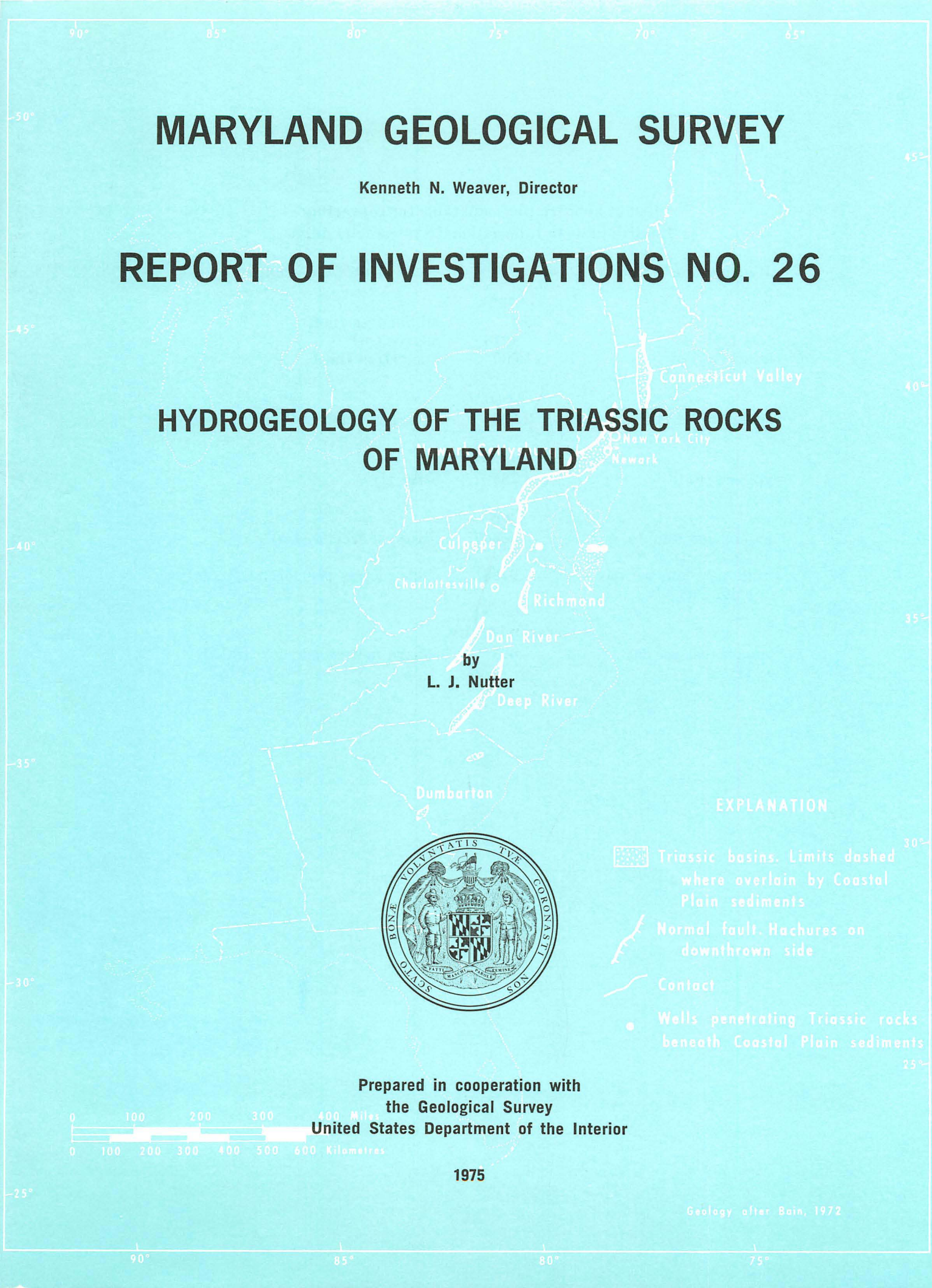
MARYLAND GEOLOGICAL SURVEY

Kenneth N. Weaver, Director

REPORT OF INVESTIGATIONS NO. 26

HYDROGEOLOGY OF THE TRIASSIC ROCKS OF MARYLAND

by
L. J. Nutter



Prepared in cooperation with
the Geological Survey
United States Department of the Interior

1975

List of abbreviations and table for converting English units to International System (SI) units.

Multiply English units	*By*	*To obtain SI units*
	Length	
inches (in)	25.4	millimetres (mm)
feet (ft)	.3048	metres (m)
miles (mi)	1.609	kilometres (km)
	Area	
square miles (mi^2)	2.590	square kilometres (km^2)
	Volume	
gallons (gal)	3.785	litres (l)
	Flow	
gallons per minute (gal/min)	.06309	litres per second (l/s)
million gallons per day (Mgal/d)	.04381	cubic metres per second (m^3/s)
	Transmissivity	
square feet per day (ft^2/d)	.093	square metres per day (m^2/d)

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CONTENTS

	Page
Abstract	1
Introduction	2
Purpose and scope	2
Methods of investigation	2
Geographic setting	3
Climate	3
Well-location system	3
Acknowledgments	3
Geologic setting	4
Triassic basins in eastern North America	4
Triassic basins beneath Coastal Plain sediments	4
Newark Group	4
Depositional environment	4
New Oxford Formation	4
Gettysburg Shale	7
Diabase dikes and sills intruding Newark Group	7
Geologic structure of Newark Group	7
General features	7
Faults	7
Joints	8
Ground-water hydrology	8
General hydrologic principles	8
Occurrence and movement	9
Hydraulic properties	10
Developing a ground-water supply	11
Factors affecting well yields	11
Geologic structure	11
Topographic position	11
Lithology	12
Well depth	13
Well-stimulation techniques	14
Water use	15
Water quality	15
Relation of chemical quality to use	16
Silica	16
Hardness	16
Iron and manganese	17
Nitrate	17
General features	17
Catoctin Manor Estates and Utica	17
Graceham and Lewistown	17
References	19
Appendix	21
Well tables	22
Chemical analyses	30
Selected lithologic logs	31
Selected geophysical logs	34

TABLES

			Page
Table	1.	Records of wells in Carroll County	22
	2.	Records of wells in Frederick County	24
	3.	Records of wells in Montgomery County	28
	4.	Chemical analyses of water samples from selected wells in the study area	30
	5.	Porosity and hydraulic conductivity data, Triassic-rock aquifers	9
	6.	Aquifer-test data, Triassic-rock aquifers	10
	7.	Summary of well-yield data, Triassic-rock aquifers	13
	8.	Summary of water-quality data from the Triassic-rock aquifers	16
	9.	Partial chemical and bacteriological analyses of water samples from wells in four areas in Frederick County	18
	10.	Lithologic description of cuttings from selected wells	31

ILLUSTRATIONS

			Page
Figure	1.	Map of Maryland showing location of study area	2
	2.	Graph showing mean monthly precipitation at Frederick, 1876-1960	3
	3.	Map of eastern United States showing Triassic basins	5
	4.	Generalized geologic map of Triassic rocks in Maryland	6
	5.	Graph showing topographic influence on the yield of wells in the Triassic-rock aquifers	12
	6.	Cumulative frequency graph of well yields in the Gettysburg Shale, New Oxford Formation, and limestone-pebble conglomerate hydrogeologic unit	12
	7.	Photograph showing effects of solution in limestone-pebble conglomerate lithofacies of the Gettysburg Shale near Thurmont	13
	8.	Graph showing the relation between well depth and average yield	13
	9.	Graph showing the yield of domestic and farm wells compared with municipal and industrial wells	14
	10.	Pie diagram contrasting ground-water use in the study area	15
	11.	Selected geophysical logs	34
Plate	1.	Map of central Maryland showing the location of wells and springs	Separate

HYDROGEOLOGY OF THE TRIASSIC ROCKS OF MARYLAND

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ABSTRACT

The rocks of the Newark Group of Late Triassic age occur in the northern and western parts of the Frederick Valley in Frederick and Carroll Counties and in the western part of Montgomery County. These consolidated bedrock aquifers consist of a complex interbedded sequence of arkosic sandstone, shale, siltstone, and quartz-pebble and limestone-pebble conglomerate.

Water is stored in and transmitted through joints, faults, and bedding-plane partings in the rock and, to a limited extent, in interstitial pore space in the weathered rock mantle; the primary pore space in the rock has been almost eliminated by compaction and cementation. The Triassic-rock aquifers are a reliable source of water for domestic, farm, and small commercial use; only 6.5 percent of the wells inventoried yield less than 3 gallons per minute (0.2 litre per second). Ground-water supplies sufficient for most commercial and light industrial use can be developed under favorable hydrogeologic conditions.

Several factors affect well yields, the most important of which include: geologic structure (occurrence of joints and faults), topographic position, lithology, and well depth. Topography is to a large extent controlled by the geologic structure because the stream network tends to be aligned along major joints and faults; therefore, wells drilled in valleys or draws are more likely to intersect water-bearing fractures than are wells drilled on hilltops. The lithology is also an important factor influencing the yield of wells. The limestone-pebble conglomerate contains many of the highest yielding wells in the study area because solution along joints and bedding-plane openings has substantially increased the permeability. Sandstone and conglomerate beds are likely to yield more water to wells than are shale and siltstone beds, mainly because joints tend to be more closely spaced in sandstone and conglomerate. Water-bearing zones in the Triassic-rock aquifers can occur at depths of 500 feet (150 metres) or more, so it is important to drill wells at least 300 or 400 feet (90 or 120 metres) deep when maximum yields are sought.

The water in the Triassic-rock aquifers is generally of good chemical quality; the most common water-quality problems are excessive concentrations of iron, manganese, and nitrate, and low pH. The nitrate concentration in ground water underlying some older communities having small lots and fairly shallow wells constitutes a potential health hazard, particularly if wells are inadequately constructed.

INTRODUCTION

PURPOSE AND SCOPE

This 2-year study was a segment of a continuing investigation of the hydrogeology of the consolidated rocks in Maryland by the U. S. Geological Survey in cooperation with the Maryland Geological Survey. The purpose of the study was to evaluate the Triassic rocks as a source of water.

The relationship between the water-yielding properties of the Triassic rocks and lithology, faulting, jointing, topography, and well depth were studied. Special emphasis was placed on evaluating the potential for developing moderately large ground-water supplies in those parts of the study area where the need for water is likely to increase substantially in the next few years owing to suburban development.

METHODS OF INVESTIGATION

During the study, an inventory of 265 wells was made (tables 1-3); chemical analyses of water samples from 28 wells are listed in table 4 along with 10 chemical analyses from previous studies. Well data from previous studies (Meyer, 1958; Dingman and Meyer, 1954; Nutter, 1973) were used in evaluating the factors influencing well yields, but these data are not included in tables 1-3. Tables of well records (tables 1-3) and the table of chemical analyses (table 4) are in the Appendix.

Two test wells were drilled during the study. A 692-ft (211-m) test well was drilled east of Taneytown in Carroll County to determine the water-bearing properties of the basal quartz-pebble conglomerate of the New Oxford Formation. An 885-ft (270-m) test well was drilled near Dickerson in Montgomery County to determine the water-bearing properties of coarse-grained arkosic sandstone and limestone-conglomerate beds. Aquifer tests were analyzed from eight wells to determine the transmissivity and storage coefficients; hydraulic conductivity and effective porosity were measured for several outcrop and core samples of residuum and bedrock. In addition, geophysical logs were run on about a dozen wells to determine the lithology and depth of water-bearing zones; commercial logs were run in one test well permitting an estimation of the effective porosity. Several cores drilled at the site of a proposed sewage treatment plant near Dickerson were examined.

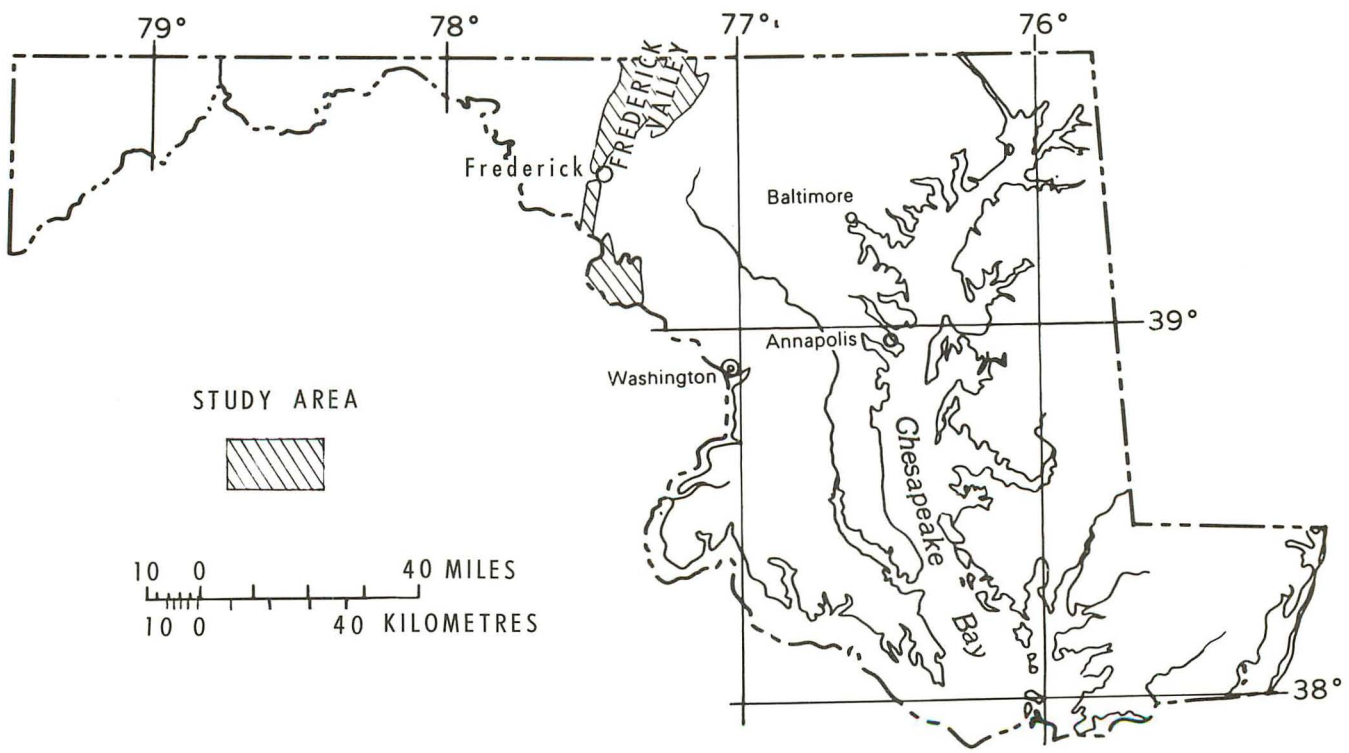
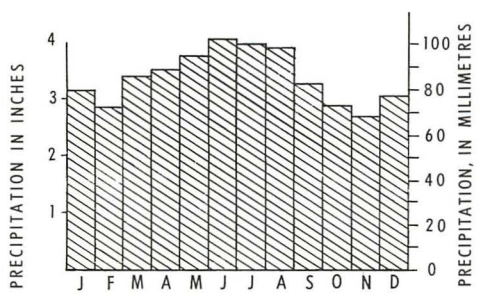


Figure 1.—Location of study area.

Ground-water pumpage data were assembled from major users, and estimates of domestic and farm use were made using population statistics. Detailed studies of the occurrence of nitrate in ground water were made at four sites in Frederick County. Water samples collected at these sites were analyzed for nitrate, chloride, specific conductance, total coliform, and fecal coliform.

GEOGRAPHIC SETTING

This report covers the area underlain by rocks of Triassic age in Maryland (fig. 1). This area occupies parts of Frederick, Carroll, and Montgomery Counties in central Maryland and is referred to as the Triassic Lowland. Triassic rocks underlie about two-thirds of the area of the Frederick Valley, the remaining area being underlain by Cambrian and Ordovician limestones. The study area is primarily drained by the Monocacy River and its tributaries, except for the Triassic Lowland in Montgomery County which is drained by Seneca Creek and a few other small streams that flow into the Potomac River.



Data from National Weather Service

Figure 2.—Mean monthly precipitation at Frederick, 1876-1960.

CLIMATE

The climate in the study area is temperate and moderately humid. The mean annual temperature is about 54°F (12.2°C), and the mean annual precipitation is about 40 in (1,016 mm). The precipitation is fairly evenly distributed throughout the year, but is generally greater in the late spring and summer months (fig. 2).

WELL-LOCATION SYSTEM

Wells in Maryland are identified and may be located on the basis of a numbering system adopted by the Maryland Geological Survey. The first 2 to 4 letters of the identification number are the county prefix; for example, for Montgomery County the prefix is Mont, for Frederick County the prefix is Fr, and for Carroll County the prefix is Car. Each county has been divided into 5-minute quadrangles of latitude and longitude. Each quadrangle, from north to south, is designated by an upper-case letter, and west to east by a lower-case letter. The wells are numbered in chronological order within the 5-minute quadrangle. Thus, Fr-Bd 14 is the 14th well inventoried in the Bd 5-minute quadrangle of Frederick County.

ACKNOWLEDGMENTS

The writer wishes to express his appreciation to the well drillers, municipal, county, and State authorities, industrial officials, and homeowners who supplied information concerning their wells, permitted hydrologic measurements to be made, or permitted water samples to be collected. Special thanks are due the Maryland National Capital Park and Planning Commission and the Maryland Highway Administration for permitting test wells to be drilled on their property. The writer is indebted to James A. Humphreville, consulting geologist, for supplying geologic and hydrologic data from the Thurmont area and to CH_2M-Hill and Associates for permitting the examination of cores obtained at the site of a proposed sewage treatment plant.

GEOLOGIC SETTING[1]

TRIASSIC BASINS IN EASTERN NORTH AMERICA

The Triassic rocks exposed in the Frederick Valley in Frederick and Carroll Counties and in western Montgomery County are part of a series of disconnected basins which extend from Nova Scotia southward at least to Georgia. These basins contain rocks of fairly similar lithologic character, and they are broadly parallel to the geologic structure of the older rocks that surround them. One margin of most of these basins is typically down-faulted, forming a halfgraben, and the sediments deposited in these basins thicken and dip toward the faulted margin. In most of these Triassic basins, the rocks have been intruded by diabase dikes and sills, and in several basins strata are interbedded with basalt flows. The sedimentary rocks and interbedded lava flows of Triassic age in the eastern United States and Canada are collectively referred to as the Newark Group, for exposures in the Newark, N. J. area.

The largest of these basins, the Newark-Gettysburg basin, extends from the New York City area to Frederick, Maryland. The northern part of the outcrop area of Triassic rocks in Maryland is part of this large basin; the Triassic rocks which crop out south of Frederick and in western Montgomery County are the northernmost part of the Culpeper basin which extends to near Charlottesville, Va. (fig. 3).

TRIASSIC BASINS BENEATH COASTAL PLAIN SEDIMENTS

Several Triassic basins covered by Coastal Plain sediments have been located by deep drilling and inferred by geophysical surveys (Bayley and Muehlberger, 1968). In Maryland, at least two Triassic basins have been located by exploratory tests. In Prince Georges County on the western shore of the Chesapeake Bay, several deep test wells were drilled for the Washington Gas Light Company to determine the feasibility of storing natural gas underground. Six of these test wells penetrated arkosic sedimentary rocks of probable Triassic age beneath Cretaceous and Tertiary sediments (Mack, 1966, p. 75; Jacobeen, 1972, p. 7). Three exploratory tests drilled by oil companies on the Eastern Shore of the Chesapeake Bay penetrated probable Triassic sedimentary rocks beneath Cretaceous sediments (Anderson, 1948).

[1] The stratigraphic nomenclature used in this report is that of the Maryland Geological Survey and does not necessarily follow the usage of the U. S. Geological Survey.

NEWARK GROUP

Depositional Environment

The sediments of the Newark Group were deposited by streams discharging into the down-faulted basins from nearby uplands. The frequent crossbedding, the presence of mud cracks, fragments of wood, vertebrate tracks, and the predominant red color of the sediments, all indicate continental conditions at the time of deposition. Many of the coarse clastic deposits, especially the conglomerates, were deposited in large alluvial fans along the foot of steep escarpments which formed along the major fault zones.

The Newark Group in Maryland is divided into two formations: the basal New Oxford Formation and the overlying Gettysburg Shale. The outcrop area of the Gettysburg Shale is limited to northeastern Frederick County and is much smaller than that of the New Oxford Formation (fig. 4).

New Oxford Formation

The New Oxford Formation contains predominantly red and gray arkose and arkosic sandstone with subordinate amounts of red shale and siltstone as well as basal conglomerate. The composition of the basal conglomerate varies but is mostly a quartz-pebble conglomerate north of Frederick (Newark-Gettysburg basin) and a limestone-pebble conglomerate south of Frederick (Culpeper basin). Some limestone-pebble conglomerate crops out in Montgomery County several hundred feet stratigraphically above the base of the New Oxford Formation.

The basal limestone-pebble conglomerate is composed of Paleozoic limestone pebbles and scattered quartz pebbles enclosed in a matrix of fine gray to red limestone and calcareous red shale containing grains of quartz (Stose and Stose, 1946, p. 85). It can be sawed and polished and has been quarried as an ornamental stone, known as "Potomac marble."

The quartz-pebble conglomerate is composed of quartz and gneiss pebbles and cobbles enclosed in a matrix of sand-size particles of feldspar and quartz and fine red shale (Palmer, 1949, p. 7).

Several cores were drilled by a consulting firm at the site of a proposed sewage treatment plant near Dickerson, and a few of these cores were examined. Two of the cores contained irregular "blobs" of calcium carbonate material, and one core contained a 10-ft (2.5-m) thick bed of light-gray calcarenite containing abundant

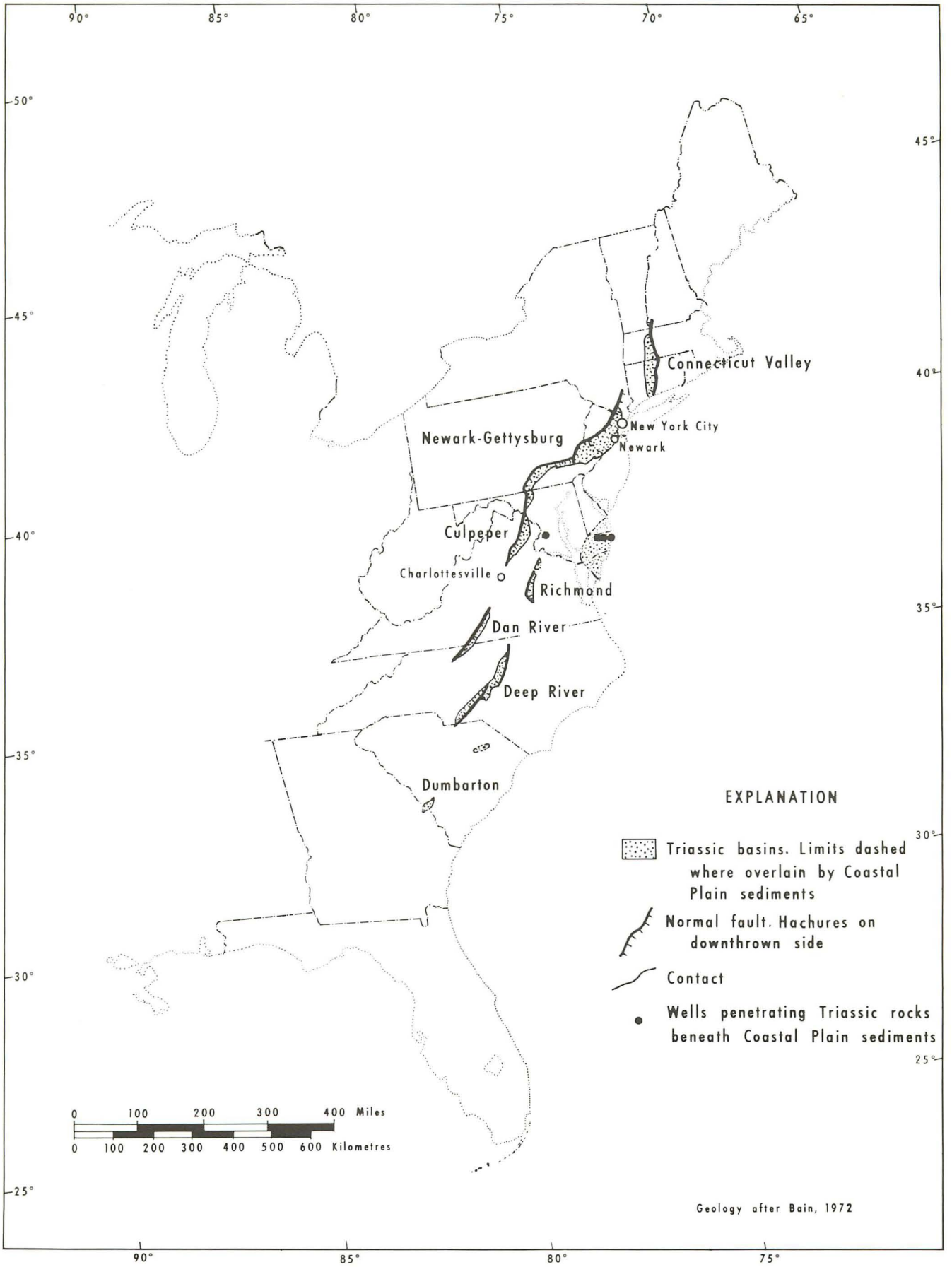


Figure 3.—Map of eastern United States showing Triassic basins.

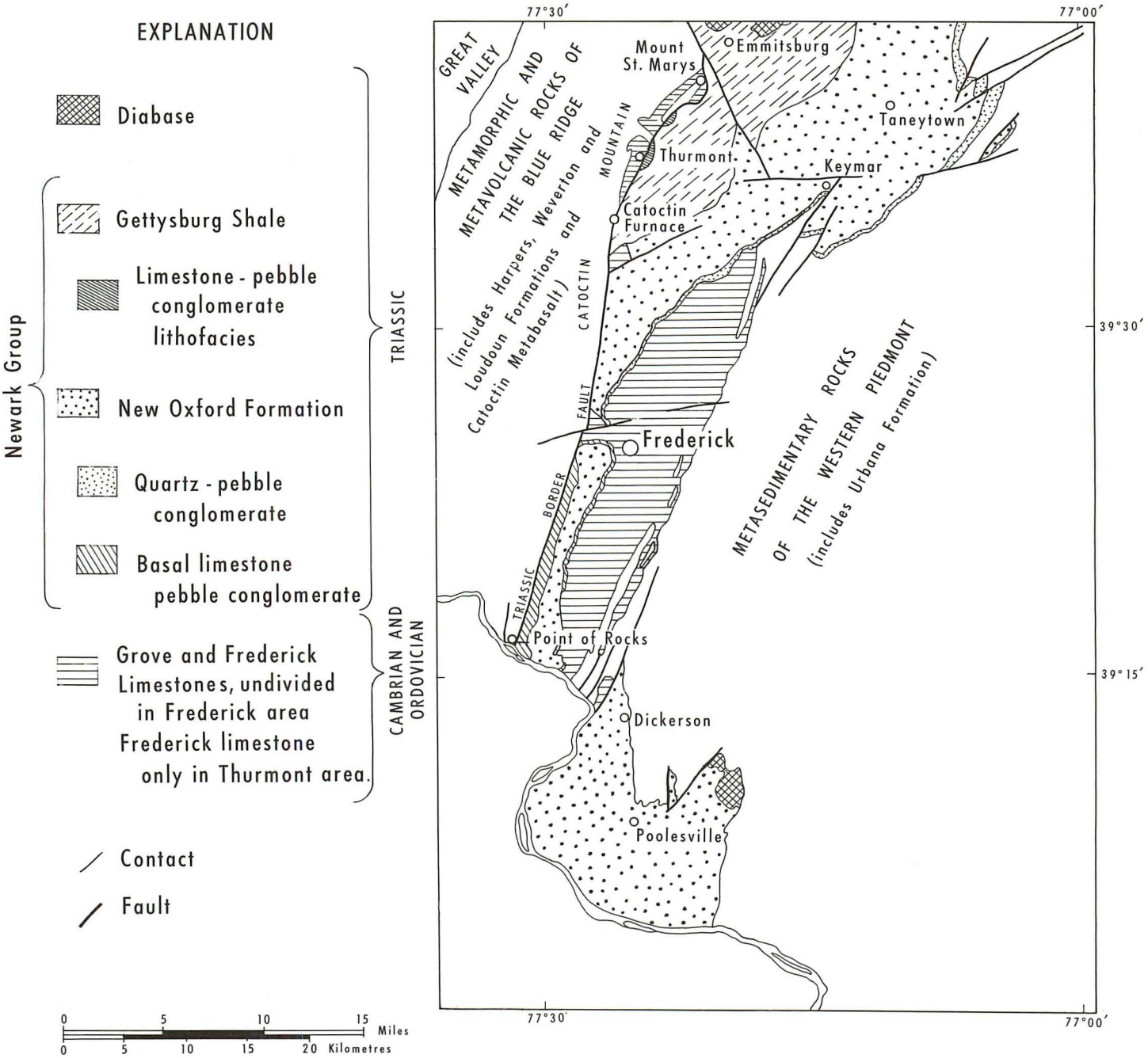


Figure 4.—Generalized geologic map of Triassic rocks in Maryland.

quartz grains. This calcium carbonate material may be caliche (Juergen Reinhardt, oral commun., 1974), somewhat similar to deposits described by Marine and Siple (1974) from cores recovered from a buried Triassic basin in South Carolina.

The thickness of the New Oxford Formation is estimated to be 4,500 ft (1,370 m) (Stose and Stose, 1946, p. 86). A thousand ft (305 m) of New Oxford Formation was penetrated in an oil test (Car-Bb 38) in Carroll County and in a water well at the Pepco Power Plant near Dickerson in Montgomery County (Mont-Cb 29).

Gettysburg Shale

The Gettysburg Shale is composed predominantly of red silty shale with subordinate amounts of soft red sandstone and red siltstone. The rather indefinite base of the Gettysburg Shale is placed where light-colored sandstones and arkoses of the underlying New Oxford Formation give way to shales that are uniformly red (Stose and Stose, 1946, p. 86).

In some areas near the Triassic border fault, especially in the vicinity of Thurmont, a limestone-pebble conglomerate lithofacies crops out. This unit is frequently concealed by mountain wash, a colluvial deposit of Quaternary age containing clay, sand, pebbles, and boulders. The extent of the limestone-pebble conglomerate unit is not accurately known, although it is certainly limited to a fairly small area. It is composed of limestone pebbles enclosed in a matrix of red sandy limestone and red calcareous shale and is interbedded with beds of red calcareous shale. An excellent exposure of this unit is in an abandoned quarry north of Moser Road on the east side of Hunting Creek near Thurmont.

The thickness of the Gettysburg Shale is estimated to be 5,000 ft (1,520 m) (Stose and Stose, 1946, p. 87).

Diabase dikes and sills intruding Newark Group

Several diabase dikes and three fairly large sills intrude Triassic rocks in Maryland. These dikes and sills postdate the deposition of the Newark Group. The location of the dikes is, in many places, marked by low ridges, but where there is no obvious topographic expression, they can be mapped by the abundant rust-colored boulders and cobbles of diabase at the surface.

The diabase in the dikes is composed of green feldspar crystals in a dark groundmass of augite. The medium-crystalline diabase is greenish-gray, and the fine-crystalline rock is nearly black. The sills are more coarsely crystalline than the dikes and are composed of elongate grayish plagioclase feldspar crystals enclosed in a groundmass of pyroxene.

The rocks of the Newark Group adjacent to the dikes and sills have been metamorphosed by the heat that accompanied the intrusion of the molten rock. The thickness of the zone of alteration, referred to as the baked zone, is in general proportional to the thickness of the dike or sill. The zone is more than half a mile wide adjacent to the sill northeast of Emmitsburg, whereas it is only a few feet wide adjacent to some of the smaller dikes.

Geologic structure of the Newark Group

General features: The Triassic rocks in Maryland are tilted gently to the northwest and west and are broken by several normal faults. A major fault (Triassic border fault), having several hundred feet of displacement, bounds the Triassic rocks on the west. However, Faill (1973, p. 725) interprets the Newark-Gettysburg basin in Pennsylvania to have developed by simple downwarp rather than by faulting.

The dip of the Triassic rocks in Carroll and Frederick Counties averages about 20° NW but ranges between 5° and 40°, and the strike is generally northeast. In Montgomery County, the dip averages about 10° W but ranges between 5° and 20°, and the strike is generally north. Reversals of regional northwest dip are rare, but Palmer (1949, p. 23) mapped reversals in a few places. Most of the dip reversals are found in the vicinity of Keymar and south of Taneytown. Near Keymar, the base of the New Oxford Formation is bent into a gentle fold apparently resulting from drag against a sizeable normal fault. In addition, the regional dip is altered by the two large diabase sills north of Emmitsburg causing the rocks for a distance of 4 or 5 mi (6 or 8 km) from the intrusions to dip north (Palmer, 1949, p. 23).

Faults: The Triassic border fault bounding the Triassic rocks on the west is the most important structural feature of the Triassic Lowland. Stose and Stose (1946) and Jonas and Stose (1938) mapped two nearly parallel faults along the eastern slope of Catoctin Mountain, the eastern fault being referred to as the Triassic border fault. The fault to the west of the Triassic border fault (Jonas and Stose, 1938) separates the Harpers Formation from the stratigraphically older Weverton and Loudoun Formations. However, Whitaker (1955) maps no Loudoun near the border fault and considers the contact between the Harpers and the Weverton on Catoctin Mountain to represent the normal stratigraphic sequence, thus eliminating the necessity for a fault. The latter explanation (shown on fig. 4) seems more reasonable because it requires less faulting.

In the area between Catoctin Furnace and Mount St. Marys, Stose and Stose (1946, p. 89) show a main fault between the Harpers Formation and the Frederick Limestone and a possible branch fault between the Frederick Limestone and the Gettysburg Shale. Whitaker (1955) saw no evidence for the main fault mapped by Stose and Stose and has placed the border fault between the Frederick Limestone and the Gettysburg Shale (fig. 4). The author agrees with Whitaker's interpretation, but recent well data indicate that the trace of the fault between Catoctin Furnace and Thurmont should be moved to the west about

0.25 mi (0.4 km). Well records are very useful for mapping the geology in the area adjacent to Catoctin Mountain because the bedrock is frequently covered by colluvium.

Several of the normal faults mapped in the Triassic seem to be based on rather tenuous evidence, for example, those near Taneytown and Keymar (fig. 4). Individual marker beds to prove displacement are rare and where present, have limited lateral extent.

Numerous moderately dipping synthetic faults and associated steeper dipping, less numerous antithetic faults have been mapped in the northern Frederick Valley (Palmer, 1949, p. 32). These faults commonly have only a foot or two displacement, and apparently represent adjustment to the dislocation along the major border fault to the west. Repetition by normal faulting, both by the small synthetic and antithetic faults and by other faults of larger displacement, has an important bearing on the calculated stratigraphic thickness of the Triassic rocks. It is probable that they are not as thick as the 25,000 to 30,000 ft (7,600 to 9,100 m) calculated by considering the dip and width of outcrop.

Joints: Joints are planes of separation between two rock masses where little or no displacement has occurred parallel to the plane. A series of parallel joints constitute a set, and in most areas there are two or more sets, forming a joint system.

In the Triassic rocks of the Frederick Valley, three joint sets are prominent and a fourth set is somewhat obscure (Palmer, 1949, p. 25). A set of nearly vertically dipping joints parallel to the strike of the bedding (strike joints) is probably most persistent, being found at nearly all outcrops. Another somewhat less prominent set usually strikes between N45°W and N60°W and dips steeply eastward. A third set strikes nearly east-west and cannot be observed at all outcrops. The three joint sets just described constitute a genetically related group which apparently is the result of shearing (Palmer, 1949, p. 25).

The fourth set of joints in the Newark Group is well defined and strikes approximately north-south. This prominent joint set apparently resulted from tension and postdates the other three sets described. The north-south tension joints are parallel to the diabase dikes in the Frederick Valley. These joints apparently offered the path of least resistance to the intrusion of the diabase because the tension tended to cause some separation of the rocks on the opposite sides of the joint planes.

GROUND-WATER HYDROLOGY

GENERAL HYDROLOGIC PRINCIPLES

Ground water is the water beneath the land surface in the zone of saturation—the zone where all the openings or interstices in the rocks or weathered mantle are filled with water. Above the upper surface of the zone of saturation (water table), the interstices are partly filled with water and partly filled with air.

Precipitation, the source of all ground water in the study area, is an element in the vast circulation system of the waters of the earth known as the hydrologic cycle. Water evaporates from the oceans and the land and becomes part of the atmosphere until it falls as rain or snow on the land or into the oceans. Some of the water falling on the land returns to the sea as surface runoff, some of it enters the soil zone and is transpired by plants, and some of it percolates downward to the zone of saturation. The ground water flows at a slow rate through the rocks, discharging through springs or seeps into streams; the streams eventually complete the cycle by returning the water to the ocean.

The porosity of a rock or soil is a measure of the interstitial space and is expressed as the percentage of the total volume of the rock or soil occupied by interstices. The capacity of an aquifer to store water is a function of its porosity. If the porosity originated when the aquifer was deposited or emplaced, it is termed primary porosity; if the porosity formed later as a result of jointing, faulting or weathering, it is termed secondary porosity. In consolidated sedimentary rocks, much of the primary pore space has been filled by compaction and cementation; thus, the available porosity is largely of secondary origin.

Water in an aquifer may occur under either unconfined (water-table) conditions or confined (artesian) conditions. In an unconfined aquifer the ground-water body is free to fluctuate in response to recharge to or discharge from the aquifer. Under confined conditions the water in an aquifer is confined under hydrostatic pressure beneath a relatively impermeable bed or layer of rock. In cased wells tapping a confined aquifer, the water level rises above the confining layer to a level called the potentiometric surface. When the potentiometric surface of an aquifer penetrated by a well is above the land surface, the well flows.

The capacity of a rock or soil to yield water

to wells is determined by its permeability or hydraulic conductivity, a measure of the ease of movement of water through a rock or soil under a hydraulic gradient. The permeability is governed chiefly by the number, size, shape, and degree of interconnection of the primary and secondary openings. The U. S. Geological Survey has adopted the term *intrinsic permeability* to refer to the property of the medium alone to transmit a fluid and *hydraulic conductivity* to include the properties of natural ground water that affect its ease of movement (Lohman, 1972, p. 5).

The *transmissivity* (T) indicates the capacity of an aquifer to transmit water through the entire thickness of an aquifer. It is defined as the rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient (Lohman, 1972, p. 6).

The *storage coefficient* (S) describes the capacity of an aquifer to store water. It is defined as the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head (Lohman, 1972, p. 8). The storage coefficient for unconfined aquifers is virtually equal to the specific yield, provided gravity drainage is complete.

The transmissivity and storage coefficient are commonly determined by means of aquifer tests. However, there are several problems, discussed in a later section of this report, involved in estimating and using T and S values based on aquifer tests in the Triassic-rock aquifers.

OCCURRENCE AND MOVEMENT

Ground water in the study area occurs in joints, faults, and bedding-plane partings in the rock and in some places in the interstitial pore space in the weathered rock mantle (residuum) below the zone of saturation. The interstitial pore space in the residuum formed as a result of weathering, mostly above the zone of saturation and within the zone of fluctuation of the water table. Some weathering-produced intergranular porosity also forms adjacent to joints, bedding-plane partings, and faults through which water moves. In the limestone-pebble conglomerate, solution along some joints and bedding planes has greatly increased the porosity and permeability.

The primary porosity that originally existed in the rocks has been almost eliminated by compaction and cementation; it is probably an in-

Table 5.—Porosity and Hydraulic Conductivity Data, Triassic-rock Aquifers.

Location	Depth (ft)	Effective porosity (percent)	Hydraulic conductivity (ft/d)	Description	Sample number
Laboratory results:					
U.S. 15 and Devilbiss Rd. Frederick Co.	0–0.5	42	4.6×10^{-2}	Residuum	72MD36
Do	0.5–1.0	24	3.6×10^{-1}	Do	72MD35
Do	1.5–2.0	28	1.3×10^{-1}	Do	72MD34
U.S. 15 north of Liberty Rd.	4.0	7.6	2.8×10^{-4}	Arkosic sandstone (chunk)	72MD42
Thomasville, Pennsylvania	333	0	impermeable at 234 psi	Arkosic sandstone (core)	72MD43
Do	373	0.23	3.03×10^{-5}	Siltstone (core)	72MD44
Geophysical log analysis:					
Dickerson, Montgomery Co.	210	6	——	Sandstone	
Do	320	3	——	Do	
Do	426	1	——	Do	
Do	694	1	——	Arkosic sandstone	
Do	830	<1	——	Argillaceous limestone	

significant factor in ground-water occurrence and movement. The few available data indicate that the primary porosity of the rocks of the Newark Group is less than 5 percent in most cases, but occasionally the interstitial pore space may be sufficient to store and transmit appreciable quantities of water. Table 5 contains some of the few data available on porosity and hydraulic conductivity of Maryland Triassic rocks.

HYDRAULIC PROPERTIES

The transmissivity and storage coefficient of an aquifer are normally determined by running aquifer tests in which a well is pumped at a constant rate and the drawdown is measured in the pumped well and in one or more observation wells. These data are used to construct time versus drawdown graphs from which T and S are computed.

The equations developed to compute T and S are based on several assumptions, including an isotropic and homogeneous aquifer. Because the Triassic-rock aquifers store and transmit water in a complex fracture system, substantial deviation from these assumptions is to be expected. In consequence of the anisotropic and nonhomogeneous nature of the Triassic-rock aquifers, the cone of depression caused by pumping a well is typically highly elongated in the direction of the strike of the bedding or the major joint set. Consider the hypothetical case of an observation well penetrating a fracture system in poor hydraulic connection with the fracture system penetrated by the pumped well. Under these conditions the observation well would experience little drawdown, and the computed T would be erroneously high. Conversely, if an observation well and the pumped well penetrate the same major fracture, the cone of depression would be highly elliptical along the strike of the fracture, and the computed T would be low.

Nevertheless, several aquifer tests have been run in the study area, and these data can be useful if they are applied with caution. Accordingly, table 6 contains a list of hydraulic coefficients from several aquifer tests in the Triassic-rock aquifers. The transmissivities listed in column 2 are based on evaluation of the aquifer tests, whereas those listed in column 5 were computed using a formula developed by Theis (1963, p. 335). This formula involves multiplying the specific capacity by a quantity containing the storage coefficient and the length of test. There are a few discrepancies between the transmissivities in columns 2 and 5, but in most cases these discrepancies are not significant. Those instances where the transmissivity in column 5 is substantially greater than in column 2 (as for Fr-Be 39), may indicate that a larger storage coefficient should have been used in the formula. In nearly all of the aquifer tests summarized in table 6, the storage coefficient could not be determined and was assumed to be 0.2 in the computation of the transmissivity. Hydraulic boundaries can also introduce substantial errors in the computation of transmissivities from specific-capacity data.

The transmissivity of the Triassic-rock aquifers, based on available aquifer-test data, would appear to range from less than 100 ft^2/d (9.3 m^2/d) to 2,700 ft^2/d (250 m^2/d). However, the 2,700 ft^2/d value is somewhat anomalous because the water comes from a highly permeable lime-

Table 6.—Aquifer-test data, Triassic-rock aquifers.

Well number	Transmissivity, in ft^2/d (pumped well)	Transmissivity, in ft^2/d (observation well)	Specific capacity, in (gal/min)/ft of drawdown (after 24 hrs or when boundary conditions were encountered)	Transmissivity, in ft^2/d (based on computation using specific capacity and formula by Theis, 1963, p. 335)	Length of test or number of hours after pumping began when boundary conditions were encountered
Mont-Dc 19	150	—	1.1	230	12
Mont-Dc 31	230	—	1.6	320	6
Mont-Cb 26	150	110	1.0	220	24
Mont-Db 16[1]	300	—	1.7	380	24
Mont-Db 26[1]	460	—	1.6	360	24
Fr-Be 39	2,700	—	20.6	4,600	24
Car-Bc 16	110	—	0.5	110	12
Car-Bb 6[2]	—	740	—	—	—

[1] Data from consultant's report to National Institutes of Health.
[2] From Meyer, 1958.

stone conglomerate member which locally contains extensive solution channels. Transmissivity values of this magnitude possibly could be expected only in a few favorable areas underlain by limestone conglomerate. Excluding the high value for well Fr-Be 39, the transmissivities in table 6 range from about 100 to 500 ft^2/d (9.3 to 46 m^2/d).

DEVELOPING A GROUND-WATER SUPPLY

FACTORS AFFECTING WELL YIELDS

Wells yielding sufficient water for domestic, farm, or small commercial use can be obtained almost anywhere in the study area; only 6.5 percent of the wells inventoried yielded less than 3 gal/min (0.2 l/s). However, wells yielding enough for industrial or municipal use are more difficult to locate, and ideally, test wells should be drilled to locate the best place for the production wells.

Well yields in the Triassic-rock aquifers are affected by several factors which should be considered when prospecting for a ground-water supply. These factors include: geologic structure, topographic position, lithology, and well depth. Theoretically, residuum thickness should influence well yields, but no definitive correlation could be developed between well yield and residuum thickness. Where thick residuum occurs below the zone of saturation, the aquifer in that vicinity clearly has greater storage capacity than in areas of thin residuum; however, thick residuum may have little direct influence on well yields, at least during short-term pumping tests. In addition, the residuum in the Triassic-rock aquifers is thin and seldom extends below the zone of saturation.

Geologic Structure

Geologic structure is the most important factor affecting well yields in the Triassic-rock aquifers because water occurs principally in joints, faults, and bedding-plane partings in the rock. The quantity of water a well yields depends primarily on the number of joints, faults, and bedding-plane partings penetrated by the borehole and the lateral extent or degree of interconnection of these fractures.

Knowledge of the location, orientation, and spacing of the joints and faults in the study area can be helpful in prospecting for moderately large ground-water supplies. Faults are fairly common in the Triassic rocks, but many are not mapped because the geology is not mapped in sufficient detail or because they are concealed by the residuum. However, where faults are mapped, areas near the fault trace offer promising sites for drilling test wells. The rocks near major fault zones are in many places severely sheared and fractured and may represent favorable localities for obtaining high-yielding wells even if the fault is not penetrated.

Knowledge of the orientation and spacing of joints can be helpful in prospecting for ground-water supplies. For example, if it is known that joints are closely spaced at a specific locality, whether from well data or field observation at an outcrop, test drilling along the strike of the most prominent joint set should indicate higher potential well yields than elsewhere. The stream network in the Triassic Lowland appears to be in part joint-controlled, although the relationship is not as definitive as in some other parts of the Piedmont or the Great Valley. Several hydrogeologists have used fracture traces on aerial photographs to assist them in locating potentially high-yielding wells, but the method has been used mostly in areas underlain by lower Paleozoic carbonate rocks and metamorphic rocks in the Piedmont (Lattman and Parizek, 1964; Woodruff and others, 1974). Fracture traces are probably helpful in prospecting for moderately large ground-water supplies in the study area, but fracture traces on aerial photographs in the Triassic Lowland are rather scarce. In addition, deep water-bearing zones which are fairly common in the Triassic-rock aquifers are unlikely to cause any surface expression.

Topographic Position

Wells drilled in valleys and draws in the study area have higher average yields than wells on slopes or hilltops. The explanation of this phenomenon apparently relates to the fact that the stream network is to some extent joint-controlled. Therefore, wells drilled in valleys or draws are more likely to intersect joint- and fault-planes than wells drilled on hilltops or slopes. The discussion of the effect of topographic position is closely related to the previous discussion of mapping fracture traces on aerial photographs because fracture traces frequently coincide with valleys and draws. However, lithology also controls the topography: for example, the areas underlain by limestone conglomerate usually form valleys and areas underlain by diabase dikes near-

ly always form ridges.

A three-fold subdivision of the available well records was adopted: hilltop, slope, and valley. The reported well yields in each category were listed in decreasing order, and frequencies were computed by the method used by Kimball (1946, p. 846). The reported yields were then plotted against cumulative frequency (fig. 5). The wells

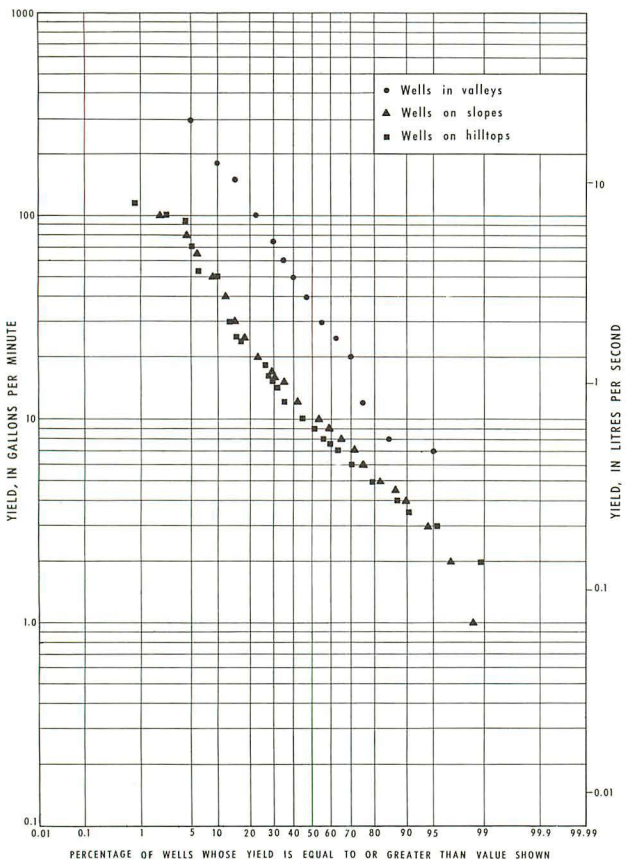


Figure 5.—Topographic influence on the yield of wells in the Triassic-rock aquifers.

penetrating limestone-pebble conglomerate hydrogeologic unit and diabase were not included in this analysis in an attempt to eliminate the effect of differences in lithology. There is virtually no difference in the water-bearing properties of wells on hilltops and slopes, but wells in valleys have substantially higher yields (fig. 5). The median (50th percentile) yield of the valley wells is 46 gal/min (2.9 l/s), whereas the median yield of the hilltop and slope wells is about 10 gal/min (0.6 l/s).

Lithology

Lithology is an important factor influencing the yield of wells in the Triassic-rock aquifers, and knowledge of the areal distribution of a lithofacies known to have high permeability can be valuable in locating high-yielding wells.

The basal limestone-pebble conglomerate of the New Oxford Formation southwest of Frederick and the limestone-pebble conglomerate lithofacies of the Gettysburg Shale, occurring locally near Thurmont, contain many of the highest-yielding wells in the study area and are considered as a hydrogeologic unit for the purpose of this report. The median yield of the wells in the limestone-pebble conglomerate hydrogeologic unit is 25 gal/min (1.6 l/s), compared with 10 gal/min (0.6 l/s) in the New Oxford Formation (excluding the basal limestone-pebble conglomerate) and 8 gal/min (0.5 l/s) in the Gettysburg Shale (excluding the limestone-pebble conglomerate lithofacies). The cumulative frequency graph of reported well yields in these three hydrogeologic units is shown in figure 6.

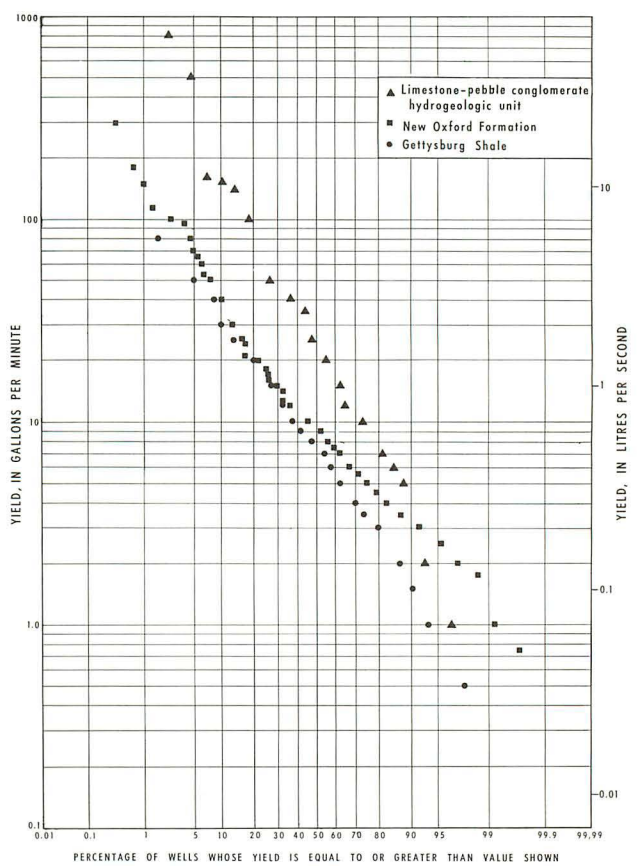


Figure 6.—Cumulative frequency graph of well yields in the Gettysburg Shale, New Oxford Formation, and limestone-pebble conglomerate hydrogeologic unit.

The limestone-pebble conglomerate hydrogeologic unit has superior water-bearing properties as a result of solution along bedding (fig. 7) and joint planes; its water-bearing properties are similar to those of the Frederick and Grove Limestone aquifers in the Frederick Valley (Nutter, 1973, p. 9).

Figure 7.—Effects of solution in the limestone-pebble conglomerate lithofacies of the Gettysburg Shale near Thurmont.

The slightly higher yield of wells in the New Oxford Formation compared to wells in the Gettysburg Shale (fig. 6) may be explained by the greater relative proportion of sandstone beds in the New Oxford. Analysis of well records, drillers' logs, and the few geophysical logs available, indicate that water-bearing zones more frequently occur within the sandstone beds than in the shale and siltstone beds. However, this knowledge is of somewhat limited value because individual sandstone beds can usually be traced for only short distances due to the rapid lateral facies changes in the Triassic rocks.

Table 7 summarizes well-yield data from the Triassic-rock aquifers in Maryland.

Well Depth

When maximum well yields are sought, it is essential to recognize the importance of drilling wells deep enough to realize the full potential of the aquifer (Nutter, 1974, p. 18). In some rock-types, such as the metamorphic and igneous rocks of the Piedmont, wells are unlikely to penetrate water-bearing zones below 250 or 300 ft (76 or 91 m). However, in the Triassic sandstone and shale aquifers, water-bearing zones below 250 ft (76 m) are much more common. Therefore, the average yield of deep wells in the Triassic-rock aquifers is substantially more than that of shallow wells (fig. 8).

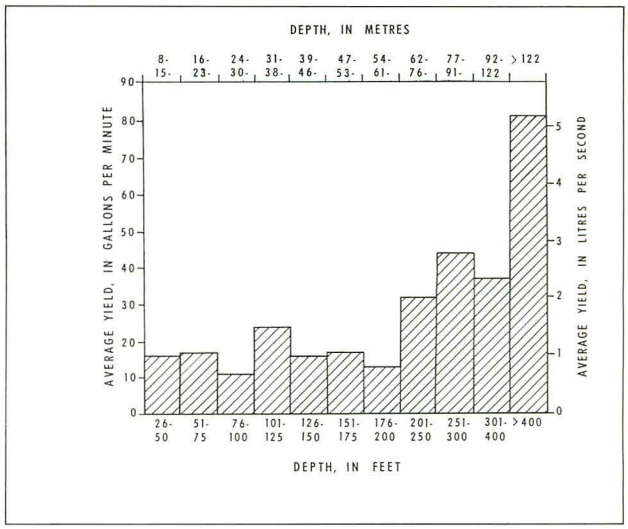


Figure 8.—Relation between well depth and average yield.

The data presented in figure 8 must be viewed with some caution because the depth of a well does not precisely indicate the depth to the water-bearing zone. However, figure 8 clearly indicates

Table 7.—Summary of well-yield data, Triassic-rock aquifers.

	Mean yield (gal/min)	Median yield (gal/min)	Mean specific capacity (gal/min)/ft	Median specific capacity (gal/min)/ft
New Oxford Formation	18	10	0.49	0.15
Gettysburg Shale	13	8	.47	.27
Limestone-pebble conglomerate hydrogeologic unit	69	25	1.90	.62
Diabase	6	5	.08	.07
Municipal and industrial wells	77	38	1.60	.57
Domestic and farm wells	15	8	.48	.18

a general correlation between depth and yield, although the yield per foot certainly decreases with depth.

A partial list of wells that penetrated deep water-bearing zones is given below.

Well no.	*Depth to water-bearing zone, in ft*
Mont-Cb 29	635
Mont-Cb 31	203
Mont-Dc 19	224
Fr-Dd 142	250
Car-Bb 38	480,615
Car-Bb 41	215,415
Car-Bc 16	335
Car-Bc 19	250

The relation between depth and yield explains in part the substantially higher average yields of municipal and industrial wells compared to domestic wells (fig. 9). Because wells drilled for household use only require about 3 gal/min (0.2 l/s), drilling is usually stopped when that quantity is obtained. By contrast, municipal and industrial users require several tens or even hundreds of gallons per minute, so these wells are almost invariably drilled deeper than domestic wells.

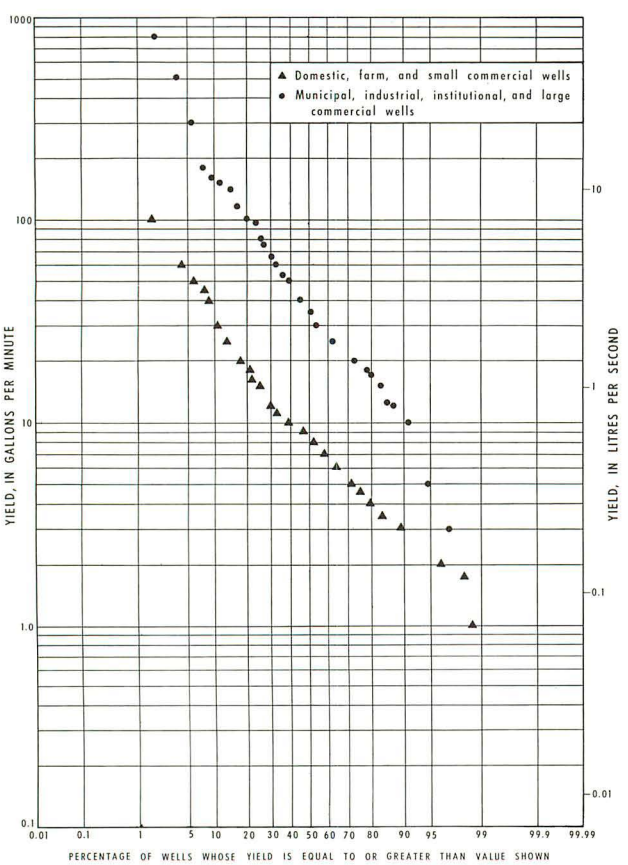


Figure 9.—Yield of domestic and farm wells compared with municipal and industrial wells.

WELL-STIMULATION TECHNIQUES

Several techniques are available for increasing well yields, but they have seldom been used by water-well contractors drilling in the study area, partly because of marginal cost-benefit ratios but also because most local water-well contractors are apparently unaware of the possibilities of stimulation. Most of the well-stimulation techniques were developed by the oil-well industry where increased oil production easily offsets the cost of such procedures, and the majority of oil wells have at some time been stimulated, some of them many times (Koenig, 1960, p. 333).

Well stimulation techniques include surging, shooting, vibratory explosion, pressure acidizing, and hydraulic fracturing.

Surging is more commonly used in the water-well industry than are the other techniques listed above. Surging involves a movement of water back and forth through the aquifer, accomplished by a surge block, air pressure, or alternately starting and stopping the pump. The purpose of surging is to remove fine material clogging the pore space or fractures in the aquifer.

Shooting consists of setting off explosives in the well. The object of shooting is to shatter the rock near the well and thus intercept water-bearing fractures that may be nearby but were not intercepted by the borehole. The improvement ratio for shooting is somewhat better than for surging (Koenig, 1960, p. 346), but this method has the serious disadvantage of expensive clean-out costs.

Vibratory explosion is a special form of shooting in which small charges are set off in rapid sequence. This technique is apparently somewhat less effective than ordinary shooting and seems to be mainly designed for removing incrustations in the well.

Pressure acidizing, which was developed in the oil industry, involves treatment with large volumes of acid solution, injected into the formation at high pressure. This procedure requires trained personnel and special equipment and is most effective in carbonate-rock aquifers or sandstone aquifers having calcareous cement.

Hydraulic fracturing seems to be the most effective of the well-stimulation techniques and offers considerable potential for use in the Triassic-rock aquifers. It involves injecting fluid into the well under such high pressure that the rock is actually fractured; sand is added to the fluid

to "prop open" the fractures. It is likely that hydraulic fracturing could substantially increase the specific capacity of water wells in Triassic rocks. However, because it requires trained personnel and special equipment, the cost may exceed the benefits in most cases.

WATER USE

Pumpage from the Triassic-rock aquifers in 1972 was about 2.2 Mgal/d (0.1 m^3/s), on the basis of pumpage records from those towns having municipal ground-water supplies (Taneytown, Thurmont, Poolesville, and Point of Rocks Estates) and on population statistics for those areas having individual wells. Emmitsburg has a municipal water system, but the water source is partly surface water and partly ground water from outside the study area. The town of Thurmont uses water from High Run and water from a well in the limestone-pebble conglomerate lithofacies of the Gettysburg Shale. Point of Rocks Estates has a privately-owned central ground-water supply obtaining water principally from wells in the basal limestone-pebble conglomerate of the New Oxford Formation. Taneytown obtains its water supply exclusively from 10 wells in the New Oxford Formation. Poolesville's water supply is from two wells in the New Oxford Formation, but approximately half the town's population is supplied by individual wells. The remaining towns, villages, housing developments, and farms in the study area obtain their water supply from individual wells; the combined domestic and farm use far exceeds the municipal ground-water use (fig. 10).

The industrial, institutional, and large commercial use accounts for only 3 percent of the 1972 total annual ground-water use of 808.7 Mgal (3.06 billion l) in the Triassic-rock aquifers.

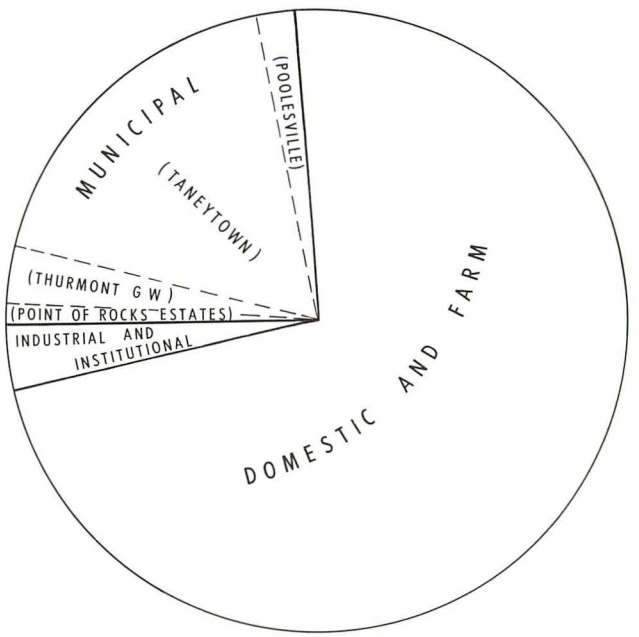


Figure 10.—Ground-water use in the study area.

WATER QUALITY

The water in the New Oxford Formation and the Gettysburg Shale aquifers is generally of good chemical quality, except in a few places subject to contamination. The native water is hard, especially in the limestone-pebble conglomerate hydrogeologic unit, and in some places it may have objectionable concentrations of iron and fairly low pH. In addition, the concentration of silica may be excessive for some industrial uses.

During the investigation, 28 samples of well water were collected for chemical analysis and 10 analyses were available from previous studies. The wells for which chemical analyses are available, including those from previous studies, are shown on plate 1 as a circled dot. In addition, nitrate, chloride, specific conductance, total coliform bacteria, and fecal coliform bacteria determinations were made on samples from 49 wells and one spring in four selected areas in Frederick County.

The complete chemical analyses are listed in table 4 and the chemical quality data are summarized in table 8.

The dissolved minerals in ground water are

Table 8.—Summary of water-quality data from the Triassic-rock aquifers. (Based on data in Table 4)

Concentration, in milligrams per litre except as indicated

Constituents	Maximum	Minimum	Mean	Median	Maximum concentration recommended for drinking water[1]
Silica	44	7.8	19	20	
Calcium	79	8.0	42	44	
Magnesium	27	1.9	10	8.2	
Sodium	42	2.2	11	9.7	
Potassium	2.5	.3	.9	.7	
Iron μg/l (micrograms per litre)	4,900	<0	313	65	300
Manganese (μg/l)	700	0	36	<5	50
Bicarbonate	286	21	148	151	
Sulfate	131	.2	21	14	250
Chloride	88	1.2	12	7.0	250
Fluoride	.4	<.0	.1	.1	1.2[2]
Nitrate (includes 39 complete analyses and 50 partial analyses)	97	.9	22	19	45
Dissolved solids (sum)	388	63	203	194	500
Hardness (Ca, Mg)	290	28	147	130	
Non-carbonate hardness	140	0	28	14	
Specific conductance (micromhos per cm at 25°C)	567	80	330	316	
pH	8.5	6.0	7.7	7.8	

[1] U.S. Public Health Service, 1962.
[2] Recommended limits for fluoride vary according to the annual average maximum daily air temperature. In the study area the recommended upper limit of fluoride concentration is 1.2 mg/l.

derived chiefly from the soils and rocks through which the water moves. The factors that control the chemical quality of ground water include the mineral composition of the soil and bedrock, the amount and seasonal distribution of precipitation, the mean annual temperature, the rate at which the water moves through the rocks or soil, and the duration of water-rock contact. In addition, the chemical quality of the water may be influenced by underground disposal of domestic sewage (septic-tank tile fields), disposal of industrial and solid wastes, and use of fertilizers and pesticides.

Water in the Triassic-rock aquifers is chiefly the calcium bicarbonate type. The chemical character of the water in some cases has been altered by the addition of nitrate and chloride derived from the decomposition of organic wastes. The fairly high concentration of nitrate in some water samples may be derived from chemical fertilizers spread on lawns and fields.

RELATION OF CHEMICAL QUALITY TO USE

The following section is a brief discussion of those chemical constituents that most frequently cause water-quality problems in the study area.

Silica

Silica is dissolved from quartz, feldspar, and other siliceous minerals in rocks and is a common constituent in nearly all ground water, although it is seldom present in high concentrations. Silica has little effect on domestic and most other uses of water, but it affects some industrial uses because it contributes to the formation of boiler scale and must be removed from feed water for most high-pressure boilers.

The silica concentration of the 38 wells sampled in the Triassic-rock aquifers is within the range expected for most quartzose rocks. It is interesting to note that the two wells having the highest concentration of silica, 44 and 33 mg/l (milligrams per litre), are adjacent to a diabase dike (table 4).

Hardness

Hardness is one of the most important fac-

tors affecting water use; hard water consumes more soap than soft water and causes the formation of a sticky, insoluble curd. Excessive hardness is objectionable because the curd is difficult to remove from containers and fabrics and because a scale is deposited in steam boilers, water pipes, and cooking utensils. The principle cause of hardness is the solution of compounds of calcium and magnesium. Other constituents causing hardness (iron, manganese, aluminum, barium, strontium, and free acid) are usually present in quantities too small to cause significant hardness.

The following hardness classification is used in this report:

Hardness as $CaCO_3$ in mg/l	*Classification*
0– 60	Soft
61–120	Moderately hard
121–180	Hard
More than 180	Very hard

On the basis of the above classification, approximately two-thirds of the wells sampled are moderately hard to hard. Water from wells penetrating the limestone conglomerate is generally harder than water from wells penetrating sandstone and shale.

Iron and Manganese

Iron and manganese are common elements in nature, but are generally dissolved in ground water in only small concentrations. Water can be made unsuitable for most uses by the presence of iron in concentrations of only a few tenths of a milligram per litre; even smaller concentrations of manganese can make water unsuitable for use. Concentrations of iron in excess of 300 μg/l (micrograms per litre, or 0.3 mg/l) cause stains on plumbing fixtures, cooking utensils, and fabrics, and concentrations of greater than 1,000 μg/l iron can cause clogging of pumps and plumbing fixtures. Concentrations of manganese in excess of 200 μg/l can cause the formation of a dark-brown or black stain on porcelain fixtures and fabrics. The Public Health Service (1962) recommends that no more than 300 μg/l iron or 50 μg/l manganese should be present in a water supply where other more suitable supplies are readily available.

Seven of the wells sampled (18.4 percent) contained concentrations of iron exceeding Public Health Service standards; five of the wells sampled (13.1 percent) contained concentrations of manganese exceeding Public Health Service standards (Table 4). Excessive concentrations of iron and manganese constitute the most common water-quality problem in the study area.

Nitrate

General Features: Nitrate (reported as NO_3) is a common constituent in ground water and in many cases its presence in high concentrations is directly attributable to contamination. Nitrogen is essential to living organisms, and nitrate is the final product of oxidation in the nitrogen cycle. The source of nitrate in excess of 10 or 15 mg/l, the probable maximum concentration in natural ground water in the study area, likely originated as septic-tank effluent, barnyard wastes, or chemical fertilizers. High nitrate concentration is probably the most serious water-quality problem in the study area.

Several medical studies have indicated that nitrate exceeding 45 mg/l in drinking water may contribute to or be the main cause of a condition in infants known as methemoglobinemia (infant cyanosis or "blue babies"). Therefore, water containing nitrate in excess of 45 mg/l should not be used for infant feeding, according to the U. S. Public Health Service (1962, p. 49).

The occurrence of high nitrate is quite variable and seems to be associated with wells that are improperly constructed or located in proximity to septic-tank tile fields or barnyard wastes.

In order to study the influence of lot size and the age of wells and the septic systems on the occurrence of nitrate in ground water, water samples were collected in two villages (Lewistown and Graceham) where the average age of the wells and septic systems was more than 15 years, and in two housing developments (Catoctin Manor Estates and Utica) where the average age of the wells and septic systems was less than 5 years. All four sampling sites had individual wells and septic systems. A total of 49 water samples was collected for partial analysis of chemical and bacteriological properties; specific conductance and temperature were measured in the field. Table 9 lists the results of the analyses.

Catoctin Manor Estates and Utica: All the water samples from the housing developments having fairly large lots and fairly new wells contained less than 45 mg/l nitrate. However, in Catoctin Manor Estates, where lots are only moderately large (about one-half to three-quarters of an acre) and the average age of the wells sampled was 5 years, the nitrate concentration of many of the wells appears to exceed that expected in natural ground water (table 9).

Analyses from wells sampled at Utica, where the lots average more than 2 acres and the average age of the wells sampled was 2 years, revealed low levels of nitrate (mean concentration 13 mg/l), and all coliform bacteria tests were negative.

Graceham and Lewistown: Both of the villages having fairly old wells and fairly small lots,

Table 9.—Partial chemical and bacteriological analyses of water samples from wells in fours areas in Frederick County.

Well number	Specific conductance (micromhos/cm at 25°C)	Cl (mg/l)	NO_3 (mg/l)	Total Coliform (colonies per 100 ml sample)	Fecal Coliform (colonies per 100 ml sample)
		CATOCTIN MANOR ESTATES			
Fr-Dd 139	220	4.5	20	None	None
Fr-Dd 144	195	4.1	19	None	None
Fr-Dd 156	140	6.8	38	None	None
Fr-Dd 158	115	3.0	19	None	None
Fr-Dd 159	155	6.9	31	None	None
Fr-Dd 161	145	2.4	25	None	None
Fr-Dd 162	200	5.1	30	None	None
Fr-Dd 163	190	11	26	2	None
Fr-Dd 164	315	7.1	18	2	None
Fr-Dd 165	108	2.4	22	None	None
Fr-Dd 166	150	7.0	42	3	None
Fr-Dd 167	80	2.4	33	None	None
Fr-Dd 168	245	29	25	4	None
Fr-Dd 169	290	5.5	22	18	Test not valid
Fr-Dd 170	330	9.0	19	2	None
Fr-Dd 171	230	7.5	14	None	None
Fr-Dd 172	270	7.2	16	None	None
Fr-Dd 173	205	14	9.3	Test not valid	None
Fr-Dd 174	270	6.5	19	None	None
		UTICA			
Fr-Ce 36	245	2.0	12	None	None
Fr-Ce 37	325	2.0	13	None	None
Fr-Ce 49	310	4.1	17	None	None
Fr-Ce 50	320	3.1	12	None	None
Fr-Ce 51	300	2.0	11	None	None
		GRACEHAM			
Fr-Be 49	330	35	80	None	None
Fr-Be 50	305	24	62	None	None
Fr-Be 51	630	76	97	59	None
Fr-Be 52	270	19	44	None	None
Fr-Be 53	430	52	62	None	None
Fr-Be 54	530	30	49	None	None
Fr-Be 55	310	26	24	None	None
Fr-Be 56	355	—	—	None	None
Fr-Be 57	650	40	66	75	10
Fr-Be 58	560	20	42	None	None
Fr-Be 59	420	16	38	None	None
Fr-Be 60	170	7.4	33	6	1
		LEWISTOWN			
Fr-Cd 33	635	39	25	1	None
Fr-Cd 34	580	28	43	None	1
Fr-Cd 35	490	21	19	None	None
Fr-Cd 36	610	26	22	5	None
Fr-Cd 37	640	55	10	None	None
Fr-Ce 40	670	34	20	None	None
Fr-Ce 42	625	34	27	—	—
Fr-Ce 43	460	21	21	None	None
Fr-Ce 44	920	66	62	None	None
Fr-Ce 45[1]	1200	110	6.6	None	None
Fr-Ce 46	800	42	4.9	None	None
Fr-Ce 47	450	12	39	None	None
Fr-Ce 41	470	44	18	25	3

[1] Water softener

contained wells with nitrate concentrations exceeding 45 mg/l; however, in Lewistown, only one water sample exceeded Public Health Service standards.

The size of the lots in Lewistown is variable: about half the wells sampled are on lots smaller than half an acre, but a few of the lots are larger than an acre. The wells having higher nitrate concentrations are on small lots for the most part. A somewhat puzzling aspect of the chemical-quality data from the wells sampled at Lewistown concerns their high chloride concentrations. The average nitrate concentration in Lewistown is only slightly higher than at Catoctin Manor Estates, but the average chloride concentration is substantially higher in Lewistown (table 9). The apparently anomalous chloride concentration of the Lewistown wells may be the result of the application of salt over a period of several years on the State highway passing through town. Another possible source of chloride is from regeneration of ion exchange water softeners using sodium chloride because the water used in regeneration is dumped into the septic systems.

Lots in the village of Graceham are exceptionally small and the average age of the wells sampled was about 30 years. Nearly half of the wells sampled in Graceham contained nitrate in excess of 45 mg/l and only one sample contained less than 30 mg/l.

Ground-water supplies in communities having individual wells and septic systems on small lots represent a potential health hazard, especially if wells are inadequately constructed.

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APPENDIX

Well Tables

Descriptions of the wells inventoried during this study are given in tables 1-3. Many of these data are reported by well drillers on completion reports filed with the Maryland Water Resources Administration. The location of all wells inventoried were checked in the field and, where practical, water-levels were measured. Most of the reported data are believed to be accurate, although in some cases the yields were estimated, and often the well-acceptance tests were of short duration. The depth and length of casing are usually accurate, and the length of casing is usually a reliable estimate of the residuum thickness. However, a minimum of 20 ft (6 m) of casing is required by Montgomery County regardless of the depth to bedrock.

Several wells penetrating aquifers adjacent to the Triassic-rock aquifers are included in the well records (tables 1-3). These wells are located within 5-minute quadrangles where Triassic rocks crop out and were included in order to avoid leaving "gaps" in the well-numbering system.

The chemical analyses of water-well samples available for study are listed in table 4 and the location of the wells are shown on plate 1 as a circled dot. Table 4 includes 10 chemical analyses from previously published reports, but the records of these wells are not included in tables 1-3.[1]

The second column in table 4 lists the aquifer codes that identify the geologic unit from which the water sample was collected; this aquifer code was devised for storing the chemical analyses in the U. S. Geological Survey water-quality computer file. The first 3 numbers identify the geologic age and the last 4 or 5 letters identify the formation name. The aquifer codes listed in table 4 and the aquifers they identify are:

231 NOXF	—New Oxford Formation
231 NOXFB	—New Oxford Formation (basal limestone-pebble conglomerate)
231 GBRG	—Gettysburg Shale
231 DIBS	—Diabase

[1] Partial chemical analyses are included in table 9.

Table 1.--Records of wells in Carroll County

Well number: See text for description of well-numbering system. Well locations are shown on Plate 1.

Static water level: Reported depths are given in feet; measured depths are given in feet and tenths or hundredths.

Water use codes

C Commercial
F Fire
H Domestic
I Irrigation
N Industrial
P Public supply
R Recreational
S Stock
T Institutional
U Unused

Pump type codes

B Bucket
J Jet
N None
P Piston
S Submergible
T Turbine

Remarks codes

A Aquifer test run
Q See chemical analysis
Z Well destroyed

Car- Well number	State permit number	Owner	Driller	Date completed	Altitude (feet)	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Water-bearing formation	Water level (feet below land surface) Static	Date	Pumping	Yield (gpm)	Hours pumped	Specific capacity (gpm/ft)	Use of water	Pumping equipment	Remarks
Ab 8	CL690051	Earl Mabe	Keyser	1968	525	130	6	36	New Oxford Fm	40	8/15/68	-	8	1	-	H	S	
Ab 9	CL690159	Ralph W. Vaughn	Funt	1968	500	150	6	22	do	60	10/15/68	142	5	1	0.06	H	S	
Ab 10	CL690223	R. Strickhouser	Reider	1968	490	185	6	23	do	35	11/20/68	183	1	1	.01	H	S	
Ab 11	CL690088	Russell Haines	-	1968	500	195	6	20	do	35	12/12/68	200	6	1	.04	H	S	
Ab 12	CL690411	John S. Clagett	Reider	1969	460	100	6	25	do	27	6/18/69	98	30	1	.42	H	S	
Ab 13	CL67W409	Francis Reaver	do	1967	465	95	6	20	do	23	2/15/67	93	50	1	.71	H	J	
Ab 14	CL67W429	Fred Hyser	do	1967	510	110	6	20	do	35	3/29/67	110	5	1	.07	H	S	
Ab 15	CL67W314	Charles F. Sanders	do	1966	545	142	6	20	do	41	11/17/66	140	7	1	.07	H	S	
Ab 16	CL710009	W. E. Fink	do	1970	526	160	6	20	do	36.5	6/7/72	160	10	1	.08	H	S	
Ab 17	CL67W270	E. R. Clabaugh	do	1966	543	164	6	23	do	35	10/7/66	164	8	1	.06	H	S	
Ab 18	CL67W466	Norman Lee Welty	do	1967	505	90	6	21	do	13	4/21/67	80	5	-	.07	H	S	Water reported cloudy
Ac 15	CL690167	Glen Wantz	Sterner	1969	550	200	6	40	do	31	3/26/69	-	2	-	-	H	S	
Ac 16	CL690341	Homer Degroft	Reider	1969	560	84	6	28	do	15	4/14/69	70	10	-	.18	H	S	
Ac 17	CL690033	Calvin Voris	do	1968	545	125	6	20	do	30	7/26/68	123	3.5	-	.03	H	S	
Ac 18	CL670223	Vernon Koontz	do	1966	540	96	6	23	do	30	9/26/66	81	4.5	-	.09	H	S	
Ac 19	CL670086	Robert Rinehart	McDonnell	1966	560	75	6	23	do	12	9/23/66	-	-	2	-	H	S	
Ba 9	CL670303	United Church of Christ	Reider	1966	490	100	6	37	do	30	11/1/66	85	5	1	.09	H	S	
Ba 10	CL700004	Carroll Wilhide	Keyser	1969	440	430	6	32	do	45	7/8/69	-	12	1	-	S	S	
Bb 38	G 36	R. H. Sheppard	Jack Drlg	1962	472	6230	-	-	do	-	-	-	-	-	-	U	N	Z, water reported at 70,175,480,and 615 ft
Bb 39	-	Allen Feeser	-	1954	510	320	6	18	do	60	7/ /71	-	About 60	-	-	C	S	Supplies warehouse Hardness 154 mg/l
Bb 40	None	Town of Taneytown	Kohl	1964	500	394	10	33	do	36	/64	284	180	24	.73	P	T	
Bb 41	CL670338	do	do	1967	495	600	12	131	do	39	7/31/67	400	300	24	.83	P	T	Water reported at 100, 215, and 415 ft; Q
Bb 42	CL690078	Wilbur S. Butler	Driver	1968	480	85	6	19	do	40	6/1/68	50	5	-	.50	H	S	
Bb 43	CL690200	David Grayson	Reichart	1968	510	212	6	17	do	35	11/22/68	-	10	-	-	H	S	
Bb 44	CL690017	B. Ausherman	Reider	1968	545	89	6	22	do	20	7/26/68	80	8	-	.13	H	S	
Bb 45	CL690106	Leonard Singel	do	1968	520	135	6	20	do	32	8/29/68	153	4	1	.03	H	S	
Bb 46	33580	Shower Lumber	Keyser	1958	500	200	6	23	do	30	7/28/58	-	10	3	-	N	S	
Bb 47	CL670225	Harley W. Weeks	Reider	1966	510	159	6	22	do	45	10/3/66	159	14	-	.12	H	S	
Bb 48	CL670265	Eugene Legg	do	1966	460	129	6	22	do	22	10/10/66	129	10	1	.09	H	S	
Bb 49	CL670274	Hugh T. Engel	do	1966	-	99	6	23	do	15	10/11/66	99	9	1	.12	H	S	
Bb 50	CL670362	Albert Wilhide	do	1967	500	110	6	20	do	25	2/6/67	108	8	1	.10	H	S	
Bb 51	CL670024	Clarence Hesson	Keyser	1966	520	175	6	32	do	60	7/20/66	-	12	1	-	H	S	
Bb 52	CL670549	Samuel C. Smith	Reider	1967	510	140	6	20	do	43	6/7/67	138	30	1	.32	H	S	
Bb 53	CL670059	Roy J. Renner	do	1966	450	163	6	21	do	48	8/16/66	161	3	1	.03	H	S	
Bb 54	CL670528	Art Stonesifer	do	1967	445	160	6	37	do	51	6/2/67	158	4	1	.04	H	S	
Bb 55	CL670607	Truman Keefer	do	1967	465	162	6	20	do	43	7/5/67	166	6	1	.05	H	S	
Bb 56	CL690413	Robert Stouffer	do	1969	510	125	6	20	do	33	6/16/69	123	30	1	.33	H	S	30 gpm at 118 ft
Bc 16	CL720308	U.S. Geol. Survey	Keyser	1971	500	690	6	60	New Oxford Fm (qtz-pbl cngl)	14.27	11/29/71	39.4	40	7	.50*	U	N	Z; Q; *Sp. cap. based on discharge of 13 gpm
Bc 17	36379	Town of Taneytown	Kohl	1959	570	416	10	34	New Oxford Fm	40	12/22/59	240	115	24	.75	P	T	
Bc 18	CL690169	Milton Bankhard	Reider	1969	-	80	6	20	do	32	6/12/69	78	6	1	.13	H	S	
Bc 19	CL670242	Brown Equip. Co.	do	1966	550	264	6	23	do	40	9/29/66	264	10	1	.04	C	S	
Bc 20	CL670334	Valley Crest	do	1967	490	90	6	20	do	30	3/3/67	88	4	1	.08	H	S	

Table 1.-- Records of wells in Carroll County--Continued

Well number: See text for description of well-numbering system. Well locations are shown on Plate 1.

Static water level: Reported depths are given in feet; measured depths are given in feet and tenths or hundredths.

Water use codes

C Commercial
F Fire
H Domestic
I Irrigation
N Industrial
P Public supply
R Recreational
S Stock
T Institutional
U Unused

Pump type codes

B Bucket
J Jet
N None
P Piston
S Submergible
T Turbine

Remarks codes

A Aquifer test run
Q See chemical analysis
Z Well destroyed

Car- Well number	State permit number	Owner	Driller	Date completed	Altitude (feet)	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Water-bearing formation	Water level (feet below land surface) Static	Date	Pumping	Yield (gpm)	Hours pumped	Specific capacity (gpm/ft)	Use of water	Pumping equipment	Remarks
Bc 21	CL670522	A. J. Irvin, Jr.	Reider	1967	460	195	6	23	New Oxford Fm	43	6/5/67	193	20	1	0.13	H	S	
Bc 22	CL690193	L. P. Hartsock	Greene	1968	525	112	6	22	do	20	11/1/68	35	24	2	1.6	H	S	
Bc 23	CL680077	Vernon Flickinger	do	1968	550	200	6	20	do	40	8/28/68	198	12	1	.08	S	S	Chicken farm
Bc 24	CL720030	H. G. Trumpower	Reider	1971	535	95	6	20	do	26	8/21/71	94	30	1	.44	H	S	
Cb 16	CL670224	Doug Yingling	do	1966	490	204	6	20	do	28	9/27/66	204	3	1	.02	H	S	

Table 2.--Records of wells in Frederick County

Well number: See text for description of well-numbering system. Well locations are shown on Plate 1.

Static water level: Reported depths are given in feet; measured depths are given in feet and tenths or hundredths.

Water use codes

C	Commercial	P	Public supply
F	Fire	R	Recreational
H	Domestic	S	Stock
I	Irrigation	T	Institutional
N	Industrial	U	Unused

Pump type codes

B	Bucket
J	Jet
N	None
P	Piston
S	Submergible
T	Turbine

Remarks codes

A	Aquifer test run
Q	See chemical analysis
Z	Well destroyed

Fr- Well number	State permit number	Owner	Driller	Date completed	Altitude (feet)	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Water-bearing formation	Water level (feet below land surface) Static	Date	Pumping	Yield (gpm)	Hours pumped	Specific capacity (gpm/ft)	Use of water	Pumping equipment	Remarks
Af 21	FR720027	Marshall Sharrer	Cline	1971	445	170	6	40	Diabase	30	7/27/71	170	10	1	0.07	H	S	
Af 22	FR720106	James D. Bowne	do	1971	445	95	6	40	do	40	9/6/71	95	100	1	1.82	H	S	
Af 23	FR710473	Jack M. Kling	Keyser	1971	420	202	6	20	Gettysburg Shale	30	4/26/71	200	50	1	.30	H	S	Q
Af 24	35425	Town of Emmitsburg	do	1959	405	161	6	23	do	30	7/21/59	97	5	3	.07	-	S	Water used for washing sewage plant
Af 25	FR720319	James Topper	do	1971	465	302	6	36	do	25	11/18/71	-	8	1	-	H	S	
Bd 49	FR710428	National Park Service	Keyser	1971	820	202	6	30	Weverton Fm	9.68	4/5/71	22	18	3	1.5	R	S	Camp Peniel
Bd 50	FR710582	Mrs. C. Rodgers	Cline	1971	450	68	5	63	Gettysburg Shale (ls-pbl cngl)	22	6/12/71	68	50	1	1.1	H	S	
Bd 51	FR710573	Elmer Sweeney	do	1971	455	45	6	40	Gettysburg Shale	12	6/11/71	45	50	1	1.6	H	S	
Bd 52	FR720200	James R. Fraley	Keyser	1971	520	121	6	115	do	48	10/8/71	-	15	1	-	H	S	
Be 38	FR690518	Town of Thurmont	do	1969	470	105	8	29	Gettysburg Shale (ls-pbl cngl)	5	7/16/69	47	500	13	11.4	P	T	
Be 39	FR720327	Town of Thurmont	do	1971	470	300	8	70	do	3	12/28/71	45	800	48	16.0	P	T	See well log, Q
Be 40	FR710513	Russell L. Moser	Cline	1971	460	210	6	70	Gettysburg Shale	65	5/10/71	210	50	1	.34	H	S	Q
Be 41	FR710569	Harry Gibson	Keyser	1971	455	222	6	41	do	40	6/21/71	-	20	1	-	H	S	
Be 42	FR720090	James Carbaugh	Funt	1971	490	80	6	20	do	8	8/12/71	24	20	2	1.3	H	S	
Be 43	FR720241	Harold Late	Cline	1971	410	245	6	45	do	25	10/12/71	245	8	1	.04	H	S	
Be 44	FR720105	Dale Sharrer	do	1971	450	195	6	20	do	20	8/19/71	195	10	1	.06	H	S	
Be 45	FR720311	Morris F. Free	do	1971	380	170	6	20	do	60	11/20/71	170	5	1	.05	H	S	
Be 46	FR730087	Thomas F. Seiss	do	1972	460	170	6	42	do	45	8/16/72	170	12	1	.10	H	S	
Be 47	FR730039	Charles Wastler	do	1972	460	170	6	42	do	45	8/16/72	170	3	1	.02	H	S	
Be 48	FR710177	William Morningstar	do	1970	450	125	6	40	do	40	10/15/70	125	25	1	.29	H	S	Q
Be 49	-	Paul Yingling	-	about 1950	490	50	6	-	do	-	-	-	-	-	-	H	J	Q
Be 50	-	C. V. Gearhart	Wantz	about 1945	490	75	6	-	do	-	-	-	-	-	-	H	J	Q
Be 51	-	Alois Meixner	-	before 1960	490	about 75	6	-	do	-	-	-	-	-	-	H	J	Q, well supplies adjacent house
Be 52	16703	Mable Null	Harris	1954	490	102	6	-	do	40	11/2/54	80	-	-	-	H	J	Q
Be 53	29011	Alton Trout	Keyser	1958	490	109	6	21	do	30	1/1/58	50	8	3	.40	H	S	Q
Be 54	-	M. B. Long	-	1960	480	100	6	-	do	-	-	-	-	-	-	H	S	Q, well supplies 2 adjacent houses and a store
Be 55	-	M. V. Springer	-	about 1900	480	35	48	35	do	30		-	-	-	-	H	P	Q, dug well
Be 56	-	C. H. Boller	-	before 1900	470	34	48	34	do	30		-	-	-	-	H	C	Q, dug well
Be 57	-	Ronnie Miller	-	about 1940	460	about 100	6	-	do	-	-	-	-	-	-	H	J	Q
Be 58	28868	Moravian Church	Keyser	1957	440	124	6	20	do	40	10/5/57	65	10	2	.40	H	S	Q, softener
Be 59	24989	James Bentz	do	1956	460	100	6	13	do	10	10/5/56	100	3	1	.03	H	S	Q
Be 60	-	Moravian Church	-	-	440	-	-	-	do	-	-	-	-	-	-	U	N	Q, spring
Be 61	FR710279	Harold Long	Cline	1970	430	225	6	40	do	40	12/8/70	225	25	1	.13	S	S	
Be 62	42001	Thomas, Bennett, and Hunter	Kohl Bros.	1961	460	120	6	21	do	10	3/20/61	80	25	1	.36	U	S	Use formerly N
Bf 21	FR720096	George Moser	Cline	1971	450	170	6	40	Gettysburg Shale (baked zone)	45	10/16/71	170	4	1	.03	H		Penetrated 90 ft of diabase
Bf 22	FR720092	Guy Ohler	Reider	1971	370	95	6	36	Gettysburg Shale	25	8/26/71	95	5	1	.07	H		
Bf 23	FR710538	Floyd Seiss	Cline	1971	460	170	6	20	New Oxford Fm	25	5/24/71	170	5	1	.03	H		
Bf 24	FR710405	Thomas H. Hahn	Cromwell	1971	410	85	6	21	New Oxford Fm (baked zone)	-	4/15/71	85	9	2	-	H		Q
Bf 25	FR720270	Marvin Stambaugh	do	1971	410	105	6	21	do	25	11/18/71	105	7	1	.09	H		
Bf 26	FR720371	M. L. Ausherman	Cline	1971	370	295	6	38	New Oxford Fm	48	12/20/71	295	7	1	.03	H		
Bf 27	FR720298	Forrest Knipple	do	1971	460	145	6	29	Diabase	45	11/10/71	145	5	1	.05	H	S	

Table 2.--Records of wells in Frederick County--Continued

Well number: See text for description of well-numbering system. Well locations are shown on Plate 1.

Static water level: Reported depths are given in feet; measured depths are given in feet and tenths or hundredths.

Water use codes

C Commercial
F Fire
H Domestic
I Irrigation
N Industrial
P Public supply
R Recreational
S Stock
T Institutional
U Unused

Pump type codes

B Bucket
J Jet
N None
P Piston
S Submergible
T Turbine

Remarks codes

A Aquifer test run
Q See chemical analysis
Z Well destroyed

Fr- Well number	State permit number	Owner	Driller	Date completed	Altitude (feet)	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Water-bearing formation	Water level (feet below land surface) Static	Date	Pumping	Yield (gpm)	Hours pumped	Specific capacity (gpm/ft)	Use of water	Pumping equipment	Remarks
Cd 27	FR720249	Cavetown Plng. Mill	Cromwell	1971	440	125	6	21	New Oxford Fm	35	11/18/71	125	12	2	0.13	H	S	
Cd 28	FR720297	Steve Boswell	Cline	1971	490	170	6	130	do	28	11/3/71	170	10	1	.06	H	S	
Cd 29	FR720041	Robert W. Eaton	do	1971	500	115	6	81	do	40	8/14/71	115	100	1	1.33	H	S	
Cd 30	FR710410	Russell S. Ellis	Keyser	1971	500	103	6	86	do	20	4/7/71	-	50	1	-	H	S	
Cd 31		Don Shoemaker	do	1972	440	42	6	21	do	5.0	10/18/72	39	100	1	2.9	H	S	
Cd 32	FR710058	Robert E. Harper	Cline	1970	480	165	5	83	do	30	8/7/70	165	100	1	.70	H	S	
Cd 33	41470	Arthur Lambert	D. Brown	1960	410	100	6	14	do	50	12/20/60	75	4	1	.02	H	S	Q
Cd 34	44485	Charlotte Webster	Keyser	1961	410	172	6	15	do	25	9/--/61	-	20	3	-	H	S	Q
Cd 35	-	Wm. De Ghetto	-	before 1966	415	about 150	6	-	do	-	-	-	-	-	-	H	J	Q
Cd 36	-	Gahlon White	-	-	415	about 100	6	-	do	-	-	-	-	-	-	H	J	Q
Cd 37	40949	Earl Bowers	Keyser	1960	400	75	6	31	do	35	10/5/60	-	12	1	-	H	S	Q
Ce 30	FR710607	Thomas E. Himes	Green	1971	520	140	6	139	Grove Ls	70	10/5/71	100	10	3	.33	H	S	
Ce 31	FR720227	Harold Perkins	do	1971	400	162	6	58	New Oxford Fm (qtz-pbl cngl)	30	10/6/71	-	6	1	-	H		
Ce 32	FR710437	Lawrence Clark	do	1971	370	223	6	43	New Oxford Fm	30	4/15/71	-	25	1	-	H		
Ce 33	FR720238	Elsie H. Chew	Reichart	1972	530	868	6	137	Grove Ls	116.3	4/18/72	-	0.5	1	<.01	H	S	Qtz-pbl cngl 0-123 ft
Ce 34	FR730175	Dorothy Lewis	Keyser	1972	320	100	6	38	New Oxford Fm	30	7/26/72	-	15	1	-	H	S	
Ce 35	FR730207	Preston Kolb	Cline	1972	390	220	6	23	do	57.3	10/18/72	-	70	1	-	S	S	
Ce 36	FR730190	Robert Perry	Keyser	1972	390	295	6	19	do	52.7	10/31/72	-	12	1	-	H	S	
Ce 37	FR730096	J. P. Lyons	Cline	1972	450	170	6	20	do	50	8/14/72	170	20	1	.17	H	S	Q
Ce 38	FR730199	Wm. Hildebrand	Cromwell	1972	420	125	6	21	do	25	9/11/72	120	20	3	.21	H	S	
Ce 39	FR710104	Wilton Stitely	Cline	1970	410	165	6	34	do	48	8/26/70	165	100	1	.85	H	S	
Ce 40	7543	Norma Stull	Keyser	1951	400	55	6	16	do	10	3/12/51	50	3	1	.07	H	J	Q
Ce 41	11354	Albert Powell	Shaff	1952	405	95	6	5	do	8	11/22/52	16	20	4	2.50	H	J	Contains coliform bacteria, not used for drinking
Ce 42	43308	Lewistown Elem. School	Keyser	1961	410	160	6	21	do	30	6/--/61	-	100	2	-	T	S	Q
Ce 43	6465	I. J. Beeson	Shaff	1950	410	72	6	12	do	10	8/24/50	18	10	6	1.25	H	J	Q
Ce 44	-	I. S. Grimes	-	1957	400	about 100	6	-	do	-	-	-	-	-	-	H	J	Q
Ce 45	29265	William Cessna	Keyser	1958	405	109	6	26	do	26	1/9/58	35	10	3	1.1	H	S	Q, water softened
Ce 46	FR690054	Reany Wachter	do	1968	405	130	6	35	do	30	1968	-	8	1	-	H	S	Q
Ce 47	-	William Dixon	-	about 1950	410	about 100	6	-	do	-	-	-	-	-	-	H	J	Q
Ce 48	-	Blaine Young	-	about 1950	405	about 100	6	-	do	-	-	-	-	-	-	H	J	
Ce 49	FR700112	Robert Hutton	Cline	1969	370	95	6	27	do	28	10/3/69	95	10	1	.15	H	S	Q, water chlorinated
Ce 50	FR710519	R. I. Glyn-Jones	do	1971	455	220	6	20	do	40	5/15/71	-	12	1	-	H	S	Q, water softened
Ce 51	FR720645	John Reburn	do	1972	450	170	6	20	do	45	9/6/72	165	8	1	.07	H	S	Q
Ce 52	FR730086	William Wickham	Cromwell	1972	430	225	6	21	do	40	8/15/72	220	5	4	.03	H	S	
Ce 53	FR66W111	St. Paul's Church	Keyser	1965	360	189	6	32	do	30	8/24/65	-	10	1	-	H	S	
Cf 41	FR710581	Earl Crabbs, Jr.	Reider	1971	430	110	6	21	do	32	7/23/71	109	5	1	.06	H	S	
Cf 42	FR720061	James C. Mercer	Keyser	1971	440	220	6	25	do	33	8/2/71	-	8	1	-	H	S	
Cf 43	FR720107	Dennis Stitley	Reider	1971	510	120	6	22	do	60	9/25/71	119	5	1	.08	H	S	
Cf 44	FR720422	Karl J. Smith Jr.	Cline	1972	500	170	6	55	do	38	2/7/72	170	4	1	.03	H	S	
Cf 45	FR710381	Glen Eaves	do	1971	470	160	6	44	do	20	3/9/71	160	100	1	.71	S	S	

Table 2.--Records of wells in Frederick County--Continued.

Well number: See text for description of well-numbering system. Well locations are shown on Plate 1.

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Water use codes

C Commercial
F Fire
H Domestic
I Irrigation
N Industrial
P Public supply
R Recreational
S Stock
T Institutional
U Unused

Pump type codes

B Bucket
J Jet
N None
P Piston
S Submergible
T Turbine

Remarks codes

A Aquifer test run
Q See chemical analysis
Z Well destroyed

Fr- Well number	State permit number	Owner	Driller	Date completed	Altitude (feet)	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Water-bearing formation	Water level (feet below land surface) Static	Date	Pumping	Yield (gpm)	Hours pumped	Specific capacity (gpm/ft)	Use of water	Pumping equipment	Remarks
Cg 20	-	Larry Hevner	Cline	1971	530	165	6	41	New Oxford Fm	10	9/1/71	165	8	1	0.05	H	S	Penetrated fault into Ijamsville Fm
Dd 135	FR720124	Lee C. Toms	do	1971	330	90	6	40	do	20	8/31/71	90	6	1	.08	H	S	Ford Acres
Dd 136	FR710560	Chris Burgess	Cromwell	1971	420	105	6	21	do	30	6/14/71	100	12	1	.17	H	S	Do.
Dd 137	FR720014	Kim Weedy	do	1971	410	105	6	22	do	30	7/9/71	90	15	1	.25	H	S	Do.
Dd 138	FR720015	Arthur Trout	do	1971	410	105	6	22	do	30	7/9/71	95	15	1	.23	H	S	Do.
Dd 139	FR720332	Robert A. O'Neal	Cline	1971	380	220	6	40	do	45	12/22/71	220	2	1	.01	H	S	Q, Catoctin Manor Estates
Dd 140	FR720474	Clarence Martz	do	1972	400	80	6	50	do	10	3/7/72	80	40	1	.57	H	S	
Dd 141	FR720157	Charles Keller	Keyser	1971	465	122	6	47	do	40	8/31/71	120	50	1	.63	H	S	
Dd 142	FR690420	BP Oil Co.	Lamerson	1969	395	285	6	67	do	60	5/6/69	250	6	1	.03	C	S	Service station
Dd 143	FR720458	S & P Modular Homes	Cline	1972	380	120	6	41	do	25	3/20/72	120	4	1	.04	H	S	
Dd 144	FR720490	Neil Corselius	do	1972	385	195	6	41	do	55	4/1/72	195	6	1	.04	H	S	Q, Catoctin Manor Estates
Dd 145	FR720497	Richard Tyeryar	do	1972	410	120	6	34	do	35	3/31/72	120	20	1	.24	H	S	
Dd 146	FR720541	Mormon Church	Keyser	1972	420	130	6	40	do	18	4/20/72	125	30	1	.28	H	S	Q
Dd 147	FR720730	Charles Keller	do	1972	440	160	6	39	do	35	7/7/72	165	15	1	.12	H	S	
Dd 148	FR720701	Urban Systems Dev.	do	1972	370	355	6	20	Grove Ls	-	-	-	7	2	-	U	N	Z, test well
Dd 149	do	do	do	1972	365	90	6	-	do	-	-	-	-	-	-	U	N	Z, hit mud
Dd 150	do	do	do	1972	370	205	8	20	do	33	8/7/72		100	24		U	N	Test well, 6-in diameter below 100 ft
Dd 151	do	do	do	1972	370	140	6	-	do	-	-	-	-	-	-	U	N	Z, hit mud
Dd 152	do	do	do	1972	370	250	6	-	do	-	-	-	6	2	-	U	N	Z
Dd 153	do	do	do	1972	375	205	6	22	do	23.75	8/7/72	-	4	2	-	U	N	Observation well
Dd 154	FR720637	Edward L. McHugh	do	1972	390	182	6	22	New Oxford Fm	38	5/25/72	177	5	1	.04	H	S	
Dd 155	FR700170	Skyline Realty	Cline	1969	410	145	6	42	do	38	11/1/69	145	50	1	.46	H	S	
Dd 156	FR700511	Raymond Free	Cromwell	1970	380	165	6	21	do	45	6/30/70	160	5	2	.04	H	S	Q, Catoctin Manor Estates
Dd 157	FR690344	Mark W. Lee	do	1969	390	165	6	21	do	45	3/7/69	160	7	2	.06	H	S	Catoctin Manor Estates
Dd 158	-	Allen Drayer	do	1971	395	180	6	21	do	65	9/27/71	175	10	3	.09	H	S	Q, Catoctin Manor Estates
Dd 159	FR700102	Mr. Miller	Harris	1969	390	100	6	30	do	25	7/24/69	90	5	1	.08	H	S	Do
Dd 160	FR700465	S. C. Midt	Cromwell	1970	380	160	6	18	do	40	6/12/70	150	8	2	.07	H	S	Catoctin Manor Estates
Dd 161	FR690426	Richard Beckley	do	1969	380	65	6	19	do	30	5/8/69	60	12	3	.37	H	S	Q, Catoctin Manor Estates
Dd 162	FR730398	Mr. Moore	Harris	1972	390	170	6	36	do	40	11/24/72	130	6	1	.07	H	S	Do.
Dd 163	FR66W412	Robert Winell	do	1966	390	165	6	41	do	50	1/20/66	158	5	1	.05	H	S	Do.
Dd 164	FR66W822	George Boston	Cromwell	1966	380	185	6	19	do	65	6/29/66	-	8	2	-	H	S	Do.
Dd 165	FR690408	Mr. Cooper	do	1969	385	125	6	19	do	40	4/30/69	-	7	2	-	H	S	Do.
Dd 166	-	Unknown	-	-	385	about 125	6	-	do	-	-	-	-	-	-	H	S	Do.
Dd 167	FR710500	Mr. Donahue	Cline	1971	385	195	6	61	do	35	5/12/71	195	12	1	.06	H	S	Do.
Dd 168	FR690436	Charles Hahn	Driver	1969	385	108	6	24	do	50	7/18/69	90	6	1	.15	H	S	Do.
Dd 169	-	Millard Boston	Cromwell	1968	390	about 125	6	-	do	-	-	-	-	-	-	H	S	Do.
Dd 170	FR66W810	Carl Marshall	do	1966	390	165	6	13	do	70	6/29/66	-	3	3	-	H	S	Do.
Dd 171	-	A. J. Sos	-	1968	390	about 125	6	-	do	-	-	-	-	-	-	H	S	Do.
Dd 172	-	J. E. Sundergill	Keyser	1966	390	about 125	6	-	do	-	-	-	-	-	-	H	S	Do.
Dd 173	44282	Franklin Wiles	Mayne	1962	390	135	6	13	do	40	1/25/62	-	3	2	-	H	S	Do.
Dd 174	FR720459	O. L. Giffin	Cline	1972	380	220	6	43	do	52	4/12/72	220	7	1	.04	H	S	Do.
Dd 175	FR690333	Donald Hahn	do	1969	380	165	6	20	do	40	3/6/69	155	50	1	.44	H	S	Catoctin Manor Estates

Table 2.--Records of wells in Frederick County--Continued.

Well number: See text for description of well-numbering system. Well locations are shown on Plate 1.

Static water level: Reported depths are given in feet; measured depths are given in feet and tenths or hundredths.

Water use codes

C	Commercial	P	Public supply
F	Fire	R	Recreational
H	Domestic	S	Stock
I	Irrigation	T	Institutional
N	Industrial	U	Unused

Pump type codes

B	Bucket
J	Jet
N	None
P	Piston
S	Submergible
T	Turbine

Remarks codes

A	Aquifer test run
Q	See chemical analysis
Z	Well destroyed

Fr- Well number	State permit number	Owner	Driller	Date completed	Altitude (feet)	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Water-bearing formation	Water level (feet below land surface) Static	Date	Pumping	Yield (gpm)	Hours pumped	Specific capacity (gpm/ft)	Use of water	Pumping equipment	Remarks
De 84	FR720701	Urban Systems Dev.	Keyser	1972	340	400	6	26	Grove Ls	+1.7	8/7/72	-	70	4	-	U	N	Test well
De 85	do	do	do	1972	335	415	6	20	do	5.2	8/7/72	-	125	4	-	U	N	Do
De 86	do	do	do	1972	330	415	6	20	do	.2	8/7/72	-	15	2	-	U	N	Observation well
Ec 20	FR720469	Fred. Co. Land Developers	do	1972	590	255	6	23	Catoctin Metabasalt	7.0	4/18/72	-	20	1	-	N	-	Test well
Ec 21	do	do	do	1972	580	220	6	21	do	2.5	4/18/72	-	46	8	-	N	-	Do
Ec 22	do	do	do	1972	590	302	6	21	do	6	4/ /72	-	40	1	-	N	-	Do
Ec 23	do	do	do	1972	540	262	6	-	do	-	-	-	2	1	-	N	-	Do
Ed 85	FR720112	C. W. Burdette	Cline	1971	345	125	6	20	New Oxford Fm (basal ls-pbl cngl)	6	8/23/71	125	100	1	0.84	H	S	Q
Ed 86	FR720291	S. Angleberger	do	1971	400	95	6	54	do	6	12/30/71	95	50	1	.56	H	S	
Ed 87	FR720001	George Stupp	Keyser	1971	430	140	6	42	New Oxford Fm	50	7/7/71	about 140	50	1	.56	H	S	
Ed 88	FR66W688	G. Gremillion	do	1966	460	130	6	83	New Oxford Fm (basal ls-pbl cngl)	25	5/31/66	about 125	50	1	.50	H	S	
Fc 29	None	National Park Service	Lamerson	1969	220	203	6	-	Catoctin Metabasalt	-	-	-	<2	-	-	U	N	Z, C & O Canal, mile-post 49.8
Fc 30	None	do	do	1969	220	150	6	42	do	22.0	5/-/69	-	7	-	-	H	P	C & O Canal, mile-post 49.9
Fc 32	FR720165	Barbar & Ross Co.	Cromwell	1971	250	75	6	44	New Oxford Fm (basal ls-pbl cngl)	25	10/28/71	50	40	5	.20	C	S	
Fc 33	FR720255	Fred. Co. Fish & Game Prot. Assoc.	Keyser	1971	240	115	6	41	do	36	10/20/71	about 110	40	1	.54	H	S	Clubhouse, Q
Fc 34	FR66W697	David Phillips	Cromwell	1966	240	165	6	14	do	40	5/12/66	about 160	40	1	.33	H	S	
Fc 35	FR65W592	Cleavers Food Ser.	Keyser	1965	255	70	6	31	do	15	5/5/65	70	20	1	.36	C	S	Restaurant
Fd 83	FR720338	Tuscarora Gun Club	Cline	1972	300	170	6	42	New Oxford Fm	42	1/13/72	170	20	1	.16	H	S	Q
Fd 84	FR700451	Wm. A. Delauter	Cromwell	1970	330	165	6	19	do	55	6/15/70	150	10	1	.10	H	S	
Fe 24	FR720275	Columbia-Comus, Inc.	Keyser	1971	450	443	6	93	Urbana Fm	10	11/22/71	-	50	1	-	U	N	Test well

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Water use codes

C Commercial
F Fire
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I Irrigation
N Industrial
P Public supply
R Recreational
S Stock
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U Unused

Pump type codes

B Bucket
J Jet
N None
P Piston
S Submergible
T Turbine

Remarks codes

A Aquifer test run
Q See chemical analysis
Z Well destroyed

Mont- Well number	State permit number	Owner	Driller	Date completed	Altitude (feet)	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Water-bearing formation	Water level (feet below land surface) Static	Date	Pumping	Yield (gpm)	Hours pumped	Specific capacity (gpm/ft)	Use of water	Pumping equipment	Remarks
Bc 3	M0720066	Columbia-Comus, Inc.	Keyser	1971	440	155	6	-	Urbana Fm	10	10/ /71	-	3	1	-	U	N	Test well
Bc 4	do	do	do	1971	420	403	6	61	do	5	10/ /71	-	12	1	-	U	N	Do
Bc 5	do	do	do	1971	430	320	6	42	do	40	10/ /71	-	8	1	-	U	N	Do
Cb 14	12458	Dickerson Methodist Church	Hilton	1953	330	71	6	26	New Oxford Fm	28	6/3/53	39	20	1	1.9	H	J	
Cb 15	28678	Potomac Electric Power Co.	do	1957	340	250	6	28	do	49	12/23/57	180	15	2	.11	U	N	2 gpm at 81 ft 13 gpm at 244 ft
Cb 16	-	do	do	1957	310	197	6	-	do	-	-	-	-	-	-	U	N	
Cb 17	-	do	do	1957	350	250	6	-	do	40	1957	-	-	-	-	U	N	
Cb 18	-	National Park Service	Hoffman	1969	210	140	6	50	do	15.6	4/1/69	-	20	-	-	H	P	C & O Canal, Q
Cb 19	-	Neutron Products	Hilton	-	375	100	6	-	do	-	-	-	-	-	-	F	S	
Cb 20	M0690053	do	do	1968	375	148	6	42	do	39	10/28/68	122	12	4	.14	N	S	
Cb 21	50547	Athony Heller	do	1963	420	150	6	28	do	19	4/18/63	86	3	2	.04	P	S	Summer camp
Cb 22	M0660438	do	do	1966	415	100	6	22	do	31	5/9/66	80	25	4	.51	R	S	Fills swimming pool
Cb 23	M0680206	Hubert Lythe	do	1968	375	114	6	24	do	38	7/1/68	93	8	-	.15	H	S	
Cb 24	M0690097	Wheaton Lumber Co.	Green	1968	350	125	6	24	do	30	11/68	100	15	4	.21	C	S	
Cb 25	M0720176	John R. Yates	Hilton	1972	395	100	6	18	do	21	4/7/72	79	3	1	.05	H	S	
Cb 26	M0720191	U.S. Geol. Survey	Keyser	1972	220	885	6	40	do	+7.0	5/19/72		75	22	1.0	U	N	Test well, Q
Cb 27	M0720191	do	do	1972	220	75	6	18	do	1.7	5/23/72	-	8	1	-	U	N	
Cb 28		Dan Westland	do	1972	380	310	6	37	do	26	6/6/72	-	15	1	-	H	S	
Cb 29		Potomac Electric Power Co.	do	1973	315	1004	6	40	do	45.6	9/6/72	144	100	47	.70	N	S	
Cc 27	31147	Stuart Ayers	Hilton	1958	440	110	6	46	New Oxford Fm (baked zone)	38	6/28/58	65	20	1	.74	U	P	
Cc 28	M0670049	John Robinson	do	1966	460	120	6	92	New Oxford Fm	26	10/26/66	111	15	2	.18	H	S	Penetrated Ijamsville at 110 ft.
Cc 29	-	Charles Weber	do	1955	350	100	6	-	do	-	-	-	-	-	-	H	S	Q
Cd 31	31439	John Moore	Keyser	1958	350	185	6	30	Diabase	10	7/24/58	30	2	10	.10	H	P	Neighbors also use water
Da 2	-	National Park Service	Hoffman	1969	200	135	6	36	New Oxford Fm	8	2/ /69	-	40	-	-	H	P	C & O Canal, water @ 58' &115', Q
Db 15	17659	St. Geo. Episc Church	Hilton	1955	405	94	6	12	do	16	2/23/55	55	10	1	.30	H	-	
Db 16	40313	Natl. Insts. of Health	do	1960	280	205	6	40	do	22	10/ /61	40	21	24	1.7	T	S	
Db 17	41677	John B. Offutt	do	1959	365	83	8	35	do	31	11/29/59	62	4.5	1	.15	H	-	
Db 18	24601	Poolesville Presbty. Church	-	1956	400	95	6	40	do	21	9/26/56	63	16	-	.38	H	-	
Db 19	31959	Levitt & Sons	Green	1958	410	141	6	10	do	15	9/20/58	98	17	3	.2	H	S	
Db 20	31960	do	do	1958	415	245	6	12	do	15	9/14/58	120	15	4	.14	H		
Db 21	44078	do	Keyser	1961	370	325	6	21	do	25	8/ /61	-	20	3	-	U	N	Test well
Db 22	35551	do	Green	1959	220	80	6	26	do	15	7/22/59	70	7	-	.1	H		
Db 23	-	do	Keyser	1961	330	325	6	13	do	20	8/ /61	-	40	12	-	U	T	
Db 24	39308	do	do	1960	400	467	6	37	do	13.3	9/17/68	-	18	-	-	U	N	Test well
Db 25	49668	Natl. Insts. of Health	Hilton	1962	280	200	6	48	do	21	11/14/62	32	25	12	2.3	T	S	
Db 26	49669	do	do	1962	280	145	6	58	do	32	11/14/62	55	25	24	1.1	T	S	
Db 27	M0670069	do	do	1966	290	190	6	40	do	29	9/2/66	70	20	4	.49	T	S	
Db 28	-	National Park Service	Hoffman	1969	200	125	6	30	do	-	-	-	12	-	-	H	P	C & O Canal, Q
Db 29	M0650460	D. J. Willard	Hilton	1965	410	103	6	45	do	28	4/28/65	67	15	4	.38	C	S	

Table 3.--Records of wells in Montgomery County--continued

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Water use codes

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Remarks codes

A Aquifer test run
Q See chemical analysis
Z Well destroyed

Mont- Well number	State permit number	Owner	Driller	Date completed	Altitude (feet)	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Water-bearing formation	Water level (feet below land surface) Static	Date	Pumping	Yield (gpm)	Hours pumped	Specific capacity (gpm/ft)	Use of water	Pumping equipment	Remarks
Db 30	M0660325	Chas. Jamison	Hilton	1966	410	143	6	41	New Oxford Fm	46	2/17/66	121	10	2	.13	C	S	
Db 31	M0670112	Roger A. Hayden	Easterday	1967	305	200	6	18	do	40	10/22/66	200	6	1	.04	H	S	
Db 32	M0670147	M. De Sterkenberg	Hilton	1967	360	122	6	26	do	31	12/9/67	93	8	2	.13	H	S	
Db 33	M0690113	do	do	1969	350	165	6	38	do	39	2/5/69	122	7	2	.08	S	S	
Db 34	M0670166	Economy Oil Co.	do	1967	410	185	6	25	do	36	1/4/67	171	5	2	.04	C	S	
Db 35	M0690154	Miller & Frauk	do	1969	300	125	6	43	do	35	4/28/69	102	4	2	.06	H	S	
Db 36	44079	Levitt & Sons	Keyser	1968	260	280	8	23	do	12.4	9/17/68	166.4	150	24	.97	U	N	Test well
Db 37	-	do	do	1968	345	325	8	26	do	.35	9/17/68	-	20	12	-	U	N	Do, Q
Db 38	-	do	do	1968	320	210	6	-	do	-	-	-	65	8	-	U	T	
Db 39	-	Izaak Walton League	Green	-	300	140	6	-	do	-	-	-	2	-	-	H	J	
Db 40	-	do	Stottle-myer	1971	280	170	6	-	do	62.7	10/19/71	-	5	-	-	U	N	
Db 41	-	do	unknown	-	230	75	5	-	do	-	-	-	-	-	-	U	P	Boy Scout camp
Db 42	-	do	do	-	230	120	6	-	do	-	-	-	8	-	-	H	P	Q
Db 43	M0650389	Myra Thomas	Mayne	1965	410	82	6	52	do	5	2/26/65	-	4	3	-	H	J	
Db 44	M0720083	Ed Hnetkovsky	Hilton	1971	310	120	6	20	do	29	12/8/71	82	20	1	.30	H	S	
Db 45	-	Charles Norris	Keyser	1956	360	100	6	-	Diabase	-	-	-	-	-	-	H	S	Q
Db 46	M072-162	R. L. Hoewing	Brown	1972	325	102	6	23	New Oxford Fm	56	10/17/72	71	10	1	.7	H	S	
Dc 14	M0660163	Elmer Jones	Hilton	1965	405	74	6	22	do	22	10/16/65	58	16	1	.44	H	S	
Dc 15	35127	Levitt & Sons	Green	1959	410	155	6	22	do	30	6/24/59	140	10	3	.09	U	N	
Dc 16	35552	do	do	1959	330	155	6	15	do	30	7/28/59	120	10	3	.11	U	N	
Dc 17	35831	do	Keyser	1959	325	317	6	23	do	25	8/15/59	40	80	-	5.3	I	T	Irrigates golf course
Dc 18	M0700014	Town of Poolesville	Sydnor	1969	395	597	7	63	do	29	8/25/69	166	53	24	.39	P	T	
Dc 19	M0700046	do	do	1969	410	450	6	63	do	30	9/17/69	125	95	24	1.0	P	T	
Dc 20	M0650553	A. C. Strang	Hilton	1965	280	165	6	20	do	39	6/18/65	136	7	2	.07	H	-	
Dc 21	M0660179	Bert B. Wolfrey	do	1966	320	120	6	22	do	19	10/9/65	111	4	2	.04	H	-	
Dc 22	M0660144	John A. Trauth	do	1965	330	145	6	22	do	41	10/14/65	123	18	2	.22	H	-	
Dc 23	M0670038	Gordon T. Darby	do	1966	370	165	6	24	do	47	8/30/66	149	6	2	.06	H	S	
Dc 24	M0670149	Edward W. Bacon	Easterday	1967	320	160	6	23	do	10	1/26/67	160	6	1	.04	H	S	
Dc 25	M0680016	Gorman H. Butler	Hilton	1967	385	143	6	31	do	26	7/24/67	121	12	2	.12	H	S	
Dc 26	M0670304	G. Morungstar	do	1967	310	143	6	20	do	18	9/24/67	116	3	2	.03	H	S	
Dc 27	M0680230	George Weedon	Brown	1968	305	64	6	30	do	40	5/23/68	50	30	1	3.0	H	S	
Dc 28	44441	Levitt & Sons	Keyser	1959	305	400	6	20	do	-	-	-	30	12	-	U	T	
Dc 29	39309	do	do	1968	360	315	8	33	do	22.6	9/17/68	187.6	60	24	.36	U	N	
Dc 30	-	Wm. R. Poole	Green	1972	280	150	6	-	do	-	-	-	-	-	-	H	S	Q
Dc 31	M0730075	Town of Poolesville	Sydnor	1972	385	285	8	82	do	12.2	10/31/72	80.8	100	24	1.5	P	T	
Dc 32	-	Alexandrice Uhl	Hilton	1955	355	90	6	-	do	-	-	-	-	-	-	H	S	Reported contaminated, Q
Dc 33	M0710156	John L. Windolph	do	1971	310	105	6	20	do	21	7/15/71	67	10	1	.22	H	S	
Dc 34	M0710074	F. Bernsdorff	do	1970	330	145	6	28	do	41	10/27/70	122	8	2	.10	H	S	
Dc 35	M0700103	Fred Campbell	do	1970	355	165	6	42	do	26	1/3/70	131	20	1	.19	H	S	
Dc 36	M0700072	David Weitzer	do	1969	280	205	6	47	do	31	11/6/69	185	11	2	.08	S	S	
Dc 37	M072--36	Ethel Fistire	do	1971	315	200	6	22	do	41	9/13/71	180	3	1	.02	H	S	
Dc 38	M0700165	John F. Windolph	do	1970	320	105	6	22	do	20	9/18/70	89	7	1	.10	H	S	
Dc 39	M0730121	Alexandrice Uhl	do	1973	355	160	6	60	do	66	2/7/73	141	12	1	.16	H	S	
Ec 6	M0680033	National Park Service	do	1967	175	124	6	40	do	28	9/6/67	36	30	6	3.8	U	N	Sediment problems
Ec 7	-	do	Delmarva	1970	190	136	6	128	do	6	10/1/70	61	10	4	.18	H	S	Supplies NPS office
Ec 8	-	do	Hoffman	1969	190	125	6	42	do	-	-	-	40	-	-	H	P	C & O Canal, Q
Ec 9	M0660395	John L. Kline	Green	1966	210	118	6	23	do	50	5/12/66	100	10	3	.20	H	S	

TABLE 4. -- CHEMICAL ANALYSES OF WATER SAMPLES FROM SELECTED WELLS IN THE STUDY AREA

WELL NUMBER	GEO-LOGIC UNIT	DATE OF SAMPLE	DIS-SOLVED SILICA (SIO2) (MG/L)	TOTAL IRON (FE) (µG/L)	TOTAL MAN-GANESE (MN) (µG/L)	DIS-SOLVED CAL-CIUM (CA) (MG/L)	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)	BICAR-BONATE (HCO3) (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)	DIS_ SOLVED NITRATE (NO3) (MG/L)	DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L)	HARD-NESS (CA,MG) (MG/L)	NON-CAR-BONATE HARD-NESS (MG/L)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)
CAR- AB 2	231NOXF	55-12-21	--	--	--	19	--	--	--	38	21	16	--	22	--	54	23	207	6.4
AB 13	231NOXF	72-06-07	18	30	<0	46	10	11	.4	152	19	8.5	.1	24	213	160	31	354	8.1
BB 4	231NOXF	46-12-18	19	60	--	40	7.9	13	1.0	151	16	8.0	.1	4.4	184	130	9	303	8.0
BB 9	231NOXF	52-02-05	22	390	<5	45	6.1	19	.7	150	24	11	.1	16	218	140	14	351	7.7
BB 41	231NOXF	71-11-10	19	20	5	44	10	20	.6	167	24	17	.2	14	231	150	14	396	8.0
BB 54	231NOXF	72-04-21	13	40	<0	38	15	30	2.0	23	27	88	.1	48	272	160	140	472	6.6
BC 16	231NOXF	71-11-29	23	70	<5	29	6.2	7.2	.3	121	4.1	3.4	.1	6.6	140	98	0	222	7.7
FR- AF 4	231GBRG	55-04-04	25	110	30	70	25	8.8	1.0	195	131	5.2	.4	1.6	364	280	120	567	8.0
231GBRG	55-12-21	--	--	--	73	--	--	--	200	105	9.0	--	2.5	--	252	88	538	7.7
AF 23	231GBRG	72-04-14	20	<0	<0	50	14	12	.9	225	9.6	3.5	.1	5.1	226	180	0	359	8.0
BE 11	231GBRG	56-05-04	14	20	50	56	10	12	.8	188	45	6.0	<.0	11	247	180	27	414	7.2
BE 39	231GBRG	72-01-19	16	620	<5	55	12	10	1.4	172	5.7	30	<.0	18	233	190	46	526	7.6
BE 40	231GBRG	72-07-28	26	20	<0	22	4.3	4.8	.3	92	.5	1.5	.1	8.4	113	73	0	166	7.7
BE 48	231GBRG	72-11-03	20	10	0	8.0	1.9	4.5	.4	24	.2	3.0	.0	13	63	28	8	80	7.0
BE 59	231GBRG	73-04-12	21	30	0	54	16	13	2.2	180	14	16	.1	38	263	200	53	433	7.8
BF 4	231NOXF	55-12-20	44	30	20	46	23	8.9	.6	209	22	14	<.0	26	287	210	38	440	7.3
BF 24	231NOXF	72-01-03	33	70	<5	27	16	11	.9	158	20	4.9	.2	6.3	197	130	4	316	7.4
CE 41	231NOXF	73-04-12	8.1	260	0	50	17	19	.5	147	41	44	.1	18	270	200	74	452	7.4
DD 3	231NOXF	53-04-14	11	1300	--	31	13	--	--	151	8.2	10	<.0	5.8	--	130	7	283	7.8
DD 65	231NOXF	56-05-04	9.8	40	20	51	9.0	2.5	.4	172	10	3.5	<.0	16	187	160	23	319	7.7
DD 146	231NOXF	72-08-04	24	100	<0	54	8.0	8.9	.6	146	26	12	.1	22	230	170	45	362	8.5
ED 85	231NOXF	72-08-08	15	20	<0	57	13	15	.8	199	15	12	.1	19	245	200	33	414	8.2
FC 24	231NOXF	69-03-24	12	--	--	79	23	10	1.3	286	53	9.5	<.0	8.5	337	290	57	564	8.2
FC 33	231NOXFB	72-08-07	7.8	70	<0	46	27	2.2	.9	225	16	4.2	.1	9.2	224	230	41	470	8.3
FD 83	231NOXF	72-07-28	17	60	100	35	3.9	4.6	.5	115	8.0	4.0	.1	7.9	138	100	9	230	7.5
MONT- CB 1	231NOXF	52-05-22	9.1	4900	50	12	4.6	4.2	1.3	21	29	8.5	<.0	7.0	86	49	32	149	6.0
CB 18	231NOXF	69-02-24	15	--	--	25	12	21	1.1	179	5.0	5.4	.1	.90	174	110	0	303	7.9
CB 26	231NOXF	72-05-01	22	340	10	32	3.1	5.2	.7	119	.2	1.2	.1	3.6	127	93	0	184	7.8
231NOXF	72-06-02	23	90	<0	33	3.2	5.1	.3	124	.5	1.3	.1	4.4	132	96	0	207	7.9
CC 29	231NOXF	72-10-04	19	40	0	38	5.2	5.2	.7	114	8.2	6.7	.1	17	156	120	23	245	8.0
DA 2	231NOXF	69-02-18	17	--	--	28	7.9	6.2	.5	120	2.0	7.5	.1	7.1	135	100	4	238	8.1
DB 1	231NOXF	52-05-22	25	40	10	73	6.8	42	2.5	195	56	48	<.0	39	388	210	50	609	6.9
DB 28	231NOXF	69-02-14	26	440	700	41	7.3	9.6	.7	172	3.1	3.6	.1	3.1	179	130	0	285	8.0
DB 37	231NOXF	71-10-14	22	20	<0	39	5.0	21	.6	196	4.0	1.7	.2	.90	191	120	0	304	7.9
DB 42	231NOXF	72-03-10	21	230	20	61	17	12	1.0	221	18	20	.1	20	279	220	41	469	7.6
DB 45	231DIBS	72-10-17	22	70	0	24	6.9	9.9	1.2	100	14	7.0	.1	3.5	138	88	6	209	7.7
DC 1	231NOXF	51-03-08	16	310	10	8.8	2.1	6.8	.6	21	25	3.2	.1	4.3	77	31	13	117	6.6
DC 30	231NOXF	72-10-04	20	30	0	44	4.3	8.2	.5	148	12	2.6	.1	7.1	172	130	6	268	8.3
DC 32	231NOXF	72-10-17	20	100	0	51	8.3	11	1.1	184	9.5	8.5	.1	15	215	160	11	345	8.2
EC 8	231NOXF	69-02-05	20	250	130	45	4.4	4.2	.8	122	9.5	6.6	.1	19	170	130	30	279	7.8

Table 10.—Lithologic description of cuttings from selected wells.

Well No. : Car-Bc 16
Owner : U. S. Geological Survey
Elevation : 505 ft
Driller : Austin Keyser Well Drilling
Location : 1 mi southwest of Mayberry

Depth (ft)	*Description*
0– 10	Fill—tan clay
10– 21	Dark red clay, soft
21– 27	Red mud
27– 42	Dark red shale
42– 48	Red-gray sandy shale (water at 48 ft)
48– 58	Red-gray fine grained sandstone (5 gal/min at 55 ft) 6-inch casing to 60 ft
58– 62	Red-brown shale
62– 70	Gray silty sandstone
70– 88	Brown-red shale (trace water at 80 ft)
88–116	Brown silty sandstone and red shale streaks
116–168	Red-brown shale and red-gray sandstone streaks (15 gal/min at 120 ft)
168–194	Red-gray sandstone, fine grained
194–212	Red-brown silty shale
212–224	Red-brown sandstone
224–235	Red-brown silty shale
235–244	Gray-green sandstone
244–306	Red-brown silty shale, few gray sandstone streaks
306–331	Gray sandstone, fine grained
331–340	Brown-red shale, soft (trace water)
340–364	Gray silty sandstone, some sandy shale streaks (water at 350 ft)
364–382	Red shale
382–392	Red-brown sandstone
392–480	Red shale with brown silty sandstone streaks
480–488	Gray sandstone with calcite material
488–556	Interbedded red shale, red-brown sandy shale, and siltstone
556–564	Red shale containing quartz pebbles
564–578	Gray sandstone, coarse grained
578–585	Quartz-pebble conglomerate
585–602	Red-brown shale and siltstone
602–656	Gray sandstone, medium to coarse grained, some beds of quartz-pebble conglomerate
656–676	Red shale containing white quartz pebbles
676–692	Gray sandstone, medium to coarse, few beds quartz-pebble conglomerate

Table 10.—Lithologic description of cuttings from selected wells.—Continued

Well No : Mont-Cb 26
Owner : U. S. Geological Survey
Elevation : 220 ft
Driller : Austin Keyser Well Drilling
Location : Dickerson Park

Depth (ft)	*Description*
0– 18	Silt, sand and gravel (alluvium?)
18– 21	Apparently coarse gravel—lost circulation
21– 40	Red shale and siltstone
40– 58	Red-brown medium grained sandstone
58– 80	Brown sandstone
80–105	Red sandy shale and sandstone
105–120	Red shale
120–133	Red-brown sandy shale
133–155	Red shale and siltstone
155–182	Red-brown siltstone and red shale
182–186	Green-gray sandstone, medium grained, with streaks of red shale
186–216	Gray sandstone, medium-coarse grained, becoming very coarse below 190 ft. Water (5 gal/min) at 188 ft, about 40 gal/min at 206 ft
216–240	Red shale, some siltstone
240–262	Gray sandstone, medium grained
262–317	Red shale, some siltstone streaks
317–329	Gray sandstone, medium-coarse grained
329–331	Red shale
331–336	Red-brown sandstone, fine grained
336–348	Red shale
348–380	Gray sandstone, medium-coarse grained
380–400	Red shale, drills fast
400–412	Red-brown sandstone, fine grained
412–420	Red shale
420–430	Gray sandstone, fine-medium grained
430–440	Red shale
440–482	Gray arkosic sandstone, medium-coarse grained, some fine-grained sandstone
482–492	Red shale
492–506	Red-brown arkosic sandstone, medium-coarse grained
506–512	Red shale
512–522	Gray sandstone, medium-coarse grained, some arkosic sandstone
522–550	Red shale and siltstone
550–574	Gray sandstone, fine-medium grained, some red-brown shale
574–578	Red shale
578–596	Gray sandstone, medium grained
596–604	Dark red shale

Table 10.—Lithologic description of cuttings from selected wells.—Continued

Well No. : Mont-Cb 26 (Continued)

Depth (ft)	*Description*
604–628	Gray sandstone, medium-coarse grained, shale streak 619-620 ft
628–634	Red-brown shale
634–660	Gray and red-brown arkosic sandstone, medium grained
660–674	Red and green-gray shale
674–710	Brown-gray arkosic sandstone, apparently some limestone conglomerate, few shale streaks
710–770	Red-brown shale and sandy shale, few fine-grained sandstone streaks
770–808	Limestone conglomerate in red shale matrix, limestone chips, pink and gray
808–838	Gray limestone, argillaceous (Frederick? Limestone)
838–846	Gray shale, calcareous, fissile
846–862	Gray argillaceous limestone
862–885	Gray, very argillaceous limestone, some gray calcareous shale

Figure 11. Selected geophysical logs

Owner: Town of Thurmont
Driller: Austin Keyser,Inc
Type log: Caliper
Well no: Fr—Be 39
Date logged: Dec 28, 1971
Aquifer: Gettysburg Shale (limestone-pebble conglomerate lithofacies)

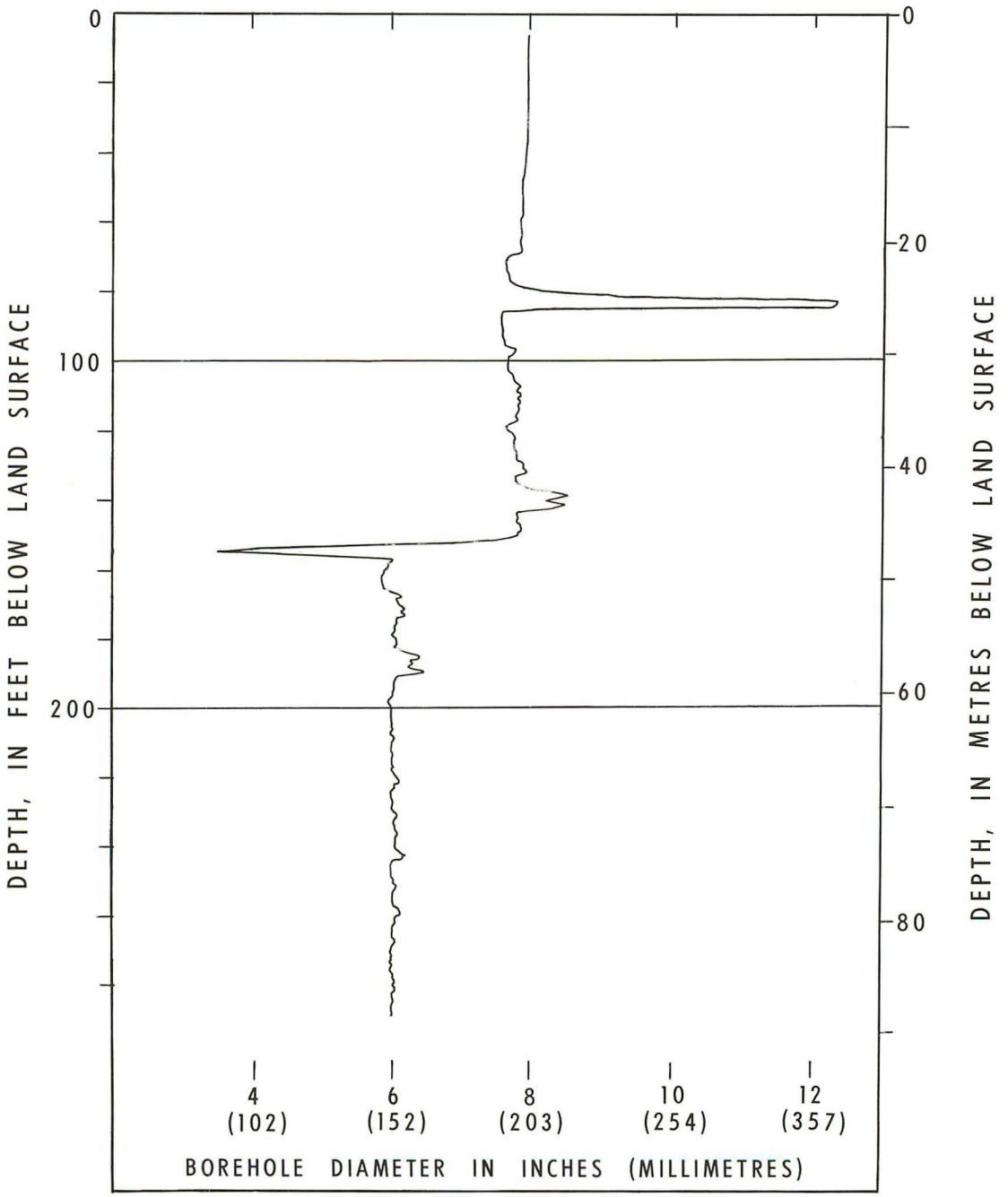


Figure 11.-- Continued

Owner: Town of Poolesville
Driller: Sydnor Hydrodynamics
Type log: Caliper
Well no: Mont-Dc 18
Date logged: Sept.12, 1969
Aquifer: New Oxford Formation

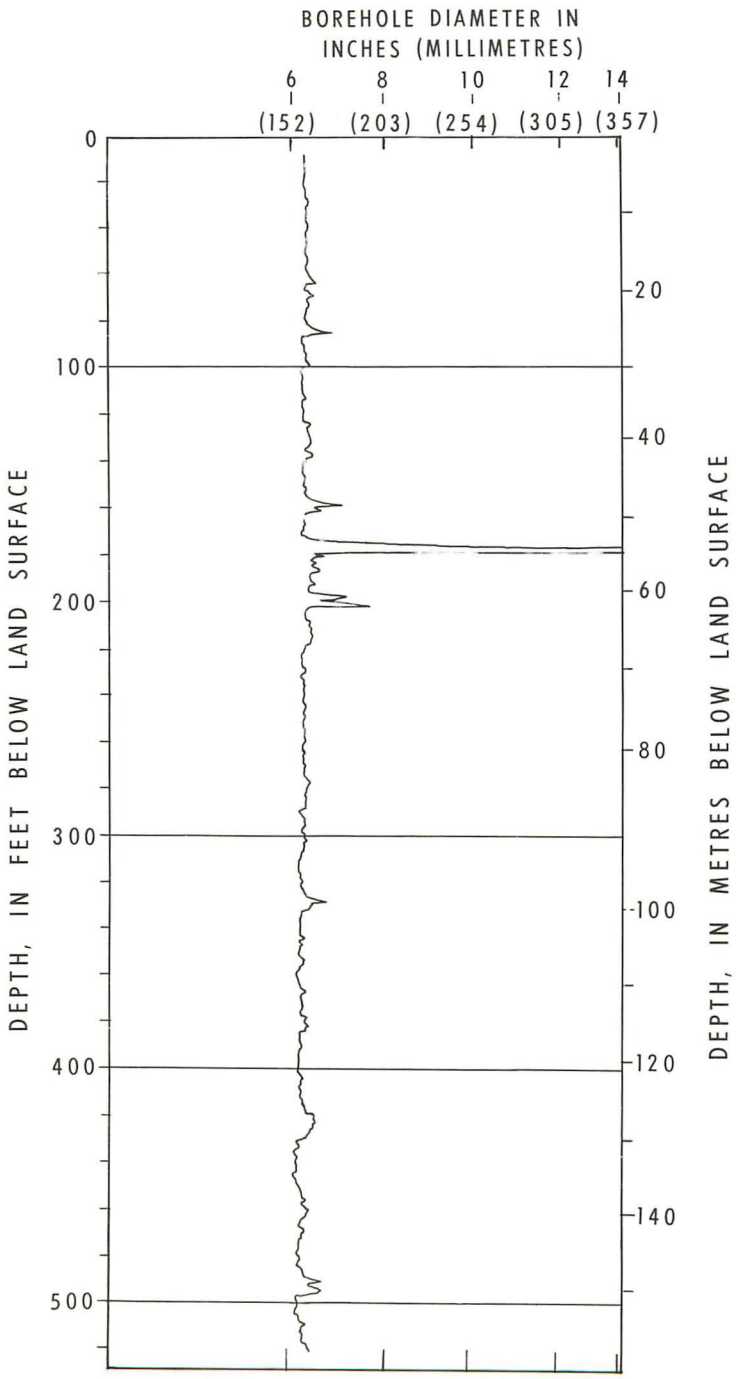
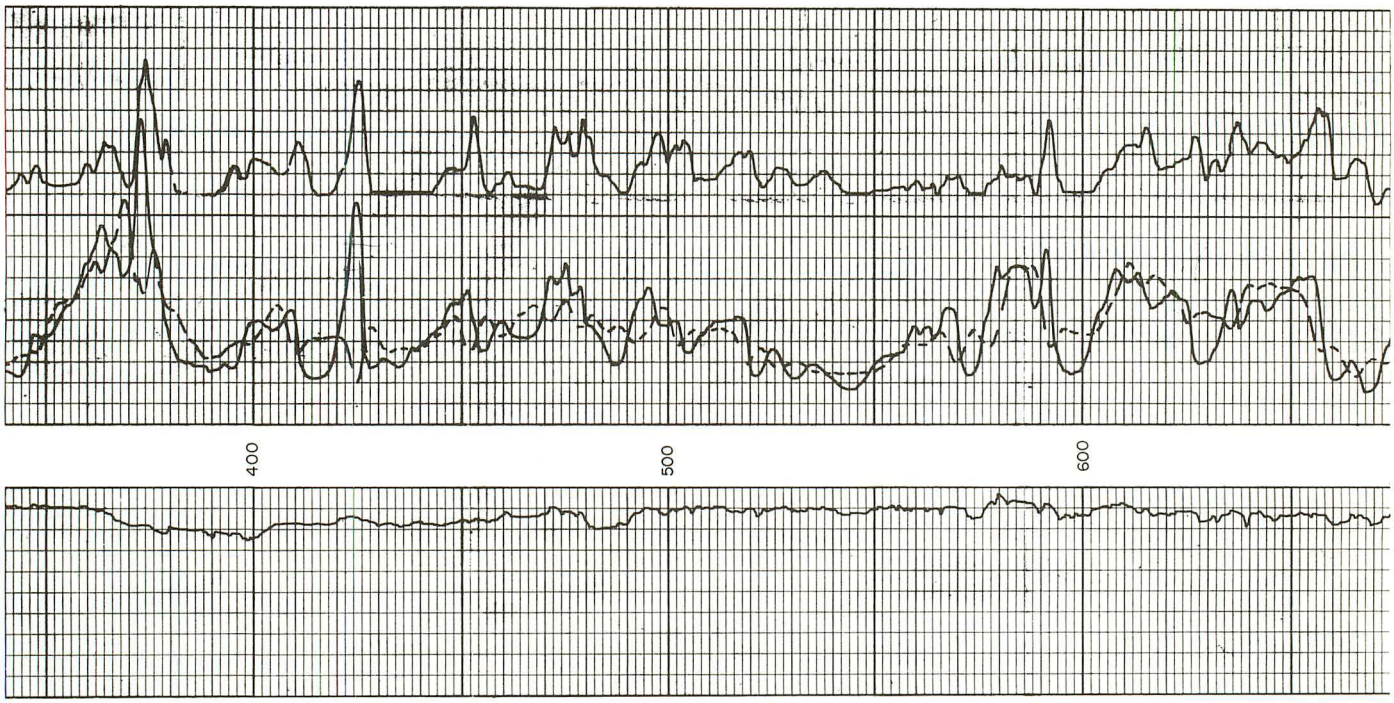
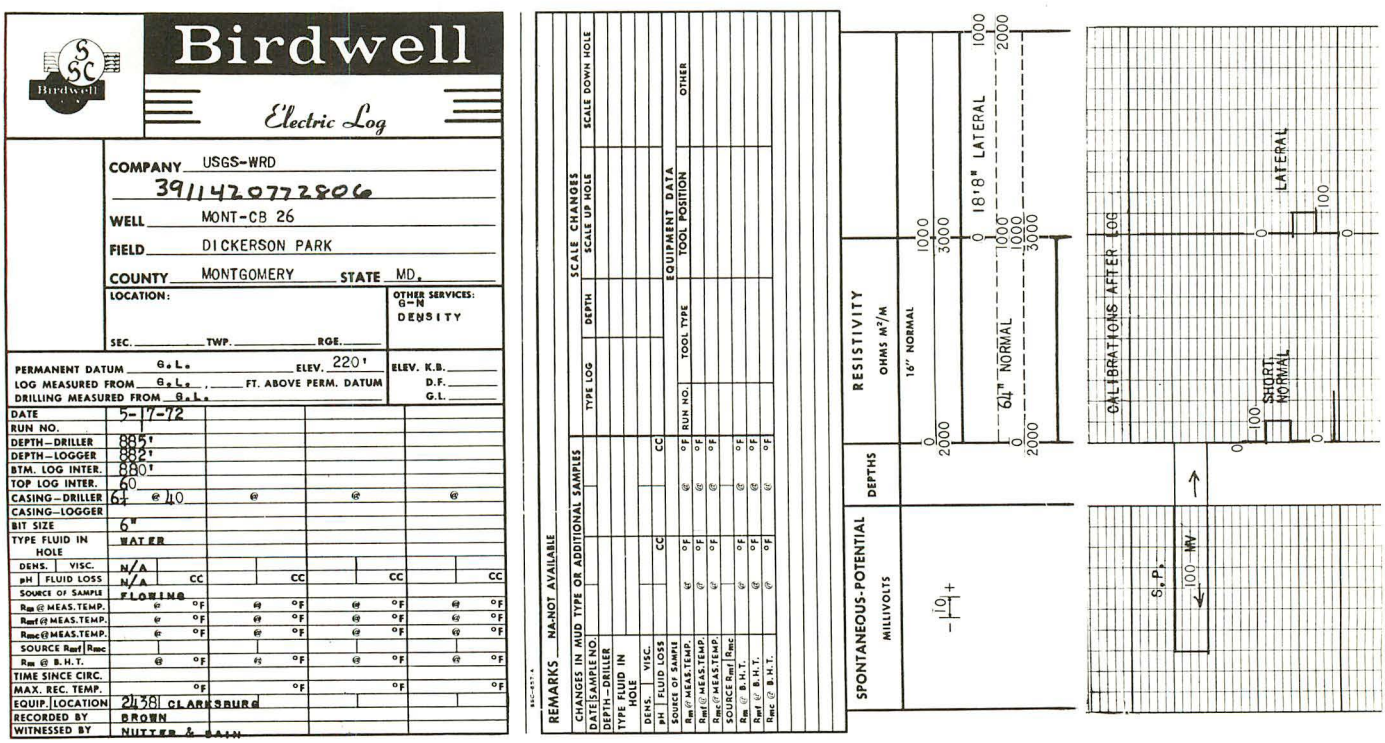
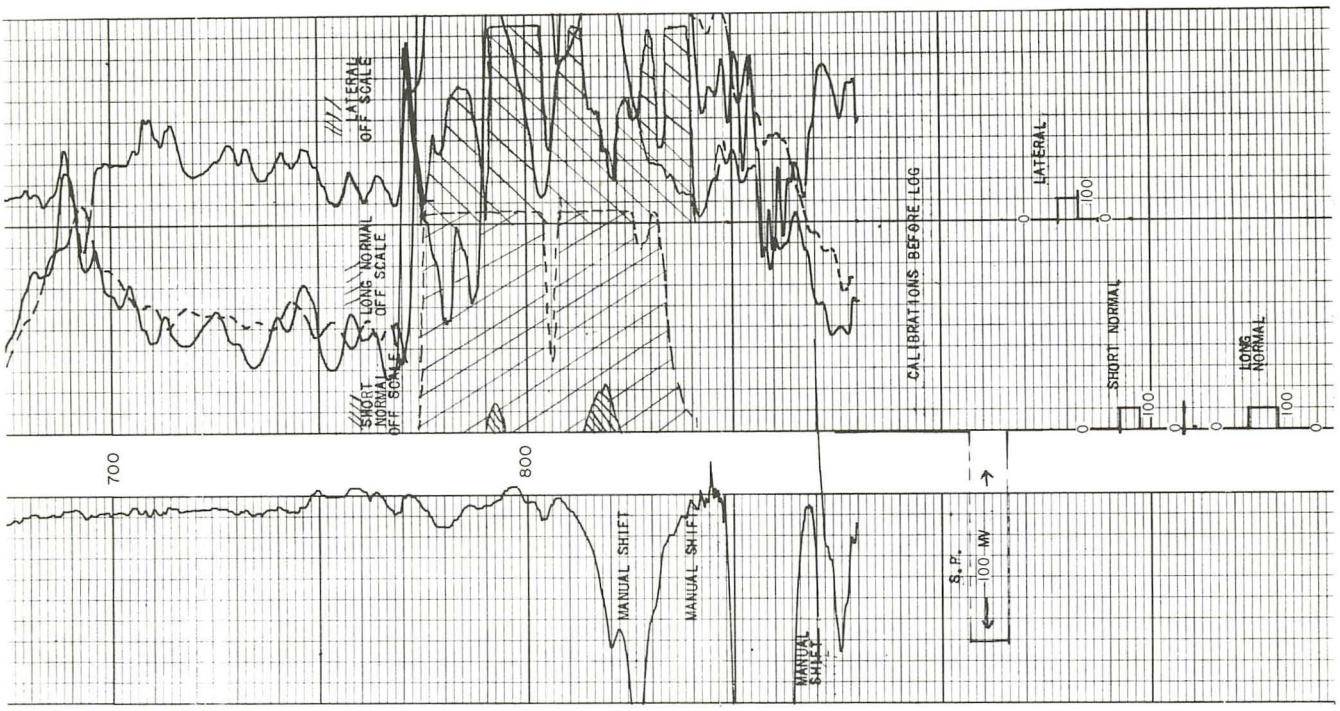
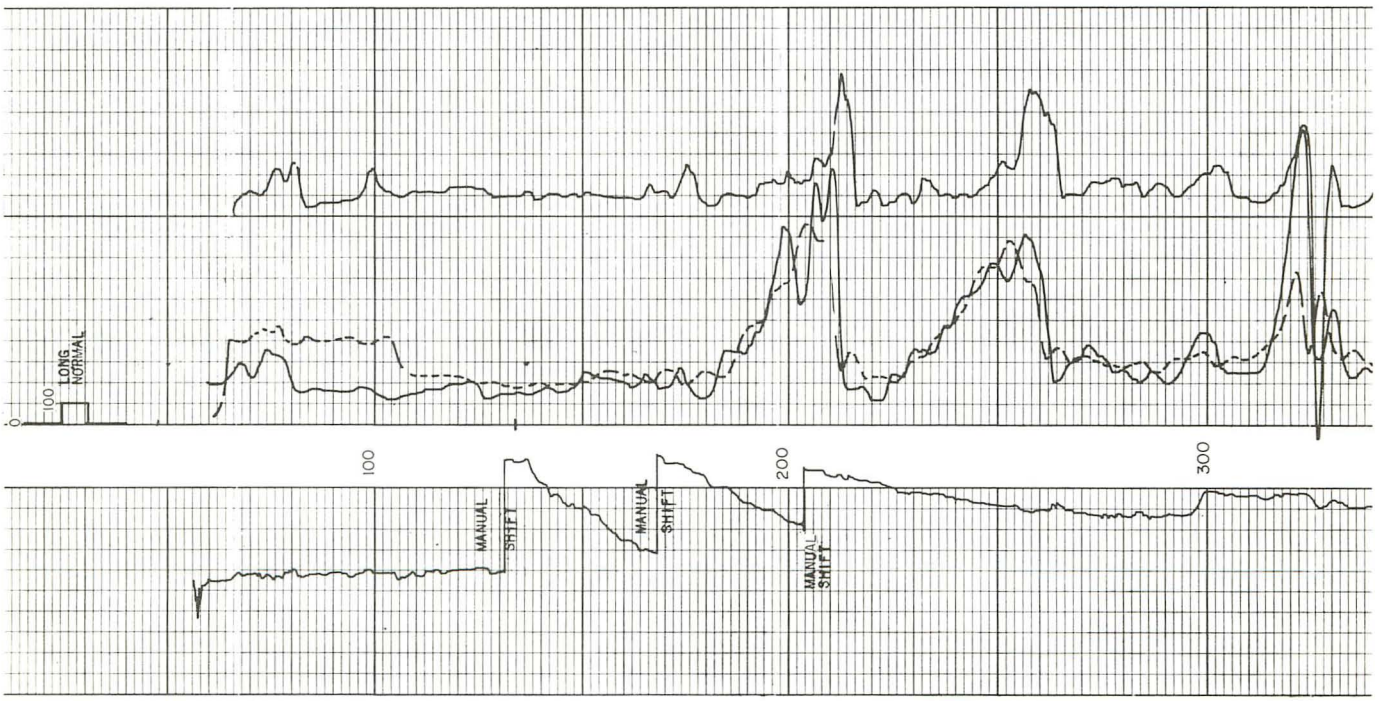


Figure 11.-- Continued






LATERAL OFF SCALE
LONG NORMAL OFF SCALE
SHORT NORMAL OFF SCALE
CALIBRATIONS BEFORE LOG
LATERAL
SHORT NORMAL
LONG NORMAL
100
0
700
800
MANUAL SHIFT
MANUAL SHIFT
MANUAL SHIFT
S.P.
100 MV


LONG NORMAL
100
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300
MANUAL SHIFT
MANUAL SHIFT
MANUAL SHIFT

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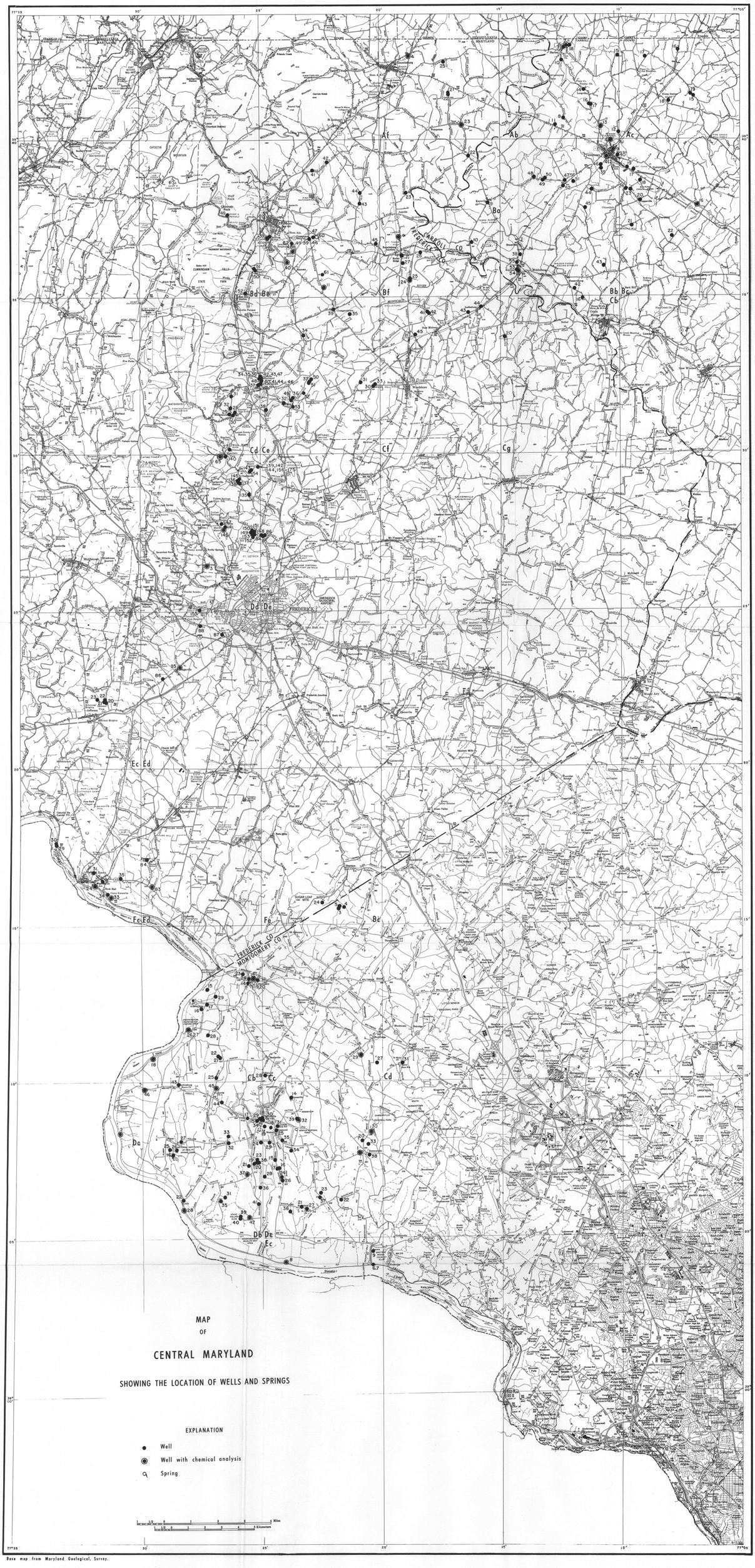

Base map from Maryland Geological Survey.

Plate 1. Map showing location of wells and springs