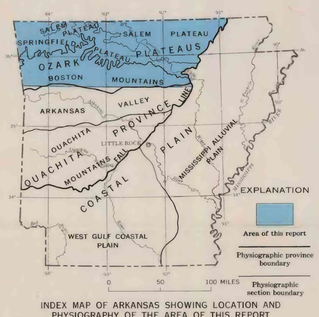
PREPARED IN COOPERATION WITH THE
ARKANSAS GEOLOGICAL COMMISSION

GROUND-WATER RESOURCES

INTRODUCTION

This hydrologic atlas deals with the water resources of the Ozark Plateaus province (Fenneman, 1938, p. 631) in northern Arkansas. (See index map.) The area is underlain by deeply dissected plateaus: the Salem Plateau, the Springfield Plateau, and the Boston Mountains. The Ozark Plateaus in Arkansas encompass all or parts of 22 counties for a total area of about 12,245 square miles.

The plateaus lie within the Arkansas and White River drainage basins. Tributaries to the Arkansas River drain the western and southwestern parts of the plateaus, about 27 percent of the area. The White River and its tributaries drain about 73 percent of the area. The White River, the largest stream in the area, originates on the northern slope of the Boston Mountains, flows northward into Missouri, and then back into Arkansas. On reentering Arkansas, it assumes a meandering southeastward course across the plateaus to the Coastal plain of Arkansas. Altitudes along the river course range from 2,500 feet above mean sea level in the Boston Mountains to 250 feet where the river leaves the plateaus.



INDEX MAP OF ARKANSAS SHOWING LOCATION AND PHYSIOGRAPHY OF THE AREA OF THIS REPORT

The climate of the plateaus is humid. The average annual precipitation ranges from 40 inches in the northern part to about 56 inches in the southern part. The precipitation is fairly well distributed throughout the year, but the seasonal maximum generally occurs in the months of April, May, and June. Only a small part of the average annual precipitation occurs as snow, and it is during the winter months that the seasonal minimum precipitation occurs. Temperature extremes normally range from about 0°F (-18°C) to 100°F (38°C), and the average annual temperature is about 60°F (16°C).

The plateaus are sparsely populated. Although the plateaus make up about 23 percent of the area of the State, the 1960 census shows that they contain only 226,000 inhabitants—about 13 percent of the State's population. The population is largely rural. In 1960 only five cities in the plateaus had populations that exceeded 5,000. These were: Fayetteville (20,274) in Washington County, Springdale (10,076) in Washington County, Harrison (6,580) in Boone County, Batesville (6,270) in Independence County, and Rogers (5,700) in Benton County. In recent years, however, the trend has been toward urban development; and the populations of these and other urban centers have increased.

The economy of the plateaus is based largely on agriculture and to a lesser extent on industry. Poultry and cattle are the chief agricultural products; but, locally, apples, peaches, and grapes are commercially important. Industry largely involves the processing and distribution of farm products; but the tourist industry has grown considerably in recent years, and is rapidly becoming a valuable part of the overall economy.

Water is a basic resource necessary for economic development of the Ozark Plateaus province. This atlas provides information on the occurrence, availability, and chemical quality of surface and ground water in sufficient detail to identify, locate, and describe the best potential sources of water. This study was made by the Water Resources Division of the U.S. Geological Survey in cooperation with the Arkansas Geological Commission.

GROUND WATER IN THE OZARK PLATEAUS

HYDROGEOLOGY

Geologic units that underlie the Ozark Plateaus consist mostly of limestone, dolomite, sandstone, and shale. On the basis of geologic and hydrologic similarity, the geologic units are combined into eight hydrologic units. (See hydrogeologic map.) Unit A, which is alluvium in the valley of the White River, is not a productive water-bearing unit because of its limited thickness and areal extent. The older hydrologic units consist of well-consolidated rocks, which dip south and become successively overlain by younger units in the dip direction. Ground water in units B-F occurs mostly in secondary openings such as fractures, joints, bedding planes, and solution channels. The secondary openings are more numerous near the surface and generally decrease in number and size with depth. Consequently, the quantity of ground water in the consolidated rocks generally decreases with depth. Wells in these units generally are less than 300 feet deep and yield less than 10 gpm (gallons per minute).

The water level in units A through F forms a subdued reflection of the land surface, and is closest to the land surface in the valleys. In the cavernous limestones and dolomites of hydrologic units D, E, and F, the water level intersects the land surface in many valleys and gives rise to springs and perennial streams. In the sandstones and shales of units B and C, ground water in some places occurs under artesian pressure, particularly where the rocks have been folded, and flowing wells may be obtained. Ground water may also occur in these rocks in a "perched" water table where a saturated and porous rock exists above the general water table. Perched water tables occur most often on mountaintops and ridges. However, both artesian wells and perched water tables are caused by local conditions and are uncommon.

Hydrologic units G and H, with outcrop areas in Missouri, occur only in the subsurface in northern Arkansas. These units consist largely of dolomite and sandy dolomite; but they also contain porous sandstone, which yields large quantities of water to wells in the northern part of the plateaus. Unit G (Roubidoux Formation) and the basal sandstone (Gunter Sandstone Member of Van Buren Formation) of unit H constitute the most productive water-bearing rocks in the plateaus. Where the maximum amount of available ground water is required, it is generally necessary to drill to the base of unit H, which generally lies from 500 to 800 feet below the top of unit G. Altitudes on the tops of unit G (Roubidoux Formation) and the basal sandstone (Gunter Sandstone Member) of unit H are shown on the structure contour maps of the units.

Throughout the northern part of the plateaus, water in units G and H is artesian and will generally rise in wells to within a few hundred feet of land surface. The approximate altitudes to which water will rise in wells that tap unit G and in wells that tap both units G and H are shown on the piezometric-contour maps. A comparison of the piezometric contours and the land-surface altitudes indicates that flowing wells may be obtained in some places from both unit G and unit H.

QUALITY OF GROUND WATER

Ground water is used without treatment for domestic supplies throughout most of the plateaus. The chemical type and prevalent dissolved-solids concentration of ground water in the rocks exposed in the Ozark Plateaus are shown on the quality-of-water map for these rocks. The quality of ground water at shallow depths in the plateaus generally is suitable for most uses, but water that is high in sulfide and sulfate occurs in the black shale (Chattanooga Shale) and phosphatic sandstone (Sylamore Sandstone Member) in area 2. Some wells in Benton and Washington Counties tap these rocks where they occur near the surface. These rocks generally are less than 70 feet thick and should be cased off when penetrated by a well. Locally, water from some shales and sandstone in area 3 contains excessive amounts of iron, sulfate, and sulfide, and one well contains a highly mineralized sulfate water unsuitable for drinking; but most of the ground water in area 3 is suitable for domestic use. Ground water in area 4 generally is low in dissolved solids, but may contain excessive amounts of dissolved iron.

The dissolved-solids content and hardness of water from wells in hydrologic unit G (Roubidoux Formation) and the basal sandstone (Gunter Sandstone Member) of hydrologic unit H are shown on the quality-of-water map for these units. Analyses of water samples from 23 wells show that water in hydrologic units G and H is a hard to very hard, calcium magnesium bicarbonate water and the dissolved-solids content ranges from 100 to 400 mg/l (milligrams per liter). No information is available on the quality of water in these units in the central and southern parts of the plateaus; but the water probably is highly mineralized in much of the southern part of the plateaus where these units are at great depths.

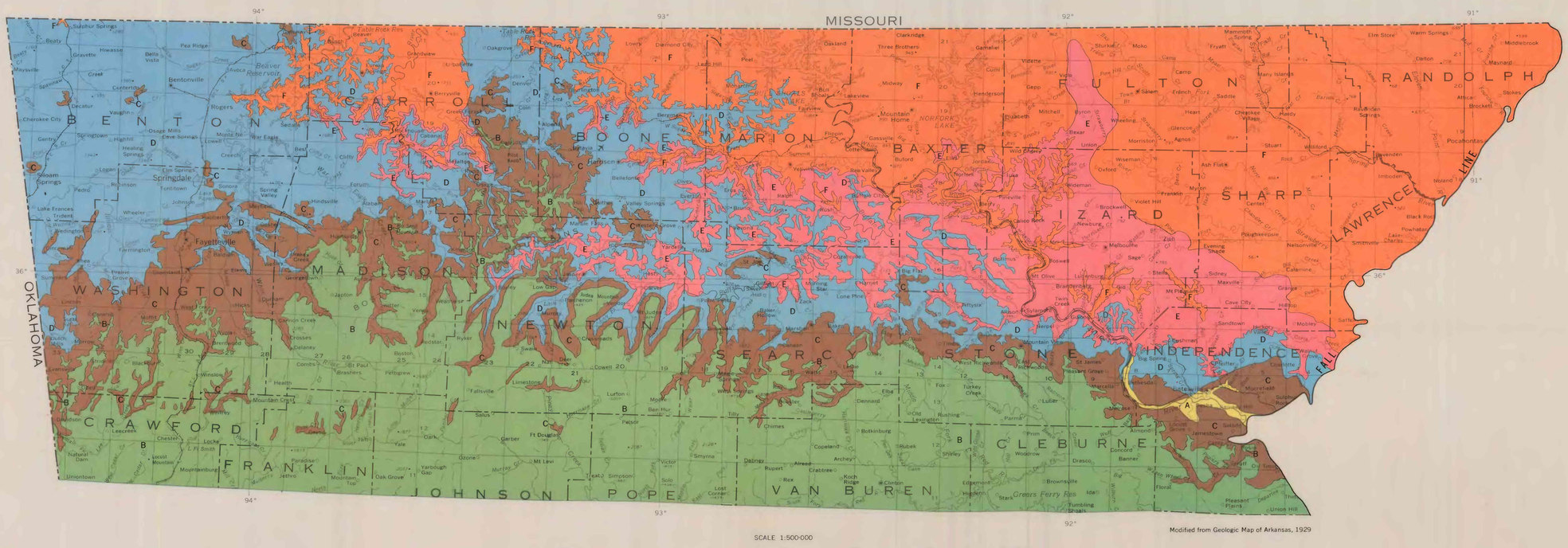
The chemical quality of water from 88 springs and wells in the Ozark Plateaus is summarized in the table below. Interpretation of this table indicates that the quality of ground water generally is suitable for most uses. The only constituent that commonly exceeds the limit recommended by the U.S. Public Health Service (1962) for drinking water on interstate carriers is iron as found in ground water from area 4.

Ground water is used extensively for domestic supply throughout the plateaus. Almost all the rural inhabitants depend upon ground water from units B-F, but a few domestic supplies are obtained from units G and H. Because of the expense involved in drilling wells to the deeper units, development of units G and H has been limited primarily to municipal, industrial, and agricultural supplies that require large quantities of water. Additional development of large ground-water supplies in the Ozark Plateaus rests primarily on the water-bearing properties of units G and H. With proper spacing and pumping practice, these units are capable of yielding water to a much greater number of wells. The water-bearing characteristics of units G and H have not been investigated in the central and southern parts of the plateaus.

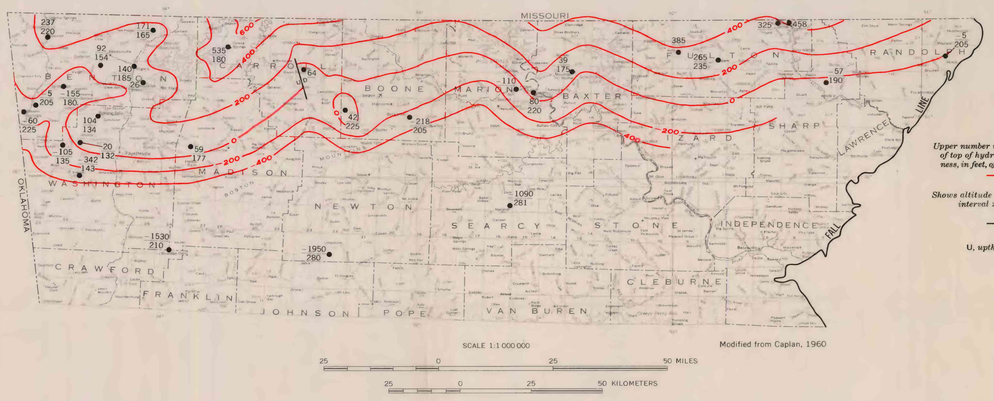
DESCRIPTION OF HYDROLOGIC UNITS

Hydrologic unit	Geologic units	Geologic age	Predominant rock types	Thickness (feet)	Water-bearing characteristics
A	Alluvium	Quaternary	Silt, clay, sand, and gravel.	0– 50	Unconsolidated deposits grading from silt and clay at the surface to gravel at the base. The sand and gravel probably can yield water to wells at a rate of 10 gpm, or more.
B	Hartshorne Sandstone Atoka Formation	Pennsylvanian	Shale, sandstone, and minor amounts of limestone and coal.	0–3,000	Yields small quantities of water to wells in the outcrop area. Water is derived from wells that tap the weathered zones, bedding planes, and fractured zones of the well-consolidated sandstone and shale. Although a few wells may yield as much as 25 gpm, most wells in this unit yield only from 1 to 3 gpm.
C	Bloyd Shale Hale Formation Pitkin Limestone Fayetteville Shale Batesville Sandstone Ruddell Shale Moorefield Formation	Mississippian	Shale, sandstone, limestone, and minor amounts of coal.	0–3,100	This unit consists primarily of shales and beds of sandstone and limestone. Locally, highly fractured zones and bedding planes may yield as much as 25 gpm, but at most places yields ranging from 2 to 5 gpm may be expected.
D	Boone Formation Chattanooga Shale Sylamore Sandstone Member Clifty Limestone Penters Chert	Mississippian Devonian	Limestone, chert, and minor beds of shale and sandstone.	0– 600	The residual cherty rubble, weathered from cherty limestones of the unit, commonly yields from 2 to 5 gpm. Many large springs occur in this unit, and some wells that tap large solution channels in the limestone yield more than 25 gpm.
E	Lafferty Limestone St. Clair Limestone Brassfield Limestone Cason Shale Fernvale Limestone Kimmswick Limestone Plattin Limestone Joachim Dolomite St. Peter Sandstone Everton Formation Jasper Member	Silurian Ordovician	Limestone, dolomite, sandstone, and minor amounts of shale.	0–2,000	The limestones and dolomites commonly yield from 5 to 10 gpm from solution channels, bedding planes, and fractures. Similar yields may be obtained from the sandstone where it is porous or fractured. This unit contains many springs. Yields from springs and some wells may exceed 50 gpm.
F	Black Rock Formation Smithville Formation Powell Dolomite Cotter Dolomite Jefferson City Dolomite	Ordovician	Dolomite, dolomitic limestone, and minor amounts of sandstone and shale.	100–1,000	The solution channels and fractures in the dolomite and dolomitic limestone commonly yield 5 to 10 gpm. Wells that tap large solution channels may yield more than 50 gpm, but large yields are uncommon. This unit yields water to several large springs.
Not exposed G	Roubidoux Formation	Ordovician	Sandstone and sandy dolomite.	100– 250	Yields of as much as 450 gpm may be obtained from some wells, but yields are highly variable and generally average less than 150 gpm.
Not exposed H	Gasconade Dolomite Van Buren Formation Gunter Sandstone Member	Ordovician	Dolomite, sandy dolomite, and sandstone.	350– 650	The most productive water-bearing rock in the area is the basal sandstone member of this unit. Wells that tap this sandstone commonly yield 150 to 300 gpm and may yield as much as 500 gpm.

A
B
Boundary of hydrologic unit



HYDROGEOLOGIC MAP



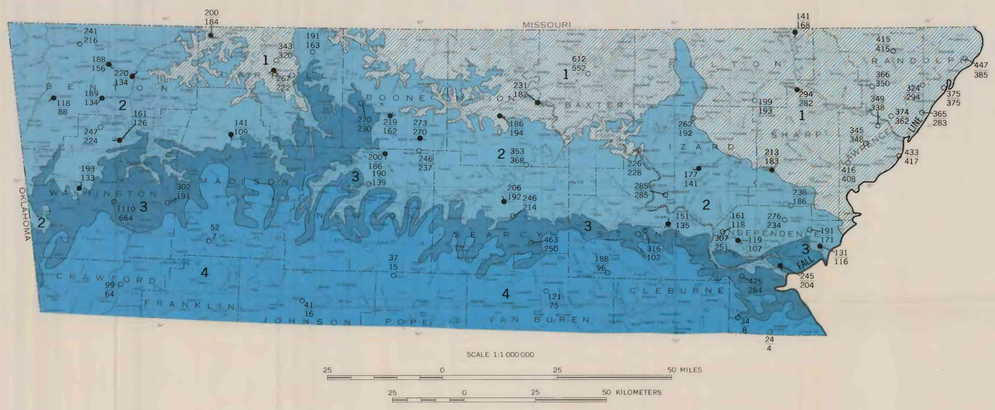
STRUCTURE-CONTOUR MAP OF HYDROLOGIC UNIT G (ROUBIDOUX FORMATION)

EXPLANATION

-218
205
Well location
Upper number is altitude, in feet above mean sea level, of top of hydrologic unit G. Lower number is thickness, in feet, of hydrologic unit G

400
Structure contour
Shows altitude of top of hydrologic unit G. Contour interval 200 feet. Datum is mean sea level

U
D
Fault
U, upthrown side; D, downthrown side



MAP SHOWING QUALITY OF GROUND WATER IN FORMATIONS EXPOSED AT THE SURFACE

EXPLANATION

213
183
Well
Upper number is dissolved solids, in milligrams per liter; lower number is hardness as $CaCO_3$, in milligrams per liter

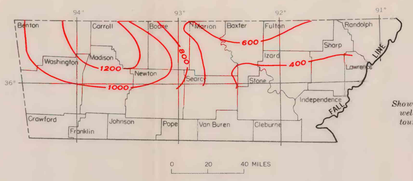
1
Calcium magnesium bicarbonate water with a dissolved-solids range of 100–650 mg/l. Moderately hard to very hard water with a hardness range of 100–550 mg/l. Generally coincides with hydrologic unit F

2
Calcium bicarbonate water with a dissolved-solids range of 100–400 mg/l. Moderately hard to very hard water with a hardness range of 80–400 mg/l. Generally coincides with hydrologic units D, E, and A

3
Calcium bicarbonate water with a dissolved-solids range of 200–1,200 mg/l. Moderately hard to very hard water with a hardness range of 100–700 mg/l. Generally coincides with hydrologic unit C

4
Calcium sodium bicarbonate water with a dissolved-solids range of 20–200 mg/l. Soft to moderately hard water with a hardness range of 0–100 mg/l. Generally coincides with hydrologic unit B

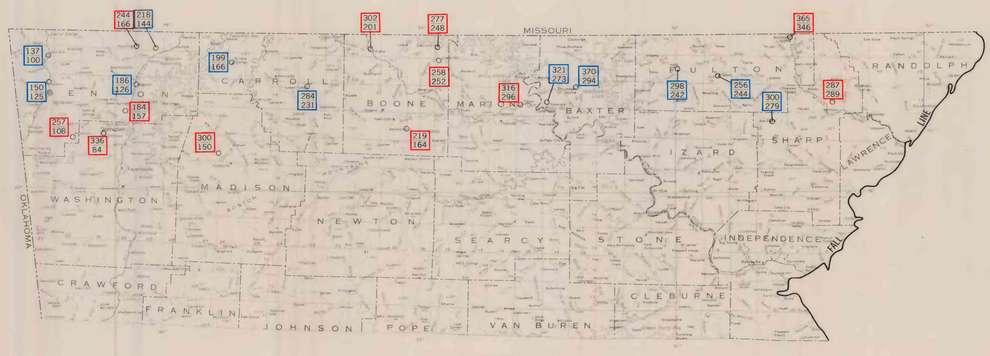
1
2
Area boundary



PIEZOMETRIC-CONTOUR MAP OF HYDROLOGIC UNIT G (ROUBIDOUX FORMATION)

EXPLANATION

600
Approximate piezometric contour
Shows altitude to which water would have risen in wells penetrating unit G in the Spring of 1968. Contour interval 200 feet. Datum is mean sea level



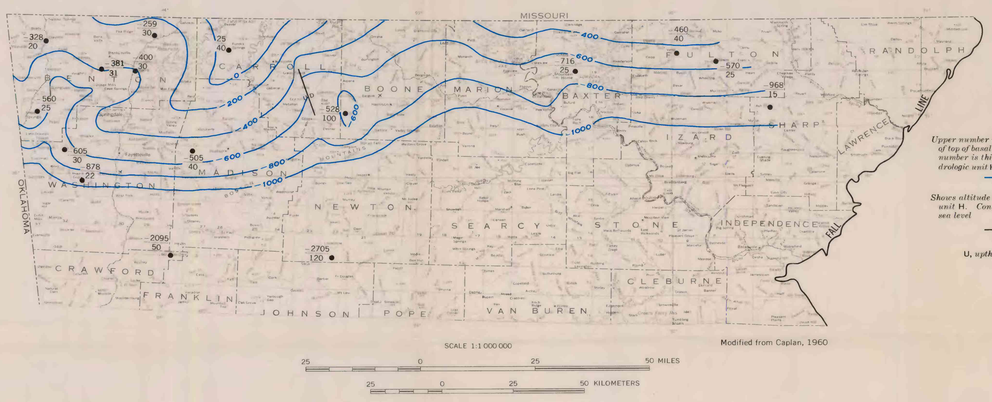
MAP SHOWING QUALITY OF GROUND WATER FROM HYDROLOGIC UNIT G (ROUBIDOUX FORMATION) AND THE BASAL SANDSTONE (GUNTER SANDSTONE MEMBER) OF HYDROLOGIC UNIT H

EXPLANATION

287
289
Well
Upper number is dissolved solids, in milligrams per liter; lower number is hardness as $CaCO_3$, in milligrams per liter

Sample collected from well tapping hydrologic unit G

Sample collected from well tapping both hydrologic unit G and the basal sandstone of hydrologic unit H



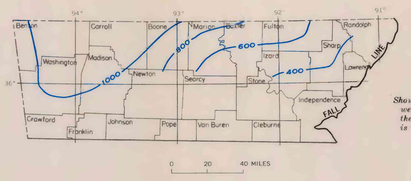
STRUCTURE-CONTOUR MAP OF THE BASAL SANDSTONE (GUNTER SANDSTONE MEMBER) OF HYDROLOGIC UNIT H

EXPLANATION

-400
30
Well location
Upper number is altitude, in feet above mean sea level, of top of basal sandstone of hydrologic unit H. Lower number is thickness, in feet, of basal sandstone of hydrologic unit H

Structure contour
Shows altitude of top of basal sandstone of hydrologic unit H. Contour interval 200 feet. Datum is mean sea level

U
D
Fault
U, upthrown side; D, downthrown side



PIEZOMETRIC-CONTOUR MAP OF HYDROLOGIC UNIT G (ROUBIDOUX FORMATION) AND THE BASAL SANDSTONE (GUNTER SANDSTONE MEMBER) OF HYDROLOGIC UNIT H

EXPLANATION

800
Approximate piezometric contour
Shows altitude to which water would have risen in wells penetrating both hydrologic units G and H in the spring of 1968. Contour interval 200 feet. Datum is mean sea level

SUMMARY OF CHEMICAL ANALYSES OF WATER FROM WELLS AND SPRINGS

[This table is a summary of the chemical analyses of 88 ground-water samples, 31 of which were analyzed by the Bureau of Environmental Engineering, Arkansas State Department of Health. Results expressed in milligrams per liter except specific conductance, pH, and color]

Chemical constituent or property	Area 1				Area 2				Area 3				Area 4				Roubidoux Formation of hydrologic unit G				Gunter Sandstone member of hydrologic unit H			
	Number of samples analyzed	Median concentration	Maximum concentration	Minimum concentration	Number of samples analyzed	Median concentration	Maximum concentration	Minimum concentration	Number of samples analyzed	Median concentration	Maximum concentration	Minimum concentration	Number of samples analyzed	Median concentration	Maximum concentration	Minimum concentration	Number of samples analyzed	Median concentration	Maximum concentration	Minimum concentration	Number of samples analyzed	Median concentration	Maximum concentration	Minimum concentration
Silica (SiO_2)	16	12	20	7.0	19	7.5	11	5.1	6	13	24	8.7	8	10	15	3.4	6	8.6	8.8	1.7	1	8.0		
Iron (Fe)	21	.10	1.3	.00	28	.02	.45	.00	8	.28	3.3	.00	8	.45	2.0	.00	10	.02	.48	.00	9	.20	3.6	0.00
Manganese (Mn)	21	.00	.71	.00	28	.00	.01	.00	8	.00	.90	.00	8	.04	.17	.03	9	.00	.00	.00	9	.00	.02	.00
Calcium (Ca)	21	69	101	26	28	52	105	33	8	77	177	29	8	4.0	24	.5	12	45	68	17	11	42	60	22
Magnesium (Mg)	21	36	71	5.2	28	2.5	38	.5	8	12	54	2.2	8	1.0	13	.6	12	24	44	10	11	30	38	9.4
Sodium (Na)	20	3.2	32	1.2	26	2.4	13	.9	7	14	54	4.0	8	2.5	26	1.1	10	6.0	82	1.0	11	5.0	29	1.0
Potassium (K)	20	1.4	7.4	.8	26	.8	16	.2	7	1.2	1.6	.2	8	.8	3.0	.3	10	2.2	3.2	.4	11	1.8	6.1	1.2
Bicarbonate (HCO_3)	21	344	498	171	28	200	426	104	8	292	446	236	8	30	121	2	12	284	361	189	11	268	383	152
Sulfate (SO_4)	21	4.4	124	.0	28	3.0	21	.0	8	17	520	4.0	8	3.2	14	.0	12	11	60	.0	11	10	24	1.2
Chloride (Cl)	21	4.2	25	1.4	28	4.6	17	1.5	8	12	33	4.5	8	2.2	66	1.2	12	3.8	44	1.5	11	3.0	11	.0
Fluoride (F)	21	.1	.3	.0	28	.1	.8	.0	8	.2	.9	.1	8	.1	.2	.0	11	.2	1.3	.0	9	.1	1.0	.0
Nitrate (NO_3)	16	3.7	21	.0	20	3.8	13	.0	6	1.0	5.1	.0	8	1.6	5.0	.2	7	.1	.4	.0	1	.0		
Dissolved solids	21	345	612	141	28	196	353	118	8	312	1,110	245	8	46	188	24	12	282	365	184	11	256	370	137
Hardness as $CaCO_3$:																								
Calcium, magnesium	21	320	522	168	28	162	368	88	8	240	664	102	8	16	96	4	12	184	346	84	11	231	294	100
Noncarbonate	21	10	151	0	28	7	63	0	8	10	423	0	8	1	50	0	12	0	37	0	11	3	27	0
Specific conductance (micromhos at 25°C)	16	581	932	320	19	364	622	192	6	478	1,390	408	8	65	352	21	5	502	549	332	3	439	469	360
pH	21	7.4	8.7	6.7	28	7.5	8.7	7.0	8	7.5	7.8	7.1	8	6.1	7.0	4.6	12	7.7	8.2	7.4	11	7.7	8.2	7.4
Color	16	0	3	0	19	1	7	0	6	1	5	1	8	1	1	0	7	1	5	0	1	8		

Base from U.S. Geological Survey 1:500 000
State base map, 1965

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1972—W70090

WATER-RESOURCES RECONNAISSANCE OF THE OZARK PLATEAUS PROVINCE, NORTHERN ARKANSAS

By
A. G. Lamonds

1972

For sale by U.S. Geological Survey, price $1.00 per set