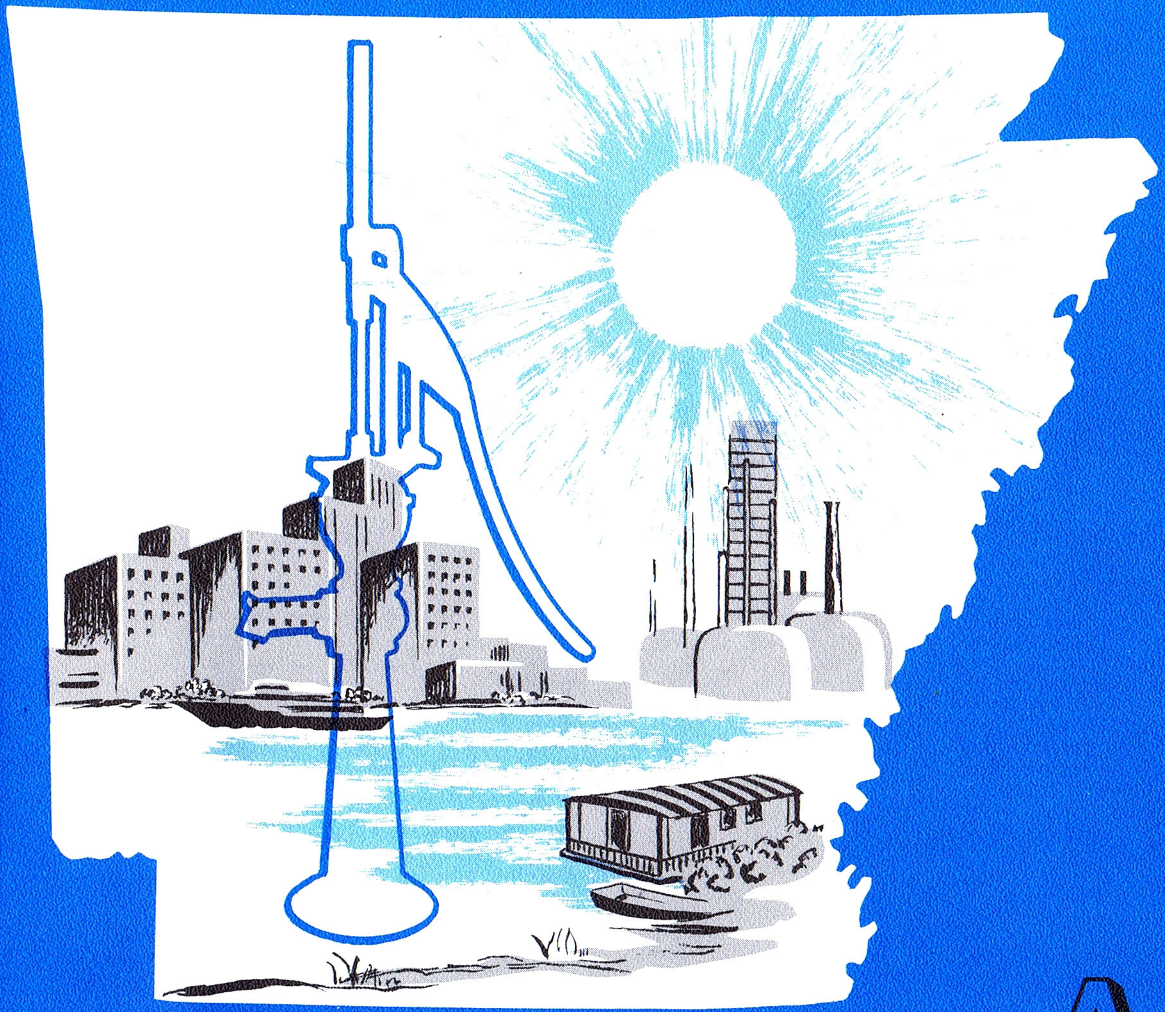


WATER FOR ARKANSAS

Prepared by the U.S. Geological Survey
in cooperation with the Arkansas Geological Commission

The names of rock formations and their ages are those used by the Arkansas Geological Commission

Prepared by the U.S. Geological Survey in cooperation with the Arkansas Geological Commission

Little Rock, Arkansas

1969

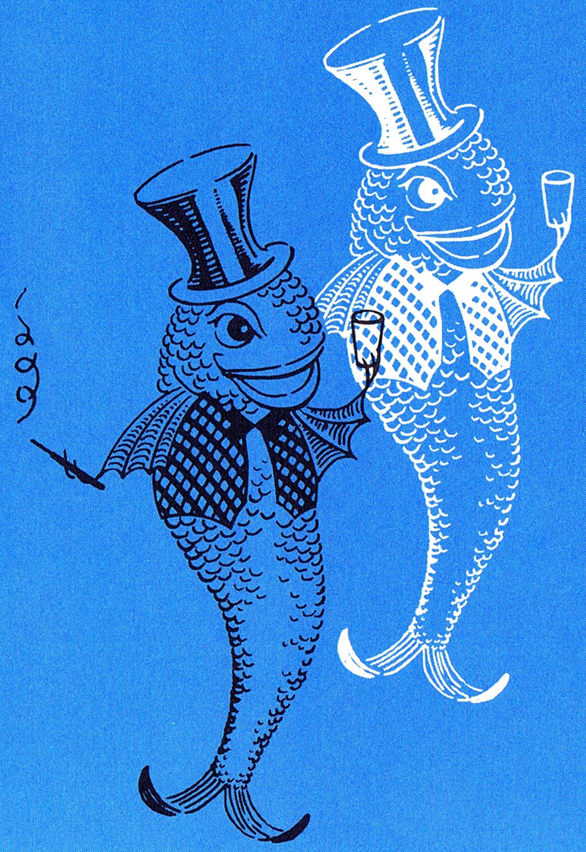
WATER FOR ARKANSAS

By R. T. Sniegocki

and

M. S. Bedinger

VIEW FROM MT. NEBO, ARKANSAS. ARKANSAS PUBLICITY AND PARKS COMMISSION. PHELPS



ACKNOWLEDGMENTS

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TO OUR AUDIENCE

$$v = Ki = -K\,\frac{dh}{ds}$$

The foregoing equation, commonly called Darcy's law, demonstrates a linear dependency between the hydraulic gradient and the discharge velocity v. Although Darcy's law is presented in differential form, it must be emphasized that in no way does it describe the state of affairs within an individual pore. Strictly speaking, Darcy's law represents the *statistical macroscopic equivalent* of the Navier-Stokes equation of motion for the viscous flow of ground water. It is precisely this equivalency that permits the subsequent development of the ground-water flow within the theoretical framework of potential flow.

BUT—as useful as the foregoing may be—

It is our intention in this book to avoid highly technical matters and to discuss the water resources of Arkansas in what we hope is a plain and interesting manner.

We further hope that when you have read this book you will know something more about water in Arkansas than you do now, and that your awareness of water and its importance will be greater. If we have provided you with greater knowledge you can better determine what is happening to our water resources, who is making it happen, and what are the consequences and alternatives.

Finally, we hope you will realize the part that you as a citizen will have to play in the future development and conservation of Arkansas' water so that our resources may continue into the indefinite future as a great asset to our State.

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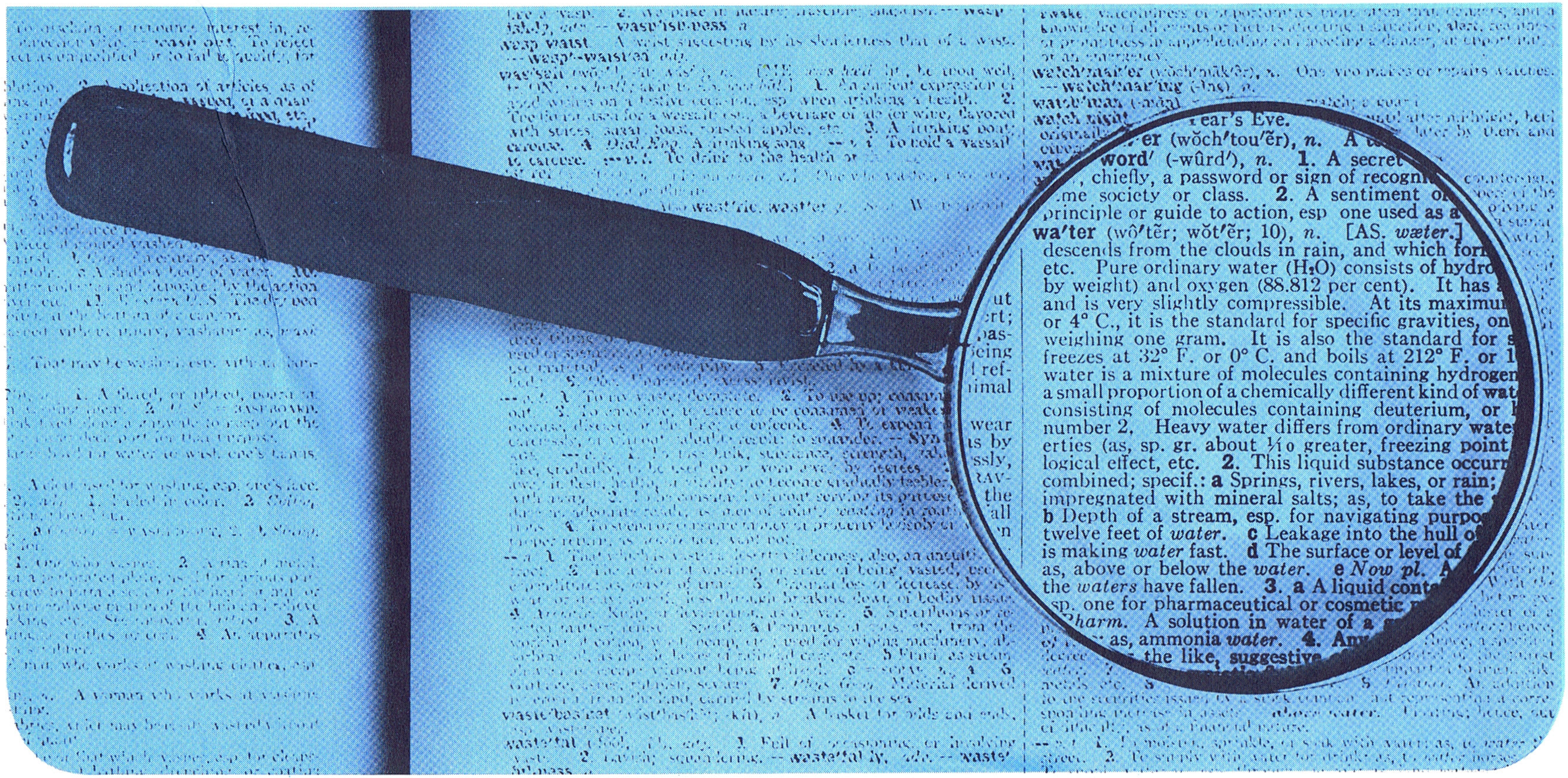
WHAT IS IT?

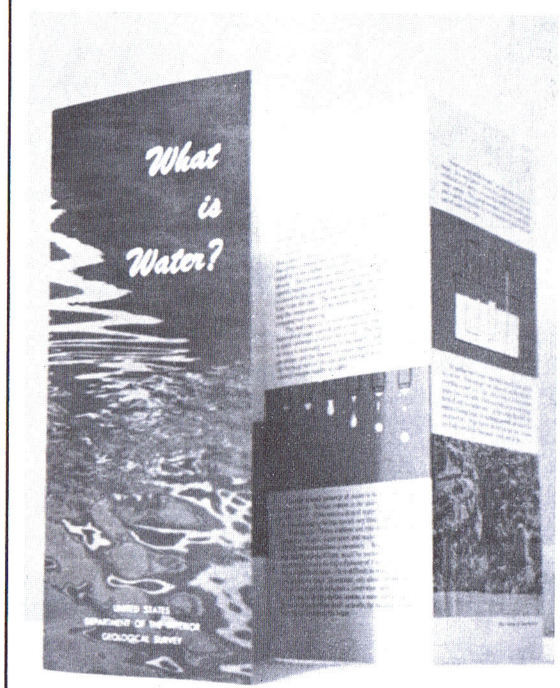


It's *water*—visible as precipitation, including rain, snow, hail, and sleet; dew and frost; clouds, fog, and steam; and surface and ground water in rivers, lakes, and springs.

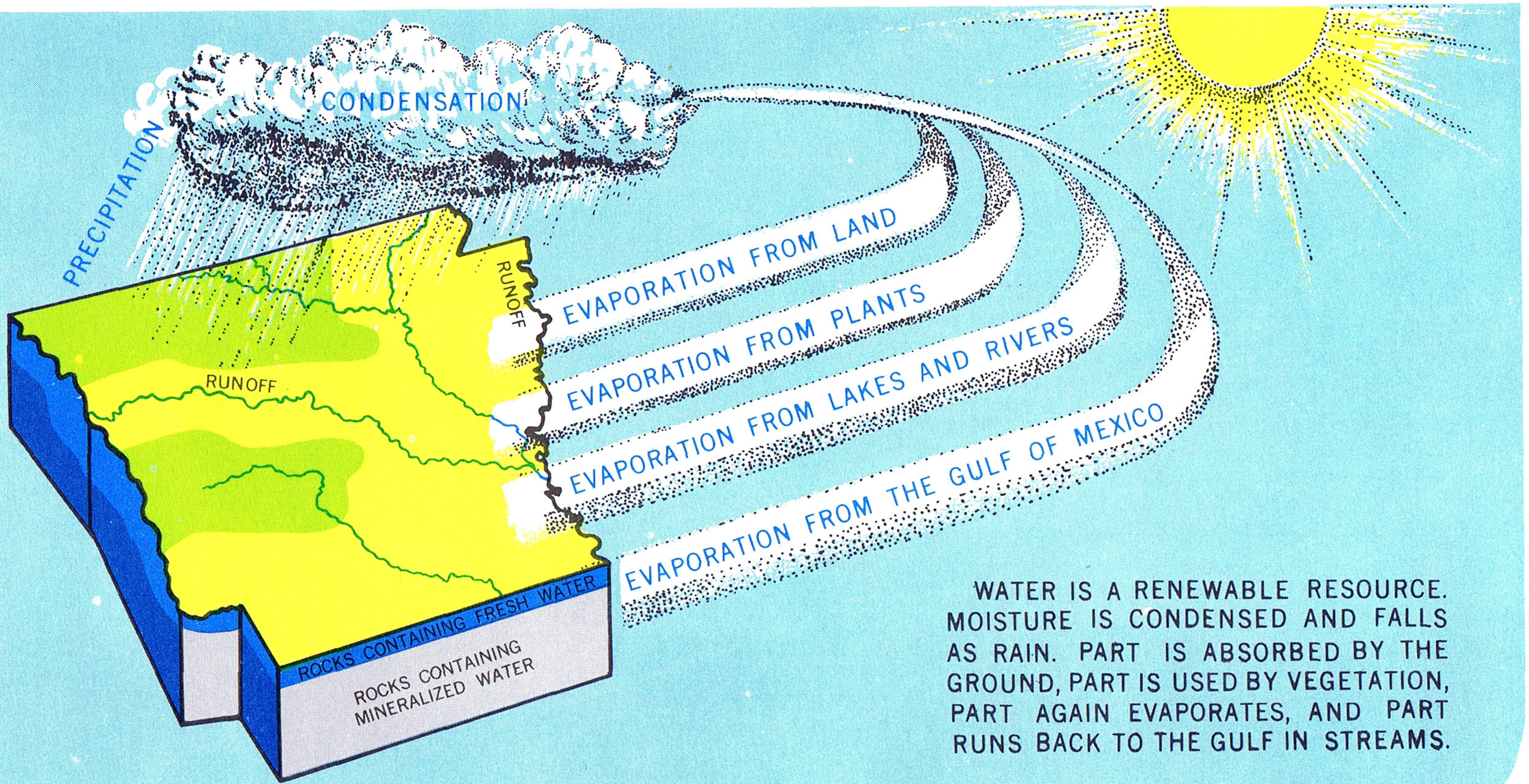
Water makes up the major part of nearly all living things and is necessary to maintain life. Its importance cannot be overemphasized.

Our water resources in Arkansas come directly or indirectly from precipitation of clouds of oceanic origin. At times we may complain about high humidity or the shower that caused us to cancel a planned activity. Such inconveniences are a part of a brighter side to Arkansas' climatic conditions. We are a water-rich State because our annual average precipitation is about 49 inches. This amounts to an average of 120 billion gallons of water each day for replenishment of our rivers, lakes, and ground-water reservoirs.

"What is it? " It's *water*—one of Arkansas' most valuable resources—that's what it is. (See brochure, "What is Water? ")



WHERE IS IT?



WATER IS A RENEWABLE RESOURCE. MOISTURE IS CONDENSED AND FALLS AS RAIN. PART IS ABSORBED BY THE GROUND, PART IS USED BY VEGETATION, PART AGAIN EVAPORATES, AND PART RUNS BACK TO THE GULF IN STREAMS.

Water is always on the move. We realize this from only casual observations of the fall of rain or snow, tricklets of *water* running to a stream during and after a rain, and the flow of a stream toward the ocean. The movement of ground *water* is sensed when we observe *water* flowing from springs or wells. Even lakes and ponds are seldom quiet, the lightest breeze causing ripples. More subtle movement of *water* is observed when we see "steam" rising from hot pavement, sidewalks, or rocks. Cloud movement and drifting fog provide further evidence of the mobility of *water*. One might conclude that *water* moves at random and has no set course. Careful measurements, however, will reveal a definite pattern of *water* movement.

When *water* vapor condenses it changes from a gas to a liquid and forms a cloud. Later if the droplets become big enough they fall as rain, or if it is cold enough, as snow. The rain feeds the rivers and lakes. Rivers carry water to the oceans. Evaporation from land and ocean puts water back in the atmosphere. This continual exchange of water between the earth and the atmosphere is called the *hydrologic cycle*.

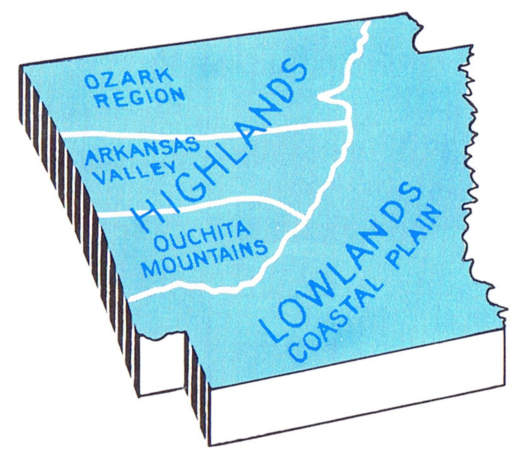
An answer, then, to the question—where is it—must account for the movement of *water* and consider its position in the *hydrologic cycle*. Obviously, we are more interested in *water* when it is positioned in the cycle where we can most conveniently and economically intercept it for use. Generally speaking, this is when *water* appears *on* the *land surface* in rivers or lakes or when it enters pore spaces in cracks and extensive bodies of *rocks* beneath the land surface.

Water on the land surface is called *surface water*. That beneath the land surface is called soil moisture and *ground water* according to whether it partially saturates the earth just beneath the surface or fully saturates the rock beneath the water table. This latter is ground water. Surface water is always associated with depressions in the land surface forming lake basins and river channels. Ground water is always associated with cracks and pore spaces in rocks. In other words, the water is in a container. The more we know about the container, the more we will know about the water. Thus, a knowledge of *rocks* (geology) and *landforms* (physiography and topography) will aid in developing *surface and ground water* for use.

The diagram (fig. 1) shows the age and location of rock formations in Arkansas. There is an interest in all of the rocks because of their potential economic value. Some of the rocks are useful as building material; others contain fuels such as gas, oil, and coal, or mineral deposits such as bauxite, zinc, lead, and diamonds. In this report we are interested in those rocks that serve as water containers from which water can be withdrawn in desired quantities through wells. *Rocks* meeting this requirement are called *aquifers*.

Not all of the rocks in Arkansas yield water to wells. However, each of the age groups of rocks shown in figure 1 includes one or more formations known to be *aquifers*. Their names and expected yields are given in table 1.

Physiographically, Arkansas is divided into two equal areas—the Highlands in the northwestern half, and the Lowlands in the southeastern half. The words "high" and "low" readily bring to mind how a river or lake would look in these two parts of the State. Highland rivers are flashy, fast running, and generally clear; those in the Lowlands are sluggish and generally muddy. Lakes and reservoirs in the Highlands are relatively deep with steep irregular shorelines. Lowland lakes and reservoirs are relatively shallow and small quantities of water will flood large areas of land as compared to equal quantities of water in a lake in the Highlands.



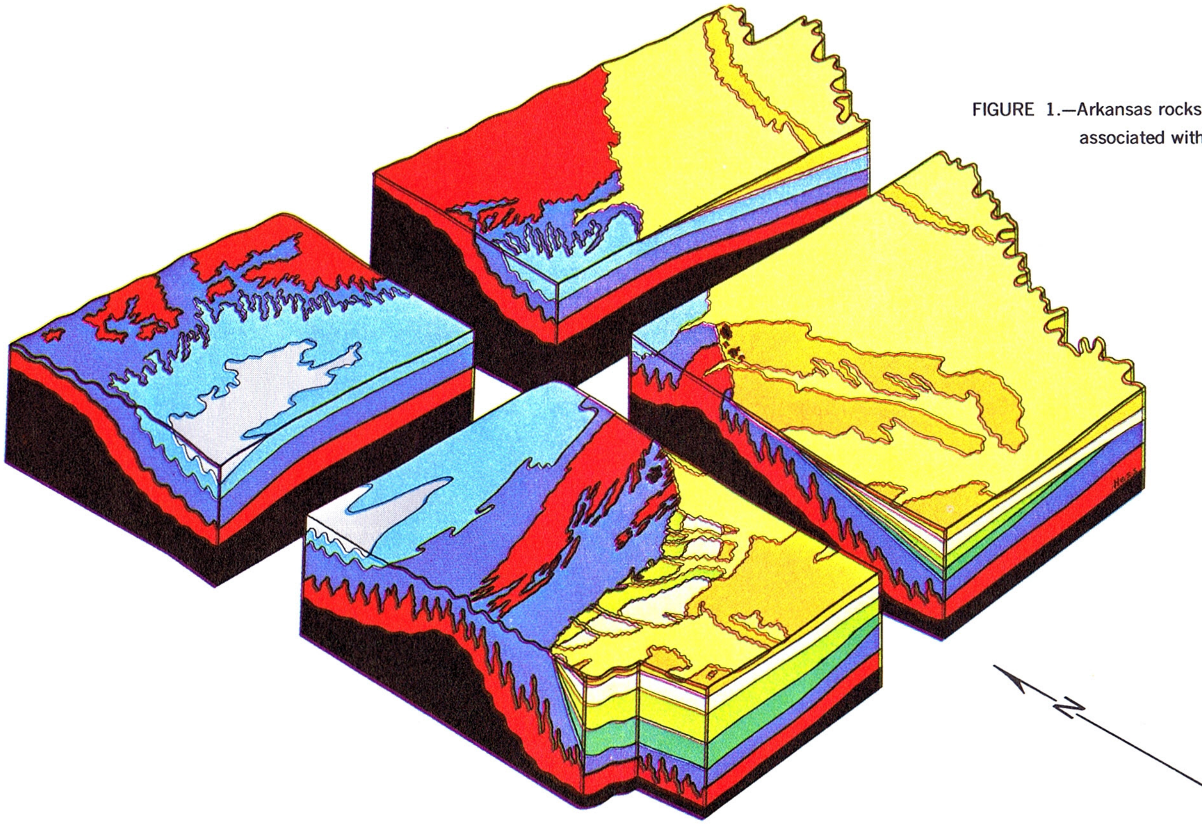


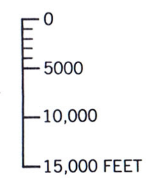
FIGURE 1.—Arkansas rocks can be identified by their composition and have been given names generally associated with geographic features (Modified from Branner, Hess, and Williams, 1959).

TABLE OF GEOLOGIC AGES

Era	Duration	Period
Cenozoic	60 Million Years	Quaternary Tertiary
Mesozoic	140 Million Years	Cretaceous Jurassic Triassic
Paleozoic	350 Million Years	Permian Pennsylvanian Mississippian Devonian Silurian Ordovician Cambrian
Proterozoic	(750 Million Years)	
Archaeozoic	(800 Million Years)	
Azoic	(1162 Million Years)	

PERIOD	ROCK NAME AND DESCRIPTION IN DESCENDING ORDER
Quaternary	Alluvium: clay, silt, sand, and gravel
Tertiary	Jackson Group to Midway Group, inclusive: Clay, silt, sand, gravel, limestone, lignite, and shale
Upper Cretaceous	Arkadelphia Marl to Woodbine Formation, inclusive: Clay, silt, sand, gravel, and chalk
Lower Cretaceous	Paluxy Sand to Pike Gravel, inclusive: Clay, silt, sand, gravel, and chalk
Jurassic	Cotton Valley Group to Eagle Mills Formation, inclusive: Shale, sandstone, marl, and limestone
Pennsylvanian	Boggy Shale to Hartshorne Sandstone, inclusive: Shale, siltstone, and sandstone
Pennsylvanian	Atoka Formation: Shale, siltstone, and sandstone
Pennsylvanian / Mississippian	Boyd Shale to Boone Formation, inclusive (Ozark Mountains): Shale, sandstone, chert, and limestone
Pennsylvanian / Mississippian	Jackfork Sandstone to Stanley Shale, inclusive (Ouachita Mountains): Shale, siltstone, and sandstone
Devonian, Silurian, Ordovician, Cambrian	Shale, sandstone, chert, limestone, and dolomite
Igneous rocks	Nepheline syenite (surface), igneous rocks and possibly metamorphic rocks (subsurface)

VERTICAL SCALE



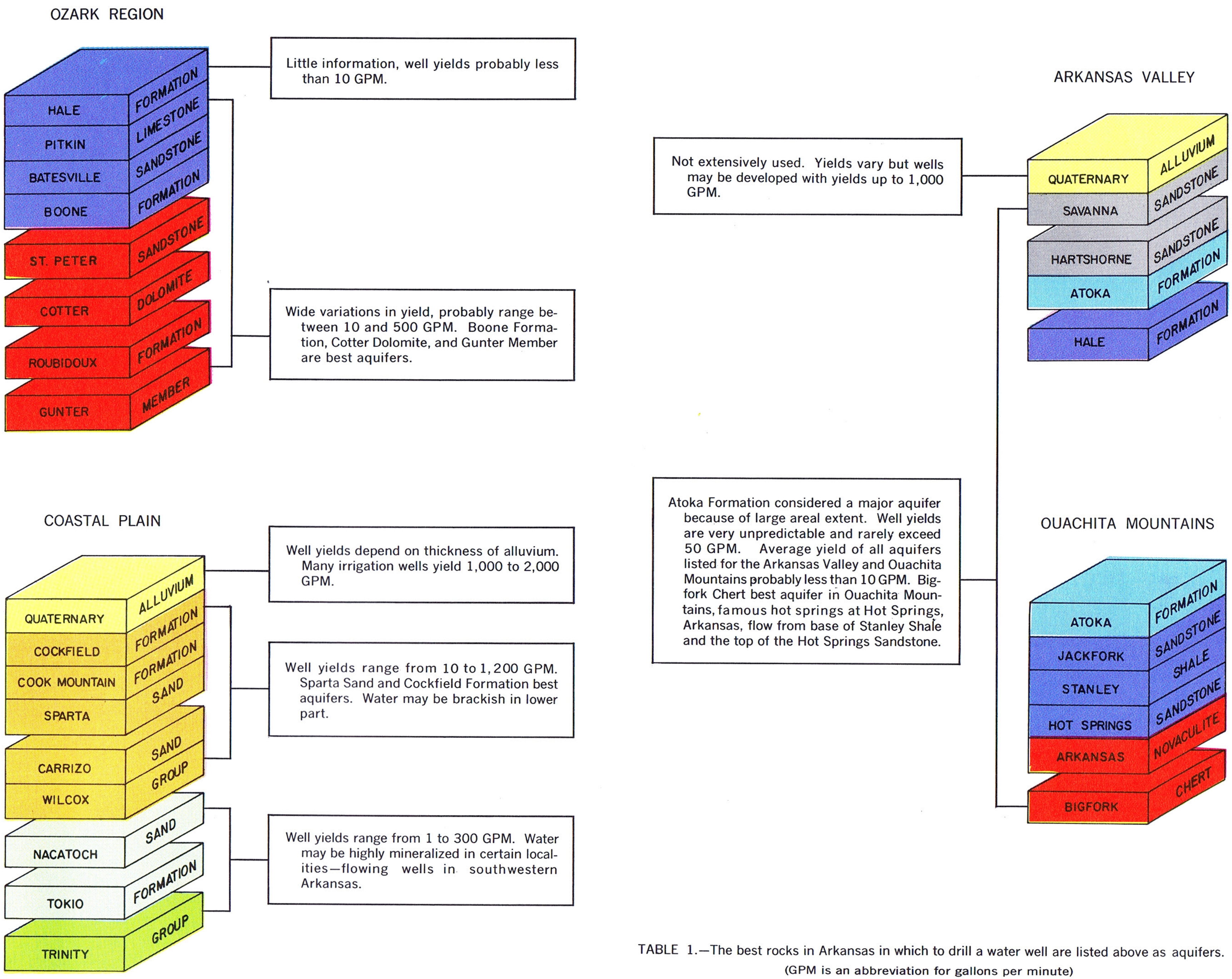


TABLE 1.—The best rocks in Arkansas in which to drill a water well are listed above as aquifers.
(GPM is an abbreviation for gallons per minute)

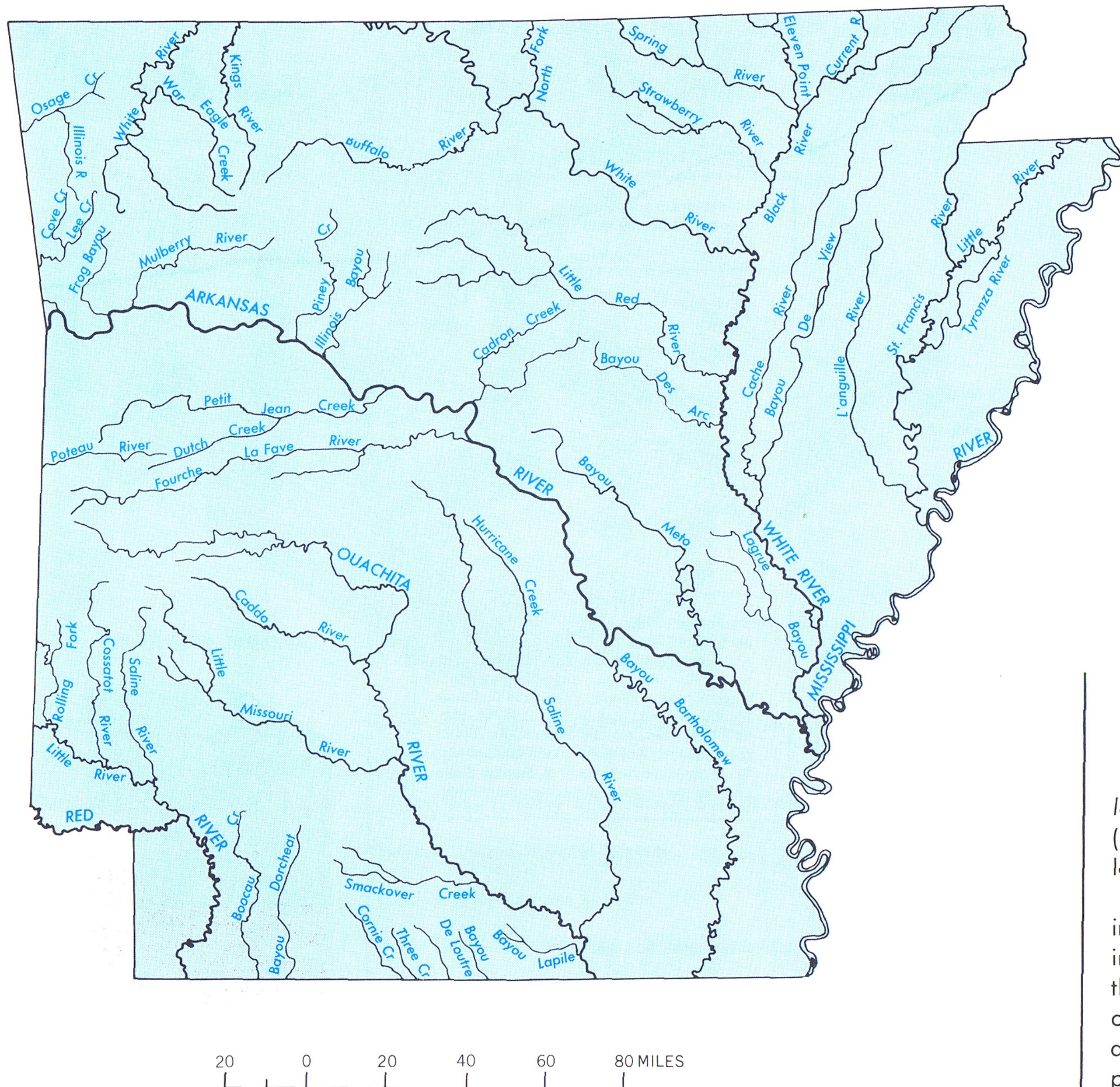


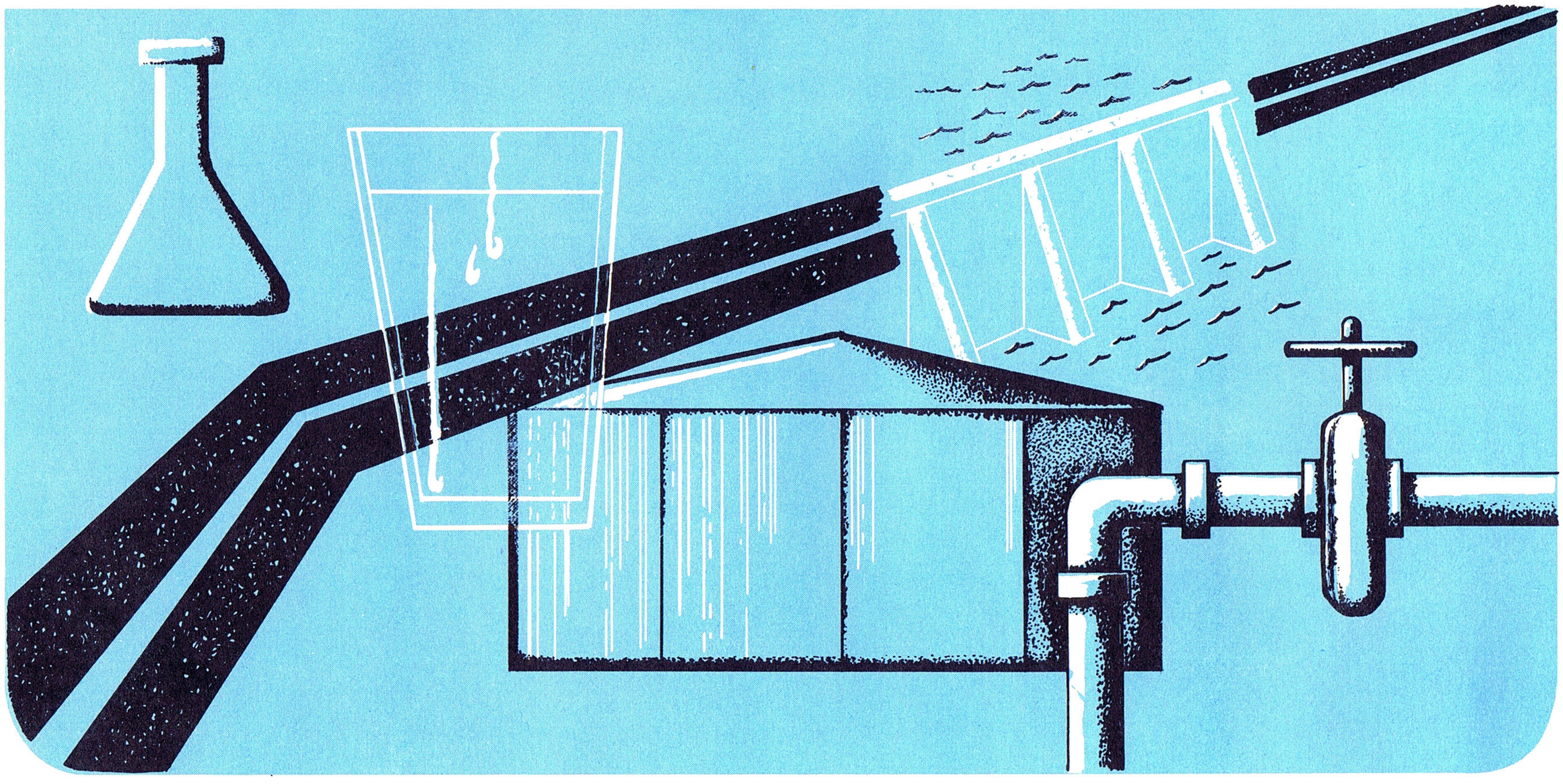
FIGURE 2.—Arkansas has about 2,700 miles of water routes within and along her borders.

Surface water comprises *rivers* and *lakes* and can be observed directly. (See figs. 2 and 11.) Figure 2 shows the location of major streams in Arkansas.

"Where is it? " Water is on the move in the *hydrologic cycle*. An understanding of water behavior at any point in the cycle is important because the total cycle controls its occurrence as surface and ground water. However, for our purposes in this report we can say water is underground in *aquifers* and on the land surface in *rivers and lakes*.

LITTLE ROCK. OBSITNIK

HOW GOOD IS IT?



Phrases such as "good drinking water" or "good water supply" are commonplace in Arkansas because *good water* can be found nearly everywhere in the State. We have good water for drinking; watering crops and yards: boating, skiing, swimming, and fishing; washing clothes and cars; industrial and commercial processes; and nearly any other desired use. We also have some water in Arkansas that is no good except for a few uses; fortunately it is not great in quantity and extent.

In a general way, we all know what we mean when we say water is good or bad. *Good water* is *clear, cold, soft, odorless, noncorrosive, tasty,* and *pure,* while bad water has few of these properties. However, evaluation of water quality in terms of good or bad does not provide us with specific standards for accurate comparisons of different waters.

The amount of impurities in water is a major characteristic that determines its *quality* and, in turn, the uses we can make of the water. For example, salt water like that in the ocean would readily be used by a chemical industry as the source of certain chemicals or the water might be used in a swimming pool.

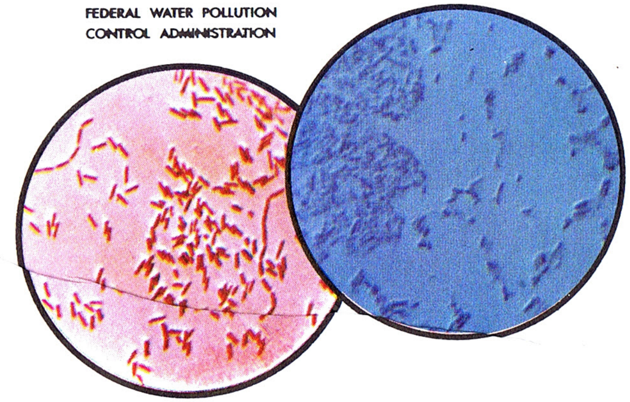
However, in its natural state, ocean water would be worthless for drinking or irrigation. If impurities in water limit its use it would seem logical that the best water for all purposes would contain nothing but water, or chemically speaking, two parts hydrogen and one part oxygen. Distilled water very nearly meets this specification but as a drinking supply is dull, flat, and completely tasteless. A limited amount of certain dissolved minerals and gases is what gives water that satisfying thirst-quenching quality.

Generally, measurements of the following water characteristics provide sufficient information to determine acceptability of water for a planned use.

1. How *much* and what *kind* of substances are *dissolved* in the water.
2. How *much* and what *kind* of sediments are *suspended* in the water.
3. Water temperature, color, corrosiveness and hardness.
4. Type and number of bacteria contained.

These features are evaluated to determine the *chemical, physical,* and *bacteriological quality* of water. Table 2 at the end of this report is for the reader who is interested in some of the limits of the foregoing measurements used by the Arkansas State Health Department to determine whether or not Arkansas waters are acceptable for public use.

Other chemical and physical qualities of water not listed in table 2 affect the suitability of water for certain uses. These consist of chemical constituents in solution and substances in suspension.



FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

Among these are copper, boron, silica, and other inorganic material, as well as a host of organic substances. Suspended materials usually consist of clay, silt, sand; organic material such as vegetable matter, living or dead microorganisms (small forms generally larger than bacteria, such as algae, diatoms, water fleas), and other substances, many of very small (colloidal) size.

Water containing significant quantities of suspended material often is called muddy water or black water or some other term descriptive of its physical appearance. Measurements of the turbidity and color of water provide quantitative information that indicates how much suspended material is in the water or how muddy it is.

The bacteriological quality of water also is an important feature when considering drinking water standards. Consequently, bacteriological examination of water usually includes a quantitative estimate of the type and number of coliforms present in a water sample. In general, the presence of any type of coliform organism suggests that the water may be polluted.

Before proceeding with a description of the quality of Arkansas' water resources we should be acquainted with the principal factors and processes through which water gains the characteristics just considered. Water containing no dissolved or suspended material is unknown in nature. Falling rain is water at its purest moment in the *hydrologic cycle* but even in this condition it contains gases and solids absorbed from the atmosphere. As rain strikes the ground it continues to move through other phases of the hydrologic cycle. At this time part of the rain becomes runoff and part enters the subsurface.

Carbon dioxide and *acids* are *added* to the water from the atmosphere and soil and from decaying vegetation. Consequently, the solvent action of water is greatly increased and more *minerals from* the earth's *rocks* and soils are *added* to the water. Obviously, the kind of rocks with which the water comes in contact and the length of time of contact will control the quantity and kind of matter found in water. Thus, the *topography* and *geology* of a region are the principal natural *factors influencing* chemical and physical *water quality*.

Man knowingly or unknowingly also significantly *affects* the chemical, physical, and bacteriological *quality of water* resources. Fertilizers and pesticides applied in farming activities may contaminate runoff water or that water moving downward to the water table. Drastic changes in water quality may be caused by disposing of municipal and industrial waste on the land surface and into streams, thus affecting the natural water quality over large areas.

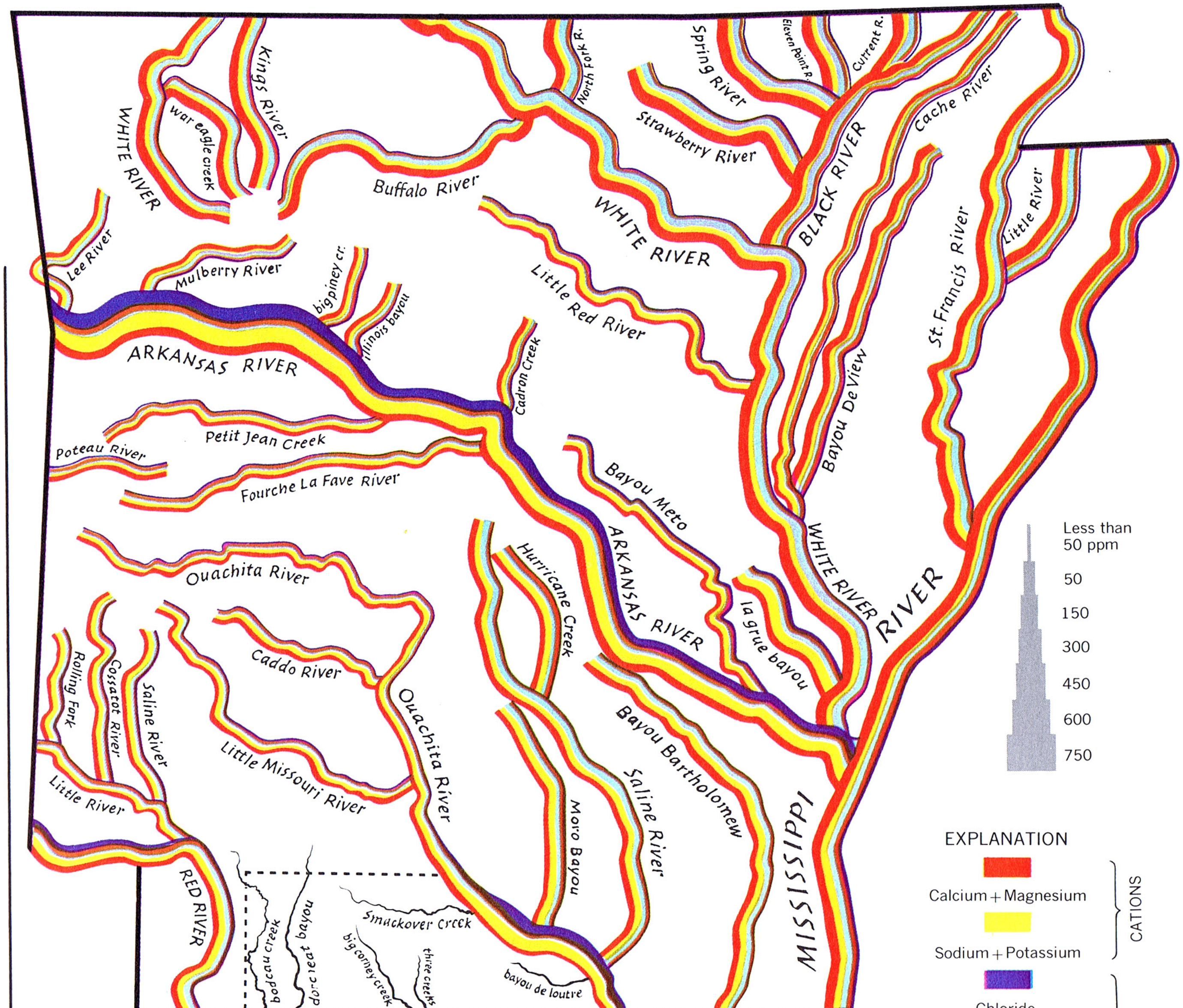
Considering this brief discussion of what makes up good and bad water and how it gets that way, let's look at the chemical condition and temperature of some of our water resources in Arkansas. Figure 3 is a map showing the chemical quality of water in major rivers in Arkansas throughout their length. In general, the *water* is chemically *suitable* for most uses. *Exceptions* to this are the *Arkansas, Red,* and lower *Ouachita Rivers*. The substance of concern in these rivers is *chloride*, shown by dark blue in figure 3. Water with a high chloride content is corrosive, tastes salty, and cannot be used for irrigation. As the water in the Arkansas and Red Rivers crosses the State the chloride concentration becomes less because good-quality water added from tributary streams and ground-water seepage dilutes the river water. While the water in the Ouachita River crosses the lowlands of Arkansas the chloride concentration increases because brines from oil fields in that part of the State enter the river. This pollution is being reduced by impounding and returning the salt water to the oil zones from which it came.

Because ground water is in contact with soils and rocks longer than is surface runoff, it usually contains more *dissolved minerals* than surface water. However, on the whole, ground water contains less bacteria and suspended sediment than most surface water and is less subject to rapid changes in chemical and physical quality than surface water.

The soil and rocks through which ground water moves screen out bacteria, tend to insulate the water, and retard chemical and physical changes.

Chemical analyses of a few of the ground-water samples collected from various aquifers in different parts of the State are shown in figure 4. In general, most of the fresh ground waters in Arkansas are classified as the *calcium bicarbonate type* because calcium and bicarbonate are the principal constituents in the water.

Not all ground water is fresh or suitable for most uses. For example, *salt water* is known to be present beneath the fresh ground water in Arkansas. A map (fig. 5) shows the depth to the base of fresh water in the Coastal Plain of the State. Less is known about the fresh-salt water contact in the Highlands of Arkansas, because fewer test holes have been drilled deep enough to reach the salt water. In general, salt water lies at a much greater depth in the Highlands than in the Coastal Plain probably because the rocks are older, higher, and have had more time to have the salt water flushed out at greater depths.



Source: U.S. Geological Survey and the University of Arkansas.

CHEMICAL QUALITY OF SURFACE WATERS OF ARKANSAS

The most frequently occurring chemical quality of the various streams in Arkansas is shown on this map. The combined width of the five colored lines represents, for each stream, the total concentration of the principal dissolved ions, in parts per million. The widths of the individual colored line represents the relative proportions of the principal ions in solution.

Some of the creeks in the area bounded by dashed lines contain oil field brines. However, this pollution is being reduced rapidly.

20 0 20 40 MILES

FIGURE 3.—Water in the Arkansas and lower Ouachita Rivers has a relatively high chloride content.

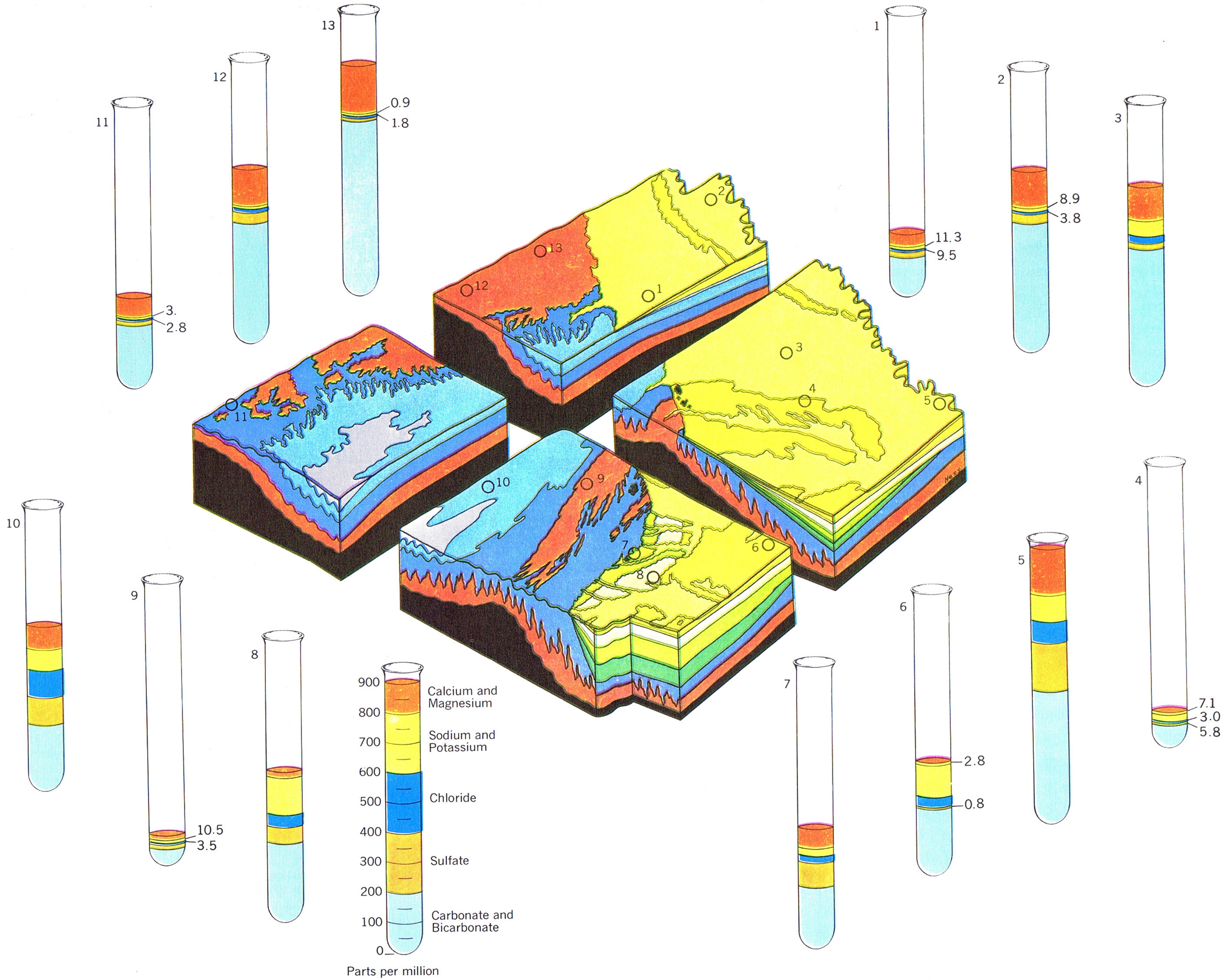


FIGURE 4.—Potable ground water in Arkansas generally contains more calcium and bicarbonate than other chemical substances.

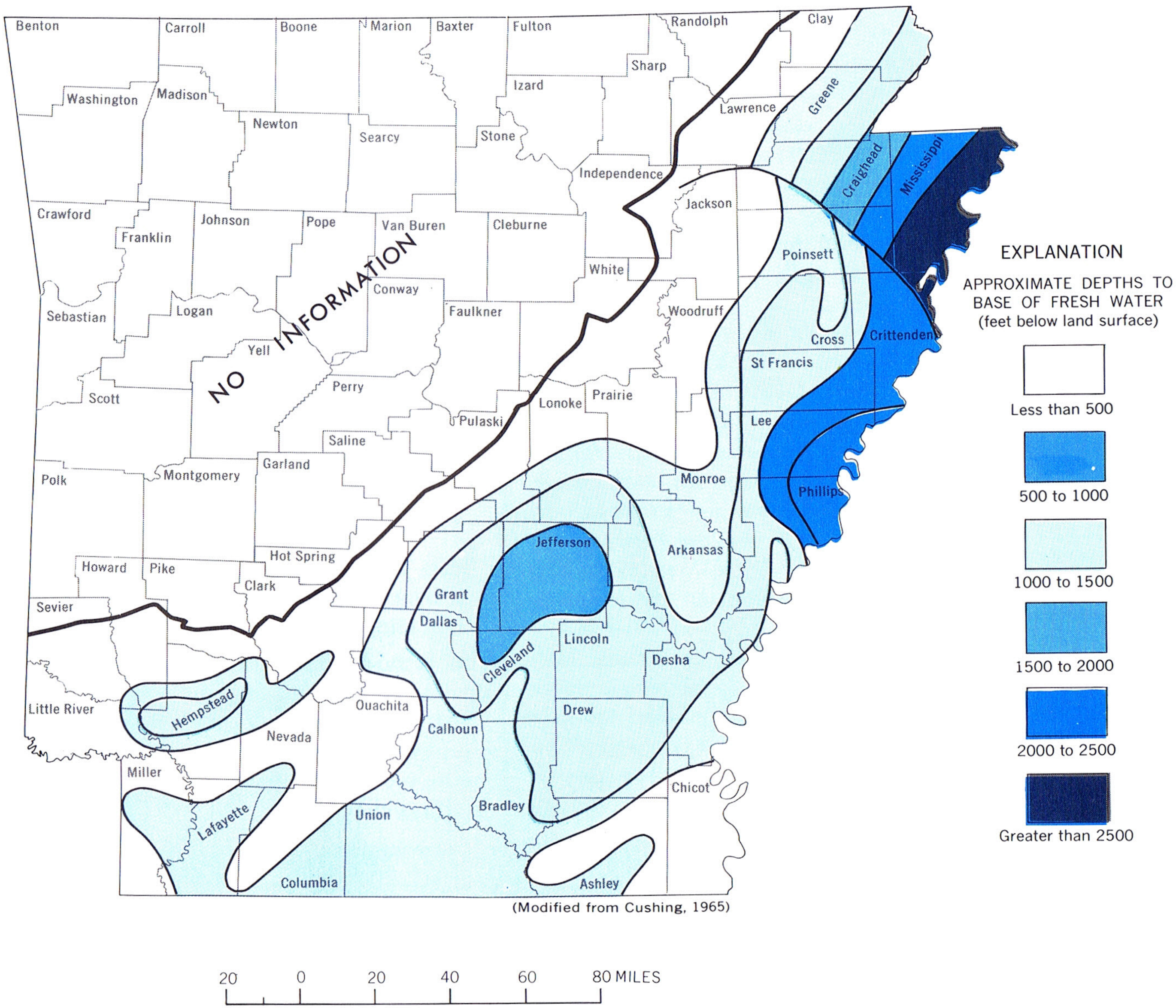
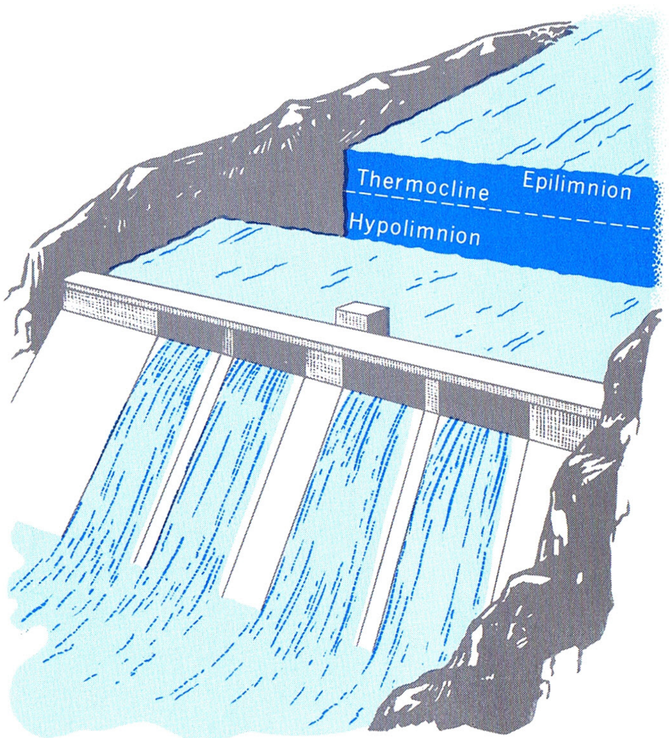


FIGURE 5,—Don't drill your well too deep unless you want to get salt water.

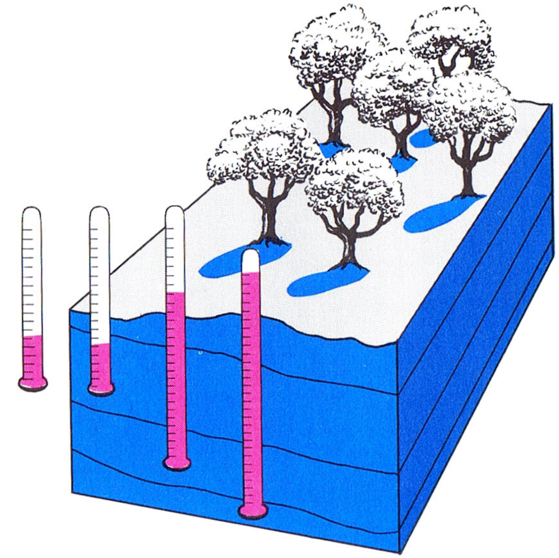
The temperature of water is a physical feature of importance to water users. Surface water is subject to relatively rapid changes in temperature, in response to daily air temperatures. In deep reservoirs such as Bull Shoals the water is found to be layered according to temperature and density. Only the upper layer of water fluctuates over a wide temperature range (epilimnion); whereas, water at the bottom of the reservoir may be colder than the average annual air temperature and undergo less temperature change (hypolimnion).



Ground water has a relatively constant temperature dependent upon the depth from which it comes. Water at less than 200 feet generally has nearly the same temperature as the average annual air temperature. Ground water at depths greater than 200 feet generally is warmer than shallower water up above because of warming by rocks deep in the earth. As a general rule, water is about 1°F warmer for each 50 to 100 feet of increased depth.

Ground-water temperatures in relation to well depths in deposits of Cretaceous, Tertiary, and Quaternary age, respectively, are shown in figures 6, 7, and 8. Water from Cretaceous deposits ranges from 62° to 98°F; whereas, water from Tertiary deposits ranges from 62° to 83°F. Water from shallow depths (Quaternary) ranges from 61° to 69°F, and exceeds the mean annual air temperature by 1° to 4°F.

Unusual subsurface conditions may cause higher than normal temperatures of ground water. Examples of this are found at Hot Springs, Ark., where the ground water issuing from the springs has a temperature of 143°F. Water



from Cretaceous deposits in the vicinity of Hope, Ark., attains an abnormally high temperature of 100°F. One theory to account for these high temperatures presumes that the ground water circulates downward to great depths, is warmed by hot rocks, and is recirculated upwards to issue from springs or to be tapped by wells.

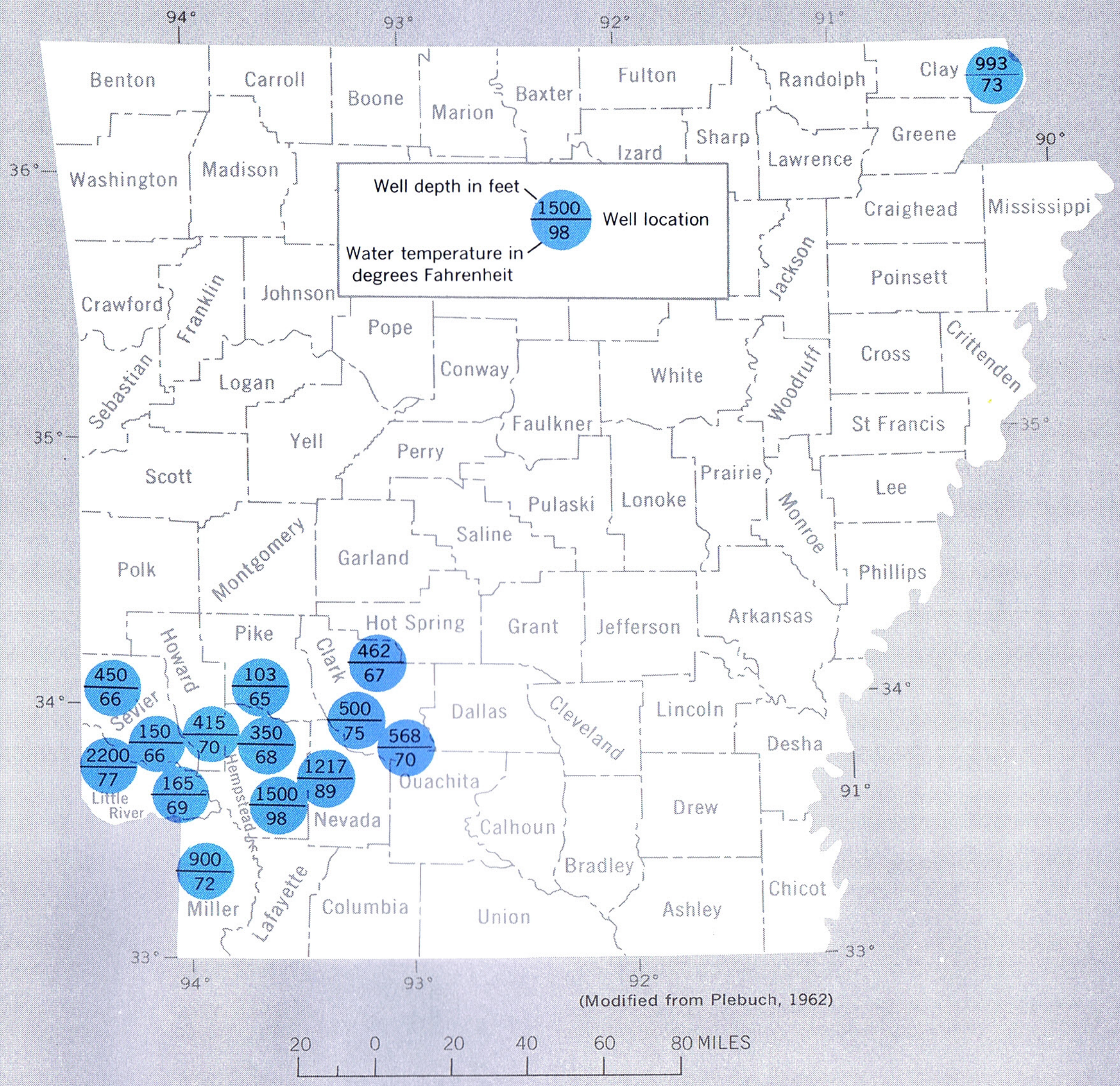


FIGURE 6.—The warmest ground water in Arkansas generally is found in Cretaceous aquifers in southwest Arkansas

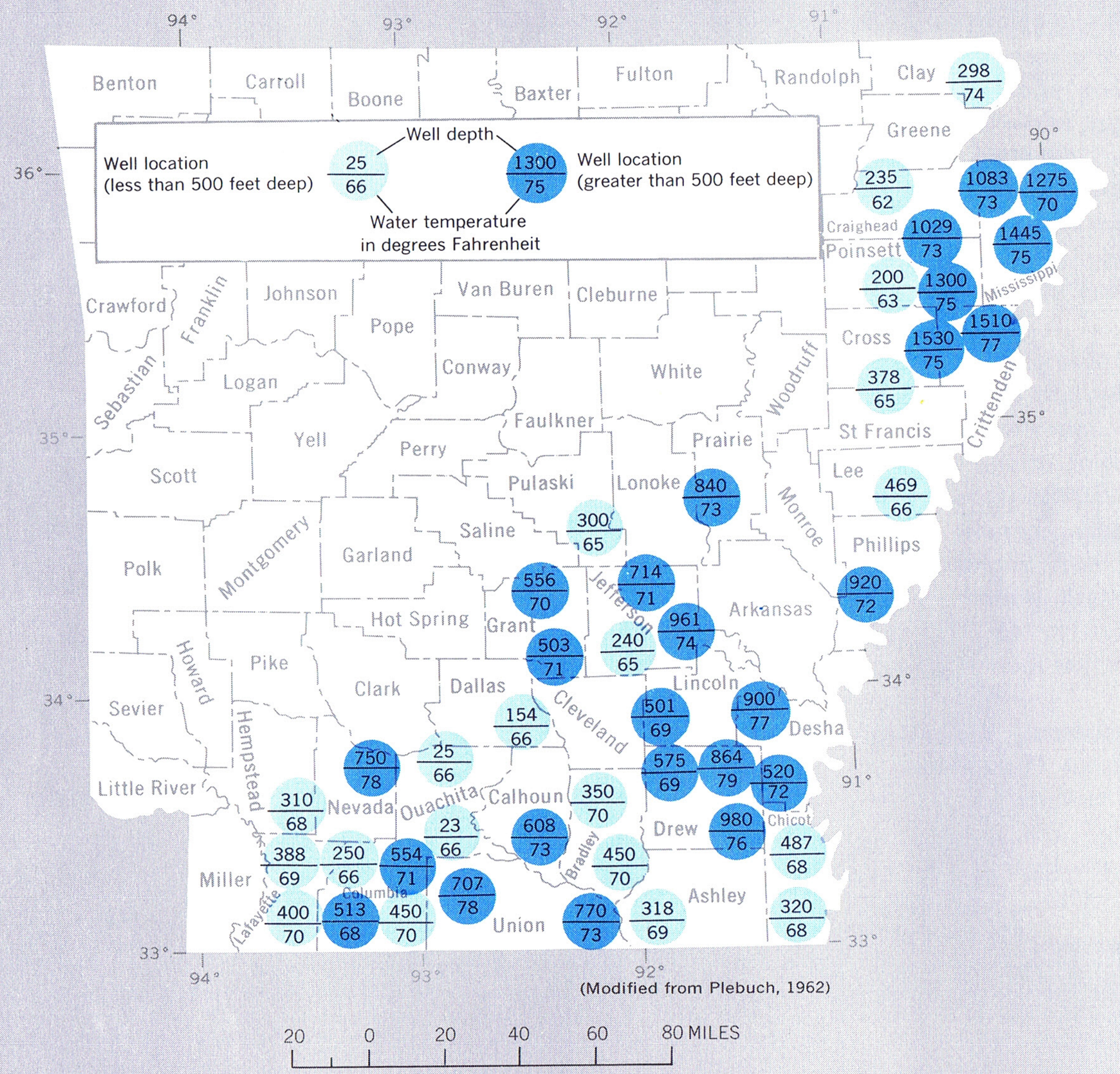
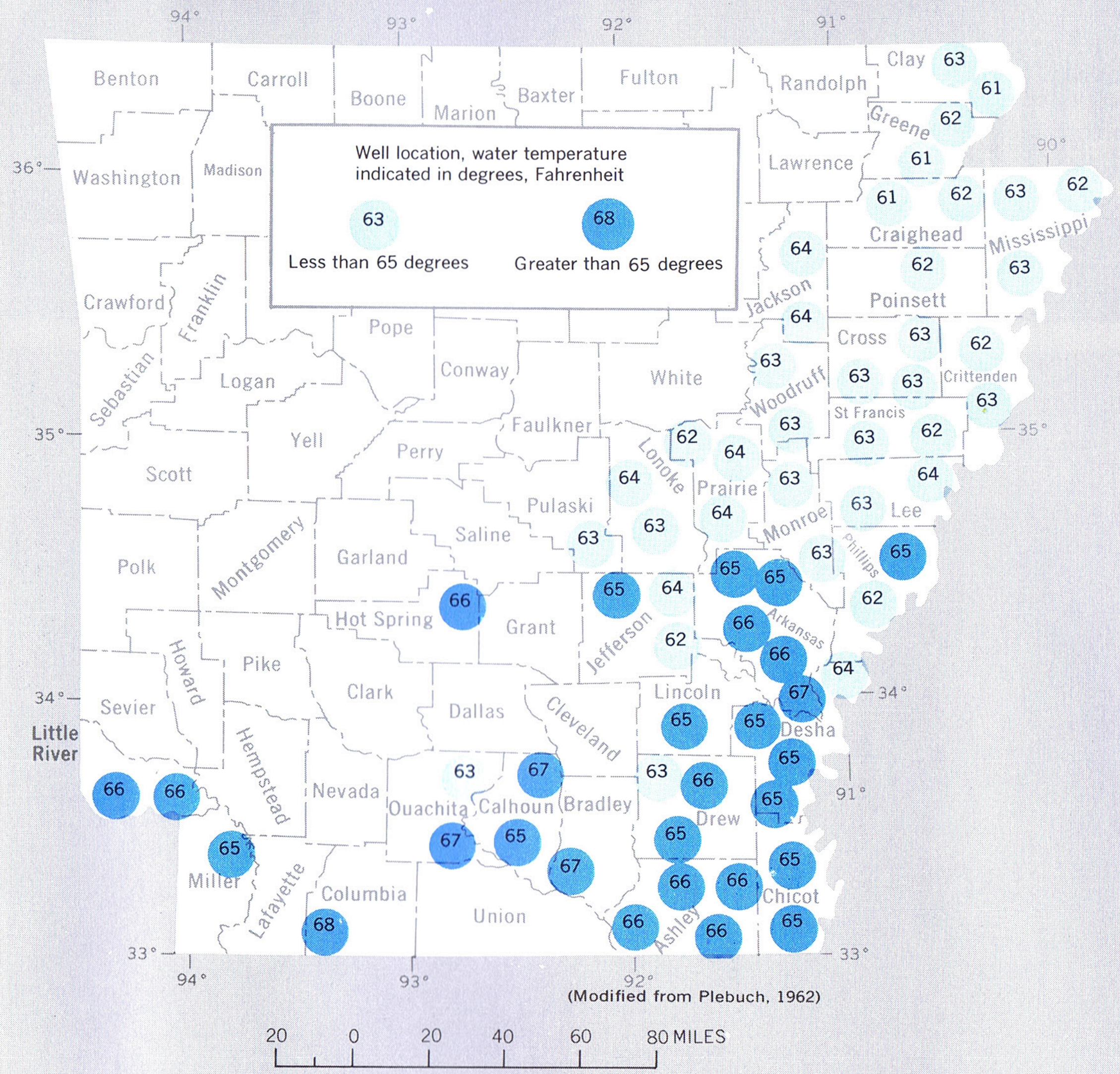


FIGURE 7.—The upper part of the Tertiary aquifers contains cooler water than that from greater depths.

FIGURE 8.—The temperature of water from Quaternary aquifers is about the same as the average annual air temperature.

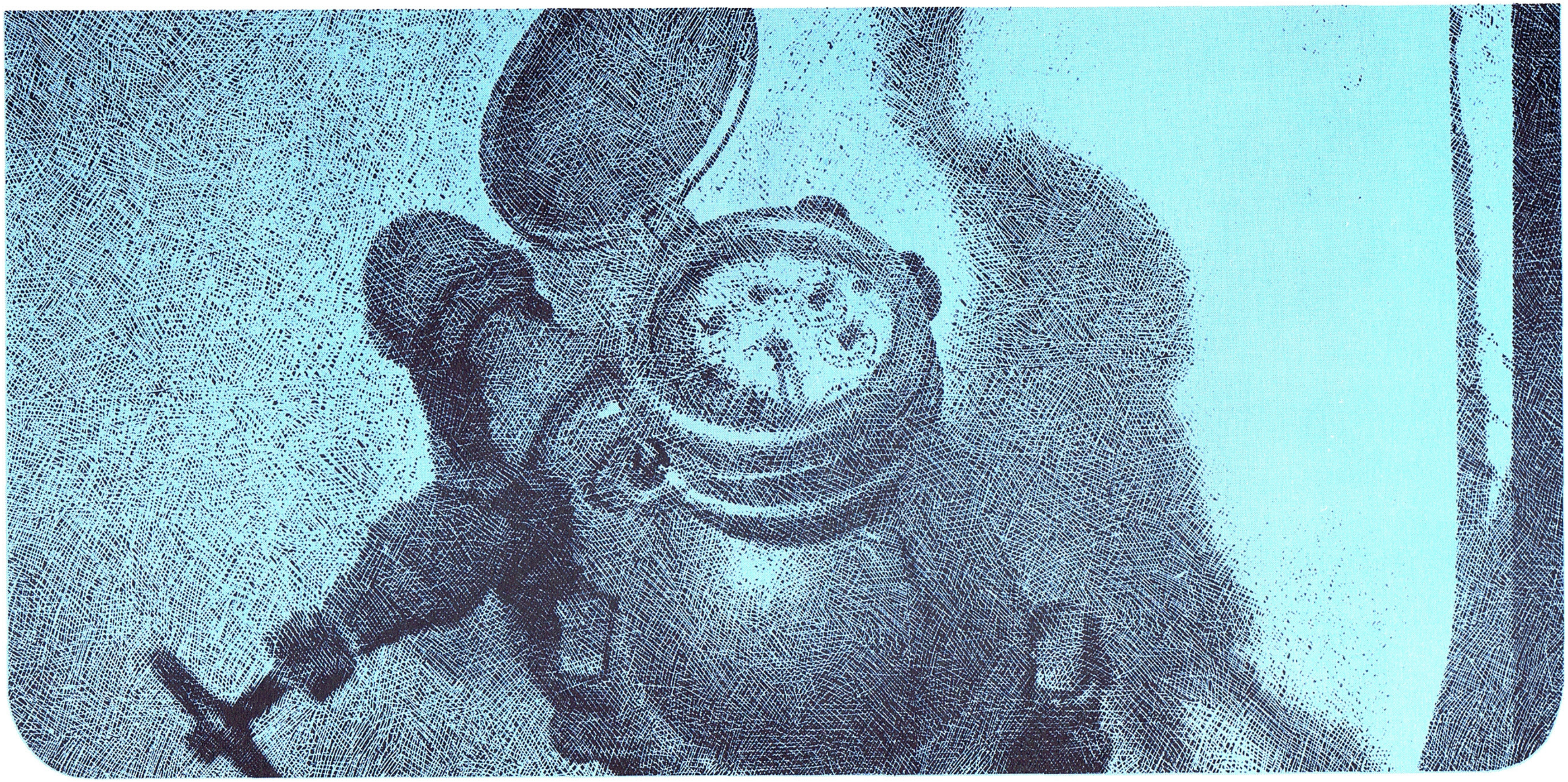
"How good is it? " Arkansas has *abundant water* resources *and most* of it is *good* for any intended use. The iron content, hardness, sediment load, and chloride pollution are the most common features of undesirability found in Arkansas waters. Generally, these poor water-quality conditions are local in extent and, where found, can yet be remedied without excessive cost.



(Modified from Plebuch, 1962)


ARKANSAS PUBLICITY AND PARKS COMMISSION PHOTO BY PHELPS

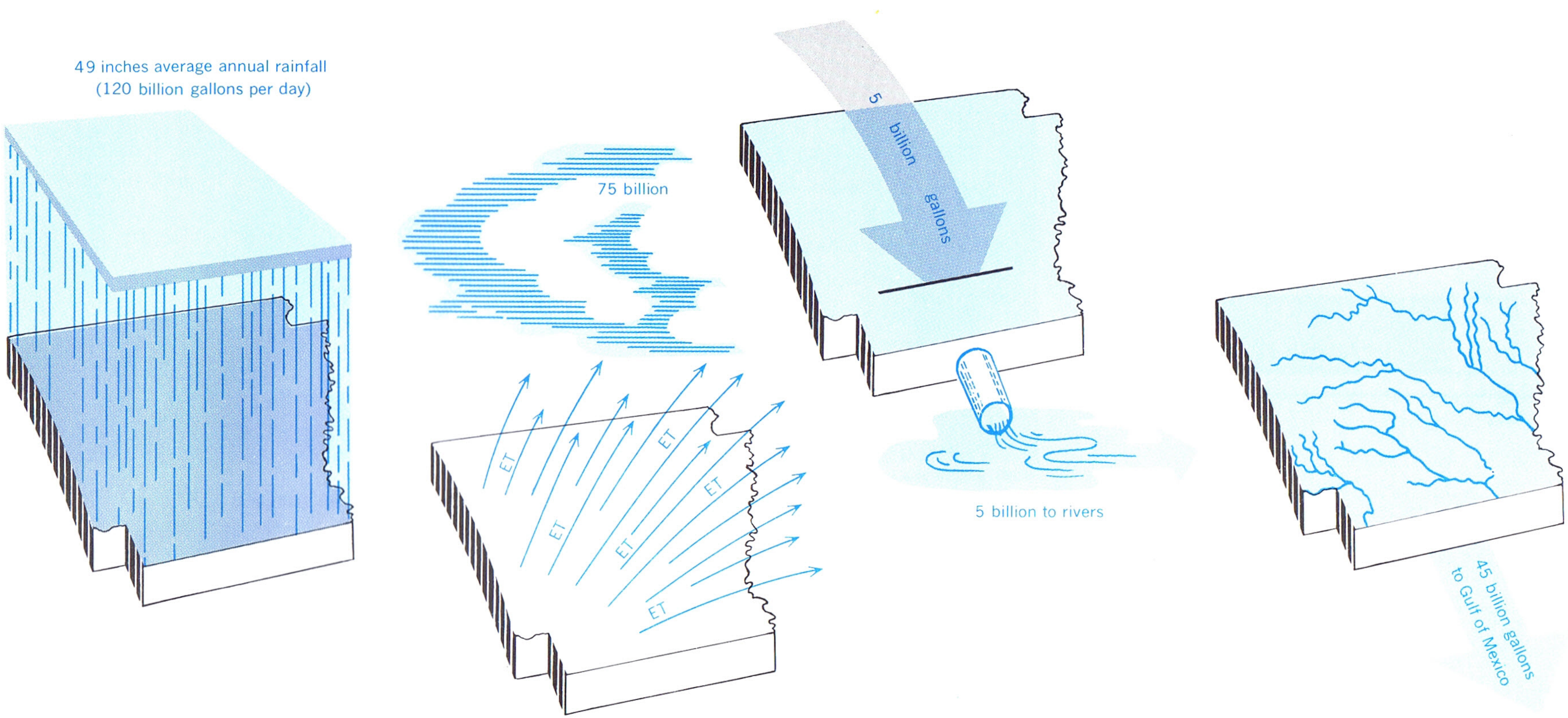
HOW MUCH IS THERE?



We know that our most important source of water in Arkansas comes from an average annual *rainfall* of *about 49 inches*. We also know that this will average out to about *120 billion gallons of water per day*. However, as we have seen, water is in constant motion in the hydrologic cycle and is not always positioned for convenient interception for use. Consequently, *not all* of the *120 billion* gallons of water per day is *available* for our use.

About 75 billion gallons of the 120 billion is immediately returned to another position in the hydrologic cycle as the precipitation evaporates from water bodies, wet land surfaces, roads, housetops, and grass, trees, and other plants (evapotranspiration, ET). Of the remaining 45 billion gallons, about *40 billion* gallons almost immediately becomes *surface-water runoff*. About *5 billion* gallons is *added* to the *underground water supply* to slowly move toward and into rivers to also eventually become runoff water.

In addition to the foregoing, Arkansas receives over 30 billion gallons of water per day from other States through the Arkansas, White, Red, and St. Francis Rivers and the tributaries to each. The Mississippi River at Memphis has an average flow of about 210 billion gallons per day (McGuinness, 1963, P. 165). Thus Arkansas has access to a large surface water supply "piped" in by natural means.



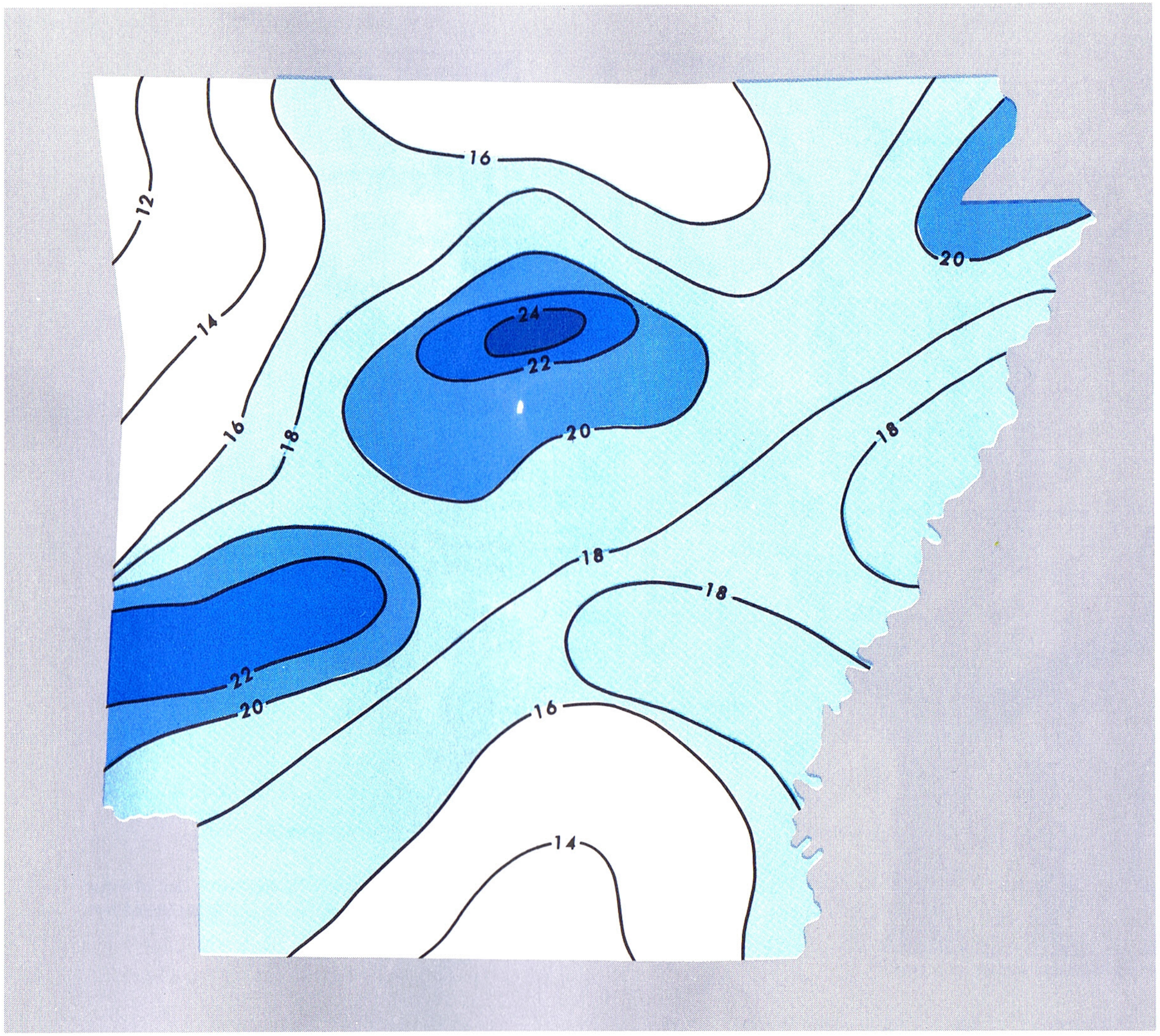
Surface-water storage in reservoirs in Arkansas has developed at a rapid rate since 1940. Water has been impounded for floods and erosion control, power, navigation, water supply, recreation, or for multiple purposes. Figure 11 shows the location of the major reservoirs in Arkansas, municipal supply impoundments, fishing reservoirs, and other natural and artificial lakes. Nearly 4,000 billion gallons of storage capacity is presently available in the State for water supply and power (Personal communication, Yost, 1965).

Many small reservoirs that are used principally for irrigation dot the landscape. The number of these has increased in the last 20 years. The Grand Prairie region in east-central Arkansas is an example of an area of extensive development of surface-water reservoirs where the water is stored for irrigation of rice and soybeans (fig. 11). More than 200 reservoirs have been constructed in the Grand Prairie region since 1910. The capacity of the reservoirs is small and more than half cover only 15 to 40 acres and are shallow.

Many small stock ponds ranging in size from 1 to 10 acres are found throughout Arkansas with new ponds being constructed almost daily. The multitude of ponds and reservoirs dotting the countryside is particularly noticeable from an airplane.

Considering all types and sizes of reservoirs, lakes, and ponds, there is about 6,000 billion gallons of storage capacity presently (1965) available on the land surface in Arkansas, not counting the more than 2,000 billion gallons storage capacity reserved specifically for storage of flood waters. (Personal communication, Yost, 1965).

The amount of water in storage in the ground is many times greater than that coursing the State in rivers and that in impoundments. An estimated average of 5 billion gallons of water per day is available from transient storage in aquifers. An additional estimated 200,000 billion gallons of water occurs as permanent storage beneath the land surface.



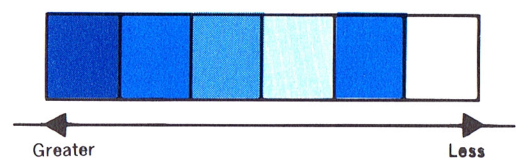
(Prepared by Mathews and others, 1965).

AVERAGE ANNUAL RUNOFF, IN INCHES, 1940–60

20 0 20 40 60 80 MILES

FIGURE 9.—In the Ozark and Ouachita Mountains almost half the average annual rainfall runs off to rivers.

Surface-water runoff in Arkansas is illustrated by two maps, figures 9 and 10. Figure 9 shows what part of the annual 49 inches of precipitation runs off with respect to locality. Runoff is highest in the Interior Highlands and lowest in the Coastal Plain in Arkansas. Figure 10 shows the mean discharge in cubic feet per second of the major streams in Arkansas after the runoff has collected in the rivers (1 cubic foot per second equals about 450 gallons per minute and usually is abbreviated as cfs).



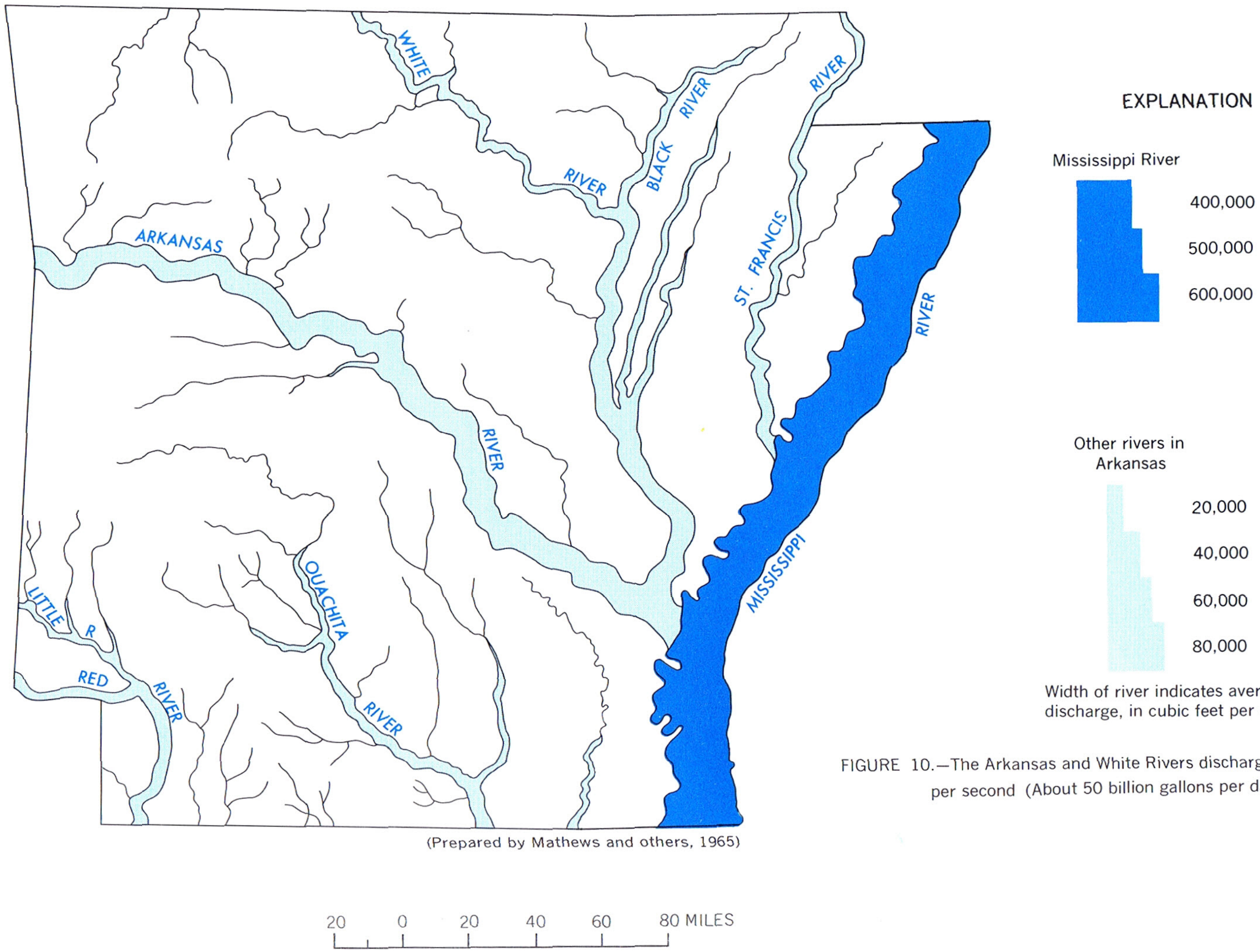
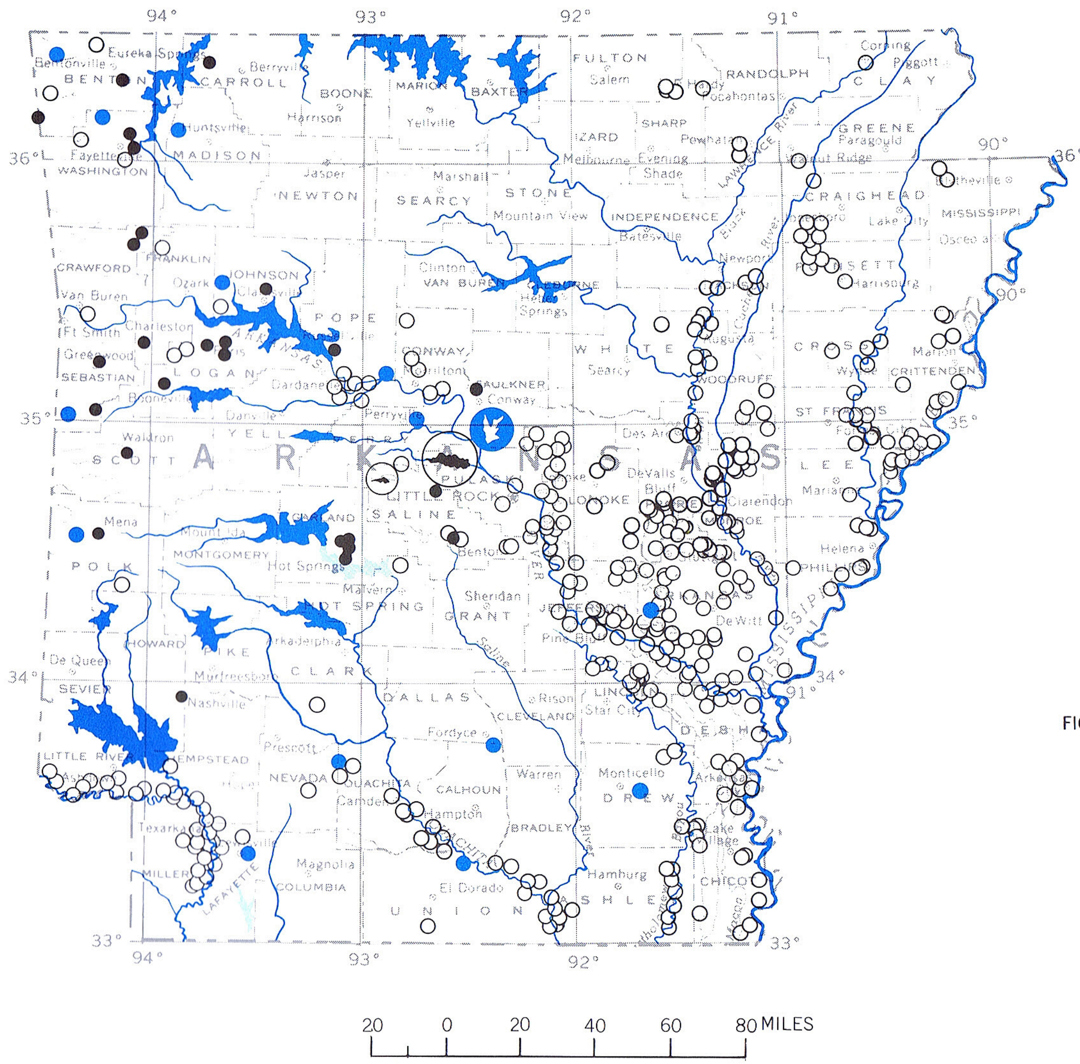


FIGURE 10.—The Arkansas and White Rivers discharge 75,000 cubic feet of water per second (About 50 billion gallons per day) into the Mississippi River.



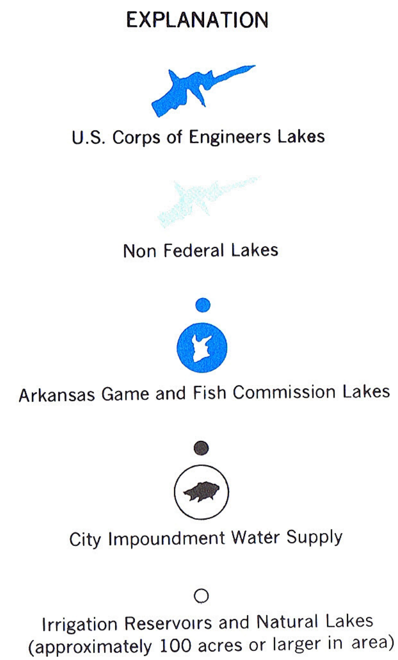
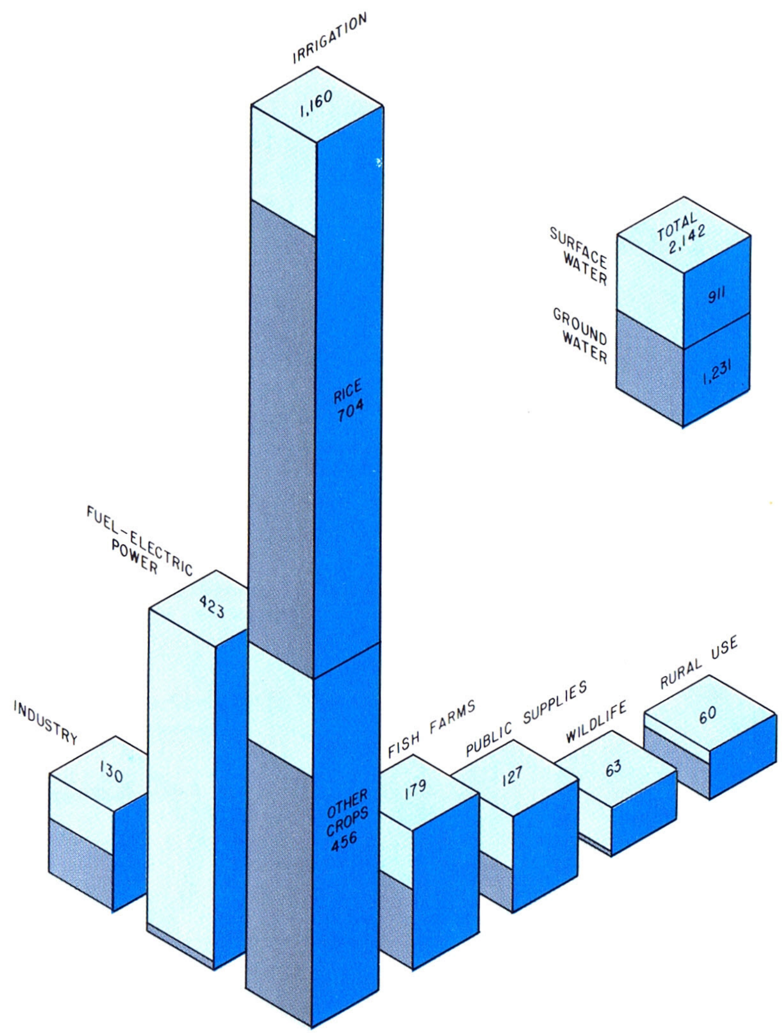


FIGURE 11.—Approximately 6,000 billion gallons of water can be stored in Arkansas in large reservoirs.



WATER USED IN ARKANSAS, 1965
In million gallons per day
(From Halberg and Stephens, 1966)

How much water is there in Arkansas? For all purposes of use from all sources, *Arkansas has* an estimated *30 billion gallons of water per day* available for the future. This is about 20 times more than the State's present requirements, assuming the water is used only one time.

Are we in danger of being short of water? Not when we view our total resources, but the availability of a large quantity of water does not insure an endless supply with no water shortages or problems. We need to know not only how much water we have but also "how do we get it?" and "*how do we keep it?*"

HAULING WATER
DURING DROUGHT,
BUFFALO RIVER
NEAR JASPER. PHELPS

HOW DO WE GET IT?

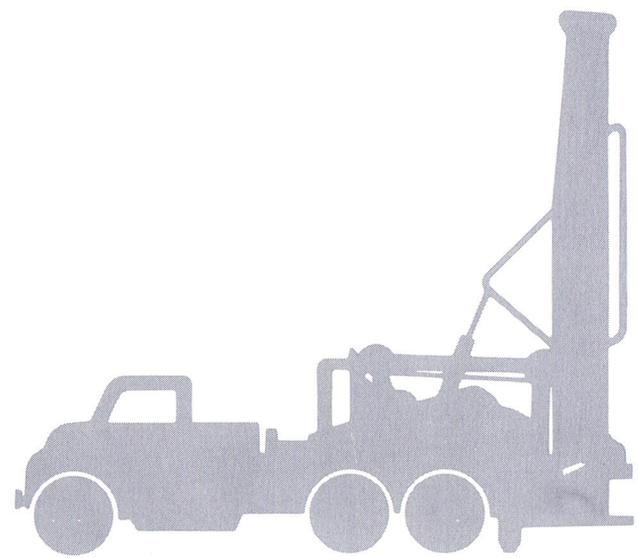
we need to get water facts

WATER FACTS ARE THE BASIS OF PLANS FOR THE USE, DEVELOPMENT, AND CONSERVATION OF WATER RESOURCES

Ground water generally is *obtained* for use *by* two methods. These are *development of springs* by cribbing, sealing, or other means to insure clean water *and* the construction of *wells* and installation of pumps or other devices to lift the water to the land surface. Some aquifers contain water under pressure and flowing wells may be developed so that no pump is necessary. Flowing wells generally are called artesian wells.

Arkansas has an abundant groundwater supply, but in some localities water-bearing rocks aren't very thick, don't contain a large quantity of water, and the rocks are so dense that water drains into a well so slowly, that large yields cannot be developed. Checking the possibilities of getting ground water at a given location before drilling a well can be done in several ways. A visit to the area will indicate whether or not wells have been drilled in the locality, and discussions with the well owners will provide valuable information about well depths and yields. *Drillers* always *should be contacted* because they keep records of wells they have constructed and, by experience, know much about the ground water in a given locality.

The Arkansas Geological Commission maintains a cooperative program of water-resources investigations with the Water Resources Division of the U.S. Geological Survey. These two organizations specialize in studying geology and water and can give much information and advice about obtaining a usable ground- or surface-water supply.



A *properly constructed* water *well* is the *result* of the *skilled workmanship* of an artisan—the *water well driller.* A driller's work consists of much more than merely poking a hole in the ground. The selection of a competent and *reputable driller* is *one* of the *most important* phases of *developing a ground-water supply.* An experienced *water consultant* working with a competent driller will *save time* and *money* and help *insure* the development of a *dependable water supply.*

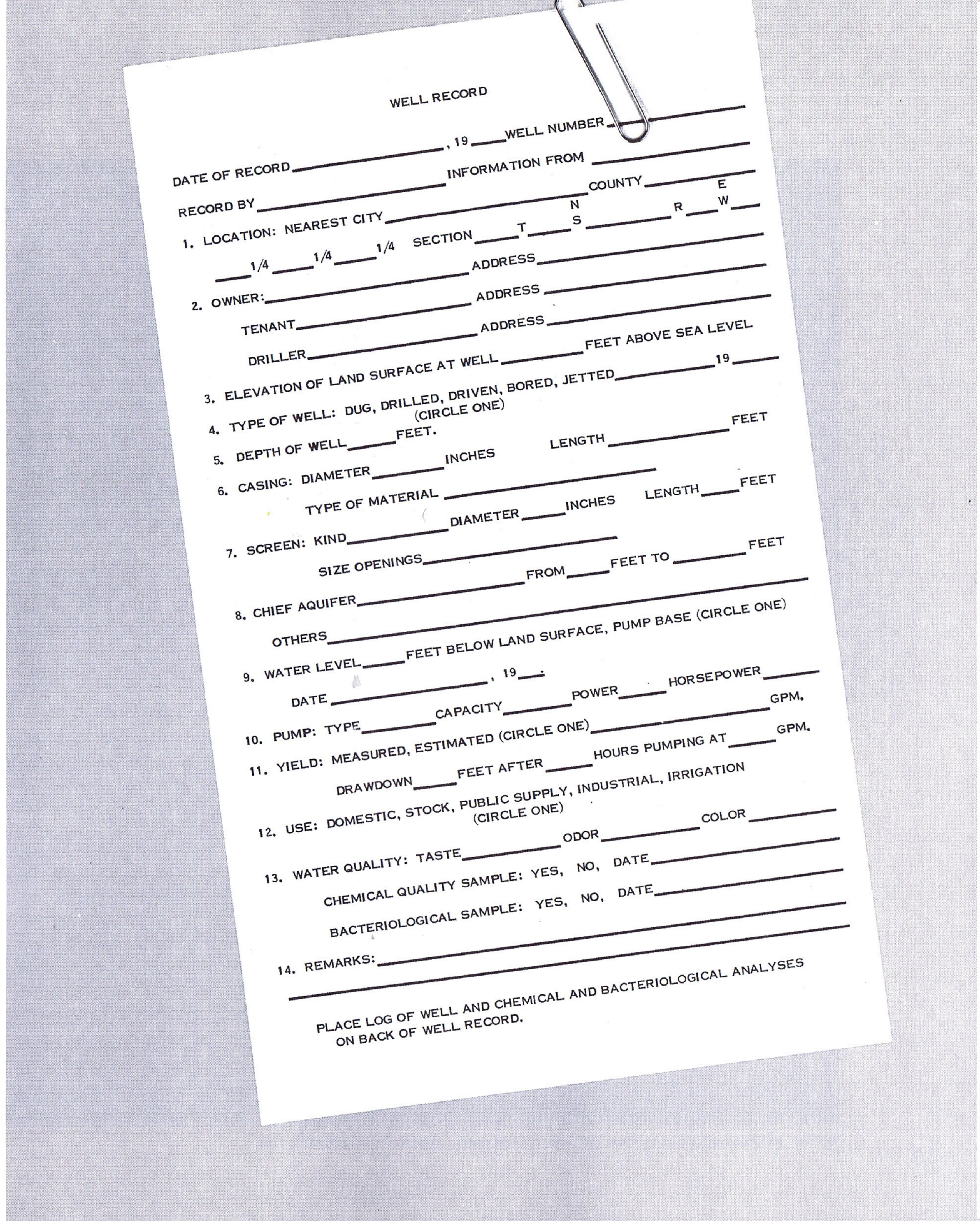
Few, if any, aquifers are so uniform in their water-bearing properties that wells may be developed in them in every hole that is drilled. If large quantities of water are required, a carefully planned *test-drilling* program is *advisable.*

The nucleus of a water system utilizing ground water is the well and it is important that *well records* be kept by the owner. The materials penetrated in drilling the well; type and length of casing and screen; depth to water; aquifer name; pump and motor specifications; pump setting; and well yield and drawdown are some of the important information that a well owner should have. All *wells should be tested* before finishing in order to determine proper pump selection, pump setting, water quality, and water quantity. Nearly all of these records and tests can be supplied by the well driller upon completion of the well. Well and pump repairs are less complicated and less costly if adequate records are available. Furthermore, the information will assist others in drilling wells and will provide records useful for compiling a regional ground-water and geologic picture. Water *problems* can be *solved* only *when adequate information is available,* thus precluding solutions based on questionable assumptions.

Even in this age of science, many people believe in the power of a "water witch" to locate a ground-water supply; however, nothing has yet been established to indicate that "*water witching*" has a scientific basis. For practically all our other needs we insist on factual scientific treatment, and we should do the same for water—our most vital need.

A few years ago it was demonstrated in the laboratory that it is possible to increase the yield of moisture-bearing clouds by artificial means and there is evidence, that under proper circumstances, it is possible to obtain net increases of precipitation in field operations. However, "rain makers" cannot cause rain when it is normally dry and rain-bearing clouds are not present.

Until more is known about weather modification rain makers are not recommended as a means to answer the question, "how do we get it?"



WELL RECORD

DATE OF RECORD ________, 19___ WELL NUMBER ________

RECORD BY ________ INFORMATION FROM ________

1. LOCATION: NEAREST CITY ________ COUNTY ________

___1/4 ___1/4 ___1/4 SECTION ___ T ___ N S ___ R ___ E W ___

2. OWNER: ________ ADDRESS ________

TENANT ________ ADDRESS ________

DRILLER ________ ADDRESS ________

3. ELEVATION OF LAND SURFACE AT WELL ________ FEET ABOVE SEA LEVEL

4. TYPE OF WELL: DUG, DRILLED, DRIVEN, BORED, JETTED ________ 19___
(CIRCLE ONE)

5. DEPTH OF WELL ___ FEET.

6. CASING: DIAMETER ___ INCHES LENGTH ________ FEET

TYPE OF MATERIAL ________

7. SCREEN: KIND ________ DIAMETER ___ INCHES LENGTH ___ FEET

SIZE OPENINGS ________

8. CHIEF AQUIFER ________ FROM ___ FEET TO ___ FEET

OTHERS ________

9. WATER LEVEL ___ FEET BELOW LAND SURFACE, PUMP BASE (CIRCLE ONE)

DATE ________, 19___.

10. PUMP: TYPE ___ CAPACITY ___ POWER ___ HORSEPOWER ___

11. YIELD: MEASURED, ESTIMATED (CIRCLE ONE) ________ GPM.

DRAWDOWN ___ FEET AFTER ___ HOURS PUMPING AT ___ GPM.

12. USE: DOMESTIC, STOCK, PUBLIC SUPPLY, INDUSTRIAL, IRRIGATION
(CIRCLE ONE)

13. WATER QUALITY: TASTE ________ ODOR ________ COLOR ________

CHEMICAL QUALITY SAMPLE: YES, NO, DATE ________

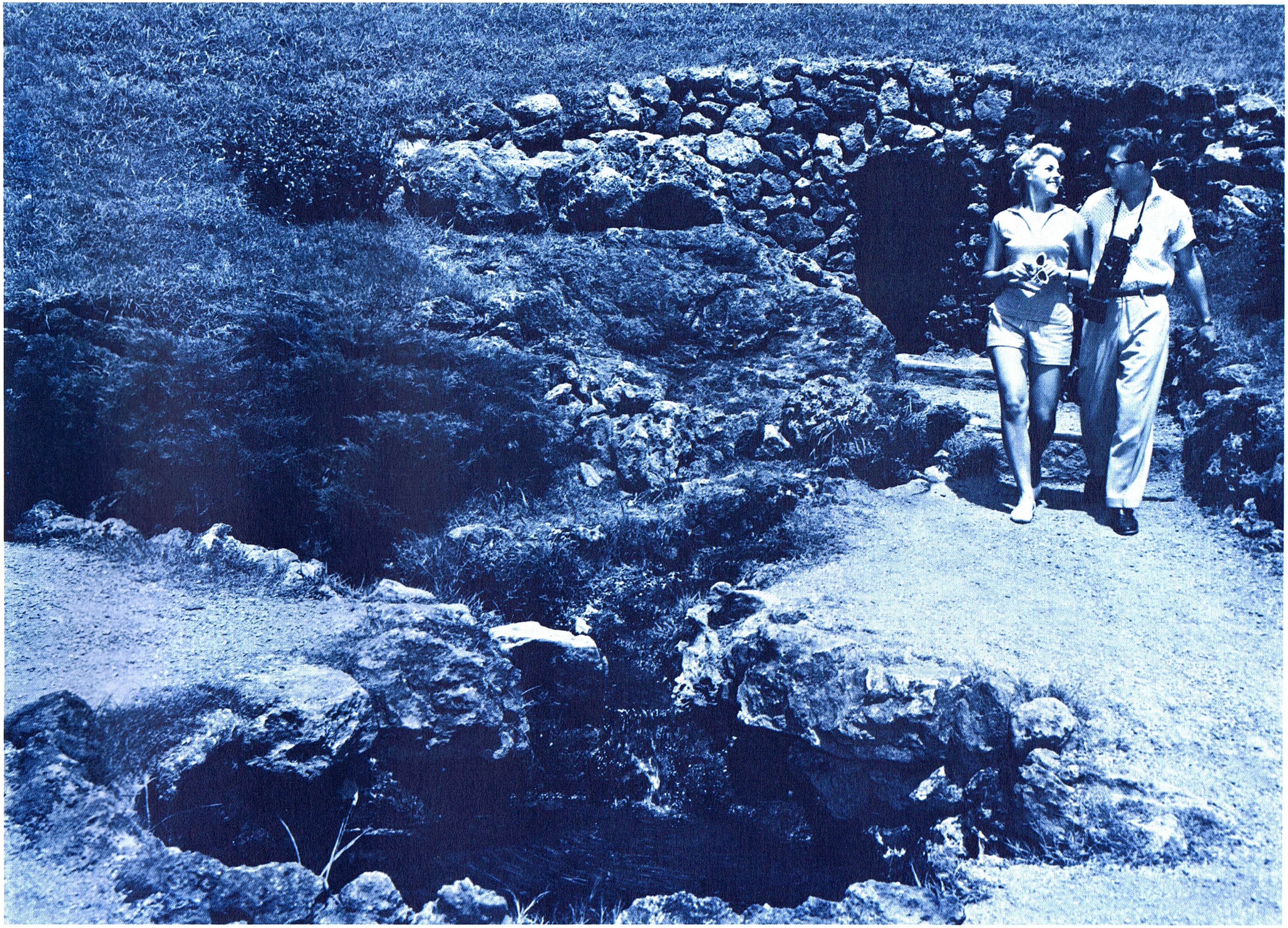
BACTERIOLOGICAL SAMPLE: YES, NO, DATE ________

14. REMARKS: ________

PLACE LOG OF WELL AND CHEMICAL AND BACTERIOLOGICAL ANALYSES ON BACK OF WELL RECORD.

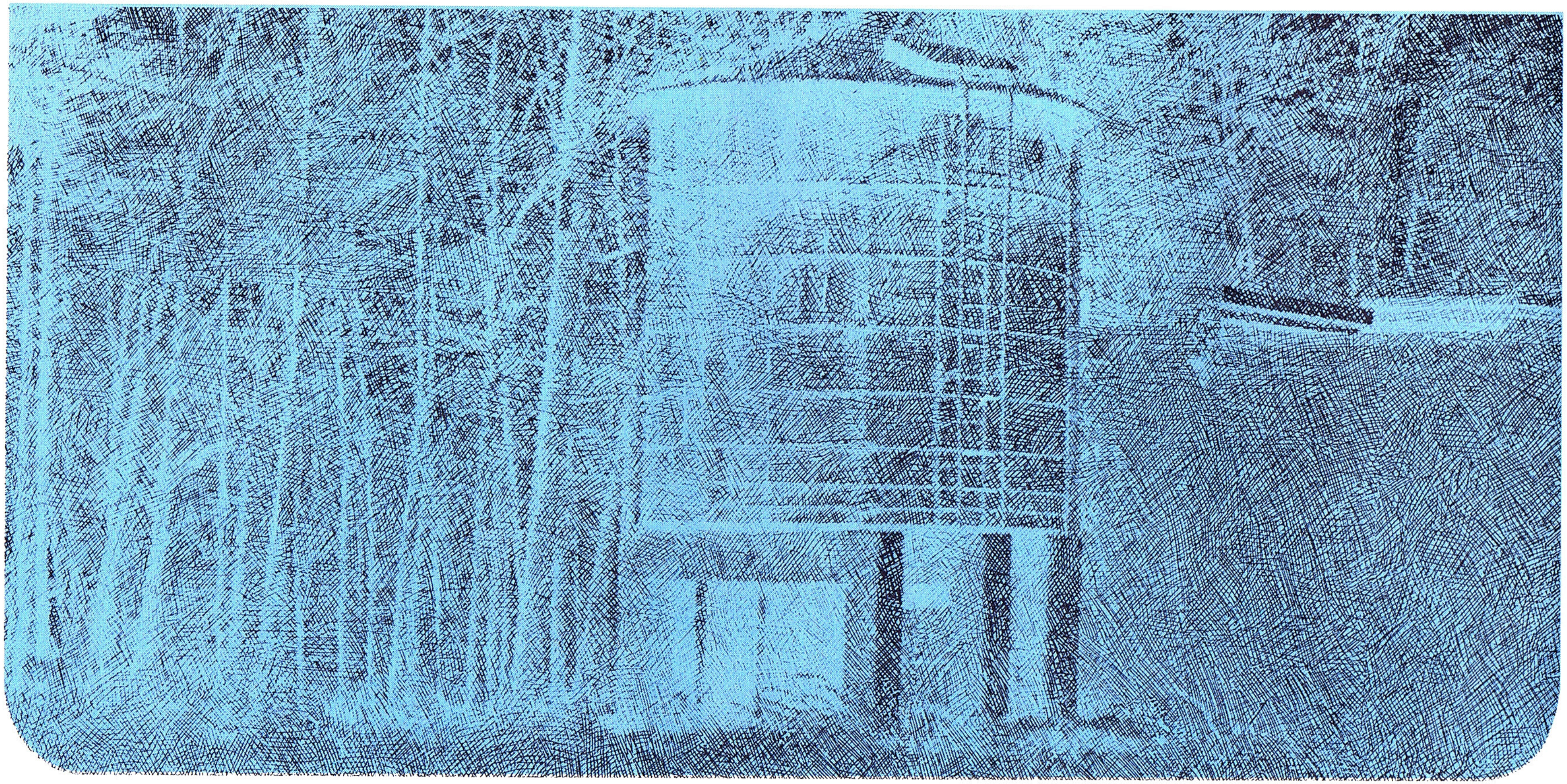
Little has been stated so far about the *development of surface water*. This resource is in rivers, lakes, and ponds and is more readily observed and measured than ground water. Surface water is more subject to pollution than ground water. Furthermore, it is more variable in chemical and physical properties; is subject to higher losses by evaporation; requires higher initial and maintenance costs in development and use; and is more subject to fluctuations in quantity as a result of droughts than ground water. However, if adequate ground-water supplies are not available the surface-water potential should be considered. Also surface-water development is required if hydroelectric power, flood control, recreation, navigation, or waste disposal and dilution is desired. Generally, surface water is the most economical to develop if larger quantities of water are required. The *hydrologic data needed* to properly develop surface-water supplies are *runoff, low flows* of streams, water requirements from which *draft-storage* requirements can be determined, *flood flows* and *reservoir inundation, sediment load,* and *water quality*. As with the development of a ground-water supply, the services of a *competent water consultant* will *insure* the development of a *reliable surface-water supply.*

A listing of reports that are concerned with the water resources of Arkansas and related subjects may be obtained from the Arkansas Geological Commission. The Commission also maintains a list of well drillers and consultants throughout the State. An answer, then, to the question, "how do we get it?" can be obtained by following the suggestions outlined in this section of the report and by referring to the data and various publications about Arkansas' water resources.



HOT SPRINGS IN ARKANSAS. ARKANSAS PUBLICITY AND PARKS COMMISSION. PHELPS

HOW DO WE KEEP IT?

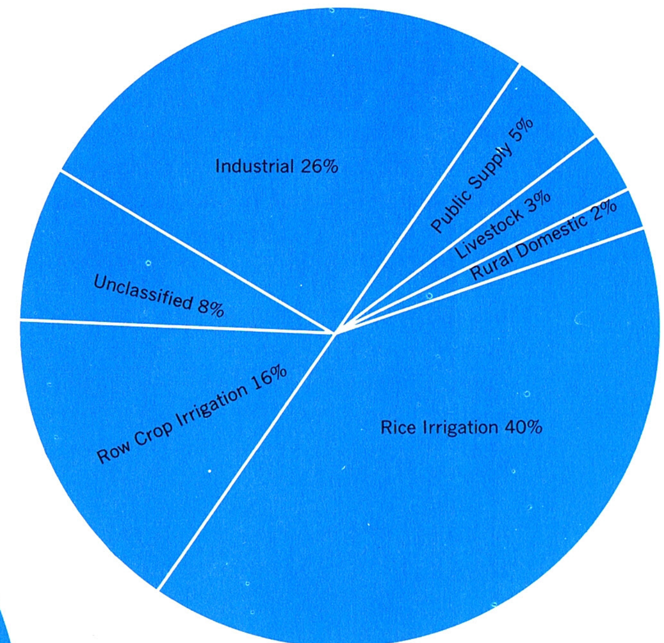


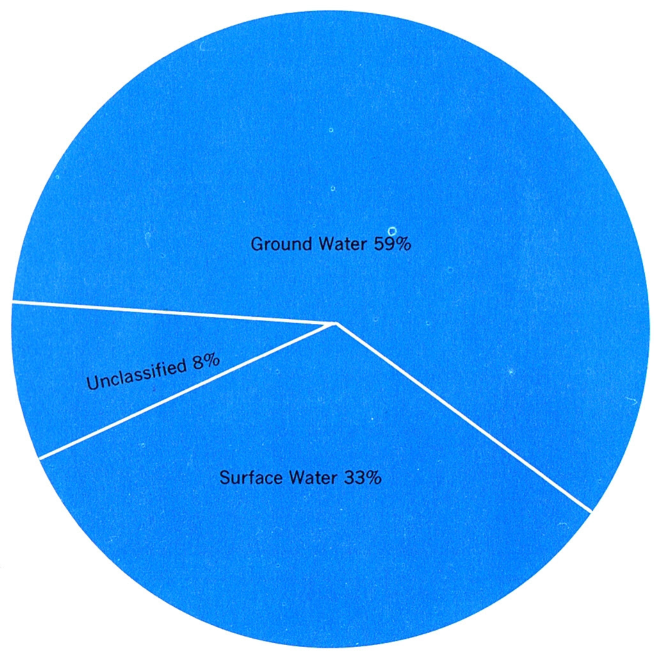
WATER CONSERVATION MEANS MAXIMUM BENEFICIAL USE OF WATER ON A CONTINUABLE BASIS

Arkansas has about 20 times more water available than is now (1965) being used. A logical question then, instead of "how do we keep it?" is, why be so concerned about water if we have so much. The important point to remember here is that we do have just so much water.

Continued increases in the amount used are gradually reducing that quantity available above our present needs. Increasing pollution and local overdevelopment of our water and inadequate flood control and storage facilities further tend to reduce the available amount now unused. Thus, it is essential to Arkansas' continued progress and well-being that we utilize our water in an efficient manner, keep water development ahead of needs, and maintain our water-rich heritage.

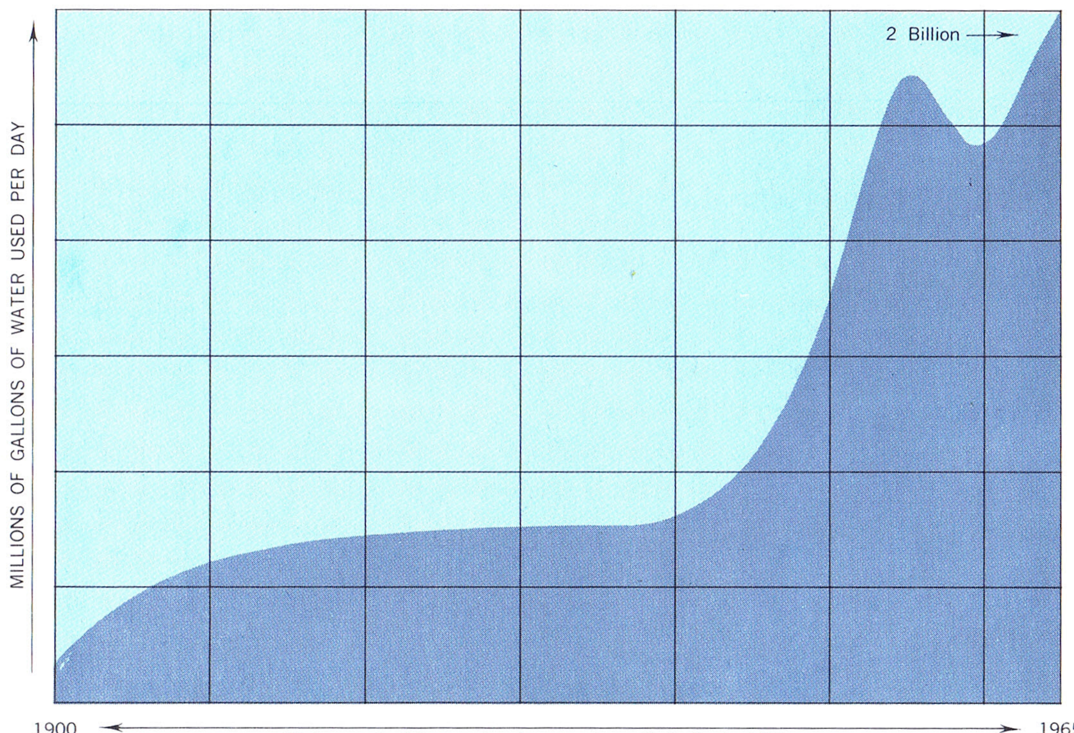
We can best protect and conserve our water resources in Arkansas by proper water development and management in accord with the realities of nature. Water development and management are properly accomplished when based on unbiased scientific water facts. Water development and management also should be based on long-range planning rather than short-term localized immediate needs and should aim toward the satisfaction of all interests to the extent required to satisfy the public interest.





WATER USE IN ARKANSAS, 1960
(From Stephens and Halberg, 1961)

A COURSE OF ACTION THAT WILL ASSIST IN KEEPING ARKANSAS WATER RICH FOLLOWS:



Water use in Arkansas has increased greatly in the last 20 years

1. *Continue* the water-resources appraisal studies now being made in cooperation with the Arkansas Geological Commission by the Water Resources Division of the U.S. Geological Survey. It is impossible to make optimum use of any material without first taking an inventory of the material to define its limits.

2. *Continue* the *collection* of *basic water data* needed for maintaining an up-to-date accounting for our water resources and for completing appraisal studies.

3. Develop *long-range* water *plans* and *water-management policies.* Water management leads to efficient use of water and includes the development and use of improved quantitative evaluations of water supplies. Water management provides for choices of water use and projection into the future of the effect of the use. Water laws, permits, and regulations are tools that sometimes must be used to provide good water management. Such legal tools must be compatible with laws of nature. Informed water managers supported by an informed public can meet Arkansas' water-management needs.

4. *Prevent waste* of our water by constructing reservoirs and ponds at appropriate sites. Much of the surface flow in Arkansas is in the form of flood runoff which quickly passes downstream and out of reach. Flood waters can be stored behind dams to be available later to carry a water user through dry periods.

5. *Prevent indirect waste* of our water resources by elimination of pollution of our water. Polluted water becomes a liability.

6. Encourage the *cooperation* of *activities* of all groups working with water, particularly the Federal and State agencies, to insure dissemination of information between agencies, prevent duplication of effort, and to prevent or resolve conflicts of interest in these groups.

7. *Complete* the *mapping* needs of the State, thus providing adequate topographic and geologic control for water studies.

8. *Maintain* a vigorous *program for updating* water facts so that as the water picture changes, as it does so rapidly today, the long-range planning and water-management policies can be changed to meet the conditions and needs.

9. *Increase* and enhance the *dissemination* of *water facts* and an understanding of water and water problems. A well-informed public is essential to optimum continued use of water; citizens cannot make informed choices on questions of water policy unless facts are available and the public avails itself of the facts.

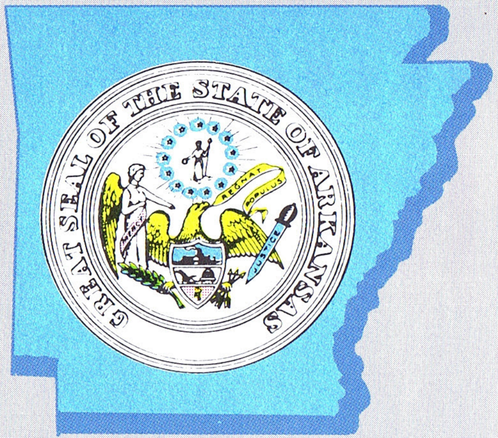
10. *Make use* of available *water facts.* Each individual and water agency should know where certain facts may be available even though no publication has been released. Thus, an individual seeking a domestic water supply might save a great deal of time and money, and a water agency might save time and money by not duplicating effort to collect basic data already available.

11. *Undertake research studies* designed to develop better water appraisal, development, and management techniques and more efficient and accurate instruments for collecting water facts.

Basically, the answer to the question, "how do we keep it?", lies within the most valuable of all of Arkansas' resources—her people. If the people respond adequately, thus meeting the challenge, the second most valuable resource of Arkansas—her water supply—will be sufficient for all needs of all Arkansas.

A WATER RESOURCES WHO'S WHO

STATE AGENCIES AND INSTITUTIONS



ARKANSAS HIGHWAY DEPARTMENT

Makes studies in hydrology as it affects highway structures. In cooperation with the U.S. Bureau of Public Roads conducts research in the hydraulics of small watersheds as related to highway structures, channels, drainage, runoff, and erosion. In cooperation with the U.S. Geological Survey on a matching fund basis makes site studies to determine floodflow characteristics and bridge-opening requirements.

ARKANSAS HIGHWAY DEPARTMENT
HIGHWAY BLDG.
LITTLE ROCK, ARK. 72201

ARKANSAS STATE BOARD OF HEALTH

BUREAU OF SANITARY ENGINEERING

Provides services for public environmental sanitation. This includes municipal water and sewerage systems and public systems for institutions, swimming pools, schools, camps, parks, commercial establishments and other public and semipublic places. The Bureau performs these functions by reviewing and approving engineering plans prior to construction. Public water supply facilities are periodically inspected and water samples are taken for chemical and bacteriological tests. The Bureau certifies processing water according to Public Health Service standards for food industries engaged in interstate commerce. The Bureau assists operators of public facilities and their consultants by publishing rules and regulations regarding water supplies and sewerage systems and assists owners of private water supplies by providing information on proper construction of water wells, water systems, and sewerage facilities. The Bureau trains people in water works and waste water plant operation, licenses water works and sewerage plant operators, and supervises operation of all waste treatment plants except industrial. Publishes chemical analyses of municipal waters.

BUREAU OF SANITARY ENGINEERING
ARKANSAS STATE BOARD OF HEALTH
NEW HEALTH BLDG.
LITTLE ROCK, ARK. 72201

ARKANSAS GAME AND FISH COMMISSION

Has an interest in maintaining the quality of Arkansas streams for the benefit of fish and wildlife. The Commission issues hunting and fishing licenses, enforces game and fish regulations, manages lakes for the procreation of fish and the recreation of people, distributes information on where to fish, cooperates with municipalities in providing public fishing facilities at municipal reservoirs, and offers staff assistance to political subdivisions, agencies, groups, and individuals on matters relating to hunting and fishing. Its publications and news features include maps of public hunting and fishing areas, reports on lake and stream conditions, and information on stocking and catching fish. The Commission makes available a number of motion picture films on Arkansas wildlife.

ARKANSAS GAME AND FISH COMMISSION
GAME AND FISH COMMISSION BLDG.
LITTLE ROCK, ARK. 72201

ARKANSAS PLANNING COMMISSION

Exercises coordination of plans as they pertain to water resources to insure orderly development of water resources to well-conceived ends. Operates in an advisory capacity with no police power. The policies of this Commission are basic to the desires of each of the Departments of the State through a technical commission made up of one member from each of the State agencies.

ARKANSAS PLANNING COMMISSION
GAME AND FISH COMMISSION BLDG.
LITTLE ROCK, ARK. 72201

ARKANSAS GEOLOGICAL COMMISSION

Makes geologic, mineralogic, and geohydrologic surveys and site investigations. Provides to individuals, companies, and groups information and advice concerning mineral resources and development of mineral prospects. Provides information and educational service to the public and to schools on geology and mineral resources of the State. Maintains a library of geologic literature for the State and region which is available for public use. Distributes U.S. Geological Survey topographic maps of Arkansas, some U.S. Geological Survey reports pertaining to Arkansas, and publishes and distributes reports of geologic and hydrologic investigations conducted by the Commission and by the Geological Survey in cooperation with the Commission.

ARKANSAS GEOLOGICAL COMMISSION
STATE CAPITOL BLDG.
LITTLE ROCK, ARK. 72201

OFFICE OF EMERGENCY PLANNING

WATER TASK FORCE COMMITTEE

Responsible for assuring adequate and safe supplies of water for essential purposes in case of an emergency. Issues directives in the name of the Governor to carry out provisions of emergency plans formulated in conformance with the State policy to first utilize all water resources for the preservation of life, sanitation, and property, and thence such other military and nonmilitary essential uses as deemed necessary by the State Water Directors.

ARKANSAS OFFICE OF EMERGENCY PLANNING
GAME AND FISH COMMISSION BLDG.
LITTLE ROCK, ARK. 72201

ARKANSAS SOIL AND WATER CONSERVATION COMMISSION

Negotiates with adjoining States relating to the protection and use of interstate waters. Cooperates with governmental agencies and groups in development and prosecution of plans for construction, operation, and maintenance of dams, lakes, levees, canals, pumping works, and improvements on lakes and streams. Administers approval of applications for construction of small watershed dams for flood protection, irrigation, water supply and recreation under the Federal Watershed Protection and Flood Prevention Act; issues permits for construction of new dams and allocates water from streams during periods of shortage; and represents various groups who may request additional water supplies from Federal impoundments.

ARKANSAS SOIL AND WATER
CONSERVATION COMMISSION
STATE CAPITOL BLDG.
LITTLE ROCK, ARK. 72201

UNIVERSITY OF ARKANSAS

Several components of the University, including the Department of Civil Engineering, Agricultural Engineering, Agronomy, Horticulture and Forestry, the Graduate Institute of Technology, the Agricultural Research Station, Water Resources Research Center and the Industrial Research and Extension Center conduct water and water-related studies. Studies may be sponsored by the University or in cooperation with various State and Federal agencies. The Water Resources Research Center administers Federal funds made available under the Water Resources Research Act of 196 by arranging for components of the University to conduct research, investigations, and experiments in relation to water resources, and trains scientists through such activities. Current and recent studies conducted by various components of the University have included influence of temperature on fish, relation between quality and quantity of flow in Arkansas streams, turbulent flow in porous media, organic waste, and assimilative characteristics of selected Arkansas streams, ecological studies, planning studies for the Arkansas River basins, ground-water resources and recharge in the rice-growing area of Arkansas, irrigation engineering, and supplemental irrigation.

UNIVERSITY OF ARKANSAS
FAYETTEVILLE, ARK. 72703

GRADUATE INSTITUTE OF TECHNOLOG
UNIVERSITY OF ARKANSAS
1200 MC ALMONT ST.
LITTLE ROCK, ARK. 72202

The Agricultural Extension Service of the University, in cooperation with the U.S. Department of Agriculture, provides services and information to farmers, groups, and county agents including in the water-management field, guidelines for management and design of irrigation systems, methods of making flow measurements, water requirements for various crops, and indications of optimum time of supplemental irrigation; and makes inventories of irrigated crop acreages.

AGRICULTURAL EXTENSION SERVI
UNIVERSITY OF ARKANSAS
1200 MC ALMONT ST.
LITTLE ROCK, ARK. 72202

OTHER STATE AGENCIES

Other State agencies concerned with aspects of water management pursuant to the fulfillment of the principal objectives include the Arkansas Industrial Development Commission, which in promoting industrial growth of the State disseminates information on water resources of the State; the Arkansas Oil and Gas Commission issues permits for oil and gas tests and requires construction measures to prevent contamination of fresh water sources; the Arkansas Publicity and Parks Commission develops and maintains areas for public use including lakes and streams and provides water for public use and sanitary facilities in areas under its care; the Arkansas Forestry Commission, which is primarily concerned with forestry management, cooperates with other agencies in certain water-management problems.

ARKANSAS INDUSTRIAL DEVELOPMENT COMMISSION
STATE CAPITOL BLDG.
LITTLE ROCK, ARK. 72201

ARKANSAS OIL AND GAS COMMISSION
314 EAST OAK ST.
EL DORADO, ARK. 71730

ARKANSAS PUBLICITY AND PARKS COMMISSION
STATE CAPITOL BLDG.
LITTLE ROCK, ARK. 72201

ARKANSAS FORESTRY COMMISSION
ROOSEVELT RD. AND PINE ST.
LITTLE ROCK, ARK. 72203

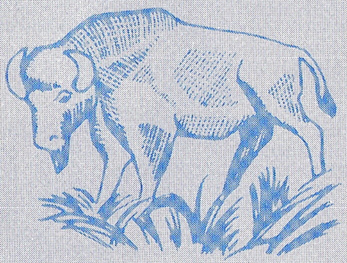
ARKANSAS POLLUTION CONTROL COMMISSION

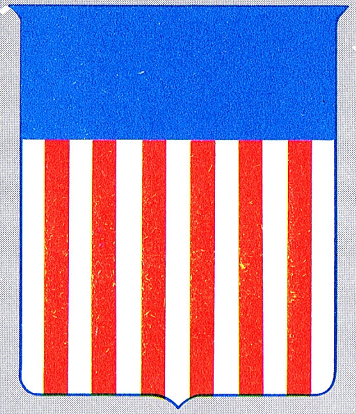
Maintains river basin surveys to locate water pollution and monitoring stations to detect air pollution. Develops programs to control, prevent, and abate water and air pollution. Sewage, industrial wastes, or other polluting substances may not be placed in any surface or underground waters of the State without a permit from the Pollution Control Commission. The Commission administers and enforces all laws relating to pollution of water and air; requires construction of pollution abatement facilities and monitors efficiency of abatement measures, and conducts research to promote new and efficient means of solving pollution problems. The Commission administers Federal grants made available for construction costs of interceptors, outfall sewers, pumping stations, and sewage treatment plants.

ARKANSAS POLLUTION CONTROL COMMISSION
1100 HARRINGTON AVE.
LITTLE ROCK, ARK. 72202

FEDERAL AGENCIES

DEPARTMENT OF THE INTERIOR





FISH AND WILDLIFE SERVICE

BUREAU OF SPORT FISHERIES AND WILDLIFE
BUREAU OF COMMERCIAL FISHERIES

Concerned with water-management problems of warm and cold surface water and with ground water pertaining to the conservation and restoration of the nation's wild birds, mammals, sport fish, and the commercial production of marketable fish. In Arkansas conducts research on diseases and parasites of fish; improvement of feeding, stocking, harvesting, processing and storage methods for commercial fish; and biological, chemical, and physical factors affecting fish. Assists in Federal projects in Arkansas by evaluating benefits and damages to fish and wildlife and develops measures for protection and enhancement of the wildlife resource.

BUREAU OF SPORT FISHERIES AND WILDLIFE
U.S. FISH AND WILDLIFE SERVICE
PEACHTREE-SEVENTH BLDG.
ATLANTA, GA. 30323

BUREAU OF COMMERCIAL FISHERIES
U.S. FISH AND WILDLIFE SERVICE
5 RESEARCH DR.
ANN ARBOR, MICH. 48103

SOUTH CENTRAL RESERVOIR INVESTIGATIONS AND
NATIONAL RESERVOIR RESEARCH STATIONS
BUREAU OF SPORT FISHERIES AND WILDLIFE
113 SOUTH EAST ST.
FAYETTEVILLE, ARK. 72701

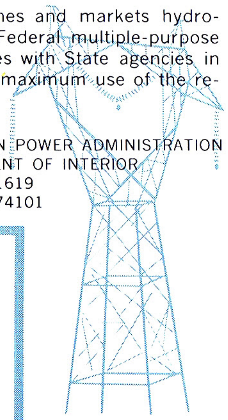
BUREAU OF COMMERCIAL FISHERIES
U.S. FISH AND WILDLIFE SERVICE
P. O. BOX 337
DUMAS, ARK. 71639

FISH FARMING EXPERIMENT STATION
BUREAU OF SPORT FISHERIES AND WILDLIFE
STUTTGART, ARK. 72160

SOUTHWESTERN POWER ADMINISTRATION

Schedules water releases through turbines and markets hydroelectric power and energy generated at Federal multiple-purpose reservoir projects in Arkansas, cooperates with State agencies in the operation of reservoirs to obtain the maximum use of the resources for various functions.

SOUTHWESTERN POWER ADMINISTRATION
U.S. DEPARTMENT OF INTERIOR
P. O. DRAWER 1619
TULSA, OKLA. 74101



Other Department of the Interior agencies concerned with water and water management in Arkansas include the National Park Service which is concerned with collection, distribution, and sanitary control of water at Hot Springs National Park and public supply and sanitation at the National Military parks and monuments in Arkansas; the Bureau of Mines which conducts inventories of water use by the mining industry of Arkansas; the Bureau of Outdoor Recreation which classifies the State's outdoor recreation needs and resources and participates with other agencies in order to provide the best combination of uses of water and related land resources; the Office of Water Resources Research which promotes the program of water research by administering Federal funds of the Water Resources Research Act of 1964 to, in Arkansas, the University of Arkansas Water Resources Research Center; and the Bureau of Reclamation, though not currently active in Arkansas which develop water resources by building dams for hydroelectric generation, water systems, and storage diversion, and conducts research in dam construction, canal lining, atmospheric conditions, and stimuli needed to induce precipitation, chemical treatment of reservoirs to reduce evaporation, and soil and moisture research as as related to irrigation practices.

NATIONAL PARK SERVICE
U.S. DEPARTMENT OF INTERIOR
FEDERAL BLDG.
P. O. BOX 10008
RICHMOND, VA. 23200

BUREAU OF MINES
U.S. DEPARTMENT OF INTERIOR
RM. 204 FEDERAL BLDG.
BARTLESVILLE, OKLA. 74004

BUREAU OF OUTDOOR RECREATION
U.S. DEPARTMENT OF INTERIOR
810 NEW WALTON BLDG.
ATLANTA, GA. 30303

OFFICE OF WATER RESOURCES RESEARCH
U.S. DEPARTMENT OF INTERIOR
RM. 5260-B INTERIOR BLDG.
WASHINGTON, D. C. 20240

BUREAU OF RECLAMATION
U.S. DEPARTMENT OF INTERIOR
P.O. BOX 1609
AMARILLO, TEX. 79105

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

Administers the Water Pollution Control Act which provides for the development or comprehensive programs of water-pollution control, interstate cooperation, research and investigation, training, grants to States and interstate agencies for water-pollution-control programs, enforcement measures against pollution of interstate waters, and grants for construction of treatment works.

FEDERAL WATER POLLUTION CONTROL
ADMINISTRATION
1114 COMMERCE STREET
DALLAS, TEX. 75202

GEOLOGICAL SURVEY

WATER RESOURCES DIVISION

Collects, analyzes, and interprets data pertaining to the occurrence, quality, and quantity of water; water problems; solutions to water problems; and water management. Makes studies of water in any phase of the hydrologic cycle and develops principles, techniques, and instrumentation needed to pursue studies. Makes records available to the public on amounts of water flowing in streams; the period over which a given streamflow can be expected; the frequency of flooding, the inundation to be expected by flooding, the amount of water in an aquifer, well yields and drawdowns; depths to water and drilling depths; changes in storage in aquifers; chemical and physical quality of surface and ground water; and water use. Maintains a program of water-resources studies in Arkansas on a match-fund basis with the Arkansas Geological Commission and Arkansas Highway Department; makes water-resources studies and collects water records for other Federal agencies.

WATER RESOURCES DIVISION
U.S. GEOLOGICAL SURVEY
2301 FEDERAL OFFICE BLDG.
LITTLE ROCK, ARK. 72201

TOPOGRAPHIC DIVISION

Prepares topographic maps showing land surface contours, lakes, springs, streams, and other water features. These maps are useful in planning watershed projects, basin surveys, and projects, recreation and water-supply reservoirs, water distribution and sewerage systems, drainage facilities, flood-control features, and railroad and highway embankments, culverts, and bridges.

TOPOGRAPHIC DIVISION
U.S. GEOLOGICAL SURVEY
P. O. BOX 133
ROLLA, MO. 65401

DEPARTMENT OF AGRICULTURE

FOREST SERVICE

Promotes conservation and best use of the National forests in Arkansas, including the management of watersheds for regulation of streamflow, reduction of flood danger and soil erosion, and protection of sources of water for power irrigation, navigation, and municipal and domestic supply.

FOREST SERVICE
OUACHITA NATIONAL FOREST
U.S. DEPARTMENT OF AGRICULTURE
P. O. BOX 1270
HOT SPRINGS, ARK. 71901

FOREST SERVICE
OZARK-ST. FRANCIS NATIONAL FORESTS
U.S. DEPARTMENT OF AGRICULTURE
RUSSELLVILLE, ARK. 72801

AGRICULTURAL STABILIZATION AND CONSERVATION SERVICE

Administers financial assistance to farmers carrying out soil and water conservation practices. Cost-sharing programs are provided for the following practices related to water management: developing springs or seeps or constructing ponds as a means of protecting the vegetative cover; building protective structures for outlets and water channels, constructing drainage systems; and development or restoration of shallow water areas for wildlife, and constructing ponds for wildlife.

AGRICULTURAL STABILIZATION AND
CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE
FEDERAL OFFICE BLDG.
LITTLE ROCK, ARK. 72201

FARMERS HOME ADMINISTRATION

Provides credit and management assistance to farmers, groups of farmers, and rural residents, including people in communities of less than 2,500 population, to develop water-supply systems for irrigation, households, and livestock use, to drain farmland and to carry out soil conservation measures. Construction of ponds and ditches, installation of wells, and purchase of pumps and piping are within the purpose of this program. Funds are not available for sewers or sewage treatment. Technical assistance is offered for making preliminary determinations regarding engineering feasibility, economic soundness, cost estimates, and financing. May provide additional assistance if applicant for loan lacks resources to design improvements. Maximum loan to an individual is $25,000. An association is limited by total indebtedness which can be no greater than $1,000,000.

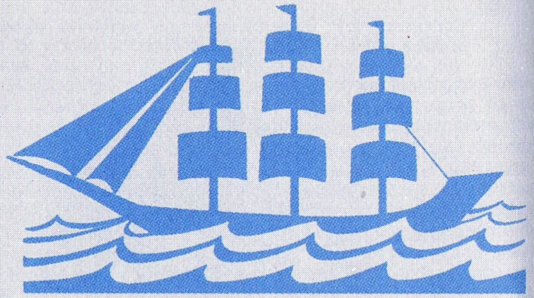
FARMERS HOME ADMINISTRATION
U.S. DEPARTMENT OF AGRICULTURE
FEDERAL OFFICE BLDG.
LITTLE ROCK, ARK. 72201

SOIL CONSERVATION SERVICE

Develops and carries on a soil and water conservation program in cooperation with landowners and operators and with other agencies of government—Federal, State, and local. Formulates plans and designs for land use to conserve soil and water resources and reduce damage by floods and sedimentation; provides in-the-field technical assistance in reducing soil erosion; provides information and assistance concerning drainage, irrigation, watershed protection, and flood prevention. "Small Watershed Projects" under Public Law 566 can be established by soil conservation districts, or other local groups in cooperation with the Service for flood prevention, agricultural phases of water management, and water supplies for municipal and industrial use, recreation and fish and wildlife development.

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE
FEDERAL OFFICE BLDG.
LITTLE ROCK, ARK. 72201

DEPARTMENT OF COMMERCE



ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION WEATHER BUREAU

Collects and disseminates meteorologic and hydrologic informatio and forecasts for the benefit of commerce, agriculture, navigatio and the general public in water management. Makes measure ments of precipitation and temperature from a network of abo 100 stations in Arkansas and at some stations makes observatio on evaporation, humidity, wind, snowfall, soil temperature, dev point, barometric pressure, sunshine, and sky cover. Furnishe information on past, current, and forecasted stages of the Arka sas, Mississippi, and White Rivers at key stations and warns of in pending floods.

WEATHER BUREAU OFFICE
U.S. DEPARTMENT OF COMMER
MUNICIPAL AIRPORT
LITTLE ROCK, ARK. 72202

BUREAU OF PUBLIC ROADS

Does research in hydrology as it affects highway structures. Provides assistance to State agencies in the preparation of hydraulic design manuals. In cooperation with the State Highway Department the Bureau conducts research in hydraulics of small watersheds as related to highway structures, channels, drainage, runoff, and erosion.

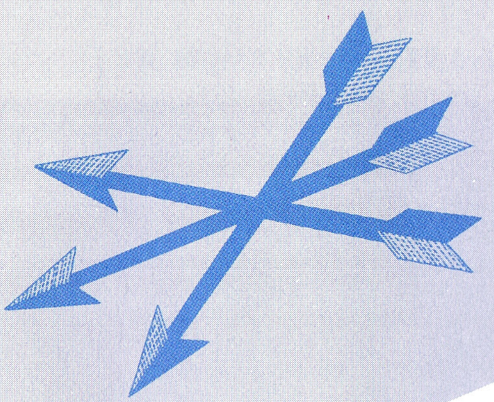
BUREAU OF PUBLIC ROADS
U.S. DEPARTMENT OF COMMERCE
FEDERAL OFFICE BLDG.
LITTLE ROCK, ARK. 72201

OTHER AGENCIES

Other Department of Commerce agencies concerned with wate Arkansas include the Coast and Geodetic Survey which provi charts and related information for safe navigation, establishes h zontal and vertical control for engineering and scientific purpo the Area Redevelopment Administration which authorizes lo for commercial facilities, and loans and/or grants for public facili

COAST AND GEODETIC SURVEY
U.S. DEPARTMENT OF COMMERCE
RM. 1006, WASHINGTON SCIENCE CENTER
ROCKVILLE, MD. 20282

AREA REDEVELOPMENT ADMINISTRAT
U.S. DEPARTMENT OF COMMERCE
U.S. POST OFFICE AND COURT HOUS
LITTLE ROCK, ARK. 72201



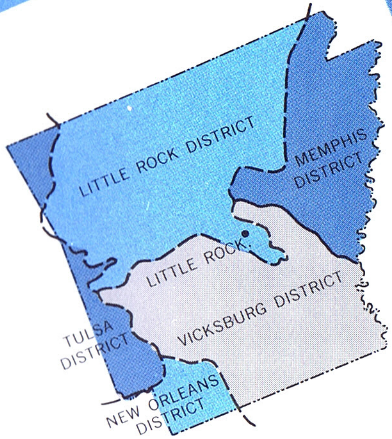
PUBLIC HEALTH SERVICE

Concerned with water quality as related to public health; establishes recommended standards for quality of water used on interstate carriers.

U.S. PUBLIC HEALTH SERVICE
1114 COMMERCE STREET
DALLAS, TEX. 75202

DEPARTMENT OF ARMY CORPS OF ENGINEERS

Designs and operates water structures for flood control, hydroelectric power, navigation, recreation, fish and wildlife, drainage, flow augmentation, bank and channel stabilization, and water supply. Information is developed on design and operation of water structures including streamflow records, logs of borings, records of wells and water levels, chemical quality of surface and ground water, sediment of streams, geologic and topographic maps, and river channel profiles and cross sections. In Arkansas the Corps of Engineers is represented by five District offices with the Little Rock District and Vicksburg District being charged with most Corps activities in the State.



LITTLE ROCK DISTRICT
U.S. ARMY CORPS OF ENGINEERS
FEDERAL OFFICE BLDG.
LITTLE ROCK, ARK. 72201

TULSA DISTRICT
U.S. ARMY CORPS OF ENGINEERS
P. O. BOX 61
TULSA, OKLA. 74102

MEMPHIS DISTRICT
U.S. ARMY CORPS OF ENGINEERS
FEDERAL OFFICE BLDG.
MEMPHIS, TENN. 38103

VICKSBURG DISTRICT
U.S. ARMY CORPS OF ENGINEERS
P. O. BOX 60
VICKSBURG, MISS. 39181

NEW ORLEANS DISTRICT
U.S. ARMY CORPS OF ENGINEERS
P. O. BOX 60267
NEW ORLEANS, LA. 70160

INDEPENDENT AGENCIES

FEDERAL POWER COMMISSION

Issues licenses to non-Federal interests, public and private, for hydroelectric power development, makes river basin planning surveys, maintains estimates of power resources, participates in interagency activities, and advises construction agencies on power matters, makes headwater benefit studies and determines payments to be made on account of such benefits, allocates the cost of certain Federal multiple-purpose projects, and approves the rates for all power produced at Federal hydroelectric projects in Arkansas.

FEDERAL POWER COMMISSION
289 UNIVERSITY PLAZA BLDG.
100 NORTH UNIVERSITY DR.
FORT WORTH, TEX. 76107

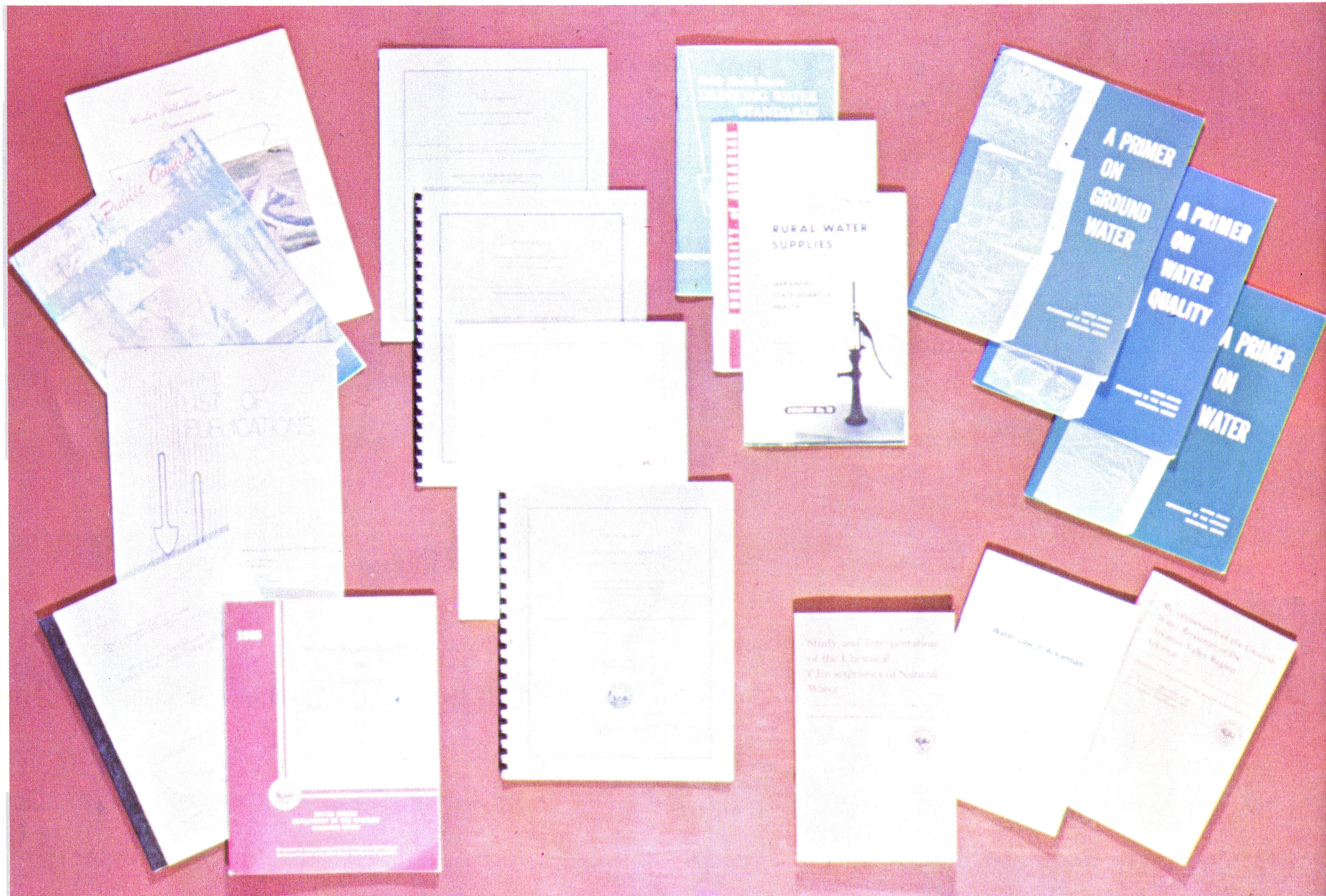
HOUSING AND HOME FINANCE AGENCY

COMMUNITY FACILITIES ADMINISTRATION

Makes arrangements for loans and grants to legally authorized municipalities for development of water supplies and sewage disposal systems.

HOUSING AND HOME FINANCE AGENCY
FEDERAL OFFICE BLDG.
LITTLE ROCK, ARK. 72201

MORE INFORMATION.....



THE FOLLOWING REPORTS ARE RECOMMENDED FOR MORE INFORMATION ABOUT BASIC WATER FACTS, PRINCIPLES, AND PROBLEMS.

A PRIMER ON WATER, by L. B. Leopold and W. B. Langbein: U.S. Geological Survey special report, 56 pages.

A PRIMER ON GROUND WATER, by H. L. Baldwin and C. L. McGuinness: U.S. Geological Survey special report, 26 pages.

A PRIMER ON WATER QUALITY, by H. A. Swenson and H. L. Baldwin: U.S. Geological Survey special report, 27 pages.

WATER FACTS FOR THE NATION'S FUTURE, USES AND BENEFITS OF HYDROLOGIC DATA PROGRAMS, by W. B. Langbein and W. G. Hoyt: 288 pages, Ronald Press Co., New York, N. Y., 1959.

NATIONAL WATER RESOURCES AND PROBLEMS, by R. E. Oltman and others: U.S. Senate (86th Congress, 2d session) Select Committee on National Water Resources, Committee Print 3, 42 pages.

THE ROLE OF GROUND WATER IN THE NATIONAL WATER SITUATION, by C. L. McGuinness: U.S. Geological Survey Water Supply Paper 1800, 1121 pages, 1963.

THE OCCURRENCE OF GROUND WATER IN THE UNITED STATES, WITH A DISCUSSION OF PRINCIPLES, by O. E. Meinzer: U.S. Geological Survey Water-Supply Paper 489, 321 pages, 1923.

OTHER PUBLICATIONS REFERRED TO IN THIS REPORT AND SELECTED PUBLICATIONS ABOUT ARKANSAS' WATER RESOURCES ARE LISTED BELOW:

TEMPERATURE OF WATER AVAILABLE FOR INDUSTRIAL USE IN THE UNITED STATES, by W. D. Collins: U.S. Geological Survey Water-Supply Paper 520–F, 7 pages, 1925.

PUBLIC HEALTH SERVICE DRINKING WATER STANDARDS, revised 1962: U.S. Department of Health, Education, and Welfare, Public Health Service Publication No. 956, 61 pages, 1962.

STUDY AND INTERPRETATION OF THE CHEMICAL CHARACTERISTICS OF NATURAL WATER, by J. D. Hem: U.S. Geological Survey Water-Supply Paper 1473, 269 pages, 1959.

WATER RESOURCES IN ARKANSAS, by E. P. Mathews and others, Atlas, 1965.

CHANGES IN WATER LEVELS IN DEPOSITS OF QUATERNARY AGE IN NORTHEASTERN ARKANSAS, by R. O. Plebuch: U.S. Geological Survey open-file report, 9 pages, 1962.

GROUND-WATER TEMPERATURES IN THE COASTAL PLAIN OF ARKANSAS, by R. O. Plebuch: U.S. Geological Survey open-file report, 5 pages, 1962.

SURFACE-WATER RESOURCES OF ARKANSAS, by J. L. Saunders and G. A. Billingsley: Arkansas Geological and Conservation Commission Bulletin 17, 181 pages, 1950.

CHEMICAL QUALITY OF SURFACE WATERS OF ARKANSAS, 1945–1955, a summary by J. W. Geurin and H. G. Jeffery: Arkansas University Engineering Experiment Station Bulletin 25, 79 pages, 1957.

ARKANSAS' GROUND-WATER RESOURCES, by R. C. Baker: Arkansas Geological and Conservation Commission, Water Resources Circular 1, 16 pages, 1955.

GEOLOGIC MAP OF ARKANSAS, reprinted with highway overlay, 1949: Arkansas Geological and Conservation Commission, 1929.

A comprehensive bibliography of water and related reports for the State of Arkansas may be obtained by inquiry to the following:

Arkansas	
Geological Commission	U.S. Geological Survey
State Capitol	Room 2301 Federal Office Bldg
Little Rock, Arkansas 72201	Little Rock, Arkansas 72201

SAFE DRINKING WATER SHOULD MEE

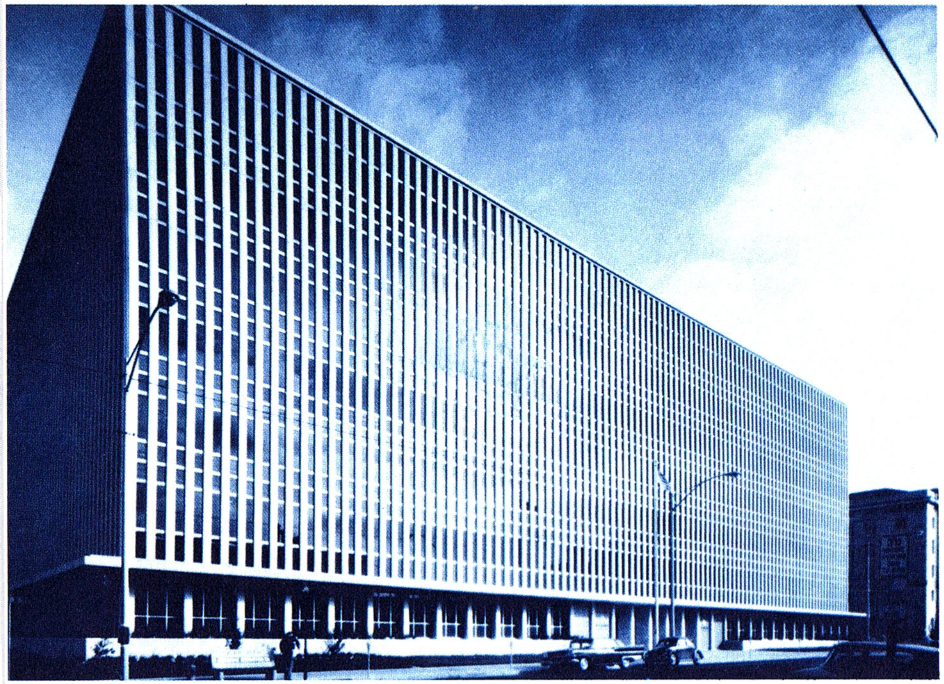
(U.S. Public Health Service, 1962, and Liquon, General Catalog G., 1950)

[The letters, ppm, used in the table are an abbreviation for parts per million and refer to the quantity of the substance in the water. For example, 1 pound of sugar dissolved in a million pounds of water would represent a sugar content of 1 part per million.]

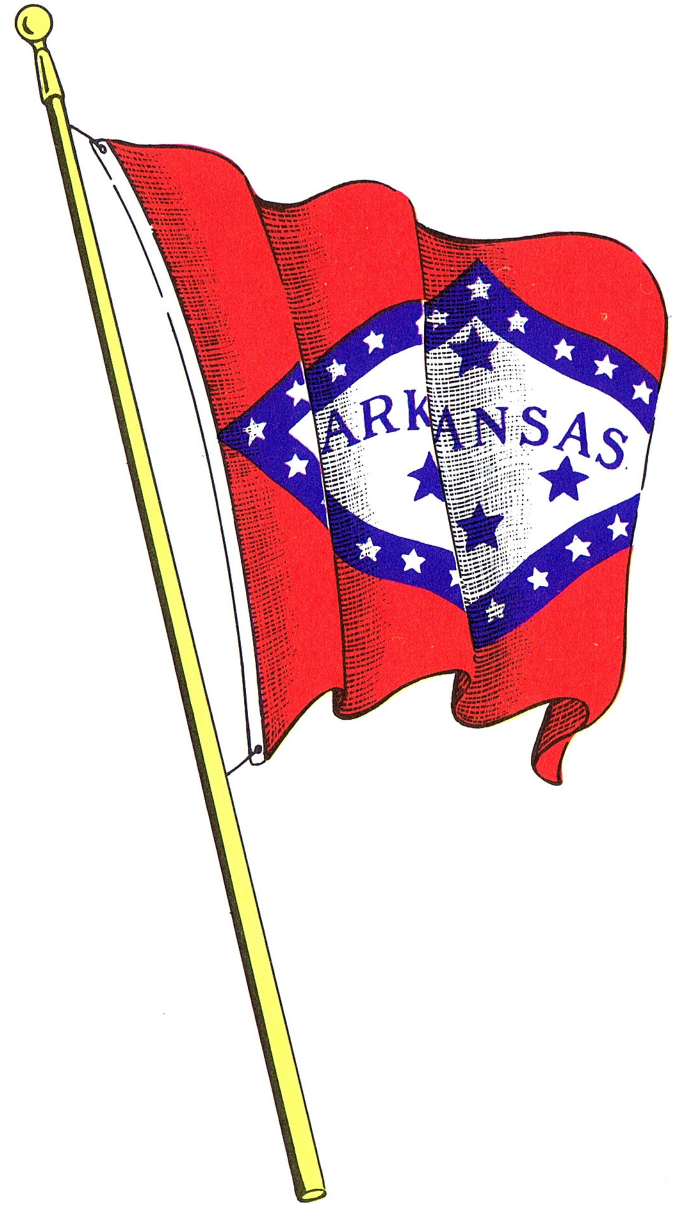
Name and symbol	Type of substance	Source or cause	Significance
Iron (Fe)	DISSOLVED SOLIDS	Dissolved from practically all rocks and soils. May also be derived from iron pipes, pumps and other equipment.	On exposure to air, iron in water oxidizes to reddish-brown sediment. More than about 0.3 ppm stains laundry and utensils reddish-brown. U.S. Public Health Service drinking water standards recommend 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 commonly associated with high iron content and with acid waters.	Same objectionable features as iron. Causes dark-brown or black stain. U.S. Public Health Service drinking water standards recommend that 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.	Causes most of the hardness and scale-forming properties of water; soap consuming (see hardness).
Sodium (Na) and Potassium (K)		Dissolved from practically all rocks and soils.	Large amounts, in combination with chloride, give a salty taste. High sodium content commonly limits 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 hot water facilities to form scale and release corrosive carbon-dioxide gas. In combination with calcium and magnesium cause hardness.
Sulfate (SO_4)		Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds.	Large amounts have a laxative effect on some people and, in combination with other substances, give a bitter taste. U.S. Public Health Service drinking water standards recommend that the sulfate content should not exceed 250 ppm.
Chloride (Cl)		Dissolved from rocks and soils. Present in large amounts in brines and sea water.	Large quantities increase the corrosiveness of water and, in combination with sodium, give a salty taste. U.S. Public Health Service drinking water standards recommend that the chloride content should not exceed 250 ppm.

CERTAIN CHEMICAL QUALITY STANDARDS

Name and symbol	Type of substance	Source or cause	Significance
Fluoride (F)	DISSOLVED SOLIDS	Dissolved in small to minute quantities from most rocks and soils.	Fluoride in drinking water reduces the incidence of tooth decay. However, it may cause mottling of the teeth. The maximum concentration of fluoride recommended by the U.S. Public Health Service for Arkansas is about 1.2 ppm, with 0.9 ppm considered the optimum concentration.
Nitrate (NO_3)		Decaying organic matter, legume plants, sewage, nitrate fertilizers, and nitrates in soil.	Nitrate encourages growth of algae and other organisms that produce undesirable tastes and odors. Concentrations much greater than the local average may suggest pollution. U.S. Public Health Service drinking standards recommend that nitrate content should not exceed 45 ppm, as there is evidence that higher concentrations may cause methemoglobinemia in infants, the so-called "blue-baby" disease, that sometimes is fatal.
Dissolved solids (total of all substances)		Chiefly mineral constituents dissolved from rocks and soils. Includes any organic matter.	U.S. Public Health Service drinking water standards recommend that the dissolved solids should not exceed 500 ppm. Waters containing more than 1,000 ppm of dissolved solids are unsuitable for many purposes.
Hardness as $CaCO_3$		In most waters nearly all the hardness is due to calcium and magnesium.	Consumes soap before a lather will form and deposits soap curd on bathtubs. Hard water forms scale in water heaters and pipes. In general, waters of hardness up to 60 ppm are considered soft; 61 to 120 ppm, moderately hard; 121 to 180 ppm, hard; more than 180 ppm, very hard.
Hydrogen ion concentration (pH)	Not a substance; rather it is a measure of the overall balance of substances dissolved in water.	Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, and phosphates raise the pH.	A pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals. May be used as a measure of the solvent power of water.
Oxygen (O_2)	GASES	Gases dissolved in water are derived from the atmosphere and decaying organic matter. Also, gases issue from the earth and may be dissolved in water. Aquatic plants and animals are an important source of oxygen and carbon dioxide.	Large amounts cause corrosion. Water should contain less than 0.005 ppm.
Carbon dioxide (CO_2)			Causes water to have a low pH; water with low alkalinity and containing large amounts of dissolved carbon dioxide will be corrosive.
Hydrogen sulfide (H_2S)			Gives the water an unpleasant "rotten-egg" odor. Water should contain less than 0.5 ppm.
Methane (CH_4)			Can cause fire and explosion hazard. Water should contain less than 1 ppm.



FEDERAL BUILDING, LITTLE ROCK, ARKANSAS



ARKANSAS STATE CAPITOL, ARCHITECTS GEORGE MANN AND CASS GILBERT. TREADWAY