GEOLOGY AND GROUND-WATER RESOURCES OF SPOTSYLVANIA COUNTY, VIRGINIA

by

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Prepared in cooperation with the
Virginia Division of Mineral Resources

Charlottesville, Virginia

1968

CONTENTS

CONTENTS--Continued

CONTENTS--Continued

CONTENTS--Continued

ILLUSTRATIONS

TABLES

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ABSTRACT

Spotsylvania County in east-central Virginia, including the independent city of Fredericksburg, has an area of 415 square miles. The combined population of the county and city was 27,458 in 1960. Farming and manufacturing are the principal occupations. The climate is humid and temperate with an average annual rainfall of 41.40 inches and an average annual temperature of 56.4°F.

The area lies within two physiographic provinces of the eastern United States--the Piedmont province and the Atlantic Coastal Plain province. The Piedmont area consists of a gently undulating upland and the Coastal Plain is an almost featureless surface sloping gently to the southeast.

The ground-water reservoir is recharged from precipitation and from stream infiltration. Ground water is discharged from the reservoir by evaporation and transpiration, seepage into streams, wells, springs, and by subsurface movements to adjacent areas.

The rocks, which range in age from Precambrian to Pleistocene and Recent, are described and their water-bearing properties discussed. The rocks of the Piedmont part of the county consist of granite, gneiss, schist, slate, and quartzite that range from Precambrian to late Paleozoic age. East of the Fall Zone, granite and granite gneiss are believed to form the basement complex which underlies the Coastal Plain part of the county. This basement complex is overlain by interbedded clay, sand, and gravel of Cretaceous, Eocene, Miocene, Pleistocene, and Recent age.

About 234 million gallons per year of ground water are obtained for domestic, public supply, and industrial and air conditioning uses. Ground water in the county is suitable for irrigation use; however, the quantity available is insufficient for proper irrigation practices. Ground water is generally soft and suitable for most domestic purposes. However, objectionable amounts of iron occur in water from the higher terrace deposits and from some wells tapping deposits of Cretaceous age. A few deep wells tapping the basement complex yield water containing up to 5,500 parts per million (ppm) of chloride.

Much of the field data upon which this report is based is given in the tables; they include records of 431 wells and springs; chemical analyses of water from 38 wells and springs, and 79 preliminary field chemical analyses. Logs of five test holes are given in this report.

INTRODUCTION

The United States Geological Survey, in cooperation with the former Virginia Division of Geology, made investigations of the geology and ground-water conditions in the Virginia Coastal Plain from 1937 to 1957, and these studies have been resumed since mid-1966. The ground-water studies in Spotsylvania County were begun in 1953.was done under the general direction of the late A. Nelson Sayre, former Chief of the Branch of Ground Water, U.S. Geological Survey, and the late William M. McGill, former State Geologist. The work was resumed in 1966 under the general direction of George E. Ferguson, Regional Hydrologist, and J. Wyatt Gambrell, District Chief, Water Resources Division, U.S. Geological Survey; and Marvin M. Sutherland, Director, Virginia Division of Conservation and Economic Development, and James L. Calver, State Geologist and Commissioner of the Division of Mineral Resources.

PURPOSE OF THE INVESTIGATION

This report appraises the ground-water resources of Spotsylvania County, and relates the occurrence, availability, quantity, and quality of ground water to the geology of the area.

The area was selected for study because of increased demands for ground water for present and future development of the area.

LOCATION OF AREA

Spotsylvania County is in east-central Viginia (fig. 1). It

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is bounded on the north by Culpeper County; on the north and northeast by Stafford County; on the east by Caroline County; on the south by Hanover and Louisa Counties; and on the west by Orange County. It is bordered along the north and northeast by the Rapidan, and Rappahonnock Rivers, and along its southern boundary by the North Anna River. (See figure 1.) Spotsylvania County and the independent city of Fredericksburg, which lies within the original boundaries of the county, include a land area of 413 square miles and a water area of 2 square miles. Fredericksburg, on the Rappahannock River at the northeast edge of the county, is 56 miles north of Richmond, the Virginia State Capitol, and 52 miles south of Washington, D.C.

PREVIOUS INVESTIGATIONS

Darton (1894) discussed the geology of part of Spotsylvania County and in 1896 made the following reference to the ground-water resources of Spotsylvania County:

> "The eastern corner of this county is underlain by the Potomac formation, and there is every prospect that this area will prove to be underlain by basal Potomac waters, if not also by water higher in that formation."

Figure 1.--Index map of Spotsylvania County, Virginia showing area of report.

The ground-water resources of part of the area were briefly described by Sanford (1913) in his report on "The Underground Water Resources of the Coastal Plain of Virginia." A preliminary report (Subitzky, 1955) summarized the geology and ground-water conditions in the vicinity of Fredericksburg.

SCOPE AND METHODS OF INVESTIGATION

Field work was begun July 1953, and was continued until the spring of 1955. Factual data were obtained on 417 wells (table 7) and 14 springs (table 8). The depth of wells and depth to water level below the land surface were measured with a steel tape. Water samples were collected from wells penetrating the representative water-bearing formations in the area, and determinations of hardness, alkalinity, and chloride concentrations were made in the field. Representative water samples were later collected for more complete laboratory analysis. Well drillers and well owners were interviewed to obtain information relating to construction, yield, and nature of the water-bearing material. A few selected wells were measured periodically to observe water-level fluctuation in the area of study.

A geologic map was compiled from field observations and existing geologic maps (fig. 10). Subsurface geologic cross-sections were based on well logs from well drillers, and a study of drill cuttings from wells examined in the laboratory with a binocular microscope. Microfossils were collected from samples of drill cuttings and studied in the office and also by specialists of the Paleontology and Stratigraphy Branch of the U. S. Geological Survey.

Altitudes for measuring points of wells and geologic cross-sections were obtained by barometric leveling and from the interpretation of topographic maps. The base maps used in this report were prepared from county maps of the Virginia Department of Highways and of the Division of Planning and Economic Development of the Department of Conservation and Development.

WELL-NUMBERING SYSTEM

The wells, springs, and test holes in Spotsylvania County have been assigned serial numbers beginning in the northeast part of the area. Wells 1 to 112 and test holes 1 to 5 were plotted on a large-scale map (fig. 2) to accommodate the many closely spaced

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wells (Subitzky, 1955). Wells 113 to 417 and springs 1 to 14 were plotted on a small-scale map (fig. 3).

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ACKNOWLEDGMENTS

The writer acknowledges the cooperation from the many well owners who furnished information on wells and allowed free access to wells for measurements and sampling. Appreciation is expressed to the Spotsylvania County Board of Supervisors for making available samples of drill cuttings from three test holes drilled under their auspices. Thanks are due to the following drillers for furnishing well logs: Leazer Pump & Well Co. and J. T. Ellington, Fredericksburg, Va.; Sydnor Pump & Well Co., Inc. and Virginia Machinery & Well Co., Richmond, Va.; Mitchells's Well & Pump Co., Petersburg, Va.; and Layne-Atlantic Co., Glen Burnie, Md. Thanks are also due to Messrs. G. L. Rigby and W. M. Preston of the U.S. Soil Conservation Service office at Fredericksburg for furnishing significant basic data on wells in adjoining areas.

Figure 2.--Map showing location of wells (1-112) and test holes (1-5) in Spotsylvania County.

Figure 3.--Map showing location of wells (113-417) and springs (1-14) in Spotsylvania County.

GEOGRAPHY

HISTORICAL SKETCH

Spotsylvania County was formed in 1720 from parts of Essex, King William, and King and Queen Counties and named for Alexander Spotswood, then Lieutenant Governor of Virginia. In 1676 a fort was first built near the falls of the Rappahannock River and a settlement was started in 1700. Alexander Spotswood brought a group of German miners to the area in 1714 and established a colony on the Rapidan River to engage in mining the numerous iron ore deposits of the area. This settlement was called Germanna and was made the county seat in 1722. The county seat was moved to Fredericksburg in 1732, in 1778 to "Old Court House," and in 1839 to its present location at Spotsylvania Court House, approximately 12 miles southwest of Fredericksburg.

Fredericksburg was named for the father of King George III and is located approximately where the first fort was founded in 1676. Official records indicate that Fredericksburg dates from a land grant issued in 1671. It was established as a town in 1727, incorporated in 1781, incorporated as a city in 1879, and became a city of the first class in 1941.

During the Civil War, Fredericksburg and Spotsylvania County witnessed almost continuous fighting from 1862-1864. The Fredericksburg and Spotsylvania National Parks are memorials to the four major battles of the area: Fredericksburg, Chancellorsville, The Wilderniess, and Spotsylvania Court House.

POPULATION

The population of Spotsylvania County and the Independent city of Fredericksburg at the time of the latest four Federal censuses is shown in table (Economic Data Report, Spotsylvania County, 1965).

Table 1.--Population of Spotsylvania County and independent city of Fredericksburg for 1930, 1940, 1950, and 1960

Year	Spotsylvania County	City of Fredericksburg
1930	10,056	6,819
1940	9,905	10,066
1950	11,920	12,158
1960	13,819	13,369

INDUSTRY

In Fredericksburg and in the county, manufacturing is the major industry. The largest industrial establishment in the area is a cellophane plant a few miles southeast of Fredericksburg. Other industries include: men's clothing, children's shoes, lumber, millwork, wooden boxes, wood preservatives, metal heating fixtures, sheet metal products, dairy products, cinder blocks, and commerical printing.

AGRICULTURE

The sandy loam and clay soils of Spotsylvania County are adaptable for raising general crops and for pasture. In 1950, there were 1,153 farms consisting of a total of 138,852 acres. This represents 52.5 percent of the land area of the county, and 47.5 percent of the county consists of timber and public land. Dairying provides a leading source of farm income. Poultry and livestock, especially cattle and hogs, are also important to the farm economy of the area.

MINERAL RESOURCES

Deposits of sand and gravel, suitable for concrete and other construction purposes, are being extensively worked southeast of Fredericksburg.

Gold, lead, zinc, and iron have been mined from time to time in the Piedmont province of the county. The earliest mining venture was the iron mine established in 1714 at Germanna, 13 miles west of Fredericksburg. Granite and sandstone suitable for building stone have been quarried in the vicinity of Fredericksburg.

TRANSPORTATION

Fredericksburg is served by the main line of the Richmond, Fredericksburg, and Potomac Railroad with service north to Washington, D. C. and south to Richmond.

Spotsylvania County is traversed by several State and Federal highways, all of which are hard-surfaced. U.S. Highway 1, extending north and south in eastern Spotsylvania County, is a four-lane super highway between Washington and Richmond. U.S. Highway 17, extending northwest and southeast, is a two-lane hard-surface road serving Fredericksburg. U.S. Highway 522 passes through the extreme southwest corner of the county and connects with several State and county roads. The principal State highways are nos. 2, 3, and 208. State Highway 2 and U.S. Highway 17 extend southeast from Fredericksburg; Highway 3 extends west from Fredericksburg and to the junction of State Highway 20 at the Orange County line and east from Fredericksburg across the Rappahannock River into Stafford County. State Highway 208 crosses the county from southwest to northeast, providing connecting junction points to the many county roads in the area.

TOPOGRAPHY

Spotsylvania County (fig. 4) includes parts of the Piedmont and

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the Atlantic Coastal Plain provinces (Fenneman, 1938).

Most of the county lies within the Piedmont province which here consists of a gently undulating dissected upland, having an altitude ranging from about 500 feet above sea level along the western border to about 300 feet above sea level along the eastern edge. The Piedmont surface slopes gently to the southeast where along its eastern edge it passes beneath younger sediments of the Coastal Plain Province. There are no outstanding hills or mountains in the area.

Figure 4.--Map of Virginia showing physiographic provinces.

(After Fenneman, 1938.)

The topography of the Coastal Plain province in the area is characterized by an almost featureless plain sloping gently to the southeast. In the vicinity of Fredericksburg the altitude of the Coastal Plain surface ranges from about 300 feet along the Fall Zone to an altitude of about 260 feet along the eastern boundary of the county.

DRAINAGE

Three major rivers drain the area. The Rapidan and Rappahannock Rivers form the northeast boundary of the county, and the North Anna River forms the southwest boundary. These major rivers have many smaller tributary streams which drain the slopes of the eastward trending central uplands. Between the major rivers a series of smaller rivers and streams have a dendritic drainage system. The more important of these smaller rivers are the Massaponax, which flows southeastward and then turns sharply to the north 4 miles below Fredericksburg to join the Rappahannock River, and the Mat, Ta, Matta, Po, and Ni Rivers, which flow southeastward into Caroline County and join to form the Mattaponi River.

CLIMATE

Spotsylvania County lies in the Middle Climatic Division of Virginia, as described by the U.S. Weather Bureau, and is characterized by a humid and temperate climate. A climatological station at Fredericksburg has been maintained for 68 years, and another station (Partlow 3 WNW) has but a few years of record. Climatological data used in this report are based on the Fredericksburg station.

Temperature

The county has a mean annual temperature of 56.4°F, a mean winter temperature of 39.5°F, and a mean summer temperature of 73.3°F. The lowest mean monthly temperature of 36.5°F occurs in January and the highest mean monthly temperature of 76.6°F occurs in July.

Precipitation

A graphic summary of precipitation of Spotsylvania County as recorded over a 68-year period at the Fredericksburg Weather Bureau station is shown in figure 5. The normal annual precipitation reported

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at the Fredericksburg station is 41.40 inches, based on the period 1859, 1893 to 1960. The wettest year of record was 1942 when 57.31 inches was recorded. This was 15.91 inches above normal. The driest year of record was 1930 when 22.82 inches was recorded, 18.58 inches below normal.

Figure 5.--Graph showing precipitation at Fredericksburg weather station for 68 years of record.

GEOMORPHOLOGY

PIEDMONT PROVINCE

The Piedmont province in Virginia lies between the Blue Ridge and the Atlantic Coastal Plain (Fig. 4). Its western border in Virginia is indistinct, and is characterized by a belt of monadnocks which extends about 15 or 20 miles east of the Blue Ridge. The eastern border of the Piedmont is marked by the Fall Zone. East of the monadnocks, the Piedmont surface is typically one of gentle slopes and slight relief, and dissected by valleys of steeper slopes. The undulating character of the surface does not permit sharp boundaries to be recognized between the general level, the valleys, and the monadnocks. Consequently, the surface of the Piedmont has been considered a peneplain. Davis (1890) concluded that there were two widespread peneplains recognizable throughout this region.

In the vicinity of Fredericksburg, the upland surface of the Piedmont ranges from 250 to 300 feet above sea level and the streams occupy broad shallow valleys. The chief stream is the Rappahannock River which is classed as a rejuvenated stream because of its entrenched meanders. The meander pattern of the river is well developed in the vicinity of Fredericksburg. The stream occupies a narrow gorge flanked by steep slopes, and its gradient of almost 10 feet per mile is responsible for many rapids.

FALL ZONE

Along the eastern border of the Piedmont province there is a belt of falls and rapids where the resistant crystalline rocks lie close to the surface beneath the soft Coastal Plain sediments; this belt is called the Fall Zone. The falls and rapids characteristic of this Zone mark the western limit of marine navigation which was of great importance during the early settlement of the eastern United States. The Fall Zone in Virginia passes through the cities of Alexandria, Fredericksburg, Richmond, Petersburg, and Emporia.

In the vicinity of Fredericksburg, the Fall Zone is characterized by streams that pass from broad shallow valleys in the Piedmont province to deeper steep-sided valleys within the zone. The gradient of the Rappahannock River is approximately 30 feet per mile within the Fall Zone, where rapids are almost continuous.

Within the Fall Zone, the surface of the Piedmont rocks slopes steeply eastward beneath the thickening wedge of Coastal Plain deposits. Near Fredericksburg, at the western edge of the zone, this slope is about 200 feet per mile and along the eastern edge about 50 feet per mile.

The local steepness and the irregularity of the buried surface of the Piedmont crystalline rock within the Fall Zone suggests that marine or fluviatile erosion may have taken place.

ATLANTIC COASTAL PLAIN

East of the Fall Zone to the Atlantic Ocean lies the emerged part of the Atlantic Coastal Plain province. It extends from Long Island, New York to Florida. It extends west and northwest from Florida to the Gulf Coastal Plain and the Mississippi Embayment.

Stream dissection, near the Fall Zone, has produced considerable relief. In the vicinity of Fredericksburg the maximum relief is about 300 feet. The Rappahannock River valley is broad and flat-bottomed, but some of its tributaries close to the Fall Zone occupy steep, almost vertical-walled valleys.

Terraces

The Cretaceous and Tertiary rocks of the Atlantic Coastal Plain are extensively covered by a mantle of brown or red sand, loam, and gravel, whose upper surface forms a series of terraces.

The origin of these terraces and underlying rocks has long been a subject of geologic controversy. The terrace surfaces, in general, slope gently both seaward and toward the major drainage basins, and it is believed that they were formed locally or modified by stream erosion. Part of these terrace deposits are believed to be of marine origin. Richards (1936) has traced the Pamlico formation of Pleistocene age from New Jersey to Florida by its fossil assemblage, and has ascribed to it a marine origin.

A more recent trend has been to associate submergence of the continent with intermittent rises and lowering of sea level during the glacial epochs. Based on this hypothesis, the terraces were formed during interglacial periods of high sea level. Seven distinct terraces have been recognized in the Atlantic Coastal Plain (Wentworth (1930), Cooke (1935), and MacNeil (1949). The correlation of these terraces to interglacial stages is shown in figure 6 as considered

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by these workers.

The relatively uniform altitude of the shorelines of the several terraces suggests that they were formed near sea level. Lowlands probably were built up by a system of coalescing alluvial fans to the profile of equilibrium by heavily-laden streams, whose headwaters were eroding the highlands to the west. The high terrace was formed first and the low terrace last as indicated by the lower terrace formations overlapping the upper terraces. As each terrace was formed, sea level dropped and a new terrace was formed.

In the vicinity of Fredericksburg, the terrace material is predominantly brown or red loam, clay, and white quartz gravel. Much of it is believed to be derived from the soils and rocks of the Piedmont, but there is also evidence that Cretaceous and Tertiary rocks of the Coastal Plain have been reworked. Subsequently, parts of the older terrace deposits have been reworked to form lower terraces.

GROUND WATER

The following discussion of the source and occurrence of ground water has been drawn largely from Meinzer (1923a).

Figure 6.--Diagrammatic profile of Coastal Plain terraces showing their relation to the interglacial stages.

In Spotsylvania County, ground water is derived from rainfall supplemented by light snowfalls during the winter months and from stream infiltration. Rain and snow may be carried away by surface runoff, it may evaporate or be transpired through vegetation, or it may seep into the soil and percolate downward through the rock layers and become subsurface water.

Water seeping downward through the rocks of the earth first enters the zone of aeration, where it is said to be suspended or vadose water. The force of gravity causes the water to seep downward; however, molecular forces trend to stop or retard this movement in the smaller interstices of the rocks and soil.

Some water seeps into the zone of saturation.or zone where all opening are filled with water. The top of this zone of saturation is called the water table. Ground water moves slowly through the rocks in directions determined by the hydraulic gradient or by the slope of the water table, which is controlled by the topography, the structure of the rocks, and the number, size, shape, and arrangement of their open spaces. In coarse gravel, the water table is essentially the upper surface of the zone of saturation. In finer materials, capillary action raises the zone of saturation above the water table.

OCCURRENCE AND MOVEMENT

The occurrence of ground water in Spotsylvania County varies according to geology. The porosity-volume of pore space to a given volume of rock - determines the amount of water a given rock type can hold.

In sedimentary rocks of the Coastal Plain, porosity is dependent upon the shape, arrangement, degree of assortment, cementation, and compaction of the constituent particles of a deposit. Whereas in crystalline rocks of the Piedmont and in some consolidated sedimentary rocks water is held chiefly in cracks and fissues. In sedimentary and crystalline rocks, porosity depends in part on the removal of mineral matter by solution by percolating water. When the rock openings are filled with water, the rock is considered to be saturated.

The permeability of a rock is defined as its capacity for transmitting water under pressure and is measured by the rate at which water is transmitted through a unit cross section under a unit hydraulic gradient. Gravel and coarse sand, if well-sorted, are very permeable and will transmit water freely. Finer sediments, such as silt and clay, may have as high a porosity as sand or gravel, but because of the small size of the openings, their permeability is much lower; clays are relatively imperable. Hence, ground water occurs in all rock formations, but not all the formations are important as sources of water supply. According to their relative water-bearing capacities, the formations are called aquifers (water-bearing) or aquicludes (essentially non-water-bearing).

The aquifers serve as storage reservoirs and as transmission conduits. They hold ground water in storage, and they transmit it toward points of discharge in response to hydraulic gradients. When a new withdrawal is imposed on an aquifer that is in equilibrium, the aquifer can obtain a new equilibrium if the quantity of water withdrawn can be balanced by an increase in recharge or decrease in natural discharge. Until such a balance is established, water is withdrawn from storage.

Ground water occurs under water-table (unconfined) or artesian (confined) conditions. It is important to know the condition of occurrence because the response of water-table aquifers to pumping is different from that of artesian aquifers, and the effects of development are therefore different.

Water-table aquifers contain ground water which is under atmospheric pressure at the top of the saturated portion. These aquifers yield water from storage and transmit the effects of pumping to other parts of the aquifer slowly, because a lowering of the head of water in a water-table aquifer (a decline of the water table) represents actual draining of water from pores.

In Spotsylvania County the water table ranges from a few feet to about 50 feet below land surface.

Artesian conditions exist in the Coastal Plain of Spotsylvania County where relatively impermeable confining beds overlie and underlie an aquifer completely filled with water under hydrostatic pressure. The height of a column of water that can be supported by the hydrostatic pressure at a given point in an aquifer is called the pressure head. The imaginary surface to which water under artesian pressure will rise in tightly cased wells in an aquifer is called the piezometric surface. The effects of a change in the head of water caused by pumping a well in an artesian aquifer is transmitted quickly to considerable distances in such aquifers. A lowering in the head of an artesian aquifer results not in draining of water from pores but in the squeezing of a small amount of water from fine-grained materials, and also in a slight expansion of the water itself. The total quantity of the water released from storage per unit volume of the aquifer is much smaller than the amount that can be drained from pores under water-table conditions; hence, a larger area of the aquifer is affected in pumping at a given rate. An artesian aquifer yields water yet remains saturated so long as the head is above the upper limit of the aquifer. Conditions change from artesian to water-table at a place when the head of water declines below the upper limit of the aquifer at that place.

Where the head of water in an artesian aquifer is above the land surface, a well tapping the aquifer will be a flowing well. So far as known, the only flowing well in Spotsylvania County is well 116, along the Rappahannock River near New Post. This well, near the western fringe of the area of artesian flow, yields approximately 8 gallons per minute (gpm) from the basal sands of the Patuxent Formation.

RECHARGE

The aquifers in Spotsylvania County are recharged almost entirely by local precipitation or their outcrop areas. Within the Coastal Plain part of the county, precipitation percolates directly into the sands of the Patuxent Formation or into the younger terrace sand and gravel. Additional recharge of the Patuxent Formation is believed to take place through the underlying fissured basement complex with which the sands of the Patuxent Formation are in direct contact, as pointed out by Cederstrom (1945a, p. 71).

All major streams in the area are perennial. Streams that head in the Piedmont province emerge from crystalline rock gorges onto the sands and gravels of the Coastal Plain deposits. In some areas recharge is augmented by stream infiltration if there is hydraulic continuity between the stream beds and the water-bearing units.

DISCHARGE

The ground water in Spotsylvania County is discharged by evaporation and transpiration, seepage into streams, wells, springs, and subsurface movement to adjacent areas.

Evaporation and Transpiration

The amount of ground water lost by evaporation and transpiration varies with seasons. The rate of loss is highest during the growing season when the temperature is high and is lowest in the winter when relatively little plant growth takes place. The depth to which roots penetrate the soil for water varies with different types of plants and soils. Most plants and grasses do not draw water from depths of more than a few feet, but under exceptional circumstances alfalfa may draw water from 20 to 30 feet below the surface. Similarly, some trees are capable of drawing water from considerable depths.

In most of Spotsylvania County the water table is considerably below the reach of plant roots so that transpiration generally takes water only from the zone of aeration and does not result in ground-water discharge. In low, swampy areas, however, it is probable that evaporation and transpiration do withdraw substantial quantities of water from below the water table.

Seepage into Streams

Discharge by seepage into streams in Spotsylvania County is negligible and is restricted to the Coastal Plain area where the altitude of the water table is above the streams. In the Piedmont province many of the smaller streams lie above the water table and therefore receive no water from the ground-water body.

Wells

The discharge of water from wells is an important method of ground-water discharge in Spotsylvania County. Water is pumped from many shallow dug or bored wells chiefly for domestic and stock use. Some water is pumped for industrial use and for public supply.

When water is withdrawn from a well a difference in head is developed between the water in the well and the water in the water-bearing material outside the well. The water table in the vicinity of a discharging well is depressed in a shape somewhat in the form of an inverted cone, whose apex is at the well, a "cone of depression" or "cone of influence." Under artesian conditions, the cone of influence takes the form of a cone-shaped depression in the piezometric surface whose apex is at the discharging well. Around any pumping well, the greater the pumping rate the greater will be the drawdown and the greater the diameter of the cone of influence. As the rate or duration of pumping are increased, the cone of depression extends farther and farther from the well until it encompasses enough recharge or eliminates enough discharge to supply the water pumped from the well. Thus it may be that water levels in wells several hundred feet or even a few miles away from the pumped well may be lowered somewhat.

Specific capacity of a well (Meinzer 1923b, p. 62) is its rate of yield per unit of drawdown, and is usually stated in gallons per minute per foot of drawdown. For example, well 83 in eastern Spotsylvania County, which penetrates sandy gravel mixed with clay of Pleistocene age, is reported to yield approximately 22 gpm with a measured drawdown of 4.94 feet. Its specific capacity therefore is about 4.5 gpm per foot of drawdown.

When a well is pumped at a constant rate, the water level drops rapidly at first and then more slowly, but may continue to decline for a period of several hours or even days until equilibrium is reached for that rate of discharge. Therefore, in testing the specific capacity of a well, it is important to maintain a constant discharge rate long enough for the water level in the well to become stationary. When the pump is stopped, the recovery of the water level is likewise rapid at first, but tapers off slowly and may continue long after pumping has ceased. Records if 417 selected wells in Spotsylvania County are given in table 7 and drillers logs of 24 wells and 5 test holes are given in table 9.

Springs

In Spotsylvania County only a few domestic stock water supplies are now obtained from springs. They are generally not used for other purposes. Small springs are numerous throughout the county, especially in the Coastal Plain province where they issue from the base of the terrace deposits of Pleistocene age.

Springs may be grouped with respect to rock structure into two broad classes: gravity springs and artesian springs (Meinzer 1923b, p. 52). The springs studied in this area are essentially gravity springs, caused by outcrop of the water table. The water from these springs percolates from permeable material under the action of gravity.

Several springs in the vicinity of Fredericksburg were once used as a source of public water supply (Sanford, 1913). Two of these, Mint Spring and Gunnery Spring, were owned by the City of Fredericksburg in 1906, but were considered unsafe for drinking at that time owing to the densely populated areas nearby. The Silk Mill Spring (table 8) reported to issue at the base of terrace deposits along the Rappahannock River in the northwest part of the City of Fredericksburg in 1905, was also judged to be dangerous for drinking by the City Board of Health. Another spring still in use in 1906 was reported to be safe for public water supply. The water from it was clear and soft and was distributed to a limited number of people by the Fredericksburg Aqueduct Water Company. According to Sanford (1913, p. 274) this was at that time one of the oldest water companies in the United States furnishing uninterrupted services.

Subsurface Movement of Ground Water to Adjacent Areas

Wells in the Coastal Plain area of Spotsylvania County provided good control for a water-table contour map (fig. 7).

Figure 7.--(caption on next page) belongs near here.

It was not practical for this investigation to extend the map over the Piedmont part of the area because wells from which water-level measurements could be obtained were widely scattered.

The direction of flow of ground water is normal to contour lines showing the water table. Shallow ground water in northeastern Spotsylvania County leaves the area along the Rappahannock River in the vicinity of Fredericksburg (fig. 7).

Confined water in formations of Cretaceous age and older moves down gradient to the east and southeast. This water is pumped in large quantities from these formations in Caroline County.

Figure 7.--Map of Coastal Plain province, Spotsylvania County, showing contours of the water table October 1955.

WATER-LEVEL FLUCTUATIONS

The fluctuation of the water table and piezometric surface depends upon the amount of recharge and discharge to and from the ground-water body. If the recharge exceeds the discharge, the water levels will rise; conversely, if the discharge exceeds the recharge, they will fall. Water levels fluctuate more by the recharge and discharge of ground water than does the level of a surface storage reservoir because ground water occupies only a fraction of the volume of a ground-water reservoir. Factors that cause a rise of the water table in Spotsylvania County are: (1) the amount of precipitation that descends to the zone of saturation, (2) infiltration from streams. The chief factors that control the rise of the piezometric surfaces in Spotsylvania County are: (1) the amount of water that enters the artesian aquifers in areas where they crop out, either by downward percolation from rainfall or by infiltration from streams, (2) the amount of water that moves downward through the unconfined aquifers into the artesian aquifers where the confining bed is somewhat permeable or, locally, has been removed by erosion, (3) the amount of water that moves upward from the underlying fractured rocks of the basement complex into the upper artesian aquifers of the overlying Patuxent formation.

The chief factors that cause a decline in the water table in this area are: (1) evaporation and transpiration, (2) discharge from springs and seeps, (3) discharging wells, (4) subsurface movement of ground water to adjacent areas. Factors causing a decline of the piezometric surfaces are: (1) leakage from artesian aquifers either through a somewhat permeable confining layer or where the confining layer has been, locally, removed by erosion (such leakage may be either upward or downward), (2) discharge from artesian springs and seeps, (3) discharging wells.

The "phreatic high," or the period when the water table is highest, occurs in Spotsylvania County during the spring (fig. 7, well 361), because of large amounts of recharge from winter rain, melted snow and the low evaporation and transpiration rate during the cold weather. The normal fluctuation of the water table in the area consists of a gradual rise in late December which continues until late March or April, and a gradual decline throughout the summer months, broken only by intermittent rises caused by heavy periodic summer rains. The lowest level usually is reached after the end of the growing season during late November or early December. The overall downward trend of the water level of well 66 (fig. 8) is

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Figure 8.--(caption on next page) belongs near here.

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believed to reflect pumping from this aquifer as far away as 1 mile. However, during the course of this investigation, deficient rainfall caused minor drought conditions during the summers of 1953 and 1954; above average rainfall resulted from hurricane "Hazel" in October 1954, and hurricanes "Connie and "Diane" in August 1955. These abnormal conditions were reflected by unusual water-level fluctuations in wells of the area (fig. 8).

GROUND-WATER TEMPERATURES

The temperature of ground water is of importance for many industrial uses. The ground-water temperature approximates the temperature of the rocks from which water is derived. Soil and rock exposed at the surface reflect daily and seasonal fluctuations in air temperature at that place. Daily fluctuations in temperature affect only a few thin layers of soil or rock and the annual fluctuation is small at 10 feet below the surface and becomes zero at a depth 30 to 60 feet (Collins, 1925). Below the zone of seasonal fluctuation, the earth temperature increases with depth at a rate that differs somewhat from one area to another but does not differ greatly in any one area.

Figure 8.--Hydrographs of observation wells in Spotsylvania County and hydrograph of rainfall at Fredericksburg.

The mean annual air temperature in Spotsylvania County is 56.4°F at the U.S. Weather Bureau climatologic station at Fredericksburg. The average ground-water temperature observed in wells less than 100 feet deep in Spotsylvania County is 57°F. Wells between 100 and 400 feet deep which tap sands of the Patuxent Formation yield waters which have an average temperature of 59°F. Water supplies obtained from wells in the area have a temperature suitable for all ordinary use.

UTILIZATION

Domestic and Stock Supplies

All rural and suburban domestic ground-water supplies in the area are obtained from wells and springs. Water supplies in the several scattered rural communities of the county are also furnished by individual wells because no municipal water supplies are available. It is estimated that a population of about 13,000 is supplied in this manner and that the total water use is about 200 million gallons per year. Ground water used for livestock is derived from wells, and, where available, from springs.

Public Supplies

Ground water for public supply in Spotsylvania County is furnished from the wells of seven privately owned water systems in housing subdivisions in the vicinity of Fredericksburg (fig. 9).

Figure 9.--(caption on next page) belongs near here.

The combined pumping of these wells is approximately 28 million gallons per year, chiefly from water-bearing units of Cretaceous and Pleistocene age. (See table 2).

Table 2.--Major pumpage of ground water from water-bearing units of Cretaceous and Pleistocene age for 1954, Spotsylvania County, Virginia

Subdivision		Gallons per year	Age of water-bearing unit
Bellevue Court	a)	2,015,800	Cretaceous
Jackson Park	b)	3,240,000	Do.
Cottage Green	b)	5,760,000	Do.
Dillard and Courtland Heights	a)	4,672,600	Do.
Spotswood Village	a)	438,960	Do.
Sylvania Heights	b)	12,080,000	Cretaceous and Pleistocene
Greenfield Village	a)	763,300	Cretaceous
Total		28,970,660	

a) Reported by owner

b) Calculated

Figure 9.--Sketch map showing location of subdivisions using ground water in the vicinity of Fredericksburg, Va.

Industrial Supplies

Ground water for industrial use in the area is limited to stream boiler feed water and for air-conditioning purposes. Wells 91 and 304 draw water from sand and gravel of Pleistocene age for stream boilers and well 81 draws water from a sand of Cretaceous age for air conditioning. Approximately 6 million gallons per year of ground water are pumped for industrial use in the county.

Irrigation Supplies

So far as known, ground water is not used for irrigation purposes in Spotsylvania County. Some irrigation has been tried in the area using surface water and two systems are presently in operation. (Personal communication, Mr. W. M. Preston, U.S. Soil Conservation Service.)

CONSTRUCTION OF WELLS

In Spotsylvania County, wells are principally dug, bored, and drilled.

Dug Wells

Dug wells generally range from 2 to 6 feet in diameter, and are usually constructed with hand tools. Dug wells furnish a large part of the ground water used in Spotsylvania County. Depending on the character of the materials penetrated, dug wells are curbed, in whole or in part, with wood, brick, stone, concrete, or tile. Several old dug wells in the Piedmont province of the county, which penetrate tough layers of residual clay, derived from the weathering of igneous and metamorphic rocks, use only a few feet of curbing at the bottom of the well. If the well is dug in loose materials, such as sand and gravel which are found in the Coastal Plain province, curbing from top to bottom is necessary. Unless properly curbed, dug wells may be polluted by entrance of surface water. Dug wells observed in the county range from 10 to 90 feet in depth and generally furnish adequate supplies of water for domestic and stock needs.

Bored Wells

Bored wells are constructed with hand and power augers, usually 2 to 36 inches in diameter. They range from 14 to 58 feet in depth according to local ground-water conditions but are usually less than 100 feet deep. Recently, many of the bored wells have been constructed by a truck-mounted power operated bucket-type auger that has a rotary table for turning the auger. These wells are usually 36 inches in diameter and are lined with concrete curbing from top to bottom. This type of well is practical in areas of unconsolidated sedimentary rocks and in areas of deeply weathered igneous and metamorphic rocks where no hard rocks are encountered.

Drilled Wells

Drilled wells in Spotsylvania County are construced by the hydraulic rotary, the cable-tool (percussion or churn-drill), or the jetting method. Many of the drilled wells in the Coastal Plain province range from 4 to 8 inches in diameter and have galvanized-iron, wrought-iron, or steel casing. In conjunction with the casing, screens or sections of slotted casing are set opposite the best water-bearing zone, or opposite several water-bearing zones.

Deep wells drilled into the crystalline rock of the Piedmont province are not cased from top to bottom. Casing extends only through the overlying weathered portion until it can be firmly seated in the fresh rock. No screen is used in these wells because the rock below the casing is firm enough to stand without support and the water enters the well through cracks in the rock.

Hydraulic Rotary Method

The hydraulic rotary well-drilling equipment used in this area usually consists of a truck-mounted derrick, cables and reels for handling tools and casing, a rotary table for rotating the drill pipe and bit, and a pump to circulate the drilling mud. Mud is pumped down through the drill pipe and out of openings in the bit, carrying the drill cuttings up and out of the hole. The drilling mud also prevents the hole from caving before the casing and screen are set.

Cable-Tool Method

The cable-tool type drilling machine consists of a mast or A-frame, draw-works, cable, drilling tools, bailer, and power unit. A walking beam moves the cable up and down, causing the bit to pound the bottom of the hole and break or crush the material penetrated in drilling; the drill cuttings are removed with the bailer at frequent intervals.

Jetting Method

The jetting method has been little used in the Coastal Plain area of Spotsylvania County. Well 116 is the only well on which data were obtained that was constructed by jetting.

The process of jetting a well consists of loosening material and elevating it to the surface by water pressure. Water is forced downward through a pipe and out through the bit against the bottom of the hole. The force of the water and the action of the bit loosens the material and the water washes it up and out of the hole in a manner similar to that in which the drilling mud removes the cuttings in the hydraulic rotary method. To insure a straight hole the drill pipe is turned slowly while drilling. Casing is usually driven as the drilling proceeds. When hard layers are encountered, the drill bit at the end of the drill pipe is raised and allowed to drop on the hard material as in the cable-tool method.

Methods of Lift and Types of Pumps

Water is obtained from most of the domestic, dug, bored, and drilled wells in the area by jet pumps operated by electricity. The jet pump raises water from a well by a stream of water under pressure. Some wells are equipped with lift and force pumps which are operated by electricity and, on a few farms in the county, windmills are still used for operating these types of pumps. The cylinders or working barrels in lift and force pumps are similar and are located below the land surface either above or below the water surface, but a lift pump is capable of discharging water only at the pump head, whereas a force pump can raise water to a higher point such as an elevated tank. Pitcher pumps are used on some wells where the water level is within the suction limit. A few wells are still equipped with chain and bucket lifts.

Wells 57, 73, and 87, furnishing water to housing subdivision, are equipped with deep-well turbine pumps driven by electric motors. Deep-well turbine pumps are used in wells with greater depth to water, and where large demand for water results in greater drawdown. Connected turbines called bowls or stages (the number of such units depending on the height the water must be raised) are submerged below the water level and are connected by a vertical shaft to a vertical motor or pulley at the top.

A few wells in the area are equipped with submersible pumps. The submersible pump is similar in operation to the deep well turbine pump. The pump consists of a long small-diameter motor which is connected to a short propelling shaft below the bowls. The motor operates submerged at all times in the well. The water being pumped is separated from the electrical parts and motor bearings by an oil-filled case. The submersible motor and turbine impellers are a compact unit attached to and supported by the discharge pipe. Electric current is provided by use of a submarine armored cable; this cable, a small copper oil tube, and the discharge pipe form the only connection between the pumping unit and the surface.

PIEDMONT PROVINCE

The Piedmont province of Spotsylvania County is underlain by granite, gneiss, schist, quartzite, and slate that range from Precambrian to Late Paleozoic age (fig. 10). A generalized description

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Figure 10 (caption on next page) belongs near here.

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of the geologic formations and water-bearing properties of the rock units in the Piedmont province of Spotsylvania County is shown in table 3.

The following discussion of the rock units of the area at the time this work was carried on was based on geologic age designations compiled by Nelson (1928) and modified in accordance with current stratigraphic nomenclature (Keroher, 1966). A more recent geologic map of Virginia (Calver and Hobbs, 1963). considers many of the crystalline rocks units of the Piedmont province of Spotsylvania County to be "Formations of uncertain age." No attempt was made by the writer to show these changes in this report.

no ¶ However, the relationship of the stratigraphic nomenclature of these units is as follows:

Geologic Map Fig. 10 (this report)	Geologic Map of Virginia (Calver and Hobbs 1963)
Pzgr - granite	gr - Granite
Pzqd - quartz diorite	qd - Diorite
Pzhg - hornblende gabbro	hgb - Hornblende gabbo and gneiss
Pzp - Petersburg Granite	Pzpb - Petersburg Granite
Oq - Quantico Slate	Not mapped
Pzws - Wissahickon Formation, schist facies Pzwg - Wissahickon Formation, granitized gneiss	M Metamorphosed sedimentary rocks
Ppc - Peters Creek Quartzite	V Metamorphosed Volcanic and sedimentary rocks
PЄb - Baltimore (?) Gneiss	grgn - Granite gneiss

(page 48 follows)

Figure 10.--Geologic map of Spotsylvania County, Va.

STRATIGRAPHIC UNITS AND THEIR WATER-BEARING PROPERTIES

Precambrian Rocks

Baltimore (?) Gneiss

Jonas (1928) considered the metamorphic rocks just west of the Fall Zone and south of Fredericksburg--which are classed as crystalline schist of sedimentary origin--as being equivalent to the Baltimore (?) Gneiss. They are therefore designated the Baltimore (?) Gneiss. These are believed to be the oldest rocks in Spotsylvania County.

Lithology and distribution

The equivalent of the Baltimore (?) Gneiss in the area is believed to be of sedimentary origin and has been intruded by gneisses of igneous origin, which are in part of the same age and in part younger. The rock may be described megascopically as medium- to fine-grained crystalline aggregate of quartz, feldspar, hornblende, and mica and characterized by conspicuous bands owing to the alternation of layers of quartz and feldspar with layers of biotite. The biotite occurs in minute specular flakes, but which are not in sufficient quantity to produce a schistose rock. Associated with the biotite are hornblende, garnet, and epidote. The gneiss commonly has a psuedo-porphyritic texture owing to lenses of quartz and feldspar scattered irregularly through the bands. Rounded grains of resistant minerals such as quartz and apatite occur in the gneiss. These rounded grains strongly suggest a sedimentary origin for the rock.

The Baltimore(?) gneiss forms a continuous belt of varying width in eastern and southeastern Spotsylvania County. This belt trends approximately north and south and appears to dip gently to the southeast. The gneiss is generally concealed beneath a thick mantle of soil derived from its weathering. In the northeastern part of the area just below Fredericksburg, the gneiss is concealed by Coastal Plain sediments. The best exposure of this formation in the county appears to be along the Matta River 1-1/2 miles south of Thornburg where the river crosses from the Piedmont surface to the Coastal Plain. Other moderately good exposures may be seen along the Ni, Po, Ta, and Mat Rivers which flow southeastward across the strike of the gneiss.

Water-Bearing Properties

The Baltimore(?) gneiss does not yield large volumes of water to wells. However, joints or cracks in the rock hold some water, and although the ratio of joint space is small compared to the total volume of rock, they furnish storage for considerable quantities of water. During weathering of the gneiss joint planes are widened and other openings develop in the rock, and more or less water works its way along the bands in the gneiss. As a result of these openings owing to weathering, a considerable volume of water is usually contained in the zone of partly weathered altered rock lying between the fresh rock and the completely disintegrated rock. Many of the wells obtain their water supply from the weathered zone.

The 56 wells in the Baltimore (?) Gneiss on which information was obtained range in depth from 16 to 300 feet and have an average depth of approximately 35 feet. The range in reported yield is from 3 to 55 gpm and an average yield of about 4 gpm. Well 289, drilled to a depth of 198 feet, has a reported yield of 55 gpm.

Results of three samples of water from the Baltimore (?) Gneiss are given in table 11. Two water samples from shallow wells penetrating weathered portions of the formation had 36 and 40 parts per million (ppm) of dissolved solids and 12 and 15 ppm of hardness. One sample from the deeper unweathered gneiss contained 102 ppm of dissolved solids and had a hardness of 31 ppm. Fifteen field determinations (table 13) indicate the range of hardness, alkalinity, and chloride content of water derived from the Baltimore (?) Gneiss.

Early Paleozoie (?) Rocks

Wissahickon Formation

The Wissahickon Formation of the Glenarm series was named from exposures along Wissahickon Creek, a tributary of Schuylkill River, in Fairmount Park, Philadelphia, Pa. The formation, which varies considerably in lithology, ranges from a gneiss to a schist. In Spotsylvania County, this formation is characterized by two facies--a crystalline schist facies of sedimentary origin altered to an injection gneiss facies containing much hornblende gabbro.

Granitized gneiss facies

Lithology and distribution.--The granitized gneiss of the Wissahickon Formation forms a very small part of the rocks of the Piedmont province of Spotsylvania County. It occurs in a small triangular area in the southeastern part of the county, and extends from the North Anna River north to the vicinity of Snell. According to Jonas (1928) the granitized gneiss is bordered on the west by granite, and on the east the rocks grade into Baltimore(?) Gneiss. The extensive weathering of these facies, both areally and in depth, has rendered few if any recognizable outcrops in the area covered by this report, and all geologic interpretation by the author regarding these facies has been from available maps and literature.

Water-bearing properties.--Wells in Spotsylvania County that tap water from the granitized gneiss facies of the Wissahickon Formation range in depth from 17 to 58 feet and average about 28 feet. The average reported yield from these wells is about 3 gpm. Water supplied to wells from this formation is obtained from the zone of weathering. From the information obtained, no wells penetrate the fresh rock.

Results of two samples of water from the granitized gneiss facies are given in table 11. Concentrations of dissolved solids range from 44 to 76 ppm and hardnesses range from 18 to 29 ppm, which permit use of the water for all domestic purposes.

Schist facies

Lithology and distribution.--The schist facies of the Wissahickon Formation of the area consist of a chlorite-muscovite schist with quartzite in the lower part and thin greenstone lava flows near its base. Included within these facies is a garnetiferous biotite schist. This variety of the schist is characterized as gray to green schist which weathers to a brownish red clay soil filled with flakes of mica and containing buff to red schist. The two facies of the Wissahickon Formation, the granitized gneiss and schist, have the same chemical composition, and it is now known that they were derived by metamorphism from arkosic sediments, that is, sediments that considered largely of unweathered feldspars.

The schist facies of the Wissahickon Formation cross the area in two belts each about 3-1/2 miles wide. The belts of schist are separated by the Peters Creek Quartzite. The schist has been subjected to considerable weathering that has resulted in outcrops of saprolite. Probably the most extensive outcrop of the schist in the area is along State Road 208 at the North Anna River bridge where the schist contains both muscovite and biotite micas and is intruded by veins of feldspar and tough glassy quartz.

Water-Bearing Properties

The schist facies of the Wissahickon formation are a fairly good source of water in Spotsylvania County. Wells dug and bored into the saprolite zone usually yield sufficient water for domestic use. The deeply lying unweathered rocks of this formation are dense and impermeable, but fortunately many joints provide openings for the storage and circulation of water. Although these openings are numerous and hold considerable amounts of water, their total volume is small compared to the pore space in porous rocks such as unconsolidated sand or gravel.

The average depth of 90 wells in this formation is about 30 feet. They range in depth from 11 to 200 feet. Well 269, reported to have been drilled to 200 feet, is believed to tap water from fractures in the fresh rock. The depth of weathering of this formation in the area is shown by well 353, which was dug to a depth of 71 feet.

The schist usually yields water low in dissolved solids and free of objectionable minerals except iron. The three samples from this facies that were analyzed range in dissolved solids from 34 to 191 ppm and in hardness from 5 to 72 ppm (table 11). In some localities in the area underlain by this formation the water is undesirably hard, as shown by analyses of water from wells 275, 335, 348, and 352 (table 13). This hard water may be due to the occurrence of numerous pegmatite dikes, many of which contain large amounts of lime-soda feldspar.

Peters Creek Quartzite

The Peters Creek Quartzite, a unit of the Glenarm series of northeastern Virginia, is correlated with the Peters Creek Quartzite of Pennsylvania. It takes its name from Peters Creek, a small stream that enters the Susquehanna River at Peach Bottom, Lancaster County, Pennsylvania. Jonas and Knopf (1921) separated the upper unit of the Wissahickon Formation that is less highly metamorphosed than the Wissahickon itself and named it the Peters Creek Schist. Jonas (1928) mapped this unit in northeastern Virginia as Peters Creek Quartzite.

Lithology and Distribution

The Peters Creek Quartzite of Spotsylvania County is characterized as a quartzite and chlorite schist interbedded with chlorite-muscovite schist. There are a few thin sandstones which have been altered to quartzite near the top of the formation. The fresh rock is gray to green, but the iron-bearing parts weather easily and iron oxides may stain the rocks yellow. Soils resulting from the weathering are difficult to distinguish from those of the Wissahickon Formation.

Within Spotsylvania County, the Peters Creek Quartzite overlies the Wissahickon Formation and occupies a narrow belt about 5 miles wide which extends along a line north-northeast to south-southwest from the Rappahannock River to the North Anna River. The Wissahickon borders along the western and eastern edge of the Peters Creek Quartzite. The surface of the quartzite has been completely disintegrated by weathering into a thick soil mantle containing abundant remains of the more resistant quartz rock.

Water-bearing properties

Most wells which tap the Peters Creek Quartzite obtain water from the weathered part of the formation. The deeper lying unweathered rocks of the quartzite are dense and impermeable, but fortunately many joints provide openings for the storage and circulation of water. Although these openings are numerous and may hold considerable amounts of water, their total volume of pore space is small compared to that of unconsolidated sand and gravel.

Wells yield sufficient supplies of water for ordinary domestic use from depths less than 50 feet. Twenty representative wells tapping this formation range in depth from 14 to 37 feet, and average about 25 feet. Their average reported yield is about 4 gpm.

The water from the Peters Creek Quartzite is somewhat similar to water from the schist of the Wissahickon, although more soft. Results of analyses of water from wells in the formation indicate hardnesses in the range of 8 to 58 ppm. (See table 13.)

Ordovician System

Upper Ordovician Series

Quantico Slate

The Quantico slate was named from exposures along Quantico Creek, in Prince William County, Virginia. It overlies the Peters Creek quartzite in Spotsylvania County and is believed to have been deposited at about the same time as the Martinsburg shale west of the Blue Ridge. From Cincinnatian fauna collected at the Powells Creek section near Dumfries, Prince William County, Watson and Powell (1911) assigned the Quantico slate to Late Ordovician age.

Lithology and distribution:--The Quantico slate in Spotsylvania County is characterized as a gray to dark-gray slate with interbedded green and maroon slates and fine texture black graphite slates. Graphite appears to be a major constituent of the slate. Lonsdale (1927) reported that as much as 3 percent of the total composition of the rock occurring at Powells Creek section, was graphite. Pyrite commonly occurs with the slate as lenses and pockets, however no workable deposits of pyrite have been found in the slate.

The slate lies in a discontinuous belt approximately 40 miles long extending from Shady Grove Corner in Spotsylvania County northeast to Quantico Creek in Prince William County. However, Watson (1916) mapped the slate in the area as being continuous from Shady Grove Corner northeast to the Rappahannock River. Several exposures of the slate have been reported in Spotsylvania County, but only the exposure at Shady Grove Corner was accessible to the author. It appears in a road cut along State Road 608 approximately 1-1/2 miles west of Shady Grove Corner.

Water-Bearing Properties.--Slate is an impervious fine-grained rock. Water circulates through openings found along joints, fault planes, bedding planes, or planes of schistosity and not through pores in the rock. Slate, because of intense folding and development of cleavage, is probably a better source of water than many less highly metamorphosed rocks.

The three wells tapping the Quantico slate on which information was obtained range in depth from 26 to 34 feet and have an average depth of 30 feet. Wells derive water from the weathered portion of the slate and sufficient water is obtained for most domestic needs.

One sample of water from the Quantico slate was analyzed and contained 310 ppm of dissolved solids and 77 ppm of hardness.

Late Paleozoic Rocks

Petersburg Granite

The Petersburg granite in Spotsylvania County was named for type exposures occurring in the vicinity of Petersburg, Virginia, where large areas of the formation have been mapped. Lonsdale (1927) divided the granite and granite gneiss in the vicinity of Fredericksburg into the Fredericksburg gneiss and Fredericksburg granite. Later Jonas (1928) grouped both rock units under the inclusive term of Petersburg granite.

Lithology and distribution

The Petersburg granite occurring in Spotsylvania County is a coarse- to fine-grained gray biotite granite with coarse-grained pink porphyritic facies, intruded by bluish granite in the vicinity of Fredericksburg. This granitic rock is derived from a magma that was intruded into the Baltimore(?) gneiss and consequently is younger than the latter. The Petersburg granite has in turn been intruded by gabbro and other ultrabasic rocks.

The exposures of the Petersburg granite (Jonas 1928) embrace an area extending about 8 miles northwest and 8 miles southwest of Fredericksburg.

The best exposures occur in the Rappahannock River in the vicinity of Fredericksburg, 2-1/2 miles northwest of Fredericksburg in several abandoned quarries along the south side of the Rappahannock River, and scattered along Hazel Run 1 mile southwest of Fredericksburg.

Water-Bearing Properties

The water-bearing properties of granitic rocks resemble those of the Baltimore(?) gneiss, and in most cases these rocks yield small quantities of water to wells, sufficient for domestic use. The rocks are jointed and water occurs chiefly along the joints. Wells that fail to obtain sufficient water above a depth of about 300 feet should be abandoned and a new site selected, as the water-bearing openings decrease in number with depth. In Spotsylvania County, 10 wells on which information was obtained tap water from the weathered portion of the granite. The wells range in depth from 19 to 56 feet, and average about 30 feet.

The water from the granitic rock is likely to be low in dissolved solids and low in hardness. Water from well 162 (table 11) had a hardness of 8 ppm. However, where the calcium content of the rocks is large, water may be higher in dissolved solids and hardness.

Late Paleozoic(?) Rocks

Localized Intrusive Rocks

Under this heading are included hornblende gabbro, quartz, diorite, and granite that have been mapped by Jonas (1928) as intrusives into the Glenarm series and Petersburg Granite. Hence, these intrusives may be of Late Paleozoic(?) age.

Lithology and distribution

The hornblende gabbro consists chiefly of hornblende associated with pyroxenite, peridotite, soapstone, and serpentine. It occurs in small elliptical masses throughout the Piedmont province of Spotsylvania County and is exposed in disconnected outcrops of different sizes. The exposures have been almost completely disintegrated by erosion and have been weathered to a soil closely resembling that of the surrounding granite.

Quartz diorite, appearing on published maps of the area, consist of oligoclase, quartz, and mica; the quartz is chiefly of a blue variety. The quartz diorite occurs in an elongated mass in the northwest part of the area, about 2 miles west of the confluence of the Rappahannock and Rapidan Rivers. Jonas (1928) shows the formation extending about 10 miles southwest into Spotsylvania County from the Rapidan River.

The area mapped as granite in Spotsylvania County (Jonas 1928) is chiefly biotite granite and quartz monzonite with some muscovite granite and pegmatites. The quartz monzonite occurring with the granite is a medium- to fine-grained dark gray rock composed primarily of quartz, feldspar, pyroxene and amphibole. The feldspars are orthoclase and plagioclase and are present in nearly equal amounts. Ferromagnesian minerals are abundant. The quartz monzonite weathers to a dark, oxidized, rough and pitted surface and crumbles easily. The granite is presumed to be derived from magma that was intruded into the Wissahickon Formation and Baltimore(?) Gneiss, and is consequently younger than these formations. It has in turn been intruded by gabbro. This granite occurs in a belt approximately 2-1/2 miles wide along the Rappahannock River west of Fredericksburg and trends southwesterly across the county to the North Anna River, and in the extreme southwest corner of the county it is exposed over an area of about 20 square miles in various stages of disintegration. The term granite as used on the published Geologic Map of Virginia (1928) is believed to include in part the Fredericksburg Granite described by Lonsdale (1927).

Water-Bearing Properties

The water-bearing properties of these intrusive rocks resemble those of the Baltimore(?) gneiss, and in most places these rocks will yield small quantities of water. The rocks are jointed and fractured and water occurs chiefly in the joint and other fracture openings. If a well under construction is still dry at a depth of 300 feet, it is considered good practice to select a new site and drill another well, because the water-bearing openings decrease in number with depth. The 55 wells on which information was obtained tap water only from the granite. The wells range in depth from 15 to 296 feet, and average about 30 feet. The range in yield is reported as a few gallons per minute to 16 gpm. Well 201, drilled to a depth of 296 feet, has a reported yield of 16 gpm, and well 202, drilled to a depth of 164 feet, has a reported yield of 8 gpm. The four water samples from this formation that were analyzed (table 11), range in dissolved solids from 102 to 190 ppm and in hardness from 11 to 78 ppm. However, water from wells 209, 230, 231, 279, 372 (table 13) had a higher hardness, which may reflect a greater calcium content of the rock.

ATLANTIC COASTAL PLAIN PROVINCE

The rocks that underlie the Coastal Plain province in Spotsylvania County shown in figure 10 range in age from pre-Cretaceous to Recent. At different depths below the surface they consist predominantly of unconsolidated sand, gravel, and clay. Locally, some of these deposits have been lithified into white arkosic sandstone, ferruginous conglomerate, and limonitic plates. Beneath these normally unconsolidated deposits, the very old and very hard rocks of the basement complex extend for a great but unknown depth. The structural relationship of the Coastal Plain sediments overlying Piedmont crystalline rocks and the basement complex is shown in figure 11.

Figure 11 (caption on next page) belongs near here.

In the vicinity of Fredericksburg, exposures include granite and granite gneiss of pre-Cretaceous age, the Patuxent Formation of Cretaceous age, the Aquia Formation of Eocene age, rocks including the Calvert Formation, terrace deposits of Pleistocene age and, locally, deposits of Recent age.

A generalized description of Coastal Plain deposits and their water-bearing properties in Spotsylvania County is given in table 4.

Figure 11.--Generalized geologic columnar section showing the rock units in the Coastal Plain of Spotsylvania County.

Table 4 .--Stratigraphic summary of rock units of the Coastal Plain, Spotsylvania County, Va.

SYSTEM	SERIES	GROUP	UNIT	CHARACTER	WATER-BEARING PROPERTIES
Quaternary	Recent		Alluvium	River silt, sand and gravel, marsh and swamp deposits.	Alluvium in the area is probably not of sufficient thickness to be of importance as a source of ground water.
	Pleistocene	Columbia	~~Terrace~~ Undifferentiated ~~deposits~~	Sand and gravel mixed with bright colored clays and loams. Cross-bedded sands occur in lower terraces of the area.	Nearly all the wells of the Coastal Plain portion of the county obtain water from terrace deposits. Wells range in depth from 6 to 60 feet and yield up to 15 gpm.
Tertiary	Miocene	Chesapeake	Undifferentiated	Gray- to buff-colored sandy clay, stained red and brown.	Non-water-bearing.
			Calvert formation (Plum Point marl member)	Gray, blue, and green silty clay, containing diatoms.	

Table 4 .--Stratigraphic summary of rock units of the Coastal Plain, Spotsylvania County, Va.--Continued

SYSTEM	SERIES	GROUP	UNIT	CHARACTER	WATER-BEARING PROPERTIES
ertiary	Eocene	~~Pamunkey~~	Aquia formation	Gray, green sand and clay containing flakes of mica, various amounts of iron which have been redeposited as limonite and glauconitic casts of microfossils.	So far as known, no wells in the area obtain water from this material.
retaceous		Potomac	Patuxent formation	Cross-bedded white and stained with limonite, containing both clear and blue quartz, and quantities of white kaolinized feldspar. Gravels and clay lenses occur through the formation. Locally, indurated sand contains gravel, imprints of tree branches, and lignitized wood.	Wells that tap this formation in the vicinity of Fredericksburg yield 15 gpm. Water contains objectionable amounts of iron and small quantities of hydrogen sulfide.

Table 4 .--Stratigraphic summary of rock units of the Coastal Plain, Spotsylvania County, Va.--Continued

SYSTEM	SERIES	GROUP	UNIT	CHARACTER	WATER-BEARING PROPERTIES
pre-Cretaceous			Basement Complex	The material underlying the sands of the Potomac group in the vicinity of Fredericksburg consists chiefly of granites and granite gneisses.	Water occurs chiefly in fissures and joints and within the weathered zone. Small quantities of water have been obtained from the weathered zone, and up to 40 gpm from the deeper fractured zone. A few deep wells have been reported to yield salt water.

STRATIGRAPHIC UNITS AND THEIR WATER-BEARING PROPERTIES

Pre-Cretaceous Rocks

The crystalline igneous and metamorphic rocks of the basement complex that underlie the Coastal Plain sedimentary rocks of northeastern Spotsylvania County reflect a complex portion of geologic history. The rocks have been altered by contact metamorphism produced by intrusive granitic rocks injected into Precambrian sedimentary rocks and believed to be later injected by younger granitic material. In the vicinity of Bowling Green, Caroline County, approximately 18 miles south-southeast of Fredericksburg, brown sandstones of Triassic age have been reported to overlie Precambrian granite (Cederstrom, 1945b, p. 30, 31). However, the westward extent of Triassic sedimentary rocks beneath the Cenozoic deposits of the Coastal Plain is indeterminable from available subsurface data, although deposits of Triassic age have been mapped in areas west and northwest of Spotsylvania County. The deeply eroded surface of the basement complex in the vicinity of Fredericksburg (fig. 12) may account for the lack of Triassic material, locally.

Figure 12 (caption on next page) belongs near here.

As the basement complex is overlain by sedimentary rocks of Cretaceous age or younger it is here termed pre-Cretaceous in age.

Figure 12.--Geologic cross section projected along line A-A' showing stratigraphy of the Coastal Plain province of Spotsylvania County, Va.

Configuration of the buried rock surface

The surface of the basement complex in the vicinity of Fredericksburg is deeply eroded and slopes to the southeast. Figure 12, showing a profile of this surface, indicates that just east of U. S. Highway 1 (Alt.) the slope of the surface steepens. At test hole 1, bedrock was encountered at approximately 8 feet below sea level. Southeast from test hole 1 the surface of the basement complex is irregular, with trench-like depressions cut to a depth of at least 145 feet below sea level. At test hole 3, the undulating surface of the trench appears to extend for a distance of about 3 miles and its profile appears thus: Wells 54 and 66, less than 1,000 feet east of test hole 1, drilled to depths of 33 and 28 feet below sea level, respectively, do not encounter the bedrock. However, approximately a quarter of a mile southeast of well 66, bedrock is reached at well 52, at 45 feet below sea level; well 72, 108 feet below sea level, and well 74, approximately a quarter of a mile east of well 72, encounters bedrock at 32 feet below sea level. Well 133, drilled to a depth of 215 feet, reached bedrock at about 10 feet below sea level. Consequently, it would appear that the surface attains its more normal slope beneath Coastal Plain sediments in the vicinity of well 133.

Cederstrom (1945a, p. 16) describes a similar condition in the Richmond-Petersburg area of the Fall Zone and attributes such depressions as possibly indicating a pre-Cretaceous channel extending east and west.

Lithology and Distribution

The basement complex of the Coastal Plain portion of the county consists chiefly of granite and granite gneiss in the vicinity of Fredericksburg and along Hazel Run west of U. S. Highway 1 (Alt.). South of Thornburg at the Matta River bridge exposures of the Baltimore(?) gneiss are overlain by a thin veneer of Coastal Plain sediments. The granite and granite gneiss of the northern part of the Fall Zone, in the vicinity of Fredericksburg, grade into rock of the Baltimore(?) gneiss, which represent the basement complex in the vicinity of Thornburg.

Water-Bearing Properties

A few wells in the Fall Zone of the area obtain water from the basement complex. The water occurs chiefly in fissures and joints in the granite rock at depth and in the weathered portion directly overlying the fresh rock. Openings in granitic rocks decrease with depth and, generally, 300 feet is considered the limit of depth to which a well should be drilled. A well owned by W. W. Lupton, 1 mile northeast of Fredericksburg in Stafford County, was reported drilled to a depth of about 1,100 feet and penetrated approximately 800 feet of granite rock. Upon completion of the well, the reported static level was 900 feet below land surface and no attempt was made to pump water from this depth. Wells 52, 72, and 112 (table 7) have been drilled to depths of 512 feet, 635 feet, and 640 feet, respectively, and have reported yields up to 40 gpm.

Water which is obtained from the basement complex ranges widely in respect to dissolved mineral constituents. Water in well 139 contains 130 ppm of dissolved solids, and is suitable for most domestic uses except for objectionable amounts of iron. (See table 11.) Water in wells 137 and 311, drilled to depths of 350 feet and 108 feet, respectively, contain less than 20 ppm of chloride and less than 50 ppm of hardness. (See table 13.) Wells tapping water from the deeper fractured zones of the basement complex have been reported to contain undesirable quantities of salt water--chloride content up to 5,500 ppm (fig. 13). Wells tapping water from sands of the overlying

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Figure 13 (caption on next page) belongs near here.

Patuxent Formation obtain some recharge water from the basement complex. Consequently, it is believed that the higher concentrations of chloride found in these waters are derived in part form residual sea water still remaining within the basement complex (Subitzky, 1961).

Figure 13.--Diagrammatic circulation system showing relation of fresh ground water to residual saline water in the basement complex rocks of the Fall Zone, Spotsylvania County, Va.

Cretaceous System

McGee (1886) introduced the name Potomac Formation to the Lower Cretaceous strata which are well exposed along the Potomac River. Clark and Bibbins (1887) proposed a four-fold classification of this formation, raising it to the rank of a group. The four formations named were Patuxent, Arundel, Patapsco, and Raritan in ascending order. Later, the Raritan Formation was demonstrated to be of Late Cretaceous age, and it was removed from the Potomac Group (Clark and Miller, 1912). Within the Coastal Plain portion of Spotsylvania County, only the Patuxent Formation is believed to be present.

Patuxent formation

The Patuxent formation was named from exposures along the Patuxent River, Maryland. It is the basal formation of the Potomac group and is regarded as the oldest Cretaceous formation in Virginia.

Although the Patapsco formation has been shown on published maps as far south as Fredericksburg, Cederstrom (1945a) points out that its presence has not been definitely proved south of Fort Belvoir, Virginia. The Arundel and Raritan formations are both believed to be entirely absent from the stratigraphic section of Virginia.

The Patuxent formation in the vicinity of Fredericksburg unconformably overlies crystalline rocks of the basement complex and in turn it is overlain unconformably by Eocene and Miocene beds. Locally, its eroded surface is covered by a mantle of terrace material of Pleistocene age and by deposits of Recent age.

The strike of the Patuxent formation in the area is almost due north and its eastward dip varies from 50 feet per mile in the vicinity of the Fall Zone to about 30 feet per mile at its easternmost exposures.

Because of the irregular configuration of the surface of the basement complex (fig. 12), the thickness of the overlying Patuxent formation is not uniform. Along Hazel Run in the vicinity of U. S. Highway 1 (Alt.) a thickness of 75 feet is attained. Approximately 3 miles to the southeast in test hole 3, 200 feet of the Patuxent formation was penetrated. This is believed to represent its maximum thickness within the area.

Lithology and Distribution

The Patuxent Formation in Spotsylvania County is commonly represented by cross-bedded white sands, composed of medium to coarse angular grains of white, colorless, and blue quartz mixed with considerable quantities of white kaolinized feldspar which renders the mass rather cohesive when wet.

The sand component of the deposit is frequently streaked with brown limonitic stains, and occasionally on the upper surfaces of clay lenses limonite has cemented the sand to form hard brown crusts known as "hard pan" or "ironstone." Associated with this limonitic cementation are hollow tubular concretions believed to have been formed by precipitation of limonite around irregular masses of clay. The clay forms the core of the tubular concretion. Later, the clay core is removed by weathering, leaving a hollow tube. The residual limonite tubes (fig. 14) range in size from a quarter of an inch to

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Figure 14 (caption on next page) belongs near here.

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approximately 1-1/2 inches in diameter and up to 5 inches long. These concretions may be observed in the outcrop areas of the Patuzent Formation along U.S. Highway 1. Occurrence of similar concretions have been discussed in the literature and the reader is referred to Smith (1948) and Schneider (1949).

Figure 14.--Common types of ferruginous concretions occurring in the Patuxent Formation in the vicinity of Fredericksburg, Va.

The limonite may well be the weathered product of pyrite, which is commonly seen in well cuttings, and helps attest to the terrestrial source of the sediments of which this formation is composed.

Locally, lithification has altered unconsolidated sands containing coarse-textured quartz sand and feldspar into a light gray to white arkosic sandstone. The sandstone shows cross-bedding and is characterized by zones of gravel and clay pellets. The best exposure of the sandstone is along U.S. Highway 17, approximately 6 miles southeast of Fredericksburg at the north corner of the bridge crossing Massaponaz Creek.

Lenses of gravel are not uncommonly developed in the formation. The pebbles are chiefly quartz, well rounded, and average 1-1/2 inches in diameter. The lenses are discontinuous, separated by a matrix of sand and clay. Gravels range in size from 1 to 3 inches in diameter, but a few boulders measure 3 feet in diameter.

Numerous clay lenses appear within the Patuxent formation, ranging in size from several inches thick and several feet in lateral extent to large beds approaching 30 feet in thickness and extending hundreds of feet. The clays are usually blocky and massive but a few are thin-bedded. They range from highly plastic to rather sandy and most are light to dark gray in color. A bed of dark green clay, which weathers to a brick-red color, lies at the base of the Patuxent formation along Hazel Run. Dark purple thin-bedded sandy clays have been noted locally near the top of the formation.

The easternmost extent of the Patuxent formation is observed along the south bank of the Rappahannock River, half a mile below the mouth of Massaponax Creek.

Paleontology

Fossils in the Patuxent formation are generally preserved as lignitized wood, silicified wood, and impressions of tree remains. Lignitized wood occurs in the uppermost part of the formation in the vicinity of Hazel Run. Impressions have furnished, by far, the most extensive flora; the flora includes ferns, cycads, conifers, and supposed angiosperms. Fontaine (1889) and Berry (1912) have described numerous plant fossils from the vicinity of Fredericksburg. Bailey (1843) described silicified conifer wood from Fredericksburg. Berry (1912, p. 73) lists 30 species of flora obtained from the site of the old steamboat landing at Fredericksburg.

Water-Bearing Properties

The Patuxent formation of the Potomac group in Spotsylvania County does not yield large supplies of water to wells. These deposits, within the Fall Zone, consist primarily of sand overlain by or grading into silt and clay. Ground water, migrating from the source of recharge to points of discharge, generally follows the sand portions of the formations.

The outcrop area of the Patuxent formation in the vicinity of Fredericksburg serves as a recharge area for its ground-water reservoir. The recharge water supplying this extensive aquifer of the Coastal Plain of Virginia is obtained primarily from precipitation and perhaps to some extent from stream infiltration. Farther down the dip than Spotsylvania County substantial recharge may possibly be obtained by leakage through the confining beds.

Information was obtained on 27 wells that tap sands of the Patuxent formation. They range in depth from 77 to 300 feet below land surface and average about 200 feet.

Well 116, drilled to a depth of 300 feet, located along the Rappahannock River in the extreme northeast corner of the county, is reported to flow at approximately 8 gpm. This is believed to mark the westernmost extent of flow from the Patuxent formation. The yield of wells from this water-bearing unit ranges from 2 to 40 gpm and averages about 15 gpm. Most wells penetrating the Patuxent formation east of U. S. Highway 1 (Alt.) in the northeastern part of the area obtain up to 10 gpm.

Water samples obtained from different water-bearing zones within the formation range from 43 to 579 ppm in content of dissolved solids, and in hardness from 17 to 164 ppm. Well 133, drilled to a depth of 215 feet, obtains water from coarse sand overlying the basement complex (fig. 12). Water from this well contains 579 ppm of dissolved solids and 137 ppm of chloride which suggests some mixing of high chloride water from the basement complex with water in the Patuxent formation. The concentration in dissolved solids and hardness is such as to permit use of this water for most domestic purposes. However, locally, the iron concentration ranges from 0.34 to 12 ppm and slight traces of hydrogen sulfide gas may render this water objectionable for cooking and laundering unless it is aerated before use.

Tertiary System

Paleocene Series

Data on Spotsylvania County are not sufficient to show whether beds of Paleocene age are present. The Mattaponi formation of Late Cretaceous and Paleocene age has been described in the subsurface section at nearby Colonial Beach and Dahlgren. The reader is referred to Cederstrom (1957) for further information regarding the Mattaponi formation.

Eocene Series

Darton (1891) applied the name Pamunkey formation to the Eocene deposits of Maryland and Virginia that are exposed along the Pamunkey River in Virginia. Clark and Martin (1901) elevated the Pamunkey formation to group status by applying the name Aquia formation to the lower part and Nanjemoy formation to the upper part. Only the Aquia formation is recognized in Spotsylvania County.

Aquia Formation

The Aquia formation has been divided into the Piscataway indurated marl member and the Paspotansa greensand marl member on the basis of paleontologic differences, according to Clark and Martin (1901). Because these members are similar lithologically, the Aquia formation is undifferentiated in this report.

Lithology and distribution.--The Aquia formation recognized in Spotsylvania County is a series of fine glauconitic, micaceous sands that contain moderate amounts of clay. Fresh samples are dark bluish-gray or black and local well drillers refer to the material as black marl. Weathered exposures are bleached to varying degrees so that the color ranges from dark gray to buff and white. The white sands of the Aquia formation are distinguished from those of the underlying Patuxent formation by their fine-grained texture and absence of cross-bedding. Indurated beds of silicified sand of the Aquia occur at nearby Stafford Court House, Stafford County, while at Aquia Creek and Fairview Beach the greensands have been cemented with calcium carbonate. Clay beds of the Aquia formation resemble those of the Patuxent formation. Small quantities of gravel have been noted in the upper portion of the formation. The pebbles consist primarily of quartz, well-rounded, and generally less than 1 inch in diameter.

Clark and Miller (1912) determined the thickness of the Aquia formation to be about 100 feet at its type locality along Aquia Creek in Stafford County. The average dip is about 15 feet per mile eastward (Gildersleeve, 1942). West of U. S. Highway 1 (Alt.), on the "heights" overlooking Fredericksburg, the Aquia formation overlies pre-Cretaceous granite and granite gneiss. To the east, the Aquia formation disappears for a short distance, reappearing along the north bank of the Rappahannock River opposite the mouth of Massaponax Creek. Additional exposures in the area occur along the south bank of the Rappahannock River for a distance of 1-1/2 miles below the mouth of Massaponax Creek. A thickness of 44 feet of Aquia formation occurs along the south bank of the Rappahannock River 1 mile below Massaponax Creek (section 6, table 10). This is believed to be the greatest thickness reported in the county.

Paleontology.--The Aquia formation as it occurs in Spotsylvania County is unique in its absence of well-preserved fossils. Elsewhere, the formation yields abundant fossils.

Clark and Miller (1912) reported the following species from the exposures along the south bank of the Rappahannock River, 1 mile below the mouth of Massaponax Creek:

Crassatellites alaeformis

Cuculaea gigantea

Ostrea compressirostra

Meretrix ovata var. *pyra*

Turritella mortoni

Gildersleeve (1942) listed 37 species of fossils from the Aquia formation of Virginia.

Water-Bearing Properties:--So far as known, no wells in the area tap the Aquia formation. However, elsewhere in the Coastal Plain of Virginia, deposits ~~of the Pamunkey group~~ of Eocene age are excellent water-bearing formations from the standpoint of permeability (Cederstrom, 1945a). It is also pointed out that wells finished in glauconitic sand, alone, yield a little greensand with the water. The water is greenish and has an unpleasant odor.

Miocene Series

The Chesapeake group of the Miocene series has been subdivided by Clark and Miller (1912) into the Calvert, Choptank, St. Marys, and Yorktown formations. Within the Coastal Plain of Spotsylvania County only the Calvert formation is present.

Shattuck (1902) first applied the name Calvert formation to the basal beds of middle Miocene age that are exposed in the Calvert Cliffs, Calvert County, Maryland. Later, Shattuck (1904) subdivided the Calvert formation into the basal Fairhaven diatomaceous earth member, which consists of a large proportion of diatoms in a finely divided quartz matrix, and the Plum Point marl member, which consists of a series of sandy clays and marls containing a large number of organic remains including diatoms. Only the Plum Point marl member has been recognized in Spotsylvania County.

Calvert Formation, Plum Point Marl Member

The Plum Point marl member was named for Plum Point, Calvert County, Maryland where typical exposures of the marl occur.

Lithology and Distribution.--The marl consists of a series of clays containing very fine white quartz sand in which are imbedded large numbers of organic remains including diatoms. The color of the material is green, bluish-gray to grayish-brown and buff. Fresh samples of the marl obtained from wells in the county contain a considerable amount of argillaceous material which is blue-green in color but whitens on contact with the atmosphere.

The Plum Point marl member occurs discontinuously in the subsurface section of the Coastal Plain province of eastern Spotsylvania County. In most of the area the formation is overlain by ~~terrace~~ sands and gravels of Pleistocene age, but locally where material of Pleistocene age has been removed by erosion it is covered by depos of Recent age (Subitzky, 1955). In turn, the Calvert formation overlies unconformab the basement complex of pre-Cretaceous age along the Fall Zone, and east of Frederi burg, the Potomac Group and deposits of Eocene age ~~and Pamunkey groups~~. The marl strikes approximately north and slopes eastward at a rate of about 10 feet per mile. Test hole 3, drilled to a depth of 364 feet below land surface, penetrated 140 feet of marl. So far as known, this is the greatest thickness penetrated in Spotsylvania County. Well 308, 0.6 mile south-southeast of Thornburg, bored to a depth of 45 feet below land surface, penetrated only the first 5 feet of the marl.

Paleontology.--The Calvert formation of Miocene age as shown on published geologic maps of the area includes in part the Plum Point marl member. Five samples of material collected from well 98, and test hole 3, yielded 96 species and varieties of marine diatoms (~~see~~ table 5). Mr. K. E. Lohman (Personal Communication, 1955) classified the material as:

Table 5.--Distribution of marine diatoms of the Plum Point marl member of the Calvert formation

Relative abundance is indicated by A - abundant; C - common; F - frequent; R - rare.

WELL	98	98	Test Hole No. 3		
Depth in feet	30-93'	23-44'	44-65'	65-85'	8[illegible]-10[illegible]
U.S.G.S. Diatom Locality Number	4138	4139	4140	4141	4142
Actinocyclus curvatulus Grunow	R				
Ellipticus Grunow	F	F	F	F	[illegible]
octonarius Ehrenberg	C	C		F	[illegible]
tenella (Brebisson) Cleve	F	F	F		
Actinoptychus campanulifer Schmidt	F				
cf. A. areolata Ehrenberg		R			
senarius Ehrenberg	C	C	C	C	C
cf. A. simbirskianus Schmidt	F				
splendens (Shadbolt) Ralfs	F	C	F	F	[illegible]
Biddulthia aurita Brebisson	F				[illegible]
semicircularis (Brightwell) Roper		R			
suborbicularis Grunow	F	F		R	[illegible]
tuomeyi Bailey	F		F	F	[illegible]
Chaetoceros sp.	F	F			[illegible]
Cocconeis cf. C. Dirupta var. flexella (Janisch and Rabenhorst) Grunow	R				
sp.	R				
Coscinodiscus cf. C. aeginensia Schmidt	R				
apiculatus Ehrenberg				F	

Table 5.--Distribution of marine diatoms of the Plum Point marl member of the Calvert formation--Continued

	Well 98		Test Hole # 3		
	4138	4139	4140	4141	4142
apiculatus var. ambigua Grunow					F
arcus Lohman	F	F	F		F
asteromphalus Ehrenberg	F			F	
convexus Schmidt	F	R			R
curvatulus Grunow			F	F	
divisus Grunow	R		R	R	
elongatus Grunow	R				
excentricus Ehrenberg	F	R		R	F
lacustris var. septentrionalis Grunow	F	F	F	R	F
lineatus Ehrenberg	F	F	F	F	F
marginatus Ehrenberg					R
nodulifer Schmidt	F	R			
obscurus Schmidt		F			R
oculus-iridis Ehrenberg	F		F	F	R
oculus-iridis var. subspinosa Grunow	R				
perforatus var. cellulosa Grunow	F		F		R
radiatus Ehrenberg	F	F	R	F	F
radiatus var. minor Schmidt					R
salisburyanus Lohman	F	F		R	
stellaris Roper	R				R
subtilis Ehrenberg	F	F	F	F	F
velatus Ehrenberg	F	R			R
vetustissimus Pantocsek			F	F	
sp.	F	F			F

Table 5.--Distribution of marine diatoms of the Plum Point marl member of the Calvert formation--Continued

	4138	4139	4140	4141	4142
Craspedodiscus coscinodiscus Ehrenberg	R	R	R		R
Cymatogonia amblyoceras (Ehrenberg) Hanna	R	R			R
Denticula lauta Bailey	R	R			R
sp.	R	R			R
Dicladia capreolus Ehrenberg	F	F			F
Dimerogramma novae-caesarae Kain & Schultze	F	F	F	R	F
Diploneis crabro var. suspecta (Ehrenberg) Van Heurck	F	R		R	R
vacillans Schmidt	R				
Dossetia lacera (Forti) Hanna					R
Endictya robusta (Grenville) Hanna and Grant	F	F	F	F	F
Fragilaria sp.	F	F			
Goniothecium rogersii Ehrenberg	F	F	F	F	F
Grammatophora sp.	F	R	F	F	R
Hercotheca mammalaris Ehrenberg	F	F		R	
Hemiaulus plymorphus Grunow	C		F		R
Hyalodiscus sp.	F			F	
Liradiacus bipolaris Lohman		F	F	F	F
minimus Lohman	F				
ovalis Greville	R				
sp.	F	F			F
Lithodesmium cf. L. minusculum Grunow		R	R		
sp.	R				R
Melosira complexa Lohman	F		R		R
sulcata (Ehrenberg) Kützing	A	A	A	A	A
sp.	F	F			F
Navicula pennata Schmidt	C	F	F	C	F
Nitzachia sp.	R				
Periptera tetracladia Ehranberg	F	F	F		R
Pleurosigma affine var. fossilis Grunow	F	F	C	F	F
Pseudsuliscus radiatus (Bailey) Rattray	R				
Pseudo-pyxilla americana (Ehrenberg) Fortié	R	R	F		
dubia Grunow	F	F	R		

Well 98 Test Hole # 3

Table 5.--Distribution of marine diatoms of the Plum Point marl member of the Calvert formation--Continued

	4138	4139	4140	4141	4142
Pterotheca kittoniana Grunow	R				R
Pyxilla sp.	F		R	R	
Rattrayella inconspicua (Rattray) Hanna			R		R
Rhaphoneis elegans Pantocsek and Grunow	F		R		
gemmifer Ehrenberg	F	F	C	F	
obesa Hanna	R				R
parilis Hanna	F	F	F	R	R
sp.	R	F	F		F
Rhizosolenia sp.	R				
Stephanogonia actinoptychus (Ehrenberg) Van Heurck	F	F	F		
polyacanths Forti	R		F		
Stephanopyxis corona (Ehrenberg) Grunow	C	F	F	F	F
grunowii Grove and Sturt	FC	F	F	F	F
lineati (Ehreberg) Forti	F	R	F		R
turris (Greville and Arnott) Ralfs	F		F	R	R
Stictodiscus kittonianus Greville	C	F	F	R	F
Thalassionema nitzachioides Grunow	C	F	C	F	F
Triceratium interpunctatum Grunow	C	F	F	R	R
Tropidoneis sp.	R				
Xanthiopyxis oblonga Ehrenberg	F	F		R	F
umbonata Greville		R			
Zygoceros circinus Bailey	R				

"Species of diatoms characteristic of and known only from the Fairhaven diatomaceous earth member in Maryland, or its stratigraphic equivalent elsewhere, are notably absent from all of the present collections. Likewise, species of diatoms characteristic of the overlying Choptank formation in Maryland and adjacent regions are also notably absent. Furthermore the characteristic and diagnostic species of the Plum Point marls which occur in the collections from the wells in Spotsylvania County have never been found in the Choptank or later formations. Therefore the evidence is overwhelming for correlating the collections 4138 to 4142 inclusive with the Plum Point marl member of the middle Miocene Calvert formation.

"These conclusions are based on the study of the diatoms from a large number of collections I have made from all zones of the Calvert, Choptank, and St. Marys formations, both from the type localities of the three formations and from other exposures in Maryland and Virginia."

Water-Bearing Properties:--The Plum Point marl member of the Calvert formation is essentially non-water bearing in Spotsylvania County but serves as a "cap rock," confining water under artesian pressure in the deeper water-bearing sands of the Potomac group. Shallow wells in the area have been carried down to but not into this formation.

Miocene Deposits, Undifferentiated

Overlying the Plum Point marl member of the Calvert formation, or, locally, sands of Cretaceous age, and the basement complex, varicolored clay appears at the base of the Pleistocene ~~terrace~~ deposits.

The clay occurs on the divides between the streams which head in the Piedmont and flow southwestward across the Coastal Plain portion of the area. Along U. S. Highway 1 (Alt.), exposures of this clay appear in road cuts between Fredericksburg and Four Mile Fork. The clay is chiefly gray in color, with brown and red mottling produced from the limonite crusts associated with the overlying ~~terrace~~ Pleistocene deposits. A study of the clay revealed no paleontological evidence as to its age, but similar material occurring in wells beneath the terrace deposits are blue-green in color and also barren of fossils. However, the material stratigraphically appears to grade into the Plum Point marl member of the Calvert formation. Published geologic maps refer to all the Miocene deposits of the area as the Calvert formation. It is possible that this clay may represent material of Calvert time that may have reworked during the Pleistocene epoch, destroying any fossil remains. Therefore, the clay may be of Miocene age. It is not water-bearing.

Quaternary System

Pleistocene Series

The Coastal Plain and the surface of the Piedmont rocks just west of the Fall Zone in Spotsylvania County are covered by deposits of sand, gravel and clay of brown, red, or yellow color. These deposits are collectively called the Columbia group.

Wentworth (1930) considered the deposits below 100 feet as being chiefly of marine origin, and those above 100 feet as being of alluvial origin, deposited as deltas and flood plains of rivers. Cooke (1931) considered terraces deposits to have been formed in the ocean and along estuaries when the sea stood at various heights above its present level. Within Spotsylvania County the terrace deposits are not subdivided but are discussed primarily as higher and lower terraces and considered to be of non-marine origin.

Lithology and Distribution

Terrace deposits consist of red, brown, and yellow loams with differing proportions of clay, silt, and sand. Irregular beds of white, well-rounded quartz gravel are common in the older (higher) terraces. Bedding is poorly developed and irregular which makes it almost impossible to trace zones in these deposits over wide areas. Cross-bedding is prominent in the younger (lower) terrace deposits but it has not been observed in other deposits. Sorting is poor; samples frequently show an almost continuous gradation in size from clay and silt particles to large cobbles. Associated with the older terrace deposits are ferruginous cementations which occur as a basal conglomerate and ferruginous plates and sheets. As a basal conglomerate it occurs along the contact of terrace deposits overlying impermeable clays. The plates or sheets within the terrace deposits develop around the lesser impermeable materials.

The terrace deposits form the greater part of the surface material in the Coastal Plain portion of the area, except where they are overlain by deposits of Recent age. They overlie with marked unconformity rocks of the older Piedmont and Coastal Plain. The unconformity is closely related to the present topography, but it cannot be inferred that the present topography was developed previous to the deposition of the terrace deposits.

These deposits range in thickness from a thin veneer in the vicinity of Five Mile Fork to about 88 feet which was penetrated in well 74, 1.8 miles northeast of Four Mile Fork. The best exposures of the higher terraces at altitudes ranging from 200 to 300 feet above sea level are along U. S. Highway 1 (Alt.) from Fredericksburg south to Four Mile Fork and from Four Mile Fork south along U. S. Highway 1 to Thornburg. Lower terraces are observed just west of U. S. Highway 17 southeast of Fredericksburg at altitudes ranging from approximately 60 to 100 feet above sea level.

Water-Bearing Properties

Many of the domestic and farm wells in the Coastal Plain part of the county obtain water from terrace deposits. The 106 wells on which information was obtained range in depth from 6 to 60 feet and average about 30 feet. These wells yield moderate quantities of water--up to 15 gpm. Well 91, bored to a depth of 23 feet in the lower terrace deposits, has been reported to yield 60 gpm with very little drawdown.

The terrace deposits usually yield water low in dissolved solids and free from objectionable minerals except iron. Objectionable concentrations of iron are associated with water from the higher terrace deposits. The four samples of water from the terrace deposits that were analyzed range in dissolved solids from 22 to 80 ppm and in hardness from 10 to 57 ppm (see table 11); field determinations of five samples show a range in hardness from 25 to 66 ppm. (See table 13.) The water derived from these deposits is in general regarded as soft and it is suitable for all domestic uses.

Recent Series

Deposits of Recent age are chiefly those that are being formed today over the submarine portion of the Coastal Plain and along many estuaries and streams.

Alluvium

Some of the streams have built up minor flood-plains during the Recent Epoch, and locally such deposits may attain sufficient thickness to yield water to shallow dug or driven wells. In Spotsylvania County, Recent alluvium is probably not present in sufficient thickness to be of importance as a source of ground water.. However, locally, Recent deposits are significant as portals for recharge to the ground-water reservoir.

QUALITY OF WATER

SOURCE AND SIGNIFICANCE OF MINERAL CONSTITUENTS IN NATURAL WATERS

Essentially all the ground water in Spotsylvania County is derived from precipitation, entering the ground directly through the soil, or indirectly from streams. The water that falls as rain or snow contains only small amounts of dissolved mineral matter, but upon reaching the earth's surface it begins to dissolve minerals from the soil and rocks. The amount and nature of the mineral constituents in ground water differ greatly from one area to another, depending upon the chemical properties of the rocks, the temperature of the water, and the length of time the water remains in contact with the rocks and soils. The mineral constituents or other characteristics of natural waters considered here include those that have a practical effect on the value of the waters for ordinary use. Results of chemical analyses of ground water in Spotsylvania County are given in tables 11, 12, and 13.

The following discussion of the chemical constituents of ground water has been adapted in part from publications of the Geological Survey.

Dissolved solids:--The quantity reported as dissolved solids (the residue on evaporation) consists mainly of the dissolved mineral matter in the water. It may contain also some organic matter and water of crystallization. Water containing less than 500 ppm of dissolved solids is usually satisfactory for domestic and most industrial uses. Water having more than 1,000 ppm of dissolved solids generally is not satisfactory because it may contain enough of certain chemical constituents to produce a noticeable taste or render the water undesirable in other respects. Dissolved solids contained in ground-water samples collected in Spotsylvania County range from 22 to 579 ppm. In general, ground water in the county is considered suitable for most uses.

Specific conductance:--The specific conductance of a water is a measure of its ability to conduct a current of electricity. It varies with the concentration and degree of ionization of the different minerals in solution. Values for specific conductance of waters analyzed from wells in Spotsylvania County range from 25.3 to 997 micromhos. The specific conductance in micromhos generally is roughly 1-1/2 times the dissolved solids in parts per million.

Hardness as $CaCO_3$:--The hardness of water is commonly indicated by the amount of soap required to make a permanent lather. Hardness is generally expressed as the amount of calcium carbonate equivalent to the calcium and magnesium in the water because calcium and magnesium are the principal constituents that cause hardness. Water having a hardness of less than 60 ppm is generally considered soft. A moderate hardness of 61 to 120 ppm does not seriously interfere with the use of water for most purposes but increases the soap consumption. Water having a hardness between 121 and 200 ppm is considered hard, and is sometimes softened for household use. A hardness of more than 200 ppm is considered excessive, necessitating treatment of the water for most uses. The hardness reported for ground water in Spotsylvania County (table 11) ranges from 5 to 169 ppm. In general, most ground water in the area is considered soft. Ground water from the igneous and metamorphic rocks of the Piedmont province contains up to 257 ppm of hardness (table 13) although much of it is very soft.

Hydrogen sulfide (H_2S):--Hydrogen sulfide is the well-known "rotten egg" gas. It is generally believed to originate from decomposition of organic matter and the reduction of sulfate. In Spotsylvania County small quantities of hydrogen sulfide are present in some waters derived from sands of Cretaceous age. Aside from imparting a disagreeable odor and taste to the water, it is entirely harmless in the small quantities present.

Silica (SiO_2):--Silica is dissolved from practically all rocks. A few natural waters contain less than 3 ppm of silica and some contain more than 50 ppm. Silica affects the usefulness of water because it contributes to the formation of boiler scale and to the embrittlement of the steel in steam boilers, particularly when present at concentrations of 60 ppm or more. Silica in the ground waters analyzed from this county ranged from 6.6 to 49 ppm.

Iron (Fe):--Iron is a common constituent of ground water. Quantities in excess of 0.3 ppm may be precipitated as ferric hydroxide and cause staining of fixtures and clothing. Excessive iron renders the water unsuitable without treatment for laundering, manufacturing of food, paper, ice, and other products. Many wells in the county yield water containing more than 0.3 ppm of iron.

Calcium and magnesium (Ca and Mg):--Calcium and magnesium are dissolved from many rocks but particularly from limestone, dolomite, and gypsum. Most waters from granite contain less than 10 ppm of calcium; many waters from limestone contain 30 to 70 ppm. Water from dolomite (magnesian limestone) may contain 20 to 50 ppm of magnesium. In soft water the concentration of magnesium may reach only 1 or 2 ppm. The calcium content of the ground waters analyzed from this county ranged from 1.8 to 31 ppm; the magnesium content, 0 to 21 ppm.

Sodium and potassium (Na and K):--Sodium and potassium are dissolved from practically all rocks and soils, but they contribute only a small part of the dissolved mineral material in most waters of the area. Ground water derived from deep aquifers is likely to contain more sodium than that from shallow aquifers. Moderate quantities of these constituents have little effect on the usability of water, but more than 50 to 100 ppm of sodium when present as the bicarbonate may cause foaming in boilers. Irrigation water that contains high percentages of sodium salts may cause deflocculation of poorly drained soils, rendering the soil relatively impervious and thus adversely affecting plant growth. The wells in Spotsylvania County sampled in connection with this investigation yield water containing from 1.3 to 176 ppm of sodium and 0.3 to 24 ppm of potassium.

Carbonate and bicarbonate (CO_3 and HCO_3):--Carbonate and bicarbonate in natural water result largely through the action of carbon dioxide, which enables the water to dissolve carbonates of calcium and magnesium. Carbonate is not present in appreciable quantities in ground water in the county. The bicarbonate in water that comes from relatively insoluble rocks like granite may amount to less than 10 ppm; water from limestone may contain 200 to 400 ppm, and some highly mineralized waters of the sodium bicarbonate type may contain 1,000 ppm or more of bicarbonate. Ground water containing large quantities of bicarbonate is unsatisfactory for use in boilers or condensing systems because the bicarbonate may contribute to foaming or to the formation of boiler scale. The bicarbonate content of ground water in Spotsylvania County generally ranges from 6 to 246 ppm and has little effect on the usefulness of the water. The carbonate content in the ground water in the county was reported as 0 ppm in all samples analyzed.

Sulfate SO_4):--Sulfate is dissolved in large quantities from gypsum and from deposits of sodium sulfate. Some sulfate is derived from the oxidation of sulfides of iron. Sulfate in water that also contains calcium and magnesium contributes to the formation of hard scale in steam boilers. Water containing sulfate in excess of 250 ppm is not suitable for domestic and certain industrial uses. The sulfate content of water collected from wells in this county ranged from less than 1 to 82 ppm.

Chloride (Cl):--In Spotsylvania County, chloride in ground water generally originated from residual sea water left after marine sediments were deposited. The chloride content of the water anaylzed from wells in the county ranged from 1.1 to 137 ppm. A few wells drilled into the basement complex in the vicinity of Fredericksburg have been reported to be very high in dissolved solids and to yield water containing from 550 to 5,550 ppm of chloride. Water containing more than 250 ppm of chloride is not desirable for most domestic and industrial uses.

Fluoride (F):--Fluoride is dissolved from fluoride-bearing minerals in rocks. Dean (1936) and other investigators report that water that contains more than 1 to 1.5 ppm of fluoride is associated with the dental defect known as mottled enamel. However, fluoride in concentrations up to about 1 ppm has been shown to lessen the incidence of tooth decay (Dean and others, 1942) if such water is used during the period of calcification of the teeth. The ground waters analyzed from the county contain up to 0.2 ppm of fluoride, not enough to be of real significance either in regard to the mottling of enamel or the prevention of decay.

Nitrate NO_3):--Nitrate in water is considered a final oxidation product of nitrogenous organic material. In places it may be derived from artificial fertilizers. Nitrate is present in small quantities in most ground waters. Some ground water contains high concentrations of nitrate, which may indicate the presence of sewage, surface wash, or other pollution. If present in quantities greater than about 45 ppm in water used in infant-feeding formulas, nitrate may cause infant cyanosis (Faucett and Miller, 1946; Waring, 1949; Maxcy, 1950).

SUITABILITY OF GROUND-WATER SUPPLIES FOR IRRIGATION

The suitability of waters for irrigation is based primarily on the concentration of soluble salts and the relative proportion of sodium. The concentration of chloride in some waters may be great enough to affect its use in irrigation. In some waters other constituents, such as high concentrations of bicarbonate or boron, may be harmful to plant growth.

Scofield (1933) devised a scheme of classification of irrigation waters based on the percentage of sodium among the cation in the water. Later work of Wilcox (1948) classified water for irrigation on the basis of the specific conductance and percent sodium.

SAR (sodium-adsorption-ratio) was introduced by the U.S. Salinity laboratory staff (1954) as an index to the amount of sodium present in a water available for adsorption by soils. The SAR value is:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

Where Na^+, Ca^{++}, and Mg^{++} represent the concentration in equivalents per million. Figure 15 shows that the diagram recommended

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Figure 15 (caption on next page) belongs near here.

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by the U.S. Salinity laboratory staff (1954) for the classification of irrigation waters which is based on (1) electrical conductivity in micromhos at 25°C and (2) the sodium-adsorption-ratio. The relationship between the salinity hazard and the sodium hazard for rating irrigation waters is described by the U.S. Salinity laboratory staff (1954) as follows:

<u>Salinity Hazard</u>

"LOW-SALINITY WATER (C_1) can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability."

"MEDIUM-SALINITY WATER (C_2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control."

"HIGH-SALINITY WATER (C_3) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected."

Figure 15.--Graph showing classification of selected samples of ground water from Spotsylvania County, Va.

"VERY HIGH SALINITY WATER (C_4) is not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected."

Sodium Hazard

"The classification of irrigation waters with respect to SAR is based primarily on the effect of exchangeable sodium on the physical conditions of the soil. Sodium-sensitive plants may, however, suffer injury as a result of sodium accumulation in plant tissues when exchangeable sodium values are lower than those effective in causing deterioration of the physical condition of the soil."

"LOW-SODIUM WATER (S_1) can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium sensitive crops such as stone-fruit trees and avocados may accumulate injurious concentrations of sodium."

"MEDIUM-SODIUM WATER (S_2) will present an appreciable sodium hazard in fine-textured soils having high cation-exchange-capacity, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soil with good permeability."

"HIGH-SODIUM WATER (S_3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management--good drainage, high leaching, and organic matter additions. Gypsiferous soils may not develop harmful levels of exchangeable sodium from such waters. Chemical amendments may be required for replacement of exchangeable sodium except that amendments may not be feasible with waters of very high salinity."

"VERY HIGH SODIUM WATER (S_4) is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the solution of calcium from the soil or use of gypsum or other amendments may make the use of these waters feasible."

In table 6, selected wells in Spotsylvania County have been listed together with determinations of conductivity, the sodium absorption ratio (SAR), and the classification symbols. As may be seen from the plotted points of the chart (fig. 15), most of the 18 samples of ground water fall in the low sodium hazard (S1) and low to medium salinity (C1-C2) categories. Well 133 tapping water from the Patuxent Formation was plotted with a classification of C3-S2 indicating a medium sodium-high salinity water. On the other hand, water from wells 73, 76, and 393 tapping the Patuxent Formation, terrace deposits, and the Wissahickon Formation, respectively, and water from well 205 and 400 tapping the Baltimore(?) Gneiss was of such low mineralization that their position was beyond the lower left corner of the field. Their classification is C1-S1.

Table 6.--Classification of water for irrigation for water pumped from selected wells in Spotsylvania County, Virginia.

Well No.	Water-bearing unit	Depth (feet)	Specific conductance (micromhos at 25°C)	Sodium adsorption ratio (SAR)	Classification
1	Patuxent Formation	150	106	0.34	C1-S1
49	do.	275	208	1.38	C1-S1
53	do.	175	149	.70	C1-S1
54	do.	275	520	1.22	C2-S1
58	do.	139	150	3.09	C1-S1
63	do.	286	195	.78	C1-S1
73	do.	107	57	.24	(see text)
76	Terrace deposits	22	25.3	.18	Do.
78	Patuxent Formation	267	378	1.70	C2-S1
133	do.	215	997	8.75	C3-S2
139	Basement complex	222	207	.66	C1-S1
180	Granite	13	127	1.85	C1-S1
205	Baltimore(?) Gneiss	300	97.9	.57	(see text)
237	Quantico Slate	26	557	3.06	C2-S1
343	Wassahickon Formation, schist facies	31	227	.76	C1-S1
360	Granite	51	197	.73	C1-S1
393	Wissahickon Formation, grantized gneiss facies	27	90.4	.94	(see text)
400	Baltimore(?) Gneiss	39	44.2	.26	Do.

The boron concentration was not determined for any of the waters analyzed, but it is believed that the concentration present is well within the limit of suitability for irrigation.

It should be borne in mind, however, that from the standpoint of yield, the quantity of water available from wells in Spotsylvania County appears to be insufficient for the proper irrigation of even moderately large fields. Although these yields are small, they may provide emergency supplies for carryover during prolonged periods of deficient precipitation.

SANITARY CONDITIONS

The analyses of the water given in tables 11, 12, and 13 in this report show only the amounts of dissolved mineral constituents present in the samples at time of collection and do not indicate their sanitary quality. Water from a well may contain mineral matter that imparts an objectionable taste or odor and yet may be free from harmful bacteria. On the other hand, tasteless and odorless water may contain harmful bacteria. Abnormal quantities of nitrate and chloride may indicate organic pollution.

Most of the residents of Spotsylvania County depend upon water supplied from wells and every precaution should be taken to protect this water supply from contamination and pollution. Wells should not be constructed near possible sources of pollution, such as barn yards, privies, and cesspools. Dug wells are more likely to be polluted from surface sources than are drilled wells because dug wells generally are not effectively sealed at the surface. Drilled wells ordinarily are protected by casing that has been driven into the material penetrated or cemented to the wall of the hole made by the drill. Even drilled wells may be poorly sealed at the top. Springs generally are more likely to be polluted than are wells, and methods of improvement and protection should be properly carried out before spring water is used for a domestic supply.

SUMMARY OF CONCLUSIONS

Moderate supplies of ground water for most domestic and farm use can be obtained from wells tapping the weathered zone of the consolidated rocks of the Piedmont province, and sand and gravel deposits of Cretaceous to Pleistocene age in the Coastal Plain part of the area. Wells obtaining ground water from weathered granite, quartzite, schist, and slate of the Piedmont province and sand and gravel of terrace deposits of the Coastal Plain province of the county yield about 200 million gallons a year for domestic and farm uses. Deposits of sand and gravel of Cretaceous and Pleistocene age yield about 28 million gallons per year to pumped wells for public supplies. It is estimated that about 6 million gallons per year are obtained for industrial and air conditioning uses. Ground water in the County is suitable for irrigation; however the quantity available is insufficient for proper irrigation practices but it may provide some emergency supplies for carryover during prolonged periods of deficient precipitation. Ground water in the area is generally soft and suitable for most domestic purposes. However, objectionable amounts of iron occur in water from the higher terrace deposits of Pleistocene age and from wells tapping deposits of Cretaceous age. A few deep wells tapping the basement complex yield water containing up to 5,500 ppm chloride.

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Table 7. —Records of wells in Spotsylvania County, Virginia

Ab, abandoned; gpm, gallons per minute;
ppm, parts per million; Temp., temperature

Type of well: B, bored; D, drilled, Dg, dug; J, jetted
Use of water: Ab, abandoned; D, domestic; I, industrial; Obs, observation; PS, public supply; S, stock

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
1	2.8 mi. ENE. of Five Mile Fork	E. B. Rowe	Virginia Machinery & Well Co.	1922	235	D	150	6	Cretaceous	Patuxent fm.	-64	7	D	See log, Table 9; analysis, Table 11. Hydrogen sulfide odor.	1
2	2.4 mi. E. of Five Mile Fork	H. F. Marcus			245	Dg	30	36	Pleistocene	Terrace deposits	-15	5	D	Reported soft.	2
3	2.1 mi. NNE. of Five Mile Fork	I. L. Dumire	C. Ward	1948	250	Dg	22	36	do.	do.	-12		D	Temp., 59° F.	3
4	1.9 mi. NNE. of Five Mile Fork	C. S. Gatewood	do.	1952	255	Dg	18	36	do.	do.	-12	5	D	Temp., 60° F.	4
5	1.7 mi. S. of Five Mile Fork	H. T. Curtis	Seay	1951	250	Dg	27	36	do.	do.	-21	5	D	Temp., 60° F.	5
6	1.0 mi. ENE. of Five Mile Fork	H. Bernstein	Sydnor Pump & Well Co., Inc.	1946	340	D	182	6	Pre-Cretaceous	Basement complex	-30		D	See log, Table 9; water level reported in 1946.	6
7	0.4 mi. ENE. of Five Mile Fork	E. O. Paytes			325	Dg	25	36	do.	do.	-19	5	D,S	Temp., 60° F.	7
8	Five Mile Fork	S. L. Powell	E. Powell	1917	342	Dg	28	24	do.	do.	(-)		D,S	Temp., 59° F.	8
9	0.2 mi. ESE. of Five Mile Fork	H. Bishop	T. Powell		342	Dg	24	30	do.	do.	-16		D,S	Temp., 58° F.	9
10	1.1 mi. ESE. of Five Mile Fork	L. A. Vaughan	Fry	1950	310	Dg	22	36	Pleistocene	Terrace deposits	-19	5	D	Temp., 60° F.	10
11	0.5 mi. SSW. of Five Mile Fork	J. M. McCarty		1939	340	Dg	29	36	do.	do.	-20	5	D,S		11
12	0.7 mi. SSW. of Five Mile Fork	E. E. Sorels			335	Dg	33	30	Pre-Cretaceous	Basement complex	-23		Ab	See analysis, Table 11. Hydrogen sulfide odor. Temp., 60° F. Water derived from weathered granite.	12
13	1.0 mi. S. of Five Mile Fork	J. E. Fitzpatrick	Banks	1951	322	Dg	25	30	Pleistocene	Terrace deposits	-14		D,S	Temp., 58° F.	13
14	1.8 mi. SE. of Five Mile Fork	T. Ross			305	Dg	27	36	do.	do.	-20	5	D	Temp., 59° F.	14
15	1.5 mi. SE. of Five Mile Fork	S. Fairchilds		1952	302	Dg	25	48	do.	do.	-20		D	Temp., 60° F.	15
16	1.6 mi. SSE. of Five Mile Fork	L. J. White		1941	270	Dg	30	40	do.	do.	-23	9	D	Temp., 59° F.	16
17	1.4 mi. SSE. of Five Mile Fork	G. Howard		1953	262	Dg	16	36	Pre-Cretaceous	Basement complex	(-)		D	Well went dry Sept. 1953.	17
18	1.2 mi. S. of Five Mile Fork	F. A. Payne			322	Dg	23	40	do.	do.	-15		D	Temp., 58° F. Well curbed with brick.	18
19	1.3 mi. S. of Five Mile Fork	D. Payne	Seay	1952	320	Dg	29	30	do.	do.	-22		D	Temp., 61° F. at kitchen tap. Water derived from weathered granite.	19
20	1.6 mi. S. of Five Mile Fork	L. Hinkle			302	Dg	45	36	Pleistocene	Terrace deposits	-26		D	Temp., 56° F. Water derived from weathered bedrock. Turbid appearance.	20

Table 7 .—Records of wells in Spotsylvania County, Virginia - Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
21	1.9 mi. SSE. of Five Mile Fork	R. Johnson			282	Dg	19	36	Pleistocene	Terrace deposits	-14		Ab	Temp., 60° F. Water reported poor in quality.	21
22	2.0 mi. SSE. of Five Mile Fork	R. P. Lewis			260	Dg	21	35	do.	do.	-12		D	Temp., 58° F. Well lined with brick.	22
23	1.8 mi. S. of Five Mile Fork	A. A. Thacker		1910?	270	Dg	35	48	do.	do.	-21		D	Temp., 58° F. Water level reported July 1953.	23
24	2.0 mi. S. of Five Mile Fork	W. Robinson	W. Robinson	1952	280	D	23	4	do.	do.	-10		D	Temp., 62° F. Water level reported July 1953.	24
25	2.2 mi. S. of Five Mile Fork	F. Lettner		1953	270	Dg	23	36	do.	do.	-16	5	D	Temp., 60° F.	25
26	2.5 mi. S. of Five Mile Fork	G. Obier	G. Obier	1951	270	Dg	35	40	Pre-Cretaceous	Basement complex	-19		D	Turbid appearance. Water derived from weathered rock.	26
27	2.7 mi. S. of Five Mile Fork	W. R. Minter	W. R. Minter	1951	270	Dg	31	36	do.	do.	-25		D	Temp., 60° F. Water derived from weathered rock.	27
28	2.9 mi. S. of Five Mile Fork	L. J. Williams	M. F. Martin	1953	270	D	36	36	do.	do.	-17		D	Temp., 58° F. Water derived from weathered rock.	28
29	3.0 mi. S. of Five Mile Fork	J. H. Crenshore	C. Ward	1951	270	Dg	28	36	Pleistocene	Terrace deposits	-17	5	D	Temp., 60° F.	29
30	3.1 mi. S. of Five Mile Fork	R. Harlow		1951	270	Dg	32	36	do.	do.	-14		D	Temp., 60° F. Water not used for drinking since 1951.	30
31	3.3 mi. S of Five Mile Fork	J. W. Seay		1951	270	Dg	23	36	do.	do.	-14	5	D	Temp., 58° F.	31
32	1.7 mi. WSW. of Four Mile Fork	Wm. A. Wilkason		1919	270	Dg	28	36	do.	do.	-20		D	Temp., 55° F.	32
33	1.4 mi. SW. of Four Mile Fork	S. B. Coleman			245	Dg	35	36	do.	do.	-16	5	D	Temp., 58° F. Reported slight iron taste	33
34	1.3 mi. WSW. of Four Mile Fork	J. Fedusia		1953	262	Dg	22	30	do.	do.	-7	5	D	Temp., 58° F.	34
35	1.1 mi. W. of Four Mile Fork	H. Hailey	H. Hailey	1953	248	Dg	31	36	do.	do.	-7		D	Temp., 57° F.	35
36	1.1 mi. WSW. of Four Mile Fork	C. F. Milstead		1936	260	Dg	23	36	do.	do.	-6	5	D	Temp., 59° F.	36
37	0.8 mi. WSW. of Four Mile Fork	J. A. Dillard			255	Dg	23	24	do.	do.	-14	5	D	Temp., 58° F.	37
38.	0.6 mi. WSW. of Four Mile Fork	F. D. Motley		1953	250	Dg	28	36	do.	do.	-10	5	D	Temp., 58° F.	38
39	0.5 mi. W. of Four Mile Fork	C. Catlett		1950	260	Dg	26	36	do.	do.	-11	5	D	Temp., 59° F.	39
40	0.7 mi. WNW of Four Mile Fork	S. B. McWhirt		1950	260	Dg	24	36	do.	do.	-13	5	D	Temp., 62° F. at outside tap.	40

Table 7. —Records of wells in Spotsylvania County, Virginia- Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (-) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
41	0.4 mi. SW. of Four Mile Fork	B. Dillard		1951	260	Dg	20	36	Pleistocene	Terrace deposits	-13	5	D	Temp., 58° F.	41
42	0.4 mi. S. of Four Mile Fork	A. K. Stephens	M. P. Martin	1953	242	B	48	30	do.	do.	-12	5	D	See analysis, Table 11. Organic odor. Reported soft. Contains iron.	42
43	Four Mile Fork	B. Kay			250	Dg	20	36	do.	do.	-11		D	Temp., 58° F. Supplies three houses.	43
44	0.3 mi. N. of Four Mile Fork	J. U. Weaver		1934	250	Dg	21	36	do.	do.	-11	5	D	Temp., 56° F. Dry summer of 1953.	44
45	0.2 mi. E. of Four Mile Fork	J. J. Dickerson		1952	255	Dg	21	30	do.	do.	-9	5	D	Temp., 56° F.	45
46	0.4 mi. ESE. of Four Mile Fork	D. W. Herren		1952	250	Dg	22	36	do.	do.	-12	5	D	Temp., 60° F. Slight yellow color after heavy rains.	46
47	Do.	L. A. Bennett	M. P. Martin	1953	253	B	23	36	do.	do.	-13	5	D	Temp., 60° F.	47
48	0.7 mi. ESE. of Four Mile Fork	T. Talley	do.	1953	245	B	25	36	do.	do.	-15	5	D		48
49	Bellevue Court Subdivision. 0.6 mi. ENE. of Four Mile Fork	Sydnor Pump & Well Co., Inc.	Sydnor Pump & Well Co., Inc.	1952?	245	D	275	6	Cretaceous	Patuxent fm.	(-)	10	PS	See analysis, Table 11.	49
50	Do.	do.	do.	1954	245	D	279	6	do.	do.	(-)		Ab	See log, Table 9.	50
51	Do.	do.	do.	1951	240	D	211	8	do.	do.	-154	2	PS	Do.	51
52	Do.	do.	do.	1946	240	B	512	8-6	do.	do.	-140		Ab	Do.	52
53	0.5 mi. NE. of Four Mile Fork	B. T. Pitts	H. Leaser	1951	250	D	175	6	do.	do.	-75	8	PS	See analysis, Table 11.	53
54	Cottage Green Subdivision. 0.7 mi. NNE. of Four Mile Fork	G. T. Waite	Mitchell's Well & Pump Co.	1949	244	D	275	8	do.	do.	(-)	25	PS	See log, Table 9; analysis, Table 11. 25 gpm after 8 hours pumping.	54
55	Do.	do.	Leaser Pump & Well Co.	1953	244	D	275	8-6	do.	do.	(-)	15	PS	See log, Table 9; analysis, Table 11. 15 gpm after 8 hours pumping.	55
56	0.7 mi. NE. of Four Mile Fork	B. Curtis		1935	240	Dg	30	48	Pleistocene	Terrace deposits	-18		Ab		56
57	Spotswood Village, 0.9 mi. NE. of Four Mile Fork	Deser and Hart	Craver and Jenkins	1950	270	D	259	6	Cretaceous	Patuxent fm.	-186	40	PS	See analysis, Table 11. Temp., 59° F. Water level obtained by air-line gage.	57
58	1.2 mi. ENE. of Four Mile Fork	W. A. Webster	Leaser Pump & Well Co.	1953	135	B	139	6	do.	do.	-74	5	D	See log, Table 9; analysis, Table 11.	58
59	1.6 mi. ENE. of Four Mile Fork	B. Tasker	C. Ward	1953	136	Dg	45	36	Pleistocene	Terrace deposits	-38	5	D	Temp., 58° F.	59
60	1.2 mi. NE. of Four Mile Fork	J. McWhirt, Jr.	Seay	1948	240	Dg	16	36	do.	do.	-10	5	D	Temp., 60° F.	60
61	1.3 mi. SE. of Four Mile Fork	H. K. Ervin		1950	245	Dg	24	36	do.	do.	-17	5	D	Temp., 58° F.	61

Table 7 .—Records of wells in Spotsylvania County, Virginia - Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
62	Jackson Park Subdivision, 1.6 mi. NNE. of Four Mile Fork.	E. E. Simpson			220	D	286	5	Cretaceous	Patuxent fm.	(-)	13	PS, Ab		62
63	Do.	do.	Mitchell's Well & Pump Co.		220	D	286	5	do.	do.	(-)	15	PS	See analysis, Table 11. Temp., 59° F. 15 gpm after 24 hour pumping. Well supplies 45 homes.	63
64	1.6 mi. NE. of Four Mile Fork	D. Smith	Gentry	1953	220	D	23	36	Pleistocene	Terrace deposits	-11	5	D	Temp., 59° F.	64
65	Courtland Hts. Subdivision, 1.7 mi. NNE. of Four Mile Fork	Sydnor Pump & Well Co. Inc.			240	Dg	25	36	do.	do.	-22		Ab		65
66	Do.	do.	Sydnor Pump & Well Co., Inc.	1949	240	D	266	8	Cretaceous	Patuxent fm.	-192	10	Ab	See log, Table 9. 10 gpm after 4 hours pumping.	66
67	Do.	do.	do.	1951	240	D	47	8	Pleistocene	Terrace deposits	-19	15	Ab	See log, Table 9. 15 gpm after 2 hours pumping.	67
68	Do.	do.	do.		240	D		8			(-)		Ab	Capped.	68
69	Do.	do.			240	Dg	34	36	Pleistocene	Terrace deposits	-21		Ab		69
70	Do.	do.	Sydnor Pump & Well Co., Inc.		240	D	30	6	do.	do.	-20		Ab		70
71	Dillard Subdivision, 1.8 mi. NE. of Four Mile Fork.	do.	do.	1952	270	D	99	8-6	Cretaceous	Patuxent fm.	-60	10-7	Ab	See log, Table 9. Temp., 59° F. 10 gpm after 14 hours pumping; 7 gpm after 3 hours pumping.	71
72	Do.	do.	do.	1949	200	D	655	8-6	Pre-Cretaceous	Basement complex	-146	14	Ab	See log, Table 9. 14 gpm after 4 hours pumping. Water reported to contain 9,844 ppm salt. Deepened to 655 feet in 1949.	72
73	Do.	do.	do.	1952	200	D	107	8	Cretaceous	Patuxent fm.	-69	30	PS	See analysis, Table 11.	73
74	Do.	do.	do.	1948	200	D	600	8-6	Pre-Cretaceous	Basement complex	-190	5	Ab	See log, Table 9. Deepened to 500 feet in 1948. 5 gpm after 5 hours pumping.	74
75	2.0 mi. NE. of Four Mile Fork	G. Lowe	Lanier Pump & Well Co.	1951	100	D	175	6	Cretaceous	Patuxent fm.	(-)		D	Reported to contain iron.	75
76	2.1 mi. NE. of Four Mile Fork	U.S. Dept. of Interior, National Park Service			120	Dg	22	36	Pleistocene	Terrace deposits	-13	5	D	See analysis, Table 11. Temp., 56° F. Iron removal filter.	76
77	Do.	do.	Sydnor Pump & Well Co., Inc.	1939	120	D	165	6	Cretaceous	Patuxent fm.	-106	15	Ab	See log, Table 9. Reported to contain iron.	77

Table 7 .—Records of wells in Spotsylvania County, Virginia - Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
78	2.0 mi. NNE. of Four Mile Fork	H-C Super Market	Leaser Pump & Well Co.	1953	235	D	267	8	Cretaceous	Patuxent fm.	(-)	10	D	See analysis, Table 11. 10 gpm after 8 hours pumping.	78
79	2.2 mi. NNE. of Four Mile Fork	P. C. Goodloe			200	Dg	57	48-36	Pleistocene	Terrace deposits	-50	5	Ab	Temp., 58° F. Dry summer of 1952 and 1953. Water level reported May 1954.	79
80	Fredericksburg	State Normal School	Sydnor Pump & Well Co., Inc.	1910	130	D	536	10-8			-120	9	Ab	See log, Table 9. 9 gpm after 4 hours pumping.	80
81	Do.	E. D. Cole	Alexander	1902	50	D	120	2	Cretaceous	Patuxent fm.	-20		Ab	See analysis, Table 11. From Va. Geol. Survey Bulletin 5, p. 274, 352-353.	81
82	Fredericksburg Victoria Theater	B. T. Pitts	Mitchell's Well & Pump Co.	1937	48	D	153	6	do.	do.	-30		D	See log, Table 9. Temp., 58° F. Used for air conditioning.	82
83	Sylvania Hts. Subdivision, 0.8 mi. SE. of Fredericksburg	A. W. Embry	W. Taylor	1937	65	Dg, D	45	36-8	Pleistocene	Terrace deposits	-15	10	PS	36-inch diameter to 26 feet, 8-inch to 45 feet.	83
84	Do.	do.		1939	65	D	46	6	do.	do.	(-)		Ab		84
85	Do.	do.		1939	65	D	50	8	do.	do.	-15	10	PS	Temp., 59° F.	85
86	Do.	do.	E. Leaser	1937	65	D	50	8	do.	do.	-16		PS		86
87	Do.	do.	Sydnor Pump & Well Co., Inc.	1950	65	D	225	10-6	Cretaceous	Patuxent fm.	-31	10	PS	See log, Table 9. Bowls of pump set 80 feet below land surface.	87
88	0.7 mi. SSE. of Fredericksburg	Shannon Airport		1950?	60	Dg	23	36	Pleistocene	Terrace deposits	-17	5	D	Temp., 60° F.	88
89	Fredericksburg	A. B. Sullivan			55	Dg	19	36	do.	do.	-16		D	Temp., 58° F. Supplies several houses. Fredericksburg city limits extended Jan. 1, 1955.	89
90	Do.	Tidewater Mill Co.		1950	70	Dg	13	36	do.	do.	-10		I	Temp., 58° F. Fredericksburg city limits extended Jan. 1, 1955.	90
91	Do.	do.	J. T. Ellington	1954	75	B	23	36	do.	do.	-12	60	I	See analysis, Table 11. Temp., 58° F. Reported small (?) drawdown in 8 hours after pumping 60 gpm.	91
92	0.2 mi. WSW. of Fredericksburg	D. Litten	Sony		80	Dg	15	36	do.	do.	-10	5	D	Temp., 59° F.	92
93	0.6 mi. SW. of Fredericksburg	R. Brooks			80	Dg	16	36	do.	do.	-11	5	D	Temp., 58° F.	93
94	0.7 mi. SSW. of Fredericksburg	W. M. Cutshall		1954	80	Dg	20	36	do.	do.	-13		D	Do.	94
95	1.4 mi. E. of Four Mile Fork	J. Tavenner		1953	119	Dg	14	36	do.	do.	-4	5		Temp., 59° F. Water reported soft.	95
96	Do.	J. Beverly		1961	121	Dg	15	36	do.	do.	-9			Temp. 59°F. Turbid appearance	96

Table 7. —Records of wells in Spotsylvania County, Virginia - Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
97	1.3 mi. S. of Four Mile Fork	R. D. Hull	Seay	1952	230	Dg	93	36	Cretaceous(?)		-86	5	D	See log, Table 9. Temp., 60° F.	97
98	1.4 mi. N. of Four Mile Fork	H. Pearson	do.	1954	228	Dg	94	36	do.		-81	5	D	See log, Table 9. Temp., 59° F.	98
99	1.3 mi. ESE. of Four Mile Fork	R. H. McCarthy	R. H. McCarthy		240	Dg	23	40	Pleistocene	Terrace deposits	-19	5	D,S	Temp., 58° F.	99
100	1.1 mi. ESE. of Four Mile Fork	R. D. Holloway	R. D. Holloway	1933	241	Dg	29	36	do.	do.	-19	5	D	Temp., 59° F.	100
101	0.9 mi. SE. of Four Mile Fork	H. M. Parker		1933	241	Dg	18	36	do.	do.	-12	4	D	Do.	101
102	1.2 mi. SSE. of Four Mile Fork	J. L. Taylor	J. L. Taylor	1946	240	Dg	30	48-30	do.	do.	-22	5	D	Temp., 58° F.	102
103	1.4 mi. SE. of Four Mile Fork	C. T. Jones			222	Dg	22	49	do.	do.	-16		S	Do.	103
104	2.0 mi. W. of New Post	F. Lucas			88	Dr	23	40-36	do.	do.	-18		D,S	Temp., 59° F. Last 3 feet of well cased. Slight hydrogen sulfide odor.	104
105	1.9 mi. W. of New Post	G. H. Mills		1940?	80	Dg	15	30	do.	do.	-11	5	D	Temp., 58° F.	105
106	1.7 mi. WNW. of New Post	J. F. Terry			88	Dg	30	36	do.	do.	-24	5	D,S	Temp., 60° F.	106
107	1.6 mi. WNW. of New Post	E. Smith	Seay	1941	88	Dg	30	36	do.	do.	-22	5	D	Temp., 58° F.	107
108	1.9 mi. WNW. of New Post	R. F. Skinner		1946	118	Dg	36	36-30	do.	do.	-27		D	Do. Last 6 feet of well cased.	108
109	2.1 mi. WNW. of New Post	H. L. Atkinson	C. Ward	1952	140	Dg	47	36	do.	do.	-35		D	Temp., 57° F.	109
110	1.7 mi. NW. of New Post	O. B. Eastriot			78	Dg	12	30	do.	do.	-6	5	D	Temp., 60° F.	110
111	2.6 mi. NNW. of New Post	Fredericksburg Country Club	H. Leaser	1946	60	D	110	8	Cretaceous	Patuxent fm.	(-)	10	D	Reported to contain iron.	111
112	Greenfield Village Subdivision, 1.2 mi. NNW. of New Post	Sydnor Pump & Well Co., Inc.			70	D	620	6	Pre-Cretaceous	Basement complex	(-)	40	Ab	Water is reported to contain 800-900 ppm of salt. Two other wells nearby provide water; wells are not as deep.	112
113	1.3 mi. N. of New Post	Massaponax Sand and Gravel Co.		1940	40	D	77	6	Cretaceous	Patuxent fm.	(-)		D	Temp., 58° F. Contains iron. Water contains less than 10 ppm chloride.	113
114	0.8 mi. NNE. of New Post	C. Ruffin		1942	65	Dg	60	30	Pleistocene	Terrace deposits	-58	5	S	Temp., 58° F.	114
115	Do.	do.			63	Dg	29	30	do.	do.	-26		D	Do. Reported to contain some iron.	115
116	1.4 mi. NE. of New Post	Belvedere Farm	Lyons		8	J	300	1½	Cretaceous	Patuxent fm.	(+)	8	D	See analysis, Table 11. Well reported flowing 8 gpm in 1944. Reported flowing in 1955.	116
117	New Post	B. Williams			63	Dg	17	48-30	Pleistocene	Terrace deposits	-16		D	Turbid appearance.	117

Table 7 .—Records of wells in Spotsylvania County, Virginia – Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (-) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
118	New Post	A. Atkinson?		1933	65	Dg	15	48-30	Pleistocene	Terrace deposits	-14		D	Temp., 59° F.	118
119	Do.	E. Covington	L. Brown	1936	65	Dg	15	48-36	do.	do.	-13		D	Do. Wooden curbing	119
120	0.7 mi. NW. of New Post	J. H. Mills	C. Madison	1950	50	Dg	12	36	do.	do.	-6	3	D	Temp., 58° F.	120
121	1.2 mi. W. of New Post	L. C. Clark Creosote Co.		1937	50	Dg	20	36	do.	do.	-10		D	Temp., 56° F. Water level reported May 1954.	121
122	1.4 mi. W. of New Post	do.		1937	50	Dg	21	24	do.	do.	-2		Obs.	Water contaminated with creosote. Well used as observation well. (See figure 7.)	122
123	4.2 mi. E. of Massaponax	M. Atkinson		1915	241	Dg	31	36	do.	do.	-29		D	See analysis, Table 13. Temp., 56° F. Water reported soft.	123
124	3.9 mi. E. of Massaponax	J. A. Johnson		1909	240	Dg	34	36	do.	do.	-32	3	D		124
125	3.2 mi. E. of Massaponax	E. Flippo		1920?	225	Dg	22	36	do.	do.	-19	3	D,S	See analysis, Table 13.	125
126	2.8 mi. ENE. of Massaponax	M. Samuel			242	Dg	14	60	do.	do.	-5		D		126
177	3.2 mi. ENE. of Massaponax	G. Turner		1949	200	Dg	22	36	do.	do.	-19		D		127
128	2.6 mi. ENE. of Massaponax	M. Willis	J. Williams	1931	248	Dg	27	60	do.	do.	-15		D	Temp., 54° F.	128
129	2.0 mi. ENE. of Massaponax	L. Williams	L. Williams	1952	242	Dg	28	36	do.	do.	-7	5	D	Temp., 55° F.	129
130	1.5 mi. E. of Massaponax	E. V. Hale	Sony	1940	240	Dg	40	36	do.	do.	-15	3	D	Do.	130
131	2.0 mi. ESE. of Massaponax	A. Ennis			245	Dg	75	36	do.	do.	-22		D	Water reported soft.	131
132	2.7 mi. ESE. of Massaponax	M. W. McAllister		1935	225	Dg	25	48	do.	do.	-21	3	D		132
133	2.6 mi. SE. of Massaponax	H. E. Bryan	Leaser Pump & Well Co.	1951	190	D	215	4	Cretaceous	Patuxent fm.	-67	5	D	See analysis, Table 11.	133
134	2.1 mi. SE. of Massaponax	E. A. Hayden	L. Brown	1950	245	Dg	31	36	Pleistocene	Terrace deposits	-30	3	D	Water reported slightly hard.	134
135	Massaponax	J. B. Shields		1946	260	Dg	13	36	do.	do.	-4	3	D	Temp., 55° F.	135
136	0.4 mi. E. of Massaponax	Baldwin Motel	Leaser Pump & Well Co.	1952	250	D	200	6	Cretaceous(?)		(-)	5	PS	See analysis, Table 13.	136
137	0.4 mi. E. of Massaponax	Sunset Motel	Mitchell's Well & Pump Co.	1946	250	D	350	6	Pre-Cretaceous	Basement complex	-105	5	PS	See log, Table 9; analysis, Table 13. Water level reported in 1950. Specific capacity of .04 gpm/ft. dd.	137
138	0.3 mi. SSW. of Massaponax	Holiday Motel		1954	270	Dg	28	36	Pleistocene	Terrace deposits	-2		PS	Water reported soft.	138

Table 7. —Records of wells in Spotsylvania County, Virginia - Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (-) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
139	0.7 mi. W. of Massaponax	Wm. G. Allison	Lester Pump & Well Co.	1952	260	D	222	6	Pre-Cretaceous	Basement complex	(-)	3	D	See analysis, Table 11. Temp., 59° F.	13
140	Do.	K. F. Yerby			250	Dg	20	48	Pleistocene	Terrace deposits	-13	3	D	Temp., 55° F.	140
141	Do.	do.	C. Coleman	1944	265	Dg	21	36	do.	do.	-14		S	Temp., 56° F.	14
142	1.2 mi. WSW. of Massaponax	R. C. Rawlings	J. T. Ellington	1955	210	D	201	6	Pre-Cretaceous	Basement complex	-31	20	D	See log, Table 9.	14
143	Do.	do.	do.	1955	200	B	31	36	Pleistocene	Terrace deposits	-12	3	D		14
144	2.2 mi. SSW. of Massaponax	Grant's Court			245	Dg	25	36	do.	do.	-19	3	PS	Water level reported in Feb. 1955.	14
145	1.9 mi. SSW. of Massaponax	B. Stanley	B. Stanley	1946	185	Dg	14	36	do.	do.	-6	5	D	Well deepened 2½ feet in 1953.	14
146	1.7 mi. SSW. of Massaponax	B. A. Tristano			170	Dg	18	40	do.	do.	-9	5	PS	Water reported to contain iron	14
147	2.0 mi. SW. of Massaponax	J. L. Acors			265	Dg	36	48	Precambrian	Baltimore(?) gneiss	-23			See analysis, Table 13.	14
148	2.5 mi. SW. of Massaponax	H. Garnett			265	Dg	32	60	do.	do.	-30	5	D		14
149	3.0 mi. WSW. of Massaponax	L. Smith	W. Coleman		310	Dg	28	60	do.	do.	-22		D	Well dry June 1955.	14
150	2.2 mi. W. of Massaponax	L. L. Kay	Wm. Banks	1948	250	Dg	35	36	do.	do.	-33		D,S	Temp., 57° F.	15
151	2.6 mi. WSW. of Massaponax	T. S. Coleman			265	Dg	31	36	do.	do.	-29	3	D	Water reported soft.	15
152	0.9 mi. WSW. of Leavells	M. Seay			240	Dg	35	36	Late Paleozoic	Petersburg granite	-34	3	D	Temp., 62° F. at kitchen tap.	15
153	1.8 mi. W. of Leavells	H. E. Toney		1935	308	Dg	34	28-24	do.	do.	-32	3	D		15
154	1.6 mi. SSE. of Five Mile Fork	W. R. Carter		1928	285	Dg	41	48	do.	do.	-27	3	D	Temp., 59° F.	15
155	1.4 mi. S. of Five Mile Fork	E. Baker	C. Ward	1939	300	Dg	30	36	do.	do.	-21	3	D	Water reported soft.	15
156	0.9 mi. SSW. of Five Mile Fork	R. B. Dickinson			325	Dg	24	30	do.	do.	-17	3	D		15
157	1.1 mi. SW. of Five Mile Fork	S. J. Golden		1952	320	Dg	22	36	do.	do.	-14	4	D	Water reported hard.	15
158	0.9 mi. W. of Five Mile Fork	B. F. Pelglaize			322	Dg	21	30	do.	do.	-14	5	D,S		15
159	1.4 mi. WSW. of Five Mile Fork	M. Ferguson	E. Hulett	1941	285	Dg	19	36	do.	do.	-17		D		159
160	1.7 mi. W. of Five Mile Fork	Chancellor School		1936	330	D		6	Late Paleozoic (?)	Granite	(-)		PS	Water reported soft.	16
161	1.9 mi. N. of Five Mile Fork	S. F. Bulley			260	Dg	56	36	Late Paleozoic	Petersburg granite	-54	5	D	Water reported soft. Spare force pump is operated by windmill.	16

Table 7. —Records of wells in Spotsylvania County, Virginia - Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (-) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
162	2.7 mi. NNW. of Five Mile Fork	S. Becraft			270	Dg	28	24	Late Paleozoic	Petersburg granite	-25	4	D	See analysis, Table 13.	162
163	2.0 mi. N. of Chancellorsville	G. Washington	C. Ward	1954	270	Dg	35	36	Early Paleozoic (?)	Wissahickon formation, schist facies	-27		D	Water reported soft.	163
164	2.1 mi. NW. of Chancellorsville	F. L. Dillard	M. I. Martin	1955	295	B	45	30	do.	do.	-40	4	D		164
165	3.9 mi. NNW. of Chancellorsville	J. Jones	J. T. Ellington	1954	290	B	29	30	do.	do.	-18		D	Water reported soft.	165
166	3.5 mi. NW. of Chancellorsville	D. F. Jones			340	Dg	22	30	do.	do.	-16		D	Temp., 55°F. Well went dry summer 1953.	166
167	3.0 mi. NW. of Chancellorsville	V. Barber	T. Catlett	1947	362	Dg	16	30	do.	do.	-13	5	D	Temp., 56°F.	167
168	2.8 mi. NW. of Chancellorsville	L. E. Gayle		1930?	364	Dg	29	30	do.	do.	-26	3	D	Water reported soft.	168
169	2.5 mi. NNW. of Chancellorsville	M. Brooke			350	Dg	25	36	do.	do.	-18		D	Temp., 52°F.	169
170	0.7 mi. WNW. of Chancellorsville	H. W. Smallwood	Talley	1952	353	Dg	27	30	do.	do.	-22	5		See analysis, Table 13.	170
171	0.4 mi. SSW. of Chancellorsville	L. Chewning	Sexy		340	Dg	26	36	do.	do.	-23	5	D		171
172	1.2 mi. WSW. of Chancellorsville	H. C. Thompson		1950	340	Dg	26	36	do.	do.	-16	4	D	Temp., 54°F.	172
173	2.8 mi. W. of Chancellorsville	F. Clore	F. Clore	1948	380	Dg	20	36	do.	do.	-6	5	D	Temp. 55°F.	173
174	3.8 mi. W. of Chancellorsville	G. Stephens	C. Ward	1947?	365	Dg	54	36	do.	do.	-50	5	D	Water reported soft.	174
175	0.8 mi. NE. of Chancellor	Tabernacle Church		1952	338	Dg	23	36	Late Paleozoic (?)	Granite	-15	5	D	Do.	175
176	1.4 mi. ESE. of Chancellor	P. Farmer			330	Dg	15	36	do.	do.	-9	5	D	Water reported soft.	176
177	1.5 mi. ESE. of Chancellor	M. G. Blackwell		1947	360	Dg	30	30	do.	do.	-29	5	D	Water reported soft. Well went dry Nov. 1954, deepened 2 feet.	177
178	1.0 mi. ESE. of Chancellor	R. S. Jones			360	Dg	25	30	do.	do.	-21	3	D	Water reported soft.	178
179	0.5 mi. SE. of Chancellor	G. M. Thornburn			330	Dg	26	36	do.	do.	-18	8	D	Water reported slightly hard.	179
180	Chancellor	A. A. McGee	R. Canaday	1948	330	Dg	13	36	do.	do.	-9	3	D	See analysis, Table 11.	180
181	1.7 mi. NW. of Chancellor	E. J. Ashley			330	Dg	22	36	Early Paleozoic (?)	Wissahickon formation, schist facies	-18	3	D,S	Water reported soft.	181
182	1.0 mi. WNW. of Chancellor	R. K. Hall	C. Ward	1950	340	Dg	24	30	do.	do.	-16		D	See analysis, Table 13. Temp., 54°F.	182

Table 7. —Records of wells in Spotsylvania County, Virginia - Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below ( ) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
183	1.3 mi. WSW. of Chancellor	T. Durrett		1949	320	Dg	18	30	Early Paleozoic (?)	Wissahickon formation, schist facies	-11		D		183
184	3.5 mi. ENE. of Parker	C. H. Brooks		1949	410	Dg	28	30-24	do.	do.	-24		D	Water reported soft. Well went dry summer 1953.	184
185	3.9 mi. ENE. of Parker	J. L. Parker	Wm. Banks	1935	320	Dg	33	30	do.	Peters Creek quartzite	-21	4	D	See analysis, Table 13. Water reported to contain iron Water level reported Dec. 1954.	185
186	4.0 mi. N. of Parker	J. C. Parker	J. T. Ellington	1954	300	B	15	30	do.	do.	-2	3	D		186
187	4.3 mi. N. of Parker	A. B. Haney	do.	1954	300	B	14	30	do.	do.	-1	3	D	Water reported soft.	187
188	4.7 mi. N. of Parker	T. B. Green	A. Robinson	1925	362	Dg	22	36	do.	do	-18	5	D	See analysis, Table 3. Water reported to contain iron.	188
189	2.0 mi. SW. of Chancellor	W. K. Wright	J. T. Ellington	1954	360	B	23	30-24	do.	Wissahickon formation, schist facies	-6	5	D	Temp., 54°F.	189
190	2.4 mi. SW. of Chancellor	L. W. Landram		1952?	285	Dg	24	36	do.	do.	-21	5	D	Water reported soft.	190
191	2.7 mi. SW. of Chancellor	A. S. Knight		1942	290	Dg	24	36	do.	do.	-15	3	D	See analysis, Table 13.	191
192	2.9 mi. SW. of Chancellor	S. M. Toombs	J. T. Ellington	1954	390	Dg	25	36	do.	do.	-9		D	Temp., 54°F. Water reported soft.	192
193	3.7 mi. N. of Spotsylvania	C. I. Weimer	C. I. Weimer	1940	340	Dg	29	24	Late Paleozoic (?)	Granite	-26		S		193
194	3.0 mi. N. of Spotsylvania Court House	J. S. Nash	M. P. Martin	1954	225	B	50	30	do.	do.	-42		D	Temp., 56°F.	194
195	3.2 mi. NNW. of Spotsylvania Court House	R. Coleman			262	Dg	15	36	do.	do.	-11		D	Turbid appearance after heavy rain.	195
196	3.1 mi. NNW. of Spotsylvania Court House	H. Carnsell	C. Collins	1951	270	Dg	18	36	do.	do.	-14	4	D,S	Well went dry Aug. 1954. Water reported hard.	196
197	2.9 mi. NNW. of Spotsylvania Court House	F. S. Carter		1947	310	Dg	29	36	do.	do.	-22	3	D	Temp., 53°F. Water reported soft.	197
198	2.6 mi. NW. of Spotsylvania Court House	J. J. Howard		1936	310	Dg	17	36	do.	do.	-11		D	Water reported soft.	198
199	0.6 mi. NNE. of Spotsylvania Court House	J. S. Alrich			280	Dg	25	48	Precambrian	Baltimore(?) gneiss	-18	4	D	Well curbed with brick.	199

Table 7 .—Records of wells in Spotsylvania County, Virginia – Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (-) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
200	0.3 mi. E. of Spotsylvania Court House	L. D. Seay			310	Dg	18	48	Precambrian	Baltimore(?) gneiss	-13	4	D	Temp., 57°F. Well curbed with brick	200
201	Spotsylvania Court House	R. E. Lee School	Sydnor Pump & Well Co., Inc.	1951	310	D	296	6	Late Paleozoic (?)	Granite	-15	16	PS	See log, Table 9. Temp., 59°F.	201
202	Do.	Spotsylvania County Court House	do.	1939	310	D	164	6	do.	do.	(-)	8	PS	See log, Table 9.	202
203	0.5 mi. SE. of Spotsylvania Court House	G. Easteridge		1950	300	Dg	24	36	Precambrian	Baltimore(?) gneiss	-18	5	D	Water reported soft.	203
204	Spotsylvania Court House	Spotsylvania High School	Sydnor Pump & Well Co., Inc.	1939	305	D	175	6	do.	do.	-155	10	Ab	Water level reported Dec. 1953. Well went dry Dec. 1954. New well drilled.	204
205	Do.	do.	do.	1955	310	D	300	6	do.	do.	-22	15	PS	See log, Table 9; analysis Table 11.	205
206	0.8 mi. S. of Spotsylvania Court House	E. Braxton			300	Dg	22	36	do.	do.	-8	5	D	Water reported hard.	206
207	1.4 mi. S. of Spotsylvania Court House	B. White	T. Watson		280	Dg	29	36	do.	do.	-24	4	D	Water reported soft.	207
208	0.7 mi. NW. of Spotsylvania Court House	Virginia Highway Department		1938	320	D	54	6	Late Paleozoic (?)	Granite	-32		Ab	Used as temporary observation well until destroyed.	208
209	Do.	do.	Seay	1954	320	Dg	36	36	do.	do.	-27	5	D	See analysis, Table 13. Temp., 56°F.	209
210	1.3 mi. NW. of Spotsylvania Court House	F. A. Willard		1939	330	Dg	23	36	do.	do.	-20	5	D	Temp., 56°F.	210
211	1.8 mi. NW. of Spotsylvania Court House	M. E. Owens		1900	320	Dg	33	30	do.	do.	-31	4	D	Water reported soft.	211
212	2.4 mi. WA. of Spotsylvania Court House	A. McWhirt	C. Ward	1951	330	Dg	22	36	do.	do.	-20	5	D	Water reported slightly hard.	212
213	2.8 mi. WA. of Spotsylvania Court House	Goshen Church	Seay	1951	325	Dg	21	36	do	do.	-17	6	D		213
214	3.7 mi. WA. of Spotsylvania Court House	M. Fauntleroy	Wo. Banks	1951	325	Dg	28	30	do.	do.	-24		D	Temp., 56°F.	214
215	3.9 mi. WA. of Spotsylvania Court House	J. F. Lewis	J. Pride	1922	325	Dg	28	30	do.	do.	-27		D		215

Table 7 .—Records of wells in Spotsylvania County, Virginia - Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (--) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
216	4.1 mi. NW. of Spotsylvania Court House	Wm. Fauntleroy	A. Robinson	1940	305	Dg	22	30	Late Paleozoic (?)	Granite	-20	5	D	Water reported soft.	216
217	4.7 mi. NW. of Spotsylvania Court House	H. C. Collins	Seay	1948	325	Dg	31	36	do.	do.	-26	6	D	Do.	217
218	5.0 mi. NW. of Spotsylvania Court House	C. H. Simpson			320	Dg	29	30	do.	do.	-24	8	D	Do.	218
219	5.2 mi. NW. of Spotsylvania Court House	C. M. Knight	M. P. Martin	1954	320	D	37	30	do.	do.	-18	6	D	Do.	219
220	5.0 mi. ESE. of Parker	B. L. Haney	Wm. Banks	1947	350	Dg	22	30	Early Paleozoic(?)	Wissahickon formation, schist facies	-17		D	Do.	220
221	4.9 mi. ESE. of Parker	H. E. Talley	E. E. Talley	1931	340	Dg	28	24	do.	do.	-21		D,S	See analysis, Table 13. Temp. 57°F.	221
222	5.1 mi. ESE. of Parker	V. Knight	Seay	1951	340	Dg	27	30	do.	do.	-22	6	D		222
223	4.5 mi. ESE. of Parker	C. Woodward		1940?	325	Dg	22	30		Peters Creek quartzite	-21		D	Temp., 57°F.	223
224	0.7 mi. SE. of Parker	L. I. Mason		1910?	400	Dg	28	28	do.	do.	-17	5	D	Water reported to contain iron.	224
225	0.3 mi. NE. of Parker	M. W. Miller			430	Dg	34	36	do.	Wissahickon formation, schist facies	-27	5	D,S	See analysis, Table 11. Water reported to contain iron.	225
226	0.5 mi. W. of Parker	do.			415	Dg	19	36	do.	do.	-12		Ab		226
227	1.0 mi. WSW. of Parker	D. Wright	Wm. Banks	1948	410	Dg	23	30	do.	do.	-6	5	D	Water reported soft.	227
228	4.5 mi. SE. of Parker	E. Woodward			325	Dg	25	36	do.	Peters Creek quartzite	-24		D	Temp., 57°F.	228
229	2.3 mi. WNW. of Spotsylvania Court House	E. Hall	Gentry	1954	280	D	98	36-24	Late Paleozoic (?)	Granite	-33	8	D	Water reported soft.	229
230	1.6 mi. W. of Spotsylvania Court House	E. Carner		1931	310	Dg	23	36	do.	do.	-20	6	D	See analysis, Table 13. Temp., 56°F.	230
231	2.5 mi. W. of Spotsylvania Court House	S. Vojnovich			265	Dg	41	60	do.	do.	-39		D	See analysis, Table 13. Temp., 56°F.	231
232	0.3 mi. W. of Spotsylvania Court House	T. M. Alsop		1929	310	Dg	23	30	do.	do.	-21	5	D	Water reported soft. Temp., 56°F.	232

Table 7. —Records of wells in Spotsylvania County, Virginia - Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (--) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
233	3.6 mi. W. of Spotsylvania Court House	G. G. Piney			305	Dg	37	30	Late Paleozoic (?)	Granite	-34		D	Water reported soft. Temp., 56°F.	233
234	3.8 mi. W. of Spotsylvania Court House	E. C. Pritchett			310	Dg	34	36	do.	do.	-32	6	D	Do.	234
235	2.8 mi. NE. of McHenry	M. Alsop			310	Dg	24	48	do.	do.	-20	4	D,S	Temp., 56°F.	235
236	2.8 mi. NNE. of McHenry	D. C. Howard			320	Dg	23	36	do.	do.	-21	5	D	Do.	236
237	2.7 mi. E. of Logan	C. P. Buchanan		1952	350	Dg	26	36	Ordovician	Quantico slate	-23		D	See analysis, Table 11. Temp., 56°F.	237
238	2.5 mi. ENE. of Logan	Pentecostal Evangelical Church No. 2			360	Dg	34	30	do.	do.	(-)		D	Well went dry Aug. 1954.	238
239	Logan	E. H. Conyers			380	Dg	33	30	Early Paleozoic(?)	Peters Creek quartzite	-27		D	See analysis, Table 13. Temp., 57°F.	239
240	2.1 mi. W. of Logan	W. T. Crady		1934?	410	Dg	30	30	do.	Wissahickon formation, schist facies	-26	5	D	Water reported soft. Temp., 56°F.	240
241	2.7 mi. W. of Logan	J. T. Baxton	J. T. Baxton	1929	410	B	23	10	do.	do.	-20		D	Water reported soft. Temp., 57°F.	241
242	2.8 mi. WNW. of Logan	E. Cakes	H. Deale	1953	400	Dg	22	36	do.	do.	-21		D	See analysis, Table 13. Temp. 57°F.	242
243	3.7 mi. W. of Logan	Greg's Baptist Church		1953	490	Dg	26	36	do.	do.	-24	5	D	Do.	243
244	3.9 mi. W. of Logan	D. D. Thomas	B. M. Paytes	1924	530	Dg	29	30	do.	do.	-26	3	D,S	Temp., 57°F.	244
245	4.2 mi. W. of Logan	J. J. Cox	Wm. Fisher	1905	530	Dg	29	40	do.	do.	-25		D	Water level reported Aug. 1954. Temp., 57°F.	245
246	4.4 mi. W. of Logan	H. Almond	Wm. Banks	1953	530	Dg	74	36	do.	do.	-22		D	Water reported soft. Temp., 58°F.	246
247	4.7 mi. WSW. of Logan	B. H. Owens	A. Ellis	1936	480	Dg	33	36	do.	do.	-30		D	Do.	247
248	3.2 mi. W. of Logan	H. E. Holbert			465	Dg	27	36	do.	do.	-23	5	D	Temp., 56°F. Well went dry, summer 1953.	248
249	3.0 mi. W. of Logan	J. A. Mills	J. Scheeler	1949	450	Dg	19	36	do.	do.	-16	5	D	See analysis, Table 13. Temp., 56°F.	249
250	2.7 mi. WSW. of Logan	A. S. Cox	E. R. Cox	1944	440	Dg	24	36	Early Paleozoic (?)	Peters Creek quartzite	-31		D	Temp., 57°F.	250
251	3.0 mi. WSW. of Logan	W. V. Chewning		1929	425	Dg	29	36	do.	do.	-23		D	Do.	251
252	2.5 mi. WSW. of Logan	H. A. Chewning		1921	440	Dg	27	36	do.	do.	-24		D,S	See analysis, Table 13. Temp., 57°F.	252
253	2.6 mi. SW. of Logan	J. H. Leatch	Wilbite and Wuest	1953	350	B	37	36	do.	do.	-33		D	See analysis, Table 13. Temp., 56°F.	253
254	2.7 mi. SW. of Logan	B. L. Wharton	A. Ellis	1952	440	Dg	25	36	do.	do.	-24		D	Do.	254
255	2.2 mi. SW. of Logan	C. B. James		1947	445	Dg	29	30	do.	do.	-19		D	Temp., 56°F.	255

Table 7. —Records of wells in Spotsylvania County, Virginia - Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (-) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
256	2.0 mi. WSW. of Logan	A. Wheele	J. Schooler	1951	425	Dg	27	36	Early Paleozoic (?)	Peters Creek quartzite	-16		D	Temp., 56°F. Well went dry. Sept. 1953.	256
257	3.4 mi. WNW. of McHenry	H. M. Brooks		1929	410	Dg	21	30	do.	do.	-19	6	D	See analysis, Table 13. Temp., 56°F.	257
258	3.2 mi. WNW. of McHenry	L. V. Loyed		1904	400	Dg	23	36	do.	do.	-22		D	Water reported soft. Temp., 56°F.	258
259	2.5 mi. W. of McHenry	F. H. Perry		1944	380	Dg	32	30-26	Ordovician	Quantico(?) slate	-28		D	See analysis, Table 13. Temp., 56°F.	259
260	2.2 mi. WSW. of McHenry	A. J. Sullivan		1929	385	Dg	33	30	Early Paleozoic (?)	Wissahickon formation, schist facies	-31	12	D,S	Water reported soft. Temp., 56°F.	260
261	2.1 mi. SW. of McHenry	M. Acors			390	Dg	28	60	do.	do.	-26		D	Water reported soft.	261
262	Brokenburg	H. Williams	H. Williams	1950	380	Dg	22	36	do.	do.	-19	5	D	See analysis, Table 11. Temp., 55°F.	262
263	0.5 mi. NE. of Brokenburg	C. M. Mastin	Banks	1921?	390	Dg	27	72	do.	do.	-23		D	Temp., 58°F.	263
264	1.0 mi. NNE. of Brokenburg	E. T. Sims	J. Schooler	1942	395	Dg	22	36	do.	do.	-20	6	D	See analysis, Table 13. Temp., 56°F. Schist injected with quartz veins; water occurs along contacts of quartz and schist.	264
265	1.1 mi. NNW of Brokenburg	Margo School		1913	405	Dg	24	36	do.	do	-18	5	PS	Temp., 56°F.	265
266	1.3 mi. N. of Brokenburg	B. S. Dickerson		1924	390	Dg	20	36	do.	do.	-18	5	D	Water reported soft. Temp., 56°F.	266
267	0.7 mi. WSW of McHenry	J. Sims		1938	380	Dg	37	36	do.	do.	-36		D	See analysis, Table 13. Temp., 56°F.	267
268	McHenry	L. Dickerson			365	Dg	19	36	do.	do.	-16		Ab		268
269	Do.	do.		1947	365	D	200	6	do.	do.	(-)		D,S		269
270	0.3 mi. SE. of McHenry	R. L. Chewning	Wm. Banks	1950	360	Dg	23	36	do.	do.	-22		D	Water reported soft. Temp. 56°F.	270
271	2.0 mi. NNE. of McHenry	J. T. Seay	do.		270	Dg	29	30	do.	do.	-27		D	Temp., 56°F. Well went dry, summer 1953.	271
272	1.1 mi. NE. of McHenry	M. Chewning		1953	360	Dg	26	30	do.	do.	-11		D	Temp., 56°F. Well furnishes water for two families.	272
273	1.2 mi. ENE. of McHenry	H. T. Mastin		1953	350	Dg	30	30	do.	do.	-26	6	S	See analysis, Table 13. Temp., 56°F.	273
274	Do.	do.		1953	345	Dg	42	30	do.	do.	-29	5	S	See analysis, Table 13.	274
275	1.2 mi. ENE. of McHenry	H. T. Mastin		1949	350	Dg	27	36	do.	do.	-26		Ab	See analysis, Table 13.	275
276	0.9 mi. E. of McHenry	do.	J. Schooler	1947	330	Dg	33	36	do.	do.	-20	5	D	See analysis, Table 13. Temp., 56°F.	276
277	0.[illegible] mi. WNW. of Post Oak	H. Sorrells	H. Sorrells	1951	310	Dg	23	36	Late Paleozoic (?)	Granite	-19		D	See analysis, Table 13.	277
278	Post Oak	J. S. Kent		1949	335	Dg	33	36	do.	do.	-30	6	D	Temp., 57°F. Well went dry Aug. 1953.	278

Table 7. —Records of wells in Spotsylvania County, Virginia - Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
279	0.9 mi. SW. of Post Oak	J. W. Massey	Wm. Danks	1949	280	Dg	26	36	Late Paleozoic (?)	Granite	-24	5	D	Temp., 57°F. Water level reported Aug. 1954.	279
280	1.9 mi. SW. of Post Oak	C. H. Bumsey		1920?	355	Dg	39	30	do.	do.	-35	4	D	Temp., 57°F. Water reported hard	280
281	2.8 mi. SSW. of Post Oak	H. B. Harlow	H. B. Harlow	1924	280	Dg	20	36	Early Paleozoic(?)	Wissahickon formation/schist facies	-20		D	Temp., 57°F.	281
282	1.5 mi. SE. of Post Oak	D. Lewis	S. Marshall	1923	260	Dg	27	36	Late Paleozoic (?)	Granite	-25		D	See analysis, Table 13.	282
283	2.1 mi. SE. of Post Oak	L. D. Coleman		1894?	240	Dg	19	40	do.	do.	-17		D, S	Temp., 57°F.	283
284	0.8 mi. WNW. of Snell	Everett Jones Corp.		1949	300	Dg	30	36	Early Paleozoic(?)	Wissahickon formation, granitized gneiss facies	-28	6	D	Water reported to contain iron.	284
285	1.4 mi. WNW. of Snell	D. Wheeler	D. Deale	1953	300	Dg	27	36	do.	do.	-24		D	Water reported soft.	285
286	1.5 mi. ENE. of Post Oak	K. Ware	Wm. Banks	1915?	310	Dg	25	36	Late Paleozoic (?)	Granite	-22		D	See analysis, Table 13.	286
287	1.6 mi. SW. of Spotsylvania Court House	M. T. Andrews	Seay	1947	290	Dg	38	36	Precambrian	Baltimore(?) gneiss	-36	5	D	Water reported soft.	287
288	1.2 mi. E. of Snell	M. T. Fauntleroy	P. Carnot	1951	210	Dg	37	36	do.	do.	-8		D	Do.	288
289	0.7 mi. NNE. of Snell	John J. Wright School	Sydnor Pump & Well Co., Inc.	1950	280	D	198	6	do.	do.	(-)	55	PS	See analysis, Table 13. Yield of 55 gpm reported after 8 hours pumping.	289
290	Snell	R. R. Finney	C. Samuels	1953	280	Dg	17	30	Early Paleozoic(?)	Wissahickon formation granitized gneiss facies	-14	6	D	Well went dry Sept. 1953.	290
291	0.3 mi. SSW. of Snell	F. H. Brooks	Gentry	1953	260	D	21	36	do.	do.	-15	4	D	See analysis, Table 13. Temp., 57°F.	291
292	0.7 mi. SW. of Snell	S. Tyler	Wm. Banks	1944	260	Dg	20	36	Precambrian	Baltimore(?) gneiss	-19	5	D	Well went dry Sept. 1953.	292
293	1.3 mi. SSW. of Snell	C. D. Apperson		1944	250	D	18	10	do.	do.	-17		D	Temp., 57°F. Water reported to contain trace of graphite.	293
294	0.3 mi. ESE. of Snell	W. T. Brown			290	Dg	32	30	do.	do.	-30		D	Temp., 58°F.	294
295	0.6 mi. E. of Snell	C. Haislip		1954	310	Dg	19	36	do.	do.	-16		D	See analysis, Table 13.	295
296	1.5 mi. ESE. of Snell	C. W. Thomas			280	Dg	23	36	do	do.	-17		D	Well deepened, summer 1954.	296
297	1.4 mi. ESE. of Snell	M. Winn			275	Dg	22	50	do.	do.	-20		D	Well line with wooden curbing.	297
298	1.8 mi. ESE. of Snell	D. C. Thomas		1948	270	Dg	21	36	do.	do.	-12	4	D	Water reported soft.	298
299	2.3 mi. ESE. of Snell	J. M. Young		1938?	290	Dg	29	36	do.	do.	-25	5	D	See analysis, Table 13. Temp. 55°F.	299
300	1.3 mi. WNW. of Thornburg	J. W. Fairfield		1930	290	Dg	37	60	do.	do.	-35		D	Water reported soft.	300
301	0.4 mi. W. of Thornburg	G. D. Haislip	Wm. Taylor	1953	265	Dg	21	30	Pleistocene	Terrace deposits	-5	3	D	See analysis, Table 11. Water reported soft.	301

Table 7. —Records of wells in Spotsylvania County, Virginia—Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (-) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
302	Thornburg	G. T. Waite Lumber Mill	Wm. Taylor	1932?	260	Dg	22	36	Pleistocene	Terrace deposits	-1		Ab		302
303	Do.	do.	do.		260	D	117	6	Pre-Cretaceous	Basement complex	(-)		I		303
304	Do.	do.		1930?	260	D	67	6	do.	do.	-12		I	See analysis, Table 13. Boiler feed water.	304
305	Do.	M. T. Heflin	J. T. Ellington	1954	250	B	26	36	Pleistocene	Terrace deposits	-2	5	D	See analysis, Table 13.	305
306	0.4 mi. E. of Thornburg	C. Smith	Wm. Brown	1953	250	Dg	23	36	do.	do.	-3	3	D	Temp., 51°F.	306
307	1.0 mi. ESE. of Thornburg	D. Minor	J. Burns		230	Dg	19	36	do.	do.	-5		D	Water reported soft.	307
308	0.5 mi. SSE. of Thornburg	Lamp Lighter Motel			260	Dg	45	28	do.	do.	-10		PS	See log, Table 9. Water reported soft.	308
309	1.0 mi. S. of Thornburg	J. C. Corthon			225	Dg	31	60	do.	do.	-28	5	D	Water reported soft.	309
310	1.8 mi. S. of Thornburg	E. J. Durrett			285	Dg	24	36	do.	do.	-19	3	D		310
311	2.1 mi. S. of Thornburg	A. L. Beasley	Mitchell's Well & Pump Co.	1928	260	D	108	6	Pre-Cretaceous	Basement complex	-17	6	D	See analysis, Table 13.	311
312	2.7 mi. ENE. of Marye	M. L. Johnson		1904	270	Dg	22	48	Precambrian	Baltimore(?) gneiss	-18		D	Temp., 57°F.	312
313	2.4 mi. ENE. of Marye	J. Michalign			280	Dg	30	36	do.	do.	-26	4	D	See analysis, Table 13. Temp., 57°F.	313
314	2.4 mi. ENE. of Marye	A. T. Stanley		1938	275	Dg	26	36	do.	do.	-24		D,S	Water reported soft.	314
315	2.0 mi. NE. of Marye	W. T. Young		1948	285	Dg	31	36	do.	do.	-30		Ab		315
316	Do.	do.	Lenser Well & Pump Co.	1954	285	B	36	30	do.	do.	-31	4	D	See analysis, Table 13. Temp., 57°F.	316
317	2.5 mi. NE. of Marye	L. Gatewood			280	Dg	33	60	do.	do.	-31		D	Temp., 58°F. Well went dry Oct. 1953.	317
318	1.5 mi. ENE. of Marye	J. Mits	A. Gents	1910	315	Dg	27	18	do.	do.	-25		D	Water reported soft.	318
319	2.0 mi. ENE. of Marye	W. Hart	W. Hart	1940	260	Dg	26	30	do.	do.	-25		D	Do.	319
320	2.5 mi. ENE. of Marye	E. Gatewood		1920	250	Dg	35	36	do.	do.	-34	4	D	Do.	320
321	2.0 mi. SSW. of Snell	E. Thompson	Wilhite & Wuest	1954	280	B	35	30	Early Paleozoic(?)	Wissahickon formation, granitized gneiss facies	-28		D	Temp., 57°F.	321
322	2.1 mi. SSW. of Snell	M. Harlow	E. D. Harlow	1929	290	Dg	28	36	do.	do.	-19	4	D	See analysis, Table 13. Temp., 57°F.	322
323	3.2 mi. SW. of Snell	C. R. Roberts	Wm. Banks	1947	320	Dg	24	36	do.	do.	-23		D	Temp., 57°F. Water reported soft.	323
324	3.0 mi. SW of Snell	Z. E. Durrett	Z. E. Durrett	1916	320	Dg	24	30	do.	do.	-23		D,S	Temp., 57°F.	324
325	3.4 mi. SW. of Snell	D. T. Holmes			320	Dg	21	36	do.	do.	-20		D		325
326	4.3 mi. SW. of Snell	G. Duerson	Hacket	1924	300	B	28	10	do.	do.	-26		D	Water reported soft.	326
327	4.7 mi. SW. of Snell	A. C. Thompson	Wilhite & Wuest	1954	300	B	31	30	do.	do.	-23		D		327
328	1.2 mi. SW. of Brokenburg	A. Seay		1920?	360	Dg	27	50	do.	Wissahickon formation, schist facies	-24		D	Temp., 57°F. Water reported soft.	328

Table 7. —Records of wells in Spotsylvania County, Virginia—Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (-) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
329	4.0 mi. E. of Belmont	B. Brooks		1954	380	Dg	24	36	Early Paleozoic (?)	Peters Creek quartzite	-22		D	Temp., 56°F.	329
330	2.8 mi. E of Belmont	C. Woolfolk	J. T. Ellington	1954	400	B	49	36	do.	Wissahickon formation, schist facies	-38	5	D	Temp., 57°F. Well went dry summer 1952. New well bored 1954.	330
331	2.1 mi. E. of Belmont	do.		1900	420	Dg	26	36	do.	do.	-25		D	Water reported soft. Temp., 57°F.	331
332	3.0 mi. ENE. of Belmont	A. F. Dickerson		1910	430	Dg	26	36	do.	do.	-25		D	Water reported hard. Temp., 57°F.	332
333	2.5 mi. ENE. of Belmont	H. Stoner	A. Ellis	1950	420	Dg	21	36	do.	Peters Creek quartzite	-17	5	D	See analysis, Table 11. Temp., 57°F.	333
334	2.0 mi. SE. of Belmont	H. Callahan			365	Dg	20	36	do.	Wissahickon formation, schist facies	-19	5	D	Water reported soft. Temp., 57°F.	334
335	3.1 mi. E. of Belmont	A. C. Hazelgrove	A. Ellis	1927	460	Dg	37	40	do.	do.	-27	5	D	See analysis, Table 13. Temp., 58°F.	335
336	2.9 mi. E. of Belmont	G. W. Bisces		1952	420	Dg	27	36	do.	do.	-23	4	D	See analysis, Table 13. Temp., 57°F.	336
337	2.5 mi. E. of Belmont	C. J. Spicer		1942	380	Dg	41	36	do.	do.	-33	5	D	Water reported soft. Temp., 57°F.	337
338	1.6 mi. NW. of Belmont	D. E. Young		1879?	360	Dg	46	36	do.	do.	-41	5	D,S	Temp., 56°F.	338
339	1.5 mi. NNW. of Belmont	A. E. Swift	Woolfolk	1904	340	Dg	51	40	do.	do.	-48	6	D	Temp., 57°F.	339
340	1.6 mi. E. of Belmont	T. R. Fletcher		1920	385	Dg	56	36	do.	do.	-47	5	D	Temp., 56°F.	340
341	1.3 mi. E. of Belmont	B. G. Whitlock	J. Jackson	1942	350	Dg	29	24	do.	do.	-24	5	D,S	Water reported soft. Temp., 57°F.	341
342	1.3 mi. NE. of Belmont	E. M. Ritchie		1890?	360	Dg	44	36	do.	do.	-41	4	D	See analysis, Table 13. Temp., 56°F.	342
343	0.6 mi. NNE. of Belmont	E. Towsey		1920?	340	Dg	31	24	do.	do.	-27	6	D	See analysis, Table 11. Temp., 57°F.	343
344	0.5 mi. S. of Belmont	Belmont School			350	Dg	41	36	do.	do.	-38	5	PS	Water reported soft. Temp., 57°F.	344
345	1.2 mi. NW. of Belmont	A. E. Young			355	Dg	35	36	do.	do.	-32	4	D	Temp., 56°F.	345
346	1.3 mi. WNW. of Belmont	W. R. Day		1904	275	Dg	48	35	do.	do.	-47	5	D,S		346
347	2.8 mi. W. of Belmont	L. T. Wright			300	Dg	33	40	do.	do.	-29	5	D	See analysis, Table 13. Temp., 57°F.	347
348	2.2 mi. W. of Belmont	H. Dickinson	Gannon	1949	320	Dg	33	36	do.	do.	-28	5	D	Do.	348
349	Do.	do.			320	Dg	29	40	do.	do.	-28		Ab		349
350	2.1 mi. W. of Belmont	E. Henderson	J. Jackson	1939	320	Dg	18	12	do.	do.	-15		D	Temp., 57°F.	350

Table 7.—Records of wells in Spotsylvania County, Virginia - Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (-) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
351	1.7 mi. W. of Belmont	E. Jackson	J. Jackson	1930	325	Dg	19	12	Early Paleozoic(?)	Wissahickon formation, schist facies	-15		D,S	Temp., 56°F.	351
352	0.8 mi. W. of Belmont	F. Baker			300	Dg	35	48	do.	do.	-27		D	See analysis, Table 13. Temp., 57°F.	352
353	0.7 mi. SSW. of Belmont	E. G. Woolfolk		1879?	320	Dg	71	40	do.	do.	-68		Ab		353
354	1.3 mi. ESE. of Belmont	W. D. Watson		1889?	370	Dg	17	36	do.	do.	-15		D		354
355	1.6 mi. SSE. of Belmont	M. E. Coleman	J. Jackson	1942	240	Dg	31	36	do.	do.	-28		D	See analysis, Table 13. Temp., 57°F.	355
356	1.7 mi. S. of Belmont	E. Gordon	Gannon	1950	350	Dg	30	36	do.	do.	-27	4	D	Temp., 57°F.	356
357	1.5 mi. S. of Belmont	E. Wingfield			342	Dg	34	40	do.	do.	-31		D	Water reported soft. Temp., 57°F.	357
358	2.7 mi. SW. of Belmont	L. Brock	C. Baker	1934	340	Dg	30	40	Late Paleozoic (?)	Granite	-28		D	See analysis, Table 11. Temp., 56°F.	358
359	2.8 mi. SW. of Belmont	F. Harris	do.	1949	320	Dg	24	40	do.	do.	-20		Ab		359
360	Do.	do.	Gentry	1951	310	D	51	6	do.	do.	-21	8	D,S	See analysis, Table 11. Temp., 57°F.	360
361	3.3 mi. WSW. of Belmont	B. E. Carpenter	Gannon	1951	320	Dg	32	36	do.	do.	-28		Obs.	See figure 7.	361
362	4.0 mi. WSW. of Belmont	L. E. Crafton		1884?	340	Dg	31	40	do.	do.	-27	4	D	Temp., 57°F.	362
363	2.7 mi. NE. of Glenora	M. U. Taylor		1800?	380	Dg	31	36	Early Paleozoic(?)	Wissahickon formation, schist facies	-19	6	D	Do.	363
364	2.3 mi. NE. of Glenora	Good Hope School		1942?	380	Dg	27	36	do.	do.	-26	5	PS	Do.	364
365	Do.	J. McGhee	E. Deale	1951	340	Dg	39	36	do.	do.	-28	4	D	See analysis, Table 13. Temp., 57°F.	365
366	2.4 mi. ENE. of Glenora	E. B. Moser		1900?	340	Dg	39	36	do.	do.	-37	4	D	Well supplies four families.	366
367	1.9 mi. NE. of Glenora	C. A. Wheeler	Wm. Banks	1950	380	Dg	28	36	do.	do.	-25	6	D	See analysis, Table 13. Temp., 57°F.	367
368	1.3 mi. NE. of Glenora	L. Sims	J. T. Ellington	1954	360	B9	39	36	do.	do.	-32		D	See analysis, Table 13.	368
369	1.0 mi. E. of Glenora	W. Lloyd	W. Lloyd	1953	250	Dg	11	40	do.	do.	-10		D	Water reported soft.	369
370	Glenora	E. W. Hairfield	L. S. Hodge	1954	340	B	32	24	do.	Po River Creek quartzite	-27	9	D	Temp., 57°F.	370
371	2.3 mi. E. of Glenora	C. Hart	J. Jackson	1939?	345	Dg	17	40-36	do.	Wissahickon formation, schist facies	-15		D		371
372	1.5 mi. WSW. of Lewiston	M. W. Luck			240	Dg	32	36	Late Paleozoic (?)	Granite	-31		S	See analysis, Table 13. Temp., 57°F.	372
373	0.5 mi. WSW. of Lewiston	J. W. Pennington	J. W. Pennington	1951	320	Dg	35	36	do.	do.	(-)		Ab	Well went dry June 1954.	373
374	Lewiston	B. Duke		1800?	320	Dg	34	36	do.	do.	-32	8	D	See analysis, Table 13.	374

Table 7.—Records of wells in Spotsylvania County, Virginia - Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (–) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
375	0.5 mi. E. of Lewiston	W. M. Moss	T. Brown	1914	320	Dg	26	40	Late Paleozoic (?)	Granite	-24		D	Water reported soft. Temp., 57°F.	375
376	1.2 mi. NE. of Lewiston	First New Hope Baptist Church		1938	280	Dg	20	36	do.	do.	-17		D		376
377	1.5 mi. NE. of Lewiston	R. Pendleton			290	Dg	25	36	do.	do.	(-)			Well went dry September 1954.	377
378	2.2 mi. NE. of Lewiston	R. Harris	Wm. Banks and C. Ward		335	Dg	25	36	do.	do.	-22		D	Temp., 57°F.	378
379	2.0 mi. NE. of Lewiston	C. Frank	L. S. Hodge	1954	290	D	31	30	do.	do.	-18	4	D,S	Water reported soft.	379
380	2.2 mi. ENE. of Lewiston	R. Ware		1894?	320	Dg	22	30	do.	do.	-18		D,S	See analysis, Table 13.	380
381	2.9 mi. ENE. of Lewiston	G. Boggs		1908	325	Dg	26	60	Early Paleozoic (?)	Wissahickon formation, granitized gneiss facies	-25		D		381
382	3.2 mi. ENE. of Lewiston	J. Edenton			340	Dg	30	36	do.	do.	-28		D,S	Water reported soft.	382
383	3.7 mi. ENE. of Lewiston	R. H. Edenton		1937	320	Dg	31	36	do.	do.	-27	5	D	See analysis, Table 13.	383
384	4.1 mi. ENE. of Lewiston	J. Edenton	J. Edenton	1949	325	Dg	27	36-26	do.	do.	-23		D	See analysis, Table 13. Well was dry July 1953, deepened 9 feet.	384
385	4.4 mi. ENE. of Lewiston	J. Sacra	J. Sacra	1945	330	Dg	19	36	do.	do.	-16		D		385
386	4.6 mi. E. of Lewiston	W. D. Edenton			300	Dg	27	36	do.	do.	-25		S		386
387	4.0 mi. E. of Lewiston	R. Burrus			310	Dg	30	40	do.	do.	(-)		D	Well went dry August 1954.	387
388	1.5 mi. SE. of Lewiston	J. W. Curtiss			300	Dg	34	36	do.	do.	-24		D	See analysis, Table 13. Temp., 57°F.	388
389	2.1 mi. SE. of Lewiston	S. Miner	S. Miner	1951	290	Dg	26	36	do.	do.	-24		D	See analysis, Table 13. Well went dry June 1953, deepened 8 feet.	389
390	3.1 mi. SSE. of Lewiston	L. Luck		1890?	260	Dg	28	40	do.	do.	-24		D	Water reported soft.	390
391	4.1 mi. SE. of Lewiston	I. V. Richard		1952	260	D	58	36	do.	do.	-55		D	Do.	391
392	3.3 mi. SE. of Lewiston	W. C. Harris	W. C. Harris	1930	300	Dg	28	36	do.	do.	-25	4	D	Do.	392
393	4.1 mi. SE. of Lewiston	R. Jones		1919?	240	Dg	27	60	do.	do.	-26		D	See analysis, Table 11.	393
394	3.3 mi. SSE. of Lewiston	A. M. Arritt		1931	240	Dg	23	36	do.	do.	-22	4	D	Well went dry September 1953.	394
395	2.0 mi. NNW. of Partlow	R. W. Acors	D. W. Acors	1950	340	Dg	29	36	Precambrian	Baltimore(?) gneiss	-25	4	D	See analysis, Table 13.	395
396	1.3 mi. NW. of Partlow	J. I. Payne		1914	320	Dg	26	36	do.	do.	-22	4	D	Do.	396

Table 7. —Records of wells in Spotsylvania County, Virginia - Continued

No.	Location	Owner or tenant	Driller	Year completed	Approximate altitude above sea level (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Principal water-bearing zone: Geologic age	Principal water-bearing zone: Stratigraphic unit or named aquifer	Approximate water level above (+) or below (−) land surface (feet)	Approximate yield (gpm)	Use of water	Remarks	No.
397	1.4 mi. WNW. of Partlow	H. S. Broaddus		1929	320	Dg	26	36	Precambrian	Baltimore(?) gneiss	-25	5		See analysis, Table 13.	397
398	0.9 mi. NNW. of Partlow	J. W. Humphries	S. Marshall	1913	380	Dg	38	36	do.	do.	-33	6		Water reported soft.	398
399	0.7 mi. NW. of Partlow	J. D. Humphries		1890?	320	Dg	30	48-36	do.	do.	-25	3		Water reported soft. Temp., 57°F.	399
400	Partlow	J. L. Davis			380	Dg	39	36	do.	do.	-36	5	D	See analysis, Table 11.	400
401	1.1 mi. NNE. of Partlow	R. Anderson			330	Dg	22	36	do.	do.	-23			Water reported muddy; not used for drinking.	401
402	0.5 mi. NE. of Partlow	I. P. Houston	I. P. Houston	1943	320	Dg	47	48-30	do.	do.	-42	5	D	See analysis, Table 13.	402
403	0.4 mi. ESE. of Partlow	C. Muller		1953	365	Dg	34	36	do.	do.	-28	4	D	See analysis, Table 13. Well deepened 5 feet, July 1954.	403
404	0.4 mi. W. of Partlow	G. A. Sacra		1944	370	Dg	31	36	do.	do.	-26	5	D, S	Water reported soft.	404
405	1.5 mi. SW. of Partlow	B. B. Hardenberg		1940	310	Dg	26	36	do.	do.	-25		D	See analysis, Table 13. Temp., 57°F.	405
406	7.1 mi. SSW. of Partlow	J. Wigglesworth	M. Wigglesworth	1946	265	Dg	37	48	do.	do.	-36		D		406
407	2.7 mi. S. of Partlow	E. Satterwhite			260	Dg	44	36	do.	do.	-40	5	D	See analysis, Table 13.	407
408	1.0 mi. SSE. of Partlow	W. Harris			340	Dg	27	60	do.	do.	-21		D	Temp., 57°F.	408
409	1.8 mi. SE. of Partlow	B. Ross			340	Dg	35	36	do.	do.	-31		D	Water reported soft.	409
410	1.8 mi. ESE. of Partlow	R. T. Pritchard	Seay	1954	360	Dg	36	30	do.	do.	-32		D	Do.	410
411	1.2 mi. SW. of Marye	R. Evans		1940	340	Dg	33	36	do.	do.	-29	4	D	Water reported soft. Temp., 57°F.	411
412	0.4 mi. W. of Marye	W. B. Nelson		1928	310	Dg	21	60	do.	do.	-19		D		412
413	0.9 mi. NW. of Marye	C. R. Coleman			300	Dg	32	36	do.	do.	-27	4	D		413
414	0.4 mi. NNW. of Marye	B. J. Hockaday		1934	300	Dg	34	36	do.	do.	-31	8	D	Water reported soft.	414
415	Marye	Marye School		1919	320	Dg	26	36	do.	do.	-23	4	PS		415
416	0.6 mi. E. of Marye	L. M. Miner			310	Dg	23	60	do.	do.	-21		D, S	See analysis, Table 11. Water reported to have "irony" taste.	416
417	1.2 mi. ENE. of Marye	P. Chew	P. Chew	1943	280	D	16	8	do.	do.	-14		D		417

Table 8 .--Record of springs in Spotsylvania County, Virginia

Use of water : Ab, abandonded; D, domestic; S, stock

No.	Location	Owner or tenant	Source	Use of Water	Remarks	No.
1	Fredericksburg	Aqeuduct Co.	Sand and gravel	Ab	See analysis, table 12. From Va. Geol. Survey Bulletin 5, p. 273-274, 396,397.	1
2	Do.	Fredericksburg	do.	do.	See analysis, table 12. From Va. Geol. Survey Bulletin 5, p. 273-274, 396, 397. Formerly known as Gunnery Spring.	2
3	Do.	do.	do.	do.	See analysis, table 12. From Va. Geol. Survey Bulletin 5, p. 273-274, 396, 397. Formerly known as Mit Spring.	3
4	Do.	do.	do.	do.	See analysis, table 12. From Va. Geol. Survey Bulletin 5, p. 273-274, 396, 397. Formerly known as Silk Mill Spring.	4
5	1.5 mi. E. of Four Mile Fork	C. Backus	do.	D	Spring reported to have been in use 150 years. Turbid appearance after heavy rains. Temp. 69°F.	5

Table 8 .--Record of springs in Spotsylvania County, Virginia--Continued

No.	Location	Owner or tenant	Source	Use of Water	Remarks	No.
6	1.0 mi. S. of Five Mile Fork	H. E. Sorels	Sand and gravel	D, S	Temp. 68°F	6
7	3 mi. NNW of Chancellorsville	G. B. Diehr	Peters Creek quartzite	D	See analysis, table 13. Temp. 53°F. Water flows from several fractures in rock.	7
8	2.5 mi. N of Post Oak	J. Callahan		D	Temp. 54°F. Spring appeared after a flood in 1907.	8
9	1.6 mi. SSE of Post Oak	R. B. Miller	Granite	D, S	Temp. 58°F	9
10	2.5 mi. SSW of Partlow	E. C. Tribble	Baltimore(?) gneiss	D, S	See analysis, table 13. Temp. 58°F. Reported to yield 2 gpm.	10
11	1.0 mi. SSW of Lewiston	R. H. Mastin	Granite	D	Temp. 58°F	11

Table 8 .--Record of springs in Spotsylvania County, Virginia--Continued

No.	Location	Owner or tenant	Source	Use of Water	Remarks	N
12	1.3 mi. SSE of Belmont	J. R. Dillard	Peters Creek quartzite	D	Temp. 56°F	1
13	2.0 mi. SW of Belmont	M. Wright	Granite	D	See analysis, table 12. Temp. 59°F.	1
14	3.5 mi. SW of Belmont	W. O. Harris, Jr.	Granite	D	See analysis, table 12.	1

MATERIALS PENETRATED

DRILLERS' LOGS

Logs of 24 wells and 5 test holes (table 9) have been furnished for use in this report by well owners and by drillers who have operated in the area.

From the writer's study of the drillers' logs and samples of cuttings, it appears that a few of the descriptive terms as used by local drillers should be defined. Marl, a fine-grained calcareous sediment resembling clay, is generally used by drillers to denote predominantly clayey material. The term rock or shale is used locally by some drillers to indicate hard-packed sand, sandstone, other cemented granular sedimentary rocks, or hard clay. Mud described in the logs generally means fine-grained sandy clay or silt that is broken down easily by drilling fluids.

Sand is a loose, unconsolidated granular sediment consisting mostly of rounded or irregularly shaped quartz grains. Sand ranges in size from very fine to coarse, and grades into fine gravel. Gravel consists of the same type of material as sand, except that minerals and rocks other than quartz are more abundant, and its component grains range in size from 2 millimeters (about one-twelfth inch) to several inches.

Silt is a fine-grained material intermediate between sand and clay. Its individual particles are visible only under magnification. Clay is the finest-grained sediment consisting of individual particles.

Table 9.--Logs of wells in Spotsylvania County, Virginia

Well 1. 2.8 mi. ESE of Five Mile Fork; N. B. Rowe

(Log by Virginia Machinery & Well Co.)

Altitude, 235 feet

	Thickness (feet)	Depth (feet)
Terrace deposit (Pleistocene)		
Clay, red	40	40
Patuxent(?) formation (Cretaceous ?)		
Marl, gray*	37	77
Sand	3	80
Marl, gray*	70	150

*Driller's term "marl," believed to refer to clay.

Well 6. 1.0 mi. SSE of Five Mile Fork; H. Bernstein

(Log by Sydnor Pump & Well Co., Inc.)

Altitude, 340 feet

Topsoil, gray	2	2
Bedrock and clay	6	8
Clay, red	59	67
Clay, yellow, and mica	15	82
Sand and clay, mixed	10	92
Sand, gray; clay, hard	17	109
Granite, gray, weathered	30	139
Granite, gray	43	182

Well 50. Bellevue Court Subdivision; Sydnor Pump & Well Co., Inc.
(Log by Sydnor Pump & Well Co., Inc.)
Altitude, 245 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Clay	5	5
Sand; clay; and gravel	7	12
Sand and gravel	33	45
Miocene deposits (undifferentiated)		
Clay, blue	5	50
Clay, blue, and gravel	35	85
Mixed boulders and clay	65	150
Patuxent formation (Cretaceous)		
Clay, white	15	165
Sand and gravel; sand and clay streaks	25	190
Clay, brown	10	200
Clay, brown, hard	40	240
Sand	10	250
Clay, brown	25	275
Clay, tough	2	277
Basement complex (pre-Cretaceous)		
Granite rock	2	279

Well 51. Bellevue Court Subdivision; Sydnor Pump & Well Co., Inc.
(Log by Sydnor Pump & Well Co., Inc.)
Altitude, 240 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Sand and clay	6	6
Clay, red; sand	34	40
Clay, gray; sand	20	60
Miocene deposits (undifferentiated)		
Clay, blue	64	124
Patuxent(?) formation (Cretaceous ?)		
Clay, red	11	135
Clay, gray	10	145
Clay and sand mixed; non-water bearing	28	173
Sand, medium-coarse; gravel; little water	5	178
Sand, gravel mixed with clay	21	199
Clay, brown, hard	12	211

Well 52. Bellevue Court Subdivision; Sydnor Pump & Well Co., Inc.

(Log by Sydnor Pump & Well Co., Inc.)

Altitude, 240 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Clay, yellow	20	20
Clay, yellow; sand	8	28
Sand and gravel; clay, yellow	10	38
Gravel	9	47
Clay, yellow; gravel	3	50
Miocene deposits (undifferentiated)		
Mud, black	75	125
Patuxent formation (Cretaceous)		
Clay, gray	25	150
Sand and clay	50	200
Clay, red	3	203
Clay, brown	79	282
Basement complex (pre-Cretaceous)		
Granite, gray	26	308
Sandstone	12	320
Granite, gray	192	512

Well 54. Cottage Green Subdivision; G. T. Waite

(Log by Mitchell's Well & Pump Co.)

Altitude, 244 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Sand and clay	20	20
Sand and gravel	10	30
Miocene deposits (undifferentiated)		
Clay, light-blue	10	40
Clay, black	71	111
Clay, blue	88	199
Patuxent formation (Cretaceous)		
Sand, gray, hard	46	245
Sand, white, hard	5	250
Sand, gray, hard	15	265
Sand, white, hard	10	275

Well 55. Cottage Green Subdivision; G. T. Waite

(Log by Leazer Pump & Well Co.)

Altitude, 244 feet

	Thickness (feet)	Depth (feet)
Soil	4	4
Terrace deposits (Pleistocene)		
Clay, sandy, yellow	21	25
Sand; water-bearing zone	10	35
Miocene deposits (undifferentiated)		
Clay, blue	35	70
Sandy clay, blue	60	130
Clay, green-blue	30	160
Patuxent formation (Cretaceous)		
Clay, red	15	175
Clay, sand, gray	25	200
Sand, fine	30	230
Clay, sand (shale?)	5	235
Sand, coarse	10	245
Clay, blue	30	275

Well 58. 1.2 mi. ENE of Four Mile Fork; W. A. Webster

(Drilled by Leazer Pump & Well Co.)

(Log by S. Subitzky)

Altitude, 135 feet

	Thickness (feet)	Depth (feet)
Soil	3	3
Terrace deposits (Pleistocene)		
Gravel; some sand; water-bearing zone	18	21
Silt, light-brown	25	46
Miocene deposits (undifferentiated)		
Clay, blue; sand and gravel; water-bearing zone	14	60
Clay, blue, green	4	64
Patuxent formation (Cretaceous)		
Clay, red	3	67
Clay, red, blue; some gravel	8	75
Clay, red, blue, green	2	77
Clay, red	2	79
Clay, gray	5	84
Clay, sand, brown (bailer test 2-1/2 gpm)	6	90
Clay, brown, blue; sand and gravel	10	100
Sand, white; clay, yellow, green	39	139

Table 9.--Logs of wells in Spotsylvania County, Virginia--Continued

Well 66. Courtland Heights Subdivision; Sydnor Pump & Well Co., Inc.

(Log by Sydnor Pump & Well Co., Inc.)

Altitude, 240 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Sand, yellow, hard	10	10
Clay, red	5	15
Sand, yellow; gravel	7	22
Sand, yellow; clay	13	35
Miocene deposits (undifferentiated)		
Clay, blue	43	78
Patuxent formation (Cretaceous)		
Clay, gray; thin streaks of gray fine sand	7	85
Sand, gray; clay	25	110
Clay, dark-gray	19	129
Sand, fine, gray	2	131
Clay, brown	4	135
Clay, red	30	165
Sand, gray, green; clay	15	180
Sand, gray	1	181
Sand, white and gray	2	183
Sand, gray; clay	17	200
Sand, gray; streaks of clay	5	205
Sand, gray; clay	4	209
Sand, coarse, gray; clay	9	218
Sand, gray; clay	10	228

Well 66. Courtland Heights Subdivision; Sydnor Pump & Well Co., Inc.--Continued

	Thickness (feet)	Depth (feet)
Patuxent formation (Cretaceous)--Continued		
Clay, green; sand	1	229
Clay; sand streaks	6	235
Clay, green; sand	15	250
Clay and sand	3	253
Clay, gray; sand	1	254
Sand, gray, coarse; gravels and clay streaks	11	265
Sand, coarse, gray	1	266

Well 67. Courtland Heights Subdivision; Sydnor Pump & Well Co., Inc.

(Log by Syndor Pump & Well Co., Inc.)

Altitude, 240 feet

Terrace deposits (Pleistocene)		
Clay, red	17	17
Sand and clay	13	30
Sand and gravel	12	42
Clay, yellow	5	47

Well 71. Dillard Subdivision; Sydnor Pump & Well Co., Inc.

(Log by Sydnor Pump & Well Co., Inc.)

Altitude, 220 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Gravel	18	18
Gravel, soft	2	20
Clay, yellow	2	22
Miocene deposits (undifferentiated)		
Clay, blue	41	63
Clay, blue; gravel	16	79
Patuxent formation (Cretaceous)		
Clay and gray sand	6	85
Sand, hard; gravel	5	90
Clay, wet; sand	9	99

Table 9.--Logs of wells in Spotsylvania County, Virginia--Continued

Well 72. Dillard Subdivision; Sydnor Pump & Well Co., Inc.

(Log by Sydnor Pump & Well Co., Inc.)

Altitude, 200 feet

	Thickness	Depth
Terrace deposits (Pleistocene)		
Clay, red; rock	10	10
Clay, red	30	40
Clay, gray	10	50
Clay, yellow	10	60
Miocene deposits (undifferentiated)		
Marl, dark	22	82
Patuxent(?) formation (Cretaceous?)		
Sand, coarse	10	92
Undescribed	16	108
Sand	2	110
Clay, red	10	120
Clay, green	20	140
Clay, red	36	176
Clay, green	4	180
Sand	12	192
Clay, green	10	202
Sand, coarse	10	212
Clay	5	217
Clay and gravel	3	220
Clay, tough	30	250

Table 9.--Logs of wells in Spotsylvania County, Virginia--Continued

Well 72. Dillard Subdivision; Sydnor Pump & Well Co., Inc.--Continued

	Thickness (feet)	Depth (feet)
Patuxent(?) formation (Cretaceous?)--Continued		
Clay, sandy, tough	50	300
Clay, gray, tough	5	305
Basement complex(?) (pre-Cretaceous)		
Slate, sandy, gray	10	315
Slate, gray	10	325
Slate, sandy	12	337
Granite, gray	10	347
Granite, light; hardpan	15	362
Granite, light	13	375
Granite, gray and black	18	393
Granite, gray	17	410
Granite, light	5	415
Granite, gray and black	45	460
Granite, gray	30	490
Granite, gray and black	18	508
Granite, gray	7	515
Granite, very light	8	523
Granite, green	7	530
Granite, gray	100	630
Granite, gray and black	10	640
Granite, gray	15	655

Well 74. Dillard Subdivision; Sydnor Pump & Well Co., Inc.

(Log by Sydnor Pump & Well Co., Inc.)

Altitude, 200 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Gravel	20	20
Clay, gray	58	78
Sand, fine; gravels	2	80
Sand, fine	8	88
Miocene deposits (undifferentiated)		
Marl, dark	16	104
Patuxent(?) formation (Cretaceous?)		
Sand, clay, red	6	110
Clay, red	30	140
Clay, green	25	165
Sand and clay	20	185
Clay, green	8	193
Sand	22	215
Marl, blue	1	216
Mud; sand and clay	16	232
Basement complex(?) (pre-Cretaceous)		
Hard material	18	250
Hardpan	15	265
Clay, hard	24	289
Granite, gray	311	600

Table 9.--Logs of wells in Spotsylvania County, Virginia--Continued

Well 77. 2.1 mi. NE of Four Mile Fork; National Park Service

(Log by Mitchell's Well & Pump Co.)

Altitude, 140 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene		
Clay, yellow; sand	35	35
Miocene deposits (undifferentiated)		
Mud, blue; sand	28	63
Patuxent(?) formation (Cretaceous?)		
Clay, yellow and red	22	85
Clay, hard, brown and blue; dry	35	120
Mud, blue; sand; some water	30	150
Sand, white	13	163
Sand, white; caving hard	2	165

Well 80. Fredericksburg; State Normal School

(Log by Sydnor Pump & Well Co., Inc.)

Altitude, 120 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Clay, red	3	3
Clay, white	2	5
Gravel, white	3	8
Miocene deposits (undifferentiated)		
Marl, blue; or clay	75	83
Basement complex (pre-Cretaceous)		
Granite, soft, blue	18	101
Granite, gray	123	224
Marl, blue, sticky (?)	1/2	224-1/2
Granite, hard, gray	98-1/2	323
Sand, loose; like decomposed sandstone	1	324
Granite, hard and soft, gray	96	420
Mud, blue; crevice	1	421
Granite, hard, light-gray	2	423
Mud, blue, sticky and sand. (Blue running sand mixed with marl on the order of quicksand. Tested well and relined with 8-inch pipe.)	4	427
Rock, soft, blue	2	429
Sand and blue mud	5	434
Rock, soft, blue	4	438
Mud, blue	7	445
Rock, soft, blue	2	447

Well 80. Fredericksburg; State Normal School--Continued

	Thickness (feet)	Depth (feet)
Basement complex (pre-Cretaceous)--Continued		
Mud, blue	11	458
Rock, soft, blue	9	467
Mud, blue	3	470
Rock, soft, blue	2	472
Mud, blue	1	473
Rock, soft, blue	2	475
Mud, blue	1	476
Sandstone, hard, brown	39	515
Sandstone, hard, brown; crevice	8	523

Well 82. Fredericksburg Victoria Theater; B. T. Pitts

(Log by Mitchell's Well & Pump Co.)

Altitude, 48 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Gravel and sand	30	30
Patuxent(?) formation (Cretaceous?)		
Mud, red	10	40
Clay, blue; gravel	54	94
Sand	11	105
Mud, blue	9	114
Basement complex (pre-Cretaceous)		
Rock, soft	34	148
Rock, hard	5	153

Table 9.--Logs of wells in Spotsylvania County, Virginia--Continued

Well 87. Sylvania Heights Subdivision; A. W. Embry

(Log by Sydnor Pump & Well Co., Inc.)

Altitude, 64 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Clay, red	4	4
Sand, gravel, and clay, red	30	34
Clay, light-red; sand, gravel, coarse	9	43
Patuxent(?) formation (Cretaceous?)		
Clay, hard, red, sticky	18	61
Sand, blue and gray; clay, muddy and sticky	8	69
Sand; clay, gray, muddy and sticky	6	75
Sandy gravel, medium-coarse; clay	17	92
Clay, blue gray, mixed	79	171
Sand, clay, gray; sand, medium-coarse	4	175
Sand, medium coarse; clay, soft, gray	50	225

Well 97. 1.3 mi. E of Four Mile Fork; R. D. Hull

(Generalized log described by Mrs. R. D. Hull)

Altitude, 230 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Sandy gravel	20	20
Clay, red and yellow	20	40
Calvert formation (Miocene)		
Plum Point marl member		
Marl (clay), blue	40	80
Patuxent formation (Cretaceous)		
Sand; sand and gravel	13	93

Well 98. 1.4 mi. E of Four Mile Fork; R. Pearson

(Log by S. Subitzky and R. Pearson)*

Altitude, 228 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Clay, sand, yellow	20	20
Calvert formation (Miocene)		
Plum Point marl member		
Clay, sandy, dark-green	10	30
Clay, green, white when dry	60	90
Patuxent formation (Cretaceous)		
Sand, yellow	2	92

*This log was compiled from material lying around the well and pointed out to the author by Mr. Pearson.

Well 137. .4 mi. N of Massaponax; Sunset Motel

(Log by Mitchell's Well & Pump Co.)

Altitude, 250 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Clay, yellow	10	10
Sand and gravel	25	35
Miocene deposits (undifferentiated)		
Marl, blue	25	60
Clay, hard, blue; some sand	45	105
Patuxent(?) formation (Cretaceous?)		
Clay, hard, red	75	180
Basement complex (pre-Cretaceous)		
Rock	170	350

Well 142. 1.2 mi. WSW of Massaponax; R. C. Rawlings

(Log by J. T. Ellington)

Altitude, 210 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Sand and gravel	25	25
Miocene deposits (undifferentiated)		
Clay, blue	5	30
Patuxent formation (Cretaceous)		
Sandstone, dark gray (?) ??	26	56
Basement complex (pre-Cretaceous)		
Rock, granite	145	201

Well 201. Spotsylvania Court House; R. E. Lee School

(Log by Sydnor Pump & Well Co., Inc.)

Altitude, 310 feet

Clay, red	48	48
Sand	17	65
Rock, gray	165	230
Granite, blue	66	296

Table 9.--Logs of wells in Spotsylvania County, Virginia--Continued

Well 202. Spotsylvania Court House; Spotsylvania County

(Log by Sydnor Pump & Well Co., Inc.)

Altitude, 310 feet

	Thickness (feet)	Depth (feet)
Clay, red; sand	18	18
Sand, white	14	32
Clay, red; sand	14	46
Sand, white	4	50
Soapstone(?)	8	58
Sand	5	63
Clay	15	78
Rock, soft	18	96
Sand	24	120
Granite	44	164

Well 205. Spotsylvania Court House; Spotsylvania High School

(Log by Sydnor Pump & Well Co., Inc.)

Altitude, 310 feet

	Thickness (feet)	Depth (feet)
Clay	35	35
Sand	15	50
Granite	65	115
Granite, gray	185	300

Well 308. .6 mi. SSE of Thornburg; Lamp Lighter Motel

(Log by S. Subitzky)*

Altitude, 260 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Undescribed	20	20
Sand and gravel; water-bearing zone	20	40
Calvert formation (Miocene)		
Plum Point marl member		
Clay, green; containing some sand and diatoms	5	45

*Log compiled by author from information furnished by well owner. Samples of materials penetrated during the construction of the well were collected and studied.

Table 9.--Logs of wells in Spotsylvania County, Virginia--Continued

Test hole 1. 1.7 mi. NNE of Four Mile Fork

(Log by Layne-Atlantic Company)

Altitude, 240 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Clay and topsoil	10	10
Clay, soft; sand, coarse	12	22
Gravel, small	10	32
Gravel and clay, red	2	34
Clay, blue, and gravel, large	29	63
Miocene deposits (undifferentiated)		
Clay, soft, blue	40	103
Patuxent(?) formation (Cretaceous?)		
Clay, blue and red, hard	58	161
Sand, fine	6	167
Clay, blue and gray	10	177
Sand, coarse	10	187
Sand, fine; clay, blue (quartz chips from 229-249)	62	249
Basement complex(?) (pre-Cretaceous?)		
Clay, blue; rock, weathered-granite	14	263

Table 9.--Logs of wells in Spotsylvania County, Virginia--Continued

Test hole 2. 1.5 mi. ENE of Four Mile Fork

(Log by Layne-Atlantic Company)

Altitude, 110 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Clay, topsoil	8	8
Clay, some gravel	15	23
Clay, gravel, and sand	5	28
Sand, coarse; gravel, large	18	46
Patuxent(?) formation (Cretaceous?)		
Clay, red, hard	8	54
Clay, white	6	60
Clay, brown	6	66
Clay, white; some sand	39	105
Clay, white and blue; gravel (small)	20	125
Clay, white and blue, hard and soft streaks	21	146
Clay, red and white	22	168
Clay, and sand, coarse	5	173
Clay, red; gravel (some)	14	187
Clay, sandy blue	25	212
Sand, fine, dirty	6	218
Sand and clay, fine; rock, weathered	9	227
Basement complex (pre-Cretaceous)		
Rock, weathered; granite	5	232

Test hole 3. 2.2 mi. ESE of Four Mile Fork

(Log by Layne-Atlantic Company)

Altitude, 220 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Clay, sandy, red; sand and gravel, coarse	14	14
Sand, coarse; gravel, small	9	23
Calvert formation (Miocene)		
Plum Point marl member		
Clay, blue		
Clay, blue, hard (silty); softer from 65-85 ft.)	41	85
Clay, sandy, blue (more sand from 106-126 ft.)	62	147
Clay, gray; sand, coarse	16	163
Patuxent(?) formation (Cretaceous?)		
Clay, red, hard	25	188
Clay, hard, red, yellow, blue	20	208
Clay, sandy, gray and yellow	21	229
Clay, sandy, gray	20	249
Clay, sandy, gray and red	6	255
Sand, medium-fine	5	260
Sand, medium coarse, interbedded with clay	17	277
Clay, red, hard, trace gray	13	290
Clay, sandy, gray	8	298
Sand, hard, coarse and fine; some clay	19	317
Sandy clay, hard, gray	10	327

Test hole 3. 2.2 mi. ESE of Four Mile Fork--Continued

	Thickness (feet)	Depth (feet)
Patuxent(?) formation (Cretaceous?)		
Sand, coarse to fine, some very hard; gravel	5	332
Clay, gray, very hard, traces of red	19	351
Sand, hard, coarse	4	355
Sand, medium coarse; micaceous	4	359
Sand, medium coarse; bedrock, weathered	5	364

Test hole 4. .7 mi. SE of Fredericksburg; American Viscose Corp.

(Log by J. T. Ellington)

Altitude, 65 feet)

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Sand and gravel	27	27
Rock (flint)	4	31
Sand and gravel	9	40
Patuxent(?) formation (Cretaceous)		
Clay, red	15	55
Clay, blue	75	130
Sandstone	140	270

Test hole 5. .7 mi. SE of Fredericksburg; American Viscose Corp.

(Log by J. T. Ellington)

Altitude, 65 feet

	Thickness (feet)	Depth (feet)
Terrace deposits (Pleistocene)		
Sand and gravel; 12-inch boulders	15	15
Gravel, coarse	3	18
Sand and gravel	15	33
Rock; flint	4	37
Sand and gravel	5	42
Patuxent(?) formation (Cretaceous)		
Clay, red	9	51

MEASURED SECTIONS

The stratigraphic sections listed in table 10 were in part measured by the writer in Spotsylvania County and contain sections described previously by Clark and Miller (1912). Many other sections were examined in the area but owing to the poor exposures they are not sufficiently complete to warrant description in this report.

Table 10. Measured geologic sections in Spotsylvania County, Virginia

1. Section in the vicinity of Hazel Run and U. S. Highway 1 (Alt.)

Altitude, 80 feet

		Feet
Pleistocene	Brown loam with angular quartz pebbles up to 6 inches in diameter, averaging 1 inch in diameter..............	2
Eocene(?) (Aquia formation)	Clay, green, silty (blocky)............	4
Cretaceous (Patuxent formation)	Sandstone, white; grades into white arkosic sand and gray clay, zone of tree impressions.....................	20
	Undescribed (covered)..................	10
	Sandstone, white, soft.................	5
	Undescribed (covered)..................	5
	Sand, white, arkosic, cross-bedded thin lenses of green clay.................	11
	Clay, green; weathers red...............	6
	Undescribed (covered)..................	5
	Clay, green; weathered (red)...........	8
	Undescribed (covered)..................	5
Pre-Cretaceous (Basement complex)	Granite, granite gneiss................	
	Total.................	81

Table 10.--Measured geologic sections in Spotsylvania County, Virginia--Continued

2. Section along U. S. Highway 1, 2 miles south of Four Mile Fork

Altitude, 160 feet

		Feet
Pleistocene	Sand and gravel mixed with clay; gravel range in size from 1 to 2 inches in diameter............................	2
Miocene(?)	Clay, buff color, stained yellow and red	2-1/2
	Clay, blue; some sand..................	7-1/2
	Total............	12

3. Section along U. S. Highway 1, 2-1/2 miles south of Four Mile Fork

Altitude, 200 feet

Pleistocene	Sand and gravel, some yellow clay.......	1
Cretaceous (Patuxent formation)	Sand, gray, fine grained; stained yellow. Cylindrical shaped ferruginous concretions occur within sand; limonite appear to have formed about a clay core.....................	10
	Total............	11

Table 10.--Measured geologic sections in Spotsylvania County, Virginia--Continued

4. Section north bank of Rappahannock River, opposite mouth of Massaponax Creek

(From Bulletin IV, Virginia Geol. Survey, p. 96)

Altitude, 30 feet

		Feet
Pleistocene	Sand, gravel, etc................about	12
Eocene (Aquia formation)	Gray argillaceous sand mottled with yellow probably weathered greensand..	5
Cretaceous (Patuxent formation)	Coarse arkosic sand and gravel, containing angular clay pebbles up to 3 inches in diameter.................	20
	Total........	37

5.--Section south bank of Rappahannock River, one-half mile below mouth of Massaponax Creek

(From Bulletin IV, Virginia Geol. Survey, p. 96)

Altitude, 30 feet

Pleistocene	Concealed except 2 feet of gravel along base........................	20
Eocene (Aquia formation)	Dark greensand not well exposed except 3 feet at base, sharp contact with underlying bed....................	22
Cretaceous (Patuxent formation)	Coarse gravelly compact arkosic sand.	12
	Total......	54

Table 10.--Measured geologic sections in Spotsylvania County, Virginia--Continued

6. Section south bank of Rappahannock River, one mile below mouth of Massaponax Creek

(From Bulletin IV, Virginia Geol. Survey, p. 97)

Altitude, 20 feet

		Feet
Pleistocene	Yellow sand and gravel with boulders..	8
Eocene (Aquia formation)	Light greenish-gray glauconitic sand, probably dark green if not weathered.	17
	Similar materials full of fossils, *Crassatellites alaeformis*, *Cuculaea gigantea*, *Ostrea compressirostra*, *Meretrix ovata* var. *pyga*, *Turritella mortoni*, etc.......	12
	Dark green compact, finely micaceous greensand..........................	15
	Total..........	52

7. Section north bank of Rappahannock River, 1-1/2 miles below mouth of Massaponax Creek

(From Bulletin IV, Virginia Geol. Survey, p. 97)

Altitude, 30 feet

Pleistocene	Sand and gravel with boulders.........	8
Eocene (Aquia formation)	Dark greensand......................about	20
	Total..........	28

Table 11.--Chemical analyses of ground waters from wells in Spotsylvania County, Virginia

(Parts per million except specific conductance)

Well number	1	12	42	49	53
Location	ESE of Five Mile Fork	SSW of Five Mile Fork	S of Four Mile Fork	ENE of Four Mile Fork	NE of Four Mile Fork
Depth (feet)	150	33	48	275	175
Water-bearing formation	Patuxent fm.	Granite	Terrace deposits	Patuxent fm.	Patuxent fm.
Date	June 23, 1955	August 12, 1953	April 1, 1955	March 17, 1954	June 23, 1954
Silica (SiO_2)	47	10	--	30	39
Iron (Fe)	a 3.0	b 5.6	0.3	a .48	a 3.9
Calcium (Ca)	7.4	4.5	--	9.5	13
Magnesium (Mg)	4.0	4.0	--	6.9	5.6
Sodium (Na)	4.7	42	--	23	12
Potassium (K)	3.1	--	--	4.5	4.5
Carbonate (CO_3)	0	0	--	0	0
Bicarbonate (HCO_3)	36	63	--	96	85
Sulfate (SO_4)	5.2	30	--	8.8	12
Chloride (Cl)	9.2	43	--	16	2.8
Fluoride (F)	.1	--	--	.2	.0
Nitrate (NO_3)	.1	2.2	--	.1	.6
Dissolved solids	104	c 169	c 75	140	120
Hardness as $CaCO_3$	35	28	--	52	56
Specific conductance (micromhos at 25°C)	106	273	119	208	149

a Fe in solution at time of collection.
b Fe in solution and suspension at time of collection.
c Calculated.

Table 11.--Chemical analyses of ground waters from wells in Spotsylvania County, Virginia--Continued

(Parts per million except specific conductance)

Well number	54	55	57	58	63
Location	NNE of Four Mile Fork	NNE of Four Mile Fork	NE of Four Mile Fork	ENE of Four Mile Fork	ENE of Four Mile Fork
Depth (feet)	275	275	259	139	286
Water-bearing formation	Patuxent fm.	Patuxent fm.	Patuxent fm.	Patuxent fm.	Patuxent fm.
Date	March 17, 1954	July 20, 1955	July 20, 1955	October 13, 1953	March 17, 1954
Silica (SiO_2)	34	--	--	33	28
Iron (Fe)	a 2.3	--	a	a 12	a 1.4
Calcium (Ca)	31	--	--	12	14
Magnesium (Mg)	21	--	--	7.5	8.2
Sodium (Na)	36	--	--	5.6	15
Potassium (K)	6.9	--	--	4.0	3.9
Carbonate (CO_3)	0	0	0	0	0
Bicarbonate (HCO_3)	84	84	82	75	102
Sulfate (SO_4)	14	--	--	10	10
Chloride (Cl)	112	114	3.0	2.0	7.6
Fluoride (F)	.2	.2	.2	.2	.2
Nitrate (NO_3)	.1	.2	.3	.0	.1
Dissolved solids	292	b 331	b 92	107	135
Hardness as $CaCO_3$	164	169	52	60	69
Specific conductance (micromhos at 25°C)	520	534	148	150	195

a Fe in solution at time of collection.

b Calculated.

(Parts per million except specific conductance)

Well number	73	76	78	91	116
Location	NE of Four Mile Fork	NE of Four Mile Fork	NE of Four Mile Fork	Fredericksburg	NE of New Post
Depth (feet)	107	22	267	23	300
Water-bearing formation	Patuxent fm.	Terrace deposits	Patuxent fm.	Terrace deposits	Patuxent fm.
Date	March 17, 1954	June 21, 1954	June 21, 1954	July 21, 1955	April 1, 1944
Silica (SiO_2)	40	13	38	--	--
Iron (Fe)	a .34	a .03	a .51	a 0.06	--
Calcium (Ca)	1.8	2.5	22	--	--
Magnesium (Mg)	3.0	.9	8.2	--	--
Sodium (Na)	2.4	1.3	37	--	--
Potassium (K)	2.2	.7	4.2	--	--
Carbonate (CO_3)	0	0	0	0	--
Bicarbonate (HCO_3)	6	11	103	16	116
Sulfate (SO_4)	17	.8	12	--	8
Chloride (Cl)	1.8	2.4	58	3.4	5
Fluoride (F)	.1	.0	.2	.1	.2
Nitrate (NO_3)	.0	.2	.3	4.4	.4
Dissolved solids	84	22	232	b 38	--
Hardness as $CaCO_3$	17	10	88	18	51
Specific conductance (micromhos at 25°C)	57	25.3	378	61.4	--

a Fe in solution at time of collection.

b Calculated.

Table 11.--Chemical analyses of ground waters from wells in Spotsylvania County, Virginia--Continued

(Parts per million except specific conductance)

Well number	133	139	180	205	209
Location	SE of Massaponax	W of Massaponax	Chancellor	Spotsylvania Court House	NW of Spotsylvania Court House
Depth (feet)	215	222	13	300	36
Water-bearing formation	Patuxent fm.	Basement complex	Granite	Baltimore(?) gneiss	Granite
Date	June 24, 1955	October 11, 1955	June 23, 1955	June 24, 1955	June 24, 1955
Silica (SiO_2)	17	21	40	49	--
Iron (Fe)	a .34	a 13	a .19	a .10	--
Calcium (Ca)	14	13	6.4	10	--
Magnesium (Mg)	10	9.8	0	1.5	--
Sodium (Na)	176	13	17	7.3	--
Potassium (K)	10	3.7	.8	1.5	--
Carbonate (CO_3)	0	0	0	0	0
Bicarbonate (HCO_3)	246	111	30	59	120
Sulfate (SO_4)	82	1.2	6.2	.0	--
Chloride (Cl)	137	11	11	1.2	2.1
Fluoride (F)	1.8	.2	.0	.1	.0
Nitrate (NO_3)	.1	.1	9.9	.1	.5
Dissolved solids	579	130	146	102	b 105
Hardness as $CaCO_3$)	76	73	16	31	78
Specific conductance (Micromhos as 25°C)	997	207	127	97.9	170

a Fe in solution at time of collection.

b Calculated.

Table 11.--Chemical analyses of ground waters from wells in Spotsylvania County, Virginia--Continued

(Parts per million except specific conductance)

Well number	225	237	262	301	333
Location	NE of Parker	E of Logan	Brokenburg	W of Thornburg	ENE of Belmont
Depth (feet)	34	26	22	21	21
Water-bearing formation	Wissahickon fm., schist facies	Quantico slate	Wissahickon fm., schist facies	Terrace deposits	Peters Creek quartzite
Date	July 6, 1955	July 6, 1955	June 21, 1955	June 24, 1955	June 21, 1955
Silica (SiO_2)	--	6.6	--	--	--
Iron (Fe)	--	a .09	--	--	--
Calcium (Ca)	--	26	--	--	--
Magnesium (Mg)	--	3	--	--	--
Sodium (Na)	--	62	--	--	--
Potassium (K)	--	24	--	--	--
Carbonate (CO_3)	0	0	0	0	0
Bicarbonate (HCO_3)	11	104	6	72	36
Sulfate (SO_4)	--	23	--	--	--
Chloride (Cl)	3.3	77	42	2.7	1.1
Fluoride (F)	.0	.1	.0	.0	.0
Nitrate (NO_3)	9.8	20	14	1.9	3.9
Dissolved solids	34	310	b 115	b 80	44
Hardness as $CaCO_3$	12	77	5	57	29
Specific conductance (micromhos at 25°C)	55.2	557	185	129	71.3

a Fe in solution at time of collection.

Table 11.--Chemical analyses of ground waters from wells in Spotsylvania County, Virginia--Continued

(Parts per million except specific conductance)

Well number	343	358	360	393	400
Location	NNE of Belmont	SW of Belmont	SW of Belmont	SE of Lewiston	Partlow
Depth (feet)	31	30	51	27	39
Water-bearing formation	Wissahickon fm., schist facies	Granite	Granite	Wissahickon fm., granitized gneiss facies	Baltimore(?) gneiss
Date	June 21, 1955	Aug. 17, 1955	June 21, 1955	June 23, 1955	June 23, 1955
Silica (SiO_2)	44	--	44	14	7.1
Iron (Fe)	a .31	--	a .10	a .17	a .04
Calcium (Ca)	14	2.1	17	3.3	5.2
Magnesium (Mg)	9.0	1.3	2.0	2.3	.6
Sodium (Na)	15	--	12	8.4	2.4
Potassium (K)	.7	--	1.8	3.2	.3
Carbonate (CO_3)	0	0	0	0	0
Bicarbonate (HCO_3)	62	19	27	21	16
Sulfate (SO_4)	12	--	0	2.5	0
Chloride (Cl)	11	35	10	9.8	1.8
Fluoride (F)	.2	--	.0	.0	.0
Nitrate (NO_3)	32	--	56	7.6	7.0
Dissolved solids	191	--	190	76	36
Hardness as $CaCO_3$	72	11	51	18	15
Specific conductance (micromhos at 25°C)	227.	149	197	90.4	44.2

a Fe in solution at time of collection.

b Calculated.

Table 11.--Chemical analyses of ground waters from wells in Spotsylvania County, Virginia--Continued

(Parts per million except specific conductance)

Well number	416
Location	E of Mayre
Depth	23
Water-bearing formation	Baltimore(?) gneiss
Date	June 23, 1955
Silica (SiO_2)	--
Iron (Fe)	--
Calcium (Ca)	--
Magnesium (Mg)	--
Sodium (Na)	--
Potassium (K)	--
Carbonate (CO_3)	0
Bicarbonate (HCO_3)	21
Sulfate (SO_4)	--
Chloride (Cl)	6.7
Fluoride (F)	0
Nitrate (NO_3)	1.1
Dissolved solids b	40
Hardness as $CaCO_3$)	12
Specific conductance (micromhos at 25°C)	64.6

a Fe in solution at time of collection.

b Calculated.

Table 12.--Chemical analyses of ground waters from springs in Spotsylvania County, Virginia

(Parts per million except specific conductance)

Spring number	1	2	3	4	13	14
Location	Fredericksburg	Fredericksburg	Fredericksburg	Fredericksburg	SW of Belmont	SW of Belmont
Source	Sand and gravel	Sand and gravel	Sand and gravel	Sand and gravel	Granite	Granite
	1906	1906	1906	1905	June 21, 1955	Aug. 17, 1954
Silica (SiO_2)	--	--	--	--	--	--
Iron (Fe)	--	tr	--	.08	--	--
Calcium (Ca)	little	little	--	6.4	--	6.5
Magnesium (Mg)	--	--	--	--	--	2.0
Sodium (Na)	--	--	--	--	--	--
Potassium (K)	--	--	--	--	--	--
Carbonate (CO_3)	--	0	0	--	0	0
Bicarbonate (HCO_3)	17	30	23	29	27	26
Sulfate (SO_4)	--	30	--	--	--	--
Chloride (Cl)	9	27	35	--	3.2	4.2
Fluoride (F)	--	--	--	--	.0	--
Nitrate (NO_3)	--	--	--	--	2.0	--
Dissolved solids	--	--	--	157	a 39	--
Hardness as $CaCO_3$	10	--	18	24	15	24
Specific conductance (micromhos at 25°C)	--	--	--	--	62.4	96.8

tr Trace.

a Calculated.

Table 13.--Field determinations in parts per million showing ranges in hardness, alkalinity and chloride of ground waters in Spotsylvania County, Virginia

Terrace deposits

Well number	Hardness	Alkalinity	Chloride
123	25	10	25
125	33	20	25
303	66	90	10
305	49	110	18

Cretaceous rocks

Well number	Hardness	Alkalinity	Chloride
136	100	140	10

Basement complex

Well number	Hardness	Alkalinity	Ch[illegible]
137	25	250	1[illegible]
304	33	90	[illegible]
311	42	100	[illegible]

Baltimore(?) gneiss

Well number	Hardness	Alkalinity	Chloride
147	25	10	31
289	68	60	10
295	42	110	10
299	17	10	10
313	42	60	10
316	58	130	17
319	17	30	10
395	58	80	6

Baltimore(?) gneiss

Well number	Hardness	Alkalinity	Chloride
396	17	5	4
397	8	14	6
402	42	140	6
403	42	65	6
405	25	40	25
407	33	40	22
409	25	60	5

Petersburg granite

Well number	Hardness	Alkalinity	Chloride
162	8	30	[illegible]

Table 15. Field determinations in parts per million
chloride of ground waters in Spotsylvania County, Virginia--Continued

Peters Creek quartzite			
Well number	Hardness	Alkalinity	Chloride
185	35	50	18
188	58	150	8
239	42	50	25
251	8	10	6
252	8	10	15
253	33	70	5
254	25	15	11
257	8	10	8
259	33	90	12

Wissahickon formation, schist facies			
Well number	Hardness	Alkalinity	Chloride
170	10	30	10
182	58	110	25
191	8	70	10
221	41	100	8
242	33	60	8
243	42	50	10
249	50	150	6
262	33	80	10
264	25	60	5
267	58	150	6
271	50	100	15
273	33	100	7
274	25	60	4

Wissahickon formation, schist facies			
Well number	Hardness	Alkalinity	Chloride
275	174	470	22
276	33	110	18
335	133	13	57
336	91	30	8
342	8	5	8
343	58	93	13
347	100	55	27
348	257	80	93
352	249	40	160
355	25	48	14
365	25	90	6
367	66	18	41
368	66	135	8

chloride of ground waters in Spotsylvania County, Virginia--Continued

Wissahickon formation, granitized gneiss facies				Granite				Granite			
Well number	Hardness	Alkalinity	Chloride	Well number	Hardness	Alkalinity	Chloride	Well number	Hardness	Alkalinity	Chloride
291	33	50	7	209	83	220	6	277	100	300	8
322	42	70	7	212	8	50	10	282	25	60	4
383	17	25	8	213	33	70	10	286	33	80	10
384	33	90	8	218	40	120	10	361	25	47	12
388	83	140	18	230	83	50	70	372	249	570	18
389	50	130	8	231	100	110	100	374	33	5	16
								380	33	70	5

Spring number	Hardness	Alkalinity	Chloride	Source
7	17	40	10	Peters Creek quartzite
10	17	8	10	Baltimore(?) gneiss

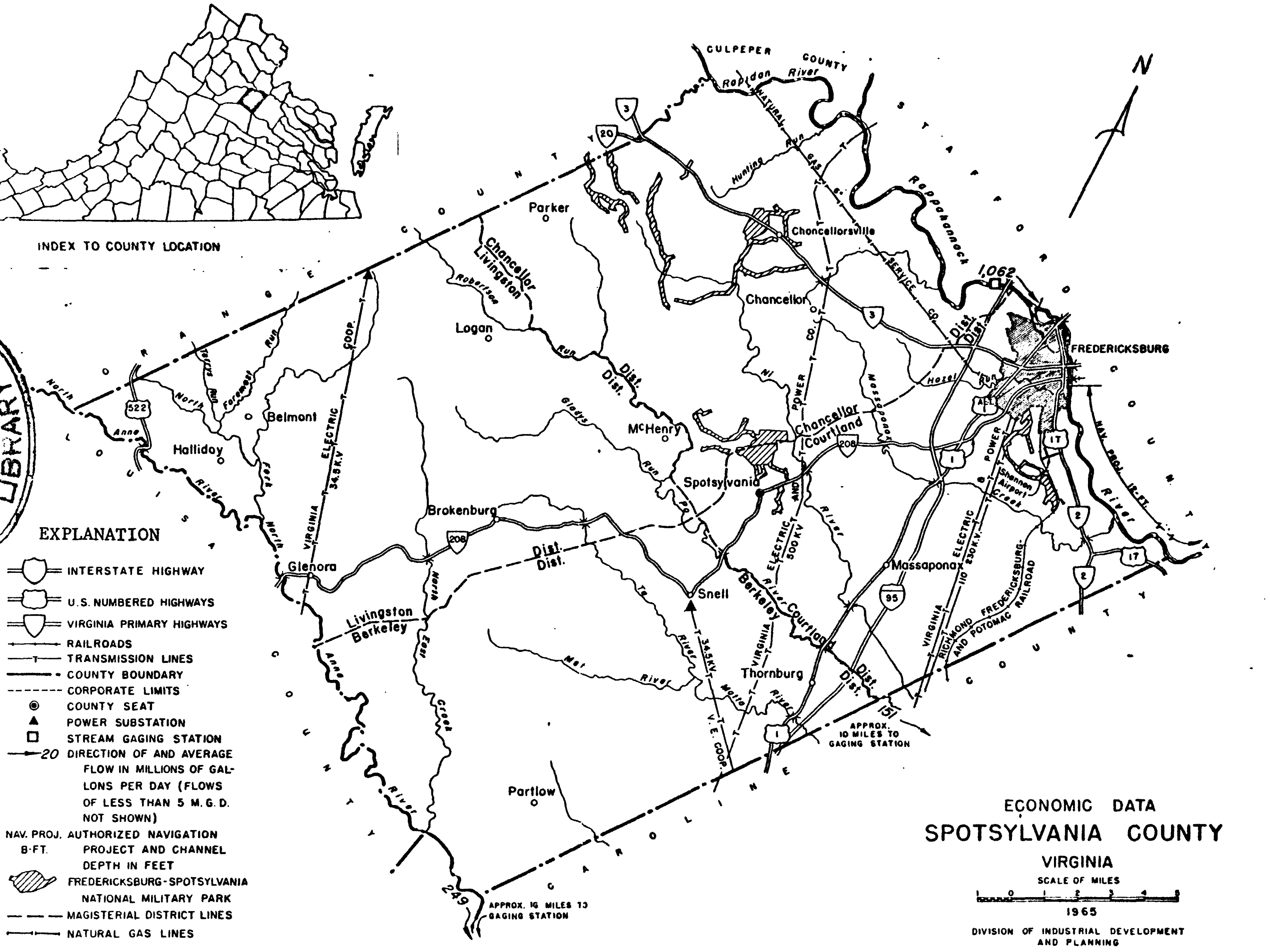

Figure 1.--Index map of Spotsylvania County, Virginia showing area of report.

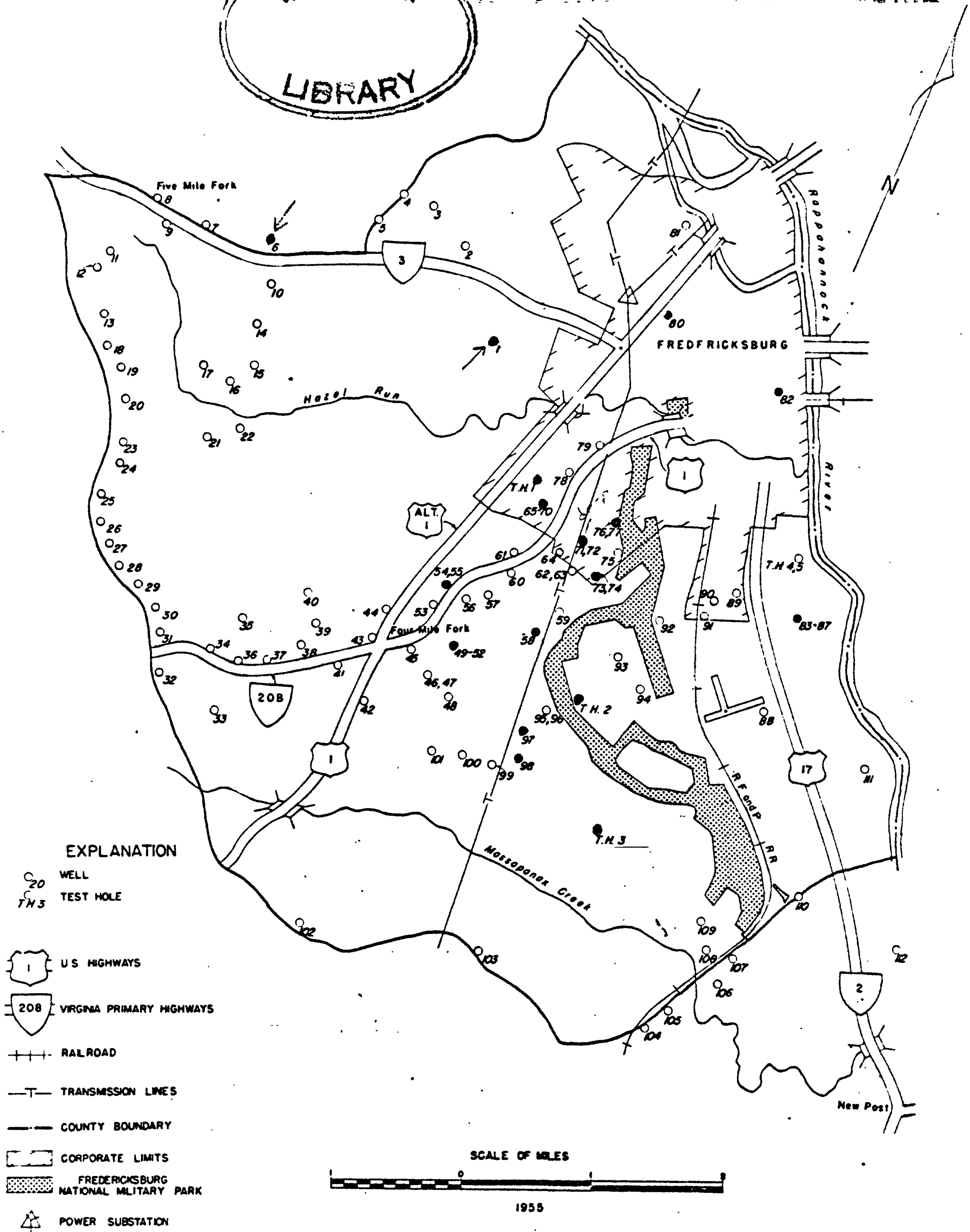

Figure 2.--Map showing location of wells (1-112) and test holes (1-5) in Spotsylvania County, Va.

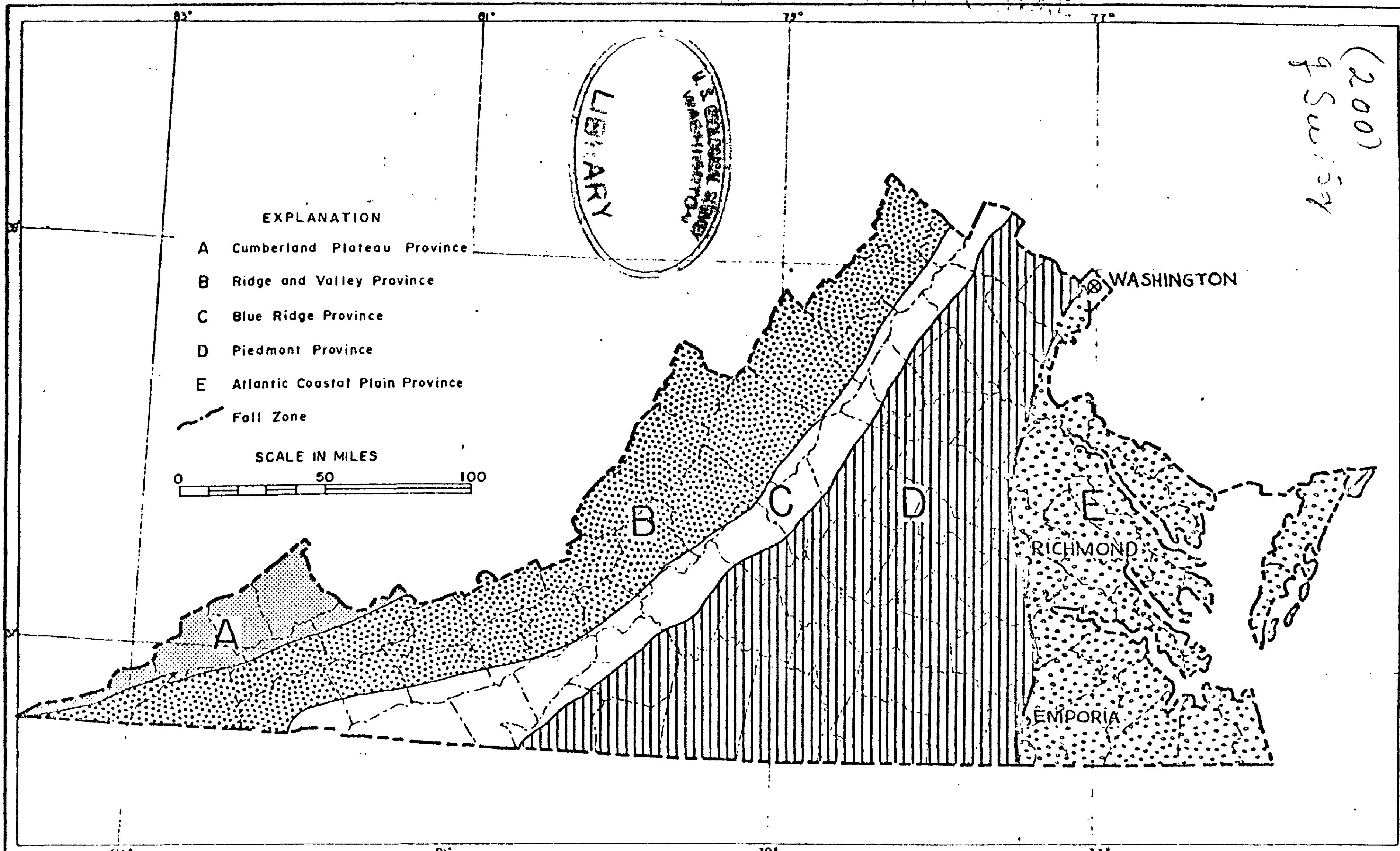

Figure 4.--Map of Virginia showing physiographic provinces. (after Fenneman, 1938)

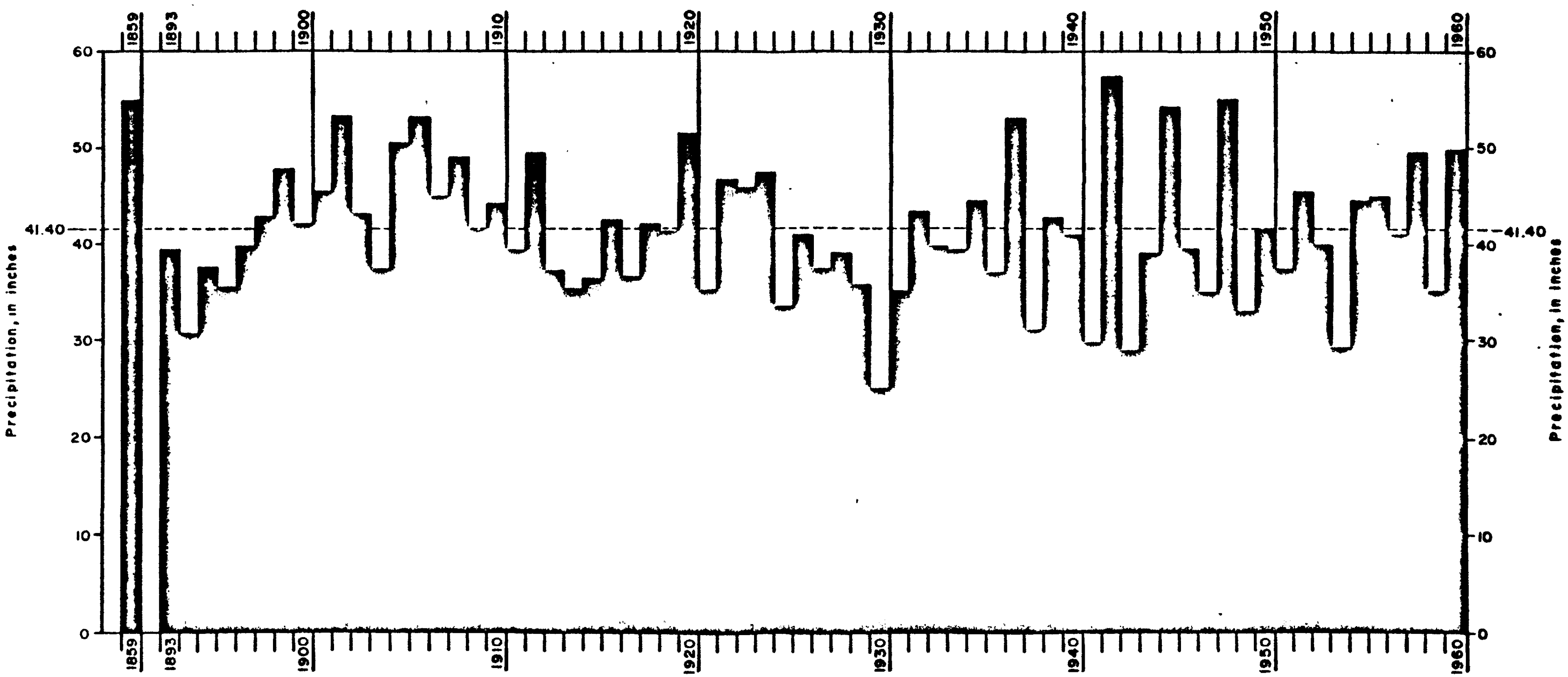

Figure 5.--Graph showing precipitation at Fredericksburg weather station for 68 years of record.

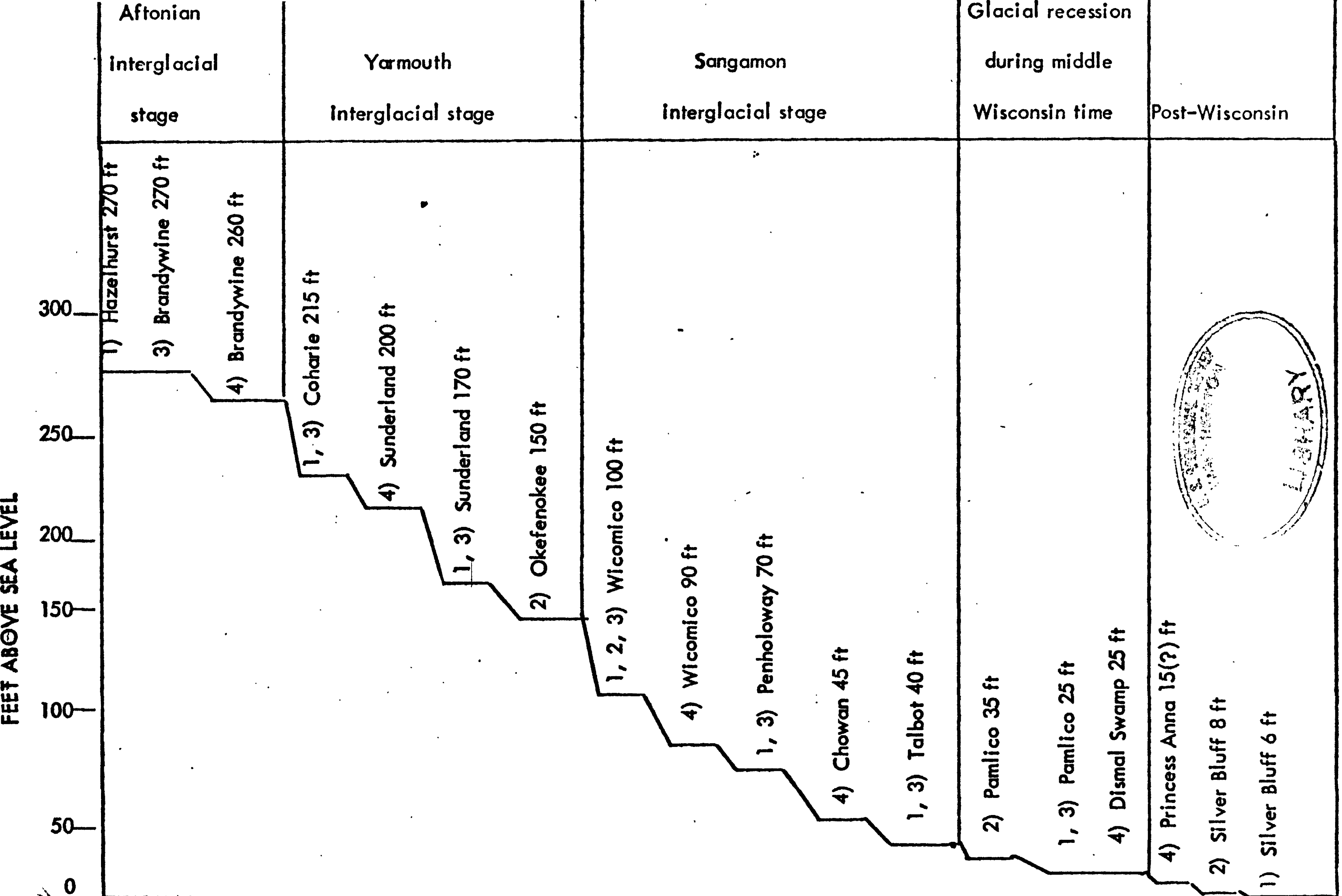

Figure 6 .--Diagrammatic profile of the Atlantic Coastal Plain terraces showing their relation to the interglacial stages. (Names and altitudes of the terraces are based upon interpretations by: 1) Cooke, 1954; 2) MacNeil, 1949; 3) Cooke, 1935; 4) Wentworth, 1930.)

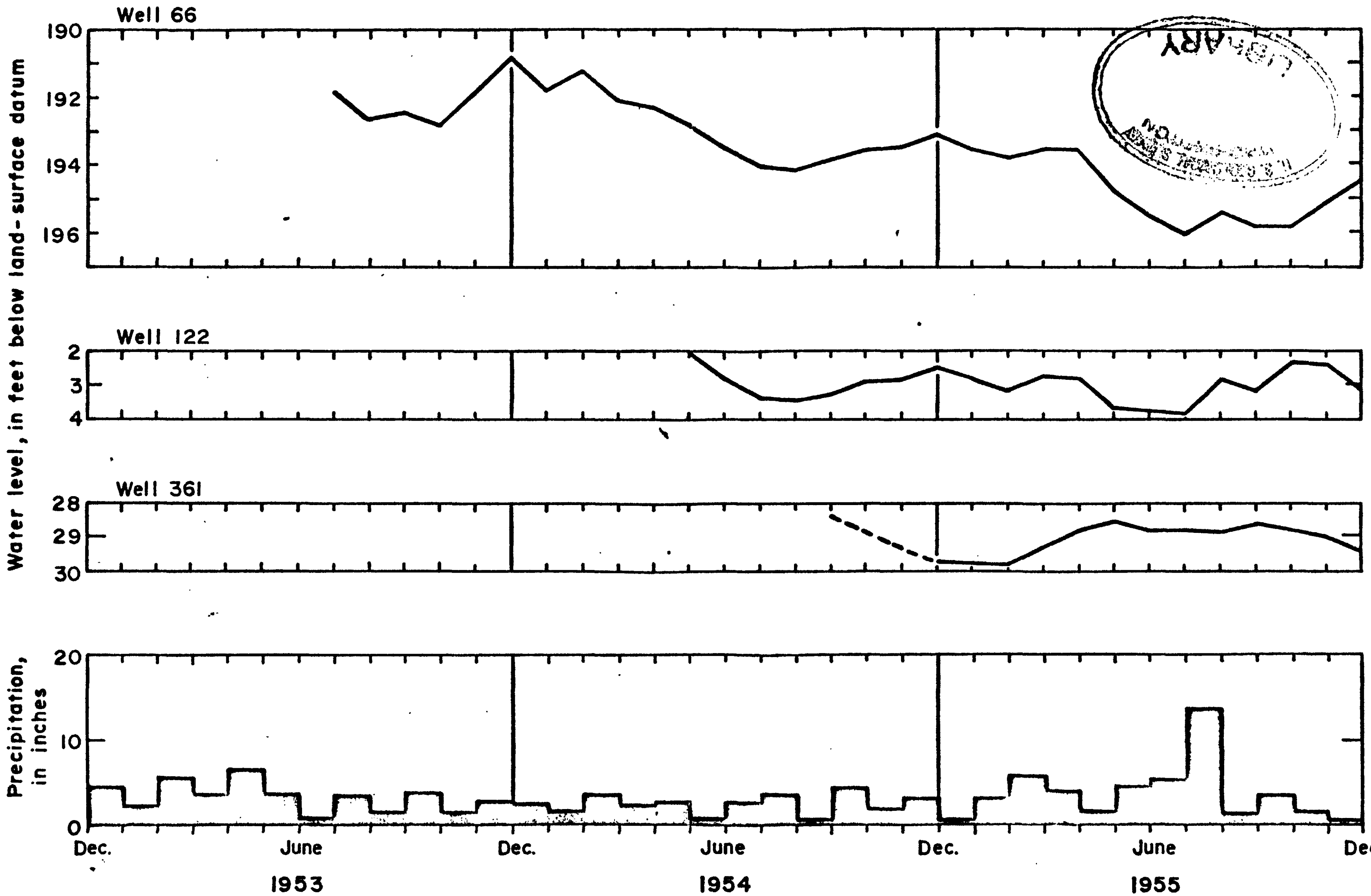

Figure 8.--Hydrographs of observation wells in Spotsylvania County and hydrograph of rainfall at Fredericksburg.

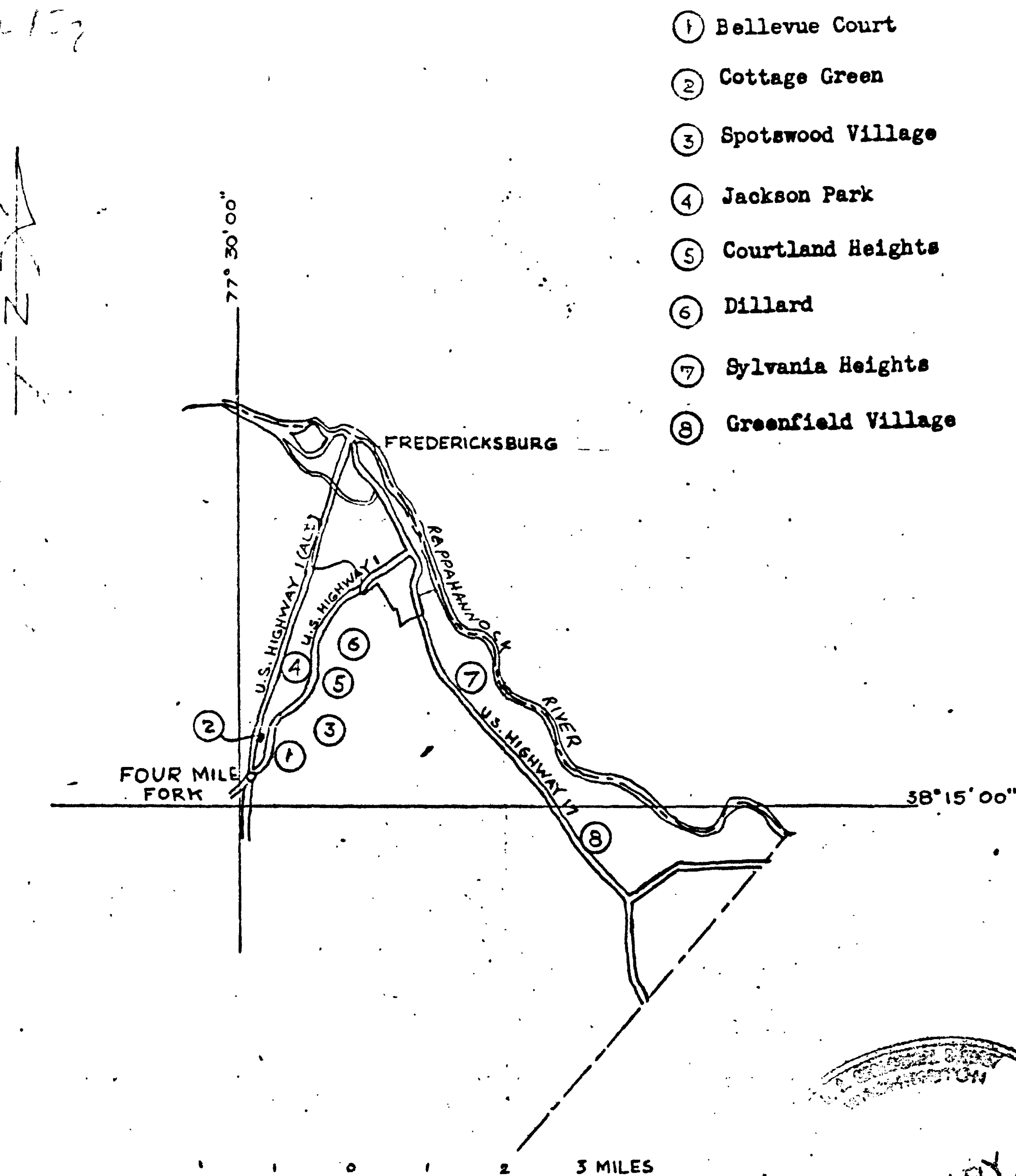

Figure 9.—Sketch map showing location of subdivisions using ground water in the vicinity of Fredericksburg, Va.

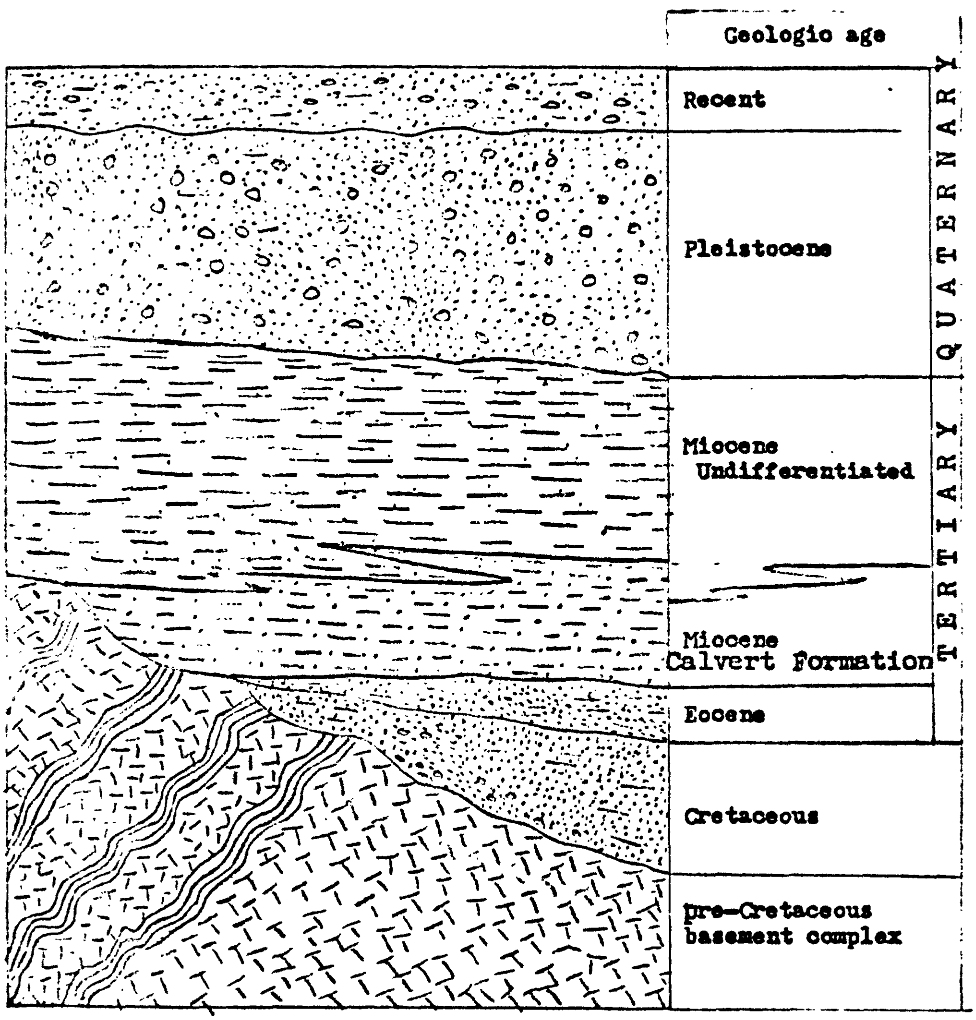

Figure 11.—Generalized geologic columnar section showing the rock units in the Coastal Plain of Spotsylvania County, Va.

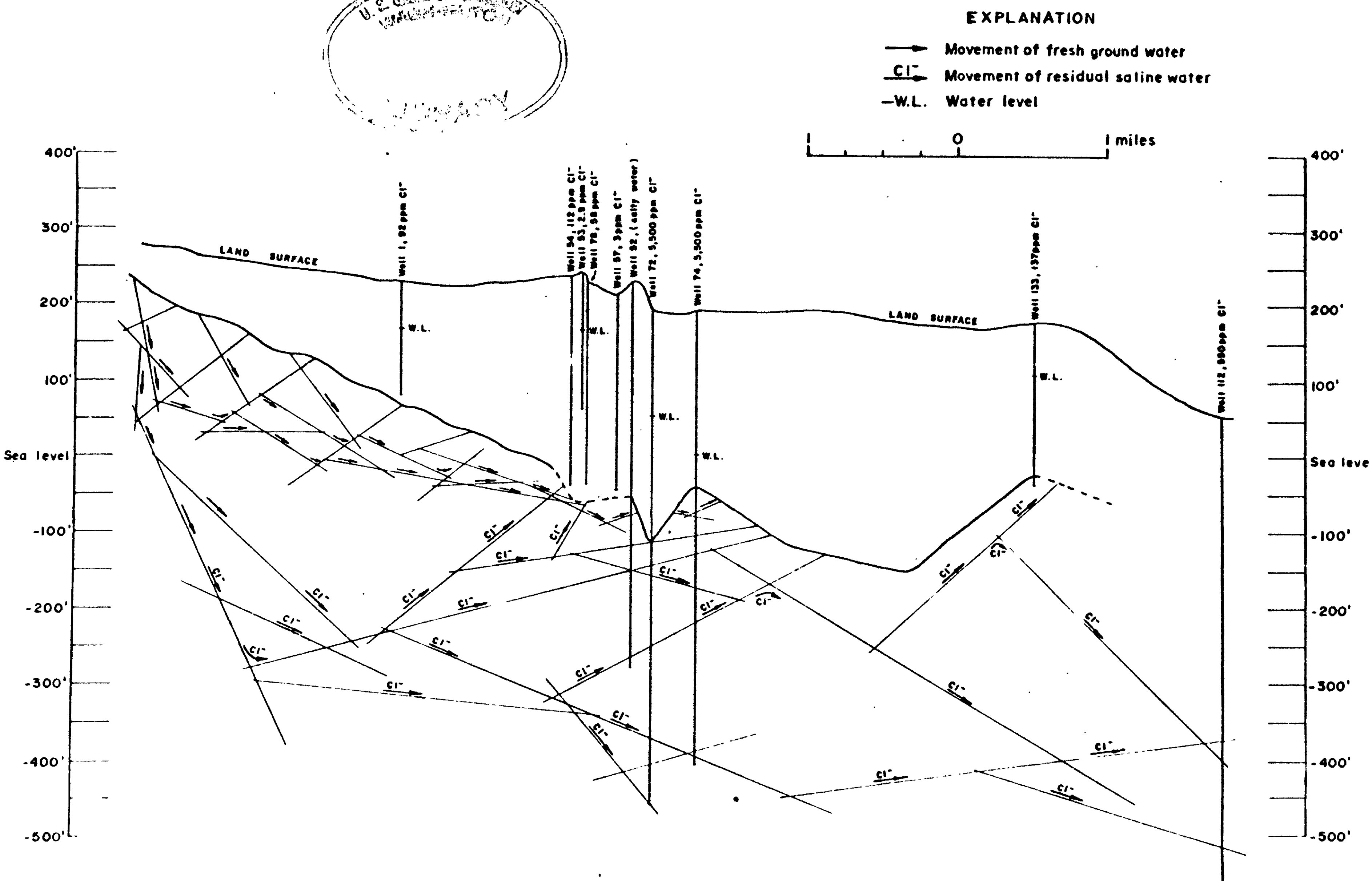

Figure 13.--Diagrammatic circulation system showing relation of fresh ground water to residual saline water in the basement complex rocks of the Fall Zone, Spotsylvania County, Va.

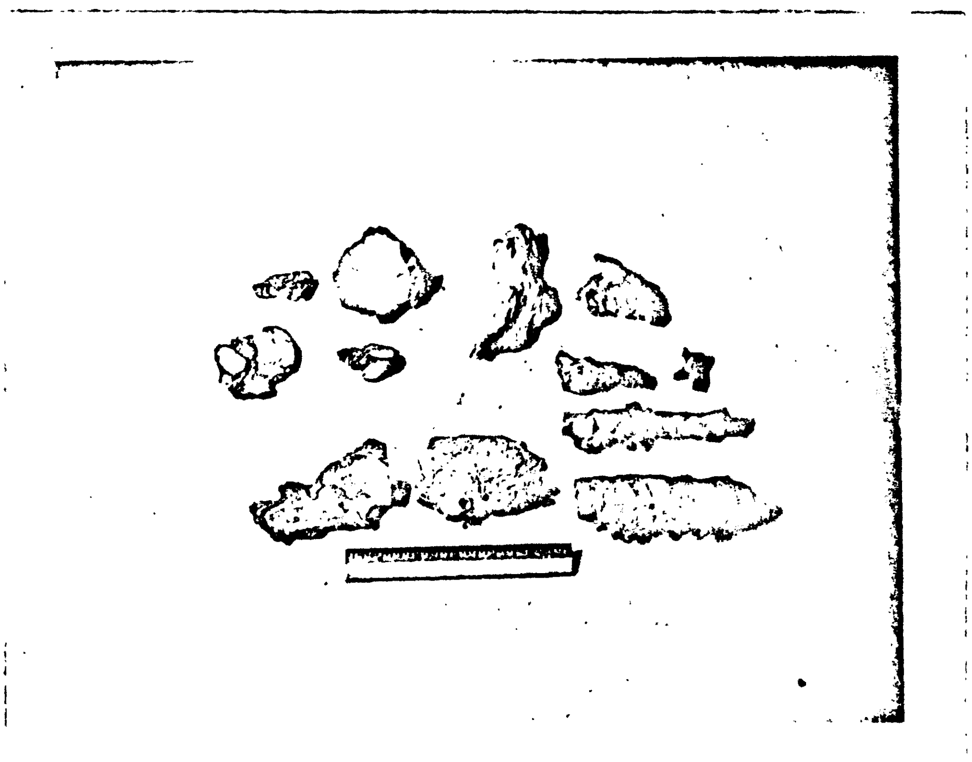

Figure 14.--Common types of ferruginous concretions occurring in the Patuxent Formation in the Vicinity of Fredericksburg, Va.