GEOLOGY AND GROUND-WATER RESOURCES
of the
MORGANTON AREA
NORTH CAROLINA

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GROUND WATER BULLETIN NUMBER 12

NORTH CAROLINA
DEPARTMENT OF WATER RESOURCES
George E. Pickett, *Director*

Division of Ground Water
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PREPARED COOPERATIVELY BY THE GEOLOGICAL SURVEY
UNITED STATES DEPARTMENT OF THE INTERIOR
AND THE
NORTH CAROLINA DEPARTMENT OF WATER RESOURCES

MARCH 1967

STATE OF NORTH CAROLINA
DEPARTMENT OF WATER RESOURCES

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March 20, 1967

The Honorable Dan K. Moore
Governor of North Carolina
Raleigh, North Carolina

Dear Governor Moore:

I am pleased to submit Ground-Water Bulletin Number 12, "Geology and Ground-Water Resources of the Morganton Area, North Carolina" by Carlton T. Sumsion and R. L. Laney.

This report contains the results of an investigation made by the U. S. Geological Survey in cooperation with the North Carolina Department of Water Resources as a part of the series of reconnaissance studies to provide a general evaluation of ground-water conditions in all parts of the State. It presents the data collected and describes the general geology and the occurrence, availability and quality of ground water in Avery, Burke, Caldwell, McDowell, Mitchell, Watauga, and Yancey counties.

This report is a valuable contribution to the knowledge of the geology and hydrology of the area, and will be available to all persons and agencies concerned with development and management of ground-water supplies.

Respectfully submitted,

George E. Pickett

George E. Pickett

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GEOLOGY AND GROUND-WATER RESOURCES OF THE MORGANTON AREA, NORTH CAROLINA

By

Carlton T. Sumsion

ABSTRACT

The Morganton area, located in the west-central part of North Carolina, comprises Avery, Burke, Caldwell, McDowell, Mitchell, Watauga, and Yancey Counties. The area includes 2,522 square miles apportioned between the Blue Ridge and inner Piedmont physiographic provinces. From southeast to northwest, the topographic relief of gentle hills and broad valleys of the inner Piedmont gives way to the steep eastern front of the Blue Ridge, beyond which more subdued slopes toward the west prevail. Streams and drainage courses are of geologically subsequent development on fracture systems which have clearly defined patterns throughout most of the area.

Metamorphic and igneous rocks underlying the area range in composition from quartzite to gabbro. Gneissic, schistose, pyroclastic, and quartzitic rocks are the most prominent lithologic types. Structural trends in the area are varied, but generally are oriented north to northeast.

Ground water is obtained from weathered rock or saprolite and alluvium by dug and bored wells. Drilled wells derive ground water from joint and shear openings in unweathered bedrock. Wells drilled in low, flat areas and narrow, linear valleys have greater yields than wells drilled on high ground or slopes. The present rate of ground-water withdrawal has only local effect on the height of the water table. The amount of ground water contained in bedrock decreases with depth, hence drilling wells deeper than about 300 feet usually will not substantially increase well yields.

One-hundred and ten water analyses are used to determine the chemical quality of the ground water in the Morganton area. Generally, ground water is slightly acid, contains less than 150 ppm dissolved solids, is soft (less than 50 ppm hardness as $CaCO_3$), and contains less

than 0.3 ppm iron. Due to differences in duration of water-rock contact, dissolved solids are highest in water from drilled wells and dug wells and least in water from springs. Based on concentrations of chloride and nitrate, dug wells are considerably more susceptible to contamination than springs or drilled wells in the Morganton area.

Chemical analyses of ground water in the Morganton area can be divided into five types by use of pattern diagrams. Ground-water types can be mapped but are shown to extend across and change within boundaries of rock units.

INTRODUCTION

Purpose and Scope

The principal objectives of this investigation were to evaluate the occurrence, quality, and availability of ground water on a reconnaissance basis in seven counties of western North Carolina. The Morganton area project comprises Avery, Burke, Caldwell, McDowell, Mitchell, Watauga, and Yancey Counties. Data for ground-water occurrence were obtained from representative well and spring inventories throughout the area. Maximum and minimum water-level fluctuations and spring-discharge measurements were determined periodically for 63 observation wells and springs in the area. Samples of ground water for chemical analyses were collected from observation wells and springs and other selected wells supplying domestic, municipal, and industrial water systems. Water analyses were used to establish a relationship between chemical characteristics of the water and the rock type from which the water was obtained. Reconnaissance geologic mapping throughout the area in 1961 and 1962 made use of the rock exposures in road cuts, railroad cuts, quarries, barrow pits, stream-bank exposures, and similar large, unconcealed outcrops. North Carolina State Highway Commission county road maps, 2.65 miles per inch, were transferred to Geological Survey 1:250,000 scale series topographic maps for publication.

Previous Work

No previous ground-water investigations have been made in this area. This investigation was made by the Branch of Ground Water, U. S. Geological Survey, in cooperation with the North Carolina Department of Water Resources. The report was prepared under the general supervision of O. Milton Hackett, Chief, Branch of Ground Water, U. S. Geological Survey, and the immediate supervision of P. M. Brown, District Geologist, Branch of Ground Water, U. S. Geological Survey.

Acknowledgments

Grateful acknowledgment is made to the many cooperative individuals who contributed data for the well and spring inventories and provided other useful information. Well and spring inventories were, in part, collected by Tom Durham and Lannie Wilson, field assistants.

GEOGRAPHY

Location and Extent of Area

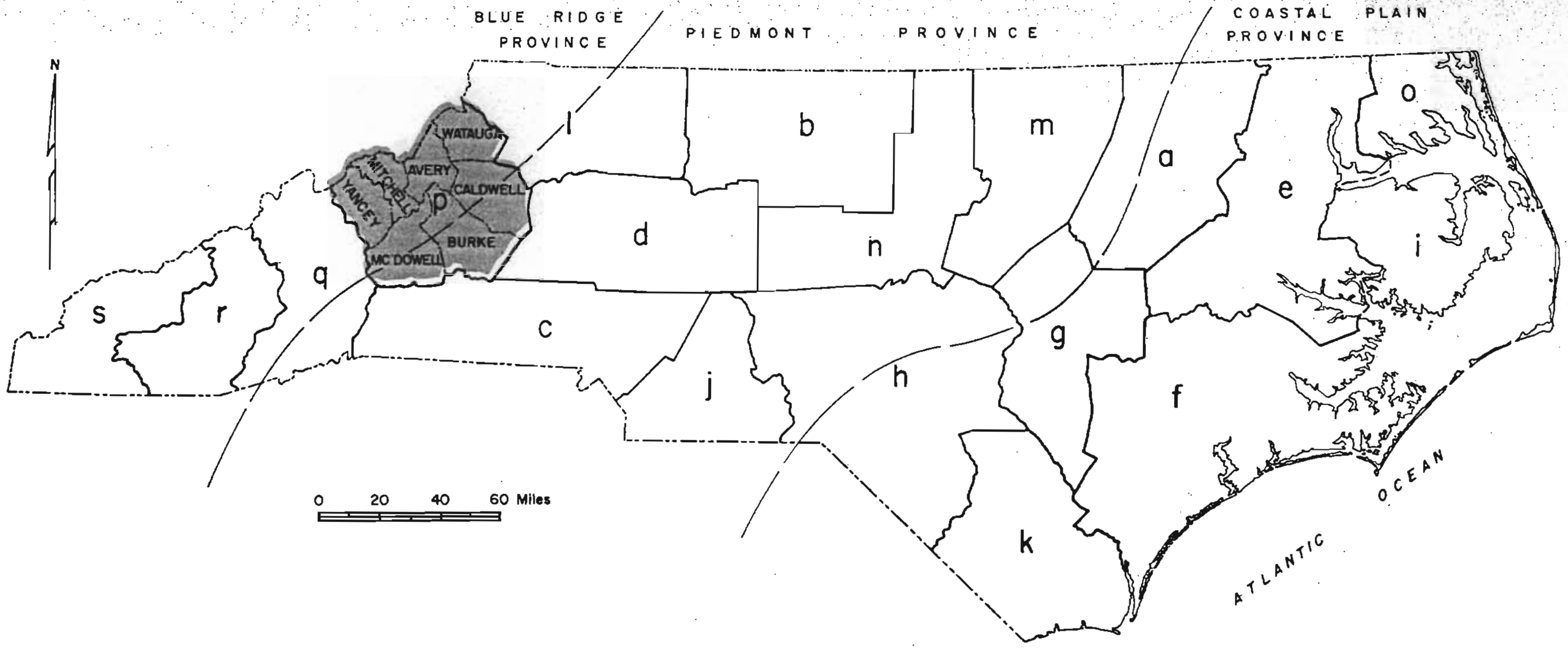
The seven counties described by this report comprise an area of 2,522 square miles of western North Carolina between 35° 32' and 36° 08' north latitude, and between 81° 20' and 82° 30' west longitude (fig. 1). The area is accessible by interstate and state highway systems, and by numerous paved or graded secondary roads. The Blue Ridge Parkway traverses the area from southwest to northeast.

Population and Economy

According to the U. S. Bureau of the Census the seven counties had a total population of 186,447 in 1960. The largest town in the area is Lenoir, county seat of Caldwell County, with a population of 10,257. The economy of the area is predominately agricultural with 592,000 acres or 36.7 percent of the total area occupied by farms. Tobacco, poultry, corn, and livestock are the principal farm products. The production of timber and other forest products supplement the farming economy. Mining industries in the Spruce Pine district of Avery, Mitchell, and Yancey Counties produce feldspar, mica, and kaolin in commercial quantities. Manufacturing, mainly of textiles and furniture, is localized in the larger towns.

Climate

Climatic data were derived from 9 offices of the U. S. Weather Bureau which provided continuous records through 1961 and 1962 in the Morganton area. Mean annual values for temperature, 51.5° F., and precipitation, 59.71 inches, in the Blue Ridge part of the area were provided by 6 weather stations. For the inner Piedmont part of the area, 3 weather stations reported a mean annual temperature of 58.2° F. and a mean annual precipitation of 52.12 inches. The highest average seasonal temperatures and precipitation occur in June, July, and August, and lowest temperatures are in January. September and October have the lowest mean monthly precipitation in the Morganton area (figs. 2 and 3).



a. Halifax area, Bulletin 51
b. Greensboro area, Bulletin 55
c. Charlotte area, Bulletin 63
d. Statesville area, Bulletin 68
e. Greenville area, Bulletin 73
f. Wilmington area, Ground-Water Bulletin 1
g. Goldsboro area, Ground-Water Bulletin 2
h. Fayetteville area, Ground-Water Bulletin 3
i. Swanquarter area, Ground-Water Bulletin 4
j. Monroe area, Ground-Water Bulletin 5
k. Southport area, Ground-Water Bulletin 6
l. Northwestern N.C. area, report in preparation
m. Raleigh area, report in preparation
n. Durham area, report in preparation
o. Elizabeth City area, report in preparation
p. Morganton area, described in this report
q. Asheville area, report in preparation
r. Waynesville area, report in preparation
s. Murphy area, report in preparation

Figure 1. Index map of North Carolina showing area of investigation by counties and physiographic divisions.

Physiography

The Morganton area lies within two major physiographic provinces; the inner Piedmont province and the Blue Ridge province. Burke, Caldwell, and McDowell Counties lie within both provinces. By definition the boundary of the provinces is at the foot of the mountains where the altitude is approximately 1,300 to 1,500 feet above mean sea level. The inner Piedmont is of gentle to moderate relief, with hills resembling monadnocks widely separated by peneplaned valleys. The topography of the Piedmont contrasts with the steep gradients and dissected ridges of the eastern Blue Ridge front. In the Blue Ridge part of the area, altitudes range from about 1,300 feet near Lake James to 6,684 feet on the summit of Mt. Mitchell. Greatest topographic relief is along the eastern front of the Blue Ridge province, where high-gradient drainage systems are tributary to the Catawba and Yadkin Rivers. The Blue Ridge topography west of the front consists mainly of subdued hills, and is of more moderate relief. Avery, Mitchell, and Yancey Counties, west of the Blue Ridge front, are drained by generally northwest-flowing streams (pl. 1). Relationships of drainage patterns to geologic features indicate that most of the streams are of subsequent development.

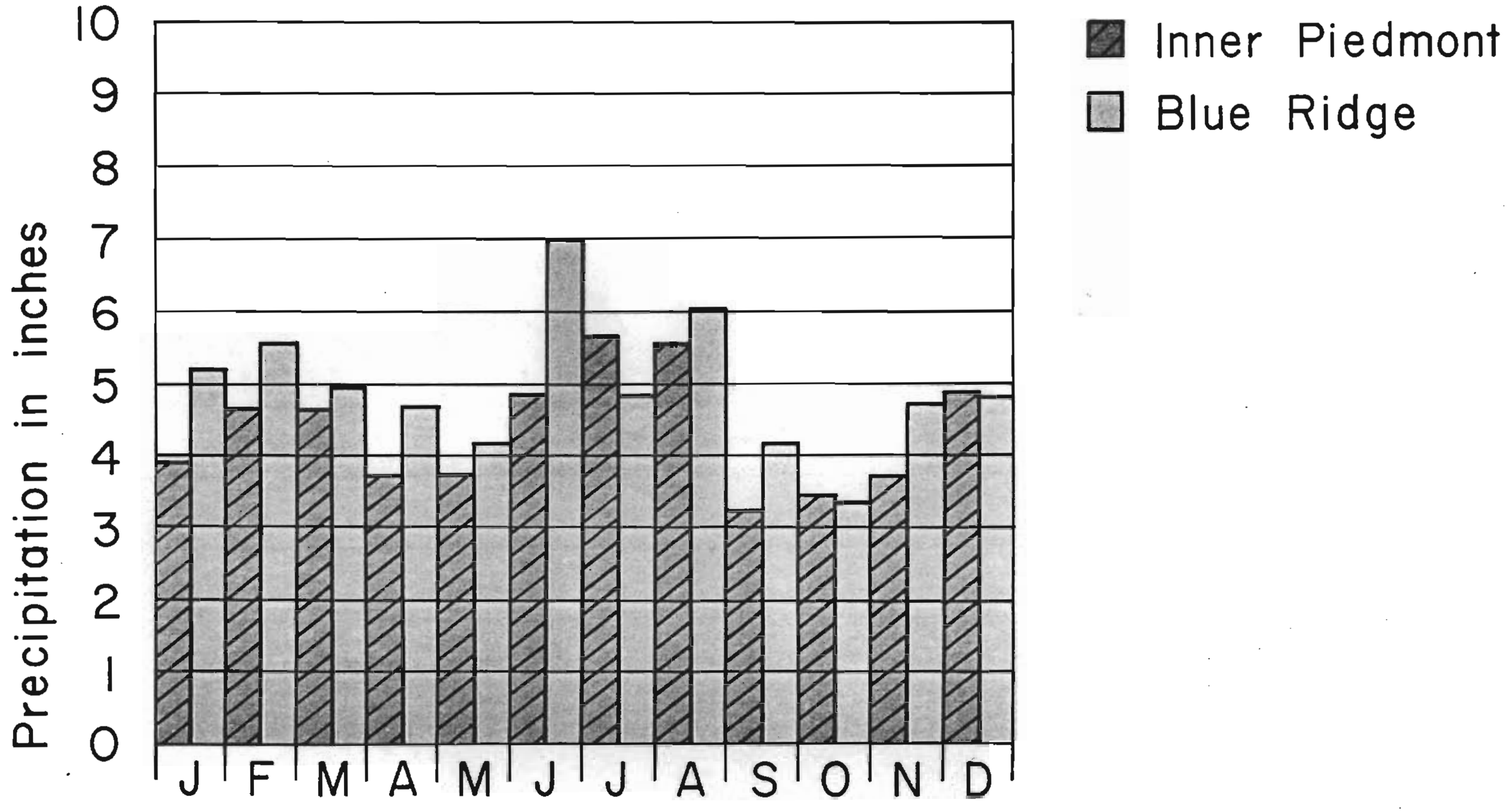


Figure 2. Mean monthly precipitation, Morganton area, 1961-62.

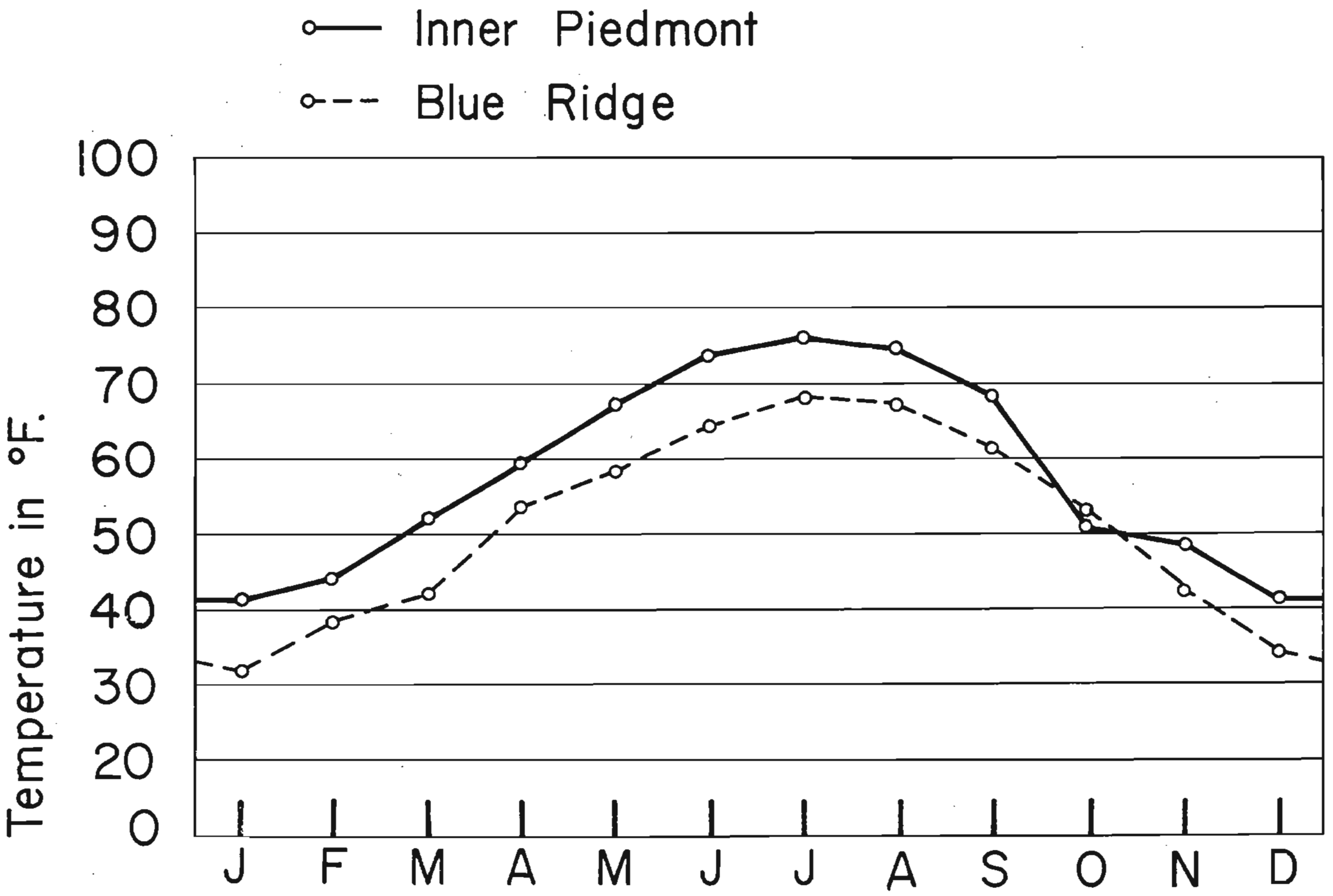
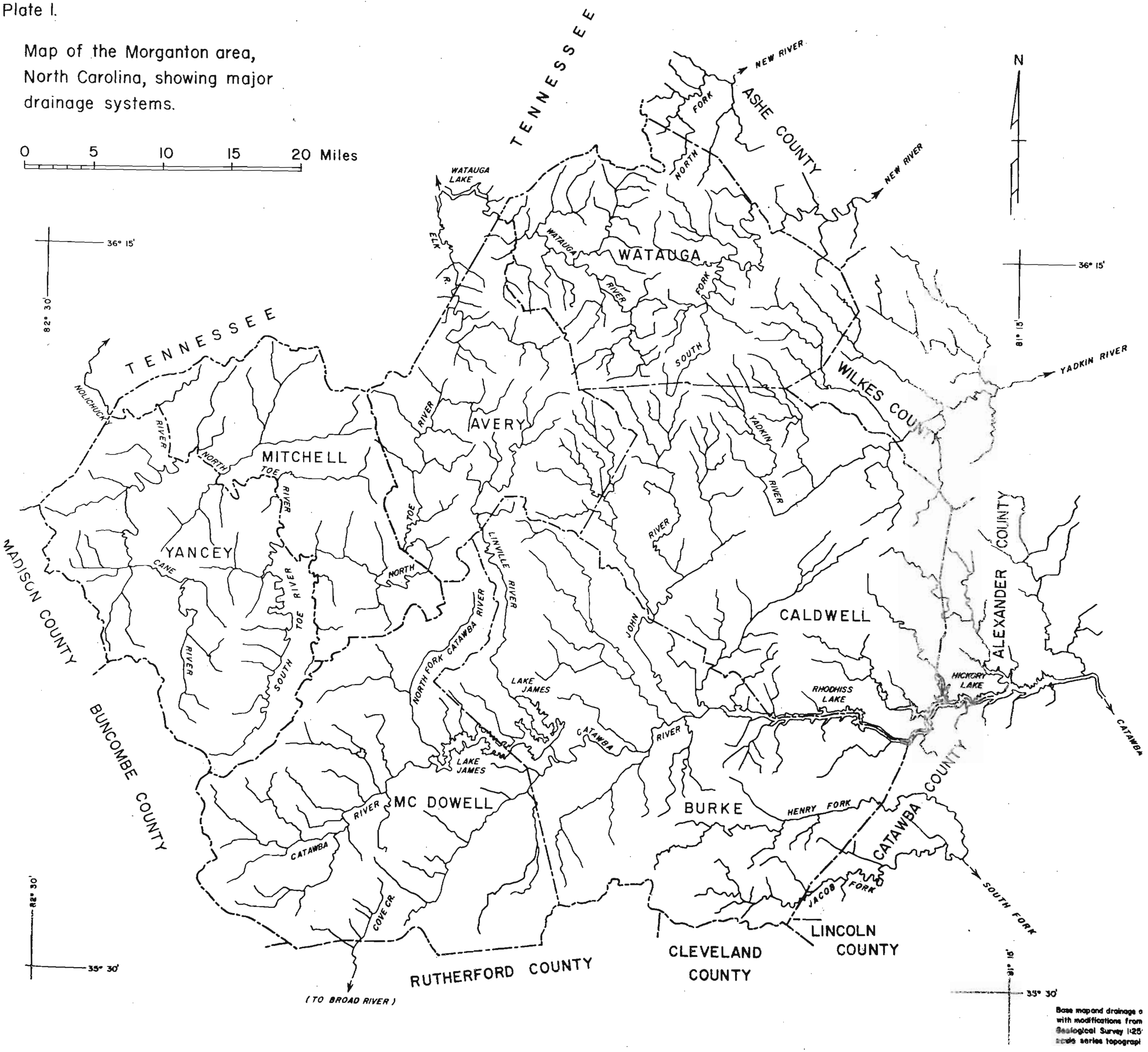


Figure 3. Mean monthly temperatures, Morganton area, 1961-62.

Plate I.

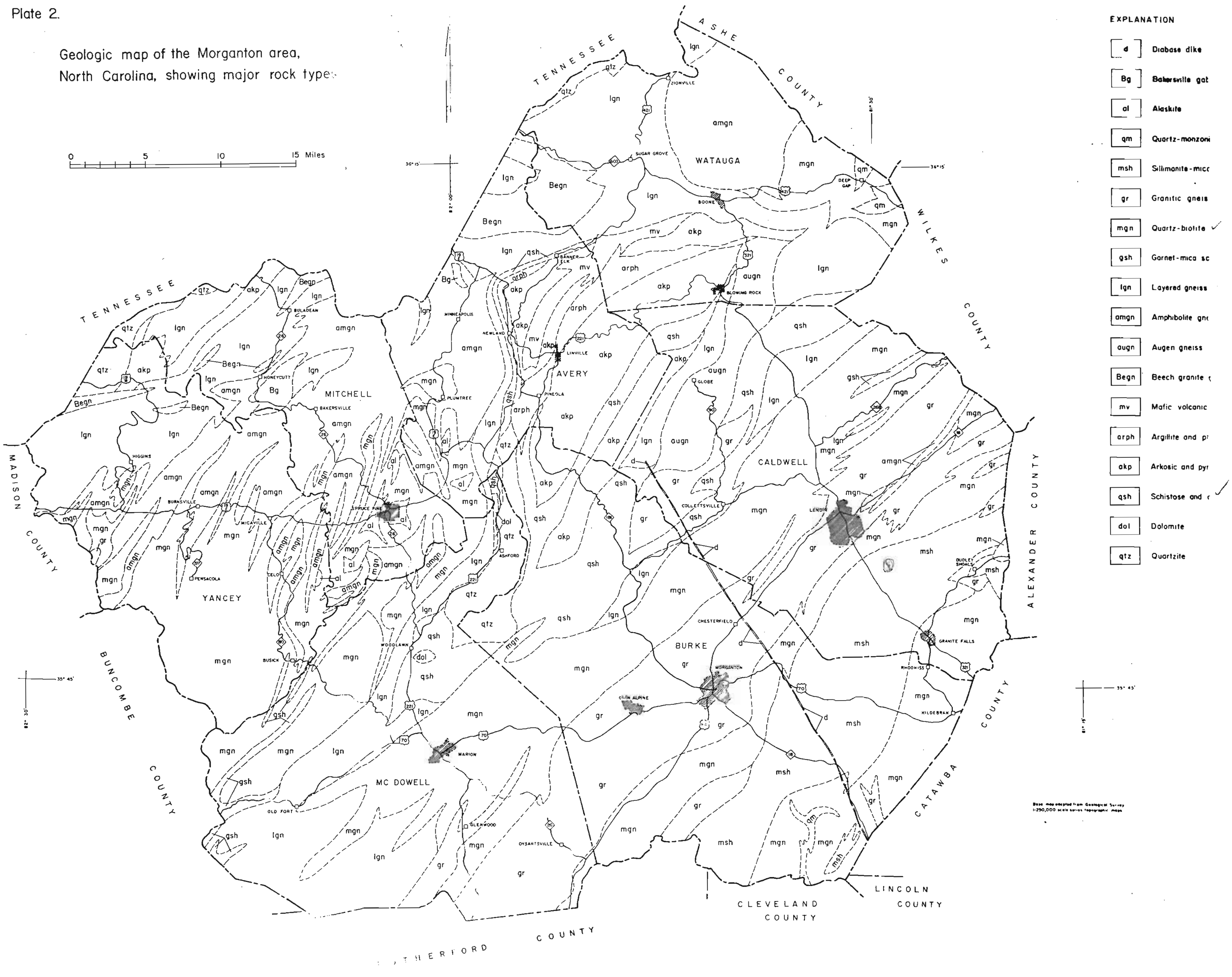
Map of the Morganton area, North Carolina, showing major drainage systems.



Base map and drainage o
with modifications from
Geological Survey 1:25
scale series topograp

Plate 2.

Geologic map of the Morganton area, North Carolina, showing major rock type:



Base map adapted from Geological Survey 1:250,000 scale series topographic maps

GEOLOGY

Introduction

The Morganton area is underlain by a complex assemblage of metamorphic rock types. These rocks were mapped on a reconnaissance basis during this investigation. In order to facilitate map representation of rock types for their relation to quantity and quality of ground water, rock classification in this report is based on composition and physical identification rather than stratigraphic relationships. Stratigraphy in the Morganton area is complex and, in places, obscure due to recurrent regional metamorphism. Boundary transitions between rock types may be defined within a few inches or feet, or they may be represented by wide zones in which the rock types are intermixed and interlayered, showing only a progressive change in dominant rock type. Generally the change in type is gradational and the contact between types is indeterminate. Hence, rock-type boundaries should be considered approximate on the geologic map (pl. 2).

The succession of geologic events which brought about the existing complex of lithologies within the inner Piedmont and Blue Ridge provinces is not yet clearly understood. Heterogeneity of rock types associated with compositional layering indicates a diverse sedimentary and igneous origin in an environment of rapid deposition. Relict sedimentary structures, current bedding and graded bedding, are present in some compositional layers. After the deposition of these intermixed sedimentary and igneous rocks, they underwent recurrent regional metamorphism by compression which has transformed them by heat and directed pressure into a folded complex of gneisses and schists. Many of the pegmatite dikes or veins within the metamorphic complex are probably by-products of this metamorphic heat and pressure. Basic igneous stocks and dikes of gabbro and diabase intruded the metamorphic-rock complex later, mainly within the Blue Ridge part of the Morganton area. The elevation and ensuing erosion of the rock complex for a very long time is evident from the beveled appearance of the inner Piedmont and the dissected aspect of the Blue Ridge province. Throughout the inner Piedmont and in many places within the Blue Ridge province deep weathering of bedrock has produced a thick residual mantle. Mechanical weathering, though effective in exposing bedrock in areas of greater relief, is less effective than the action of chemical weathering in most of the area.

Areal Distribution and Character of Rocks

Pegmatite

Veins or dikes of this rock type are irregular, light-colored, coarsely crystalline quartz, feldspar, and mica. In the red-brown saprolite mantle pegmatites appear as contrasting light-gray to white masses of clay. Pegmatite veins or dikes are formed by the solidification of highly mineralized, volatile solutions which originated at high temperatures and pressures. Although they are commonly considered to be by-products of igneous intrusion, their temperatures and pressures of origin are not inconsistent with those likely undergone by the host rocks during regional metamorphism. Crystals in pegmatites are of mineralogic interest because they are usually large and well formed. These veins or dikes are common in most of the metamorphic rock types of the Morganton area. They range in thickness from a few inches to many feet and may be traced for greater linear distances, but they are not large enough to define on the geologic map.

Bakersville Gabbro and diabase dikes

Gabbro is a dark gray, greenish, or black rock, finely crystalline. The rock is said to have a diabasic texture when its fine laths of plagioclase are enclosed in augite. Gabbro and diabase rocks weather to a dark-red earth, and weathered bedrock exposures show characteristically rounded exfoliation surfaces. West of Bakersville in the vicinity of Red Hill, Mitchell County, a small gabbro stock has intruded metamorphic rocks west of Elk Park in Avery County. In these same areas numerous small diabase dikes, apparently related to the intrusive stocks, strike northwestward, roughly parallel to structural trends of amphibolite gneiss and layered gneiss which the dikes intrude. These dikes are not large enough to define on the geologic map. A diabase dike unrelated to the gabbro stocks is shown on the geologic map in Burke and Caldwell Counties because of its great length and apparent continuity. It strikes about N. 35° W., roughly normal to regional structural trends. The width of this dike, where it can be seen in outcrops, ranges from less than 10 feet to nearly 30 feet (fig. 4).

Alaskite

Alaskite is a light-colored, coarsely crystalline or granular rock of granitic composition, but with few or no mafic mineral constituents. Pegmatite veins or dikes are associated with the alaskite which is regarded as having an igneous origin. Alaskite is a relatively massive rock type, more resistant to weathering and erosion than the amphibolite and quartz-biotite gneisses and schists that it intrudes. Hence alaskite stands out from surrounding rocks as steep hills or mounds. It weathers to a light-colored, clay-textured earth, in places iron-stained by ferromagnesian minerals. Groups of alaskite masses of varying sizes occur in the general vicinity of Spruce Pine in Mitchell County.

Quartz-monzonite gneiss

Characteristic or regional metamorphic rock types, the medium-gray, quartz-biotite-monzonite gneiss has wide variations in texture and composition, although it is invariably gneissic. The weathered residuum of this rock type is a reddish clay not readily distinguishable from that of other gneissic rocks of the area. Quartz-monzonite gneiss occurs in bodies of varied sizes in southeastern Burke County and eastern Watauga County. Outcrops too small to define on the geologic map occur at other scattered localities within the Morganton area.

Sillimanite-mica schist

As with other heterogeneous rock types of this area, the sillimanite content and the types of mica in this schist have considerable variation. Layers of light-brown to light-gray quartzite are usually common to this rock type, and small lenticular zones of dark-green; garnetiferous, amphibolite gneiss and schist, and dark-gray, graphitic schist are also present. Where exposed in road cuts the schist is highly contorted and sheared. The weathered residuum varies from yellow to dark-red clay according to the amount of biotite mica in the schist. A northeast-trending belt of sillimanite-mica schist, ranging in width from about 4 miles to about 8 miles occurs in southeastern Burke and Caldwell Counties.

FIGURE 4. DIABASE DIKE ALONG HIGHWAY 90, ABOUT 300 FT. EAST OF WILSON CREEK BRIDGE, CALDWELL COUNTY.

Granitic gneiss

Outcrops of this heterogeneous complex are generally granite gneiss. Intermixed and interlayered with the granite gneiss are biotite-muscovite schist, amphibolite gneiss and schist, compositionally layered gneiss, micaceous quartzite, dolomitic gneiss, and quartz-biotite-monzonite gneiss. Boundary transitions of this complex rock type are generally wide zones which show only a progressive change in dominant components. The granitic gneiss complex weathers to a reddish-clay residuum. This complex extends from southeastern McDowell County northeastward through central Burke and Caldwell Counties.

Quartz-biotite gneiss

This mica gneiss complex consists predominately of quartz-biotite gneiss and schist, compositionally layered gneiss, schistose quartzite, dolomitic gneiss, quartz-monzonite gneiss, and micaceous crystalline limestone. Its boundary transitions are rarely well defined. The mica gneiss complex weathers to reddish-clay saprolite which contains schistose layers of light-brown decayed mica. As shown on the geologic map, quartz-biotite gneiss is the most extensive rock type in the Morganton area.

Garnet-mica schist

This schist is varied in color from green, to gray, and rust. Dark-gray graphitic layers are not uncommon in this unit. Contacts of this rock are sharply defined where they are exposed. The garnet-mica schist weathers to a reddish clay in which much of the original schistosity is preserved. Several elongate units of this garnetiferous, quartz-muscovite schist extend northeastward from western McDowell County into southern Yancey County. A compositionally similar unit occurs in eastern Caldwell County.

Layered gneiss

As with other metamorphic-rock complexes in the Morganton area, the layered-gneiss complex has a wholly heterogeneous aspect (figs. 6 and 7). It is distinguished by primary compositional layering. In outcrops tens of feet wide it is generally gray, feldspathic, quartzose rock with sharply defined compositional layers which have continuity and fairly uniform thickness throughout the exposure. Layers range from less than an inch to several feet in thickness, and show considerable variation in mineral components. The layers may consist of amphibolite gneiss or schist, dolomitic gneiss, sericitic quartzite, mica gneiss, thin layers of mica schist, and light-colored, coarse-textured, quartzose, feldspathic constituents within a dark-colored, fine or aphanitic groundmass. The layered gneiss complex weathers to varied shades of red clay containing dispersed, schistose laminae of light-brown, decayed mica. It is common throughout most of the Morganton area.

Amphibolite gneiss

This rock type occurs as gneissic and schistose layers of greatly contrasting thickness. Mica gneiss and mica schist, sparsely intercalated with the amphibolite layers, impart a heterogeneous aspect to the outcrops. Amphibolite gneisses and schists, black to dark green, consist almost entirely of fine-to-coarse, elongate, amphibolite crystals. Amphibolite weathers to dark-red or red-brown clay. Amphibolite gneiss is most abundant in the Blue Ridge part of the Morganton area.

Augen gneiss

In this rock type lentoid, light-gray to white augen lie in roughly parallel alignment within a well foliated, dark-green, aphanitic groundmass of quartz, biotite, chlorite, and amphibolite. Layers of dark-gray quartzose gneiss, and dark-gray phyllite with mica schist are common within the augen gneiss. In a road cut exposure about 1/2 mile north of Aho, on the Blue Ridge Parkway, fine-grained, dark-gray, gneissic, compositional layering within the augen gneiss is highly calcitic. An elongate, north-northeast-trending body of augen gneiss extends from near Brown Mountain in western Caldwell County to the vicinity of Bamboo in Watauga County. Fresh outcrops of this rock are well exposed along highway 321 south of Blowing Rock (fig. 8).

Beech Granite

This is a coarse-grained, gneissic rock, varied in color from gray to pinkish gray. Although not common, layers of light-green quartzite, dark-gray phyllite, and feldspathic quartzite occur within

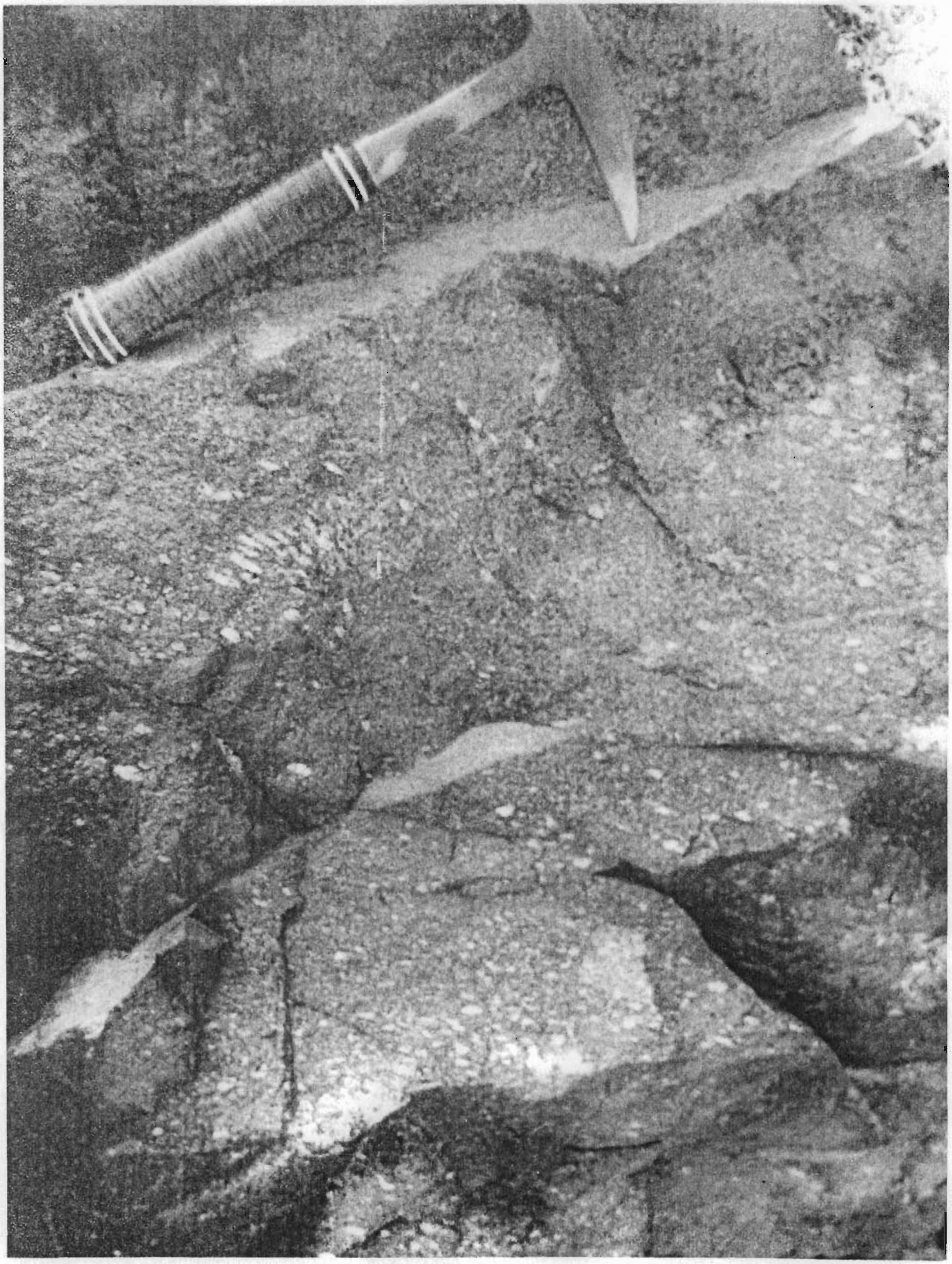


FIGURE 5. FLATTENED PEBBLES IN QUARTZ-BIOTITE GNEISS ON THE BLUE RIDGE PARKWAY, 1.7 MILES EAST OF THE STATE ROAD TO MT. MITCHELL, YANCEY COUNTY.

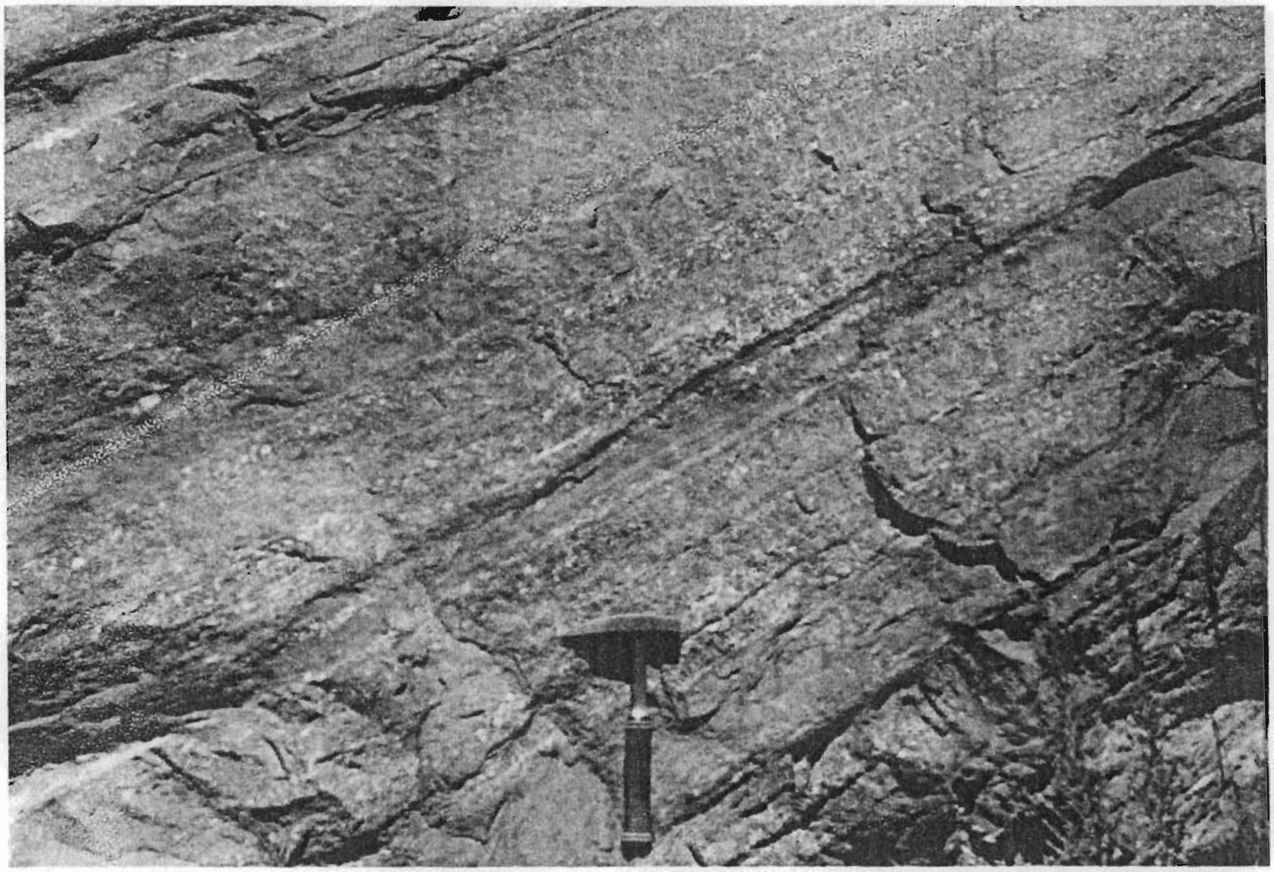


FIGURE 6. LAYERED GNEISS ALONG HIGHWAY 40, ABOUT 3 MILES NORTHWEST OF OLD FORT, McDOWELL COUNTY.

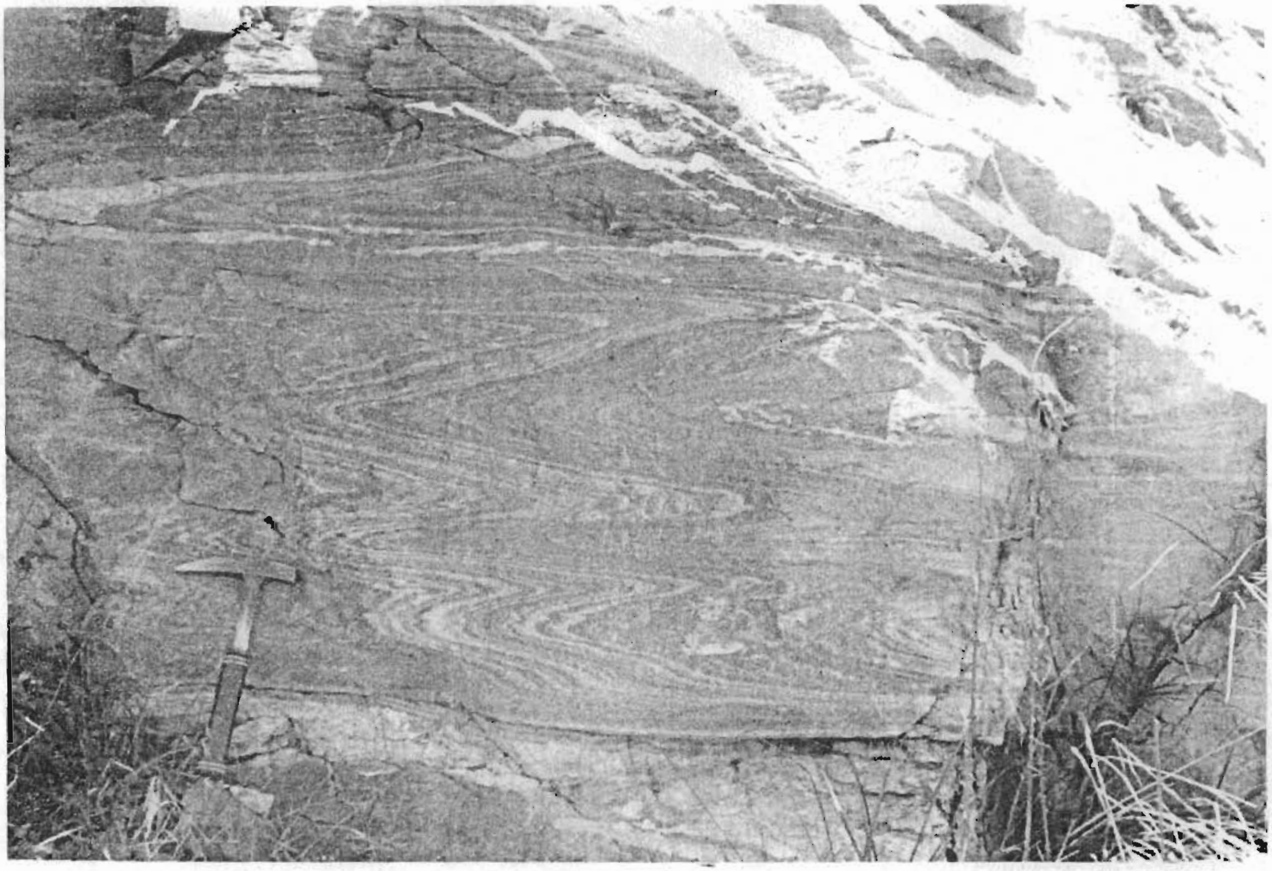


FIGURE 7. DOLOMITIC LAYERED GNEISS ALONG HIGHWAY 40, 2 MILES EAST OF MARION McDOWELL COUNTY

FIGURE 8. AUGEN GNEISS ALONG HIGHWAY 321, 2 MILES SOUTH OF BLOWING ROCK, CALDWELL COUNTY.

the Beech Granite. The gneiss weathers to a light-brown sandy clay. The rock type designated as Beech Granite occurs as dispersed outcrops in the northwestern part of the Morganton area.

Mafic volcanic rocks

These metavolcanic rocks include what were probably diabase dikes or sills, basalt flows, and other dark, igneous flows or pyroclastic rocks. Relict flow banding and vesicular textures are often conspicuous in the fresh outcrops. These rocks weather to a rest-brown clay. Mafic volcanic rocks occur in Avery and Watauga Counties where they are well exposed in road cuts along highway 105 between Boone and Linville.

Argillite and phyllite

These rock types appear as dark-blue and dark-gray argillite with irregular zones of phyllite. In fresh outcrops they are seen to contain very small, rust-colored, calcareous, lentoid pods, and light-gray crystalline limestone or marble partings and layers. These metamorphic rocks weather to yellow-brown clay. They occur in Avery and Watauga Counties, and are exposed in road cuts along Highway 105 northeast of Linville and along Shulls Mill road.

Arkosic and pyroclastic rocks

Included in a heterogeneous sequence of metamorphosed pyroclastic and sedimentary rocks are: green-gray to pinkish-gray, fine- to coarse-grained cross beds and graded beds of arkose; light-green, fine- to coarse-grained, cross-bedded and laminar, water-lain pyroclastic rocks with intercalated cobble conglomerates (fig. 9); light-tan to pinkish-white, fine-grained, laminar, feldspathic, quartzitic rocks; dark-gray slate; and metagraywacke. These rocks weather to light-colored clay and sandy earth. As shown on the geologic map, this heterogeneous sequence occurs in adjoining parts of Avery, Burke, Caldwell, and Watauga Counties. Similar rock types occur in northern Yancey and Mitchell Counties.

Schistose quartzitic rocks

Although completely heterogeneous, in gross aspect these rocks are composed predominately of schistose, quartzitic, rock types. They comprise: intermixed and interlayered, tan-to-white and light-green, schistose quartzites; light-colored, schistose, pyroclastic rocks; mica schist; layered gneiss; mica gneiss; dark-gray phyllite; graphitic schist; light-gray quartzite; dolomitic, quartzitic rocks; and light-colored, feldspathic quartzite. They weather to varied shades of red, sandy clay. Designated as schistose, quartzitic rocks on the geologic map, they extend northeastward from McDowell County through Burke, Caldwell, and Watauga Counties.

Dolomite and limestone

Where it is exposed in quarries, bedding in the light-gray, dense, crystalline dolomite is massive, with only local thin beds and dark-gray, argillaceous partings. Linville Caverns, north of Ashford in McDowell County, is a network of solution channels developed on joint systems within the dolomite. Near Woodlawn, McDowell County, the dolomite is quarried for road metal. A small outcrop of light-gray and white dolomite, too small to define on the geologic map, is exposed in a railroad cut about 1½ miles northwest of Bandanna in Mitchell County. Dark-blue and dark-gray, foliated, micaceous, crystalline limestone outcrops, too small to define on the geologic map, occur north and west of Marion in McDowell County (fig. 10). These small limestone outcrops appear to be aligned on a trend of approximately N. 55° E., consistent with regional structural trends.

Quartzite

The light-tan and white, massive- and cross-bedded, fine-grained quartzite locally contains dark-gray and dark-green, graphitic, argillaceous partings (fig. 11). It weathers to a light-colored, sandy earth, in some places resembling unmetamorphosed, friable sandstone. The quartzite is exposed in a large, dissected anticline near the central part of the Morganton area. A similar quartzite, coarse-grained, containing varied amounts of feldspathic constituents, light-colored pyroclastic layers, with dark-gray and black argillaceous interbeds, occurs in northern Mitchell, Watauga, and Yancey Counties.

Saprolite

Mechanical and chemical weathering of rocks in the Morganton area has formed an extensive residual mantle of soils and saprolite. Saprolite, or decomposed rock, in this area developes best on gneissic and

FIGURE 9. PYROCLASTIC ROCKS CONTAINING PEBBLES AND COBBLES OF GRANITIC ROCKS, ALONG SHULLS MILL ROAD, I MILE SOUTH OF HIGHWAY 105, WATAUGA COUNTY.

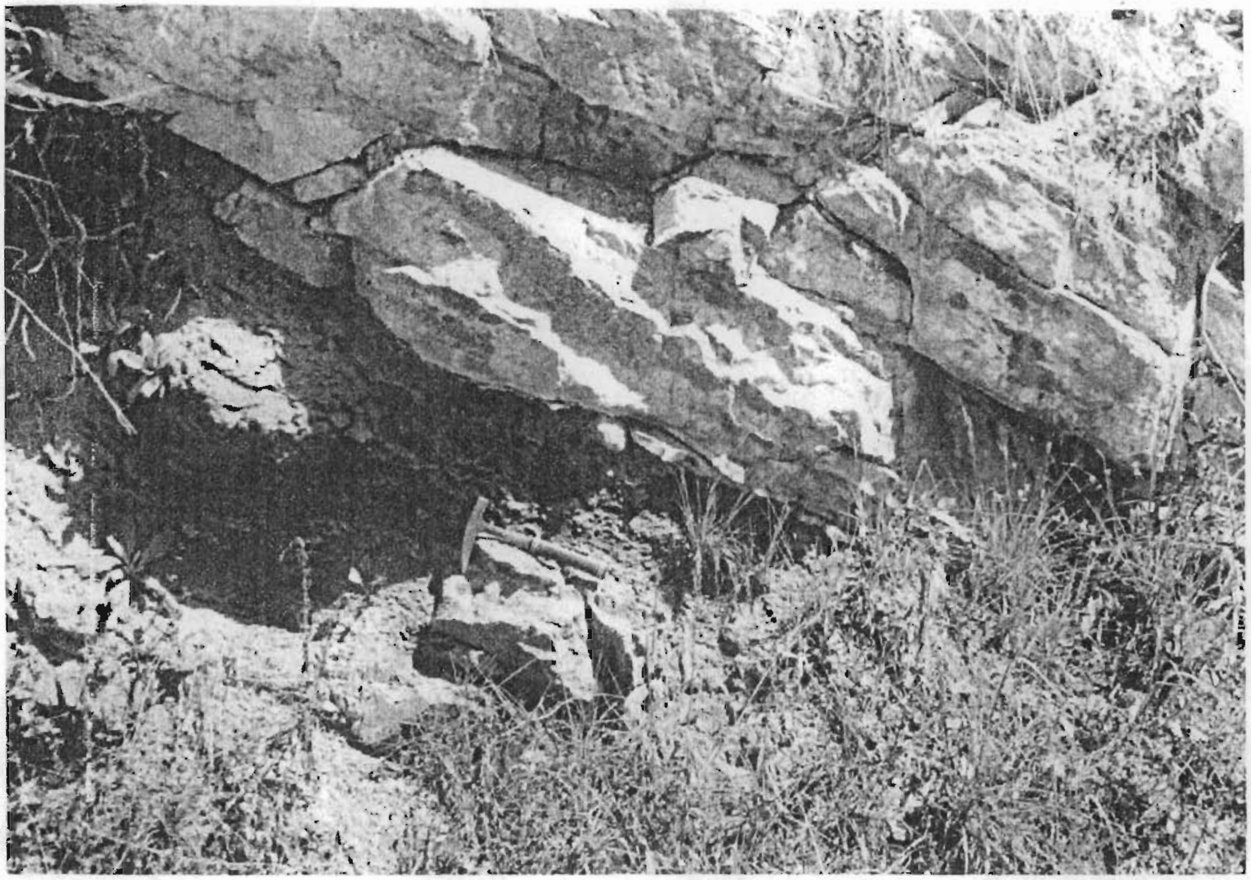


FIGURE 10. MICACEOUS LIMESTONE (DARK) UNDERLYING LAYERED GNEISS (LIGHT), ABOUT 1 MILE WEST OF MARION, McDOWELL COUNTY.

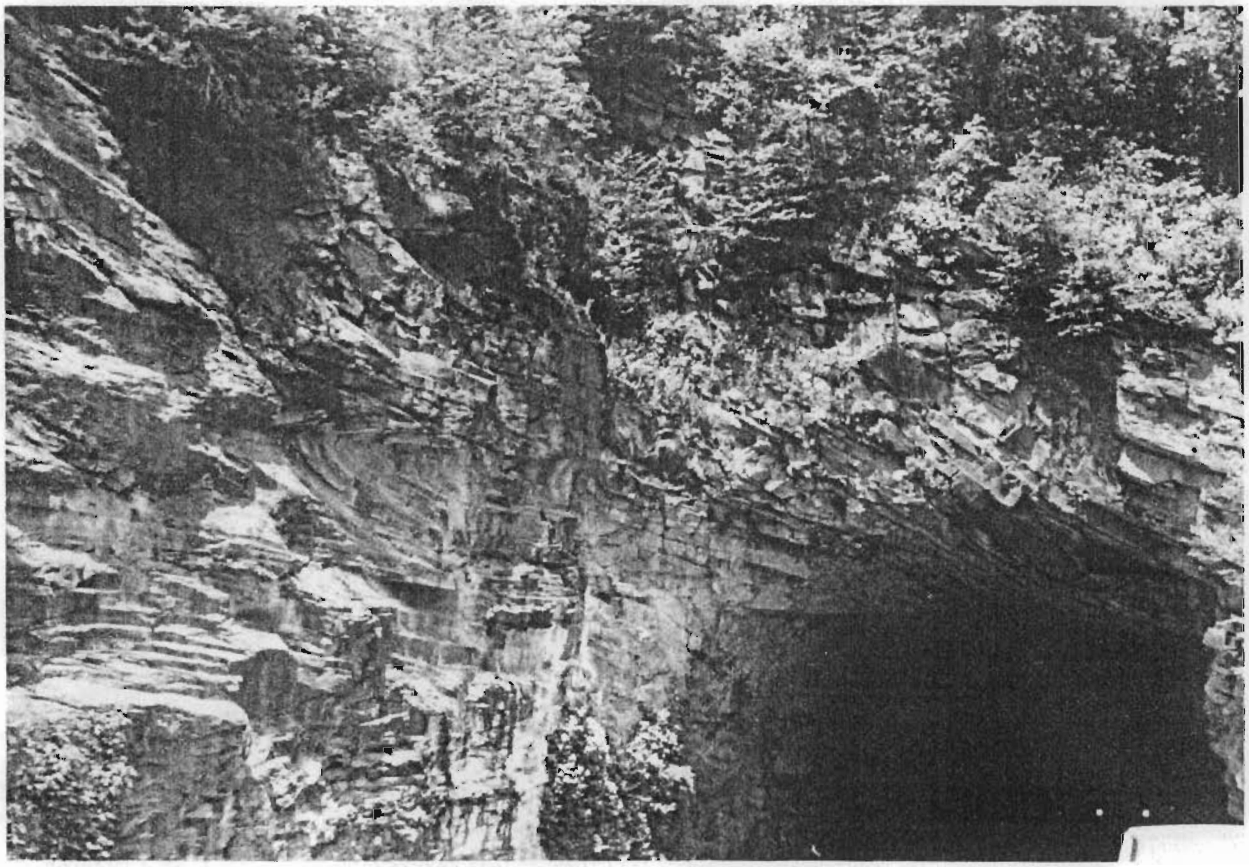


FIGURE 11. RECUMBENT FOLDS IN QUARTZITE AT WILDACRES TUNNEL, BLUE RIDGE PARKWAY, MITCHELL COUNTY.

schistose rocks containing feldspar or amphibolite minerals as these are very unstable in the presence of air and moisture. As weathering progresses, soluble products of weathering (and some colloids) are continually removed by ground-water circulation. The residuum of clay minerals, oxides of iron and aluminum, quartz, and other insoluble accessory minerals, with partly weathered rock constituents, compose saprolite. Where the mantle is more deeply developed and least affected by erosion, it may comprise a zone of soils, an intensely weathered zone of saprolite, and a transitional zone between saprolite and unweathered rock. Relict schistosity or foliation and partly weathered laminae of mica are common where the mantle has been undisturbed. The thickness of the mantle in the Morganton area ranges from less than 1 foot to over 100 feet. The saprolite mantle is deepest and best developed over low areas of the inner Piedmont and in areas of subdued relief in parts of the Blue Ridge upland.

Alluvial sediments

Much of the surface material throughout the Morganton area has been transported varied distances by alluvial processes. In the larger stream valleys coarsely stratified sediments of sizes ranging from clay to small boulders form alluvial deposits up to 50 feet thick. Auger-hole transections to test for thickness and character of sediments and for ground-water occurrence in the Catawba and Yadkin River valleys penetrated varied thicknesses of alluvium consisting of high percentages of clay. Rapid weathering processes may be partly responsible for the large amounts of clay in stream-valley sediments. Terrace deposits of coarse gravel and boulders are present along most of the larger perennial streams.

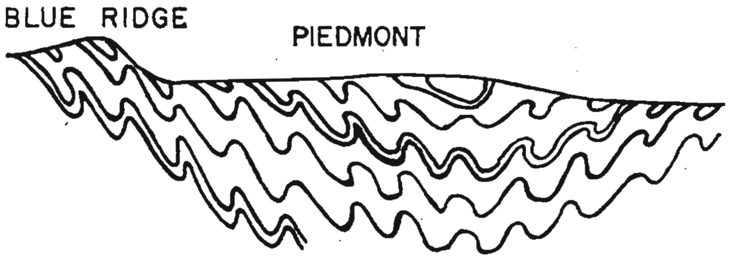
GEOLOGIC STRUCTURE

Regional Patterns

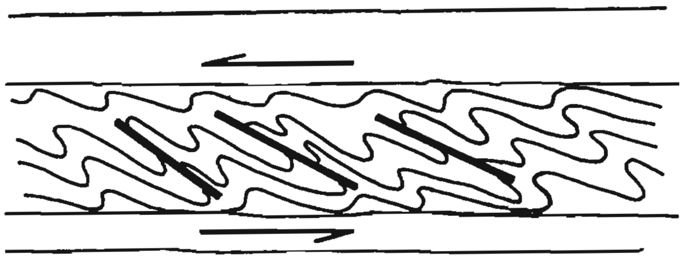
On the basis of reconnaissance data, structural geologic features of the area are interpreted to be part of the west limb of a broad, northeast-trending, composite downfold or synclinorium which extends northeastward through the central part of the State (fig. 12). Gross linear outcrop patterns on the geologic map indicate this trend. In the Piedmont province these folds have been beveled. Their structural attitudes and relationship to the synclinorium may be seen in road cuts and may be inferred by the more rapidly changing and repetitive lithologies normal to the main structural trend than parallel to it. Along the Blue Ridge front, exposures of the component anticlinal and synclinal folds and sheared recumbent folds are more common. North-northeast-trending Linville Mountain in McDowell and Burke Counties may be seen to be the resistant quartzite crest of a dissected anticlinal fold, part of the synclinorium. This fold is well exposed at the southwest side of Dobsons Knob as viewed from the vicinity of Woodlawn in McDowell County. Road-cut exposures along the Blue Ridge Parkway, such as the recumbent folds of quartzite at Wildacres Tunnel, show the complex structural nature of the west limb of the synclinorium (fig. 11). Detailed structure sections of the area await a more comprehensive geologic investigation.

Faults and joints

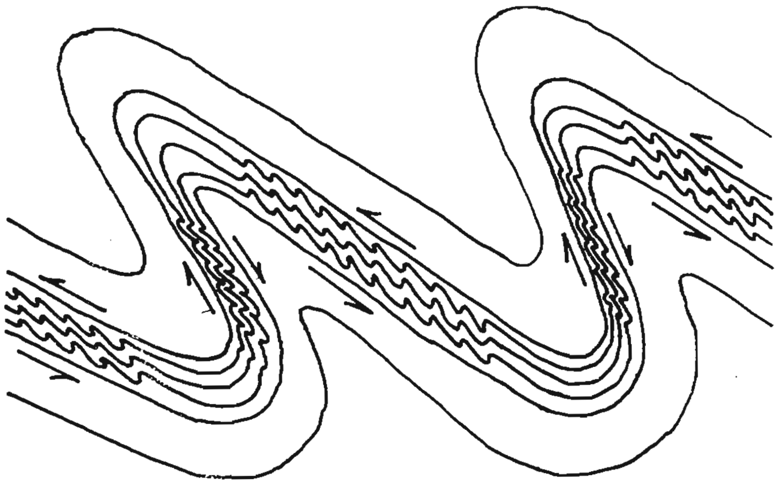
Due to the extensive mantle of saprolite, faults and joints are not readily apparent except where exposed in railroad cuts, road cuts, quarries, or similar excavations. Few such exposures fail to show a number of faults, shear zones, and joints. However, these linear structural features are generally not traceable for any great distances. Faults are very common. They are apparently of small displacement and not of regional extent. Faults generally strike northeastward and are vertical or dip at steep angles southeastward. Faults stroking northwestward, though present, are less common. The predominant joint systems strike about N. 60° E. and N. 40° W., and are vertical or dip steeply southeastward and southwestward. Less prominent joint systems trending nearly north and nearly east occur locally.



a. Diagrammatic synclinorium (not to scale).



c. Heavy lines represent shearing in drag folds of an incompetent bed.



b. Diagram showing development of drag folds in an incompetent bed between two competent beds. Arrows show direction of shear forces.

Figure 12. Diagrams of some structural features of the Morganton area (not to scale).

Shear zones

Formation of the composite downfold or synclinorium was accompanied by lateral pressure on weaker rock layers between strata more resistant to folding. This directed pressure resulted in formation of a series of parallel "drag" folds in the weaker layers (fig. 12). Continued lateral pressure caused rupture or shearing of the tightly folded weaker beds (fig. 12). The weaker or incompetent rock layers are heterogeneous gneisses and schists, and shear zones are generally present where these highly folded rocks are exposed. The zones are characterized by their fractured and brecciated or schistose nature, and may appear to be continuous in some places owing to their more-or-less parallel alignment. Discontinuous outcrops and complexity of folding preclude exact measurement of displacement on shear zones or faults.

CHEMICAL QUALITY OF GROUND WATER

By

R. L. Laney

Water quality is dependent upon the amount and kind of dissolved mineral constituents in the water. Rain water seeping downward through soil and rocks contains gases dissolved from the atmosphere, the soil, and organic matter. Carbon dioxide, the principal dissolved gas, in water forms a weak acid which acts as a solvent on practically all minerals.

Although many factors affect the amount and kind of chemical constituents dissolved in ground water, the two most important factors in the Morganton area are the chemical and physical nature of the rocks and the duration of contact between the water and the mineral grains of the rock.

Minerals are dissolved when rocks undergo chemical weathering. Most chemical constituents go into solution in one of two forms: as cations (positively charged particles) and as anions (negatively charged particles). Iron may be in water as a cation or as colloidal-sized particles. Silica is in subcolloidal or colloidal form in most natural waters.

Chemical analyses of water measure the amounts of cations, anions, and non-ionic material in solution. Amounts of individual constituents in water are reported in parts per million (ppm) which is the concentration by weight of each constituent in a million unit weights of water.

Nearly all ground waters sampled in the Morganton area are suitable for most domestic and industrial purposes. A discussion follows of each constituent commonly reported in water analyses. Range in concentration, arithmetic mean (average), and median (a value above and below which lie half of the cases reported) are included in table 1.

Silica (SiO_2)

Silica is derived from the weathering or chemical breakdown of silicate minerals which constitute most of the rocks in the Morganton area. The chemistry involved in the decomposition of silicates is highly complex and the form of silica in ground water is not completely

TABLE 1. Range in concentration, arithmetic mean, and median values of constituents reported in analyses of ground water from the Morganton area.

	Concentrations in parts per million			
Constituents	Low	High	Mean	Median
Silica (SiO_2)	3	33	15	14
Iron (Fe)	.00	4.6	.20	.04
Calcium (Ca)	.4	28	6.5	4.3
Magnesium (Mg)	.1	27	2.1	1.6
Sodium (Na)	.5	45	4.9	2.8
Potassium (K)	.1	11	1.5	.9
Bicarbonate (HCO_3)	3	140	31	25
Sulfate (SO_4)	.1	49	3.2	.8
Chloride (Cl)	.1	53	4.0	1.8
Nitrate (NO_3)	.0	65	3.8	.9
Hardness	2	140	25	20
Dissolved solids	13	248	57	49
Hydrogen ion concentration (pH)	5.2	9.1	6.5	6.4
Specific conductance in micromhos	11	450	78	65

understood, but it is thought that silica is not in true ionic solution.

The range in concentration of silica is variable but the percent silica of the total dissolved solids is generally high. For example, in water from granite gneiss, silica usually exceeds 45 percent of the total dissolved solids, while water from other rock types generally contains less than this amount. Percent silica in ground water from igneous and metamorphic rocks can be related to the percent silica in the rock. Granitic rocks contain the highest percentage silica, whereas, ultramafic rocks contain the lowest percentage silica. Percent silica is highest in water from granitic rocks and lowest in water from ultramafic rocks.

Most industrial processes tolerate silica in the concentrations normally found in ground water in the Morganton area. However, in boiler feed and steam turbine water silica is undesirable because it forms a hard scale.

Aluminum (Al)

Many silicate minerals contain considerable amounts of aluminum. However, aluminum is highly resistant to removal by solution during the weathering processes and remains in place to form clay minerals in soils. Therefore, high concentrations of aluminum are rare in natural waters. Aluminum concentrations in ground waters sampled in the Morganton area varied from 0.0 to 0.4 ppm. Ninety-four percent of 110 samples analyzed contained 0.1 ppm or less aluminum.

Iron (Fe)

Iron is abundant in most rocks especially those containing a high percentage of ferromagnesium minerals, such as amphibolite gneiss, gabbro, and mafic volcanics. The concentration of iron in ground water depends upon other factors in addition to the nature and amount of iron mineral present in the rock or soil. The hydrogen ion concentration (pH), which is a measure of bacisity and acidity of water, exercises much control on the amount of iron dissolved. Acidic waters generally have higher iron concentrations than alkaline waters. Normally, only small concentrations of iron occur naturally in ground waters in the Morganton area. Additional iron may be added by the action of corrosive water passing through the iron pipes and tanks of water distribution systems.

Water containing as much as 0.3 ppm iron is suitable for most domestic purposes. More than 0.3 ppm iron will stain laundry and utensils and impart an unpleasant taste to the water. Many industrial uses require water with iron concentrations less than 0.1 ppm. Sixty-nine percent of all ground water sampled in the Morganton area contained less than 0.1 ppm iron and eighty-five percent contained less than 0.3 ppm iron.

The values for iron are reported in one of two ways: total iron, which is the iron that is in solution when the water sample is collected; and dissolved iron, which is the iron that remains in solution several days after the sample is collected. Unless otherwise stated, total iron will be used in the text and tables of analyses.

Manganese (Mn)

The chemical behavior of manganese in water resembles that of iron. Manganese is much less abundant in rocks; consequently, manganese concentrations in natural waters are generally lower than iron. U. S.

Public Health Service recommends that manganese not exceed 0.05 ppm in drinking water. Only one sample analyzed from the Morganton area contained more than 0.05 ppm manganese. Eighty-one percent of all samples analyzed for manganese contained less than 0.02 ppm.

Calcium (Ca)

Calcium is a major constituent in all rocks. Limestone (calcium carbonate) and dolomite (calcium-magnesium carbonate) are common sources of calcium in ground water. More pertinent to this investigation are the presence of calcium-bearing silicate minerals, such as, plagioclase feldspars, pyroxenes, and amphiboles. Rocks containing these minerals would be expected to yield ground water containing relatively high concentrations of calcium. Generally, calcium is the most abundant cation in ground water from layered gneiss, mica schist, quartz-biotite gneiss, arkosic pyroclastics, and quartzite. Calcium and magnesium account for most of the hardness in ground water.

Magnesium (Mg)

Magnesium is commonly a component of the silicate minerals in dark-colored ferromagnesium and ultramafic rocks. These minerals include olivine, pyroxenes, amphiboles, and dark colored micas. Magnesium is abundant in limestones and dolomite. Amphibolite gneiss typically contains ground water with relatively high magnesium concentrations. Magnesium and calcium account for most of the hardness of ground water.

U. S. Public Health Service recommends that drinking water contain less than 125 ppm magnesium. All ground waters sampled in the Morganton area contain less than 28 ppm magnesium.

Sodium (Na)

Feldspar is the only important silicate mineral which contains appreciable amounts of sodium. Feldspars are alumino-silicate minerals and contain variable amounts of sodium, potassium, and calcium. Sodium-calcium ratios obtained from analyses of ground water from igneous and metamorphic terranes may reflect the type of feldspar present in the rock. The granite gneiss located approximately in the southernmost one-third of McDowell County contains ground water in which sodium is the dominant cation. This granite gneiss contains appreciable amounts of sodic feldspar. The concentrations of sodium in ground water in the Morganton area has little effect on the utilization of water. More than 50 ppm sodium in boiler water will cause foaming and high pressure boiler feed water should contain no more than 3 ppm sodium. All ground water sampled in the Morganton area contained less than 46 ppm sodium.

Potassium (K)

Feldspar and certain types of mica contain appreciable amounts of potassium. Potassium is slightly less abundant than sodium in silicate minerals. However, in ground water from this area sodium concentrations normally are more than double potassium concentrations. Differences in concentrations of sodium and potassium in ground water are a result of their different reactions during the chemical weathering of rocks. Sodium is removed in solution by ground water, while potassium tends to remain as a constituent of clay minerals in the soil. Potassium in ground water in the Morganton area has little or no effect on the utilization of water.

Lithium (Li)

Lithium-bearing minerals are comparatively rare. Spodumene (a pyroxene) and lepidolite (a mica) are the two most common lithium-bearing silicate minerals. Lithium occasionally occurs concentrated in granite. The scarcity of lithium in rocks accounts for low lithium concentrations in ground water. Lithium concentrations in ground water in the Morganton area ranged from 0.0 to 0.4 ppm. Eighty-six percent of the ground water samples analyzed contained less than 0.2 ppm lithium.

Bicarbonate (HCO_3)

Bicarbonate is the dominant anion in ground water in the Morganton area. Carbon dioxide gas (CO_2), which promotes solution of minerals by ground water, is readily available in the atmosphere and soil. As ground water containing carbon dioxide reacts with minerals, cations (calcium, magnesium, sodium, and potassium) are added to the water and carbon dioxide (CO_2) is converted to the bicarbonate anion (HCO_3). A bicarbonate water which contains mostly calcium and magnesium cations will have a higher hardness value than a bicarbonate water of similar total concentration in which sodium is the dominant cation. Bicarbonate has little affect on the domestic utilization of water.

Sulfate (SO_4)

Sulfur is a minor constituent of silicate minerals. Certain sulfides of metals, for example pyrite (FeS_2), occur disseminated throughout some metasedimentary rocks or in small mineralized veinlets in other metamorphic and igneous rocks. Sulfides are oxidized to soluble sulfates in the weathering process and are removed by the ground water. U. S. Public Health Service recommends that drinking and culinary water contain no more than 250 ppm sulfate. Concentrations of sulfate in ground water sampled in the Morganton area are less than 50 ppm.

Chloride (Cl)

Natural ground water in the Morganton area usually contains less than 3 ppm chloride. Concentrations higher than 3 ppm may result from contamination by sewage, industrial wastes, and fertilizers. Human and animal wastes, which probably are the cause of most ground-water pollution in the Morganton area, contain much chloride and nitrogenous material. The presence of abnormally high concentrations of chloride and more than 1 ppm of nitrate in ground water are indicative of possible pollution.

U. S. Public Health Service recommends that chloride concentrations in drinking and culinary water not exceed 250 ppm. All ground water sampled in the Morganton area contained less than 54 ppm chloride.

Fluoride (F)

Fluoride in ground water originates from the solution of fluoride-bearing minerals, such as, hornblende, mica, and apatite. These minerals are common constituents of many rocks in the Morganton area. Some fluoride may occur in ground water from the leaching of phosphate fertilizer by water percolating through the soil zone. Also, insecticides may release fluoride to ground water.

Mica, or specifically biotite, may be the main source of fluoride in the Morganton area. Nine of fifteen samples of ground water containing 0.2 ppm or more fluoride came from rocks containing a high percentage of mica (mica schist and quartz biotite gneiss).

Fluoride concentrations greater than 1.5 ppm in drinking water may cause permanent mottling of teeth (dental fluorosis) when consumed by children. However, there is abundant evidence which indicates that concentrations of fluoride between 1.0 and 1.5 ppm in drinking water reduces tooth decay in children.

Fluoride concentrations in ground water in the Morganton area ranged from 0.0 to 1.3 ppm. Eighty-six percent of the samples analyzed for fluoride contained less than 0.2 ppm fluoride and fifty-six percent contained less than 0.1 ppm fluoride.

Nitrate (NO_3)

Nitrate in ground water may be considered the final product in the decomposition of organic wastes. Concentrations of nitrate in ground water greater than 1 ppm usually indicate a nearby source of pollution. Excessive nitrate in ground water usually indicates human or animal wastes as the source of pollution, particularly when the nitrate occurs in conjunction with chloride concentration greater than 3.0 ppm.

Shallow dug wells are often subject to pollution from sewage, fertilizers, and contaminated surface waters. Properly cased wells will minimize surface contamination.

The U. S. Public Health Service recommends that water containing more than 45 ppm nitrate should not be fed to infants. Medical research indicates that drinking water with a high nitrate content may cause cyanosis in infants ("blue baby"). Seventy-three percent of the ground water sampled in the Morganton area contained less than 3.0 ppm nitrate.

Phosphate (PO_4)

Phosphate in ground water may be derived from the mineral apatite, which is common in some igneous and metamorphic rocks. Phosphate fertilizers may yield some phosphate to ground water. Phosphate concentrations ranged from 0.0 to 1.1 ppm. Eighty-seven percent of the ground water samples contained less than 0.2 ppm phosphate.

Hardness

The property of hardness of water has generally been associated with effects observed with the use of soap, or the amount of soap necessary to form and maintain a lather in a particular water.

Incrustation and scale on cooking utensils and in boilers are the result of the hardness of water.

Calcium and magnesium are the principal chemical constituents that cause hardness in water. When water is evaporated or reacted with soap these cations form insoluble residues. The U. S. Geological Survey uses a classification of water hardness which is reported in terms of calcium carbonate ($CaCO_3$) as follows:

Hardness as $CaCO_3$ in parts per million	Classification
0-60	soft water
61-120	moderately hard water
121-180	hard water
181 and above	very hard water

Ninety-six percent of the ground water sampled in the Morganton area is classified as soft water.

Total and Computed Dissolved Solids

Total dissolved solids are the residues remaining after a given volume of water has been evaporated and dried at some definite temperature (180°C by the U. S. Geological Survey). Computed dissolved solids are determined by adding approximately half of the bicarbonate plus the sum of the other chemical constituents. Generally, total and computed dissolved solids are approximately the same. Computed dissolved solids are used in this report, unless stated otherwise.

The U. S. Public Health Service recommends that public water supplies should not contain more than 500 ppm dissolved solids. In the Morganton area no water which was analyzed contained more than 500 ppm of dissolved solids.

Hydrogen-ion Concentration (pH)

The hydrogen-ion concentration (pH) is defined as the negative logarithm of the concentration of hydrogen ions in moles per liter. The pH indicates whether a water is acid or basic. The pH scale extends from 0 to 14. A water having a pH value of 7.0 is neutral, below 7.0 is acid, and above 7.0 is basic. Generally, ground water in the Morganton area is slightly acid.

The pH values are important as an indication of the corrosive potential of ground water. Waters which have a low pH and low dissolved solids are corrosive on plumbing systems.

Specific Conductance

Specific conductance is a measure of the property of water to conduct an electric current. The conductance of water is primarily dependent upon the amount of dissolved mineral constituents and their degree of ionization. Therefore, specific conductance values are used to estimate the total amount of solids in solution. Specific conductance values are expressed in reciprocal ohms times 10^6 (micromhos) at a standard temperature of 25°C.

WATER QUALITY RELATED TO SOURCE

The amounts and type of mineral constituents dissolved in ground water from the Morganton area differ somewhat according to the source of the water. Table 1 shows the range, the arithmetic mean, and the median of concentrations of dissolved solids, nitrate, and chloride in water from springs, drilled wells, and dug wells. Nitrate and chloride are considered because excessive concentrations of each (more than 1 and 3 ppm respectively) in ground water in the Morganton area are indicative of possible pollution.

Figure 13 shows the mean concentration of dissolved solids, chloride, and nitrate from the three ground water sources in the Morganton area. Based on mean concentrations, water from drilled and dug wells contains more than two times as much dissolved solids as water from springs. The water-rock contact is of shorter duration for water from springs; therefore, dissolved solids are lower. Concentrations of chloride and nitrate are relatively low in water from springs and drilled wells. Mean nitrate and chloride concentrations in water from dug wells exceeds those from drilled wells and springs by approximately 4 times. Therefore, a comparison of the mean and range of concentration of chloride and nitrate in figure 13 and table 2 shows that dug wells are considerably more susceptible to contamination than springs or drilled wells.

TABLE 2. Variation of dissolved solids, chloride, and nitrate in water from springs, drilled wells, and dug wells in the Morganton area.

		Concentrations in parts per million (ppm)			
		Low	High	Mean	Median
Springs	Dissolved solids	14	71	31	29
	NO_3	0.0	14	2.0	0.8
	Cl	0.1	4.0	1.3	0.8
Drilled wells	Dissolved solids	14	150	74	75
	NO_3	0.0	14	2.3	0.8
	Cl	0.0	6.8	2.4	1.9
Dug wells	Dissolved solids	16	248	73	60
	NO_3	0.1	65	9.2	2.3
	Cl	0.5	53	11	3.7

RELATIONSHIPS OF THE CHEMICAL COMPOSITION OF GROUND WATER TO THE GEOLOGY

Chemical analyses are commonly reported in parts per million (ppm). Expressions of parts per million are a convenient means of expressing the results of an individual water analysis or of comparing selected constituents among several water analyses. However, relating the chemical composition of ground water to the geology requires a method of comparing the relative amounts of chemical constituents in one water to those in another. Results of water analyses in equivalents per million (epm) are useful in this respect.

Expressions of equivalent-weight units or equivalents per million are based on the concept of chemical equivalence. In any water the sum of the cations in epm equals the sum of the anions in epm. Equivalents per million for an ion may be calculated by multiplying ppm by an appropriate factor. A method using epm to show the general chemical characteristics of ground water is illustrated by the pattern diagrams in figure 14. Cations in epm are plotted to the left of the zero line and anions in epm are plotted to the right. The plotted points are connected and the resulting patterns are characteristic of water of different chemical composition.

Chemical analyses of ground water in the Morganton area generally can be subdivided into five basic patterns or types. Bicarbonate is the major anion in all five types. The distinction between types is determined by the relative amounts of calcium, magnesium, and sodium. The pattern diagram of each water type in figure 14 does not necessarily represent actual amounts of chemical constituents in a particular water, but instead shows relative amounts of ions in equivalents per million which are typical of each ground-water type. For example, dissolved solids in ground water classed as Type I vary from 20 to 112 ppm. Generally, water types cannot be determined from water containing less than 20 ppm dissolved solids.

Type I Ground Water

The significant characteristics of type I are the predominance of calcium, resulting in a calcium bicarbonate water, and the relative abundance of magnesium and sodium. Water of this type results from the

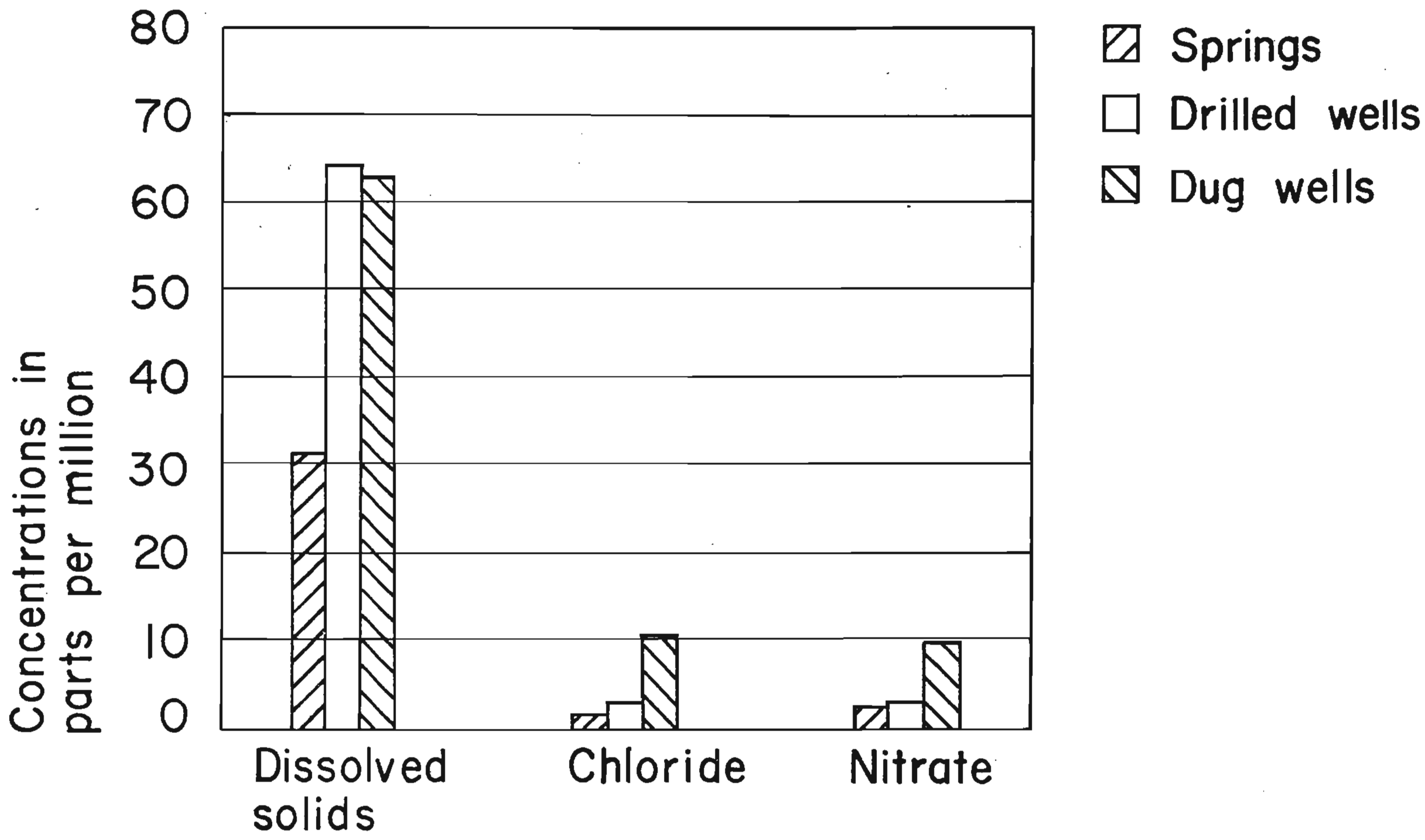
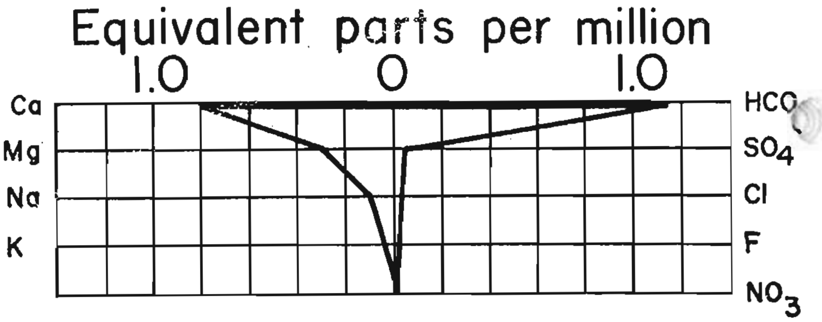
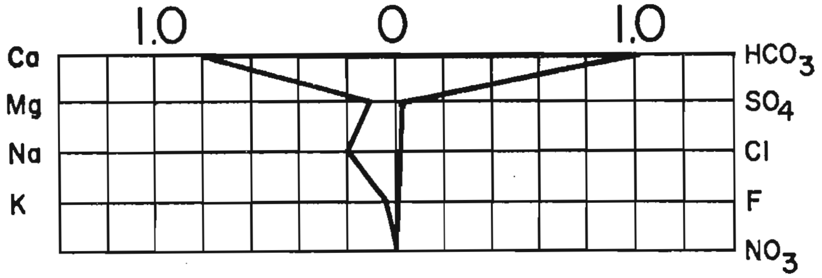
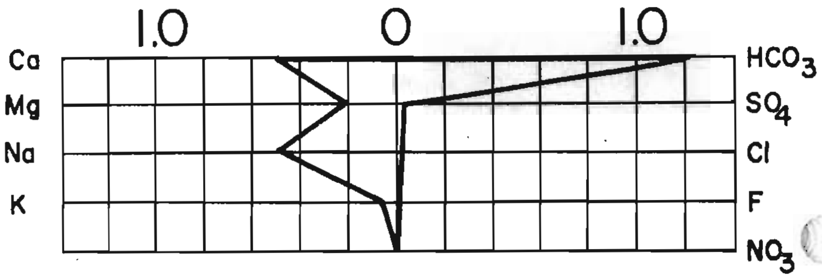
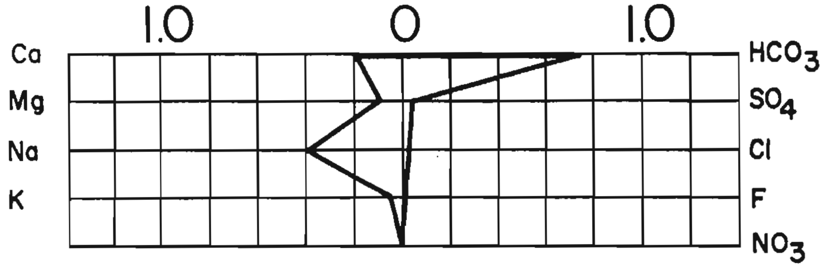


Figure 13. Mean concentrations in parts per million of dissolved solids, chloride, and nitrate in water from springs, drilled wells, and dug wells in the Morganton area.


Type I - calcium, magnesium, sodium bicarbonate


Type II - calcium, sodium, magnesium bicarbonate


Type III - calcium-sodium, magnesium bicarbonate


Type IV - sodium, calcium magnesium bicarbonate

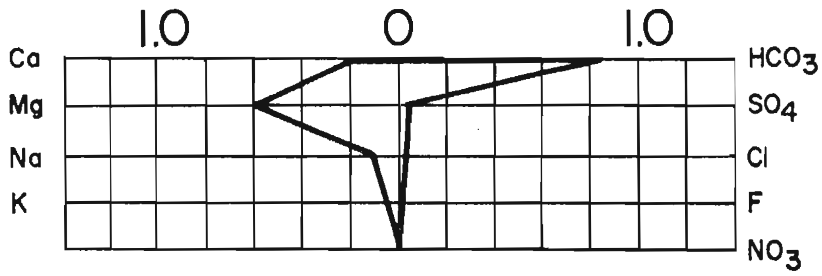

Type V - magnesium, calcium, sodium bicarbonate

Figure 14. Pattern diagrams illustrating the five basic ground-water types in the Morganton area. Scale is in equivalent parts per million.

solution of calcium-bearing minerals which occur in layered gneiss, amphibolite gneiss, quartz-biotite gneiss, arkosic and pyroclastic rocks, quartzite, argillite and phyllite, and in granitic rocks and gneiss.

In many rock units in the Morganton area calcium carbonate occurs disseminated throughout the rock. Calcium carbonate dissolves more readily than the silicate minerals, therefore an analysis of ground water from a rock unit containing a small amount of calcium carbonate may show a relatively high percentage of calcium. The solution of calcium carbonate could mask the effect of the more abundant, but less soluble, silicate minerals.

Type II Ground Water

Although type II is a calcium bicarbonate water, it is distinguished from type I by the relative amounts of magnesium and sodium. Sodium exceeds magnesium and calcium exceeds the sum of both sodium and magnesium. This water occurs predominantly in sillimanitic-mica schist, quartz-biotite gneiss, and arkosic and pyroclastic rocks.

Type III Ground Water

Generally, type III is associated with rocks which have a granitic composition, and is a calcium-sodium bicarbonate water with sodium and calcium being about equal and magnesium the least abundant of the three principal cations. It occurs in quartz-biotite gneiss, amphibolite gneiss, granitic gneiss, layered gneiss, and augen gneiss. Relatively high concentrations of sodium indicate the presence of sodic feldspars.

Type IV Ground Water

Type IV is essentially a sodium-bicarbonate water. Sodium exceeds calcium and magnesium, with the latter being the least abundant of the three cations. Normally, it is associated with granite and granite gneiss; however, it occurs also in layered gneiss, and quartz-biotite gneiss, amphibolite gneiss, and augen gneiss. This water results from the decomposition of sodic plagioclase feldspar which is a principal mineral in many rock units especially granite gneiss.

Type V Ground Water

As indicated in figure 14, type V is a magnesium-bicarbonate water. Magnesium varies from slightly greater than the second abundant cation to more than 2 times the sum of sodium and calcium. Usually sodium is the least abundant of the three cations. Water of this type occurs in quartz-biotite gneiss, layered gneiss, amphibolite gneiss, arkosic and pyroclastic rocks, and quartzite. Biotite and hornblende probably contribute much magnesium to the water in these two rock units.

Table 3 shows a comparison of the number of analyses representing the five water types versus rock units. The following are rock types which have a characteristic water type: layered gneiss--type I; sillimanite-mica schist--type II; amphibolite gneiss--type I and V.

Nearly all rock units contain more than one type of water. Quartz-biotite gneiss, for example, contains all five types. Lack of complete correlation of water type and lithology probably is caused by changes in mineral composition within rock units and/or mixing of different types of ground water. Although there are certain discrepancies in water-type and lithology relationships, ground water composition indicates the general chemical characteristics of the rock from which it comes. Detailed geologic mapping and water sampling would show a closer relationship.

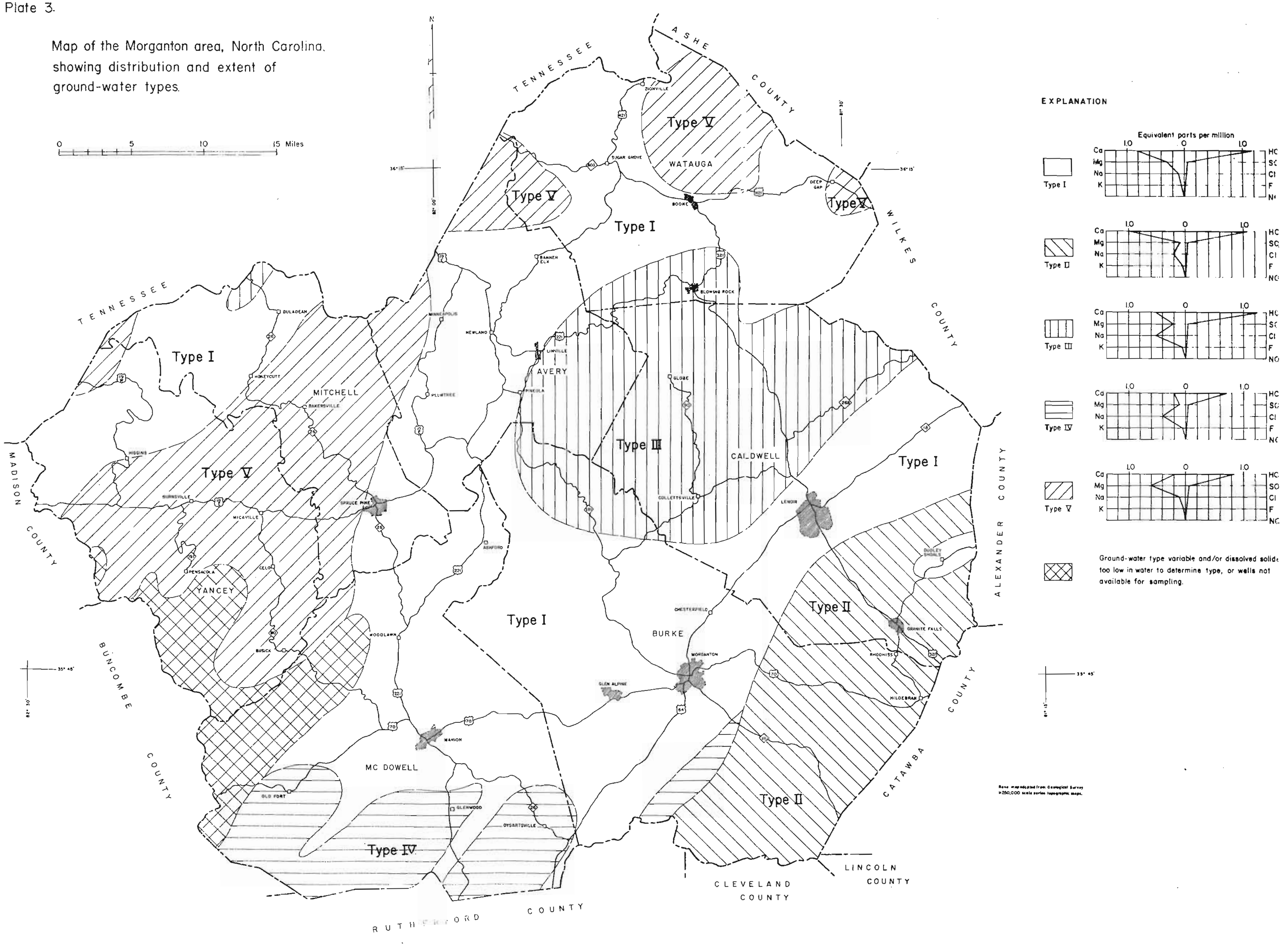
An areal distribution of water types in the Morganton area is shown in plate 3. Type I occurs over a large part of the area and the boundaries of this type cross geologic contacts. A large area of this type is located in Burke and McDowell Counties with segments extending northeastward across Caldwell County and northward into Avery and Watauga Counties. Also, another sizeable area is located in the western part of Mitchell and Yancey Counties. In this latter area, the type I - type V boundary roughly parallels the layered gneiss-amphibolite gneiss contact.

Type II is associated with sillimanite-mica schist in southeastern Caldwell and Burke Counties. The boundary between type I and type II follows the sillimanite-mica schist quartz-biotite gneiss contact along the western edge of the schist unit. However, this boundary does not coincide with the contact along the eastern edge of the sillimanite-mica schist unit.

Type III occurs in the northwestern half of Caldwell County and adjacent parts of Burke, Avery, Watauga Counties. The boundary is somewhat ill-defined along the Blue Ridge due to lack of data.

Plate 3.

Map of the Morganton area, North Carolina, showing distribution and extent of ground-water types.



Ground-water type variable and/or dissolved solids too low in water to determine type, or wells not available for sampling.

Base map adapted from Geological Survey 1:250,000 scale series topographic maps.

TABLE 3. Number of water analyses representing the five water types versus rock units in the Morganton area. Analyses which have less than 20 ppm dissolved solids are not included.

ROCK TYPE	WATER TYPE				
	I	II	III	IV	V
Quartz-monzonite gneiss				1	
Sillimanite-mica schist		4			
Granitic gneiss	3	1	1	2	
Quartz-biotite gneiss	6	6	2	3	6
Layered gneiss	12	1	1	4	3
Amphibolite gneiss	4		2	2	6
Augen gneiss			1	1	
Argillite and phyllite	2	1			
Arkosic and pyroclastic rocks	1	3			2
Schistose quartzitic rocks	1				
Quartzite	1		1		1

Type IV occurs in southern McDowell, southern Caldwell, northern Avery, and eastern Watauga Counties and is associated with granite gneiss. In western and eastern McDowell County, the composition of the ground water changes along strike of the granite gneiss unit which indicates a possible change in the mineral composition in the rock. The chemical composition of the water changes from a sodium-bicarbonate water (type IV) to a calcium-bicarbonate water (type I).

Type V occurs in Mitchell, Yancey, and Watauga Counties. It is associated chiefly with amphibolite gneiss.

GROUND-WATER HYDROLOGY

The Hydrologic Cycle

The constant circulation of water vapor and water between the earth and the atmosphere is called the hydrologic cycle. Heat from the sun causes water from the oceans and the rivers, lakes, and soil of the land to evaporate into the atmosphere. The oceans cover about three-fourths of the earth's surface, but nearly 5½ times as much water is evaporated from the oceans as from the land surfaces. The amount of water vapor the atmosphere is able to hold depends on its temperature; as its temperature increases the atmosphere can retain more moisture. Relative humidity is the amount of water vapor in the air compared with the maximum amount of water vapor that the air could hold at a given temperature. When moisture in the atmosphere attains a relative humidity of 100 percent, the saturation point, either by cooling or acquisition of water vapor, conditions are favorable for precipitation that may fall as rain, sleet, hail, or snow. Dew is an important source of moisture for plants in arid regions. Water from precipitation on the land surfaces may run off into lakes and streams and return to the oceans, or some may infiltrate the soil and percolate downward to the zone of saturation from whence it may move laterally to reappear at lower surfaces as seeps and springs or streams, or precipitation may evaporate after falling on the earth and return directly to the atmosphere (fig. 15). This transfer of moisture between the earth and the atmosphere through many complex and divergent routes is unending.

The water table

Subsurface water is that which has infiltrated the earth's surface or the soil layer. It may be used and transpired by plants, it may be evaporated directly from the soil, or it may percolate downward to the zone of saturation where it becomes part of the ground-water reservoir. Subsurface water in the unsaturated zone, known as the zone of aeration, occurs in three layers: the soil layer, an intermediate layer, and a lower layer or capillary fringe which lies directly over the zone of saturation or ground-water reservoir (fig. 15). When sufficient water has infiltrated the soil layer to overcome the molecular attraction of soil particles, it will begin to percolate downward through the

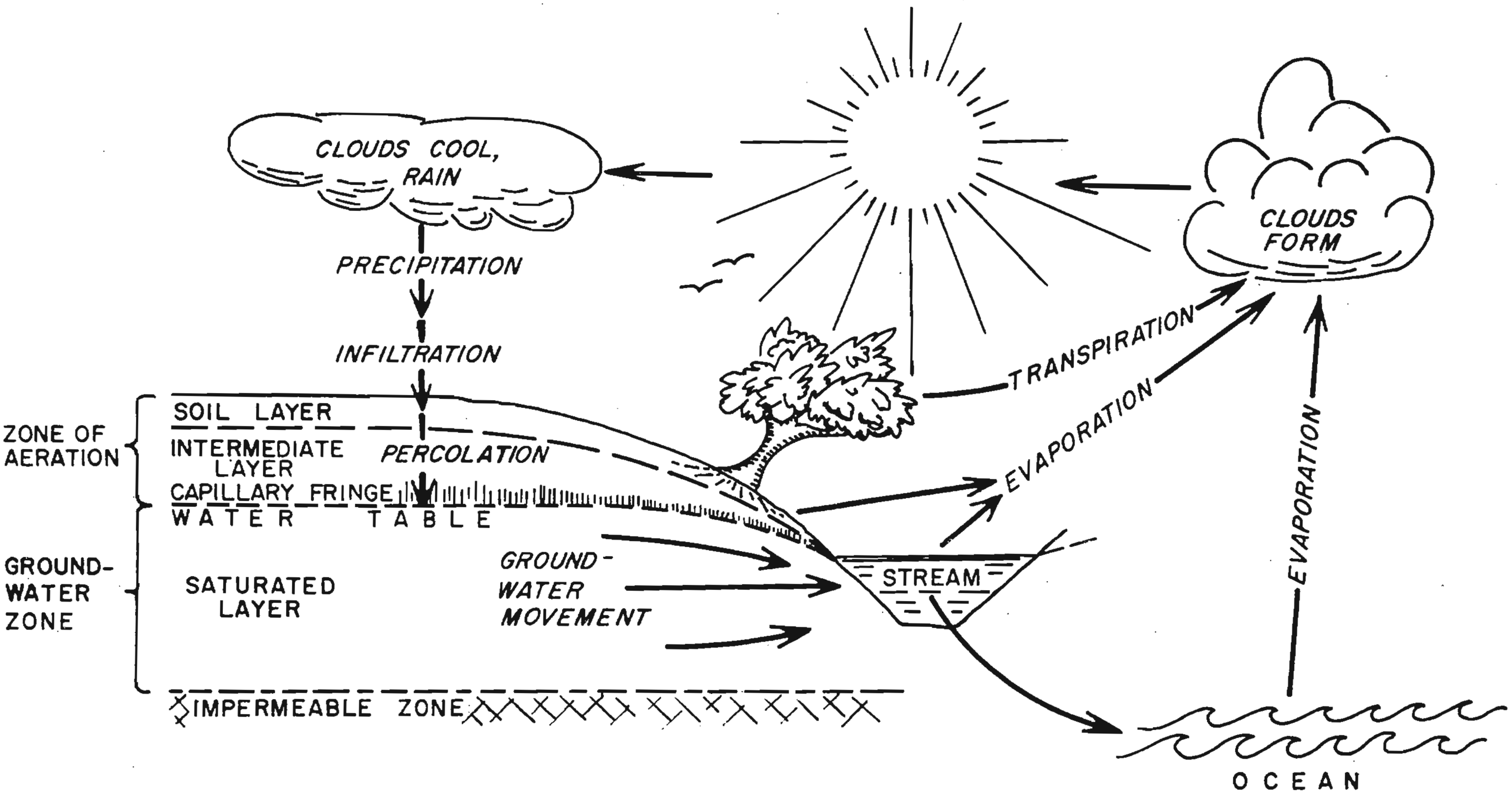


Figure 15. Simplified diagram of the hydrologic cycle and subsurface water zones.

intermediate layer by the pull of gravity. The capillary fringe consists of water held above the zone of saturation by capillary attraction; in fine silts or clayey earth it may rise several feet and in coarse gravel it may rise less than an inch. The upper surface of the zone of saturation is known as the water table. The zone of saturation is the vast system of ground-water reservoirs in permeable rock that provide water to seeps, springs, and effluent streams, and to wells. Configuration of the water table is generally a subdued reflection of topographic relief, although it may be discontinuous between joint and shear systems in bedrock. The bottom of the zone of saturation is obscure; it may be defined conditionally as the greatest depth at which ground-water circulation occurs in joint and shear systems.

Occurrence of ground water

Ground water in the Morganton area occurs in the deeply weathered residual mantle or saprolite and in joints or shear openings in bedrock. Trend of ground-water movement in saprolite or bedrock openings is more or less directly from higher interfluvial places in topography, and the water table, to lower areas, generally to effluent perennial streams. Rate of ground-water movement is dependent on hydraulic gradient and permeability of the water-saturated zone. Where relict schistosity is present in saprolite, it influences the movement of ground water, as transmission takes place more freely parallel to relict schistose layers than normal to them. Shallow wells in saprolite have long been a source of ground water for domestic use wherever the weathered mantle is of sufficient thickness and permeability to yield ground water. Although this shallow source of water continues to be of significance for individual domestic water supplies, it seldom provides sufficient water for industrial or municipal applications. Aerial photographs and topographic maps show many subsequent streams of the Morganton area in rectangular-trellis patterns which are, by reconnaissance field data, indicative of underlying joint and shear systems in bedrock. Circulation of ground water along joint and shear systems causes enlargement of these linear openings by solution with consequent increasing permeability, particularly in gneissic rock types which contain calcic plagioclase and in dolomitic rocks. Surficially the increase in permeability is manifested by development of linear depressions over the underlying pattern of joint and shear systems. These linear depressions, generally in rectangular patterns, are persistent for considerable distances and range in width from tens of feet to about a quarter of a mile. They may or may not retain perennial streams, depending on topographic circumstances. These linear zones of relatively high permeability are most obvious in the inner Piedmont, but they are present throughout the Morganton area and represent the best sites for development of ground water (pl. 1).

Dug and bored wells

The oldest source of ground water in this area is from wells dug in the water-bearing saprolite or flood-plain alluvium. Bored wells differ from the older dug wells only in the manner in which they are excavated and in their slightly greater depths; they are usually augered through saprolite to or nearly to bedrock. Dug and bored wells are the source of domestic water supplies for individual farms or outlying residences not availed of municipal water systems. Of 125 dug and bored wells inventoried, the average depth is 35 feet and the average depth to the water table is 23 feet. The deepest bored well in the area is 150 feet and the greatest depth to the water table is 120 feet. Insufficient data preclude any estimate of yields from these wells except that they provide enough water for domestic use. Quality of ground water from dug and bored wells is generally comparable to that from drilled wells as relating to hardness or dissolved minerals. Risk of contamination in shallow wells is greater because of their obvious nearness to possible surface sources of contamination. Bored wells, and perhaps some dug wells, will continue to be a source of domestic supplies for new residences in outlying areas. Caution should be taken to locate a dug or bored well at sufficient elevation or distance from any septic tank, sewage field, barn, stable, sty, or similar source of contamination. Tests for possible contamination of household-water supplies from shallow wells should be made at fairly frequent intervals. Water-table fluctuations are shown from monthly measurements of 26 dug or bored observation wells in the Morganton area, mostly in the inner Piedmont province, in figures 17, 19, 21, 23, 25, and 29.

Drilled wells

Drilled wells are a source of ground water for individual, industrial, and municipal water systems throughout the area. They are drilled and cased through the residual saprolite mantle and obtain ground water from fractures or similar openings in unweathered bedrock. The available quantity of ground water from drilled wells is dependent on the degree to which the source rock is fractured and permeable to ground-water movement. At greater depths, beyond about 300 feet, fractures or similar openings in bedrock decrease in size and number; hence the average optimum depth of drilled wells is not over 300 feet (table 4). Inventories of drilled wells show that most are about 6 inches in diameter. Larger well diameters will provide greater yields due to increased number of intersected rock openings and greater rock surface from which ground water will be available. A few industrial and municipal wells are 8 or 12 inches in diameter. Drilled wells will generally yield greater quantities of water from topographically low or flat areas and from draws or swales, as these features generally represent differential weathering of more fractured and permeable underlying bedrock (table 5). No attempt has been made to relate yield of wells to the many rock types of the area due to the deficiency of representative wells in each rock type. Fractures and similar openings appear to be of more consequence to yield of drilled wells than rock type. Hardness of ground water from drilled wells is generally low. Locally, dissolved iron may be sufficient to preclude ground water from some industrial uses. Iron in ground water of this area is probably derived from pyroxene, amphibole, and iron-sulphide minerals. Iron may also come from ground water contact with well casing, pump parts, and other iron objects. Where the well head is properly sealed, possibility of contamination of water in drilled wells from surface sources is unlikely. Present rates of ground-water withdrawal have no discernable effect on the water table. Ground-water use in the Morganton area is negligible in comparison to the amount of water available as recharge.

Springs

High annual precipitation in the area of this investigation favors a large number of springs, particularly in the Blue Ridge province. Saturation of residual mantle and fracture zones in bedrock results in discharge of ground water from the storage reservoirs where the water table

TABLE 4. Average yield of drilled wells according to depth in the Morganton area.

Range in depth (feet)	Number of wells	Average depth (feet)	Average yield (gpm)	Average yield per foot of well
0-100	130	76	13.0	0.17
101-200	164	145	14.5	0.10
201-300	42	245	19.5	0.08
Deeper than 300	41	377	17.5	0.05
All wells	377	156	15.0	0.10

is intersected by land surface, usually in draws or on slopes where the mantle-bedrock contact is exposed. Rate of spring discharge is dependent on hydraulic gradient of the water table and permeability where the spring issues from the ground-water reservoir. Fluctuation of spring discharge is dependent on the size and permeability of the reservoir or source rock, and on variations in precipitation. Springs from large underground reservoirs of relatively low permeability will show less fluctuation than those issuing from small underground reservoirs of relatively high permeability. Where springs are common in the Morganton area they are used for domestic and municipal water supplies. Most springs used are of small discharge, 1 to 3 gallons per minute, and the water is usually retained in a large-capacity storage tank against greater-than-discharge demands of short duration. Quality of spring water in the Blue Ridge province is generally very good, as it contains few dissolved mineral substances. Due to the near-surface origin of spring water, contamination is a possibility not to be overlooked. Use of springs for domestic and public water supplies should receive equal consideration with respect to possible pollution as shallow dug or bored wells. Monthly fluctuations of 37 observation springs in the area, mostly in the Blue Ridge province, are shown in figures 17, 19, 21, 23, 25, 27, and 29.

Municipal water supplies

In the Morganton area there are 22 towns or communities supplied by municipal water systems. Ten of these municipal systems obtain water

TABLE 5. Average yield of drilled wells according to topographic location.

COUNTIES	TOPOGRAPHIC LOCATIONS OF WELLS											
	FLAT			SLOPE			DRAW			HILL TOP		
	Av. Depth	Av. Q	Av. Q/ft.	Av. Depth	Av. Q	Av. Q/ft.	Av. Depth	Av. Q	Av. Q/ft.	Av. Depth	Av. Q	Av. Q/ft.
AVERY	159	27.5	0.17	104	10.5	0.10	151	26.5	0.18	451	5.0	0.01
BURKE	175	18.5	0.11	160	7.0	0.04	179	56.5	0.32	298	5.0	0.02
CALDWELL	193	19.5	0.10	185	2.5	0.01	242	48.5	0.20	369	5.0	0.01
McDOWELL	110	18.0	0.17	156	10.5	0.07	167	25.0	0.15	151	8.5	0.06
MITCHELL	92	8.0	0.86	124	4.0	0.03	171	49.0	0.29	307	5.0	0.02
WATAUGA	124	21.5	0.15	170	12.0	0.07	136	31.0	0.23	429	4.0	0.01
YANCEY	125	22.5	0.18	73	7.5	0.10	121	35.0	0.29	450	8.0	0.02
AREA AVERAGE	140	19.5	0.25	139	7.5	0.06	167	38.5	0.24	350	6.0	0.02

Q= Yield in GPM

solely from surface-water sources, eight obtain water solely from wells, three municipal supplies come from springs, and only one is using a combined source of well water and surface runoff. Ground water from deep wells as a source of municipal supplies is desirable for its clarity, constant temperature, and its absence of bacteria, organic growths, tastes, and odors that commonly occur in surface waters. Far more ground water lies in the natural, underground reservoirs than is or possibly could be retained by surface storage. These underground reservoirs are not as subject to variability as is surface runoff during periods of drought. Ground water is capable of much greater development for municipal and industrial use in this area. It has been estimated that consumptive use of water will increase by about one-third the present rate within the next decade. Average per capita use of municipal water in North Carolina is 131 gallons per day (McKichan and Kammerer, 1961). Municipal supplies of the Morganton area are listed alphabetically with their descriptions.

Bakersville, Mitchell County

Ownership: Municipal.
Source: One well 12 inches in diameter, 401 feet deep, yielding 200 gpm.
Treatment: None.
Storage: One reservoir of 165,000 gallons.
Population served: About 450.
Remarks: Water is slightly hard. Its source rock is amphibilite gneiss.

Banner Elk, Avery County

Ownership: Edgar Tufts Memorial Association.
Source: Three wells 6 inches in diameter, 173, 204, and 115 feet deep, each yielding 50 gpm.
Treatment: None.
Storage: One reservoir of 100,000 gallons.
Population served: About 900.
Remarks: The source is meta-arkose and pyroclastic rocks.

Blowing Rock, Watauga County

Ownership: Municipal.
Source: Impoundment of Flat Top Mountain watershed in Brickhouse Creek Dam.
Treatment: Filtration and chlorination, 500,000 gpd capacity.
Storage: One standpipe of 425,000 gallons of finished water and 20,000,000 gallons of raw water in Brickhouse Creek Dam.

Population served: About 5,000 during the summer, but only 711 during the remainder of the year.
Remarks: The watershed is in a metavolcanic terrane.

Boone, Watauga County

Ownership: Municipal.
Source: Winklers Creek Dam about 5 miles southwest of town and three wells, 380, 420, and 460 feet deep, each yielding 75 gpm. The wells are located about 1 mile apart and are pumped only during the summer.
Treatment: Filtration, chlorination, and ammoniation of surface water, 250,000 gpd capacity. The well water is not treated.
Storage: Two clear wells of 275,000 and 500,000 gallons capacity.
Population served: About 4,200.
Remarks: The watershed is in metavolcanic terrane and the wells are in layered gneiss.

Burnsville, Yancey County

Ownership: Municipal.
Source: Impoundment of Bolens Creek about 4 miles southeast of town.
Treatment: Filtration and chlorination, 800,000 gpd capacity.
Storage: Two reservoirs of finished water, 250,000 gallons each.
Population served: About 2,600.
Industrial use: About 50 percent.
Remarks: The watershed is in amphibolite-gneiss terrane.

Crossnore, Avery County

Ownership: Crossnore School, Inc.
Source: Two wells 186 and 203 feet deep yielding 50 gpm and 75 gpm.
Treatment: None.
Storage: One reservoir of 15,000 gallons.
Population served: About 250.
Remarks: The source rock is schistose quartzite.

Drexel, Burke County

Ownership: Municipal.
Source: Probst Creek impoundment at the north side of town.
Treatment: Prechlorination, coagulation with alum and lime, sedimentation, filtration, and postchlorination, 666,000 gpd capacity.
Storage: Three tanks totaling 310,000 gallons of finished water, and 500,000 gallons of raw water in Probst Creek impoundment.
Population served: About 1,600.
Industrial use: About 15 percent.
Remarks: Probst Creek watershed is in granitic-complex terrane.

Elk Park, Avery County

Ownership: Municipal.
Source: A spring about $1\frac{1}{2}$ miles north of town. The rate of discharge and fluctuations are not known.
Treatment: None.
Storage: One clear well of 100,000 gallons.
Population served: About 850.
Remarks: The spring originates in Beech granite gneiss.

Glen Alpine, Burke County

Ownership: Municipal.
Source: One well 355 feet deep, 8 inches in diameter, yielding 225 gpm.
Treatment: None.
Storage: One standpipe of 75,000 gallons.
Population served: About 1,700.
Remarks: The source rock is a granite-gneiss complex.

Granite Falls, Caldwell County

Ownership: Municipal.
Source: Lake Rhodhiss, an impoundment of the Catawba River.
Treatment: Prechlorination, coagulation with alum and lime, addition of carbon for control of taste and color, sedimentation, filtration, postchlorination, and addition of Calgon for corrosion control, capacity 600,000 gpd.
Storage: Two clear wells totaling 335,000 gallons and two elevated tanks totaling 300,000 gallons.
Population served: About 2,700.
Remarks: The watershed is in widely varied terrane.

Hudson, Caldwell County

Ownership: Hudson Cotton Manufacturing Company.
Source: One well 1,058 feet deep, 8 inches in diameter, reportedly yielding 300 gpm. The Lenoir municipal water system is available to Hudson but is not being used.
Treatment: Chlorination, 100,000 gpd capacity.
Storage: One elevated tank of 75,000 gallons of finished water.
Population served: About 1,900.
Industrial use: About 5 percent.
Remarks: The source rock is mica schist.

Lenoir, Caldwell County

Ownership: Municipal.
Source: Zacks Fork impoundment about 1 mile northeast of town and Lake Rhodhiss.
Treatment: Prechlorination, coagulation with alum and lime, sedimentation, anthracite filtration, postchlorination, adjustment of pH with lime, and fluoridation. Zacks Fork plant capacity is 1,500,000 gpd and Lake Rhodhiss plant capacity is 3,000,000 gpd.

Storage: Two clear wells totaling 750,000 gallons and three elevated tanks totaling 2,500,000 gallons, all finished water.
Population served: About 12,500.
Remarks: Zacks Fork watershed is in granite-gneiss complex and Lake Rhodhiss watershed is in widely varied terrance.

Linville, Avery County

Ownership: Linville Resorts, Inc.
Source: Two wells 245 and 247 feet deep, 10 and 8 inches in diameter, each yielding 60 gpm.
Treatment: Chlorination.
Storage: One elevated tank of 50,000 gallons, finished water.
Population served: About 350.
Remarks: The source rock is metavolcanic and meta-arkose.

Little Switzerland, McDowell County

Ownership: Municipal.
Source: Four springs about 1/2 mile northwest of town. Their rate of discharge and fluctuations are not known.
Treatment: None.
Storage: Two reservoirs totaling 37,000 gallons.
Population served: About 165.
Remarks: The source rock is amphibolite gneiss.

Marion, McDowell County

Ownership: Municipal.
Source: Direct gravity flow from Clear Creek and Mackeys Creek, and direct pumpage from Buck Creek to the filter plant. Lake Tahoma impoundment is available in event of shortage.
Treatment: Filtration and chlorination, 2,000,000 gpd capacity.
Storage: One clear well of 1,250,000 gallons.
Population served: About 12,000.
Industrial use: About 40 percent.
Remarks: The watersheds are in predominantly biotite-gneiss terrane.

Montezuma, Avery County

Ownership: Mrs. C. M. French.
Source: A spring about ½ mile east of town. Its yield and fluctuation are not known.
Treatment and storage: None.
Population served: About 250.
Remarks: The source rock is metavolcanic.

Morganton, Burke County

Ownership: Municipal.
Source: Directly from the Catawba River and the Henry Fork.
Treatment: Filtration and chlorination, 4,000,000 gpd capacity.
Storage: Two standpipes totaling 1,500,000 gallons and two clear wells totaling 2,000,000 gallons, all finished water.
Population served: About 12,500.
Industrial use: About 65 percent.
Remarks: The watersheds are in widely varied terrane.

Newland, Avery County

Ownership: Municipal.
Source: One well 219 feet deep, 8 inches in diameter, yielding 165 gpm.
Treatment: Chlorination.
Storage: One reservoir of 185,000 gallons of finished water.
Population served: About 600.
Remarks: Source rock is metavolcanic.

Old Fort, McDowell County

Ownership: Municipal.
Source: Jarrett Creek impoundment about 3 miles north of town.
Treatment: Chlorination, 200,000 gpd capacity.
Storage: Impoundment of 1,000,000 gallons, all raw water.
Population served: About 700.
Remarks: The watershed lies in biotite-gneiss terrane.

Rhodhiss, Burke County

Ownership: Municipal.
Source: Two wells 151 and 386 feet deep, 6 and 10 inches in diameter, yielding 20 gpm and 105 gpm.
Treatment: Chlorination.
Storage: Two standpipes totaling 100,000 gallons, all finished water.
Population served: About 1,000.
Remarks: The source rock is biotite gneiss.

Spruce Pine, Mitchell County

Ownership: Municipal.
Source: Beaver Creek impoundment about 5 miles north of town, and Graveyard Creek impoundment about 3 miles southeast of town.
Treatment: Filtration and chlorination, 200,000 gpd capacity.
Storage: Two reservoirs totaling 700,000 gallons, all finished water.
Population served: About 3,500.
Industrial use: About 20 percent.
Remarks: The watersheds lie in widely varied terrane.

Valdese, Burke County

Ownership: Municipal.
Source: Lake Rhodhiss and City Lake at the east side of town.
Treatment: Prechlorination, coagulation with alum, soda ash, and lime, sedimentation, filtration, and postchlorination, 3,000,000 gpd capacity.
Storage: Four clear wells totaling 1,740,000 gallons of finished water.
Population served: About 3,500.
Industrial use: About 85 percent.
Remarks: City Lake watershed is in mica schist and Lake Rhodhiss watershed lies in widely varied terrane.

COUNTY DESCRIPTIONS

A brief summary of physiography, economy, geology, and ground-water occurrence of each county of the Morganton area is presented in the following section of this report. Tables of well data, water analyses, a well and spring location map, and observation well and spring hydrographs for each county follow the county descriptions.

Well yields are generally the driller's estimate, based on a pumping or bailing test of short duration. Only controlled pumping tests can provide more accurate data.

Analyses of ground water from the Morganton area are shown in tables 8, 11, 14, 17, 20, 23, and 26. A small number of analyses show iron concentrations which are above the recommended maximum concentrations of 0.3 ppm. Water from several wells has high nitrate and chloride concentrations which are indicative of possible pollution. In this report, a sample is considered to have "high" chloride and nitrate concentrations if these constituents exceed 3 and 1 ppm respectively. However, excluding the waters which have excessive iron concentrations nearly all ground waters sampled in the Morganton area contain less than the maximum recommended concentrations of chemical constituents set by the U. S. Public Health Service.

Avery County

(Area 247 square miles; 1960 population, 12,009)

Avery County lies in the Blue Ridge part of the area of investigation and is bounded on the northwest by Tennessee (fig. 1). Topography in Avery County is varied, ranging from moderately wide valleys and subdued hills to deeply dissected slopes. Altitudes range from about 3,500 feet above mean sea level in the southern tip of the county to 6,189 feet at Big Yellow Mountain on the western boundary. Tributaries of the Catawba River drain the steep eastern front of the Blue Ridge in southeastern Avery County. The northwest-coursing Watauga River and tributaries of the south-coursing North Toe River constitute the drainage systems of the greater part of the county.

The largest towns are Newland, the county seat, Elk Park, Linville, Banner Elk, and Crossnore. The economy is predominantly agricultural; nearly 36 percent of the area is farmland. Forest products and mining supplement agriculture. A southeastern segment of Avery County is traversed by the scenic Blue Ridge Parkway.

Metamorphic rock types in Avery County are highly varied, ranging from mafic volcanics to granitic gneiss, but amphibolite gneiss predominates in the northwest and pyroclastics with associated argillite and phyllite are predominant in the southeast (pl. 2). Structural trends of the rocks are generally north-northeast to northeast. Lower areas of subdued topography have a thin but well developed residual mantle of weathered rock. Thin deposits of gravel are sought for road metal in some of the wider stream valleys.

Drilled wells supply much of the domestic, industrial, and municipal water requirements of Avery County. Springs are used, where they are available, by farms and many outlying residences. Dug and bored wells are not common, as the residual mantle is thin or absent in many localities. Most of the drilled wells in Avery County are less than 200 feet deep. Of 32 such wells the average depth is 120 feet and the average yield 16 gallons per minute. Wells having the highest yields are in low, flat areas or draws.

Municipal water supplies of Newland, Banner Elk, Crossnore, and Linville are provided by wells. Springs supply municipal water to Elk Park and the community of Montezuma. Although it is well endowed with surface water in three major drainage basins, surface runoff in Avery County is not utilized for municipal water supplies.

Analyses of ground water from Avery County are shown in table 8. Water from well 10 and spring 5A contained more than 0.3 ppm iron. Water from wells 4, 10, 13, 50 and springs 2A and 3A had high nitrate and chloride concentrations. Water from well 13 contained an unusually high amount of sulfate (49 ppm). This water may have passed through a zone of sulfide mineralization. Oxidation of sulfides to soluble sulfates and removal by ground water could account for the high sulfate concentration in this water.

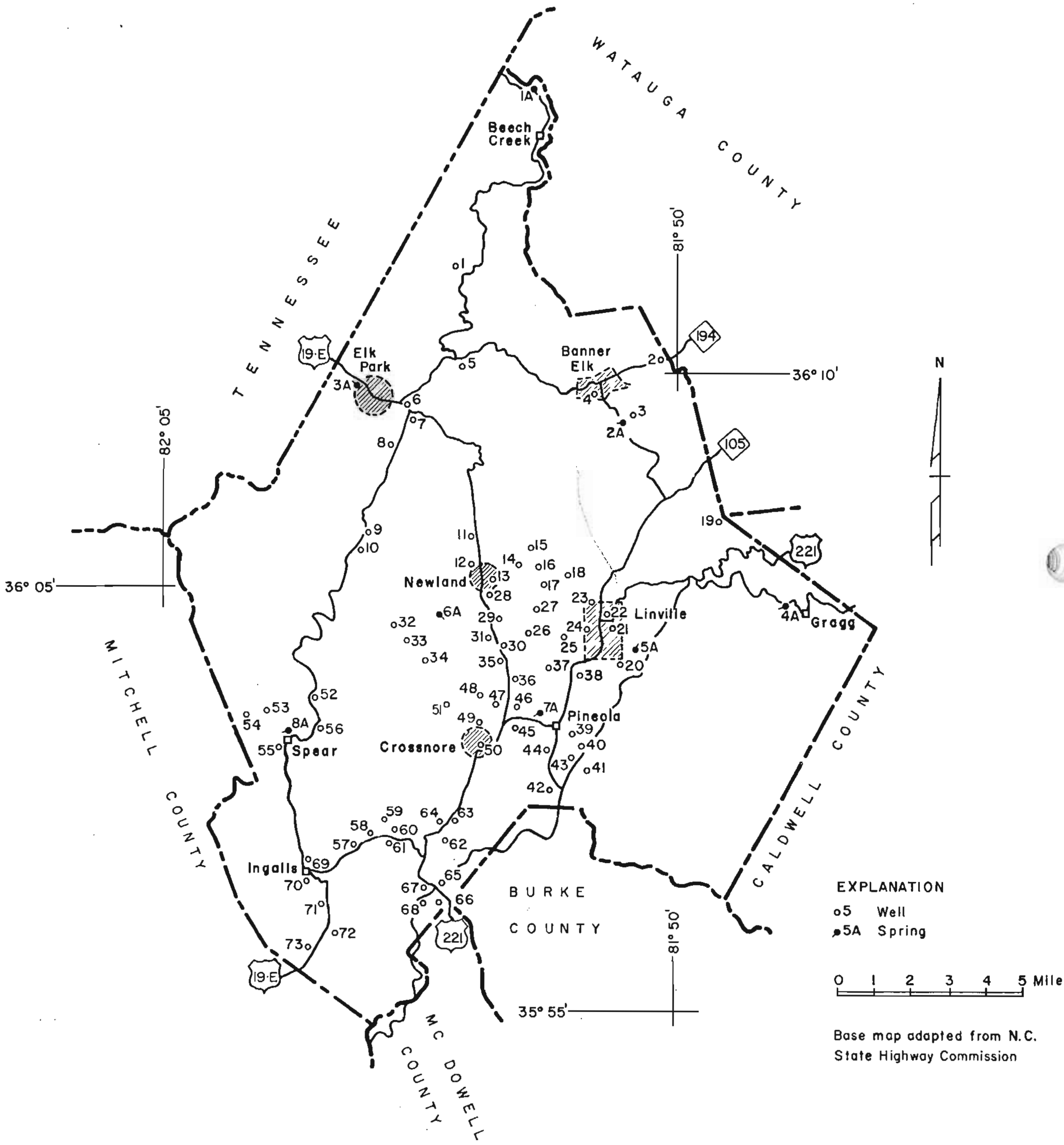


Figure 16. Map of Avery County showing locations of wells and springs.

TABLE 6. RECORDS OF WELLS IN AVERY COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Draw-down (ft)	Topography	Remarks
1	0.4 Mi. W of Dark Ridge	J. Parlier	Drilled	53	6	8	Granitic gneiss	43	8.0	-----	Slope	
2	2.0 MI. E of Banner Elk	R. Shoemaker	--do--	87	6	33	Quartzite	4	18.0	-----	Draw	
3	0.6 Mi. S of Banner Elk	County Hospital	--do--	215	6	21	Pyroclastics	10	35.0	-----	--do--	
4	Banner Elk	E. Tufts Mem. Assoc.	--do--	173	6	-----	--do--	-----	50.0	-----	Flat	
5	Heaton	Church	--do--	150	6	50	Layered bneiss	33	10.0	-----	--do--	
6	0.5 Mi. E of Elk Park	H. Shell	--do--	100	6	70	--do--	15	-----	-----	--do--	
7	1.0 Mi. N of Cranberry	Cranberry High School	--do--	175	6	60	--do--	22	50.0	-----	--do--	
8	Cranberry	Town of Cranberry	--do--	150	6	62	Amphibolite gneiss	-----	10.0	-----	--do--	Hard water
9	Minneapolis	J. W. Callahan	--do--	50	6	7	--do--	15	7.0	-----	Slope	
10	--do--	E. L. Smith	--do--	73	6	73	--do--	43	8.5	-----	Flat	
11	1.2 Mi. N of Newland	G. Andrews	--do--	83	6	36	Phyllite	-----	5.0	-----	Slope	
12	Newland	Town of Newland	--do--	450	6	30	Quartzite	-----	50.0	-----	Flat	Hard water
13	--do--	--do--	--do--	219	8	20	Phyllite	-----	165.0	-----	--do--	
14	1.1 Mi. E of Newland	H. Carpenter	--do--	62	5	-----	Pyroclastics	13	25.0	-----	Slope	
15	2.0 Mi. NE of Newland	D. Banner	--do--	59	5	20	--do--	-----	30.0	-----	--do--	
16	1.6 Mi. NE of Newland	F. Banner	--do--	52	6	20	--do--	-----	20.0	-----	--do--	
17	1.4 Mi. NE of Newland	H. Braswell	--do--	100	6	45	--do--	-----	5.0	-----	--do--	
18	3.0 Mi. E of Newland	L. W. Ruth	--do--	96	6	35	Volcanics and arkose	-----	10.0	-----	--do--	
19	Grandfather Mtn.	H. Morton	--do--	451	6	6	--do--	436	5.0	-----	Hilltop	
20	0.7 Mi. SE of Linville	M. Honeycutt	Drilled	125	5	5	Volcanics and arkose	-----	15.0	-----	Flat	
21	Linville	Linville Resorts Inc.	--do--	245	8	-----	Phyllite	-----	60.0	-----	--do--	
22	--do--	Linville Lodge	--do--	417	6	74	Arkose and phyllite	-----	85.0	-----	--do--	
23	--do--	F. Hampton	--do--	105	6	50	Volcanics and arkose	-----	20.0	-----	--do--	
24	--do--	Pivie Motel	--do--	160	6	90	Phyllite	-----	20.0	-----	--do--	
25	0.5 Mi. E of Montezuma	E. Carpenter	--do--	96	6	21	Volcanics and arkose	20	-----	-----	Slope	
26	Montezuma	L. W. Sudderth	--do--	101	6	42	--do--	12	-----	-----	Flat	Bedrock @ 40 feet
27	1.0 Mi. N of Montezuma	R. Braswell	--do--	212	6	30	--do--	15	-----	-----	--do--	
28	0.5 Mi. S of Newland	M. Hodney	--do--	475	6	20	Phyllite	-----	20.0	-----	--do--	
29	1.0 Mi. S of Newland	H. Taylor	--do--	100	5	40	Amphibolite gneiss	-----	10.0	-----	Slope	
30	2.0 Mi. S of Newland	M. Jackson	--do--	48	5	22	Volcanics and arkose	-----	8.0	-----	Flat	
31	1.8 Mi. S of Newland	E. G. Foster	--do--	60	5	20	Layered gneiss	-----	4.0	-----	Slope	
32	5.1 Mi. W of Newland	C. Taylor	--do--	53	6	20	Amphibolite gneiss	-----	4.0	-----	--do--	
33	4.6 Mi. SW of Newland	C. Freeman	--do--	80	6	44	--do--	-----	7.0	-----	--do--	
34	3.5 Mi. SW of Newland	J. Moody	Dug	18	18	18	Saprolite	7	-----	-----	--do--	
35	2.5 Mi. S of Newland	M. Andrews	Drilled	127	5	60	Volcanics and arkose	-----	12.0	-----	Flat	
36	3.0 Mi. S of Newland	T. Reed	--do--	103	5	17	--do--	-----	5.0	-----	Slope	

TABLE 6. RECORD OF WELLS IN AVERY COUNTY (Continued)

Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
37	0.8 Mi. SE of Montezuma	J. Smith	Drilled	76	5	47	Volcanics and arkose	——	15.0	——	Flat	
38	1.0 Mi. SW of Linville	E. C. Robbins	—do—	150	5	95	Phyllite	——	7.0	——	—do—	
39	1.0 Mi. E of Pineola	G. E. Greene	—do—	109	5	16	Volcanics and arkose	——	8.0	——	—do—	
40	1.5 Mi. SE of Pineola	J. Baker	—do—	66	6	61	—do—	——	7.0	——	—do—	
41	2.0 Mi. SE of Pineola	M. Shink	—do—	125	6	36	—do—	——	7.0	——	—do—	
42	2.5 Mi. S of Pineola	B. Aldridge	—do—	112	8	67	Quartzite	28	——	——	—do—	
43	1.1 Mi. SE of Pineola	B. Webb	—do—	97	5	47	Volcanics and arkose	——	5.0	——	Slope	
44	1.3 Mi. NW of Pineola	H. W. Clark	—do—	107	6	40	Phyllite	10	——	——	Flat	
45	1.2 Mi. W of Pineola	H. Delinger	—do—	75	5	16	—do—	——	4.0	——	—do—	
46	1.5 Mi. NE of Crossnore	M. Franklin	—do—	75	5	44	—do—	——	4.0	——	Slope	
47	1.6 Mi. N of Crossnore	F. McKinney	—do—	60	5	20	Quartzite	——	10.0	——	—do—	
48	2.1 Mi. NW of Crossnore	M. Foster	—do—	117	5	20	—do—	——	20.0	——	Flat	
49	0.6 Mi. N of Crossnore	Crossnore Inc.	—do—	186	8	——	—do—	——	50.0	——	—do—	
50	Crossnore	Crossnore Inc.	—do—	203	6	30	—do—	——	70.0	——	—do—	
51	1.6 Mi. NW of Crossnore	E. Phillips	—do—	110	5	68	Layered gneiss	——	3.0	——	Slope	
52	0.5 Mi. N of Plumtree	D. Watson	—do—	71	6	——	Amphibolite gneiss	30	——	——	—do—	
53	1.4 Mi. NW of Spear	——	—do—	87	5	32	—do—	32	15.0	——	—do—	
54	1.6 Mi. NW of Spear	M. Huston	—do—	125	5	42	—do—	——	5.0	——	Flat	
55	Spear	V. Stafford	—do—	64	6	44	—do—	15	——	——	—do—	
56	Plumbtree	T. B. Vance	—do—	142	6	——	—do—	7	——	——	—do—	
57	1.7 Mi. E of Ingalls	——	Dug	17	48	——	Saprolite	12	——	——	Slope	Observation well
58	0.2 Mi. W of Three Mile	R. McFee	Drilled	137	6	62	Amphibolite gneiss	8	2.0	——	Flat	
59	1.0 Mi. N of Three Mile	State Prison No. 131	—do—	90	4	——	—do—	15	——	——	Draw	
60	0.5 Mi. NE of Three Mile	M. Rose	—do—	89	5	54	—do—	——	5.0	——	Slope	
61	0.3 Mile E of Three Mile	C. McFee	—do—	128	6	95	—do—	——	7.0	——	—do—	
62	Altamont	Church	—do—	275	6	——	—do—	11	——	——	Flat	
63	—do—	M. Lambert	—do—	50	6	25	Layered gneiss	——	11.0	——	—do—	
64	—do—	H. Stroup	—do—	36	6	18	—do—	6	——	——	—do—	Bedrock @ 15 feet
65	0.5 Mi. NW of Linville Falls	Parkway Motor Lodge	—do—	153	6	52	—do—	——	30.0	——	Slope	
66	Linville Falls	Sellers Oil Co.	—do—	119	6	50	—do—	——	20.0	——	—do—	
67	0.7 Mi. NW of Linville Falls	Blue Ridge Parkway	—do—	297	5	54	—do—	48	6.0	——	—do—	
68	0.7 Mi. W of Linville Falls	—do—	—do—	303	6	54	—do—	48	6.0	——	—do—	
69	Ingalls	B. Engram	—do—	94	6	44	Mica gneiss	——	10.0	——	Flat	
70	—do—	J. L. Blanchard	—do—	125	6	51	Amphibolite gneiss	——	10.0	——	Slope	
71	1.3 Mi. S of Ingalls	—do—	—do—	82	6	——	Mica gneiss	31	——	——	Flat	
72	2.0 Mi. S of Ingalls	M. Isaac	—do—	160	2	160	—do—	25	——	——	—do—	Hard water
73	3.0 Mi. S of Ingalls	F. Hollman	Dug	50	36	50	Saprolite	40	5.0	——	—do—	

TABLE 7. RECORDS OF SPRINGS IN AVERY COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
1A	1.7 Mi. N of Beech Creek	T. Reece					Layered gneiss		0.8		Slope	Observation spring
2A	0.6 Mi. S of Banner Elk	County Hospital					Pyroclastics		0.6		--do--	--do--
3A	Elk Park	W. R. Rieds					Layered gneiss		1.2		--do--	--do--
4A	1.0 Mi. NW of Gragg	W. Barnes					Volcanics and arkose		2.6		--do--	--do--
5A	0.5 Mi. SE of Linville	————					Saprolite		1.5		--do--	--do--
6A	2.3 Mi. SW of Newland	B. Wise					Amphibolite gneiss		0.8		--do--	--do--
7A	0.3 Mi. N of Pineola	J. Smith					Phyllite		2.0		Draw	--do--
8A	Spear	C. Snider					Saprolite		0.6		Slope	--do--

TABLE 8.- CHEMICAL ANALYSES OF GROUND WATER FROM AVERY COUNTY

Chemical analyses, in parts per million

Number	Rock type 1/	Water type 2/	Source and depth (ft.) 3/	Date of collection	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids: Residue at 180°C	Dissolved solids: Calculated	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH	Color
4	akp	I	Dr-173	Apr. 15, 1959	22	0.0	0.01	0.02	11	5.3	2.9	0.2	0.0	53	1.8	3.3	0.1	7.1	0.2	79	80	49	5	109	6.9	5
10	amgn	*	Dr- 73	Jan. 11, 1963	18	--	.46	--	28	6.0	5.8	1.6	--	59	49	4.2	.3	4.4	--	--	147	94	46	221	6.6	--
13	arph	I	Dr-219	Aug. 12, 1958	27	.0	--	.00	7.6	3.5	6.1	.8	.0	39	3.3	4.8	.0	4.5	.2	78	78	33	1	88	6.5	4
44	arph	II	Dr-107	Jan. 11, 1963	14	--	.04	--	7.6	.8	3.1	.8	--	34	.8	.7	.1	.0	--	--	45	22	0	53	6.5	--
50	qtz	I	Dr-203	Aug. 12, 1958	22	.0	.01	.00	9.2	3.6	4.7	1.6	.0	46	1.9	3.8	.0	2.8	.2	73	73	38	0	98	6.6	2
57	mgn	C	Du- 17	Mar. 19, 1962	3.9	.1	.03	.02	.5	.7	1.8	1.0	.0	6	.2	4.3	.0	.1	.0	20	16	4	0	26	5.6	--
1A	lgn	IV	S	Mar. 19......	16	.0	.01	.00	1.3	.2	2.5	.7	.0	12	2.4	.1	.0	.9	.1	29	30	4	0	24	6.0	--
2A	akp	I	S	Mar. 19......	14	.0	.01	.02	5.7	2.6	2.8	1.3	.0	31	3.2	2.9	.0	2.0	.1	48	50	25	0	72	6.3	--
3A	lgn	I	S	Mar. 19......	14	.0	.03	.00	2.4	1.2	2.3	.8	.0	14	1.2	2.1	.1	3.4	.0	37	34	11	0	44	6.4	--
4A	akp	D	S	Mar. 19......	8.9	.0	.07	.00	1.1	.3	1.2	.3	.0	9	.2	.8	.0	.0	.0	17	17	4	0	15	6.2	--
5A	akp	D	S	Mar. 19......	6.2	.0	.64	.04	.6	.3	1.1	.4	.0	6	.6	.2	.0	1.8	.0	13	14	3	0	14	5.7	--
6A	amgn	I	S	Mar. 19......	11	.0	.00	.00	1.7	.9	1.2	.2	.0	12	.2	1.1	.0	.0	.1	20	22	8	0	22	6.9	--
7A	arph	D	S	Mar. 19......	7.4	.0	--	.00	.6	.2	1.1	.9	.0	5	.2	.5	.0	.8	.0	13	14	2	0	16	5.6	--
8A	mgn	IV	S	Mar. 19......	10	.0	.01	.00	.6	.7	2.2	.5	.0	7	.2	.5	.0	2.6	.0	21	20	4	0	25	6.3	--

1/ Rock Type

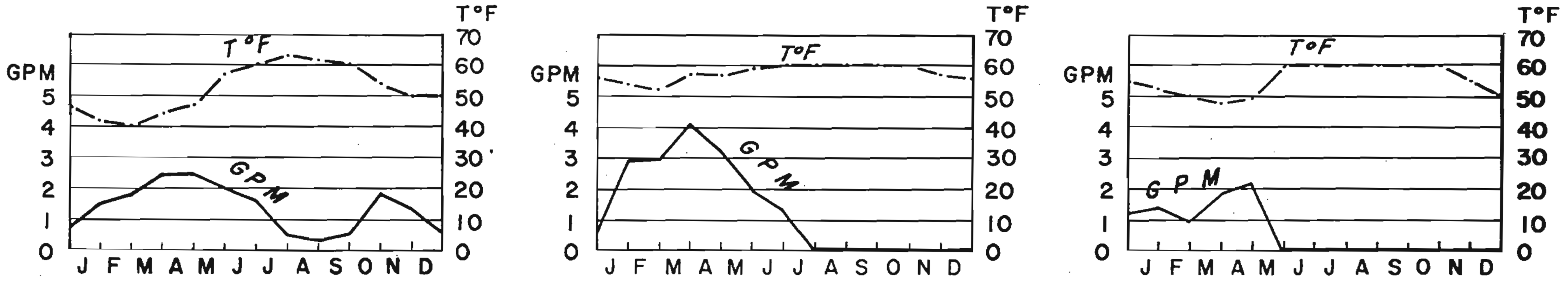
qm - quartz-monzonite gneiss
msh - sillimanite-mica schist
gr - granitic gneiss
mgn - quartz-biotite gneiss
lgn - layered gneiss
amgn - amphibolite gneiss
augn - augen gneiss
Begn - Beech Granite
arph - argillite and phyllite
akp - arkosic and pyroclastic rocks
qsh - schistose quartzitic rocks
qtz - quartzite

2/ Water Type

I - calcium, magnesium, sodium bicarbonate
II - calcium, sodium, magnesium bicarbonate
III - calcium-sodium, magnesium bicarbonate
IV - sodium, calcium, magnesium bicarbonate
V - magnesium, calcium, sodium bicarbonate
* - calcium sulfate
D - dissolved solids too low to reflect effects of lithology upon water composition
C - excessive chloride and/or nitrate masks effects of lithology upon water composition

3/ Source

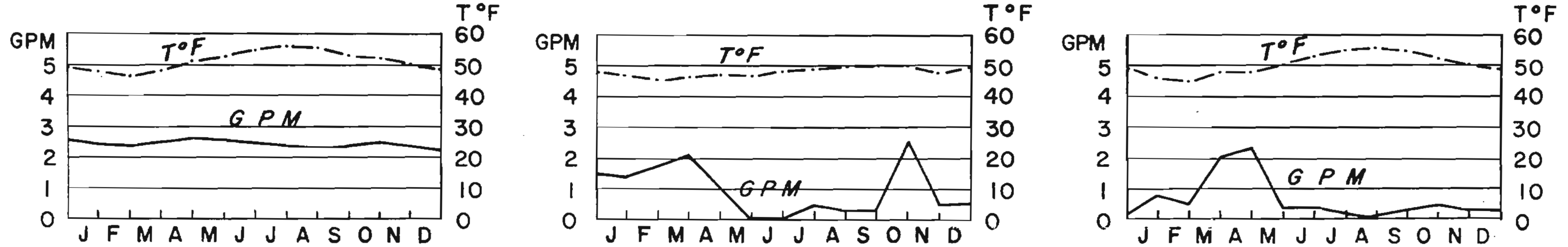
S - spring
Dr - drilled well
Du - dug well



1A, 1.7 mi. N of Beech Creek

2A, 0.6 mi. S of Banner Elk

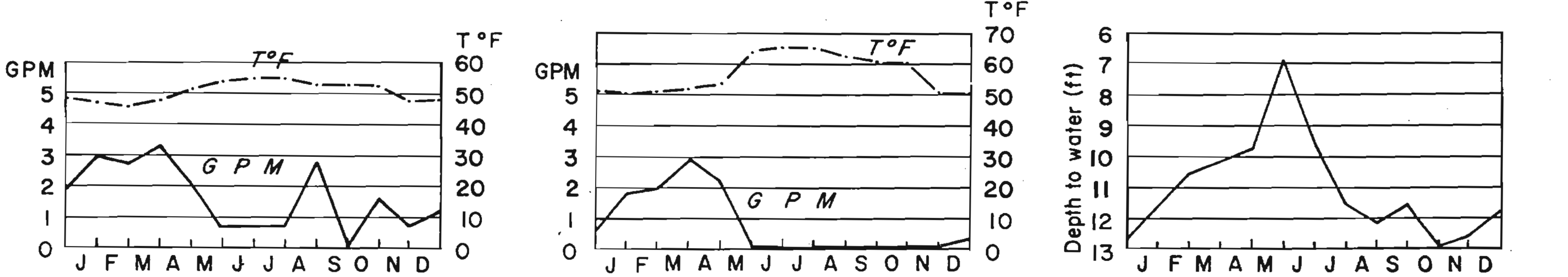
3A, Elk Park



4A, 1.0 mi. NW of Gragg

5A, 0.5 mi. SE of Linville

6A, 2.3 mi. SW of Newland



7A, 0.3 mi. N of Pineola

8A, Spear

57, 1.7 mi. E of Ingalls

Figure 17. Avery County observation spring and well hydrographs, 1962.

Burke County

(Area, 506 square miles; 1960 population, 52,701)

Burke County is in the southeastern part of the area of investigation (fig. 1). It is mostly within the inner Piedmont province, but in the northwest it lies in part on the steep eastern slope of the Blue Ridge province. Topography in Burke County is of greatly contrasting relief; from monadnock-like hills separated by broad valleys in the inner Piedmont to high-gradient, deeply dissected slopes on the Blue Ridge front. Altitudes range from less than 1,000 feet above mean sea level at several places on the southeast boundary to 4,350 feet on Long Arm Mountain in northwest Burke County near Linville Falls. Burke County lies within the Catawba River drainage basin. Streams and drainage courses generally appear to be of subsequent development as they are closely related to geologic structural features; joint and shear systems are coincident to most streams.

The largest towns are Morganton, the county seat, Glen Alpine, Drexel, Valdese, and Hildebran. The economy is predominantly agricultural; about 27 percent of the county area is farmland. Forest products supplement agriculture. Manufacturing, mainly of textiles and furniture, is localized in and near the larger towns. The northwest tip of Burke County is crossed by the Blue Ridge Parkway.

Metamorphic rock types in Burke County are heterogeneous, but mica gneiss, mica schist, granitic gneiss, and shistose quartzite predominate. Structural trends of these rocks are generally oriented northeastward (pl. 2). A unique diabase dike strikes nearly normal to the regional structural trend in the eastern part of Burke County. Monadnock-like hills and steep, dissected slopes appear to be errosional remnants rather than structural features. The residual mantle of weathered bedrock or saprolite is well developed over most of the inner Piedmont part of Burke County.

Drilled wells furnish much of the domestic, industrial, and municipal water supplies, but surface-water storage provides the greatest quantities of industrial and municipal water in Burke County. Principal sources of surface water are the impoundments of the Catawba River in Lake Rhodhiss and the Henry Fork of the Catawba River. The Lake James impoundment of the Catawba River is primarily a source of hydroelectric power. Most drilled wells in Burke County are less than 200 feet deep. Of 62 such wells the average depth is 137 feet and average yield 14 gallons per minute. Wells having the highest yields are in: Low, flat areas; narrow, linear valleys; or draws. Dug and bored wells are common in outlying areas. Of 32 dug and bored wells the average depth is 40 feet and the average depth to the water table is 27 feet. Data of yields from the dug and bored wells are insufficient to provide a statistical representation. Springs are not as commonly used in Burke County as in counties wholly within the Blue Ridge province. Glen Alpine and Rhodhiss are the only communities in Burke County which use ground water for municipal supplies. All other municipal water systems use surface runoff which is filtered, chlorinated, and additionally treated before use.

Analyses of ground water from Burke County are shown in table 9. Water from wells 59 and 104 contained iron in excess of 0.3 ppm. High nitrate and chloride concentration occurred in water from wells 3, 16, 62, 72, 88, 112, and 113. Well 62 contains water having nitrate concentrations greater than 45 ppm.

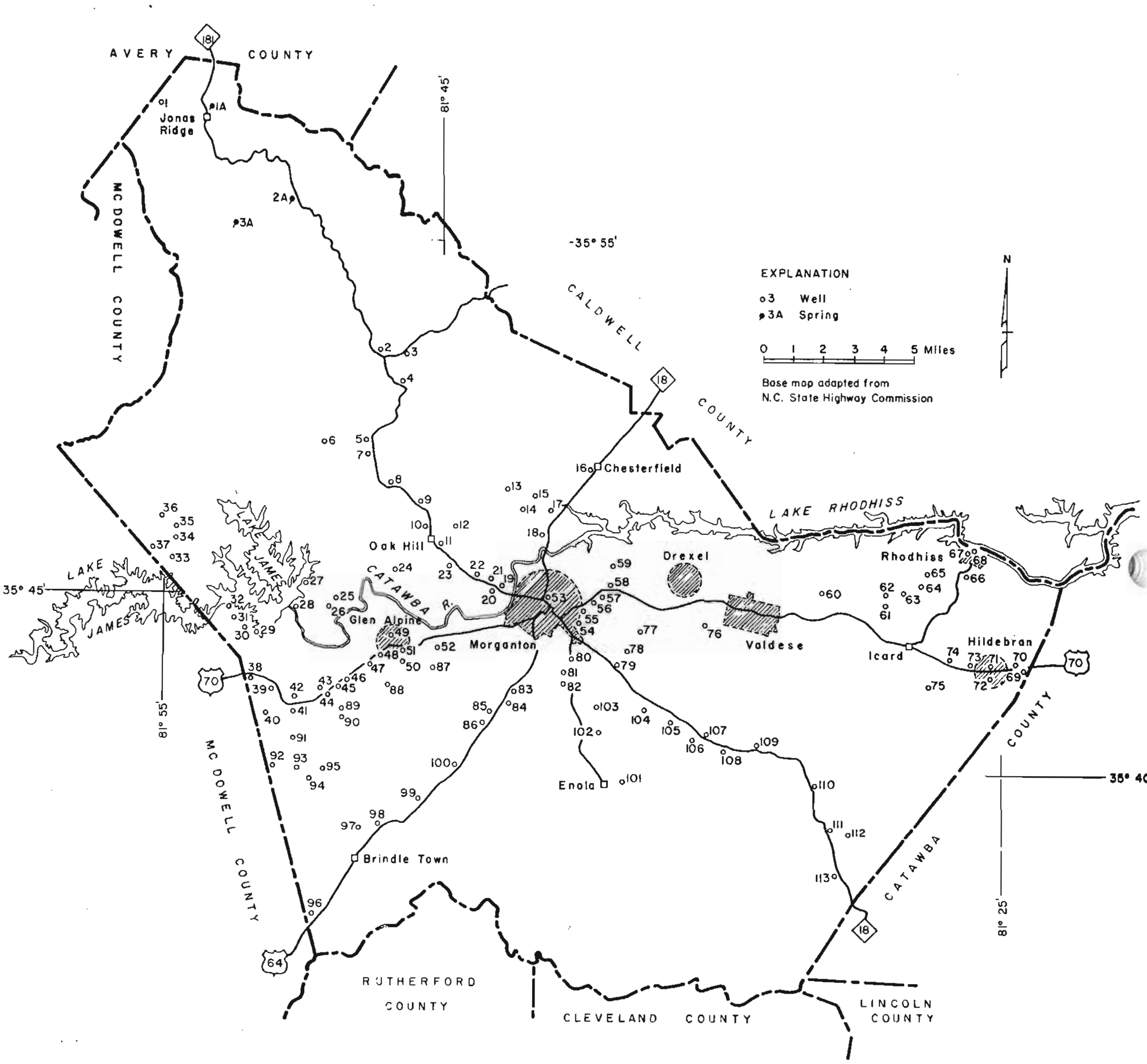


Figure 18. Map of Burke County showing locations of wells and springs.

TABLE 9. RECORDS OF WELLS IN BURKE COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Draw-down (ft)	Topography	Remarks
1	2.7 Mi. W of Jonas Ridge-	Blue Ridge Parkway	Drilled	200	6	10	Quartzite----	24	40.0	105 ft. after 20 min.	Draw——	Water came from six different intervals———
2	12.5 Mi. NW of Morganton-	Optimist Park———	--do---	120	6	40	Layered gneiss———	80	35.0	———	Slope—	Bedrock @ 40 feet—-
3	13.4 Mi. NW of Morganton-	E. Sanders———	Dug———	33	30	------	Saprolite----	16	----	———	Flat——	Observation well—-
4	11.0 Mi. NW of Morganton-	H. Perry———	Bored--	32	30	32	--do———	17	———	———	—do——	
5	1.6 Mi. SE of Table Rock-	P. Kinkaid———	Drilled	70	6	70	Layered gneiss------	20	20.0	———	—do——	
6	1.8 Mi. SW of Table Rock-	G. W. Crouch———	--do---	105	6	65	Quartzite----	70	———	———	Slope--	
7	8.5 Mi. NW of Morganton—	J. A. McGimsey———	Bored—	56	24	56	Saprolite----	48	5.0	———	—do---	
8	7.0 Mi. NW of Morganton—	W. D. Lowder———	Dug———	50	30	50	--do———	35	———	———	—do---	
9	6.0 Mi. NW of Morganton--	C. D. Nichols———	Bored--	70	30	70	--do———	50	———	———	—do---	Bottom on bedrock-
10	5.1 Mi. NW of Morganton--	S. Miller———	--do——	80	30	80	—do———	———	———	———	Draw---	
11	4.5 Mi. NW of Morganton--	B. Galloway———	--do---	45	30	45	—do———	35	———	———	Slope--	
12	1.0 Mi. E of Oak Hill----	P. Beek———	Drilled	200	6	72	Granitic gneiss------	70	3.0	———	—do——	
13	5.0 Mi. N of Morganton---	E. Weaver———	--do——	127	6	58	--do———	———	6.0	———	—do——	
14	4.0 Mi. N of Morganton——	C. Webb———	--do---	163	6	129	--do———	25	10.0	———	Flat——	
15	3.8 Mi. NE of Morganton--	T. Dooley———	--do—-	114	6	42	--do———	40	4.0	———	Slope—	
16	5.3 Mi. NE of Morganton--	G. B. Arney———	Dug———	45	36	------	Saprolite	15	———	———	Flat---	Observation well——
17	3.4 Mi. NE of Morganton—	P. Jones———	Drilled	150	6	80	Granitic gneiss------	65	20.0	———	Flat——	
18	2.5 Mi. NE of Morganton--	H. M. Speas———	--do---	219	6	45	--do———	75	20.0	———	Slope--	
19	1.5 Mi. NW of Morganton--	J. C. Smith———	--do—-	132	6	90	--do———	90	7.0	———	—do—-	
20	1.7 Mi. NW of Morganton--	L. Shuffler———	--do——	150	6	60	--do———	60	7.5	———	—do—-	
21	2.5 Mi. NW of Morganton--	C. Suddith———	--do——	152	6	100	--do———	90	15.0	———	Flat——	Hard water———
22	2.9 Mi. NW of Morganton—	E. Davis———	Bored—	92	30	92	Saprolite----	74	———	———	Slope—	
23	4.0 Mi. NW of Morganton—	L. Silvers———	--do——	52	30	52	--do———	44	———	———	—do——	
24	8.7 Mi. NW of Morganton—	R. L. LaFevers———	Drilled	73	6	44	Granitic gneiss------	40	3.5	———	—do——	
25	2.5 Mi. NW of Glen Alpine	P. Dale———	—do——	170	6	80	—do———	62	20.0	———	Draw——	
26	2.5 Mi. NW of Glen Alpine	P. Dale———	--do——	107	6	55	Mica gneiss--	50	1.0	———	Slope—	
27	3.5 Mi. NW of Glen Alpine	C. Browning———	--do---	115	6	75	--do———	35	20.0	———	Flat——	
28	5.0 Mi. NW of Glen Alpine	J. C. Smith———	—do——	165	6	43	--do———	35	4.0	———	Slope--	
29	1.0 Mi. N of Bridgewater-	J. Carswell———	—do—-	131	6	90	Granitic gneiss------	60	9.5	———	—do——	
30	1.3 Mi. N of Bridgewater-	J. Carswell———	--do——	135	6	85	Mica gneiss—	60	7.0	———	—do—-	
31	1.8 Mi. NW of Bridgewater	T. Rich———	--do——	115	6	60	--do———	———	4.5	———	—do——	
32	2.1 Mi. NW of Bridgewater	H. F. Bobbett———	--do——	175	6	55	—do———	45	6.0	———	—do---	
33	0.8 Mi. W of Longtown——	J. C. Dellinger---	--do——	75	6	30	—do———	6	8.0	———	Flat——	
34	0.8 Mi. N of Longtown----	W. P. Case———	--do—-	165	6	150	--do———	50	10.0	———	Draw——	
35	1.1 Mi. N of Longtown----	B. M. Bristol———	—do---	140	6	116	Schistose quartzite——	50	6.0	———	Slope—	
36	1.6 Mi. N of Longtown——	H. Edwards———	—do---	184	6	120	Mica gneiss--	65	15.0	———	Draw——	
37	1.8 Mi. NW of Longtown——	R. Edwards———	—do——	165	6	140	—do———	80	25.0	———	—do——	
38	1.2 Mi. S of Bridgewater-	G. Himphill———	—do——	215	6	60	--do———	40	4.5	———	Slope—	Hard water———
39	6.0 Mi. SW of Glen Alpine	C. Carswell———	Bored—	60	30	60	Saprolite----	———	———	———	--do---	
40	6.5 Mi. SW of Glen Alpine	J. McElarth———	Drilled	300 (110)	6	45	Granitic gneiss———	35	40.0	———	Flat---	Drilled to 300 ft. and gravel filled to 110 ft.———
41	6.0 Mi. SW of Glen Alpine	J. Patton———	—do——	210	6	78	--do———	45	15.0	———	--do---	

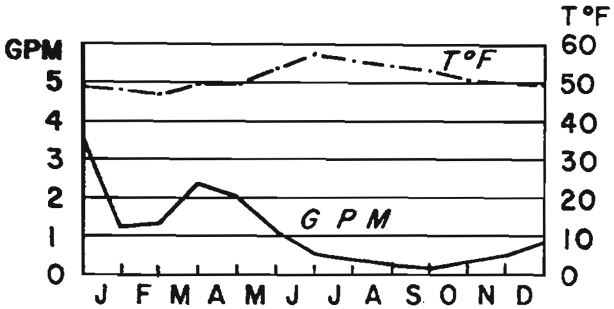
TABLE 9. RECORDS OF WELLS IN BURKE COUNTY (Continued)

Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Draw-down (ft)	Topography	Remarks
42	4.6 Mi. SW of Glen Alpine	J. Farris----------	Drilled	140	6	60	Granitic gneiss------	----	30.0	----	Draw---	
43	3.5 Mi. SW of Glen Alpine	M. A. Taylor------	--do---	141	6	46	--do--------	45	25.0	----	--do---	
44	2.7 Mi. SW of Glen Alpine	R. McNeilley------	--do---	122	6	60	--do--------	30	30.0	----	Flat---	
45	2.2 Mi. SW of Glen Alpine	W. Taylor--------	--do---	333	6	65	--do--------	50	4.0	----	Slope--	
46	1.9 Mi. SW of Glen Alpine	W. Taylor--------	--do---	315	6	85	--do--------	55	4.5	----	--do---	Hard water--------
47	1.0 Mi. SW of Glen Alpine	T. Clontz--------	--do---	100	6	60	--do--------	35	9.0	----	Flat---	
48	0.5 Mi. SW of Glen Alpine	T. Rich----------	--do---	150	6	60	--do--------	65	5.5	----	Slope--	
49	Glen Alpine------------	Town of Glen Alpine----------	--do---	355	8	----	--do--------	----	255	----	Draw---	Yield questionable
50	0.7 Mi. S of Glen Alpine-	O. Brach----------	--do---	119	6	86	--do--------	60	20.0	----	--do---	
51	0.5 Mi. SE of Glen Alpine	J. F. Proctor-----	--do---	86	6	43	Granitic gneiss------	----	10.0	----	Flat---	
52	1.5 Mi. E of Glen Alpine-	Church-----------	--do---	300	6	75	--do--------	60	5.0	----	Slope--	
53	Morganton--------------	B. Busic----------	--do---	124	6	80	--do--------	70	20.0	----	Draw---	
54	1.5 Mi. SE of Morganton--	N. Epley----------	--do---	176	6	70	--do--------	30	4.0	----	Slope--	
55	1.8 Mi. SE of Morganton--	H. Towery---------	--do---	275	6	60	--do--------	60	----	----	--do---	Hard water--------
56	2.2 Mi. E of Morganton---	C. H. Bumgarner---	--do---	150	6	80	--do--------	65	12.0	----	Flat---	
57	2.4 Mi. E of Morganton---	J. S. Kinkaid-----	--do---	90	6	16	--do--------	25	20.0	----	--do---	
58	2.2 Mi. E of Morganton---	J. Farris---------	--do---	71	6	30	--do--------	33	20.0	----	--do---	
59	4.0 Mi. NE of Morganton--	C. Leonhardt------	--do---	235	6	55	--do--------	95	----	----	Slope--	
60	Rutherford College------	Valdese Gen. Hospital---------	--do---	400	8	----	Mica schist--	----	----	----	Flat---	
61	3.7 Mi. SW of Rhodhiss---	C. Tunmire--------	--do---	65	5	----	--do--------	25	----	----	--do---	
62	3.3 Mi. SW of Rhodhiss---	Zimmerman---------	Dug----	62	4'x4'	----	Saprolite----	52	----	----	--do---	Observation well--
63	3.0 Mi. SW of Rhodhiss---	O. Mabry----------	--do---	45	5'x5'	45	--do--------	39	----	----	--do---	
64	2.5 Mi. SW of Rhodhiss---	E. M. Aikens------	Drilled	51	36	51	--do--------	23	----	----	--do---	
65	2.1 Mi. SW of Rhodhiss---	L. Brown----------	--do---	75	6	----	Mica schist--	62	3.0	----	Slope--	
66	1.1 Mi. S of Rhodhiss----	Smith-Moore Co.---	Bored--	35	24	35	Saprolite----	23	----	----	--do---	
67	Rhodhiss---------------	Rhodhiss Mills----	Drilled	151	6	----	Mica gneiss--	38	20.0	----	Flat---	Water has high iron content----------
68	Rhodhiss---------------	--do------------	--do---	846	8	----	--do--------	32	35.0	----	--do---	
69	1.2 Mi. E of Hildebran---	Church-----------	--do---	134	6	60	--do--------	64	11.0	----	--do---	
70	0.9 Mi. E of Hildebran---	J. S. Hildebran---	Dug----	42	48	----	Saprolite----	30	----	----	Slope--	
71	Hildebran--------------	Quaker Meadows Mills----------	Drilled	370	8	252	Mica gneiss--	53	20.0	205 ft. after 3 hrs. @ 20 gpm	Flat---	Water treated for iron content-------
72	Hildebran--------------	Clines Mills------	Dug----	45	48	----	Saprolite----	30	----	----	Slope--	Observation well---
73	0.9 Mi. W of Hildebran---	Southern Desk Co. #2--------	Drilled	200	8	----	Mica gneiss--	30	100.0	----	Draw---	Ideal well location
74	1.5 Mi. W of Hildebran---	R. Stilwell-------	Bored--	30	18	30	Saprolite----	15	----	----	Flat---	
75	2.3 Mi. SW of Hildebran--	J. B. Sweet-------	Drilled	180	6	----	Mica gneiss--	15	100.0	----	Draw---	
76	8.0 Mi. E of Morganton---	L. Hiergesull-----	--do---	149	6	74	--do--------	55	10.0	----	Slope--	
77	5.0 Mi. E of Morganton---	M. Selzer---------	--do---	120	6	75	Granitic gneiss------	35	7.0	----	Flat---	
78	4.0 Mi. SE of Morganton--	R. Moxley---------	--do---	298	6	85	--do--------	28	5.0	----	Hilltop	
79	4.2 Mi. SE of Morganton--	P. Smith----------	Bored--	36	6	36	Saprolite----	10	----	----	Flat---	
80	2.7 Mi. S of Morganton---	F. Duckworth------	Drilled	120	6	40	Granitic gneiss------	30	20.0	----	Flat---	
81	3.1 Mi. S of Morganton---	F. Mull-----------	--do---	132	6	70	--do--------	----	----	----	--do---	
82	3.4 Mi. S of Morganton---	J. C. Digh--------	--do---	133	6	106	--do--------	45	12.0	----	Slope--	
83	3.1 Mi. SW of Morganton--	J. Duckworth------	--do---	145	6	110	--do--------	55	6.0	----	--do---	

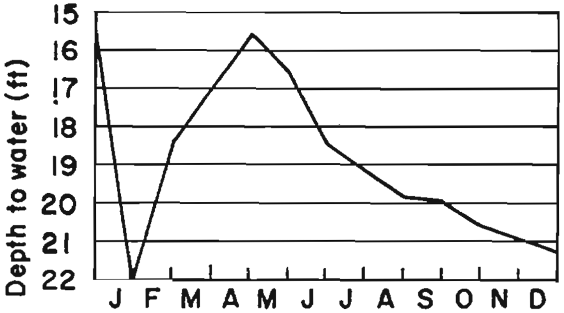
84	3.5 Mi. SW of Morganton	J. C. Propst	--do--	180	6	160	Granitic gneiss	—	25.0	—	Flat	
85	4.0 Mi. SW of Morganton	P. Propst	--do--	220	6	65	--do--	70	20.0	—	--do--	
86	4.5 Mi. SW of Morganton	M. Propst	--do--	153	6	85	Mica gneiss	58	6.5	—	Slope	
87	5.0 Mi. SW of Morganton	Hush Puppy Fish Camp	Bored	14	24	14	Saprolite	13	2.0	—	--do--	
88	1.4 Mi. S of Glen Alpine	B. Self	Dug	33	48	—	--do--	28	—	—	Slope	Observation well
89	5.5 Mi. SW of Glen Alpine	T. Rich	Drilled	103	6	70	Granitic gneiss	—	15.0	—	Flat	
90	5.8 Mi. SW of Glen Alpine	J. O. Taylor	--do--	165	6	50	--do--	38	25.0	—	--do--	
91	6.1 Mi. SW of Glen Alpine	J. Allen	--do--	158	6	70	--do--	65	3.0	—	Slope	Bedrock @ 90 feet
92	7.6 Mi. SW of Glen Alpine	P. Dooley	--do--	124	6	108	--do--	—	5.0	—	--do--	
93	7.4 Mi. SW of Glen Alpine	Church	--do--	195	6	55	--do--	62	3.0	—	--do--	
94	7.9 Mi. SW of Glen Alpine	H. Patton	--do--	132	6	50	--do--	48	10.0	—	--do--	
95	7.5 Mi. SW of Glen Alpine	E. Tallent	--do--	225	6	20	--do--	20	20.0	—	Flat	
96	14.0 Mi. SW of Morganton	W. C. Burns	Bored	30	30	30	Saprolite	20	—	—	--do--	Hard water
97	11.0 Mi. SW of Morganton	B. Morrison	Drilled	100	6	60	Granitic gneiss	—	25.0	—	--do--	
98	10.3 Mi. SW of Morganton	C. B. Leonhardt	Dug	24	30	—	Saprolite	20	—	—	Slope	Observation well
99	8.2 Mi. SW of Morganton	L. J. Denton	--do--	18	36	—	--do--	14	—	—	Flat	
100	6.6 Mi. SW of Morganton	R. Rich	Drilled	105	6	20	Mica gneiss	20	20.0	—	--do--	
101	6.8 Mi. S of Morganton	W. Chapman	--do--	210	6	20	Mica gneiss	—	15.0	—	--do--	Hard water
102	3.7 Mi. S of Morganton	W. Chapman	--do--	120	6	60	Granitic gneiss	—	10.0	—	--do--	
103	2.6 Mi. S of Morganton	W. R. Mull	Dug	55	40	—	Saprolite	43	—	—	Slope	
104	4.0 Mi. SE of Morganton	J. E. Muehlhouser	Drilled	185	6	115	Mica gneiss	85	5.0	—	--do--	
105	5.0 Mi. SE of Morganton	F. C. Port	--do--	175	30	160	--do--	15	7.0	—	--do--	
106	6.0 Mi. SE of Morganton	C. C. Shouppe	Dug	20	30	3	--do--	16	—	—	--do--	Dug in bedrock except for soil at surface
107	6.3 Mi. SE of Morganton	M. Willis	--do--	22	36	22	Saprolite	20	—	—	--do--	Observation well
108	7.1 Mi. SE of Morganton	W. R. Mull	Bored	9	24	9	--do--	7	—	—	--do--	
109	8.2 Mi. SE of Morganton	Z. C. Peeler	Dug	12	30	12	--do--	6	—	—	--do--	
110	10.7 Mi. SE of Morganton	R. E. Moses	--do--	35	36	—	--do--	20	—	—	--do--	
111	13.6 Mi. SE of Morganton	R. Tallant	--do--	26	30	13	--do--	16	—	—	--do--	
112	14.9 Mi. SE of Morganton	B. Hildebran	--do--	27	48	—	--do--	24	—	—	Flat	Observation well
113	15.1 Mi. SE of Morganton	W. H. Huffman	Bored	60	24	60	--do--	30	—	—	--do--	

TABLE 10. RECORDS OF SPRINGS IN BURKE COUNTY

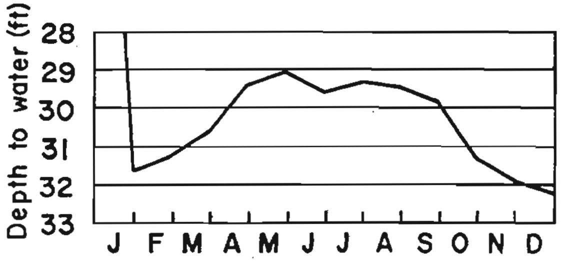
Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
1A	0.1 Mi. NE of Jonas Ridge	———————					Arkose———		4.4		Slope——	49° F. - 4-9-62——
2A	3.1 Mi. SE of Jonas Ridge	———————					--do————		3.5		Draw——	48° F. - 12-12-61 Observation spring——————
3A	8.1 Mi. S of Jonas Ridge-	———————					Quartzitic arkose———		1.7		--do——	45° F. - 4-10-62—



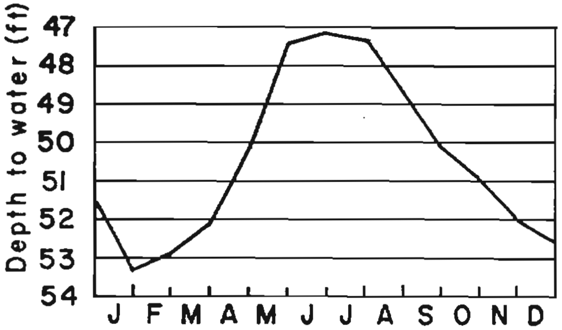
2A, 3.1 mi. SE of Jonas Ridge



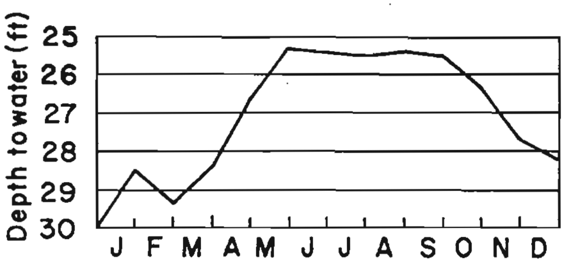
3, 13.4 mi. NW of Morganton



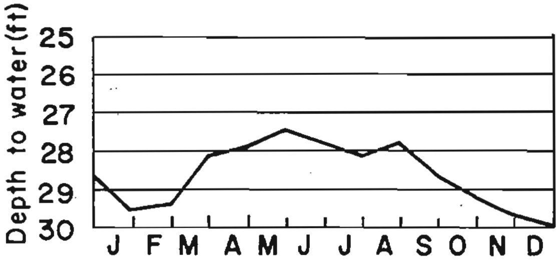
16, 5.3 mi. NE of Morganton



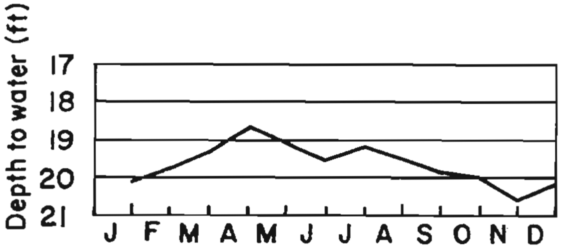
62, 3.3 mi. SW of Rhodhiss



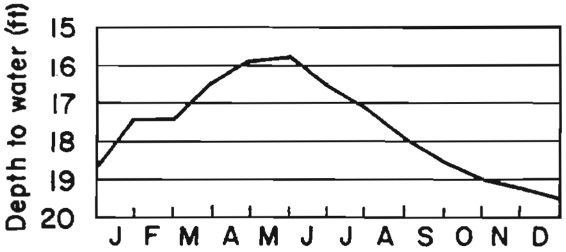
72, Hildebran



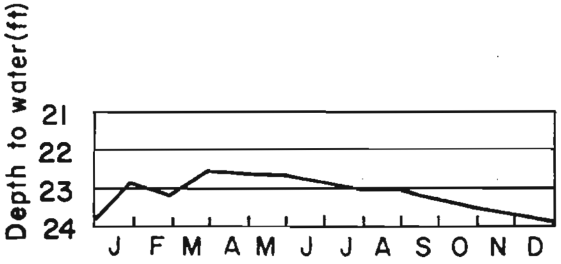
88, 1.4 mi. S of Glen Alpine



98, 10.3 mi. SW of Morganton



107, 6.3 mi. SE of Morganton



112, 14.9 mi SE of Morganton

Figure 19. Burke County observation spring and well hydrographs, 1962.

TABLE 11.- CHEMICAL ANALYSES OF GROUND WATER FROM BURKE COUNTY

Chemical analyses, in parts per million

Number	Rock type 1/	Water type 2/	Source and depth (ft.) 3/	Date of collection	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids		Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH	Color
																				Residue at 180°C	Calculated	Calcium, Magnesium	Non-carbonate			
3	lgn	I	Du- 33	Jan. 16, 1962	8.4	0.1	0.12	--	5.6	2.1	3.8	2.9	0.1	23	7.8	3.8	0.1	1.7	0.5	--	48	24	4	67	6.3	10
16	gr	C	Du- 45	Jan. 16......	5.5	.0	.02	--	16	3.7	25	4.0	.2	31	.2	53	.1	14	1.1	--	138	54	30	230	7.0	0
59	msh	II	Dr-400	Mar. 22, 1952	29	--	.48	0.00	17	1.7	7.4		--	69	6.9	1.1	.1	.0	--	98	98	49	--	130	7.1	5
62	msh	C	Du- 62	Jan. 16, 1962	4.9	.1	.09	--	1.3	2.1	45	5.7	.3	9	.8	52	.0	48	.0	--	164	12	5	283	5.3	5
67	mgn	II	Dr-151	Apr. 18, 1957	29	.0	.01	.00	17	2.7	5.5	3.6	.2	76	7.0	3.0	.2	.0	.1	105	108	54	0	140	6.9	0
68	msh	III	Dr-846	Apr. 18......	15	.0	.01	.01	9.2	3.4	14	1.6	.4	64	6.4	6.8	.2	.8	.1	81	90	37	0	128	6.9	0
72	mgn	C	Du- 45	Jan. 16, 1962	4.3	.1	.04	--	1.9	1.2	21	2.0	.2	6	2.6	25	.0	19	.0	82	80	10	6	140	5.2	5
73	mgn	II	Dr-200	Jan. 12, 1963	25	--	.17	--	10	2.1	5.7	2.3	--	51	6.2	1.4	.2	.1	--	--	78	34	0	100	6.7	--
88	gr	I	Du- 33	Jan. 16, 1962	11	.0	.07	--	14	1.2	2.6	2.7	.1	45	1.8	2.4	.1	5.0	.8	68	64	40	3	88	6.9	10
98	mgn	I	Du- 24	Mar. 21......	11	.0	.15	.02	13	1.1	1.6	1.0	.0	48	1.0	1.6	.0	.7	.0	55	55	38	0	93	6.6	--
104	mgn	IV	Dr-185	Jan. 12, 1963	27	--	.44	--	3.3	1.0	5.8	1.4	--	30	.2	1.0	.1	.0	--	--	55	12	0	52	6.3	--
112	mgn	C	Du- 27	Jan. 16, 1962	8.8	.1	.12	--	5.3	2.2	4.5	2.5	.1	18	1.8	9.7	.0	4.6	.0	--	49	22	8	74	6.2	5
113	mgn	II	B - 60	Jan. 12, 1963	12	--	.10	--	4.6	.3	3.3	2.4	--	20	.4	3.0	.1	3.0	--	--	39	13	0	49	5.9	--
2A	akp	D	S	Jan. 16, 1962	7.4	.0	.02	--	.6	.1	1.4	.5	.1	6	.2	.7	.0	.1	.0	--	14	2	0	11	6.7	5

1/ Rock Type

qm	quartz-monzonite gneiss
msh	sillimanite-mica schist
gr	granitic gneiss
mgn	quartz-biotite gneiss
lgn	layered gneiss
amgn	amphibolite gneiss
augn	augen gneiss
Begn	Beech Granite
arph	argillite and phyllite
akp	arkosic and pyroclastic rocks
qsh	schistose quartzitic rocks
qtz	quartzite

2/ Water Type

I	calcium, magnesium, sodium bicarbonate
II	calcium, sodium, magnesium bicarbonate
III	calcium-sodium, magnesium bicarbonate
IV	sodium, calcium, magnesium bicarbonate
V	magnesium, calcium, sodium bicarbonate
D	dissolved solids too low to reflect effects of lithology upon water composition
C	excessive chloride and/or nitrate masks effects of lithology upon water composition

3/ Source

S	spring
Dr	drilled well
Du	dug well
B	bored well

Caldwell County

(Area, 476 square miles; 1960 population, 49,552)

Caldwell County is in the eastern part of the area of investigation (fig. 1). The northwestern part of the county lies on the deeply dissected slope of the eastern Blue Ridge front, and the lower ground in the southeast is within the inner Piedmont province. Topography in Caldwell County is of mounting relief from southeast to northwest; monadnock-like hills separated by moderately broad valleys of the inner Piedmont give way to high gradients on the rugged slopes of the Blue Ridge front. Altitudes range from less than 1,000 feet near Lake Rhodhiss to over 5,900 feet above mean sea level on Grandfather Mountain at the northwest corner of the county. Caldwell County lies mostly in the Catawba River drainage basin, but the northeast part of the county is drained by the Yadkin River and its tributaries. Streams and drainage courses are believed to be of subsequent development as they appear to be closely related to structural geologic features; joint and shear systems are coincident to most streams.

Lenoir, the county seat, is the largest town in Caldwell County. Other towns of substantial size are Whitnel, Hudson, Granite Falls, and Patterson. Caldwell County is predominantly agricultural; about 31 percent of the county is farmland. Forest products supplement agriculture. Manufacturing, mainly of textiles and furniture, is localized in the larger towns.

The metamorphic rock types of Caldwell County are heterogeneous and complex, but mica gneiss, mica schist, and granitic gneiss predominate in the inner Piedmont province. Schistose quartzite and layered gneiss predominate in the Blue Ridge part of the county. Structural trends of these rocks are generally oriented northeastward (pl. 2). A deeply weathered residual mantle of saprolite is present over most of the inner Piedmont part of Caldwell County. It is thin or absent on the Blue Ridge front.

Surface-water storage, principally from impoundment of the Catawba River in Lake Rhodhiss, provides most of the municipal and industrial water supplies in Caldwell County. The water is filtered, chlorinated and additionally treated before use. Ground water is the source of the municipal supply at Hudson. Drilled wells provide water for farms and outlying residences throughout the county. Most of the drilled wells are less than 200 feet deep. Of 59 such wells the average depth is 123 feet and average yield is 9 gallons per minute. Dug and bored wells are common in the inner Piedmont part of the county. Their average depth is 30 feet and average depth to the water table is 22 feet. Drilled wells having the highest yields are located in: low, flat areas; relatively narrow, linear valleys; or draws. Springs are most commonly used in the Blue Ridge part of the area to provide domestic water supplies.

Analyses of ground water from Caldwell County are shown in table 14. Water from wells 20, 36, and 88 had iron concentrations above 0.3 ppm. Dug wells 36 and 85 contained water with high concentrations of nitrate and chloride.

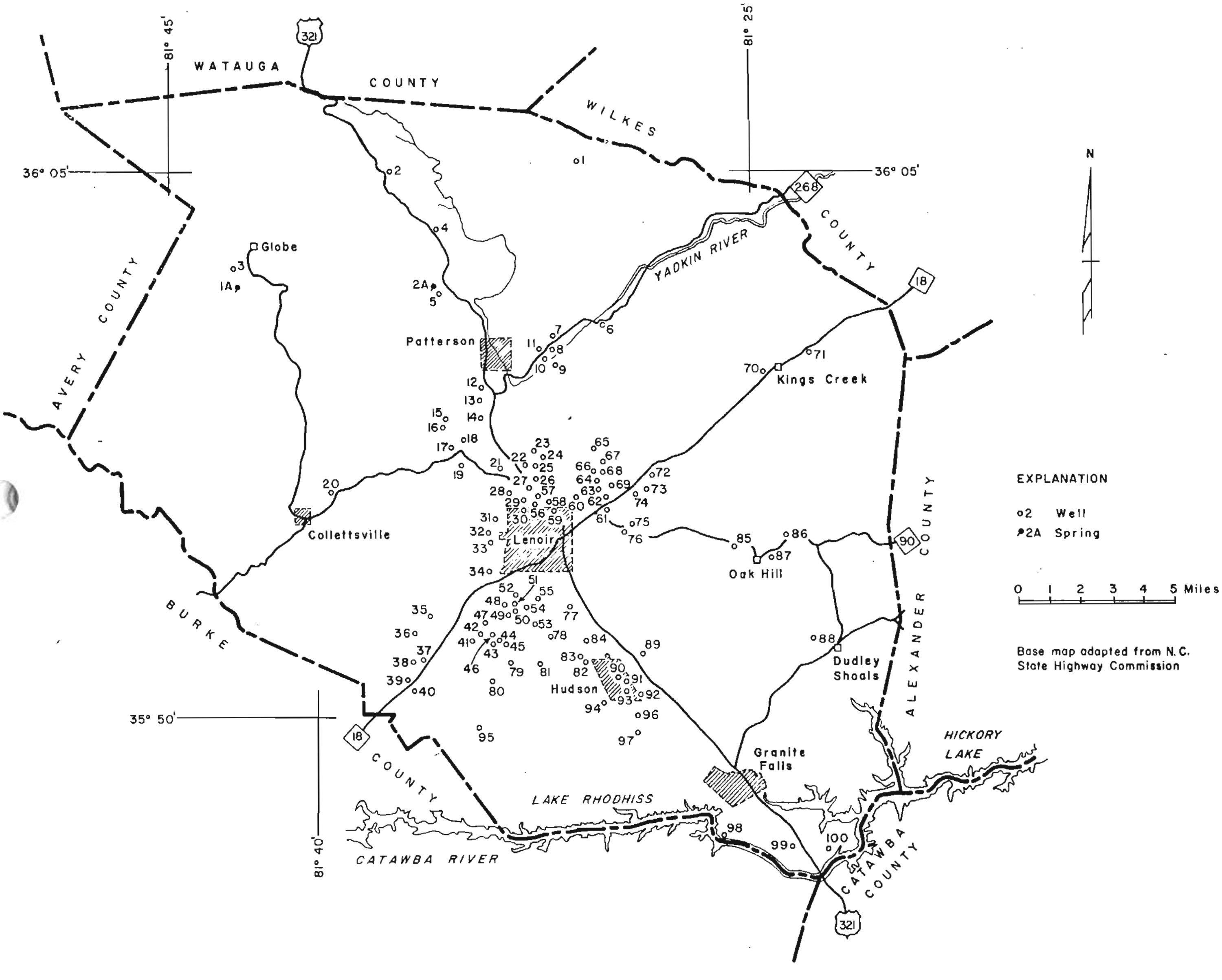


Figure 20. Map of Caldwell County showing locations of wells and springs.

TABLE 12. RECORDS OF WELLS IN CALDWELL COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
1	10.4 Mi. NE of Patterson	J. W. Hawkins	Drilled	55	6	32	Mica gneiss	—	6.0	—	Slope	
2	7.5 Mi. NW of Patterson	R. A. Harrison	--do--	337	6	37	Schistose quartzite	—	12.0	—	--do--	
3	10.6 Mi. NW of Collettsville	N. Gragg	--do--	86	6	66	Augen gneiss	—	4.0	—	--do--	
4	4.9 Mi. NW of Patterson	C. Hartley	--do--	280	6	33	Layered gneiss	—	6.0	—	--do--	
5	2.7 Mi. NW of Patterson	C. Lee	--do--	114	6	30	--do--	18	7.0	—	--do--	
6	3.9 Mi. NE of Patterson	C. B. Taylor	Dug	19	36	—	Saprolite	15	—	—	Flat	Observation well
7	1.9 Mi. NE of Patterson	E. Dobbins	Drilled	105	6	80	Mica gneiss	50	8.0	—	--do--	
8	1.7 Mi. NE of Patterson	L. Dillard	--do--	66	6	61	--do--	—	7.0	—	--do--	
9	3.0 Mi. E of Patterson	J. Melton	--do--	90	6	45	--do--	50	6.0	—	--do--	
10	1.3 Mi. E of Patterson	G. W. Watson	--do--	115	6	93	--do--	—	6.0	—	--do--	
11	1.5 Mi. E of Patterson	G. Callis	--do--	103	6	85	--do--	50	8.0	—	--do--	
12	1.0 Mi. S of Patterson	D. Gentry	--do--	99	6	86	--do--	—	2.0	—	Slope	
13	1.4 Mi. SW of Patterson	W. McLean	--do--	100	6	60	--do--	—	3.0	—	--do--	
14	2.0 Mi. SW of Patterson	F. McLeary	--do--	107	6	77	--do--	—	4.0	—	--do--	
15	3.0 Mi. SW of Patterson	C. Miller	--do--	86	6	66	--do--	50	5.0	—	--do--	
16	3.2 Mi. SW of Patterson	R. Miller	--do--	110	6	39	--do--	—	8.0	—	Flat	
17	3.5 Mi. SW of Patterson	E. Woodruff	--do--	100	6	50	--do--	50	10.0	—	--do--	
18	3.3 Mi. SW of Patterson	H. S. Rich	--do--	136	6	50	--do--	—	10.0	—	--do--	
19	4.2 Mi. SW of Patterson	C. R. Whisnant	--do--	100	6	50	--do--	—	10.0	—	--do--	
20	1.3 Mi. NE of Collettsville	A. F. Setzer	Dug	38	36	38	Saprolite	24	—	—	Slope	Observation well
21	2.0 Mi. NW of Lenoir	G. Little	Drilled	305	5	70	Mica gneiss	35	4.0	—	--do--	Hard water
22	2.5 Mi. N of Lenoir	I. Borders	--do--	121	6	38	Granitic gneiss	60	8.0	—	Flat	
23	2.8 Mi. N of Lenoir	B. Borders	--do--	157	6	63	Mica gneiss	—	8.0	—	--do--	
24	2.5 Mi. N of Lenoir	H. Arnett	--do--	174	6	97	Granitic gneiss	—	10.0	—	--do--	
25	2.6 Mi. N of Lenoir	R. Palmer	--do--	89	6	88	--do--	—	4.0	—	Slope	
26	2.2 Mi. N of Lenoir	J. Lynn	--do--	130	6	92	--do--	—	5.0	—	--do--	
27	1.8 Mi. N of Lenoir	Valmead Fire Dept.	--do--	74	6	69	--do--	—	12.0	—	Flat	
28	1.9 Mi. NW of Lenoir	B. Messick	--do--	100	6	75	Mica gneiss	—	5.0	—	Slope	
29	1.3 Mi. NW of Lenoir	G. McGennis	--do--	36	6	30	Granitic gneiss	—	3.0	—	Flat	
30	1.1 Mi. NW of Lenoir	J. Walker	--do--	326	6	140	--do--	—	6.0	—	--do--	
31	1.7 Mi. NW of Lenoir	R. Moore	--do--	100	6	65	Mica gneiss	—	7.0	—	Slope	
32	1.8 Mi. W of Lenoir	D. Dula	--do--	76	6	30	--do--	45	12.0	—	Flat	
33	1.8 Mi. W of Lenoir	L. Banner	--do--	101	6	91	--do--	—	7.0	—	Slope	
34	2.0 Mi. SW of Lenoir	C. W. Suddrith	--do--	—	6	33	Granitic gneiss	48	3.0	—	--do--	
35	4.7 Mi. SW of Lenoir	J. J. Wooten	--do--	133	6	58	Mica gneiss	55	4.0	—	--do--	
36	6.0 Mi. SW of Lenoir	T. J. Winkler	Dug	36	36	36	Saprolite	23	—	—	--do--	Observation well
37	5.7 Mi. SW of Lenoir	L. Star	Drilled	96	6	50	Granitic gneiss	50	5.0	—	--do--	
38	6.1 Mi. SW of Lenoir	J. Ragsdale	--do--	96	6	76	--do--	—	10.0	—	Flat	
39	7.2 Mi. SW of Lenoir	C. Herman	--do--	150	6	83	--do--	—	7.0	—	--do--	
40	7.3 Mi. SW of Lenoir	C. Goble	--do--	165	6	80	Mica gneiss	—	5.0	—	--do--	
41	5.0 Mi. SW of Lenoir	M. Corpening	--do--	178	6	156	Granitic gneiss	—	15.0	—	--do--	
42	4.8 Mi. SW of Lenoir	V. Corpening	--do--	280	6	90	--do--	—	10.0	—	--do--	
43	4.7 Mi. SW of Lenoir	H. Hartley	--do--	385	6	26	--do--	—	20.0	—	--do--	

44	5.2 Mi. SW of Lenoir	W. M. Stryken	--do--	308	6	28	--do--	----	15.0	----	Slope	
45	5.3 Mi. SW of Lenoir	A. West	--do--	125	6	88	--do--	----	10.0	----	Flat	
46	5.0 Mi. SW of Lenoir	J. V. Harper	--do--	216	6	37	--do--	----	10.0	----	Slope	
47	4.5 Mi. SW of Lenoir	J. Dula	--do--	194	6	36	--do--	----	4.0	----	--do--	
48	3.5 Mi. SW of Lenoir	C. R. Leonard	--do--	99	6	85	--do--	----	8.0	----	Flat	
49	3.7 Mi. SW of Lenoir	W. J. McGallinard	--do--	90	6	39	--do--	----	6.0	----	--do--	
50	3.6 Mi. SW of Lenoir	R. Smith	--do--	369	6	53	--do--	----	5.0	----	Hilltop	
51	3.5 Mi. SW of Lenoir	M. McNeil	--do--	88	6	62	--do--	----	10.0	----	Flat	
52	2.5 Mi. SW of Lenoir	D. Lackey	--do--	200	6	143	--do--	----	15.0	----	--do--	
53	2.9 Mi. S of Lenoir	C. Corpening	--do--	338	6	17	--do--	----	2.0	----	Slope	
54	3.5 Mi. SW of Lenoir	L. B. Eller	--do--	268	6	18	--do--	----	5.0	----	Flat	
55	2.7 Mi. S of Lenoir	C. Triplett	--do--	219	6	65	--do--	----	10.0	----	--do--	
56	1.2 Mi. N of Lenoir	C. Tuttle	--do--	87	6	65	--do--	----	6.0	----	Slope	
57	1.4 Mi. N of Lenoir	G. Kinkaid	--do--	110	6	86	--do--	----	2.0	----	--do--	
58	1.5 Mi. N of Lenoir	N. Taylor	--do--	169	6	127	--do--	----	3.0	----	--do--	
59	1.2 Mi. NE of Lenoir	H. Keys	--do--	99	6	86	--do--	----	5.0	----	Flat	
60	2.2 Mi. NE of Lenoir	M. M. Pennell	--do--	206	6	63	--do--	----	10.0	----	--do--	
61	2.9 Mi. NE of Lenoir	F. L. German	--do--	67	6	38	Mica gneiss	30	----	----	--do--	
62	3.0 Mi. NE of Lenoir	G. Sherril	--do--	122	6	36	Granitic gneiss	80	----	----	Slope	
63	3.2 Mi. NE of Lenoir	J. Triplett	--do--	147	6	97	--do--	----	12.0	----	Flat	
64	3.6 Mi. NE of Lenoir	J. German	--do--	237	6	42	--do--	----	12.0	----	--do--	
65	4.0 Mi. NE of Lenoir	J. Wilson	--do--	200	6	85	--do--	----	15.0	----	--do--	
66	3.5 Mi. NE of Lenoir	G. B. Laws	--do--	414	6	26	--do--	----	15.0	----	--do--	
67	4.0 Mi. NE of Lenoir	H. Ervin	--do--	88	6	50	--do--	----	7.0	----	Slope	
68	3.9 Mi. NE of Lenoir	J. B. Teeters	--do--	391	6	73	--do--	----	11.0	----	Flat	
69	3.0 Mi. NE of Lenoir	W. B. Bare	--do--	90	6	30	--do--	50	----	----	--do--	
70	7.4 Mi. NE of Lenoir	V. Keller	--do--	305	5	72	--do--	50	4.0	250 ft. in 1 hr. @ 4 gpm	Slope	Hard water
71	8.8 Mi. NE of Lenoir	C. Hedrick	Bored	28	36	28	Saprolite	17	----	----	--do--	Observation well
72	5.1 Mi. NE of Lenoir	A. Verbyla	Drilled	225	5	51	Mica gneiss	55	8.0	215 ft. in 3 hrs. @ 8 gpm	--do--	
73	4.9 Mi. NE of Lenoir	D. Olbeck	--do--	445	6	16	Granitic gneiss	105	7.0	----	Slope	
74	4.5 Mi. NE of Lenoir	A. Walsh	--do--	180	6	62	Mica gneiss	----	9.0	----	--do--	
75	4.1 Mi. E of Lenoir	R. Barlow	--do--	242	5	26	--do--	35	2.0	----	--do--	
76	3.8 Mi. E of Lenoir	C. Taylor	Dug	30	48	----	Saprolite	26	----	----	--do--	Observation well
77	2.8 Mi. S of Lenoir	R. F. Shipley	Drilled	137	6	72	Mica gneiss	----	5.0	----	Flat	
78	5.2 Mi. S of Lenoir	K. Kirby	--do--	77	6	38	--do--	----	10.0	----	--do--	
79	6.3 Mi. S of Lenoir	C. Price	--do--	116	6	42	--do--	70	10.0	----	--do--	
80	7.2 Mi. SW of Lenoir	Church	--do--	132	6	67	Granitic gneiss	----	7.0	----	--do--	
81	6.2 Mi. S of Lenoir	R. T. Andrews	--do--	130	6	66	Mica gneiss	----	10.0	----	--do--	
82	7.3 Mi. SE of Lenoir	Joyceton Mill	--do--	305	6	27	Mica schist	32	10.0	----	--do--	
83	7.0 Mi. SE of Lenoir	--do--	--do--	400	6	27	--do--	32	10.0	----	--do--	
84	5.0 Mi. SE of Lenoir	Blowing Rock Furniture Co.	--do--	150	6	80	--do--	----	10.0	----	--do--	
85	6.0 Mi. E of Lenoir	F. West	Bored	11	24	11	Saprolite	8	----	----	Slope	Observation well
86	7.6 Mi. E of Lenoir	Church	Drilled	385	5	58	Mica gneiss	75	3.0	----	--do--	
87	6.7 Mi. E of Lenoir	V. White	--do--	61	6	49	Mica schist	----	3.0	----	--do--	
88	11.1 Mi. SE of Lenoir	Church	--do--	345	5	73	Granitic gneiss	60	5.0	300 ft. in 1 hr. @ 5 gpm	--do--	
89	4.9 Mi. SE of Lenoir	H. C. Huffman	--do--	225	5	71	Mica schist	60	60.0	75 ft. in 4 hrs. @ 60 gpm	Draw	

TABLE 12. RECORDS OF WELLS IN CALDWELL COUNTY (Continued)

Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
90	5.2 Mi. SE of Lenoir	Hudson Cotton Mfg. Co.	Drilled	1,058	8	----	Mica schist	----	300.0	----	Flat	Yield questionable
91	5.3 Mi. SE of Lenoir	--do--	--do--	159	6	62	--do--	----	10.0	----	--do--	
92	6.2 Mi. SE of Lenoir	W. Bolick	--do--	130	6	95	--do--	----	12.0	----	--do--	
93	6.0 Mi. SE of Lenoir	E. Shoun	Dug	50	36	50	Saprolite	40	----	----	Slope	Observation well
94	7.0 Mi. SE of Lenoir	S. Lingle	Drilled	101	6	33	Mica schist	----	5.0	----	--do--	
95	9.2 Mi. SW of Lenoir	W. Cook	--do--	170	5	46	Granitic gneiss	40	75.0	100 ft. in 5 hrs. @ 75 gpm	Draw	
96	7.0 Mi. SE of Lenoir	C. Presswood	--do--	330	5	23	Mica schist	15	10.0	110 ft. in 10 hrs. @ 10 gpm	--do--	
97	7.6 Mi. SE of Lenoir	F. L. German	--do--	86	6	22	--do--	----	10.0	----	Flat	
98	1.6 Mi. SW of Granite Falls	Rhodhiss Mills	--do--	386	8	----	--do--	30	105.0	----	--do--	
99	2.7 Mi. SE of Granite Falls	B. Huffman	--do--	245	5	135	Mica gneiss	80	25.0	150 ft. in 3 hrs. @ 25 gpm	--do--	Hard water
100	3.8 Mi. SE of Granite Falls	J. Hilkes	--do--	217	5	67	--do--	35	5.5	120 ft. in 4 hrs. @ 5.5 gpm	--do--	Hard water

TABLE 13. RECORDS OF SPRINGS IN CALDWELL COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
1A	10.5 Mi. NW of Collettsville----------	C. Moore----------					Augen gneiss-		0.8		Slope--	Observation spring
2A	2.8 Mi. NW of Patterson--	F. Woods----------					Layered gneiss------		0.5		Flat--	--do----------

TABLE 14.- CHEMICAL ANALYSES OF GROUND WATER FROM CALDWELL COUNTY

Chemical analyses, in parts per million

Number	Rock type 1/	Water type 2/	Source and depth (ft.) 3/	Date of collection	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids: Residue at 180°C	Dissolved solids: Calculated	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH	Color
6	mgn	III	Du- 19	Jan. 17, 1962..	2.7	0.3	0.07		9.6	2.4	6.5	11	0.4	55	11	3.7	0.1	0.9	0.1	79	76	36	0	127	7.0	30
7	mgn	III	Dr-105	Jan. 12, 1963..	25	--	.01		4.3	2.5	5.3	.8	--	35	1.0	2.7	.2	.9	--	--	60	21	0	68	6.6	--
20	mgn	III	Du- 38	Jan. 17, 1962..	20	.0	.42		3.8	1.5	4.7	1.6	.0	30	.2	2.1	.1	.3	.1	--	49	16	0	53	6.1	5
36	mgn	I	Du- 36	Jan. 17.......	25	.0	.59		24	3.1	4.8	2.3	.1	88	.2	2.7	.0	7.3	.0	--	112	72	0	156	6.8	0
71	mgn	I	B - 28	Jan. 16.......	22	.0	.29		12	1.7	3.4	.9	.0	52	.4	1.2	.0	.2	.0	65	68	37	0	85	6.4	0
75	mgn	I	Dr-242	Jan. 12, 1963..	33	--	.22		27	4.5	7.1	4.5	--	101	22	1.3	.2	.0	--	--	150	86	0	200	7.0	--
76	gr	C	Du- 30	Jan. 17, 1962..	4.0	.2	.15		2.8	.6	2.0	4.9	.1	12	4.0	2.6	.1	2.3	.1	--	30	10	0	46	5.6	25
85	msh	II	B - 11	Jan. 16.......	4.1	.1	.09		13	.4	2.3	3.3	.1	46	.2	3.8	.1	1.7	.0	56	52	34	0	81	7.7	0
88	gr	II	Dr-345	Jan. 11, 1963..	8.7	--	1.5		7.3	.8	1.6	.8	--	30	.2	.1	.1	.0	--	--	34	21	0	50	6.5	--
93	msh	C	Du- 50	Jan. 16, 1962..	5.9	.0	.27	0.04	12	3.6	30	3.1	.2	52	22	27	.1	6.1	1.0	--	138	44	2	250	6.5	5
1A	augn	III	S	Jan. 17.......	13	.0	.02		1.7	.5	2.1	.9	.0	14	.2	.6	.1	.0	.2	--	26	6	0	23	5.3	0
2A	lgn	IV	S	Jan. 17.......	16	.1	.03		1.3	.2	3.1	.8	.1	14	.2	1.1	.1	.1	.0	29	30	4	0	23	5.6	0

1/ Rock Type

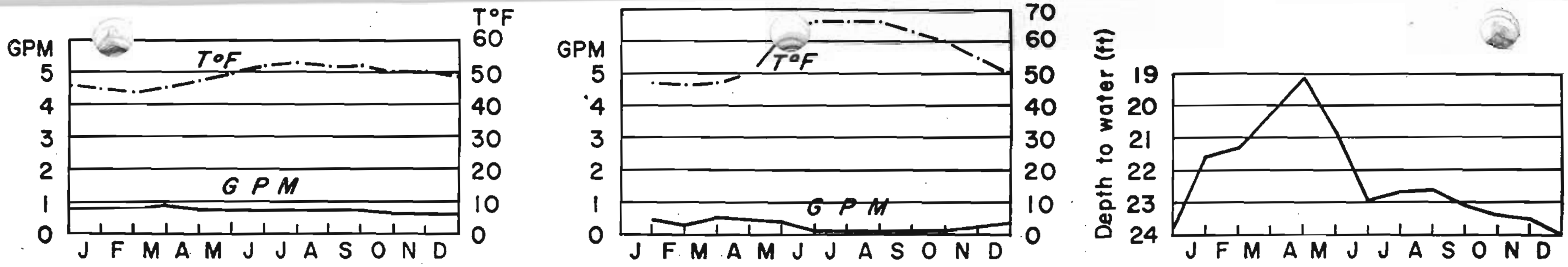
qm - quartz-monzonite gneiss
msh - sillimanite-mica schist
gr - granitic gneiss
mgn - quartz-biotite gneiss
lgn - layered gneiss
amgn - amphibolite gneiss
augn - augen gneiss
Begn - Beech Granite
arph - argillite and phyllite
akp - arkosic and pyroclastic rocks
qsh - schistose quartzitic rocks
qtz - quartzite

2/ Water Type

I - calcium, magnesium, sodium bicarbonate
II - calcium, sodium, magnesium bicarbonate
III - calcium-sodium, magnesium bicarbonate
IV - sodium, calcium, magnesium bicarbonate
V - magnesium, calcium, sodium bicarbonate
D - dissolved solids too low to reflect effects of lithology upon water composition
C - excessive chloride and/or nitrate masks effects of lithology upon water composition

3/ Source

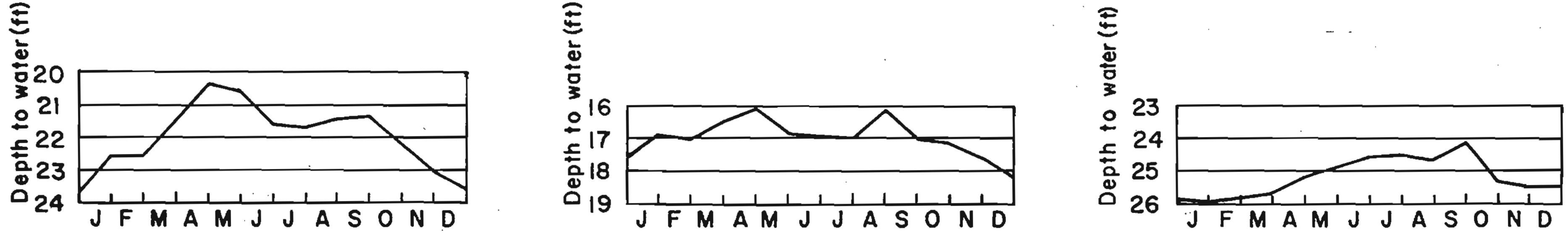
S - spring
Dr - drilled well
Du - dug well
B - bored well



1A, 10.6 mi. NW of Collettsville

2A, 2.8 mi. NW of Patterson

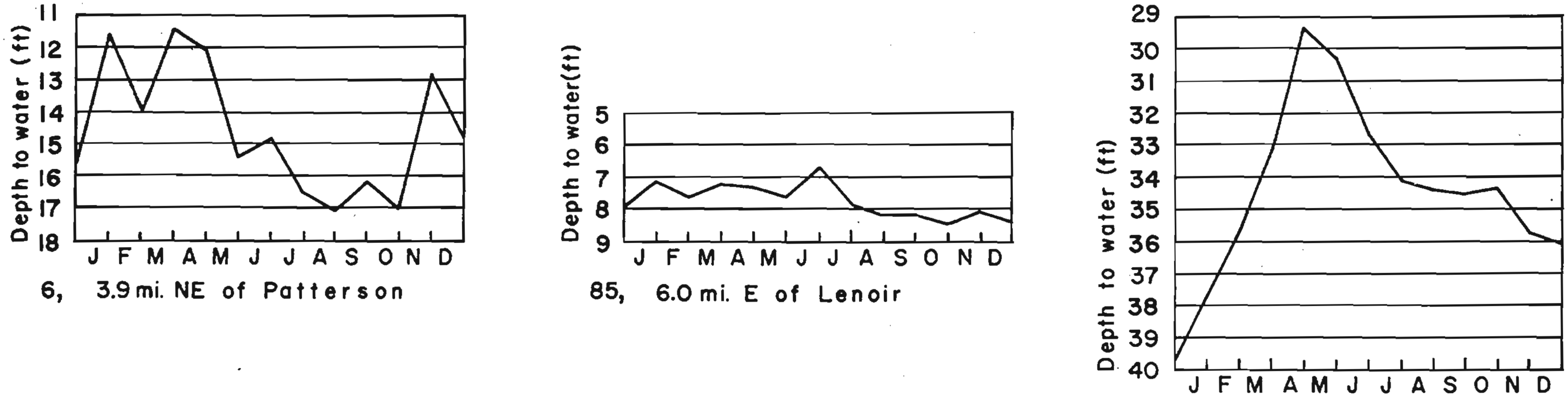
20, 1.3 mi. NE of Collettsville



36, 6.0 mi. SW of Lenoir

71, 8.8 mi. NE of Lenoir

76, 3.8 mi. E of Lenoir



6, 3.9 mi. NE of Patterson

85, 6.0 mi. E of Lenoir

93, 6.0 mi. SE of Lenoir

Figure 21. Caldwell County observation spring and well hydrographs, 1962.

McDowell County

(Area, 442 square miles; 1960 population, 27,742)

McDowell County is situated in the southwest part of the area of investigation (fig. 1). In common with Burke and Caldwell Counties, it lies partly in the inner Piedmont province and partly in the Blue Ridge physiographic province. From southeast to northwest monadnock-like hills separated by moderately wide, linear valleys in southeast McDowell County yield to deeply dissected, rugged slopes of the eastern Blue Ridge front near the Catawba River. Altitudes range from less than 1,000 feet in the southeast corner to 5,665 feet above mean sea level on High Pinnacle at the northwest corner of the county. McDowell County lies mostly within the Catawba River drainage basin. Tributaries of the Broad River drain a small part of southern McDowell County. The Catawba River courses northeastward near the Blue Ridge-inner Piedmont boundary and is impounded in Lake James. Streams and drainage courses appear to be of subsequent development, as they are mostly coincident to joint and shear systems.

Marion, the county seat, is the largest town and Old Fort is the only other town of substantial size in McDowell County. Agriculture dominates the economy to which forest products are supplementary. About 23 percent of the county is farmland. Manufacturing, mainly of furniture and textiles, is localized in and near Marion and Old Fort. Quarrying, about 8 miles north of Marion, produces dolomite used mostly for road metal. The northwest boundary of McDowell County is traversed by nearly 40 miles of the scenic Blue Ridge Parkway.

Mica gneiss predominates in exposures of the complex metamorphic rock types of this area (pl. 2). Layered gneiss, granitic gneiss, and quartzite are other prominent rock types. Structural trends range from nearly north to northeast. A deeply weathered residual mantle of saprolite overlies most of the inner Piedmont part of McDowell County. Saprolite is thin or absent on the Blue Ridge front.

Surface water is the source of municipal supplies for Marion and Old Fort. The water is filtered, chlorinated, and additionally treated before use. Drilled wells furnish water to many farms and outlying residences. Most of the drilled wells are less than 200 feet deep. Of 27 such wells the average depth is 110 feet and the average yield is 14.5 gallons per minute. Drilled wells having the highest yields are located in: low, flat areas; relatively narrow, linear valleys; or draws. Dug and bored wells are common throughout the inner Piedmont portion of McDowell County, providing domestic water for farms and residences. Of 60 dug and bored wells the average depth is 39 feet and the average depth to the water table is 27 feet. Insufficient data preclude statistical representation of yields from dug and bored wells. Springs are more commonly used in the Blue Ridge part of McDowell County. The community of Little Switzerland procures its municipal water supply from springs.

Analyses of ground water from McDowell County are shown in table 17. Water from wells 29 and 64 contained more than 0.3 ppm iron. Water from wells 39 and 64 contained high concentrations of chloride and/or nitrate. Analysis of water from well 6 is noteworthy. Water from this well had the highest pH (9.1) of any water sampled in the Morganton area, a strong "rotten egg" odor (hydrogen sulfide), and relatively high sodium and sulfate concentrations. This well probably is receiving water from pegmatite containing sodic feldspar and sulfides.

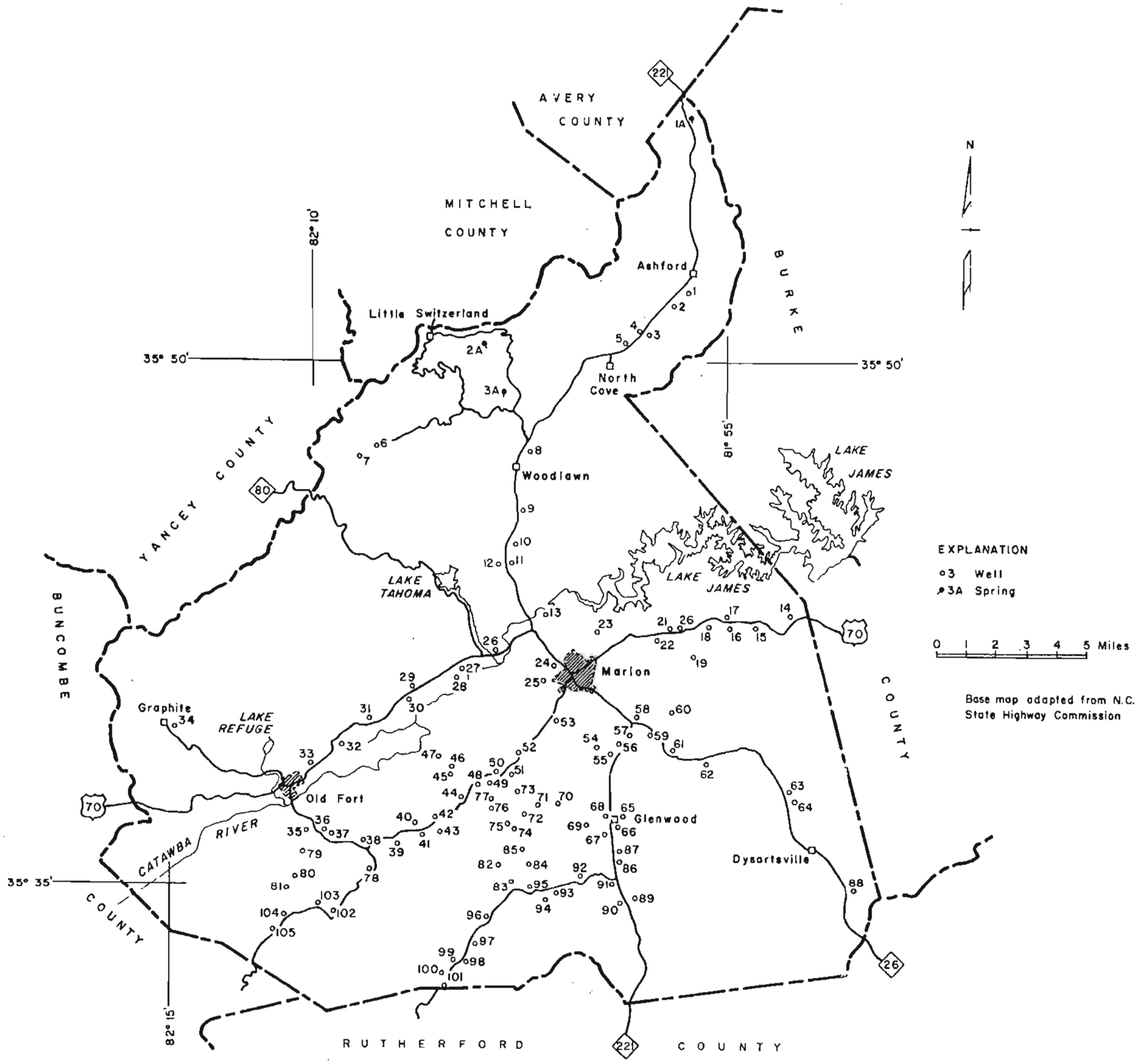


Figure 22. Map of McDowell County showing locations of wells and springs.

TABLE 15. RECORDS OF WELLS IN McDOWELL COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
1	Ashford	S. C. Gouge	Bored	37	24	37	Alluvium	25	----	----	Flat	Hard water
2	1.1 Mi. S of Ashford	Sam Brown	--do--	27	24	27	--do--	20	----	----	--do--	Slightly hard water
3	1.5 Mi. N of North Cove	C. Weathers	Drilled	120	6	80	Quartzite	30	----	----	--do--	--do--
4	1.6 Mi. N of North Cove	J. G. Childers	Bored	40	30	40	--do--	20	----	----	--do--	
5	0.8 Mi. N of North Cove	B. McCall	--do--	16	30	16	Alluvium	10	----	----	--do--	Observation well
6	6.8 Mi. W of Woodlawn	N. C. State Fish Hatchery	Drilled	253	6	20	Amphibolite gneiss	4.9	12.0	----	Slope	SO_2 in water, not potable
7	7.2 Mi. W of Woodlawn	--do--	--do--	120	6	20	--do--	1	----	----	--do--	
8	0.6 Mi. N of Woodlawn	L. J. Robinson	--do--	190	6	150	Quartzite	25	----	----	--do--	
9	1.6 Mi. S of Woodlawn	Ray Byrd	Bored	16	30	16	Saprolite	4	----	----	Flat	Bedrock at 16 feet
10	2.7 Mi. N of Marion	Bill Nichols	--do--	7	18	7	Alluvium	2	----	----	--do--	Observation well
11	2.1 Mi. N of Marion	R. Lavender	--do--	60	30	60	Saprolite	5	----	----	Slope	
12	2.0 Mi. N of Marion	G. Biddix	--do--	12	30	12	--do--	3	----	----	Flat	
13	1.1 Mi. N of Marion	J. Lauder	Drilled	137	6	137	Layered gneiss	----	11.0	----	Slope	
14	6.6 Mi. E of Marion	K. Thombs	--do--	115	6	34	Biotite gneiss	72	9.0	----	Hilltop	
15	5.3 Mi. E of Marion	Z. B. Adams	Bored	40	30	40	--do--	25	----	----	Slope	
16	4.5 Mi. E of Marion	C. E. Edwards	Drilled	139	6	139	--do--	60	3.5	----	--do--	
17	4.3 Mi. E of Marion	G. Mace	--do--	130	6	130	--do--	----	----	----	--do--	Iron in water
18	3.8 Mi. E of Marion	O. Aldridge	--do--	68	6	68	Biotite gneiss	----	----	----	--do--	Slightly hard water
19	4.5 Mi. E of Marion	G. C. Welch	--do--	136	6	100	--do--	4	7.5	----	--do--	
20	4.0 Mi. E of Marion	Hollifield and Church	Bored	24	24	24	Saprolite	12	----	----	Flat	
21	3.7 Mi. E of Marion	G. Holland	--do--	16	24	16	--do--	7	----	----	--do--	Observation well
22	3.5 Mi. E of Marion	Lingerfelt	Dug	20	4'x4'	----	--do--	14	----	----	--do--	
23	2.0 Mi. NE of Marion	V. Davis	Drilled	237	6	100	Biotite gneiss	60	----	----	Slope	
24	0.7 Mi. NW of Marion	W. F. Morris	--do--	325	6	80	--do--	80	2.5	----	--do--	
25	1.0 Mi. W of Marion	J. G. Hollifield	Bored	67	24	67	Saprolite	54	7.0	----	--do--	
26	2.0 Mi. NW of Marion	P. E. Edwards	Drilled	84	6	74	Mica gneiss	----	20.0	----	Flat	
27	5.0 Mi. NW of Marion	G. Crawford	--do--	310	6	----	Layered gneiss	----	11.0	----	--do--	
28	5.2 Mi. W of Marion	W. V. Shuford	--do--	64	6	44	--do--	8	8.0	----	--do--	
29	6.2 Mi. W of Marion	Sam Parker	Dug	21	36	----	Saprolite	3	----	----	--do--	Observation well
30	5.5 Mi. NE of Old Fort	T. M. Burnett	Drilled	85	6	85	--do--	----	25.0	----	--do--	
31	4.0 Mi. NE of Old Fort	W. R. McDaniel	Dug	40	30	40	--do--	----	----	----	Slope	
32	2.8 Mi. NE of Old Fort	S. N. Allison	Drilled	57	6	35	Layered gneiss	32	----	----	--do--	
33	1.3 Mi. NE of Old Fort	R. E. Evans	--do--	63	6	50	--do--	----	75.0	----	Flat	
34	Graphite	----	Bored	19	18	19	Saprolite	11	----	----	Slope	
35	1.3 Mi. S of Old Fort	M. Wilson	Drilled	100	6	80	Layered gneiss	----	15.0	----	Slope	
36	1.3 Mi. SE of Old Fort	G. R. Early	--do--	120	6	60	--do--	----	8.5	----	--do--	
37	1.6 Mi. SE of Old Fort	T. B. Faw	Dug	36	36	36	Saprolite	30	8.0	----	Flat	Often cloudy
38	3.9 Mi. SE of Old Fort	Church	Bored	75	30	75	--do--	67	----	----	Slope	
39	4.8 Mi. SE of Old Fort	R. F. Cathey	Dug	48	40	----	--do--	43	----	----	--do--	Observation well
40	5.8 Mi. SE of Old Fort	----	Bored	28	30	28	--do--	12	----	----	Flat	
41	6.0 Mi. SE of Old Fort	J. Reel	Drilled	79	6	62	Mica gneiss	50	7.5	----	--do--	
42	6.3 Mi. SE of Old Fort	B. W. Simpson	--do--	115	6	75	--do--	15	----	----	--do--	
43	6.0 Mi. SE of Old Fort	A. F. Hill	Bored	45	30	45	Saprolite	27	----	----	Slope	
44	1.2 Mi. SW of Providence	F. J. Day	--do--	48	30	48	--do--	32	----	----	--do--	
45	2.0 Mi. W of Providence	C. Wall	Drilled	302	6	58	Layered gneiss	----	20.0	----	--do--	

TABLE 15. RECORDS OF WELLS IN McDOWELL COUNTY (Continued)

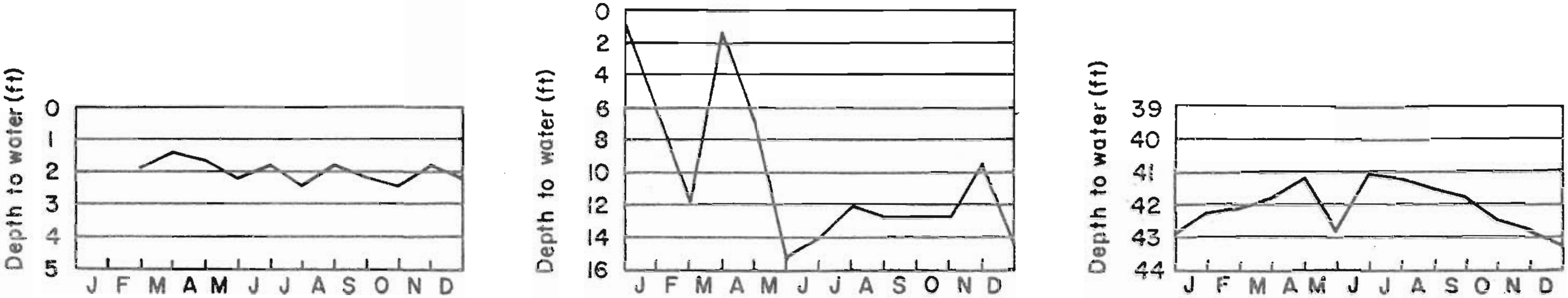
Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
46	2.2 Mi. W of Providence	C. Wall	Drilled	296	6	58	Mica gneiss	----	20.0	----	Slope	
47	2.5 Mi. W of Providence	R. Daves	--do--	28	6	24	Saprolite	12	8.0	----	Flat	
48	0.9 Mi. SW of Providence	A. Shelton	Bored	38	30	38	--do--	20	----	----	--do--	
49	0.7 Mi. SW of Providence	C. Barlow	--do--	44	30	44	--do--	30	----	----	--do--	
50	Providence	J. Davis	Dug	37	30	37	--do--	27	----	----	Slope	
51	--do--	R. W. Wilson	Drilled	72	6	72	Layered gneiss	60	22.0	----	Flat	
52	1.0 Mi. NE of Providence	R. O. McCurry	Bored	38	30	38	Saprolite	22	----	----	Slope	
53	1.6 Mi. SW of Marion	M. Sultles	Drilled	132	6	91	Mica gneiss	50	10.0	----	Slope	
54	2.5 Mi. S of Marion	D. Potide	--do--	184	6	65	--do--	----	25.0	----	Draw	
55	2.8 Mi. S of Marion	M. Williams	--do--	161	6	64	--do--	----	20.0	----	Slope	
56	2.5 Mi. SE of Marion	J. C. Bowman	--do--	130	6	68	--do--	----	3.5	----	--do--	
57	2.8 Mi. SE of Marion	E. Ross	--do--	210	6	79	--do--	5	15.0	----	Flat	
58	2.2 Mi. SE of Marion	P. Sherrill	--do--	100	6	100	Mica gneiss	----	15.0	----	--do--	
59	2.9 Mi. SE of Marion	P. Hunter	Bored	62	24	62	Saprolite	42	----	----	--do--	
60	3.5 Mi. SE of Marion	J. J. Harris	--do--	58	30	58	--do--	38	----	----	--do--	
61	3.5 Mi. SE of Marion	H. Whitson	Dug	50	30	50	--do--	44	----	----	Hilltop	
62	5.8 Mi. NW of Dysartsville	D. Peters	Drilled	67	6	67	Mica gneiss	----	10.0	----	--do--	
63	2.5 Mi. NW of Dysartsville	R. Berryhill	Dug	17	30	17	Saprolite	12	----	----	Flat	
64	6.4 Mi. SE of Marion	Z. Martin	--do--	54	5'x5'	----	--do--	45	----	----	Hilltop	Observation well
65	Glenwood	J. D. Pyatt	Bored	30	30	30	--do--	15	----	----	Flat	
66	0.2 Mi. SW of Glenwood	N. England	--do--	26	24	26	--do--	6	----	----	--do--	
67	0.6 Mi. SW of Glenwood	E. Barker	Dug	27	36	----	--do--	22	----	----	--do--	Observation well
68	0.4 Mi. W of Glenwood	F. Holland	Bored	150	30	150	--do--	120	----	----	Slope	
69	0.8 Mi. W of Glenwood	E. Higgins	--do--	55	30	55	--do--	40	----	----	Flat	
70	2.3 Mi. NW of Glenwood	W. B. Shufford	Drilled	64	6	48	Mica gneiss	----	8.0	----	Slope	
71	1.5 Mi. SE of Providence	W. H. Pace	Dug	22	30	22	Saprolite	11	----	----	Flat	
72	1.2 Mi. SE of Providence	G. Gardner	Bored	51	30	51	--do--	36	----	----	--do--	
73	0.7 Mi. SE of Providence	G. Little	Dug	60	30	60	--do--	50	----	----	Slope	
74	2.4 Mi. N of Sugar Hill	L. R. Webb	--do--	18	30	18	--do--	12	----	----	Flat	Bottom on bedrock
75	2.6 Mi. N of Sugar Hill	C. Birchfield	Bored	34	36	34	--do--	18	----	----	--do--	
76	1.3 Mi. S of Providence	K. Wilson	Drilled	120	6	120	Layered gneiss	----	12.0	----	Slope	Bedrock @ 60 feet
77	0.9 Mi. S of Providence	W. F. Stroud	--do--	187	6	100	--do--	55	8.0	----	Hilltop	
78	4.3 Mi. SE of Old Fort	P. Elliot	Dug	20	30	20	Saprolite	15	----	----	Flat	
79	2.1 Mi. S of Old Fort	J. Thomas	Bored	28	18	28	--do--	23	----	----	Slope	Observation well
80	3.1 Mi. S of Old Fort	E. A. Williams	--do--	40	30	40	--do--	34	----	----	--do--	
81	3.6 Mi. SW of Old Fort	C. Davis	Drilled	222	6	55	Layered gneiss	50	10.0	----	Flat	Bedrock @ 55 feet
82	**1.1 Mi. NW of Sugar Hill**	H. E. Hensley	Dug	35	36	35	Saprolite	32	----	----	Slope	
83	**0.4 Mi. NW of Sugar Hill**	G. Ray	Bored	65	30	65	--do--	46	----	----	--do--	Slightly hard water
84	**1.0 Mi. NE of Sugar Hill**	W. R. Cable	--do--	69	30	69	--do--	55	----	----	--do--	
85	**2.2 Mi. N of Sugar Hill**	C. Jenkins	--do--	20	30	20	--do--	12	----	----	Flat	
86	**1.6 Mi. S of Glenwood**	L. L. Parker	--do--	30	30	30	--do--	20	----	----	--do--	
87	**1.4 Mi. S of Glenwood**	A. F. Hunt	Drilled	150	6	150	Mica gneiss	120	25.0	----	Draw	
88	**2.0 Mi. SE of Dysartsville**	K. Fortune	--do--	60	6	40	Saprolite	22	4.0	----	Slope	
89	**3.0 Mi. S of Glenwood**	G. C. Smith	Dug	18	30	18	--do--	14	----	----	Hilltop	Hard water with SO_2
90	**3.2 Mi. S of Glenwood**	J. E. Butler	--do--	15	30	15	--do--	11	----	----	Flat	Hard water
91	**2.5 Mi. S of Glenwood**	A. W. Ward	--do--	35	30	35	--do--	25	----	----	--do--	--do--
92	**3.7 Mi. SW of Glenwood**	N. Lewis	Bored	40	30	40	--do--	30	----	----	Slope	--do--
93	**1.5 Mi. E of Sugar** Hill	H. E. Greene	Drilled	148	6	135	Granitic gneiss	100	13.0	----	--do--	

94	1.0 Mi. E of Sugar Hill	F. Richardson	Drilled	196	6	158	Granitic gneiss	100	28.0	----	Slope	Hard water
95	0.3 Mi. E of Sugar Hill	F. Conner	Bored	40	30	40	Saprolite	30	-----	----	Flat	
96	1.3 Mi. SW of Sugar Hill	F. Lawing	--do--	48	30	48	--do--	30	-----	----	--do--	
97	2.3 Mi. SW of Sugar Hill	W. E. Ledbetter	--do--	10	30	10	--do--	7	-----	----	--do--	
98	3.1 Mi. SW of Sugar Hill	C. Weathers	--do--	40	30	40	--do--	20	20.0	----	--do--	
99	3.2 Mi. SW of Sugar Hill	R. M. Wilkerson	Drilled	272	6	262	Layered gneiss	70	11.0	----	Slope	Hard water
100	3.9 Mi. SW of Sugar Hill	J. H. Harris	Bored	85	30	85	Saprolite	70	-----	----	Flat	Bottom on bedrock
101	4.0 Mi. SW of Sugar Hill	Church	Drilled	140	6	140	Layered gneiss	80	10.0	----	--do--	
102	6.0 Mi. SE of Old Fort	P. L. Jordan	Bored	23	24	23	Saprolite	14	-----	----	Slope	Hard water
103	5.5 Mi. S of Old Fort	E. Davis	--do--	65	30	65	--do--	59	-----	----	--do--	
104	5.0 Mi. S of Old Fort	J. Elliott	--do--	20	18	20	--do--	10	-----	----	Flat	
105	5.5 Mi. SW of Old Fort	E. W. Davis	Drilled	52	8	11	Layered gneiss	17	9.0	----	Slope	Bedrock @ 11 feet

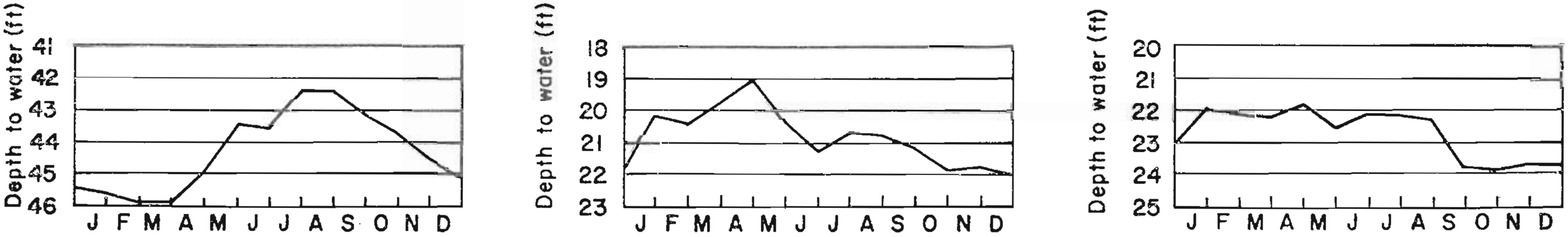
TABLE 16. RECORDS OF SPRINGS IN McDOWELL COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
1A	5.6 Mi. N of Ashford-----	------------------	Unimproved				Quartzite---		3.0		Slope--	49° F., 4-9-62----
2A	0.4 Mi. W of Gillespie Gap------------------	------------------	Reservoir				Amphibolite gneiss-----		4.0		--do---	53° F., 3-30-62---
3A	2.3 Mi. N of Woodlawn----	O. Washburn------	--do--				Layered gneiss-----		1.8		Draw---	Observation spring-

21, 3.7 mi. E of Marion 5, 0.8 mi. N of North Cove 3A, 2.3 mi. N of Woodlawn



10, 2.7 mi. N of Marion 29, 6.2 mi. W of Marion 39, 4.8 mi. SE of Old Fort



64, 6.4 mi. SE of Marion 67, 0.6 mi. SW of Glenwood 79, 2.1 mi. S of Old Fort

Figure 23. McDowell County observation well and spring hydrographs, 1962.

TABLE 17.- CHEMICAL ANALYSES OF GROUND WATER IN McDOWELL COUNTY

Number	Rock type 1/	Water type 2/	Source and depth (ft.) 3/	Date of collection	Chemical analyses, in parts per million Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids Residue at 180°C	Dissolved solids Calculated	Hardness as $CaCO_3$ Calcium, Magnesium	Hardness as $CaCO_3$ Non-carbonate	Specific conductance (micromhos at 25°C)	pH	Color
5	qtz	II	B - 16	Jan. 15, 1962.	5.6	0.1	0.02	0.01	14	0.8	2.4	2.0	0.1	52	0.4	0.5	0.1	0.2	0.0	--	52	38	0	86	7.6	0
6	amgn	IV	Dr-253	Oct. 26, 1961.	17	.0	.02	.00	4.5	.1	23	.4	.1	* 17	20	6.0	.6	.8	.0	--	91	11	0	129	9.1	--
21	mgn	I	B - 16	Jan. 15, 1962.	5.7	.4	.07	.01	10	5.9	1.5	1.4	.2	64	.2	1.7	.0	1.1	.0	58	60	52	0	102	6.0	10
29	lgn	I	Du- 21	Jan. 15.......	5.2	.1	.62	.00	11	.8	2.4	2.9	.1	33	4.8	3.4	.0	.5	.0	--	47	30	2	76	6.0	10
36	lgn	IV	Dr-120	Jan. 12, 1963.	31	--	.00	--	3.2	.5	6.1	1.2	--	31	.2	.3	.2	.0	--	--	58	10	0	50	6.5	--
39	mgn	C	Du- 48	Jan. 15, 1962.	7.8	.1	.12	.02	1.6	3.9	8.3	2.9	.1	8	.2	20	.0	7.4	.0	67	56	20	14	96	5.3	0
64	gr	C	Du- 54	Jan. 15.......	5.6	.0	.73	.08	1.3	.4	2.0	1.5	.1	3	.2	2.0	.0	5.9	.0	24	20	4	2	35	5.9	5
67	gr	IV	Du- 27	Jan. 15.......	7.6	.0	.11	.01	.4	.3	1.8	.9	.1	6	.2	2.3	.0	.1	.0	--	17	2	0	20	5.2	0
77	lgn	II	Dr-187	Jan. 12, 1963.	20	--	.04	--	22	2.1	5.6	1.8	--	80	9.6	1.0	.5	.0	--	--	102	64	0	144	7.6	--
88	gr	IV	Dr- 60	Jan. 12.......	14	--	.12	--	1.1	.7	2.0	.7	--	13	.2	1.0	.0	.0	--	--	26	6	0	22	5.8	--
3A	lgn	I	S	Jan. 15, 1962.	16	.0	.09	.00	3.3	1.5	2.0	1.0	.0	24	.2	.5	.0	.1	.0	33	37	14	0	38	6.3	5

1/ Rock Type

qm - quartz-monzonite gneiss
msh - sillimanite-mica schist
gr - granitic gneiss
mgn - quartz-biotite gneiss
lgn - layered gneiss
amgn - amphibolite gneiss

augn - augen gneiss
Begn - Beech Granite
arph - argillite and phyllite
akp - arkosic and pyroclastic rocks
qsh - schistose quartzitic rocks
qtz - quartzite

2/ Water Type

I - calcium, magnesium, sodium bicarbonate
II - calcium, sodium, magnesium bicarbonate
III - calcium-sodium, magnesium bicarbonate
IV - sodium, calcium, magnesium bicarbonate
V - magnesium, calcium, sodium bicarbonate
D - dissolved solids too low to reflect effects of lithology upon water composition
C - excessive chloride and/or nitrate masks effects of lithology upon water composition

3/ Source

S - spring
Dr - drilled well
Du - dug well
B - bored well

* Carbonate (CO_3) 10 ppm

Mitchell County

(Area, 220 square miles; 1960 population, 13,906)

Mitchell County lies within the Blue Ridge portion of the area of investigation (fig. 1). The county is bounded on the north by Tennessee. Topography in Mitchell County ranges from narrow valleys and moderately subdued hills to highly dissected, steep slopes. Altitudes range from less than 1,700 feet above mean sea level, where the Nolichucky River enters Tennessee at the northwest corner of Mitchell County, to 6,267 feet on Roan High Bluff in Northeast Mitchell County. Mitchell County lies entirely in the Nolichucky River drainage basin. The river forms much of the county's western boundary. The angular nature of stream courses in Mitchell County suggests their subsequent development on joint and shear systems.

The largest town in Mitchell County is Spruce Pine. Bakersville, the county seat, is the only other town of substantial size. Agriculture dominates the economy; nearly 46 percent of the county area is farmland. Forest products supplement agriculture. Feldspar and mica are produced from mines of the Spruce Pine district. The scenic Blue Ridge Parkway traverses the southern boundary of Mitchell County.

Of the many complex metamorphic and igneous rock types in Mitchell County, amphibolite gneiss and layered gneiss predominate. A gabbro stock and many small diabase dikes occur in the northern half of the county. Alaskite stocks or pods and pegmatite dikes or sills provide mineable deposits of feldspar and mica. A weathered mantle of residual saprolite and alluvium is present in some of the more topographically subdued areas, but is generally thin or absent in most localities. Structural trends of the metamorphic and igneous rocks in Mitchell County are oriented northeastward (pl. 2).

Surface runoff from watersheds near Spruce Pine provides the town's municipal water supplies. A single drilled well supplies municipal water to Bakersville. Springs are abundant and are commonly used for domestic water supplies in outlying areas. Most drilled wells in Mitchell County are less than 200 feet deep. Of 22 such wells the average depth is 100 feet and the average yield is 8.5 gallons per minute. Drilled wells having the highest yields are located in: low, flat areas; narrow, linear valleys; and draws. Dug and bored wells are not as common in Mitchell

County as in counties of the inner Piedmont province. In the thin residual and alluvial mantle of Mitchell County, dug and bored wells average 26 feet in depth. Average depth to the water table is 12 feet. Insufficient data preclude statistical representation of yields from dug and bored wells.

Analyses of ground water from Mitchell County are shown in table 20. All ground water sampled contained less than 0.3 ppm iron. Water from springs 19A, 41A, and 55A had slightly high nitrate and chloride concentrations.

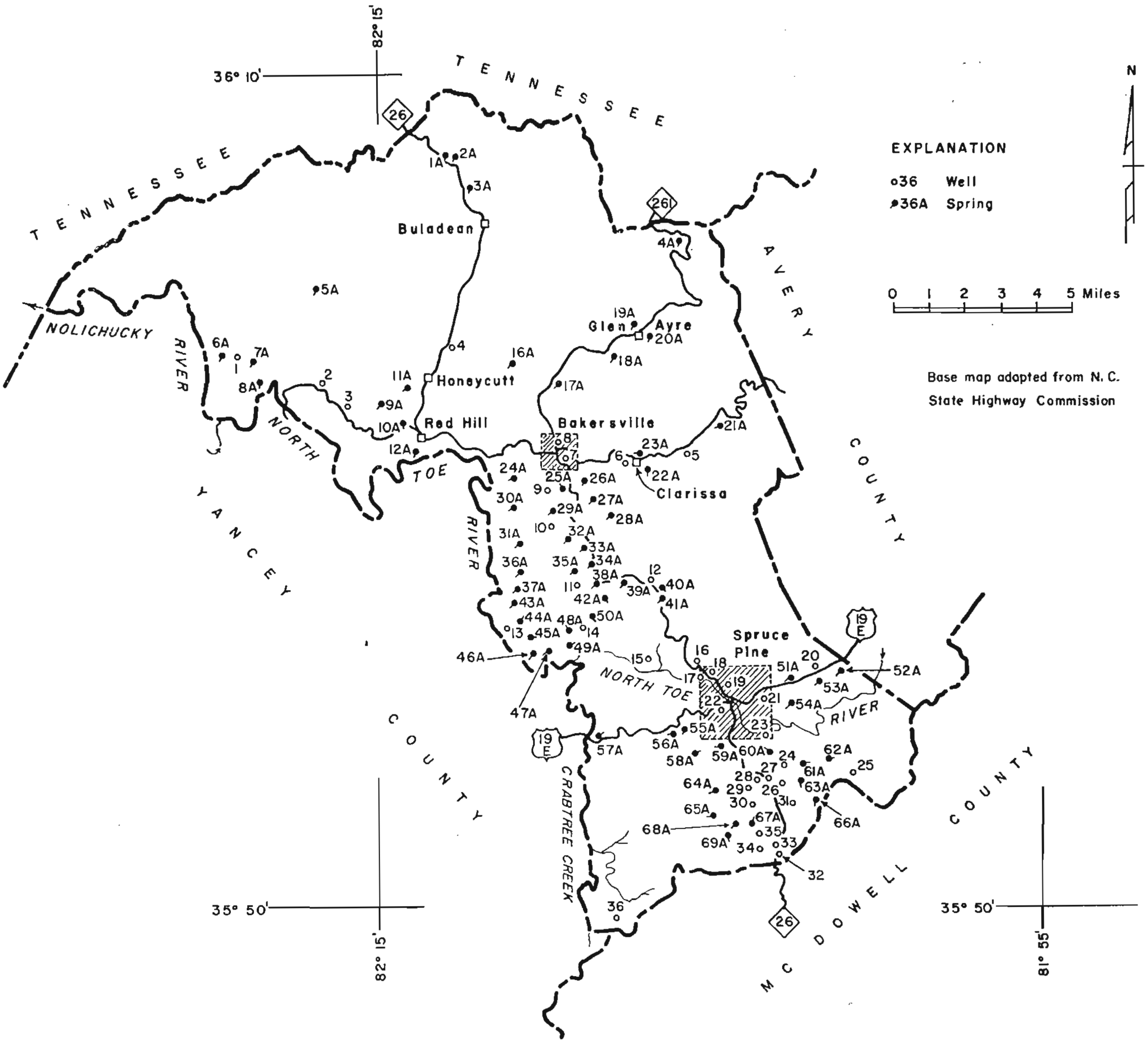


Figure 24. Map of Mitchell County showing locations of springs and wells.

TABLE 18. RECORDS OF WELLS IN MITCHELL COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Draw-down (ft)	Topography	Remarks
1	3.4 Mi. NW of Relief	G. T. Barrett	Dug	6	36	----	Saprolite	3	1.0	----	Flat	
2	1.3 Mi. NE of Relief	J. W. Webb	Drilled	152	6	20	Layered gneiss	80	5.0	----	--do--	Hard water
3	Tipton Hill	F. Tipton	--do--	50	6	20	Amphibolite gneiss	8	5.0	----	--do--	
4	1.4 Mi. NE of Honeycutt	F. Whitson	Dug	13	30	13	Saprolite	12	----	----	Slope	Observation well
5	Hawk	C. Pittman	--do--	15	36	----	--do--	8	2.0	----	Flat	
6	1.5 Mi. E of Bakersville	P. Ledford	Drilled	225	6	90	Amphibolite gneiss	----	6.0	----	Slope	
7	Bakersville	Town of Bakersville	--do--	401	12	50	--do--	----	200.0	----	Draw	Slightly hard water
8	Bakersville	M. Green	--do--	212	6	42	--do--	----	30.0	----	Flat	
9	2.0 Mi. S of Bakersville	H. Buchanon	--do--	101	6	90	--do--	----	4.0	----	--do--	Hard water
10	2.5 Mi. S of Bakersville	W. B. Ellis	--do--	50	5	40	--do--	----	5.0	----	--do--	
11	1.6 Mi. W of Ledger	C. Sparks	--do--	75	6	30	Mica gneiss	----	5.0	----	Slope	
12	1.2 Mi. E of Ledger	E. Duncan	--do--	65	6	35	Amphibolite gneiss	----	20.0	----	Draw	
13	Kona	M. Todd	--do--	111	6	75	--do--	60	6.0	----	Flat	Hard water
14	2.1 Mi. NE of Boonford	H. Phillips	Dug	20	36	7	Saprolite	8	2.0	----	Slope	
15	0.2 Mi. N of Penland	H. Chase	Drilled	303	6	110	Amphibolite gneiss	----	4.0	----	--do--	Hard water
16	2.0 Mi. NW of Spruce Pine	--do--	--do--	307	6	84	Mica gneiss	100	5.0	----	Hilltop	--do--
17	1.7 Mi. NW of Spruce Pine	J. Hoyle	--do--	76	5	18	--do--	35	10.0	----	Flat	--do--
18	1.6 Mi. NW of Spruce Pine	L. Hollifield	Dug	31	36	----	Saprolite	6	2.0	----	--do--	
19	Spruce Pine	F. Watson	Drilled	115	6	52	Mica gneiss	30	3.0	----	Slope	
20	2.9 Mi. E of Spruce Pine	----	--do--	60	5	15	--do--	----	9.0	----	Flat	
21	0.5 Mi. E of Spruce Pine	G. Jones	--do--	100	6	40	Alaskite	----	4.0	----	Slope	Hard water
22	Spruce Pine	O. Burleson	--do--	142	6	95	Mica gneiss	----	3.0	----	--do--	
23	1.5 Mi. SE of Spruce Pine	S. Montague	--do--	303	6	40	--do--	----	15.0	----	Flat	
24	3.2 Mi. SE of Spruce Pine	C. Greenlee	--do--	118	6	30	Amphibolite gneiss	40	4.0	----	Slope	
25	0.7 Mi. NE of McKinney Gap	R. Harrison	--do--	146	6	46	--do--	----	18.0	----	Draw	
26	2.5 Mi. N of Gillespie Gap	P. Riddle	Dug	15	36	----	Saprolite	8	5.0	----	Flat	
27	2.7 Mi. N of Gillespie Gap	Church	Drilled	150	6	21	Amphibolite gneiss	50	20.0	----	--do--	
28	2.9 Mi. N of Gillespie Gap	J. Cox	--do--	123	6	35	--do--	----	4.0	----	--do--	
29	3.1 Mi. N of Gillespie Gap	A. Hollifield	--do--	360	6	45	--do--	120	1.0	----	Slope	
30	2.7 Mi. NW of Gillespie Gap	D. Collis	--do--	100	6	70	--do--	26	15.0	----	Draw	
31	1.9 Mi. NE of Gillespie Gap	B. Mitchell	Dug	20	36	----	Saprolite	10	3.0	----	Flat	
32	Gillespie Gap	L. Snipes	--do--	60	36	----	Amphibolite gneiss	40	6.0	----	Slope	
33	0.6 Mi. N of Gillespie Gap	W. Cox	Drilled	100	6	48	--do--	90	4.0	----	--do--	
34	0.6 Mi. NW of Gillespie Gap	Blue Ridge Parkway	--do--	180	6	3	--do--	3	20.0	10 ft. in 1 hr. @ 20 gpm	Draw	Bedrock @ 3 feet

35	1.3 Mi. NW of Gillespie Gap	V. J. McKinney	--do--	56	6	7	--do--	----	7.0	----	Slope
36	5.5 Mi. SW of Gillespie Gap	Blue Ridge Parkway	--do--	135	6	50	Amphibolite gneiss	15	20.0	28 ft. in 14 hrs. @ 20 gpm	Draw

TABLE 19. RECORDS OF SPRINGS IN MITCHELL COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft)	Diam-eter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Draw-down (ft)	Topo-graphy	Remarks
1A	2.1 Mi. NW of Buladean	N. Butler					Pyroclastics		0.5		Slope	
2A	1.9 Mi. NW of Buladean	J. Davis					Layered gneiss		1.3		--do--	Observation spring
3A	0.8 Mi. S of Buladean	E. Moffit					--do--		1.5		--do--	
4A	5.6 Mi. NE of Glen Ayre	----------					Amphibolite gneiss		17.1		--do--	Observation spring
5A	3.9 Mi. N of Relief	B. Grey					Layered gneiss		1.0		--do--	
6A	3.7 Mi. S of Poplar	E. Peterson					Pyroclastics		0.5		--do--	
7A	3.0 Mi. NW of Relief	R. Hughes					--do--		1.5		--do--	
8A	1.6 Mi. NW of Relief	P. Peterson					Layered gneiss		0.8		--do--	
9A	0.6 Mi. SW of Peppers	M. Masters					Amphibolite gneiss		0.8		--do--	
10A	0.5 Mi. NW of Red Hill	E. Renfro					Layered gneiss		1.0		Flat	
11A	1.1 Mi. SW of Honeycutt	A. P. Harrell					Amphibolite gneiss		1.5		--do--	
12A	0.6 Mi. SW of Red Hill	M. Gouge					Gabbro		0.4		Slope	Observation spring
13A	1.1 Mi. E of Red Hill	J. Slaigle					--do--		2.0		--do--	
14A	1.6 Mi. SE of Red Hill	S. Gouge					--do--		0.5		--do--	
15A	2.9 Mi. SE of Red Hill	H. Webb					Amphibolite gneiss		1.5		--do--	
16A	4.0 Mi. NE of Honeycutt	B. M. Slagle					Layered gneiss		0.5		--do--	
17A	2.5 Mi. N of Bakersville	J. N. McKinney					Amphibolite gneiss		2.5		--do--	
18A	1.1 Mi. SW of Glen Ayre	J. N. McKinney					--do--		1.5		--do--	
19A	Glen Ayre	D. Wilcox					Layered gneiss		1.7		Flat	Observation spring
20A	--do--	F. Thomas					--do--		1.0		Slope	
21A	1.0 Mi. NE of Hawk	C. Pittman					Amphibolite gneiss		1.0		--do--	
22A	0.6 Mi. S of Clarissa	C. Green					--do--		1.3		--do--	Observation spring
23A	Clarissa	H. E. Hughes					--do--		1.5		--do--	
24A	1.0 Mi. SW of Bakersville	E. A. Bowditch					--do--		1.5		Flat	
25A	1.0 Mi. S of Bakersville	J. V. Johnson					--do--		1.0		Slope	
26A	1.0 Mi. SE of Bakersville	J. M. Pawwell					--do--		1.5		--do--	
27A	2.0 Mi. SE of Bakersville	E. Wilson					--do--		0.5		--do--	
28A	2.5 Mi. SE of Bakersville	E. Wilson					--do--		2.0		Flat	
29A	2.1 Mi. SW of Bakersville	B. Hoilman					--do--		1.0		Slope	
30A	3.2 Mi. SW of Bakersville	P. Hoilman					--do--		0.5		--do--	
31A	0.7 Mi. N of Bandanna	J. A. Buchanon					--do--		1.5		--do--	
32A	3.0 Mi. SW of Bakersville	C. Thomas					--do--		1.5		--do--	
33A	3.5 Mi. S of Bakersville	H. Buchanon					--do--		1.0		--do--	
34A	1.2 Mi. NW of Ledger	W. Ellis					Mica gneiss		1.5		--do--	
35A	2.0 Mi. W of Ledger	T. Keener					Mica schist		1.0		--do--	
36A	Bandanna	W. Robenson					Amphibolite gneiss		1.0		Draw	
37A	1.0 Mi. S of Bandanna	G. B. Howell					--do--		1.5		Slope	
38A	0.8 Mi. W of Ledger	H. Wilson					--do--		1.0		--do--	
39A	0.4 Mi. E of Ledger	A. W. Willis					--do--		0.5		Flat	
40A	1.6 Mi. E of Ledger	C. Norman					--do--		4.0		Slope	
41A	1.8 Mi. SE of Ledger	R. Burleson					--do--		2.4		--do--	Observation spring

42A	0.5 Mi. SW of Ledger	D. E. King	Mica schist	0.8	—do—	
43A	1.0 Mi. N of Kona	A. D. Sparks	Amphibolite gneiss	2.0	Draw	
44A	0.8 Mi. NE of Kona	W. Young	—do—	0.5	Flat	
45A	1.0 Mi. N of Boonford	F. Jarrett	Mica gneiss	1.0	Slope	
46A	0.3 Mi. N of Boonford	A. B. Young	Amphibolite gneiss	1.0	Flat	
47A	0.6 Mi. E of Boonford	C. Boone	—do—	1.0	Draw	
48A	1.8 Mi. NE of Boonford	P. Fortner	—do—	1.0	Slope	
49A	1.4 Mi. NE of Boonford	C. A. Hensley	Mica gneiss	1.5	—do—	
50A	1.4 Mi. SW of Ledger	C. R. Phillips	Amphibolite gneiss	2.0	—do—	
51A	2.0 Mi. E of Spruce Pine	B. Young	Mica gneiss	2.0	—do—	
52A	3.8 Mi. E of Spruce Pine	F. Hall	—do—	3.0	—do—	
53A	3.0 Mi. E of Spruce Pine	J. Phillips	Mica gneiss	3.0	—do—	
54A	2.4 Mi. E of Spruce Pine	J. Freeman	—do—	1.0	—do—	
55A	3.1 Mi. W of Spruce Pine	I. S. McKinney	—do—	1.6	—do—	Observation spring
56A	3.4 Mi. W of Spruce Pine	R. Sparks	—do—	1.0	Draw	
57A	5.1 Mi. W of Spruce Pine	L. Byrd	—do—	1.0	Slope	
58A	3.0 Mi. SW of Spruce Pine	Swiss Pine Lake Community	—do—	60.0	Draw	
59A	2.0 Mi. SW of Spruce Pine	R. O. Wilson	Amphibolite gneiss	0.5	Slope	
60A	2.8 Mi. SE of Spruce Pine	E. Cline	Mica gneiss	3.0	Draw	
61A	3.7 Mi. SE of Spruce Pine	D. Allen	Amphibolite gneiss	4.0	—do—	
62A	3.3 Mi. SE of Spruce Pine	F. Hefner	—do—	3.5	—do—	
63A	2.6 Mi. NE of Gillespie Gap	G. McKinney	—do—	3.0	Flat	
64A	4.1 Mi. NW of Gillespie Gap	S. Hammitt	—do—	2.0	—do—	
65A	3.9 Mi. NW of Gillespie Gap	S. V. Hollifield	—do—	3.5	Draw	
66A	2.5 Mi. NE of Gillespie Gap	Blue Ridge Parkway	Mica gneiss	2.7	Slope	Observation spring
67A	1.5 Mi. NW of Gillespie Gap	D. Sheppard	Amphibolite gneiss	2.0	Draw	
68A	4.0 Mi. NW of Gillespie Gap	C. Dale	—do—	2.0	Slope	
69A	3.7 Mi. NW of Gillespie Gap	P. Hollifield	—do—	6.0	Draw	

TABLE 20.- CHEMICAL ANALYSES OF GROUND WATER FROM MITCHELL COUNTY

Chemical analyses, in parts per million

Number	Rock type	Water type	Source and depth (ft.)	Date of collection	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids: Residue at 180°C	Dissolved solids: Calculated	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH	Color
	1/	2/	3/																							
4	lgn	I	Du- 13	Mar. 20, 1962.	18	0.0	0.03	0.00	4.2	1.9	2.4	0.4	0.0	25	0.2	0.5	0.1	1.2	0.0	43	41	18	0	53	6.4	
7	amgn	I	Dr-401	Aug. 12, 1958.	25	.0	--	--	18	3.7	6.1	2.2	.0	52	26	3.0	.1	.0	.0	112	110	59	17	150	7.6	5
2A	lgn	IV	S	Mar. 20, 1962.	14	.0	.01	.00	1.6	.6	2.2	.6	.0	14	.2	1.0	.0	.0	.2	26	27	6	0	25	6.3	
4A	amgn	V	S	Mar. 20.......	7.3	.0	.00	.01	1.0	.6	.8	.1	.0	7	.8	.2	.0	.2	.0	12	14	5	0	16	5.9	
12A	amgn	V	S	Mar. 20.......	25	.1	.10	.01	7.1	4.1	3.7	.7	.0	36	8.2	1.6	.1	2.5	.0	71	71	35	6	96	6.5	
19A	lgn	V	S	Mar. 20.......	11	.0	.01	.01	4.5	2.8	1.7	.6	.0	19	.8	3.1	.1	8.2	.0	43	42	22	8	63	6.2	
22A	amgn	V	S	Mar. 20.......	15	.0	.04	.01	1.8	1.2	1.6	1.0	.0	16	.2	.6	.0	.2	.0	28	30	10	0	32	6.2	
41A	amgn	V	S	Mar. 20.......	14	.0	.01	.00	2.2	2.2	1.6	.5	.0	14	.2	3.1	.0	3.3	.0	33	34	14	3	45	6.3	
55A	mgn	V	S	Mar. 20.......	16	.0	.01	.01	2.8	2.3	2.4	.8	.1	19	.2	3.5	.0	3.4	.0	45	40	16	1	53	6.1	
66A	mgn	D	S	Mar. 20.......	8.7	.0	.01	.00	.8	.2	1.2	.5	.0	7	.2	.5	.0	.1	.0	17	15	3	0	14	6.3	

1/ Rock Type

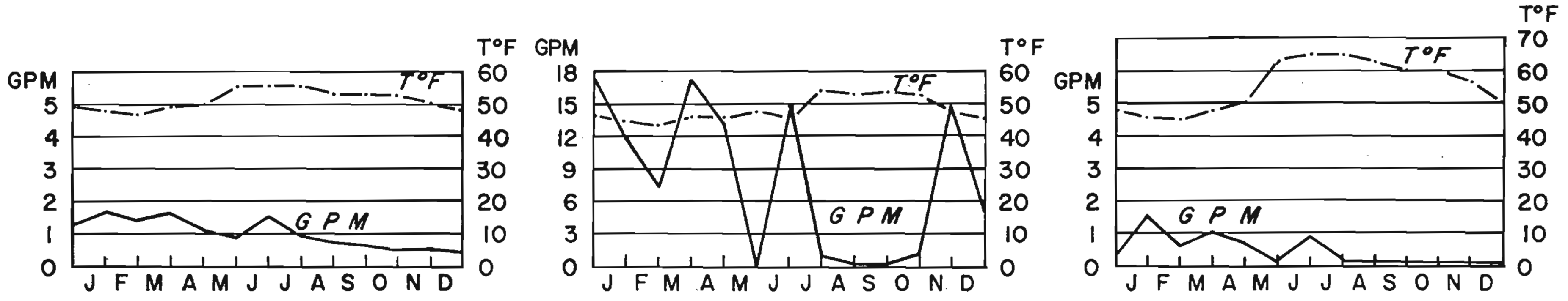
qm - quartz-monzonite gneiss
msh - sillimanite-mica schist
gr - granitic gneiss
mgn - quartz-biotite gneiss
lgn - layered gneiss
amgn - amphibolite gneiss
augn - augen gneiss
Begn - Beech Granite
arph - argillite and phyllite
akp - arkosic and pyroclastic rocks
qsh - schistose quartzitic rocks
qtz - quartzite

2/ Water Type

I - calcium, magnesium, sodium bicarbonate
II - calcium, sodium, magnesium bicarbonate
III - calcium-sodium, magnesium bicarbonate
IV - sodium, calcium, magnesium bicarbonate
V - magnesium, calcium, sodium bicarbonate
D - dissolved solids too low to reflect effects of lithology upon water composition
C - excessive chloride and/or nitrate masks effects of lithology upon water composition

3/ Source

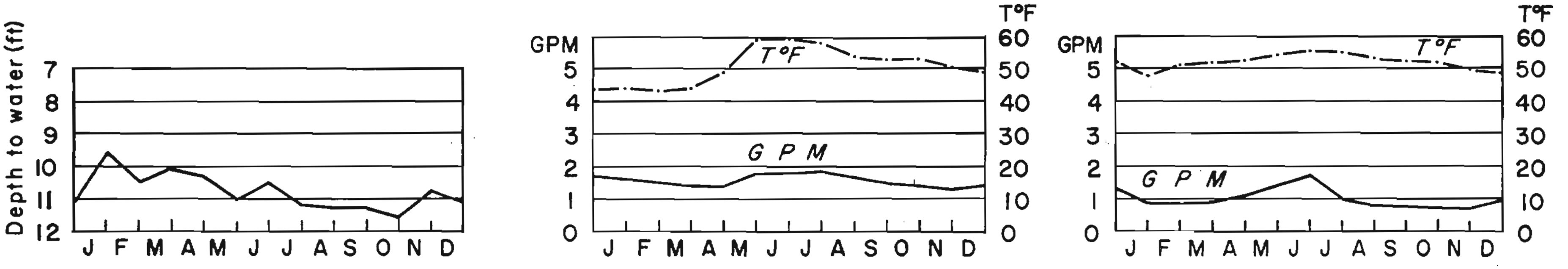
S - spring
Dr - drilled well
Du - dug well



2A, 1.9 mi. NW of Buladean

4A, 5.6 mi. NE of Glen Ayre

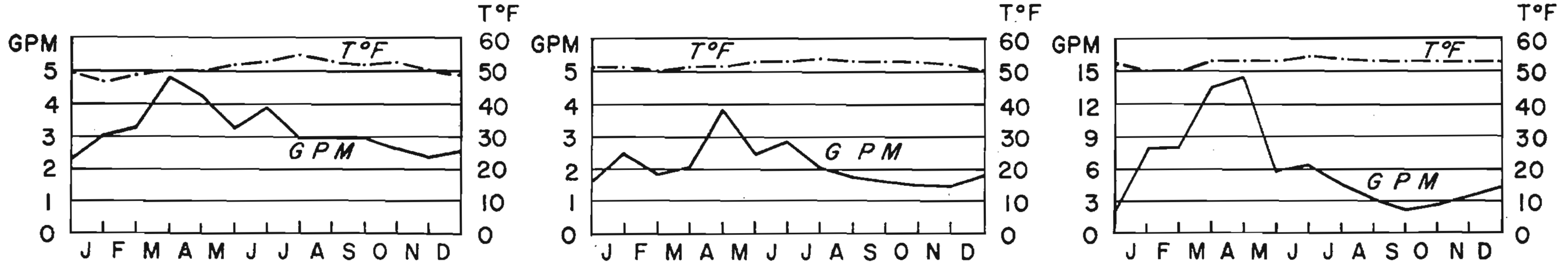
12 A, 0.6 mi. SW of Red Hill



4, 1.4 mi. NE of Honeycutt

19A, Glen Ayre

22A, 0.6 mi. S of Clarissa



41A, 1.8 mi SE of Ledger

55A, 3.1 mi. W of Spruce Pine

66A, 2.5 mi. NE of Gillespie Gap

Figure 25. Mitchell County observation spring and well hydrographs, 1962.

Watauga County

(Area, 320 square miles; 1960 population, 17,529)

Watauga County, in the Blue Ridge physiographic province, occupies the northeast portion of the area of investigation (fig. 1). The county is bounded on the northwest by Tennessee. Topography in Watauga County is varied, rising from moderately broad valleys and subdued hills to highly dissected, rugged slopes. Altitudes range from less than 1,500 feet on the eastern boundary to more than 5,900 feet above sea level on Grandfather Mountain at the southwest corner of Watauga County. Western Watauga County is drained by the northwest-coursing Watauga River, the central part of the county is drained by the northeast-coursing New River, and the eastern portion of the county is drained by southeast-coursing tributaries of the Yadkin River. Angularity of the stream courses suggests their geologically subsequent development coincident to joint and shear systems.

The largest towns in Watauga County are Boone, the county seat, and Blowing Rock. Watauga County economy is agricultural; over 60 percent of the area is farmland. The eastern part of the county is traversed by the Blue Ridge Parkway.

Of the many metamorphic rock types in Watauga County, layered gneiss and amphibolite gneiss predominate (pl. 2). Other rock types range compositionally from mafic volcanics to granitic gneiss. Structural trends of the rocks are varied, but generally are oriented northeastward. The residual saprolite mantle is present in areas of more subdued relief, and deposits of gravel are sought for road metal in some of the wider stream valleys.

Municipal water supplies of Boone are derived from surface runoff, and these are supplemented by ground water during the summer. Blowing Rock water supplies originate as watershed runoff. Drilled wells supply water to many farms and outlying residences. Most of the drilled wells in Watauga County are less than 200 feet deep. Of 56 such wells the average depth is 103 feet and the average yield is 17.5 gallons per minute. Drilled wells having the highest yield are located in: low, flat areas; relatively narrow, linear valleys; or draws. Springs provide water for domestic use throughout most of the county for farms and outlying residences, hence dug and bored wells are scarce.

Analyses of ground water from Watauga County are shown in table 23. Water from wells 30 and 51 had iron concentrations above 0.3 ppm. High chloride and/or nitrate occurred in water from wells 5, 30, 92, and springs 1A, 2A, and 7A.

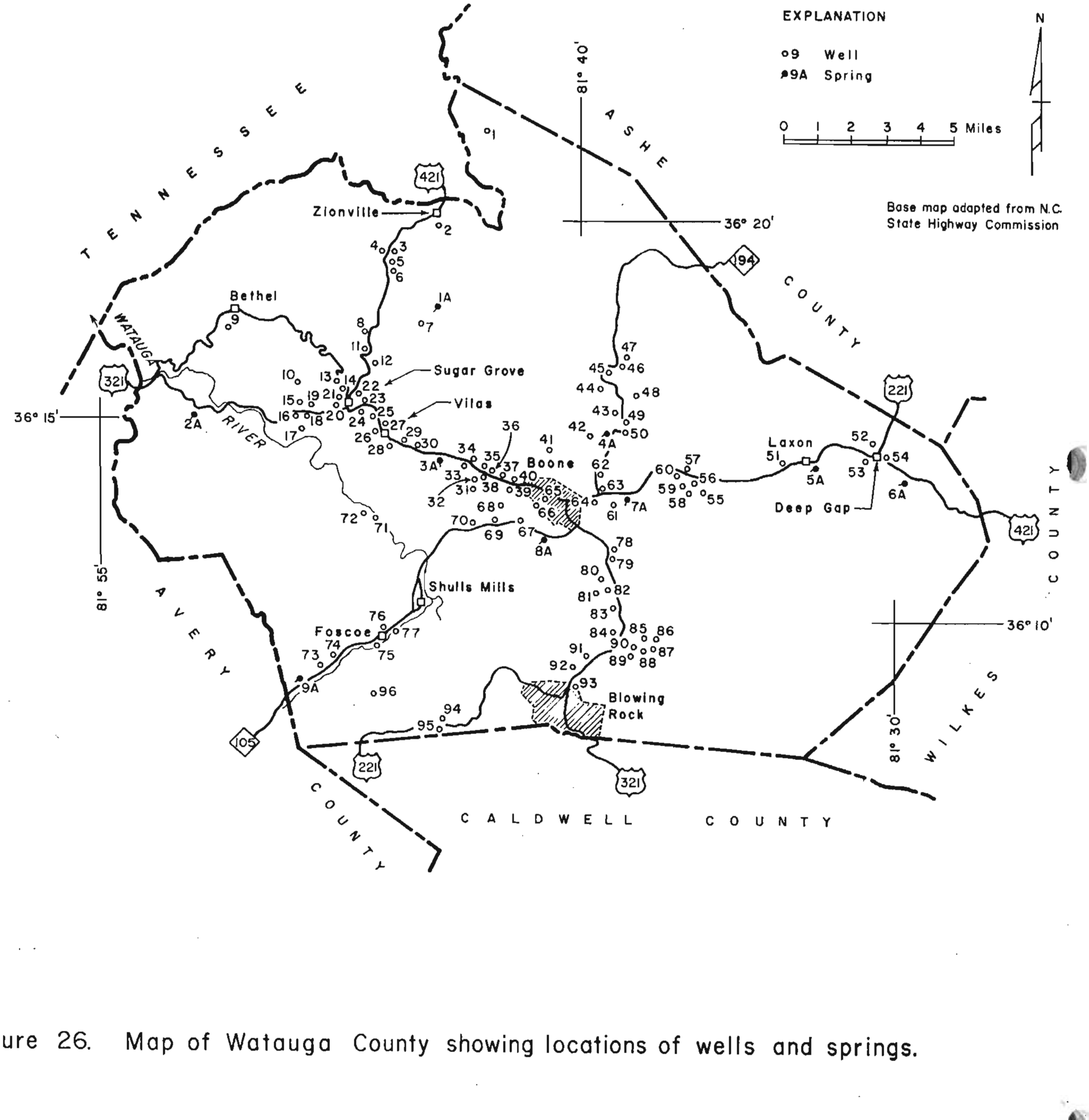


Figure 26. Map of Watauga County showing locations of wells and springs.

TABLE 21. RECORDS OF WELLS IN WATAUGA COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Draw-down (ft)	Topography	Remarks
1	3.4 Mi. NE of Zionville	T. Snyder	Drilled	80	6	—	Layered gneiss	6	—	—	Draw	
2	Zionville	E. Wilson	—do—	139	6	64	—do—	13	35.0	—	—do—	
3	1.6 Mi. SW of Zionville	M. L. Warren	—do—	471	5	50	—do—	55	—	—	Slope	
4	Mabel	S. Dishman	—do—	70	6	30	—do—	—	20.0	—	—do—	
5	—do—	Mabel School	—do—	200	6	—	—do—	15	25.0	—	Flat	
6	0.2 Mi. S of Mabel	O. Yonce	—do—	45	6	44	Alluvium	—	15.0	—	—do—	
7	Silverstone	W. Greer	—do—	107	6	55	Amphibolite gneiss	—	10.0	—	Slope	
8	Mast	J. B. Mast	—do—	96	6	15	Layered gneiss	14	—	—	Flat	
9	Bethel	Bethel School	—do—	175	6	—	—do—	30	30.0	—	—do—	
10	2.5 Mi. NW of Sugar Grove	L. Isics	—do—	132	6	55	—do—	—	15.0	—	—do—	
11	Amantha	J. C. Mast	—do—	90	6	24	—do—	15	19.0	35 ft. in 20 min. @ 19 gpm	—do—	
12	0.4 Mi. N of Sherwood	R. Henson	—do—	73	4	—	—do—	50	—	—	Slope	
13	1.0 Mi. N of Sugar Grove	W. Eller	—do—	48	6	8	—do—	—	7.0	—	Flat	
14	0.8 Mi. N of Sugar Grove	J. W. Mast	—do—	42	6	20	—do—	—	20.0	—	—do—	
15	1.5 Mi. W of Sugar Grove	T. Moody	—do—	102	6	—	—do—	—	10.0	—	—do—	
16	1.7 Mi. W of Sugar Grove	O. Henson	—do—	47	6	30	—do—	—	20.0	—	—do—	
17	1.8 Mi. SW of Sugar Grove	W. Moody	—do—	81	6	42	—do—	—	20.0	—	—do—	
18	1.0 Mi. W of Sugar Grove	W. Pane	—do—	145	6	40	—do—	—	15.0	—	—do—	
19	1.1 Mi. W of Sugar Grove	R. Hayes	—do—	65	6	25	—do—	—	13.0	—	—do—	
20	Sugar Grove	A. M. Mast	—do—	82	6	12	—do—	18	12.0	—	—do—	
21	0.5 Mi. N of Sugar Grove	Cove Creek High School	—do—	180	6	—	—do—	30	12.0	—	—do—	
22	0.8 Mi. N of Sugar Grove	L. J. Mast	—do—	85	6	18	—do—	17	—	—	—do—	
23	0.4 Mi. E of Sugar Grove	C. Glenn	—do—	72	6	12	—do—	12	12.0	—	—do—	
24	0.4 Mi. E of Sugar Grove	W. G. Sherwood	—do—	73	6	12	—do—	35	9.0	—	—do—	
25	0.6 Mi. E of Sugar Grove	C. A. Clay	Dug	15	10	15	Saprolite	11	—	—	Slope	
26	0.2 Mi. W of Vilas	I. Fox	Drilled	70	6	20	Layered gneiss	—	20.0	—	—do—	
27	0.3 Mi. NW of Vilas	E. Sherwood	—do—	119	6	54	—do—	—	15.0	—	Flat	
28	0.4 Mi. E of Vilas	W. R. Hodges	—do—	52	6	22	—do—	14	12.0	—	—do—	
29	0.6 Mi. E of Vilas	R. A. Farthing	—do—	20	6	20	Alluvium	6	7.0	—	—do—	
30	1.0 Mi. W of Lovill	W. H. Walker	—do—	84	6	—	Layered gneiss	3	15.0	—	—do—	
31	2.4 Mi. SW of Boone	W. McGinnis	—do—	64	6	—	—do—	28	18.0	—	Slope	
32	2.1 Mi. SW of Boone	B. Pennel	—do—	100	6	—	—do—	35	6.0	—	—do—	
33	1.9 Mi. W of Boone	D. Hinson	—do—	45	6	30	—do—	—	10.0	—	—do—	
34	2.1 Mi. W of Boone	C. Earp	—do—	92	6	80	—do—	—	15.0	—	—do—	
35	1.8 Mi. NW of Boone	D. Hampton	—do—	95	6	44	—do—	—	30.0	—	Draw	
36	1.6 Mi. NW of Boone	L. Presnell	—do—	105	5	57	—do—	30	8.0	60 ft. in 2 hrs. @ 8 gpm	Slope	
37	1.0 Mi. NW of Boone	J. D. Miller	—do—	65	6	35	—do—	—	30.0	—	Draw	
38	1.7 Mi. NW of Boone	County Health Center	—do—	215	6	75	—do—	—	30.0	—	Slope	
39	0.6 Mi. NW of Boone	T. Miller	—do—	198	6	35	—do—	—	10.0	—	—do—	
40	0.4 Mi. NW of Boone	R. Wilson	—do—	117	6	80	—do—	—	30.0	—	Draw	
41	1.5 Mi. N of Boone	G. Kirsten	—do—	117	5	38	Amphibolite gneiss	30	—	—	Flat	Hard water

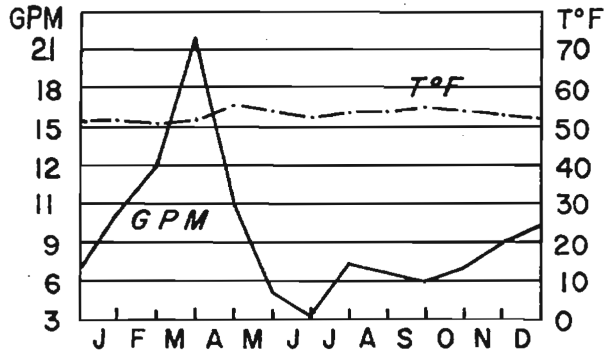
TABLE 21. RECORDS OF WELLS IN WATAUGA COUNTY (Continued)

Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Draw-down (ft)	Topography	Remarks
42	2.1 Mi. N of Perkinsville	J. Miller	Drilled	99	5	26	Amphibolite gneiss	19	2.5	—	Slope	
43	3.0 Mi. N of Perkinsville	W. A. Allen	—do—	121	6	43	—do—	—	—	—	—	
44	3.5 Mi. N of Perkinsville	J. F. Green	—do—	151	6	—	—do—	30	—	—	Flat	
45	4.0 Mi. N of Perkinsville	H. Foster	—do—	154	6	90	—do—	—	20.0	—	—do—	
46	4.5 Mi. N of Perkinsville	R. Jones	—do—	28	6	20	—do—	—	20.0	—	—do—	
47	4.8 Mi. N of Perkinsville	Green Valley School	—do—	160	6	—	—do—	35	15.0	—	—do—	
48	3.5 Mi. N of Perkinsville	R. Shull	—do—	479	6	58	—do—	—	3.0	—	Hilltop	
49	2.5 Mi. N of Perkinsville	R. Brown	—do—	82	6	54	—do—	—	10.0	—	Slope	
50	2.3 Mi. N of Perkinsville	R. Jones	—do—	35	6	30	—do—	15	—	—	—do—	
51	0.7 Mi. W of Laxon	Parkway School	—do—	400	6	—	Mica gneiss	100	4.0	—	Hilltop	
52	Deep Gap	W. S. Moretz	—do—	64	6	12	—do—	8	—	—	Flat	
53	Deep Gap	F. L. Wilcox	—do—	155	6	37	—do—	18	—	—	—do—	
54	—do—	F. K. Smith	—do—	50	6	30	—do—	—	7.0	—	—do—	
55	0.4 Mi. W of Rutherwood	D. L. Stansbury	—do—	125	5	41	Layered gneiss	6	4.5	125 ft. in 3 hrs. @ 4.5 gpm	Draw	
56	0.5 Mi. NW of Rutherwood	—do—	—do—	145	5	46	—do—	—	5.0	—	Slope	
57	1.5 Mi. NW of Rutherwood	T. W. Phillips	—do—	185	6	—	Mica gneiss	40	—	—	—do—	
58	1.0 Mi. SW of Rutherwood	D. L. Stansbury	—do—	385	5	43	Layered gneiss	—	5.0	—	—do—	
59	1.0 Mi. W of Rutherwood	—do—	—do—	205	5	12	—do—	—	7.0	—	Flat	
60	1.3 Mi. W of Rutherwood	C. W. Hoke	—do—	28	12	28	Saprolite	4	—	—	—do—	
61	Perkinsville	H. H. Hartley	—do—	261	6	90	Layered gneiss	—	20.0	—	Slope	
62	0.5 Mi. N of Perkinsville	H. Hollars	—do—	82	6	46	Amphibolite gneiss	—	20.0	—	—do—	
63	Perkinsville	L. Carroll	—do—	28	6	20	—do—	—	40.0	—	Draw	
64	—do—	S. Wilcox	—do—	80	6	25	Layered gneiss	—	5.0	—	Slope	
65	Boone	Bus Terminal	—do—	350	8	62	—do—	—	140.0	—	Flat	
66	—do—	IRC Plant	—do—	450	6	42	—do—	—	100.0	—	—do—	
67	1.5 Mi. SW of Boone	E. H. Kiziah	—do—	122	6	100	—do—	10	100.0	—	Draw	
68	1.6 Mi. W of Boone	C. Brown	—do—	103	6	20	—do—	—	20.0	—	Flat	
69	1.7 Mi. SW of Boone	M. A. Waddell	—do—	120	6	—	—do—	6	—	—	Slope	
70	2.6 Mi. SW of Boone	Mountain Brook Motel, Inc.	—do—	187	6	100	—do—	10	60.0	—	Draw-Slope	
71	Valle Crucis	J. Hyrd	—do—	51	5	23	—do—	4	—	—	Flat	
72	—do—	Valle Crucis School	—do—	155	6	—	—do—	12	35.0	—	—do—	
73	2.1 Mi. SW of Foscoe	Church	—do—	205	5	186	Argillite	60	7.0	125 ft. in 4 hrs. @ 7 gpm	Slope	
74	1.6 Mi. SW of Foscoe	S. Aldridge	—do—	174	6	—	—do—	20	—	—	—do—	
75	Foscoe	V. Shook	Dug	25	24	—	Alluvium	19	—	—	Flat	
76	—do—	W. Bowers	Drilled	104	6	100	Argillite	—	20.0	—	Slope	
77	—do—	A. C. Calloway	—do—	110	6	73	—do—	8	—	—	Flat	
78	1.2 Mi. SE of Boone	R. L. Greene	—do—	125	5	22	Volcanics and arkose	20	17.0	50 ft. in 4 hrs. @ 17 gpm	—do—	

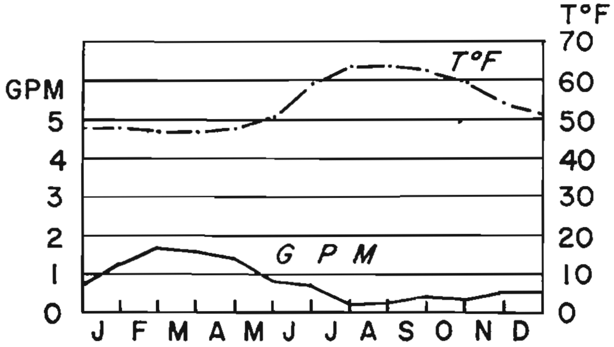
79	1.3 Mi. SE of Boone	—do—	—do—	305	5	18	—do—	—	10.0	—	—do—	
80	2.0 Mi. SE of Boone	W. L. Ballard	—do—	85	5	27	—do—	16	—	—	Draw	
81	2.4 Mi. S of Boone	P. Winkler	—do—	136	6	100	—do—	—	30.0	—	Flat	
82	2.2 Mi. S of Boone	R. B. Keller	—do—	219	5	144	Augen gneiss	38	—	—	Slope	
83	3.5 Mi. N of Blowing Rock	Texaco Co.	—do—	86	6	40	—do—	12	25.0	—	Flat	
84	2.7 Mi. N of Blowing Rock	Tweetsie R. R.	—do—	237	5	15	—do—	50	11.0	180 ft. in 8 hrs @ 11 gpm	Slope	
85	3.0 Mi. SW of Boone	Demette Realty Co.	—do—	465	5	11	—do—	125	2.0	200 ft. in 4 hrs. @ 2 gpm	—do—	
86	3.2 Mi. SW of Boone	Demette Realty Co.	—do—	165	5	9	—do—	100	15.0	150 ft. in 3 hrs. @ 15 gpm	Draw	
87	3.4 Mi. SW of Boone	—do—	—do—	245	5	16	—do—	60	11.0	200 ft. in 4 hrs. @ 11 gpm	—do—	
88	3.6 Mi. SW of Boone	—do—	—do—	285	5	23	—do—	70	2.5	100 ft. in 3 hrs. @ 2.5 gpm	Slope	
89	3.8 Mi. SW of Boone	—do—	—do—	185	5	14	—do—	60	10.0	150 ft. in 5 hrs. @ 10 gpm	Flat	
90	3.0 Mi. SW of Boone	—do—	—do—	225	5	14	—do—	65	5.0	215 ft. in 3 hrs. @ 5 gpm	Draw	
91	0.8 Mi. N of Blowing Rock	C. Hollifield	—do—	65	8	65	—do—	—	10.0	—	Flat	
92	0.6 Mi. N of Blowing Rock	R. Colvard	—do—	172	6	100	—do—	20	35.0	—	Draw-Slope-	
93	Blowing Rock	E. C. Coker	—do—	70	6	47	—do—	—	20.0	—	Flat	
94	5.0 Mi. W of Blowing Rock	H. V. Davenport	—do—	153	6	45	Volcanics and arkose	73	20.0	100 ft. in 1 hr. @ 20 gpm	Slope	Hard water
95	5.2 Mi. W of Blowing Rock	G. Robbins	—do—	425	6	10	—do—	—	8.0	—	Slope	
96	1.8 Mi. S of Foscoe	D. A. Drexel	—do—	183	6	110	—do—	85	—	—	—do—	

TABLE 22. RECORDS OF SPRINGS IN WATAUGA COUNTY

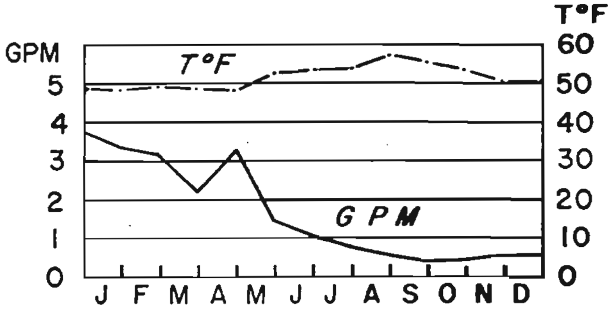
Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
1A	3.5 Mi. N of Vilas	R. Greene					Amphibolite gneiss		4.3		Slope	Observation spring
2A	5.7 Mi. W of Sugar Grove	M. Trivett					Beech Granite gneiss		0.8		—do—	—do—
3A	2.5 Mi. W of Boone	J. Crump					Layered gneiss		3.6		—do—	—do—
4A	1.9 Mi. N of Perkinsville	N. C. State Highway Dept.					Amphibolite gneiss		0.4		—do—	—do—
5A	0.3 Mi. E of Laxon	Z. Ticknor					Mica gneiss		2.6		Draw	—do—
6A	1.0 Mi. E of Deep Gap	O. O. Watson					Monzonite gneiss		3.0		—do—	—do—
7A	1.0 Mi. E of Perkinsville	R. W. Moretz					Layered gneiss		3.2		—do—	—do—
8A	1.5 Mi. SW of Boone	G. Winkler					—do—		30.0		Slope	—do—
9A	2.8 Mi. SW of Foscoe	A. Shook					Arkose		5.2		Draw	—do—



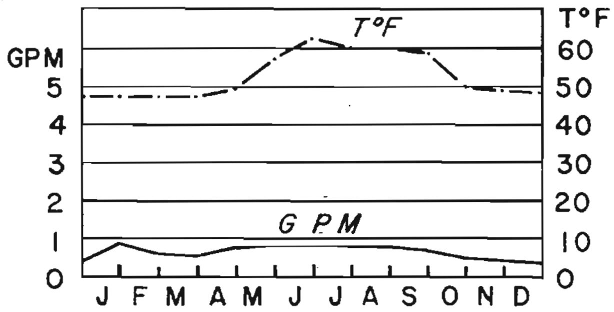
1A, 3.5 mi. N of Vilas



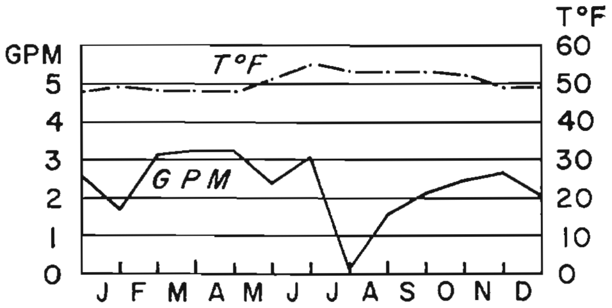
2A, 5.7 mi. W of Sugar Grove



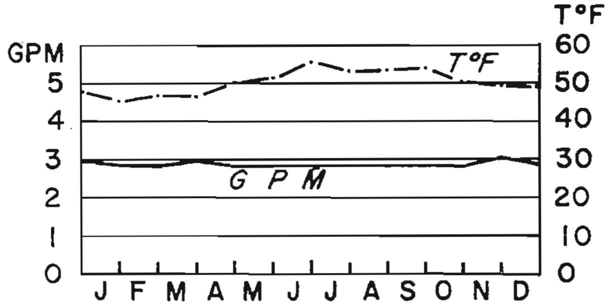
3A, 2.5 mi. W of Boone



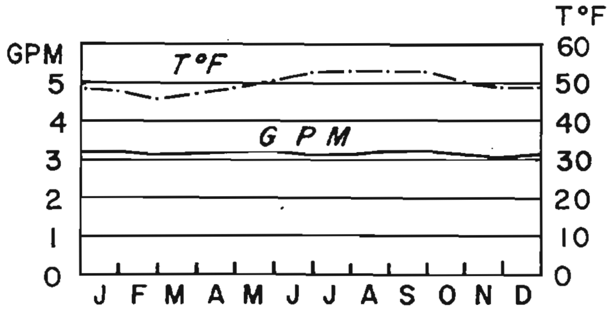
4A, 1.9 mi. N of Perkinsville



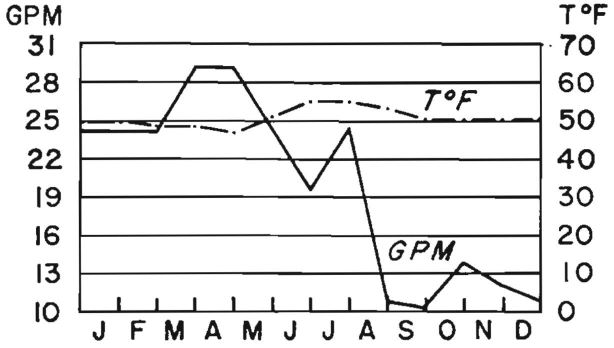
5A, 0.3 mi. E of Laxon



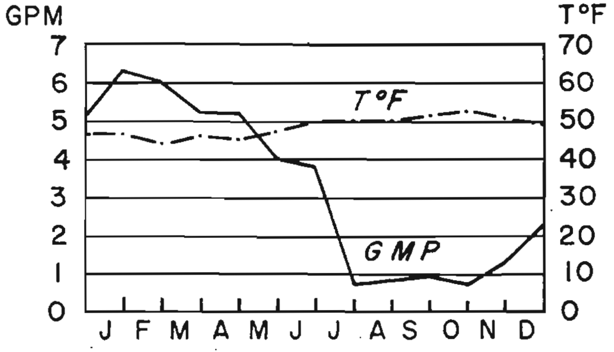
6A, 1.0 mi. E of Deep Gap



7A, 1.0 mi. E of Perkinsville



8A, 1.5 mi. SW of Boone



9A, 2.8 mi. SW of Foscoe

Figure 27. Watauga County observation spring hydrographs, 1962.

TABLE 23.- CHEMICAL ANALYSES OF GROUND WATER FROM WATAUGA COUNTY

Chemical analyses, in parts per million

Number	Rock type 1/	Water type 2/	Source and depth (ft.) 3/	Date of collection	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids		Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH	Color
																				Residue at 180°C	Calculated	Calcium, Magnesium	Non-carbonate			
5	lgn	III	Dr-200	Jan. 11, 1963.	17	--	0.04	--	13	1.9	12	2.7	--	68	3.6	3.9	1.2	0.4	--	--	89	39	0	130	7.5	--
30	lgn	I	Dr- 84	Jan. 11.......	17	--	.32	--	9.6	5.0	3.4	2.9	--	40	2.8	6.3	.2	10	--	--	78	44	12	113	6.5	--
51	mgn	I	Dr-400	Jan. 11.......	10	--	.49	--	5.0	2.1	2.6	1.3	--	30	1.8	1.5	.1	.0	--	--	39	21	0	59	6.3	--
66	lgn	I	Dr-450	Apr. 15, 1959.	16	0.0	.06	0.04	3.8	1.8	2.8	.6	0.0	28	1.7	1.0	.1	.8	0.0	40	43	17	0	46	6.6	15
92	augn	III	Dr-172	Jan. 11, 1963.	10	--	.06	--	3.6	.9	2.5	.6	--	18	.2	1.9	.1	2.3	--	--	31	13	0	39	6.3	--
1A	amgn	V	S	Mar. 19, 1962.	17	.0	.06	.00	5.0	3.1	3.0	.8	.0	20	.2	4.4	.0	11	.8	55	55	26	10	77	7.0	--
2A	Begn	C	S	Mar. 19.......	13	.0	.00	.00	4.4	1.7	2.8	1.0	.0	8	.2	3.8	.0	14	.2	46	45	18	12	65	6.5	--
3A	lgn	I	S	Jan. 17.......	10	.0	.01	--	2.6	1.0	1.8	.8	.1	10	3.2	.6	.1	3.7	.0	--	29	10	2	33	6.2	5
4A	amgn	IV	S	Jan. 17.......	19	.1	.02	--	2.9	.6	3.6	1.1	.0	21	.2	1.1	.0	.3	.1	--	39	10	0	38	6.1	5
5A	mgn	D	S	Jan. 17.......	8.1	.0	.01	--	1.1	.7	1.3	.6	.0	12	.2	.3	.0	.2	.0	--	19	6	0	17	5.9	0
6A	qm	IV	S	Jan. 17.......	11	.0	.02	--	1.0	.2	1.8	.5	.0	8	.2	.6	.0	.4	.0	--	20	4	0	16	6.4	0
7A	lgn	I	S	Jan. 17.......	16	.0	.01	--	3.8	1.8	2.2	.7	.0	20	.4	1.8	.1	1.7	.0	--	39	17	0	43	6.5	0
8A	lgn	V	S	Jan. 17.......	9.2	.0	.04	--	1.6	1.1	1.6	.2	.1	14	.2	.5	.0	.1	.1	--	22	8	0	21	6.4	0

1/ Rock Type

qm - quartz-monzonite gneiss
msh - sillimanite-mica schist
gr - granitic gneiss
mgn - quartz-biotite gneiss
lgn - layered gneiss
amgn - amphibolite gneiss

augn - augen gneiss
Begn - Beech Granite
arph - argillite and phyllite
akp - arkosic and pyroclastic rocks
qsh - schistose quartzitic rocks
qtz - quartzite

2/ Water Type

I - calcium, magnesium, sodium bicarbonate
II - calcium, sodium, magnesium bicarbonate
III - calcium-sodium, magnesium bicarbonate
IV - sodium, calcium, magnesium bicarbonate
V - magnesium, calcium, sodium bicarbonate
D - dissolved solids too low to reflect effects of lithology upon water composition
C - excessive chloride and/or nitrate masks effects of lithology upon water composition

3/ Source

S - spring
Dr - drilled well
Du - dug well

Yancey County

(Area, 311 square miles; 1960 population, 14,008)

Yancey County lies in the western part of the area of investigation, and is situated wholly within the Blue Ridge physiographic province. The county adjoins Tennessee on the northwest (fig. 1). Topographic relief is varied, rising from moderately wide valleys and subdued hills to rugged, highly dissected slopes. Altitudes range from less than 1,700 feet, where the Nolichucky River enters Tennessee at the northern end of the county, to 6,684 feet above mean sea level on Mt. Mitchell, the highest ground in the eastern United States. Yancey County lies within the Nolichucky River drainage basin, the river forming much of the county's northeastern boundary. The angular character of streams and drainage courses in Yancey County suggests their geologically subsequent origin upon joint and shear systems.

The largest town in Yancey County is Burnsville, the county seat. Agriculture dominates the economy, as nearly 51 percent of the county area is farmland. Forest products supplement agriculture. Mining of mica and feldspar is carried out on a small scale. Manufacturing is localized in and near Burnsville.

Mica gneiss, layered gneiss, and amphibolite gneiss are the predominant rock types of a heterogeneous metamorphic assemblage. Diabase dikes and sills occur in the east-central part of Yancey; they are related to the gabbro stock in central Mitchell County. Structural trends of the rocks are oriented generally north to northeast (pl. 2). A thin residual mantle of saprolite and alluvium is present in some of the topographically subdued areas.

The municipal water supply of Burnsville is provided by watershed impoundment. Springs are common and furnish a convenient source of water for domestic use in outlying areas. Drilled wells are not numerous and most are less than 200 feet deep. Of 18 such wells the average depth is 103 feet and the average yield 25 gallons per minute. Drilled wells having the highest yields are located in: low, flat areas; relatively narrow, linear valleys; and draws. Dug and bored wells are uncommon owing to the thin residual and alluvial mantle overlying bedrock in Yancey County. The average depth of dug and bored wells in Yancey County is 19 feet and the average water-table depth is 11 feet.

Insufficient data preclude statistical representation of yields from dug and bored wells.

Analyses of ground water from Yancey County are shown in table 26. No water from any well or spring sampled contained more than 0.3 ppm iron. Water from 27 contained high chloride and nitrate concentrations.

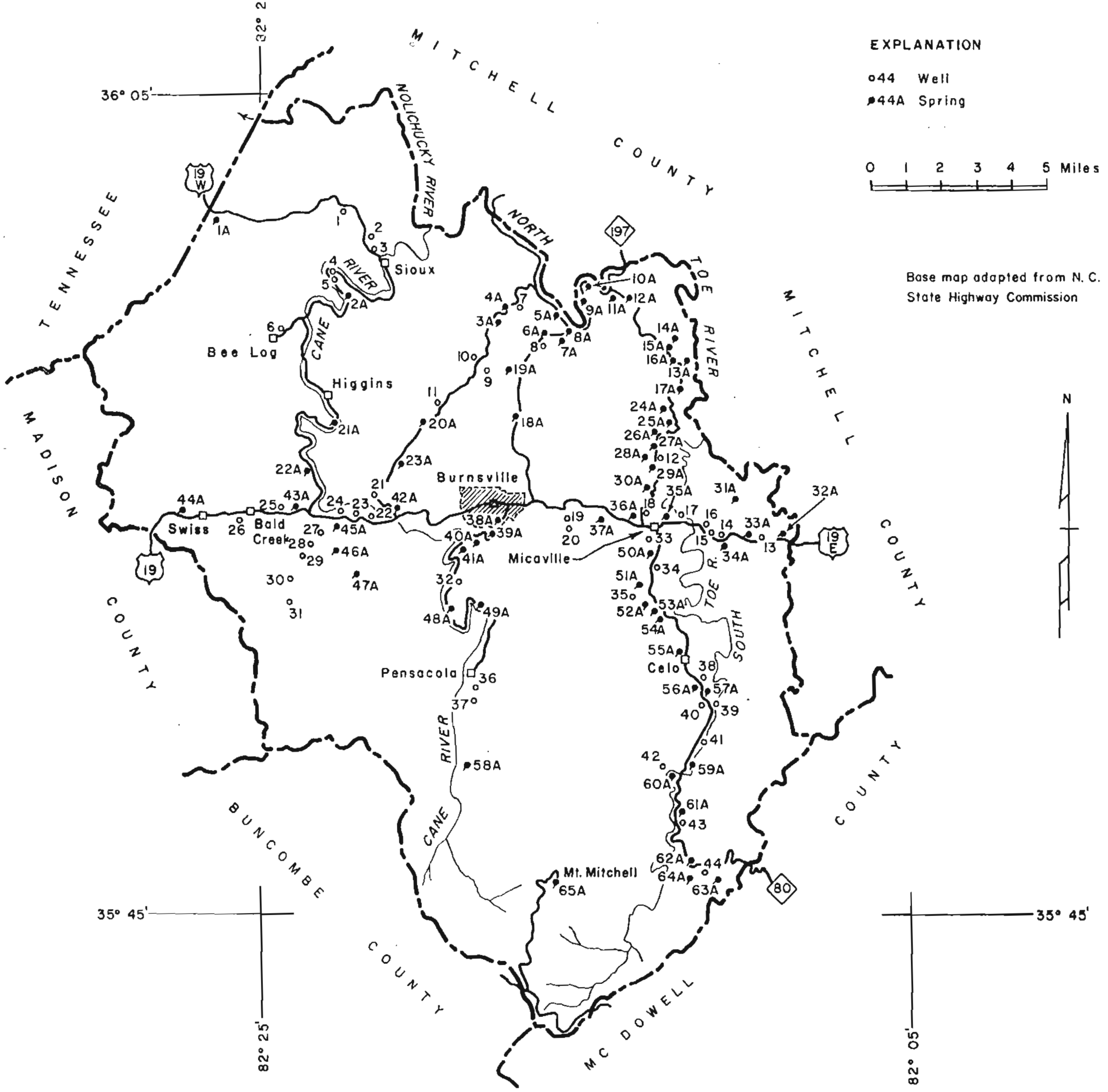


Figure 28. Map of Yancey County showing locations of wells and springs.

TABLE 24. - RECORDS OF WELLS IN YANCEY COUNTY

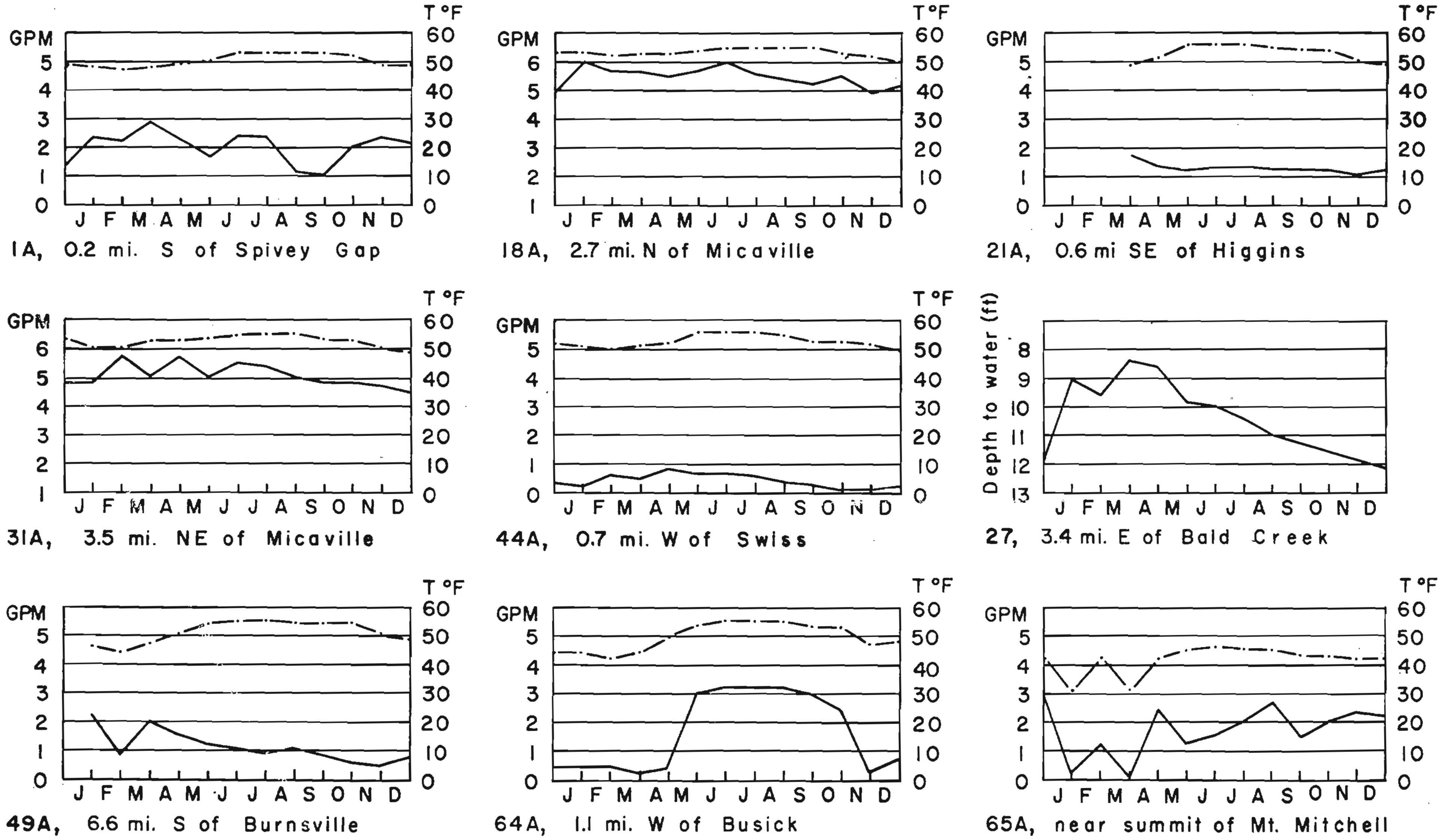
Well No.	Location	Owner	Type of Well	Depth (ft.)	Diameter (in.)	Depth of Casing (ft.)	Water-bearing material	Water level (ft.)	Yield (gpm)	Drawdown (ft.)	Topography	Remarks
1	2.6 mi NW of Sioux-------	------------------	Dug----	10	36	10	Alluvium-----	6	-----	-----	Flat---	
2	1.5 mi NW of Sioux-------	D. Higgins--------	Drilled	71	6	9	Layered gneiss	21	36.0	-----	Draw---	
3	0.6 mi NW of Sioux-------	D. Adkins---------	--do---	113	6	5	--do---------	3	40.0	-----	--do---	
4	1.7 mi NW of Ramsaytown--	W. D. Adkin-------	--do---	82	6	40	--do---------	30	5.0	-----	Slope--	
5	1.9 mi NW of Ramsaytown--	J. B. Hensley-----	--do---	42	6	22	--do---------	20	5.0	-----	--do---	
6	0.5 mi NE of Bee Log-----	B. R. Hensley-----	Dug----	15	36	12	--do---------	3	-----	-----	Flat---	Bedrock @ 12 feet.-
7	1.8 mi NE of Daybook-----	I. Peterson-------	--do---	18	48	6	Alluvium-----	6	-----	-----	--do---	
8	Toledo-------------------	E. B. Bailey------	Drilled	40	5	------	Amphobolite gneiss------	8	-----	-----	--do---	
9	Daybook------------------	Clearmont School--	--do---	83	6	------	--do---------	28	45.0	-----	--do---	
10	0.5 mi W of Daybook------	D. J. Peterson----	Dug----	16	48	------	Alluvium-----	10	-----	-----	--do---	
11	2.3 mi SW of Daybook-----	J. Byrd-----------	Drilled	22	12	------	--do---------	12	-----	-----	--do---	
12	4.1 mi N of Micaville----	H. Jones----------	--do---	39	6	------	Amphibolite gneiss------	33	-----	-----	Slope--	
13	3.7 mi E of Micaville----	J. Woody----------	--do---	76	6	33	--do---------	25	40.0	-----	Draw---	
14	2.3 mi E of Micaville----	W. Wilson---------	--do---	96	6	------	--do---------	3	12.0	-----	Slope--	
15	2.1 mi E of Micaville----	W. Howell---------	--do---	71	6	------	--do---------	8	-----	-----	Flat---	
16	1.6 mi E of Micaville----	B. Robinson-------	--do---	175	8	------	--do---------	22	-----	-----	--do---	
17	1.0 mi E of Micaville----	M. Sparks---------	--do---	96	6	------	--do---------	45	15.0	-----	--do---	
18	0.9 mi N of Micaville----	E. Robinson-------	--do---	122	5	------	--do---------	12	-----	-----	Slope--	
19	2.5 mi E of Burnsville---	East Yancey High School-----------	--do---	197	6	------	Mica gneiss--	75	20.0	-----	Draw---	
20	2.6 mi E of Burnsville---	--do--------------	--do---	150	6	------	--do---------	85	50.0	-----	--do---	
21	3.7 mi W of Burnsville---	R. Hensley--------	Dug----	18	48	------	Saprolite----	6	-----	-----	Slope--	
22	3.8 mi W of Burnsville---	R. Pittman--------	Drilled	78	6	------	Mica gneiss--	4	-----	-----	--do---	
23	4.3 mi W of Burnsville---	J. S. Ledford-----	--do---	92	6	------	Amphibolite gneiss------	17	-----	-----	--do---	
24	2.7 mi E of Bald Creek---	Cane River High School----------	--do---	167	6	------	--do---------	30	20.0	-----	Flat---	
25	1.2 mi E of Bald Creek---	G. Edwards--------	Dug----	13	48	------	Alluvium-----	11	-----	-----	--do---	
26	Bald Creek---------------	Bald Creek School-	Drilled	157	6	------	Amphibolite gneiss------	45	20.0	-----	--do---	
27	3.4 mi E of Bald Creek---	M. Wray-----------	Dug----	17	36	17	Alluvium-----	9	-----	-----	--do---	Observation well---
28	4.0 mi SE of Bald Creek--	R. Edwards--------	Drilled	47	6	------	Amphibolite gneiss------	27	20.0	-----	--do---	
29	4.3 mi SE of Bald Creek--	C. Edwards--------	--do---	92	6	------	--do---------	12	40.0	-----	--do---	
30	5.2 mi SE of Bald Creek--	A. Edwards--------	Dug----	38	36	------	--do---------	13	-----	-----	Slope--	Dug in bedrock-----
31	6.3 mi SE of Bald Creek--	M. Robinson-------	--do---	30	36	------	Alluvium-----	22	-----	-----	Flat---	
32	3.2 mi S of Burnsville---	M. Thompson-------	Drilled	145	8	------	Amphibolite gneiss------	58	12.0	-----	--do---	
33	Micaville----------------	Micaville School--	--do---	87	6	------	--do---------	20	40.0	-----	--do---	Bedrock @ 17 feet.-
34	0.9 mi S of Micaville----	E. Hensley--------	Dug----	20	36	------	Alluvium-----	17	-----	-----	Slope--	
35	2.0 mi S of Micaville----	Bowditch Feldspar Corp.------------	--do---	12	48	------	--do---------	2	-----	-----	Flat---	
36	Pensacola----------------	I. D. Williams----	--do---	12	36	------	--do---------	11	-----	-----	--do---	
37	--do---------------------	Pensacola School--	Drilled	255	6	------	Mica gneiss--	-----	12.0	-----	--do---	Bedrock @ 1.5 feet.
38	0.9 mi S of Celo---------	T. H. Ray---------	Dug----	31	36	------	Saprolite----	23	-----	-----	Slope--	
39	2.0 mi S of Celo---------	Toe River School--	Drilled	250	5	------	Amphibolite gneiss------	100	20.0	-----	Flat---	
40	2.1 mi S of Celo---------	T. G. Gurley------	--do---	60	6	------	--do---------	45	15.0	-----	--do---	
41	3.3 mi S of Celo---------	R. J. Volmer------	--do---	100	6	------	--do---------	12	10.0	-----	--do---	
42	4.6 mi S of Celo---------	D. Robinson-------	--do---	40	6	------	--do---------	37	-----	-----	Slope--	
43	3.4 mi N of Busick-------	J. L. Griffin-----	--do---	40	6	------	Mica gneiss--	20	-----	-----	--do---	
44	Busick-------------------	A. Wilson---------	--do---	450	6	------	--do---------	80	8.0	-----	Hilltop	

TABLE 25. - RECORDS OF SPRINGS IN YANCEY COUNTY

Well No.	Location	Owner	Type of Well	Depth (ft.)	Diameter (in.)	Depth of Casing (ft.)	Water bearing material	Water level (ft.)	Yield (gpm)	Draw-down (ft.)	Topography	Remarks
1A	0.2 mi S of Spivey Gap	U.S. Forest Service					Quartzite		1.4		Slope	Observation spring
2A	2.1 mi NE of Lewisburg	A. Whitson					Layered gneiss		0.7		--do--	
3A	1.3 mi NE of Daybook	J. H. Hunter					Amphibolite gneiss		0.3		--do--	
4A	1.8 mi NE of Daybook	I. Peterson					--do--		4.0		--do--	
5A	Green Mountain	Green Mt. Store					--do--		12.0		--do--	
6A	Toledo	E. B. Bailey					--do--		0.5		Draw	
7A	0.5 mi E of Toledo	C. Deyton					--do--		5.0		--do--	
8A	0.5 mi SE of Green Mt.	L. Peterson					--do--		0.6		--do--	
9A	2.0 mi E of Green Mt.	C. T. Garland					--do--		2.0		--do--	
10A	2.6 mi E of Green Mt.	G. Tipton					--do--		8.0		Slope	
11A	3.2 mi E of Green Mt.	E. Hughes					--do--		0.5		--do--	
12A	4.3 mi NW of Lunday	B. Deyton					--do--		1.4		--do--	
13A	3.2 mi N of Lunday	G. M. Randolph					--do--				--do--	
14A	3.4 mi N of Lunday	I. C. Thomas					--do--		10.0		Draw	
15A	3.2 mi N of Lunday	A. J. Thomas					--do--		12.0		--do--	
16A	2.5 mi N of Lunday	J. M. Randolph					--do--		6.5		--do--	
17A	1.0 mi N of Lunday	A. Thomas					--do--		2.0		Slope	
18A	2.7 mi N of Micaville	E. Edwards					--do--		5.0		Draw	Observation spring
19A	2.5 mi N of Burnsville	D. Harris					Amphib. gneiss		5.0		Slope	
20A	3.0 mi SW of Daybook	N. Wengerd					--do--		4.0		Draw	
21A	0.6 mi SE of Higgins	B. Silver					Layered gneiss		1.7		Slope	Observation spring
22A	4.0 mi S of Higgins	W. Edwards					Amphib. gneiss		4.0		--do--	
23A	4.5 mi SW of Daybook	J. B. Stamey					--do--		0.6		--do--	
24A	Lunday	J. Thomas					--do--		12.0		Draw	
25A	0.6 mi S of Lunday	S. Robinson					--do--		0.2		Slope	
26A	4.9 mi N of Micaville	M. Buchanon					--do--		5.0		Draw	
27A	4.5 mi N of Micaville	R. H. Robinson					--do--		0.6		Slope	
28A	2.7 mi N of Micaville	J. Bisray					--do--		5.0		Draw	
29A	2.5 mi N of Micaville	W. Buchanon					--do--		0.1		Slope	
30A	1.8 mi N of Micaville	M. Anglin					--do--		0.6		--do--	
31A	3.5 mi NE of Micaville	B. R. Yound					Mica gneiss		4.8		Draw	Observation spring
32A	4.4 mi E of Micaville	D. Gurley					Amphib. gneiss		2.5		--do--	
33A	3.3 mi E of Micaville	L. Grindstaff					--do--		2.3		Slope	
34A	2.7 mi E of Micaville	C. Young					--do--		3.3		Flat	
35A	0.4 mi E of Micaville	J. Wilson					--do--		0.3		Slope	
36A	0.7 mi W of Micaville	R. Duvall					--do--		3.2		--do--	
37A	3.8 mi E of Burnsville	D. Thomas					Mica gneiss		11.0		--do--	
38A	0.5 mi S of Burnsville	W. Fox					Amphib. gneiss		12.0		Draw	
39A	1.0 mi S of Burnsville	---					--do--		1.1		Slope	
40A	1.6 mi S of Burnsville	J. Lewis					Mica gneiss		0.5		--do--	
41A	2.2 mi S of Burnsville	--do--					--do--		5.5		Draw	
42A	2.9 mi W of Burnsville	F. Cooper					Amphib. gneiss		3.0		Slope	
43A	1.5 mi E of Bald Creek	B. Ray					--do--		2.5		--do--	
44A	0.7 mi W of Swiss	W. Angel					Mica gneiss		0.3		--do--	Observation spring
45A	2.6 mi E of Bald Creek	C. Hunter					Amphib. gneiss		20.0		--do--	
46A	4.3 mi SE of Bald Creek	R. Fox					--do--		0.7		Draw	
47A	5.8 mi SE of Bald Creek	V. Anglin					--do--		2.0		--do--	
48A	4.3 mi S of Burnsville	C. Edwards					--do--		0.5		Slope	
49A	6.6 mi S of Burnsville	---					Mica gneiss		2.2		--do--	Observation spring
50A	0.5 mi S of Micaville	B. Blalock					Amphib. gneiss		1.1		--do--	
51A	2.1 mi S of Micaville	Bowditch Feldspar Corp.					alashite		50.0		--do--	
52A	2.2 mi N of Celo	H. R. Branch					Amphib. gneiss		8.0		--do--	

TABLE 25. - RECORDS OF SPRINGS IN YANCEY COUNTY (Continued)

Well No.	Location	Owner	Type of Well	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water-bearing material	Water level (ft)	Yield (gpm)	Drawdown (ft)	Topography	Remarks
53A	1.9 Mi. N of Celo--------	L. Blevins--------					Amphibolite gneiss------		6.0		Slope--	
54A	1.6 Mi. N of Celo--------	C. Murphy---------					--do---------		5.5		--do---	
55A	0.2 Mi. N of Celo--------	E. B. Chrislawn---					--do---------		0.8		Flat---	
56A	1.0 Mi. S of Celo--------	F. W. Robinson---					--do---------		0.3		Slope--	
57A	1.4 Mi. S of Celo--------	E. Burgin---------					--do---------		2.0		--do---	
58A	3.9 Mi. S of Pensacola---	D. W. Riddle------					Mica gneiss--		2.6		Flat---	
59A	4.1 Mi. S of Celo--------	Webb's Grocery----					Amphibolite gneiss------		0.9		Slope--	
60A	4.3 Mi. S of Celo--------	A. Burgin---------					--do---------		3.0		Flat---	
61A	3.7 Mi. N of Busick------	G. Stensel--------					Mica gneiss--		2.7		Slope--	
62A	0.8 Mi. N of Busick------	F. W. Bowditch----					--do---------		1.0		--do---	
63A	0.5 Mi. SE of Busick-----	D. H. Autry-------					Amphibolite gneiss------		1.7		--do---	
64A	1.1 Mi. W of Busick------	J. Chaffin--------					Mica gneiss--		0.4		--do---	Observation spring
65A	Top of Mt. Mitchell------	Mt. Mitchell State Park-------					--do---------		2.9		--do---	--do------------



1A, 0.2 mi. S of Spivey Gap

18A, 2.7 mi. N of Micaville

21A, 0.6 mi SE of Higgins

31A, 3.5 mi. NE of Micaville

44A, 0.7 mi. W of Swiss

27, 3.4 mi. E of Bald Creek

49A, 6.6 mi. S of Burnsville

64A, 1.1 mi. W of Busick

65A, near summit of Mt. Mitchell

Figure 29. Yancey County observation spring and well hydrographs, 1962

TABLE 26.- CHEMICAL ANALYSES OF GROUND WATER FROM YANCEY COUNTY

Chemical analyses, in parts per million

Number	Rock type 1/	Water type 2/	Source and depth (ft.) 3/	Date of collection	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids: Residue at 180°C	Dissolved solids: Calculated	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH	Color
27	amgn	V	Du- 17	Mar. 20, 1962	13	0.0	0.01	0.00	13	27	26	8.8	0.4	140	23	30	0.1	38	0.1	261	248	140	26	450	7.0	
1A	qtz	V	S	Apr. 27......	15	.0	.06	.00	1.6	1.0	1.9	.4	.0	14	.2	.6	.0	.0	.1	31	28	8	0	28	6.5	
18A	amgn	V	S	Mar. 20......	26	.0	.00	.00	4.6	3.0	3.6	1.0	.0	33	.2	1.5	.0	2.6	.0	61	58	24	0	71	6.6	
21A	lgn	V	S	Apr. 27......	19	.0	.01	.00	2.5	1.6	1.9	.6	.0	18	.4	.5	.0	.5	.1	36	36	12	0	35	6.7	
31A	mgn	V	S	Mar. 20......	26	.0	.00	.00	4.0	3.7	2.5	.4	.0	30	.2	2.5	.0	1.7	.1	58	56	25	0	67	6.4	
44A	mgn	I	S	Mar. 20......	18	.0	.03	.00	3.2	1.8	2.7	1.5	.0	26	.2	1.1	.1	.3	.0	44	42	16	0	51	6.7	
49A	mgn	V	S	Mar. 20......	16	.0	.01	.02	1.4	1.6	2.5	1.2	.0	18	.2	1.0	.0	.1	.0	39	33	10	0	36	6.8	
64A	mgn	V	S	Apr. 27......	9.0	.0	.05	.01	1.0	.8	.8	.1	.1	9	.2	.3	.0	.0	.0	19	16	6	0	18	5.9	
65A	mgn	V	S	Apr. 27......	5.4	.1	.11	.03	1.3	1.2	1.1	.4	.0	4	2.2	1.8	.0	2.5	.0	21	18	8	5	26	5.7	

1/ Rock Type

qm - quartz-monzonite gneiss	augn - augen gneiss
msh - sillimanite-mica schist	Begn - Beech Granite
gr - granitic gneiss	arph - argillite and phyllite
mgn - quartz-biotite gneiss	akp - arkosic and pyroclastic rocks
lgn - layered gneiss	qsh - schistose quartzitic rocks
amgn - amphibolite gneiss	qtz - quartzite

2/ Water Type

I - calcium, magnesium, sodium bicarbonate
II - calcium, sodium, magnesium bicarbonate
III - calcium-sodium, magnesium bicarbonate
IV - sodium, calcium, magnesium bicarbonate
V - magnesium, calcium, sodium bicarbonate
D - dissolved solids too low to reflect effects of lithology upon water composition
C - excessive chloride and/or nitrate masks effects of lithology upon water composition

3/ Source

S - spring
Dr - drilled well
Du - dug well

SUMMARY

The area of investigation is underlain by a heterogeneous assemblage of igneous and metamorphic rocks which range in composition from gabbro to quartzite.

A mantle of deeply weathered residual material, saprolite, overlies unweathered bedrock in most places. It ranges in thickness from less than one foot to about 150 feet. Alluvial material, clayey sand and gravel, is present in the wider stream valleys to depths of about 50 feet.

Ground water occurs in saprolite and alluvium, and in fracture openings of the underlying bedrock.

Discharge and recharge of ground water takes place mainly through weathered, clayey earth or saprolite and alluvium. Ground-water circulation also occurs in joint and shear systems.

All perennial streams in the area are effluent, receiving discharge from interfluvial areas, hence streams represent the lowest levels of the water table. Configuration of the water table is generally a subdued reflection of topographic relief, although it may be discontinuous between joint and shear systems where the water table lies in unweathered bedrock.

Direction and rate of ground-water movement depend on hydraulic gradient or degree of inclination of the water table, its slope direction, and permeability of the saturated zone. Dispersal from a contaminated source of ground-water recharge in the saturated zone is dependent on rate of ground-water movement and permeability. Contaminated recharge disperses and is diluted as it spreads in a fanshaped pattern, increasing in width and dilution down gradient from its source.

In unweathered bedrock containing the more soluble minerals, such as calcic plagioclase and dolomite, ground-water circulation enlarges the joint and shear openings by solution, hence increasing permeability. These zones of increased permeability are expressed topographically as linear depressions; long, relatively narrow valleys and draws. They are the best locations for drilled wells of high yield.

The bottom of the ground-water zone is indistinct. It may be defined as the depth at which ground-water storage and circulation in joints and shear zones ceases. As bedrock fractures decrease in size and frequency, there is inappreciable ground-water movement or storage below about 400 feet in most localities.

Yields of wells range from less than 1 to about 300 gallons per minute. Average yield of drilled wells in the area of investigation is 15 gallons per minute and average depth is 156 feet.

The quantity of ground water withdrawn from wells in the Morganton area is negligible in comparison to the amount of water available as recharge. Discharge and recharge of ground water are in parity; there is no divergence or perennial trend from this natural balance.

Ground water quality in the Morganton area depends primarily upon the amount and type of dissolved gases in rainfall and ground water, the chemical composition of rock and soil, and the duration of water-rock contact.

Nearly all ground water sampled in the Morganton area is suitable for most domestic and industrial purposes. Iron concentrations in water greater than the recommended maximum of 0.3 ppm occur at scattered locations. Eighty-five percent of the ground water analyzed for iron contained less than 0.3 ppm.

The amount and type of dissolved solids, chloride, and nitrate differ somewhat according to the source of the water. Based on mean concentrations, water from drilled and dug wells contains more than two times the dissolved solids as water from springs, and water from dug wells contains approximately four times the nitrate and chloride as water from drilled wells and springs. Excessive chloride and nitrate indicate that dug wells are considerably more susceptible to contamination than drilled wells or springs.

Pattern diagrams, based primarily on the ratios of calcium, magnesium, sodium, and bicarbonate, expressed in equivalents per million, are used to divide the analyses of ground water into five types:

Type I.	Calcium, magnesium, sodium bicarbonate;
Type II.	Calcium, sodium, magnesium bicarbonate;
Type III.	Calcium-sodium, magnesium bicarbonate;
Type IV.	Sodium, calcium, magnesium bicarbonate; and
Type V.	Magnesium, calcium, sodium bicarbonate.

Layered gneiss, mica schist, amphibolite gneiss, quartzite, phyllite, and augen gneiss contain a typical water type. Nearly all rock units contain more than one type of water.

Water types can be mapped but they extend across and change within boundaries of rock units. Lack of complete water type-lithology correlation is caused by changes in mineral composition within rock units and/or mixing of different types of water.