GROUND-WATER RESOURCES of CLEVELAND COUNTY, NORTH CAROLINA

By

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Hydrologists, Division of Ground Water

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December 29, 1966

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

Dear Governor Moore:

I am pleased to submit Ground-Water Bulletin Number 11, "Ground Water Resources of Cleveland County, North Carolina" by Donald A. Duncan and Richard R. Peace, Jr.

This report contains the results of a detailed study of the ground-water resources of Cleveland County and should prove to be a valuable contribution toward the industrial and economic development of the County.

Respectfully submitted,

George E. Pickett

George E. Pickett

GROUND-WATER RESOURCES OF CLEVELAND COUNTY, NORTH CAROLINA

BY DONALD A. DUNCAN AND RICHARD R. PEACE, JR.

ABSTRACT

This report describes the results of a study of the geology and ground-water resources of Cleveland County, North Carolina conducted by the Division of Ground Water of the North Carolina Department of Water Resources as a part of the continuing state-wide program of investigations.

Cleveland County comprises about 466 square miles in the western Piedmont plateau, and is characterized by gentle to steep slopes, low rounded hills, and is thoroughly and deeply dissected. Monadnocks are found in the northwestern and southeastern portions of the County. Broad River and its tributaries drain the entire area and flow southeastward into South Carolina. The average annual precipitation at Shelby is 47.5 inches and is about 25 percent less in the fall than in other seasons.

The consolidated water-bearing formations are metamorphic and igneous rocks of late Precambrian to Devonian age and metasedimentary rocks of the Kings Mountain group of early Paleozoic age.

The metamorphic rocks include the mica schist and gneiss complex, an immense series of mica schist, mica gneiss, and granitoid layers. The mica schist is usually predominate. Enough water for domestic, stock, commercial, and industrial use generally can be obtained from these rocks. Recoverable ground water occurs in the interconnected joints and fracture zones and is yielded in amounts ranging from 1/4 to 200 gpm (gallons per minute) to wells ranging in depth from 42 to 1,213 feet.

The metasedimentary rocks of early Paleozoic age underlie the south-eastern corner of the County and are predominately interbedded quartzite, marble, and conglomerate. Water supplies sufficient for domestic, stock, commercial and industrial use can be obtained from wells penetrating these rocks. Reported yields range from 8 to 120 gpm.

The igneous rocks are the Toluca quartz monzonite of Ordivician age and the Cherryville quartz monzonite of Devonian age. The Toluca quartz monzonite occurs as bodies of various shapes and sizes in a belt across

the central and western portions of the County. This rock is an important source of ground water for domestic and agricultural supplies with the average well yielding about 10 gpm. The Cherryville quartz monzonite occurs as a broad belt in the southeastern part of the County. This rock is an important source of water for industry in the Grover-Kings Mountain area. Ground water is recovered from interconnected joints, faults, and other fractures in this rock. The yields range from 1 to 200 gpm with the average well producing about 30 gpm. The average depth is 200 feet.

Unconsolidated deposits of sand, silt, clay, and gravel of Quaternary to Recent age underlie the flood plains of the river valleys. Those deposits range in thickness from less than 1 foot to as much as 30 feet. The largest single user of ground water in the County obtains its supply from these deposits.

The ground water is mostly of the calcium bicarbonate type with a low total mineral content, and is suitable for most purposes.

Pumpage of ground water averaged about 8 million gallons per day in 1965, with about half the amount being used by industry and half for domestic purposes. Ground water is the source of supply for all public and semipublic water systems in Cleveland County except those served by the towns of Shelby and Kings Mountain.

INTRODUCTION

Ground water is one of the most important resources of Cleveland County, as it is the source of water supply for the small municipalities, rural homes and farms outside the urban areas served by the water systems of Shelby and Kings Mountain (fig. 1). Ground water is also the source of water for many industries, and is becoming a prime factor in the selection of new industrial sites in the area. With the growing demand for clean water, the importance and value of the ground-water resources will continue to increase, thus, an adequate evaluation of the potential of this source of water supply is essential.

The current investigation of ground-water conditions in Cleveland County is part of a continuing state-wide program of investigations, data collection and research conducted by the Division of Ground Water of the North Carolina Department of Water Resources (fig. 2). The purpose of this program is to delineate, map, describe and quantitatively and qualitatively evaluate the ground-water reservoirs of the State as sources of water supply, storage reservoirs and distribution systems; to develop reservoir management plans; and to assist in the establishment of management systems that will permit optimum use of the ground-water resources.

Field work for this report was accomplished during 1965 and 1966. The geology of the area was studied chiefly as it related to the occurrence of ground water. Most of the work consisted of reconnaissance mapping of the surface geology, collection of subsurface geologic data, a study of the relation between geology and ground-water hydrology, and water quality.

Basic data collected for investigation include records for 286 wells. These data are shown in table 7 and the locations of wells are shown in figure 3. Well data were collected from the files of industrial concerns, municipalities, water-well contractors, from previous ground-water reports, and by interviewing well owners. Information on many of these wells was reported by drillers and owners from memory and commonly the records are incomplete. The records of completed wells filed with the North Carolina Division of Ground Water since 1959 were of great value in bringing the well inventory up to date.

Chemical analyses of 43 water samples from selected wells tapping the principal water-bearing units were made by the North Carolina Division of Ground Water. Selected analyses from reports published by the North Carolina Department of Water Resources and other governmental agencies are also included in this report.

Previous Investigations

Many previous geologic and hydrologic studies included all or parts of Cleveland County. Of general interest are the works of Keith and Sterrett (1931), Kesler (1942), Overstreet and Griffitts (1951-55), Overstreet, Griffitts, and Yates (1963). Prior studies of the geology and ground-water resources of the area include Stuckey (1929), Mundorff (1945), LeGrand and Mundorff (1952). Any other investigations have been of a local nature.

Acknowledgements

The writers are grateful for the cooperation and assistance given by many well owners, well contractors, drillers, and governmental agencies--local, County, and State--in Cleveland County. The owners of domestic, farm, and industrial wells furnished useful data on wells, springs, and local ground-water conditions, and were most cooperative in allowing their wells to be used for hydrologic observations. Drillers' logs, details of well construction, and formation samples were provided through the generous cooperation of the local well contractors, and were invaluable in the preparation of this report. The owners and operators of all municipal water-supply systems in the County provided data on well construction and pumpage. Particular thanks are offered to Messrs: H. A. Beam, Water Commissioner, Town of Fallston; H. M. Broadwater, General Superintendent, Foote Mineral Company, Kings Mountain Plant; A. d'Audiffret, President, Aqua-Ran Water Supplies, Inc.; Ralph Dedmond and Bob Hayes, Sanitarians, Cleveland County Health Department; W. K. Dickson, Owner, W. K. Dickson & Company, Inc.; Robert Gold, Owner, Southeastern Well Corporation; Ollie Harris, Member, Kings Mountain Chamber of Commerce; G. H. Hollis, Assistant Plant Manager, Pittsburgh Plate Glass, Fiber Glass Division; W. V. Kerr, President, Ranney Water Systems, Inc.; Paul Lancaster, Superintendent, and Hugh Lancaster, Kings Mountain Mica Company; Paul Limrick, Manager, Shelby Chamber of Commerce; L. L. Martin, Onwer, Hickory Well Drilling Company; W. W. McCarter, Water Commissioner, Minette Mill, Inc., and Town of Grover; Hal Morris Pump Service, Dow Perry, Engineer, Fiber Industries, Inc.; Lee Phoenix, Superintendent, and Charlie Beam, Maintenance Supervisor, Cleveland County Schools; Jay Powell, Superintendent, Superior Stone Company, Kings Mountain Plant; E. B. Stafford, Consulting Engineer; and Ford White, Driller for Lindsay Well Drilling Company.

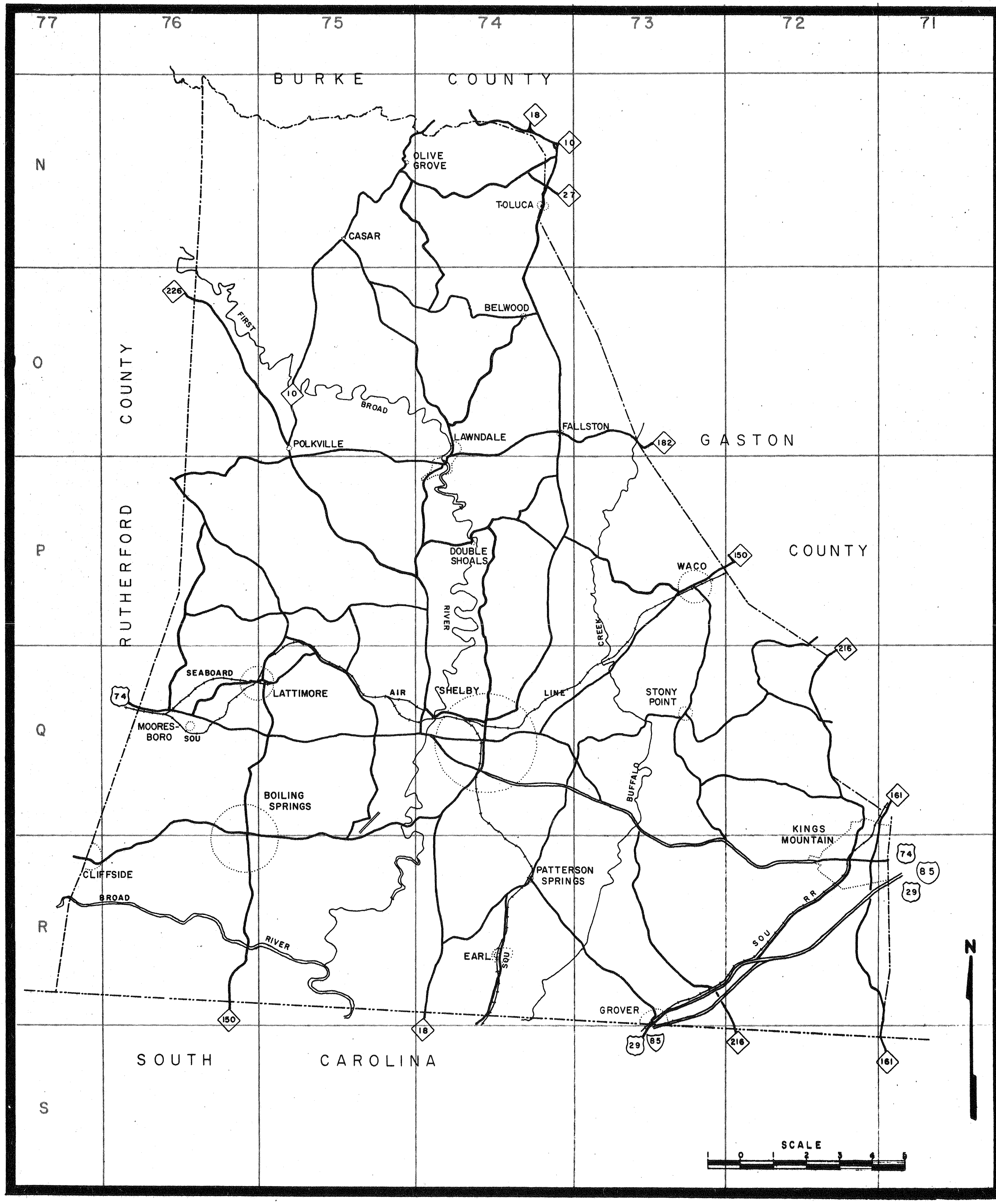


FIGURE 1- CLEVELAND COUNTY

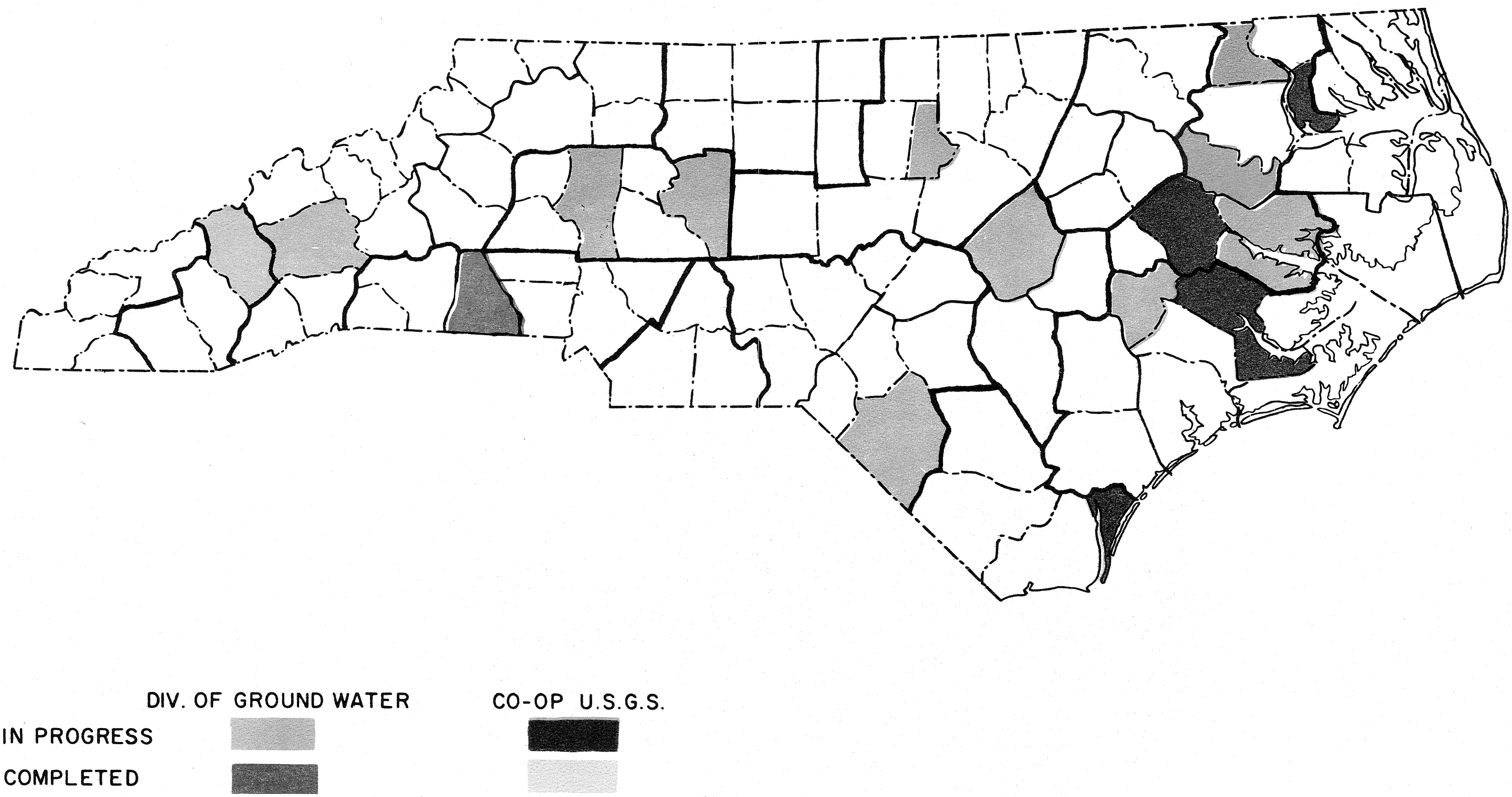


FIGURE 2-INDEX MAP OF NORTH CAROLINA SHOWING AREAS STUDIED BY DIV OF GROUND WATER

Well Location and Numbering System

The location and numbering of wells in this report are based on a state-wide grid system of longitude and latitude.

The state is divided into quadrangles of 5-minutes of latitude, identified by upper-case letters, and 5-minutes of longitude, identified by numbers. Each 5-minute quadrangle is divided into twenty-five 1-minute quandrangles, identified by lower-case letters. The wells in each 1-minute quadrangle are numbered serially. Thus, a well numbered P73t-2 would be well 2 in the 1-minute quadrangle "t" of the 5-minute quadrangle P-73 (fig. 3).

GEOGRAPHY

Cleveland County comprises about 466 square miles of the inner portion of the Piedmont physiographic province in southwestern North Carolina (fig. 1). It has a north-south length of about 28 miles and an east-west width of about 25 miles, and lies approximately between the 35°10' and 35°35' parallels of north latitude and the 82°21' and 80°45' meridians of west longitude. It is bounded on the north by Burke County, on the east by Lincoln and Gaston Counties on the south by South Carolina, and on the west by Rutherford County.

Population and Economy

The population of Cleveland County, according to the U. S. Bureau of the Census, was 66,048 in 1960, showing an increase of about 2.6 percent over 1950. Shelby, near the geographic center of the county, is the county seat and largest town, with a population of 17,698 in 1960. Other towns and communities are Kings Mountain (pop. 8,001), Boiling Springs (pop. 1,311), Lawndale (pop. 723), Grover (pop. 538), Lattimore (pop. 275), and Waco (pop. 256).

Shelby and the surrounding communities constitute a major center of textile manufacture. Kings Mountain is also a center of textile manufacture as well as mining. Outside these principal industrial areas, the County contains some of the most intensively developed farmland in the State, with cotton, grain, dairying and poultry production the major sources of farm income.

Climate

The climate is of the modified-continental type and is warm and temperate. The warmest month in summer (July) averages 79°F, and the coldest month in winter (January) averages 43°F.

Figure 4 is compiled from the records of the U. S. Weather Bureau recording station at Shelby, North Carolina, and is based on 22 years of record, 1931-52.

The average annual rainfall is 47.5 inches, and the average annual snowfall is 7.1 inches. Precipitation is about 25 percent less in the fall than in other seasons. Moderately dry periods of 2 to 5 weeks often occur late in spring and early in summer and are common in fall.

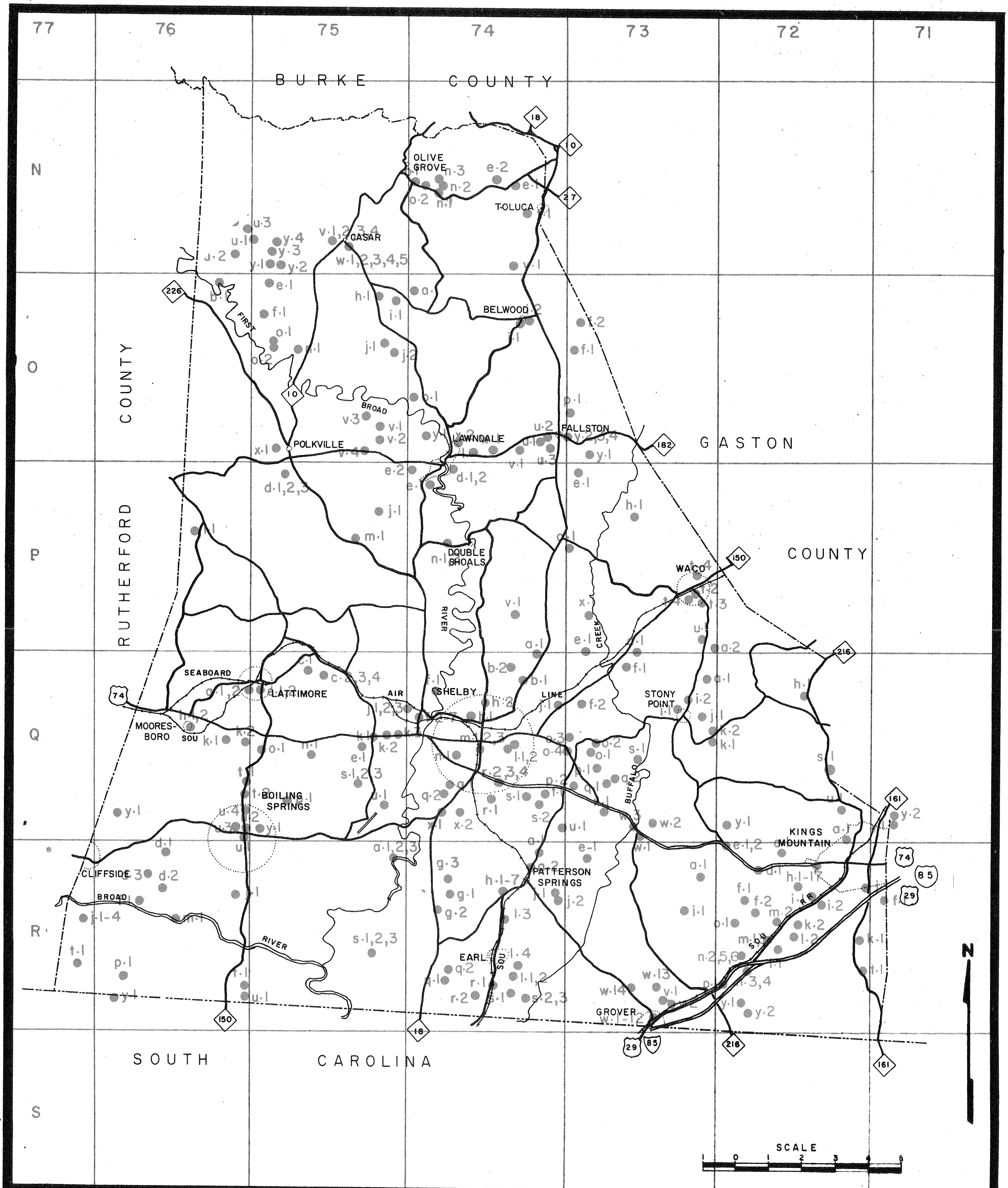
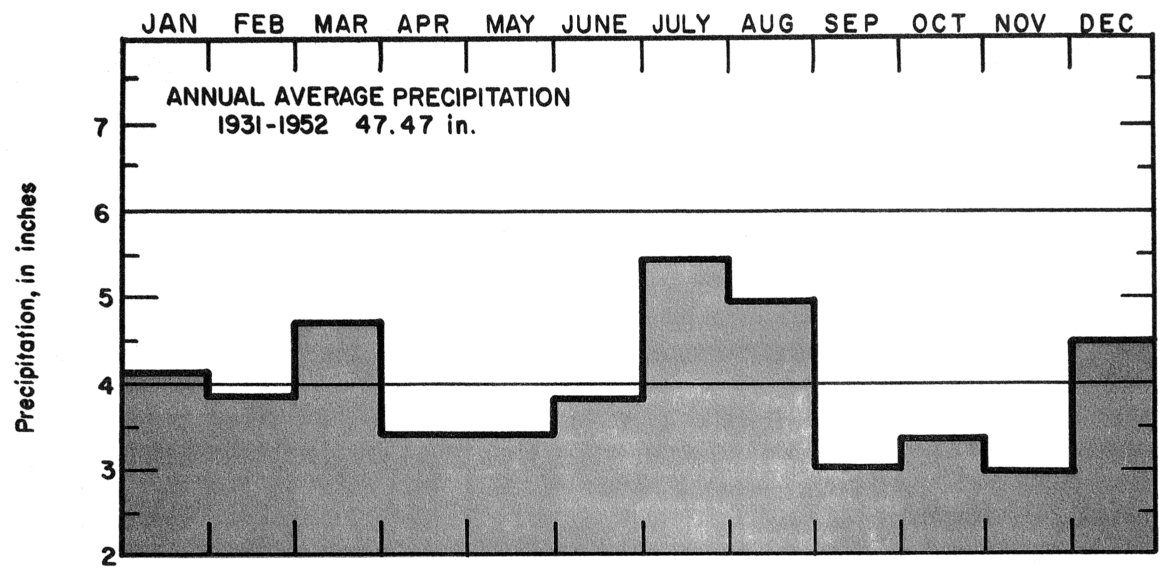
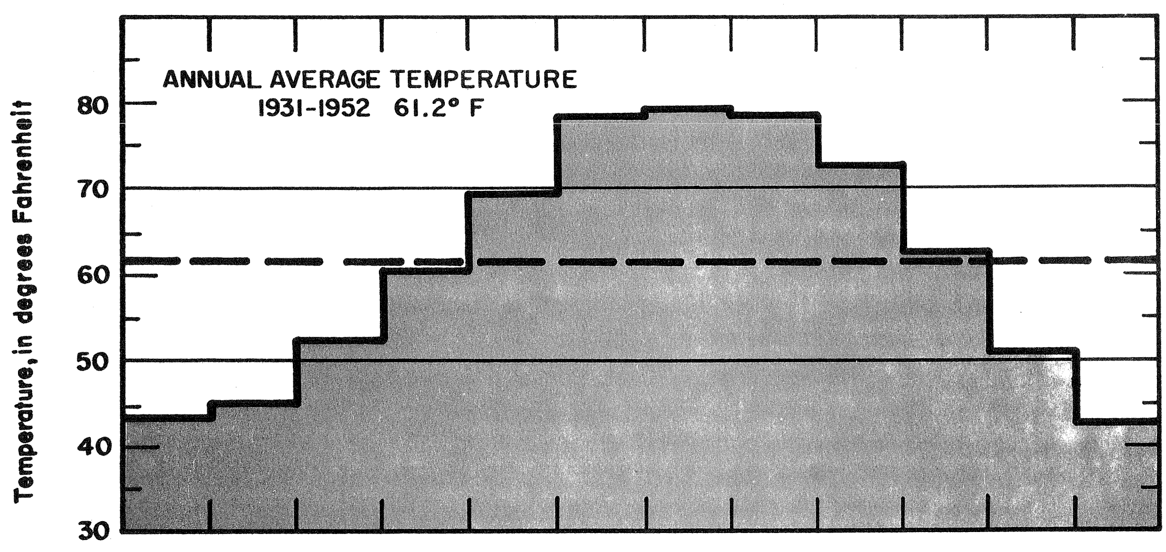


FIGURE 3 - LOCATION OF INVENTORIED WELLS



MONTHLY AVERAGE PRECIPITATION (1931-1952) AT SHELBY, N. C.



MONTHLY AVERAGE TEMPERATURE (1931-1952) AT SHELBY, N. C.

FIGURE 4. MONTHLY PRECIPITATION AND TEMPERATURE AT SHELBY, N. C.

Broad River near the South Carolina line. Other important streams in the County include Boween River, Buffalo Creek, Whiteoak Creek, Beason Creek, Brushy Creek, Sandyrun Creek, and Beaverdam Creek.

GEOLOGY

Field work for this report included a reconnaissance survey of the geology in the County as related to the ground-water conditions. The existing geologic maps generally proved to be sufficiently accurate for the purposes of this investigation. The four major rock units shown on the geologic map (fig. 5) are generalized, to some extent, as they usually include more than one type of rock.

Cleveland County is entirely within the Piedmont geologic province. Rocks occurring in the county represent two distinct geologic belts, the Inner Piedmont Belt and the Kings Mountain Belt. The Inner Piedmont Belt consists of polymetamorphosed mica schists, granitic and mafic gneisses with numerous conformable bodies of intrusives, predominantly quartz monzonite and associated pegmatites and comprises the mica schist-gneiss complex, the Toluca quartz monzonite and the Cherryville quartz monzonite units. These rocks are intensively folded and faulted (fig. 6) and are generally considered to be late Precambrian to early Paleozoic in age. The Kings Mountain Belt consists of low rank metamorphic schists and phyllites which contain distinctive beds of quartzite, kyanite quartzite, conglomerate, marble, and pyroclastic volcanics.

Mica Schist and Gneiss Complex

General Character and Extent

The mica schist and gneiss complex is the most widespread of all the rocks occurring in Cleveland County and probably underlies as much as 75 percent of the total land area, outcropping in irregular and complex patterns. The mica schist and gneiss complex represents polymetamorphosed sedimentary and pyroclastic volcanic rocks. They are considered to be the oldest rocks in the area and are generally regarded as late Precambrian or early Paleozoic in age.

These rocks consist of an immense series of mica schist, mica gneiss, and granitoid layers, locally porphyritic, in which mica schist usually predominates. However, the more gneissic rocks may predominate locally. It is light to dark gray, mostly dark, except where layers of mica gneiss occur, and weathers to dull gray, yellow, and various shades of red. Bands and lenses of mica gneiss, composed of quartz, feldspar, with biotite and muscovite in varying amounts, with the biotite predominate at most localities, are common in the unit. Also occurring in many places are thin, interbedded layers of hornblende gneiss and schist. Included in the complex are decidedly younger bodies of quartz monzonite, gabbro, and dikes and lenses of pegmatite. The bands, lenses, interbedded layers, and dikes here described are generally too small to show on the map. The mica schist is essentially composed of biotite, muscovite, sillimanite, quartz, and a little feldspar.

Much of the mica gneiss undoubtedly represents metamorphosed sedimentary material, that resembling granite gneiss may well represent granitic intrusions that have been strongly metamorphosed. The contacts and boundary zones separating the mica schists and gneisses from other rock units are generally indefinite because of their gradational character.

The mica schist and gneiss complex is deeply weathered at most areas and is covered by a thick layer of residual clay containing fragments and layers of the parent material. The soil cover overlying the thick residual clay and weathered rock is usually light and thin.

Water-bearing Properties

Ground water in the schist and gneiss complex occurs in and moves principally through intersecting sets of fractures. Little, if any, water is obtained from pore spaces between crystal grains or from vesicles. As the mica schist and gneiss complex consists of interbedded schist and gneiss, some wells are drilled into schist, some in gneiss, and others in gneiss and schist. As schist is the predominate rock in the unit, more wells (117) were inventoried in the schist. The average depth of these 117 wells in schist is 189 feet and the median depth is 150 feet, with total depths ranging from 42 to 750 feet. The yield of wells in schist ranges from 0 to 150 gpm, with the average and median yields being 25 gpm and 19 gpm respectively. Most wells drilled into gneiss usually encounter some schist. Data from 56 wells drilled into rock which is predominantly gneiss show the average depth to be 226 feet, the median depth is 200 feet, with the total depth ranging from 61 to 1,213 feet. Yields of these wells range from 0 to 200 gpm, the average yield is 35 gpm and the median yield is 20 gpm. Most drilled wells in gneiss and schist obtain adequate supplies for domestic and farm use at depths ranging from 100 to 200 feet. The average depth of all 173 wells penetrating the mica schist and gneiss complex is 208 feet and the median depth is 165 feet. The yield of these wells ranges from 0 to 200 gpm; the average yield is 30 gpm and the median yield is 20 gpm.

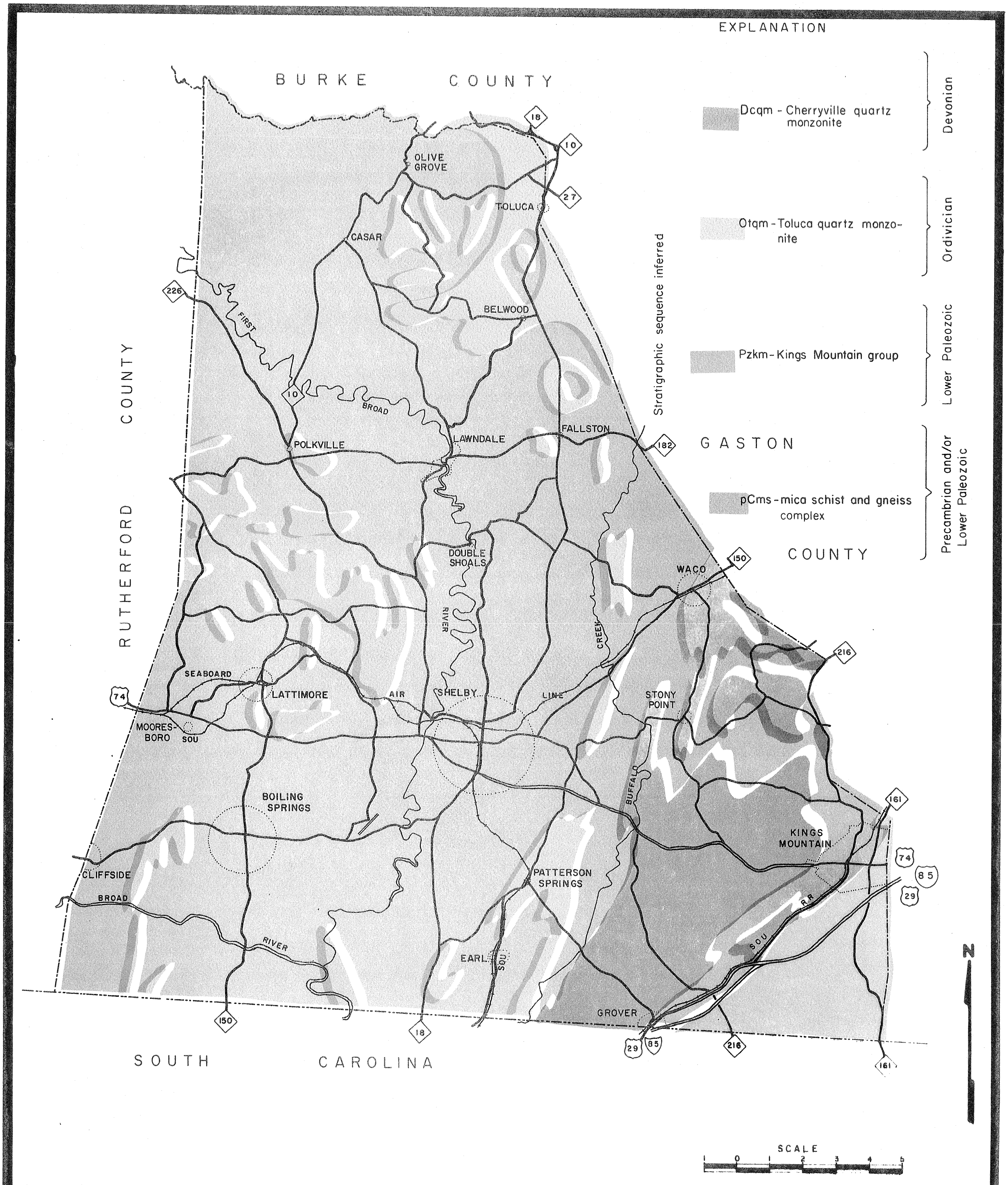


FIGURE 5 - GEOLOGIC MAP OF CLEVELAND COUNTY

FIGURE 6-FAULT ZONE IN TOLUCA QUARTZ MONZONITE SOUTHEAST OF SHELBY

CLOSE-UP

The probability of obtaining a well whose yield is equal to or more than a specified amount in the mica schist and gneiss complex is shown in figure 7. The schist curve shows that 20 percent of all wells penetrating this rock, the yield equals or exceeds 35 gpm. The curve representing wells drilled in predominately gneissic rock show that the yield of 20 percent of the wells equal or exceeds 45 gpm. The higher yield in the more gneissic rock is reasonable because the fracturing of the coarser grained and more brittle rocks, such as gneisses, has produced wider and more continuous joint openings than the fracturing in the finer grained rocks, such as schist.

The depth below which interconnected joints and fractures in gneiss and schist are too tightly closed to contain recoverable water is not known and probably varies greatly from place to place. If a sufficient supply of water is not obtained after drilling to a depth of about 300 feet, available records indicate the chances of obtaining the needed water by drilling deeper are poor. In general, where a well is drilled about 200 feet into rock and no water is encountered, it is often practical to move to a different location.

Kings Mountain Group

General Character and Extent

Rocks of the Kings Mountain Group occur in the southeast corner of the County as northeastward-trending belts. They consist of interbedded quartzite, marble, conglomerate, phyllite, schist, and pyroclastic volcanics and are generally considered to be early Paleozoic in age.

The quartzite unit of the Kings Mountain Group is generally a white to brown, fine-to coarse-grained quartzite, kyanitic quartzite, and quartz conglomerate. The calcareous rocks consist of white to bluish gray, fine-grained dolomitic marble containing tremolite, phlogopite, and hornblende and calcareous metashales. The schistose units are essentially, a white, gray or bluish black fine-grained, laminated sericite schist with sericite phyllite, quartz-mica schist, and biotite schist being present locally. Volcanic rocks exhibiting pyroclastic textures, while not generally abundant, are present in sufficient amounts to indicate that the volcanics constitute a substantial portion of the Kings Mountain Group.

The quartzite and quartz conglomerate beds being highly resistant to the forces of weathering and erosion are expressed topographically as prominent northeast-trending ridges such as Kings Mountain. The marble and calcareous beds being highly susceptible to the weathering processes are found underlying narrow northeast-trending valleys. Generally, neither the quartzite beds nor the limestone beds are more than a few hundred feet wide.

Water-bearing properties

Rocks of the Kings Mountain Group are an important source of water for rural homes and commercial enterprises in the southeastern corner of Cleveland County. Ground water in the rocks of the Kings Mountain Group is contained in and moves along intergranular pore spaces, bedding-plane partings, and secondary openings, principally joints and faults. The openings along joints and bedding planes are probably the most important avenues for the movement and storage of water in these rocks. Most of the original intergranular pore spaces in these rocks is now occupied by recrystallized minerals, chiefly quartz. This is substantiated by drillers reports that all or part of the yield of a well drilled in these rocks is obtained from a specific depth or depths, which implies widely spaced, narrow openings.

As the location of water-filled openings at depth is not known in detail, the yield of an individual well tapping metasedimentary rocks cannot be predicted with any degree of certainty. Usually a well drilled into those rocks will penetrate a few water-bearing joints or bedding-plane partings and yield at least a small supply of water. Reported yields of wells drilled in the Kings Mountain Group range from 8 to 120 gpm. The average and median yield of wells is 26 and 15 gpm. The depth of these wells ranges from 95 to 300 feet, and averages 169 feet. The median depth is 151 feet.

The probability of obtaining a well in the Kings Mountain Group whose yield is equal to or more than a specified amount is indicated in figure 7. The curve plotted from data on wells in these rocks indicate that the yield of 25 percent of all wells equals or exceeds 20 gpm.

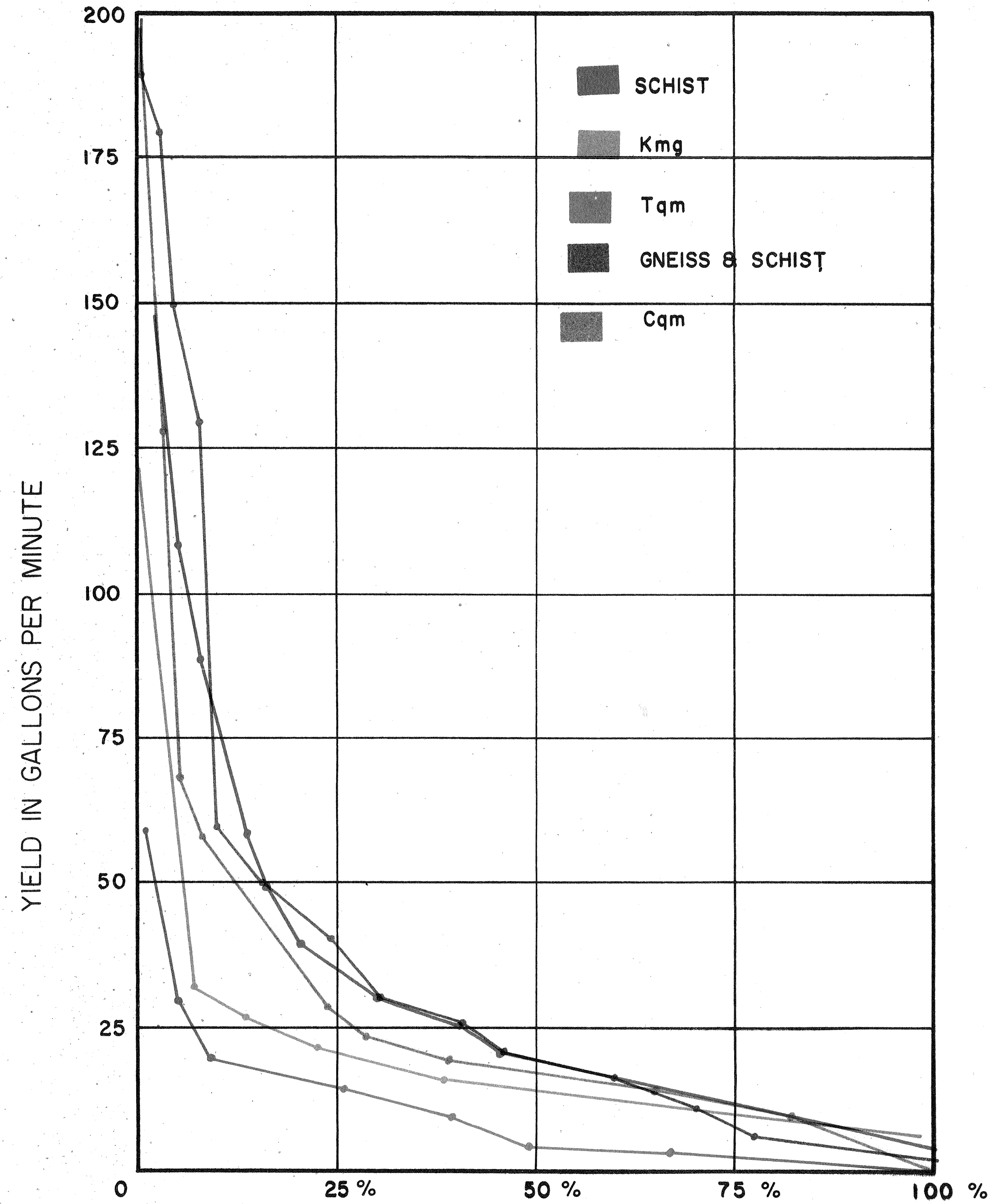


FIGURE 7 - CUMULATIVE FREQUENCY CURVES ACCORDING TO ROCK TYPE

Toluca Quartz Monzonite

General character and extent

The Toluca Quartz Monzonite consists of many bodies of various shapes and sizes occurring in a belt across the central and western portions of Cleveland County. These rocks, along with the associated dikes and sills of pegmatite, are generally considered to have been emplaced during the Ordivician deformation. Also, at the same time the surrounding sedimentary and pyroclastic rocks were folded and regionally metamorphosed to schists and gneisses. These bodies range in thickness from a few feet to thousands of feet, and in length from tens of feet to several miles. Structurally, they are generally parallel to the foliations and general structural trends of the schists and gneisses which they intrude, but north and west of Shelby they bend north and westward across the structural features of the country rock. Toluca Quartz Monzonite is typically a gray, medium-grained gneissic biotite-quartz monzonite. Generally the smaller intrusions are more gneissic than the larger bodies, however, the larger ones usually display strong foliation, especially in and near the contact zones. The chief minerals consist of feldspar, quartz, and biotite with lesser amounts of garnet and muscovite.

The Toluca quartz monzonite along with the surrounding gneisses and schists are weathered to saprolite (disintegrated rock that lies in its original place and retains most of its original textures and structures). The saprolite developed from the Toluca quartz monzonite extends from the surface of the ground to depths as great as 100 feet and averages 30 to 70 feet deep at most places. This weathering tends to bring about a convergence in the surface appearance of the quartz monzonite, schist, and gneiss; making the most thoroughly weathered rocks, despite differences in origin and original composition, difficult to distinguish from one another in the field.

Water-bearing properties

The Toluca quartz monzonite underlies approximately 10 percent of Cleveland County and in these areas it is an important source of ground water for domestic and agricultural supplies. The percentage of primary pore spaces in this rock, like other consolidated crystalline rocks, is probably one percent or less, and is small compared to the porosity of the unconsolidated alluvial sand and gravel deposits. The pore spaces are so small that little or no water is transmitted through them, and probably yield no significant amounts of water to wells. The wells that have been drilled in these rocks only yield water that enters from one or more separated levels in the hole. Most recoverable ground water occurs in interconnected joints and fracture zones. The permeability of the Toluca quartz monzonite is determined largely by the size and extent of these fractures. Spacing between individual joints of parallel sets range from a few inches to several feet. Because appreciable water is yielded to a well only where there is a sufficient number of joints and because the location of joints is not known in detail, the success or failure of a well in Toluca quartz monzonite cannot be predicted with certainty.

The yield and depth of wells in Toluca quartz monzonite vary areally, both widely and locally from well to well, depending on the number and size of openings and on the topography. Therefore, data for a single well or a group of wells may be applied only in a general way to indicate the probability of obtaining a required yield in any given locality. Records of 25 wells penetrating the Toluca quartz monzonite are available for the Cleveland County area. Most wells are 6 inches in diameter. Their reported yields range from 1/4 to 56 gpm. The average yield is about 10 gpm and the median is 5 gpm. These wells are from 38 to 700 feet deep; the average depth is 246 feet and the median is 225 feet. The probability of obtaining a required yield from a well in these rocks is shown in figure 7. Of all wells penetrating the Toluca quartz monzonite, 20 percent yield 17 gpm or more.

Cherryville Quartz Monzonite

General character and extent

The Cherryville quartz monzonite occurs as a broad, irregular, northeastward-trending belt across the southeastern portion of the County. Essentially, it is a light gray, fine- to medium-grained, massive- to weakly-foliated muscovite-biotite-quartz monzonite, frequently containing abundant inclusions of the mica schist and gneiss it intrudes (fig. 8). This quartz monzonite intrusive usually occurs as a massive, homogeneous, crystalline rock with only local variations in texture and physical appearance. These variations are generally found in and near the contact zones

FIGURE 8 - CHERRYVILLE QUARTZ MONZONITE WITH INTRUSIONS OF MICA GNEISS

CLOSE-UP

and are due, in part, to the type of country rock intruded, the amount of country rock absorbed by the magma, and the rate the igneous solutions cooled. In Cleveland County the quartz monzonite was injected into the older rocks, parallel to their foliations and other structures. Overstreet and Griffitts (1955) considered the emplacement of the Cherryville quartz monzonite to have occurred during the Devonian Period, at which time the surrounding country rocks were metamorphosed. Numerous coarsely crystalline dikes, or pegmatites, genetically related with the Cherryville quartz monzonite are found in Cleveland County. Of particular interest are the spodumene-bearing pegmatites in the vicinity of Kings Mountain.

The Cherryville quartz monzonite, like the surrounding crystalline rock, is deeply weathered and covered by thick layers of weathered rock and soil. Data from well records which show the amount of casing required to extend through the soil and saprolite into bedrock indicate that the depth of the weathered material ranges from 10 to 140 feet. The average depth is 59 feet and the median is 60 feet. The overlying surficial soils produced by the weathering processes are usually a light tan to gray sandy material.

Water-bearing properties

The Cherryville quartz monzonite is an important source of ground water, particularly in the area extending from Grover to Kings Mountain where many industrial and several public supplies have been developed. The water-bearing properties of the Cherryville quartz monzonite are similar to those of the other crystalline rocks in Cleveland County in that ground water is primarily obtained from interconnected joints, faults, and other fractures in the bedrock. An analysis of the reported yields of 42 wells drilled in this rock shows that the yield ranges from 1 to 200 gpm with the average well producing about 30 gpm and the median yield is 20 gpm. These wells range in total depth from 49 to 605 feet and average about 200 feet. The median depth is 167 feet.

The probability of drilling a well whose yield is equal to or more than a specific amount in the Cherryville quartz monzonite is shown in figure 7. The curve shows that 20 percent of all wells drilled in this rock yield 40 gpm or more.

Flood-Plain Deposits

General character and extent

The streams of Cleveland County are usually flanked by terrain that is relatively flat and smooth. These areas, called flood plains, are underlain by sediments that have been deposited by the streams as they migrated back and forth across the valley floor. The flood-plain deposits are generally thickest near the center of the valleys and get gradually thinner toward the valley walls. In Cleveland County, the flood-plain deposits consist primarily of bedded, poorly sorted, unconsolidated clay, silt, sand, and some thin lenses of gravel. These deposits are generally gray or tan in the lower half to pink or red in the upper weathered portions and overlie weathered crystalline rocks. Flood-plain deposits are not differentiated on the geologic map. These deposits range in thickness from less than 1 foot to as much as 30 feet and are considered to be Quaternary to Recent in age.

Water-bearing properties

At the present time no detailed studies have been made on the location, extent, thickness, or water-bearing characteristics of the deposits underlying the flood plains in Cleveland County. However, many of the flood plains appear to be underlain by deposits of permeable sand and gravel of sufficient size to permit the withdrawal of large amounts of water to properly designed wells. One such well, a Ranney water collector, has been installed by Fiber Industries, Inc., the largest single user of ground water in Cleveland County, along the west bank of Buffalo Creek. Fiber Industries, Inc. reportedly pumps over one mgd (million gallons per day) from this well. A part of the water pumped from this well is probably dirived from natural ground-water storage, and part from Buffalo Creek by induced infiltration.

As previously stated, no studies have been made of the flood-plain deposits in this area; however, the North Carolina Division of Ground Water is currently making plans for comprehensive investigations to include all of the major flood plains of the river basins in the Piedmont and Mountain provinces of North Carolina. The flood-plain deposits in Cleveland County, along with those in the rest of the Piedmont and Mountain areas have been generally overlooked as a source of water, but they are considered to constitute a potentially valuable and important source of water for industry and the expanding population, especially where they may be recharged by induced infiltration from the nearby streams.

GROUND-WATER HYDROLOGY

Hydrologic Cycle

The primary source of the ground water is precipitation. Of the total precipitation, part returns directly to the atmosphere, part infiltrates the ground, and part runs off overland into the streams. Much of the water moving downward into the soil and subsoil is retained at a shallow depth as soil moisture which is subject to evaporation and the demands of plant growth. During the summer, evapotranspiration may return moisture to the atmosphere at rates similar to or exceeding those of precipitation. During the remainder of the year, water available after the soil-moisture requirements have been met moves down through the soil and rocks to the water table and becomes ground water (fig. 9).

Occurrence and Movement

Below a certain depth, the rocks of Cleveland County are generally saturated with water and are said to be in the zone of saturation. The upper surface of the zone of saturation is called the water table. In general, the water table is a subdued replica of the configuration of the land surface. In Cleveland County ground water is recovered from dug, bored, and drilled wells. The dug and bored wells are large-diameter up to 4 feet, wells that generally are shallow and do not penetrate bedrock. These wells recover ground water from the surficial material consisting of clayey and sandy soil and weathered rock. Water occurs in this material only between the individual rock fragments and mineral grains. As the water table does not remain in a stationary position but fluctuates seasonally with variations in the gain or loss of water, these wells are often affected by extended periods of drought.

The drilled wells are small-diameter, usually 6 inches, are relatively deep and penetrate bedrock. These wells recover water from the structural openings such as faults, joints, and similar fractures in the crystalline bedrock. The thick layer of clayey and sandy soil and weathered bedrock that overlies most of the area, which as a rule is highly porous and permeable, acts as a recharge reservoir from which water flows into the structural openings and fractures in the bedrock. Therefore, the yield of wells penetrating bedrock should be uniform throughout the year and affected little by short periods of drought.

Water-Level Fluctuations

Ground-water levels are continuously changing, reflecting changes in storage that may result from one or more of many factors. These factors include ground-water recharge, natural discharge, evaporation, transpiration, withdrawals by pumping, and variations in the atmospheric pressure.

In Cleveland County, recharge from precipitation, natural discharge and evapotranspiration are the principal causes of water-level fluctuations. Water levels are normally highest in the spring when rainfall is abundant and the evaporation rate is low. They are lowest in the fall and early winter when rainfall is least abundant and the ground-water storage has been depleted because of evapotranspiration during late summer and early fall.

The ideal time to evaluate the productivity of a well is during periods of water-level lows. Tests made at such times accurately indicate the dependability of a well and permit determination of the most efficient pumping rate and maximum yield.

Selection of Well Sites

Well sites in Cleveland County generally have been selected on the basis of convenience, quantity of water available, quality of water, or a combination of these factors. However, most were selected primarily for their convenience; that is, they were drilled as close as possible to the building where the water would be used. The selection of a well site for convenience is usually a poor practice to follow, especially if a large amount of water is needed. This conclusion is substantiated by data from 232 wells and is illustrated in figure 10. The lower curve is the cumulative frequency curve of the yields of 116 wells in Cleveland County which were drilled primarily for domestic purposes and in locations selected largely for convenience by the owners or drillers. The upper curve is based on yields of 116 industrial and public supply wells, many of which were drilled at sites selected for their potential ability to yield larger amounts of water. The curves show that the yield of 20 percent of the 116 domestic wells equals or exceeds 27 gpm, whereas the yield of 20 percent of the industrial and public supply wells equals or exceeds 45 gpm.

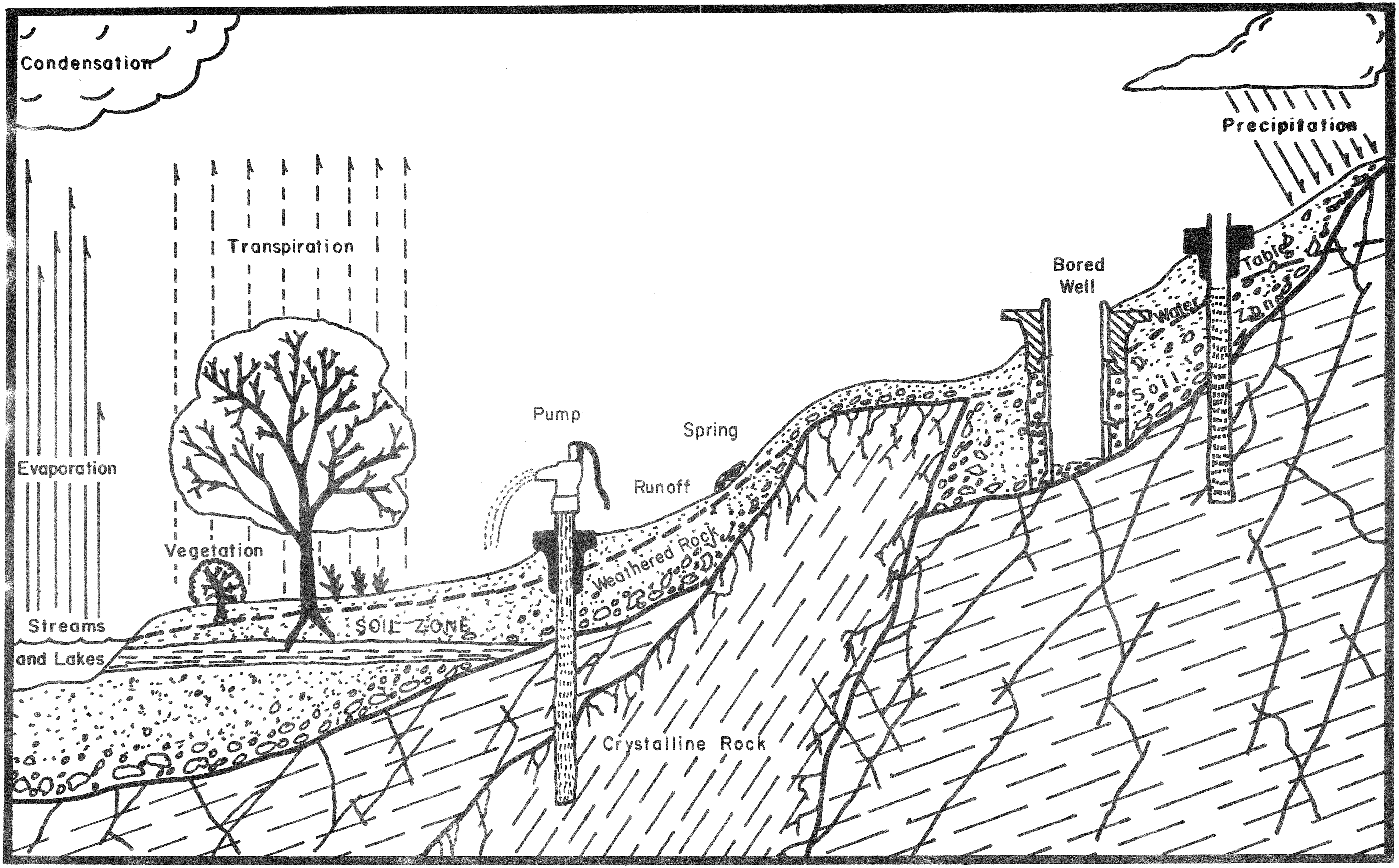


FIGURE 9 - THE HYDROLOGIC CYCLE AND COMMON TYPES OF WELLS

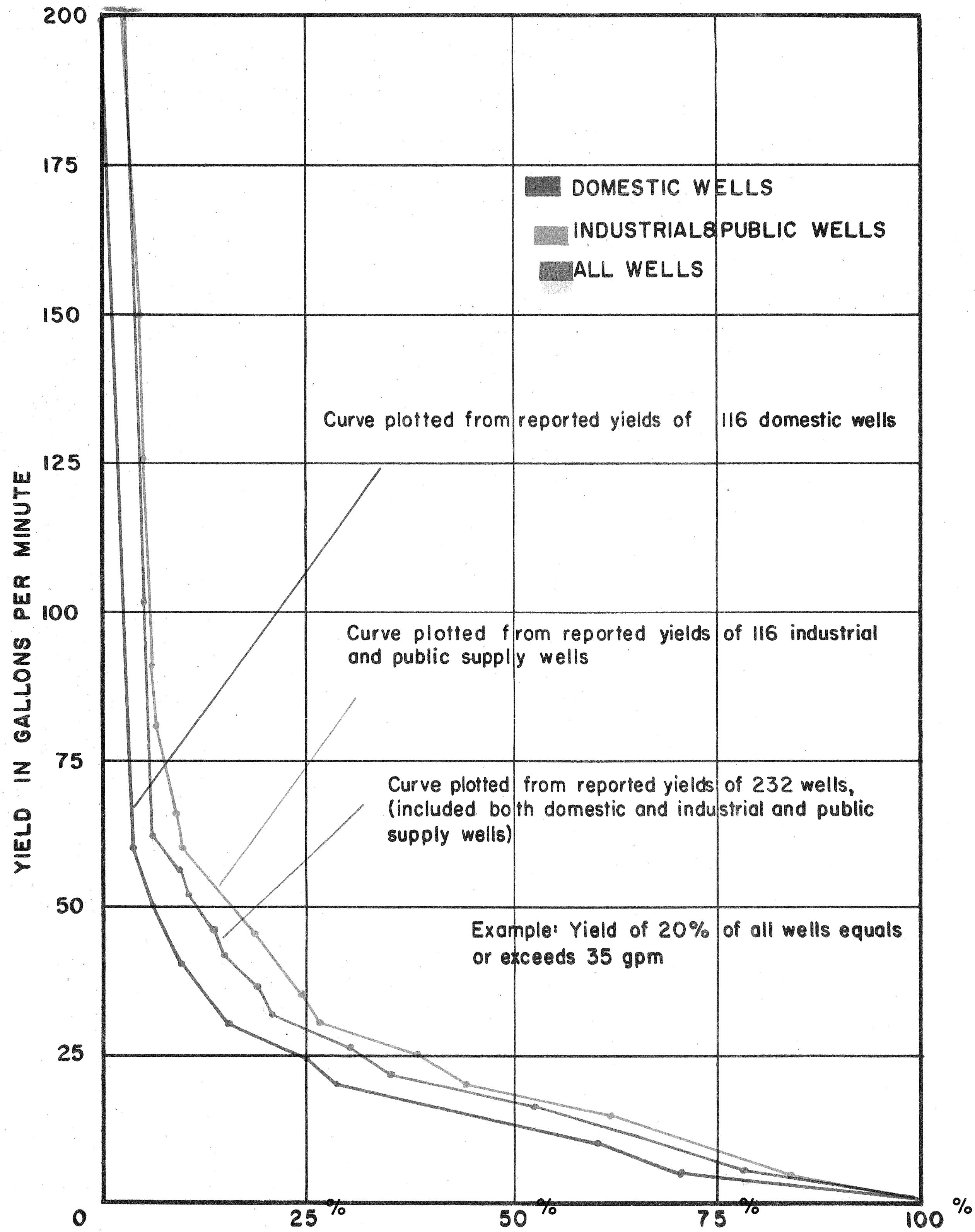


FIGURE 10- CUMULATIVE FREQUENCY CURVES ACCORDING TO USE

Rock structure

Geologic structure is the most important consideration in locating water wells in the Piedmont of North Carolina. As the topography is generally a surface expression of the geologic structures and rock types underlying an area, a careful examination and interpretation of the topographic features can be helpful in locating satisfactory water-well sites.

Hills, as a rule, are the least favorable locations for a well. They represent areas that are normally most resistant to erosion and are usually underlain by rocks that are hard and contain relatively few joints and fractures through which ground water may readily flow. Draws and valleys represent zones of weakness in the rocks where fracturing and jointing are more highly developed; therefore, a well located in a valley or draw generally has a greater probability of yielding water in large quantities. Another factor to take into consideration is that the direction of movement of ground water is towards the draws and valleys and away from the hills. These statements are substantiated by the data illustrated in figure 11. The upper cumulative frequency curve represents the reported yields of 64 wells located in a valley or draw and the lower curve was plotted from reported yields of 52 wells located on a hill or ridge. The yield of 20 percent of the wells located in a valley or draw, equals or exceeds 80 gpm, whereas the yield of 20 percent of the wells located on hills or ridges equals or exceeds only 18 gpm.

Rock Type

An equally important factor to consider when locating water wells in Cleveland County is rock type. It is commonly known that some rock types of this area will generally yield more water than others. The primary reason that one rock type is a better water producer than another is that, because of the lithic character and composition, it usually contains more interconnected and wider structural openings which permit the free circulation of water to a well. These openings and other geologic features which control movement and circulation of ground water have been thoroughly discussed in an earlier section of this report which dealt with the water-bearing properties of the various geologic formations.

Because appreciable water is yielded to a well only where there is a sufficient number of interconnected joints and fractures and because the location of these interconnected joints and fractures is not known in detail, the success or failure of a well in crystalline rock cannot be predicted with certainty. However, a careful analysis of field conditions and available data usually results in the selection of successful well sites.

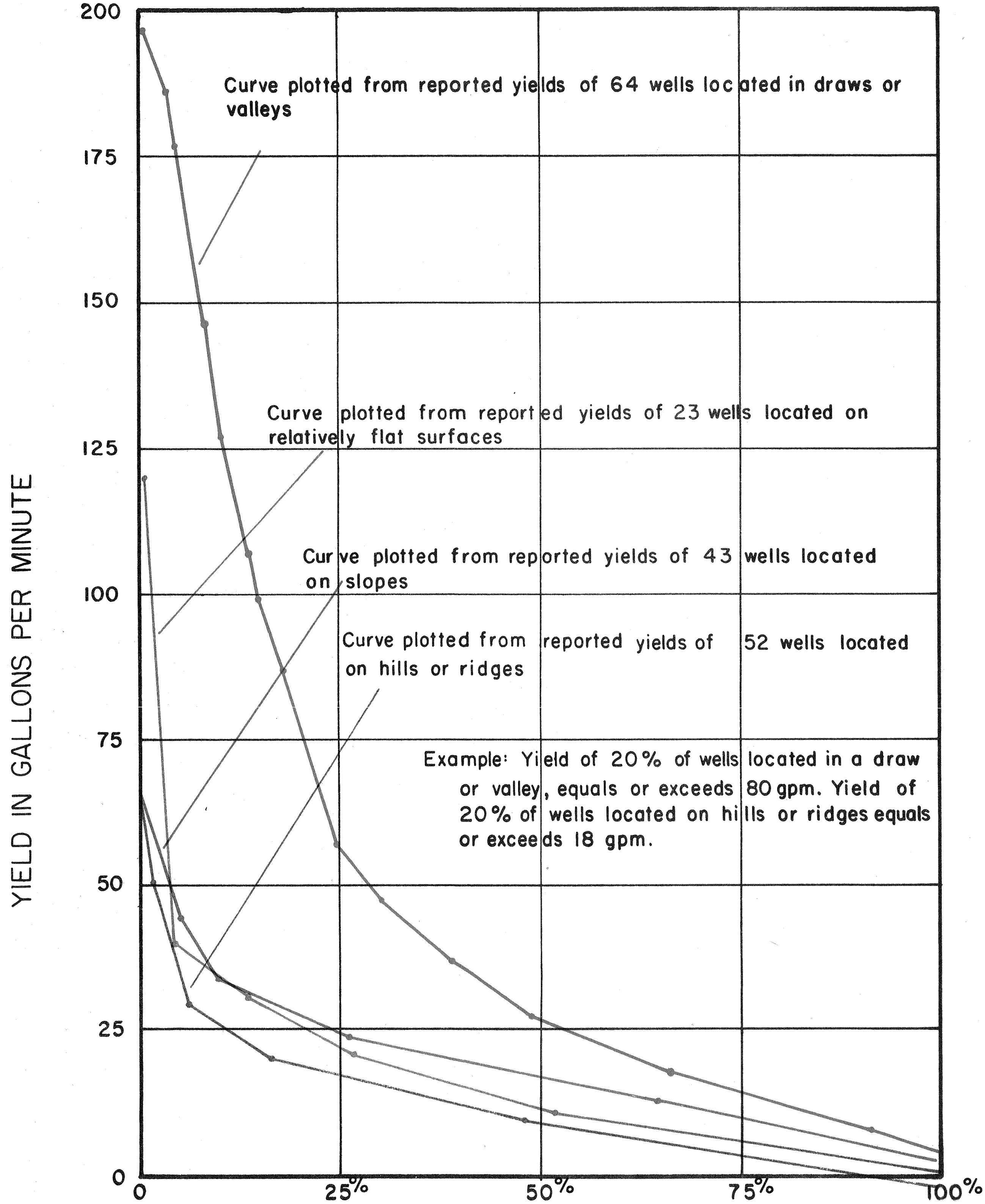


FIGURE 11 - CUMULATIVE FREQUENCY CURVES ACCORDING TO TOPOGRAPHY

QUALITY OF THE GROUND WATER

Water quality is becoming as important today as water quantity. A few years ago only industries and a few municipalities were concerned about the quality of water. Today, because of advanced technology and decreasing cost of conditioning poor quality of water, almost every industry, the majority of municipalities, and many individuals are concerned with improving the quality of the water from existing sources or finding new sources of better quality. This section of the report is intended to serve as a guide to the quality of ground water that can be developed in Cleveland County.

Chemical and Physical Characteristics

Precipitation falling toward the earth's surface contains only minor amounts of dissolved matter. However, while falling, it absorbs a small amount of carbon dioxide that later aids in dissolving minerals from the earth's crust. Upon reaching the surface, the water begins to dissolve matter from the soils and rocks through or over which it passes. The amount and kind of dissolved matter is not uniform from place to place but varies with the chemical composition of the soils and rocks, the length of time that the water is in contact with them, and the water temperature.

The chemical quality of water may limit its use for domestic, municipal, or industrial supplies, Standards for drinking water established by the U. S. Public Health Service (1962) to control the quality of water supplied by common carriers are commonly quoted as limits for drinking water. According to these standards, supplies should not contain more than 0.3 ppm (parts per million) of iron, 250 ppm of sulfate, 250 ppm of chloride, 0.8 to 1.7 ppm of fluoride (depending on the annual average of maximum daily air temperature), 45 ppm of nitrate, and 500 ppm of total dissolved solids. If water containing as little as 500 ppm of dissolved solids is not available, as much as 1,000 ppm is permissible. Table 1 lists the recommended limits of water quality of various industrial uses as suggested by the New England Water Works Association (140, p. 271).

A study of 69 laboratory analyses of water was made for this report (fig. 12, table 8). A general discussion of the principal mineral and physical characteristics of ground water in Cleveland County is given below.

Table 1. -- Suggested water-quality tolerances for selected industrial uses.[1]

Industry or use	Allowable Limits in ppm: Turbidity	Color	Hardness as $CaCO_3$	Iron Fe	Total solids	Alkalinity as $CaCO_3$	Odor, taste	Hydrogen sulfide	Other requirements
Air conditioning				[2]0.5			Low	1.	No corrosiveness, no slime formation.
Baking	10	10		[2].2			Low	.2	P[3]
Canning legumes	10		25-75	[2].2			Low	1	P
General	10			[2].2			Low	1	P
Carbonated beverages	2	10	250	.2 [2](.3)	850	50-100	Low	.2	P. No organic color. Oxygen consumed less than 10 ppm.
Cooling	50		50	[2].5				5	No corrosiveness, no slime formation.
Ice	5	5		[2].2			Low		P. SiO_2 less than 10 ppm.
Laundering			50	.2					
Tanning	20	10-100	50-135	[2].2		Total 135. Hydroxide, 8			
Textiles, general	5	20		.25					
Dyeing	5	5-20		[2].25	200				Constant composition.
Wool scouring		70		[2]1.0					
Cotton bandage	5	5		[2].2			Low		

1 After New England Water Works Assoc. Jour., v. 54, p. 271, 1940.

2 Limit given applies both to iron alone, and to the sum of iron and manganese.

3 P indicates that potable water, conforming to U. S. Public Health Service standards, is necessary.

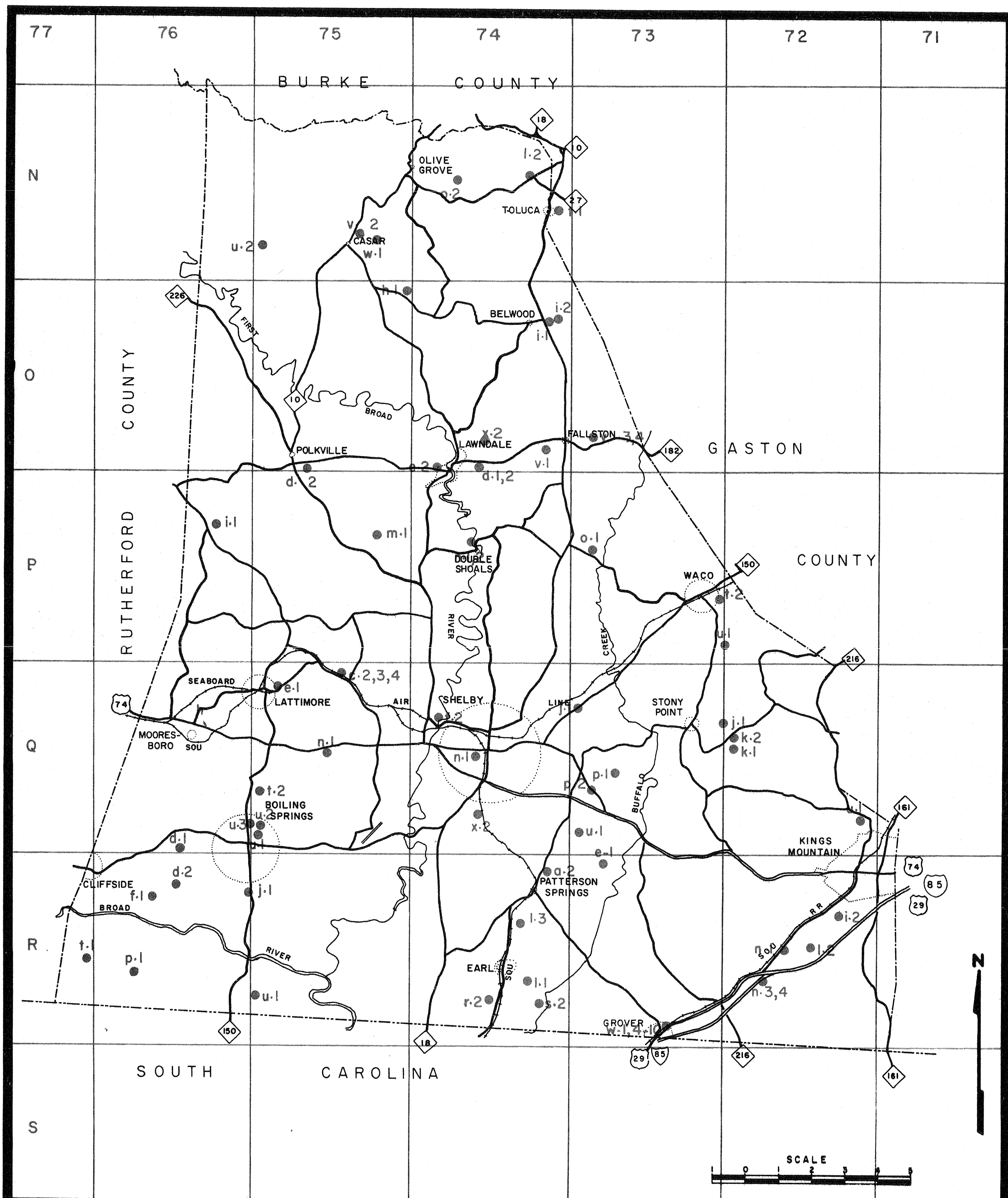


FIGURE 12-LOCATION OF WELLS SAMPLED FOR QUALITY OF WATER ANALYSIS

Alkalinity (OH, CO_3, HCO_3)

Alkalinity is the capacity of a water containing a compound or compounds to neutralize acids to a pH of 4.5. It is caused primarily by the presence of hydroxides (OH), carbonates (CO_3) and/or bicarbonates (HCO_3). It is determined by titrating a water sample with a standard-strength acid to select end points (equivalency). For hydroxide and carbonate alkalinity the end point is taken as pH 8.2 and the bicarbonate alkalinity as pH 4.5.

Analyses of 60 water samples, from wells in Cleveland County, showed a bicarbonate content range of 6 to 150 ppm and a median of 48 ppm. These concentrations have little or no effect on use of the water.

Calcium (Ca)

Calcium is dissolved from practically all rocks and particularly from calcareous rocks such as limestone. Limestone is primarily calcium carbonate and, as such, is soluble in water only up to about 13 ppm; but when the water contains carbon dioxide the limestone is changed to calcium bicarbonate and in this form is soluble in quantities up to about 1,000 ppm. Calcium and other alkaline earths impart the property of hardness to water and when present with bicarbonate or sulfate may cause boiler scale. Irrigation water that contains a high ratio of calcium to sodium is desirable because of the soil flociation it causes.

In 57 samples of water from wells in Cleveland County, the calcium content ranged from 1.8 to 29 ppm and the median was 13 ppm. Only in the extreme southeast corner of Cleveland County where some of the area is underlain by calcareous rocks would the ground water be expected to have relatively large content of calcium.

Carbon Dioxide (CO_2)

Carbon dioxide is mainly a respiration product of animals and aquatic plants and one of the by-products in the decomposition of organic matter. Free carbon dioxide is the chief cause of acidity and low pH values in ground water. The amount of carbon dioxide in water that is to be used in the making of concrete should not exceed 20 ppm. Waters that support fish should not exceed 5 ppm and it is desirable that it not exceed 1.5 ppm.

The carbon dioxide content of water from 25 wells in the County ranged from 10 to 143 ppm and the median was 43 ppm.

Chloride (Cl)

Most chlorides that occur naturally are very soluble, and most common chloride in ground water is sodium chloride or common salt. Chlorides of calcium, magnesium, and iron all add to the permanent hardness of water and may increase the corrosive action of the water. Very corrosive hydrochloric acid is released when magnesium chloride is heated. A high concentration of chloride and nitrogen is sometimes indicative of pollution by industrial, human or animal wastes.

In Cleveland County, as in most of the Mountain and Piedmont regions, natural ground water contains very low concentrations of chloride, thus local occurrences of relatively high concentrations generally indicate some pollution. Analyses of 60 water samples from wells in the County show that the chloride content ranges from 0 to 228 ppm, with the median about 10 ppm.

Color

Color in water is due to mineral, animal, or vegetable matter in solution, and is undesirable for most uses for obvious reasons. Color in water is measured in units equal to that produced by 1 mg of chloroplatinate standard per liter. The tolerable limit for domestic water supplies is generally considered to be about 20 units. Industries that need color-free water include beverage, food-processing, ice-making, laundering, photographic, and textiles.

The color content of ground water analyses of 60 water samples in Cleveland County is generally very low, they show color that ranges from 0 to 200 units.

Dissolved Solids

Dissolved solids is the residue obtained on evaporation of a water sample at 180° C for one hour. For practical purposes, it represents the total quantity of mineral constituents except those changed or volatized during heating. The tolerances of dissolved solids vary with different industries. However, few industrial processes can permit more than 1,000 ppm dissolved solids. Analyses of 54 water samples from wells in Cleveland County indicate that the dissolved-solid content ranges from about 30 to 500 ppm, with a median of about 70 ppm.

Fluoride (F)

Fluoride occurs in most natural waters in only small amounts. Water that contains more than 1.0 ppm of fluoride is associated with the dental defect known as mottled enamel, which may occur if the water is used continuously during the calcification stage of tooth formation. Rainwater and Thatcher (1960, p. 163) stated, "Available evidence indicates that water containing less than 1.0 - 0.9 ppm of fluoride seldom causes mottling of children's teeth, and the literature describing the beneficial effect of 0.88 - 1.5 ppm in drinking water as an aid in the reduction of tooth decay in children is abundant."

Analyses of 49 water samples from wells in Cleveland County indicate that the fluoride content of the ground water ranges from 0 to 0.5 ppm, well within acceptable limits.

Hardness

Hardness of water is the property attributable to the presence of the two principal alkaline earths, calcium and magnesium. It results from the solution of the alkaline-earth minerals from the soil and rocks. Hardness in conjunction with other chemical properties is an indication of the soap consuming power of the water. Hardness of water causes incrustations of calcium and magnesium carbonate to form in pipes and boilers and, depending on the industry, the tolerances may vary from less than 2 ppm to more than 100 ppm. The following is a common classification of water hardness:

Hardness as $CaCO_3$	Classification
0 - 60 ppm	soft
61 - 120 ppm	moderately hard
121 - 180 ppm	hard
181 or more	very hard

As indicated by analyses of 69 samples of water from wells in Cleveland County the ground water is generally soft to slightly hard. The total hardness of these samples ranged from 10 to 103 ppm and the median was 40 ppm.

Iron

Iron concentration of more than 0.3 ppm in water may precipitate and form an insoluble hydroxide that results in reddish-brown stains on kitchen and bath room fixtures and on clothing. Industrial tolerances of iron varies, but excessive (more than 0.3 ppm) iron is unsuitable for laundries, food manufacturing, paper, ice, and some phases of textile manufacturing.

Analyses of 66 water samples from wells in Cleveland County show a range in iron content of ground water from 0 to 5.75 ppm and with a median of 0.1 ppm.

Nitrogen (NO_2 and/or NO_3)

The N. C. Division of Ground Water test for nitrogen includes both nitrate (NO_3) and nitrite (NO_2). As nitrite (NO_2) is unstable in the presence of oxygen and is absent or present only in minute quantities in most ground waters, it is assumed that all the nitrogen reported in table 3 is nitrate (NO_3) nitrogen.

Nitrate in ground water is attributed to the decomposition of organic material in the soil and by the oxidation of nitrogen of the air by bacteria. It may also be added directly to a water resource by fertilizer. A high concentration of nitrate and chloride is sometimes indicative of pollution by human or animal waste. Nitrates in large amounts are injurious to the dyeing of wool and silk and are undesirable in fermentation processes.

The nitrogen content of 49 samples of ground water in Cleveland County ranged from 0 to 33 ppm with a median of .8 ppm.

pH

The pH of a water sample is a measure of the hydrogen-ion activity and is expressed by a number denoting the negative logarithm of the concentration of the hydrogen ions. The pH numbers range from 0 to 14. The number 7.0 indicates neutrality, a pH progressively greater than 7.0 denotes increasing alkalinity, and a pH progressively less than 7.0 denotes increasing acidity. The pH of a water generally indicates its corrosive activity on metal surfaces. As the pH increases, the corrosive activity of water normally decreases; however, excessively alkaline waters are corrosive to some metals, particularly zinc. Extremes in pH cannot usually be tolerated by industry.

Analyses of 66 samples of water from wells in Cleveland County show that the ground water is generally acidic. The pH values ranged from 5.3 to 8.3 and the median was 6.2

Silica

Water occurring in rocks high in silicate minerals often contain up to 60 ppm of silica. The rocks that underlie Cleveland County contain some quartz and feldspar, therefore, most of the ground water will probably contain varying amounts of silica. Except for boilers operating at 400 pounds per square inch, having an upper limit for silica of 1 ppm, industrial processes can usually tolerate the silica content found in natural waters.

The silica content of water from 49 wells in Cleveland County ranged from 9 to 45 ppm with a median of 24 ppm.

Specific Conductance

The specific conductance is a measure of the ability of the water to carry an electric current and is, indirectly, a measure of the mineral content expressed in mhos or micromhos. Because conductance varies with temperature, the specific conductance is based on a standard temperature of 25° C.

The specific conductance was determined as a part of the analyses of water from Cleveland County and is used as a general index of mineral content. The specific conductance of 54 samples ranged from less than 50 to 745 micromhos and the median was 104 micromhos.

Sulfate (SO_4)

Sulfate is present in most rocks and is a common constituent in ground water. The sulfate content of ground water is not very critical in many industrial processes; however, when present in sufficient quantity, it combines with calcium and magnesium to form a hard boiler scale.

The sulfate content determined on 49 water samples ranged from 0 to 26 ppm and the median was 5 ppm.

Turbidity

Turbidity is the optical property of water with reference to how much light is scattered or absorbed by suspended material in a water sample when a light is viewed through the sample. It is a function of the partial sizes and the concentration of the suspended material. Turbid water is abrasive to pipes and pumps and most industrial tolerances are under 20 Jackson units.

The North Carolina Division of Ground Water expresses turbidity as Jackson units. The reader should note that in table 8, the turbidities calculated by the N. C. State Board of Health are apparently expressed in parts per million. The turbidity determined on 42 samples of water ranged from 0 to 70 Jackson units.

Odor and Temperature

The ground water analyzed during this study, was free of any odors. The cause of odor in the water samples from well 073y-3 was due to ferric (Fe^{+3}) iron deposit inside the casing. If this well were used regularly, the iron would be flushed from the casing and no odor would result.

The temperature of 15 samples ranged from 58° to 63° F and median was 60.5° F.

Water Quality in Relation to Geologic Units

Ground-water quality in any area depends primarily on the type of soils and rocks with which the percolating water has been in contact. Therefore, the chemical character of the water should reflect the general mineral composition of the reservoir rock. As a part of the study, comparison was made of the mineral content of the ground water and the major geologic units underlying Cleveland County, which are the mica schist and gneiss complex, Kings Mountain Group, Toluca Quartz Monzonite, and Cherryville Quartz Monzonite (fig. 5). The median determinations of the different ground-water constituents versus rock types are shown in table 2. The ranges of specific conductance and pH in Cleveland County are illustrated in figures 13 and 14, respectively. They show a definite relationship to the underlying geologic rock unit. When plotted on a map, the iron determinations do not show any definite pattern or relationship either within a geologic rock unit or between different geologic units. Accumulation of additional data may eventually permit determination of some relationship between the iron content of the water and the geology or other factors.

Stiff diagrams were constructed to represent the chemical compositions of ground water that occur in the rocks of Cleveland County by plotting the major cations (positive ions) against the major anions (negative ions) from the water analyses (fig. 15). Because the comparison of cations to anions is an atomic weight relationship, it is necessary to use equivalents per

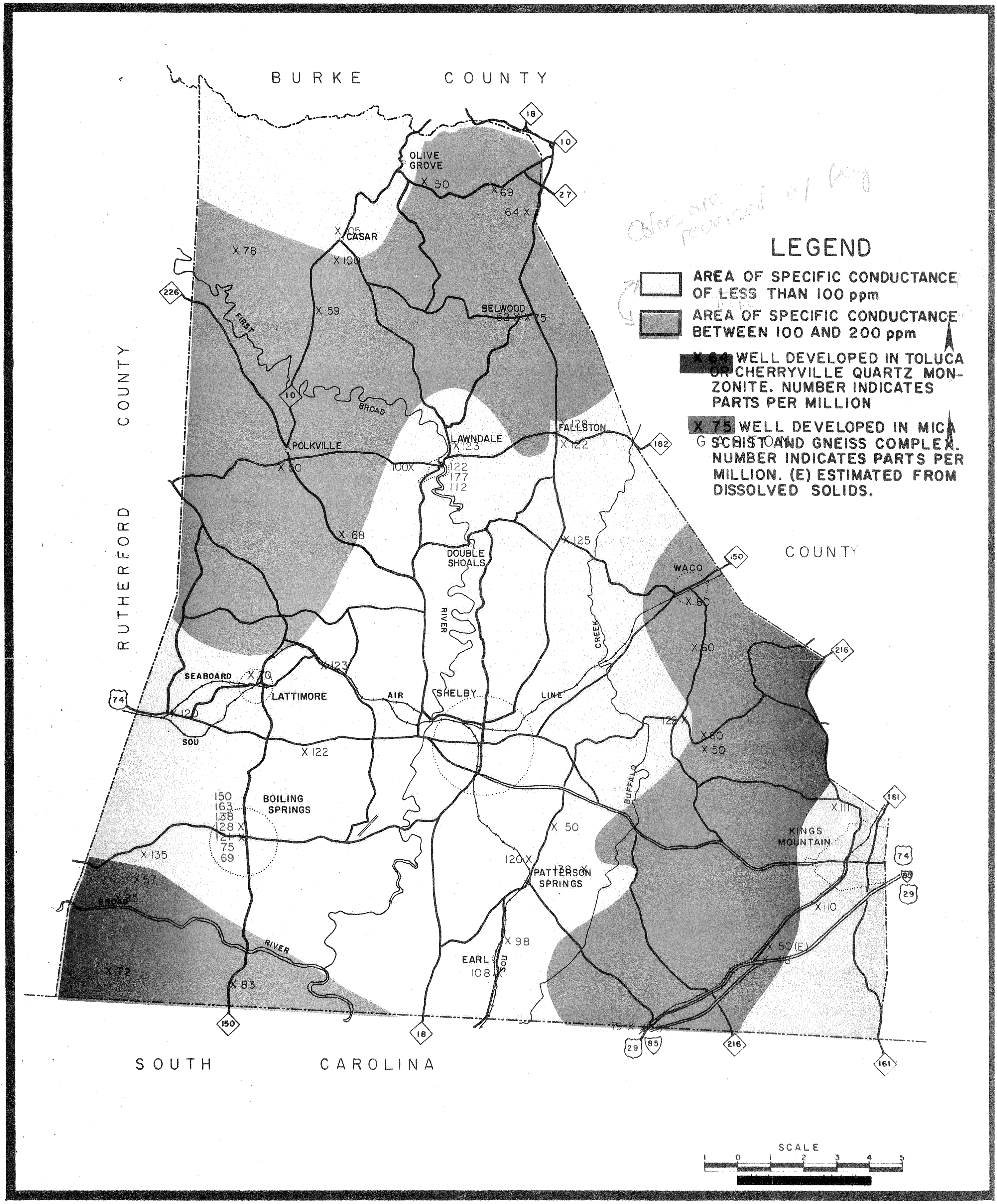


FIGURE 13-RANGE OF SPECIFIC CONDUCTANCE VALUES FOR GROUND-WATER

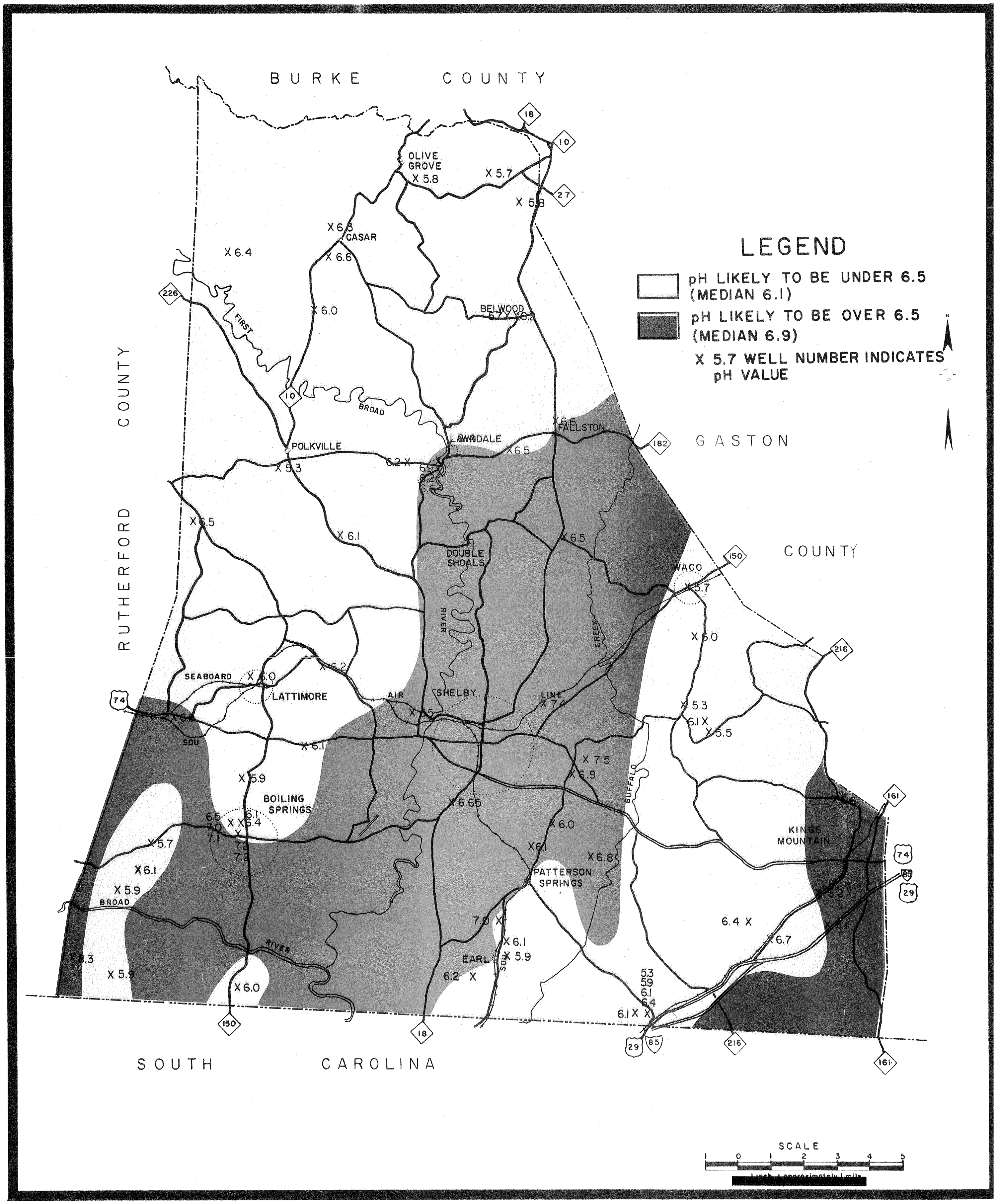


FIGURE 14-RANGE OF pH VALUES FOR GROUND-WATER

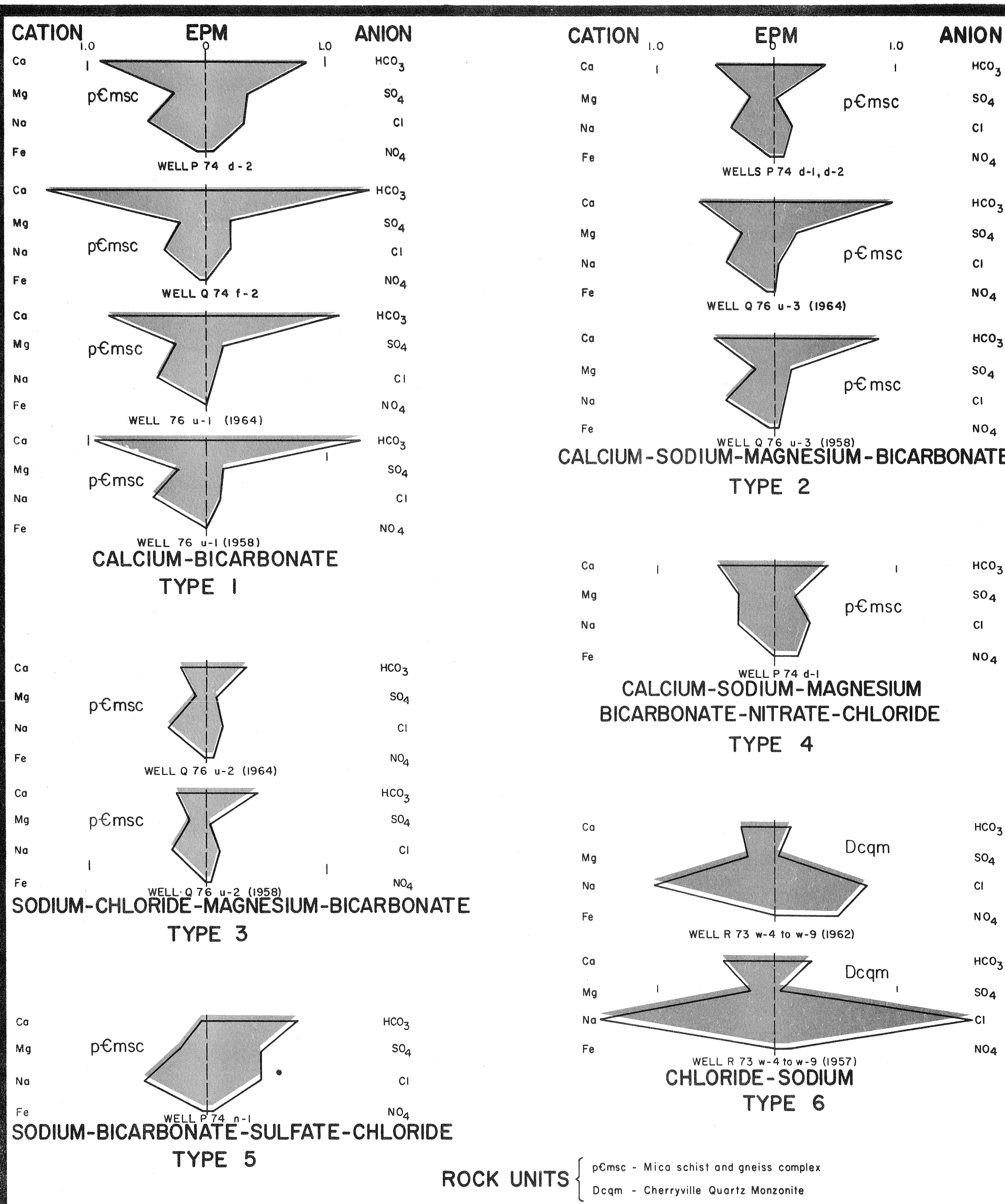


FIGURE 15-STIFF DIAGRAMS ILLUSTRATING GROUND-WATER TYPES IN CLEVELAND CO.

Table 2. -- Medians of Ground-Water Constituents Correlated with Rock Units

$\frac{35}{10}$ - $\frac{\text{median, in ppm}}{\text{number of samples}}$

Constituent	Bicarbonate Alkalinity	Calcium	Carbon Dioxide	Chloride	Color	Dissolved Solids	Fluoride	Hardness (total)	Iron	Nitrogen (NO_2 & NO_3)	pH	Silica	Spec. Cond.	Sulfate	Turbidity	Temperature
Mica Schist and Gneiss Complex	50/43	14/35	47/16	8.5/51	2/41	70/37	0.0/33	47/47	0.15/46	0.5/33	6.3/44	24/33	106/36	5/33	0/26	60.5/11
Toluca Quartz Monzonite	68/6	14/7	14/3	12/6	0/8	51/6	0.0/5	38/6	0.08/8	1.8/5	6.1/8	27/5	69/7	4/5	0/7	—
Cherryville Quartz Monzonite	35/10	7/12	44/5	19/12	0/10	65/10	0.0/10	30/15	0.08/11	1.4/10	6.0/13	26/10	85/10	4/10	0/7	60.7/4

million (epm) rather than the customary parts per million. In this report the major cations were calcium, magnesium, sodium, and iron and the major anions were bicarbonate, sulfate, chloride, and nitrate. These diagrams, or patterns, can be used as guidelines to compare types of water to types of rocks.

Six types of ground water occur in the county as follows:

Type 1 - calcium-bicarbonate
Type 2 - calcium-sodium-magnesium-bicarbonate
Type 3 - sodium-calcium-magnesium-bicarbonate
Type 4 - calcium-sodium-magnesium-bicarbonate-nitrate-chloride
Type 5 - sodium-bicarbonate-sulfate-chloride
Type 6 - sodium-chloride

By naming only the cation and the anion that has the greatest ionic action, the water classification can be reduced to three general types: calcium-bicarbonate; sodium-chloride; and sodium-bicarbonate.

Mica Schist and Gneiss Complex

The quality of ground water occurring in the mica schist and gneiss complex is good to excellent, the dissolved mineral content being relatively low. The water is classified as soft, having a median hardness of 47 ppm. Although several water samples from the schist and gneiss complex had a slightly high iron content, about two-thirds of the samples had an iron content lower than the U. S. Public Health's recommended limit of 0.3 ppm. The iron content ranged from 0 to more than 5 ppm and had a median of 0.15 ppm. The schist and gneiss will generally yield water with a specific conductance of 100 to 170 micromhos and a pH greater than 6.5 (figs. 13 and 14).

Classification of water in the mica schist and gneiss complex, based on analyses of 11 samples from 7 different wells, includes types 1, 2, 3, 4, and 5 (fig. 15). The different cations are most likely due to differences in the feldspar minerals within the rock unit. The calcium is probably from solution of plagioclase feldspars, having a general chemical composition of $CaAl_2Si_2O_8$, and the sodium from orthoclase feldspars, with a general chemical composition of $Na(K)AlSi_3O_8$. Bicarbonate is the most common anion, as it is generally in excess of the chlorides, nitrates, and sulfates in the schist and gneiss complex. Bicarbonate anions are formed by the reaction of carbon dioxide, usually in the form of H_2CO_3, with available cations, usually in the form of $CaCO_3$ or Na_2CO_3. All of the bicarbonate-forming minerals are readily available in the mica schist and gneiss complex that underlies Cleveland County.

Kings Mountain Group

The Kings Mountain Group was excluded from table 2 as only one sample of water (Well R721-1) was analyzed from the Group. This sample had the highest hardness content (103 ppm) recorded during this study. A relatively high hardness content should be more characteristic of water in the Kings Mountain than water in adjacent geologic formations, because of the weathered beds of marble and calcareous metashales that occur in the Group. All other mineral determinations of water from this sample were within the high and low ranges shown in the section entitled "Chemical and Physical Characteristics".

Ground water from the Kings Mountain Group was not classified by type because the analysis of water from Well R721-2 was incomplete; however, the proportion of bicarbonate anions to the other anions is of such magnitude that it can be reasonably assumed to be the major anion in all water from the Kings Mountain Group.

Toluca Quartz Monzonite

Ground water from the Toluca Quartz Monzonite had the lowest dissolved solids content and specific conductance of any water analyzed and listed in this report (tables 8 and 2). The low mineral content in water from the Toluca Monzonite is also illustrated by comparing the map showing the range of specific conductance (fig. 13) with the geologic map (fig. 5). The medians in table 2 show that the water occurring in the Toluca is very good to excellent. The iron content will be troublesome in isolated areas, but the iron median (0.08 ppm) is very low.

The pH of the ground water from the Toluca Quartz Monzonite is about the same as the pH of the Cherryville Quartz Monzonite. However, the water is slightly more acidic (lower pH) than water from the mica schist and gneiss complex. This latter comparison would be expected, as the schist and gneiss complex contain more hornblende, a basic mineral. Also, both the monzonite units may contain slightly more orthoclase feldspar, and acid mineral, than the rocks in the complex.

The ground water from the Toluca Quartz monzonite was not classified by type because of the lack of complete mineral analyses from the rock unit. However, a study of tables 8 and 2 indicates that about half of all wells drilled in the Toluca will yield Type 2 (calcium-sodium-magnesium-bicarbonate) water, about one-fourth will yield Type 1 (calcium-bicarbonate) water, and about one-fourth will yield Type 3 (sodium-calcium-magnesium-bicarbonate) water.

Cherryville Quartz Monzonite

The Cherryville Quartz Monzonite yields water of very good to excellent quality. The median calcium and hardness contents were the lowest recorded during this study. The iron content of water from the formation, as in other geologic units in Cleveland County, may be a problem at certain localities. However, the median content for iron in water occurring in the Cherryville rocks was very low (0.08 ppm). The Cherryville Quartz Monzonite underlies most of the area between Grover and Kings Mountain and, as may be noted in figures 13 and 14, water from this region has a lower specific conductance and pH than that of the adjacent rock units.

Ground water from the Cherryville Quartz Monzonite has a close chemical similarity to ground water from the Toluca Monzonite (table 2). Both contain water with higher chloride and nitrogen content than that of the mica schist and gneiss complex. The median iron content is low in waters from both monzonite units, and the pH median values are only one logarithmic unit different, 6.0 to 6.1. However, the high and low limits of the Cherryville are lower than the Toluca. The pH of water from the Cherryville Monzonite ranges from 5.3 to 6.7, and that from the Toluca Monzonite from 5.7 to 7.0 (table 8).

Ground water occurring in the Cherryville Quartz Monzonite is classified as Type 6 (sodium-chloride), as determined from two samples, both of which were composite samples from the same six wells (R73w-4 to 9). Stiff diagrams were also plotted for two other wells (Mundorff and LeGrand, wells no. 111 and 112, p. 46, 1952) in the immediate area and these diagrams also showed Type 6 water. It is possible that the two wells are included in the composite of the six listed above, however, the well-construction data of these two wells would not correspond with the data for any of the wells in use. Thus, because of the uncertain identity of the wells from which the samples were taken, the diagrams are not included in this report.

During collection of basic data in the Grover area, the authors of this report observed a varicolored, industrial-liquid waste being discharged into a drainage ditch about 50 feet from well R73w-4. The analyses of water from this well (table 8, p.52) strongly indicates that the ground water in the immediate area is being contaminated. Therefore, the composite sample, which includes water from well R73w-4 probably is not representative of the water type occurring naturally in the Cherryville Quartz Monzonite.

Analyses of water from other wells developed in the Cherryville Quartz Monzonite show that bicarbonate has the most ionic action, however, the major cation was not determined for these samples. The mineral composition of the Cherryville Monzonite indicates that either calcium or sodium is the principal cation, thus the type water occurring in the Cherryville Quartz Monzonite in Cleveland County is probably calcium or sodium-bicarbonate. Only in isolated wells, where contamination is a distinct possibility, would a sodium-chloride water be expected.

Flood-plain Deposits

Ground water from the flood-plain deposits was not analyzed for this study. However, based on the study of reports from other areas and general knowledge, the water from the flood-plain sediments should be very low in dissolved minerals. Bicarbonate is probably the major anion and either calcium or sodium the major cation.

UTILIZATION OF GROUND WATER

Ground water supplies all the water requirements of the people of Cleveland County except those living in the town of Shelby and Kings Mountain. The ground-water supplies are generally obtained from drilled or bored wells. Springs are the source of a few domestic and stock supplies in the County, but the use of springs has greatly declined in recent years.

Domestic Supplies

In Cleveland County, about two-thirds of the population (about 40,000 people) depend on ground water for their domestic needs. Using the national average of 100 gallons of water per person per day for domestic needs, ground-water use would be about 4,000,000 gpd (gallons per day) in Cleveland County. Wells for domestic supplies in the County range from about 1,500 gpd to about 288,000 gpd (table 7) and the average domestic well will average about 18,000 gpd. With some foresight and choice in selecting the well site, the present average or greater yields can be developed from domestic wells in Cleveland County.

Public Supplies

Ground water is the source of many public water supplies in Cleveland County, including municipal supplies for the towns of Boiling Springs, Fallston, Grover and Lawndale, water supplies for 19 schools, several small privately owned water systems, several recreational areas, restaurants, motels and private clubs.

The approximate quantities of water available from existing wells of municipal systems are as follows:

	No. Wells	Gallons per day
Boiling Springs	5	500,000
Fallston	5	300,000
Grover	4	175,000
Lawndale - served in part by Cleveland Mills		

Industrial Supplies

Many of the industries in Cleveland County depend either entirely or partially on ground water for their needs. The results of this investigation indicate that by using care in selecting well sites, ground-water supplies of 100,000 to 1,000,000 gallons per day can be developed in most areas of the county. The approximate quantities of ground water available from existing systems of selected industries in Cleveland County are shown below:

Carnation Company	40,000 gallons per day
Cleveland Mills Co.	80,000
Craftspun Yarns, Inc.	150,000
Dover Mill Company	600,000
Ester Mill Corp.	90,000
Fiber Industries	1,000,000
Kings Mountain Mfg. Co.	125,000
Mass. Mohair Plush Co., Inc. Neisler Mills, Div.	700,000
Minette Mills, Inc.	490,000
Park Yarn Mills, Co.	140,000
Ora Mill, Inc.	100,000
Pittsburg Plate Glass Co.	200,000

The immediate vicinity of the Town of Grover and Minette Mills is the only place in the County where present ground-water development appears to be approaching the maximum. Further ground-water exploration in the Grover area should be done in areas adjacent to the present boundaries of the town and mill to expand the supply.

Shelby and Kings Mountain have areas zoned for industry, most of which are served by the municipal systems. However, many industries within the two towns have wells to supply a part of their water needs (table 7). Doubtlessly, considerable quantities of ground water are available at some of the properties zoned for industry. The Town of Fallston has a 65-acre industrial park and an adjoining 60 acres to be developed in the future. A reconnaissance of the industrial park was made and an area of potentially productive well sites was selected (fig. 16). A drilling program to determine the availability of water for industries at the park would be a great asset toward its development.

The lateral-type or collector-type well used by Fiber Industries is of special interest in the collection and reporting of data for industrial water in Cleveland County. This well is located on Buffalo Creek south of Patterson Springs and is the only known well of this type construction in the state (fig. 17).

The collector-type well is generally constructed in sands and gravels adjacent to a stream or other body of surface water, and consists of a large-diameter central well with radiating lateral screens. The sands and

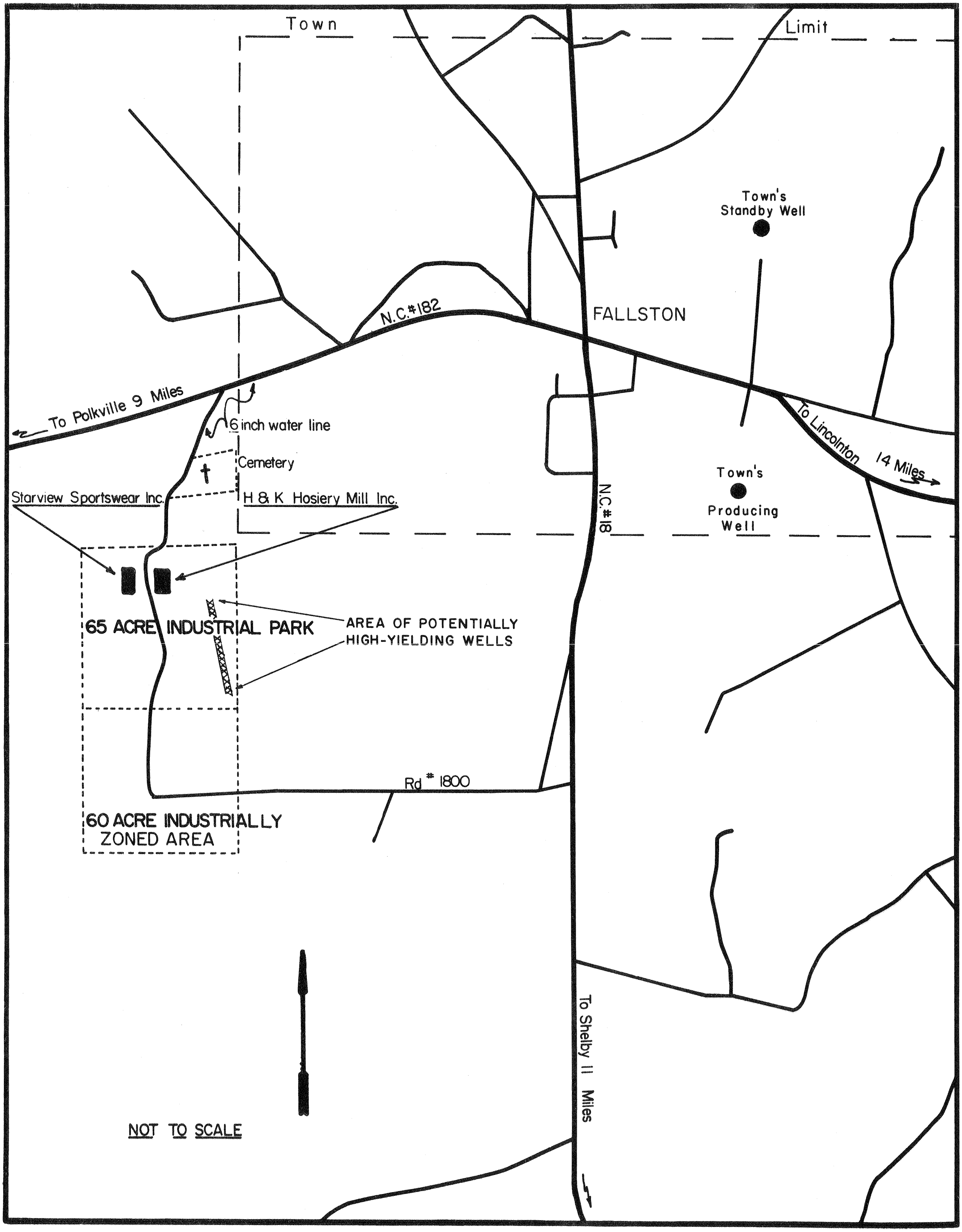


FIGURE 16 - MAP OF FALLSTON SHOWING INDUSTRIAL PARK AND WELL SITES

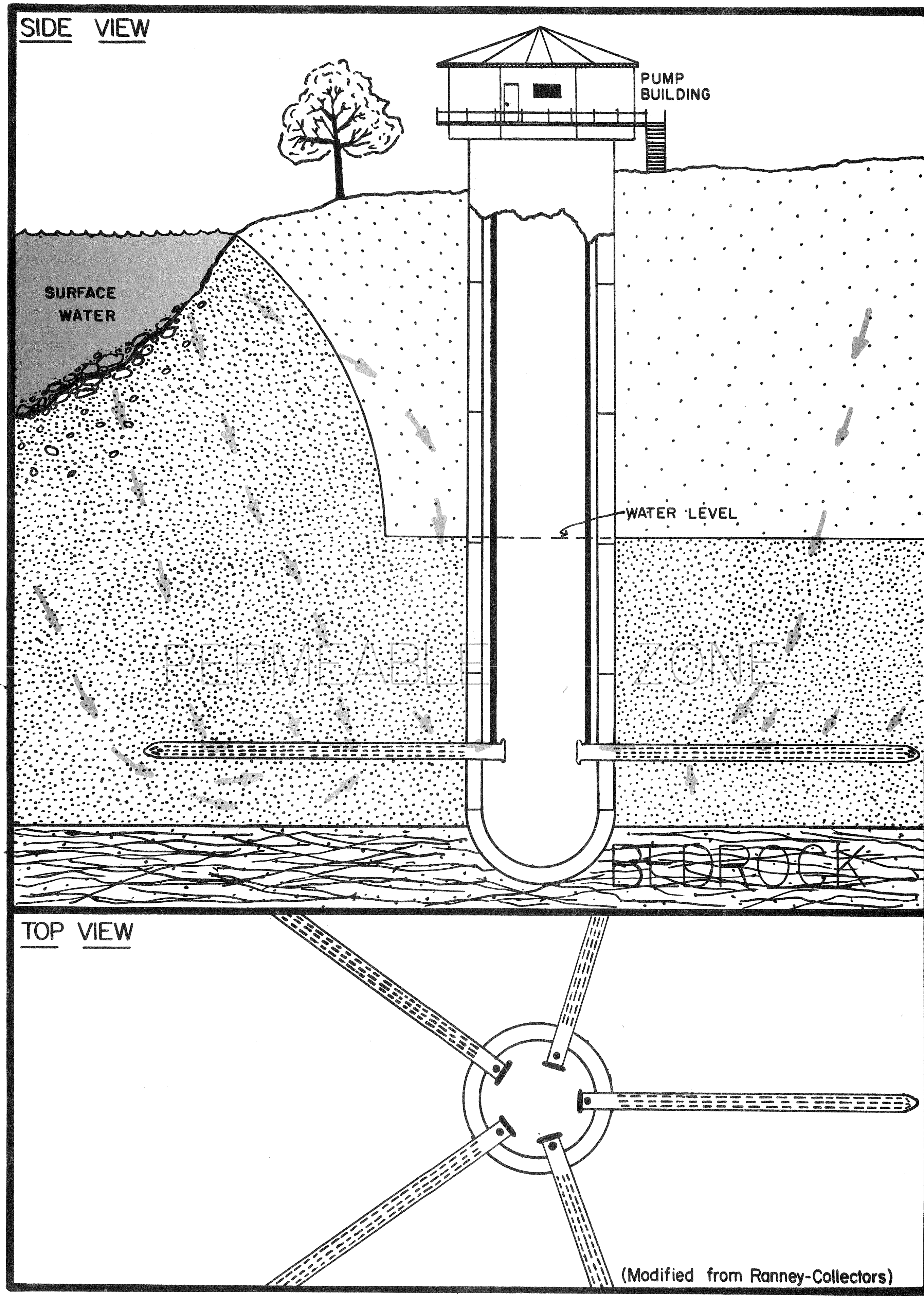


FIGURE 17 - DIAGRAM SHOWING LATERAL-TYPE WELL

gravels yield water from storage and also serve as a natural filter for recharge from the surface-water source. Industries requiring moderate to large quantities of water should consider sites where such systems may be feasible.

Sources of Emergency Water Supplies

Much emphasis is presently being placed on state-wide planning for possible emergency situations such as storms, floods and other natural disasters as well as nuclear explosions. Planning for disaster conditions should include the establishment of a system of emergency sources for an adequate water supply for the entire population.

Existing or new wells offer the most practical approach to emergency water supplies, as biologic or radioactive contamination of the ground-water sources is remote, suitable wells are available in all areas, and protection of the facility and the installation of emergency power supplies or even manual pumps would be relatively inexpensive.

Some of the wells that might be included in a system of emergency water supplies are listed below (see fig. 3 and table 7):

Community	Well Number	Gallons Per Day (approx.)	Community	Well Number	Gallons Per Day (approx.)
Casar	N75v-2	30,000	Lattimore	Q75c-2	60,000
	N75v-3	50,000		Q75c-4	60,000
	N75y-1	30,000	Shelby	073o-2	50,000
Belwood	N74v-1	40,000		Q73w-3	200,000
	074i-1	100,000		Q74f-3	200,000
Polkville	075x-1	40,000		Q74f-4	150,000
	P75d-1	50,000		Q74h-2	200,000
Lawndale	074w-1	100,000	Boiling Springs	Municipal Wells	
	P74d-1	30,000	Patterson Springs	R74g-3	30,000
	P74d-2	30,000	Kings Mountain	Q75y-1	60,000
Fallston	073y-3	150,000		R72b-1	50,000
	073y-4	75,000		R72h-1	80,000
	074u-3	80,000		R72h-11	100,000
Double Shoals	P74n-1	10,000		R72k-2	120,000
Waco	P73h-1	35,000	Earl	R74s-3	25,000
	Q73f-2	150,000	Grover	Municipal Wells	

FUTURE DEVELOPMENT OF GROUND WATER

The ground-water resources of Cleveland County have been developed only to a very limited extent. Assuming that only 10 percent of the annual precipitation of about 440 billion gallons is added to the ground water reservoir, the recharge to all aquifers is about 44 billion gallons annually. Thus, the estimated average annual use of 3 billion gallons is less than 7 percent of the assumed total recharge. The extent to which the draft on ground water can be increased and sustained will depend largely on whether a proper balance can be achieved locally between the rate of withdrawal from wells and the rate of replenishment of ground water. No accurate estimates are available on the percentage of the precipitation that reaches the zones of saturation in the bedrock or the direction and rate of movement of the ground water. Investigations to provide such information would include an extensive network of water-level observation wells to map and record any long-term downward trends in water levels, aquifer tests to determine their hydraulic and hydrologic characteristics, and periodic sampling of water to determine physical, chemical and bacteriological changes that may occur.

Ground-water supplies of at least a few thousand gallons per day, adequate for domestic and similar purposes, can be obtained almost anywhere in the area from individual wells tapping the bedrock aquifers. In areas of concentrated housing, where each dwelling is served by a bedrock well, interference between pumps and possible contamination by sewage-disposal systems may be potential problems in ground-water development. Such problems may be avoided or minimized by adequately spacing and properly constructing wells and providing a central sewage system. In most areas, a central water supply obtained from a few wells, located at the most favorable sites and isolated from potential sources of contamination, offers the most practical approach to ground-water development for community supplies.

Moderate to large supplies of ground water--sufficient for most industrial, commercial, and municipal uses--can be obtained from most of the geologic formations of Cleveland County. Rock-types capable of yielding moderate supplies to individual wells (100-200+ gpm) are the mica schist and gneiss complex, Kings Mountain Group, Toluca quartz monzonite, and the Cherryville quartz monzonite. There are many favorable sites for ground-water development in the areas underlain by each of these rock types, and consideration should be given to reserving some of the most favorable sites for water-supply development. A few such sites are briefly described below.

A favorable site for potential ground-water development is located on an unnamed tributary of Beaverdam Creek, 1.4 miles northeast of the center of Boiling Springs and 0.4 miles south of the intersection of County Roads 1158 and 1159. This area is underlain by interlayered biotite schist and gneiss, and sillimanite-muscovite schist and gneiss. The schists and gneisses have been intruded by numerous pegmatite sills and dikes.

In the Fallston area, favorable drilling sites are located in a small area southwest of the town and immediately east of Moss Pond. Here the mica schist and gneiss complex has been intruded by Toluca quartz monzonite and pegmatite dikes and should be considered as a potential source of additional ground-water supplies.

Favorable drilling sites in the Lawndale area are located east of First Broad River and south of Fallston Road. This area is underlain by biotite schist and gneiss that have been intruded by massive quartz-biotite pegmatites occurring in large dikes, sills, and irregular masses. These massive pegmatites are oriented in a northwest-southeast direction with a maximum length of about one mile and a maximum width of approximately 0.3 mile.

At the present time, the ground-water resources in and around the town of Grover and Minette Mills have been developed at or near their maximum. Data gathered during the investigation indicate the occurrence of well interferences and the gradual decline of well yields. These yields, in some instances, have declined as much as 25-30 percent. In this area of approximately one-quarter square mile, 25 wells have been drilled--11 of which have been abandoned. Of the remaining 14, 10 are pumped and the remaining 4 used as stand-by wells.

Future development should be located outside this area. Favorable drilling sites exist in well-developed draws both north and west of the town along Jakes Branch and Lick Branch. Wells in these areas should provide any additional ground water that is needed and would not be affected by the present ground-water withdrawals in Grover.

The flood-plain deposits occurring along the major streams of the County are also a potential source of large quantities of ground water. Test drillings, to determine the thickness and permeability of these deposits, would be required to locate the most favorable areas for development. As an aid in determining productive localities, future plans of the North Carolina Division of Ground Water include a program of exploratory drilling and testing to systematically evaluate the flood-plain aquifers of the entire region.

SURFACE WATER

Surface and ground water are such closely related components of the hydrologic cycle that objective long-range planning for water-resource development and management cannot be accomplished without understanding and consideration of this relationship. Together, they comprise the available sources of water supply from precipitation, and this interrelation is reflected by the sustained flow of surface streams during periods between rains, by the occurrence of springs and seeps along stream beds, and the close correlation of stream discharge with ground-water levels.

The many factors that determine the availability of both surface and ground-water include (1) the total amount, areal and seasonal distribution, and intensity of precipitation; (2) air temperature; (3) physiography: (4) distribution and type of vegetation; (5) texture, porosity and permeability of surface materials; and (6) permeability and porosity of the ground-water reservoir.

The surface-water resources of Cleveland County consist of the major streams and their tributaries, small farm ponds, and other impoundments (fig. 18). Adequate water supplies of good quality are available for present and projected future requirements from surface sources. The existing public and industrial surface water-supply facilities are listed in tables 8 and 2. Future plans of the towns of Shelby and Kings Mountain include the addition of new sources of withdrawal from Broad River and Buffalo Creek.

Three continuous stream-gaging stations are maintained cooperatively by the Department of Water Resources and the U. S. Geological Survey in Cleveland County, and another is located just across the county line in Rutherford County. Streamflow data compiled from these four stations are shown in table 3. Data on the chemical and physical character of the water at these stations are shown in table 4.

Table 3. --Public surface-water facilities in Cleveland County, N. C.

Community	Population served	Estimated use (mgd)	Design capacity (mgd)	Treatment	Source
Kings Mountain	8,200	0.700	2.000	Conventional	Davidson and Sipes Creeks
Shelby	17,000	2.300	4.000	Conventional with pre-chlorination	First Broad River

Table 4. --Industrial surface-water facilities in Cleveland County, N. C.

Location and industry	Average use (mgd)	Impounded	Treatment	Source
Cliffside				
Duke Power Company	280.0 (1)	No	Conventional	Broad River
Grover				
Allen Mica Company	0.015	No	None	Tributary to Buffalo Creek
Cleveland Mica Co.	0.030	Yes	None	Kings Creek
Minette Mills, Inc. (2)	0.222	Yes	None	Tributary Jakes Branch
Kings Mountain				
Foote Mineral Company	14.000	Yes	Ferric Floc. caustic soda	South Creek
Superior Stone Co.	16.000	Yes	None	Kings Creek
Cleveland Mill Co.	0.300	Yes	Alum coagulation filtration	Bracketts Creek

(1) Includes 9 gpm used for domestic purposes after conventional treatment and 60 gpm used for boiler-feed purposes after conventional treatment, less chlorination. Remainder used for cooling.

(2) Supplements ground-water supply.

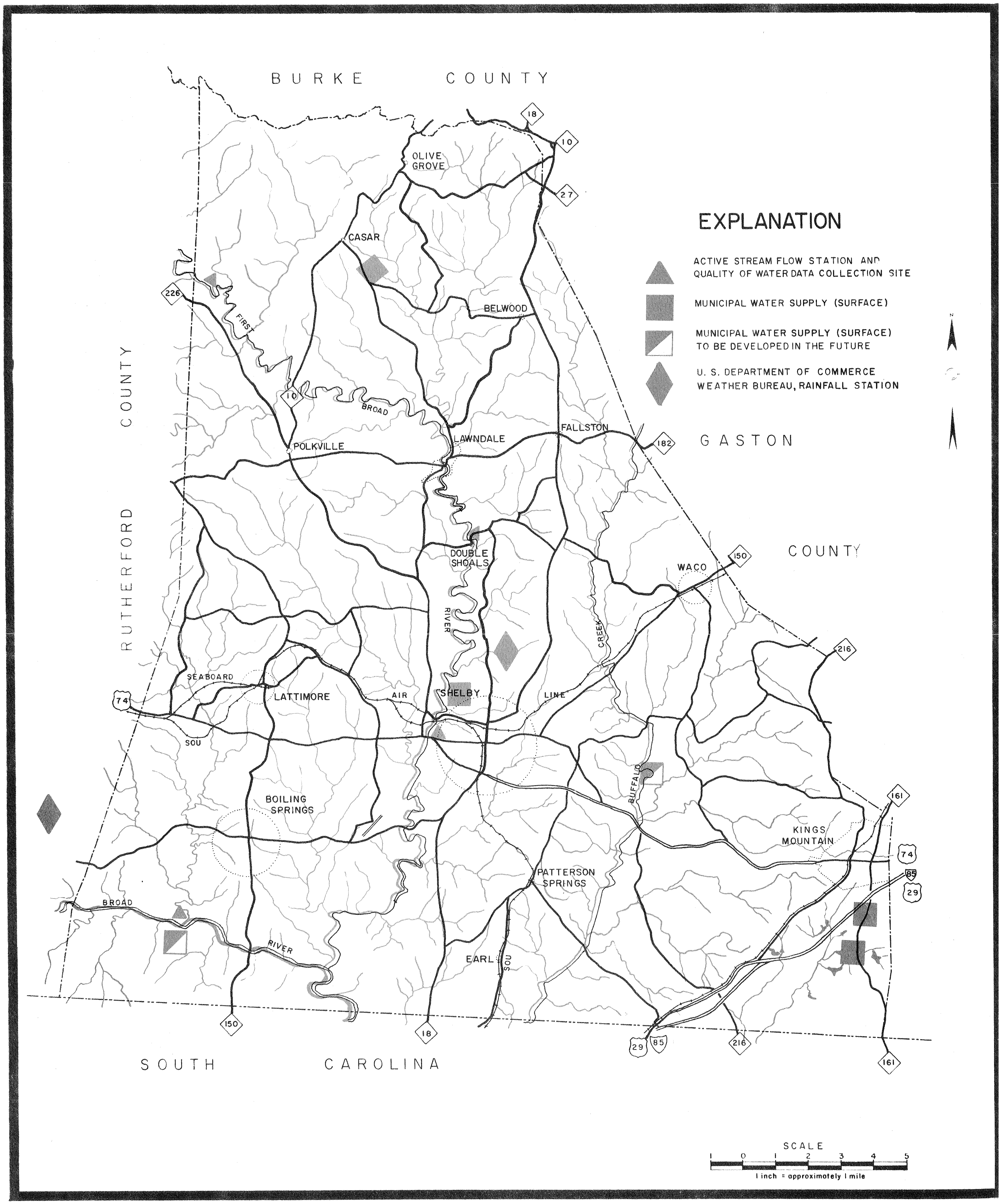


FIGURE 18-SURFACE-WATER RESOURCES

Table 5.--Stream-discharge measurements in Cleveland County, N. C.

Location (fig. 19)	Stream	Years of record	Average discharge (cfs*)	Extremes	
				minimum	maximum
A	Broad River near Boiling Springs, N.C.	1925-1961	1,414 cfs	40 cfs, Oct. 17, 1954	73,000 cfs, Aug. 16, 1928
B	Second Broad River at Cliffside, N. C. (Rutherford County)	1925-1961	294 cfs	4 cfs, Sept. 27, 1935 Aug. 3, 1937 July 24, 1943	15,000 cfs, Aug. 14, 1940
C	First Broad River near Casar, N.C.	1959-1961	----	30 cfs, Aug. 17-20-23 24, 1959	3,700 cfs, Oct. 10, 1959
D	First Broad River near Lawndale, N.C.	1940-1961	271 cfs	13 cfs, Sept. 18, 1955	32,500 cfs, Aug. 14, 1940

*Cubic feet per second

Table 6. —Chemical and physical character of surface water in Cleveland County, N. C.

Station	Broad River near Boiling Springs		First Broad River near Casar		First Broad River near Lawndale		First Broad River at Shelby
Discharge (cfs)	1,224	1,444	42.4	85.4	171	252.0	--
Silica (SiO_2)	14	14	14	14	11	12	10
Iron (Fe)	.02	.01	.06	.10	.01	.00	.05
Calcium (Ca)	2.7	2.7	2.2	2.9	2.4	2.4	2.9
Magnesium (Mg)	1.3	.9	1.1	1.0	1.2	1.1	.9
Sodium (Na)	3.7	2.6	2.3	2.0	2.3	2.3	3.5
Potassium (K)	1.0	.9	0.7	1.2	1.1	1.3	1.3
Bicarbonate (HCO_3)	16	16	16	16	16	16	18
Sulfate (SO_4)	1.4	4.0	2.0	1.2	1.8	1.6	4.6
Chloride (Cl)	2.0	1.1	1.5	2.6	2.5	2.4	3.0
Fluoride (F)	.1	.1	0.0	0.0	0.1	0.0	0.0
Nitrate (NO_3)	1.4	1.2	0.3	0.3	0.7	0.7	0.4
Dissolved Solids	36	38	32	33	31	32	36
Hardness as $CaCO_3$:							
Calcium, Magnesium	12	11	10	11	11	10	10
Noncarbonate	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Specific Conductance (micromhos at 25°C.)	38	38	36	38	39	36	45
pH	7.4	6.9	7.0	7.0	6.5	6.9	6.6
Color	10	15	8	27	5	10	10
Date	1-61	7-61	1-61	7-61	1-61	7-61	1-61

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TABLE 7. -- Records of Wells in Cleveland County, North Carolina.

1 Quadrangle and Well Number	2 Location (Nearest Town)	3 Owner	4 Driller	5 Date Drilled	6 Depth of Well	7 Casing Depth (feet)	Casing Diameter (in.)	8 Yield	9 Use	10 Water Bearing Formation	11 Remarks
N741-1	Toluca	J. B. Smith	Crotts & Cagle Well Company	1958	210	20	6	0.5	Dom	Otqm	ridge; wl-30'
1-2	...do..........	C. Barrier	...do..........	1965	150	--	6	5	Dom	Otqm	draw; A
n-1	...do..........	V. Cook	...do..........	1954	65	20	6	10	Dom	msh	hill; wl-20'; contains fe
n-2	...do..........	P. Johnson	...do..........	1955	186	15	6	1	Dom	tqm	slope
n-3	...do..........	A. Walker	...do..........	1965	165	50	6	1.5	Dom	msh	slope; wl-60'
o-1	...do..........	G. Glover	...do..........	1964	85	25	6	30	Dom	msh	slope; wl-30'
o-2	...do..........	C. Buff	...do..........	----	---	--	6	----	Dom	msh	ridge; A
t-1	...do..........	Edwards Nursing Home	Va. Machine Co.	1-17-42	410	26	8	15	P.S.	Otqm	flat; A
v-1	Belwood	K. Sain	Southeastern Well Corp.	----	65	31	6	40	Dom	msh	
N75v-1	Casar	A.A. Richards & J. L. McNeilly	Faw Drilling Co.	----	522	62	6	9	Dom	msh	draw; hardness rept. 20 ppm.
v-2	...do..........	C. A. Britain	....	----	447	43	6	30+	Dom	msh	slope; A
v-3	...do..........	A.A. Richards	Faw Drilling Co.	----	535	55±	6	50	Dom	msh	
v-4	...do..........	....	Lindsay Drg. Co.	----	209	30	6	5	Dom	msh	
w-1	...do..........	Casar School	....	----	190	--	6	7	P.S.	msh	hill; A
w-2	...do..........	K. Allen	....	----	114	31	6	5	Dom	msh	hill
w-3	...do..........	B. Hildebran	Crotts and Cagle Well Company	----	350	40	6	.5	Dom	msh	hill
w-4	...do..........	R. Smith	Lindsay Drg. Co.	----	79	60	6	20	Dom	msh	valley
w-5	...do..........	E. Coston	...do..........	----	70	40	6	30	Dom	msh	slope
y-1	...do..........	R. Stencil	...do..........	----	193	45	6	30+	Dom	msh	slope
y-2	...do..........	G. Meade	...do..........	----	150	35	6	2.5	Dom	msh	hill
y-3	...do..........	C. Lindsey	...do..........	----	166	40	6	20	Dom	msh	hill
y-4	...do..........	New Home Methodist Church	...do..........	----	290	50	6	20	P.S.	msh	slope
N76t-1	...do..........	O. Wall	Lindsay Brths.	----	92	50	6	35	Dom	msh	hill; Dug 50'
u-1	...do..........	F. White	Lindsay Drg. Co.	----	121	21	6	2	Dom	msh	hill
u-2	...do..........	C. Lindsay	...do..........	----	166	40	6	1.5	Dom	msh	ridge; A
u-3	...do..........	J. R. Price	...do..........	----	259	--	6	----	Dom	msh	hill; hardness rept. 40 ppm.
u-4	...do..........	R. C. Fortonberry	...do..........	----	70	47	6	4.5	Dom	msh	hill; wl-46'; dug 46'
073f-1	Belwood	M.I. Lutz & B. Lutz	Hickory Well Drg Company	----	165	56	6	25	Dom	msh	hill; dug 56'
f-2	...do..........	L. Wilson	Hoke Drg. Co.	----	190	50	6	30	Dom	Otqm	slope; hardness rept. 70 ppm.
p-1	Fallston	Town of Fallston	Southeastern Well Corp.	----	---	--	6	6	P.S.	msh	draw; not used
y-1	...do..........	Y. Beam	Va. Machine Co.	----	130	--	6	7	Dom	msh	slope; wl-25'
y-2	...do..........	Town of Fallston	South. Well Corp	----	350	--	6	3	P.S.	msh	flat; not used
y-3	...do..........	...do..........	...do..........	----	152	--	6	142	P.S.	msh	draw; A; not used
y-4	...do..........	...do..........	...do..........	----	212	--	6	75.5	P.S.	msh	draw; A
074i-1	Belwood	Elmore & Peeler	...do..........	7-63	94	69.5	6	90	Ind	msh	draw; A; supply for poultry farm
i-2	...do..........	Belwood School	....	----	185	--	6	----	P.S.	msh	hill; A; supplies 407 students
o-1	Lawndale	S. Ivester	....	----	50	--	24	----	Dom	sap	hill; hard.rept. 30p pm
u-1	Fallston	Town of Fallston	South. Well Corp	----	262	--	6	7	P.S.	msh	flat; not used
u-2	...do..........	Fallston School	....	----	57	--	6	30	P.S.	msh	hill; not used
u-3	...do..........	J. S. Cline	A.B. Taylor Drilling Co.	----	122.5	45	6	80	Dom	msh	hardness rept. 40 ppm
v-1	...do..........	Philadelphia Sch.	....	----	---	--	--	----	P.S.	Otqm	slope; A; supplies 268 students.
w-1	Lawndale	Burns School	South. Well Corp	3-15-66	333	39	6	100+	P.S.	msh	draw
x-1	...do..........	H. Cline	...do..........	----	105	46	6	20	Dom	msh	
x-2	...do..........	Piedmont School	....	----	---	--	--	----	P.S.	msh	slope; A; supplies 369 students
y-1	...do..........	Century Construction Company	Suburban Well Drillers	7-2-65	125	35	5.5	12	P.S.	msh	hill; wl-38'
075a-1	Casar	C. Harrison	Lindsay Drg. Co.	----	143	31	6	12	Dom	msh	slope
e-1	...do..........	A. H. Logan	Cecil Linsey	----	110	--	6	20	Dom	msh	hill; hard. rept. 40 ppm
f-1	Polkville	S. Proctor	Lindsay Drg. Co.	----	70	--	6	4	Dom	msh	slope
h-1	Casar	L. Martin	...do..........	----	150	102	6	20	Ind.	msh	slope; A; supplies poultry farm
i-1	...do..........	W. Walker	South. Well Corp	10-22-63	158	101	6	30	Dom	msh	
j-1	...do..........	C. R. Turner	Kirby Drg. Co.	----	149	--	6	1	Dom	Otqm	hill
j-2	Lawndale	J. C. Downs	Will Barrow	----	80	--	6	----	Dom	msh	
n-1	Polkville	Brackets Cedar Pk.	Lindsay Drg Co.	----	70		6	15	P.S.	msh	slope

Key to abbreviations:

Column 1 - See page 5 for description of well-numbering system.
Column 9 - Dom: Domestic; Ind: Industrial; P.S.: Public Supply.
Column 10- all: alluvium; Dcqm: Cherryville quartz monzonite; Pzkm: Kings Mountain group; mgn: mica gneiss; msh: mica schist; sap: saprolite; Otqm: Toluca quartz monzonite.
Column 11- A: chemical analysis; Abd: abandoned; wl: water level below land surface.

1 Quadrangle and Well Number	2 Location (Nearest Town)	3 Owner	4 Driller	5 Date Drilled	6 Depth of Well	7 Casing Depth (feet)	Casing Diameter (in.)	8 Yield	9 Use	10 Water Bearing Formation	11 Remarks
o-1	...do..........	A.R. Hollands	...do..........	----	72	58	6	10	Dom	msh	
o-2	...do..........	...do..........	...do..........	----	280	--	6	0	Dom	msh	Abd.
v-1	...do..........	J. Shalley	...do..........	1965	150	44	6	2	Dom	msh	
v-2	...do..........	Palm Tree Church	Claude Hoke	----	480	--	4	0	P.S.	msh	hill; abd.
v-3	...do..........	D. Shuford	South. Well Corp	----	173	63	8	25	Dom	msh	
v-4	...do..........	P. Shuford	...do..........	----	185	41	6	10	Dom	msh	
x-1	...do..........	S. Elliot	....	----	119	--	6	40	Dom	msh	draw; wl-19'; formerly supplied cotton gin
076b-1	Casar	O. S. Hunt	Lindsay Drg. Co.	----	120	80	6	30	Dom	msh	
P73e-1	Fallston	W. A. Royster	Va. Machine Co.	----	139	--	6	5	Dom	msh	slope; hard.rept. 35ppm
h-1	Waco	V. V. Wright	South. Well Corp	7-29-64	138	48	6	36	Dom	msh	
o-1	Fallston	M. Beam	...do..........	----	445	85	6	30	Dom	msh	A
t-1	Waco	Town of Waco	Boggs Drg. Co.	----	110	--	3	9+	P.S.	msh	slope; wl-12'; hardness rept. 40 ppm
t-2	...do..........	Waco School	Robbins Drg. Co.	----	148	--	6	23	P.S.	Dcqm	slope; hard.rept. 30ppm
t-3	...do..........	A. W. Black	Boggs Drg. Co.	----	106	--	3	1	Dom	Dcqm	slope; wl-20'; hard. rept. 30 ppm
P73t-4	Waco	M. C. Whitworth	Robbins Drg. Co.	----	158	---	6	30	Dom	Dcqm	wl-34'
u-1	...do..........	Wash. School	....	----	---	---	--	---	P.S.	Dcqm	A
x-1	...do..........	R. W. Morris	South. Well Corp	----	245	36	6	2	Dom	msh	
P74d-1	Lawndale	Cleveland Mills	Robbins Drg. Co.	----	150	---	6	30	Ind	msh	valley; A
d-2	...do..........	...do..........	...do..........	----	150	---	6	30	Ind	msh	valley; A
e-1	...do..........	Century Cons. Co	Hick. W. Drg. Co	8-16-65	105	30	5.5	5	Dom	msh	hill; wl-30'
e-2	...do..........	Douglas School	....	----	---	---	--	---	P.S.	msh	slope; A
n-1	Double Shoals	D. Shoals Mill	Va. Machine Co.	----	200	---	6	12	Ind	msh	draw; A
n-2	...do..........	...do..........	....	----	42	---	6	4	Ind	msh	slope
n-3	...do..........	...do..........	Va. Machine Co.	----	190	---	6	10	Ind	msh	valley
v-1	Shelby	J. S. Cline	South. Well Corp	5-28-64	305	100	6	5	Dom	msh	
P75d-1	Polkville	J. L. Hunt	Lindsay Drg. Co.	----	204	45	6	47	Dom	msh	hill; wl-54'
d-2	...do..........	Polkville School	....	----	---	---	--	---	P.S.	msh	flat; A; supplies studs.
d-3	...do..........	...do..........	Robbins Drg. Co.	----	147	---	6	10	P.S.	msh	hill
j-1	...do..........	J. White	Lindsay Drg. Co.	1965	116	70	6	12	Dom	msh	
m-1	...do..........	R. Gold	South. Well Corp	----	148	106	6	12	Dom	msh	flat; A
P76i-1	...do..........	K. E. Mauney	....	----	---	---	--	---	Dom	Otqm	A
Q71y-1	Kings Mountain	M. Scism	Surb. Well Drs.	5-13-65	125	85	6	30	Dom	Pzkm	flat; wl-15'
y-2	...do..........	W. Kennedy	South. Well Corp	10-9-64	225	163	--	20	Dom	Pzkm	
Q72h-1	...do..........	J. L. Hallman	...do..........	3-25-63	149	33	8	15	Dom	Dcqm	
s-1	...do..........	J. W. Black	Ralph Robbins	----	111.5	90	6	28	Dom	mgn	slope; wl-13'
u-1	...do..........	K. Mt. Mica Co.	Spearman	----	---	---	--	---	Ind	mgn	slope; A
y-1	...do..........	G. Hoyle	....	2-21-64	185	51	6	60	Dom	Dcqm	
Q73a-1	Stony Point	C. C. Rhyne	....	----	46	46	24	---	Dom	sap	hill; hardness rept. 45ppm; wl-38'
a-2	Waco	W. Ross	South. Well Corp	----	205	65	--	2	Dom	Dcqm	
d-1	Shelby	Harrison & Walker Mill Company	....	----	35	35	30	---	Ind	sap	slope; hard. rept. 30ppm; wl-30'
e-1	...do..........	L. R. Walker	....	----	50	50	30	---	Dom	sap	hard. rept. 40ppm; wl-35'
f-1	...do..........	G. A. Spake	....	---	25	25	24	---	Dom	sap	hill; hard. rept. 30ppm; wl-21'
f-2	Waco	P. F. Morton	South. Well Corp	10-15-64	430	66	--	150	Dom	msh	
i-1	Stony Point	Mt. Olive Baptist Church	Surb. Well Drs.	6-2-65	154	60	6	9	P.S.	Dcqm	flat; 4gpm @ 90', 5gpm @ 138'
i-2	...do..........	F. Harmon	Robbins Drg. Co.	----	128	---	6	20	Dom	Dcqm	draw; wl-46'
j-1	...do..........	J. Goforth	....	----	92	60	6	---	Dom	Dcqm	hill; A
k-1	...do..........	A. Hoyle	....	----	86	86	36	---	Dom	Otqm	hill; A
k-2	...do..........	J. F. Wallace	....	----	---	---	6	---	Dom	Otqm	hill; A; small yield
o-1	Shelby	J. White	Surb. Well Drs.	2-13-64	300	---	--	0	Dom	Otqm	hill; abd.
o-2	...do..........	...do..........	...do..........	2-17-64	155	58.5	5.5	56	Dom	Otqm	hill; wl-15'; casing slotted 46-53'
o-3	...do..........	U. L. Patterson	Va. Machine Co.	----	500	80	6	23	Dom	msh	hill; wl-30'
o-4	...do..........	...do..........	Robbins Drg. Co.	----	83	---	6	20	Dom	msh	draw; hard. rept 30ppm
p-1	...do..........	St. Prison Dept.	....	----	285	---	--	22	P.S.	msh	draw; A
p-2	...do..........	D. Beam	....	----	---	---	--	---	Dom	msh	A
q-1	...do..........	C. Thrift	South. Well Corp	----	118	47	--	12	Dom	msh	
q-2	...do..........	B. Randell	...do..........	1-8-64	145	52	--	15	Dom	msh	
r-1	Stony Point	C. Austell & G. Carpenter	....	----	265	---	6	---	Dom	msh	hill; adeq. supply
s-1	...do..........	...do..........	....	----	92	---	6	---	Dom	msh	hill; hard. rept. 30ppm; wl-53'
w-1	Shelby	F. Shytle	Robbins Drg. Co.	----	185	115	6	15	Dom	msh	hill; hard.rept. 30ppm
w-2	...do..........	...do..........	...do..........	----	145	10	6	15	Dom	Dcqm	hill; hard.rept. 49ppm
w-3	...do..........	Shelby Moose Lodge	South. Well Corp	3-1966	363	75	6	200	P.S.	Dcqm	valley; 1gpm @ 120'
x-1	...do..........	P. Harmon	Suburban Well Drs	10-22-65	250	70	7	4	Dom	Dcqm	ridge; wl-50'
Q74a-1	...do..........	F. S. Dedmon	....	----	100	---	6	---	P.S.	msh	flat; used by 5 families
b-1	...do..........	G. E. Sperling	Robbins Drg. Co.	----	95 to 100	---	6	4	Dom	msh	slope; hard. rept. 30ppm; wl-46.6'
b-2	...do..........	E. P. McSwain & L. E. Ludlum	....	----	260	---	6	---	P.S.	msh	flat; supplies 9 families
f-1	...do..........	Radio Sta. WADA	South. Well Corp	----	145	55	6	20	Dom	msh	
f-2	...do..........	Dover Mills Co.	A. B. Taylor Drg. Company	----	165	---	6	50	Ind	mgn-msh	valley; A; artesian; temp. 61°F.
f-3	...do..........	...do..........	....	----	200	40	6	180	Ind	mgn-msh	valley
f-4	...do..........	...do..........	....	----	225	42	6	150	Ind	mgn-msh	draw
f-5	...do..........	...do..........	....	----	203	43	6	53	Ind	mgn-msh	draw
f-6	...do..........	...do..........	A.B. Taylor Drg.	----	165	---	6	40	Ind	mgn-msh	valley; hard rept 65ppm
f-7	...do..........	...do..........	...do..........	----	165	---	6	20	Ind	mgn-msh	valley; hard rept 45 ppm; temp. 60.5°F

1	2	3	4	5	6	7		8	9	10	11
Quadrangle and Well Number	Location (Nearest Town)	Owner	Driller	Date Drilled	Depth of Well	Casing		Yield	Use	Water Bearing Formation	Remarks
						Depth (feet)	Diameter (in.)				
h-1	...do.........	Carnation Co.	....	----	200±	---	6	30	Ind	mgn-msh	slope; hard rept 40ppm
h-2	...do.........	J. Gold	South. Well Corp	3-1966	365	31	6	200	Dom	mgn-msh	draw
j-1	...do.........	J. Eubanks	....	----	---	---	---	---	Dom	msh	A
l-1	...do.........	Ester Mills Corp	....	----	262	35	---	50	Ind	mgn-msh	
l-2	...do.........	...do.........	A.B. Taylor Drg.	----	150	40	6	15	Ind	mgn-msh	slope; wl-17.5'
m-1	...do.........	Shelby Cotton Mill	....	----	100	---	6	2	Ind	mgn-msh	slope
m-2	...do.........	...do.........	Va. Machine Co.	----	1213	---	8	10	Ind	mgn-msh	abd
m-3	...do.........	...do.........	A.B. Taylor Drg.	----	288	---	6	10	Ind	mgn-msh	flat
n-1	...do.........	E. Hamrick	....	----	---	---	---	---	Dom	mgn-msh	A
q-1	...do.........	P. Young	Camp Bros. Drg.Co	4-24-64	112	30	6	6	Dom	msh	flat; wl-30'
q-2	...do.........	...do.........	...do.........	6-1-64	70	33	6	40	Dom	msh	flat; wl-20'
r-1	...do.........	...do.........	...do.........	9-23-64	130	30	6	4	Dom	msh	hill; wl-30'
r-2	...do.........	Belmont Mills	....	----	200-300	---	6	5	Ind	mgn-msh	flat; hard rept 15ppm
r-3	...do.........	Lily Mills Co.	Robbins Drg. Co.	----	186	---	6	5	Ind	mgn-msh	slope; wl-5.25'; not in use
Q74r-4	Shelby	Lily Mills Co.	Robbins Drg. Co.	----	104	48	6	20	Ind	mgn-msh	draw; hard rept 40 ppm; temp. 61.5°F; artesian
s-1	...do.........	D. Hawkins	....	----	30	30	30	---	Dom	sap	hill; hard rept 15 ppm; wl-25'
s-2	...do.........	W. Gant	....	----	429	---	6	---	Dom	msh	hill; hard rept 15ppm; small yield
t-1	...do.........	Z. V. Cline	Va. Machine Co.	----	108	---	6	---	P.S.	msh	hill; hard rept 30ppm; supplies 5 families
u-1	...do.........	B. B. Rhyne	South. Well Corp	10-17-62	153	---	6	---	P.S.	msh	A; sup. small subdiv.
x-1	...do.........	M. L. Spake	....	----	24	---	24	---	Dom	sap	flat; hard rept 20ppm; wl-21'; adeq. supply
x-2	...do.........	F. Young	....	----	---	---	---	---	P.S.	mgn-msh	A; sup. several homes
Q75c-1	Lattimore	R. Scruggs	Camp Bros. Drg.Co.	4-8-65	105	50	6	18	Dom	Otqm	ridge
c-2	...do.........	Pittsburg Plate Glass Co. Fiber Glass Div.	South. Well Corp	9-1959	230	---	6	60	Ind	mgn-msh	slope; A
c-3	...do.........	...do.........	...do.........	9-1959	255	---	6	30	Ind	mgn-msh	slope; A
c-4	...do.........	...do.........	...do.........	----	260	---	---	60	Ind	mgn-msh	slope; A
e-1	...do.........	Lattimore School	...do.........	7-10-64	185	57	6	30	P.S.	mgn-msh	flat; A
e-2	...do.........	...do.........	....	----	110	---	6	15+	P.S.	mgn-msh	flat
j-1	Shelby	Ora Mill Company	....	----	180	---	6	20	Ind	mgn-msh	slope; hard rept 30ppm
j-2	...do.........	...do.........	....	----	150	---	6	30	Ind	mgn-msh	draw; hard rept 30 ppm wl-11'; temp. 61°F
j-3	...do.........	...do.........	....	----	150	---	6	30	Ind	mgn-msh	draw; hard rept 35 ppm wl-11'; temp. 61°F
k-1	...do.........	S. E. Jones	....	----	75	75	18	---	Dom	sap	wl-65'
k-2	...do.........	G. Blanton	....	----	210	---	6	10+	Dom	mgn-msh	slope
k-3	...do.........	G. Blanton & C. H. Church	....	----	54	---	6	---	Dom	msh	slope; wl-54'
l-1	...do.........	C.C. Blanton & W. C. Davidson	....	----	100	---	6	---	Dom	msh	hill; wl-45.5'; adeq. supply
n-1	Lattimore	L. Rogers	....	----	75	---	6	50	Dom	mgn-msh	A
o-1	...do.........	M. B. Hastings	....	----	18	18	24	---	Dom	sap	draw; hard. rept. 45ppm wl-7.2'
p-1	Boiling Springs	M. Philbeck	South. Well Corp	----	205	57.5	---	3	Dom	mgn-msh	
s-1	Shelby	Crest School	...do.........	11-9-65	398	---	6	0	P.S.	mgn-msh	Abd
s-2	...do.........	...do.........	...do.........	11-10-65	205	69	6	4	P.S.	mgn-msh	slope
s-3	...do.........	...do.........	...do.........	11-12-65	305	32	6	42.5	P.S.	mgn-msh	draw
u-1	...do.........	G. Hambrick & B. L. Poston	....	----	35	---	35	---	Dom	sap	hard rept 25ppm; wl-31'
y-1	Boiling Springs	Town of B. Sprgs.	South. Well Corp	10-19-65	225	60	6	185	P.S.	mgn-msh	draw; wl-13'
Q76a-1	Lattimore	P. D. Crowder	A.B. Taylor Drg.	----	485	---	6	---	Dom	mgn-msh	flat; wl-30'; abund sup.
a-2	...do.........	J. B. Lattimore	....	----	230	---	6	.5	Dom	mgn-msh	hill
h-1	Mooresboro	Mooresboro School	....	----	70	---	6	10+	P.S.	msh	slope; A; wl-25'
h-2	...do.........	...do.........	South. Well Corp	----	240	---	---	20	P.S.	msh	slope
k-1	...do.........	B. Bruce	Camp Bros. Drg Co	1-11-64	171	12	6	15	Dom	mgn-msh	hill; wl-20'
k-2	Lattimore	G. L. Hamrick	....	----	128	---	6	6	Dom	mgn-msh	hill
t-1	Boiling Springs	B. Rhyne	Lindsay Drg. Co.	----	150	108	---	15	Dom	mgn-msh	
t-2	...do.........	P. Navy	....	----	---	---	---	---	Dom	mgn-msh	A
u-1	...do.........	Town of B. Sprgs.	Faw Drilling Co.	----	455	---	---	40	P.S.	mgn-msh	draw; A
u-2	...do.........	...do.........	...do.........	----	350	---	---	25	P.S.	mgn-msh	draw; A
u-3	...do.........	...do.........	McSwain	----	354	---	---	125	P.S.	mgn-msh	draw; A
u-4	...do.........	A. K. Green	....	----	110	---	6	---	Dom	mgn-msh	flat
y-1	Mooresboro	G. Franklin	Camp Bros. Drg Co	8-14-64	89	80	6	7	Dom	msh	hill; wl-40'
R71f-1	Kings Mountain	C. Bumgardner	South. Well Corp	6-23-64	118	66	---	12	Dom	Pzkm	
R72a-1	...do.........	K. Mt. Mfg. Co.	....	----	60	---	120	60	Ind	msh	formerly shaft of tin mine
b-1	...do.........	E. Harmon	South. Well Corp	3-1966	103	20	6	50	Dom	mgn	
c-1	...do.........	T. D. Tindale	...do.........	1-2-64	205	103	6	6	Dom	Dcqm	
d-1	...do.........	Z. F. Crawford	....	----	200	---	6	---	Dom	Dcqm	hill; abundant supply
e-1	...do.........	Bethward School	....	----	332	---	6	18	P.S.	Dcqm	slope
e-2	...do.........	...do.........	....	----	62	62	24	---	P.S.	sap	slope; not in use
f-1	...do.........	....	Sub. Well Drg.Co.	6-14-65	75	40	6	15	Dom	Dcqm	wl-40'
f-2	...do.........	Bethlehem Vol. Fire Dept.	...do.........	5-31-65	305	68	6	5	P.S.	Dcqm	flat
h-1	...do.........	Neisler Mills	Robbins Drg. Co.	----	90	90	8-6	80	Ind	msh	draw
h-2	...do.........	...do.........	Va. Machine Co.	8-25-41	430	129	8	30	Ind	msh	hill; wl-57'
h-3	...do.........	...do.........	...do.........	8-2-41	262	61	8	16	Ind	msh	hill; wl-53'
h-4	...do.........	...do.........	....	----	211	---	6	5	Ind	msh	flat; not used
h-5	...do.........	...do.........	....	----	220	---	6	---	Ind	msh	flat
h-6	...do.........	...do.........	Robbins Drg. Co.	----	181 3/4	120	6	35	Ind	msh	flat
h-7	...do.........	...do.........	....	----	151	---	6	---	Ind	msh	flat; abd

1 Quadrangle and Well Number	2 Location (Nearest Town)	3 Owner	4 Driller	5 Date Drilled	6 Depth of Well	7 Casing Depth (feet)	Casing Diameter (in.)	8 Yield	9 Use	10 Water Bearing Formation	11 Remarks
h-8	...do.........	...do.........	Robbins Drg. Co.	----	147.5	32	8	55	Ind	msh	draw; wl-15'
h-9	...do.........	...do.........	Va. Machine Co.	----	750	---	8	60	Ind	msh	draw
h-10	...do.........	...do.........	....	----	150 or 200	---	6	12	Ind	msh	flat
h-11	...do.........	...do.........	Neisler Mills	----	212	0	6	100	Ind	msh	draw; wl-12'
h-12	...do.........	...do.........	...do..........	----	265	100	6	40	Ind	msh	draw
h-13	...do.........	...do.........	Hickory W. Drg Co	12-2-47	603	101	6	33	Ind	msh	draw
h-14	...do.........	...do.........	....	1-2-43	100	65	6	20	Ind	msh	draw
h-15	...do.........	...do.........	Hickory W. Drg Co	8-2-47	326	31	6	5	Ind	msh	flat
h-16	...do.........	...do.........	...do..........	9-5-47	142	55	6	25	Ind	msh	draw
h-17	...do.........	...do.........	...do..........	10-1-47	200	99	6	53	Ind	msh	draw
i-1	...do.........	Park Grace School	....	----	100	---	6	---	P.S.	msh	adequate supply
i-2	...do.........	Park Yarn Mills	....	----	78	23	4	19	Ind	msh	draw; A
j-1	...do.........	R. Owens	Sub. Well Drg. Co.	12-6-65	285	220	6.25	12	Dom	Pzkm	slope; wl-50'
R72k-1	Kings Mountain	I. Biddix	South. Well Corp	10-31-63	158	86	6	25	Dom	Pzkm	
k-2	...do..........	Craftspun Mill	Morris Drg. Co.	----	300	---	8-6	120	Ind	Pzkm	flat; 8" to 140' 6" from 140' to 300'
l-1	...do..........	E. M. Wyatt	Sub. Well Drg Co	7-6-65	185	120	6	12	Dom	Pzkm	valley; wl-35'
l-2	...do..........	NC St Hwy Comm	Ray Taylor W.Drg	----	----	---	--	---	P.S.	Pzkm	slope; A
m-1	...do..........	E. Smith	Sub. Well Drg Co	10-21-65	125	20	6	8	Dom	Pzkm	flat; wl-35'
m-2	...do..........	C. Bess	...do..........	11-8-65	95	66	6	20	Dom	Pzkm	ridge; wl-40'
m-3	...do..........	G. Owen	South. Well Corp	----	105	60	6	15	Dom	Pzkm	
n-1	...do..........	Mid-Pines Wtr Co	...do..........	10-7-65	523	85	6	18	P.S.	Dcqm	ridge; A; wl-58'
n-2	...do..........	...do..........	...do..........	10-14-65	605	76	6	12	P.S.	Dcqm	ridge; wl-55'
n-3	...do..........	K. Mt. Mica Co.	Morris Drg. Co.	----	110	---	6	20	Ind	Dcqm	slope; A
n-4	...do..........	...do..........	...do..........	1960	134	24	6	25	Ind	Dcqm	ridge; A
n-5	...do..........	H. Roberts	South. Well Corp	----	118	98	6	35	Dom	Dcqm	draw
n-6	...do..........	A. S. Adams	...do..........	----	98	70	6	20	Dom	Dcqm	draw
o-1	...do..........	P. E. Hayes	Robbins Drg. Co.	----	40	20	6	20	Dom	Dcqm	slope; wl-28.5'
o-2	...do..........	H. K. Dickson	South. Well Corp	2-1-64	140	29	6	10	Dom	Dcqm	
p-1	Grover	Archdale Farms	Robbins Drg Co.	----	169	70	6	18	Dom	mgn	hill; hard rept 30 ppm wl-51'
t-1	Kings Mountain	W. A. Wallace	Sub. Well Drg Co	10-20-65	165	120	6	8	Dom	Pzkm	flat; wl-50'
y-1	Grover	.. ..	...do..........	4-23-65	145	70	6.25	15	Dom	Pzkm	hill; wl-38'
y-2	...do..........	J. B. Ellis	....	----	98	---	24	---	Dom	sap	hill; wl-85'
R73a-1	Kings Mountain	J. S. Wells	Sub. Well Drg Co	3-26-65	65	39	6.25	15	Dom	Dcqm	flat; wl-45'
e-1	Patterson Springs	Pleasant Hill Baptist Church	....	----	---	---	6	---	P.S.	----	draw; A
i-1	Kings Mountain	M. Dixon	South. Well Corp	6-27-64	445	66	6	60	Dom	Dcqm	
v-1	Grover	Grover School	Robbins Drg. Co.	----	48.5	37	6	15	P.S.	Dcqm	slope; hard rept 25ppm
v-2	...do..........	...do..........	....	----	301	65	6	6	P.S.	Dcqm	slope; not in use
w-1	...do..........	Town of Grover	....	----	225	54	6	20	P.S.	Dcqm	draw; A
w-2	...do..........	...do..........	....	----	255	60	6	65	P.S.	Dcqm	draw
w-3	...do..........	...do..........	....	----	295	58	6	15	P.S.	Dcqm	draw; standby well
w-4	...do..........	Minette Mills	....	1935	75	---	6	20	Ind	Dcqm	draw; A; wl-56'
w-5	...do..........	...do..........	....	1948	190	140	4	20	Ind	Dcqm	draw
w-6	...do..........	...do..........	....	----	190	---	6	22	Ind	Dcqm	draw
w-7	...do..........	...do..........	....	1952	210	---	6	43	Ind	Dcqm	draw; wl-30'
w-8	...do..........	...do..........	....	----	150	---	8	46	Ind	Dcqm	draw
w-9	...do..........	...do..........	....	1953	175	---	6	125	Ind	Dcqm	draw
w-10	...do..........	Town of Grover	....	----	295	---	6	30	P.S.	Dcqm	draw; A; standby well
w-11	...do..........	Minette Mills	....	1955	260	---	6	40	Ind	Dcqm	draw
w-12	...do..........	...do..........	....	1960	220	---	6	22	Ind	Dcqm	draw
w-13	...do..........	J. B. Ellis	Hickory W. Drg Co	----	155	44	6	20	Dom	Dcqm	draw; hard rept 25ppm wl-22'
w-14	...do..........	V. J. Hardin	Va. Machine Co.	----	110	---	6	20	Dom	Dcqm	flat; hard rept 30ppm
R74a-1	Shelby	Hunt Const. Co.	Lindsay Drg. Co.	----	146	72	6	20	P.S.	Otqm	
a-2	Patterson Springs	Troutman Trlr Park	....	----	---	---	6	---	P.S.	Otqm	A
g-1	...do..........	F. Young	Camp Bros. Drg	11-11-64	61	28	6	20	Dom	mgn-msh	hill; wl-12
g-2	Earl	C.C. Brooks	....	----	30	---	48	---	Dom	sap	slope; hard rept 20ppm; wl-19'
g-3	Patterson Springs	F. Young	Camp Bros. Drg	11-13-65	100	30	6	30	Dom	mgn-msh	
h-1	...do..........	Hunt Const. Co.	Lindsay Drg. Co.	----	300	65	6	8	P.S.	Otqm	
h-2	...do..........	...do..........	...do..........	----	206	67	6	12	P.S.	Otqm	
h-3	...do..........	...do..........	...do..........	----	300	67	6	20	P.S.	Otqm	
h-4	...do..........	...do..........	...do..........	----	300	79	6	20	P.S.	Otqm	
h-5	...do..........	...do..........	South. Well Corp	----	245	34	6	1	P.S.	Otqm	
h-6	...do..........	...do..........	...do..........	----	300	55	6	1	P.S.	Otqm	
h-7	...do..........	...do..........	...do..........	----	225	22.5	6	1.5	P.S.	Otqm	
j-1	...do..........	J. D. Ellis	...do..........	----	350	70	6	.75	Dom	Otqm	
j-2	...do..........	...do..........	...do..........	----	245	21	6	5	Dom	Otqm	
l-1	Earl	Earl School	....	----	60	60	24	---	P.S.	sap	slope; A; wl-30'
l-2	...do..........	...do..........	....	----	40.5	40.5	24	---	P.S.	sap	hill; wl-36'; standby
l-3	...do..........	Township #3 School	Va. Machine Co.	----	700	---	6	6	P.S.	Otqm	hill; A
l-4	...do..........	C. L. Lavender	South. Well Corp	----	385	96.5	6	2	Dom	Otqm	ridge
q-1	...do..........	L. P. Davis	....	----	23.5	---	36	---	Dom	sap	hill; wl-17.5'; temp. 61°F
q-2	...do..........	C. E. McSwain	South. Well Corp	3-1966	300	40	6	15	Dom	Otqm	
r-1	...do..	B. Bettis	....	----	102	---	6	---	Dom	mgn-msh	flat; wl-15'; abundant
r-2	...do..........	E. McSwain	South. Well Corp	----	205	---	6	2	Dom	mgn-msh	A
s-1	...do..........	W. C. Sarratt	Easler Drg. Co.	----	232.5	110	6	20	Dom	mgn-msh	hill; temp. 61.5°F
s-2	...do..........	M. Runyans	Bridges Well Co.	----	98	6	6	15	Ind	mgn-msh	slope; A; not in use
s-3	...do..........	W.C. Sarratt Dairy	Easler Drg. Co.	----	153	85	6	25	Ind	mgn-msh	hill
t-1	...do..........	Fiber Ind.,Inc.	....	----	20	20	156	750	Ind	all	valley

1 Quadrangle and Well Number	2 Location (Nearest Town)	3 Owner	4 Driller	5 Date Drilled	6 Depth of Well	7 Casing Depth (feet)	 Diameter (in.)	8 Yield	9 Use	10 Water Bearing Formation	11 Remarks
R75a-1	Shelby	River Bend Acres	Hickory W Drg Co	1-11-65	365	40	6	1	P.S.	msh	hill
a-2	...do..........	...do..........	...do..........	1-12-65	300	22	6	2.5	P.S.	msh	hill
a-3	...do..........	...do..........	...do..........	1-13-65	105	21	6	0	P.S.	msh	hill
s-1	Earl	B. Bailey	....	----	30	---	30	---	Dom	sap	wl-22.8'; hard rept 30ppm; temp. 61.5°F
s-2	...do..........	J. V. Rollins	Lassiter-Harkey	2-15-66	150	20	5	5	Dom	mgn-msh	hill; wl-17'
s-3	...do..........	J. N. Bowen	...do..........	2-23-66	130	16	5	20	Dom	mgn-msh	draw; wl-15'
R76a-1	Boiling Springs	Town of B. Spring	Faw Drilling Co.	----	300	---	6	40	P.S.	msh	draw
d-1	...do..........	C. P. Hambrick	....	----	140	---	6	2	Dom	Otqm	hill; A; hard rept 30 ppm; wl-70.1'; temp. 60°F
d-2	...do..........	A. B. Hambrick	....	----	38	---	6	---	Dom	Otqm	slope; A; wl-18.2'
d-3	...do..........	E. Hambrick	....	----	108	---	6	---	Dom	Otqm	hill; hard rept 40ppm; wl-44.6'; temp 62°F
R76f-1	Boiling Springs	J. R. Cromer	Camp Bros. Drg	2-4-65	165	126	6	10	Dom	msh	slope; A; wl-60'
j-1	...do..........	B. Brooks	...do..........	9-18-64	166	106	6	12	Dom	msh	ridge; wl-40'
m-1	...do..........	R.L. Humphries	....	----	62.5	---	72	---	Dom	sap	slope; wl-43.2'; adequate supply
p-1	Cliffside	M. McCraw	Camp Bros. Drg	----	---	---	--	---	Dom	msh	hill; A
t-1	Boiling Springs	G. D. Jolley	....	----	43	---	48	---	Dom	sap	hill; wl-40.3
u-1	...do..........	D. Bridges	South. Well Corp	----	205	55	6	---	Dom	msh	flat; A; wl-20'
y-1	...do..........	U. Davis	....	----	28.5	---	48	---	Dom	sap	hill; hard rept 20 ppm; wl-23.8'; temp. 60°F
R77j-1	Cliffside	Duke Power Co.	Robbins Drg. Co.	----	174	6	6	15	Ind	msh	draw
j-2	...do..........	...do..........	...do..........	----	247	---	6	10	Ind	msh	draw; abd.
j-3	...do..........	...do..........	....	----	280	---	6	20	Ind	msh	draw; temp. 61.5°F
j-4	...do..........	...do..........	A.B. Taylor Drg.	----	72	40±	6	16	Ind	msh	slope
t-1	...do..........	M. Plumber	....	----	---	---	--	---	Dom	msh	flat; A

Table 8 -- Chemical and physical analyses of water from selected wells in Cleveland County, North Carolina
(Analyses by the N. C. Division of Ground Water - except as noted. Results of chemical and analyses are in parts per million.)

Well		N741-2	N74o-2	N74t-1	N75v-2	N75w-1	N76u-2	N73y-3
Calcium (Ca)		8	6	7	14	13	20	18
Iron (Fe)		0.16	4.6	0.00	1.7	0.00	0.05	5.0
Carbonate (CO_3)		0	0	0	0	0	0	0
Bicarbonate (HCO_3)		40	68	70	122	50	146	64
Chloride (Cl)		24	18	14	20	8.0	12	10
Fluoride (F)		0.0	0.0	0.0	0.1	0.0	0.0	0.1
Nitrogen (NO_2 and/or NO_3)		0.0	0.0	1.8	0.8	0.2	0.0	0.1
Sulfate (SO_4)		0.0	8.0	1.0	11	5.0	8.0	18
Hardness	as $CaCO_3$	20	15	17	34	34	51	45
	total	35	34	30	34	51	68	51
Silica (SiO_2)		18	20	30	22	19	31	28
Carbon dioxide (CO_2)		--	--	--	97	20	92	26
Hydrogen sulfide (H_2S)		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dissolved solids		--	45	42	68	65	50	83
Color (apparent)		2	190	0	85	5	0	200
Turbidity (Jackson units)		4	70	0	20	0	0	60
pH		5.8	5.7	5.8	6.3	6.6	6.4	6.6
Specific conductance in micromhos at 25° C		<50	69	64	105	100	78	128
Odor		none	none	none	none	none	none	slight
Temperature (F°)		--	--	--	--	--	--	--
Date analyzed		2-24,25-66	2-24,25-66	2-24,25-66	2-24,25-66	2-11,14,66	2-24,25-66	2-11,16-66
Date and appearance when collected		2-23-66 clear	2-23-66 turbid	2-23-66 clear	2-23-66 clear	2-10-66 clear	2-23-66 clear	2-10-66 turbid

Table 8 -- Chemical and physical analyses of water from selected wells in Cleveland County, North Carolina - Continued

Well	073y-4	074i-1	074i-2	074v-1	074x-2	075h-1	P73o-1
Calcium (Ca)	18	12	13	12	18	7	14
Iron (Fe)	0.50	0.05	0.00	0.00	0.00	2.50	0.10
Carbonate (CO_3)	0	0	0	0	0	0	--
Bicarbonate (HCO_3)	70	48	46	41	62	70	--
Chloride (Cl)	6.0	10	8.0	10	10	12	--
Fluoride (F)	0.3	0.0	0.0	0.0	0.0	0.0	--
Nitrogen (NO_2 and/or NO_3)	0.0	1.0	0.2	3.7	0.5	0.0	--
Sulfate (SO_4)	3.0	0.0	1.0	1.0	5.0	7.0	--
Hardness as $CaCO_3$	45	30	34	30	45	17	34
Hardness total	45	34	34	35	70	17	34
Silica (SiO_2)	34	45	40	24	31	34	--
Carbon dioxide (CO_2)	--	48	--	21	39	111	--
Hydrogen sulfide (H_2S)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dissolved solids	79	49	34	45	80	38	81
Color (apparent)	0	0	0	5	0	20	0
Turbidity (Jackson units)	0	0	0	0	0	0	0
pH	--	6.2	5.7	6.5	6.4	6.0	6.5
Specific conductance in micromhos at 25° C	122	75	52	69	123	59	125
Odor	none	none	none	none	none	none	none
Temperature (°F°)	--	--	--	--	--	--	60.0
Date analyzed	2-11,16,66	2-11,14-66	1-11,14-66	2-11,14-66	2-11,17-66	2-24,25-66	5-13-66
Date and appearance when collected	2-10-66 clear	2-10-66 clear	2-10-66 clear	2-10-66 clear	2-10-66 clear	2-23-66 clear	5-13-66 clear

Table 8 -- Chemical and physical analyses of water from selected wells in Cleveland County, North Carolina - Continued

Well	P73t-2	P73u-1	P74d-1	P74d-2	P74d-1,2	P74e-2	P74n-1
Calcium (Ca)	7	6	9.9	18	9.2	14	1.8
Iron (Fe)	0.00	0.00	.02	2.1	.06	0.20	.10
Carbonate (CO_3)	0	0	0	0	0	0	0
Bicarbonate (HCO_3)	35	90	32	50	28	50	45
Chloride (Cl)	6.0	16	11	12	8.4	12	17
Fluoride (F)	0.0	0.2	.0	.1	.1	0.1	.0
Nitrogen (NO_2 and/or NO_3)	2.2	1.4	11	5.2	8.2	4.4	2.2
Sulfate (SO_4)	0.0	6.8	6.8	17	3.9	4.0	23
Hardness as $CaCO_3$	17	15	--	--	--	35	--
Hardness total	34	30	42	58	32	51	58
Silica (SiO_2)	44	34	13	20	16	21	19
Carbon dioxide (CO_2)	--	143	--	--	--	10	--
Hydrogen sulfide (H_2S)	0.0	0.0	--	--	--	0.0	--
Dissolved solids	52	39	94	122	74	65	123
Color (apparent)	0	0	4	4	2	0	--
Turbidity (Jackson units)	0	0	--	--	--	0	--
pH	5.7	6.0	6.6	6.9	6.2	6.2	--
Specific conductance in micromhos at 25° C	80	60	122	170	112	100	--
Odor	none		--	--	--	none	--
Temperature (°F)	60.0	--	60	60	--	--	--
Date analyzed	1-13,18-66	2-24.25-66	--	--	--	2-11,17-66	--
Date and appearance when collected	1-13-66 clear	2-23-66 clear	5-22-64 --	5-22-64 --	2-15-57 --	2-10-66 clear	12-8-48 --
			(a)	(a)	(b)		(c)

Table 8 -- Chemical and physical analyses of water from selected wells in Cleveland County, North Carolina - Continued

Well	P75d-2	P75m-1	P76i-1	Q72u-1	Q73j-1	Q73k-1	Q73k-2
Calcium (Ca)	6	14	--	--	12	6	6
Iron (Fe)	0.05	1.10	5.75	--	0.09	0.23	0.18
Carbonate (CO_3)	0	0	--	--	0	0	0
Bicarbonate (HCO_3)	6	30	25.0	14	60	40	70
Chloride (Cl)	10	14	0	3	16	24	12
Fluoride (F)	0.0	0.0	--	--	0.0	0.0	0.0
Nitrogen (NO_2 and/or NO_3)	2.2	2.1	--	--	0.0	0.0	0.0
Sulfate (SO_4)	0.0	5.0	--	--	5.0	0.0	0.0
Hardness as $CaCO_3$	15	35	--	20	30	17	15
Hardness total	20	35	18.0	40	34	17	17
Silica (SiO_2)	12	23	--	--	25	18	30
Carbon dioxide (CO_2)	--	38	--	--	--	--	85
Hydrogen sulfide (H_2S)	0.0	0.0	--	--	0.0	0.0	0.0
Dissolved solids	--	44	--	82	79	--	39
Color (apparent)	0	12	8	--	0	0	0
Turbidity (Jackson units)	0	0	54.0	--	0	0	0
pH	5.3	6.1	6.5	6.6	5.3	5.5	6.1
Specific conductance in micromhos at 25° C	<50	68	--	--	122	<50	60
Odor	none	none	--	--	none	none	none
Temperature (°F)	--	--	--	--	60.0	--	--
Date analyzed	2-11,16-66	2-11,16-66	7-3-64	1-29-64	5-13-66	5-13-66	5-13-66
Date and appearance when collected	2-10-66 clear	2-10-66 clear	6-29-64 -- (d)	-- -- (e)	5-12-66 clear	5-12-66 clear	5-12-66 clear

Table 8 -- Chemical and physical analyses of water from selected wells in Cleveland County, North Carolina - Continued

Well	Q73p-1	Q73p-2	Q74f-2	Q74j-1	Q74n-1	Q74u-1	Q74x-2
Calcium (Ca)	4.8	--	28	--	--	7	--
Iron (Fe)	0.10	0.05	0.21	<0.05	0.10	0.00	1.52
Carbonate (CO_3)	--	--	--	--	--	0	--
Bicarbonate (HCO_3)	29	71	86	35	--	24	22.0
Chloride (Cl)	1.6	7	9.2	3	--	19	2.0
Fluoride (F)	.1	--	.1	--	--	0.3	--
Nitrogen (NO_2 and/or NO_3)	2.2	--	.0	--	--	0.3	--
Sulfate (SO_4)	1.2	--	13	--	--	1.0	--
Hardness as $CaCO_3$	--	--	--	--	--	17	--
Hardness total	17	92	81	54	57	17	20.0
Silica (SiO_2)	24	--	22	--	--	19	--
Carbon dioxide (CO_2)	--	--	--	--	--	38	--
Hydrogen sulfide (H_2S)	--	--	--	--	--	0.0	--
Dissolved solids	56	--	129	--	--	32	--
Color (apparent)	--	0	--	5	--	0	0
Turbidity (Jackson units)	--	3	--	2	--	0	15
pH	7.5	6.9	6.5	7.4	--	6.0	6.65
Specific conductance in micromhos at 25° C	--	--	--	--	--	50	--
Odor	--	--	--	--	--	none	--
Temperature (°F)	58	--	61	--	--	60.8	--
Date analyzed	--	11-23,24-65	--	8-25-65	--	1-12,17-66	8-24,27-64
Date and appearance when collected	11-1962 --	11-22-65 --	11-1946 --	8-24-65 --	-- --	1-12-66 clear	8-20-64 --
	(f)	(d)	(f)	(d)	(d)		(d)

Table 8 -- Chemical and physical analyses of water from selected wells in Cleveland County, North Carolina - Continued

Well	Q75c-2,3,4	Q75e-1	Q75n-1	Q76h-1	Q76t-2	Q76u-1	Q76u-1
Calcium (Ca)	17	24	18	16	--	19	16
Iron (Fe)	0.22	0.10	0.10	0.50	0.09	.29	.08
Carbonate (CO_3)	0	0	--	0	--	0	0
Bicarbonate (HCO_3)	62	82	--	82	46	80	70
Chloride (Cl)	1.0	8.0	--	15	2	4.1	3.0
Fluoride (F)	0.0	0.1	--	0.0	--	.2	.1
Nitrogen (NO_2 and/or NO_3)	0.0	0.2	--	1.0	--	.3	.4
Sulfate (SO_4)	7.0	14	--	12	--	7.4	7.8
Hardness as $CaCO_3$	43	60	45	40	--	--	--
Hardness total	51	86	51	50	58	59	51
Silica (SiO_2)	30	28	--	44	--	37	29
Carbon dioxide (CO_2)	62	131	--	41	--	--	--
Hydrogen sulfide (H_2S)	0.0	0.0	0.0	0.0	--	--	--
Dissolved solids	80	45	79	78	--	120	108
Color (apparent)	0	0	0	2	2	8	3
Turbidity (Jackson units)	0	0	0	0	5	--	--
pH	6.2	6.0	6.1	6.5	5.9	7.2	7.2
Specific conductance in micromhos at 25° C	123	70	122	120	--	163	138
Odor	none	none	none	none	--	--	--
Temperature (°F)	62.0	--	--	--	--	--	65
Date analyzed	1-13,17-66	1-13,18-66	5-13-66	2-9,17-66	8-2-65	--	--
Date and appearance when collected	1-13-66 clear	1-13-66 clear	5-12-66 clear	2-9-66 clear	7-28-65 -- (d)	6-16-58 -- (b)	5-22-64 -- (a)

Table 8 -- Chemical and physical analyses of water from selected wells in Cleveland County, North Carolina - Continued

Well	Q76u-2	Q76u-2	Q76u-3	Q76u-3	Q76u-3	R72i-2	R721-2
Calcium (Ca)	5.0	4.4	14	11	13	20	20
Iron (Fe)	.03	.08	1.90	1.8	1.5	0.20	0.00
Carbonate (CO_3)	0	0	0	0	0	--	0
Bicarbonate (HCO_3)	26	20	78	54	62	--	120
Chloride (Cl)	5.5	4.9	13	3.2	3.5	--	20
Fluoride (F)	.1	.1	0.0	.2	.1	--	0.0
Nitrogen (NO_2 and/or NO_3)	3.4	5.4	0.7	.2	.0	--	0.9
Sulfate (SO_4)	2.5	4.8	9.0	6.8	10	--	8.0
Hardness as $CaCO_3$	--	--	34	--	--	51	51
Hardness total	21	18	68	38	47	68	103
Silica (SiO_2)	24	20	38	41	33	--	20
Carbon dioxide	--	--	39	--	--	--	19
Hydrogen sulfide (H_2S)	--	--	0.0	--	--	0.0	0.0
Dissolved solids	64	67	98	102	107	72	131
Color (apparent)	5	0	15	15	7	0	0
Turbidity (Jackson units)	--	--	7	--	--	0	0
pH	6.4	6.1	6.5	7.0	7.1	5.2	7.1
Specific conductance in micromhos at 25° C	74.7	69	150	121	128	110	198
Odor	--	--	none	--	--	none	none
Temperature (°F)	--	--	60.5	--	63	60.5	--
Date analyzed	--	--	1-13,17-66	--	--	5-13-66	1-12,18-66
Date and appearance when collected	6-16-58 -- (b)	5-22-64 -- (a)	1-13-66 clear	6-16-64 -- (b)	5-22-64 -- (a)	5-12-66 clear	1-12-66 clear

Table 8 -- Chemical and physical analyses of water from selected wells in Cleveland County, North Carolina - Continued

Well	R72n-1	R72n-3	R72n-4	R73e-1	R73w-1	R73w-4	R73w-10
Calcium Ca)	--	--	--	20	7	14	7
Iron (Fe)	0.95	--	--	0.48	0.00	0.00	1.30
Carbonate (CO_3)	--	--	--	--	0	0	0
Bicarbonate (HCO_3)	20.0	44	14	--	35	10	12
Chloride (Cl)	2	3	5	--	6.0	228	16
Fluoride (F)	--	--	--	--	0.0	0.0	0.0
Nitrogen (NO_2 and/or (NO_3)	--	--	--	--	0.0	8.8	1.7
Sulfate (SO_4)	--	--	--	--	5.0	4.0	4.0
Hardness as $CaCO_3$	--	27	3	51	17	34	17
Hardness total	12	37	10	51	17	51	17
Silica (SiO_2)	--	--	--	--	27	23	11
Carbon dioxide (CO_2)	--	--	--	--	44	--	15
Hydrogen sulfide (H_2S)	--	--	--	0.0	0.0	0.0	0.0
Dissolved solids	--	108	38	89	51	494	--
Color (apparent)	0	--	--	0	0	0	--
Turbidity (Jackson units)	4	--	--	0	0	0	--
pH	6.4	6.7	5.9	6.8	6.1	5.3	6.1
Specific conductance in micromhos at 25° C	--	--	--	138	79	745	<50
Odor	--	--	--	none	none	none	none
Temperature (°F)	--	--	--	--	60.8	62.0	--
Date analyzed	11-12,15-65	--	--	5-13-66	1-13,17-66	1-12,17-66	1-12,18-66
Date and appearance when collected	11-10-65 --	5-30-63 --	1-29-64 --	5-12-63 clear	1-12-66 clear	1-12-66 clear	1-12-66 slightly turbid
	(d)	(e)	(e)				

Table 8 -- Chemical and physical analyses of water from selected wells in Cleveland County, North Carolina - Continued

Well	R73w-4-9	R73w-4-9	R74a-2	R741-1	R741-3	R74r-2	R74s-2
Calcium (Ca)	9.2	6.3	14	18	18	--	18
Iron (Fe)	.04	.02	0.71	0.40	0.00	3.97	0.74
Carbonate (CO_3)	0	0	0	0	0	--	--
Bicarbonate (HCO_3)	20	9	62	100	150	26	--
Chloride (Cl)	60	26	16	12	8.0	1	--
Fluoride (F)	.1	.0	0.2	0.0	0.5	--	--
Nitrogen (NO_2 and/or NO_3)	8.8	33	0.0	0.0	2.2	--	--
Sulfate (SO_4)	2.3	26	8.0	1.0	4.0	--	--
Hardness as $CaCO_3$	--	--	34	45	45	--	45
Hardness total	35	27	51	50	78	40	51
Silica (SiO_2)	30	19	27	10	30	--	--
Carbon dioxide (CO_2)	--	--	79	126	14	--	--
Hydrogen sulfide (H_2S)	--	--	0.0	0.0	0.0	--	0.0
Dissolved solids	176	133	78	65	98	--	70
Color (apparent)	2	5	0	0	0	20	0
Turbidity (Jackson units)	--	--	0	0	0	65	0
pH	5.9	6.4	6.1	6.1	7.0	6.2	5.9
Specific conductance in micromhos at 25° C.	265	171	120	98	150	--	108
Odor	--	--	none	none	none	--	none
Temperature (°F)	--	--	--	--	--	--	--
Date analyzed	--	--	1-12,17-66	2-9,15-66	2-9,17-66	12-17-65	5-13-66
Date and appearance when collected	2-15-57 -- (b)	10-17-62 -- (g)	10-12-66 clear	2-9-66 clear	2-9-66 clear	12-16-65 -- (d)	5-12-66 clear

Table 8 -- Chemical and physical analyses of water from selected wells in Cleveland County, North Carolina - Continued

Well	R76d-1	R76d-2	R76f-1	R76p-1	R76u-1	R77t-1
Calcium (Ca)	23	14	13	6	10	--
Iron (Fe)	1.10	0.08	3.40	0.25	0.00	0.44
Carbonate (CO_3)	--	--	--	0	0	--
Bicarbonate (HCO_3)	--	--	--	76	58	28.0
Chloride (Cl)	--	--	--	16	12	3.0
Fluoride (F)	--	--	--	0.0	0.0	--
Nitrogen (NO_2 and/or NO_3)	--	--	--	1.9	0.9	--
Sulfate (SO_4)	51	--	34	0.0	2.0	--
Hardness as $CaCO_3$						
total	--	34	--	32	45	34.0
Silica (SiO_2)	--	--	--	12	9.0	--
Carbon dioxide (CO_2)	--	--	--	--	92	--
Hydrogen sulfide (H_2S)	0.0	0.0	0.0	0.0	0.0	--
Dissolved solids	88	37	64	47	54	--
Color (apparent)	0	0	0	0	2	10
Turbidity (Jackson units)	0	0	0	0	0	10.5
pH	5.7	6.1	5.9	5.9	6.0	8.3
Specific conductance in micromhos at 25° C	135	57	95	72	83	--
Odor	none	none	none	none	none	--
Temperature (°F)	--	--	61.0	--	--	--
Date analyzed	5-13-66	5-13-66	5-13-66	2-9,14-66	2-9,16-66	3-12,17-65
Date and appearance when collected	5-12-66 clear	5-12-66 clear	5-12-66 clear	2-9-66 clear	2-9-66 clear	3-9-65 --
						(d)

(a) N. C. Dept. of Water Resources, 1965
(b) N. C. Department of Water Resources, 1961
(c) LeGrand and Mundorff, 1952
(d) N. C. State Board of Health
(e) Kings Mountain Mica Company
(f) U. S. Geological Survey, Quality of Water
(g) N. C. Department of Water Resources, 1964

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