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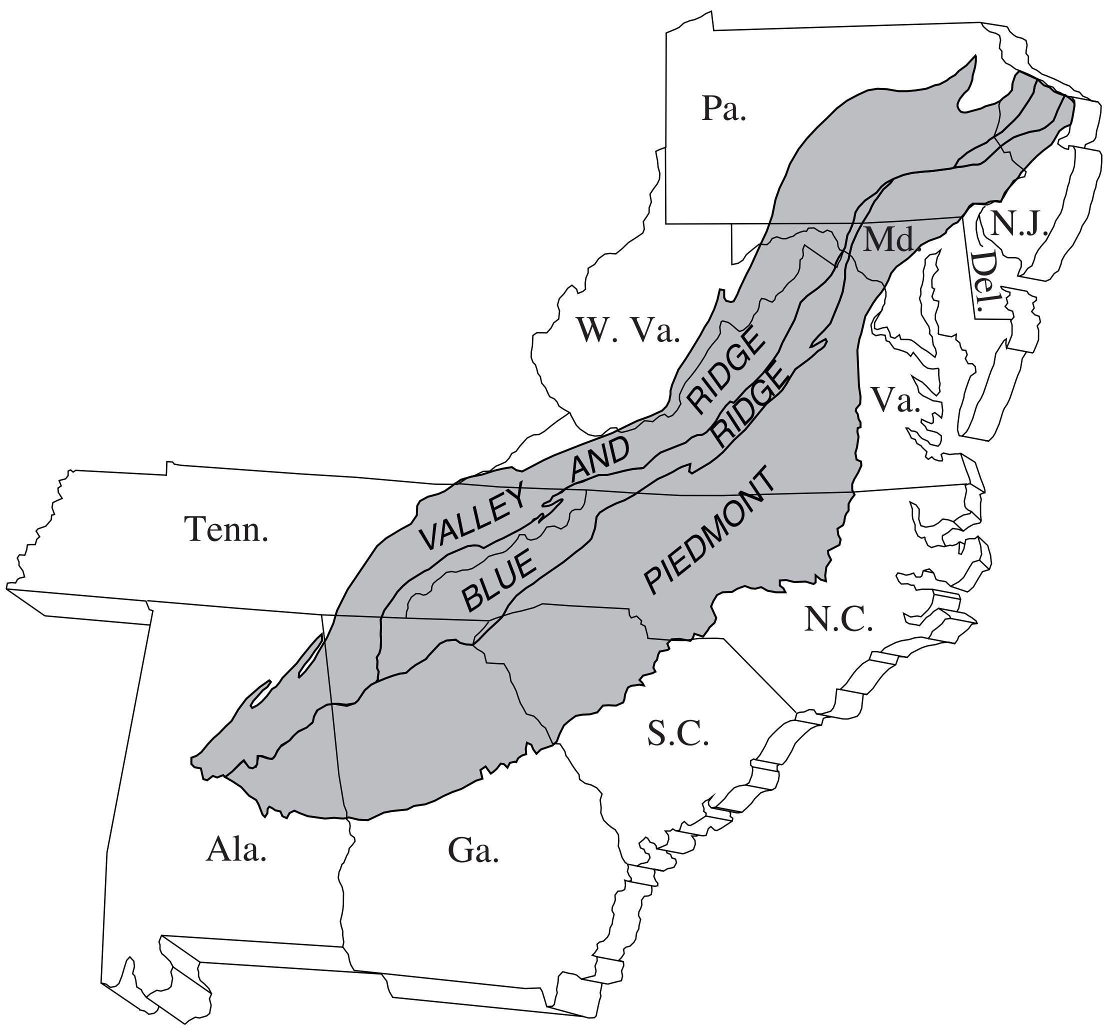
Regional Aquifer-System Analysis

Summary of the Hydrogeology of the Valley and Ridge, Blue Ridge, and Piedmont Physiographic Provinces in the Eastern United States



Professional Paper 1422-A

U.S. Department of the Interior
U.S. Geological Survey

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By Lindsay A. Swain, Thomas O. Mesko, and Este F. Hollyday

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Appalachian Valley and Piedmont

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Foreword

The Regional Aquifer-System Analysis Program

The RASA Program represents a systematic effort to study a number of the Nation's most important aquifer systems, which, in aggregate, underlie much of the country and which represent an important component of the Nation's total water supply. In general, the boundaries of these studies are identified by the hydrologic extent of each system and, accordingly, transcend the political subdivisions to which investigations have often arbitrarily been limited in the past. The broad objective for each study is to assemble geologic, hydrologic, and geochemical information, to analyze and develop an understanding of the system, and to develop predictive capabilities that will contribute to the effective management of the system. The use of computer simulation is an important element of the RASA studies to develop an understanding of the natural, undisturbed hydrologic system and the changes brought about in it by human activities and to provide a means of predicting the regional effects of future pumping or other stresses.

The final interpretive results of the RASA Program are presented in a series of U.S. Geological Survey Professional Papers that describe the geology, hydrology, and geochemistry of each regional aquifer system. Each study within the RASA Program is assigned a single Professional Paper number beginning with Professional Paper 1400.

Charles G. Groat
Director

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Conversion Factors and Horizontal Datum

Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
billion gallons per day (Bgal/d)	3.785	billion liters per day (BL/d)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
gallon per minute per foot [(gal/min)/ft)]	0.2070	liter per second per meter [(L/s)/m]
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)

Water-Quality Unit

milligram per liter (mg/L)

Horizontal coordinate information is referenced to the North American Datum of 1983.

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Abstract

The Appalachian Valley and Piedmont Regional Aquifer-System Analysis study (1988-1993) analyzed rock types in the 142,000-square-mile study area, identified hydrogeologic terranes, determined transmissivity distributions, determined the contribution of ground water to streamflow, modeled ground-water flow, described water quality, and identified areas suitable for the potential development of municipal and industrial ground-water supplies. Ground-water use in the Valley and Ridge, the Blue Ridge, and the Piedmont Physiographic Provinces exceeds 1.7 billion gallons per day.

Thirty-three rock types in the study area were analyzed, and the rock types with similar water-yielding characteristics were combined and mapped as 10 hydrogeologic terranes. Based on well records, the interquartile ranges of estimated transmissivities are between 180 to 17,000 feet squared per day (ft^2/d) for five hydrologic terranes in the Valley and Ridge; between 9 to 350 ft^2/d for two terranes in the Blue Ridge; and between 9 to 1,400 ft^2/d for three terranes in the Piedmont Physiographic Province. Based on streamflow records, the interquartile ranges of estimated transmissivities for all three physiographic provinces are between 290 and 2,900 ft^2/d. The mean ground-water contribution to streams from 157 drainage basins ranges from 32 to 94 percent of mean streamflow with a median of 67 percent. In three small areas in two of the physiographic provinces, more than 54 percent of ground-water flow was modeled as shallow and local. Although ground-water chemical composition in the three physiographic provinces is distinctly different, the water generally is not highly mineralized, with a median dissolved-solids concentration of 164 milligrams per liter, and is mostly calcium, magnesium, and bicarbonate. Based on aquifer properties and current pumpage, areas favorable for the development of municipal and industrial ground-water supplies are underlain by alluvium of glacial origin near the northeastern part of the study area, by clay-free carbonate rocks primarily in the Valley and Ridge Physiographic Province, and by siliciclastic rocks in the three northernmost Mesozoic basins.

Introduction

The aquifers of the Valley and Ridge, Blue Ridge, and Piedmont Physiographic Provinces are a major source of drinking-water supplies in the United States. The aquifers underlie the District of Columbia and parts of 11 States—New Jersey, Delaware, Pennsylvania, Maryland, Virginia, West Virginia, Tennessee, North Carolina, South Carolina, Georgia, and Alabama—a total area of about 142,000 mi^2 (fig. 1). For the purposes of this report, the small area in the New England Physiographic Province that is within the study area in New Jersey and Pennsylvania was treated as part of the Piedmont Physiographic Province. The analysis of aquifers in that part of the Valley and Ridge, New England, and Piedmont Provinces that lie within New York State and the New England States is described in publications of the Northeastern Glacial Valleys Regional Aquifer-System Analysis.

An average annual rainfall of 43 inches provides an average of about 13 inches of recharge to the aquifers of the unglaciated part of the three physiographic provinces. In 1990, the aquifers provided water supplies for about 38 million people in rural households and municipal or county water systems in the area. The larger ground-water supply systems are within Bergen, Morris, Essex, and Union Counties, New Jersey; and Blair, Lehigh, and Montgomery Counties, Pennsylvania. In 1985, about 1.7 Bgal/d were withdrawn from the aquifers for all uses in the study area. Although pumping stresses have produced local cones of depression, almost 90 percent of the study area has no significant ground-water-level decline. However, despite the enormous amounts of untapped water available from the aquifers, sufficient quantities of ground water are not always available to meet local municipal or industrial needs.

During 1988-93, the U.S. Geological Survey (USGS) conducted a Regional Aquifer-System Analysis (RASA) of the aquifers of the Valley and Ridge, Blue Ridge, and Piedmont Physiographic Provinces, which included the review and synthesis of many previous studies and hydrologic data, the acquisition of additional well records, and the extensive use of hydrograph recession analysis and statistical methods to organize and summarize hydraulic and water-quality data. The

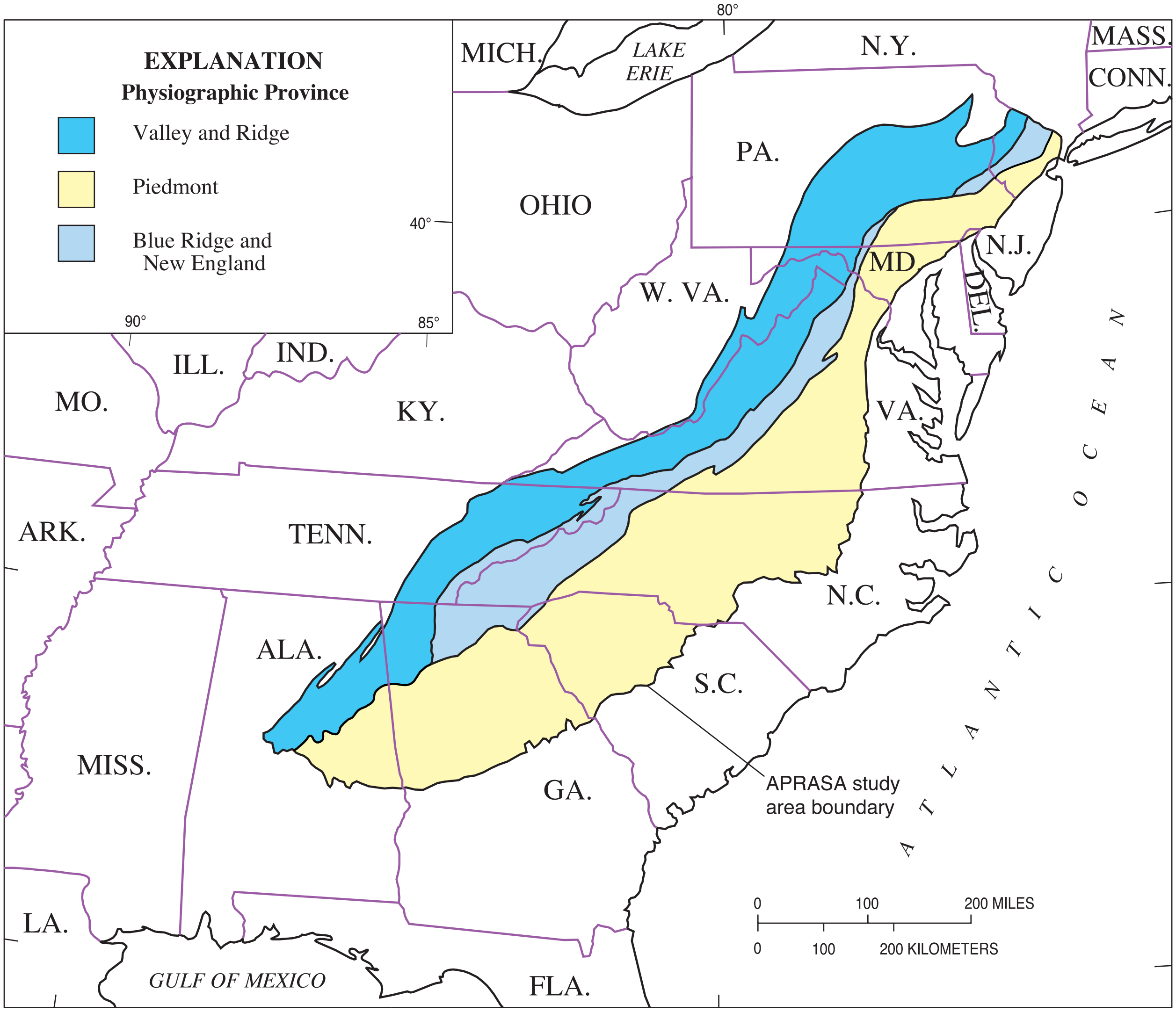

Figure 1. The Appalachian Valley and Piedmont Regional Aquifer-System Analysis (APRASA) study area and physiographic provinces.

Appalachian Valley and Piedmont Regional Aquifer-System Analysis (APRASA), summarized in this report, is one of about two dozen USGS RASA programs that provide quantitative appraisals of the major ground-water systems of the United States.

Background, Major Objectives, and Approach

The aquifer systems of the three physiographic provinces consist of hundreds of aquifers composed of metamorphic, igneous, and sedimentary rock units. Although the ground-water reservoirs in these units typically lack regional continuity, the rock units may be considered to form a complex regional aquifer system that is characterized primarily by local ground-water flow. Ground-water development has not been extensive. Large withdrawals have been concentrated in a few areas—primarily in the more densely populated northeastern part of the study area. In this area, rapid industrial growth and urban expansion have caused all sources of freshwater to be used at or near maximum capacity. Future growth and expansion is expected to cause the same problems in urban areas in the southern and western parts of the study area. Hydrologic processes of recharge, discharge, storage, ground-water flow, and stream-aquifer relations within the three physiographic provinces are poorly understood. This lack of hydrologic understanding is due primarily to the diverse and complex nature of the hydrologic system. The APRASA study advances understanding of the system and provides a basis for more efficient use and management of the ground-water resources in the three physiographic provinces.

Specifically, the objectives of the APRASA study were: (1) to provide a description of the hydrologic framework; (2) to identify the major processes that affect ground-water quantity and quality; (3) to quantify the components of ground-water flow in local “type areas;” (4) to provide regional estimates of the ground-water budget; (5) to determine the relation between surface-water and ground-water flow systems; (6) to provide a description of ground-water quality; and (7) to develop a database to aid in planning, development, and management of the ground-water resources in the three physiographic provinces. The hydrogeologic framework was described in terms of hydrogeologic terranes based on the relation between the hydraulic properties of the rocks and the lithology, structure, topography, or other relevant features. The type areas, where ground-water flow was simulated with digital models, were selected to be representative of the different hydrogeologic terranes and typical combinations of terranes. Within the type areas, emphasis was placed on factors controlling recharge and discharge and on response to ground-water development.

To meet the project objectives, efforts concentrated on the assembly and analysis of the vast amount of data primarily in the National Water Information System (NWIS) database of the USGS including the data for well records, streamflow daily values, water quality, and water use. Prior to the study, much information existed on the geologic framework, and aquifer hydraulic characteristics had been measured in several places. However, the greatest amount of hydrogeologic data and a few ground-water flow models were clustered in the northeast and at widely scattered waste-disposal sites throughout the study area. Data are scarce in many areas where large untapped ground-water supplies exist. A data-collection effort was undertaken to fill data gaps in well records southwest of Pennsylvania and Maryland.

Well records in the Ground-Water Site Inventory (GWSI) database of the USGS for Pennsylvania were analyzed statistically to determine factors related to the water-yielding potential of the rocks in order to classify hydrogeologic terranes (Knopman, 1990; Knopman and Hollyday, 1993). A computer-assisted analysis of streamflow recession was developed to determine recession characteristics, basin diffusivity, and ground-water recharge and discharge (Rutledge, 1998). A computer-assisted method was developed for compiling, analyzing, and plotting large quantities of water-quality data on trilinear diagrams (Briel, 1993). A geographic information system database of well records and mapped geologic units was developed to assist in the classification of hydrogeologic terranes and the analysis of ground-water recharge and discharge (Mesko, 1993).

Purpose and Scope

The APRASA was conducted to describe various aspects of the geology, hydrology, and geochemistry of the aquifers of the Valley and Ridge, Blue Ridge, and Piedmont Physiographic Provinces. This report summarizes important aspects of the hydrogeologic framework, hydraulic properties of the hydrogeologic terranes, typical flow systems, and geochemistry, which are discussed in detail in USGS Professional Papers 1422-B through 1422-D (Rutledge and Mesko, 1996; Hollyday and Hileman, 1996; and Briel, 1997) and USGS Hydrologic Investigations Atlas HA-732-B (Mesko and others, 1999). Emphasis in those four reports is placed on classification and description of hydrogeologic terranes, surface-water and ground-water relations, and ground-water geochemistry. Descriptions of local ground-water flow systems are contained in the following three reports: USGS Water-Resources Investigations Reports 94-4090 (Chichester, 1996) and 94-4147 (Lewis-Brown and Jacobson, 1995), and USGS Water-Supply Paper 2341-C (Daniel and others, 1997).

Professional Paper 1422-B (Rutledge and Mesko, 1996) presents an analysis of streamflow hydrograph recession and base flow in 157 drainage basins in, or partially in, the APRASA study area. The analysis of streamflow recession provides estimates of master recession curves, recession indexes, and transmissivity of the rocks. The recession index is related to basin relief, precipitation, basin latitude, the yield of wells in the basin, and low-flow variables. The base flow analysis provides estimates of ground-water recharge and discharge, and the remaining components of the water budget of each basin. Ground-water recharge and base-flow index also are related to basin relief, precipitation, the well yields in the basin, and low-flow variables.

Professional Paper 1422-C (Hollyday and Hileman, 1996) presents an analysis of geology and records of wells in the Valley and Ridge Physiographic Province, which resulted in a classification and map of hydrogeologic terranes. Specific capacity and median value of reported drawdowns were used to estimate statistical parameters of potential municipal and industrial well yields in the five hydrogeologic terranes.

Hydrologic Investigations Atlas HA-732-B (Mesko and others, 1999) presents an analysis of geology and records of wells in the Blue Ridge and Piedmont Physiographic Provinces, which resulted in a classification and map of hydrogeologic terranes. Reported yields of nondomestic wells were used to estimate statistical parameters of nondomestic well yields in the two hydrogeologic terranes of the Blue Ridge and the three hydrogeologic terranes of the Piedmont Physiographic Provinces.

Professional Paper 1422-D (Briel, 1997) presents an analysis of the major-ion chemistry of water withdrawn from wells, issuing from springs, and from streams in the study area. Comparisons were made by physiographic province and water source. The principal chemical processes that operate in the ground-water flow system are explained using trilinear diagrams.

Summary of Previous Investigations

Hundreds of reports describing the hydrology, geology, and water chemistry of parts of the Appalachian Valley and Piedmont aquifer systems have been published. Many of these reports were used in making the observations described in the RASA series. A few of the reports provided major contributions to the knowledge of the aquifer system and are noted here.

Fuller (1905) related the importance of secondary openings to the storage and movement of ground water, particularly in joints in the crystalline-rock aquifers of the Blue Ridge and Piedmont, in open channels and caverns in the carbonate rocks of the Valley and Ridge, and at greater depth in the fractures and joints in the siliciclastic rocks in the Mesozoic basins of the Piedmont. McGuinness (1963) stated that the rocks of the Piedmont are among the Nation's most reliable aquifers for small yields needed for domestic supply; large yields are not common. McGuiness (1963) concluded that the carbonate rocks of the Valley and Ridge are erratic in the yield of water to wells. For the Piedmont, LeGrand (1967) succinctly summarized ground-water occurrence, flow, water quality, well siting, well hydraulics, and aquifer response to pumping. Parizek and others (1971) combined several papers and articles dealing with ground-water occurrence, flow, and geochemistry in carbonate rocks of the Valley and Ridge in central Pennsylvania. In a study of well yields in the northern quarter of the APRASA study area, Cederstrom (1972) stressed the desirability of relying on the hydrologic analysis of municipal and industrial well records, which he believed represented an effort to develop a maximum supply of water. Trainer and Watkins (1975) developed the concept of combining rock types and soil thicknesses into geohydrologic terranes for the Upper Potomac River Basin. Cressler and others (1983) stated that large well yields are available in the Piedmont near Atlanta, Ga., but only in areas where the rocks have localized increases in permeability, which are associated with selected stratigraphic or structural features.

The National Water Summary for 1984 (U.S. Geological Survey, 1985) provided a uniform discussion, with selected key references, of water use, principal aquifers, and ground-water development and management in each of the 11 states in the APRASA study area. The state geologic maps of each of the 11 states provided a wealth of stratigraphic and structural information. Patchen and others (1985a, b) provided a concise summary of the stratigraphy of the Valley and Ridge Physiographic Province, which allowed correlation of aquifers among states. Daniel (1989) discussed the importance of well diameter, well depth, topography, and the transition zone between regolith and bedrock on large well yields. Swain and others (1991) discussed the geology, hydrology, water use, and water problems in the APRASA study area and presented the planned objectives of and methods for the APRASA study. Daniel and others (1993) edited the proceedings from the first conference on ground water in the Piedmont. The proceedings contains more than 60 papers covering a vast variety of topics that deal with quantity and quality of ground water in the Piedmont.

Finally, the greatest source of information on the aquifer systems is contained in the hundreds of reports published by the 11 states and in USGS Open-File Reports and Water-Resources Investigations Reports series. Many of these studies were conducted by the USGS in cooperation with various State, county, and municipal governments. These reports and supporting computer files provide the basic hydrologic data, as well as interpretations of the local hydrology, without which, this regional study could not have been successfully completed.

Hydrogeologic Terranes

Hydrogeologic terranes, rather than aquifers and confining units, were identified because of the complexity of the geology in the APRASA study area. For the purpose of this study, a hydrogeologic terrane is defined as a regionally mappable area characterized by similar water-yielding properties in a grouping of selected rock types. The term "terrane" was used because the original intent was to include climatic, geomorphic, and pedologic variables, in addition to bedrock lithology, in the analysis. Five hydrogeologic terranes were identified in the Valley and Ridge, three in the Piedmont, and two in the Blue Ridge Physiographic Provinces.

The Valley and Ridge, Blue Ridge, and Piedmont Physiographic Provinces are underlain by metamorphic, igneous, and sedimentary rocks; gneiss, schist, granite, and siliciclastic sedimentary rock underlie almost two-thirds of the study area. Following faulting and folding, as well as one or more periods of metamorphism and igneous intrusion of the rocks in most of the study area, the entire area was uplifted during the Cenozoic Era. Subsequent weathering and erosion enlarged existing fractures in the bedrock and may have created new fractures by stress relief.

The water-storage and transmissive characteristics of the bedrock and regolith, and the hydraulic connection between the bedrock and regolith determine the water-supply potential of the hydrogeologic terranes (fig. 2). Because of the relatively high porosity of the regolith, most recharge is stored in this unit and is released slowly to underlying bedrock fractures. Because fractures and dissolution openings in the bedrock are conduits for ground-water flow, well yields are greatest where wells intersect fractures or dissolution openings that are large, numerous, or both. Under natural (pre-pumping) conditions, most ground-water flow is within 200 feet below land surface. However, an analysis of well records in seven areas of the Piedmont Physiographic Province indicated that four of these seven areas have average well yields that are substantially greater for wells completed between 400 and 600 feet below land surface compared with wells completed between 100 and 200 feet below land surface (Mesko and others, 1999).

Hydrogeologic terranes were classified within each of the three physiographic provinces by relating rock type, as described in State geologic maps, to records of either specific capacity or well yields in the GWSI database. State geologic maps were scanned, edited, and annotated to produce coverages of the mapped occurrence of each geologic unit in the study area. Geologic units with the same rock type were merged to create a coverage of more than 50 rock types. Records of 62,345 wells in the APRASA part of the three physiographic provinces were retrieved from the GWSI database for each State. Values of either specific capacity (Valley and Ridge) or yield (Blue Ridge and Piedmont) were retrieved from each well record, grouped by province and rock type, and analyzed to derive statistical characteristics of specific capacity or yield for 33 rock types for which these data were sufficiently numerous for

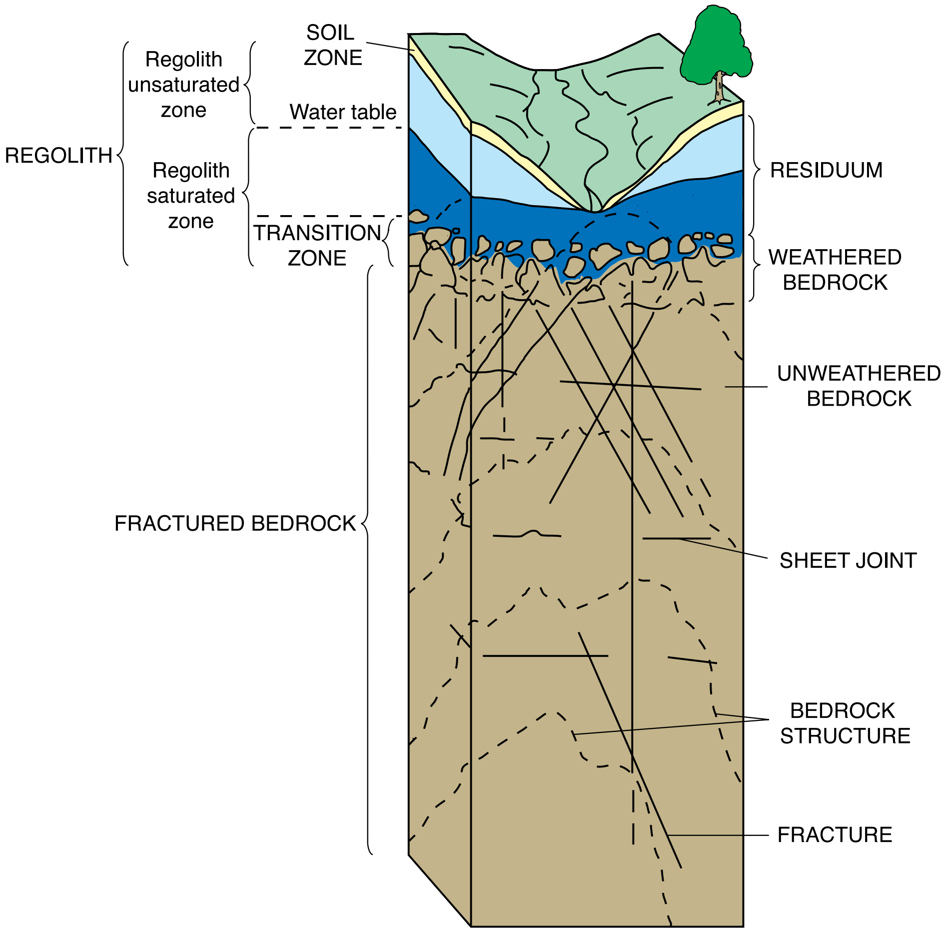

Figure 2. Principal hydrogeologic components of regolith and bedrock in the Valley and Ridge, Blue Ridge, and Piedmont Physiographic Provinces. (From Daniel and others, 1997, fig. 4.)

statistical analysis. For each physiographic province, the rock types were then ranked in order of increasing specific capacity or yield and grouped into two or more hydrogeologic terranes according to selected ranges in median specific capacity (Valley and Ridge) or median yield (Blue Ridge and Piedmont).

For the Valley and Ridge, potential well yields were estimated by multiplying the values of specific capacity by the medians of reported drawdowns for municipal and industrial wells. Included in these estimates were all records of municipal and industrial wells with casing diameter equal to, or greater than, 7 inches that were located in valleys. The interquartile ranges in estimated potential yields of these most-productive wells in the five hydrogeologic terranes of the Valley and Ridge were 70 to 280 gal/min for siliciclastic rock, 65 to 850 gal/min for argillaceous carbonate rock, 80 to 720 gal/min for limestone, 210 to 1,400 gal/min for dolomite, and 170 to 580 gal/min for alluvium (Hollyday and Hileman, 1996). For the Blue Ridge, the interquartile ranges in reported yields of nondomestic wells in the two hydrogeologic terranes were 8 to 32 gal/min for gneiss-granite, and 10 to 61 gal/min for schist-sandstone (Mesko and others, 1999). For the Piedmont, the interquartile ranges in reported yields of nondomestic wells in the three hydrogeologic terranes were 5 to 20 gal/min for phyllite-gabbro, 10 to 60 gal/min for gneiss-schist, and 35 to 220 gal/min for shale-sandstone.

Hydrogeologic terranes were mapped (fig. 3) by assigning rock types to the appropriate hydrogeologic terrane based on specific capacity (Valley and Ridge) or yield (Blue Ridge and Piedmont). The dolomite hydrogeologic terrane in the Valley and Ridge Physiographic Province has the largest median potential well yield and is predominantly dolomite with limestone in widely distributed valleys of Alabama, Georgia, and Tennessee, and in valleys primarily along the southeastern margin of the Valley and Ridge in Maryland, New Jersey, Pennsylvania, Virginia, and West Virginia (fig. 3). The shale-sandstone hydrogeologic terrane in the Piedmont Physiographic Province has the largest median well yield of any hydrogeologic terrane in either the Blue Ridge or Piedmont Physiographic Provinces and is predominantly shale, sandstone, and siltstone in the Mesozoic basins in Maryland, New Jersey, Pennsylvania, and Virginia.

Hydrogeologic terranes with intermediate values of transmissivity may act as either an aquifer or a confining unit to an adjacent hydrogeologic terrane depending upon their relative transmissivities. Geologic structure is complex within the study area, and faults and folds, as much as stratigraphic position, may determine which hydrogeologic terranes are aquifers or confining units within a local structural setting (fig. 3).

Hydraulic Properties

The hydraulic properties of the terranes of the study area were estimated from well and streamflow data compiled from various sources and published reports describing the hydrogeologic characteristics of geologic units within the terranes. The sources of well data included site inventories by project staff, published reports, unpublished USGS well data, and data from the GWSI database in NWIS. The source of mean-daily streamflow data was the USGS data in NWIS.

Storage Coefficient and Specific Yield

A storage coefficient of 0.0005 was used for estimating the transmissivity of the hydrogeologic terranes from the specific

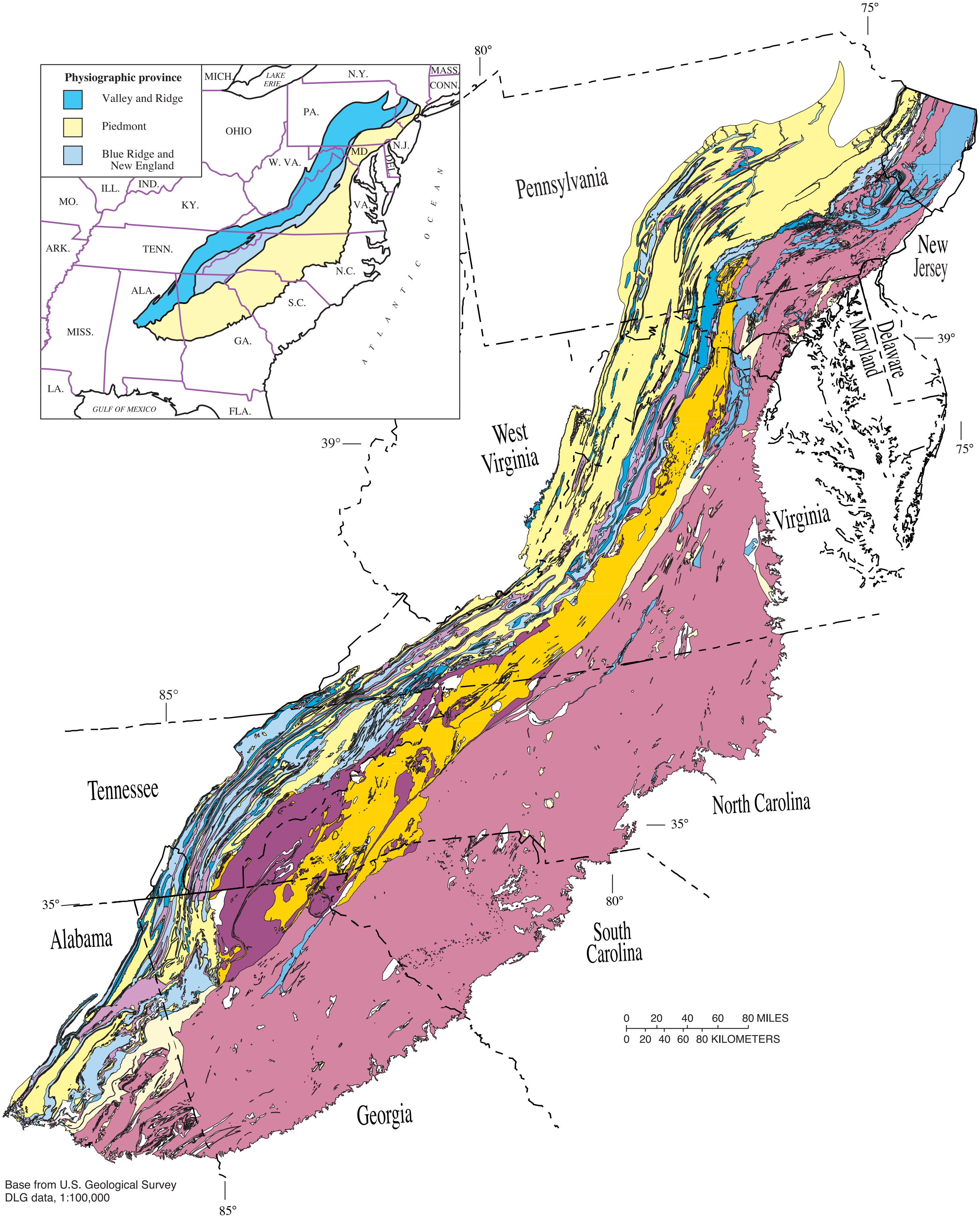

Figure 3. Hydrogeologic terranes of the Valley and Ridge, Blue Ridge, and Piedmont Physiographic Provinces in the Eastern United States.

EXPLANATION

Description of hydrogeologic terranes—The sequence of units is not intended to imply stratigraphic position. See State geologic maps for stratigraphic position among geologic units in the hydrogeologic terranes.

Valley and Ridge Physiographic Province

Siliciclastic rock hydrogeologic terrane—Interquartile range in estimated potential yield to most-productive wells 70 to 280 gal/min. Includes geologic units that are predominantly shale with little or no carbonate content, claystone, siltstone, sandstone, and conglomerate that consists of clay minerals, quartz grains, or siliceous rock fragments

Argillaceous carbonate rock hydrogeologic terrane—Interquartile range in estimated potential yield to most-productive wells 65 to 850 gal/min. Includes geologic units that are predominantly clay-rich dolomite or limestone, as well as shale units that contain abundant calcite or magnesium calcite

Limestone hydrogeologic terrane—Interquartile range in estimated potential yield to most-productive wells 80 to 720 gal/min. Includes geologic units that are predominantly limestone and limestone with less than 30 percent dolomite

Dolomite hydrogeologic terrane—Interquartile range in estimated potential yield to most-productive wells 210 to 1,400 gal/min. Includes geologic units that are predominantly dolomite, a combination of dolomite and sandstone or chert, and dolomite and limestone with as much as 70 percent limestone

Alluvium hydrogeologic terrane—Interquartile range in estimated potential yield to most-productive wells 170 to 580 gal/min. Includes geologic units that are predominantly alluvium, outwash, and stratified drift in and adjacent to the glacial margin in northern New Jersey and northern and eastern Pennsylvania

Blue Ridge Physiographic Province

Gneiss-granite hydrogeologic terrane—Interquartile range in yield to nondomestic wells 8 to 32 gal/min. Includes geologic units that are predominantly basalt, gneiss, granite, phyllite, rhyolite, and shale

Schist-sandstone hydrogeologic terrane—Interquartile range in yield to nondomestic wells 10 to 61 gal/min. Includes geologic units that are predominantly amphibolite, dolomite, limestone, quartzite, sandstone, and schist

Piedmont Physiographic Province

Phyllite-gabbro hydrogeologic terrane—Interquartile range in yield to nondomestic wells 5 to 20 gal/min. Includes geologic units that are predominantly gabbro, greenstone, phyllite, and serpentine

Gneiss-schist hydrogeologic terrane—Interquartile range in yield to nondomestic wells 10 to 60 gal/min. Includes geologic units that are predominantly argillite, conglomerate, diabase, diorite, gneiss, granite, gravel, limestone, metavolcanics, mudstone, quartzite, sand, schist, tuff, and volcanics

Shale-sandstone hydrogeologic terrane—Interquartile range in yield to nondomestic wells 35 to 220 gal/min. Includes geologic units that are predominantly basalt, dolomite, graywacke, marble, sandstone, shale, and siltstone

Valley and Ridge, Blue Ridge, and Piedmont Physiographic Provinces

Hydrogeologic terranes not defined—Includes geologic units whose rock type had fewer than ten samples of either specific capacity or well yield or whose lithologic composition was too varied to assign a rock type. Also includes a few areas within the Valley and Ridge near the boundary with the Blue Ridge or the Piedmont that contain geologic units that are commonly associated with these latter two provinces

capacity of wells (Theis and others, 1963). This value is about an order of magnitude lower than the median value of storage coefficient reported by Trainer and Watkins (1975, table 2, p. 18) from aquifer tests in the carbonate and siliciclastic rocks of the Valley and Ridge, the Blue Ridge, and the Piedmont Physiographic Provinces in the Potomac River Basin. The value is within the mid-range of values of storage coefficient reported by Lewis-Brown and Jacobsen (1995, table 3, p. 19) for siliciclastic sedimentary rocks in the Newark Basin of New Jersey. The value is less than an order of magnitude higher than the storage coefficient selected by Daniel and others (1997, p. C58) for estimating the transmissivity of fractured gneiss and schist in the Piedmont of North Carolina.

The storage coefficient of granular material, including regolith, under water-table conditions is equal to the specific yield. A range in specific yield from 0.01 to 0.08 (Rutledge and Mesko, 1996, p. B15) was used for estimating the transmissivity of the rocks in the three physiographic provinces from stream-basin diffusivity methods (Rorabaugh and Simons, 1966). This range corresponds to the 25th and 75th percentiles in a distribution of 21 values of specific yield taken from published reports (Rutledge and Mesko, 1996, table 5, p. B18).

Transmissivity from Specific Capacity of Wells

Values of specific capacity were converted to estimates of transmissivity (fig. 4) by using the method described by Theis and others (1963). Percentile values of specific capacity of municipal and industrial wells in the Valley and Ridge Physiographic Province (Hollyday and Hileman, 1996, fig. 12, p. C21) and nondomestic wells in the Blue Ridge and Piedmont Physiographic Provinces (Mesko and others, 1999, fig. 5) were selected from boxplots of the distribution of specific-capacity values of wells in the 10 hydrogeologic terranes. The nondomestic wells recorded in GWSI for the study area are primarily used for municipal, industrial, and commercial water supply. The inclusion of water uses other than municipal and industrial in the nondomestic category would tend to lower the values of transmissivity compared to values derived from municipal and industrial data alone.