Department of Natural Resources

MARYLAND GEOLOGICAL SURVEY

Kenneth N. Weaver, Director

REPORT OF INVESTIGATIONS NO. 42

MARYLAND SPRINGS — THEIR PHYSICAL, THERMAL, AND CHEMICAL CHARACTERISTICS

by

Edmond G. Otton
and
John T. Hilleary

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

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NOTE:

SPRINGS FOR HOUSEHOLD USE AND HUMAN CONSUMPTION ARE SUBJECT TO APPROVAL BY COUNTY AND STATE HEALTH AUTHORITIES

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MARYLAND SPRINGS — THEIR PHYSICAL, THERMAL, AND CHEMICAL CHARACTERISTICS

by

Edmond G. Otton and John T. Hilleary

ABSTRACT

This report describes the investigation and appraisal of the flow and temperature of 100 springs in a 4,500-square-mile area comprising the Piedmont and Appalachian provinces of Maryland. The flow of these springs ranges from less than 1 to nearly 10,000 gallons per minute. The largest flow is from the Potomac Blue Spring in the Potomac River valley near Cumberland, Maryland. The flow of most springs ranges widely throughout an annual cycle, in some instances by as much as two orders of magnitude. All but 1 of 26 springs would be classed as variable to sub-variable, according to a variability index proposed by Meinzer.

Temperatures of 76 Maryland springs were measured through an annual cycle. Variations at individual springs ranged from 1.5 to 18.9 degrees Celsius (°C). The maximum temperature recorded was 19.9°C. Mean annual water temperature is usually within 1° to 2°C of the mean annual air temperature at the locality. The lowest mean temperatures generally occur in the highland areas of Garrett County, while the highest temperatures occur in southern Montgomery County. Measurements of flow and temperature of a large spring in Washington County show that an energy transfer involving a reduction of its mean temperature by 5°C would yield 1,320,000 watts per hour. Other springs of comparable flow and thermal characteristics are in Washington, Frederick, and Allegany Counties. Therefore, Maryland springs represent a large potential source of thermal energy.

Chemical analyses of the water from 24 springs show that most of them have calcium-magnesium bicarbonate type water, or water of a mixed type. Nearly all the water is of a chemical character suitable for most uses, although water from limestone springs is hard to moderately hard. Concentrations of the trace elements aluminum, cadmium, chromium, copper, lead, lithium, mercury, nickel, silver, and lead are all below the U.S. Environmental Protection Agency's maximum allowable contaminant levels.

INTRODUCTION

Since ancient times, springs have been a source of interest and importance to man, and even today are still used in many places as a source of water supply. Support of their former esteem and importance exists in the names of places where springs occur. In Maryland, for example, there is the Green Spring Valley in Baltimore County, the town of Silver Spring in Montgomery County, and the town of Clear Spring in Washington County, to mention only a few. Although nearly everyone knows what a spring is, little is known about the details of the source of spring water, the variability of spring flows, their annual temperature range, and the chemical character of the water. This report provides this information on many springs in the Piedmont and Appalachian areas of the state.

A further impetus to the study of springs resulted from the rapid rise in the cost of energy during the 1970's. The increasing use of heat pumps and the feasibility of using ground water as a source of heat energy prompted this study of springs as a possible source of energy and a possible source of energy disposal (cooling). The amount of energy potentially available from a spring is a function of both its temperature and its discharge; thus, periodic measurements were made of the temperature and the flow of several springs during the investigation. This study was done by the U.S. Geological Survey in cooperation with the Maryland Geological Survey.

PURPOSE AND SCOPE

The purpose of this report is to present basic information on the occurrence, availability, temperature, and quality of spring water in the sedimentary and crystalline rocks of 10 Maryland counties and Baltimore City. Examinations were made of the hydrologic characteristics of the springs and an inventory made of their current use as sources of water. Ground-water samples were collected for chemical analyses, pH, and temperature determinations. Spring-flow variability and the potential of Maryland springs as sources of thermal energy also are discussed.

LOCATION OF AREA

This report contains information on 100 springs in the Piedmont and Appalachian physiographic provinces of Maryland. These two provinces cover an area of about 4,500 mi^2, or slightly less than half the total land area of the state (figs. 1 and 5). From east to west, they

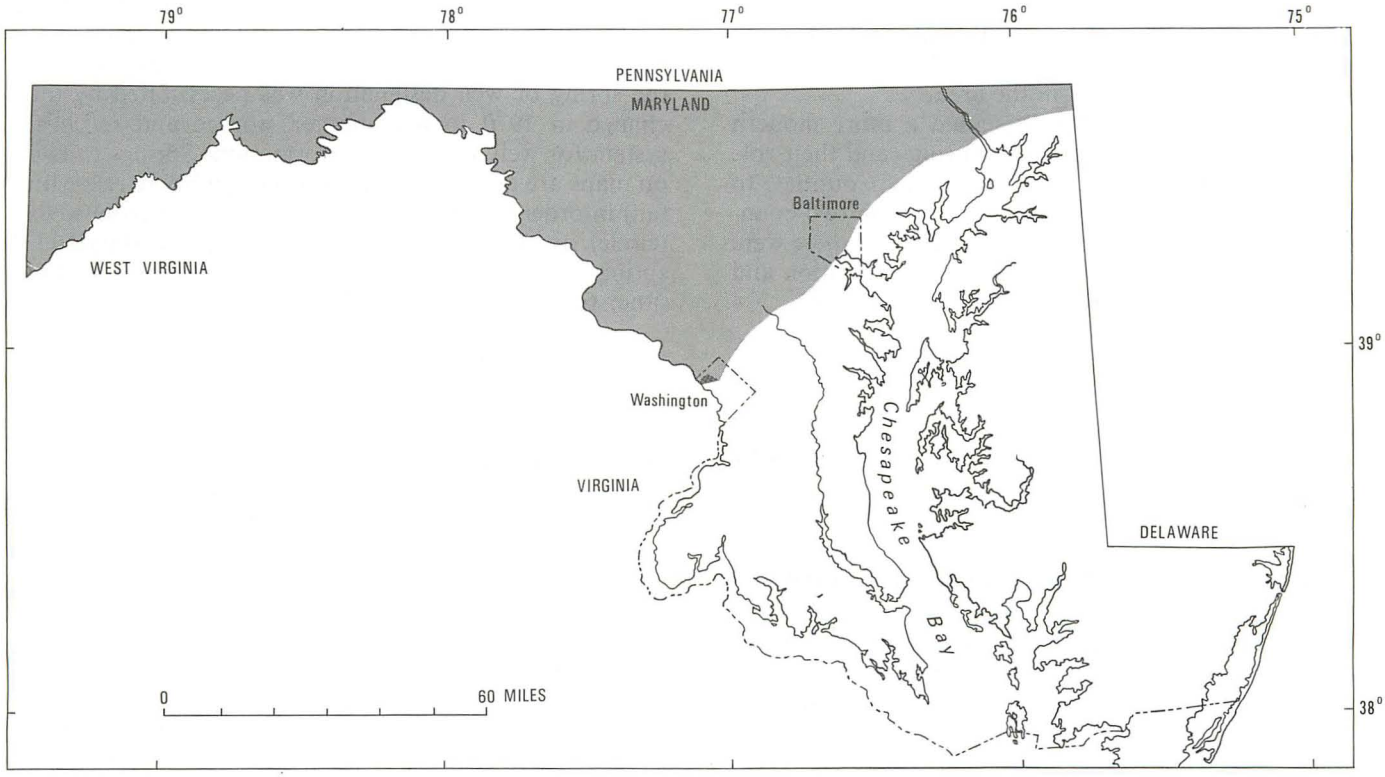


Figure 1.—Area of this investigation.

include the Piedmont part of Cecil, Harford, and Baltimore Counties, and all of Carroll, Montgomery, Frederick, Washington, Allegany, and Garrett Counties. The latter three counties are entirely in the Appalachian province.

PREVIOUS STUDIES

Scattered references to springs are found in the literature pertaining to Maryland geology and water resources. Most of this information is from the publications of the Maryland Geological Survey. In an early report, Clark, Mathews, and Berry (1918, p. 234) described briefly the mode of occurrence of a few springs in Maryland. They also mentioned a spring used in downtown Baltimore, which reportedly flowed at a rate of 200 gal/min. Mention also was made of the Royal Springs at Ruxton in Baltimore County, and of the Rock Crystal Springs at Dickeyville, west of Baltimore, but little information is given about these springs. The town of Aberdeen (Harford County) was reported to have been supplied by a spring, and Bel Air (also in Harford County) was supplied in part with water from Wallis Spring. In Frederick County, the towns of Frederick, Middletown, Braddock Heights, and Emmitsburg were reported to have used springs as a sole or partial source of water. Cloos (1951, p. 181) mentioned springs only briefly in this report on Washington County. He indicated that water for the town of Clear Spring was piped from a spring along the eastern slope of Fairview Mountain. Mathews and Watson (1929, p. 289) reviewed briefly the occurrence of springs in Baltimore County and mentioned the existence of the Chattolanee Spring and the Brooklandwood Spring in the Green Spring Valley north of Baltimore, as well as other lesser known springs in the area.

Meyer (1958, p. 28-30) presented a more modern and comprehensive evaluation of springs and their role in the hydrology of Carroll and Frederick Counties. In addition, Meyer listed several springs in the two counties in his table of wells and springs. Some of these were reexamined during the course of this investigation and additional information was obtained about them.

Probably the most thorough and complete study of Maryland springs was that of Slaughter (1962), who inventoried and measured the flow of a number of springs in Allegany and Washington Counties. Slaughter described and listed 106 springs in Allegany County and 198 springs in Washington County. In addition to measurements of discharge and temperature of several springs, Slaughter listed chemical analyses of the water from many of them, including iron concentration, hardness, and pH. Slaughter's report provides a valuable insight into the nature and character of limestone springs in the Hagerstown Valley.

SPRING AND WELL-NUMBERING SYSTEM

The springs and wells described in this report are numbered according to a coordinate system in which Maryland counties are divided into 5-minute quadrangles of latitude and longitude. The first letter of the spring or well number designates a 5-minute segment of latitude; the second letter designates a 5-minute segment of longitude. These letter designations are followed by a number assigned to wells or springs chronologically. This letter-number sequence is the quadrangle designation, which is preceded by an abbreviation of the county name. Thus, spring MO-CG 18 is the 18th spring or well inventoried in quadrangle CG in Montgomery County. In reports describing springs or wells in only one county, the county prefix letters are frequently omitted from the number. However, the numbering system currently in use (1982) differs slightly from that used in earlier published reports, such as Dingman and Meyer (1954). In the 1954 report, spring MO-CG 18 was designated as Mont-Cg 18. The discontinuance of lowercase letters in the spring or well designation was necessitated by the change in 1970 to a computer storage and retrieval system for well and spring information. Springs shown on maps are designated by a special symbol (circle with tail) in order that they may be distinguished from wells (circle). In some water-resources reports on Maryland, springs are included in the same tables with wells, and in other reports they are listed separately.

GEOHYDROLOGY OF SPRINGS

GEOLOGIC SETTING AND CLASSIFICATION

A spring is a concentrated discharge of ground water issuing from a more or less defined opening. It is to be distinguished from a seep, or seepage area, in which the ground water appears at the land surface along a zone of wetness or oozing flow. Meinzer (1942, p. 417) designates springs which ooze or percolate out of many small openings as "seepage springs". He indicates that at all true springs the water issues from the ground due to hydrostatic pressure. Such areas are to be distinguished from areas of moist soil or earth where the water reaches the surface soil due to capillarity. Such moist zones are not to be considered springs according to Meinzer. Throughout much of the Piedmont and Appalachian areas, springs issue from fractures and fissures and (or) along contact zones between two rock types of different permeability. Springs issue from most geologic units outcropping in Maryland; units mentioned in this report are listed in table 1.

Table 1.—Age and major rock type of geologic units[1]

System and Erathem	Series	Formation/Group	Major rock type
Quaternary	-	Alluvium	Sand, gravel
Triassic	Upper	New Oxford Formation Dikes, sills	Sandstone Diabase
Paleozoic	-	Bachman Valley Formation Cockeysville Marble Ellicott City Granodiorite Ijamsville Phyllite James Run Formation Loch Raven Schist Marburg Schist Mount Washington Amphibolite Port Deposit Gneiss Prettyboy Schist Setters Formation Sykesville Formation Urbana Phyllite Wissahickon Formation Wakefield Marble Baltimore Gabbro Complex	Metabasalt Marble Granodiorite Phyllite Gneiss Schist Schist Amphibolite Gneiss Schist Quartzite Gneiss Phyllite Schist Marble Gabbro
Pennsylvanian	Upper	Conemaugh Formation	Sandstone, shale Siltstone
Mississippian	Upper	Mauch Chunk Formation Greenbrier Formation	Sandstone Sandstone, shale, limestone
	Lower	Pocono Formation	Sandstone, shale
Devonian	Upper	Hampshire Formation Jennings Formation	Sandstone, shale Shale, siltstone
	Lower	Oriskany Group Ridgeley Sandstone Helderberg Limestone	 Sandstone Limestone
Silurian	Upper	Tonoloway Limestone	Limestone
Ordovician	Upper	Martinsburg Shale	Shale
	Middle	Chambersburg Limestone St. Paul Group	Limestone Limestone
	Lower	Beekmantown Group Rockdale Run Formation Stonehenge Formation Grove Limestone	 Dolomite, limestone Limestone Limestone
Cambrian	Upper	Conococheague Limestone Elbrook Limestone Libertytown Metarhyolite	Limestone Limestone Metarhyolite
	Lower	Frederick Limestone Araby Formation Tomstown Formation Weverton Quartzite	Limestone Phyllite Dolostone Quartzite
Precambrian	-	Baltimore Gneiss Catoctin Formation	Gneiss Metabasalt

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

Springs and seeps have a role in altering the landscape simply because the moving water carries with it dissolved minerals which have been acquired in its passage through the rocks and soil. Some authors believe that ground-water discharge by means of both springs and seeps, including ground-water discharge below normal stream level, may be responsible for as much as half of the land erosion taking place in humid areas like Maryland (Cleaves and others, 1970, p. 3,015).

With regard to the physical forces responsible for bringing ground water to the surface, early investigators, namely Bryan (1919, p. 557) and Meinzer (1923, p. 52), considered that springs resulted from (1) gravity flow, and (2) artesian flow. More modern concepts do not attempt to make this distinction, recognizing that springs and seeps result from differences in potentiometric head involving gravity, pressure, and other forces such as differential thermal properties. Also, some springs flow due to the buoyant effect of gases dissolved in the water. Because of the complex reasons causing springs to flow, it is difficult to assign the flow of a spring to any one physical force, although certainly gravity is a major factor.

Springs may be classified or grouped in several ways according to their (1) mean flow or discharge, (2) geologic setting (rock structure), (3) mean temperature, and (4) chemistry of their water. Classification may also be made by a combination of one or more of the above elements. However, no system of classification is perfect. For example, to classify a spring by its flow, a series of flow measurements must be made over a period of time, preferably at least through one annual seasonal cycle. In his study of large springs in the United States, Meinzer (1927, p. 3) proposed the following classification, based on magnitude of mean flow:

Magnitude	Cubic feet per second	Gallons per minute	Gallons per day
First	>100	-	>6.46×10^7
Second	10 - 100	4,490 - 44,900	6.46×10^6 - 6.46×10^7
Third	1 - 10	449 - 4,490	6.46×10^7 - 6.46×10^6
Fourth	0.22 - 1	100 - 449	1.44×10^5 - 6.46×10^5
Fifth	-	10 - 100	14,400 - 144,000
Sixth	-	1 - 10	1,440 - 14,400
Seventh	-	0.12 - 1.0	173 - 1,440
Eighth	-	0.12*	180

*0.12 gal/min = 1 pint/min.

Based on the above classification scheme, only a few springs in Maryland rank as high as third magnitude (449 to 4,490 gal/min) and only one spring is of the second magnitude. The largest of these, and probably the largest spring in Maryland, is AL-CE 1, known as the Blue Spring or the Potomac Blue Spring. Based on four reliable measurements, its mean flow is about 5,700 gal/min (12.7 ft^3/s). This spring is located along the valley of the Potomac River about 4 mi south of Cumberland, Md. The flow of all springs vary, in some instances by more than two orders of magnitude, which makes it difficult to classify springs by their flow. Most of the springs in the Maryland Piedmont and Appalachian region are of the fourth through eighth magnitude.

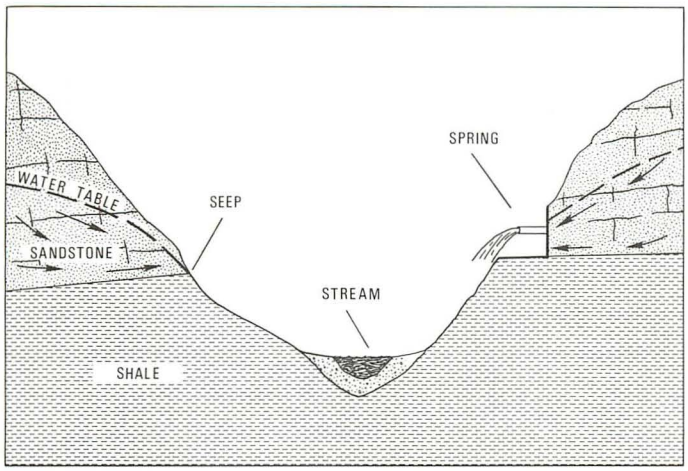
A common type of spring is the contact spring, which results when ground water moves downward through a permeable layer (or zone) and encounters a less permeable layer. Some or all of the flow may be diverted laterally and emerge at the land surface as a spring. Figure 2(A) shows an example of a contact spring, common in the Appalachian province.

Probably the most common type of spring in the area is one that occurs at a fracture or crevice. Here, the ground water moves downward in response to gravity flow through fractures and crevices in the rocks and emerges as a spring where a major fracture in the system of fractures intercepts the land surface along a swale or ravine. Figure 2(B) shows an example of a typical Piedmont spring issuing from a fracture in crystalline rocks. Because of the limited storage capacity of the crystalline rocks, springs of this type generally have a highly variable flow.

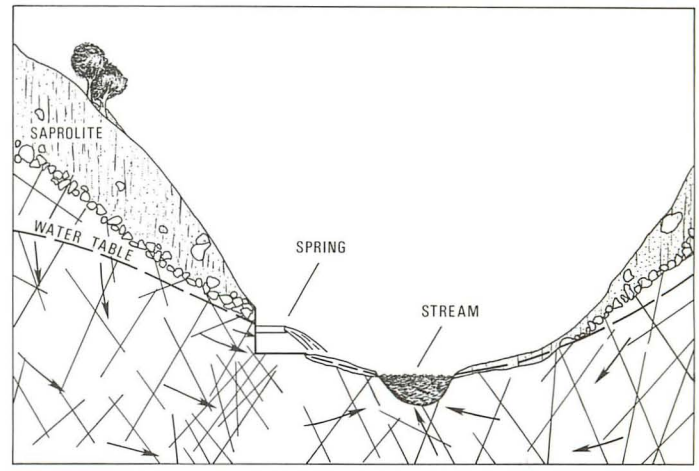
A modification of the fracture type of spring is the scree spring, which occurs on the steep slopes of mountains, such as South Mountain and Catoctin Mountain. Here, the ground water appears to move downslope along the mountainside at the base of boulders and cobbles of scree where it emerges at discreet spring openings at or near the base of the slope, or at a change in slope on the mountain side. Springs of this type currently supply water for the towns of Myersville and Thurmont in Frederick County. Figure 2(C) shows a typical scree type spring.

The fault spring is a fourth type of spring, probably more common than is believed. Springs of this category occur when water moves downward through a permeable formation and encounters a less permeable formation due to the presence of a fault in the rocks. In some cases, the change in permeability may be due to the presence of fault gouge, which retards or inhibits the movement of water across the fault. In other instances, the fault may increase the water-transmitting capability of the rocks due to intensive fracturing of brittle rocks that lie near the fault contact. Here, flow may occur along the base of the fractured zone. Figure 2(D) shows an example of a fault-plane spring of this type. Because of concealment by vegetation and the occurrence of thick soil and weathered rock debris, faults have been only infrequently mapped in the Maryland Piedmont and, thus, the relationship of faults to springs must be largely inferred or assumed.

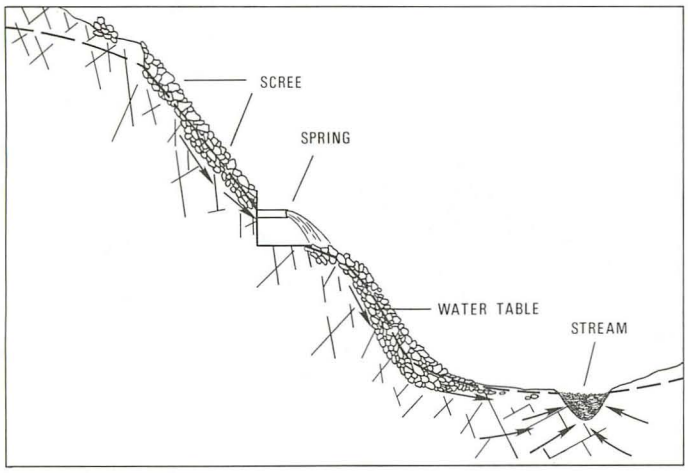
Springs issuing from limestone or marble comprise another distinctive type. Most of the larger springs in Maryland discharge from calcareous rocks. Limestone, because of its relative solubility to percolating ground water, favors the development of solutionally developed channels along joints, fractures, and bedding planes. These channels are capable of transmitting and storing large quantities of water. Most of the large springs in



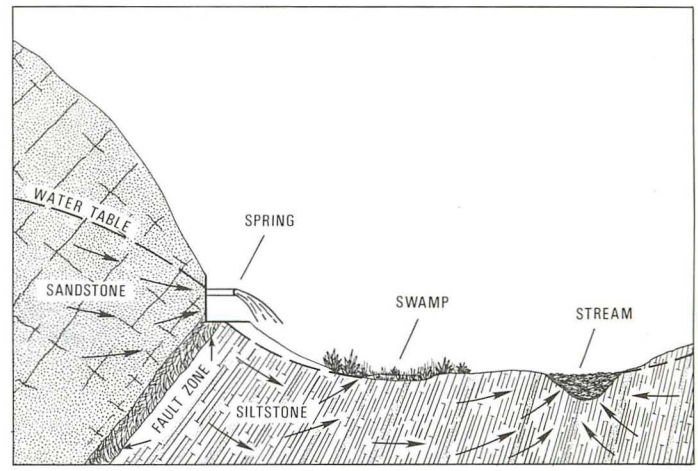
A. Spring at contact of two different rock types



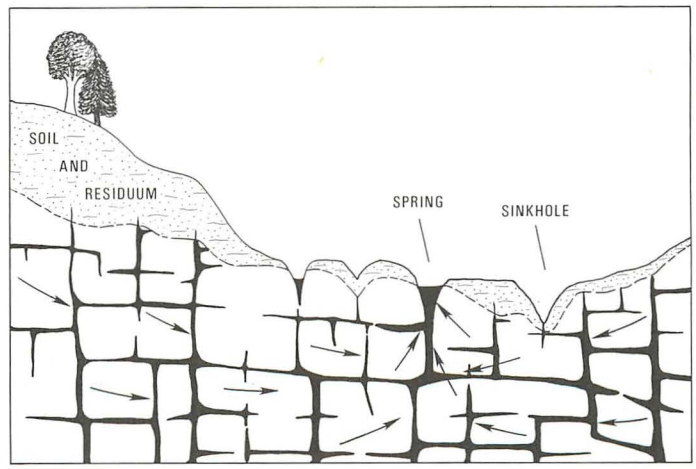
B. Spring occurring where a major fracture zone intercepts the land surface.



C. Scree spring resulting from emergence of shallow ground-water flow at change in slope along a steep mountainside.



D. Spring occurring where a fault plane intersects the land surface.



E. Occurrence of a spring and a sinkhole in limestone terrain.

Figure 2.—Kinds of springs based on rock structure or type.

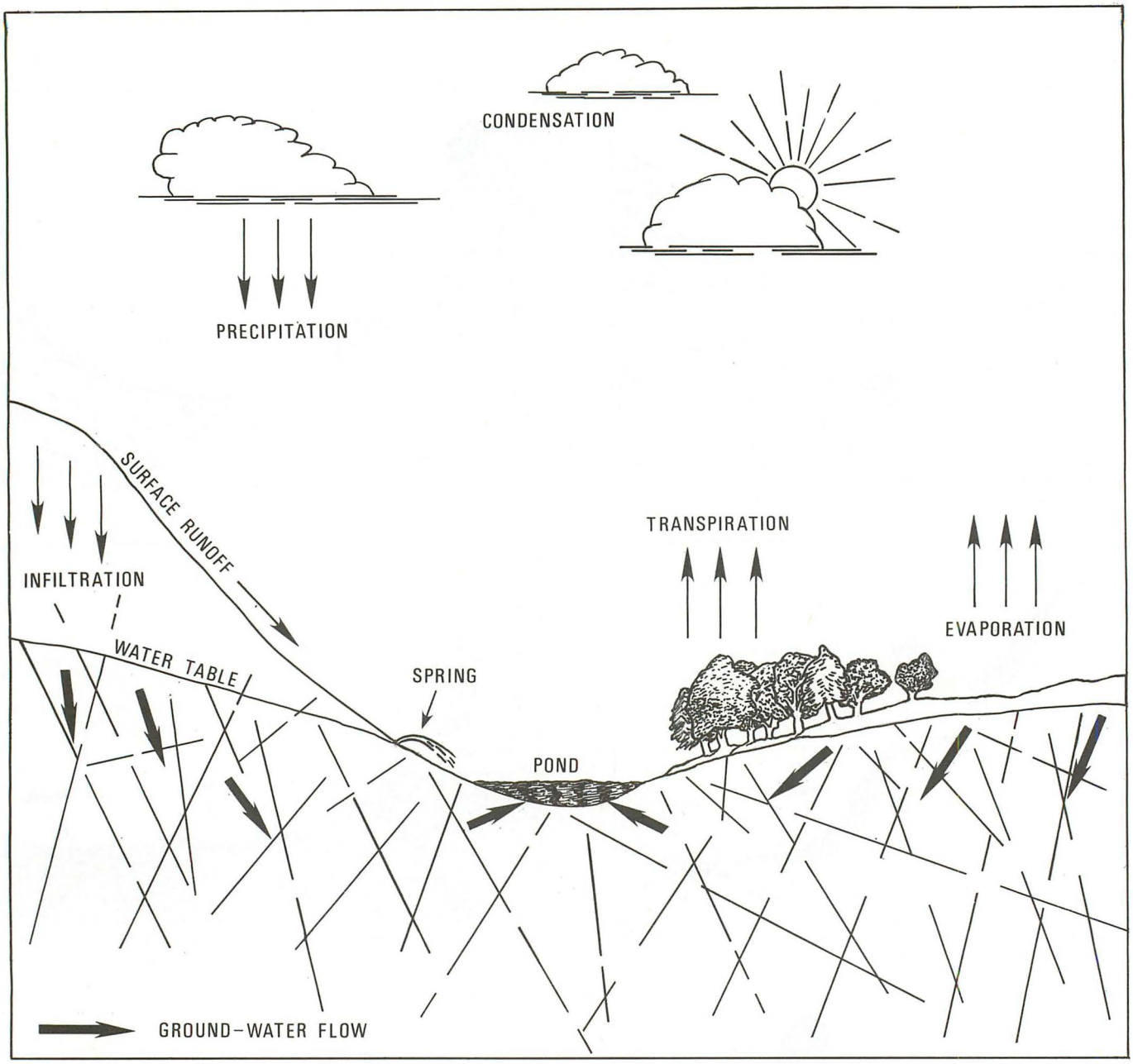


Figure 3.—The hydrologic cycle.

the Appalachian and Piedmont regions are found in limestone terrain. Areas where they are common are the marble valleys of Baltimore and Carroll Counties, and the Frederick and Hagerstown Valleys of Frederick and Washington Counties. Figure 2(E) shows a typical limestone spring of the type that occurs in the Hagerstown Valley. The figure also shows the existence of a sinkhole, a ground-water phenomenon largely restricted to calcareous terranes, and the presence of residuum, weathered rock material resulting from the breakdown of the limestone rocks.

SPRINGS AND THE HYDROLOGIC CYCLE

Springs are an important link in the natural hydrologic cycle. Precipitation is the beginning element of the vast unending circulation of the water on the Earth, known as the hydrologic cycle (fig. 3). This system operates chiefly from the energy of the sun. Water is evaporated from the oceans, the land, and smaller bodies of water such as streams, lakes, and ponds. The water moves as vapor through the atmosphere where it collects as clouds and eventually returns as precipitation both on land and sea. Some of the water falling on the land returns to the sea as overland runoff, but some of it enters the soil zone and percolates downward to saturate the underlying rocks. The water level in the saturated rocks rises to a position sufficiently high to cause water to discharge into nearby streams or ponds. Thus, a lag-time is introduced into the system and some water is stored in the rocks for variable periods of time. Ultimately, however, the system is balanced and, over a

long period of time, the input into the rocks (or aquifers) must equal the output, or ground-water discharge must equal ground-water recharge. Thus, the water in storage in the rocks must equal a constant in the hydrologic equation. This equation in ordinary terms (assuming that ground-water pumping is negligible) can be expressed as follows:

$$P = ET + R \pm \Delta S$$

where:

P = precipitation;

ET = evapotranspiration;

R = runoff, or streamflow; and

ΔS = change in ground-water storage.

Precipitation and runoff are relatively easy to measure. Evapotranspiration, because it is more difficult to measure, is commonly determined as the water unaccounted for after runoff is subtracted from the amount of precipitation in the basin. Over a long period of time (usually a few years), change of ground-water storage (ΔS) must equal zero but, for short periods (weeks or months), water may be added to or subtracted from the aquifers. Where a sufficient number of observation wells are available, changes in the quantity of water in storage in the aquifers are shown by changes in the position of the static water levels.

An exception to this could occur where geohydrologic conditions provide a means for water to move out of a stream basin and discharge into another basin, or into an estuary bay, or the ocean. Generally, in the Piedmont and Appalachian regions the surface-drainage basin also comprises the ground-water basin. An exception to this may occur with surface-drainage basins in limestone terrain. Here, some of the underground-drainage systems may not coincide with the surface drainage. Another exception may occur in areas where active coal mining is taking place. Water pumped from operating mines may be transferred to another drainage basin (Duigon and Smigaj, 1985).

Precipitation

The source of all water issuing from springs in Maryland is precipitation. The central and western part of the state is characterized by a humid continental climate where the average annual precipitation ranges from 47 in. in the Allegheny Plateau to 35 in. in the "rain shadow" area east of the Allegheny Plateau near Cumberland. Elsewhere in the state, the precipitation generally ranges between 40 to 46 in. Table 2 shows the mean monthly and annual precipitation of five major weather stations in the study area, and table 3 shows the monthly and mean annual temperatures at the five stations.

Annual average precipitation for the five weather stations in table 2 ranges from 34.8 to 47.1 in., and their mean is 40.2 in. It is significant that the station with the greatest precipitation (Oakland 1 SE) has about 35 percent more precipitation than the station with the least precipitation (Chewsville-Bridgeport near Hagerstown). The Oakland station is only 95 mi west of the Chewsville-Bridgeport station, but they are separated by several Appalachian mountain ranges. Oakland lies high on the Allegheny Plateau at an elevation of 2,420 ft, and Chewsville-Bridgeport is in the Hagerstown Valley at an elevation of 570 ft. The difference in annual precipitation between the two stations is due to the "rain shadow" effect caused by the prevailing westerly winds dropping their moisture as they rise up the slopes of the plateau at Oakland. As the winds descend on the eastern side of the mountains, the air is warmed, causing the clouds to dissipate and thus provide less moisture as the air mass moves eastward (National Oceanic and Atmospheric Administration, 1977, p. 3).

East of the mountains in the Piedmont province, the average annual precipitation again increases as shown in table 2. At the Westminster station (2 SSE), the annual precipitation is 42.4 in., or about 22 percent greater than at the Chewsville-Bridgeport station. Although Westminster lies only 35 mi east of Chewsville-Bridgeport, its climate is affected by the moisture-laden winds moving northward from the Chesapeake Bay. The stations are separated by South Mountain and Catoctin Mountain, which probably isolate the Hagerstown Valley from the climatic modification caused by the Bay.

Evapotranspiration

Evapotranspiration, the first term on the right side of the hydrologic budget equation, is the water returned to the atmosphere by evaporation from the soil and water bodies and includes the water transpired by plants as part of their life processes. Because it is measured directly only with difficulty, it is commonly determined in the hydrologic budget as the remainder after subtracting streamflow from precipitation. As the evaporation of water requires energy, a method has been devised to compute the potential evapotranspiration of water in an area or in a drainage basin. This method, developed by Thornthwaite and Mather (1955, p. 348-354), is commonly used to show the theoretical limits of evapotranspiration, based on thermal energy received.

The potential evapotranspiration at Westminster, Md., is shown in figure 4. It is based on the Thornthwaite method and was prepared from precipitation and temperature records for the period 1951-74. The figure shows that during the cool season (November-May) more water is available than can be used by evapotranspiration. A large part of this water goes to ground-water recharge. The warm period from June to October is a period when the growing plants use soil water and when evaporation from bare soil is at a maximum. Therefore, less water is available to recharge the ground-water reservoirs. Accordingly, rainfall in

Table 2.—Summary of monthly and annual precipitation at five weather stations in Maryland[1]

Month	Precipitation, in inches									
	Oakland 1 SE MD (1951-74)		Chewsville-Bridgeport (Hagerstown) (1951-71)		Frederick WFMD (1951-70)		Westminster 2 SSE (1951-74)		Baltimore-Washington Airport (1941-70)	
	Mean monthly total	Maximum monthly total	Mean monthly total	Maximum monthly total	Mean monthly total	Maximum monthly total	Mean monthly total	Maximum monthly total	Mean monthly total	Maximum monthly total
January	3.90	7.19	2.30	4.06	2.17	4.22	2.88	4.58	2.91	5.27
February	3.36	7.19	2.35	3.92	2.57	4.20	3.06	5.52	2.81	6.21
March	4.63	9.36	3.08	5.39	3.43	5.35	3.87	6.17	3.69	6.80
April	4.61	8.70	3.08	7.80	3.52	10.53	3.81	9.81	3.07	8.15
May	4.44	8.58	3.37	7.15	3.28	8.16	3.71	6.46	3.61	7.10
June	4.20	8.32	3.29	8.79	3.25	11.26(1951)	3.99	18.79(1972)	3.77	9.95
July	4.48	10.28(1958)	3.36	10.01(1956)	3.71	8.82	3.94	12.73	4.07	8.18
August	4.34	9.32	3.39	8.85	3.57	9.59	4.14	13.33	4.21	18.35(1955)
September	3.09	6.93	2.88	7.69	2.82	10.82	3.26	8.91	3.12	8.62
October	2.87	8.35	2.46	5.22	2.30	3.73	2.66	4.79	2.81	8.09
November	3.20	6.28	2.73	6.07	2.92	5.95	3.37	7.42	3.13	7.68
December	3.99	6.98	2.59	5.02	2.87	6.95	3.69	7.94	3.26	7.44
Mean annual	47.11	-	34.88	-	36.41	-	42.38	-	40.46	-

[1] Values from Climatological Data - Annual Summaries, National Oceanic and Atmospheric Administration. Station designations as given by the reporting agency.

Table 3.—Summary of mean monthly and annual temperatures at five weather stations in Maryland[1]

Month	Mean temperature									
	Oakland 1 SE MD (1951-74)		Chewsville-Bridgeport (Hagerstown) (1951-71)		Frederick WFMD (1951-70)		Westminster 2 SSE (1951-74)		Baltimore-Washington Airport (1941-70)	
	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
January	-3	27	-0.5	31	-0.5	31	-0.5	31	-0.5	33
February	-1	29	1	33	1	33	1	33	1.7	35
March	2	36	5	41	5	41	4.5	40	6	43
April	8	47	12	53	12	53	11	52	12.5	54
May	13	56	16	62	16	62	15.8	61	18	64
June	18	64	21	71	21	71	21	70	22	72
July	19.5	67	24	75	24	75	23.6	74	25	77
August	19	66	23	73	23	73	23	73	24	75
September	15.5	60	19.5	67	19.5	67	19	66	20	68
October	10	50	13.3	56	13	55	13	55	14	57
November	4	39	6.4	44	6.4	44	6.4	44	8	46
December	-1	30	1	34	1	34	1	34	2	35
Mean annual	9	48	12	53	12	53	12	53	13	55

[1] Values from Climatological Data - Annual Summaries, National Oceanic and Atmospheric Administration. Station designations as given by the reporting agency.

August, for example, is not as effective in recharging the aquifers as it is in November or March. The total potential evapotranspiration (fig. 4) amounts to 27.5 in. at Westminster.

Studies by various authors provide quantitative information on the amount of evapotranspiration determined by analyzing the streamflow records of streams in various locations in Maryland. These data are in table 4. The annual precipitation in the five basins ranged from 34.8 to 43.5 in., and the annual water loss by evapotranspiration ranged from 23.4 to 30.9 in. (table 3). Although Antietam Creek in the Hagerstown Valley had the lowest annual precipitation (34.8 in.), its evapotranspiration loss of 23.4 in. was very close to the mean percentile of the five basins (66.6 percent). Throughout most of the Piedmont, including the Hagerstown Valley, evapotranspiration is about 65 percent of the precipitation.

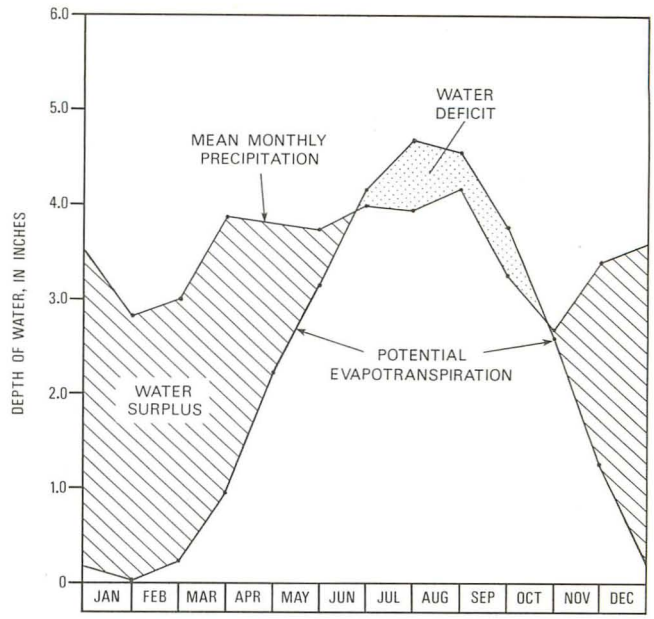


Figure 4.—Mean monthly precipitation and potential evapotranspiration at Westminster, Md.

Runoff

Runoff is considered to be synonymous with streamflow and is the sum of surface flow and ground-water flow that reaches the streams. Surface runoff is that water which travels over the soil surface to the nearest stream channel. It is also defined as that part of the runoff of a drainage basin that has not passed beneath the surface since precipitation; it may, however, include storm seepage, which is that part of the precipitation that infiltrates the surface soil and moves toward the streams as ephemeral, shallow, perched ground water above the main ground-water level. Ground-water runoff is that water which has passed into the ground, entered the zone of saturation, and discharged into a stream channel from springs or seeps.

Water discharging from transient storage in the aquifers by means of springs and seeps maintains the flow of streams during dry periods. The major factors determining spring discharge are aquifer permeability, hydraulic gradient, areal extent of the aquifer system, and the magnitude and distribution of recharge to the system. In some types of terrain (for example, limestone terrain), moderate to large springs are common and the flow of many of the streams is due largely to discharge from identifiable springs in the upper reaches of the tributary streams, but, in shale terrain, fewer identifiable springs exist and the discharge of ground water occurs mainly as seeps. Because of the poor storativity

Table 4.—Summary of hydrologic budget studies in the Maryland Appalachian and Piedmont provinces

Basin	Area upstream from gage (mi^2)	Type of terrain	Period of record	Annual precipitation, P (inches)	Annual evapotranspiration, E-T (inches)	Percentage of P	Total runoff R (inches)	Percentage of P
Antietam Creek [1] (Washington County)	281	Dolomite, limestone, and shale	1951-66	34.8	23.4	67	11.4	33
Big Pipe Creek at Bruceville [2] (Carroll County)	102	Quartzose phyllite and schist	-	41.0	27.7	68	13.3	32
Rock Creek [3] (Montgomery County)	62	Quartzose schist	1933-49	43.5	30.9	71	12.6	29
Little Gunpowder Falls [4] (Baltimore and Harford Counties)	36	Quartzose schist, gneiss, and meta-gabbro	1927-49	42.6	25.5	60	17.1	40
Seneca Creek at Dawsonville [2] (Montgomery County)	101	Phyllite, schist, shale, and sandstone	-	42.0	28.3	67	13.7	33

[1] From Nutter (1973, p. 13).
[2] From Trainer and Watkins (1975, p. 25).
[3] From Dingman and Meyer (1954, p. 39).
[4] From Dingman and Ferguson (1956, p. 48).

of the shale aquifers, the flow of springs in these areas may cease entirely even during minor droughts. This results in a decrease in streamflow and, thus, streams draining shale terrain are characterized by rapidly generated high flow and by a relatively rapid decline of streamflow during droughts.

Recharge

Aquifers are recharged periodically by precipitation percolating through the soil and rock. In general, before recharge can occur, any soil moisture deficiency must be satisfied and the demands of the plants must also be met. Thus, most ground-water recharge in Maryland occurs during winter and early spring (February, March, and April), except during periods when the ground is frozen. Another period of recharge occurs during the fall (November and December) when the plants have become dormant (fig. 4). However, records of observation wells show that recharge to the aquifers can occur at any time of the year if the precipitation is great enough and ground conditions are suitable.

Studies based on separation of streamflow hydrographs into base flow and surface runoff have shown that the effective ground-water recharge in the Maryland Piedmont ranges from 16 to 27 percent. These data are summarized by Richardson (1982, table 3, p. 13). Her summary follows, plus an estimate of ground-water recharge made by Slaughter (1962, p. 33) for a small basin on the west side of South Mountain, and an estimate by Nutter for Antietam Creek in Washington County (1973, p. 13).

Drainage basin	Basin area (square miles)	Annual precipitation (inches)	Effective ground-water recharge (inches)	Recharge as percent of precipitation
Rock Creek	62	43.5	8.5	20
Little Gunpowder Falls	36	42.6	11.3	27
Bennett Creek	62.8	42	11	27
South Branch of Patapsco River[1]	-	43	10	23
Warner Gap Hollow	2.2	39	6.5	16
Antietam Creek	281	35	9.1	26

[1]Method is based on use of water levels in wells and not on streamflow (Ferris and others, 1962, p. 131).

The six estimates of effective ground-water recharge given above range from 6.5 to 11.3 in. annually and the mean value is 9.4 in. This is equivalent to about 430,000 gallons per square mile per day, a reasonable average for the eastern half of the study area. Few reliable estimates are available for effective ground-water recharge for the mountainous western half of the study area.

AQUIFER CHARACTERISTICS

Storage

All rocks in the Piedmont and Appalachian region have at least some capacity to store water. The water is stored in voids in the residuum and in the saprolite and soil above the hard, unweathered rock; in the rocks themselves the water is stored chiefly in fractures, joints, and along bedding-plane partings. In limestone areas of extensive solutional development, the water may be stored in caverns or tubular channels, ranging up to several feet in diameter. Generally, the storage potential of all rocks decreases with depth and, at depths of 1,000 to 2,000 ft, it must be very low — probably less than 1 percent. The storage coefficient (S) of an aquifer is defined as the volume of water an aquifer releases from or takes into storage per unit of surface area per unit of change in head (Lohman, 1972, p. 8). The storage coefficient for unconfined aquifers is approximately equal to gravity drainage, provided gravity drainage is complete.

Commonly, storage coefficients range between values of 0.30 and 0.00001 (Ferris, 1962, p. 76-78). The following three different conditions may exist within the common range of coefficients:

Storage coefficient (dimensionless)	Condition
0.30 to 0.05	Water table
0.049 to 0.001	Intermediate (modified artesian)
0.0009 to 0.00001	Artesian

Storage coefficients determined for unconfined aquifers at shallow depths would probably be most applicable to studies of springs. For this study, shallow depth is considered to be depths not exceeding 150–200 ft below land surface. Storage coefficients (gravity yield) for small basins in Maryland, Pennsylvania, and Virginia have been determined by various investigators. The results of these studies are in table 5.

Of the 10 storage coefficients determined for small stream basins (table 5), 5 are in the water-table range and 5 are in the intermediate range, as categorized on p. 48. The three lowest values, 0.007, 0.011, and 0.012, are from stream basins underlain by shale, siltstone, phyllite, and schist. However, the values are determined, in part, on the length of observation-well and streamflow records used in the analysis. A longer record would presumably give higher values, provided the rocks drained were not of a less porous nature.

Storage coefficients are significant with regard to the flow of springs, inasmuch as springs issuing from aquifers of poor storativity may show a wide variability of flow. During prolonged droughts, such springs may cease flowing entirely, which often happens in shale-siltstone terrain. Springs, in general, appear to be less common in such terrain.

Table 5.—Storage coefficients (gravity yield) of small drainage basins in Maryland, Pennsylvania, and Virginia

Basin studied	Rock type	Storage coefficient (dimensionless)	Reference
East Mahantango Creek basin, Pa.	Sandstone/siltstone and shale	0.12	Cline (1968).
Muddy Creek, Pa.	Quartz-mica schist	.08	Lloyd and Growitz (1977, p. 28).
Piney Run, Carroll County, Md.	do.	.08	Nutter and Otton (1969, p. 28).
Brandywine Creek, Pa.	Schist, gneiss and granite	.07	Olmsted and Hely (1962, p. A-16).
Lebanon Valley, Pa.	Limestone and dolomite	.05	Meisler (1963, p. 32).
Little Conestoga Creek basin, Pa.	do.	.04	Meisler and Becher (1971, p. 56).
Pleasant Gap subbasin, Pa.	Sandstone, siltstone, and shale	.025*	Konikow (1971, p. 79).
Big Pipe Creek at Bruceville, Md.	Phyllite and schist	.012	Trainer and Watkins (1975, p. 25).
Goose Creek near Leesburg, Va.	Shale, siltstone, and diabase	.011	Do.
Seneca Creek at Dawsonville, Md.	Shale, siltstone, and schist	.007	Do.

* Based on a drainage period of 40 days.

Table 6.—Storage coefficients from aquifer tests in the Maryland Appalachian and Piedmont provinces

Locality	Rock type	Storage coefficient (dimensionless)	Reference
Cumberland	Limestone	0.04	Slaughter (1962, p. 127).
Cearfoss	Limestone and dolomite	.14	Slaughter (1962, p. 74).
Hagerstown	Limestone	.03	Do.
Adamstown	do.	.00002	Meyer (1958, p. 39).
Westminster	Marble	.004	Do.
Burkittsville	Metabasalt	.02	Do.
Arcadia	Schist	.003	Dingman and Ferguson (1956, p. 28).
Hampstead	do.	.03	Meyer (1958, p. 39).
Laytonsville	do.	.017	Nutter and Otton (1969, p. 33).
Do.	do.	.003	Do.
Mt. Airy	do.	.02	Meyer (1958, p. 39).
Taneytown	Shale and sandstone	.001	Do.
Do. (well CL-BB 6)	do.	.0002	Do.
N.I.H.-Poolesville	do.	.004	Consultant's report to N.I.H.
Do.	do.	.0006	Do.
Poolesville, town (well MO-DB 54)	do.	.00008	Otton (1981, p. 7).
(well MO-DB 79)	do.	.0002	Do.
Cresaptown	Shale	.008	Slaughter (1962, p. 127).

Storage coefficients may also be determined from aquifer tests. Such a determination requires a pumping well and at least one observation well. However, the values obtained by this method are generally lower than the values obtained by the methods involving gravity drainage. This is probably due to the shorter period of drainage available during aquifer tests, which are seldom more than 1 or 2 days' duration. Of the 18 storage coefficients determined from aquifer tests (table 6), only 1 is in the water-table category (aquifer test at Cearfoss near Hagerstown), 13 are in the intermediate category, and 4 are in the artesian category. The lowest value (0.00008) was based on a test on well MO-DB 54 at Poolesville, in shale and siltstone of Triassic age. Possibly the storage values obtained from aquifer tests on wells are not applicable to situations involving springs, which drain largely by gravity.

As stated previously, the water-bearing properties of a rock mass are governed both by the fractures in the rock and by the nature of the mantle of unconsolidated material. Where the weathered mantle is thick and saturated, or the rocks are overlain by porous saturated alluvium, there is more storage space than where the mantle is thin or absent. In the rock itself where fractures are thin, infrequent, or absent, little or no water can be stored and these rocks are generally poor aquifers.

Hydraulic Conductivity

Hydraulic conductivity is a measure of the rate which water moves through earth materials and is commonly measured in cubic feet per day per square foot of area across which the flow takes place under a unit hydraulic gradient. Hydraulic conductivity is designated as "K" in mathematical formulae and is affected by temperature, which affects the viscosity of the water. The higher the temperature of the water, the lower will be its viscosity and the easier it will be for the water to pass through the pores of the aquifer. Because ground water is of relatively uniform temperature, this property is seldom included in hydraulic computations. For laboratory tests, K is commonly expressed at 20°C.

Transmissivity

Transmissivity is the capacity of an aquifer to transmit water through its entire thickness and is designated as "T". Aquifer thickness is commonly designated as "m", and the relation between hydraulic conductivity and transmissivity is:

$$T = K \times m$$

Aquifer tests conducted in fractured and creviced rock are used to determine their transmissivity (T), and in many situations the values obtained are approximations. However, determination of aquifer thickness (m) is difficult; m is needed to compute K where laboratory values of the latter are not available. Estimates of the depth of occurrence of water-yielding fractures reported by well drillers indicate that below a depth of about 250 ft, fractures decrease markedly in frequency and productivity. In the absence of more precise information, a general measure of aquifer thickness (m) of 250 ft is reasonable for rocks in the Piedmont province. In the Appalachian province, thickness (m) might be about 150 to 200 ft. This subject is discussed in further detail by Otton (1981, p. 13).

Transmissivity of aquifers may be determined by aquifer tests in wells, by water-level fluctuations in wells related to base flow of streams, by recession of water levels in wells, and by base-runoff recession as shown by stream hydrographs. The magnitude and duration of the flow of springs (as is true for pumping wells) is determined by the hydraulic characteristics of the aquifer, chiefly its transmissivity and storage, and by recharge and discharge to the system. As a result of the geohydrologic investigations undertaken in Maryland and adjacent states since 1942, numerous measurements of transmissivity have been made, chiefly from aquifer tests on wells. In the Piedmont and Appalachian regions, these values range from 5 ft^2/d to about 26,700 ft^2/d. The range and median value of transmissivity for several rock types are given in table 7.

Based on the median values of transmissivity in table 7, limestone conglomerate has the maximum value of 2,300 ft^2/d. The next highest median value of 1,400 ft^2 is from the 18 aquifer tests conducted on limestone and marble aquifers in Washington, Frederick, and Baltimore Counties. The maximum value, 26,700 ft^2/d, was reported by Slaughter (1962, p. 60) for an aquifer test on the Stonehenge Limestone (Beekmantown Group) at the Victor Products Company plant in Hagerstown. This test is of interest in that the pumping of well WA-BI 26 at a rate of 200 gal/min caused a cessation of flow in spring WA-BI 21, located approximately 800 ft from the pumping well. Prior to the test, the spring had a measured flow of 22 gal/min (Slaughter, 1962, p. 60). This report is one of the few documented instances of a pumping well affecting a nearby spring. However, such an effect should be expected and can be predicted on the basis of hydraulic theory.

Table 7.—Range and median values of transmissivity for rock aquifers in the Maryland Appalachian and Piedmont provinces[1]

Type of rock	Transmissivity (range in ft ^{2}/d)	Number of values	Median value (ft ^{2}/d)
Conglomerate (limestone)	2,000 to 2,500*	3	2,300
Gabbro	5 to 160	3	130
Gneiss	700 to 1,870	2	1,200
Limestone and marble	5 to 26,700	18	1,400
Metabasalt and metarhyolite	70 to 300	5	250
Phyllite	10 to 800	4	70
Quartzite	---	1	450
Sandstone	130 to 1,900	6	500
Schist	270 to 870	7	400
Shale and siltstone	5 to 2,000	17	80

[1] Values weighted in favor of more productive segments of the aquifers.
* Values reported by Trainer and Watkins (1975, p. 19); data from files of U.S. Geological Survey in Reston, Va.

MARYLAND SPRINGS — THEIR OCCURRENCE AND CHARACTERISTICS

The chief elements of this study of springs involved the location, site examination, and measurement of temperature, flow, and chemical character of 100 springs in the Piedmont and Appalachian provinces of Maryland. Several of the springs monitored during this study were located in the field by previous investigators and these old records are published in ground-water reports of the Maryland Geological Survey. About 625 springs have been documented in these reports on various Piedmont and Appalachian counties. Several additional springs were inventoried and monitored as part of this study. Data for all springs included in this project can be found in table 8. The locations of springs are shown in figure 5, which also shows the major physiographic provinces of Maryland west of the Chesapeake Bay and their divisions.

The Coastal Plain physiographic province lies east of the Piedmont province and is underlain by semi-consolidated stratified layers of sand, clay, silt, and gravel. These strata extend from the Fall Line eastward to the Atlantic Ocean. The Coastal Plain province was not included in the area of this project.

The easternmost physiographic province included in this study is the Piedmont province (fig. 5), which covers about 2,500 mi^2, or about one-fourth the land area of Maryland. It is underlain by ancient crystalline rocks consisting of gneiss, schist, gabbro, marble, phyllite, and related igneous and metamorphic rocks. Along the western margin of the province near Frederick, Md., Cambrian-Ordovician limestones are present which, in places, are overlain by red shales, siltstone, and sandstone of Triassic age. Land elevations in the Piedmont range from sea level along the mouth of the Susquehanna and Patapsco Rivers to about 1,100 ft in northeastern Carroll County near the Pennsylvania border. The topography is rolling to undulating, with steep, narrow valleys along some of the major streams.

The Piedmont is characterized by numerous springs, many of which issue from a permeable zone at or near the base of the saprolite. The flow of these springs varies seasonally, with the greatest flow occurring in late winter or early spring. Table 8 contains information on 61 springs in this province.

The Appalachian province extends westward from

the Piedmont border to the West Virginia state line (fig. 5). It includes about 2,000 mi^2, or about one-fifth the land area of Maryland. The Appalachian province is divided into four divisions: The Blue Ridge, the Great Valley (or Hagerstown Valley as it is known in Maryland), the Valley and Ridge, and the Allegheny Plateau.

The Blue Ridge division consists of two massive quartzite ridges with associated phyllitic and metavolcanic rocks split by a valley area underlain by granite gneiss and granodiorite. Land elevations in the Blue Ridge range from about 230 ft at Point of Rocks to about 1,900 ft along the crest of the ridge near Wolfsville.

The Great Valley division is a broad lowland floored chiefly with a thick sequence of Cambrian and Ordovician limestones and shales. Sinkholes and karst topography occur in several localities underlain by limestone and dolostone. The topography is level to rolling, but moderately hilly in places, particularly along some of the major streams. Elevations range from about 300 ft along the Potomac River to more than 800 ft near Ringgold, just south of the Pennsylvania state line.

The Valley and Ridge division lies between the Great Valley and the Allegheny Plateau. This division is characterized by a series of northeast-trending ridges and valleys where the ridges are comprised mostly of sandstone and the intervening valleys of weaker shale and thin limestone beds. The tops of the ridges are roughly at the same elevation. The relief in the division is about 1,760 ft. Sea level elevations range from 440 ft along the Potomac River to nearly 2,200 ft in a few miles east of Cumberland.

The Allegheny Plateau division includes all of Garrett County and the western part of Allegany County. The plateau extends north, west, and south of Maryland into adjacent states. Elevations range up to 3,360 ft at the highest point in Maryland, near the West Virginia state line. The underlying sedimentary strata, consisting chiefly of shale, sandstone, siltstone, limestone, and coal, lie in broad folds, deeply dissected in places by both Potomac River drainage and by the Youghiogheny River, a tributary of the Ohio River drainage system.

Springs are common in the Appalachian province where they are found along nearly all valleys and ravines. Springs in shale and siltstone terrain tend to be intermittent, with cessation of flow common during droughts. The largest and most sustained springs are in the limestones of the Great Valley. They are responsible for the settlement sites of many of the original homes and towns in the area. Table 8 lists 39 springs in the Appalachian province.

SPRING DISCHARGE

The use of springs as a source of water depends in large part on their flow characteristics, both the quantity and constancy of flow. The measured flow of springs in Maryland ranges from less than 1 gal/min to a maximum of nearly 10,000 gal/min in spring AL-CE 1 (Potomac Blue Spring), measured during April 1958. This and subsequent measurements of the flow of this spring indicate that it is the largest in Maryland. Based on four measurements (table 9), its mean flow is 5,700 gal/min. Flow measurements of other large springs are also included in table 9. For this study, any spring having a measured flow of at least 1 Mgal/d (695 gal/min) is considered a large spring.

Flows of large and medium-sized springs were measured by conventional streamflow-measuring techniques using a current meter and a stopwatch to measure water velocities across a section of the discharge channel. Weirs or flumes were used where their installation was practicable. Flow measurements were made using a bucket and a stopwatch for most of the smaller springs. This method was feasible only where the spring flowed from an open discharge pipe. The flow of some springs could not be measured accurately because of leakage around and under the walls of spring pits or collection boxes.

Spring flows may vary through at least two orders of magnitude. Some springs flow at rather steady rates, but other springs yield several gallons per minute and then dry up completely during droughts. Examination of the graph of daily measured flow (fig. 6) of spring WA-AK 3 near Smithsburg shows the wide variation in its flow from 290 gal/min on April 11 to 3,140 gal/min on April 14, 1981. The significant increase in flow during the period beginning on April 11 was due to a 4-day storm in which 2.7 in. of rain fell on the Hagerstown area.

The measurements of spring flow compiled during this study as well as flow data reported by other investigators show that most springs, especially those of shallow origin, vary widely in their flow. Meinzer (1923, p. 53) recognized this characteristic of springs many years ago and proposed a variability index of spring flow based on the following formula:

$$v = \left(\frac{m-l}{a}\right) 100$$

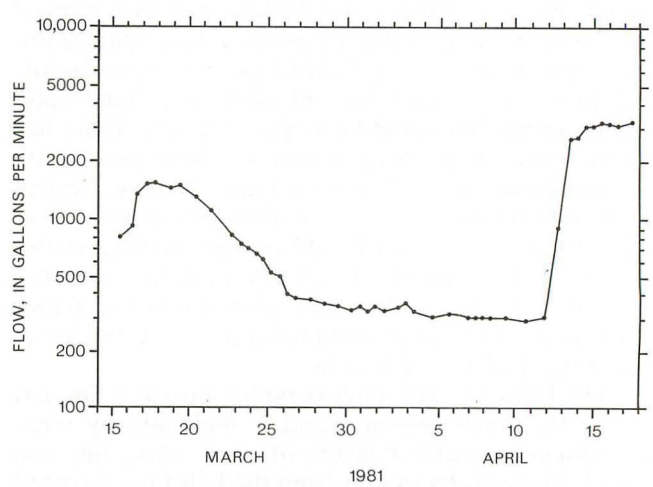


Figure 6.—Daily measured flow of spring WA-AK 3 near Smithsburg, Md.

Table 9.—Measured flows and mean temperature of several large springs in Maryland

Spring No.	Flow measurement gal/min	Flow measurement ft^3/s	Flow measurement date	Mean temperature (°C)	Aquifer
AL-BF 1	3,000	6.68	4/09/58	11	Tonoloway Limestone
	812	1.18	7/08/81		
	370	.82	7/30/59		
AL-CE 1	9,750	21.7	4/17/58	11	Oriskany Group (Ridgeley Sandstone)
	4,940	11.0	9/02/80		
	4,620	10.3	7/23/81		
	3,500	7.79	9/18/59		
AL-BD 34	1,750	3.89	4/16/58	-	Tonoloway Limestone
	330	.73	10/08/57		
FR-DE 42	1,427	3.18	4/09/59	12	Grove Limestone
	1,380	3.07	4/31/81		
	1,020	2.27	10/31/80		
	1,014	2.26	6/18/59		
GA-GA 1	750	1.67	7/--/50	-	Conemaugh Formation
WA-AG 1	2,450	5.46	5/23/58	-	Chambersburg Limestone
	360	.80	1/21/59		
WA-AK 3	3,140	7.00	4/18/81	11	Tomstown Dolomite
	2,400	5.34	2/16/59		
	110	.24	7/30/59		
WA-BF 3	1,150	2.56	5/08/59	12	Conococheague Limestone
	1,100	2.45	5/26/58		
	800	1.78	10/01/59		
WA-BJ 4	3,600	8.02	5/21/58	-	Elbrook Limestone
	1,900	4.23	1/13/60		
WA-CH 2	1,050	2.34	4/29/59	12	Conococheague Limestone
	860	1.91	5/29/58		
	410	.91	7/27/59		
	337	.75	4/21/81		
WA-DI 6	2,500	5.57	5/22/58	12	Tomstown Dolomite
	1,603	3.57	4/22/81		
	880	1.96	8/26/59		
	820	1.83	1/15/59		

where:

v = variability index, in percent;

m = maximum flow;

l = minimum flow;

a = average flow of a series of measurements.

Meinzer further defined a variable spring as one in which the index number is 100 percent or more. A subvariable spring is one in which the index number lies between 25 and 100 percent, and a constant spring is one in which the index number is not more than 25 percent. Of course, all springs which fail (have zero flow) during part of the year are variable springs. Although no number of measurements is specified in computing the

average flow, it would seem prudent to obtain a series of measurements through at least one annual cycle. As part of this study, flow measurements were made monthly for a year on 29 of the smaller springs and less frequently on some of the larger springs. These data were used to compile table 10, which shows the variability indices of the measured springs. The index numbers range from 14 to 295. Only one spring, 3N-3E-3 in Baltimore City, has a constant flow. Nine springs (31 percent) have subvariable flow, and 19 springs (66 percent) have a variable flow. No correlation could be made between the variability index and the type of rocks comprising the aquifers.

Annual mean flow based on monthly measurements was determined for 11 springs in the Appalachian province and 23 springs in the Piedmont province. The springs were placed in five yield classes, based on their annual mean flow. These classes are:

Gallons per minute	*Could be considered for*
0.7 - 4.9	Household use.
5.0 - 9.9	Household and farm.
10 - 19.9	Limited institutional or commercial.
20 - 34	Various uses, possibly limited public supply.
35 - 70+	Small public supplies.

Figure 7 shows the distribution by yield class of springs according to their location in the Piedmont or Appalachian province. Most of the low-yielding springs are in the Piedmont province, while the Appalachian province has more high-yielding springs. The graph does not include data from a few high-yielding springs in the Piedmont, nor does it include data from several high-yielding limestone springs in the Hagerstown Valley reported by Slaughter (1962, table 43). If more recent flow data were available for these springs, it would no doubt indicate the prevalence of large springs in the Appalachian province (See table 8).

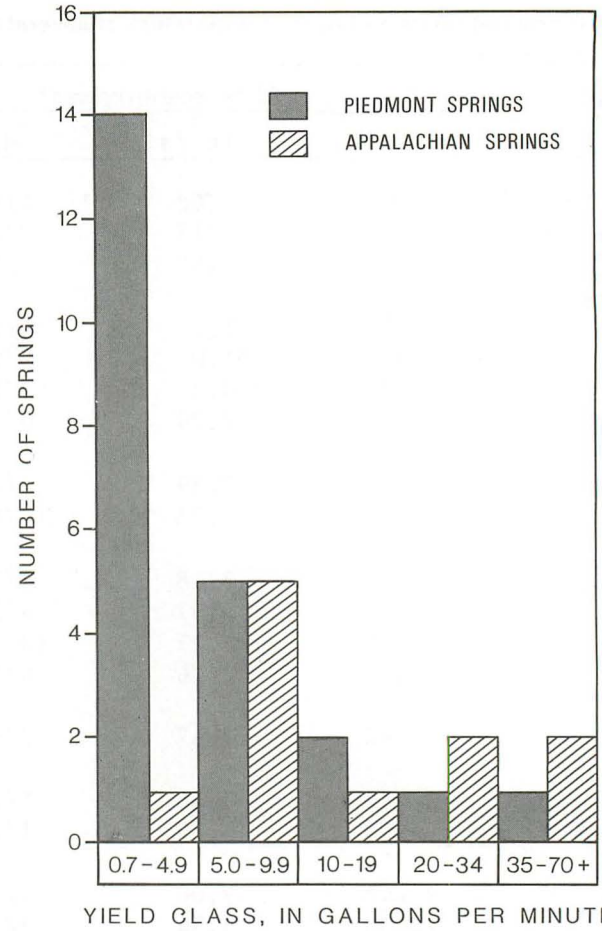


Figure 7.—Distribution of annual mean flow of 34 springs in the Piedmont and Appalachian provinces.

Relation of Drainage Areas of Springs to Mean Flow

Where a spring is used as a source of water supply, it may be important to estimate the drainage area furnishing water to it. Since a spring's collecting system is underground and may not be directly related to the surface-drainage system observable on maps, it is difficult to even estimate the area of the underground system. However, an approximation of the drainage area of a spring can be obtained if some measurements of its flow are available, and if an estimate can be made of the annual ground-water recharge available to the aquifer supplying the spring.

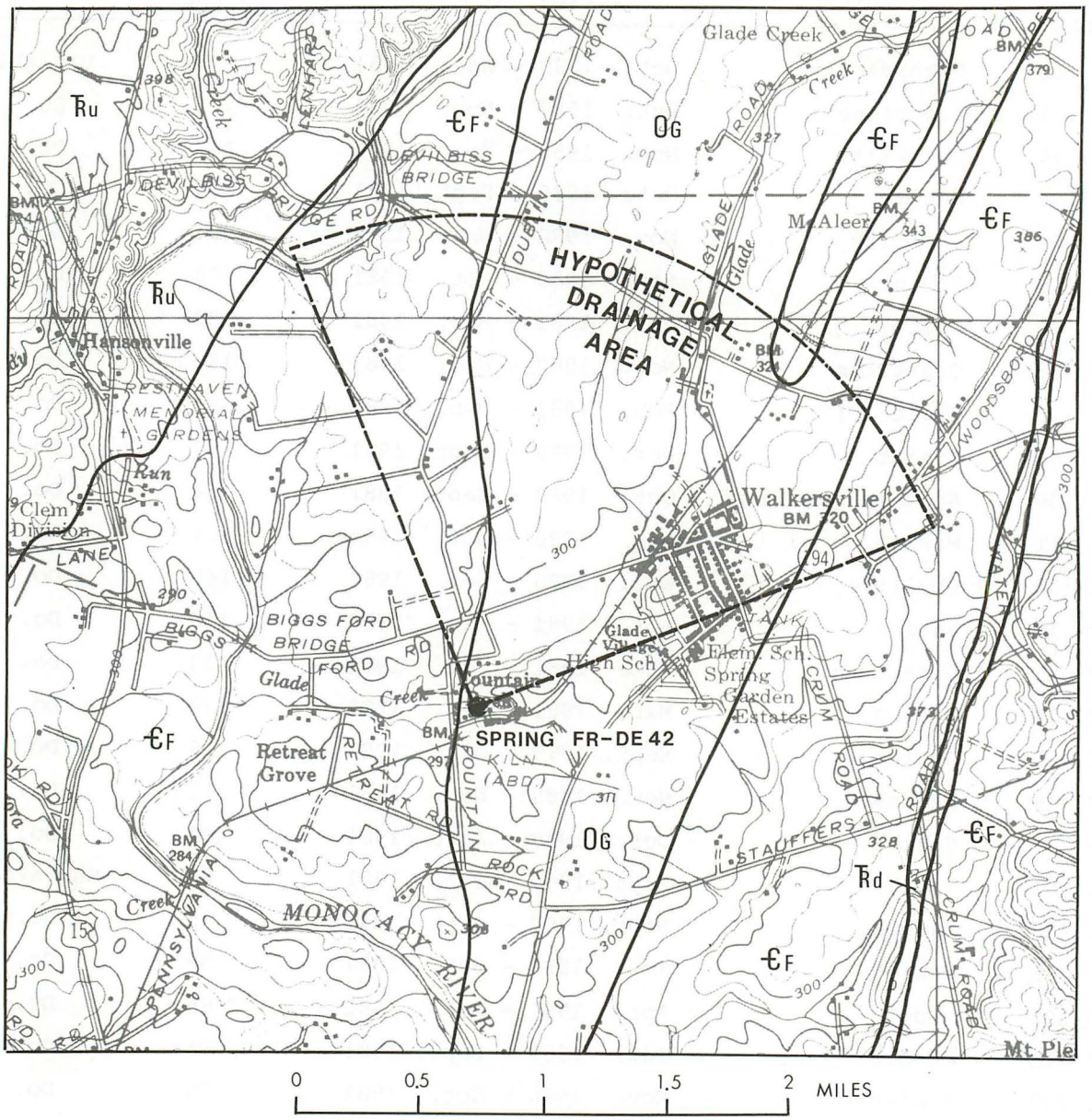
Such information is available for one of the major springs in Frederick County, FR-DE 42, near Walkersville. This spring (Fountain Rock Spring) is currently (1983) used as a source of water for a trout farm and fishpond (fig. 8). It is characterized by a relatively even discharge, ranging from 1,014 gal/min to 1,427 gal/min and a mean discharge of about 1,210 gal/min (or 2.695 ft^3/s). The spring issues from the Grove Limestone, probably the most productive aquifer in Frederick County.

What is the underground drainage (catchment) area necessary to sustain a relatively steady flow of, for example, 1,200 gal/min? The aquifer furnishing this flow must receive recharge amounting to this quantity (over the long term) to maintain a hydraulic head sufficient to sustain the flow of the spring. Because the amount of long-term precipitation and evapotranspiration is a relatively constant value, the specified flow is dependent upon the catchment area of the aquifer required to supply it. The drainage area required to yield values of mean annual spring discharge at annual recharge rates of 8, 10, and 12 inches is shown in figure 9.

Figure 9 is modified after a graph by Davis and DeWiest (1966, p. 64) in their discussion of ground-water discharge and springs. It is important to understand that the underground drainage network of a spring, especially in a limestone region, may occur beneath a surface stream that could be losing part of its flow through infiltration to the underground system. Thus, a short circuit would exist in the hydraulic system and one of the assumptions inherent in using the graph could be rendered invalid. This assumption is that all spring flow is derived from ground-water recharge.

Table 10.—Flow variability indices of 29 Maryland springs, computed according to the Meinzer formula

Spring No.	Aquifer	Period covered	Variability Index No.	Category
FR-FB 12	Granodiorite	Oct. 1980 - Nov. 1981	295	Variable.
GA-CD 1	Limestone	Oct. 1980 - Nov. 1981	281	Do.
FR-BD 54	Quartzite	Nov. 1980 - Nov. 1981	257	Do.
CL-CD 94	Marble	Oct. 1980 - Sept. 1981	254	Do.
CL-AF 84	Phyllite	Nov. 1980 - Oct. 1981	207	Do.
CL-AF 8	Schist	Sept. 1980 - Oct. 1981	203	Do.
CE-CC 40	Gneiss	Apr. 1981 - Mar. 1982	187	Do.
FR-CD 38	Quartzite	Nov. 1980 - Nov. 1981	183	Do.
GA-DD 5	Shale (?)	Feb. 1981 - Feb. 1982	181	Do.
BA-BC 264	Schist	Oct. 1980 - Sept. 1981	157	Do.
HA-BC 30	Schist, quartzose	Oct. 1980 - Sept. 1981	154	Do.
CL-CC 111	Marble	Oct. 1980 - Oct. 1981	151	Do.
CL-BE 100	Phyllite	Nov. 1980 - Oct. 1981	147	Do.
HA-BF 18	Gneiss	Apr. 1981 - Mar. 1982	146	Do.
GA-BB 3	Limestone	June 1981 - May 1982	133	Do.
CE-AE 34	Gneiss	Mar. 1981 - Feb. 1982	129	Do.
BA-AC 150	Schist	Sept. 1980 - Oct. 1981	126	Do.
MO-FF 18	Gneiss	Nov. 1980 - Nov. 1981	111	Do.
HA-AA 9	Schist	Oct. 1980 - Aug. 1981	107	Do.
CL-DC 165	do.	Sept. 1980 - Oct. 1981	98	Subvariable.
BA-DC 440	Marble	Sept. 1980 - Sept. 1981	95	Do.
BA-BD 25	Schist	Nov. 1980 - Oct. 1981	89	Do.
BA-DD 298	do.	Apr. 1981 - Mar. 1982	86	Do.
BA-DC 18	Marble	Oct. 1980 - Sept. 1981	86	Do.
BA-DD 297	Schist	Nov. 1980 - Oct. 1981	79	Do.
AL-BF 21	Sandstone (?)	Feb. 1981 - Feb. 1982	68	Do.
CL-EF 50	Granite (?)	Mar. 1981 - Feb. 1982	55	Do.
HO-BF 35	Quartzite	Sept. 1980 - Sept. 1981	50	Do.
3N-3E 3	Schist (?)	Jan. 1981 - Dec. 1981	14	Constant.



EXPLANATION

TRIASSIC	Ꞧu	Triassic rock, undifferentiated
	Ꞧd	Diabase
ORDOVICIAN	Og	Grove Formation
CAMBRIAN	Ꞓf	Frederick Limestone

Figure 8.—Location of spring FR-DE 42 near Walkersville, Md., local areal geology, and hypothetical drainage area above the spring.

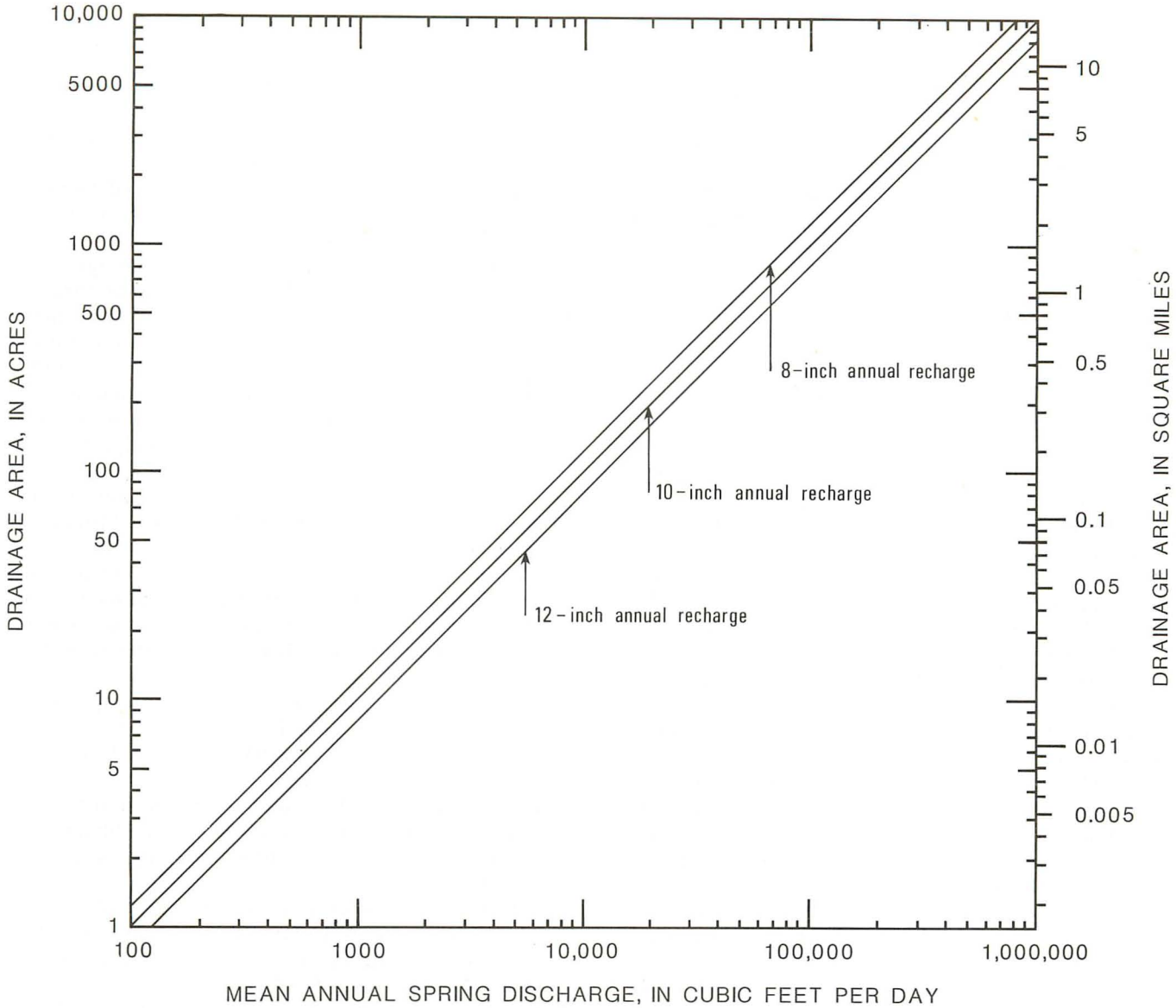


Figure 9.—Relation between drainage area of a spring and spring discharge for various amounts of annual recharge.

Nevertheless, figure 9 was used to compute the approximate drainage area of spring FR-DE 42. Based on four measurements (table 8), the mean flow of this spring is about 1,210 gal/min, or about 233,000 ft^3/d. Examination of the data on p. 12 indicates that 10 in. of effective ground-water recharge is a reasonable value for the Walkersville area in the Monocacy River basin. To determine the approximate drainage area of spring FR-DE 42, read up from the 233,000 ft^3/d value in figure 9 to the 10-in.-sloping recharge line and across the left to 2,300 acres, or to the right to the equivalent 3.6 mi^2. This value tells us only the approximate area contributing to the flow of the spring system; it does not define its shape or its boundaries. If the drainage boundary of the spring formed a perfect circle around the spring (highly unlikely), then the radius of a circle with an area of 3.6 mi^2 would be 1.15 mi according to the following formula:

$$r = \sqrt{\frac{A}{\Pi}}$$

where:

r = radius of a circle, in miles; and

A = area of a circle, in square miles.

However, spring FR-DE 42 lies near the end of a south-sloping limestone valley drained at the surface chiefly by Glade Run (fig. 8). If we assume the underground drainage also comes mainly from the north, it may be more appropriate to designate the area drained by a quarter circle, as shown in figure 8. In this instance, the appropriate formula is:

$$r = \sqrt{\frac{A(4)}{\Pi}} = 2.14 \text{ mi (radius of 1/4 circle having an area of 3.6 mi}^2\text{)}.$$

In the light of present knowledge, the drainage area of this spring could best be mapped by detailed geophysical surveying, or by the use of chemical tracers put into the aquifer. However, the method used above provides a crude approximation of the answer sought.

An analysis similar to that of spring FR-DE 42 near Walkersville, was made on a much smaller spring in Baltimore County, BA-DC 18 (table 8). This spring, known locally as Big Spring, is in Worthington Valley about 1.7 mi west of Shawan. It issues from the Cockeysville Marble near its contact with the Baltimore Gneiss. The flow of BA-DC 18 ranged from 10 to 30 gal/min and averaged 21 gal/min during the period October 1980 to September 1981. Thus, the daily mean flow was about 4,060 ft^3/d. Using the graph in figure 9, and based on an average effective annual recharge rate of 10 in/yr, the area supplying water to spring BA-DC 18 is about 40 acres (0.06 mi^2). If the annual recharge rate were 12 in. instead of 10 in., the graph indicates that the area furnishing water to the spring would be only 34 acres (0.05 mi^2). Examination of the topographic map near spring BA-DC 18 suggests that much of the water may be coming from the south and east direction along the Worthington Valley, as this is the direction of the surface drainage. The hard water issuing from spring BA-DC 18 (see field tests in table 8) indicates a limestone source, and the geologic map of the area shows that marble is present along a 0.4-mi-wide belt immediately to the south.

THERMAL CHARACTERISTICS OF SPRINGS

An important aspect and one of the major elements of this investigation of springs concerns their temperature and enthalpy, and thus their use as a source of thermal energy and a source of energy disposal (cooling). Because a discussion of this subject may involve some terms unfamiliar to many readers, the following brief glossary is presented:

British thermal unit (Btu).—The quantity of heat required to raise the temperature of a standard pound of water from 63° to 64°F.

Calorie (cal).—The quantity of heat required to raise temperature of a gram of water from 14.5° to 15.5°C[1] (252 cal = 1 Btu).

Conduction.—The process by which thermal agitation of molecules is passed along through a substance.

Convection.—The mode of heat transfer in which heat is carried from one place to another by a physical agent such as a flowing fluid (usually air or water).

Enthalpy.—A thermodynamic quantity defined as the sum of a body's internal energy, plus the product of its volume, times the pressure (or simply, its heat content).

Erg.—A measurement of work or force; an erg is the work done when a force of 1 dyne acts through a distance of 1 centimeter.

Geothermal gradient.—The rate of increase in temperature in the Earth with depth; the gradient may differ from place to place, depending on the heat flow in the region and on the thermal conductivity of the rocks.

Hot spring.—A spring having a mean temperature warmer than 38°C (100°F).

Joule.—A measurement of work defined as 1×10^7 ergs (4.186 joules = 1 calorie).

Nonthermal spring.—A spring having a mean temperature that does not exceed the mean annual air temperature of the surrounding area by more than 5°C (9°F).[2]

Specific heat.—The number of calories required to raise the temperature of 1 gram of a substance of 1°C; for water it is the amount of heat required to raise 1 gram from 4.0°C to 5.0°C.

Warm spring.—A spring having a mean temperature at least 5°C (9°F) higher than the local mean annual atmospheric temperature, but lower than 38°C (100°F).[3]

Watt.—A watt is 1 joule per second (or 4.186 calorie per second).

[1]The reference temperatures are stated because there is a slight variation in heat needed for a 1-degree temperature rise with the interval chosen.

[2]Reference is Mundorff (1971, p. 1).

[3]Reference is Mundorff (1970, p. 7).

The source of thermal energy in ground water is twofold: The energy in the shallow ground water is largely from the sun; the energy in the deeper water is derived from upward flow from the Earth's interior. White and others (1963) indicate that in tropical areas the depth of nearly uniform temperature occurs at about 33 ft (10 meters), and in the polar regions this depth increases to 66 ft (20 meters). However, this range is imprecise as the ground temperature profile is influenced by several factors, among which are (1) mean annual air temperature, (2) character of the soil and ground cover, (3) thermal conductivity of the zone of aeration, (4) thermal conductivity of the zone of saturation, and (5) presence or absence of rapidly circulating ground water at depth.

Annual air temperature cycles probably affect ground-water temperatures in the Piedmont and Appalachian provinces down to a depth between 40 and 60 ft, except where special ground-water flow conditions prevail. Records of subsoil temperature at various depths throughout an annual cycle are given by Smith and others (1964, p. 8) from a study at Belgrade, Yugoslavia. The study site is at an elevation of 456 ft and is in the temperate zone at latitude 40°48′N. The soil and geological conditions are not specified in the report, but the data could apply to Maryland. The temperature range at various depths is:

Depth (feet)	Annual temperature range (°F)	(°C)
4	25.6	14.2
6.6	18.7	10.4
13	8.5	4.7
26	.54	0.3
33	.36	0.2
39	.18	0.1
46	.0	0.0

Thus, the Belgrade measurements indicate no significant annual temperature change below about a 40-ft depth.

Geothermal Gradients

Although no precise depth range can be given below 40 to 60 ft, seasonal temperature effects are generally negligible and the ground temperature is affected chiefly by the heat loss from the interior of the Earth. The increase in Earth temperature with increasing depth is known as the geothermal gradient. It is not a constant value. Measured gradients in a few wells in Maryland and adjacent states are given in table 11; these gradients

Table 11.—Geothermal gradients in wells in Maryland and adjacent states

Locality	Well depth (ft)	Rock type	Geothermal gradient °F/100 ft	°C/100 m	Reference
McDonald, Pa. (near Pittsburgh)	5,380	Shale, sandstone, siltstone, and coal	1.44	2.62	Darton (1920, p. 72).
Minnehaha Springs, W.Va.[1]	3,111	Cambrian and Ordovician rocks	1.17	2.14	Hobba and others (1979, p. E20). Pocohantas No. 1 gas well.
Aberdeen, Md.	160	Metagabbro	.90	1.64	USGS well HA-DE 38 (unpublished data).
Washington, D.C. area (in Md. or Va.)	-	Quartz mica-schist	.85	1.54	Diment and Werre (1964, p. 2143).
Damascus, Md.	1,008	Mica schist	.53	.96	USGS well MO-EE 66 (unpublished data).
Falling Spring, Va.[2]	1,000	Limestone	.51	.93	Costain (1976, p. 31).
Perryville, Md.	220	Amphibolite and felsite (James Run Formation)	.20	.36	USGS well CE-CC 38 (unpublished data).

[1] Located 52 miles south of Elkins, W. Va.
[2] Located 32 miles west of Lexington, Va.

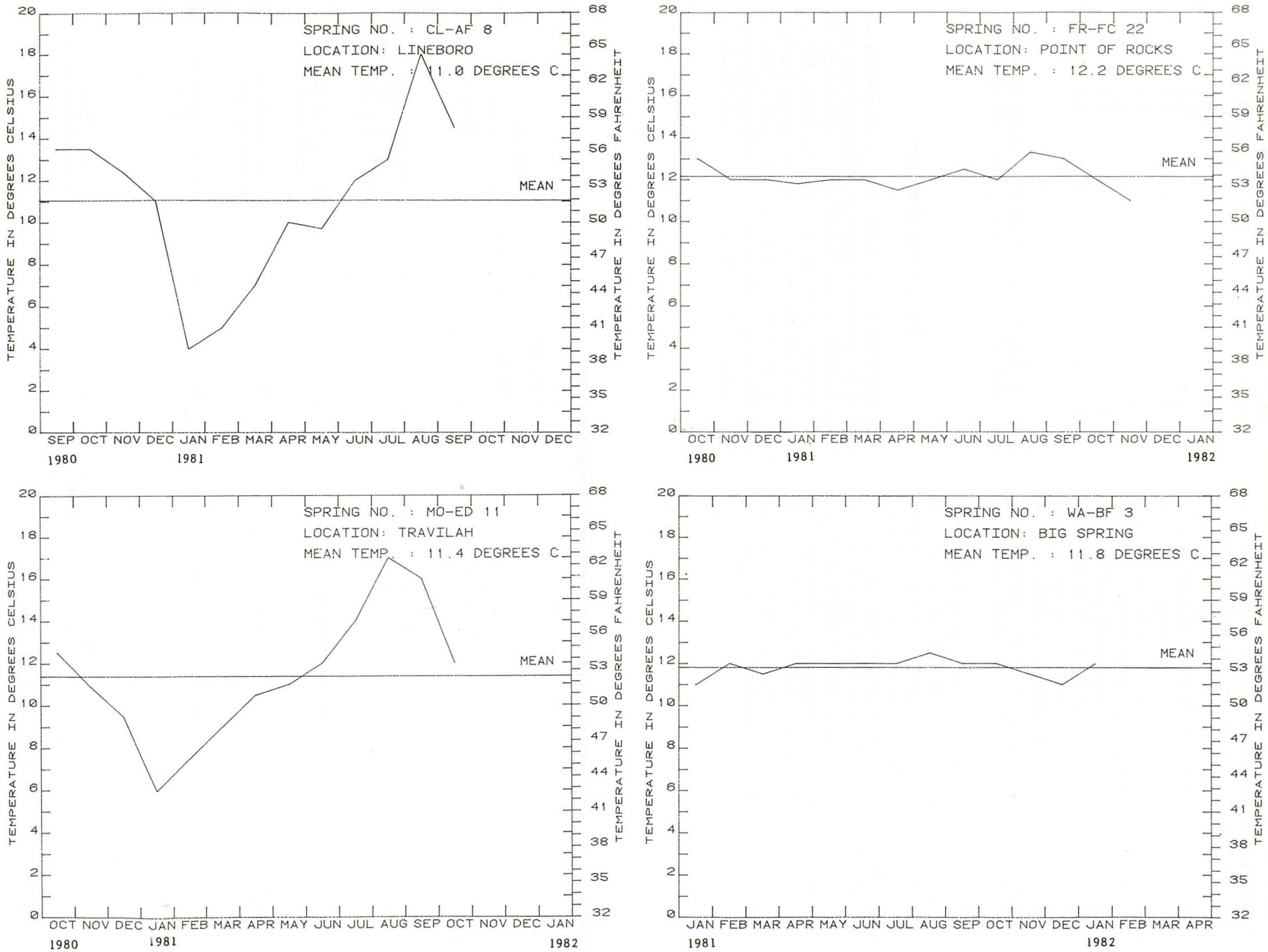


Figure 10. Annual temperature in four springs showing different thermal regimes.

range from 0.20°F/100 ft at Perryville, Md., to as much as 1.44°F/100 ft at McDonald, Pa. All geothermal gradients shown in the table are based on measurements below the zone of annual seasonal fluctuation. The table does not include gradients determined in Coastal Plain wells. Excluding the high values for the two wells in Pennsylvania and West Virginia, the mean value for the remaining five wells is 0.6°F/100 ft). This is somewhat lower than the values quoted by various authors such as Heath (1964, p. D204), who indicates that the geothermal gradient in northern New York is 1.54°F/100 ft of depth for carbonate rocks. According to Cartwright (1968, p. 396), the geothermal gradient in Illinois is 1.4°F/100 ft for clastic rocks. Possibly the lower geothermal gradient of the five Maryland and Virginia wells in table 11 is due to the higher thermal conductivity of metamorphic and igneous rocks in contrast with lower conductivities of limestones and shales in the Pennsylvania and West Virginia wells.

Variability of Thermal Properties

Ground water provides a viable means of storing thermal energy in the subsurface. As the water discharges from springs, it carries this energy with it. For some of the larger springs, a surprisingly large quantity of energy is available in the water. The temperature of most springs, especially the smaller ones, fluctuates with the annual seasonal climatic cycles. During this study, monthly temperature measurements were made on 76 springs and some of these data are plotted graphically in table 8 for each spring. Spring-water temperatures are highly variable, with some springs showing wide changes in temperature throughout a yearly cycle and other springs showing relatively small changes. Figure 10 shows graphically the annual temperature range of four selected springs. Two of these, FR-FC 22 and WA-BF 3, show relatively little annual range in temperature. Spring FR-FC 22, Kanawha Spring near Point of

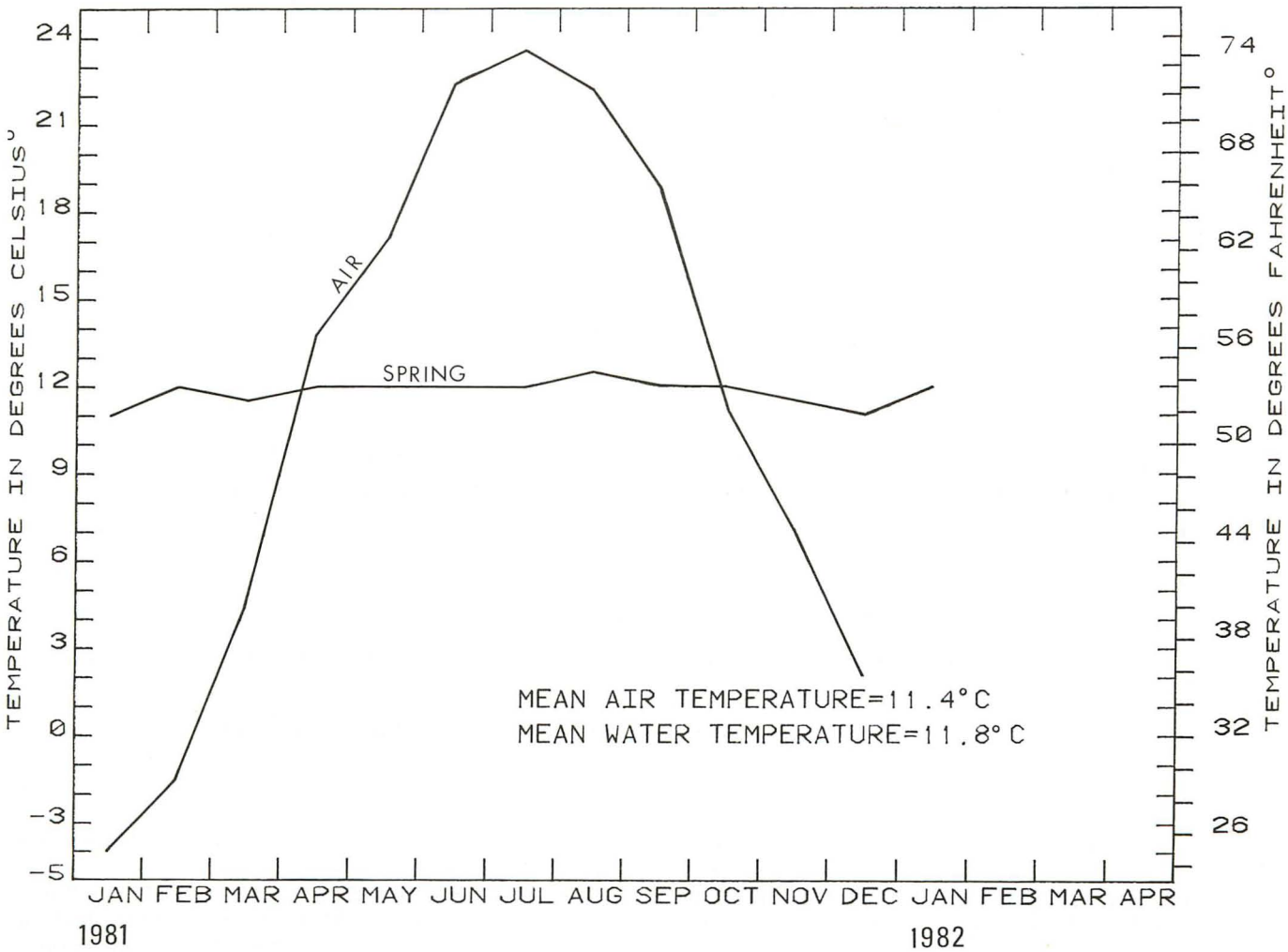


Figure 11.—Monthly temperature of spring WA-BF 3 (Big Spring) and mean monthly air temperature at the Hagerstown weather station for 1981.

Table 12.—Thermal diffusivities of some common rocks, in square centimeters per second

	(1)	(2)	(3)
Quartz sand (dry)	0.0020	-	-
Quartz sand (8.3 percent moisture	.0033	-	-
Sandy clay (15 percent moisture	.0037	-	-
Gravel	-	-	0.0057-0.0062
Shale	-	0.004	-
Andesite	-	0.005 - .006	-
Tuff	-	.004 - .009	-
Basalt	-	.007	-
Traprock	.0075	-	-
Rhyolite	-	.008	-
Quartz latite porphyry	-	-	.007 - .011
Dolomite	-	.008	-
Limestone	.0081	.005 - .011	.0095
Granite	.0127	.006 - .013	-
Marble	.0097	.0106- .011	-
Sandstone	.0113	.012 - .014	-
Schist	-	.027 - .088	-
Quartzite	-	.023 - .031	-

* Thermal diffusivity is defined as the thermal conductivity of a substance divided by the product of its density and specific heat capacity.

(1) From Ingersoll and others (1954, p. 244)

(2) From International Critical Tables of the National Research Council (1927, p. 55-56).

(3) In-hole determinations, East Tintic district, Utah (Lovering and (Goode, 1963, p. 35).

Rocks, had an annual range of only 3.2°F (1.8°C) during the period of measurement, and a measured flow of 350 gal/min on April 22, 1981. Spring WA-BF 3, Big Spring near Williamsport, had an annual range of only 2.7°F (1.5°C) during the measurement period. This spring had a flow of 1,100 gal/min in May 1958. Spring FR-DD 178, just north of Frederick, is similar in its thermal characteristics. It had an annual range of only 5.4°F (3.0°C), and its discharge was 270 gal/min on April 21, 1981.

At the other extreme, spring MO-ED 11 near Watts Branch on River Road (Montgomery County) had an annual range of 20°F (11°C). The flow of this spring, from a quartzose schist, ranged from less than 0.5 to 1 gal/min during the period of measurement. An even greater annual range was measured in spring CL-AF 8 at

Lineboro, Md., just south of the Pennsylvania state line. This spring, issuing from schistose rocks, had an annual range of 25°F (14°C) with a January low of 39°F and an August high of 64°F. It is possible that this extreme temperature range was because the measurements were made at the end of a buried discharge pipe about 40 ft from the sealed spring pit. The temperature of the discharging water may have been significantly affected by seasonal changes in the temperature of the pipe and surrounding soil. The flow of CL-AF 8 ranged from 0.1 to 8.0 gal/min during the measurement period. Spring CL-BE 105, Martin Spring at Camp Hashawa, had an annual range of 22.5°F (12.5°C). This spring also issues from schistose rocks and its estimated flow ranged from less than 0.5 to 2 gal/min. Analysis of the temperature records from these and other springs suggests that springs with a wide range in temperature commonly have a small flow and may have a relatively shallow source. There are more springs in this and in an intermediate group than there are springs of relatively constant temperature. The latter type of spring has a larger flow (many are limestone springs) and apparently has a deeper source, although the source depth of the water is largely conjectural.

The average temperature of a spring throughout an annual cycle is very close to the average annual air temperature at the site. This is shown in figure 11, a graph of the monthly temperature of spring WA-BF 3 (Big Spring) and the mean annual air temperature at the Hagerstown weather station, 15 mi distant. The mean annual spring temperature was 53°F during 1981 and the mean annual air temperature at Hagerstown was 52.8°F for the same period. Such close agreement must be fortuitous as the mean annual temperature of other springs near the weather station was as follows: WA-AK 3, 52°F; WA-BF 24, 54°F; and WA-BI 36, 54°F.

Spring Temperature and Depth of Water Source

It may be important in some instances to determine the depth (or depths) from which springs derive water. Water from extremely shallow sources, for example, might be more subject to pollution by agricultural chemicals, pesticides, or similar contaminants. The flow regime of springs having a deep source might be less likely to be altered by nearby construction activities at the surface (ditch digging, foundation construction, and related activities). Studies of heat conduction by Ingersoll and other (1954, p. 47-53) provide some basic equations used to predict the cyclical flow of heat into the ground and its attenuation with depth. One of the Ingersoll equations was modified by Bair and Parizek (1978, p. 259) and used to predict the theoretical temperature variations at shallow depths in a well field in southeastern Pennsylvania. The equation used by Bair and Parizek and the definitions of their terms are:

$$\Delta T = T(S) \exp - z \left(\frac{\Pi}{aP}\right)^{1/2}$$

where:

exp = exponential function

z = mean depth below the land surface of the source of spring water, in centimeters;

ΔT = peak-to-peak amplitude of annual temperature variation of the ground water, in degrees Celsius (°C), at depth z;

T(S) = peak-to-peak amplitude of mean monthly air temperature at the land surface;

a = thermal diffusivity of the earth material, in square centimeters per second (see table 12); and

P = period of the annual temperature wave, in seconds (or 1 year = 31.536×10^6 seconds).

The previous equation contains all the elements needed to predict the mean depth of water flow from a spring. The equation was modified for this purpose as follows:

$$z = \frac{-\log_e [\Delta T/T(S)]}{\left(\frac{\Pi}{aP}\right)^{1/2}}$$

NOTE: $-\log_e [\Delta T/T(S)] = \log_e [T(S)/\Delta T]$

Conversion: 1 centimeter = 0.0328 foot, and
1 foot = 30.48 centimeters.

Spring BA-BC 264 was used to test the above equation as a predictive device. This spring is in northwestern Baltimore County at the base of a steep valley near a small stream, tributary to Prettyboy Reservoir. Records of spring temperatures are available from October 1980 to September 1981, and weather station records for the same period are available from Parkton, Md., about 3 mi east of the spring. The area above the spring is forested and the crest of the hill above it is about 250 ft higher than the spring. The spring issues from the Prettyboy Schist. Its mean flow during the period of record was about 3 gal/min. Figure 12 shows monthly spring temperatures and the corresponding mean monthly air temperatures at Parkton. From these and other data, the following parameters were obtained for use in the modified equation:

ΔT = 4°C;

T(S) = 25°C;

a = 0.0514 cm^2/s (thermal diffusivity of schist, as determined from temperature logs of well BA-CE 21); and

P = 31.536×10^6 seconds.

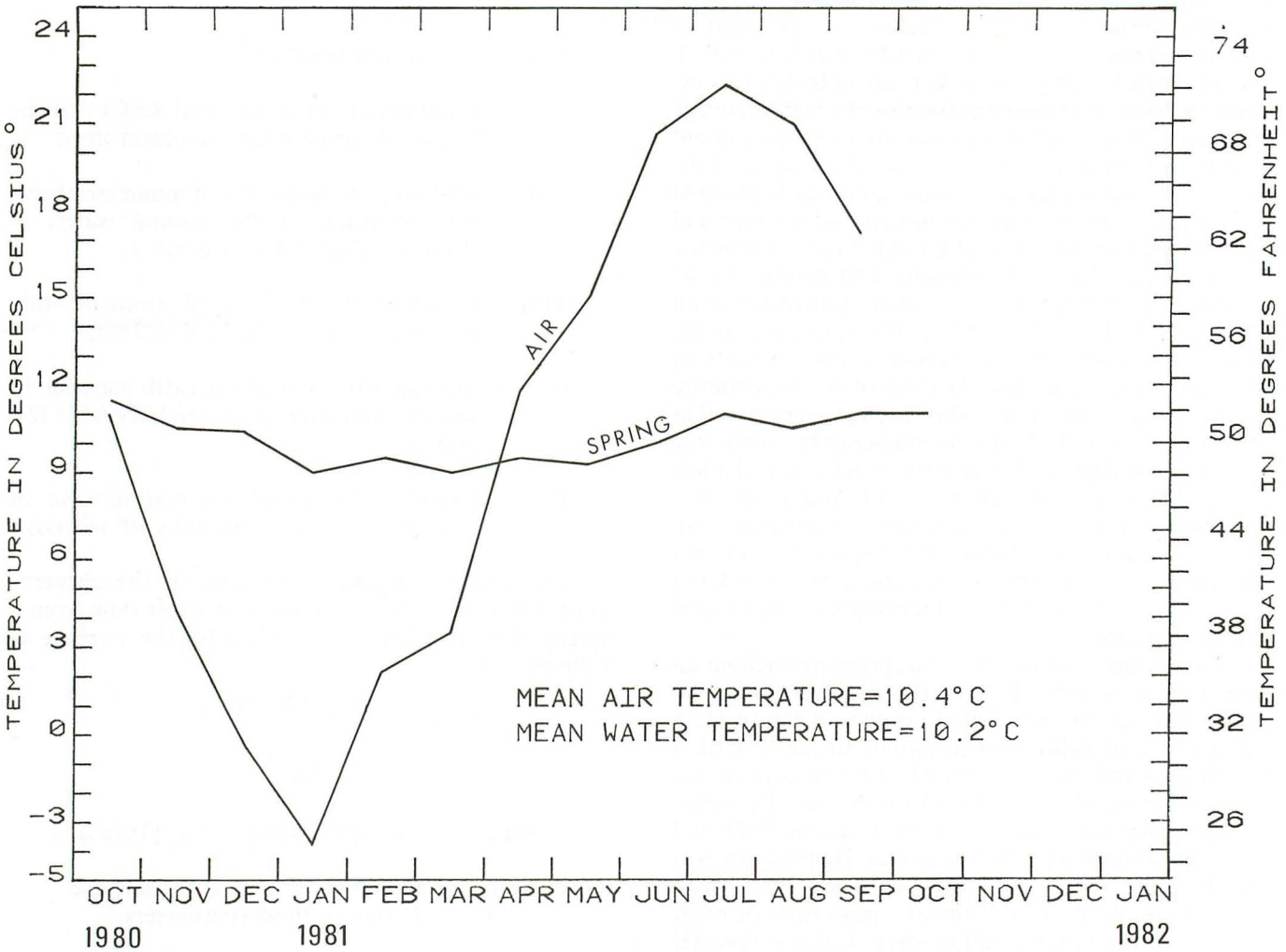


Figure 12.—Monthly and mean water temperature of spring BA-BC 264 near Prettyboy Reservoir and monthly and mean annual air temperature at Parkton, Md.

Using these values, the results are:

$$z = \frac{\log_e [25/4]}{(3.14/1.620 \times 10^6)^{0.5}} = \frac{1.833}{0.0014} = \begin{matrix} 1{,}310 \text{ cm} \\ (43 \text{ ft}) \end{matrix}$$

Using a value of a = 0.088 cm^2/s (the lower limit of a schist in table 11):

$$z = \frac{\log_e [25/4]}{(3.14/2.775 \times 10^6)^{0.5}} = \frac{1.833}{0.00106} = \begin{matrix} 1{,}729 \text{ cm} \\ (57 \text{ ft}) \end{matrix}$$

Thus, the formula predicts that the flow to the spring is derived from a depth between 43 and 57 ft. There are no means to verify the answers obtained, but the available geohydrologic data at the site of spring BA-BC 264 suggests that the water is derived from recharge on or near the top of the hill. It flows downslope at or near the base of a moderately thin saprolite and emerges from a crevice at the base of the hill. The moderately thin saprolite in the area meets the requirements for a relatively shallow source, as predicted by the equation.

Location Versus Temperature of Springs

Analysis of the thermal regimes of 76 springs measured monthly showed that the median temperature of 51 Piedmont springs was 52°F (11.3°C). The range in temperature was from a minimum of 34°F (1.5°C) in a spring in Howard County to a maximum of 64°F (18.0°C) in a spring in Carroll County and one in Cecil County. Figure 13 shows the distribution of mean temperatures of the 76 springs.

Analysis of the thermal regimes of 25 Appalachian springs shows that the median temperature was 51°F (10.6°C). Temperatures ranged from a low of 34°F (1.0°C) in a Washington County spring, to a high of 68°F (19.9°C) in the same spring. The difference in the median values for the two provinces, 1°F, suggests that Appalachian springs are slightly cooler than Piedmont springs, but the difference is not statistically significant.

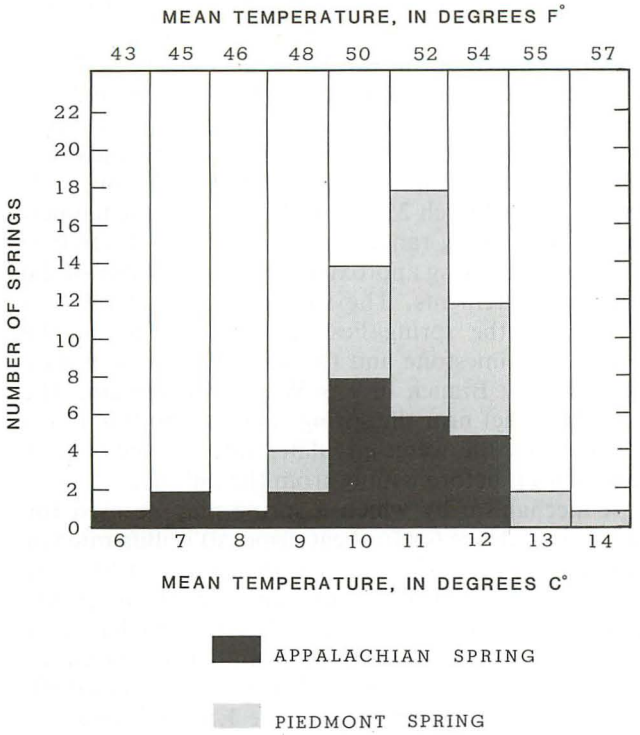


Figure 13.—Distribution of mean temperature of 76 springs in the Appalachian and Piedmont provinces.

Energy Potential from Springs

Based on the flow of springs and their temperature, it is possible to estimate the amount of thermal energy available from them. Obviously, a spring of highly variable flow would not be as reliable a source of energy (or water supply) as would a spring of relatively constant flow and uniform temperature. Thus, the ideal spring to be used for household heating or cooling purposes would have a steady flow and a relatively uniform temperature. Table 13, based on the conversion factors in the glossary on p. 22, shows the energy available in calories and power in watts from spring water.

Analysis of the flow and temperature records of spring BA-AC 150 (Bentley Spring) in northern Baltimore County indicates that its mean flow was 3.5 gal/min and its mean temperature was about 52°F (11°C). The annual temperature range was from 46°F (8°C) to 57°F (14°C). Table 13 shows that a spring flowing at 3.5 gal/min has 795,000 calories available per hour for each 1°C decline in temperature (equivalent to 924 watts per

Table 13.—Energy available from a spring source flowing at various rates and at a constant temperature of 60°F (15.5°C)

Flow rate of spring		Calories available per hour per °C decline in temperature	Power in watts/hr
gal/min	gal/hr		
1	60	227,100	264
2	120	454,200	528
5	300	1.135×10^6	1,320
10	600	2.271×10^6	2,640
20	1,200	4.542×10^6	5,280
35	2,100	7.948×10^6	9,240
50	3,000	11.35×10^6	13,200
75	4,500	17.02×10^6	19,800
100	6,000	22.71×10^6	26,400
200	12,000	45.42×10^6	52,800
500	30,000	113.5×10^6	132,000
1,000	60,000	227×10^6	264,000

hour). A drop of the mean temperature from 46°F to 37°F (8°C to 3°C) would yield 3.97 x 10^6 calories per hour (or 4,620 watts per hour). Of course, some of this energy will be lost in transferring it to heat or electrical energy in the heat exchanger. It should be noted that water leaving the heat exchange system will be cooler in proportion to the quantity of heat removed. This cooler water may adversely affect the downstream environment and, thus, raise some legal or administrative objections to this use of water. Where a spring is used for energy disposal (cooling), the reverse will occur and the water in the downstream direction will be proportionally warmer.

A similar analysis of a much larger spring (WA-BF 3, Big Spring in Washington County) indicates that with an estimated mean flow of 1,000 gal/min (table 9), a 5°C lowering of its mean temperature from 53°F (11.7°C) to 44°F (6.7°C) would yield 11.35 x 10^8 calories per hour (equivalent to a power output of 1.32 x 10^6 watts per hour).

Hobba and others (1979, p. E21), in their study of large Appalachian springs, show that the warm spring at Berkeley Springs, W. Va., has a measured flow of about 1,630 gal/min and a mean temperature of 71°F (21.8°C). Using this flow rate and the data in table 13, a power output of about 430,000-watts/hour/°C decline in temperature is computed for this spring. Berkeley Springs, located 6 mi south of Hancock, Md., is designated as a warm spring by the definition used in this report. Spring AL-AG 37, 1 mi south of Flintstone, is the only known spring in Maryland which could be classed as a warm spring. Slaughter (1962, p. 102) indicated that the mean annual temperature of this spring was approximately 64°F (18°C). Six monthly measurements by the authors during the period October 21, 1982, through March 25, 1983, showed that the temperature of this spring ranged from 61°F to 63°F (16.0°C to 17.0°C), verifying approximately the reliability of the earlier measurements. The source of its water is not known, but the spring lies near the contact of the Helderberg Limestone and Oriskany Group at a place where Murley Branch bisects Warrior Mountain. The maximum relief near the spring is about 980 ft and it is probable that the water circulates through the core of the mountain before issuing from the hillside.

A mechanism by which a spring may be used for heating a residence (or for heat disposal) is illustrated in figure 14. Elements shown in the figure are not to scale, nor is the geology of the spring indicated. However, the temperatures shown for water in the pipes are based on a successful domestic heat-pump unit in operation at Easton, Md., as reported by Lord and others (1980, p. 130). The heat-pump unit for the 1,800-ft^2 residence described by these authors was operated for two seasons using Easton municipal water with an approximate temperature of 55°F (13°C). The flow rate of the water

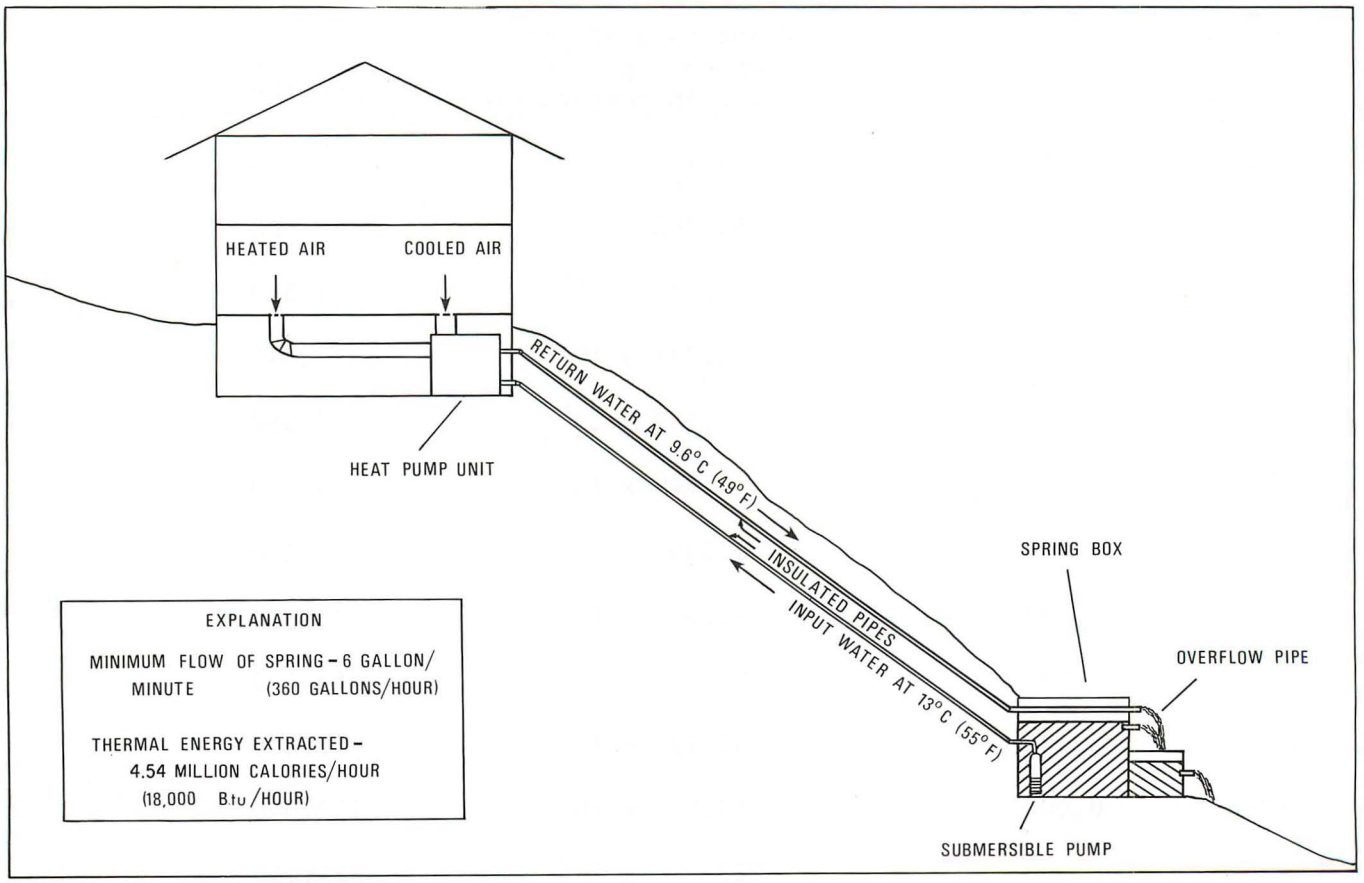


Figure 14.—How a spring may be used as a source of thermal energy for a residence.

circulated through the heat-pump unit was 360 gal/hr and the temperature differential of the input and output water was 6°F (3.3°C), providing a heat transfer of 4.5 million calories per hour (or 18,000 Btu/hr). The unit had a coefficient of performance (C.O.P.) of 2.2[1].

The hypothetical system shown in figure 14 uses a spring as the energy source. The spring is assumed to have a mean flow of at least 6 gal/min and its temperature is relatively constant at 55°F (13°C). Use of a spring having a constant temperature of 53.6°F (12°C) would require a slightly greater flow rate, or an increase in the heat extraction efficiency of the heat-pump unit. Any system designed to use a spring as a source of heat energy should be based on measurements of its flow rate and its temperature. It is suggested that anyone considering use of a spring as a heat source should consult specialists in the field of heat pumps and hydrology.

[1]The coefficient of performance (COP_H) of a heat pump is the heat energy into the home (Q_H) divided by the energy required to produce it (electrical input = W), so that the formula (Lord and others, 1980, p. 5) is:

$$COP_H = \frac{Q_H}{W}$$

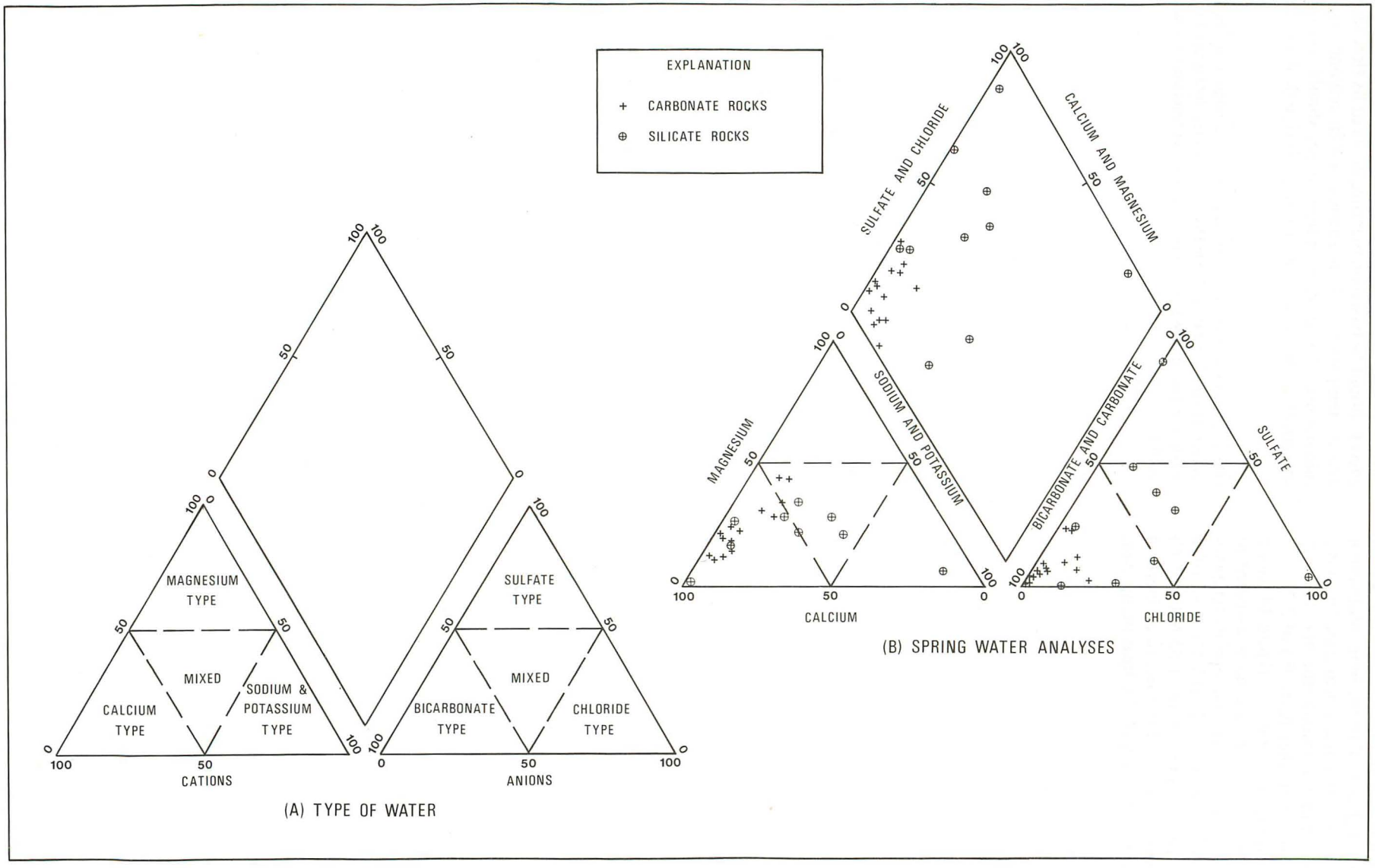


Figure 15.—Plot of classification of 24 analyses of Maryland spring water according to the method of Hill (1940) and Piper (1944); values in percent of total equivalents per liter.

CHEMICAL CHARACTERISTICS OF SPRINGS

Chemical analyses of 26 springs sampled during this study are given in table 14 and miscellaneous field measurements are given in table 8. In addition, chemical analyses of several springs are published in cited previous investigations.

Chemical analyses of spring water are useful in classifying the water by type and in determining its uses for the many purposes where water quality is important. For classification, the so-called trilinear diagram scheme of Hill (1940) and Piper (1944) was used. The chemical analyses of the major cations and anions were used to compute the percentage of total equivalents per liter, and each analysis was then plotted on two triangular diagrams where the percentage values range from 0 to 100. Associated with the triangles is a diamond-shaped diagram where plots of values of related cations and anions are used to produce a vector plot. Thus, each analysis is represented by a point on both triangles and on the diamond. Figure 15(B) shows the plots of 24 analyses of water from Maryland springs. The two lower triangles of figure 15(A) show the types of water that can occur. All but two of the water samples analyzed are either calcium-magnesium bicarbonate type or water of a mixed type. The two analyses not of these types are from springs WA-BH 19 and MO-FG 10. Based on the analysis given by Slaughter (1962, table 39), water from spring WA-BH 19 is a calcium-magnesium sulfate type. Slaughter recognized the distinctive chemical character of the water from this source and stated (1962, p. 67) that this spring may issue from gypsum-bearing strata (sulfate content of the water was 679 mg/L). The authors concur with Slaughter's observation and make the further observation that the spring is located along a major fault on the east side of Conococheague Creek where the Martinsburg Shale is faulted against the Rockdale Run Formation of the Beekmantown Group. It is possible that the water from this spring moves upward from a deep source along the fault plane through gypsum-bearing strata.

Water from spring MO-FG 10 is a sodium-potassium chloride type, soft, and has an acid pH. Spring MO-FG 10 is known as Takoma Spring and was the source of water for some of the residents of Takoma Park prior to the installation of the public water system. The aquifer supplying water to this spring is shown on the geologic map as a gneiss, but the presence of Tertiary Coastal Plain gravel in a nearby road cut suggests that the aquifer might be a clayey, silty, gravel deposit. As this spring is in an urban environment, it is possible that the chemical character of the water may reflect this environment—that is, the effect of leaking sewer pipes, leachate from lawn fertilizers, and leaching from various types of landfill.

Table 15 lists the source, significance, range and median values of the important dissolved mineral constitutents and physical properties of Maryland spring water. Some of the constitutents relevant to springs are discussed below:

Silica

Most of the dissolved silica (SiO_2) observed in natural water results originally from the chemical breakdown of silicate minerals in the process of weathering. The dissolved silica content of ground water increases with increasing temperature, up to certain solubility limits. Hem (1970, p. 106) reports the silica content of a spring in New Mexico was 103 mg/L (milligrams per liter), where the water temperature was 101°F (38.3°C). Hem (p. 106) also reports silica content as high as 363 mg/L from a hot spring in the Upper Geyser basin, Yellowstone Park, Wyoming. This spring has a water temperature of 201°F (94°C). The low silica content of 35 Maryland springs studied here (ranging from 1.7 to 27 mg/L) and other evidence suggest that most of these springs have a relatively shallow source. The maximum silica content of 27 mg/L was from spring HA-BF 18, along the Susquehanna River, 3 mi north of Havre de Grace, Md. This spring issues from fractures in the Port Deposit Gneiss. Its temperature is about average for springs in the area and there is no apparent explanation for its relatively high silica content.

Iron

Iron (Fe) is a widespread and abundant constituent of rocks and soils. The solution of iron from silicate minerals by mildly acidic ground water is a slow process, but near-surface weathering of iron-bearing silicates may produce an accumulation of ferric oxide or hydroxide. The oxides and sulfides of iron are the principal sources from which the dissolved iron in ground water is derived (Hem, 1970, p. 116). The solubility characteristics of iron and its relation to pH and Eh is complex and beyond the scope of this report.

Spring water appears to contain less iron than well water. The median concentrations of total iron in 39 analyses of spring water was 130 μg/L (micrograms per liter). Only about 20 percent of the spring water contained iron in excess of the limiting values of 300 μg/L, the threshold above which iron in water may stain bathroom fixtures, laundry, and utensils. The iron content of water can be lowered by proper iron-removal treatment techniques.

Table 14.—Chemical analyses of selected springs

SPRING NO.	GEO-LOGIC UNIT[1]	DATE OF SAMPLE	FLOW RATE, INSTAN-TANEOUS (GPM)	SPE-CIFIC CON-DUCT-ANCE (UMHOS)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS CACO3)	HARD-NESS, NONCAR-BONATE (MG/L CACO3)
				ALLEGANY						
AL-BF 1	351TNLY	81-08-27	--	385	8.0	11.0	.20	--	200	19.00
				BALTIMORE						
BA-AC 150	300PRTB	81-08-10	--	155	6.2	14.0	.30	--	43.00	21.00
DC 18	300CCKV	81-08-10	--	410	7.4	13.0	.50	6.4	160	14.00
DD 297	300LCRV	81-08-10	--	28	5.8	14.0	.50	9.8	5.00	.00
DE 1	300CCKV	81-08-10	--	615	7.5	13.0	.50	4.2	240	19.00
				CARROLL						
CL-BF 183	--	81-08-14	--	33	6.1	14.0	.50	8.8	84.00	35.00
CC 111	300WKFD	81-08-14	50	520	7.2	13.0	.50	6.6	230	43.00
				CECIL						
CE-CC 40	300LFPF	81-08-13	--	190	5.4	13.0	.20	--	46.00	38.00
				FREDERICK						
FR-BD 54	377WVRN	81-08-21	24	21	5.9	15.0	.50	--	.00	.00
CD 38	--	82-05-11	--	--	6.7	12.0	<1.00	--	4.00	.00
				GARRETT						
GA-EB 33	337PCCN	81-10-29	--	--	6.7	11.0	.50	--	34.00	11.00
EC 1	331GRBR	81-10-30	150	--	6.6	10.0	.30	--	69.00	.00
GA 1	321CNMG	81-10-29	5.5	86	6.9	11.0	.70	--	31.00	10.00
GA 4	321CNMG	81-10-29	12	21	5.1	9.0	--	9.1	--	--
				HARFORD						
HA-BC 30	300WSCK	81-08-13	--	32	5.6	14.0	.50	--	7.00	.00
BF 18	300PRDP	81-08-13	--	155	7.2	15.5	1.00	--	40.00	22.00
				HOWARD						
HO-BD 15	300CCKV	81-08-14	--	280	7.1	14.0	.50	6.0	120	3.00
				MONTGOMERY						
MO-FF 18	--	81-08-19	.9	155	5.7	13.0	.30	--	44.00	5.00
FG 10	--	81-08-19	3	129	4.7	16.0	4.40	--	3.00	2.00
				WASHINGTON						
WA-BI 36	--	81-08-27	40	680	7.7	12.0	.20	--	370	126
	--	82-05-04	--	--	--	11.0	.60	--	350	81.00
CH 2	--	81-08-25	--	650	7.9	11.0	.20	--	310	50.00
DI 6	377TMSN	81-08-25	--	480	7.6	11.0	.20	--	260	44.00
				BALTIMORE CITY						
3N3E 3	300LCRV	81-08-13	--	500	7.1	15.0	.00	8.8	190	32.00

[1] See footnote at end of table.

Table 14.—Chemical analyses of selected springs—Continued

SPRING NO.	DATE OF SAMPLE	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	POTAS-SIUM 40 DIS-SOLVED (PCI/L AS K40)	ALKA-LINITY LAB (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)
				ALLEGANY						
AL-BF 1	81-08-27	63.0	10.0	.90	.70	--	180	17.0	2.3	.10
				BALTIMORE						
BA-AC 150	81-08-10	9.2	4.9	6.10	2.70	2.00	22.000	4.6	12.0	<.10
DC 18	81-08-10	44.0	13.0	5.00	1.19	.90	150	4.2	13.0	.10
DD 297	81-08-10	.9	.7	1.60	.60	.40	6.000	.5	1.7	<.10
DE 1	81-08-10	66.0	18.0	3.90	2.70	2.00	220	17.0	11.0	<.10
				CARROLL						
CL-BF 183	81-08-14	21.0	7.7	19.00	1.40	1.00	49.000	1.1	52.0	<.10
CC 111	81-08-14	70.0	14.0	4.20	.80	.60	190	21.0	12.0	<.10
				CECIL						
CE-CC 40	81-08-13	9.6	5.4	8.60	.60	.40	--	.6	37.0	<.10
				FREDERICK						
FR-BD 54	81-08-21	.2	.1	.90	1.00	.70	3.000	2.2	1.1	<.10
CD 38	82-05-11	.6	.6	.90	.80	--	5.000	3.0	1.3	<.10
				GARRETT						
GA-EB 33	81-10-29	11.0	1.5	1.19	.10	--	23.000	7.6	1.3	.00
EC 1	81-10-30	24.0	2.1	1.00	.40	--	68.000	1.3	.7	.00
GA 1	81-10-29	8.8	2.1	.60	.60	--	21.000	6.5	.7	.10
GA 4	81-10-29	--	--	--	--	--	--	--	--	--
				HARFORD						
HA-BC 30	81-08-13	1.4	.8	2.00	.60	.40	19.000	.2	2.0	<.10
BF 18	81-08-13	11.0	3.1	7.50	1.00	.70	18.000	21.0	3.7	<.10
				HOWARD						
HO-BD 15	81-08-14	31.0	11.0	4.60	1.80	1.30	120	1.9	5.3	<.10
				MONTGOMERY						
MO-FF 18	81-08-19	9.0	5.2	8.00	.90	.70	39.000	6.8	7.3	<.10
FG 10	81-08-19	.6	.4	12.00	1.80	1.30	1.000	1.9	21.0	<.10
				WASHINGTON						
WA-BI 36	81-08-27	130	10.0	10.00	2.40	--	240	40.0	23.0	.10
	82-05-04	120	11.0	14.00	2.50	--	270	42.0	33.0	<.10
CH 2	81-08-25	110	8.4	8.10	2.20	1.60	260	31.0	23.0	.20
DI 6	81-08-25	84.0	13.0	4.70	2.10	1.60	220	17.0	9.6	.20
				BALTIMORE CITY						
3N3E 3	81-08-13	44.0	20.0	10.00	2.60	1.90	160	5.9	25.0	<.10

Table 14.—Chemical analyses of selected springs—Continued

SPRING NO.	DATE OF SAMPLE	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, SUS-PENDED RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, SUS-PENDED RECOV. (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)
			ALLEGANY					
AL-BF 1	81-08-27	630	620	10	.00	<10.00	--	<10.00
			BALTIMORE					
BA-AC 150	81-08-10	160	--	<10	.00	<10.00	--	4.00
DC 18	81-08-10	110	--	<10	.00	<10.00	--	2.00
DD 297	81-08-10	780	--	<10	.00	<10.00	--	2.00
DE 1	81-08-10	100	--	<10	.00	<10.00	--	<1.00
			CARROLL					
CL-BF 183	81-08-14	270	--	<10	.00	10.00	6.00	4.00
CC 111	81-08-14	150	--	<10	20.00	<10.00	--	<1.00
			CECIL					
CE-CC 40	81-08-13	220	--	<10	.00	<10.00	--	2.00
			FREDERICK					
FR-BD 54	81-08-21	190	170	20	.00	10.00	--	<10.00
CD 38	82-05-11	180	170	15	--	20.00	20.00	2.00
			GARRETT					
GA-EB 33	81-10-29	40	--	<3	.00	<10.00	--	<1.00
EC 1	81-10-30	40	--	<3	.00	<10.00	--	<1.00
GA 1	81-10-29	80	40.00	36	.00	<10.00	--	2.00
GA 4	81-10-29	--	--	--	--	--	--	--
			HARFORD					
HA-BC 30	81-08-13	330	300	30	.00	10.00	6.00	4.00
BF 18	81-08-13	1400	1400	50	10.00	30.00	30.00	1.00
			HOWARD					
HO-BD 15	81-08-14	400	380	20	.00	<10.00	--	2.00
			MONTGOMERY					
MO-FF 18	81-08-19	110	--	<10	.00	<10.00	--	<10.00
FG 10	81-08-19	240	150	90	10.00	170	10.00	160
			WASHINGTON					
WA-BI 36	81-08-27	320	300	20	.00	10.00	--	<10.00
	82-05-04	40	30.00	10	--	<10.00	--	1.00
CH 2	81-08-25	130	120	10	.00	20.00	--	<10.00
DI 6	81-08-25	110	--	<10	.00	10.00	--	<10.00
			BALTIMORE CITY					
3N3E 3	81-08-13	970	--	<10	.00	10.00	--	<1.00

Table 14.—Chemical analyses of selected springs—Continued

SPRING NO.	DATE OF SAMPLE	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, SUS-PENDED RECOV. (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)
				ALLEGANY						
AL-BF 1	81-08-27	7.00	225	209	200	100	100	<1	4.00	5
				BALTIMORE						
BA-AC 150	81-08-10	7.50	85	60	100	--	<100	1	3.00	2
DC 18	81-08-10	9.80	181	180	200	--	<100	1	1.00	3
DD 297	81-08-10	9.60	30	19	100	--	<100	1	5.00	23
DE 1	81-08-10	16.00	299	267	100	.00	100	1	5.00	2
				CARROLL						
CL-BF 183	81-08-14	10.00	216	142	100	--	<100	2	10.00	5
CC 111	81-08-14	9.40	295	245	100	--	<100	1	4.00	4
				CECIL						
CE-CC 40	81-08-13	22.00	134	89	<100	--	<100	1	7.00	3
				FREDERICK						
FR-BD 54	81-08-21	6.50	16	14	200	.00	200	2	20.00	2
CD 38	82-05-11	6.30	16	17	<100	--	<100	--	8.00	--
				GARRETT						
GA-EB 33	81-10-29	5.90	46	42	100	--	<100	<1	10.00	6
EC 1	81-10-30	7.30	76	78	200	--	<100	<1	10.00	3
GA 1	81-10-29	4.70	45	37	200	100	100	<1	8.00	10
GA 4	81-10-29	--	--	--	--	--	--	--	--	--
				HARFORD						
HA-BC 30	81-08-13	11.00	30	29	200	--	<100	1	9.00	3
BF 18	81-08-13	27.00	108	85	900	--	<100	1	5.00	5
				HOWARD						
HO-BD 15	81-08-14	24.00	166	152	<100	--	<100	1	2.00	3
				MONTGOMERY						
MO-FF 18	81-08-19	20.00	106	81	200	100	100	2	20.00	3
FG 10	81-08-19	9.10	82	48	400	100	300	2	20.00	10
				WASHINGTON						
WA-BI 36	81-08-27	8.80	412	368	200	--	<100	<1	8.00	7
	82-05-04	9.70	417	396	<100	--	<100	--	10.00	--
CH 2	81-08-25	9.80	404	349	1000	900	100	<1	20.00	2
DI 6	81-08-25	9.90	310	273	200	100	100	<1	20.00	2
				BALTIMORE CITY						
3N3E 3	81-08-13	13.00	257	216	200	--	<100	1	10.00	6

Table 14.—Chemical analyses of selected springs—Continued

SPRING NO.	DATE OF SAMPLE	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)
		ALLEGANY			
AL-BF 1	81-08-27	<.1	1	<1	20.00
		BALTIMORE			
BA-AC 150	81-08-10	<.1	3	<1	30.00
DC 18	81-08-10	<.1	9	<1	20.00
DD 297	81-08-10	<.1	3	<1	20.00
DE 1	81-08-10	<.1	3	2	10.00
		CARROLL			
CL-BF 183	81-08-14	<.1	7	<1	60.00
CC 111	81-08-14	<.1	5	<1	30.00
		CECIL			
CE-CC 40	81-08-13	<.1	5	<1	20.00
		FREDERICK			
FR-BD 54	81-08-21	<.1	5	2	10.00
CD 38	82-05-11	--	--	<1	40.00
		GARRETT			
GA-EB 33	81-10-29	<.1	1	<1	40.00
EC 1	81-10-30	<.1	<1	<1	40.00
GA 1	81-10-29	<.1	2	<1	70.00
GA 4	81-10-29	--	--	--	--
		HARFORD			
HA-BC 30	81-08-13	<.1	2	<1	40.00
BF 18	81-08-13	<.1	5	<1	20.00
		HOWARD			
HO-BD 15	81-08-14	<.1	3	<1	30.00
		MONTGOMERY			
MO-FF 18	81-08-19	<.1	9	<1	10.00
FG 10	81-08-19	<.1	17	5	40.00
		WASHINGTON			
WA-BI 36	81-08-27	.1	1	<1	20.00
	82-05-04	--	--	--	10.00
CH 2	81-08-25	<.1	2	<1	20.00
DI 6	81-08-25	<.1	3	<1	20.00
		BALTIMORE CITY			
3N3E 3	81-08-13	<.1	3	<1	40.00

[1] Listing of geologic time codes and aquifer abbreviations with appropriate geologic units as sources of spring water.

Geologic time code	Aquifer abbreviation	Aquifer
300	WSCK	Wissahickon Formation
300	PRDP	Port Deposit Gneiss
300	JMSR	James Run Gneiss
300	LFPF	James Run Formation, Principio Furnace Member
300	WKFD	Wakefield Marble
300	LCRV	Loch Raven Schist
300	CCKV	Cockeysville Marble
300	PRTB	Prettyboy Schist
321	CNMG	Conemaugh Formation
331	GRBR	Greenbrier Formation
337	POCN	Pocono Group
351	TNLY	Tonoloway Limestone
377	WVRN	Weverton Quartzite
377	TMSN	Tomstown Dolomite
400	MTRL	Metarhyolite and associated pyroclastic sediments

Table 15.—Source, significance, range, and median values of dissolved mineral constituents and physical properties of spring water

Constituent or property	Source of origin	Significance	Range in Maryland spring water
Silica (SiO_2)	Dissolved from almost all rocks and soils, usually in small amounts from 1-30 mg/L. High concentrations--as much as 100 mg/L--generally occur in highly alkaline water.	Forms hard scale in pipes and boilers. Carried over in steam of high-pressure boilers to form deposits on blades of steam turbines. Inhibits deterioration of zeolite-type water softeners.	1.7 to 27 mg/L in 35 analyses; median value = 9 mg/L.
Iron (Fe)	Dissolved from almost all rocks and soils. May also be derived from iron pipes, pumps, and other equipment. More than 1,000-2,000 µg/L of soluble iron in surface water usually indicates acid wastes from mine drainage or other sources.	On exposure to air, iron in ground water oxidizes to reddish-brown sediment. Content of more than about 300 µg/L stains laundry and utensils reddish brown. Objectionable for food processing, beverages, dyeing, bleaching, ice manufacture, brewing, and other processes.	0 to 1,400 µg/L in 39 analyses; median value = 130 µg/L.
Manganese (Mn)	Dissolved from some rocks and soils. Not as common as iron. Large quantities often associated with high iron content and with acid water.	Same objectionable features as iron. Causes dark-brown or black stain.	0 to 170 µg/L in 29 analyses; median value = 10 µg/L.
Calcium (Ca) and magnesium (Mg)	Dissolved from almost all soils and rocks, especially limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Large quantities of magnesium are present in sea water.	Cause most of the hardness and scale-forming properties of water; soap consuming (see) hardness). Water with low calcium and magnesium contents desired for electroplating, tanning, dyeing, and textile manufacturing.	Calcium - 0.2 to 130 mg/L in 35 analyses; median value = 31 mg/L. Magnesium- 0.1 to 21 mg/L in 35 analyses; median value = 7.7 mg/L.
Sodium (Na) and potassium (K)	Dissolved from almost all rocks and soils. Found also in ancient brines, sea water, some industrial brines, and sewage.	Large amounts, in combination with chloride, give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers, and a high sodium ratio may limit the use of water for irrigation.	Sodium - 0.8 to 19 mg/L in 32 analyses; median value = 4.0 mg/L. Potassium- 0.1 to 2.7 mg/L in 31 analyses; median value = 1.0 mg/L.

Table 15.—Source, significance, range, and median values of dissolved mineral constituents and physical properties of spring water—Continued

Constituent or property	Source of origin	Significance	Range in Maryland spring water
Nitrate (NO_3 as N)	Decaying organic matter, sewage, and soil nitrates.	Concentrations much greater than the local average may suggest pollution. There is evidence that more than about 10 mg/L of nitrogen may cause a type of methemoglobinemia in infants, sometimes fatal. Nitrate (NO_3) has shown to be helpful in reducing intercrystalline cracking of boiler steel. It also encourages growth of algae and other organisms which produce undesirable tastes and odors.	0.0 to 8.4 mg/L in 13 analyses (laboratory); median value = 1.5 mg/L. 0.0 to 4.0 mg/L in 32 analyses (field tests); median value = 0.9 mg/L.
Dissolved solids	Chiefly mineral constituents dissolved from rocks and soils. Includes any organic matter and some water of crystallization.	Water becomes unsuitable for many purposes when it contains more than 1,000 mg/L of dissolved solids.	16 to 730 mg/L in 32 analyses; median value = 150 mg/L.
Hardness as $CaCO_3$	Nearly all the hardness in spring water is due to calcium and magnesium. All metallic cations other than the alkali metals also cause hardness.	Consumes soap before a lather will form. Deposits soap curd on bathtubs. Hard water forms scale in boilers, water heaters, and pipes. Hardness equivalent to the bicarbonate and carbonate is called carbonate hardness. Any hardness in excess of this is called noncarbonate hardness. Water of hardness up to 60 mg/L is considered soft; 61-120 mg/L, moderately hard; 121-220 mg/L, hard; more than 200 mg/L, very hard.	1.0 to 370 mg/L in 45 analyses (laboratory); median value = 47 mg/L. 4.0 to 279 mg/L in 86 analyses (field tests); median value = 36 mg/L.
Hydrogen-ion concentration (pH)	Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxide, silicates, and borates raise the pH.	pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. The pH is a measure of hydrogen-ion activity. The corrosive properties of water generally increase with decreasing pH; however, excessively alkaline water may also attack metals.	Results of many measurements show a range in pH of from less than 6.0 to more than 8.0; pH values may change slightly from day to day in the same spring.

Table 15.—Source, significance, range, and median values of dissolved mineral constituents and physical properties of spring water—Continued

Constituent or property	Source of origin	Significance	Range in Maryland spring water
Alkalinity (HCO_3+CO_3)	Action of carbon dioxide in water on carbonate rocks such as limestone and dolomite.	Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot-water facilities to form scale and release corrosive carbon dioxide gas. In combination with calcium and magnesium cause carbonate hardness.	1.0 to 270 mg/L in 27 analyses; median value = 68 mg/L.
Sulfate (SO_4)	Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Usually present in mine water and in some industrial wastes.	Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts, sulfate in combination with other ions gives bitter taste to water. Some calcium sulfate is considered beneficial in the brewing process.	0.2 to 679 mg/L in 36 analyses; median value = 5.8 mg/L.
Chloride (Cl)	Dissolved from rocks and soils. Present in sewage and effluent from septic tanks. Found in large amounts in ancient brines, sea water, and industrial brines.	In large amounts in combination with sodium gives salty taste to drinking water. In large quantities increases the corrosiveness of water.	0.7 to 52 mg/L in 43 analyses (laboratory); median value = 4.6 mg/L. 0.7 to 151 mg/L in 86 analyses (field tests); median value = 29 mg/L.
Fluoride (F)	Dissolved in small to minute quantities from most rocks and soils, especially apatite-bearing rocks.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of calcification. However, it may cause mottling of the teeth depending on the concentration of fluoride, age of the child, amount of drinking water consumed, and susceptibility of the individual.	0.0 to 0.5 mg/L in 33 analyses; median value = 0.1 mg/L.

Manganese

Manganese (Mn) in water is similar to iron in its properties and characteristics. Manganese is an essential element in plant metabolism. The most common form of manganese in rocks and soils is the oxide and the hydroxide. Most of the ground water having large manganese concentrations are from thermal springs. White, Hem, and Waring (1963, p. F50) report examples of these. The manganese content of 29 analyses of spring water in the study area ranges from 0 to 170 μg/L and the median value is 10 μg/L. One sample from spring MO-FG 10 at Takoma Park exceeded the secondary maximum contaminant level of 50 μg/L established by the U.S. Environmental Protection Agency (EPA) (1977b, p. 17, 146). Manganese should not be a problem in most of the spring water in Maryland.

Sulfate

Elemental sulfur is not a major constituent of the Earth's outer crust, but is widely distributed in reduced form both in igneous and sedimentary rocks as metallic sulfides, such as pyrite or marcasite. As part of the weathering process, aerated water oxidizes the sulfide minerals producing sulfate ions and hydrogen ions. Pyrite is common in sediments such as coal and gray or black shale. Sulfate (SO_4) may also be derived from the solution of calcium sulfate (gypsum), common in certain sedimentary rocks. Sulfate has also been reported in rainfall, where concentration may exceed 1 mg/L (Hem, 1970, p. 164). Sulfate in the air is derived from volcanic gases and from the burning of coal in powerplants, factories, and other coal-burning installations. The sulfate content in 36 analyses of Maryland spring water ranges from 0.2 to 679 mg/L, with a median value of 5.8 mg/L.

As of 1982, the U.S. Environmental Protection Agency (1977a, p. 126) had not established a maximum contaminant level for sulfate. The agency describes a study in North Dakota that indicated that water containing more than 750 mg/L of sulfate had a laxative effect on most people, but water with less than 600 mg/L had little effect. Only one spring water analyzed (WA-BH 19 near Williamsport) had more than 600 mg/L of sulfate.

Chloride

Chloride (C1) is present in all ground water and a small amount is also present in precipitation. The chemical behavior of chloride in natural water is subdued compared to other major ions. Chloride ions do not significantly enter into oxidation or reduction reactions, are not significantly absorbed on mineral surfaces, and play few vital biochemical roles (Hem, 1970, p. 172). Chloride is present in all plants and animals and is a necessary element, at least in small amounts, for their survival.

Based on a series of chemical analyses from 1970 to 1971, Cleaves and others (1974, p. 439) show the mean ionic content and pH of precipitation at a site 12 mi north of Baltimore to be:

Ion or property	Milligrams per liter
Chloride (Cl)	0.4
Nitrate (NO_3 as N)	.4
Sulfate (SO_4)	3.74
Silicate (SiO_2)	.9
Calcium and magnesium (Ca + Mg)	.51
Sodium and potassium (Na + K)	.39
pH	4.1

Chloride content of 43 laboratory analyses of spring water ranges from 0.7 to 52 mg/L, with the median being 4.6 mg/L. Seven springs (16 percent) had a chloride content of less than 2 mg/L, which approaches the mean value of 0.4 mg/L for precipitation measured by Cleaves and others (table 16).

Table 16 lists seven springs having water of low mineral content. All the springs are in rugged or mountainous terrain, and all except GA-EC 1, issue from silicate rock aquifers consisting chiefly of schist, quartzite, and sandstone. Spring GA-EC 1, near Oakland, issues from sandy limestone and (or) calcareous siltstone. It also has the highest dissolved solids content of the group and is the source of the famous Deer Park spring water served on the dining cars of the Baltimore and Ohio Railroad for many years.

Table 16.—Springs with water of significantly low chloride and mineral content

Spring No.	Aquifer	Chloride (mg/L)	Dissolved solids (mg/L)
BA-BD 25	Loch Raven Schist	1.1	16
BA-DD 297	Loch Raven Schist	1.7	30
CL-DC 165	Prettyboy Schist	1.6	20
FR-CB 7	Catoctin Formation	1.5	—
FR-CD 38	Weverton Quartzite	1.3	16
GA-EB 33	Pocono Formation	1.3	46
GA-EC 1	Greenbrier Formation	0.7	76

Fluoride

Fluoride (F) is a minor constituent of most ground water where it is commonly derived from solution of the minerals fluorite or apatite. Minerals of the mica group may also contribute fluoride to solution in ground water. Fluoride in excessive concentrations is undesirable in water used for drinking, and continued ingestion

of such water may cause dental fluorosis (mottled teeth) in some individuals. The fluoride content of 33 samples of spring water ranges from 0.0 to 0.5 mg/L. The maximum value (from spring WA-CH 7) is well below the approved limiting range of 1.4 to 2.4 mg/L established by the U.S. Environmental Protection Agency (1977a, p. 67). Fluoride generally is not a problem element in Maryland spring water, based on the available analyses.

Nitrate

Most of the nitrate (NO_3) ions in ground water appear to be derived from the decomposition of organic matter in the soil, although small amounts may be derived from the decomposition of igneous rocks. The average concentration of nitrogen (N) in precipitation near Baltimore was reported by Cleaves and others (1974, p. 439) to be 0.4 mg/L.

Springs comprise a distinctive situation with regard to their nitrate content. The collecting boxes or pits are frequently the site of organic debris and the home of frogs, salamanders, small fish, and insects, both alive and dead. Thus, the nitrate content of the water may vary in response to the contained biota. Nevertheless, both laboratory and field analyses of nitrogen were made and the laboratory values of 14 samples of nitrate as nitrogen ranged from 0.0 to 8.4 mg/L, with a median of 1.5 mg/L. Nitrates measured with a field kit (32 analyses) ranged from 0.0 to 4.0 mg/L, and the median was 0.9 mg/L.

The median values of both field and laboratory measurements are well below the U.S. Environmental Protection Agency's mandatory limiting value of 10 mg/L as nitrogen (1977a, p. 81).

Dissolved Solids

Dissolved solids include essentially all the mineral salts found in ground water plus any organic compounds which may be present. Ordinarily, water containing more than 500 mg/L of dissolved solids is not recommended for public supplies (EPA, 1977b, p. 17, 146), but water containing as much as 1,000 mg/L is acceptable if a better source is not available. Dissolved solids concentration in water from 32 Maryland springs range from 16 to 730 mg/L, with a median value of 150 mg/L.

Hardness

Hardness (as $CaCO_3$) is caused chiefly by compounds of calcium and magnesium, and ground water from a limestone terrain is generally hard. About 48 percent of spring water is moderately hard to very hard, based on a total of 45 laboratory analyses. About 18 percent of the springs analyzed have soft water with a total hardness of less than 10 mg/L as $CaCO_3$. Spring BA-BD 25 at Camp Alkor in northern Baltimore County had the softest water (1 mg/L as $CaCO_3$). Here, water flows from a fracture in the Loch Raven Schist at the base of a steep hillside in a forested area. The bedrock consists of quartzose schist having a thin saprolite cover.

Trace Metals

Spring water in the Maryland Piedmont and Appalachian provinces was analyzed for the following 10 trace metals: aluminum, cadmium, chromium, copper, lead, lithium, mercury, nickel, silver, and zinc[1]. Nearly all the analyses showed that these elements were present only in very low concentrations. Trace metals in natural or in uncontaminated ground water, with the exception of iron, usually occur in concentrations below 1,000 μg/L. The concentrations are low because of constraints imposed by the solubility of the minerals containing them, or because they are absorbed on clay minerals or on hydrous oxides with organic matter in the soils or subsoils. None of the spring water analyzed exceeded the U.S. Environmental Protection Agency's maximum contaminant levels for cadmium, chromium, copper, lead, mercury, silver, and zinc. Almost all Maryland springs are chemically suitable for most uses, provided they are not bacteriologically contaminated or contaminated with organic compounds such as herbicides or pesticides. No analyses for these compounds were made of spring water during this study.

Aluminum: Small concentrations of aluminum (Al) are present in nearly all ground water. Aluminum is derived largely from the weathering of feldspathic rocks. Aluminum appears to go into solution more readily in water of low pH, that is acidic water (Hem, 1970, p. 113). In 27 analyses of Maryland spring water, total aluminum concentrations ranged from 50 to 1,000 μg/L with the median value being 100 μg/L. The maximum concentration was found at spring WA-CH 2 at the St. James School south of Hagerstown. This spring issues from the Conococheague Limestone.

Cadmium: Cadmium (Cd) concentrations in natural ground water are extremely low, but cadmium may be introduced into water from zinc-galvanized iron in which cadmium is a contaminant, and from other sources of pollution. The average concentration in drinking water from community supplies in the United States is 1.3 μg/L (EPA, 1977a, p. 59). In 24 analyses of Maryland spring water, cadmium concentrations ranged from 0 to 2 μg/L, with the median value being 1 μg/L. The maximum contaminant level for cadmium in water systems has been established by the U.S. Environmental Protection Agency as 10 μg/L, well above the concentrations found in Maryland springs.

Chromium: Chromium (Cr) in ground water may be present in trace amounts when dissolved from chrome-bearing rocks. Chromium in the hexavalent state is toxic to man, and in sufficient concentrations, may produce skin sensitization (EPA, 1977a, p. 63).

[1]Trace metals are those that typically occur in concentrations of less than 1.0 mg/L, or 1,000 μg/L, (Hem, 1970).

Durum and Haffty (1963, p. 1-11) report that the median concentration for North American rivers was 5.8 μg/L. Durfor and Becker (1964, p. 78) report the median concentration for public water supplies in the United States was 0.4 μg/L as Cr. Chromium concentration in 24 analyses of spring water ranged from 1 to 20 μg/L, with a median of 8.5 μg/L. The maximum value of 20 μg/L was from several springs, including FR-DD 178 located immediately north of Frederick at the Monteview Property. This spring issues from the Frederick Limestone. The maximum contaminant level for chromium in public drinking water supplies is 50 μg/L (EPA, 1977a, p. 63). The concentration of chromium in Maryland springs sampled in this study is well below this limit.

Copper: Copper (Cu) in ground water may be present in trace amounts due to solution from copper-bearing rocks. Copper may also be present in domestic water supplies where it is dissolved from copper piping in the distribution system. However, where springs are sampled at the source, the copper content must be indigenous to the rocks or soil unless the water is polluted. Small amounts of copper are essential in the nutrition of plants and animals and small amounts of copper salts are commonly added to reservoir water to inhibit the growth of algae.

The concentrations of copper in 26 analyses from Maryland springs ranged from 2 to 23 μg/L, with a median value of 4.5 μg/L. In contrast, the copper concentration in 97 analyses of well water (from the same area) ranged from about 5 to 3,300 μg/L, with a median of 10 μg/L. The higher concentrations found in well water probably are due to collection of the samples from household faucets where the water passed through copper piping. Some acidic ground water may dissolve considerable amounts of copper from the piping system.

The copper content of all of the spring water analyzed is well below the limiting concentration of 1,000 μg/L recommended by the U.S. Environmental Protection Agency for domestic water supplies (1977b, p. 17, 143-17, 146).

Lead: Lead (Pb) may occur in rocks as lead sulfide (galena), or it may be present in the minerals aragonite and potassium feldspar. It may be dissolved from these minerals by percolating acidic ground water. Lead may also be dissolved from solder used to join copper pipes in household distribution systems, or it may be present in soils near major highways as a result of its presence in automobile exhaust and its accumulation over several decades.

Lead is toxic in both acute and chronic exposures and may present a special hazard to young children (EPA, 1977a, p. 69). For this reason, the Federal regulatory agency has a mandatory limit for drinking water supplies of 50 μg/L of lead.

The lead concentrations in 23 analyses of Maryland spring water range from .0 to 20 μg/L, with a median of 5 μg/L, or only one-tenth the mandatory limiting value. The maximum concentration of 20 μg/L was in water from spring CL-CC 111, owned by the town of New Windsor and used as a source of public water supply. This spring flows from the Wakefield Marble.

Lithium: Lithium (Li) is one of the alkali metals and is one of the lightest metals known. It tends to occur chiefly in granites and pegmatites and may also occur in evaporite deposits. In sufficiently high concentrations, lithium is potentially toxic to plants (Hem, 1970, p. 193).

Lithium concentrations in six analyses of Maryland spring water range from 0.0 to 0.3 μg/L, with a median of 0.05 μg/L. However, the range in 86 analyses of well water (in the same area) is from less than 50 to 600 μg/L, with a median of 100 μg/L. Durum and Hafty (1963, p. 1-11) indicate that the median lithium concentration in the major rivers of North America is 1.1 μg/L.

No limiting value for lithium content in drinking water has been established by State or Federal regulatory agencies.

Mercury: Very little natural water contains detectable concentrations of mercury (Hem, 1970, p. 205). However, mercury (Hg) may be introduced into water through disposal of mining, metallurgical or other industrial wastes. Mercury may also be introduced into the hydrologic environment through its use as a fungicide or a slimicide. Mercury poisoning may be acute or chronic; chronic poisoning results from the ingestion of small amounts of mercury during an extended period of time (EPA, 1977a, p. 77). The mercury concentration of 23 analyses of Maryland spring water ranged from less than 0.1 to 0.1 μg/L. None of these values approached the mandatory limiting value of 2 μg/L established by the Federal regulatory agency.

Nickel: Nickel (Ni) is relatively rare in most rocks, and in the Maryland area it would most likely be found in some of the mafic (iron rich) igneous rocks. It appears to be relatively non-toxic to humans in dilute concentrations in most forms, although airborne nickel compounds have been suspected of being carcinogenic (Waldbott, 1973). The median concentration of nickel in North American rivers was reported by Durum and Hafty (1963, p. 2) to be 10 μg/L. In 23 analyses of Maryland spring water, the concentration of nickel ranged from 1 to 17 μg/L and the median was 3 μg/L. The maximum value of 17 μg/L was found in water from spring MO-FG 10 at Takoma Park (adjacent to Washington, D.C.). As this spring is in an urban environment, the possibility exists that it may be slightly polluted. No standard has been established for nickel in drinking water supplies by the U.S. Environmental Protection Agency.

Silver: Silver (Ag) is one of the rarer elements and its concentration in Maryland rocks and soils would be very low. Normally, natural water contains very little silver. However, sometimes silver is added to water as a disinfectant. The chief effect of silver on the human body is cosmetic. It consists of a permanent blue-gray discoloration of the skin, eyes, and mucous membranes. This condition is known as argyrosis (EPA, 1977a, p. 118). For these reasons, the Federal regulatory agency has set a mandatory limit of silver in drinking water supplies of 50 μg/L. The range in silver content in 23 analyses of Maryland spring water is from less than 1 to 5 μg/L, with a median of 1 μg/L. The maximum value again was from spring MO-FG 10 at Takoma Park, Md.

Zinc: In rocks, zinc (Zn) is commonly present as the sulfide mineral, sphalerite. Zinc may also partly replace iron or magnesium in certain other minerals and it may be present in carbonate sediments. Zinc is also used as a coating in galvanized steel pipe, where it affords a degree of corrosion protection. Zinc is another trace element necessary for human metabolism in dilute concentrations, but zinc in higher concentrations can be toxic in both human and aquatic life. The U.S. Environmental Protection Agency has set a secondary maximum contaminant level of 5,000 μg/L for zinc in public water systems (EPA, 1977b, p. 17,146).

The zinc content in 27 analyses of Maryland spring water ranges from 5 to 70 μg/L, with a median of 20 μg/L. The maximum value was in water from spring CL-BF 183, part of the water system for the town of Manchester in northeastern Carroll County. This spring flows from fractures in phyllitic rocks in the Bachman Valley Formation of Crowley[1].

In contrast to springs, the zinc content in 98 well water analyses (in the study area) ranged from less than 5 to 3,300 μg/L, with a median value of 430 μg/L. The maximum value was from a 65-ft drilled well (MO-ED 1) west of Rockville, Md., and it is probable that the high zinc content of this water was due to solution of the galvanized metal in the household distribution system from which the sample was collected.

SPRING CONSTRUCTION AND SANITATION

In recent years, springs have fallen out of favor as sources of potable water because many springs give the appearance of being polluted or contaminated, whether they are or not. Some springs are contaminated because the spring pit is unenclosed, providing ready access to leaves, debris, animals, insects, and other biologic contaminants. However, even springs that appear to be adequately sealed may contain frogs, salamanders, small fish and insects. In some instances, these organisms may enter the spring through the overflow pipe or trough during low-flow intervals. Most spring water in Maryland used as a source of public supply is treated by chlorination, and in some places the water is also filtered, thus assuring its safety from a health standpoint. Spring water treated by filtration and chlorination is as sanitary as most reservoir or stream sources and is much less likely to contain chemical contaminants introduced into streams from upstream industrial or municipal sewage-treatment plants.

Spring construction should be undertaken only after careful evaluation of the site. If the water is for potable use, the site should not be immediately below a domestic underground sewage-disposal pit or drain field, or near frequently manured or fertilized farm fields. Figure 16 shows a common type construction of a concrete spring box (or pit). The figure is largely self-explanatory, but it does not show the installation of piping and a pump to deliver water to the user, a subject beyond the scope of this report. For information on pumps and distribution systems, reference is made to Wright (1956, p. 39-40) and the U.S. Environmental Protection Agency (1973, p. 56-58). Of course, all springs for household use and human consumption are subject to approval by local health authorities.

[1]From unpublished geologic map of William Crowley, Maryland Geological Survey, 1975.

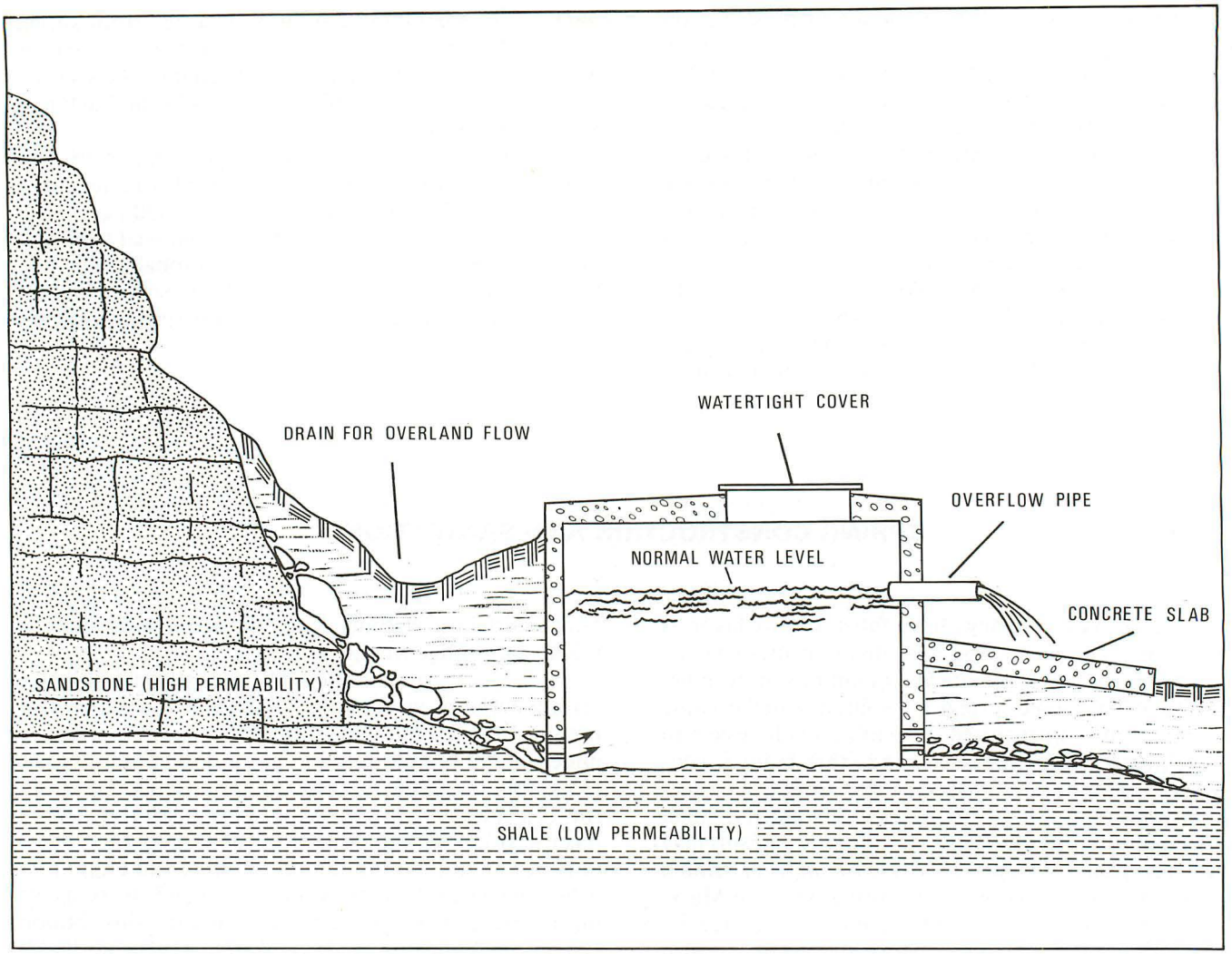


Figure 16.—Typical spring box (or pit) along the side of a valley in the Appalachian province.

SUMMARY AND CONCLUSIONS

This report describes the role of springs in Maryland in relation to the hydrologic cycle. It describes the flow characteristics, thermal regimes, and chemical character of 100 springs in the Piedmont and Appalachian provinces of the state. Springs and seeps are a major component of ground-water runoff and a rough measure of effective ground-water recharge. Based on measurements in six stream basins ranging in area from 2.2 to 281 mi^2, the annual ground-water runoff ranged from 6.5 to 11.3 in., or 16 to 27 percent of the annual precipitation.

The flow of springs is governed in part by the transmissivity of the aquifer which supplies the spring. Median values of transmissivity of the rock aquifers in the Appalachian and Piedmont regions range from 70 to 2,300 ft^2/d. Maximum transmissivities occur in the limestones and marbles and minimum transmissivities occur in phyllite, shale, and siltstone.

A wide range exists in the flow characteristics of springs. Spring flow may range through nearly two orders of magnitude from wet to dry periods. Most of the larger springs in Maryland are in Washington and Allegany Counties in the Appalachian province. The largest spring is AL-CE 1, the Potomac Blue Spring, located a few miles south of Cumberland. Its flow, based on four measurements, ranged from 3,500 to 9,750 gal/min, with a mean of 5,700 gal/min. This is equivalent to more than 8 Mgal/d. Another large spring is FR-DE 42, just south of Walkersville. This spring, known as Fountain Rock Spring, has a mean flow of 1,200 gal/min, based on four measurements. It is believed to be the largest spring in Frederick County.

The flow variability index of 29 Maryland springs, based on a formula proposed by O. E. Meinzer, ranges

from 14 to 295. All but one of the springs for which the variability index was computed are classed as subvariable to variable. The single spring rated as constant was Hall Spring, No. 3N3E-3, located in Baltimore City.

Maryland springs represent a largely untapped source of thermal energy. Temperatures of 76 springs were measured through an annual cycle. Variations at individual springs ranged from 34°F to 68°F, with the minimum fluctuation in WA-BF 3, near Williamsport, and the maximum fluctuation in CL-AF 8 at Lineboro, a short distance south of the Pennsylvania state line. The mean annual temperature of nearly all springs in this study is within 1° to 2°F of the average annual air temperature at the locality. The maximum temperature recorded was 68°F and the minimum was 33°F.

Analysis of the flow and temperature records of a small spring in northern Baltimore County, BA-AC 150, indicated that its water would yield 795,000 calories per hour for each 1.8°F (1°C) drop in temperature caused by heat transfer for energy extraction. A decline of the mean temperature of this spring from 46°F (8°C) to 37°F (3°C) would yield about 4,620 watts per hour.

A similar analysis of spring WA-BF 3, Big Spring in Washington County, shows that a lowering of its mean temperature by 9°F (5°C) would yield about 1,320,000 watts per hour. Thus, springs in Maryland offer a largely untapped source of thermal energy, whose recovery and use may cause some modification of the downstream thermal regime.

Chemical analyses of the water from 24 springs show that most of the water is a calcium-magnesium-bicarbonate type, or water of a mixed type. One spring, WA-BH 19 near Williamsport, has a calcium-magnesium sulfate water, suggesting that this water is derived from strata containing beds of gypsum (calcium sulfate). Spring MO-FG 10 at Takoma Park, yields a sodium-potassium chloride water with an acidic pH. This spring may issue from Coastal Plain sediments, or its chemical character may be affected by leaking sewers, lawn fertilizers, or other contaminants in the urban environment. Chemical analyses of seven springs draining schistose or quartzose rocks show low concentrations of chloride (Cl) and dissolved solids.

Spring water was analyzed for the following trace elements: aluminum, cadmium, chromium, copper, lead, lithium, mercury, nickel, silver, and zinc. None of the spring water analyzed exceeded the U.S. Environmental Protection Agency's maximum contaminant levels for cadmium, chromium, copper, lead, mercury, silver, and zinc. Almost all Maryland springs are chemically suitable for most uses, provided they are not bacteriologically contaminated or contaminated by organic compounds such as herbicides or pesticides. No analyses for these compounds were made of spring water during this study.

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TABLE 8. RECORDS OF SPRINGS

SPRING NO.: AL-AG 37

COUNTY: Allegany

NAME: Not known

OWNER: W. H. Elliott

LATITUDE: 39°41'10"

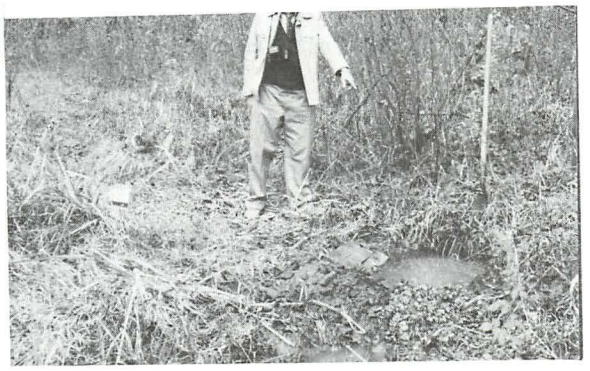
LONGITUDE: 78°34'13"

ELEVATION: 760 feet

AQUIFER: Oriskany Group (Sandstone)

IMPROVEMENTS: Apparently none

USE: Not used, but may have been many years ago



PHOTOGRAPH OF SPRING Date: November 1982

CHEMICAL ANALYSIS (field)

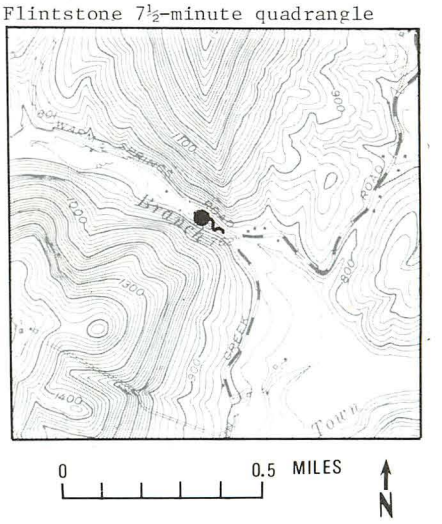
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/21/82	7.4	-	-	30
11/18/82	8.3	480	-	36
12/15/82	7.8	430	-	38
1/13/83	7.1	-	-	30
2/10/83	8.1	420	-	22
3/25/83	7.7	445	-	33

REMARKS

Slaughter (1962, p. 187) reported this spring had a flow of 150 gal/min in Sept. 1957. This is believed to be Maryland's only warm spring.

LOCATION MAP

Flintstone 7½-minute quadrangle



TEMPERATURE DATA

Date	
10/21/82	17°C (63°F)
11/18/82	17°C (63°F)
12/15/82	16°C (61°F)
1/13/83	16°C (61°F)
2/10/83	16°C (61°F)
3/25/83	16.5°C (62°F)

DISCHARGE DATA

Date	
11/18/82	30-50 gal/min (est.)

SPRING NO. : AL-BC 8

COUNTY : Allegany

NAME : Red Hill Spring

OWNER : Mr. Labor

LATITUDE : 39°38'26"

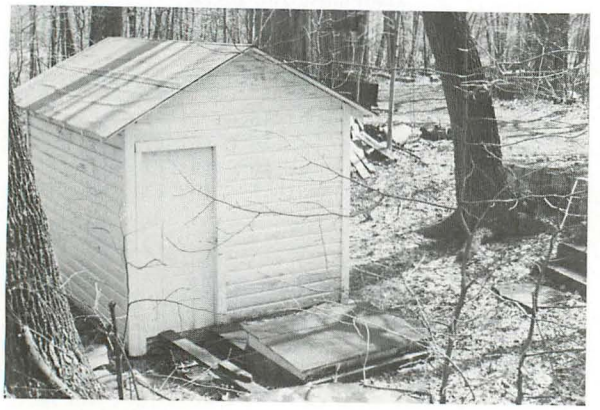
LONGITUDE : 78°51'25"

ELEVATION : 1,240 feet

AQUIFER : Greenbrier Formation

IMPROVEMENTS : Spring pit with cover; also has pumphouse to deliver water to La Vale

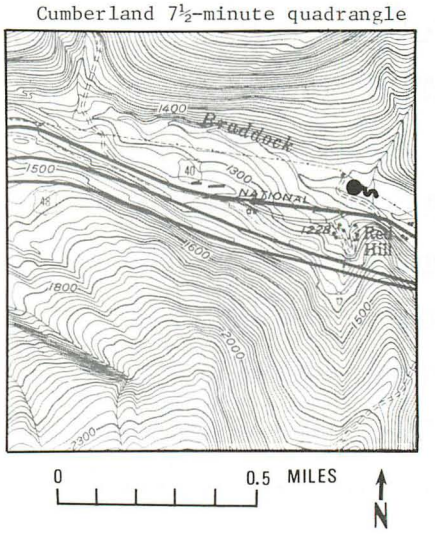
USE : Part of municipal supply for town of La Vale



PHOTOGRAPH OF SPRING Date: March 1982

LOCATION MAP

Cumberland 7½-minute quadrangle



TEMPERATURE DATA

Range: 10°C to 11.7°C (50°F to 53°F)

Period: 1/13/81 to 1/27/82

Mean: 10.7°C
(Based on 13 measurements)

DISCHARGE DATA

Date	
10/18/51[1]	5 gal/min (est.)

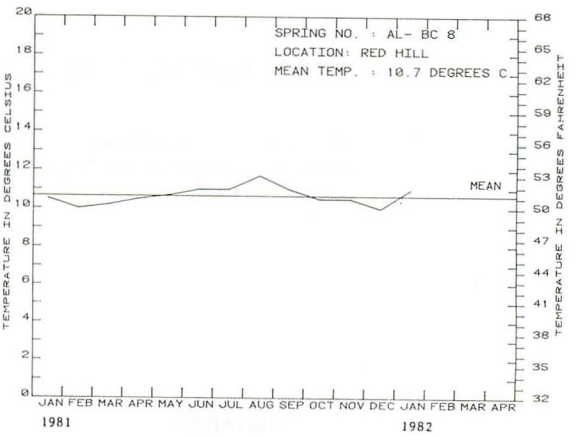
[1] Measurement by Slaughter (1962, p. 187)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
1/13/81	6.8	245	92	30
2/24/81	7.2	200	70	22
3/20/81	6.9	225	90	40
4/22/81	6.8	235	74	36

REMARKS

Field test for nitrate (N) = 0.4 mg/L on 5/28/82.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : AL-BF 1

COUNTY : Allegany

NAME : Murley Branch Spring

OWNER : George Stickley

LATITUDE : 39°39'40"

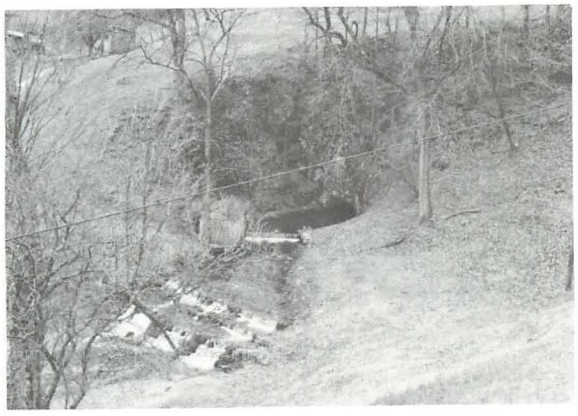
LONGITUDE : 77°37'10"

ELEVATION : 980 feet

AQUIFER : Tonoloway Limestone

IMPROVEMENTS : Small dam in stream below spring; springhouse off to one side

USE : Domestic



PHOTOGRAPH OF SPRING Date: March 1982

CHEMICAL ANALYSIS (field)

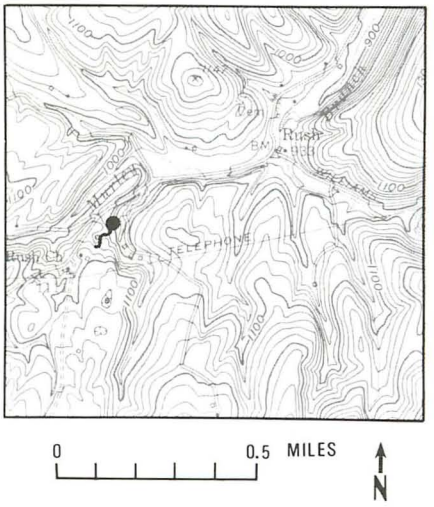
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
6/23/81	7.0	410	182	32
8/11/81	7.0	412	-	-
9/23/81	7.5	370	-	-
10/27/81	7.2	400	-	-

REMARKS

Water issues at base of limestone rock wall from a moderately large opening; mean discharge of four measurements = 685 gal/min (1.81 ft^3/s). This spring may be resurgence of water from Twiggs Cave, 2 miles south.

LOCATION MAP

Flintstone 7½-minute quadrangle



TEMPERATURE DATA

Range: 10.0°C to 12.3°C (50°F to 54°F)

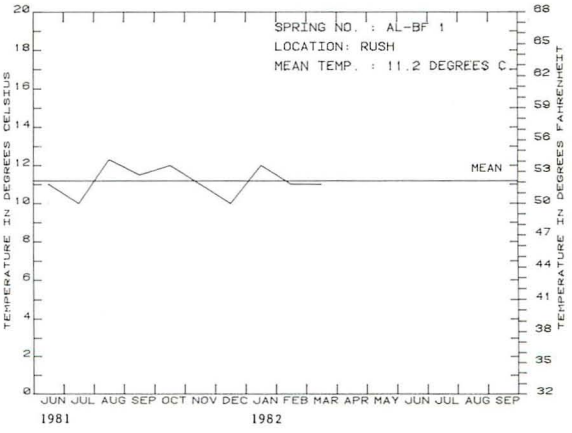
Period: 6/23/81 to 5/15/82

Mean: 11.2°C (52°F)
(Based on 12 measurements)

DISCHARGE DATA

Date	
10/08/57 [1]	410 gal/min (0.91 ft^3/s)
9/22/78	850 gal/min (1.90 ft^3/s)
9/02/80	670 gal/min (1.50 ft^3/s)
7/08/81	810 gal/min (1.81 ft^3/s)

1 Measurement by Slaughter (1962, p. 188).



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : AL-BF 21

COUNTY : Allegany

NAME : Unknown

OWNER : E. S. Higgins

LATITUDE : 39°38'10"

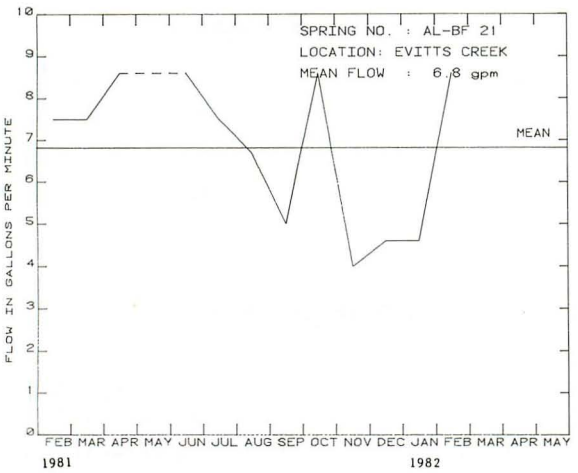
LONGITUDE : 78°37'47"

ELEVATION : 1,370 feet

AQUIFER : Oriskany Group (Ridgeley (?) Sandstone)

IMPROVEMENTS : Springhouse, discharge pipe, and trough

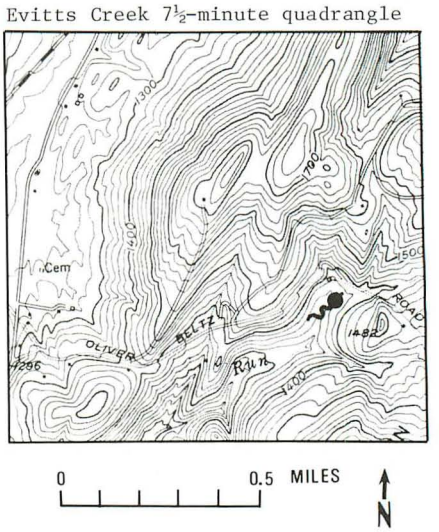
USE : Domestic



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

Evitts Creek 7½-minute quadrangle



TEMPERATURE DATA

Range: 9.0°C to 12.7°C (48°F to 55°F)

Period: 2/20/81 to 1/28/82

Mean: 10.4°C
(Based on 12 measurements)

DISCHARGE DATA

Range: 4.0 to 8.6 gal/min

Period: 2/20/81 to 2/24/82

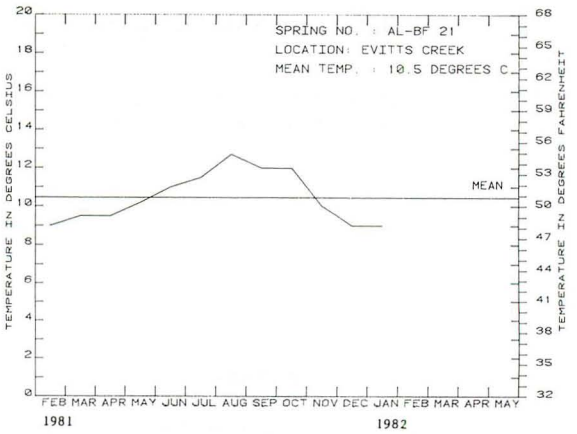
Mean: 6.6 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
2/20/81	7.8	43	19	22
3/20/81	7.4	29	13	25
4/22/81	6.9	39	10	28
6/25/81	7.1	33	10	40
5/28/82	6.4	-	-	-

REMARKS

Field test for nitrate (N) = 0.1 mg/L on 5/28/82.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : AL-BH 3

COUNTY : Allegany

NAME : Black Sulfur Spring

OWNER : State of Maryland (Forest Service)

LATITUDE : 39°39'56"

LONGITUDE : 78°29'59"

ELEVATION : 910 feet

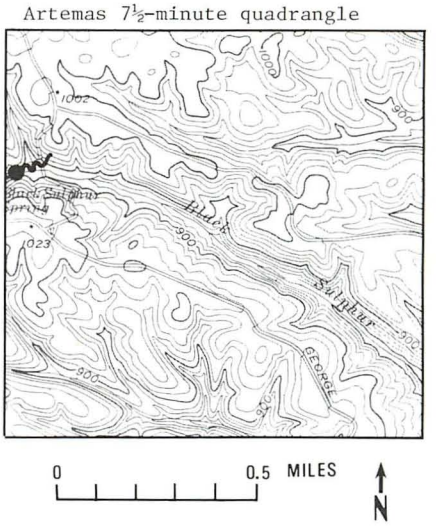
AQUIFER : Jennings Formation

IMPROVEMENTS : Terra-cotta discharge pipe

USE : None

LOCATION MAP

Artemas 7½-minute quadrangle



PHOTOGRAPH OF SPRING Date: March 1982

TEMPERATURE DATA

Date	
3/02/81	7.0°C (44°F)
4/22/81	8.5°C (47°F)
6/23/81	10.5°C (51°F)

DISCHARGE DATA

Date	
3/02/81	0.5 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
3/07/81	7.3	270	46	26
4/22/81	7.6	280	46	39
6/23/81	7.9	280	48	39

REMARKS

Although shown on the Artemas 7½-minute U.S. Geological Survey quadrangle, this spring apparently has not been used for many years. The spring pit is largely filled with debris and sediment and the spring is probably polluted. It had nearly ceased to flow at the time of examination in March 1982.

SPRING NO. : AL-BH 8

COUNTY : Allegany

NAME : White Sulphur Spring

OWNER : State of Maryland (Forest Service)

LATITUDE : 39°39'02"

LONGITUDE : 78°29'30"

ELEVATION : 800 feet

AQUIFER : Jennings Formation[1]

IMPROVEMENTS : None visible

USE : None

LOCATION MAP

Artemas 7½-minute quadrangle

0 0.5 MILES N

PHOTOGRAPH OF SPRING Date: March 1982

TEMPERATURE DATA

Date	
3/02/81	8.0°C (46°F)
3/20/81	7.5°C (45°F)
4/22/81	9.0°C (48°F)
6/23/81	11.0°C (51°F)

DISCHARGE DATA

Date	
3/02/81	<2 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
3/02/81	7.5	151	49	22
3/20/81	7.8	270	54	36
4/22/81	7.3	150	42	32
6/23/81	7.7	262	40	30

REMARKS

This spring has deteriorated and apparently has not been used for many years.

[1] May be in Romney Formation.

SPRING NO. : AL-BH 10

COUNTY : Allegany

NAME : Not known

OWNER : Long Pond Rod and Gun Club

LATITUDE : 39°39'48"

LONGITUDE : 78°25'37"

ELEVATION : 910 feet

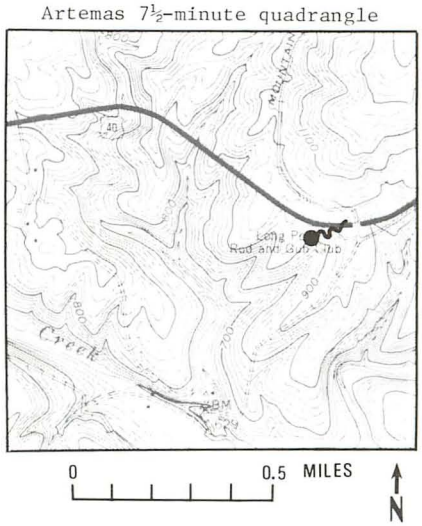
AQUIFER : Hampshire Formation

IMPROVEMENTS : Springhouse and concrete box

USE : Club use

LOCATION MAP

Artemas 7½-minute quadrangle



PHOTOGRAPH OF SPRING Date: March 1982

TEMPERATURE DATA

Range: 9.0°C to 14.5°C (48°F to 58°F)

Period: 6/23/81 to 5/15/82

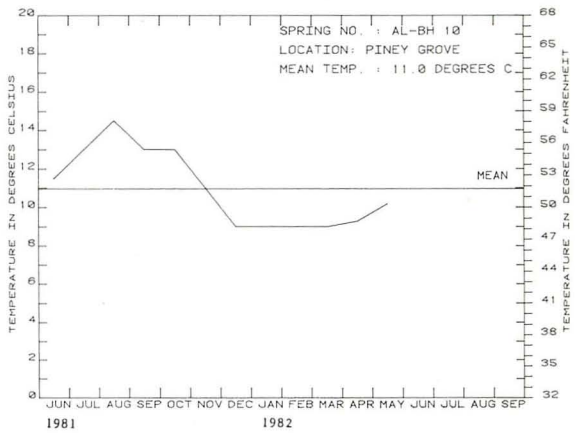
Mean: 10.9°C
(Based on 12 measurements)

DISCHARGE DATA

Date	
8/11/81 (min.)	<1-10 gal/min (est.)
7/--/57 (max.)	

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
6/23/81	6.6	610	97	151
7/23/81	6.7	502	-	-
8/11/81	6.4	580	-	-
9/23/81	6.9	490	-	-



GRAPH SHOWING MONTHLY TEMPERATURE

REMARKS

Located behind clubhouse about 500 feet west of Mountain Road overpass on U.S. Route 40. Field test for nitrate (N) = 0.1 on 5/27/82. High chloride content (151 mg/L) suggests contamination by road salt.

SPRING NO. : AL-CE 1

COUNTY : Allegany

NAME : Blue Spring or Potomac Blue Spring

OWNER : U.S. Department of the Interior (Park Service)

LATITUDE : 39°34'28"

LONGITUDE : 78°43'51"

ELEVATION : 560 feet

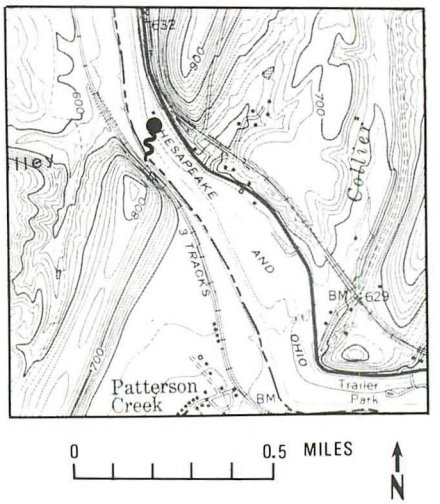
AQUIFER : Oriskany Group (Ridgeley Sandstone)

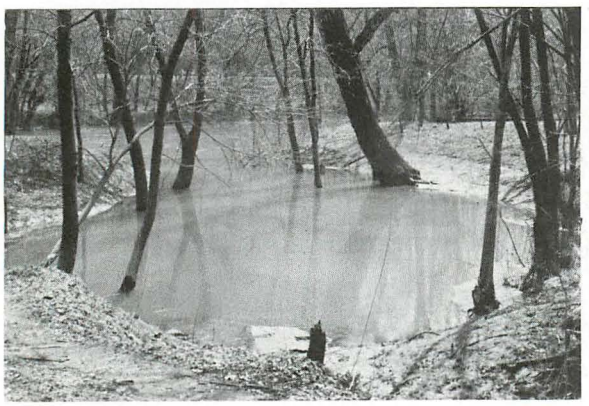
IMPROVEMENTS : None, except path to spring

USE : None

LOCATION MAP

Patterson Creek 7½-minute quadrangle





PHOTOGRAPH OF SPRING Date: March 1982

TEMPERATURE DATA

Range: 10.0°C to 12.4°C (50°F to 54.3°F)

Period: 2/20/81 to 2/24/82

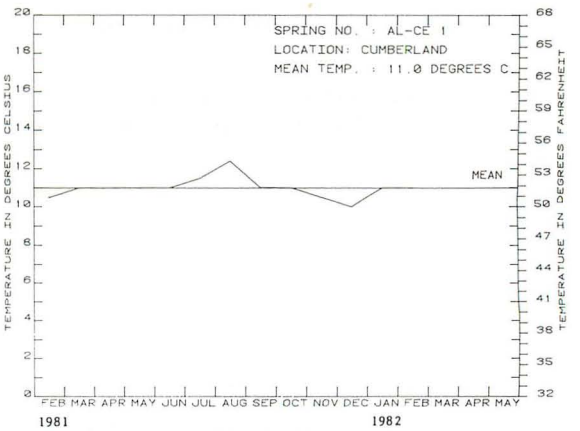
Mean: 11.0°C
(Based on 12 measurements)

DISCHARGE DATA

Date	
4/17/58	9,750 gal/min (21.7 ft^3/s)
9/02/80	4,937 gal/min (11.0 ft^3/s)
7/23/81	4,623 gal/min (10.3 ft^3/s)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
2/20/81	7.8	280	118	26
3/20/81	7.4	330	130	32
4/22/81	6.8	370	160	26
6/23/81	7.1	345	144	32



GRAPH SHOWING MONTHLY TEMPERATURE

REMARKS

Spring located a short distance from the Potomac River. Water may issue from a formation contact or from a fault-plane fracture. Additional information is in Slaughter (1962, p. 20). Spring is subject to flooding by the nearby river (see photo). Field test for nitrate (N) = 0.3 mg/L on 5/27/82.

SPRING NO. : 3N-3E-3

COUNTY : Baltimore City

NAME : Hall Spring

OWNER : City of Baltimore

LATITUDE : 39°20'06"

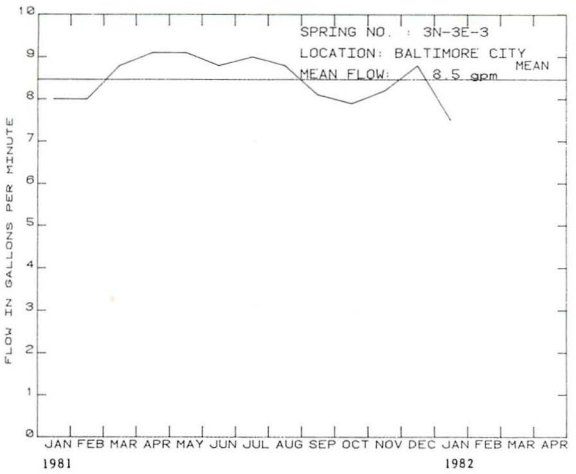
LONGITUDE : 76°34'35"

ELEVATION : 140 feet

AQUIFER : Loch Raven (?) Schist

IMPROVEMENTS : Concrete wall, floor, discharge drain, and two discharge pipes

USE : Used by passersby for general purposes



GRAPH SHOWING MONTHLY DISCHARGE

CHEMICAL ANALYSIS (field)

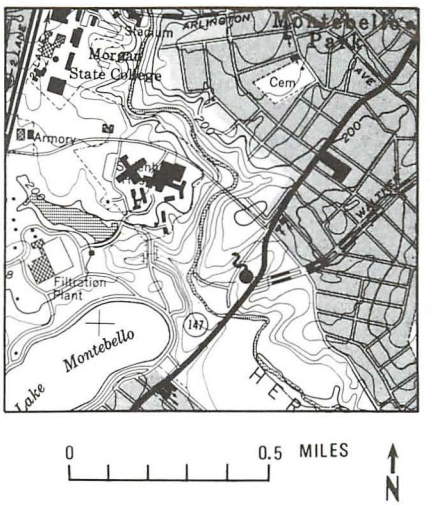
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
1/23/81	6.9	460	172	42
2/02/81	6.8	470	172	40
3/04/81	6.9	430	184	50
6/04/81	6.8	450	184	60

REMARKS

Data on hardness suggest spring may issue from Cockeysville Marble, but geologic map shows Loch Raven Schist.

LOCATION MAP

Baltimore East 7½-minute quadrangle



TEMPERATURE DATA

Range: 13.0°C to 15.0°C (55°F to 59°F)

Period: 1/23/81 to 12/02/81

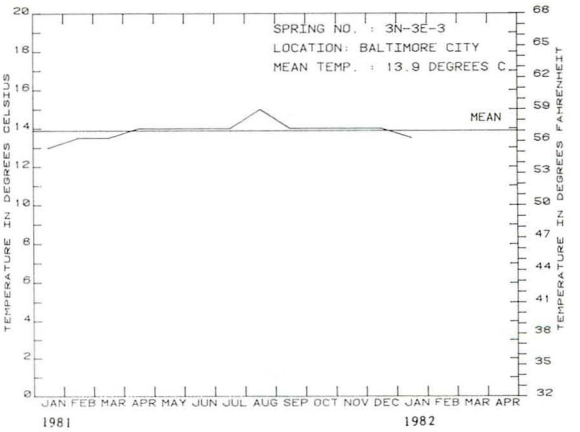
Mean: 14°C
(Based on 12 measurements)

DISCHARGE DATA

Range: 7.9 to 9.1 gal/min

Period: 1/23/81 to 12/02/81

Mean: 8.5 gal/min



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : BA-AC 150

COUNTY : Baltimore

NAME : Bentley Spring

OWNER : J. T. Dell

LATITUDE : 39°40'26"

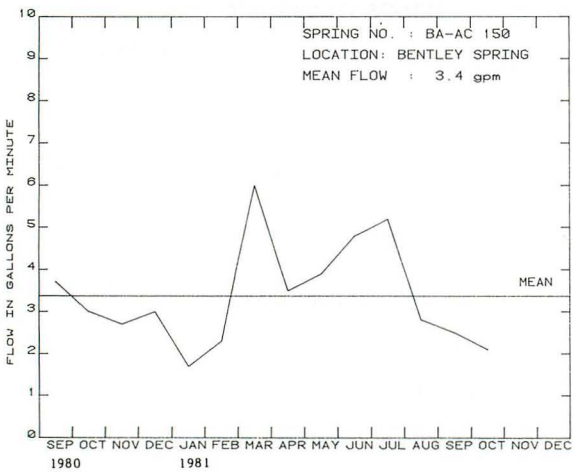
LONGITUDE : 76°40'16"

ELEVATION : 520 feet

AQUIFER : Prettyboy Schist

IMPROVEMENTS : Small collecting box uphill from 2-inch discharge pipe

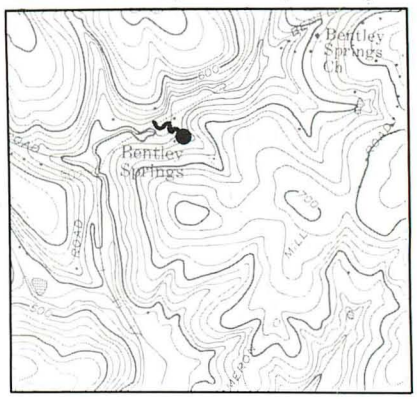
USE : Passersby. Owner has well for domestic supply



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

New Freedom 7½-minute quadrangle



0 0.5 MILES N

TEMPERATURE DATA

Range: 8.0°C to 14.0°C (46°F to 57°F)

Period: 9/11/80 to 9/08/81

Mean: 11.3°C
(Based on 14 measurements)

DISCHARGE DATA

Range: 1.7 to 6.0 gal/min

Period: 9/11/80 to 8/07/81

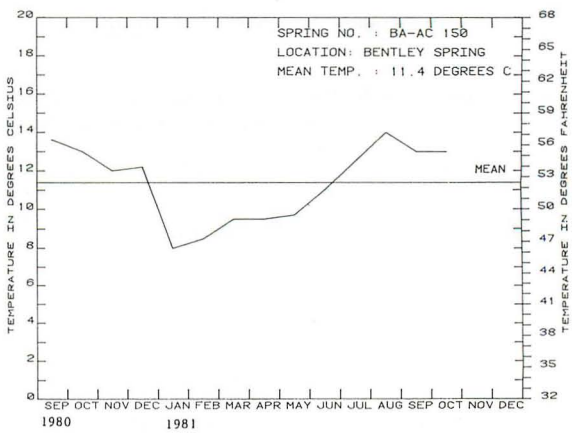
Mean: 3.5 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/06/80	6.8	86	22	19
11/05/80	6.5	89	24	22
2/02/81	6.9	107	31	20
4/01/81	6.9	104	33	24

REMARKS

Formerly supplied small bottling plant. Discharge pipe near culvert at road corner approximately 200 feet southeast of store with sign saying "Bentley Springs."



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : BA-BC 264

COUNTY : Baltimore

NAME : Not known

OWNER : City of Baltimore (Prettyboy Reservoir)

LATITUDE : 39°38'42"

LONGITUDE : 76°43'08"

ELEVATION : 570 feet

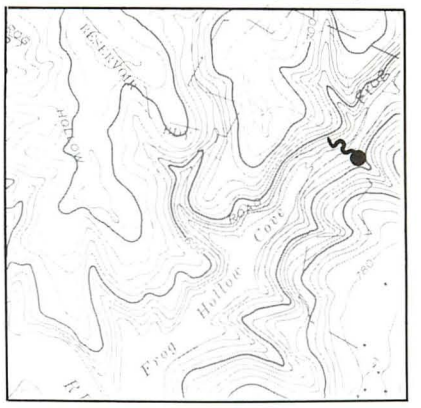
AQUIFER : Prettyboy Schist

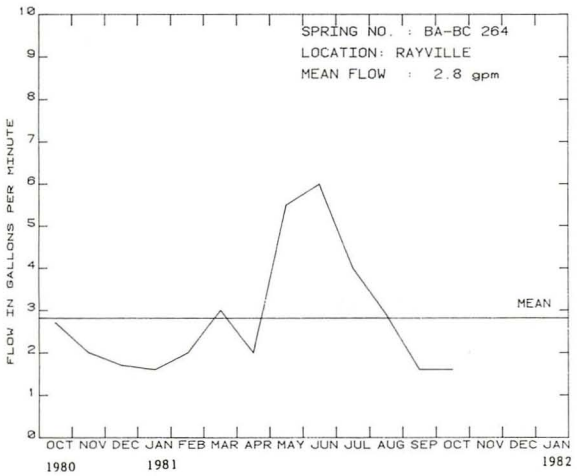
IMPROVEMENTS : Stone and concrete wall with discharge pipe

USE : Occasional use by passersby

LOCATION MAP

New Freedom 7½-minute quadrangle





GRAPH SHOWING MONTHLY DISCHARGE

TEMPERATURE DATA

Range: 9.0°C to 11.5°C (48°F to 52°F)

Period: 10/03/80 to 10/06/81

Mean: 10.2°C (Based on 13 measurements)

DISCHARGE DATA

Range: 1.6 to 6.0 gal/min

Period: 10/03/80 to 9/08/81

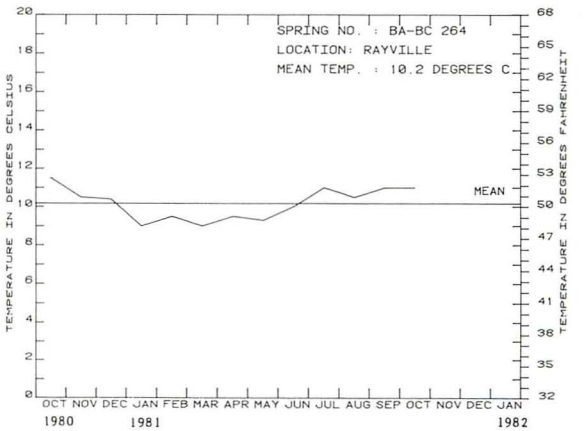
Mean: 2.8 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
1/06/81	6.8	21	15	18
2/02/81	6.6	26	8	19
3/04/81	6.9	22	8	40
4/01/81	7.0	25	10	24

REMARKS

Minimum flow of 1.6 gal/min on 1/06/81.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : BA-BD 25

COUNTY : Baltimore

NAME : Camp Alkor Spring

OWNER : Gunpowder Youth Camps, Inc.

LATITUDE : 39°35'37"

LONGITUDE : 76°38'16"

ELEVATION : 425 feet

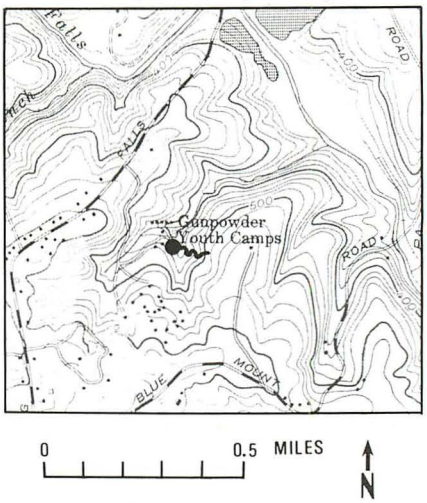
AQUIFER : Loch Raven Schist

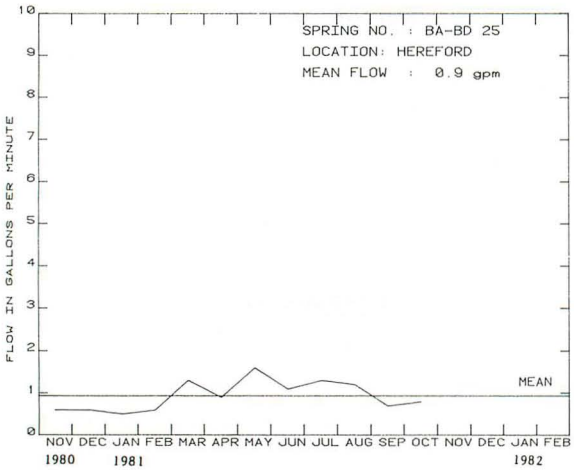
IMPROVEMENTS : Concrete box with pit and 2-inch discharge pipe

USE : Not authorized for camp use

LOCATION MAP

Hereford 7½-minute quadrangle





GRAPH SHOWING MONTHLY DISCHARGE

TEMPERATURE DATA

Range: 6°C to 13°C (43°F to 55°F)

Period: 11/14/80 to 10/06/81

Mean: 9.8°C
(Based on 12 measurements)

DISCHARGE DATA

Range: 0.5 to 1.3 gal/min

Period: 11/14/80 to 10/06/81

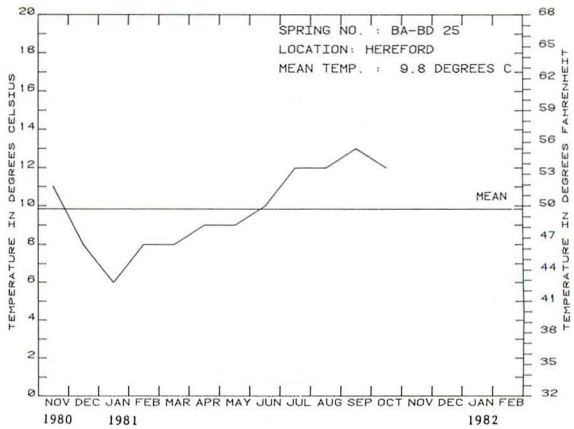
Mean: 0.9 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
12/23/80	-	101	40	30
1/16/81	6.8	101	34	34
2/02/81	6.9	110	35	21
3/04/81	6.8	87	39	32

REMARKS

Camp supplied by wells; spring not used for many years.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : BA-DC 18

COUNTY : Baltimore

NAME : Big Spring

OWNER : John W. Martin

LATITUDE : 39°29'43"

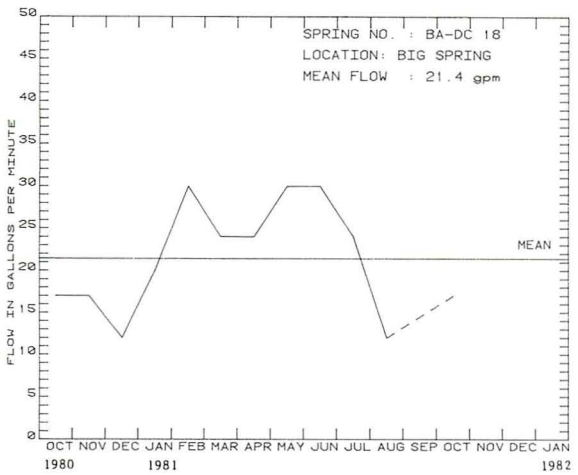
LONGITUDE : 76°13'56"

ELEVATION : 400 feet

AQUIFER : Cockeysville Marble

IMPROVEMENTS : Collecting box with overflow pipe to stream; also pumphouse

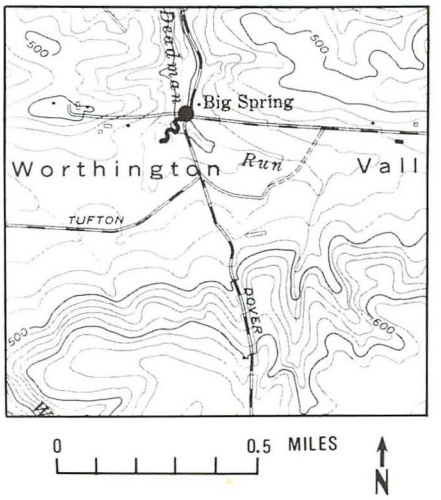
USE : None. Formerly supplied house and barns



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

Cockeysville 7½-minute quadrangle



TEMPERATURE DATA

Range: 10.0°C to 13.0°C (50°F to 55.4°F)

Period: 9/12/80 to 9/08/81

Mean: 12.1°C
(Based on 13 measurements)

DISCHARGE DATA

Range: 12 to 30 gal/min

Period: 10/06/80 to 9/08/81

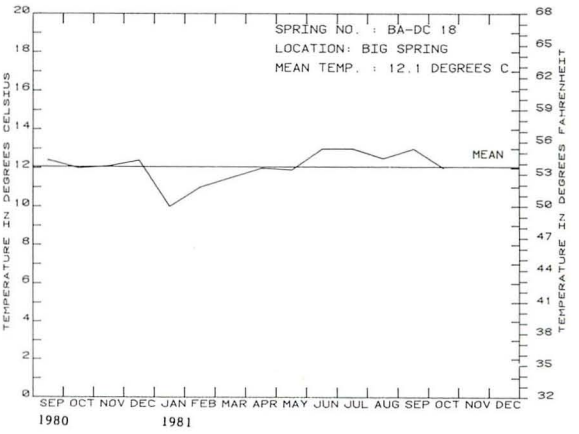
Mean: 21.4 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/06/80	7.9	325	122	27
11/05/80	7.3	370	128	27
12/02/80	7.4	340	136	29
1/06/81	7.3	330	138	32

REMARKS

Spring listed by Dingman and Ferguson (1956, Table 16, p. 102).



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : BA-DC 117

COUNTY : Baltimore

NAME : Not known

OWNER : Chestnut Ridge Country Club, Inc.

LATITUDE : 39°26'28"

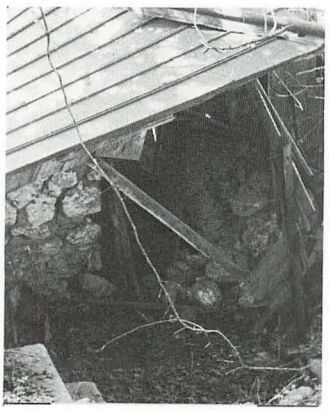
LONGITUDE : 76°41'17"

ELEVATION : 525 feet

AQUIFER : Loch Raven Schist

IMPROVEMENTS : Shelter and stone walls built into hillside; shelter in disrepair

USE : None during 1980-81. Formerly used for golf course irrigation



PHOTOGRAPH OF SPRING Date: May 1982

CHEMICAL ANALYSIS (field)

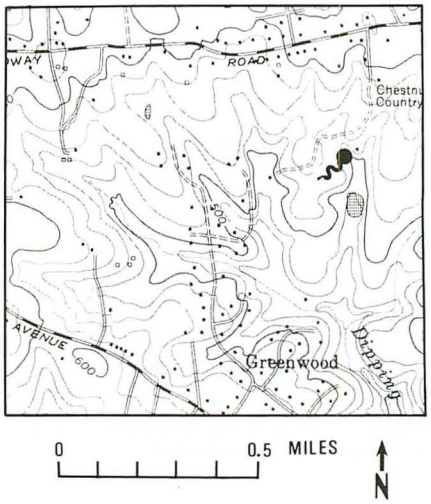
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/06/80	6.9	100	20	22
11/05/80	6.5	91	25	24
12/02/80	6.9	93	27	18
1/06/81	6.9	92	40	26

REMARKS

No flow observed on 5/18/81, 6/02/81, and on 8/06/81. Lack of flow during dry periods may be the reason this spring has been abandoned by the owner. Flow may also be affected by nearby irrigation well.

LOCATION MAP

Cockeysville 7½-minute quadrangle



TEMPERATURE DATA

Date	
9/22/80	13.5°C (56°F)
1/06/81	4.0°C (39°F)
4/01/81	9.5°C (49°F)
7/06/81	15.0°C (61°F)

DISCHARGE DATA

Date	
4/01/81	0-3 gal/min (est.)

SPRING NO. : BA-DC 440

COUNTY : Baltimore

NAME : Unknown

OWNER : Baltimore County Department of Parks

LATITUDE : 39°29'48"

LONGITUDE : 76°41'14"

ELEVATION : 370 feet

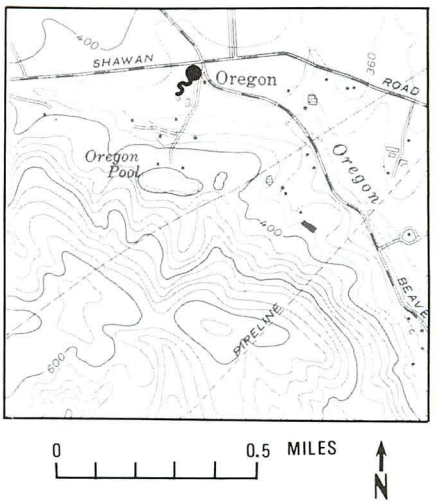
AQUIFER : Cockeysville Marble

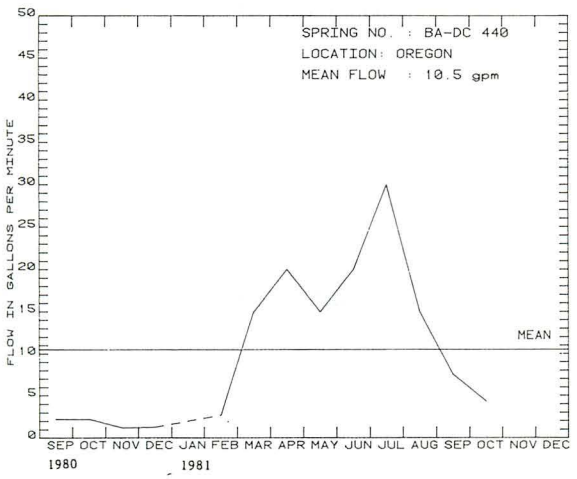
IMPROVEMENTS : Stone springhouse and discharge pipe to nearby ditch

USE : Unused

LOCATION MAP

Cockeysville 7½-minute quadrangle





GRAPH SHOWING MONTHLY DISCHARGE

TEMPERATURE DATA

Range: 6.5°C to 13.0°C (43°F to 55°F)

Period: 9/17/80 to 9/08/81

Mean: 11.7°C
(Based on 13 measurements)

DISCHARGE DATA

Range: 0 to 30 gal/min

Period: 9/17/80 to 9/08/81

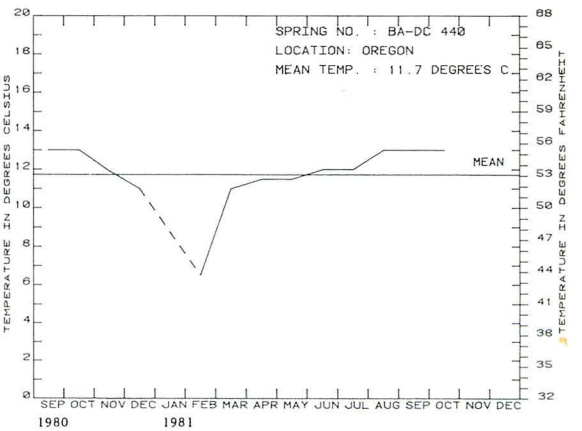
Mean: 10.5 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/06/80	7.4	420	150	27
11/05/80	7.5	427	180	26
12/02/80	7.2	420	180	28
5/05/81	7.0	420	182	42

REMARKS

Formerly supplied large house, but not used for many years.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : BA-DD 297

COUNTY : Baltimore

NAME : Not known

OWNER : Chapel Associates (Keelty Realty Co.)

LATITUDE : 39°27'09"

LONGITUDE : 76°39'30"

ELEVATION : 490 feet

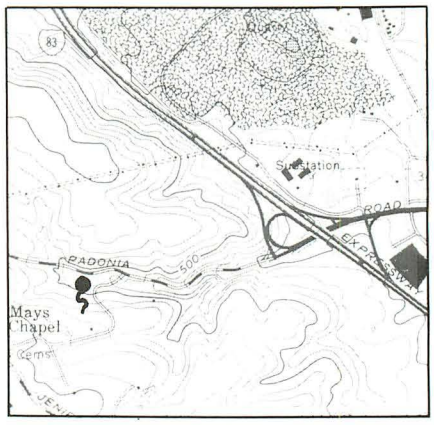
AQUIFER : Loch Raven Schist

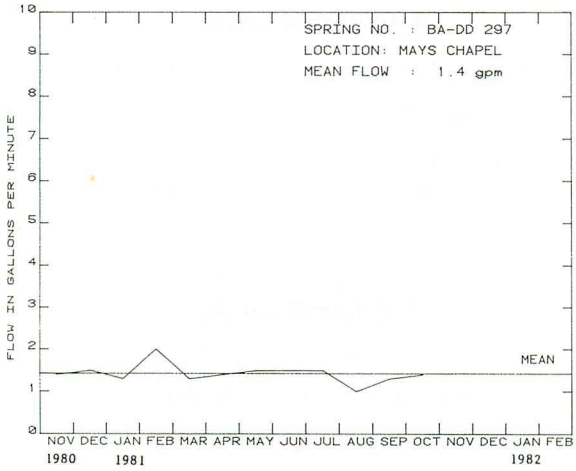
IMPROVEMENTS : Concrete-walled pit approximately 8 feet deep with shelter house, unused pump, and 2-inch discharge pipe to nearby stream

USE : None

LOCATION MAP

Cockeysville 7½-minute quadrangle





GRAPH SHOWING MONTHLY DISCHARGE

TEMPERATURE DATA

Range: 4.9°C to 15.0°C (40°F to 59°F)

Period: 11/14/80 to 10/06/81

Mean: 11.0°C
(Based on 12 measurements)

DISCHARGE DATA

Range: 0.9 to 2.0 gal/min

Period: 11/14/80 to 10/06/81

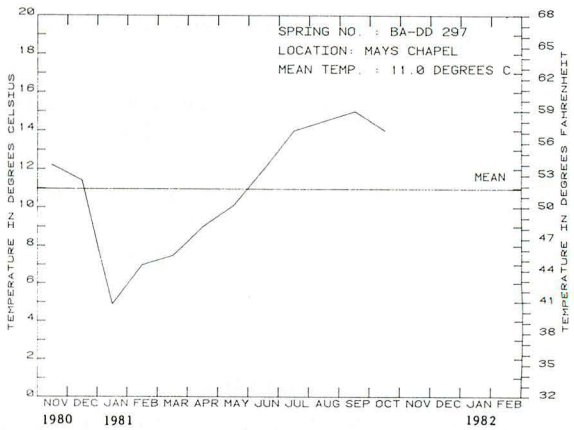
Mean: 1.4 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
12/02/80	6.9	120	65	26
1/06/81	6.5	113	50	34
2/02/81	6.6	124	45	28
3/04/81	6.8	110	36	40

REMARKS

Buried discharge pipe empties into stream 30 feet north of springhouse. Field test for nitrate (N) = 0.1 mg/L on 5/13/82.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : BA-DD 298

COUNTY : Baltimore

NAME : Ashland Spring

OWNER : City of Baltimore (Loch Raven Reservoir)

LATITUDE : 39°29'38"

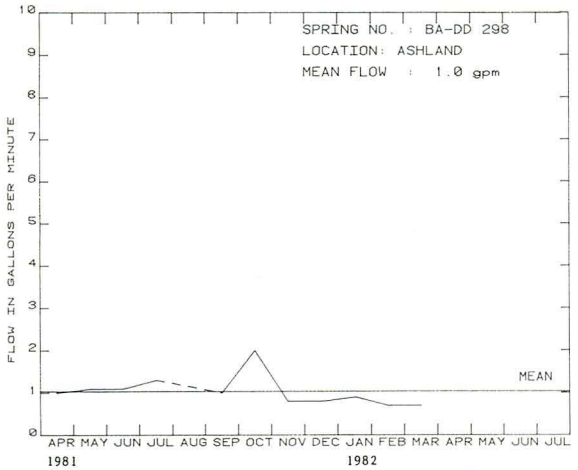
LONGITUDE : 76°38'04"

ELEVATION : 440 feet

AQUIFER : Loch Raven Schist

IMPROVEMENTS : Two stone and concrete collecting basins; water flows from lower basin via pipeline to community of Ashland

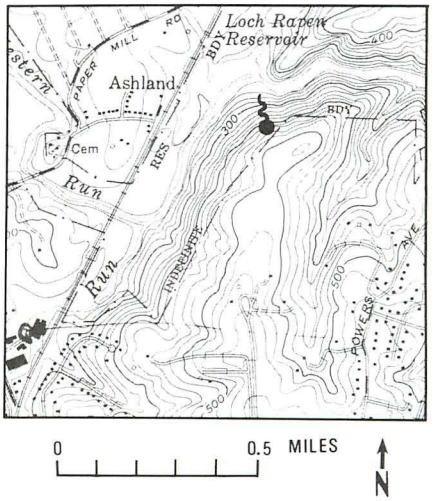
USE : At the time of this study (1981), supplied 30 to 40 people in the community of Ashland



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

Cockeysville 7½-minute quadrangle



TEMPERATURE DATA

Range: 6.0°C to 13.8°C (43°F to 57°F)

Period: 4/07/81 to 3/17/82

Mean: 10.3°C
(Based on 12 measurements)

DISCHARGE DATA

Range: 0.7 to 1.9 gal/min

Period: 4/07/81 to 3/17/82

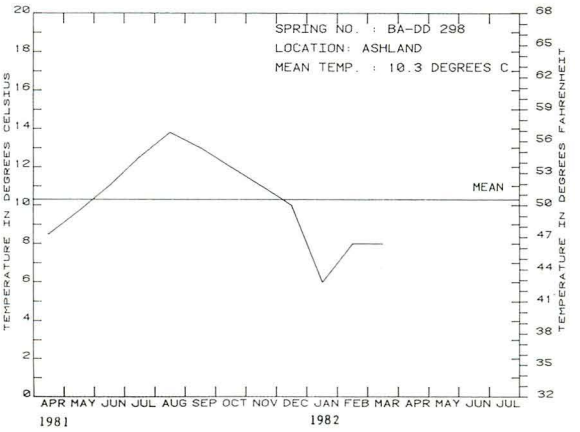
Mean: 1.0 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
4/07/81	6.8	29	10	25
5/05/81	-	23	6	40
6/02/81	6.1	23	8	25
7/06/81	6.4	24	-	-

REMARKS

Ownership uncertain; spring may be on private property. Because of dense woods, unable to pinpoint exact location.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : BA-DE 1

COUNTY : Baltimore

NAME : Villa Maria Spring

OWNER : Sisters of Notre Dame (Catholic Diocese)

LATITUDE : 39°26'31"

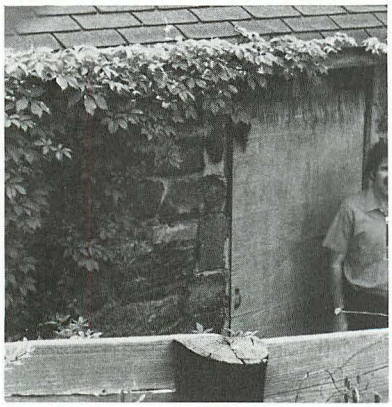
LONGITUDE : 76°30'48"

ELEVATION : 240 feet

AQUIFER : Cockeysville Marble (Metadolostone Member)

IMPROVEMENTS : Stone springhouse with overflow pipe; also has pump to supply white framehouse to the west

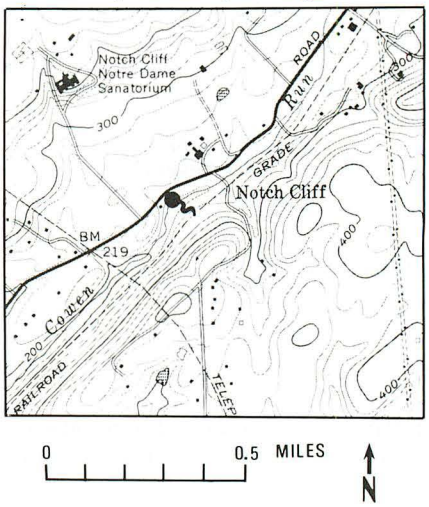
USE : Domestic



PHOTOGRAPH OF SPRING Date: May 1982

LOCATION MAP

Towson 7½-minute quadrangle



TEMPERATURE DATA

Range: 12.0°C to 13.5°C (54°F to 56°F)

Period: 9/17/80 to 9/08/81

Mean: 12.5°C
(Based on 13 measurements

DISCHARGE DATA

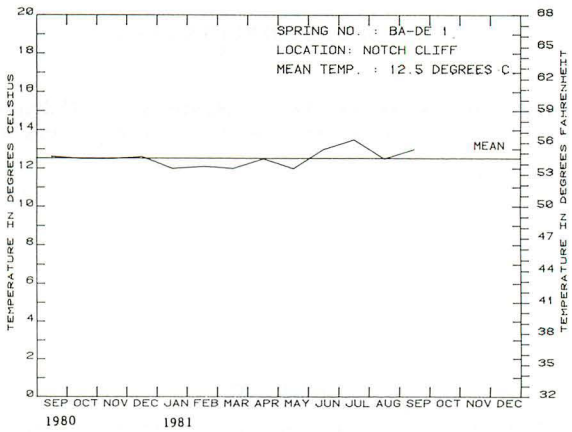
Date	
9/17/80	15 to 20 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
11/06/80	7.3	520	200	28
12/02/80	7.1	456	200	26
1/06/81	7.7	505	218	30
2/02/81	6.9	530	218	30

REMARKS

Formerly supplied approximately 100 persons at sanatorium on the hilltop. Spring currently (1982) supplies only one dwelling. Sanatorium now supplied by two wells above the spring.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : BA-FB 77

COUNTY : Baltimore

NAME : Not known

OWNER : Baltimore Gas and Electric Co.

LATITUDE : 39°15'17"

LONGITUDE : 76°45'58"

ELEVATION : 240 feet

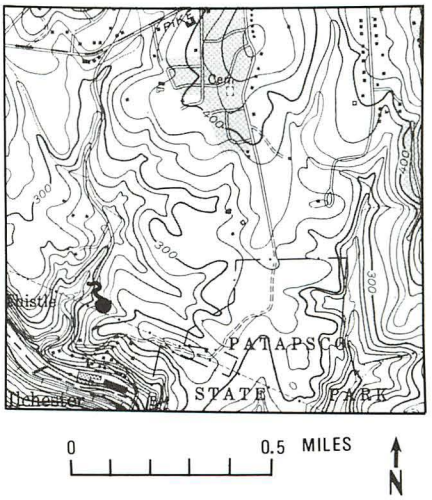
AQUIFER : Ellicott City Granodiorite

IMPROVEMENTS : Concrete shed with discharge pipe

USE : None

LOCATION MAP

Ellicott City 7½-minute quadrangle



PHOTOGRAPH OF SPRING Date: March 1982

TEMPERATURE DATA

Date	
4/01/81	8.5°C (47°F)
5/19/81	10.0°C (50°F)
6/12/81	14.0°C (57°F)
7/09/81	14.0°C (57°F)
8/20/81	16.0°C (61°F)

DISCHARGE DATA

Date	
5/19/81 (max.)	0 to 0.5 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
4/01/81	6.4	490	155	36
5/19/81	6.2	400	122	47
6/12/81	6.2	425	151	36
7/09/81	6.4	440	-	-

REMARKS

Measurements discontinued in August 1981 because of decline in flow of spring.

SPRING NO. : CL-AF 8

COUNTY : Carroll

NAME : Lineboro Spring

OWNER : Mrs. Minnie Wareheim

LATITUDE : 39°43'06"

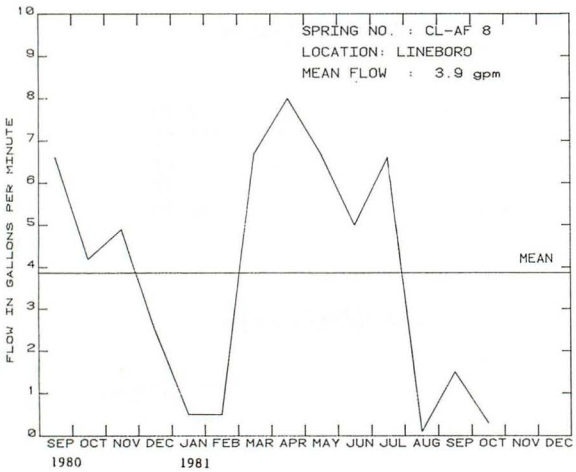
LONGITUDE : 76°51'02"

ELEVATION : 800 feet

AQUIFER : Prettyboy Schist

IMPROVEMENTS : Two concrete cisterns with discharge pipe going under highway to small pond

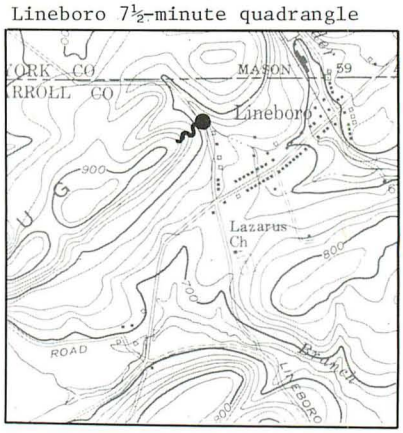
USE : Supplies small pond



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

Lineboro 7½-minute quadrangle



TEMPERATURE DATA

Range: 4°C to 18°C (39°F to 64°F)

Period: 9/29/80 to 9/10/81

Mean: 11.0°C
(Based on 13 measurements`

DISCHARGE DATA

Range: 0.1 to 8.0 gal/min

Period: 9/29/80 to 8/06/81

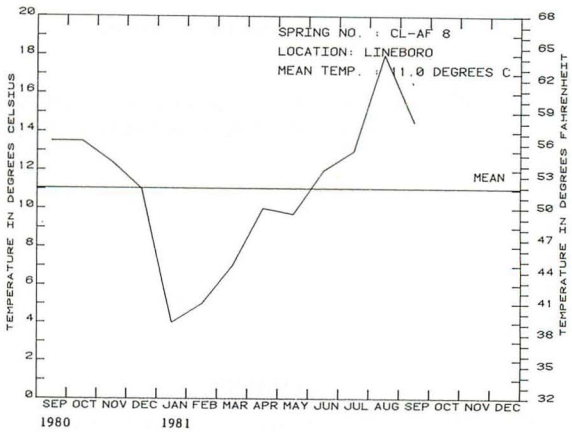
Mean: 3.9 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
9/29/80	6.3	96	28	20
10/17/80	6.9	97	30	20
11/05/80	-	95	24	20
4/06/81	6.6	100	34	36

REMARKS

Meyer (1958, p. 58) reports eight temperature measurements on this spring during 1954-56. Meyer also gives a chemical analysis in Table 11.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : CL-AF 84

COUNTY : Carroll

NAME : Not known

OWNER : Vernon Krebs

LATITUDE : 39°41'18"

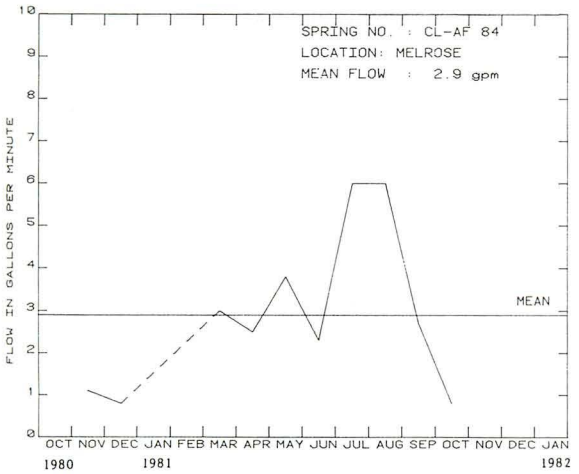
LONGITUDE : 76°53'43"

ELEVATION : 830 feet

AQUIFER : Bachman Valley Formation (of Crowley)

IMPROVEMENTS : Stone springhouse with inside trough

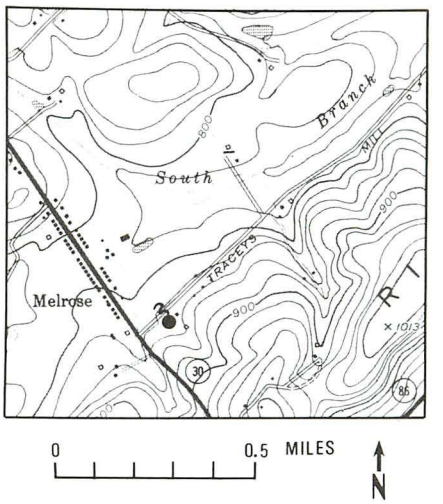
USE : Limited farm and domestic. Owner also has a well



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

Manchester 7½-minute quadrangle



TEMPERATURE DATA

Range: 8.0°C to 14°C (46°F to 57°F)

Period: 9/29/80 to 9/10/81

Mean: 11.7°C
(Based on 13 measurements)

DISCHARGE DATA

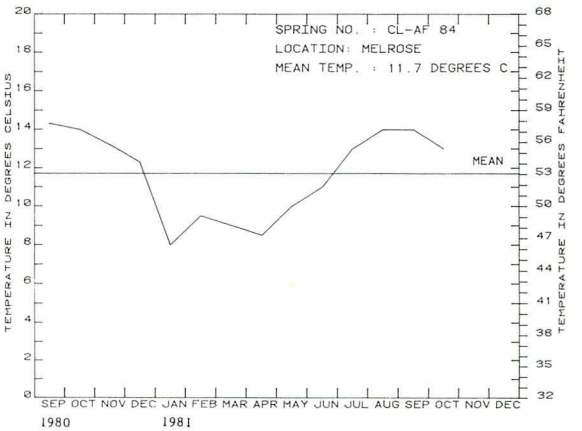
Range: 0 to 6 gal/min

Period: 10/17/80 to 9/10/81

Mean: 2.9 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
9/29/80	6.7	112	26	26
10/17/80	6.3	110	32	28
11/05/80	6.5	121	24	20
12/08/80	6.7	115	20	26



GRAPH SHOWING MONTHLY TEMPERATURE

REMARKS

Spring reported to have been in use during the Civil War. Minimum flow observed during January and February 1981. Field test for nitrate (N) = 1.4 mg/L on 5/11/82.

SPRING NO. : CL-BE 100

COUNTY : Carroll

NAME : Not known

OWNER : Edward Bollinger

LATITUDE : 39°38'38"

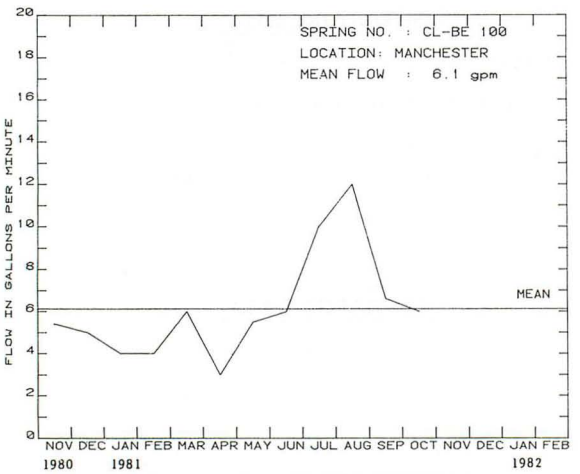
LONGITUDE : 76°55'38"

ELEVATION : 760 feet

AQUIFER : Bachman Valley Formation (of Crowley)

IMPROVEMENTS : Pipe leading from small shed to farm pond

USE : Supplies farm pond



GRAPH SHOWING MONTHLY DISCHARGE

CHEMICAL ANALYSIS (field)

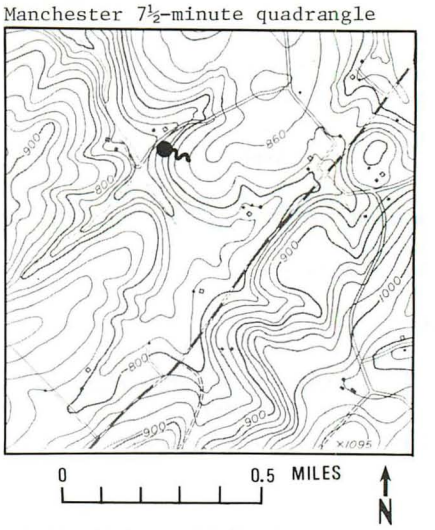
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/03/80	6.9	48	21	14
11/05/80	6.0	45	11	20
12/08/80	6.6	46	16	20
1/08/81	6.1	47	16	18

REMARKS

Spring formerly supplied water for a farmhouse and barns.

LOCATION MAP

Manchester 7½-minute quadrangle



TEMPERATURE DATA

Range: 6°C to 12°C (43°F to 54°F)

Period: 10/03/80 to 10/02/81

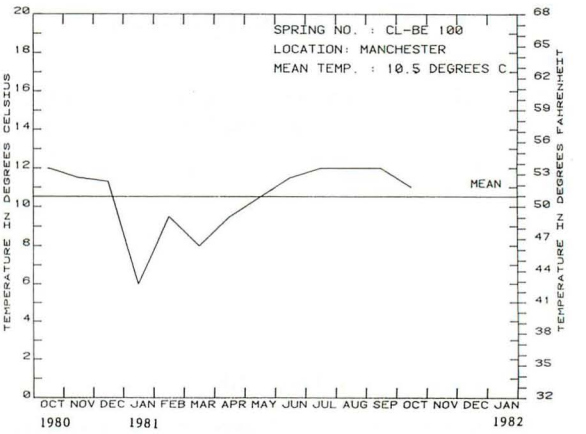
Mean: 10.5°C
(Based on 13 measurements)

DISCHARGE DATA

Range: 3 to 12 gal/min

Period: 11/05/80 to 10/02/81

Mean: 6.1 gal/min



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : CL-BE 105

COUNTY : Carroll

NAME : Martin Spring

OWNER : Carroll County Commissioners (Camp Hashawa)

LATITUDE : 39°38'50"

LONGITUDE : 76°59'24"

ELEVATION : 680 feet

AQUIFER : Marburg Schist

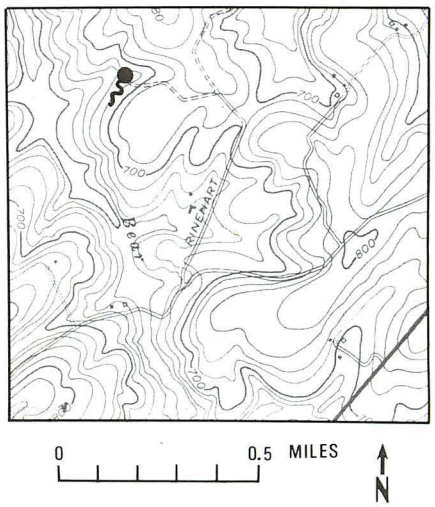
IMPROVEMENTS : Small shingle-roofed shed. Spring flows from under a large oak tree

USE : Not approved for camp use

PHOTOGRAPH OF SPRING Date: May 1982

LOCATION MAP

Manchester 7½-minute quadrangle



TEMPERATURE DATA

Range: 2°C to 15°C (36°F to 59°F)

Period: 9/30/80 to 9/10/81

Mean: 11.1°C
(Based on 12 measurements)

DISCHARGE DATA

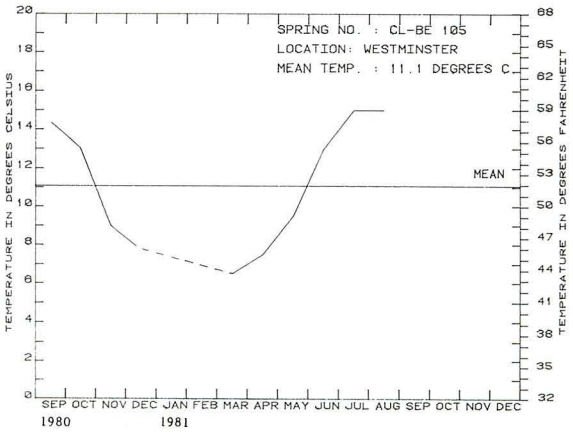
Date	
9/30/80 to 8/07/81	<1 to 2 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
9/30/80	5.7	85	30	28
10/17/80	6.7	92	40	16
11/05/80	6.0	89	22	20
12/08/80	6.7	89	22	17
5/11/82	6.9	-	-	-

REMARKS

Spring at foot of hill near restored pioneer cabin. Spring frozen over on January 8, 1981, and no water sample taken. Field test for nitrate (N) = 0.7 mg/L on 5/11/82.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : CL-BF 183

COUNTY : Carroll

NAME : Manchester Spring

OWNER : Town of Manchester

LATITUDE : 39°39'38"

LONGITUDE : 76°53'05"

ELEVATION : 880 feet

AQUIFER : Bachman Valley Formation (of Crowley)

IMPROVEMENTS : Pipe across Maryland Route 27 from spring to concrete collecting box with overflow pipe

USE : Municipal supply; town also has a well and another spring

PHOTOGRAPH OF SPRING Date: March 1982

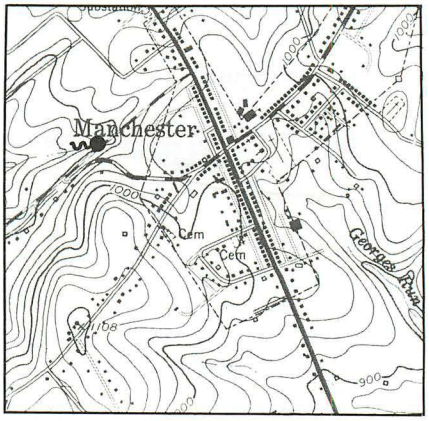
CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
1/08/81	6.6	320	80	65
2/06/81	6.5	330	78	60
3/05/81	6.7	290	80	80
4/06/81	5.8	310	72	68

[1] Town uses spring intermittently, and these measurements are flow in excess of demand. Field test for nitrate (N) = 2.7 mg/L on 5/11/82.

LOCATION MAP

Manchester 7½-minute quadrangle



0 0.5 MILES N

TEMPERATURE DATA

Range: 6°C to 14°C (43°F to 57°F)

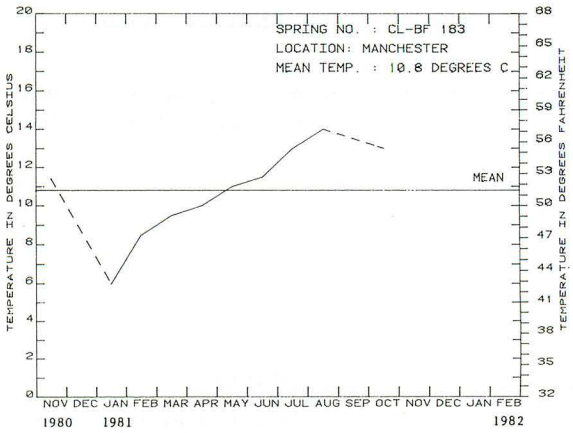
Period: 12/08/80 to 10/02/81

Mean: 10.8°C (Based on 12 measurements)

DISCHARGE DATA [1]

Date	Flow (gal/min)	Date	Flow (gal/min)
11/05/80	27	5/19/81	33.3
1/08/81	60	6/11/81	50
2/06/81	24	7/07/81	43
3/05/81	37.5	8/06/81	40
4/06/81	30	10/02/81	33

Mean of 10 overflow measurements above is 38 gal/min.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : CL-CB 3

COUNTY : Carroll

NAME : Not known

OWNER : J. Paul Bowmam

LATITUDE : 39°34'46"

LONGITUDE : 77°10'46"

ELEVATION : 420 feet

AQUIFER : Wakefield (?) Marble

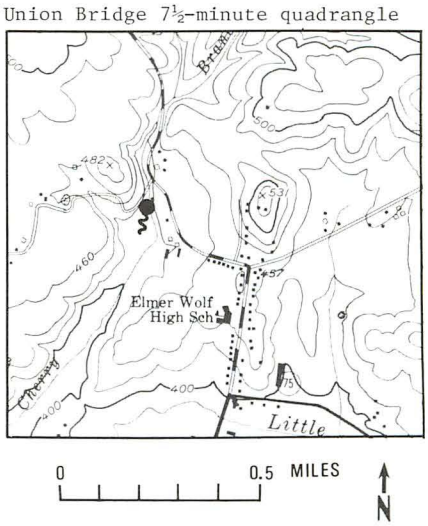
IMPROVEMENTS : Stone springhouse

USE : None

PHOTOGRAPH OF SPRING Date: April 1982

LOCATION MAP

Union Bridge 7½-minute quadrangle



TEMPERATURE DATA

Range: 9°C to 16°C (48°F to 61°F)

Period: 10/08/80 to 10/02/81

Mean: 12.6°C
(Based on 12 measurements)

DISCHARGE DATA

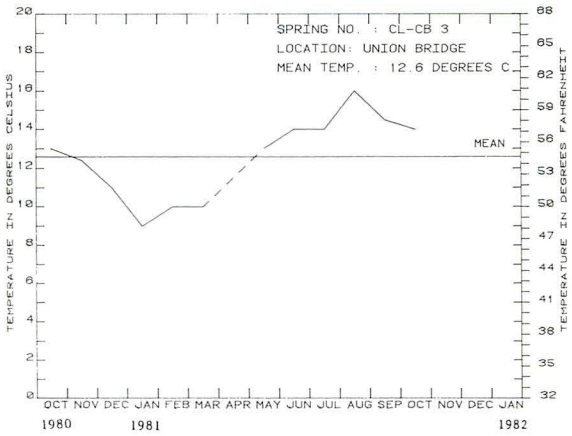
Date	
6/22/55 (by Meyer)	25 to 50 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/08/80	6.8	350	134	30
11/05/80	7.1	370	140	18
12/08/80	6.8	360	128	28
1/08/81	6.7	360	146	27

REMARKS

Discharge not readily measurable; flow during 1980-81 appeared to be less than estimated by Meyer. Field analysis for nitrate (N) = 2.8 mg/L (4/13/82).



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : CL-CC 111

COUNTY : Carroll

NAME : Unknown

OWNER : Town of New Windsor

LATITUDE : 39°32'20"

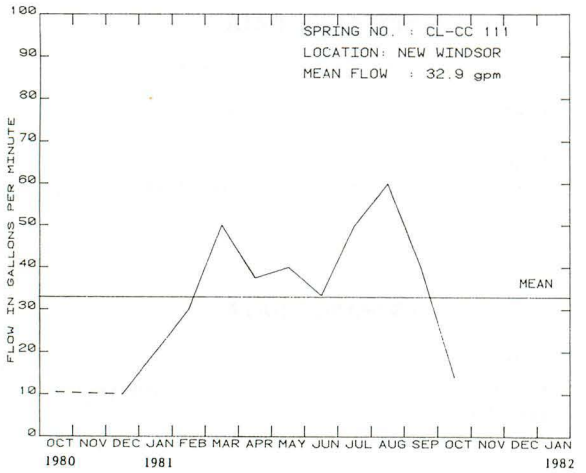
LONGITUDE : 77°06'33"

ELEVATION : 450 feet

AQUIFER : Wakefield Marble[1]

IMPROVEMENTS : Springhouse with plastic pipe discharging water to stream

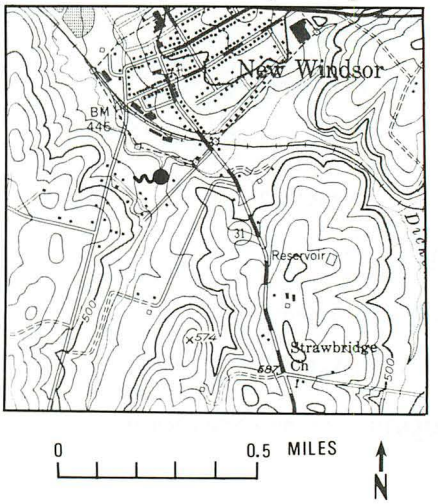
USE : Part of town supply



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

New Windsor 7½-minute quadrangle



TEMPERATURE DATA

Range: 11°C to 13°C (52°F to 55.4°F)

Period: 10/17/80 to 10/02/81

Mean: 11.9°C
(Based on 13 measurements)

DISCHARGE DATA

Range: 10 to 60 gal/min

Period: 10/17/80 to 9/10/81

Mean: 33 gal/min

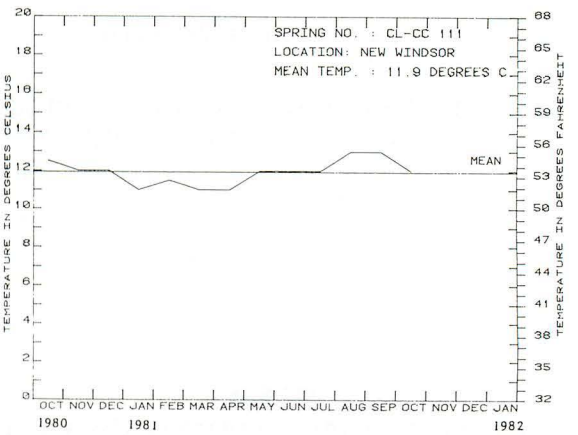
CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
11/05/80	6.5	510	180	26
12/08/80	6.9	460	200	26
1/08/81	7.1	520	226	42
2/06/81	7.0	540	200	34

REMARKS

Measurements represent overflow when spring is not in use. Dissolved oxygen = 6.6 mg/L on 8/14/81.

[1] This unit designated as Bachman Valley Formation by Wm. Crowley.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : CL-CD 94

COUNTY : Carroll

NAME : Not known

OWNER : Phillip Beachem, Sr.

LATITUDE : 39°33'21"

LONGITUDE : 77°02'03"

ELEVATION : 550 feet

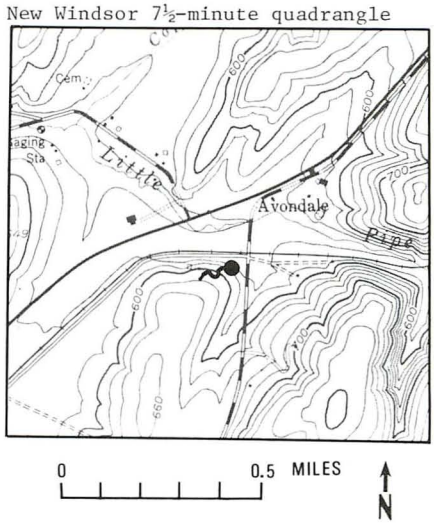
AQUIFER : Wakefield (?) Marble

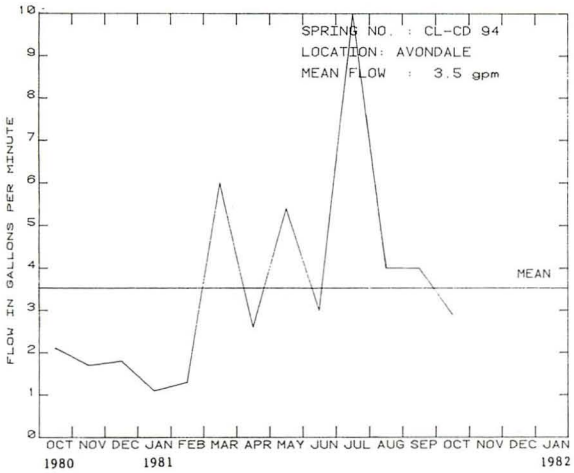
IMPROVEMENTS : Concrete spring pit and discharge pipe

USE : None

LOCATION MAP

New Windsor 7½-minute quadrangle





GRAPH SHOWING MONTHLY DISCHARGE

TEMPERATURE DATA

Range: 7°C to 16°C (45°F to 61°F)

Period: 9/24/80 to 9/10/81

Mean: 11.6°C
(Based on 13 measurements)

DISCHARGE DATA

Range: 1.1 to 10 gal/min

Period: 10/17/80 to 9/10/81

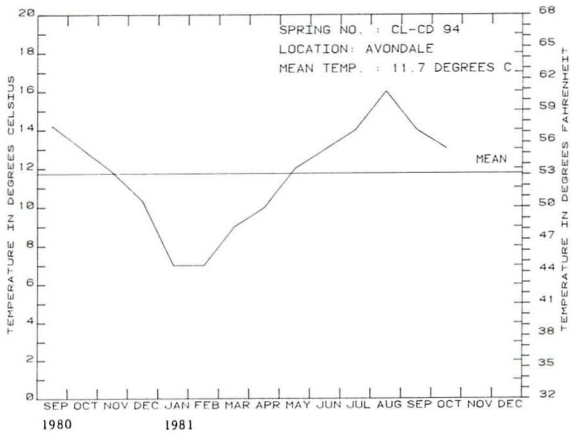
Mean: 3.5 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
9/24/80	7.3	290	113	28
10/17/80	6.8	287	112	26
11/05/80	7.2	280	114	28
12/08/80	6.8	280	111	22

REMARKS

Spring may be located at the contact with the Ijamsville Phyllite.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : CL-CD 179

COUNTY : Carroll

NAME : New Windsor Spring

OWNER : Town of New Windsor

LATITUDE : 39°30'53"

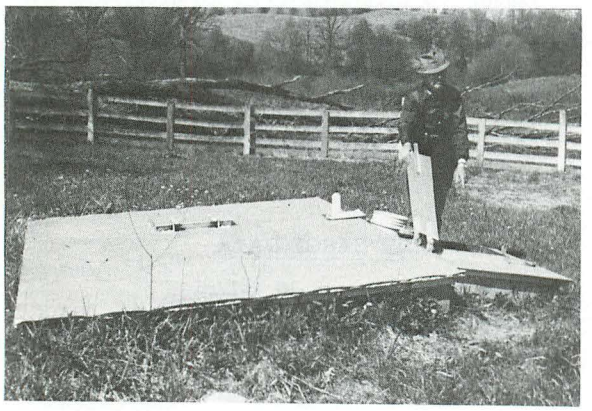
LONGITUDE : 77°04'54"

ELEVATION : 590 feet

AQUIFER : Bachman Valley Formation

IMPROVEMENTS : Concrete pit and cover; one of several springs in vicinity which flow into a pipeline and northward to New Windsor

USE : Town supply



PHOTOGRAPH OF SPRING Date: April 1982

CHEMICAL ANALYSIS (field)

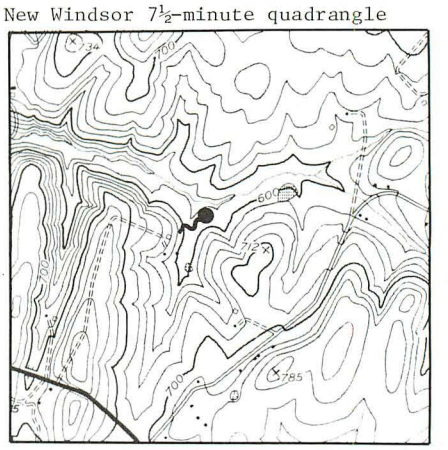
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
2/06/81	-	270	110	18
3/06/81	-	245	114	30
4/06/81	-	250	96	24
5/14/81	7.4	235	104	25

REMARKS

Samples could be collected at spring box only when spring was overflowing. Field test for nitrate (N) = 1.3 mg/L on 4/29/82. During dry seasons, all the flow of this spring and other nearby springs flow via pipeline to the town.

LOCATION MAP

New Windsor 7½-minute quadrangle



TEMPERATURE DATA

Date	
2/06/81	10.0°C (50°F)
3/06/81	11.0°C (52°F)
4/06/81	11.0°C (52°F)
5/14/81	12.0°C (54°F)
6/12/81	12.0°C (54°F)
4/29/82	11.5°C (53°F)

DISCHARGE DATA

Date	
3/06/81 (min.)	1 to 20 gal/min (est.
7/07/81 (max.)	overflow)

SPRING NO. : CL-DC 165

COUNTY : Carroll

NAME : Unknown

OWNER : M. Braxton

LATITUDE : 39°28'18"

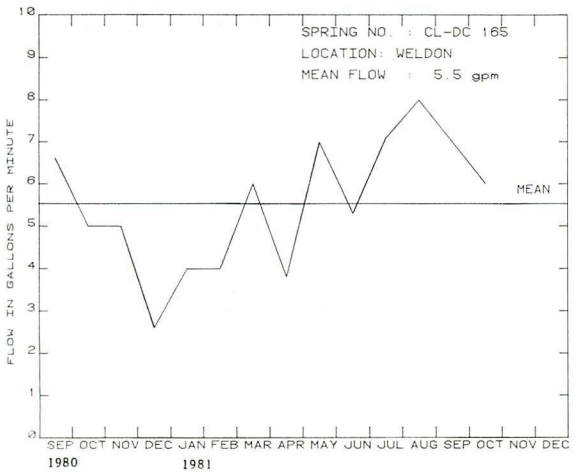
LONGITUDE : 77°06'58"

ELEVATION : 710 feet

AQUIFER : Prettyboy Schist

IMPROVEMENTS : Pipe extending into rock fracture

USE : None



GRAPH SHOWING MONTHLY DISCHARGE

CHEMICAL ANALYSIS (field)

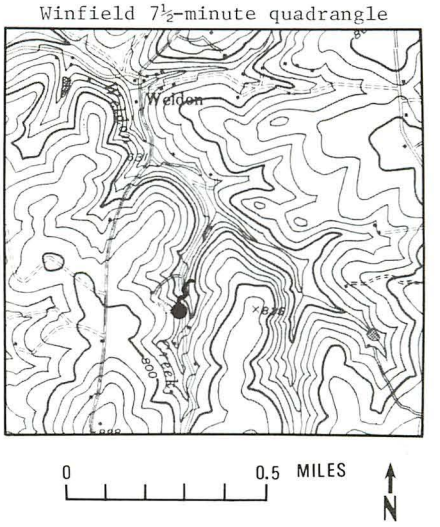
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
9/24/80	6.8	28	8	16
10/17/80	6.7	27	12	16
11/06/80	6.8	26	12	28
12/08/80	6.8	27	10	16

REMARKS

Located on west side of Roop Road south of community of Weldon. Field test for nitrate (N) on 5/28/82 = 0.3 mg/L.

LOCATION MAP

Winfield 7½-minute quadrangle



TEMPERATURE DATA

Range: 9.5°C to 12°C (49°F to 54°F)

Period: 9/24/80 to 9/10/81

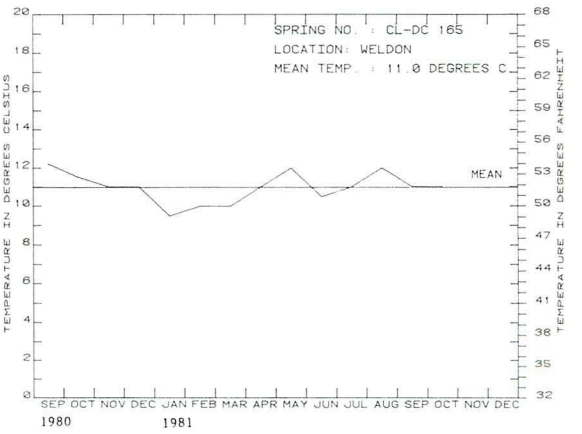
Mean: 11.0°C
(Based on 13 measurements)

DISCHARGE DATA

Range: 2.6 to 8.0 gal/min

Period: 9/24/80 to 8/11/81

Mean: 5.5 gal/min



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : CL-DF 76

COUNTY : Carroll

NAME : Unknown

OWNER : City of Baltimore (Liberty Reservoir property)

LATITUDE : 39°26'28"

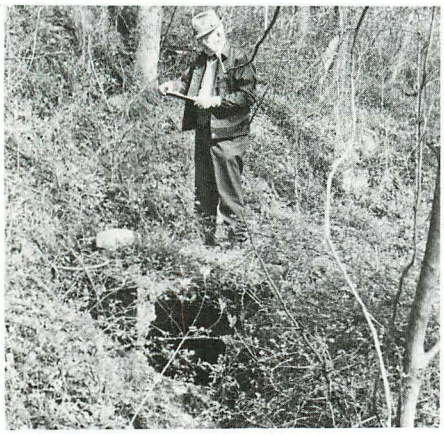
LONGITUDE : 76°53'43"

ELEVATION : 460 feet

AQUIFER : Sykesville Formation

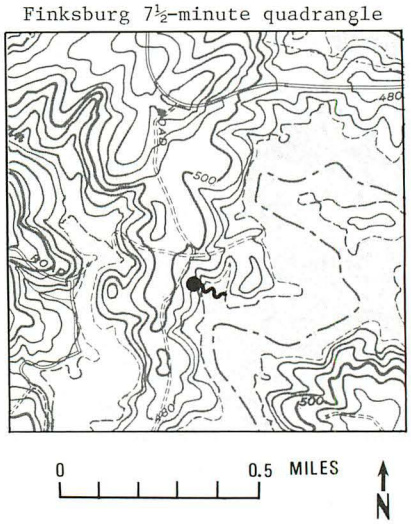
IMPROVEMENTS : Concrete pit or box

USE : None; probably supplied abandoned farmhouse on reservoir property



LOCATION MAP

Finksburg 7½-minute quadrangle



TEMPERATURE DATA

Range: 5.0°C to 12.0°C (41°F to 54°F)

Period: 2/05/81 to 2/02/82

Mean: 9.8°C (Based on 13 measurements)

DISCHARGE DATA

Range: 0.2 to 2.6 gal/min

Period: 2/05/81 to 1/08/82

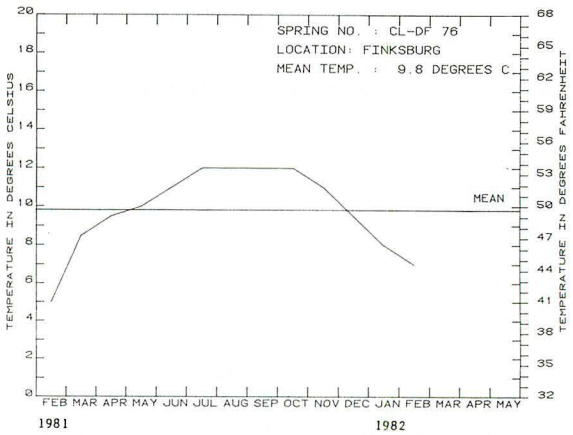
Mean: 0.7 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
2/05/81	6.8	55	12	20
3/05/81	6.7	51	20	24
4/08/81	6.8	52	20	25
6/12/81	6.4	56	20	33

REMARKS

Spring in wooded area on west side of Liberty Reservoir. Field analysis for nitrate (N) = 0.4 mg/L (4/29/82).



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : CL-EF 50

COUNTY : Carroll

NAME : Unknown

OWNER : State of Maryland (Highway Administration)

LATITUDE : 39°21'22"

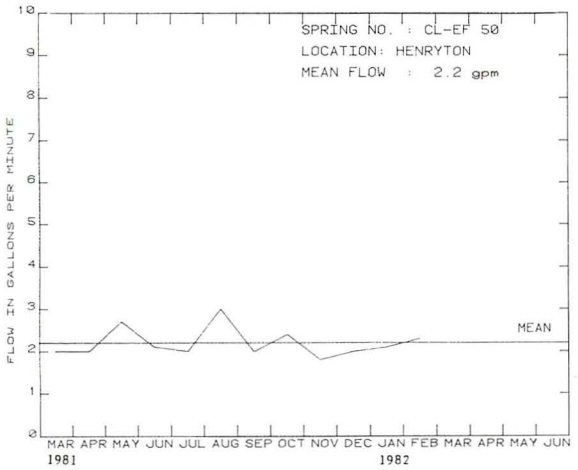
LONGITUDE : 76°54'20"

ELEVATION : 420 feet

AQUIFER : Sykesville (?) Formation

IMPROVEMENTS : Spring box and discharge pipe

USE : None, except for passersby on road



GRAPH SHOWING MONTHLY DISCHARGE

CHEMICAL ANALYSIS (field)

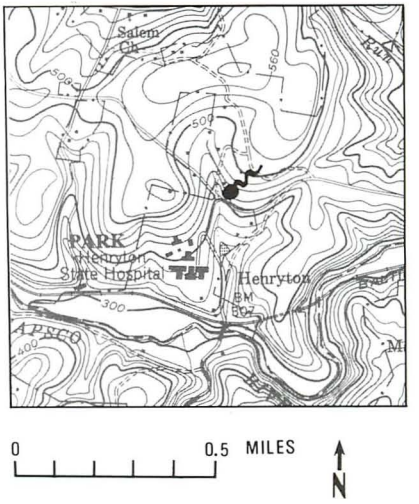
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
3/24/81	6.8	102	57	28
4/08/81	6.7	106	44	24
5/14/81	6.8	101	44	33
6/11/81	6.0	106	41	32

REMARKS

Field nitrate (N) = 0.2 mg/L on 9/16/82.

LOCATION MAP

Sykesville 7½-minute quadrangle



TEMPERATURE DATA

Range: 10.0°C to 13.0°C (50°F to 55°F)

Period: 3/24/81 to 2/02/82

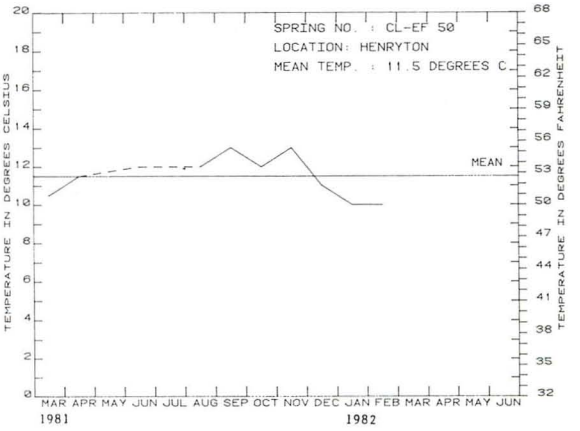
Mean: 11.5°C (Based on 12 measurements)

DISCHARGE DATA

Range: 1.8 to 3.0 gal/min

Period: 3/24/81 to 2/02/82

Mean: 2.2 gal/min



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : CE-AA 11

COUNTY : Cecil

NAME : Unknown

OWNER : Susquehanna Electric Company

LATITUDE : 39°41'03"

LONGITUDE : 76°11'37"

ELEVATION : 140 feet

AQUIFER : Baltimore Gabbro Complex

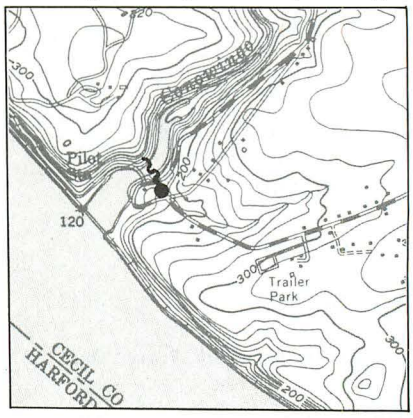
IMPROVEMENTS : Steel discharge pipe and brace

USE : Domestic

PHOTOGRAPH OF SPRING Date: April 1982

LOCATION MAP

Conowingo Dam 7½-minute quadrangle



0 0.5 MILES N

TEMPERATURE DATA

Date	
2/12/81	2.0°C (36°F)
3/03/81	8.0°C (46°F)
4/02/81	12.0°C (54°F)
5/18/81	12.0°C (54°F)
7/01/81	16.0°C (61°F)
4/30/82	12.0°C (54°F)

DISCHARGE DATA

Date	
3/03/81 (max.) 6/03/81 (min.)	0 - 0.5 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
2/12/81	6.8	90	25	24
3/03/81	6.9	88	27	23
4/02/81	6.3	134	46	28
5/18/81	6.6	132	44	40

REMARKS

Measurements intermittent after 6/01/81 because spring ceased flowing; flowed again on 4/30/82. Field test for nitrate (N) = 1.2 mg/L on 4/30/82.

SPRING NO. : CE-AB 23

COUNTY : Cecil

NAME : Unknown

OWNER : Thomas Cook

LATITUDE : 39°42'58"

LONGITUDE : 76°06'39"

ELEVATION : 365 feet

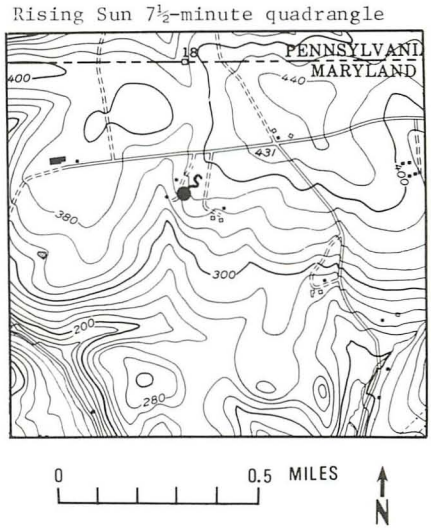
AQUIFER : Baltimore Gabbro Complex

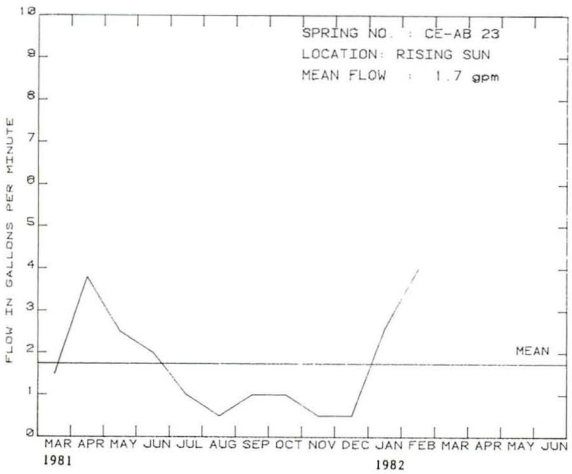
IMPROVEMENTS : Small shed and piping

USE : Domestic

LOCATION MAP

Rising Sun 7½-minute quadrangle





GRAPH SHOWING MONTHLY DISCHARGE

TEMPERATURE DATA

Range: 2.0°C to 13.0°C (36°F to 55°F)

Period: 3/31/81 to 2/01/82

Mean: 10.7°C

DISCHARGE DATA

Range: 0.3 to 4.0 gal/min

Period: 3/31/81 to 2/01/82

Mean: 1.7 gal/min[1]

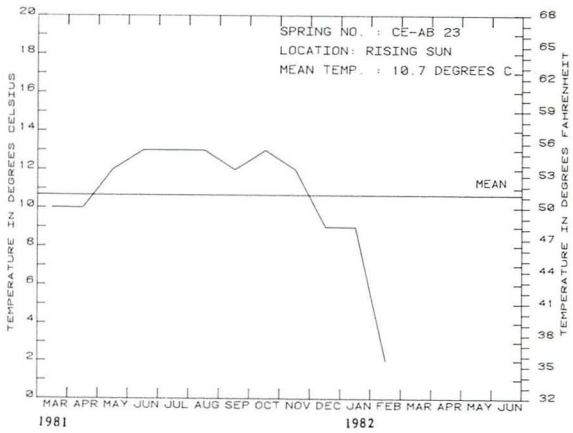
CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
3/31/81	6.5	205	73	42
4/15/81	6.8	215	71	37
5/18/81	6.6	200	72	36
6/03/81	6.8	200	74	39

REMARKS

Field test for nitrate (N) on 2/02/82 = 1.1 mg/L.

[1] Mean discharge based on 12 measurements.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : CE-AD 50

COUNTY : Cecil

NAME : Unknown

OWNER : State of Maryland (Highway Administration)

LATITUDE : 39°42'41"

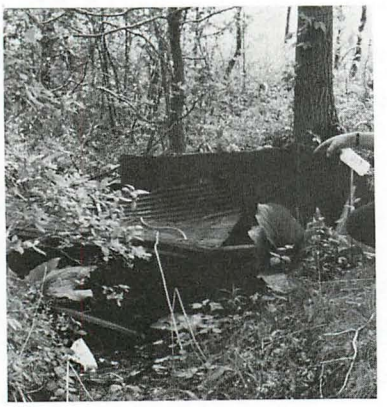
LONGITUDE : 75°58'49"

ELEVATION : 390 feet

AQUIFER : Wissahickon Formation (pelitic schist facies)

IMPROVEMENTS : Formerly had wood cover

USE : None. Spring in state of deterioration in 1981



PHOTOGRAPH OF SPRING Date: May 1982

CHEMICAL ANALYSIS (field)

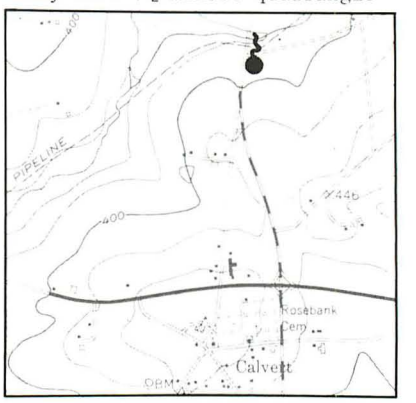
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
3/03/81	6.8	92	28	27
4/03/81	6.1	102	28	28
5/18/81	6.3	97	32	40
6/03/81	6.5	94	36	37

REMARKS

Located south of intersection of Fell Road and Maryland Route 272. Measurements discontinued because of lack of flow.

LOCATION MAP

Bay View 7½-minute quadrangle



0 0.5 MILES N

TEMPERATURE DATA

Date	
3/03/81	9.0°C (48°F)
4/03/81	12.5°C (54°F)
5/18/81	11.0°C (52°F)
6/03/81	13.0°C (55°F)

DISCHARGE DATA

Date	
3/30/81 (max.) 7/01/81 (min.)	0 - 1 gal/min (est.)

SPRING NO. : CE-AE 34

COUNTY : Cecil

NAME : Unknown

OWNER : Leonard Spratt

LATITUDE : 39°40'44"

LONGITUDE : 75°52'37"

ELEVATION : 260 feet

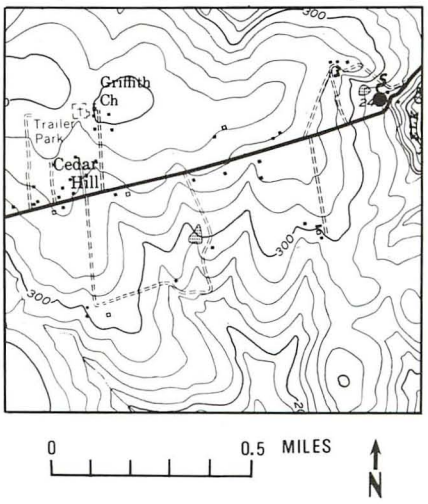
AQUIFER : James Run Formation

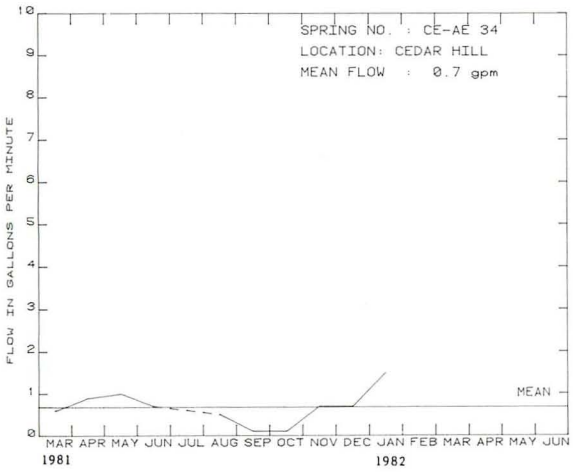
IMPROVEMENTS : Iron discharge pipe from springhouse to road

USE : Supplies turtle tank during summer

LOCATION MAP

Bay View 7½-minute quadrangle





GRAPH SHOWING MONTHLY DISCHARGE

TEMPERATURE DATA

Range: 7.0°C to 18.0°C (45°F to 64°F)

Period: 3/31/81 to 2/01/82

Mean: 12.6°C
(Based on 12 measurements)

DISCHARGE DATA

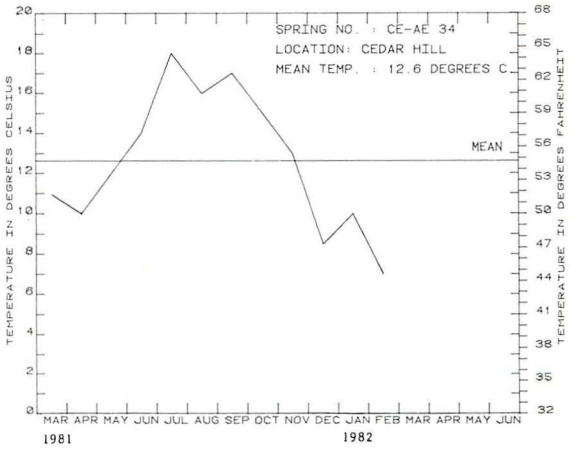
Range: <0.1 to 1.0 gal/min

Period: 3/31/81 to 2/01/82

Mean: 0.7 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
3/31/81	6.9	152	38	26
4/15/81	6.4	152	48	30
5/18/81	6.5	153	50	34
6/03/81	6.6	152	43	36



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : CE-BB 16

COUNTY : Cecil

NAME : Unknown

OWNER : Conrail (formerly Penn Central RR)

LATITUDE : 39°37'08"

LONGITUDE : 76°08'00"

ELEVATION : 40 feet

AQUIFER : Port Deposit Gneiss

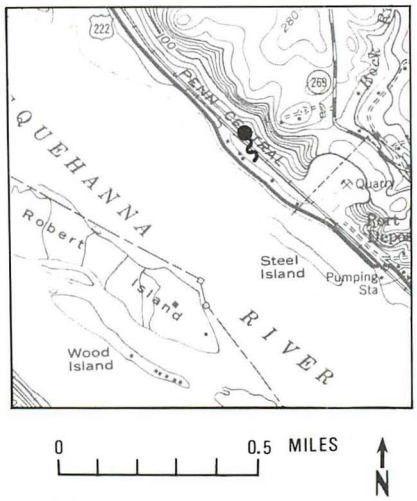
IMPROVEMENTS : Circular concrete tank (or pit) with discharge pipe to storage tank below railroad tracks

USE : May be used by trailer park residents. No apparent signs of use

PHOTOGRAPH OF SPRING Date: April 1982

LOCATION MAP

Aberdeen 7½-minute quadrangle



TEMPERATURE DATA

Range: 8.0°C to 16.0°C (46°F to 61°F)

Period: 4/03/81 to 3/04/82

Mean: 11.5°C (Based on 12 measurements)

DISCHARGE DATA

Range: 0.2 to 1.3 gal/min (meas.)

Period: 4/03/81 to 3/04/82

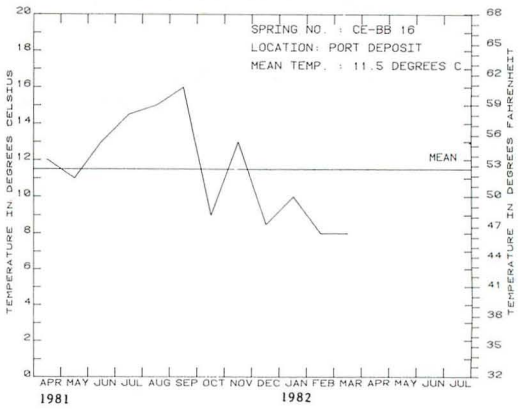
Mean: 0.4 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
4/03/81	6.7	118	21	27
5/18/81	6.6	112	26	31
6/03/81	6.5	106	23	24

REMARKS

Field test for nitrate (N) = 0.5 mg/L on 4/30/82; nitrate (N) = 0.3 on 5/13/82.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : CE-BB 30

COUNTY : Cecil

NAME : Unknown

OWNER : Port Deposit Associates, Inc.

LATITUDE : 39°37'04"

LONGITUDE : 76°07'28"

ELEVATION : 160 feet

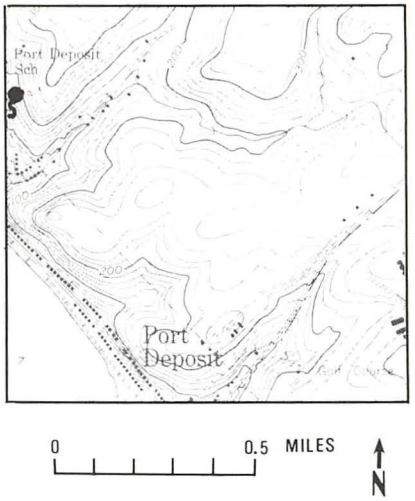
AQUIFER : Port Deposit Gneiss

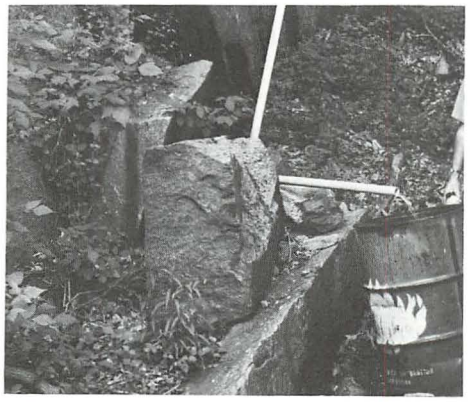
IMPROVEMENTS : Plastic discharge pipe and barrel

USE : Not known. May be used by passersby

LOCATION MAP

Havre de Grace 7½-minute quadrangle





PHOTOGRAPH OF SPRING Date: May 1982

TEMPERATURE DATA

Date	
3/03/81	7.0°C (44°F)
4/03/81	13.0°C (55°F)
6/03/81	14.0°C (57°F)
7/01/81	17.5°C (63°F)
4/30/82	12.0°C (54°F)
10/28/82	11.0°C (51°F)

DISCHARGE DATA

Date	
10/28/82	0.8 gal/min (meas.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
3/03/81	6.9	124	24	40
4/03/81	6.7	130	34	21
6/03/81	6.3	122	25	38
10/28/82	-	113	-	-

REMARKS

Measurements temporarily discontinued as spring was dry on 5/18/81 and again on 8/04/81; spring flowing again on 4/30/82. Field test for nitrate (N) = 1.4 mg/L on 4/30/82; nitrate (N) = 1.7 mg/L on 5/13/82.

SPRING NO. : CE-BE 79

COUNTY : Cecil

NAME : Unknown

OWNER : Louis Slack

LATITUDE : 39°39'18"

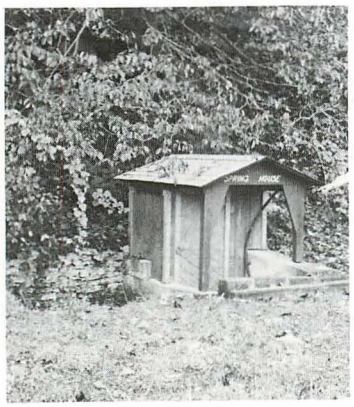
LONGITUDE : 75°52'32"

ELEVATION : 150 feet

AQUIFER : James Run Formation

IMPROVEMENTS : Springhouse with locked door

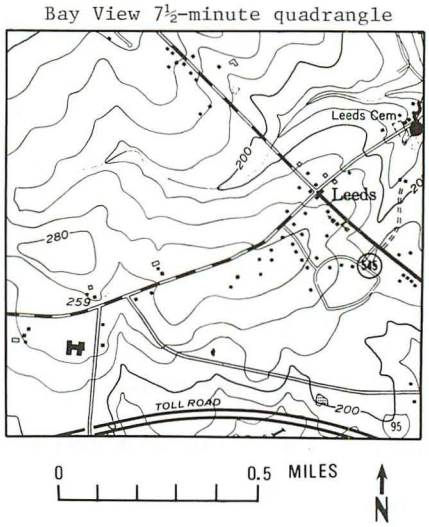
USE : Domestic



PHOTOGRAPH OF SPRING Date: 10/28/82

LOCATION MAP

Bay View 7½-minute quadrangle



TEMPERATURE DATA

Range: 9.0°C to 15.0°C (48°F to 59°F)

Period: 3/31/81 to 2/01/82

Mean: 11.5°C
(Based on 12 measurements)

DISCHARGE DATA

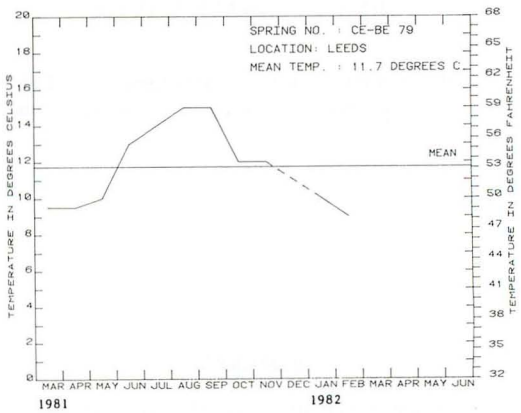
Date	
3/31/81	0.2 gal/min (meas.)
4/15/81	0.9 gal/min (meas.)
9/02/81	0 gal/min (meas.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
3/31/81	6.7	90	22	35
4/15/81	6.3	82	21	50
5/18/81	5.8	80	19	30
6/03/81	6.0	82	22	37

REMARKS

Spring ceased flowing during the fall of 1981; mean flow during period of observation less than 0.5 gal/min. Field test for nitrate (N) = 1.2 mg/L on 4/30/82.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : CE-CC 40

COUNTY : Cecil

NAME : Unknown

OWNER : John R. McMullen

LATITUDE : 39°34'59"

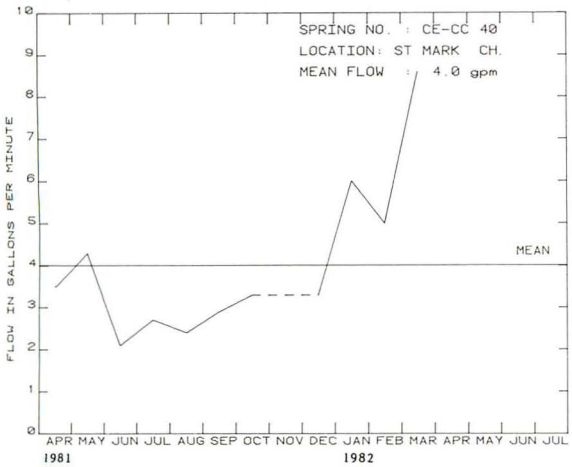
LONGITUDE : 76°04'50"

ELEVATION : 170 feet

AQUIFER : James Run Formation

IMPROVEMENTS : Gray plastic discharge pipe (2 inch); drains to small stream

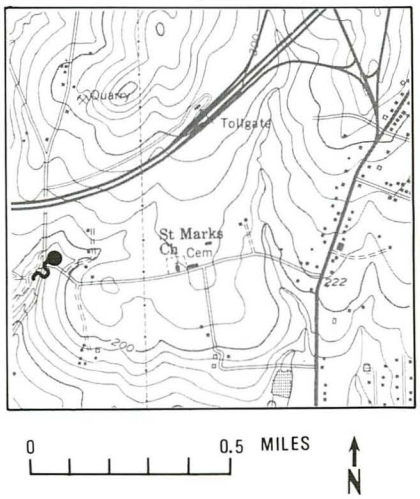
USE : None



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

Havre de Grace 7½-minute quadrangle



TEMPERATURE DATA

Range: 10.0°C to 12.0°C (50°F to 54°F)

Period: 4/03/81 to 3/04/82

Mean: 11.1°C
(Based on 12 measurements)

DISCHARGE DATA

Range: 2.1 to 8.6 gal/min

Period: 4/31/81 to 3/04/82

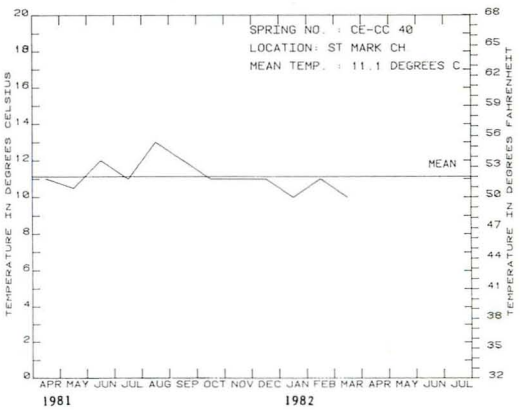
Mean: 4.0 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as CaCO)	Chloride (mg/L)
4/03/81	5.8	156	46	54
5/18/81	5.5	152	40	56
6/03/81	5.4	152	43	66

REMARKS

Flow and temperature measurements available for this spring for several years beginning in 1958. See files of U.S.G.S. in Towson, Md., for these records.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : FR-AE 39

COUNTY : Frederick

NAME : Unknown

OWNER : R. B. Derlinger

LATITUDE : 39°41'45"

LONGITUDE : 77°27'30"

ELEVATION : 880 feet

AQUIFER : Catoctin Formation

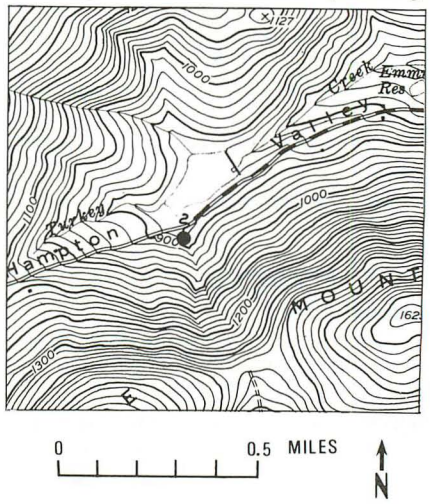
IMPROVEMENTS : Small concrete box on south side of Hampton Valley Road

USE : None, except for passersby

PHOTOGRAPH OF SPRING Date: March 1982

LOCATION MAP

Blue Ridge Summit 7½-minute quadrangle



TEMPERATURE DATA

Range: 5.0°C to 15.5°C (41°F to 60°F)

Period: 11/13/80 to 11/17/81

Mean: 10.2°C
(Based on 13 measurements)

DISCHARGE DATA

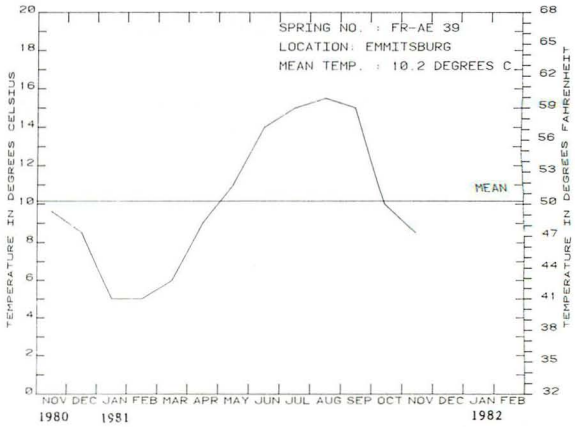
Date	
5/11/82 11/17/81	5 - 75 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
11/13/80	6.9	34	11	18
12/12/80	6.6	32	10	20
1/14/81	6.8	34	11	20
2/26/81	6.9	35	10	26

REMARKS

Field test for nitrate (N) = 0.0 mg/L on 5/11/82; original record compiled by G. Meyer (1956, table 26, p. 172).



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : FR-BD 54

COUNTY : Frederick

NAME : Unknown

OWNER : Town of Thurmont

LATITUDE : 39°36'23"

LONGITUDE : 77°26'00"

ELEVATION : 740 feet

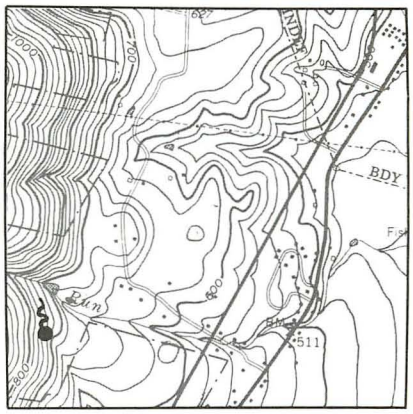
AQUIFER : Weverton Quartzite

IMPROVEMENTS : Spring collecting box and collecting pipe to concrete reservoir

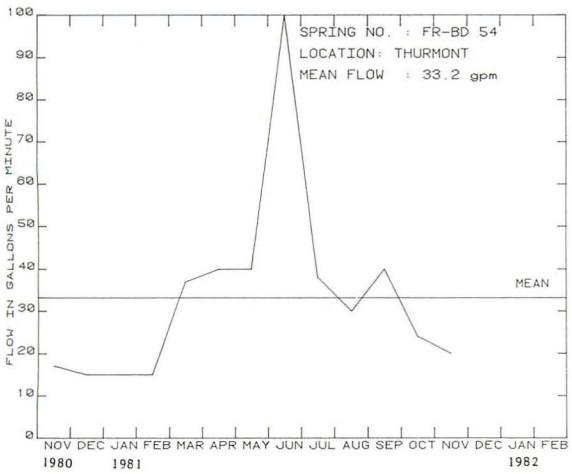
USE : Municipal supply

LOCATION MAP

Catoctin Furnace 7½-minute quadrangle



0 0.5 MILES N



GRAPH SHOWING MONTHLY DISCHARGE

TEMPERATURE DATA

Range: 2.5°C to 15°C (36°F to 59°F)

Period: 11/13/80 to 11/17/81

Mean: 9.9°C
(Based on 13 measurements)

DISCHARGE DATA

Range: 15 to 100 gal/min

Period: 11/13/80 to 11/17/81

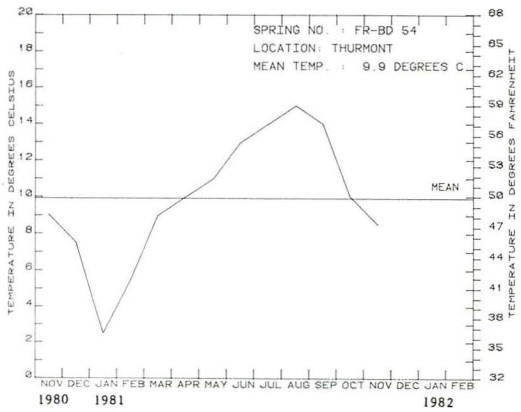
Mean: 33 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
11/13/80	6.6	21	0	20
1/14/81	6.8	20	12	28
3/13/81	6.8	24	8	24
5/22/81	7.0	22	11	30
6/08/82	5.8	-	-	-

REMARKS

Group of three nearby springs feeds to reservoir located an estimated 700 feet to the north. Reservoir also supplied by a small surface stream.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : FR-CB 7

COUNTY : Frederick

NAME : Myersville Springs

OWNER : Town of Myersville

LATITUDE : 39°32'50"

LONGITUDE : 77°35'23"

ELEVATION : 1,220 feet

AQUIFER : Catoctin Formation

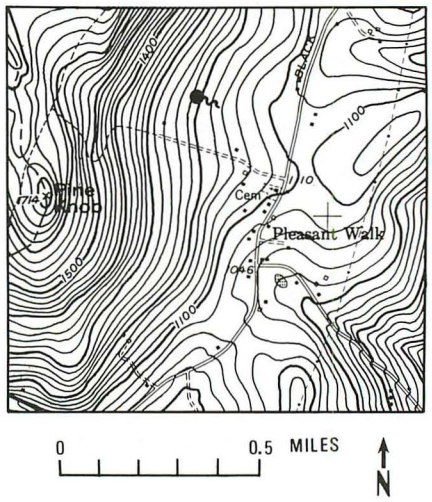
IMPROVEMENTS : Concrete spring pits with covers; pipeline to concrete overflow box (see photo), and pipeline to the town at elevation 600-700 ft, about 2.5 miles SE

USE : Town supply

PHOTOGRAPH OF SPRING Date: April 1982

LOCATION MAP

Myersville 7½-minute quadrangle



TEMPERATURE DATA

Date		
4/13/82	5.3°C	(41°F)
5/11/82	11°C	(52°F)
6/08/82	12°C	(54°F)
7/21/82	13°C	(55°F)
11/19/82	9°C	(48°F)

DISCHARGE DATA

Date	
4/13/82	75 - 100 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)	Nitrate (N) mg/L
4/13/82	5.7	88	-	9.0	0.0
5/11/82	6.8	22	-	-	0.0
6/08/82	5.8	-	-	-	-
7/21/82	6.2	-	-	-	-
11/19/82	6.5	25	-	23	-

REMARKS

Flow not readily measurable as part of it goes via pipeline to the town of Myersville. Mr. Gaver, Water Plant Manager, estimated the town's use at 75,000 to 78,000 gal/d during March 1982. These springs are on the east side of South Mountain and west of Black Rock Road.

SPRING NO. : FR-CD 38

COUNTY : Frederick

NAME : Fish Hatchery Spring

OWNER : State of Maryland
(Maryland Fisheries Administration)

LATITUDE : 39°32'18"

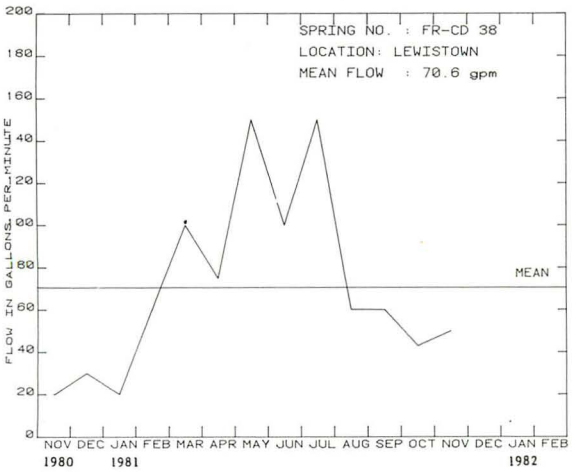
LONGITUDE : 77°27'10"

ELEVATION : 820 feet

AQUIFER : Weverton Quartzite

IMPROVEMENTS : Concrete block shed with roof and pipeline down mountain to collecting basin near road

USE : Potable use at work center. Formerly used to supply fish hatchery



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

Catoctin Furnace 7½-minute quadrangle

0 0.5 MILES N

TEMPERATURE DATA

Range: 9.0°C to 16.0°C (48°F to 61°F)

Period: 11/13/80 to 11/17/81

Mean: 11.9°C
(Based on 13 measurements)

DISCHARGE DATA

Range: 20 to 150 gal/min

Period: 11/13/80 to 10/18/81

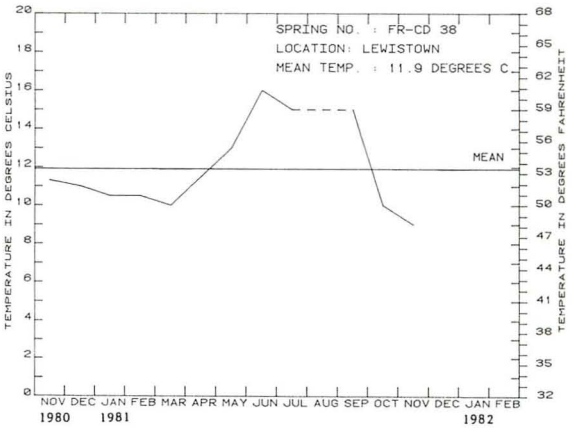
Mean: 71 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
11/13/80	6.7	19	0	21
12/12/80	6.5	20	0	28
1/14/81	5.9	20	10	29
2/17/81	6.1	18	6	25

REMARKS

Spring located on wooded mountainside above building and facilities. Field test for nitrate (N) = 0.0 mg/L on 5/13/82.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : FR-DD 75

COUNTY : Frederick

NAME : "Spout" Spring

OWNER : State of Maryland (Highway Administration)

LATITUDE : 39°29'30"

LONGITUDE : 77°28'27"

ELEVATION : 760 feet

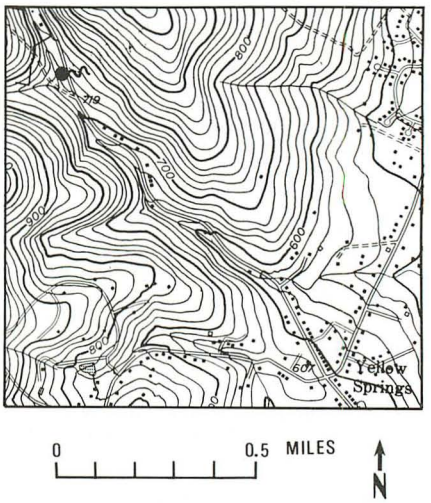
AQUIFER : Weverton Quartzite

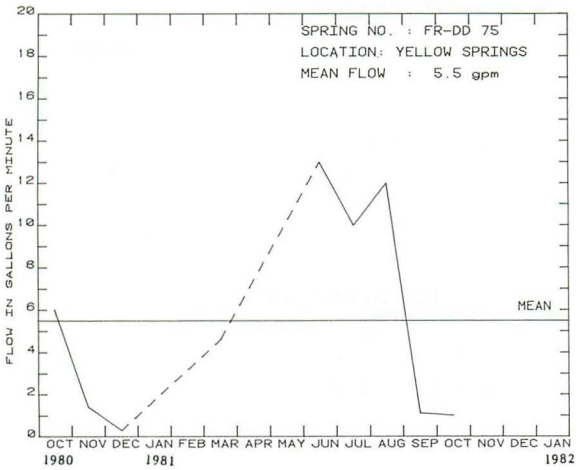
IMPROVEMENTS : Discharge pipe from small reservoir pit. During high flows, some leakage takes place along spring line

USE : None, except from passersby

LOCATION MAP

Frederick 7½-minute quadrangle





GRAPH SHOWING MONTHLY DISCHARGE

TEMPERATURE DATA

Range: 5.0°C to 14.0°C (41°F to 57°F)

Period: 10/08/80 to 9/17/81

Mean: 11.2°C (Based on 13 measurements)

DISCHARGE DATA

Range: 0 to 13.6 gal/min

Period: 10/08/80 to 9/17/81

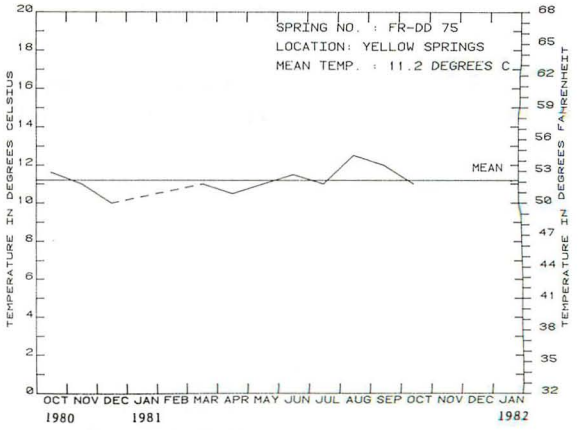
Mean: 5.5 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
11/20/80	6.6	18	0	20
12/19/80	6.9	18	0	20
3/13/81	6.5	22	9	22
5/22/81	6.7	30	11	18

REMARKS

Located along Hamburg Road, 1.2 miles north of community of Yellow Springs.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : FR-DD 78

COUNTY : Frederick

NAME : Bootjack Spring

OWNER : State of Maryland (Gambrills State Park)

LATITUDE : 39°28'22"

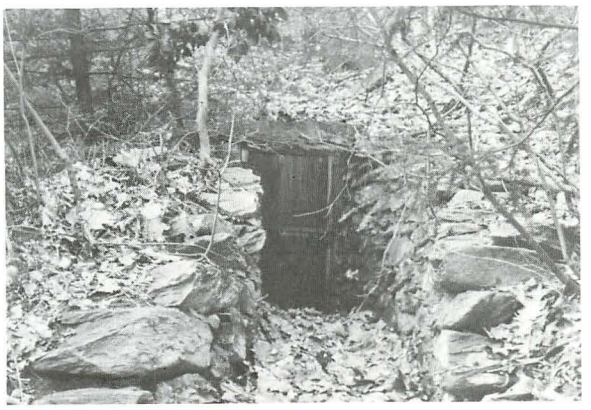
LONGITUDE : 77°29'29"

ELEVATION : 1,400 feet

AQUIFER : Weverton Quartzite

IMPROVEMENTS : Spring issues from tunnel below crest of hill. Access by old unimproved road

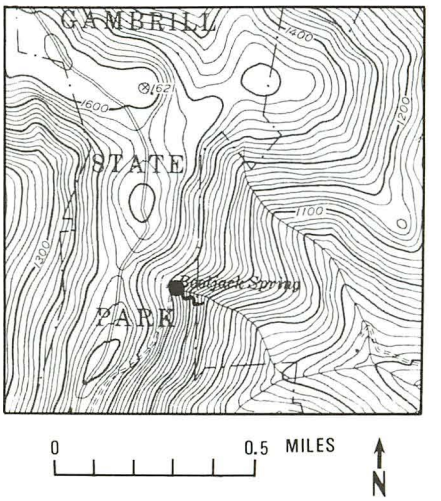
USE : This spring and one nearby well supply Park office and garage at the top of the mountain



PHOTOGRAPH OF SPRING Date: March 1982

LOCATION MAP

Frederick 7½-minute quadrangle



TEMPERATURE DATA

Range: 7.0°C to 13.0°C (45°F to 55°F)

Period: 10/08/80 to 9/17/81

Mean: 10.3°C (Based on 13 measurements)

DISCHARGE DATA

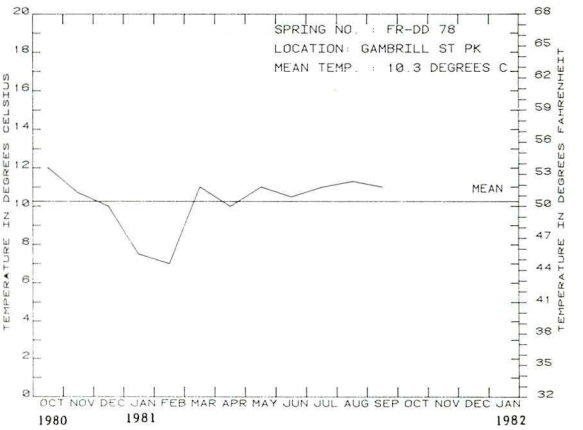
Date	
5/26/81 (max.) 8/10/81 (min.)	<2 - 5 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/08/80	5.7	32	-	-
11/20/80	5.8	30	0	18
12/19/80	6.6	26	0	31
1/19/81	-	24	12	24

REMARKS

Spring has wooden door on concrete frame at outer end of tunnel. Water flow originates back in old tunnel in hillside.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : FR-DD 178

COUNTY : Frederick

NAME : Unknown

OWNER : Frederick County (Monteview Property)

LATITUDE : 39°25'52"

LONGITUDE : 77°26'22"

ELEVATION : 315 feet

AQUIFER : Frederick Limestone

IMPROVEMENTS : Two springhouses, a spring collecting pit, and a discharge pipe for overflow

USE : None. Formerly used for hospital supply. Trout observed under covered shelter

PHOTOGRAPH OF SPRING Date: February 1982

CHEMICAL ANALYSIS (field)

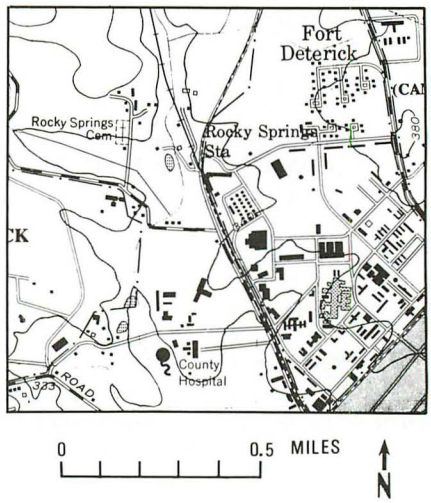
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/21/80	7.0	455	164	44
11/20/80	7.0	450	166	32
12/19/81	6.9	480	206	42
2/17/81	6.9	500	190	40

REMARKS

Spring flow measured a short distance downstream from main spring pit.

LOCATION MAP

Frederick 7½-minute quadrangle



TEMPERATURE DATA

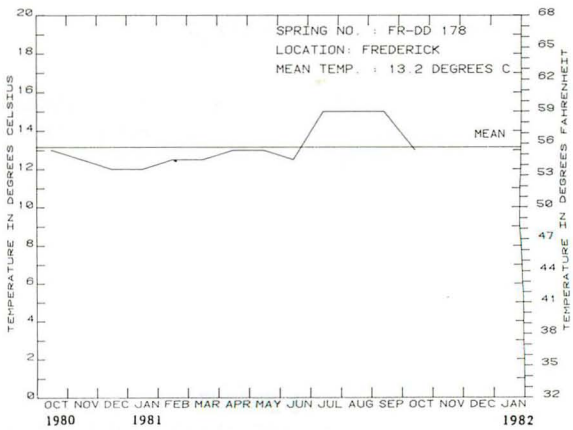
Range: 12°C to 15°C (54°F to 59°F)

Period: 10/21/80 to 10/20/81

Mean: 13.2°C (Based on 13 measurements)

DISCHARGE DATA

Date	
4/21/81	270 gal/min (meas.) ($0.6\ ft^3/s$)



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : FR-DE 42

COUNTY : Frederick

NAME : Fountain Rock Spring

OWNER : Thomas Denike (lessee)

LATITUDE : 39°28'31"

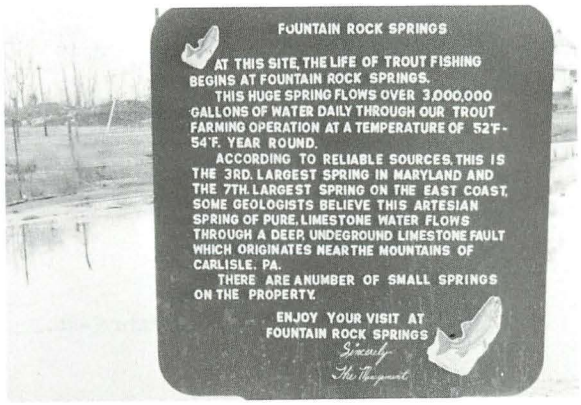
LONGITUDE : 77°22'10"

ELEVATION : 285 feet

AQUIFER : Grove Limestone

IMPROVEMENTS : Concrete pit, piping system, and several basins

USE : Used as a trout farm and fishponds



PHOTOGRAPH OF SPRING Date: March 1982

CHEMICAL ANALYSIS (field)

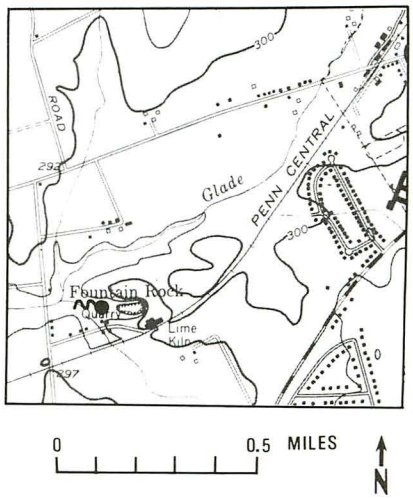
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/21/80	6.9	530	200	36
11/21/80	7.2	540	200	32
2/17/81	6.9	525	220	31
5/22/81	7.0	500	218	37

REMARKS

Flow measurements made in small stream, just west of trout farm. Entire flow of stream is from spring FR-DE 42. Field test for nitrate (N) = 1.9 mg/L on 6/03/82.

LOCATION MAP

Walkersville 7½-minute quadrangle



TEMPERATURE DATA

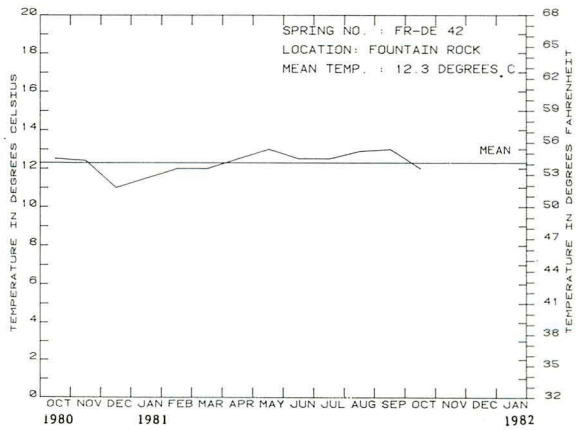
Range: 11.0°C to 13.0°C (52°F to 55°F)

Period: 10/21/80 to 10/20/81

Mean: 12.3°C
(Based on 13 measurements)

DISCHARGE DATA

Date	
4/09/59	1,427 gal/min (meas.) (3.18 ft^3/s)
10/31/80	1,020 gal/min (meas.) (2.27 ft^3/s)
4/21/81	1,380 gal/min (meas.) (3.07 ft^3/s)



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : FR-DF 25

COUNTY : Frederick

NAME : Unknown

OWNER : Eaglehead Country Club, Inc.

LATITUDE : 39°29'37"

LONGITUDE : 77°16'20"

ELEVATION : 400 feet

AQUIFER : Libertytown Metarhyolite

IMPROVEMENTS : Small fieldstone house

USE : None. Formerly supplied old house at site

PHOTOGRAPH OF SPRING Date: 1982

CHEMICAL ANALYSIS (field)

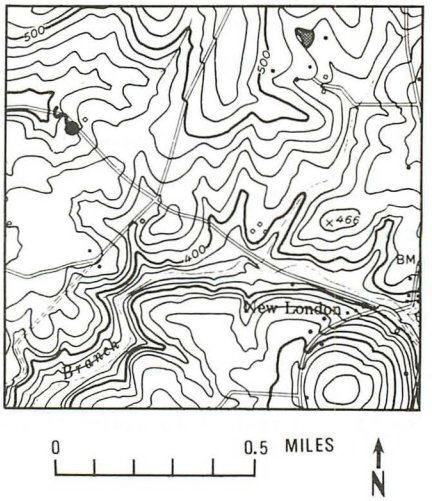
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
4/16/81	6.5	155	62	25
5/22/81	6.8	152	52	31
6/16/81	6.9	156	64	40

REMARKS

Field test for nitrate (N) = 0.9 mg/L on 12/18/81; nitrate (N) = 1.1 mg/L on 4/13/82.

LOCATION MAP

Walkersville 7½-minute quadrangle



TEMPERATURE DATA

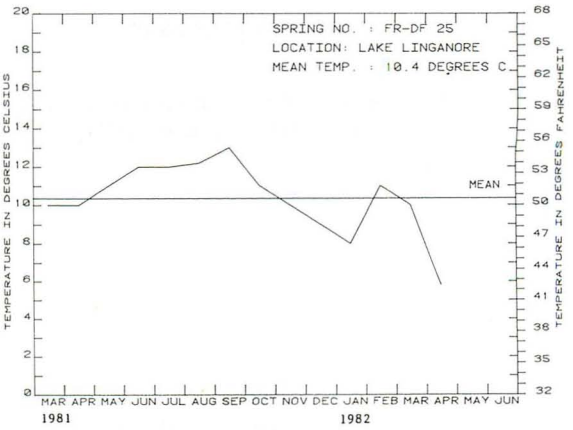
Range: 8.0°C to 13.0°C (46°F to 55°F)

Period: 3/24/81 to 3/18/82

Mean: 10.4°C
(Based on 13 measurements)

DISCHARGE DATA

Date	
4/16/81 (max.) 8/10/81 (min.)	<1 - 5 gal/min (est.)



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : FR-FB 12

COUNTY : Frederick

NAME : Unknown

OWNER : City of Brunswick

LATITUDE : 39°18'46"

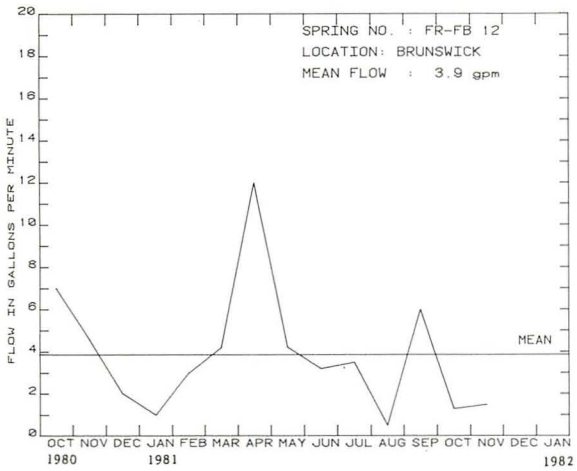
LONGITUDE : 77°37'05"

ELEVATION : 300 feet

AQUIFER : Granodiorite and biotite granite gneiss

IMPROVEMENTS : Steel discharge pipe into ditch on east side of road

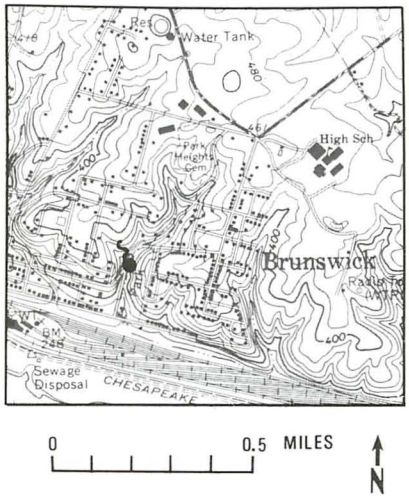
USE : None, except for passersby. (This spring is not used as a public water supply.)



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

Point of Rocks 7½-minute quadrangle



TEMPERATURE DATA

Range: 11.0°C to 15.6°C (52°F to 59.6°F)

Period: 10/21/80 to 10/20/81

Mean: 12.5°C
(Based on 14 measurements)

DISCHARGE DATA

Range: 0.5 to 12 gal/min

Period: 10/21/80 to 11/17/81

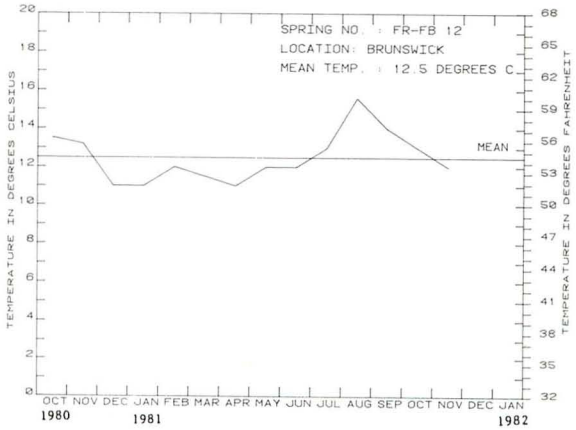
Mean: 3.9 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/21/80	6.9	372	120	44
12/19/80	6.9	343	110	45
2/17/81	6.9	335	94	47

REMARKS

This spring is adjacent to "Old Gum Spring", a historic spring in Frederick County. Field test for nitrate (N) = 2.0 mg/L on 4/29/82. Earlier measurements available from files of U.S. Geological Survey, in Towson, Md.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : FR-FC 22

COUNTY : Frederick

NAME : Kanawha Spring

OWNER : U.S. Dept. of the Interior (National Park Service)

LATITUDE : 39°16'14"

LONGITUDE : 77°31'48"

ELEVATION : 230 feet

AQUIFER : New Oxford Formation (basal conglomerate)

IMPROVEMENTS : Deep pit (hole) surrounded by heavy screen fence. Discharge ditch at south side carries flow to Potomac River

USE : None, although spring was water source for C & O Canal mules in 19th Century

PHOTOGRAPH OF SPRING Date: March 1982

CHEMICAL ANALYSIS (field)

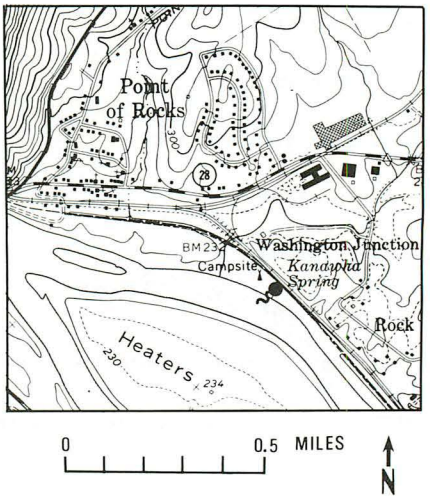
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/21/80	7.1	460	172	16
11/20/80	7.2	460	196	20
2/17/81	7.4	420	188	22
3/13/81	7.1	430	200	36

REMARKS

May be located along contact or fault plane. Field test for nitrate (N) = 1.0 mg/L on 4/29/82.

LOCATION MAP

Point of Rocks 7½-minute quadrangle



TEMPERATURE DATA

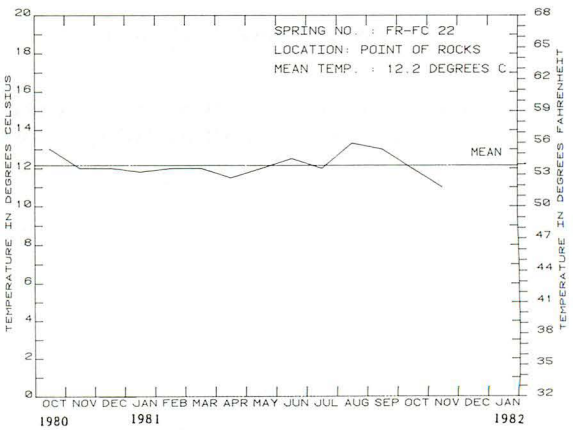
Range: 11.5°C to 13°C (52.7°F to 55.4°F)

Period: 10/21/80 to 9/17/81

Mean: 12.2°C (Based on 12 measurements)

DISCHARGE DATA

Date	
4/22/81	350 gal/min (meas.) (0.78 ft^3/s)
3/18/69	300 gal/min (meas.) (0.67 ft^3/s)



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : FR-FD 55

COUNTY : Frederick

NAME : Lily Pons Spring

OWNER : George Thomas

LATITUDE : 39°16'44"

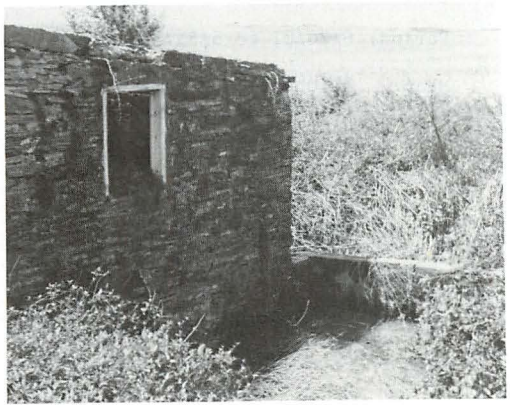
LONGITUDE : 77°27'55"

ELEVATION : 280 feet

AQUIFER : Frederick Limestone

IMPROVEMENTS : Concrete wall around spring at northwest corner of small shed or garage

USE : None during 1981-82



PHOTOGRAPH OF SPRING Date: May 1982

CHEMICAL ANALYSIS (field)

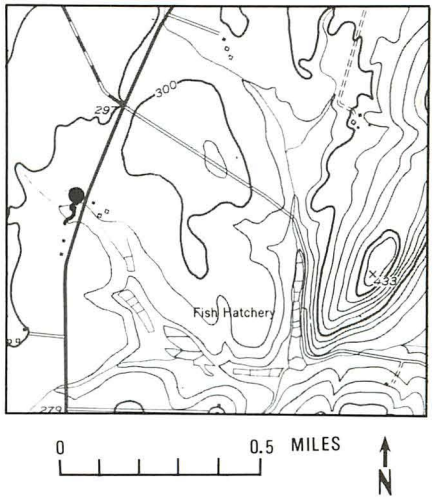
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
12/16/81	6.9	600	265	58

REMARKS

Flow disperses into several channels after leaving spring box. Flow estimated near road culvert below spring. Field test for nitrate (N) = 2.8 mg/L on 12/16/81; = 3.0 mg/L on 4/29/82; = 2.7 mg/L on 6/03/82.

LOCATION MAP

Buckeystown 7½-minute quadrangle



TEMPERATURE DATA

Date	
3/19/69	12.2°C (54°F)
7/28/81	13.0°C (55.4°F)
12/16/81	7.0°C (44.6°F)
4/29/82	13.0°C (55.4°F)
6/03/82	13.0°C (55.4°F)

DISCHARGE DATA

Date	
6/04/82	200 to 300 gal/min

SPRING NO. : GA-BB 3

COUNTY : Garrett

NAME : Unknown

OWNER : State of Maryland (Highway Administration)

LATITUDE : 39°39'33"

LONGITUDE : 79°22'11"

ELEVATION : 1,760 feet

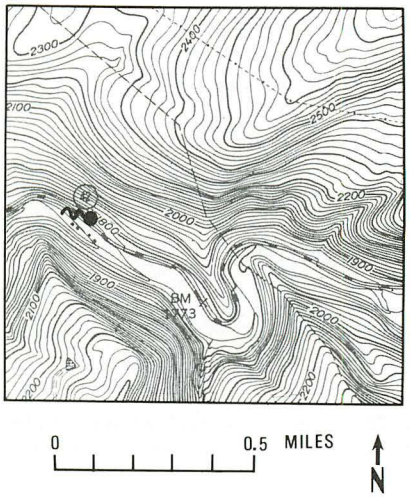
AQUIFER : Greenbrier Formation

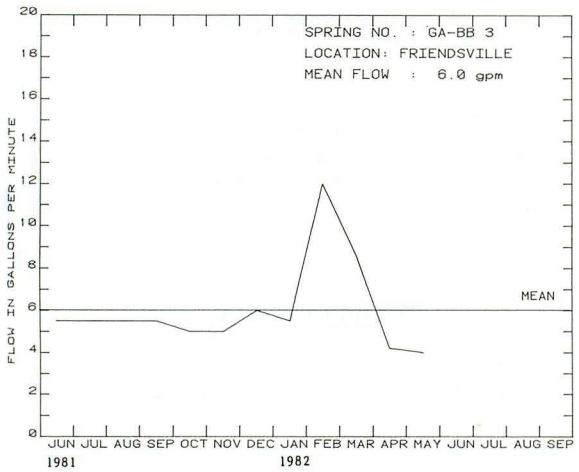
IMPROVEMENTS : Box and plastic discharge pipe

USE : None, except for passersby

LOCATION MAP

Accident 7½-minute quadrangle





GRAPH SHOWING MONTHLY DISCHARGE

TEMPERATURE DATA

Range: 9.5°C to 10.8°C (49°F to 51°F)

Period: 6/26/81 to 5/31/82

Mean: 10°C (Based on 12 measurements)

DISCHARGE DATA

Range: 4.0 to 12 gal/min

Period: 6/26/81 to 5/31/82

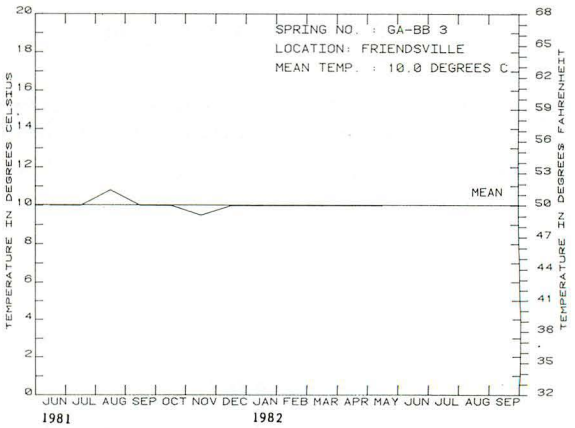
Mean: 6.0 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
6/26/81	7.3	76	30	31
7/29/81	7.0	97	-	-
8/14/81	6.3	71	-	-
9/24/81	6.8	84	-	-
6/08/82	6.8	-	-	-

REMARKS

Located on Maryland Route 42, 3 miles northwest of Accident.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : GA-BD 38

COUNTY : Garrett

NAME : Unknown

OWNER : State of Maryland (Highway Administration)

LATITUDE : 39°35'25"

LONGITUDE : 79°13'06"

ELEVATION : 2,500 feet

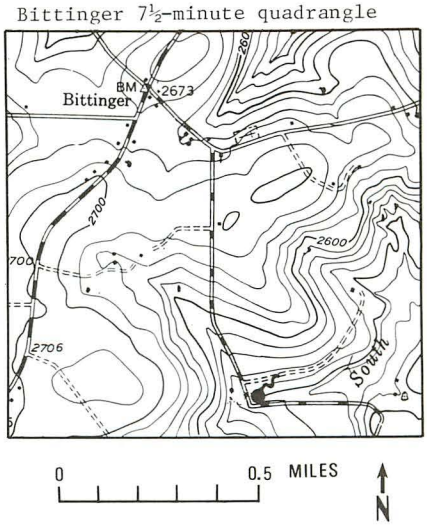
AQUIFER : Conemaugh Formation

IMPROVEMENTS : None

USE : None

LOCATION MAP

Bittinger 7½-minute quadrangle



PHOTOGRAPH OF SPRING Date: June 1982

TEMPERATURE DATA

Range: 4.5°C to 11.0°C (39°F to 52°F)

Period: 10/16/80 to 9/24/81

Mean: 8.0°C (Based on 10 measurements)

DISCHARGE DATA

Range: 1 to 2 gal/min (est.)

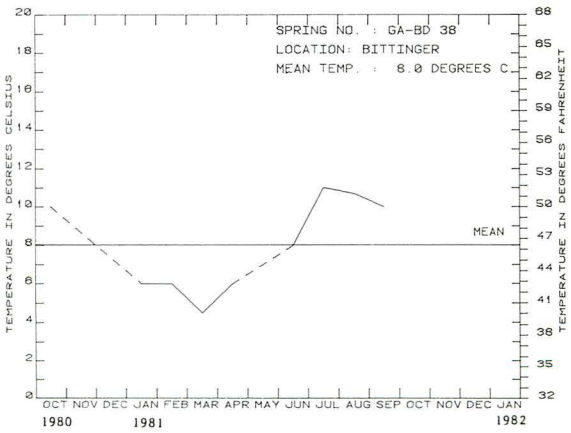
Period: 10/16/80 to 9/24/81

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/16/80	6.5	97	32	20
1/13/81	7.0	82	33	28
2/18/81	7.0	100	38	21
3/19/81	6.8	73	28	29

REMARKS

Located along Frank Brenneman Road approximately 0.9 miles south of Bittinger.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : GA-BD 88

COUNTY : Garrett

NAME : Unknown

OWNER : State of Maryland (Highway Administration)

LATITUDE : 39°39'15"

LONGITUDE : 79°11'11"

ELEVATION : 2,320 feet

AQUIFER : Conemaugh Formation

IMPROVEMENTS : Discharge pipe from hillside

USE : None

PHOTOGRAPH OF SPRING Date: Summer 1981

CHEMICAL ANALYSIS (field)

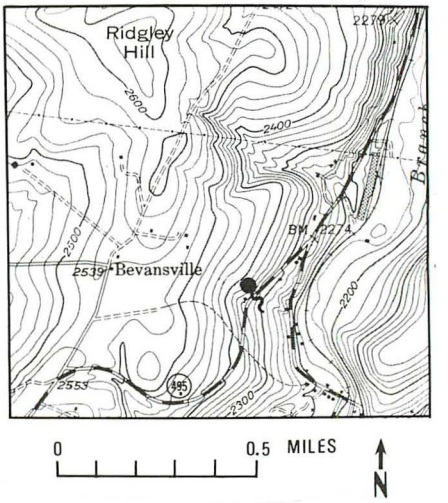
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
2/19/81	7.5	78	20	27
3/19/81	7.2	78	10	25
4/24/81	7.1	79	28	26
5/13/81	6.9	86	36	33

REMARKS

Located approximately 3.5 miles south of Grantsville on west side of Maryland Route 495.

LOCATION MAP

Grantsville 7½-minute quadrangle



TEMPERATURE DATA

Range: 5.0°C to 15.3°C (41°F to 59°F)

Period: 2/19/81 to 1/27/82

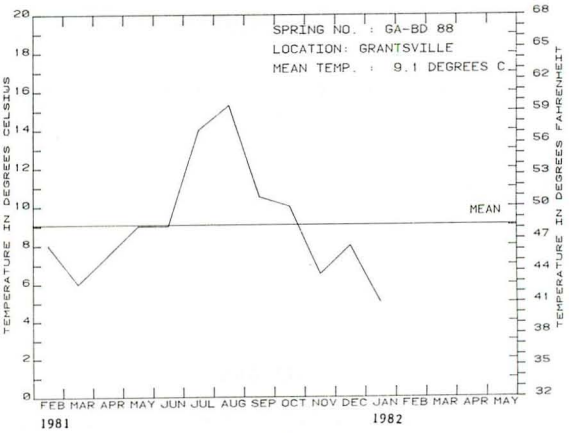
Mean: 9.1°C (Based on 12 measurements)

DISCHARGE DATA

Range: 0.1 to 1.2 gal/min

Period: 2/19/81 to 1/27/82

Mean: 0.6 gal/min



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : GA-CD 1

COUNTY : Garrett

NAME : Unknown

OWNER : Harvey Bittinger

LATITUDE : 39°33'59"

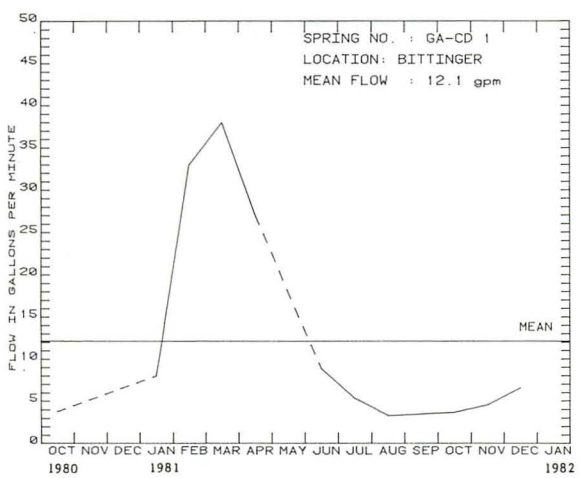
LONGITUDE : 79°12'29"

ELEVATION : 2,480 feet

AQUIFER : Greenbrier (?) Formation

IMPROVEMENTS : Spring box and discharge pipe

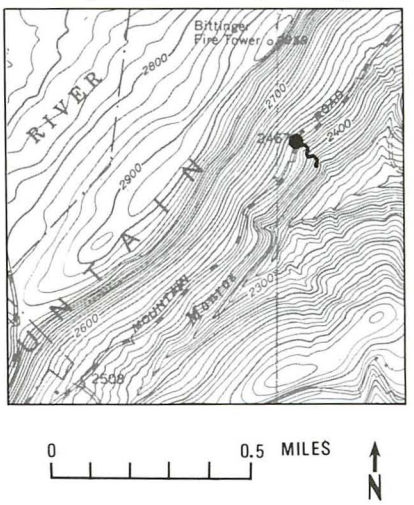
USE : Domestic--supplies two homes



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

Bittinger 7½-minute quadrangle



0 0.5 MILES N

TEMPERATURE DATA

Range: 8.0°C to 11.0°C (46°F to 52°F)

Period: 10/15/80 to 11/25/81

Mean: 9.1°C
(Based on 13 measurements)

DISCHARGE DATA

Range: 3.3 to 37 gal/min

Period: 10/15/80 to 11/25/81

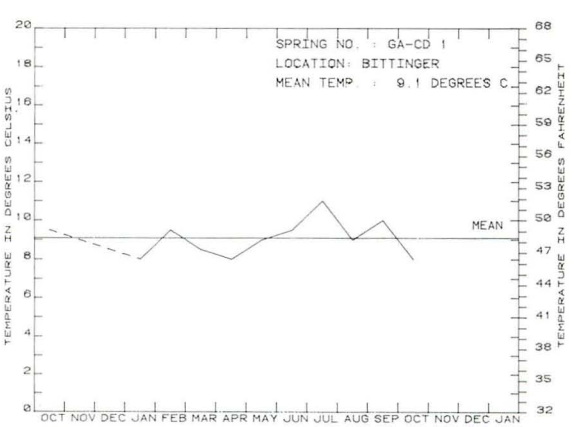
Mean: 12 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/15/80	6.4	127	43	14
1/13/81	7.0	98	40	21
2/18/81	6.8	83	32	21
3/19/81	6.8	85	37	36
6/09/81	6.1	-	-	-

REMARKS

During February, March, and April 1981, flow was greater than indicated because of leakage from walls of spring box.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : GA-DD 5

COUNTY : Garrett

NAME : Unknown

OWNER : State of Maryland (Highway Administration)

LATITUDE : 39°26'13"

LONGITUDE : 79°14'48"

ELEVATION : 2,870 feet

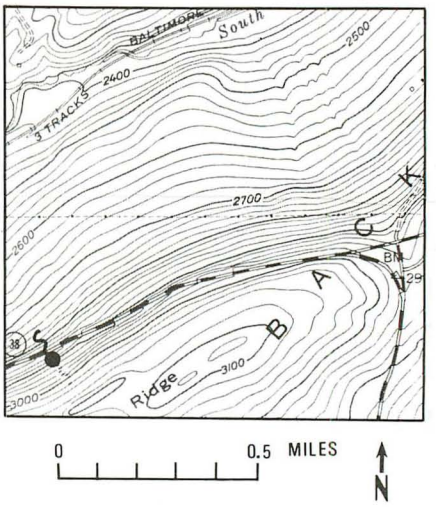
AQUIFER : Mauch Chunk Formation

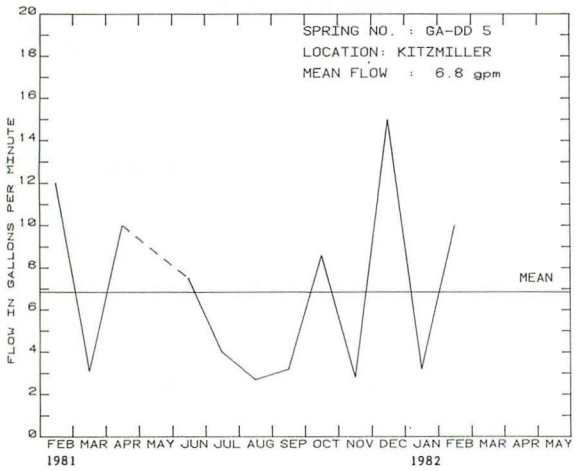
IMPROVEMENTS : Discharge pipe and trough

USE : None

LOCATION MAP

Kitzmiller 7½-minute quadrangle





GRAPH SHOWING MONTHLY DISCHARGE

TEMPERATURE DATA

Range: 3.5°C to 11.4°C (38°F to 52°F)

Period: 2/24/81 to 1/28/82

Mean: 6.8°C (Based on 13 measurements)

DISCHARGE DATA

Range: 2.7 to 15 gal/min

Period: 2/24/81 to 2/26/82

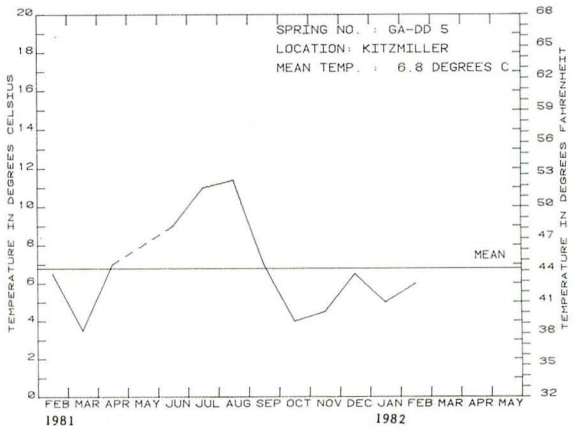
Mean: 6.8 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
2/24/81	7.1	43	12	22
3/19/81	6.9	40	26	37
4/24/81	7.0	39	14	35
6/26/81	7.3	38	14	36
6/08/82	6.0	-	-	-

REMARKS

Spring on south side of Maryland Route 38, approximately 1.7 miles southwest of Swanton.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : GA-EB 33

COUNTY : Garrett

NAME : Unknown

OWNER : Mountain Lake Water Company

LATITUDE : 39°21'56"

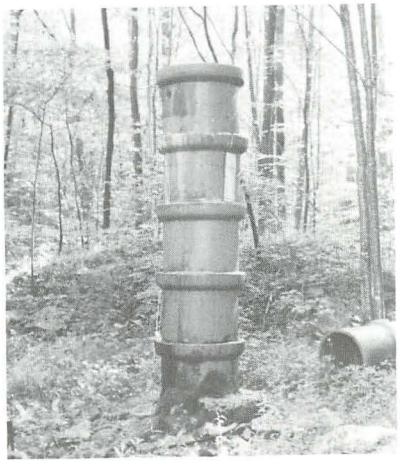
LONGITUDE : 79°21'13"

ELEVATION : 2,600 feet

AQUIFER : Pocono Formation

IMPROVEMENTS : Collection box with pipeline from 6(?) springs

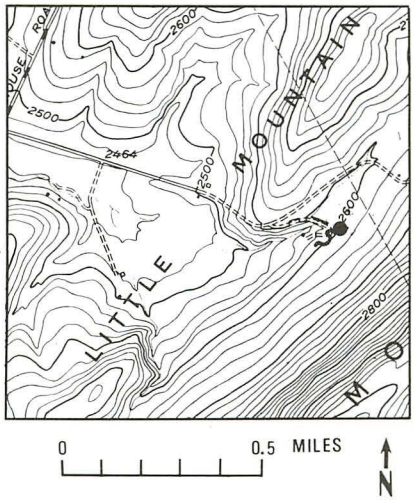
USE : Supplies towns of Mountain Lake Park and Loch Lynn



PHOTOGRAPH OF SPRING Date: June 1982

LOCATION MAP

Gorman 7½-minute quadrangle



TEMPERATURE DATA

Date	
10/29/81	11.0°C (52°F)
6/08/82	10.0°C (50°F)

DISCHARGE DATA

Date	
10/29/81	40 gal/min (meas.) (0.09 ft^3/s)

REMARKS

Field test: pH = 6.5 on 6/08/82. Spring near base of west slope of Backbone Mountain approximately 0.5 mile west of Kelso Gap.

SPRING NO. : GA-EB 72

COUNTY : Garrett

NAME : Unknown

OWNER : City of Oakland (?)

LATITUDE : 39°24'15"

LONGITUDE : 79°22'17"

ELEVATION : 2,410 feet

AQUIFER : Jennings Formation

IMPROVEMENTS : Stone basin and wall box. Three-inch discharge pipe conducts flow to small pond

USE : None

PHOTOGRAPH OF SPRING Date: June 1982

CHEMICAL ANALYSIS (field)

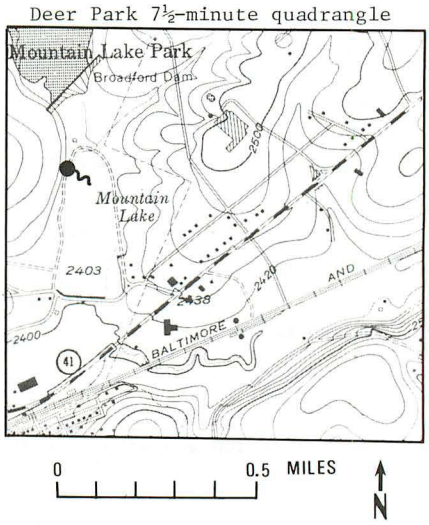
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/30/81	5.1	34	-	-
6/08/82	5.4	-	-	-

REMARKS

Located northeast of Oakland in vicinity of MD Route 219. Flow measured with bucket and stopwatch. Flow estimated at 50 to 75 gal/min on 6/08/82.

LOCATION MAP

Deer Park 7½-minute quadrangle



TEMPERATURE DATA

Date	
10/30/81	10.0°C (50°F)
6/08/82	9.0°C (48°F)

DISCHARGE DATA

Date	
8/09/78	25 gal/min
10/30/81	20 gal/min

SPRING NO. : GA-EC 1

COUNTY : Garrett

NAME : Boiling Spring

OWNER : Nestle Company

LATITUDE : 39°24'03"

LONGITUDE : 79°18'22"

ELEVATION : 2,500 feet

AQUIFER : Greenbrier Formation

IMPROVEMENTS : Roofed concrete springhouse (gazebo) and built-in weir; 6-inch-diameter pipeline leads to town and bottling plant

USE : Supplies bottling plant for Deer Park Spring Water and town of Deer Park

PHOTOGRAPH OF SPRING Date: Not certain
(taken at time of construction of springhouse)

CHEMICAL ANALYSIS (field)

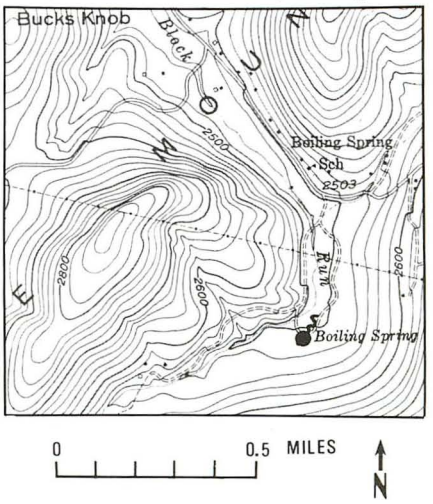
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/16/81	7.6	142	69	0.7
10/30/81	-	150	-	-
6/09/82	6.4	-	-	-

REMARKS

Bottling plant not operating at time of visit on 10/16/81. Measurement of discharge does not include small quantity being supplied to Deer Park community. For many years, this spring supplied the bottled water used on the B & O Railroad (Chessie System) dining cars.

LOCATION MAP

Deer Park 7½-minute quadrangle



TEMPERATURE DATA

Date	
10/16/81	9.0°C (48°F)
6/09/82	11.0°C (52°F)

DISCHARGE DATA

Date	
7/27/78	200 gal/min ($0.45\ ft^3/s$)
10/16/81	126 gal/min ($0.28\ ft^3/s$)

SPRING NO. : GA-FA 8

COUNTY : Garrett

NAME : Unknown

OWNER : State of Maryland (Highway Administration)

LATITUDE : 39°17'51"

LONGITUDE : 79°25'24"

ELEVATION : 2,920 feet

AQUIFER : Mauch Chunk Formation

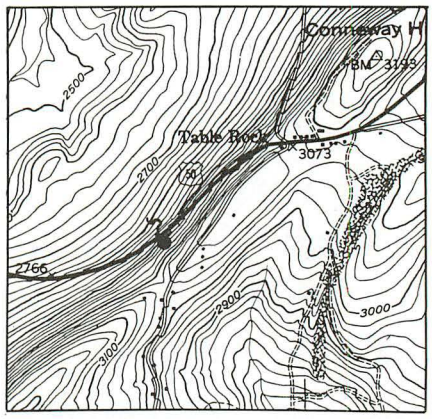
IMPROVEMENTS : Discharge pipe on hillside

USE : None, except for passersby

PHOTOGRAPH OF SPRING Date: June 1982

LOCATION MAP

Table Rock 7½-minute quadrangle



TEMPERATURE DATA

Range: 4.5°C to 11.5°C (39°F to 52°F)

Period: 2/24/81 to 1/28/82

Mean: 4.7°C (Based on 12 measurements)

DISCHARGE DATA

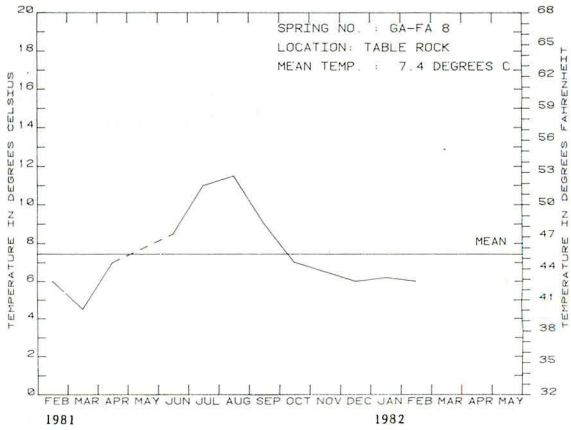
Date	
10/29/81	75 gal/min (meas.) (0.17 ft^3/s)
11/25/81	50 gal/min (meas.) (0.11 ft^3/s)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
2/24/81	7.4	37	9	21
3/19/81	6.5	37	12	24
4/24/81	6.9	37	13	26
6/26/81	7.4	36	10	32

REMARKS

Spring just below contact with overlying Pottsville sandstone. Nutter and others (1980, p. 53) report owner of this spring is Bill Biel.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : GA-GA 1

COUNTY : Garrett

NAME : Kempton Spring

OWNER : Town of Kempton

LATITUDE : 39°12'32"

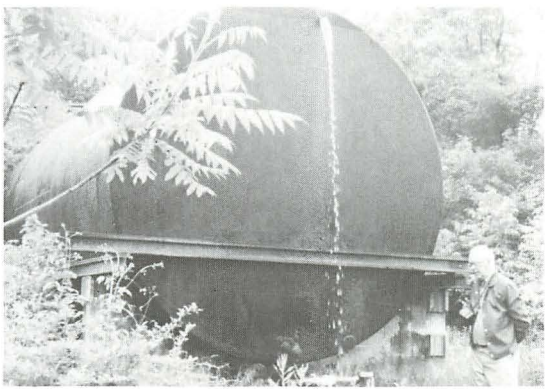
LONGITUDE : 79°28'50"

ELEVATION : 2,880 feet

AQUIFER : Conemaugh Formation

IMPROVEMENTS : Concrete pit with pipeline to large steel tank used for water storage

USE : Domestic supply for the few remaining homes in Kempton. Town was partially deserted in 1981-82



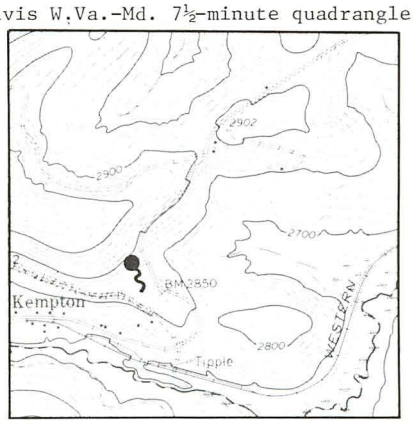
PHOTOGRAPH OF SPRING Date: June 1982
(Photograph of storage tank downhill from spring.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/29/81	6.9	86	-	-
6/08/82	6.3	-	-	-

LOCATION MAP

Davis W.Va.-Md. 7½-minute quadrangle



0 0.5 MILES N

TEMPERATURE DATA

Date	
10/29/81	11.0°C (50°F)
6/08/82	13.5°C (56°F)

DISCHARGE DATA

Date	
10/29/81	5.5 gal/min[1]

[1] Overflow from steel storage tank measured. This is only part of total flow of spring--main flow supplies 4 to 6 houses in Town of Kempton.

SPRING NO. : GA-GA 4

COUNTY : Garrett

NAME : Unknown

OWNER : Paul Radeheaver

LATITUDE : 39°14'33"

LONGITUDE : 79°26'58"

ELEVATION : 2,660 feet

AQUIFER : Conemaugh Formation

IMPROVEMENTS : Collecting pit and discharge pipe

USE : Domestic (used by nearby property owner)

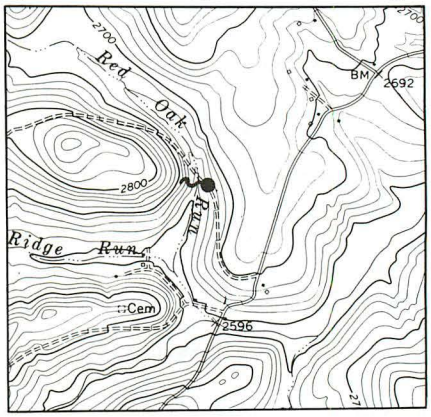
PHOTOGRAPH OF SPRING Date: June 1982

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/29/81	5.1	34	-	-
6/08/82	5.2	-	-	-

LOCATION MAP

Davis W.Va.-Md. 7½-minute quadrangle



TEMPERATURE DATA

Date	
10/29/81	10°C (50°F)
6/08/82	9°C (48°F)

DISCHARGE DATA

Date	
10/29/81	12 gal/min (meas.)[1]

[1] Able to measure only part of total flow, estimated to be ±100 gal/min on 10/29/81.

SPRING NO. : HA-AA 9

COUNTY : Harford

NAME : Unknown

OWNER : Milton Smith

LATITUDE : 39°41'53"

LONGITUDE : 76°32'57"

ELEVATION : 660 feet

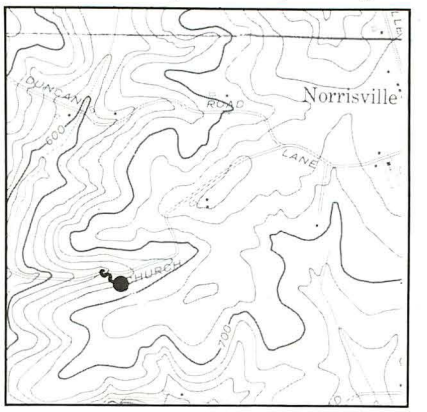
AQUIFER : Prettyboy Schist (Crowley)

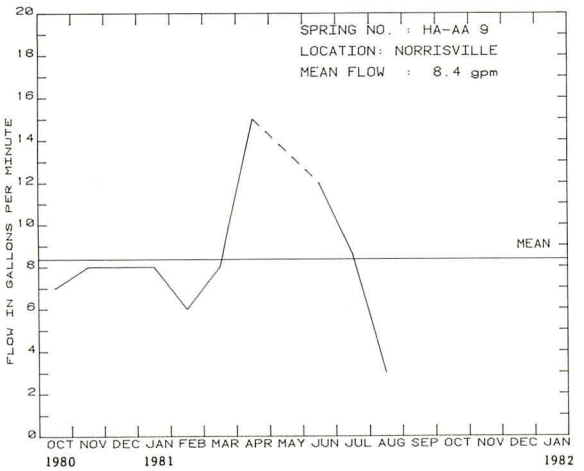
IMPROVEMENTS : Spring box with lid; 4-inch-diameter plastic discharge pipe which ends about 100 feet west of source

USE : Supplies water to cattle in pasture

LOCATION MAP

Norrisville 7½-minute quadrangle





GRAPH SHOWING MONTHLY DISCHARGE

TEMPERATURE DATA

Range: 9.5°C to 14.0°C (49°F to 57°F)

Period: 10/06/80 to 9/03/81

Mean: 11.5°C
(Based on 13 measurements)

DISCHARGE DATA

Range: 6 to 15 gal/min

Period: 10/06/80 to 10/01/81

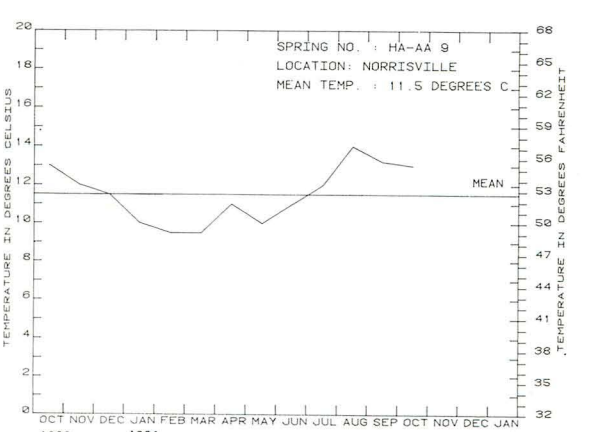
Mean: 8.4 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/06/80	5.8	110	31	26
11/06/80	6.5	124	32	26
12/05/80	6.6	118	30	36
1/05/81	6.8	110	32	30

REMARKS

Located in field on south side of Church Lane Road.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : HA-AA 24

COUNTY : Harford

NAME : Church Lane Spring

OWNER : Harford County Roads Department

LATITUDE : 39°41'52"

LONGITUDE : 76°33'05"

ELEVATION : 640 feet

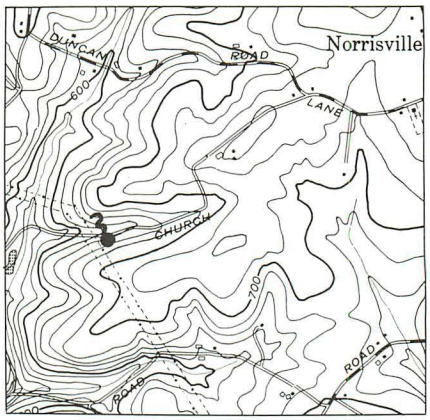
AQUIFER : Prettyboy Schist (of Crowley)

IMPROVEMENTS : Steel barrel placed over spring opening at base of hill; flows to nearby ditch

USE : Local passersby

LOCATION MAP

Norrisville 7½-minute quadrangle



TEMPERATURE DATA

Range: 9.0°C to 12°C (48°F to 54°F)

Period: 9/05/80 to 9/03/81

Mean: 10.7°C
(Based on 13 measurements)

DISCHARGE DATA

Range: 0 to 2 gal/min (est.)

Period: 9/05/80 to 9/03/81

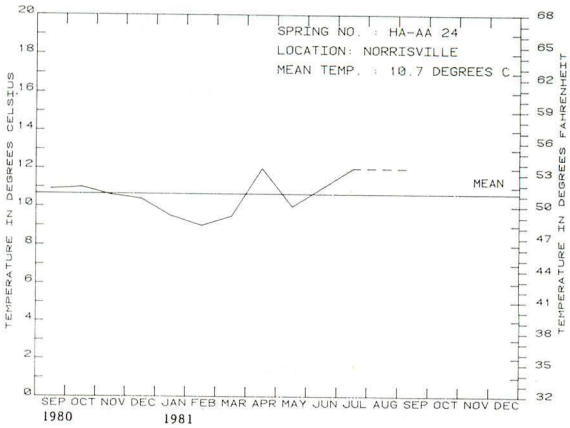
PHOTOGRAPH OF SPRING Date: May 1982

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/06/80	6.1	99	20	26
11/06/80	6.4	111	34	20
12/02/80	6.1	110	28	28
1/05/81	6.1	96	40	26
5/13/82	6.1	-	-	-

REMARKS

Sanitation of this spring is questionable. Field test for nitrate (N) = 2.3 mg/L on 4/30/82; nitrate (N) = 2.9 mg/L on 5/13/82.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : HA-AA 25

COUNTY : Harford

NAME : Unknown

OWNER : Len Billingslea

LATITUDE : 39°41'45"

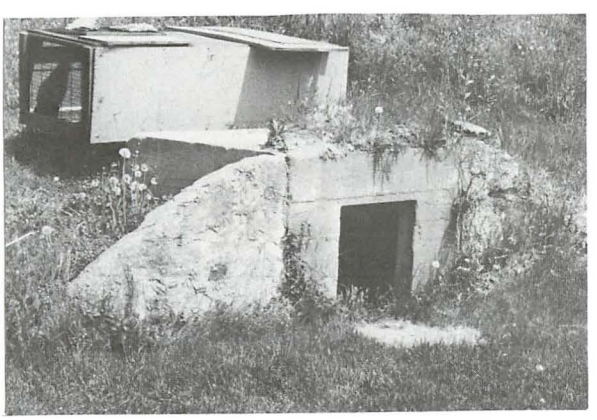
LONGITUDE : 76°32'57"

ELEVATION : 460 feet

AQUIFER : Prettyboy Schist (of Crowley)

IMPROVEMENTS : Spring box below and south of road near house

USE : None, apparently



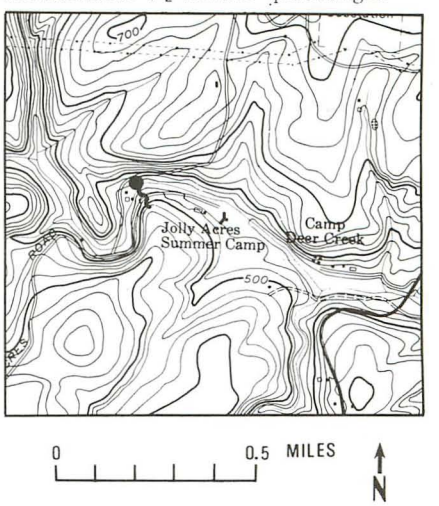
PHOTOGRAPH OF SPRING Date: May 1982

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)

LOCATION MAP

Norrisville 7½-minute quadrangle



TEMPERATURE DATA

Date	
9/05/80	13.9°C (57°F)
5/13/82	12.0°C (54°F)

DISCHARGE DATA

Date	
5/13/82	2 to 3 gal/min (est.)

REMARKS

Formerly used as camp supply. Prior to 1981, this spring was part of Camp Jolly Acres, owned by the Lutheran Inner Mission Society. Field test for nitrate (N) = 0.0 mg/L on 5/13/82; field test conductivity = 35 µmhos/cm on 5/13/82.

SPRING NO. : HA-AA 26

COUNTY : Harford

NAME : Unknown

OWNER : Len Billingslea

LATITUDE : 39°41'44"

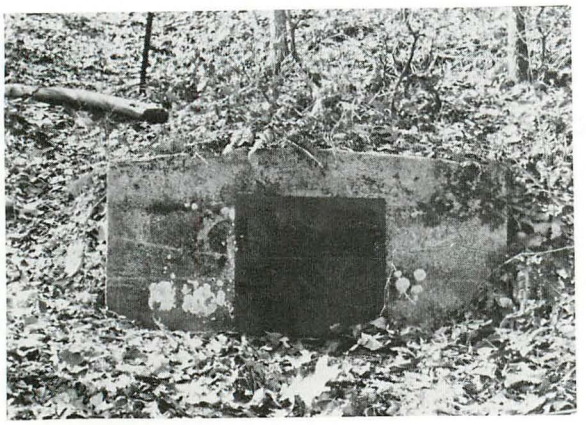
LONGITUDE : 76°33'10"

ELEVATION : 470 feet

AQUIFER : Prettyboy Schist (of Crowley)

IMPROVEMENTS : Small concrete spring box on hillside above road; steel door provides access to spring; discharge pipe downhill and probably beneath road; unable to locate exact point of discharge

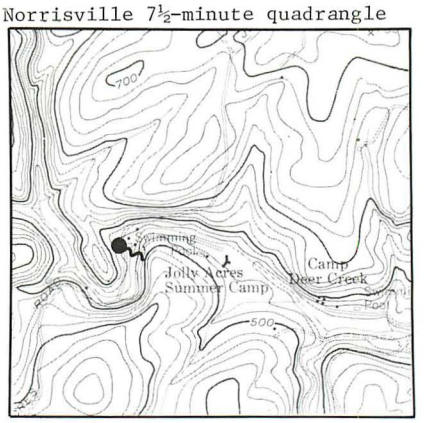
USE : None (formerly used by camp)



PHOTOGRAPH OF SPRING Date: April 1982

LOCATION MAP

Norrisville 7½-minute quadrangle



0 0.5 MILES N

TEMPERATURE DATA

Range: 5.0°C to 14.0°C (41°F to 57°F)

Period: 9/11/80 to 9/03/81

Mean: 10.0°C
(Based on 13 measurements)

DISCHARGE DATA

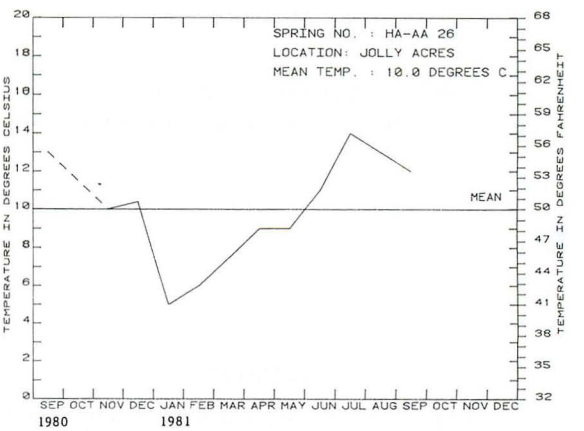
Date	
5/06/81	<1 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/06/80	6.8	38	14	16
11/06/80	6.5	34	13	19
12/02/80	6.9	34	-	20
1/05/81	6.5	31	-	26

REMARKS

Formerly, this spring was one of several supplying Camp Jolly Acres. Field test for nitrate (N) = 0.0 mg/L on 4/30/82; nitrate (N) = 0.0 on 5/13/82.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : HA-AD 14

COUNTY : Harford

NAME : Unknown

OWNER : Boy Scouts of America (Broad Creek Scout Camp)

LATITUDE : 39°41'42"

LONGITUDE : 76°16'11"

ELEVATION : 300 feet

AQUIFER : Wissahickon Formation (metagraywacke facies)

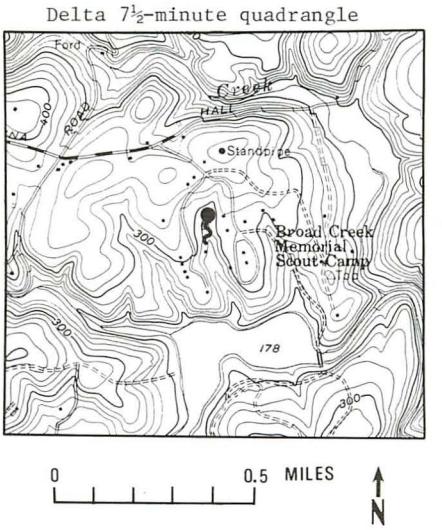
IMPROVEMENTS : Pipe leading from hillside to edge of pond

USE : Not approved for drinking purposes by County Health Department

PHOTOGRAPH OF SPRING Date: April 1982

LOCATION MAP

Delta 7½-minute quadrangle



TEMPERATURE DATA

Date	
10/07/80	12.2°C (54°F)
11/06/80	11.8°C (53°F)
12/05/80	11.4°C (52°F)
1/05/81	9.0°C (48°F)
3/03/81	10.5°C (51°F)

DISCHARGE DATA

Date	
11/06/80	0 to 0.5 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/07/80	6.6	58	20	14
11/06/80	6.8	57	13	17
12/05/80	5.9	58	16	30
1/05/81	6.7	52	19	20

REMARKS

Spring dry on 2/03/81, 4/02/81, 5/06/81, 6/04/81, and 7/01/81. Measurements discontinued after 7/01/81, and very little flow on 4/30/82.

SPRING NO. : HA-BC 29

COUNTY : Harford

NAME : Unknown

OWNER : Howard Arnold

LATITUDE : 39°38'59"

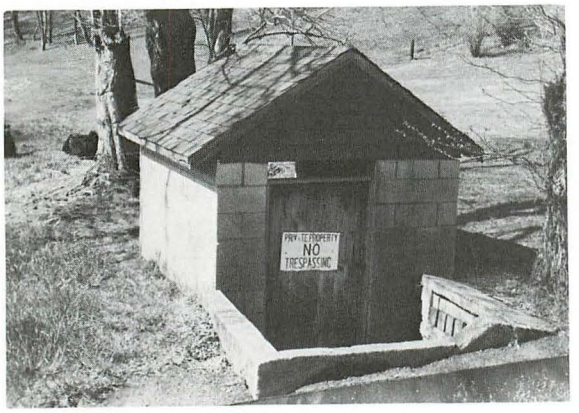
LONGITUDE : 76°24'40"

ELEVATION : 370 feet

AQUIFER : Wissahickon Formation

IMPROVEMENTS : Springhouse in pit near stream. Discharges to nearby stream

USE : None



PHOTOGRAPH OF SPRING Date: April 1982

CHEMICAL ANALYSIS (field)

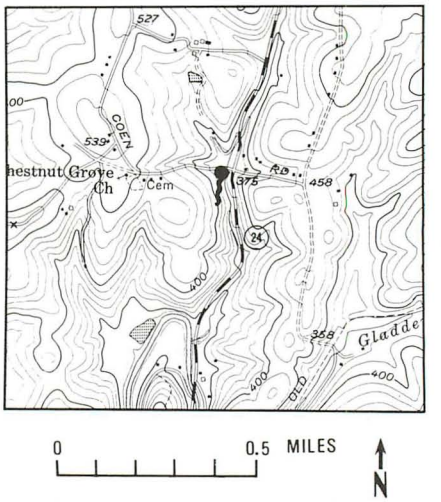
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/06/80	6.1	47	8	20
11/06/80	6.8	44	19	18
12/05/80	6.4	50	26	26
1/05/81	6.7	49	24	34

REMARKS

Measurements discontinued because flow of spring essentially ceased. Spring located behind store at southwest corner of Coen and Rocks Roads. Spring flowed again on 4/30/82. Field test for nitrate (N) = 0.6 mg/L on 4/30/82.

LOCATION MAP

Fawn Grove 7½-minute quadrangle



TEMPERATURE DATA

Date	
9/11/80	15.4°C (60°F)
10/06/80	14.0°C (57°F)
12/05/80	7.2°C (44°F)
2/03/81	5.0°C (41°F)
4/30/82	10.0°C (50°F)

DISCHARGE DATA

Date	
9/11/80	<1 - 2 gal/min (est.)

SPRING NO. : HA-BC 30

COUNTY : Harford

NAME : 4-H Camp Spring

OWNER : State of Maryland (4-H Camp)

LATITUDE : 39°37'57"

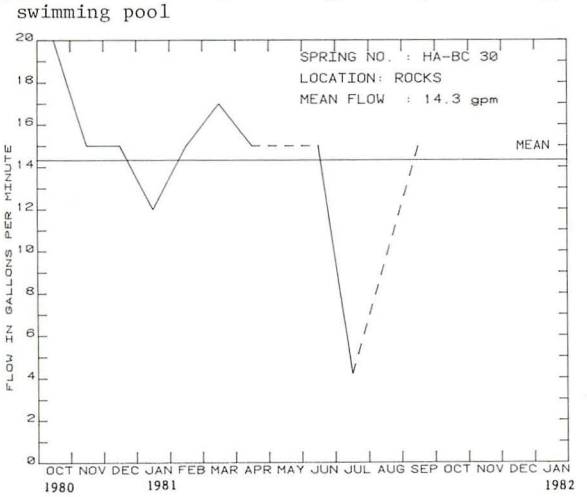
LONGITUDE : 76°24'01"

ELEVATION : 290 feet

AQUIFER : Wissahickon Formation

IMPROVEMENTS : Springhouse with roof; concrete collecting box and below that, a concrete cylinder with a discharge pipe where flow was measured

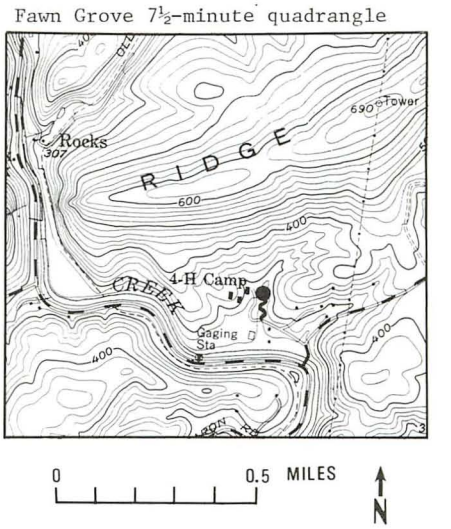
USE : Limited camp use. Apparently also supplies swimming pool



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

Fawn Grove 7½-minute quadrangle



TEMPERATURE DATA

Range: 9.0°C to 14.0°C (48°F to 57°F)

Period: 10/06/80 to 9/03/81

Mean: 11.3°C (Based on 13 measurements)

DISCHARGE DATA

Range: 20 to 42 gal/min

Period: 10/06/80 to 9/03/81

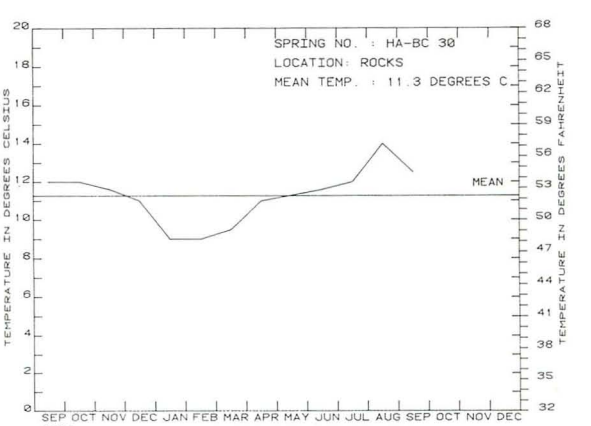
Mean: 14.3 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/06/80	5.9	32	9	22
11/06/80	6.3	28	12	20
12/05/80	6.5	29	-	20
1/05/81	6.6	28	-	18

REMARKS

Erratic flow measurements (see July measurement) may be due to diversion of flow for pool use.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : HA-BF 18

COUNTY : Harford

NAME : Unknown

OWNER : State of Maryland (Highway Administration)

LATITUDE : 39°36'01"

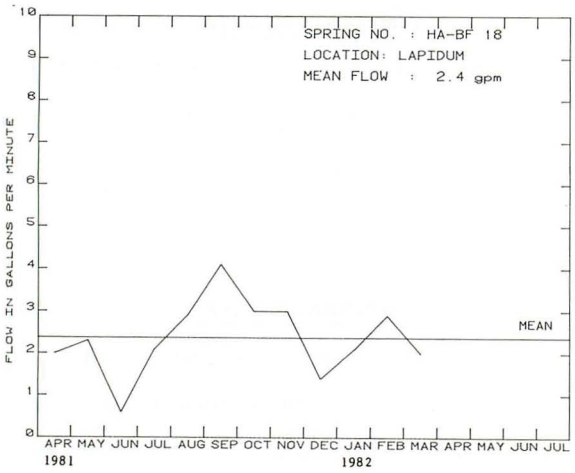
LONGITUDE : 76°07'54"

ELEVATION : 20 feet

AQUIFER : Port Deposit Gneiss

IMPROVEMENTS : Discharge pipe in rock crevice

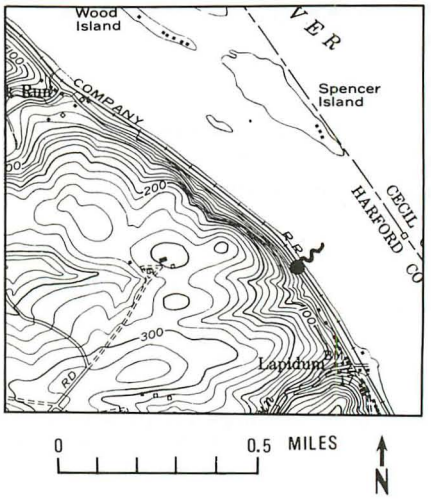
USE : Occasional use by passersby



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

Aberdeen 7½-minute quadrangle



TEMPERATURE DATA

Range: 7.0°C to 15.5°C (45°F to 60°F)

Period: 4/02/81 to 3/04/82

Mean: 11.5°C (Based on 12 measurements)

DISCHARGE DATA

Range: 0.6 to 4.1 gal/min

Period: 4/02/81 to 3/04/82

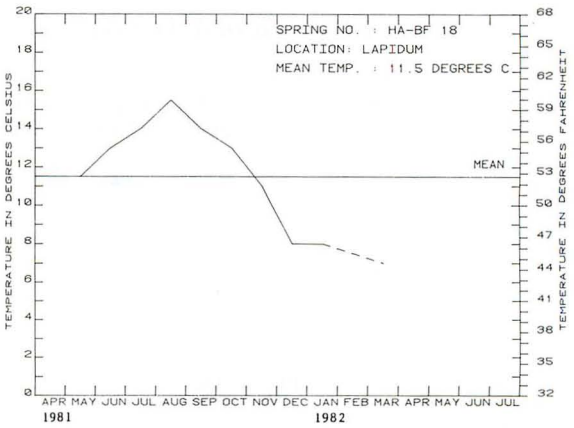
Mean: 2.4 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
4/02/81	6.9	140	33	29
5/06/81	7.1	136	40	25
6/03/81	6.6	138	38	37
7/01/81	7.0	136	-	-

REMARKS

Spring along Stafford Road, 0.7 mile southeast of old Mill Race Building in State Park.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : HO-AC 78

COUNTY : Howard

NAME : Unknown

OWNER : Elsie Franklin

LATITUDE : 39°20'34"

LONGITUDE : 77°03'35"

ELEVATION : 580 feet

AQUIFER : Wissahickon Formation (albite schist)

IMPROVEMENTS : Small house with discharge pipe between basin and trough

USE : None

PHOTOGRAPH OF SPRING Date: February 1982

CHEMICAL ANALYSIS (field)

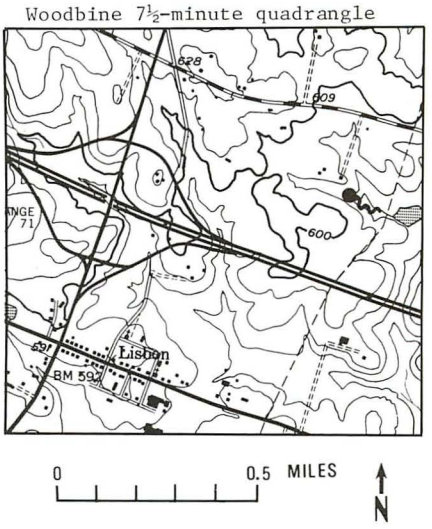
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/17/80	6.6	132	40	30
11/10/80	7.2	140	37	20
12/08/80	6.8	133	44	30
2/10/81	6.1	150	50	20

REMARKS

Located southeast of community of Woodbine and north of I-70.

LOCATION MAP

Woodbine $7\frac{1}{2}$-minute quadrangle



TEMPERATURE DATA

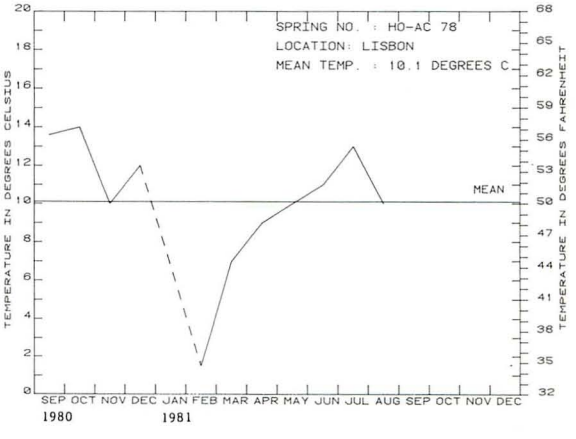
Range: 1.5°C to 14°C (34°F to 57°F)

Period: 9/29/80 to 8/20/81

Mean: 10.1°C (Based on 12 measurements)

DISCHARGE DATA

Date	
10/17/80	<1 gal/min (est.)



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : HO-BC 142

COUNTY : Howard

NAME : Cool Spring

OWNER : David De Bernardo

LATITUDE : 39°19'11"

LONGITUDE : 77°02'46"

ELEVATION : 540 feet

AQUIFER : Wissahickon Formation (albite schist facies)

IMPROVEMENTS : Small springhouse with trough leading to farm pond

USE : None; owner uses well water (spring supplies pond)

PHOTOGRAPH OF SPRING Date: September 1982

CHEMICAL ANALYSIS (field)

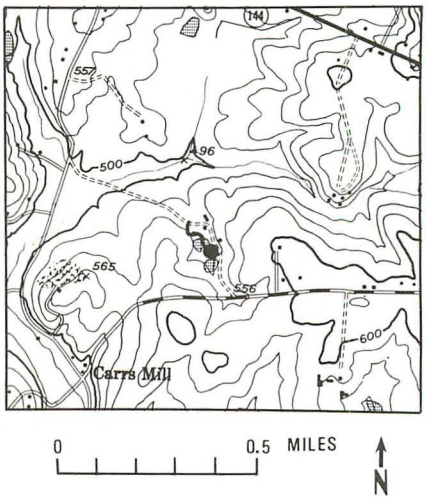
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/20/80	6.9	56	20	18
10/10/80	6.6	57	26	17
12/08/80	6.8	55	20	22
1/07/81	6.8	55	20	23
9/01/82	-	55	-	-

REMARKS

Located on north side of Bush Park Road and west of residence.

LOCATION MAP

Woodbine 7½-minute quadrangle



TEMPERATURE DATA

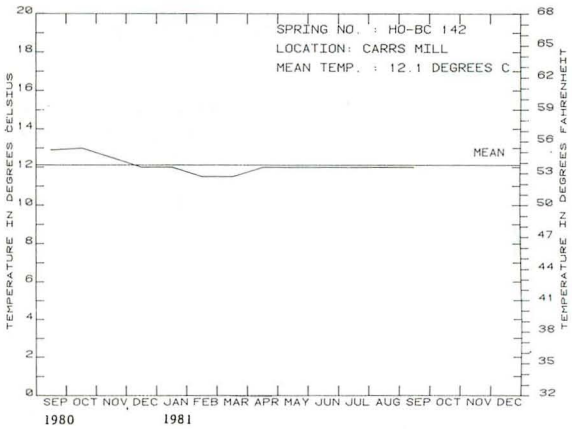
Range: 11.5°C to 13°C (53°F to 55.4°F)

Period: 9/24/80 to 9/11/81

Mean: 12.1°C (Based on 13 measurements)

DISCHARGE DATA

Date	
11/10/80	±1 gal/min (est.)



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : HO-BD 15

COUNTY : Howard

NAME : Unknown

OWNER : Franciscan Fathers (Catholic Diocese)

LATITUDE : 39°15'33"

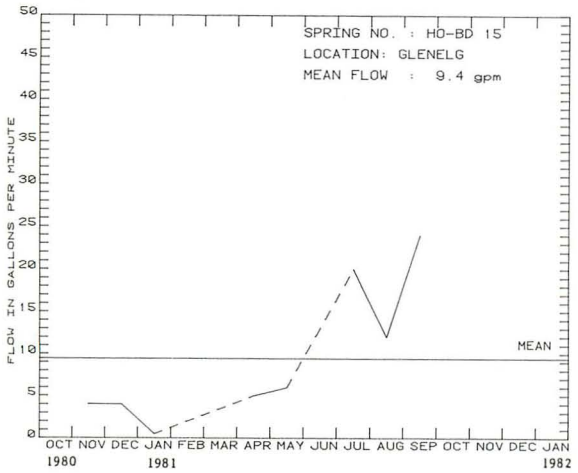
LONGITUDE : 76°56'33"

ELEVATION : 450 feet

AQUIFER : Cockeysville Marble (?)

IMPROVEMENTS : Concrete bunker with pipe leading to swimming pool

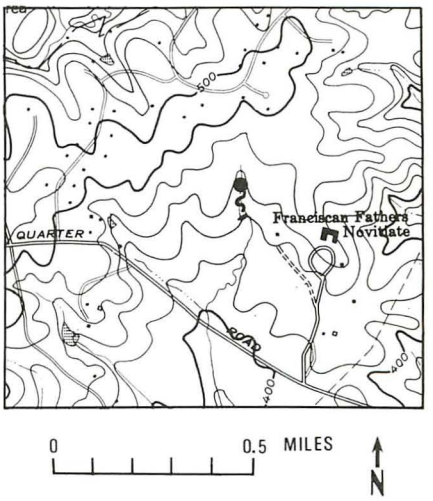
USE : To fill swimming pool together with a nearby well



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

Sykesville 7½-minute quadrangle



TEMPERATURE DATA

Range: 7°C to 16°C (45°F to 61°F)

Period: 10/02/80 to 10/05/81

Mean: 12.9°C (Based on 13 measurements)

DISCHARGE DATA

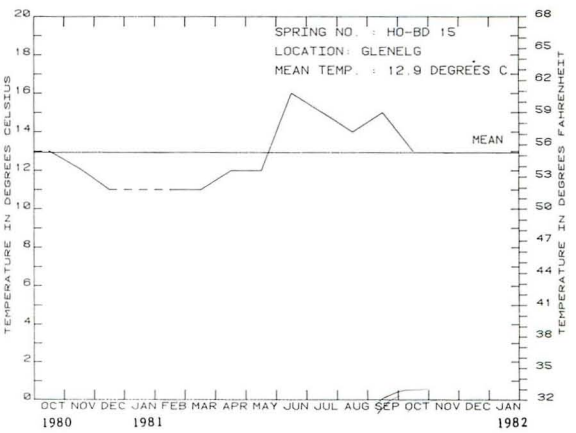
Range: 0 to 24 gal/min[1]

Period: 10/02/80 to 10/05/81

Mean: 9.4 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
11/07/80	7.4	275	101	19
12/08/80	6.5	143	35	24
1/07/81	6.9	151	54	38
2/10/81	6.2	320	140	19



GRAPH SHOWING MONTHLY TEMPERATURE

[1] Zero flow observed during January and February 1981 may be due to freezing of discharge pipe. Flow reported at 20 gal/min in July 1952 (Dingman and Meyer, 1954, p. 65).

SPRING NO. : HO-BF 35

COUNTY : Howard

NAME : Never-Ending Spring

OWNER : State of Maryland (Forest and Park Services)

LATITUDE : 39°18'52"

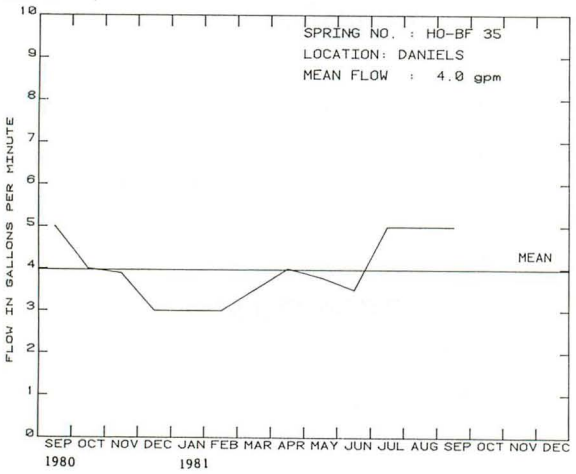
LONGITUDE : 76°48'48"

ELEVATION : 360 feet

AQUIFER : Setters Formation

IMPROVEMENTS : Spring pit with pipeline going downhill to a large enclosed reservoir

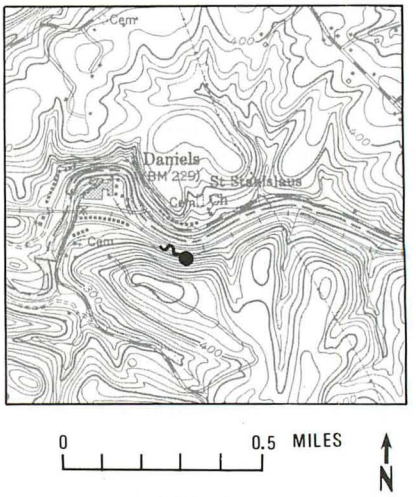
USE : None. Formerly supplied town of Daniels and an old mill



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

Ellicott City 7½-minute quadrangle



TEMPERATURE DATA

Range: 3.5°C to 17°C (38°F to 63°F)

Period: 9/24/80 to 9/11/81

Mean: 10.8°C (Based on 13 measurements)

DISCHARGE DATA

Range: 3.0 to 5.0 gal/min

Period: 9/24/80 to 9/11/81

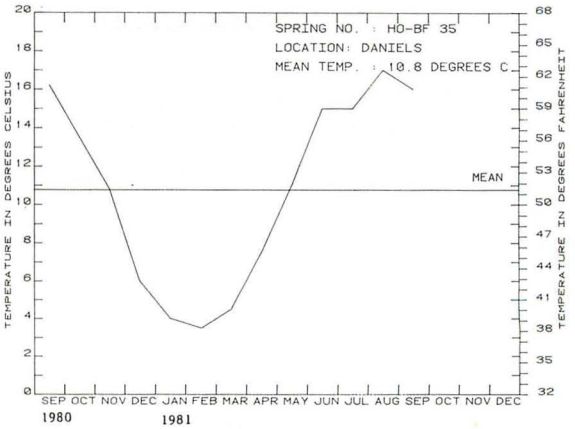
Mean: 4.0 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/17/80	6.7	130	30	38
11/07/80	6.5	120	36	29
12/30/80	6.9	132	30	50
1/08/81	6.3	132	32	38

REMARKS

Spring flow measured inside large brick reservoir from 2-inch-diameter vertical discharge pipe.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : HO-CE 54

COUNTY : Howard

NAME : Unknown

OWNER : Rouse and Associates, Inc.

LATITUDE : 39°12'20"

LONGITUDE : 76°53'47"

ELEVATION : 380 feet

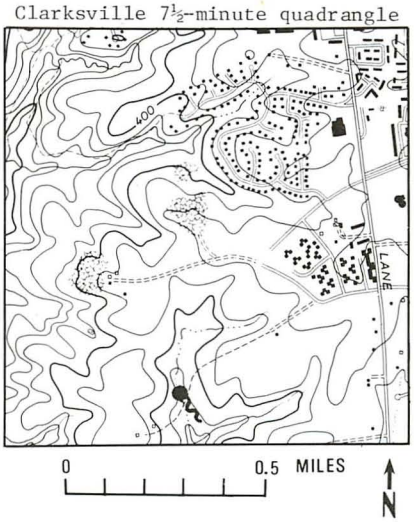
AQUIFER : Wissahickon Formation (Oligoclase facies)

IMPROVEMENTS : Small spring box

USE : None

LOCATION MAP

Clarksville 7½-minute quadrangle



PHOTOGRAPH OF SPRING Date: March 1982

TEMPERATURE DATA

Range: 3.5°C to 13°C (38°F to 55°F)

Period: 9/25/80 to 9/11/81

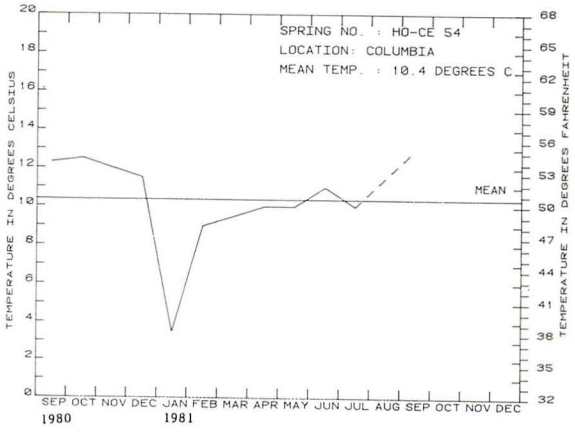
Mean: 10.4°C
(Based on 13 measurements)

DISCHARGE DATA

Date	
10/20/80 to 9/11/81	1 to 2 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
9/25/80	6.5	41	10	20
10/20/80	6.0	49	11	20
11/10/80	6.6	39	10	21
12/08/80	6.3	40	11	24



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : HO-CF 32

COUNTY : Howard

NAME : Unknown

OWNER : Ernest Schnellenger

LATITUDE : 39°14'48"

LONGITUDE : 76°46'20"

ELEVATION : 260 feet

AQUIFER : Mount Washington Amphibolite

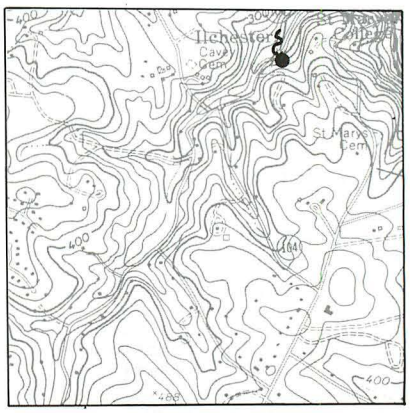
IMPROVEMENTS : Small spring pit and discharge pipe

USE : Domestic

PHOTOGRAPH OF SPRING Date: March 1982

LOCATION MAP

Savage 7½-minute quadrangle



0 0.5 MILES N

TEMPERATURE DATA

Range: 4.0°C to 14.0°C (39°F to 57°F)

Period: 9/22/80 to 9/11/81

Mean: 10.9°C
(Based on 13 measurements)

DISCHARGE DATA

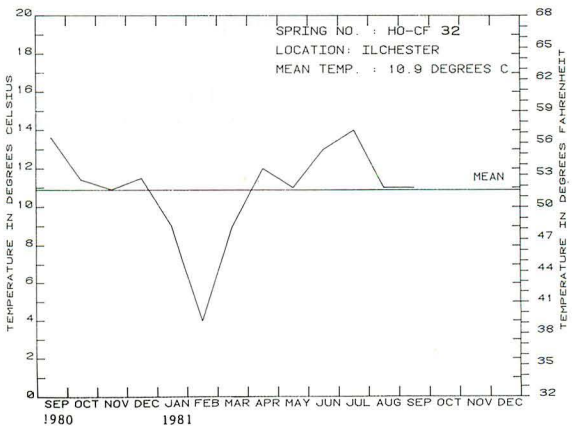
Date	
2/10/81 (min.) 3/06/81 (max.)	<0.5 to 2 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
11/07/80	6.4	255	71	26
12/08/80	5.9	240	72	26
1/07/81	6.4	240	80	30
2/10/81	6.8	250	75	30

REMARKS

Spring was once open to passersby; however, it was closed in 1969 because of debris accumulation.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : HO-CF 38

COUNTY : Howard

NAME : Unknown

OWNER : Baltimore Gas and Electric Co. (lessee)

LATITUDE : 39°11'16"

LONGITUDE : 76°49'54"

ELEVATION : 310 feet

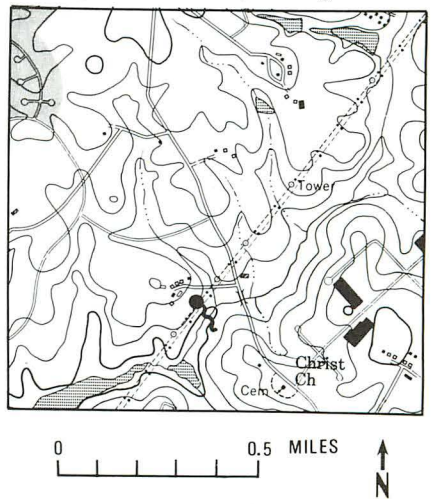
AQUIFER : Baltimore Gabbro Complex

IMPROVEMENTS : Concrete blockhouse

USE : Domestic (user has easement on spring)

LOCATION MAP

Savage 7½-minute quadrangle



PHOTOGRAPH OF SPRING Date: September 1982

TEMPERATURE DATA

Range: 10.0°C to 14.0°C (50°F to 57°F)

Period: 4/08/81 to 3/17/82

Mean: 12.4°C
(Based on 12 measurements)

DISCHARGE DATA

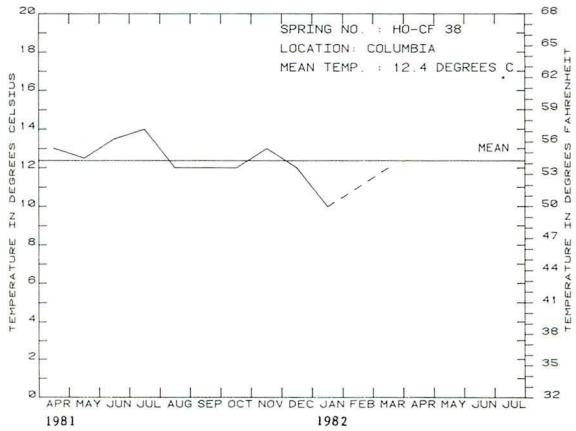
Date	
4/08/81 (max.) 12/09/81 (min.)	<0.5 to 5 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
4/08/81	6.0	154	50	24
5/19/81	6.4	156	61	32
6/12/81	6.6	154	56	34
7/09/81	6.9	155	-	-

REMARKS

Located along high tension lines north of Snowden Parkway. Field test for nitrate (N) = 0.9 mg/L on 12/09/81; = 0.8 mg/L on 9/16/82.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : HO-CG 20

COUNTY : Howard

NAME : Unknown

OWNER : State of Maryland (Highway Administration)

LATITUDE : 39°13'08"

LONGITUDE : 76°42'59"

ELEVATION : 140 feet

AQUIFER : James Run Formation

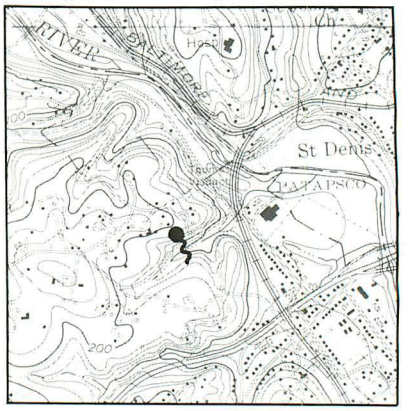
IMPROVEMENTS : Concrete basin built into road cut near foot of hill

USE : None (intermittent by passersby)

PHOTOGRAPH OF SPRING Date: February 1982

LOCATION MAP

Relay 7½-minute quadrangle



0 0.5 MILES N

TEMPERATURE DATA

Range: 8.0°C to 15.5°C (46°F to 60°F)

Period: 9/24/80 to 9/11/81

Mean: 12.0°C (Based on 13 measurements)

DISCHARGE DATA

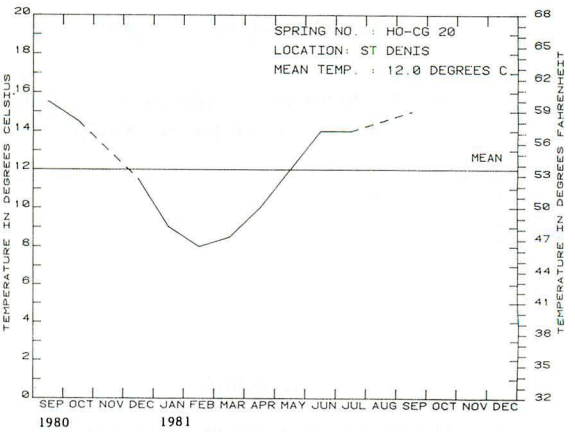
Date	
10/20/80 to 9/11/81	0 to <1 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
9/24/80	6.3	139	42	26
10/20/80	5.9	157	34	28
11/07/80	5.9	151	46	20
12/08/80	6.1	142	34	30

REMARKS

Located south of Patapsco River and west of Chessie System Railroad tracks along Lawyers Hill Road.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : MO-BF 7

COUNTY : Montgomery

NAME : Unknown

OWNER : Roger Watkins

LATITUDE : 39°17'52"

LONGITUDE : 77°09'55"

ELEVATION : 640 feet

AQUIFER : Urbana Formation[1]

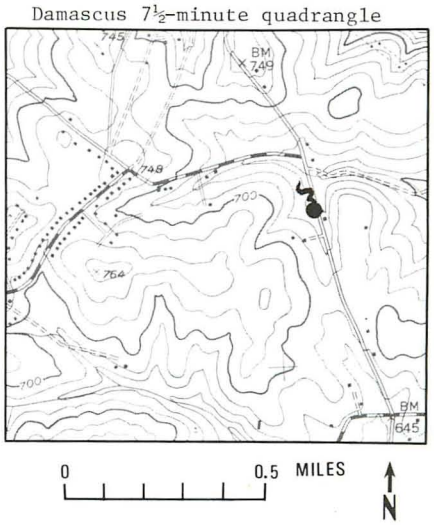
IMPROVEMENTS : Springhouse

USE : None

PHOTOGRAPH OF SPRING Date: September 1982

LOCATION MAP

Damascus 7½-minute quadrangle



TEMPERATURE DATA

Range: 3.0°C to 14.0°C (37°F to 57°F)

Period: 4/13/81 to 3/17/82

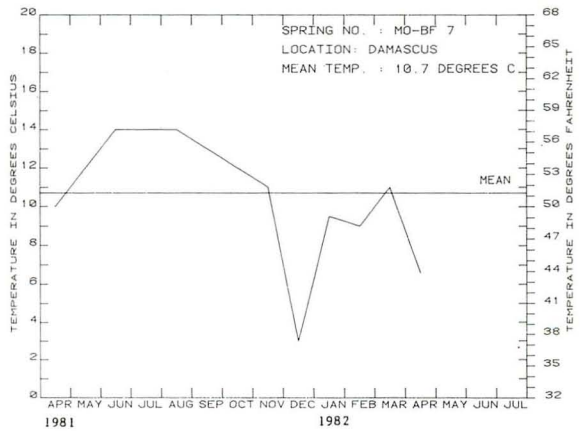
Mean: 10.7°C
(Based on 12 measurements)

DISCHARGE DATA

Date	
10/14/81 (min.) 4/13/81 (max.)	0 to 1 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
4/13/81	5.8	123	30	36
5/22/81	5.7	124	25	35
6/15/81	5.8	120	22	38
4/13/82	5.3	183	-	17
9/01/82	-	144	-	-



GRAPH SHOWING MONTHLY TEMPERATURE

REMARKS

Located on Long Corner Road approximately 2 miles east of Damascus. Chemical field tests: Nitrate (N) = 4.0 mg/L on 12/09/81, and nitrate (N) = 2.5 mg/L on 4/15/82.

[1] Designated as Unit A (phyllite) on geologic map by A. J. Froelich (1975).

SPRING NO. : MO-CB 12

COUNTY : Montgomery

NAME : Unknown

OWNER : John Armentrout

LATITUDE : 39°10'13"

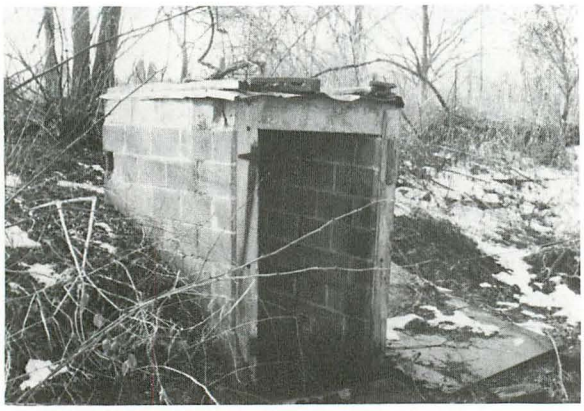
LONGITUDE : 77°28'12"

ELEVATION : 360 feet

AQUIFER : New Oxford Formation[1]

IMPROVEMENTS : Cinder-block springhouse and submerged barrel casing

USE : None, although the spring was in use during the Civil War and supplied nearby camps of Union forces



PHOTOGRAPH OF SPRING Date: February 1982

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
1/22/81	5.8	94	22	44
2/13/81	5.8	116	32	34
3/27/81	5.7	118	38	48
4/13/81	5.8	127	37	35

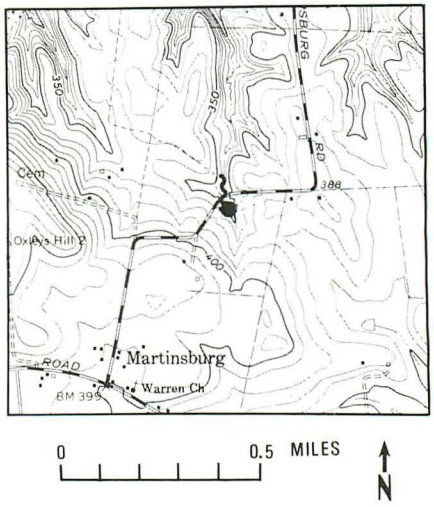
REMARKS

Spring not flowing when examined on 9/14/81. Formerly used as domestic supply for tenant house.

[1] Probably at base of sandstone layer.

LOCATION MAP

Poolesville 7½-minute quadrangle



TEMPERATURE DATA

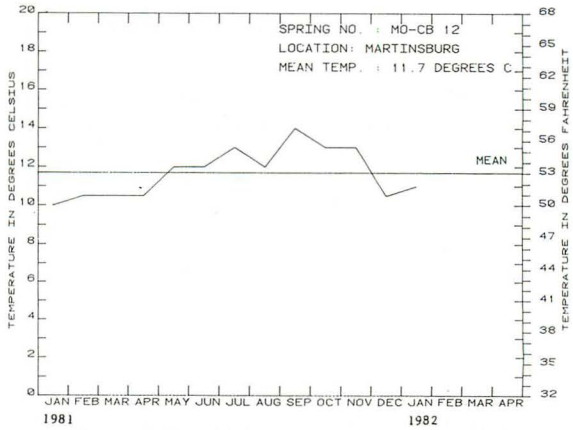
Range: 10.0°C to 14.0°C (50°F to 57°F)

Period: 1/22/81 to 1/04/82

Mean: 11.7°C
(Based on 13 measurements)

DISCHARGE DATA

Date	
1/22/81 to 1/04/81	0 to 2 gal/min (est.)



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : MO-CB 13

COUNTY : Montgomery

NAME : Unknown

OWNER : National Park Service (C & O Canal)

LATITUDE : 39°13'21"

LONGITUDE : 77°26'59"

ELEVATION : 230 feet

AQUIFER : New Oxford Formation

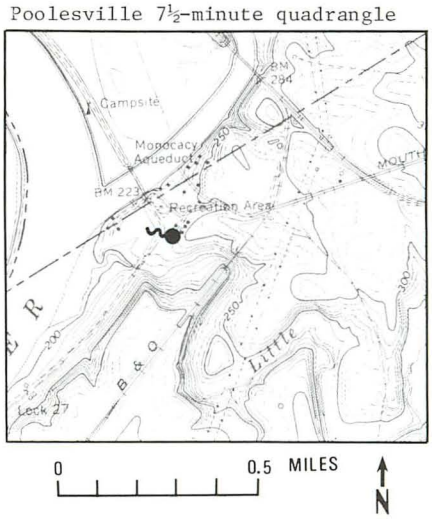
IMPROVEMENTS : Small stone structure

USE : None

PHOTOGRAPH OF SPRING Date: March 1982

LOCATION MAP

Poolesville 7½-minute quadrangle



TEMPERATURE DATA

Range: 4.0°C to 16.0°C (39°F to 61°F)

Period: 1/22/81 to 8/31/81

Mean: 9.6°C
(Based on 8 measurements)

DISCHARGE DATA

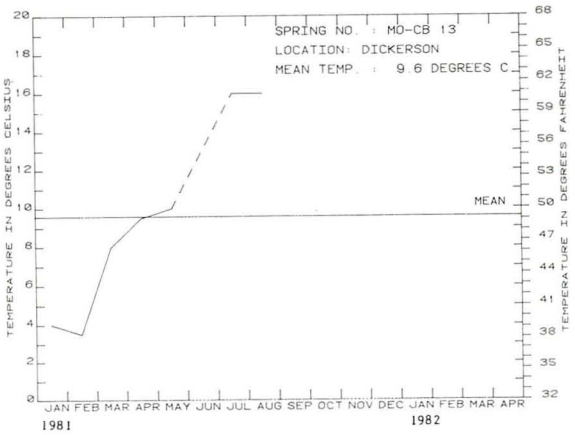
Date	
1/22/81 to 9/14/81	0 to 1 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
2/13/81	5.8	128	32	24
3/09/81	5.6	126	37	37
4/13/81	5.9	124	37	22
5/22/81	5.9	122	40	29

REMARKS

In November 1952, flow reported to be ±1 gal/min by Dingman and Meyer (1954, p. 80). Spring empties to adjacent small stream.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : MO-CC 71

COUNTY : Montgomery

NAME : Unknown

OWNER : L. H. Maxwell

LATITUDE : 39°14'51"

LONGITUDE : 77°21'00"

ELEVATION : 600 feet

AQUIFER : Urbana (?) Formation[1]

IMPROVEMENTS : Springhouse

USE : None

PHOTOGRAPH OF SPRING Date: February 1982

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
2/13/81	6.2	460	60	84
3/09/81	5.6	350	40	78
4/13/81	5.5	400	53	94
5/22/81	6.1	360	53	94

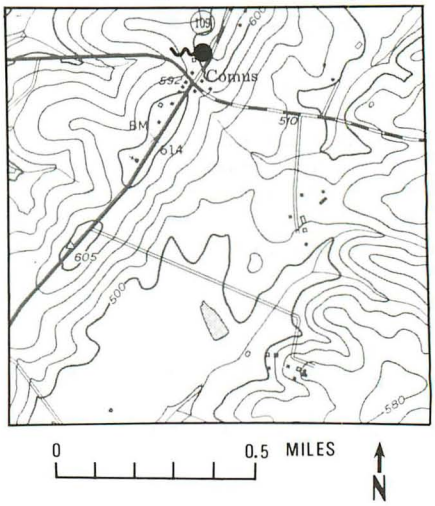
REMARKS

Owner reports spring is contaminated. Nitrate (as N) was 0.9 mg/L for field test on 12/18/81.

[1] Designated as phyllite (Unit A) on 1975 geologic map of Montgomery County by A. J. Froelich.

LOCATION MAP

Germantown 7½-minute quadrangle



TEMPERATURE DATA

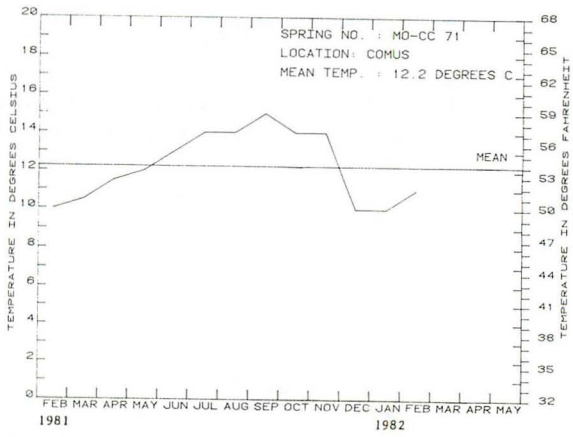
Range: 10.0°C to 15.0°C (50°F to 59°F)

Period: 2/13/81 to 2/04/82

Mean: 12.2°C
(Based on 13 measurements)

DISCHARGE DATA

Date	
2/13/81 to 2/04/82	0.5 to 5 gal/min (est.)



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : MO-CG 20

COUNTY : Montgomery

NAME : Unknown

OWNER : Washington Suburban Sanitary Commission

LATITUDE : 39°14'08"

LONGITUDE : 77°03'21"

ELEVATION : 420 feet

AQUIFER : Gneiss[1]

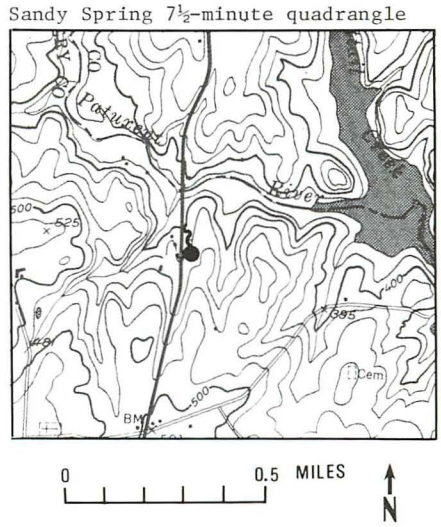
IMPROVEMENTS : Stone spring pit

USE : None

PHOTOGRAPH OF SPRING Date: April 1982

LOCATION MAP

Sandy Spring 7½-minute quadrangle



TEMPERATURE DATA

Range: 10.0°C to 14.0°C (50°F to 57°F)

Period: 4/13/81 to 3/17/82

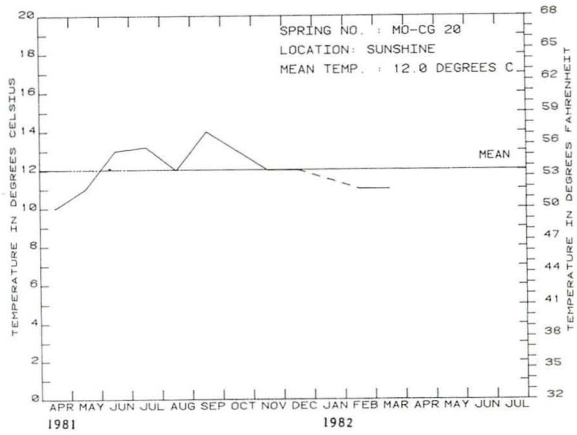
Mean: 12.0°C
(Based on 12 measurements)

DISCHARGE DATA

Date	
4/13/81 (meas.)	1.5 gal/min
	<1 to 2.5 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
4/13/81	6.1	98	30	36
5/20/81	6.1	94	28	40
6/12/81	6.3	97	25	44
7/13/81	6.4	98	-	-
4/13/82	6.2	159	-	14



GRAPH SHOWING MONTHLY TEMPERATURE

REMARKS

Located on east side of Maryland Route 97 about 0.2 mile south of bridge across Patuxent River. Chemical field tests: Nitrate (N) = 0.9 mg/L on 12/09/81; nitrate (N) = 2.1 mg/L on 4/15/82.

[1] Designated as Unit D (Gneiss) on lithologic map of A. J. Froelich (1975).

SPRING NO. : MO-ED 11

COUNTY : Montgomery

NAME : Herron Spring

OWNER : J. Shaver

LATITUDE : 39°02'35"

LONGITUDE : 77°16'00"

ELEVATION : 190 feet

AQUIFER : Wissahickon Formation (Upper Pelitic Facies)

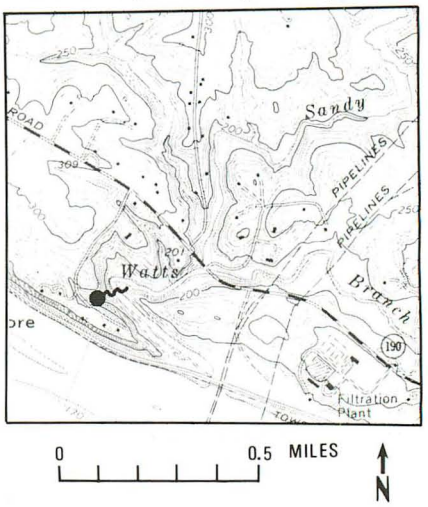
IMPROVEMENTS : Springhouse, pump, and large concrete reservoir under springhouse

USE : None; formerly served several homes at end of Spring Ridge Road

PHOTOGRAPH OF SPRING Date: February 1982

LOCATION MAP

Seneca 7½-minute quadrangle



TEMPERATURE DATA

Range: 6°C to 17°C (43°F to 63°F)

Period: 10/22/80 to 10/13/81

Mean: 11.4°C (Based on 13 measurements)

DISCHARGE DATA

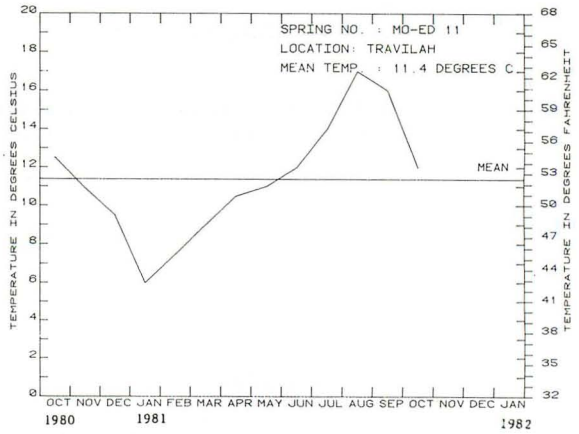
Date	
10/22/80 to 9/14/81	0 to 1 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
11/21/80	6.9	78	26	26
12/19/80	6.8	78	26	24
11/12/81	6.2	77	20	34
3/09/81	5.8	98	28	38

REMARKS

In October 1964, flow measured at 0.4 gal/min by USGS; measurements could only be made of overflow. Nitrate (N) = 0.4 mg/L on 9/16/82.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : MO-EF 50

COUNTY : Montgomery

NAME : All Pure Spring

OWNER : All Pure Spring Water Company[1]

LATITUDE : 39°03'38"

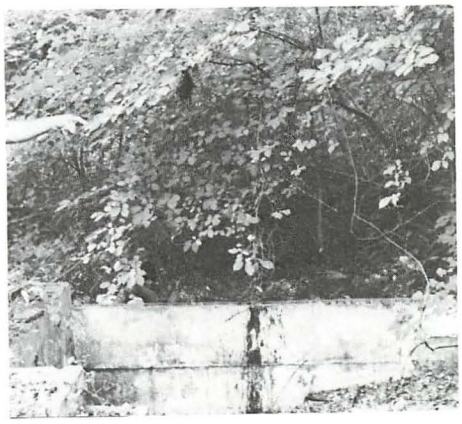
LONGITUDE : 77°09'45"

ELEVATION : 360 feet

AQUIFER : Wissahickon Formation (Upper Pelitic Facies)

IMPROVEMENTS : Discharge pipe leading from ruins of springhouse

USE : None during 1980-82



PHOTOGRAPH OF SPRING Date: September 1982

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/02/80	6.5	110	24	38
11/10/80	6.5	112	23	28
12/11/80	5.5	110	34	34
1/12/81	6.2	115	21	40

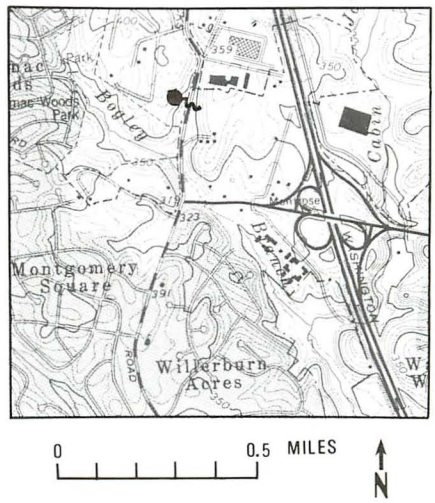
REMARKS

Partial chemical analysis of this spring given in Dingman and Meyer (1954, p. 55). Field nitrate (N) = 1.2 mg/L on 9/16/82.

[1] Name of owner in 1954 (Dingman and Meyer, p. 104).

LOCATION MAP

Rockville 7½-minute quadrangle



TEMPERATURE DATA

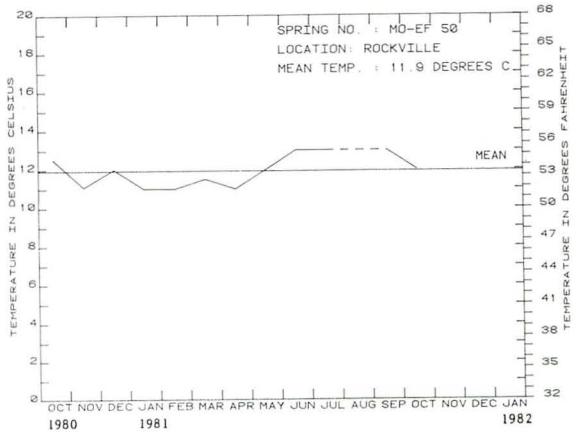
Range: 11°C to 13°C (51.8°F to 55.4°F)

Period: 10/02/80 to 10/13/81

Mean: 11.9°C (Based on 13 measurements)

DISCHARGE DATA

Date	
10/02/80 to 10/13/81	2 to 5 gal/min (est.)



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : MO-FF 18

COUNTY : Montgomery

NAME : River Road Spring

OWNER : State of Maryland (Highway Administration)

LATITUDE : 38°59'46"

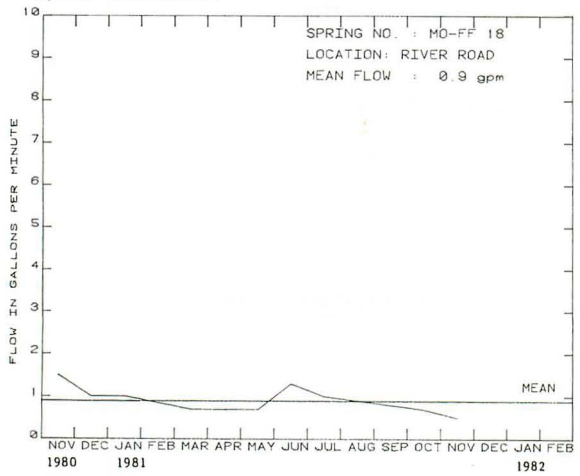
LONGITUDE : 77°09'59"

ELEVATION : 180 feet

AQUIFER : Gneiss[1]

IMPROVEMENTS : Stone ledge and plastic discharge pipe

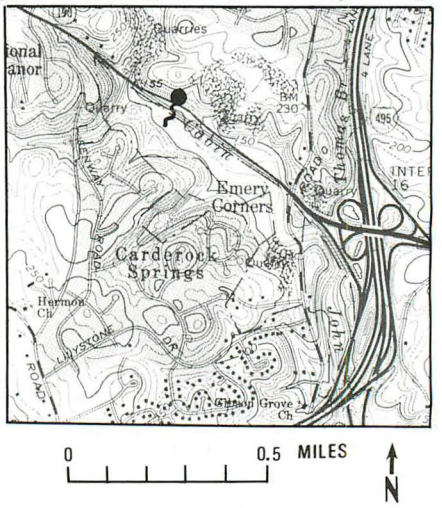
USE : Used by passersby to fill jugs and other containers



GRAPH SHOWING MONTHLY DISCHARGE

LOCATION MAP

Falls Church VA-MD 7½-minute quadrangle



TEMPERATURE DATA

Range: 10.5°C to 14.0°C (51°F to 57°F)

Period: 11/07/80 to 11/16/81

Mean: 12.3°C (Based on 13 measurements)

DISCHARGE DATA

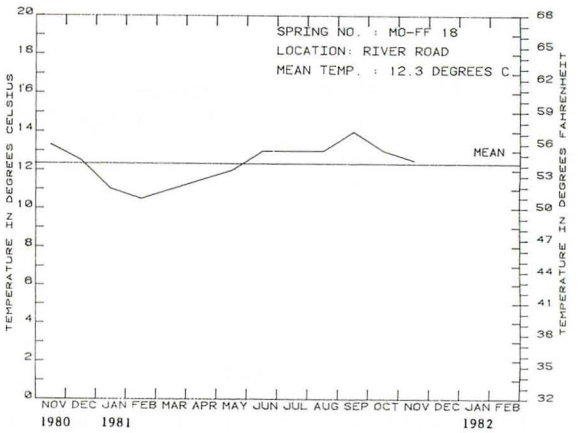
Range: 0.5 to 1.5 gal/min

Period: 11/07/80 to 11/16/81

Mean: 0.9 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
11/07/80	6.0	150	46	26
12/11/80	6.2	140	40	38
1/12/81	5.9	140	46	26
2/13/81	5.8	144	38	23



GRAPH SHOWING MONTHLY TEMPERATURE

REMARKS

Located just west of I-495 on River Road. Minimal flow probably due to removal of stone from quarry behind spring, and reduction of head.

[1] Unit D of bedrock map of Montgomery County by A. J. Froelich (1975).

SPRING NO. : MO-FG 10

COUNTY : Montgomery

NAME : Takoma Spring

OWNER : City of Takoma Park

LATITUDE : 38°58'24"

LONGITUDE : 77°00'19"

ELEVATION : 200 feet

AQUIFER : Gneiss[1]

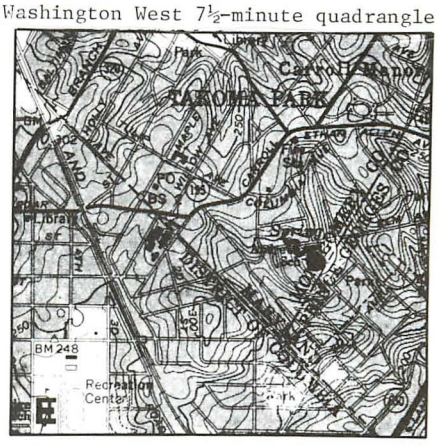
IMPROVEMENTS : Springhouse and discharge trough below Andrews School. Apparently drains into public sewer

USE : None. Spring was known and used during colonial period

PHOTOGRAPH OF SPRING Date: March 1982

LOCATION MAP

Washington West 7½-minute quadrangle



TEMPERATURE DATA

Range: 11.0°C to 17.0°C (52°F to 63°F)

Period: 10/02/80 to 10/13/81

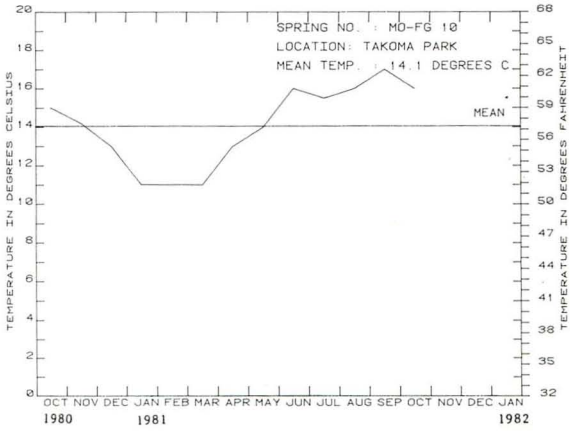
Mean: 14.1°C
(Based on 13 measurements)

DISCHARGE DATA

Date	
10/02/80 to 10/13/81	2 to 3 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/02/80	5.4	140	10	46
11/07/80	5.4	132	21	36
12/11/80	4.8	131	10	42
1/12/81	4.9	132	14	48



GRAPH SHOWING MONTHLY TEMPERATURE

REMARKS

Water may be issuing from Coastal Plain gravel at or near contact with underlying gneiss. Spring is located near Prince George's County line.

[1] Unit D of bedrock map of Montgomery County by A. J. Froelich (1975).

SPRING NO. : WA-AH 10

COUNTY : Washington

NAME : Troupe Springs

OWNER : A. G. Stotelmyer

LATITUDE : 39°40'27"

LONGITUDE : 77°47'34"

ELEVATION : 440 feet

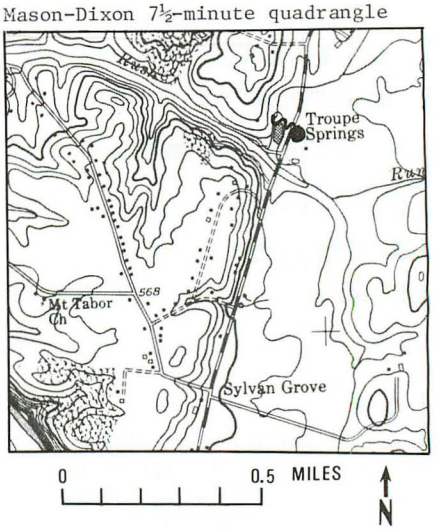
AQUIFER : St. Paul Group

IMPROVEMENTS : Discharge ditch and stone retaining wall

USE : None

LOCATION MAP

Mason-Dixon 7½-minute quadrangle



PHOTOGRAPH OF SPRING Date: March 1982

TEMPERATURE DATA

Range: 10°C to 15.7°C (50°F to 61°F)

Period: 1/28/81 to 12/08/81

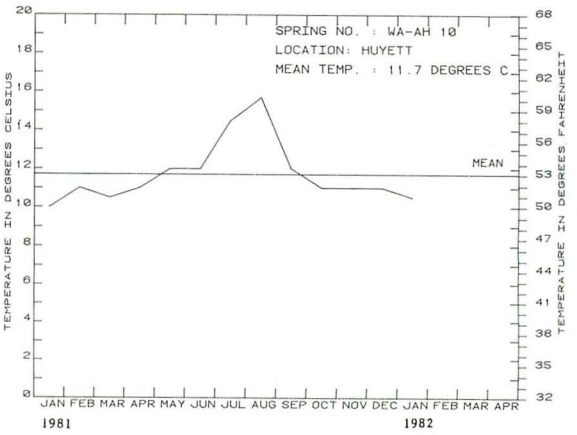
Mean: 11.7°C
(Based on 13 measurements)

DISCHARGE DATA

Date	
5/22/81 (max.)	200 to 300 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
1/28/81	7.3	740	280	40
2/25/81	7.2	640	244	30
3/18/81	7.4	630	270	52
5/22/81	7.1	660	272	43



GRAPH SHOWING MONTHLY TEMPERATURE

REMARKS

Slaughter (1962, p. 229) reports the following field tests: Hardness as $CaCO_3$ = 248 mg/L; Chloride (Cl) = 14 mg/L; and pH = 7.0.

SPRING NO. : WA-AK 3

COUNTY : Washington

NAME : Unknown

OWNER : Elwood Hauver

LATITUDE : 39°40'40"

LONGITUDE : 77°34'19"

ELEVATION : 650 feet

AQUIFER : Tomstown Formation

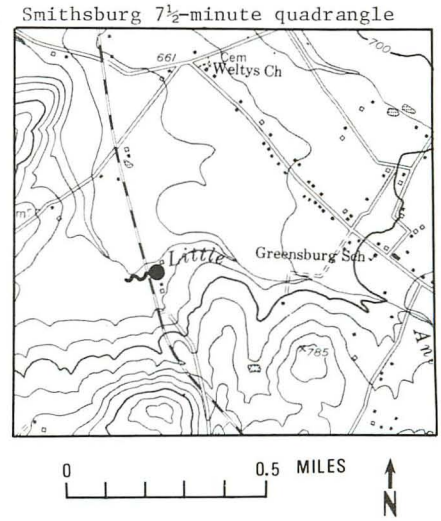
IMPROVEMENTS : Stone house built over spring that flows into a pond; retaining wall around pond. Water discharges through a culvert under the highway

USE : Domestic supply and heat pump

PHOTOGRAPH OF SPRING Date: March 1982

LOCATION MAP

Smithsburg 7½-minute quadrangle



TEMPERATURE DATA

Range: 7.0°C to 14.0°C (45°F to 57°F)

Period: 3/17/81 to 2/19/82

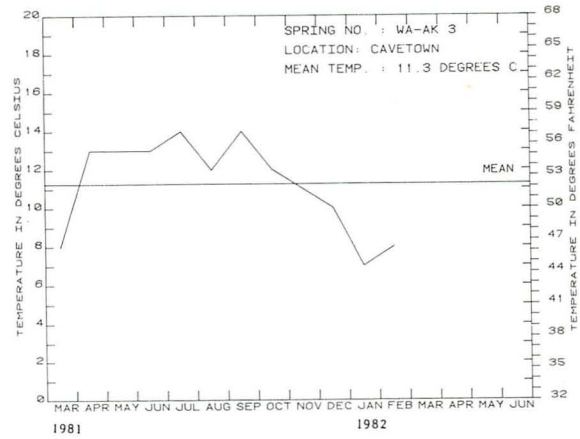
Mean: 11.3°C
(Based on 13 measurements)

DISCHARGE DATA

Date	
3/15/81 to 4/21/81	290 to 3,140 gal/min[1] (meas.) (0.6 to 7.0 ft^3/s)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
3/17/81	7.4	250	70(?)	48
4/10/81	8.0	405	146	68
5/26/81	7.0	370	135	58
6/18/81	7.0	240	86	47



GRAPH SHOWING MONTHLY TEMPERATURE

REMARKS

Owner uses spring for air conditioning in summer and for heating in winter.

[1] Flow measurements reported by Martin Walther of the Maryland Water Resources Administration.

SPRING NO. : WA-AK 32

COUNTY : Washington

NAME : Glen Afton Spring

OWNER : Washington County Parks

LATITUDE : 39°42'54"

LONGITUDE : 77°30'41"

ELEVATION : 1,180 feet

AQUIFER : Weverton Quartzite

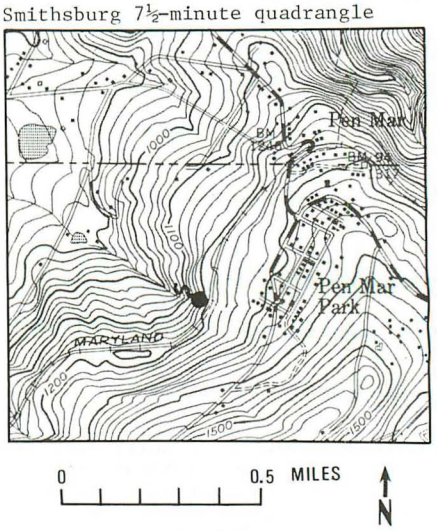
IMPROVEMENTS : Formerly had a frame shelter over spring pit with a pipeline running uphill to the resort park, which has been partially restored

USE : Not used for many years prior to 1982. This spring was formerly the supply for Pen Mar Park and may have supplied some dwellings in the Town of Pen Mar

PHOTOGRAPH OF SPRING Date: November 1982

LOCATION MAP

Smithsburg 7½-minute quadrangle



TEMPERATURE DATA

Date	
10/21/82	10.5°C (50.5°F)
10/28/82	10.5°C (50.5°F)
11/18/82	11.0°C (52°F)
1/13/83	10.0°C (50°F)
2/10/83	10.0°C (50°F)
3/25/83	10.5°C (50.5°F)

DISCHARGE DATA

Date	
10/28/82	3.0 gal/min (meas.)[1]
11/18/82	4.4 gal/min (meas.)
12/15/82	1.0 gal/min (meas.)
1/13/83	1.0 gal/min (meas.)
2/10/83	0.7 gal/min (meas.)
3/25/83	7.7 gal/min (meas.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
10/21/82	6.4	40	-	33
11/18/82	5.6	44	-	30
12/15/82	5.4	44	-	32
1/13/83	5.8	-	-	36
2/10/83	6.0	-	-	32
3/25/83	5.3	68	-	40

REMARKS

Spring located west of Western Maryland Railroad tracks about 0.4 mile south of point where railroad tracks cross the Pennsylvania State line. Spring is downhill from site of restored park in Town of Pen Mar.

[1] Measured at tile discharge pipe on hillside. Some leakage occurring so that total flow of spring could not be measured--may be two to three times the quantity measured. Mean of six measured flows (1982-83)= 3.0 gal/min.

SPRING NO. : WA-BF 3

COUNTY : Washington

NAME : Big Spring

OWNER : Mrs. Leroy P. Clark

LATITUDE : 39°37'46"

LONGITUDE : 77°56'21"

ELEVATION : 420 feet

AQUIFER : Conococheague Limestone

IMPROVEMENTS : House built above main spring outlet. Small springhouse located to the south

USE : Domestic

PHOTOGRAPH OF SPRING Date: March 1982

CHEMICAL ANALYSIS (field)

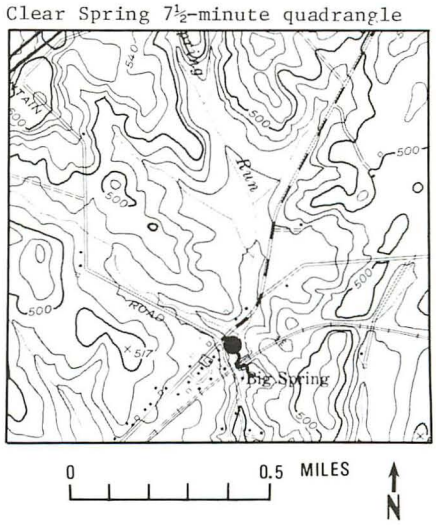
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
1/28/81	7.9	400	171	29
2/25/81	7.0	380	160	20
3/18/81	7.4	400	164	40
5/26/81	7.5	400	178	42

REMARKS

Flow measured by Slaughter (1962, table 39).

LOCATION MAP

Clear Spring 7½-minute quadrangle



TEMPERATURE DATA

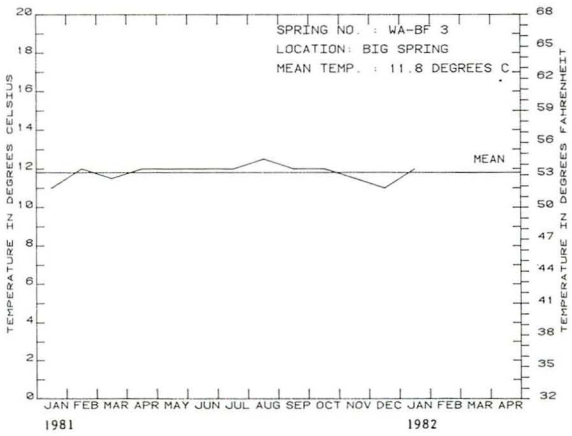
Range: 11.0°C to 12.5°C (52°F to 54.5°F)

Period: 1/28/81 to 12/08/81

Mean: 11.8°C
(Based on 12 measurements)

DISCHARGE DATA

Date	
May 1958	1,100 gal/min (meas.)



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : WA-BF 24

COUNTY : Washington

NAME : Clear Spring

OWNER : Town of Clear Spring (?)

LATITUDE : 39°39'19"

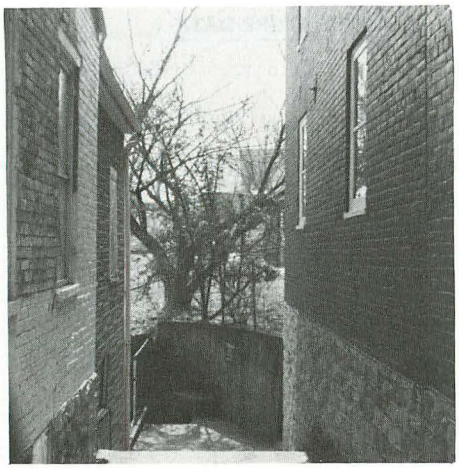
LONGITUDE : 78°55'49"

ELEVATION : 550 feet

AQUIFER : Conococheague Limestone

IMPROVEMENTS : Concrete shed with trough

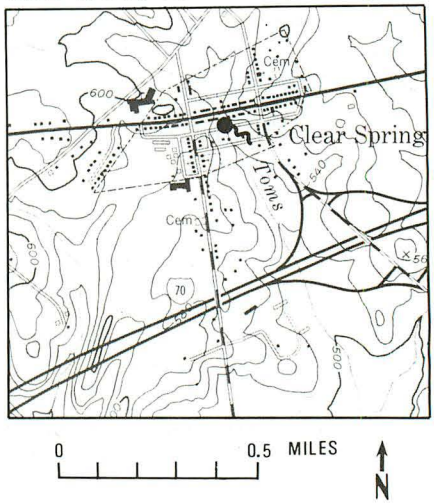
USE : None. Nearby sign says "Unsafe to Drink"



PHOTOGRAPH OF SPRING Date: March 1982

LOCATION MAP

Clear Spring 7½-minute quadrangle



TEMPERATURE DATA

Range: 12.0°C to 13.0°C (53.6°F to 55.4°F)

Period: 4/17/81 to 3/11/82

Mean: 12.3°C
(Based on 12 measurements)

DISCHARGE DATA

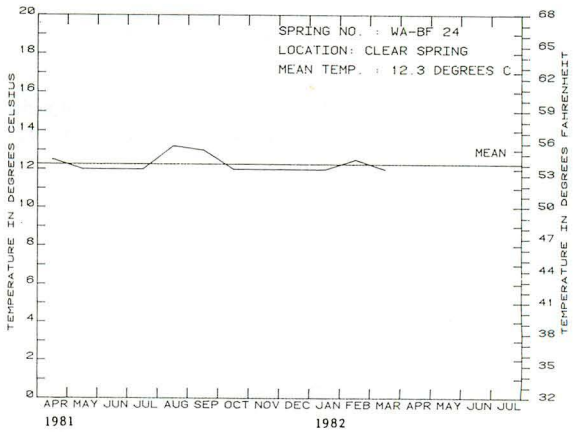
Date	
6/18/81 (max.)	3 to 5 gal/min (est.)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
5/26/81	7.3	510	200	46
6/18/81	7.4	500	221	50
7/17/81	7.5	510	-	-
8/11/81	7.0	567	-	-
6/08/82	6.9	-	-	-

REMARKS

This is reported to be the original "clear spring" from which the town was named. Twelve-inch trout observed in stone-lined trough leading away from spring.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : WA-BI 36

COUNTY : Washington

NAME : Museum Spring

OWNER : City of Hagerstown

LATITUDE : 39°38'07"

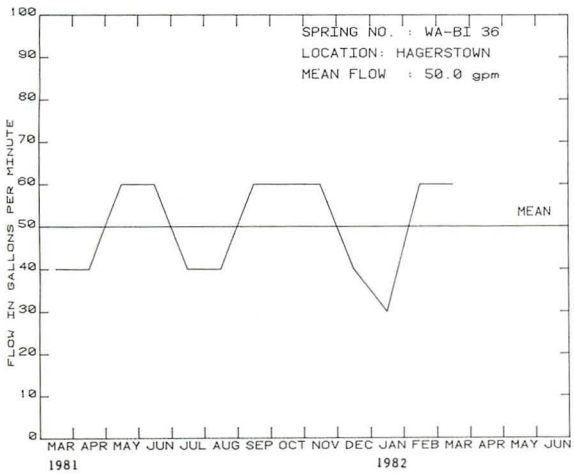
LONGITUDE : 77°43'53"

ELEVATION : 550 feet

AQUIFER : Stonehenge Formation

IMPROVEMENTS : Stone and concrete dam forming a small pool

USE : None, except to supply pond in city park



GRAPH SHOWING MONTHLY DISCHARGE

CHEMICAL ANALYSIS (field)

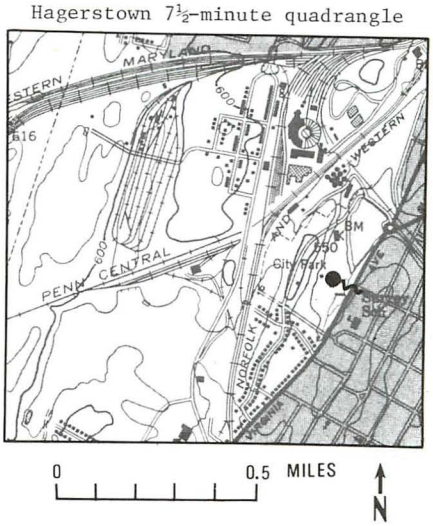
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
4/17/81	6.4	730	290	54
5/26/81	6.9	697	294	45
6/18/81	7.0	700	284	59
7/17/81	7.2	700	-	-
4/29/82	7.3	-	-	-

REMARKS

This is one of a group of springs feeding ponds in the city park. High flow rate measured with 2-gallon container.

LOCATION MAP

Hagerstown 7½-minute quadrangle



TEMPERATURE DATA

Range: 11.0°C to 13.3°C (52°F to 56°F)

Period: 3/18/81 to 2/19/82

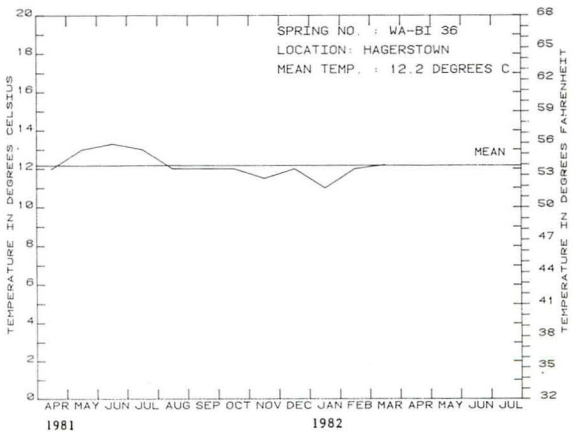
Mean: 12.2°C
(Based on 12 measurements)

DISCHARGE DATA

Range: 30 to 60 gal/min

Period: 3/18/81 to 2/19/82

Mean: 50 gal/min



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : WA-CH 2

COUNTY : Washington

NAME : St. James Spring

OWNER : St. James School

LATITUDE : 39°34'27"

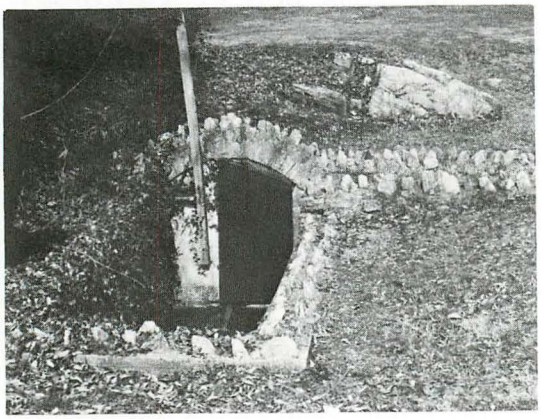
LONGITUDE : 77°45'33"

ELEVATION : 490 feet

AQUIFER : Conococheague Limestone

IMPROVEMENTS : Stone house with door and walled discharge channel

USE : School use



PHOTOGRAPH OF SPRING Date: March 1982

CHEMICAL ANALYSIS (field)

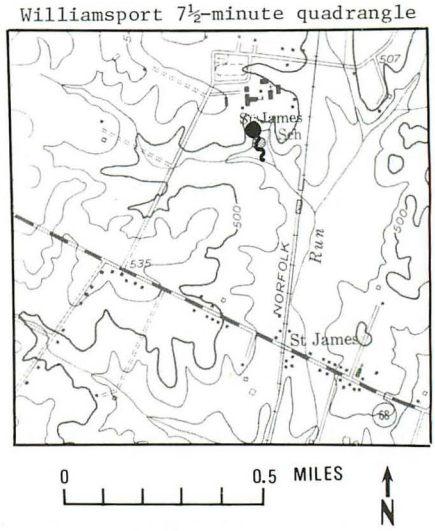
Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
5/26/81	7.1	650	264	46
6/18/81	7.3	652	294	54
7/17/81	7.5	620	-	-
8/11/81	6.8	694	-	-

REMARKS

Slaughter reports flow of 860 gal/min on 5/29/58 (1962, table 43).

LOCATION MAP

Williamsport 7½-minute quadrangle



TEMPERATURE DATA

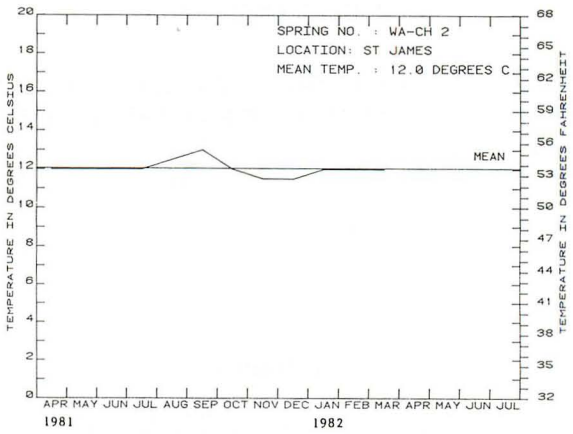
Range: 11.5°C to 13.0°C (53°F to 55°F)

Period: 4/17/81 to 3/11/82

Mean: 12.0°C
(Based on 12 measurements)

DISCHARGE DATA

Date	
4/21/81	337 gal/min (meas.) (0.75 ft^3/s)



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : WA-CI 83

COUNTY : Washington

NAME : Unknown

OWNER : Robert Beckley

LATITUDE : 39°33'33"

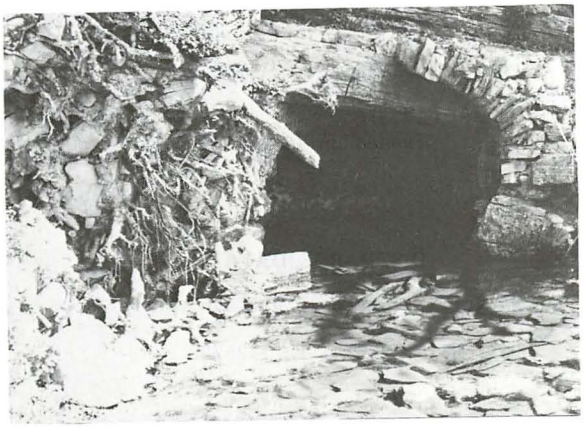
LONGITUDE : 77°44'08"

ELEVATION : 460 feet

AQUIFER : Conococheague Limestone

IMPROVEMENTS : None

USE : None, except by cattle in pasture



PHOTOGRAPH OF SPRING Date: May 1982

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
5/11/82	7.5	520	-	-
6/08/82	6.7	-	-	-

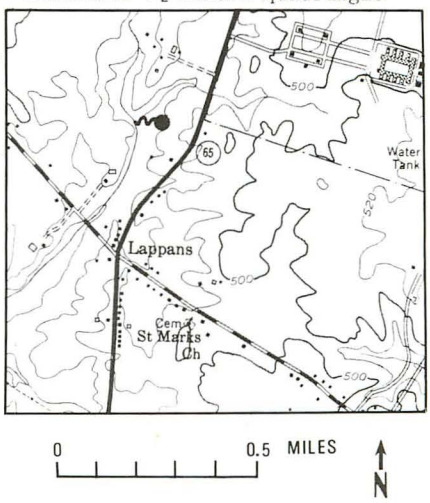
REMARKS

Field test for nitrate = 1.9 mg/L on 5/11/82.

[1] Measured by L. J. Nutter and M. J. Smigaj

LOCATION MAP

Funkstown 7½-minute quadrangle



TEMPERATURE DATA

Date	
5/11/82	12°C (54°F)
6/08/82	14°C (57°F)

DISCHARGE DATA

Date	
7/06/77	150 gal/min (meas.)[1]
5/11/82	25 to 50 gal/min (est.)

SPRING NO. : WA-CJ 68

COUNTY : Washington

NAME : Unknown

OWNER : State of Maryland (Highway Administration)

LATITUDE : 39°33'55"

LONGITUDE : 77°36'45"

ELEVATION : 760 feet

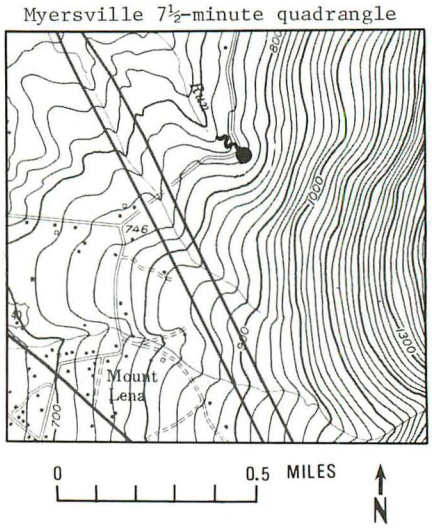
AQUIFER : Quaternary Alluvium

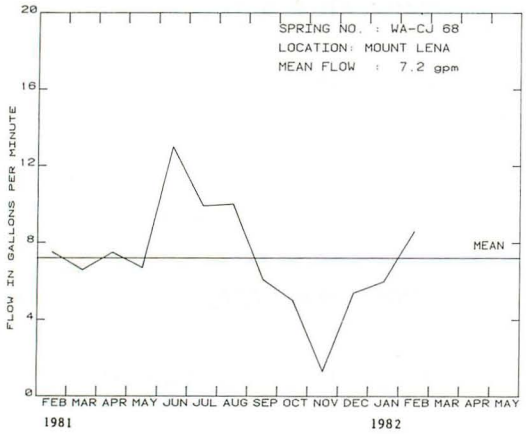
IMPROVEMENTS : Pit and discharge pipe

USE : None, except for passersby

LOCATION MAP

Myersville 7½-minute quadrangle





GRAPH SHOWING MONTHLY DISCHARGE

TEMPERATURE DATA

Range: 1.0°C to 19.9°C (34°F to 68°F)

Period: 2/25/81 to 2/19/82

Mean: 10.3°C (Based on 13 measurements)

DISCHARGE DATA

Range: 1.3 to 13 gal/min

Period: 2/25/81 to 1/25/82

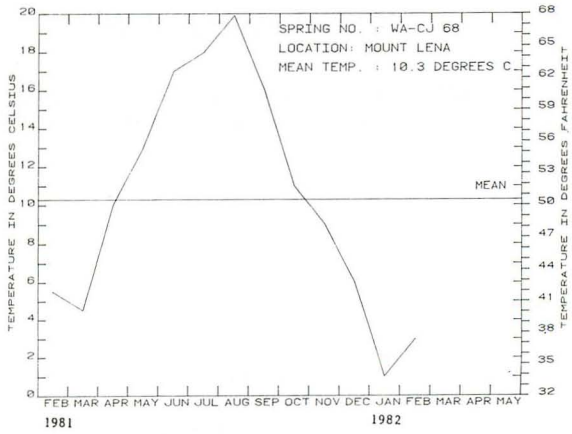
Mean: 7.2 gal/min

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
3/24/81	6.7	24	14	25
4/17/81	6.8	29	10	25
5/26/81	6.6	18	6	33
6/18/81	6.6	19	15	24

REMARKS

Note wide range in measured temperature and flow values.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : WA-DI 6

COUNTY : Washington

NAME : Keedysville Spring

OWNER : Town of Keedysville

LATITUDE : 39°29'15"

LONGITUDE : 77°41'33"

ELEVATION : 370 feet

AQUIFER : Tomstown Formation

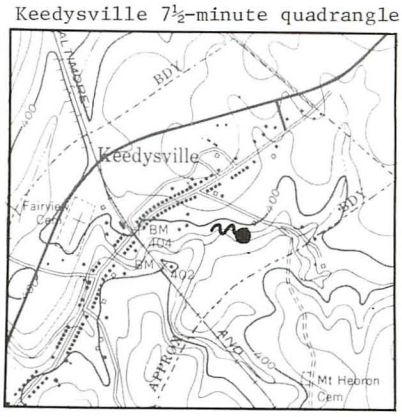
IMPROVEMENTS : Storage tank and water pumping facilities.

USE : Supplies Keedysville and Boonsboro.

PHOTOGRAPH OF SPRING Date: March 1982

LOCATION MAP

Keedysville 7½-minute quadrangle



TEMPERATURE DATA

Range: 11.0°C to 12.6°C (52°F to 55°F)

Period: 4/22/81 to 3/11/82

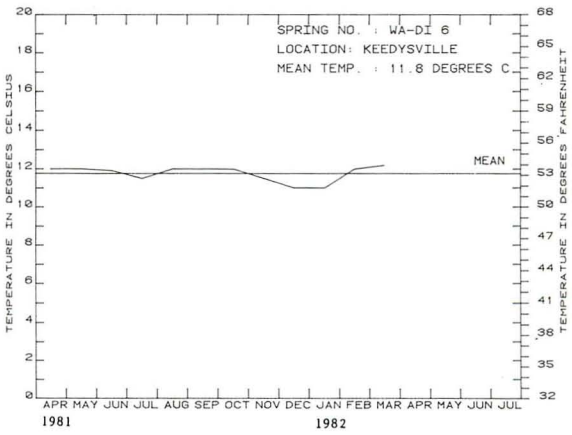
Mean: 11.8°C
(Based on 12 measurements)

DISCHARGE DATA

Date	
4/22/81	1,603 gal/min (meas.) (3.57 ft^3/s)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
5/26/81	7.3	498	218	34
6/18/81	7.4	500	200	36
7/17/81	7.4	470	-	-
8/11/81	-	517	-	-



GRAPH SHOWING MONTHLY TEMPERATURE

REMARKS

On May 22, 1958, T. H. Slaughter reported the following field test results on this spring (table 43, p. 235): Total iron (Fe) = 0 mg/L; Hardness = 222 mg/L, Chloride (Cl) = 11 mg/L; and pH = 7.2.

SPRING NO. : WA-DI 8

COUNTY : Washington

NAME : Sharpsburg Spring

OWNER : Town of Sharpsburg

LATITUDE : 39°27'28"

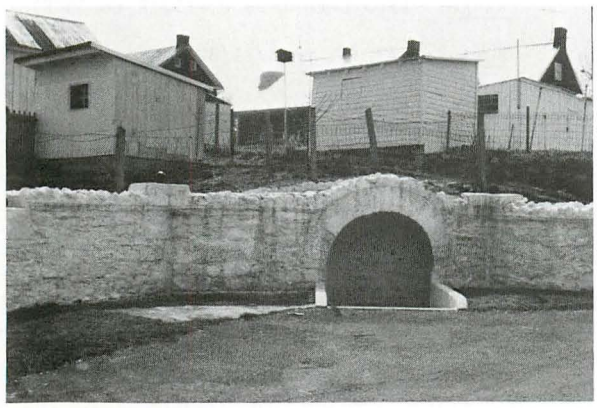
LONGITUDE : 77°44'54"

ELEVATION : 410 feet

AQUIFER : Conococheague Limestone

IMPROVEMENTS : Stone wall and concrete pit

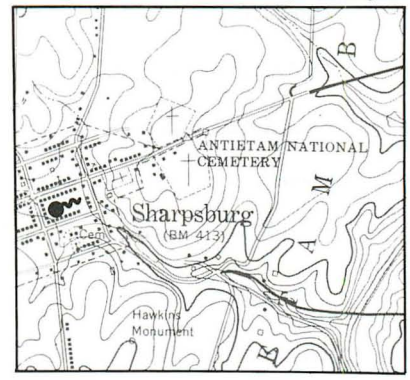
USE : May be used by local passersby. Spring reported to be contaminated



PHOTOGRAPH OF SPRING Date: March 1982

LOCATION MAP

Keedysville 7½-minute quadrangle



0 0.5 MILES N

TEMPERATURE DATA

Range: 12.0°C to 14.0°C (54°F to 57°F)

Period: 4/17/81 to 3/11/82

Mean: 12.5°C
(Based on 12 measurements)

DISCHARGE DATA

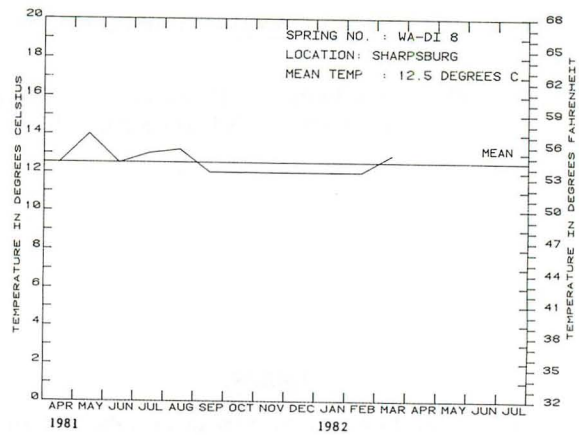
Date	
4/22/81	300 gal/min (meas.) (0.67 ft^3/s)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
4/17/81	6.6	600	224	41
5/26/81	7.3	530	209	40
6/18/81	7.4	530	239	37
7/17/81	7.6	500	-	-

REMARKS

T. H. Slaughter reported the following field test on April 29, 1959, for this spring (1962, table 43): Total iron (Fe) = 0 mg/L; Hardness = 248 mg/L; Chloride (Cl) = 14 mg/L; and pH = 7.0.



GRAPH SHOWING MONTHLY TEMPERATURE

SPRING NO. : WA-EJ 4

COUNTY : Washington

NAME : Part of Yourtee Spring group

OWNER : Town of Brunswick

LATITUDE : 39°22'32"

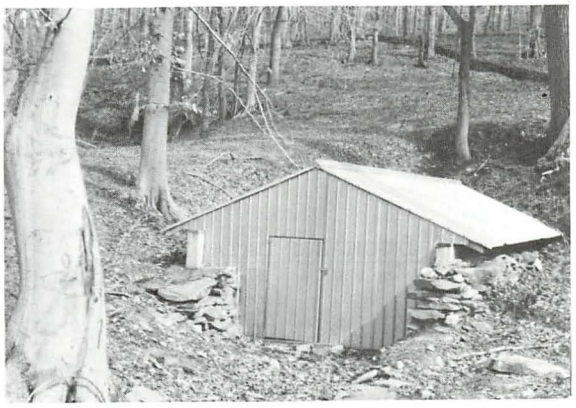
LONGITUDE : 77°39'34"

ELEVATION : 590 feet

AQUIFER : Catoctin Formation[1]

IMPROVEMENTS : Concrete walled pit with metal shed and roof

USE : Supplies Town of Brunswick (in Frederick County)



PHOTOGRAPH OF SPRING Date: March 1982

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
8/28/81	6.9	156	-	34

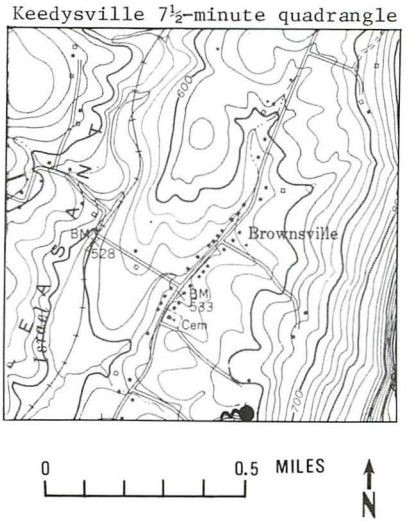
REMARKS

This spring and WA-EJ 5 are about 100 feet distant. Both feed into a single collecting chamber where they flow by gravity to the Town of Brunswick. See record of WA-EJ 5 for flow measurements and temperature and chemical data. These springs were first inventoried by Slaughter in 1958 (1962, table 3). Location may be slightly south of point shown.

[1] The water may be, in part, from colluvium at the base of the mountain.

LOCATION MAP

Keedysville 7½-minute quadrangle



TEMPERATURE DATA

Date	
8/28/81	13.0°C (52°F)
9/25/81	12.0°C (51°F)
10/15/81	11.5°C (53°F)

DISCHARGE DATA

Date	
10/15/81	12 to 15 gal/min (est.)

SPRING NO. : WA-EJ 5

COUNTY : Washington

NAME : Yourtee Spring

OWNER : Town of Brunswick

LATITUDE : 39°22'32"

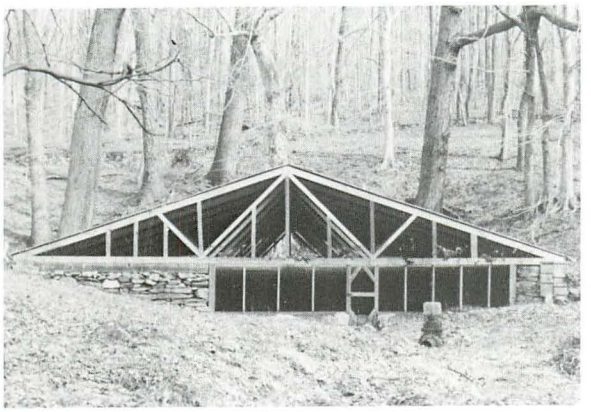
LONGITUDE : 77°39'34"

ELEVATION : 590 feet

AQUIFER : Catoctin Formation

IMPROVEMENTS : Wood and steel shed over stone-walled basin. Discharge pipe to central collecting basin

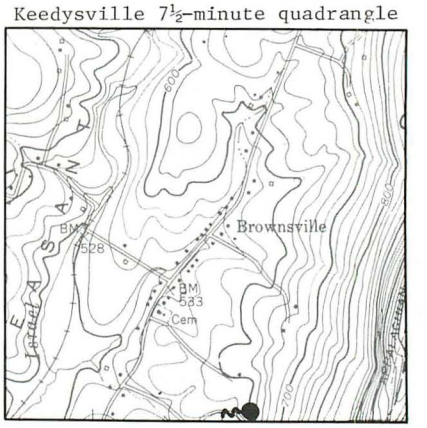
USE : Supplies Town of Brunswick (in Frederick County)



PHOTOGRAPH OF SPRING Date: March 1982

LOCATION MAP

Keedysville 7½-minute quadrangle



0 0.5 MILES N

TEMPERATURE DATA

Date		
9/25/81	12.0°C	(52°F)
10/15/81	11.5°C	(51°F)
4/29/82	13.0°C	(55°F)

DISCHARGE DATA

Date	
10/13/81	149 gal/min[1] (0.33 ft^3/s)
10/14/81	146 gal/min (0.32 ft^3/s)

CHEMICAL ANALYSIS (field)

Date	pH	Conductivity (µmhos/cm)	Hardness (mg/L as $CaCO_3$)	Chloride (mg/L)
9/25/81	6.7	148	-	-
10/15/81	7.4	144	-	-
4/29/82	7.2	-	-	-

REMARKS

T. H. Slaughter reported the flow of this spring was 170 gal/min on January 8, 1958 (1962, table 43). Flow estimated at 400 to 500 gal/min on 4/29/82. Spring is situated at the foot of the west side of South Mountain.

[1] Combined flow of springs WA-EJ 4 and EJ 5 measured at water treatment plant in Brunswick.

CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

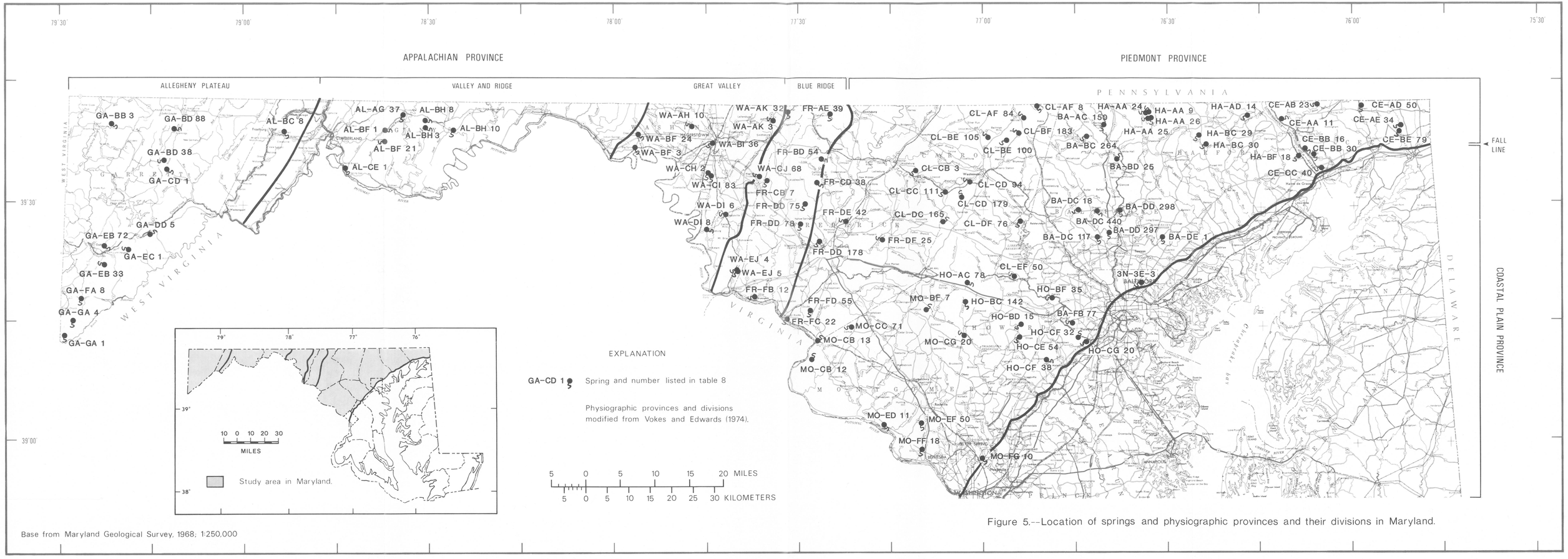
Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	0.003785	cubic meter (m^3)
million gallons (Mgal)	3,785	cubic meter (m^3)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon per minute (gal/min)	0.0608	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
	Transmissivity	
square foot per day (ft^2/d)	0.09290	square meter per day (m^2/d)
	Temperature	
degree Fahrenheit (°F)	°C = 5/9 (°F-32)	degree Celsius (°C)
	Specific Conductance	
micromho per centimeter at 25° Celsius (μmho/cm at 25°C)	1.000	microseimens per centimeter at 25° Celsius (μS/cm at 25°C)

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level, is referred to as sea level in this report.

MARYLAND GEOLOGICAL SURVEY
The Rotunda
711 W. 40th Street
Baltimore, Maryland 21211

Selected Reports of Investigations:

3. Water resources of the Salisbury area, Maryland, by D. H. Boggess and S. G. Heidel, 1968, 69 p. $3.00
5. Chemical quality reconnaissance of water of Maryland streams, by J. D. Thomas, 1966, 61 p. 2.00
9. Chemical and physical character of municipal water supplies in Maryland, by J. D. Thomas and S. G. Heidel, 1969, 52 p. 1.00
10. Ground-water occurrence in the Maryland Piedmont, by L. J. Nutter and E. G. Otton, 1969, 56 p. 2.50
13. Extent of brackish water in the tidal rivers of Maryland, by W. E. Webb and S. G. Heidel, 1970, 46 p. 1.50
14. Geologic and hydrologic factors bearing on subsurface storage of liquid wastes in Maryland, by E. G. Otton, 1970, 39 p. 2.75
17. Water resources of Dorchester and Talbot Counties, Maryland: With special emphasis on the ground-water potential of the Cambridge and Easton areas, by F. K. Mack, W. E. Webb, and R. A. Gardner, 1971, 107 p. 5.25
18. Solid-waste disposal in the geohydrologic environment of Maryland, by E. G. Otton, 1972, 59 p. 3.00
19. Hydrogeology of the carbonate rocks, Frederick and Hagerstown Valleys, Maryland, by L. J. Nutter, 1973, 70 p. 3.50
20. Hydrogeology of the formation and neutralization of acid waters draining from underground coal mines of western Maryland, by E. F. Hollyday and S. W. McKenzie, 1973, 50 p. 2.25
22. An evaluation of the Magothy Aquifer in the Annapolis area, Maryland, by F. K. Mack, 1974, 75 p. 3.00
24. Availability of fresh ground water in northeastern Worcester County, Maryland: With special emphasis on the Ocean City area, by J. M. Weigle, 1974, 64 p. 4.00
26. Hydrogeology of the Triassic rocks of Maryland, by L. J. Nutter, 1975, 37 p. 2.50
28. Digital simulation and prediction of water levels in the Magothy Aquifer in Southern Maryland, by F. K. Mack and R. J. Mandle, 1977, 42 p. 3.00
31. Simulated changes in water level in the Piney Point Aquifer in Maryland, by J. F. Williams III, 1979, 50 p. 6.25
33. A quasi three-dimensional finite-difference ground-water flow model with a field application, by G. Achmad and J. M. Weigle, 1979, 22 p. with appendix 6.50
34. The availability of ground water in western Montgomery County, Maryland, by E. G. Otton, 1981, 76 p. 5.75
35. Characteristics of streamflow in Maryland, by D. H. Carpenter, 1983, 237 p. 12.50
37. Geohydrology of the fresh-water aquifer system in the vicinity of Ocean City, Maryland, with a section on simulated water-level changes, by J. M. Weigle and G. Achmad, 1982, 55 p. 10.00
38. Hydrogeology, digital simulation, and geochemistry of the Aquia and Piney Point-Nanjemoy aquifer system in Southern Maryland, by F. H. Chappelle and D. D. Drummond, 1983, 100 p. 14.50
39. Hydrogeology of the upper Chesapeake Bay area, Maryland, with emphasis on aquifers in the Potomac Group, by E. G. Otton and R. J. Mandle, 1984, 62 p. 11.00
41. First report on the hydrologic effects of underground coal mining in southern Garrett County, Maryland, by M. T. Duigon and M. J. Smigaj, 1985, 99 p. 6.75
42. Maryland springs — their physical, thermal, and chemical characteristics, by E. G. Otton and J. T. Hilleary, 1985, 151 p. 11.25



Base from Maryland Geological Survey, 1968; 1:250,000

Figure 5.--Location of springs and physiographic provinces and their divisions in Maryland.