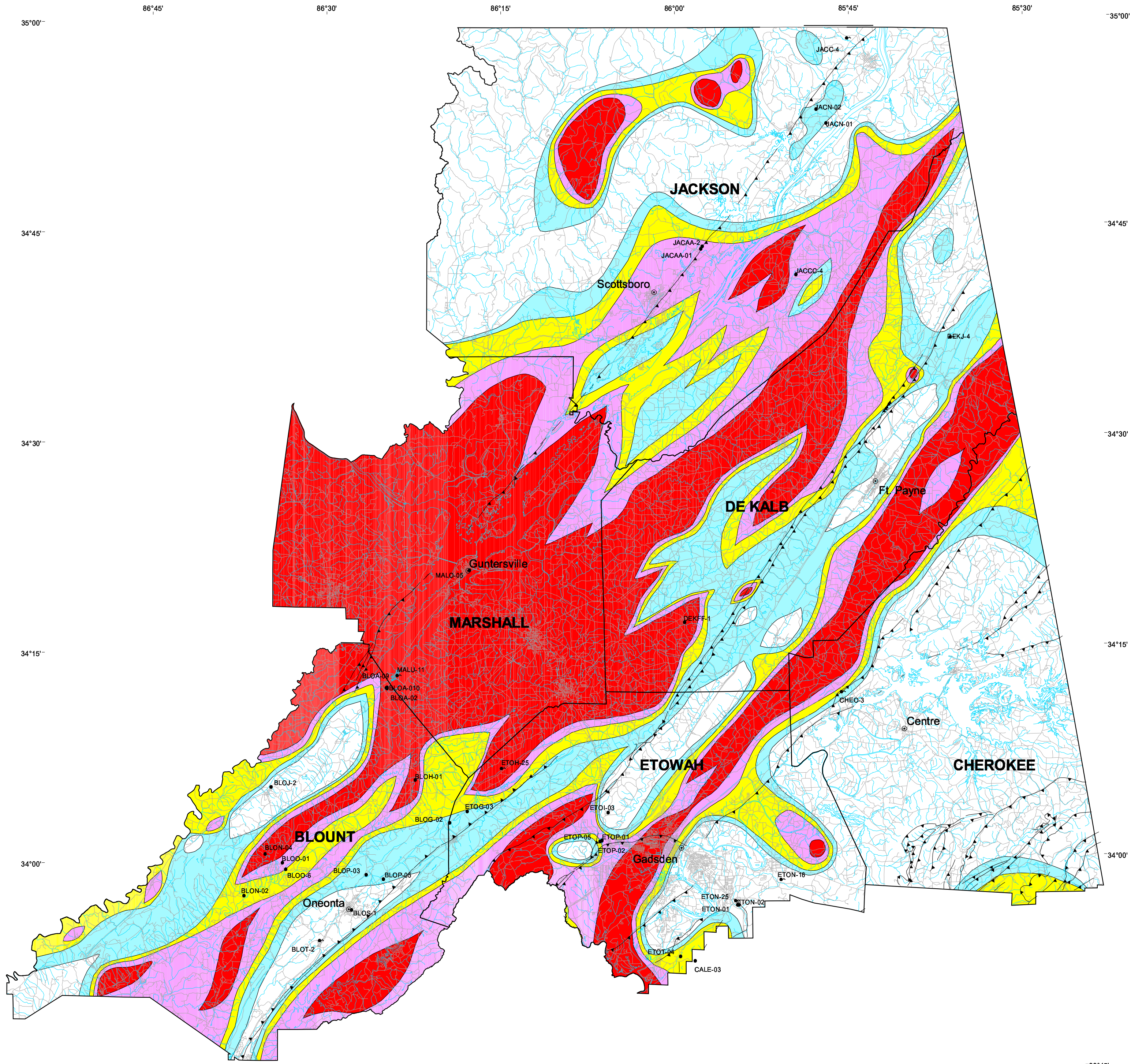
Iron Concentration

- < 0.10 mg/L
- 0.10 - 0.30 mg/L
- 0.30 - 0.50 mg/L
- 0.50 - 1.00 mg/L
- > 1.00 mg/L

- Thrust or reverse fault, sawteeth on upper plate, dashed where inferred
- Fault for which sense of movement is unknown
- Roads
- Streams
- County Seat

INDEX MAP





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SCALE

10 0 10 Miles

CONCENTRATION OF IRON IN SHALLOW GROUND WATER IN AREA 2

By David C. Kopaska-Merkel

2003

BERRY H. (NICK) TEW, JR.
State Geologist

GIS by Ruth T. Collier

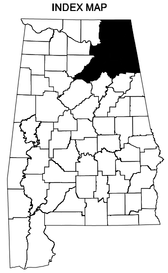
EXPLANATION

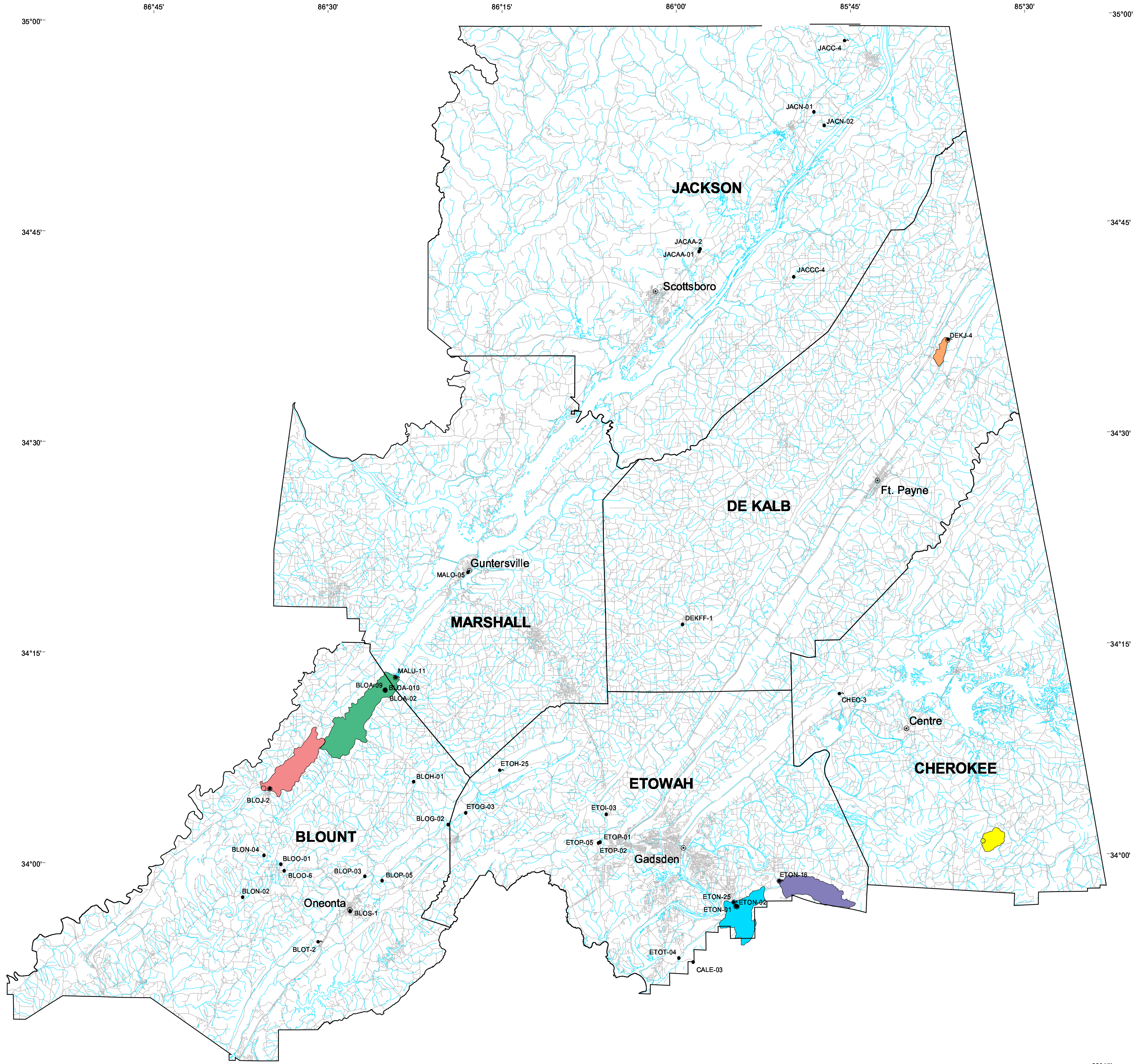
BLOS-1 Public water supply well or spring number
• Public water supply well
Public water supply spring

Wellhead Protection Areas

- Blountsville
- Cherokee County
- Douglas
- Glencoe
- Hokes Bluff
- Valley Head
- Roads
- Streams
- County Seat

INDEX MAP





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SCALE
10 0 10 Miles

LOCATIONS OF SELECTED WATER SUPPLY WELLS AND SPRINGS AND WELLHEAD PROTECTION AREAS IN AREA 2

By David C. Kopaska-Merkel

2003

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GIS by Ruth T. Collier