MARYLAND GEOLOGICAL SURVEY

Kenneth N. Weaver, *Director*

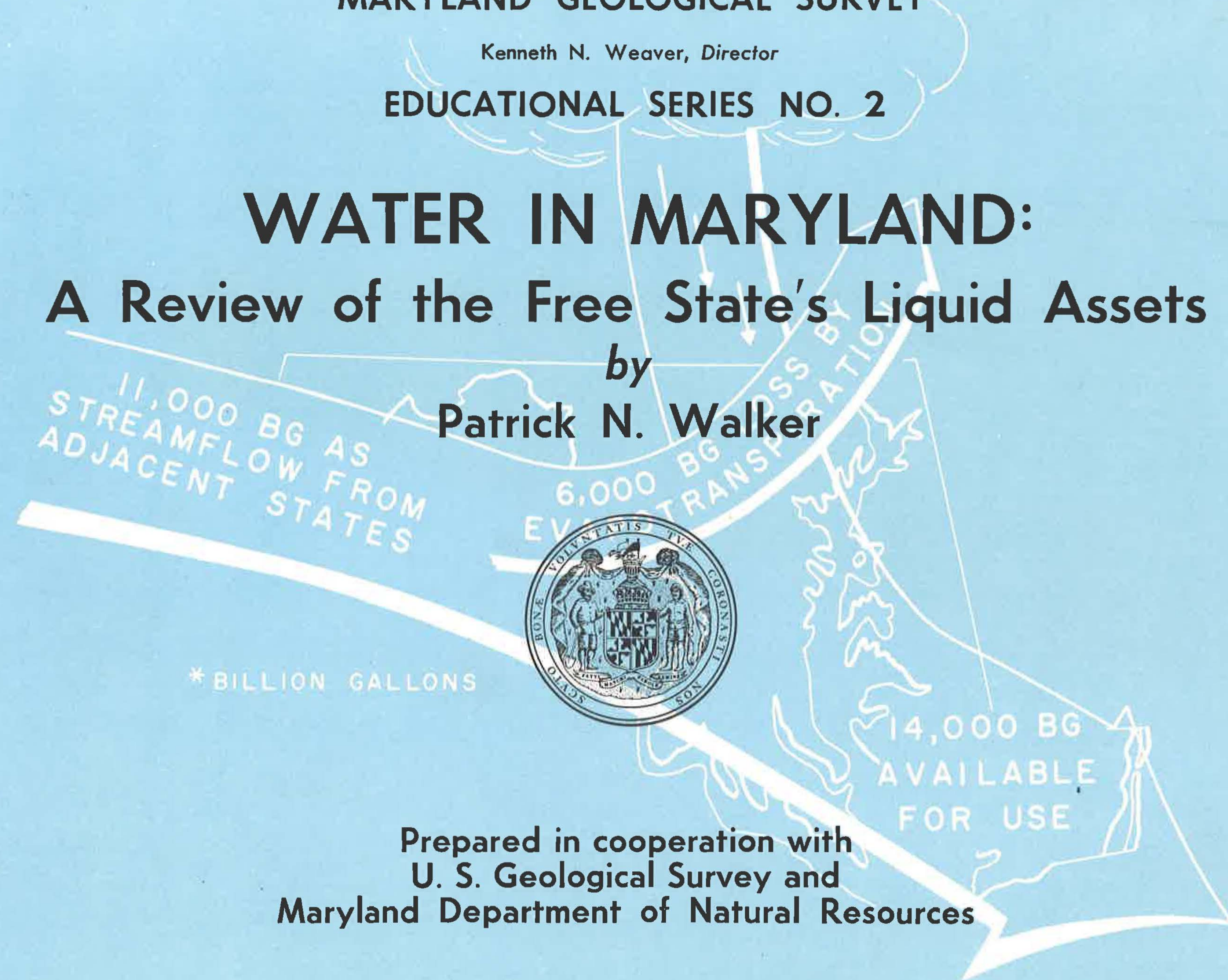
EDUCATIONAL SERIES NO. 2

WATER IN MARYLAND:

A Review of the Free State's Liquid Assets

by

Patrick N. Walker



Prepared in cooperation with
U. S. Geological Survey and
Maryland Department of Natural Resources

1970

MARYLAND GEOLOGICAL SURVEY

Baltimore, Maryland 21218

Kenneth N. Weaver, *Director*

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Patrick N. Walker
U. S. Geological Survey

Drafting by J. F. Goodell

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COMMISSION
MARYLAND GEOLOGICAL SURVEY

WATER IN MARYLAND:

Preface

Mismanagement of our monetary income can lead to bankruptcy. Mismanagement of our water income can also have disastrous results. Marylanders live in a water-rich area and historically have had no major water problems. Our water needs are increasing as our population increases, and it is time we begin to look at the way we manage our water resources. Public awareness is the first requisite to proper management of any resource.

This report is intended to present to the citizens of Maryland an account of possibly the most important natural resource they have —water. Chapters are titled as though they dealt with parts of a financial budget because water resources must be managed just as finances must be managed. A precise analogy between a monetary budget and a natural resource does not exist. Thus the various financial terms used in describing water resources may differ slightly from the definition as given in the dictionary. The terms serve as a familiar frame of reference for our water resources picture.

If this booklet causes any increased public consciousness that our water resources need to be used properly and conserved for the future citizens of Maryland, then it has served its purpose.

"Water in Maryland" was prepared in the Towson, Md., office of the Water Resources Division, U. S. Geological Survey, under the direction of Walter F. White, District Chief, in cooperation with the Maryland Geological Survey, Kenneth N. Weaver, Director.

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CHAPTER 1

Maryland: Nature's beneficiary

Maryland, the "Free State," like several of the other Thirteen Original States, is small in area. Within its borders are 9,874 square miles of land, 703 square miles of inland waters, and 1,726 square miles of Chesapeake Bay—a total of 12,303 square miles. Although the State ranks 42nd in size among the 50 States, it is 20th in population with 3,534,000 citizens in 1965.

There are five physiographic (land-form) provinces in Maryland, each characterized by its own combination of geology, topography, and climate.

The geology of Maryland exhibits a striking diversity. The age of the earth materials, or rocks, exposed in Maryland ranges from the geologically young sediments (less than one million years old) deposited on the Coastal Plain during the Pleistocene Epoch or "Ice Age" to the ancient metamorphic rocks of Precambrian age (as old as 1 billion years) in the Piedmont province. Movements of the earth's crust and the forces of erosion acting upon these diverse rock types have produced the land forms and soils of the State.

The topography of Maryland is about as varied as any State in the Nation. In the east, about 3,200 miles of tidewater shoreline borders the gentle slopes of the Coastal Plain province. In western Maryland the Appalachian Plateau includes several mountains that rise about 3,000 feet; the highest, Backbone Mountain, crests 3,360 feet above sea level. In between these extremes are the rolling hills of the Piedmont province, the sharp, high ridges of the Blue Ridge province, and the broad valleys and long, straight mountain crests of the Valley and Ridge province.

The climate of Maryland is temperate and subhumid. Average annual temperature ranges from about 48°F in the mountains to about 58°F in the southern Coastal Plain. Annual temperature variations throughout the State are usually within the range that we consider pleasant. The precipitation segment of the climate will be discussed at some length later, but it, too, is usually about the right amount to provide for our well-being.

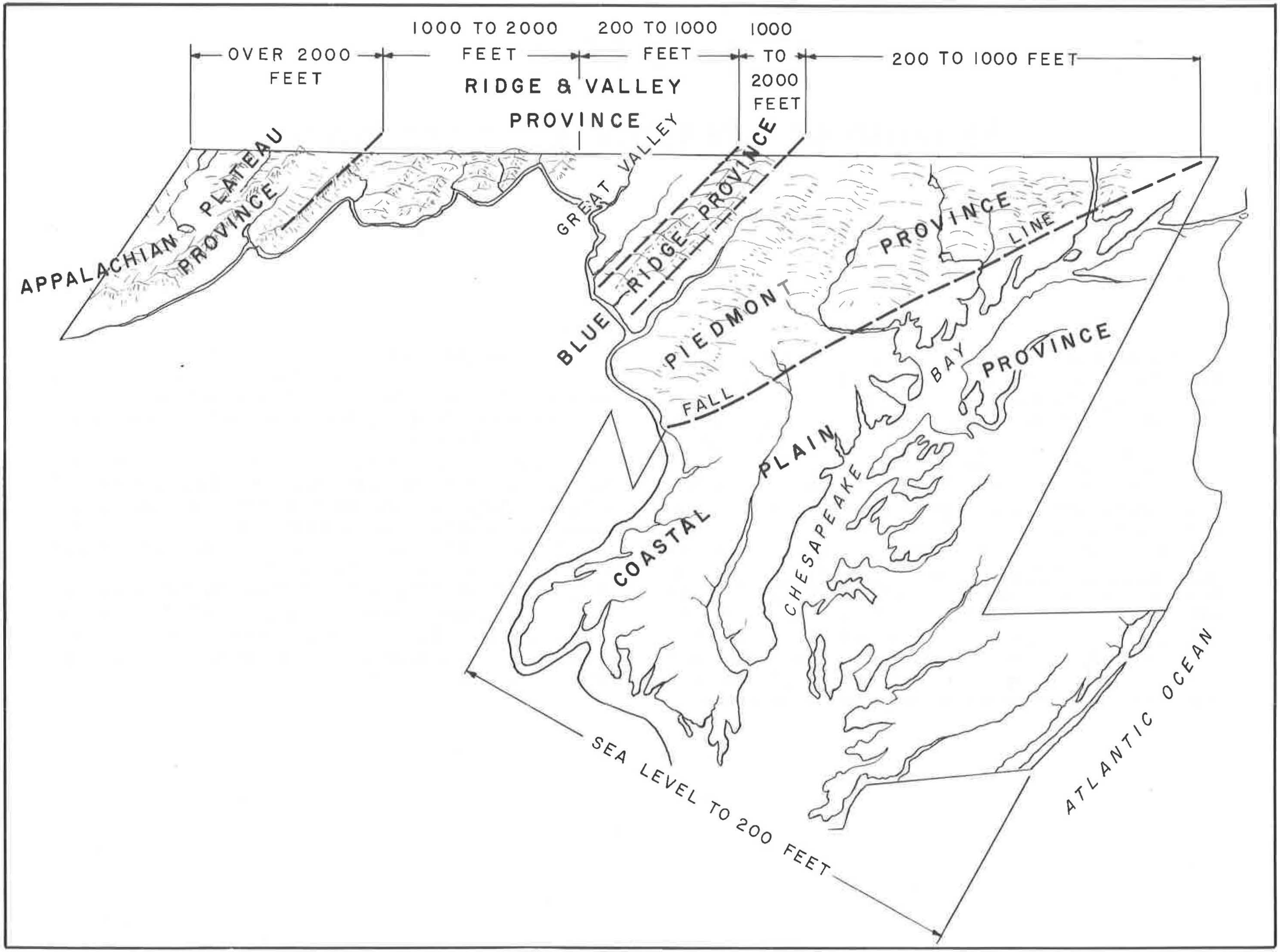
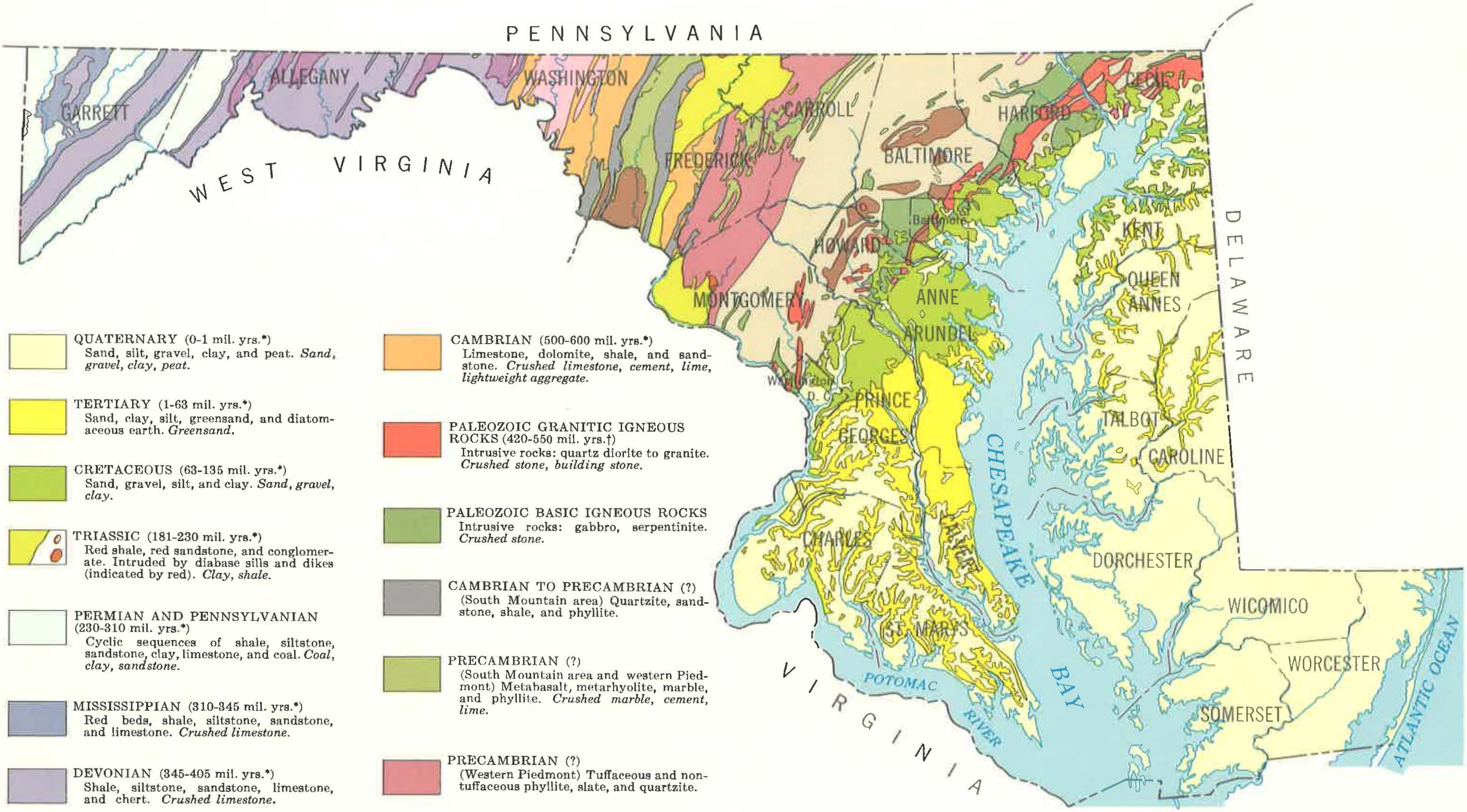


Figure 1. Land-surface elevation generally increases from east to west across Maryland



QUATERNARY (0-1 mil. yrs.*)
Sand, silt, gravel, clay, and peat. *Sand, gravel, clay, peat.*

TERTIARY (1-63 mil. yrs.*)
Sand, clay, silt, greensand, and diatomaceous earth. *Greensand.*

CRETACEOUS (63-135 mil. yrs.*)
Sand, gravel, silt, and clay. *Sand, gravel, clay.*

TRIASSIC (181-230 mil. yrs.*)
Red shale, red sandstone, and conglomerate. Intruded by diabase sills and dikes (indicated by red). *Clay, shale.*

PERMIAN AND PENNSYLVANIAN (230-310 mil. yrs.*)
Cyclic sequences of shale, siltstone, sandstone, clay, limestone, and coal. *Coal, clay, sandstone.*

MISSISSIPPIAN (310-345 mil. yrs.*)
Red beds, shale, siltstone, sandstone, and limestone. *Crushed limestone.*

DEVONIAN (345-405 mil. yrs.*)
Shale, siltstone, sandstone, limestone, and chert. *Crushed limestone.*

SILURIAN (405-425 mil. yrs.*)
Shale, mudstone, sandstone, and limestone. *Glass sand, crushed limestone.*

ORDOVICIAN (425-500 mil. yrs.*)
Limestone, dolomite, shale, siltstone, and red beds. Slate and conglomerate in northern Harford County. *Crushed limestone, cement, clay, lime.*

CAMBRIAN (500-600 mil. yrs.*)
Limestone, dolomite, shale, and sandstone. *Crushed limestone, cement, lime, lightweight aggregate.*

PALEOZOIC GRANITIC IGNEOUS ROCKS (420-550 mil. yrs.†)
Intrusive rocks: quartz diorite to granite. *Crushed stone, building stone.*

PALEOZOIC BASIC IGNEOUS ROCKS
Intrusive rocks: gabbro, serpentinite. *Crushed stone.*

CAMBRIAN TO PRECAMBRIAN (?)
(South Mountain area) Quartzite, sandstone, shale, and phyllite.

PRECAMBRIAN (?)
(South Mountain area and western Piedmont) Metabasalt, metarhyolite, marble, and phyllite. *Crushed marble, cement, lime.*

PRECAMBRIAN (?)
(Western Piedmont) Tuffaceous and nontuffaceous phyllite, slate, and quartzite.

PRECAMBRIAN (?)
(Eastern Piedmont) Schist, metagraywacke, quartzite, marble, and metavolcanic rocks. *Crushed stone, crushed marble, building stone.*

PRECAMBRIAN BASEMENT COMPLEX (1100 mil yrs.†)
Gneiss, migmatite, and augen gneiss.

MARYLAND GEOLOGICAL SURVEY
Kenneth N. Weaver, Director

GENERALIZED GEOLOGIC MAP OF MARYLAND‡

1967

10 0 10 20 30 40
1 inch equals 25 miles

Most important mineral products in italics.
* Age ranges from Kulp, J. L., 1961, Geologic time scale: Science, v. 133, no. 3459, p. 1105-1114.
† Radiometric dates made on Maryland rocks.

‡ A detailed Geologic Map of Maryland, 1968 at a scale of 1 inch equals 4 miles, is also available.

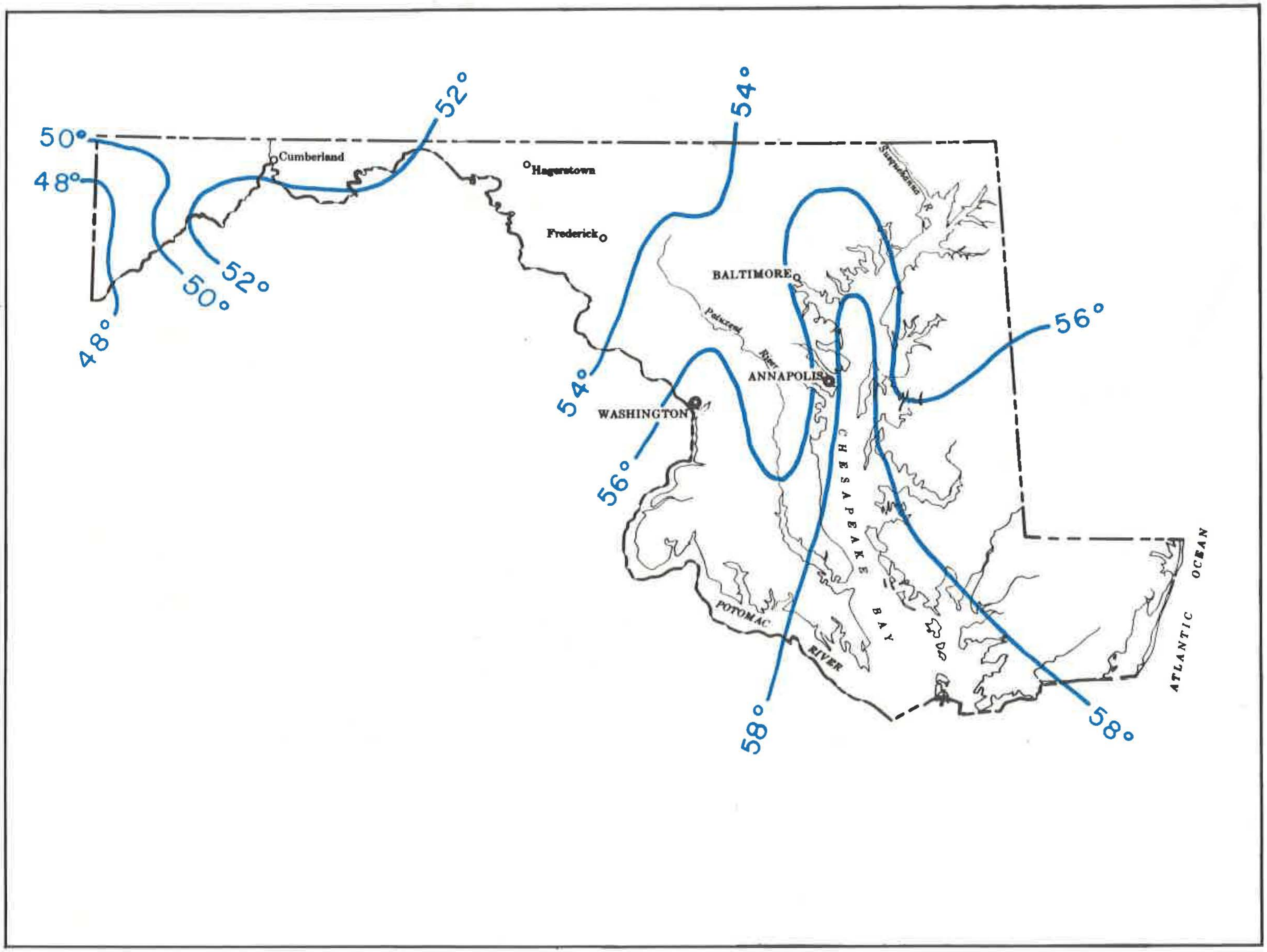


Figure 3. Maryland's average annual temperature indicates a temperate climate

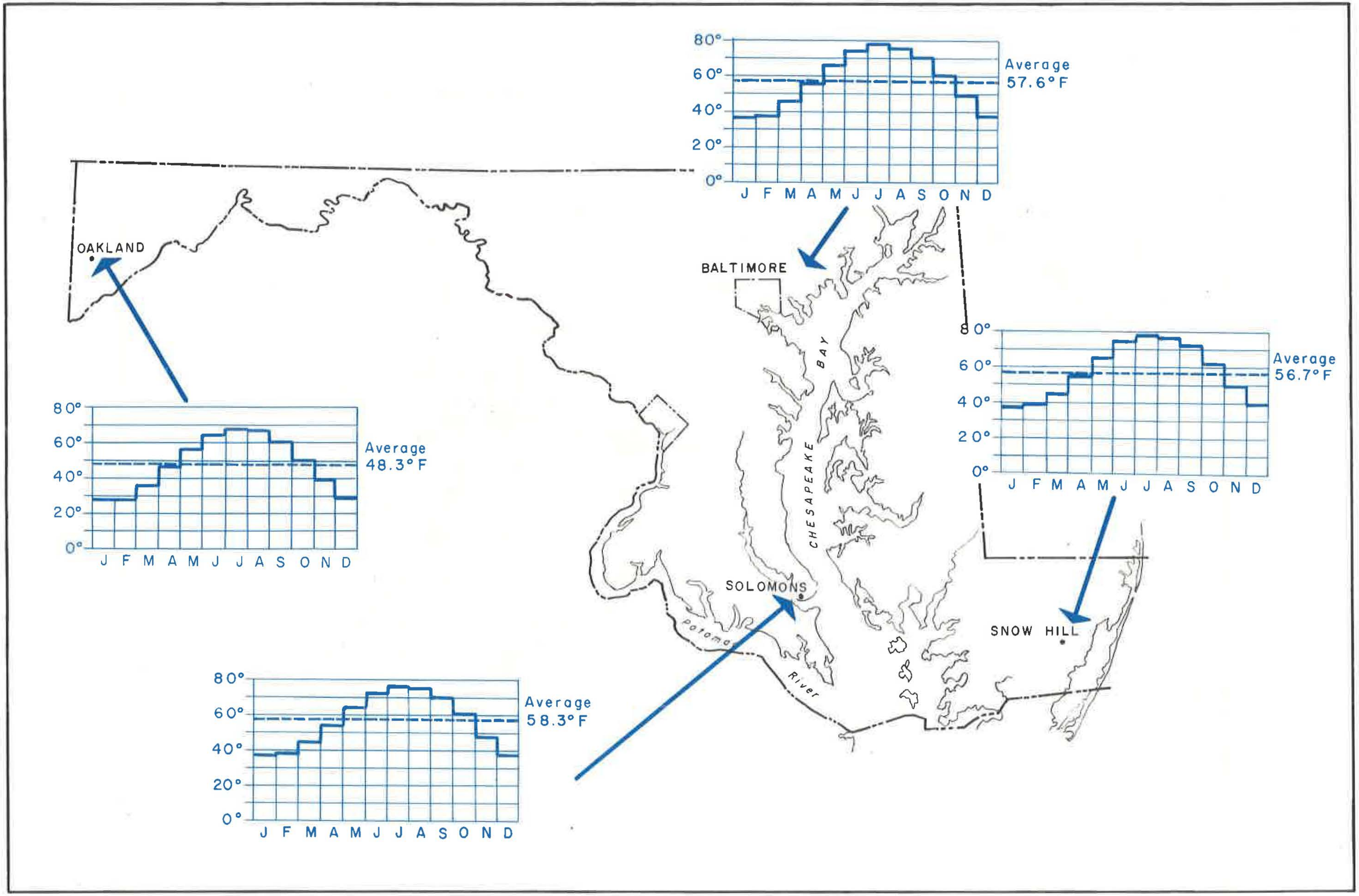


Figure 4. Monthly averages indicate the variation of temperature across the State

CHAPTER 2

Water: Nature's bounty

Water occurs in nature in three forms: Liquid, solid, and vapor. Each form is part of the never-ending process known as the hydrologic cycle. In this cycle, water vapor is evaporated from the oceans and other wet surfaces or transpired by plants, transported as a vapor by winds, condensed by cooling into liquid or solid form, and precipitated, eventually to be recirculated. The complete hydrologic cycle is a grand complex involving the sun, the oceans, river systems, ice caps, winds, vegetation, soils, and rocks.

Water is continuously evaporated from the ocean as vapor, most of which soon condenses and falls back to the ocean. Some, however, is borne along by winds to land areas, where it condenses and precipitates, chiefly in the form of rain or snow. Most of this precipitation is re-evaporated and returns to the atmosphere but some runs off over the ground to a stream to become "streamflow" and soon returns to the ocean.

A portion of the precipitation that falls on land seeps into the earth to become "soil moisture" or to become "ground water". Soil moisture remains in the upper few inches or feet of the earth where plant roots draw upon it and return it to the atmosphere by transpiring it through their pores as part of the plant's growth processes. Of the precipitation that reaches a ground-water reservoir (a saturated body of rock or earth materials) some will travel through the ground until it emerges in a spring or seeps into a stream channel. In near-shore areas some ground water moves directly into tidewater or into the ocean without ever emerging at land surface.

Two things should be remembered about the earth's supply of water: First, that there is a fixed amount of it (an estimated 326 million cubic miles), and second, that this amount is ceaselessly in motion, perhaps stored in an ice cap or an ocean for a few thousand years but never entirely halted.

Maryland is blessed with large quantities of water in her bays, streams, and underground reservoirs. In a typical year the State receives 20,000 billion gallons of water as precipitation or streamflow. In addition, an estimated 130,000 billion gallons of ground water are contained in the rocks of the State. However, if the world's water supply were considered to be equivalent to a million dollars, Maryland's share would be only about forty cents.

Before examining Maryland's water-resource budget in detail, it should be pointed out that we frequently use only averages or totals in describing water. However, if anything characterizes water resources it is variability—varability in time and space, variability in quantity and quality, and variability in location and content. Because the use of averages or totals tends to disguise these variations, it is well to remember that the ranges and extremes of flow are also significant.

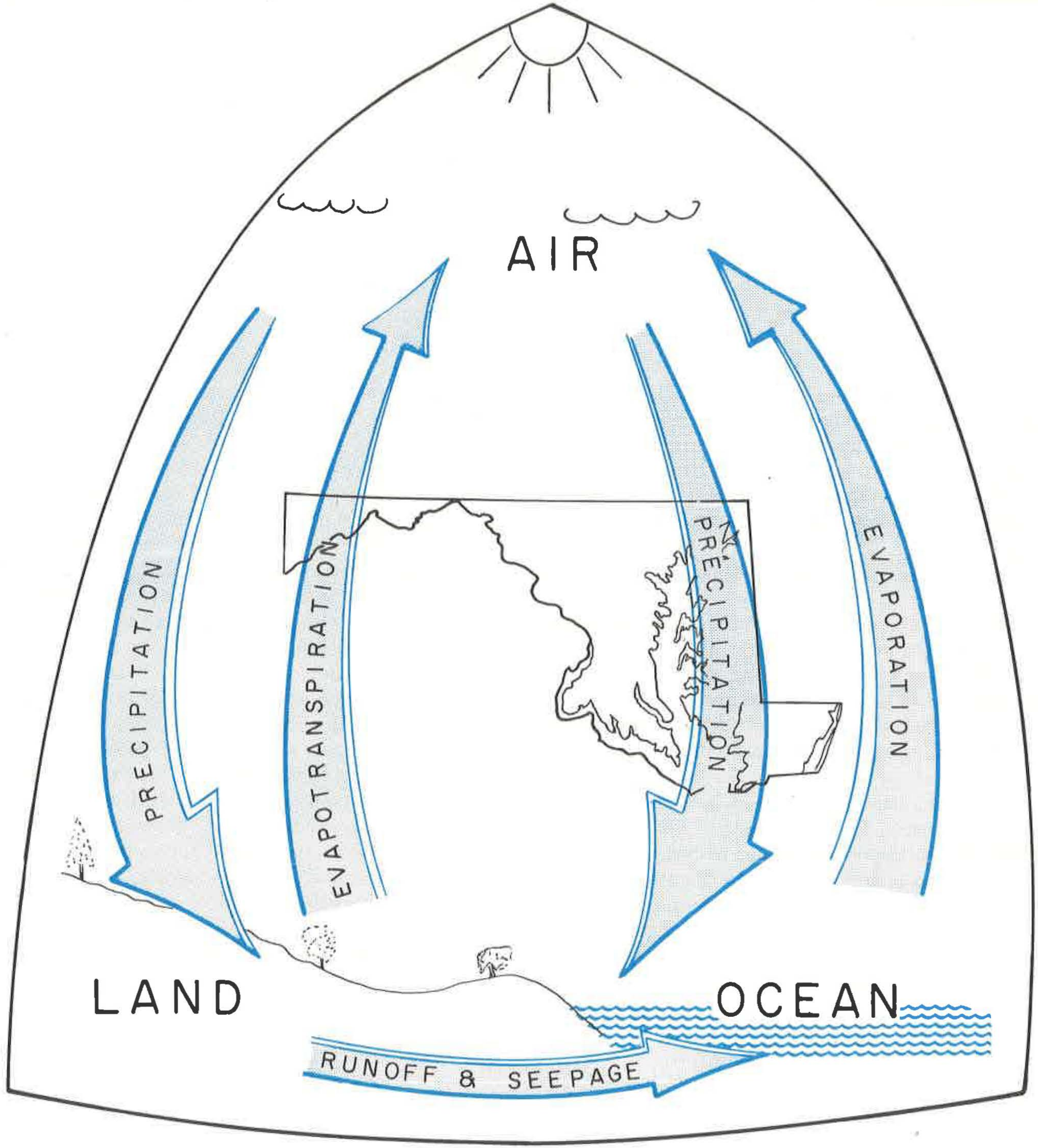


Figure 5. One of Nature's greatest mechanisms is the hydrologic cycle

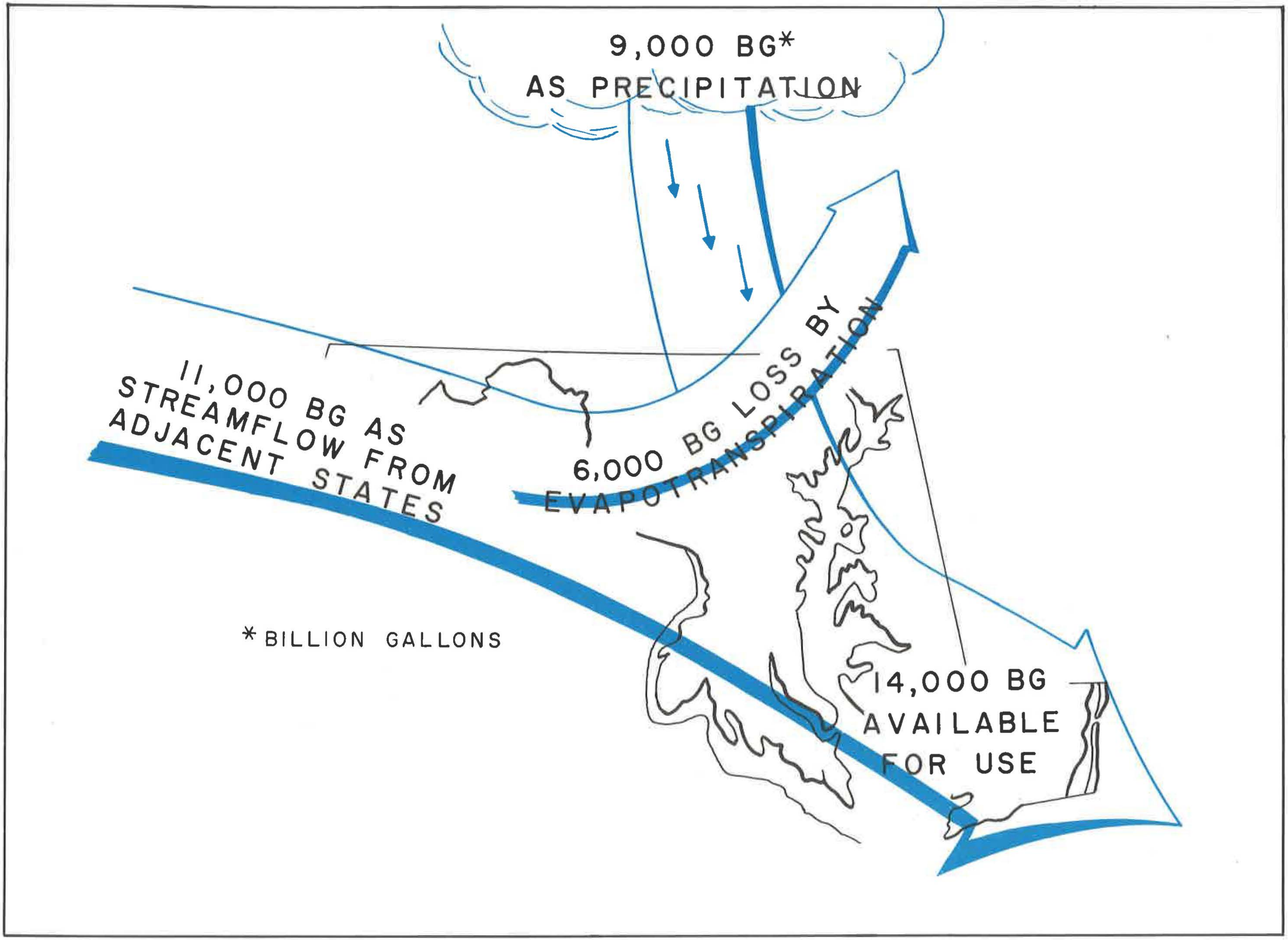


Figure 6. Our annual water budget involves billions of gallons of water

CHAPTER 3

Precipitation: Our income

Precipitation is the agent by which nature gives us our water income. Maryland's average precipitation is about 42 inches per year. It ranges, however, from about 55 inches a year in Garrett County to about 36 inches near Cumberland. In general, precipitation is higher in the eastern and extreme western parts of the State than it is in the west-central part. Topography and proximity to large water bodies are probably the major factors in the complex mechanism that controls our annual precipitation. For example in the west, the influence that the mountains exert on weather is shown by the large variations in average precipitation within fairly small distances. On the other hand, in the east, the Chesapeake Bay and the Atlantic Ocean help modify weather variations so that precipitation is fairly uniform over large areas.

Unlike a salary or a fixed income, water income varies with time as well as with location. Although Maryland does not have distinct wet and dry seasions, there is some relation between seasons and amount of precipitation. In general, the wettest months, or months of most precipitation, occur in the spring or summer and the driest months occur in the fall or winter. The causes for the seasonal differences lie in the different storm types and storm paths that come with each season. In the summer, thunder storms with frequently heavy precipitation are common. In the winter, although storms are common, moisture precipitated by them is usually light in intensity and amount.

A fact to remember about precipitation is that it follows no precise cycle. Certainly we have "wet spells" and "dry spells" but there is no regular pattern to them—no regular length or regular frequency of return.

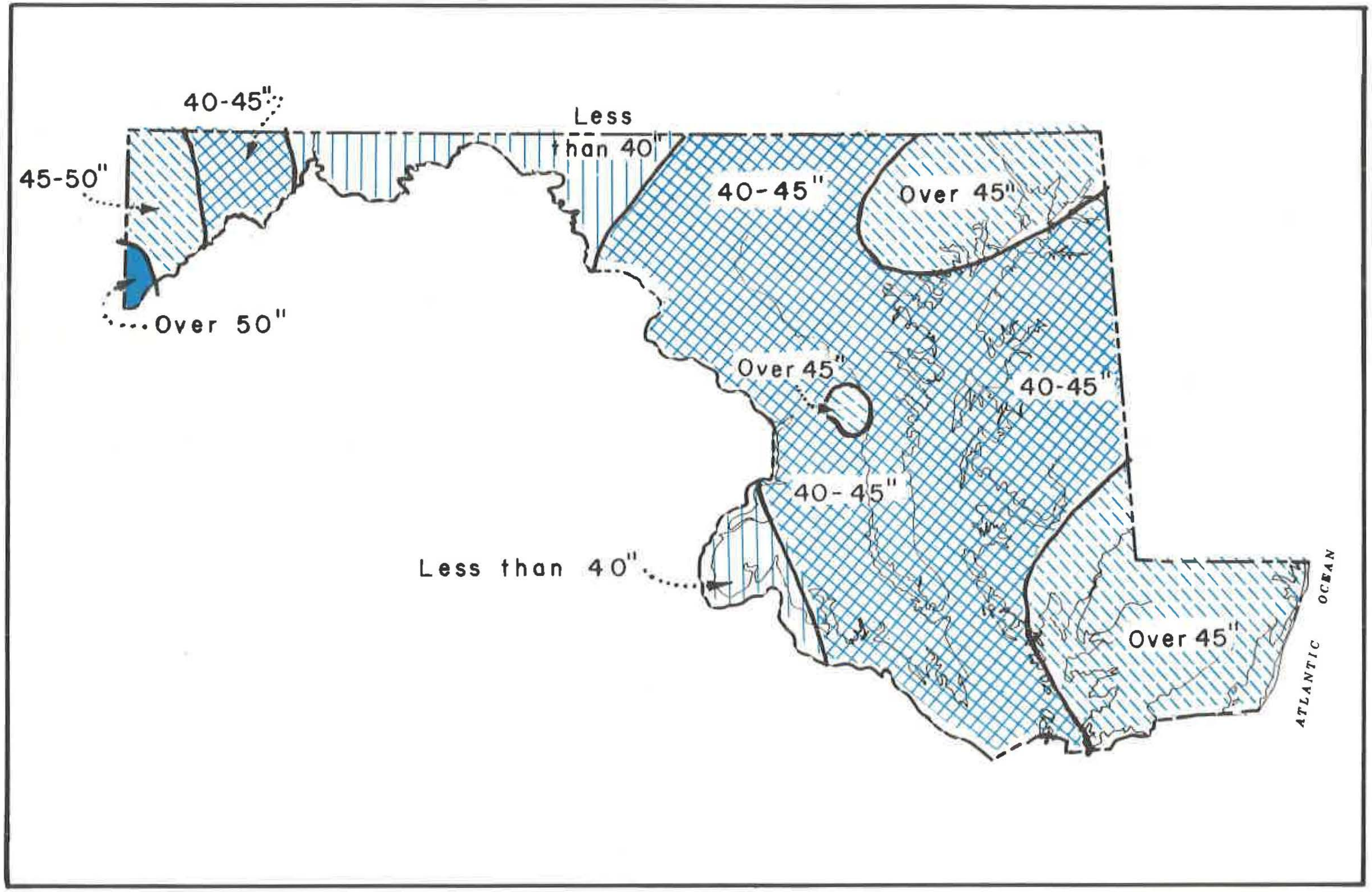


Figure 7. Our annual water income from precipitation varies across the State

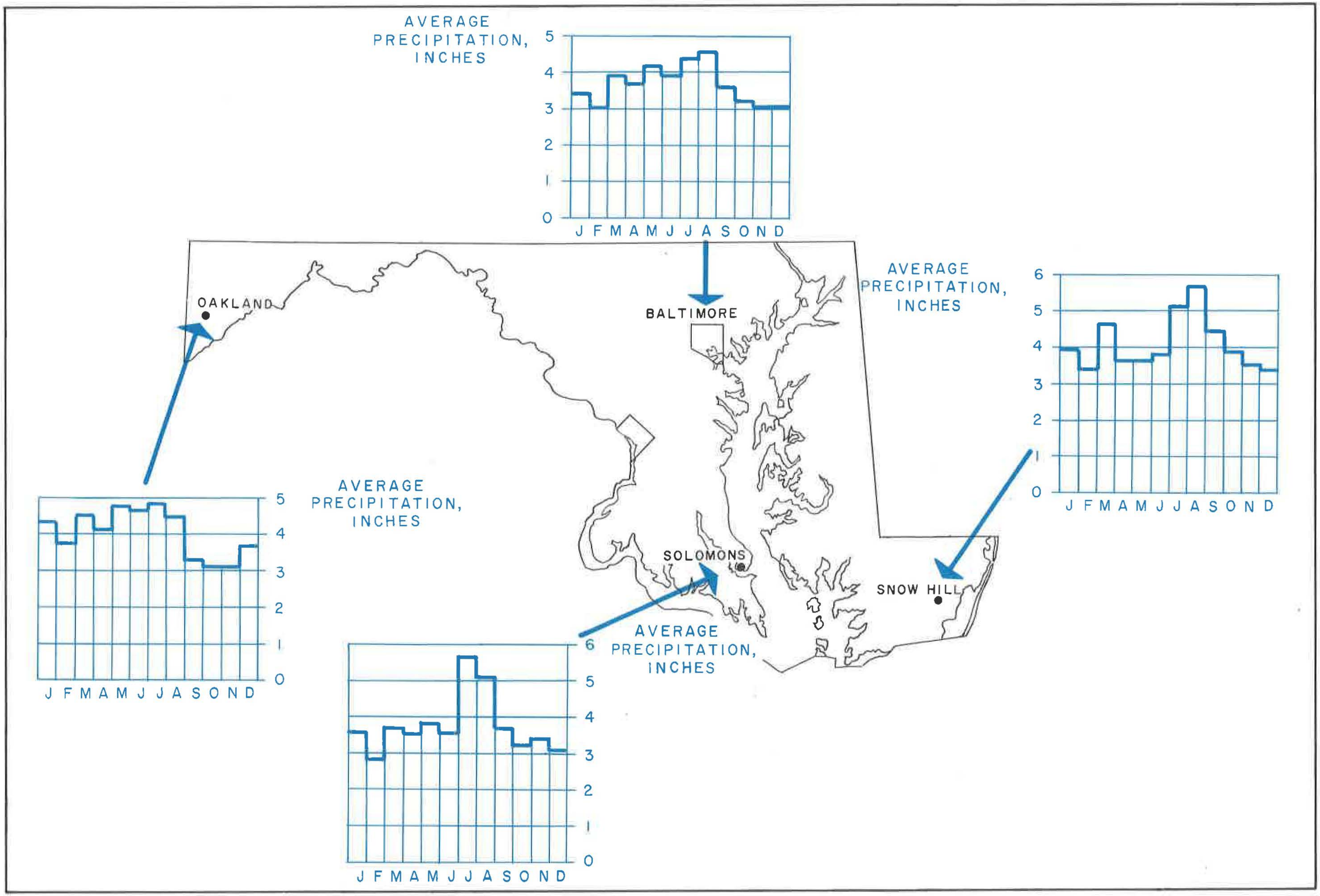


Figure 8. The average monthly precipitation illustrates the variability of our water income

CHAPTER 4

Evapotranspiration: Nature's income tax

Evapotranspiration is a coined word that combines two words, evaporation and transpiration, into one. It represents nature's taxes on water resources. Evaporation is the process of removing water vapor from a liquid water surface. Transpiration is the process by which plants discharge water vapor to the atmosphere. The combined demand of these two processes is an important consideration in Maryland's water budget because the evapotranspiration loss is equivalent to about two-thirds of the State's annual precipitation—a rather excessive rate of taxation.

Evapotranspiration losses, like other phases of water resources, show variability. They vary with time and location. Evaporation and transpiration are greatest when the weather is hot, dry, and windy. There is a great variation in evapotranspiration losses across the State because of differences in temperature, winds, water-surface area and vegetation.

The fact to remember about evapotranspiration in Maryland is that of our 42 inches of precipitation each year, about two-thirds or 28 inches goes back to the atmosphere and nature takes those 28 inches *first.*

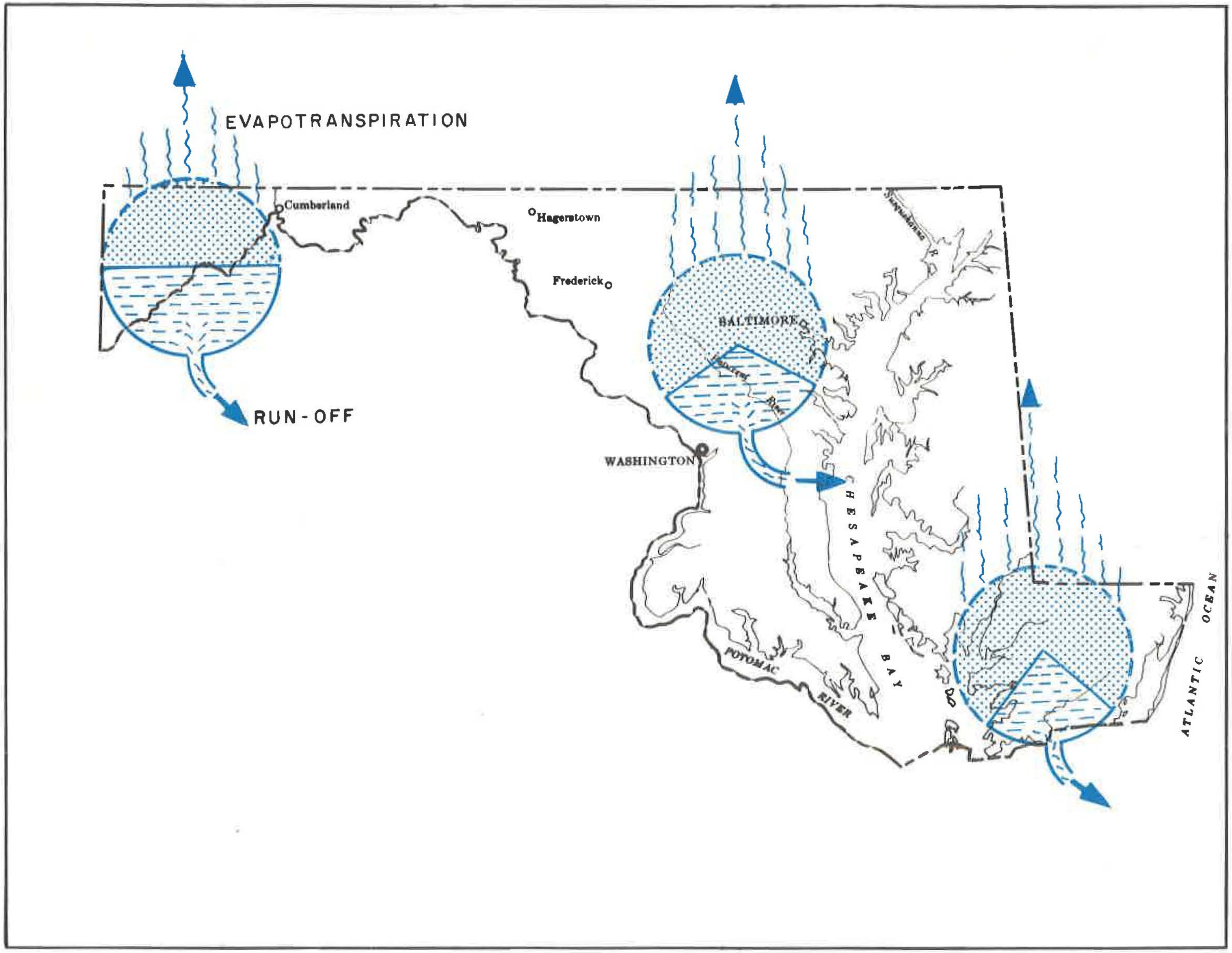


Figure 9. The deductions by evapotranspiration from annual precipitation vary from about one-half in western Maryland to nearly three-fourths on the Eastern Shore

CHAPTER 5

Surface water: Our checking account

Surface water is the term normally applied only to rivers and streams. In its broadest, most literal sense it means all water on the surface of the earth as opposed to ground water, which is water that lies below the surface of the earth. Surface water is analogous to our household checking account because it is the portion of our income that is the most readily available, most quickly diminished, and most rapidly replenished.

Maryland's streams are fed by precipitation, either directly as rainfall or snowmelt, or as water draining from ground-water aquifers. Surface water from all our streams eventually reaches the Atlantic Ocean. Some streams in Worcester County flow directly into the ocean; some in Garrett County flow to the ocean by means of the Mississippi River drainage system; and all others in the State drain to the ocean by way of the Chesapeake Bay.

Records collected on many of Maryland's rivers and streams show that each year about 14,000 billion gallons of water leave the State as streamflow. Some 11,000 billion gallons of this water originates outside of Maryland but traverses part of the State, principally in the Susquehanna and Potomac Rivers.

Surface-water flow exhibits nearly as much variability as the precipitation that fathers it. A stream on the southeastern shore with a 1-square mile drainage basin might have an annual water yield of only 150 million gallons. In the mountains of Garrett County, a 1-square mile drainage basin might yield nearly 600 million gallons in a year.

Streamflow is generally lowest during the late summer and fall when evapotranspiration rates are at a maximum and water draining from the ground-water aquifers is at a minimum. The seasonal trend of streamflow is illustrated by relative values of monthly discharge. Superposed on this seasonal pattern are the extremes of discharge—the floods or the drought flows.

An idea of the possible range in discharge can be derived from records of flow collected on the South Branch Patapsco River. The average flow of the stream at the measuring site is about 42,000,000 gpd (gallons per day) but the rate of flow has ranged from 260,000 gpd to 7,800,000,000 gpd.

Maryland is not in a flood-plagued region and floods are rarely a problem. The State, however, has experienced some severe

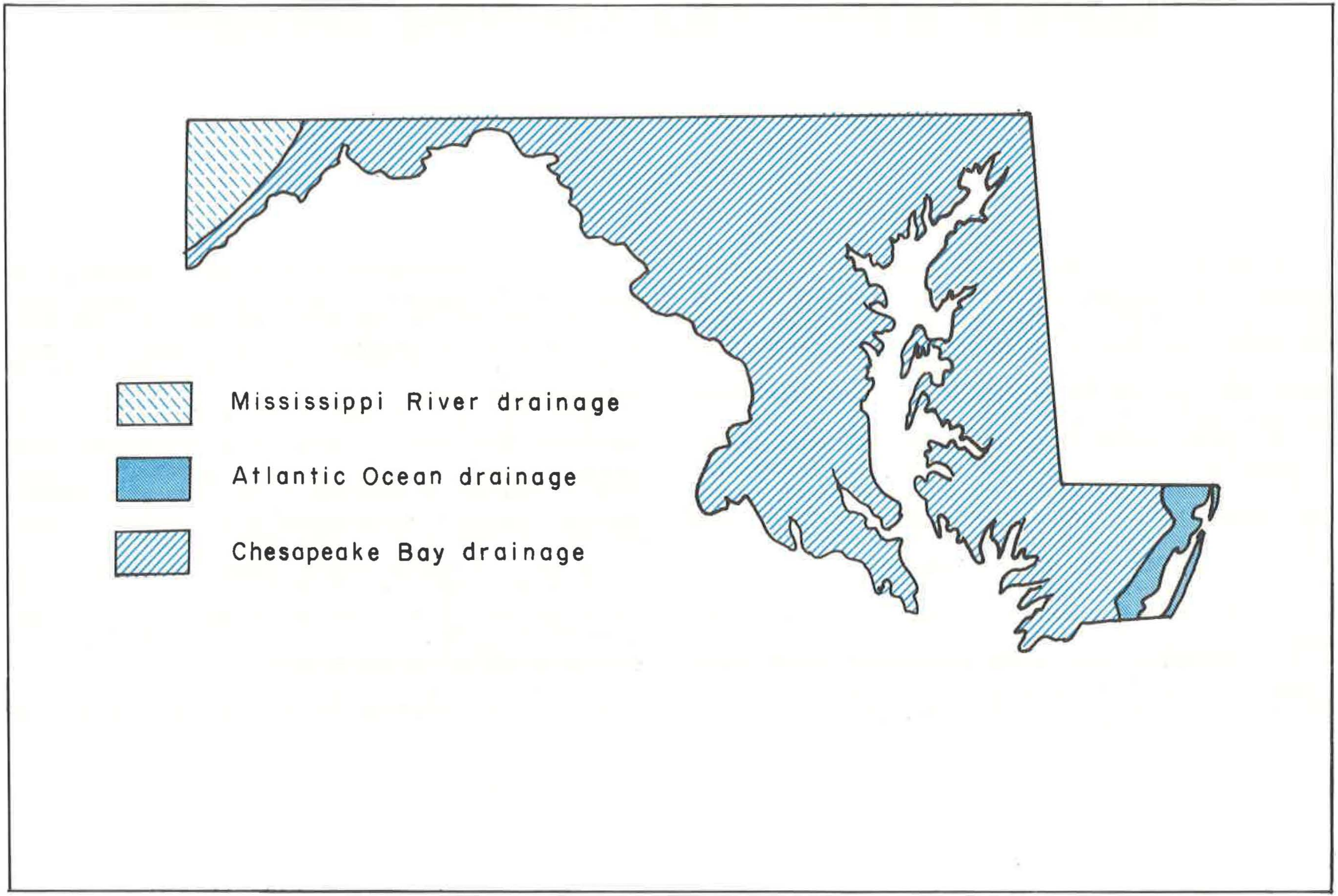


Figure 10. Most of Maryland's streams drain to the Atlantic Ocean by way of Chesapeake Bay

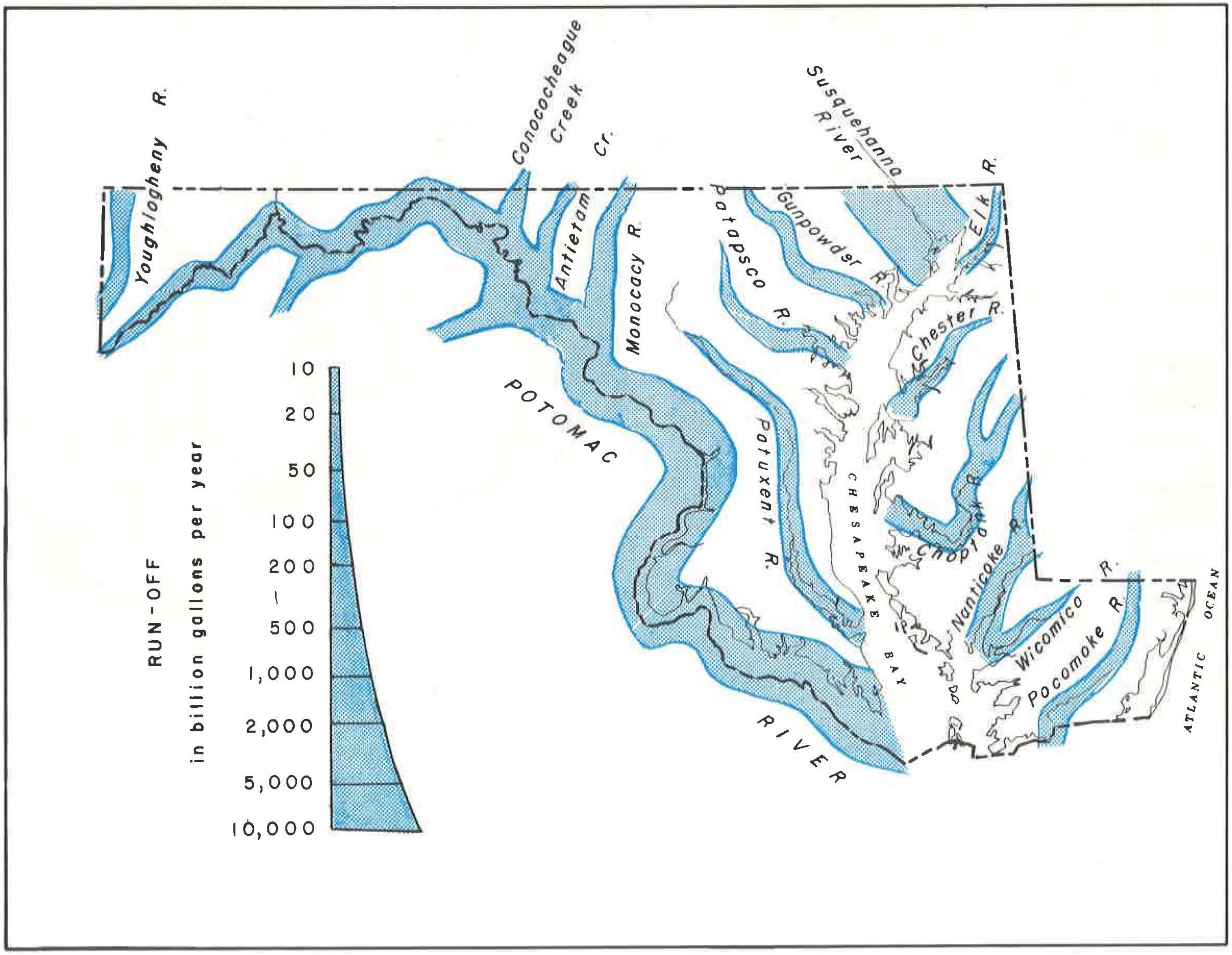


Figure 11. Most of the runoff of Maryland's larger streams originates outside her boundaries

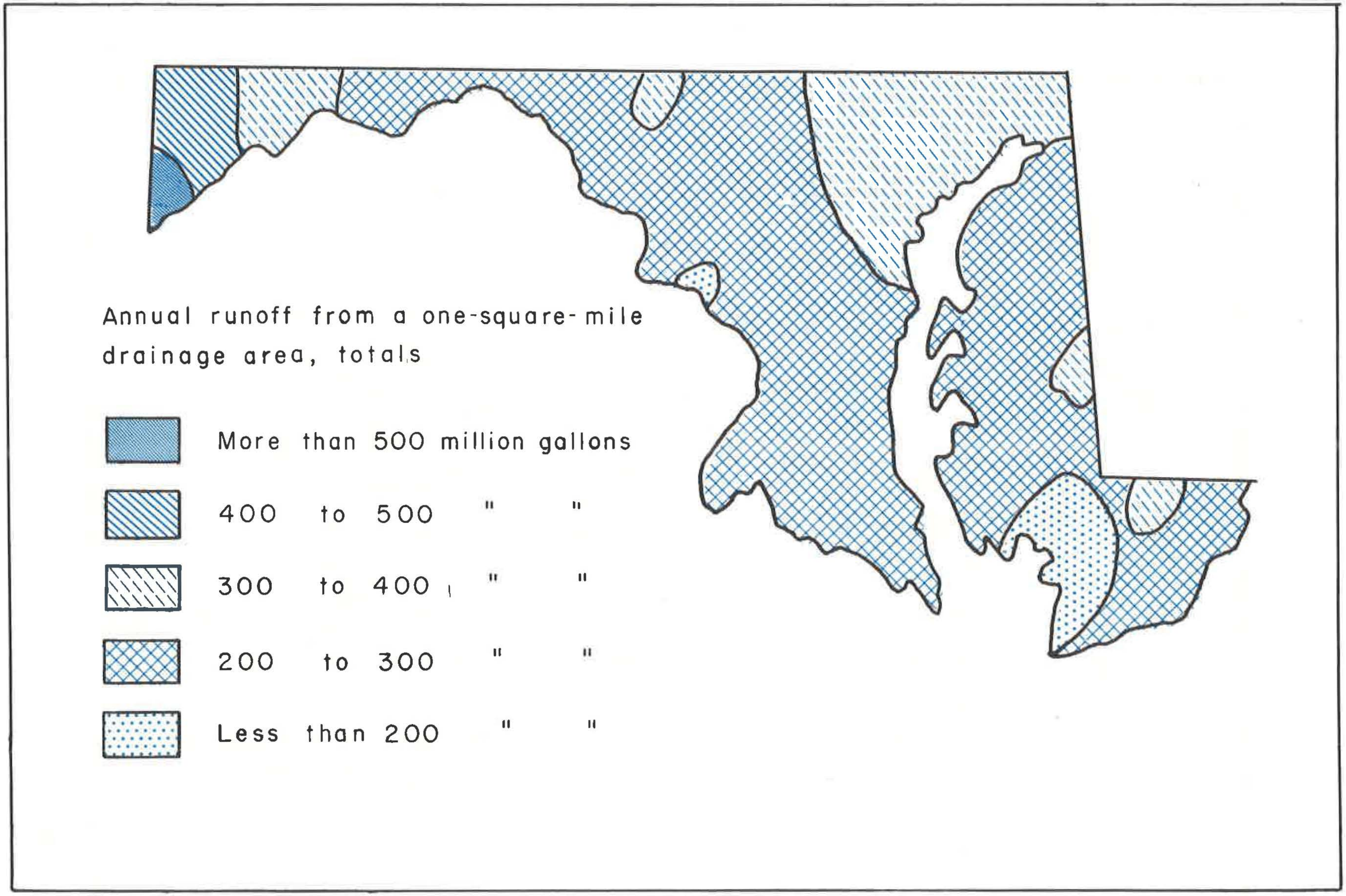


Figure 12. Variations in annual runoff are the results of differences in local climate, topography, and geology

floods in the past. Very severe floods have occurred on the large rivers—for example, the Susquehanna River flood of 1936, and the Potomac River floods of 1889, 1936, and 1942. Some flooding also occurs every year on small streams throughout the State. In addition, hurricane winds and tides have occasionally caused flooding in tidewater areas.

Topography bears great influence on the severity of floods. The steep land-surface slopes common in mountains and hilly country cause flood waters to peak sharply and quickly and to run off rapidly. The flat relief and gentler slopes of the coastal areas retard runoff so that floods tend to have broad peaks and to run off slowly.

Low discharges are a normal part of streamflow. In the summer and fall, when temperatures are commonly high and plants are using vast quantities of moisture, streamflows are reduced. During this time, most of the water in the streams is ground-water drainage.

During every low-flow period and particularly during the severe droughts, the effect of geology on streamflow becomes evident. Each variety of earth material found in Maryland yields its water to streams differently. In the next chapter, the general yield characteristics of some varieties of earth materials will be discussed at some length, but simple logic tells us that porous material should yield water readily and dense material should not. For example, in the western part of the State where dense rocks are common, flows are small during droughts. On the other hand, in the Great Valley near Hagerstown, streamflows, even during droughts, are well sustained by water contributed by the underlying porous limestone.

Some facts to remember about surface water are: (1) It is the quickest to respond to precipitation; (2) its extremes are a normal part of the streamflow picture; and (3) in general, high flows are influenced most by topography while low flows are influenced most by geology.

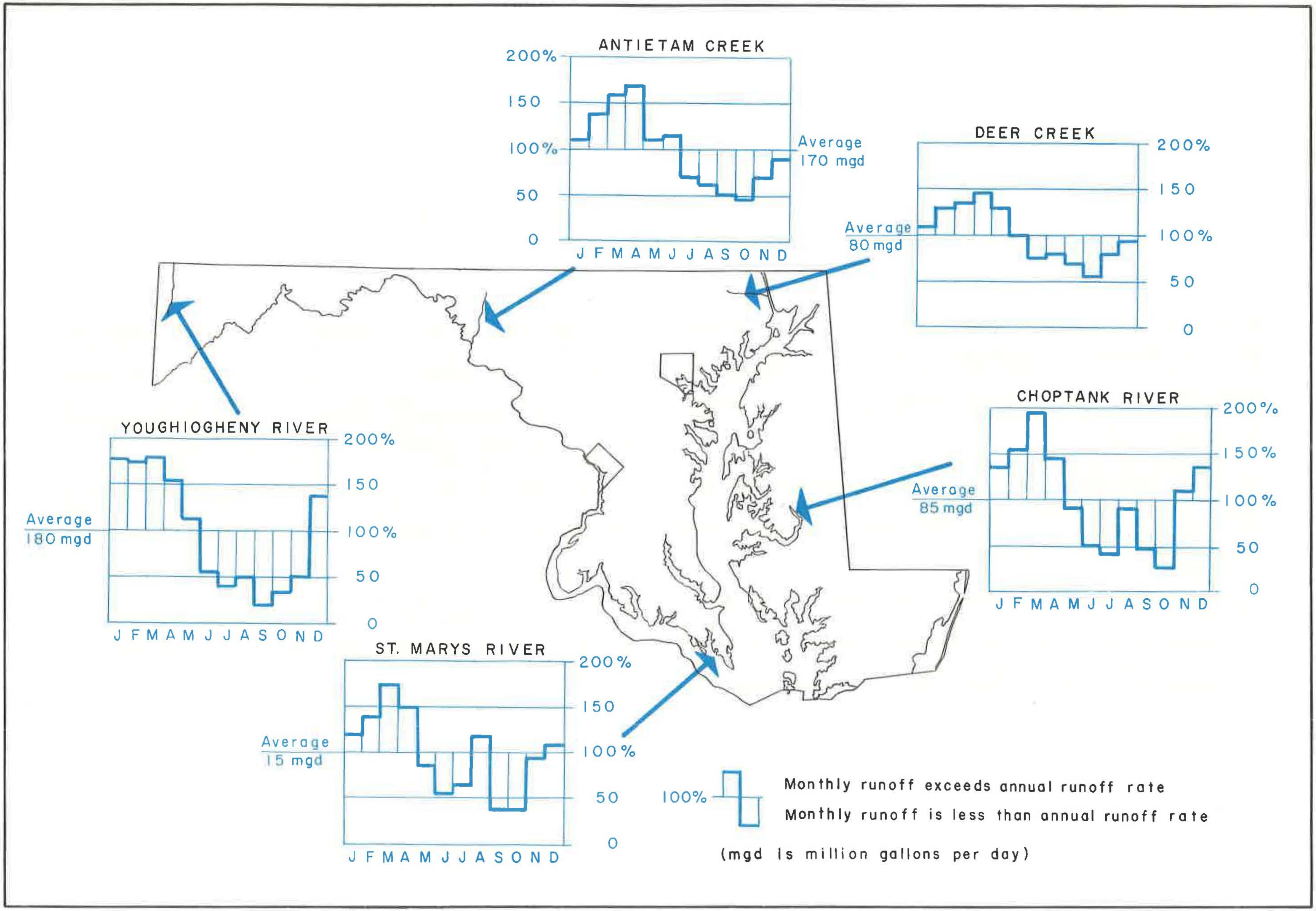


Figure 13. Relative values of monthly discharge provide some indication of the seasonal trend and variation in stream flow

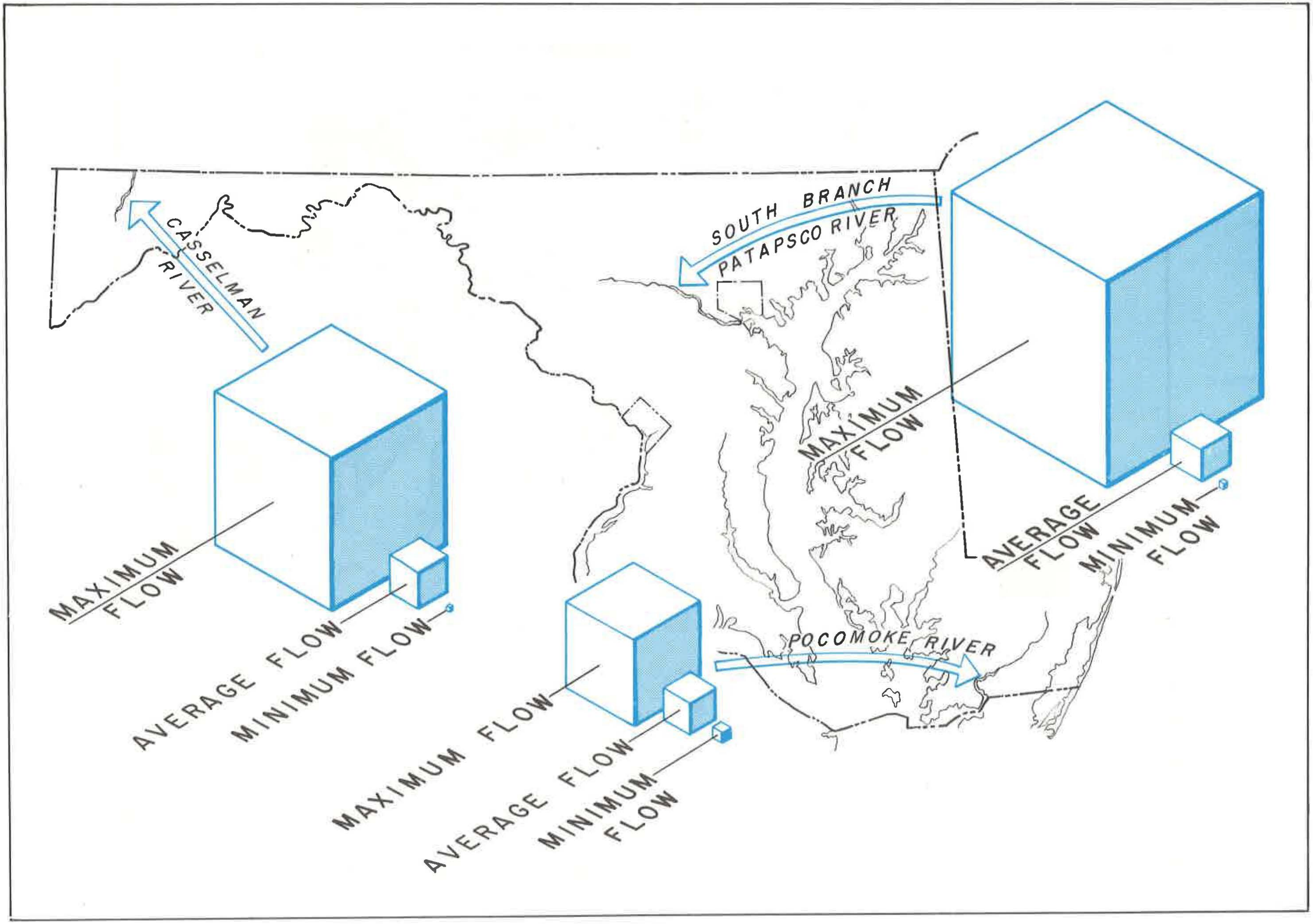


Figure 14. The average flow of a Maryland stream gives little clue to the range in the extremes of flow

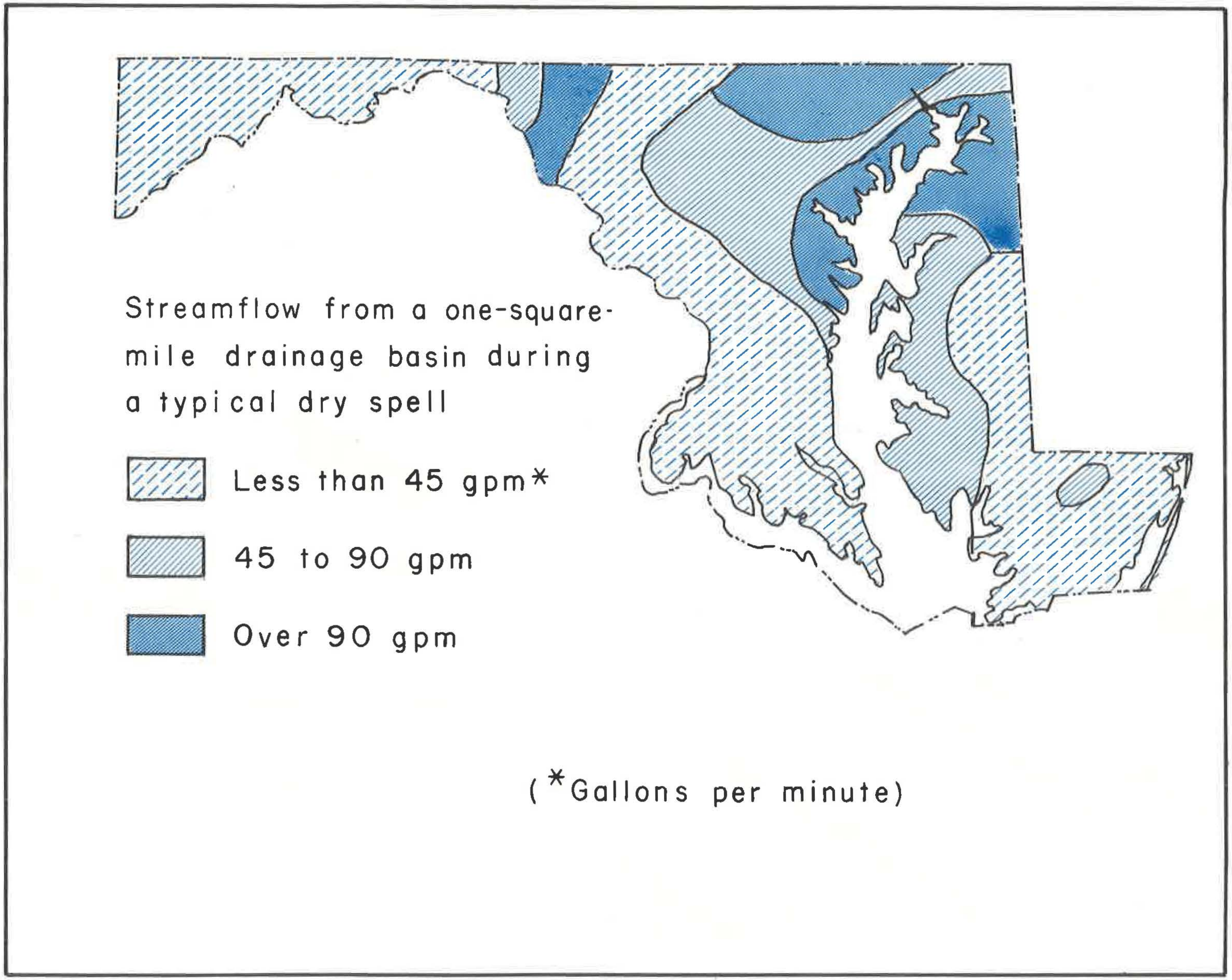


Figure 15. Variations in streamflow when precipitation is deficient reflect the differences in water-yield patterns of the State's many types of rocks

CHAPTER 6

Ground water: Our savings account

Ground water occurs under every square mile of Maryland and most of it originates as precipitation that fell directly on the State. Contrary to folk lore it does not come to us by underground rivers or by seepage from the Great Lakes.

Ground water resembles a savings account in several ways. First, it is the income that is left over after immediate needs are met. After precipitation falls, some water immediately runs overland to streams, some is evaporated, some enters the ground to be tapped by plant roots and subsequently transpired, and the remainder enters the ground-water regimen. Second, it is stored nearby, available for use upon withdrawal. Third, excess amounts are used to help maintain our checking account during periods of deficiency. During dry weather the overflow from the ground-water reservoir maintains streamflow.

Earth materials that can store and transmit ground water are called aquifers. Maryland possesses great reserves of ground water in her aquifers but the amount varies in different areas in the State because ground water depends upon the characteristics of the local earth materials. The part of the State west of the Fall Line is underlain by consolidated rocks which, except for some limestones, store and transmit water in relatively small cracks and fissures. The ground-water supply that is available from such rocks is usually small. However, in those areas underlain by limestones, large amounts of ground water can be stored and transmitted in cavities and channels.

The Coastal Plain, or that part of the State east of the Fall Line, is underlain by unconsolidated, stratified sediments which include sands, silts, clays, and mixtures of each. These sediments store tremendous quantities of water. It has been estimated, for example, that as much as 800 cubic miles of ground water may be stored in our Coastal Plain sediments.

Sediments that are composed mainly of very fine materials—clay and silt, while storing large amounts of water, cannot transmit it freely. This is because of the relatively small size of their void spaces and the poor degree of interconnection between the spaces. These fine-grained sediments are practically impermeable and do not function as aquifers.

On the other hand, many strata of the Coastal Plain sediments are composed of fairly coarse, sand-sized materials. These strata not only store large amounts of water, but because of the large openings and their degree of interconnection they can also transmit water freely. These coarser sediments are the principal aquifers that make ground water the predominant water resource in the Coastal Plain.

Maryland's ground waters usually travel at a slow rate but they do move. Movement in tight clays may be inches per century. Movement in large solution channels in limestone may be almost as rapid as that of a surface stream. Ground-water movement in sand aquifers usually does not exceed a foot or two per day.

Some facts to remember concerning ground water: (1) It occurs almost everywhere; (2) in Maryland, it originates primarily as precipitation that has fallen on the State; (3) quantities stored in limestone or other consolidated rocks are less than those stored in Coastal Plain deposits; and (4) movement of water through the earth is usually very slow.

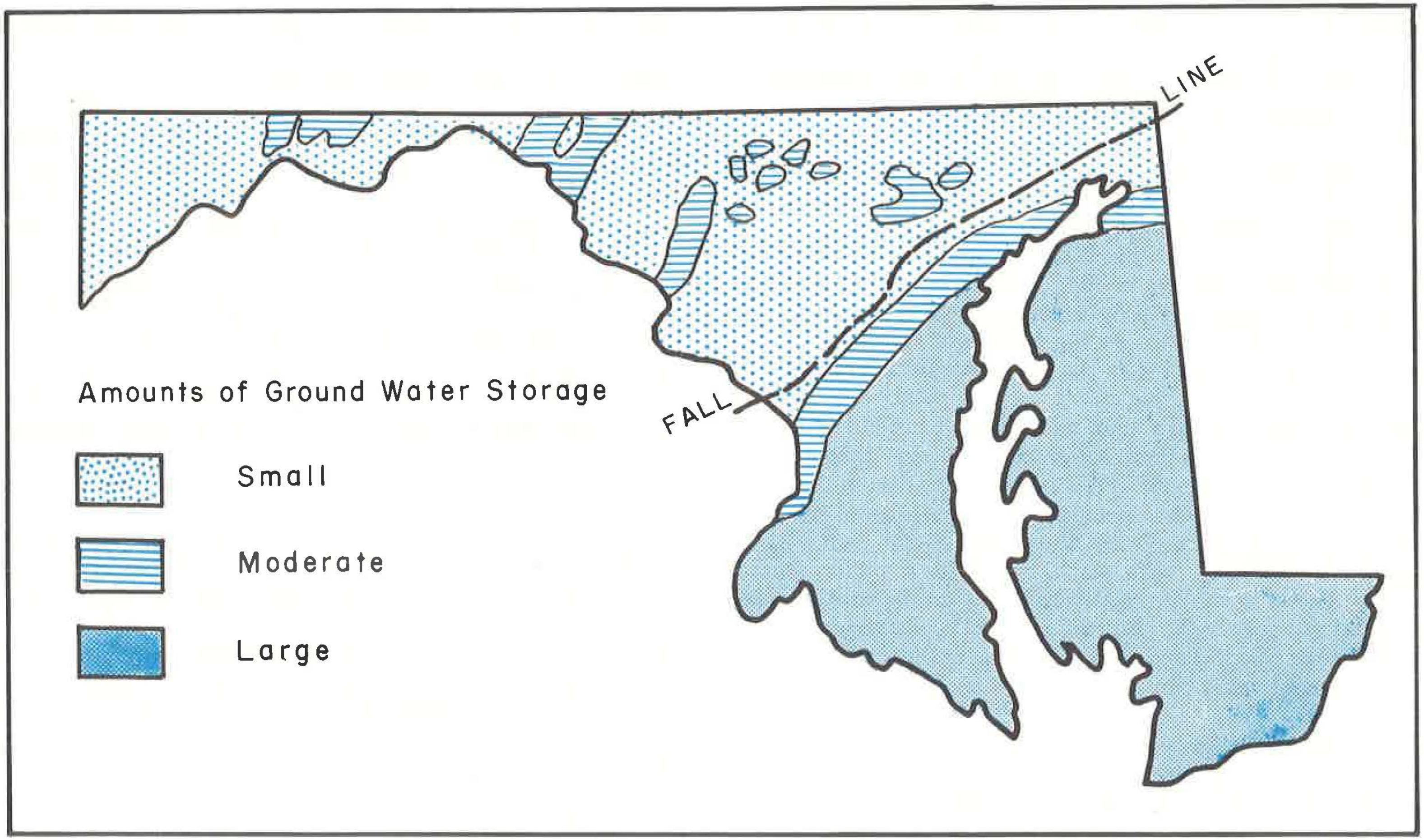


Figure 16. The amount of ground water in storage varies in different areas of the State

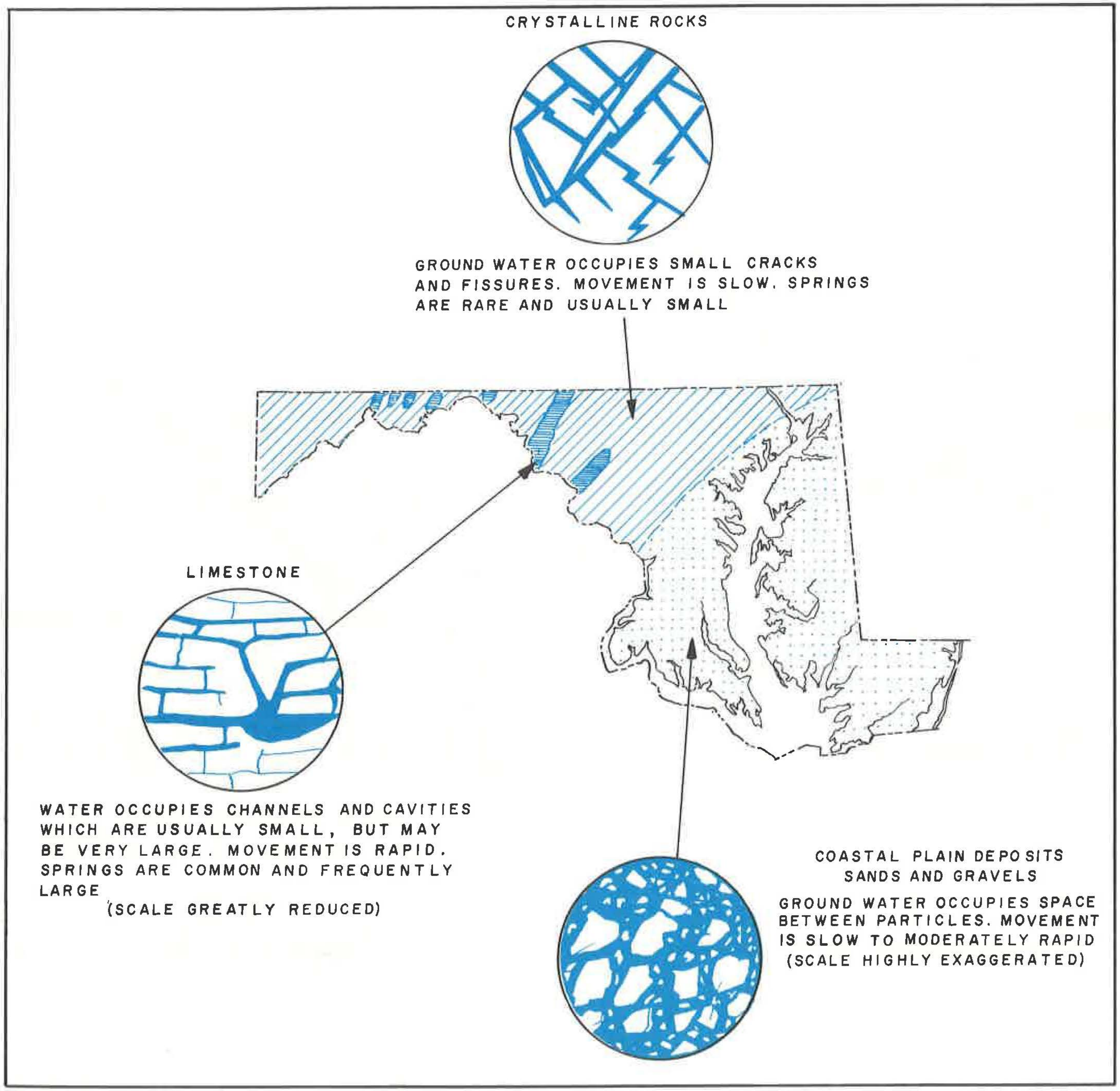


Figure 17. The potential of ground water as the predominant water resource depends on the aquifer characteristics of the local rocks

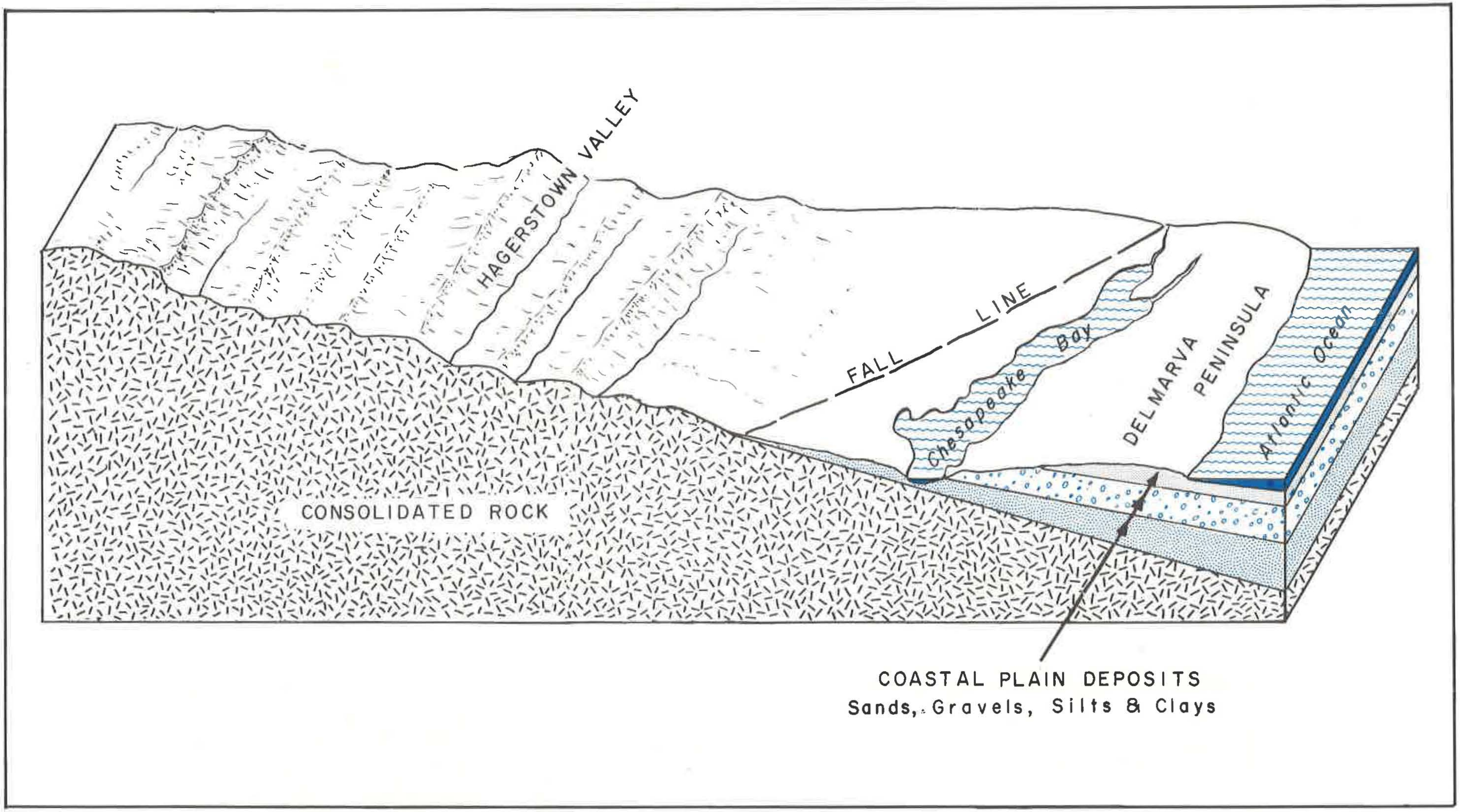


Figure 18. Coastal Plain deposits contain most of Maryland's ground water

CHAPTER 7

Tidal water: Nature's trust fund

Maryland and the Chesapeake Bay are almost synonymous in the minds of many people. The Bay and the tidewaters along the Atlantic Ocean form major features of Maryland's water resources. This resource resembles a trust fund—it is something valuable in addition to our income that we may use and enjoy but must pass on, undiminished, to succeeding generations.

The value of Maryland's tidewaters to fish and wildlife is well known. The Chesapeake Bay in particular is immensely important as a habitat for many varieties of fauna and flora. A feature that makes the Bay so valuable to wildlife is that it is a great mixing bowl where the fresh water of upland streams meets the salty water of the ocean. This mixing provides the proper ranges of salinity important in many types of fish and plant propagation. However, the salty water of the Bay is in contact with the outcrops of some of the major ground-water aquifers and constitutes a threat of salt-water contamination to some of our ground water.

The influence of the Bay on weather is important to the central part of the State. Because of this great body of water, temperatures

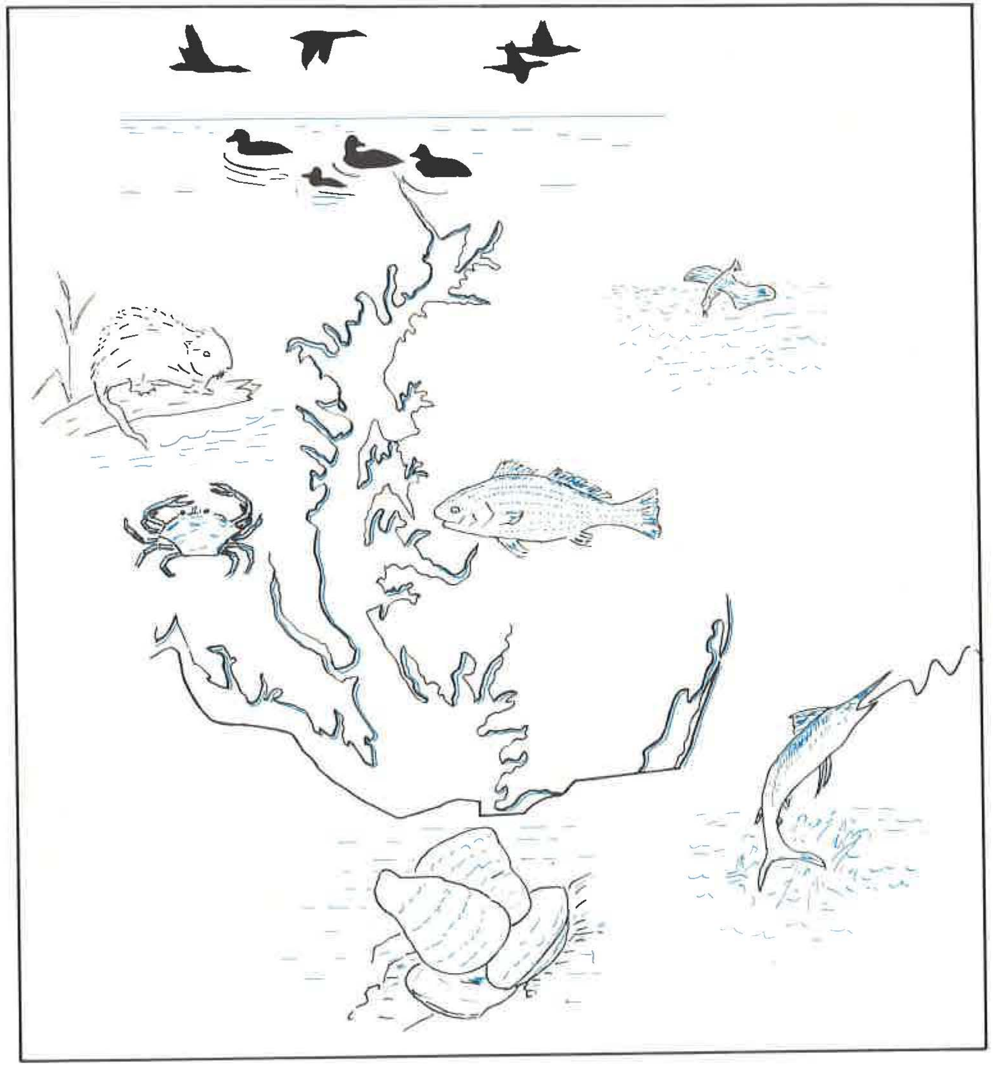


Figure 19. Maryland's tidewaters provide a habitat for many varieties of fish and wildlife

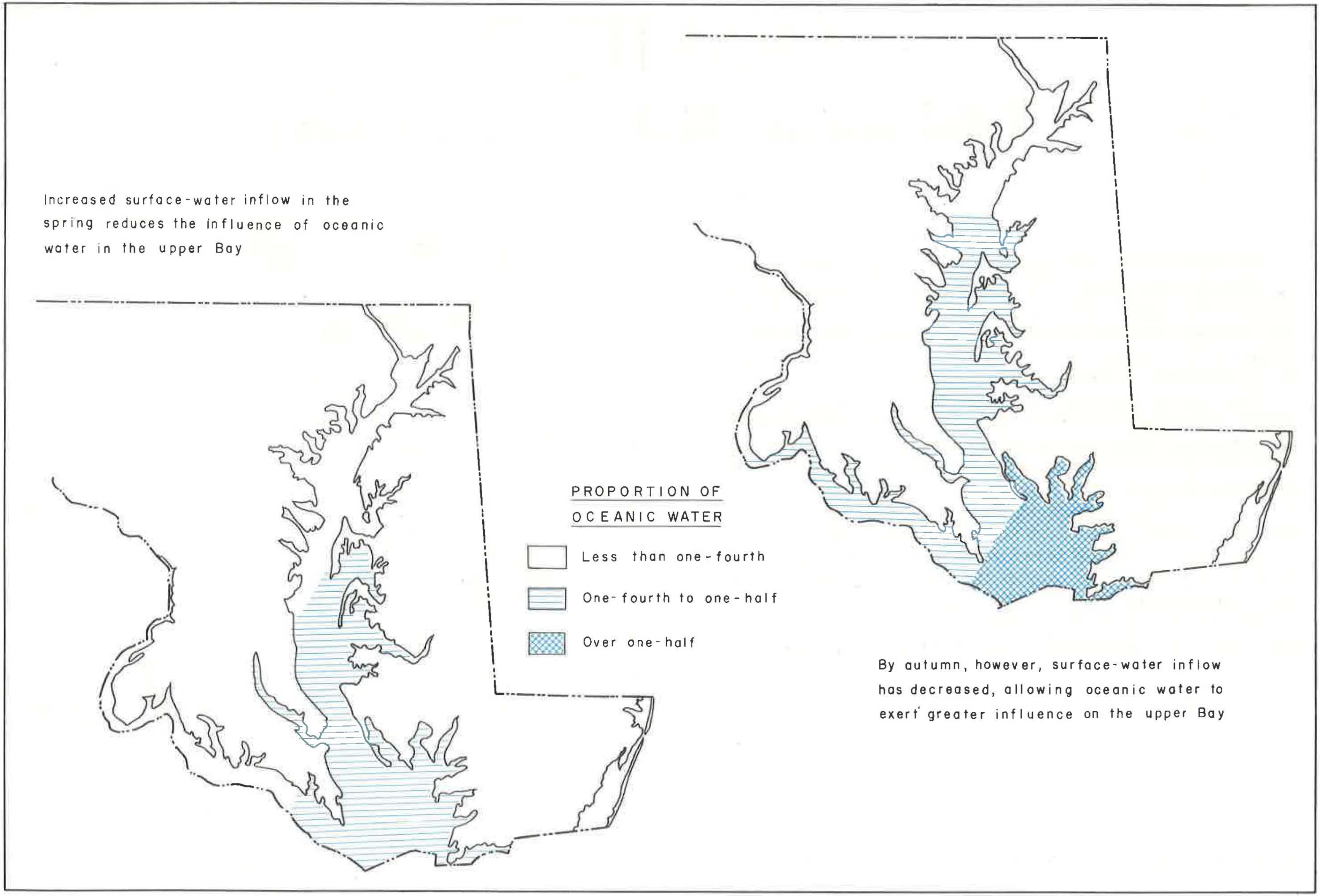


Figure 20. The influence of the ocean on salinity is modified by the fresh-water inflow brought by the upland streams

in much of the Piedmont and Coastal Plain are warmer in the winter and cooler in the summer than are similar areas in other Middle Atlantic States.

The tidewaters exhibit variability, just as the other phases of water resources do. However, the variations in quantity are not so pronounced as they are in a river or creek. The lunar tides are the most obvious feature of the Bay's variability. There are other less obvious variations, though. For example, there are seasonal variations in tidal height. The tides in the summer are higher than those in the winter. This is probably due to the change in direction of prevailing winds from the south in the summer to more northerly in winter.

Facts to remember about Chesapeake Bay are: (1) It is a great mixing bowl, blending fresh and salt water into a proper habitat for many creatures, (2) it gives to the central part of the State the advantages and disadvantages of many miles of tidal shoreline, and (3) it exerts great influence on the weather of central Maryland.

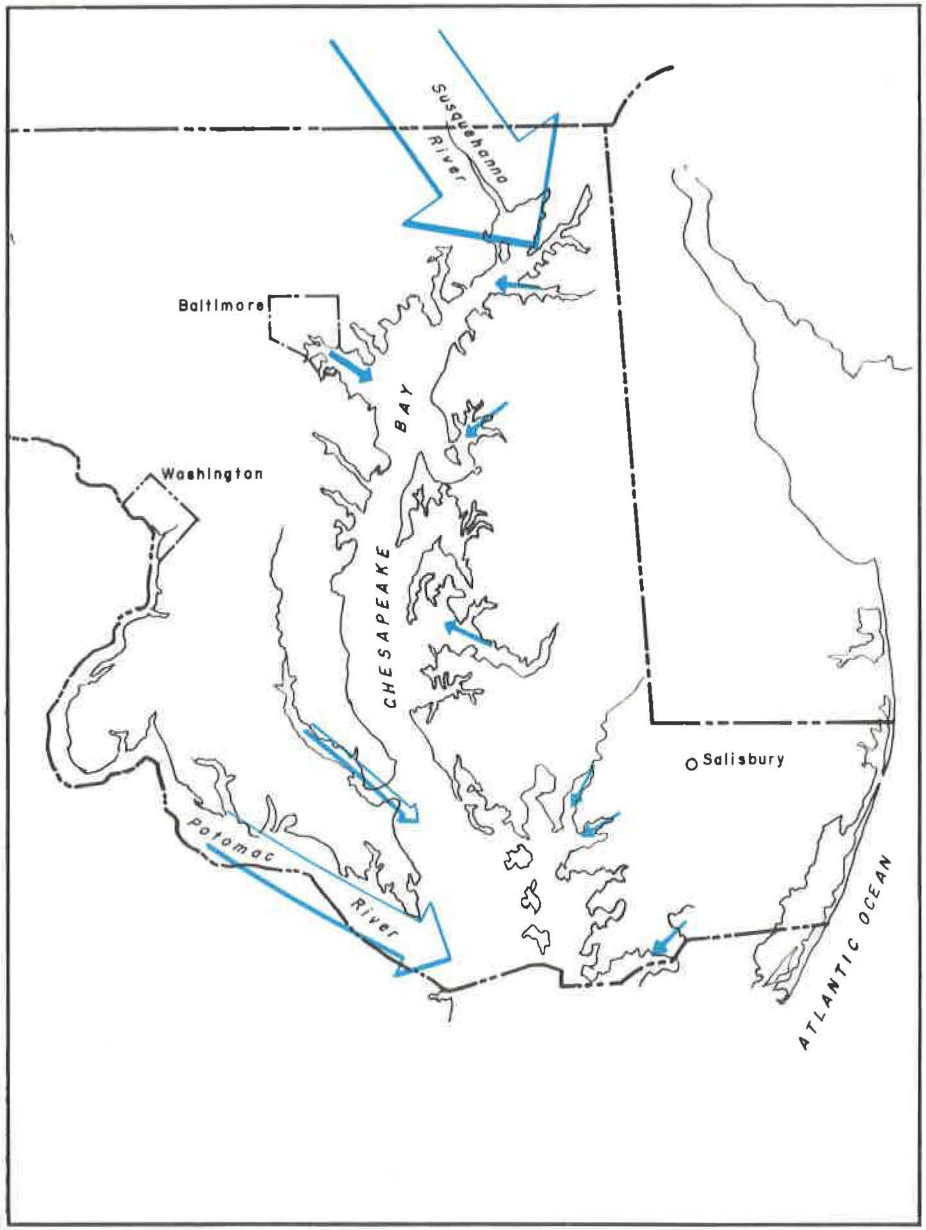


Figure 21. The Susquehanna and Potomac Rivers contribute most of the fresh water brought by streams into the Chesapeake Bay

CHAPTER 8
Water quality: Our solvency

Solvency in finances is the term that describes our financial soundness; it is the condition or usefulness of our money resources. Solvency can be applied to the water resource, too, in considering its quality or usefulness. If the quality of our water is good, it is usable on demand to meet almost any need. If quality is poor, the usefulness is restricted and tremendous effort may be required to restore it. Thus, the quality of our water resource is as important as its quantity.

Water quality is usually described in four ways: (1) By chemical quality, or what is dissolved in the water; (2) by physical quality, or what is carried mechanically by the water; (3) by thermal quality, or the temperature of the water, and (4) by biological quality, or what lives in the water.

Chemical quality is expressed as the concentration of dissolved materials in the water in milligrams per liter (mg/l). One liter of water containing 1 gram (one thousand milligrams) of dissolved minerals in solution is said to have a dissolved-solids concentration of 1,000 mg/l. All natural water contains some dissolved materials, even precipitation, which we usually think of as "pure" water.

Because water is an excellent solvent, it dissolves a little of each mineral it contacts. The amount dissolved depends on the solubility of the mineral and the length of time the water is in contact with it. Thus storm runoff which moves rapidly overland toward streams is likely to be less mineralized than ground water which moves slowly through the soil and rocks. Similarly, water in contact with relatively insoluble rocks is likely to be less mineralized than water in contact with highly soluble rocks.

At a given point, ground-water quality usually remains constant for long periods of time whereas surface-water quality varies widely and rapidly. The chemical quality of a stream at any given time depends on how much of the flow is contributed by ground water and how much is direct runoff from precipitation. During storm events, the chemical quality of water in streams may be almost identical to the chemical quality of the precipitation. On the other hand, ground water and the water in streams during low flows may be hundreds of times more mineralized than precipitation.

Physical quality is determined in part by the amount and kind of sediment carried by the water. Although ground water contains some sediment, the dominant transporter of sediment is surface water. Sediment is measured in concentration in parts per million (ppm), but the major significance of the sediment quality is in the load of sediment transported; that is the actual weight of material transported by the stream during a given period of time. The sediment concentration of water in a small stream that drains a badly eroded field may be very great, but the total sediment load carried by the stream may be quite small because of the small total streamflow. Sediment concentrations in the Potomac River, conversely, are usually quite low, even during a flood; but because of its large water discharge, the river moves many thousands of tons of material a year.

Stream sediments move in two ways: as suspended load, or as bed load. Suspended sediment is usually made up of small particles of clay and silt, some so small they never settle out even in still water. The bed load is so named because the sediment moves on or near the bed of the stream. The bed load involves larger particles, the size depending on the speed and depth of the stream. Very large rocks sometimes are moved as bed load.

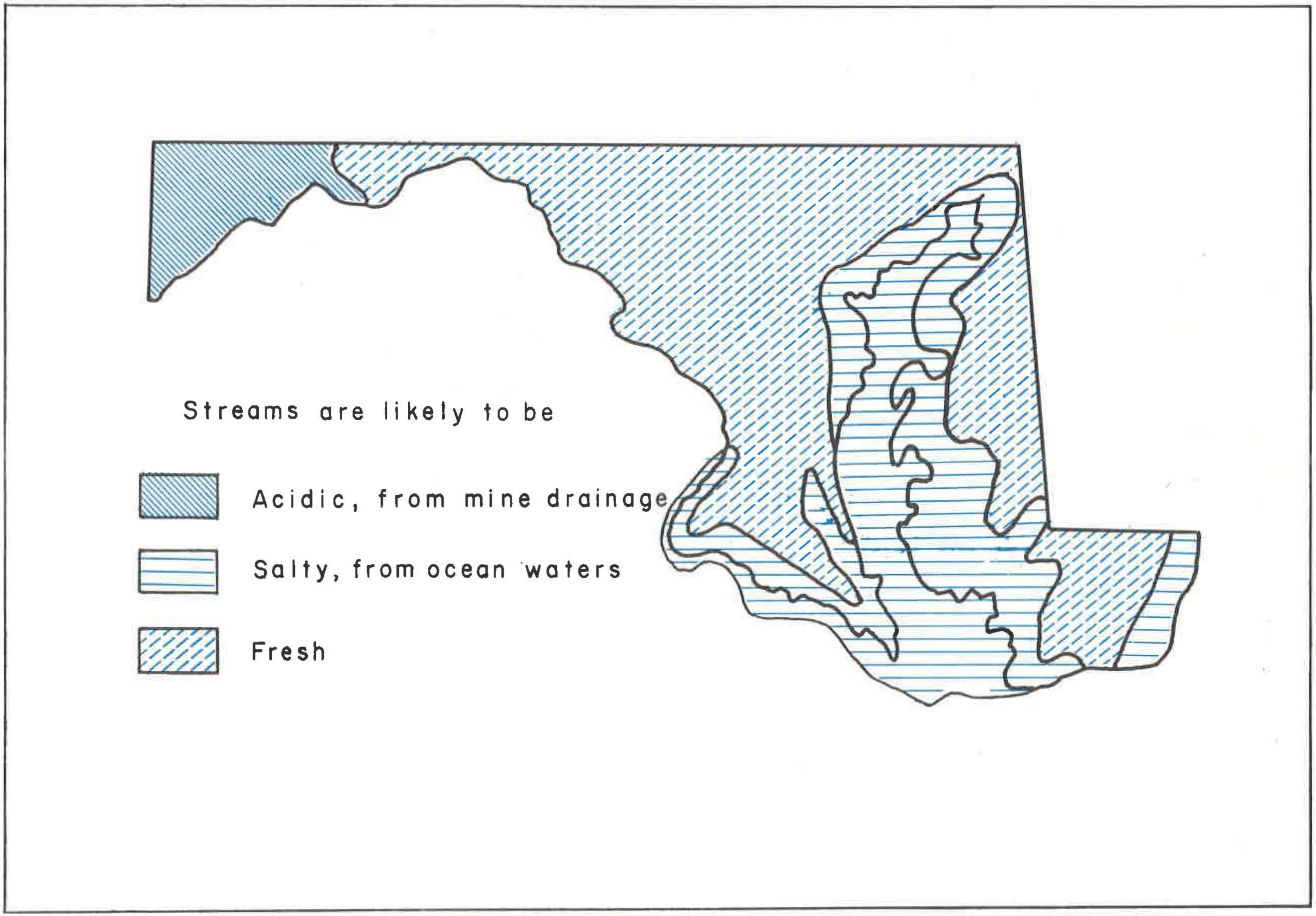


Figure 22. The general quality of surface water in the State is related to geographic location

The streams in Maryland always carry some sediment. The amount of sediment that is transported by streams depends primarily on the condition of the drainage basin, or watershed, of the stream. More sediment is available to the stream when the basin has no plant cover to protect the soil from disturbance. Conversely, a forested drainage area, well covered with leaf litter and humus, has little exposed soil area to be disturbed and yields little sediment.

Thermal quality helps to determine the types of plant and animal life that can live in the water. Surface water and shallow ground water usually follow the general pattern of local air temperature but within a smaller range—never less than freezing, of course, and usually less than about 90°F. It is obvious, for example, that Chesapeake Bay experiences a wide range in temperature during the year. In the winter, parts of the Bay freeze, whereas in the summer the Bay is warm enough for swimming.

On the other hand, the temperature of moderately deep ground water (between about 50 and 200 feet below land surface) will remain at about the local mean annual air temperature. At greater depths, however, ground-water temperature increases by about 1°F per 100 feet of additional depth.

Biological quality pertains to everything that lives in water, from microscopic creatures to large fish, and is intricately involved with chemical, physical, and thermal quality. In general, the biological quality of Maryland's waters is good, but it may be easily upset. An example of this may be found in the areas of the State that contain coal deposits. The water that drains from coal-bearing rocks usually contains sulfuric acid derived from a chemical reaction between sulfur in the coal and oxygen. This mine water, draining into a stream in sufficient quantity is lethal to all life in the stream until diluted sufficiently by non-acidic water.

Facts to remember about water quality are: (1) All natural waters contain some naturally derived constituents; (2) each measure of water quality is dependent on all of the other measures; and (3) Maryland's waters are generally of excellent quality.

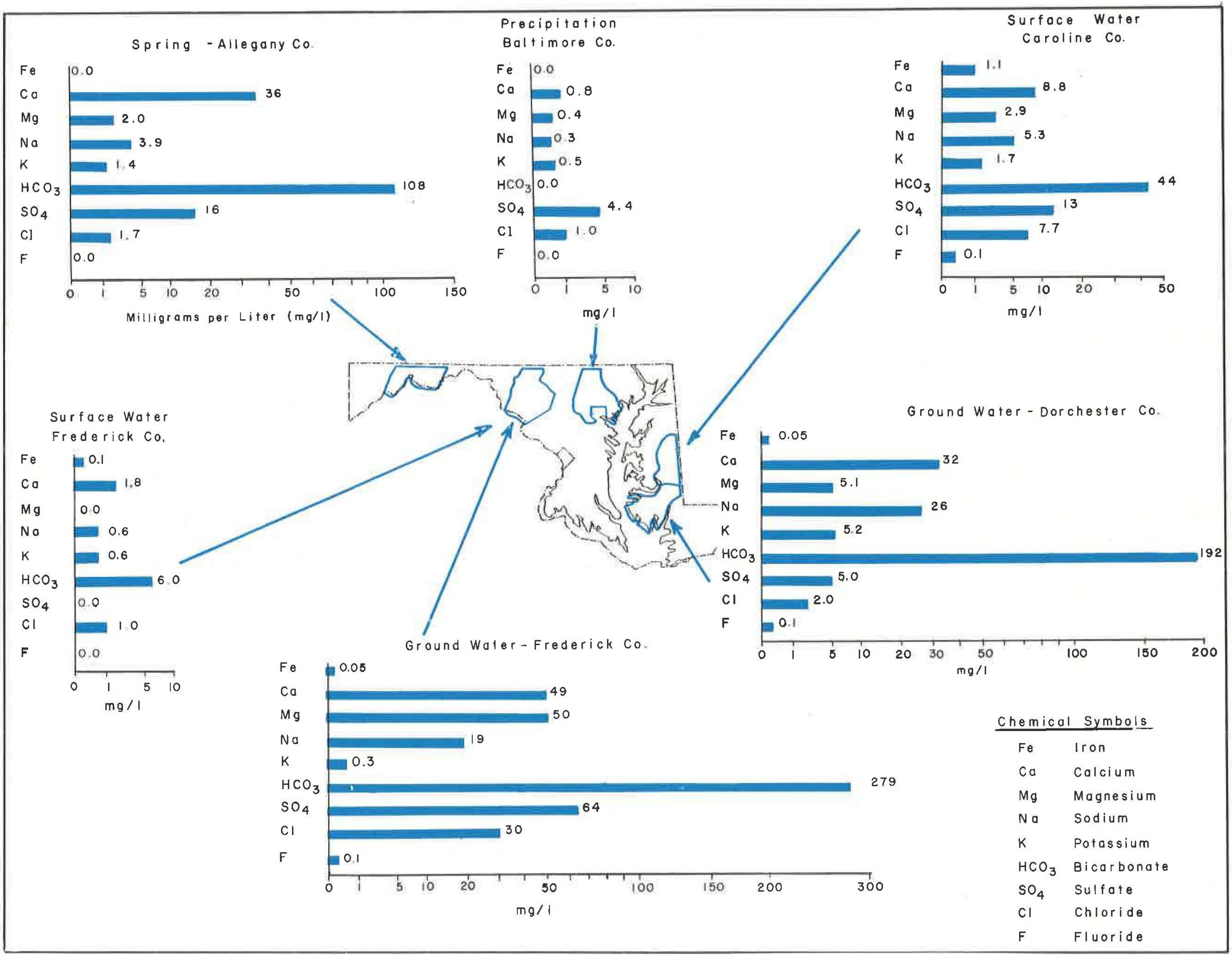


Figure 23. All of Maryland's water resources contain natural chemical constituents in varying concentrations

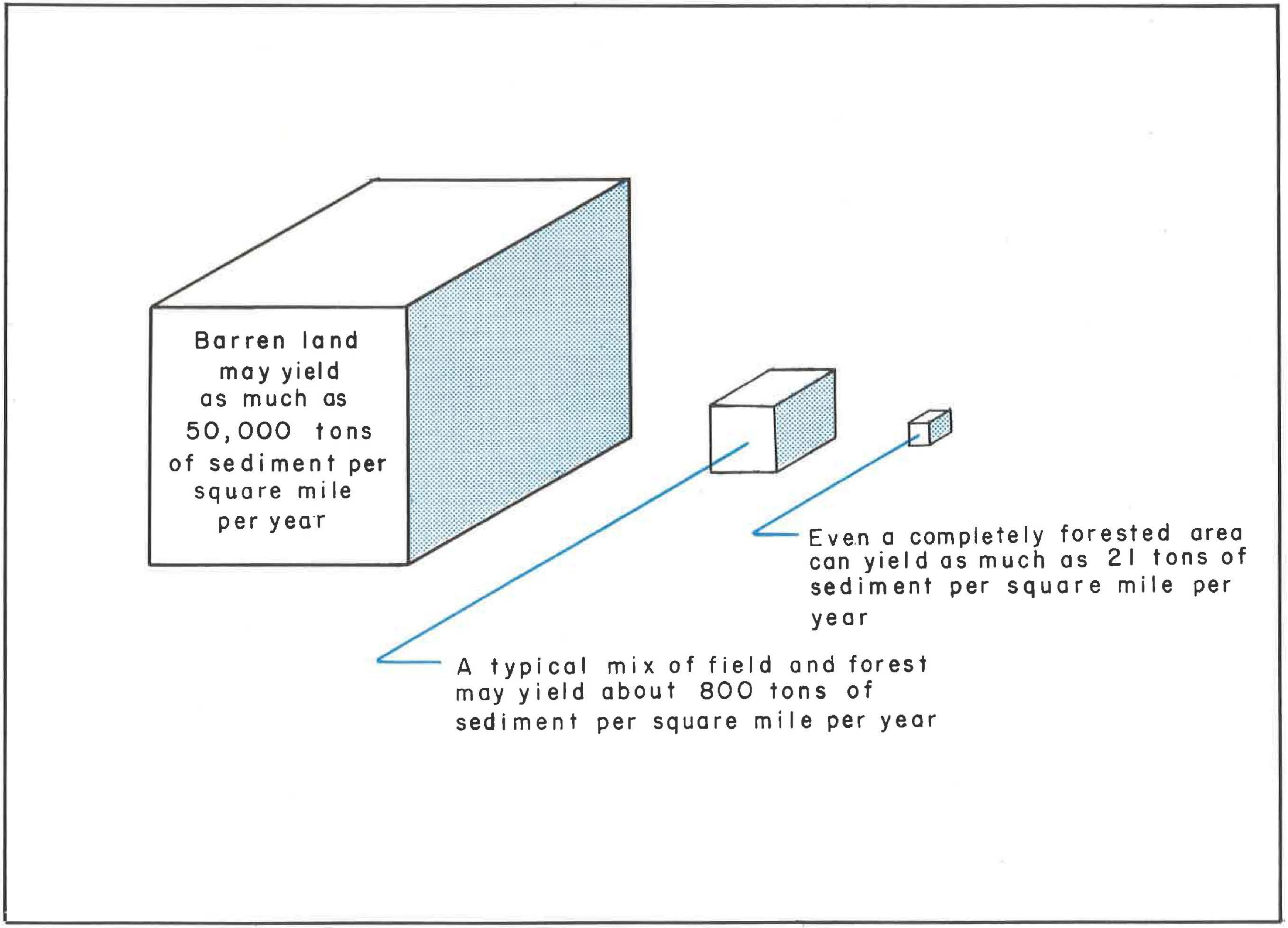


Figure 24. The sediment available to a Maryland stream is related to the physical condition of the watershed

CHAPTER 9

Water use: Our expenditures

Up to this point, we have been talking about a simple budget and its analogy to a natural resource. Now we must assess our expenditures—the way we use the resource. Have we used it wisely? Does our budget need revision? Are we facing bankruptcy or should we take different action to make better use of our income?

We must have water to support life and to maintain civilization. Each use we make of water exerts some changes in quantity or quality. Not all changes are detrimental to further use. This is fortunate because only the detrimental changes must be identified and remedied or eliminated.

Maryland's water expenditures range from domestic uses to the most sophisticated industrial uses. During 1965, an average of 4,100 million gallons of water was withdrawn for use in our State every day. This figure does not include nonwithdrawal uses such as those for water power, recreation, or transportation.

Most of our water use is nonconsumptive; that is, the water remains available for reuse. An example of reuse is the use by one Maryland industry, of municipal sewage-plant effluent for cooling water.

Consumptive uses of water include irrigation, air conditioning, and food processing—anything that significantly diminishes the quantity of water initially withdrawn by evaporating it or by incorporating it in a product. Consumptive use is increasing and is becoming a more important consideration to proper water-resource management.

The use made of water is often determined by the quantity and quality available. The water used by an average Marylander for his household needs is about 50 to 100 gallons per day and, although he will drink only 2 quarts of it, all of it must be of high quality. On the other hand, the water used in the production of a ton of steel amounts to many thousand gallons but because none is consumed by humans, it can be of lower-than-drinking quality.

Nature has partly determined the potential use of water in various areas of the State. West of the Fall Line, surface water is the predominant usable water resource. In this area of the State are found the largest streams and the greater number of reservoir sites.

An industry needing great quantities of water or an industry requiring water with a low mineral content would look to a surface-water supply, and would most likely find it west of the Fall Line.

Some of the largest uses of fresh surface water are for cooling purposes in thermoelectric generation, for large municipal water supplies, and for dilution of sewage. The requirements of each of these uses can sometimes be met by a "run of the river" operation—that is, no significant storage is required. Usually, though, some storage must be provided when large amounts of water are required. For example, Baltimore City provided storage for its first municipally-owned water system about 1860 when a dam was built on Jones Falls. The reservoir thus formed was at first called Swann Lake and later Lake Roland. The capacity of this reservoir was 500,000,000 gallons. The Jones Falls system was used until about 1915, by which time Gunpowder Falls had been impounded. Over the years, the storage capacity of the Baltimore City reservoirs has been increased to 86,000 million gallons by construction of larger dams on Gunpowder Falls and the Patapsco River, and the city has still had to obtain an auxiliary supply from the Susquehanna River.

Our reservoirs usually serve more than one need, although a reservoir generally is built to serve one principal purpose. Each reservoir in the next table provides some additional benefits aside from the principal purpose shown. For example, recreation is provided at each one.

Ground-water use west of the Fall Line is generally limited to rural and suburban homes and small industries. East of the Fall

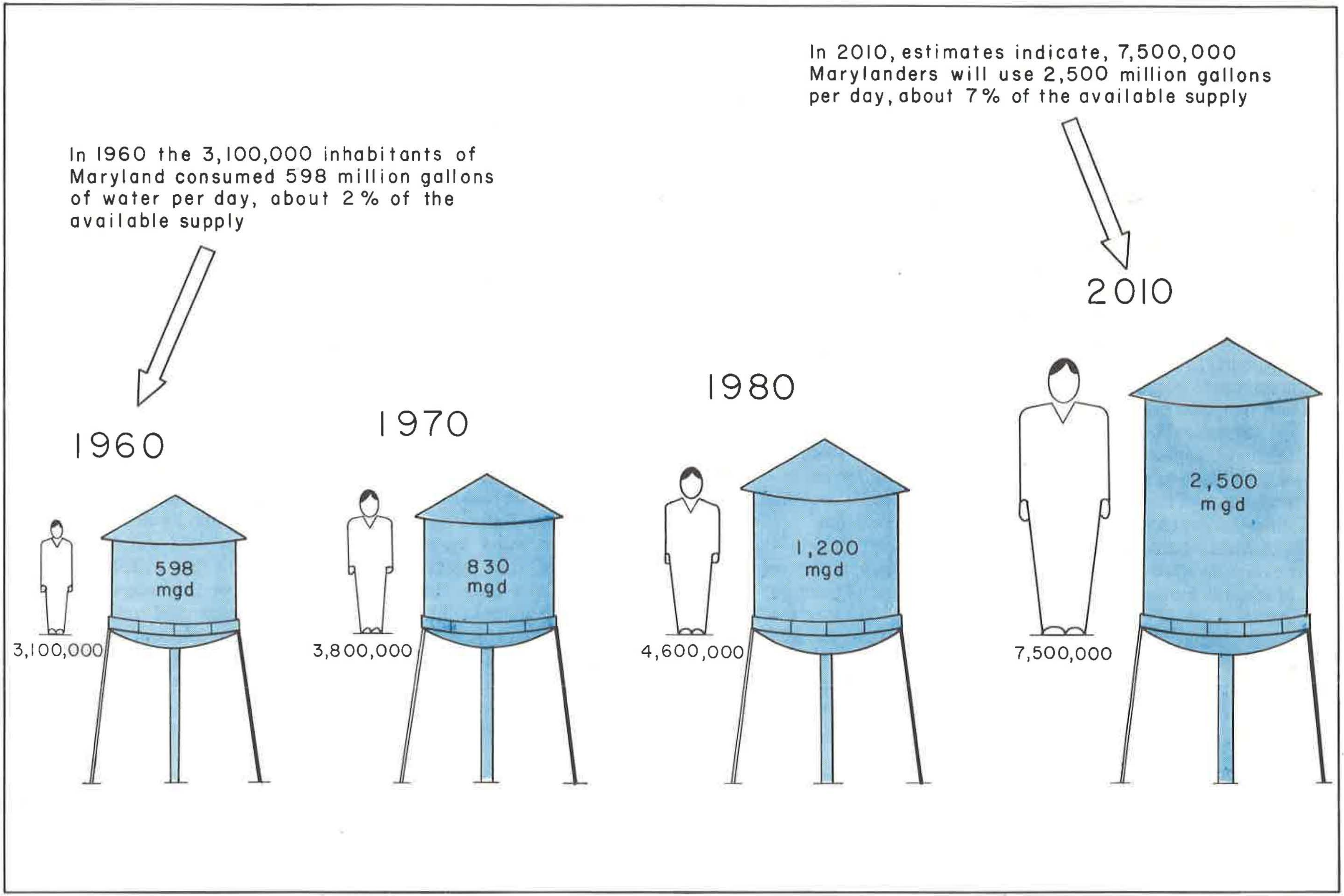


Figure 25. Consumptive use of water is expected to increase at an accelerated rate

Line, in the Coastal Plain, ground water predominates as the usable water resource. The aquifers of the Coastal Plain can provide a vastly greater supply of fresh water than the small streams and rivers that drain the region. This is particularly true because the gently rolling landscape has practically no potential for surface reservoir development.

The quantity and quality of ground water obtained from a well depends not only upon the aquifer the well taps but also upon where the aquifer is tapped. Each aquifer may vary in depth, thickness, ability to transmit water, and in geochemical characteristics. Wells tapping the same aquifer at different locations may produce water with a wide disparity in quality and at vastly different depths.

Almost all the water used in the Coastal Plain, except for some areas adjacent to Baltimore and Washington, is obtained from wells. About two-thirds of the 120 million gallons taken from the ground each day is for domestic and municipal use. The remaining one-third is used for industrial and irrigation purposes.

Name of reservoir and stream	*Drainage area (square miles)*	*Total storage (million gallons)*	*Surface area (acres)*	*Principal purpose*
Brighton (Triadelphia) Patuxent River	78.4	6,600	857	Municipal supply
Conowingo Susquehanna River	27,098	100,000	8,563	Power production
Deep Creek Deep Creek	66.5	34,600	4,500	Power production
Liberty North Branch Patapsco River	164	43,300	3,100	Municipal supply
Loch Raven Gunpowder Falls	303	23,700	2,391	Municipal supply
Prettyboy Gunpowder Falls	80	19,600	1,498	Municipal supply
T. Howard Duckett (Rocky Gorge) Patuxent River	132	6,000	773	Municipal supply
Savage River Savage River	105	6,600	360	Flood control

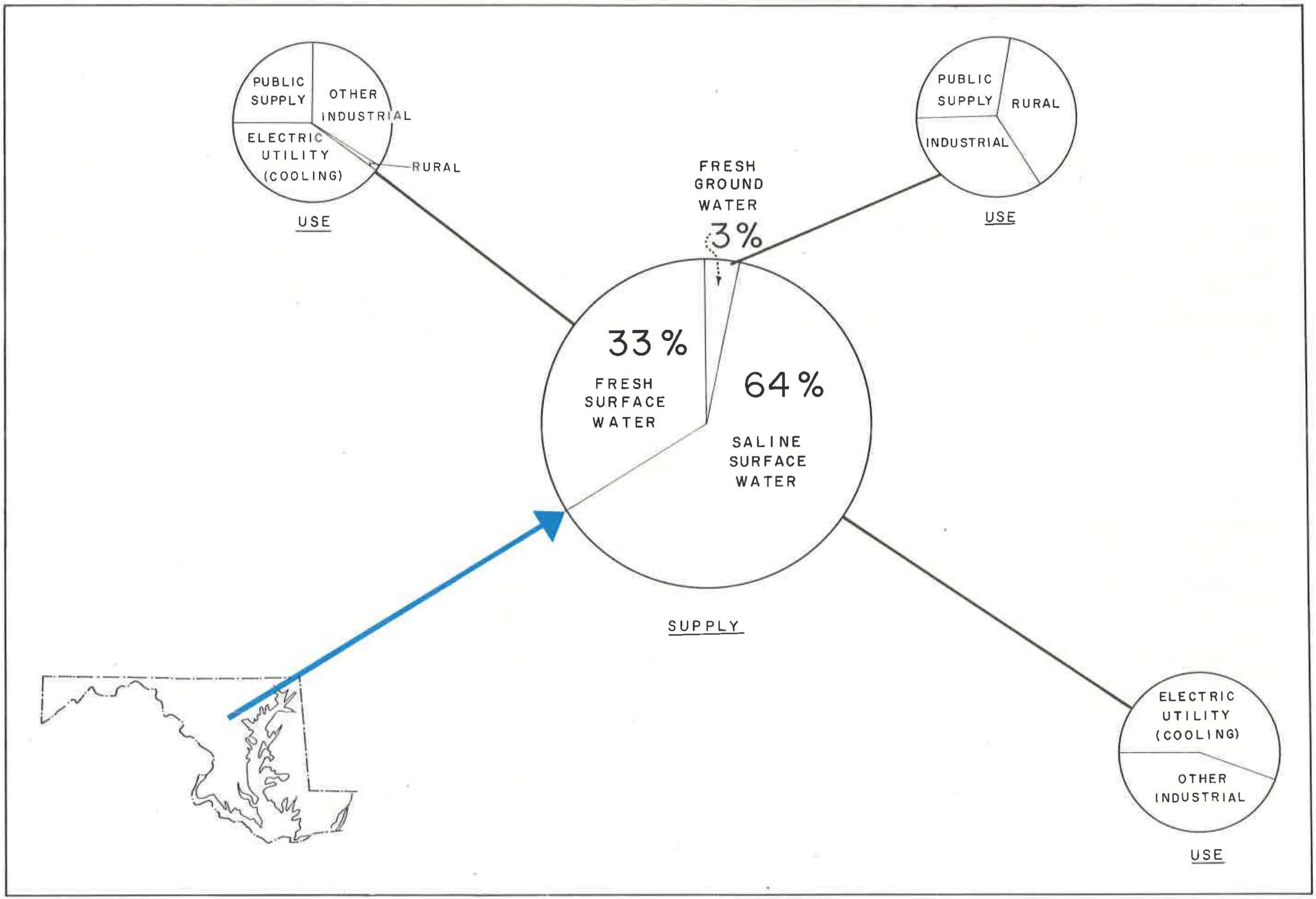


Figure 26. Availability and quality of water determines the use made of it in Maryland

Marylanders have great quantities of water available for their use but the quality of that water is becoming of great concern. For example, we have always used our streams to transport sewage. We have all heard that a river can purify itself and, in a sense, this is true—organic waste is oxidized and assimilated in oxygenated water such as that found in streams that have been aerated by wind or at rapids. However, every pound of waste uses up several pounds of dissolved oxygen and unless the stream can be reaerated, eventually all of the oxygen is used. When insufficient or no oxygen is left for fish and other water creatures, we have a dead stream.

In addition, a stream cannot clean itself of dissolved material. Although inorganic wastes may be greatly diluted in a receiving stream, some substances are undesirable, unpleasant, or unsafe even in extremely small amounts. For example, one type of chlorinated phenol can be tasted in concentrations as dilute as 1 part in 100 billion —equivalent to one quart poured in Loch Raven Reservoir.

Many examples of the misuse of our water resources can be found in the State—the acid-mine drainage in western Maryland; the silt-burdened streams that drain housing and industrial developments during construction; the beaches condemned because of bacterial pollution; the encroachment of salt water into excessively pumped aquifers; the loss of wild life due to many causes. Our problems, however, are no different from those of other populous areas.

Plain common sense may help us to manage our water resources in an even more beneficial manner in the future. We have large quantities of water to use as we see fit, but only proper management of that water will assure us and our progeny of an adequate supply. Proper management includes correcting problems before they become intolerable. It is cheaper to prevent than to cure. Some problems, unfortunately, have no cure. For example, consider contamination of a ground-water aquifer by salt-water intrusion. Prevention of salt-water intrusion is relatively simple—just don't overdevelop the aquifer. Removal of the salt water once contamination has occurred is practically impossible.

We cannot keep all of our waters in a pristine state—we must use them to live—but neither can we tolerate short-sighted exploitation of our water resources.

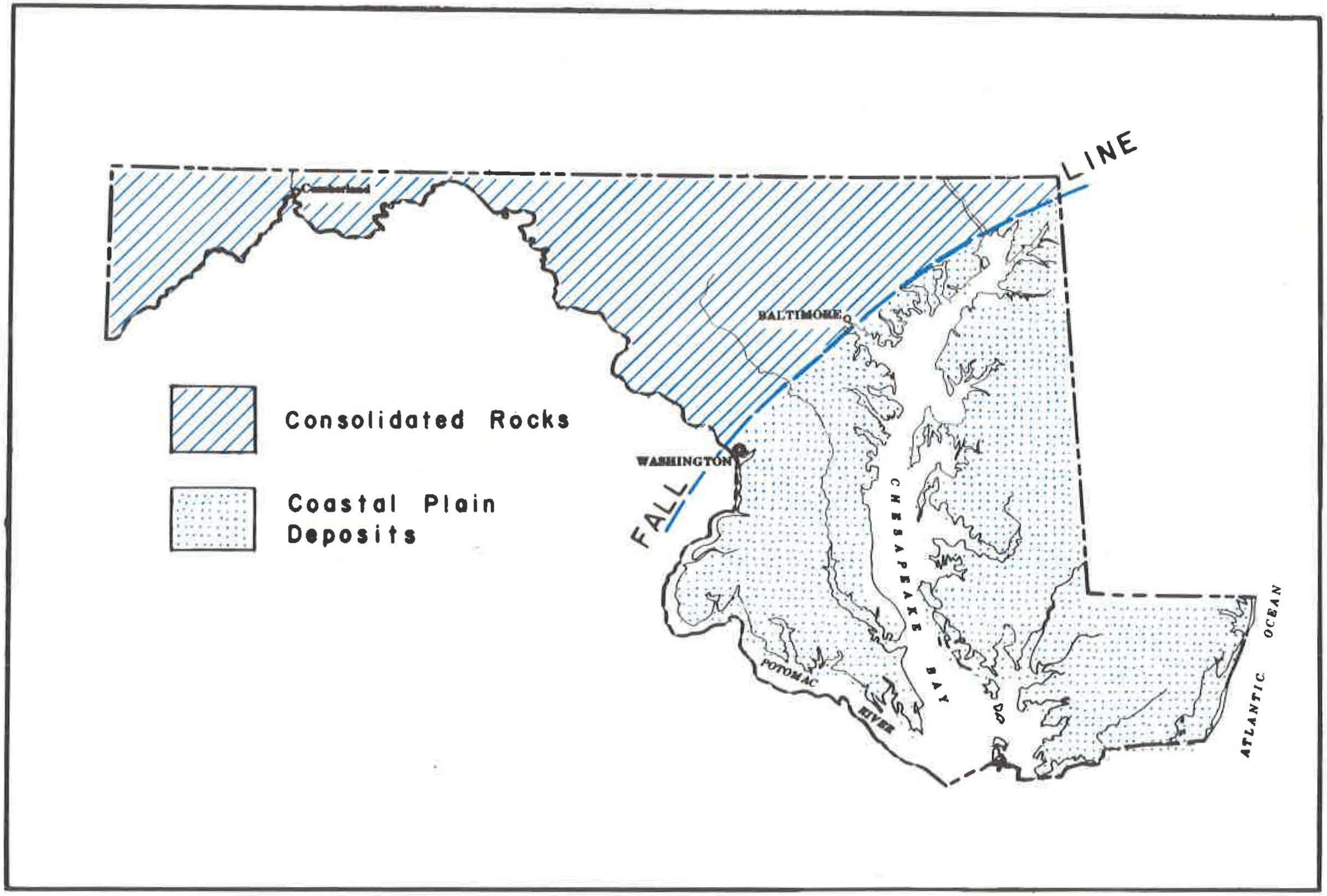


Figure 27. Surface-water development predominates west of the Fall Line while ground-water development predominates east

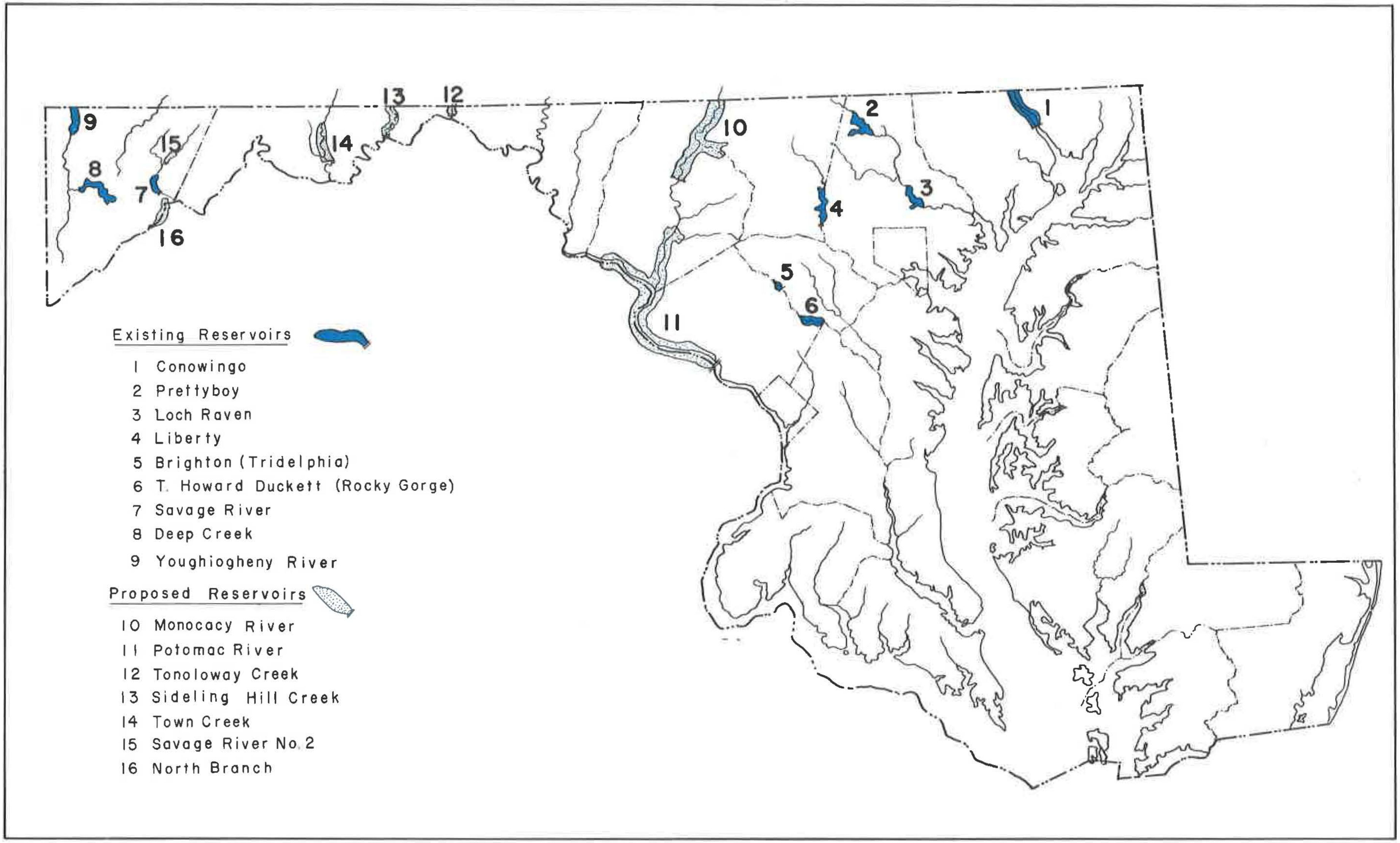


Figure 28. Large-scale development of Maryland's streams entails construction of storage and regulating reservoirs

CHAPTER 10

Water resources agencies: The auditors

In the business world, auditors are employed to examine financial dealings and accountings in order to make sure that a healthy, profitable operation exists. Water resources need similar auditing, and this is provided by many agencies representing all levels of government. In the accompanying table will be found those agencies whose principal duties relate to Maryland's water resources. This is not a comprehensive list of agencies, but will provide a reference for further information. A list of addresses to which inquiries should be directed is included.

The list of "water-resource auditors" provides a stopping point in this short accounting. We have merely touched on the wide field of water resources. Hopefully, that touch will stimulate interest in this all-important substance of which we are furnished such an abundance for our use. The key word is "use." We do not own our water resources, we are entrusted with them to use and to pass along, in a usable condition, to our descendants. That is a responsibility that can be met only by an informed public.

STATE AGENCIES

AGENCY	ADDRESS	CONTACT FOR INFORMATION ON
Department of Natural Resources	The Director State Office Bldg. Annapolis, Md. 21401	State policy regarding natural resources
Department of Water Resources	The Director State Office Bldg. Annapolis, Md. 21401	Public hearings on water-resources developments Permits for: Appropriation and use of water, surface or underground Waterway obstructions and developments Developments affecting the Potomac River Well drilling Licensing well drillers Pollution control water quality standards Shore erosion control
Maryland Geological Survey	The Director Johns Hopkins University Baltimore, Md. 21218	State and county maps Geology Water-resources reports Mineral resources Research on tidal littoral processes
Department of Chesapeake Bay Affairs	The Director State Office Bldg. Annapolis, Md. 21404	Boating and boating safety on Chesapeake Bay
Fish and Wildlife Administration	The Director State Office Bldg. Annapolis, Md. 21404	Marine Police Game and fish laws Licenses for hunting, fishing, trapping, etc.
University of Maryland College of Agriculture	University of Maryland College Park 20740	Soil conservation districts Drainage of agricultural land Irrigation systems Farm waste disposal
Natural Resources Institute	The Director P. O. Box 38 Solomons, Md. 20688	Biological research on Chesapeake Bay and its estuaries
Department of Health Bureau of Resources Protection	2305 N. Charles Street Baltimore, Md. 21218	Water supplies; public and private Sewage systems and waste disposal; public and private Public beaches and swimming pools

FEDERAL AGENCIES

AGENCY	ADDRESS	CONTACT FOR INFORMATION ON
Department of the Army Corps of Engineers	District Engineer U. S. Army Engineer District P. O. Box 1715 Baltimore, Md. 21203	Flood control projects Channel dredging Waterway improvements
Department of the Interior Geological Survey Water Resources Division	District Chief 8809 Satyr Hill Road Parkville, Md. 21234	Streamflow Ground-water levels Water quality Droughts and floods Water-resources reports
Federal Water Quality Administration	Chesapeake Bay Field Station Annapolis Science Center Annapolis, Md. 21401	Chesapeake Bay
Department of Agriculture Soil Conservation Service	Room 522 Hartwick Bldg. 4321 Hartwick Road College Park, Md. 20740	Erosion control Irrigation Farm ponds
Department of Commerce Environmental Science Services Administration	The State Climatologist Room 34 Symons Hall University of Maryland College Park, Md. 20740	Weather records and statistics
	Weather Bureau Washington National Airport, Va. 20301	Flood-crest prediction

OTHER AGENCIES

AGENCY	ADDRESS	CONTACT FOR INFORMATION ON
Washington (D. C.) Suburban Sanitary Commission	4017 Hamilton Street Hyattsville, Md. 20781	Utility permits in Montgomery and Prince Georges Counties Storm drainage Water supply and sanitary sewerage facilities
The Maryland-National Capital Park and Planning Commission	8737 Georgia Avenue Silver Spring, Md. 20910	Flood plain zoning in Washington vicinity Water-based recreation facilities
Upper Potomac River Commission	P. O. Box 66 Westernport, Md. 21562	Savage River Dam and reservoir
Chesapeake Bay Institute of the Johns Hopkins University	Edgewood Road Annapolis, Md. 21404	Chesapeake Bay Oceanography
Interstate Commission on the Potomac River Basin	Suite 407 Global Bldg. 1025 Vermont Ave., N. W. Washington, D. C. 20005	Potomac River Basin
The Potomac River Fisheries Commission	P. O. Box 128 Colonial Beach, Va. 22443	Regulations governing fin fish and shell fish Licenses for fishing and clam dredging