MARYLAND GEOLOGICAL SURVEY
REPORT OF INVESTIGATIONS NO. 5

CHEMICAL QUALITY RECONNAISSANCE OF WATER OF MARYLAND STREAMS

By
Jolly D. Thomas

prepared in cooperation with the

GEOLOGICAL SURVEY
UNITED STATES DEPARTMENT OF THE INTERIOR

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Kenneth N. Weaver, *Director*

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CHEMICAL QUALITY RECONNAISSANCE OF WATER OF MARYLAND STREAMS

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Abstract

This is the first report of a systematic study of the chemical quality of Maryland streams. The sampling program was designed to cover the whole State on the reconnaissance level.

Surface waters of Maryland are satisfactory for most industrial, agricultural, and municipal uses. Most of the water is of the calcium bicarbonate type. Streams on the Eastern Shore above salt-water encroachment have dissolved-solids concentration less than 100 ppm (parts per million). Streams on the Piedmont contain a higher range of dissolved-solids concentration than streams on the Coastal Plain because of geologic conditions. The streams draining the eastern part of the Appalachian Region contain hard water.

Western Maryland streams receiving acid mine drainage are: North Branch Potomac, Youghiogheny, and Savage Rivers, Georges Creek, and some tributaries to these streams.

The streams entering the Potomac River vary in chemical quality. The type of water in the Potomac River will depend upon the discharge and the quality of water contributed by these streams.

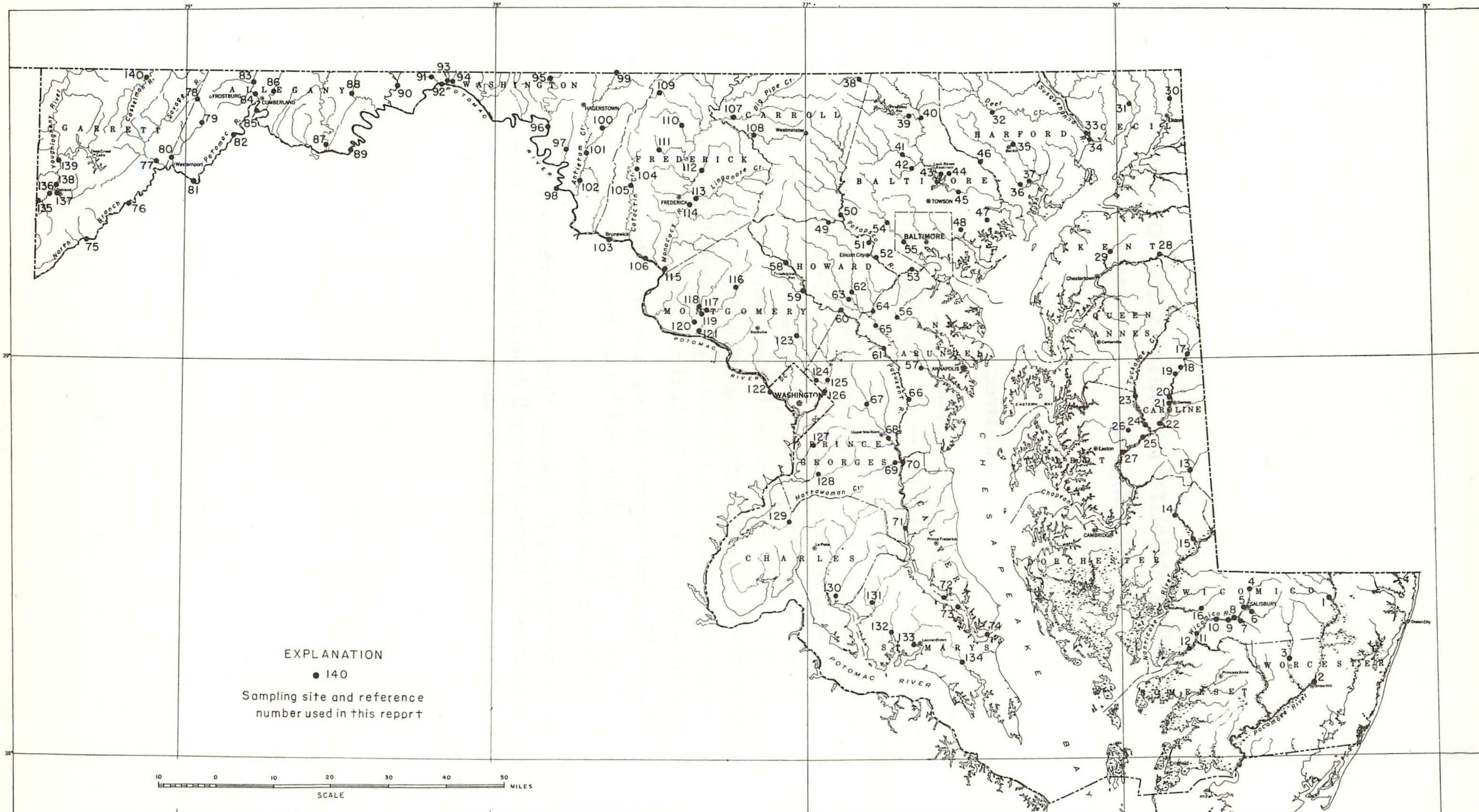

Figure 1—Map showing location of sampling sites.

Introduction

Purpose and scope of investigation

Nearly every major stream in Maryland is undergoing development or is being considered as a source of water for future needs. Since no systematic chemical study had been made of the surface streams of the State, this reconnaissance was undertaken to obtain the basic data necessary to define the general chemical quality of the State's streams and to pinpoint areas for more extensive investigation.

The U. S. Geological Survey began a 2-year chemical quality reconnaissance of the surface streams of the State on July 1, 1963 in cooperation with the Maryland Geological Survey. Samples were collected for chemical analysis at 140 locations. Figure 1 shows the location of sampling sites and the station identification number used in this report. These numbers correspond to the numbers in the table of analyses. Field determinations of pH, temperature and specific conductance were made at several additional locations to further define the areal changes in quality. Seven stations on the major streams were sampled periodically to indicate seasonal variations.

The station locations were selected to (1) define the dominant chemical characteristics of major streams, (2) define the quality of water draining major geologic formations and (3) determine the quality of water below known sources of pollution. The reports of the Maryland Geological Survey were very helpful in locating stations to determine the effect of geology on stream quality. Wherever possible, stations were located at gaging stations because records of streamflow are necessary to determine the relationship between discharge rate and chemical quality changes. In interpreting the results of laboratory analyses consideration was given to flow and seasonal conditions prevailing during the period of the observations, and to concentration of those mineral constituents in the water which might be critical for the particular water uses anticipated. Discharge measurements were usually made at sampling locations or the records of nearby gages were extrapolated to determine the rate of flow.

Acknowledgments

This report was prepared for publication by the Maryland Geological Survey, Dr. Kenneth N. Weaver, Director and under the supervision of John W. Wark, District Chief, U. S. Geological Survey.

The chemical analyses were made in the U. S. Geological Survey laboratory in Washington, D. C. under the direction of Herman R. Feltz.

Summary

Interest in the chemical quality of water was stimulated to a large degree by the growth of industry. An increasing population and a rising standard of living call for expanding industries, municipalities, agricultural activities, and recreational activity, all of which greatly increase the quantity of water used. This increased use of water usually causes a deterioration in the quality of water.

Streams in the western part of the State are affected by acid mine drainage. The North Branch Potomac River is polluted for almost its entire length either by mine drainage or industrial waste.

Antietam and Conococheague Creeks contain water that is hard because of the geologic conditions.

The North and South Branch Potomac join near Oldtown to form the Potomac River. The South Branch Potomac contains water of good chemical quality and the mixing of the streams improves the quality of the water from the North Branch Potomac.

The Potomac River is the dominant river in the State and drains about one-third of the State. The chemical quality changes with both time and place. The North Branch Potomac contains calcium sulfate type water, which reflects the mine drainage and industrial waste in the area. In the vicinity of Hancock, the water begins to change from a calcium sulfate type to calcium bicarbonate sulfate water. The Potomac River from Point of Rocks to the head of tide is a calcium bicarbonate type water most of the time. Pollution from the Washington, D. C. area has an important effect also on the chemical and biological quality of the water downstream from Point of Rocks. The Monocacy River basin drains streams that are high in dissolved-solids concentrations and other streams which run comparatively low in dissolved-solids concentration.

Streams in the Coastal Plain generally have water that contains dissolved-solids concentrations less than 100 ppm, unless affected by tidal encroachment of salt water.

In any individual stream basin and at any particular station many factors may contribute to the quality of the water. Only in small isolated basins will the quality be completely dominated by natural phenomena. In most streams, the chemical quality of the water is due to a complex mixture of elements leached from the soils and rocks plus industrial, domestic, or agricultural wastes. In many streams, one factor (generally geology) will determine the type of water quality. However, a knowledge of other controlling quality factors is necessary so that sources of pollution can be recognized and evaluated.

Description of Maryland

Maryland has an area of 12,303 square miles of which 9,887 square miles is land; 2,310 square miles is Chesapeake Bay and its tidal rivers; and 106 square miles is in Chincoteague Bay. The extreme width from east to west is 240 miles; the extreme length from north to south is 125 miles. The altitudes range from sea level to 3,360 feet at the summit of Backbone Mountain in Garrett County. The climate is as varied as its surface configuration. The region near the Chesapeake Bay has almost an "oceanic" climate while the rest of the State can be considered to be "continental" (Vokes, 1957, p. 19). Mean annual temperatures range from 46° in western Garrett County to 60° in southern Maryland. Precipitation ranges from 36 to 48 inches, the lowest in Allegany and the highest in Garrett and Worcester Counties.

The State lies in five well-defined physiographic provinces which can be further subdivided. These divisions are defined by differences in both physiography and geology which have a profound effect upon the quality of the streams draining these areas. The provinces are: the Coastal Plain, the Piedmont, the Blue Ridge, the Valley and Ridge, and the Appalachian Plateau. The locations of these provinces and their subdivisions are shown in figure 2.

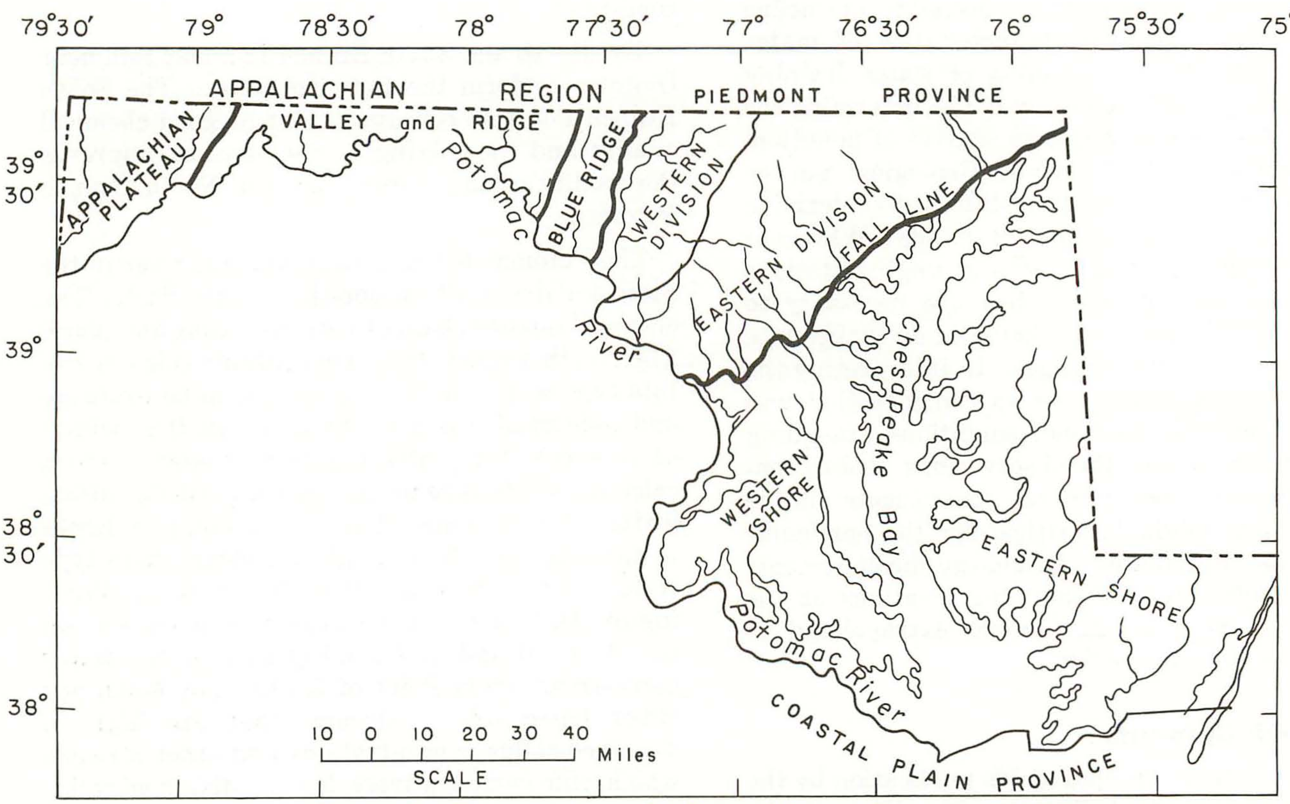

Figure 2—Map showing physiographic provinces and divisions.

The Coastal Plain province

The Atlantic Coastal Plain, bordered on the east by the Continental Shelf and on the west by the Piedmont province, is partly submerged. The surface slopes gently to the southeast and is underlain by southeastward-dipping unconsolidated sedimentary rocks. These formations are Cretaceous to Miocene in age and are overlain in some parts of the area by a mantle of Pliocene and Pleistocene sediments.

Along the west edge of the Coastal Plain, these sediments feather out over the crystalline rocks of the Piedmont province. In stream valleys this boundary, frequently called the "Fall Line," is marked by the development of rapids and falls.

Streams developed in the sediments of the Coastal Plain have low longitudinal profiles and meandering or braided courses. These streams discharge into estuaries, the Chesapeake Bay, or the Atlantic Ocean. Much of the low-lying marsh area along shorelines is tidal. Areas overlain by surficial sands and gravels exhibit the characteristically low-drainage densities associated with sediments having good internal drainage.

The Piedmont province

This province extends from the Fall Line to the slopes of the Catoctin Mountains. It is marked by a broad undulating surface with low knobs and ridges rising above the general elevation and incised by numerous deep and narrow stream valleys. The low undulating hills gradually rise in elevation and terminate at Parrs Ridge which rises several hundred feet above the surrounding area.

In Carroll County, Parrs Ridge divides streams flowing directly into the Chesapeake Bay and those draining into the Potomac River and is the boundary between eastern and western divisions of the Piedmont province.

The eastern division is underlain by complex metamorphic rocks including gneiss, slates, phyllites, schists, marble, serpentine, and granite. The streams have steep gradients. Rapids and waterfalls are common.

The western division is underlain by metamorphic rocks in the east and by Cambrian and Ordovician limestones, shales, sandstones, and siltstones in the western part (Frederick Valley). Most of the streams in the western division are in the Monocacy drainage basin.

The Appalachian Region

The part of Maryland lying west of the Piedmont province is in the Appalachian Region. Its three main divisions are the Blue Ridge province, the Valley and Ridge province, and the Appalachian Plateau province. The eastern part of the Valley and Ridge province is known as the Great Valley, or in Maryland as the Hagerstown Valley. It is a broad, gently rolling lowland underlain by Cambrian and Ordovician limestones and Ordovician shales. The valley is drained by Antietam and Conococheague Creeks. West of the valley is a series of ridges and valleys underlain with massive sandstones, shales, and limestones.

The westernmost counties of the State are in the broad, rolling upland, the Appalachian Plateau province. The average elevation is about 2,000 feet and the highest point in the State is in this area at Backbone Mountain in Garrett County. The area is deeply incised by stream valleys and the streams are shallow and turbulent. They drain consolidated sedimentary rocks, including shales and siltstones and smaller amounts of coals and limestones.

Previous investigations

For Maryland's Eastern Shore, some quality of surface-water data are available. Murphy (1957) has surveyed the tidal encroachment of salt water in the Pocomoke, Wicomico, Nanticoke, Choptank, and Chester Rivers. About 30 samples for chemical analyses collected above the point of maximum encroachment showed the water to be soft and low in dissolved solids.

Data are available on the Anacostia River basin. The District of Columbia Department of Sanitary Engineering samples seven stations in the tidal reach of the river. Analysis of these samples include the temperature, turbidity, alkalinity, pH, D.O. (dissolved oxygen) and coliform bacteria counts of the water. A few analyses have been taken on the Northeast and Northwest Branches of the Anacostia River by the U. S. Geological Survey in connection with a recent sediment reconnaissance of the Potomac River basin (Wark, Keller, and Feltz, 1963).

The chemical quality of the Patuxent River is defined more completely than this reconnaissance could accomplish. In connection with a 1963-64 trace element study (Heidel and Frenier, 1965), six stations were sampled every 10 days for major elements and quarterly for trace elements. In addition, 13 stations were sampled on a less frequent basis for the major elements. Samples were collected throughout the basin in both the tidal and non-tidal reaches and over a large range of discharge and tidal conditions.

In the Piedmont province, investigations with varying degrees of intensity have been undertaken in the Patapsco, Gunpowder, Susquehanna, and Monocacy River basins. Analyses of streams in the Patapsco River basin are available from the U. S. Geological Survey files. Water from the North Branch of the Patapsco River is used by Baltimore City as part of its municipal supply. Partial analyses of the raw water, including temperature, D.O., turbidity, coliform bacteria counts, hardness, pH, iron, and manganese, are made daily by the City. In addition, monthly composites of bi-hourly samples are subjected to complete chemical analyses. The Maryland Department of Water Resources sampled the Patapsco River monthly at 22 locations from March 1961 to December 1962, and determined pH, temperature, solids, turbidity, D. O., B. O. D. (biochemical oxygen demand), color, chloride, coliform bacteria, and hardness.

Prettyboy and Loch Raven Reservoirs on Gunpowder Falls impound water which is used as part of Baltimore's municipal supply. The same type of analyses made on the Patapsco city supply are available for Prettyboy Reservoir water. In addition analyses were made on various tributaries of Gunpowder Falls (O'Bryan and McAvoy, 1966). Many analyses of the Susquehanna River in Pennsylvania are available (Durfor and Anderson, 1963, p. 40). The U. S. Public Health Service (1961—), made weekly determinations of pH, B.O.D., D.O., ammonia, chlorides, alkalinity, sulfates, phosphates, dissolved solids, color, turbidity, and coliform bacteria of the water in the Susquehanna River below the Conowingo Dam. U. S. Geological Survey Water-Supply Paper 1499F contains data for streams in the Baltimore area. Analyses for the Potomac River at Williamsport and Washington, D. C. are available in the U. S. Public Health Service annual compilation of data.

Extensive data are available for the Monocacy River at Bridgeport. Between April 1948 and June 1951, 144 samples were taken for complete chemical analyses and the results published (U. S. Geological Survey Water-Supply Papers 1132; p. 138; 1162, p. 168-169; 1186, p. 131-132 and 1197, p. 130). At least 15 additional analyses of water were made from the Monocacy basin between 1946 and 1962. The city of Frederick and Fort Detrick use the Monocacy for domestic and industrial supply and both routinely determine the hardness and alkalinity of the raw water. In addition, Fort Detrick submits a sample to the U. S. Geological Survey for complete analysis annually.

In the Appalachian Region chemical-quality data are available on the Antietam and Conococheague Creek basins. The U. S. Geological Survey made 144 analyses of the waters of Antietam Creek near Waynesboro, Pa. (near the Maryland State Line), between April 1948 and June 1951 (U. S. Geological Survey Water-Supply Papers 1132, p. 136; 1162, p. 144-145; 1186, p. 126-127). These data are summarized by Darling (1962).

Chemical-quality data are available in the Appalachian Plateau province for Georges Creek and Youghiogheny River basin. The ICPRB (Interstate Commission on Potomac River basin) has reported monthly averages of temperature, turbidity, pH, D.O., B.O.D., alkalinity, coliform bacteria, and solids for several locations in the Potomac River basin. These data are published in the Potomac River Water Quality Network Report (1950-65). In the Youghiogheny River basin the Maryland Department of Water Resources collected monthly water samples from 32 points between November 1960 and January 1963. Analytical results included data on B.O.D., D.O., coliforms, Escherichia Coli, pH, acidity, alkalinity, and iron. A survey to determine what streams are affected by mine drainage was completed in the summer of 1963 (Rubelmann, 1963). The purposes of a second phase of this study included determining the water quality and locating the point sources of mine drainage. The results of the survey are discussed in a three-volume report (Hopkins, 1966).

At low flow most streams of the State depend heavily on ground-water discharges to maintain flow. For this reason, stream quality reflects ground water quality during dry periods of the year. Ground-water analyses from all physiographic provinces and most major geologic formations are listed in Maryland Geological Survey Bulletins that have been published for all counties.

Methods of investigation

During the summer months of 1963 and 1964, all of the major streams were sampled during periods of base flow. When samples were taken at ungaged sites, discharge measurements were usually made. In each basin or sub-basin, samples were taken on all principal tributaries. To insure that all points were sampled during the same flow conditions, each sub-basin was sampled usually in two or three days. In locating these stations, the geology of the basins and records of ground-water analyses were used to predict differences in general water quality.

A sample was taken for about every 150 square miles of area in the large drainage basins. These samples were analyzed for all common elements. Field measurements of pH, temperature, and specific conductivity were recorded at frequent intervals between the major sampling stations to spot abrupt or unexpected changes. When changes were noted, more samples were taken for complete analyses.

Seven stations in the Potomac River basin were sampled periodically, to indicate major seasonal variations. As mentioned before, the Patuxent was sampled every 10 days in connection with another study. As the Potomac and Patuxent drain one-half of the land of Maryland and about three-quarters of the Western Shore (fig. 1), the investigation of seasonal variations was deemed adequate for this reconnaissance study.

Factors affecting water quality

The quality of the surface water of Maryland is determined by the physical, biological, and chemical environments to which the water is exposed. Meteorologic, geologic, tidal, and cultural influences are particularly significant for understanding the reconnaissance data.

Rainfall

Nearly all of the non-tidal surface water of Maryland begins as precipitation, entering the stream as direct runoff or as ground-water discharge which enters the stream when it cuts the water table. Precipitation as it falls would be expected to be at its purest moment in the hydrologic cycle; however, contact with the atmosphere enables gases, mineral matter, and dust particles to become dissolved or suspended in the raindrops. Rain may also become polluted by smoke and gases from industrial areas or from nuclear explosions.

When the rainwater reaches the earth's crust, it dissolves mineral matter from rocks and soils and transports non-dissolved matter as sediment. The carbon dioxide dissolved from the atmosphere lowers the pH of water and aids the solution process. However, direct runoff is usually so rapid that the net effect is largely a dilution of the water already in the streams.

Geology

The quality of water draining undeveloped areas is largely determined by the mineralogy of the rocks with which the water comes in contact. Even when there are strong cultural influences, the principal chemical characteristics of the water are usually determined by the geologic conditions.

The quantity of minerals dissolved depends upon the time of contact, the lithologic character of the geologic formations and their solubility, and the previous chemical quality of the water. The rock types comprising the aquifers exert the strongest influence during dry periods when the streamflow is maintained by discharge from ground-water aquifers. During high rainfall periods some ground water also enters the streams from seepage and from springs. Due to longer time of contact the ground water is more highly mineralized than the surface runoff and increases the dissolved-solids content of the streams.

Maryland is underlain by a wide variety of rocks and geologic formations. The limestone and dolomite areas of the Frederick and Hagerstown Valleys have large solution channels and yield large amounts of ground water with high pH, hardness and dissolved solids. The water is magnesium calcium bicarbonate in character and highly buffered. The sandstones and shales of western Maryland and the crystalline metamorphic rocks of the Piedmont province are less soluble. The dissolved-solids concentrations are usually below 250 ppm and the water is calcium magnesium bicarbonate in character. In the Coastal Plain the sediments have been well leached and are mostly insoluble. Therefore, waters of low mineral content are usually found.

Tidal saline invasion

Most of the major Maryland streams, including the Potomac, Patuxent, Patapsco, Susquehanna, Gunpowder Falls and those of the Eastern Shore, empty into tidal waters. For distances up to 100 river miles from the mouth, the tide affects or dominates the flow, and the saline water of the Chesapeake Bay or the Atlantic Ocean drastically influences the chemical quality. The extent of salt-water encroachment changes with river flow, season, height of the tide, position on the tidal cycle, wind speed and directions, and other hydrologic and physical factors. The extent of salt-water encroachment has been determined to varying degrees of accuracy for some rivers in Maryland.

Cultural influences

Man's activity can have an important effect upon water quality. A great variety of materials is introduced into the stream from municipal and industrial wastes and from agricultural practices. They may produce color and odor, reduce dissolved-oxygen content, and be toxic to human and aquatic life.

Waters draining from coal mines contain sulfuric acid, the source of which is oxidation and leaching of the pyrite and marcasite present in coal and associated strata.

Mine drainage water is usually low in pH, and high in iron, sulfate, dissolved solids, and free sulfuric acid content. Fortunately, only a few streams such as small tributaries of the Youghiogheny, North Branch Potomac, and Savage Rivers and Georges Creek are affected by acid mine pollution.

Dissolved-mineral constituents of natural waters

The dissolved-mineral constituents of water are derived from several sources as shown below. The significance of the constituents as they affect water use are also indicated.

Constituent	*Source or cause*	*Significance*
Silica (SiO_2)	Dissolved from practically all rocks and soils, usually in small amounts from 1-30 ppm. High concentrations, as much as 100 ppm, generally occur in highly alkaline waters.	Forms hard scale in pipes and boilers. Carried over in steam of high pressure boilers to form deposits on blades of steam turbines.
Iron (Fe)	Dissolved from practically all rocks and soils. May also be derived from iron pipes, pumps, and other equipment. More than 1 or 2 ppm of soluble iron in surface waters usually indicate acid wastes from mine drainage or other sources.	On exposure to air, iron in ground water oxidizes to reddish-brown sediment. More than about 0.3 ppm stains laundry and utensils reddish-brown. Objectionable for food processing, beverages, dyeing, bleaching, ice manufacture, brewing, and other processes. Federal drinking water standards state that iron should not exceed 0.3 ppm. Larger quantities cause unpleasant taste and favor growth of iron bacteria.
Manganese (Mn)	Dissolved from some rocks and soils. Not so common as iron. Large quantities often associated with high iron content and with acid waters.	Same objectionable features as iron. Causes dark brown or black stain. Federal drinking water standards state manganese should not exceed 0.05 ppm.
Calcium (Ca) and Magnesium (Mg)	Dissolved from practically all soils and rocks, but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in sea water.	Cause most of the hardness and scale-forming properties of water; soap consuming. Water low in calcium and magnesium desired in electroplating, tanning, dyeing, and in textile manufacturing.
Sodium (Na) and Potassium (K)	Dissolved from practically 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 quantites 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.
Bicarbonate (HCO_3) and Carbonate (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.
Sulfate (SO_4)	Dissolved from rock and soils containing gypsum, iron sulfides, and other sulfur compounds. Usually present in mine waters and in some industrial wastes.	Sulfate in water containing calcium forms hard calcium sulfate 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. Federal drinking water standards recommend that the sulfate content should not exceed 250 ppm.

Constituent	Source or cause	Significance
Chloride (Cl)	Dissolved from rocks and soils. Present in sewage and 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. Federal drinking water standards recommend that the chloride content should not exceed 250 ppm.
Fluoride (F)	Dissolved in minute quantities from most rocks and soils.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth depending on the concentration of fluoride, the age of the child, amount of drinking water consumed, and susceptibility of the individual. (Maier, F. J., 1950, Fluoridation of public water supplies, Jour. Am. Water Works Assoc., v. 42, part 1, p. 1120-1132)
Nitrate (NO_3)	Decaying organic matter, sewage, and nitrates in soil.	Concentrations much greater than the local average may suggest pollution. There is evidence that more than about 45 ppm of nitrate (NO_3) may cause a type of methemoglobinemia in infants, sometimes fatal. Water of high nitrate content should not be used in baby feeding (Maxcy, K. F., 1950, Nat. Research Council Bull. San. Eng., p. 265, App. D). Nitrate has shown to be helpful in reducing intercrystalline cracking of boiler steel. It encourages growth of algae and other organisms which produce undesirable tastes and odors.

General water quality of Maryland

The fresh surface waters of Maryland are satisfactory for most industrial, agricultural, and municipal purposes. The generalized geologic map, figure 3, illustrates the range of dissolved solids in surface waters in relation to the geologic areas of the State. This range does not include the Potomac River and areas that are affected by salt-water encroachment.

In the following discussion the type of water is classified on the basis of the predominant cation and anion present, as expressed in equivalents per million. For example, water in which the predominant cation is sodium and the predominant anion is chloride is classified as a sodium chloride type water.

The majority of the Eastern Shore streams are calcium bicarbonate type water and soft. The dissolved-solids concentrations of these streams above salt-water encroachment are less than 100 ppm.

Streams in the Piedmont province generally contain a higher dissolved-solids concentration than the Coastal Plain streams. These higher concentrations are due to geologic conditions and to discharge of wastes. The hardness of water ranges from soft to very hard.

The Appalachian Region streams contain less than 300 ppm dissolved solids if they are not affected by acid-mine drainage or other sources of pollution.

Chemical quality of water

Eastern Shore basins

The nine counties of the Eastern Shore of Maryland are so similar in geology and topography, that it seems wise to consider the streams draining this area as a whole and not attempt a basin-by-basin description. More than 90 percent of the land of the Eastern Shore is in the Coastal Plain province. Only the western two-thirds of Cecil County, drained mostly by the Susquehanna River, is in the Piedmont province. The headwaters of most of the Eastern Shore rivers are in Delaware. The rocks of the Coastal Plain are unconsolidated sand, clay, silt, and gravel which were formed by the deposition of large volumes of sediment carried by streams from the Appalachian Mountains and the Piedmont province. In the Coastal Plain the active erosion of the rivers decreased and aggradation occurred in extensive alluvial fans, deltas, estuaries, bays, and the open sea.

Ground water is the major source of water in this area. The water supply of the cities and towns, the rural homes, the farms, and the canneries and other industries, is supplied by wells. The use of surface water is limited because ground-water supplies are plentiful and because many of the rivers are tidal and saline. Brackish marshes and swamps are prevalent in the lowland areas.

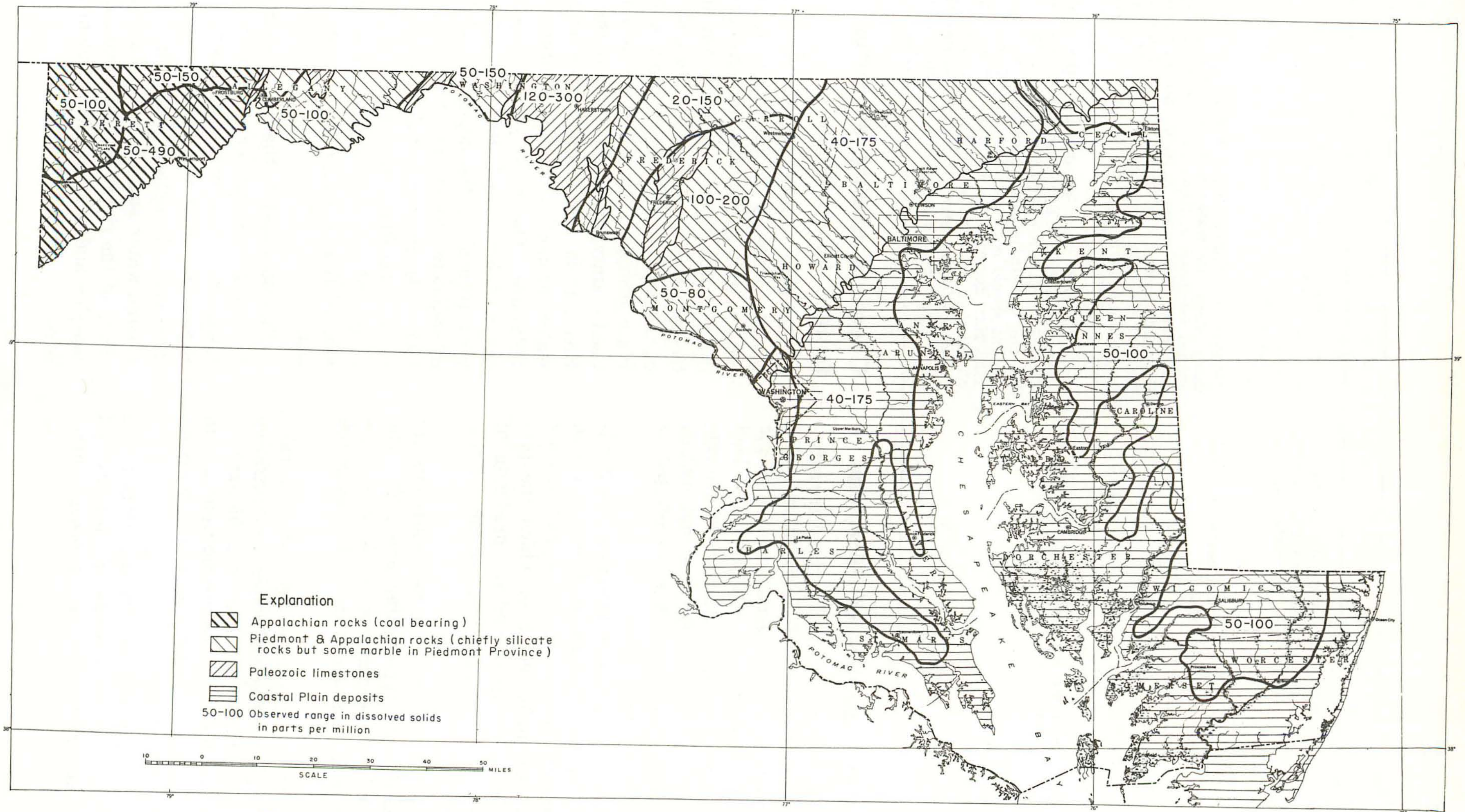

Figure 3—Generalized geologic map showing range of dissolved solids in surface waters.

The Eastern Shore river basins sampled during this reconnaissance were the Pocomoke, Wicomico, Nanticoke, Choptank, Chester, Northeast, and Elk. Samples were collected in the Pocomoke River basin at Snow Hill near Willards, on the main stem, and from Nassawango Creek near Snow Hill, one of the major tributaries. Both sites are above salt-water encroachment. The water is sodium bicarbonate type, soft and with dissolved-solids concentrations less than 100 ppm. One objection to use of the water in the area may be the high iron concentration which will require treatment for some uses. The extent of tidal movement was not investigated, but it has been reported about 25 miles from the mouth of the river (Murphy, 1957, p. 430). Murphy reported no evidence of saline water intrusion at Pocomoke City which is only 17 miles from the mouth of the river.

On September 25-26, 1963, evidence of salt-water encroachment was found at Shad Point on the Wicomico River. The chloride concentration at various locations during high tide is shown in figure 4. Above the point of salt-water encroachment, the water of the basin is of good chemical quality because it is soft, and low in dissolved-solids concentration (less than 75 ppm).

Beaverdam Creek near Salisbury may require treatment for some uses because of the water color. The iron concentrations will probably interfere with the use of water from the North Prong Wicomico River.

A salinity survey of the Nanticoke River and Marshy Hope Creek, one of the major tributaries of the Nanticoke, was made on December 8, 1964, during the high tide. Salt-water encroachment was found in the Nanticoke River above the Maryland-Delaware State line. In Marshy Hope Creek evidence of salt water was found upstream as far as 10 miles from the mouth. The specific

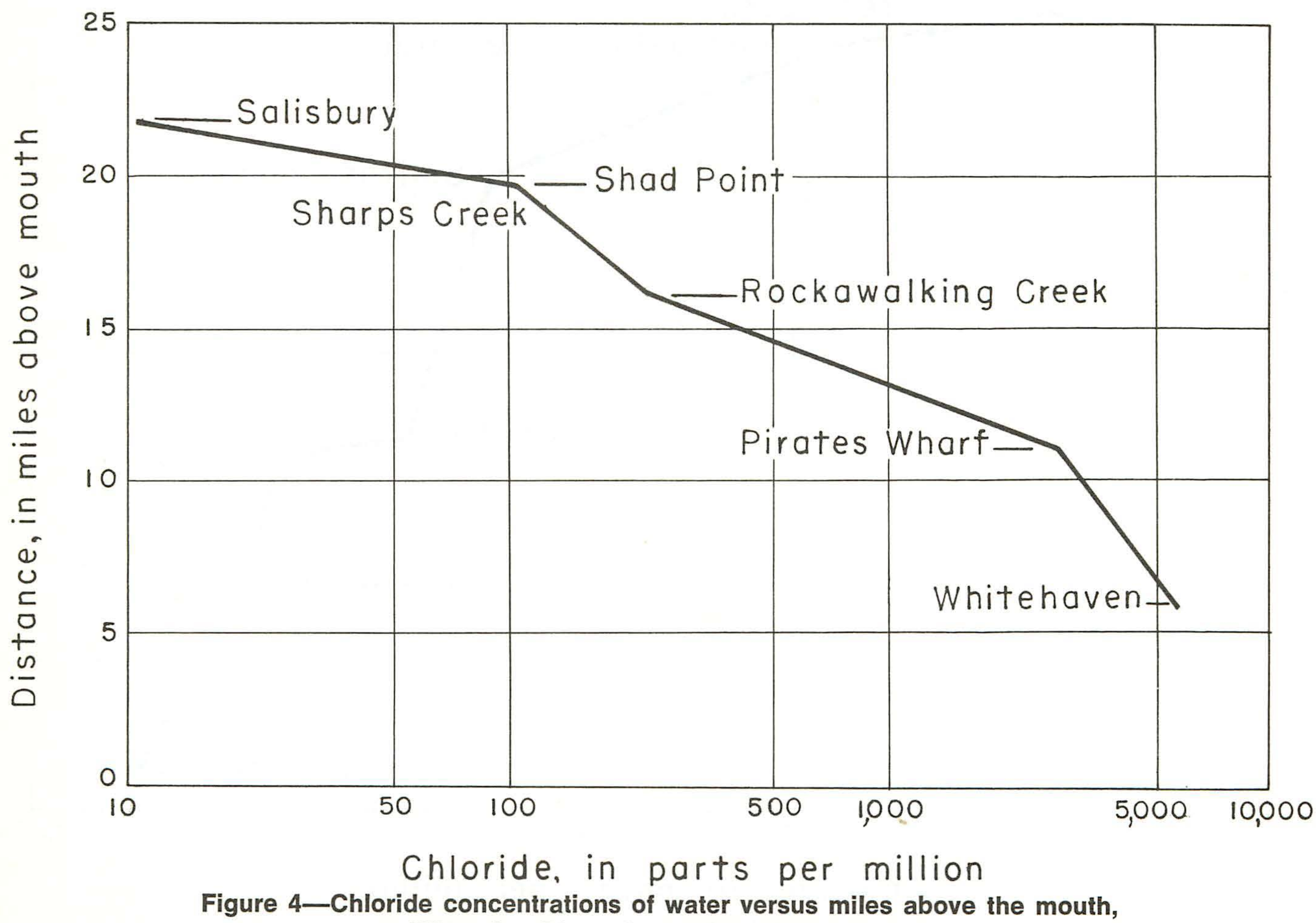

Figure 4—Chloride concentrations of water versus miles above the mouth, Wicomico River, September 25-26, 1963.

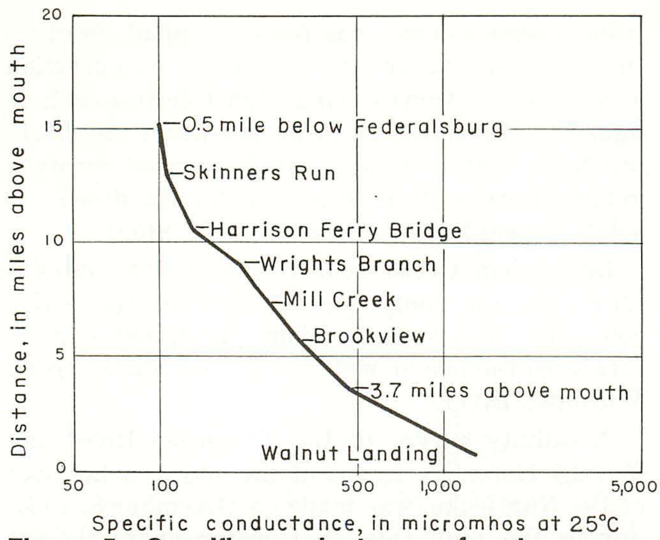

Figure 5—Specific conductance of water versus miles above the mouth, Marshy Hope Creek, December 8, 1964.

conductance of the water at various locations during this survey is shown in figure 5.

Evidence of salt-water encroachment in the Choptank River was detected about one mile below Greensboro during a survey September 10, 1964. Salt-water encroachment was found upstream further than Murphy (1957) detected during his survey because of the lower flow conditions. Figure 6 shows the chloride concentrations at various locations September 10, 1964. Water above the salt-water encroachment is sodium bicarbonate water with low dissolved solids. It is soft and the pH averages 6.7 units.

The Chester River at Millington and Morgan Creek near Kennedyville are above salt-water encroachment, and have soft water with dissolved-solids concentration less than 75 ppm. The Chester River was not investigated for salt-water en-

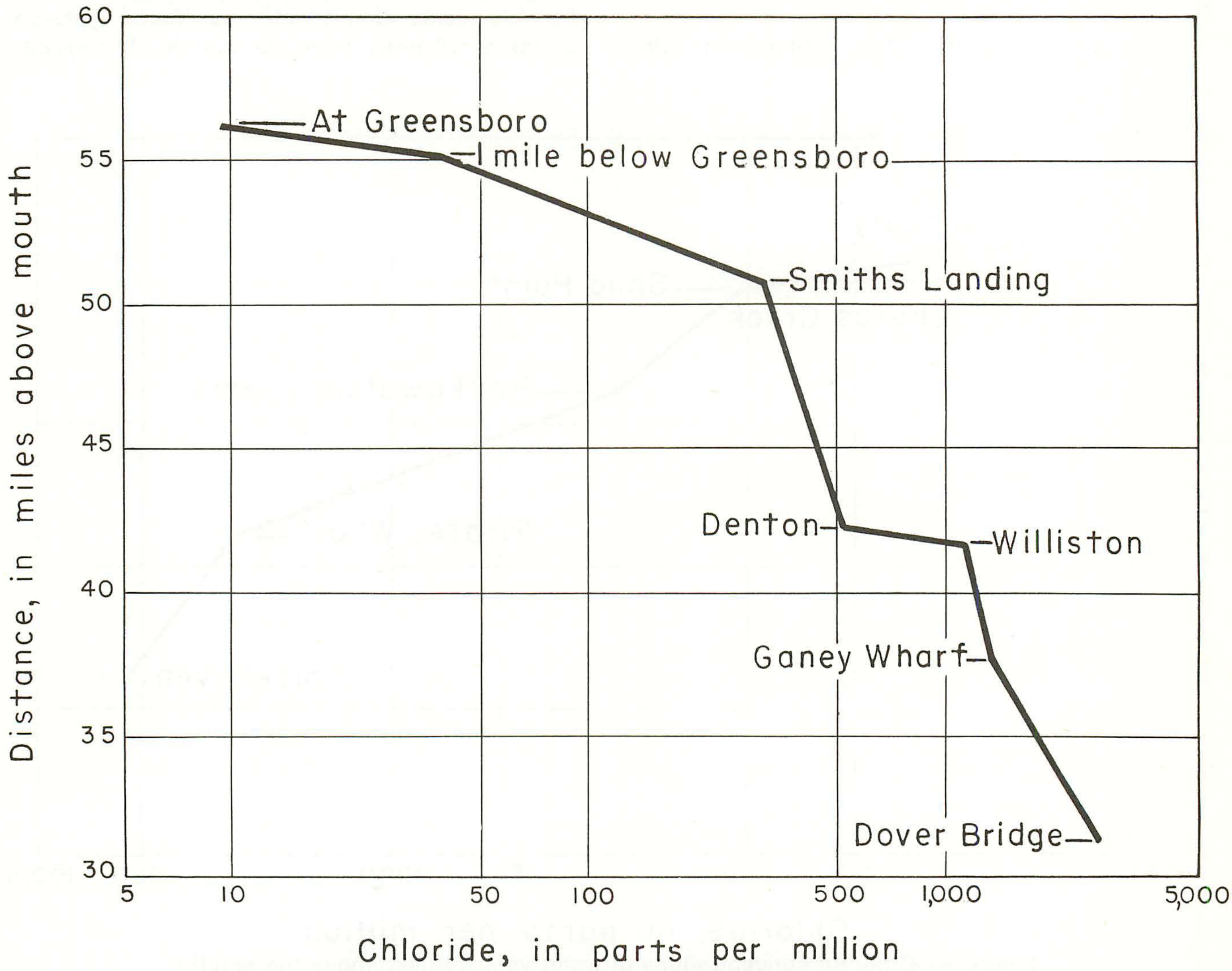

Figure 6—Chloride concentrations of water versus miles above the mouth, Choptank River, September 10, 1964.

croachment during this reconnaissance, but salt water occurs at least 23 miles upstream from the mouth (Murphy, 1957, p. 439).

The headwaters of Elk River are the Big Elk Creek and Little Elk Creek in the Piedmont province. Big Elk Creek at Elk Mills contained water of good chemical quality; it is soft, and is a calcium bicarbonate type. Little Elk Creek receives pollution from industrial activities which tends to lower the quality of the water.

Susquehanna River basin

The Susquehanna River drains 27,469 square miles of New York, Pennsylvania, and Maryland. Only 282 square miles of the total basin is in Maryland. In Maryland, the River's tributaries drain the Piedmont province which is underlain by crystalline rocks of Precambrian or early Paleozoic ages and includes schists, gneiss, phyllite, gabbro, quartzite, and marble.

The ground water in the Maryland part of the basin is a calcium bicarbonate type, soft and generally low in dissolved solids. The Susquehanna River is a calcium sulfate type water. However, the streams in Maryland flowing into the Susquehanna River make little contribution to its overall chemical quality.

The Susquehanna River is used as a source of public supply for Havre de Grace and Perry Point Hospital. Baltimore City began using the Susquehanna River as a supplemental supply in January 1966.

Bush River basin

The main stem of Bush River is tidal and mostly brackish. Bynum Run at Bel Air and Winters Run at Singer Road near Edgewood were selected for chemical analyses. The waters are the calcium bicarbonate type, soft, and the dissolved-solids concentrations are less than 120 ppm. Field measurements indicate the streams are representative of non-polluted streams entering Bush River.

Winters Run serves as a water supply for the town of Bel Air, and part of the water supply for Edgewood Arsenal at Edgewood.

Gunpowder River basin

Gunpowder Falls and Little Gunpowder Falls are the major tributaries to the Gunpowder River. Gunpowder Falls, including Little Gunpowder Falls, (58.3 square miles drainage area), drains an area of 408 square miles, of which 11 square miles is in Pennsylvania (Otton, Martin, and Durum, 1964, p. F31).

Baltimore City receives part of its water supply from Gunpowder Falls. The streams entering Prettyboy and Loch Raven Reservoirs vary in chemical concentrations. The average hardness (61 ppm) for samples collected October 21 and 24, 1963, from streams in the basin is the same as the yearly average hardness of samples collected every 2 hours at the Montebello filter plant in Baltimore during 1962. Higher dissolved-solids concentrations were found in Beaverdam Creek at Cockeysville which drains the Cockeysville Marble.

Little Gunpowder Falls contains water that is soft and low in dissolved-solids concentration. Water in the basin is a calcium bicarbonate type and can be used for most purposes.

Patapsco River basin

The Patapsco River drains 611 square miles of Baltimore, Howard, Carroll, and Anne Arundel Counties. The drainage from the basin is predominantly from the Piedmont province, but the area southeast of U. S. Highway 40 is in the Coastal Plain.

The water of South Branch Patapsco River at Henryton is of good chemical quality. The water can be used for most purposes.

The Patapsco River was sampled at Hollofield which is 8.1 miles downstream from the confluence of the North and South Branches. Liberty Reservoir on the North Branch serves as part of the municipal supply for Baltimore. The streams entering the reservoir are protected from pollution. The average hardness of the water of a composite of samples collected every 2 hours at the Ashburton filter plant from January 1959 to December 1962 was 47 ppm and the total dissolved-solids concentration was 76 ppm.

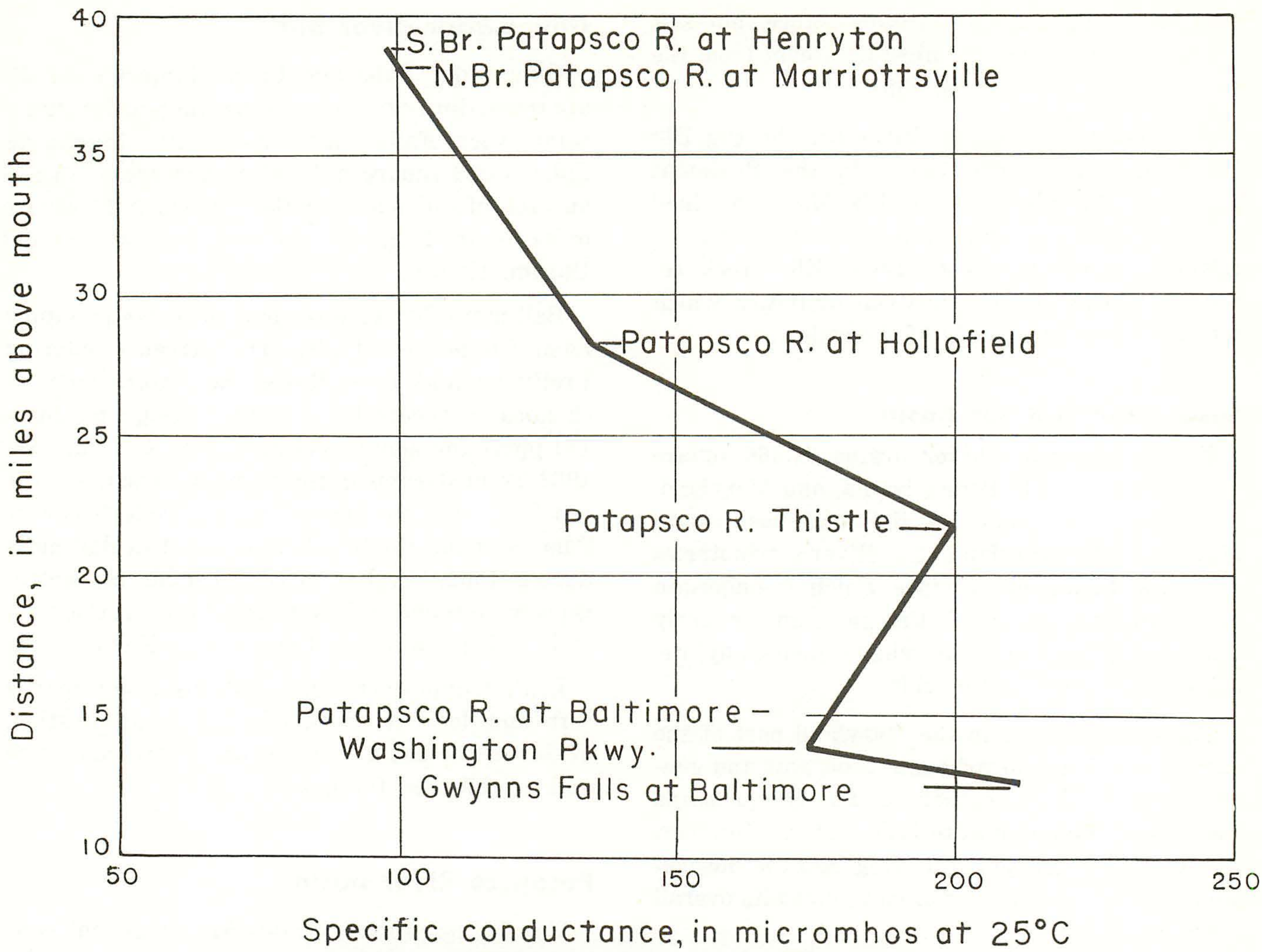

Figure 7—Specific conductance of water versus miles above the mouth, Patapsco River basin, August 27-28, 1963.

Figure 7 shows the specific conductance at various locations in the Patapsco River basin on August 27-28, 1963. The highest value is on Gwynns Falls which drains the more soluble gabbro and serpentine formations. The schists generally yield water of lower dissolved-solids concentrations. The water in the basin was a calcium bicarbonate type and soft at all sampling sites except Gwynns Falls and the Patapsco River at Thistle where the water was moderately hard. Chemical characteristics of water in the basin are shown in figure 8. The North Branch Patapsco River is used as part of Baltimore municipal supply and is protected from pollution.

North River basin

The North River, a tributary of the South River, is underlain by sedimentary rocks, chiefly beds of marine sandy clay and sand of Cretaceous and Eocene ages. The water from this area reflects the lithology and is soft, low in dissolved-solids concentration, and slightly acidic on the pH scale. An iron content above 1.0 ppm generally occurs in ground water in this area.

Waters in the lower part of the river are affected by salt-water encroachment from the Chesapeake Bay.

Patuxent River basin

The headwaters of the Patuxent River are in the Piedmont province, which drain resistant rocks consisting of schists, granite, and small amounts of marble. The remainder of the river drains Coastal Plain sediments which consist of sands and clays. The water is of good chemical quality except where it is subject to salt-water intrusion.

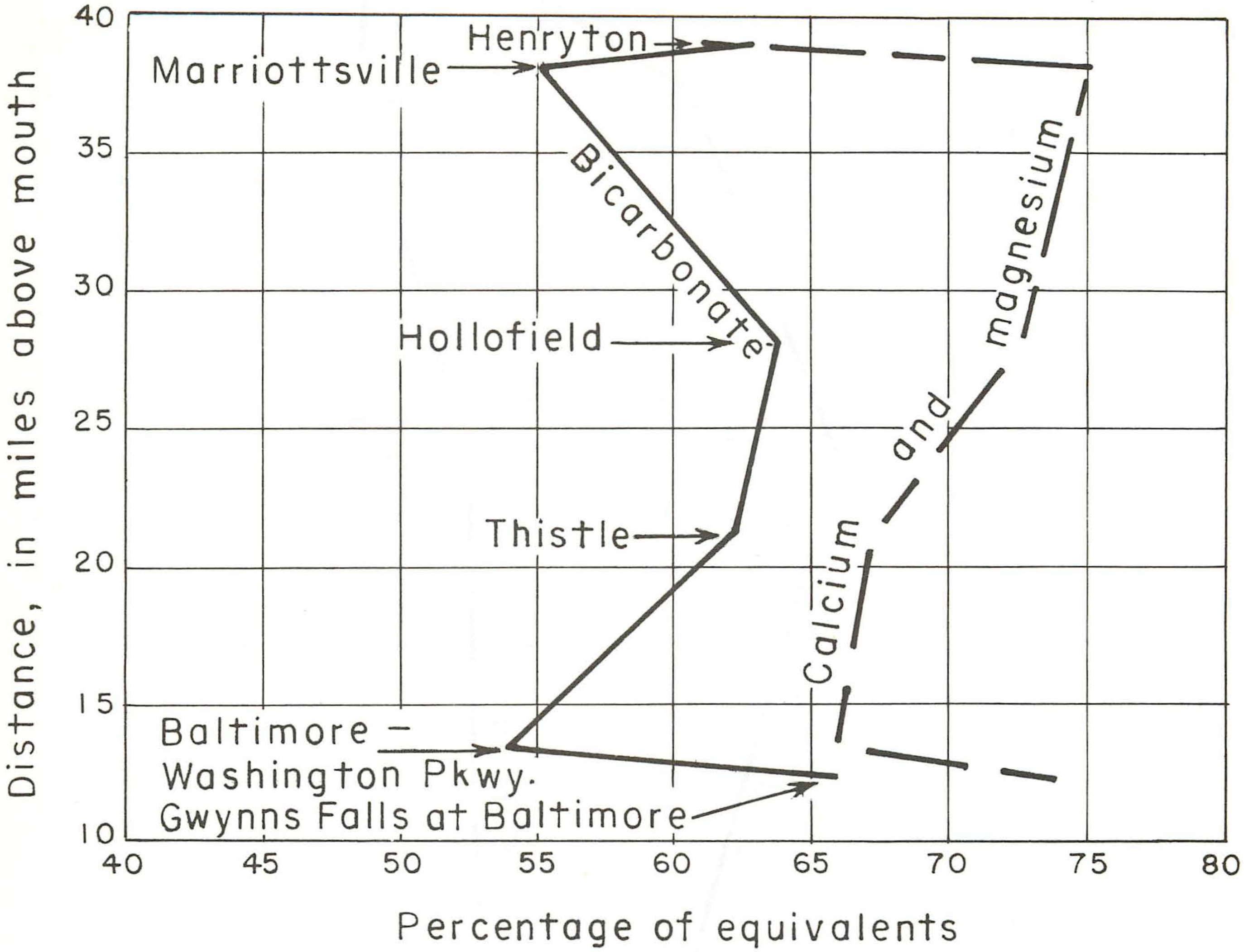

Figure 8—Percentage equivalents of ions in the Patapsco River basin, August 27-28, 1963.

The Washington Suburban Sanitary Commission operates two dams in the basin at Brighton and Laurel. These dams are built to provide storage for a water supply for the citizens of the Sanitary District. The reservoirs are a controlling factor in the chemical quality of the water in the basin, because of the regulated discharge and the protection from pollution which these reservoirs receive as a water supply for public use. At Laurel, the dissolved-solids concentrations are very low and average 50 ppm with a range of 41 to 60 ppm for the 18 samples collected (Heidel and Frenier, 1965). The water is soft, and is a calcium magnesium bicarbonate type.

The Little Patuxent River, a major tributary to the Patuxent, receives treated sewage from Howard County Metropolitan Commission, Fort Meade, and the Maryland House of Correction.

The Patuxent River at Hardesty (Queen Anne Bridge) is considered to be representative of the entire non-tidal part of the basin, and the range of dissolved-solids concentration (from 49 to 99 ppm during 1963-64) at Hardesty is representative of most water flowing into the estuary (Heidel and Frenier, 1965). Figure 9 shows the chemical characteristics of the tidal and non-tidal part of the stream.

The salinity of the Patuxent River estuary depends on discharge, tide and wind direction. The salt-water intrusion extends upstream 40 or 50 miles, or about to Upper Marlboro. Figure 10 shows the specific conductance at several locations during a survey made June 27-28, and July 1-2, 1963.

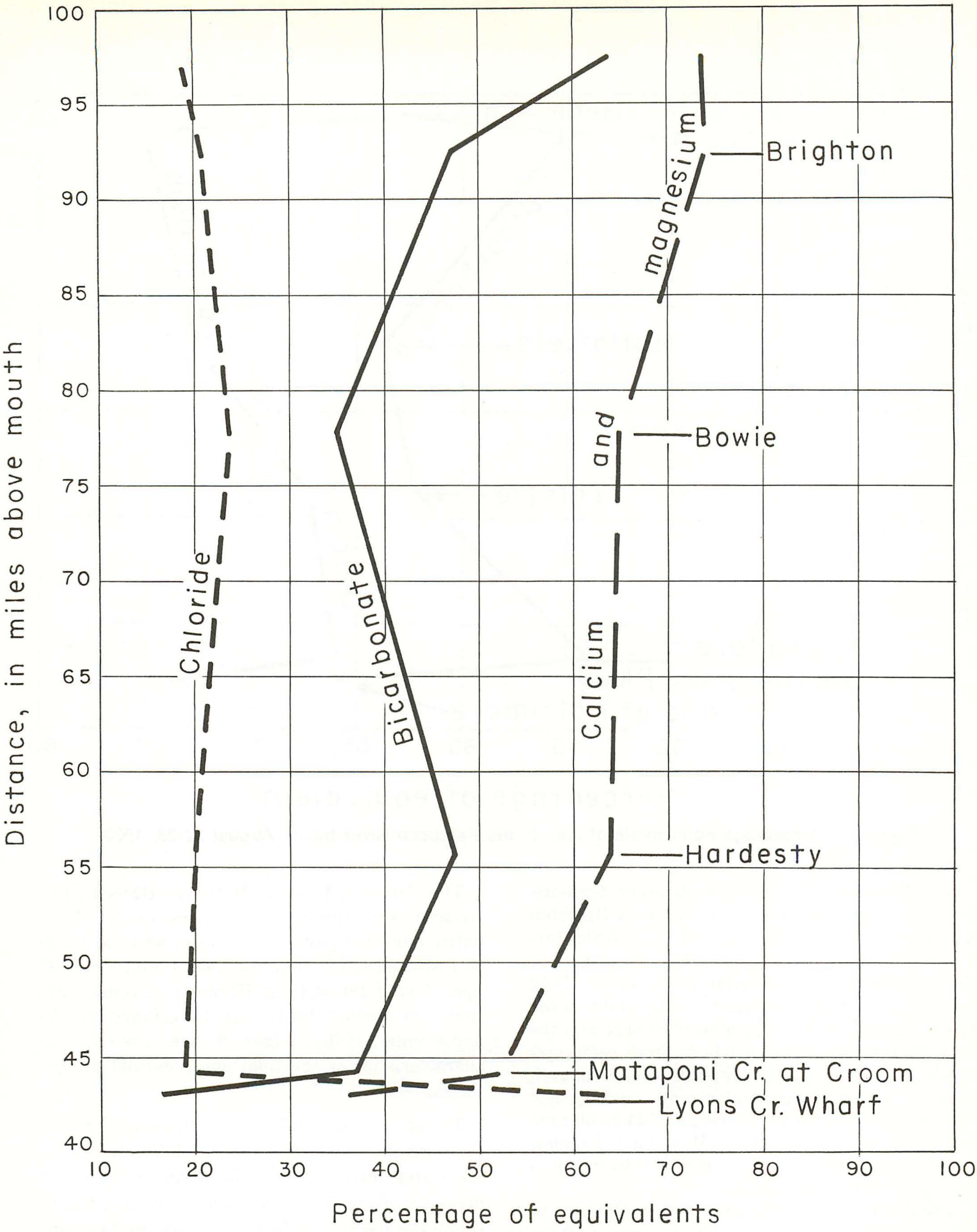

Figure 9—Percentage equivalents of ions in the Patuxent River basin, June 27-28, 1963, and July 1-2, 1963.

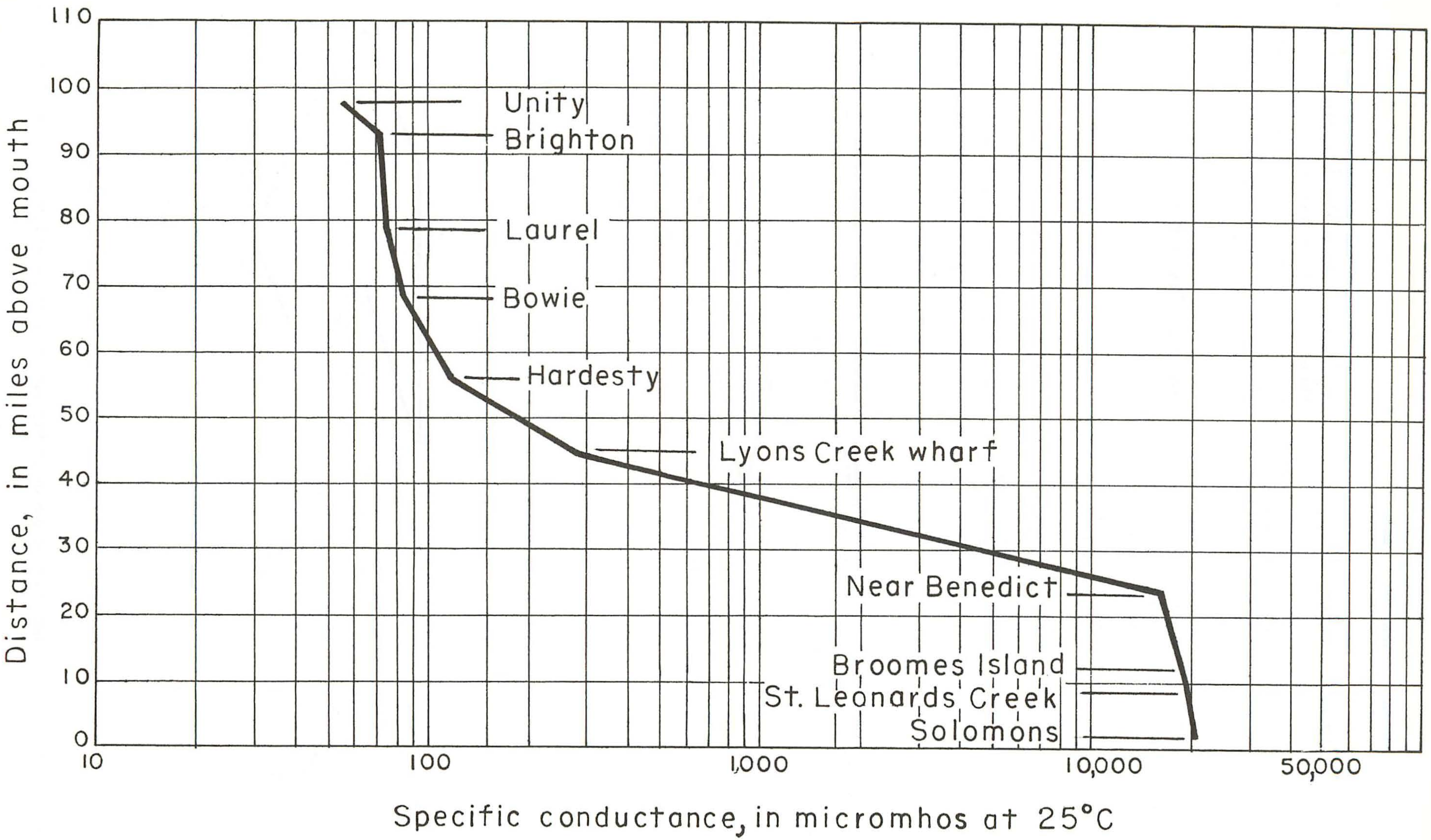

Figure 10—Specific conductance of water versus miles above the mouth, Patuxent River basin, June 27-28, and July 1-2, 1963.

North Branch Potomac River

The North Branch Potomac River which forms part of the boundary between Maryland and West Virginia heads in the mountainous areas of western Maryland and West Virginia.

The North Branch is polluted by coal-mine drainage upstream from the confluence with the Savage River and from mill waste and mine drainage below the Savage River confluence. Figure 11 shows the chemical characteristics of the North Branch at various locations during the stream survey on October 21, 1964. The chemical composition of the North Branch changes from a calcium sulfate type water above Luke to sodium calcium sulfate water below Luke. The chemical quality of the North Branch near Cumberland should be representative of the river at the confluence with the South Branch. Figure 12 shows the chemical characteristics of the North Branch near Cumberland.

Savage River basin

The Savage River drains consolidated sedimentary rocks of Devonian, Mississippian, and Pennsylvanian ages. These formations are mostly shales and sandstones and smaller amounts of coals and limestones.

Only a few small tributaries receive pollution from mine drainage. The city of Frostburg obtains part of its water supply from the headwaters of

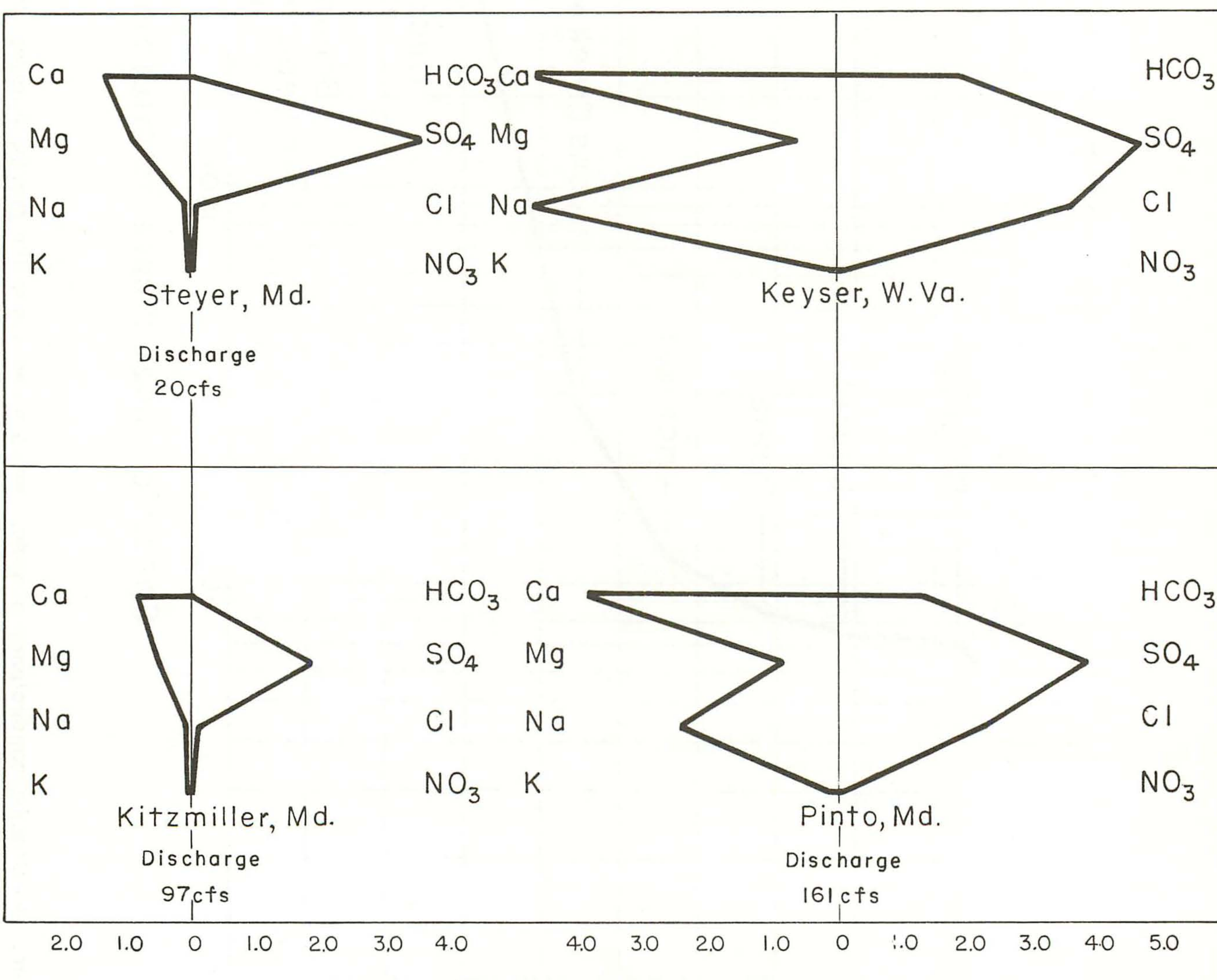

Figure 11—Chemical characteristics of water in the North Branch Potomac River, October 21, 1964.

Savage River. The city of Westernport obtains water from the Savage River Reservoir located about 4 miles from the mouth. The dam was built for flood control. Water released from the reservoir is of good chemical quality.

Georges Creek basin

Georges Creek drains about 80 square miles of eastern Garrett and western Allegany Counties. The basin is in the easternmost part of Maryland's Appalachian Plateau province and is underlain by shale, siltstone, sandstone, coal, and limestones similar to the formations underlying the rest of Garrett County. Crests of the mountains commonly consist of erosion-resistant sandstone. The basin is heavily forested. Most of the population is in small towns along Georges Creek.

The headwaters of Georges Creek are polluted by sewage from the towns and villages, whereas in the lower part of the basin, sewage and acid mine drainage are the main source of pollution.

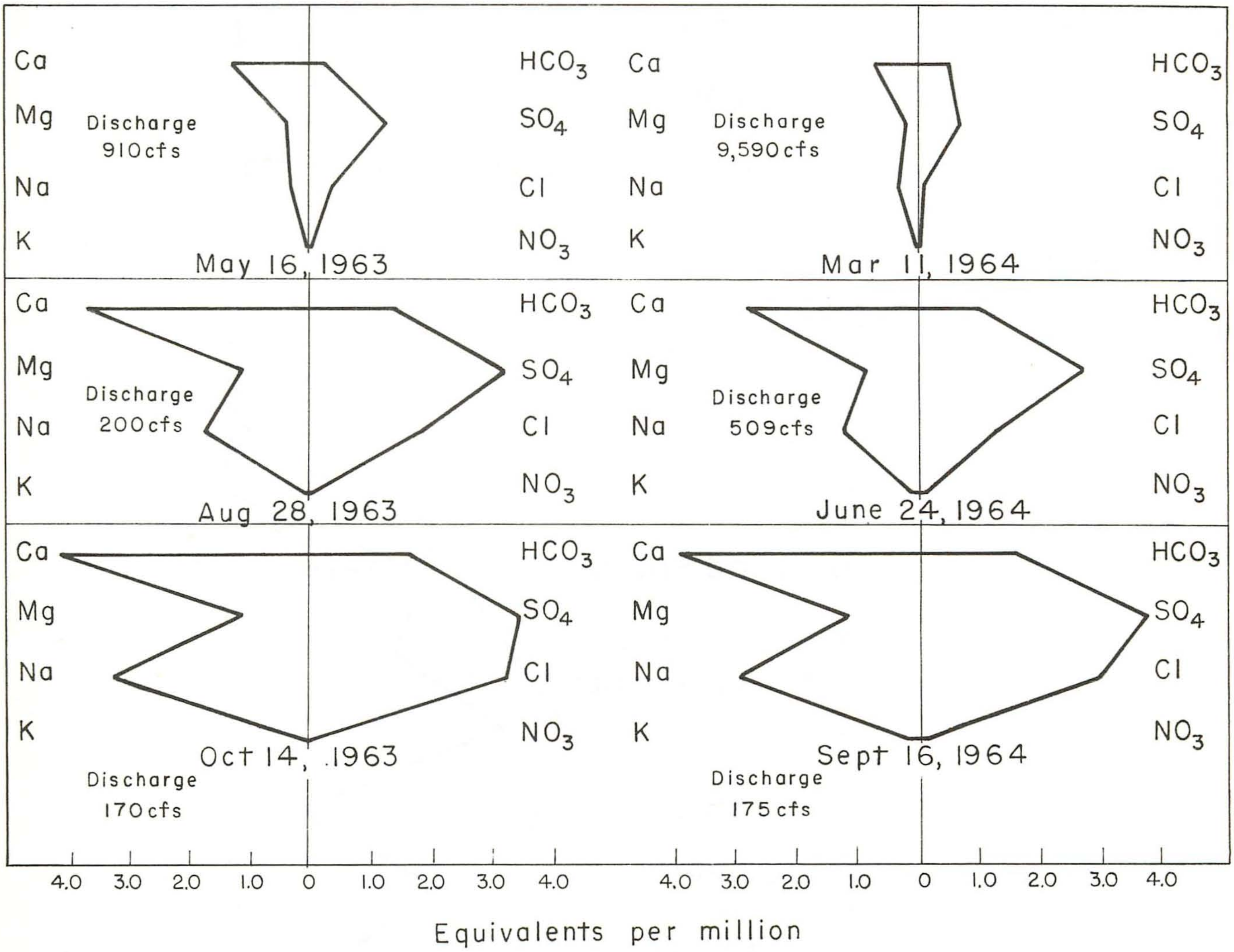

Figure 12—Chemical characteristics of water in the North Branch Potomac River near Cumberland, Md.

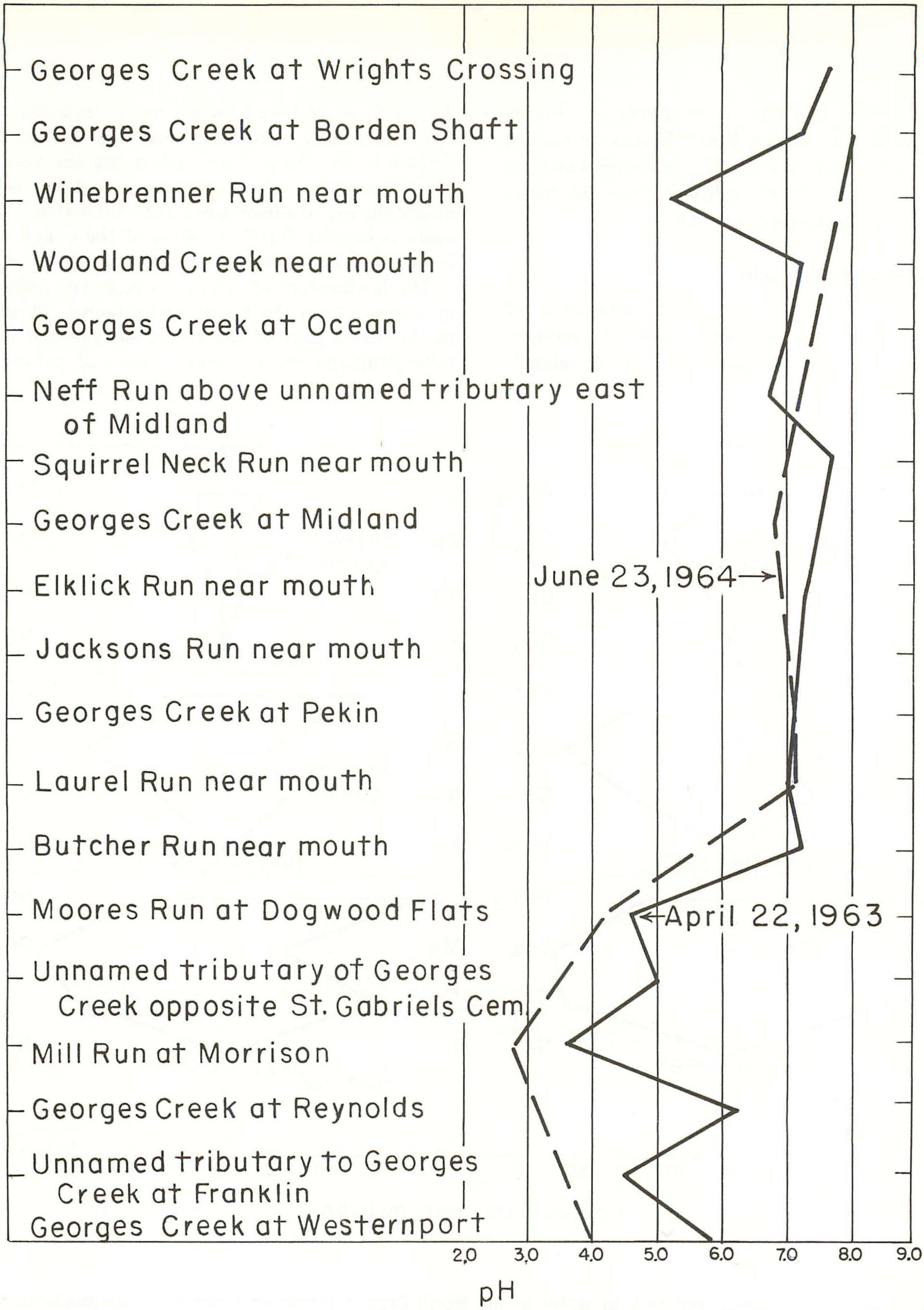

Figure 13—pH of water in Georges Creek basin, April 22, 1963, and June 23, 1964.

The pH surveys made April 22, 1963 and June 23, 1964 at various locations are shown in figure 13 (data for April survey was taken from Rubelmann, 1963). The improvement of the water at Midland is due to the increase in discharge and decrease in the pollution entering the stream. Figure 14 shows the specific conductance at various locations during stream surveys on June 22-23, 1964. Below Midland the stream receives water from the coal-mining areas which lowers the pH and increases the iron and sulfate concentrations. The quality of water and the type depend on the location, amount of pollution, and stream discharge.

The West Virginia Pulp and Paper Co. samples Georges Creek at Westernport. Monthly averages of flow, temperature, turbidity, pH, D.O., B.O.D., alkalinity, coliforms, and dissolved solids have been reported in the Potomac River Water Quality Network (1958-64).

The data give little insight into the natural chemical quality of the stream, but give indications of acid-mine drainage. The yearly average pH ranged from 4.25 to 5.7 between 1958 and 1964

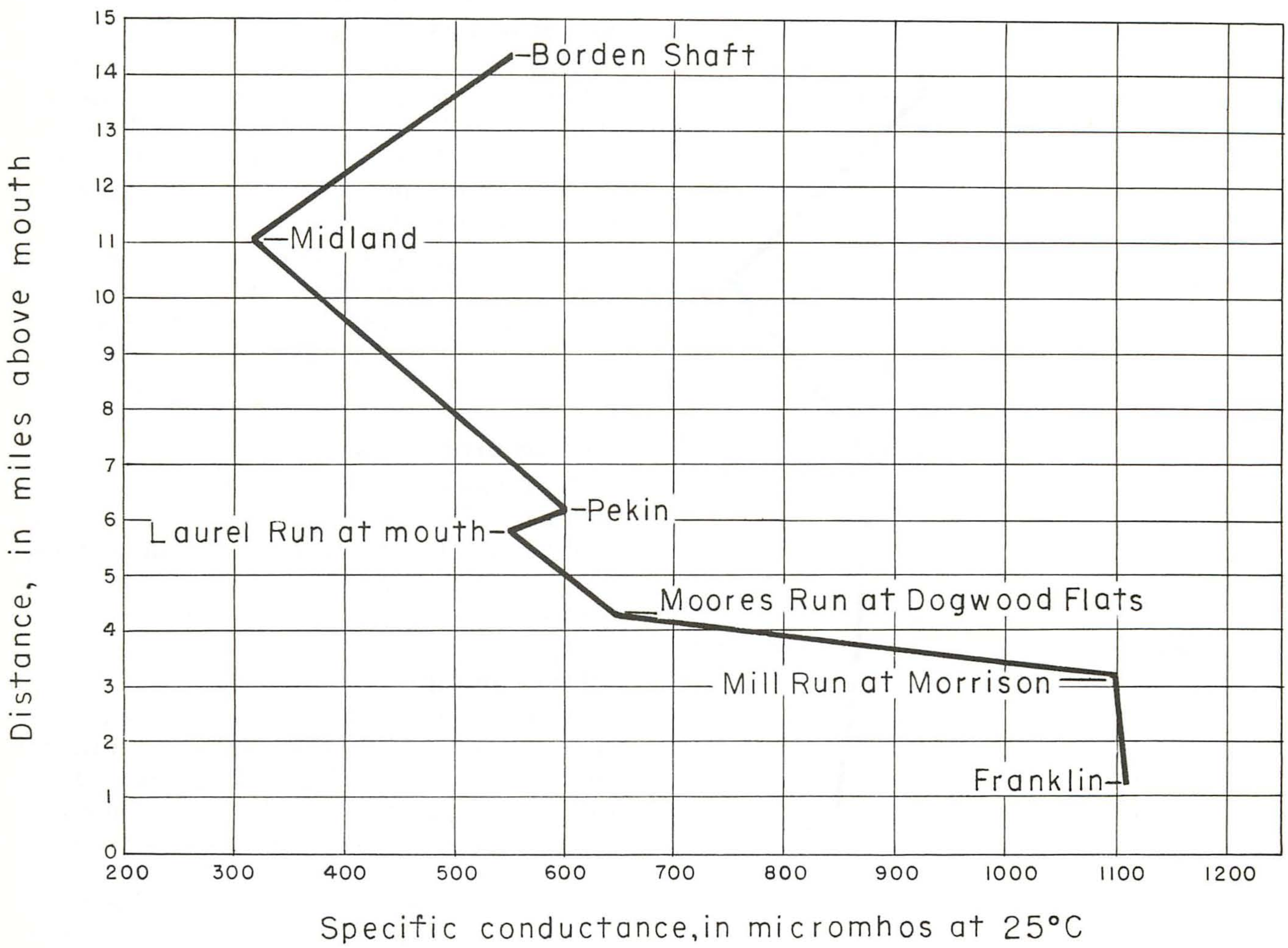

Figure 14—Specific conductance of water versus miles above the mouth, Georges Creek basin, June 22-23, 1964.

(fig. 15). During the 1963 water year, the dissolved-solids concentrations ranged from 230 to 1,033 and averaged 567 ppm.

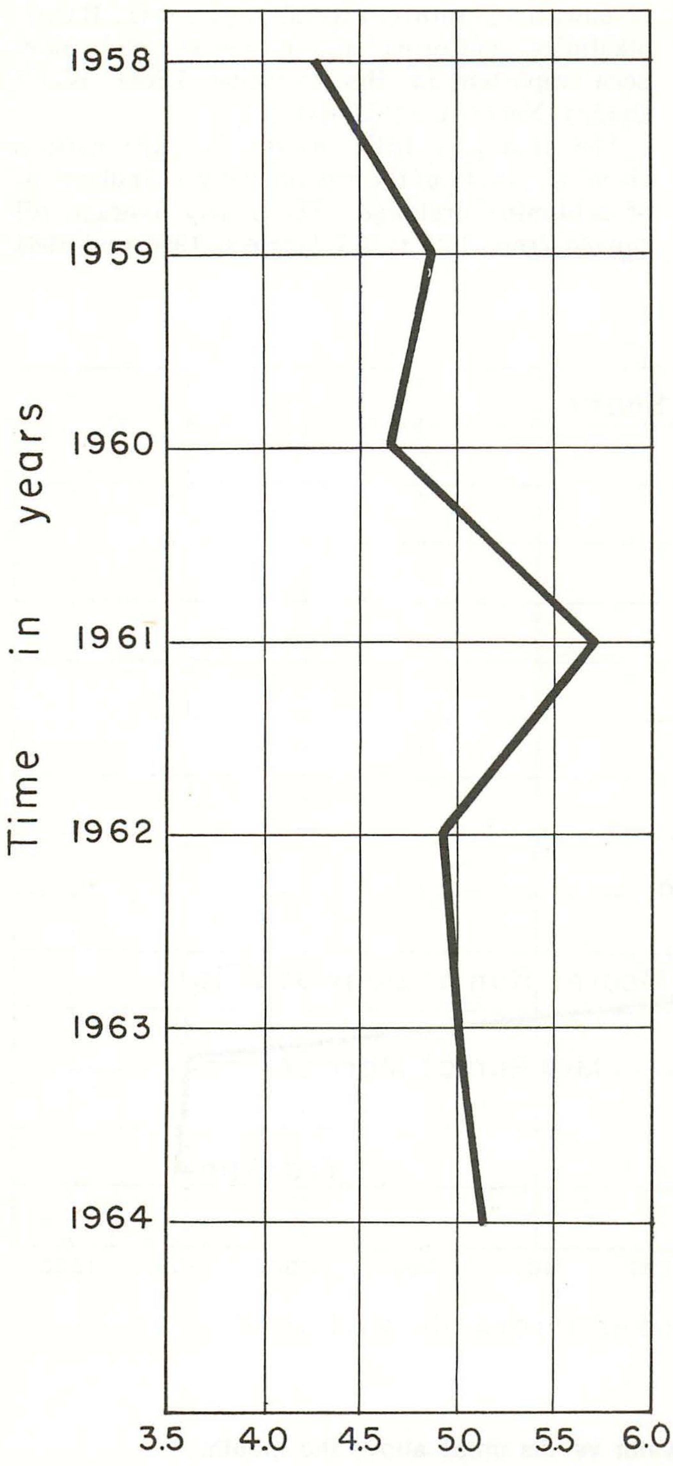

Figure 15—Average yearly pH of Georges Creek, 1958-64.

Town and Sideling Hill Creek basins

Town and Sideling Hill Creeks drain a large part of Allegany County. Sideling Hill Creek forms the natural boundary between Washington and Allegany Counties. The streams are in the Valley and Ridge province. The rocks in the basin are predominantly shale except for a few sandstone ridges. The formations are mostly of Devonian and Mississippian age.

The surface water is low in dissolved-solids concentration, soft, and of the calcium bicarbonate type.

Tonoloway and Little Tonoloway Creek basins

Tonoloway Creek is almost entirely in Pennsylvania and drains water from the alluvium and the Jennings Formation. Water from Tonoloway Creek near Hancock is moderately hard with calcium constituting 67 percent of the cations and bicarbonate 68 percent of the anions.

Little Tonoloway Creek contains water similar to that of Tonoloway Creek but with less dissolved-solids concentrations. The predominant ions are calcium and bicarbonate. The water is soft and a pH of 7.7 was measured at a discharge of 2.3 cfs.

Licking Creek basin

The headwaters of Licking Creek are in Pennsylvania and drain formations similar to Tonoloway Creek. The water is hard, and contained dissolved-solids concentrations of 145 ppm at a discharge of 50 cfs.

Conococheague Creek basin

Conococheague Creek drains 563 square miles of the Valley and Ridge province, of which only 66 square miles is in Maryland. The basin forms part of the Hagerstown Valley and is underlain by shales and limestones. Conococheague Creek at Fairview, Md. was sampled periodically to show variations of chemical constituents. The results are shown in figure 16. The higher concentrations occurred during October and September and the lowest during March.

The water is a calcium bicarbonate type with pH ranging from 6.9 to 9.6. The hardness of water ranges from moderately hard to very hard depending on the flow conditions. Figure 17 shows the percent of time the hardness of water was equaled

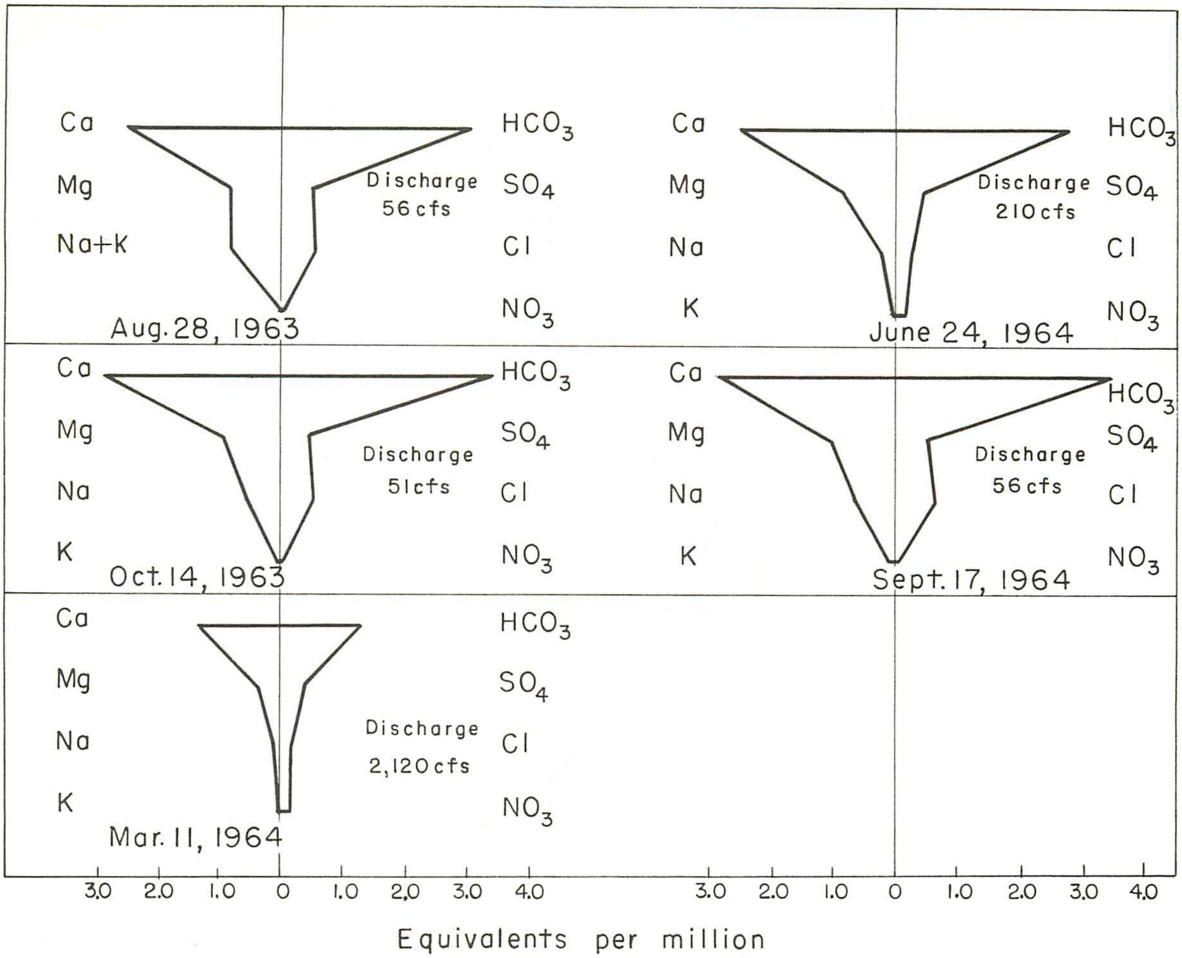

Figure 16—Chemical characteristics of water in Conococheague Creek at Fairview, Md.

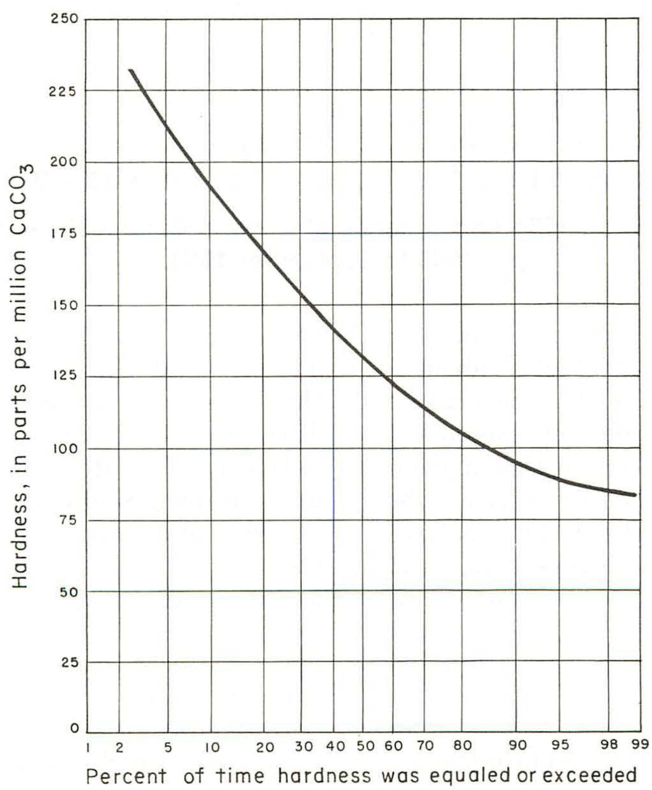

Figure 17—Frequency curve of hardness of water in Conococheague Creek at Fairview, Md., April 1948 to September 1950.

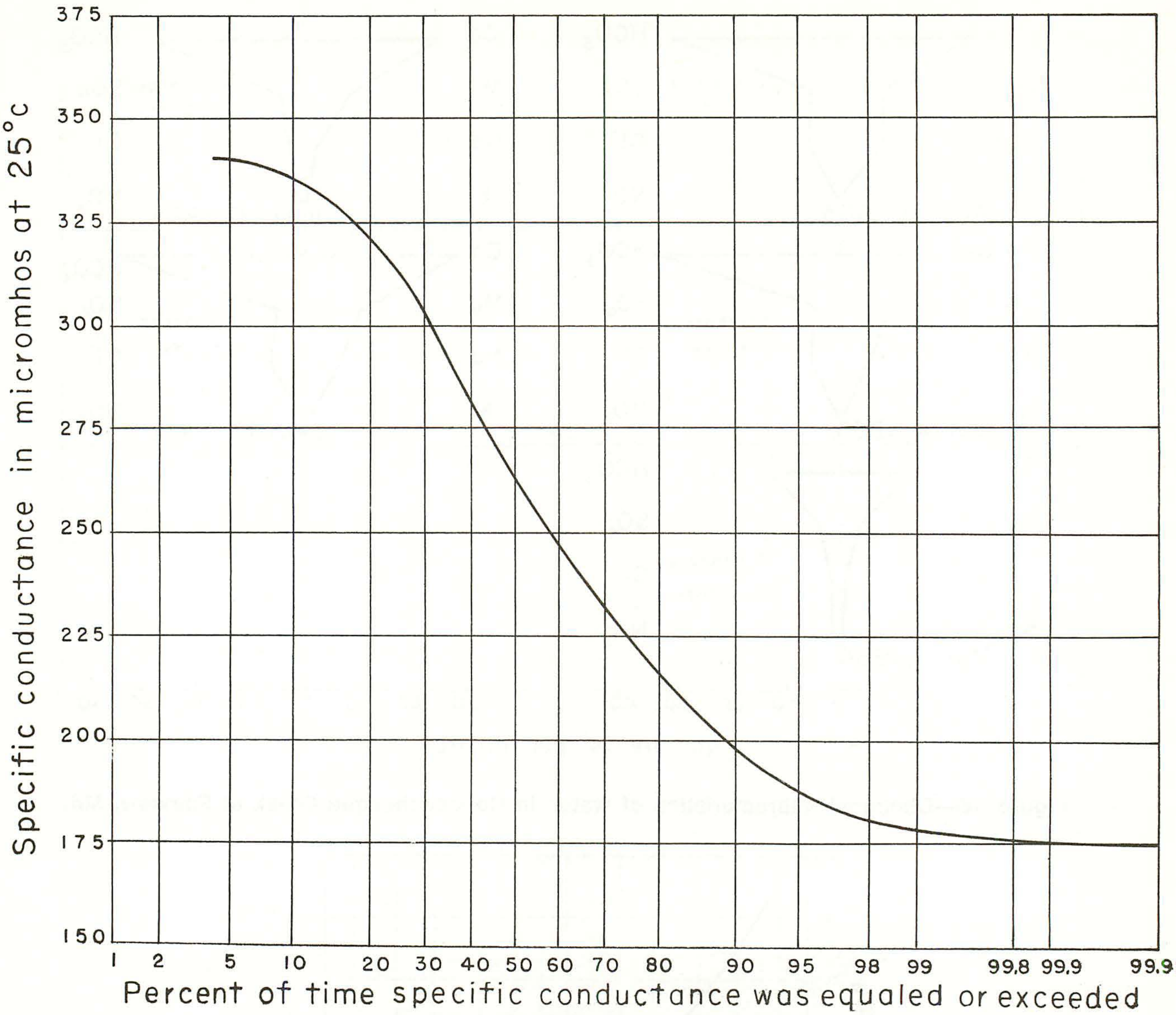

Figure 18—Frequency curve of specific conductance of water in Conococheague Creek at Fairview, Md., April 1948 to September 1950.

or exceeded. In general the water reflects the geologic conditions. Nitrates averaging about 9 ppm (includes all analyses) indicate some organic pollution. The iron content did not exceed 1.1 ppm. Figure 18 shows the percent of time a given specific conductance was equaled or exceeded for the period April 1948 to Sept. 1950. The analyses are published in Water-Supply Papers 1132, 1162, and 1186, and are summarized by Darling (1962, p. 257).

Antietam Creek basin

Antietam Creek basin drains 297 square miles of Maryland and Pennsylvania. Approximately two-thirds of this basin is in Washington County. The stream drains the Hagerstown Valley area of the Valley and Ridge province, and the South Mountain-Elk Ridge area of the Blue Ridge province. The Hagerstown Valley includes the area between South Mountain and Elk Ridge on the east, and Fairview and Powell Mountains on the west. The area is underlain with limestone and dolomite deposits.

The eastern parts of the basin drain the more resistant rocks of the South Mountain-Elk Ridge water province.

Antietam Creek drains the predominantly limestone rocks which are quite soluble; thus geologic

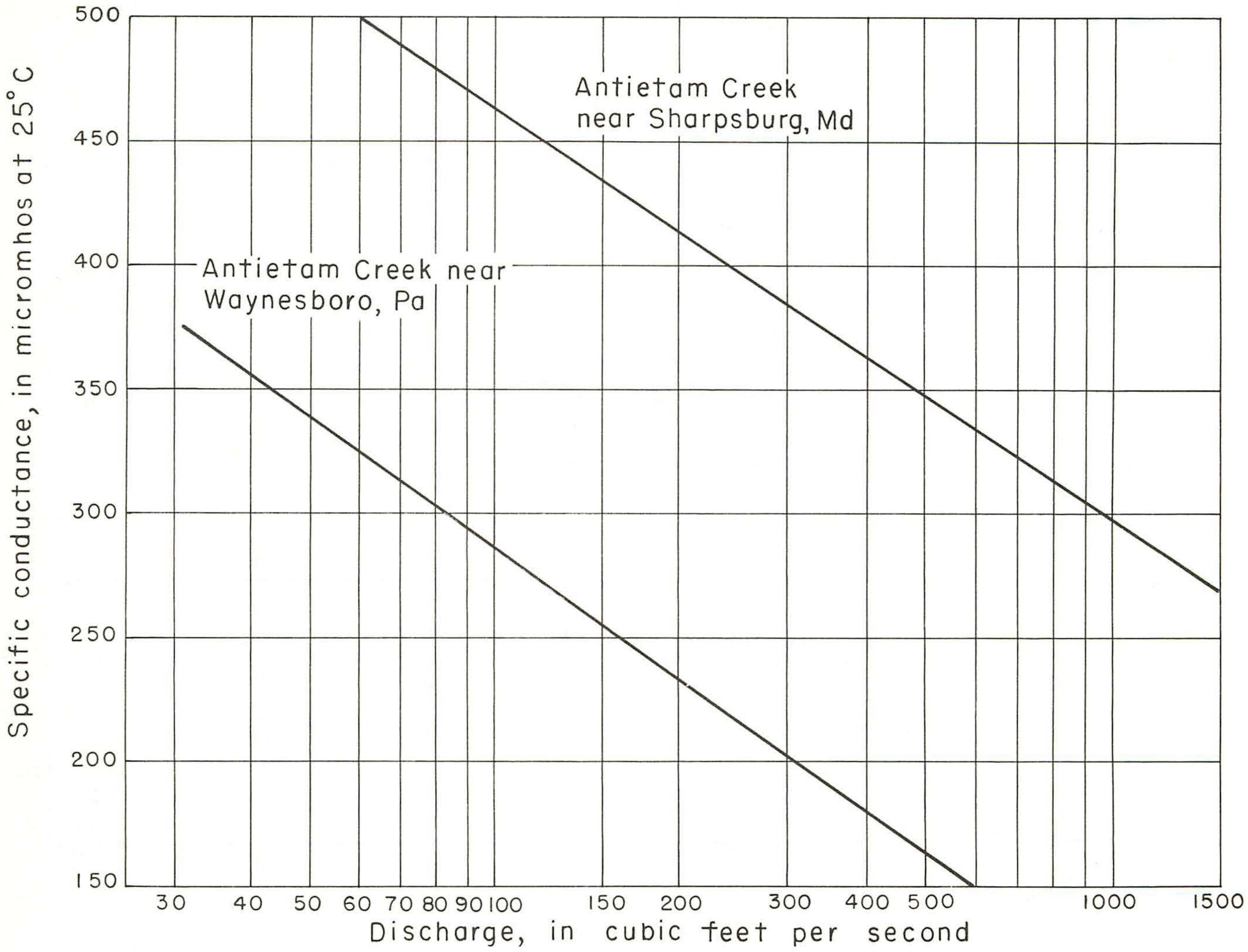

Figure 19—Specific conductance of water versus discharge, Antietam Creek near Waynesboro, Pa., and near Sharpsburg, Md.

conditions and manmade changes are expected to be the main factors affecting chemical quality. Hagerstown discharges its sewage effluent into Antietam Creek and this materially affects the quality of water below Hagerstown. However, the waters still remain predominantly calcium bicarbonate in nature.

Samples for complete analyses were taken on the main stem at Sharpsburg, Rose Mill, and Waynesboro, and from Beaver Creek near Millpoint. The sample taken at Rose Mill on the main stem defines the effect the Hagerstown sewage effluent has on the quality. The Beaver Creek samples are representative of streams draining the limestone.

Relation of specific conductance to discharge is shown in figure 19 for Antietam Creek at Waynesboro, Pa., and Sharpsburg, Md. Records at complete range of flow conditions are available at Waynesboro but most available data are at high-flow conditions at Sharpsburg. Figure 20 shows the chemical characteristics of Antietam Creek near Sharpsburg during different flow conditions. The water contained higher dissolved-solids concentrations during October and lower concentrations during March, resulting from different flow conditions.

The specific conductance and alkalinity of water in streams in the basin and in the ground water are about the same. Field data indicate Little Antietam Creek above Dog Creek near Keedysville has the lowest conductivity and alkalinity which reflects the influence of the geology of the area.

Highest conductivities are in the main stem south of Hagerstown, but the alkalinities do not follow the same relationship. This indicates some manmade influence in the Hagerstown area, probably the sewage discharged into the stream below the city. The specific conductance of water in Antietam Creek at various locations is shown in figure 21.

The discharge at Waynesboro was 34 cfs, at Beaver Creek, 16 cfs and 131 cfs at Sharpsburg. This is 0.269, 0.491, and 0.468 cfs per square mile, respectively. The 131 cfs at Sharpsburg is equaled or exceeded 80 percent of the time. The city of Hagerstown pumps water from the Potomac for its municipal supply and discharges sewage into Antietam Creek.

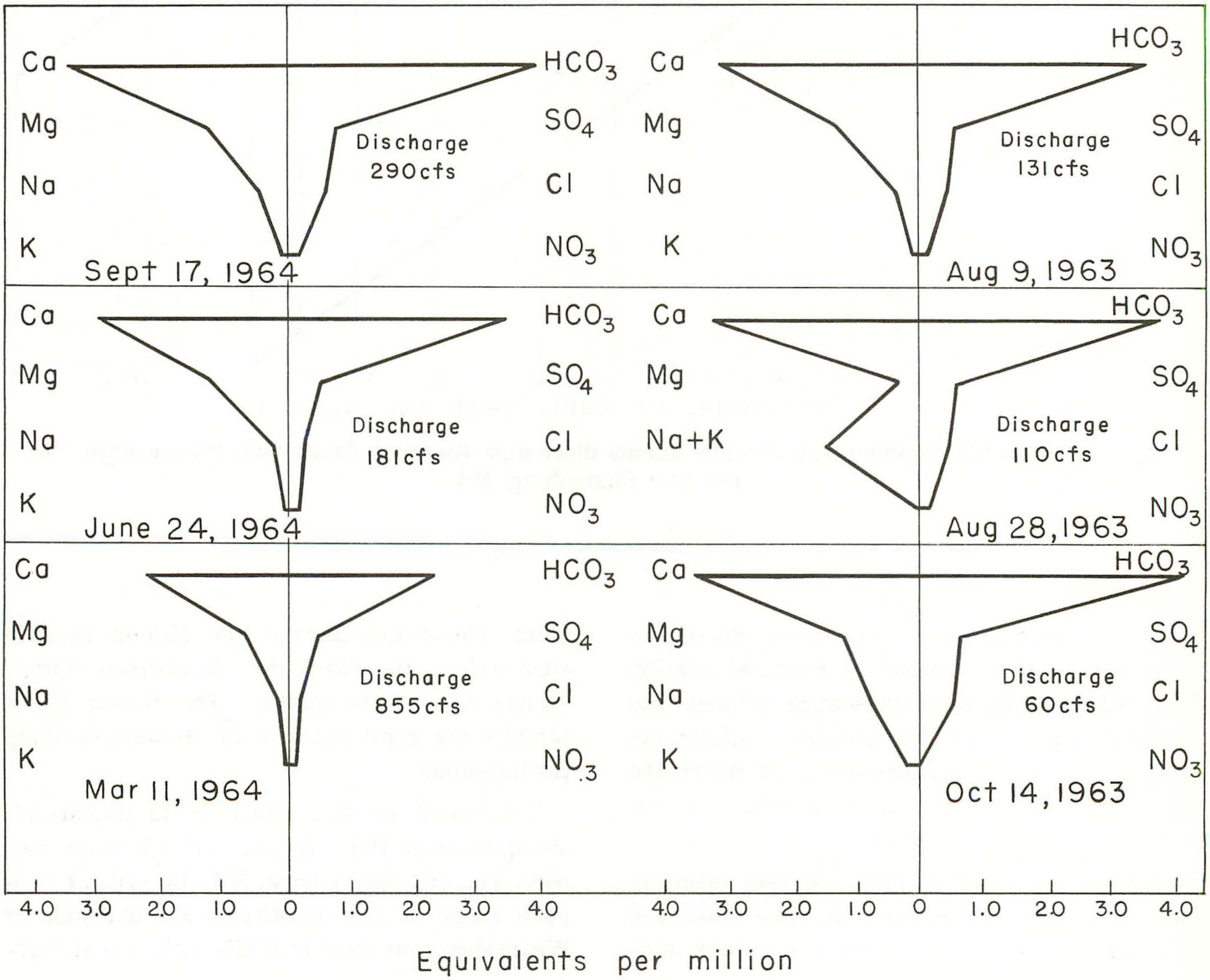

Figure 20—Chemical characteristics of water in Antietam Creek near Sharpsburg, Md.

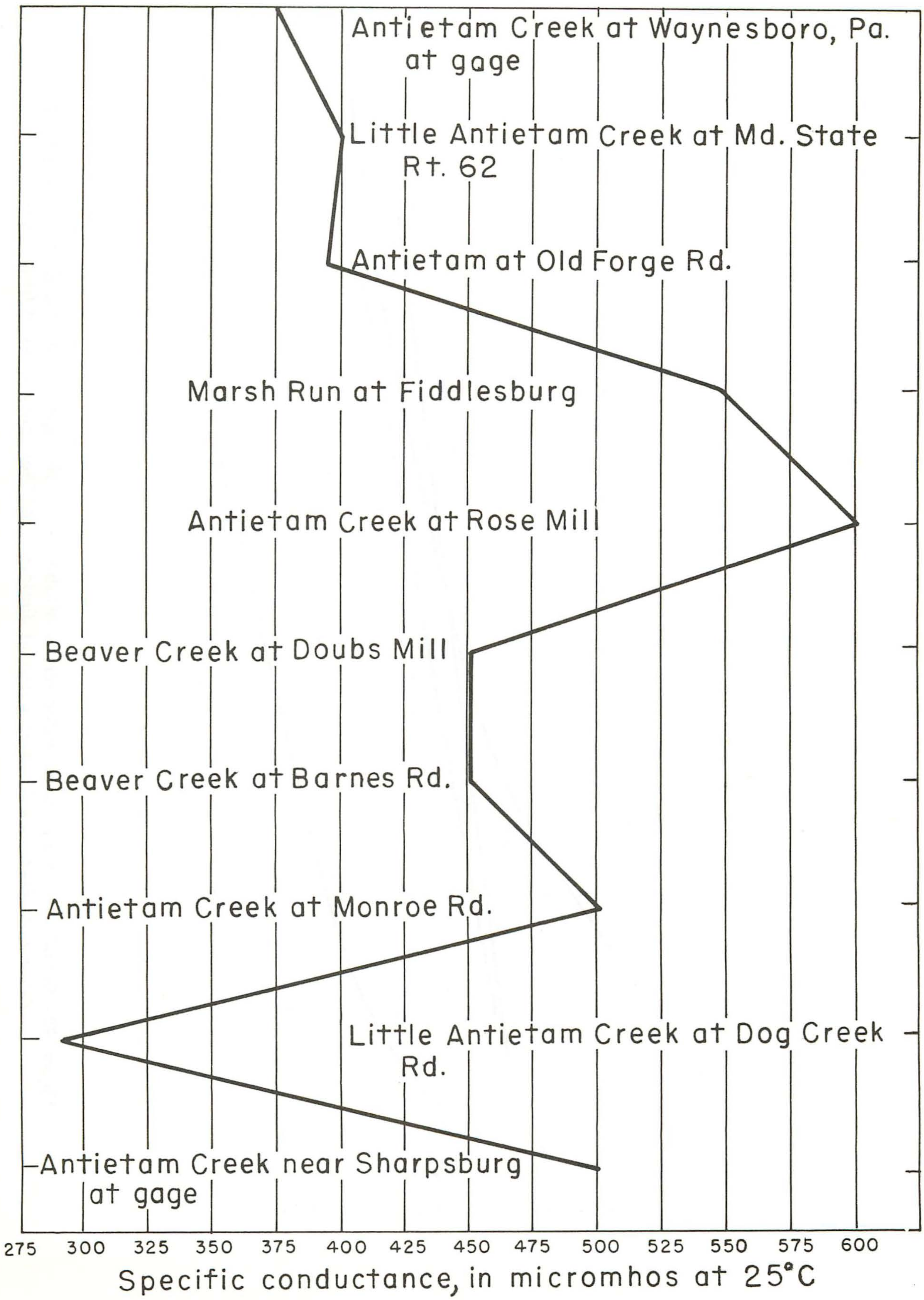

Figure 21—Specific conductance of water in Antietam Creek basin, August 9, 1963.

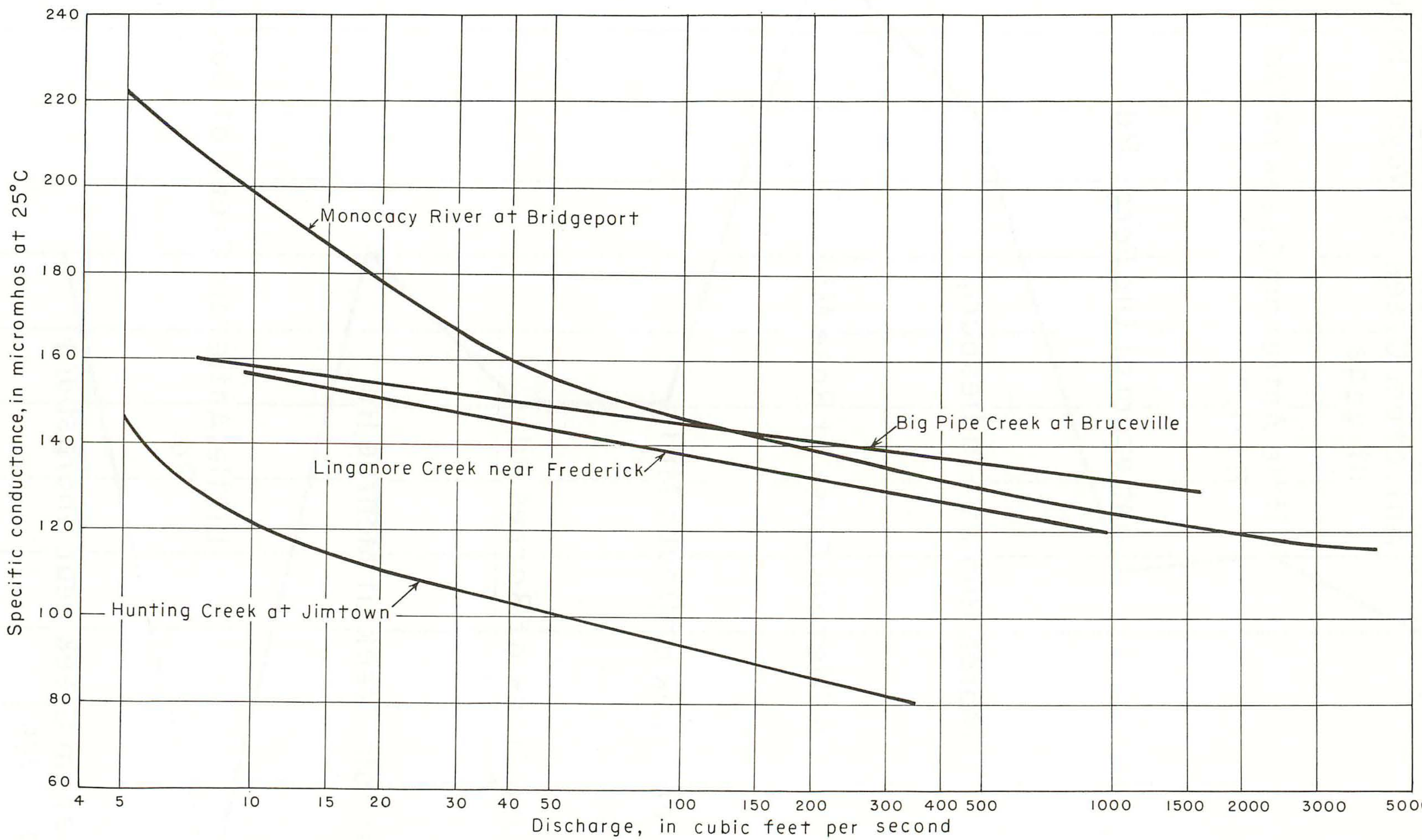

Figure 22—Specific conductance of water versus discharge for Big Pipe Creek at Bruceville, Linganore Creek near Frederick, Hunting Creek at Jimtown, and Monocacy River at Bridgeport.

Catoctin Creek basin

Catoctin Creek is underlain by granodiorite, granite gneiss, and metabasalt. Water from the basin was a calcium bicarbonate type and the iron concentration was less than 0.5 ppm.

Monocacy River basin

The Monocacy River basin drains 742 square miles of Frederick and Carroll Counties in Maryland, and 228 square miles of Adams County in Pennsylvania. The basin lies almost entirely in the Piedmont province, and extends to Catoctin Mountain. The eastward flowing tributaries of the Monocacy River head on the east slopes of Catoctin Mountain. The westward flowing tributaries head on the slopes of Dug Hill Ridge and Parrs Ridge.

Frederick and Carroll Counties are primarily agricultural areas, but the city of Frederick relies upon the Monocacy River for part of its municipal water supply and discharges treated waste disposal in it. Other communities use the river or its tributaries for waste disposal.

On the basis of geologic conditions and because gaging stations existed at these sites, samples were collected for complete chemical analyses of Monocacy River at Jug Bridge near Frederick, Linganore Creek near Frederick, and Big Pipe Creek at Bruceville. Previous chemical analyses are also available from these sites and it was desired to compare the earlier analyses with those obtained during the study. An additional sample collected at Route 28, near the mouth of the Monocacy River, at an ungaged site, represents a mixture of all the streams entering the river above this point. Israel Creek and Little Pipe Creek drain areas of more or less uniform geology. Israel Creek drains limestone and Little Pipe drains metabasalt.

Figure 22 shows the relation of specific conductance to discharge for Big Pipe Creek at Bruceville, Linganore Creek near Frederick, Hunting Creek at Jimtown, and Monocacy River at Bridgeport.

From the surface water analyses and the ground water data, geology appears to be the factor controlling the chemical quality at base flow. This conclusion is based on the following:

The surface-water analyses are similar to ground-water analyses in all geologic terranes except the metabasalt. Conductivities are high in the Monocacy River, Israel, and Big Pipe Creeks, which drain limestones and sandstones. Relatively high conductance values also occur in the analyses of ground water from these areas. Linganore and Bennett Creeks, which drain less soluble phyllites, have relatively low conductance readings.

Fishing, Hunting, and Owens Creeks have low conductivity and low bicarbonate concentrations, because they drain mountainous regions of less soluble rocks. These streams also have a higher discharge per square mile than those of the lower regions of the basins and probably have a greater proportion of overland flow as total discharge.

The sample from Little Pipe Creek, having a conductivity of 310 micromhos and a bicarbonate content of 149 ppm does not correlate well with five samples of ground water from wells ending in metabasalt and aporhyolite, which have an average conductivity of 135 micromhos and an average bicarbonate content of 149 ppm. It is possible that the drainage from a marble quarry into Little Pipe may cause an anomalous increase in the mineralization of the water.

Gages are on Hunting Creek at Jimtown, Fishing Creek above the reservoir, Owens Creek at Lantz, and the Monocacy at Bridgeport. The relation of specific conductance to discharge in figure 22 for the Monocacy River at Bridgeport was determined on the basis of weekly samples collected from April 1948 to September 1950. Partial analyses were also taken at other stations to improve the areal coverage. The chemical characteristics of water in the Monocacy River at Jug Bridge near Frederick are shown in figure 23. The water is a calcium bicarbonate type and the dissolved-solids concentrations range from 109 to 197 ppm. The high nitrates and chlorides of 13 ppm and 18 ppm suggest sewage pollution. Figure 24 shows the relation of specific conductance to discharge for the Monocacy River at Jug Bridge near Frederick.

Seneca Creek basin

Seneca Creek drains 129.3 square miles of western Montgomery County. The entire basin is located in the Piedmont province and drains into the Potomac River.

Seneca Creek drains four geologic units: the Wissahickon Formation, the Ijamsville Phyllite, the New Oxford Formation, and diabase rocks.

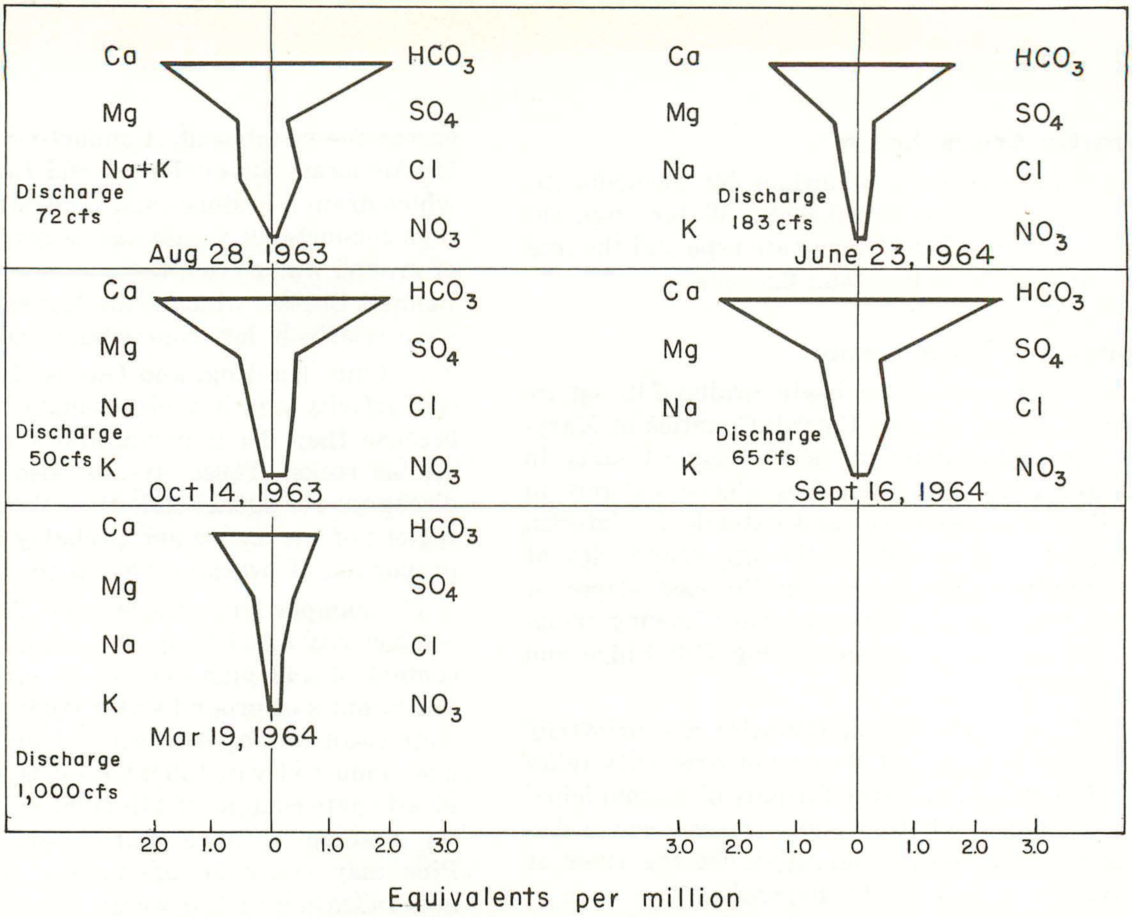

Figure 23—Chemical characteristics of water in the Monocacy River at Jug Bridge near Frederick, Md.

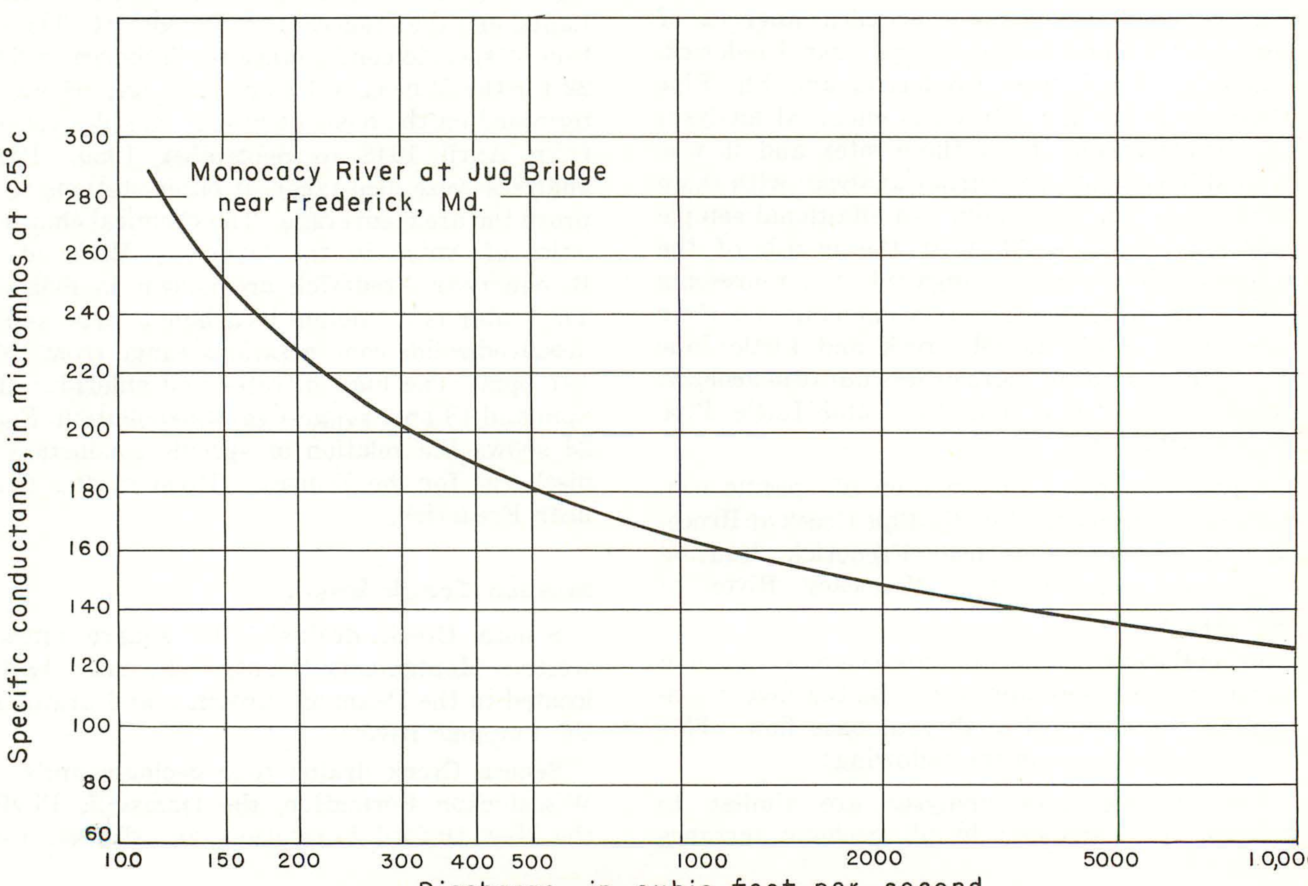

Figure 24—Specific conductance of water versus discharge for the Monocacy River at Jug Bridge near Frederick, Md.

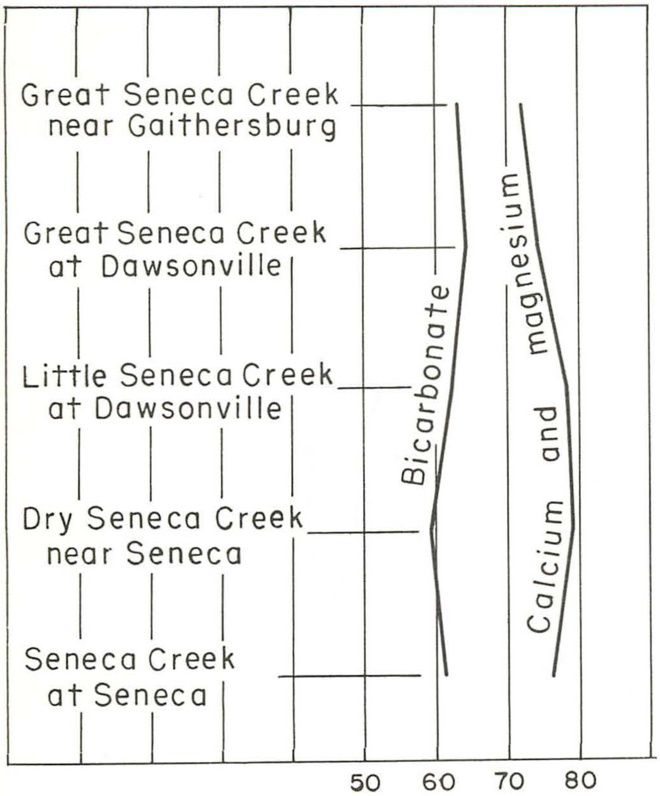

Figure 25—Percentage equivalents of ions in Seneca Creek basin, June 17, 1963.

Two of these units can be expected to contribute most to the quality of the water. These are: the Wissahickon Formation, which consists of quartz-mica schist, and the New Oxford Formation, which consists chiefly of red sandstone and shale. The New Oxford underlies most of the western part of the basin and it is drained almost exclusively by Dry Seneca Creek. Little Seneca and some of the tributaries of Great Seneca drain the Ijamsville Phyllite, but this unit probably contributes water similar in quality to the Wissahickon. A small intrusion of diabasic rock is located near Boyds, but its area in the basin is too small to make any significant contribution to the water quality of the stream.

Samples of water for complete chemical analysis were taken to define the quality from a main tributary. These streams are Dry Seneca Creek, Little Seneca Creek, Great Seneca Creek, and Seneca Creek at Seneca. The sample from the latter site represents the entire basin. Figure 25 shows the percentage equivalents of common cations and anions in Seneca Creek basin June 17, 1963. Samples were taken periodically of Seneca Creek at Dawsonville to show seasonal variations. Figure 26 shows the chemical characteristics of water at this location. The water in the basin is a calcium bicarbonate type and soft.

Anacostia River basin

The Anacostia River basin drains 169.9 square miles of Montgomery and Prince Georges Counties and the District of Columbia. The basin drains low rolling hills of the Piedmont province in Montgomery County and the Coastal Plain. The Fall Line lies approximately on the Prince Georges-Montgomery County line. The Anacostia River becomes tidal at approximately the District of Columbia line.

The Anacostia River basin drains two main geologic units: (1) the crystalline rocks of Montgomery County, mostly the Wissahickon Formation and the Laurel Gneiss of Cloos and Broedel, 1940; and (2) the Coastal Plain sands and clays of Prince Georges County. These include the Patuxent Formation which is chiefly sand and sandy clay, and the Patapsco Formation of similar lithology. These formations are separated by the Arundel Clay.

The sample from the Northwest Branch Anacostia River taken at Hyattsville is representative of water chiefly from the crystalline rocks. The Northeast Branch Anacostia River basin drains the Coastal Plain deposits and a small area of crystalline rocks. The sample taken at the Riverdale gage (Northeast Branch) contains higher dissolved-solids concentrations than the sample taken near Hyattsville (Northwest Branch), although the hardness of the Riverdale sample is only half that of the Hyattsville sample.

Conductivity was determined at several locations in the basin and the results are shown in figure 27. Both conductivity and alkalinity increase downstream, but there is considerably more variation in conductivity.

Data concerning discharge and conductivity have been related in figure 28 for the Northwest Branch Anacostia River near Colesville. A relationship covering a large range of flows is available for the Northwest Branch near Colesville. Sufficient specific conductance data are available only at high flow for the Northwest Branch at Hyattsville and the Northeast Branch at River-

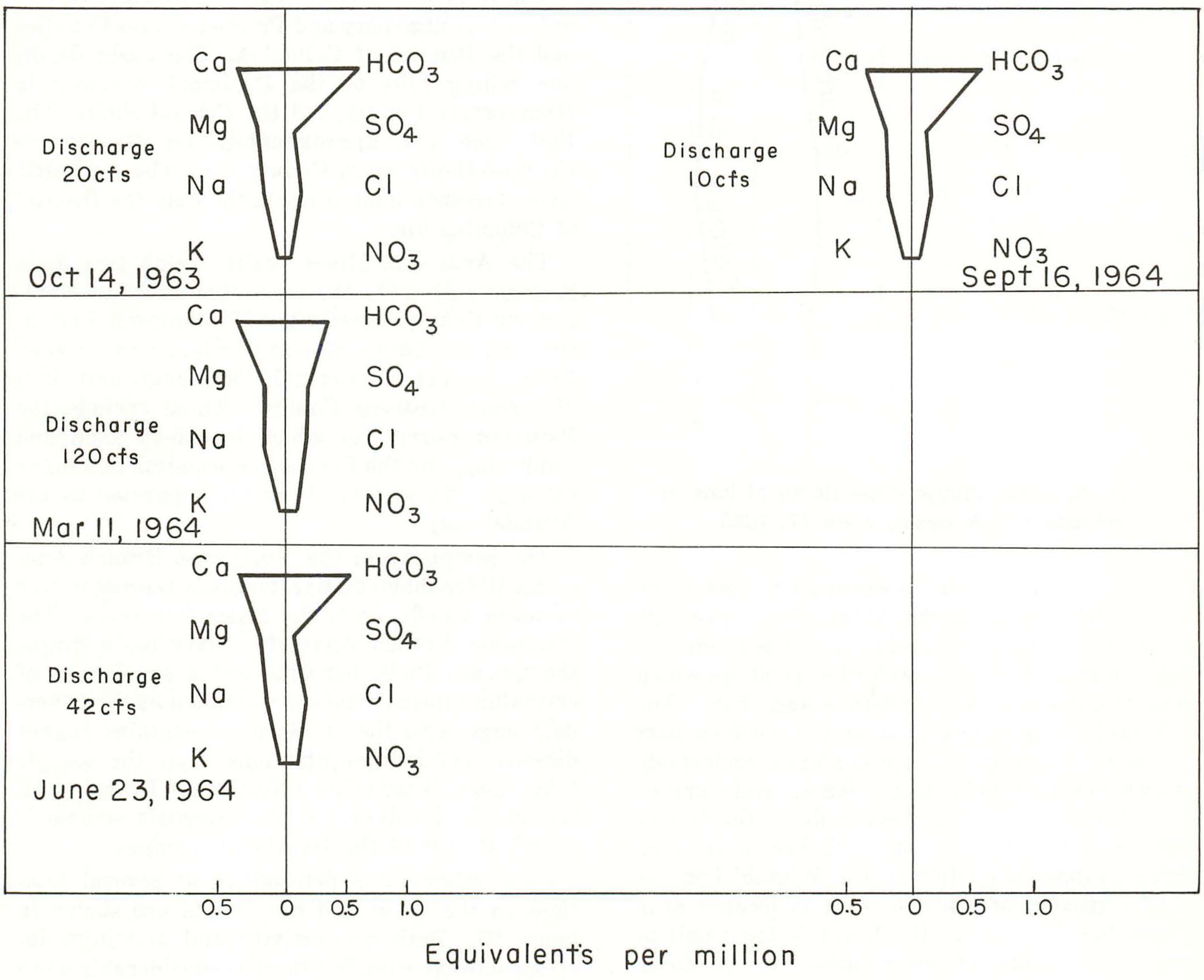

Figure 26—Chemical characteristics of water in Seneca Creek at Dawsonville, Md.

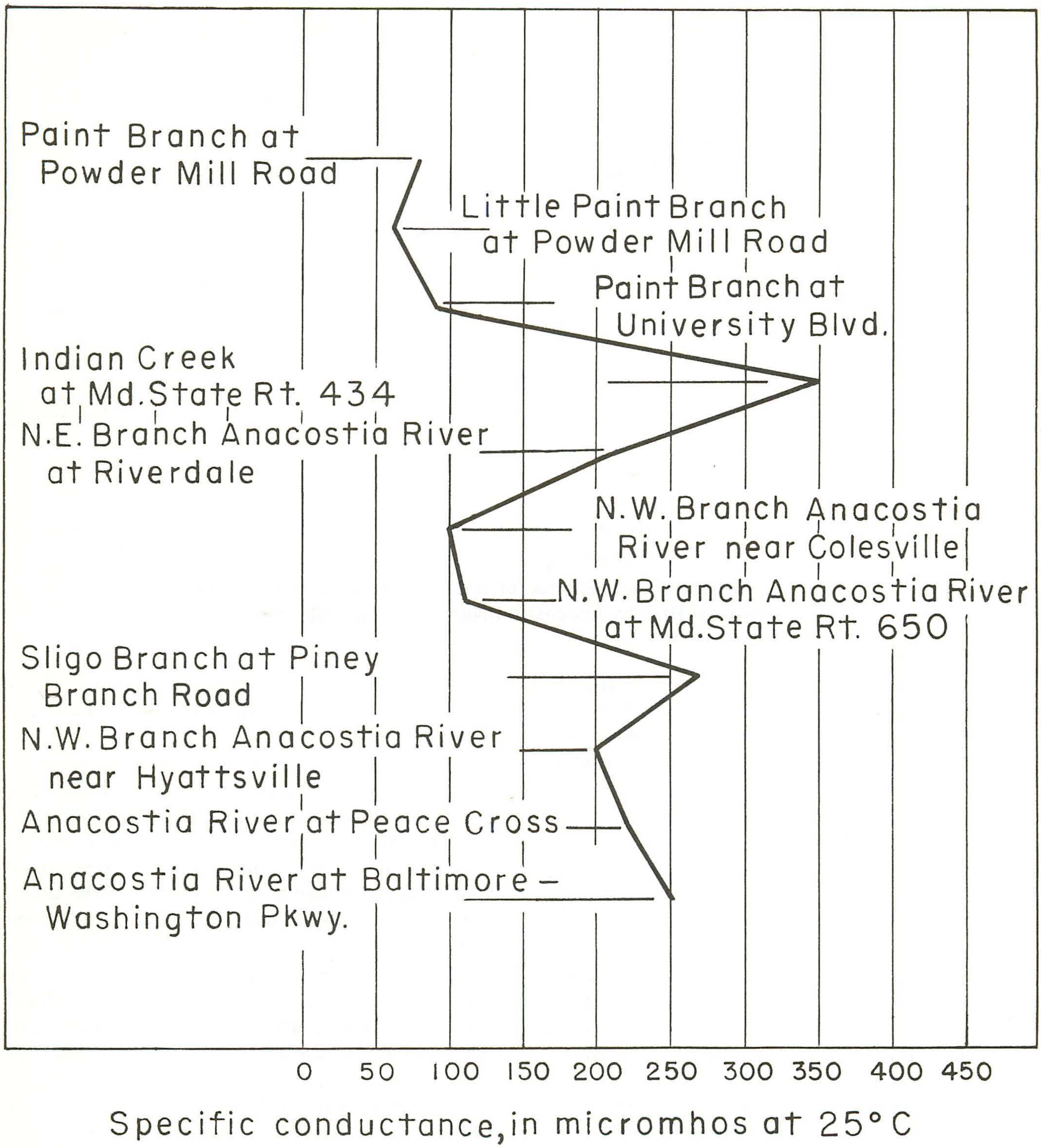

Figure 27—Specific conductance of water in the Anacostia River basin, August 19-20, 1963.

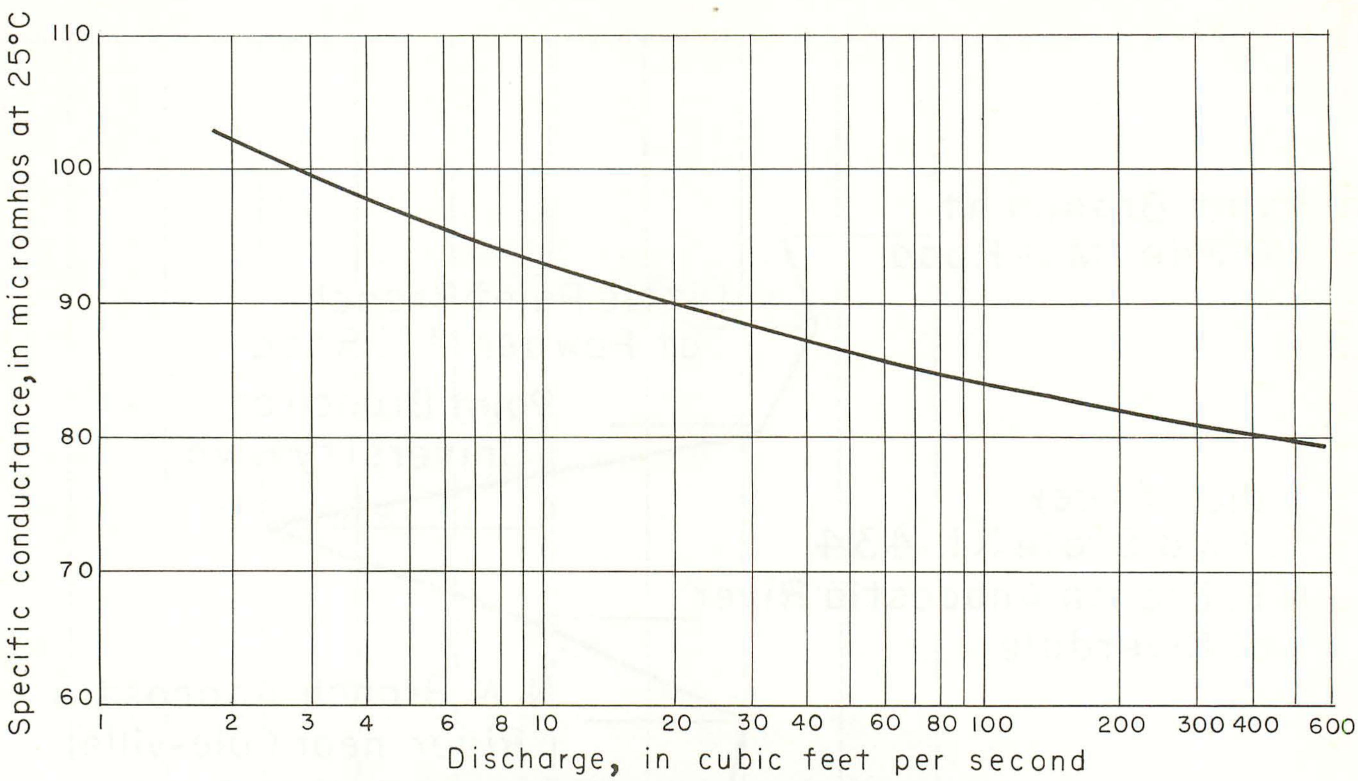

Figure 28—Specific conductance of water versus discharge for the Northwest Branch Anacostia River near Colesville, Md.

dale, but the few lowflow values indicated a large negative slope in both cases. Figure 29 shows the chemical characteristics of water in the Anacostia River basin; the water is principally a calcium bicarbonate type.

Potomac River basin

The Potomac River drains large areas of Maryland, Virginia and West Virginia, a small area of Pennsylvania and all of the District of Columbia. The out-of-state drainage is of concern to this investigation only insofar as it affects the quality of the stream within the State of Maryland. The North Branch Potomac River joins the South Branch Potomac River near Oldtown, Maryland to form the Potomac River. The South Branch contains a calcium bicarbonate type water of low dissolved-solids concentration which improves the quality of the water from the North Branch that is polluted from industrial activities. The North Branch contains a calcium sulfate type water.

The dissolved-solids concentration in the Potomac River at Hancock is about 300 ppm and the water is a calcium bicarbonate sulfate type water during base flow. The mouth of the Shenandoah River is at Harpers Ferry. The Shenandoah River contains water that is high in bicarbonate and dissolved solids.

The Potomac River at Point of Rocks is a calcium bicarbonate water most of the time. The dissolved-solids concentrations range from about 100-350 ppm, depending on the discharge. Figure 30 shows the chemical characteristics in the main stem of the Potomac River. This shows the variations of the water during seasonal changes and discharges.

Other major tributaries to the Potomac River such as the Monocacy River, Antietam and Conococheague Creeks, are calcium bicarbonate type water and do not greatly change the overall quality of the Potomac River water.

Below the head of tide, the influence of the Chesapeake Bay is felt in both the flow characteristics and in the chemical quality. During low-flow periods salt-water intrusion may be noted 90 miles above the mouth. Figure 31 shows the specific conductance of the water at several locations in the Potomac River basin. These specific conductances give an indication of dissolved-solids content of some of the streams in the basin.

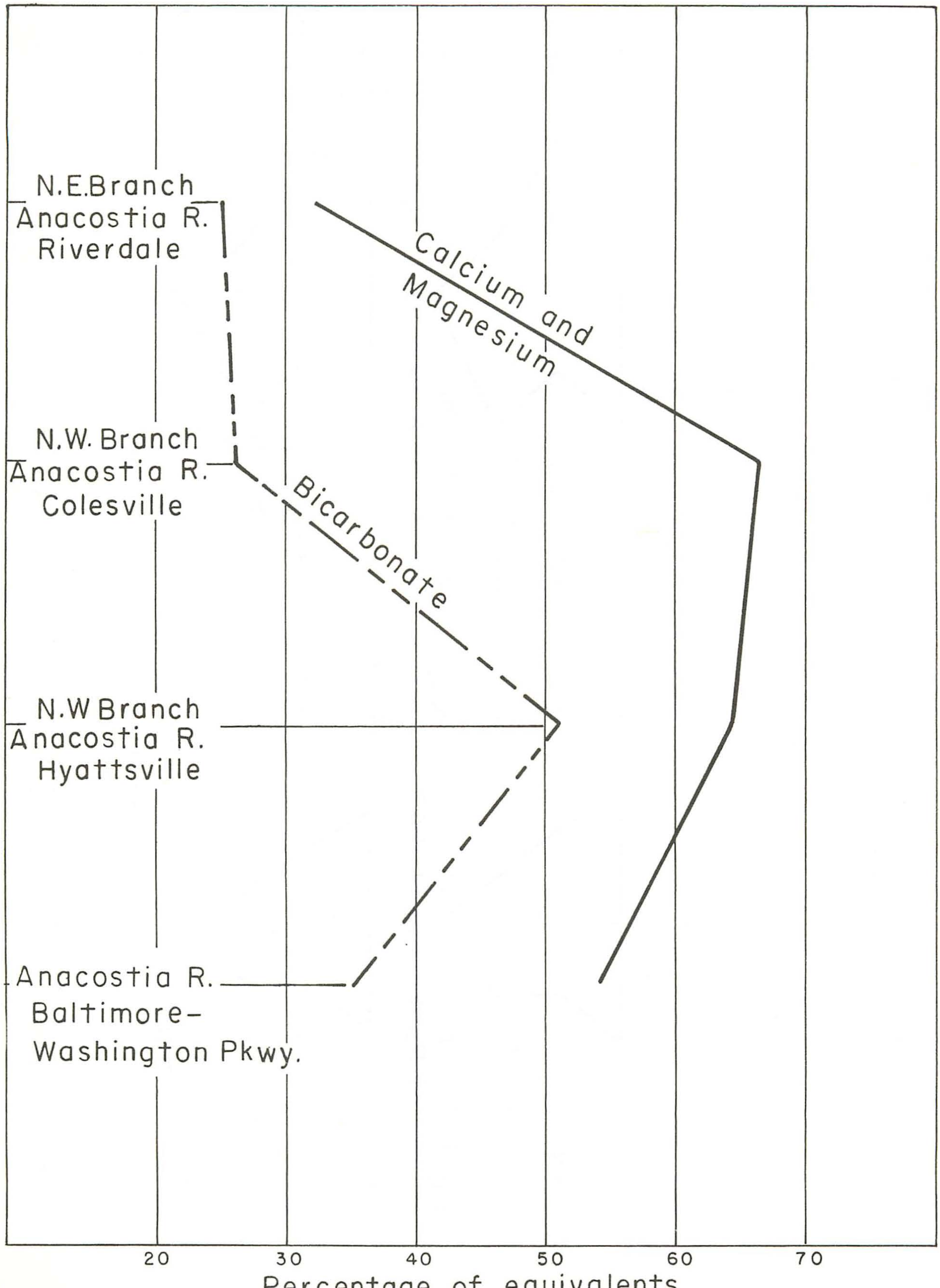

Figure 29—Percentage equivalents of ions in the Anacostia River basin, August 19-20, 1963.

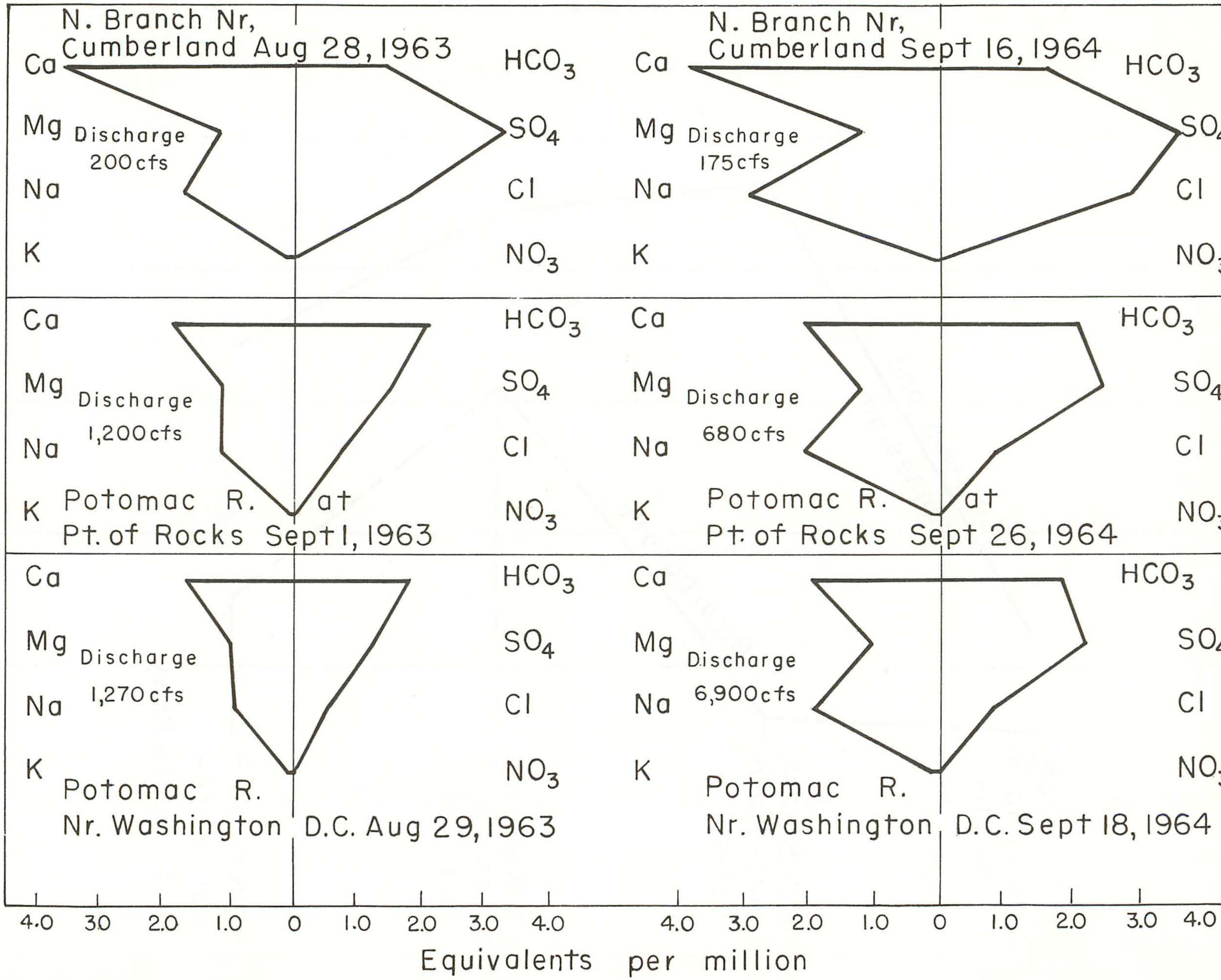

Figure 30—Chemical characteristics of water in the Potomac River basin.

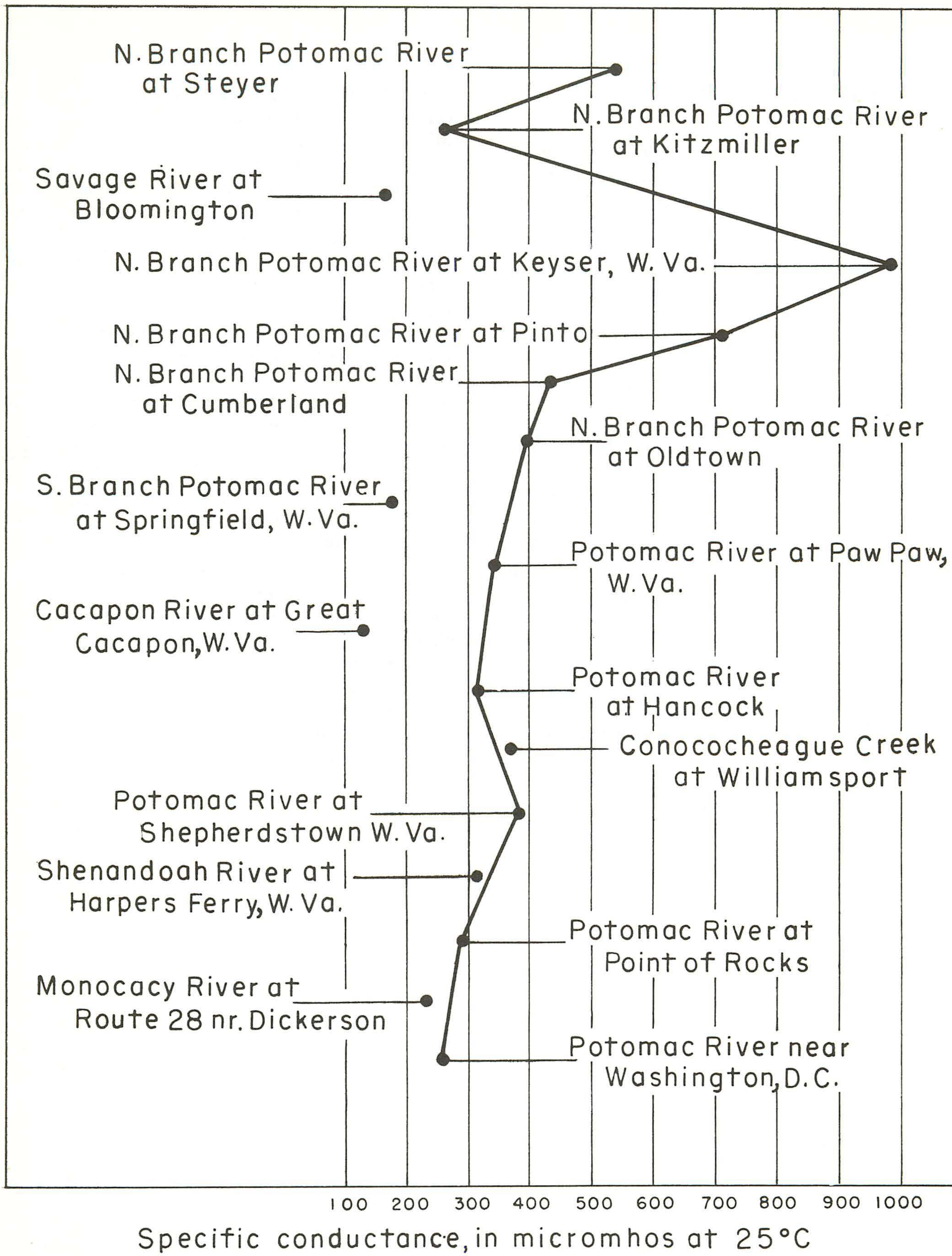

Figure 31—Specific conductance of water in the Potomac River basin on October 21-22, 1964.

Streams flowing into the Potomac estuary

Chemical characteristics of streams flowing into the Potomac estuary below Washington, D. C. are shown in figure 32. The majority of these streams are calcium bicarbonate type with dissolved solids ranging from 47 to 171 ppm. Waters from these streams should be representative of other streams entering the estuary from this area. The extent of salt-water encroachment was not investigated during this reconnaissance.

Youghiogheny and Casselman River basins

The Youghiogheny and Casselman Rivers drain most of Garrett County, and are subject to the same geologic and climatic conditions and thus will be considered together.

The county lies within the Appalachian Plateau physiographic province and is rolling upland deeply incised by stream valleys. Backbone Mountain and Meadow Mountain are part of a major north-south-trending divide in the eastern United States that separates areas that drain into the Ohio River basin from those that drain into the Atlantic Ocean. The Youghiogheny and Casselman Rivers drain north into the Ohio River basin.

The Youghiogheny and Casselman Rivers drain consolidated sedimentary rocks of Devonian, Mississippian, and Pennsylvanian ages which underlie Garrett County to known depths of several thousand feet. These formations are mostly shale and sandstone and some beds of coal and limestone.

Surface water in the Casselman and Youghiogheny River basins is acidic and a calcium sulfate type, indicating pollution from mine drainage. Figure 33 shows the specific conductance at various locations in the Youghiogheny River basin. Field measurements and laboratory analyses show evidence of acid mine drainage on Snowy Creek and Laurel Run at Crellin. At Laurel Run analyses showed dissolved-solids concentration of 488 ppm, sulfate of 320 ppm and pH of 2.9 at a discharge of 0.77 cfs. Dissolved-solids concentrations for the main stem of the Youghiogheny River are usually less than 100 ppm and frequently less than 50 ppm except in areas of local pollution.

The Maryland Water Pollution Control Commission (Department of Water Resources since 1964) has collected extensive data in the Youghiogheny River basin which includes 320 square miles of Garrett County. The data are pollution-oriented, and include D.O., B.O.D., coliforms, E. Coli, pH, acidity, alkalinity, and iron. Evidence of sewage pollution was found in the Little Youghiogheny River.

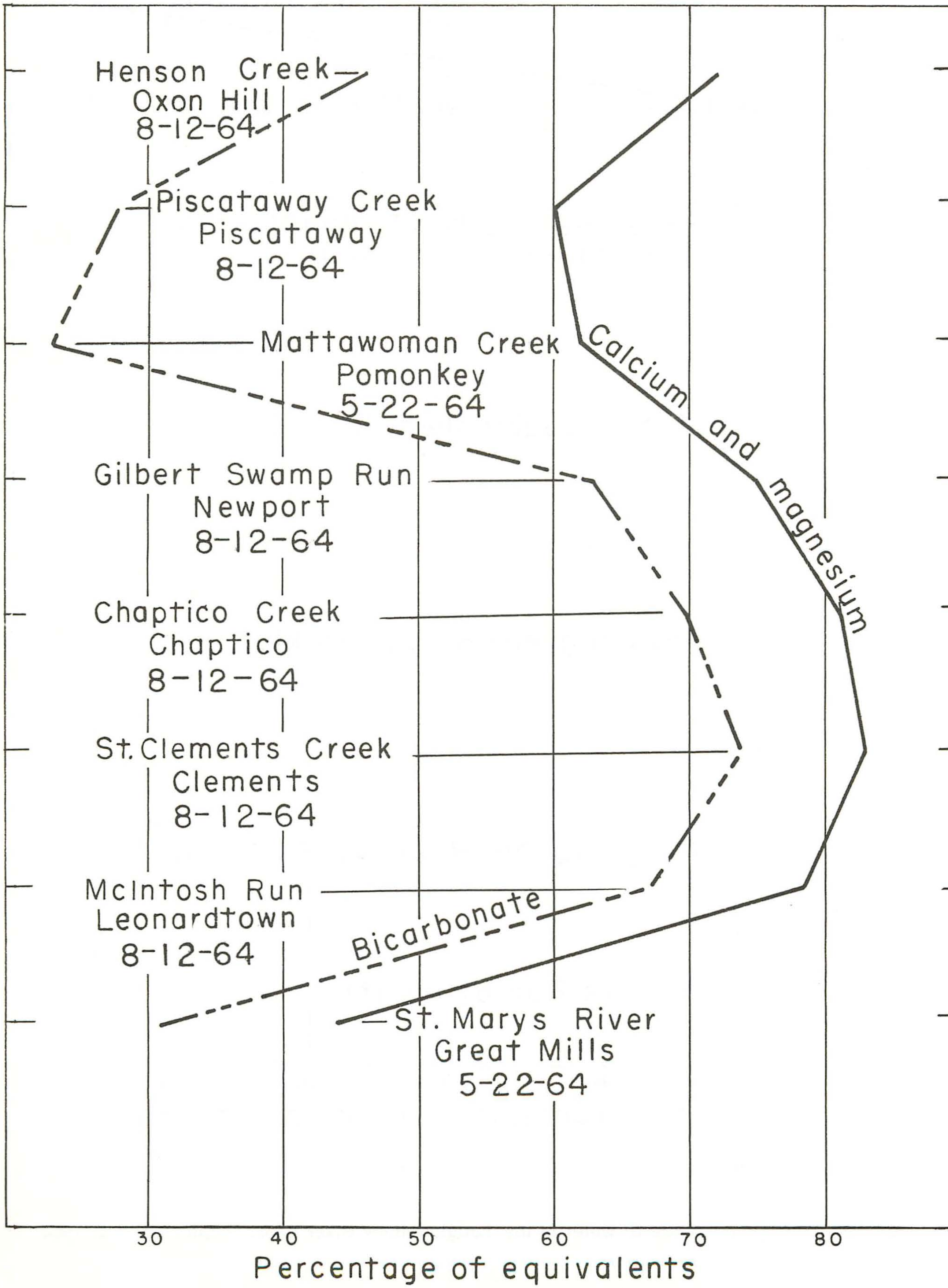

Figure 32—Percentage equivalents of ions in streams flowing into the Potomac estuary.

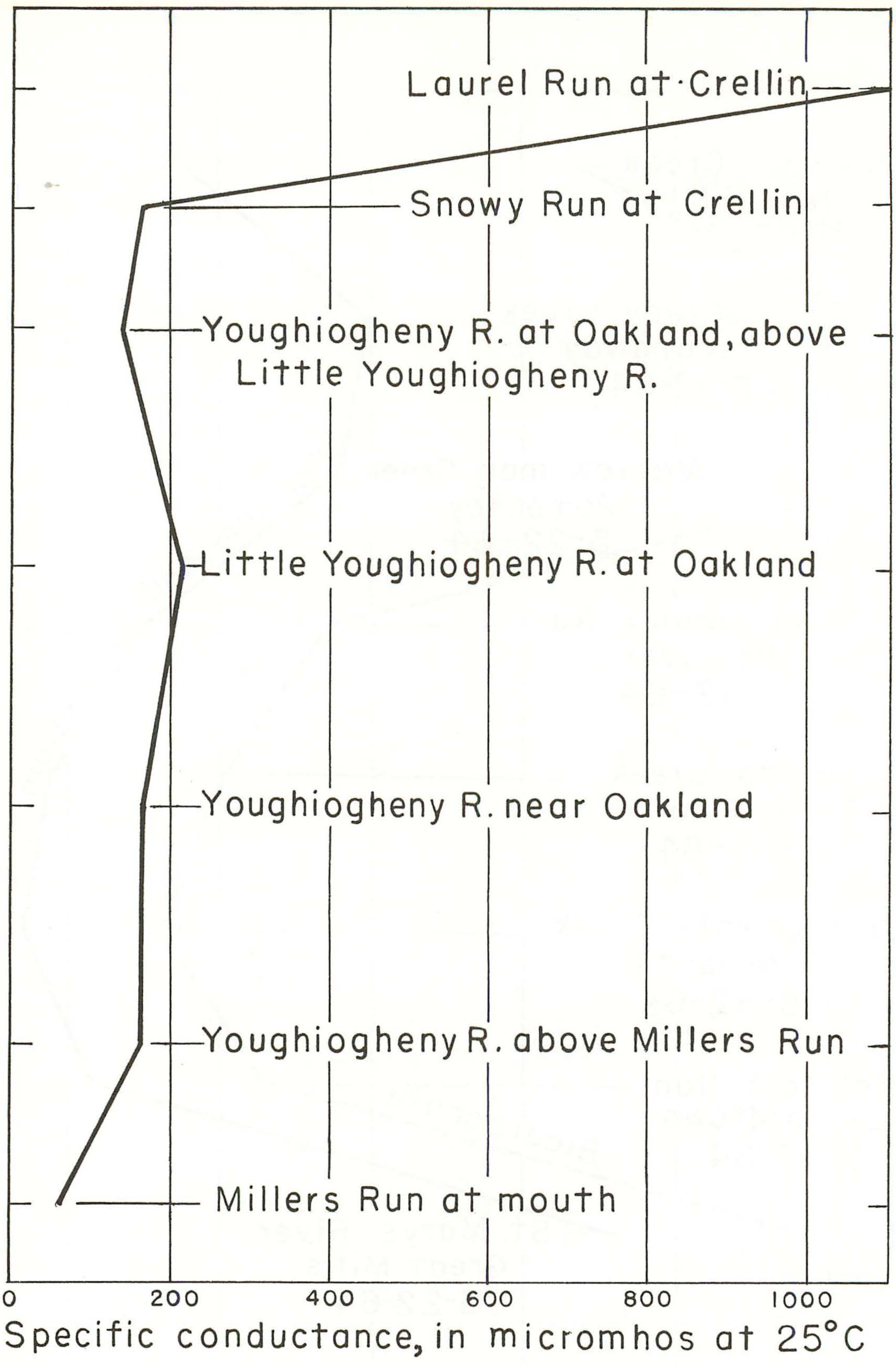

Figure 33—Specific conductance of water in the Youghiogheny River basin, September 1-2, 1964.

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APPENDIX A

Explanation of terms

Dissolved solids—This is the residue of dissolved mineral constitutents after evaporating the water sample and heating for 1 hour at 180°C.

Equivalents per million (epm)—A unit chemical combining weight of a constituent in a million unit weights of water; it is calculated by dividing the concentration in parts per million by the chemical combining weight of the constituent. The percentage equivalent is a value obtained by dividing the equivalents per million of the particular anion [or cation] by the summation of the equivalents per million of all of the anions [or cations].

Hardness of water — The hardness of water is defined as the property of water attributable to the presence of alkaline earths and is expressed as equivalent calcium carbonate ($CaCO_3$). Hardness equivalent to carbonate and bicarbonate ions is called carbonate hardness; the hardness in excess of this quantity is called non-carbonate hardness. Waters having a hardness of 60 ppm or less are considered soft; 61 to 120 ppm, moderately hard; 121 to 180 ppm, hard; and more than 180 ppm, very hard.

Hydrogen-ion concentration (pH)—The degree of acidity or alkalinity of water is indicated by the hydrogen-ion concentration, expressed as pH. A pH of 7.0 is considered neutral; a pH lower than 7.0 indicates acidic properties, and a pH higher than 7.0 indicates alkalinity.

Parts per million (ppm)—A part per million is a unit weight of a constituent in a million unit weights of water. In terms of percent, one part per million is equivalent to one ten-thousandth of one per cent (0.0001%). Results given in parts per million can be converted to grains per United States gallon by dividing by 17.12. The quantity of dissolved solids in tons per day may be obtained by multiplying the dissolved solids in parts per million by the discharge in cubic feet per second by the factor 0.0027 (ppm x cfs x 0.0027).

Specific conductance—The specific conductance is a measure of the ability of the water to conduct a current of electricity and can be used to indicate the ionic strength of solutions within rather wide limits. Specific conductance is expressed in reciprocal ohms times 10^6 (micromhos) at a standard temperature of 25°C.

APPENDIX B

Table 1. Chemical analyses of surface waters of Maryland

APPENDIX B

Table 1. Chemical analyses of surface waters of Maryland

POCOMOKE RIVER BASIN AND WICOMICO RIVER BASIN
Chemical analyses in parts per million

Station number on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
1	1-4850. POCOMOKE RIVER NEAR WILLARDS, MD.																					
	Sept. 29, 1964	5.0	26		2.4	0.00	3.9	1.3	8.8	1.6	28	3.4	7.0	0.0	0.3	74	15	0		74	6.7	--
2	POCOMOKE RIVER AT SNOW HILL, MD.																					
	Sept. 29, 1964		8.6		0.68	0.00	4.6	2.3	13	3.0	30	9.2	13	0.1	1.7	81	21	0		114	6.7	--
3	1-4855. NASSAWANGO CREEK NEAR SNOW HILL, MD.																					
	Sept. 29, 1964	1.6	25		3.1	0.00	2.2	1.3	10	3.0	16	1.4	8.8	0.0	9.8	82	11	0		82	6.4	--
4	LEONARD POND RUN NEAR DELMAR, MD.																					
	Sept. 25, 1963	2.98	16		0.03[a]	0.00[a]	3.5	0.1	7.8	--	16	4.0	6.2	0.0	0.4	54	9	0		59	6.3	20
5	NORTH PRONG WICOMICO RIVER NEAR SALISBURY, MD.																					
	Sept. 25, 1963	17.8	22		0.01[a]	0.00[a]	4.0	0.5	8.1	1.5	16	2.6	7.2	0.0	6.5	66	12	0		74	6.2	--
6	1-4865. BEAVERDAM CREEK NEAR SALISBURY, MD.																					
	June 19, 1963	18 [b]	12		0.29	0.00	4.0	0.2	6.9	0.6	14	3.6	7.1	0.1	2.2	60	11	0		62	6.3	40

[a] In solution when analyzed.
[b] Daily mean discharge at gaging station.

POCOMOKE RIVER BASIN AND WICOMICO RIVER BASIN—Continued

Chemical analyses in parts per million

Station number on Fig. 1	Date of collection	Tidal Stage	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
7	TONYTANK CREEK AT FRUITLAND, MD																					
	Sept. 25, 1963	3.14 [c]	17		0.04 [a]	0.00 [a]	5.0	0.9	7.4	1.5	19	3.2	7.6	0.0	3.3	62	16	1		74	6.5	--
8	WICOMICO RIVER SOUTH OF SHAD POINT, MD.																					
	Sept. 26, 1963		--		--	--	--	--	--	--	--	--	102	--	--	257	--	--		457	--	--
9	WICOMICO RIVER NEAR FRUITLAND, MD.																					
	Sept. 26, 1963		--		--	--	--	--	--	--	--	--	136	--	--	--	--	--		583	--	--
10	WICOMICO RIVER AT ROCKAWALKING CREEK NEAR SALISBURY, MD																					
	Sept. 26, 1963	Flood, top	--		--	--	--	--	--	--	--	--	232	--	--	--	--	--		914	--	--
	Sept. 26, ...	Ebb, top	--		--	--	--	--	--	--	--	--	212	--	--	--	--	--		834	--	--
	Sept. 26, ...	Flood, bottom	--		--	--	--	--	--	--	--	--	320	--	--	--	--	--		1,250	--	--
11	WICOMICO RIVEP AT PIRATES WHARF, MD.																					
	Sept. 26, 1963		--		--	--	--	--	--	--	--	--	2,120	--	--	--	--	--		6,780	--	--
	Sept. 26, ...		--		--	--	--	--	--	--	--	--	2,640	--	--	--	--	--		8,240	--	--
12	WICOMICO RIVER AT WHITEHAVEN, MD																					
	Sept. 26, 1963		--		--	--	--	--	--	--	--	--	4,900	--	--	9,640	--	--		14,100	--	--

[a] In solution when analyzed.
[c] Discharge in cfs.

NANTICOKE RIVER BASIN AND CHOPTANK RIVER BASIN
Chemical analyses in parts per million

Station number on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
13	MARSHY HOPE CREEK ABOVE SKINNERS RUN, MD.																					
	Dec. 8, 1964		14		0.03 a/	0.00 a/	5.6	2.7	8.8	2.7	16	13	13	0.0	3.9	71	25	12		109	6.2	
14	MARSHY HOPE CREEK AT HURLOCK, MD.																					
	Dec. 8, 1964		-		-	-	-	-	-	-	19	-	26	-	-	-	28	-		153	6.0	
15	MARSHY HOPE CREEK AT BROOKEVIEW, MD.																					
	Sept. 29, 1964	--	--		--	--	--	--	--	--	--	--	470	--	--	924	--	--		1,670	--	--
16	QUANTICO CREEK NEAR QUANTICO, MD.																					
	Sept. 25, 1963	1.26	27		0.70	---	4.8	1.0	8.8	1.7	17	8.0	11	0.0	0.6	86	16	2		83	6.4	--
17	1-4910. CHOPTANK RIVER NEAR GREENSBORO, MD.																					
	June 11, 1964	14.0	13		1.1 a/	0.02 a/	8.8	2.9	5.3	1.7	24	13	7.7	0.1	3.3	77	34	15		98	6.7	4
	Sept. 10, 1964		6.0		.00 a/	.00 a/	15	2.8	6.0	2.3	43	13	8.5	.1	5.3	83	49	14		125	6.7	5
18	CHOPTANK RIVER AT GREENSBORO, MD.																					
	Sept. 10, 1964	8.0	5.5		.00 a/	.01 a/	13	5.5	8.2	2.4	44	12	9.5	0.1	3.7	85	47	11		138	6.6	--
19	CHOPTANK RIVER 1 MILE BELOW GREENSBORO, MD.																					
	Sept. 10, 1964	--	--		--	--	--	--	--	--	--	--	39	--	--	121	--	--		245	--	--
20	CHOPTANK RIVER AT SMITH'S LANDING, MD.																					
	Sept. 9, 1964	--	--		--	--	--	--	--	--	--	--	206	--	--	435	--	--		800	--	--
	Sept. 10,....	--	--		--	--	--	--	--	--	--	--	316	--	--	634	--	--		1,170	--	--

a/ In solution when analyzed.

NANTICOKE RIVER BASIN AND CHOPTANK RIVER BASIN—Continued
Chemical analyses in parts per million

Station number on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
21	CHOPTANK RIVER AT DENTON, MD.																					
	Sept. 10, 1964	--	--		--	--	--	--	--	--	--	--	526	--	--	1,010	--	--		1,870	--	--
22	CHOPTANK RIVER NEAR WILLISTON, MD.																					
	Sept. 10, 1964	--	1.1		0.02[a]	0.00[a]	46	69	647	--	43	156	1,140	0.1	0.2	2,210	401	366		3,690	6.6	--
23	TUCKAHOE CREEK AT HILLSBORO, MD.																					
	Sept. 10, 1964	--	18		0.01[a]	0.00[a]	11	1.8	5.4	2.0	31	8.0	6.6	0.1	6.2	75	35	10		105	6.5	--
24	TUCKAHOE CREEK AT RT. 328, HILLSBORO, MD.																					
	Sept. 10, 1964	--	--		--	--	--	--	--	--	--	--	864	--	--	1,640	--	--		2,950	--	--
25	CHOPTANK RIVER AT GANEY WHARF, MD.																					
	Sept. 10, 1964	--	--		--	--	--	--	--	--	--	--	1,340	--	--	2,510	--	--		4,430	--	--
26	1-4920. BEAVERDAM BRANCH AT MATTHEWS, MD.																					
	June 11, 1964	0.3	12		1.1	0.01	14	2.9	5.4	1.7	39	12	8.8	0.1	5.5	94	47	15		125	6.9	4
27	CHOPTANK RIVER AT DOVER BRIDGE, MD.																					
	Sept. 10, 1964	--	--		--	--	--	--	--	--	--	--	2,660	--	--	4,940	--	--		8,220	--	--

[a] In solution when analyzed.

CHESTER, ELK, NORTHEAST, SUSQUEHANNA, AND BUSH RIVER BASINS

Chemical analyses in parts per million

Station number on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
28	CHESTER RIVER AT MILLINGTON, MD.																					
	Sept. 29, 1964	--	7.6		0.58	0.07	8.4	3.6	6.5	3.0	28	9.6	13	0.0	4.3	74	36	13		118	7.2	--
29	1-4935. MORGAN CREEK NEAR KENNEDYVILLE, MD.																					
	June 10, 1964	4.5	12		2.0	0.10	9.5	2.1	3.3	1.8	34	2.8	5.7	0.1	3.5	65	32	4		89	6.9	1
30	1-4950. BIG ELK CREEK AT ELK MILLS, MD																					
	June 10, 1964	34	12		0.20	0.01	6.6	2.3	5.7	2.0	22	8.0	6.5	0.1	5.8	66	26	8		89	6.9	3
31	1-4960. NORTHEAST CREEK AT LESLIE, MD.																					
	June 9, 1964	11	17		0.39	0.02	6.8	4.9	4.8	1.6	44	5.2	4.9	0.1	3.7	76	37	1		104	6.8	3
32	1-5800. DEER CREEK AT ROCKS, MD.																					
	March 7, 1955	158	6.5		0.09	--	6.8	1.8	2.6	1.4	14	9.5	5.0	0.1	6.2	53	25	13		75	6.8	20
33	SUSQUEHANNA RIVER, ABOVE GARRETT ISLAND AT PERRYVILLE, MD.																					
	Aug. 20, 1964	--	--		--	--	--	--	--	--	--	--	13	--	--	--	--	--		420	7.3	--
34	SUSQUEHANNA RIVER AT PERRY POINT HOSPITAL AT PERRYVILLE, MD.																					
	Aug. 20, 1964	--	--		--	--	--	--	--	--	--	--	13	--	--	--	--	--		412	7.3	
35	1-5815. BYNUM RUN AT BELAIR, MD.																					
	June 9, 1964	4.01	19		0.36	0.02	16	6.3	5.5	1.2	64	9.6	7.3	0.2	5.6	117	66	14		157	6.7	5
36	WINTERS RUN OFF RT. 24 ON SINGER ROAD, NEAR EDGEWOOD, MD.																					
	June 9, 1964	39	12		.74	0.20	6.6	3.5	4.3	1.7	28	7.4	5.9	0.1	4.6	68	31	8		92	6.8	3
37	WINTERS RUN AT EDGEWOOD ARSENAL, MD.																					
	June 7, 1960	-	11	0.0	0.20	0.07	7.8	3.3	4.1 (Na+K)		30	6.2	5.5	0.2	3.4	63	33	9		91	6.8	3
	Aug. 13. 1962	-	8.5	.0	.13	.10	8.0	2.4	6.7 (Na+K)		32	6.2	6.5	.0	3.5	62	30	4		94	6.8	5
	Sept. 6, 1963	-	5.2	.3	.43	.04	7.5	4.3	6.4 (Na+K)		38	6.6	7.5	.1	1.3	60	36	5		101	6.8	8

GUNPOWDER AND BACK RIVER BASINS
Chemical analyses in parts per million

Station number on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
38	GUNPOWDER FALLS AT LINEBORO, MD.																					
	Oct. 24, 1962	5.29	7.5		--	--	12	2.4	3.9	--	36	4.0	5.7	0.0	8.6	63	40	11		101	7.9	--
39	GUNPOWDER FALLS NEAR GUNPOWDER, MD.																					
	Oct. 21, 1962	12.3	5.4		--	--	24	9.2	5.8	--	110	8.4	7.8	0.1	0.8	119	98	8		216	7.9	--
40	1-5820. LITTLE FALLS AT BLUE MOUNT, MD.																					
	Oct. 24, 1962	21	8.1		--	--	6.0	1.9	5.5	--	22	5.0	6.2	0.0	4.2	48	23	5		74	7.5	--
41	1-5835. WESTERN RUN AT WESTERN RUN, MD.																					
	Oct. 24, 1962	19.5	11		--	--	18	6.1	5.1	--	78	6.0	6.0	0.0	3.1	92	70	6		160	7.9	--
42	BEAVERDAM CREEK AT COCKEYSVILLE, MD.																					
	Oct. 24, 1962	--	9.7		--	--	35	13	5.8	--	116	14	25	0.0	5.6	196	142	42		310	8.4	--
43	OVERSHOT RUN NEAR SUNNYBROOK, MD.																					
	Oct. 24, 1962	.47	12		--	--	6.5	5.4	2.1	--	26	3.6	8.9	0.0	6.3	58	38	17		87	7.2	--
44	LOWER EAST FORK DULANEY VALLEY BRANCH LOCH RAVEN RESERVOIR NEAR LONG GREEN, MD.																					
	Oct. 24, 1962	0.2	13		--	--	7.0	0.4	9.9	--	32	3.4	5.9	0.0	2.8	56	19	0		85	7.5	--
45	1-5840. GUNPOWDER FALLS NEAR CARNEY, MD.																					
	Oct. 24, 1962	4.8	7.2		--	--	34	13	7.8	--	157	12	9.4	0.1	0.1	158	138	10		292	8.2	--
46	1-5845. LITTLE GUNPOWDER FALLS AT LAUREL BROOK, MD.																					
	Dec. 13, 1954	20.5	12	-	0.45	0.00	6.9	3.1	3.3	1.8	30	4.0	3.0	0.2	8.8	70	30	6		81	7.4	7
	Mar. 7, 1955	52.2	8.8	-	.25	.00	7.7	2.3	2.7	1.8	20	10	4.0	.1	6.8	63	29	12		88	6.9	7
47	1-5851. WHITE MARSH RUN AT WHITE MARSH, MD.																					
	Aug. 20, 1964	2.3	3.8		1.0	0.04	11	5.0	14	3.1	38	10	22	0.2	10	102	48	17		170	6.3	--
48	1-5853. STEMMERS RUN AT ROSSVILLE, MD.																					
	Aug. 20, 1964	0.6	9.9		0.82	0.40	19	6.0	24	--	57	26	29	0.2	12	172	72	26		268	6.5	--

SEVERN AND SOUTH RIVER BASINS

Chemical analyses in parts per million

Station numbers on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
49	1-5875. SOUTH BRANCH PATAPSCO RIVER AT HENRYTON, MD.																					
	Aug. 27, 1963	10	5.9		0.00[a]	0.00[a]	9.5	2.1	9.2		41	5.2	7.5	0.1	2.4	57	32	0.0		98	6.9	5
	Oct. 31, ...	14	7.7		.07	.00	8.0	3.4	4.2	2.1	39	4.6	5.4	.0	.6	60	34	2		94	6.7	5
	June 4, 1964	39	7.2		.20	.10	6.1	2.4	3.5	1.4	24	5.0	4.9	.0	5.6	54	25	6		75	6.6	2
50	NORTH BRANCH PATAPSCO AT MARRIOTTSVILLE, MD.																					
	Aug. 27, 1963	19	3.9		0.00[a]	0.00[a]	8.5	3.4	5.5		32	7.6	5.9	0.8	3.3	56	35	9		100	6.7	5
51	1-5890. PATAPSCO RIVER AT HOLLOFIELD, MD.																					
	Aug. 27, 1963	20	8.7		0.00[a]	0.00[a]	13	3.8	7.8		52	10	7.0	0.2	2.1	86	48	6		138	7.3	5
	June 4, 1964	71	8.0		.60	.02	10	2.2	5.2	1.4	35	7.2	5.7	.1	3.1	66	34	6		99	6.5	5
52	PATAPSCO RIVER AT THISTLE, MD.																					
	Aug. 27, 1963		9.9		0.60	0.02	18	4.4	17		76	19	12	0.2	0.7	122	63	1		198	6.5	6
53	PATAPSCO RIVER AT BALTIMORE-WASHINGTON PARKWAY, BALTIMORE, MD.																					
	Aug. 27, 1963		9.1		0.03[a]	0.00[a]	15	4.5	12		55	16	14	0.4	1.5	105	56	11		174	6.4	5
54	1-5893. GWYNNS FALLS AT VILLA NOVA, MD.																					
	Aug. 20, 1964	8.6	3.3		0.52	0.06	20	7.1	6.1	2.9	76	11	13	0.0	2.6	116	79	17		192	7.0	-
55	GWYNNS FALLS AT BALTIMORE, MD.																					
	Aug. 27, 1963	7.5	9.1		0.00[a]	0.00[a]	21	6.4	13		86	12	16	0.2	1.5	124	79	9		212	7.3	5
56	SEVERN RIVER NEAR ODENTON, MD.																					
	Aug. 19, 1964	1.6	6.8		0.44	0.01	6.2	2.1	3.0	2.1	9	13	5.2	0.1	4.6	51	24	17		77	6.2	-
57	1-5900. NORTH RIVER NEAR ANNAPOLIS, MD.																					
	Aug. 19, 1964	3.6	18		1.7	0.02	4.6	2.6	1.6	1.1	13	9.2	3.1	0.2	0.1	55	22	12		53	6.3	-

[a] In solution when analyzed.

PATUXENT RIVER BASIN

Chemical analyses in parts per million

Station numbers on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
58	1-5910. PATUXENT RIVER NEAR UNITY, MD.																								
	July 1, 1963	14	7.7		0.00[a]	0.00[a]	3.8	2.1	2.7	10		20		1.6	3.4	0.1	3.3		41	18	2		55	6.5	3
59	PATUXENT RIVER BELOW TRIADELPHIA RESERVOIR NEAR BRIGHTON, MD.																								
	July 1, 1963	43	4.0		0.00[a]	0.00[a]	6.0	1.7	2.8	2.1		17		6.8	4.3	0.2	3.5		43	22	8		71	6.3	5
60	1-5925. PATUXENT RIVER NEAR LAUREL, MD.																								
	July 1, 1963	14	7.3		1.3[a]	0.5[a]	6.0	2.4	3.0	2.4		24		6.0	4.4	0.2	2.5		54	25	6		75	6.5	7
61	PATUXENT RIVER, NEAR BOWIE, MD.																								
	July 2, 1963	22	5.5		0.03[a]	0.00[a]	6.0	2.2	4.7	2.5		16		11	6.5	0.2	3.6		59	24	11		85	6.0	5
62	1-5935. LITTLE PATUXENT RIVER AT GUILFORD, MD.																								
	June 27, 1963	11	19		0.04[a]	0.00[a]	11	1.6	6.2	1.7		40		8.0	5.0	0.2	3.2		75	34	1		110	6.5	5
63	MIDDLE PATUXENT RIVER NEAR GUILFORD, MD.																								
	June 27, 1963		15		0.02[a]	0.00[a]	11	1.6	4.7	1.6		40		5.2	5.0	0.1	1.9		69	34	1		101	6.6	2
64	DORSEY RUN, NEAR JESSUP, MD.																								
	July 2, 1963	5.2	8.8		0.01[a]	0.00[a]	9.5	3.0	12	3.5		26		15	15	0.3	9.7		97	36	14		139	6.3	5
65	LITTLE PATUXENT RIVER AT FORT GEORGE G. MEADE, MD.																								
	June 27, 1963	41	15		0.57	0.06	12	2.2	24	3.3		64		26	7.6	0.4	5.1		137	39	0		204	6.4	8
66	1-5944.5. PATUXENT RIVER AT HARDESTY, MD.																								
	June 27, 1963	85	13		2.0	0.10	10	1.9	7.4	2.5		30		13	1.5	0.2	5.0		75	33	1		120	6.4	2
67	1-5945. WESTERN BRANCH NEAR LARGO, MD.																								
	June 27, 1963	3.7	14		0.02[a]	0.00[a]	14	1.7	3.7	2.0		28		15	9.6	0.4	0.8		85	42	19		120	6.4	3

a/ In solution when analyzed.

PATUXENT RIVER BASIN—Continued
Chemical analyses in parts per million

Station number on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
68	WESTERN BRANCH AT U. S. 301 NEAR UPPER MARLBORO, MD.																								
	July 3, 1963	44	15		0.00[a]	0.00[a]	17	2.3	3.5	3.5		40		18	7.4	0.3	0.9		99	52	19		136	6.5	7
69	MATAPONI CREEK NEAR CROOM, MD.																								
	July 3, 1963		21		0.04[a]	0.00[a]	6.8	1.7	2.7	1.2		14		13	4.4	0.2	0.2		69	24	13		68	6.0	7
70	PATUXENT RIVER AT LYONS CREEK WHARF, MD.																								
	June 28, 1963		3.3		3.0	0.05	11	4.0	35	3.2		26		22	56	0.3	0.8		173	44	23		287	6.1	5
71	1-5947. PATUXENT RIVER AT BENEDICT, MD.																								
	June 28, 1963		3.8		0.24	0.00	149	383	3,240	118		60		930	5,880	0.8	1.9		11,700	1,950	1,900		16,800	6.5	5
72	PATUXENT RIVER OPPOSITE BROOMES ISLAND, MD.																								
	June 28, 1963		2.9		0.02[a]	0.00[a]	199	417	3,730	107		66		950	6,890	0.8	3.1		13,900	2,220	2,160		19,300	6.7	2
73	PATUXENT RIVER OPPOSITE ST. LEONARDS CREEK																								
	June 28, 1963		2.9		0.02[a]	0.00[a]	219	425	3,740	107		66		984	6,960	0.8	0.9		14,100	2,300	2,240		19,700	6.6	3
74	1-5948.3. PATUXENT RIVER AT SOLOMONS, MD.																								
	June 28, 1963		2.3		0.11	0.00	209	419	4,270	119		23		1,040	7,490	1.0	5.9		15,300	2,250	2,190		21,000	6.6	2

[a] In solution when analyzed.

POTOMAC RIVER BASIN
Chemical analyses in parts per million

Station numbers on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
75	1-5950. NORTH BRANCH POTOMAC RIVER AT STEYER, MD.																					
	Oct. 21, 1964	20	8.4		3.3	0.00	27	11	2.4	1.8		169	2.2	0.1	0.1	247	112	112	1.3	533	3.2	
76	1-5955. NORTH BRANCH POTOMAC RIVER AT KITZMILLER. MD.																					
	Oct. 21, 1964	97	5.9		1.7	0.00	17	6.7	1.4	1.3		91	2.1	0.0	0.0	128	70	70	0.5	255	3.9	
77	SAVAGE RIVER AT BLOOMINGTON, MD.																					
	Oct. 21, 1964		3.9		0.34	0.00	24	3.9	2.4	1.2	20	57	2.7	0.0	0.1	98	76	60		166	6.9	
78	GEORGES CREEK AT BORDEN SHAFT, MD.																					
	June 23, 1964	-	-	-	-	-	-	-	-	-	-	-	50	-	0.9	-	-	-		600	7.8	-
79	GEORGES CREEK AT MIDLAND, MD.																					
	July 23, 1964	0.65	0.1	-	0.31	-	33	9.4	13	3.9	60	79	15	0.2	1.9	216	121	72		319	6.8	3
80	1-5990. GEORGES CREEK AT FRANKLIN, MD.																					
	June 23, 1964	62	13	-	1.4	-	150	48	7.4	3.6		612	5.9	0.4	1.4	937	570	570	0.9	1,110	4.0	2
81	NORTH BRANCH POTOMAC RIVER AT KEYSER, WEST VIRGINIA																					
	Oct. 21, 1964		6.5		0.09[a]	0.00[a]	94	6.8	110	6.6	116	226	127	0.2	0.5	641	263	168		997	6.8	
82	1-6000. NORTH BRANCH POTOMAC RIVER AT PINTO, MD.																					
	Oct. 21, 1964	161	6.1		0.80	0.00	79	10	56	5.2	77	185	79	0.2	0.5	459	240	177		721	6.8	
83	WILLS CREEK AT CORRIGANVILLE. MD.																					
	July 22, 1964	-	2.3	-	0.08	-	15	4.5	2.2	1.8	50	17	2.9	0.0	0.1	84	56	15		130	7.2	7
84	1-6015. WILLS CREEK NEAR CUMBERLAND, MD.																					
	June 24, 1964	41	6.1	-	0.51	-	91	17	4.2	1.9	52	243	6.4	0.2	1.0	440	297	254		572	6.9	2

a/ In solution when analyzed.

POTOMAC RIVER BASIN—Continued

Chemical analyses in parts per million

Station numbers on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
85	1-6030. NORTH BRANCH POTOMAC RIVER NEAR CUMBERLAND, MD.																					
	May 16, 1963	910	4.9		0.16[a]	0.01[a]	26	4.6	7.8	1.4	26	59	14	0.1	0.5	163	84	63		226	6.8	20
	Aug. 28,....	200	6.4		2.8	.02	74	13	39	3.2	86	157	65	.2	.4	435	240	170		662	6.6	10
	Oct. 14,....	170	6.4		.79	.06	84	13	75	3.9	101	166	114	.1	.4	529	261	178		840	7.3	80
	Mar. 11, 1964	9,590	4.4		1.4	.10	14	2.7	7.3	1.3	30	32	2.9	.0	1.2	86	46	22		147	6.7	
	June 24, ...	509	6.6		.70	.20	56	10	28	3.2	58	128	44	.2	3.1	359	182	135		500	6.9	7
	Sept.16, ...	175	6.0		.81	.23	80	14	68	4.4	98	178	106	.3	.3	530	258	177		821	6.8	--
86	EVITTS CREEK NEAR CUMBERLAND, MD.																					
	June 24, 1964	2.3	2.9		0.39	--	38	6.8	1.7	1.8	131	17	1.9	0.2	0.3	150	123	16		245	7.5	4
87	TOWN CREEK NEAR OLD TOWN, MD.																					
	Dec. 16, 1964		5.7		0.08	0.00	23	0.6	2.2	1.3	47	24	2.5	0.0	1.0	84	60	22		133	6.8	
88	FIFTEENMILE CREEK AT U. S. 40 NEAR PINEY GROVE, MD.																					
	Dec. 16, 1964	884	5.9		0.06	0.00	3.8	2.6	3.3	1.0	10	13	4.1	0.0	0.8	40	20	12		62	6.7	
89	POTOMAC RIVER AT PAW PAW. WEST VIRGINIA																					
	Oct. 22, 1964		5.2		0.07	0.00	48	7.8	14	2.5	86	86	17	0.1	0.4	224	152	82		369	7.0	
90	SIDELING HILL CREEK AT U. S. 40 NEAR HANCOCK, MD.																					
	July 14, 1964	9.5	3.4		0.03	--	10	2.2	7.4	2.2	27	9.6	13	0.0	0.3	72	34	12		108	6.7	6
91	1-6125. LITTLE TONOLOWAY CREEK NEAR HANCOCK, MD.																					
	July 14, 1964	2.3	6.8		0.11	--	12	2.9	5.6	2.1	32	14	9.8	0.0	1.0	84	42	16		121	7.7	5
92	1-6130. POTOMAC RIVER AT HANCOCK, MD.																					
	May 16, 1963	2,490	1.9		0.10[a]	0.00[a]	38	6.0	10	1.8	73	60	13	0.1	0.5	204	118	58		296	7.3	5
	July 14, 1964	686	1.0		.36	--	52	9.1	26	2.6	88	91	41	.1	.3	316	167	95		464	7.2	6
93	TONOLOWAY CREEK AT HANCOCK, MD.																					
	July 14, 1964	16	2.8		0.01	--	21	4.0	3.0	2.3	65	17	4.4	0.1	0.9	103	69	16		156	7.2	7

a/ In solution when analyzed.

POTOMAC RIVER BASIN—Continued
Chemical analyses in parts per million

Station numbers on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
94	LICKING CREEK NEAR HANCOCK, MD.																					
	July 15, 1964	50	3.7		0.03	--	34	11	1.9	2.1	140	13	3.6	0.0	2.2	145	130	16		254	7.6	6
95	1-6145. CONOCOCHEAGUE CREEK NEAR FAIRVIEW, MD.																					
	Aug. 28, 1963	56	1.4		0.38	0.00	52	10	19	--	173[d]	24	20	0.2	3.4	224	171	16		382	8.6	7
	Oct. 14, ...	51	.4		.16	.00	59	13	13	3.3	215	22	18	.1	.8	236	200	24		420	6.9	--
	Mar. 11, 1964	2,120	6.6		1.1	.10	27	4.7	2.9	1.6	80	17	5.0	.2	8.0	119	87	22		195	8.1	--
	June 24, ...	210	5.6		.12	--	51	10	6.2	2.5	173	20	10	.1	8.4	230	170	28		349	7.2	5
	Sept. 17,....	56	.7		.07	.00	58	13	14	3.0	218	24	22	.1	2.3	240	198	20		415	7.5	--
96	POTOMAC RIVER AT WILLIAMSPORT, MD.																					
	Apr. 20, 1964	--	--		--	--	--	--	3.8	--	48	29	--	--	0.3	--	--	--		165	7.0	--
97	1-6178.00. MARSH RUN AT GRIMES, MD.																					
	Aug. 9, 1963	4.5	9.2		0.01[a]	--	88	9.8	4.6	2.2	243	34	12	0.3	15	300	260	61		476	7.4	5
98	1-6180. POTOMAC RIVER AT SHEPHERDSTOWN, WEST VIRGINIA																					
	Apr. 21, 1964	9,440	-		-	-	-	-	3.8	-	72	-	-	-	1.9	-	-	-		201	7.4	
	Oct. 22, ...	2,380	2.5		0.11	0.00	42	10	23	2.5	138	78	10	0.0	0.8	226	146	33		384	7.2	
99	1-6190. ANTIETAM CREEK NEAR WAYNESBORO, PA.																					
	Aug. 9, 1963	37	6.9		0.00[a]	--	44	16	3.3	2.2	184	15	8.0	0.3	9.7	216	175	24		336	7.9	5
100	BEAVER CREEK NEAR MILLPOINT, MD.																					
	Aug. 9, 1963	16	8.1		0.00[a]	--	58	21	2.5	2.4	240	19	7.5	0.4	12	274	230	33		425	8.1	5

a/ In solution when analyzed.
d/ Includes equivalent of 8 parts per million of carbonate (CO_3^-).

POTOMAC RIVER BASIN—Continued

Chemical analyses in parts per million

Station numbers on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
101	ANTIETAM CREEK AT ROSE MILL, MD.																					
	Aug. 9, 1963	37	7.3		0.00[a]	--	64	13	16	4.4	213	30	22	0.4	11	298	214	39		449	7.3	5
102	1-6195. ANTIETAM CREEK NEAR SHARPSBURG, MD.																					
	Aug. 9, 1963	131	9.4		0.00[a]	--	64	15	8.8	3.8	224	28	15	0.3	9.6	292	222	38		440	8.1	5
	Aug. 28,....	110	3.9		.00[a]	0.00[a]	65	3.9	34	--	228	30	17	.5	10	278	178	0		460	8.2	7
	Oct. 14,....	60	2.3		.14	.01	71	14	17	4.6	258	31	20	.3	.4	288 [e]	235	24		504	7.0	20
	Mar. 11, 1964	855	7.5		.87	.04	46	7.8	4.2	2.5	143	22	6.9	.0	8.7	201	147	30		328	7.1	--
	June, 24,....	181	7.0		.16	.01	61	15	6.0	3.4	213	25	10	.3	12	272	212	38		419	7.7	2
	Sept. 17,....	290	4.2		.07	.00	71	15	11	3.8	240	34	21	.4	11	286	239	43		486	7.7	--
103	POTOMAC RIVER AT BRUNSWICK, MD.																					
	Apr. 21, 1964	--	--		--	--	--	--	9.1	--	109	--	--	--	2.7	--	--	--		270	7.4	--
104	1-6370. LITTLE CATOCTIN CREEK AT HARMONY, MD.																					
	Oct. 31, 1963	--	15		0.41	0.01[a]	14	4.9	5.8	--	56	9.6	6.6	0.1	2.0	92	55	9		141	7.0	--
105	1-6375. CATOCTIN CREEK NEAR MIDDLETOWN, MD.																					
	Oct. 31, 1963	22	7.0		0.44	0.01[a]	17	6.0	11	--	67	11	14	0.1	4.9	115	67	12		191	6.9	--
106	1-6385. POTOMAC RIVER AT POINT OF ROCKS, MD.																					
	May 16, 1963	3,450	0.1		0.07[a]	--	34	7.9	9.1	1.9	108	40	7.0	0.1	0.5	177	116	28		277	8.0	5
	Sept. 1,....	1,200	.3		.17	.00	38	15	26	2.5	127	74	26	.2	.6	241	155	51		427	7.2	3
	Oct. 14,....	800	.6		.20	.04	48	12	25	2.5	144	73	24	.2	.1	262	170	52		441	7.3	--
	Mar. 11, 1964	36,000	5.9		1.1	.00	21	3.5	2.4	1.3	53	21	3.3	.0	4.0	101	67	24		163	7.0	--
	June 23, ...	3,420	2.8		.54	.10	49	11	10	2.6	146	46	14	.2	3.2	242	167	48		361	7.4	2
	Sept. 16,....	680	1.8		.20	.00	42	15	48	2.7	132	121	31	.2	.3	335	166	58		538	7.3	--

a/ In solution when analyzed.

e/ Sum of mineral constituents.

POTOMAC RIVER BASIN—Continued

Chemical analyses in parts per million

Station number on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
107	1-6395. BIG PIPE CREEK AT BRUCEVILLE, MD.																					
	July 24, 1963	14	3.4		0.00[a]	0.00[a]	20	3.4	7.8	--	71	6.4	10	0.1	2.3	88 [e]	64	6		150	6.9	--
	Oct. 30, ...	10	3.5		.71	.01	22	4.1	4.4	--	80	6.4	5.4	.1	1.8	90	72	7		165	7.4	--
108	LITTLE PIPE CREEK NEAR LADIESBURG, MD.																					
	July 24, 1963	10	6.4		0.00[a]	0.00[a]	46	6.6	11	--	149	20	12	0.3	5.2	187	142	20		310	7.0	5
109	1-6405. OWENS CREEK AT LANTZ, MD.																					
	Oct. 30, 1963	.4	18		0.32	0.00	7.0	2.8	2.9	0.9	36	4.6	2.0	0.0	0.0	60	29	0		78	7.4	5
110	1-6410. HUNTING CREEK AT JIMTOWN, MD.																					
	Oct. 30, 1963	2.2	12		0.21	0.01	21	6.0	11	--	86	7.8	9.4	0.1	9.0	123	77	7		208	7.0	--
111	1-6415. FISHING CREEK NEAR LEWISTOWN, MD.																					
	Oct. 29, 1963	1.5	5.9		0.09	0.00	1.8	0.0	0.6	0.6	6	0.0	1.0	0.0	0.0	19	4	0		16	6.0	5
112	ISRAEL CREEK NEAR MT. PLEASANT, MD.																					
	July 25, 1963	1.8	6.4		0.00[a]	0.00[a]	47	2.1	17	--	153	19	11	0.2	3.3	187	126	1		312	7.0	10

a/ In solution when analyzed.
e/ Sum of mineral constituents.

POTOMAC RIVER BASIN—Continued

Chemical analyses in parts per million

Station numbers on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
113	1-6425. LINGANORE CREEK NEAR FREDERICK, MD.																					
	July 24, 1963	9.7	4.2		0.00[a]	0.00[a]	19	5.0	5.3	--	75	6.0	6.5	0.1	2.9	88	68	7		154	6.9	7
	Oct. 29, ...	9.0	3.1		.24	.01	19	5.5	3.2	--	78	5.4	4.4	.0	1.8	84	70	6		157	7.3	--
114	1-6430. MONOCACY RIVER AT JUG BRIDGE NEAR FREDERICK. MD.																					
	Aug. 28, 1963	72	4.9		.00[a]	.00[a]	37	6.7	13	--	128	14	16	.2	6.7	176	120	15		292	7.1	7
	Oct. 14, ...	50	1.9		.38	.11	40	7.1	8.8	4.6	123	19	13	.2	13	176	129	28		300	7.7	--
	Mar. 19, 1964	1,000	7.5		.22	.03	20	4.1	4.4	1.5	48	19	6.7	.1	8.3	109	67	28		176	6.8	--
	June 23, ...	183	4.2		.16	.02	31	5.0	5.3	2.3	98	13	7.4	.1	6.6	138	98	18		213	7.3	4
	Sept. 16,....	65	4.7		.16	.00	46	7.5	11	3.9	149	19	18	.2	11	197	146	24		336	7.2	--
115	MONOCACY RIVER AT RT. 28 NEAR DICKERSON, MD.																					
	July 24, 1963	167	3.2	-	0.00[a]	0.00[a]	32	5.3	8.5	-	110	14	11	0.1	0.3	135	102	12		231	6.7	8
116	1-6445. GREAT SENECA CREEK NEAR GAITHERSBURG, MD.																					
	June 17, 1963	16.4	9.8		0.02[a]	0.00[a]	7.0	2.6	3.7	2.1	29	2.8	4.1	0.0	6.4	58	28	4		83	7.1	5
117	GREAT SENECA CREEK NEAR DAWSONVILLE, MD.																					
	June 17, 1963	27	8.2		0.04[a]	0.11[a]	9.0	2.1	3.9	1.8	32	3.4	4.9	0.0	5.1	62	31	5		90	7.2	5
118	LITTLE SENECA CREEK AT DAWSONVILLE, MD.																					
	June 17, 1963	15	9.2		0.03[a]	0.00[a]	9.0	2.3	3.1	1.8	31	6.8	3.7	0.0	4.5	64	32	7		92	6.8	5

[a] In solution when analyzed.

POTOMAC RIVER BASIN—Continued

Chemical analyses in parts per million

Station numbers on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
119	1-6450. SENECA CREEK AT DAWSONVILLE, MD.																					
	Oct. 14, 1963	20	9.0		1.1	0.12	7.5	2.8	4.0	2.4	36	3.0	4.6	0.1	1.3	53	30	1		88	6.9	--
	Mar. 11, 1964	120	8.3		.38	.03	7.6	2.2	4.0	1.3	20	8.0	5.6	.1	5.3	56	28	12		93	6.6	--
	June 23, ...	42	11		.72	--	7.4	2.8	3.8	2.1	31	3.6	5.2	.0	5.2	63	30	5		84	6.6	3
	Sept. 16,....	10	8.9		.45	.00	7.0	2.3	4.2	2.2	33	3.0	4.9	.1	2.8	49	27	0		80	6.9	--
120	DRY SENECA CREEK NEAR SENECA, MD.																					
	June 17, 1963	4.48	7.2		0.02[a]	0.04[a]	13	3.3	4.7	1.7	42	13	5.0	0.0	2.9	82	46	12		123	6.9	5
121	SENECA CREEK AT SENECA, MD.																					
	June 17, 1963	4.5	10		0.02[a]	0.00[a]	10	2.2	3.9	1.9	33	6.8	4.8	0.0	3.8	66	35	8		89	6.7	2
122	1-6465. POTOMAC RIVER NEAR WASHINGTON, D. C.																					
	May 17, 1963	3,730	0.4		0.01[a]	--	32	8.1	8.1	1.8	107	34	7.0	0.1	0.1	166	112	25		263	7.6	5
	Aug. 29,....	1,270	1.1		.43	.00	32	12	20	2.9	110	59	18	.2	1.0	201	128	38		355	7.6	7
	Oct. 14,....	1,000	.03		.77	.04	40	12	32	3.0	120	90	22	.2	.0	264	150	52		439	7.3	--
	June 25, 1964	3,370	4.0		.17	.10	34	10	16	2.6	111	51	13	.1	.9	212	128	37		318	7.8	4
	Sept. 18,....	6,900	1.5		.16	.00	39	13	44	2.7	118	109	30	.2	.2	305	150	54		484	7.2	--
123	1-6505. NORTHWEST BRANCH ANACOSTIA RIVER NEAR COLESVILLE, MD.																					
	June 3, 1963	142	9.3		0.10[a]	0.02[a]	7.5	1.6	3.7	3.1	17	12	6.8	0.0	11	82	25	11		81	6.2	70
	Aug. 20, ...	600	5.5			.94	5.0	.9	2.5	2.4	4	14	3.5	.1	1.2	40	16	13		69	5.9	5
124	1-6495. NORTHEAST BRANCH ANACOSTIA RIVER AT RIVERDALE, MD.																					
	Aug. 19, 1963	13	7.5		0.05[a]	0.00[a]	9.0	1.8	27	3.8	30	40	19	0.1	3.6	126	30	6		212	6.5	5
125	1-6510. NORTHWEST BRANCH ANACOSTIA RIVER NEAR HYATTSVILLE, MD.																					
	Aug. 19, 1963	2.70	8.5		0.00[a]	0.00[a]	18	3.6	16	--	58	18	19	0.2	0.9	114	60	13		199	7.4	5
126	ANACOSTIA RIVER AT BALTIMORE-WASHINGTON PARKWAY, WASHINGTON, D. C.																					
	Aug. 19, 1963		4.2		0.00[a]	0.00[a]	18	4.2	21	5.1	51	43	18	0.2	7.0	151	62	20		253	6.5	5

[a] In solution when analyzed.

POTOMAC RIVER BASIN—Continued
Chemical analyses in parts per million

Station numbers on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
127	1-6535. HENSON CREEK AT OXON HILL, MD.																					
	Aug. 12, 1964	1.4	7.7		2.0	0.02	12	5.6	7.9	2.8	42	16	16	0.2	1.0	119	53	19		157	6.8	--
128	1-6536. PISCATAWAY CREEK AT PISCATAWAY, MD.																					
	Aug. 12, 1964	2.0 f/	6.9		0.67	0.02	20	5.8	22	--	42	33	29	0.4	14	171	74	40		266	6.6	
129	1-6580. MATTAWOMAN CREEK NEAR POMONKEY, MD.																					
	May 22, 1964	15	8.8		0.99	0.01	4.0	1.0	3.4	0.7	6	8.0	5.2	0.1	0.2	47	14	9		49	5.8	15
130	GILBERT SWAMP RUN AT NEWPORT, MD.																					
	Aug. 12, 1964	0.5 f/	3.8		1.6	0.05	6.6	1.8	2.6	1.8	24	3.6	5.0	0.1	0.4	52	24	5		66	6.6	--
131	1-6610. CHAPTICO CREEK AT CHAPTICO, MD.																					
	Aug. 12, 1964	1.4	11		1.6	0.02	9.5	1.8	2.7	1.1	33	4.0	4.6	0.1	0.6	56	31	4		77	6.8	--
132	ST. CLEMENT CREEK AT CLEMENTS, MD.																					
	Aug. 12, 1964	1.0 f/	12		1.2	0.05	13	1.8	3.3	1.1	45	4.4	5.4	0.1	0.5	75	40	3		99	6.8	--
133	MCINTOSH RUN AT RT. 5 NEAR LEONARDTOWN, MD.																					
	Aug. 12, 1964		3.2		0.03	0.00	10	2.4	3.8	1.3	36	5.2	5.8	0.1	0.8	71	35	6		89	6.7	--
134	1-6615. ST. MARYS RIVER AT GREAT MILLS, MD.																					
	May 22, 1964	7.5	7.8		3.0	0.00	2.5	0.5	3.7	0.7	6.6	2.8	6.0	0.1	0.6	49	8	0		41	6.7	70

f/ Estimated.

YOUGHIOGHENY RIVER BASIN

Chemical analyses in parts per million

Station number on Fig. 1	Date of collection	Discharge (cfs)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Total acidity as H^{+1}	Specific conductance (micromhos at 25°C)	pH	Color
135	3-759. LAUREL RUN AT CRELLIN, MD.																					
	March 11, 1964	200	5.2		2.5	0.32	6.0	2.6	0.3	0.5	0	49	0.3	0.1	0.0	86	25	25	0.5	205	3.6	0
	Sept. 1, ...	0.77	24		3.6	1.1	38	16	1.0	1.6	0	320	.5	.2	.3	488	160	160	3.7	1,100	2.9	--
136	YOUGHIOGHENY RIVER ABOVE MOUTH OF LITTLE YOUGHIOGHENY NEAR OAKLAND, MD.																					
	Sept. 1, 1964	10	3.9		0.00	0.06	15	3.0	2.9	1.9	3	50	2.9	0.0	0.8	84	50	48		138	5.6	--
137	LITTLE YOUGHIOGHENY RIVER NEAR OAKLAND, MD.																					
	Sept. 1, 1964	2.0	2.2		0.36	0.03	21	1.3	16	4.5	66	14	15	0.2	15	131	58	4		212	6.4	--
138	3-756. YOUGHIOGHENY RIVER NEAR OAKLAND, MD.																					
	March 11, 1964	1,260	3.6		1.4	0.12	3.8	1.5	1.1	0.7	0	14	2.2	0.1	1.0	34	15	15	0.0	58	4.6	1
139	YOUGHIOGHENY RIVER ABOVE MILLER RUN, MD.																					
	Sept. 2, 1964	12	1.6		0.04	0.02	12	6.8	6.6	2.6	18	44	7.1	0.1	3.9	102	58	43		168	6.0	--
140	3-780. CASSELMAN RIVER AT GRANTSVILLE, MD.																					
	Aug. 31, 1964	4.8	2.7		0.01	0.08	26	8.8	3.6	1.6	24	83	3.5	0.1	0.2	144	101	82		237	6.6	--

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