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Ground-Water Resources

OF THE

Southern Maryland Coastal Plain

by E. G. Otton

PREPARED IN COOPERATION WITH THE GEOLOGICAL SURVEY

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GROUND WATER RESOURCES OF THE SOUTHERN MARYLAND COASTAL PLAIN

BY

E. G. OTTON

Abstract

The Southern Maryland area, comprising the five counties of Anne Arundel, Prince Georges, Calvert, Charles, and St. Marys, includes more than 1,900 square miles, and had a population of about 375,000 in 1950. The area lies within the Coastal Plain physiographic province and has a maximum relief of only about 460 feet. Approximately 60 percent of Southern Maryland is farmland. Tobacco is the chief crop.

The sedimentary rocks of Southern Maryland consist of sand, gravel, clay, sandy clay, shell beds, and marl, which range in geologic age from Early Cretaceous to Recent. They are underlain by a "floor" or "basement" of hard crystalline rocks, chiefly pre-Cambrian. The crystalline-rock floor slopes gently southeast from the Fall Zone along the northwestern boundary of the Coastal Plain, or roughly along U. S. Route 1 between Baltimore and Washington, D. C. The sedimentary rocks thicken wedge-like southeastward to a thickness of more than 3,000 feet at Solomons Island at the mouth of the Patuxent River in Calvert County.

The Patuxent, Patapsco, Raritan, and Magothy formations of Cretaceous age are the most important aquifers in the area. The yields of wells tapping the sand and gravels in these formations are, in a few localities, greater than 1,000 gallons per minute. The Aquia greensand and the Nanjemoy formation of Eocene age are the chief aquifers in Calvert and St. Marys Counties, although the yields of wells are seldom more than 400 gallons a minute. Many of the dug wells supplying farms and rural residents yield 5 to 20 gallons a minute from the sands and gravels of Pliocene(?) and Pleistocene age. Local precipitation is the source of essentially all ground water in Southern Maryland. The water in dug and drilled wells occurs under both water-table and artesian conditions. Some ground water moves vertically between the essentially horizontal beds, indicating the existence of so-called "leaky" aquifers. In some of the tidewater areas flowing wells are obtained when the deeper artesian strata are penetrated. In a few localities the artesian head has declined so that wells which formerly flowed at the land surface must now be pumped.

Of the slightly more than 20 million gallons of ground water pumped, or discharged, daily during 1951 in Southern Maryland, about 11½ million gallons

(54 percent) was used for domestic and rural consumption, about 5⅓ million gallons (24 percent) for military and institutional purposes, and the remainder, 4½ million gallons (22 percent) was for public-supply and commercial purposes. The Patapsco and Raritan formations furnished about 6¾ million gallons (more than 30 percent) and the Aquia greensand, the next important aquifer, furnished a little less than 4 million gallons (about 18 percent). The remainder, about 11 million gallons a day, was withdrawn chiefly from the Patuxent, Magothy, and Nanjemoy formations, and from deposits of Pliocene(?) and Pleistocene age.

Chemical analyses of about 275 samples of water from the major aquifers show the quality of the ground water is satisfactory for most uses. In a few localities the iron content is excessive (as much as 30 parts per million), and treatment for iron removal is necessary even for domestic use. Some of the water in eastern Anne Arundel County and northern Prince Georges County contains free acid and has a low pH. The hardness of the water from most aquifers is below 100 parts per million. The chloride and nitrate contents of uncontaminated water are commonly below 25 parts per million. The relation of the chemical character of the water to the geology and hydrology of the area is discussed. Base exchange, or natural water softening, takes place in some of the water-bearing strata.

On the basis of hydrologic and geologic data from pumping tests, well records, sample studies, and piezometric and geologic maps, the available ground-water supplies in four subareas of the Southern Maryland peninsula were estimated. The estimates indicate the untapped ground-water supplies are extensive and constitute one of the most valuable natural resources of the area.

The report contains records of representative wells, drillers' logs, and sample-study logs of key wells.

Introduction

Location of the Area

The Southern Maryland area, an irregularly shaped peninsula of 1,944 square miles, is bounded on the south and west by the Potomac River; on the northwest by the District of Columbia and by Howard and Montgomery Counties, on the north by the Patapsco River and small parts of Baltimore City and Baltimore County, and on the east by the Chesapeake Bay along which it extends for 90 miles (fig. 1). It lies between parallels 38°02′ and 39°14′ north latitude, and meridians 76°18′ and 77°17′ west longitude.

Purpose and Scope of the Report

During the years 1944 to 1952, the ground-water resources of the five counties of Southern Maryland, Anne Arundel, Calvert, Prince Georges, St. Marys, and Charles, were investigated under a cooperative agreement between the United

FIG. 1. Map of Maryland showing physiographic provinces and location of the Southern Maryland area

States Geological Survey and the Maryland Department of Geology, Mines and Water Resources. As the work in the successive counties was completed, the results were published by the Maryland Department of Geology, Mines and Water Resources in five county reports. Since Southern Maryland is a geologic and hydrologic unit, the purpose of this report is to integrate the five separate county reports into a comprehensive interpretation of the geology and hydrology of the whole area.

The report was prepared under the general supervision of A. N. Sayre, Chief of the Ground Water Branch of the United States Geological Survey, and under the immediate supervision of R. R. Bennett, District Geologist in charge of the ground-water investigations in Maryland.

A county coordinate system is used to designate and locate the wells. Each county is divided into 5-minute quadrangles of latitude and longitude designated from north to south in upper-case letters and from west to east in lower-case letters. The quadrangle designation is preceded by an abbreviation of the county name. The wells in a quadrangle are numbered in the order in which they were inventoried. Thus well Cal-Bc 2 is the second well inventoried in quadrangle Bc in Calvert County.

PREVIOUS INVESTIGATIONS AND ACKNOWLEDGMENTS

Much of the basic data in this report is from the five published reports describing the ground-water conditions in the Southern Maryland counties. These reports contain information on the yields, depths, locations, and static water levels of hundreds of wells in the area. The reports are Charles County in the county report series by Overbeck (1948); Bulletin 5, Anne Arundel County by Brookhart (1949); Bulletin 8, Calvert County by Overbeck (1951); Bulletin 10, Prince Georges County by Gerald Meyer (1952); and Bulletin 11, St. Marys County by Ferguson (1953). Substantial contributions were analyses of pump test data by Rex R. Meyer and the foraminiferal studies (Table 35) by Glenn G. Collins which formed the basis for the classification of the marine formations. The discussion and analysis of water-level fluctuations is largely the work of Claire A. Richardson. Substantial additional data and much help was received from these members of the cooperative ground-water staff in the preparation of this report.

The writer is greatly indebted to numerous residents of the area who supplied information concerning privately owned ground-water supplies and to personnel of industrial plants and military installations who assisted in the collection of ground-water data.

W. O. Monroe, Chief Engineer, provided pumpage data and records of wells drilled for the Anne Arundel County Sanitary Commission. George L. Hall, Chief Engineer of the Maryland State Department of Health, supplied chemical analyses of water and other information on public ground-water

supplies in Southern Maryland. Whitman, Requardt and Associates supplied copies of engineering reports dealing with the ground-water supplies at Annapolis and at the Patuxent Naval Air Station. Allen Lee, Engineer, Maryland State Roads Commission, furnished elevations of benchmarks on road rights-of-way.

Acknowledgment is made of the use of an unpublished report by Whitman, Requardt and Associates (consulting engineers) which provides considerable data on the treatment, source, and distribution of water at Annapolis (1946).

In 1948 the J. E. Greiner Company of Baltimore prepared an engineering report on the proposed (now completed) Chesapeake Bay Bridge which contains a detailed geologic section across the Bay at the site of the bridge. The section reveals the complexity of the sedimentary deposits in the vicinity of the Bay and was useful in interpreting the ground-water conditions in the area.

Julia A. Gardner of the U. S. Geological Survey, named and determined the geologic ages of fossil specimens.

Considerable data were obtained from an unpublished report (Fiedler and Jacob, 1939) describing the hydrologic conditions at the Indian Head Naval Powder Factory in Charles County which contains the results and analyses of extensive pumping tests of wells at the powder factory.

Thanks are due Richard C. Erd of the Geologic Division of the U. S. Geological Survey for counting and identifying the heavy minerals in the well cuttings.

Particular thanks are due the well drillers who collected and submitted the sample cuttings and who supplied data on the construction, depths, and yields of wells.

Geography

PHYSIOGRAPHY

Southern Maryland lies within the Coastal Plain physiographic province, one of five physiographic provinces into which the State of Maryland has been divided (fig. 1). These five provinces are, from west to east, the Appalachian Plateaus, the Valley and Ridge province, the Blue Ridge, the Piedmont Plateau, and the Coastal Plain.

The Piedmont Plateau is characterized by moderately dissected to rolling topography. The Piedmont surface has been carved chiefly into ancient crystalline rocks, which are more resistant to erosion than the softer sedimentary materials of the Coastal Plain. The boundary between the Piedmont and the Coastal Plain is known as the "Fall Line" or, more properly, the "Fall Zone." This zone, a few miles in width, is characterized by an increase in the gradient of streams crossing it, narrow, steep-walled valleys, and by rapids and waterfalls in the streams. The Fall Zone passes through and near the cities of Baltimore and Washington, D. C., and follows approximately the route of U. S. Highway 1 connecting those cities.

The Coastal Plain province is an area of less relief than the Piedmont province. Swampy areas are common adjacent to the major waterways, and flat upland plains exist in some of the interstream areas, but, generally, the topography is gently rolling to undulating. The streams are characterized by low gradients and few, if any, waterfalls and rapids. Geologically, the two provinces are dissimilar, the Coastal Plain province consisting of softer sedimentary materials derived from the erosion and decomposition of the older, harder rocks of the Piedmont province to the west. The highest point in the area is in northern Prince Georges County near the Montgomery County line at an elevation of about 460 feet above sea level.

A prominent topographic feature in the area is a group of hills in northern Anne Arundel County near the towns of Elvaton and Lipins Corner. These hills are erosional remnants of indurated strata in the outcropping Raritan formation (Upper Cretaceous). Another prominent topographic feature is a ridge-like hill near the District of Columbia-Prince Georges County line. Part of this ridge, known as Good Hope Hill, attains an elevation of about 290 feet above sea level. Its height is conspicuous because it is bordered on the north and west by the valleys of the Anacostia and Potomac Rivers where the Coastal Plain strata are deeply dissected.

The numerous estuaries and river valleys of Southern Maryland are the most prominent physiographic features. The estuaries are characterized by irregular shorelines, wide mouths, and tidal marshes; in many places they are shallow and not easily navigable. Water depths of 10 feet or less are common in most of the estuaries.

CLIMATE

Southern Maryland lies in the humid temperate climatic belt of the eastern part of the United States. It has warm summers and wet, but not extremely cold, winters. Weather-reporting stations have been maintained in the area for a number of years, and the records of several stations are sufficiently long to give a reliable picture of the climatic conditions. Table 1 gives the stations, the lengths of record, the average annual precipitation and the average annual temperature.

The precipitation is fairly uniformly distributed throughout the year. During the driest month, November, the precipitation averages about 60 percent of that during the wettest month, July (Table 2). Anne Arundel and Prince Georges Counties appear to have slightly more rainfall than the other three counties. Central Prince Georges County has about 120 days a year during which 0.01 inch or more of precipitation occurs (Weeks, 1939, p. 20). The rest of Southern Maryland has 100 to 120 days during which 0.01 inch or more of precipitation occurs. In general, 15 to 20 inches of snowfall occurs during the winter season throughout Southern Maryland.

The record of precipitation at the Cheltenham station, covering the period from 1902 through 1951, shows that the year 1930 was the driest. The total precipitation that year amounted to 22.58 inches or about half the mean annual

TABLE 1

Weather-reporting stations in Southern Maryland and annual precipitation and temperature

Station	County	Years of record	Average annual precipitation (inches)	Average annual temperature (°F)
U. S. Naval Academy	Anne Arundel	86	44.04	55.6
Solomons Island	Calvert	60	38.44	57.3
La Plata	Charles	37	43.86	56.2
Cheltenham	Prince Georges	51	44.06	55.0
College Park	do	65	41.79	54.7
Charlotte Hall	St. Marys	30	41.44	55.7
Leonardtown	do	17	39.97	56.2

TABLE 2

Mean monthly precipitation, in inches, in Southern Maryland

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
U. S. Naval Academy	3.37	3.21	3.70	4.07	4.04	4.03	4.41	4.52	3.79	3.16	2.82	3.34
Charlotte Hall	3.30	3.10	3.31	3.61	3.67	3.56	5.19	3.76	3.03	3.32	2.63	2.96
Cheltenham	3.72	2.77	3.66	3.93	3.67	4.23	4.51	4.93	3.60	3.04	2.78	3.22
College Park	3.31	3.02	3.53	3.50	3.96	3.89	4.16	4.34	3.43	2.89	2.73	3.03
La Plata	3.84	—	3.30	3.88	3.88	4.27	4.62	4.59	3.72	3.10	2.86	2.91
Leonardtown	3.06	2.92	4.07	3.06	3.23	3.67	4.64	4.10	2.32	3.21	2.84	2.85
Solomons Island	3.10	2.85	3.29	3.17	3.24	3.39	4.62	4.04	2.97	2.70	2.32	2.75
All stations	3.38	2.97	3.55	3.63	3.67	3.86	4.59	4.32	3.26	3.06	2.71	3.00

From Annual Summary Climatological Data, U. S. Weather Bureau, 1951.

precipitation during the 50-year period of record. At Cheltenham only 12 years have an annual precipitation of less than 40 inches.

Records of temperature at the seven stations in Southern Maryland show a range of mean annual temperatures from 54.7°F at College Park to 57.3°F at Solomons Island, or a range of about 3°F from the northern part of the area to the southern part. The highest temperature recorded at the weather station at La Plata was on July 20, 1930, when 108°F was measured. The lowest temperature recorded at this station was on January 12, 1912, when −12°F was measured (Brancato, 1948, p. 220).

The length of the growing season, or the period from the last killing frost in the spring to the first killing frost in the fall, ranges from a mean of 210 days in the vicinity of Point Lookout to 180 days in the Laurel-Bowie area (Weeks, 1939, p. 19). Records of the weather station at La Plata show that the longest growing season was 237 days and the shortest was 165 days; the mean length of the growing season at this station is 189 days.

Records at the La Plata station also show that the mean annual number of clear days is 164 and of cloudy days is 103. The sun shines about 60 percent of the possible time from May through October. The cloudiest period of the year is during December and January when the sun shines only about 46 percent of the possible time (Brancato, 1948, p. 227).

The chief geographical factor affecting the climate of Southern Maryland are the two major water bodies adjoining the area, the Chesapeake Bay and the Potomac River. They modify somewhat the extremes of weather conditions in their vicinity. Maps showing the position of annual isotherms (lines of equal mean annual temperature) indicate that the average annual temperature near Baltimore is about the same as that at La Plata and Prince Frederick, which are roughly 50 miles south of Baltimore. For example, the 56° isotherm trends easterly through La Plata and Prince Frederick and then abruptly bends northward and crosses the Chesapeake Bay near the Patapsco River, indicating an anomaly in a northerly direction about 40 miles long (Weeks, 1939, p. 9).

POPULATION, TRANSPORTATION, RESOURCES, AND INDUSTRY

Southern Maryland was largely rural prior to 1940. During the decade 1940 to 1950, the fringe areas of Anne Arundel and Prince Georges Counties near Baltimore and Washington, D. C., respectively, increased considerably in population. During this decade the population of Charles and St. Marys Counties also increased markedly. The population growth of Southern Maryland is due in part to increased economic opportunities within the area and in part to a migration from the cities of Baltimore and Washington. The population by counties (1950 census) and the percentage of increase during the preceding decade is shown in Table 3.

The population of the major towns in Southern Maryland (1950 census) is shown in Table 4.

Southern Maryland was settled during colonial times largely because of the excellent natural harbors and availability of water transportation. Towns such as Port Tobacco, Lower Marlboro, Annapolis, and St. Marys City were for many years thriving seaport and harbor towns. With the exception of Annapolis, which has continued to thrive, the decline in water transportation and the growth of the road system during the past 50 years have caused marked changes in the growth and prosperity of the towns of Southern Maryland. The development of the system of modern paved roads has been chiefly responsible for shifting the centers of commerce from the older seaport communities to the inland towns. Among the major highways in Southern Maryland are U. S. Route 301, linking northern Virginia with Washington, D. C. and Baltimore; Maryland Route 2, which extends southward from Baltimore to Solomons

TABLE 3

Population by counties in Southern Maryland

County	Population 1950	Percent increase (1940–50)
Anne Arundel	117,392	71.7
Calvert	12,100	15.4
Charles	23,415	32.9
Prince Georges	194,182	117.0
St. Marys	29,111	99.0
Total	376,200	67.2

TABLE 4

Population of towns in Southern Maryland

Town or city	Population
Annapolis	10,047
Bowie	860
Capitol Heights	2,729
Chesapeake Beach	504
College Park	11,170
Colmar Manor	1,732
Glen Burnie	12,000[a]
Hyattsville	12,308
La Plata	708
Laurel	4,482
Leonardtown	1,017
North Beach	314
Odenton	1,059
Severna Park-Round Bay	1,095
Solomons	270
Upper Marlboro	702

[a] Unincorporated; population estimated from sources other than the Census Bureau.

Island; Maryland Route 5, which links the District of Columbia with Waldorf in Charles County and with Leonardtown in St. Marys County; and U. S. Route 1, which connects Baltimore with Washington, D. C., and passes across northern Prince Georges County. In addition to these roads, superhighways are now under construction which will provide quick transportation between Washington and Baltimore, and between Washington and Annapolis and the Chesapeake Bay Bridge.

Rail facilities are generally lacking in Southern Maryland, although the Baltimore and Ohio Railroad and the Pennsylvania Railroad both have main tracks passing through the northern part of the area connecting Baltimore and Washington. The Baltimore and Annapolis Railroad in Anne Arundel County connecting the two cities has recently abandoned passenger service. The only other rail facilities in the area are a single-track line extending south from the Pennsylvania Railroad at Bowie to Popes Creek in Charles County and to the Patuxent River Naval Air Station in St. Marys County.

Farming continues to be the chief occupation of the inhabitants of Southern

TABLE 5

Mineral production of Southern Maryland in 1950

County	Quantity (short tons)	Value
Sand and gravel		
Prince Georges	1,060,172	$1,275,493
Anne Arundel	557,587	724,293
Total	1,617,759	$1,999,786
Clay, all types		
Prince Georges	140,395	$ 103,888
Anne Arundel	1,451	8,865
Total	141,846	$ 112,753
Agricultural limestone (oyster shells)		
Anne Arundel	50	$ 400

Maryland, although some industrialization has taken place near Baltimore and Washington. Many hundreds of persons in the area are employed at the various military and naval installations such as the Patuxent River Naval Air Station, the Indian Head Naval Powder Factory, the U. S. Naval Academy at Annapolis, and Fort George G. Meade. The many beaches and shore areas have been responsible for rapid and continuous growth of the resort industry. Fishing and oystering are now minor economic activities, although a century ago these industries ranked second to agriculture in importance.

In Southern Maryland during 1950 about 60 percent of the land area was under cultivation. Tobacco is the most important crop raised, although some corn, hay, and small grains are grown. The total value of all crops sold in 1949 was nearly 20 million dollars.

The major industrial plants are in northern Anne Arundel and western Prince Georges Counties. Chemical and fertilizer plants, as well as clay and brick plants, are located adjacent to Baltimore City along the Patapsco River. A large plant at Odenton manufactures plastic products. Other clay and brick plants are in the Laurel-Hyattsville area of Prince Georges County, and one plant in that locality manufactures mineral pigments.

Sand and gravel are an important and extensively utilized mineral resource of Southern Maryland. The value of the 1950 production amounted to about 2 million dollars. Although minable clay deposits occur in northern Anne Arundel and Prince Georges Counties, they are at present largely undeveloped. Extensive deposits of diatomaceous earth are at or near the surface in some localities in southern Prince Georges and northern Calvert Counties, but these beds have not been commercially developed to any extent. Greensand is abundant at many places in Southern Maryland, but the market for this material has not been sufficient to stimulate its production.

Table 5 lists the mineral production, by counties, of Southern Maryland in 1950.

General Geology and Hydrology

The rocks in Southern Maryland consist chiefly of sedimentary formations composed of clay, sand, marl, gravel, and diatomaceous earth ranging in geologic age from Early Cretaceous to Recent. They form a wedge-shaped mass which thickens to the southeast and pinches out to the west and northwest. Underlying these deposits are much older and harder crystalline rocks, chiefly of pre-Cambrian age. The position and extent of the rocks underlying Southern Maryland are shown in a sectional diagram compiled from drillers' logs and well cuttings (Pl. 1). The crystalline rocks are exposed at the surface in the Piedmont Plateau immediately to the west and northwest of the Southern Maryland area and along a few stream valleys in northern Prince Georges County. The age of the crystalline rocks may range from pre-Cambrian to Ordovician, but for convenience they are considered in this report to be pre-Cambrian.

During most of the Paleozoic era and much of Triassic and Jurassic time Southern Maryland is believed to have been above sea level and undergoing erosion, so that the crystalline-rock surface was reduced to a peneplain of low or moderate relief (Stephenson and others, 1935, p. 5).

At the beginning of the Cretaceous period the Southern Maryland area (and adjacent parts of the Atlantic Coast) was tilted or downwarped eastward and the shoreline of the Atlantic Ocean stood somewhere west of the present shoreline. Possibly this downwarping of the crystalline-rock mass was accompanied by faulting along the present border of the Cretaceous deposits at the Fall Zone. The gradient of the eastward-draining streams was sufficient to carry sand, silt, clay, and organic debris and deposit these materials between the Atlantic Ocean to the east and the highlands to the west. The nature of the continental deposits suggests that they were carried by low-gradient streams whose channels meandered back and forth across a land surface of gentle relief. The sediments commonly contain plant fragments and occasionally the remains of dinosaurs or other reptiles, but in many places fossil remains are scarce or lacking. The deposits are characterized by the presence of lenticular bodies of sand, which may be very coarse and gravelly or fine and clayey, that grade into varicolored clays and sandy clays. Nodules and bands of ironstone are common, and in some places the ironstone layers attain a thickness of more than 5 feet. An essentially deltaic, flood-plain environment is believed to have existed during much of the time when the Patuxent, Arundel, Patapsco, and Raritan formations were being deposited in Southern Maryland.

The logs of a few deep wells that completely penetrate these continental deposits show that their thickness increases from about 950 feet in the vicinity of Glenn Dale in Prince Georges County to approximately 3,700 feet near Salisbury in Wicomico County (Anderson and others, 1948).

After the deposition of the Raritan formation, the sea advanced westward, so that during the time interval represented by the deposition of the Magothy formation, the sedimentary environment changed and tongues of estuarine deposits mingled with the fluvial deposits. Beds of irregularly distributed sand and clay were deposited under conditions of sedimentation probably not greatly different from those at the mouth of the Mississippi River today. Some marine shells have been found in the Magothy formation, and the carbonaceous remains of plants are common. By the end of Cretaceous time marine waters probably covered the entire Southern Maryland area, and the sands and muds washed into the Late Cretaceous sea constitute the Matawan and Monmouth formations. The marine sediments deposited in the advancing Cretaceous sea are the oldest in Maryland in which the mineral glauconite is abundant.

Conditions of sedimentation similar to those of Late Cretaceous time existed during most of Paleocene and Eocene time, as glauconite is also a common constituent of the Paleocene and Eocene formations. Their relatively high glauconite content indicates that the Southern Maryland area was covered by shallow seas which received only small amounts of coarse terrigenous material from the north and west. The fauna of Paleocene and Eocene time, however, do show differences from the Cretaceous forms. The rock material and the Foraminifera show that during late Eocene (Jackson) time the waters of the sea were sufficiently quiet and free from land-derived detritus that thin layers of limestone formed in the sea bottom. Locally the "shell" or limestone beds attain a thickness of 3 feet or more.

Sedimentary rocks of Oligocene and early Miocene age are not known to be present in Maryland, and the time interval is believed to be represented in Maryland by a period of retreat of the sea accompanied by erosion of the Eocene sediments (Stephenson and others, 1935, p. 10). During middle Miocene time the seas once again flooded the Coastal Plain region from New Jersey southward to North Carolina. Deposits of the Miocene epoch have been found on the crystalline rocks of the Piedmont Plateau in northern Virginia about 90 miles west of the present Atlantic Coast. They consist of sand, clay, sandy clay, and beds of diatomaceous earth. They attain a thickness of about 350 feet in the southern tip of St. Marys County and thicken eastward to more than 1,000 feet near Salisbury in Wicomico County (Anderson and others, 1948, p. 98).

At the close of Miocene time the Miocene sediments along the Atlantic Coast were raised above sea level, and during Pliocene(?) and early Pleistocene time the rivers draining the highlands to the west deposited fan-shaped sheets of sand, gravel, and clay on the surface of the gently undulating sediments. The Potomac, Patuxent, Patapsco, and Susquehanna Rivers probably transported much of this alluvial material to the Southern Maryland area. The sediments carried southeastward by the various streams formed broad coalescing deltas, which eventually merged into a gently sloping veneer of deposits completely covering the Miocene sediments. During much of Pliocene time the shoreline is believed to have lain to the east and south of Southern Maryland. However, marine fossils of Pliocene age have been reported south of the James River in Virginia, indicating that tongues of the Pliocene sea spread to a point not far south of Southern Maryland. The stratigraphic break recorded in the sediments between the Pliocene and Pleistocene series in the northern Atlantic Coastal Plain is not conspicuous. In general, these sands and gravels are devoid of remains of life, except for a few plant fossils.

The Pleistocene epoch was characterized by at least four major stages of glaciation, of which no direct record is found in the rocks of Maryland. The glacial and interglacial stages of the Pleistocene were characterized by world-wide changes in sea level, the lowering of the seas having been caused by the withdrawal of water from the oceans to be locked up in the great continental ice sheets. The successive fall and rise of the sea level during this period permitted the erosion and filling of the stream valleys in the Chesapeake Bay area. Thus, the Pleistocene sedimentary rocks in and along the tributaries of the major streams in the Southern Maryland area have a complex geologic history. Although the extent of this fall and rise is inconclusive and open to discussion, it is at least 300 feet or more. The youngest deposits in Southern Maryland are those laid down during the Recent epoch or during the time since the retreat of the last continental ice sheet from North America. These deposits are variable in nature and contain the remains of modern species of plants and animals.

Although most of the ground-water supplies in Southern Maryland are obtained from the Coastal Plain deposits, some are derived from the crystalline rocks along a narrow belt in northern Prince Georges County. Many wells drilled into the rock yield only small quantities of water, as the crystalline-rock formations are not generally considered to be good aquifers. The sands and gravels in the Coastal Plain constitute a vast reservoir for storing and transmitting ground water, which is readily tapped by wells. Although many of the sands are discontinuous and somewhat irregular, they are sufficiently connected that they may be grouped into geologic and hydrologic units and traced across the Maryland coastal plain and into adjacent areas. In general, the major water-bearing strata are separated from each other by relatively impermeable clays or sandy clays. The principal aquifers in the area are the Patuxent, the Patapsco, and the Magothy formations of Cretaceous age, the Aquia greensand, and the Nanjemoy and Piney Point formations of Eocene age, and the deposits of Pleistocene age.

Except where the aquifers occur at great depth, where they may contain connate water, the source of all water in them is precipitation. It is probable that the aquifers have been largely filled with water since the time of their deposition. The ground water stored in and transmitted through the water-bearing strata is a part of the hydrologic cycle, in which water is in continual movement from the atmosphere to the land, to the sea, and back to the atmosphere again. Some of the water falling on the earth's surface evaporates, some is utilized by plants and animals, some runs directly to the sea in rivers and streams, and some percolates down into the rock formations where it may remain for a few hours, for days, or for centuries before it comes close enough to the surface to be evaporated, or enters the streams and rivers (and thence the sea) via springs, seeps, and underflow. Some water may migrate during long periods of time through permeable strata and enter the ocean directly. A relatively small proportion of it may become chemically bound to the rock materials and its return to the atmosphere be delayed indefinitely.

Perhaps the most commonly observed ground-water feature is the upper limit of the zone of saturation, or the water table. This is a gently undulating surface, which must be penetrated by wells if they are to obtain water from the ground-water reservoir. The water table rises and falls in response to changes in ground-water storage and rates of recharge and discharge. Where water occurs in a permeable bed overlain by a confining bed of lesser permeability (usually a clay or other fine-grained material) artesian conditions exist. Ground water occurs in most of the aquifers in Southern Maryland under both artesian and nonartesian (water-table) conditions, artesian conditions existing in the subsurface and water-table conditions in the outcrop areas. The important water-bearing formations in Southern Maryland and their hydrologic properties are shown in Table 6.

Geologic Formations and their Water-bearing Properties

PRE-CAMBRIAN CRYSTALLINE ROCKS

Distribution and character.—The crystalline rocks of the Piedmont Plateau northwest and west of Southern Maryland dip beneath the Coastal Plain sediments in the vicinity of the Fall Zone. They are important as a source of water in Southern Maryland only along a narrow belt in northern Anne Arundel and Prince Georges Counties. Farther southeast the crystalline rocks lie at considerable depth, and the presence of several overlying sedimentary aquifers has made it unnecessary to drill water wells to the pre-Cambrian rocks.

The crystalline rocks consist mainly of hard dense granite, schist, gabbro, diorite, gneiss, and marble. They are exposed in places along tributaries of the Anacostia River near the northern limit of the area, and in scattered patches along Walker Branch, Bear Branch, and the main channel of the Patuxent River north of Laurel. At many places the crystalline rocks have been decomposed or "rotted" to depths which, in places, may exceed 100 feet, although commonly not greater than 50 feet. The weathered rock frequently retains many of the textural and structural features of the original material. Most of the ground water derived from the crystalline rocks occurs in crevices, joints and other fractures. These tend to disappear and become less numerous beyond depths of a few hundred feet, and hence are not a likely source of ground-water supplies at great depths.

Configuration of the bedrock surface.—The crystalline rocks do not constitute a major aquifer where they are overlain by more than a relatively thin mantle of sedimentary rocks, as openings sufficiently large to permit the movement of ground water are not likely to exist at great depths beneath the sedimentary overburden. Comparatively small yields are obtained from the few water wells ending in the crystalline rocks where they are deeply buried by sediments. The crystalline-rock surface sloping beneath the Coastal Plain is, therefore, a "floor" below which it is not advisable to explore for ground-water supplies.

The records of a comparatively few deep wells in Prince Georges, Anne Arundel, and Charles Counties and the published reports describing the geology of adjacent areas provide the main source of data concerning the depth to bedrock in Southern Maryland. Bennett and Meyer (1952, Pl. 5) show that crystalline rock was encountered at a depth of 750 feet below sea level at Sparrows Point in Baltimore County. A deep well (AA-Ad 29) drilled for the Anne Arundel County Sanitary Commission near Glen Burnie encountered crystalline rock at a depth of 490 feet below sea level. A well (PG-Ce 16) drilled about a mile south of Glenn Dale in Prince Georges County at the Glenn Dale Sanatorium encountered crystalline rock at a depth of 801 feet below sea level. A well (AA-Df 59) at the U. S. Naval Experiment Station near Annapolis failed to penetrate crystalline rock at a depth of 1,000 feet. On the east bank of the Potomac River in Charles County a well (Ch-Bb 10) at the Indian Head Naval Powder Factory, penetrated bedrock at a depth of 709 feet below sea level. Well Ch-Ce 8 at La Plata in Charles County, approximately 11.5 miles east of Indian Head, failed to reach crystalline rock at a depth of 934 feet below sea level. It is estimated that at La Plata the crystalline rock lies at a depth of about 1,400 feet below sea level.

TABLE 6

Geologic formations in Southern Maryland

System	Series	Group	Formation	Approximate thickness (feet)	Physical character	Water-bearing properties
Quaternary (approximate duration 2,000,000 years)	Recent and Pleistocene		Lowland deposits	0–150	Sand, gravel, sandy clay, and clay.	Yields limited quantities of water to dug wells. North of Baltimore City yields a few hundred gallons a minute to drilled wells, but largely undeveloped as a source of ground water in Southern Maryland area.
Quaternary and Tertiary (?)	Pleistocene and Pliocene (?)		Upland deposits	0–55	Irregularly stratified cobbles, gravel, sand, and clay lenses.	Yields moderate quantities of ground water to dug or bored wells. Source of numerous rural water supplies.
Tertiary (approximate duration 53,000,000 years)	Miocene	Chesapeake	St. Marys	0–50	Sand, clayey sand, and blue clay; fossiliferous.	Yields limited supplies of water to dug wells in Calvert and St. Marys Counties. Not an important aquifer.
			Choptank	20–105	Fine sand, sandy clay, and sand with fossiliferous layers.	Yields small supplies of water to a few dug wells near outcrop area. Not an important aquifer.
			Calvert	20–180	Sandy clay and fine sand, fossiliferous; diatomaceous earth.	Yields small quantities of water to dug or bored wells in outcrop area. A few drilled wells may tap basal sand.

	Eocene		Piney Point	0–60	Sand, slightly glauconitic, with intercalated "rock" layers.	Hydrologically connected with underlying Nanjemoy formation. Yields up to 200 gallons a minute reported from drilled wells.
		Pamunkey	Nanjemoy	40–240	Glauconitic sand with clayey layers. Basal part is red or gray clay.	An important aquifer in Calvert and St. Marys Counties. Yields from individual wells reported up to 60 gallons a minute.
			Aquia greensand	30–203	Glauconitic, greenish to brown sand with indurated or "rock" layers in middle and basal parts.	An important aquifer in Calvert, Charles, and St. Marys Counties. Yields up to 300 gallons a minute reported from individual wells.
	Paleocene		Brightseat	0–40	Gray to dark-gray micaceous silty and sandy clay.	Not known to be an aquifer in Southern Maryland.
Cretaceous (approximate duration 55,000,000 years)	Upper Cretaceous		Monmouth and Matawan	20–135	Sandy clay and sand, dark-gray to black, with some glauconite. Basal part is lighter in color and less glauconitic.	Not a major aquifer in Southern Maryland, but yields up to 50 gallons a minute have been reported from individual drilled wells.
			Magothy	0–140	Light-gray to white sand and fine gravel with interbedded clay layers; contains pyrite and lignite.	An important aquifer in Prince Georges and Anne Arundel Counties. A few wells reportedly yield 1,000 gallons a minute, but average yields are considerably less.

TABLE 6—*Continued*

System	Series	Group	Formation	Approximate thickness (feet)	Physical character	Water-bearing properties
			Raritan	100±	Interbedded sand and clay with ironstone nodules; locally contains indurated layers.	Utilized by drilled and dug wells chiefly in Anne Arundel County. Yields up to a few hundred gallons a minute reported.
		Potomac	Patapsco	100–650	Interbedded sand, clay, and sandy clay; color variegated but chiefly hues of red and yellow.	An important aquifer in Prince Georges and Anne Arundel Counties. Large-diameter drilled wells yield up to 1,000 gallons a minute.
			Arundel clay	25–200	Red, brown, and gray clay; in places contains ironstone nodules and plant remains	Not generally a water-bearing formation in Southern Maryland.
	Lower Cretaceous		Patuxent	100–450+	Chiefly gray and yellow sand with interbedded clay; kaolinized feldspar and lignite common. Locally clay layers predominate.	Utilized by wells in parts of of Prince Georges and Anne Arundel Counties; yields up to 540 gallons a minute. Aquifer largely undeveloped in Southern Maryland at present.
Pre-Cambrian (duration several hundred million years)				Unknown	Chiefly gneiss, granite, gabbro, metagabbro, quartz diorite, and granitized schist.	Yields moderate supplies of ground water, generally not more than 50 gallons a minute per well. Some wells are unproductive.

As no wells are known to have penetrated crystalline rock in eastern Charles, southern Prince Georges, southern Anne Arundel, Calvert, and St. Marys Counties, the depth to bedrock in this part of Southern Maryland is not known, except as indicated by recent geophysical work and the logs of three deep oil-test wells on the Eastern Shore of Maryland. A geophysical sounding at a point in the Chesapeake Bay near the mouth of the Patuxent River just east of Solomons Island indicates that crystalline rocks are present at a depth of about 3,050 feet below sea level (Ewing and others, 1946, p. 918). Thus, the crystalline-rock surface drops about 2,350 feet between Indian Head and the mouth of the Patuxent River, or at a rate of about 50 feet per mile along a horizontal distance of 46 miles. Bedrock was encountered at a depth of 5,293 feet below sea level in the Hammond well near Salisbury, about 45 miles east of Solomons Island (Anderson and others, 1948, p. 98). Therefore, the slope of the bedrock surface continues at about 50 feet per mile between the mouth of the Patuxent River (Solomons Island) and Salisbury.

The slope of the bedrock surface beneath the sedimentary rocks varies from place to place. Locally, as in the Harbor and Canton districts of Baltimore City (Bennett and Meyer, 1952, Pl. 5), the slope of the surface is as much as 125 to 150 feet to the mile. Darton (1950, fig. 9), describing the configuration of the bedrock surface in the District of Columbia, shows a small, well-defined channel in the vicinity of the Washington Monument where the gradient of the eroded pre-Cambrian surface is as much as 50 feet in a horizontal distance of 1,000 feet. Relief of this magnitude is probably exceptional for the surface as a whole. Darton states that, in general, the slope of the bedrock surface in the District of Columbia is between 100 and 150 feet per mile. The records of deep wells at Indian Head, Mount Vernon, Glenn Dale, Glen Burnie, and other localities not far east of the Fall Zone indicate that the slope of the bedrock is greatest near the Fall Zone and that it decreases somewhat to the east toward the Chesapeake Bay.

Water-Bearing Properties.—The crystalline rocks are important as a source of ground-water supplies in Southern Maryland only along a belt a few miles in width which extends northeastward from the District of Columbia to the Patuxent River and into Howard County just west of the Anne Arundel County line. In this area the Coastal Plain sediments are thin, or occur only as isolated patches capping the upland interstream divides. Where the sediments lie above the zone of saturation (whose surface is the water table), or where they lie within the zone of saturation but consist of clay or sandy clay, they are commonly cased off and the wells are completed in the crystalline rocks. Rock wells are successful only where a sufficient number of water-bearing openings or crevices are encountered that are able to transmit water into the well at a rate about equal to that at which it is being withdrawn. In some cases, where rock wells are pumped at a relatively high rate, the yields quickly decline because much of the water is derived from storage in the rocks and the rate of replenishment is slow.

As the crystalline rocks are nearly everywhere in Southern Maryland covered with a mantle or veneer of weathered rock and sediments, they have been utilized as a source of ground water only where the sediments have failed to provide an adequate supply. As most of the crystalline-rock wells are in places where the rocks lie beneath a sedimentary cover, it is pertinent to evaluate the water-bearing properties of the crystalline rocks under these conditions. Table 7 shows the depth, diameter, yield, and thickness of rock penetrated in 30 crystalline-rock wells in and near the Southern Maryland area. In most of the wells casing was driven to the top of hard, dense rock beneath sediments; in a few wells much of the material cased off consisted of weathered crystalline rock. None of the wells were screened. The wells penetrated from 3 to 255 feet of rock. The thickness of sediments above the hard, dense rock ranged from 39 to 228 feet. The yields of the wells ranged from less than 1 to 25 and averaged about 6.5 gallons a minute. Thus for every 10 feet of rock penetrated an average of about 0.8 gallon a minute was obtained. Most of the wells listed are domestic wells where a supply of a few gallons a minute was adequate. It is therefore likely that the drillers did not pump some of the wells at their maximum capacity. The logs of a few wells with moderately high yields suggest that water-bearing sediments lie above the crystalline rocks. The water pumped from such a well may be derived from an overlying sand which was cased off, and leakage may occur along the walls of the casing.

The specific capacity provides a means of comparing the relative efficiencies of wells. The specific capacities of 17 wells in Table 7, based on the drawdowns reported by the drillers, range from 0.03 to 1 and average about 0.2 gallon a minute per foot. Thus, on the average, the wells yield 1 gallon a minute for every 5 feet of drawdown, indicating that the crystalline-rock wells are usually much less efficient than screened wells tapping the sedimentary deposits.

In general, the crystalline rocks are not a source of large ground-water supplies in Southern Maryland. In some localities even small domestic supplies can be obtained only with difficulty.

CRETACEOUS SYSTEM

LOWER CRETACEOUS SERIES

Patuxent formation (Potomac group)

Distribution and character.—The Patuxent formation is exposed in Southern Maryland along a belt extending from the Patapsco River southwestward near Deep Run, thence to the Patuxent River south of Laurel, and into the District of Columbia. The outcrop belt of the Patuxent ranges from about 4 to 7 miles in width and narrows to about 2 miles in the District of Columbia (Pl. 7).

TABLE 7

Yields and specific capacities of crystalline-rock wells in Southern Maryland and adjacent areas

Well	Location	Diameter (in.)	Total depth (ft.)	Thickness of rock penetrated (ft.)	Thickness of overlying sediments incl. weathered rock (ft.)	Yield (gal./min.)	Specific capacity (gal./min./ft.)	Remarks
PG-Ad 1	Laurel, Md.	6	164	59	105	10	0.2	
Ad 2	do	6	220	120	100	3	.03	
Ad 4	do	6	212	100	112	3	.1	
Ad 5	do	6	253	153	100	5	.03	
Ad 6	do	6	70	25	45	3	—	
Ad 7	do	7	102	52	50	6	.1	
Ad 14	do	6	130	60	70	2	.02	
Bc 1	Beltsville	6	308	194	114	5	.03	
Bc 2	do	6	184	119	65	5	.1	
Bc 4	do	6	248	146	102	10	.1	31 ft. of soft rock.
Bc 8	do	6	271	106	165	.7	—	23 ft. of soft rock.
Bc 9	do	6	123	64	59	7	.2	
Bd 13	do	8	465	255	210	8	.5	
Bd 14	do	8	304	76	228	19	.1	20 ft. of screen in well, position unknown.
Cc 2	College Park	—	135	61	74	8	.4	
Cc 13	Takoma Park	6	145	105	40	.8	—	
How-Cf 1	Waterloo	8–6	201	156	45	12	—	17 ft. of weathered rock.
Cf 7	West Elkridge	6	142	46	96	2	—	
Cf 17	Jonestown	6	85	25	60	5	—	20 ft. of weathered rock.
Cf 13	Waterloo	6	110	70	40	10	.3	25 ft. of weathered rock.
Cf 19	Jonestown	6	70	25	45	10	1.0	May be producing from Patuxent formation.
Cf 20	do	6	90	30	60	7	.7	
Cg 9	Elkridge	6	125	87	38	10	—	
Cg 11	West Elkridge	6	100	50	50	2	—	
Cg 15	Harwood Park	6	112	47	65	3	—	
Cg 16	do	6	108	43	60	3	—	
De 1	Laurel	6	117	78	39	6	.1	
Df 7	Savage	6	148	60	88	1.5	—	14 ft. of weathered rock.
Df 8	Montevideo	—	88	3	85	25	—	15 ft. of weathered rock.
Df 15	Savage	6	104	54	50	3	—	

The Patuxent formation immediately overlies the crystalline rocks and consists chiefly of sands, clays, sandy clays, and arkosic sands deposited mainly in a continental and fluviatile environment. The individual beds of sand or silt rapidly give way to others in both a horizontal and a vertical direction, suggesting alluvial-fan or deltaic deposition. Between the irregularly distributed stream channels, conditions favoring a quiet-water, swamp environment existed. Under these conditions were deposited the clay layers in which are found carbonized logs, stumps, and other plant remains. In some localities lignitized tree stumps have been found in an upright position, indicating rapid deposition of the sediments. The sands in many places are crossbedded, gravelly, white to yellowish gray, and either relatively free from clay or slightly clayey. Locally, the individual sand beds are 40 or 50 feet thick. Beds of clay commonly occur as partings or stringers interbedded with the sands. The clay in many places is lignitic, and its color ranges from purple to brick-red, gray, or almost pure white. Bands or seams of iron oxide are common. A hard, indurated brownish-purple gravel layer is exposed in a small gully near Halethorpe and in adjacent localities. This layer, at least 4 feet thick, is probably 10 to 20 feet above the contact of the formation with the underlying crystalline rock.

Subsurface character.—Table 8 shows the total thickness and the percentage of different types of sediments in the Patuxent formation as reported in the drillers' logs. Some of the material called sand by the drillers may be clayey sand, and some of the clay may be sandy clay or silt; nevertheless, the lithologic types shown in the logs are believed to be essentially correct. Table 8 shows that the proportion of sand to clay and similar materials varies from place to place in a given area, and also from one area to another. Thus, the logs of three wells drilled near Beltsville in Prince Georges County show that in one well (PG-Bc 8) the formation was 142 feet thick, of which 47 feet, or 33 percent, is sand and gravel, but two nearby wells (PG-Bd 14 and PG-Bd 26) penetrated a total of 435 feet of the formation, of which 270 feet, or 62 percent, was logged as sand and gravel. The average for the three wells is 55 percent of sand and gravel.

The logs of four wells in the District of Columbia penetrating a total of 903 feet of the Patuxent show that 331 feet, or nearly 37 percent of the formation, consists of sand and gravel. The logs of four wells farther south along the Potomac River valley at Indian Head, and at Quantico, Fort Humphrey, and Mount Vernon in Virginia, show that 246 feet of sand and gravel was encountered, or 23 percent, in 1,066 feet of formation penetrated. In the Mount Vernon-Indian Head area the Patuxent formation has not been as extensively developed for large ground-water supplies as it has in localities to the northeast, where the proportion of sand and gravel in the formation is higher. Thus the logs of 8 wells penetrating a total thickness of 1,206 feet of Patuxent formation in the Curtis Bay district of Baltimore show that 739 feet, or 61 percent, is sand and gravel (Bennett and Meyer, 1952, Table 4), and in this area the Patuxent formation is extensively utilized as a source of large industrial ground-water supplies. Bennett and Meyer indicate that for the Baltimore area as a whole about half the formation consists of sand and gravel.

TABLE 8

Thickness, in feet, and percentage of different types of sediments encountered in wells penetrating the Patuxent formation

Well	Locality	Thickness of formation penetrated (ft.)	Sand and/or gravel (ft.)	Sand and/or gravel (percent of formation)	Clay and sediments other than sand (ft.)	Clay, etc. (percent of formation)
AA-Ad 29	Glen Burnie	216	123	57	93	43
Bd 23	do	206	137	66	69	34
Ad 8	Curtis Bay	236[a]	33	14	203	86
Bb 5	Fort George G. Meade	160	25	16	135	84
Bb 20	do	128	63	49	65	51
Bc 28	Dorsey	136	26	19	110	81
PG-Ad 5	Laurel	100	87	87	13	13
Bc 8	Beltsville	142	47	33	95	67
Bd 14	do	180	104	58	76	42
Bd 26	do	255	166	65	89	35
Cc 16	Hyattsville	147	53	36	94	64
Ce 13	Glenn Dale	171[a]	26	15	145	85
Ce 16	do	275	98	35	177	65
Ch-Bb 10	Indian Head	437	102	23	335	77
D.C. 2	District of Columbia	207	80	39	127	61
4	do	253	78	31	175	69
9	do	252	96	38	156	62
10	do	191[a]	77	40	114	60
Va. 1199	Quantico, Va.	185	21	11	164	89
1536	Fort Humphrey	222	84	38	138	62
1690	Mount Vernon	222	39	18	183	82
All wells		4,321 (Total)	1,565 (Total)	37 (Average)	2,756 (Total)	63 (Average)

[a] Formation not completely penetrated.

Mechanical analyses.—Mechanical analyses of six samples of sediments from the Patuxent formation are shown in figure 2. The samples are from the coarser beds (sands and gravels) in the formation. No separations were made of particles smaller than very fine sand (0.125 mm.). The analyses show the variations in the grain size of the sediments of the Patuxent, and may be useful to drillers in selecting the proper screen size for producing water wells. The samples are from both surface exposures and well cuttings.

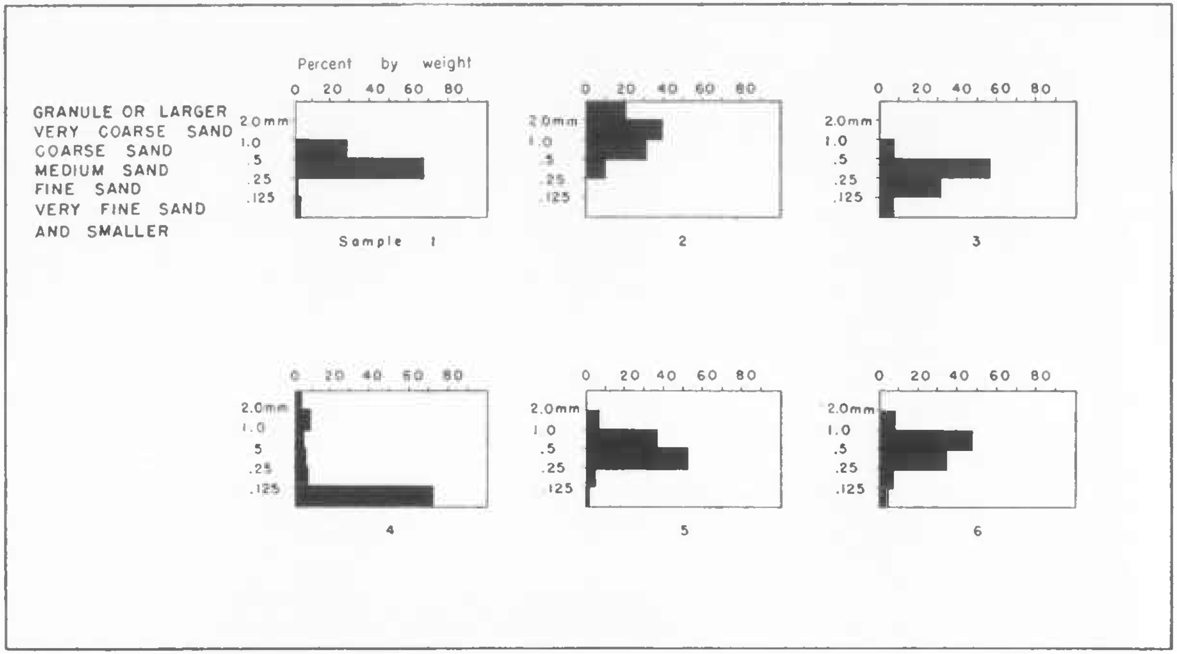


FIG. 2. Histograms of samples from the Patuxent formation

Samples 1. Coarse, clean sand about 5 feet above road at rear of Elkridge Drive-in Theatre, 0.5 mile southwest of Elkridge on north side of U. S. 1, Howard County.

2. Sand from depth 70 to 75 feet, well 2S1W-35, Race and Ostend Sts., Baltimore City.

3. Sand about 6 feet above base of pit of the Caton Corp., Halethorpe, Baltimore County.

4. Sandy clay from depth 496 to 522 feet, well AA-Bd 23, near Harundale, Anne Arundel County.

5. Sand from depth 168 to 175 feet, well AA-Bd 24, near Jessup, Anne Arundel County.

6. Sand from depth 145 to 160 feet, well PG-Cc 27, near Hyattsville, Prince Georges County.

The number of grain-size analyses is inadequate for a statistical evaluation of the size properties of the sediments of the Patuxent formation, but they do show that the coarse sands vary in degree of sorting and contain relatively small amounts of material finer than fine sand. The grains are predominantly of the medium and coarse sand fractions. Sample 4, from a depth of 496 to 522 feet in well AA-Bd 23 at Harundale, consists largely of clay, silt, and very fine sand. The drilling interval of this sample was logged by the driller as clay, but the analysis shows that 29 percent of the material is coarser than very fine sand, which is probably typical of many of the so-called clay layers in the Patuxent formation.

Heavy minerals.—To aid in the tracing and identification of the geologic units in Southern Maryland and in the nearby parts of Baltimore City and County, heavy-mineral determinations were made of 404 samples of cuttings from wells and from outcrops of several of the formations, chiefly of Cretaceous age. The heavy minerals were counted and identified by Richard C. Erd of the Geochemistry and Petrology Branch of the U. S. Geological Survey. Some of the samples contained so few heavy minerals as to be of no use. The results of the heavy-mineral examinations of the cuttings from four wells are shown graphically in Plate 2. The data are presented in a modified well-log form in which the heavy-mineral constituents are grouped on the log in their stratigraphic position. It is thus possible to compare the changes in the dominant minerals at various horizons in the same well. The data are in two main groups: (1) a group in which the grain count of the detrital nonopaque minerals totals 100 percent; (2) a group in which the proportions (or percentages) of the opaque, nonopaque, authigenic, and platy minerals total 100 percent. The total grain count of minerals in group 1 is also that of group 2. This method of presentation was chosen in order that the extremely high proportion of some of the more common authigenic minerals in the sediments, such as glauconite and siderite, would not dominate the analyses.

As all the samples graphed on Plate 2 are from wells drilled by the rotary method, some of them may have been subject to contamination by material encountered farther up the hole. In all, 28 samples from the Patuxent formation were examined for heavy-mineral content. The chief detrital minerals are zircon, tourmaline, epidote, staurolite, kyanite, and chloritoid; minor constituents are rutile, anatase, garnet, andalusite and sphene.

The heavy-mineral studies show that the proportions of heavy minerals (especially the detrital group) vary as much from well to well in suites from the Patuxent formation as they vary in a given well between the suites from the Patuxent formation and the suites from other formations of the Potomac group. For example, in well 5S3E-46 seven suites from the Patuxent formation contain kyanite (about 50 percent) as the dominant heavy mineral of the detrital group. Zircon, staurolite, and tourmaline are next in abundance. Ten mineral suites from well AA-Bd 23 contain zircon (35 percent) as the dominant mineral of the detrital group, and tourmaline (22 percent) and chloritoid (16 percent) next in abundance. Five suites from well 1S4E-19 contain zircon (about 48 percent) as the dominant detrital constituent, and tourmaline (18 percent) next in abundance; only minor amounts of chloritoid and kyanite are present in the Patuxent formation in this well. Six suites (Patuxent formation) from well 3S5E-32 are characterized by high proportions of zircon and tourmaline; staurolite, kyanite, and epidote are present only in minor amounts.

To summarize, the heavy-mineral examinations of samples of the Patuxent formation show that the detrital minerals zircon and tourmaline are present in significant proportions in all samples. Staurolite, although common, is not abundant; kyanite and chloritoid are common in the samples from only two wells, and are almost entirely absent in the other two wells. The authigenic mineral siderite is abundant in a few suites from wells penetrating clayey zones in the formation, as, for example, suites from depths of 122 to 160 feet in well 1S4E-19.

Thickness and stratigraphic relations.—The thickness of the Patuxent formation cannot always be determined from drillers' logs or from the sample cuttings. In some places the upper part of the formation consists largely of clay similar to the overlying Arundel clay. Although the Arundel clay possesses distinguishing characteristics, the drillers often fail to note or record them. Also both the Patuxent and the Arundel formations may change their lithologic character downdip from their outcrop areas and may lose their identities as mappable geologic units.

In some of the deep wells in southeastern Prince Georges County, as, for example, in well PG-Fb 14, drilled to a depth of 1,000 feet at Fort Washington, the Patuxent formation cannot be separated from the overlying Arundel clay on the basis of the driller's log. However, it can be separated from the overlying Arundel in several wells in northern Prince Georges and Anne Arundel Counties, where its thickness ranges from a featheredge along the Fall Zone to as much as 300 feet in the Glenn Dale-Bowie area. In western Charles County near Indian Head the Patuxent may be more than 400 feet thick. In the subsurface of the Baltimore area the formation ranges in thickness from less than 100 to nearly 300 feet (Bennett and Meyer, 1952, p. 35). Where it has been completely penetrated by wells in Southern Maryland the Patuxent formation ranges in thickness from 150 to about 400 feet.

The contact of the Patuxent formation with the underlying crystalline rocks marks a pronounced unconformity in the geologic column. The nature of the contact between the sedimentary deposits and the underlying crystalline rocks varies from place to place, and the contact is not always readily identified in the drillers' logs. In some localities the weathered, decomposed crystalline rock is largely micaceous clay, which is not always distinguishable in the logs from dull-colored or gray clays of the Patuxent formation. In other places, as in an exposure near the National Zoological Park in Washington, D. C. (Darton, 1950, p. 6), the lowermost deposits of the Patuxent consist of coarse, arkosic sand, gravel, and boulders which contrast sharply in character with the underlying gneissic crystalline rock. In the sample cuttings the change from sedimentary to crystalline rock is usually marked by an increase in the coarseness of the rock fragments, the presence of fresh coarse, angular quartz grains, an increase in micaceous clay, and, where the crystalline rock material is unweathered and dense, the appearance of fresh fragments of gneiss, schist, granite, or other crystalline rock.

The upper surface of the Patuxent formation is rather irregular and has a variable but gentle slope to the southeast. In northern Anne Arundel County between wells AA-Ac 15 and AA-Ad 29 the top of the Patuxent formation dips 194 feet in 4.1 miles, or 47 feet to the mile. In northern Prince Georges County, northwest of Glenn Dale, it dips 514 feet in 4.5 miles, or at a rate of 114 feet per mile. Locally, as at Beltsville, the irregularities in the upper surface of the formation cause slight reversals of the slope.

Water-bearing properties.—The water-bearing properties of the Patuxent formation vary from one locality to another in Southern Maryland, as would be expected in view of the inhomogeneity of the sediments. The layers of sand and gravel, constituting 25 to 50 per cent of the formation, vary from fine, clayey sands to clean, coarse sandy gravels. Where wells are screened in the coarse gravels the highest yields are generally obtained, although the yield of a well is dependent also on other factors, such as the size of screen used, the diameter of the casing, the type of pumping equipment, and the development of the well.

Table 9 shows the range in yield, the length of screen, and the specific capacity of 37 wells in the Patuxent formation. Although it would be desirable to compare the water-bearing properties of the formation in various localities, unfortunately in many areas only one or two wells tap the Patuxent formation; the yields and specific capacities of those wells obviously are inadequate to evaluate the water-bearing properties of the formation as a whole for those localities. Also, the reported yields for some wells may not be the maximum yields obtainable from those wells; furthermore, some wells are screened in only one of two or more water-bearing sands, and are probably capable of yielding more water if additional sands in the well were screened. In order to obtain a closer appraisal of the maximum yields from the formation, domestic and farm wells yielding only a few gallons a minute are not included in Table 9. The yields listed range from 17 gallons a minute in well PG-Be 10 near Bowie to 439 gallons a minute in well PG-Eb 1 at Forest Heights; most of the wells yield from 100 to 300 gallons a minute. In general, the Patuxent does not appear to be as good an aquifer in Southern Maryland as it is in the industrial district of Balti-

TABLE 9

Yields and specific capacities of wells screened in the Patuxent formation

Well	Locality	Diameter of casing (in.)	Length of screen (ft.)	Yield (gal./min.)	Drawdown (ft.)	Specific capacity (gal./min./ft.)
AA-Ac 11	Friendship-Linthicum	6	8	60	85	0.7
Ac 23	do	4-2	5	20	32	.6
Ad 43	do	10	16	250	78	3.2
Ad 8	Curtis Bay	8-6	—	100	78	1.3
Bb 3	Laurel	10	10	43	36	1.2
Bb 5	do	12	22	66	108	.6
Bb 22	do	6	10	60	11	5.5
PG-Bc 3	Beltsville	6	—	20	14	1.4
Bd 4	do	8-6	15	250	80	3.1
Bd 15	do	8	20	110	114	.9
Bd 17	do	8	28	20	32	.6
Bd 19	do	6	—	100	135	.7
Bd 21	do	6	60	100	88	1.1
Bd 22	do	6	—	60	85	.7
Bd 25	do	6	19	73	78	.9
Bd 27	do	6	21.5	120	109	1.1
Bd 28	do	6	42.5	165	56	2.9
Be 2	Bowie	—	—	100	71	1.4
Be 8	do	10	20	125	23	5.0
Be 10	do	6	—	17	50	.3
Cc 5	Bladensburg	10-8	30	300	57	5.3
Cc 7	College Park	8	—	125	85	1.4
Eb 1	Oxon Hill-Forest Heights	18-10-8	40	439	244	1.8
Ch-Ce 8	La Plata	10-8-6	24	100	285	.3
Bc 6	Indian Head-Glymont	18-8	50	385	64	6.0
Bb 1	do	8	42[a]	150[b]	71	2.1
Bb 2	do	8	80[a]	134[b]	32	4.2
Bb 4	do	8	47[a]	143[b]	49	2.9
Bb 5	do	8	32[a]	124[b]	39	3.2
Bb 6	do	8	41[a]	248[b]	69	3.6
Bb 7	do	8	51[a]	154[b]	62	2.5
Bb 8	do	8	52[a]	212[b]	46	4.6
Bb 9	do	8	51[a]	126[b]	16	7.9
Bc 1	do	8	—	86[b]	13	6.6
Bc 2	do	8	—	132[b]	13	10.2
Bc 3	do	8	—	242[b]	52	4.7
Bc 4	do	8	—	304[b]	62	4.9

[a] Multiple-screened well, partly screened in the Patapsco formation.
[b] Yield and drawdown measured in 1938.

more City, where wells have been reported to yield up to 900 gallons a minute, and many of the industrial wells yield from 400 to 600 gallons a minute (Bennett and Meyer, 1952, p. 43).

The specific capacity of a well affords a more accurate measure of the water-bearing properties of a formation than the yield alone, in that it eliminates one variable, namely that the maximum yield obtainable from wells is limited by the available drawdown. The drawdown of a well is not constant but changes as the well is pumped. As the pumping tests cover time intervals of different lengths, the specific capacities computed from the drawdowns are still only a rough means of evaluating the hydrologic properties of the formation. The specific capacities of the wells in Table 9 range from 0.3 to 10.2 gallons a minute per foot of drawdown and average 2.8. Since 23 of the 37 wells listed in the table are located at Beltsville and Indian Head, the average values are weighted in favor of these localities and may not be indicative of the Patuxent formation throughout its extent in Southern Maryland. A comparison of the specific capacities of 10 wells in the Beltsville area and 13 wells in the Indian Head area shows that the Indian Head wells have a greater average specific capacity than the wells at Beltsville, 4.8 contrasted with 1.3 gallons a minute per foot. Also, the yields of the wells at Indian Head average more than those at Beltsville; the average yield of the Indian Head wells is about 187 gallons per minute and that of the Beltsville wells is 102 gallons per minute.

Bennett and Meyer (1952, p. 45) report that five wells ending in the Patuxent formation in the Curtis Bay area have an average specific capacity of 7.6 gallons per minute per foot and an average yield of 340 gallons a minute, or almost twice the average yield of the wells at Indian Head.

Permeability, transmissibility, and storage coefficients.—The hydrologic properties of earth materials may be expressed quantitatively by the use of the terms *coefficient of permeability*, *coefficient of transmissibility*, and *coefficient of storage*. The *permeability* of a substance is its capacity to transmit fluids through its interstices; the *coefficient of permeability*, as defined by the U. S. Geological Survey, is the volume of water, in gallons a day, that will pass through a cross-sectional area of 1 square foot of material under a hydraulic gradient of unity (1 foot per foot) at a temperature of 60° F, or, expressed more conveniently, through a strip of the aquifer 1 foot thick and 1 mile wide, under a hydraulic gradient of 1 foot per mile. This unit by which the coefficient is expressed has been termed the *Meinzer unit*, or simply the *meinzer*. The *field coefficient of permeability* is that quantity of water which passes through earth materials at the prevailing ground-water temperature. Earth materials tested in the hydrologic laboratory of the U. S. Geological Survey had coefficients of permeability ranging from 0.0002 to about 90,000 (Meinzer and others, 1942, p. 453). However, the permeabilities of most water-bearing materials are between 10 and 5,000.

The *coefficient of transmissibility* (Theis, 1935, p. 520) is the product of the field coefficient of permeability and the saturated thickness of the water-bearing bed. It is best expressed as the quantity of water, in gallons a day, moving through a strip of the aquifer 1 mile wide under a hydraulic gradient of 1 foot per mile, at the prevailing temperature of the water.

The *coefficient of storage* is a measure of the ability of an aquifer to store water. It is the quantity of water, expressed as a fraction of a cubic foot, released from each vertical column of the aquifer having a basal area of 1 square foot for each foot of lowering of head. The lowering of head in an artesian aquifer is accompanied by a slight compression of the aquifer, and probably a slight rearrangement of the earth materials. It is believed that this compression and rearrangement, plus slight expansion of the water itself as the head is lowered, contribute the water indicated by the coefficient of storage. The coefficient of storage for water table conditions is analogous to the *specific yield*, which is the volume of water that will drain by gravity from 1 cubic foot of saturated material; *specific yield* is commonly expressed as a percentage of the total volume of the saturated material. In general, with an equal lowering of water level, the quantity of water released from storage in an artesian aquifer is only one-hundredth to one ten-thousandth of that released from a water-table aquifer. A common range of the coefficient of storage for artesian conditions is 0.00001 to 0.001; for water-table conditions, from a percent or two to 30 percent.

The coefficient of permeability of earth materials may be determined by means of laboratory tests on small samples, or by pumping test on wells. In determining the hydrologic properties of aquifers through pumping tests, the rate of pumping, or discharge, is measured and changes in the water levels in the pumped well and in nearby observation wells are measured. These measurements are commonly continued for a period after pumping has ceased. Changes in hydraulic head that occur in an aquifer as a result of pumping define quantitatively the hydrologic properties of the aquifer.

Two basic types of mathematical formulas, the equilibrium and the nonequilibrium, are commonly used for determining the coefficients of transmissibility and storage by means of pumping tests. Both formulas involve an analysis of the behavior of the slope of the water table or piezometric surface[1] around a discharging well. The basic equilibrium formula, known as the Thiem formula, is applicable when the cone of depression surrounding a discharging well has essentially reached equilibrium shape; that is, the cone is declining at an equal

[1] The piezometric (pressure-head-indicating) surface of an artesian aquifer is analogous to the water table of an unconfined aquifer. It is the imaginary surface defined by the level to which water will rise in tightly cased wells penetrating the artesian aquifer. The water table may be considered one type of piezometric surface—that indicating the head of water in an unconfined aquifer.

rate throughout the area covered by observation wells. The formula, shown below modified for artesian conditions, is discussed in detail by Wenzel (1942, p. 81) and has been commonly used in quantitative ground-water studies during recent years:

$$T = \frac{527.7Q \log \frac{r_2}{r_1}}{s_1 - s_2}$$

where T = the coefficient of transmissibility, in gallons a day per foot

Q = the rate of pumping, in gallons a minute

r_1 = the distance, in feet, of one observation well from the pumped well

r_2 = the distance, in feet, of a second observation well from the pumped well

s_1 = drawdown, in feet, of the water level in the observation well at distance r_1

s_2 = drawdown, in feet, of the water level in the observation well at distance r_2

This formula is based on the assumption that the hydraulic system has reached a state of steady flow (so-called equilibrium conditions), a condition that is not generally achieved during pumping tests of relatively short duration. The factor of time is included in the formula only in the sense that the well is assumed to have been discharging for a sufficient length of time to produce conditions of hydraulic equilibrium.

In 1935 Theis described a formula (nonequilibrium) based on the behavior of the cone of depression around a discharging well which includes the factor of time, and hence does not depend on the hydraulic system reaching a state of equilibrium. The formula also takes into account the factor of removal of ground water from storage. It is based on the assumption that Darcy's law is analogous to the laws governing the flow of heat by conduction. The formula may be expressed as follows:

$$s = \frac{114.6Q}{T} \int_{\frac{1.87r^2S}{Tt}}^{\infty} \frac{e^{-u}}{u}\, du$$

where s = the drawdown, or recovery, in feet, at any point within the cone of influence of the discharging well

Q = the discharge of the well, in gallons a minute

T = the coefficient of transmissibility of the aquifer, in gallons a day per foot

S = the coefficient of storage as a decimal fraction

r = the distance, in feet, of the observation well from the discharging well

t = time, in days, since pumping (or discharging) was started or stopped

As the coefficient of transmissibility (T) appears on both sides of the equation, the formula cannot be solved directly for T. However, T may be determined graphically by the use of type curves. The formula may be written as follows:

$$s = \frac{114.6Q}{T} W(u)$$

where $W(u)$ is defined as the "well function of u" or

$$-0.577216 - \log_e u + u - \frac{u^2}{2 \cdot 2!} + \frac{u^3}{3 \cdot 3!} \cdots$$

The coefficient of transmissibility may then be computed by the formula:

$$T = 114.6Q \frac{W(u)}{s}$$

The use and derivation of this formula are described by Meinzer and Wenzel (Meinzer and others, 1942, p. 472).

Theis (1935, p. 519–524) also introduced a formula for determining the transmissibility of an aquifer from the recovery of the water level in a well after pumping or discharge has stopped. Modified somewhat by Cooper and Jacob (1946), the formula is a variation of the nonequilibrium formula and may be expressed as follows:

$$T = \frac{264Q}{\Delta s}$$

where Q = the discharge in gallons per minute

Δs = the time, in minutes, since pumping began divided by the time since pumping stopped, plotted over one log cycle on semilogarithmic paper against the recovery, in feet, of the water level in the pumped well

The nonequilibrium formulas are based on assumptions that are seldom, if ever, completely fulfilled in nature; they are (1) that the aquifer is homogeneous and isotropic, that is, capable of transmitting water equally well in all directions, (2) that the formation has an infinite areal extent, (3) that the discharging well penetrates the entire thickness of the aquifer, (4) that water is released instantaneously from storage with a decline in head, (5) that the discharging well is of an infinitesimally small diameter, and (6) that the formation is bounded on the top and bottom by impermeable layers. Probably the most serious sources of error in the use of the nonequilibrium formulas in quantitative ground-water studies occur because the aquifers are seldom homogeneous and almost never isotropic, and because the water is not instantaneously released from storage with a decline in head. Experiments on the rates at which water drains by the force of gravity from water-bearing materials show that even after a period of months or years a small quantity of water continues to drain from the material. However, despite the theoretical limitations of the formulas, they afford a reasonable and highly useful means of evaluating the hydrologic properties of aquifers. The applicability and usefulness of these formulas are discussed by Brown (1953, p. 844–866).

Pumping tests were made on several wells tapping water-bearing sands in the Patuxent formation in Southern Maryland. The results and analyses of these tests are shown in Table 10. The coefficients of permeability, transmissibility, and storage represent only a sampling of the hydrologic properties of the formation. In practically every locality the formation consists of more than one water-bearing sand, but wells generally are screened in only one. The permeability of individual layers of sand or gravel may vary from place to place owing to differences in grain size and in textural characteristics of the sediments. The field coefficients of permeability, as indicated by the pumping tests, range from 22 to 380 gallons per day per square foot. The minimum value was obtained on well AA-Bb 5 at the District Training School for Boys, just west of Fort Meade in Anne Arundel County, which yields water from a 27-foot sand near the base of the formation. The test indicated a transmissibility of 600 gallons per day per foot. The maximum value was obtained in a recovery test on well PG-Cc 5, near Hyattsville in Prince Georges County, which has a transmissibility of 10,750, showing that the water-bearing sand at this locality is more permeable than the sands in the other localities where the hydrologic properties of the formation were determined by pumping tests.

A test utilizing wells Bd 32 and Bd 33, at the plant of the Mineral Pigments Corp. near Muirkirk, in Prince Georges County, showed a coefficient of transmissibility of 450 to 640, which averaged 550 gallons per day per foot. The coefficients here are in general agreement with those obtained at the District Training School. The aquifer at the Mineral Pigments plant consists of two sands, totaling 14 feet in thickness, overlain by clay and sandy clay. The coefficient of transmissibility obtained from this test may be less than the true amount because the test was relatively short (353 minutes), the test well was pumped at a low rate (27 gallons a minute), and the well screen may be partially clogged.

TABLE 10

Summary of permeability, transmissibility, and storage coefficients of the Patuxent formation

Well	Location	Duration of test (min.)	Screen length in well (ft.)	Effective sand thickness[c] (ft.)	Analysis formula	Coefficient of transmissibility (gal./day/ft.)	Field coefficient of permeability (gal./day/ft.²)	Coefficient of storage (cu.ft./ft.)	Estimate of accuracy of test
AA-Bb 5[a]	District Training School	179	23.5	27	Recovery	600	22	—	Fair
PG-Bd 32	Beltsville-Muirkirk	142	—	14	do	450	32	0.00013	Good
Do	do	353	—	14	do	590	42	—	Fair
Do	do	139	—	14	Nonequilibrium (Jacob)	640	46	.00001	Good
Bd 33[a]	do	30	15	14	do	580	41	—	Fair
Cc 3[a]	Bladensburg	271	8	8	do	560	70	—	Good
Cc 5[a]	Hyattsville	303	30	28	do	10,750	380	—	Good
Ch-Bb 1-Bb 9	Indian Head[b]	14,580	54	70	Nonequilibrium (Theis)	4,210	60	.00037	Good

[a] Denotes pumped well.

[b] Data from unpublished report by Fiedler and Jacob (1939, p. 39, 41). Values for screen lengths and effective sand thickness averaged from a group of wells.

[c] Thickness of saturated aquifer or thickness of screened aquifer.

In 1938 Fiedler and Jacob (1939, p. 39, 41) made an extensive series of pumping tests at the Indian Head Naval Powder Factory in Charles County. These tests, extending over a period of more than 10 days, show that two sands in the Patuxent formation in this locality have a coefficient of transmissibility of about 4,200 gallons per day per foot and a field coefficient of permeability of about 60 gallons per day per square foot.

The coefficients of storage obtained from the pumping tests range from 0.00001 in the Beltsville-Muirkirk area to 0.00037 in the Indian Head area. The latter value is probably more nearly correct for the water-bearing zones of the Patuxent formation where it occurs under artesian conditions.

In the Sparrows Point district of the Baltimore industrial area the average coefficient of transmissibility of the Patuxent formation is about 50,000 gallons per day per foot (Bennett and Meyer, 1952, p. 50) and the average field coefficient of permeability is 900 gallons per day per square foot. These values are higher than those obtained in the Southern Maryland area, showing the formation is less permeable where it has been tested in Anne Arundel, Prince Georges, and Charles Counties than it is in the Baltimore area. This conclusion is supported by the data in Table 8, which show that the amount of clay and sandy clay in the formation increases southwest of Baltimore. In general, the specific capacities and yields of wells tapping the formation are lower in Southern Maryland than in the Baltimore industrial area (see Table 9). However, where it lies at depths of more than a few hundred feet the formation has not been adequately tested by deep wells and its hydrologic properties are unknown.

UPPER CRETACEOUS SERIES

Arundel clay (Potomac group)

Distribution and character.—The Arundel formation is composed largely of clay and in recent years has been designated the Arundel clay. It extends southward in an irregular belt 1 to 4 miles wide from the Bush River in Harford County to Muirkirk and Bladensburg in Prince Georges County. South of Bladensburg the Arundel clay is difficult to distinguish from the other formations of the Potomac group, although it has been tentatively identified in a few wells in the District of Columbia and in Charles County. In northern Anne Arundel County the outcrop belt of the clay forms a poorly defined ridge of southwest-trending hills east of Dorsey, Montevideo, Jessup, and immediately west of Fort George G. Meade, or roughly along the route of the new Washington-Baltimore Expressway. The clay may be seen in a number of road cuts along this highway, where it is commonly overlain by sand, gravel, or silt of Pliocene(?) or Pleistocene age. The following section, measured near Jessup in the autumn of 1952, shows the Arundel clay where it is overlain by deposits of

Pliocene(?) age:

Geologic section showing Arundel clay overlain by Pliocene(?) deposits along the Baltimore-Washington Expressway (See fig. 3 for diagram of section)

Location: In Anne Arundel County, 1.3 miles southeast of Jessup, 200 feet north of Maryland Route 175 overpass.

Altitude: Base of section 270 feet above mean sea level (by altimeter).

Bed Number		*Thickness* (feet)
	Pliocene(?) series:	
7	Soil and covered interval	1.5
6	Sand and gravel, coarse, clean, yellowish-gray to grayish-brown; contains quartz pebbles up to 4 inches in diameter	5.5
	Upper Cretaceous series:	
	Arundel clay:	
5	Clay, grayish, white, tough, with ironstone layer at top; ironstone layer composed of reddish-black indurated gravel about 0.3 foot thick (absent 15 feet southeast)	3.6
4	Ironstone layer, sandy, rusty to reddish-purple, hard (absent about 35 feet southeast)	0.5
3	Clay, grayish-white and red, mottled, streaked, tough, slightly sandy	3.0
2	Concealed (cut-back slope covered with sandy wash)	1.5
1	Clay, tough, red, slightly greasy, streaked, mottled brown to grayish-yellow	13.0
	Total	28.6

(Base of section at road level during construction)

The Arundel clay consists chiefly of clay and sandy clay containing interbedded layers of ironstone and nodules of iron carbonate. It is commonly lignitic and contains carbonaceous stumps, fragments of logs, and small pieces of disseminated lignitic matter. Colors vary from red to purplish red and grayish white to yellowish gray. Small amounts of pyrite and gypsum are common. The clay appears to have been deposited chiefly in a quiet-water, lacustrine environment as coarse sandy beds are absent or are of minor extent.

Subsurface character.—In drilled wells the Arundel clay may be identified chiefly by its toughness or resistance to penetration by the drill. In many wells the drillers find a zone of tough, red or gray clay and interbedded thin ironstone layers. In some wells thin beds of sand are encountered which probably are lenses of limited extent, as they are not reported in nearby wells. In a few wells, as in wells PG-Bd 29 at the Beltsville Research Center and PG-Cc 16 near Hyattsville, water-bearing sands have been reported; however, the sands are only a few feet thick and are not a satisfactory source of ground water.

Mechanical analyses.—No particle-size analyses of the Arundel clay were made.

Heavy minerals.—Heavy-mineral suites were examined and grain counts made from 10 samples of the Arundel clay in wells 1S4E-19, 3S5E-32, and AA-Bd 23. Although the base of the Arundel clay is not definitely established in well 1S4E-19 (Crown Cork and Seal Company well), it is believed that 7 heavy-mineral suites from depths of 45 to 87 feet are from the clay. One suite

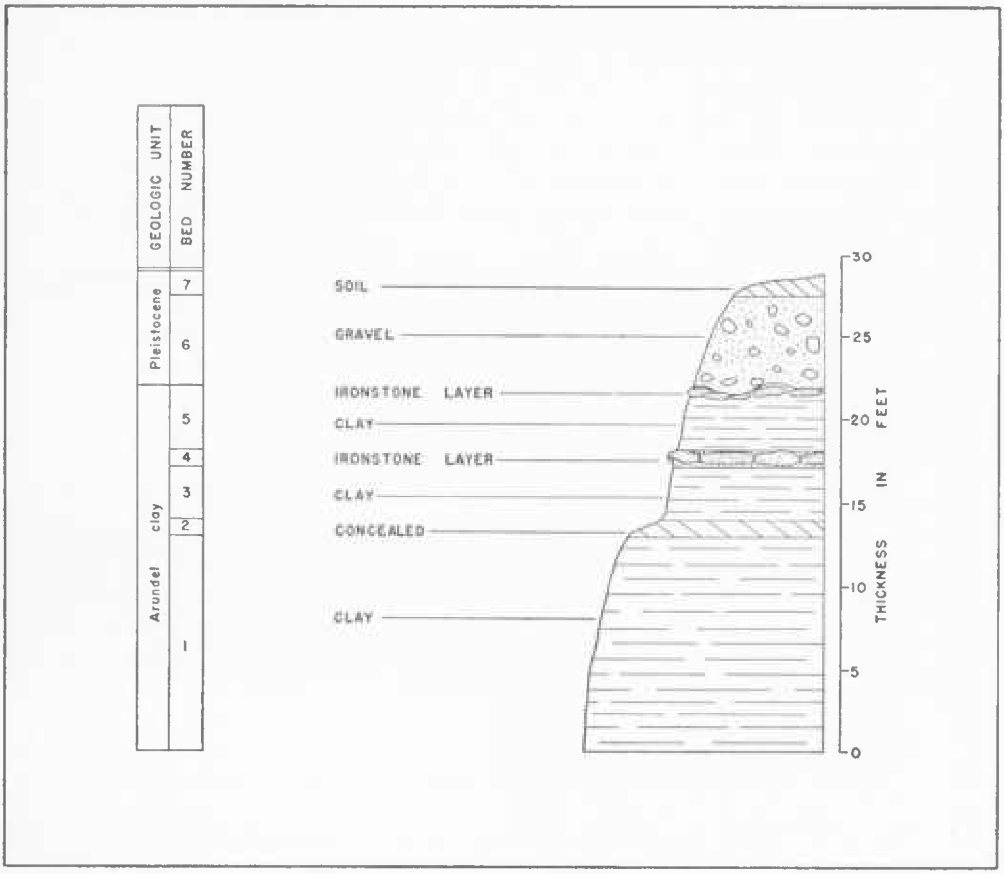


FIG. 3. Geologic section near Jessup (Anne Arundel County) showing the Arundel clay overlain by the Pliocene(?) upland deposits

from depths of 170 to 190 feet in well 3S5E-32 and two suites from depths of 298 to 411 feet in well AA-Bd 23 are from the Arundel.

Zircon and tourmaline are the dominant detrital minerals; kyanite, staurolite, hornblende, chloritoid, and epidote are minor minerals. In the authigenic mineral group siderite is very abundant in most of the samples, and in some it is the main constituent of the heavy fraction. The graphs on Plate 2 show that the Arundel clay cannot readily be separated from the underlying Patuxent formation on the basis of the relative proportions of heavy minerals or the presence of specific minerals, although the mineral siderite is more abundant in the Arundel than in the Patuxent.

Thickness and stratigraphic relations.—The Arundel clay in Anne Arundel County ranges in thickness from less than 25 feet in well AA-Ad 8 in the Curtis Bay district to as much as 165 feet in well AA-Ac 11 at Friendship Airport. The average thickness in 8 wells in the county is approximately 100 feet. In northern Prince Georges County its thickness ranges from 30 feet in well PG-Bd 19 near Beltsville to 196 feet in well PG-Ce 16 at the Glenn Dale Sanatorium. Its average thickness in 15 wells in Prince Georges County is 112 feet. The Arundel clay has been tentatively identified in 6 wells drilled at the Indian Head Naval Powder Factory in Charles County, where it is from 86 to 124 feet thick and averages 108 feet.

The Arundel clay lies unconformably on the irregular surface of the Patuxent formation and is overlain unconformably by sand and clay of the Patapsco formation. The upper surface of the formation is irregular in slope and dip. Southeasterly from Beltsville to the Glenn Dale Sanatorium the surface dips 413 feet across a distance of 5.7 miles, or about 70 feet per mile; southeasterly from North Linthicum to Glen Burnie the formation dips 66 feet along a distance of 2.6 miles, or about 24 feet to the mile. In the Sparrows Point district of the Baltimore industrial area the slope of the formation is about 100 feet to the mile, but in a few places in the Baltimore area the slope of the upper surface of the Arundel is somewhat greater (Bennett and Meyer, 1952, pl. 8).

Water-bearing properties.—The Arundel clay is not regarded as a water-bearing formation, although a few dug wells yield small domestic supplies, probably derived from sandy zones in the clay. The drillers' logs of a few wells show lenses of water-bearing sand which are less than 5 feet thick. They were not utilized as a source of water in the wells in which they were encountered. Because of its relative impermeability the formation functions chiefly as a confining layer for the water-bearing sands in the underlying Patuxent and the overlying Patapsco formations.

Patapsco and Raritan formations

Distribution and character.—The Patapsco formation is the uppermost formation of the Potomac group and is now considered to be of Late Cretaceous age by the U. S. Geological Survey. The Patapsco is overlain unconformably by the Raritan formation. In Southern Maryland the two formations are similar lithologically, consisting chiefly of deposits of sand, gravel, sandy clay, and clay. Cuttings from a number of drilled wells penetrating the two formations have failed to reveal lithologic characteristics to serve as a basis for the separation of the two units. Since the formations have similar hydrologic properties and cannot readily be separated on a lithologic basis, they are treated in this report as one unit.

The Patapsco and Raritan formations extend southward from Baltimore City across Anne Arundel and Prince Georges Counties as a poorly defined band. In northern Anne Arundel County they are exposed along a broad belt extending southeast about 12 miles from Stony Run and the Patapsco River to Round Bay on the Severn River. In west-central Anne Arundel County, along the Patuxent River, their outcrop belt narrows to about 8 miles, owing partly to the overlap of the overlying Magothy, Monmouth, and Aquia formations (Pl. 8). In northeastern Prince Georges County both formations are exposed in a belt about 7 miles wide extending from Muirkirk to the vicinity of the Bowie Race Track. Further southwest the belt of outcrop narrows to about 2 miles near the junction of Oxon Run and the Potomac River. Southward in Prince Georges and Charles Counties additional exposures are seen only along the Potomac River cliffs as, for example, at Fort Washington and Glymont (Pl. 8).

The materials composing the Patapsco and Raritan formations are similar in character to those of the underlying Arundel and Patuxent formations, consisting chiefly of deposits derived from the eroded crystalline rocks to the west and from reworked Lower Cretaceous sediments. The sediments were deposited in a deltaic and estuarine environment of relatively low relief in which meandering streams deposited sand and gravel in essentially swampy or quiet water, in which the associated and interbedded clays accumulated. During the deposition of the sediments composing the Raritan formation tongues of the Atlantic Ocean spread as far north and west as Salisbury and southern Charles County. At Maryland Point in Charles County fragments of marine shells were identified in the well cuttings at a depth of 300 feet from the J. R. Hampton well which penetrated the Patapsco or Raritan formation (well Ch-Ec 5, Table 34).

The sediments of the Patapsco and Raritan formations consist of red, gray, grayish-yellow, and brown clay and interbedded sand and sandy gravel. Ironstone layers and bands are common, but most of them are not more than a few feet thick and are of variable extent and character, consisting chiefly of nodules or ledges of sandy iron carbonate or limonite. The sands are commonly cross-bedded, in places clayey, and generally not as arkosic as the sands in the Patuxent formation. Carbonaceous material and pyrite are dispersed throughout some of the sand and clay layers.

Near Elvaton in northern Anne Arundel County the Raritan formation contains layers of silica-cemented sand, which form a group of small hills that rise 40 to 60 feet above the surrounding countryside and are capped by a 10- to 20-foot layer of especially tough sandstone. Drillers report "rock" layers in wells a few miles south of the Elvaton area, which may indicate that the layers dip southward and are continuous in that vicinity. "Rock" layers, chiefly ironstone, are also common at the base of the Arundel clay and in the Patuxent formation at some localities.

Subsurface character.—The sands and gravels in the Patapsco and Raritan formations are the most important water-bearing beds in the Southern Maryland area, but the variable nature of the deposits precludes the tracing of individual beds for more than short distances. In some places, however, the formations are more clayey than in others. Table 11, compiled from drillers' logs of about 75 wells completely or partly penetrating the formations, shows the relative proportions of sand and gravel to clay, sandy clay, and related fine-grained sediments. The data, grouped by localities, indicate significant variations in these proportions from place to place. A total of 18,404 feet of deposits were logged of which 3,748 feet, or 20 per cent, were sand and gravel. Thus about 80 percent of the Patapsco and Raritan formations in the Southern Maryland area consist of clay, sandy clay, rock, or sediments other than sand or gravel. The proportion of sand to clay varies widely from well to well in some localities, but, in general, the groupings show a similarity. Only those wells are used in Table 11 in which a fair thickness of the formations was logged. The greatest proportion of sand in the Patapsco and Raritan formations is in the Odenton area, where the logs of six wells show that of a total 976 feet of deposits logged, 433 feet consist of sand and 543 feet consist of clay and related sediments; thus, 44 per cent of the deposits consist of sand and gravel. The Odenton area is the site of heavy industrial ground-water development where, in 1952, about a million gallons per day was pumped from wells of the National Plastic Products Co.

Bennett and Meyer (1952, p. 61) report that the logs of 8 wells in the Curtis Bay and Fairfield districts of Baltimore City show 201 feet of sand and gravel in a total of 470 feet of Patapsco formation, or about 43 percent sand. The Curtis Bay district is the site of moderately heavy industrial development of ground water from the Patapsco formation.

In the Annapolis area a total of 2,864 feet of formation was logged in 7 wells, of which 818 feet was sand and 2,046 feet was clay. Thus, about 29 percent of the formation here is sand and 71 percent clay and related sediments. The Annapolis area is the site of several large-capacity wells producing from the Patapsco and Raritan formations, chiefly at the various U. S. Naval establishments.

In 4 wells at Glen Burnie in northern Anne Arundel County, which penetrated a total of 656 feet of the Patapsco formation, 19 percent of the material encountered was sand and 81 percent was clay and related sediments (128 feet of sand and 528 feet of clay). The proportion of sand to clay at Glen Burnie is approximately the same as the average for the Patapsco and Raritan formations in the Southern Maryland area.

In general, the ratio of sand to clay in the formations in Prince Georges and Charles Counties is less than in Anne Arundel County. The logs of 7 wells in the Bowie-Glenn Dale area show that, of a total of 1,814 feet of formations logged, 419 feet, or 23 percent, is sand and 1,395 feet, or 77 percent, is clay.

TABLE 11

Thickness, in feet, and percentage of different types of sediments encountered in wells penetrating the Patapsco and Raritan formations

Well	Locality	Thickness of formation penetrated (ft.)	Sand and/or gravel (ft.)	Sand and/or gravel (percent of formation)	Clay and sediments other than sand or gravel (ft.)	Clay, etc. percent of formation
AA-Ad 8	Curtis bay	130	80	61	50	39
Ae 4	do	165	67	41	98	59
Ae 5	do	163	72	44	91	56
Ad 29	Glen Burnie	130	16	12	114	88
Ad 40	do	100	33	33	67	67
Ad 41	do	148	40	27	108	73
Bd 23	do	278	39	14	239	86
Ae 28	Stony Creek	238	54	23	184	77
Be 48	do	254	81	32	173	68
Be 58	Lipins Corner	489	151	31	338	69
Bf 10	Bodkin Creek	431	226	52	205	48
Bc 1	Odenton	174	93	53	81	47
Bc 30	do	148	46	31	102	69
Bc 38	do	182	54	30	128	70
Bc 39	do	152	58	38	94	62
Bc 40	do	168	119	71	49	29
Bc 45	do	152	63	41	89	59
Cd 10	Crownsville	436	87	20	349	80
Ce 52	Arnold	200	44	22	156	78
De 44	Annapolis	522	89	17	433	83
Df 3	do	322	139	43	183	57
Df 4	do	294	63	21	231	79
Df 7	do	285	166	58	119	42
Df 19	do	318	79	25	239	75
Df 20	do	377	145	38	232	62
Df 59	do	746	137	18	609	82
PG-Be 5	Bowie-Glenn Dale	242	88	36	154	64
Be 6	do	179	12	7	167	93
Be 14	do	106	61	57	45	43
Ce 3	do	130	78	60	52	40
Ce 13	do	480	19	4	461	96
Ce 16	do	474	120	25	354	75
Ce 24	do	203	41	20	162	80

TABLE 11.—*Continued*

Well	Locality	Thickness of formation penetrated (ft.)	Sand and/or gravel (ft.)	Sand and/or gravel (percent of formation)	Clay and sediments other than sand or gravel (ft.)	Clay etc. percent of formation
PG-Ec 2	Oxon Hill	267	27	10	240	90
Ec 4	do	290	5	2	295	98
Ec 14	do	228	10	4	218	96
Ec 25	do	185	21	11	164	89
Dc 4	do	368	17	5	351	95
Bd 4	Beltsville	119	42	35	77	65
Bd 21	do	35	2	6	33	94
Bd 23	do	134	28	21	106	79
Bd 24	do	82	11	13	71	87
Bd 29	do	27	13	48	14	52
Bd 30	do	60	8	13	52	87
Ec 5	Camp Springs-Andrews Field	230	5	2	225	98
Ec 24	do	240	0	0	240	100
Ed 2	do	248	19	7	229	93
Ed 3	do	261	39	15	222	85
Ed 21	do	297	12	4	285	96
Ed 24	do	250	103	41	147	59
Ed 32	do	479	81	17	398	83
Ed 34	do	487	48	10	439	90
Eb 3	Fort Foote-Fort Washington	285	10	3	275	97
Eb 6	do	294	12	4	282	96
Fb 1	do	187	1	0.5	186	99.5
Fb 2	do	199	6	3	193	97
Fb 4	do	215	6	3	209	97
Fb 13	do	372	42	11	330	89
Fb 17	do	194	35	18	159	82
Fb 18	do	360	1	.3	359	99.7
Cd 1	Dodge Park	227	18	8	209	92
Cd 9	do	185	100	54	85	46
Cf 25	Hall	235	104	44	131	56
Dd 17	Seat Pleasant	214	33	15	181	85
Dd 3	Randolph Village	330	17	5	313	95

TABLE 11.—*Continued*

Well	Locality	Thickness of formation penetrated (ft.)	Sand and/or gravel (ft.)	Sand and/or gravel (percent of formation)	Clay and sediments other than sand or gravel (ft.)	Clay, etc. per cent of formation
Ch-Bb 7	Indian Head-Glymont	133	11	8	122	92
Bb 9	do	166	16	10	150	90
Bb 10	do	204	24	12	180	88
Bb 11	do	145	7	5	138	95
Bc 6	do	130	0	0	130	100
Bc 15	do	145	0	0	145	100
Bc 16	do	141	0	0	141	100
Cb 7	do	132	28	21	104	79
Cd 7	La Plata	164	11	7	153	93
Ce 8	do	436	82	19	354	81
Ce 16	do	208	33	16	175	84
All wells		18,404	3,748	20 (Average)	14,656	80 (Average)

In the Camp Springs-Andrews Field area the logs of 8 wells show that of a total of 2,492 feet of formation penetrated, only 307 feet, or 12 percent, is sand. An attempt was made to develop a ground-water supply at Andrews Field when this base was under construction, but as the yields of most wells were below the quantities desired, it was necessary to obtain water from another source (the District of Columbia municipal system). The sanding of a number of wells was also a contributing factor leading to the abandonment of the well supply.

Near Fort Foote and Fort Washington the proportion of sand to clay in the Patapsco and Raritan formations is the smallest in the Southern Maryland area. The logs of 8 wells penetrating a total of 2,106 feet of the formations show that only 113 feet, or 5 percent, consists of sand and gravel, 1,933 feet, or 95 percent, consists of clay or clayey sediments.

The logs of 8 wells in the Indian Head-Glymont area show that, of a total 1,196 feet of formation logged, 86 feet, or 7 percent, consists of sand and gravel. Although moderately large ground-water supplies have been developed in the Indian Head area, to obtain a sufficient quantity of water it has been necessary to screen the wells opposite sands in both the Patuxent and the Patapsco formations. Most of the wells at the Indian Head Naval Powder Factory are believed to be producing chiefly from sands in the Patuxent formation.

Mechanical analyses.—Mechanical analyses of six samples of sand and gravel from the Patapsco and Raritan formations are shown in figure 4. Five of the

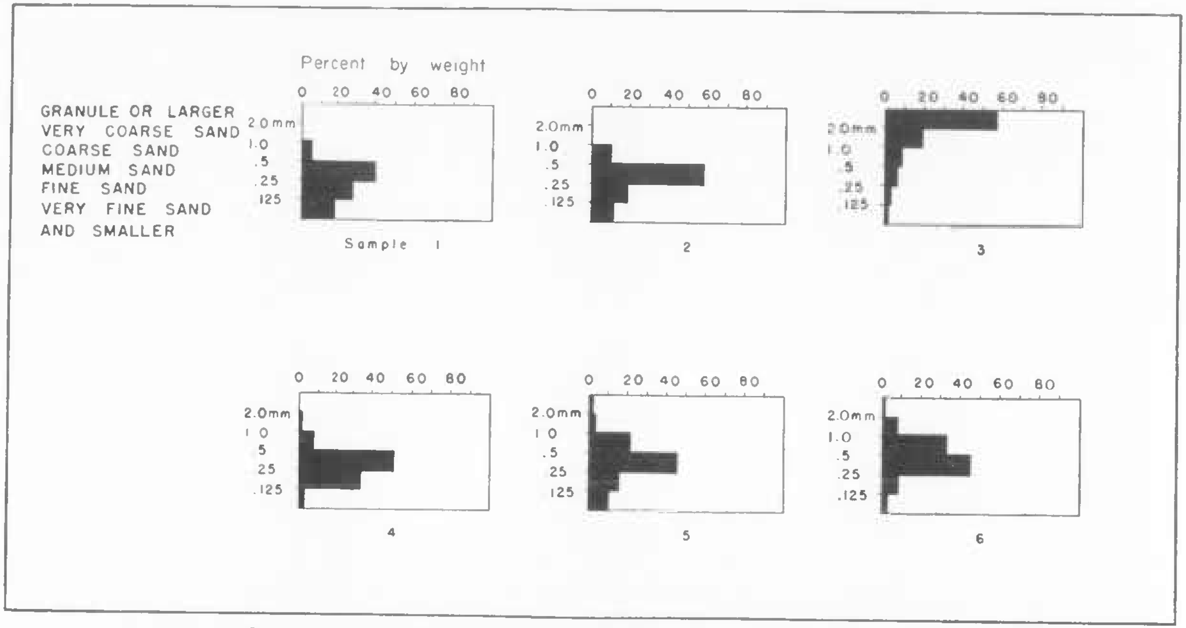


FIG. 4. Histograms of samples from the Patapsco and Raritan formations

Samples 1. Sand about 5 feet above base of exposure of Raritan formation near Benfield along the Severn River, Anne Arundel County.

2. Sand from depth 74 to 79 feet, well AA-Be 75, drilled for M. Madary near Pasadena, Anne Arundel County.

3. Sand from depth 240 to 244 feet, well PG-Dd 19, drilled for the County Commissioners near Forestville, Prince Georges County.

4. Sand from depth 458 to 463 feet, well PG-Fc 16, drilled for the Maryland Vestar Corp. near Accokeek, Prince Georges County.

5. Sand from depth 400 to 410 feet, well Ch-Cd 9, Port Tobacco School, Charles County.

6. Sand from depth 410 to 420 feet, well Ch-Cd 9, Port Tobacco School, Charles County.

samples were obtained from drilled wells and one from an exposure of cross-bedded sand in the vicinity of the Severn River in Anne Arundel County. The number of analyses is insufficient to evaluate the size characteristics of the sands throughout the formations. However, the samples show, in general, that the sands in the Patapsco and Raritan formations are only moderately well sorted and that in five of the six samples medium sand (0.25 to 0.5 mm.) is the chief constituent. About 55 percent of the material in sample 3, from a well near Forestville in Prince Georges County, is classed as granule or larger (greater than 2.0 mm.). Layers of fine gravel similar to that of sample 3 are commonly reported by drillers in the Patapsco and Raritan formations in northern Anne Arundel County.

Heavy minerals.—Plate 2 shows graphically the heavy-mineral suites of 14 samples of the Patapsco formation from 3 wells, 3S5E-32, 5S3E-46, and AA-Bd 23. One suite only is from well 3S5E-32, drilled for the Chemical & Pigment Co. of Baltimore. The other suites are from 2 wells located, respectively, in the Curtis Bay district of Baltimore and in northern Anne Arundel County. Authigenic minerals are largely absent in well 5S3E-46 and hornblende and zircon are the dominant detrital minerals; epidote is present in moderate amounts; staurolite, tourmaline, kyanite, rutile, and anatase are minor minerals. Authigenic and platy minerals are present in minor amounts only in the suites from well AA-Bd 23. Tourmaline and zircon are the predominant detrital minerals; chloritoid, staurolite, epidote, garnet, and sillimanite are minor detrital minerals. The high hornblende content of well 5S3E-46 may be the result of contamination of the sample cuttings from the overlying Pleistocene deposits, which are present to a depth of 45 feet in this well. Otherwise, the mineral suites from the two wells are similar. Bennett and Meyer (1952, p. 62) found only moderately small amounts of hornblende in 7 heavy-mineral suites from a well drilled into the Patapsco formation in the Sparrows Point district of Baltimore County, whereas the Pleistocene deposits in this well contain a large proportion of hornblende. Suites of outcrop samples of the Patapsco formation listed by Bennett and Meyer have tourmaline and zircon as the dominant detrital minerals.

In summary, no valid criteria have been established for separating the formations of the Potomac group on the basis of the heavy-mineral suites from wells and outcrop samples. It is not implied, however, that such criteria cannot be established if a study is made of a large number of suites obtained from wells or outcrops that are adequately distributed geographically.

Thickness and stratigraphic relations.—The thickness of the Patapsco and Raritan formations in the Southern Maryland area ranges from a featheredge along the western part of the outcrop belt to at least 746 feet in well AA-Df 59 in the Annapolis area. Near Glen Burnie, where only the Patapsco formation is present, its thickness ranges from 130 to 278 feet. Near Odenton, a few miles south of Glen Burnie, 182 feet of the Patapsco formation was penetrated in well AA-Bc 38 without reaching the underlying Arundel clay. In a deep test well drilled to the base of the Patuxent formation at the Glenn Dale Sanatorium (PG-Ce 13) in Prince Georges County 480 feet of combined Patapsco and Raritan formations was penetrated. At La Plata in Charles County 436 feet of sediments constituting the Patapsco and Raritan formations were encountered in well Ch-Ce 8 at depths of 380 to 816 feet. In the parts of Anne Arundel, Prince Georges, and Charles Counties where the Patapsco and Raritan formations are extensively utilized as a source of ground water, they are from 150 to 700 feet thick.

The thickness of the individual beds of water-bearing sand ranges from a few inches to a reported maximum of 57 feet. A water-bearing sand and gravel is 57 feet thick, at a depth of 523 to 580 feet, in well AA-Df 16 at the U. S. Naval Academy. In the vicinity of Glen Burnie 24 feet of coarse water-bearing sand and gravel was penetrated by well AA-Bd 23 at a depth of 101 to 125 feet; a 1-foot clay streak was reported in the middle of the sand.

Solid beds of variegated clay in the Patapsco and Raritan formations exceed 200 feet in thickness in some wells in western Prince Georges County, but commonly in southern Maryland the individual clay beds are less than 100 feet in thickness. A zone of gray, brown, and yellow clay with interspersed thin sandy layers was reported to be 209 feet thick at a depth of 130 to 339 feet in well PG-Fb 4 near Accokeek in Prince Georges County.

The Patapsco formation lies unconformably on the Arundel clay or directly on the Patuxent formation where the Arundel clay is absent. The Patapsco formation is said (Clark and others, 1916b; p. 59) to be separated from the Raritan formation by an unconformity, but the similarity of the sediments comprising the two formations makes difficult its recognition and tracing. If it exists in Southern Maryland, the unconformity is probably marked chiefly by differences in the flora of the two formations. The Raritan formation is separated from the overlying Magothy formation by an unconformity. The contact between the two units is usually recognized by the presence of vari-colored clays (chiefly reddish) in the Raritan which contrast with the drab or dull-gray clays and carbonaceous sands of the Magothy formation. In places the Magothy is absent and the marine Cretaceous, Paleocene, or Eocene strata directly overlie the Patapsco or Raritan formation. In southeastern Prince Georges County and in central and western Charles County the overlap of the younger strata on the Patapsco and Raritan formations becomes important with respect to the availability of ground-water supplies. Here the Magothy formation (an important aquifer) is absent and the Patapsco formation is over-lain by the relatively impervious, nonproductive Monmouth and Brightseat formations. Because of the absence of the Magothy formation, and because of the clayey nature of all the formations, it has been necessary to drill some wells

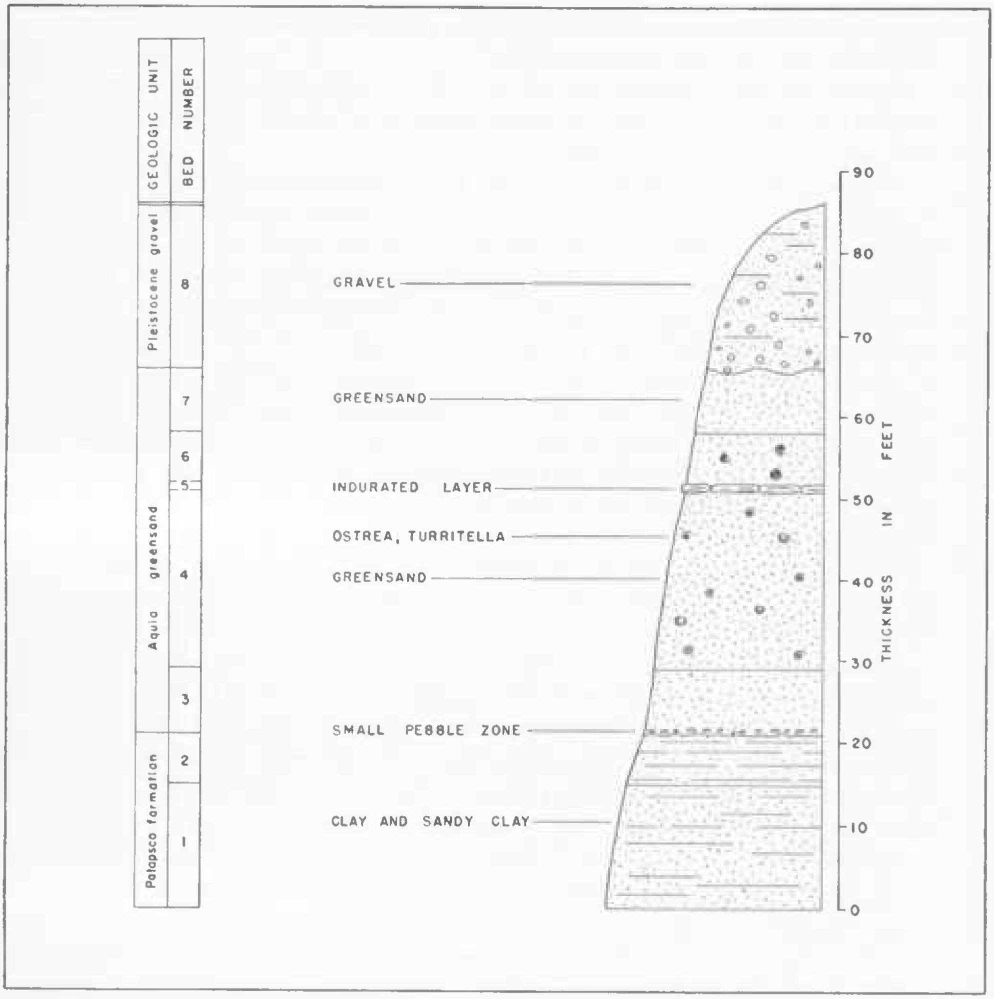


FIG. 5. Geologic section near Glymont (Charles County) showing the Pleistocene deposits and the Aquia greensand overlying the Patapsco formation

Bed No.	
8	Reddish material with pebbles and boulders.
7	Light yellowish and greenish sands; greensand without fossils, much weathered.
6	Greensand with fossils, much weathered toward top.
5	Indurated zone, impressions and shells.
4	Fossiliferous greensand; quite green but not dark. *Ostrea* and *Turritella* common.
3	Greensand without fossils; quite dark near base and lighter (more weathered?) upward. Sharp contact, with few small pebbles above base. Minor erosional irregularities.
2	Light blue or olive yellowish or brownish clays, weathering light gray to whitish.
1	Yellow sands and sandy clays. Firmly indurated zone ½-inch thick at top.

to considerable depths into the Patapsco or Raritan formation before water-bearing sands have been encountered.

Dryden (Dryden, Overbeck and others, 1948, p. 78) describes an exposure in western Charles County where the Aquia greensand of Eocene age rests unconformably on the Patapsco formation (fig. 5).

The upper surface of the Patapsco and Raritan formations slopes generally to the southeast. The degree of slope, or the dip, varies from place to place. Well logs at Crownsville and Annapolis show that the top of the Raritan formation dips southeast about 183 feet in approximately 7 miles, or about 26 feet per mile. Southwestward the slope of the surface increases to about 37 feet per mile from well PG-Df 16 near Hardesty to well AA-Fd 13 near Mount Zion. In central Prince Georges County the upper surface of the formations is irregular and the records of some wells indicate a local reversal of the general slope direction. Thus, the log of well PG-Ec 5, near Oxon Hill, shows that the top of the Patapsco formation is 80 feet above sea level, and the log of well PG-Ec 1, located 1.5 miles north of PG-Ec 5, shows the top of the formation is 25 feet above sea level, indicating a northward dip of 55 feet between the two wells. Eastward from Pomonkey to Bryantown, in Charles County, the top of the Raritan formation declines 377 feet in a horizontal distance of 14 miles, or about 27 feet per mile (see logs of wells Ch-Bc 12 and Ch-Cf 9).

Water-bearing properties.—Although the Patapsco and Raritan formations include the most extensively developed aquifers in Southern Maryland, their hydrologic properties vary considerably from one locality to another. The yields of wells ending in the formations range from a few gallons a minute in many domestic wells to as much as 1,000 gallons a minute (reported from well AA-Df 12 at the U. S. Naval Academy). In general, the highest yields are obtained where comparatively thick beds of coarse, clean sand and gravel are encountered. The individual water-bearing sands, however, are irregular in extent and character, and can seldom be traced for more than a few miles.

At Glen Burnie, in northern Anne Arundel County, a lens of water-bearing sand and gravel in the Patapsco formation can be traced throughout an area of about 5 square miles. This sand has a maximum thickness of about 40 feet, as is shown in the log of well AA-Ad 2. Its upper surface slopes eastward from approximately 25 feet above sea level in well AA-Bd 34 near Harmans to approximately 70 feet below sea level in well AA-Bd 37 at Harundale. The public-supply wells at Glen Burnie produce from this sand; one well produces about 450 gallons a minute, and all the large-capacity wells average about 250 gallons a minute. Thin clay streaks within the aquifer are reported in a few of the logs, but the sand is generally coarse and permeable.

Near Odenton and Gambrills at least three water-bearing sands have been identified at different stratigraphic positions in the Patapsco formation. The uppermost sand, about 10 feet thick, has been identified in three wells (AA-Bc

31, AA-Bc 38, and AA-Bc 39), where its top lies at an altitude of 60 to 75 feet above mean sea level. The sand yields water to one of these wells, but is reported to be fine-grained in the other two wells. In several wells the interval in the formation occupied by this sand is reported as sandy clay. The sand varies in water-bearing properties from well to well and is so clayey in some places that it is not capable of yielding water to wells. A deeper sand in the Odenton area is utilized as the source of industrial ground-water supply at the plant of the National Plastic Products Co. This sand, which is about 35 feet thick, has been identified in the logs of 9 wells in the area, and can be traced as a continuous unit throughout 3 square miles from the west end of Odenton eastward to the U. S. Naval Academy Dairy at Gambrills. Its top is approximately at sea level in well AA-Bc 23 and slopes eastward to about 50 feet below sea level at Gambrills. The sand in most wells is reported to be coarse and permeable. One 12-inch-diameter well of the National Plastic Products Company (AA-Bc 40) yields more than 500 gallons a minute from it. A third and still deeper water-bearing sand is penetrated by only one well, AA-Cc 2 at the Naval Academy Dairy. No log is available for well AA-Cc 2, but it is assumed that the top of the 20-foot screen in the well is opposite the top of the sand body, which is about 278 feet below sea level. In 1914 the well reportedly yielded 42 gallons a minute, but it has since been abandoned.

The water-bearing properties of the Patapsco and Raritan formations in Southern Maryland can be roughly evaluated by comparing the yields and specific capacities of wells grouped according to localities or areas where the formations are utilized as a source of ground water. Table 12 shows the yields, lengths of screen, drawdowns, and specific capacities of 78 wells producing from the Patapsco, Raritan, or both. Many domestic wells with small yields have been omitted from the table in order to indicate more clearly the maximum yields obtained. The specific capacities range from 0.1 (wells PG-Ec 14 and PG-Dc 3) to 12.0 (well AA-Df 5). The average specific capacity for the formations as a whole, based on the yields of 66 wells, is 3.2 gallons per minute per foot

The specific capacities of 8 wells in the Annapolis area range from 0.1 to 12.0 and average 9.5 gallons per minute per foot. The yields of the large-capacity wells at Annapolis are among the highest known in Southern Maryland. The average yield of 8 of the best wells is about 600 gallons a minute. The yield per foot of screen is about 11 gallons a minute.

The specific capacities of 7 wells in the Glen Burnie area range from 3.7 to 8.8 gallons per minute per foot and average 6.3 gallons. Yields of the large-diameter wells in this group range from 96 to 467 gallons a minute. The yield per foot of well screen is approximately 17 gallons a minute.

The specific capacities of wells in the Odenton-Gambrills area range from 0.7 to 11.4 and average 4.8 gallons. The yields of the five most productive wells

TABLE 12

Yields and specific capacities of wells screened in the Patapsco and Raritan formations

Well	Locality	Diameter of casing (in.)	Length of screen (ft.)	Yield (gal./min.)	Drawdown (ft.)	Specific capacity (gal./min./ft.)
AA-Ae 10	Curtis Bay	10	—	35	17	2.1
Bf 1	Fort Smallwood-Pinehurst	6-4½	16	50	—	—
Bf 2	do	8-6	19	84	34	2.5
Bf 5	do	6	8	50	35	1.4
Bf 6	do	8-6-4½	16	90	16	5.6
Bf 19	do	3	—	15	5	3.0
Ae 4	North Linthicum-Friendship	6	12	50	40	1.2
Ad 44	do	8	10	100	42	2.4
Ad 1	Glen Burnie	18	—	220	—	—
Ad 2	do	8	10	280	32	8.8
Ad 23	do	18	10	150	—	—
Ad 40	do	20-10	22	292	34	8.6
Ad 41	do	18-8	20	250	58	4.2
Bd 1	do	18	—	178	48	3.7
Bd 2	do	10	—	96	19	5.0
Bd 36	do	20	25	439	66	6.6
Bd 37	do	20-10	25	467	63	7.4
Bc 1	Odenton-Gambrills	10-8	20	250	47	5.3
Bc 20	do	8	21	307	55	5.6
Bc 31	do	6	5	15	20	.7
Bc 40	do	16-12	22	527	46	11.4
Cc 1	do	10	—	260	—	—
Cc 2	do	—	19	42	—	—
Cc 22	do	4	10	150	—	—
Cc 27	do	6	7	30	30	1.0
Cd 10	Crownsville	8-6	12	120	—	—
Be 51	Pasadena	4	3	10	3	3.3
Ce 52	Arnold	6-2	22	90	22	4.1
Cf 1	Gibson Island	10-8-6	20	100	82	1.2
Cf 2	do	20-10	15	300	71	4.2

TABLE 12.—*Continued*

Well	Locality	Diameter of casing (in.)	Length of screen (ft.)	Yield (gal./min.)	Drawdown (ft.)	Specific capacity (gal./min./ft.)
AA-Df 4	Annapolis	12-10-8	6	300	—	—
Df 5	do	15-12-10	36	748	62	12.0
Df 6	do	12-10-8	32	374	45	8.3
Df 7	do	12-10-8	34	501	46	10.9
Df 8	do	12-10-8	42	498	43	11.6
Df 12	do	18	67	1,000	105	9.5
Df 13	do	18	70	920	95	9.7
Df 16	do	12	142	620	44	14.0
Df 20	do	10-8-6	40[a]	28	172	.1
PG-Be 4	Bowie-Glenn Dale	—	—	40	—	—
Be 15	do	4	5	21	20	1.0
Ce 1	do	6	None	10	10	1.0
Ce 2	do	6	do	10	5	2.0
Ce 3	do	6	—	10	15	.6
Ce 13	do	10-4½	—	50	15	3.3
Ce 24	do	6	5	30	105	.3
Cf 4	do	6	6	15	30	.5
Ce 18	Woodmoor	6-4	10	45	20	2.3
Cf 25	Hall	6	6	60	40	1.5
Dc 1	Silver Hill	6	—	23	25	0.9
Dc 3	do	6	—	20	140	.1
Dc 4	do	8-6	15	50	125	.4
Dd 2	Largo	6	10	20	20	1.0
Dd 3	do	8	11.5	25	159	.2
Eb 3	Fort Foote-Fort Washington	6	None	10	10	1.0
Eb 6	do	6	6	60	88	.7
Eb 7	do	6	6	33	100	.3
Eb 8	do	8	14	50	80	.6
Ec 10	do	6	11	40	105	.4
Ec 1	Clinton	—	—	40	30	1.3
Ec 2	Oxon Hill	6	10	10	30	0.3
Ec 4	do	6	None	10	30	.3
Ec 14	do	6	10	20	150	.1
Ec 25	do	6	13	40	36	1.1
Ec 26	do	6	6	40	66	.6

TABLE 12.—*Continued*

Well	Locality	Diameter of casing (in.)	Length of screen (ft.)	Yield (gal./min.)	Drawdown (ft.)	Specific capacity (gal./min./ft.)
PG-Ed 2	Camp Springs-Andrews Field	8 or 6	—	60	60	1.0
Ed 4	do	8	10	50	23	2.2
Ed 22	do	—	—	50	—	—
Ed 32	do	8-6	38	80	—	—
Ed 33	do	8-6	9	50	100	.5
Ed 34	do	8	20	135	79	1.7
Ch-Cc 7	La Plata-Port Tobacco	6	5.5	35	100	0.3
Cd 9	do	6	7	40	204	.2
Ce 16	do	8-6	15	60	—	—
De 1	do	6	7	24	30	.8
Bc 13	Indian Head-Glymont	6	None	10	20	0.5
Cb 6	do	4	5	35	6	5.8
Cb 7	do	8-6	12	151	54	2.8

[a] Also producing from the Magothy formation.

in the area average about 290 gallons a minute. The average yield per foot of screen is about 13 gallons a minute.

The specific capacities of 7 wells in the Bowie-Glenn Dale area of Prince Georges County range from 0.3 to 2.0 and average 1.2 gallons. The yields of the five most productive wells average about 30 gallons a minute. The yield per foot of screen (only 3 wells) averages slightly more than 4 gallons a minute.

The specific capacities of 4 wells in the Camp Springs-Andrews Field area range from 0.5 to 2.2 and average 1.3. The yields of the 6 best wells average 70 gallons a minute, and the yield per foot of screen averages 4.1 gallons a minute.

The specific capacities of 5 wells in the Fort Foote-Fort Washington area range from 0.4 to 1.0 and average 0.6. The reported yields of the four most productive wells average 45 gallons a minute, and the yield per foot of screen averages 5.2 gallons a minute.

The specific capacities of wells producing from the Patapsco and Raritan formations in Southern Maryland show that their water-bearing properties change from place to place. Where the sands are thin or less permeable, the formations have not been extensively utilized as a source of water supply. Where the sands and gravels are thick, permeable, and capable of yielding large quantities of water, they have been extensively utilized, as in the Glen Burnie, Odenton, and Annapolis areas.

In the Annapolis area and at Gibson Island the high iron content of the water from the Patapsco and Raritan formations has necessitated treatment before use; because of the poor quality of the water, these formations have not been tapped extensively by either domestic or commercial wells.

Permeability, transmissibility, and storage coefficients.—The results of several pumping tests on wells tapping the Patapsco and Raritan formations in Southern Maryland show a wide range in the coefficients of transmissibility and permeability. Pertinent data concerning these tests are shown in Table 13. As most of the wells tested are in Anne Arundel County, the results are weighted in favor of that county. The coefficients of transmissibility determined from the tests range from 1,300 gallons per day per foot in well PG-Eb 7 in the Fort Foote area to 76,400 gallons per day per foot in well AA-Ad 2 near Glen Burnie. Coefficients of permeability range from 140 to about 3,300 gallons per day per square foot. As these figures represent a sampling of scattered segments of the formations, it is doubtful if an average of all the tests would be of special significance.

A series of pumping tests made on the public-supply wells of the Anne Arundel County Sanitary Commission at Glen Burnie and Harundale furnish fairly reliable values for the coefficients of permeability and transmissibility for the Patapsco formation there. The wells penetrate a 25-foot-thick water-bearing sand in the Patapsco formation, which is 150 to 250 feet thick at Glen Burnie. Field coefficients of permeability range from 820 to 3,300 and average 1,400 gallons per day per square foot. Coefficients of transmissibility range from 21,300 to 76,400 and average 35,600 gallons per day per foot. The figure of 1,400 for the field coefficient of permeability is higher than the average figure of 320 reported by Bennett and Meyer (1952, p. 66) for the lower part of the Patapsco formation in the Sparrows Point district of the Baltimore industrial area, indicating that the formation is more permeable in the Glen Burnie area. The trend of increased permeability southwestward from the Sparrows Point district is confirmed by the field coefficient of permeability of 970 gallons per foot reported by Bennett and Meyer as the result of a pumping test in the Curtis Bay district.

Values of the coefficient of storage, exclusive of the high figure of 0.0010 obtained from the test on well AA-Ad 2, range from 0.00003 to 0.00053 and average 0.0002 cubic foot per foot. This average is a reasonable coefficient of storage for an unconsolidated sand where the ground water occurs under artesian conditions. The duration of pumping in some of the tests was not long enough to obtain a more reliable figure for the coefficient of storage.

The field coefficients of permeability derived from a series of pumping tests on wells tapping the Patapsco and Raritan formations in the Annapolis area range from 230 to 850 gallons per day per square foot and average about 580, indicating that the formations are less permeable in the Annapolis area than

TABLE 13

Summary of permeability, transmissibility, and storage coefficients of the Patapsco and Raritan formations

Well	Location	Duration of test (min.)	Screen length in well (ft.)	Effective sand thickness[b] (ft.)	Analysis formula	Coefficient of transmissibility (gal./day/ft.)	Field coefficient of permeability (gal./day/ft.²)	Coefficient of storage (cu.ft./ft.)	Estimate of accuracy of test
AA-Ad 3	Linthicum	27	13	24	Recovery	4,930	205	—	Good
Ad 2	Glen Burnie-Harundale	375	30	30	Nonequilibrium (Theis)	33,050	1,100	0.00012	Good
Ad 2	do	375	30	30	Nonequilibrium (Jacob)	24,600	820	.00018	Good
Ad 40	do	495	22	23	Nonequilibrium (Theis)	76,400	3,320	.0010	Fair
Ad 41	do	495	10	25	do	34,880	1,390	.00053	Good
Ad 41	do	510	10	25	Nonequilibrium (Jacob)	48,900	1,950	.00031	Good
Bd 36[a]	do	445	25	25	Recovery	21,400	850	—	Fair
Bd 37	do	405	25	25	Nonequilibrium (Theis)	37,000	1,480	.00003	Good
Bd 37	do	456	25	25	Nonequilibrium (Jacob)	21,300	850	.00007	Good
Bd 37	do	510	25	25	Recovery	22,870	910	—	Good
Bc 20	Odenton	460	21.5	30	Nonequilibrium (Theis)	51,100	1,030	.00021	Good
Bc 20	do	452	21.5	30	Nonequilibrium (Jacob)	20,500	680	.00001	Good
Bc 47[a]	do	300		30±	Recovery	33,600	1,120	—	Fair
Bf 2[a]	Fort Smallwood	123	18	85	do	20,970	240	—	Good
Cc 1[a]	Gambrills	185	—		do	40,790	2,060	—	Good

Df 12	Annapolis (U. S. Naval Academy)	840	67	61	Nonequilibrium (Theis)	52,100	850	.00001	Good
Df 12	do	840	67	61	Nonequilibrium (Jacob)	38,500	630	.00061	Good
Df 14	do	413	—	76	Nonequilibrium (Theis)	45,400	600	.00018	Fair
Df 16[a]	do	367	117	76	Recovery	17,300	230	—	Fair
PG-Eb 7[a]	Fort Foote	357	10	9	do	1,300	140	—	Good
Ch-Cb 7[a]	Indian Head	45	14	14	do	8,690	640	—	Fair

[a] Pumped well.
[b] Thickness of saturated aquifer or thickness of screened aquifer.

at Glen Burnie. The thickness of the combined Patapsco and Raritan formations at Annapolis is in excess of 700 feet, and the wells tap water-bearing sands approximately 60 to 75 feet thick. Coefficients of transmissibility range from 17,300 to 52,100 gallons per day per foot and average 38,300, or about the same as at Glen Burnie. Three coefficients of storage in the Annapolis area range from 0.00001 to 0.00061 and average 0.00026. This average is in the general range of coefficients of storage obtained where the ground water in unconsolidated sedimentary deposits occurs under artesian conditions.

On the basis of a recovery test on well PG-Eb 7 in the Fort Foote area of Prince Georges County, the coefficient of permeability of a 9-foot sand in the Patapsco formation is 140 gallons per day per square foot and the transmissibility is 1,300. Although one test is not an adequate sampling of the hydrologic properties of the formation, the results of this test are in agreement with the low yields and low specific capacities of the wells tapping the Patapsco and Raritan formations in western Prince Georges County along the Potomac River valley (Table 12). The formations are probably poorer aquifers in this area because of the greater proportion of clay and sandy clay. It is doubtful, therefore, if large ground-water supplies are available from the Patapsco and Raritan formations in the Oxon Hill-Fort Foote area.

Magothy formation

Distribution and character.—In Anne Arundel County the Magothy formation, of Late Cretaceous age, is irregularly but prominently exposed along a belt about 5 miles wide near Severna Park and in the interstream area between the Severn and Magothy Rivers. Southward its outcrop belt narrows to about 3 miles in the vicinity of the little Patuxent River. On the geologic map accompanying Darton's report (1939) on the gravel and sand deposits of eastern Maryland it is shown to occupy a rather narrow outcrop belt in Prince Georges County southwestward from the Patuxent River to Glenn Dale. Cooke (1952, p. 7), however, believes that the formation is overlapped by the Monmouth formation in Prince Georges County, and does not show it on the revised geologic map of the county (Cooke and Cloos, 1951).

The Magothy formation consists chiefly of lignitic or carbonaceous light gray to yellowish quartzitic sand with interspersed clay layers. The sand commonly is coarse and slightly arkosic, and in many places is crossbedded or laminar. Nodules and undulating bands of iron oxide are present in some places. Pyrite is a common mineral in the sand, as is glauconite in places. The somewhat plastic clay layers are gray, grayish black, or brown and in some outcrops occur as lenses which grade rapidly horizontally into sandy clay or clean sand. An excellent exposure of the formation occurs in the bluffs of the Severn River at Sullivan Cove, just south of Severna Park. This exposure, measured and described by R. M. Overbeck, is shown graphically in figure 6.

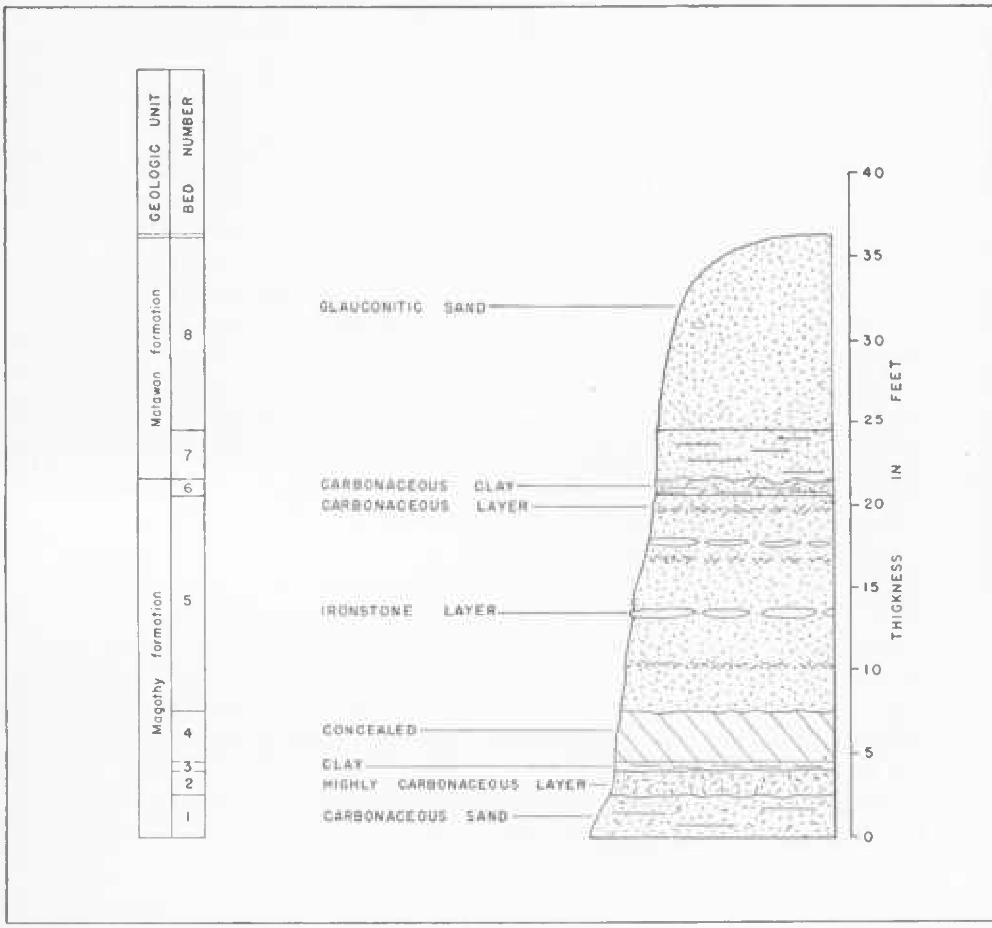


FIG. 6. Geologic section at Sullivan Cove on the Severn River (Anne Arundel County) showing the Magothy formation overlain by the Matawan formation

Bed No.	
8	Light-grayish glauconitic sand.
7	Pale-brownish glauconitic and argillaceous sand.
6	Pale brown sandy clay carrying pieces of lignite; pale brown clay.
5	Rather thin-bedded, cross-bedded coarse white sand, iron layers, and carbonaceous layers.
4	Concealed, but probably as above.
3	Brown carbonaceous clay.
2	Very carbonaceous beds, black and brown.
1	White sand and dark interbedded carbonaceous material.

Subsurface character.—Throughout most of the Southern Maryland area the Magothy formation can be identified readily in the well cuttings or in the drillers' logs by its stratigraphic position and by the grayish-white or grayish color of the sands, which frequently have a high content of carbonaceous matter. The clays of the Magothy formation generally lack the pink or reddish hue common to the clays of the underlying Raritan formation. The Magothy may be distinguished from the overlying Matawan or Monmouth formations chiefly by its lesser glauconite content, its lighter color, and by the more clayey nature of the overlying formations.

The Magothy formation is one of the important aquifers in the Southern Maryland area where a number of drilled wells utilize it as a source of supply. The logs of 12 wells in Anne Arundel County that penetrate a total of 1,317 feet of the formation show that 1,137 feet (or 86 percent) is sand and gravel, and 180 feet (or 14 percent) is clay and related sediments. The logs of 9 wells completely penetrating the formation in Prince Georges County show that of 375 feet of formation 280 feet (or 75 percent) is sand and 95 feet (or 25 percent) is clay. Near Annapolis and Sandy Point the formation consists almost entirely of sand and gravel; some of the logs show no clay. In central Anne Arundel County the Magothy is not readily distinguishable, in the drillers' logs or in the sample cuttings, from the upper part of the Raritan formation which commonly consists of similar coarse clean sand and sandy gravel. However, the top of the Raritan in a few wells in central Anne Arundel County and in most wells in Prince Georges and northern Charles Counties is characterized by a red or pinkish clay which can be distinguished from the grayish-white or gray clay of the Magothy.

The sediments composing the Magothy formation are believed to have been deposited mainly in a deltaic and lagoonal environment. Many of the sands are typical of those deposited in meandering streams, and the abundance of lignitic matter suggests that swamp conditions existed in which plant life flourished. The presence of thick beds of coarse sand and gravel in the Annapolis-Sandy Point area may indicate a high rate of deposition during Magothy time by rather active stream currents carrying considerable amounts of coarse sediments from the Piedmont uplands.

In some localities the top of the Magothy formation consists of medium to coarse gray sand, but in other places it is characterized by gray sandy clay, although medium to coarse sand is usually present within a few feet of the top.

Mechanical analyses.—Sieve analyses of six samples of sand and gravel from the Magothy formation are shown in figure 7. Two of the samples are from outcrops of the formation and four are from well cuttings. The samples show only a moderate degree of sorting and are characteristic of stream-channel sands and gravels. In five of the six samples medium sand (0.25 to 0.5 mm.) is the chief constituent, and the fine-grained fractions are largely lacking. Sample

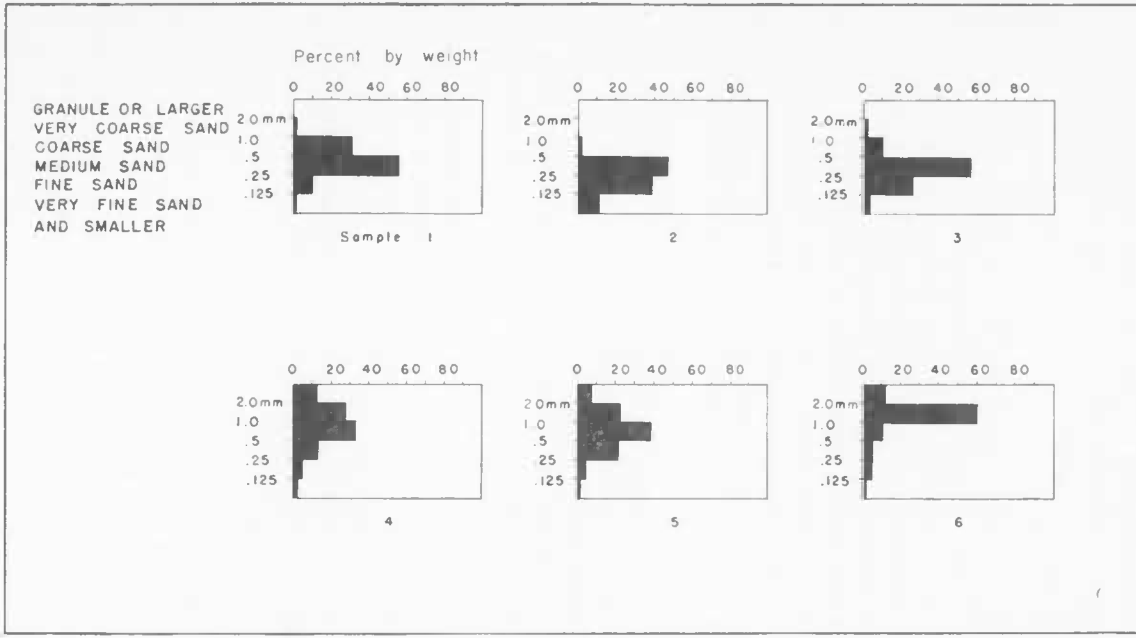


FIG. 7. Histograms of samples from the Magothy formation

Samples 1. Outcrop sample at base of bed no. 5 at Sullivan Cove near Severna Park, Anne Arundel County (fig. 6).
2. Outcrop sample about 5 feet above base of north wall at the pit of the Arundel Corp. at Pasadena, Anne Arundel County.
3. Sand from depth 161 to 171 feet, well PG-De 18 at the Maryland Tobacco Research Farm north of Upper Marlboro, Prince Georges County.
4. Sand from depth 351 to 366 feet, well PG-Ef 3, drilled for G. Buchheister near Upper Marlboro, Prince Georges County.
5. Sand from depth 170 to 185 feet, well AA-Dc 7, drilled for the Department of Defense near Priest Bridge, Anne Arundel County.
6. Sand from depth 110 to 121 feet, well AA-Cd 33, St. Stephens Church, Anne Arundel County.

6 (well AA-Cd 33) is chiefly coarse material, containing 61 percent in the very coarse sand fraction (1.0 to 2.0 mm.) and 12 percent in the fine gravel fraction (2 to 8 mm.). This sand is highly permeable and is an excellent source of ground water. No mechanical analyses were made of the clay layers in the Magothy formation.

Thickness and stratigraphic relations.—The Magothy formation varies in thickness throughout Southern Maryland, ranging from a featheredge at its outcrop to a maximum of 130 feet near Annapolis. In the logs of some wells in the Annapolis area the Magothy formation is not readily separated from the underlying Raritan because of the lithologic similarity of the sands of the two formations. However, the driller's log and sample-study log of well AA-De 45 (City of Annapolis) show 130 feet of grayish-white to gray coarse sand and gravel, probably the Magothy formation, underlain by 160 feet of bluish-gray and reddish-brown clay and sandy clay typical of the Raritan formation. The driller's log of well AA-Df 10 (U. S. Naval Academy) shows about 130 feet of sand and clay of the Magothy formation underlain, at a depth of 307 feet, by 30 feet of red clay marking the top of the Raritan formation. As the Magothy is only about 40 feet thick at Sullivan Cove, the subsurface information indicates a southward basinlike thickening toward Annapolis where the formation apparently attains its maximum thickness. Two miles east of Priest Bridge near the Patuxent River well AA-Dc 5 penetrated 71 feet of the Magothy formation. In the vicinity of Collington, Prince Georges County, well PG-Cf 4 encountered 51 feet. At Andrews Field, 5 miles southeast of the District of Columbia, the formation is about 43 feet thick, as shown by the driller's log of well PG-Ed 24. It is 49 feet thick in well PG-Fd 11 at the Cheltenham Naval Communication Station in southern Prince Georges County. The formation ranges from 25 to 50 feet in thickness throughout most of its extent in Prince Georges County, but it probably thins rapidly in northwestern Charles County; only 4 feet was encountered in well Ch-Bc 12 near Pomonkey. It is at least 18 feet thick near Waldorf, as shown by the log of well Ch-Bf 5 (Maryland State Police Barracks) which did not completely penetrate the formation, but appears to be absent at La Plata and southward. East of La Plata it may thicken somewhat, as it is about 75 feet thick in well Ch-Cf 9 at Bryantown.

In the Annapolis area the thickness of the individual beds of sand and gravel in the Magothy ranges from a few feet to about 50 feet, according to well logs. Near Upper Marlboro individual beds range in thickness from a few feet to as much as 31 feet.

Throughout part of Prince Georges and northern Charles Counties the Magothy formation is overlapped by the Monmouth formation. Plate 3, showing by contours the approximate altitude of the uppermost water-bearing sand in the Magothy formation, also shows that the sands on the Magothy formation are not present in Prince Georges County west and northwest of a line extending from Bowie southward through Morningside and east of Piscataway. In Charles County the formation thins markedly west of Pomonkey and south of White Plains. It is not known if it was deposited in the area west of these towns and later removed by erosion, or if it was never deposited there. The Magothy unconformably overlies the Raritan formation throughout most of the Southern Maryland area.

The Magothy formation strikes generally northeast and the dip, or rate of slope, is fairly uniform throughout the Southern Maryland area. From Gambrills to the south bank of the West River the top of the uppermost sand declines 545 feet in a horizontal distance of 16.5 miles or at the rate of about 33 feet per mile. In northern Calvert County the dip of the formation decreases to about 20 feet per mile. In a few localities, as in the vicinity of Camp Springs, the dip increases to about 48 feet per mile. The average dip in Southern Maryland is about 35 feet per mile.

Water-bearing properties.—The water-bearing sands in the Magothy formation are sufficiently coarse and permeable to yield ample supplies of water to drilled wells throughout most of the area where they have been encountered. At Annapolis yields of as much as 1,000 gallons a minute have been obtained from large-diameter wells. However, in a few localities, particularly near its outcrop area in Prince Georges County, the formation does not yield water to wells, and to obtain adequate supplies it has been necessary to drill to deeper aquifers, usually to sands in the Raritan or Patapsco formation. In some places the clayey nature of the upper part of the Raritan formation necessitates drilling to depths of 200 to 300 feet below its top before an aquifer capable of yielding even domestic supplies is encountered.

In and near Upper Marlboro and Brandywine the formation is separated into two sands, the uppermost of which is fine-grained and clayey in some wells. This condition was encountered in well PG-Ef 3 (Buchheister well) a few miles northeast of Upper Marlboro; the well was originally screened opposite 10 feet of water-bearing sand at a depth of 324 to 334 feet, but a satisfactory supply of clear water could not be obtained at this depth, and the well was later drilled to 366 feet. The top of a deeper sand, which yielded 35 gallons a minute, was encountered at a depth of 351 feet. The log of well PG-Ed 32, supplying a housing development north of Camp Springs, shows 15 feet of fine muddy sand at a depth of 265 to 280 feet which was not sufficiently permeable to be utilized as a source of ground water.

The log of well PG-Ed 34, 1.4 miles northeast of PG-Ed 32, shows four thin streaks of fine- to medium-grained water-bearing sand in the Magothy formation between depths of 253 and 291 feet, but as a moderately large water supply was needed the driller completed the well in the underlying Patapsco formation.

The sands in the Magothy formation are coarser, thicker, and more permeable throughout most of Anne Arundel County, particularly near Annapolis and

TABLE 14

Yields and specific capacities of wells screened in the Magothy formation

Well	Locality	Diameter of casing (in.)	Length of screen (ft.)	Yield (gal./min.)	Drawdown (ft.)	Specific capacity (gal./min./ft.)
AA-Cd 11	Crownsville	10	20	175	27	6.5
Cd 12	do	10-8	25	175	—	—
Cd 6	Severn Crossroads	6	6	15	21	.7
Cd 7	do	6	6	25	17	1.5
Ce 51	Arnold	4	5	20	6	3.3
Cf 30	do	4	5	50	—	—
Cf 21	Cape St. Claire	6	7	15	50	.3
Cg 6	Sandy Point	6-4	10	220	71	3.1
Cg 8	do	10-8	15	225	58	3.9
Cg 10	do	10-6	—	38	5.5	6.9
Dc 5	Priest Bridge	4-2	10	15	6	2.5
Dc 7	do	6	10	47	19	2.5
Dd 16	Davidsonville	4-2	10	20	10	2.0
De 45	Annapolis	20-10	50	1,000	102	9.8
De 46	do	20-10	—	1,000	52	19.2
Df 9	do	16-12-10	60	235	82	2.9
Df 58	do	6	10	100	—	—
Ed 19	Mount Zion-Harwood	6	—	45	62	.7
Fd 13	do	8-6	20	76	20	3.8
Cal-Bb 10	Sunderland	10-6	15	30	103	.3
PG-Dd 9	Forestville	6	5	20	40	.5
Df 21	Hall	6	6	60	60	1.0
Ed 8	Andrews Field	6	12	50	91	.5
Ed 27	do	6	—	25	85	.3
Ed 5	Clinton	6	15	50	—	—
Ed 31	do	6	10	40	25	1.6
Ee 2	Upper Marlboro	2	—	8	14	.6
Ee 3	do	6	12	60	30	2.0
Ee 4	do	6	6	12	85	.1
Ee 6	do	8-6	15	180	87	2.1
Ee 31	do	6	8	30	40	.8
Ef 1	do	8	8	153	90	1.7
Ef 5	do	8	—	70+	—	—
Ee 32	Mellwood	6	9	30	35	.9
Fc 1	Hyde Field	8-6	—	55	60	.9
Fd 1	Cheltenham-Brandywine	6	—	35	82	.4
Fd 2	do	6	—	42	23	1.8
Fd 5	do	8	21	165	121	1.4
Fd 6	do	8	30	150	40	3.8
Fd 11	do	8	46	239	61	3.9
Fd 24	do	8	14	70	55	1.3
Fd 32	do	8	12	80	130	.6

TABLE 14—*Continued*

Well	Locality	Diameter of casing (in.)	Length of screen (ft.)	Yield (gal./min.)	Drawdown (ft.)	Specific capacity (gal./min./ft.)
Ch-Bc 12	Pomonkey	6	0	12	35	.3
Bd 11	do	6	10	25	60	.4
Bf 5	Waldorf	6	12	40	45	.9
Bf 93	do	6	5.5	70	68	1.0
PG-Fd 35	do	6	5.5	70	65	1.1
Ch-Cf 9	Bryantown	6-3	20	50	—	—

Crownsville, than to the southwest in Prince Georges and Charles Counties. It is likely that the formation will be developed most extensively as a source of water supply in southern and central Anne Arundel County.

The yields, lengths of screen, drawdowns, and specific capacities of 48 wells producing from the Magothy formation are listed in Table 14. At only a few places, as Upper Marlboro, Cheltenham and Annapolis, are there data on a sufficient number of wells to make possible a comparison of the hydrologic properties of the formation. The yields of the wells range from less than 20 to about 1,000 gallons a minute (wells AA-De 45 and De 46 at the Annapolis Water Works). The maximum yield from the formation in Prince Georges County is 239 gallons a minute (well PG-Fd 11 at the U. S. Naval Communication Station). Many of the wells listed yield less than 100 gallons a minute, but it is likely that some of them have not been tested at their maximum capacity, as a smaller yield was adequate for the needs of the owner. The specific capacities of 42 wells, most of which are based on the drillers' pumping tests, range from 0.1 to 19.2 and average 2.4. In general, the specific capacities are lower than those computed for wells tapping the Patapsco and Raritan formations where these aquifers are highly productive, as at Odenton, Glen Burnie, and Annapolis.

At Crownsville the Magothy is coarse and highly permeable, as is shown by the records of wells AA-Cd 11 and AA-Cd 12. Here it is about 90 feet thick and consists chiefly of coarse sand and gravel containing a few thin clay streaks. Both wells yield about 175 gallons a minute. The specific capacity of well AA-Cd 11 is 6.5, which indicates this well is one of the most efficient wells tapping the formation.

The yields of 7 wells near Upper Marlboro range from 8 to 180 gallons a minute. The specific capacities range from 0.6 to 2.1 gallons per minute per foot and average 1.2, which is considerably less than those of many wells in Anne Arundel County. Drillers' logs show that the formation at Upper Marlboro contains less coarse gravel than it does at Crownsville and Annapolis.

The yields of 7 wells near Cheltenham range from 35 to 239 gallons a minute.

The specific capacities range from 0.4 to 3.9 and average 1.8. It is likely that at many localities in Southern Maryland yields in excess of the reported maximums can be obtained from the Magothy formation by means of large-diameter wells properly screened and developed opposite maximum thicknesses of permeable sand and gravel.

Permeability, transmissibility, and storage coefficients.—Table 15 shows the coefficients obtained from several pumping tests on wells ending in the Magothy formation. Most of the wells test pumped are in Anne Arundel County, although a few are in Prince Georges County. The values for the coefficients of permeability, transmissibility, and storage are weighted in favor of those areas where the formation is most widely utilized as an aquifer. Field coefficients of permeability range from 240 to 3,800 gallons per foot. Coefficients of transmissibility range from 6,300 in the vicinity of Mount Zion to 93,000 at Crownsville. The highest values were obtained in the general area of the lower Severn River near Annapolis, Crownsville, and Sandy Point.

An extensive pumping test was made on a group of wells in and near the Sandy Point State Park in Anne Arundel County. Well AA-Cg 8, which is 294 feet deep and contains 15 feet of screen opposite a coarse sand, was pumped at an average rate of 225 gallons a minute for 48 hours. During the period of pumping drawdowns were measured in 5 nearby observation wells. At the end of 48 hours the pump was shut off and the recovery of the water level measured in the pumped well and in the 5 observation wells.

A shorter test was made on well AA-Cg 10, also at Sandy Point, which was pumped at an average rate of 38.5 gallons a minute for 6⅓ hours. After shutting off the pump the recovery of the water level was measured in the pumped well for 3½ hours. As the wells were adjacent to the Chesapeake Bay, a tidal gage was installed in order to correct the measured water levels for the effect of cyclic tidal changes. The results of the tests were analyzed by the Theis recovery method and by modifications of the Theis nonequilibrium formula proposed by Jacob (1944). The method of computation and the formulas used in one analysis of the tests are shown in figure 8. The Sandy Point tests show that the coefficients of transmissibility range from 10,330 to 91,200 gallons per day and average about 38,000. Coefficients of permeability range from 450 to 3,800 and average 1,600 gallons per foot per day. Variations in the results obtained by using different methods of analysis may be ascribed to the fact that the hydrologic conditions do not conform to the theoretical limitations on which the formulas are based. The water-bearing sand varies in thickness from well to well, is probably anisotropic, and varies in permeability within short distances. Some of the wells may be screened in only a small part of the water-bearing bed or in more than one water-bearing bed in the formation. The sample cuttings obtained from well AA-Cg 8 (the pumped well in the 48-hour test) show that material overlying the water-bearing sand is a clayey sand, which probably func-

TABLE 15

Summary of permeability, transmissibility, and storage coefficients of the Magothy formation

Well	Location	Duration of test (min.)	Screen length in well (ft.)	Effective sand thickness[b] (ft.)	Analysis formula	Coefficient of transmissibility (gal./day/ft.)	Field coefficient of permeability (gal./day/ft.^{2})	Coefficient of storage (cu.ft./ft.)	Estimate of accuracy of test
AA-Cd 11	Crownsville	408	20	25	Nonequilibrium (Theis)	74,200	2,960	0.000028	Good
Cd 11	do	255	20	25	Nonequilibrium (Jacob)	93,000	3,720	.00032	Fair
Cg 4	Sandy Point	1,200	—	24	do	35,350	1,470	.00012	Good
Cg 4 and 9	do	1,000	—	24	do	91,200	3,800	.00120	Fair
Cg 5 and 9	do	100	—	24	do	59,750	2,480	.00092	Good
Cg 5 and 9	do	1,000	—	24	do	41,500	1,730	.00540	Good
Cg 7	do	510	10	17	do	10,330	610	.00006	Fair
Cg 8	do	2,880	—	24	do	21,700	900	.00018	Fair
Cg 9	do	525	—	24	do	10,900	450	.00005	Fair
Cg 10[a]	do	390	—	25	Recovery	31,760	1,270	—	Good
De 1	Annapolis (City Water Works)	450	—	90	Nonequilibrium (Jacob)	74,300	830	.00023	Good
De 1 and 45	do	450	—	90	do	79,000	880	.00014	Good
De 2	do	450	—	90	Nonequilibrium (Theis)	74,000	820	.00090	Good
De 2	do	165	—	90	Recovery	66,900	740	—	Good
De 45	do	165	50	90	Nonequilibrium (Jacob)	70,000	780	.00007	Good
Df 9[a]	Annapolis (Naval Academy)	267	60	61	Recovery	23,100	370	—	Fair
Fd 13[a]	Mount Zion	265	20	26	do	6,300	240	—	Good
PG-Ef 1[a]	Upper Marlboro	230	—	20±	do	22,700	1,130	—	Fair
Fd 5	Cheltenham	210	21	40	Nonequilibrium (Theis)	17,200	430	.00001	Good
Fd 5	do	195	21	40	Nonequilibrium (Jacob)	13,700	340	.00007	Good

[a] Pumped well.
[b] Thickness of saturated aquifer or thickness of screened aquifer.

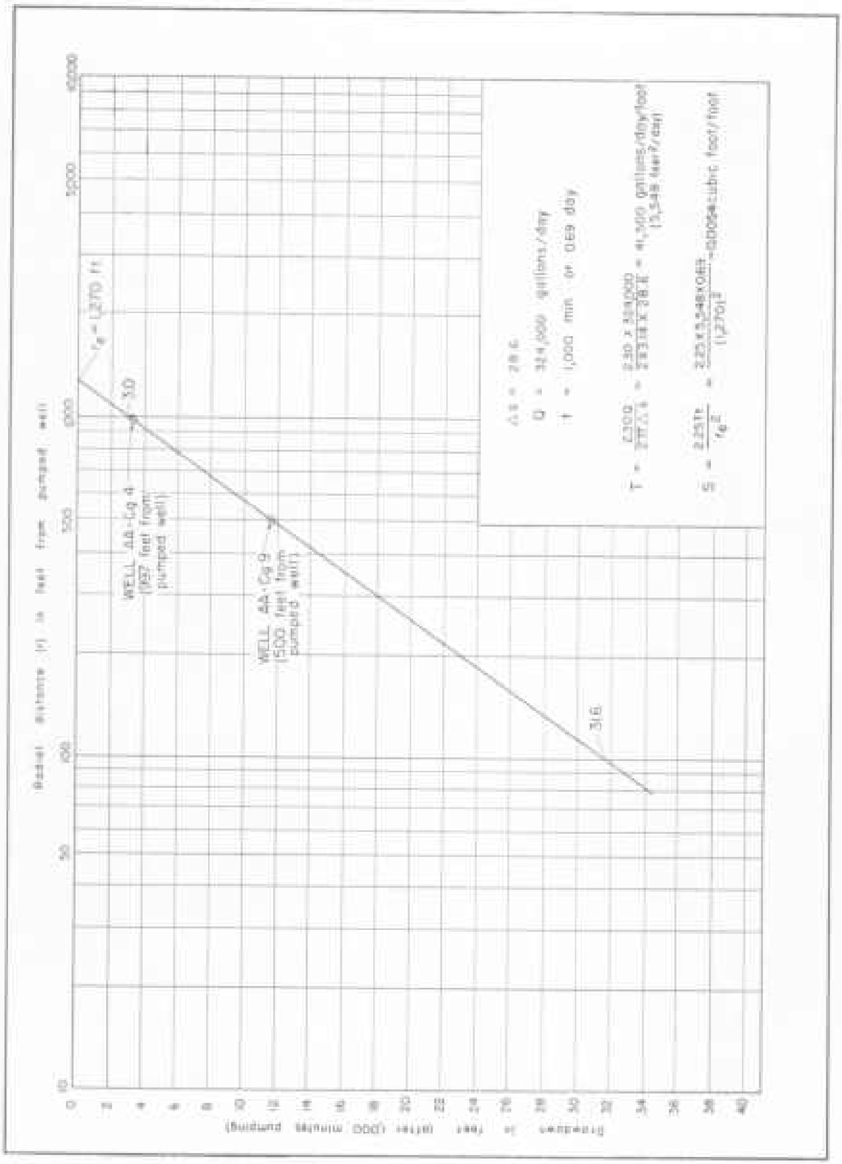


FIG. 8. Graph showing a method of determining coefficients of transmissibility and storage in the Magothy formation from a pumping test on well AA-Cg 8

tions as an imperfect confining layer. However, an average of the results obtained by the various methods of analysis provides a reasonably accurate value of the permeability of the Magothy formation at Sandy Point. The total thickness of the formation in the Sandy Point-Severn River area is estimated to be about 100 feet, of which one-half consists of water-bearing sand. If the average field coefficient of permeability of 1,600 gallons per foot is multiplied by 50 feet of effective sand thickness, the coefficient of transmissibility of 80,000 gallons per day per foot mile is obtained for the formation as a whole.

Seven figures obtained for the coefficient of storage in the Sandy Point area range from 0.00005 to 0.0054 and average 0.00014 cubic foot per foot, which probably is of the correct order of magnitude. A 48-hour test is probably not sufficiently long to determine accurately the coefficient of storage. The high figures of 0.0054 and 0.0012 indicate that imperfect confining layers overlie the aquifer at Sandy Point.

The results of pumping tests utilizing wells AA-De 1, -De 2, -De 45, and -De 46 (the pumped well) at the Annapolis Water Works show a rather close agreement when various methods of analysis are applied. The coefficients of permeability range from 740 to 880 and average 810 gallons per foot per day. Coefficients of transmissibility range from 66,900 to 79,000 and average 72,800 gallons per day per foot mile. The total thickness of the formation at the Annapolis Water Works is about 100 feet, of which about 90 feet is permeable coarse sand and gravel. Thus, although the sand at the Water Works is less permeable (810 compared with 1,600 gallons per foot) than that in the Sandy Point area, the formation as a whole is capable of transmitting about as much water as it is in the Sandy Point area (coefficient of transmissibility of 72,800 compared with 80,000). This is mainly because of the greater thickness of water-bearing material at the Annapolis Water Works. The coefficients of transmissibility of the Magothy formation in the Annapolis and Sandy Point areas are among the highest of any aquifer in Southern Maryland.

Coefficients of storage determined in the tests at the Annapolis Water Works range from 0.0007 to 0.00023 cubic foot per foot and average 0.0003 cubic foot per foot. This value is of the general order of magnitude to be expected for unconsolidated sedimentary sands under artesian conditions.

The drawdown and recovery curves obtained from a pumping test on well PG-Fd 5 at Cheltenham in Prince Georges County show that the transmissibility of the sand is between 13,500 and 17,200 gallons per day. According to the log of nearby well PG-Fd 11, the formation at this locality is approximately 50 feet thick and consists largely of coarse sand separated by clay layers a few feet thick. It is estimated that in the Cheltenham area about four-fifths of the formation, or 40 feet, is water-bearing sand, and on this basis the field coefficient of permeability is between 340 and 430 gallons per day per square foot. If these figures are in the correct order of magnitude, the Magothy formation not only becomes thinner near Cheltenham but is somewhat less permeable than it is near Annapolis. This conclusion is further supported by the specific capacities of 12 wells ending in the Magothy formation in the Cheltenham-Waldorf area. The average specific capacity of the wells there is 1.4 gallons per foot of drawdown in comparison with 5.9 gallons per foot for 7 large-capacity wells in the Annapolis-Sandy Point area.

Coefficients of storage for the Cheltenham test are 0.00001 and 0.00007. These are probably somewhat below the true values, because of the relatively short duration of the test (well PG-Fd 5 was pumped for only 3½ hours).

Matawan and Monmouth formations

Distribution and character—In central Anne Arundel County the Matawan and Monmouth formations of Late Cretaceous age, are exposed in an irregular band 5 to 7 miles wide extending southwestward from Gibson Island to Priest Bridge. In Prince Georges County, southwest of Priest Bridge, the Matawan formation is absent, and the outcrop belt of the Monmouth narrows to about 2 miles near Bowie and to less than a quarter of a mile near Seat Pleasant and Capitol Heights. The formations are not known to be exposed in Charles County.

In the sample cuttings and in the drillers' logs the Matawan and Monmouth formations are inseparable, and in this report they are treated as one unit. They consist chiefly of gray to grayish-black micaceous sandy clay. Where weathered the sediments are frequently a dull brown to grayish brown. Clark (1916b, p.66) indicates that the Matawan formation commonly contains oval nodules or concretions of clayey ironstone. Glauconite is common in both formations, although Clark states that it is more abundant in the Monmouth. Fossils also are common, several species of fish remains, gastropods, pelecypods, forams, and ostracods having been found. Locally, the Monmouth formation contains thin lenses of rather clean sand or gravel. Cooke (1952, p. 8) states that a bed of sand and gravel about 2 feet thick occurs near the base of the formation in Prince Georges County. The sand and gravel grades upward into fine micaceous sand, which weathers rusty brown.

Subsurface character.—The Matawan and Monmouth formations are the oldest of a sequence of marine formations. These formations tend to be more homogeneous than the underlying nonmarine formations. The fossiliferous nature of these and the overlying Eocene formations enables them to be traced and identified with comparative ease.

The Matawan and Monmouth formations in the subsurface may be separated from the overlying strata by their greater mica content, by their dark or medium gray color, and by the occurrence, in some places, of pellets of bone phosphate and small rounded granules of gray to blue-gray or violet quartz. The Matawan and Monmouth formations may usually be separated from the underlying Magothy formation by its lighter color and by the appearance, in the latter unit, of lignitic or carbonaceous debris.

The logs of a few wells in Southern Maryland show sands 1 to 10 feet thick that are probably in the Matawan or Monmouth formations; for example, 10 feet of sand was reported in well AA-Cd 11 near Crownsville, 2 feet of water-bearing sand in well AA-Df 9 at the U. S. Naval Academy, 1 foot of water-bearing sand in well PG-Ed 24 at Andrews Field, 6 feet of water-bearing sand in well PG-Fd 33 near Brandywine, and 12 feet of sand in well Ch-Bf 15 at Waldorf. The occurrence of sand layers in the formations is somewhat erratic, as the logs of several wells adjacent to those listed above show no coarse sands.

Mechanical analyses.—No mechanical analyses were made of the Matawan and Monmouth formations. However, Goldman (1916, p. 111-176) lists three particle-size analyses of material from the Matawan formation in the vicinity of the Chesapeake and Delaware Canal, which show that 64 to 75 percent of the material consists of sand, mostly fine, and 21 to 29 percent of clay. Much of the material composing the formations in Southern Maryland probably is fine- to medium-grained sand and silt.

Thickness and stratigraphic relations.—The Matawan and Monmouth formations range in thickness from a few feet or less along parts of their outcrop area to more than 130 feet in well AA-De 45 at the Annapolis Water Works. The average thickness of both formations in several wells in the Annapolis and Sandy Point areas is about 100 feet. The formations thin to the west and average about 45 feet in Prince Georges County. The combined formations average about 25 feet in thickness in several wells in Charles County, but this interval may include the Brightseat formation, which, in some places, is not readily separable from the Monmouth formation. It is likely that the formations thin in Calvert County southward from the area of maximum thickness, near Annapolis. The sample cuttings from well Cal-Bb 10, at the Mount Hope School near Sunderland, indicate that the Matawan and Monmouth formations are approximately 60 feet thick in this well. The thickness of the formations in southern Calvert or St. Marys County is not known.

The Matawan formation unconformably overlies the Magothy formation and in parts of Prince Georges and Charles Counties is unconformable on the Raritan and Patapsco formations. Clark (1926b, p. 67) indicates that the Monmouth formation overlies the Matawan unconformably, but in the subsurface studies this relationship could not be detected, as the two units are similar lithologically. The Monmouth formation is overlain unconformably by the Brightseat formation of Paleocene age and, where that unit is absent, by the Aquia greensand of Eocene age. In some localities in Prince Georges County the Calvert formation of Miocene age immediately overlies the Monmouth formation.

Water-bearing properties.—Because the Matawan and Monmouth formation are composed chiefly of sandy clay and clay, which are generally too impermeable to yield water to wells, the formations are not important aquifers. However, the records of a few wells in the Southern Maryland area indicate that where lenses of coarse sand are present the formations may be utilized as a source of water. One such well (AA-Cg 2), 6 inches in diameter, drilled to a depth of 138 feet at the abandoned Sandy Point ferry terminal in Anne Arundel County, reportedly yielded 20 gallons a minute in 1943. The water was of poor quality, and the well was abandoned in a few years after its construction. Two wells at Waldorf, in Charles County, are believed to be producing water from a sand or sands in the Monmouth formation. One of these, Ch-Bf 15, drilled to a depth of 392 feet and containing 11 feet of screen, yields 50 gallons a minute and has a specific capacity of 1.8 gallons per foot; the other well, Ch-Bf 92, drilled to a depth of 381 feet, yields 50 gallons a minute and has a specific capacity of 1.0 gallon per foot. Well PG-Fd 33, drilled 370 feet to supply a service station a few miles north of Waldorf, yields about 7 gallons a minute from a sand probably in the Monmouth formation.

Tertiary System

PALEOCENE SERIES

Brightseat formation

Distribution and character.—The Brightseat formation (Bennett and Collins, 1952) is exposed at a few localities near Brightseat and Capitol Heights in Prince Georges County. Foraminifera of Paleocene age, which may indicate strata equivalent to the Brightseat formation, have been identified by Shifflett (1948) and others (Anderson and others, 1948) from wells in the Maryland Coastal Plain. Exposures of the Brightseat formation are irregular and it has not been found at the surface in Anne Arundel or Charles County. It consists chiefly of gray to dark gray sandy clay similar in character to the marine Cretaceous formations. The Paleocene deposits, however, generally contain less fragmental carbonaceous material than the underlying Cretaceous strata, are somewhat softer, and do not tend to break into large pieces or blocks.

Subsurface character.—In the well cuttings the Brightseat formation has been separated from the overlying Aquia greensand chiefly on the basis of diagnostic Foraminifera and a change in the color of the sediments from the typical greenish gray of the Aquia to the medium gray or dark gray of the Brightseat. The Brightseat formation may be separated from the underlying Monmouth formation by the relative abundance of finely divided mica and carbonaceous fragments in the Monmouth.

Mechanical analyses.—No particle-size analyses of the Brightseat formation were made.

Thickness and stratigraphic relations.—The Brightseat formation ranges in thickness in Southern Maryland from a featheredge to as much as 40 feet in well

PG-Ef 3 near Upper Marlboro. The formation apparently thickens to the southeast and may attain its maximum thickness on the east side of the Chesapeake Bay (Shifflett, 1948, p. 26). The Brightseat formation has been identified by means of foraminiferal studies and sample examinations in the wells in Southern Maryland listed in Table 16.

The Brightseat overlies the Monmouth unconformably, although the contact between the two formations has been observed at only one outcrop. It is overlain unconformably by the Aquia greensand, the basal portion of which, in places, is characterized by a pebble zone consisting of black phosphatic nodules. The Brightseat strikes northeast and dips southeast at a rate similar to that of the Monmouth. The top of the Brightseat is 95 feet above sea level in well PG-Ed 4 at Morningside, and 3 feet below sea level in well PG-Ed 8 south of Andrews Field, indicating a dip of about 98 feet in a distance of 3.4 miles (or 29 feet to the mile).

TABLE 16

Brightseat formation in wells in Southern Maryland

Well	Location	Approximate thickness (feet)
PG-Df 21	North of Upper Marlboro	30
Ed 4	Morningside Village	10
Ed 8	Just east of Andrews Field	20
Ed 31	Town of Clinton	20
Ef 3	Northeast of Upper Marlboro	40
Ch-Bc 12	Pomonkey	10
Bf 5	North of Waldorf	20
De 1	North of Bel Alton	20

Water-bearing properties.—No wells are known to yield water from the Brightseat formation in Southern Maryland, and as the formation is composed chiefly of sandy clay it is not believed to be an aquifer.

EOCENE SERIES

Aquia greensand (Pamunkey group)

Distribution and character.—In the Annapolis-Crownsville area of Anne Arundel County the Aquia greensand crops out along a 12-mile belt; southwestward in Prince Georges County the outcrop belt narrows and the greensand is overlapped by younger Eocene and Miocene formations. Along the east bank of the Potomac River near Broad Creek it is exposed only in hillsides and in major tributaries of the river, such as Henson and Piscataway Creeks. In Charles County exposures of the greensand may be seen near Glymont, at a few places along Mattawoman Creek, along Reeder Run, and in a fresh road cut on Maryland Route 563 near Clifton Beach (Pl.9).

The Aquia greensand consists chiefly of glauconitic sand and sandy clay containing, in many places, numerous calcareous and fossiliferous layers. In central Anne Arundel County the calcareous layers are absent, but nodules and bands of ironstone are common. The color of the greensand ranges from greenish brown to greenish black or bluish green. When weathered, its color is drab rusty-brown, due chiefly to the oxidation of iron in the glauconite. In some outcrops its base is marked by a pebble zone consisting largely of rounded phosphatic nodules.

The character of the Aquia where it contains abundant nodules and crenulated ironstone is shown by an excellent exposure in a sand pit just south of U. S. Route 50 in eastern Anne Arundel County. This exposure is described below:

Location: In Anne Arundel County 1.0 mile northeast of St. Margarets, about 200 feet south of U. S. Route 50 near Broad Neck Road.

Altitude: Base of section 15 feet above mean sea level (estimated).

Bed number		*Thickness (feet)*
	Pleistocene series:	
6	Sand and gravel, reddish-brown to drab-brown; gravel more abundant near base of bed and thin ironstone layers common near base	13
5	Pebbles and cobbles up to 6 inches in diameter, quartzitic and rust-colored; layer partially cemented with ironstone	0.5 to 1
	Eocene series:	
	Aquia greensand:	
4	Greensand, dull greenish-brown, even-textured; contains thin ironstone layers	4
3	Greensand, grayish-green (covered in part with slope debris)	9±
2	Greensand, clean, grayish-green; crenulated ironstone layers common	7
1	Covered with slope wash, although greensand present at north end of pit	6
	Total	40±

Subsurface character.—In the subsurface the Aquia greensand is characterized by an abundance of glauconite, which in some of the sample cuttings constitutes more that 50 percent of the sample. The grains of glauconite are botryoidal to oblate, dull to shiny, and greenish black to light tan or reddish brown. The quartz grains and granules are subangular to rounded, dull to shiny, and range in color from white to yellow or yellowish gray. Microfossils and shell fragments, including corals, small gastropods, pelecypods, and ostracods are common in the cuttings from some wells. The Aquia greensand may be identified in the subsurface by its position beneath the pink Marlboro clay member of the Nanjemoy formation, by the occurrence of numerous indurated shell layers, by the presence of characteristic Foraminifera (Shifflett, 1948, p. 19 and 20), and in some places by an abundance of yellow subrounded to rounded quartz grains. The Aquia is distinguished from the underlying Brightseat or Monmouth formation, by an increase in mica content in the underlying formations and by the change in color of the sediments from pale green or greenish gray in the Aquia to dark gray or black in the Brightseat or Monmouth formation.

Mechanical analyses.—Particle-size analyses of nine samples from the Aquia greensand are shown graphically in figure 9. The analyses are of outcrop samples and well cuttings. In general, they show a greater sorting of the Aquia sediments and a more uniform texture than is shown by the analyses of sediments of continental origin from the Cretaceous fromations. Although nine samples are not representative of the formation in its entirety, they do show that medium sand (0.25 to 0.5 mm.) is the dominant size. Fine sand (0.125 to 0.25 mm.) is common in all samples and next in abundance. Material of silt and clay size is present in all samples, and sample 6, from well PG-Dd 19 near Forestville, consists largely of fine sand, silt, and clay. Sample 7, from well St.M-Dc 10 near Compton, consists largely of coarse and medium sand; many domestic wells in this locality yield water from the Aquia greensand at about the horizon of this sample. Some of the analyses show a particle-size distribution similar to that shown by Krumbein and Sloss (1951, p. 208) for sediments typically deposited in a beach or near-shore environment.

Thickness and stratigraphic relations.—The thickness of the Aquia greensand ranges from a few feet at the outcrop to 203 feet in well Cal-Bb 10, drilled near Sunderland for the Calvert County School Board. Throughout much of southern Prince Georges County a thickness of 100 to 150 feet prevails. In Anne Arundel County the maximum thickness of the greensand is 134 feet, in well AA-Ed 19 near Mount Zion.

The thickness of the permeable coarse sandy beds ranges from less than a foot to more than 40 feet in St. Marys and Calvert Counties (wells St.M-Dc 2, -Dc 5, -Dg 2; Cal-Gd 6, -Gd 7, and others). Near Birdsville in southern Anne Arundel County 20 feet of coarse water-bearing sand is reported in well AA-Fd 19. The thickness of the hard indurated layers commonly found in the formation ranges from less than a foot to as much as 8 feet, noted in a fossiliferous ledge near Clifton Beach in western Charles County.

The Aquia greensand lies unconformably on the Brightseat formation of Paleocene age or on the older formations of Cretaceous age. It appears to overlap successively older formations in a southwesterly direction from central Anne Arundel County, where it lies directly on the Monmouth formation. At Glymont in Charles County it directly overlies the Patapsco formation (fig. 5).

Throughout most of Southern Maryland the Aquia greensand is overlain by the Nanjemoy formation, probably unconformably, for the contact of the Marlboro clay member with the greensand is distinct and slightly undulating.

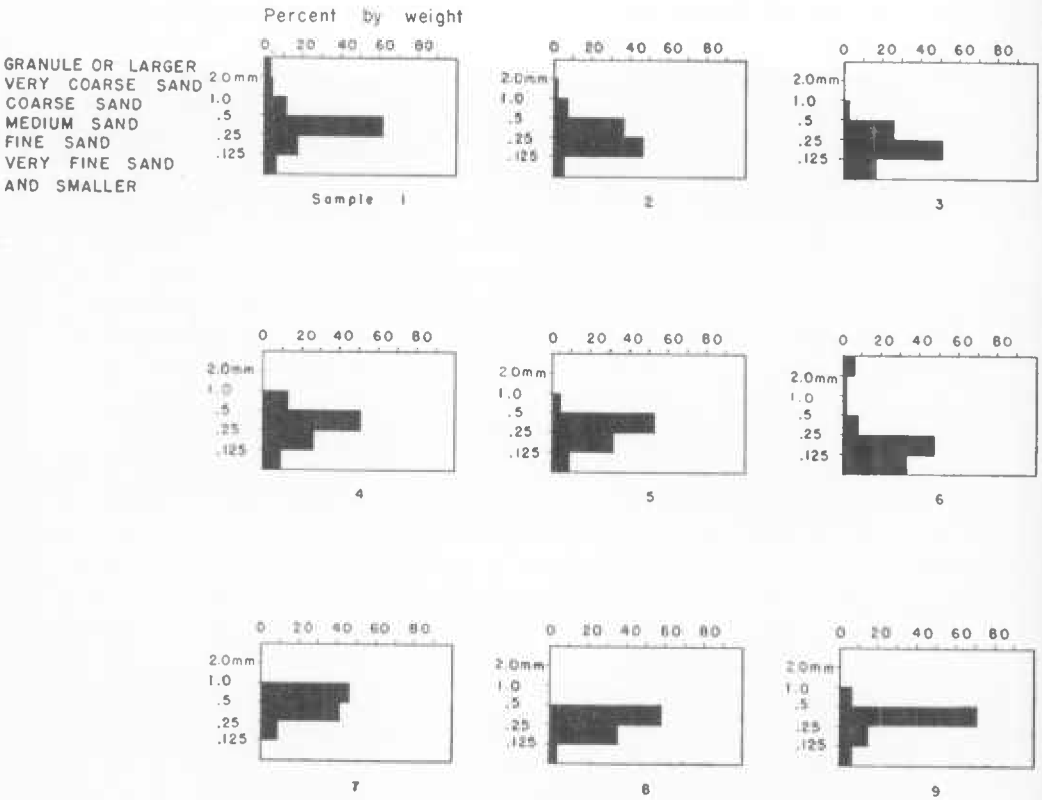


FIG. 9. Histograms of samples from the Aquia greensand

Samples 1. Outcrop 3 feet above Cretaceous contact at bluff, 1,500 feet north of wharf, Glymont, Charles County (from Dryden and others, 1948, p. 43).

2. Outcrop 3 feet above base of section in sand pit south of U. S. Route 50 near St. Margarets, Anne Arundel County.

3. Outcrop 5 feet above base of road cut on south side of Md. Route 214, west of Woodland Beach, Anne Arundel County.

4. Sand from depth 110 to 120 feet, well AA-Fe 30, drilled for William Myers, Cape Anne, Anne Arundel County.

5. Outcrop at base of road cut along Md. Route 202, in Upper Marlboro, Prince Georges County.

6. Sand from depth 170 to 180 feet, well PG-Dd 19, drilled for the County Commissioners near Forestville, Prince Georges County.

7. Sand from depth of 336 feet, well St.M-Dc 10, near Compton in St. Marys County.

8. Sand from depth 320 feet, well St.M-Dc 10, near Compton in St. Marys County.

9. Sand from depth 150 to 160 feet, well AA-Ee 41, drilled for James Stewart near Edgewater, Anne Arundel County.

The Aquia greensand strikes approximately northeast along its outcrop belt in Prince Georges and Anne Arundel Counties (Pl. 4). Its upper surface dips southeastward from an altitude of 130 feet above sea level in central Prince Georges County to 450 feet below sea level near Solomons Island at the mouth of the Patuxent River. The dip ranges from as much as 37 feet per mile in the area south of Upper Marlboro to less than 6 feet per mile south of Chaptico in St. Marys County. In the vicinity of Bel Alton and Port Tobacco reversals in the direction of slope occur, which may indicate structural anomalies. Plate 4 shows that the rate of dip of the formation increases rather sharply along a northeast-southwest belt which extends from Herring Bay in Anne Arundel County to Port Tobacco in Charles County. Southeast of this belt the surface of the formation flattens. It is not known if this structural terrace is reflected in the deeper formations, for only a few wells in Calvert and St. Marys Counties have penetrated below the Aquia greensand.

Water-bearing properties.—The Aquia greensand is one of the most widely utilized and important aquifers in Southern Maryland. It is the source of a number of domestic and public supplies, including military and naval installations in St. Marys and Calvert Counties. It is tapped by many domestic wells in the Wayside-Cobb Island area of Charles County and in the Fairhaven and Deale areas of Anne Arundel County. Although the formation has been encountered in the drilling of many wells in the area west of U. S. Route 301 in western Charles and Prince Georges Counties, it consists, in that area, chiefly of sandy clay and clayey greensand. At only a few places west of Route 301—for example, at Port Tobacco and Popes Creek—is the greensand sufficiently coarse and water-yielding for successful wells to be completed in it. Where it is too clayey wells can be completed in productive sands in the underlying Cretaceous strata. In general, the greensand yields adequate ground-water supplies to drilled wells in the area south of the minus 50-foot contour on Plate 4.

The yields, specific capacities, diameters, and screen lengths of 40 wells producing from the Aquia greensand are grouped by location in Table 17. Only the most productive wells are included in the table; domestic wells producing less than 10 gallons a minute are omitted. The reported or tested yield of a well may not represent the maximum yield obtainable, but, nevertheless, the information serves as a rough means of evaluating the water-bearing properties of the aquifer.

The formation is tapped by several hundred domestic wells in southeastern Anne Arundel County. The reported yields of 4 of the most productive wells in the Mayo-Shadyside area range from 15 to 210 gallons a minute. Specific capacities of 3 of the wells range from 0.2 to 1.7 gallons per minute per foot of drawdown.

The most productive wells tapping the Aquia greensand are in the vicinity of the Patuxent Naval Air Station. Yields there range from 125 to 350 gallons

TABLE 17

Yields and specific capacities of wells screened in the Aquia greensand

Well	Locality	Diameter of casing (in.)	Length of screen (ft.)	Yield (gal./min.)	Draw-down (ft.)	Specific capacity (gal./min./ft.)
AA-Ee 4	Mayo-Shadyside	6	7.5	20	80	0.2
Ee 6	do	8	8	210	—	—
Ee 15	do	6	12	20	22	.9
Ee 46	do	4	20	15	9	1.7
Ge 2	Fairhaven	8	12	125	208	.6
PG-Df 5	Hall	5	—	20	40	.5
Ff 1	Naylor-Croom	6	12	40	120	.3
Ff 16	do	6	7.5	65	70	.9
Cal-Ca 2	Lower Marlboro	6	None	53	27	2.0
Cc 18	Randle Cliffs	4	14	42	46	.9
Cc 19	do	6	14	40	62	.6
Db 5	Prince Frederick	8	—	75	120	.5
Db 21	do	6	14	75	75	1.0
Dc 26	do	6	10	65	65	1.0
Fd 1	Solomons Island-Patuxent Naval Air Station	8-6	23	125	151	.8
Gd 6	do	8-6	24	150	75	2.0
Gd 7	do	8	25	350	100	3.5
St.M-Df 1	do	8	20	225	53	4.2
Df 3	do	10-8	20	257	77	3.3
Df 4	do	10-8	20	300	152	2.0
Df 5	do	8	20	300	150	2.0
Df 10	do	8-6	20	225	98	2.3
Bb 4	Mechanicsville	6	10	50	35	1.4
Bb 9	do	6	11	60	67	.9
Bc 1	do	6	10	20	30	.6
Db 29	Bushwood	6	10	40	140	.3
Dc 26	St. Clement Shores	6	10	50	42	1.2
Dd 1	Leonardtown	8	20	150	110	1.3
Dd 2	do	8	—	200	90±	2.2
Ef 17	Park Hall	6	21	109	88	1.2
Fe 21	Piney Point-Webster Field	6	12	48	108	.4
Fe 23	do	8	8	220	70	3.0
Fe 24	do	6-4	5.5	25	17	1.5
Ff 21	do	8	22	150	115	1.3
Ch-Cg 1	Hughesville	6	10	50	150	.3
Ee 39	Wayside-Cobb Island	6	10	40	50	.8
Ee 41	do	6-4	—	60	20	3.0
Ef 4	do	6	—	25	33	.7
Ef 5	do	6	—	24	28	.8
Ff 33	do	3½-2½-1½	40	15	20	.7
Ff 36	do	1½	20	15	23	.6

a minute, and specific capacities of 8 wells range from 0.8 to 4.2 and average 2.5 gallons per foot. In general, these values are the highest known for the aquifer. All the large-capacity wells here have 20 to 25 feet of screen placed opposite sand near the top of the formation. The Aquia greensand is not nearly as productive an aquifer as the Patapsco-Raritan formations when the specific capacities of the wells at Solomons are compared with the specific capacities of the wells in the Patapsco-Raritan formations at Annapolis. The average specific capacity of the wells at Solomons is 2.5 in comparison with a specific capacity of 9.5 at Annapolis. However, the Aquia greensand is a satisfactory source of supply in the Solomons area for the quantity of ground water currently needed.

In the Wayside-Cobb Island area of southeastern Charles County the yields of the most productive wells range from 15 to 60 gallons a minute. Specific capacities range from 0.6 to 3.0 and average 1.3 gallons per foot. This would indicate that the aquifer is not potentially as productive in this locality as in the Solomons area, but such a conclusion may not be warranted as there are only a few large-capacity wells in the Cobb Island area.

Yields and specific capacities of a few wells near Naylor and Croom in Prince Georges County suggest that the formation is less permeable and less productive in this county than to the south and east, in St. Marys and Calvert Counties. The yields of 3 wells in the Naylor-Croom area range from 20 to 65 gallons a minute; specific capacities range from 0.3 to 0.9 gallon per foot.

For the remainder of Southern Maryland specific-capacity figures are available for only a few large-capacity wells, so that the water-bearing properties of the aquifer for these localities cannot be evaluated with any accuracy.

For the formation as a whole, the average specific capacity of the 40 wells in Table 17 is 1.3 gallons per foot.

Permeability, transmissibility, and storage coefficients.—The results of six pumping tests on wells in the Aquia greensand are shown in Table 18. The tests show field coefficients of permeability ranging from 130 to 1,340 gallons per day per square foot. The maximum value is from a recovery test made on well St. M-Fe 23 at Piney Point in St. Marys County. Coefficients of transmissibility determined from the tests range from 5,500 at well Cal-Gd 7 near Solomons Island to 33,000 gallons per day at well St.M-Dg 2 at the Patuxent Naval Air Station.

A coefficient of transmissibility of 10,100 was obtained from a recovery test of well Cal-Cc 18 at the Naval Experiment Station at Randle Cliffs in northern Calvert County. The well was pumped for 3 hours at an average rate of 42 gallons a minute. At the end of this period the pump was shut off and the recovery of the water level was measured for 130 minutes. The coefficients of transmissibility and permeability obtained from this test are about in the median range of the values obtained from all the tests on wells in the Aquia.

The transmissibility coefficient of 33,000 gallons per day obtained from a test

TABLE 18

Summary of permeability, transmissibility, and storage coefficients of the Aquia greensand

Well	Location	Duration of test (min.)	Screen length in well (ft.)	Effective sand thickness[b] (ft.)	Analysis formula	Coefficient of transmissibility (gal./day/ft.)	Field coefficient of permeability (gal./day/ft.^{2})	Coefficient of storage (cu.ft./ft.)	Estimate of accuracy of test
Ch-Cg 1[a]	Hughesville	152	10	16	Recovery	6,680	410	—	Good
Cal-Cc 18[a]	Randle Cliffs	130	14	14	do	10,100	720	—	Fair
Gd 6[a]	Solomons Island	135	24	40±	do	5,650	130	.0001[c]	Good
Gd 7[a]	do	—	25	40±	do	5,500	130	—	Good
St.M-Dg 2	Patuxent Naval Air Station	320	20	28	Nonequilibrium (Jacob)	33,000	1,170	.00023	Fair
Fe 23[a]	Piney Point	180	8	15	Recovery	20,200	1,340	—	Good

[a] Pumped well.
[b] Thickness of saturated aquifer or thickness of screened aquifer.
[c] Coefficient of storage estimated (Bennett, 1944, p. 17).

on well St.M-Dg 2 at the Patuxent Naval Air Station is considerably higher than the coefficients of 5,650 and 5,500 obtained from recovery tests on wells Cal-Gd 6 and Cal-Gd 7 near Solomons Island, although the Air Station well is only about 5 miles south of the Solomons wells. The coefficient of 33,000 was computed from the measured recovery in the water level of well St.M-Dg 2 after cessation of pumping in well St.M-Dg 1, located about 1,500 feet from St.M-Dg 2. The recovery of the water level in St.M-Dg 2 was affected to some degree by tidal loading and by the pumping of other wells at the Air Station. The effects of these factors could not be completely handled in the analysis, so that the computed coefficient is probably somewhat higher than the true figure.

In general, the pumping tests on wells in the Aquia greensand in Southern Maryland show that the formation transmits water less readily than do the Upper Cretaceous aquifers in localities to the north. It is likely that, for the water-bearing parts of the formation as a whole, the coefficients of transmissibility are in the range of 10,000 to 20,000 gallons per day per foot, and coefficients of permeability in the range of 500 to 1,000 gallons per day per square foot.

The figure for the coefficient of storage (0.00023 cubic foot per foot) obtained on the test on well St.M-Dg 2 is probably of the correct order of magnitude, but is only an approximation.

To determine the hydraulic characteristics of the aquifer more accurately, it would be necessary to run additional pumping tests utilizing one or more observation wells and to extend the period of pumping and recovery over a period of at least 1 or more days.

Nanjemoy formation (Pamunkey group)

Distribution and character.—The basal part of the Nanjemoy formation consists of a bed of pink or red plastic clay known as the Marlboro clay member. The remainder of the formation consists chiefly of greensand and clayey greensand.

The Nanjemoy crops out as an irregular belt about 10 miles in width, which extends southwestward from the Chesapeake Bay in southern Anne Arundel County into Prince Georges County near Upper Marlboro and into southern Charles County where it narrows to about 8 miles (Pl. 10). The formation strikes northeast in Anne Arundel and Prince Georges Counties but changes to nearly due north in southern Charles County.

The Marlboro clay member, one of the most distinctive stratigraphic markers in the coastal plain of Maryland, consists chiefly of reddish brown or pink soft clay which changes to a gray color in the subsurface in southern St. Marys and Calvert Counties. The clay locally contains a few thin sandy glauconitic streaks, but usually it is rather pure. Nodules or pellets of siderite are found in some places in the clay, which is well exposed in road cuts and stream valleys near Upper Marlboro, Davidsonville, Woodland Beach, and Piscataway.

The upper part of the Nanjemoy formation consists chiefly of glauconitic sand and clayey sand, containing, in some localities, an abundance of marine megafossils and microfossils.

Subsurface character.—In the subsurface the Nanjemoy formation differs from the overlying Calvert formation of Miocene age by an abundance of green-

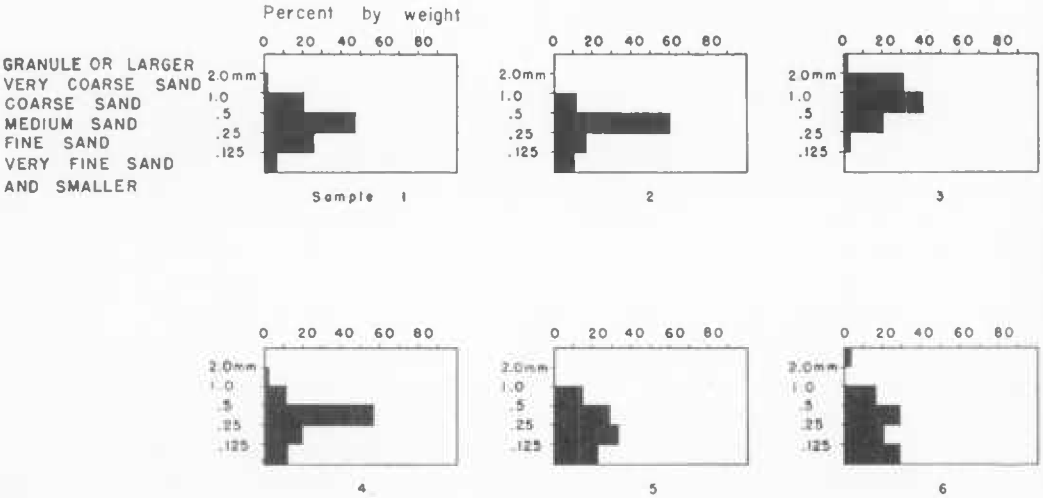


FIG. 10. Histograms of samples from the Nanjemoy formation

Samples 1. Sand from depth 139 to 141 feet, well AA-Fe 35, drilled for D. M. Grady near Sudley, Anne ArundelCounty.
2. Sand from depth 250 to 260 feet, well Cal-Bc 14, drilled for Archie Norfolk near North Beach, Calvert County.
3. Sand from depth 262 to 273 feet, well Cal-Ed 6, drilled for Robert Hall, Long Beach, Calvert County.
4. Sand from depth 321 to 330 feet, well Cal-Cc 37, drilled for O. L. Evans near Parran, Calvert County.
5. Outcrop sample from road cut, east side of U. S. Route 301 about 400 feet north of intersection with Md. Route 4 near Upper Marlboro, Prince Georges County.
6. Sand from depth 140 to 150 feet, well PG-Ff 16, Naylor School, Prince Georges County.

sand, by the presence of small amounts of microgranular pyrite, and by yellowish or pale green subrounded quartz grains. The cuttings from many wells also contain distinguishing assemblages of Foraminifera. Where the Nanjemoy formation is overlain by the Piney Point formation, as in southern St. Marys and Calvert Counties, the contact between them is gradational and the top of the Nanjemoy formation is not so easily identified. The sample cuttings from many wells, however, show that the Piney Point-Nanjemoy contact is marked by a color change in the sediments from light gray to dark gray-green, due largely to the greater abundance of glauconite in the Nanjemoy. Where microfossils are encountered the assemblage from the Nanjemoy formation is usually distinct from that of the Piney Point formation.

Mechanical analyses.—The particle-size analyses of six samples of the Nanjemoy formation are shown graphically in figure 10. Five samples are from drilled or jetted wells and one sample is from an outcrop in southern Prince Georges County. In samples 1, 2, and 4, medium sand (0.25 to 0.5 mm.) is the dominant grain size; the sorting of these samples is generally good and the histograms are similar to that shown by Krumbein and Sloss (1951, p. 208) for a beach sand or sediment deposited in a littoral environment.

Samples 3, 5, and 6 are less sorted than the other samples. Sample 3, containing a high proportion of medium and coarse sand, may be typical of the Nanjemoy formation where it is tapped by many wells along the bay shore of Calvert County. Sample 5, from an outcrop of the formation in the Upper Marlboro area, contains nearly 30 percent of material finer than 0.125 mm., or very fine sand, silt, and clay; the fineness of sample 6 may be representative of the sediments of the Nanjemoy in the Upper Marlboro area, as the formation is not known to yield water to drilled wells there.

Thickness and stratigraphic relations.—The Nanjemoy formation in Southern Maryland ranges in thickness from a few feet in its outcrop belt to as much as 240 feet in well St.M-Bc 1 near Mechanicsville. The formation generally is less than 100 feet thick along an irregular belt trending southwestward from Davidsonville in Anne Arundel County to Pomonkey in northern Charles County. It increases in thickness to the southeast and attains its maximum thickness in the area bordering the lower Patuxent River and including most of Calvert County. In St. Marys County the formation thins southward from a maximum of 240 feet at Mechanicsville to 148 feet in well St.M-Df 22 at Lexington Park. Where this thinning takes place the overlying Piney Point formation, which is not present in central Calvert and eastern Charles Counties, attains its maximum thickness. Thus, the two formations, the Nanjemoy and Piney Point, appear to be complemental with respect to their thickness.

Where the Nanjemoy formation is thickest the Aquia greensand is also relatively thick, although sample cuttings are available from only three wells that completely penetrate both the Nanjemoy formation and the Aquia greensand in their area of maximum thickness. These wells and the total thickness of Eocene strata are: Ch-Cf 9 near Bryantown, 371 feet; Cal-Bb 10 near Sunderland, 390 feet; and Cal-Ca 2 near Lower Marlboro, 318+ feet. It thus appears that the lower part of the Patuxent River valley constituted a more or less prominent basin of marine deposition during the part of Eocene time represented by the Nanjemoy and Aquia formations.

The thickness of the Marlboro clay member ranges in the subsurface from 2 feet in St. Marys County (wells St.M-Eb 2 and St.M-Bc 2) to as much as 40 feet in Charles County (well Ch-Ce 8). Throughout most of Prince Georges

County the clay member is about 25 feet thick, but it thins to the southeast in Calvert and St. Marys Counties; it is only 6 feet thick in well Cal-Dc 17 at Prince Frederick and only 8 feet thick in well St.M-Fe 24 at Piney Point.

The Nanjemoy formation overlies the Aquia greensand unconformably, although it is likely that the hiatus between the units was of short duration, as the sediments composing the two formations, with the exception of the Marlboro clay member, are similar.

The Nanjemoy formation is overlain by the Piney Point formation in the southern part of Calvert and St. Marys Counties (Pl. 5). It is not known whether the contact between the two formations is unconformable, as the Piney Point formation has been recognized only in the subsurface. Northwest of the known limits of the Piney Point formation, the Calvert formation unconformably overlies the Nanjemoy. The dip of the Nanjemoy formation is to the southeast but the rate of dip varies. Near Croom in southern Prince Georges County the formation dips 75 feet in 5 miles or 15 feet per mile. Near the mouth of the Wicomico River along the boundary between Charles and St. Marys Counties the dip decreases to about 4 feet to the mile. The contact of the Nanjemoy formation with the overlying Calvert formation along Md. Route 210 near Piscataway (Cooke, 1952, p. 37) is approximately 145 feet above sea level; 53 miles southeast, at well St.M-Fh 3 near Point No Point, the top of the Nanjemoy formation lies 374 feet below sea level, a drop in altitude between the two points of 519 feet, or a little less than 10 feet per mile. This is about the average dip of the formation throughout the Southern Maryland area.

Water-bearing properties.—The Nanjemoy formation is an important aquifer in Calvert and St. Marys Counties where it is tapped by several hundred wells, most of which are domestic wells yielding less than 10 gallons a minute. In southern Anne Arundel, southern Prince Georges, and eastern Charles Counties, it is not generally productive of ground water. It yields water to a few dug wells near its outcrop area in Anne Arundel County and to a few wells along the Patuxent River valley in southern Prince Georges County. No wells are known to yield water from the formation in Charles County. Where it has not been productive of ground water the drillers' logs and sample studies show that it is composed chiefly of marl, sandy clay, and blue and pink clay (basal Marlboro clay member). The log of well PG-Ff 16 shows that the formation, which is 234 feet thick at this site, is composed chiefly of sandy clay and clayey sand containing a few thin rock layers. The log of well PG-Fd 32 at the Brandywine School describes similar lithology.

Marl, sandy marl, and black clay are reported in a number of wells penetrating the formation in the Waldorf-La Plata area, where it is not productive. It is likely that at least moderate amounts of ground water could be obtained from the formation in localities where it is not now utilized. For example, no wells are known to end in the Nanjemoy in southern Anne Arundel County, although the

the driller's log of well AA-Ed 19, near Birdsville, shows 4 feet of black and white water-bearing sand in the Nanjemoy at a depth of 170 to 174 feet.

East of an ill-defined line trending northward across Calvert and St. Marys Counties the Nanjemoy formation commonly yields water to drilled wells (Pl. 10).

Permeable water-bearing sands occur chiefly in the uppermost 80 feet of the Nanjemoy formation throughout the southeastern third of St. Marys and Calvert Counties, where it is overlain by the Piney Point formation. The latter formation, consisting largely of permeable glauconitic sands and layers of rock, is probably hydrologically connected with the Nanjemoy formation. Many of the wells are screened in both aquifers, or, where screens are not used, the wells are cased only to the base of the overlying Calvert formation and yield water from both uncased aquifers. It is difficult to evaluate the hydrologic properties of each formation on the basis of data from such wells. Wells drilled into the Nanjemoy but screened opposite only the Piney Point formation are discussed in the description of the water-bearing properties of that formation.

The yields, specific capacities, and lengths of screen of 19 wells in the Nanjemoy in Southern Maryland are shown in Table 19. In order to provide information on the maximum yields available, data on many domestic wells are omitted from the table, especially where nearby large-diameter commercial or public-supply wells tap the aquifer.

In the North Beach-Willows Beach area of northern Calvert County the yields of 9 domestic wells range from 3 to 10 gallons a minute, and the specific capacities range from 0.2 to 1.6 and average 0.8 gallon per foot. It is probable that the efficiency of many of the domestic wells for which specific capacity figures are available is less than the potential efficiency of properly screened large-diameter wells ending in the same aquifer. Undoubtedly yields of as much as 100 gallons a minute could be obtained from the Nanjemoy formation in the North Beach area.

The yields of 6 wells near Hollywood in St. Marys County range from 22 to 60 gallons a minute; the wells are 6 and 8 inches in diameter and contain 5 to 12 feet of screen. Specific capacities in the Hollywood area range from 0.2 to 1.2 and average 0.6 gallon per foot.

For the formation as a whole, the specific capacities of 19 wells range from 0.1 to 2.4 and average 0.8 gallon per foot. Using the specific capacity of 0.8 as a rough index of the hydrologic properties of the aquifer, it is apparent that the Nanjemoy formation is less permeable than most of the deeper and geologically older aquifers.

To evaluate the hydrologic properties of the Nanjemoy formation more fully it would be desirable to test it with large-capacity wells screened opposite the greatest number of water-bearing sands. In many localities the formation has been tapped only by domestic wells yielding 5 gallons a minute or less, and screened opposite only one water-bearing sand. Throughout a large part of Calvert and St. Marys Counties the formation constitutes an important and readily accessible source of ground water of a quality suitable for most uses.

Permeability, transmissibility, and storage coefficients.—Data concerning the coefficients of transmissibility and permeability are available from pumping tests on only two wells ending in the Nanjemoy formation. In 1944 a recovery test was made on well Cal-Gd 5 at the site of the former U. S. Naval Amphibi-

TABLE 19

Yields and specific capacities of wells producing from the Nanjemoy formation

Well	Locality	Diameter of casing (in.)	Length of screen (ft.)	Yield (gal./min.)	Drawdown (ft.)	Specific capacity (gal./min./ft.)
PG-Gf 1	Aquasco	6	11	15	110	0.1
Cal-Bc 7	North Beach-Willows Beach	2½	None	3	5	.6
Bc 12	do	2	do	4	17	.2
Bc 14	do	2½	do	5	3	1.6
Cc 1	do	2	do	8	9	.9
Cc 2	do	2	do	8	9	.9
Cc 5	do	2	do	10	13	.7
Cc 6	do	2	do	10	12	.8
Cc 26	do	2	do	10	11	.9
Cc 27	do	2	do	10	11	.9
Dc 16	Scientists Cliffs	6	10	40	50	.8
Dc 27	do	2½	None	4	7	.5
Ec 3	St. Leonard	6	10	60	25	2.4
St.M-Ce 4	Hollywood	6	9	45	36	1.2
Ce 14	do	8	11	50	115	.4
Ce 20	do	6	5	60	98	.6
De 3	do	6	12	60	50	1.2
De 6	do	6	12	30	65	.4
De 7	do	6	7	22	105	.2

ous Training Base near Solomons Island. Well Cal-Gd 5 is an 8-inch well, 248 feet deep, with 15 feet of screen set opposite a bed of water-bearing greensand at a depth of 217-232 feet. Prior to the test the well had been pumped at a rate of about 100 gallons a minute for several days. Measurements were made of the recovery of the water level in the pumped well and on the basis of these data a coefficient of transmissibility of approximately 2,000 gallons per day was computed (Bennett, 1944, p. 11). As the effective sand thickness at the site of well Cal-Gd 5 is about 30 feet, the field coefficient of permeability is 66 gallons per day per foot. It was not possible to determine the coefficient of storage from the test on this well.

The results of a recovery test on well PG-Hf 3, a 200-foot well ending in the Nanjemoy formation at the town of Eagle Harbor, indicate a coefficient of transmissibility that ranges from 260 to 840 gallons per day per foot. The field coefficient of permeability could not be determined as the thickness of the water-bearing sand was not known. The test is not considered reliable, as the well reportedly had been flowing for 26 years prior to the test, and the recovery of the artesian head in the well was measured only for a period of 18 minutes. It is also likely that the well is inefficient because of incrustation and corrosion.

To determine more accurately the hydraulic characteristics of the Nanjemoy formation in Southern Maryland it is necessary to make additional pumping tests, preferably in localities where one or more observation wells can be utilized.

Piney Point formation (Jackson age)

Distribution and character.—Strata of Jackson age were first identified in the Maryland coastal plain by Shifflett (1948, pp. 26, 27, and 30) in a well near Sollers in Calvert County and in two wells in Dorchester and Somerset Counties. Approximately 30 feet of strata of Jackson age are identified in well Cal-Fd 19 at a depth of 220 feet. No formational name was given to these deposits, which consist of light gray to yellowish glauconitic sand and interbedded "rock" or shell layers containing a foraminiferal assemblage distinctive from that of the overlying and underlying deposits. The character of the strata is shown by the driller's logs and sample logs in reports on the ground-water resources of Calvert and St. Marys Counties (Overbeck, 1951, and Ferguson, 1953).

The cuttings from wells in Calvert, St. Marys, and Charles Counties show that sediments exhibiting the characteristic Jackson lithology are present throughout Southern Maryland southeast of a line extending southwestward from Kenwood Beach across Calvert and St. Marys Counties to the vicinity of Cobb Island in Charles County (Pl. 5). This distinctive lithologic unit, containing a characteristic fauna of Jackson age, is recognizable in the subsurface in Charles, Calvert, St. Marys, Dorchester, and Somerset Counties, and in Northumberland and Westmoreland Counties in Virginia. Deposits of Jackson Age have not been recognized in surface exposures and are not known to lie above an altitude of 75 to 80 feet below sea level (wells Ch-Ff 43 and St.M-Bc 12).

The hitherto unnamed glauconitic sands and interspersed shell beds of Jackson age lying above the Nanjemoy formation and below the Calvert formation are herein named the Piney Point formation from their typical development in a well at Piney Point along the north bank of the Potomac River in St. Marys County. This well (St.M-Fe 24), which penetrated 50 feet of the Piney Point formation, is designated the type-locality well. It was drilled for Curtiss Steuart in 1950 near the tip of the Piney Point peninsula 0.8 mile northeast of the Piney Point lighthouse. The well produces water from the Aquia greensand at a depth of 399 to 411 feet and its altitude is approximately 5 feet above mean sea level. Sample cuttings collected at 10-foot intervals from the surface to the bottom of the hole are on file at the Maryland Department of Geology, Mines and Water Resources. Microfossils obtained from the cuttings, with species and generic identifications, are on file with the well cuttings. They are listed in Table 35. The log of the well is in Table 34.

The indurated shell layers characteristic of the Piney Point formation at its type locality are believed to be formed by recrystallization of calcium carbonate dissolved from the fossil shells by circulating ground water. The number and thickness of the individual layers is not always known, as the churn drill grinds and mixes the material of the indurated layers with the sands separating the rock layers. In many wells rock layers are reported by the drillers to range in thickness from a few inches to as much as 5 feet. In places the sands of the Piney Point formation grade from grayish green to grayish white, owing in part to a decrease in the amount of glauconite in the sand.

Subsurface character.—In the subsurface the overlying Calvert formation may readily be separated from the Piney Point, as the lower part of the Calvert consists chiefly of diatomaceous clay or sandy clay, usually light olive-gray to grayish olive. In some places the diatomaceous beds of the Calvert formation are resistant to penetration by the light jetting rigs commonly employed by drillers of domestic wells, whereas the underlying sand layers in the Piney Point formation are more readily penetrated by these rigs. The change of rate of penetration is noticed by the drillers. The rate of penetration may decrease markedly, however, when rock is encountered in the Piney Point formation. The underlying Nanjemoy formation is identified by a greater proportion of greenish brown and brown glauconite in the cuttings, by a larger proportion of clay in the sand, and by the absence of the indurated light-colored rock layers.

Mechanical analyses.—No particle-size analyses were made of samples of the Piney Point formation. The well cuttings suggest that the sand layers are composed mainly of medium- to fine-grained material.

Thickness and stratigraphic relations.—The Piney Point formation occurs as a wedge-shaped geologic unit overlying the Nanjemoy formation. It attains its maximum known thickness of 60 feet at wells St.M-Df 22 and St.M-Ec 11 near Lexington Park and Breton Beach. The formation thins to the northeast and is only 12 feet thick at well Cal-Eb 2, a few miles west of the town of Island Creek; at well St.M-Bc 12, on the south bank of the Patuxent River near Cremona, it is 10 feet thick. Table 20 gives the approximate thicknesses of the Piney Point formation in wells based on an examination of the sample cuttings and foraminiferal studies:

The lithologic character of the Piney Point and Nanjemoy formations in the subsurface suggests that they are probably conformable; changes in the faunal assemblages are not great. In a few wells in St. Marys County the basal 10 to

15 feet of the Piney Point formation grades into the underlying Nanjemoy with no sharp lithologic break, and the contact can be only approximated.

The Calvert formation overlies the Piney Point, the contact between the formations being marked chiefly by the change from the gray sand and indurated shell layers of the Piney Point to the diatomaceous clay of the Calvert. In some wells the base of the Calvert formation is marked by a fine-grained sand, generally lacking in microfossils, which is distinctive from the overlying diatomaceous

TABLE 20

Thickness of the Piney Point formation in wells

Well no.	County	Approximate location	Thickness (ft.)
Cal-Eb 2	Calvert	Island Creek	12
Ec 3	do	St. Leonard	25
Ec 19	do	Parkers Wharf	12
Fd 5	do	Appeal	18
Fd 7	do	Johnstown	42
Fd 19	do	Sollers	32
Fd 22	do	Bertha	42
Fe 2	do	Cove Point	31
Gd 30	do	Solomons	31
St.M-Cd 1	St. Marys	Sandgates	20
Db 14	do	Avenue	40(?)
Dc 34	do	Compton	30
Dd 1	do	Leonardtown	20
Dd 14	do	Beauvue	40
Df 22	do	Lexington Park	60
Ec 11	do	Breton Beach	60
Ee 26	do	Callaway	50
Fe 24	do	Piney Point	50
Fh 3	do	Point No Point	40
Gg 1	do	Scotland	40
Ch-Ff 20	Charles	Cobb Island	12

beds. It commonly does not contain shells and is characterized by only minor amounts of glauconite. In the vicinity of Cobb Island and at Breton Beach, the Calvert formation has been removed by erosion, and the estuarine Pleistocene deposits lie directly on the Piney Point or the Nanjemoy formation.

Plate 5, showing the altitude of the base of the Miocene series, also shows the strike and dip of the top of the Piney Point formation where it immeditely underlies the Calvert formation. The formation strikes north-northeast and dips to the east at a relatively gentle rate ranging from less than 5 feet per mile in the area south of Leonardtown to about 12 feet per mile in the vicinity of Smith Creek and Jutland Neck. The formation is 75 feet below sea level in well Ch-Ff 43 at Cobb Island and 334 feet below sea level in well St.M-Fh 3 at Point No

Point, indicating a decline in elevation of about 260 feet across St. Marys County.

Water-bearing properties.—The Piney Point formation is widely utilized as a source of domestic ground-water supplies throughout those parts of Calvert and St. Marys Counties where it is as much as 40 to 50 feet thick. It is estimated that from 500 to more than 1,000 domestic wells tap the Piney Point and Nanjemoy formations. Some of the wells flow, and many are equipped with small-capacity pumps. The indurated layers in the Piney Point formation seemingly prevent caving of the interspersed sandy strata, which would clog the wells so that many of the wells are not screened opposite the Piney Point formation, as is the common practice when wells are completed in most other aquifers. The yields of the domestic wells are generally adequate, ranging from 3 to 20 gallons a minute. At the Naval bases near Solomons Island and Cedar Point, large-capacity wells, screened opposite the Piney Point, and the upper part of the Nanjemoy formation, yield as much as 190 gallons a minute. Table 21 shows the yields, specific capacities, screen lengths, and diameters of 27 wells tapping the Piney Point formation.

In southern Calvert and eastern St. Marys Counties the Piney Point formation and the upper part of the Nanjemoy formation probably function as a hydrologic unit, for both formations contain permeable water-bearing beds adjacent to one another. The classification of the well data in Table 21 is, therefore somewhat arbitrary with respect to the formation from which the ground water is produced, but it permits the hydrologic unit in the two formations to be compared with other hydrologic units in a single formation.

The specific capacities of 25 wells tapping the Piney Point formation range from 0.1 to 3.3 and average 1.2 gallons per foot. The average for the formation as a whole is weighted in favor of 12 large-capacity wells in the Solomons Island-Patuxent Naval Air Station area. The average specific capacity for the 12 wells in this area is 1.4 gallons per foot, which is slightly more than half the average specific capacity of 2.5 gallons per foot for 8 wells tapping the Aquia greensand in the same area. The reported yields of wells tapping the two formations are roughly in the same proportion. Hence, the deeper aquifer, the Aquia greensand, is more permeable and capable of more extensive ground-water development.

At Chingville, in St. Marys County, well St.M-Ec 4 yields 60 gallons a minute and has a specific capacity of 1.0 gallon per foot. Data on yields and specific capacities of wells tapping the formation in localities other than the Solomons Island area are too scanty to warrant a comparison. The formation is not generally utilized as a source of ground water in its area of pinch-out or minimum thickness in central Charles, southeastern Prince Georges, and northwestern Calvert Counties. Here the logs of some wells show that the formation is water-bearing, but the underlying Aquia greensand is tapped as it is thicker and more uniform in its water-bearing properties.

TABLE 21

Yields and specific capacities of wells producing from the Piney Point formation

Well	Locality	Diameter of casing (in.)	Length of screen (ft.)	Yield (gal./min.)	Drawdown (ft.)	Specific capacity (gal./min./ft.)
Cal-Ec 6	Broomes Island	3-2	None	3	32	0.1
Ec 8	do	1½	do	15	15	1.0
Ed 6	Long Beach	2½	do	50	—	—
Fd 4	St. Leonard Creek	2	do	3	12	.3
Fe 2	Cove Point	2½	do	20	12	1.7
Fe 3	do	3	do	10	5	2.0
Fe 4	do	2½	do	20	10	2.0
Fe 5	do	2½	do	20	10	2.0
Fe 10	do	2½	do	10	14	.7
Ed 31	Solomons Island-Patuxent Naval Air Station	5-3½	do	30	27	1.1
Gd 3	do	6	13	50	70	.7
Gd 4	do	8	15	100	65	1.5
Gd 5	do	8	15	110	70	1.3
Gd 9	do	2½	None	10	3	3.3
Gd 34	do	8	12.5	180	115	1.6
St.M-Df 6	do	6-4	13	25	50	.5
Df 8	do	4	10±	25	40	.6
Df 9	do	8	15	190	63	3.0
Df 23	do	6	9	40	30	1.3
Df 30	do	6	10	40	42	1.0
Df 35	do	6	—	80	60	1.3
Df 25	California	6	11	60	50	1.2
Ee 4	Chingville	6	12	60	63	1.0
Ee 30	Great Mills	6	6.5	55	—	—
Ef 3	do	6	12	20	45	.5
Ef 13	do	6	9	30	25	1.2
Fh 2	Point No Point	6-4	None	10	20	.5

MIOCENE SERIES

Calvert formation (Chesapeake group)

Distribution and character.—In Southern Maryland the Chesapeake group is divided into the Calvert, Choptank, and St. Marys formations (Shattuck, 1902). In Anne Arundel and Calvert Counties the basal formation of the group, the Calvert, is exposed along the stream valleys from Davidsonville south as far as Governors Run on the Chesapeake Bay. In Prince Georges County the Calvert is present at the surface on hillsides near the District of Columbia line and crops out at progressively lower altitudes to the southeast. It is exposed along many of the stream valleys in eastern Charles County and it may be seen at the surface in St. Marys County as far southeast as Sandgates and St. Clement Creek.

The Calvert formation is divided, chiefly on a lithologic basis, into two members, the lower Fairhaven diatomaceous earth member, consisting mainly of diatomaceous clay and fine sandy clay, and the upper Plum Point marl member, consisting of sandy clays and shell beds.

At the base of the Fairhaven a thin bed of fine-grained white sand is observed at some exposures and has been noted in cuttings from a number of wells. Above the basal sand are thick beds of yellowish diatomaceous earth, many of which are more than 50 percent skeletal remains of diatoms, a form of marine plant life. This material, which consists mainly of silica, commonly bleaches to a whitish gray on weathering, and as such forms the cliffs in the vicinity of Fairhaven in southern Anne Arundel County. The Fairhaven member ranges in thickness from 52 feet in the vicinity of Chesapeake Beach (Clark, Shattuck, and Dall, 1904) to as much as 80 feet in well Ch-Bf 5 at the State Police Barracks at Waldorf.

The upper member of the Calvert formation, the Plum Point marl, consists of sandy clay and clayey sands containing several shell beds; layers of sandy diatomaceous earth are common, although they are not as thick or prominent as in the Fairhaven member. The Plum Point marl is 50 to 75 feet thick in Charles County (Dryden, Overbeck, and others 1948). However, in the subsurface throughout much of Southern Maryland the two members cannot easily be split and their thicknesses are not known.

The following section of the Calvert formation was measured in northern Calvert County where the toughness and resistance to erosion of the sandy clays is well illustrated. Samples of the formation from beds 1, 2, and 3 were collected for particle-size analysis.

Geologic section of the Calvert formation along the Calvert Cliffs

Location: In Calvert County along the Chesapeake Bay approximately 1,500 feet south of the wharf at Camp Roosevelt

Altitude: Base of section at mean sea level

Bed No.		*Thickness* (feet)
7	Covered interval (may include Pleistocene deposits)	15±
6	Sand, clayey, yellowish-gray to brownish-gray, slightly diatomaceous	10
5	Clay, silty, tough, yellowish-gray to reddish-gray	5
4	Clay, thin, sandy; pelecypods abundant; contains forams	1
3	Clay, tough, blue-gray; forms almost vertical cliff at this spot; fossil shells rare or absent (sample no. 8)	35
2	Clay, sandy, dark-gray, tough; marine shells abundant (sample no. 7)	12
1	Clay, blue, tough, highly diatomaceous (sample no. 6)	17
	Total	95±

Subsurface character.—In the well cuttings it has not been possible to separate the Calvert formation from the other formations of the Chesapeake group, except where the cuttings contain microfossils or small megafossils. In some wells the top of the Calvert formation has been arbitrarily placed where conspicuous beds of diatomaceous earth appear, although this material has been found also in the overlying Choptank formation. The base of the Miocene series (bottom of the Calvert formation) may be determined in the subsurface by the change from the glauconitic greensand of the underlying Eocene strata to fine-grained whitish sand with associated small phosphatic pebbles, or to yellowish diatomaceous beds. The Calvert formation contains a distinctive suite of Foraminifera that serve to separate it from the underlying and overlying formations. Diatoms also serve to identify the Calvert formation and, especially, to separate it from other formations of the Chesapeake group.

Sample cuttings from well St.M-Fe 24 at Piney Point were examined by K. E. Lohman of the U. S. Geological Survey, who placed the top of the Calvert formation in this well at a depth of 120 feet on the basis of an assemblage of diatoms in the cuttings from depths of 120 to 150 feet. The species identified by Lohman and his statement concerning the classification of the strata are:

Actinocyclus octonarius Ehrenberg
Actinoptychus cf. *A. heliopelta* Grunow
    senarius Ehrenberg
    cf. *A. vulgaris* Schumann
    spp.
Annellus californicus Tempere
Asterolampra marylandica Ehrenberg
Aulacodiscus sp.
Cestodiscus marylandicus Lohman
Coscinodiscus apiculatus Ehrenberg
    arcus Lohman
    cf. *C. argus* Ehrenberg
    convexus Schmidt
    cf. *C. curvatulus* Grunow
    elegans Greville
    excavatus Grunow
    lewisianus Greville
    lineatus Ehrenberg
    monicae Grunow
    radiatus Ehrenberg
    salisburyanus Lohman
    stellaris Roper
    spp.
Cladogramma ellipticum Lohman
Craspedodiscus coscinodiscus Ehrenberg
Cymatogonia amblyoceras (Ehrenberg) Hanna
Dicladia sp.
Diploneis subcincta (Schmidt) Cleve

Endictya robusta (Greville) Hanna and Grant
Goniothecium rogersii Ehrenberg
Grammatophora sp.
Hemiaulus bipons (Ehrenberg) Grunow
polymorphus Grunow
Hyalodiscus laevis Ehrenberg
Liradiscus sp.
Melosira complexa Lohman
sulcata (Ehrenberg) Kützing
Nitzschia sp.
Periptera tetracladia Ehrenberg
Pleurosigma affine var. *marylandica* Grunow
Plioaria petasiformis Pantocsek
Pseudopyxilla americana (Ehrenberg) Forti
Pyxilla johnsoniana var. *intermedia* Tempere and Forti
Rhaphoneis augustata Pantocsek
gemmifera Ehrenberg
aff. *R. immunis* Lohmann
spp.
Sceptroneis cf. *S. caducea* Ehrenberg
Stephanogonia sp.
Stephanopyxis barbadensis Grunow
lineata (Ehrenberg) Forti
turris (Greville and Arnott) Ralfs
Thalassionema sp.
Thalassiothrix longissima Cleve and Grunow
Triceratium interpunctatum Grunow
tessellatum Greville
Xanthiopyxis maculata Hanna
oblonga Ehrenberg

"This assemblage indicates definitely that the beds at depths between 120 and 150 feet are in the upper part of the marine Calvert formation, of middle Miocene age. More specifically, they can be correlated with zones 11 to 13 inclusive as used by the Maryland Geological Survey in 1904. I have made collections from the 24 zones assigned to the Calvert, Choptank, and St. Marys formations and have used those collections as comparative material in making this assignment."

Mechanical analyses.—Particle-size analyses of nine samples of the Calvert formation are shown graphically in figure 11. Although the formation is composed mostly of beds of clay and sandy clay, it contains beds of coarse shelly sand locally. Sample 2, from an outcrop 2½ miles east of Hughesville, consists of 90 percent material classed as medium and coarse sand, and samples 4 and 5, also from surface exposures in Charles County, consist chiefly of fine and medium sand. The histograms of these samples contrast sharply with those of samples 8 and 9 from the Calvert Cliffs and Port Tobacco. Sample 8 consists of 96 percent clay and silt and is representative of some of the toughest and most erosion-resistant sediments in the Southern Maryland area; sample 9, consisting of 99 percent clay and silt, is similar in texture. Where material of this character

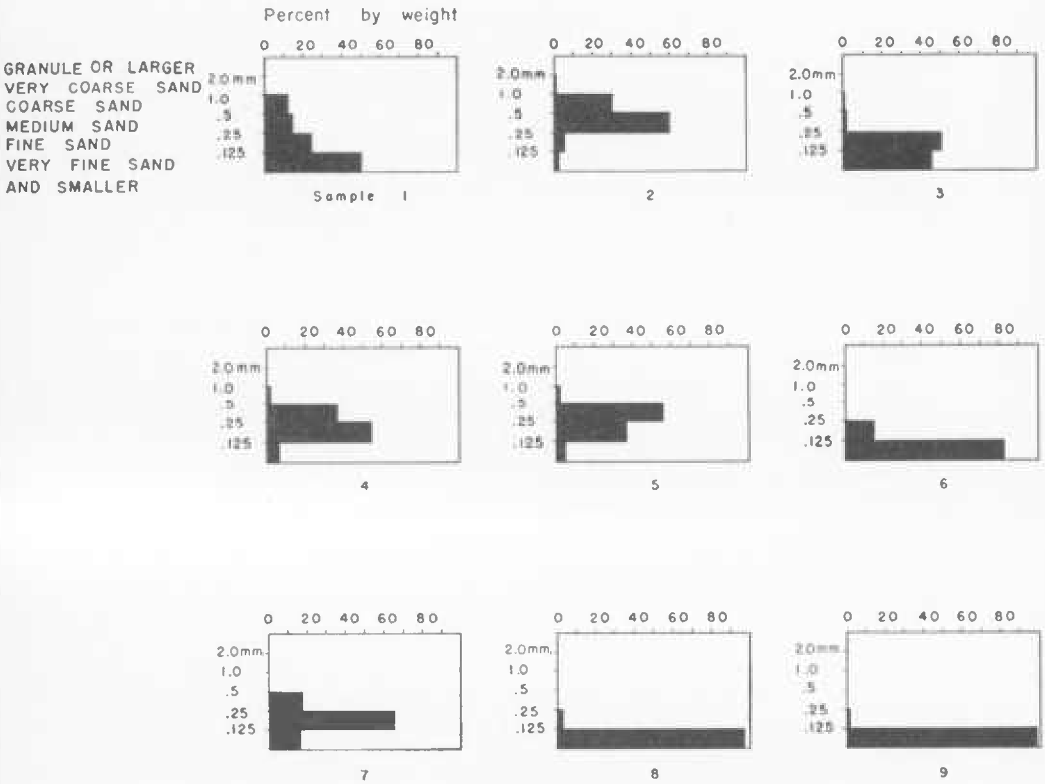


FIG. 11. Histograms of samples from the Calvert formation

Samples 1. Outcrop in road cut 7 miles south-southeast of La Plata in Charles County; sample taken about 25 feet below contact with Pleistocene deposits (from Dryden, Overbeck, and others, 1948, p. 59, sample 5).

2. Outcrop from ravine on property of Elmer Stonestreet, 2½ miles east of Hughesville, Charles County; coarse material largely shell fragments (from Dryden, Overbeck, and others, 1948, p. 59, sample 6).

3. Outcrop a few feet below Pleistocene contact in bluff at Popes Creek, Charles County (from Dryden, Overbeck, and others, 1948, p. 59, sample 7).

4. Outcrop a few feet below Calvert-Pleistocene contact in exposure along Md. Route 429 near Popes Creek (from Dryden, Overbeck, and others, 1948, p. 59, sample 8).

5. Outcrop from base of section near Rogers Mill along Md. Route 6, 3.5 miles southwest of La Plata, Charles County (from Dryden, Overbeck, and others, p. 59, sample 9).

6. Outcrop 1 foot above tide level from bed no. 1, measured section 1,500 feet south of wharf, Camp Roosevelt, Calvert County.

7. Outcrop 2 feet above base of bed no. 2, same locality as sample 6.

8. Outcrop 5 feet above base of bed no. 3, same locality as sample 6.

9. Clay from depth 40 to 50 feet, well Ch-Cd 9, at the new school at Port Tobacco, Charles County.

is encountered by the drillers, it is common practice to set the casing of a well in the clay and to leave the remainder of the hole uncased. The material is sufficiently tough and impervious that the well does not collapse, even after being used for a number of years.

Thickness and stratigraphic relations—The thickness of the Calvert formation in Southern Maryland ranges from a few feet near the edge of its area of outcrop to 184 feet at well Cal-Bb 10 near Sunderland in Calvert County. In wells in which diagnostic forams or diatoms were not identified it was difficult to separate the Calvert from the other formations of the Chesapeake group. However, the microfaunas were studied in a sufficient number of wells to determine that the formations of the Chesapeake group vary in thickness. In general, the Calvert formation is thicker than the Choptank or the St. Marys formation. In Prince Georges County the Calvert formation ranges in thickness from 20 feet at well PG-Ec 25 to 100 feet at well PG-Ec 24. In Anne Arundel County it ranges in thickness from 20 feet at well AA-Ge 2 near Fairhaven to 135 feet at well AA-Fd 13 at Mount Zion. Part of the formation has been removed by erosion in the vicinity of well AA-Ge 2. In Charles County it is less than 20 feet thick at well Ch-Ff 21 near Cobb Island and about 125 feet thick at well Ch-Cg 1 at Hughesville; at the latter well the Calvert formation comprises two-thirds of the thickness of the Chesapeake group. It is less than 20 feet thick at well St.M-Dc 34 near Compton and about 150 feet thick at well St.M-Eg 16 near St. James. In many localities, particularly near the major estuaries in the Potomac River valley, the formation is relatively thin as a result of its erosion and subsequent replacement with deposits of Pliocene(?) or Pleistocene age. Similarly in outcrops along the Calvert cliffs, Pleistocene channel deposits locally occupy valleys cut in the underlying Miocene formations.

Throughout most of the Southern Maryland area the Calvert formation lies on Eocene strata consisting of the Aquia greensand, the Nanjemoy formation, and the Piney Point formation. Shattuck (1902) believed that the Calvert formation was overlain unconformably by the Choptank, but Cooke (1952, p. 34), among others, has questioned this view, and the relationship between the two formations is somewhat uncertain. Identification of several small pelecypods in the cuttings from well St.M-Dd 1 at Leonardtown indicates that the Choptank formation is absent and the Calvert formation is overlain directly by the St. Marys formation.[2] In many places the Calvert is overlain unconformably by the sands and gravels of Pliocene(?) or Pleistocene age.

The Calvert formation strikes northeast and dips generally southeast at rates ranging from 25 feet per mile near Croom in southern Prince Georges County to less than 4 feet per mile in the vicinity of the lower Wicomico River in Charles and St. Marys Counties, probably averaging 15 feet per mile through-

[2] Formations identified on the basis of fossils examined by Julia A. Gardner of the Paleontology and Stratigraphy section of the U. S. Geological Survey.

out the Southern Maryland area as a whole (Pl. 5). The upper surface of the formation is irregular and has not been recognized in many wells where it is overlain by other formations of the Chesapeake group. The eroded top of the formation is 220 feet above mean sea level at well PG-Ec 24 near Camp Springs, and 115 feet below sea level at well St.M-Fe 24 at Piney Point, 50 miles southeast, an average slope of about 6.7 feet per mile.

Water-bearing properties.—The Calvert formation is not an important source of ground water in Southern Maryland. No drilled wells are known to yield water from the formation, but in and near its area of outcrop it supplies a number of dug wells ranging in depth from 20 to as much as 91 feet. Little information is available concerning the yields of these wells, but they probably can supply no more than ordinary domestic needs. Where diatomaceous beds of the Fairhaven member are present the formation is relatively impervious and functions chiefly as a confining layer, creating artesian or semiartesian conditions in the underlying water-bearing sands in the Eocene formations.

Choptank formation (Chesapeake group)

Distribution and character.—The Choptank formation is well exposed in Calvert County in the Calvert Cliffs, from Dares Wharf south to Rocky Point, and it can be seen along the banks of several streams tributary to the Patuxent River in Calvert, Prince Georges, and St. Marys Counties. The formation consists chiefly of beds of yellowish gray to gray sandy clay, sand, and shells. Ledges or layers of indurated rock as much as 10 feet thick occur at some localities, as at Mackall in southern Calvert County. Drillers report "rock" layers 1 to 2 feet thick in a few wells that penetrate the Choptank in southern Calvert County.

The Choptank formation is not greatly different in lithology from the upper member of the Calvert formation or from the overlying St. Marys formation, and is separable in exposures along the Calvert Cliffs mainly on the basis of the megafossil zones (Clark, Shattuck, and Dall, 1904).

In the vicinity of Brandywine, in southern Prince Georges County, the Calvert formation is overlain by a fine-grained sand about 40 feet thick, which appears to be of marine origin and may be equivalent to, or a part of, the Choptank formation. The sand has been recognized in outcrops in Charles County and in parts of northern Calvert County along the Patuxent River valley. It is described in a recent publication (Hack, Nikiforoff, and Overbeck, 1950, p. III-4) and is shown as an unnamed geologic unit on the map of the Brandywine quadrangle included in their report. The fine-grained, even-textured, unfossiliferous character of this sand, however, is not typical of the sandy clays and shell beds comprising the Choptank formation where it is exposed along the Calvert Cliffs. It is believed that sediments of late Miocene age similar in nature to this sand are present in some of the wells in Southern Maryland. For example, fine-grained, even-textured, yellowish sand occurs at a depth of 30 to 50 feet in well

PG-Fd 5 at the Cheltenham Reform School; the log of well AA-Ed 19 near Birdsville in Anne Arundel County shows fine, uniform-textured, angular, yellowish orange, silty sand to a depth of 20 feet; the log of well Cal-Bb 10 at Sunderland shows yellowish brown clayey sand at a depth of 26 to 44 feet. These sediments may be the Choptank formation. Hack and Nikiforoff believe that Shattuck included this somewhat distinctive lithologic unit in his Sunderland and Brandywine formations in the earlier geologic mapping of the Southern Maryland counties.

The Choptank formation strikes approximately northeast and dips southeast. Its rate of dip is not known with certainty. The truncated upper surface of the formation is about 125 feet above sea level at well Cal-Dc 17 at Prince Frederick, and 84 feet below sea level at well St.M-Fh 3 at Point No Point, 31 miles southeast, indicating roughly a southeast dip of 7 feet per mile.

Subsurface character.—The lithology of the Choptank formation is so variable that no lithologic criteria have been established by which the formation can readily be identified in sample cuttings. In a few localities where the Miocene deposits are relatively thick, at least a part of the sediments are assumed to belong to the Choptank formation. On this basis, Dryden and Overbeck (1948, p. 67) suggest that 50 feet of the formation may be present at well Ch-Cg 1 at Hughesville. Twenty to thirty feet of the Choptank may be present in wells near Cheltenham, Birdsville, and Sunderland, but its presence was not established with certainty. Where forams or diatoms from the well cuttings were studied it was possible to identify the formation with reasonable accuracy as in wells St.M-Fh 3, Cal-Dc 17, and Cal-Fe 2.

Mechanical analyses.—Particle-size analyses of samples from the Choptank formation were not made. It is likely such analyses would show a considerable variation in the sorting and grades of the sediments, although much of the material would consist of clay, silt, or fine-grained sand.

Thickness and stratigraphic relations.—The thickness of the Choptank formation ranges from a few feet on the edge of its outcrop area to as much as 60 feet in well St.M-Fh 3. Probably it is not more than 40 to 50 feet thick in southern Prince Georges and eastern Charles Counties. Where the formation has been identified in wells in Calvert and St. Marys Counties it is usually less than 100 feet thick, and in a few wells downdip from the outcrop area it appears to be absent entirely. It is significant that in wells where the Calvert formation is relatively thick, the Choptank formation is comparatively thin. Commonly, the total thickness of the Miocene formations is nearly equal in nearby wells, suggesting little variation in the environment of sedimentation for all of them.

The stratigraphic relation of the Choptank to the underlying Calvert formation is not clear, although Clark and Shattuck (1904, p. 80) state that the Choptank lies unconformably on the Calvert. Other more recent geological studies indicate that the two units may grade into one another with no sharp break between them (Cooke, 1952, p. 34; Hack, Nikiforoff, and Overbeck, 1950, p. III-24). In places the Choptank formation is unconformably overlain by the St. Marys formation. In general, the Choptank does not appear to be a well-defined formation, and it probably cannot be accurately separated in the field or in the subsurface except on the basis of diagnostic fossils.

Water-bearing properties.—No drilled wells are known to produce water from the Choptank formation in Southern Maryland. Some dug wells, yielding a few gallons a minute, probably penetrate the formation near its area of outcrop in southern Prince Georges, central Calvert, and northern and central St. Marys Counties. It is likely that the water from these wells is derived mainly from the overlying Pleistocene sands and gravels. Where permeable beds of shelly sand interspersed throughout the formation lie beneath the water table, the formation undoubtedly will yield water to wells, but, as the beds are irregularly distributed and little is known of their water-bearing properties, wells are generally finished in beds known to be productive. Several small springs were observed to issue from a layer of shelly sand at an outcrop of the formation along Cole Creek in northern St. Marys County. The formation is not an aquifer of any importance.

St. Marys formation (Chesapeake group)

Distribution and character.—The St. Marys formation crops out at scattered localities in Calvert and St. Marys Counties along bluffs and tributaries of the Chesapeake Bay, the Patuxent River, and the Potomac River southeast of a line joining the communities of St. Leonard, Calvert Beach, Hollywood, and Leonardtown. It is commonly fossiliferous, and is lithologically similar to the underlying Choptank and Calvert formations, although somewhat less clayey. It consists of beds of grayish blue to gray or yellowish gray sandy clay, clay and sand.

Subsurface character.—In the subsurface the St. Marys formation does not appear to have any distinctive lithologic characteristics which make it possible to separate it from the other formations of the Chesapeake group, although it is generally less clayey than the Calvert formation and lacks the thick beds of diatomaceous earth common in that unit. Fragmental and whole pelecypod and gastropod shells are common in the sample cuttings, but identical species are found also in the Choptank formation in the cuttings from many wells. The St. Marys is readily separated from the overlying Pleistocene deposits, as the latter commonly consist of reddish brown to yellowish brown (oxidized) sandy gravel, clayey sand, or tough brown to gray clay. In well St.M-Dd 1 at Leonardtown the St. Marys formation consists of light olive-gray, fine- to medium-grained sand. Small pelecypods, sponge spicules, and ostracods are common in the cuttings. Suites of small megafossils from depths of 50 to 80 feet were examined by

Julia A. Gardner of the U. S. Geological Survey, who identified several species of pelecypods that occur only in the St. Marys formation.

The fossils identified by Miss Gardner are listed below; those marked (R) are known to have been found only in the St. Marys formation:

Nucularia sinaria Dall
Arca sp.
Cardium sp.
Dosinia acetabulum Conrad
Mactra clathrodon Isaac Lea
Dentalium caduloide Dall (R)
Turritella sp.
Polinices (*Neverita*) *duplicatus* (Say)?
Uzita peralta Conrad
Terebra (*Hastula*) *simplex* Conrad (R)
Andara sp.
Corbula inequalis Conrad
Crepidula fornicata (Linnaeus) (R)
Uzita marylandica (Martin)?
Bulliopsis sp. (?)
Oliva sp.
Terebra (*Hastula*) *inornata* Whitfield

In well St.M-Fh 3 at Point No Point the St. Marys formation consists of about 60 feet of fine clayey sand containing a zone of abundant shell fragments underlain by approximately 20 feet of light olive-gray sandy clay. The St. Marys formation was identified in this well by Glenn Collins on the basis of the forams.

Mechanical analyses.—No sieve analyses of the St. Marys formation in Southern Maryland were made. Examination of well cuttings suggests that the formation is similar in texture to the underlying Choptank formation.

Thickness and stratigraphic relations.—The thickness of the St. Marys formation in the subsurface of Calvert and St. Marys Counties ranges from 30 feet in well St.M-Dd 1 to 80 feet in well St.M-Fh 3 but may locally exceed 80 feet.

The St. Marys formation lies unconformably on the Choptank formation, but in the vicinity of Leonardtown (well St.M-Dd 1) the latter unit is absent and the St. Marys lies directly on the Calvert. The St. Marys is overlain unconformably by the Pleistocene deposits. It strikes approximately north-northeast and dips southeast. Its eroded upper surface is at an altitude of 47 feet above sea level in well St.M-Dd 1 at Leonardtown, and 4 feet below sea level in well St.M-Fh 3, 20.5 miles to the east, indicating a slope across St. Marys County of about 2.5 feet per mile.

Water-bearing properties.—Little is known of the water-bearing properties of the St. Marys formation in Southern Maryland for it has seldom been tapped by drilled or jetted wells. A few shallow augered wells in the vicinity of Great Mills furnish domestic supplies from permeable zones in the formation. Where examined at outcrops in Calvert County it appears to be too clayey to be capable of supplying water to drilled wells. It is likely that where sandy zones are present, as at Leonardtown, domestic ground-water supplies could be obtained from dug or augered wells.

Tertiary(?) and Quaternary Systems

pliocene(?), pleistocene, and recent series

Classification and origin.—The surficial deposits of the Maryland coastal plain consist of a blanket of sand, coarse gravel, silt, and clay deposited during the Pliocene(?), Pleistocene, and Recent geologic epochs. Shattuck (1906) separated these sediments in Maryland into four formations, the Lafayette, Sunderland, Wicomico, and Talbot, largely on the basis of their topographic position and their rather ill-defined physiographic expression as terraces They were believed to have been formed as a result of deposition and erosion during successive stages of the Atlantic Ocean. More recent studies by other geologists (reviewed in Dryden, Overbeck and others, 1948, p. 68–69) have created doubt as to the marine origin of three of the formations, the Lafayette (name changed later to Brandywine), Sunderland, and Wicomico. Evidence is cited to show that the Pliocene and Pleistocene geologic history of the Maryland coastal plain is complex, and that the Pliocene(?) and Pleistocene deposits now found at elevations of more than 40 to 60 feet above mean sea level are probably of fluviatile origin, derived mainly from the deposition of sand, gravel, boulders, and silt carried into the region chiefly by the drainage systems of the Susquehanna and Potomac Rivers. It is likely that these deposits were coalescing alluvial fans whose remnants now cap the upland interstream areas between the present river valleys. There is general agreement that the deposits now lying less than 40 feet above sea level are chiefly of marine or estuarine origin. It is also generally held that the major stream terraces of Pleistocene and Recent age bordering the Potomac and Patuxent Rivers represent successive periods of alluviation in the Quaternary history of the streams.

For convenience in describing the occurrence of ground water in Maryland the deposits of Pliocene(?) and Pleistocene age are grouped into two main units, upland and lowland (Bennett and Meyer, 1952, p. 68). The upland deposits are arbitrarily considered to consist of sediments of Pliocene(?) and/or Pleistocene age lying higher than 40 feet above sea level; the lowland deposits consist chiefly of sediments of Pleistocene and Recent age lying below this elevation and extending to depths as great as 200 feet below sea level. They occupy extensive areas along the bays and estuaries of the Southern Maryland area (Pl. 6).

pliocene(?) and pleistocene (upland) deposits

Distribution and character.—The upland deposits are a surficial mantle or covering on the older sediments in the topographically higher parts of Southern

Maryland, except in northern Anne Arundel County and in parts of northern Prince Georges County where they are absent locally. Southwestward along a broad belt, 10 to 20 miles in width, extending from Gibson Island and Bodkin Point on the Chesapeake Bay to the District of Columbia boundary near the Anacostia River, the upland Pleistocene deposits are present only as erosional remnants capping the higher hills and as stream terrace deposits along the Patuxent River and its tributaries. Throughout most of this belt they are underlain by formations of Early and Late Cretaceous age.

The upland deposits vary in lithology from place to place, but they are characteristically composed of yellowish gray to reddish brown sand and gravel containing layers of clean sand and clayey silt. Boulders and cobbles up to several inches in diameter are common in the coarser layers. The upland deposits are economically important as a source of shallow ground-water supplies and of sand and gravel for road building and construction purposes. The sand pit of the Arundel Supply Corporation, in central Prince Georges County at the intersection of Walkers Mill Road and Addison Road, about one-half mile north of District Heights, shows in excellent detail the permeable nature of the Pliocene(?) deposits. The geologic section exposed in this pit is:

Bed number		*Thickness (feet)*
	Pliocene(?) deposits:	
6	Soil, buff to brown	1
5	Sand and gravel, clayey, reddish to rusty brown, streaked; gravel composed mostly of white to yellowish rounded quartz pebbles less than 2 inches in maximum diameter	5+
4	Clay, sandy, buff-gray to chocolate-brown, composed in part of angular detrital reddish clay fragments containing small quartz pebbles; may be a soil zone; carbonaceous material present	3+
3	Clayey sand grading downward to sand, mottled buff to gray, gravel pebbles in base	2±
2	Sand, coarse, clean, white to yellowish, rust-streaked; rounded lumps of grayish-white clay, 4 to 5 inches in maximum diameter, in sand matrix	3.5
1	Gravel, coarse, clean; yellowish to grayish-white; quartz pebbles up to about 4 inches in maximum diameter	12
	Total	26.5±

Hack and Nikiforoff (1950, p. III-3) have shown that in the Brandywine quadrangle the Pliocene(?) upland deposits (Brandywine formation) consist of two members. The basal member, 5 to 40 feet thick, is mainly gravel in a coarse sandy matrix, which grades laterally into beds of sand and fine silt. The upper member is poorly sorted sandy clay which grades upward to a silty loam. In places the entire upper member is loamy. Detailed field studies would probably reveal the presence of two or more members in the Pliocene(?) and Pleistocene upland deposits throughout a large part of Southern Maryland.

Subsurface character.—In the subsurface the Pliocene(?) and Pleistocene upland deposits are readily recognized by their lithologic character. The reddish brown to dark yellowish-orange sands, gravels and sandy clays, containing coarse, broken pebbles and granules of gray, white, or pink chert and associated arkosic sand, are markedly different from the underlying drab to grayish Tertiary marine sands and clays. Globules and lumps of limonitic material and pieces of woody material are common in the sample cuttings from the Pliocene(?) and Pleistocene deposits. Shells and marine fossils are not known to occur in the deposits, although some of the sample cuttings contain small amounts of glauconite, probably derived from the preexisting Eocene formations.

In some localities in Southern Maryland the fine-grained sands in the Calvert or Choptank formation are yellowish brown to dull orange, owing largely to oxidation, and are similar in appearance to the sands of Pliocene(?) and Pleistocene age. However, the latter are generally more arkosic and less sorted, and frequently contain small pieces of plant debris.

Mechanical analyses.—Histograms of 9 samples of sand and gravel from the upland deposits are shown in figure 12. The samples are unlike the marine strata of Eocene and Miocene age, and also somewhat different from the Lower and Upper Cretaceous continental deposits. They are characterized generally by poor sorting; for example, sample 3 from the vicinity of Camp Lee is composed mostly of material coarser than granule size (2.0 mm.) and smaller than very fine sand (0.125 mm.). Sample 4, from a gravel pit near Broomes Island, consists mainly of coarse sand with lesser proportions of medium and fine sand and silt; the histogram suggests deposition of the material by swift currents in a stream channel. The histogram of sample 1 is characteristic of coarse gravel in which only a small proportion of the sediment is less than granule size (2.0 mm.). The histograms show great textural variation in the deposits.

Thickness and stratigraphic relations.—The thickness of the upland deposits in Southern Maryland reported in drillers' logs ranges from a few feet to as much as 55 feet (well PG-Dc 3 near Silver Hill in Prince Georges County). The deposits are 50 feet thick at well Cal-Ec 3 near St. Leonard in southern Calvert County. They are 62 feet thick at an exposure near Little Cove Point (Clark, Shattuck, and Dall, 1904, p. 91). The average thickness reported in the driller's logs and sample cutting logs of 45 wells in Prince Georges County is 28 feet.

The upper surface of the upland deposits conforms essentially to the present land surface, but the basal surface is undulating in character and variable in the direction of strike. The basal surface is at an elevation of approximately 250 feet above sea level at well PG-Ed 24 in the vicinity of Andrews Field; 192 feet at well PG-Fd 2 near Cheltenham; 110 feet at well AA-Ed 16 near Davidsonville; 140 feet in well Ch-De 16 at the Bel Alton school; and 60 feet in well St.M-Df 25 at California. In general, the basal surface of the upland deposits shows an eastward and a westward slope from a high central ridge extending south from the vicinity of Andrews Field through Cheltenham, Brandywine, Mechanicsville,

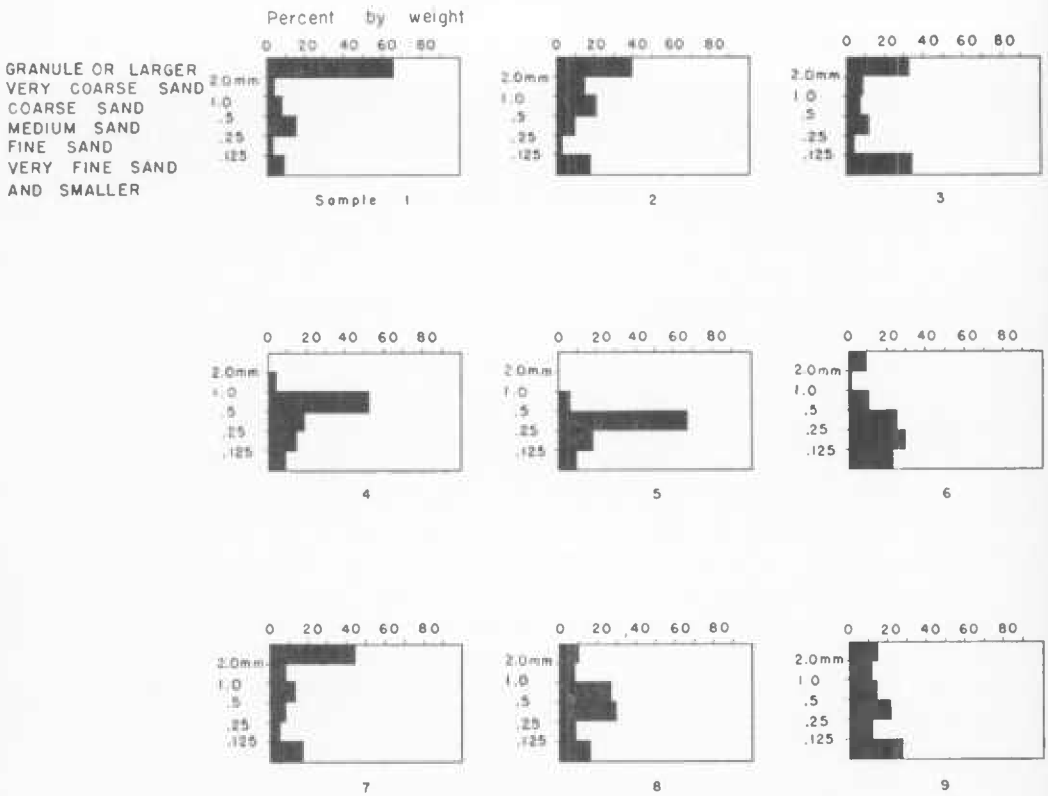


FIG. 12. Histograms of samples from the Pliocene(?) and Pleistocene upland deposits

Samples 1. Outcrop from roadside pit on highway 1¼ miles west of Lorton, Fairfax County, Virginia (Wentworth, 1930, p. 42).

2. Outcrop 4 feet below top of railroad cut at Franconia, Fairfax County, Virginia (Wentworth, p. 42).

3. Outcrop at an elevation of 170 feet from exposure near Camp Lee, Prince George County, Virginia (Wentworth, p. 54).

4. Outcrop from road cut on Md. Route 264, 1 mile north of Broomes Island, Calvert County.

5. Outcrop from bed no. 2 in Arundel Supply Corp. sand pit near District Heights, Prince Georges County.

6. Outcrop from bed no. 5 in Arundel Supply Corp. sand pit near District Heights.

7. Sand from depth 0 to 10 feet in well PG-Dd 19, drilled for the Prince Georges County Commissioners, near Forest Heights.

8. Outcrop from bed no. 6 at exposure along the Washington-Baltimore Expressway near Jessup, Anne Arundel County (fig. 3).

9. Sand from depth 10 to 20 feet in well Ch-Cd 9, Port Tobacco School, Charles County.

and California. The configuration of this surface seems to conform roughly with the present land surface.

Water-bearing properties.—The Pliocene(?) and Pleistocene upland deposits are an important source of ground-water supplies throughout the rural areas of Southern Maryland. They are tapped by a number of dug wells ranging in depth from less than 10 to about 50 feet. Many of the wells are not equipped with power pumps, but where such a pump is used, the delivery of a few gallons a minute is generally adequate; reported yields commonly range from 2 to 10 gallons a minute. The coarse sands and gravels constituting the major part of the deposits are fairly permeable and, where saturated to a sufficient thickness, are capable of yielding large quantities of water. The maximum yield reported from a well tapping the upland deposits is 25 gallons a minute (St.M-Bb 1 at New Market). This well is 13 feet deep and consists of a concrete-lined pit 10 feet square. The water is used during the summer for ice manufacturing.

A number of springs issue from the upland deposits, and in a few places they have been utilized as a source of ground water. At the Charlotte Hall Military Academy in St. Marys County a series of springs near the base of the deposits has supplied the institution for more than 50 years. The springs have been improved by means of concrete pits at their discharge points; approximately 7 springs supply 60 to 80 gallons a minute. A spring issuing from the upland deposits provides the water for the small industrial plant of the J. H. Mulholland Corporation, near Pomonkey in Charles County. This spring, located near the base of a small draw, reportedly yields 17 gallons a minute. Other springs are used as a source of ground-water supply in Southern Maryland, but little information is available concerning their permanence of flow or their rate of discharge. Springs in general are subject to fluctuation in their rate of flow due to seasonal variations in the position of the water table, and for that reason are not always regarded as a dependable source of supply in Southern Maryland. Probably the relative ease of well construction has been a factor contributing to the lack of use of springs. Because of their thinness, elevated position, and dissection, the upland deposits are not reliable sources of water during prolonged dry periods. They are most reliable where thickest and least dissected.

PLEISTOCENE AND RECENT (LOWLAND) DEPOSITS

Distribution and character.—These deposits, consisting of sediments lying below an altitude of approximately 40 feet above sea level, include the strata mapped as the Talbot formation by Shattuck (1906, p. 25) and by Clark and Mathews on the geologic maps of the Southern Maryland counties (Clark, 1903, 1916a; Mathews, 1939). Deposits of Pleistocene and Recent age in Prince Georges County mapped by Cooke (Cooke and Cloos, 1951) as the Pamlico formation are included in the lowland deposits. The lowland deposits are largely of marine or estuarine origin and consist of sand, clay, gravel, and boulders occupying trenches or valleys in preexisting sediments. Diatoms, marine shells, logs, stumps, and fragments of plant debris are common in the clayey parts of the sediments.

The logs of wells and the records of borings for the Chesapeake Bay Bridge and the Patuxent River Bridge at Holland Point indicate the nature and thickness of these deposits in Southern Maryland. At well St.M-Fe 4 near Piney Point sand and gravel constituting the basal part of the lowland deposits lie at an altitude of 149 feet below sea level; at Solomons Island on the Patuxent River the base of the lowland deposits lies at an altitude of 121 feet below sea level. Approximately 24 miles upstream, at the bridge at Holland Point, borings by the Maryland State Roads Commission show that the basal gravel of the lowland unit is 96 feet below sea level. Borings a few miles east of Sandy Point at the site of the Chesapeake Bay Bridge (J. E. Greiner Co., 1948) show that the lowland deposits, consisting in the basal part of sand and gravel, extend to a depth of 194 feet below sea level. The distribution of the lowland deposits and their thickness in parts of Calvert, Charles, and St. Marys Counties is shown on Plate 6.

Subsurface character.—The lowland deposits commonly consist of three lithologic units, a basal sand and gravel, an intermediate bed of tough clay, and an upper bed or beds of sandy clay or clayey gravel. The basal unit consists of 10 to 20 feet of coarse arkosic sand and gravel, which in places contains cobbles up to 6 inches in diameter. In some places the drillers are unable to penetrate the cobble zone with lightweight jetting rigs and are forced to abandon a well or complete it by some other method. The basal gravel is overlain by a few feet to as much as 90 feet of tough brown to gray clay, which is overlain by 10 to 30 feet of sand and gravel, part of which is probably of Recent age. The lowland deposits may be recognized by the toughness and grittiness of the clays which commonly contain the soft bluish mineral vivianite, by the angularity and fresh appearance of the quartz granules in the sand and gravel, by occasional pebbles of schistose rock in the gravel, and by the prevalence of small pieces of plant debris, especially in the uppermost sandy zones. The sample-cutting log of well St.M-Dc 20 near Abell, in St. Marys County, shows the typical lithology of the lowland deposits. A collection of small megafossils from depths of 50 to 70 feet in the well were submitted to Julia A. Gardner of the U. S. Geological Survey, who identified three species, *Mulinia lateralis* (Say), *Rangia cuneata* Gray, and *Skeniopsis planorbis* (Fabricus), which establish the Pleistocene age of the sediments. The pelecypod *Rangia cuneata* was noted in the cuttings of several wells penetrating the lowland Pleistocene deposits. *Rangia cuneata* also has been identified from a Pleistocene outcrop locality near Wailes Bluff in St. Marys County.

Mechanical analyses.—No particle-size analyses were made of samples from the lowland deposits. Wentworth (1930, p. 95) has published the histograms of a number of samples of Recent deposits in Virginia which show a wide variation in grain size. Most of his samples comprise material coarser than fine sand (0.125 mm.).

Thickness and stratigraphic relations.—The thickness of the lowland deposits in Southern Maryland ranges from a few feet to as much as 150 feet near Scotland Beach in well St.M-Gg 4. At Solomons Island in well Cal-Gd 30 the deposits are 126 feet thick, and at Cove Point on the eastern tip of Calvert County they are 65 feet thick; near the center of the Chesapeake Bay, according to data obtained from the deep borings (J. E. Greiner Company, 1948), they are 112 feet thick.

The lowland deposits lie unconformably on rocks ranging in age from pre-Cambrian through upper Miocene. Darton (1950, p. 25) shows that Recent deposits lie directly on the crystalline rocks at the Arlington Memorial Bridge across the Potomac River. The log of well Ch-Cb 7 drilled at the Naval Powder Factory in western Charles County shows 35 feet of clay and gravel of Pleistocene and Recent age overlying deposits of Late Cretaceous age, presumably the Patapsco formation. The sample log of well St.M-Fh 3 at Point No Point shows 10 feet of fine sand, probably of Recent age, overlying the St. Marys formation.

Water-bearing properties.—The water-bearing sands and gravels in the lowland deposits have not been extensively developed in the Southern Maryland area, except at some localities bordering the Potomac and Patuxent Rivers where numerous dug wells, generally not more than 30 feet in depth, furnish domestic supplies. These wells tap surficial sands and gravels of Recent or late Pleistocene age. Yields are generally not more than 5 to 10 gallons a minute.

The basal bed of sand and gravel reported so frequently in the drillers' logs of wells is usually waterbearing and, as in many places it contains cobbles and pebbles up to several inches in diameter, it is believed to be highly permeable. In St. Marys County the basal sand and gravel ranges in thickness from a few feet to as much as 87 feet in well St.M-Ee 7, a few miles northwest of Piney Point. Commonly it is less than 20 feet thick. A few drillers report that the water from the basal sand and gravel has an irony, or otherwise unpleasant, taste. Chiefly for this reason, comparatively few drilled wells in the Southern Maryland area are completed in the basal gravel. However, two drilled wells in Charles County tap the aquifer. Well Ch-Eb 3 near Riverside, screened opposite 7 feet of coarse gravel, is 96 feet deep and yields 25 gallons a minute. Well Ch-Ee 6, drilled for a small housing development at Morgantown, is 80 feet deep and yields about 10 gallons a minute.

During World War II three collector wells (a type of large-diameter dug well utilizing radial collector pipes) were constructed at Marshall Hall as an auxiliary source of water supply for the Indian Head Naval Powder Factory. One of these, well Ch-Ac 2, is 68 feet deep and reportedly yielded 200 to 350 gallons a minute, presumably from the lowland deposits. These wells are no longer used. Bennett and Meyer (1952, p. 72) report that well Bal-Gc 1, a collector-type well tapping the lowland deposits in the alluvium of the Patapsco River south of Relay, yields 1,000 gallons a minute. This is the maximum yield reported from any well tapping the lowland deposits in, or adjacent to, Southern Maryland.

The lowland deposits, particularly the basal gravel bed, constitute a little-utilized reservoir of ground water, which can be further developed as a source of supply. However, in many localities, because of the nearness of the water-bearing sands to the overlying brackish water in the estuaries, heavy ground-water withdrawals would probably result in the encroachment of salt water into the water-bearing zones as it has in the adjacent Baltimore area. It is also probable that in many places the high iron content of the water or its turbidity might require its treatment for most uses, including ordinary domestic use.

Occurrence of Ground Water

General Principles

The general principles governing the occurrence and movement of ground water have been discussed comprehensively by various authors, among them Meinzer (1923; Meinzer and others, 1942), Tolman (1937), King (1899), and Slichter (1899).

Most of the important supplies of ground water in Southern Maryland, are obtained from the sands and gravels in the unconsolidated sedimentary deposits. These deposits consist largely of rock and mineral particles or grains separated by interstices or voids through which ground water moves in response to differences in hydraulic head. The deposits vary widely in the size, shape, and arrangement of their interstices and in the total volume of interstitial space. The interstices are usually connected, and in sedimentary rocks the stratification of the earth materials produces a laminar arrangement of the interstices, which is a factor of fundamental importance in the movement of ground water. The most productive aquifers are beds composed of well-sorted, or uniform-sized, coarsely granular material such as coarse sand and gravel.

The source of all fresh ground water in the area is precipitation. However, only a part of the total precipitation enters the ground-water reservoirs. Some of the water runs off the surface and enters the streams, and some is returned to the atmosphere as water vapor by direct evaporation from the soil zone and by transpiration (evaporation due to the life processes of plants). The part of the precipitation that moves downward below the soil zone and enters the ground-water reservoirs constitutes recharge. This water, however, is stored only temporarily, for the major part of it moves slowly through the ground-water reservoirs into the streams, or other bodies of surface water. Thus, the water is in continual movement, except for that water bound to the rocks chemically or by the forces of molecular attraction. This continual movement and circulation of water from the atmosphere to the earth and back again to the atmosphere is known as the hydrologic cycle. The water present in one stage of this cycle, that which occurs beneath the water table, is called ground water.

WATER-TABLE AND ARTESIAN CONDITIONS

Subsurface water occupies two zones with respect to its position and the manner in which it is held in the voids in the rock and soil zone. The lower zone is called the "zone of saturation"; in this zone the voids or interstices are filled with water which is free to move under the influence of gravity and which is called ground water. The upper surface of the ground water is called the "water table." It is not, however, a sharply defined surface, as molecules of water are continually passing between this zone and the overlying vadose zone (zone of aeration) where the water is held against the force of gravity by forces of adhesion (capillarity). The lower part of the zone of aeration is the capillary fringe; the lower part of the capillary fringe is nearly or completely saturated, and the water is held above the water table by capillarity and is not free to flow into a well. The exact surface of the water table within granular materials is difficult to determine; however, when the zone of saturation is penetrated by wells or other excavations, the ground-water surface lies at a level that may be measured rather exactly. In general, the water table is a sloping surface which shows irregularities related to, and conformable with, the land surface—although usually of lesser relief. The position of the water table is continually changing, owing chiefly to variations in the amount of water reaching it from the zone of aeration. In Southern Maryland the maximum effective recharge occurs during the late winter and early spring, at which time the water table is generally at its highest position; during the late summer and early fall the water table is at its lowest position. This periodic rise and fall of the water table is illustrated in the graphs showing the measured water levels in several shallow observation wells in the area (see Water-Level Fluctuations).

Locally a bed of permeable rock underlain by a bed of relatively impermeable material may be saturated with ground water and lie above the general zone of saturation in the area. The surface of this upper saturated bed is call a perched water table. During long dry periods, or periods of no recharge to the water-bearing bed, the perched reservoir may drain completely and cease to be capable of supplying wells or springs. A condition somewhat analogous to this exists at some localities in the coastal plain of Southern Maryland where dug wells situated on the crests of isolated gravel-capped hills occasionally fail during intervals of little or no rainfall near the end of the summer.

Artesian conditions exist where a bed of water-bearing material is overlain by a less permeable or a relatively impermeable bed and where the contained water is confined under hydrostatic pressure. The distinction in nature between artesian and nonartesian, or water-table, conditions is not always precise, as many of the strata regarded as confining layers are not entirely impermeable, but merely less permeable than the adjacent water-bearing beds. However, the rate at which water is transmitted through such confining layers may be many thousands of times less than the rate at which it is transmitted through the aquifer. When an artesian reservoir is penetrated by a well the water will rise in the well above the level of the base of the confining layer; such a well is said to be an artesian well. There are both nonflowing and flowing artesian wells. As the water in an artesian aquifer is confined by the essentially impervious overlying rock, it has no water table; there is, however, an imaginary surface defined as the level to which the water will rise in wells. This level is known as the "piezometric" or pressure-head-indicating surface of the aquifer. Flowing wells occur where the piezometric surface is at a higher elevation than the land surface.

More than one piezometric, or artesian-pressure, surface can exist in a single geologic formation composed of 2 or more water-bearing beds separated by relatively impermeable or less permeable beds. This condition exists in the Odenton area of Anne Arundel County. Odenton is underlain at the surface by about 200 feet of sediments of the Patapsco formation. As the town has no municipal water-supply system many domestic and commercial wells have been drilled into this formation. The National Plastic Products Company pumps about 1,000,000 gallons a day from 4 wells ending in a water-bearing sand approximately 30 feet thick, the top of which lies at an altitude approximately 10 feet below sea level. A number of domestic wells end in a shallower water-bearing sand approximately 10 feet thick, which lies at an altitude of about 75 feet above sea level. The upper and lower sands are separated by beds of clay and sandy clay. Water-level measurements during a 2-day period in February 1953 showed that the nonpumping (static) water levels in wells tapping the higher sand were about 40 feet above those in wells ending in the lower sand, the artesian head of which is directly affected by the pumping from the industrial plant. Ground water in both water-bearing sands occurs under artesian conditions, although the Odenton area is within the outcrop belt of the Patapsco formation. It is probable, however, that the upper sand is hydrologically connected with the deeper sand, either directly at an indeterminate distance and direction from the Odenton area, or through the intervening confining bed, or both. The upper sand probably is receiving ground-water recharge from Severn Run, which drains the area, and from precipitation at a rate faster than it can be depleted by leakage to the lower sand, from which heavy withdrawals of ground water are being made. The ground-water conditions at Odenton serve to illustrate the extreme complexity of hydrologic conditions where the aquifers are irregular in extent and thickness, variable in permeability, and hydrologically connected with one another to an indeterminate extent.

MOVEMENT OF GROUND WATER

Rate of movement

The rate of movement of water in earth materials varies widely, but in general, in the aquifers in Southern Maryland, the movement is very slow under natural gradients. If the permeability, the hydraulic gradient, the porosity, and the cross-sectional area of a formation are known, it is possible to compute the rate at which ground water is moving. The following formula may be used in computing the approximate average velocity of ground water moving through sediments:

$$V = \frac{Pi}{p}$$

where V = average velocity in feet per day
P = permeability in cubic feet per day per square foot
i = hydraulic gradient expressed as a decimal fraction
p = porosity expressed as a decimal fraction

From this equation a rough approximation can be obtained of the rate at which ground water is moving through one of the major aquifers in Southern Maryland, the Patapsco formation. The generalized piezometric map (Pl. 8) shows that across a section of the aquifer extending from Odenton to the Patuxent River the average hydraulic gradient was about 16 feet per mile (expressed as a decimal, 0.003) in 1951. The Patapsco formation here is about 200 feet thick, of which about 90 feet consists of water-bearing sand and gravel. The average coefficient of transmissibility determined from the pumping tests in the Odenton area is 35,000 gallons per day. The field coefficient of permeability is therefore $\frac{35{,}000}{90}$ or 388 gallons per day per square foot (51.8 cubic feet per square foot per day). The porosity of the water-bearing sediment in the Patapsco formation is not known, but a value of 35 percent may be reasonably assumed. Substituting the values in the formula we obtain:

$$V = \frac{51.8 \times .003}{.35} = 0.44 \text{ foot per day}$$

At this rate it would take a particle of water almost 33 years to move 1 mile toward the discharge area from the point where it entered the aquifer. The natural hydraulic gradients vary from place to place, and the permeability and porosity of the aquifers also vary, but as the normal hydraulic gradients in the artesian aquifers are seldom more than a few feet per mile it is apparent that the average rate of movement of water through the aquifers is exceedingly slow. Most of the ground water now being withdrawn by wells from the artesian aquifers in Southern Maryland entered the water-bearing strata several tens or hundreds of years ago.

Recharge and discharge

The energy that keeps ground water in motion is provided by the head or potential differences at various points along the path of movement. As the water moves energy is lost to the surrounding materials through friction. If no replenishment to the ground-water reservoirs occurred, the movement of the water resulting from the initial differences in hydraulic head would ultimately cease, much as a clock would stop after the potential energy stored in the mainspring was utilized. However, the ground-water reservoirs are constantly being replenished, either by direct infiltration from precipitation or by flow from another aquifer.

The proportion of precipitation that recharges the ground-water reservoir may be increased by decreasing the amount of water held in or removed from the soil zone or returned to the atmosphere by direct evaporation. Withdrawals of ground water by pumping in the area of outcrop of an aquifer tend to lower the water table, which may salvage some of the water leaving the area as surface runoff or ground-water underflow. In a humid area such as Southern Maryland the replenishment of water to the ground-water reservoirs usually exceeds the depletion of the reservoirs due to pumping from wells, artesian flow, or leakage into adjacent beds, so that in the outcrop or recharge areas of the water-bearing strata the excess water is discharged from the water-bearing beds into the streams or by evapotranspiration. It is this discharge, or rejected recharge, that maintains the flow of surface streams in the area of recharge during periods of little or no precipitation. Heavy ground-water withdrawals where the ground water occurs under water-table conditions may effectively reduce the rate of flow of water from the aquifers to the surface streams. The normal hydraulic gradient from the aquifer to the surface stream may even be reversed, and the stream may contribute water to the aquifer.

The effect of heavy withdrawals of ground water from an artesian aquifer is somewhat different. In such cases heavy pumping usually does not result in an actual dewatering of the aquifer (unless the pumping level in the wells is drawn down below the base of the confining layer), but merely results in a lowering of the artesian pressure (the piezometric surface) in the vicinity of the pumped well or wells. The cone-shaped depression in the piezometric surface continues to expand until the withdrawal of ground water from the aquifer is balanced by the flow of water into the area of withdrawal. Water is also contributed to the aquifer as a result of compression of the strata and by leakage through the confining layers. These increments of water further serve to balance the withdrawals. In a perfect artesian system, where the rate of withdrawal of water exceeds the rate at which the aquifer can transmit the water to the point of withdrawal, the cone of depression continues to expand until it reaches the outcrop area of the aquifer. Further pumping then causes a lowering of the water table in the outcrop area and a consequent decrease in discharge from the aquifer to the surface streams. In this manner some of the rejected recharge, or normal discharge to the surface streams, may be salvaged.

Within a few days after a period of rainfall most of the direct runoff in surface streams has vanished, and the water that has percolated into the ground continues to maintain the flow of the stream as it moves out of the reservoir rocks adjacent to the stream channel. This flow constitutes ground-water runoff or the "base flow" of the stream. Where long and continuous records of streamflow are available for a particular drainage basin in the recharge area of an aquifer, a determination of the base flow constitutes one of the most reliable methods of estimating the rejected recharge from the ground-water reservoirs. Ground-water runoff may also be called "effective" recharge or the net recharge after subtraction of any water lost by evapotranspiration.

Streamflow records of the North River near Annapolis show that the ground-water runoff, or effective recharge, amounted to about 640,000 gallons a day per square mile of drainage area, or about 38 percent of the precipitation. The river drains an area of about 8.5 square miles and the records analyzed cover a period of 3¾ years beginning in January 1946. It is estimated that ground-water runoff, or effective recharge, in Southern Maryland ranges from 20 to 35 percent of the precipitation, or from 8 to 15 inches per year.

Bennett and Meyer (1948, p. 14) found that in the drainage basin of Beaverdam Creek near Salisbury, the effective recharge to a shallow Pleistocene aquifer amounted to about 600,000 gallons a day per square mile of drainage area, which was equivalent to 27 percent of the precipitation.

Discharge from the ground-water reservoirs in the water-table areas occurs chiefly in the form of rejected recharge, through pumping from wells, and through evapotranspiration. Soil evaporation and plant transpiration are particularly effective processes for removing ground water from the reservoirs where the soil zone and the plant roots are at or near the water table. The amount of water lost by these processes varies seasonally and is greatest during the growing season, which in Southern Maryland is usually from early April until late October or mid-November. Probably from 50 to 70 percent (21 to 30 inches) of the total annual precipitation returns to the atmosphere through evaporation and transpiration.

The disposition of ground water after it enters the reservoir rocks may be expressed in the following manner:

Discharge =
- Loss by evapotranspiration (water-table conditions)
- Rejected recharge, including spring discharge (water-table conditions)
- Removal by flowing or pumped wells (water-table or artesian conditions)
- Leakage through confining layers (artesian conditions)

SPRINGS

Springs are not as important in Southern Maryland as they were during the early period of settlement of the area, when towns and homesites were frequently located near them as the only sources of potable water. Springs may be classified on the basis of the magnitude of their yield or their geologic occurrence. In Southern Maryland they are chiefly depression or contact springs. Depression springs occur where erosion or dissection by streams has cut below the water table into saturated zones of permeable material. Contact springs occur in valleys or draws where permeable water-bearing material, commonly sand and gravel in Southern Maryland, is underlain by relatively impermeable material. Many springs are found at the base of Pliocene(?) and Pleistocene sand and gravel where it overlies the less permeable sandy clay of the Miocene series. Springs also issue from outcropping Cretaceous deposits where a clay layer underlies a bed of saturated sand and gravel. The discharge of individual springs in the area is not generally large, although the aggregate quantity of water discharged from the aquifers by this means is considerable.

Several contact springs may be observed along the Calvert Cliffs in Calvert County, along the east bank of the Potomac River in Charles County, and along the bluffs of the Patuxent River. At the Charlotte Hall Military Academy in northern St. Marys County a series of springs at the base of a sand and gravel bed of Pleistocene age provide the water supply. The discharge from these springs during the summer of 1950 was more than 60 gallons a minute.

Many springs in Southern Maryland have been abandoned as a source of domestic water supply because the flow decreases markedly or ceases entirely during prolonged drought periods, the springs are not readily accessible, or they are subject to surface pollution and contamination.

DISTRIBUTION OF ARTESIAN PRESSURE

The piezometric maps on Plates 7 to 10 show the outcrop areas and the static water levels or artesian heads in wells tapping the important aquifers in Southern Maryland. The maps show the areas of ground-water intake and discharge in the aquifers, the distribution of artesian head, and the effects of heavy pumping on those heads. They show also the differences in artesian head in the different aquifers.

PATUXENT FORMATION

Plate 7 shows the distribution of artesian head in the Patuxent formation in 1951 in northern Anne Arundel and Prince Georges Counties. The general slope of the piezometric surface is to the southeast. The steepest gradients occur in the outcrop area. The general trough in the vicinity of College Park and Hyattsville along the valley of the Anacostia River shows that the base flow of the Anacostia River is maintained in part by ground-water discharge from the Patuxent formation. In flatlands in the river valley south of Hyattsville and Bladensburg the artesian head is above the land surface and many wells flow. Clark and others (1918, p. 390) report that the artesian head in a 160-foot well near the town of Tuxedo on Beaverdam Branch was 45 feet above mean sea level in 1918.

Recent measurements in the locality indicate that the artesian head in the aquifer is 30 to 40 feet lower.

The artesian head in wells in the Patuxent formation in northern Anne Arundel County shows a hydraulic gradient from the Fort Meade-Jessup area to the Curtis Bay section of Baltimore City of about 100 feet. Thus, the water in the formation is moving to points of discharge in the valley of the Patapsco River near Baltimore City. The hydraulic gradient is in part the slope of the cone of depression created by heavy pumping from the formation in the Baltimore industrial area, which in 1945 amounted to about 28 million gallons a day (Bennett and Meyer, 1952, p 78). Probably, the quantity of water pumped from the aquifer in the industrial area has not changed materially and the cone of influence has remained essentially stable. This pumping has slightly lowered the artesian heads in the Patuxent formation in nearby wells in northern Anne Arundel County.

PATAPSCO AND RARITAN FORMATIONS

The distribution of artesian pressure in the Patapsco and Raritan formations in northern Prince Georges and Anne Arundel Counties, shown on Plate 8, is based on the artesian heads in more than 100 cased wells ending in the water-bearing sands of these formations Although based chiefly on accurately measured water levels, the map presents a generalization of the complex hydrologic conditions in the aquifers. To the extent that all water-bearing sands in the formations are hydrologically connected a particular water-level measurement shows the artesian head in the formations at a given time. The distribution of artesian head indicates that the major river valleys and estuaries, such as the Patuxent and Severn Rivers, incising the formations approximately at right angles to their strike, are discharge areas into which ground water is continually moving from the interstream recharge areas. Thus, the Patuxent River valley between the towns of Odenton and Bowie is a major discharge area for the Patapsco and Raritan formations. South of Bowie and west of the Patuxent River the hydraulic gradient is more than 20 feet per mile across a distance of approximately 3 miles.

Similar gradients exist in the aquifers in the upper Severn River valley southeast of Gambrills and north of Annapolis. Northwest of Herald Harbor hydraulic gradients in the Patapsco formation along the Severn River average about 10 feet per mile. Along each mile of the river about 700,000 gallons of water a day is discharged from the water-bearing sands in the Patapsco and Raritan formations. This figure was obtained on the basis of an assumed transmissibility of the formation of 35,000 gallons per day per mile under an average hydraulic gradient of 10 feet to the mile toward the river from both sides. The fresh water discharging from the ground-water reservoirs reduces, perhaps considerably, the salinity of the estuaries of the Chesapeake Bay, such as the Severn River.

Glen Burnie area

The position of the 0- to +20-foot contours shows a local cone of depression near Glen Burnie resulting from ground-water pumping by the Anne Arundel County Sanitary Commission. During 1951 pumpage from 4 wells at the Sawmill Branch well field averaged about 290,000 gallons a day. The contours show that the effective cone of depression is confined to an area within a radius of about a mile from the center of the field.

U. S. Naval Academy

In only a few wells at the U. S. Naval Academy could measurements be made of the artesian head in the Patapsco or Raritan formation. The measurements suggest that no extensive cone of depression has been developed as a result of pumping. It is probable that the pumpage (1 million gallons a day in 1949) is largely from wells ending in the overlying Magothy formation and that artesian heads in the deeper sands are only slightly affected by the withdrawals from the Magothy. However, the artesian head in the Patapsco and Raritan formations has been lowered to some extent since 1918 as Clark and others (1918, p. 373) report that the artesian head in a 600-foot well at the Naval Academy was 20 feet above mean sea level. In 1951 the head in well AA-Df 13 (which may be the same well) was 8 feet above sea level. Apparently the artesian head in the Patapsco and Raritan formations has declined about 12 feet in the period between the measurements. In view of the relatively large ground-water pumpage at the Naval Academy in recent years, a decline in head of this small amount shows that no large amount of water has been withdrawn from storage in the Patapsco and Raritan formations in the vicinity.

MAGOTHY FORMATION

In general, artesian heads in the Magothy formation are similar to those in the older Cretaceous aquifers, particularly the Patapsco formation. The highest water levels are found in wells immediately downdip from the outcrop area of the formation in central Anne Arundel and Prince Georges Counties. Near Crownsville, in central Anne Arundel County, the artesian head was 52 feet above sea level in 1949. Near Largo, in Prince Georges County, it was 86 feet above sea level, and farther south at Cheltenham it was 48 feet above sea level. The piezometric surface in the aquifer slopes gently southeast from a general recharge area in central Prince Georges County where the water levels in wells are more than 80 feet above mean sea level. In southeastern Anne Arundel County near Woodland Beach and Shadyside the water levels are approximately 10 to 15 feet above mean sea level.

Upper Marlboro area

Near Upper Marlboro the Magothy formation is the source of supply for a number of domestic and commercial wells. It is also tapped by the municipal-supply wells of the town. The distribution of artesian head in the vicinity of Upper Marlboro is shown in figure 13. The piezometric surface in the Magothy slopes eastward toward Upper Marlboro at a rate of about 7 feet per mile from an altitude of about 70 feet above sea level (71 feet in well PG-Ed 8) to about

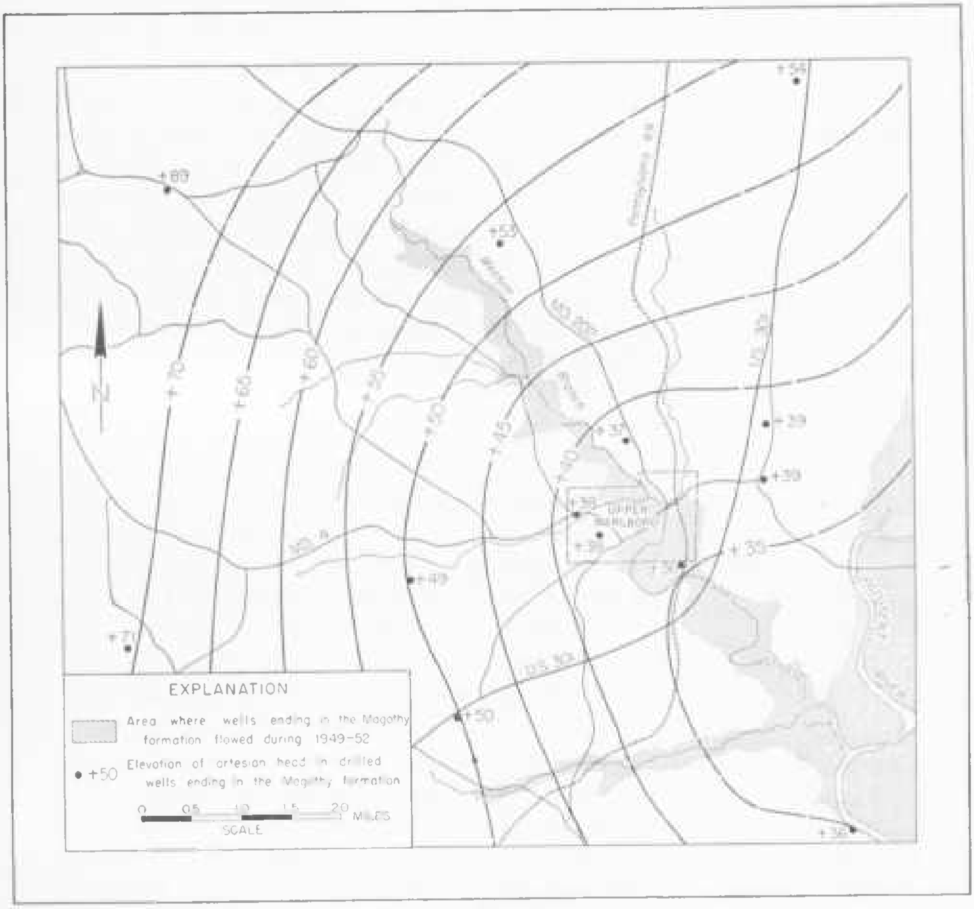


FIG. 13. Map showing artesian head in the Magothy formation near Upper Marlboro (Prince Georges County) during the period 1949–52

38 feet above sea level in the vicinity of the municipal-supply well field. Along the valley of Western Branch and at its junction with the Patuxent River the head is sufficiently high that wells will flow.

Some of the flowing wells at Upper Marlboro were drilled at least 50 years ago. Clark and others (1918, p. 390) report that in 1918 the artesian head in two of the municipal-supply wells was approximately 42 feet above mean sea level. In the summer of 1951 the artesian heads in wells PG-Ef 1, PG-Ee 2, and PG-Ee

6 were 36 to 38 feet above sea level. The apparent decline of about 4 to 6 feet may be attributed primarily to increased pumping from the public-supply wells, which furnished the town with about 100,000 gallons a day during 1951. Some lowering of head may have resulted also from the discharge from commercial and domestic wells in the town.

AQUIA GREENSAND

Plate 9 shows that the artesian head (or, in some places, the water table) in part of the outcrop area of the Aquia greensand is lower than in localities where the formation is overlain by the Nanjemoy and Calvert formations, which function as confining layers. This reveals the important fact that recharge is occurring through those confining layers. In general, the hydraulic gradients within the aquifer are related to and governed by the general configuration of the land surface; artesian wells in the topographically high, undissected coastal-plain uplands commonly have higher heads than wells situated in the topographically low areas adjacent to the major streams and estuaries.

Waldorf-Port Tobacco area

Near Waldorf artesian head in the Aquia greensand (and the Monmouth formation) ranges from 56 to 60 feet above sea level (wells Ch-Bf 15 and -Bf 92). Waldorf is in the center of an upland plain where the surficial deposits are sand and gravel of Pliocene(?) or Pleistocene age. The surface of the plain is 200 to 215 feet above sea level. Water levels in the shallow dug wells are 10 to 20 feet below the land surface, or about 180 to 205 feet above sea level. Replenishment to the water-bearing gravels occurs frequently and is usually adequate to maintain a high water table in the area. To the south, east, and west where the upland plain is dissected by tributaries of the Patuxent and Potomac Rivers, artesian heads in wells in the Aquia greensand are lower than in the central area of the plain. At Port Tobacco and Chapel Point the artesian head is respectively 27 and 16 feet above sea level. Thus, the artesian pressure surface slopes away from the center of the plain. The +10- and +5-foot contours in Plate 9 indicate that the area along the north bank of the Potomac River southeast from Port Tobacco to Compton is an area of ground-water discharge from the Aquia greensand. Flowing wells are common in the vicinities of Morgantown, Mount Victoria, Allens Fresh, and Chaptico. However, at Cobb Island and St. Clement Shores pumpage from a large number of domestic wells has reduced the artesian head to such an extent that the wells no longer flow.

Although the Aquia greensand is not generally tapped by wells along its outcrop area near Piscataway and Pomonkey, the artesian head in this area is probably below that at Waldorf, which is near the center of the piezometric high in the formation. The +50- and +40-foot contours on Plate 9 probably close to the west. As the movement of water in an aquifer is in a direction normal to the direction of the piezometric contours, the outcrop area of the greensand between Piscataway and mouth of Mattawoman Creek must be an area in which ground water is discharging. As the ground water stored in the aquifer is in continual movement from points of high hydraulic head to points of lower head, it must move downgradient across the +50- and +40-foot contours. This water must be replaced by additional increments of water to the aquifer or the artesian head would slowly decline in the Waldorf-Brandywine area. As there is no evidence that such a decline has taken place, or is taking place, water is being transmitted through the overlying strata at a rate sufficient to maintain the existing gradients. In the Waldorf area two aquifers are present, one in the Aquia greensand and the other in the Pleistocene deposits, in which the pressure or hydrostatic head differential is as much as 150 feet. The difference in head is possible only because of the relative impermeability of the intervening Nanjemoy formation and the formations of the Chesapeake group. If the vertical permeability of the approximately 300-foot column of sediments between the two aquifers were known, the rate of downward movement of water between the two points of head differential could be estimated. The movement of ground water in the Aquia greensand is more complex, therefore, than the simple condition of replenishment of an aquifer at its outcrop area and downdip movement of water to areas of discharge.

Mount Zion-West River area

Plate 9 shows that a local "mound," or dome, of higher artesian head occurs in the Aquia greensand near Mount Zion in southern Anne Arundel County. Here the top of the formation strikes northeast and dips southeast at a rate of about 25 feet per mile (Pl. 4). Mount Zion is on an undulating upland where much of the area consists of broad, flat-topped divides which lie at altitudes of 160 to 180 feet above sea level. Artesian heads in the formation are from 20 to 33 feet above sea level. Artesian heads in wells to the east along the West River, to the southeast near Herring Bay, and to the west along the Patuxent River are from 2 to 10 feet above sea level. The position of the +20- and +30-foot contours encircling Mount Zion and the +10-foot contour west and east of Mount Zion indicate the general radial movement of ground water from the area of high artesian head to areas of lower head along the lower Patuxent River and the Chesapeake Bay near the West River and Herring Bay. Hence, ground water discharged near the West River was derived chiefly from the Mount Zion area immediately to the west, where the greatest artesian heads occur, and not from the outcrop area of the formation north and northwest, where the water levels are generally less than 10 feet above sea level. The existence and maintenance of the piezometric "high" is possible only because of leakage into the formation from the overlying water-saturated sediments at a rate about equal to the rate at which the formation is discharging ground water in the areas of low artesian head.

Solomons-Patuxent River area

Since the establishment of the Patuxent Naval Air Station in 1942 and the drilling of many wells tapping the Aquia greensand, there has been continuous heavy withdrawal of ground water. The effect of this withdrawal has been to modify the natural hydraulic gradients within the aquifer and to create a relatively large cone of depression which extends radially 8 to 10 miles from the center of pumping at the Naval Air Station (Pl. 9). The net decline in artesian head from 1942 to 1951 in and near the center of pumping was approximately 40 feet. The complex hydrologic systems in this heavily pumped area where several aquifers are present are shown diagrammatically in figure 14, which was prepared from measured artesian heads in wells ending in the Aquia and in the Nanjemoy and Piney Point formations. These formations are overlain by the Pleistocene deposits in which the ground water occurs under essentially water-table conditions. In the Solomons Island area the artesian heads in the Nanjemoy and Piney Point formations had declined below sea level by the summer of 1951, and in the Aquia greensand to an even lower level. The positions of the piezometric surfaces during the summer of 1951 were the result of an average ground-water withdrawal of about 1,500,000 gallons a day, of which it is estimated about 65 percent was pumped from the Aquia greensand and about 35 percent from the Nanjemoy and Piney Point formations. The direction of movement of the ground water in the two artesian aquifers is chiefly from the north, or from right to left in the plane of the diagram. The arrows on the diagram indicate the most likely directions of ground-water movement in the aquifers and in the so-called confining layers.

The detailed movement of ground water in these systems is only partly understood. The ground water in the upper system (Pleistocene deposits) occurs chiefly under water-table conditions; the water table slopes gently toward the surface of the Patuxent River at sea level. Ground-water replenishment in the Pleistocene deposits (tapped by wells Cal-Gd 20 and -Fd 26) occurs mainly by infiltration of local precipitation. Ground water in the Pleistocene gravels at depths of 50 to 100 feet below sea level occurs under artesian head but is probably hydrologically connected with the adjacent surficial aquifers. Circulation within this hydrologic system results in discharge of much of the ground water into the Patuxent River.

A second hydrologic system, that of the Nanjemoy and Piney Point formations, exists chiefly because of the relatively impermeable character of the overlying Calvert and Choptank formations. As a result of the withdrawal of about 500,000 gallons a day from the Nanjemoy and Piney Point formations, the artesian surface in this system slopes from north to south. The center of pumping from the aquifers is in the well field at the Patuxent Naval Air Station. As measured in well St.M-Df 14, the artesian head in the Nanjemoy and Piney Point formations was about 25 feet below sea level during 1951; thus a head difference existed between the Nanjemoy-Piney Point hydraulic system and the Pleistocene aquifers. A head difference of about 25 feet existed also between the Nanjemoy-Piney Point system and the surface of the Patuxent River. This head difference could be maintained only because of the comparative impermeability of the clayey layers in the Calvert and Choptank formations. The most likely direction of movement of water in this hydraulic system is shown by arrows on figure 14, but the arrows do not show the amounts of water moving through the confining layers compared to the amounts of water moving horizontally through the aquifers. It is reasonably certain that most of the water pumped from the Nanjemoy and Piney Point formations in the area is derived from localities away from the center of pumping and that it chiefly moves to the pumped wells horizontally through the aquifer. Nevertheless, a hydraulic gradient exists between the aquifer and the overlying strata, and some movement of water through the confining layers must occur in response to this gradient. This water may be included in the coefficient of storage determined from the pumping tests of wells.

The third hydrologic system shown in figure 14, that of the Aquia greensand, is possible because of the impermeable nature of the confining layers in the Nanjemoy formation, chiefly the Marlboro clay. In the summer of 1951 the artesian head in well St.M-Df 13 in the Aquia hydrologic system was about 35 feet below sea level, or more than 35 feet below that of the shallow Pleistocene aquifers and about 10 feet below that of the Nanjemoy formation. These head differences existed because of the pumping of about 1 million gallons a day from wells ending in the Aquia greensand at the Naval Air Station. The arrows in figure 14 indicate that most of the water in the Aquia greensand is moving horizontally from areas of higher head in the aquifer to areas of lower head. Nevertheless, a vertical component of movement into the aquifer is present, which may also be included in the coefficient of storage determined from pumping tests.

Under the hydraulic gradients existing in 1951 in the Solomons Island-Patuxent River area, if a well were to be screened, or were to develop casing leaks opposite two or three of the aquifers, the movement of water in the well would be in the direction of equalization of the head differences. That is, in the geologic section (fig. 14) the flow of ground water would be from the Pleistocene deposits and the Nanjemoy and Piney Point formations to the Aquia greensand. As the Pleistocene deposits in the Solomons area are probably connected hydrologically with the brackish water of the Chesapeake Bay, contamination of the deeper artesian aquifers through leaking wells would be possible if the head in them were drawn below sea level. However, periodic sampling of the water pumped at the Patuxent Naval Air Station has provided no indication of contamination of the deeper artesian aquifers with high-chloride water from the Pleistocene deposits or from any other source.

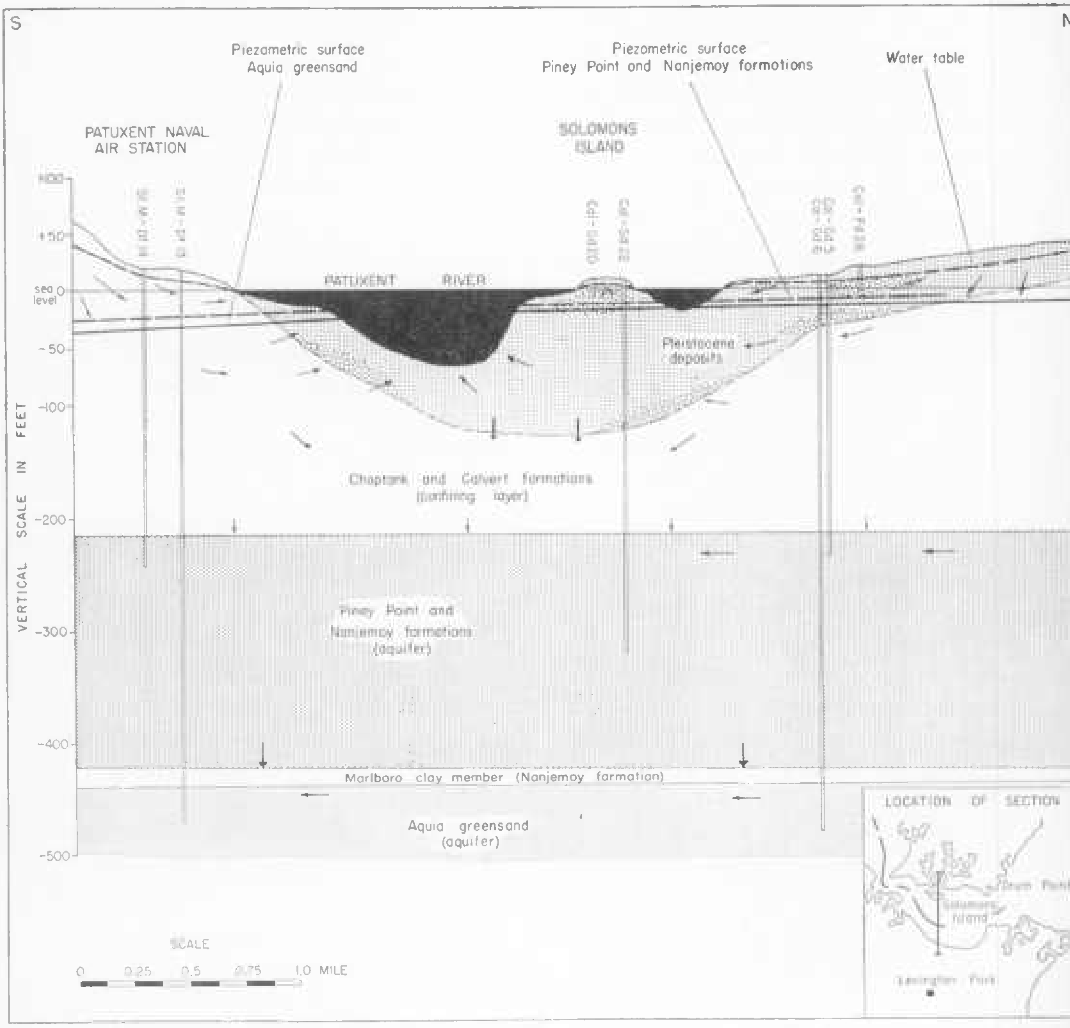


FIG. 14. Geologic section in the vicinity of Solomons Island showing hydrologic condition resulting from pumping at the Patuxent Naval Air Station (direction of movement of ground water shown by arrows)

There are indications that ground water from the Nanjemoy and Piney Point formations is leaking through wells into the Aquia greensand. Much of this leakage probably occurs by vertical movement through the packers or alongside the casings of wells tapping the Aquia greensand. Presumably when most of these wells were constructed the Nanjemoy and Piney Point formations were cased off. However, the records of some of the deeper wells show that the casings were reduced in size at the approximate position of the water-bearing sands in the Nanjemoy formation. Leakage probably occurs at this place in the wells.

The evidence of aquifer leakage through wells in this area is twofold and is summarized briefly as follows:

(1) Of the total daily pumpage of 1,500,000 gallons only about 100,000 (approximately 7 percent) was from a well ending in the Nanjemoy and Piney Point formations. Although several other wells that tapped this aquifer had been drilled at the Air Station, by 1951 either they had been abandoned or their use had been restricted to emergencies. Nevertheless, the cone of depression in the aquifer in 1951 (Pl. 10) seems entirely too large to be the result of the relatively small pumpage from the only well known to be producing from it.

(2) The chemical character of the ground water obtained from wells ending in both artesian aquifers in the vicinity of the Patuxent Naval Air Station shows that, when unmixed, they contain two slightly different types of water. Water from the shallower aquifer, the Nanjemoy and Piney Point formations, contains about 50 parts per million of silica (SiO_2) and has a total hardness of approximately 100 parts per million. Water from the deeper aquifer, the Aquia greensand, contains about 10 parts per million of silica and has a total hardness of about 15 parts per million. Chemical analyses show the intermediate character of some of the water yielded from wells screened in the Aquia greensand, and serve as a basis for a rough estimate of the proportion of water leaking from the upper aquifer into the lower one and then entering the wells. This leakage probably amounted to about 400,000 gallons a day in 1951.

NANJEMOY AND PINEY POINT FORMATIONS

The distribution of artesian head in the Nanjemoy and Piney Point formations is shown on Plate 10, which is based on water levels measured during 1951 in about 90 wells in Calvert and St. Marys Counties. A north-south ridge of high artesian head extends through the northern two-thirds of Calvert County. Artesian heads in the center of this ridge are slightly more than 30 feet above sea level, but they are less than 10 feet above sea level along most of the Calvert Cliffs and along the Patuxent River as far north as Benedict. The central part of Calvert County consists, topographically, of a partially dissected north-south ridge with altitudes ranging from 160 to 180 feet above sea level. On the ridge are irregular and isolated patches of the Pleistocene upland deposits that overlie the Calvert and Choptank formations which are exposed in places in the gulleys and small valleys. The Nanjemoy formation underlies the entire county. Its top is at sea level in the northern part of the county near Dunkirk, but slopes southeastward to about 240 feet below sea level near the mouth of the Patuxent River (Pl. 5). The piezometric contours in northern Calvert County are roughly conformable to the topography, indicating perennial "leakage" of ground water to the Nanjemoy from the Pleistocene deposits. Slopes on both the east and west sides of the piezometric "ridge" in northern Calvert County range from less than 5 feet to more than 15 feet per mile. Thus, the entire eastern edge and part of the western edge of Calvert County comprise extensive areas of discharge from the Nanjemoy formation; flowing wells are commonly found along these belts.

Dares Beach area

The geologic and hydrologic conditions in the Nanjemoy and overlying strata at Dares Beach are shown in figure 15. The altitude of the water table is assumed, but is probably a close approximation to its true position. The extent of the area of artesian flow beneath the Chesapeake Bay is largely unknown, but it may extend as far as a mile east of the shoreline. North of Dares Beach, at North Beach and at Randle Cliffs, there are flowing wells now a few hundred feet off shore. Some of these wells are said to have been drilled more than 50 years ago at the terminal ends of piers which have since been destroyed; many of the wells have been flowing continuously since they were drilled.

The arrows in figure 15 show the general direction of ground-water movement resulting from differences in hydraulic head. Ground water entering the upland deposits in the area west of the Bay moves downgradient and discharges chiefly by means of seeps and springs near the shoreline or into surface streams draining the uplands. At least two hydrologic systems function here. Precipitation recharges the surficial deposits and maintains a relatively high water table. The clayey beds in the underlying Calvert and Choptank formations retard the downward movement of water from the surficial deposits. Because clayey beds transmit some water, however, sufficient head is maintained in the underlying Nanjemoy formation to cause wells to flow near the Bay shore and to create an area of discharge some distance from the shoreline. The arrows show the downward direction of ground-water movement through the confining layers in the upland recharge area and the upward movement in the coastal discharge areas where the water moves from the artesian aquifer through the confining layers. The rate and extent of this movement is related to the permeability of the aquifer and the confining layers, and to the hydraulic head or potential between the points of recharge and discharge.

Patuxent River valley area

The valley of the Patuxent River south of Lower Marlboro is a discharge area for the Nanjemoy and Piney Point formations. The extent of this area is not as clearly defined as is that on the Bay side, owing to the scarcity of wells in which the artesian head in the aquifer could be determined. The available data show that there is a westward-sloping hydraulic gradient in the aquifer. There are a number of 2-and 3-inch-diameter flowing wells along the tidal flats of the lower Patuxent River valley.

South of the Patuxent River, near the towns of California and Leonardtown

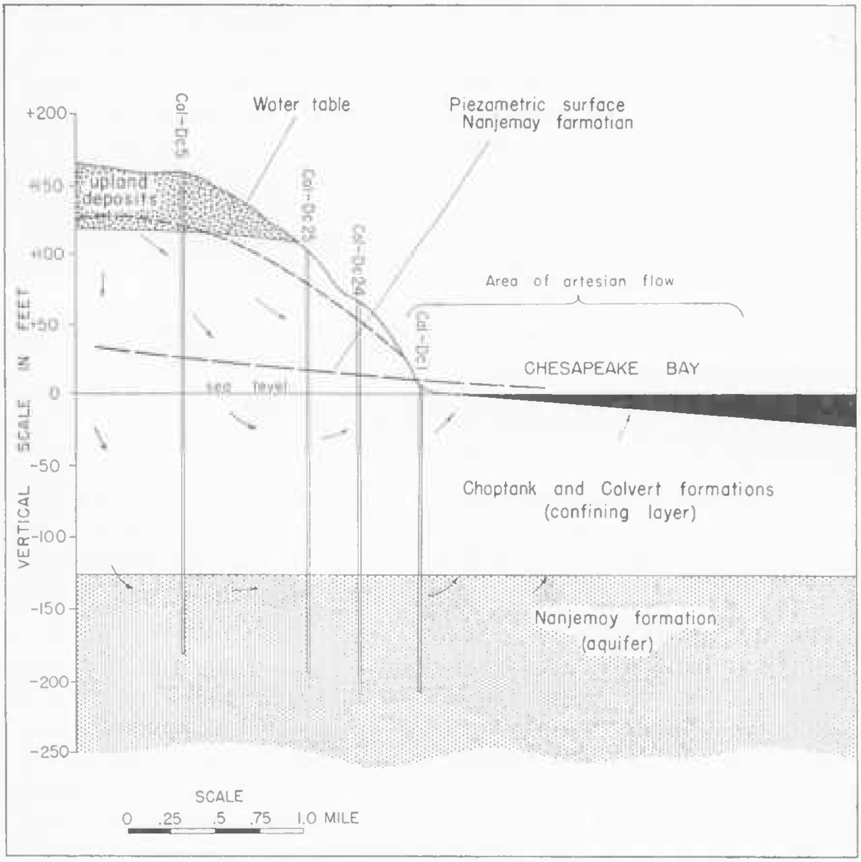


FIG. 15. Section showing geologic and hydrologic conditions near Dares Beach in northern Calvert County (direction of movement of ground water shown by arrows)

in St. Marys County, hydraulic gradients in the aquifer conform to the pattern in central and northern Calvert County. The south-central portion of St. Marys County is an area of dissected upland forming a ridge with elevations of 100 to 125 feet above sea level. The approximate position of this ridge is shown on Plate 10 by the +10- and +20-foot piezometric contours that trend southeastward along the south bank of the Patuxent River and curve south and west to form a nose east of Leonardtown.

The position of the contours showing artesian head in the Nanjemoy and Piney Point formations changes markedly in the vicinity of the Patuxent Naval Air Station in both southern Calvert and southern St. Marys Counties. Although part of the Air Station and the area west of it are on the terminus of the topographic ridge mentioned above, the contours here show mainly the cone of depression created by the pumping at the Air Station. The center of this cone is near well St.M-Df 9. It extends to the south about 8 miles and to the north about 6 miles, or nearly as far north as Cove Point in Calvert County. The cone is elongate in a north-south direction, caused possibly by a preferential direction of permeability within the aquifer.

The measurable effect of pumping from the aquifer at the Patuxent Naval Air Station is estimated to extend eastward beneath the Chesapeake Bay 3 to 5 miles beyond the center of pumping. Decline in artesian head in the aquifer in the center of the heavily pumped area at the Naval Air Station from the beginning of pumping in 1942 to the summer of 1951 may have amounted to as much as 40 feet. Probably most of the decline occurred within the first few years of pumping.

UTILIZATION OF GROUND WATER

HISTORY OF GROUND-WATER DEVELOPMENT IN SOUTHERN MARYLAND

Little information is available concerning the use and development of ground-water supplies in Southern Maryland prior to 1890. Ducatel (1836, p. 12) refers to the sinking of a well to a depth of 76 feet on Holland's Island (now a swampy promontory) in southern Anne Arundel County near the town of Fairhaven and to the sinking of wells at Upper Marlboro to depths ranging from 20 to 38 feet. As the economy of Southern Maryland was almost entirely rural during the 19th century and as modern methods of well construction were not known, springs and shallow dug wells were the main sources of water supply. Most of our knowledge of the development of ground-water supplies and of wells drilled prior to 1918 is contained in the report by Clark, Mathews, and Berry describing the surface and underground water resources of Maryland. They report that in 1885 two wells were drilled to Eocene strata at depths of about 400 feet at Cornfield Harbor in St. Marys County. In 1887 a 5-inch well was drilled into the Patuxent formation to a depth of 96 feet at Hyattsville in northern Prince Georges County. In 1895 a well was drilled at the town of Upper Marlboro into the Magothy formation to a depth of 222 feet. The well flowed, and may still be in existence, but its exact location could not be ascertained. Between 1895 and 1899 four wells were drilled at the Indian Head Naval Powder Factory to depths of 388 to 397 feet. In 1896 a well 1½ inches in diameter was jetted into the Aquia greensand to a depth of 267 feet near Wayside in southern Charles County. Darton (1896, p. 135) reports the drilling of a well to a depth of 148 feet near Laurel. In 1897 a well was drilled to a depth of 130 feet to the Aquia greensand near Deale in Anne Arundel County. In 1898 a well was drilled at Fort Armistead (Hawkins Point) in the same county, to a depth of 570 feet, ending in the Patuxent formation; the well yielded 50 gallons a minute.

During 1900 ten deep wells were drilled at the plant of the Annapolis Water Company to depths ranging from 129 to 160 feet. The wells were to have been used to supplement the existing surface-water supply, but they were used only on an emergency basis because of the relatively high mineral content of the water. During the period 1902–04 several wells were drilled at the U. S. Naval Academy to depths ranging from 300 to approximately 600 feet. By 1922 about 800,000 gallons a day was pumped from seven wells at the Academy.

In 1909 two wells, 90 and 108 feet deep, were constructed to supply water for the community of East Linthicum Heights. The wells have since been abandoned, and water is now supplied from the distribution system of the Anne Arundel County Sanitary Commission.

In 1911 a 6-inch well was drilled for the town of La Plata to a depth of 560 feet, ending in a water-bearing sand of Late Cretaceous age. The yield of this well was insufficient to supply the town, and in 1916 a second well was completed at a depth of 470 feet. This well reportedly yielded 14 gallons a minute.

In 1915 a 6-inch well (AA-Cd 9) was drilled to a depth of 400 feet at the Crownsville State Hospital, in central Anne Arundel County; the well yielded about 175 gallons a minute, but it was later abandoned as the water was of poor quality. During the same year a 6-inch well was drilled to a depth of 237 feet at the Maryland Agricultural College (now the University of Maryland) at College Park, which reportedly flowed 1 gallon a minute when completed. Two additional wells were later drilled at College Park, and by 1917 the average daily consumption of ground water was estimated to be 70,000 gallons. The wells were later abandoned and the University is now supplied with water by the Washington Suburban Sanitary Commission.

During 1917 seven or eight wells were drilled at Fort George G. Meade, Anne Arundel County. The wells ranged in depth from 43 to 593 feet and yielded from 20 to 115 gallons a minute. The capacities of the wells were considered inadequate for the needs of the camp and a surface-water supply was subsequently installed.

In 1918 six wells were drilled to serve as a public water supply for the town of Hyattsville in northern Prince Georges County. The wells ranged in depth from 112 to 240 feet. The wells were later abandoned and the town now obtains its water from the Washington Suburban Sanitary Commission.

Prior to 1922 the water-supply system of Glen Burnie consisted of privately owned wells and distribution facilities. In that year the Anne Arundel County Sanitary Commission was created and the ownership and operation of the Glen Burnie supply was transferred to the Commission. During 1926–27 two wells were drilled into the Patapsco formation at depths of 62 and 65 feet. Additional wells were added to the system as the demand for water increased, until by the middle of 1949 the average daily pumpage from the Glen Burnie well field (Sawmill Branch) was 660,000 gallons.

In 1923 an 8-inch well (AA-Cf 1) was drilled to a depth of 319 feet for the Gibson Island Corporation. A second well, of approximately the same depth, was added to the supply in 1929. During 1946 the two wells supplied an average of about 100,000 gallons of water a day to the community. The ownership and operation of this water system was transferred to the Anne Arundel County Sanitary Commission in 1950.

During 1925 a distribution system, a storage tank, and a 10-inch well, completed at a depth of 383 feet, were constructed as part of the public water-supply system for Leonardtown in St. Marys County; the well yielded 55 gallons a minute from the Aquia greensand. By 1928 the daily average pumpage at Leonardtown from two public-supply wells was 60,000 gallons, and by 1940 it had increased to 90,000 gallons a day.

During the period 1931 to 1934 a number of wells were drilled at the U. S. Department of Agriculture's Beltsville Research Center. The wells ranged in depth from 197 to 600 feet, ending in the Patuxent formation and the pre-Cambrian crystalline rocks. Yields of these wells ranged from 20 to 110 gallons a minute. The quality of the water from some wells was such that treatment was required. Additional wells were added to the supply subsequent to 1934 until, by 1943, the total pumpage at the Research Center was approximately 390,000 gallons a day; by January of 1948 the total average daily pumpage had increased to approximately 450,000 gallons a day.

During the years 1942 to 1944 seven wells were drilled at the U. S. Naval installations near Solomons Island in Calvert County. The wells ranged in depth from 247 to 540 feet and produced from both the Nanjemoy and Piney Point formations and the Aquia greensand. The total pumpage early in 1944 from all wells at the Naval installations in the Solomons Island area was estimated by Bennett (1944, p. 16) to be about 1 million gallons a day. By 1946, as a result of the decreased activity at the installations, the pumpage had declined to a daily average of about 260,000 gallons per day, and most of the supply was obtained from wells ending in the Aquia greensand; by 1950 only two wells were in use and the daily average pumpage had decreased to 83,000 gallons.

From 1942 to 1949 a total of 19 wells were drilled at the Patuxent Naval Air Station. The daily average pumpage fluctuates seasonally, the maximum pumpage generally occurring during July and August and the minimum during January and February. Near the end of World War II the pumpage was the greatest of record, amounting to more than 2 million gallons daily. Table 22 shows the average daily pumpage at the Naval Air Station during the period 1944 through 1951.

In 1944 a well 174 feet deep was completed in the Patapsco formation, at the National Plastic Products Company plant at Odenton. Three additional wells were completed in the same aquifer, so that by late 1952 the plant was supplied by four large-capacity wells. The pumpage from the well field for air-conditioning and manufacturing purposes was approximately 1 million gallons a day in February 1953.

During 1945 and 1946 two wells (PG-Eb 1 and -Eb 2) were constructed at Forest Heights, in Prince Georges County, for the Washington Suburban Sanitary Commission. The wells are 603 and 630 feet deep and produce from water-bearing sands in the Patuxent and Patapsco formations. In 1949 the average daily pumpage from the wells was approximately 170,000 gallons, and by 1951 it had increased to about 200,000 gallons. About 2,600 persons are supplied with water from this source. The monthly pumpage is shown in figure 18.

TABLE 22

Daily average pumpage (in million gallons) at the Patuxent Naval Air Station 1944 through 1951

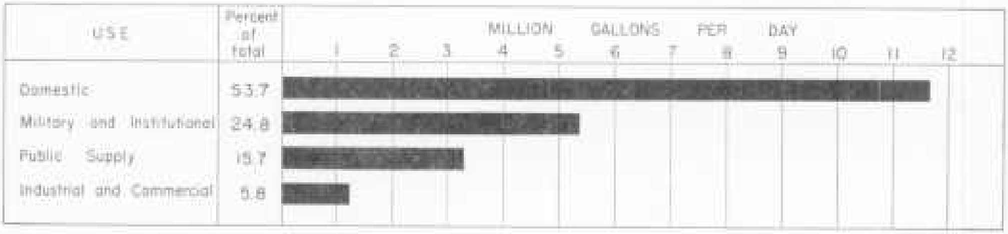
Year	Metered pumpage
1944	2.22[a]
1945	1.50
1946	1.17
1947	1.28
1948	1.41
1949	1.63
1950	1.54
1951	1.73

[a] Estimated on the basis of pumpage metered for the last quarter of the year.

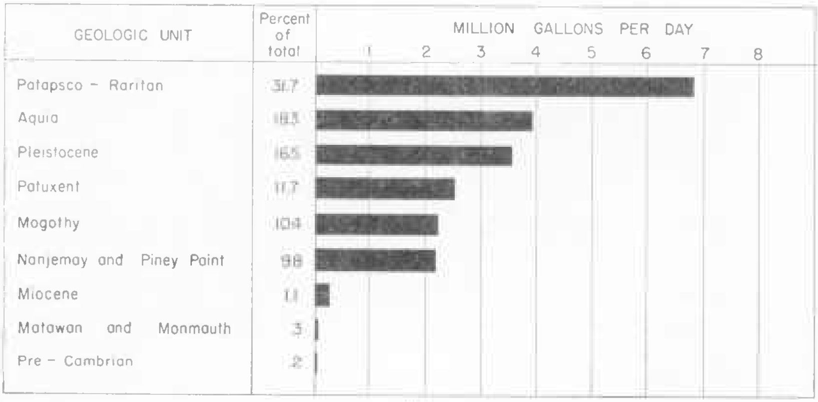
DISTRIBUTION OF PUMPING AND USE OF WATER DURING 1951

The average daily pumpage of ground water in Southern Maryland in 1951, distributed according to use and geologic source, is shown in figure 16. On the basis of the type of use ground-water supplies may be classed into four main groups: (1) domestic supplies, serving individual farms and homes, as well as small commercial establishments where the consumption of water is generally less than 100 gallons a day; (2) military and institutional supplies, which includes government-owned military installations, such as the Patuxent Naval Air Station, the U. S. Naval Powder Factory at Indian Head, and the U. S. Naval Academy at Annapolis; (3) public supplies, all publicly owned systems utilizing wells as a source of supply and privately-owned systems supplying housing projects; and (4) industrial and large commercial supplies. A partial breakdown of the data summarized in figure 16 is shown in Table 23. As the pumpage from many of the wells is not metered, the daily pumpage is estimated on the basis of the population served, or on the basis of the capacities of the individual wells multiplied by the reported or estimated number of hours a day they were in use. The computations of daily ground-water pumpage are, therefore, only approximations.

The use of ground water in Southern Maryland for air conditioning has increased in recent years. A reliable estimate of the amount of water used for



(A)



(B)

FIG. 16. Graphs showing average daily ground-water pumpage in Southern Maryland during 1951: (A) according to use, (B) by geologic units

this purpose could not be obtained, but a major part of the water pumped at a few industrial and commercial establishments is for air conditioning. Well PG-Cc 8 (owned by the Engineering and Research Corporation) supplies about 25,000 gallons of water a day for such use. Much of the pumpage at the National Plastic Products Company at Odenton is used for air conditioning; it was reported that during the warmest period of the summer of 1952 the daily pumpage at the plant exceeded 3 million gallons. About 100,000 gallons a day is pumped from wells ending in the Patuxent formation for air conditioning at Greenbelt. It is estimated that 200,000 to 300,000 gallons a day is used for air conditioning at the Patuxent Naval Air Station, the pumpage during the summer months increasing about 10 percent over that of the winter months.

Comparatively little ground water is used for irrigation in the Southern Maryland area, although moderate quantities are used for this purpose at the Beltsville Research Center. Small quantities of water are used for irrigation at a few small farms in northern Anne Arundel County and at the southern end of St. Marys County.

Water-Level Fluctuations

HISTORY OF WATER-LEVEL MEASUREMENTS

Prior to 1946 most of the water-level measurements in wells in Southern Maryland were irregular and scattered. Many of these measurements are listed in the report by Clark and others (1918); some of them were made about 1880 and provide the oldest available record of water levels in Southern Maryland.

In 1939 the U. S. Geological Survey made a detailed study (Fiedler and Jacob, 1939) of the ground-water conditions at Indian Head in Charles County. This investigation included pumping tests and water-level measurements.

During 1940–41 two wells in Prince Georges County, PG-Cc 15 at Hyattsville and PG-Dc 6 at Suitland, were measured approximately weekly by the U. S. Geological Survey (Water-Supply Papers 907, p. 57–58, and 937, p. 63–64) in an investigation of the ground-water resources of the District of Columbia and vicinity.

In 1944 a study was made of ground-water conditions in the Solomons-Patuxent River area in Calvert and St. Marys Counties (Bennett, 1944), which included pumping tests and water-level measurements.

In the course of the ground-water investigations in Southern Maryland, observation wells were established in 1946 in Anne Arundel, Charles, and St, Marys Counties; in 1947 in Calvert County; and in 1948 in Prince Georges County. In most wells the measurements are made periodically by hand. Some wells are equipped with automatic water-level recorders which give a continuous record. Measurements in some wells were discontinued when it was found that the records were unsatisfactory or when the well was abandoned or covered. At the end of 1952 there were 73 observation wells in Southern Maryland, of which 40 were being measured monthly; four of these (AA-Ad 29, AA-Ad 30, Cal-Gd 5, Cal-Gd 6) were equipped with continuous automatic recorders. The geographic distribution of the active wells is:

County	*Number of observation wells*
Anne Arundel	7
Calvert	9
Charles	6
Prince Georges	9
St. Marys	9

TABLE 23

Major sources of ground-water pumpage in Southern Maryand in 1951 according to use

Owner	Location	County	Aquifer	Pumpage (gal. p.d.)
Military and institutional supplies				
U. S. Government	Naval Academy, Annapolis	Anne Arundel	Magothy and Patapsco	1,000,000
do	Engineering Experiment Station, Annapolis	do	Patapsco-Raritan	450,000
District of Columbia	District Training School, Laurel	do	Patuxent	200,000
State of Maryland	Crownsville	do	Magothy and Patapsco	250,000
U. S. Government	Naval Communication Station, Cheltenham	Prince Georges	Magothy	330,000
do	Beltsville Research Center	do	Patuxent	500,000
do	Naval Powder Factory, Indian Head	Charles	Patuxent and Patapsco	1,000,000
do	Naval Air Station, Calvert Annex (Solomons Island)	Calvert	Aquia	71,000
do	Patuxent Naval Air Station, Cedar Point	St. Marys	Aquia, Nanjemoy, and Piney Point	1,500,000
do	Naval Station (Piney Point)	do	Aquia	40,000
Total				5,341,000
Public supplies				
Anne Arundel County Sanitary Commission	Glen Burnie	Anne Arundel	Patapsco	321,000
do	Harundale	do	do	468,000
do	Linthicum Heights	do	do	80,000
do	Severna Park	do	do	74,000
do	Gibson Island	do	Raritan	80,000
City of Annapolis	Annapolis	do	Magothy	1,500,000[a]
Epping Forest Water Co.	Epping Forest	do	do	22,000
Washington Suburban Sanitary Commission	Forest Heights	Prince Georges	Patuxent and Patapsco	200,000
Town of Upper Marlboro	Upper Marlboro	do	Magothy	100,000
Hopkins and Wayson	Morningside Village	do	Patapsco	120,000
do	Potomac Heights	Charles	Patuxent	112,000
Town of La Plata	La Plata	do	Raritan and Patapsco	58,000
City of Leonardtown	Leonardtown	St. Marys	Aquia	110,000
Patuxent Park Corp.	Lexington Park	do	do	140,000
Total				3,385,000

Industrial and commercial supplies[b]				
National Plastic Products Co.	Odenton	Anne Arundel	Patapsco	1,000,000
Mineral Pigments Corp.	Muirkirk	Prince Georges	Patuxent	50,000
West Brothers Brick Co.	Cedar Heights	do	do	36,000
Engineering and Research Corp.	College Park	do	do	25,000
Greenbelt Consumers Service	Greenbelt	do	do	100,000
Dr. Pepper Bottling Co.	Waldorf	Charles	Monmouth	20,000
Curtiss Steuart Co.	Piney Point	St. Marys	Aquia	14,000
E. V. Dyson Ice Co.	Charlotte Hall	do	Pleistocene	15,000
Total				1,260,000
Domestic supplies				
Various	All of Southern Maryland	All counties	All aquifers	11,600,000

[a] Includes some surface water from the Broad Creek reservoir.
[b] Does not include pumpage from industrial plants in the Curtis Bay area adjacent to Baltimore City (See Bennett and Meyer, 1952, p. 81).

The measurements are published annually by the U. S. Geological Survey as water-supply papers, titled *Water Levels and Artesian Pressures in Observation Wells in the United States, Part II: Southeastern States* (for the years 1946–51 inclusive, Water-Supply Papers 1072, p. 167–191; 1097, p. 162–193; 1127, p. 155–176; 1157, p. 156–180; 1166, p. 180–200; 1192, p. 146–161).

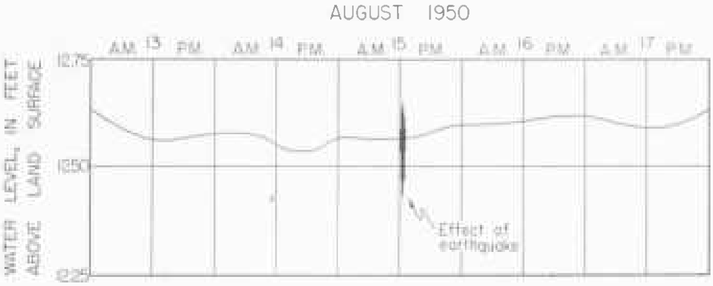
CAUSES OF WATER-LEVEL FLUCTUATIONS

Water-level fluctuations in wells are usually the resultant of several forces, which may be either natural or artificial, or both. One of the forces is often dominant and may mask the effects of the others. Fluctuations of the water level in most of the shallow water-table wells are due chiefly to natural causes. Where the water level is unaffected by pumping it is usually lowest in the fall and highest in the spring. In Maryland the greatest precipitation occurs during June, July, and August but because this period coincides with the growing season (the period of increased water discharge through evapotranspiration), the effect of the increased precipitation is only rarely reflected in pronounced rises in the water levels. The period of lowest water levels occurs in the early fall when the water demand of the plants is still high and the precipitation is the least. In general, precipitation after the growing season will cause a greater rise in the water levels in shallow wells than that caused by the same amount of precipitation during the growing season.

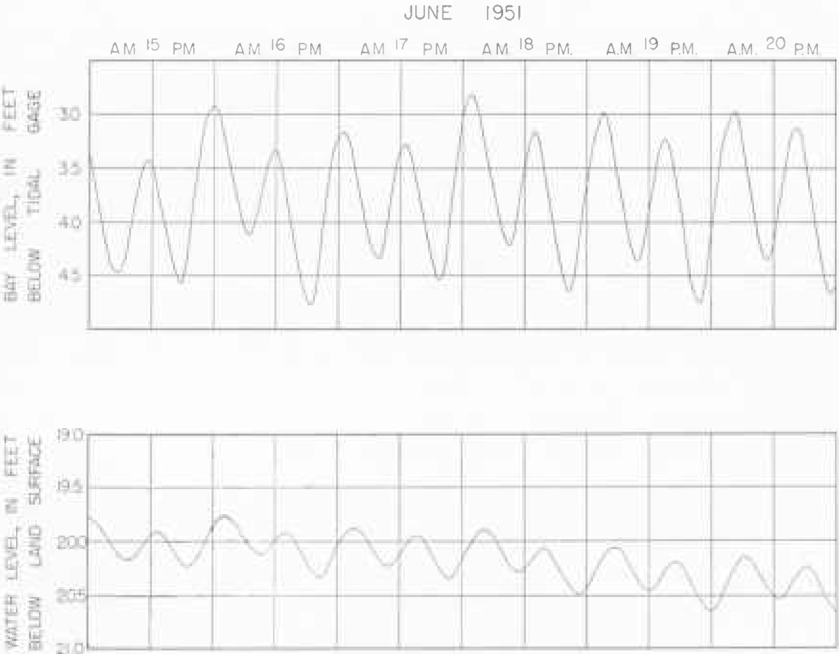
Changes in precipitation are not readily reflected by changes in the water levels of artesian wells, except in wells near the recharge area. However, other natural forces do cause fluctuations in artesian wells, one of which is tidal loading. The added weight of water at high tide is sufficient to compress an artesian aquifer and the overlying strata, and thus to cause a rise in the artesian head. The effect of tidal loading is noticeable in two observation wells ending in artesian strata at Solomons Island: well Cal-Gd 5, which is 248 feet deep and ends in the Nanjemoy and Piney Point formations, and well Cal-Gd 6, which is 493 feet deep and ends in the Aquia greensand. Recorder charts of the water levels in both wells show semidiurnal fluctuations of about one-half foot. Figure 17 shows the effects of tidal loading on the water level of well Cal-Gd 5.

Fluctuations of water levels in wells are caused also by changes in barometric pressure. Such effects are not generally observed in water-table wells; they are more commonly noted in artesian wells. The effects of barometric pressure on the water levels of wells in Southern Maryland have not been determined.

The effect of earthquakes on water levels is noticeable chiefly in artesian wells. The degree of transmission of the earth shock varies with the geologic structure, the character of the beds transmitting the wave, the distance of the well from the epicenter of the quake, and the intensity and rate of energy release of the shock. The effect of earth shocks probably is noticed more read-



(A) Effect of earthquake shock on the water level in well AA-Ad 29 (530 feet deep) at Glen Burnie.



(B) Tidal fluctuations at Solomons Island and water-level fluctuations in well Cal-Gd 5 (248 feet deep) ending in the Nanjemoy and Piney Point formations.

FIG. 17. Graphs showing fluctuations in artesian head in deep wells due to earthquake waves and tidal forces

ily in deep wells than in shallow wells. Although Maryland is not normally affected by earthquakes, some severe quakes in other parts of the world have been recorded on the graphs of the automatic water-level recorders. In August 1950 a severe earthquake near Assam, on the China-India-Burma border, was observed on the water-level graph from well AA-Ad 29 at Glen Burnie (fig. 17). Well AA-Ad 29 is an unused 4-inch well, 530 feet in depth, ending in the Patuxent formation. The normal amplitude of daily fluctuation in the well is about 0.05 foot, but at the time of the earthquake (around noon, August 15) a sharp irregular series of fluctuations was recorded on the graph for about a half hour. The maximum range of the fluctuations was about 0.22 foot.

The chief manmade, or artificial, cause of water-level fluctuation in a well is a change in the rate of pumping or discharge. In Southern Maryland most of the major changes in water levels in the deeper artesian wells are due to this cause.

FLUCTUATIONS IN THE PATUXENT FORMATION

Of the five observation wells ending in the Patuxent formation, only at well PG-Ad 8 at Laurel do water-table conditions exist. Periodic water-level measurements made in this well during the 4-year period 1949–52 show there has been no great net change in level during this time. The annual fluctuation of about 5 feet in this well corresponds to the normal seasonal fluctuation of the water table in Southern Maryland.

Other observation wells ending in the Patuxent formation in Southern Maryland are artesian. Well PG-Cc 3, near Bladensburg, shows a rather high water level in the spring of the year and a low water level in the late summer and early fall, a pattern that is characteristic of water-table wells. During the period of record, 1949–52, well PG-Cc 3 had a net decline in water level of 0.15 foot.

Fluctuations in well AA-Ad 29 at Glen Burnie reflect changes in the pumpage from wells tapping the Patuxent formation in the Baltimore industrial area, about 3 to 5 miles northeast. The water-level graph shows a slight net rise during the period of record, June 1948 through 1952.

In well PG-Bd 17, 251 feet deep, near Beltsville, the changes in water level reflect mainly variations in pumping from the Patuxent formation at the Beltsville Research Center. The water level shows a seasonal decline during July and August due chiefly to increased pumping, but by January or February it has generally recovered. No net decline in water level occurred during the period of record, December 1948 through December 1952.

In summary, there has been no marked change in water levels or artesian head in observation wells ending in the Patuxent formation during the period of observation. A few wells show a slight upward trend due, in part, to changes in the rate of pumping in adjacent localities. Observation wells ending in the

Patuxent formation, their depths, the periods of record, and the highest and lowest water levels recorded are listed in Table 24.

FLUCTUATIONS IN THE PATAPSCO AND RARITAN FORMATIONS

Eight observation wells in Southern Maryland end in the Patapsco and Raritan formations. Two of these are shallow water-table wells and six are artesian. Table 25 lists the highest and lowest water levels in these wells during the periods of record.

The fluctuations in the two shallow wells, AA-Ad 30 near Glen Burnie and AA-Be 54 at Riviera Beach (northern Anne Arundel County), show changes in the position of the water table. Measurements in well AA-Ad 30 since July 1948 show a net decline in the water level of 0.5 foot, although since January 1950 the trend has been upward. The water level in this well shows the characteristic seasonal fluctuation of water-table wells. Because of the below-normal rainfall during the latter part of 1949 the water levels in the spring of 1950 were lower than normal. The record low was in January of 1950.

The water-level measurements in well AA-Ad 10 (109 feet deep) near Curtis Bay in northern Anne Arundel County reflect the effect of pumping from the Patapsco formation in the Baltimore industrial area. Water levels in this well were measured from March 1946 through December 1952. The range of fluctuation during the period of record was 5.1 feet; the lowest level, 35.7 feet below the land surface, occurred in January 1947; the highest level, 30.6 feet below the land surface, occurred in June 1949. The fluctuations in this well show no marked trend, although a slight rise was noticeable during 1952.

Measurements of the water level in well AA-Be 13 (depth 232 feet) near Riviera Beach in northern Anne Arundel County extend from February 1946 through December 1948. The water level in this well reflects, in part, the changes in pumping from the Patapsco formation at Sparrows Point and in the Curtis Bay industrial area (Bennett and Meyer, 1952, Pl. 14). The level fluctuated approximately 3.2 feet during the period of record; the lowest level, measured in March 1948, was 20.9 feet below land surface; the highest level, in April 1946, was 17.6 feet below the land surface. A general decline occurred through the years 1946 and 1947 and continued until March 1948, when the water abruptly rose more than 2 feet. The 2-year decline probably resulted from increased pumping from the aquifer at Sparrows Point by the Bethlehem Steel Co.

Water-level measurements in well AA-Cd 10 (depth 668 feet) at Crownsville extend over a period from March 1949 through December 1952. As this well is adjacent to and is affected by pumping from other wells at the Crownsville State Hospital, the levels are somewhat erratic and the range in fluctuations, 15.8 feet, is greater than in a deep artesian well unaffected by nearby pumping. The highest water level, which occurred in March 1949, was approx-

TABLE 24

Observation wells ending in the Patuxent formation

Well no.	Location	Depth, in feet	Period of record	Record water level, in feet below land-surface datum			
				Highest	Date	Lowest	Date
AA-Ad 29	Glen Burnie	530	June 1948–Dec. 1952	14.04[a]	Sept. 2, 1952	10.88[a]	June 10, 1948
Bb 18	Fort Meade Jct.	108	Apr. 1946–Dec. 1952	18.81	May 27, 1949	24.47	Nov. 18, 1948
PG-Ad 8	Laurel	35	Feb. 1949–Dec. 1952	11.59	Feb. 9, 1949	17.06	Sept. 22, 1951
Bd 17	Beltsville Research Center	251	Dec. 1948–Dec. 1952	20.60	May 26, 1952	23.91	Sept. 16, 1949
Cc 3	Bladensburg	162	Dec. 1948–Dec. 1952	8.24	Mar. 28, 1950	10.20	Oct. 29, 1952

[a] Feet above land-surface datum.

TABLE 25

Observation wells ending in the Patapsco and Raritan formations

Well no.	Location	Depth, in feet	Period of record	Record water level, in feet below land-surface datum			
				Highest	Date	Lowest	Date
AA-Ad 10	Curtis Bay	109	Mar. 1946–Dec. 1952	30.61	June 20, 1949	35.71	Jan. 8, 1947
Ad 30	Glen Burnie	13	July 1948–Dec. 1952	8.11	May 3, 1952	12.16	Jan. 25, 1950
Be 13	Riviera Beach	232	Feb. 1946–Dec. 1948	17.67	Apr. 4, 1946	20.90	Mar. 5, 1948
Be 54	do	16	Sept. 1946–Dec. 1948	11.41	June 8, 1948	14.21	May 3, 1947
Cd 10	Crownsville	668	Mar. 1949–Dec. 1952	109.62	Mar. 15, 1949	125.51	Nov. 6, 1951
Df 14	Annapolis	578	Jan. 1946–Dec. 1952	65.40	Jan. 2, 1951	83.87	Sept. 2, 1952
PG-Dc 1	Suitland	365	Dec. 1948–Dec. 1952	19.21	Sept. 2, 1952	200.27	Jan. 25, 1949
Ec 10	Oxon Hill	252	June 1949–Dec. 1952	30.90	June 22, 1949	33.16	Nov. 17, 1950

imately 109 feet below the land surface; the lowest, in November 1951, was 125 feet. The downward trend of the water level in this well (2 feet in 4 years) is probably caused by the increased consumption of ground water at Crownsville from the Patapsco formation.

Measurements of the water level in well AA-Df 14 (578 feet deep) at the Naval Engineering Experiment Station extend from January 1946 through December 1952. They form an erratic pattern which reflects mainly pumping from other wells at the Experiment Station and at the U. S. Naval Academy. A range in water level of more than 18 feet is shown. The highest observed level, 65.4 feet, occurred in January 1951 and the lowest, 83.8 feet, in September 1952. No marked trend is indicated by the measurements in this well, although they suggest a slight downward trend of a few feet during 1952, probably due to an increase in pumping at the naval installations in the Annapolis area.

Well PG-Ec 10 (depth 252 feet) near Oxon Hill was maintained as an active observation well, from June 1949 through December 1952. Water levels ranged from a high of 30.9 feet in June 1949 to a low of 33.1 feet in November 1950. The well is approximately 3 miles from the Forest Heights well field, a part of the Washington Suburban Sanitary Commission water-supply system. The trend of the water levels during the 3 years indicates a decline of about 0.7 foot, probably due chiefly to the pumping at Forest Heights.

The water levels in two of the observation wells penetrating the Patapsco and Raritan formations are shown in figure 18, in which the water levels are compared with the records of pumpage from nearby well fields.

FLUCTUATIONS IN THE MAGOTHY FORMATION

Two observation wells in Southern Maryland end in the Magothy formation. Both of these, well AA-Cd 21 near Waterbury and well PG-Ef 1 at the Southern Maryland Agricultural Fairgrounds near Upper Marlboro seem to penetrate aquifers that are at least partially confined.

The water-level graph for well AA-Cd 21 does not show the characteristic curve of water-table wells and the fluctuations are somewhat irregular. The unusually low water levels during 1947 may have been due to the deficient rainfall in 1946 and 1947, as the well is not known to be affected by pumping. Measurements in this well were discontinued after about 2½ years of observation, at which time the water level was about a foot above the first measurement.

Well PG-Ef 1 reflects the increase in pumping from the town wells ending in the Magothy formation. During the period of record, June 1947 to December 1952, the water level declined about 2½ feet. Although about 230 feet of younger sediments, mainly sandy clay and clayey sand, lie above the Magothy formation at this location, the water level seems to fluctuate in an annual

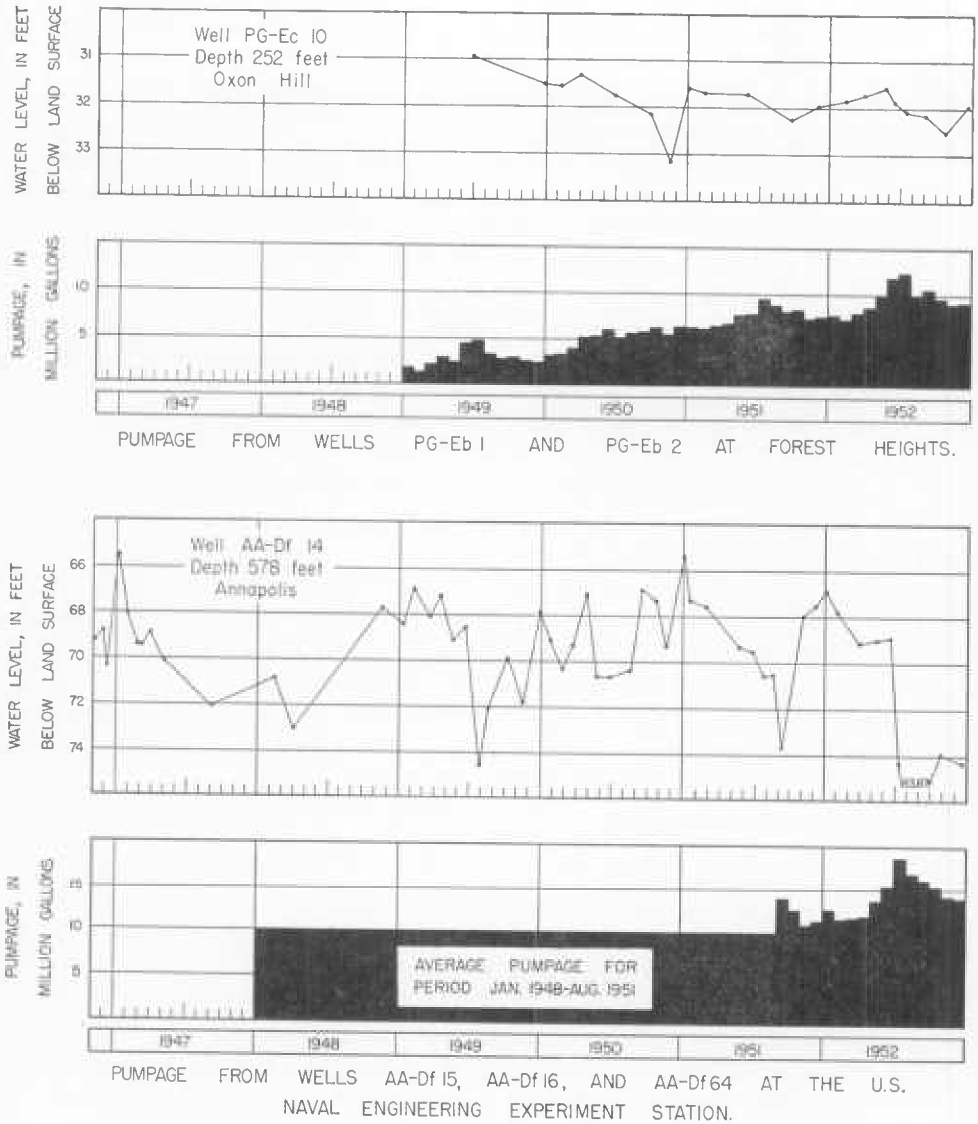


FIG. 18. Hydrographs of two observation wells ending in the Patapsco and Raritan formations and the pumpage from nearby wells

cycle; the highest levels are found in the early part of the year and the lowest in the fall or winter.

In summary, water levels in wells ending in the Magothy formation probably have not changed much, except in areas where there is considerable pumping. Table 26 lists the highest and lowest water levels measured in the two observation wells ending in this formation.

FLUCTUATIONS IN THE AQUIA GREENSAND

Seven observation wells in Southern Maryland end in the Aquia greensand. The records of two of these, AA-Ef 3 at Arundel-on-the-Bay and PG-Df 5 at Hardesty, show fluctuations of the water table in the outcrop area of the formation. The remaining wells, AA-Ee 14 at Selby Beach, Cal-Fd 14 and Cal-Gd 6 at Solomons, St.M-Df 1 at the Patuxent Naval Air Station, and St.M-Ef 27 at Portobello, show fluctuations of artesian head.

Water levels in wells AA-Ef 3 and PG-Df 5 are not affected by pumping, but the level in PG-Df 5 may be slightly affected by changes in the level of the Patuxent River. The water-level graphs for these wells do not follow the characteristic annual cycle but show minor irregular fluctuations of uncertain cause. During the period of record ($6\frac{1}{2}$ and $3\frac{1}{2}$ years, respectively) there has been almost no net change in water level.

Only artesian observation well AA-Ee 14, ending in the Aquia greensand, is unaffected by pumping. During the latter half of 1946 the trend of the water level was downward, but by the end of the period of observation (December 1948) the water level had risen about 2 feet. The measurements in this well are somewhat irregular, and the reasons for the decline and then the persistent rise in the water level are unknown.

The other four artesian observation wells in the Aquia are affected by pumping at the Patuxent Naval Air Station (fig. 19). The water level in well St.M-Df 1, at the Patuxent Naval Air Station, was measured periodically from June 1943 to December 1946. By January 1945 it had declined from about 124 to about 160 feet below land surface where it stabilized, at least until the cessation of measurements in 1946. A measurement made in July 1949 showed a rise of about 18 feet (to 142 feet below land surface) due to a general decrease in pumping during the interval.

Observations of the water level in well Cal-Fd 14 extend from May 1947 through December 1952. At the beginning of the period of measurement the water level was recovering because of a decrease in pumping from the U. S. Naval installations late in 1945. From 1948 through 1952 there was almost no net change, but from the beginning to the end of the period of observation there was a net rise of about 10 feet. The water level in this well declines slightly during the late summer and early fall, mainly because of the increased use of ground water during the summer months.

Water-level observations in well Cal-Gd 6, drilled to a depth of 493 feet in the Solomons Island area, extend from October 1949 through December 1952. They show seasonal changes in the water level in the aquifer resulting from heavier pumping during the summer. During $3\frac{1}{4}$ years of record the well

TABLE 26

Observation wells ending in the Magothy formation

Well no.	Location	Depth, in feet	Period of record	Record water levels, in feet below land-surface datum			
				Highest	Date	Lowest	Date
AA-Cd 21	Waterbury	55	May 1946–Dec. 1948	44.74	June 15, 1948	48.83	Sept. 9, 1947
PG-Ef 1	Upper Marlboro	235	June 1947–Dec. 1952	4.36[a]	Mar. 23, 1949	1.45[a]	Dec. 22, 1952

[a] Feet above land-surface datum.

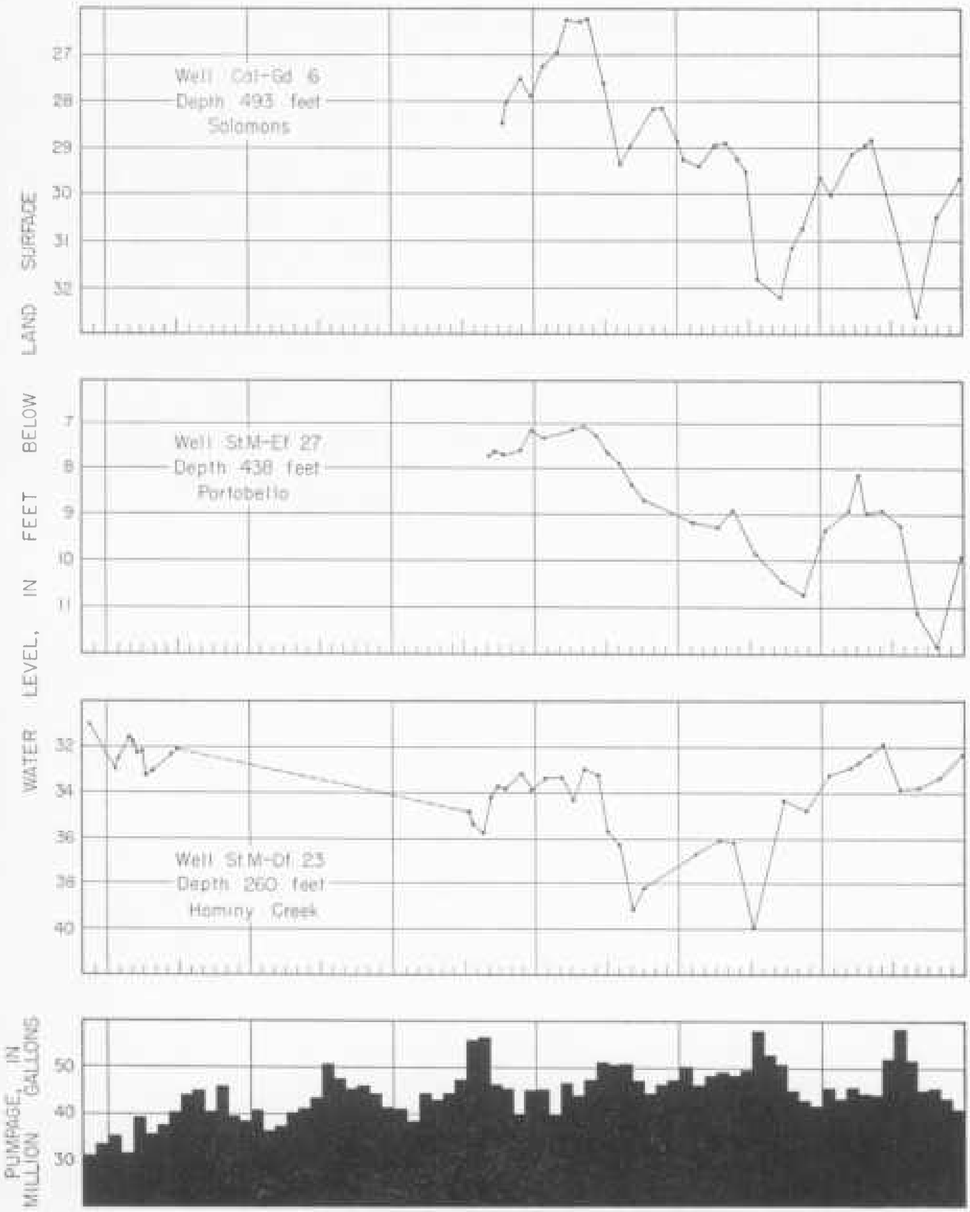


FIG. 19. Hydrographs of three observation wells ending in the Aquia greensand and Nanjemoy and Piney Point formations and the pumpage at the Naval Air Station

showed a net decline of slightly more than 1 foot; however, the range from winter to summer is 3 to 4 feet. Minor fluctuations of about half a foot are caused chiefly by tidal loading.

The water level in well St.M-Ef 27, drilled in 1909 to a depth of 438 feet, about 7 miles south of the center of pumping at the Patuxent Naval Air Station, was measured periodically from September 1949 through December 1952. In December 1952 it was approximately 10 feet below land surface. About 1918, however, Clark and others (1918, p. 412) reported that the water level was 10 feet above the land surface and the well was flowing at the rate of 10 gallons per minute. It is likely that most of the 20-foot decline in water level in this well during the 34 years from 1918 to 1952 occurred after the beginning of heavy pumping in 1942 from the Aquia at the Patuxent Naval Air Station. The graph of the water level in well St.M-Ef 27 is similar to that of Cal-Gd 6 in that a "high" is commonly observed early in the spring of the year and a "low" in the late summer.

In summary, the records of water-level fluctuations in the outcrop area of the Aquia greensand show no evidence of a general change in the position of the water table. Where ground water in the aquifer occurs under artesian conditions there has apparently been no general decline in water levels, except where the formation is heavily pumped, as at the Patuxent Naval Air Station. The records of several observation wells there show that most of the decline took place during the period of heavy ground-water withdrawal in 1942-43, and that since then no appreciable decline has taken place. The highest and lowest water levels in the observation wells ending in the Aquia greensand are listed in Table 27.

FLUCTUATIONS IN THE NANJEMOY AND PINEY POINT FORMATIONS

Of the eight observation wells in Southern Maryland ending in the Nanjemoy or the Piney Point formation, only one is a dug well (PG-Df 2). This well, near Leeland in Prince Georges County, penetrates the Nanjemoy formation near its outcrop. Its water-level record, which extends from November 1948 through December 1952, fails to show the characteristic seasonal curve typical of water-table wells. The reason for this is not clear. The net change in water level during the 4 years of record was a rise of a few tenths of a foot, but there was no noticeable trend during that period.

The other seven observation wells penetrate both the Nanjemoy and the Piney Point formations where they are under artesian head. Wells Cal-Gd 5 and Cal-Gd 22 are in the Solomons Island area. The effects of heavier summer pumping at the Patuxent Naval Air Station are noticeable in both wells, but are more pronounced in well Cal-Gd 5. The water levels are lowest in the late summer or early fall, and generally highest in March or April.

The continuous record obtained from the automatic recorder on well Cal-Gd

TABLE 27

Observation wells ending in the Aquia greensand

Well no.	Location	Depth, in feet	Period of record	Record water level, in feet below land-surface datum			
				Highest	Date	Lowest	Date
AA-Ee 14	Selby Beach	101	June 1946–Dec. 1948	21.18	Nov. 18, 1948	26.33	Dec. 6, 1946
Ef 3	Arundel-on-the-Bay	61	June 1946–Dec. 1952	5.00	Apr. 8, 1948	7.02	Sept. 30, 1949
Cal-Fd 14	Solomons Island	455(?)	Apr. 1947–Dec. 1952	5.51	Apr. 30, 1952	16.90	May 29, 1947
Gd 6	do	493	Oct. 1949–Dec. 1952	25.72	May 16, 1950	33.02	Sept. 3, 1952
PG-Df 5	Hardesty	90	Apr. 1949–Dec. 1952	3.38	Sept. 3, 1952	6.48	Sept. 24, 1951
St.M-Df 1	Patuxent Naval Air Station	587	May 1943–Dec. 1946	123.5	May 1943	165.5	Mar. 1946
Ef 27	Portobello	488	Sept. 1949–Dec. 1952	7.09	May 3, 1950	11.85	Oct. 29, 1952

5 shows the effect of tidal loading on water levels in the Nanjemoy formation. In this well there was a net rise of almost 2 feet for the 3¼ years of record, October 1949 through December 1952. The other well in the Nanjemoy, Cal-Gd 22, showed a net rise of about 4 feet during the 5½-year period of record, May 1947 through December 1952.

From May 1943 to July 1944 the water level in well St.M-Df 9 declined about 46 feet, chiefly because of heavy pumping at the Naval Air Station. During most of 1945 and all of 1946 the water level stabilized at about 80 to 90 feet below the land surface (33 to 43 feet below sea level). Periodic measurements in this well were discontinued at the end of 1946, but subsequent measurements in May and August 1951 showed no essential change in the water level.

Water-level measurements in well St.M-Df 23, about 2 miles northwest of the center of pumping at the Naval Air Station, extend from May 1946 through December 1952. They show an irregular decline of the water level from 30 feet below the land surface in 1946 to about 40 feet in July 1951. The water level subsequently recovered to slightly more than 32 feet below the land surface in December 1952. The fluctuations reflect seasonal changes in pumping. No general downward trend is shown to suggest that the draft on the aquifer is excessive.

Water-level measurements in well St.M-Eg 3, which is more than 6 miles south of the center of pumping at the Air Station, extend from November 1946 through December 1952. The water level in this well declined from 13 feet below the land surface in early 1947 to more than 16 feet in November 1951. Subsequent measurements during the winter of 1952 showed a recovery of only 1.8 feet. Measurements in this well suggest that the cone of depression resulting from the pumping at the Naval Air Station spread southward during 1951 and 1952, probably as the result of the pumping from newer wells in the southeastern part of the Station.

Water-level measurements in well St.M-Fg 4, located near Ridge, about 12 miles south of the center of pumping, also extend from November 1946 through December 1952. The trend of water levels in this well is similar to that in well St.M-Eg 3; the net decline during more than 6 years is approximately 1½ to 2 feet. The measurements in this well show the slight effect of heavy groundwater withdrawals from the aquifer at about 12 miles from the well field.

All the observation wells ending in the Nanjemoy and Piney Point formations are so situated that they reflect the heavy pumping at the Patuxent Naval Air Station. The two wells near Solomons Island show little or no trend during the period of observation. The fluctuations in well St.M-Df 9 indicate that the period of greatest decline in water level followed the beginning of heavy pumping, which extended into 1945. The water levels in the other wells show a gradual decline continuing through 1952, which in most wells amounted to only a few feet. The measurements in well PG-Df 2, near the outcrop area of the Nanjemoy formation, suggest that, except in areas where there has been a lowering of water levels due to pumping there was little net change in the water level over the period of record. The highest and lowest water levels in observation wells ending in the Nanjemoy or Piney Point formation are listed in Table 28.

FLUCTUATIONS IN THE PLIOCENE(?) AND PLEISTOCENE DEPOSITS

Sixteen observation wells in Southern Maryland end in the deposits of Pliocene(?) and Pleistocene age (Table 29). All but well Ch-Ff 24 end in the upland deposits. It ends in the lowland deposits. The wells range in depth from 6 to 58 feet and average 27 feet. The length of record of the water-level measurements ranges from 3½ to more than 6 years, extending from November 1946 through December 1952. In all wells the fluctuations of the water levels reflect changes in the position of the water table. However, the range in fluctuations varies widely from a minimum of 1.6 feet in well St.M-Ec 23 in southern St. Marys County to a maximum of 19.0 feet in well Cal-Bb 1 in Calvert County; the average range in fluctuation of the water levels in the 16 wells is 6.6 feet.

The water-level graphs from four somewhat typical wells are shown in figure 20, which also includes the record of the precipitation at La Plata during the same period. The graphs show the seasonal changes in water level associated with seasonal changes in precipitation and evapotranspiration. Late 1949 and early 1950 was a period of generally low water levels resulting from cumulative deficient rainfall, whereas April and May in both 1949 and 1951 were periods of high water levels corresponding with high precipitation.

The water-level fluctuations in well PG-Fd 16 are probably typical of those in many shallow wells in southern Prince Georges County. Well PG-Fd 16, near Brandywine, is a dug well 22 feet deep in the upland deposits. The observations cover a period of 3¾ years (April 1949 through December 1952) and show a range in fluctuation of more than 9 feet. The lowest water level occurred in December 1949 when it was more than 17 feet below the land surface; the highest level occurred in May 1952 when it was slightly more than 8 feet below the land surface.

Well Ch-Bf 2 is a dug well, 18.5 feet deep, near Waldorf. The water-level measurements in this well span a period of more than 6 years (November 1946 through December 1952). The water levels correspond in a general way to the seasonal and annual distribution of precipitation and show a range in fluctuation of 4.7 feet. The lowest water level (approximately 16 feet below land surface) occurred in January 1950; the highest (about 12 feet below the land surface) occurred in April 1949.

Well St.M-Db 24, near Milestown in southwestern St. Marys County, is

TABLE 28

Observation wells ending in the Nanjemoy and Piney Point formations

Well no.	Location	Depth, in feet	Period of record	Record water level, in feet below land-surface datum			
				Highest	Date	Lowest	Date
Cal-Gd 5	Solomons Island	248	Oct. 1949–Dec. 1952	17.98	May 16, 1950	22.23	Sept. 18, 1951
Gd 22	do	320	May 1947–Dec. 1952	12.75	Apr. 26, 1950	18.79	May 15, 1949
PG-Df 2[a]	Leeland	82	Nov. 1948–Dec. 1952	72.25	Oct. 19, 1949	75.96	Nov. 19, 1951
St.M-Df 9	Patuxent Naval Air Station	285	May 1943–Dec. 1946	30.30	May 1943	90.25	July 1946
Df 23	Hominy Creek	260	May 1946–Dec. 1952	31.02	Nov. 14, 1946	39.93	July 9, 1951
Df 24	Little Kingston Creek	280	Nov. 1946–Dec. 1952	3.77	Apr. 30, 1952	5.99	Nov. 20, 1951
Eg 3	St. James	387	Nov. 1946–Dec. 1952	12.80	Mar. 25, 1947	16.38	Nov. 20, 1951
Fg 4	Ridge	420	Nov. 1946–Dec. 1952	7.92	Mar. 25, 1947	10.72	Oct. 29, 1952

[a] Well penetrates the Nanjemoy formation only.

TABLE 29

Observation wells ending in the Pliocene(?) and Pleistocene deposits

Well no.	Location	Depth, in feet	Period of record	Record water level, in feet below land-surface datum			
				Highest	Date	Lowest	Date
Cal-Bb 1[a]	Dunkirk	44	Jan. 1947–Dec. 1952	14.74	Apr. 30, 1952	33.71	July 29, 1949
Cb 4[a]	Armiger	33	Apr. 1949–Dec. 1952	18.85	Apr. 30, 1952	21.40	Sept. 14, 1949
Dc 18[a]	Prince Frederick	26	July 1947–Dec. 1952	18.17	Apr. 10, 1951	19.91	Jan. 24, 1950
Ec 4[a]	Mutual	49	Apr. 1947–Dec. 1952	39.73	May 13, 1952	46.31	Sept. 7, 1950
Ch-Bc 10	Potomac Heights	39	Nov. 1946–Dec. 1952	25.26	Mar. 28, 1949	32.05	June 11, 1947; Sept. 9, 1950
Bf 2	Mattawoman	19	Nov. 1946–Dec. 1952	11.79	Apr. 13, 1949	16.49	Jan. 25, 1950
Dc 2	Ironsides	39	Jan. 1948–Dec. 1952	14.97	Feb. 12, 1949	33.40	July 12, 1951
Dd 6	McConchie	25	Jan. 1947–Dec. 1952	20.08	Mar. 8, 1949	23.32	June 11, 1947
Ee 16	Wayside	23	Jan. 1947–Dec. 1952	12.97	Apr. 3, 1952	20.65	Dec. 20, 1949
Ff 24	Issue	15	Nov. 1946–Dec. 1952	1.30	Feb. 13, 1951	8.41	Sept. 28, 1951
PG-Fd 16	Brandywine	22	Apr. 1949–Dec. 1952	8.50	Apr. 6, 1949	17.64	Dec. 28, 1949
St.M-Bb 2	Newmarket	11	Mar. 1947–Dec. 1952	2.29	Apr. 30, 1952	7.46	Sept. 16, 1949
Db 24	Milestown	10	July 1949–Dec. 1952	1.72	May 1, 1952	8.33	Oct. 14, 1949
Df 26	California	58	Nov. 1946–Dec. 1952	50.57	June 6, 1949	54.37	Jan. 16, 1952
Ee 23	Poplar Hill Creek	8	July 1949–June 1952	1.32	May 1, 1952	2.96	Dec. 21, 1949
Ee 24	Chingville	6	July 1949–June 1952	1.74	Aug. 3, 1949	3.80	Sept. 28, 1949

[a] Also taps Miocene deposits.

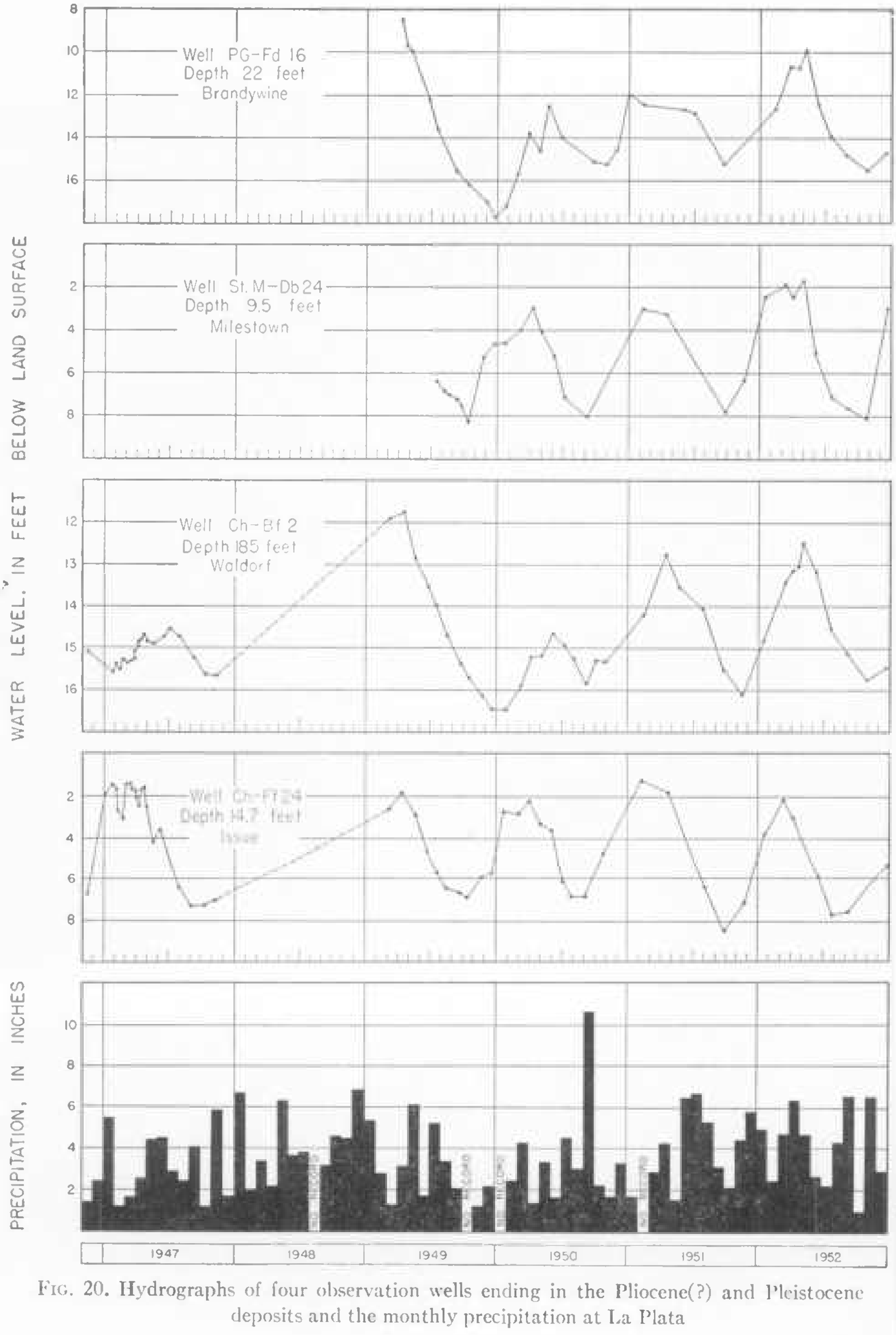


FIG. 20. Hydrographs of four observation wells ending in the Pliocene(?) and Pleistocene deposits and the monthly precipitation at La Plata

one of the shallowest wells (9.5 feet deep) for which water-level measurements were made. The water level fluctuated about 6 feet during the 3½ years of record, from July 1949 through December 1952. The lowest water level, in October 1949, was a little more than 8 feet below the land surface; the highest, in May 1952, was 1.7 feet below the land surface. The record of fluctuations in this well shows no trend.

Chemical Character of Ground Water

In Table 31 are 278 chemical analyses of water from wells penetrating all the important aquifers in Southern Maryland. The areal distribution of the samples is not uniform, but the average is a sample per 7 square miles. The table lists the wells from which samples were obtained, the water-bearing formations, the date of collection of the samples, the analysts, and the results of the analyses. In most of the analyses the chief mineral constituents were determined; however, several are partial analyses, giving only pH, total hardness, and chloride and sulfate content. The latter are chiefly of samples from wells in Anne Arundel County. Most of the analyses were made in the Quality of Water laboratory of the U. S. Geological Survey; a few were made by the Maryland State Health Department and by private analytical chemists. About 25 field tests for total hardness and chloride content are not shown in Table 31, but were used in the compilation of the geochemical maps (Pls. 11, 12, and 13).

CHEMICAL CONSTITUENTS IN RELATION TO USE

DISSOLVED SOLIDS

The residue left after the evaporation of a natural water consists mainly of mineral constituents but may include some water of crystallization and a small amount of organic matter. Ground water containing less than 500 parts per million of dissolved solids is generally satisfactory for domestic use, except where the iron content or hardness of the water is excessive. Water containing more than 1,000 parts per million of dissolved solids is likely to contain a concentration of constituents that impart a noticeable taste or are undesirable in other respects (Lohman, 1939, p. 69). In Southern Maryland the dissolved solids in ground water range from 12 to over 580 parts per million and average about 150 parts. Wells tapping the upland Pliocene (?) and Pleistocene deposits or ending in sands of Cretaceous age in or near their outcrop area commonly yield water having the lowest dissolved-solids content. The maximum, minimum, and average dissolved-solids content of ground water from the various geologic units is shown in Table 30.

HARDNESS

Hardness is a characteristic of water containing certain dissolved salts. Degrees of hardness may be recognized by the amounts of soap required to produce

TABLE 30

Range in dissolved solids, hardness, iron, and pH in ground water in Southern Maryland

(In parts per million, except pH)

Geologic unit	Dissolved solids				Hardness (as $CaCO_3$)				Iron (Fe)				pH			
	Number of analyses	Maximum	Minimum	Average	Number of analyses	Maximum	Minimum	Average	Number of analyses	Maximum	Minimum	Average	Number of analyses	Maximum	Minimum	Average
Pleistocene and Recent lowland deposits	8	587	78	225	12	403	15	93	12	34	0.10	3.4	12	7.8	5.0	6.3
Pliocene(?) and Pleistocene upland deposits	19	265	31	98	20	146	9	46	19	6.8	.02	1.0	19	7.4	5.1	6.4
Nanjemoy and Piney Point formations	19	439	163	231	19	239	22	93	15	3.8	.07	.5	20	8.3	7.7	8.0
Aquia greensand	48	300	67	189	55	325	9	81	52	16	.03	1.1	55	8.8	5.2	7.8
Monmouth formation	2	510	174	342	4	270	9	153	4	32	.30	13.2	3	7.8	5.3	6.5
Magothy formation	27	264	47	131	33	178	13	91	34	30	.02	9.5	29	8.0	3.8	6.5
Patapsco and Raritan formations	53	345	12	110	82	563	2	35	71	30	.04	4.8	73	8.6	3.5	5.7
Patuxent formation	33	227	18	91	33	80	1	14	35	15	.03	2.1	33	8.2	4.7	6.1
Pre-Cambrian rocks	3	196	68	146	3	56	20	33	3	6.5	.10	2.3	2	7.9	7.0	7.4
All geologic units	212	587	12	145	261	563	1	59	245	34	.02	3.7	246	8.8	3.5	6.6

a lather and by the deposits of insoluble salts when the water is heated or evaporated. In hard water considerable curd or insoluble material is formed prior to the formation of suds or lather. Total hardness is caused almost entirely by the salts of calcium and magnesium and is expressed in parts per million of calcium carbonate ($CaCO_3$). Other constituents such as iron, aluminum, manganese, barium, or free acid may cause hardness, but they are generally not present in ground water in any great concentration. However, in some localities in Southern Maryland where the iron content and free acid is excessive, part of the hardness may be caused by these constituents. The hardness caused by calcium and magnesium ions equivalent to the bicarbonate ions in the water is called the carbonate or "temporary" hardness. The remaining hardness is called the noncarbonate or "permanent" hardness. The hardness of most of the ground water from Southern Maryland is predominantly in the carbonate form. Water may be classed according to various degrees of hardness, but the following scale proposed by Collins (Collins and others, 1934, p. 15–19) is commonly used by the U. S. Geological Survey:

Hardness range (parts per million as $CaCO_3$)	Class	Character of the water
0–60	(A)	Soft. Hardness scarcely noticed for general household use.
61–120	(B)	Moderately soft to moderately hard. Suitable for many purposes without treatment, but soap consumption increases. Softening may be profitable for a laundry.
121–180	(C)	Hard. Hardness noticeable. Many cities having water of a total hardness of 150 parts per million or more soften the water.
180+	(D)	Very hard. Necessary to soften for use in laundry or steam boilers. Some supplies would be unsatisfactory even after softening.

The hardness in 261 samples of water from Southern Maryland ranges from 1 to 563 parts per million. The average hardness is 59 parts per million, just within the "soft" range. Treatment for the removal of hardness is necessary only in some localities, or only where extremely soft water is required for a special use, such as boiler feed. The distribution of ground water of varying degrees of hardness within the sands of Cretaceous age and within the Aquia greensand is shown on Plates 11 and 13. Plate 11 shows that the water obtained from the Cretaceous sands has a hardness of less than 60 parts per million except in an area embracing southern Anne Arundel, northern Calvert, southern and central Prince Georges, and northeastern Charles Counties. Within this area, wells tapping the Cretaceous sands commonly yield water falling into hardness classes B or C. The hardness in a few samples (chiefly from the Magothy formation near Upper Marlboro) is in excess of 170 parts per million. Exceptionally soft water is obtained along the Potomac River valley south of

Washington, D. C. from wells ending in the Cretaceous water-bearing sands. The hardness of ground water supplying the Indian Head Naval Powder Factory ranges from 6 to 10 parts per million; the supply is obtained chiefly from sands in the Patuxent formation at depths of 150 to 400 feet.

The distribution of water of varying degrees of hardness within the Aquia greensand (Pl. 13) indicates that this aquifer also yields extremely soft water in some localities and moderately hard water in others. The variations in the hardness of ground water are discussed further in the section of the report describing the geochemical relationships of ground water in Southern Maryland.

IRON

Iron is an objectionable constituent in many ground-water supplies. It is present in almost all rocks and is readily dissolved by percolating ground water, particularly if the water is acidic. Water having a high iron content (in excess of about 0.3 part per million) commonly precipitates the element after exposure to the air. Iron stains utensils, dishes, and plumbing, and imparts a reddish color to laundry washed in such water. Excess iron also clogs pipes and valves when it precipitates in a water-supply system and interferes with the efficient operation of some types of water softeners.

Iron may be removed from water by various methods, of which the aeration of the water over a bed of coke or charcoal is among the most common. Lime compounds and chemical softening of the water commonly remove much of the dissolved iron. The iron content of ground water in Southern Maryland is erratic. In an area in east-central Anne Arundel County and in eastern Prince Georges County the ground water is excessively high in it (Pl. 12). The water from drilled wells in these localities is commonly acidic and has an iron content in excess of 10 parts per million. High iron content is found in water from wells at the Naval Academy, the Annapolis Water Works, the Sandy Point State Park, and the communities of Severna Park and Gibson Island. Ground water in these places is acidic and must be treated for iron removal before use. Because of the iron content of water from some drilled wells (100 to 300 feet deep) in the vicinity of Jacobsville and Bodkin Point, in Anne Arundel County, the wells have been abandoned in favor of shallower dug wells that yield water of considerably lower iron content. Iron-removal installations are available which are designed for domestic supplies and which are relatively inexpensive to operate and maintain. The iron is removed chemically.

The iron content of 245 samples of ground water ranges from 0.02 part per million to 34 parts per million and averages about 3 parts per million. The highest iron content is found in water from wells ending in sands of Late Cretaceous age. Water of the lowest iron content is commonly slightly alkaline (pH greater than 7.0) and is generally from wells ending in the greensand of Eocene age. An average value for iron content of ground water is not particularly meaningful, for the inclusion of a few samples having an extremely high iron content affects to a marked degree the average value. Table 31 shows that many of the samples have an iron content of less than 1 part per million and several contain more than 5 parts per million, but comparatively few are in the range of 2 to 5 parts per million (which is the range in which the average value falls).

HYDROGEN-ION CONCENTRATION

The pH, or logarithm of the reciprocal of the hydrogen-ion concentration, is a quantitative expression of the acidity or alkalinity of a water. Acid water has a pH of less than 7.0, and alkaline water has a pH greater than 7.0. A change of one unit represents an increase or decrease of 10 times; that is, water having a pH of 5.0 is 10 times as acid as water whose pH is 6.0. Natural ground water in Southern Maryland has been observed to range in pH from 3.5 to 8.8. Many of the acidic waters are from wells ending in water-bearing sands of the Patuxent, Patapsco, and Magothy formations in northern Prince Georges and Anne Arundel Counties. Plate 12 shows the distribution of the pH of water samples from wells ending in those sands. The pH of a water will vary slightly from time to time, and the value shown is only approximate, as some of the determinations of pH were made several days after the samples were collected. The highest values for total iron content are generally found in waters of low pH.

FREE ACID

A distinct type of ground water is found in wells in eastern Anne Arundel County in the area north of the Severn River along the outcrop belt of the Patapsco, Raritan, and Magothy formations. Many drilled wells in this belt yield water containing free mineral acidity (expressed chemically as parts per million of sulfuric acid, H_2SO_4). Such water has a low pH (less than about 4.5) and is generally corrosive. It is generally low in dissolved mineral solids but comparatively high in dissolved iron and manganese. The sulfate content of the water is also high. The analyses of 22 samples of water from the acid-water belt of eastern Anne Arundel County show that the average pH is 3.9, which is strongly acidic for natural water. The average concentration of free acid (as H_2SO_4) is 18.5 parts per million. The depths of the wells yielding the acid water range from 100 to more than 500 feet, but most of them are less than 300 feet deep.

The occurrence of the free-mineral-acid ground water is probably related to the relative abundance of the minerals pyrite and marcasite in the Upper Cretaceous formations. Foster (1942, p. 652) shows that natural sulfuric acid from the reaction of ground water with sulfide minerals in the rocks is fairly common. The reaction may be expressed by the equation:

$$2FeS_2 + 7H_2O + 15O = 2Fe(OH)_3 + 4H_2SO_4$$

However, pyrite is also common in the Upper Cretaceous sands where the water from these aquifers is not acidic but is mildly alkaline as in the Upper Marlboro area and in northern Charles County near La Plata. The differences in the character of the ground water from the Upper Cretaceous water-bearing sands may be due to lithologic differences in the overlying strata. Where the overlying strata consist of noncalcareous or only slightly calcareous sands and clays, ground water from the Upper Cretaceous sands may be expected to be acidic, but where the sands lie beneath calcareous beds of Eocene or Miocene age the ground water from the Cretaceous sands may be mildly alkaline. North of an irregular belt extending eastward from the District of Columbia through Seat Pleasant and Hall in northern Prince Georges County the ground water from the Cretaceous aquifers is generally acidic, but south of this belt most of the water is mildly alkaline. The belt roughly marks the limit of the outcrop of the Calvert formation, and is approximately the northern limit of the calcareous layers in the underlying Eocene formations. This correlation between acid ground water and the absence of calcareous sediments appears to be valid, but requires further confirmation.

CHLORIDE

Chloride is present in small quantities in almost all ground water, but it is not objectionable for most domestic uses unless it exceeds 250 parts per million. This is the limit established by the U. S. Public Health Service (1946) for potable water used for drinking purposes in interstate common carriers. The chloride content of uncontaminated ground water in the Southern Maryland coastal plain is generally less than 15 parts per million. The presence of a higher concentration of chloride, especially where associated with a high nitrate content, in dug or bored wells in areas distant from tidewater may indicate contamination by sewage or surface drainage. The analysis of a water sample from well St.M-Bb 1, producing from the Pleistocene upland deposits near Charlotte Hall, shows a chloride content of 55 parts per million, which is higher than the normal chloride content of uncontaminated ground water in the vicinity. As the well is used by an ice-manufacturing concern, it is likely that leakage of brine from the plant has contaminated the ground water.

The water from well AA-Cg 2 at the Sandy Point Ferry (now abandoned) had a chloride content of 146 parts per million. The well produced from a sand in the Monmouth formation (?) which may be contaminated locally with brackish water from the Bay. The deeper aquifers in the vicinity (Magothy and Patapsco formations) yield water low in chloride content, but commonly acidic and high in iron.

Water having a chloride content of 380 to 3,500 parts per million was encountered in a few domestic jetted wells in the Solomons Island area of Calvert County in 1946 and 1947 (Overbeck, 1951, p. 23). The high chloride content of water from a few of these wells is believed to have resulted from the downward movement of brackish water along the outside of casings in wells near the strand line. The contamination apparently has been confined to a few wells and there is no evidence that it has spread appreciably.

MINOR CONSTITUENTS

Silica

Silica (SiO_2) is present in practically all natural ground water, but generally in such small quantities as to be of negligible importance. Nevertheless, any silica in water contributes to the formation of boiler scale, and it is especially troublesome in water carrying large quantities of sodium bicarbonate. Some ground water from Southern Maryland is of the sodium bicarbonate type and is characterized by a rather high silica content. The average silica content of 204 water samples from all aquifers is 17.9 parts per million, and the range is from 0.7 to 61 parts per million. A silica content of 61 parts per million was found in well St.M-Df 6, which yields water from the Nanjemoy and Piney Point formations. In general, in St. Marys and Calvert Counties, the silica content of water from the Nanjemoy and Piney Point formations is comparatively high, averaging 39 parts per million in 18 samples.

Sulfate

Sulfate (SO_4) is found in small amounts in almost all natural ground water. It may be derived from solution of the mineral gypsum, from the oxidation of the minerals pyrite or marcasite, or from other sources. The sulfate content of ground water in amounts less than 100 parts per million has little significance in relation to the use of the water. In 246 samples from Southern Maryland the amount of sulfate ranges from 0.2 to 142 parts and averages 14.5 parts per million. The sulfate content of 142 parts per million found in the water from well St.M-Fg 40 may result from contamination with brackish water; the well is only 14 feet deep and ends in Pleistocene or Recent deposits adjacent to tidewater.

Nitrate

Nitrate (NO_3) in ground water is generally a final oxidation product of nitrogenous organic material. Where it is in excess of about 5 parts per million, its presence suggests that the water may be contaminated with organic material. Fertilizers also may be a source, and in some areas (though not in Southern Maryland so far as is known) the nitrate content is substantial even though there is no possibility of origin by contamination or from fertilizers. In the normal range in which nitrate occurs in ground water, it has little effect on the use of the water. However, recent studies have shown that an unusually large amount of nitrate in water may cause cyanosis when the water is used in the preparation of an infant's food or drink. Water that contains more than 90 parts per million of nitrate is considered by the Kansas State Board of Health likely to cause infant cyanosis. Water containing less than 45 parts per million nitrate is generally considered safe (Davis and Carlson, 1952, p. 248). The nitrate content of 256 samples of ground water from Southern Maryland ranges from 0.04 to 83 and averages 2.9 parts per million. The maximum of 83 parts per million was found in water from a 36-foot dug well near Suitland, in Prince Georges County. This well was probably contaminated with surface drainage.

Phosphate

Phosphate (PO_4) is a relatively unimportant constituent found in some ground water. It may be present as a result of the solution of phosphate-bearing sediments of marine origin. The phosphate content of 34 samples of ground water from Southern Maryland ranges from 0.09 to 1.0 and averages 0.1 part per million. One part per million of phosphate was found in a water sample from well Ch-Cd 7, which is screened in the Raritan formation; the water is of the sodium bicarbonate type and is relatively high in iron (5.3 parts per million) and fluoride (1.3 parts per million). Few data are available concerning the normal range of phosphate in ground water.

Fluoride

Fluoride (F) is fairly common in small amounts in much of the ground water in the Maryland coastal plain. The element is dissolved from various fluoride-bearing minerals in the rocks, such as apatite, fluorapatite, and some minerals common in clay such as muscovite and sericite mica. The presence of fluoride in drinking water much in excess of 1 part per million may cause permanent mottling of tooth enamel if the water is used continually by young children (Dean, 1936). The Public Health Service (1946) recommends 1.5 parts per million as the maximum. The fluoride content of ground water from Cretaceous and Eocene aquifers ranges from 0.1 to 1.4 and averages 0.3 part per million. The water containing the greatest amounts of fluoride is from wells tapping Cretaceous sands along the lower Potomac River valley. Generally, fluoride is present in such low concentrations in the ground water of Southern Maryland that its presence is of no concern.

Manganese

Manganese (Mn) in excessive concentrations in water is objectionable when the water is used for laundry purposes; it is also objectionable where it precipitates along with iron in the pipes of a water system. Unless present in unusually high concentrations the element may be removed from water by the same treatment methods that reduce or eliminate iron. The manganese content of 113 water samples from Southern Maryland ranges from 0.00 to 0.5 and averages 0.06 part per million. The water containing the highest concentration was an acidic water derived from sand of Late Cretaceous age; the iron content of the sample also was high.

Aluminum

Aluminum (Al) content was determined in 59 analyses of ground water from Southern Maryland. Aluminum is chemically similar to ferric iron, but is not generally present in as high concentrations as is iron. The range in aluminum in the 59 samples is from 0.09 to 3.9 parts per million and the average is 0.3 part per million. The maximum concentration was in a sample from well AA-Ac 21 which ends in the Patuxent formation near its outcrop area in northern Anne Arundel County. The reason for the high aluminum content of this water is not known.

GEOCHEMISTRY OF GROUND WATER IN RELATION TO WATER-BEARING FORMATIONS AND HYDROLOGY

METHODS OF EXPRESSION

Chemical analyses of water are commonly expressed in parts per million (milligrams per liter). Such analyses show only the chemical composition of a water and not its chemical character, for the physical weight of a radical does not indicate its chemical value in a system of dissolved salts in water (Palmer, 1911, p. 7). It is therefore desirable to minimize the effect of concentration of the radicals and elements and to use instead the reacting capacity or reacting values of the ions in the water. It is thus possible to readily type or classify a water. The reacting value of an ion or radical is determined by dividing its content, expressed as parts per million, by the equivalent combining weight of the ion (which is the same as multiplying the content in parts per million by the reciprocal of the equivalent combining weight, sometimes called the reaction coefficient). The reaction coefficients of the radicals and elements common in the ground water of Southern Maryland are:

Cations (metals)		Anions (nonmetals)	
Calcium (Ca)	0.0499	Carbonate (CO_3)	0.0333
Magnesium (Mg)	.0822	Bicarbonate (HCO_3)	.0163
Sodium (Na)	.0434	Sulfate (SO_4)	.0208
Potassium (K)	.0255	Chloride (Cl)	.0282
		Nitrate (NO_3)	.0161

In natural water the cations and anions (metallic and nonmetallic ions) are in chemical equilibrium with each other. In addition to the common cations calcium, magnesium, sodium, and potassium, most natural water contains iron, aluminum, and manganese. The most abundant anions are bicarbonate, sulfate, and chloride. Carbonate, fluoride, and nitrate are common but generally occur only in small amounts. Some water contains phosphate or borate. Most of the heavier metallic ions are absent, or present in only small amounts. Iron, manganese, and silica are believed to exist in the water mainly in the colloidal state, and therefore are not in chemical balance with the ionic constituents. Neglecting the colloidal constituents, the total reacting values of the cations (metallic ions) balance those of the anions (nonmetallic ions). When the ionic constituents are in chemical equilibrium the sum of each type equals 50 percent of the total reacting values.

This method of presenting a water analysis affords a means of verifying the accuracy of the analysis. The method is useful also in classifying a water for comparison with another water even though the concentration of dissolved minerals in one sample may be much higher than that in another sample.

Many combinations of plotting the reacting values have been used, but two simple types of plotting seem best adapted to the study of the geochemistry of the Southern Maryland ground water. One involves plotting each analysis on a rectangular graph by a dot, square, or other symbol that identifies the geologic unit from which the water was derived. The position of the symbol on the horizontal axis is determined by the relative proportion of the calcium and magnesium on the one hand and of the sodium and potassium on the other. The position of the symbol on the vertical axis is determined by the relative proportion of the carbonate and bicarbonate on the one hand and of the sulfate, chloride, and nitrate on the other (fig. 21). This method of plotting places most of the ground water in Southern Maryland in the following groups or types:
Group 1. Sodium and potassium ions in excess of calcium and magnesium ions (more than 25 per cent Na and K); and sulfate, chloride, and nitrate ions high and bicarbonate ions low (less than 25 per cent bicarbonate). Water from shallow dug wells contaminated by surface pollution (high in nitrate or chloride) and brackish water from the Chesapeake Bay fall in this group.
Group 2. Calcium and magnesium ions in excess of sodium and potassium ions (more than 25 per cent Ca and Mg); and sulfate, chloride, and nitrate ions high and bicarbonate ions low (less than 25 per cent bicarbonate). Much of the slightly acidic water from the Upper Cretaceous aquifers falls in this category and is characterized chiefly by a relatively high content of sulfate ions.
Group 3. Calcic bicarbonate water characterized by being relatively hard and containing more than 25 per cent calcium and magnesium ions. Such water is high in bicarbonate and low in sulfate, chloride, and nitrate. Many deep wells penetrating calcareous sediments yield water falling in this group.
Group 4. Sodic bicarbonate water which results chiefly from the reaction of calcium bicarbonate water with base-exchange minerals in the sediments. Such water is characterized by an excess of sodium and potassium over calcium (more than 25 per cent Na and K) and by a high bicarbonate content (more than 25

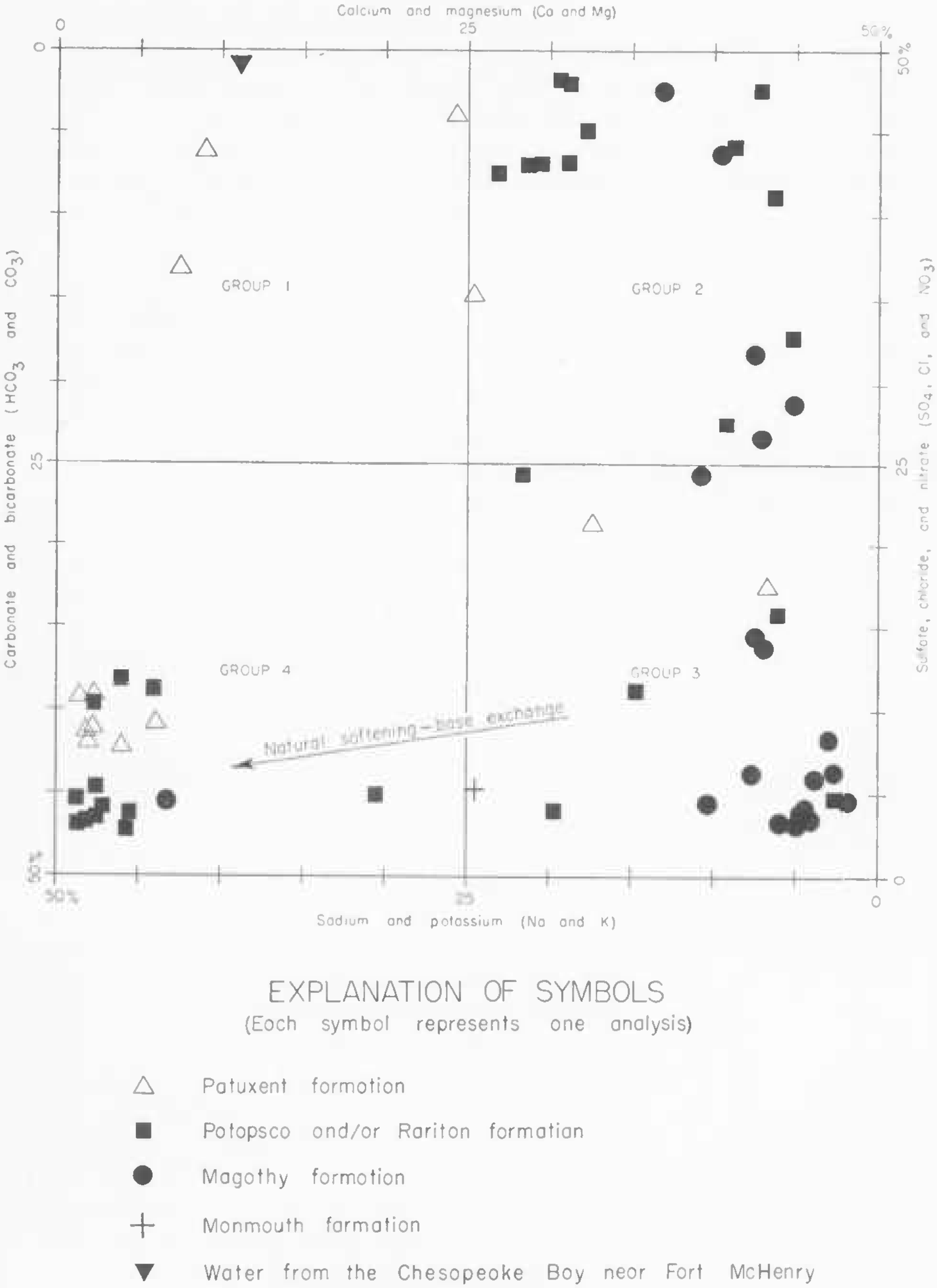


FIG. 21. Chemical character of ground water from Cretaceous aquifers shown by the percent reacting values of the ions

per cent HCO_3). Many of the deeper wells ending in the Eocene and Cretaceous aquifers in Charles and St. Marys Counties yield water in this category.

A fifth type of natural ground water, containing free acid, is common in wells tapping the Cretaceous sands in northern Anne Arundel County. This water is not in chemical equilibrium and cannot be satisfactorily shown on a graph along with most other natural ground waters. The acid waters appear to be chemically similar to those of group 2, but the metallic ions of calcium, magnesium, sodium, and potassium are partially replaced by the cation hydrogen.

The other method of plotting the percent reacting values is by bar diagrams. This method is used in Plate 14 to show these values in relation to the geology of the area.

NATURAL WATER SOFTENING BY BASE EXCHANGE

Some water undergoes natural softening in its circulation through the rock materials. This process, by which the calcium and magnesium ions in the water are exchanged for sodium and potassium ions, is known as base exchange. Foster (1942, p. 651–652), in discussing the process, states:

"Many waters from the sedimentary deposits contain sodium and bicarbonate as the predominant basic and acidic constituents, and some contain approximately equal quantities of calcium and sodium. Many such waters are found in the Atlantic and Gulf Coastal Plain. The same formation may yield both sodium and calcium bicarbonate waters. In such a formation the calcium bicarbonate waters are usually the shallower waters, and the sodium bicarbonate waters are the deeper waters. The waters appear to undergo an alteration in character with increasing depth in the formation. The calcium and magnesium content decreases and the waters become softer; at the same time the sodium content increases but the bicarbonate and total mineral content often remain approximately the same . . . These waters appear to be the result of a secondary action between the waters and the rock materials—exchange of calcium and magnesium in solution in the waters for the sodium of base-exchange minerals in the rock materials. The most important of these base-exchange minerals is glauconite, or greensand, a green granular silicate of potassium and iron that is formed near the mud line off continental shores and that is consequently often found in sedimentary deposits. Certain hydrous alumino-silicates that are derived from the weathering of the crystalline rocks and that may make up part of the clastic material of the sedimentary deposits are also capable of base exchange.

"The depth at which softening begins depends on the relative proportion of calcium and magnesium carbonates to base-exchange minerals in the beds through which the water passes. If the base-exchange minerals are present in at least an equivalent amount to the carbonates, the two processes may be almost simultaneous, the calcium being exchanged almost as soon as it is taken into solution . . . If the carbonates are present in the rock materials in amounts more than equivalent to the exchange minerals, or if the exchange capacity of the base-exchange minerals has been exhausted in the shallower materials, the ground waters must travel farther before being softened. In formations that contain little or no base-exchange materials, or in the limestone formations, the deep waters, as well as the shallow waters, are calcium bicarbonate waters."

Natural water softening by base exchange is common in the aquifers of Southern Maryland. Water in the Cretaceous and Eocene aquifers changes markedly in character as it moves through strata containing base-exchange minerals such as glauconite or the hydrated aluminosilicates.

GROUND WATER FROM THE CRETACEOUS AQUIFERS

Patuxent formation

The dissolved solids in water from the Patuxent formation range from 18 to 227 and average 91 parts per million. The pH of the water, as indicated by 33 determinations, ranges from 4.7 to 8.2 and averages 6.1.

Figure 21 shows that the water from the Patuxent formation varies widely in character. Three samples fall in the high sodic sulfate (or chloride) class of group 1. Two samples, from wells in the outcrop belt of the formation in northern Prince Georges and Anne Arundel Counties, are characterized by a pH of less than 7 and by a relatively low content of dissolved solids. The iron and manganese content in both samples is relatively high. These waters are probably typical of the Patuxent formation where it is not overlain by younger Tertiary formations containing calcareous shell fragments.

A few samples from the Patuxent formation fall in group 3, the calcium bicarbonate type of water, but most of them fall in group 4, characterized by a high content of sodium or potassium and bicarbonate. Many of the analyses of ground water from the Patuxent show a definite grouping in figure 21, as would be expected since the water samples are mainly from wells at the Naval Powder Factory and in northeastern Prince Georges County.

Patapsco and Raritan formations

Dissolved solids in 53 analyses from the Patapsco and Raritan formations range from 12 to 345 and average 110 parts per million. Hardness ranges from 2 to 563 parts per million. The pH in 73 analyses ranges from 3.5 to 8.6 and averages 5.7. Much of the water from the Patapsco and Raritan formations is characterized by a high iron content, which in a few samples is about 30 parts per million; the average iron content in 73 analyses is 4.8 parts per million. In general, high iron content is typical of the acidic sulfate waters in the Cretaceous strata in northern and central Anne Arundel and Prince Georges Counties.

Most of the ground water from the Patapsco and Raritan formations falls in groups 2 and 4 (fig. 21). None falls in group 1 (high sodic chloride or sulfate water), and only five samples fall in group 3 (the calcic bicarbonate or hard water). The twelve that fall in group 4 (soft water high in sodium and bicarbonate) are mainly from wells in southern Prince Georges and central Charles Counties, chiefly in the La Plata-Bel Alton area. The water-bearing sands from which soft, mildly alkaline, sodium bicarbonate water is derived are commonly overlain by Eocene or Miocene strata containing calcareous beds. The distribution of hard, moderately hard, and soft waters from wells ending in the Cretaceous aquifers is shown on Plate 11.

Magothy formation

The dissolved-solids content in 27 analyses of water from the Magothy formation ranges from 47 to 264 and averages 131 parts per million. In 33 analyses the hardness ranges from 13 to 178 parts per million and averages 91 parts per million. The iron content of the water also varies widely but is commonly rather high, a maximum of 30 parts per million having been determined. The pH in 29 analyses ranges from 3.8 to 8.0 and averages 6.5.

The analyses of samples from the Magothy formation fall chiefly in groups 2 and 3 (fig. 21). No samples fall in group 1, and only one sample in group 4. The five samples in group 2 are chiefly from wells in eastern Anne Arundel County tapping the formation near its outcrop; these waters are characterized by a low pH and by a relatively high sulfate content. Fifteen samples fall in group 3, characterized by a relatively high content of calcium or magnesium bicarbonate, and are therefore rather hard. The total iron content is variable but commonly is less than in the acidic water from the formation near its outcrop area. Many of the waters of the Magothy from wells in the Brandywine-Upper Marlboro area cluster together at one point on figure 21, verifying their common source.

Monmouth formation

The dissolved-solids content in two samples of ground water from the Monmouth formation is 174 and 510 parts per million, respectively. The iron content in four samples ranges from 0.3 to 32 parts per million. The pH of the water in three samples ranges from 5.3 to 7.8 and averages 6.5. Because the Monmouth formation is not extensively utilized as an aquifer in Southern Maryland and only a few analyses are available, the true character of water from the formation may not be indicated by these analyses.

A dissolved-solids content of 510 parts per million was found in water from well AA-Cg 2 at the Sandy Point Ferry. The iron content of this water was 20 parts per million, the chloride content was 150 parts per million, and the hardness was 170 parts per million. A 443-foot well (Ch-Ce 6) ending in a water-bearing sand in the Monmouth formation in Charles County yields water of a better quality than that in well AA-Cg 2, having an iron content of only 0.5 part per million, a pH of 7.8, and a hardness of only 78 parts per million.

GROUND WATER FROM THE EOCENE AQUIFERS

Aquia greensand

The dissolved-solids content in 48 analyses of water from the Aquia greensand, ranges from 67 to 300 and averages 189 parts per million. The hardness of the water in 55 samples ranges from 9 to 325 parts per million. The iron content is generally low, but a few water samples were fairly high in iron, the maximum being 16 parts per million. The pH ranged from 5.2 to 8.8 and averaged 7.8. Most of the acid water was from comparatively shallow wells near the outcrop of the formation.

Figure 22 shows that the water, with the exception of one sample from a dug well in the outcrop area in Prince Georges County, belongs in groups 3 and 4; that is, it is high bicarbonate water, generally low in sulfate and chloride, which ranges from high calcic to high sodic types. The phenomenon of base exchange is illustrated by the grouping of the samples from the Aquia greensand. Many of the samples from deep wells in central St. Marys and Calvert Counties plot in group 3 (hard bicarbonate waters). The distribution of the analyses shows a progressive softening of the water, that is, a replacement of the calcium and magnesium ions by sodium and potassium ions in the vicinity of Cobb Island, Leonardtown, St. Marys City, Lexington Park, and Solomons Island. The grouping in the lower left corner of the figure indicates a common source of this soft sodium bicarbonate water. Diagrams such as figure 22 thus afford a means of establishing the source of a water sample where other data that would normally identify the source (depth of the well, position of the well screen, etc.) are not definitive.

The position of the symbol representing a sample of water from the Chesapeake Bay indicates the usefulness of a diagram of this type for identifying mixed or contaminated waters. The normal water of the Aquia greensand is so different from the Bay water that the mixing of even small amounts of Bay water with it would change its character to such an extent that its position on the graph should identify the source.

Nanjemoy and Piney Point formations

The dissolved solids in 19 analyses of water from the Nanjemoy and Piney Point formations range from 163 to 439 and average 231 parts per million. The total hardness ranges from 22 to 239 and averages 93 parts per million. The iron content is generally low, ranging from 0.07 to 3.8 parts per million. The average iron content (0.5 ppm per million) is the lowest of any of the water-bearing strata in Southern Maryland. The pH ranges from 7.7 to 8.3 and aver-

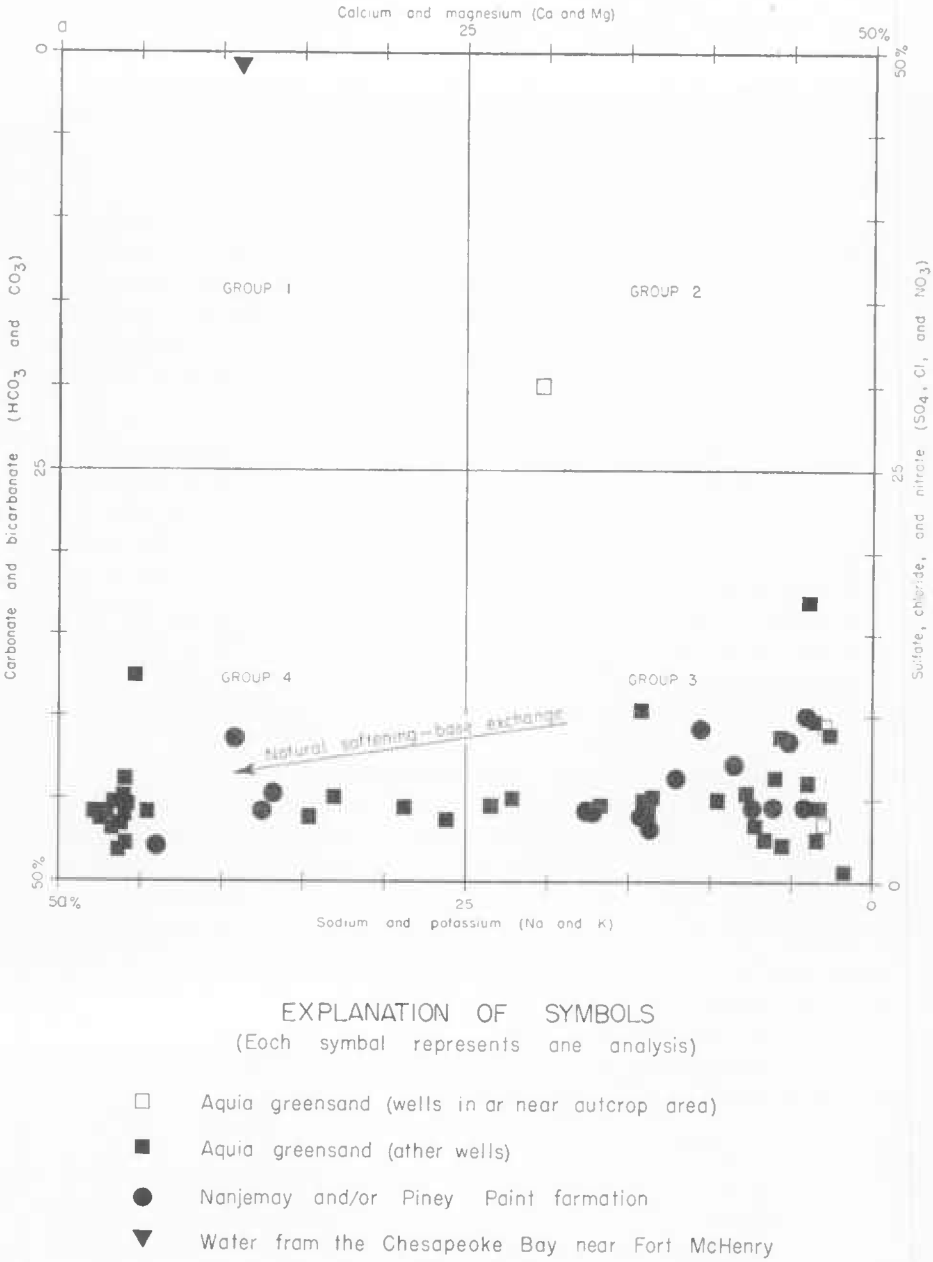


FIG. 22. Chemical character of ground water from the Eocene aquifers shown by the percent reacting values of the ions

ages 8.0. The water from these formations is characterized by a rather high silica content, which averages about 40 parts per million. The high silica content may result from the downward-moving waters passing through the diatomaceous layers in the overlying Calvert formation. In general, water from the Nanjemoy and Piney Point formations is slightly harder and more mineralized than water from the Aquia greensand.

All the analyses plot in groups 3 and 4 (high bicarbonate waters of a calcic or sodic type). Many of the analyses in figure 22 are clustered in the lower right corner of group 3, showing the general hard character of the water. A few analyses trend to the left part of the diagram and four analyses plot in group 4, indicating that base exchange has occurred. Most of the high sodic bicarbonate waters are from wells located in the extreme southern tip of St. Marys County in the vicinity of Point No Point and St. Jerome Neck.

GROUND WATER FROM THE PLIOCENE(?), PLEISTOCENE, AND RECENT AQUIFERS

Upland deposits

Dissolved solids in 19 analyses of water from the upland deposits range from 31 to 265 and average 98 parts per million. The hardness in 20 analyses ranges from 9 to 146 and averages 46 parts per million. The iron content in 19 analyses ranges from 0.02 to 6.8 parts per million and averages 1 part per million. In many wells where the upland deposits overlie strata of Late Cretaceous age, the iron content of the water is considerably lower than that of water from the Cretaceous strata. The pH ranges from 5.1 to 7.4 and averages 6.4. Some ground water from the upland deposits is high in nitrate content, doubtless chiefly because of contamination by surface drainage through improperly sealed dug wells.

Analyses of the water from the upland deposits are widely scattered through groups 1, 2, and 3. Nine analyses fall in group 3, indicating that these samples are of the calcium bicarbonate type. The other analyses fall in groups 1 and 2, indicating water characterized by an excess of sulfate, chloride, and nitrate over bicarbonate. One of these samples, a sodic chloride water, is from well St.M-Bb 1, a dug well near Newmarket in St. Marys County. The other two in group 1 are from wells that may be contaminated by surface drainage. Normally, high sodium nitrate or chloride content is not encountered in uncontaminated water in the upland deposits.

Lowland deposits

The dissolved solids in 8 samples of water from the lowland deposits range from 78 to 587 and average 225 parts per million. The hardness in 12 analyses ranges from 15 to 403 and averages 93 parts per million. The iron content varies from 0.1 to 34 parts per million and averages more than 3 parts per million. The pH of 12 samples ranges from 5.0 to 7.8 and averages 6.3. In some localities the water from the lowland deposits is reported to be brown and to have a "marshy" or organic taste. Decomposition of organic material buried in the estuarine valley flats is probably the cause of this taste. No samples of such water were analyzed.

The five analyses of water from the lowland deposits (fig. 23) show that the water varies in chemical character, though three of the five fall in groups 1 and 2. The analysis in group 4 is of water from well St.M-Ec 10, 130 feet deep, in the Protestant Point section of St. Marys County. The well is not screened and may end in the underlying Piney Point formation, but the driller's log indicates that the water is chiefly from the basal gravel of the lowland deposits.

The number of analyses is insufficient to show adequately the character of the water from the lowland deposits.

GEOCHEMISTRY IN RELATION TO MOVEMENT

To understand the principles governing the chemistry of ground water in a coastal-plain region of artesian circulation one must have knowledge not only of the chemical reactions involving the water and the rock minerals (and the reactions between different types of water), but also of the subsurface geology and of the pattern of circulation, or movement, of the ground water. Many of the misconceptions regarding the geochemical relations of ground water in an artesian area are due to inadequate data concerning the movement of ground water through the aquifers and the so-called confining beds. It seems reasonable, therefore, to base a study of geochemical relations on three elemental prerequisites. They are: (1) a large number of complete chemical analyses of water from wells or springs whose geologic source is known; (2) detailed knowledge of the geology of the area, particularly the subsurface, so that individual water-bearing strata and the less permeable beds separating them may be traced from well to well across distances measured in miles; (3) and the basic pattern of ground-water movement. Available information on the geology and hydrology of Southern Maryland satisfies reasonably well these three requirements. Plates 11, 12, and 13 show the distribution of hardness and iron content within some of the aquifers, and figures 21, 22, and 23 show the types of water in the aquifers. Plate 14 shows the types of water in vertical sections across Southern Maryland, traces the important aquifers across the area, and relates, through the superjacent bar diagrams showing the percent reacting values, the type of water with the aquifer from which it is derived. Sampling an aquifer at several places downdip, reveals progressive downdip changes in the chemical character of the water. Thus in section B-B′ (Pl. 14) well Ch-Df 9 near Newport yields water from the Aquia greensand in which only partial softening has taken place (sodium plus potassium reacting value equals 23.3 percent). Water from

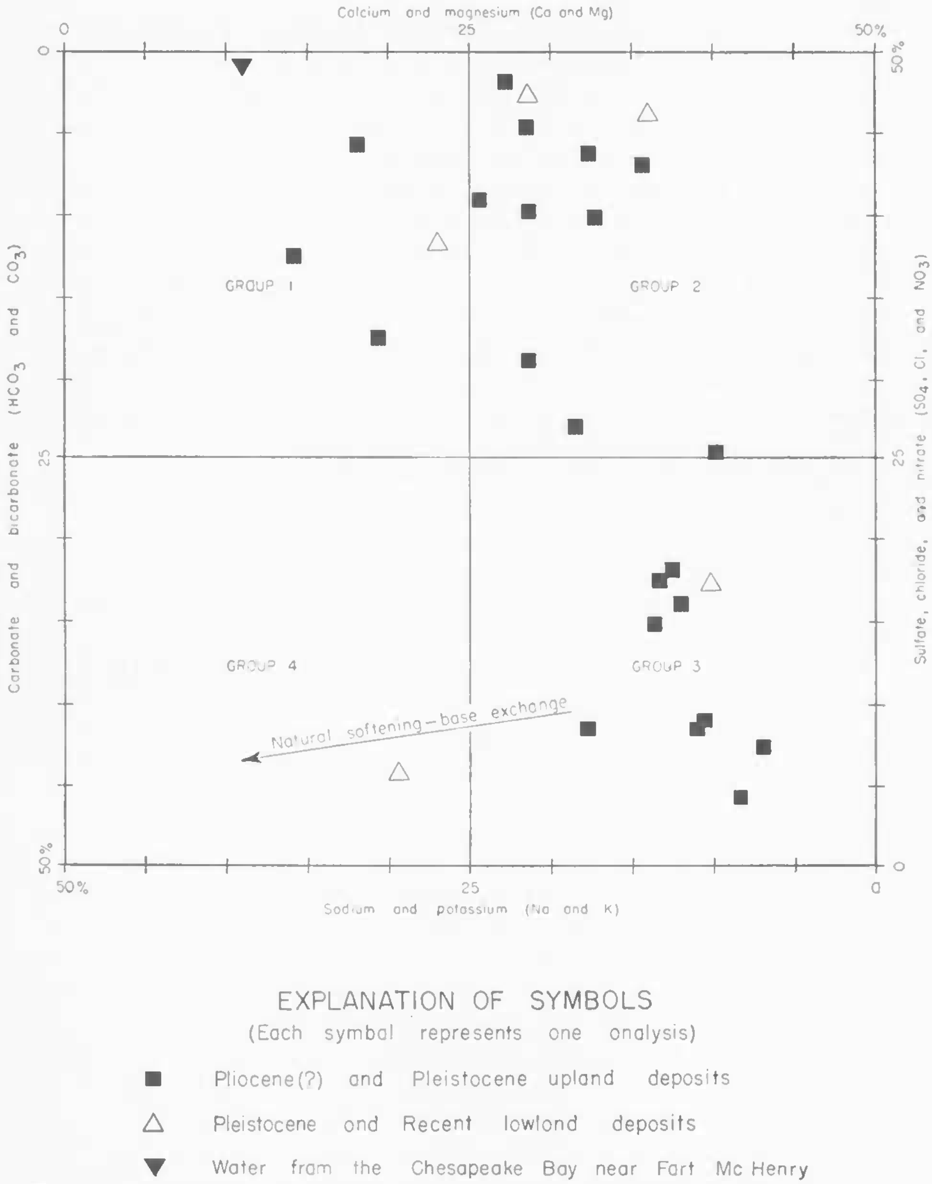


FIG. 23. Chemical character of ground water from the Pliocene(?) Pleistocene and Recent aquifers shown by the percent reacting values of the ions

well St.M-Cb 1 at Chaptico, some 8 miles downdip, is less hard (sodium plus potassium reacting value equals 33.0 percent). Continued downdip softening of water from the Aquia greensand is shown by the water from well St.M-Fe 1 at Piney Point (here the sodium plus potassium reacting value equals 47.2 percent). At Piney Point most of the calcium and magnesium ions in the water have been exchanged for sodium and potassium.

In Southern Maryland the movement of ground water is best known in the Aquia greensand, from which aquifer a large number of complete chemical analyses are available. Since most of the recharge to the greensand occurs in the topographically high central upland area of northern Charles, southern Prince Georges, and northern Calvert Counties, chiefly by leakage through the overlying formations (Pl. 9), water from the Aquia greensand in this upland recharge area (roughly the area lying above the +30-foot contour on Plate 9) should be of a chemical character more nearly like the water from the immediately overlying Nanjemoy and Calvert formations. Unfortunately, no analyses are available from either formation within the main recharge area of the Aquia greensand, as the Nanjemoy is too clayey to constitute a usable aquifer here and the Miocene formations, the Calvert and Choptank, are not water bearing. The surficial Pleistocene deposits, therefore, are the only shallower aquifer from which water analyses are available for comparison with those from the Aquia greensand.

The water from the upland deposits, especially in the Waldorf-La Plata-Brandywine area, is typically a calcium bicarbonate water, relatively low in dissolved solids, in which little or no base exchange has taken place. Water from wells PG-Ge 10 (30 feet deep), PG-Fd 16 (22 feet deep), Ch-Cd 10 (20 feet deep), and Ch-Ce 14 (23.5 feet deep) is normal calcium bicarbonate water from the upland deposits. Moving downward into and through the Calvert and Choptank formations, the normal calcium bicarbonate water commonly increases in hardness and in calcium and magnesium content as a result of contact with the calcareous layers in the Miocene beds. As the water moves into the glauconite-rich but also calcareous Eocene formations, any tendency toward an increasing content of calcium bicarbonate is balanced by the base-exchange properties of the glauconite in the Nanjemoy and Aquia formations. As these formations are composed in part of shell layers rich in calcium carbonate, the softening action of the greensand may be balanced or modified by the tendency of the water to dissolve more calcium carbonate from the shells and thus increase in hardness. With continued vertical and lateral movement through beds containing an abundance of base-exchange minerals and little or no calcareous material, the water becomes progressively softer. This is illustrated by comparing Plate 13, showing the distribution of water of varying degrees of hardness within the Aquia greensand with Plate 9, showing the distribution of artesian pressure. The shaded area on Plate 13 (hardness of more than 60 parts per million) roughly coincides with the area of high artesian head, or the intake area of the aquifer on Plate 9. Thus, the intake area of the aquifer is also the area of hardest water, derived chiefly from vertical percolation through the overlying calcareous layers.

A number of wells near Popes Creek, Cobb Island, St. Clement Shores, and Leonardtown, along the north bank of the Potomac River, yield water from the Aquia greensand that is characteristically soft and of the sodium bicarbonate type (Pl. 13 and fig. 24). The soft-water localities are in the area of low artesian head, generally less than 10 feet above sea level, shown on Plate 9 except along the northern part of Calvert County on the Chesapeake Bay, where the hardness of water from the Aquia greensand does not decrease in the direction of decreasing artesian head (flowing wells at North Beach yield moderately hard calcium bicarbonate water). There is no obvious explanation for this exception.

There is evidence to indicate that the clays in some of the Cretaceous strata function more effectively as base-exchange agents than does the greensand of the Eocene strata. Plate 14 shows that the water from the Patuxent formation at Indian Head (in wells Ch-Bb 8 and Ch-Bc 3) is a soft sodium bicarbonate water of a mildly alkaline character. The Patapsco formation yields water of a similar character farther east in Charles County near Ripley and at La Plata (wells Ch-Cc 5 and Ch-Ce 3). In fact, the ground water from the Patapsco formation in central Charles County is softer (lower in calcium and magnesium content) than the water from the Aquia greensand in parts of eastern Charles and northern St. Marys Counties (compare the analyses of samples from wells Ch-Ce 3 and Ch-Dd 10 with those from Ch-Df 9 and St.M-Bb 4).

Temperature of Ground Water

An important and useful property of ground water is its relatively constant temperature throughout the year. For this reason ground water is increasingly in demand in Southern Maryland for industrial process cooling and for air conditioning. The temperature of ground water at depths of less than 25 feet may vary a few degrees from winter to summer, but water in the deeper artesian aquifers remains at a nearly constant temperature throughout the year. Ground-water temperatures measured in 100 wells in Southern Maryland range from 47.5°F to 65.5°F and average about 58.2°F.

The coolest water (47.5°F) was in a 110-foot drilled well, which ends in the Patuxent formation near Beltsville, in northern Prince Georges County. The reason for the relatively low temperature encountered in this well is not known.

The warmest water (65.5°F) was measured in a 493-foot well (Cal-Gd 6) ending in the Aquia greensand at the State Conservation Center near Solomons Island. The water from a nearby well (St.M-Df 14) ending in the Nanjemoy and Piney Point formations at the Patuxent Naval Air Station was reported to

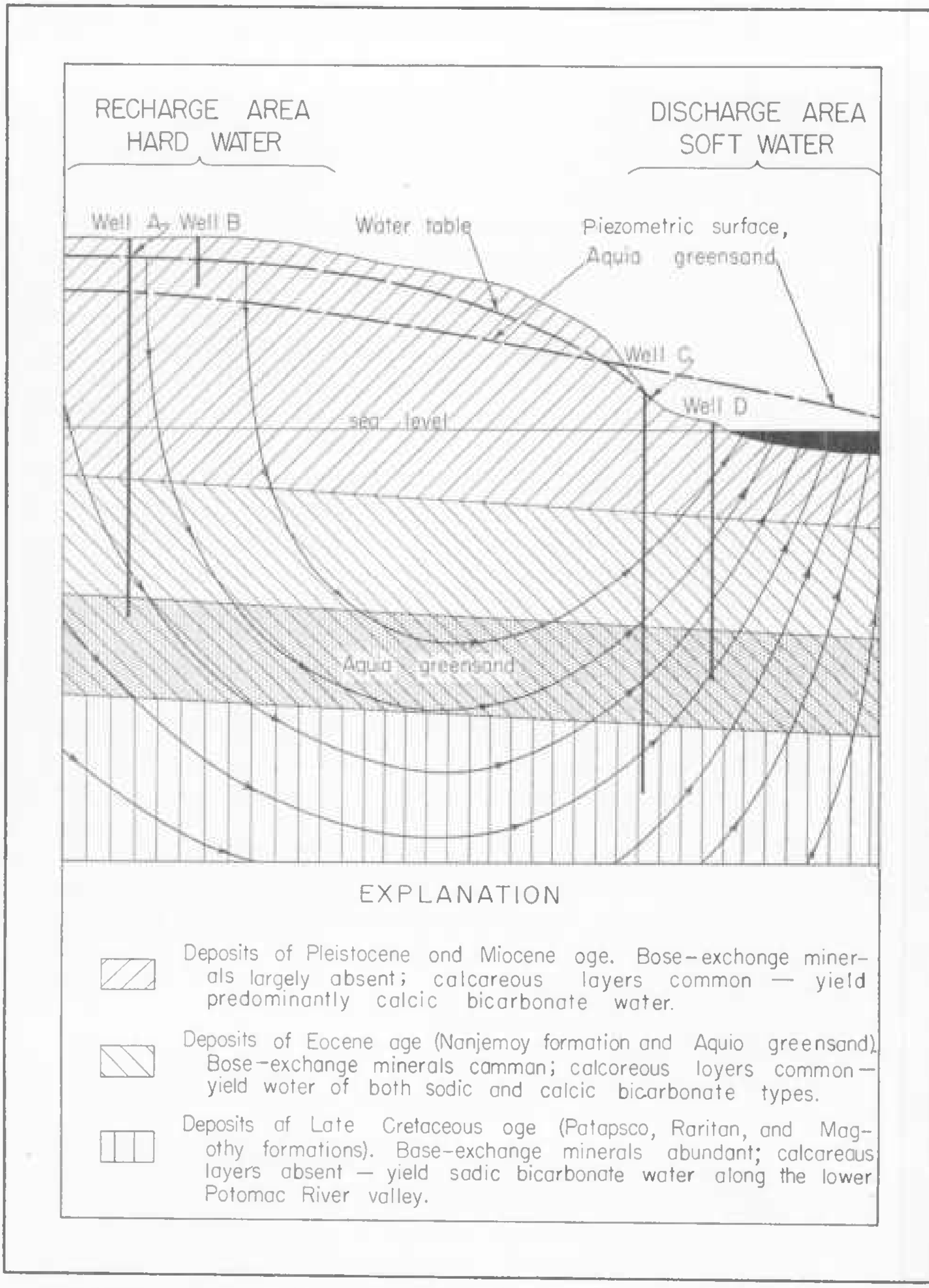


FIG. 24. Geologic section showing movement of ground water and distribution of hard and soft water in the Aquia greensand (and in other aquifers) along the lower Potomac River valley (direction of movement of ground water shown by arrows)

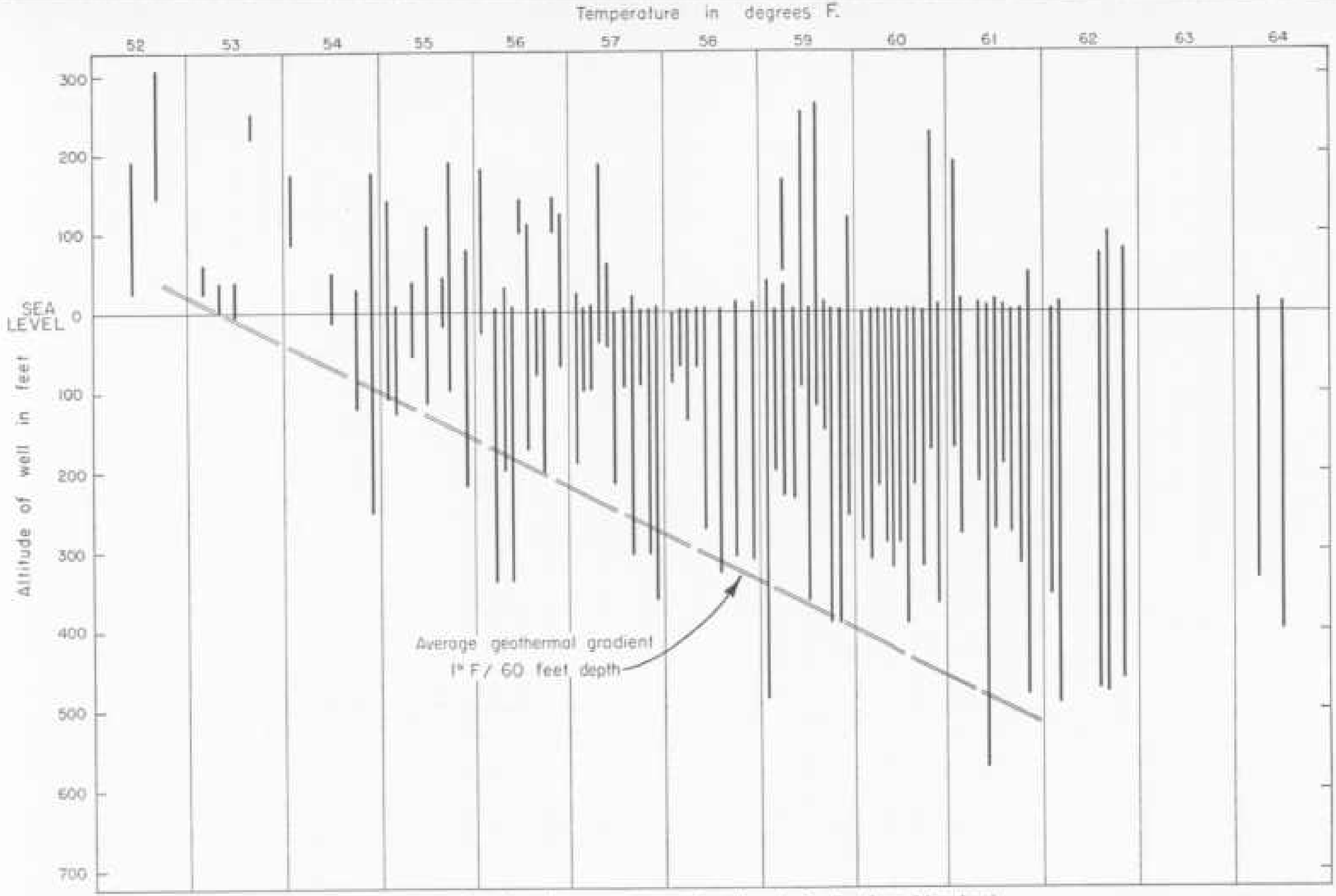


FIG. 25. Diagram showing the temperature of well water in Southern Maryland

have a temperature of 65°F. Generally, the reported temperatures of the deep artesian wells in southern Calvert and St. Marys Counties range from 60° to 65°F. The average temperature of water from 25 wells in St. Marys County was 60.4°F.

The temperature of ground water rises with increasing depth in the earth's crust, in conformity with the geothermal gradient. The temperature of the earth usually rises 1°F for each 60 to 90 feet of depth. The geothermal gradient in Southern Maryland is shown on figure 25, in which the position of a well in which the water temperature was measured with reference to sea level is shown by a vertical bar. Wells with extremes of water temperature are not shown. The coolest waters (52° to 53°F) were from both drilled and dug wells that terminate at elevations above sea level; most of these wells are in northern Prince Georges County.

Summary of Ground Water Resources

Southern Maryland may be divided arbitrarily into the four economic and geologic units of unequal area shown in figure 26.

AREA 1

Area 1 comprises the northern half of Anne Arundel County extending south to U. S. Route 50 and west from Annapolis to Priest Bridge on the Patuxent River. The area is underlain chiefly by formations of Early and Late Cretaceous age, which contain several thick and permeable water-bearing beds. The Patuxent, Patapsco, Raritan, and Magothy formations yielded an estimated 6 million gallons of ground water daily during 1951 to industrial, military, and public-supply users. The Cretaceous formations attain a thickness of more than 1,000 feet in the vicinity of Annapolis and are capable of yielding more than 1,000 gallons a minute to properly constructed wells. The common range in yield of the large-capacity wells in the Cretaceous strata is from 100 to 400 gallons a minute.

Pumping of about 1 million gallons a day from the Patapsco formation during 1951 and 1952 from well fields at Odenton and Glen Burnie has not resulted in noticeable depletion of the ground-water reservoirs or in an extensive decline in the artesian head in the vicinity of the pumping. The existing pumpage is not, therefore, in excess of the perennial or "safe" yield of the aquifer. Pumping of about 1 million gallons daily during 1951 from the well field of the city of Annapolis near Broad Creek has resulted in no extensive decline in artesian head in the Magothy formation in the vicinity of the pumping, so that the limit of safe withdrawal of ground water from this aquifer in the Annapolis area has not been exceeded. In view of the relatively high yields obtainable from the Cretaceous water-bearing sands and because of their wide distribution and extent in Area 1, the potential ground-water resources of the area are

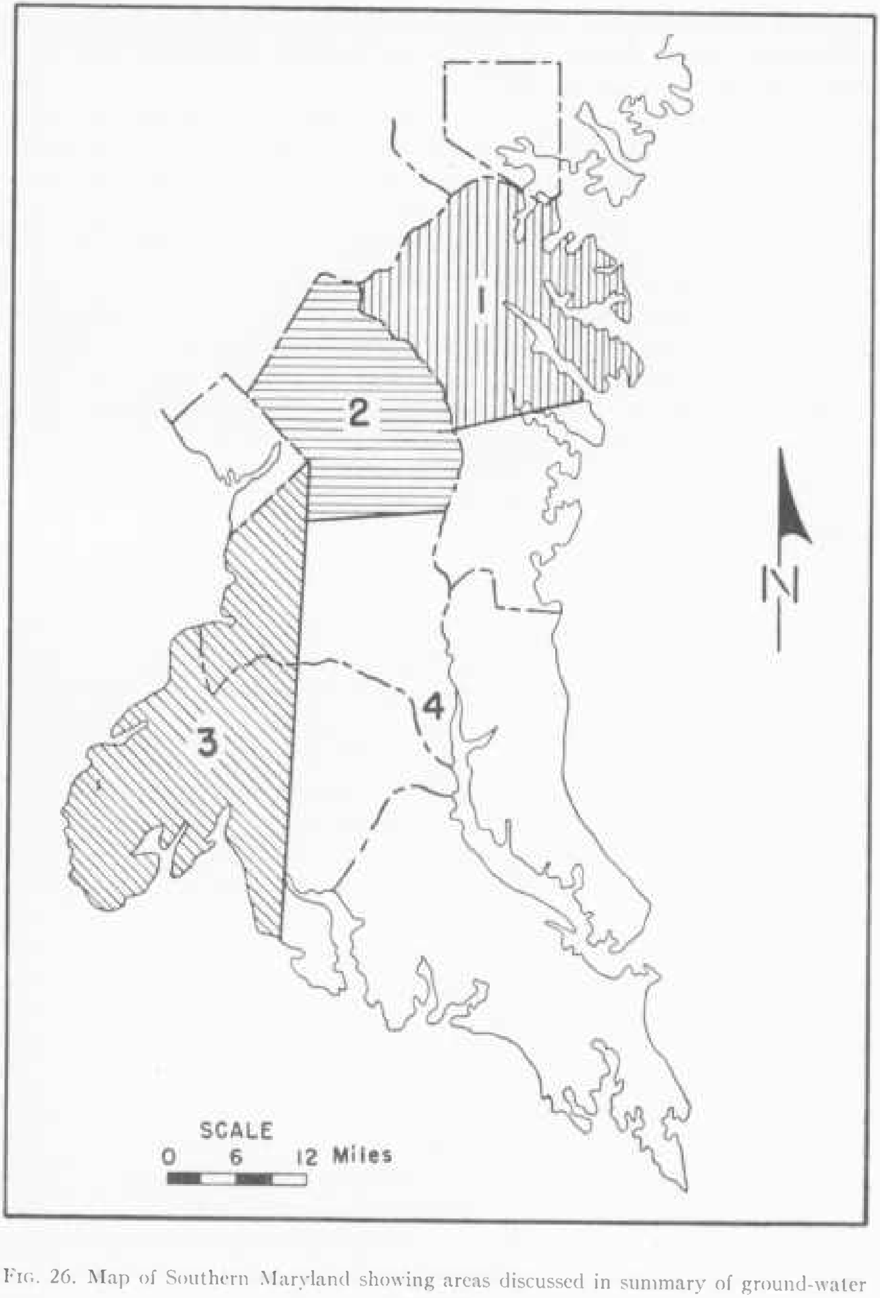


FIG. 26. Map of Southern Maryland showing areas discussed in summary of ground-water resources

greatly in excess of existing demands. It is likely that 10 or 20 times as much ground water can be economically withdrawn from the several aquifers, if care be given to the proper spacing and development of well fields. In several of the areas of moderately heavy pumping, relatively untapped water-bearing sands lie above and below those now being extensively pumped. Thus, in the Odenton area the Patuxent formation has not even been penetrated by test wells, and at least two lightly pumped water-bearing sands lie above the heavily pumped sand in the Patapsco formation (it yielded about 1 million gallons a day in 1951 with only slight declines in water levels in the area).

Future development of ground water from the Cretaceous sands in Area 1 must be based on the understanding that the quality of the water is variable, and that in the southeastern part of the area the acidity and the high iron content (more than 30 parts per million in some wells) may require treatment of the water for most uses. Although the iron content can be reduced to make the water satisfactory for most purposes, the cost of treatment must be evaluated when comparing this ground-water source with an alternative source of water.

AREA 2

Area 2 comprises the heavily populated northern half of Prince Georges County adjacent to the District of Columbia. It is underlain chiefly by Cretaceous strata, which attain a thickness of about 950 feet near Glenn Dale. As much of Area 2 is supplied by the surface-water system of the Washington Suburban Sanitary District, the consumption of ground water is not extremely heavy. In 1951 the total consumption for public-supply, industrial, and military purposes was estimated to be 700,000 to 1,000,000 gallons daily, most of which was obtained from water-bearing sands in the Patuxent formation. Adding 2 million gallons a day of estimated domestic pumpage brings the total to 3 million gallons a day.

Test drilling into and through the Patapsco and Raritan formations near Glenn Dale and at adjacent localities in Area 2 indicates that the water-bearing sands in these formations thin, disappear, or become less permeable west of the Patuxent River. Area 2 is less favorable for the development of large additional supplies of ground water than Area 1; nevertheless, it is likely that with judicious planning and spacing of wells additional well fields could be economically developed in the area which would supply from 5 to 10 times the amount of ground water in current daily use (15 to 30 million gallons additional).

The water in Area 2 is commonly slightly acidic and of variable iron content. In some wells the total iron content is in excess of 10 parts per million and treatment for iron removal would be required for most uses. Soft water is commonly encountered in the area north of Seat Pleasant and Hall, but to the south some of the Upper Cretaceous aquifers yield water having a hardness of more than

170 parts per million. However, the harder water, mainly from the Magothy formation, commonly is mildly alkaline and has a lower iron content than is characteristic of water from the Cretaceous sands a few miles farther north.

AREA 3

Area 3 comprises the Maryland side of the lower Potomac River valley south of the District of Columbia as far as Popes Creek. It includes southwestern Prince Georges County and the western half of Charles County. The surficial Pliocene(?) and Pleistocene deposits are underlain by a few feet to a few hundred feet of strata of Eocene and Miocene age which apparently do not yield water to drilled wells. Most of the existing ground-water supplies, other than supplies from the dug wells, are derived from wells tapping sands of Cretaceous age. As the area is chiefly rural and the demand for water limited, large ground-water supplies have been developed at only a few localities, such as Indian Head, Forest Heights, and La Plata. The total ground-water pumpage for municipal, industrial, and military purposes in 1951 was from 1½ million to 1¾ million gallons daily, of which about 1 million gallons was pumped by the Naval Powder Factory at Indian Head. Probably an additional 2 million gallons of water was pumped daily from domestic and rural wells. Thus, the total daily pumpage in Area 3 was about 3½ million gallons.

A few drilled wells in the area yield as much as 450 gallons a minute, but most wells yield less than 100 gallons a minute. North of Pomonkey the strata are very clayey, averaging, in the Oxon Hill and Fort Washington areas, more than 90 percent clay and less than 10 percent water-bearing sand.

Although the Aquia greensand and the Nanjemoy formations are present at relatively shallow depths throughout a large part of Area 3, they consist largely of relatively impermeable sandy clay and clayey sand. However, in the Port Tobacco area of Charles County, the Aquia greensand is sufficiently permeable to yield moderate domestic supplies to drilled wells. Much of Area 3 is covered by a veneer of 20 to 40 feet of Pliocene(?) and Pleistocene sand and gravel which are not capable of furnishing large quantities of ground water to wells, because the volume of ground water in storage fluctuates widely during the year and in many localities only a few feet of these deposits lie within the zone of saturation.

Most of the existing large ground-water supplies are derived from the Cretaceous formations, which range in thickness in the area from 600 to about 1,500 feet, and which contain several water-bearing sands. The deeper sands have been explored in only a few localities, as at Indian Head, La Plata, and Forest Heights. As the complete thickness of sedimentary rocks has been penetrated only at Indian Head, the thickness, extent, and reservoir characteristics of the water-bearing sands through most of the area are not known. Additional ground-water supplies must be developed chiefly from water-bearing sands of

Cretaceous age, which lie at increasingly greater depths eastward from the Potomac River. At Indian Head the top of the strata of Cretaceous age are a few feet above sea level and at La Plata they are about 220 feet below sea level.

It is estimated that an additional 17 million to 35 million gallons of water can be withdrawn daily from the ground-water reservoirs in Area 3 without serious decline in water levels within the aquifers if the wells or well fields are properly spaced and designed for maximum efficiency.

The quality of the water in Area 3 is generally good. Much of the water is soft and of mildly alkaline sodium bicarbonate type, which can be used for most purposes without treatment. The iron content of much of the water is less than 1 part per million, although in a few samples it ranges up to more than 5 parts.

AREA 4

Area 4, comprising southern Anne Arundel, southern Prince Georges, eastern Charles, and all of Calvert and St. Marys Counties, includes about half the area of Southern Maryland.

The surficial rocks consist largely of Pliocene(?) and Pleistocene sands and gravels, which furnish adequate water supplies for many of the rural residents. Although many domestic jetted and drilled wells tap the Nanjemoy formation and the Aquia greensand in the tidewater localities, the demand for large ground-water supplies is confined essentially to the naval installations in the vicinity of Cedar Point, Solomons Island, and Piney Point. The ground-water pumpage for all municipal, military, and industrial uses amounted to about 2.3 million gallons a day in 1951, most of which was from Eocene strata at the Naval Air Station. Adding 2.7 million gallons of domestic pumpage to the municipal and military pumpage gives a total consumption of 5 million gallons daily.

The Cretaceous water-bearing strata lie at relatively great depths in most of Area 4, and, except for two deep wells that probably tap Upper Cretaceous sands at Point Lookout and St. Marys City, and some wells that tap the Magothy formation near Upper Marlboro, Cheltenham, Mount Zion, and Sunderland, they have not been explored. The thickness, extent, and reservoir characteristics of the water-bearing sands are largely unknown. Therefore, the potential ground-water resources of Area 4 can be evaluated only roughly. Of the estimated 3,000 feet of sedimentary strata at Solomons Island, only about 600 feet, or one-fifth of the sedimentary column, has been penetrated by wells and tapped as a source of ground water. The remaining 2,400 feet consists chiefly of Upper and Lower Cretaceous formations that yield abundant ground-water supplies where they have been tapped nearer their outcrop. Probably several millions of gallons a day could be developed economically from the deeper Cretaceous aquifers in Area 4, but definite conclusions regarding the water-yielding potential of these deposits must await additional test drilling and exploration.

Of the shallower and younger formations, only the upland deposits, the Nanjemoy and Piney Point formations, and the Aquia greensand are regarded as important aquifers.

Although serving as a source of supply for numerous dug wells, the surficial Pliocene(?) and Pleistocene sands and gravels are not regarded as a dependable source of large ground-water supplies, because the greater part of the deposits, in many localities, lies above the zone of saturation. Where only 5 or 10 feet of water-saturated gravel is present, the drawdown available for pumping from wells is very limited. Furthermore, the volume of ground water stored in the shallow reservoirs fluctuates widely because of seasonal and annual changes in the rate and amount of precipitation.

Although widely used in Area 4 as a source of domestic supply for jetted and drilled wells, the Nanjemoy and Piney Point formations, because of their comparatively low transmissibility and because of their relative impermeability west of central St. Marys and Calvert Counties, are not considered capable of furnishing ground-water supplies of several million gallons daily.

Additional large ground-water supplies in Area 4 must come, therefore, from the Aquia greensand or the underlying Cretaceous formations. Although pumped heavily in the Solomons Island area, the Aquia is an extensive untapped reservoir throughout a large part of Area 4. The drilling of additional wells and the development of new well fields in the Aquia greensand, however, should be preceded by additional studies and analysis of existing data in order that the wells (or well fields) may be so spaced as to permit the most efficient withdrawal of water from the aquifer. It is probable that the Aquia greensand alone will supply several million additional gallons of water daily in Area 4. The total amount of ground water that may be economically withdrawn from all aquifers in Area 4 is probably 5 to 10 times the present daily consumption (or 25 to 50 million gallons).

The quality of water from the aquifers tapped at present is generally good, although locally the water has a fairly high iron content. The dissolved-solids content is generally less than 400 parts per million. The hardness of the water in the deeper Eocene and Upper Cretaceous sands ranges from less than 10 parts per million in St. Marys County near Cedar Point to more than 170 parts per million in Prince Georges County near Upper Marlboro and Cheltenham. Both sodium and calcium bicarbonate types of water are found in the area. In the southern part of Area 4 very little is known of the chemical character of the deeper water-bearing sands of Cretaceous age. In the Solomons Island-Cedar Point area, below depths of about 1,000 feet, ground water containing more than 250 parts per million of chloride may be encountered.

The preceding estimates of potential production in the four areas add up to the order of 100 to 200 million gallons per day. This is not a large amount, considering the area of Southern Maryland (nearly 2,000 square miles), the precipitation (more than 40 inches), and the generally favorable geologic conditions for the occurrence of ground water. More detailed studies might warrant increasing the estimate of total potential yield.

Foraminiferal Fauna of the Geological Formations

by Glenn G. Collins

The age determinations and correlations of the Foraminifera in the well logs are based upon a study of the contained foraminiferal fauna in the cuttings from 19 wells in the Southern Maryland Coastal Plain. Table 35 shows the stratigraphic range and relative abundance of the identified species and their depth range in the wells in which they were found in the cuttings. The lithologic logs of these 19 wells or references to them in the published county reports are given in Tables 33 and 34. Illustrations and descriptions or references to descriptions of nearly all of the species of Foraminifera listed in Table 35 may be found in Bulletin 2 (Tertiary and Cretaceous Subsurface Geology of the Eastern Shore) and Bulletin 3 (Eocene Stratigraphy and Aquia Foraminifera) of the Department of Geology, Mines and Water Resources.

The Pleistocene series is fossiliferous in only one well, Cal-Fe 2, in Calvert County at Cove Point, in which yellowish-gray clayey sand extends to a depth of 65 feet. Foraminifera in this interval are the following:

Elphidium discoidale (d'Orbigny)
Elphidium insertum (Williamson)
Elphidium insertum clavatum Cushman
Rotalia beccarii (Linné), var. *parkinsoniana* Cushman and Cole

At least one formation of the Miocene series is present in all the wells. The Calvert formation is the most widespread, attaining the greatest thickness of around 190 feet in wells Cal-Ed 6 and St.M-Fh 3. Some of the characteristic Foraminifera in the Calvert formation are:

Spiroplectammina mississippiensis (Cushman)
Spiroplectammina spinosa Dorsey
Textularia cf. *T. foliacea* Heron-Allen and Earland
Robulus americanus (Cushman)
Robulus americanus spinosus (Cushman)
Planularia vaughani (Cushman)
Guttulina austriaca d'Orbigny
Guttulina rectiornata Dorsey
Guttulina elegans Dorsey
Pseudopolymorphina rutila (Cushman)
Siphogenerina lamellata Cushman
Siphogenerina spinosa (Bagg)
Bolivina calvertensis Dorsey
Uvigerina kernensis Barbat and von Estorff
Discorbis valvulata (d'Orbigny)
Valvulineria floridana Cushman
Cassidulina crassa d'Orbigny

The overlying Choptank formation is present in Calvert and St. Marys Counties but is not more than 60 feet thick. Some of the characteristic Foraminifera in the Choptank formation are:

Textularia consecta d'Orbigny
Textularia ultima-inflata Dorsey
Massilina glutinosa Cushman and Cahill
Massilina quodrans Cushman and Ponton
Triloculina cf. *T. trigonula* (Lamarck)
Uvigerina carmeloensis Cushman and Kleinpell
Discorbis warreni Dorsey
Cibicidella variabilis (d'Orbigny)

The St. Marys formation is found in two wells in St. Marys County; its maximum thickness is 90 feet in well St.M-Fh 3, one mile southeast of Point No Point. Some of the characteristic Foraminifera in the St. Marys formation are:

Massilina monsfieldi Cushman and Cahill
Textularia obliqua Dorsey
Cassidulina laevigata d'Orbigny, var. *carinata* Cushman
Pyrgo subsphaerica (d'Orbigny)

The Eocene Piney Point formation is present in Calvert and St. Marys Counties, and on Cobb Island in southeast Charles County where it may be as much as 21 feet thick. The formation attains a thickness of 50 feet in the type-locality well, St.M.-Fe 24, at Piney Point in St. Marys County. Foraminifera are more common in the St. Marys County wells than in the two wells, Cal-Fe 2 and Cal-Ed 6, in Calvert County. Some of the Foraminifera in this formation are:

Robulus olato-limbotus (Gümbel)
Robulus gutticostatus (Gümbel)
Plectofrondicularia cookei Cushman
Valvulineria jocksonensis Cushman
Asterigerino sp.
Cibicides cocoaensis (Cushman)
Cibicides lobatulus (Walker and Jacob)

Other wells penetrating the formation add the following important species to the fauna:

Quinqueloculina longirostro d'Orbigny
Marginulina cocooensis Cushman
Dentalina cooperensis Cushman
Sigmomorphino jacksonensis (Cushman)
Bolivina jacksonensis Cushman and Applin
Uvigerina dumblei Cushman and Applin
Siphonina jocksonensis (Cushman)

The Nanjemoy formation of Claiborne and Wilcox age is present in all the wells. The base is marked by the Marlboro clay member in which Foraminifera are absent on outcrop and probably in the subsurface, as the Foraminifera found in this member in the well samples are probably due to contamination from above. Foraminifera are generally scarce or absent in the Nanjemoy formation and when present are usually small and poorly preserved. The same species are found also in the Aquia greensand.

The Aquia greensand of Wilcox age is present in the subsurface in all the counties, but not all the wells penetrated deep enough to encounter the greensand. Wells St.M-Fh 3, Cal-Fe 2, and Cal-Ed 6 end in the Nanjemoy formation. Two substages of the Aquia greensand are recognized paleontologically, the lower or Piscataway and the upper or Paspotansa. These substages were found in the subsurface in all the Southern Maryland counties but in Calvert and St. Marys Counties are not well differentiated. Foraminifera are scarce or rare in the Paspotansa substage but are common in the Piscataway substage and include the following species:

Spiroplectammina wilcoxensis Cushman and Ponton
Robulus midwayensis (Plummer), var. *virginianus* Shifflett
Robulus wilcoxensis Cushman and Ponton
Dentalina virginiana Cushman
Dentalina wilcoxensis Cushman
Guttulina irregularis (d'Orbigny)
Guttulina problema d'Orbigny
Sigmomorphina semitecta (Reuss)
Gümbelina wilcoxensis Cushman and Ponton
Entosolenia laevigata (Reuss)
Entosolenia marginata (Walker and Jacob)
Entosolenia oslatus Shifflett
Virgulina wilcoxensis Cushman and Ponton
Angulogerina parvula (Cushman and Thomas)
Angulogerina virginiana Cushman
Discorbis amicus Shifflett
Discorbis assulata Cushman
Valvulineria scrobiculata (Schwager)
Valvulineria wilcoxensis Cushman and Ponton
Eponides labiomargus Shifflett
Ceratobulimina wilcoxensis (Cushman)
Alabamina wilcoxensis Toulmin
Anomalina umbonifera (Schwager)
Cibicides howelli Toulmin
Cibicides marylandicus Shifflett
Cibicides neelyi Jennings

The Paleocene Brightseat formation is found in two of the three wells in Prince Georges County, wells PG-Ed 4 and PG-Ed 8. The Foraminifera are fairly common (in well PG-Ed 4) to abundant (in well PG-Ed 8). The fauna is particularly marked by an abundance of specimens of large species of the genus *Robulus*. The fauna is distinct from that of the overlying Eocene Aquia or underlying Cretaceous Monmouth and includes the following species:

Robulus sp.
Robulus midwayensis (Plummer)
Robulus midwayensis carinatus (Plummer)
Robulus cf. *R. piluliferus* Cushman
Dentalina colei Cushman and Dusenbury
Dentalina plummerae Cushman
Pseudoglandulina pygmaea (Reuss)
Polymorphina cushmani Plummer
Pseudouvigerina naheolensis Cushman and Todd
Gyroidina subangulata (Plummer)
Eponides elevatus (Plummer)
Ceratobulimina perplexa (Plummer)
Anomalina midwayensis (Plummer)
Cibicides reprimatus Cushman and Bermudez

Foraminifera are present, though rather rare, in the Upper Cretaceous sediments of the Monmouth formation in the wells of Prince Georges County. The maximum thickness of the formation is about 40 feet. The distinctive Foraminifera are *Anomalina navarroensis* Plummer and *Lamarckina* sp.

In Anne Arundel County Upper Cretaceous deposits underlie the Eocene Aquia formation, but Foraminifera were not found in the well samples studied.

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TABLE 31

Chemical analyses of ground water in Southern Maryland

(In parts per million, except pH and specific conductance)

[Analyst: A, U. S. Geological Survey; B, Maryland State Health Department; C, Penniman & Browne, Inc.; D, Permutit Co.; E, Wiley & Co.; F, C. S. Walton Co.; G, The Duro Co.]

Well	Water-bearing formation	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Phosphate (PO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Manganese (Mn)	Aluminum (Al)	Hardness as $CaCO_3$	pH	Specific conductance (Micromhos at 25°C)	Analyst
AA-Ac 8	Patuxent	Nov. 24, 1945	52	1.0	1.2	1.1	Trace	—	—	—	—	—	4.0	—	0.0	—	—	20	6.0	—	E
Ac 21	do	Mar. 31, 1952	48	10	3.7	1.8	1.1	2.6	1.0	36	5.5	—	3.9	0.0	.2	0.04	3.9	9.0	6.4	73	A
Ad 1	Patapsco	June 21, 1943	—	—	—	—	—	—	—	4	1.0	—	2.8	—	5.6	—	—	10	6.7	—	A
do	do	Apr. 1, 1946	25	6.3	.28	1.6	.8	2.1	.5	2	1.0	—	2.9	.0	6.0	—	—	7.3	5.2	31	A
Ad 2	do	July 30, 1941	—	.7	.04	1.2	.3	—	—	—	—	—	—	—	.0	—	—	2.0	5.1	—	B
do	do	June 21, 1943	—	—	—	—	—	—	—	4	1.0	—	3.5	—	8.6	—	—	16	6.0	40	A
Ad 3	do	June 21, 1943	—	—	—	—	—	—	—	6	1.0	—	5.5	—	10	—	—	18	6.9	53	A
do	do	Apr. 1, 1946	42	6.4	.09	3.3	1.3	4.1	.7	4	1.2	—	6.1	.1	12	—	—	14	5.1	57	A
Ad 4	do	Aug. 19, 1943	—	—	—	—	—	—	—	6	1.0	—	5.0	—	8.4	—	—	18	6.8	44	A
do	do	Apr. 6, 1945	34	—	—	—	—	—	—	—	—	—	28	—	—	—	—	7.2	4.5	—	F
Ad 5	do	Aug. 2, 1943	—	—	—	—	—	—	—	6	1.0	—	13	—	4.2	—	—	18	6.4	—	A
do	do	June 15, 1945	36	7.7	.04	2.2	.9	3.5	1.0	6	.6	—	5.5	.0	5.8	—	—	9.2	5.7	42	A
Ad 6	do	Aug. 19, 1943	—	—	.35	—	—	—	—	5	1.0	—	5.0	—	6.1	—	—	18	6.4	40	A
do	do	Apr. 6, 1945	12	—	—	—	—	—	—	—	—	—	14	—	—	—	—	5.2	4.6	—	F
Ad 7	do	Aug. 19, 1943	—	—	.57	—	—	—	—	1	7.0	—	2.0	—	.0	—	—	12	5.1	27	A
do	do	June 15, 1945	23	9.3	.04	1.3	.5	1.8	.7	2	6.5	—	1.4	.0	.0	—	—	5.3	5.0	27	A
Ad 17	do	Mar. 31, 1914	—	—	—	—	—	—	—	—	—	—	9.4	—	—	—	—	6.0	—	—	B
Ad 20	Patuxent	June 15, 1945	24	9.5	1.8	.9	.5	2.0	.8	3	5.9	—	1.4	.0	.0	—	—	4.3	5.2	24	A
Ad 29	do	May 13, 1948	24	11	2.2	.9	.5	1.5	1.0	1	6.9	—	1.2	.1	.0	.02	—	4.3	4.7	—	A
Ae 1	Patapsco	Aug. 26, 1943	—	—	.4	—	—	—	—	4	7.0	—	2.0	—	.0	—	—	12	6.4	27	A
Ae 2	Pleistocene (lowland)	Aug. 26, 1943	—	—	.79	—	—	—	—	22	46	—	14	—	9.1	—	—	68	5.6	206	A
Ae 3	Patapsco	Aug. 26, 1943	—	—	.2	—	—	—	—	35	70	—	17	—	.1	—	—	87	6.3	269	A
Ae 4	do	Jan. 31, 1944	—	—	—	—	—	—	—	—	16	—	4.0	—	.5	—	—	10	4.3	64	A
Ae 22	do	Jan. 14, 1946	329	4.4	.46	48	7.1	37	5.4	68	70	—	40	.0	59	—	—	149	6.8	506	A
Bb 5	Patuxent	Mar. 31, 1952	30	8.5	.18	.3	.1	5.9	.3	5	7.5	—	3.2	.0	.1	.01	.0	1.0	5.2	39	A

AA-Bb 8	Pre-Cambrian	Aug. 17, 1927	176	—	0.1	—	—	—	—	—	4.6	—	—	—	0.0	—	—	56	—	—	B
Bc 1	Patapsco	July 24, 1944	26	—	.28	—	—	—	—	—	—	—	—	—	10	—	—	19	4.9	—	C
Bd 6	do	Mar. 28, 1946	19	8.0	.08	1.1	0.5	1.2	0.3	2	4.6	—	1.5	0.1	.1	—	—	4.8	5.0	21	A
Bd 7	do	May 20, 1946	—	—	—	—	—	—	—	0	3.0	—	3.0	—	.1	—	—	6.0	4.5	29	A
Bd 23	Patuxent	Aug. 23, 1948	50	23	3.0	.9	.05	—	—	—	—	—	—	—	.0	—	—	—	5.4	—	B
Be 3	Patapsco	Sept. 17, 1935	56	—	6.0	—	—	—	—	—	—	—	4.2	—	.0	—	—	16	5.8	—	B
Be 21	do	Jan. 26, 1946	25	8.1	.59	1.0	.5	2.0	.6	0	9.4	—	1.8	.0	1.6	0.00	—	10	3.9	64	A
Be 32	Patapsco-Raritan	Feb. 15, 1946	—	—	2.9	—	—	—	—	—	9.0	—	4.0	—	.1	—	—	9.0	3.8	87	A
Be 33	do	Feb. 15, 1946	—	—	3.7	—	—	—	—	—	10	—	4.0	—	.0	—	—	9.0	3.9	80	A
Be 36	do	Feb. 26, 1946	—	—	.85	—	—	—	—	6	1.0	—	6.0	—	3.2	—	—	10	5.2	48	A
Be 42	do	Feb. 26, 1946	—	—	—	—	—	—	—	—	12	—	64	—	.3	—	—	27	4.3	271	A
Be 45	do	Apr. 16, 1946	75	2.8	.35	6.2	2.3	6.1	1.4	2	14	—	7.0	.2	21	.10	—	25	4.7	114	A
Be 46	Raritan	Apr. 16, 1946	41	3.5	.08	3.1	1.6	3.9	.8	1	15	—	3.2	.1	4.2	.00	—	14	4.9	65	A
Bf 1	Patapsco	Aug. 2, 1932	58	—	6.4	—	—	—	—	—	—	—	5.2	—	.0	—	—	20	6.4	—	B
do	do	Aug. 3, 1943	—	—	18	—	—	—	—	20	2.0	—	3.0	—	.0	—	—	16	6.1	71	A
Bf 2	do	Aug. 3, 1943	—	—	7.5	—	—	—	—	2.4	2.0	—	1.5	—	.0	—	—	18	4.2	56	A
do	do	May 1, 1951	34	9.0	2.5	1.8	.6	1.3	1.6	0	9.0	0.0	2.0	.0	.2	.07	0.0	7.0	4.1	54	A
Bf 4	do	Aug. 3, 1943	—	—	—	—	—	—	—	3	6.0	—	4.2	—	1.0	—	—	12	6.0	32	A
Cc 1	do	Apr. 15, 1946	28	5.8	.33	1.6	1.2	3.2	.6	5	1.4	—	4.6	.0	5.5	—	—	9.0	5.7	39	A
Cc 7	Patuxent(?)	Apr. 23, 1946	18	7.2	2.1	.5	.3	1.4	.3	5	.7	—	2.1	.1	.5	—	—	3.3	5.1	18	A
Cc 12	Raritan	May 1, 1946	—	—	.15	—	—	—	—	32	1.0	—	2.0	—	1.8	—	—	22	6.3	62	A
Cc 13	Pleistocene (lowland)	Mar. 31, 1952	90	5.5	.20	12	1.5	2.7	6.8	5	30	—	4.2	.1	11	.25	.2	36	5.0	134	A
Cc 15	do	May 6, 1946	—	—	.42	—	—	—	—	7	1.0	—	4.0	—	16	—	—	15	5.6	69	A
Cd 3	Raritan	Feb. 10, 1930	52	—	.0	—	—	—	—	—	—	—	3.4	—	.4	—	—	48	—	—	B
do	do	Jan. 12, 1938	15	—	—	—	—	—	—	—	—	—	5.0	—	.3	—	—	2.0	3.8	—	B
Cd 6	Magothy	Mar. 14, 1946	—	—	1.1	—	—	—	—	40	3.0	—	16	—	3.9	—	—	30	6.5	166	A
Cd 11	do	Apr. 18, 1946	52	18	2.0	.9	.7	2.6	.8	0	26	—	1.0	.1	.0	.00	1.6	22	3.8	97	A
Cd 19	do	May 6, 1946	47	9.3	1.2	.9	1.3	2.0	1.0	0	24	—	2.1	.0	.1	.06	—	13	4.0	93	A
Cd 23	Raritan	May 7, 1946	—	—	8.3	—	—	—	—	9	36	—	4.0	—	.3	—	—	26	5.6	104	A
Ce 1	Patapsco-Raritan	Apr. 1, 1946	53	6.2	30	6.0	3.6	2.2	1.4	10	26	—	1.8	.3	.1	—	—	30	5.3	86	A
Ce 4	do	Jan. 17, 1946	25	8.7	2.2	1.0	.5	1.2	.6	0	10	—	.8	.0	.1	.02	—	10	3.9	60	A
Ce 10	Raritan	Feb. 18, 1946	—	—	7.3	—	—	—	—	0	20	—	3.0	—	.1	—	—	15	3.8	138	A
Ce 14	do	Apr. 1, 1946	29	8.4	1.1	.7	.3	1.6	.3	0	12	—	1.2	.1	.1	—	—	9.4	3.9	70	A
Ce 17	Patapsco-Raritan	Feb. 28, 1946	—	—	8.3	—	—	—	—	0	50	—	2.0	—	.1	—	—	21	3.5	170	A
Ce 18	Raritan	Feb. 28, 1946	—	—	8.1	—	—	—	—	0	56	—	4.0	—	.1	—	—	15	3.5	167	A
Ce 32	Patapsco	Apr. 17, 1946	25	8.1	4.0	.8	.6	1.8	.3	0	15	—	1.9	.1	.1	—	—	14	4.0	54	A
Ce 33	do	Apr. 17, 1946	28	11	2.8	.4	.3	1.1	.3	0	12	—	.8	.1	.1	.0	—	12	3.9	62	A
Ce 34	Raritan	Apr. 1, 1946	36	9.5	2.9	1.2	.5	1.8	.5	0	16	—	1.8	.1	.1	—	—	12	3.9	82	A
Ce 36	do	Apr. 26, 1946	—	—	.4	—	—	—	—	0	15	—	2.5	—	.0	—	—	9.0	—	72	A
Ce 37	do	May 1, 1946	—	—	5.8	—	—	—	—	0	22	—	1.0	—	.0	—	—	7.5	3.9	73	A

TABLE 31—*Continued*

Well	Water-bearing formation	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Phosphate (PO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Manganese (Mn)	Aluminum (Al)	Hardness as $CaCO_3$	pH	Specific conductance (Micromhos at 25°C)	Analyst
AA-Ce 38	Patapsco-Raritan	May 7, 1946	35	11	1.5	0.7	1.2	1.5	1.2	0	16	—	1.1	0.0	0.1	0.05	—	12	4.0	86	A
Ce 46	Magothy	May 8, 1946	62	13	11	7.8	3.5	2.1	2.7	21	20	—	2.0	.3	.0	—	—	34	5.6	95	A
Cf 1	Patapsco-Raritan	Apr. 11, 1946	36	6.7	9.4	1.4	1.2	1.6	.7	0	19	—	.9	.1	.1	—	—	17	3.8	105	A
Cf 4	do	Jan. 30, 1946	—	—	17	—	—	—	—	1	—	—	.2	—	.1	—	—	6.0	6.1	22	A
Cf 11	Magothy	Apr. 16, 1946	55	9.1	21	6.2	2.5	1.8	1.8	5	25	—	1.5	.3	.0	.30	—	26	4.9	83	A
Cf 13	do	Apr. 16, 1946	56	7.4	30	5.8	3.1	1.8	1.3	0	31	—	.8	.2	.0	.40	—	30	4.3	97	A
Cf 15	do	Apr. 17, 1946	75	7.8	29	8.7	4.4	2.9	1.6	0	42	—	1.8	.2	.1	.40	—	42	4.4	125	A
Cg 1	do	Sept. 29, 1943	—	—	15	33	4.0	—	—	—	34	—	1.0	—	—	—	—	37	5.4	—	D
Cg 2	Monmouth	Aug. 5, 1943	510	3.5	20	90	10	—	—	—	7.8	—	150	—	—	—	—	270	—	—	E
do	do	Sept. 3, 1943	—	—	32	—	41	—	—	—	6.0	—	146	—	—	—	—	255	6.6	—	D
Cg 6	Magothy	Mar. 15, 1950	75	8.3	26	7.8	3.8	4.4	2.8	3	44	—	.9	.2	.0	.22	—	35	4.7	123	A
Dc 7	do	Mar. 31, 1952	86	31	8.5	14	2.0	2.1	2.5	45	10	—	1.9	.3	.3	.10	0.0	43	6.3	102	A
Dd 12	Monmouth	June 6, 1946	—	—	.3	—	—	—	—	5	1.0	—	8.0	—	4.6	—	—	9.0	5.3	58	A
De 3	Magothy	Apr. 25, 1932	66	16	26	9.9	4.2	2.3	2.6	44	11	—	2.0	—	.0	—	—	42	—	—	A
do	do	Feb. 15, 1943	—	—	8.8	—	—	—	—	29	13	—	2.0	—	.0	—	—	34	5.9	101	A
De 11	Aquia	June 11, 1946	—	—	.1	—	—	—	—	16	2.0	—	4.0	—	2.2	—	—	20	5.7	48	A
De 12	do	June 11, 1946	—	—	.9	—	—	—	—	14	1.0	—	3.0	—	9.4	—	—	15	6.1	53	A
De 20	do	June 14, 1946	121	16	.7	7.3	5.3	7.7	5.0	3	1.0	—	12	.0	56	—	—	40	5.2	144	A
De 34	do	June 25, 1946	—	—	.44	—	—	—	—	12	1.0	—	8.0	—	24	—	—	28	5.5	104	A
De 35	do	June 25, 1946	238	33	1.4	67	5.4	2.6	5.0	220	12	—	2.2	.1	.2	—	—	189	7.8	365	A
De 42	Magothy	July 19, 1946	—	—	14	—	—	—	—	78	28	—	2.0	—	.1	—	—	82	6.3	181	A
De 43	Aquia	Apr. 25, 1946	—	—	2.8	—	—	—	—	—	—	—	8.0	—	—	—	—	38	5.1	—	B
De 47	Magothy	Apr. 25, 1932	62	13	11	10	2.6	2.1	1.9	28	17	—	2.0	—	.0	—	—	36	—	—	A
Df 9	Raritan-Magothy	Mar. 20, 1945	104	9.5	20	16	5.5	1.9	2.6	37	38	—	1.6	.5	.0	.2	—	63	5.8	—	A
Df 12	Patapsco-Raritan	Mar. 20, 1945	66	7.6	19	7.9	3.8	1.5	1.7	9	32	—	1.2	.2	.0	.4	—	35	5.2	—	A
Df 13	do	Mar. 20, 1945	74	7.9	20	6.2	3.6	1.5	1.7	2	34	—	.9	.2	.0	.4	—	30	4.6	—	A
Df 15	Magothy	Mar. 20, 1945	106	8.6	26	15	5.7	1.8	2.4	32	45	—	1.4	.5	.0	.4	—	61	5.8	—	A
Df 16	Patapsco-Raritan	July 19, 1944	111	—	24	4.6	3.9	—	—	—	—	—	—	—	—	—	—	25	—	—	C
Df 16	do	Mar. 20, 1945	80	8.5	18	5.7	3.6	1.8	1.9	26	36	—	.9	.1	.0	.4	—	29	5.8	—	A
Ed 8	Magothy	June 28, 1946	209	17	1.2	50	7.7	4.2	7.2	190	15	—	2.5	.1	1.5	—	—	156	7.2	342	A

AA-Ed 15	Aquia	July 17, 1946	—	—	0.6	—	—	—	—	162	34	—	2.0	—	0.1	—	—	147	7.5	314	A
Ed 16	do	Mar. 27, 1950	213	56	2.4	45	5.3	2.9	4.2	157	12	—	2.8	0.2	.2	0.03	—	135	7.3	275	A
Ee 6	do	June 28, 1946	285	36	.8	75	9.1	4.0	3.3	235	34	—	2.2	.1	.4	—	—	225	7.4	451	A
Ee 10	do	June 29, 1946	271	45	2.4	76	3.1	4.2	3.9	247	6.1	—	3.9	.0	.1	—	—	202	7.2	408	A
Ee 12	do	June 29, 1946	—	—	1.6	—	—	—	—	189	9.0	—	2.0	—	.0	—	—	153	7.9	317	A
Ee 22	Magothy	July 17, 1946	—	—	25	—	—	—	—	58	36	—	2.0	—	.0	—	—	75	6.1	190	A
Ee 32	Aquia	July 29, 1946	244	20	.7	58	9.9	5.0	3.8	162	61	—	1.6	.2	.2	—	—	185	7.6	374	A
Ef 2	do	June 18, 1946	276	32	4.0	83	3.9	5.2	4.1	264	1.8	—	11	.0	.0	—	—	223	7.4	430	A
Ef 4	do	Nov. 20, 1945	—	—	1.8	—	—	—	—	—	32	—	12	—	—	—	—	54	6.1	—	D
Ef 5	Pleistocene (lowland)	Nov. 20, 1945	—	—	1.3	—	—	—	—	—	27	—	18	—	—	—	—	88	7.0	—	D
Fc 1	Aquia	Mar. 31, 1952	183	17	.19	49	5.1	2.8	4.1	153	27	—	1.4	.0	.4	.01	0.00	143	7.7	292	A
Fc 4	Magothy	July 12, 1946	200	13	.9	58	6.3	3.3	2.6	183	23	—	1.9	.0	.3	—	—	171	7.4	337	A
Fd 13	do	Dec. 28, 1948	197	10	13	55	6.2	—	—	—	63	—	3.2	—	—	—	—	164	6.7	—	C
Fd 16	Pleistocene (upland)	Mar. 31, 1952	240	25	.73	50	3.1	12	7.0	107	54	—	15	.2	14	.05	.8	138	6.3	353	A
Fe 8	Magothy	July 27, 1946	—	—	15	—	—	—	—	80	50	—	2.0	—	.0	—	—	100	6.6	246	A
Fe 14	Aquia	July 30, 1946	—	—	.46	—	—	—	—	166	13	—	1.0	—	.9	—	—	126	7.5	289	A
Fe 30	do	Mar. 27, 1950	164	11	1.4	40	8.3	4.4	5.7	140	23	—	1.2	.3	.5	.00	—	134	8.2	280	A
Ge 2	do	Mar. 9, 1949	166	14	.37	33	11	5.6	2.0	166	8.9	—	3.5	.2	.9	—	—	128	7.6	—	A
Cal-Bb 1	Pleistocene (upland)	Jan. 13, 1947	73	5.1	6.8	5.5	2.7	5.2	7.3	2	14	—	7.8	.1	21	.00	—	25	5.1	116	A
Bb 6	do	Mar. 27, 1950	107	15	.1	27	.8	2.6	6.8	95	2.0	—	3.2	.1	.8	.00	—	.7	7.3	171	A
Bb 9	Aquia	Apr. 30, 1952	162	15	.20	30	14	3.2	9.2	161	14	0.0	1.2	.3	.5	.00	.1	132	7.7	276	A
Bb 10	Magothy	Apr. 1, 1952	149	7.5	4.8	36	9.5	4.7	5.3	167	7.0	.1	1.0	.3	.3	.10	.0	128	7.5	269	A
Bc 9	Aquia	Mar. 6, 1951	174	15	.06	34	12	4.4	10	175	10	—	1.5	.2	.8	.02	.1	134	7.9	296	A
Ca 2	do	Mar. 27, 1950	169	15	.47	31	16	4.4	13	182	13	—	1.1	.2	.1	.00	—	143	7.8	309	A
Cb 9	Nanjemoy	Mar. 6, 1951	194	36	.20	28	13	5.2	17	156	22	—	1.5	.1	.9	.00	.1	121	8.0	298	A
Cc 17	Aquia	Jan. 23, 1952	171	15	.30	32	13	4.3	10	173	9.2	.0	1.5	.3	.7	—	.0	133	7.8	287	A
Cc 18	do	Jan. 23, 1952	181	15	.86	35	11	4.9	13	179	10	.0	3.1	.3	.2	—	.0	133	8.0	295	A
Cc 19	do	Jan. 23, 1952	176	16	.52	35	12	4.3	9.6	179	9.5	.0	1.0	.3	.2	—	.0	137	7.9	290	A
Cc 28	Nanjemoy	Mar. 27, 1950	333	57	.46	63	20	3.4	11	255	44	—	4.2	.1	.4	.00	—	239	7.9	492	A
Db 3	Aquia	Mar. 27, 1950	154	13	.51	22	6.2	9.8	15	162	10	—	2.0	.2	.8	.00	—	108	7.9	277	A
Db 5	do	Jan. 13, 1947	153	9.8	—	22	12	9.8	16	158	12	—	1.1	.2	.7	—	—	104	8.0	279	A
Db 6	Pleistocene (upland)	Mar. 27, 1950	96	8.2	.16	5.6	3.5	8.0	3.6	6	4.1	—	14	.1	28	.00	—	28	6.8	134	A
Ec 1	Nanjemoy	Jan. 13, 1947	173	40	—	28	11	3.9	12	136	14	—	2.2	.2	.1	—	—	115	8.2	259	A
Ec 3	Nanjemoy-Piney Point	Mar. 23, 1949	168	40	.21	23	11	3.7	1.6	132	11	—	2.5	.2	1.6	—	—	103	7.7	246	A
Ed 1	Aquia	Apr. 30, 1952	137	15	.03	9.8	2.8	30	13	133	4.5	.0	2.1	.3	.2	.00	.0	36	7.9	222	A
Fd 1	do	June 24, 1952	153	12	.67	2.9	.4	50	5.3	130	5.5	.3	4.2	.3	.2	.00	.0	19	8.5	234	A
Fd 3	Nanjemoy-Piney Point	Jan. 13, 1947	221	18	—	8.6	4.2	59	12	177	27	—	1.5	.4	.2	—	—	39	8.2	350	A
Gd 4	do	Jan. 13, 1947	204	19	3.8	10	4.8	50	13	187	12	—	3.1	.3	.1	—	—	45	8.0	327	A
Gd 6	Aquia	Jan. 13, 1947	156	11	.43	2.4	.7	52	6.4	124	8.4	—	2.6	.2	.3	—	—	9	8.7	255	A
Gd 36	do	June 24, 1952	153	12	.67	2.9	.4	50	5.3	130	5.5	.3	4.2	.3	.2	.00	.0	9	8.5	234	A

TABLE 31—*Continued*

Well	Water-bearing formation	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Phosphate (PO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Manganese (Mn)	Aluminum (Al)	Hardness as $CaCO_3$	pH	Specific conductance (Micromhos at 25°C)	Analyst
Ch-Bb 1	Patuxent-Patapsco	July 15, 1938	210	42	0.06	1.0	0.6	65	2.1	155	12	—	7.6	1.0	0.4	—	—	6.5	—	—	A
do	do	May 26, 1952	195	34	.03	1.1	.2	60	2.1	149	10	—	6.2	.7	.3	0.01	—	4.0	7.7	261	A
Bb 4	do	May 28, 1952	215	25	.04	.4	.1	68	2.7	152	16	0.8	10	.8	.4	.02	—	—	8.2	291	A
Bb 6	do	May 28, 1952	196	25	1.3	.5	.0	64	2.4	151	12	.5	7.1	.7	.3	.02	—	1.0	8.0	282	A
Bb 8	do	May 15, 1952	198	34	.1	.3	.2	64	2.6	150	14	—	6.6	.7	.2	.00	—	2	7.9	276	A
Bc 3	do	July 27, 1938	211	26	.1	1.5	.4	72	2.2	169	11	—	11	1.1	.6	—	—	8	—	—	A
Bc 5	do	May 26, 1952	227	27	.26	.5	.1	77	2.8	172	11	—	19	.8	.4	.02	—	.2	7.8	337	A
Bc 12	Magothy	Mar. 28, 1950	224	16	.48	5.9	2.4	70	8.6	210	13	—	1.2	.5	.7	.00	—	25	7.8	357	A
Be 13	Pleistocene (upland)	Apr. 2, 1952	31	3.8	.59	2.2	1.6	2.2	3.0	5	13	.0	2.5	.0	.2	.00	0.0	12	6.0	46	A
Bf 5	Magothy	Sept. 15, 1949	159	9.6	.62	31	11	8.7	10	172	9.9	—	1.2	.2	.8	.00	.7	123	7.6	288	A
Bf 15	Monmouth or Aquia	Jan. 9, 1947	196	16	.8	44	15	6.3	9.9	222	7.3	—	1.2	.1	.5	—	—	172	8.0	354	A
Bg 5	Pleistocene (upland)	Apr. 17, 1952	53	15	.02	7.2	.7	4.8	.6	36	.5	.0	6.9	.1	.2	.00	.7	21	6.2	77	A
Cc 5	Patapsco(?)	Apr. 2, 1952	265	19	1.9	5.9	3.5	88	7.6	265	7.5	.3	.5	.9	.8	.00	.0	29	7.9	411	A
Cd 7	Patapsco	Apr. 3, 1952	306	24	5.3	2.1	.2	116	4.9	304	4.0	1.0	7.0	1.3	.8	.08	.0	6	7.9	465	A
Cd 10	Pleistocene (upland)	Apr. 17, 1952	110	15	.07	28	1.3	4.4	2.8	96	5.8	.0	3.8	.0	.6	.00	.5	75	6.8	173	A
Ce 3	Patapsco-Raritan	Jan. 22, 1947	338	34	.39	1.1	.8	121	4.7	321	11	—	3.8	1.2	.2	—	—	6	8.0	514	A
Ce 6	Monmouth	May 17, 1948	174	14	.57	22	5.7	0.35		168	13	—	1.0	.2	.6	—	—	78	7.8	292	A
Ce 14	Pleistocene (upland)	Apr. 10, 1950	90	14	2.4	14	1.4	9.2	2.9	70	5.7	—	7.1	.0	.3	.04	—	41	6.9	142	A
Cf 9	Patapsco-Raritan	Apr. 17, 1952	158	11	.73	21	8.3	20	11	165	11	.0	.9	.3	.5	.00	.0	87	7.5	268	A
Cg 1	Aquia	Oct. 28, 1946	162	10	2.4	29	13	5.3	14	174	12	—	1.4	.1	1.4	—	—	126	7.7	298	A
Da 1	Patapsco-Raritan	Mar. 20, 1951	244	32	1.8	15	9.4	54	7.6	229	9.0	—	6.8	.1	.8	.05	.7	76	7.4	371	A
Db 7	Pleistocene (upland)	Apr. 2, 1952	46	11	.07	4.2	1.1	3.8	.8	14	.2	.0	7.2	.0	4.2	.00	.0	15	6.2	58	A
Dd 3	Pleistocene (lowland)	Jan. 22, 1947	587	13	.18	146	9.4	42	9.4	392	84	—	46	.2	26	—	—	403	7.8	952	A
Dd 5	Aquia	Jan. 22, 1947	206	16	1.4	2.9	1.7	69	4.8	184	11	—	2.5	.4	.3	—	—	14	8.5	332	A
Dd 10	Patapsco-Raritan	Mar. 7, 1951	245	19	.98	1.4	1.2	85	4.0	216	16	—	2.4	.7	.4	.04	.4	8	8.2	365	A
Dd 12	Pleistocene (lowland)	Apr. 2, 1952	177	26	.14	16	7.3	15	3.9	27	12	.0	18	.0	60	.09	.0	70	6.3	244	A
De 15	Pleistocene (upland)	Apr. 10, 1950	106	11	.45	12	1.8	8.4	7.5	30	9.0	—	10	.1	20	.00	—	37	6.2	154	A
De 16	Patapsco-Raritan	Apr. 17, 1952	210	15	.13	1.7	1.0	77	5.6	208	9.5	.3	1.4	.4	.4	.00	.0	8.0	8.0	329	A
Df 9	Aquia	Mar. 21, 1951	168	32	.20	17	6.1	21	12	143	8.0	—	1.6	.3	1.1	—	.1	68	8.1	252	A
Df 11	Pleistocene (upland)	Apr. 3, 1952	66	6.8	2.0	1.3	1.5	12	2.0	12	3.0	.1	16	.2	5.4	.07	.1	9	6.3	89	A
Ec 5	Patapsco-Raritan	Apr. 6, 1950	320	28	5.7	1.6	1.4	102	19	304	7.4	—	3.8	.5	.5	.00	—	20	8.0	491	A

Ch-Ee 18	Raritan	Jan. 27, 1947	204	13	0.96	3.4	1.6	68	5.7	188	8.5	—	2.2	0.3	0.3	—	—	15	8.6	327	A
Ee 43	Aquia	Apr. 10, 1950	208	12	.08	4.1	2.1	69	5.7	180	9.4	—	1.6	.5	.1	—	—	19	8.6	330	A
Ff 12	do	Apr. 10, 1950	182	13	.27	3.7	1.2	64	4.8	165	8.5	—	2.1	.3	.3	0.00	—	14	8.2	287	A
Ff 18	do	Jan. 8, 1947	201	10	.10	3.4	1.6	69	6.0	176	8.6	—	2.5	.4	.0	—	—	15	8.8	335	A
PG-Ad 13	Pre-Cambrian	Mar. 31, 1952	68	24	6.5	4.0	3.2	5.8	2.4	51	2.2	0.0	2.5	.2	.3	.17	1.1	23	7.0	90	A
Bc 1	do	Mar. 21, 1949	196	18	.36	4.2	2.4	64	1.5	184	10	—	2.5	.2	.2	—	—	20	7.9	299	A
Bc 5	Patuxent	1948	—	—	3.0	—	—	—	—	—	—	—	4.8	—	—	—	—	51	—	—	G
Bc 10	do	Mar. 17, 1950	64	3.7	2.3	5.6	4.4	6.0	3.8	36	1.8	—	11	.2	6.5	.12	—	21	7.3	136	A
Bd 4	do	1950	42	5.4	.40	.3	.3	—	—	—	3.0	—	5.0	—	.0	.0	.5	10	5.3	—	B
Bd 18	do	1945	36	—	.10	—	—	—	—	—	—	—	4.0	—	.0	—	—	4	5.0	—	B
Bd 19	do	1946	20	—	.0	—	—	—	—	—	—	—	3.2	—	.4	—	—	5	5.4	—	B
Bd 22	do	1936	84	—	12	—	—	—	—	—	—	—	8.0	—	—	—	—	26	6.0	—	B
Bd 26	do	1945	30	—	.8	—	—	—	—	—	—	—	3.9	—	—	—	—	9	5.0	—	B
Bd 29	do	Mar. 22, 1949	27	7.4	.47	1.0	.6	2.0	.4	4	1.8	—	3.0	.0	2.2	—	—	5	6.0	27	A
Bd 30	do	1943	26	—	.18	—	—	—	—	—	—	—	4.1	—	.5	—	—	33	4.9	—	B
Bd 31	do	1950	44	—	.80	—	—	—	—	—	—	—	7.7	—	.7	—	—	8	5.3	—	B
Be 2	do	1943	34	4.7	1.7	.3	.0	—	—	—	11	—	20	—	—	—	—	10	4.7	—	B
Be 4	Patapsco	1944	—	—	1.7	—	—	—	—	—	—	—	3.4	—	—	—	—	—	5.3	—	B
Be 5	Patuxent	1942	66	8.6	5.2	2.7	.4	—	—	—	9.2	—	5.8	—	.2	.50	.0	—	6.0	—	B
Be 6	do	Apr. 13, 1950	57	3.1	58	1.0	.8	14	2.3	6	31	—	3.0	.0	.0	.45	—	7	5.3	97	A
Be 7	do	1945	24	—	.4	—	—	—	—	—	—	—	3.5	—	—	—	—	8	5.3	—	B
Be 8	do	1940	—	—	1.19	—	—	—	—	5	—	—	3	—	—	—	—	—	5.3	—	A
Cd 2	do	1947	—	—	15	—	—	—	—	—	—	—	—	—	—	—	—	34	—	—	?
Cd 7	Patapsco	Apr. 13, 1950	26	7.7	4.5	—	—	—	—	19	2.3	—	2.2	.0	.1	—	.3	14	5.8	34	A
Ce 16	Patuxent	Nov. 8, 1935	30	8.8	1.4	.9	.6	4.0		1	10	—	1.5	—	.0	.0	—	5	4.7	—	A
Ce 17	Magothy	Nov. 4, 1949	108	4.4	.32	21	2.0	3.4	2.1	40	18	—	12	.1	1.4	.00	1.0	61	7.5	149	A
Ce 18	Patapsco	Nov. 4, 1949	99	7.6	1.8	20	6.8	3.5	2.6	73	22	—	2.4	.1	.1	.2	.6	78	6.5	177	A
Cf 1	do	Nov. 4, 1949	20	3.7	26	2.1	.7	2.4	1.3	10	5.4	.0	1.8	—	.1	.3	.3	8	5.7	41	A
Cf 2	Magothy	Mar. 22, 1949	128	45	12.7	17	2.0	3.1	1.0	58	13	—	2.5	.1	.8	.1	—	51	6.5	132	A
Cf 11	Aquia	Apr. 17, 1950	67	20	16	6.0	1.5	5.1	3.5	18	4.1	—	11	.0	3.7	.02	—	21	6.1	80	A
Cf 25	Patapsco	Apr. 17, 1952	60	22	10	7.6	1.2	1.6	1.8	17	14	.0	2.0	.2	.1	.12	.0	24	5.9	69	A
Dc 4	do	1941	104	—	.80	—	—	—	—	—	—	—	4.1	.2	.1	—	—	74	6.7	—	B
Dc 8	do	Nov. 12, 1919	112	16	7.1	19	6.9	4.0		81	16	—	.8	—	.4	—	—	76	—	—	A
Dc 9	Pliocene(?)	Nov. 9, 1919	181	11	.50	9.4	13	13		—	1.6	—	26	—	83	—	—	77	—	—	A
Dd 6	Pleistocene (upland)	Mar. 21, 1949	91	8.7	.30	11	4.2	4.1	1.0	2	43	—	5.5	.2	2.8	—	—	45	5.1	135	A
Dd 17	Patuxent	Apr. 18, 1951	58	10	10	8.8	3.9	1.5	1.9	39	5.9	—	3.8	.0	.5	.21	.0	38	6.6	95	A
Df 5	Aquia	Mar. 26, 1950	212	33	5.2	59	3.8	2.5	4.1	198	9.7	—	2.1	.1	.2	.04	—	163	7.8	320	A
Eb 1	Patuxent	Mar. 28, 1949	180	24	.19	1.2	.1	60	.8	132	20	—	4.5	.1	1.6	—	—	3	8.0	255	A
Eb 2	Patuxent-Patapsco	1946	214	19	.10	.7	.2	30	—	—	9.9	—	—	—	.0	.00	.6	9	7.5	—	C
Eb 3	Patuxent or Patapsco	Mar. 17, 1950	163	21	1.3	1.3	.6	53	2.4	120	21	—	2.0	.3	.4	.00	—	5	7.8	237	A
Ec 1	Patapsco	1948	140	—	.40	—	—	—	—	—	—	—	4.2	—	.60	—	—	60	6.9	—	B

TABLE 31—*Continued*

Well	Water-bearing formation	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Phosphate (PO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Manganese (Mn)	Aluminum (Al)	Hardness as $CaCO_3$	pH	Specific conductance (Micromhos at 25°C)	Analyst
PG-Ec 5	Patuxent	1950	140	—	0.60	—	—	—	—	—	—	—	4.5	—	0.50	—	—	29	7.4	—	B
Ec 14	Patapsco	1950	104	—	3.0	—	—	—	—	—	—	—	3.3	—	.30	—	—	45	6.9	—	B
Ec 26	do	Mar. 31, 1952	157	13	.95	3.4	1.6	50	4.8	123	24	0.3	1.5	0.1	.8	0.00	0.0	15	7.8	246	A
Ed 2	do	1941	176	—	4.9	—	—	—	—	—	—	—	3.3	—	.0	—	—	130	7.5	—	B
Ed 4	do	Mar. 31, 1949	179	30	.62	48	5.2	3.1	.5	158	8.5	—	2.0	.1	1.7	—	—	141	7.7	264	A
Ed 8	Magothy	Apr. 17, 1950	171	16	.69	46	8.5	4.6	4.4	185	8.3	—	2.0	.0	.3	.01	—	150	8.0	296	A
Ed 17	Pliocene(?)	Apr. 13, 1950	52	6.4	2.0	4.1	2.0	6.9	2.1	8	9.2	—	9.9	.0	7.6	.3	—	18	5.4	83	A
Ed 32	Patuxent	Mar. 6, 1951	136	10	.20	17	9.1	5.9	16	113	22	—	1.6	.3	.2	.17	.4	80	7.7	236	A
Ee 6	Magothy	1947	264	24	.30	100	4.6	—	—	—	22	—	4.4	—	.0	.0	.9	178	7.6	—	B
Ee 30	do	Before 1918	—	26	.02	61	6.0	5.1	—	205	13.9	—	2.7	—	.0	—	.8	178	—	—	?
Ef 3	do	June 6, 1949	183	15	14	50	5.2	5.0	1.9	178	10	—	2.1	.2	.2	—	—	146	6.9	307	A
Ef 5	do	Apr. 15, 1946	210	25	.31	60	6.7	3.1	1.7	192	18	—	2.0	.3	.2	—	—	177	7.5	33	A
Fb 7	Patapsco	Mar. 31, 1949	209	32	.59	2.8	1.0	6.0	.6	130	28	—	1.5	.3	1.1	—	—	11	8.1	265	A
Fc 14	Magothy	Apr. 13, 1950	149	13	1.8	29	11	4.2	9.2	147	13	—	1.2	.3	.6	.00	—	118	7.7	263	A
Fd 6	do	Mar. 25, 1949	169	13	.21	37	7.9	3.4	1.2	158	13	—	1.5	.2	1.8	—	—	125	7.7	285	A
Fd 10	do	Apr. 14, 1952	149	16	.28	35	8.6	2.7	4.8	153	9.6	.1	1.8	.2	.3	.00	.0	123	7.9	254	A
Fd 16	Pliocene(?)	Mar. 28, 1950	265	18	1.9	48	6.1	16	17	166	40	—	6.5	.1	7.5	.00	—	146	7.2	380	A
Fd 24	Magothy	1945	180	4.0	.40	38	3.0	—	—	—	1.3	—	5.2	—	.06	.0	.5	170	7.8	—	B
Fd 32	do	Apr. 17, 1952	184	12	.83	39	15	4.9	5.5	203	9.2	.0	1.4	.1	.5	.00	.0	159	7.8	320	A
Fd 34	Pliocene(?)	Mar. 15, 1951	88	5.2	.11	22	2.5	7.9	.7	84	1.9	—	8.8	.0	.1	—	—	65	7.4	163	A
Ff 5	Pleistocene (lowland)	Mar. 20, 1951	78	22	.85	5.6	2.7	5.3	1.9	6	8.1	—	8.5	.0	18	.00	.2	25	5.8	102	A
Ff 16	Aquia	Mar. 31, 1952	205	15	.65	47	13	5.0	8.4	225	7.0	.0	1.3	.1	.9	.00	.0	171	7.8	340	A
Ge 10	Pliocene(?)	Mar. 6, 1951	46	7.8	.03	8.2	1.1	2.9	1.5	28	5.1	—	3.9	.1	.4	.06	.1	25	6.9	71	A
Gf 1	Nanjemoy	Mar. 28, 1949	163	33	.32	21	12	2.1	5.6	142	4.3	—	2.0	.3	1.3	—	—	102	8.0	239	A
St.M-Bb 1	Pleistocene (upland)	Jan. 17, 1947	152	4.7	.45	14	1.5	33	4.4	15	22	—	55	.0	4.8	—	—	41	7.4	283	A
Bb 4	Aquia	Mar. 28, 1950	132	11	.45	18	11	9.6	12	122	13	—	4.4	.1	6.2	.00	—	90	7.4	245	A
Bb 10	Pleistocene (upland)	Apr. 17, 1952	72	11	.68	17	1.4	3.3	.9	60	2.5	.0	5.6	.1	.0	.00	.6	48	6.4	117	A
Bd 1	Aquia	Jan. 17, 1947	145	13	.65	15	8.7	18	15	124	10	—	1.2	.1	.2	—	—	73	8.5	251	A
Cb 1	do	do	155	14	.05	11	4.4	34	12	140	9.9	—	1.1	.1	.0	—	—	46	8.4	258	A
Cb 9	Pleistocene (upland)	Apr. 2, 1952	102	12	.08	3.8	3.3	19	2.2	28	8.0	.0	22	.1	9.0	.00	1.0	23	6.3	163	A
Cc 6	do	Mar. 28, 1950	115	7.7	.19	11	5.6	7.5	3.1	12	22	—	12	.1	27	.00	—	51	7.1	165	A
Cd 1	Nanjemoy-Piney Point	Mar. 9, 1949	176	43	.23	23	11	5.5	3.0	142	8.7	—	3.0	.2	.3	—	—	103	7.9	255	A

St.M-Ce 14	Nanjemoy-Piney Point	Mar. 28, 1950	194	33	1.3	27	15	9.0	17	174	14	—	2.5	0.3	0.6	0.03	—	130	7.8	318	A
Db 24	Pleistocene (lowland)	do	176	8.8	2.3	34	6.1	14	8.1	121	27	—	16	.0	2.5	.00	—	111	6.7	307	A
Dc 12	Aquia	do	212	50	.08	17	7.7	31	13	171	7.9	—	2.5	.4	.4	.00	—	74	7.9	304	A
Dc 17	do	Apr. 2, 1952	213	12	.42	4.2	.8	75	7.2	200	8.0	0.3	9.2	.3	.7	.00	.0	14	8.2	340	A
Dd 1	do	Mar. 9, 1949	148	10	.17	3.6	1.1	49	1.9	136	8.9	—	2.5	—	.6	—	—	14	8.5	236	A
Dd 5	Nanjemoy-Piney Point	do	183	32	.33	22	9.8	14	6.9	162	9.2	—	3.5	.2	.4	—	—	95	8.0	282	A
Dd 12	do	Mar. 28, 1950	185	31	.07	8.5	3.3	46	9.9	152	9.7	—	2.5	.2	.3	.00	—	35	8.3	278	A
Df 1	Aquia	Oct. 29, 1951	225	12	—	2.4	1.0	76	9.0	195	5.5	—	2.5	.5	.2	—	—	10	8.5	316	A
Df 2	Aquia-Nanjemoy[1]	do	213	48	.10	25	14	14	12	184	6.0	—	3.5	.3	.2	—	—	120	8.0	299	A
Df 3	Aquia	do	204	12	.10	3.2	.7	72	9.0	186	6.5	—	2.8	.4	.2	—	—	11	8.6	301	A
Df 4	do	do	214	15	—	3.2	1.0	73	8.0	190	5.5	—	2.8	.5	.2	—	—	12	8.5	301	A
Df 5	do	do	206	12	.00	2.4	1.0	73	9.0	188	5.5	—	2.5	.4	.2	—	—	10	8.6	302	A
Df 6	Nanjemoy-Piney Point	Nov. 27, 1951	210	61	.11	30	14	4.6	10	174	7.5	—	3.9	.3	.2	—	—	132	8.0	286	A
Df 7	Aquia-Nanjemoy [1]	Nov. 6, 1951	203	45	.10	21	12	19	12	179	4.6	—	3.2	.4	.6	—	—	102	8.0	311	A
Df 9	Nanjemoy-Piney Point	do	206	54	.10	21	12	18	12	178	7.2	—	3.5	.4	.5	—	—	102	7.9	295	A
Df 10	Aquia	Jan. 16, 1947	196	13	.58	2.8	1.4	65	5.7	177	7.3	—	2.8	.5	.4	—	—	13	8.7	313	A
Df 11	Aquia-Nanjemoy [1]	Nov. 6, 1951	206	52	1.1	22	12	16	12	176	7.0	—	3.2	.4	.7	—	—	104	8.1	300	A
Df 12	do [1]	do	203	40	.10	14	7.8	37	9.4	181	7.4	—	3.0	.4	.2	—	—	67	8.1	300	A
Df 13	do [1]	Nov. 27, 1951	206	51	.08	21	11	20	12	177	7.0	—	2.9	.3	.1	—	—	98	8.0	283	A
Df 14	Nanjemoy-Piney Point	do	204	56	.08	22	12	17	12	175	6.8	—	2.9	.3	.0	—	—	104	8.0	280	A
Df 31	Pleistocene (lowland)	Apr. 2, 1952	99	13	.22	2.5	5.1	18	1.4	19	9.5	.0	28	.0	3.8	.00	.2	27	6.3	164	A
Df 39	Nanjemoy-Piney Point	Nov. 27, 1951	210	54	.10	21	12	17	14	176	8.8	—	2.9	.4	.1	—	—	102	8.0	284	A
Dg 1	Aquia	Nov. 21, 1952	208	12	—	2.8	1.6	76	7.0	201	6.0	—	4.2	.4	.3	—	—	14	8.5	325	A
Dg 2	Aquia-Nanjemoy[1]	Nov. 20, 1951	217	52	.05	18	10	27	15	180	9.8	—	2.1	.3	.2	—	—	86	8.0	306	A
Dg 3	Aquia	Nov. 21, 1951	206	13	.15	9.4	1.1	67	9.0	194	7.8	—	4.2	.4	.5	—	—	28	8.5	323	A
Dg 5	do	do	207	12	.13	3.8	2.6	72	8.0	202	5.0	—	3.2	.4	.3	—	—	20	8.6	319	A
Dg 6	do	do	193	11	.04	3.2	1.7	69	6.6	185	6.0	—	3.6	.4	.3	—	—	15	8.6	303	A
Ec 10	Pleistocene (lowland)	Mar. 5, 1950	182	35	34	9.9	8.3	34	13	164	4.7	—	9.8	.3	1.2	.04	—	62	7.6	294	A
Ee 4	Nanjemoy-Piney Point	Mar. 28, 1950	210	56	.39	25	12	11	16	169	9.1	—	.6	.4	.8	.00	—	112	7.8	293	A
Ef 4	Raritan(?)	Jan. 16, 1947	192	13	.31	1.0	.7	70	3.5	176	7.7	—	2.8	.6	.2	—	—	5.4	8.4	308	A
Eg 14	Pleistocene (upland)	Apr. 2, 1952	47	9.5	.06	6.8	1.4	2.8	1.7	27	4.8	.0	4.5	.1	.7	.00	.0	23	6.6	69	A
Fe 1	Aquia	Jan. 16, 1947	282	12	.19	2.8	1.5	101	6.0	266	9.5	—	5.0	.9	.4	—	—	13	8.6	460	A
Fe 21	do	Dec. 13, 1950	300	12	.40	4.2	1.3	107	7.6	275	9.0	—	3.5	.7	.4	.0	.1	16	8.6	472	A
Ff 8	Nanjemoy-Piney Point	Mar. 7, 1950	308	22	.44	5.4	3.0	102	11	292	8.4	—	3.8	.9	.9	.00	—	26	8.0	499	A
Ff 30	do	Dec. 19, 1951	412	27	—	10	4.4	136	12	308	14	.2	52	.6	.5	—	—	43	8.4	654	A
Fg 4	do	Mar. 7, 1950	439	24	79	4.5	2.4	159	10	405	3.6	—	9.8	1.4	.8	.00	—	22	8.3	712	A
Fg 40	Pleistocene (lowland)	Apr. 2, 1952	414	33	.10	57	6.9	54	6.2	20	142	.0	92	.3	3.8	.00	.0	171	6.5	646	A
Gh 1	Raritan(?)	Mar. 18, 1947	345	12	.35	1.8	.5	132	6.9	280	21	—	2.6	.9	.6	—	—	7	8.6	563	A

[1] Well screened in Aquia greensand but yielding from both aquifers.

TAB

Records of

Static water level: Reported depths are designated by "a." Water levels above land surface are recorded under "Remarks."
Pumping equipment: Method of lift: A, airlift; B, bucket; C, cylinder; I, impeller (turbine or centrifugal); J, jet; N, none; Sb,
Type of power: E, electricity; G, gasoline; H, hand.
Use of water: C, commercial or industrial; D, domestic; F, farm; I, institutional, camp, or school; M, military; N, none; P, pub

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
AA-Ac 4	Old Oak Dairy	Washington Pump & Well Co.	1945	190	Drilled	165	6	See remarks	Patapsco
Ac 8	C. E. Duckworth	Randallstown Pump & Well Co.	1945	180	do	128	6–5½–4½	do	Patuxent
Ac 11	Bituminous Construction Co.	Washington Pump & Well Co.	1948	130	do	320	6	312–320	do
Ac 14	Stanley Kulis	Layne-Atlantic Co.	1950	150	do	220	6	See remarks	do
Ac 15	Stanley I. Goddard	do	1950	180	do	273	4	do	do
Ac 21	William A. Smith	do	1950	145	do	247	6–2	do	do
Ac 23	Lycester E. Cavey	do	1952	200	do	337	4–2½	do	do
Ad 1	County Sanitary Commission	do	1926	45	do	65	18	do	Patapsco
Ad 2	do	do	1941	40	do	9.5	18–8	65–95	do
Ad 3	do	—	1927	50	do	62.5	18	See remarks	do
Ad 4	Charles S. Walton & Co., Inc.	Hosball	1919	45	do	94–126	6	—	do
Ad 5	do	do	1919	45	do	127	6	—	do
Ad 6	do	do	1919	45	do	157	6	—	do
Ad 7	do	do	1923	45	do	312	6	—	do
Ad 8	U. S. Army Ordnance Depot	—	1918	49	do	391	8–6	See remarks	Patuxent
Ad 10	do	—	1918	45	do	109	8–6	do	Patapsco
Ad 17	East Linthicum Heights	—	1909	160	do	80–90	6	—	do
Ad 20	Kavanaugh Products, Inc.	Washington Pump & Well Co.	1944	40	do	392	8	—	Patuxent
Ad 23	County Sanitary Commission	Layne-Atlantic Co.	1945	45	do	78	18 or 20	63–73	Patapsco

LE 32

selected wells

submersible; Sc, suction.

lic supply.

Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
70[a]	—	110	Jan. 9, 1946	I, E	50	—	—	C	52.5	Driller's log in Bull. 5, p. 86. 12 ft. of screen used; position unknown.
39.4	Jan. 14, 1946	—	—	I, E	—	—	—	F	—	See chemical analysis. 6 ft. of screen used; position unknown.
90[a]	Apr. 23, 1948	175[a]	Apr. 23, 1948	I, E	60	Apr. 23, 1948	0.7	N	—	See driller's log. 8 ft. of screen used; position unknown. Well destroyed.
136[a]	Jan. 23, 1950	—	—	J, E	10	Jan. 23, 1950	—	D	—	See driller's log. 10 ft. of screen used; position unknown.
—	—	168[a]	Jan. 27, 1950	C, E	10	Jan. 27, 1950	—	D	—	5 ft. of screen used; position unknown.
83.75	Apr. 9, 1950	—	—	C, E	28	Apr. 9, 1950	—	D	—	See chemical analysis. 10 ft. of screen used; position unknown.
154.3	Mar. 21, 1952	186[a]	Feb. 13, 1952	J	20	Feb. 13, 1952	—	D	—	See driller's log. 5 ft. of screen used; position unknown.
See remarks	—	25[a]	—	I, E	220–225	1943	—	P	55	See chemical analysis. Driller's log in Bull. 5, p. 86. Screen used; position and length unknown. Flowing well.
22[a]	—	54[a]	1941	I, E	280	—	—	P	55	See chemical analysis. See driller's log in Bull. 5, p. 86.
—	—	—	—	I, E	175	1943	—	P	54.5	See chemical analysis. Screen used; position and length unknown.
—	—	—	—	A	28	1942	—	C	—	See chemical analysis.
—	—	—	—	A	32	1942	—	C	—	do
—	—	—	—	A	46	1942	—	C	—	do
—	—	—	—	A	48	1942	—	C	—	do
50[a]	Nov. 1918	128[a]	1918	N	100	1918	1.3	N	—	Driller's log in Bull. 5, p. 87. Screen used; position and length unknown.
31.80	Dec. 24, 1952	—	—	N	50	1918	—	N	—	Driller's log in Bull. 5, p. 87. Screen used; position and length unknown. Observation well.
—	—	—	—	Windmill	45	—	—	N	—	See chemical analysis.
76.13	Aug. 1944	90[a]	1944	I, E	130	1944	—	C	—	Driller's log in Bull. 5, p. 88. See chemical analysis.
—	—	—	—	I, E	150	1945	—	P	—	

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
AA-Ad 29	County Sanitary Commission	Layne-Atlantic Co.	1945	35	Drilled	530	3–2	490–530	Patuxent
Ad 30	do	U. S. Geological Survey	1948	40	do	13	4	None	Patapsco
Ad 33	Adrian Hall	Crouse	1947	140	Driven	147	4	—	do
Ad 39	J. C. Howard	do	1947	140	do	178	4	—	do
Ad 40	County Sanitary Commission	Layne-Atlantic Co.	1947	45	Drilled	102	20–10	80–102	do
Ad 41	do	do	1947	40	do	153	18–8	126–146	do
Ad 43	do	do	1951	47	do	279	20–10	See remarks	Patuxent
Ad 44	do	do	1951	44	do	63	8–6	do	Patapsco
Ae 1	Armour Fertilizer Works	—	1918	10	do	350	8	—	do
Ae 2	Cooperative Fertilizer Service	Cooperative Fertilizer Service	1936	10	Dug	23	48	—	Pleistocene (lowland)
Ae 3	do	do	1936	7	Dug and drilled	65	48–6	—	Patapsco
Ae 4	U. S. Coast Guard	—	1934	22	Drilled	195	12–10–8	185–193	do
Ae 5	do	—	—	15	do	189	6	—	do
Ae 10	U. S. Army Ordnance Depot	—	1917	16	do	76	10	See remarks	do
Ae 22	Zamostny's Amoco Station	Deitz	±1937	50	do	150	6	do	do
Ae 28	Harry M. Clark	Eiler	1946	10	do	238	3–2	—	do
Bb 3	District Training School	Virginia Machinery & Well Co.	1930	150	do	240	10	See remarks	Patuxent
Bb 5	do	Washington Pump & Well Co.	1944	123	do	199	12	146–152 159–178	do
Bb 8	Maryland House of Correction	Downing	1907	225	do	675	6	—	Pre-Cambrian
Bb 18	William J. Harris	—	—	173	Dug and drilled	108	6	—	Patuxent
Bb 20	District Training School	Shannaban	—	210	Drilled	208	5	See remarks	do
Bb 22	Maryland State Fair	Layne-Atlantic Co.	1947	150	do	61	12–6	do	do
Bb 24	Mrs. Mary Bell	do	1952	295	do	180	4–2	do	do
Bb 26	U. S. Army	Bunker	1952	290	do	188	6	183–188	do

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
See remarks	Dec. 24, 1952	—	—	N	12	June 3, 1948	—	N	—	Driller's log in Bull. 5, p. 89. See chemical analysis. Observation well. Static water level 13.25 ft. above land surface, Dec. 24, 1952.
9.68	Dec. 22, 1952	—	—	N	—	—	—	N	—	Observation well.
123[a]	Oct. 31, 1947	130[a]	Oct. 31, 1947	C	8	Oct. 31, 1947	1.1	D	—	See sample-study log.
117[a]	Aug. 11, 1947	125[a]	Aug. 11, 1947	C, E	8	Aug. 11, 1947	1.0	D	—	See driller's log.
28[a]	Apr. 9, 1947	62[a]	Apr. 9, 1947	I, E	292	Apr. 9, 1947	8.6	P	—	
10[a]	June 4, 1947	68[a]	June 4, 1947	I, E	250	June 4, 1947	4.2	P	—	
20.42	Sept. 10, 1951	100[a]	Aug. 17, 1951	I, E	250	Aug. 17, 1951	—	P	—	See driller's log. Screen used; position and length unknown.
See remarks	—	—	—	I, E	100	Sept. 15, 1951	—	P	—	10 ft. of screen used; position unknown. Flowing well.
28.94	Sept. 5, 1951	—	—	A	—	—	—	C	56.5	See chemical analysis.
14.46	Aug. 24, 1943	—	—	C, E	9	Aug. 24, 1943	—	C	—	do
6.8	Aug. 24, 1943	—	—	C, E	—	—	—	C	—	do
24[a]	1941	—	—	C, E	—	—	—	N	—	Driller's log in Bull. 5, p. 90. See chemical analysis.
—	—	—	—	—	150	—	—	N	—	Driller's log in Bull. 5, p. 91.
13[a]	1918	32[a]	—	—	35	1918	1.8	N	—	Screen used; position and length unknown.
60[a]	—	—	—	C, E	—	—	—	C	—	See chemical analysis. 4 ft. of screen used; position unknown.
19[a]	June 7, 1946	21[a]	June 7, 1946	C, H	6	June 7, 1946	3.0	D	—	Driller's log in Bull. 5, p. 94.
24[a]	1943	58[a]	—	C, E	43	Sept. 1944	—	I	—	10 ft. of screen used; position unknown.
28.94	1951	—	—	I, E	53–69	—	—	I	—	See sample-study log and chemical analysis.
60[a]	—	—	—	N	50	—	—	N	—	See chemical analysis.
22.28	Dec. 19, 1952	—	—	N	—	—	—	N	—	Observation well.
80.07	Feb. 8, 1946	—	—	N	—	—	—	I	—	Driller's log in Bull. 5, p. 95. Measured depth of well, 123 ft.
1[a]	May 9, 1947	12.3[a]	May 9, 1947	I, E	60	May 9, 1947	5.3	C	—	Driller's log in Bull. 5, p. 96. 10 ft. of screen used; position unknown.
140[a]	Mar. 3, 1952	160[a]	Mar. 3, 1952	J	15	Mar. 3, 1952	.8	D	—	5 ft. of screen used; position unknown.
151[a]	Oct. 1952	174[a]	Oct. 1952	—	14	Oct. 1952	.6	M	—	See driller's log.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
AA-Bc 1	National Plastic Products Co.	Shannahan	1944	130	Drilled	175	10–8	146–166	Patapsco
Bc 20	do	do	1945	131	do	180	10–8	146–166	do
Bc 23	Lester L. Disney	Washington Pump & Well Co.	1942	165	do	175	4	See remarks	do
Bc 28	Steve Kowalski	Smith	1946	200	do	211	6	—	Patuxent
Bc 30	J. H. Otto	Crouse	1946	223	Driven	148	4	—	Patapsco
Bc 31	A. D. Riden & Co.	Washington Pump & Well Co.	1947	145	Drilled	91	6	See remarks	Patapsco-Raritan
Bc 38	Odenton Volunteer Fire Department	Layne-Atlantic Co.	1948	162	do	187	6–3	do	Patapsco
Bc 39	Century Dunbrick & Dunstone Corp.	Crouse	1947	140	Driven	152	4	—	do
Bc 40	National Plastic Products Co.	Shannahan	1947	120	Drilled	168	16–12	146–168	do
Bc 45	Roger L. Mushrush	do	1951	125	do	152	3–2	See remarks	do
Bc 47	National Plastic Products Co.	do	1950	138	do	185	18–12	153–185	do
Bd 1	Arundel Corporation	Layne-Atlantic Co.	1927	140	do	65	48	See remarks	do
Bd 2	Maryland Training School	Shannahan	1932	90	do	91	10	—	do
Bd 6	Rae	Bunker	1945	2	do	84	2	—	do
Bd 7	George B. Furman	—	—	20	do	80	—	—	do
Bd 23	County Sanitary Commission	Layne-Atlantic Co.	1948	30	do	617	4	—	Patuxent
Bd 34	Albert Green	Crouse	1948	85	Driven	64	4	—	Patapsco-Raritan
Bd 36	County Sanitary Commission	Layne-Atlantic Co.	1949	50	Drilled	123	20–10	98–123	Patapsco
Bd 37	do	do	1949	20	do	115	20–10	See remarks	do
Be 3	Jacobsville Elementary School	Washington Pump & Well Co.	1932	115	do	385	4	—	do
Be 11	Andrew and Roselle Katoski	Eiler	1945	50	do	96	4–3	—	do
Be 13	R. LeMoine	Novak	1940	26	do	232	4	—	do
Be 21	G. Bryce	Bryce	1943	0	do	150	3	—	do
Be 32	Webster Griebel	Garvan	1925	3	do	160–210	3	—	Patapsco-Raritan
Be 33	George H. Mank	do	1928	2	do	180	4	—	do
Be 36	School near Pasadena	Leatherbury	1932–3	80	do	120	6	—	do
Be 42	W. R. Young	Young	—	5	do	110±	—	—	do

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
41[a]	—	83[a]	—	I, E	280	—	—	C	—	Driller's log in Bull. 5, p. 96. See chemical analysis.
38.10	Mar. 27, 1946	94[a]	—	I, E	307	—	—	C	—	
84	Apr. 23, 1946	—	—	C, E	10	—	—	D	—	Screen used; position and length unknown.
106.31	July 24, 1946	—	—	—	—	—	—	D, F	—	Driller's log in Bull. 5, p. 97.
113[a]	Dec. 4, 1946	—	—	C, E	—	—	—	D	—	Driller's log in Bull. 5, p. 97.
30[a]	Nov. 25, 1947	50[a]	Nov. 25, 1947	C, E	15	Nov. 25, 1947	0.8	D	—	Driller's log in Bull. 5, p. 97. 5 ft. of screen used; position unknown.
69[a]	Dec. 1948	—	—	J, E	30	Dec. 1948	—	C	—	10 ft. of screen used; position unknown.
45[a]	May 3, 1947	60[a]	May 3, 1947	J, E	5	May 3, 1947	.3	C	—	
37[a]	Dec. 1947	83[a]	Apr. 17, 1950	I, E	527	Apr. 17, 1950	11.5	C	—	See driller's log and sample-study log.
44[a]	Oct. 24, 1951	70[a]	Oct. 24, 1951	J, E	9	Oct. 24, 1951	.3	D	—	5 ft. of screen used; position unknown.
50.59	Oct. 14, 1951	73.79	Oct. 14, 1951	I, E	281	Oct. 14, 1951	12.1	C	—	
—	—	—	—	—	178	1927	—	N	—	Driller's log in Bull. 5, p. 98. 18 in. of screen used; position unknown.
5[a]	1932	24[a]	1932	—	96	1932	5.1	N	—	Driller's log in Bull. 5, p. 98.
See remarks	—	—	—	I, E	6	Mar. 6, 1946	—	D	56.5	See chemical analysis. Flowing well.
do	—	—	—	N	20	—	—	D	—	do
do	1948	—	—	N	16	June 25, 1948	—	—	—	Driller's log in Bull. 5, p. 99. See chemical analysis. Flowing well. Test well.
24[a]	Apr. 5, 1948	—	—	J	5	Apr. 5, 1948	—	D	—	
3.13	July 3, 1951	70[a]	1949	I, E	439	July 3, 1951	—	P	—	
8.70	July 3, 1951	70[a]	1949	I, E	467	1949	—	P	—	25 ft. of screen; position unknown.
—	—	—	—	C, E	15	—	—	I	—	See chemical analysis.
38.72	Dec. 3, 1945	43[a]	1945	J, E	8	1945	—	D, C	—	Driller's log in Bull. 5, p. 103. See sample-study log.
24.87	Sept. 5, 1951	—	—	I, E	7	1940	—	D	—	Observation well.
See remarks	—	—	—	C, E	—	—	—	D	—	See chemical analysis. Well flows 10 gal. a min.
do	—	—	—	I, E	—	—	—	D	56.5	See chemical analysis. Well flows 3 gal. a min.
do	—	—	—	I, E	—	—	—	D	53	See chemical analysis. Well flows 4 gal. a min.
—	—	—	—	I, E	15	—	—	I	—	See chemical analysis.
See remarks	—	—	—	C, E	—	—	—	D	56	See chemical analysis. Flowing well.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
AA-Be 45	Harold Bunker	Bunker	1945	80	Drilled	67	—	See remarks	Patapsco-Raritan
Be 46	Mrs. Appleton	—	1939	65	Dug	24	48	—	Raritan
Be 48	John Reiser, Jr.	Reibold	1946	23	Drilled	254	3–2	None	Patapsco
Be 51	Charles T. Corrigan	Novak	1946	20	do	57	4	See remarks	Raritan
Be 54	R. LeMoine	—	—	26	Dug	16	36	—	do
Be 58	Maryland Department of Forests and Parks	Layne-Atlantic Co.	1947	160	Drilled	494	4–3–2	463–483	Patapsco
Be 75	Melvin Madary	Bunker	1951	104	do	79	4–2	See remarks	Patapsco-Raritan
Bf 1	Fort Smallwood	Hoshall and Shannahan	—	10	do	377	6–4½	360–377	Patapsco
Bf 2	do	Shannahan	—	10	do	378	8–6–4½	360–378	do
Bf 4	Rogers-Townsend Boat Co.	—	1936	5	do	140	2	None	do
Bf 5	E. E. Robinson	Shannahan	1926	10	do	173	6	165–173	Patapsco-Raritan
Bf 6	do	do	1926	10	do	276	8–6–4½	260–276	Patapsco
Bf 10	Southern Products Co.	do	1908	10	do	431	8	—	do
Bf 19	William L. Musch	Eiler	1946	15	do	56	3	—	Raritan
Bf 20	C. J. Mendelis	Layne-Atlantic Co.	1949	15	do	164	4.3	See remarks	Patapsco-Raritan
Cc 1	U. S. Naval Academy Dairy	Layne-Atlantic Co.	1941	160	do	408	10	—	Patapsco
Cc 2	do	Shannahan	1914	100	do	397	10–6	378–397	do
Cc 7	A. D. Riden & Co.	—	1910	80	do	300	5	—	Patuxent(?)
Cc 12	J. W. Wagner	—	±1910	210	do	92	4	—	Raritan
Cc 13	Alan E. Barton	—	—	65	Dug	14	30	—	Pleistocene (lowland)
Cc 15	Joseph Chowanetz	—	—	90	do	21	30	—	do
Cc 22	School near Conaways	Layne-Atlantic Co.	1948	120	Drilled	166	4–3	See remarks	Patapsco-Raritan
Cc 23	do	do	1949	±220	do	265	10	—	do
Cc 27	Glen F. Swank	Washington Pump & Well Co.	1946	±165	do	167	6	See remarks	Patapsco
Cd 3	Arundel High School	do	1943	110	do	146	6–2½	do	Raritan
Cd 6	M. W. Shaul	do	1946	180	do	153	6	147–153	Magothy
Cd 7	Baldwin Memorial Church	do	1946	100	do	97	6	91–97	Raritan
Cd 10	Crownsville State Hospital	Shannahan	1915	135	do	668	8–6	654–668	Patapsco
Cd 11	do	do	1930	110	do	232	20–16–10	206–226	Magothy
Cd 12	do	do	1936	110	do	230	10–8	202–227	do

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
32[a]	—	—	—	C, E	25	—	—	P	56	See chemical analysis. 10 ft. of screen used; position unknown.
18.67	Apr. 16, 1946	—	—	C, E	—	—	—	P	56	See chemical analysis.
18[a]	Apr. 17, 1946	24[a]	Apr. 17, 1946	I, E	8	Apr. 17, 1946	1.3	D	—	Driller's log in Bull. 5, p. 105.
17[a]	Apr. 1946	20[a]	Apr. 1946	J, E	10	Apr. 1946	3.3	D	—	Driller's log in Bull. 5, p. 106. 3 ft. of screen used; position unknown.
13.92	Sept. 26, 1946	—	—	N	—	—	—	N	—	Observation well.
165[a]	Oct. 15, 1947	180[a]	Oct. 15, 1947	C, E	25	Oct. 15, 1947	1.7	D	—	Driller's log in Bull. 5, p. 107.
49.58	Nov. 4, 1951	—	—	N	10	Nov. 2, 1951	—	D	—	5 ft. of screen used; position unknown.
—	—	—	—	C, E	50	—	—	P	57	See chemical analysis.
29[a]	—	59[a]	—	I, E	84	—	—	P	60	do
See remarks	—	—	—	G	—	—	—	C	58	See chemical analysis. Well flows 3 gal. a min.
15[a]	—	50[a]	—	—	50	—	—	N	—	
15[a]	—	31[a]	—	I, E	90	—	—	P	—	
4[a]	—	—	—	—	10	—	—	N	—	Driller's log in Bull. 5, p. 108.
13[a]	July 3, 1946	18[a]	July 3, 1946	J	15	July 3, 1946	3.0	D	—	Driller's log in Bull. 5, p. 110.
21[a]	Mar. 1949	—	—	J	10	Mar. 1949	—	D	—	See driller's log, 5 ft. of screen used; position unknown.
104.19	June 6, 1946	—	—	I, E	260	1941	—	C	55.5	See chemical analysis. Well filled back to 245 ft.
106.42	July 19, 1951	—	—	A	42	—	—	N	—	
7.15	Apr. 23, 1946	—	—	C, E	40–50	—	—	D	55.5	See chemical analysis.
—	—	—	—	C, E	—	—	—	D	—	do
11.03	May 6, 1946	—	—	C, E	—	—	—	D	—	do
17[a]	—	—	—	C, H	—	—	—	D	—	do
75[a]	Sept. 13, 1948	—	—	—	150	Sept. 13, 1948	—	I	—	Driller's log in Bull. 5, p. 110. 10 ft. of screen used; position unknown.
—	—	168[a]	Feb. 1949	I, G	300	Aug. 1949	—	I	—	See driller's log.
110[a]	Nov. 24, 1946	140[a]	Nov. 24, 1946	C, E	30	Nov. 24, 1946	1.0	D	—	7 ft. of screen used; position unknown.
—	—	—	—	E	—	—	—	I	—	See chemical analysis. 8 ft. of screen used; position unknown.
119[a]	Feb. 1946	140[a]	Feb. 1946	C, E	12	Feb. 1946	.6	D	—	Driller's log in Bull. 5, p. 111. See chemical analysis.
38[a]	Mar. 21, 1946	55[a]	Mar. 21, 1946	C	25	Mar. 21, 1946	1.5	I	—	Driller's log in Bull. 5, p. 111.
113.52	Dec. 22, 1952	—	—	A	175	—	—	N	—	Observation well.
79[a]	1930	106[a]	—	I, E	175	—	—	I	55.5	Driller's log in Bull. 5, p. 112. See chemical analysis.
78[a]	1936	—	—	I, E	175	—	—	I	—	Driller's log in Bull. 5, p. 113.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
AA-Cd 19	Mrs. Richard Whitall	Hagmann	1931	180	Drilled	208	6	See remarks	Magothy
Cd 21	do	do	—	100	do	55	6	—	do
Cd 23	Frank Kaczynski	Crouse	1939	65	do	107	4	None	Raritan
Cd 33	St. Stephen's Church	Bunker	1949	160	do	142	4	See remarks	Magothy
Ce 1	County Sanitary Commission	do	1933	13	do	213	8–6	do	Patapsco-Raritan
Ce 4	Charles A. Ernest	Smith	1945	5	do	106	6	—	do
Ce 10	J. H. Jacobs	—	1932	10	do	150–200	4	—	Raritan
Ce 14	Folger McKinsey	—	±1920	2	do	140	4	—	do
Ce 17	H. B. Little	Garvan	1928	1	do	220	2	—	Patapsco-Raritan
Ce 18	John Heinstadt	do	—	1	do	90	2	—	Raritan
Ce 32	Elinor Clifford	Bunker	—	13	do	512	10	—	Patapsco
Ce 33	do	do	—	5	do	200	—	—	do
Ce 34	County Sanitary Commission	Layne-Atlantic Co.	1944	5	do	165	3	See remarks	Raritan
Ce 36	L. S. Zimmerman	—	1920	3	do	100	—	—	do
Ce 37	Mrs. Elizabeth Fulton	Bunker	1941	40	do	160	4	—	do
Ce 38	W. Mentzell	—	1926	3	do	208	3	—	Patapsco-Raritan
Ce 46	Epping Forest Water Co.	Leatherbury	1931	3	do	96	8	—	Magothy
Ce 51	Mathais J. Reckenwald	Layne-Atlantic Co.	1947	40	do	60	4–2	55–60	do
Ce 52	Arnold Elementary School	do	1947	135	do	493	6–2	455–477	Patapsco-Raritan
Ce 60	Joseph Y. Dreisonstok	Crouse	1950	±80	do	243	4	See remarks	Magothy(?)
Cf 1	County Sanitary Commission	Shannahan	1923	25	do	319	10–8	299–319	Patapsco-Raritan
Cf 4	L. V. Hare	Harr	1932	10	do	205	6	None	do
Cf 11	Frank DiPaula	Bunker	1933	5	do	95	2	—	Magothy
Cf 13	Leonard Ruck	Bunker(?)	1938	10	do	±190	4	—	do
Cf 15	Labrot Estate(?)	Leatherbury	1945	3	do	280	2	See remarks	do
Cf 21	K. H. Leese	Maryland Drilling Co.	1949	±30	do	145	6	138–145	Magothy(?)

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
—	—	—	—	I, E	—	—	—	D	56	See chemical analysis. Screen used; position and length unknown.
47.80	May 6, 1946	—	—	N	—	—	—	N	—	Observation well.
—	—	—	—	H	—	—	—	D, F	57	See chemical analysis.
108[a]	Nov. 8, 1949	—	—	C, E	5	Nov. 8, 1949	—	I	—	See sample-study log. Screen used; position and length unknown.
9[a]	1933	—	—	I, E	50	—	—	P	—	See chemical analysis. 10 ft. of screen used; position unknown.
See remarks	—	8[a]	1945	I, E	15	1945	1.7	D	—	Driller's log in Bull. 5, p. 114. See chemical analysis. Well flows 5 gal. a min. Static water level: reported 1 ft. above land surface in 1945.
do	—	—	—	N	—	—	—	N	57.3	See chemical analysis. Well flows 4 gal. a min.
do	—	—	—	—	—	—	—	D	57.3	See chemical analysis. Flowing well.
do	—	—	—	C, E	—	—	—	D	57.5	See chemical analysis. Well flows 4 gal. a min.
do	—	—	—	—	—	—	—	N	58	do
do	—	—	—	Water wheel	100	—	—	D	62	See chemical analysis. Flowing well.
do	—	—	—	N	20	—	—	D	59	do
do	—	—	—	C	43	—	—	P	—	See chemical analysis. 10 ft. of screen used; position unknown. Flowing well.
do	—	—	—	C, E	—	—	—	D	57	See chemical analysis. Well flows 5 gal. a min.
70[a]	—	—	—	J, E	—	—	—	D	—	See chemical analysis.
See remarks	—	—	—	C, E	—	—	—	D	57	See chemical analysis. Well flows 4 gal. a min.
do	—	—	—	I, E	—	—	—	P	56.8	See chemical analysis. Well flows.
44[a]	Sept. 11, 1947	50[a]	Sept. 11, 1947	J, E	20	Sept. 11, 1947	3.3	D	—	Driller's log in Bull. 5, p. 116.
128[a]	Sept. 24, 1947	150[a]	Sept. 24, 1947	I, E	90	Sept. 24, 1947	4.1	I	—	do
115[a]	Aug. 15, 1951	140[a]	Aug. 15, 1951	C, E	5	Aug. 15, 1951	.2	D	—	See driller's log. Screen used; position and length unknown.
32[a]	1941	114[a]	1941	C, E	100	1941	1.2	P	—	Driller's log in Bull. 5, p. 117. See chemical analysis.
15[a]	—	—	—	C, E	25	—	—	D	56	See chemical analysis.
See remarks	—	—	—	C, E	—	—	—	D	—	See chemical analysis. Flowing well.
do	—	—	—	—	—	—	—	D	58	do
do	—	—	—	N	12	—	—	F	58.5	See chemical analysis. Flowing well. Screen used; position and length unknown.
21[a]	July 1949	71[a]	—	—	15	July 1949	—	D	—	

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
AA-Cf 22	County Sanitary Commission	Layne-Atlantic Co.	1950	23	Drilled	384	20-10-8	304-319	Patapsco-Raritan
Cf 30	Wilson K. Barnes	Bunker	1950	8	do	60	4-2	55-60	Magothy(?)
Cg 1	State Roads Commission	Leatherbury	±1941	9	do	270	3-2-1¼	See remarks	Magothy
Cg 2	do	do	±1941	9	do	138	6	do	Monmouth
Cg 4	Labrot Estate(?)	—	±1938	6	do	700(?)	—	—	Patapsco
Cg 5	do	Leatherbury	1936	7	do	300(?)	—	—	Raritan
Cg 6	Maryland Department of Public Improvements	Layne-Atlantic Co.	1949	10	do	278	6-4	258-268	Magothy
Cg 7	do	do	1950	20	do	278	6-4	258-268	do
Cg 8	do	do	1950	19	do	294	20-10-8	257-272	do
Cg 9	do	do	1950	19	do	270	4	See remarks	do
Cg 10	State Roads Commission	Shannahan	—	12	do	265	10-6	—	do
Dc 5	Edward S. Barber	Layne-Atlantic Co.	1949	165	do	263	4-2	See remarks	Raritan or Magothy
Dc 7	U. S. Army	Columbia Pump & Well Co.	1951	119	do	180	6	do	Magothy
Dd 12	Kenneth Hauer	Miller	—	40	do	45	2½	do	Monmouth
Dd 16	Davidsonville Elementary School	Layne-Atlantic Co.	1947	145	do	331	4-2	321-331	Magothy(?)
De 1	Annapolis Water Co.	do	1939	20	do	—	6	See remarks	Raritan-Magothy
De 2	do	do	1939	20	do	—	8	do	do
De 3	do	—	1930	40	do	244	—	—	Magothy
De 11	P. A. Donald	Leatherbury	1943	100	do	85	—	—	Aquia
De 12	A. J. Daniels	McKnight	—	70	do	65	2	—	do
De 20	W. M. Vickers	—	—	35	do	31	2	—	do
De 34	A. Gordon Fleet	Bunker	1941	20	do	60	3	See remarks	Aquia
De 35	George C. Meeks	Phipps	1937	10	do	81	1½	—	do
De 42	J. B. Semple, Jr.	Bunker	1941	14	do	230	6	See remarks	Magothy
De 43	Mrs. Pearl Addison	—	±1910	40	Dug	48	—	—	Aquia

—Continued

Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
18.9	Jan. 4, 1951	90[a]	1950	I, E	300	1950	—	P	—	See sample-study log.
6[a]	July 5, 1950	—	—	C, E	50	1950	—	D	—	
8.58	May 21, 1945	—	—	C, E	4	1943	—	D	—	See chemical analysis. Screen used; position and length unknown.
6.82	Jan. 8, 1946	134[a]	—	N	20	1943	—	N	—	See chemical analysis. 12 ft. of screen used; position unknown.
See remarks	—	—	—	N	—	—	—	F	58.5	Flowing well.
do	—	—	—	—	—	—	—	F	56	do
10.50	Nov. 9, 1949	80[a]	Sept. 1949	I, E	220	Sept. 1949	—	P	—	See chemical analysis.
24.4	May 15, 1951	—	—	—	—	—	—	—	—	
10.52	Mar. 15, 1950	—	—	—	—	—	—	P	—	See sample-study log.
22.7	May 15, 1951	—	—	—	—	—	—	N	—	Screen used; position and length unknown.
1.41	Apr. 24, 1951	—	—	N	—	—	—	N	—	
130[a]	Mar. 22, 1949	136[a]	Mar. 22, 1949	—	15	Mar. 22, 1949	2.5	D	—	Driller's log in Bull. 5, p. 117. 10 ft. of screen used; position unknown.
81.95	Apr. 6, 1951	104[a]	Mar. 19, 1951	I, E	47	Mar. 19, 1951	—	M	—	See sample-study log and chemical analysis. 10 ft. of screen used; position unknown.
36[a]	—	—	—	C, E	—	—	—	D	—	See chemical analysis. Screen used; position and length unknown.
105[a]	Aug. 16, 1947	115[a]	Aug. 16, 1947	I, E	20	Aug. 16, 1947	2.0	I	—	
See remarks	—	—	—	I, E	400	Apr. 1942	—	P	—	Screen used; position and length unknown. Flowing well.
do	—	—	—	I, E	2,000(?)	1942	—	P	—	do
do	—	—	—	—	—	—	—	N		Driller's log in Bull. 5, p. 118. See chemical analysis. Flowing well.
—	—	—	—	C, E	—	—	—	D	—	See chemical analysis.
40[a]	—	—	—	C, E	—	—	—	D	—	do
24.63	June 14, 1946	—	—	C, E	—	—	—	D	57	do
34.70	June 25, 1946	—	—	J, E	—	—	—	D	—	See chemical analysis. Screen used; position and length unknown.
10[a]	June 25, 1946	—	—	C, E; H	—	—	—	D	56	See chemical analysis.
See remarks	—	—	—	I, E	22	1941	—	N	61	See chemical analysis. 10 ft. of screen used; position unknown. Flowing well.
42.6	Mar. 27, 1947	—	—	C, E	—	—	—	D	53.5	See chemical analysis.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
AA-De 44	Annapolis Water Co.	Layne-Atlantic Co.	1947	20	Drilled	793	—	—	Patapsco
De 45	do	do	1947	20	do	242	20–10	192–242	Magothy
De 46	do	do	1947	20	do	248	20–10	—	do
De 47	do	do	1931	20	do	258	—	—	do
Df 3	U. S. Naval Academy	Shannahan	1910	13	do	602	12–10–8–6	See remarks	Patapsco
Df 4	do	do	1912	10	do	603	12–10–8–6	do	do
Df 5	do	—	1918	10	do	588	15–12–10	do	do
Df 6	do	—	1918	10	do	601	12–10–8	do	do
Df 7	do	—	1925	10	do	586	12½–10–8	do	do
Df 8	do	—	1925	10	do	588	12½–10–8	do	do
Df 9	do	—	1933	9	do	307	16–12–10	224–250 271–307	Raritan-Magothy
Df 10	do	Bunker	1933	9	do	350	6–4	—	do
Df 12	do	Layne-Atlantic Co.	1939	10	do	600	18	426–493	Patapsco-Raritan
Df 13	do	do	1944	14	do	606	18–8	518–588	do
Df 14	U. S. Naval Academy Rifle Range	—	1920	60	do	578	8–6–4	—	Patapsco
Df 15	U. S. Navy Experiment Station	Bunker	±1932	10	do	210	6	See remarks	Magothy
Df 16	do	Layne-Atlantic Co.	1944	10	do	597	12–8	do	Patapsco-Raritan
Df 19	U. S. Navy High Power Radio Station	—	1931	13	do	627	10–8–6	565–590	Patapsco
Df 20	do	Washington Pump & Well Co.	1933	23	do	680	10–8–6	233–253 374–394	Patapsco-Magothy
Df 58	Star Theatre	Bunker	1940	20	do	207	6	See remarks	Magothy
Df 59	U. S. Navy Experiment Station	American Drilling Co.	1947	36	do	1,000	8	None	Patapsco
Ed 8	Floyd Lankford	Leatherbury	1945	125	do	265	2	See remarks	Magothy
Ed 15	T. Clyde Collinson	do	1946	140	do	274	2	do	Aquia

—Continued

Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
—	—	—	—	—	—	—	—	N	—	Driller's log in Bull. 5, p. 118.
8[a]	Aug. 1, 1947	110[a]	Aug. 1, 1947	I, E	1,000	Aug. 1, 1947	9.8	P	—	See sample-study log.
12[a]	July 7, 1947	110[a]	July 7, 1947	I, E	1,000	July 7, 1947	10.2	P	—	Driller's log in Bull. 5, p. 119.
See remarks	—	—	—	N	—	—	—	N	—	Driller's log in Bull. 5, p. 119. See chemical analysis. Flowing well.
—	—	—	—	N	478	May 27, 1910	—	N	—	Screen used; position and length unknown.
—	—	—	—	N	300	1912	—	N	—	Driller's log in Bull. 5, p. 121. 6 ft. of screen used; position unknown.
0[a]	Sept. 11, 1918	62[a]	Sept. 11, 1918	N	748	Sept. 11, 1918	12.1	N	61	36 ft. of screen used; position unknown.
4.7[a]	Aug. 8, 1918	89.8[a]	Aug. 8, 1918	N	374	—	—	N	—	32 ft. of screen used; position unknown.
14[a]	Mar. 26, 1925	47[a]	Mar. 26, 1925	N	501	Mar. 26, 1925	15.2	N	56	Driller's log in Bull. 5, p. 122. 34 ft. of screen used; position unknown.
2[a]	June 15, 1925	41.4[a]	June 15, 1925	N	499	June 15, 1925	12.7	N	—	Driller's log in Bull. 5, p. 123. 42 ft. of screen used; position unknown.
7.5[a]	1933	—	—	I, E	—	—	—	M	—	Driller's log in Bull. 5, p. 124 See chemical analysis.
See remarks	—	—	—	—	—	—	—	N	—	Driller's log in Bull. 5, p. 125. Flowing well.
2[a]	Jan. 4, 1939	107[a]	Jan. 4, 1939	I, E	1,000	Feb. 27, 1946	—	M	—	See chemical analysis.
—	—	—	—	I, E	920	Nov. 10, 1945	—	M	—	Driller's log in Bull. 5, p. 126. See chemical analysis.
74.34	Dec. 22, 1952	—	—	N	20–30	—	—	N	—	Observation well.
See remarks	—	—	—	I, E	170	—	—	M	—	See chemical analysis. 10 ft. of screen used; position unknown. Well reported to flow 25 gal. a min.
do	—	32.2[a]	Feb. 27, 1946	I, E	620	1944	—	M	55–56	Driller's log in Bull. 5, p. 127. See chemical analysis. 142 ft. of screen used; position unknown. Static water level reported 11.9 ft. above land surface, 1946.
—	—	—	—	A	79	Mar. 11, 1931	—	M	—	Driller's log in Bull. 5, p. 127.
8[a]	1933	180[a]	1933	I, E	28	1933	.2	M	—	Driller's log in Bull. 5, p. 128.
19[a]	—	—	—	I, E	100	—	—	C	—	10 ft. of screen used; position unknown.
—	—	—	—	—	—	—	—	N	—	Driller's log in Bull. 5, p. 131.
—	—	—	—	C, E	—	—	—	F	—	See chemical analysis. Screen used; position and length unknown.
140[a]	—	—	—	C, E	—	—	—	D	—	do

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
AA-Ed 16	Francis Gardiner	Leatherbury	1947	150	Drilled	190	2	See remarks	Aquia
Ed 17	Harrison Colhoun	do	1948	165	do	222	3	do	do
Ed 19	F. M. Claggett	Washington Pump & Well Co.	1950	165	do	463	6	—	Magothy
Ed 21	Mrs. Katherine Claggett	do	1950	170	do	271	6	265–270	Aquia
Ee 4	James Stewart	do	1946	40	do	140	6	See remarks	do
Ee 6	Robert L. Forest	Layne-Atlantic Co.	1933	10	do	138	8	do	do
Ee 10	Camp Letts	Bunker	1934	5	do	72	4	None	do
Ee 12	H. R. Robey	Purner	1931	5	do	104	1½	—	do
Ae 14	A. B. Smith	Leatherbury	1941	32	do	101	2	See remarks	do
Ee 15	Mayo Elementary School	Washington Pump & Well Co.	1939	40	do	107	6	do	do
Ee 22	Murray Estate	L. Rude & Son	—	5	do	329	2½	—	Magothy
Ee 32	Hartge Yacht Yard	Purner	1935	1	do	±150	2	—	Aquia
Ee 41	James Stewart	do	1950	110	do	150	2	—	Aquia(?)
Ee 45	John Lansdale	do	1949	20	do	105	2	—	Aquia
Ef 1	A. E. Goldstein	Atwell	1926	15	do	40	1½	—	do
Ef 2	E. L. Rudd	—	1928	5	do	65	1½	—	do
Ef 3	C. L. Meredith	—	1928	7	do	61	1½	—	do
Ef 4	H. B. Stonebraker	—	—	10	do	—	—	—	—
Ef 5	do	—	—	20	Dug	44	48	—	Pleistocene (lowland)
Fc 1	Morgan B. Wayson	Leatherbury	±1940	45	Drilled	120	6	See remarks	Aquia
Fc 4	Frank C. Krauss	Purner	1940	±3	do	327	2	None	Magothy
Fc 8	American Tobacco Growers Corp.	Leatherbury	1949	±45	do	110	3	82–110	Aquia
Fd 5	Amos Moore	—	1941	145	Dug	45	48	None	Calvert
Fd 13	Southern High School	Layne-Atlantic Co.	1949	168	Drilled	575	8–6	See remarks	Magothy
Fd 16	Moreland's Service Station	—	—	170	Dug	30	—	—	Pleistocene (upland)
Fe 3	Camp Kahlert	Crandall (?)	1925	7	Drilled	150(?)	1½	—	Aquia

—*Continued*

Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
—	—	—	—	C, E	5	Mar. 24, 1948	—	D	53	Driller's log in Bull. 5, p. 132. See chemical analysis. Screen used; position and length unknown.
140[a]	Apr. 1948	—	—	C, E	4	Apr. 1948	—	D	—	See sample-study log. Screen used; position and length unknown.
150[a]	Apr. 10, 1950	217[a]	Apr. 10, 1950	C, E	45	Apr. 10, 1950	0.7	D	—	
137.13	Oct. 3, 1950	200[a]	Aug. 4, 1950	C, E	6	Aug. 4, 1950	—	D	—	See driller's log.
40[a]	Apr. 20, 1946	120[a]	Apr. 20, 1946	C, E	20	Apr. 20, 1946	.3	D	—	Driller's log in Bull. 5, p. 132. 7 ft. of screen used; position unknown.
13[a]	—	—	—	I, E	210	—	—	D, F	55	See chemical analysis. 8 ft. of screen used; position unknown.
5[a]	—	—	—	I, E	50	—	—	I	58.5	See chemical analysis.
—	—	—	—	C, E; H	—	—	—	D	57	do
22.05	Dec. 9, 1948	—	—	N	—	—	—	N	—	Screen used; position and length unknown. Observation well.
39[a]	1939	61[a]	1939	C, E	20	1939	1.0	I	—	Driller's log in Bull. 5, p. 132. 12 ft. of screen used; position unknown.
See remarks	—	—	—	N	15	—	—	N	60	See chemical analysis. Flowing well.
do	—	—	—	C, E	—	—	—	C	59	do
80-90[a]	Feb. 1950	111[a]	Feb. 1950	J, E	—	—	—	D	—	
24[a]	Oct. 1949	30[a]	Oct. 1949	H	3	—	—	D	—	
15.11	June 18, 1946	—	—	C, E	—	—	—	D	—	
5[a]	—	—	—	C, E; H	—	—	—	D	57	See chemical analysis.
6.06	Dec. 22, 1952	—	—	N	—	—	—	N	—	Observation well.
—	—	—	—	C, E	—	—	—	—	—	See chemical analysis.
18	June 29, 1946	—	—	J, E	—	—	—	D	—	do
34[a]	—	—	—	C, E	—	—	—	C, D	—	See chemical analysis. Screen used; position and length unknown.
See remarks	—	—	—	Ram	9	—	—	D	60	See chemical analysis. Flowing well.
36[a]	May 1949	65[a]	May 1949	E	4	May 1949	.1	C	—	See driller's log.
15[a]	—	—	—	C, E	—	—	—	D	—	
139.12	Aug. 22, 1951	—	—	I, E	75	1951	—	I	—	Sample-study log in Bull. 5, p. 138. See chemical analysis. 20 ft. of screen used; position unknown.
—	—	—	—	Sc	—	—	—	D	—	See chemical analysis.
See remarks	—	—	—	N	—	—	—	N	60.5	Flowing well.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
AA-Fe 8	Franklin Thomas	Leatherbury	1935	±5	Drilled	±400	4	—	Magothy
Fe 14	R. T. Brooke	Wilde	1926	4	do	156	2	None	Aquia
Fe 30	William M. Myers	Phipps	1949	±5	do	150	1¼	—	do
Fe 31	Walter Bauman	Wilde	1947	±10	do	180	1½	—	do
Fe 35	D. M. Grady	Leatherbury	1950	60	do	235	6–3	See remarks	do
Ge 2	J. E. Rose	Washington Pump & Well Co.	1948	5	do	325	8	do	do
Bal-Gc 1	Calvert Distilling Co.	Ranney Water Well Co.	1942	20	do	33	—	—	Pleistocene (lowland)
1S4E-19	Crown Cork & Seal Co.	Layne-Atlantic Co.	1945	—	do	—	—	219–237	Patuxent
3S5E-32	Chemical & Pigment Co.	Shannahan	1948	15	do	359	16–10	311–348	do
5S3E-12	U. S. Industrial Chemical Co.	do	1938	20	do	282	—	259–282	do
5S3E-46	do	do	1945	20	do	364	—	—	do
2S1W-35	Read Drug Co.	Maryland Drilling Co.	1952	15	do	87	10	44–75	do
Cal-Bb 1	Gorman Lyons	—	—	144	Dug	44	48	—	Pleistocene (upland)
Bb 6	G. Smith	—	—	140	do	25	—	—	do
Bb 9	Earl Hicks	Ward	1950	130	Drilled	285	2½	None	Aquia
Bb 10	Mount Hope Elementary School	Layne-Atlantic Co.	1951	189	do	720	10–6	See remarks	Magothy
Bc 7	Charles Buckmaster	Ward	1948	104	do	260	2½	None	Nanjemoy
Bc 9	U. S. Navy	WashingtonPump & Well Co.	1944	0	do	335	6	—	Aquia
Bc 12	Mrs. Joseph Cox	Leatherbury	1949	100	do	252	2	None	Nanjemoy
Bc 13	Roger Norfolk	Ward	1951	132	do	294	2½	—	do
Bc 14	Archie Norfolk	do	1951	149	do	315	2½	—	do
Bc 15	Mrs. Joseph I. LaSalle	do	1951	6	do	210	1½	None	do
Bc 17	—	—	—	4	do	147(?)	3(?)	—	Nanjemoy(?)
Ca 2	Y.M.C.A. of Baltimore	Shannahan	1949	23	do	468	6	—	Aquia

—Continued

Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
See remarks	—	—	—	N	—	—	—	N	60	See chemical analysis. Well flowed 18.75 gal. a min., July 29, 1946.
do	—	—	—	I, E	—	—	—	D	59	See chemical analysis. Flowing well.
3[a]	Dec. 1949	8[a]	Dec. 1949	C, H	5	Dec. 1949	1.0	D	54	See sample-study log and chemical analysis.
5[a]	May 1947	—	—	C	6	May 1947	—	D	—	
26[a]	Nov. 3, 1950	—	—	J	9	Nov. 3, 1950	—	F	—	46 ft. of screen used; position unknown.
2[a]	Feb. 25, 1948	210[a]	Feb. 25, 1948	I, E	125	Feb. 25, 1948	.6	P	61.5	Driller's log in Bull. 5, p. 136. See chemical analysis. 12 ft. of screen used; position unknown.
—	—	24.07	Oct. 6, 1943	I, E	1,000	—	—	C	63.5	
—	—	—	—	—	—	—	—	—	—	See driller's log.
85[a]	Jan. 1948	96[a]	Jan. 1948	—	80	Jan. 1948	7.3	C	—	do
112[a]	1938	192[a]	1938	I, E	500	1938	6.3	C	—	Driller's log in Bull. 4, p. 339.
—	—	—	—	—	—	—	—	C	—	See driller's log.
21[a]	Oct. 16, 1952	35[a]	Oct. 16, 1952	—	130	Oct. 16, 1952	9.3	C	—	
19.02	Dec. 22, 1952	—	—	C, H	—	—	—	D	56.5	See chemical analysis. Observation well.
21.20	Apr. 5, 1949	—	—	—	—	—	—	N	—	See chemical analysis.
120[a]	May 20, 1950	—	—	C, E	4	May 20, 1950	—	D	—	Sample-study log in Bull. 8, p. 53. See chemical analysis.
167[a]	Dec. 4, 1951	270[a]	Dec. 4, 1951	S	30	Dec. 4, 1951	.3	I	—	See sample-study log and chemical analysis. 15 ft. of screen used; position unknown.
95[a]	Oct. 1948	100[a]	Oct. 1948	C, E	3	Oct. 1948	.6	D	—	Driller's log in Bull. 8, p. 43.
See remarks	—	—	—	I, E	60	—	—	M	—	See driller's log and chemical analysis. Well flowed about 10–15 gal. a min., July 19, 1950.
103[a]	July 29, 1949	120[a]	July 29, 1949	C, E	4	July 29, 1949	.2	D	—	
110[a]	Apr. 4, 1951	—	—	C, E	4	Apr. 1951	—	D	—	See driller's log.
115[a]	Apr. 5, 1951	118[a]	Apr. 5, 1951	C, E	5	Apr. 5, 1951	1.7	D	—	See sample-study log.
See remarks	—	—	—	N	10	—	—	D	—	Well flowed about 1–2 gal. a min., Apr. 4, 1951.
do	—	—	—	N	—	—	—	N	—	Static water level 2.78 ft. above land surface, Apr. 10, 1951.
do	—	23[a]	Nov. 8, 1949	I	53	Nov. 1949	—	I	63	Sample-study log in Bull. 8, p. 55. See chemical analysis. Well flowed 6 gal. a min., Nov. 27, 1949.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
Cal-Cb 4	J. Armiger	—	±1944	150	Dug	31	—	—	Pleistocene (upland) (?)
Cb 9	B. A. Garner	Ward	±1940	15	Drilled	235	2	—	Nanjemoy
Cc 1	William E. Day	Leatherbury	1947	8	do	211	2	None	do
Cc 2	do	do	1947	8	do	211	2	do	do
Cc 5	B. Trosell	do	1948	8	do	210	2	do	do
Cc 6	A. Seller	do	1947	8	do	210	2	do	do
Cc 17	U. S. Navy	—	1948	112	do	472	6	—	Aquia
Cc 18	do	Columbia Pump & Well Co.	—	104	do	476	4	462–476	do
Cc 19	do	Washington Pump & Well Co.	1941	96	do	462	6	448–462	do
Cc 26	Charles M. Cassidy Co.	Leatherbury	1949	8	do	210	2	None	Nanjemoy
Cc 27	do	do	1949	8	do	210	2	do	do
Cc 28	J. Cranston	Ward	1949	47	do	273	2½	do	do
Cc 37	Otis L. Evans	do	1950	120	do	330	2½	—	do
Db 3	Mrs. V. P. Virts	L. Rude & Son	1948	19	do	419	2½	See remarks	Aquia
Db 5	Calvert County Courthouse	Washington Pump & Well Co.	1944	147	do	552	8	—	do
Db 6	G. Denton	—	—	158	Dug	23	—	—	Pleistocene (upland)
Db 18	Maryland National Guard	Layne-Atlantic Co.	1951	122	Drilled	637	4–2	See remarks	Aquia
Db 19	State Roads Commission	L. Rude & Son	1951	20	do	390	2½–1½	do	do
Db 21	Calvert County Hospital	Washington Pump & Well Co.	1952	130	do	540	6	526–540	do
Dc 16	G. F. Gravatt	Columbia Pump & Well Co.	1947	96	do	360	6	do	Nanjemoy
Dc 17	A. Goldstein	L. Rude & Son	1947	147	do	555	3–1½	do	Aquia
Dc 18	do	—	—	147	Dug	26	—	—	Pleistocene (upland) (?)
Dc 26	Brooks High School	Washington Pump & Well Co.	1951	142	Drilled	563	6–5½	553–563	Aquia
Dc 27	John P. Broome	Ward	1951	140	do	440	2½	—	Nanjemoy-Piney Point

—Continued

Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
18.87	Apr. 6, 1949	—	—	—	—	—	—	D	—	Observation well.
do	—	—	—	C, E	16	—	—	D	—	See chemical analysis. Static water level: 14.2 ft. above land surface, Apr. 11, 1951.
do	—	8[a]	Nov. 6, 1947	Sc	8	Nov. 6, 1947	0.9	D	—	Sample-study log in Bull. 8, p. 58. Static water level reported 1 ft. above land surface, Nov. 6, 1947.
do	—	8[a]	Nov. 8, 1947	Sc	8	Nov. 8, 1947	.9	D	—	Static water level reported 1 ft. above land surface, Nov. 8, 1947.
1[a]	Apr. 14, 1948	14[a]	Apr. 14, 1948	Sc	10	Apr. 14, 1948	.7	D	—	Driller's log in Bull. 8, p. 44.
0[a]	Apr. 8, 1947	12[a]	Apr. 8, 1947	Sc	10	Apr. 8, 1947	.8	D	—	do
—	—	—	—	I, E	25	July 1950	—	M	—	See chemical analysis.
—	—	160[a]	—	I, E	25	—	—	—	—	do
98[a]	June 1944	160[a]	June 1944	I, E	25	July 1950	—	—	—	do
1[a]	Feb. 16, 1949	12[a]	Feb. 16, 1949	Sc	10	Feb. 16, 1949	.9	D	—	Driller's log in Bull. 8, p. 44
1[a]	Feb. 18, 1949	12[a]	Feb. 18, 1949	Sc	10	Feb. 18, 1949	.9	D	—	do
32.46	June 20, 1949	—	—	C	3	July 1949	—	C, D	—	Sample-study log in Bull. 8, p. 60. See chemical analysis.
105[a]	Nov. 1950	—	—	C, E	3	Nov. 1950	—	D	—	See sample-study log.
1.55	Apr. 17, 1951	10[a]	1948	Sc	10	1948	—	D	—	See chemical analysis. 10 ft. of screen used; position unknown.
120[a]	—	240[a]	—	I, E	75	—	—	P	—	See chemical analysis.
12.84	Apr. 6, 1949	—	—	B	—	—	—	D	—	do
122.58	Apr. 18, 1951	—	—	—	—	—	—	M	—	See driller's log. 10 ft. of screen used; position unknown.
See remarks	—	—	—	Sc, E	45	Sept. 1951	—	D(?)	—	See driller's log. 24 ft. of screen used; position unknown. Flowing well.
135[a]	Apr. 1952	210[a]	Apr. 1952	C	75	Apr. 1952	1.0	I	—	
73.22	May 6, 1947	150[a]	May 15, 1947	—	40	May 15, 1947	—	P	—	10 ft. of screen used; position unknown.
130[a]	July 15, 1947	—	—	C	—	—	—	D	—	Sample-study log in Bull. 8, p. 65. 12 ft. of screen used; position unknown.
19.27	Dec. 22, 1952	—	—	H	—	—	—	N	—	Observation well.
135[a]	May 5, 1951	190[a]	May 5, 1951	C	65	May 5, 1951	1.2	I	—	See driller's log.
120[a]	Mar. 16, 1951	127[a]	Mar. 16, 1951	C, E	4	Mar. 16, 1951	.6	D	—	do

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
Cal-Eb 2	L. S. Bowen	—	1943	110	Dug	54	—	—	Pleistocene (upland)(?)
Eb 4	H. A. Crane	Ward	1950	20	Drilled	399	2½	—	Aquia-Nanjemoy
Ec 1	George W. Dorsey	do	±1920	1	do	225	—	—	Nanjemoy
Ec 3	H. B. Trueman Lumber Co.	Columbia Pump & Well Co.	1946	109	do	345	6	See remarks	Nanjemoy-Piney Point
Ec 4	Mrs. W. W. Ross	—	±1903	173	Dug	53	—	—	Pleistocene (upland)(?)
Ec 6	Benjamin Parran	Leatherbury	1947	26	Drilled	233	3–2	None	Nanjemoy-Piney Point
Ec 8	S. L. Barnett	Ward	1948	10	do	273	1½	—	do
Ec 19	Sam Bauman	Leatherbury	1951	18	do	251	3–2	—	do
Ed 1	Y.M.C.A. Camp Conoy	Shannahan	1931	62	do	540	6–4½–3	520–540	Aquia
Ed 6	Robert C. Hall	L. Rude & Son	1948	3	do	274	2½	None	Nanjemoy
Fd 1	U. S. Navy	Washington Pump & Well Co.	1942	21	do	500	8–6	477–500	Aquia
Fd 3	D. Barrett	L. Rude & Son	±1932	3	do	362(?)	1½	None	Nanjemoy-Piney Point
Fd 4	G. D. Wait	Leatherbury	1947	28	do	252	2	—	do
Fd 5	Harry B. Richardson	L. Rude & Son	1946	29	do	325	3–2½	None	do
Fd 7	Benjamin Dowell	do	1946	18	do	320	2½	do	do
Fd 14	W. B. Glascock	do	—	1	do	—	1½	—	Eocene
Fd 19	Duke Adams	do	1947	28	do	300	2½	None	Nanjemoy-Piney Point
Fd 22	William Rekar	do	1948	136	do	461	3	do	do
Fd 26	Alec Barrett	—	—	25	Dug	22	—	—	Pleistocene (lowland)
Fd 31	Sarah C. Glascock	L. Rude & Son	1949	18	Drilled	320	5–3½	None	Nanjemoy-Piney Point
Fe 2	Irene Michitoff	do	1946	5	do	315	2½	do	do
Fe 3	Edgar Bowen	do	1946	130	do	525(?)	3	do	do
Fe 4	Olga Morosoff	do	1946	5	do	320	2½	do	do
Fe 5	Serge G. Koushnareff	do	1946	5	do	320	2½	do	do
Fe 10	Mrs. L. G. Tomptson	do	1948	5	do	375	2½	do	do
Gd 3	U. S. Navy	Washington Pump & Well Co.	1942	19	do	247	6	234–247	do

—*Continued*

Water level (feet below land surface): Static	Water level: Date	Water level: Pumping	Water level: Date	Pumping equipment	Yield: Gallons a minute	Yield: Date	Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
36.70	Apr. 7, 1949	—	—	B	—	—	—	D	—	
10[a]	May 30, 1950	—	—	Sc, E	4	May 30, 1950	—	D	—	
See remarks	—	—	—	N	—	—	—	—	60	See chemical analysis. Well flowed 5 gal. a min., Jan. 13, 1947.
125[a]	Dec. 18, 1946	150[a]	Dec. 18, 1946	I, E	60	Dec. 18, 1946	1.2	C	—	Sample-study log in Bull. 8, p. 71. See chemical analysis. Screen used; position and length unknown.
43.76	Dec. 22, 1952	—	—	E	—	—	—	D	—	Observation well.
28[a]	Apr. 17, 1947	60[a]	Apr. 17, 1947	C, E	3	Apr. 17, 1947	.1	F	—	Driller's log in Bull. 8, p. 45.
5[a]	1948	20[a]	1948	Sc, E	15	1948	1.0	D	—	do
11.75	June 20, 1951	—	—	Sc	9	June 7, 1951	—	D	—	See sample-study log.
30[a]	—	—	—	C, E	10	June 10, 1944	—	I	—	Driller's log in Bull. 8, p. 46. See chemical analysis.
See remarks	—	—	—	H	50	1948	—	D	—	Sample-study log in Bull. 8, p. 76. Static water level 3.56 ft. above land surface, Apr. 18, 1951.
10.13[a]	1942	161.37[a]	1942	I, E	125	1942	.8	M	—	See chemical analysis.
See remarks	—	20[a]	July 17, 1946	Sc, E	—	—	—	C	—	See chemical analysis. Well flowed ¼ gal. a min. Jan. 13, 1947.
28[a]	Apr. 2, 1947	40[a]	Apr. 2, 1947	C	3	Apr. 2, 1947	.3	D	—	Sample-study log in Bull. 8, p. 78.
20.59	Jan. 13, 1947	—	—	C, E	10	Aug. 17, 1946	—	D	—	Sample-study log in Bull. 8, p. 79.
25[a]	Sept. 3, 1946	—	—	J	—	—	—	C	—	Sample-study log in Bull. 8, p. 81.
6.33	Dec. 22, 1952	—	—	N	—	—	—	N	—	Observation well.
25[a]	June 6, 1947	—	—	J	25	June 6, 1947	—	D	—	Sample-study log in Bull. 8, p. 84.
135[a]	June 1948	—	—	—	5	1948	—	D	—	Sample-study log in Bull. 8, p. 86.
12.85	May 20, 1949	—	—	—	—	—	—	D	—	
20[a]	Apr. 20, 1949	47[a]	Apr. 20, 1949	C	20	Apr. 20, 1949	1.1	C	—	
5[a]	July 20, 1946	17[a]	July 20, 1946	Sc	20	July 20, 1946	1.7	D	—	Sample-study log in Bull. 8, p. 89.
145[a]	Apr. 15, 1946	150[a]	Apr. 15, 1946	C	10	Apr. 15, 1946	2.0	D	—	
5[a]	Aug. 13, 1946	15[a]	Aug. 13, 1946	Sc	20	Aug. 13, 1946	2.0	D	—	Driller's log in Bull. 8, p. 48.
5[a]	Aug. 9, 1946	15[a]	Aug. 9, 1946	Sc	20	Aug. 9, 1946	2.0	D	—	do
6[a]	1948	20[a]	1948	Sc	10	1948	.7	D	—	
20[a]	June 19, 1942	70[a]	June 19, 1942	I, E	50	June 19, 1942	1.0	M	—	

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
Cal-Gd 4	U. S. Navy	Washington Pump & Well Co.	1942	15	Drilled	251	8	236–251	Nanjemoy-Piney Point
Gd 5	do	do	1942	10	do	248	8	233–248	do
Gd 6	do	do	1942	10	do	493	8–6	469–493	Aquia
Gd 7	do	Layne-Atlantic Co.	1943	17	do	570	10–8	504–519 531–541	do
Gd 9	Mrs. Sadie Webster	L. Rude & Son	1946	7	do	320	2½	None	Nanjemoy-Piney Point
Gd 20	G. Francis Beavan	—	1944	15	Driven	13	—	—	Pleistocene (lowland)
Gd 22	Esso Standard Oil Co.	—	—	1	Drilled	320	3	—	Nanjemoy-Piney Point
Gd 30	Joseph Lore	L. Rude & Son	1948	5	do	315	5–3½	None	do
Gd 34	Drum Point Beach Cooperative	Washington Pump & Well Co.	1949	30	do	285	8	273–285	Piney Point
Gd 36	U. S. Navy	do	1944	16	do	505	8–6	See remarks	Aquia
Gd 43	Taylor	—	—	33	do	—	3	—	—
Ch-Ac 2	U. S. Navy	Ranney Collector Well Co.	—	20	do	68	—	—	Pleistocene (lowland)
Bb 1	do	—	1899–1910	29	do	388	8	177–189; 302–316; 343–359	Patuxent-Patapsco
Bb 2	do	—	1899–1910	27	do	409	8	180–199; 266–306; 342–363	do
Bb 3	do	—	1899–1910	33	do	432	8	—	do
Bb 4	do	—	1910	34	do	394	8	231–242; 278–289; 331–347; 351–360	do
Bb 5	do	—	1910	43	do	395	8	228–238; 277–289; 338–348	do
Bb 6	do	—	1915	38	do	398	8	213–223; 263–273; 338–359	do
Bb 7	do	—	1915	39	do	419	8	216–226; 269–278; 338–360	do
Bb 8	do	—	1915	36	do	397	8	187–195; 226–237; 274–285; 336–358	do
Bb 9	do	—	1915	32	do	390	8	153–163; 203–213; 252–262; 323–344	do

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
44[a]	Sept. 14, 1944	129[a]	Sept. 14, 1944	I, E	100	1944	—	M	59	Driller's log in Bull. 8, p. 49. See chemical analysis.
19.21	Dec. 22, 1952	85.6[a]	1942	I, E	110	1942		N	59	Observation well.
29.67	Dec. 22, 1952	63.5[a]	1942	I, E	135	1942	—	N	65.5	See chemical analysis. Observation well.
70[a]	Feb. 2, 1944	139[a]	Feb. 2, 1944	I, E	300	Feb. 2, 1944	4.3	M	—	
16[a]	May 3, 1946	19[a]	May 3, 1946	Sc	10	May 3, 1946	3.3	D	—	Driller's log in Bull. 8, p. 50.
13.9	Apr. 23, 1947	—	—	—	—	—	—	N	—	
14.29	Dec. 22, 1947	—	—	Sc	—	—	—	C	—	Observation well.
16[a]	1948	—	—	C	50	1948	—	C	—	Sample-study log in Bull. 8, p. 92.
45[a]	May 10, 1949	160[a]	May 10, 1949	C	180	May 10, 1949	1.6	P	—	Driller's log in Bull. 8, p. 52.
—	—	—	—	I, E	—	—	—	M	—	Driller's log in Bull. 8, p. 52. See chemical analysis. 23 ft. of screen; position unknown.
37.38	May 5, 1951	—	—	C, E	—	—	—	D	—	
—	—	—	—	I, E	200-350	Mar. 3, 1945	—	M	—	
—	—	220[a]	Mar. 5, 1945	I, E	—	—	—	M, P	—	See chemical analysis.
—	—	—	—	A	70	Dec. 1944	—	M, P	—	
180.94	Apr. 18, 1952	—	—	N	—	—	—	N	—	
—	—	—	—	A	80	Dec. 1944	—	M, P	—	do
—	—	—	—	I, E	—	—	—	M, P	—	
—	—	220[a]	Mar. 1945	I, E	—	—	—	M, P	—	do
—	—	—	—	I, E	120	Mar. 5, 1945	—	M, P	—	
—	—	—	—	I, E	155	Mar. 5, 1945	—	M, P	—	do
—	—	—	—	I, E	110	Dec. 1945	—	M, P	—	See driller's log.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
Ch-Bb 10	U. S. Navy	—	—	32	Drilled	1,200	—	—	Pre-Cambrian
Bb 11	do	Washington Pump & Well Co.	1952	80	do	258	8	242–250	Patuxent(?)
Bc 1	do	—	1918	14	do	396	8	—	Patuxent-Patapsco
Bc 2	do	—	1918	—	do	409	8	—	do
Bc 3	do	—	1918	—	do	390	8	—	do
Bc 4	do	—	1918	—	do	393	8	—	do
Bc 5	do	—	1918	—	do	430	8	—	do
Bc 6	Indian Head Defense Housing Project	Layne-Atlantic Co.	1941	65	do	412	18–8	362–412	do
Bc 10	Mrs. Louise Brown	—	1919	125	Dug	39	36	—	Pleistocene (upland)
Bc 12	Ford's Wonder Bar	Columbia Pump & Well Co.	1949	145	Drilled	234	6	None	Magothy
Bc 13	Aubrey W. Posey	do	1951	130	do	260	6	—	Raritan(?)
Bc 15	U. S. Navy	Washington Pump & Well Co.	1952	80	do	542	8	263–279 347–378	Patuxent
Bc 16	do	do	1952	80	do	450	8	345–361	do
Bd 11	School at Pomonkey	Columbia Pump & Well Co.	1950	180	do	269	6	259–269	Magothy
Bd 13	Peter Pfisterer	Seek	1951	140	do	200	6	—	Aquia(?)
Be 13	Middletown School (abd.)	—	±1900	200	Dug	—	36	—	Pleistocene (upland)
Bf 2	Maryland State Police	—	1934	222	do	18	54	—	do
Bf 5	do	Columbia Pump & Well Co.	1947	215	Drilled	440	6	See remarks	Magothy
Bf 15	L. L. Parlett	Washington Pump & Well Co.	1946	215	do	392	6	381–392	Monmouth or Aquia
Bf 92	Dr. Pepper Bottling Plant	Columbia Pump & Well Co.	1948	210	do	381	6	See remarks	Monmouth
Bf 93	Waldorf Motor Court	Washington Pump & Well Co.	1952	205	do	480	6	do	Magothy
Bg 5	Malcolm Elementary School	—	—	205	Dug	±25	42	—	Pleistocene (upland)
Cb 6	Norment Alden	Layne-Atlantic Co.	1951	40	Drilled	208	4–2	See remarks	Patapsco
Cb 7	U. S. Navy	Washington Pump & Well Co.	1952	36	do	400	8–6	144–167	Patuxent
Cc 5	Miriam Scott	Seek	1950	170	do	274	5	—	Patapsco(?)

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
—	—	—	—	N	—	—	—	N	—	Log p. 171, Charles County report, Well 17. Well now covered by road.
120.12	Apr. 18, 1952	—	—	—	—	—	—	N	—	Unsuccessful well.
151.34	Apr. 18, 1952	—	—	N	—	—	—	N	—	
—	—	—	—	I, E	—	—	—	M, P	—	
—	—	—	—	I, E	—	—	—	M, P	—	See chemical analysis.
—	—	—	—	I, E	—	—	—	M, P	—	
—	—	—	—	I, E	—	—	—	M, P	—	do
174.5[a]	1945	238.5[a]	1945	I, E	385	1941	—	P	—	See driller's log.
30.67	Dec. 18, 1952	—	—	B	—	—	—	D	—	Observation well.
125[a]	Oct. 4, 1949	160[a]	Oct. 4, 1949	C, E	12	Oct. 4, 1949	0.3	C	—	See sample-study log and chemical analysis.
120[a]	Aug. 24, 1951	140[a]	Aug. 24, 1951	J, E	10	Aug. 24, 1951	.5	D	—	
156.96	Apr. 18, 1952	—	—	—	25	—	—	—	—	See driller's log.
—	—	—	—	—	—	—	—	N	—	Well destroyed.
150[a]	Nov. 6, 1950	210[a]	Nov. 6, 1950	C	25	Nov. 6, 1950	.4	I	—	See sample-study log.
47[a]	May 5, 1951	198[a]	May 5, 1951	C	3	May 5, 1951	.02	D	—	See driller's log.
—	—	—	—	H	—	—	—	N	—	See chemical analysis.
15.45	Dec. 18, 1952	—	—	N	—	—	—	N	—	Observation well.
175[a]	Oct. 6, 1947	—	—	C	40	1947	—	D	—	Sample-study log, p. 108, Charles County report. See chemical analysis. 12 ft. of screen used; position unknown.
155.7	Aug. 30, 1946	187[a]	Sept. 25, 1946	C, E	50	Sept. 25, 1946	1.8	D	—	Sample-study log, p. 117, Charles County report. See chemical analysis.
150[a]	Mar. 18, 1948	—	—	I, E	50	1948	—	C	—	See driller's log. 12 ft. of screen used; position unknown.
155.5[a]	May 16, 1952	225.5[a]	May 16, 1952	—	70	1952	—	C	—	See driller's log. 5½ ft. of screen used; position unknown.
—	—	—	—	C, H	—	—	—	I	—	See chemical analysis.
35[a]	May 1, 1951	41[a]	May 1, 1951	C	35	May 1, 1951	5.8	D	—	See driller's log. 5 ft. of screen used; position unknown.
67[a]	Mar. 3, 1952	140[a]	Mar. 3, 1952	—	152	Feb. 1952	—	N	—	See driller's log.
68[a]	Nov. 24, 1950	—	—	C	8	Nov. 24, 1950	—	D	—	See sample-study log and chemical analysis.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
Ch-Cd 7	Hawthorne Country Club	Washington Pump & Well Co.	1948	160	Drilled	565	6	554–565	Patapsco
Cd 9	Port Tobacco Elementary School	do	1952	149	do	423	6	416–423	Raritan
Cd 10	J. Johnson	—	—	170	Dug	20	36	—	Pleistocene (upland)
Cd 12	John H. Mitchell	Wilson	1952	64	Drilled	420	2–1½	240–260; 400–420	Raritan(?) or Aquia
Ce 3	Town of La Plata	Sydnor Pump & Well Co.	1930	193	do	650	10	—	Patapsco-Raritan
Ce 6	U. S. Army	—	—	196	do	443	8–6	—	Monmouth
Ce 8	Town of La Plata	Sydnor Pump & Well Co.	1947	160	do	1,094	10–8–6	See remarks	Potomac group
Ce 14	Parkway Texaco Station	—	1949	195	Dug	24	36	—	Pleistocene (upland)
Ce 15	Parkway Tourist Center	Columbia Pump & Well Co.	1950	190	Drilled	415	6	See remarks	Patapsco-Raritan
Ce 16	Town of La Plata	Sydnor Pump & Well Co.	1950	185	do	608	8–6	583–598	do
Cf 9	St. Marys Church	Layne-Atlantic Co.	1949	185	do	679	6–3	630–649	do
Cg 1	Southern Maryland Electric Cooperative	Columbia Pump & Well Co.	1946	179	do	548	6	See remarks	Aquia
Da 1	E. Sullivan	Wilson	1947	28	do	210	3½–2½–1½	—	Patapsco-Raritan
Db 7	Mount Hope Elementary School	—	—		Dug	±35	—	—	Pleistocene (upland)
Dc 2	Bernward C. Juhle	—	±1900	120	do	39	48	—	do
Dd 3	Jesuit Missionary Order	—	1910	20	do	26	36	—	Pleistocene (lowland)
Dd 5	do	—	—	20	Drilled	212	1½	—	Aquia
Dd 6	Roy Greer	—	±1920	145	Dug	25	36	—	Pleistocene (upland)
Dd 10	Paul Nitze	Columbia Pump & Well Co.	1950	120	Drilled	414	6	—	Patapsco-Raritan
Dd 11	St. Ignatius Church	Payne	1950	20	do	210	2½	See remarks	Aquia
Dd 12	Grimes	—	—	20	Dug	34	—	—	Pleistocene (lowland)
De 1	Southern Maryland Cleaners	Columbia Pump & Well Co.	1947	165	Drilled	632	6	512–519	Patapsco or Raritan

—*Continued*

Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
165[a]	Sept. 22, 1948	265[a]	Sept. 22, 1948	I, E	35	Sept. 1948	0.4	D	—	See driller's log and chemical analysis.
130[a]	May 28, 1952	334[a]	May 28, 1952	—	40	May 28, 1952	.2	I	—	See driller's log.
—	—	—	—	Sc, E	—	—	—	D	—	See chemical analysis.
4.67	June 12, 1952	43[a]	June 3, 1952	—	10	June 3, 1952	.4	D	—	See driller's log.
190[a]	—	—	—	I, E	40	—	—	P	—	See chemical analysis.
—	—	—	—	I, E	—	—	—	M	—	See driller's log and chemical analysis.
135[a]	Nov. 19, 1947	420[a]	Nov. 19, 1947	I, E	100	Nov. 19, 1947	.4	P	—	Sample-study log, p. 104, Charles County report. 24 ft. of screen used; position unknown.
13.10	Apr. 10, 1950	—	—	E	—	—	—	C	—	See chemical analysis. Well may be abandoned.
142.6	July 20, 1950	240[a]	July 24, 1950	—	40	July 1950	.4	C	—	See sample-study log. 10 ft. of screen used; position unknown.
190[a]	Oct. 30, 1950	210[a]	Nov. 1950	Sb, E	60	Nov. 1950	—	P	—	See driller's log.
130[a]	Apr. 1949	—	—	I, E	50	Apr. 1949	—	I	—	See driller's log and chemical analysis.
140.58	Nov. 11, 1946	300[a]	Oct. 28, 1946	C	50	Oct. 28, 1946	—	C	—	Sample-study log, p. 122, Charles County report. See chemical analysis. 10 ft. of screen used; position unknown.
21[a]	Aug. 1, 1947	29[a]	Aug. 1, 1947	C	18	Aug. 1, 1947	2.3	D	—	Sample-study log, p. 125, Charles County report. See chemical analysis.
—	—	—	—	C, H	2–3	Apr. 1952	—	I	—	See chemical analysis.
19.17	Dec. 11, 1952	—	—	N	—	—	—	F	—	Observation well.
16[a]	July 1, 1946	—	—	E, H	—	—	—	D, F	53.3	See chemical analysis.
See remarks	—	—	—	N	—	—	—	F	57.5	See chemical analysis. Well flowed ¼ gal. a min., Jan. 22, 1947.
21.03	Dec. 23, 1952	—	—	I, E	—	—	—	D	—	Observation well.
160[a]	Sept. 1950	230[a]	Sept. 1950	C, E	20	Sept. 1950	.3	D	—	See sample-study log and chemical analysis.
20[a]	July 19, 1950	—	—	J, E	6	July 19, 1950	—	D	—	See driller's log. Screen used; position and length unknown.
—	—	—	—	Sc, H	2–3	Apr. 1952	—	D	—	See chemical analysis.
150[a]	Apr. 18, 1947	180[a]	Apr. 18, 1947	—	24	Apr. 18, 1947	.8	C	—	Sample-study log, p. 120, Charles County report.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
Ch-De 15	Paul Mason	—	—	175	Dug	19	36	—	Pleistocene (upland)
De 16	Bel Alton High School	Washington Pump & Well Co.	1949	170	Drilled	445	6	See remarks	Patapsco-Raritan
Df 9	St. Marys Church	Wilson	1948	153	do	374	4–2½	—	Aquia
Df 11	J. Bagley	—	—	185	Dug	40	48	—	Pleistocene (upland)
Eb 3	Merrick Boys Camp	Columbia Pump & Well Co.	1946	20	Drilled	96	6	See remarks	Pleistocene (lowland)
Ec 5	John R. Hampton	do	1949	30	do	325	6	None	Patapsco-Raritan
Ee 4	State Roads Commission	—	—	20	do	250	2	—	Aquia
Ee 6	Potomac Enterprises, Inc.	—	—	2	do	80	8	—	Pleistocene (lowland)
Ee 16	J. B. Bowling	—	—	40	Dug	20	42	—	do
Ee 18	Southern Maryland Electric Cooperative	Washington Pump & Well Co.	1940	10	Drilled	300	6	266–280	Raritan
Ee 39	F. C. Pace	Columbia Pump & Well Co.	1947	60	do	310	6	See remarks	Aquia
Ee 41	Wedding	Wilson	1947	5	do	281	6–4–2½	—	do
Ee 43	Charles Fenwick	do	1949	4	do	236	3½–2½–1½	216–236	do
Ee 47	Wayside Consolidated School	Washington Pump & Well Co.	1951	128	do	523	6	518–523	Raritan
Ef 4	H. J. Orth	Columbia Pump & Well Co.	1947	38	do	324	6	See remarks	Aquia
Ef 5	Foster M. Reeder	do	1947	16	do	347	6	do	do
Ef 8	J. C. Clemens	Wilson	1947	150	do	398	6–4–2½	378–398	do
Ff 12	William L. Simms	do	1946	17	do	273	3½–2½–1½	253–273	do
Ff 13	Miles Norris	do	1946	14	do	277	3–2½	257–277	do
Ff 18	W. F. Smith	do	1946	3	do	260	2½–1½	240–260	do
Ff 20	F. M. Posey	do	1946	12	do	275	2½–1½	See remarks	do
Ff 21	L. J. Menders, Jr.	do	1946	9	do	273	3½–2½–1½	253–273	do
Ff 24	Joseph Holton	—	1945	5	Dug	15	32	—	Pleistocene (lowland)
Ff 33	Potomac Fish & Oyster Co.	Wilson	1946	5	Drilled	283	3½–2½–1½	243–283	Aquia
Ff 36	J. M. Hill	do	1947	14	do	260	1½	240–260	do

—*Continued*

Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
—	—	—	—	C, H	—	—	—	F	52	See chemical analysis.
130[a]	Mar. 23, 1949	260[a]	Mar. 23, 1949	I, E	40	Mar. 23, 1949	0.3	I	—	See driller's log and chemical analysis. 9 ft. of screen used; position unknown.
123.25	July 25, 1951	—	—	C, E	5	Dec. 1948	—	I	—	See chemical analysis.
—	—	—	—	C, H	—	—	—	D	—	do
20.41	Jan. 27, 1947	35[a]	Apr. 25, 1946	N	25	Apr. 25, 1946	—	I	—	See sample-study log. Screen used; position and length unknown.
20[a]	June 1949	80[a]	June 1949	J, E	10	June 1949	.2	D	—	See sample-study log and chemical analysis.
See remarks	—	—	—	—	16	Aug. 1946	—	—	—	See driller's log. Flowing well.
4.32	Jan. 22, 1947	—	—	J	—	—	—	—	—	Probably abandoned.
14.06	Dec. 23, 1952	—	—	N	—	—	—	N	—	Observation well.
—	—	—	—	I,E	40	—	—	C	—	See chemical analysis.
30[a]	June 21, 1948	80[a]	June 21, 1948	C	40	June 21, 1948	.8	D	—	Sample-study log, p. 116, Charles County report. 10 ft. of screen used; position unknown.
See remarks	—	—	—	—	60	1947	—	D	—	Driller's log, p. 170, Charles County report. Well flows 3 gal. a min.
do	—	—	—	J, E	9	1949	—	D	—	See chemical analysis. Well flows 1 gal. a min.
115.04	July 27, 1951	230[a]	Jan. 1951	—	70	Jan. 1951	—	I	—	See driller's log.
17[a]	Feb. 1, 1947	50[a]	Feb. 1, 1947	J	25	Feb. 1, 1947	.8	D	—	Sample-study log, p. 114, Charles County report. Screen used; position and length unknown.
5.81	July 31, 1951	30[a]	Mar. 1, 1947	—	24	Mar. 1, 1947	—	D	—	Screen used; position and length unknown.
100[a]	Oct. 15, 1947	110[a]	Oct. 15, 1947	C, E	6	Oct. 15, 1947	.6	D	—	See driller's log.
5[a]	July 31, 1946	22[a]	July 31, 1946	Sc	8	July 31, 1946	.5	C	—	See chemical analysis.
9[a]	June 6, 1946	22[a]	June 6, 1946	Sc	8	June, 1946	.7	D	—	Tested for 5 hours.
See remarks	June 21, 1946	10[a]	June 21, 1946	Sc	15	June 21, 1946	—	D	60.5	See chemical analysis. Well flows 1 gal. a min.
7[a]	July 2, 1946	22[a]	July 2, 1946	Sc	10	July 2, 1946	.7	D	—	20 ft. of screen used; position unknown.
3[a]	July 11, 1946	19[a]	July 11, 1946	Sc	9	July 11, 1946	.8	D	—	Sample-study log, p. 112, Charles County report.
5.31	Dec. 22, 1952	—	—	B	—	—	—	D, F	—	Observation well.
See remarks	—	15[a]	Sept. 17, 1946	N	15	Sept. 17, 1946	—	C	—	Well flows 2 gal. a min.
7[a]	May 8, 1947	—	—	Sc	15	May 8, 1947	—	D	—	

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
Ch-Ff 43	— Rossiter	Wilson	1947	12	Drilled	270	2½–1½	—	Aquia
Ff 48	James A. Hawkins	Payne	1950	7	do	265	1½	See remarks	do
How-Cf 1	Maryland State Police	Washington Pump & Well Co.	1937	232	do	201	8–6	—	Pre-Cambrian
Cf 7	Francis Cugle	E. Brown	1950	370	do	142	6	—	do
Cf 13	Joseph Giampaali	J. Greene	1950	220	do	110	6	—	do
Cf 17	James A. Rieger	E. Brown	1946	500	do	85	6	—	do
Cf 19	W. C. McFarland	Haines	1949	430	do	70	6	—	do
Cf 20	E. W. Vaughn	do	1949	420	do	90	6	—	do
Cg 9	Tilton Dobbin	G. Edgar Harr Sons	1947	220	do	125	6	—	do
Cg 11	H. T. Moreland	Dillon	1949	220	do	100	6	—	do
Cg 15	Lechner Construction Co.	Rogers	1946	180	do	112	6	—	do
Cg 16	do	do	1946	180	do	103	6	—	do
De 1	Cities Service Gas Station	E. Brown(?)	—	200	do	117	6	—	do
How-Df 7	G. P. Morrell	Rogers	1949	220	do	148	6	—	do
Df 8	H. S. Cannell	do	1948	180	do	88	6	40–45; 65–70	do
Df 15	Maurice Haslup	do	1947	240	do	104	6	—	do
PG-Ad 1	Thomas B. Connell	Derflinger	1946	310	do	164	6	None	do
Ad 2	W. L. Faust	do	1947	326	do	220	6	do	do
Ad 4	E. Whistler	do	1947	210	do	212	6	do	do
Ad 5	R. H. Whitehead	do	1947	210	do	253	6	do	do
Ad 6	Harold H. Harding	Rogers	1947	260	do	70	6	—	do
Ad 7	C. B. Spence	Derflinger	1947	270	do	102	6	None	do
Ad 8	Francis Gosnell	—	Before 1850	179	Dug	35	48	—	Patuxent
Ad 13	— Collier	Green (or Greene)	1951	298	Drilled	100	6	—	Pre-Cambrian
Ad 14	Russell Paul	Derflinger	1950	196	do	130	6	None	Pre-Cambrian-Patuxent
Bc 1	W. C. Beach	do	1947	325	do	308	6	do	Pre-Cambrian
Bc 2	John Hottenstein, Jr.	do	1946	250	do	184	6	do	do
Bc 3	Claude E. Derflinger	do	1946	235	do	124	6	do	Patuxent
Bc 4	Oscar Zook	do	1948	255	do	248	6	do	Pre-Cambrian-
Bc 5	G. A. Wills	do	1948	284	do	163	6	do	Patuxent
Bc 8	William L. Spicknall	do	1948	255	do	271	6	do	Pre-Cambrian
Bc 9	F. B. Morgan	do	1946	185	do	123	6	do	do

—Continued

Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
5[a]	Aug. 15, 1947	20[a]	Aug. 15, 1947	Sc	8	Aug. 15, 1947	0.5	D	—	Driller's log, p. 170, Charles County report.
2.5[a]	Apr. 11, 1950	19[a]	Apr. 11, 1950	Sc	6	Apr. 11, 1950	.4	D	—	See sample-study log. 20 ft. of screen used; position unknown.
—	—	—	—	C	12	—	—	D	—	Well penetrated 45 feet of Cretaceous sediments and weathered rock.
38[a]	Nov. 19, 1950	—	—	J, E	2	Nov. 19, 1950	—	D	—	
25[a]	May 12, 1951	—	—	J, E	10	May 12, 1951	—	D	—	
31.15	Aug. 7, 1952	—	—	—	5	July 18, 1946	—	D	—	
30[a]	June 1949	40[a]	June 1949	C, E	10	June 1949	1.0	D	—	
55[a]	July 1949	65[a]	July 1949	—	7	July 1949	.7	D, F	—	
40[a]	Oct. 1, 1947	80[a]	Oct. 1, 1947	C, E	10	Oct. 1, 1947	.3	D	—	
40[a]	Jan. 17, 1949	—	—	—	—	—	—	N	—	
70[a]	July 1946	—	—	—	3	July 1946	—	D	—	Located in Harwood Park.
65[a]	Aug. 1946	—	—	—	3	Aug. 1946	—	D	—	do
18.58	Apr. 21, 1952	—	—	C, E	6	—	—	C	—	Red clay above hard rock.
55[a]	July 1949	—	—	J, E	1½	July 1949	—	C	—	Well penetrated 88 feet of sediments and weathered rock.
26.30	Apr. 23, 1952	43[a]	Aug. 4, 1948	J, E	25	Aug. 4, 1948	—	D	—	
44[a]	Sept. 25, 1947	—	—	—	3	—	—	C	—	
57.70	Nov. 4, 1948	121.5[a]	Sept. 9, 1946	C, H	10	Sept. 9, 1946	.2	D	52	Driller's log in Bull. 10, p. 164.
60.64	Nov. 4, 1948	190[a]	July 15, 1947	C, E	3	July 15, 1947	.03	D	—	do
53.47	Nov. 4, 1948	110[a]	Apr. 30, 1947	C, E	3	Apr. 30, 1947	.1	D	—	do
67.71	Nov. 17, 1948	230[a]	Dec. 3, 1947	J, E	5	Dec. 3, 1947	.03	D	—	do
12.9	Dec. 7, 1948	—	—	J, E	3	Oct. 23, 1947	—	C	—	Driller's log in Bull. 10, p. 165.
14.0	Dec. 10, 1948	90[a]	Oct. 8, 1947	C, H	6	Oct. 8, 1947	.1	D	—	do
13.14	Dec. 19, 1952	—	—	N	—	—	—	N	—	Observation well.
13.13	Nov. 16, 1951	—	—	C, H	—	—	—	D	—	See chemical analysis.
29.47	Nov. 20, 1951	120[a]	June 1950	C, H	2	June 1950	.02	D	—	Sample-study log in Bull. 10, p. 227.
93.50	Nov. 9, 1948	250[a]	Sept. 25, 1947	C, E	5	Sept. 25, 1947	.03	D	—	Driller's log in Bull. 10, p. 165. See chemical analysis.
30[a]	Nov. 4, 1946	80[a]	Nov. 4, 1946	C, E	5	Nov. 4, 1946	.1	D	—	Driller's log in Bull. 10, p. 165.
96.5	Nov. 17, 1948	102[a]	Aug. 28, 1946	J, E	20	Aug. 28, 1946	5.0	D	—	Driller's log in Bull. 10, p. 166.
57.4	Nov. 26, 1948	219[a]	May 8, 1948	N	10	May 8, 1948	.1	D	—	do
92[a]	Apr. 21, 1948	133[a]	Apr. 21, 1948	C, E	11	Apr. 21, 1948	.3	D	—	Driller's log in Bull. 10, p. 166. See chemical analysis.
100.00	Nov. 26, 1948	271[a]	Nov. 26, 1948	C, E	0.7	Nov. 26, 1948	.004	D, F	—	Driller's log in Bull. 10, p. 166.
25[a]	Aug. 3, 1946	60[a]	Aug. 3, 1946	J, E	7	Aug. 3, 1946	.2	D	—	do

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
PG-Bc 10	W. D. Normandy	Derflinger	1947	315	Drilled	110	6	None	Patuxent
Bd 4	Greenbelt Consumers' Service	Washington Pump & Well Co.	1947	155	do	396	8–6	See remarks	do
Bd 13	Chateau Le Paradis	William Strothoff Co., Inc.	1925	180	do	465	8	—	Pre-Cambrian
Bd 14	Beltsville Agricultural Research Center	do	1931	150	do	304	8	See remarks	Pre-Cambrian-Patuxent
Bd 15	do	Columbia Pump & Well Co.	1934	116	do	250	8	147–167	do
Bd 17	do	William Strothoff Co., Inc.	1931	124	do	251	8	See remarks	do
Bd 18	do	Washington Pump & Well Co.	1934	125	do	363	6	156–172; 214–220; 226–231	Patuxent
Bd 19	do	do	1937	125	do	197	6	—	do
Bd 21	do	do	1934	153	do	425	6	160–190; 235–265	Pre-Cambrian-Patuxent
Bd 22	do	do	1934	150	do	262	6(?)	—	Patuxent
Bd 23	do	do	1932	190	do	221	6(?)	—	do
Bd 24	do	do	1932	155	do	82	6(?)	—	Patapsco
Bd 25	do	Kohl Bros.	1938	162	do	180	6	157–176	Patuxent
Bd 26	do	Kohl Bros. and Sydnor Pump & Well Co.	1938–39	120	do	±368	6	—	do
Bd 27	do	Washington Pump & Well Co.	1939	145	do	255	6	231–252	do
Bd 28	do	do	1939	162	do	167	6	124–167	do
Bd 29	do	Sydnor Pump & Well Co.	1939	120	do	232	8–6	204–220	do
Bd 30	do	Washington Pump & Well Co.	1937	155	do	310	8	—	do
Bd 31	do	Sydnor Pump & Well Co.	1939	125	do	185	8	166–183	do
Bd 32	Mineral Pigments Corp.	Brown	±1943	170	do	±100	8	—	do
Bd 33	do	Columbia Pump & Well Co.	1947	170	do	100	8	62–69	do
Bd 42	Midway Bar and Restaurant	Layne-Atlantic Co.	1951	180	do	286	6	272–277	do
Be 2	State Teachers College	Washington Pump & Well Co.	1943	102	do	380	—	—	do
Be 4	do	—	Before 1934	103	do	177	—	—	Patapsco

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
70[a]	Aug. 12, 1947	80[a]	Aug. 12, 1947	C, H	10	Aug. 12, 1947	1.0	I	47.5	Driller's log in Bull. 10, p. 166. See chemical analysis.
70[a]	Aug. 21, 1947	150[a]	Aug. 21, 1947	I, E	250	Aug. 21, 1947	3.1	C	—	Driller's log in Bull. 10, p. 167. See chemical analysis. 15 ft. of screen used; position unknown.
54[a]	Dec. 10, 1948	—	—	C, E	0.5	1925	—	N	—	Driller's log in Bull. 10, p. 169.
30[a]	May 1931	180[a]	May 1931	N	19	May 1931	.1	N	—	Driller's log in Bull. 10, p. 169. 20 ft. of screen used; position unknown.
16[a]	1934	130[a]	1934	I, E	110	1934	.9	D, F	—	Driller's log in Bull. 10 p., 170.
21.99	Dec. 19, 1952	55[a]	June 1931	N	20	June 1931	.6	N	—	Driller's log in Bull. 10, p. 170. 20 ft. of screen used; position unknown. Observation well.
45[a]	1934	155[a]	1934	I, E	47	1934	.4	N	—	Driller's log in Bull. 10, p. 171. See chemical analysis.
35[a]	1937	170[a]	1937	I, E	100	1937	.7	D, F	56	do
57.65	Nov. 23, 1951	145[a]	1934	I, E	100	1934	1.1	D, F		Driller's log in Bull. 10, p. 172.
65[a]	1934	150[a]	1934	N	60	1934	.7	N	—	Driller's log in Bull. 10, p. 173. See chemical analysis.
—	—	—	—	N	60	1932	—	N	—	Driller's log in Bull. 10, p. 173.
—	—	—	—	N	10	1932	—	N	—	Driller's log in Bull. 10, p. 174.
41.7	Dec. 22, 1948	119[a]	1938	I, E	73	1938	.9	D, F	—	do
13.88	Nov. 27, 1951	—	—	N	80(?)	—	—	D, F	—	Driller's log in Bull. 10, p. 174. See chemical analysis.
55[a]	1939	164[a]	1939	I, E	120	1939	1.1	D, F	55	Driller's log in Bull. 10, p. 175.
49.24	Nov. 23, 1951	105[a]	1939	I, E	165	1939	3.1	D, F	—	Driller's log in Bull. 10, p. 176.
20.12	Nov. 23, 1951	—	—	I, E	—	—	—	D, F	56	Driller's log in Bull. 10, p. 176. See chemical analysis.
66.61	Nov. 23, 1951	—	—	N	125	1937	—	N		Driller's log in Bull. 10, p. 177. See chemical analysis.
15[a]	1939	—	—	I, E	—	—	—	D, F	—	do
8.36	July 31, 1949	—	—	I, E	—	—	—	N	—	
9.83	July 31, 1949	62[a]	July 31, 1949	I, E	27	July 31, 1949	.5	C	57	Driller's log in Bull. 10, p. 177.
60[a]	July 13, 1951	69[a]	July 13, 1951	I, E	30	July 13, 1951	3.3	C	—	See driller's log.
39.0	Nov. 27, 1951	110[a]	May 17, 1943	I, E	100	May 17, 1943	1.3	I	—	Driller's log in Bull. 10, p. 179. See chemical analysis.
45.40	Nov. 27, 1951	—	—	I, E	40	Before 1934	—	N	—	See chemical analysis.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
PG-Be 5	Beltsville Agricultural Research Center	J. E. Greiner Co.	1942	174	Drilled	417	8–6	403–417	Patuxent
Be 6	do	Washington Pump & Well Co.	1934	177	do	430	8–6	—	do
Be 7	do	Sydnor Pump & Well Co.	1939	155	do	381	8–6	364–380	do
Be 8	Patuxent Research Refuge	Layne-Atlantic Co.	1940	165	do	302	10	240–245; 280–295	do
Be 10	Bowie Elementary School	Washington Pump & Well Co.	1942	170	do	377	6	—	do
Be 14	Beltsville Agricultural Research Center	Layne-Atlantic Co.	1950	155	do	115	4–2	107–112	Patapsco
Be 15	U. S. Fish & Wildlife Service	do	1952	145	do	107	4	See remarks	do
Cc 2	Aiton	Washington Pump & Well Co.	1941	150	do	135	—	—	Patuxent-Pre-Cambrian
Cc 3	Southern Oxygen Co., Inc.	do	1942	18	do	162	6	—	Patuxent
Cc 5	Washington Suburban Gas Co.	Layne-Atlantic Co.	1945	18	do	162	10–8	120–150	do
Cc 7	Engineering and Research Corp.	Washington Pump & Well Co.	1939	50	do	71	8	—	do
Cc 8	do	do	1940–42	50	do	280	8	—	do
Cc 13	George Brown	Derflinger	1949	170	do	145	6	None	Pre-Cambrian
Cc 15	Town of Hyattsville	Downing	1900	20	do	242	10 or 8	—	Patuxent
Cc 16	do	Shannahan	1905	20	do	247	6	222–240	do
Cd 1	Mrs. Esther Dodge	Washington Pump & Well Co.	1947	190	do	227	6	See remarks	Potomac group
Cd 2	M. K. Jones	do	1947	185	do	290	6	284–290	Patuxent
Cd 7	Al Rowell	Derflinger	1949	185	do	179	6	169–179	Patapsco
Cd 9	St. Joseph Church	Washington Pump & Well Co.	1946	140	do	185	6	175–185	do
Ce 1	J. K. Williams	Derflinger	1947	160	do	78	6	None	do
Ce 2	C. Bluett	do	1947	160	do	114	6	do	do
Ce 3	Frank E. Brown	Washington Pump & Well Co.	1948	165	do	130	6	—	do
Ce 13	Glenn Dale Sanatorium	Virginia Machinery & Well Co.	1932–33	160	do	798	10–4½	—	do

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
80[a]	Nov. 1, 1942	90–92[a]	Nov. 1, 1942	N	55	Nov. 1, 1942	5.0	N	—	Driller's log in Bull. 10, p. 179. See chemical analysis.
94.90	Dec. 12, 1951	215[a]	1934	I, E	80	1934	.7	D, F	54.5	Driller's log in Bull. 10, p. 180. See chemical analysis.
48.2	Dec. 22, 1948	—	—	N	—	—	—	N	—	do
60[a]	Mar. 12, 1940	83[a]	Mar. 12, 1940	I, E	125	Mar. 12, 1940	5.4	C, D	—	See chemical analysis.
70[a]	Aug. 4, 1942	120[a]	Aug. 4, 1942	I, E	17	Aug. 4, 1942	3.0	I	—	Driller's log in Bull. 10, p. 181.
42.51	Dec. 10, 1951	—	—	J, E	22	Dec. 10, 1951	—	D	—	Sample-study log in Bull. 10, p. 228.
40.84	Nov. 6, 1952	52[a]	Oct. 1952	—	21	Oct. 1952	1.9	D	—	See driller's log. 5 ft. of screen used; position unknown.
60[a]	1941	80[a]	1941	J, E	8	1941	.4	D	—	Driller's log in Bull. 10, p. 183.
9.20	Dec. 19, 1952	120[a]	Oct. 21, 1949	N	58	1942	.5	N	59.5	Driller's log in Bull. 10, p. 183. Observation well.
See remarks	—	71[a]	Nov. 9, 1945	N	300	Nov. 9, 1945	3.9	N	55.5	Sample-study log in Bull. 10, p. 228. Static water level 5.46 ft. above land surface, Aug. 13, 1951.
35[a]	1939	120[a]	1939	I, E	125	1939	1.5	N	—	Driller's log in Bull. 10, p. 183.
—	—	—	—	I, E	—	—	—	C	—	Reportedly drilled to bedrock.
14[a]	July 18, 1949	140[a]	July 18, 1949	J, E	0.8	July 18, 1949	—	D	—	Sample-study log in Bull 10., p. 229.
See remarks	—	—	—	N	—	—	—	N	—	Flowing well.
do	—	—	—	N	44	Oct. 1905	—	N	—	Driller's log in Bull. 10, p. 184. Reported static water level 15 ft. above land surface, Oct. 1905.
145[a]	Feb. 3, 1947	154[a]	Feb. 3, 1947	C	10	Feb. 3, 1947	1.1	D	57	Driller's log in Bull. 10, p. 186. 6 ft. of screen used; position unknown.
120[a]	Oct. 15, 1947	185[a]	Oct. 15, 1947	C, E	20	Oct. 15, 1947	.3	D	—	Driller's log in Bull. 10, p. 186. See chemical analysis.
59.41	May 6, 1949	130[a]	Jan. 3, 1949	C, E	8	Jan. 3, 1949	.1	D	55	Driller's log in Bull. 10, p. 187. See chemical analysis.
75[a]	Jan. 1, 1946	140[a]	Jan. 1, 1946	J, E	30	Jan. 1, 1946	.5	D, I	—	Sample-study log in Bull. 10, p. 229.
43[a]	July 5, 1947	53[a]	July 5, 1947	J, E	10	July 5, 1947	1.0	D	—	Driller's log in Bull. 10, p. 188.
36.24	Nov. 17, 1948	55[a]	Aug. 2, 1947	J, E	10	Aug. 2, 1947	2.0	D	—	do
79.04	Nov. 17, 1948	102[a]	Aug. 2, 1948	J, E	10	Aug. 2, 1948	.7	D	—	do
100[a]	1933	115[a]	1933	N	50	1933	3.3	N	—	do

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
PG-Ce 16	Glenn Dale Sanatorium	Virginia Machinery & Well Co.	1938	145	Drilled	946	—	—	Patuxent
Ce 17	Newton H. White	Sydnor Pump & Well Co.	1939	170	do	118	6	106–112	Magothy
Ce 18	do	do	1939	140	do	464	6–4	450–460	Patapsco
Ce 24	Glenn Dale Elementary School	Washington Pump & Well Co.	1950	155	do	203	6	198–203	do
Cf 1	Chaney Lumber Co.	do	1947	35	do	105	6	See remarks	do
Cf 2	Mitchellville Elementary School	do	—	110	do	171	—	—	Magothy
Cf 4	William Woodward	do	1946	130	do	270	6	264–270	Patapsco
Cf 11	Morris Suit	—	Before 1940	130	Dug	23	42	—	Aquia
Cf 25	Mitchellville Elementary School	Washington Pump & Well Co.	1950	110	Drilled	398	6	392–398	Patapsco
Dc 1	C. L. Jenkins & Sons	L. R. Bee & Co.	1924	290	do	365	6	—	do
Dc 3	Chesapeake & Potomac Telephone Co.	Washington Pump & Well Co.	±1941	293	do	388	6	See remarks	do
Dc 4	Colebrook Development Co.	do	1941	280	do	620	8–6	do	do
Dc 6	Harrison Nursery	—	Before 1940	285	do	106	8	—	Magothy(?)
Dc 8	Ernest Gerstenberg	—	—	290	do	450	6	437–450	Patapsco
Dc 9	J. A. West	West	—	290	Dug	36	96	—	Pliocene(?)
Dd 2	H. Norair	Columbia Pump & Well Co.	1947	185	Drilled	377	6	367–377	Patapsco
Dd 3	Washington Suburban Sanitary Commission	Hagmann	1948	135	do	409	8	See remarks	Potomac group
Dd 4	Z. M. Brady	Columbia Pump & Well Co.	1945	250	do	476	6–4	do	Patapsco
Dd 6	Wall Florist	—	—	140	Dug	16	±120	—	Pleistocene (upland)
Dd 9	E. M. Beall	Washington Pump & Well Co.	1949	170	Drilled	143	6	138–143	Magothy
Dd 17	West Bros. Brick Co.	do	1949	50	do	214	8	202–214	Patuxent
Dd 18	Italo-American World War Veterans Relief Association	Derflinger	1951	210	do	218	6	See remarks	Patapsco-Raritan
Dd 19	Prince Georges County	Washington Pump & Well Co.	1952	270	do	325	6	318–325	do

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
71.80	Dec. 6, 1948	—	—	N	—	—	—	N	—	Sample-study log in Bull. 10, p. 230. See chemical analysis.
85[a]	1939	—	—	I, E	30	1939	—	D	59	Driller's log in Bull. 10, p. 189. See chemical analysis.
93[a]	1939	113[a]	1939	I, E	45	1939	2.3	D, F	57.5	do
42.53	Dec. 12, 1951	160[a]	Nov. 8, 1950	I, E	30	Nov. 8, 1950	.3	I	—	Driller's log in Bull. 10, p. 190.
5.74	Oct. 28, 1948	—	—	C, H	10	Sept. 10, 1947	—	C	—	Sample-study log in Bull. 10, p. 232. See chemical analysis. 5 ft. of screen used; position unknown.
60[a]	—	—	—	I, E	—	—	—	N	57	Driller's log in Bull. 10, p. 191. See chemical analysis.
33.81	Mar. 30, 1949	70[a]	Oct. 7, 1946	C, G	15	Oct. 7, 1946	.5	D	—	Driller's log in Bull. 10, p. 191.
14.34	Apr. 25, 1949	—	—	C, H	—	—	—	D	55	See chemical analysis.
100[a]	July 12, 1950	140[a]	July 12, 1950	I, E	60	July 12, 1950	.7	I	—	Driller's log in Bull. 10, p. 191. See chemical analysis.
199.32	Dec. 22, 1952	205[a]	1924	N	23	1924	.9	N	—	Driller's log in Bull. 10, p. 192. Observation well.
210[a]	±1941	350[a]	±1941	C, E	20	±1941	.1	N	—	Driller's log in Bull. 10, p. 192. Screen used; position unknown.
255[a]	1941	380[a]	1941	I, E	50	1941	.4	P	—	Driller's log in Bull. 10, p. 193. See chemical analysis. 15 ft. of screen used; position unknown.
—	—	—	—	N	—	—	—	N	—	
—	—	—	—	N	5	—	—	N	—	See chemical analysis.
32[a]	1919	34[a]	1919	N	10	1919	5.0	N	—	do
105.71	Mar. 10, 1949	150[a]	Apr. 5, 1947	N	20	Apr. 5, 1947	1.0	N	—	Driller's log in Bull. 10, p. 193.
54.14	Dec. 1, 1948	226[a]	Mar. 20, 1948	I, E	25	Mar. 20, 1948	.2	P	—	Sample-study log in Bull. 10, p. 232. 12 ft. of screen used; position unknown.
230[a]	Sept. 20, 1945	—	—	C, E	20	Sept. 20, 1945	—	D	—	Driller's log in Bull. 10, p. 194. 14 ft. of screen used; position unknown.
4.30	Mar. 21, 1949	—	—	C, E	—	—	—	F	—	See chemical analysis.
84.10	Sept. 19, 1949	120[a]	July 12, 1949	J, E	20	July 12, 1949	.5	D	—	Driller's log in Bull. 10, p. 194.
11.01	Jan. 3, 1951	110[a]	Aug. 26, 1949	C, E	120	Aug. 26, 1949	1.3	C	—	Driller's log in Bull. 10, p. 195. See chemical analysis.
105[a]	Jan. 25, 1951	140[a]	Jan. 25, 1951	—	18	Jan. 25, 1951	.5	C	—	See driller's log. 10 ft. of screen used; position ununknown.
150[a]	June 20, 1952	180[a]	June 10, 1952	J	20	June 20, 1952	1.0	C	—	See driller's log.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
PG-De 18	Maryland Tobacco Research Farm	Washington Pump & Well Co.	1951	92	Drilled	171	6	165–171	Magothy
Df 2	Dr. Bowie	—	1946	145	Dug	82	48	—	Nanjemoy
Df 5	Charles F. Thorington	Rogers	1948	31	Drilled	90	5	—	Aquia
Df 16	Earl W. Heathcote	Layne-Atlantic Co.	1948	90	do	289	6	251–261	Magothy
Df 21	Thomas E. Hayes	Washington Pump & Well Co.	1949	167	do	298	6	292–298	do
Eb 1	Washington Suburban Sanitary Commission	Layne-Atlantic Co.	1945	20	do	603	18–10–8	357–377; 568–588	Patuxent
Eb 2	do	do	1946	22	do	630	20–10–8	277–282; 347–352; 521–526; 550–560; 600–605	Patuxent-Patapsco-Raritan
Eb 3	R. Walters	Columbia Pump & Well Co.	1948	115	do	290	6	None	Patuxent or Patapsco
Eb 6	Carter Bryan	Washington Pump & Well Co.	1950	160	do	322	6	316–322	Potomac group
Eb 7	Careybrook Co.	Hagmann	1950	135	do	275	6	269–275	do
Eb 8	Fort Foote Village, Inc.	Columbia Pump & Well Co.	1951	155	do	343	8	See remarks	Patapsco-Raritan
Ec 1	J. Chester Pyles	Washington Pump & Well Co.	1941	275	do	510	—	—	Patapsco
Ec 2	I. P. Frohmans	Columbia Pump & Well Co.	1946	205	do	327	6	See remarks	Potomac group
Ec 4	Louis Singer	do	1947	195	do	330	6	None	do
Ec 5	Rosecroft Trotting and Pacing Ass'n., Inc.	Washington Pump & Well Co.	1949	120	do	720	8–6	694–720	Patuxent
Ec 10	Ralph E. Clark	do	1946	58	do	252	6	See remarks	Patapsco
Ec 14	Henson Hill Water Co.	Columbia Pump & Well Co.	1949	230	do	358	6	348–358	do
Ec 24	Mrs. Mary A. Slye	do	1949	240	do	240	6	None	—
Ec 25	Glen Shank	Washington Pump & Well Co.	1950	255	do	312	6	299–312	Patapsco
Ec 26	Oxon Hill Elementary School	do	1950	240	do	324	6	318–324	do
Ed 2	Hopkins and Wayson	do	1941	265	do	497	8 or 6	—	do
Ed 3	do	do	1949	260	do	566	8	320–340	do

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
40[a]	June 4, 1951	135[a]	June 4, 1951	—	20	June 4, 1951	0.2	F	—	See sample-study log.
73.33	Dec. 22, 1952	—	—	J, E	—	—	—	D	—	Observation well.
4.95	Dec. 22, 1952	48[a]	June 23, 1948	C, H	20	June 23, 1948	.5	C, D	—	Driller's log in Bull. 10, p. 196. See chemical analysis. Observation well.
45[a]	June 1, 1948	—	—	C, E	15	June 1, 1948	—	D	—	Driller's log in Bull. 10, p. 196.
115.23	Sept. 21, 1949	185[a]	Sept. 30, 1949	I, E	60	Sept. 30, 1949	.9	C	—	Sample-study log in Bull. 10, p. 233.
93.04	Apr. 19, 1949	337[a]	Dec. 18, 1945	I, E	439	Dec. 18, 1945	1.8	P	52.5	Driller's log in Bull. 10, p. 197. See chemical analysis.
108.91	May 20, 1949	224[a]	Sept. 10, 1946	I, E	540	Sept. 10, 1946	4.4	P	—	See chemical analysis.
113.00	Jan. 7, 1949	121[a]	Jan. 14, 1948	C, E	10	Jan. 14, 1948	1.0	D	56	Driller's log in Bull. 10, p. 198. See chemical analysis.
148[a]	July 25, 1950	236[a]	July 25, 1950	C, E	60	July 1950	.7	D	—	Driller's log in Bull. 10, p. 198.
120.58	Feb. 14, 1951	214.7[a]	Apr. 15, 1951	I, E	33	Oct. 19, 1950	.3	P	—	Driller's log in Bull. 10, p. 199.
160[a]	Nov. 21, 1951	240[a]	Nov. 21, 1951	I, E	50	Nov. 21, 1951	.6	P	—	See driller's log. 14 ft. of screen used; position unknown.
250[a]	1941	280[a]	1941	I, E	40	1941	1.3	P	—	Driller's log in Bull. 10, p. 199. See chemical analysis.
200[a]	Apr. 18, 1946	230[a]	Apr. 18, 1946	C, E	10	Apr. 18, 1946	.3	D	—	Driller's log in Bull. 10, p. 199. 10 ft. of screen used; position unknown.
190[a]	Dec. 28, 1947	—	—	E	10	Dec. 28, 1947	.3	D	—	Sample-study log in Bull. 10, p. 236.
63[a]	Feb. 23, 1949	250[a]	Feb. 23, 1949	I, E	120	Feb. 23, 1949	.6	C	—	Driller's log in Bull. 10, p. 200. See chemical analysis.
31.96	Dec. 22, 1952	155[a]	Jan. 11, 1946	N	40	Jan. 11, 1946	.4	N	—	Sample-study log in Bull. 10, p. 237. 11 ft. of screen used; position unknown. Observation well.
150[a]	July 29, 1949	300[a]	July 29, 1949	I, E	20	July 29, 1949	.1	P	—	Driller's log in Bull. 10, p. 202. See chemical analysis.
—	—	—	—	N	0	Dec. 6, 1949	—	N	—	Sample-study log in Bull. 10, p. 237.
195[a]	June 28, 1950	231[a]	June 28, 1950	C, E	40	June 28, 1950	1.1	D	—	Sample-study log in Bull. 10, p. 238.
207[a]	Oct. 6, 1950	273[a]	Oct. 6, 1950	I, E	40	Oct. 6, 1950	.7	I	—	Driller's log in Bull. 10, p. 203. See chemical analysis.
182.20	Mar. 31, 1949	220[a]	1941	I, E	60	1941	1.0	P	—	do
215[a]	Jan. 12, 1950	301[a]	Jan. 12, 1950	I, E	78	Jan. 12, 1950	.9	P	—	Driller's log in Bull. 10, p. 204.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
PG-Ed 4	Hopkins and Wayson	Washington Pump & Well Co.	1946	265	Drilled	385	8	See remarks	Patapsco
Ed 5	Surrattsville Elementary School	do	1942	230	do	375	6	do	Magothy
Ed 8	Frank Kearny	Columbia Pump & Well Co.	1946	257	do	350	6	do	do
Ed 9	Maryland Oil and Development Co.	—	1906	240	do	1,511	6	None	—
Ed 17	Clinton Elementary School	—	—	250	Dug	24	—	—	Pliocene(?)
Ed 21	W. Eugene Pyles	Washington Pump & Well Co.	1941	265	Drilled	607	—	—	Patapsco(?)
Ed 22	Andrews Army Air Base	—	1943	270	do	427	—	—	Patapsco
Ed 24	do	Sydnor Pump & Well Co.	1943	270	do	595	—	—	Patapsco and/or Magothy
Ed 27	do	Washington Pump & Well Co.	1942	270	do	338	6	—	Magothy
Ed 31	B. K. Miller	Columbia Pump & Well Co.	1950	245	do	347	6	335–345	do
Ed 32	Dewey Freeman	Washington Pump & Well Co.	1950	270	do	759	8–6	720–758	Patuxent
Ed 33	Camp Springs Elementary School	do	1952	260	do	784	8–6	757–766	Patapsco
Ed 34	Morningside Village Water Co.	do	1952	270	do	793	8	773–793	do
Ee 2	Albert W. Posey	Leatherbury	1947	28	do	220	2	—	Magothy
Ee 3	S. A. Wyvill	Washington Pump & Well Co.	1948	150	do	321	6	See remarks	do
Ee 4	M. E. Gardner	do	1948	145	do	319	6	do	do
Ee 6	Town of Upper Marlboro	do	1946	64	do	262	8–6	do	do
Ee 30	County Courthouse	—	1895	40	do	222	—	—	do
Ee 31	Thomas L. Steward	Washington Pump & Well Co.	1950	190	do	340	6	See remarks	do
Ee 32	George Perry	do	1950	208	do	329	6	320–329	do

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
173[a]	June 20, 1946	196[a]	June 20, 1946	I, E	50	June 20, 1946	2.2	P	59	Sample-study log in Bull. 10, p. 239. See chemical analysis. 10 ft. of screen used; position unknown.
—	—	215[a]	May 1942	I, E	50	May 1942	—	I	—	Driller's log in Bull. 10, p. 205. 15 ft. of screen used; position unknown.
192.53	Dec. 13, 1951	275[a]	Sept. 20, 1946	C, E	50	Sept. 20, 1946	2.0	D	59	Sample-study log in Bull. 10, p. 240. See chemical analysis. 12 ft. of screen used; position unknown.
—	—	—	—	—	—	—	—	—	—	Sample-study log in Bull. 10, p. 241.
—	—	—	—	C, H	1	—	—	I	53.5	See chemical analysis.
—	—	—	—	N	25	1941	—	N	—	Driller's log in Bull. 10, p. 206.
—	—	—	—	I, E and G	50	1943	—	N	—	Driller's log in Bull. 10, p 207.
—	—	—	—	I, E	—	—	—	N	—	do
195[a]	Oct. 20, 1942	280[a]	Oct. 20, 1942	N	25	Oct. 20, 1942	.3	N	—	Driller's log in Bull. 10, p. 210.
190[a]	Sept. 29, 1950	215[a]	Sept. 29, 1950	N	40	Sept. 29, 1950	1.6	C	—	Sample-study log in Bull. 10, p. 242.
232[a]	Sept. 5, 1950	—	—	I, E	80	Sept. 5, 1950	—	P	—	Driller's log in Bull. 10, p. 211. See chemical analysis.
221.78	Apr. 9, 1952	340[a]	Feb. 15, 1952	—	50	Feb. 15, 1952	.5	I	—	See driller's log.
236[a]	Nov. 5, 1952	315[a]	Nov. 5, 1952	C	135	Nov. 5, 1952	1.7	P	—	do
See remarks	—	4[a]	Sept. 30, 1947	I, E	8	Sept. 30, 1947	1.3	D	57	Driller's log in Bull. 10, p. 212. Static water level 10.5 ft. above land surface, Nov. 29, 1951.
130[a]	Jan. 8, 1948	160[a]	Jan. 8, 1948	I, E	60	Jan. 8, 1948	2.0	P	—	Sample-study log in Bull. 10, p. 243. 12 ft. of screen used; position unknown.
107.2	Nov. 30, 1948	300[a]	Jan. 5, 1948	N	12	Jan. 5, 1948	.1	C	—	Sample-study log in Bull. 10, p. 244. 6 ft. of screen used position unknown.
23.08	Sept. 20, 1949	110[a]	July 15, 1946	I, E and G	180	July 15, 1946	2.1	P	—	Sample-study log in Bull. 10, p. 244. See chemical analysis. 15 ft. of screen used; position unknown.
See remarks	—	—	—	N	—	—	—	N	—	See chemical analysis. Static water level reported 13 ft. above land surface, and flow reported 25 gal. a min., 1895; no flow in 1949.
140[a]	Feb. 7, 1950	180[a]	Feb. 7, 1950	C, E	30	Feb. 7, 1950	.8	D	—	Sample-study log in Bull. 10, p. 245. About 8 ft. of screen used; position unknown.
165[a]	Dec. 19, 1950	200[a]	Dec. 19, 1950	C, E	30	Dec. 19, 1950	.8	D	—	

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
PG-Ee 34	Orchard Hills Subdivision	Washington Pump & Well Co.	1952	144	Drilled	297	8	282–297	Magothy
Ef 1	Southern Maryland Agricultural Fair Ass'n.	do	1946	32	do	235	8	227–235(?)	do
Ef 3	Gustav A. Buchheister	do	1948	165	do	366	6	351–366	do
Ef 5	Town of Upper Marlboro	do	1940	25	do	226(?)	8	—	do
Ef 6	Sasscer High School	do	1935	25	do	210	4	See remarks	do
Fb 1	F. M. Holcomb	Columbia Pump & Well Co.	1948	30	do	217	6	—	Patapsco
Fb 2	C. W. Collins	do	1946	90	do	244	6	See remarks	do
Fb 4	Bonds Retreat Water Co.	Hoppe	1948	150	do	345	6	—	do
Fb 7	Fort Washington	Sydnor Pump & Well Co.	1902	35	do	263	—	—	do
Fb 13	do	do	1942–43	165	do	500–600	—	—	Patuxent
Fb 14	do	—	Before 1918		do	1,000	—	—	—
Fb 17	U. S. Army	Columbia Pump & Well Co.	1948	70	do	259	6	See remarks	Patapsco
Fb 18	William Kenneaster	do	1950	5	do	395	6–4	—	Potomac group
Fb 20	Accokeek Elementary School	Washington Pump & Well Co.	1953	195	do	548	6	538–548	Patapsco-Raritan
Fc 1	Hyde Field	do	1943	240	do	315	8–6	—	Magothy
Fc 14	G. Finch	Hoppe	—	30	do	150	6	—	do
Fc 16	Maryland Vestar Corp.	Sydnor Pump & Well Co.	1953	95	do	308(?)	12–8	272–292	Raritan(?)
Fd 1	Gwynn Park High School	Washington Pump & Well Co.	1942	225	do	427	6	See remarks	do
Fd 2	Cheltenham Magnetic Observatory	do	1938	225	do	391	6	—	do
Fd 4	H. Butterworth	Hoppe	1938	200	do	156	6	None	Aquia
Fd 5	Cheltenham School for Boys	Columbia Pump & Well Co.	1949	237	do	438	8	417–438	Magothy

—*Continued*

Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
95[a]	May 1952	—	—	I, E	250	May 1952	—	P	—	See driller's log.
See remarks	—	88[a]	Mar. 20, 1946	I, E	110	Aug. 31, 1951	1.8	C	56.6	Sample-study log in Bull. 10 p. 247. Observation well. Static water level 1.45 ft. above land surface, Dec. 22, 1952.
125[a]	June 20, 1948	200[a]	June 20, 1948	C, E	35	June 20, 1948	.5	D	—	Sample-study log in Bull. 10, p. 248. See chemical analysis.
See remarks	—	—	—	I, E	70+	1949	—	P	—	Driller's log in Bull. 10, p. 215. See chemical analysis. Well reported to flow 45 gal. a min. in 1949.
do	—	—	—	N	—	—	—	N	—	Driller's log in Bull. 10, p. 216. Screen used; length and position unknown. Well reported to flow 40 gal. a min.
26.12	Dec. 24, 1948	80[a]	Nov. 1, 1948	J, E	10	Nov. 1, 1948	.5	D	—	Driller's log in Bull. 10, p. 216.
52.85	Dec. 24, 1948	81[a]	Sept. 27, 1946	J, E	40	Sept. 27, 1946	4.0	D	—	Driller's log in Bull. 10, p. 216. Screen used; position and length unknown.
124[a]	Nov. 14, 1948	—	—	I, E	—	—	—	P	—	Sample-study log in Bull. 10, p. 250.
—	—	—	—	I, E	60	—	—	P	59.5	See chemical analysis.
169.50	Dec. 10, 1951	280[a]	1942–43	I, E	342	1942–43	3.1	P	—	Driller's log in Bull. 10, p. 218.
—	—	—	—	N	—	—	—	N	—	Driller's log in Bull. 10, p. 218. Well covered.
60[a]	Nov. 22, 1948	225[a]	Nov. 22, 1948	I, E	22	Nov. 22, 1948	.1	—	—	Driller's log in Bull. 10, p. 250. 20 ft. of screen used; position unknown.
5[a]	July 1950	—	—	C, H	—	—	—	D	—	
168[a]	Feb. 2, 1953	280[a]	Feb. 2, 1953	C	30	Feb. 2, 1953	.3	I	—	See driller's log.
180[a]	Jan. 12, 1943	240[a]	Jan. 12, 1943	I, E	55	Jan. 12, 1943	.9	C	—	Driller's log in Bull. 10, p. 220.
—	—	—	—	C, E	—	—	—	D	54	See chemical analysis.
17.30	Dec. 18, 1952	—	—		60	May 1953	—	P	—	First well drilled to 480 ft. and abandoned.
193[a]	May 27, 1942	275[a]	May 27, 1942	I, E	35	May 27, 1942	.4	I	—	Driller's log in Bull. 10, p. 221. Screen used; position and length unknown.
175[a]	1939	198[a]	1939	I, E	42	1939	1.8	—	—	Driller's log in Bull. 10, p. 221.
See remarks	—	—	—	—	—	—	—	D, F	57	Well flows 10 gal. a min. (est.).
188.79	May 7, 1949	311[a]	Jan. 20, 1949	N	165	Jan. 20, 1949	1.4	I	—	Sample-study log in Bull. 10, p. 252.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
PG-Fd 6	Cheltenham School for Boys	Washington Pump & Well Co.	1944	230	Drilled	404	8	See remarks	Magothy
Fd 10	U. S. Navy	Shannahan	1944	190	do	366	8	—	do
Fd 11	do	do	1949	230	do	444	8	See remarks	do
Fd 16	A. T. Robinson	—	1946	225	do	22	48	—	Pliocene(?)
Fd 24	Hopkins and Wayson	Washington Pump & Well Co.	1948	237	do	459	8	445–459	Magothy
Fd 32	Brandywine Elementary School	do	1950	230	do	490	8	478–490	do
Fd 33	Sherwood Oil Co.	Bunker	1951	230	do	370	4	365–370	Aquia(?)
Fd 34	U. S. Navy	—	—	230	—	25	2	—	Pliocene(?)
Fd 35	Cadillac Motel	Washington Pump & Well Co.	1952	200	Drilled	442	6	430–442	Magothy
Ff 1	C. Elwood Sager	do	1945	130	do	291	6	See remarks	Aquia
Ff 5	John R. Windsor	—	Before 1944	30	Dug	26	—	—	Pleistocene (lowland)
Ff 16	Holly Grove Elementary School	Washington Pump & Well Co.	1951	129	Drilled	379	6	372–379	Aquia
Ge 10	Percy S. Wilkinson	—	1951	200	Dug	±30	36	—	Pliocene(?)
Gf 1	Lloyd E. Holsinger	Washington Pump & Well Co.	1947	169	Drilled	360	6	See remarks	Nanjemoy
Hf 3	Town of Eagle Harbor	—	1925	1	do	±200	—	—	Nanjemoy(?)
St.M-Bb 1	E. V. Dyson	—	1933	170	Dug	13	120	—	Pleistocene (upland)
Bb 2	U. S. Navy	—	—	170	do	11	—	—	do
Bb 4	H. L. Norman	Hagmann	1947	176	Drilled	480	6	470–480	Aquia
Bb 9	Mechanicsville Elementary School	Washington Pump & Well Co.	1951	165	do	480	6	469–480	do
Bb 10	School near Charlotte Hall	—	—	180	Dug	±30	—	—	Pleistocene (upland)
Bc 1	Holmes Fowler	Washington Pump & Well Co.	1947	165	Drilled	470	6	460–470	Aquia

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
150[a]	1944	190[a]	1944	I, E	150	1944	3.8	I	60.5	Driller's log in Bull. 10, p. 222. See chemical analysis. 30 ft. of screen used; position unknown.
144.34	July 19, 1949	—	—	I, E	40	1944	—	—	—	Driller's log in Bull. 10, p. 223. See chemical analysis.
183.93	July 19, 1949	—	—	I, E	239	May 12, 1949	3.9	—	—	Driller's log in Bull. 10, p. 224. 46 ft. of screen used; position and length unknown.
14.63	Dec. 22, 1952	—	—	C, E	—	—	—	F	—	See chemical analysis. Observation well.
181.92	May 5, 1949	240[a]	Dec. 2, 1948	I, E	70	Dec. 2, 1948	1.3	P	—	Driller's log in Bull. 10, p. 224. See chemical analysis.
181.27	Nov. 30, 1950	340[a]	Nov. 25, 1950	I, E	80	Nov. 25, 1950	.6	I	—	Driller's log in Bull. 10, p. 225. See chemical analysis.
183.62	June 19, 1951	—	—	C, E	7	June 1951	—	C	—	Driller's log in Bull. 10, p. 226.
—	—	—	—	—	6	Mar. 15, 1951	—	—	—	See chemical analysis.
142.73	June 4, 1952	210[a]	May 28, 1952	—	70	May 28, 1952	1.1	C	—	See driller's log.
80[a]	Dec. 3, 1945	199.5[a]	Dec. 3, 1945	I, E	40	Dec. 3, 1945	.3	D	—	Driller's log in Bull. 10, p. 226. 12 ft. of screen used; position unknown.
22.20	July 27, 1949	—	—	C, H	—	—	—	D	—	See chemical analysis.
93.17	Apr. 6, 1951	170[a]	Feb. 19, 1951	I, E	65	Feb. 19, 1951	.9	I	—	Sample-study log in Bull. 10, p. 254. See chemical analysis.
—	—	—	—	C, H	—	—	—	D	—	See chemical analysis.
91.10	Dec. 29, 1948	195[a]	Sept. 25, 1947	I, E	15	Sept. 25, 1947	.1	C, D	59	Driller's log in Bull. 10, p. 227. See chemical analysis. 11 ft. of screen used; position unknown.
See remarks	—	—	—	N	—	—	—	P	59(?)	Static water level 10.8 ft. above land surface, Nov. 29, 1951. Well flows 1 gal. a min.
5.13	Feb. 17, 1947	10.8	June 13, 1947	Sc, E	25	1946	4.4	C	—	See chemical analysis.
4.17	Dec. 22, 1952	—	—	Sc, E	—	—	—	N	—	Observation well.
140[a]	May 21, 1947	175[a]	May 21, 1947	I, E	50	May 21, 1947	1.4	D, F	—	Sample-study log in Bull. 11, p. 151. See chemical analysis.
145[a]	Apr. 11, 1951	212[a]	Apr. 11, 1951	—	60	Apr. 11, 1951	.9	I	—	See driller's log.
—	—	—	—	C, H	—	—	—	D	—	See chemical analysis.
150[a]	Nov. 17, 1947	180[a]	Nov. 17, 1947	I, E	20	Nov. 17, 1947	.7	D	—	Sample-study log in Bull. 11, p. 152.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
St.M-Bc 2	M. M. Coleman	Wilson	1947	3	Drilled	336	2½	316–336	Aquia
Bc 12	Philip Davis	Payne	1951	18	do	357	1½	337–357	do
Bc 13	J. Mattingly	do	1951	5	do	352	1½	See remarks	do
Bd 1	H. C. Davidson	Washington Pump & Well Co.	1939	3	do	350	6	—	do
Bd 5	Martin Storey	Payne	1951	8	do	252	1½	—	Nanjemoy-Piney Point
Cb 1	S. S. Reeves	Wilson	1937	10	do	350	1½	342–350	Aquia
Cb 2	S. S. Mattingly	Payne	1946	12	do	300	1½	280–300	do
Cb 9	Bryan Knott	—	1935	125	Dug	26	36	—	Pleistocene (upland)
Cb 15	William F. Stembler	Payne	1950	22	Drilled	291	1½	See remarks	Aquia
Cc 6	Leonard Latham	—	1948	140	Dug	27	36	—	Pleistocene (upland)
Cd 1	N. C. Hines & Son	Payne	1948	10	Drilled	230	1½	—	Nanjemoy-Piney Point
Ce 4	John R. Long	Washington Pump & Well Co.	1947	120	Drilled	378	6	368–378	Nanjemoy-Piney Point
Ce 14	Mervell Dean	do	1949	85	do	363	8	352–363	do
Ce 20	Hollywood Elementary School	do	1951	125	do	383	6	378–383	do
Db 14	Clements Cheseldine	Payne	1947	16	do	310	1½	290–310	Aquia
Db 24	Clifton Downs	—	1947	50	Dug	10	30	—	Pleistocene (lowland)
Db 29	Sacred Heart Church	Washington Pump & Well Co.	1945	140	Drilled	410	6	400–410	Aquia

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
See remarks	—	—	—	N	—	—	—	D	—	Driller's log in Bull. 11, p. 80. Static water level 20 ft. above land surface. Well flowed 4 gal. a min., May, 1949.
do	—	—	—	—	7	June 21, 1951	—	D	—	Driller's log in Bull. 11, p. 81. Well flowed ¾ gal. a min., June 21, 1951.
do	—	12[a]	June 26, 1951	—	10	June 26, 1951	0.4	D	—	See driller's log. 20 ft. of screen; position unknown. Static water level 14.85 ft. above land surface, July 9, 1951.
do	—	22[a]	—	Sc, E	35	—	—	F	64.5	Driller's log in Bull. 11, p. 81. See chemical analysis. Flowing well.
do	—	16[a]	Mar. 13, 1951	N	8	Mar. 13, 1951	.4	D	—	See driller's log. Static water level 4.45 ft. above land surface, July 9, 1951. Well flows ½ gal. a min.
do	—	—	—	Sc, E	—	—	—	C, D	60.5	See chemical analysis. Static water level 13.94 ft. above land surface, and well flowed 8.5 gal. a min., Jan. 29, 1947.
do	—	12[a]	Aug. 1946	Sc, E	—	—	—	D	60.5	Driller's log in Bull. 11, p. 82. Static water level 6.43 ft. above land surface, and well flowed 1.72 gal. a min., Jan. 29, 1947.
19.6	July 22, 1949	—	—	B; Sc, E	—	—	—	D	—	See chemical analysis.
0	Sept. 30, 1950	16[a]	Sept. 30, 1950	Sc, E	10	Sept. 30, 1950	.6	D	—	See driller's log. 20 ft. of screen used; position unknown.
24.9	Aug. 16, 1949	—	—	Sc, E	—	—	—	D	—	See chemical analysis.
See remarks	—	10[a]	Apr. 28, 1948	Sc, E	6	Apr. 28, 1948	—	C	—	Sample-study log in Bull. 11, p. 155. See chemical analysis. Well flowed 3 gal. a min., July 26, 1949.
97[a]	June 30, 1947	133[a]	June 30, 1947	I, E	45	—	1.3	C	59.3	Driller's log in Bull. 11, p. 85.
85[a]	June 16, 1949	200[a]	June 16, 1949	I, E	50	June 16, 1949	.4	D	—	Driller's log in Bull. 11, p. 87. See chemical analysis.
100[a]	Apr. 13, 1951	200[a]	Apr. 13, 1951	I, E	60	Apr. 13, 1951	.6	I	—	See driller's log.
7[a]	May 2, 1947	17[a]	May 2, 1947	Sc, H	5	May 2, 1947	.5	D	—	Sample-study log in Bull. 11, p. 161.
3.00	Dec. 22, 1952	—	—	C, H	—	—	—	N	—	See chemical analysis. Observation well.
130[a]	June 11, 1945	270[a]	June 11, 1945	I, E	40	—	.3	I	—	

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
St.M-Db 32	Robert E. Bullard	Payne	1941	15	Drilled	294	1½	274–294	Aquia
Dc 2	Thomas B. Johnson	do	1947	2	do	333	1½	313–333	do
Dc 5	G. T. Sperry	do	1948	15	do	339	1½	319–339	do
Dc 10	James M. Hazel	do	1947	5	do	340	1½	320–340	do
Dc 12	C. Guy	Wilson	1947	13	do	326	1½	306–326	do
Dc 17	Ida L. Dent	do	1947	6	do	326	1½	306–326	do
Dc 20	Francis Gibson	Wilson	1947	11	do	315	1½	295–315	do
Dc 26	Town of St. Clement Shore	Washington Pump & Well Co.	1947	2	do	350	6	340–350	do
Dc 34	B. I. Mattingly	Payne	1949	12	do	336	2–1½	316–336	do
Dc 38	Jimmie Smith	do	1951	8	do	336	1½	316–336	do
Dd 1	City of Leonardtown	Washington Pump & Well Co.	1926	93	do	494	8	474–494	do
Dd 2	do	Shannahan	1921	3	do	360	—	—	do
Dd 5	do	L. Rude & Son	1907	22	do	263	1½	—	Nanjemoy-Piney Point
Dd 12	State Roads Commission	Payne	1941	11	do	200	3½–2½–1½	—	do
Dd 14	Charles Greenwell	do	1949	35	do	250	2½	None	do
De 3	Myers C. Dean	Washington Pump & Well Co.	1947	107	do	363	6	351–363	do
De 6	Weber and McCloud	do	1948	120	do	341	6	329–341	do
De 7	D. B. McMillian	do	1947	120	do	380	6	373–380	do
Df 1	Patuxent Naval Air Station	do	1943	96	do	587	8	567–587	Aquia
Df 2	do	do	1943	112	do	595	8–6	571–595	Aquia-Nanjemoy
Df 3	do	do	1943	105	do	585	10–8	565–585	Aquia
Df 4	do	do	1944	81	do	547	10–8	527–547	do
Df 5	do	do	1944	76	do	552	8	532–552	do
Df 6	do	do	1942	123	do	357	6–4	344–357	Nanjemoy-Piney Point
Df 7	do	do	1943	43	do	518	8–6	498–518	Aquia-Nanjemoy

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
1[a]	Mar. 17, 1951	18[a]	Mar. 17, 1951	Sc, H	9	Mar. 17, 1951	0.5	D	—	See driller's log.
See remarks	—	—	—	—	—	—	—	D	62	Driller's log in Bull. 11, p. 95. Well flowed 2.1 gal. a min. Mar. 27, 1947.
14[a]	June 28, 1948	20[a]	June 28, 1948	Sc, E	5	June 28, 1948	.8	D	—	Driller's log in Bull. 11, p. 95.
See remarks	—	20[a]	Aug. 31, 1947	Sc, E	5	Aug. 31, 1947	—	C	—	Well flows at high tide.
1[a]	Aug. 8, 1947	8[a]	Aug. 8, 1947	Sc, E	22	Aug. 8, 1947	3.1	D	—	Sample-study log in Bull. 11, p. 163. See chemical analysis.
1[a]	Sept. 2, 1947	12[a]	Sept. 2, 1947	Sc, H	15	Sept. 2, 1947	1.4	D	—	Driller's log in Bull. 11, p. 98. See chemical analysis. Well flowed ¼ gal. a min., June 10, 1949.
6[a]	Apr. 28, 1947	30[a]	Apr. 28, 1947	Sc, E	8	Apr. 28, 1947	.3	D	—	Sample-study log in Bull. 11, p. 165.
See remarks	—	42.5[a]	July 25, 1947	I, E	50	July 25, 1947	—	P	—	Driller's log in Bull. 11, p. 100. Well flows 2½ gal. a min.
9[a]	Sept. 27, 1949	19[a]	Sept. 27, 1949	Sc, E	5	Sept. 27, 1949	.5	D	—	Sample-study log in Bull. 11, p. 166.
4[a]	May 1, 1951	19[a]	May 1, 1951	—	7	May 1, 1951	.5	D	—	See driller's log.
90[a]	1946	200[a]	1946	I, E	150	1946	1.4	P	—	Sample-study log in Bull. 11, p. 168. See chemical analysis.
See remarks	—	86.5	Jan. 15, 1947	I, E	200	1947	—	P	—	Well flows at high tide
do	—	—	—	N	—	—	—	N	—	See chemical analysis. Well flowed 1½ gal. a min., Jan. 30, 1947.
do	—	—	—	Sc, E	—	—	—	D	—	See chemical analysis. Well flowed 1¼ gal. a min., Sept. 12, 1949.
27[a]	Aug. 10, 1949	35[a]	Aug. 10, 1949	J, E	4	Aug. 10, 1949	.5	D	—	Sample-study log in Bull. 11, p. 169.
80[a]	May 16, 1947	130[a]	May 16, 1947	I, E	60	May 16, 1947	1.2	C	—	Driller's log in Bull. 11, p. 103.
125[a]	Aug. 22, 1948	190[a]	Aug. 22, 1948	C, E	30	Aug. 22, 1948	.5	D	—	do
95[a]	Oct. 2, 1947	200[a]	Oct. 2, 1947	J, E	22	Oct. 2, 1947	.2	C	—	do
123.5[a]	June 1, 1943	176.5[a]	June 1, 1943	I, E	225	June 1, 1943	4.2	M	62	See chemical analysis.
108.8[a]	Nov. 22, 1943	160.8[a]	Nov. 22, 1943	I, E	300	Nov. 22, 1943	5.8	M	—	do
103.7[a]	Dec. 7, 1943	180.7[a]	Dec. 7, 1943	I, E	257	Dec. 7, 1943	3.3	M	—	Driller's log in Bull. 11, p. 105. See chemical analysis.
98[a]	May 1944	250[a]	May 1944	I, E	300	1944	2.0	M	—	do
100[a]	Jan. 1944	250[a]	Jan. 1944	I, E	300	1944	2.0	M	—	Driller's log in Bull. 11, p. 106. See chemical analysis.
125[a]	1942	170[a]	1942	I, E	25	1942	.6	M	—	do
50[a]	Mar. 31, 1943	155[a]	June 1, 1943	I, E	171	—	1.6	M	—	do

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
St.M-Df 8	Patuxent Naval Air Station	Washington Pump & Well Co.	1942	45	Drilled	282	8–4	272–282	Nanjemoy-Piney Point
Df 9	do	do	1943	47	do	285	8	270–285	do
Df 10	do	do	1943	43	do	534	8–6	514–534	Aquia
Df 11	do	do	1943	46	do	515	8	495–515	Aquia-Nanjemoy
Df 12	do	do	1944	11	do	489	10–8	469–489	do
Df 13	do	do	1944	19	do	490	8–6	470–490	do
Df 14	do	do	1943	18	do	262	8	See remarks	Nanjemoy-Piney Point
Df 22	Patuxent Water Co.	do	1946	111	do	606	8–6	576–600	Aquia
Df 23	G. S. Davis	do	1946	22	do	260	6	251–260	Nanjemoy-Piney Point
Df 24	Frank Borley	Payne	1946	6	do	280	1½	None	do
Df 25	W. B. Long	Washington Pump & Well Co.	1946	110	do	360	6	349–360	do
Df 26	Thomas K. Clark	Herbert	1940	110	Dug	58	48–36	—	Pleistocene (upland)
Df 30	Philip E. Grey	Washington Pump & Well Co.	1947	106	Drilled	348	6	338–348	Nanjemoy-Piney Point
Df 31	J. Q. Bean	—	—	15	Dug	19	36	—	Pleistocene (lowland)
Df 35	J. E. O'Brien	Washington Pump & Well Co.	—	35	Drilled	261	6	—	Nanjemoy-Piney Point
Df 39	Patuxent Naval Air Station	—	±1943	±25	do	284	—	—	do
Dg 1	do	Washington Pump & Well Co.	1943	19	do	480	8	460–480	Aquia
Dg 2	do	do	1943	11	do	486	10–8	466–486	Aquia-Nanjemoy
Dg 3	do	do	1943	13	do	489	8–6	469–489	Aquia
Dg 5	do	do	1950	18	do	494	8	475–494	do
Dg 6	do	do	Before 1942	18	do	489	—	—	do
Eb 2	Jessie Gass	Payne	1947	12	do	318	1½	298–318	do
Ec 10	C. Parker	do	1941	18	do	130	1½	None	Pleistocene (lowland)
Ec 11	R. F. Sapp	do	1950	4	do	250	1½	do	Nanjemoy-Piney Point
Ee 4	L. Roger Richardson	Washington Pump & Well Co.	1946	100	do	325	6	313–325	do
Ee 23	State Roads Commission	—	—	15	Dug	8	36	None	Pleistocene (lowland)

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Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
40[a]	1942	80[a]	1942	N	25	1942	0.6	N	—	Driller's log in Bull. 11, p. 106.
33[a]	May 31, 1943	96[a]	May 31, 1943	I, E	191	June 1, 1943	3.0	M	—	Driller's log in Bull. 11, p. 107. See chemical analysis. Observation well.
45[a]	June 26, 1943	143[a]	June 26, 1943	I, E	225	June 26, 1943	2.3	M	—	Driller's log in Bull. 11, p. 107. See chemical analysis.
58.3[a]	June 1, 1943	179.3[a]	June 1, 1943	I, G	71	June 1, 1943	5.7	M	—	do
22[a]	Apr. 1944	200[a]	Apr. 1944	I, E	300	1944	1.7	M	—	Driller's log in Bull. 11, p. 107. See chemical analysis.
35[a]	June 20, 1944	—	—	I, E	—	—	—	M	—	See chemical analysis.
33[a]	May 31, 1943	198[a]	May 31, 1943	I, E	170	May 31, 1943	1.0	M	—	Driller's log in Bull. 11, p. 108. See chemical analysis. Screen used; position and length unknown.
140[a]	Oct. 10, 1946	230[a]	Oct. 10, 1946	I, E	225	1946	2.5	P	—	Sample-study log in Bull. 11, p. 170.
30[a]	1946	60[a]	1946	J, E	40	1946	1.3	D	—	Driller's log in Bull. 11, p. 109. Observation well.
5[a]	July 19, 1946	17[a]	July 19, 1946	Sc, H	4	1946	.3	D	58	do
120[a]	Mar. 20, 1946	170[a]	Mar. 20, 1946	I, E	60	Mar. 20, 1946	1.2	P	—	
53.30	Dec. 22, 1952	—	—	C, E	—	—	—	D	—	Observation well.
118[a]	May 16, 1947	160[a]	May 16, 1947	I, E	40	May 16, 1947	1.0	D	—	Driller's log in Bull. 11, p. 110.
—	—	—	—	Sc, H	—	—	—	D	—	See chemical analysis.
40[a]	—	115[a]	—	J, E	90	—	1.2	P	—	Driller's log in Bull. 11, p. 111.
34.10	Sept. 6, 1950	—	—	I, E	—	—	—	M	—	See chemical analysis.
86[a]	Jan. 28, 1944	151[a]	Jan. 28, 1944	I, E	162	Jan. 28, 1944	2.5	M	—	do
17[a]	Dec. 9, 1943	97[a]	Dec. 9, 1943	I, E	340	Dec. 9, 1943	4.3	M	—	Driller's log in Bull. 11, p. 112. See chemical analysis.
37[a]	Oct. 23, 1943	200[a]	Oct. 23, 1943	I, E	300	Oct. 23, 1943	1.8	M	—	do
38[a]	Aug. 1950	200[a]	Aug. 1950	N	210	Aug. 1950	1.3	M	—	Driller's log in Bull. 11, p. 113. See chemical analysis.
25.00	Sept. 6, 1950	—	—	I, E	—	—	—	M	—	See chemical analysis.
5[a]	Apr. 22, 1947	15[a]	Apr. 22, 1947	Sc, E	5	Apr. 22, 1947	.5	D	—	Sample-study log in Bull. 11, p. 173.
8.12	Sept. 24, 1949	—	—	Sc, H	—	—	—	D	—	See chemical analysis.
See remarks	—	14[a]	May 2, 1950	Sc, E	6	May 2, 1950	.4	D	—	Sample-study log in Bull. 11, p. 174. Static water level 0.70 ft. above land surface, June 9, 1950.
97[a]	Feb. 1946	160[a]	Feb. 1946	C, E	60	Feb. 1946	1.0	D	—	Driller's log in Bull. 11, p. 120. See chemical analysis.
1.92	June 4, 1952	—	—	N	—	—	—	—	67	Observation well. For forest-fire prevention.

TABLE 32

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
St.M-Ee 24	State Roads Commission	—	—	91	Dug	6	36	None	Pleistocene (upland)
Ee 26	Harry C. Raley	Payne	1949	90	Drilled	349	3–2	do	Nanjemoy-Piney Point
Ee 30	Holy Face Church	Washington Pump & Well Co.	1951	89	do	320	6	312–318	do
Ef 3	Chesapeake & Potomac Telephone Co.	do	1946	100	do	322	6	310–322	do
Ef 4	St. Marys Female Seminary	do	1936	20	do	661	8–6	647–661	Raritan(?)
Ef 13	B. G. Hohensee	do	1948	85	do	308	6	298–308	Nanjemoy-Piney Point
Ef 17	Heath Steele	do	1943	31	do	497	6	476–497	Aquia
Ef 27	J. Allen Coad	L. Rude & Son	1909	1	do	488	1½	None	do
Eg 3	J. W. Elms	Deagle	1946	15	do	387	1½	do	Nanjemoy-Piney Point
Eg 7	F. P. Veitch	Watts	1946	23	do	300	2	do	do
Eg 14	William O. Wise	—	1948	100	do	30	36	—	Pleistocene (upland)
Eg 16	T. A. McInerny	Payne	1950	11	do	315	2½–1½	295–315	Nanjemoy-Piney-Point
Fe 1	U. S. Navy	Washington Pump & Well Co.	1942	10	do	412	6	400–412	Aquia
Fe 4	Mrs. N. Puchetti	Deagle	1946	3	do	275	1½	None	Nanjemoy-Piney Point
Fe 21	U. S. Navy	Washington Pump & Well Co.	1941	9	do	409	6	398–409	Aquia
Fe 23	Curtiss Steuart	do	1950	4	do	405	8	391–405	Aquia
Fe 24	do	do	1950	5	do	411	6–4	402–411	do
Ff 8	James Deagle	Deagle	1946	5	do	285	1½	None	Nanjemoy-Piney Point
Ff 9	Thomas McKay	Payne	1947	3	do	273	1½	do	do
Ff 21	U. S. Navy	Washington Pump & Well Co.	1945	10	do	486	8	464–486	Aquia
Ff 30	do	Layne-Atlantic Co.	1951	4	do	259	4–2	249–259	Nanjemoy-Piney Point
Fg 4	John A. Bradburn	Deagle	1946	10	do	420	1½	None	do
Fg 40	Earl Trossbach	—	—	7	Dug	—	40	—	Pleistocene (lowland)
Fh 2	M. A. Mace	Washington Pump & Well Co.	1946	9	Drilled	355	6–4	None	Nanjemoy-Piney Point
Fh 3	C. A. Ferris	Wilson	1949	6	do	415	1½	do	do
Gg 1	J. Linwood Trossbach	Deagle	1946	6	do	420	2	do	do

—*Continued*

Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
2.62	June 4, 1952	—	—	N	—	—	—	—	—	Observation well. For forest-fire prevention.
90[a]	Sept. 15, 1949	98[a]	Sept. 15, 1949	C, H	3	Sept. 15, 1949	0.4	D	—	Sample-study log in Bull. 11, p. 176.
90[a]	May 18, 1951	273[a]	May 18, 1951	N	55	May 18, 1951	.3	I	—	
105[a]	Aug. 12, 1946	150[a]	Aug. 12, 1946	I, E	20	Aug. 12, 1946	.4	C	—	Driller's log in Bull. 11, p. 125.
See remarks	—	160[a]	1936	I, E	53	1936	—	I	67	See chemical analysis. Flowing well.
100[a]	July 2, 1948	125[a]	July 2, 1948	I, E	30	July 2, 1948	1.2	C	—	Driller's log in Bull. 11, p. 126.
35[a]	Jan. 18, 1943	123[a]	Jan. 18, 1943	I, G	109	Jan. 18, 1943	1.2	D, F	—	Driller's log in Bull. 11, p. 127.
9.92	Dec. 23, 1952	—	—	N	—	—	—	N	—	Observation well. Formerly flowed 10–12 gal. a min.
15.65	Dec. 22, 1952	—	—	Sc, E	5	Dec. 22, 1952	—	D	—	Driller's log in Bull. 11, p. 129. Observation well.
18[a]	Aug. 6, 1946	30[a]	Aug. 6, 1946	Sc, H	6	Aug. 6, 1946	.5	D	58	Driller's log in Bull. 11, p. 129.
29.1	Sept. 7, 1949	—	—	Sc, E	—	—	—	D	—	See chemical analysis.
18[a]	Sept. 5, 1950	25[a]	Sept. 5, 1950	J, E	5	Sept. 5, 1950	.7	D	—	Sample-study log in Bull. 11, p. 179.
8.66	May 18, 1950	60[a]	1942	I, E	25	1942	.4	M, P	64.5	Driller's log in Bull. 11, p. 129. See chemical analysis.
1.85	Mar. 19, 1947	—	—	Sc, H	10	1946	—	D	—	Driller's log in Bull. 11, p. 130.
11.44	May 17, 1950	120[a]	—	I, E	48	—	.4	P	—	Driller's log in Bull. 11, p. 134. See chemical analysis.
2.46	May 16, 1950	72[a]	May 16, 1950	I, E	218	May 16, 1950	3.1	C	—	Driller's log in Bull. 11, p. 134.
8[a]	Apr. 12, 1950	25[a]	Apr. 12, 1950	I, E	25	Apr. 12, 1950	1.5	C	—	See sample-study log.
—	—	—	—	Sc, E	—	—	—	D	—	See chemical analysis.
1.5[a]	Apr. 11, 1947	10[a]	Apr. 11, 1947	Sc, H	5	Apr. 11, 1947	.6	D	—	Driller's log in Bull. 11, p. 135.
10[a]	1945	125[a]	1945	I, E	150	1945	1.3	M	—	Driller's log in Bull. 11, p. 136.
4[a]	Dec. 29, 1951	14[a]	Dec. 29, 1951	Sc, E	25	Dec. 29, 1951	2.5	M	—	Driller's log in Bull. 11, p. 137. See chemical analysis.
9.72	Dec. 22, 1952	—	—	Sc, E	11	1946	—	D	59.5	Driller's log in Bull. 11, p. 138. See chemical analysis. Observation well.
4.72	Apr. 2, 1952	—	—	Sc, E	—	—	—	D	—	See chemical analysis.
20[a]	July 18, 1946	40[a]	July 18, 1946	Sc, E	10	July 18, 1946	.5	D	—	Driller's log in Bull. 11, p. 145.
7[a]	Sept. 29, 1949	—	—	Sc, H	15	Sept. 29, 1949	—	D	—	
3[a]	Sept. 7, 1946	12[a]	Sept. 7, 1946	Sc, E	12	Sept. 7, 1946	1.3	D, F	—	Sample-study log in Bull. 11, p. 183.

Well number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Water-bearing formation
St.M-Gg 4	J. J. Quinn	Watts	1946	3	Drilled	360	2	None	Nanjemoy-Piney Point
Gh 1	Point Lookout Hotel	—	1928	5	do	697	8	—	Raritan(?)
D.C.-2	Washington Terminal Co.	Layne-Atlantic Co.	1948	10	do	400	—	—	Pre-Cambrian-Patuxent

Water level (feet below land surface)				Pumping equipment	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Date	Pumping	Date		Gallons a minute	Date				
8[a]	June 20, 1946	20[a]	June 20, 1946	Sc, H	3	June 20, 1946	0.3	D	—	Driller's log in Bull. 11, p. 147.
See remarks	—	—	—	Sc, E	24	1928	—	C	—	See chemical analysis. Static water level estimated to be 20 ft. above land surface, Mar. 1947.
—	—	—	—	—	—	—	—	—	—	See sample-study log. Test hole.

TABLE 33

Drillers' logs of selected wells in Southern Maryland

[A more complete listing is in the published reports on the ground-water resources of the five counties.]

ANNE ARUNDEL COUNTY

	Thickness (feet)	Depth (feet)
Well AA-Ac 11 (Altitude: 130 feet)		
Patapsco formation:		
Sand	10	10
Clay, white	10	20
Arundel(?) clay:		
Clay, sandy, white	110	130
Sand	10	140
Clay, red	165	305
Clay, white	5	310
Patuxent formation:		
Sand and gravel (water)	10	320
Well AA-Ac 14 (Altitude: 150 feet)		
Patapsco formation:		
Surface clay	6	6
Sand, white	3	9
Arundel clay:		
Clay, hard, pink	29	38
Sandstone	1	39
Clay, white and pink	29	68
Clay, white, and sand	11	79
Clay, hard, red	9	88
Clay, white and red	19	107
Sandstone, hard	1	108
Clay, white and pink	20	128
Patuxent formation:		
Sand, coarse, and gravel, small	13	141
Clay, medium hard, white	13	154
Clay, pink	10	164
Sand, fine, tight, white	10	174
Clay, hard, white	9	183
Sand, fine, white	3	186
Sand, coarse (water)	28	214
Pre-Cambrian rocks:		
"Difficult drilling"	6	220
Well AA-Ac 23 (Altitude: 200 feet)		
Pleistocene deposits and Patapsco formation:		
Clay, yellow	9	9
Sand, yellow	3	12
Clay, hard, white	8	20
Sand and gravel, heavy	13	33
Clay, hard, white	15	48
Sand, fine, hard-packed	20	68

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Ac 23—*Continued*		
Clay, hard, white	5	73
Sand, fine	8	81
Clay, hard, white	2	83
Clay, white, and streaks of sand, fine	19	102
Clay, hard, white	9	111
Sand, fine; fast drilling	33	144
Arundel clay:		
Clay, very hard, red, becoming clay, yellow	45	189
Clay, medium hard, gray	19	208
Clay, hard, gray; then streaks of rock	21	229
Clay, medium hard, mixed gray and red	33	262
Patuxent formation:		
Rock	3	265
Clay, medium hard, white	27	292
Sand, fine, hard-packed, and streaks of clay, white	35	327
Sand, medium coarse	5	332
Clay, hard, red	5	337
Well AA-Ad 39 (Altitude: 140 feet)		
Pleistocene deposits:		
Gravel and clay	15	15
Sand	25	40
Patapsco formation:		
Clay, red	7	47
Clay, white or gray	15	62
Clay, blue	13	75
Clay, white	10	85
Clay, red	5	90
Sand, coarse, red	12	102
Rock	2	104
Sand	20	124
Clay, white	2	126
Sand (water)	5	131
Clay, white	6	137
Gravel	3	140
Sand	17	157
Clay, white	3	160
Sand (water)	1	161
Clay, white	14	175
Sand (water)	3	178
Well AA-Ad 43 (Altitude: 47 feet)		
Pleistocene deposits:		
Surface soil; fill sand and boulders	5	5
Sand, coarse	7	12
Patapsco formation:		
Clay, medium hard to hard, white, mixed with clay, pink	27	39

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Ad 43—*Continued*		
Sand, fine, tight	20	59
Sand, medium coarse	4	63
Arundel clay:		
Clay, hard, red	1	64
Rock, hard	5	69
Clay, very hard, gray	18	87
Clay, medium hard, gray	1	88
Rock	6	94
Clay, medium hard, gray	1	95
Patuxent formation:		
Rock	10	105
Rock, very hard	22	127
Clay, soft, sandy, white, and streaks of sand, fine	5	132
Clay, hard, pink, mixed with clay, white	17	149
Clay, medium hard, red; thin streaks of sand, fine	4	153
"Rough streaks of rock formation"	13	166
Sand, fine to coarse (water)	9	175
Clay, hard, sandy, red	10	185
Clay, medium hard, gray; thin streaks of sand, fine	10	195
Clay, soft, gray	2	197
Clay, hard, gray, becoming clay, red	25	222
Clay, medium hard, sandy, red	13	235
Clay, soft, blue	7	242
Sand, fine (water)	6	248
Sand, medium coarse (water)	1	249
Rock	20	269
Clay, hard, blue	5	274
Rock, weathered, hard	4	278
Pre-Cambrian rocks:		
Granite rock	1	279
Well AA-Bb 26 (Altitude: 290 feet)		
Pleistocene deposits and Patapsco formation:		
Clay, brown	3	3
Clay, yellow and brown	2	5
Sandrock, hard	2	7
Sand, coarse, red and brown	8	15
Clay, white	3	18
Sand, very coarse, tan	10	28
Gravel, small	6	34
Sand, coarse, tan	15	49
Clay, white	4	53
Sand, coarse, tan, with some clay, white	8	61
Arundel clay and Patuxent formation:		
Clay, white	17	78
Clay, blue	13	91
Clay, brown, white, and blue	10	101

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Bb 26—*Continued*		
Sand, coarse, and gravel, small	23	124
Sand, coarse	30	154
Clay, white and blue	9	163
Clay, white and brown	11	174
Sand, coarse, and gravel, small	14	188
Well AA-Bc 40 (Altitude: 120 feet)		
Raritan and Patapsco formations:		
Sand	62	62
Clay, red	13	75
Clay, white	10	85
Clay, red	6	91
Clay, sandy, white	9	100
Clay, white	8	108
Sand	9	117
Sand, coarse	7	124
Clay, white	4	128
Sand	16	144
Clay	.5	144.5
Sand	25.5	170
"Iron ore"	1	171
Well AA-Bf 20 (Altitude: 15 feet)		
Pleistocene deposits:		
Sand, yellow, and clay	18	18
Sand, fine, dirty, and wood	18	36
Sand, fine	33	69
Sand and clay, mucky, dark	62	131
Raritan and Patapsco formations:		
Sand, medium coarse (water)	20	151
Clay, medium hard, mixed red and blue	13	164
Well AA-Cc 23 (Altitude: 220 feet)		
Pleistocene deposits:		
No record	15	15
Sand, coarse, hard	11	26
Magothy(?) formation:		
Hard streaks, "iron pyrites" and gravel	3	29
Gravel and clay, sandy, medium hard, yellow	28	57
Hard streaks, "iron pyrites" and gravel	4	61
"Iron pyrites"	7	68
Clay, sandy, yellow	2	70
"Iron pyrites"	10	80
Sand, and gravel, small, brown	9	89
Sand, fine, brown; streaks of iron oxide	10	99

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Cc 23—*Continued*		
Raritan and Patapsco formations:		
Sandrock, hard streak	1	100
Clay, soft streak, white	2	102
Clay, hard, brown and white; sand, coarse	12	114
Clay, hard, red and white	45	159
Clay, medium hard, blue	12	171
Clay, sandy, white	6	177
Sand, fine	5	182
Clay, white	2	184
Sand, fine	3	187
Clay, white streaks	11	198
Sand, medium hard, white	28	226
Sand, coarse, gravel, small, and clay	17	243
Clay, white	1	244
Sand, coarse, gravel, small, and clay	6	250
Clay, in thin layers, medium soft	5	255
Clay, white, thin layers of sand, some gravel	4	259
Sand medium coarse, chunks of clay, white, gravel, small; traces of iron oxide	6	265
Well AA-Ce 60 (Altitude: 80 feet)		
Aquia greensand, Monmouth and Matawan formations:		
Loam, yellow	18	18
Rock	2	20
Clay, brown	40	60
Rock	5	65
Clay, brown	15	80
Rock	2	82
Sand, yellow	17	99
Clay, brown	13	112
Sand, black	8	120
Clay, black	30	150
Clay, green	5	155
Rock	3	158
Clay, black	4	162
Magothy formation:		
Sand, coarse, gray (water)	—	162
Sand, gray	8	170
Clay, black	10	180
Sandrock, brown	18	198
Sand, black	21	219
Clay, hard, blue	2	221
Sand, white (water)	1	222
Clay, sandy, gray	3	225
Sand, black	4	229
Sand, black and white	10	239

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Ce 60—*Continued*		
Raritan formation:		
Rock, hard	3	242
Sand, white (water)	—	243
Well AA-Ed 21 (Altitude: 170 feet)		
Pleistocene deposits:		
Soil and clay, yellow	21	21
Calvert and Nanjemoy formations:		
Marl	185	206
Clay, brown	29	235
Aquia greensand:		
Marl, green	3	238
Rock	1	239
Marl, sandy	21	260
Marl and shells	5	265
Rock and sand, black (water)	6	271
Well AA-Fc 8 (Altitude: 45 feet)		
Pleistocene deposits:		
Sand	35	35
Gravel, small	10	45
Nanjemoy formation:		
Sand	22	67
Fuller's earth, red	5	72
Aquia greensand:		
Sand, salt-and-pepper (water)	38	110
Well AA-Fc 28 (Altitude: 5 feet) (Bulletin 5, p. 135)		
Well AA-Ge 7 (Altitude: 10 feet)		
Pleistocene deposits:		
Sand, fine, clayey	21	21
Calvert formation:		
Clay, gray, diatoms; shells	63	84
Nanjemoy formation:		
Sand, green, with gray clay; forams	116	200
Clay, pink to gray	20	220
Aquia greensand:		
Sand, dark green, glauconitic, some clay; mollusk and bryozoan fragments; forams common	40	260
Sand, brown and green, fine to coarse, glauconitic	50	310
CALVERT COUNTY		
Well Cal-Bc 9 (Altitude: 4 feet)		
Calvert and Nanjemoy formations:		
Clay, blue	50	50
Marl	100	150

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well Cal-Bc 9—*Continued*		
Sand, black	20	170
Clay, blue	75	245
Sand, black	10	255
Clay, brown	20	275
Aquia greensand:		
Sand, fine	39	314
Sand, coarse (water)	41	355
Well Cal-Bc 13 (Altitude: 132 feet)		
Pleistocene deposits:		
Sand, red	10	10
Clay, yellow, and sand	10	20
Calvert formation:		
Clay, gray	30	50
Clay, bluish	50	100
Clay, hard, green	50	150
Nanjemoy formation:		
Clay, green, and shells	20	170
Clay, green, and sand, black	19	189
Clay, green	16	205
Clay, green, and sand, black (some water 215–230)	25	230
Sand, black (water)	50	280
Clay, green	14	294
Well Cal-Db 18 (Altitude: 122 feet)		
Pleistocene deposits:		
Clay, sandy, yellow	4	4
Clay, soft, brown	10	14
Clay, soft, brown	10	24
Choptank and Calvert formations:		
Clay, soft, gray	8	32
Clay, hard, gray, and shells	5	37
Sand, gray	16	53
Clay, hard, gray	12	65
Clay, soft, gray	184	249
Nanjemoy formation:		
Shell rock, hard	0.5	249.5
Clay, sandy, black	90.5	340
Sand, dark green	15	355
Clay, sandy, black	40	395
Clay, hard, blue	17	412
Sand, black or green	40	452
Clay, hard, blue and pink	11	463
Sand, fine, black	11	474
Clay, mixed blue and pink	4	478
Aquia greensand:		
Sand, fine, black	12	490

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well Cal-Db 18—*Continued*		
Clay, mixed, blue and pink	10	500
Sand and shells	15	515
Streaks of shell and clay, blue, with pink	6	521
All shell formation	29	550
Sand, mushy, and shells	80	630
Clay, hard, pink	7	637
Well Cal-Db 19 (Altitude: 20 feet)		
Pleistocene deposits:		
Fill dirt	7	7
Marsh	3	10
Sand	10	20
Clay	5	25
Sand and shells	38	63
Calvert and Nanjemoy formations:		
Clay	62	125
Sand, gray	15	140
Sand, black (water)	50	190
Sand, black	162	352
Clay, purple	18	370
Aquia greensand:		
Sand, brown (water)	20	390
Well Cal-Dc 26 (Altitude: 143 feet)		
Pleistocene deposits:		
Sand	47	47
Choptank, Calvert, and Nanjemoy formations:		
Marl	104	151
Marl and shells	9	160
Marl	298	458
Clay, brown	15	473
Aquia greensand:		
Sand, black and white	45	518
Sand, medium, and shells	45	563
Well Cal-Dc 27 (Altitude: 140 feet)		
Pleistocene deposits:		
Clay, yellow	8	8
Sand and gravel	10	18
Pleistocene deposits, Choptank and Calvert formations:		
Sand, gravel, and clay, grayish	22	40
Clay, gray	10	50
Clay, blue	90	140
Clay, green	20	160
Clay, green, and shells	40	200
Clay, blue	80	280

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well Cal-Dc 27—*Continued*		
Piney point and Nanjemoy formations:		
Rock	2	282
Sand, white	8	290
Rock	2	292
Sand, greenish	18	310
Clay, green, and sand	40	350
Rock	1	351
Sand, blackish	19	370
Sand, greenish	25	395
Clay, blue, and sand	45	440

CHARLES COUNTY

	Thickness (feet)	Depth (feet)
Well Ch-Bb 9 (Altitude: 32 feet)		
Pleistocene deposits:		
Clay	15	15
Sand	8	23
Clay and sand	9	32
Patapsco formation:		
Clay	23	55
Clay, red	17	72
Clay, dark	33	105
Clay	30	135
Clay, red	15	150
Clay and sand	10	160
Clay	22	182
Sand	16	198
Arundel(?) clay:		
Clay	22	220
Clay, gray	15	235
Sand	10	245
Clay	33	278
Sand and clay	21	299
Clay	23	322
Patuxent formation:		
Sand and clay	37	359
Sand	20	379
Sand and clay	10	389
Clay	9.5	398.5
Well Ch-Bc 6 (Altitude: 65 feet)		
Pleistocene deposits:		
Clay, red	10	10
Clay, sandy, red	8	18
Clay and boulders	21	39
Patapsco formation and Arundel clay:		
Clay, chalky, white	36	75
Clay, yellow	40	115

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Bc 6—*Continued*		
Clay, sandy, soft, yellow	5	120
Clay, tough, yellow	57	177
Clay, medium red	20	197
Clay, sandy, red	58	255
Sand, fine, mixed with clay	33	288
Sand, hard-packed (a little water)	23	311
Clay, sandy, blue	47	358
Sand, green (water)	39	397
Sand, white (water)	15	412
Clay, hard, brown	5	417
Well Ch-Bc 15 (Altitude: 80 feet)		
Pleistocene deposits:		
Clay, red	20	20
Sand and gravel	38	58
Patapsco formation:		
Clay, mixed	17	75
Clay, brown	8	83
Clay, gray and brown	82	165
Clay, blue	31	196
Clay, sandy, blue	7	203
Arundel(?) clay:		
Clay, blue and brown	14	217
Clay, sandy, blue	4	221
Clay, gray	9	230
Clay, sandy	10	240
Clay, mixed	17	257
Clay, sandy	3	260
Clay, gray	3	263
Sand and gravel, muddy	7	270
Clay, brown	2	272
Sand and gravel, muddy	7	279
Clay, blue	6	285
Clay, brown	16	301
Clay, blue	3	304
Patuxent formation:		
Clay, sandy, blue	18	322
Sand and clay, muddy	6	328
Clay, sandy, blue	14	342
Sand, muddy	5	347
Sand, coarse, muddy	9	356
Clay, blue	1	357
Sand, coarse, and clay	12	369
Clay, blue	2	371
Sand, coarse, with clay streaks	7	378
Clay, blue	15	393
Sand, fine	3	396
Clay, blue	6	402

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Bc 15—*Continued*		
Clay, sandy, gray	20	422
Clay, blue	3	425
Clay, blue and brown	20	445
Clay, brown	32	477
Clay, sandy, blue	11	488
Sand, fine	3	491
Clay, blue	2	493
Clay, sandy, blue	22	515
Clay, blue, and gravel	8	523
Clay, sandy, blue	9	532
Clay, brown	10	542
Well Ch-Bd 13 (Altitude: 130 feet)		
Pleistocene deposits:		
Clay, red, and gravel	30	30
Nanjemoy formation:		
Clay, and sand, blue, sea shells	70	100
Clay, red	35	135
Aquia greensand:		
Clay, red, and sand, blue, mixed	15	150
Sand, dark blue, and shells	25	175
Shells and sand rock	5	180
Sand, dark blue	20	200
Well Ch-Bf 92 (Altitude: 210 feet)		
Pleistocene deposits:		
Clay, brown	8	8
Sand and gravel	12	20
Calvert and Nanjemoy formations:		
Marl, blue	80	100
Marl, green	95	195
Clay, pink	30	225
Aquia greensand and Monmouth formation:		
Marl and shells	30	255
Rock	3	258
Marl and shells	12	270
Marl, sandy, black	92	362
Marl, black	10	372
Sand (water)	9	381
Well Ch-Bf 93 (Altitude: 205 feet)		
Pleistocene deposits:		
Sand and gravel	20	20
Calvert and Nanjemoy formations:		
Marl, sandy, blue	180	200
Clay, brown	20	220
Aquia greensand and Monmouth formation:		
Marl, blue, and shells	33	253

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Bf 93—*Continued*		
Rock	15	268
Marl, sandy, blue	77	345
Rock	2	347
Marl	19	366
Sand, fine, gray	11	377
Marl, tough, blue	38	415
Sand, very fine	5	420
Clay, gray	8	428
Sand, fine	5	433
Clay, pink	11	444
Sand, fine	4	448
Clay, black	2	450
Magothy formation:		
Sand, fine	8	458
Clay, pink	2	460
Sand, fine (water)	10	470
Sand, coarse (water)	10	480
Well Ch-Cb 6 (Altitude: 20 feet)		
Pleistocene deposits:		
Clay, yellow	11	11
Clay, white	6	17
Sand and gravel	3	20
Clay, light blue, and sand	6	26
Sand, coarse	14	40
Patapsco formation:		
Clay, medium hard, brown and blue	20	60
Clay, medium hard, brown	7	67
Sand, coarse (water)	12	79
Clay, medium hard, gray	45	124
Clay, sandy, soft, blue and gray; wood	23	147
Sand, fine (water)	6	153
Clay, medium hard, pink and blue, mixed	23	176
Sand, fine and coarse (water)	26	202
Clay, hard, blue	6	208
Well Ch-Cb 7 (Altitude: 36 feet)		
Pleistocene deposits:		
Clay, brown	10	10
Clay, sandy, brown	11	21
Clay, gray, and gravel	7	28
Gravel	7	35
Patapsco formation:		
Clay, gray	5	40
Clay, sandy, and gravel	11	51
Gravel	5	56
Clay, sandy, and gravel	4	60

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Cb 7—*Continued*		
Clay, sandy, blue	34	94
Clay, mixed colored	9	103
Clay, sandy, fine	41	144
Sand, medium, some clay (water)	9	153
Sand, coarse (water)	14	167
Clay, blue	6	173
Clay, sandy, blue	15	188
Clay, blue	2	190
Clay, brown	30	220
Clay, sandy, blue	18	238
Arundel(?) clay:		
Clay, mixed colored	9	247
Clay, sandy, blue	5	252
Clay, soft, varicolored	4	256
Clay, hard, varicolored	4	260
Clay, brown	13	273
Clay, blue	7	280
Clay, sandy, blue and brown	46	326
Clay, sandy, blue	6	332
Clay, blue and brown	38	370
Clay, sandy, blue	8	378
Clay, mixed	10	388
Clay, sandy, blue	5	393
Clay, blue and brown	7	400
Well Ch-Cd 7 (Altitude: 160 feet)		
Pleistocene deposits:		
Soil	5	5
Clay, brown and white	33	38
Calvert and Nanjemoy formations:		
Marl	192	230
Clay, brown	20	250
Aquia greensand:		
Marl, sandy	140	390
Magothy(?) formation:		
Sand, muddy	10	400
Raritan formation:		
Clay, varicolored	153	553
Sand, gray (water)	11.5	564.5
Well Ch-Cd 9 (Altitude: 149 feet)		
Pleistocene deposits:		
Soil	10	10
Sand and gravel	14	24
Calvert and Nanjemoy formations:		
Marl	184	208

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Cd 7—*Continued*		
Clay, brown	24	232
Clay, gray	8	240
Aquia greensand and Monmouth formation:		
Marl	38	278
Rock	3	281
Marl and shells	75	356
Raritan formation:		
Clay, brown	48	404
Sand, fine	5	409
Sand, coarse (water)	14	423
Well Ch-Cd 12 (Altitude: 64 feet)		
Pleistocene deposits:		
Clay, yellow	8	8
Gravel	10	18
Nanjemoy formation:		
Sand, black, and clay	108	126
Clay, red	42	168
Aquia greensand and Monmouth formation:		
Rock, hard	2	170
Sand and layers of rock, black (water)	103	273
Clay, sticky, brown	122	395
Raritan formation:		
Sand, coarse, gray (water)	25	420
Well Ch-Ce 6 (Altitude: 196 feet)		
Pleistocene deposits:		
Clay, red	20	20
Gravel and clay	10	30
Gravel, white	10	40
Calvert and Nanjemoy formations:		
Marl, blue	180	220
Marl, sticky, blue	20	240
Marl, blue	8	248
Clay, sticky, brown	42	290
Aquia greensand:		
Marl, blue	13	303
Rock	2	305
Shell	3	308
Rock	2	310
Sand, green	20	330
Marl, black	5	335
Clay, sandy, green	55	390
Clay, sandy, blue	8	398
Brightseat and Monmouth formations:		
Marl, black	17	415
Sand, coarse	17	432
Marl, black	17	449

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Ce 16 (Altitude: 185 feet)		
Pleistocene deposits:		
Clay, yellow	20	20
Calvert and Nanjemoy formations:		
Sand and clay	40	60
Clay, blue	108	168
Shell rock	2	170
Clay, gray	15	185
Clay, blue	15	200
Clay, brown	35	235
Clay, light brown	20	255
Aquia greensand, Brightseat and/or Monmouth formation:		
Mud, blue, and shells	5	260
Clay, green	5	265
Clay, dark	15	280
Clay, blue, and sand	17	297
Shell rock	3	300
Sand, green	10	310
Clay, green	30	340
Clay, dark	30	370
Raritan and Patapsco formations:		
Clay, white	20	390
Clay, light brown	17	407
Clay, dark brown	41	448
Sand, white	4	452
Clay, yellow	38	490
Clay, sticky, brown	10	500
Clay, sticky, yellow	15	515
Clay, sticky, dark gray	11	526
Sand	4	530
Sand, white	11	541
Clay, sticky, yellow	24	565
Clay, yellow	15	580
Sand, fine, white	4	584
Sand, coarse	3	587
Sand, fine	5	592
Clay, sticky, yellow	3	595
Sand, fine	2	597
Clay, yellow	11	608
Well Ch-Cf 9 (Altitude: 185 feet)		
Pleistocene deposits:		
Soil	12	12
Sand, soft, mushy, yellow	23	35
Choptank, Calvert, and Nanjemoy formations:		
Clay, sandy, soft	6	41
Clay, soft, blue	17	58
Clay, blue	30	88

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Cf 9—*Continued*		
Clay, blue, and shell	16	104
Clay, soft, blue, little shell	58	162
Sand and shell	4	166
Clay, soft, dark	46	212
Sand, mushy, black	91	303
Clay, blue	80	383
Sandstone	3	386
Aquia greensand and Monmouth formation:		
Sand, fine, soft	5	391
Sand, rock, shell, in streaks	28	419
Clay, green, and shell	25	444
Sand, mushy	12	456
Marl, green	93	549
Marl, black	25	574
Magothy formation:		
Lignite and sand	3	577
Clay, light brown	38	615
Gravel, small, and sand	4	619
Clay, light blue, and sand	11	630
Sand and gravel (water)	19	649
Raritan formation:		
Clay, pink and gray	30	679
Well Ch-Dd 11 (Altitude: 20 feet)		
Pleistocene deposits:		
Sand and clay	18	18
Clay	5	23
Gravel	6	29
Nanjemoy formation:		
Clay and sand	41	70
Clay, pink	22	92
Aquia greensand:		
Rock and sand	75	167
Sand (water)	43	210
Well Ch-De 16 (Altitude: 170 feet)		
Pleistocene deposits:		
Clay, red	20	20
Gravel	10	30
Calvert and Nanjemoy formations:		
Sand, muddy, brown	20	50
Marl	145	195
Clay, sandy, gray	75	270
Clay, brown	30	300
Aquia greensand and Monmouth formation:		
Marl, sandy	10	310
Rock	2	312

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-De 16—*Continued*		
Marl	9	321
Rock	3	324
Clay, sandy	56	380
Sand, black	6	386
Clay, black	44	430
Clay, blue	5	435
Sand, medium coarse (water)	10	445
Well Ch-Ee 4 (Altitude: 20 feet)		
Pleistocene deposits:		
Topsoil	2	2
Clay, sandy, yellow	12	14
Sand, yellow	19	33
Nanjemoy formation:		
Marl, sandy, black	93	126
Clay, blue	34	160
Rock	1	161
Clay, blue	15	176
Clay, brown	21	197
Aquia greensand:		
Marl, black	19	216
Rock	6	222
Sand, black (water)	5	227
Rock	2	229
Sand, green (water)	6	235
Rock	2	237
Well Ch-Ee 47 (Altitude: 128 feet)		
Pleistocene deposits:		
Clay, sandy, red	40	40
Calvert and Nanjemoy formations:		
Marl	178	218
Clay, blue	82	300
Clay, pink	27	327
Aquia greensand:		
Marl, sandy	153	480
Raritan(?) formation:		
Clay, blue	30	510
Sand, fine, white	6	516
Clay, blue	2	518
Sand, coarse (water)	5	523
Well Ch-Ef 8 (Altitude: 147 feet)		
Pleistocene deposits:		
Clay, red, and sand	10	10
Sand and gravel	20	30

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Ef 8—*Continued*		
Calvert and Nanjemoy formations:		
Clay, greenish, and sand	30	60
Sand, gray, and shells	50	110
Clay, green, and sand	40	150
Clay, green	20	170
Sand, black, and clay	105	275
Sand, black, and clay, gray	35	310
Sand, gray	68	378
Aquia greensand:		
Sand (water)	20	398
Well Ch-Ff 13 (altitude: 14 feet)		
Pleistocene deposits:		
Clay, yellow	17	17
Sand and gravel, yellow	7	24
Clay, black and mud	31	55
Gravel and sand	5	60
Calvery and Nanjemoy formations:		
Clay, gray and sand	40	100
Sand, black and clay	100	200
Clay, red	35	235
Aquia greensand:		
Sand, black (water)	42	277

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	Thickness (feet)	Depth (feet)
Well PG-Bd 42 (Altitude: 180 feet)		
Patapsco formation and Arundel clay:		
Clay, sandy	8	8
Clay, hard, red	17	25
Clay, hard, pink	10	35
Gumbo, medium hard, mixed clay	70	105
Clay, hard, red	21	126
Clay, dry, mixed	49	175
Sand, fine, and clay in streaks	15	190
Clay, hard, dry, brown	4	194
Sand, very fine (water)	34	228
Clay, medium hard, mixed	12	240
Sand, very fine (water)	8	248
Clay, medium hard, mixed	6	254
Sand, very fine (water)	16	270
Sand, medium coarse, sharp (water)	10	280
Clay, medium hard	6	286
Well PG-Be 15 (Altitude: 145 feet)		
Pleistocene deposits:		
Clay, yellow	13	13
Sand, coarse, and gravel, small	5	18

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well PG-Be 15—*Continued*		
Gravel, heavy	4	22
Patapsco formation:		
Clay, medium hard, mixed pink and white	3	25
Clay, medium hard, white	22	47
Sand, medium coarse, and streaks of clay, white	12	59
Clay, hard, white	2	61
Sand, fine	8	69
Clay, medium hard, white	2	71
Sand, fine	7	78
Sand, medium coarse, brown	5	83
Clay, medium hard, white	4	87
Sand, fine, dirty	3	90
Clay, medium hard, white	4	94
Clay, hard, white	2	96
Sand, coarse, and gravel, small	2	98
Sandrock, soft	1	99
Sand, coarse, and gravel, small	7	106
Clay, hard, light gray	1	107
Well PG-Dd 18 (Altitude: 210 feet)		
Pleistocene deposits:		
Clay, yellow, and gravel	6	6
Clay, yellow	15	21
Aquia greensand and/or Monmouth formation:		
Marl, dark brown	53	74
Rock	1.5	75.5
Clay, brown	15.5	91
Raritan and Patapsco formations:		
Rock	2	93
Clay, red	88	181
Clay, brown, and sand	11	192
Sand	26	218
Well PG-Dd 19 (Altitude: 270 feet)		
Pleistocene deposits:		
Sand, gravel, and sandy clay	30	30
Clay, brown and red, sandy	20	50
Calvert and Nanjemoy formations and Aquia greensand:		
Marl, blue, and rock	92	142
Marl, shells and rock	78	220
Clay, black	10	230
Magothy formation:		
Sand, gravel and clay, white	7	237
Raritan(?) formation:		
Sand and clay, white	62	299
Clay, gray	7	306
Sand, medium (water)	19	325

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well PG-Eb 8 (Altitude: 155 feet)		
Pleistocene deposits:		
Clay	4	4
Gravel	8	12
Eocene(?) deposits:		
Sand, fine	8	20
Marl	15	35
Raritan and Patapsco formations:		
Clay, red	95	130
Sand, fine	10	140
Clay, blue	20	160
Sand, fine	45	205
Clay	15	220
Sand, fine	12	232
Clay, red and blue	102	334
Sand (water)	9	343
Well PG-Ed 33 (Altitude: 260 feet)		
Pleistocene deposits:		
Gravel	24	24
Sand, brown	6	30
Calvert and Nanjemoy formations:		
Clay, blue	46	76
Marl	34	110
Clay, blue	10	120
Clay, red	21	141
Aquia greensand and Monmouth formation:		
Marl, black	29	170
(Description missing)	7	177
Rock	2	179
Marl, black	27	206
Rock	4	210
Clay, blue	27	237
Raritan and Patapsco formations:		
Clay, red	106	343
Clay, pink	72	415
Clay, blue	33	448
Clay, red	28	476
Clay, yellow	28	504
Clay, pink	14	518
Clay, red	37	555
Clay, yellow	45	600
Clay, red	33	633
Clay, yellow	4	637
Clay, blue	5	642
Sand, very fine	6	648
Clay, blue	5	653
Clay, yellow	21	674

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well PG-Ed 33—*Continued*		
Clay, red	20	694
Clay, blue	3	697
Sand, very fine (water)	6	703
Clay, white	4	707
Clay, red	47	754
Clay, white	3	757
Sand, medium (water)	9	766
Clay, white	18	784
Well PG-Ed 34 (Altitude: 270 feet)		
Pleistocene deposits:		
Sand and gravel	20	20
Calvert and Nanjemoy formations:		
Clay, black	20	40
Marl, blue	60	100
Clay, red	10	110
Clay, blue	10	120
Clay, varicolored	10	130
Aquia greensand and Monmouth formation:		
Marl, blue, and shells	17	147
Rock and shells	12	159
Sand, dry, black	8	167
Rock	3	170
Marl, sandy, blue	8	178
Rock	2	180
Marl, sandy, blue	9	189
Rock	1	190
Marl, sandy, blue	30	220
Clay, black	33	253
Magothy formation:		
Sand (water)	2	255
Clay, blue	6	261
Clay, white	2	263
Sand, fine, black and white	2	265
Clay, white	1	266
Sand, fine, white	7	273
Clay, white	7	280
Sand, medium (water)	11	291
Clay, white	1	292
Sand, fine, white	14	306
Raritan and Patapsco formations:		
Clay, varicolored	41	347
Clay, brown	3	350
Clay, varicolored	15	365
Clay, red	5	370
Clay, brown	5	375
Clay, varicolored	10	385

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well PG-Ed 34—*Continued*		
Clay, blue	15	400
Rock	1	401
Clay, blue	19	420
Rock	1	421
Sand, fine, brown	3	424
Clay, varicolored	3	427
Clay, brown	3	430
Clay, varicolored	20	450
Clay, red	15	465
Clay, varicolored	5	470
Clay, gray	8	478
Clay, red	52	530
Clay, varicolored	10	540
Clay, brown	7	547
Clay, blue	23	570
Clay, white	5	575
Clay, blue	20	595
Sand, fine, white	2	597
Clay, blue	1	598
Sand, fine, white	2	600
Clay, sandy, white	7	607
Sand, fine, gray	2	609
Clay, sandy, white	14	623
Sand, fine	2	625
Clay, white	5	630
Rock, and sand, brown	8	638
Clay, blue	2	640
Sand, gray, and clay streaks	13	653
Clay, blue	1	654
Clay, brown	13	667
Clay, sandy, brown	16	683
Clay, sandy, white	11	694
Clay, brown	3	697
Sand, dry, brown	6	703
Clay, brown	32	735
Clay, blue	5	740
Clay, brown	24	764
Clay, blue	1	765
Sand, gray	5	770
Clay, yellow	2	772
Sand, gray (water)	10	782
Clay, yellow	3	785
Sand, gray and brown	8	793
Well PG-Ee 34 (Altitude: 144 feet)		
Calvert and Nanjemoy formations:		
Soil	5	5

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well PG-Ee 34—*Continued*		
Clay, sandy	20	25
Marl	6	31
Clay, brown	45	76
Aquia greensand and Monmouth formation:		
Marl	189	265
Magothy formation:		
Clay, pink	2	267
Sand, coarse (water)	30	297
Well PG-Fb 20 (Altitude: 195 feet)		
Pleistocene deposits:		
Clay, sandy	18	18
Gravel	21	39
Nanjemoy formation:		
Marl, blue	63	102
Clay, brown	36	138
Aquia greensand and Monmouth formation:		
Marl, blue, and shells	32	170
Rock	2	172
Marl	10	182
Rock	3	185
Marl	10	195
Rock	4	199
Marl	46	245
Clay	37	282
Magothy(?) formation:		
Sand (water)	2	284
Raritan and Patapsco formations:		
Clay, tough	55	339
Sand, muddy, brown	3	342
Clay, varicolored	89	431
Sand, muddy, brown	8	439
Clay, varicolored	100	539
Sand, medium, gray (water)	9	548
Well PG-Fd 35 (Altitude: 200 feet)		
Pleistocene deposits:		
Sand and gravel	20	20
Calvert and Nanjemoy formations:		
Marl, blue	150	170
Clay, blue	15	185
Clay, brown	27	212
Aquia greensand and Monmouth formation:		
Marl, blue	24	236
Rock	1	237
Marl and shells	3	240
Rock	3	243

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well PG-Fd 35—*Continued*		
Marl, blue	103	346
Sand, fine	2	348
Marl, blue	53	401
Magothy formation:		
Sand, fine	2	403
Clay, tough, pink	4	407
Sand, fine (water)	18	425
Clay, pink	2	427
Sand, medium coarse, pearl gray (water)	15	442
ST. MARYS COUNTY		
Well St.M-Bb 9 (Altitude: 165 feet)		
Pleistocene deposits:		
Clay, sandy, and gravel	40	40
Calvert, Choptank, and Nanjemoy formations:		
Marl, blue	100	140
Marl, green	290	430
Clay, blue	10	440
Clay, gray	5	445
Clay, brown	10	455
Aquia greensand:		
Sand, fine, black	5	460
Sand, medium, brown, and shells	20	480
Well St.M-Bc 13 (Altitude: 5 feet)		
Pleistocene deposits:		
Sand, brown, and gravel	14	14
Clay, blue	14	28
Marsh mud and trash	16	44
Clay, white	15	59
Clay	11	70
Sand and gravel	13	83
Calvert and Nanjemoy formations:		
Clay, greenish	4	87
Sand and shells	19	106
Sand and clay	94	200
Sand, black, and clay	100	300
Clay, white	8	308
Clay, pink	17	325
Aquia greensand:		
Sand (water)	27	352
Well St.M-Bd 5 (Altitude: 7 feet)		
Pleistocene deposits:		
Sand	14	14
Calvert formation:		
Clay	26	40

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well St.M-Bd 5—*Continued*		
Clay and sand	68	108
Clay	55	163
Piney point and Nanjemoy formations:		
Sand and rock	47	210
Sand (water)	30	240
Well St.M-Cb 15 (Altitude: 20 feet)		
Pleistocene deposits:		
Topsoil, and clay, brown	9	9
Sand, brown	11	20
Clay, blue	38	58
Gravel, and sand, white	3	61
Sand, gray, and clay	28	89
Gravel, and sand, white	4	93
Nanjemoy formation:		
Sand, black, and clay	153	246
Clay, white	3	249
Clay, pink	10	259
Aquia greensand:		
Sand (water)	32	291
Well St.M-Ce 20 (Altitude: 124 feet)		
Pleistocene deposits:		
Clay, sandy, red	30	30
Calvert and Choptank formations:		
Clay, blue	70	100
Sand, fine	95	195
Marl	105	300
Piney Point and Nanjemoy formations:		
Sand and shells	35	335
Clay, black	38	373
Sand, medium	10	383
Well St.M-Db 32 (Altitude: 15 feet)		
Pleistocene deposits:		
Sand, brown	18	18
Clay	31	49
Sand and gravel	16	65
Calvert and Nanjemoy formations:		
Clay	5	70
Sand	14	84
Sand and clay	105	189
Sand, black, and clay	61	250
Clay, white	2	252
Clay, pink	9	261
Aquia greensand:		
Sand (water)	33	294

TABLE 33—*Continued*

	Thickness (feet)	Depth (feet)
Well St.M-Dc 38 (Altitude: 14 feet)		
Pleistocene deposits:		
Clay, brown	21	21
Sand	9	30
Clay, blue	75	105
Gravel, sand, and clay	22	127
Piney Point and Nanjemoy formations:		
Rock and sand	20	147
Sand, black, and clay	151	298
Clay, pink	2	300
Aquia greensand:		
Sand (water)	36	336

TABLE 34

Logs of selected wells in Southern Maryland from which sample cuttings were obtained

[A more complete listing is in the published reports on the ground-water resources of the five counties.]

ANNE ARUNDEL COUNTY

	Thickness (feet)	Depth (feet)
Well AA-Ad 33 (Altitude: 140 feet)		
Pleistocene deposits:		
Sand, micaceous, clayey, medium-brown; sand, angular, medium- to coarse-grained, coated with iron oxide; gravel pebbles up to ½ inch in diameter; coarse mica plates common; plant fragments common; black mineral grains common	10	10
Sand and gravel, slightly clayey, light-brown; gravel subrounded, pebbles up to ¾ inch in diameter; sand, coarse, angular, consisting of white, pale-gray, pink, and clear quartz; most grains dull and many iron-oxide-coated	10	20
Patapsco formation:		
Sand, coarse, slightly clayey, mostly well sorted, dark yellowish-orange; quartz and chert grains, angular, dull, white, pale-pink, and yellow; some feldspar; modal diameter of sand 0.5 to 1.0 mm. (coarse sand)	10	30
Clay, soft, silty and slightly sandy, pale-red; quartz fine- to coarse-grained, angular, white to clear; irregular blobs hematite common; small amount mica; few grains chlorite	10	40
Clay, soft, silty, grayish-pink; iron-oxide-coated quartz grains common; blobs red hematite(?) common	10	50
Clay, slightly sandy, grayish-pink; quartz, fine- to coarse-grained, angular; coarse plates mica; blobs reddish hematitic clay; small amount feldspar	12	62

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Ad 33—*Continued*		
Clay, as above, slightly sandy, grayish-pink; quartz, fine- to medium-grained, angular, dull; some mica plates; smaller amount iron oxide; heavy minerals finer in size; feldspar rare to common	8	70
Sand, medium- to coarse-grained, clean, grayish-orange; white to pale-pink and orange, angular, semivitreous to dull quartz and chert; few grains feldspar; mica plates rare	10	80
Sand and fine gravel, slightly clayey, grayish-orange to dark-yellowish-orange; modal diameter greater than 2.0 mm.; mostly pink and white quartz grains from coarse sand to gravel size; some feldspar	25	105
Clay, slightly sandy, grayish-orange-pink; fine- to medium-grained, angular, dull, white to clear quartz; few gravel pebbles of pink and white chert; small amount mica; small amount fine black mineral grains	40	145
Sand, fine- to coarse-grained, slightly clayey, grayish-orange; plant fragments frequent; modal diameter of sand 0.25 to 0.5 mm.; fine- to coarse-grained, gravelly quartz, pale-pink and yellow to white	2	147
Well AA-Bb 5 (Altitude: 115 feet)		
Arundel clay and Patuxent formation:		
Clay, sandy, micaceous, moderate yellowish-brown; plant fragments common; coarse, angular white and clear sand grains, blobs of iron oxide, siderite(?); some black platy minerals	3	3
Sand, clayey, gravelly, highly micaceous, moderate brown; plant fragments abundant	27	30
Clay, lignitic or coaly, hard, micaceous, light olive-gray; some coarse angular quartz grains in clay matrix	20	50
Clay, finely micaceous, sandy, grayish-pink to yellowish-gray; chert, pale-yellow and pale-pink, angular; few fragments of iron oxide; fine mica fragments	14	64
Clay, silty, very pale orange, generally gravel-free; very little carbonaceous matter	24	88
No sample	2	90
Clay, tough, streaked, sandy, grayish-orange-pink to moderate red; some blobs of siderite(?)	45	135
Clay, silty, highly micaceous, medium-light-gray; contains small fragments of black mineral	7	142
Clay, smooth, tough, medium-gray; appears to contain a few blobs of decomposed chlorite; fine mica dispersed through the clay	6	148
Sand, fine to medium, pyritic, yellowish-gray; quartz grains generally dull, angular, white-gray to pale pinkish-gray; some fragments of black mineral	4	152
Clay, slightly sandy and silty, medium-gray; small plates of black, dull mineral	5	157
Sand, fine- to medium-grained, fairly clean, yellowish-gray; quartz and chert grains mostly dull, angular; feldspar present; pyrite, fine, rare	21	178

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Bb 5—*Continued*		
Pre-Cambrian rocks:		
Rock, schistose or phyllitic, rotted, crumbly, dusky-yellow to pale-olive; largely quartz grains in matrix of micaceous clay	12	190
Well AA-Bc 40 (Altitude: 165 feet)		
Patapsco formation:		
Sand, slightly clayey, pale yellowish-brown; quartz, coarse to granular, angular, white, pink, and pale-yellow; feldspar grains common; black minerals, dull, rare; plant fragments rare	13	13
Clay, gravelly, very pale orange; varicolored sand and gravel; chert granules, mostly pink, white, and yellow, rounded; few lumps ironstone, fine	9	22
Sand, gravelly, slightly clayey, pale-yellow, brown; quartz and feldspar grains, coarse to granular, white, pale-pink, and white-gray angular; few pieces limonitic material; black minerals, dull, rare	4	26
Clay, sandy, white to grayish-orange-pink; quartz grains mostly fine- and medium-grained, varicolored; lumps and irregular masses red-purple hematite abundant; carbonaceous material rare	10	36
Sand, clayey, fine to medium, mottled pale-yellow-brown; quartz grains mostly coarse, angular, varicolored; black minerals, coarse, dull, rare	41	77
Sand and gravel, clayey, mottled-brown (color indefinite); sand similar to above sample but coarser; some gravel pebbles up to ⅜ inch in diameter	4	81
Sand, clayey, gravelly, mottled-pale-brown to white (color indefinite); lumps of white clay common; medium angular dull-white quartz abundant; few quartz pebbles up to ½-inch maximum diameter	19	100
Sand, clayey, medium-grained; pale yellow-brown; medium to coarse angular pink, white, clear, and pale-yellow quartz and feldspar grains; fine black minerals rare	13	113
Sand, medium-grained, clean, grayish-orange	33	146
Sand, coarse-grained, clean, grayish-orange; similar to above but coarser; yellow and brown iron-stained quartz grains more common	10	156
Clay, gravelly, very pale orange: gravel mostly varicolored rounded quartz pebbles; few lumps limonitic material with clay	2	158
Sand, medium- to coarse-grained, mottled-gray-orange; similar to samples from 146 to 156 feet	5	163
Well AA-Be 11 (Altitude: 50 feet)		
Patapsco formation:		
Sand, medium-grained, clayey, moderate reddish-brown; white, pale-yellow, and pink angular, medium, stained dull quartz and chert grains; few lumps iron oxide; few gravel pebbles	10	10
Clay, sandy, moderate reddish-brown; partly streaked with gray clay; fine to coarse, angular, clear to pale-yellow and pink quartz grains; small blobs iron oxide; some mica; some feldspar	10	20

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Be 11—*Continued*		
Sand, fine, slightly clayey, moderate reddish-orange; fine to very fine, angular quartz grains; iron oxide, fine, similar to sand grains; small amount mica, fine; sorting of sample, good	10	30
Clay, slightly sandy, dark yellowish-brown; fine, dull, angular quartz grains; small red iron oxide oolites abundant; lignite fragments common; one fossil plant spore; few fine grains pyrite	10	40
Clay, silty, moderate red to moderate reddish-brown; fine to medium, dull white to pink quartz grains; some hematitic oolites as above; small lumps iron oxide; some mica	10	50
Clay, silty, reddish-brown, mottled white; microgranular hematite and limonite blobs common; some coarse plates mica; some feldspar	10	60
Sand, fine, slightly clayey, moderate reddish-orange; well-sorted fine, angular, dull to semivitreous quartz grains, white, pale-pink, and pale-yellow; few fine-grained iron oxides; few feldspars; some mica, fine; modal diameter of sample is between 0.125 and 0.25 mm.	10	70
Sand, fine, well-sorted, micaceous, moderate reddish-orange; mica, less common; modal diameter of sample 0.125 to 0.25 mm.	10	80
Sand, as above, moderate reddish-orange; largely fine-grained quartz; modal diameter of unwashed material 0.125 to 0.25 mm.	10	90
Sand, medium-grained, well-sorted, grayish-orange; white, clear, and pale yellow, dull to semi-vitreous quartz; some feldspar; modal diameter of sample 0.125 to 0.25 mm.	6	96
Well AA-Cd 33 (Altitude: 160 feet)		
Monmouth and Matawan formations:		
Sand, clayey, micaceous, moderate yellowish-brown; quartz, fine- to medium-grained, glassy, angular, rust-coated; glauconite, fine, botryoidal, olive-green to brown	7	7
Sand, fine, well-sorted, moderate yellowish-brown; quartz grains very glassy, angular to subangular; glauconite common, olive-green; few blobs iron oxide; few plates mica, coarse	13	20
Sand, clayey, medium- to coarse-grained, moderate yellowish-brown; quartz, fine- to medium-grained, angular, glassy; mica, coarse; glauconite, fine, botryoidal, olive-green, green, and brown; iron oxide in blobs which contain small grains glauconite and quartz (fairly common in residue); few lumps gray soft clay	8	28
Sand, clayey, semi-indurated, moderate yellowish-brown; quartz, fine- to medium-grained, glassy, angular except for few large subrounded grains; glauconite as above; large mica plates common; rust-coated quartz grains common	10	38
Clay, silty, micaceous, dark-gray; quartz sand, fine to coarse, clear to blue-gray, fine grains generally angular, coarse grains mostly subrounded, some grains frosted suggesting wind action; glauconite, fine, medium to olive-green, rare; few grains pyrite	65	103

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Cd 33—*Continued*		
Gravel and sand, clayey, moderate yellowish-brown; gravel consists of tan and white chert, subangular, blocky, many grains coated with iron oxide; glauconite rare, fine, olive-green	7	110
Sand, very coarse to fine, clean; dark yellowish-orange; coarse mica, small amount	11	121
Sand, as above, very slightly clayey; mostly coarse iron-oxide-coated quartz grains	21	142
Well AA-Cf 22 (Altitude: 25 feet)		
Matawan formation:		
Sand, slightly clayey, dusky-yellow; mostly medium- to fine-grained subangular yellow, tan, orange, and clear quartz; glauconite, fine, green, and olive-green, rare; few lumps of indurated brown silt	18	18
Sand, clayey, light olive-gray; similar to above with increased amount of coarse, clear and gray subrounded quartz; glauconite, fine, light-green, rare; pyrite, rare; few lumps of limonite	18	36
Magothy(?) formation:		
Sand, coarse, dirty, olive-gray; medium to coarse, angular to subangular gray, white, violet, and pale-pink quartz; light-green glauconite, oblate, rare; pyrite and pyritized wood common; few pieces of lignite	2	38
Sand, clayey, lignitic, olive-gray to medium-gray; similar to above with increase in proportion of medium-grained quartz; light-green glauconite, rare; sample characterized by abundance of lignite	19	57
Clay, sandy, medium dark-gray; medium to coarse, gray, clear, and white subangular quartz; pyrite common; pyritized wood abundant; mica, coarse, abundant; glauconite, light-green, oblate, frequent	10	67
Sand, silty, light olive-gray; quartz much coarser grained than above with gray-white quartz abundant; pyritized wood common; mica common; glauconite as above, rare	12	79
Sand, clayey, dirty, light olive-gray; similar to above with coarse subrounded, pink and yellow quartz common; pyritized wood less common	18	97
Sand, clayey, light olive-gray; mostly medium to coarse, subangular, white, gray, yellow, and pink quartz; few pieces of pyritized wood; some feldspars	10	107
Sand, dirty, light olive-gray; quartz as above, mostly dull, coarse; pyrite, fine, very rare	27	134
Raritan and Patapsco formations:		
Clay, light-brown; quartz and chert, mostly fine, angular, dull, pink and white; small lumps of hematite common; feldspar frequent; mica rare	6	140
Sand, clayey, light olive-gray; fine to coarse quartz, clear and gray, dull; pyrite, rare; glauconite, fine, light-green, rare; mica fine; lumps of iron oxide common	18	158

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Cf 22—*Continued*		
Sand, clayey, light olive-gray; quartz similar to above; glauconite, rare; pyrite fine, rare; few pieces of lignitized wood; lumps of siderite or iron oxides frequent	30	188
Sand, pale yellowish-brown; mostly coarse, subangular, pink, yellow, clear, and white quartz; feldspar grains, white, common; mica, fine, rare	5	193
Sand, slightly clayey, pale yellowish-brown, similar to above; coarse pink and yellow quartz grains common	18	211
Clay, sandy, light-brown; heterogeneous mixture of fine and coarse, angular, clear, pink, green, and gray quartz grains; few grains of fine glauconite, light-green; lumps of iron oxide and siderite common	8	219
Clay, sandy, light-brown; quartz as above, fine to coarse; siderite spherules very abundant; lumps of hematite common; lignite and pyritized wood common; glauconite as above, frequent	6	225
Clay, sandy, light-brown; similar to above with siderite spherules abundant; hematite, lumpy, common; pyrite, fine, rare; lumps of indurated silt, frequent; black minerals frequent	12	237
Clay, streaked white and pale reddish-brown; similar to above, but less sandy	12	249
Sand, clayey, light-brown; similar to above; siderite rare; no pyrite	9	258
Sand, medium-grained, light-brown; quartz and chert, angular, similar to above, mostly white, pink, and yellow	22	280
Sand, clayey, light-brown, more clayey than above	20	300
Sand, light-brown to grayish-orange; similar to above; few coarse granules of white and pink chert	24	324
Sand, clayey, light-brown; similar to above, but sand mostly medium-grained; few lumps of limonite; mica rare	25	349
Clay, sandy, light-brown; similar to above, iron-stained quartz abundant; siderite rare; lumps of red hematite abundant; pyrite, rare; mica fine, rare	30	379
Well AA-Cg 8 (Altitude: 19 feet)		
Pleistocene deposits:		
Clay, sandy, grayish-orange to grayish-yellow; quartz sand, clear, subangular, fine- to very coarse-grained, vitreous; glauconite, very fine, oblate, green to olive-green, dull; blobs iron oxide common; agglomerates gray soft clay common	10	10
Clay, sandy and gravelly, grayish-orange to pale-orange; quartz, clear, blue-gray, pale-pink, white, and yellow, medium- to coarse-grained, subrounded to angular, vitreous, some dull; chert, angular, yellow and white, fine to medium; very fine green, oblate glauconite; small blobs iron oxide	10	20
Aquia greensand:		
Sand, medium to coarse, dark yellowish-orange; quartz sand, medium to coarse-grained, subangular, dull, yellow and brown; glauconite, very fine, oblate, green to olive-green; few pieces subangular, blocky, white chert	10	30

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Cg 8—*Continued*		
Sand, coarse, light-brown; quartz, clear, subrounded, medium- to coarse-grained, vitreous, yellow and brown; glauconite, brown, coarse, oblate, common; glauconite, light-green, irregular, fine; chert, white and tan, subangular; small blobs of iron oxide common	10	40
Sand, medium to coarse, similar to above, with a few small lumps gray hard clay, light-brown	10	50
Sand, medium to coarse, slightly clayey, light-brown; quartz as above, coarse, brown, subrounded; glauconite as above, brown, olive-green; blobs and pieces fine quartz sand cemented by iron oxide abundant; few plates mica, coarse	10	60
Monmouth and Matawan formations:		
Sand, fine, light olive-gray to dusky-yellow; quartz, mostly clear, fine, angular, vitreous; some yellow quartz, medium-grained subangular; glauconite green, fine, irregular to oblate; small amount brown, oblate, medium, shiny glauconite; fine mica common; few small blobs gray clay; few pieces fine-grained calcite(?)	10	70
Sand, fine, clayey, similar to above; lumps gray clay common	10	80
Sand, medium-grained, slightly clayey, grayish-olive; quartz, clear and pale-green to white, fine to coarse, coarse grains mostly subrounded, dull; glauconite, green and pale-green, fine, botryoidal to oblate (glauconite 40 percent of residue); small blobs brown-gray clay; mica, coarse, frequent	10	90
Sand, medium-grained, clayey, grayish-olive; quartz, clear, pale-green, medium- to coarse-grained, angular and subangular; quartz, yellow, subangular, medium, moderate lustre, common; glauconite, green, botryoidal, shiny, abundant (40 to 50 percent of residue); pieces gray clay, common; iron oxide blobs, common; few garnets(?)	10	100
Sand, medium, clayey, grayish-olive, similar to above; agglomerates fine green glauconite cemented by clay or calcite	10	110
Sand, slightly clayey, similar to above; light olive-gray; glauconite, green, botryoidal, medium, abundant (30 to 40 percent of residue)	10	120
Sand, clayey, light olive-gray, similar to above	10	130
Sand, clayey, light olive-gray, similar to above; few lumps iron oxide	10	140
Sand, fine, slightly clayey, light olive-gray to grayish-olive, similar to above	10	150
Sand, fine, slightly clayey, grayish-olive, similar to above; increased amount iron oxide lumps	10	160
Sand, clayey, grayish-olive; similar to above; quartz mostly medium, subangular, clear; glauconite as above; fine sand grains cemented by iron oxide common	10	170
Sand, more clayey, grayish-olive; similar to above; one piece black phosphatic material (bone); few ovoid gray clay pellets	10	180
Sand, very clayey, light olive-gray, similar to above; glauconite, fine, green, irregular, less common; few grains microgranular pyrite; small amount fine mica; few phosphatic plates (bone)	10	190

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Cg 8—*Continued*		
Sand, very clayey, olive-gray; quartz, coarse, gray, subrounded, common; one fish tooth; pyrite common; fine mica more common	10	200
Sand, very clayey, fine, olive-gray; quartz, yellow to brown, coarse to fine, angular to subrounded, common; glauconite, green, irregular, fine, rare; microgranular pyrite common; iron oxide blobs common; few plates black phosphate	10	210
Sand, very clayey, olive-gray, similar to above with more pale-green quartz; microgranular pyrite common; glauconite fine, green, irregular, rare; iron oxide blobs common; few fish teeth	10	220
Sand, very clayey, olive-gray, similar to above; coarse, subrounded, dull-gray quartz grains common; pink quartz, subangular, coarse, rare; glauconite, light green, irregular, fine; pyrite common	10	230
Sand, very clayey, olive-gray, similar to above; less coarse, subrounded, yellow and gray quartz grains; glauconite as above, common	10	240
Sand, very clayey, olive-gray, similar to above; small amount coarse, gray, subrounded quartz; glauconite fine, irregular, light-green, dull, common; mica, fine, common	10	250
Magothy formation:		
Sand, coarse, less clayey, olive-gray to dark-gray; quartz, medium- to coarse-grained, subrounded, blue-gray and gray; quartz pink and white, medium to coarse, subangular to subrounded, common; pyrite and pyritized wood, abundant; glauconite, fine, light-green, rare	10	260
Sand and gravel, medium-gray to dark-gray; quartz, white, gray, and pink, dull, coarse, subrounded, abundant; medium-grained gray angular quartz, cemented by pyrite into agglomerates; lignite and pyritized lignite very abundant	10	270
Sand, coarse, lignitic, light-gray, similar to above; pyritized wood common; pyrite, granular and microgranular, common; quartz brown, coarse, subrounded, semi-vitreous; iron oxide blobs	10	280
Clay, sandy, carbonaceous, mottled dark-gray; some coarse, subrounded, white and gray, semi-vitreous quartz; carbonaceous and lignitic matter common; glauconite, medium, botryoidal, light-green, rare; granular and microgranular pyrite common; few lumps iron oxide	10	290
Well AA-Dc 7 (Altitude: 119 feet)		
Pleistocene deposits:		
Sand, grayish-orange to moderate yellow-brown; quartz, mostly medium to coarse, yellow white, and pale-pink, subangular, dull; some pink feldspar; black minerals, fine, rare	10	10
Sand, slightly clayey, grayish-orange to moderate yellow-brown, similar to above; few coarse flakes mica; pink feldspar frequent	10	20
Aquia greensand:		
Sand, clayey, moderate yellow-brown to light olive-brown; quartz, medium to coarse, shiny, rounded to subrounded, clear, yellow,		

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Dc 7—*Continued*		
and brown; few rounded quartz granules up to ¼-inch maximum diameter; one piece brown claystone; glauconite, green, botryoidal, common; lumps limonite, irregular, common	10	30
Sand, clayey, fine- to medium-grained, grayish-olive; fine- to medium-grained, clear, pale-gray and pale-green, subrounded quartz; mica, fine, frequent; glauconite, green, irregular to botryoidal, frequent	10	40
Sand, clayey, dark greenish-gray; fine- to medium-grained clear and pale-gray quartz; mica, fine, rare; glauconite, common, green	10	50
Monmouth(?) formation:		
Sand, very clayey, olive-gray; quartz, medium-grained subrounded and rounded, clear, common; mica, fine to coarse, abundant; glauconite, green, botryoidal, common; phosphatic pebbles and plates, black, frequent	10	60
Sand, very clayey, olive-gray; quartz, fine- to medium-grained; glauconite, green, common; mica, medium-grained, abundant; one ostracod; few fish teeth	10	70
Sand, clayey, olive-gray, similar to above; quartz mostly fine; glauconite, green, irregular, finer than above; mica common; rounded granules black phosphatic material, frequent; pyrite, fine, rare	20	90
Sand, very clayey, olive-gray; quartz, dirty, gray, coarse, subrounded, common; glauconite absent; few coarse lumps microgranular pyrite; few pieces lignite	10	100
Sand, clayey, olive-gray; quartz, medium to coarse, clear and pale-gray, subrounded; mica, fine, frequent to rare; few small pellets and fragments black phosphatic material; one complete pyritized pelecypod cast	10	110
Sand, less clayey, olive-gray; quartz as above; few pieces pyritized wood; phosphatic plates, black, small, rare; few lumps yellow-gray indurated silt; pyrite, fine, rare	20	130
Sand, clayey, olive-gray to olive-black; mostly medium- to coarse-grained, dull, subrounded, gray quartz, few grains pale-pink and yellow; few coarse lumps pyrite; mica, fine, rare; glauconite, fine, light green, rare	10	140
Magothy formation:		
Clay, sandy, olive-gray and light olive-gray; quartz as above, few coarse granules; pyrite, lumpy, frequent; few pieces carbonaceous material; glauconite, green, coarse and fine, botryoidal, very rare	10	150
Clay, sandy, medium-gray to light olive-gray; similar to above, with pink and yellow angular quartz frequent; carbonaceous material common, fine; lumps pyrite common	10	160
Sand, coarse, light-gray; quartz, coarse, angular and subangular, dull, gray and gray-white; pyrite and marcasite, fine, abundant	10	170
Sand, coarse, white to yellowish-gray, similar to above; pyrite less common	15	185

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-De 45 (Altitude: 20 feet)		
Monmouth and Matawan formations:		
Sand, clayey, moderate yellowish brown; quartz, subrounded to subangular, clear, pale-brown, and yellow, dull to semivitreous (many grains coated with iron oxide); glauconite, botryoidal, green and brown; blobs iron oxide common	21	21
Sand, fine- to medium-grained, slightly clayey, olive-gray to yellowish-brown; quartz, angular, clear; some coarse, subrounded, pale-tan and clear quartz; glauconite, green and brown, fine to coarse; some iron oxide (modal diameter of sand 0.25 to 0.5 mm.)	30	51
Sand, fine- to medium-grained, slightly clayey; olive-gray; quartz, fine to medium, clear to cloudy, subangular to angular; chert, coarse, subrounded, yellow-brown; glauconite, fine to medium, green and olive-green, botryoidal; one fish vertebra; some iron oxides (modal diameter of sand 0.125 to 0.25 mm.)	22	73
Sand, fine- to medium-grained, slightly clayey, olive-gray; quartz, medium-grained, clear, subangular, common; glauconite, medium to fine, olive-green and green, irregular to botryoidal	22	95
Sand, as above, clayey, olive-gray; a few plant fragments; quartz, medium-grained, clear, subangular, semivitreous; some coarse, tan-yellow subrounded quartz or chert; glauconite, green, coarse to fine, less common; some mica	23	118
Clay, silty, micaceous, dark-gray; subangular granules white-gray quartz or chert; subangular, clear, semi-vitreous quartz; subrounded, tan-yellow quartz; some light green glauconite; mica common; few fragments black carbonaceous material	22	140
Clay, sandy and gravelly, micaceous, dark-gray; quartz, medium- to coarse-grained, gray, blue-gray, clear, dull to semi-vitreous; particles lignitized wood common; glauconite, irregular, fine, green; pyritized blobs of fine sand; iron oxides frequent	23	163
Magothy formation:		
Sand, coarse, slightly gravelly, clayey, lignitic, medium dark-gray to light-gray; large fragments lignitized wood common; fine- to medium-grained, green glauconite frequent; few lumps pyritized silt	22	185
Sand, clean, coarse, grayish-white, slightly glauconitic; chert and quartz, white to pale-gray and pink, subangular, coarse, dull, common; lignitic material, rare (modal diameter sand 1.0 to 2.0 mm.)	23	208
Sand, clayey, medium- to coarse-grained, dull gray; less sorted than above; glauconite less common; pyritized and lignitized wood frequent	22	230
Well AA-Ed 17 (Altitude: 165 feet)		
Calvert formation:		
Silt, very fine, clayey, dark yellowish-orange; dark glauconite, fine, rare; diatoms common	12	12
Silt, dark yellowish-orange as above; diatoms common	10	22

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Ed 17—*Continued*		
Clay, dark yellowish-orange to pale yellowish-orange; few small grains dark glauconite; some whitish clay; diatoms common	10	32
Clay, as above, lighter in color with a few blotches oxidized material; diatoms frequent (base of oxidized zone, at about 35 feet)	10	42
Clay, light olive-gray; fine, clear, angular quartz sand; small phosphatic pellets and plates; diatoms common	10	52
Sand, fine, clayey, angular; greenish-gray; phosphatic plates and fragments of shells numerous; sponge spicules common; comminuted shell fragments common	20	72
Clay, slightly sandy, color as above; sand mostly angular clear quartz grains; small grains phosphatic material common	20	92
Nanjemoy formation:		
Sand, coarse, highly glauconitic, dark greenish-gray; quartz mostly clear, subrounded and coarse; glauconite finer grained, dark-green, botryoidal	10	102
Sand, medium-grained, salt-and-pepper; quartz, medium-grained; glauconite uniformly dark-green (glauconite 60 to 70 percent of sample)	10	112
Sand, as above, somewhat clayey; large quartz grains, subrounded, dull (glauconite 50 to 60 percent of sample)	10	122
Sand, as above (glauconite 60 to 75 percent of sample)	10	132
Sand, as above, more clayey; clay ranges from white to pale-olive; small quartz grains angular to subangular; large grains subrounded, dull or semivitreous	10	142
Sand, medium-grained, angular to subangular, slightly clayey; few phosphatic plates; glauconite, medium-grained, dark-green (glauconite less than 25 percent of sample)	10	152
Sand, clayey, light olive-gray; phosphatic fragments and plates common; quartz grains, small and angular	14	166
Aquia greensand:		
Sand, more clayey, slightly micaceous, light olive-gray to grayish-olive; glauconite, fine-grained, green; few phosphatic plates; few small forams	14	180
Sand, clayey, medium-grained, light olive-gray with reddish hue; quartz, subangular, clear to white or pale-green; glauconite green, irregular to botryoidal; some fine mica with clay	10	190
No samples	30	220
Well AA-Ed 19 (Altitude: 165 feet)		
Calvert formation:		
Clay, slightly sandy, moderate yellowish-brown; quartz, mostly fine, clear, angular and subangular; chert granules, yellow, large, moderate lustre, rare; blobs iron oxide common; few pellets siderite	10	10
Clay, slightly sandy, pale yellowish-orange; quartz, mostly very fine to fine, clear, angular; very fine, green irregular glauconite; small blobs iron oxide common (base oxidized zone)	10	20

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Ed 19—*Continued*		
Clay, pale-olive to light olive-gray; quartz, fine, clear, angular and subangular, abundant; phosphatic plates, black, fine, common; iron oxide blobs, rare; glauconite fine, very rare	10	30
Clay, slightly sandy, light olive-gray; quartz, clear and yellow, fine, angular, abundant; few granules white chert, dull; phosphatic plates, fine, black; sponge spicules common; few fish vertebrae; fine shell fragments, rare	10	40
Clay, yellowish-gray; quartz, very fine, angular, clear; quartz violet and yellow subangular; phosphatic plates, fine, black, common; glauconite, green, fine; sponge spicules common; shell fragments rare, few pelecypods, one scaphopod	10	50
Clay, yellowish-gray to light olive-gray; quartz, clear and pale-yellow, fine to medium, angular; phosphatic plates, black, fine, rare; sponge spicules common; few ostracods; few pellets siderite, brown	10	60
Clay, sandy, yellowish-gray; quartz, clear and yellow, medium-grained, angular, abundant; phosphatic plates, black, common; pelecypod fragments abundant	10	70
Clay, light olive-gray; phosphatic plates, black, fine, rare; glauconite, rare, very fine, green; sponge spicules rare; shell fragments rare; few pellets siderite(?)	10	80
Clay, silty, light olive-gray; quartz, fine to medium-grained, clear and pale yellow, angular; phosphatic plates, black, common; glauconite very fine, green, rare; sponge spicules common; pelecypod fragments common	20	100
Clay, light olive-gray; fine quartz sand, common; glauconite, green, fine, rare; phosphatic plates, black, rare; pelecypod fragments common; few sponge spicules	10	110
Nanjemoy formation:		
Sand, clayey, dark greenish-gray; quartz, medium-grained, clear, subangular, common; quartz, coarse, dull, pitted, gray, subrounded, rare; glauconite, green, medium, botryoidal, abundant (50 to 60 percent of sample); mica, fine, rare	10	120
Sand, clayey, dark greenish-gray; quartz, as above; glauconite, as above; sponge spicules rare; few pieces coarse, black phosphate or black limestone	20	140
Sand, clayey, dark greenish-gray; quartz, clear to pale-green, angular to subangular, fine- to medium-grained; mica, fine, common; glauconite, fine to medium, botryoidal, green; phosphatic plates and pellets, fine, rare	10	150
Sand, clayey, dark greenish-gray, similar to above	20	170
Sand, glauconitic, greenish, and clay, light brownish-gray; quartz sand, as above, mostly clear and pale-green; glauconite as above; few small blobs iron oxide; pyrite, microgranular, rare	10	180
Clay, even-textured, light-brown; quartz sand, medium-grained, clear, subangular, common; pyrite, microgranular, rare; glauconite, botryoidal, medium, green, frqeuent	10	190

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Ed 19—*Continued*		
Aquia greensand:		
Sand, clayey, mottled greenish-gray; quartz sand, fine- to medium-grained, clear to yellow, subangular; glauconite, as above; pyrite, microgranular, common; pieces gray, smooth clay, common	20	210
Sand, clayey, grayish-olive-green, similar to above; pyrite, fine, less common; one lump glauconite grains cemented by black limestone or phosphate	10	220
Sand, very clayey, mottled gray and dusky yellow-green; quartz sand, clear and pale-green, medium-grained, subangular to angular, common; glauconite, botryoidal, irregular, green, common; few pieces glauconite cemented by calcite (rock); pyrite, rare; forams, common; shell fragments common	10	230
Sand, clayey, dusky yellow-green; forams, common; one pelecypod; ostracods, common; one coral fragment; one scaphopod	20	250
Sand, clean, mottled yellow-green; few shell fragments; few pieces fine glauconite in brown clay matrix	10	260
Sand, clean, mottled yellow-green, similar to above; forams, common; ostracods, rare	10	270
Sand, very clayey, light olive-brown; quartz, clear, subangular, subrounded, medium, common; quartz, yellow and brown, medium to coarse, subrounded, common; quartz, pale pink, subangular, dull, rare; glauconite, green, oblate; phosphate, shiny, black, rare	10	280
Sand, clayey, light olive-brown; quartz, as above, brown and yellow, common; glauconite, green, dull, rare (5 to 10 percent of sample)	20	300
Sand, clayey, light olive-brown; quartz, fine to medium, clear, subangular, abundant; quartz, yellow and brown, medium, subrounded, common; glauconite, olive-green and brown; blobs of fine glauconite in brown clay matrix, common; mica, coarse, rare	20	320
Sand, clean, mottled pale-olive, similar to above	10	330
Monmouth and Matawan formations:		
Sand, clayey, micaceous, grayish-olive; quartz, clear and pale-yellow, fine- to medium-grained, subrounded to subangular, abundant; glauconite, green and olive-green, botryoidal, common; mica, coarse, common; phosphatic pellets, black, rare; pelecypod fragments, rare	10	340
Sand, clayey, micaceous, grayish-olive, similar to above; mica, fine to medium, abundant; pyrite, fine, rare	10	350
Sand, clayey, micaceous, dark greenish-gray; glauconite mostly green, botryoidal, medium (about 20 percent of sample); mica, medium, common; few pieces gray, soft clay; few granules black phosphate	20	370
Sand, fine, slightly clayey, light olive-gray; quartz, clear, fine- to medium-grained, angular to subangular, abundant; mica, coarse, rare; glauconite, green, medium, botryoidal, rare (5 percent of sample)	20	390
Sand, clayey, medium dark-gray; quartz, as above; quartz, yellow, angular, medium, dull, rare; quartz, coarse, subangular, violet,		

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Ed 19—*Continued*		
dull, rare; glauconite, as above, rare; mica common; pyrite, fine, rare	10	400
Clay, tough, finely micaceous, medium-gray; quartz, clear, yellow and brown, fine- to coarse-grained, as above; quartz, violet, coarse, subangular, rare; mica, abundant; glauconite, green, botryoidal, rare; few pieces pyritized wood; one fish tooth	10	410
Sand, very clayey, dark-gray; quartz, clear, yellow, and gray, fine to medium, angular to subangular; pyrite, fine, rare; phosphatic plates, fine, shiny, common	20	430
Sand, very clayey, dark-gray, similar to above	10	440
Magothy(?) formation:		
Clay, sandy, dark greenish-gray; quartz, clear, gray, violet, coarse-grained, subrounded to subangular; glauconite, fine, light-green, irregular, common; pyrite, fine, rare	10	450
Sand, clean, coarse, medium-gray; quartz, fine- to coarse-grained, angular to subrounded, clear, violet, gray, and pale-pink; few pieces lignite; pyrite, granular, rare	5	455
Well AA-Fe 30 (Altitude: 5 feet)		
Pleistocene deposits:		
Clay, silty, slightly micaceous, dark yellowish-orange to light olive-gray; fine-grained, angular, clear to white quartz grains; some coarse mica plates; small amount green glauconite; few blobs limonite; few pieces lignite	10	10
Clay, as above, with increased amount of light olive-gray clay; few coarse, angular grains pale-green glassy quartz; glauconite, black and green, rare; pyrite, rare; few plant fragments	10	20
Nanjemoy formation:		
Sand, salt-and-pepper, highly glauconitic, slightly clayey; clear to white, mostly clear, subangular quartz, medium-grained; dark green botryoidal glauconite, abundant (60 to 70 percent of sample); few blobs limonitic material (modal diameter of sand 0.5 to 1.0 mm.)	10	30
Sand, salt-and-pepper, clayey, highly glauconitic; small blobs pale-gray clay; botryoidal glauconite as above (60 to 70 percent of sample)	10	40
Sand, salt-and-pepper, highly glauconitic, slightly clayey (glauconite 60 to 70 percent)	20	60
Sand, as above; increased amount of pale-brown clay; highly glauconitic (glauconite 50 to 60 percent); (modal diameter of sample 0.5 to 1.0 mm.)	20	80
Sand, as above, highly glauconitic (glauconite about 50 percent); few plates phosphatic material; modal diameter of sample 0.25 to 0.5 mm.)	20	100
Sand, glauconitic, with fragments of pink and dark yellowish-orange clay; clear and pale-green, angular to subangular quartz; dark-green, botryoidal glauconite, fine- to medium-grained; few fragments phosphatic material	10	110

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well AA-Fe 30—*Continued*		
Sand, clayey, salt-and-pepper, dusky yellow-green; increased amount pale light-brown clay; few phosphatic fragments; forams rare (modal diameter of sample 0.5 to 1.0 mm.)	10	120
Sand, less clayey, finer, similar to above	10	130
Sand, coarser than above, less glauconitic; tan quartz abundant; some olive-green glauconite; forams rare; one ostracod; few calcite fragments	20	150
CALVERT COUNTY		
Well Cal-Bb 9 (Altitude: 130 feet) (Bulletin 8, p. 53)		
Well Cal-Bb 10 (Altitude: 189 feet)		
Pleistocene deposits:		
Sand, clayey, pale yellowish-brown; quartz, mostly clear to white, dull angular medium-grained; pink and white feldspar; few pieces of green, botryoidal glauconite	6	6
Sand, clayey, mottled, pale yellowish-brown; similar to above with some pieces angular grayish-white flint; feldspar frequent; few grains dull-green glauconite; few grains coarse, subrounded, violet quartz	12	18
Clay, sandy and gravelly, pale yellowish-brown; coarse, rounded, dull granules gray, white, and yellow quartz and flint; glauconite green, botryoidal, rare; blobs limonitic silt, frequent	8	26
Choptank(?): formation		
Sand, clayey, pale yellowish-brown; mostly fine to medium-grained, clear, subangular quartz; some coarse subangular to subrounded granules yellow and white quartz and chert; few blobs limonite; glauconite, fine, irregular, rare	18	44
Calvert formation:		
Clay, silty and sandy, grayish-orange to light olive-gray; fine, angular, clear and pale yellow, subangular quartz; coarse, rounded granules gray, white, and pale yellow quartz; glauconite, green irregular, rare; few shell fragments	16	60
Clay, silty, light olive-gray; mostly fine-grained angular, clear to pale-gray quartz; sponge spicules common; pelecypod shells and fragments common; few ostracods; few pieces black phosphatic material	21	81
Clay, sandy, light olive-gray to olive-gray; mostly medium quartz, clear, pale-gray, and pale-pink and yellow; few coarse chert granules; black phosphatic fragments common; sponge spicules, abundant; broken shells common; blobs glauconite cemented by calcite, frequent; pieces aragonite, common; forams, small, frequent	35	116
Clay, yellowish-gray, diatomaceous; quartz, fine- and medium-grained, clear, gray, pink, angular and rounded; glauconite, green and brown; sponge spicules, common; forams, small, frequent	26	142
Clay, yellowish-gray, diatomaceous; quartz, fine- and medium-grained, clear, yellow and gray, subangular to subrounded, dull to		

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Cal-Bb 10—*Continued*		
shiny; glauconite, brown and green, frequent; sponge spicules common; some aragonite; few forams (one large *Nodosaria sp.*); few blobs pyrite	66	208
Clay, yellowish-gray, diatomaceous, similar to above	19	227
Rock, chiefly pelecypod fragments, white to grayish	1	228
Nanjemoy formation:		
Sand, clayey, light olive-gray to olive-gray; quartz, fine- to medium-grained, clear and pale-yellow to green; glauconite, green and light-green, irregular to botryoidal, abundant; mica, coarse to fine, common; forams, small, common; one gastropod cast, black; some shell fragments	32	260
Sand, clayey, mottled dusky yellow-green to light olive-gray, similar to above but finer grained; few lumps of glauconite cemented by pyrite	10	270
Sand, clayey, dark greenish-gray, similar to above with green-black, fine glauconite abundant; forams, small, frequent	28	298
Sand, clayey, mottled greenish-gray; forams, rare	34	332
Sand, clayey, color as above; some microgranular pyrite; few thin barnacle plates	9	341
Clay, sandy, greenish-gray; quartz, dull, fine-grained, clear and gray-green; glauconite green-black, botryoidal, fine to medium; mica, fine-grained, abundant; forams, small, common	49	390
Sand, clayey, mottled olive-gray; glauconite, green-black, botryoidal; forams rare; few plates black, phosphatic material	5	395
Clay, sandy, light brownish-gray to light olive-gray; medium to coarse-grained varicolored quartz, rare; lumps pyrite frequent; one large foram; shiny plates black phosphatic material; few broken shell fragments	20	415
Aquia greensand:		
Sand, medium-grained, mottled grayish-olive; medium- to coarse-grained, subangular, clear, olive-green, pale-green, and gray quartz; glauconite, green-black and green; pyrite rare; few forams; few lumps black phosphatic material	32	447
Sand, clayey and shelly, light olive-gray; medium- to coarse-grained, rounded, tan, white, and pale-green quartz; glauconite, coarse, oblate to botryoidal, tan and green-black; lumps calcite cementing glauconite and fine quartz abundant ("rock" of drillers); pelecypod shells common; two corals; one gastropod cast	45	492
Sand, slightly clayey, dark yellowish-brown; medium-grained subangular, varicolored quartz; glauconite, medium-grained, oblate to botryoidal, brown, tan, and green; forams, small, frequent; sponge spicules, common; one barnacle; few scaphopods; pieces of "rock"	23	515
Clay, sandy, light olive-gray, similar to above with increase in amount shell fragments; one barnacle; some fine mica; few lumps iron oxide	21	536
Clay, sandy, grayish-olive; quartz, medium- to coarse-grained, vari-		

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Cal-Bb 10—*Continued*		
colored subangular; glauconite, brown, red-brown, and green-black; shell fragments common; few forams (one *Robulus sp.*); few thin plates black phosphatic material; mica, coarse, rare	51	587
Clay, sandy, light olive-gray; small forams very common; broken shells common; pyrite, microgranular; one large *Robulus sp.*	31	618
Monmouth formation:		
Sand, clayey, olive-gray; mostly fine- to medium-grained, clear, pale-green and pale-yellow subangular quartz; glauconite, fine, green, and brown, less common; mica common; forams, frequent (a few *Robulus sp.*); pyrite, fine, rare; one small pelecypod	22	640
Sand, clayey, olive-gray, similar to above; glauconite, about 10 percent; small amount of pyrite; few fish teeth; pieces soft gray clay; one ostracod; few lumps of shiny black phosphatic material	38	678
Magothy formation:		
Sand, clayey, mottled light olive-gray to olive-gray; medium- to coarse-grained, dull, subrounded gray, gray-violet, yellow and white quartz; glauconite, coarse, green, rare; lumps carbonaceous material; few sponge spicules; forams rare; pyrite, fine, rare	10	688
Sand, clean, coarse-grained, mottled gray; subrounded to subangular, dull, gray, gray-violet, pale-pink, and white quartz; few small lumps pyrite; carbonaceous material, fine, rare	3	691
Sand, clayey, light olive-gray	7	698
Sand, mottled gray to grayish-white	13	711
No sample	7	718
Well Cal-Bc 14 (Altitude: 149 feet)		
Pleistocene deposits or Choptank formation:		
Sand, fine- to medium-grained, slightly clayey, dark yellowish-orange; mostly white and yellow, fine-grained, subangular quartz; fine-grained black minerals, subrounded, rare; one plant fragment; one pebble of quartz	20	20
Sand, fine, grayish-orange, similar to above, mostly fine quartz; fine black minerals, rare; few small blobs limonite	10	30
Sand, fine, slightly clayey, dark yellowish-orange to grayish-orange	10	40
Choptank and Calvert formations:		
Sand, fine, clayey, yellowish-gray; fine- to medium-grained, subangular, clear and pale-gray to yellow quartz; broken pelecypod shells abundant; black phosphatic plates common; few coarse blobs limonitic material; few fish teeth	10	50
Clay, sandy, yellowish-gray; fine-grained, angular, gray to clear quartz; sponge spicules common; forams common; ostracods frequent; pieces brown-red shell or bone fragments; few small blobs limonitic sand	10	60
Clay, sandy, yellowish-gray, similar to above; shell fragments common; sponge spicules abundant; few ostracods	10	70
Clay, stiff, slightly sandy, light olive-gray; fine-grained quartz sand and silt; forams and sponge spicules abundant; few ostracods	10	80

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Cal-Bc 14—*Continued*		
Clay, slightly sandy, light olive-gray to yellowish-gray, similar to above; forams less common; fine black phosphatic fragments, common	10	90
Clay, sandy and silty, light olive-gray to yellowish-gray; forams frequent, small; some fine mica; one barnacle plate; one fish tooth	20	110
Clay, light yellowish-gray; fine quartz sand, nearly silt size; fine mica rare; sponge spicules frequent; diatoms, large, frequent	20	130
Clay, yellowish-gray, diatomaceous; black phosphatic pellets common	30	160
Clay, sand, yellowish-gray; fine-grained quartz as above; gray platy shell fragments abundant; glauconite, fine, green-black, rare; some forams; few ostracods; plates of black phosphatic material; few sponge spicules	30	190
Nanjemoy formation:		
Sand, clayey, light olive-gray; medium- to coarse-grained subangular, clear quartz; glauconite, light green, irregular, common; shell fragments; fragments black phosphatic material frequent; forams rare; small whole pelecypod shells common	10	200
Sand, clayey, dark greenish-gray; medium- to coarse-grained, clear to dull, gray, subrounded quartz; glauconite, light-green and green, botryoidal, common; pyrite, microgranular, frequent; mica, fine, rare; few rounded granules black phosphatic material; forams, small; few ostracods	30	230
Sand, clayey, dark greenish-gray, similar to above; greenish glauconite, 60 to 70 per cent	30	260
Sand, slightly clayey, dark greenish-gray; glauconite, 60 to 75 percent	30	290
Sand, as above, slightly clayey, dark greenish-gray	25	315
Well Cal-Ca 2 (Altitude: 32 feet) (Bulletin 8, p. 55)		
Well Cal-Cc 37 (Altitude: 120 feet)		
Choptank formation:		
Sand, fine-grained, even-textured, dark yellowish-orange; fine- to medium-grained, subangular, clear and pale-brown quartz; small amount mica, fine; few grains, fine, green, irregular glauconite	25	25
Choptank and Calvert formations:		
Clay, silty, greenish-gray; fine- to medium-grained, clear and pale-gray, angular quartz; glauconite, green, fine, very rare; one large diatom	25	50
Sand, clayey, light olive-gray; similar to above but coarser-grained; phosphatic plates more common; one small gastropod	10	60
Clay, sandy, light olive-gray, similar to above, but much finer-grained quartz; sponge spicules common	10	70
Clay, sandy, light olive-gray, similar to above	10	80
Clay, sandy, light olive-gray, medium-grained, angular, clear and		

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Cal-Cc 37 (*Continued*		
pale-gray quartz; small particles black phosphatic material; shells abundant (gastropods, pelecypods, *Turritella sp.*, etc.)	10	90
Sand, clayey, loose, light olive-gray; quartz sand as above with an abundance of broken shells; some pieces indurated sand (rock); few large diatoms; few pieces gypsum; few grains green glauconite; sponge spicules common; ostracods, rare; coarse mica, rare	40	130
Clay, silty, yellowish-gray, similar to above; fine quartz sand; small forams frequent	40	170
Clay, silty, yellow-gray; fine-grained quartz as above; sponge spicules common; small forams; shell fragments of black phosphate common; few casts of gastropods	20	190
Sand, clayey, light olive-gray, similar to above, with sand coarser; few grains green, irregular, dull glauconite; phosphatic plates and fragments common	10	200
Nanjemoy formation:		
Sand, clayey, olive-gray; fine- to coarse-grained, subrounded to subangular quartz; light-green, irregular glauconite common; shell fragments common; forams, rare to frequent; dull, green-gray, subrounded quartz grains, common	10	210
Sand, slightly clayey, grayish-olive to olive-brown; pale-green and yellow, subrounded, medium- to coarse-grained quartz; light-green, irregular glauconite common; few black phosphatic granules; coarse, mica, rare	30	240
Sand, slightly clayey, dusky-yellow to light olive-gray; few small lumps brown hard clay	10	250
Sand, clayey, olive-gray; quartz similar to above, but finer; glauconite, mostly fine, green and green-black, botryoidal; some fine shell fragments; fine mica, frequent; few forams (one *Robulus sp.*)	20	270
Sand, clayey, dark greenish-gray, similar to above; green-black botryoidal glauconite, 60 to 70 per cent of sample	50	320
Sand, clayey, and clay, sandy, dark greenish-gray, similar to sample above	10	330
Well Cal-Dc 17 (Altitude: 147 feet) (Bulletin 8, p. 65)		
Well Cal-Ec 19 (Altitude: 18 feet)		
Pleistocene and Recent deposits:		
Sand, medium- to fine-grained, clayey, pale yellowish-orange; subangular and angular yellow pale-pink and white quartz; few grains green shiny glauconite	11	11
Sand and gravel, mottled, pale yellowish-orange; fine- to coarse-grained, angular, yellow, orange, clear, and gray quartz; granules and pebbles white, brown and tan quartz; few grains fine, irregular glauconite; mica, fine to coarse, frequent	10	21
Choptank and Calvert formations:		
Clay, silty and sandy, light olive-gray; fine- to very fine-grained subangular, clear and pale-gray quartz; plates and lumps black shiny		

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Cal-Ec 19 (*Continued*)		
phosphatic material; sponge spicules and small forams common; one ostracod; few coarse white chert pebbles	20	41
Clay, silty, light olive-gray; much fine sand and silt with a few white quartz granules; clay, diatomaceous; few small forams; one ostracod; sponge spicules common	30	71
Clay, silty, shelly, light olive-gray; fine-grained, angular, clear and pale-gray quartz; forams and black phosphatic plates, frequent; broken pelecypod shells abundant	10	81
Clay, silty, light olive-gray, similar to above; lesser amount shell fragments; forams common; few large diatoms at 115 feet	40	121
Clay, light olive-gray to pale-olive; fine-grained, angular, clear and pale-gray quartz; fine black phosphatic plates; few large diatoms; small forams common	30	151
Piney Point formation:		
Sand, slightly clayey, light olive-gray; mostly medium-grained, subangular and angular, clear and pale-gray quartz; few grains milky quartz; black shiny phosphatic plates and fragments common; coarse shell fragments common	20	171
Nanjemoy formation:		
Sand, clayey, grayish-olive; mostly medium- to coarse-grained, subrounded, clear, pale-yellow and brown quartz; glauconite, common, botryoidal, shiny, green and brown; microgranular pyrite, rare; few pieces coarse shell; forams, rare	10	181
Sand, slightly clayey, grayish-olive, similar to above	20	201
Sand, coarser, slightly clayey, grayish-olive to light olive-gray, similar to above	50	251
Well Cal-Ed 6 (Altitude: 5 feet) (Bulletin 8, p. 76)		
Well Cal-Fe 2 (Altitude: 5 feet) (Bulletin 8, p. 89)		
CHARLES COUNTY		
Well Ch-Bc 12 (Altitude: 145 feet)		
No samples	50	50
Nanjemoy formation:		
Clay, medium, glauconitic, silty, slightly fossiliferous, dark gray	20	70
Clay, same, less glauconitic; few phosphatic nodules	18	88
Clay, smooth, pale yellowish-brown; few phosphatic plates	12	100
Clay, yellowish-gray, with some streaks pale-red clay; few coarse blobs indurated glauconitic and pyritic sand; one phosphatic pellet; few fragments brown "rock"	10	110
Aquia greensand:		
Sand, very clayey, light olive-gray to greenish-gray; fine- to medium-grained, clear and pale-green subangular quartz, glauconite, green to green-black, irregular; mica, coarse; a few ostracods; shells common, including *Turritella sp.*	10	120

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Bc 12 (*Continued*)		
Sand, clayey, dark greenish-gray, similar to above with increase in fine sand; shell fragments common, including *Turritella sp.*	10	130
Clay, sandy, olive-gray, similar to above, with decrease in glauconite; mica very common; few plates brown phosphatic material; shells rare, small	10	140
Sand, clayey, olive-gray, similar to above; mica abundant; shell fragments rare	10	150
Sand, clayey, olive-gray to dark greenish-gray, similar to above with mica common; glauconite fine, irregular, 5 to 10 percent; forams rare; few blobs indurated sand; shell fragments, common	20	170
Sand, clayey, olive-gray to dark greenish-gray, similar to above with mica more common; few ostracods; few coarse pieces orange chert; few forams	30	200
Brightseat and/or Monmouth formation:		
Sand, clayey, olive-gray, similar to above; coarse mica more common; few ostracods; one large *Robulus sp.*	10	210
Clay, sandy, olive-gray; quartz, fine- to coarse-grained, angular to rounded, gray, clear, milky, yellow, and pale-pink; glauconite, irregular, green, frequent; few shells; some mica; few pieces pyrite;	10	220
Magothy(?) formation:		
Clay, sandy, mottled gray; fine- to coarse-grained, angular to subangular, violet, gray, clear, pink, and yellow quartz; some microgranular pyrite; glauconite, green, irregular, rare; some mica	5	225
No sample	2	227
Sand, gravelly, grayish-yellow; mostly coarse varicolored quartz with a few granules yellow and pink chert; few pieces of lignitic material	4	231
Raritan(?) formation:		
Sand, clayey, dusky yellow, similar to above; some green, shiny, oblate glauconite; some pyrite and iron oxides	2	233
Well Ch-Bd 11 (Altitude: 180 feet)		
Pleistocene deposits:		
Clay, sandy and gravelly, dark yellowish-orange; mostly yellow, pink and white, and tan, medium- to coarse-grained sand and gravel; quartz grains chief constituent; some dark, angular feldspar; few blobs iron oxide	10	10
Sand, clayey and gravelly, dark yellowish-orange to moderate yellowish-brown	10	20
Sand and gravel, clayey, dark yellowish-orange, similar to above with increase in coarse brown and tan chert granules; rounded gravel up to 1 inch in diameter	20	40
Nanjemoy formation:		
Sand, clayey, dark greenish-gray; fine to medium, subangular, clear to pale-gray quartz; greenish-black and green glauconite common; few rounded pellets phosphatic material; pelecypod shell fragments very abundant; few scaphopods; few pieces coral	10	50
Clay, sandy, light olive-gray; fine- to medium-grained, clear and		

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Bd 11 (*Continued*)		
gray, subrounded to subangular quartz grains; glauconite green fine, irregular to oblate, frequent; black phosphatic plates, frequent, coarse pieces brown angular quartz	20	70
Clay, slightly sand, light olive-gray, similar to above; coarse grains pale-yellow and violet quartz; phosphatic nodules and shell fragments common	20	90
Slit, clayey, shelly, olive-gray to dark greenish-gray; quartz, fine-grained, clear, subangular; glauconite, fine, green, irregular, common; mica, fine, abundant; pyrite, microgranular, frequent; pelecypod shells common	20	110
Clay, soft, pale yellowish-brown; few coarse grains white and pink, angular quartz; few pieces fine pyrite or marcasite; pieces indurated, smooth, tan rock; few plant fragments	15	125
Aquia greensand:		
Sand, fine, clayey, olive-gray; fine-grained, clear, pale-gray and pale-green quartz; fine-grained, green glauconite; mica abundant; some shell fragments and small forams (*Nodosaria sp.* and *Robulus sp.*); *Turritella sp.*, rare; few fish teeth	25	150
Clay, sandy, shelly, olive-gray, similar to above with pieces indurated glauconitic sand (rock); shell fragments common; some fine pyrite filling shell cavities	10	160
Clay, sandy, medium greenish-gray; fine- to medium-grained, subangular, clear, gray, and pale-green quartz; glauconite, irregular to botryoidal, green and green-black, common; pieces rock common; small forams abundant; few ostracods; shell fragments common	10	170
Sand, very clayey, shelly, dark greenish-gray; quartz as above; glauconite, fine to medium-grained, botryoidal, green-black, common; small forams common; pelecypod fragments common	30	200
Sand, clayey, greenish-gray, similar to above, with rock fragments common; few pieces of shell	20	220
Brightseat(?) formation:		
Sand, clayey, olive-gray; fine- to coarse-grained, clear, angular and subangular quartz; glauconite green, irregular, rare; mica, abundant; some blobs pyrite; round black pellets of phosphatic material, frequent	10	230
Magothy(?) formation:		
Clay, sandy, mottled gray; much fine-grained, varicolored quartz sand, micaceous; coarse-grained, subrounded, gray, green, and pale-yellow quartz granules, frequent; few coarse lumps phosphatic material; pyrite common	10	240
No sample	10	250
Clay, silty, yellowish-gray, similar to above; mostly fine arkosic quartz sand; few black granules phosphate; some blobs siderite	10	260
Magothy formation:		
Sand, coarse, mottled gray; medium- to coarse-grained, angular, clear, white, gray, pale violet and yellow quartz; some feldspar; pyrite rare, fine	10	270

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Bf 15 (Altitude 215 feet)		
(Charles County report, 1948, p. 117, Parlett Well)		
Well Ch-Cc 5 (Altitude: 170 feet)		
No samples	18	18
Calvert formation:		
Clay, yellowish-gray; fine- to coarse-grained, angular, clear to pale-yellow quartz; few pieces of brown, angular chert; brown-black phosphatic material; few lumps of iron oxide; mica, fine, frequent	7	25
Nanjemoy formation:		
Sand, clayey, light olive-gray; medium- to coarse-grained, clear, white and pale-yellow angular quartz and chert; coarse brown granules, frequent; glauconite, medium, botryoidal, green, common; shell fragments; mica, fine, frequent; pyrite, granular, rare	10	35
Sand, very clayey, light olive-gray; large, similar to above with coarse angular and subangular, yellow, white, clear and gray quartz and chert; few granules up to ⅜ in. in diameter; glauconite as above, common; pyrite frequent; few shell fragments; black phosphatic plates, rare	30	65
Sand, clayey, greenish-gray to dark greenish-gray; mostly fine- to medium-grained, subangular, clear and pale-green quartz; glauconite, medium, botryoidal, irregular, green, abundant; mica common; few small forams; pelecypod fragments less common; pyrite, fine, rare	30	95
Clay, sandy, light olive-gray; mostly fine- to medium-grained, subangular, clear and pale-green quartz; glauconite, fine to medium, irregular, green, common; pyrite, fine, frequent; mica, fine abundant; forams, common; phosphatic lumps, abundant	20	115
Sand, clayey, shelly, olive-gray; coarse pieces green "glauconitized" shell; pyrite common; mica, common; forams, frequent; rounded black granules of phosphatic material, frequent; few internal pelecypod casts; few lumps of brown "rock"	10	125
Marlboro clay member:		
Clay, light-brown; few coarse-grained, angular quartz granules; few pelecypod shells; pyrite granules, coarse, rare; several pieces green "glauconitized" shell	10	135
Clay, pale yellowish-brown, similar to above; fine, angular, clear quartz; fine, irregular, green glauconite	10	145
Aquia greensand:		
Sand, very clayey, light olive-gray; fine and medium-grained, clear and pale-green, subangular quartz; glauconite, fine and irregular, green, common; mica, fine, very abundant; forams, common; few ostracods; few coarse lumps of microgranular pyrite	10	155
Clay, silty, light olive-gray, similar to above; forams less common	10	165
Sand, clayey, fine, olive-gray, similar to above; fine mica abundant; forams rare	20	185
Sand, clayey, greenish-gray; clear and pale-green, subangular to rounded quartz; glauconite, green, botryoidal, abundant; forams, common; ostracods, rare; coarse shells and pieces "rock" common	10	195

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Cc 5 (*Continued*)		
Sand, fine clayey, olive-gray; fine to medium-grained, clear and pale-green quartz; glauconite, irregular, green and green-black; mica abundant; ostracods, rare; forams rare	10	205
Sand, clayey, fine, olive-gray to greenish-gray, similar to above; mica common; few coarse pelecypod shells; forams rare; sponge spicules rare	10	215
Magothy or Raritan formation:		
No samples (driller reported coarse sand at 215 feet)		at 215
Well Ch-Cc 15 (Altitude: 190 feet)		
Pleistocene deposits:		
Clay, gravelly, dark yellowish-orange; quartz and chert, yellow, gray, white, clear and pink, fine- to coarse-grained, angular; gravel up to ½ inch maximum diameter; feldspar grains common; plant fragments; blobs limonitic material	10	10
Calvert formation:		
Clay or silt, light olive-gray; mostly clear and pale-gray, fine- and very fine-grained, angular quartz grains; few small pebbles black phosphatic material	10	20
Clay, silty, light olive-gray; fine-grained, angular, clear and gray quartz; few small plates black phosphatic material; few grains black, oblate to botryoidal glauconite; one fish vertebra	20	40
Nanjemoy formation:		
Sand, clayey, light olive-gray to greenish-gray; quartz, medium-grained, subangular, clear, pale-green; glauconite, medium- to fine-grained, botryoidal, green-black, abundant; few coarse mica flakes; phosphatic fragments, black, rare; forams, small, rare	10	50
Sand, fine, very clayey, light olive-gray; quartz, as above; glauconite as above; few small pieces shell; forams and sponge spicules frequent	50	100
Sand, fine, clayey, olive-gray to light olive-gray; shell fragments more abundant	10	110
Sand, clayey, dark greenish-gray, similar to above; forams rare; some shells	30	140
Sand, very clayey, semi-indurated, greenish-gray; fine and medium-grained glauconitic sand; small pelecypod shells abundant; forams common	10	150
Clay, sandy, dark greenish-gray; fine quartz sand and fine, green, glauconite; mica abundant	10	160
Clay, pale yellowish-brown to light-brown; dull-gray and pale-green, subangular quartz; some glauconite; pieces of shell common; few black nodules; pyrite, fine, rare	30	190
Aquia greensand:		
Sand, very clayey, olive-gray; quartz, fine- to medium-grained, clear and pale-green; glauconite, green-black, fine, irregular to botryoidal; mica, fine, common; few small shell fragments (gastropods and pelecypods); few nodules yellow rock; forams rare	20	210

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Ce 15 *Continued*		
Clay, marly, sandy, dark greenish-gray, similar to above; shell fragments abundant; pieces of "rock" common; ostracods and scaphopods frequent	20	230
Sand, clayey, marly, dark greenish-gray	20	250
Clay, sandy, marly, greenish-gray; medium-grained, clear and pale-green quartz; green, botryoidal glauconite; forams, small, extremely abundant; few ostracods; few sponge spicules; some mica	10	260
Sand, clayey, olive-gray to dark greenish-gray; forams common; glauconite, green, botryoidal, common	40	300
Brightseat and/or Monmouth formation:		
Sand, clayey, light olive-gray to olive-gray; glauconite less abundant, mica flakes common	10	310
Clay, sandy to silty, olive-gray to medium-gray; fine quartz sand; mica abundant; glauconite, green, medium to coarse, botryoidal, frequent; few coarse rounded phosphatic pellets; few forams; pyrite, rare	20	330
Raritan formation:		
Clay, silty, mottled-yellowish-gray, dusky-yellow, and moderate yellowish-brown; medium- to coarse-grained, subangular gray, clear, and pale-violet quartz; pyrite common; red hematite pellets common	10	340
Clay, mottled, moderate yellowish-brown and yellowish-gray; quartz as above; pyrite common; hematite and limonite blobs abundant; yellow needle-like mineral; glauconite green, botryoidal, rare	10	350
Clay, moderate yellowish-brown; pellets and spherules of siderite abundant; a little hematite; few pieces of dull, coarse, black mineral	20	370
Clay, silty, light-brown; fine, white, gray and pink, angular quartz sand, bright green, botryoidal, glauconite common; blobs of hematite and siderite abundant; some feldspar	38	408
Sand, clean, coarse; medium- to coarse-grained, white, gray, pale-pink, and pale violet-gray subangular to angular quartz; some feldspar	2	410
Well Ch-Dd 10 (Altitude: 120 feet)		
Pleistocene deposits:		
Sand, clayey, light-brown; fine- to medium-grained, clear, white, yellow, and brown quartz and chert; mica, fine; plant fragments common; feldspar common	20	20
Nanjemoy formation:		
Sand, clayey, olive-gray; fine- to medium-grained; subangular, clear to pale-green quartz; glauconite, green and green-black, irregular to botryoidal, abundant; shell fragments frequent; fine mica; few coarse yellow chert granules; few scaphopods	30	50
Sand, very clayey, olive-gray, similar to above with a few brown rounded chert granules; small forams frequent; one pelecypod shell	20	70

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Dd 10 (*Continued*)		
Sand, clayey, olive-gray, similar to above; fine- to medium-grained, clear, gray-white and pale-green, subangular quartz; glauconite green-black, fine to medium; small forams; shell fragments; few blobs of red hematite and "rock"	40	110
Sand, very clayey, olive-gray to dark greenish-gray, shelly, similar to above; much fine quartz and glauconite; few rounded granules yellow-brown quartz; few ostracods at 130 feet; fine mica common 150 to 170 feet	60	170
Sand, clayey, olive-gray, similar to above; fine mica common; few ostracods; forams small, frequent; blobs "rock" common at 190–200 feet	50	220
Sand, clayey, olive-gray, similar to above; small forams; few pieces of brown woody material	10	230
Marlboro clay member:		
Clay, pebbly, pale reddish-brown to pale-red; granules gray and green indurated silt; blobs and molds of glauconite; pelecypod and gastropod fragments; pellets black phosphatic material; few yellow quartz granules	10	240
Clay, smooth, grayish orange-pink; pelecypod shells; pieces of "rock"; fine pale-green and clear quartz; few fish teeth; few pieces yellow quartz; black glauconite, rare	10	250
Aquia greensand:		
Sand, clayey, olive-gray; fine- to medium-grained, gray, clear, and pale-green, subangular quartz; coarse pelecypod and gastropod shells abundant (several *Turritella sp.*); fine mica	10	260
Sand, fine, or silt, clayey, olive-gray to pale greenish-gray, similar to above; pieces indurated glauconitic silt; shell fragments common, including *Turritella sp.*; gastropod shells; some pyrite	30	290
Sand, fine, clayey, grayish-olive to olive-gray, similar to above; much light-green and green botryoidal, fine glauconite; few pieces gray clay; large shell plates at 310 feet; small forams abundant 310–320 feet	30	320
Sand, clayey grayish-olive; fine- to medium-grained subangular, clear and pale-green quartz; fine green glauconite abundant; fine mica; few forams at 350 feet (*Robulus sp.*); fine mica common at 350 feet	40	360
Brightseat and/or Monmouth formation:		
Clay, very sandy, micaceous, olive-gray to olive-black; fine- to medium-grained, clear, gray and grayish-white, subangular quartz; green oblate glauconite, fine, common; fine mica abundant; few black phosphatic pellets	10	370
Sand, clayey, micaceous, color as above; glauconite content decreased to 5 percent or less; few coarse yellow and gray, subrounded quartz granules	10	380

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Dd 10 (*Continued*)		
Raritan(?) formation:		
Clay, sandy, mottled and streaked dusky-yellow and light olive-gray; quartz, fine to coarse, yellow, clear, gray and pale-green, subangular to subrounded; glauconite green, medium-grained, irregular, frequent; small blobs limonite; few dull black granules; some fine mica	20	400
Sand, medium- to coarse-grained, mottled, yellow-gray; mostly coarse-grained, angular, pale-violet, gray, white, and pink quartz	4	404
Well Ch-Eb 3 (Altitude: 20 feet)		
Pleistocene deposits:		
Sand, clayey; moderate yellowish-brown; fine- to medium-grained, subangular clear, pale-pink, yellow, and white quartz; little fine green oblate glauconite; mica plates common; few blobs of iron oxide	10	10
Sand, fine, very clayey, moderate yellowish-brown; plant fragments; mostly fine, angular white, clear, pale-pink, and tan quartz grains; some coarse, subrounded chert grains; mica common; iron oxides present; glauconite rare	20	30
Sand, fine- to medium-grained, light olive-gray to moderate yellowish-brown, clayey; few coarse grains pink and gray chert; mostly fine-grained blue-gray, clear, white and tan, semi-vitreous quartz grains; mica common; feldspar frequent; glauconite, very fine, medium green, irregular	20	50
Sand, medium to coarse-grained, fairly clean, pale yellowish-brown; medium, clear, angular and subangular quartz grains; blue-gray, angular and subangular quartz; medium-grained feldspar; small amount of light-green glauconite, coarse mica; one shell fragment; blobs of bluish vivianite	20	70
Sand, pale yellowish-brown, slightly clayey, slightly micaceous; fine- to coarse-grained sand, poorly sorted; fine portion clear to white or pale-pink angular quartz; coarse portion clear to white or pale-pink subangular quartz; some feldspar; greenish chlorite; small amount of fine glauconite	20	90
Sand and gravel, coarse, heterogeneous, clean; white and tan chert pebbles up to ¾ inch in diameter; tan, clear, and blue-gray chert granules; a coarse green mineral resembling chlorite; some feldspar; small amount of iron oxide	7	97
Well Ch-Ec 5 (Altitude: 30 feet)		
Pleistocene deposits:		
Clay, sandy, mottled yellowish-gray and moderate yellow; medium- to fine-grained, angular and subangular, clear, white, yellow, and pink quartz; mica plates; some feldspar	10	10
Clay, sandy, dark yellowish-orange and light-gray; medium to coarse-grained, clear, white and yellow, angular quartz grains, dull to vitreous; blue-gray quartz; coarse mica; fine to medium feldspar	10	20

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Ec 5 (*Continued*)		
Sand, clayey, yellowish-gray, semi-coherent, fine- to medium-grained; clear, white and smoky-gray angular quartz grains, semi-vitreous; some feldspar, fine, white and pink; few plates of coarse mica	10	30
Nanjemoy(?) formation:		
Sand, clayey, grayish-olive; macrofossil fragments abundant; few fragments of pinkish-red clay; fine-grained clear and pale-green subangular quartz grains; fine to medium botryoidal, green-black to green glauconite; forams abundant; few ostracods; few coarse phosphatic fragments	10	40
Aquia greensand:		
Sand, dark-gray, clayey, with macrofossil fragments; clear, fine-grained, subangular quartz; glauconite, fine- to medium-grained, irregular to botryoidal, green-black; small forams common; few ostracods; microgranular pyrite	10	50
Sand, medium- to dark-gray, clayey, semiindurated; gray, silty, glauconitic calcite or indurated sand fragments, common; forams rare; shell fragments common	20	70
Sand, dark-gray to olive-gray, clayey; fine- to medium-grained, clear, angular quartz grains; dark-green, coarse and fine, botryoidal glauconite; few pyrite grains; small forams abundant; few ostracods; few small pelecypods; shell fragments abundant	30	100
Sand, as above, micaceous, fossil fragments common, clayey, olive-gray; coarse, subrounded and rounded quartz grains; mica flakes common; forams rare, small; few ostracods; few *Turritella sp*	20	120
Sand, fine, micaceous, olive-gray; mica flakes common; fine green-black glauconite abundant; few Turritella and other shell fragments; forams rare; small amount of pyrite	20	140
Sand, fine, clayey, fossilferous, olive-gray as above; increase in medium-grained, subrounded quartz; *Turritella sp.*; light-green, irregular glauconite; few small grains of pyrite	20	160
Sand, fine, clayey, olive-gray as above; fine-grained, subangular, clear to pale-green quartz; fine, green-black glauconite and coarse, botryoidal, green-black glauconite; few fragments of phosphatic material; fine mica common; macrofossil fragments abundant; forams rare; ostracods common; some lumps "rock"	20	180
Sand, fine, clayey, light olive-gray, streaked with pale yellowish-brown clay; a few plant fragments; fine- to medium-grained, subangular, clear quartz; some medium- to coarse-grained, subrounded quartz; glauconite green-black, botryoidal, medium-grained; few ostracods; few small forams; microgranular pyrite grains; some macrofossil fragments; few grains of pink, tan, and violet quartz or chert	20	200
Raritan(?) formation:		
Clay, sandy, streaked and mottled, dark yellowish-orange; angular and subangular, vitreous, medium to coarse, white, yellow, pink, and pale-violet quartz grains; some feldspar; few grains of olive and green glauconite	10	210

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Eb 5 (*Continued*)		
Clay, sandy, as above, streaked dark yellowish-orange and gray; fine, clear and white quartz grains, common; violet, tan, and reddish quartz grains common; feldspar frequent; small amount of green glauconite	10	220
Clay, sandy, color as above, mottled; iron oxides	20	240
Clay, sandy, streaked pale-gray, light-brown, and dark yellowish-orange; violet and gray, subangular quartz grains common; few plant fragments; few fragments indurated glauconitic silt (rock)	20	260
Clay, sandy, streaked pale yellowish-brown; some shell fragments markedly rounded, as if by wave action; pyrite grains common; rounded fragments of pale-green mineral	20	280
Clay, pale yellowish-brown, smooth; a few plant fragments; pelecypod shell fragments common; microgranular pyrite common; glauconite, irregular, rare; quartz fine to medium, mostly clear	20	300
Clay and sand, dark greenish-gray, streaked with pale yellowish-brown clay, slightly sandy; glauconitic sand with shell fragments; few forams	20	320
Sand, coarse-grained, well sorted, medium gray, slightly clayey; angular, coarse, gray-violet, white, clear and pink quartz	4	324
Well Ch-Ee 39 (Altitude: 60 feet)		
(Charles County report, 1948, p. 116, Pace Well)		
Well Ch-Ff 48 (Altitude: 6 feet)		
Pleistocene deposits:		
Clay, silty, grayish-yellow to dusky-yellow; sand, fine- to medium-grained, dull, white and gray; glauconite, dull, fine, green, frequent; few blobs limonite; plant fragments abundant	20	20
Clay, tough, yellowish-gray to dusky-yellow; quartz, medium-grained, angular, pale-pink, gray, and clear; glauconite, green, fine, botryoidal, rare; few pieces gray flint	10	30
Clay, sandy and silty, yellowish-gray to light olive-gray, similar to above with more fine-grained quartz; mica flakes frequent; sand characterized by angularity of grains and by frequency of pale-pink and violet quartz; few pieces microgranular pyrite	20	50
Clay, sandy, light olive-gray; medium to coarse-grained, gray, pale-pink, and milky, angular to subangular quartz grains abundant; vivianite blobs rare; few carbonized plant fragments; pelecypod fragments common; few blobs limonitic material	10	60
Gravel and sand, clean, grayish, pink, white, gray, and yellow chert and quartz grains and granules; some feldspar; gray and brown angular flint	10	70

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well Ch-Ff 48 (*Continued*)		
Piney Point and Nanjemoy formations(?):		
Clay, sandy, light olive-gray; quartz, medium-grained, rounded, clear to gray and pale-green, common; glauconite, medium, botryoidal, green-black, rare; carbonized black and brown plant remains common; mica fine, frequent; some gray, soft clay fragments	10	80
Sand, clayey, olive-gray; fine- to coarse-grained, pale-green, gray, and yellow, subrounded and rounded quartz abundant; glauconite, green and light-green, common; pyrite, fine, rare; mica, fine, frequent; pelecypod fragments common	20	100
Sand, very clayey, grayish-olive; fine- to medium-grained quartz, pale-green, clear and white, abundant; glauconite, fine, botryoidal, green and olive-green, common; shell fragments very abundant, including scaphopods, pelecypods, forams and a few pieces coral; few ostracods; some fine pyrite	40	140
Sand, clayey, grayish-olive; shell fragments more abundant than above; green and green-black glauconite, about 70 percent; few ostracods	30	170
Sand, medium-grained, clean to clayey, color as above, glauconitic; some pale yellowish-brown clay at 210–220 feet	60	230
Clay, light-brown, slightly glauconitic	15	245
Aquia greensand:		
Sand, medium-grained, glauconitic, mottled grayish-olive, and clay, light-brown	20	265
PRINCE GEORGES COUNTY		
Well PG-De 18 (Altitude: 92 feet)		
Aquia greensand and Monmouth formation:		
Clay, silty and sandy, olive-gray; fine- to medium-grained, gray to white, subangular to angular quartz; fine mica, very common; glauconite, fine irregular, dark-green, common; plates fine black phosphatic material, rare; few small forams; few small sponge spicules; lumps siderite, rare	20	20
Sand, clayey, grayish-olive; mostly dull to shiny, clear, yellow and pale-green, medium-grained quartz; glauconite, medium, dark-green and light-green, botryoidal, common; few lumps iron oxide; small forams common; mica, rare	10	30
Sand, clayey, fine, olive-gray; fine- to coarse-grained quartz; coarse grains, gray, pale-violet and pink, subrounded; fine grains, angular, dull, gray to clear; mica, fine to coarse, common; glauconite, botryoidal, green-black, common; forams, small, rare; few coarse lumps black phosphatic material	20	50
Sand, clayey, semiindurated, olive-gray; few lumps quartz sand cemented by calcite with forams and glauconite; fine, angular, gray quartz common; mica, fine, abundant; few pieces carbonaceous material; glauconite, fine, green-black, rare; few small forams	30	80

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well PG-De 18 (*Continued*)		
Sand, as above, olive-gray; fine- to coarse-grained angular to subrounded, clear, pale-gray, pale-violet, pink and yellow quartz; glauconite, common, green, botryoidal; mica common; small forams common	10	90
Clay, very sandy, olive-gray, similar to above	10	100
Sand, slightly clayey, fine- to medium-grained, olive-gray, similar to above, with many small forams; large lump black phosphatic material; glauconite, green-black and olive-green, common; few lumps limonite	40	140
Sand, clayey, grayish-olive, similar to above; small forams common; few lumps black phosphate	20	160
Magothy formation:		
Clay, silty, micaceous, with woody material, dark gray	1	161
Sand, clean, mottled light-gray; mostly medium- to coarse-grained angular white, gray, pink, and yellow quartz; few lumps pyrite or marcasite; feldspar grains; few pieces carbonaceous material	10	171
Well PG-Ed 4 (Altitude: 265 feet) (Bulletin 10, p. 239)		
Well PG-Ed 8 (Altitude: 257 feet) (Bulletin 10, p. 240)		
Well PG-Fc 3 (Altitude: 50 feet) (Bulletin 10, p. 251)		
ST. MARYS COUNTY		
Well St. M-Cb 5 (Altitude: 100 feet) (Bulletin 11, p. 154)		
Well St. M-Dd 1 (Altitude: 93 feet) (Bulletin 11, p. 168)		
Well St. M-Fe 24 (Altitude: 5 feet)		
Pleistocene deposits:		
Clay, slightly sandy, grayish-yellow; sand, fine- to medium-grained, mostly angular, clear, and yellow quartz; small amount green, fine, irregular glauconite; feldspar grains, fine, pink to white; few grains coarse, subrounded, pale-violet quartz	10	10
No sample	10	20
Clay, silty and sandy; yellowish-gray; quartz, medium- to coarse-grained, gray, violet, and clear, subangular to angular; mica, coarse, rare; few pieces angular gray flint; glauconite, fine, oblate, rare	10	30
Clay, light olive-gray, tough; quartz, medium- to coarse-grained, clear, gray and violet, subangular to angular; some coarse, yellow quartz; pieces gray and brown angular flint; few pieces vivianite; few grains coarse mica; few pieces pyritized wood; subrounded fossil fragments; glauconite, irregular, green, medium, rare	10	40

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well St. M-Fe 24 (*Continued*)		
Clay, tough, light olive-gray; similar to above with lesser amount of quartz; glauconite, finer, more common; few pieces lignite, vivianite frequent; some pyrite	20	60
Clay, tough, light olive-gray; quartz, fine- to medium-grained, angular to subangular, clear, yellow, and violet; vivianite common; feldspar rare; glauconite, fine, green, rare; few plant fragments; few pieces gray flint; few satiny shell fragments	10	70
Clay, tough, light olive-gray and mottled yellowish-gray; glauconite, fine, irregular, rare; feldspar, fine, white; pyrite, microgranular, rare; vivianite, fine, common; one small foram	10	80
Clay, tough, light olive-gray to medium-gray, similar to above; few plates black phosphatic material; vivianite frequent; shell fragments common; glauconite, green, irregular, very rare	10	90
Clay, tough, medium light-gray to greenish-gray; medium- to coarse-grained, subangular, clear, violet, gray, pale-pink, and yellow quartz; pieces gray angular flint; pelecypod fragments common; black phosphatic tubular fossil fragment	10	100
Sand, coarse- to medium-grained, mottled light-olive-gray, clayey; mostly coarse, varicolored, subangular quartz grains; few grains black opaque mineral; small amount glauconite	20	120
Calvert formation:		
Clay, soft, light olive-gray; quartz sand, fine- to coarse-grained, clear, angular and subangular, gray, pink, violet, and brown; black phosphatic plates and fragments common; few coarse grains green glauconite; forams common; sponge spicules frequent; one piece brown limestone	10	130
Clay, soft, light olive-gray, light in weight, similar to above	10	140
Clay, soft, silty, slight olive-gray; glauconite, green, fine, irregular to oblate, rare; sponge spicules rare; forams common; few pieces of satiny shell fragments	10	150
Clay, soft, light olive-gray; quartz sand, fine- to coarse-grained, angular to subangular, clear, yellow, white and gray; few pieces brown phosphate; sponge spicules common; forams common; glauconite, dark-green, botryoidal, rare	10	160
Clay, light olive-gray, similar to above; quartz grains as above, less common; sponge spicules abundant; forams common; phosphate plates rare; glauconite, green, very rare	10	170
Clay, light olive-gray to yellowish-gray; quartz, coarse, angular, clear, violet, gray, and red; few pieces brown, angular flint; phosphatic pebbles, black, rare; forams, frequent; sponge spicules rare; glauconite, coarse, green, botryoidal, rare	10	180
Clay, diatomaceous, slightly sandy, yellowish-gray; mostly clear and gray, fine-to medium-grained, angular quartz grains; few grains pale-pink and violet, subangular quartz; small amount microgranular pyrite; sponge spicules common; shell fragments common; several small pelecypods; forams common; phosphatic fragments, black, small; glauconite, fine, green, rare	20	200

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well St. M-Fe 24 (*Continued*)		
Clay, light olive-gray to grayish-olive; diatoms abundant, sponge spicules common; quartz, mostly fine, angular, shiny	10	210
Clay, silty, pale-olive to light olive-gray; shell fragments common; forams abundant; quartz as above; ostracods common; small amount fine, irregular glauconite	10	220
Piney Point formation:		
Sand, medium-grained, slightly clayey, mottled-gray to grayish-green; quartz grains fine to coarse, clear, yellow and brown; glauconite light-green to brown, medium; pyrite, fine, rare; agglomerates quartz and glauconite grains cemented by calcite ("rock" of drillers)	10	230
Sand, medium grained, mottled-gray to grayish-green; quartz grains as above, subrounded to rounded; small pelecypod shells common; glauconite, oblate to botryoidal, green, light-green, and brown; pieces indurated rock common	10	240
Sand, medium-grained, mottled-gray to yellowish-gray; glauconite, fine- to medium-grained, botryoidal to irregular; rock agglomerates common; small pelecypod shells	10	250
Sand, medium- to coarse-grained, mottled-gray to grayish-green, glauconitic; rock agglomerates common; forams common; small shell fragments common	10	260
Sand, medium- to coarse-grained, as above, glauconitic; quartz grains subrounded to rounded, yellow, clear, and pale-brown; glauconite, botryoidal to irregular, green and olive-green; pyrite common; rock agglomerates common; few large forams	10	270
Nanjemoy formation:		
Sand, clayey, grayish-olive; quartz grains commonly pale-brown and yellow, subrounded; glauconite abundant, oblate to irregular, brown to dark-green, shiny; forams scarce; pyrite very scarce	10	280
Sand, clayey, grayish-olive; brown to yellow quartz grains very common; brown irregular to botryoidal glauconite very common; small forams, rare	10	290
Sand, clayey, olive-gray; brown subrounded to rounded quartz grains common; brown and dark-green botryoidal glauconite common; small forams, rare	10	300
Clay, sandy, dark greenish-gray; quartz, coarse grained, subrounded, green, clear, and brown, dull to moderate lustre; glauconite, green-black, botryoidal, coarse-grained, abundant; small amount oblate brown glauconite; sponge spicules rare; few forams; pyrite, fine, rare	40	340
Clay, sandy, dark greenish-gray; quartz, as above, slightly coarser, pale-green, clear, white and yellow; glauconite, green-black; pyrite, fine, rare; sponge spicules rare; few large forams; mica rare	20	360
Clay, sandy, dark greenish-gray, and clay, pale yellowish-brown; glauconite, green-black, botryoidal, coarse; pyrite, fine, rare; few pieces pink calcite; forams rare	20	380
Clay, sandy, dark greenish-gray, similar to above; few pieces of "rock"; forams rare	10	390

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well St. M-Fc 24 *Continued*		
Clay, yellowish-gray, streaked; quartz, medium- to coarse-grained, clear, pale-green, yellow and brown, subangular to subrounded; glauconite, green, irregular to botryoidal, common; a few pieces white calcite; blobs fine green glauconite in pale yellow-brown clay	10	400
Aquia greensand:		
Sand, medium-grained, mottled light olive-brown; quartz, medium- to coarse-grained, clear, brown and yellow, subangular to subrounded; brown quartz very abundant; glauconite, medium-grained, green, olive-green and brown, botryoidal to oblate, common; few pieces soft white calcite	10	410
Well St.M-Fh 3 (Altitude: 6 feet) (Bulletin 11, p. 181)		

DISTRICT OF COLUMBIA

	Thickness (feet)	Depth (feet)
Well D.C. 2 (Altitude: 10 feet)		
Pleistocene and Recent deposits:		
Clay, finely micaceous, silty, tan and red; pebbly	13	13
Clay, gray, streaked with red and tan clay	11	24
Gravel, fine, slightly clayey; consists of rounded and subangular pebbles of gray, white, and pink chert	9	33
Patapsco and Arundel formations:		
Clay, silty, finely micaceous, red; contains inclusions of gray-green silty clay	20	53
Clay, sandy, micaceous, gray and red; sample contains a few subrounded gravel pebbles	17	70
Clay, gray, sandy, with inclusions red clay	10	80
Clay, red and pink, with inclusions of white clay; a few siderite spherules	43	123
Clay, as above	8	131
Clay, as above, one fragment black, vesicular, carbonaceous material	39	170
Sand, clean, coarse, well sorted, subangular; consists largely of gray and white quartz grains; few lumps of iron oxide	12	182
Gravel, consisting of rounded pebbles of chert and red and gray clay (sample 60 percent clay pebbles and fragments)	13	195
Patuxent formation:		
Sand, coarse, clean, gray; contains some quartz pebbles of gravel size	30	225
Gravel, similar in character to that from 182–195 feet	5	230
Sand, medium- to coarse-grained, gray-white, slightly feldspathic	12	242
Sand, red, coarse (composed of quartz and reworked red clay granules); one piece lignite	15	257
Sand, red-gray, fine to medium (quartz sand with associated red clay granules); few pellets lignitic material	14	271
Sand, gray-white, medium-grained, angular; some pyrite and marcasite: few pieces lignite	24	295

TABLE 34—*Continued*

	Thickness (feet)	Depth (feet)
Well D.C. 2 (*Continued*)		
Clay, silty, red, with associated fine gravel	23	318
Sand, medium- to coarse-grained, clean, gray; contains associated red clay blobs	22	340
Clay, red and gray; consists of rounded clay lumps and some rounded quartz or chert pebbles	5	345
Sand, medium-grained, subrounded, clean, gray; a few pieces of marcasite	9	354
Gravel, fine, red and gray (sample consists of 50 percent quartz pebbles and 50 percent rounded clay pebbles)	23	377
Pre-Cambrian rocks:		
Clay, dull-brown and gray; pebbles of quartz and pieces of green schist or phyllite	23	400

TABLE 35

Distribution of Foraminifera in Well Cuttings

ANNE ARUNDEL COUNTY

Species of Foraminfera	AA-Ed 19 Birdsville Alt.: 165 ft. Depth: 455 ft.		AA-Fd 13 Mt. Zion Alt.: 160 ft. Depth: 585 ft.		AA-Fe 28 Franklin Manor Alt.: 5 ft. Depth: 200 ft.		AA-Ge 7 Fairhaven Alt.: 10 ft. Depth: 310 ft.		Geologic Range								
										Miocene			Eocene				
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Spiroplectammina mississippiensis (Cushman)	50– 90	F	10–140	C								x					
Spiroplectammina spinosa Dorsey	60– 70	F	10–120	F								x					
Textularia cf. *T. foliacea* Heron-Allen & Earland	50– 90	C	10–110	C								x					
Textularia gramen d'Orbigny	40– 90	C	10–140	C								x					
Robulus americanus (Cushman)			10– 70	R								x					
Robulus americanus spinosus Cushman			10– 70	R								x					
Saracenaria sp.			100–140	R								x					
Lagena clavata (d'Orbigny)			100–140	R								x					
Lagena tenuis (Bornemann)			100–110	R								x					
Nonion advenus (Cushman)	60– 70	F	70–110	R								x					
Nonion grateloupi (d'Orbigny)	30– 90	F	10–140	C								x					
Nonion marylandicus Dorsey			140	R								x					
Nonion pizarrense W. Berry	30– 90	F	10–140	C								x					
Nonionella auris (d'Orbigny)	30– 60	R	50–140	F								x					
Buliminella curta Cushman			10– 40	R								x					
Buliminella elegantissima (d'Orbigny)	50–240	R	10–290	C	178–182	R						x			x		
Bulimina elongata d'Orbigny	30– 90	R	10–380	C			40– 50	R				x			x		
Bulimina ovata d'Orbigny	60– 70	R										x					
Virgulina fusiformis Cushman	30– 40	R	60– 80	R								x					
Virgulina (*Virgulinella*) *miocenica* Cushman & Ponton			90–140	R								x					

Bolivina calvertensis Dorsey			10– 80	F								x				
Bolivina floridana Cushman	50– 60	R	60–150	F								x				
Bolivina marginata Cushman			60–110	R								x				
Bolivina marginata multicostata Cushman			60– 70	C								x				
Bolivina obliqua Barbat & Johnson			60–150	F								x				
Bolivina paula Cushman & Cahill	50– 90	R	10–150	F								x				
Bolivina plicatella Cushman	30– 60	R	10– 70	R								x				
Uvigerina auberiana d'Orbigny	60– 70	F	100–110	F								x				
Uvigerina calvertensis Cushman	50– 60	R	100–110	R								x				
Uvigerina kernensis Barbat & von Estorff	60– 90	R	70–110	R								x				
Uvigerina subperegrina Cushman & Kleinpell	60– 70	R	70– 80	R								x				
Ellipsolagena bidens Cushman			70–150	R								x				
Discorbis cavernata Dorsey	30– 40	R										x				
Discorbis floridana Cushman	50– 60	R	60– 70	R								x				
Discorbis valvulata (d'Orbigny)	50– 60	R	10– 40	R								x				
Valvulineria floridana Cushman	30– 70	F	40–150	C								x				
Rotalia bassleri Cushman & Cahill			10–120	F								x				
Rotalia beccarii tepida Cushman			10–120	F								x				
Pulvinulinella pontoni Cushman			140–150	R								x				
Cassidulina crassa d'Orbigny			100–110	R								x				
Globigerina altispira Cushman & Jarvis			40–150	R								x				
Globigerina sp.	50– 90	R	40–150	F								x				
Globigerinoides sp.			60– 80	R								x				
Globorotalia sp.			50– 60	R								x				
Cibicides americanus (Cushman)			10–400	F	168–202	R	70–310	F				x		x	x	
Cibicides concentricus (Cushman)			10–120	C								x				
Cibicides floridanus (Cushman)	30– 40	R	10– 50	R								x				
Cibicides lobatulus (Walker & Jacob)	60–290	R	10–410	F	178–202	R	180–310	F				x		x	x	
Cibicides lobatulus arnatus (Cushman)	60– 70	R	10–120	F								x				
Dyocibicides biserialis Cushman & Valentine			10– 40	F								x				
Spiroplectammina wilcoxensis Cushman & Ponton			160–410	C	68–202	R	180–310	F						x	x	

TABLE 35—*Continued*

Species of Foraminifera	AA-Ed 19 Birdsville Alt.:165 ft. Depth: 455 ft.		AA-Fd 13 Mt. Zion Alt.: 160 ft. Depth: 585 ft.		AA-Fe 28 Franklin Manor Alt.: 5 ft. Depth: 200 ft.		AA-Ge 7 Fairhaven Alt.: 10 ft. Depth: 310 ft.		Geologic Range								
										Miocene			Eocene				
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	epth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Textularia cf. *T. claibornensis* Weinzier & Applin			210–370	R			270–310	R						x	x		
Textularia cf. *T. hannai* Davis			250–390	R			270–310	R						x	x		
Marssonella sp.	250–260	R													x		
Robulus Knighti Toulmin							270–290	R							x		
Robulus midwayensis virginianus Shifflett	230–290	F	160–410	F	198–202	R	140–310	F						x	x		
Robulus wilcoxensis Cushman & Ponton	230–240	R	310–400	F			200–290	R							x		
Astucolus cf. *A. danvillensis* (Howe & Wallace)	230–240	R	310–390	R											x		
Dentalina communis d'Orbigny	230–270	R	180–400	R	198–202	R								x	x		
Dentalina virginiana Cushman	230–270	R													x		
Dentalina wilcoxensis Cushman	230–240	R	160–410	R	198–202	R	200–290	R						x	x		
Nodosaria affinis Reuss			280–410	R	128–132	R									x		
Nodosaria latejugata Gümbel			340–380	R											x		
Nodosaria latejugata carolinensis Cushman			340–410	F			270–290	R							x		
Guttulina hantkeni Cushman & Ozawa	250–260	R													x		
Guttulina irregularis (d'Orbigny)	230–290	R	160–410	F	188–202	R	160–310	R						x	x		
Guttulina problema d'Orbigny			160–410	F			200–310	R						x	x		
Globulina gibba d'Orbigny	230–240	F	160–410	F	188–192	R	160–310	R						x	x		
Globulina inaequalis Reuss					148–152	R									x		
Globulina munsteri (Reuss)			340–410	R			200–210	R							x		
Globulina rotundata (Bornemann)	230–240	F	310–410	F											x		
Sigmomorphina semitecta terquemiana (Fornasini)	230–240	R	360–380	R	128–132	R	230–310	R							x		
Polymorphina advena nuda Howe & Roberts	230–240	R					230–250	R							x		
Nonion planatus Cushman & Thomas	230–270	R	170–180	R										x	x		
Nonionella hantkeni fayettei (Cushman & Ellisor)			260–320	F											x		

Nonionella insecta (Schwager)			310–320	R											x	
Nonionella spissa Cushman			170–360	R										x	x	
Bolivinopsis curta (Cushman)	230–260	R													x	
Gümbelina wilcoxensis Cushman & Ponton					178–182	R									x	
Gümbelitria sp.					68– 72	F								x		
Eouvigerina excavata Cushman	230–240	R	370–380	R	158–172	R	250–270	F							x	
Buliminella robertsi (Howe & Ellis)			150–250	F	68–152	R	40–200	F						x	x	
Bulimina cacumenata Cushman & Parker					128–162	R	140–310	F						x	x	
Entasolenia marginata (Walker & Jacob)			310–390	R			270–290	R							x	
Virgulina wilcoxensis Cushman & Ponton							120–140	F						x		
Loxostomum claibornense Cushman	230–240	R	240–400	R	158–162	F	140–160	F						x	x	
Uvigerina russelli Howe			240–310	F	128–182	F	140–160	C						x	x	
Angulogerina parvula (Cushman & Thomas)					168–182	R	180–210	R							x	
Angulogerina virginiana Cushman	230–240	F			128–202	F	120–270	F						x	x	
Trifarina wilcoxensis (Cushman & Ponton)			160–320	R	68–202	R	70–250	R						x	x	
Discorbis amicus Shifflett	220–240	R													x	
Discorbis calyptra Shifflett	230–290	F	310–410	C	168–202	F	200–310	F							x	
Lamarckina marylandica Cushman	230–240	C	310–390	R											x	
Lamarckina marylandica claibornensis Cushman	230–250	F	370–380	R	168–202	R									x	
Valvulineria scrobiculata (Schwager)	230–290	C	310–410	C	168–202	R	180–310	F							x	
Valvulineria wilcoxensis Cushman & Ponton			160–400	R	68–162	C	140–170	F						x	x	
Gyroidina aequilateralis (Plummer)			370–410	R			180–200	F							x	
Gyroidina soldanii octocamerata Cushman & G. D. Hanna	260–270	F	150–390	F	138–192	R	180–270	F						x	x	
Eponides labiomargus Shifflett	210–270	C	310–410	C	48–202	F	140–280	C						x	x	
Eponides lotus (Schwager)	230–290	C	160–400	C	68–202	F	120–310	F						x	x	
Cancris claibornensis Howe & Wallace							290–310	R							x	
Siphonina claibornensis Cushman			270–280	R	68–162	R	120–180	R						x	x	
Siphonina wilcoxensis Cushman			160–370	R	98–162	F	60–310	F						x	x	
Alabamina wilcoxensis Toulmin	200–290	F	290–410	C	168–202	F	160–310	C						x	x	
Pulvinulinella danvillensis Howe & Wallace	220–250	R	240–400	F	128–172	R	120–290	R						x	x	
Pullenia quinqueloba angusta Cushman & Todd			350–360	R			250–310	R							x	

TABLE 35—*Continued*

Species of Foraminfera	AA-Ed 19 Birdsville Alt.: 165 ft. Depth: 455 ft.		AA-Fd 13 Mt. Zion Alt.: 160 ft. Depth: 585 ft.		AA-Fe 28 Franklin Manor Alt.: 5 ft. Depth: 200 ft.		AA-Ge 7 Fairhaven Alt.: 10 ft. Depth: 310 ft.		Geologic Range								
										Miocene			Eocene				
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Globigerina bulloides d'Orbigny			180–190	R										x			
Globigerina danvillensis Howe & Wallace			160–170	R			270–310	F						x	x		
Globigerina ouachitaensis Howe & Wallace			160–170	R			230–270	R						x	x		
Globigerina pseudobulloides Plummer			370–380	R			230–290	R							x		
Globigerina triloculinoides Plummer			160–380	R	78– 82	R	70–210	R						x	x		
Globorotalia cf. *G. angulata* (White)			310–320	R											x		
Globorotalia crassata (Cushman)	230–240	R	180–190	R			140–310	R						x	x		
Globorotalia crassata aequa Cushman & Renz			310–370	R			140–180	R						x	x		
Globorotalia wilcoxensis Cushman & Ponton	230–240	F	160–310	R	168–182	R	120–250	R						x	x		
Globorotalia wilcoxensis acuta Toulmin	230–240	R					180–270	R							x		
Anomalina umbonifera (Schwager)	230–290	R	300–380	R	178–202	R	140–280	R						x	x		
Cibicides sp.			160–170	F			160	R						x			
Cibicides howelli Toulmin	200–290	F	290–410	F	68–202	R	140–310	F						x	x		
Cibicides marylandicus Shifflett	230–290	C	310–410	C	168–202	C	180–310	C							x		
Cibicides neelyi Jennings	200–290	C	310–410	C	168–202	F	180–290	C							x		
Cibicides praecursorius (Schwager)	240–250	R	180–190	R	168–192	R								x	x		
Cibicides pseudoungerianus (Cushman)			240–410	F	98–102	R								x	x		
Cibicides pseudowuellerstorfi Cole	230–290	C	160–410	C	168–202	F	140–310	F						x	x		
Cibicides westi Howe							230–270	R							x		
Cibicidina danvillensis (Howe & Wallace)	230–260	R	310–400	F			200–290	R							x		

TABLE 35—*Continued*

CALVERT COUNTY

Species of Foraminifera	Cal-Bb 9 Chaney Alt.: 130 ft. Depth: 288 ft.		Cal-Ca 2 Huntington Alt.: 32 ft. Depth: 468 ft.		Cal-Dc 17 Prince Frederick Alt.: 147 ft. Depth: 555.3 ft.		Cal-Ed 6 Long Beach Alt.: 5 ft. Depth: 273 ft.		Cal-Fe 2 Cove Point Alt.: 5 ft. Depth: 304.5 ft.		Geologic Range								
												Miocene			Eocene				
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Elphidium discoidale (d'Orbigny)									25– 30	R	x								
Elphidium insertum (Williamson)									25– 65	F	x								
Elphidium insertum clavatum Cushman									25– 65	F	x								
Rotalia beccarii parkinsoniana Cushman & Cole									40– 65	R	x								
Spiroplectammina mississippiensis (Cushman)	25–115	C	30– 50	R	84–324	F	32–189	F	74–284	C				x	x				
Spiroplectammina spinosa Dorsey					138–148	R	74–158	R	95–242	F				x					
Textularia cf. *T. badenensis* Lalicker									65– 74	R			x						
Textularia candeiana d'Orbigny					95–148	F	20– 84	F	116–126	F				x					
Textularia cf. *T. foliacea* Heron-Allen & Earland	41– 51	R			105–169	F	32– 84	F	74–179	C				x					
Textularia gramen d'Orbigny	41–115	F			33–241	C	20–168	F	65–231	C			x	x					
Textularia mayori Cushman					33– 84	F			65– 74	R			x						
Textularia ultima-inflata Dorsey					33– 54	R							x						
Quinqueloculina cf. *Q. fusca* H. B. Brady					33– 43	R							x						
Quinqueloculina seminula (Linnaeus)					33–138	R							x	x					
Sigmoilina tenuis (Czjzek)									116–147	R				x					
Robulus americanus (Cushman)	30– 41	R			105–158	R	42–179	R	74–242	R				x					
Robulus americanus spinosus (Cushman							74– 95	R	137–147	R				x					

TABLE 35—*Continued*

Species of Foraminfera	Cal-Bb 9 Chaney Alt.: 130 ft. Depth: 288 ft. Depth range (feet)	Rel. abun.	Cal-Ca 2 Huntington Alt.: 32 ft. Depth: 468 ft. Depth range (feet)	Rel. abun.	Cal-Dc 17 Prince Frederick Alt.: 147 ft. Depth: 555.3 ft. Depth range (feet)	Rel. abun.	Cal-Ed 6 Long Beach Alt.: 5 ft. Depth: 273 ft. Depth range (feet)	Rel. abun.	Cal-Fe 2 Cove Point Alt.: 5 ft. Depth: 304.5 ft. Depth range (feet)	Rel. abun.	Geologic Range: Pleistocene	Miocene: St. Marys	Miocene: Choptank	Miocene: Calvert	Eocene: Jackson	Eocene: Nanjemoy	Eocene: Aquia	Paleocene	Cretaceous
Robulus branneri Cushman & Kleinpell					105–127	R	20– 32	R						x					
Planularia vaughani Cushman					84–116	R								x					
Marginulina sp.					190–200	R								x					
Nodosaria pyrula d'Orbigny	105–115	R												x					
Lagena aculicostata Reuss			442–458	F					65– 74	R			x				x		
Lagena clavata (d'Orbigny)			343–355	R	230–534	R			126–137	R				x			x		
Lagena substriata Williamson					127–138	R								x					
Lagena tenuis (Bornemann)					127–138	R			231–242	R				x					
Guttulina austriaca d'Orbigny	105–115	R												x					
Guttulina elegans Dorsey					158–169	R								x					
Pseudopolymorphina decora (Reuss)	62–72	R			158–169	R								x					
Pseudopolymorphina rutila (Cushman)					148–158	R								x					
Sigmomorphina marylandica Cushman	105–115	R												x					
Nonion advenus (Cushman)	25– 83	F			200–251	C	147–158	R	252–273	F				x	x				
Nonion grateloupi (d'Orbigny)	20–115	F			84–251	C	20–189	C	65–231	C				x					
Nonion marylandicus Dorsey					64–200	F							x	x					
Nonion medio-costatus (Cushman)	41– 83	F			33– 54	R							x	x					
Nonion pizarrense W. Berry	20–115	F			127–251	F	20–189	F	65–242	C			x	x					
Nonionella auris (d'Orbigny)					74–148	R	20– 32	R					x	x					
Buliminella curta Cushman					74–148	R							x	x					

Buliminella elegantissima (d'Orbigny)	41–288	R			21–241	C	126–137	R	74–242	C			x	x		x	x		
Bulimina elongata d'Orbigny	30–200	C			21–324	C	20–189	C	65–242	C			x	x		x			
Bulimina inflata Seguenza					148–158	R								x					
Virgulina fusiformis Cushman					95–200	F			74–147	C			x	x					
Virgulina (Virgulinella) miocenica Cushman & Ponton					105–200	R								x					
Bolivina calvertensis Dorsey					105–241	F	20–137	R	74–242	C				x					
Bolivina floridana Cushman					21–241	F	20– 95	R	105–242	F			x	x					
Bolivina marginata Cushman									74–210	F				x					
Bolivina marginata multicostata Cushman					138–169	R			74–242	C				x					
Bolivina obliqua Barbat & Johnson					21–200	F	105–179	R	74–242	C			x	x					
Bolivina paula Cushman & Cahill					21–241	C	42– 95	R	74–242	C			x	x					
Bolivina plicatella Cushman					84–158	F	42– 53	C	65–168	C				x					
Uvigerina auberiana d'Orbigny	105–115	F			148–251	F			231–242	R				x					
Uvigerina calvertensis Cushman					241–251	R								x					
Uvigerina kernensis Barbat & von Estorff	105–115	F			105–251	F	168–179	R	74–242	R				x					
Uvigerina subperegrina Cushman & Kleinpell	105–115	F			84–251	F	75– 84	R	116–242	F				x					
Siphogenerina lamellata Cushman									136–147	R				x					
Siphogenerina spinosa (Bagg)									116–126	R				x					
Ellipsolagena bidens Cushman	105–115	R												x					
Discorbis candeiana (d'Orbigny)					21– 33	R							x						
Discorbis cavernata Dorsey	105–115	R			84–127	R	42– 53	R	116–126	R				x					
Discorbis floridana Cushman					64–116	R			65– 84	R			x	x					
Discorbis valvulata (d'Orbigny)	20– 62	R			116–251	F	168–189	F						x					
Valvulineria floridana Cushman	25–115	C			84–241	C	20–189	C	65–242	C				x					
Eponides mansfieldi Cushman					21– 84	C							x						
Rotalia bassleri Cushman & Cahill	30–115	R			95–105	R	42– 53	R						x					
Rotalia beccarii tepida Cushman	105–115	R			21– 95	F			231–242	R			x	x					

TABLE 35—*Continued*

Species of Foraminifera	Cal-Bb 9 Chaney Alt.: 130 ft. Depth: 288 ft.		Cal-Ca 2 Huntington Alt.: 32 ft. Depth: 468 ft.		Cal-Dc 17 Prince Frederick Alt.: 147 ft. Depth: 555.3 ft.		Cal-Ed 6 Long Beach Alt.: 5 ft. Depth: 273 ft.		Cal-Fe 2 Cove Point Alt.: 5 ft. Depth: 304.5 ft.		Geologic Range								
												Miocene			Eocene				
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Cancris sagra communis Cushman & Todd					116–148	R								x					
Pulvinulinella pontoni Cushman					127–230	R	32– 42	R	74–242	F				x					
Cassidulina crassa d'Orbigny					116–190	R	32– 42	R	74–221	F				x					
Globigerina altispira Cushman & Jarvis					127–251	R	63– 84	R						x					
Globigerina sp.	105–115	R			95–251	R	42– 84	R	116–126	R				x					
Globigerinoides sp.	41–115	R			116–169	R	74– 84	R	116–126	R				x					
Cibicides americanus (Cushman)	30–115	F	30–442	F	21–324	F	20–179	F	65–294	F			x	x		x	x		
Cibicides concentricus (Cushman)	105–115	F			84–241	A	32–158	C	65–242	C			x	x					
Cibicides floridanus (Cushman)	93–105	R	30– 50	R	138–148	R								x					
Cibicides lobatulus (Walker & Jacob)	41–273	R	30–458	F	33–324	F	20–262	R	65–315	C			x	x	x	x	x		
Cibicides lobatulus ornatus (Cushman	62– 72	R	30– 50	F	190–251	R	74– 84	R	116–242	F				x					
Dyocibicides biserialis Cushman & Valentine			30– 50	F	95–230	F			116–126	C				x					
Cibicidella variabilis (d'Orbigny)					33– 54	R							x						
Spiroplectammina wilcoxensis Cushman & Ponton	221–288	F	334–458	F	291–534	F										x	x		
Textularia cf. *T. dibollensis* Cushman & Applin			380–442	R													x		
Textularia cf. *T. hannai* Davis			380–458	R													x		
Gaudryina cf. *G. geometrica* Howe	273–288	R	370–380	R													x		
Quinqueloculina laevigata d'Orbigny									263–284	R					x				
Robulus alato-limbatus (Gümbel)									273–284	F					x				

Robulus gutticostatus (Gümbel)							200–210	R	242–263	R					x			
Robulus knighti Toulmin	252–263	R			524–534	R											x	
Robulus midwayensis virginanus Shifflett	210–288	F	334–458	R	270–534	R			294–305	R						x	x	
Robulus wilcoxensis Cushman & Ponton			334–458	R	310–534	R										x	x	
Marginulina cocoaensis Cushman									263–284	R					x			
Dentalina communis d'Orbigny			343–380	R	310–534	F			284–305	R						x	x	
Dentalina hexacostata Howe	273–284	R	400–410	R													x	
Dentalina virginiana Cushman	284–288	R	343–458	R													x	
Dentalina wilcoxensis Cushman			370–458	R	524–534	F											x	
Nodosaria affinis Reuss	263–273	R	400–458	F													x	
Nodosaria latejugata Gümbel	210–221	R														x		
Nodosaria latejugata carolinensis Cushman	263–284	F	310–458	F													x	
Lagena costata (Williamson)	221–231	R	355–442	R					294–305	R						x	x	
Guttulina irregularis (d'Orbigny)	137–288	F	370–380	F	260–545	R	200–210	R	242–305	F					x	x	x	
Guttulina problema d'Orbigny			334–458	R	270–534	R	189–200	R	263–305	R					x	x	x	
Guttulina spicaeformis (Roemer)	242–288	R	370–380	R	310–534	R										x	x	
Globulina gibba d'Orbigny	137–273	R	334–458	R	251–545	R			284–294	R						x	x	
Globulina inaqeualis Reuss	158–168	R	370–458	R	310–534	R										x	x	
Globulina münsteri (Reuss)	210–264	R							242–263	R					x	x	x	
Globulina rotundata (Bornemann)			380–442	R			210–221	R	242–305	R					x	x	x	
Sigmomorphina cf. *S. costifera* Cushman									242–252	R					x			
Sigmomorphina semitecta (Reuss)	273–288	R			291–300	R										x	x	
Sigmomorphina semitecta terquemiana (Fornasini)					310–324	R										x		
Polymorphina advena nuda Howe & Roberts			334–400	R													x	
Nonion planatus Cushman & Thomas	147–158	R	442–458	R	260–324	F										x	x	
Nonionella insecta (Schwager)	189–200	R			291–503	R										x	x	
Nonionella spissa Cushman	137–189	R	380–390	R	310–419	R										x	x	

TABLE 35—*Continued*

Species of Foraminfera	Cal-Bb 9 Chaney Alt.: 130 ft. Depth: 288 ft.		Cal-Ca 2 Huntington Alt.: 32 ft. Depth: 468 ft.		Cal-Dc 17 Prince Frederick Alt.: 147 ft. Depth: 555.3 ft.		Cal-Ed 6 Long Beach Alt.: 5 ft. Depth: 273 ft.		Cal-Fe 2 Cove Point Alt.: 5 ft. Depth: 304.5 ft.		Geologic Range								
												Miocene			Eocene				
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Bolivinopsis curta (Cushman)			370–390	R					242–263	R					x		x		
Gümbelina wilcoxensis Cushman & Ponton)	263–273	R															x		
Gümbelitria sp.					300–324	R			294–305	R						x			
Eouvigerina excavata Cushman			355–400	R													x		
Buliminella robertsi (Howe & Ellis)	137–288	F			300–503	F			283–305	R						x	x		
Bulimina ovata d'Orbigny			380–442	R	319–419	R										x	x		
Bulimina cf. *B. simplex* Terquem					319–324	F			284–315	F						x			
Entosolenia marginata (Walker & Jacob)			442–458	R													x		
Virgulina dibollensis Cushman & Applin					310–319	R			273–284	R					x	x			
Virgulina wilcoxensis Cushman & Ponton	210–288	R	370–442	R												x	x		
Bolivina jacksonensis Cushman & Applin							189–200	R							x				
Bolivina cf. *B. taylori* Howe	137–147	R														x			
Loxostomum claibornense Cushman			370–380	R	260–270	R			284–294	R						x	x		
Uvigerina dumblei Cushman & Applin									273–284	R					x				
Uvigerina elongata Cole					319–419	R										x			
Uvigerina gardnerae Cushman	147–158	R			310–324	R										x			

Uvigerina russelli Howe	231–288	R															x	
Angulogerina sp.					270–324	R										x		
Angulogerina parvula (Cushman & Thomas)	263–273	R	355–361	R	251–324	R										x	x	
Angulogerina virginiana Cushman	231–273	R	370–400	R	408–534	R										x	x	
Trifarina wilcoxensis (Cushman & Ponton)	137–288	F			300–534	F										x	x	
Discorbis amicus Shifflett			430–458	R													x	
Discorbis calyptra Shifflett	221–288	F	310–458	F	260–534	F										x	x	
Lamarckina marylandica Cushman	273–288	F															x	
Valvulineria jacksonensis Cushman							189–252	R	242–284	R					x	x		
Valvulineria scrobiculata (Schwager)	221–288	F	310–458	C	524–545	F										x	x	
Valvulineria wilcoxensis Cushman & Ponton	126–231	F	334–458	R	260–545	R	284–315	F								x	x	
Gyroidina soldanii octocamerata Cushman and G. D. Hanna	137–273	F	310–442	F	251–524	F	189–242	R	242–315	F					x	x	x	
Gyroidina subangulata Plummer			370–390	F													x	
Eponides lotus (Schwager)	137–288	C	334–458	R	260–324	R	200–210	R	284–294	R					x	x	x	
Eponides labiomargus Shifflett	210–288	F	334–458	F	523–545	F										x	x	
Siphonina claibornensis Cushman	210–241	R	380–390	R												x	x	
Siphonina wilcoxensis Cushman	137–242	F	390–458	R	310–534	R			294–305	R						x	x	
Cancris claibornensis Howe			380–390	R													x	
Asterigerina sp.									273–284	R					x			
Alabamina wilcoxensis Toulmin	178–288	C	334–458	C	310–545	F			384–305	F						x	x	
Pulvinulinella danvillensis Howe & Wallace	221–288	R	370–400	R	408–534	R			294–305	F						x	x	
Globigerina bulloides d'Orbigny	137–288	R	370–458	R	291–534	F	231–242	R								x	x	
Globigerina danvillensis Howe & Wallace	158–168	R	370–400	F	310–324	F										x	x	
Globigerina cf. *G. ouachitaensis* Howe & Wallace	137–242	R			310–503	R										x	x	
Globigerina cf. *G. pseudobulloides* Plummer	273–284	F	370–442	R	291–324	F										x	x	

TABLE 35—*Continued*

Species of Foraminifera	Cal-Bb 9 Chaney Alt.: 130 ft. Depth: 288 ft.		Cal-Ca 2 Huntington Alt.: 32 ft. Depth: 468 ft.		Cal-Dc 17 Prince Frederick Alt.: 147 ft. Depth: 555.3 ft.		Cal-Ed 6 Long Beach Alt.: 5 ft. Depth: 73 ft.		Cal-Fe 2 Cove Point Alt.: 5 ft. Depth: 304.5 ft.		Geologic Range								
												Miocene			Eocene				
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Globigerina triloculinoides Plummer	137–228	F	343–458	F	270–534	F										x	x		
Globorotalia crassata (Cushman)			343–458	R	513–534	R											x		
Globorotalia crassata aequa Cushman and Renz	210–273	F	380–390	R	524–534	R										x	x		
Globorotalia membranacea (Ehrenberg)			355–390	R													x		
Globorotalia wilcoxensis Cushman & Ponton	210–288	F	355–442	F	482–534	R										x	x		
Globorotalia wilcoxensis acuta Toulmin	221–284	F	370–442	F												x	x		
Anomalina umbonifera (Schwager)	126–231	F	343–400	R	319–503	R										x	x		
Cibicides cocoaensis (Cushman)							200–210	R	263–284	R					x				
Cibicides howelli Toulmin	131–288	C	343–458	F	270–534	F			284–305	R						x	x		
Cibicides marylandicus Shifflett	178–288	F	334–458	F	524–534	C			284–305	F						x	x		
Cibicides neelyi Jennings	221–288	C	320–458	C	408–555	C										x	x		
Cibicides ocalanus Cushman							242–252	R								x			
Cibicides praecursorius (Schwager)	252–273	R	370–380	R	300–324	C			284–305	R						x	x		
Cibicides pseudoungerianus (Cushman)	200–288	F	310–355	F	251–555	R	200–242	R	284–294	R					x	x	x		
Cibicides pseudowuellerstorfi Cole	200–288	F	310–458	F	310–545	F			294–305	R						x	x		
Cibicidina danvillensis (Howe & Wallace)	210–288	R	334–458	F	300–534	F			242–294	R					x	x	x		

TABLE 35—*Continued*

Charles County

Species of Foraminfera	Ch-Bf 15 Waldorf Alt.: 215 ft. Depth: 393 ft.		Ch-Ee 39 Wayside Alt.: 60 ft. Depth: 310 ft.		Ch-Ff 13 Cobb Island Alt.: 14 ft. Depth: 277 ft.		Geologic Range								
								Miocene			Eocene				
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Robulus americanus (Cushman)	123–125	R								x					
Lagena clavata (d'Orbigny)	123–195	F								x		x			
Nonion grateloupi (d'Orbigny)	116–125	F								x					
Nonion pizarrense W. Berry	123–125	C								x					
Buliminella elegantissima (d'Orbigny)	123–125	C			137–147	R				x		x			
Bulimina elongata d'Orbigny	116–125	C								x					
Entosolenia lucida Williamson	123–125	R								x					
Virgulina fusiformis Cushman	123–125	F								x					
Virgulina (*Virgulinella*) *miocenica* Cushman & Ponton	123–125	R								x					
Bolivina paula Cushman & Cahill	123–125	R								x					
Discorbis valvulata (d'Orbigny)	123–125	F								x					
Spiroplectammina wilcoxensis Cushman & Ponton	135–379	F	260–300	F	116–252	R						x	x		
Marssonella sp.	295–300	R											x		
Robulus knighti Toulmin			270–290	R									x		
Robulus midwayensis virginianus Shifflett	185–379	F	260–310	R	210–242	R						x	x		
Robulus wilcoxensis Cushman & Ponton	185–195	F										x			
Marginulina toulmini Cushman	338–341	R											x		
Dentalina communis d'Orbigny	190–355	F	270–300	F								x	x		
Dentalina cooperensis Cushman					63–74	R					x				
Dentalina virginiana Cushman	260–300	R	270–280	F									x		
Dentalina wilcoxensis Cushman	185–190	R	270–280	R								x	x		

TABLE 35—*Continued*

Species of Foraminfera	Ch-Bf 15 Waldorf Alt.: 215 ft. Depth: 393 ft.		Ch-Ee 39 Wayside Alt.: 60 ft. Depth: 310 ft.		Ch-Ff 13 Cobb Island Alt.: 14 ft. Depth: 277 ft.		Geologic Range									
								Miocene			Eocene					
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Lagena acuticostata Reuss	190–195	R										x			
Lagena costata (Williamson)	142–195	R			116–137	R						x			
Guttulina irregularis (d'Orbigny)	125–374	F	270–300	F	63–241	F					x	x	x		
Guttulina problema d'Orbigny	149–341	F			63–147	R					x	x	x		
Guttulina spicaeformis (Roemer)					63–221	R					x	x			
Guttulina wilcoxensis Cushman & Ponton					137–147	F						x			
Globulina gibba d'Orbigny	165–374	R			74–158	R					x	x	x		
Globulina inaequalis Reuss	260–379	R	270–290	F	116–158	R						x	x		
Globulina rotundata (Bornemann)	268–355	R			241–252	R							x		
Sigmomorphina jacksonensis (Cushman)					63– 84	R					x				
Sigmomorphina semitecta (Reuss)	260–268	R											x		
Sigmomorphina semitecta terquemiana (Fornasini)	142–355	R	270–280	R								x	x		
Polymorphina advena nuda Howe & Roberts	260–268	R											x		
Nonion advenus (Cushman)					126–147	F						x			
Nonion planatus Cushman & Thomas	185–268	R	270–290	F								x	x		
Nonionella insecta (Schwager)	135–155	R										x			
Nonionella spissa Cushman	162–180	R										x			
Gümbelina wilcoxensis Cushman & Ponton	142–149	R	290–300	R								x	x		
Gümbelitria sp.	162–165	R			116–137	C						x			
Eouvigerina excavata Cushman	260–300	R	270–280	F									x		
Buliminella robertsi (Howe & Ellis)	135–195	F			126–147	F						x			
Robertina cf. *R. moodyensis* Cushman & Todd					63– 84	R					x				

Bulimina cacumenata Cushman and Parker	185–190	F										x		
Entosolenia laevigata (Reuss)			270–280	R									x	
Entosolenia marginata (Walker & Jacob)	185–190	R										x		
Entosolenia oslatus Shifflett	260–341	R											x	
Virgulina dibollensis Cushman & Applin	125–155	F			116–126	F						x		
Virgulina wilcoxensis Cushman & Ponton	190–195	R										x		
Loxostomum claibornense Cushman	185–195	F										x		
Loxostomum wilcoxensis Cushman & Ponton	185–195	R										x		
Uvigerina dumblei Cushman & Applin					126–137	R						x		
Uvigerina gardnerae Cushman					63–221	R					x	x		
Angulogerina parvula (Cushman & Thomas)	260–379	F	270–290	F	231–241	R						x	x	
Angulogerina virginiana Cushman	135–374	F	270–310	F	137–221	R						x	x	
Trifarina wilcoxensis (Cushman & Ponton)	135–180	R	260–290	R	241–252	F						x	x	
Discorbis amicus Shifflett	260–268	R	270–290	F									x	
Discorbis calyptra Shifflett	260–370	F											x	
Lamarckina marylandica Cushman	260–268	R	270–290	F									x	
Lamarckina ocalana Cushman					137–241	R						x		
Valvulineria scrobiculata (Schwager)	185–374	C	270–300	C								x	x	
Valvulineria wilcoxensis Cushman & Ponton	135–195	F			105–241	C						x		
Gyroidina acquilateralis (Plummer)	260–268	R			241–252	R							x	
Gyroidina soldanii octocamerata Cushman & G. D. Hanna	125–341	F			74–241	R					x	x	x	
Eponides labiomargus Shifflett	260–379	C	270–300	F	241–252	R							x	
Eponides lotus (Schwager)	135–341	F			63–252	F					x	x	x	
Siphonina claibornensis Cushman	135–195	R			210–241	R						x		
Siphonina wilcoxensis Cushman	149–185	R	280–290	R	84–137	R						x	x	
Alabamina wilcoxensis Toulmin	260–379	C	260–310	F									x	
Ceratobulimina sp.					63–158	R					x	x		
Ceratobulimina wilcoxensis (Cushman)	260–274	R	260–310	R	189–200	R						x	x	
Pulvinulinella danvillensis Howe & Wallace	135–374	F	260–290	F									x	
Globigerina bulloides d'Orbigny	370–374	R	290–300	R								x	x	
Globigerina danvillensis Howe & Wallace	328–379	F	270–280	F									x	

TABLE 35—*Continued*

Species of Foraminfera	Ch-Bf 15 Waldorf Alt.: 215 ft. Depth: 393 ft.		Ch-Ee 39 Wayside Alt.: 60 ft. Depth: 310 ft.		Ch-Ff 13 Cobb Island Alt.: 14 ft. Depth: 277 ft.		Geologic Range								
								Miocene			Eocene				
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Globigerina ouachitaensis Howe & Wallace	162–365	F										x	x		
Globigerina pseudobulloides Plummer	125–365	F	270–300	F	147–158	R						x	x		
Globigerina triloculinoides Plummer	125–355	F	100–300	R	116–158	R						x	x		
Globorotalia crassata (Cushman)	260–341	F											x		
Globorotalia crassata aequa Cushman & Renz	190–195	R										x			
Globorotalia membranacea (Ehrenberg)	358–365	R	270–280	R									x		
Globorotalia wilcoxensis Cushman & Ponton	149–355	F	260–300	R								x	x		
Globorotalia wilcoxensis acuta Toulmin	185–374	R	280–300	R								x	x		
Anomalina umbonifera (Schwager)	185–379	R	260–310	F	210–273	R						x	x		
Cibicides sp.	185–190	F			210–273	F						x	x		
Cibicides americanus (Cushman)	135–142	F										x			
Cibicides howelli Toulmin	135–379	F	270–310	F								x	x		
Cibicides lobatulus (Walker & Jacob)	260–268	F	270–290	F									x		
Cibicides marylandicus Shifflett	260–374	C	270–310	C									x		
Cibicides neelyi Jennings			260–290	F									x		
Cibicides praecursorius (Schwager)	260–268	R	260–310	F									x		
Cibicides pseudoungerianus (Cushman)	190–355	F	270–290	F	63– 74	F					x	x	x		
Cibicidina danvillensis (Howe & Wallace)	260–374	F	260–300	F									x		

TABLE 35—*Continued*

PRINCE GEORGES COUNTY

Species of Foraminfera	PG-Ed 4 Morningside Village Alt.: 265 ft. Depth: 360 ft.		PG-Ed 8 Upper Marlboro Alt.: 257 ft. Depth: 350 ft.		PG-Fc 3 Piscataway Alt.: 50 ft. Depth: 175 ft.		Geologic Range								
								Miocene			Eocene				
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Spiroplectammina wilcoxensis Cushman & Ponton	120–170	R	50–270	F	32–113	F						x	x	x	
Marssonella sp.					75–86	R							x		
Robulus knighti Toulmin					62–104	R							x		
Robulus midwayensis virginianus Shifflett	120–180	F	50–260	F	32–113	R						x	x	x	
Robulus wilcoxensis Cushman & Ponton	170–180	F	210–280	F									x	x	
Darbyella sp.			60–70	R								x			
Dentalina communis d'Orbigny	160–170	R	50–270	F	32–86	F						x	x	x	
Dentalina virginiana Cushman			180–250	F	55–86	F							x		
Nodosaria affinis Reuss			250–280	F									x	x	
Lagena acuticostata Reuss			60–90	R								x			
Lagena costata (Williamson)	120–150	R	60–280	R								x	x	x	
Lagena laevis (Montagu)			160–230	R									x		
Guttulina irregularis (d'Orbigny)	120–170	R	50–280	F	55–70	R						x	x	x	
Guttulina problema d'Orbigny	130–220	R	50–280	F	55–70	R						x	x	x	x
Guttulina spicaeformis (Roemer)			170–180	R									x		
Globulina gibba d'Orbigny	120–160	F	80–280	F								x	x	x	
Globulina inaequalis Reuss			190–250	F	55–137	F							x		
Globulina rotundata (Bornemann)	170–180	R	90–280	F								x	x	x	
Sigmomorphina semitecta (Reuss)	130–140	R	190–200	F									x		
Sigmomorphina semitecta terquemiana (Fornasini)	130–140	R	50–280	F	80–104	R						x	x	x	
Nonion planatus Cushman & Thomas	120–170	F	70–230	R	37–70	R						x	x		
Nonionella insecta (Schwager)			120–130	R									x		

TABLE 35—*Continued*

Species of Foraminfera	PG-Ed 4 Morningside Village Alt.: 265 ft. Depth: 360 ft.		PG-Ed 8 Upper Marlboro Alt.: 257 ft. Depth: 350 ft.		PG-Fc 3 Piscataway Alt.: 50 ft. Depth: 175 ft.		Geologic Range								
								Miocene			Eocene				
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Nonionella spissa Cushman			60–120	R								x			
Bolivinopsis curta (Cushman)	120–170	F			70– 75	R							x		
Gümbelina wilcoxensis Cushman & Ponton			50–250	R	62– 70	R						x	x		
Eouvigerina excavata Cushman	120–180	R	210–230	F	55– 86	R							x	x	
Buliminella elegantissima (d'Orbigny)	120–130	F	50–190	F	80– 86	R						x	x		
Buliminella robertsi (Howe & Ellis)			50–230	C	75– 80	R						x	x		
Bulimina cacumenata Cushman & Parker	170–180	A	50–190	F								x	x	x	
Bulimina elongata d'Orbigny			50– 90	R								x			
Bulimina ovata d'Orbigny			90–100	R								x			
Bulimina cf. *B. simplex* Terquem			110–120	R								x			
Entosolenia laevigata (Reuss)	120–130	R	110–250	R	62– 75	R						x	x		
Entosolenia marginata (Walker & Jacob)			190–240	R									x		
Entosolenia oslatus Shifflett	120–180	R	180–210	R	62– 70	R							x	x	
Virgulina wilcoxensis Cushman & Ponton			50–260	R								x	x		
Bolivina huneri Howe			80– 90	F								x			
Bolivina cf. *B. taylori* Howe			70–110	R								x			
Loxostomum claibornense Cushman			50–240	F								x	x		
Uvigerina dumblei Cushman & Applin			60–120	R								x			
Uvigerina elongata Cole			100–170	R								x	x		
Angulogerina parvula (Cushman & Thomas)	120–130	R			55– 70	F							x		
Angulogerina virginiana Cushman	120–180	C	50–100	F	37– 80	F						x	x	x	
Trifarina wilcoxensis (Cushman & Ponton)			90–100	R									x		

Discorbis amicus Shifflett			230–240	R	55– 86	R							x		
Discorbis assulata Cushman			220–250	F									x		
Discorbis calyptra Shifflett	130–150	R	200–240	R	55– 86	F							x		
Lamarckina marylandica Cushman			230–250	R	55– 80	F							x		
Valvulineria scrobiculata (Schwager)	120–170	F	200–260	C	55–120	F							x		
Valvulineria wilcoxensis Cushman & Ponton			50–170	C								x	x		
Gyroidina aequilateralis (Plummer)			210–280	R									x	x	
Gyroidina soldanii octocamerata Cushman & G. D. Hanna			50–250	F	55– 75	F						x	x		
Eponides labiomargus Shifflett	120–170	C	180–260	C	55–120	C							x		
Eponides lotus (Schwager)			50–250	R	55– 70	C						x	x		
Siphonina claibornensis Cushman			50–180	F	28– 32	F						x	x		
Siphonina wilcoxensis Cushman			220–240	R									x		
Alabamina wilcoxensis Toulmin	120–180	F	180–280	C	55–137	C							x	x	
Ceratobulimina wilcoxensis (Cushman)	120–170	F	50–260	F	55–113	F						x	x		
Pulvinulinella danvillensis Howe & Wallace	120–170	F	50–170	F	20–137	C						x	x		
Cassidulina subglobosa Brady					62– 86	R							x		
Pullenia eocenica Cushman & Siegfus			190–200	R	55– 62	R							x		
Pullenia quinqueloba (Reuss) *angusta* Cushman & Todd			170–250	R									x		
Globigerina bulloides d'Orbigny			60–280	F								x	x	x	
Globigerina danvillensis Howe & Wallace	120–170	C	100–250	C	55– 94	F						x	x		
Globigerina ouachitaensis Howe & Wallace	140–150	R	170–200	F									x		
Globigerina pseudobulloides Plummer			90–280	F	55–137	F						x	x	x	
Globigerina triloculinoides Plummer	120–190	R	50–280	F	28–104	F						x	x	x	x
Globorotalia cf. *G. angulata* (White)	130–140	R			55– 62	R							x		
Globorotalia crassata (Cushman)			100–250	R								x	x		
Globorotalia membranacea (Ehrenberg)			230–240	R									x		
Globorotalia wilcoxensis Cushman & Ponton			50–250	F	62– 86	R						x	x		
Globorotalia wilcoxensis acuta Toulmin			170–200	R	62– 70	F							x		
Anomalina umbonifera (Schwager)	120–170	F	50–250	F	28– 94	F						x	x		
Cibicides sp.			60– 70	R								x			

TABLE 35—*Continued*

Species of Foraminfera	PG-Ed 4 Morningside Village Alt.: 265 ft. Depth: 360 ft.		PG-Ed 8 Upper Marlboro Alt.: 257 ft. Depth: 350 ft.		PG-Fc 3 Piscataway Alt.: 50 ft. Depth: 175 ft.		Geologic Range								
								Miocene			Eocene				
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocen	Cretaceous
Cibicides americanus (Cushman)	120–170	F	110–180	F	28– 86	F						x	x		
Cibicides howelli Toulmin	130–170	R	170–280	F	55–137	F							x	x	
Cibicides lobatulus (Walker & Jacob)			210–250	R									x		
Cibicides marylandicus Shifflett	140–160	R	180–260	C	56– 86	C							x		
Cibicides neelyi Jennings	120–150	R	180–250	F	55–113	F							x		
Cibicides praecursorius (Schwager)			80–280	R	55–104	R						x	x	x	
Cibicides pseudoungerianus (Cushman)			50–250	F								x	x		
Cibicides pseudowuellerstorfi Cole			200–210	F									x		
Cibicidina danvillensis (Howe & Wallace)	120–170	F	200–250	F	55– 70	F						x	x		
Robulus sp.	170–180	R	260–280	F										x	
Robulus arkansasanus Cushman & Todd			270–280	R										x	
Robulus midwayensis (Plummer)	170–180	F	260–280	F										x	
Robulus midwayensis carinatus (Plummer)			270–280	R										x	
Robulus cf. *R. piluliferus* Cushman	170–180	R	260–280	F										x	
Dentalina colei Cushman & Dusenbury	170–180	R	270–280	F										x	
Dentalina plummerae Cushman	170–180	R												x	
Pseudoglandulina pygmaea (Reuss)	170–180	F	260–280	F										x	
Polymorphina cushmani Plummer			270–280	F										x	
Pseudouvigerina naheolensis Cushman & Todd	170–180	R												x	
Bulimina (*Desinobulimina*) *quadrata* Plummer			270–280	R										x	
Gyroidina subangulata (Plummer)	170–180	F	260–280	F										x	
Eponides elevatus (Plummer)	170–180	R	270–280	R										x	

Ceratobulimina perplexa (Plummer)	170–180	F	260–280	F										x	
Anomalina midwayensis (Plummer)	170–180	F	270–280	C										x	
Cibicides newmanae (Plummer)			260–280	F										x	
Cibicides reprimatus Cushman & Bermudez			270–280	R										x	
Gaudryina rugosa d'Orbigny	180–210	F	280–300	F											x
Dorothia cf. *D. conula* (Reuss)			280–300	F	158–166	R									x
Trochammina sp.			280–290	R											x
Kyphopyxa sp.	180–190	R													x
Bolivinopsis cf. *B. papillata* (Cushman)					146–151	R									x
Gümbelina sp.	180–190	R			146–166	R									x
Gümbelitria sp.					158–166	R									x
Pseudouvigerina plummerae Cushman	180–190	F			158–166	F									x
Lamarckina sp.	180–220	F	290–300	C	158–166	R									x
Ceratobulimina cf. *C. cretacea* Cushman & Harris	200–220	R			158–166	R									x
Anomalina clementiana (d'Orbigny)			280–300	F											x
Anomalina navarroensis Plummer	180–220	C	280–300	C	146–166	F									x

TABLE 35—*Continued*

St. Marys County

Species of Foraminfera	St.M-Cb 5 Chaptico Alt.: 100 ft. Depth: 412 ft.		St.M-Dd 1 Leonardtown Alt.: 97 ft. Depth: 510 ft.		St.M-Fe 24 Piney Point Alt.: 5 ft. Depth: 410 ft.		St.M-Fh 3 Point No Point Alt.: 6 ft. Depth: 420 ft.		Geologic Range								
										Miocene			Eocene				
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Spiroplectammina mississippiensis (Cushman)			80–240	C	120–270	C	150–330	C				x	x				
Spiroplectammina spinosa Dorsey			100–160	F	180–190	F	230–330	F				x					
Textularia cansecta d'Orbigny							30– 60	R		x							
Textularia cf. *T. foliacea* Heron-Allen & Earland			80–200	F	120–220	F	230–340	C				x					
Textularia gramen d'Orbigny			50–210	C	130–220	F	30–330	C		x	x	x					
Textularia mayori Cushman			70– 80	R			30– 80	F		x							
Textularia obliqua Dorsey							30– 90	F		x							
Quinqueloculina cf. *Q. fusca* H. B. Brady							70– 80	R		x							
Quinqueloculina seminula (Linnaeus)			50– 80	F			30– 80	C		x							
Massilina glutinosa Cushman & Cahill							70– 80	R		x							
Massilina mansfieldi Cushman & Cahill			60– 70	R			30– 70	R		x							
Massilina marylandica Cushman & Cahill			50– 60	R			30– 40	R		x							
Massilina quadrans Cushman & Ponton							50– 70	R		x							
Sigmoilina tenuis (Czjzek)							230–320	C				x					
Triloculina cf. *T. trigonula* (Lamarck)							30– 60	F		x							
Robulus americanus (Cushman)			80–210	F	120–220	C	170–340	A				x					
Robulus americanus spinosus (Cushman)			90–200	R	130–200	F	230–340	A				x					
Robulus branneri Cushman & Kleinpell					150–180	R	30–310	F		x	x	x					
Robulus cf. *R. iotus* (Cushman)							290–330	F				x					
Planularia vaughani (Cushman)					120–130	R	250–330	F				x					

Marginulina sp.					80–200	F						x				
Lagena clavata (d'Orbigny)	78– 84	R	110–120	R			190–200	R				x				
Lagena laevis (Montagu)							230–240	R				x				
Lagena tenuis (Bornemann)					210–220	R	70–330	R		x		x				
Guttulina austriaca d'Orbigny					130–180	R	310–320	R				x				
Guttulina elegans Dorsey					130–210	R	250–340	R				x				
Guttulina problema d'Orbigny					210–220	R						x				
Guttulina rectiornata Dorsey			190–200	R								x				
Pseudopolymorphina decora (Reuss)			220–230	R								x				
Pseudopolymorphina rutila (Cushman)					200–220	R						x				
Polymorphina advena Cushman, var. *nuda* Howe & Wallace			480–490	R	210–220	R	250–260	R				x			x	
Nonion advenus (Cushman)					200–220	R						x				
Nonion grateloupi (d'Orbigny)			80–230	C	120–220	C	40–330	C		x	x	x				
Nonion marylandicus Dorsey					200–220	F	40– 50	R		x		x				
Nonion medio-costatus (Cushman)							50–140	C		x	x					
Nonion pizarrense W. Berry			50–230	C	120–220	F	30–330	C		x	x	x				
Nonionella auris (d'Orbigny)							30–300	F		x	x	x				
Elphidium poeyanum (d'Orbigny)			50– 60	R			30– 50	F		x						
Nodogenerina advena Cushman & Laiming			200–210	R								x				
Buliminella elegantissima (d'Orbigny)	78– 84	R	80–230	R	200–220	VA	80–330	F		x	x	x				
Bulimina elongata d'Orbigny	78–126	F	80–350	C	120–220	C	50–340	A		x	x	x		x		
Bulimina inflata Seguenza							250–300	C				x				
Entosolenia lucida Williamson							210–330	F				x				
Virgulina fusiformis Cushman			190–200	F	200–220	F	70–320	F		x	x	x				
Virgulina (*Virgulinella*) *miocenica* Cushman & Ponton							70–80	R		x						
Virgulina pontoni Cushman			190–200	F	210–220	F	240–330	F				x				
Bolivina calvertensis Dorsey			80–160	F	208–210	F	160–330	C				x				
Bolivina floridana Cushman			80–230	F	180–190	R	250–330	C				x				
Bolivina marginata Cushman			80–200	F	130–200	R	290–330	A				x				

TABLE 35—*Continued*

Species of Foraminfera	St.M-Cb 5 Chaptico Alt.: 100 ft. Depth: 412 ft.		St.M-Dd 1 Leonardtown Alt.: 97 ft. Depth: 510 ft.		St.M-Fe 24 Piney Point Alt.: 5 ft. Depth: 410 ft.		St.M-Fh 3 Point No Point Alt.: 6 ft. Depth: 420 ft.		Geologic Range								
										Miocene			Eocene				
	Depth range (feet)	Rel. abun	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Bolivina marginata multicostata Cushman			80–150	F	180–220	F	290–330	A				x					
Bolivina obliqua Barbat & Johnson	78– 84	F	80–210	R	200–220	F	170–330	F				x					
Bolivina paula Cushman & Cahill	78– 84	F	100–230	F	120–220	C	60–330	C		x	x	x					
Bolivina plicatella Cushman	78– 84	R	80–220	C	180–190	R	130–320	C			x	x					
Reussia cf. *R. spinulosa* (Reuss)					200–210	F						x					
Uvigerina auberiana d'Orbigny			220–230	R	180–190	R	240–320	C				x					
Uvigerina calvertensis Cushman							230–320	C				x					
Uvigerina carmeloensis Cushman & Kleinpell							90–100	F			x						
Uvigerina kernensis Barbat & von Estorff			100–190	R			230–320	C				x					
Uvigerina subperegrina Cushman & Kleinpell			80–230	F	120–220	F	140–340	C			x	x					
Siphogenerina lamellata Cushman					120–130	R	240–330	C				x					
Siphogenerina spinosa (Bagg)							270–330	F				x					
Angulogerina occidentalis (Cushman)	78– 84	R			210–220	R						x					
Discorbis candeiana (d'Orbigny)							130–150	R			x						
Discorbis consobrina (d'Orbigny)							160–240	R				x					
Discorbis floridana Cushman					200–220	F						x					
Discorbis valvulata (d'Orbigny)	116–126	R	160–230	R	150–200	R	240–250	R				x					
Discorbis warreni Dorsey							110–140	F			x						
Valvulineria floridana Cushman			160–230	R	120–190	F	190–320	R				x					
Gyroidina marylandica Cushman							230–320	F				x					
Eponides sp.							250–310	R				x					
Eponides mansfieldi Cushman			50– 60	F			30–100	C		x	x						
Rotalia bassleri Cushman & Cahill					200–220	C	270–330	F				x					

Rotalia beccarii tepida Cushman			60– 70	R	200–220	C	30–110	F		x	x	x				
Pulvinulinella pontoni Cushman	78–126	R	110–230	F	200–220	A	130–330	C			x	x				
Cassidulina crassa d'Orbigny			130–230	R			250–330	R				x				
Cassidulina laevigata d'Orbigny							250–280	F				x				
Cassidulina laevigata carinata Cushman							50– 80	F		x						
Pullenia sp.							260–320	R				x				
Globigerina sp.			80–210	F	140–220	F	230–330	C				x				
Globigerina altispira Cushman & Jarvis			80–210	R	120–170	R	100–110	R			x	x				
Globigerinoides sp.			80–200	F	130–220	F	50–310	F		x	x	x				
Globorotalia sp.			80– 90	R	120–130	R	250–330	F				x				
Cibicides americanus (Cushman)	78–241	F	180–270	F	200–220	F	90–310	F			x	x		x		
Cibicides concentricus (Cushman)	105–147	R	80–230	C	120–220	C	150–330	C				x				
Cibicides floridanus (Cushman)					200–220	C	140–320	R			x	x				
Cibicides lobatulus (Walker & Jacob)	84–126	R	220–250	F	200–300	C	90–390	R		x	x	x	x	x		
Cibicides lobatulus ornatus (Cushman)							100–190	F			x	x				
Spiroplectammina wilcoxensis Cushman & Ponton	189–357	R	370–380	R	280–300	R	350–360	R					x	x		
Textularia dibollensis Cushman & Ponton					230–270	R	340–400	F					x	x		
Quinqueloculina longirostra d'Orbigny			240–250	F									x			
Robulus alato-limbatus (Gümbel)			230–250	R	230–240	R							x			
Robulus knighti Toulmin	189–200	R												x		
Robulus midwayensis virginianus Shifflett	200–378	F			300–310	F								x		
Marginulina cf. *M. variata* Hussey					300–400	F								x		
Dentalina communis d'Orbigny			480–490	R			350–360	R					x		x	
Dentalina wilcoxensis Cushman			280–290	R	400–410	R								x	x	
Nodosaria affinis Reuss					270–280	R								x		
Nodosaria latejugata carolinensis Cushman			230–240	R	220–240	R							x			
Lagena costata (Williamson)	200–210	R			240–250	R							x	x		
Guttulina irregularis Reuss	189–367	F	240–480	R	240–410	R	350–390	F					x	x	x	
Guttulina problema d'Orbigny	200–273	R	240–250	F	230–240	R							x	x		
Globulina gibba d'Orbigny	189–200	R	240–270	R	240–250	R	340–380	R					x	x		
Globulina inaequalis Reuss	200–210	R												x		
Globulina rotundata (Bornemann)	263–273	R	240–250	R									x	x		

TABLE 35—*Continued*

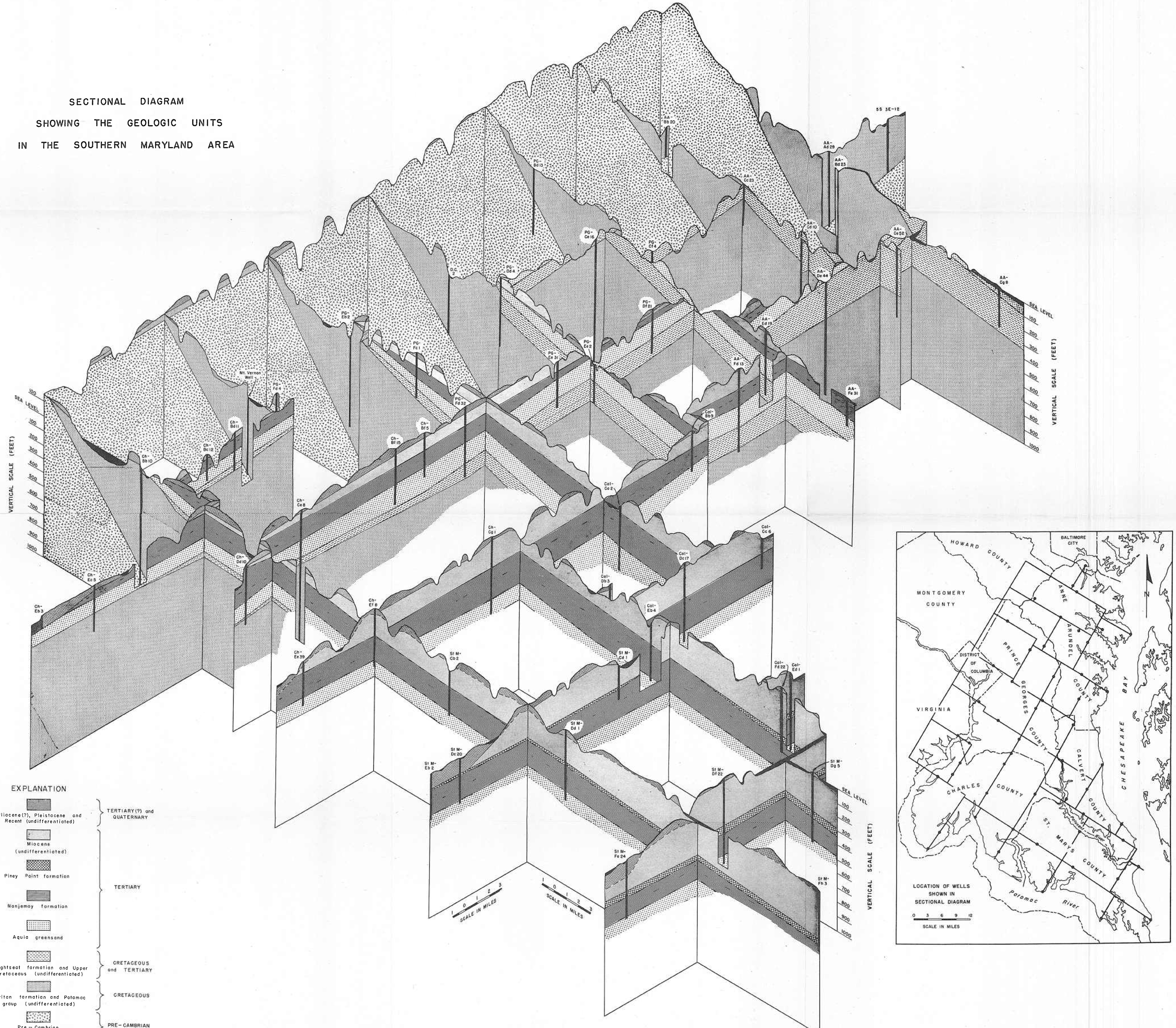
Species of Foraminifera	St.M-Cb 5 Chaptico Alt.: 100 ft. Depth: 412 ft.		St.M-Dd 1 Leonardtown Alt.: 97 ft. Depth: 510 ft.		St.M-Fe 24 Piney Point Alt.: 5 ft. Depth: 410 ft.		St.M-Fh 3 Point No Point Alt.: 6 ft. Depth: 420 ft.		Geologic Range								
										Miocene			Eocene				
	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Depth range (feet)	Rel. abun.	Pleistocene	St. Marys	Choptank	Calvert	Jackson	Nanjemoy	Aquia	Paleocene	Cretaceous
Sigmomorphina jacksonensis (Cushman)			240–250	R									x				
Nonion advenus (Cushman)							350–360	R					x				
Nonion planatus Cushman & Thomas	189–252	R												x			
Gümbelina wilcoxensis Cushman & Ponton	189–200	R					390–400	R						x			
Gümbelitria sp.	189–273	F	260–270	F										x			
Plectofrondicularia cookei Cushman					230–240	R							x				
Buliminella robertsi (Howe & Ellis)	200–273	F	260–280	F										x			
Bulimina cacumenata Cushman & Parker	357–378	R												x			
Entosolenia laevigata (Reuss)	200–210	R												x			
Virgulina dibollensis Cushman & Applin	252–263	R												x			
Virgulina wilcoxensis Cushman & Ponton	200–267	R												x			
Loxostomum claibornense Cushman	200–210	R												x			
Loxostomum wilcoxensis Cushman & Ponton	252–367	R												x			
Uvigerina gardnerae Cushman			310–320	R	240–250	F							x	x			
Uvigerina russelli Howe	200–273	F												x			
Angulogerina virginiana Cushman	189–367	F	260–480	F										x	x		
Trifarina wilcoxensis (Cushman & Ponton)	189–273	R	260–500	R	300–410	R	400–410	R						x	x		
Discorbis assulata Cushman	200–210	R												x			
Discorbis calyptra Shifflett	241–263	R	280–290	F										x			
Valvulineria jacksonensis Cushman			230–250	F	220–230	R	370–380	R					x				
Valvulineria scrobiculata (Schwager)			480–500	F	400–410	R									x		
Valvulineria wilcoxensis Cushman & Ponton	221–367	R	260–380	F	270–410	C								x	x		
Gyroidina aequilateralis (Plummer)			280–290	F	270–280	R								x			

Gyroidina soldanii octocamerata Cushman & G. D. Hanna	189–273	F	230–250	F	300–310	R	340–420	C					x	x		
Eponides labiomargus Shifflett			470–500	R	400–410	R									x	
Eponides lotus (Schwager)	200–273	R	470–490	R	260–370	F							x	x	x	
Siphonina claibornensis Cushman	221–378	R	260–380	F	300–390	F								x		
Siphonina jacksonensis (Cushman)			230–240	R									x			
Siphonina wilcoxensis Cushman	252–263	R	260–270	F	280–340	F								x		
Asterigerina sp.					220–270	F							x			
Alabamina wilcoxensis Toulmin			260–500	R	270–410	R	390–400	R						x	x	
Ceratobulimina wilcoxensis (Cushman)	210–221	R												x		
Pulvinulinella danvillensis Howe & Wallace	189–378	F	370–500	F										x	x	
Parrella cf. *P. expansa* Toulmin					310–410	R								x	x	
Pullenia quinqueloba angusta Cushman & Todd	189–263	R			220–230	R							x	x		
Globigerina bulloides d'Orbigny	200–273	F	240–290	R	240–350	R							x	x		
Globigerina danvillensis Howe & Wallace	200–210	F												x		
Globigerina ouachitaensis Howe & Wallace	200–252	R	280–290	R	300–310	R								x		
Globigerina pseudobulloides Plummer	189–273	R			270–280	R								x		
Globigerina triloculinoides Plummer	189–357	F	260–280	R	240–410	R	390–400	R					x	x	x	
Globorotalia crassata aequa Cushman & Renz					400–410	R									x	
Globorotalia membranacea (Ehrenberg)					280–290	R								x		
Globorotalia wilcoxensis Cushman & Ponton					300–410	R								x	x	
Anomalina acuta Plummer					300–400	R								x		
Anomalina umbonifera (Schwager)	367–378	R	300–480	R	400–410	R								x	x	
Cibicides sp.	200–273	F	260–270	F	300–410	F								x	x	
Cibicides cocoaensis (Cushman)			230–250	C	220–270	R	350–370	R					x			
Cibicides howelli Toulmin	189–367	F	260–490	F	270–410	F	380–410	F						x	x	
Cibicides marylandicus Shifflett			470–500	R											x	
Cibicides neelyi Jennings			470–500	F										x	x	
Cibicides cf. *C. ouachitaensis* Howe & Wallace							340–410	F					x	x		
Cibicides praecursorius (Schwager)			260–270	R	290–300	R								x		
Cibicides pseudoungerianus (Cushman)					230–410	R	350–390	R					x	x	x	
Cibicidina danvillensis (Howe & Wallace)							340–380	F					x			
Cibicidina mississippiensis (Cushman)	200–210	F	240–250	F									x	x		

INDEX*

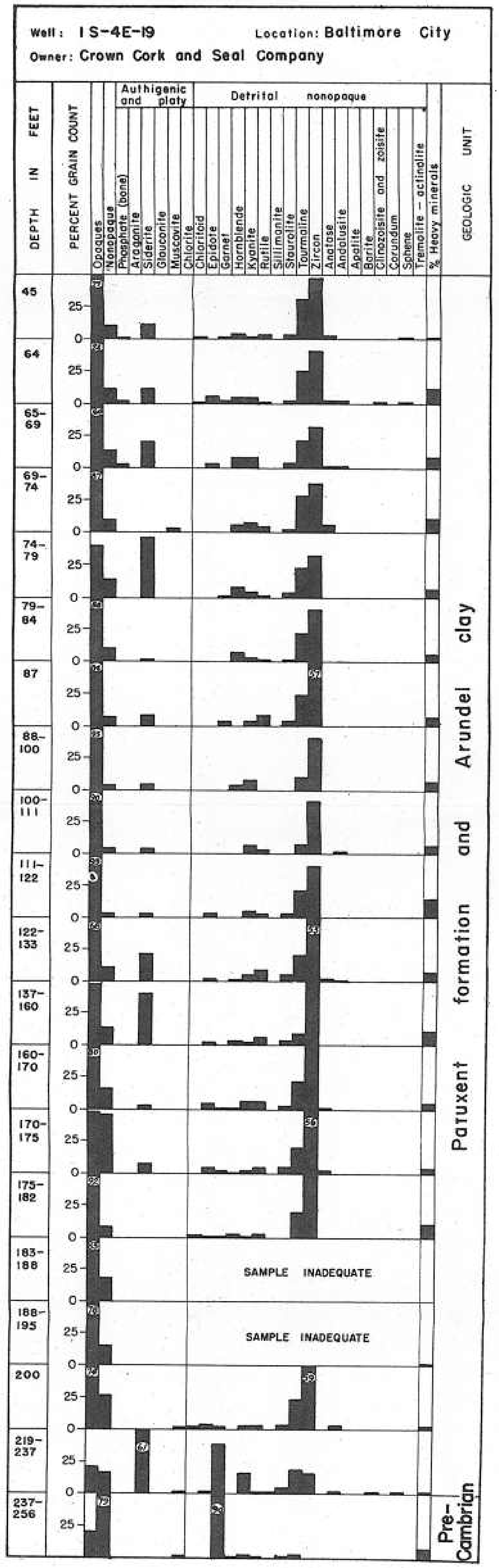
* Page numbers in **boldface** indicate detailed descriptions.

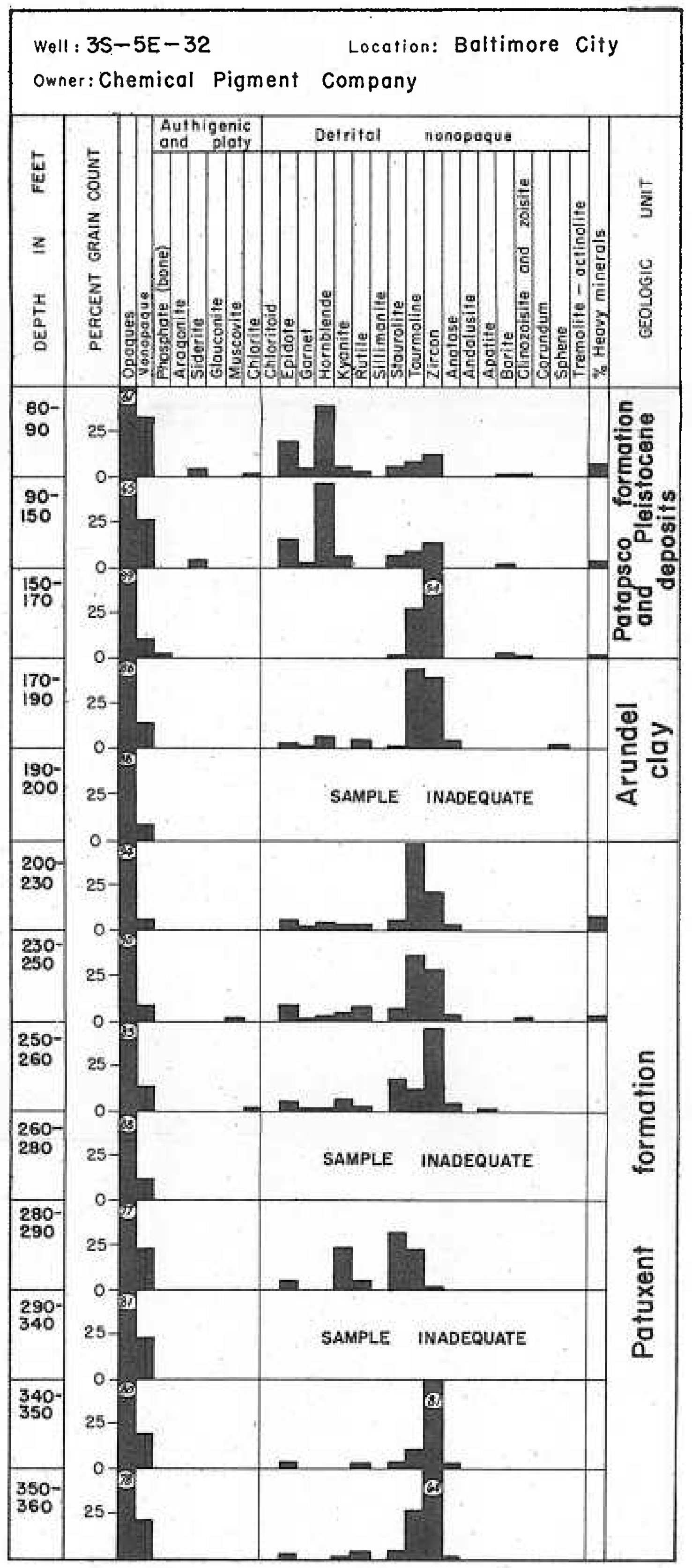
SECTIONAL DIAGRAM SHOWING THE GEOLOGIC UNITS IN THE SOUTHERN MARYLAND AREA

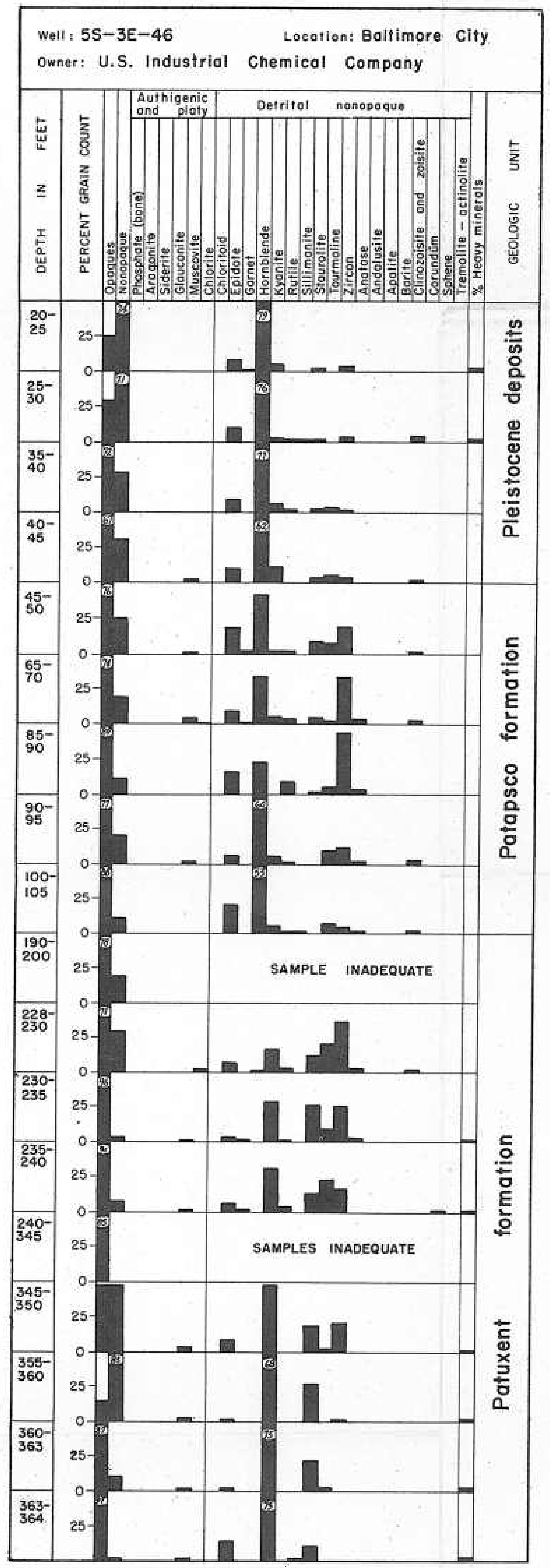


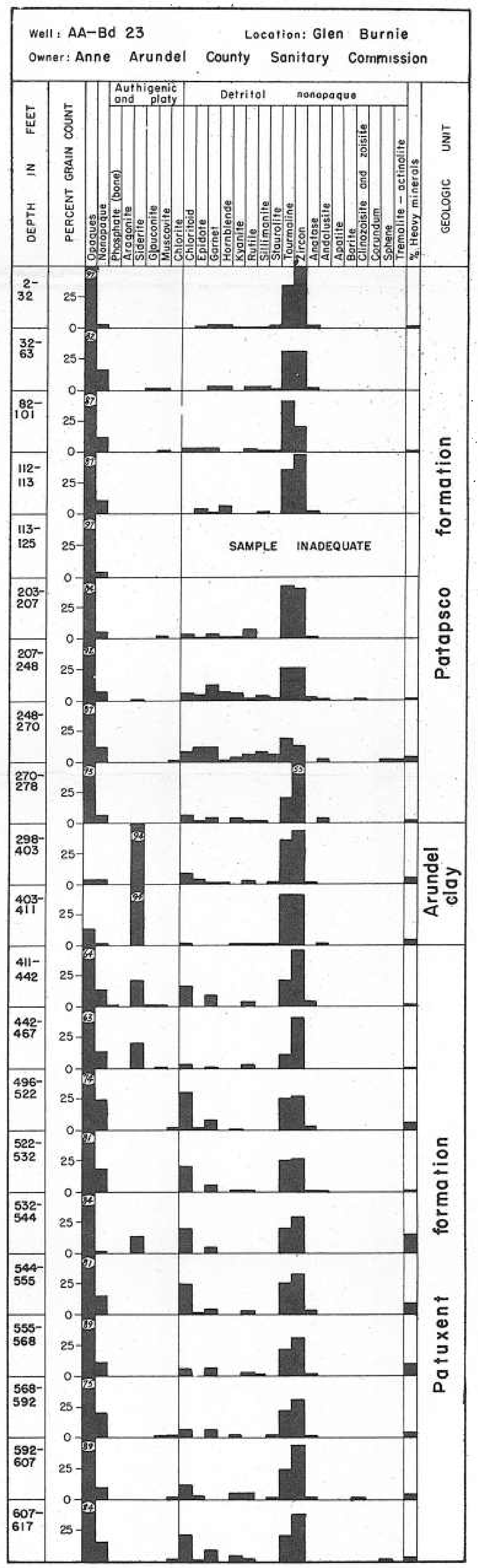
EXPLANATION

	Pliocene(?), Pleistocene and Recent (undifferentiated)	TERTIARY(?) and QUATERNARY
Miocene	Miocene (undifferentiated)	TERTIARY
Eocene	Piney Point formation	TERTIARY
Eocene	Nanjemoy formation	TERTIARY
Eocene	Aquia greensand	TERTIARY
	Brightseat formation and Upper Cretaceous (undifferentiated)	CRETACEOUS and TERTIARY
	Raritan formation and Potomac group (undifferentiated)	CRETACEOUS
	Pre-Cambrian (undifferentiated)	PRE-CAMBRIAN

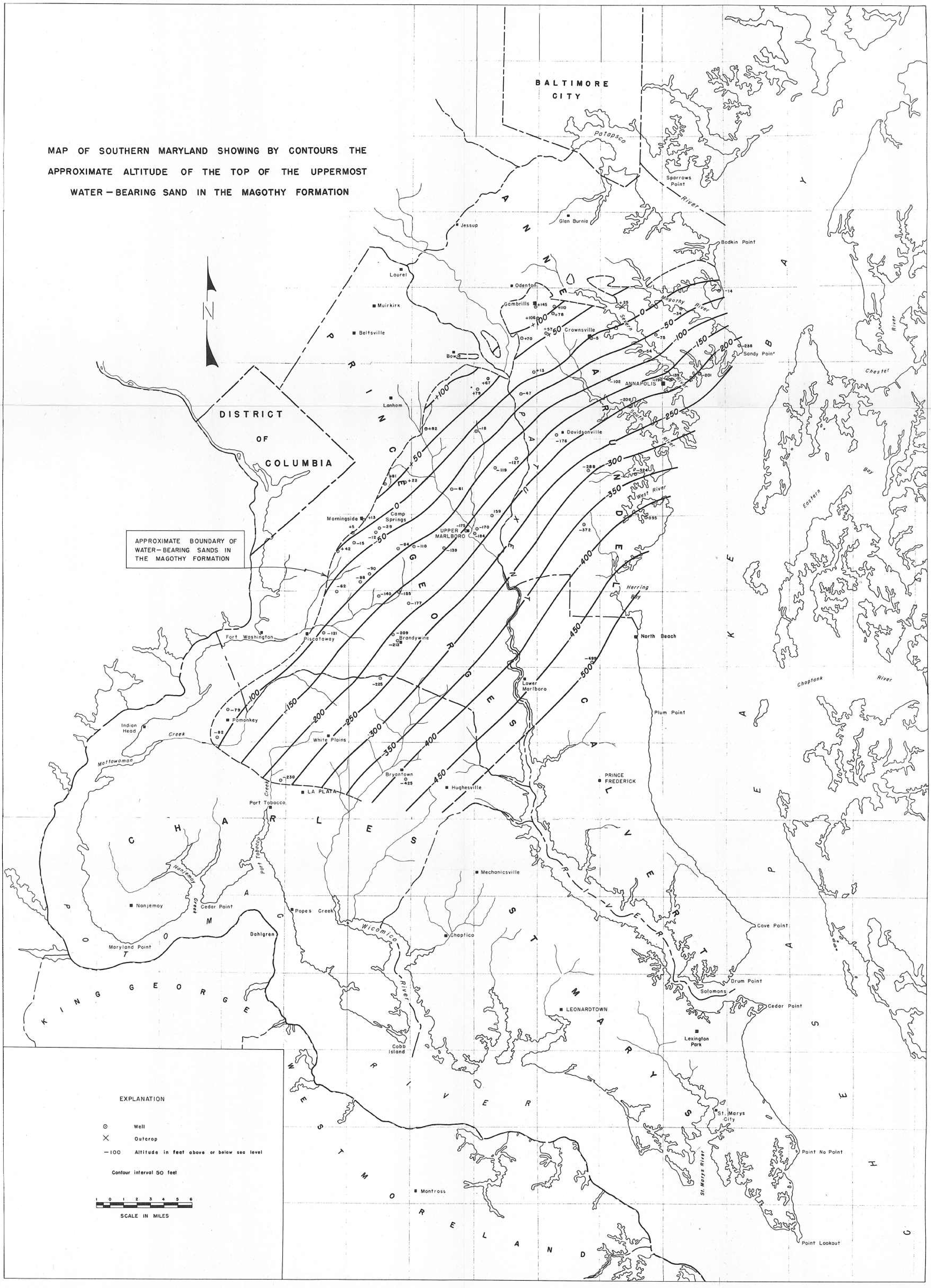


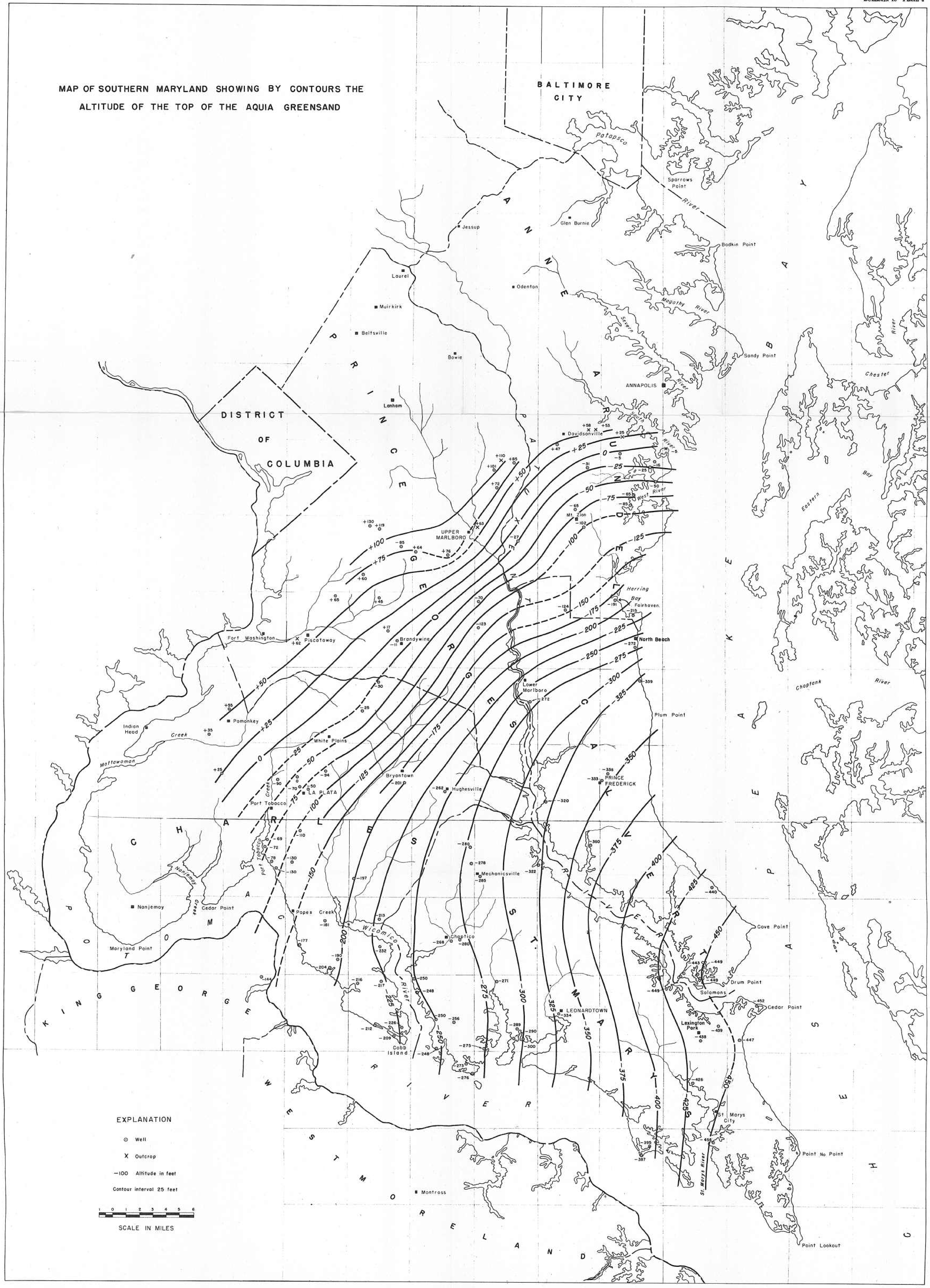


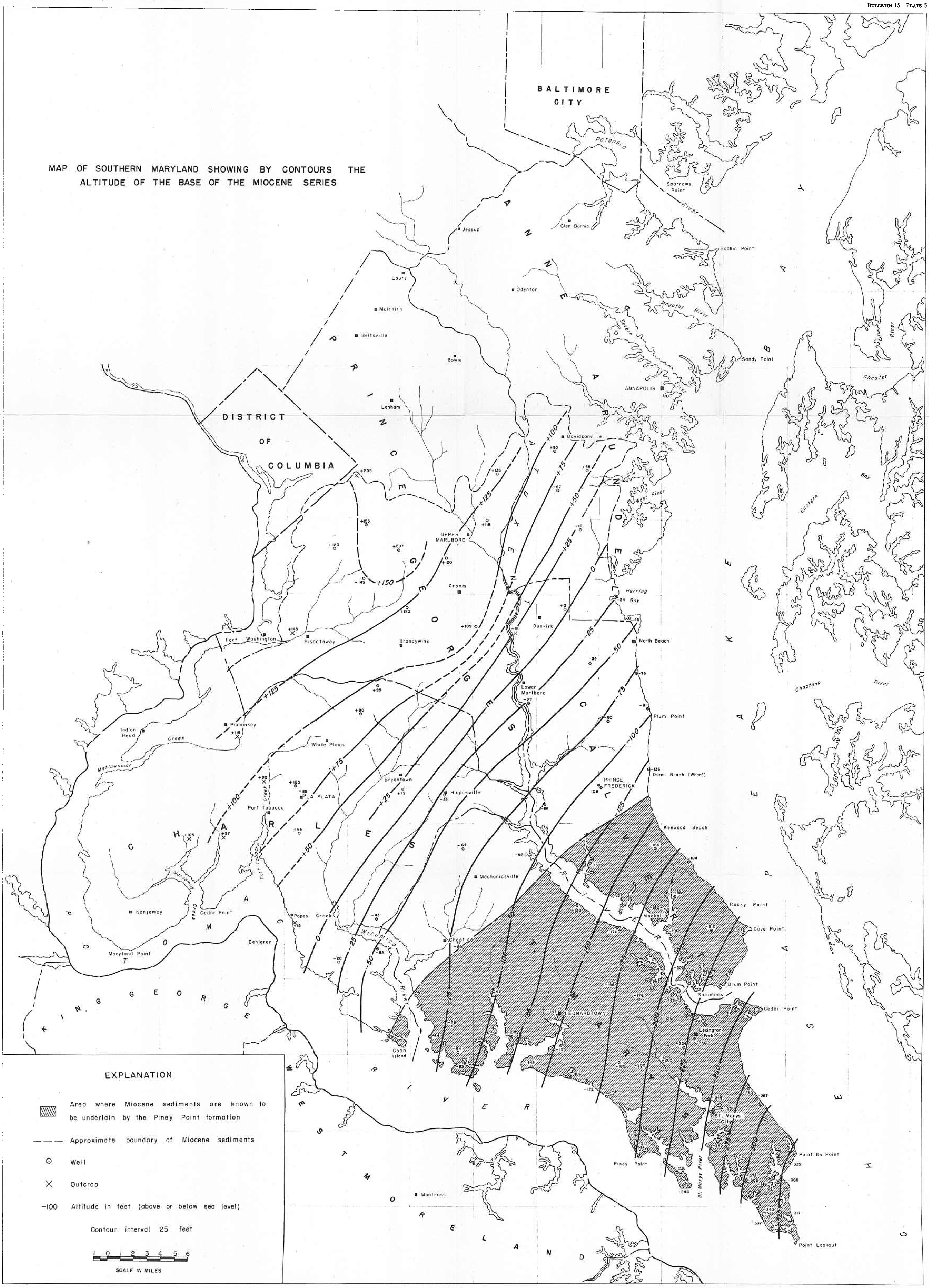


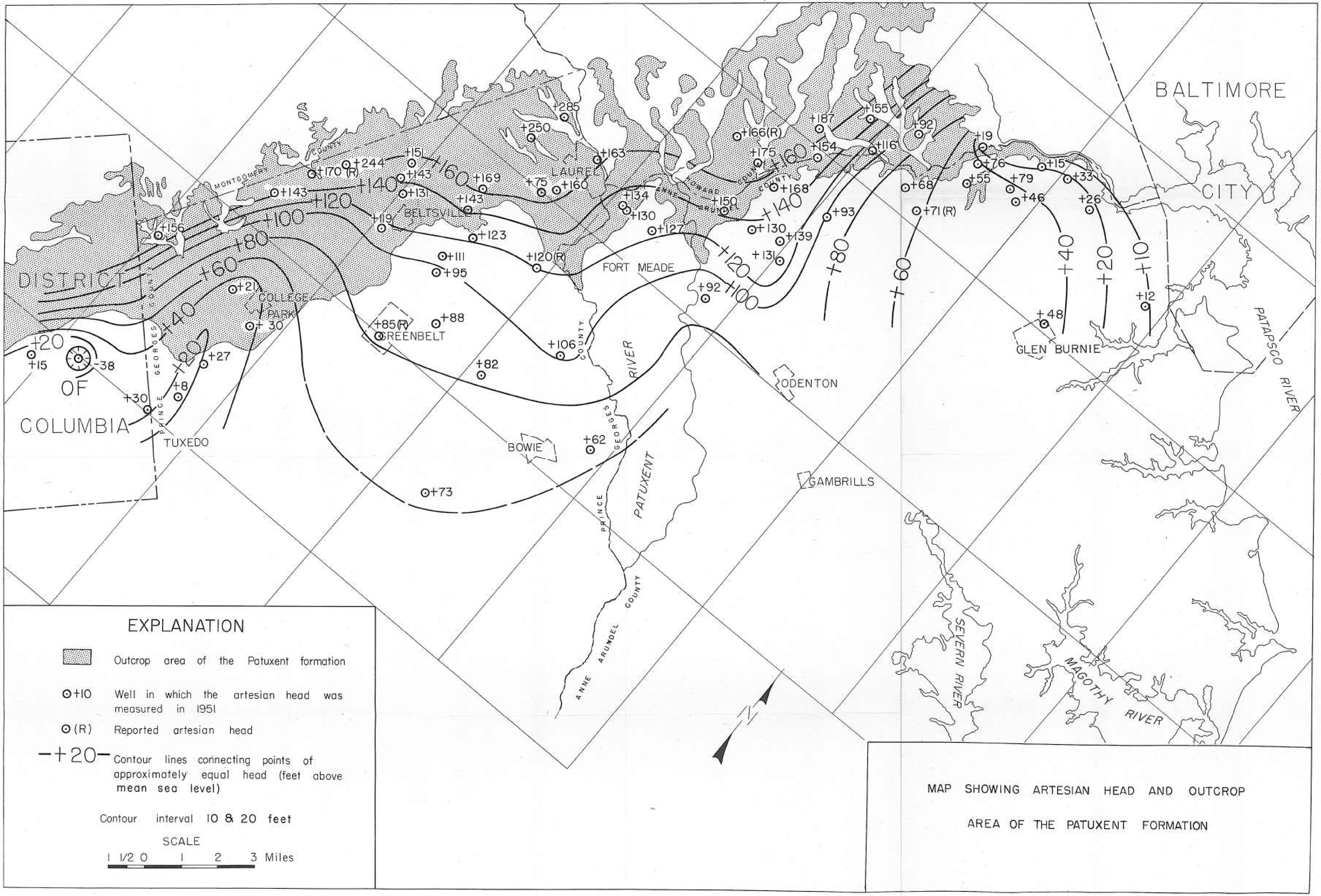


GRAPHIC LOGS SHOWING PERCENT HEAVY MINERALS IN FOUR WELLS IN THE MARYLAND COASTAL PLAIN

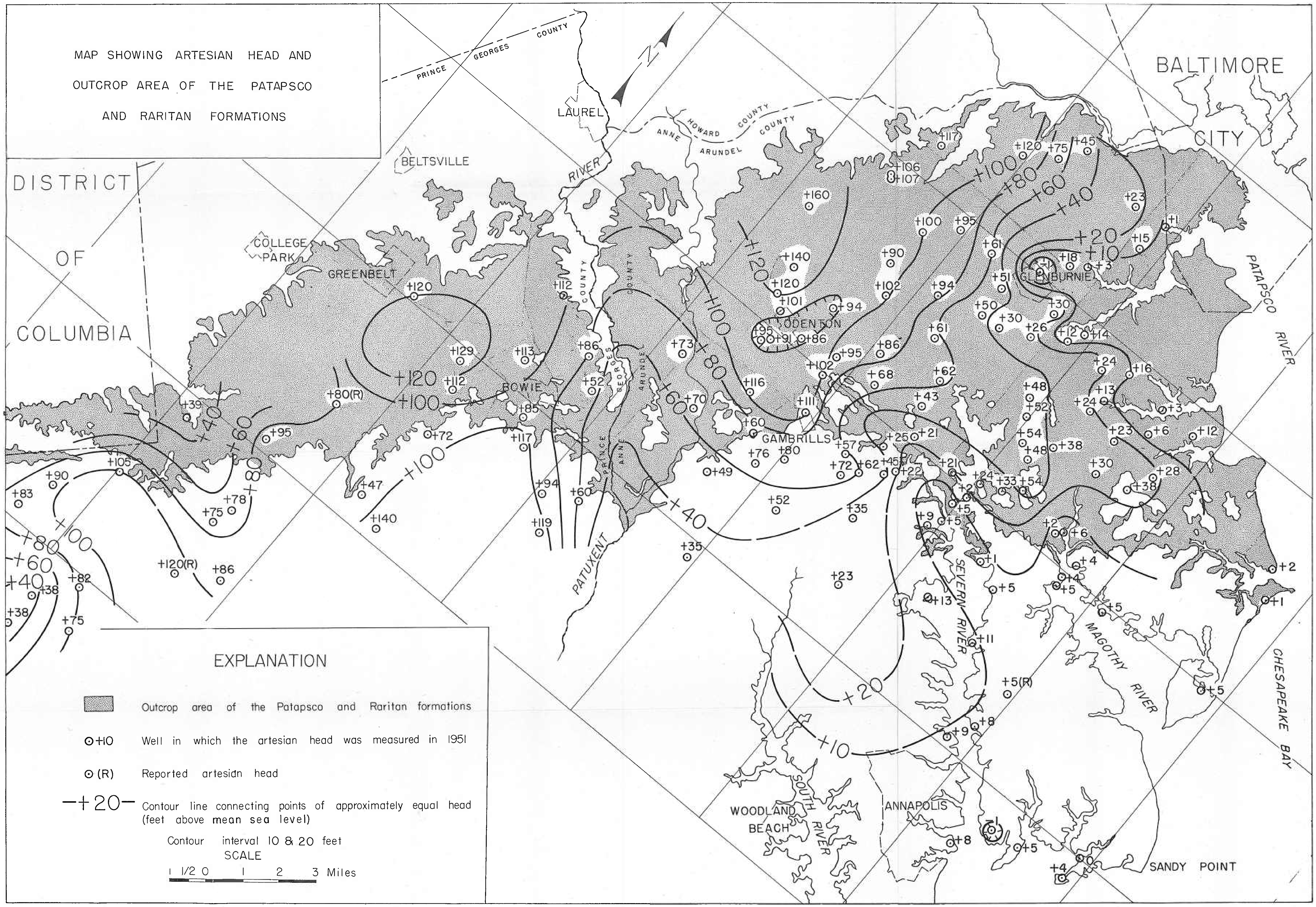

MAP OF SOUTHERN MARYLAND SHOWING BY CONTOURS THE APPROXIMATE ALTITUDE OF THE TOP OF THE UPPERMOST WATER-BEARING SAND IN THE MAGOTHY FORMATION
APPROXIMATE BOUNDARY OF WATER-BEARING SANDS IN THE MAGOTHY FORMATION
EXPLANATION
Well
Outcrop
−100 Altitude in feet above or below sea level
Contour interval 50 feet
SCALE IN MILES
BALTIMORE CITY
DISTRICT OF COLUMBIA
ANNE ARUNDEL
PRINCE GEORGES
CHARLES
CALVERT
ST. MARYS
KING GEORGE
WESTMORELAND
CHESAPEAKE BAY
Patapsco River
Magothy River
Severn River
South River
West River
Chester River
Eastern Bay
Choptank River
Patuxent River
Potomac River
Wicomico River
Mattawoman Creek
Port Tobacco Creek
Nanjemoy Creek
St. Marys River
Sparrows Point
Glen Burnie
Jessup
Bodkin Point
Laurel
Odenton
Gambrills
Crownsville
Muirkirk
Beltsville
Bowie
Sandy Point
Annapolis
Lanham
Davidsonville
Morningside
Camp Springs
Upper Marlboro
Herring Bay
North Beach
Fort Washington
Piscataway
Brandywine
Lower Marlboro
Plum Point
Indian Head
Pomonkey
White Plains
Bryantown
Hughesville
Prince Frederick
La Plata
Port Tobacco
Mechanicsville
Nanjemoy
Cedar Point
Popes Creek
Dahlgren
Maryland Point
Chaptico
Cove Point
Drum Point
Solomons
Leonardtown
Lexington Park
Cobb Island
St. Marys City
Point No Point
Montross
Point Lookout

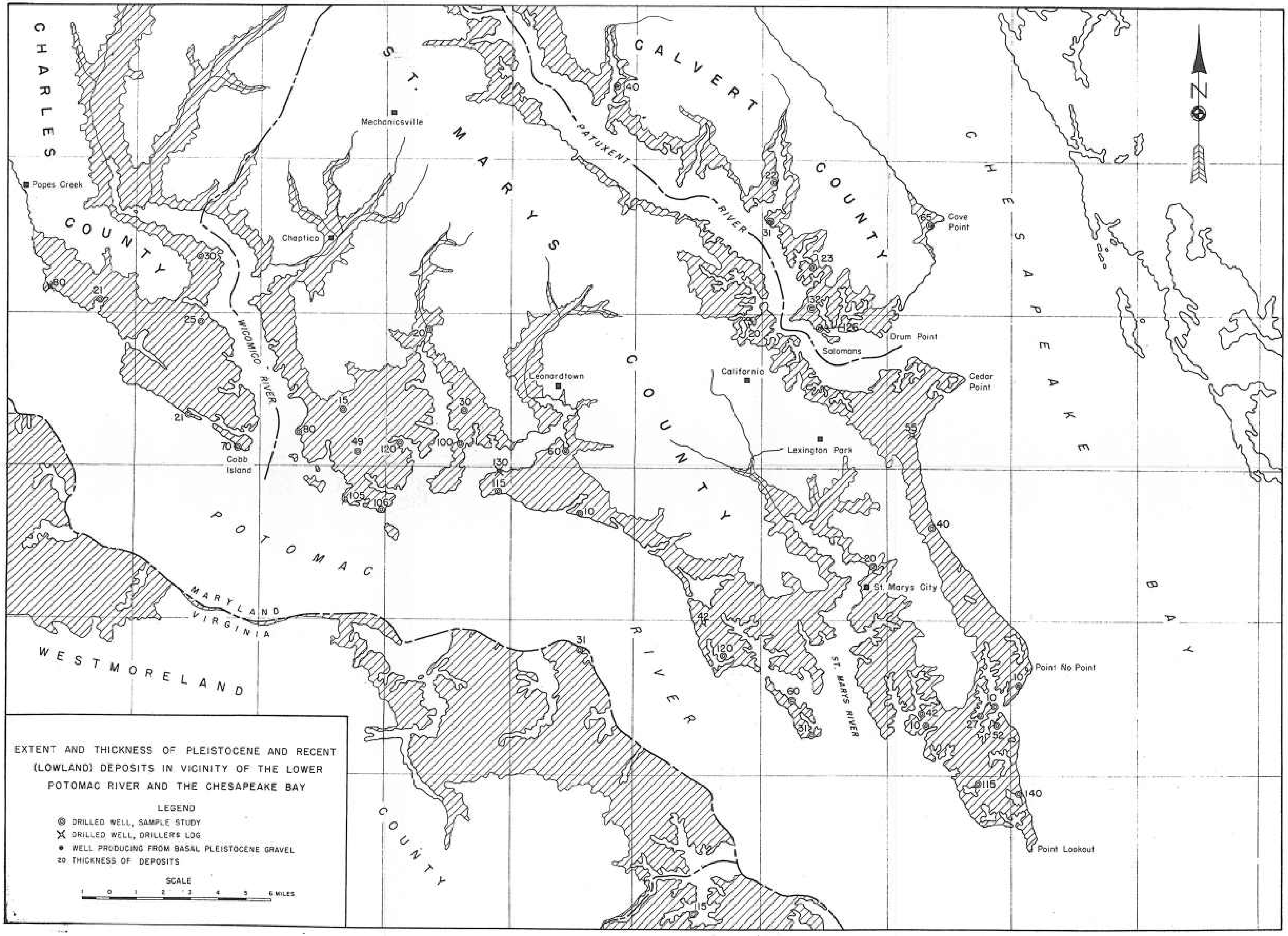

MAP OF SOUTHERN MARYLAND SHOWING BY CONTOURS THE ALTITUDE OF THE TOP OF THE AQUIA GREENSAND
BALTIMORE CITY
Patapsco River
Sparrows Point
Glen Burnie
Jessup
Bodkin Point
Laurel
Odenton
Muirkirk
Magothy River
Severn River
Beltsville
Bowie
Sandy Point
ANNAPOLIS
Chester River
Lanham
DISTRICT OF COLUMBIA
Davidsonville
South River
West River
Mt. Zion
UPPER MARLBORO
Eastern Bay
Herring Bay
Fairhaven
North Beach
Fort Washington
Piscataway
Brandywine
Lower Marlboro
Choptank River
Plum Point
Indian Head
Pomonkey
Mattawoman Creek
White Plains
Port Tobacco Creek
Port Tobacco
LA PLATA
Bryantown
Hughesville
PRINCE FREDERICK
Nanjemoy Creek
Nanjemoy
Mechanicsville
Cedar Point
Popes Creek
Wicomico River
Chaptico
Cove Point
Maryland Point
Drum Point
Solomons
LEONARDTOWN
Cedar Point
Lexington Park
Cobb Island
St Marys City
St. Marys River
Point No Point
Montross
Point Lookout
PRINCE GEORGES
ANNE ARUNDEL
CHARLES
CALVERT
ST. MARYS
KING GEORGE
WESTMORELAND
POTOMAC RIVER
CHESAPEAKE BAY
EXPLANATION
Well
Outcrop
—100 Altitude in feet
Contour interval 25 feet
SCALE IN MILES

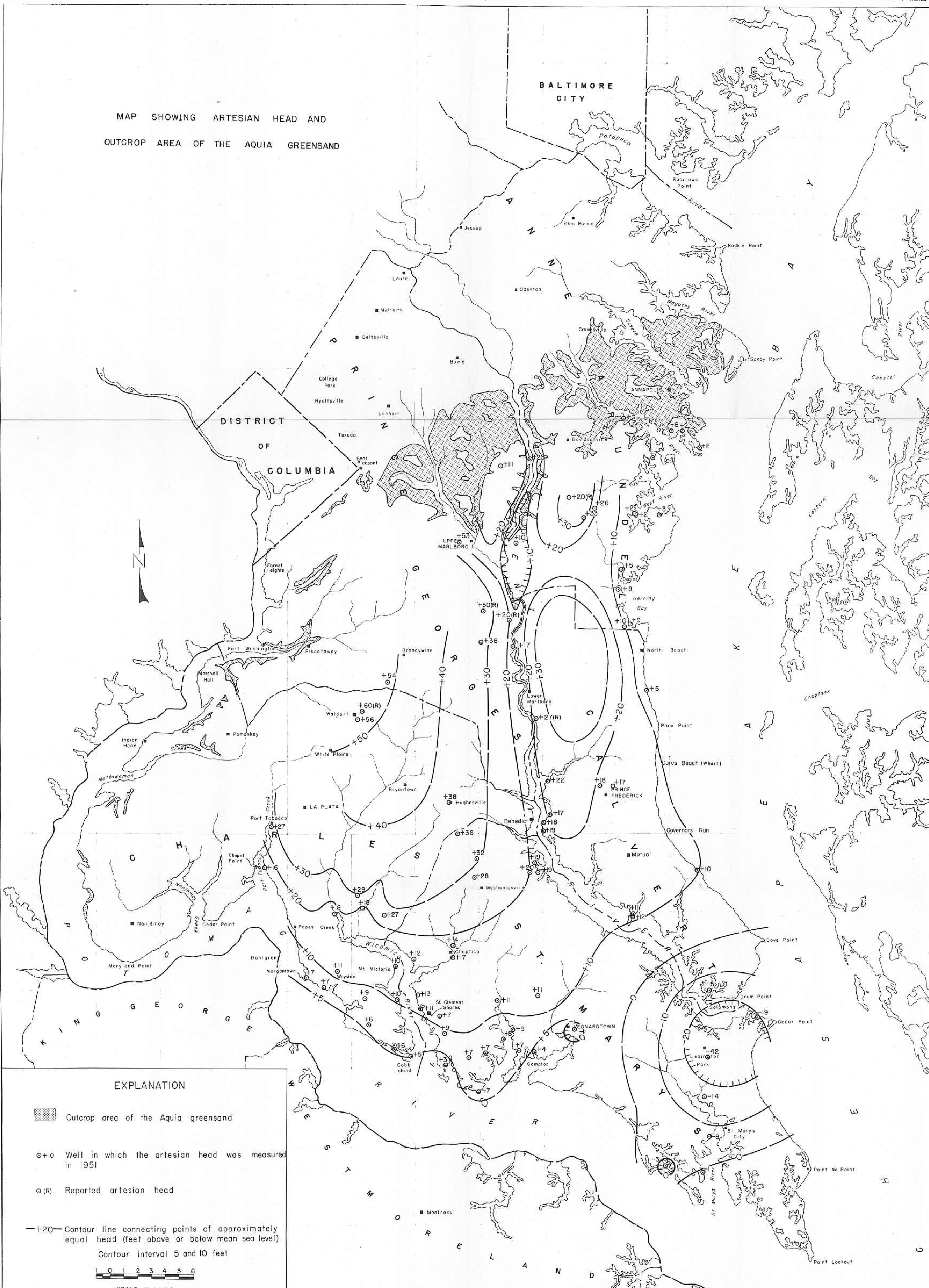

MAP OF SOUTHERN MARYLAND SHOWING BY CONTOURS THE ALTITUDE OF THE BASE OF THE MIOCENE SERIES
BALTIMORE CITY
DISTRICT OF COLUMBIA
ANNE ARUNDEL
PRINCE GEORGES
CHARLES
CALVERT
ST. MARYS
KING GEORGE
WESTMORELAND
POTOMAC RIVER
CHESAPEAKE BAY
Patapsco River
Magothy River
Severn River
South River
West River
Chester River
Eastern Bay
Choptank River
Herring Bay
Wicomico River
St. Marys River
Mattawoman Creek
Nanjemoy Creek
Port Tobacco Creek
Sparrows Point
Glen Burnie
Jessup
Bodkin Point
Odenton
Laurel
Muirkirk
Beltsville
Bowie
Sandy Point
ANNAPOLIS
Lanham
Davidsonville
UPPER MARLBORO
Croom
Dunkirk
North Beach
Fort Washington
Piscataway
Brandywine
Lower Marlboro
Plum Point
Pomonkey
Indian Head
White Plains
Bryantown
Hughesville
LA PLATA
Port Tobacco
PRINCE FREDERICK
Dares Beach (Wharf)
Kenwood Beach
Mechanicsville
Nanjemoy
Cedar Point
Popes Creek
Dahlgren
Maryland Point
Chaptico
Rocky Point
Cove Point
Drum Point
Solomons
LEONARDTOWN
Lexington Park
Cobb Island
St. Marys City
Piney Point
Point No Point
Point Lookout
Montross
EXPLANATION
Area where Miocene sediments are known to be underlain by the Piney Point formation
Approximate boundary of Miocene sediments
Well
Outcrop
-100 Altitude in feet (above or below sea level)
Contour interval 25 feet
SCALE IN MILES

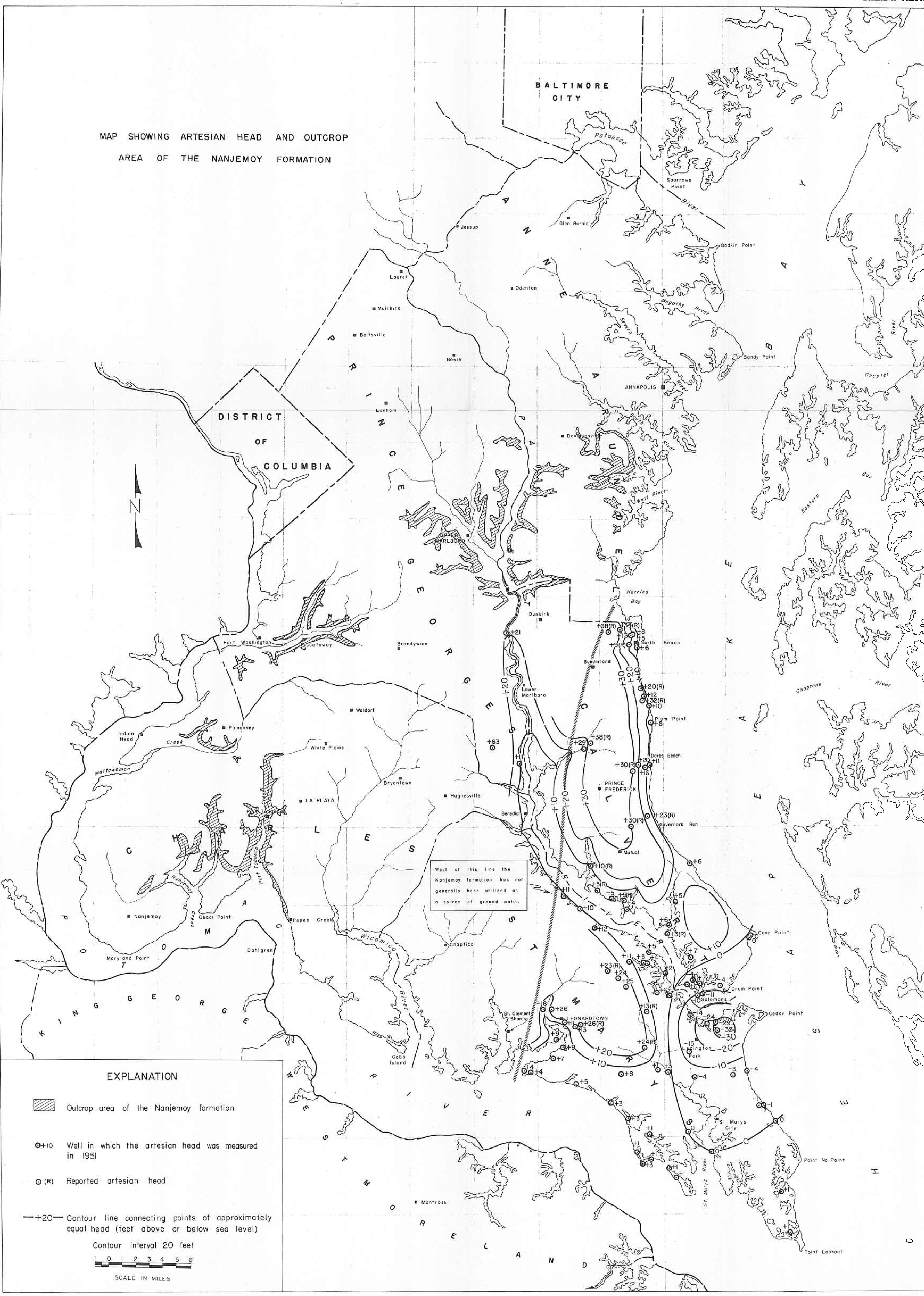


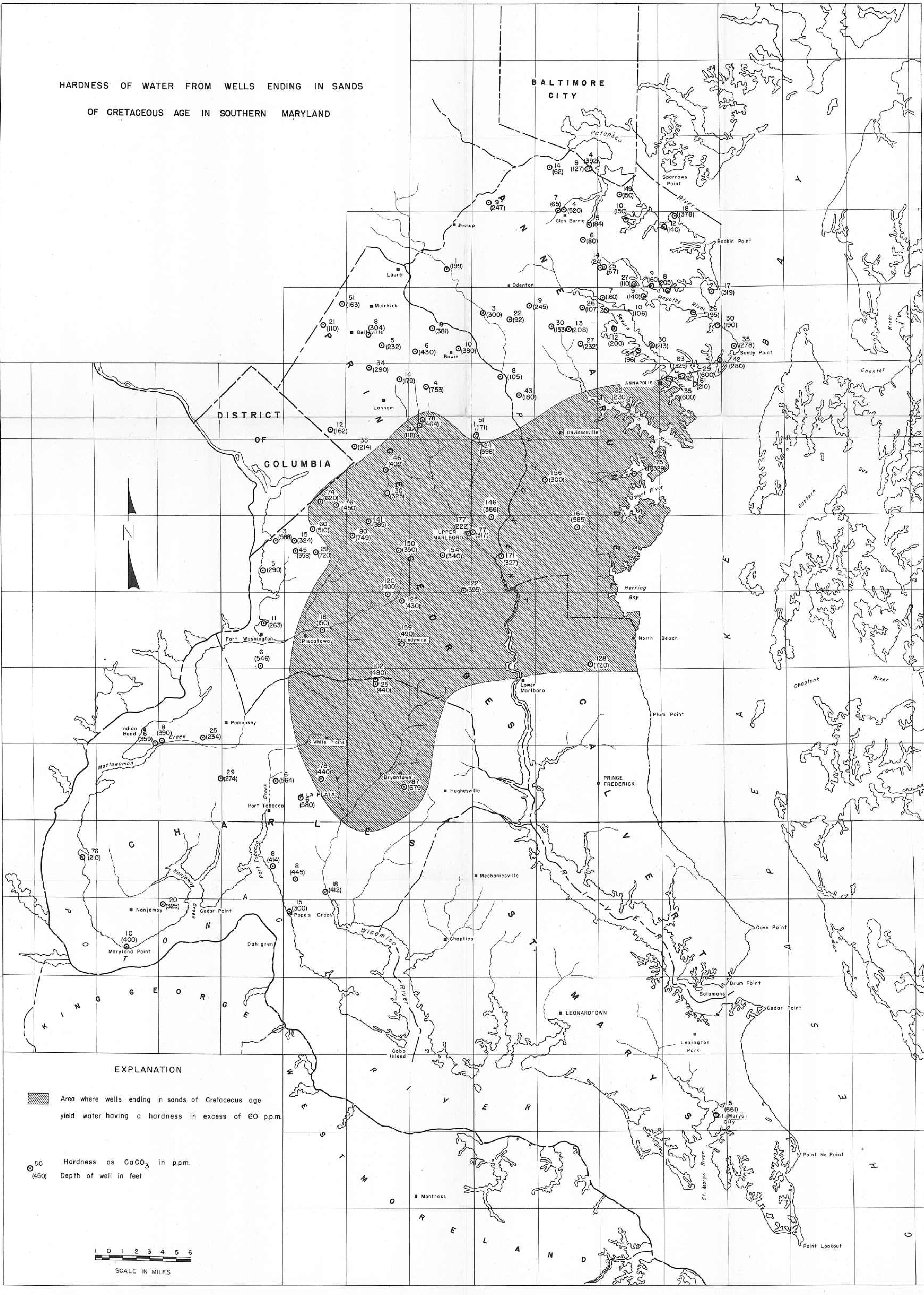
MAP SHOWING ARTESIAN HEAD AND OUTCROP AREA OF THE PATUXENT FORMATION

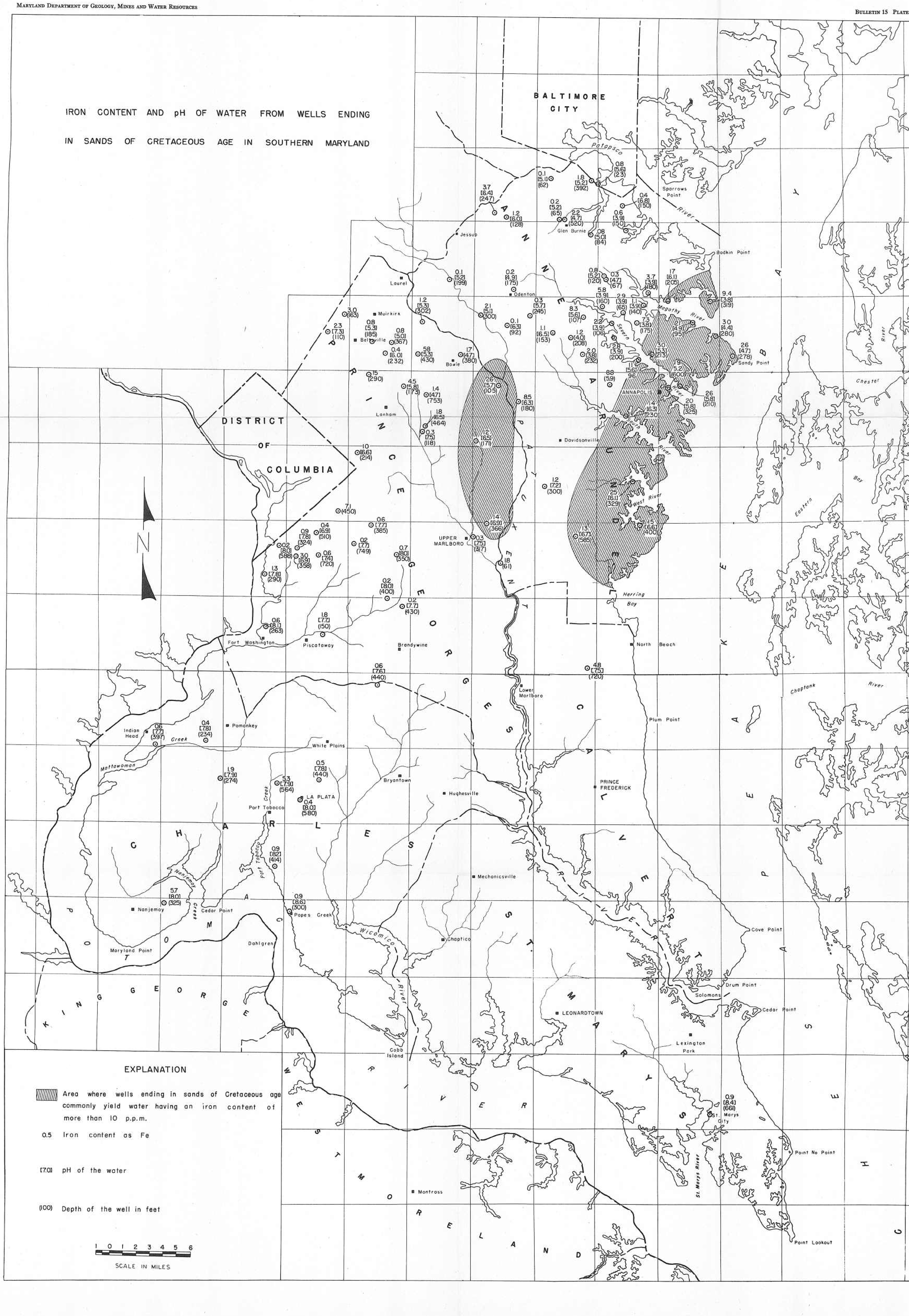

MAP SHOWING ARTESIAN HEAD AND
OUTCROP AREA OF THE PATAPSCO
AND RARITAN FORMATIONS
EXPLANATION
Outcrop area of the Patapsco and Raritan formations
⊙+10 Well in which the artesian head was measured in 1951
⊙ (R) Reported artesian head
—+20— Contour line connecting points of approximately equal head (feet above mean sea level)
Contour interval 10 & 20 feet
SCALE
1 1/2 0 1 2 3 Miles
DISTRICT OF COLUMBIA
BALTIMORE CITY
PRINCE GEORGES COUNTY
HOWARD COUNTY
ANNE ARUNDEL COUNTY
LAUREL
BELTSVILLE
COLLEGE PARK
GREENBELT
BOWIE
ODENTON
GAMBRILLS
GLEN BURNIE
PATUXENT RIVER
PATAPSCO RIVER
SEVERN RIVER
MAGOTHY RIVER
SOUTH RIVER
CHESAPEAKE BAY
ANNAPOLIS
WOODLAND BEACH
SANDY POINT


CHARLES COUNTY
ST. MARYS COUNTY
CALVERT COUNTY
WESTMORELAND COUNTY
CHESAPEAKE BAY
POTOMAC RIVER
PATUXENT RIVER
WICOMICO RIVER
ST. MARYS RIVER
MARYLAND
VIRGINIA
N
Popes Creek
Mechanicsville
Chaptico
Cobb Island
Leonardtown
California
Lexington Park
St. Marys City
Solomons
Drum Point
Cove Point
Cedar Point
Point No Point
Point Lookout
EXTENT AND THICKNESS OF PLEISTOCENE AND RECENT (LOWLAND) DEPOSITS IN VICINITY OF THE LOWER POTOMAC RIVER AND THE CHESAPEAKE BAY
LEGEND
DRILLED WELL, SAMPLE STUDY
DRILLED WELL, DRILLER'S LOG
WELL PRODUCING FROM BASAL PLEISTOCENE GRAVEL
20 THICKNESS OF DEPOSITS
SCALE
1 0 1 2 3 4 5 6 MILES

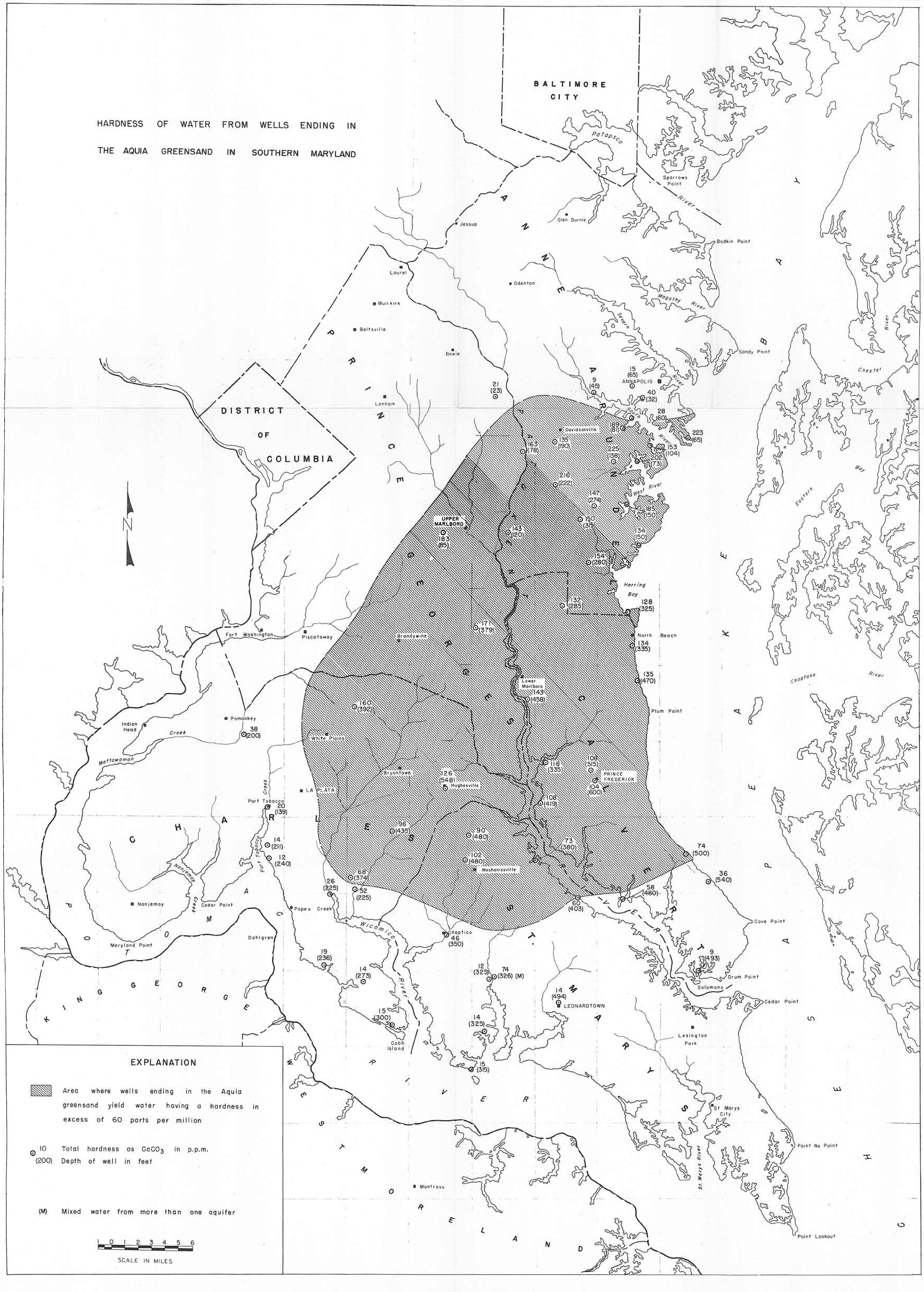

MAP SHOWING ARTESIAN HEAD AND
OUTCROP AREA OF THE AQUIA GREENSAND
BALTIMORE CITY
DISTRICT OF COLUMBIA
ANNE ARUNDEL
PRINCE GEORGES
CHARLES
CALVERT
ST. MARYS
KING GEORGE
WESTMORELAND
POTOMAC RIVER
CHESAPEAKE BAY
Patapsco River
Magothy River
Severn River
South River
West River
Herring Bay
Chester River
Eastern Bay
Choptank
Mattawoman Creek
Nanjemoy Creek
Port Tobacco Creek
Wicomico River
St Marys River
Sparrows Point
Glen Burnie
Jessup
Bodkin Point
Odenton
Laurel
Muirkirk
Beltsville
Crownsville
Bowie
Sandy Point
College Park
Hyattsville
Lanham
Annapolis
Tuxedo
Davidsonville
Seat Pleasant
Upper Marlboro
Forest Heights
Fort Washington
Piscataway
Marshall Hall
Brandywine
North Beach
Waldorf
Pomonkey
Indian Head
White Plains
Lower Marlboro
Plum Point
Dares Beach (Wharf)
Bryantown
Prince Frederick
Hughesville
La Plata
Port Tobacco
Benedict
Governors Run
Chapel Point
Mutual
Mechanicsville
Nanjemoy
Cedar Point
Popes Creek
Cove Point
Chaptico
Dahlgren
Morgantown
Mt. Victoria
Wayside
Maryland Point
St. Clement Shores
Drum Point
Solomons
Leonardtown
Cedar Point
Lexington Park
Cobb Island
Compton
St Marys City
Point No Point
Montross
Point Lookout
EXPLANATION
Outcrop area of the Aquia greensand
⊙+10 Well in which the artesian head was measured in 1951
⊙(R) Reported artesian head
—+20— Contour line connecting points of approximately equal head (feet above or below mean sea level)
Contour interval 5 and 10 feet
0 1 2 3 4 5 6
SCALE IN MILES


MAP SHOWING ARTESIAN HEAD AND OUTCROP
AREA OF THE NANJEMOY FORMATION
EXPLANATION
Outcrop area of the Nanjemoy formation
Well in which the artesian head was measured in 1951
Reported artesian head
Contour line connecting points of approximately equal head (feet above or below sea level)
Contour interval 20 feet
SCALE IN MILES
West of this line the Nanjemoy formation has not generally been utilized as a source of ground water.
BALTIMORE CITY
DISTRICT OF COLUMBIA
ANNE ARUNDEL
PRINCE GEORGES
CHARLES
CALVERT
ST MARYS
KING GEORGE
WESTMORELAND
POTOMAC
POTOMAC RIVER
CHESAPEAKE BAY
Patapsco
Sparrows Point
Glen Burnie
Jessup
Bodkin Point
Laurel
Odenton
Muirkirk
Magothy River
Severn River
Beltsville
Bowie
Sandy Point
Chester River
ANNAPOLIS
Lanham
Davidsonville
South River
West River
Eastern Bay
UPPER MARLBORO
Herring Bay
Dunkirk
Fort Washington
Piscataway
Brandywine
North Beach
Sunderland
Lower Marlboro
Choptank River
Waldorf
Indian Head
Pomonkey
Mattawoman Creek
White Plains
Plum Point
Dares Beach
Bryantown
LA PLATA
Hughesville
PRINCE FREDERICK
Port Tobacco
Benedict
Governors Run
Mutual
Nanjemoy
Nanjemoy Creek
Cedar Point
Popes Creek
Wicomico
Chaptico
Maryland Point
Dahlgren
Cove Point
Drum Point
Solomons
St. Clements Shores
LEONARDTOWN
Cedar Point
Cobb Island
Wicomico River
St Marys City
St. Marys River
Point No Point
Montross
Point Lookout

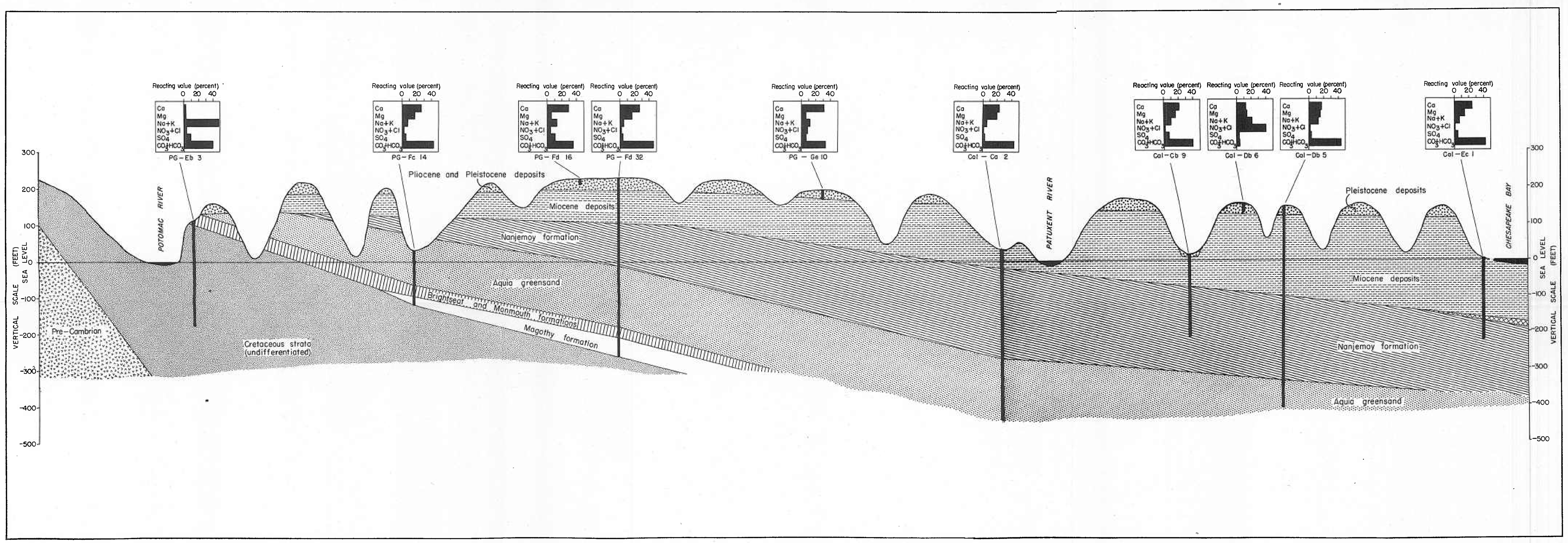

HARDNESS OF WATER FROM WELLS ENDING IN SANDS
OF CRETACEOUS AGE IN SOUTHERN MARYLAND
BALTIMORE CITY
DISTRICT OF COLUMBIA
PRINCE GEORGES
ANNE ARUNDEL
CALVERT
CHARLES
ST. MARYS
KING GEORGE
WESTMORELAND
POTOMAC RIVER
CHESAPEAKE BAY
N
Patapsco River
Sparrows Point
Bodkin Point
Glen Burnie
Jessup
Laurel
Odenton
Muirkirk
Beltsville
Bowie
Lanham
Magothy River
Severn River
Sandy Point
ANNAPOLIS
South River
West River
Davidsonville
UPPER MARLBORO
Herring Bay
North Beach
Fort Washington
Piscataway
Brandywine
Lower Marlboro
Plum Point
Pomonkey
Indian Head
Mattawoman Creek
White Plains
Port Tobacco
LA PLATA
Bryantown
Hughesville
PRINCE FREDERICK
Mechanicsville
Nanjemoy
Cedar Point
Popes Creek
Maryland Point
Dahlgren
Wicomico River
Chaptico
Cove Point
Drum Point
Solomons
Cedar Point
LEONARDTOWN
Lexington Park
Cobb Island
St. Marys City
St. Marys River
Point No Point
Montross
Point Lookout
Chester River
Eastern Bay
Choptank River
EXPLANATION
Area where wells ending in sands of Cretaceous age yield water having a hardness in excess of 60 p.p.m.
50 Hardness as $CaCO_3$ in p.p.m.
(450) Depth of well in feet
0 1 2 3 4 5 6
SCALE IN MILES


IRON CONTENT AND pH OF WATER FROM WELLS ENDING IN SANDS OF CRETACEOUS AGE IN SOUTHERN MARYLAND
EXPLANATION
Area where wells ending in sands of Cretaceous age commonly yield water having an iron content of more than 10 p.p.m.
0.5 Iron content as Fe
[7.0] pH of the water
(100) Depth of the well in feet
SCALE IN MILES
N
BALTIMORE CITY
DISTRICT OF COLUMBIA
ANNE ARUNDEL
PRINCE GEORGES
CHARLES
CALVERT
ST. MARYS
KING GEORGE
WESTMORELAND
POTOMAC RIVER
PATUXENT RIVER
CHESAPEAKE BAY
Patapsco River
Sparrows Point
Bodkin Point
Sandy Point
Glen Burnie
Jessup
Laurel
Odenton
Muirkirk
Beltsville
Bowie
Lanham
Davidsonville
ANNAPOLIS
Magothy River
Severn River
South River
West River
Herring Bay
North Beach
UPPER MARLBORO
Lower Marlboro
Fort Washington
Piscataway
Brandywine
Indian Head
Pomonkey
Mattawoman Creek
White Plains
Bryantown
Hughesville
LA PLATA
Port Tobacco
Port Tobacco Creek
Nanjemoy Creek
Nanjemoy
Cedar Point
Popes Creek
Maryland Point
Dahlgren
Mechanicsville
Chaptico
Wicomico River
PRINCE FREDERICK
Plum Point
Cove Point
Drum Point
Solomons
Cedar Point
LEONARDTOWN
Lexington Park
Cobb Island
St. Marys City
St. Marys River
Point No Point
Point Lookout
Montross
Chester River
Eastern Bay
Choptank River

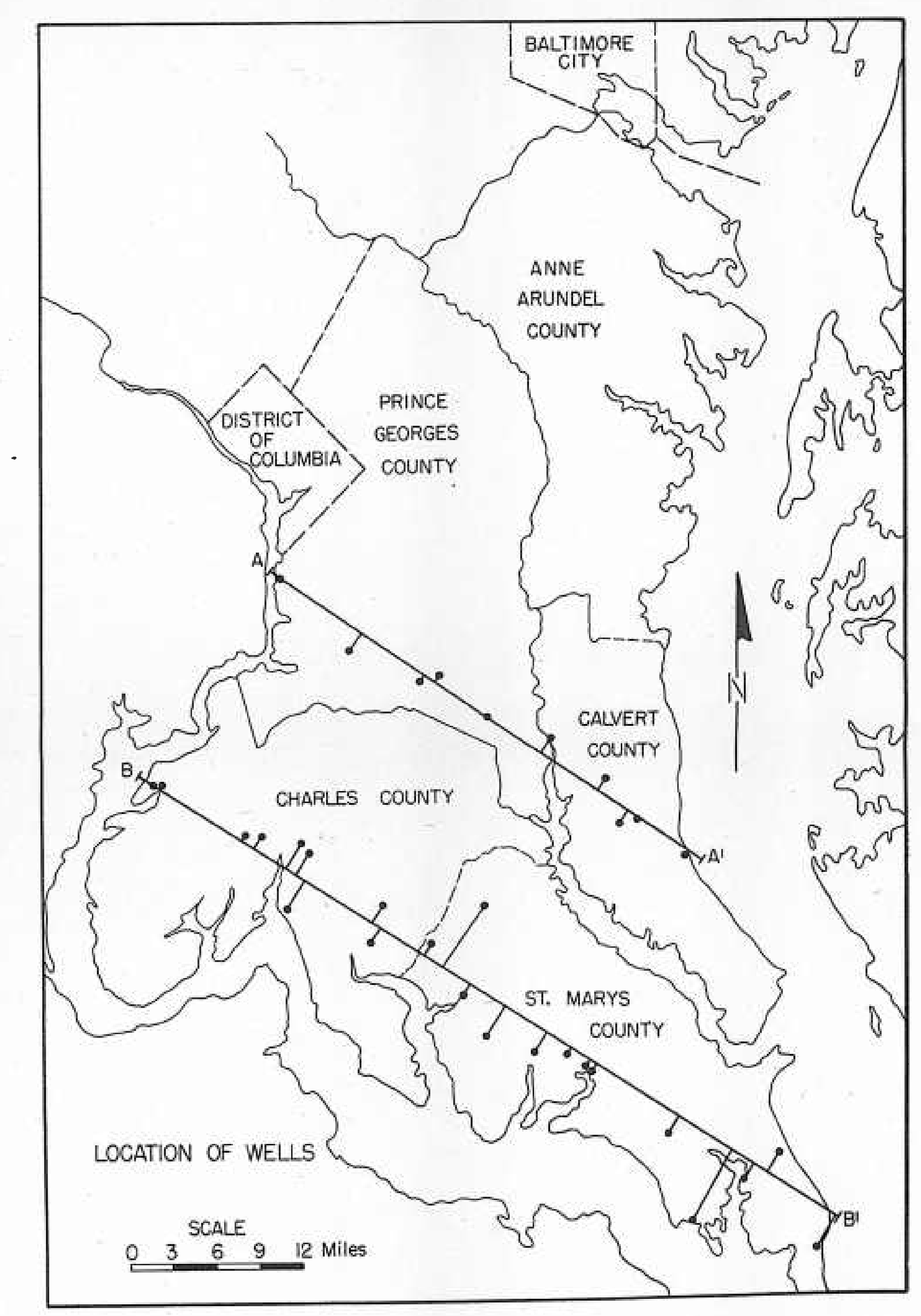
HARDNESS OF WATER FROM WELLS ENDING IN THE AQUIA GREENSAND IN SOUTHERN MARYLAND



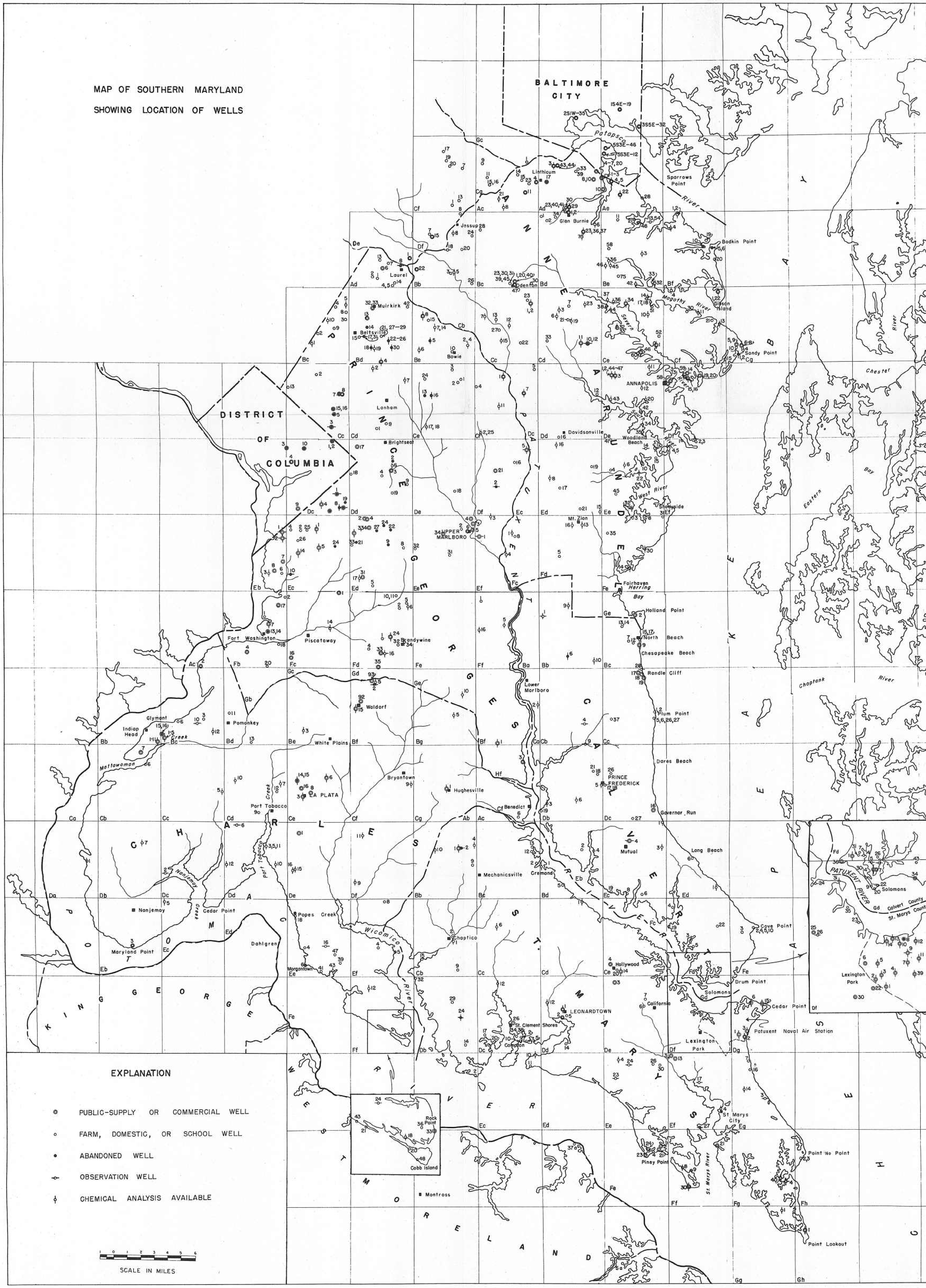
B–B' Section from Indian Head on the Potomac River to Point No Point on the Chesapeake Bay.



A–A' Section from Forest Heights on the Potomac River to Kenwood Beach on the **Chesapeake Bay.**



GEOLOGIC SECTIONS ACROSS SOUTHERN MARYLAND **AND** GRAPHS SHOWING THE CHEMICAL CHARACTER OF THE GROUND WATER


MAP OF SOUTHERN MARYLAND
SHOWING LOCATION OF WELLS
BALTIMORE CITY
DISTRICT OF COLUMBIA
ANNE ARUNDEL
PRINCE GEORGES
CHARLES
CALVERT
ST. MARYS
KING GEORGE
WESTMORELAND
Patapsco River
Chester
Eastern Bay
Choptank River
Patuxent River
Potomac
Wicomico River
St. Marys River
Severn River
Magothy River
South River
West River
Herring Bay
ANNAPOLIS
UPPER MARLBORO
PRINCE FREDERICK
LA PLATA
LEONARDTOWN
Laurel
Beltsville
Muirkirk
Bowie
Lanham
Brightseat
Odenton
Glen Burnie
Linthicum
Jessup
Davidsonville
Mt. Zion
Brandywine
Piscataway
Fort Washington
Waldorf
White Plains
Bryantown
Hughesville
Benedict
Lower Marlboro
Mechanicsville
Chaptico
Hollywood
California
Lexington Park
Solomons
Cedar Point
Patuxent Naval Air Station
St Marys City
Piney Point
Point No Point
Point Lookout
Cobb Island
Rock Point
Morgantown
Popes Creek
Dahlgren
Nanjemoy
Maryland Point
Indian Head
Glymont
Pomonkey
Port Tobacco
Mattawoman Creek
Mutual
Long Beach
Cove Point
Governor Run
Dares Beach
Plum Point
Randle Cliff
Chesapeake Beach
North Beach
Holland Point
Fairhaven
Shadyside
Woodland Beach
Sandy Point
Gibson Island
Bodkin Point
Sparrows Point
Montross
St. Clement Shores
Compton
Cremona
Drum Point
EXPLANATION
PUBLIC-SUPPLY OR COMMERCIAL WELL
FARM, DOMESTIC, OR SCHOOL WELL
ABANDONED WELL
OBSERVATION WELL
CHEMICAL ANALYSIS AVAILABLE
SCALE IN MILES