THE LARGE SPRINGS OF MISSOURI

by

H. C. BECKMAN and N. S. HINCHEY

Vol. XXIX, Second Series

Prepared in Cooperation with the Water Resources Branch of the United States Geological Survey

1944

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Missouri Geological Survey and Water Resources
ROLLA, MISSOURI

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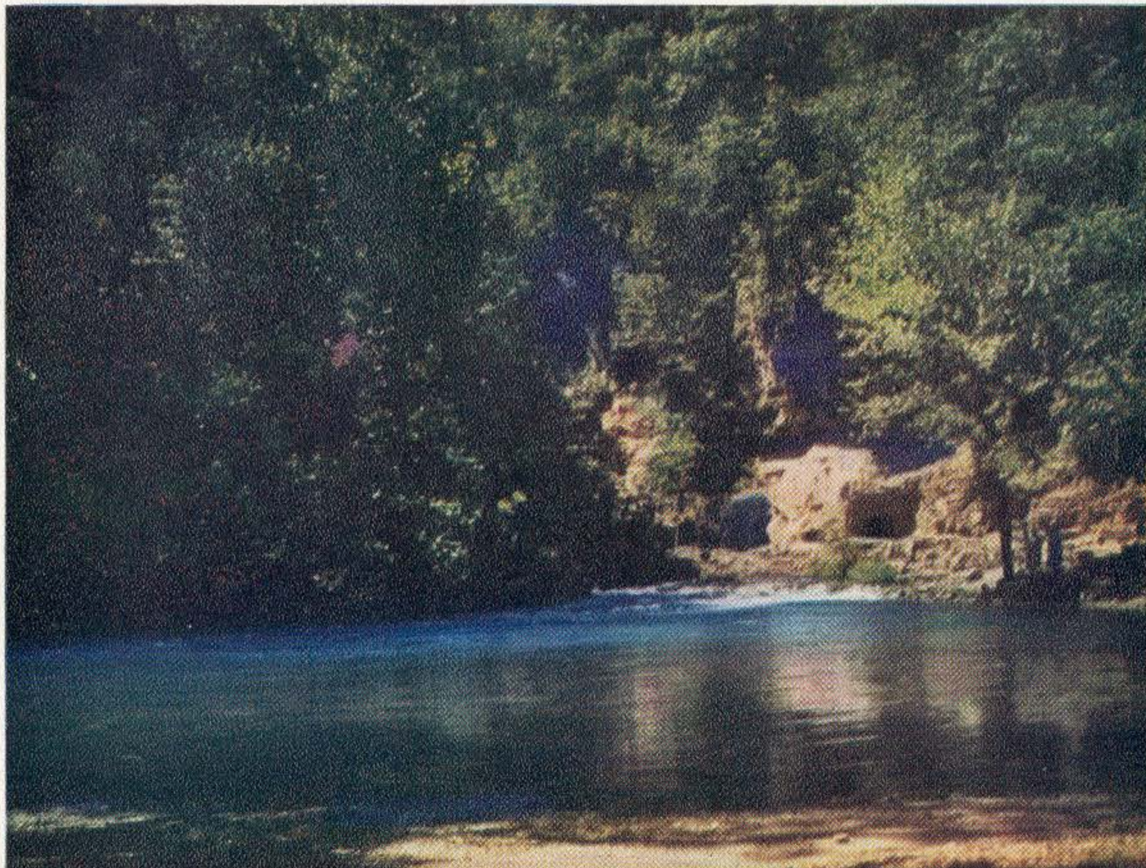
MID-STATE PRINTING COMPANY
Jefferson City, Missouri



(Photograph by O. R. Grawe, Missouri School of Mines.)

Big Spring, Carter County

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Honorable Forrest C. Donnell
Governor of Missouri
Jefferson City, Missouri

December 16, 1944

Dear Governor Donnell:

I have the honor and pleasure to transmit herewith a report on the Large Springs of Missouri by H. C. Beckman and N. S. Hinchey.

The data incorporated in this report have been compiled during the past 23 years. The report will be of particular value in the development of the recreational facilities of the State. The small pamphlet previously published by the Survey met with great demand and the supply soon became exhausted. Repeated requests for copies of this pamphlet led to the compilation of the data incorporated and the preparation of the report. This is the first comprehensive discussion and description of the springs and their waters.

It is believed that this report will be in great demand and will be very popular with the layman as well as the geologist and hydraulic engineer.

Respectfully submitted,

EDWARD L. CLARK, State Geologist.

CHAPTER I

Introduction

BEAUTY AND IMPORTANCE OF SPRINGS

The Ozark region of Missouri is noted for its many large and beautiful springs, some of which are among the largest in the United States and are really small rivers in themselves. The clear, cold, and sparkling water comes out of the rocks or the gravel beds in never-ending streams, many of which issue in wooded valleys at the base of high, rocky cliffs, where they are surrounded by rugged and picturesque landscapes. The fine supply of water for domestic uses and for propagating fish life, and the beauty of the surrounding scenery, are important factors in making this region such an attractive recreation area.

The phenomenon of such large volumes of clear, cold water issuing as springs amid rustic and picturesque surroundings, make places of wonder and rare natural beauty, which offer a lure and an inspiration to the nature lover and to the vacationist. They invite the people of the cities and the less scenic agricultural regions to come and view these extraordinary manifestations of nature, and to play, rest, and refresh themselves in a peaceful and inspiring environment. The springs are visited each year by thousands of tourists and pleasure seekers. Most of the springs can now be reached easily and in comfort by driving over well-improved State highways or over good all-weather roads.

So appealing to the popular fancy are the springs that several of the largest and most attractive ones—such as Big, Alley, Round, Bennett, and Roaring River Springs—have been acquired to serve as the principal features of State parks that bear their names, in order that the springs may be preserved as places of enjoyment for the people. Here the Missouri State Park Board provides special facilities to minister to the comfort and pleasure of the visitors, such as stoves for cooking, tables for picnics, and suitable sites for camping. Attractive cabins may be rented in or near the parks. The fisherman may practice his art on the spring branches and the streams into which they flow—streams which are stocked with trout and other game fish by the State Conservation Commission. In or near most of the parks are excellent facilities for swimming and boating. There is much to attract and please the visitor in the State parks which contain large springs. The same may also be said for many other beautiful springs outside the parks, although some may not be so readily accessible to the public.

The fine quality of the clear, cold water of the springs makes them sought as sites for cabins, club houses, and recreational hotels, as well as for farm homes. Besides furnishing domestic water supplies for these places, the springs also serve for cooling purposes to preserve and make more palatable such articles as milk, butter, fruits, and beverages, where other means of refrigeration are not readily available.

The springs make a valuable contribution to fishlife in the State. First, they provide favorable sites for fish hatcheries, a number of such hatcheries utilizing springs are maintained by the State Conservation Commission for raising trout, bass, and other game fish to be used in stocking the streams of the State; and some hatcheries are also maintained by private interests who raise fish to sell to the market. Second, by discharging relatively large quantities of clear, cold water into the creeks and rivers, the springs provide conditions in those streams that are the controlling factor favorable for the propagation and maintenance of certain game fish and aquatic life. This is particularly true for the small-mouthed bass. Were it not for the influence of the springs, these streams would become too small and too warm during the hot summer months to permit such fish to live and multiply. Through the presence of the many springs, Missouri excels in this type of fishing.

The remains of old grist mills along some of the spring branches are evidence of the importance which the springs played in the early settlement of the Ozark region. These sites today retain an historic charm, for they are enchantingly reminiscent of the activity of by-gone days when the mills were powered by the flow from rustic and picturesque springs.

The springs are indeed among the great natural assets of the State, ever ready to contribute to recreation, to the love of the beautiful in nature, and to the pleasure of the people.

PURPOSE OF REPORT

The principal purposes of this study and report upon the large springs of Missouri are to:

1. Supply information to meet innumerable inquiries from tourists, pleasure seekers, persons seeking sites for cabins or country homes, and the general public,
2. Make visits to the springs more interesting, enjoyable, and informative,
3. Locate water supplies suitable for private and public use,
4. Enable interested parties to determine which springs are suitable for the propagation of trout and other game fish,
5. Make the information and records readily available to scientists who are engaged in the study of such phenomena and to teachers of science in the public schools of the State.

COOPERATION AND ACKNOWLEDGMENTS

The information contained in this report was collected by the Missouri Geological Survey and Water Resources, in cooperation with the Water Resources Branch of the United States Geological Survey, as an auxiliary part of the regular river-measurement program relating to water power, flood control, municipal and industrial water supplies, stream pollution, bridge design, and soil conservation. The Missouri State Park Board furnished the services of the gage readers for some of the springs in the State parks.

The writers wish to acknowledge assistance and valuable suggestions from Edward L. Clark, State Geologist of Missouri, and members of the staff of the State Geological Survey, and from the late H. A. Buehler, State Geologist until the time of his death in 1944. Josiah Bridge, formerly a member of the faculty of the Missouri School of Mines and Metallurgy and a part-time employee of the Missouri Geological Survey, but now with the United States Geological Survey, has long had an active interest in Missouri's springs. Bridge's observations and published accounts have been drawn upon by the authors in the preparation of the descriptions of several of the springs. O. E. Meinzer, W. L. Doll, and other members and former members of the United States Geological Survey have supplied data or criticism which has been most helpful. Grateful thanks are

due also to Noel Hubbard, of the Missouri School of Mines and Metallurgy, and to Walter H. Pohl, of the Missouri State Highway Department, for their kind permission to use photographs made by them. Gilbert L. Campbell, of the Missouri School of Mines and Metallurgy, has prepared some of the photographs for the report.

The senior author has directed the work of measurement of spring flows over a period of more than twenty years and has prepared this report with the assistance of the junior author, who has added data on the geology of the springs and the spring region.

SPRINGS SHOWN ON MAP

Spring	*Number*
Alley	68
Allgire	148
Althea	113
Amsden	81
Armstrong, East	149
Armstrong, West	150
Bartlett Mill	42
Beaver	23
Bennett	144
Big	101
Big	115
Big	128
Big	132
Blue	9
Blue	70
Blue	78
Blue	93
Blue	109
Blue	116
Blue	137
Blue	147
Blue Grass	3
Boiling	38
Boiling	60
Boylers Mill	159
Boze Mill	107
Brewer Bay	89
Brook	29
Brown	55
Brown	135
Bryant	121
Camp Beaver	126
Carter	84
Cave	64
Cave	100
Cave	141
Chesapeake	133
Clarkson	131
Clear	69
Clear	87
Cold	12
Collins	19
Conn	146
Coppedge	50
Cove	77
Creasy	40
Crystal	120
Crystal	125
Cullen	155
Davis	34
Dazey	85
Double	114
Ebb-and-Flow	67
Ebb-and-Flow	75
Eldorado	142
Elm	7
Elm	26
Evans	20
Falling	6
Falling	104
Falling	41
Famous Blue	145
Gaines Ford	32
Gang	76
Gollahon	36
Gravel	79
Gravois Mill	158
Greer	106
Hahatonka	154
Hall	140
Hazleton	58
Hearell	130
Highley	65
Hodgson Mill	117
Hopewell	13
Howes Mill	17
Indian	22
Jackson Mill	122
James	11
Jordan	99

Spring	*Number*
Keener	95
Kelly	127
King Bee	98
Kratz	8
Lake	54
Land	49
Lane	51
Leeper	90
Little Gaines Ford	33
Little Toronto	153
Lord	94
Lost	111
Lumlee	134
Mammoth	110
Markham	92
Martin	35
McCubbens	71
McDade	27
McIntosh	25
McMahon	129
Meramec	30
Midco	103
Mill	91
Mill	96
Mill Creek	86
Miller	48
Mint	18
Montague	136
Montauk	61
Morrow	156
Moulder	157
Onandaga	10
Ousley	45
Paxton	143
Paydown	31
Phillips	102
Piney	53
Pittman	88
Powder Mill	74
Prewett	56
Pulltight	63
Racing	14
Randolph	80
Reed	82
Reeds	123
Richart	28
Roaring	5
Roaring	24
Roaring	59
Roaring River	124
Rock	4
Rockbridge	119
Rolufs	37
Ross	97
Rott Road	2
Robidoux	43
Round	66
Rymer	72
Santa Fe	1
Schlight	39
Sequiota	139
Shanghai	44
Slabtown	57
Slater	73
Steelville	21
Stone Mill	47
Thomasson Mill	108
Toronto	152
Turner Mill	105
Warner Bay	83
Welch	62
Westover	15
Wet Glaize	151
Wilder	112
Wilkins	46
Winoka	138
Woodlock	16
Yancy Mill	52
Zanoni	118

Spring	*Number*
Santa Fe	1
Rott Road	2
Blue Grass	3
Rock	4
Roaring	5
Falling	6
Elm	7
Kratz	8
Blue	9
Onandaga	10
James	11
Cold	12
Hopewell	13
Racing	14
Westover	15
Woodlock	16
Howes Mill	17
Mint	18
Collins	19
Evans	20
Steelville	21
Indian	22
Beaver	23
Roaring	24
McIntosh	25
Elm	26
McDade	27
Richart	28
Brook	29
Meramec	30
Paydown	31
Gaines Ford	32
Little Gaines Ford	33
Davis	34
Martin	35
Gollahon	36
Rolufs	37
Boiling	38
Schlight	39
Creasy	40
Falling	41
Bartlett Mill	42
Roubidoux	43
Shanghai	44
Ousley	45
Wilkens	46
Stone Mill	47
Miller	48
Land	49
Coppedge	50
Lane	51
Yancy Mill	52
Piney	53
Lake	54
Brown	55
Prewett	56
Slabtown	57
Hazleton	58
Roaring	59
Boiling	60
Montauk	61
Welch	62
Pulltight	63
Cave	64
Highley	65
Round	66
Ebb-and-Flow	67
Alley	68
Clear	69
Blue	70
McCubbens	71
Rymer	72
Slater	73
Powder Mill	74
Ebb-and-Flow	75
Gang	76
Cove	77
Blue	78
Gravel	79
Randolph	80

Spring	*Number*
Amsden	81
Reed	82
Warner Bay	83
Carter	84
Dazey	85
Mill Creek	86
Clear	87
Pittman	88
Brewer Bay	89
Leeper	90
Mill	91
Markham	92
Blue	93
Lord	94
Keener	95
Mill	96
Ross	97
King Bee	98
Jordan	99
Cave	100
Big	101
Phillips	102
Midco	103
Falling	104
Turner Mill	105
Greer	106
Boze Mill	107
Thomasson Mill	108
Blue	109
Mammoth	110
Lost	111
Wilder	112
Althea	113
Double	114
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Hodgson Mill	117
Zanoni	118
Rockbridge	119
Crystal	120
Bryant	121
Jackson Mill	122
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Armstrong, West	150
Wet Glaize	151
Toronto	152
Little Toronto	153
Hahatonka	154
Cullen	155
Morrow	156
Moulder	157
Gravois Mill	158
Boylers Mill	159

CHAPTER II

General Information on Springs

LOCATION OF SPRINGS

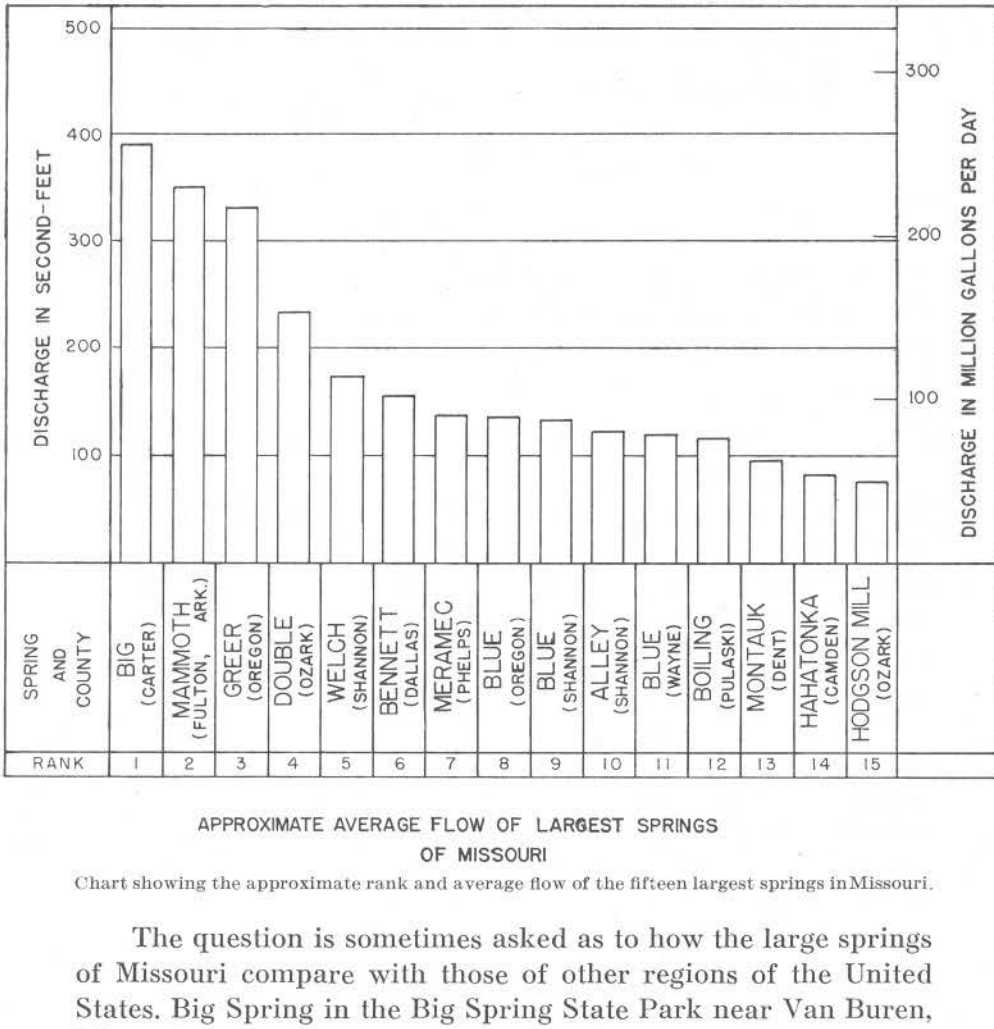
The large springs of Missouri are located in the Ozark region in the southern half of the State. A map showing the location and relative size of the springs is included here as plate I.

SIZE AND RANK OF SPRINGS

What constitutes a large spring? The answer to this question would vary in different localities. In many localities a spring with a flow of a million gallons per day would be regarded as being extraordinarily large, but this would not be true in Missouri, Florida, Oregon, or Idaho, which have springs with flows of more than a hundred times that amount. Perhaps it may be somewhat difficult for the average reader to get a clear conception of the size of a spring merely from statements of its flow in terms of gallons per day or second-feet (abbreviation for cubic feet per second), as hereinafter expressed. It may, therefore, help somewhat to say that the average flow of Big Spring in the Big Spring State Park near Van Buren, Missouri, during the past 20 years was large enough to supply the City of St. Louis.

Much interest attaches to the relative size of the springs of the State. Records of the flow of these springs as measured by the Missouri Geological Survey and Water Resources in cooperation with the United States Geological Survey are given elsewhere in this report. Daily records of flow, through a considerable period of time, have been obtained for only six of the largest springs, and only occassional measurements at different times have been made of the others. From these occasional measurements it is impossible to determine with exactness the relative size of the springs of the State, but on plate II are shown the approximate rank and average flow of the fifteen largest springs in the State.

MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES PLATE II



APPROXIMATE AVERAGE FLOW OF LARGEST SPRINGS OF MISSOURI

Chart showing the approximate rank and average flow of the fifteen largest springs in Missouri.

The question is sometimes asked as to how the large springs of Missouri compare with those of other regions of the United States. Big Spring in the Big Spring State Park near Van Buren, Missouri, is the largest spring in the Ozark region of Missouri and Arkansas, and practically the entire flow comes from a single outlet. Large springs exist in Florida, Idaho, California, Oregon, and Montana, but the larger ones consist of groups of spring outlets, some fairly close together and others rather far apart. From the information available, Silver Springs near Ocala, Florida, are the largest of this type. Most of the flow of Silver Springs emerges in a single pool, but considerable additional flow comes from other outlets a quarter of a mile or more downstream. Some measurements have been made of the flow from the upper outlet in the pool, but the information as to the average flow over a period of years is less definite and complete than is that for Big Spring in Missouri. The available records indicate that the average flow of Big Spring in Missouri is about equal to that from the upper pool of Silver Springs in Florida and that these two share the distinction of being the largest single-outlet springs in the United States, although the total flow of the Silver Springs group is considerably larger than that of Big Spring.

The following table shows the number of springs of first magnitude—that is, springs with a probable average flow of 100 second-feet (equal to 64,600,000 gallons per day) or more—in the various regions of large springs in the United States. The information has been extracted from a table in Water-Supply Paper 557, entitled "Large Springs in the United States", by O. E. Meinzer, published by the United States Geological Survey in 1927. The number of springs shown for the Ozark region of Missouri has been revised by the writers on the basis of more recent information.

NUMBER OF SPRINGS OF FIRST MAGNITUDE IN THE UNITED STATES

(Average flow of 100 second-feet or more)

Region	Number of springs
Snake River Basin in Idaho	15
Ozark region of Missouri (including Mammoth Spring just south of Missouri-Arkansas State line)	12
Florida and adjacent parts of Georgia and Alabama	11
Deschutes River Basin, Oregon	8
Sacramento River Basin, California	7
Willamette and Umpqua River Basins, Oregon	5
Balcones fault belt in Texas	4
Montana	3
Klamath River Basin, Oregon	2
Northern Alabama and adjacent areas	1
Interior basins of Oregon	1
Total in the United States	69

SOURCE OF SPRINGS

What is the source of the large springs of Missouri? Where do they derive such large quantities of clear, cold water? What physical causes and geological factors are involved in producing these extraordinary phenomena? These are questions which the inquiring mind is prone to ask.

The source of nearly all water on or under the surface of the earth is precipitation, either from rain or melting snow. A part of the water derived from rain and snow runs over the surface of the ground into nearby channels and is discharged into the creeks and rivers; and a part passes into the earth, either by infiltration into the soil or by passage through crevices in the rocks. Of the water that seeps into the soil or rocks, a part returns to the atmosphere through evaporation and the transpiration from trees or other vegetation, and a part percolates deeper to form the body of ground water, a portion of which feeds the springs and some of the surface streams during periods of dry weather.

But why does much of the ground water flow into the surface streams in large concentrations as springs in the Ozark region of Missouri instead of seeping imperceptibly into the streams throughout the entire course of their channels as occurs in most other parts of the country? What explanations may be given for these differences, and what are the causes and sources of the Missouri springs?

One repeatedly hears questions as to whether the springs may not come either (1) from the rivers themselves, through a part of the flow entering the ground and following an underground channel to the point of outlet, or (2) from distant sources of higher altitude, as from surrounding States, from the Rocky Mountains, or from the Great Lakes. The first of these possibilities is disproved by special series of flow measurements, including measurements of the springs themselves, made independently by the Geological Survey and the United States Army Engineers at numerous places along the Current River where some of the largest springs are located. These measurements show that there is no detectable decrease in the flow of Current River, such as would be necessary to produce the volume of water flowing from any of the large springs. However, it should be pointed out that there are localities in the Ozarks where small streams of water enter the ground through solution sinkholes located in the stream bed. The second possibility is denied by the geologic structure of the region. The Great Lakes are at a lower elevation than are the outlets of many Missouri Springs, which factor alone would make it impossible for those lakes to be a source of such spring flow. Observations in the spring area itself give the best clues to the source of the water which supplies them.

As described more fully later in this chapter under the headings "Geology of Spring Region" and "Flow Characteristics of Springs", there can be found in the areas surrounding or adjacent to most of the large springs either or both of the following conditions: (1) large areas of porous surface material, such as gravel and poorly consolidated residual stony soil and subsoil; and (2) many large depressed areas with no surface drainage outlets, known as "sinks" or "sinkholes". These surface conditions are conducive to the collection of large parts of the precipitation into the many large solution channels in the underlying rocks, thus forming large underground streams that discharge at the spring outlets. This view that the spring water is derived from relatively nearby sources is confirmed by the quick increase in the flow of the springs in response to rainfall in those localities, as shown on plate III, and also by the tendency of the water to become somewhat turbid after such rains—thus indicating some rather direct surface connections through crevices, solution channels, and similar interconnected openings which serve as water conduits through the bedrock layers. In an appreciable number of instances, witnesses have reported clear evidence of connections between surface and subsurface drainage. Such reports tend to substantiate beliefs of the existence of water routes between certain sinks or streams at the surface and nearby large springs. Several of these accounts have been detailed elsewhere in this report, under the description of the individual springs involved; and the interested reader is referred particularly to the descriptions of Alley Spring (Shannon County), Mammoth Spring (in Arkansas near the Missouri State boundary), Roaring River Spring (Barry County), Big Spring (Carter County), and Hahatonka Spring (Camden County).

W. L. Doll[1] of the Geological Survey attempted through field observations and rainfall-runoff studies to outline the areas from which many of the large springs of Missouri derive their flow. In view of the fact that some of these areas extend beyond the surface divides of the river drainage basins in which

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[1]Doll, W. L., "Hydrography of the Larger Springs of the Ozark Region of Missouri": unpublished thesis submitted to the School of Mines & Metallurgy of the University of Missouri, Rolla, Mo., 1938.

the spring outlets are located, he came to the conclusion that underground stream piracy so resulted. Although considerable uncertainty must be attached to the exact boundaries of the areas that feed the springs, it is reasonably conceivable that these areas may extend somewhat beyond the surface divides between the drainage basins, and that some piracy does exist.

GEOLOGY OF SPRING REGION

The large springs of Missouri are located in the portion of the State south of the Missouri River which is known as the "Missouri Ozarks"; most of them are in that part of the "Ozark Plateau" which has been designated the "Salem Plateau" (figure 1). The Ozark Plateau is a broad, gently-arched upland surface which extends across much of northwestern Arkansas and southern Missouri and which has been dissected by the streams and rivers that have incised their valleys into the flanks of this low asymmetrical, topographic dome, which is roughly

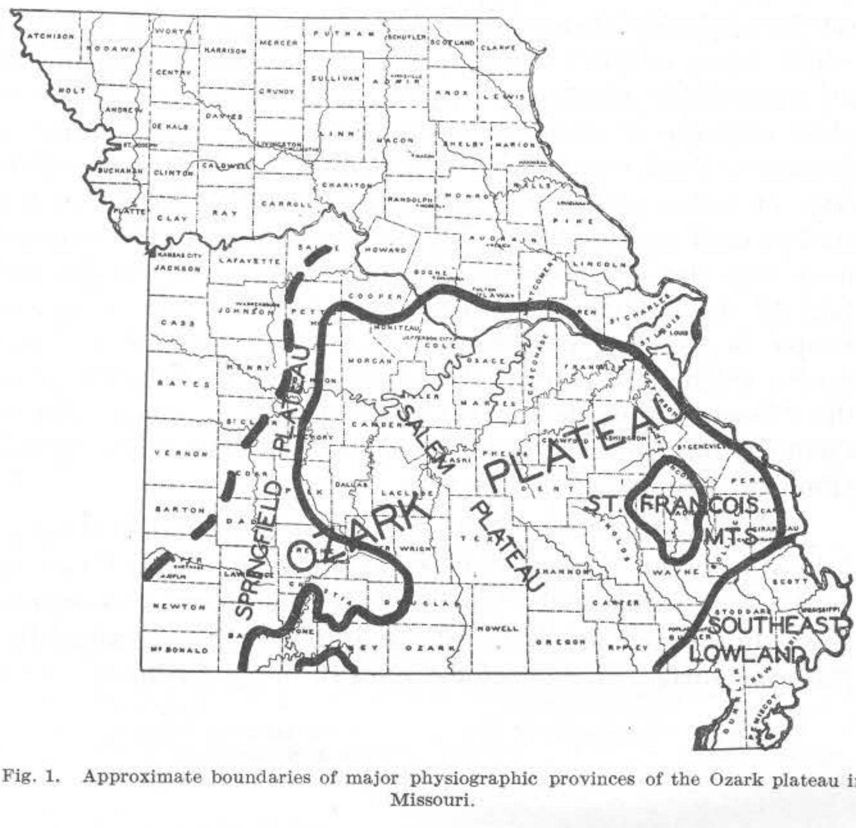

Fig. 1. Approximate boundaries of major physiographic provinces of the Ozark plateau in Missouri.

elliptical in outline. In general, the major axial "crest" of the upland trends in a roughly east-west direction in Missouri, from the St. Francois Mountains on the east, through Salem and Springfield, whence it curves through Barry County into northwestern Arkansas. Its flanks slope gently from its crest, with a somewhat steeper slope to the east and southeast than to the west and northwest.

The highest surface elevations on the plateau in Missouri are approximately 1700 feet above sea level. Such altitudes are reached by isolated remnants of the upland in the St. Francois Mountains, in Iron and Reynolds counties, southeastern Missouri; and near the common corner of Wright, Douglas, and Webster counties, in south-central Missouri. Much of the interstream, upland area of the plateau is well above an elevation of 1000 feet in the southern half of Missouri. Appreciably lower elevations exist in the valley areas where the major streams of the region have cut their drainage systems into the plateau. It is in the valleys of the streams, which have variously dissected the ancient plateau, that the great majority of the larger springs of Missouri are found; for at places the deep incision of erosion by major streams has encountered those subterranean main water conduits which supply the flow of the springs. Thus, we find most of the largest springs near or at the local valley floor levels of such rivers as the Meramec, Gasconade, Niangua, North Fork, Eleven Point, Current, Black, St. Francis, and other principal streams of the Ozark area which have cut down into the flanks of the topographic uplift.

The term "Salem Plateau" has been applied to that portion of the larger Ozark Plateau from which younger rock formations have been stripped away by processes of erosion, leaving a great area in the Missouri Ozarks in which the surface rock formations are chiefly of Ordovician or older age, with but few, scattered upland outliers of younger strata. The large springs are located in this region. In delimiting the Salem Plateau, one physiographer[1] has applied the name to that portion of the Ozarks where the surface rocks are Ordovician or older, and including remnants of younger sediments, but excluding the St. Francois Mountains. The plateau receives its name from the

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[1]Fenneman, N. M., Physiography of the Eastern United States, p. 647. New York, McGraw-Hill Book Co., Inc., 1938.

town of Salem, Dent County, which lies on the gently rolling upland of the plateau.

A few of the large springs (though none of the larger, first-magnitude ones) are located in that physiographic sub-province of the Ozark Plateau in southwestern Missouri which has been designated by workers[1] in Ozark physiography as the "Springfield Plateau". The surface of this sub-province is capped with Mississippian or younger sedimentary rooks and lies, in general, to the west of the larger Salem Plateau sub-province. As it has suffered less stream dissection than has the Salem Plateau, the Springfield surface is more readily recognized as a plain or plateau area. These two physiographic sub-divisions of the Ozark Plateau are thus unlike in their surface geology, and pertinent differences between them will be described briefly in this summary of the geology of the spring region.

The most abundant bedrocks of the Ozark Region in Missouri are dolomite (a magnesium rich limestone) and limestone. Each of these rocks contain various amounts of chert or sand at certain horizons. Sandstone is far less common among the indurated bedrock strata, though at places it makes up an appreciable part of the residual detritus which lies above the bedrock and beneath the soils. In the Salem Plateau area of the Ozarks, these Paleozoic marine sedimentary rocks are predominantly cherty dolomites or magnesian limestones of Cambrian and Ordovician age in a thick succession of beds which lies upon an ancient pre-Cambrian basement that is made up chiefly of granite and porphyry. In the Springfield Plateau area to the west, the Ordovician rocks are overlain by younger Paleozoic strata, and in much of that region the surface bedrock is limestone and cherty limestone of Mississippian age, capped at places with Pennsylvanian shales and sandstones. The larger springs in this latter area flow from the Mississippian limestones and cherty limestones or dolomites.

In the St. Francois Mountains, and at places in Shannon, Carter, and Reynolds counties, the pre-Cambrian igenous rocks protrude at the surface. Elsewhere in the Ozarks these pre-Cambrian basement rocks lie beneath the Paleozoic sedimentary

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[1]Fenneman, N. M., op cit., pp. 652-655, pl. VI.

Marbut, C. F., Physical Features of Missouri: Mo. Geol. Survey, vol. 10, ser. 1, pp. 11-109, 1896.

Purdue, A. H. and Miser, H. D., Eureka Springs and Harrison Quadrangles, Arkansas-Missouri: U. S. Geol. Survey Atlas, Folio 202, pp. 1-2, fig. 2, 1916.

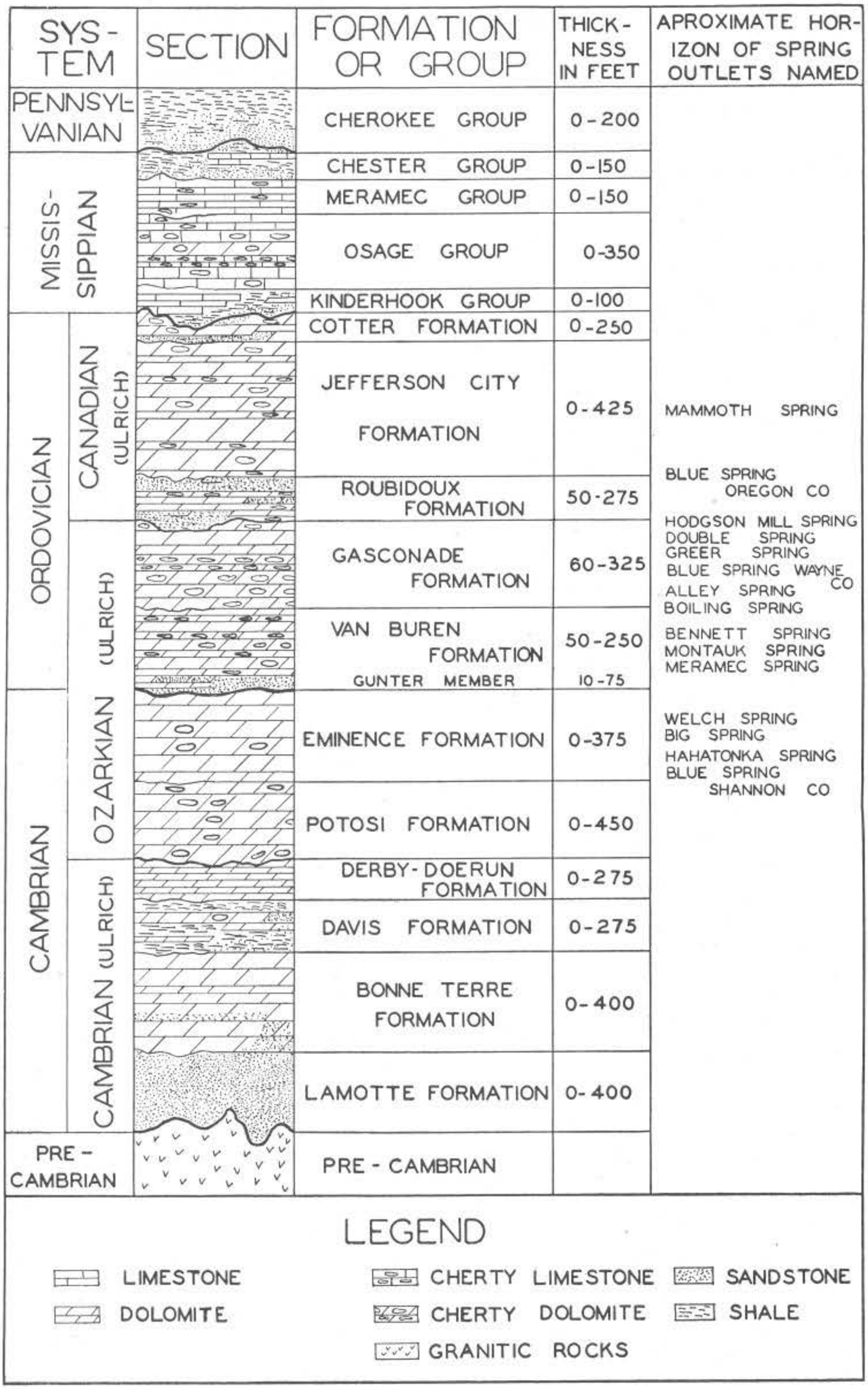


FIGURE 2. Generalized geological columnar section for the spring region.

strata at depths which in most places are probably less than 2500 feet. The accompanying, highly generalized, graphic columnar section (figure 2) gives a summary of the lithology and approximate thicknesses of the principal rock units of the area, and shows the name and the stratigraphic position of each of the Paleozoic formations which are mentioned elsewhere in this report.

In structure, the Ozark uplift in Missouri is a dome, but the dome is neither symmetrical in shape nor simple in its details of form. Local folding and faulting affect the attitude of the strata and make irregular bulges and depressions on the broadly and gently domed structure of the region. The structural uplift is perhaps most pronounced in the St. Francois Mountains area, which may be considered as the structural center of most pronounced doming, away from which the Paleozoic sedimentary formations dip. However, a prominent broad region of uplift, which has its center near the Lake of the Ozarks area in Camden County, makes a distinct structural bulge on the northwest flank of the dome. Other local distortions of the dome structure, as in the Shannon County area, are known to interrupt the regional inclination of the beds away from the structural center of the broad arching. In general, the Paleozoic beds dip much more steeply to the east and northeast from the St. Francois Mountain region toward the Illinois Basin area, than toward the west, northwest, or south of that center of doming.

The gentle regional dip, over the major part of the Ozark area, has produced a large structural province in which the beds are almost flat-lying or are only slightly inclined from a horizontal position. This attitude of the strata, the broad topographic uplift of the surface of the area, the gently rolling interstream uplands, the climate, and the predominantly calcareous nature of the surface and subsurface rock formations—all are factors which have contributed to making the region one in which nearly optimum conditions for the action of solution work have long existed. Thus underground drainage systems have been established in this humid region.

Uplift of the region has mechanically produced minute and narrow cracks, joints, and fractures in the bedrock. Part of the precipitation which falls on the ground percolates downward through the surface mantle of soil and residual material, reaches the upper surface of the bedrock, and starts dissolving the rock. This water which gets into the ground contains dissolved carbon dioxide and oxygen which it has acquired in its descent below the surface. In this condition the ground water acts as a weak but efficient solvent. The limestone and dolomite formations of the Ozark region are thus steadily attacked by the slow solvent action of the ground water which moves through open spaces, linking them together at places to increase the permeability of the rock; and enlarging any crevices, cracks, and joints which it enters by carrying away in solution the magnesium and calcium carbonate of the rock. Long-continued solution work by this slow process ultimately produces relatively large caverns, fissures, and channelways which may become an interconnected network of openings (figure 3).

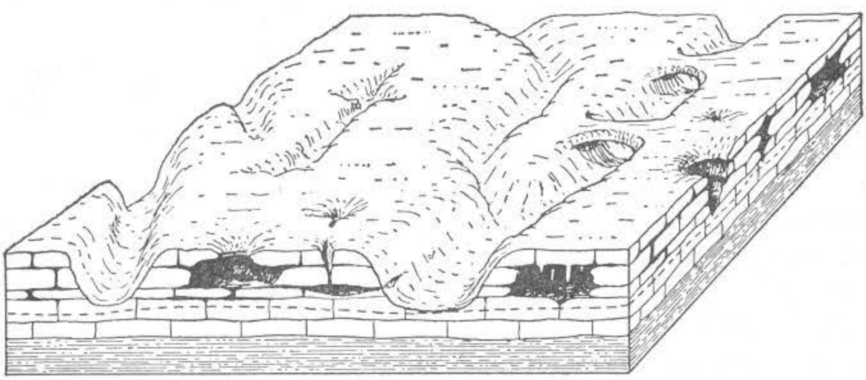


Figure 3. "Karst topography, showing caverns, sinks, solution valleys, and natural bridges. Dashed line represents water table." Reprinted by permission from "Outlines of Physical Geology" by Longwell, Knopf & Flint, published by John Wiley & Sons, Inc.
A diagram showing system of solution openings in near-surface bedrock.

The Ozark region of Missouri is noted for the many caves and caverns which have been discovered and explored, and one can readily believe that there are many more such underground openings which have not yet been seen by man. Well-drillers in the Ozarks report that the drill-bit not infrequently encounters such openings, many of which are water-bearing.

A cavern may become enlarged by solution in such a manner and to such an extent that its roof becomes so thinned that it is no longer able to support its own weight. The collapse of such a cavern roof produces vertical-walled surface sinkholes of a type that is known to many in this region. The pool area near the outlet of Round Spring in Shannon County is an example of this type of cavern. In a number of instances, individuals have reported the sudden formation of sinkholes at various places in this southern Missouri region. In some cases a gradual settling, rather than a sudden collapse, has apparently produced sinks. Bridge[1] has reported cases of sudden cavern collapse in Shannon County and in Gasconade County in recent years. Another type of sink may form simply by solution at or near the surface where ground-water percolation has enlarged a crack or fissure in the bedrock as it trickles downward. Further enlargement of the crevice may cause slow slumping or settling of the surface oil and residuum toward the crevice.

Many sinkholes are directly connected with present-day underground waterways. This relation is discussed in the descriptions of Mammoth Spring, Big Spring (Carter County), Hahatonka Spring, Roaring River Spring, and others. It is evident that most of the rainwater which falls into these enclosed depressions is discharged into the underground water system, and it is noteworthy that sinks are common in the vicinity of the large springs of the State.

Some of the "dry valleys' in the Ozarks are thought to contribute appreciably to the underground drainage. A number of these valleys "drain" a large surface area but carry a surface stream only for a short time after prolonged, heavy rainfall. The valleys are usually gravel-floored and water apparently sinks through this permeable gravel to flow along the underlying bedrock surface or into openings or solution channels in the rock. Prominent examples of such valleys are the Dry Fork and Asher Hollow in the vicinity of Meramec Spring (in Phelps County), Logan Creek in the vicinity of Blue Spring (in Shannon County), and Davis Creek in the vicinity of Big Spring (in Carter County). In some places, small streams flow above ground for a considerable distance and then disappear underground at places where their channels are choked with beds of gravel. As in the cases of River Cave at Hahatonka Spring and the Grand Gulf near Mammoth Spring, a large area may be seen to drain, through a surface valley, directly into an open sink in the bottom of that valley.

Prolonged solution work in the geologic past has removed much of the original dolomite and limestone at and near the

[1]Bridge, Josiah, Geology of the Eminence and Cardareva Quadrangles: Mo. Bureau Geol. & Mines, vol. 24, 2nd ser., pp. 42-43, 1930.

surface of the region. The slow, steady removal in solution of these more soluble carbonate rocks from parts of the upland has left behind the less soluble portions of the bedrock strata. Thus there has accumulated, on the upland surface over wide areas, great thicknesses of residual, unconsolidated rock material—chert, sandstone blocks and boulders, loose sand, clays, and similar less soluble rock debris which has lagged behind and escaped removal by the solvent action of ground water. In deep road cuts and other excavations, appreciable thicknesses of this material can be seen, and Ozark hillsides are commonly strewn with masses of chert boulders and pebbles and sandstone blocks. Water wells drilled at some places on the upland in the central Ozarks have been carried to depths of 100 or 150 feet in this detrital, residual material before the drill-bit encountered "solid", indurated bedrock. This porous, pervious residue, where it has accumulated to form a thick mantle over upland areas and in broad, flat valleys, serves as a medium through which surface water percolates and filters without great difficulty down to the subsurface bedrock with its network of interconnected solution openings.

Thus it is seen that the nature of surface and subsurface topographic and geologic conditions have been favorable for the development of an elaborate system of subsurface ground-water drainage in the area of the large springs of southern Missouri.

It is noteworthy that the top-ranking fifteen large springs of the State issue from rock formations which are composed chiefly of dolomite or cherty dolomite, or magnesian limestone, and which are notably cavernous at many places where they are seen to outcrop at the surface. Notations on the graphic columnar section (figure 2) indicate that nine of these fifteen largest springs rise in the Gasconade and Van Buren dolomites and cherty dolomites, and that four others issue from the Eminence dolomite. Examination of the State Geologic Map shows that most of the other large springs in the Salem Plateau area flow from these formations, especially from the Gasconade and Van Buren formations, though some issue from strata of the Cotter, Jefferson City, and Roubidoux formations. Springs in the Springfield Plateau region emerge from openings in the Burlington-Keokuk and Warsaw formations which are composed chiefly of limestone or cherty limestone. It must be borne in mind that these generalizations refer only to the large springs of the area.

As has been noted, most of the larger springs are located at or near the level of the valley floors of the Ozark rivers, where they have cut their channels into the flanks of the plateau. Most of the imperfectly drained, "karst" area of the large spring region, which lies northwest, west, and southwest of the St. Francois Mountain area, is capped with gently dipping or nearly flat-lying beds of dolomite, cherty dolomite, and sandstones. Where the major surface streams have cut their valleys down into the cavernous Gasconade and Van Buren formations, below the Roubidoux, the large springs flow out of these lower formations. A greater number of the large springs described herein flow from the Gasconade and Van Buren formations than from any other stratigraphic horizons. This numerical preponderance might well be expected, for these formations outcrop as the bedrock in the valley floors through long distances where major streams such as the Gasconade, Niangua, North Fork, Eleven Point, and other rivers have deeply incised the uplift.

Where the major streams have cut down into the Eminence or Potosi formations at places in Shannon, Reynolds, Wayne, and central Camden Counties, large springs discharge from openings in the Eminence and Potosi formations. Comparable topographic and geologic conditions exist in those areas in which large springs flow out of openings in the Roubidoux, Jefferson City, or Cotter formations of Ordovician age; or, in the Springfield Plateau region, out of formations of the Osage Group, of Mississippian age.

The dolomite and cherty dolomite formations of the Ozark region are known to be reliable producers of relatively large amounts of fresh water in deep wells in the area. This would indicate that these strata are permeable and open or cavernous in the subsurface zone of saturation below the level of the water table, as well as above that level. Some seasonal fluctuations of the elevation of the water table are known from water-well observations.

Evidence of rather direct connections between the springs and the surface in the general vicinity of their outlets has been mentioned. Although the springs have a steady flow through periods of drought, their immediate response to local rains is graphically portrayed by the accompanying illustration, plate III, which shows the rapid increase in the flow of Greer Spring after heavy local precipitation—a typical example of the effect of heavy, general rains in the vicinity of that large spring. A number of the springs increase in flow and become turbid within a few hours after heavy rains in the surrounding areas. The flow usually returns to "normal" within a few days after the precipitation ceases. These variations in flow are discussed further under the topic heading, "Flow Characteristics of Springs".

Although the flow of the large springs decreases somewhat during prolonged periods of dry weather, as illustrated for Greer Spring on plate III, the continuance of rather large flows through months of drought indicates a very large storage capacity in the solution channels forming the underground drainage system. This does not mean necessarily that the water is stored in one huge lake or reservoir; it is more probable that the storage is in many small cavities, pools, and streams.

The variation in the flow from such an underground storage system may be compared, in a crude way, to the flow of water from a large reservoir formed by a dam on a river or from an orifice near the bottom of a large tank. The higher the water stands in the reservoir or the tank the greater will be the rate of flow over the spillway of the dam or through the orifice in the tank due to the hydrostatic pressure. When the upper surface of the zone of ground-water "saturation" (water table) is high, during wet periods, the volume and head of water in the underground storage system is greater than during dry periods, when the water table is lower. Consequently, during wet periods the water in the underground openings rises to higher elevations, thus producing a higher rate of flow at the spring outlets. During dry periods the height of the water decreases, and the flow of the springs decreases accordingly.

As the surface streams into which the springs flow gradually erode their channels to lower elevations, the springs also accomodate themselves to this process by making new outlets at lower elevations and abandoning their former outlets. Visible evidence of the results of such action are the abandoned openings several feet above the present outlet of Big Spring in the Big Spring State Park (plate XI, B). The process apparently is in progress at Greer Spring, which has two distinct outlets—an upper outlet from the mouth of a cave, and a lower outlet from a cirular basin in the stream bed, 300 feet downstream and at an elevation 8 feet lower than the upper outlet. The upper outlet now carries an appreciable flow of water only during wet periods, and its flow becomes very small or ceases entirely during prolonged dry periods. In the course of time the upper outlet will be abandoned completely. Other springs in the Ozark area have abandoned higher outlets for lower ones as the stream valley in which the springs are located reached lower levels in the course of their down-cutting. The presence of dry and abandoned tubes and openings in the valley walls above present outlets are mentioned in the individual descriptions of several of the springs in Chapter III of this report. Attention may be directed particularly to examples presented in the descriptions of Alley Spring and Sequiota Spring and to the accompanying photographs which show abandoned outlets at and near the sites of those springs, plate VII, A and plate VII, B.

Recent work by Bretz[1] on caves and springs includes a discussion of the nature of various types of openings associated with the flow of ground water in limestone regions. In his paper Bretz states (p. 751) that "The Missouri big springs, the dominant visible feature of subterranean drainage in the Ozarks, are all discharges from below the water table . . . . . They are the result of 'lateral flow in the upper zones of the water-table' but this flow is below the lowest drought levels of that table." The rapid, great fluctuations in flow from many of the springs after heavy local rainfall is an indication that the discharge of lowest drought levels is appreciably augmented by a temporary increment of flow from levels above the water table of extreme and protracted drought. Broad seasonal variations in spring flow indicate seasonal fluctuations in the elevation of the variable water table in the vicinity of the springs.

In this sketch of some of the geologic features of the spring region, brief mention may be made of one or two of the minor structural features which are obviously associated with some of the springs. It is well known, for example, that jointing in the limestones and dolomite determines in part the course of flow of ground water in many areas. An obvious, visible example of such joint control may be seen at Sequiota Spring, Greene County. There, rather definite, approximately east-

[1]Bretz, J. H., Vadose and phreatic features of limestone caverns: Jour. Geol., vol. 50, No. 6, pt. II, 1942.

west and north-south intersecting joint systems show in the Burlington limestone where the spring emerges from a cave mouth. Following the course of this underground stream by boat into the cave, one is readily aware that the extension of the cavern follows a similar pattern in these same compass directions, with rather sharp, right-angle turns between the east-west and north-south course of the cavern which it has enlarged. Similar master control of cavern routes by joint patterns have been shown in a number of caverns which have been observed and mapped in detail.

Springs which have been produced as a result of faulting have been described by a number of geologists who have been concerned with the origin of springs. The location of some springs along faults and their intimate association with such geologic structures is well known. Probably very few Missouri springs owe their origin or location to faulting in the bedrock, but one obvious example of this type of spring is discussed below under the description of McDade Spring, in Crawford County. Detailed geologic mapping has shown that it is located at, or within a few feet of, the surface trace of a fault.

A number of the general observations given above, which sketch some of the features associated with the geologic setting of the large springs of the Missouri Ozarks, are amplified and supplemented later in this report—where the individual springs are described separately. The attention of the interested reader is referred particularly to the descriptions of the following springs: Alley, Shannon County (p. 48); Blue, Shannon County (p. 59); Big, Carter County (p. 54); Greer, Oregon County (p. 78); Hahatonka, Camden County (p. 81); Mammoth, Fulton County, Arkansas (p. 90); McDade, Crawford County (p. 92); Meramec, Phelps County (p. 94); Montauk, Dent County (p. 100); Roaring River, Barry County (p. 108); Round, Shannon County (p. 114); Sequiota, Greene County (p. 118); Turner Mill, Oregon County (p. 122); and Winoka, Greene County (p. 126).

CLIMATOLOGICAL DATA

The mean annual precipitation in the Ozark region of Missouri is about 43 inches, ranging from about 40 inches in the northern and western parts to 48 inches in the southeastern part. The amount of the precipitation in any particular year may, of course, differ appreciably from these figures.

The mean annual evaporation from a free water surface in this region is equal approximately to the mean annual precipitation.

The mean annual temperature of the region is about 56 degrees Fahrenheit.

FLOW CHARACTERISTICS OF SPRINGS

The flow of the large springs is extraordinarily uniform compared with that of ordinary surface streams. This is illustrated in plate IV, which shows a comparison of the flow of Greer Spring with the flow of the St. Francis River at Patterson for the periods indicated. The chart shows that during periods of high flow the discharge of the river is about five times as great as that of the spring, but that during periods of low water, such as in August 1936, it was only about one-tenth as large. The large amount of storage in the underground drainage system of the spring tends strongly to equalize the flow. Consequently, the flow of streams fed by many large springs, such as Current, Eleven Point, North Fork, and Niangua Rivers, is much more uniform than that of other streams in those regions which are not spring-fed to so large an extent.

Contrary to a commonly accepted opinion, however, the flow of the springs is not entirely uniform; and, as has been noted above, it fluctuates somewhat from season to season and year to year in accordance with the varying local rainfall. The relationship between the daily flow of Greer Spring, in Oregon County, and the daily rainfall in that region during the year ending September 30, 1935, is shown on plate III, which indicates that the flow increased sharply after the heavy rains of March 9-10 and June 1-3. Such an increase may be regarded as characteristic of the larger springs under such conditions. A rather extreme and unusual example of a large increase in the flow of a spring of medium size after a heavy rain is that of Roubidoux Spring, in Pulaski County, during August 1934. On August 3, during a severe and prolonged drought, the flow of the spring was measured as 5.3 second-feet, or 3,420,000 gallons per day; and 15 days later, on August 18, after very heavy rains on the two preceding days (a total of 5.82 inches having been recorded at Rolla, the nearest U. S. Weather Bureau station, 32 miles away) the flow was measured as 159 second-feet, or thirty times as great as that on August 3. The low flow of

August 3 probably continued until the start of the heavy rain on August 16, after which it increased rapidly to the amount measured on August 18. The quick response in the flow of these and other large springs to heavy rains in their vicinities, and the fact that after such rains the springs become somewhat turbid for a few days, proves that the springs do have some rather direct surface connections, which permit the ready entrance of some of the storm water into the solution channels in the underlying rock. Occasionally bits of floating debris, such as cornstalks, have been observed to pass from some spring outlets, but this is unusual.

The mean monthly discharge of seven large springs over a period of several years is shown on plate V. In the years 1927 and 1929 the rainfall was above normal, whereas 1934 and 1936 were affected by serious, prolonged droughts. The discharge of the springs reflected these differences in rainfall, but to a much smaller extent than did those surface streams which receive little of their flow from springs. Examples of the effect which large springs have upon the maintenance of stream flow during very dry periods are shown in the following table. (The reader is referred to page 48 of this report for a definition of terms used here):

COMPARISON OF FLOW OF STREAMS IN SEVERAL DRAINAGE BASINS OF MISSOURI DURING SEVERE DROUGHT OF AUGUST, 1936

River	Location	Drainage area sq. mi.	Mean flow		Approximate per cent of flow derived from large springs
			Sec.-ft.	Sec.-ft. per sq. mi.	
Eleven Point	Bardley	793*	199	0.251*	70
Current	Doniphan	2,038*	951	.467*	62
Current	Eminence	1,272*	405	.318*	59
Current	Van Buren	1,667*	551	.331*	59
St. Francis	Patterson	956	11.2	.012	0
Salt	New London	2,480	.18	.00007	0
Grand	Gallatin	2,250	7.1	.00320	0
South Grand	Brownington	1,660	0	0	0

*Revised figures superseding those published in Vol. XXVI, Second Series, and in Geological Survey Water-Supply Papers.

In this table of comparative flow, attention is at once attracted to the flow of the spring-fed Current River at Van Buren, Mo., and the flow of South Grand River at Brownington, Mo. The latter stream receives essentially none of its flow from springs. The drainage areas above each of these gaging points are very nearly the same size. While South Grand River at Brownington, Henry County, was showing no flow, the spring-fed Current River was discharging 551 cubic-feet (more than 4,000 gallons) per second at Van Buren, Carter County.

A question may arise as to the relationship of the size of springs to their altitude. For the three largest springs of the Ozark region the quantity of flow is in the reverse order of the elevation of the outlets above mean sea level—Big Spring near Van Buren, Mo., elevation 433 feet, is the largest; Mammoth Spring near Mammoth Spring, Ark., elevation 470 feet, is next largest; and Greer Spring at Greer, Mo., elevation 586 feet, is the smallest of the three. On the other hand, Bennett Spring at Bennett Springs, Mo., elevation 866 feet, is the sixth largest in the Ozark region, and is much larger than many other springs at substantially lower elevations. Blue Spring (Oregon County) and Blue Spring (Wayne County) are at elevations which are below 400 feet. The following list shows that sea level elevation obviously is not the controlling factor in the size of springs:

APPROXIMATE ELEVATION ABOVE SEA LEVEL OF LARGEST SPRINGS OF MISSOURI

Approximate order of size	Spring	County	Approximate elevation
1	Big	Carter	433
2	Mammoth	Fulton, Ark	470
3	Greer	Oregon	586
4	Double	Ozark	660
5	Welch	Shannon	790
6	Bennett	Dallas	866
7	Meramec	Phelps	780
8	Blue	Oregon	390
9	Blue	Shannon	560
10	Alley	Shannon	672
11	Blue	Wayne	340
12	Boiling	Pulaski	675
13	Montauk	Dent	930
14	Hahatonka	Camden	660
15	Hodgson Mill	Ozark	660

QUALITY OF SPRING WATER

The water issuing from the springs is usually very clear—often as clear as that from deep wells or as that used in the best city water supplies. After heavy rains the water sometimes becomes milky or turbid but usually clears within a few days.

The fact that many of the springs are named "Blue Spring" in itself implies the characteristic color of many of the springs. But when a glassful of the water is observed it looks very clear and shows no color. What is the cause of the blue hue when the water is in the spring basins? According to a summary of papers on the color of water, in a book on the properties of water by N. E. Dorsey of the U. S. Bureau of Standards, it is generally agreed that the color of pure water in a long column is blue. Departures from the blue color are attributed to the presence of foreign substances. The best explanation of the blue color of many of the Missouri springs seems to be the following: First, the water is very clear on account of the low content of suspended matter; second, the water in the basins is rather deep; and third, the basins are shut in by trees or rock bluffs so that the blue light of the sky strikes them from above. The relative clarity of the spring water in periods of normal flow is apparently due in part to natural filtration of the percolating water through porous soil and subsoil material; and in part to the fact that, during such periods, there is an opportunity for some settling of any suspended material in the subsurface openings which make up the underground reservoir for the spring flow. Turbidity after heavy rains is due to slight surging and flushing action through the surface material and in the underground reservoir.

Many observations over a period of years have been made of the temperature of the water in the large springs, and this has seldom been found to vary more than one degree from the average figure of 58 degrees Fahrenheit, regardless of the season of the year. This is very close to the mean annual temperature of the region, 56 degrees Fahrenheit, which indicates that the spring waters come from depths below those affected by seasonal changes in temperature.

Owing to the direct and indirect surface connections of most of the springs, as evidenced by their greatly increased flow and their tendency to become somewhat turbid after heavy rains, the danger of contamination from surface sources is always present. The possibility of such contamination and the diseases it may cause should be recognized by those who desire to use the springs for drinking purposes. Untreated spring water should not be used as a drinking water supply.

During 1925 and 1926, the Missouri Geological Survey made chemical analyses of samples of water from a number of springs in the State. The detailed results of those analyses were published in a pamphlet entitled "Chemical Analyses of River and Spring Waters" and are reprinted here in tabular form. The analyses show that, in general, the springs are not highly minerarlized and that the water is only moderately hard—not quite as hard as the water from deep wells in the Ozark region.

The following tables give the results of analyses of samples of spring waters collected from about 90 springs throughout the State. Where more than one analysis was made the average mineral content is given in a summary. The turbidity was determined in the laboratory of the State Board of Health, which department also made bacteriological examinations of samples collected by the Survey.

In each case a gallon sample was collected and in making the analysis the suspended matter was filtered out and determined. The results are expressed in parts per million. For the convenience of those who may desire the results in other forms, it may be stated that, for practical purposes, multiplying parts per million by 0.058 gives the equivalent in grains per U. S. gallon and multiplying by 0.070 gives the equivalent in grains per imperial gallon.

In the tables, the analyses of the springs are further classified according to drainage basins in which the springs are located. The locations from which samples were taken appear on one page with such information as is relevant, and the analyses appear on the page directly opposite. Each location is given a number which corresponds to the number of the analysis on the opposite page. The drainage basins and sources are arranged alphabetically.

The coefficient of fineness is the ratio of the suspended matter to the turbidity and is a measure of the size of the particles in suspension. Total hardness has been calculated as calcium carbonate from determined calcium and magnesium after the magnesium content has been calculated to calcium.

Alkalinity has been calculated as calcium carbonate from the carbonate and bi-carbonate radicals. The sum of constituents has been reported rather than the customary "total dissolved solids". It is equivalent to the latter designation in the usual analysis.

All samples were collected during the dry season unless otherwise stated. Figures showing flow of springs indicate that measurements were made the same day the sample was taken. Where the flow was not measured at that time the fact is designated by the letter (a).

The analyses were made by H. W. Mundt and W. D. Turner.

ANALYSES OF SPRING WATERS

Drainage basin.	No.	Spring.	Town.	County.	Sec.	T.	R.	Flow million gal. per day.	Date.	Remarks.
	1	Amsden	Centerville	Reynolds	19	31N	1E	1.6	Aug. 1, 1925	
	2	Carter	Piedmont	Reynolds	34	29N	2E	1.0	Aug. 1, 1925	
	3	Faulkenberry	Lesterville	Reynolds	16	32N	2E	.6	July 31, 1925	
	4	Keener	Keener	Butler	9	26N	5E	12.3	Aug. 3, 1925	
	5	Leeper	Leeper	Wayne	27	28N	3E	.3	Aug. 1, 1925	
Black	6	Markham	Williamsville	Wayne	23	27N	4E	4.8	Aug. 1, 1925	
	7	Mill	Mill Spring	Wayne	36	28N	3E	7.0	Aug. 1, 1925	
	8	Randolph	Ellington	Reynolds	20	30N	1E	.6	Aug. 1, 1925	
	9	Reeds	Centerville	Reynolds	28	32N	1E	4.9	July 31, 1925	
	10	Warner Bay	Lesterville	Reynolds	9	31N	2E	10.4	July 31, 1925	
	11	Summary of ten samples								
	12	Alley	Alley	Shannon	25	29N	5W	57.0	June 19, 1925	
	13	Big	Van Buren	Carter	6	26N	1E	283.0	Aug. 15, 1925	
	14	Blue	Eminence	Shannon	21	29N	2W	(a)	June 19, 1925	
	15	Montauk	Montauk	Dent	23	32N	7W	(a)	June 19, 1925	
Current	16	Phillips	Barren	Carter	10	25N	1E	5.7	Aug. 15, 1925	
	17	Pulltight	Ink	Shannon	4	30N	5W	(a)	July 27, 1925	
	18	Round	Owls Bend	Shannon	20	30N	4W	(a)	June 19, 1925	
	19	Welch	Cedar Grove	Shannon	14	31N	6W	(a)	June 19, 1925	
	20	Summary of eight samples								
	21	Blue	Alton	Oregon	16	22N	2W	43.0	Aug. 22, 1925	
	22	Boze Mill	Alton, 15 mi. E.	Oregon	16	23N	2W	8.4	Aug. 15, 1925	
	23	Graham	Thomasville	Oregon	31	25N	5W	.3	Aug. 15, 1925	
Eleven Point	24	Greer	Greer	Oregon	36	25N	4W	(a)	Aug. 13, 1925	
	25	Thomasson Mill	Couch	Oregon	16	22N	2W	17.0	Aug. 12, 1925	
	26	Turner Mill	Alton	Oregon	3	24N	3W	1.6	Aug. 15, 1925	
	27	Vaugt	Couch	Oregon	16	22N	2W	.4	Aug. 11, 1925	
	28	Summary of seven samples								
	29	Bartlett Mill	Waynesville	Pulaski	16	36N	12W	(a)	Aug. 6, 1925	
	30	Blue or Shanghai	Hooker	Pulaski	24	36N	11W	(a)	July 21, 1925	
	31	Boiling	Hooker	Pulaski	33	37N	10W	(a)	June 11, 1925	
Gasconade	32	Boiling	Licking	Texas	24	32N	10W	7.8	Aug. 14, 1925	
	33	Coppedge or Relfe	Relfe	Phelps	36	35N	10W	(a)	July 16, 1925	
	34	Creasy	Waynesville	Pulaski	16	36N	12W	(a)	Aug. 6, 1925	
	35	Falling	Waynesville	Pulaski	20	36N	12W	(a)	Aug. 6, 1925	

No.	Turbidity.	Coef. of fineness.	Total suspended matter.	Vol. suspended matter.	Non-vol. suspended matter.	Total hardness as $CaCO_3$.	Alkalinity as $CaCO_3$.	Sum of constituents.	Residue after ignition.	Silica. (SiO_2)	Iron. (Fe)	Calcium. (Ca)	Magnesium. (Mg)	Sodium and potassium. (Na)	Carbonate. (CO_3)	Bicarbonate. (HCO_3)	Sulphate. (SO_4)	Chloride. (Cl)	Nitrate. (NO_3)	Error, per cent.	No.
1	....	....	0.1	0.0	0.1	136.2	140.5	137.6	83.0	4.8	0.66	28.7	15.7	0.5	9.9	151.3	0.0	3.4	0.08	−3.0	1
2	0	....	1.3	0.6	0.7	166.7	176.2	175.9	169.0	8.6	0.22	37.3	17.9	2.2	12.9	188.5	10.6	2.9	0.72	−2.7	2
3	0	....	0.0	....	....	172.3	174.5	171.4	108.0	7.4	0.66	36.1	20.0	0.5	13.2	186.0	0.0	2.6	0.00	−1.3	3
4	0	....	0.5	0.2	0.3	163.1	168.6	173.0	140.0	13.8	0.59	33.6	19.3	1.4	12.9	179.4	0.0	3.2	0.51	−2.1	4
5	0	....	0.9	0.3	0.6	264.1	253.0	250.4	175.0	9.0	0.83	54.5	31.2	0.1	18.9	269.9	0.0	3.4	0.44	+1.1	5
6	0	....	2.6	0.6	2.0	176.8	192.1	210.3	171.0	21.2	0.21	38.2	19.8	7.1	11.7	210.4	5.3	3.2	0.17	−2.4	6
7	0	....	0.1	0.1	0.0	169.0	167.7	166.8	114.0	7.8	0.70	34.8	20.0	0.6	12.3	179.4	0.0	2.7	0.27	−0.3	7
8	0	....	2.6	0.6	2.0	155.7	170.2	168.7	156.0	6.0	0.24	35.4	16.4	2.5	10.5	186.0	1.4	2.7	2.17	−4.6	8
9	0	....	0.2	0.2	0.0	114.7	132.7	128.0	68.0	6.2	0.66	23.9	13.4	2.3	16.0	129.4	0.0	2.2	0.34	−6.5	9
10	0	....	1.0	0.6	0.4	133.8	134.5	134.0	84.0	7.4	0.77	27.6	15.8	0.0	7.8	148.2	0.2	2.2	0.00	−1.3	10
11	....	....	0.9	0.3	0.6	165.2	171.0	171.6	126.8	9.2	0.55	35.0	19.0	1.7	12.6	182.9	1.8	2.9	0.47	−2.5	11
12	5—	0.44	2.2	0.9	1.3	150.5	137.4	148.4	114.0	5.4	0.17	30.5	18.1	4.6	3.6	160.3	1.4	5.0	0.91	+4.6	12
13	0	....	0.6	0.3	0.3	192.1	185.0	187.7	109.0	6.0	0.36	39.9	22.5	4.9	0.0	225.2	1.0	2.1	0.31	+3.6	13
14	5—	0.06	0.3	0.1	0.2	145.6	141.7	146.0	150.0	5.6	0.32	29.2	17.7	3.8	5.6	161.4	0.4	3.7	0.54	+2.2	14
15	5—	0.34	1.7	0.6	1.1	151.2	148.0	152.9	98.0	2.4	1.33	31.3	17.8	5.2	7.8	165.4	0.2	4.8	2.05	+1.7	15
16	0	....	1.0	0.3	0.7	188.0	182.7	181.5	113.0	5.4	0.50	39.1	22.0	1.7	0.0	222.5	1.6	2.1	0.00	+1.2	16
17	0	....	0.6	0.0	0.6	158.2	157.5	157.7	103.0	7.4	0.25	32.6	18.7	1.4	2.1	187.8	0.4	2.2	0.53	0.0	17
18	5—	0.30	1.5	1.1	0.4	165.0	167.0	168.2	134.0	7.2	0.28	33.3	19.9	4.1	6.2	190.9	0.6	2.4	0.53	+0.6	18
19	5—	0.40	2.0	0.6	1.4	172.8	175.0	170.6	130.0	2.2	0.57	35.7	20.4	1.2	11.4	191.0	0.2	4.1	1.33	−2.0	19
20	....	....	1.2	0.5	0.7	165.4	161.8	164.1	118.9	5.2	0.47	34.0	19.7	3.4	4.6	188.1	0.7	3.3	0.78	+1.9	20
21	0	....	1.2	0.4	0.8	253.1	248.8	248.2	143.0	7.4	0.33	53.2	29.3	3.5	0.0	303.2	1.8	2.4	1.13	+1.1	21
22	0	....	3.7	1.6	2.1	227.5	224.0	224.3	130.0	8.6	0.50	47.5	26.5	3.1	0.0	272.6	1.2	1.7	1.40	+1.3	22
23	0	....	1.5	1.1	0.4	182.9	175.9	181.9	115.0	13.2	0.62	38.4	21.3	0.0	0.0	214.0	0.0	1.9	1.61	+1.0	23
24	0	....	0.4	0.2	0.2	184.5	182.7	181.7	118.0	6.8	0.33	38.7	21.4	0.0	0.0	222.5	1.4	1.9	1.86	−0.9	24
25	10	0.15	1.5	0.5	1.0	252.5	243.8	241.5	148.0	6.6	0.38	52.8	29.4	1.7	0.0	297.0	1.6	2.0	1.21	+1.4	25
26	40	0.01	0.5	0.4	0.1	207.6	203.6	200.7	120.0	7.8	0.32	43.5	24.1	0.0	12.9	222.0	1.0	2.7	0.36	−0.1	26
27	0	....	1.0	0.0	1.0	201.6	196.5	199.5	130.0	5.0	1.37	42.1	23.5	4.5	0.0	239.2	2.7	2.5	1.26	+1.9	27
28	....	....	1.4	0.6	0.8	215.7	210.8	211.1	129.1	7.9	0.55	45.2	25.1	1.8	1.8	252.9	1.2	2.2	1.26	+1.0	28
29	0	....	1.1	0.5	0.6	188.3	196.1	223.7	155.0	25.4	0.63	39.7	21.7	9.7	10.5	217.8	4.1	4.4	1.03	+0.4	29
30	40	0.21	8.5	0.8	7.7	182.3	179.0	183.4	133.0	7.4	0.73	41.1	19.4	1.7	7.2	203.5	2.5	2.9	1.01	−0.3	30
31	....	....	0.7	0.5	0.2	138.8	135.1	145.4	101.2	6.8	0.21	27.8	16.9	5.8	0.6	163.5	1.8	2.7	2.47	+2.9	31
32	0	....	0.9	0.7	0.2	199.0	187.5	195.4	123.0	6.8	0.30	41.7	23.1	4.2	0.0	228.6	3.7	2.6	0.80	+3.1	32
33	....	....	1.1	0.3	0.8	160.7	158.5	162.7	97.0	6.6	0.29	33.6	18.7	2.2	1.5	190.0	3.3	2.4	0.79	0.0	33
34	0	....	0.7	0.5	0.2	183.3	189.1	211.5	130.0	26.6	0.38	39.2	20.8	2.5	13.5	203.1	4.5	3.2	1.18	−2.6	34
35	0	....	1.3	0.3	1.0	179.2	195.5	213.9	136.0	20.8	0.29	38.7	20.1	9.1	11.7	214.2	4.1	3.3	0.51	−1.4	35

ANALYSES OF SPRING WATERS

Drainage basin.	No.	Spring.	Town.	County.	Sec.	T.	R.	Flow million gal. per day.	Date.	Remarks.
	36	Gaines Ford	Rolla	Maries	35	39N	9W		Aug. 6, 1925	
	37	Hazleton	Hazleton	Texas	34	33N	10W	2.8	Aug. 14, 1925	
	38	Mammoth or Prewett	Edanville	Pulaski	32	34N	10W	11.1	July 21, 1925	
	39	Miller (Ebb and Flow)	Big Piney	Pulaski	6	34N	10W	(a)	July 21, 1925	
	40	Ousley	Spring Creek	Phelps	10	35N	10W		Aug. 7, 1925	
	41	Paydown	Paydown	Maries	2	40N	8W	(a)	June 18, 1925	
	42	Piney	Yancy Mills	Phelps	4	35N	8W	3.2	June 19, 1925	
	43	Roubidoux or Waynesville	Waynesville	Pulaski	25	36N	12W	(a)	June 11, 1925	
Gasconade	44	Sands	Sands	Phelps	3	36N	8W	.12	July 22, 1925	
	45	Schlicht	Schlicht	Pulaski	30	37N	13W	.6	Aug. 6, 1925	
	46	Slabtown	Edanville	Texas	15	33N	10W	8.4	July 21, 1925	
	47	Stone Mill	Spring Creek	Pulaski	21	35N	10W	14.9	Aug. 7, 1925	Wet season.
	48	Sugar Tree	Newburg	Phelps	36	38N	10W		Aug. 6, 1925	
	49	Thox Rock	Newburg	Phelps	7	38N	9W		Aug. 6, 1925	
	50	Yancy	Yancy Mills	Phelps	32	36N	8W	1.0	June 19, 1925	
	51	Youngs	Rolla	Phelps	2	37N	9W		Aug. 22, 1925	
	52	Summary of twenty-three samples								
	53	Jones	Springfield, 4 mi. E.	Greene	27	29N	21W	.8	Aug. 31, 1925	
James	54	Reeds	Reeds Spring	Stone	25	24N	23W		Sept. 4, 1925	
	55	Summary of two samples								
Lamine	56	Sweet	Sweet Springs, 1 mi. S.	Saline	14	48N	23W	.01	Aug. 25, 1925	
	57	Beaver	Steelville	Crawford	34	37N	5W	.1	July 6, 1925	
	58	Blue	Bourbon	Crawford	2	39N	3W	3.2	Aug. 16, 1925	
	59	House	Eureka	St. Louis	4	42N	4E	.5	Sept. 2, 1925	
	60	Idlewild	Cuba	Crawford					Aug. 16, 1925	
Meramec	61	Kratz	Stanton	Franklin	19	41N	2W	(a)	July 19, 1925	
	62	Lake	Lake Springs	Dent	2	35N	7W	.06	July 22, 1925	
	63	Meramec	St. James	Phelps	1	37N	6W	73.7	June 27, 1925	
	64	Onandaga Cave	Leasburg	Crawford	25	39N	3W		Aug. 16, 1925	
	65	Roaring	Stanton	Franklin	19	41N	1W	.65	Sept. 3, 1925	
	66	Summary of nine samples								
Mississippi	67	Mark Twain	Hannibal	Marion	28	57N	4W		Sept. 15, 1925	
	68	Glencoe Hollow	Eureka	St. Louis	10	44N	3E		Aug. 16, 1925	
Missouri	69	Rollins	Columbia	Boone	12	48N	13W		Aug. 29, 1925	
	70	Summary of two samples								

No.	Turbidity.	Coef. of fineness.	Total suspended matter.	Vol. suspended matter.	Non-vol. suspended matter.	Total hardness as $CaCO_3$.	Alkalinity as $CaCO_3$.	Sum of constituents.	Residue after ignition.	Silica. (SiO_2)	Iron. (Fe)	Calcium. (Ca)	Magnesium. (Mg.)	Sodium and potassium. (Na)	Carbonate. (CO_3)	Bicarbonate. (HCO_3)	Sulphate. (SO_4)	Chloride. (Cl)	Nitrate. (NO_3)	Error, per cent.	No.
36	5	0.28	1.4	0.3	1.1	230.2	228.8	235.2	145.0	7.8	0.26	48.3	26.7	4.4	2.7	273.0	6.6	3.4	0.79	−0.3	36
37	0	....	0.6	0.3	0.3	161.5	156.4	155.7	98.0	5.6	0.30	33.6	18.9	0.6	9.0	172.5	0.0	2.8	0.32	+0.6	37
38	5	0.12	0.6	0.2	0.4	183.1	184.5	180.7	117.0	7.6	1.63	38.3	21.3	0.3	2.7	219.3	0.2	1.9	0.39	−1.1	38
39	5	1.30	6.5	0.6	5.9	188.6	208.0	209.5	139.0	10.4	0.52	38.7	22.4	8.3	7.2	238.5	0.8	3.3	0.92	−1.7	39
40	....	....	8.0	3.1	4.9	257.4	275.0	301.2	211.0	35.8	0.36	53.1	30.4	12.1	30.3	273.5	2.1	2.5	0.15	+0.5	40
41	15	0.21	3.2	1.3	1.9	102.0	105.0	131.8	99.0	13.0	1.00	19.8	12.8	4.1	3.6	120.6	14.8	2.4	1.92	−6.1	41
42	5—	0.28	1.4	0.9	0.5	156.1	155.8	166.6	111.0	9.6	0.04	32.1	18.5	5.3	4.5	180.7	2.9	3.4	1.29	+0.9	42
43	....	....	0.4	0.2	0.2	167.3	159.3	164.0	115.0	4.8	0.22	33.3	20.5	5.0	3.0	188.1	2.0	1.0	1.81	+4.2	43
44	5—	0.84	4.2	1.0	3.2	251.4	236.2	253.7	173.0	9.6	0.38	51.5	29.9	3.0	9.9	267.8	12.7	3.6	1.62	+1.4	44
45	....	....	19.1	3.2	15.9	212.3	199.0	447.6	163.0	21.8	0.24	44.4	24.7	6.5	15.0	212.0	3.7	5.4	0.45	+3.4	45
46	5	0.14	0.7	0.3	0.4	144.1	150.8	148.2	101.0	6.6	0.23	30.1	16.8	1.1	1.5	180.7	1.2	1.4	0.53	−2.5	46
47	....	....	1.0	0.5	0.5	188.1	196.7	201.2	148.0	6.4	0.31	40.0	21.5	7.3	15.6	208.0	2.3	3.2	2.35	−0.2	47
48	0	....	0.3	0.2	0.1	245.3	251.5	258.1	170.0	7.4	0.52	53.3	27.3	7.2	0.0	306.4	7.8	3.7	0.35	−0.8	48
49	0	....	2.5	0.4	2.1	277.3	277.0	286.5	167.0	11.0	0.33	59.1	31.6	4.7	0.0	337.1	2.3	6.5	5.22	−0.8	49
50	5—	0.20	1.0	0.2	0.8	159.2	153.1	171.6	116.0	6.8	1.41	32.9	18.8	10.5	5.9	174.8	5.4	3.2	2.05	+5.1	50
51	0	....	1.0	0.5	0.5	190.1	187.0	204.6	122.0	6.8	0.60	39.3	22.4	10.4	0.0	227.9	6.2	4.9	2.39	+2.4	51
52	....	....	2.8	0.7	2.1	188.9	189.8	211.0	133.4	11.8	0.49	39.5	22.0	5.5	6.8	217.5	4.1	3.2	1.32	+0.3	52
53	0	....	0.6	0.3	0.3	228.2	199.0	269.1	159.0	9.6	1.04	85.5	3.5	15.3	0.0	242.5	10.1	15.1	10.46	+4.4	53
54	25	0.40	1.0	0.6	0.4	171.0	161.6	182.7	101.0	6.4	0.31	63.3	3.1	4.4	0.0	197.0	2.2	4.4	1.89	+2.4	54
55	....	....	0.8	0.5	0.3	199.6	180.3	225.9	130.0	8.0	0.68	74.4	3.3	9.9	0.0	219.8	6.2	9.8	6.12	+3.5	55
56	5—	0.36	1.8	0.8	1.0	969.3	202.2	2,902.4	2,661.0	10.6	1.31	223.7	100.0	740.0	0.0	246.5	112.5	1,590.0	0.18	+0.3	56
57	5	0.8	0.4	0.2	0.2	235.3	228.5	235.7	129.0	8.2	0.24	48.5	27.8	5.7	5.1	268.0	4.7	2.7	0.98	+1.9	57
58	0	....	26.0	0.0	26.0	163.2	155.5	169.8	101.0	6.6	0.62	35.1	18.4	3.5	7.8	173.8	9.0	1.9	1.86	+0.4	58
59	10	0.12	1.2	0.0	1.2	281.7	248.2	289.4	196.0	9.8	0.62	92.3	12.4	0.0	0.0	302.3	19.3	3.6	3.03	+1.1	59
60	0	....	1.0	0.6	0.4	289.2	276.8	276.0	155.0	7.0	0.34	58.3	35.0	6.0	1.5	334.0	2.0	1.7	0.00	+3.7	60
61	....	....	19.0	0.0	19.0	124.1	118.0	132.7	95.0	8.6	0.23	25.5	14.7	1.4	3.3	137.0	8.0	2.7	0.98	−1.7	61
62	5—	0.38	1.9	0.5	1.4	202.2	197.8	203.4	132.0	12.4	0.26	41.7	23.9	2.2	7.8	225.0	0.0	4.1	0.39	−0.7	62
63	0	....	1.4	0.4	1.0	149.0	147.9	153.2	87.0	6.2	0.87	30.2	17.9	3.3	8.4	163.1	2.7	2.4	1.73	+0.2	63
64	....	....	Trace	....	....	221.0	216.1	220.8	137.0	8.0	0.44	47.6	24.9	2.2	16.2	230.6	4.3	2.7	1.39	+0.2	64
65	20	0.06	1.3	0.6	0.7	180.2	165.3	185.3	120.0	7.8	0.58	36.5	21.7	1.9	0.0	201.6	10.5	6.6	1.06	−0.8	65
66	....	....	5.8	0.3	5.5	205.1	194.8	207.4	128.0	8.3	0.47	46.2	21.8	2.9	5.6	226.2	6.7	3.2	1.27	+0.8	66
67	0	....	3.1	2.0	1.1	1,341.2	237.1	12,153.1	11,244.0	7.2	0.39	452.0	51.5	3,990.0	0.0	289.0	1,112.0	6,398.0	Trace	−2.0	67
68	....	....	4.3	0.8	3.5	256.7	236.2	176.2	201.0	12.0	0.24	86.9	9.6	11.3	5.1	227.5	30.6	5.1	1.86	+0.8	68
69	5—	15.20	76.0	21.0	55.0	397.1	324.8	482.1	307.0	11.2	0.60	145.5	8.1	22.7	5.4	384.9	78.8	12.6	8.25	+1.7	69
70	....	....	40.2	10.9	29.3	326.9	280.5	329.2	254.0	11.6	0.42	116.2	8.9	17.0	5.3	331.2	54.7	8.8	5.06	−3.6	70

ANALYSES OF SPRING WATERS

Drainage basin.	No.	Spring.	Town.	County.	Sec.	T.	R.	Flow million gals. per day.	Date.	Remarks.
	71	Bennett	Brice	Dallas	1	34N	18W	(a)	July 1, 1925	
	72	Blue or Sweet	Eldridge	Laclede	30	36N	17W	10.0	Aug. 6, 1925	
Niangua	73	Blue or Sweet	Eldridge	Laclede	30	36N	17W	10.0	Aug. 6, 1925	
	74	Hahatonka	Hahatonka	Camden	2	37N	17W	49.3	July 1, 1925	
	75	Summary of four samples								
	76	Bryant	Bryant	Douglas	7	27N	15W	1.3	Sept. 8, 1925	
	77	Crystal	Larissa	Douglas	22	26N	15W		Sept. 8, 1925	
	78	Double	Dormis	Ozark	32	24N	11W	53.2	Sept. 7, 1925	
North Fork of	79	Hodgson Mill	Sycamore	Ozark	34	24N	12W		Sept. 7, 1925	
White	80	Morris	Rockbridge	Ozark	4	24N	13W		Sept. 7, 1925	
	81	Siloam	Siloam Springs	Howell	32	25N	10W		Sept. 7, 1925	
	82	Taylor	Elijah	Ozark	35	23N	11W	.06	Sept. 6, 1925	
	83	Wilder	Elijah	Ozark	21	23N	11W	4.0	Sept. 6, 1925	
	84	Summary of eight samples								
Osage	85	Gravois Mills	Gravois Mills	Morgan	19	41N	17W		July 6, 1925	
Pomme de Ter.	86	Eidson	Bolivar	Polk	10	33N	22W		Aug. 8, 1925	
	87	Cave	Pearl	Greene	4	30N	23W	.3	Aug. 31, 1925	
	88	Chesapeake	Chesapeake	Lawrence	25	28N	25W		Sept. 21, 1926	
	89	Dunnegan	Dunnegan	Polk		34N	24W		Aug. 8, 1925	
Sac	90	Fullbright	Springfield, 4 mi. N.	Greene	2	29N	22W	6.5	Aug. 31, 1925	
	91	Humansville	Humansville	Polk		35N	24W		Aug. 8, 1925	
	92	Paris	Paris Springs	Lawrence	28	29N	25W	.002	Aug. 31, 1925	
	93	Stockton	Stockton	Cedar	8	34N	26W		Aug. 7, 1925	
	94	Summary of seven samples								
	95	Big	Mt. Vernon	Lawrence	28	28N	27W	5.6	Sept. 1, 1925	
	96	Big	Neosho	Newton	19	25N	31W		Sept. 2, 1925	
	97	Big	Neosho	Newton	19	25N	31W		June 24, 1926	
Spring	98	Clarkson	Pierce City	Lawrence	17	27N	28W	5.2	Sept. 1, 1925	
	99	Morse Park	Neosho	Newton	19	25N	31W		May 4, 1926	
	100	Pierce City	Pierce City	Lawrence	28	26N	28W		July 2, 1925	
	101	Verona or Marbut	Verona	Lawrence	17	26N	26W		July 2, 1925	
	102	Summary of seven samples								
White	103	Roaring River	Cassville	Barry	27	22N	27W	(a)	Sept. 3, 1925	

No.	Turbidity.	Coef. of fineness.	Total suspended matter.	Vol. suspended matter.	Non-vol. suspended matter.	Total hardness as $CaCO_3$.	Alkalinity as $CaCO_3$.	Sum of constituents.	Residue after ignition.	Silica. (SiO^2)	Iron. (Fe)	Calcium. (Ca)	Magnesium. (Mg)	Sodium and potassium. (Na)	Carbonate. (CO_3)	Bicarbonate. (HCO_3)	Sulphate. (SO_4)	Chloride. (Cl)	Nitrate. (NO_3)	Error, per cent.	No.
71	0	....	0.9	0.0	0.9	187.9	182.0	185.7	110.0	5.6	0.94	38.6	22.3	4.1	8.7	204.4	1.4	1.9	2.47	+2.3	71
72	0	....	0.7	0.3	0.4	232.8	242.0	256.9	174.0	23.2	1.87	47.7	27.7	5.5	20.1	254.0	2.7	4.1	0.78	−1.3	72
73	0	....	1.6	0.9	0.7	235.1	226.0	232.6	140.0	8.0	0.85	48.1	28.0	5.5	12.9	249.0	2.3	4.0	1.17	+2.6	73
74	0	....	0.7	0.2	0.5	194.9	192.5	194.3	105.0	7.4	0.65	39.4	23.5	1.9	7.2	219.8	1.6	2.7	2.30	−0.1	74
75	....	....	1.0	0.4	0.6	212.7	210.6	217.4	132.3	11.1	1.08	43.5	25.4	4.3	12.2	231.8	2.0	3.2	1.68	+1.0	75
76	0	....	1.6	1.5	0.1	196.3	177.2	191.1	116.0	5.2	0.28	47.2	19.1	0.0	9.6	196.5	8.4	3.9	0.90	−1.2	76
77	0	....	0.2	0.2	0.0	248.4	239.6	240.2	135.0	4.0	0.24	54.9	27.1	2.5	5.4	281.0	3.5	3.2	1.20	+1.1	77
78	0	....	0.6	0.2	0.4	221.2	212.0	213.2	126.0	4.8	0.21	47.3	25.1	0.0	7.8	242.8	3.9	3.7	1.10	−0.2	78
79	0	....	0.3	0.3	0.0	217.7	208.6	210.6	133.0	4.8	0.33	46.4	24.8	0.0	3.6	247.0	4.3	3.9	1.20	−0.5	79
80	0	....	0.8	0.7	0.1	254.0	250.3	245.5	157.0	5.8	0.23	55.5	28.1	0.0	6.9	291.5	1.6	3.7	0.40	−0.7	80
81	5	0.44	2.2	1.0	1.2	348.5	330.3	344.3	191.0	7.2	0.45	72.0	41.1	5.1	9.9	382.5	6.1	8.0	6.50	+0.9	81
82	50	0.02	0.9	0.8	0.1	302.7	262.0	303.8	176.0	8.2	0.35	57.0	38.7	6.5	0.0	319.0	32.9	3.3	0.09	+2.5	82
83	5	0.26	1.3	0.8	0.5	229.6	212.0	222.0	160.0	7.2	0.41	46.4	27.7	1.7	5.1	247.6	6.4	3.3	2.24	+2.0	83
84	....	....	1.0	0.7	0.3	252.3	236.5	246.3	149.3	5.9	0.30	53.3	28.9	2.0	6.0	275.9	8.4	4.1	0.28	+1.2	84
85	5	0.26	1.3	0.3	1.0	287.5	282.9	275.6	166.0	6.8	0.38	58.7	34.3	1.2	7.8	329.4	1.4	3.0	0.27	+0.3	85
86	0	....	1.3	0.6	0.7	239.0	230.5	242.2	133.0	8.2	1.15	48.2	28.9	6.3	16.2	248.1	3.9	5.8	2.52	+1.5	86
87	5—	0.60	3.0	0.5	2.5	230.1	224.0	257.7	173.0	8.0	0.23	90.7	0.8	3.8	0.0	273.2	6.4	4.9	8.62	−1.2	87
88	....	....	3.6	3.6	0.0	224.3	205.2	229.6	161.0	9.6	0.48	58.9	18.8	4.9	13.2	223.5	2.7	4.7	3.03	+3.9	88
89	0	....	1.9	1.2	0.7	254.1	238.2	260.4	200.0	6.8	0.61	56.2	27.7	7.1	15.0	260.0	14.8	3.7	1.13	+1.9	89
90	....	....	4.1	1.2	2.9	188.0	187.6	210.3	137.0	8.8	1.60	71.8	1.7	0.9	0.0	228.9	3.3	6.1	5.08	−4.0	90
91	0	....	0.6	0.4	0.2	270.3	262.1	273.6	133.0	7.8	0.57	56.8	31.3	5.8	16.8	285.5	8.0	5.3	1.24	+0.6	91
92	20	0.45	9.0	0.0	9.0	248.5	178.0	335.0	260.0	22.8	1.10	84.0	9.4	14.9	0.0	216.9	86.6	10.5	0.00	−0.4	92
93	0	....	2.4	0.5	1.9	262.0	242.1	285.4	165.0	9.0	0.45	74.1	18.7	8.2	16.8	260.8	6.0	8.5	15.62	+1.3	93
94	....	....	3.5	1.1	2.4	239.6	219.6	264.6	175.6	10.4	0.72	70.4	15.5	6.5	8.9	249.5	18.2	6.2	4.96	+0.5	94
95	0	....	0.6	0.0	0.6	172.3	158.6	197.0	116.0	9.4	0.29	59.1	6.0	7.2	0.0	193.4	7.4	6.6	6.10	+1.9	95
96	5—	0.08	0.4	0.0	0.4	148.3	142.5	172.4	104.0	10.2	0.73	58.0	0.8	2.8	0.0	173.7	3.9	5.3	5.91	−1.6	96
97	....	....	19.0	19.0	0.0	119.4	107.5	123.1	106.0	6.8	0.12	45.8	1.2	0.9	0.0	131.0	1.0	2.9	0.00	+3.6	97
98	0	....	1.8	0.1	1.7	147.7	140.1	168.7	103.0	9.4	0.22	54.3	2.9	1.1	0.0	170.7	3.5	5.8	7.60	−2.4	98
99	....	....	3.4	2.8	0.6	149.8	137.9	173.0	117.0	10.0	0.40	57.8	1.3	8.5	6.6	154.7	0.0	7.1	4.94	+5.0	99
100	0	....	2.1	0.4	1.7	131.8	102.6	160.1	95.0	10.2	0.77	50.6	1.3	3.9	4.8	115.4	10.5	9.6	12.35	+1.1	100
101	0	....	0.9	0.1	0.8	145.6	134.1	159.7	92.0	7.2	0.75	56.1	1.3	0.0	11.1	141.2	2.7	4.0	7.87	−1.2	101
102	....	....	4.0	3.2	0.8	144.9	131.9	164.9	104.7	9.0	0.47	54.5	2.1	3.5	3.2	154.4	4.1	5.9	6.39	+0.2	102
103	0	....	1.4	0.9	0.5	161.6	153.0	173.5	107.0	6.4	0.91	58.1	4.0	3.3	0.0	186.3	2.1	4.4	3.36	+1.5	103

EBBING-AND-FLOWING SPRINGS

A recent description, by O. E. Meinzer[1], of ebbing-and-flowing springs includes the following remarks:

"Ebbing-and-flowing or periodic springs are distinctive features that are entirely different from the ordinary intermittent springs that flow in wet seasons and disappear in dry seasons. An ebbing-and-flowing spring has periods of flow, when it flows vigorously, and periods of ebb, when it ceases to flow or flows at a greatly reduced rate. The periods of flow may occur at nearly regular intervals or at very irregular intervals; they may occur at intervals of a few minutes or a few hours or even a few days or longer. All or nearly all the springs of this type issue from limestone. Nearly all are far from the ocean and they have no relation whatever to oceanic tides. In their periodic action they resemble geysers, but their water has the normal temperature of ordinary ground water, and they do not generally emit any noticeable amount of gas.

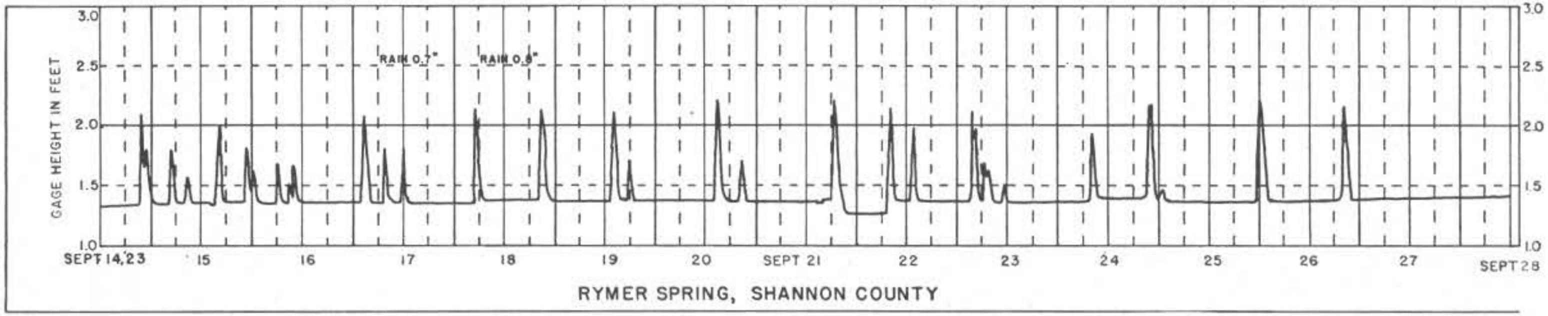
"After many years of inquiry and search incidental to other work, only 23 springs of this kind have been located in the United States, of which 9 are in Virginia, 4 (now known to be 5) in Missouri, 3 in Tennessee, 2 in West Virginia, and 1 each in Nevada, New Mexico, Pennslyvania, Utah, and Wyoming.****

"In 1724 the periodic action of springs of this type was ascribed by J. T. Desaguliers to natural siphons in the rocks. Study of the springs and of their performance, as shown by continuous records, seems to confirm the siphon theory and suggests that the irregularities are caused chiefly by variations in water supply and in air-tightness of the siphon system with alternations of wet and dry seasons and successive freezing and thawing of the ground. Some puzzling features, however, remain unexplained."

Five such ebbing-and-flowing springs are located in Missouri. A special study of the behavior of the two largest of these—namely Rymer Spring (also called Ebb-and-Flow Spring) about 8 miles northwest of Birch Tree, Shannon County, and Miller Spring, 3 miles northwest of Big Piney, Pulaski County—was made by Josiah Bridge in 1923 while in the employ of the Missouri Geological Survey and continued during his service

[1]Meinzer, O. E., Hydrology, pp. 428-430, New York, McGraw-Hill Book Co., Inc., 1942.

on the faculty of the Missouri School of Mines and Metallurgy. A recording gage was installed and operated for several weeks on each of these springs in order to get a graphic record of the periodic variations in the stage and discharge. These are reproduced in plate VI. Under the headings of the individual springs in Chapter III of this report are given abstracts of further information collected by Bridge on these two springs and on two other smaller ebbing-and-flowing springs—namely, Ebb-and-Flow Spring on Thompson Creek and Ebb-and-Flow Spring in Spring Valley, both in Shannon County. More complete and detailed information on Bridge's study of these four springs is given in his report "Ebb-and-Flow Springs in the Ozarks" published in 1923 by the Missouri School of Mines and Metallurgy as a Bulletin, Volume 7, Number 1. Elm Spring near Fanning, Crawford County, also described in Chapter III of this report, is the fifth ebbing-and-flowing spring known in Missouri at the time of this writing.



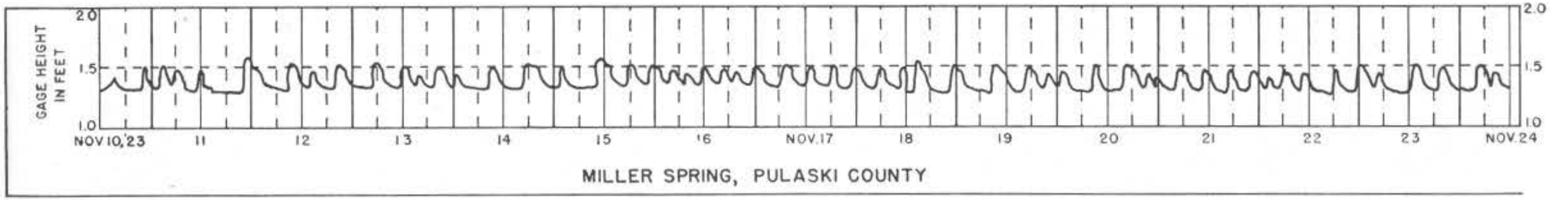


Chart showing the periodic variations in stage of Rymer Spring, Shannon County, and Miller Spring, Pulaski County.

CHAPTER III

Description and Flow of Individual Springs

EXPLANATION OF DATA

The Missouri Geological Survey and Water Resources, in cooperation with the United States Geological Survey, has made measurements of the flow of the larger springs of the State for the purposes enumerated in Chapter I, page 9, as an auxiliary part of the regular river measurement program relating to water power, flood control, municipal and industrial water supplies, stream pollution, bridge design, and soil conservation.

Daily records of flow throughout an appreciable period of time have been obtained for only six of the largest springs, and only occasional measurements at different times have been made of the others. A large proportion of the occasional, or miscellaneous, discharge measurements were made during the months of August, September, and October, when the flow is usually small. Most of the smaller springs, of which only one measurement was obtained, were gaged during that season. Such measurements, therefore, are likely to represent the minimum or near minimum flow of the springs, or in other words, the dependable flow. For the larger springs, and for some of the smaller ones, several measurements were made—one or more during dry periods of low flow, and one or more during wet periods of average or high flow. The measurements so listed may usually be regarded as representing the approximate limits of range between the ordinary low and high flows of the spring, but not necessarily the minimum and maximum flows.

The discharge measurements of the springs were made by engineers of the Geological Survey with instruments known as "current meters". In determining the daily discharge for the six large springs for which continuous daily records of flow were obtained, daily gage-height records from either a staff gage or an automatic recording gage were also collected for use with the occasional current meter measurements.

The volume of water flowing in a stream—the "runoff" or "discharge"—is expressed in various terms. The terms used in this report may be defined as follows:

"Second-feet" is an abbreviation for "cubic feet per second". A second-foot is the rate of discharge of water flowing at an average velocity of 1 foot per second in a channel of rectangular cross section 1 foot wide and 1 foot deep. It is generally used as a fundamental unit from which others are computed. One "second-foot" of flow is approximately equal to 449 gallons per minute, or 646,000 gallons per day.

"Second-feet per square mile" is the average of cubic feet of water flowing per second from each square mile of area drained, with the assumption that the runoff is distributed uniformly both as regards time and area.

The term "gallons per day" needs no definition.

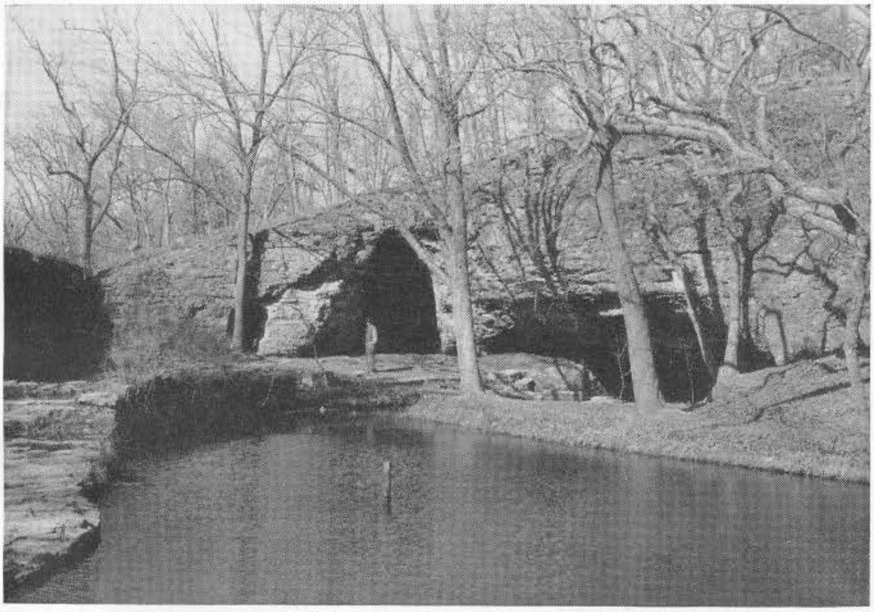
DESCRIPTION AND MEASUREMENTS OF FLOW OF INDIVIDUAL SPRINGS

ALLEY SPRING is located in Alley Spring State Park in sec. 25, T. 29 N., R. 5 W., at Alley, Shannon County, about 5 miles west of Eminence. It can be reached readily by driving over State Highway 106 or Shannon County Route E. The spring issues from the base of a 100-foot semi-circular cliff of Gasconade dolomite 672 feet above mean sea level, flows over a low dam which forms a small circular lake of clear, blue water with a maximum depth of about 40 feet, and empties into Jacks Fork at a distance of half a mile. An old mill at the dam, which formerly was used to develop power for grinding feed, operating a saw mill, and furnishing electric lights for nearby houses, is preserved intact. The spring and its surroundings are rustic and picturesque and form an attractive setting for the State park.

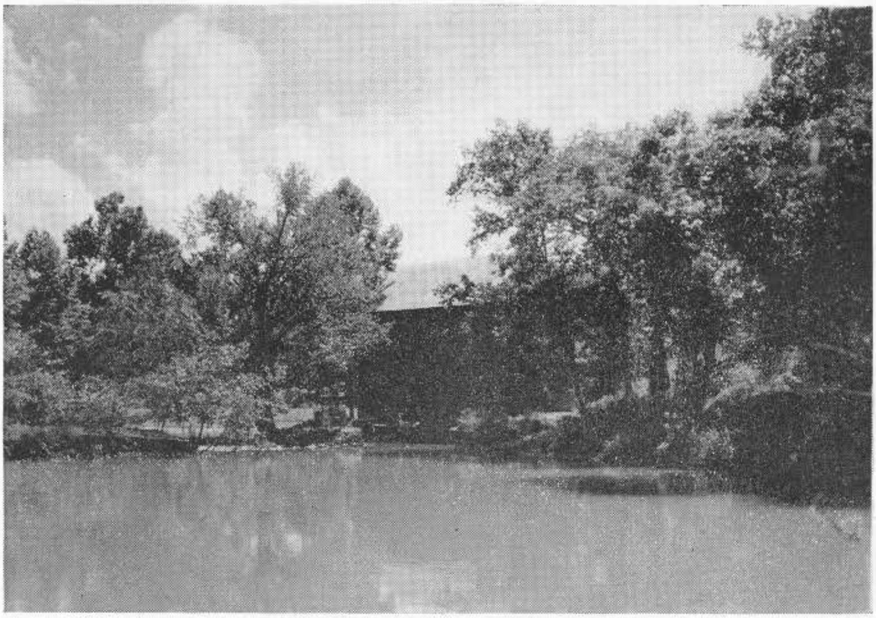
The excellent facilities for recreation which are provided in the park include picnic tables, hearths for cooking, and camping sites. Cabins may be rented for a nominal sum. The spring branch is stocked with trout by the State Conservation Commission. Other game fish which abound in the nearby Jacks Fork offer a strong lure to the fisherman. Good swimming may be enjoyed in Jacks Fork.

The source of the spring is believed to include a rather large area to the west and north of the spring outlet.

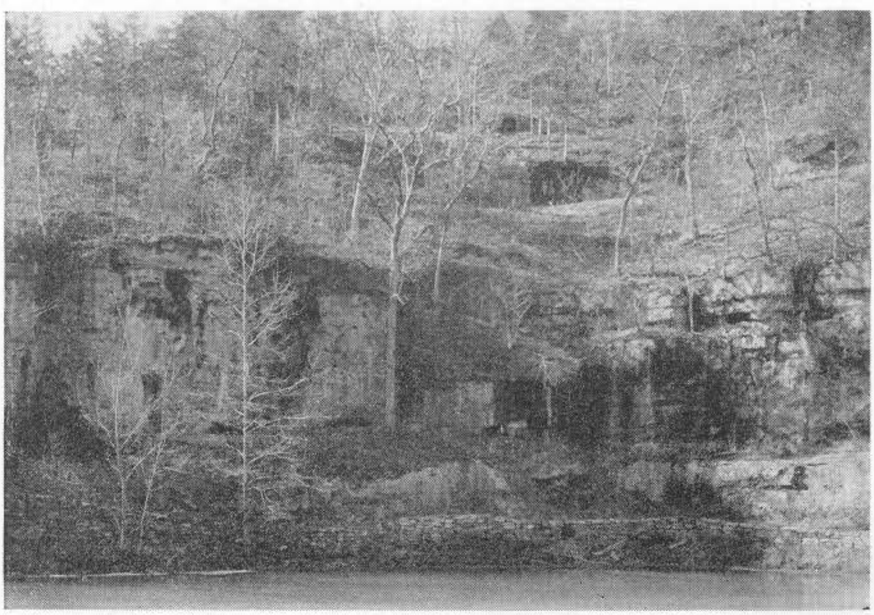
A. Abandoned solution openings above present level of Alley Spring. View along Alley Spring Branch, at Alley Spring State Park, Shannon County. (Photograph by W. H. Pohl, Missouri State Highway Department.)



B. Abandoned solution openings in limestone at Sequiota Spring and Cave, Sequiota State Park, Greene County. (Photograph by W. H. Pohl, Missouri State Highway Department.)



A. Old mill at Alley Spring, Alley Spring State Park, Shannon County. (Photograph by W. H. Pohl, Missouri State Highway Department.)



B. Alley Spring, Alley Spring State Park, Shannon County. (Photograph by W. H. Pohl, Missour State Highway Department.)

"An interesting story, which appears to be well authenticated is told about this spring: On a certain day the flow of the spring was observed to be decreasing rapidly and it finally ceased altogether and the water in the spring basin sank to about five feet below its normal level. It remained in this condition for about 12 hours and then suddenly resumed flow. For several days the water was quite muddy, but it gradually cleared up. At about the same time a large sink was suddenly formed in the plateau about 15 miles to the northwest of the spring. It appears probable that the material which fell into the underground channel when this sink was formed, blocked it temporarily, and thus checked the flow of the spring."[1]

Attention should be called to the abandoned tubular openings in the dolomite bluffs above the present level of the spring pool. Some of these openings present a sub-circular cross section and may well be ancient, abandoned subsurface water courses which formerly were water conduits. Continued erosion and the more recent deepening of the valley of Alley Branch have left these former flow channels some 15 to 20 feet above the present level of the impounded pool of the spring. Similar anastomosing tubular openings may be seen in the bluff along the spring branch, downstream from the old mill (plate VII-A), where they form interconnected networks of small cavernous vents, which are former waterways.

This is approximately the tenth largest spring in the State. Records of the daily flow of the spring (including also the occasional runoff from the small creek above the spring outlet) have been collected from October 1928 to September 1939. During this period the flow was as follows:

	Date	Second-feet	Gallons per day
Maximum	March, 1935	1,060*	685,000,000*
Minimum	October, 1934	54	34,900,000
Average	1929-39	125	80,800,000

*Includes surface runoff from small valley above spring after heavy rain.

[1]Bridge, Josiah, Geology of the Eminence and Cardareva Quadrangles: Mo. Bur. Geol. and Mines, vol. XXIV, 2nd ser., p. 41, 1930.

A hydrograph of the mean monthly flow of the spring over a period of several years is shown on plate V. Records of the daily flow may be had upon request.

Photographs of Alley Spring are reproduced on plates VII-A; VIII-A, B.

ALLGIRE SPRINGS (also called Celt Springs) are located in sec. 8, T. 36 N., R. 18 W., at Celt, and 3 miles northeast of Leadmine, Dallas County. There are usually about seven separate outlets, within a quarter of a mile, which issue from coarse gravel beds in a steep valley amid rugged surroundings. A boys' camp, including a lodge and several cabins, is located nearby. Measurements of the combined flow of the springs, which constitute the source of Mill Creek, have been made as follows:

Date	Second-feet	Gallons per day
November 19, 1942	4.81	3,110,000
October 7, 1943	5.15	3,330,000

ALTHEA SPRING (also called Patrick Spring) is located in sec. 25, T. 23 N., R. 12 W., at the abandoned hamlet of Althea, Ozark County, 5 miles northeast of Tecumseh, and can be reached by driving over a good county road. It rises in a small depression and flows into North Fork River at a distance of 600 feet. Formerly it was used to operate a mill. Although privately owned, the spring site is a favorite place for camping. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 29, 1926	27	17,500,000
October 17, 1932	15.0	9,690,000
August 18, 1934	17.8	11,500,000
August 17, 1936	13.3	8,560,000

AMSDEN SPRING (also called Amazon or Amsolen Spring) is located in sec. 19, T. 31 N., R. 1 E., about 6 miles south of Centerville, Reynolds County. The water bubbles up from a gravel bed along a former State highway. Its pretty surroundings and its ready accessibility make the spring a favorite place for picnics and camping. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 1, 1925	2.5	1,620,000
August 6, 1936	.53	342,000

ARMSTRONG SPRING, EAST, is located in NW¼ sec. 6, T. 36 N., R. 14 W., Camden County, 6 miles north of Stoutland. It issues from a recess in a low bluff of cherty dolomite of the Roubidoux formation, and flows over a small rock dam which raises the water level about 5 feet, and empties into Sellers Creek at a distance of 40 feet. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
November 18, 1942	40.2	26,000,000
December 8, 1942	9.05	5,850,000
October 8, 1943	4.48	2,900,000

ARMSTRONG SPRING, WEST, is located in NW¼NW¼ sec. 6, T. 36 N., R. 14 W., Camden County, a quarter of a mile north of "Armstrong Spring, East", and 6 miles north of Stoutland. It issues from the gravel at the mouth of a small cave at the head of a narrow ravine and flows half a mile into Sellers Creek. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
November 18, 1942	3.19	2,060,000
October 8, 1943	1.18	763,000

BARTLETT MILL SPRING (also called Pippin Spring) is located in NW¼ sec. 16, T. 36 N., R. 12 W., at Pippin Lodge in Pulaski County, 5 miles northwest of Waynesville, from which it can be reached over a good road. It issues from the Gasconade formation at the foot of a hill, flows 600 feet to a dam 10 feet high where power is developed to operate a grist mill, and then empties into the Gasconade River. The small lake formed by the dam and the wooded surroundings make a very attractive place. It is privately owned. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 4, 1914	12.2*	7,890,000
September 10, 1926	11.2	7,240,000
October 12, 1932	.31	200,000
June 2, 1936	4.66	3,010,000
September 21, 1942	10.4	6,720,000

*Measured by Engineering Experiment Station, University of Missouri.

BEAVER SPRING is located in SE¼SW¼ sec. 34, T. 38 N., R. 5 W., Crawford County, about 6 miles west of Steelville. The spring issues from the base of a low hill and flows about 100 feet through an artificial rock canal before entering into a series of two lakes, each about half an acre in size. The lakes, lying in a little valley surrounded by gently rolling hills, form a beautiful vista from the nearby summer cottages. The spring may be reached easily by driving from Steelville on State Highway 8, but visitors must obtain permission from the property owner to enter his premises in order to see the spring. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
July 6, 1925	0.20	129,000
September 11, 1936	.19	123,000

BENNETT SPRING is located in Bennett Spring State Park in sec. 1, T. 34 N., R. 18 W., Dallas County, half a mile southeast of the village of Bennett Springs (formerly called Brice) and about 11 miles west of Lebanon. It issues from a circular basin in gravel deposits in the bed of Spring Creek, and flows

A. Outlet of Bennett Spring, Bennett Spring State Park, Dallas and Laclede Counties. (Photograph by G. L. Campbell.)

B. Dam at Bennett Spring, Bennett Spring State Park, Dallas and Laclede Counties. (Photograph by G. L. Campbell.)

$1\frac{1}{2}$ miles before entering the Niangua River. Bluffs of dolomite of the Gasconade formation rise above the west bank of the spring branch. As the water surface in the basin is at an elevation of about 866 feet above mean sea level, it is one of the highest of the larger springs of the State. A dam about half a mile below the spring outlet forms a small lake and diverts water to the State fish hatchery and a grist mill, which is being preserved to lend historic interest to the place. The park and spring can be reached readily by driving over State Highway 64.

The main source of the spring is believed to include the drainage area of Spring Creek, upstream from the spring. The bed of the creek is floored with a deep deposit of gravel and is dry except for short periods after heavy rains when it carries off storm water.

Bennett Spring State Park is one of the most popular parks in the State. The large volume of clear, cold water issuing from the spring outlet, the placid lake formed by the dam, the glistening water flowing over the dam, the novelty of the many graceful trout in the State hatchery pools, the fishing furnished by the well-stocked spring branch, the historic charm provided by the old mill, the excellent facilities provided in the park for picnicking and camping, the park lodge, the availability of attractive cabins for a nominal rental, the facilities for swimming and boating in Niangua River, and the natural beauty of the entire region—all these combine to make the park an area of extraordinary interest and attraction to the vacationist, the pleasure-seeker, and the lover of nature.

Bennett Spring is approximately the sixth largest spring in the State. Records of the daily flow of the spring (including also the occasional, wet-weather runoff from a drainage area of 42 square miles above the spring) from September 1916 to March 1920 were collected by the Engineering Experiment Station, University of Missouri, and from October 1928 to September 1939 by the Geological Survey. During this latter period (1928 to 1939) the flow was as follows:

	Date	Second-feet	Gallons per day
Maximum....	June 20, 1935..........	4,800*	3,100,000,000*
Minimum.....	November 13, 1934....	55	35,500,000
Average......	1928-39................	154	99,500,000

*Mostly surface runoff from drainage area of 42 square miles above spring after heavy rain.

A hydrograph of the mean monthly flow of the spring over a period of several years is shown on plate V. Records of the daily flow may be had upon request.

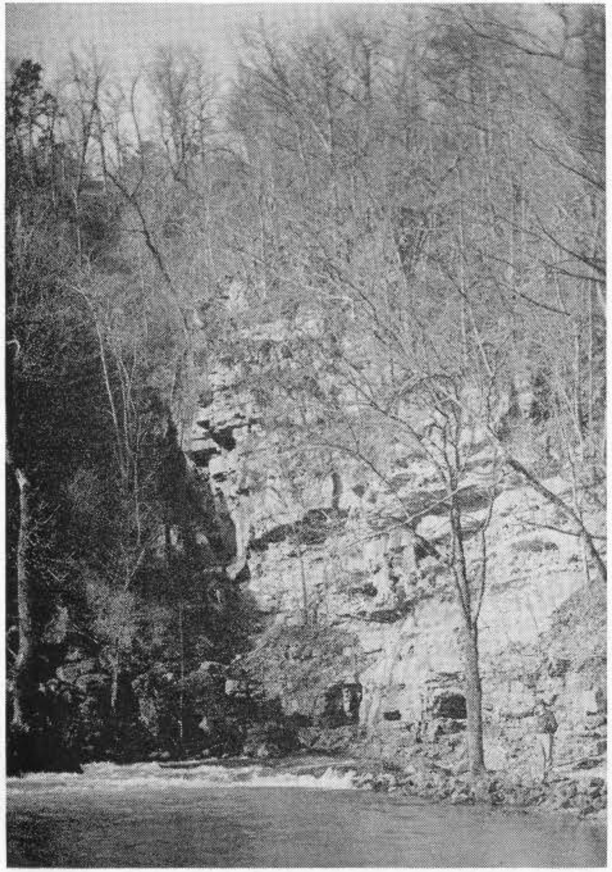
The outlet of Bennett Spring and the dam on the spring branch are pictured in photographs as plate IX-A and IX-B.

BIG SPRING is located in Big Spring State Park in NW¼ NE¼ sec. 6, T. 26 N., R. 1 E., Carter County, 4 miles southeast of Van Buren. The clear, cold water gushes with considerable force from the base of a rocky cliff and hill of Eminence dolomite, about 75 feet below the Gunter sandstone. The spring rises at an elevation of about 433 feet above mean sea level, and flows into Current River at a distance of 1,000 feet. Large tubular openings in the rock a few feet above the present outlet served as former outlets of the spring before Current River valley was excavated by erosion to its present level (plate XI-A). The spring branch is bordered on one side by a high, rugged, and wooded hill, and by a level wooded flood plain a few feet above the water surface on the other side. As the spring outlet is only a few feet above low stage of Current River, the spring is flooded during all high rises of the river.

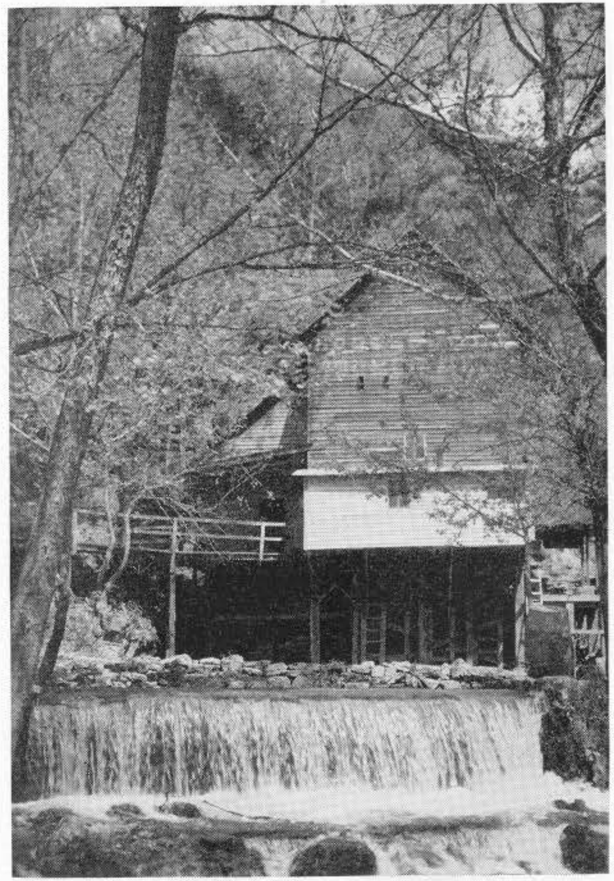
Big Spring is the largest spring in the Ozark region of Missouri and Arkansas. As explained more fully on page 17, the available records indicate that its average flow is about equal to that from the upper pool of Silver Springs in Florida and that these two share the distinction of being the largest single-outlet springs in the United States. Big Spring may truly be said to be the outflow from an "underground river". Records of the flow of the spring are given in a later paragraph, but a clearer conception of its magnitude may be given by the statement that the average flow of the spring during the past 20 years was more than enough to supply the City of St. Louis.

A. Cottage at Big Spring State Park, Carter County. (Photograph by Noel Hubbard, Missouri School of Mines.)

B. Big Spring, Big Spring State Park, Carter County. (Photograph by Noel Hubbard, Missouri School of Mines.)



A. Big Spring. Big Spring State Park, Carter County. Note abandoned solution openings in bluff above spring. (Photograph by W. H. Pohl, Missouri State Highway Department.)



B. Hodgson Mill and Spring at Sycamore, Ozark County. (Photograph by W. H. Pohl, Missouri State Highway Department.)

Big Spring State Park is a place of extraordinary interest and beauty. The visitor is first impressed by the imposing, rugged, wooded landscapes along the winding, hilly route of State Highway 103 from Van Buren to the State park. His sense of wonder and admiration are aroused by the unique and inspiring sight of the large volume of clear, cold water rushing noisily to the surface at the base of the high bluff. He is impressed with the natural beauty of the surroundings—the placid and clear spring branch; the towering, rocky cliffs along one bank and the wooded area along the other bank; and the clear, swift Current River into which the spring branch flows. Besides these natural attractions to the visitor, very good facilities are provided in the park for picnicking and camping, and cabins may be rented for a reasonable price. A dining lodge serves meals during the summer months, and swimming, boating, and fishing may be enjoyed in Current River. All these attractions serve to draw many vacationists and pleasure-seekers to the park.

Bridge's remarks concerning probable sources of some of the flow of Big Spring are pertinent: "There are a number of sinks in the bed of Davis Creek just south of the town of Midco and it is definitely known that water draining into these comes to the surface again in Big Spring, which is 10 miles away in a straight line. When the plant (iron furnace) at Midco was in operation (in about 1918) quantities of chemical waste were discharged into the dry bed of Davis Creek at Midco, and this soon contaminated the water at Big Spring.

"In the NE¼ sec. 18, T. 27 N., R. 2 W., there is a sinkhole about 70 feet in diameter in the floor of the valley. During wet seasons the water in this hole rises to within a few feet of the rim, but in dry seasons the hole is about 20 feet deep and connects with an underground passage, in which a stream flows to the southeast. This passage has not been explored, but the inhabitants sometimes place a lighted candle on a small plank and set it afloat on the stream and they declare that the light may be seen for a long distance. This stream is probably one of the feeders of Big Spring.

"The area which drains underground to Big Spring must be very large, and doubtless contains most of the drainage basin of Pike, Sycamore, and Davis Creeks, the upper portion of Mill Creek, as well as a large territory south and east of the

Eminence region. It may also receive a portion of its water from some of the dry valleys on the north side of Current River."[1]

The gushing surge of water which leaps to the surface at Big Spring indicates the presence of a subterranean, restricted orifice which, by virtue of its nozzle effect, churns the surface of the spring pool at its main outlet and creates the "boil" that characterizes several of the larger springs of the Ozarks. This area of boiling waters at the foot of the high, vertical, bare bluff of dolomite rock is a dramatic sight — clear, brawling waters which seem to leap to the surface, freed from the confinement of their underground channels. Great blocks of dolomite have fallen from the overhanging bluff into the spring—blocks which have fallen from the former face of the cliff as a result of the slow, steady undermining of the solution-work of the spring waters.

Some fifty yards southeast, or downstream, from the main outlet a smaller spring flows into the spring branch from a level which is apparently higher than the visible source of the main spring. The flow of this smaller spring is reported by regular observers to vary more than does that of the main spring. Large, abandoned flow tubes are seen in the bluff some thirty feet above the smaller spring; and others are prominent at the path-level, just above the pool of the main, "Big" spring.

Records of the daily flow of the spring have been collected from January to June 1922 and from April 1923 to date. During this period the flow was approximately as follows:

	Date	Second-feet	Gallons per day
Maximum	June, 1928	1,300*	840,000,000*
Minimum	Junly 4-6, 12, 1936	247	164,000,000
Average	1923-26, 1929-43	390	252,000,000

*Estimated on account of spring branch being flooded by Current River.

A hydrograph of the mean monthly flow of the spring over a period of several years is shown in plate V. Records of the daily flow may be had upon request.

[1]Bridge, Josiah, Geology of the Eminence and Cardareva Quadrangles: Mo. Bur. Geol. and Mines, vol. XXIV, 2nd ser., p. 40, 1930.

Photographs of Big Spring appear on plates X-A and B; XI-A; and as the frontispiece.

BIG SPRING is located in NW¼ sec. 26, T. 25 N., R. 11 W., 400 feet from Big Spring School in Douglas County, 1 mile south of Roosevelt. It issues from beneath a large talus pile of sandstone blocks at the base of a hill and flows into Spring Creek at a distance of 60 feet. The spring is at an elevation of approximately 730 feet above sea level. It can be reached readily by driving about one mile over a gravel road from State Highway 14, and is a favorite place for camping. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 26, 1927	26.8	17,300,000
October 17, 1932	3.2	2,070,000
August 18, 1936	10.2	6,590,000

BIG SPRING is located at the base of Baptist Hill in SE¼-NE¼ sec. 28, T. 28 N., R. 27 W., along a scenic river road, in Lawrence County, 4 miles west of Mount Vernon. It issues from a cavernous bed at the base of a cliff of cherty Burlington limestone and flows across the road and into Spring River 200 feet away. The flow emerges from the foot of the bluff approximately 1,110 feet above sea level. Religious conventions are held in a building on the hill and tourists frequently camp at the spring. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 1, 1925	8.6	5,600,000
October 28, 1943	20.5	13,200,000
October 28, 1943	19.8	12,800,000
August 13, 1944	16.6	10,700,000

BIG SPRING is located in sec. 19, T. 25 N., R. 31 W., at Neosho, Newton County. It issues from the base of a cliff of interbedded chert and limestone layers of the Keokuk formation, in front of the Big Spring Inn, two blocks west of the court house square. It has been used at times to furnish water for the City of Neosho. The surrounding area is maintained as a public park, and the flow from the spring cascades through a series of terraced pools. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 1, 1925	1.5 (Est.)	1,000,000
September 25, 1936	.66	427,000
March 7, 1939	1.25	808,000

BIG BLUE SPRING.—See Blue Spring in Laclede County.

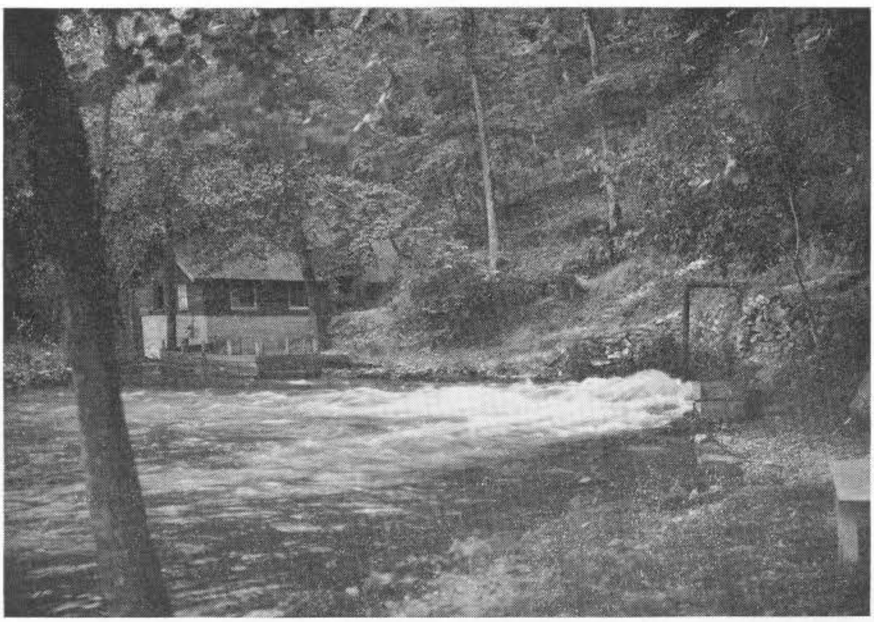
BLUE SPRING is located in sec. 16, T. 22 N., R. 2 W., 14 miles southeast of Alton, Oregon County, and can be reached over an all-weather road. It issues from the base of a rocky cliff of cherty dolomite beds, of the lower Jefferson City formation, about 50 feet high, called "The Narrows", which separates Fredericks Fork from Eleven Point River. The spring branch flows into the latter stream at a distance of about 1,000 feet.

This is approximately the eighth largest spring in the State. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 12, 1925	67	43,300,000
October 25, 1932	64	41,400,000
September 14, 1933	70	45,200,000
August 17, 1934	59	38,100,000
July 18, 1935	100	64,600,000
August 13, 1936	54	34,900,000
July 23, 1942	98	63,300,000

BLUE SPRING is located in NE¼ sec. 21, T. 29 N., R. 2 W., Shannon County, 12 miles east of Eminence. The spring is on the east side of Current River below Booming Shoal Ford, and about 1¼ miles south of State Highway 106, where highway traffic is carried over Current River by the Powder Mill Ferry. The spring issues with scarcely a ripple from a circular basin

A. Blue Spring, near Powder Mill Ferry over Current River at Owl's Bend, Shannon County. (Photograph by W. H. Pohl, Missouri State Highway Department.)



B. Double Spring (Rainbow Spring), Ozark County. (Photograph by W. H. Pohl, Missouri State Highway Department.)

75 feet in diameter and 40 feet deep at the base of a slightly overhanging cliff of Eminence dolomite 30 feet high. The water flows swiftly down the turbulent spring branch a distance of a quarter of a mile into Current River—the fall in the branch being about 12 feet during ordinary stages of the river. The surroundings are heavily wooded, and an attractive private clubhouse is located nearby. Although the place is privately owned, visitors are permitted access to the spring.

The water in the deep basin is very clear, still, and of a remarkable deep blue tint—in fact, it is generally considered the deepest blue of all the large springs in the State. An explanation of the probable reason for the blue color of springs is given on page 35. According to local legend, the Indians called this the "Spring of the Summer Sky". The clearness, deep blue hue, and stillness of the spring basin, the surge of the swiftly flowing water in the spring branch on its way to the river, the impressiveness of the rocky cliff behind the basin, and the heavily wooded surroundings, make this one of the most beautiful places in the State.

Bridge discussed the probable source of the spring flow as follows: "Blue Spring appears to derive most of its water from the Logan Creek drainage basin, though the upper portion of Car Creek may also be a contributor. Logan Creek, which is dry except for short stretches most of the year, contains a number of sinks into which small streams are continually running, and a number of others which carry the surface water away rapidly in time of high water. It has been observed that Blue Spring always rises after heavy rains on the upper portion of Logan Creek, but that it is not affected by rains on the upper portion of Current River.

"In addition to the evidence already presented, the following observations seem to confirm this belief:

"1. The general trend of the porphyry ridges is northwest southeast and the eastern boundary of the central porphyry mass is a few miles west of Blue Spring. As this rock is practically impervious not much ground water may be expected to migrate toward Blue Spring from the west or south.

"2. The general dip of the stratified rocks is from Logan Creek toward Blue Spring, and the latter lies almost in the trough of a shallow, sharply asymmetrical syncline, and therefore the water might easily migrate down the dipping bedding planes; and be forced to the surface when it reached the bottom of the trough.

"3. The valley of Logan Creek is about 200 feet higher than the spring."[1]

Blue Spring is at an elevation of about 560 feet above sea level.

This is approximately the ninth largest spring in the State. Measurements of the flow of the spring have been made as follows:

Date	Second-feet	Gallons per day
August 1, 1923	133	86,000,000
October 11, 1923	84	54,300,000
June 25, 1929	214	138,000,000
October 10, 1932	62	40,100,000
August 6, 1936	68	44,000,000
September 15, 1941	90	58,100,000
July 16, 1942	136	87,900,000

A photograph of Blue Spring is shown as plate XII-A.

BLUE SPRING (also called Davidson Spring) is located in sec. 4, T. 27 N., R. 6 E., 2 miles southwest of Kime post office, and 8 miles southeast of Greenville, Wayne County. The spring is now permanently submerged by the reservoir created by the dam on the St. Francis River at Wappapello and, therefore, is no longer visible. Before the construction of the dam, the spring issued from the base of a rock ledge and flowed about 300 feet to the river. The spring and the abundance of surrounding pine trees made it a popular place. Measurements of the flow of the spring before it was submerged were made as follows:

[1]Bridge, Josiah, Geology of the Eminence and Cardareva Quadrangles: Mo. Bur. Geol. and Mines, vol. XXIV, 2nd ser. pp. 40-41, 1930.

Date	Second-feet	Gallons per day
October 30, 1932	48.6	31,400,000
August 15, 1934	46.0	29,700,000
August 10, 1936	42.3	27,400,000
May 22, 1937	79.1	51,100,000
June 10, 1938	57.4	37,100,000
May 20, 1939	55.4	35,800,000

BLUE SPRING is located in SW¼SW¼ sec. 14, T. 24 N., R. 11 W., at McCabe, Ozark County, 3 miles southeast of Dora. A good road leads to within a quarter of a mile of the spring, which rises on the east bank of North Fork River, from the base of ledges of cavernous dolomite of the upper portion of the Gasconade formation. Picnic tables and benches are provided in a public parking area immediately north of the spring, and a foot trail has been built along the river edge to the spring basin. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
November 9, 1926	30.0	19,400,000
October 17, 1932	9.5	6,140,000
August 18, 1934	12.3	7,950,000
August 18, 1936	11.3	7,300,000

BLUE SPRING (also called Big Blue Spring and Sweet Spring) is located in NE¼ sec. 30, T. 36 N., R. 17 W., 6 miles west of Eldridge, Laclede County. It issues quietly from the base of a low cliff of Lower Gasconade dolomite and flows into the Niangua River about 200 feet away. The spring is not readily accessible by road, and is submerged by ordinary high water in the Niangua River. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
July 1, 1913	23*	14,900,000
September 10, 1925	16	10,300,000
October 20, 1932	11.0	7,100,000
September 18, 1936	13.7	8,850,000

*Measured by Engineering Experiment Station, University of Missouri.

BLUE SPRING is located in NW¼SE¼ sec. 31, T. 28 N., R. 6 W., Shannon County, 7 miles northeast of Mountain View. It issues from a small cave at the base of a rocky cliff about 80 feet high at the edge of Jacks Fork, into which it flows. The surroundings are rugged and picturesque, and the place can be reached readily by automobile road. Camping facilities are available. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 25, 1927	7.9	5,100,000
October 16, 1932	2.0	1,290,000
August 20, 1936	6.6	4,270,000

BLUE SPRING is located in Christian County, in sec. 32 T. 28 N., R. 22 W., 2½ miles southeast of Battlefield, Greene County. It rises in a small basin surrounded by cultivated fields at the edge of the James River bottoms, flows 300 feet in a winding branch, and empties into James River just above the Blue Spring Bridge. It is a favorite place for picnics as it is located but a few yards from a well-traveled road. The surrounding upland area in this portion of Christian County is pock-marked with sinkholes, which without doubt serve as the intake for the major part of the water flowing from this spring. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
October 23, 1928	3.3	2,130,000
October 20, 1932	2.0	1,290,000

BLUE SPRING is located in sec. 2, T. 39 N., R. 3 W., 2 miles southeast of Bourbon, Crawford County. The spring rises in a small private park which contains a fish hatchery and has conveniences for guests. Some large resort buildings and a small lake add to the attractiveness of the place. The flow on Sept. 3, 1925, was 4.9 second-feet, or 3,170,000 gallons per day.

BLUE SPRING.—See Famous Blue Spring, McDade Spring, and Shanghai Spring.

BLUE GRASS SPRING is located in NW¼SW¼ sec. 34, T. 44 N., R. 4 E., St. Louis County, 3½ miles east of Eureka. The spring issues from the base of a small ledge of middle Ordovician limestone and flows about 300 feet through beds used for growing water cress. The flow passes under U. S. Highway 66, and empties into Antire Creek, a tributary of Meramec River. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 23, 1934	0.1	64,600
October 1, 1936	.04	25,900
April 19, 1937	1.2	776,000

BOILING SPRING is located in sec. 33, T. 37 N., R. 10 W., 2½ miles northeast of Hooker, Pulaski County. It boils up in the edge of the Gasconade River at the base of a bluff of Gasconade dolomite about 2 miles below the mouth of Piney Creek. The spring is submerged when the river is high, but is a favorite fishing place when the river is low. It is on private property. The flow on Sept. 21, 1923, and on Oct. 21, 1932, was 65 second-feet, or 42,000,000 gallons per day.

BOILING SPRING is located in sec. 24, T. 32 N., R. 10 W., 8 miles southwest of Licking, Texas County. It boils up on the wooded bank of Piney Creek and is submerged when the creek is high. It can be reached by driving from Licking, although part of the road becomes bad in wet weather. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 18, 1925	12	7,760,000
October 18, 1932	18.3	11,800,000
August 14, 1934	31.0	20,000,000
August 14, 1936	15.2	9,820,000

BOYLERS MILL SPRING is located in sec. 7, T. 41 N., R. 19 W., at Boylers Mill, Morgan County, 11 miles southwest of Versailles. It rises in a lake having an area of about an acre, flows over a dam which formerly was used to develop power to operate a mill, and empties into Buffalo Creek about a quarter of a mile away. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
December 9, 1926	1.2	775,000
October 14, 1932	1.1	711,000

BOZE MILL SPRING is located in sec. 16, T. 23 N., R. 2 W., about 10 miles east of Alton, Oregon County. It rises in a low swale and flows into Eleven Point River about 500 feet away. The remains of an old dam and waterwheel, which formerly were used to develop power to operate a mill, are still visible near the mouth of the spring branch. The place is rather attractive and is easily reached by driving from Alton. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 13, 1925	13	8,400,000
September 8, 1931	16.4	10,600,000
April 5, 1932	32.0	20,700,000
October 25, 1932	14.0	9,050,000
September 14, 1933	24.5	15,800,000
August 16, 1934	13.9	8,980,000
August 12, 1936	15.9	10,300,000

BREAKUP SPRING.—See Wilder Spring.

BREWER BAY SPRING (also called Deadman Spring) is located in SW¼NW¼ sec. 5, T. 28 N., R. 3 E., about 4 miles southwest of Piedmont, Wayne County. The spring rises in a grove at the base of a hill and flows about 2 miles before entering Brewer's Bay. The bay is a slough of the Black River but is kept clear by the spring inflow. The attractive surroundings and the nearby rustic tables afford a pleasant place for picnics. The spring can be reached easily by driving from Piedmont. The flow on Aug. 11, 1936, was 2.09 second-feet, or 1,351,000 gallons per day.

BRICE SPRING.—See Bennett Spring.

BROOK SPRING is located in SW¼ sec. 22, T. 38 N., R. 6 W., Phelps County, 2½ miles east of St. James, from which it can be reached readily by driving. The water rises in a hexagonal rock basin about 20 feet in diameter, flows into a larger pool, and empties into a small creek 500 feet away. The spring is at the foot of a series of stone steps leading up to a huge stone mansion set on the brow of a low, wooded hill. The surroundings are attractively landscaped with shrubs and weeping willows. The spring is on private property. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
June 28, 1935	4.69	3,031,000
May 10, 1936	.65	420,000
September 7, 1939	.62	401,000

BROWN SPRING is located in sec. 12, T. 26 N., R. 24 W., at Brown Spring, Stone County, 12 miles east of Aurora. It flows from an opening at the base of a small cliff of cavernous Osage (Mississippian) cherty limestone on the west bank of Spring Creek, flows over a weir, and empties into Spring Creek. The flow on May 8, 1931, was 11 second-feet, or 7,110,000 gallons per day. Brown Spring is 1,130 feet above sea level.

BROWN SPRING is located in sec. 17, T. 35 N., R. 6 W., Dent County, about 1½ miles southeast of Hobson and 15 miles southeast of Rolla. The spring issues from a very small cave or fissure at the base of a low bluff and flows directly into a small pool, from which it meanders for about 500 feet through dense undergrowth and empties into Dry Fork Creek. Recently, the spring has been used as a watering place for cattle and the surroundings are overgrown. The road leading to the spring is little more than a trail and is almost impassable, except during dry weather. The flow on May 18, 1936, was 0.14 second-foot, or 90,500 gallons per day.

BRYANT SPRING is located in sec. 8, T. 27 N., R. 15 W., at Bryant, Douglas County, 6 miles north of Ava. It rises in a marshy lake which has an area of about an acre, flows 200 feet in a raceway to a mill, and then flows into Bryant Creek at a distance of 300 feet. It is near a good highway, and the place is provided with an attractive camp ground. Visitors are welcome. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 27, 1926	1.8	1,160,000
October 18, 1932	.97	627,000
August 19, 1936	.57	368,000

BUBBLING SPRING.—See Creasy Spring.

CAMP BEAVER SPRING is located in NE¼ sec. 12, T. 22 N., R. 33 W., in the north part of Anderson, McDonald County, near U. S. Highway 71. It issues beneath a rock bluff, at a railroad fill, and flows into Beaver Branch at a distance of 20 feet. It is used as a source of water supply for the nearby cabin camp, the appearance of which is enhanced by the spring and by Beaver Branch valley. The flow on March 3, 1941, was 4.12 second-feet, or 2,660,000 gallons per day.

CAMP GROUND SPRING.— See Wet Glaize Springs.

CARTER SPRING is located in sec. 34, T. 29 N., R. 2 E., Reynolds County, 7 miles west of Piedmont. The water flows from a hole in a cliff and is used to operate a water-wheel and grindstone. The spring is not readily accessible by road. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 1, 1925	1.6	1,030,000
August 11, 1936	.91	588,000

CAVE SPRING is located in sec. 28, T. 31 N., R. 5 W., 9 miles southeast of Cedar Grove, Shannon County. It issues from a cave at the base of a rock cliff 40 feet high and empties into

Current River 50 feet away. The place is scenic but is rather difficult to reach. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
June 22, 1924	72	47,000,000
November 30, 1939	25	16,000,000

CAVE SPRING is located in S½ Lot 2 NW¼ sec. 19, T. 26 N., R. 2 E., 3½ miles west of Hunter, Carter County. It issues from a cave, flows over a concrete dam about 5 feet high, and empties into Current River about three-quarters of a mile away. It can be reached by driving from Hunter. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
July 26, 1934	2.14	1,380,000
August 11, 1936	1.17	758,000
January 6, 1937	12.0	7,760,000

CAVE SPRING is located in sec. 4, T. 30 N., R. 23 W., near Pearl, Greene County, 13 miles northwest of Springfield. It issues from a rock outcrop of Burlington limestone (Mississippian, Osage Group) and flows 200 feet into Asher Creek. The spring is used as a domestic water supply by nearby residents. On Sept. 1, 1925, the flow was estimated as 0.4 second-foot, or 258,000 gallons per day.

CELT SPRING.—See Allgire Springs.

CHESAPEAKE SPRING is located in SW¼SW¼ sec. 21, T. 28 N., R. 25 W., at Chesapeake, Lawrence County. It issues from a gravel bed just north of State Highway 14. The underground relations of this spring are not shown, but the outlet is in the zone of brecciation along the Chesapeake fault and undoubtedly this faulting is responsible for the development of the spring. The rocks in the vicinity of the spring belong to the Cotter formation. The water is used by the State Conservation

Commission to supply water for a large hatchery for propagating such game fish as bass, crappie, perch, and channel-catfish. An excellent place for picnics and camping is provided by the State. The spring outlet is about 1,180 feet above mean sea level. Measurements of the flow of the main spring combined with that of several small springs rising nearby have been made as follows:

Date	Second-feet	Gallons per day
August 26, 1926	5.6	3,620,000
October 19, 1932	1.6	1,030,000
January 19, 1936	3.1	2,010,000

CLARKSON SPRING is located in SE¼ sec. 17, T. 27 N., R. 28 W., 7 miles north of Pierce City, Lawrence County. It flows from the gravel at the base of a small bluff of Osage (Mississippian) cherty, cavernous, channeled limestone, and empties into Center Creek a few hundred feet away. The spring basin is surrounded by a concrete wall. On Sept. 1, 1925, the flow was 7.9 second-feet, or 5,110,000 gallons per day.

CLEAR SPRING is located in NE¼ sec. 19, T. 28 N., R. 8 W., Texas County, 12 miles northwest of the town of Willow Springs, Howell County. The spring boils up in a bed of coarse gravel and flows through a swampy pasture into South Fork of Jacks Fork, about half a mile away. At present the spring, which is on private property, is used only as a source of domestic water supply. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
December 3, 1935	0.89	575,000
August 20, 1936	1.15	743,000

CLEAR SPRING is located in SW¼NW¼ sec. 36, T. 28 N., R. 1 W., 4 miles north of Van Buren, Carter County. It issues from beneath a small rock ledge at the foot of a gently sloping plain, flows in a concrete box and through a rock spring house, and empties into Henpeck Creek, 300 feet away. The spring is used as a source of domestic water supply by one family. On Nov. 19, 1942, the flow was 0.96 second-foot, or 620,000 gallons per day. Nearby residents stated that the spring ceased flowing from August to October 1940, and from August to September 1941; but that these were the only periods known to them in which the spring had no flow.

COLD SPRING (formerly known as Trout Lodge Spring) is located in E½ SW¼ sec. 4, T. 37 N., R. 1 E., near Floyd, Washington County, 8 miles northwest of Potosi. It rises from the Gasconade formation near the head of a short hollow and flows down the spring branch, which has a fall of about 30 feet in the first quarter of a mile. The surroundings are attractive, and the place was formerly used as a trout hatchery. It is now owned by the Cold Spring Club. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
October 8, 1926	3.3	2,130,000
October 12, 1932	.69	446,000

COLLINS SPRING is located in sec. 3, T. 37 N., R. 4 W., one mile southeast of Steelville, Crawford County. The water issues from the gravel inside a concrete spring house, and part of it is pumped to the Kelley estate nearby. On October 11, 1932, the flow was 1.6 second-feet, or 1,030,000 gallons per day.

COLLINS SPRING.—See Gravois Mills Spring.

CONN SPRING (also called Sand Spring) is located in sec. 25, T. 35 N., R. 18 W., Dallas County, one mile northwest of the village of Bennett Springs. It issues from a gravel bed about 200 yards from Niangua River. The spring is almost filled with aquatic plant growth and is often submerged by the river. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 20, 1932	5.1	3,300,000
January 7, 1936	4.9	3,170,000

COPPEDGE SPRING (also called Relfe Spring and Freeman Spring) is located in sec. 36, T. 35 N., R. 10 W., at Relfe, Phelps County. The spring issues from the side of an all-weather county road and flows into Spring Creek a short distance away. The spring is situated at a level which is low in the valley and becomes submerged when the Spring Creek is high. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
November 24, 1923	23	14,900,000
May 23, 1925	29	18,700,000
September 12, 1925	20	12,900,000
October 20, 1932	16.6	10,700,000
August 2, 1934	15.4	9,950,000

COVE SPRING is located in NE¼SW¼ sec. 9, T. 29 N., R. 2 W., Shannon County, 11 miles east of Eminence. It issues from a cave beneath a ledge of Eminence dolomite, and is the source of Powder Mill Creek. The low cave mouth is readily accessible from State Highway 106, which is only a few yards from the spring. On Nov. 18, 1942, the flow was 3.70 second-feet, or 2,390,000 gallons per day.

On the same day another spring (without name), located about 300 feet southeast of Cove Spring, had a flow of 0.274 second-foot, or 177,000 gallons per day.

CREASY SPRING (also called Bubbling Spring) is located in sec. 16, T. 36 N., R. 12 W., near Pippin Lodge, Pulaski County, 5 miles northwest of Waynesville, from which it can be reached over a good road to Pippin Lodge. It issues from a conical basin about 15 feet in diameter and 8 feet deep and flows quietly into Gasconade River at a distance of 50 feet. The force of the water issuing from the bed of the spring keeps the coarse gravel constantly in motion and presents an interesting sight. Creasy Spring is surrounded by woods and can be reached best by boat from nearby Pippin Lodge. It is submerged whenever the Gasconade River is high. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 14, 1914	20.6*	13,300,000
September 10, 1926	26.6	17,200,000
October 12, 1932	18.7	12,100,000
June 2, 1936	23.6	15,300,000

*Measurement made by the Engineering Experiment Station, University of Missouri.

CRYSTAL SPRINGS are located in NW¼SW¼ sec. 21, T. 23 N., R. 27 W., half a mile north of Cassville, Barry County. An upper outlet is from a coarse gravel bed; and a lower outlet, about a quarter of a mile downstream, rises in a pool surrounded by a concrete wall. Water is supplied from this pool to other, similar, adjacent ones; and all of them are used by the Crystal Springs Trout Farm to raise trout to sell to the market. By raising an earth embankment around the first outlet, the owner is able to decrease the flow from this outlet and correspondingly increase the flow from the second outlet to meet the fish rearing requirements. The spring branch, carrying the flow from both outlets, discharges into Flat Creek at a distance of a few hundred feet. Visitors are welcome at the hatchery. On December 11, 1942, the combined flow from the two outlets was 11.0 second-feet, or 7,110,000 gallons per day.

It is of interest to note that Crystal Springs are located on or very near the crest of a small, asymmetrical anticline, or monocline, in the cherty limestone strata of the Osage (Mississippian) beds. This low arching of the rock strata is seen in the road-cut at the bridge over Flat Creek, a few yards east of the springs. The presence of springs at the crest of such a fold at once suggests the probability that the folding of the rock layers was accompanied by some fracturing along the top of the arch and that ground water has found easy access to the surface along some of these fractures. A very small spring flows from the limestone, near the crest of this gentle fold, on the east bank of Flat Creek at a point about a quarter of a mile S. 70° E. of the upper spring of Crystal Springs.

Crystal Springs basin is at a surface elevation of approximately 1,285 feet above sea level. Thus it may be noted that Crystal Springs are about 240 feet above the elevation of Roaring River Spring, seven miles to the southeast.

CRYSTAL SPRING is located in sec. 22, T. 26 N., R. 15 W., at Larissa, Douglas County, 6 miles southeast of Ava. It flows from the base of a hill at the edge of a lake formed by an earth dam. It is used to develop power for an ice plant and for lighting a nearby resort. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 8, 1925	7 (Est.)	4,520,000
August 19, 1934	17.3	11,200,000
August 19, 1936	12.1	7,830,000

CULLEN SPRING is located in NW¼ sec. 35, T. 38 N., R. 17 W., 1½ miles north of Hahatonka, Camden County. The spring issues from several openings in the rocks at the foot of a hill and flows half a mile to the Lake of the Ozarks. It is used for domestic purposes by the nearby Cullen cabin camp. On November 19, 1942, the flow was 1.17 second-feet, or 756,000 gallons per day.

DAVIDSON SPRING.—See Blue Spring near Kime.

DAVIS SPRING is located in NE¼ sec. 34, T. 39 N., R. 9 W., Maries County, half a mile west of Gaines Ford Spring and 12 miles northwest of Rolla. The spring issues from the base of a bluff beside the road leading from Gaines Ford, flows through a pasture, and empties into a slough on the west side of the Gasconade River about a quarter of a mile from the spring outlet. The spring is used as a watering place for livestock. The flow on May 8, 1936, was 0.042 second-foot, or 27,000 gallons per day.

DAZEY SPRING is located in NW¼SE¼ sec. 22, T. 28 N., R. 1 W., 6 miles northwest of Van Buren, Carter County. It issues about 12 feet above the foot of a rock bluff 40 feet high, flows down the face of the bluff, and empties into a small creek in Spring Hollow at a distance of 25 feet. A hydraulic ram is used to pump water from the spring to an estate half a mile downstream. On November 19, 1942, the flow was 1.24 second-feet, or 801,000 gallons per day.

DOUBLE SPRING (also called Rainbow Spring) is located in NE¼NE¼ sec. 32, T. 24 N., R. 11 W., 6 miles south of Dora, Ozark County. The spring boils up vigorously from the approximate top of the Gasconade formation at the foot of a high hill, and flows east for about 50 feet before dividing into two branches. One branch flows north for 700 feet, and the other south for 1,500 feet, before emptying into North Fork River. The members of a private club, which owns the spring, have built several summer cottages along one branch and have at times utilized the spring to propagate trout. The spring and its surroundings are unique and picturesque, and this is truly one of the most beautiful large springs of the State. It can be reached readily by driving, but visitors must have written permission from the owners in order to obtain admission to the property.

This is the fourth largest spring in the Ozark region of Missouri and Arkansas. Double Spring is pictured on plate XII-B.

Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 8, 1919	136*	87,900,000*
September 6, 1924	163	105,000,000
September 7, 1925	82	53,000,000
August 18, 1934	142	91,800,000
August 17, 1936	57	37,000,000
July 24, 1942	212	137,000,000

*Measured by Engineering Experiment Station, University of Missouri.

EBB-AND-FLOW SPRING.—See Miller Spring, Rymer Spring, Elm Spring near Fanning, Ebb-and-Flow Spring (in Spring Valley), and Ebb-and-Flow Spring (on Thompson Creek). A general discussion of the nature of ebbing and flowing springs is presented on pages 44 and 45 of this report.

EBB-AND-FLOW SPRING (in Spring Valley) is located in SW¼ sec. 19, T. 30 N., R. 4 W., 8 miles northwest of Eminence, Shannon County. This is one of the five known ebbing-and-flowing springs in the State, further information upon which is given on pages 44 and 45 of this report. When the spring was visited late in the summer of 1923, an 8-hour period of no flow was observed, but a high-water mark indicated that there had been some flow a short time previously—perhaps as much as a second-foot.

EBB-AND-FLOW SPRING (on Thompson Creek) is located in SW¼ sec. 9, T. 29 N., R. 3 W., 7 miles northeast of Eminence, Shannon County. This is one of the five ebbing-and-flowing springs in the State, further general information upon which is given on pages 44 and 45 of this report. It issues from beneath a large sycamore tree at the foot of a steep hillside. The spring was visited on July 9, 1922, and July 5, 1923, and its flow was estimated to vary from nothing to one-sixth of a second-foot. At the time of measurement on November 18, 1942, the flow was 0.14 second-foot, apparently during a period of low flow. Further information upon this spring is given in Bulletin 1, Volume 7, Missouri School of Mines and Metallurgy, "Ebb and Flow Springs in the Ozarks" by Josiah Bridge (1923).

ELDORADO SPRING is located in NE¼SW¼ sec. 21, T. 36 N., R. 28 W., in a fork on the main street of Eldorado Springs, Cedar County. The outlet is enclosed by a constructed manhole from which the water is piped to a basin with a concrete retaining wall on one side and two sets of concrete steps on opposite sides leading down to two outlet pipes suitable for catching water in receptacles. Discharge from the pipes flows into a rectangular basin, from which it is carried in a small flume and a pipe to a sunken pit in a park. The water is used for drinking purposes by residents of that vicinity. It has a sweet taste and is supposed to have beneficial medicinal effects. On September 3, 1943, the flow was 0.01 second-foot, or 6,500 gallons per day (4½ gallons per minute).

ELM SPRING is located in SW¼ sec. 11, T. 40 N., R. 2 W., in Meramec State Park, 2 miles east of Sullivan, Franklin County. It issues from an artificially walled-in basin 30 feet in diameter, at the foot of a hill beside State Highway 114 and near the entrance to the park. The flow passes through a culvert under the highway and empties into Meramec River at a distance of 1½ miles. Portions of the spring branch support an abundant aquatic plant growth, which adds to the beauty of the park. The flow on May 25, 1937, was estimated at 1.2 second-feet, or 800,000 gallons per day.

ELM SPRING is located in SW¼ sec. 9, T. 38 N., R. 5 W., 1 mile southwest of Fanning, Crawford County. The spring issues from the base of a rocky bluff and empties into a small artificial basin from which part of the water is diverted to a hydraulic ram to furnish water for a large summer home at the top of the hill. The rest of the water flows into a series of five lakes used for the propagation of trout. The inhabitants of the vicinity state that the first lake was built in 1880 for the purposes of raising trout to be shipped alive to St. Louis, and that trout have flourished in the lakes ever since. The spring and lakes are on private property, and visitors are not encouraged to enter.

This is one of the five ebbing-and-flowing springs in the State. Further information upon such springs and the probable cause of their periodic action is given on pages 44 and 45 of this report. The flow at the time of measurement on September 10, 1936, was 0.75 second-foot, or 485,000 gallons per day, and on December 17, 1936, it was .0234 second-foot, or 15,100 gallons per day.

EVANS SPRING is located in NW¼ sec. 2, T. 37 N., R. 4 W., one mile southeast of Steelville, Crawford County. The water issues from the base of a rocky cliff and is diverted by a concrete wall into a small lake formed by a dam, from which it flows about a quarter of a mile in a flume along the hillside to a former hydroelectric plant and then into a nearby creek. The lake is stocked with trout. The site is attractive and interesting but may be visited only through permission from the owner. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 26, 1924	5.3	3,430,000
August 6, 1930	2.6	1,680,000
October 11, 1932	.4	259,000

FALLING SPRING is located on line between secs. 17 and 20, T. 36 N., R. 12 W., near Pippin Lodge, 5 miles northwest of Waynesville, Pulaski County. It issues from the side of a wooded hill, flows over an earth and rock dam 8 feet high, and empties into Gasconade River at a distance of 50 feet. The outlet of the spring is about 10 feet above ordinary stages of the river. The place can be reached only by walking or by boat from Pippin Lodge. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 11, 1925	2.3	1,490,000
September 10, 1926	7.4	4,780,000
October 12, 1932	1.4	905,000
June 2, 1936	2.6	1,680,000

FALLING SPRING is located in NE¼ sec. 14, T. 40 N., R. 2 W., in Meramec State Park, 2 miles east of Sullivan, Franklin County. The spring issues from the base of a low rock ledge on the side of a hill, and flows about 60 feet with a fall of about 20 feet before passing through a culvert under State Highway 114 into Elm Spring Branch at a point about half a mile from Meramec River. The spring is marked and is a source of water supply for campers and tourists. The flow on May 25, 1937, was estimated as 0.08 second-foot, or about 50,000 gallons per day.

FALLING SPRING is located in NW¼ sec. 4, T. 25 N., R. 3 W., Oregon County, on the west bank of Hurricane Creek, one mile west of New Liberty, and 6¾ miles northeast of Greer. It issues about 15 feet above the base of a rock bluff. The opening is partially concreted to confine the flow to a small wooden flume in which it is carried to a water-wheel. During periods of medium and high flow the wheel is used to grind feed and to generate electricity for charging batteries. During periods of low flow the water is allowed to spill directly into an artificial pool where it is used as a private water supply for livestock. Overflow from the pool flows into Hurricane Creek, a tributary of Eleven Point River. On September 8, 1944, the flow was 0.14 second-foot, or 90,400 gallons per day.

FAMOUS BLUE SPRING (also called Blue Spring) is located in NW¼ sec. 36, T. 35 N., R. 18 W., Dallas County, one mile west of the village of Bennett Springs. It rises in a low swale at the edge of a field and flows into Niangua River 800 feet away just above the mouth of Bennett Spring branch. The spring is submerged when the river is high. On September 2, 1933, the flow was 4.44 second-feet, or 2,870,000 gallons per day.

FREEMAN SPRING.—See Coppedge Spring.

GAINES FORD SPRING (also called Nagogami Spring) is located in NW¼W¼ sec. 35, T. 39 N., R. 9 W., Maries County, 10 miles northwest of Rolla. It issues from the base of a talus slope of a high rock bluff and flows into Gasconade River at a distance of 500 feet. It can be reached readily by driving over a farm-to-market road, Phelps County Route E, and thence a short distance over a county road. The spring and its rugged, picturesque surroundings are important attractions of the near-by Nagogami Lodge and the Rolla Country Club. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
April 28, 1926	18	11,600,000
June 26, 1932	4.2	2,740,000
October 21, 1932	3.3	2,130,000

GANG SPRING is located in lot 8, NW¼ sec. 1, T. 29 N., R. 3 W., at the former Gang post office, 10 miles northeast of Eminence, Shannon County. It rises in a stone spring-house beside a large oak tree at the foot of a small hill, and flows in a natural drain along the Gang mail route a quarter of a mile to Blair Creek. On November 18, 1942, the flow was 0.77 second-foot, or 50,000 gallons per day.

GOLLAHON SPRING is located in SW¼ sec. 17, T. 37 N., R. 8 W., 4 miles southwest of Rolla, Phelps County. It rises in the edge of a small field and flows through a narrow ditch to Little Beaver Creek about 70 feet away. It has been excavated to form a pond for propagating fish but has become filled with aquatic vegetation. It can be reached readily by driving. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
April 1, 1931	0.27	174,000
August 5, 1936	.26	168,000

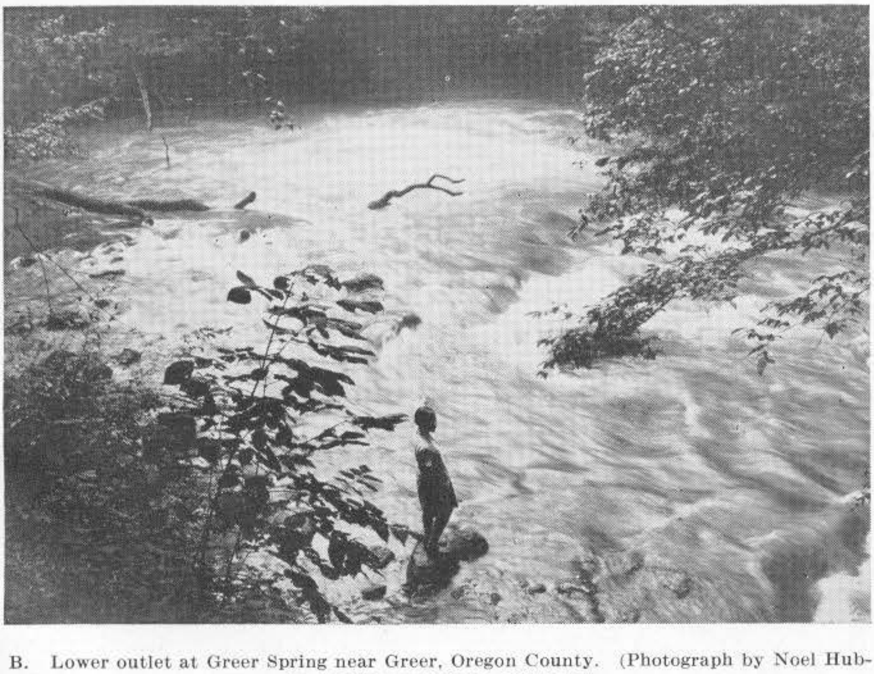
GRAVEL SPRING is located in sec. 4, T. 28 N., R. 1 W., Shannon County, 2 miles northwest of Clear Spring and 10 miles northwest of Van Buren. As its name implies, it issues from the very coarse gravel at the edge of Current River, and is submerged when the river is high. Much of the water enters the river without coming to the surface of the gravel. The very rugged surroundings make it quite inaccessible except by boat. On June 1, 1934, the flow was roughly estimated as 15 second-feet, or 9,700,00 gallons per day, and on August 7, 1936, it was measured as 16.5 second-feet, or 10,700,000 gallons per day; apparently on both dates there was additional water flowing through the gravel which did not appear at the surface and, therefore, could not be measured.

GRAVOIS MILL SPRING (also called Collins Spring) is located in sec. 19, T. 41 N., R. 17 W., one mile west of Gravois Mill and 10 miles south of Versailles, Morgan County. It issues from the gravel floor of a small rugged ravine in the upper part of the Gasconade formation and flows 500 feet into several small lakes created by dams. A fish hatchery is located nearby, and the lakes are used for propagating fish. An old grist mill, which stood three-quarters of a mile downstream was flooded by the creation of the artificial Lake of the Ozarks. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
May 19, 1926	8.8	5,690,000
October 15, 1932	5.4	3,490,000

GREER SPRING is located in SW¼ sec. 36, T. 25 N., R. 4 W., Oregon County, one mile north of the village of Greer and 6 miles north of Alton. The spring has two outlets which are located in a very deep and narrow gorge that is covered with a dense growth of trees. The outlets are about 300 feet apart horizontally and eight feet vertically. The country rock is the Gasconade dolomite. At the upper outlet (plate XIII-A) the water flows laterally and rather quietly from a picturesque, low-roofed cave in the rocks, overhung by vines and shrubs; whereas at the lower outlet (plate XIII-B), which consists of a circular

A. Upper outlet from cave, Greer Spring, near Greer, Oregon County.



B. Lower outlet at Greer Spring near Greer, Oregon County. (Photograph by Noel Hubbard, Missouri School of Mines.)

basin in the rocky channel of the stream from the upper outlet, the water boils up with much force. The water then flows swiftly between and over the rocks in the spring branch 1¼ miles to Eleven Point River. The total fall from the upper outlet to the river level at ordinary stages is about 62 feet.

It seems likely that the greater part of the flow, or perhaps all of it, formerly came from the upper outlet; but, as time passed, more flow was gradually diverted to the lower outlet as a result of either (1) the underground stream cutting downward and forming an additional channel at a lower elevation or (2) the surface stream cutting its gorge deeper and encountering another water-bearing zone. The former appears to be more probable. At the present time a substantial flow comes from the upper outlet during wet seasons, but during long dry periods this flow ceases entirely. In the relatively near future, geologically speaking, the upper outlet will probably be abandoned and the total flow during all seasons may then come from the lower outlet. One of the dolomite walls of the narrow gorge between the two outlets is honeycombed with openings and solution channels, some of which are partly filled with clay. Many of these openings in the cavernous rock are interconnected in a coalescing network. They represent abandoned channelways which formerly served as underground water conduits and which have now been exposed to view by the gorge-deepening processes.

The well-sustained flow from the lower outlet indicates that it is an orifice which is directly connected with the saturated zone of ground water below the level of the water table. Flow from this source is augmented from time to time by shallower subsurface water during periods of seasonal or local heavy rainfall (plate III).

The large and uniform discharge of the spring, the narrowness of the gorge in which it flows, and the large available fall to the Eleven Point River, make the spring well suited for the development of water power; but, because of the scenic beauty of the place, such development may never be made. Formerly power was developed here to operate a mill at the top of the hill.

The large volume of clear, cold, and sparkling water issuing from the rocks with such force and then plunging rapidly down the narrow, rocky gorge with its heavily-wooded, steep slopes, makes this a place of extraordinary beauty and striking grandeur. It is indeed one of the scenic gems of the State. The writers express the hope, which is echoed by many citizens of the State, that this may at some time be acquired as a public park so that its outstanding beauty may be preserved perpetually for the benefit and enjoyment of the people.

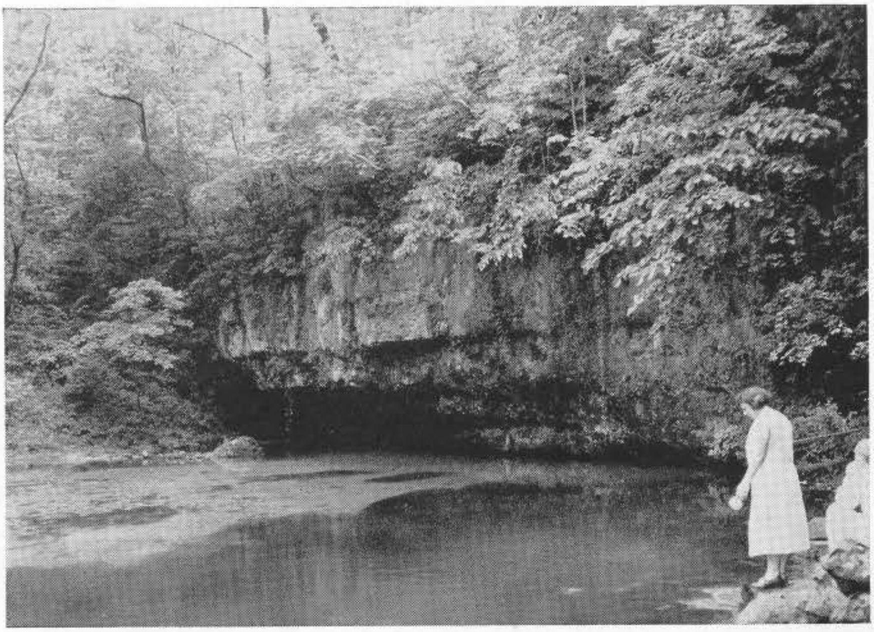
Although the place is privately owned, visitors are permitted to visit the spring and they are requested to help maintain the natural beauty of the site. It can be reached readily by driving over State Highway 19 to the old mill at the north edge of Greer, and then walking along a steep path down the hill to the spring.

The source of Greer Spring is believed to include a large part of the drainage basin of the Eleven Point River above the confluence of the spring branch and the river. This area contains many broad, gravel-filled valleys having little or no surface drainage except for short periods after heavy rains, and it also contains many sinks, some of which are visible from the highways within or bordering the region. Obviously, much of the rainfall in the region goes almost directly into the subsurface drainage system. According to Benjamin A. Davis of Van Buren, at least two nearby sinks are known to have been formed by the collapse of underground cavern roofs during the past twenty years—one in the Chapel Hill neighborhood about 5 miles south of Mountain View, in which local inhabitants reported that whole trees dropped into the sink; and another one about 50 feet in diameter on the Whitt Holden farm about 5 miles southwest of Montier.

Greer Spring is the third largest spring of the Ozark region of Missouri and Arkansas. It is the only one of the very large springs of Missouri (not counting Mammoth Spring at Mammoth Spring, Ark.) that is never submerged by the stream into which it flows—a condition which aids in the accurate determination of its discharge after heavy rains and makes it more suitable for rainfall-runoff studies. The relation of the flow of the spring to the rainfall in that region and to the flow of St. Francis River near Patterson, Mo., are shown on plates III and IV, respectively.

Records of the daily flow of the spring have been collected from December 1921 to date. During this period the flow has been as follows:

A. Hahatonka Spring at Hahatonka, Camden County. View showing gravel bar at mouth of spring. (Photograph by G. L. Campbell.)



B. Hahatonka Spring, Camden County. (Photograph by Noel Hubbard, Missouri School of Mines.)

	Date	Second-feet	Gallons per day
Maximum....	December 27, 1942...	1,060*	684,000,000*
Minimum.....	August-September, 1936	116	75,000,000
Average......	1922-43.............	332	214,000,000

*Includes about 400 second-feet, or 258,000,000 gallons per day, from drainage area above spring.

Records of the daily flow of the spring may be had upon request. A hydrograph of the mean monthly flow over a period of several years is shown on plate V. The spring is approximately 586 feet above mean sea level.

HAHATONKA SPRING is located in sec. 2, T. 37 N., R. 17 W., at Hahatonka, Camden County; its elevation is about 660 feet above sea level. It emerges from the base of a rocky bluff in the Eminence dolomite; flows through a narrow, deep, and precipitous-walled canyon 1,000 feet long known as "Trout Glenn"; and empties into the Niangua River arm of the Lake of the Ozarks. A stately edifice known widely as "Hahatonka Castle", originally built to serve as a private residence, stood at the top of the hill overlooking Trout Glenn until its destruction by fire in 1942.

The clear, sparkling water in the spring branch and pool; the deep, steep-sided, wooded chasm; the sinkholes and the natural bridge; the grandeur of the "Castle" ruins;—all make the Hahatonka area a scenic region of fascinating interest to the scientist and the nature lover.

Hahatonka is widely known for this natural beauty and is visited by many tourists. It can be reached readily by driving a few miles over all-weather county roads from either State Highway 5 or U. S. Highway 54. The visitor should walk to the spring outlet and Trout Glenn in the valley and to the site of the former "Castle" at the top of the bluff which overlooks the spring in order to enjoy fully the magnificient scenes available there.

Although the place is privately owned, visitors are welcomed. The owner of the property, through lessees, maintains cottages, camping sites, boats, and other conveniences in the valley, for visitors.

While in the vicinity of the spring one should also drive to the bridge on State Highway 5 across the Lake of the Ozarks and to the Bagnell Dam on U. S. Highway 54, in order to see the many beautiful views of the lake that may be obtained from the highways and the side roads in that region.

It is believed that a relatively large surface area to the east and south of Hahatonka spring may contribute some of the subsurface water which flows from the spring outlet. Several large sinkholes, such as the Big Red Sink, are to be found in this direction from the spring, and "dry valleys" are not uncommon in the area. "Dry Hollow" is a typical example of a valley which carries surface runoff immediately after heavy rainfall, but which is usually dry at other times.

Dry Hollow is a small valley which drains some of the upland east of Hahatonka and flows westward toward the spring. About half a mile east of the spring, two sinkholes occur in the bottom of the creek bed of Dry Hollow. All surface water which travels this far down the valley of the creek flows into the upper of these two sinks and continues its course underground through River Cave which may be entered by the lower, downstream, sinkhole. River Cave has been explored for a short distance below the sinkhole entrance, and it is seen to have a winding course through the dolomite of the uppermost portion of the Eminence formation. This underground channel way unquestionably contributes water to nearby Hahatonka Spring. The cave is choked at places with rock debris, large logs, boulders, and course gravel. One is impressed also with the large gravel bar which has formed at the outlet of Hahatonka Spring—an apparent indication of the carrying power of the spring waters at flood stages. (See plate XIV-A)

The locally famous natural bridge which spans the deep, elongated sinkhole a quarter of a mile east of the spring is an arch capped with sandstone strata of the Gunter member of the Van Buren formation. A subterranean cavern was evidently formed by the solution work of percolating ground water which dissolved portions of the rather pure dolomite of the uppermost part of the Eminence formation. The Gunter sandstone, which lies immediately above the Eminence dolomite and is far less soluble than the dolomite, formed the roof of this cavern. Later, when most of the cavern roof collapsed to form the sinkhole, a small part of the sandstone roof held its position and survived to make the span which is now the natural bridge over the sink.

The sinkholes in Dry Hollow at the entrance to River Cave are located about 1,000 feet northeast of the natural bridge. The abandoned stream bed of Dry Hollow between these two sinks is floored with Gunter sandstone, and the sinks are themselves collapsed portions of the Gunter sandstone strata which formed the ceiling over a subterranean cavern in the uppermost beds of dolomite of the Eminence formation.

Records of the daily flow of the spring have been collected from November 1922 to June 1923 and from October 1923 to September 1926. During this period the average flow was aproximately 75 second-feet, or 48,000,000 gallons per day, and the minimum flow 43 second-feet, or 28,000,000 gallons per day. The maximum flow could not be determined on account of backwater from the Niangua River. A hydrograph of the mean monthly flow is shown on plate V. Records of the daily flow may be had upon reqest.

HALL SPRING is located in sec. 33, T. 30 N., R. 22 W., about 3 miles northwest of the city limits of Springfield, Greene County. On October 10, 1940, the flow was 0.11 second-foot, or 71,000 gallons per day.

HAZLETON SPRING is located in sec. 34, T. 33 N., R. 10 W., at Hazleton, Texas County, 8 miles west of Licking. It rises in a 5-acre pond formed by a dam about 12 feet high in the spring branch, which provides power for a grist mill, and empties into Piney Creek about 500 feet below the mill. The lake is stocked with fish. The place can be reached readily by driving from Licking. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 18, 1925	4.3	2,780,000
October 18, 1932	4.6	2,970,000
August 14, 1934	7.4	4,780,000

HEARELL SPRING is located in NE¼ sec. 30, T. 25 N., R. 31 W., about 600 feet southwest of the building of the Government fish hatchery at the east edge of Neosho, Newton County. The outlet of the spring is enclosed by a covered box, from which the water is piped to the rearing pools of the hatchery. On September 6, 1943, the flow was 1.08 second-feet, or 698,000 gallons per day.

HIGHLY SPRING is located in sec. 33, T. 32 N., R. 3 W., Dent County, 4 miles southwest of Bunker. It issues from the base of a 30-foot rock ledge and flows 2 miles into Sinking Creek. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
October 13, 1932	3.5	2,260,000
August 6, 1936	3.84	2,480,000

HODGSON MILL SPRING is located in sec. 34, T. 24 N., R. 12 W., near Sycamore, Ozark County. It issues from a point near the foot of a bluff of cherty and sandy dolomite and sandstone of the lower part of the Roubidoux formation. A grist mill utilizes a direct water fall of 9 feet, and the spring water flows from the mill into Bryant Creek at a distance of 600 feet. A portion of the flow is diverted to a circular rock basin from which it cascades to the spring branch. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 29, 1926	23.6	15,300,000
October 17, 1932	34.4	22,200,000
August 18, 1934	44.7	28,900,000
August 18, 1936	28.1	18,200,000

A view of the flow from the rock basin at the mill is shown on plate XI-B.

HOPEWELL SPRING is located in NE¼NE¼ sec. 33, T. 37 N., R. 3 E., 5½ miles southeast of Potosi, Washington County. It rises in a small depression and flows 150 feet into Mill Creek. On March 9, 1942, the flow was 2.03 second-feet, or 1,310,000 gallons per day.

HOWES MILL SPRING is located in SW¼ sec. 15, T. 34 N., R. 3 W., at Howes Mill, Dent County, 18 miles east of Salem. It issues from the base of a rocky hillside on State Highway 32. A dam across the spring branch forms a small lake which formerly supplied water to operate a grist mill. The spring is on the north side of the state highway and is a few yards east of Huzzah Creek. Outcrops of Eminence dolomite may be seen near the mill pond and in the bed of Huzzah Creek at the mill. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
October 13, 1932	8.06	5,210,000
August 5, 1936	7.09	4,590,000

INDIAN SPRING is located in NW¼NW¼ sec. 36, T. 38 N., R. 5 W., at the Indian Spring Lodge near State Highway 8, about 3½ miles west of Steelville, Crawford County. The spring has two outlets. The upper outlet rises in a circular pool at the base of a low hill and the lower outlet in another pool 100 feet away, both pools being surrounded by rock walls. The combined flow is carried in an artificial rock channel for a distance of about 100 feet and then in a natural channel for a quarter of a mile before entering Meramec River. The landscaped surroundings are very pretty and constitute an attractive part of the Indian Springs Resort, which is open to the public. Cabins may be rented nearby and tennis, bathing, boating, and fishing are among the sporting attractions available.

The combined flow from the two outlets on September 11, 1936, was 0.24 second-foot, or 155,000 gallons per day.

JACKSON MILL SPRINGS are located in SE¼SW¼ sec. 35, T. 26 N., R. 17 W., 8 miles southwest of Ava, Douglas County. The four spring outlets, within a distance of 100 feet of each other, emerge from rock outcrops in a small picturesque valley 800 feet west of the old Jackson Mill. Formerly the flow of the springs was carried in a flume to operate the grist mill, which was built about 90 years ago, but which is no longer in use. The spring branch empties into Beaver Creek 200 feet downstream from the mill. The place can be reached readily by driving 7 miles southwest from Ava on State Highway 76, crossing the bridge over Beaver Creek, and then following a road downstream along the west bank of the creek one mile to the mill. The flow on December 22, 1943, was 2.39 second-feet, or 1,540,000 gallons per day.

JAMES SPRING is located in sec. 36, T. 38 N., R. 3 W., 8 miles east of Steelville, Crawford County. It issues from several sources in a cultivated field and flows half a mile into Dry Creek. On October 12, 1932, the flow was 2.2 second-feet, or 1,430,000 gallons per day.

JORDAN SPRING is located in W½NE¼SW¼ sec. 24, T. 26 N., R. 1 E., 3½ miles west of Hunter, Carter County. It issues from a bed of gravel near the edge of a cultivated field and flows into Current River half a mile away. It can be reached by driving from Hunter. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
July 26, 1934	11.8	7,630,000
August 11, 1936	7.66	4,950,000

KEENER SPRING is located in SE¼ sec. 4, T. 26 N., R. 5 E., one mile northwest of Keener Station, Butler County, and 3 miles southeast of Williamsville. The water issues from several places in the base of a low bluff of sandstone beds of the Roubidoux formation, and flows into Black River at a distance of 600 feet. The remains of an old dam are visible about 150 feet above the mouth of the spring branch. The place can be reached readily by driving, and Keener Cave Resort on the property is visited by tourists and vacationists. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 18, 1913	14*	9,050,000
August 3, 1925	19	12,300,000
October 29, 1932	17	11,000,000
August 14, 1934	15	9,690,000
March 18, 1935	43	27,800,000
August 10, 1936	13.8	8,920,000
December 4, 1939	18.8	12,200,000

*Measured by Engineering Experiment Station, University of Missouri.

KELLEY SPRING is located in SE¼ sec. 18, T. 23 N., R. 32 W., one mile southwest of Goodman, McDonald County, on the west side of U. S. Highway 71. It issues from a gravel bed, flows into Beaver Branch and thence into Indian Creek, 5 miles below Kelley Spring. A small dam, 300 feet downstream from the spring outlet, forms a pretty pool of deep blue color, which is stocked with trout and in which the public may fish, upon payment of a fee. Trout raised in a nearby hatchery are sold commercially. Several cabins and a store are located nearby. On March 3, 1941, the flow was 0.41 second-foot, or 265,000 gallons per day. According to reports there is no flow below the dam during extended drought periods.

KING BEE SPRING is located in SE¼SE¼ sec. 19, T. 24 N., R. 4 E., 5 miles northeast of Flatwoods, Ripley County. It flows into little Black River at a distance of 600 feet. On June 18, 1940, the flow was 3.29 second-feet, or 2,130,000 gallons per day.

KRATZ SPRING is located in sec. 19, T. 41 N., R. 2 W., 5 miles west of Stanton, Franklin County. The water flows from a gravel bed in a cultivated field and forms the source of Spring Creek, which empties into Bourbeuse River. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 3, 1925	6.8	4,390,000
September 4, 1936	10.0	6,460,000

LAKE SPRING is located in SE¼ sec. 3, T. 35 N., R. 7 W., Dent County, at Lake Spring, about 11 miles southeast of Rolla. The water issues at the base of a low hill, flows into a rock-walled pool about 12 feet square, and empties into Hyers Branch a few feet away. The spring is in a wooded area about 100 feet upstream from the bridge on State Highway 72. The flow on May 12, 1936, was 0.022 second-foot, or 14,400 gallons per day.

LAND SPRING is located in lot 4, sec. 4, T. 34 N., R. 13 W., Pulaski County, 3 miles northwest of Brownfield, and 7 miles southeast of Gascozark. It issues from a small cave at the base of a rocky cliff and flows into Cole Creek at a distance of 50 feet. On November 26, 1937, the flow was 0.18 second-foot, or 116,000 gallons per day.

LANE SPRING is located in NW¼ sec. 32, T. 36 N., R. 8 W., three-quarters of a mile north of Yancy Mill post office, Phelps County. The water bubbles up through sand in a cultivated field and flows 200 feet into Little Piney Creek. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
October 21, 1932	17.9	11,600,000
sAugust 2, 1934	4.8	3,100,000

LEEPER SPRING is located in sec. 27, T. 28 N., R. 3 E., in Leeper, Wayne County. It bubbles up in a small concrete basin in the center of a street and flows into Black River half a mile away. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
April 8, 1932	0.17	109,000
August 11, 1936	.04	26,000

LITTLE GAINES FORD SPRING is located in NW¼ sec. 35, T. 39 N., R. 9 W., Maries County, across the Gasconade River from Gaines Ford Spring, 12 miles northwest of Rolla. The spring rises through sand and gravel beside a road leading to Gaines Ford and flows only a short distance before entering a slough of the Gasconade River. The flow on May 8, 1936, was 0.034 second-foot, or 21,900 gallons per day.

LITTLE TORONTO SPRING is located in SE¼ sec. 25, T. 38 N., R. 15 W., at Toronto, Camden County. The spring issues from the base of a rock bluff and flows through a channel which is usually filled with water cress. On November 18, 1942, the flow was 0.42 second-foot, or 271,000 gallons per day.

LORD SPRING is located in SE¼ sec. 28, T. 27 N., R. 5 E., 3 miles east of Williamsville, Wayne County. It issues from the base of a rock ledge, flows into a 5-acre lake formed by a dam across the spring branch, and empties into Black River nearby. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
October 30, 1932	0.43	278,000
August 10, 1936	.58	375,000

LOST RIVER.—See Onandaga Spring.

LOST SPRING is located in SW¼NW¼NE¼ sec 26, T. 22 N., R. 9 W., about 12 miles south of West Plains, Howell County. The spring issues from the gravel in a small rock-lined basin, from which it flows through pasture land into West Fork Creek about a mile away. A nearby rural school obtains water from the spring. The adjacent hillside is strewn with large boulders and bears a heavy stand of oak timber. The place is difficult to reach. The flow on November 21, 1934, was 0.015 second-foot, or 10,000 gallons per day.

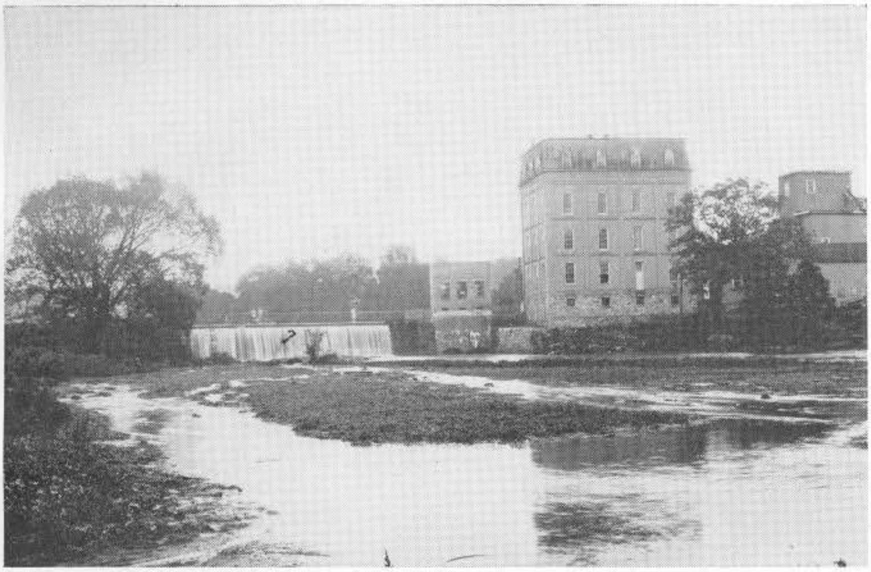
LUMLEE MILL SPRING is located in NW¼NW¼ sec. 12, T. 29 N., R. 26 W., 7 miles northwest of Halltown, Lawrence County. It issues from several sources within an area of about an acre and flows half a mile into Turnback Creek. On October 19, 1932, the flow was 3.7 second-feet, or 2,390,000 gallons per day.

MAMMOTH SPRING is located near the line between secs. 5 and 8, T. 21 N., R. 5 W., at the town of Mammoth Spring, Fulton County, Arkansas, just south of the Missouri State line. The spring rises in an artificial lake of several acres which completely submerges the spring outlet. A Government fish hatchery with landscaped grounds is located at the spring. Some conception of the size of the spring is given by the fact that its flow is used to operate a large mill and to develop hydroelectric power to serve the town of Mammoth Spring and several other towns in that vicinity. A view of the flow over the dam (plate XV-A) gives an impression of the large size of the spring.

The source of Mammoth Spring includes a large area to the north and northwest of the spring outlet. This region is one in which surface drainage is poorly established, and in which there is abundant evidence that much of the rainfall enters the ground through sinkholes and similar solution-formed openings and thus contributes appreciable amounts of water to the subsurface drainage system. The area is characterized by broad, shallow valleys which carry very little or no surface runoff except at times of very heavy rainfall. Many sinkholes and sink-depressions dot a large upland area of low relief—an area northwest of the spring outlet which extends at least as far north as the town of West Plains and west into southern Howell County. A remarkable sinkhole region extends west and south of the town of Koshkonong.

Within this latter area is the justly famous and spectacular "Grand Gulf", some 3½ miles south of Koshkonong (plate XV-B). The "Gulf" is an elongated collapsed cavern—or series of collapsed caverns, which makes a truly unusual landscape feature. Grand Gulf is more than half a mile long, 50 to 200 feet wide, and as much as 120 feet deep. It is a precipitous-walled chasm—similar to a narrow surface canyon or gorge, save that it is a completely enclosed depression which drains out through sinks and caverns in its own floor. Near its southeast end (its greatest length is in a northwest-southeast direction) the Gulf bifurcates and an east fork is separated from the main portion of the depression by an area which is roofed by a great natural bridge.

The vertical walls of the Gulf are composed of dolomite of the Jefferson City formation. At a number of places along its winding course, the floor of the narrow depression itself has caved into sinkholes which indicate the present-day subsurface



A. Mammoth Spring, Fulton County, Arkansas. Spring water flowing over dam at hydroelectric plant and mill. (Photograph by Noel Hubbard, Missouri School of Mines.)

B. Grand Gulf. (Photograph by Noel Hubbard, Missouri School of Mines.)

drainage at levels below the bottom of the Gulf. A surface area of several square miles to the northwest drains into the Grand Gulf, and the runoff from that area floods the Gulf temporarily during times of torrential rainfall. The Grand Gulf is the exposed portion of the course of a former underground drainageway—exposed by the collapse of portions of its roof along a distance of half a mile.

Reports from local inhabitants of the area have regularly stated that certain identifiable objects which were thrown into the cave waters in the northeast part of the Grand Gulf reappeared in the pool of the artificial lake of Mammoth Spring. Whether or not these reports are well-founded, it is logical to believe that the large, poorly-drained surface area which includes the Grand Gulf region contributes to the subsurface drainage system which supplies some part of the flow of Mammoth Spring.

This is the second largest spring of the Ozark region of Missouri and Arkansas. The following table gives the results of measurements of the flow of Mammoth Spring, in gallons per day, and the comparison with the flow of Big Spring near Van Buren, Mo., and Greer Spring at Greer, Mo., on the same days:

Date	Big Spring	Mammoth Spring	Greer Spring
December 11, 1924...	183,000,000	155,000,000	133,000,000
June 11, 1926.......	231,000,000	200,000,000	180,000,000
April 28, 1942.......	337,000,000	279,000,000	270,000,000

These figures indicate that Mammoth Spring ranks between Big and Greer Springs in regard to quantity of flow.

MAMMOTH SPRING.—See Prewett Spring.

MARKHAM SPRING is located in SW¼NW¼ sec 23, T. 27 N., R. 4 E., 3 miles west of Williamsville, Wayne County. It rises in a small lake at the foot of a hill of dolomite of the Eminence formation, and empties into Black River half a mile away. The place is privately owned. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 3, 1925	7.4	4,780,000
October 29, 1932	6.7	4,330,000
August 15, 1934	7.6	4,910,000
August 10, 1936	5.5	3,560,000

MARTIN SPRING is located in sec. 8, T. 37 N., R. 8 W., 3½ miles west of Rolla, Phelps County. It issues from beds near the contact between the Gasconade and Roubidoux formations inside a stone spring house by the side of U. S. Highway 66, and flows about 500 feet before entering Little Beaver Creek. On March 13, 1935, immediately after an unusually heavy rain, the flow was 1.3 second-feet, or 840,000 gallons per day.

McCUBBENS SPRING is located in E½W½ lot 1 NW¼ sec. 6, T. 27 N., R. 6 W., Shannon County, 5 miles northeast of Mountain View. It issues from the base of a low rock ledge and flows into Jacks Fork at a distance of a quarter of a mile. The spring branch is in a deep, wooded valley, and the surroundings are quite pretty, but the place is rather inaccessible. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 25, 1927	2.4	1,550,000
October 16, 1932	.78	504,000
August 20, 1936	.40	259,000

McDADE SPRING (also called Blue Spring) is located in NE¼NW¼ sec. 16, T. 39 N., R. 5 W., 5 miles northwest of Cuba, Crawford County. It boils up gently from joint cracks in flat-lying sandstone and flows directly into a tributary of Brush Creek only a few feet away.

Though this is a relatively small spring, the geologic setting in which it occurs is of interest, for it is apparently a typical "fault-line spring". McDade Spring issues from prominent joints or fracture openings in the sandstone beds at a point which is very near the surface trace of the plane of a fault which has disturbed the strata in this area. A few yards east of the spring, the sandstone strata (which are essentially flat-lying beds at, and to the southwest of, the spring) are steeply inclined to the northeast. At the low dam in the creek, the strata are seen to dip downward to the northeast where they are tilted to make an angle of from 25° to 30° with the horizontal. These inclined beds apparently represent the "drag" along the fault, which is known in this region as the "Cuba Fault".

The Cuba Fault or fault zone has, during the progress of geologic mapping in this portion of Crawford County, been traced for more than 25 miles. The location of this structural feature is shown, by the conventional symbol for representing faults, on the geological map of Missouri. At McDade Spring, this disturbance has brought beds of the (older) Roubidoux formation on the west side of the fault up to the level of beds of the (younger) normally superjacent Jefferson City formation on the east side of the fault. Thus the Roubidoux is exposed on the upthrow (west) side of the fault plane.

The faulting has broken and fractured the rock on the relatively upthrown side of the fault in a manner which has left openings and fractures which make open channelways for the migration of ground water to the surface at McDade Spring. The fault plane itself, just east (northeast) of the spring, may serve as an impervious barrier to the normal migration of subsurface water at the location of the spring. Thus, the fault may be serving as a subsurface "dam" at this place—checking the flow of a small underground stream and causing that stream to be pooled to such an extent that some of its water is diverted to the surface through the open joints and fractures which are visible at the spring.

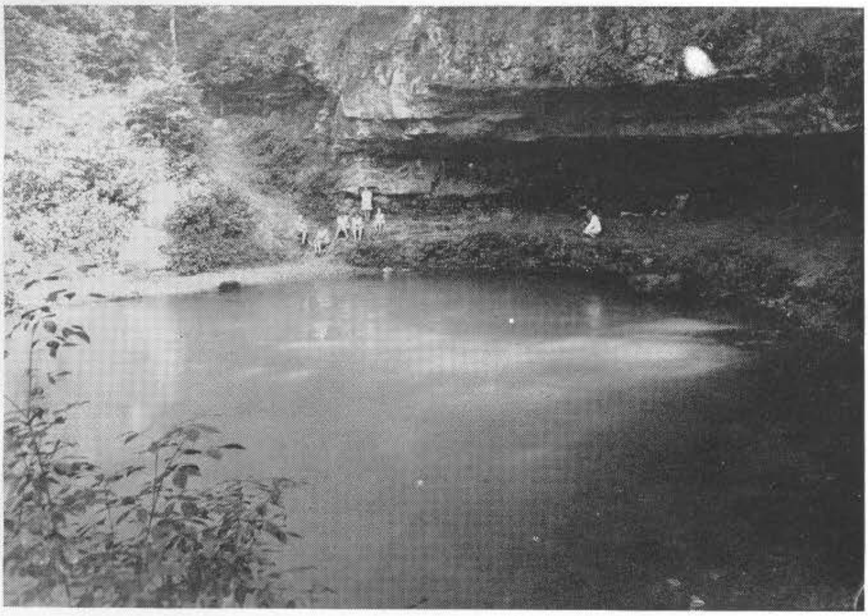
The spring is rather inaccessible but can be reached in dry weather by driving from Cuba or from County Highway F. It is surrounded by thick woods, and the place was formerly a favorite place for rural picnics. The flow on October 7, 1934, was estimated as 0.8 second-foot, or 520,000 gallons per day.

McINTOSH SPRING is located in NE¼NE¼ sec. 13, T. 38 N., R. 5 W., about 3 miles south of Cuba, Crawford County. The water issues from the sand in a circular basin surrounded by trees near the edge of a cultivated field and flows into Pine Creek a few hundred feet away. Formerly, the spring was diverted through an open ditch for a distance of about 400 feet to fill a small lake created by an earth dam about 300 feet farther down the valley. Thence the water was diverted by another ditch about 50 feet long to a point where it was used to operate a water wheel. Thus, with a total fall of about 15 feet, the flow ultimately discharged into the mouth of a large cave. Only a few remains of the former structures are visible. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
February 10, 1935	1.36	881,000
September 10, 1936	.95	614,000

McMAHON SPRING is located in SE¼ sec. 28, T. 25 N., R. 31 W., 2 miles southeast of Neosho, Newton County. It issues from the foot of a steep hill of cherty Osage (Mississippian) limestone and the main outlet is submerged by a pool formed by a low dam about 30 feet long in the spring branch, 100 feet downstream from the upper outlet. A part of the flow is carried in a 12-inch pipe to the Government fish hatchery in Neosho where it is used to supply the rearing pools. Operators at the hatchery report that the water has a fall of 24 feet, in its travel from McMahon Spring to the pools in Neosho, and that the pipe delivers about 700 gallons per minute for their use. The remainder of the flow at the spring passes over the dam and discharges into nearby Hickory Creek. That part of the flow which passes over the dam was measured October 25, 1943, after a heavy rain, and found to be 5.33 second-feet, or 3,440,000 gallons per day.

MERAMEC SPRING is located in NW¼SE¼ sec. 1, T. 37 N., R. 6 W., Phelps County, 6 miles southeast of St. James. The water surges up in a circular basin at the foot of a bluff of Van Buren dolomite, spreads and falls over an old rock dam, and flows swiftly down the spring branch half a mile into Meramec River. The spring oulet is about 790 feet above mean sea level. The clear water bubbling from the basin and rushing over the falls, under an arch bridge, and down the spring branch, adds to the picturesque charm of the valley and its surrounding wooded hills. The spring can be reached



A. Meramec Spring, near St. James, Phelps County. (Photograph by Noel Hubbard, Missouri School of Mines.)

B. View of Meramec Spring pool, near St. James, Phelps County. (Photograph by W. H. Pohl, Missouri State Highway Department.)

readily by driving from St. James on State Highway 8. Although the place is privately owned, visitors are welcome during the daytime, and facilities for cooking on hearths and for picnicking are provided for them.

At times during the period 1826 to 1877, water power was developed at the spring to serve the Meramec iron works which exploited a deposit of hematite iron ore that had been found at the surface about half a mile west of the spring. The blast furnace and other works at the spring have been described by several historians. The following paragraph, extracted from a recently published account, describes the probable nature of the early works:

"In the early period of its history, the Meramec furnace probably had a capacity of only 9 tons per day. This would make it somewhat below the 14-ton average of the furnaces in the Hanging Rock district of Ohio and Kentucky which were of similar type. Besides the furnace, the plant included three forges—refinery, ancony, and chaffery—and a grist mill and a sawmill, the site of which has not been located. The ancony forge had two fires, the chaffery had one, and the refinery forge probably had two if it conformed to the usual plan of the early ironworks. Each forge was operated by a separate undershot wooden water wheel which drove both a trip hammer and a blower. The pole type and the refiner hammer may have been similar, although no evidence has been found. The heads and other iron parts of hammers of the ancony and chaffery forges are still on the site."[1]

The ruins of the old blast furnace and the remains of the chimneys of the forges still stand in a broad, shaded park beside the spring branch. Picknickers and visitors to the spring enjoy the beautiful natural setting which surrounds these vestiges of one of Missouri's early mining communities. Today a new power plant takes advantage of the fall of the spring branch, to develop electric power which is supplied to the nearby Meramec Farms dairy buildings and ice plant.

The source of Meramec Spring is thought to include portions of an area which lies to the south, west, and southwest of the spring. Asher Hollow and Brown Hollow, which have a drainage area of some twelve square miles south of the spring, are

[1]Cozzens, A. B., The iron industry of Missouri: The State Historical Society of Missouri, Missouri Historical Review, vol. 35, No. 4, p. 527, July 1941.

usually "dry" creeks which carry appreciable amounts of surface runoff only at times of heavy local rainfall. The large drainage basin of Dry Fork lies to the southwest and west of Meramec Spring, and it is probable that much of the rainfall on the lower portion of Dry Fork basin seeps into the ground through openings and solution crevices in the cherty dolomite bed rock of the region—thus contributing to the subsurface drainage system of the spring region.

Most of the upland area to the southwest, south, and east of Meramec Spring is capped with sandstone and cherty dolomite of the Roubidoux formation beneath a veneer of residual material composed chiefly of soil mantle, blocks of sandstone, clay and sand detritus, and boulders and pebbles of chert. This permeable regolith of unconsolidated rock matter is the residue which has remained in place after the removal of the interbedded layers of the more soluble dolomite of the original bed rock of the region. Thus, the broad plateau regions are capped at the surface with poorly consolidated, permeable rock debris which permits ready percolation downward of rain water—percolation into the underlying strata, some of which are probably honeycombed with solution channels and an anastomosing network of crevices and cavities. Sinkholes are also present on this upland—the products of underground cavern roof collapses. These funnel-like topographic depressions serve as collecting areas for surface water which is diverted to underground channels. In this way many of the surface streams and rivers of this area are robbed of a portion of the rainfall which would otherwise contribute runoff to their valleys. As a result, parts of the Ozark uplands are areas of "dry streams" which carry only storm waters.

By the slow processes of erosion in the course of geologic time, surface streams such as the Meramec River cut their valleys deeper and deeper into the bed rock layers. In the course of such down-cutting, the lowered valley bottom levels may encounter openings in the rock which are connected with subsurface water courses that are active flow conduits, such as Meramec Spring. The underground supply routes of Meramec Spring are obviously connected with surface feeder routes, as is evidenced by the response of the spring to both heavy rainfall and protracted periods of drought. The flow in the spring basin is known to become turbid, or even muddy, soon after heavy rainfall in the surrounding area.

The overhanging bluff above the spring outlet is a feature typical of several of the large springs of the Ozarks. Apparently, the solution work of the spring flow is slowly sapping and undermining the bluff. No doubt this work accounts for a steady plucking action which causes slow migration of the rock face of the bluff back into the hill. As the overhang becomes progressively more pronounced, there comes a time at which the undermined, jointed blocks of the overlying dolomite fall into the spring basin. These fallen blocks may then be taken into solution very slowly by the flowing spring waters. Different stages of this process may be seen at various springs in the Ozarks, and some spring pools contain blocks which have recently fallen from the face of the bluff above such springs. Open, vertical joints or narrow fissures in the bed rock of the bluff would facilitate this process of "natural quarrying", and such joints or vertical "seams" would account for the vertical bluffs which rise above some of the spring outlets. Meramec Spring exemplifies this process, for it is obvious that the bluff above the spring is not a valley wall carved by a surface stream.

Meramec Spring is approximately the seventh largest spring in the State. Records of the daily flow have been collected from December 1921 to October 1929. During this period the flow has been as follows:

	Date	Second-feet	Gallons per day
Maximum....	1927, 1928............	650	420,000,000
Minimum.....	August 1, 1934........	56	36,200,000
Average......	1922-29...............	149	96,300,000

A hydrograph of the mean monthly flow over a period of several years is shown on plate V. Records of the daily flow may be had upon request. Photographs taken at Meramec Spring are shown on plate XVI.

MIDCO SPRING is located in NW¼ sec. 22, T. 27 N., R. 2 W., at the site of the former town of Midco, Carter County, 2 miles north of Fremont and 8 miles west of Van Buren. It issues from the side of a rock bluff of Gasconade dolomite 70 feet high and flows into Davis Creek at a distance of half a mile. In the past it was used as a water supply for the town of

Midco and for the Mid-Continent Iron Company plant, which has since been dismantled. It can be reached readily over all-weather roads. The flow on June 23, 1928, was 2.7 second-feet, or 1,700,000 gallons per day.

MILL SPRING is located in sec. 36, T. 28 N., R. 3 E., at Mill Spring, Wayne County. The water flows from ledges at the foot of a steep hill of Eminence (Cambrian) dolomite, near the right-of-way of the Missouri Pacific Railroad. Water from the spring is pumped to the railroad water tank at Mill Spring and used to supply locomotives. The spring can be reached readily by driving to Mill Spring and then walking a few hundred feet down the railroad right-of-way. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
October 4, 1922	10	6,460,000
August 2, 1925	11	7,110,000
June 17, 1926	12	7,750,000
April 8, 1932	15	9,690,000
August 14, 1934	9.2	5,930,000
May 21, 1936	10.6	6,860,000
August 11, 1936	9.7	6,270,000

MILL SPRING is located in SE¼SW¼ sec. 4, T. 26 N., R. 7 E., 2 miles southwest of Wappapello, Wayne County. The spring formerly issued in a deep, sand-bottomed pool at the foot of a low hill and flowed into Asher Creek about 1½ miles away. The spring is now submerged by the reservoir resulting from the dam recently constructed on the St. Francis River at Wappapello. Measurements of the flow has been made as follows:

Date	Second-feet	Gallons per day
July 13, 1935	5.64	3,650,000
May 22, 1936	5.21	3,370,000

MILL CREEK SPRING is located in NW¼SE¼ sec. 6, T. 27 N., R. 1 W., Carter County, 6 miles west of Van Buren.

Issuing from a rock ledge at the foot of a steep hillside covered with boulders and rock-slabs, it furnishes nearly all of the permanent flow of Mill Creek. The place is somewhat difficult to reach. On November 20, 1942, the flow was 40.4 second-feet, or 26,100,000 gallons per day, and on November 2, 1943, there was no flow.

On November 20, 1942, another spring (without name), located in SE¼NE¼ sec. 1, T. 27 N., R. 2 W., about a mile northwest of Mill Creek Spring, was measured as 0.13 second-foot, or 84,000 gallons per day.

MILLER SPRING is located in sec 6, T. 34 N., R. 10 W., 3 miles northeast of Big Piney, Pulaski County. It rises in a pool at the base of a high bluff of Gasconade dolomite and flows a quarter of a mile into Piney Creek. Owing to the periodic fluctuations in its flow, Miller Spring is known as an "ebbing-and-flowing" spring. A reproduction of a recording gage graph showing the variations in stage of the spring over a period of several weeks is on plate VI.

Measurements of the flow of the spring have been made as follows:

Date	Time	Second-feet	Gallons per day
November 25, 1923		20	12,900,000
November 25, 1923		4.8	3,100,000
October 8, 1943		7.2	4,700,000
October 13, 1943	11:00-11:30 a.m.	21.2	13,700,000
October 13, 1943	12:05-12:25 p.m.	17.7	11,400,000
October 13, 1943	1:00- 1:20 p.m.	11.4	7,400,000
October 13, 1943	2:00- 2:20 p.m.	8.7	5,600,000
October 13, 1943	3:00- 3:15 p.m.	7.9	5,100,000
October 13, 1943	3:45- 4:00 p.m.	7.7	5,000,000
October 13, 1943	4:00-4:20 p.m.	16.9	10,900,000
October 13, 1943	4:25- 4:45 p.m.	23.6	15,300,000
October 13, 1943	4:50- 5:05 p.m.	23.2	15,000,000

More complete information upon this spring is given in Bulletin 1, Volume 7, Missouri School of Mines and Metallurgy, "Ebb and Flow Springs in the Ozarks" by Josiah Bridge (1923).

Further information upon ebbing-and-flowing springs and the probable cause of their periodic action is given on pages 44 and 45 of this report.

MINT SPRING is located in SE¼ sec. 13, T. 35 N., R. 5 W., about 10 miles northeast of Salem, Dent County. The water rises in a bed of coarse gravel near the bottom of a small valley and flows 800 feet before entering Meramec River just above the bridge on State Highway 19. A part of the water rises in a vertical 24-inch tile and passes through a large box, which is used for cooling milk and foodstuffs. The surroundings are attractive and, although the site of the spring is privately owned, it is a favorite place for picnics and outings. The spring is used as a source of water for a nearby farm house. The flow on August 27, 1936, was estimated as 0.60 second-foot, or 387,600 gallons per day.

MONTAGUE SPRING is located in NE¼ sec. 27, T. 26 N., R. 22 W., in the village of Montague, about 4 miles southwest of Highlandville, Christian County. The water is used in a private fish hatchery which permits public fishing for a fee and sells fresh trout. The flow on May 14, 1941, was 2.81 second-feet, or 1,820,000 gallons per day.

MONTAUK SPRINGS is a term applied to a group of springs located in SE¼ sec. 22, T. 32 N., R. 7 W., at the north end of Montauk State Park. A dam on the southwest branch submerges the two springs which feed it and forms Spring Lake, which is used to supply water to several fish rearing ponds. The northeast branch is composed of the flow from a varying number of spring outlets, usually about seven in all, which emerge from gravel beds or from rocks at the base of a hill of Lower Gasconade dolomite. The flow of this latter branch is augmented by the smaller flow from Pigeon Creek above. The two branches unite near the park headquarters to form the headwaters of Current River.

The spring outlets are inconspicuous if compared with those of some other large springs in the State, but their combined flow (constituting the headwaters of Current River) forms an excellent stream for trout fishing—a stream which is stocked from the State hatchery nearby. The surrounding area is well wooded and the entire setting is very picturesque. A sugar maple grove is located in the State park. An old grist mill, which was formerly operated from the spring flow, has been preserved to lend historic interest to the place. Picnic grounds equipped with ovens and tables and a camping area are provided for the use of visitors. Well-equipped cabins are available at a reasonable rental and a dining lodge is open from March 1 to November 1. The entire region offers many attractions to the fisherman and the tourist.

The source of the springs is believed to include the drainage basin of Pigeon Creek above the spring oulets. This basin contains wide, gravel-filled valleys with little or no surface drainage except after heavy rains. The upland area of the Salem Plateau to the north and east of the spring is a region which, in many places, has rather poorly established surface drainage and which is marked with sinkholes and broad, flat depressed areas which serve as small, temporary rainfall catchment basins that drain into underground channels by slow percolation downward through poorly consolidated residual rock and stony soil. At Montauk, Pigeon Creek and the headwaters of Current River have cut deep enough into the Salem Plateau to encounter levels at which underground streams occur, and the subsurface water which has entered the valley floor is now aiding in the process of deepening the surface valley below the springs.

It may be noted with interest that this large spring is approximately 930 feet above sea level. The combined flow of the springs is determined by subtracting the flow of Pigeon Creek (measured just above the northeast springs) from that of Current River (measured below the confluence of the northeast and southwest spring branches). Determinations of the combined flow of the springs have thus been made as follows:

Date	Second-feet	Gallons per day
October 2, 1923	63	40,700,000
October 13, 1932	46	29,700,000
August 13, 1934	38.2	24,700,000
August 21, 1936	48.9	31,600,000
May 15, 1939	123	79,500,000
July 15, 1942	95.4	61,600,000

MORROW SPRING is located in NW¼ sec. 29, T. 38 N., R. 17 W., 2½ miles north of Roach, Camden County. The spring, which issues from a gravel bed, is surrounded by a concrete wall, and flows half a mile to the Lake of the Ozarks. A hydraulic ram at the spring oulet pumps water to some nearby clubhouses. The spring branch contains an abundance of aquatic vegetation. On November 19, 1942, the flow was 2.53 second-feet, or 1,640,000 gallons per day.

MOULDER SPRING is located in SE¼SE¼ sec. 19, T. 38 N., R. 17 W., 3 miles north of Roach, Camden County. The spring issues from a small cave and flows down a steep channel to the Lake of the Ozarks. It is used as a domestic water supply for the nearby Owen's camp. On November 19, 1942, the flow was estimated as 0.04 second-foot, or 30,000 gallons per day.

NAGOGAMI SPRING.—See Gaines Ford Spring.

ONANDAGA SPRING is located in NW¼NW¼ sec. 35, T. 39 N., R. 3 W., at the outlet of Onandaga Cave 5 miles southeast of Leasburg, Crawford County. The subterranean stream can be seen in Missouri Caverns, where it is called Lost River, and from which it flows through Onandaga Cave, emerging from the cave opening in a hillside in the Eminence formation. These two caves are in reality one large continuous cave with a division between them which marks the property line of spearate ownerships. Both contain many beautiful stalactites and stalagmites and other curious and grotesque dripstone formations. A dam in the spring branch 100 feet downstream from the oulet from Onandaga Cave forms a pool on which a boat is operated in Onandaga Cave and backs the water nearly into Missouri Caverns. After emerging from the cave, the spring flows 500 feet to the Meramec River, through wooded and picturesque surroundings.

Onandaga Spring can be reached readily by driving from Leasburg over the farm-to-market road, Crawford County Route "H". The spring outlet may be visited free of charge by the public, but a fee is charged for admission to the caves.

Measurements of the flow of the spring have been made as follows:

Date	Second-feet	Gallons per day
December 2, 1934	5.36*	3,460,000*
May 12, 1936	1.92*	1,240,000*
July 26, 1936	1.42*	918,000*
December 31, 1937	1.30*	840,000*
September 5, 1938	1.19*	769,000*
September 1, 1942	1.55*	1,000,000*
September 1, 1942	1.91**	1,230,000**

*Measured in Missouri Caverns.
**Measured below outlet from Onandaga Cave.

OUSLEY SPRING is located in sec. 10, T. 35 N., R. 10 W., one mile northeast of Spring Creek post office, Phelps County. It issues from the base of a high hill and flows 250 feet into Piney Creek. The flow on October 20, 1932, was 0.95 second-foot, or 613,000 gallons per day.

PATRICK SPRING.—See Althea Spring.

PAXTON SPRING is located in block 13 of the Fisher and Beaty Addition to the town of Humansville, Polk County. The spring is enclosed by a house and is used as a water supply for the town of Humansville. The surrounding rocks are dolomite of the Jefferson City formation. On August 6, 1937, the flow was 0.688 second-foot, or 445,000 gallons per day.

PAYDOWN SPRING is located in SW¼ sec. 2, T. 40 N., R. 8 W., near Paydown post office, 13 miles northeast of Vienna, Maries County. It has one main outlet and several small ones in gravel bars within a radius of 300 feet and flows into Gasconade River about 1¼ miles away. The stratigraphic horizon at which the springs rise in the gravel beds is at or near the contact between the Roubidoux formation and the subjacent Gasconade formation, both of the Ordovician age. The spring formerly supplied power to operate the Bray and the Givens grist mills and the Bray woolen mill about half a mile below the outlets. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 25, 1924	18	11,600,000
October 20, 1932	6.8	4,390,000
September 18, 1936	7.4	4,780,000
October 11, 1942	6.0	3,880,000

PHILLIPS SPRING is located in sec. 10, T. 25 N., R. 1 E., 12 miles southeast of Van Buren, Carter County. The water issues from a gravel bar at the base of a rock ledge and empties into Current River at a distance of a quarter of a mile. It is very inaccessible by road, but can be reached readily by boat on Current River, and is a favorite camping place for fishermen. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 15, 1925	8.8	5,680,000
August 7, 1936	9.0	5,820,000

PINEY SPRING is located in SE¼ sec. 4, T. 35 N., R. 8 W., 1½ miles southeast of Yancy Mill post office, 14 miles south of Rolla, Phelps County. It emerges from a rock bluff and flows into Little Piney Creek 500 feet away. The spring can be reached by driving along the east side of Little Piney Creek to a point about one mile upstream from U. S. Highway 63 and then walking the remaining distance of half a mile. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
July 24, 1925	5.0	3,200,000
October 20, 1932	.1	64,000

PIPPEN SPRING.—Sell Bartlett Mill Spring.

PITTMAN SPRING is located in NW¼NW¼ sec. 8, T. 28 N., R. 3 E., about 6 miles southwest of Piedmont and 6 miles northwest of Leeper, Wayne County. The spring issues from three separate outlets about 20 feet apart at the base of a low cliff of Upper Cambrian dolomite of the Potosi formation. They merge into one channel that flows into Black River at a distance of 200 feet, about 1½ miles downstream from the Clearwater dam site. The spring water is clear and cold and the wooded surroundings make this an attractive place for picnics and camping. It is used frequently by fishermen and others while floating down the river, but it is not readily accessible by automobile. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
April 6, 1942	34.9	22,500,000
September 3, 1942	32.3	20,900,000
November 3, 1943	34.6	22,400,000

POWDER MILL SPRINGS consist of two springs located in NE¼NW¼ sec. 16, T. 29 N., R. 2 W., within about 100 feet of State Highway 106, and 10 miles east of Eminence, Shannon County. The first spring issues from the gravel in a circular basin about 20 feet in diameter and flows 50 feet into Powder Mill Creek at a point about 0.2 mile above the mouth of that creek. The second spring also rises in a gravel bed on the opposite bank of Powder Mill Creek, 100 feet upstream from the first spring, and empties into the creek at a distance of 30 feet. On November 18, 1942, the flow of the first spring was 1.31 second-feet, or 847,000 gallons per day, and that of the second spring 1.13 second-feet, or 730,000 gallons per day.

(See also the description of Cove Spring which is located approximately half a mile upstream from Powder Mill Springs.)

PREWETT SPRING (also called Mammoth Spring) is located in sec. 32, T. 34 N., R. 10 W., Pulaski County, 6 miles north of Hazleton, and 14 miles northwest of Licking. It issues from the rocks beside a road at the base of a bluff, flows along a cultivated field, and empties into Big Piney River at a distance of half a mile. The rugged surroundings and poor roads make the place quite inaccessible. So far as is known, the outlet of the spring has never been flooded by the river. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
July 17, 1925	17	11,000,000
October 18, 1932	16.5	10,700,000
August 14, 1934	15.6	10,100,000

PULLTIGHT SPRING is located in NE¼ sec. 4, T. 30 N., R. 5 W., 6 miles northwest of Round Spring post office, and 14 miles north of Eminence, Shannon County. The water flows from the rocks at the base of a cliff and, after passing over three small dams with a combined height of about 10 feet, it empties into Current River 500 feet away. A clubhouse is located nearby in the spring valley. The spring is in a remarkably beautiful natural setting, but the rugged surroundings make it rather hard to reach except by boat on Current River.

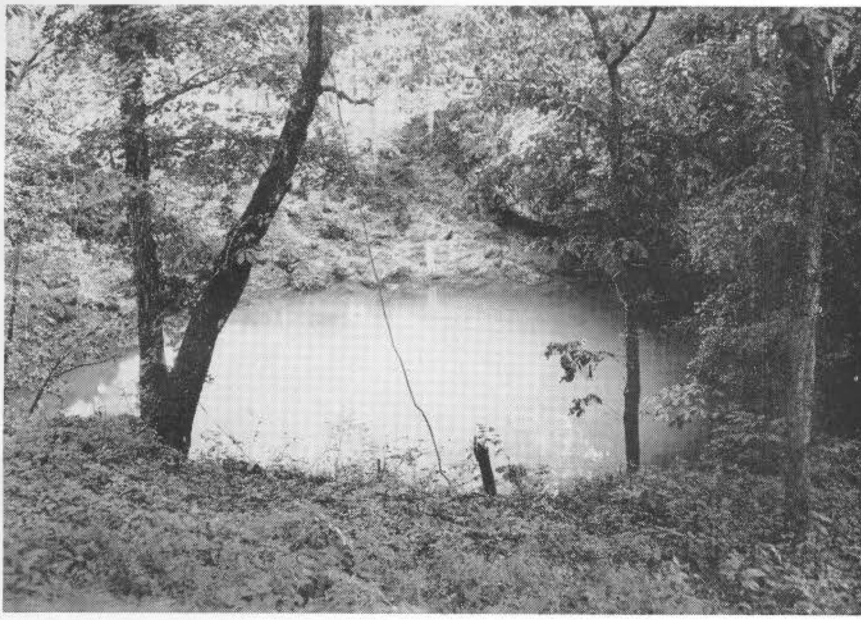
A picture of the spring appears as plate XVII-B. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
October 3, 1923	31	20,000,000
June 22, 1924	141	91,000,000
October 14, 1932	5.9	3,810,000

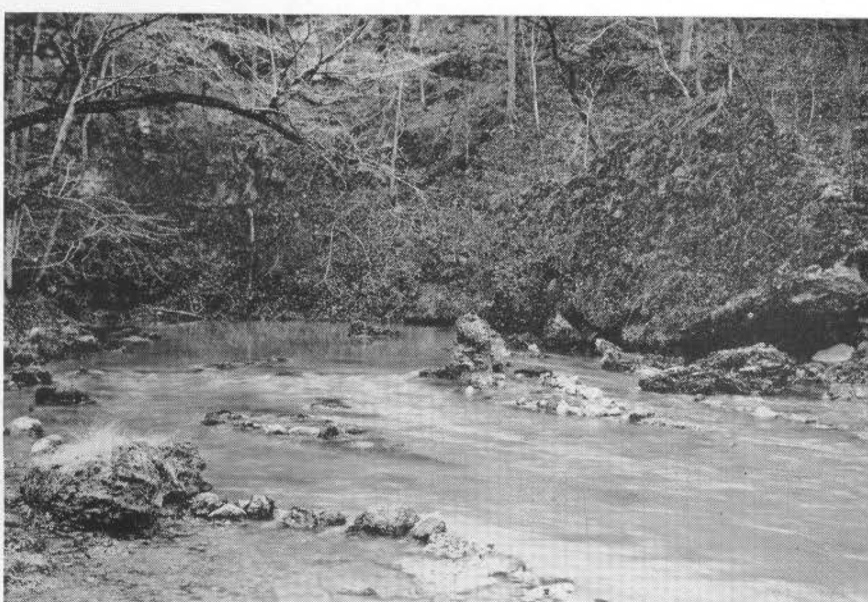
RAINBOW SPRING.—See Double Spring.

RACING SPRING (also known as Shirley Spring) is located in SE¼ sec. 21, T. 37 N., R. 1 E., half a mile southwest of Shirley, Washington County, where it issues from the Gasconade formation. On March 6, 1941, the combined flow from the main outlet and two smaller outlets was 2.28 second-feet, or 1,510,000 gallons per day.

RANDOLPH SPRING is located in sec. 20, T. 30 N., R. 1 E., at the side of a highway, 2½ miles north of Ellington, Reynolds County. It rises in a small slough in Dry Creek which empties into Logan Creek. On August 1, 1925, the flow was 1 second-foot, or 650,000 gallons per day.



A. Round Spring, Round Spring State Park, Shannon County. (Photograph by Noel Hubbard, Missouri School of Mines.)



B. Pulltight Spring, Shannon County. (Photograph by W. H. Pohl, Missouri State Highway Department.)

REED SPRING is located in sec. 28, T. 32 N., R. 1 E., half a mile east of Centerville, Reynolds County. The spring rises in a small artificial basin and the water passes over a series of dams, through two lower pools to flow into West Fork of Black River. The total fall is about 15 feet, and the flow was used formerly to furnish power for lights for Centerville and to operate a grist mill. The place is picturesque and is visited by many people. A pleasure resort is located nearby. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
July 31, 1925	7.5	4,850,000
June 17, 1926	15	9,700,000
August 5, 1936	6.8	4,400,000

REEDS SPRING is located in SW¼ sec. 25, T. 24 N., R. 23 W., in the center of a street 300 feet east of the main intersection in the town of Reeds Spring, Stone County. It rises in a walled basin at the base of a flight of concrete steps, and is used as a source of water supply by nearby residents. Many farmers haul water from the spring during dry periods. It was named for an early settler, and the town derived its name from the spring. On September 7, 1943, the flow was 0.32 second-foot, or 207,000 gallons per day.

RELFE SPRING.—See Coppedge Spring.

RICHART SPRING is located in NE¼SE¼ sec. 29, T. 38 N., R. 5 W., 4 miles south of Fanning, Crawford County. The spring rises in a small basin at the foot of a high hill about 100 feet from the Meramec River and flows about half a mile almost parallel with the river before entering it. The surrounding hills and timber, and landscaping at the spring outlet, make this an attractive place. The spring is in the front yard of a clubhouse and is not open to the public. The flow on September 10, 1936, was 1.25 second-feet, or 808,000 gallons per day.

ROARING SPRING is located in sec. 22, T. 38 N., R. 5 W., 3½ miles southeast of Fanning, Crawford County. The water issues from several outlets near the bank of Meramec River.

To reach the place it is necessary to walk three-quarters of a mile from Fox Spring Lodge, a private resort. On December 1, 1932, the flow was 4.1 second-feet, or 2,650,000 gallons per day.

ROARING SPRING is located in E½ sec. 19, T. 41 N., R. 1 W., 2 miles east of Stanton, Franklin County. It issues from a cave in a cliff and flows into Meramec River about 30 feet away. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 3, 1925	1.0	650,000
September 4, 1936	2.36	1,530,000

ROARING SPRING is located in sec. 35, T. 33 N., R. 10 W., 8 miles northwest of Licking, Texas County. The spring issues from the base of a high, steep hill and flows a distance of 25 feet, during which it falls about 10 feet, over and around large stones into Big Piney River. The falling water produces a roaring sound which can be heard from the top of the hill. The surroundings are scenic, but the spring can be reached only over a series of crude steps leading from a clubhouse above—a clubhouse called "The End of the World in The Aux Arcs". The flow on August 14, 1936, was 1.45 second-feet, or 937,000 gallons per day.

ROARING RIVER SPRING is located in Roaring River State Park, in SE¼NE¼ sec. 27, T. 22 N., R. 27 W., Barry County, 7 miles south of Cassville. The spring issues from a cave at the base of a high vertical cliff in Roaring River Hollow at an elevation of about 1,045 feet above mean sea level and flows directly into a small pool created by a dam. Part of the water is diverted to the State fish hatchery. The spring flows through the park grounds and enters a lake of several acres created by a dam on the spring branch. From the lake, the water falls over a broad spillway to form Roaring River, a tributary of White River. The surroundings are exceptionally rugged and wildly picturesque. The park and the spring can be reached readily by driving over scenic State Highway 112 from either Cassville or Seligman.

The approach to the spring area over the paved highway from Cassville is an impressive experience for the motorist. The highway leaves Cassville to follow a relatively smooth course for several miles over the flat and gently rolling farmland of the upland of the Springfield Plateau. At a point about 4 miles south of the town, the road takes a winding and curving path along and near the crest of a narrow ridge. For about 2 miles along such a course, one is afforded strikingly beautiful views of the deep, steep-walled, heavily-wooded valleys below the road and distant vistas of the wild, rugged topography which has been carved by the erosion work of streams cutting back the "Burlington Escarpment" at the edge of the upland plateau. As one enters the State park, the highway winds down into the deep valley of Roaring River Hollow, more than 400 feet below the high, flat upland which lies between Cassville and the boundary of the park area.

The spring and the park offer many attractions to the tourist and vacationist. Good fishing is available in the spring branch and the large lake, both of which are stocked with trout from the State hatchery. The lake also affords facilities for boating and swimming. Hiking and riding over mountainous trails are available to those who prefer these diversions. A short climb takes the hiker to the "Devil's Kitchen", an interesting spot where great, massive, joint blocks of St. Joe limestone have started to break away and creep downhill on the soft underlying shale. These blocks now lie tilted and leaning against one another in a haphazard manner.

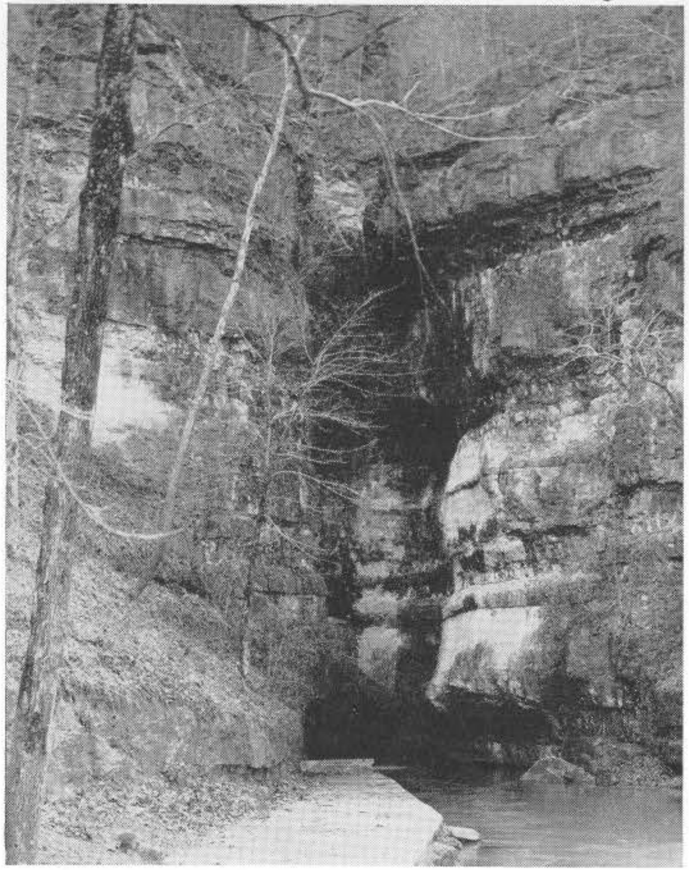
The excellent facilities which are available in the park to minister to the convenience and comfort of the visitors include rustic hearths and tables for picnicking, suitable sites for camping, an attractive hotel and dining pavilion, and modern, well-equipped cabins that may be had for a nominal rental. All these advantages, combined with the impressive natural setting of the spring and its rugged, wild surroundings, attract the vacationist, the sportsman, and the nature lover.

The spring flows from a low-roofed cave mouth at the base of a cliff of massive and bedded ledges of dolomite of the Cotter formation. A prominent vertical joint crevice, which has been slightly enlarged by solution work and which extends upward in the face of the bluff above the spring outlet, suggests that the underground flow at this point may be directed in part by the pattern of jointing in the rocks. The present spring level is approximately 75 feet below the top of the Cotter formation. Headward plucking and sapping, by solution of the dolomite rocks below, has created a narrow recessed notch in the valley wall at the spring. (Plate XVIII-A.)

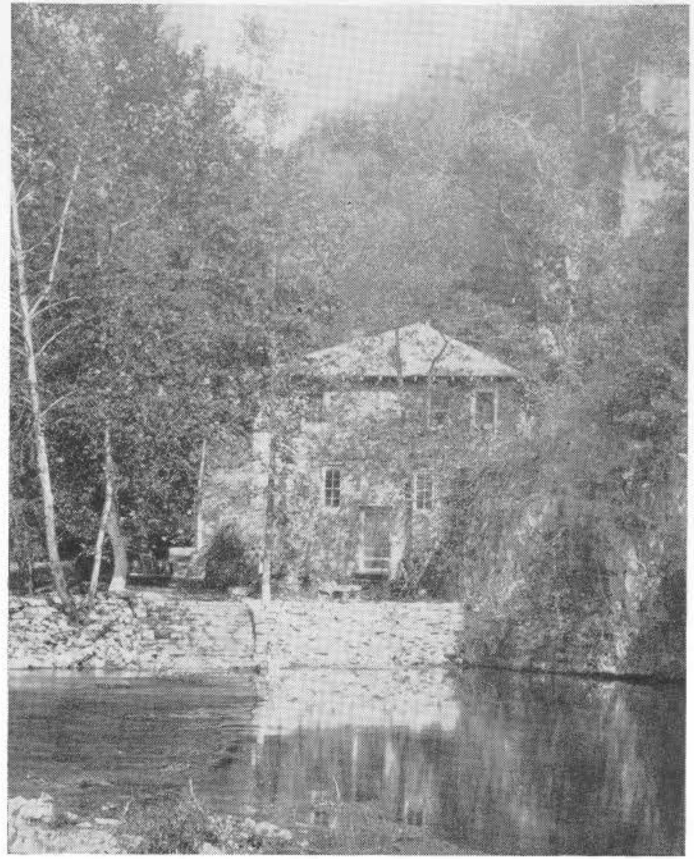
It is of interest to observe that a small spring is located about 90 feet directly above the Roaring River Spring. This upper spring flows out of a small, cavernous solution channel at the base of the St. Joe (Mississippian) limestone formation at its contact with underlying Kinderhook (Mississippian) shales. Apparently this small spring has its source in the overlying limestone and cherty limestone strata of Mississippian age and discharges water which has percolated from the surface downward through joints, crevices, and openings in those limestones. Its further downward movement has been checked by the relatively impervious shales, upon which it has followed a lateral course along the top of the shale beds to emerge in the crevice above the big Roaring River Spring. Thus the smaller flow is "perched" upon the impervious shale strata.

The big Roaring River Spring has a large flow even during dry periods and apparently its underground flow is fed by contributory sources from a comparatively wide area. The spring emerges in the valley wall of Roaring River Hollow, which is a dry, gravel-floored valley above the spring. This upper valley carries only the storm water which flows for a short time after periods of very heavy rains. In fact, a large surface area to the north, west, and south of the spring is an area of little or no permanent surface runoff. Parts of the upland drain into sinkhole depressions. Stream gradients are steep and valley walls are precipitous in the area of rugged, sharp relief. An area of approximately 20 square miles to the west and southwest of Roaring River Spring drains into a well-named main valley, "Dry Hollow", which carries surface water only during periods of prolonged or heavy rainfall.

The strong topographic relief of the State park area stands out in sharp contrast with the broad, gently rolling upland of the plateau to the west and northwest. Roaring River Spring outlet and the valley floor of Roaring River below the spring are approximately 400 to 500 feet lower than the high portions of the plateau of the Cassville area to the northwest. The greater part of these rugged, deeply dissected areas of



A. Roaring River Spring outlet, Roaring River State Park, Barry County. (Photograph by W. H. Pohl, Missouri State Highway Department.)



B. Welch Spring, near Cedar Grove, Shannon County.

dry valleys, and much of the adjoining plateau area, are capped with a thick mantle of poorly consolidated residual rock material which lies beneath the soil and above the jointed, creviced and channeled bedrock of the Mississippian and Ordovician limestones and cherty limestones and magnesian limestones. Thus, water falling on the surface in these areas has comparatively easy access to subsurface channels and underground conduits. Though the upland plateau is mantled with a veneer of clay and soil, this area is known to contribute water to the underground drainage system, for sinkholes and caverns are common in the area.

An interesting story is related which gives a clue to the possible nature, in one instance, of a connection between surface and subsurface drainage in the Roaring River Spring area. Mr. H. S. Brixey, former Superintendent of Roaring River State Park and one who has long observed the big spring, reports an incident which occurred in 1939 or 1940, while he was in charge of the park. The gist of the sequence of events which transpired may be briefly summarized by the following account. A large sinkhole on the upland plateau, about 3 miles northeast of the town of Washburn and about 5 miles northwest of and some 350 feet higher than the Roaring River Spring outlet, contained a lake of several acres for a number of years. Mr. Brixey states that this lake, in 1939 or 1940, suddenly became drained—apparently through outlets in its bottom which had, until that time, been sealed with impervious material. He states that, at approximately the same time, Roaring River Spring was very muddy for several hours, causing a near disaster in the rearing pools for baby trout whose respiratory processes were affected by the muddy water. Mr. Brixey is of the opinion that there was some direct connection between the sudden draining of the water-filled sinkhole and the muddying of the spring flow. He also states that corn stalks from this upland sinkhole area have at times entered into the subterranean drainage channels and appeared in the spring flow. Mr. Brixey advises that his experience indicated that heavy rainfall on the plateau area to the north and west caused a turbidity of the spring water which was not noticeable when local rains fell on the area to the east.

Such inferred connections—between the phenomena of sinkhole drainage or cavern collapse on the one hand, and a resultant effect upon some nearby spring flow on the other—have been reported by observers of several of the large springs of the State, including Alley Spring in Shannon County, Bennett Spring in Laclede County, and others. Mention is made elsewhere in this report of the supposed underground connection between the Grand Gulf sink and Mammoth Spring, Arkansas. These reports give clues to the nature of subsurface conditions which might well be expected to obtain in those regions which are characterized both by poorly established surface drainage and large springs.

Plate XVIII-A is a view of the outlet of Roaring River Spring.

Measurements of the flow of the spring have been made as follows:

Date	Second-feet	Gallons per day
July 15, 1923	23	14,900,000
July 16, 1923	28	18,100,000
October 19, 1932	10	6,460,000
July 18, 1934	14.4	9,310.000
February 26, 1935	32.0	20,700,000
January 13, 1936	29.5	19,100,000
September 24, 1936	60.8	39,300,000
March 6, 1937	44.0	28,500,000
June 3, 1938	108	69,800,000
September 29, 1942	12.9	8,340,000

ROCK SPRING is located in NE¼ sec. 15, T. 43 N., R. 3 E., 2½ miles southeast of Allenton, St. Louis County. It issues from the base of a rock ledge in a small valley and flows into Meramec River about half a mile away. Some summer cottages are located nearby. On March 3, 1935, the flow was estimated as 0.1 second-foot, or 65,000 gallons per day.

ROCKBRIDGE SPRING is located in sec. 5, T. 27 N., R. 13 W., at Rockbridge, Ozark County, 18 miles southeast of Ava. The name is applied to a series of springs which rise in the bed of a lake about 1,500 feet long and 400 feet wide formed by a dam. The dam produces a head of 9 feet, which is used to operate a mill. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 29, 1926	23	14,900,000
October 17, 1932	24	15,500,000
August 18, 1936	15.2	9,840,000

ROLUFS SPRING is located in sec. 25, T. 37 N., R. 10 W., 1½ miles southwest of Arlington, Phelps County. It issues from the sand in the bottom of "Smith Gorge" and flows 1 mile northeast into Little Piney Creek. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 16, 1931	0.24	155,000
October 2, 1936	.55	356,000

ROSS SPRING is located in NE¼ sec. 1, T. 25 N., R. 10 E., 4 miles northeast of Dexter, Stoddard County. The spring may be regarded as having two outlets—the first rising in a swale and flowing into a small lake formed by a dam 1,000 feet downstream at the Ross house, and the second flowing up through a tile beside the lake. Two gravel washing plants utilize the water. On April 9, 1937, the flow was measured below the spillway from the lake as 0.231 second-foot, or 149,000 gallons per day—the entire flow apparently coming from the first outlet.

ROTT ROAD SPRING is located in NE¼SE¼ sec. 14, T. 44 N., R. 5 E., three-quarters of a mile south of Kirkwood, St. Louis County. It rises in a small depression and flows down a short gulley to Meramec River. On August 7, 1937, the flow was 0.024 second-foot, or 15,500 gallons per day.

ROUBIDOUX SPRING (also called Waynesville Spring) is located in NE¼NW¼ sec. 25, T. 36 N., R. 12 W., half a mile south of Waynesville, Pulaski County. The spring issues from a rocky basin, approximately 775 feet above sea level, at the foot of a concrete retaining wall, which protects a road that lies between the spring and a high bluff of dolomite and cherty dolomite beds of the Gasconade formation. The water flows about 100 feet before entering Roubidoux Creek. As Roubidoux Spring is near the level of the bed of Roubidoux Creek, the spring is submerged when the the creek is high. The place can be reached easily from U. S. Highway 66, and is visited by many people.

Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 11, 1914	12*	7,750,000*
July 15, 1924	73	47,100,000
November 8, 1931	11	7,100,000
October 12, 1932	5.7	3,680,000
August 3, 1934	5.3	3,420,000
August 18, 1934	159**	103,000,000**
May 13, 1936	36.0	23,300,000

*Measured by Engineering Experiment Station, University of Missouri.
**Measured after very heavy rain.

ROUND SPRING is located in Round Spring State Park in NW¼ sec. 20, T. 30 N., R. 4 W., at Round Spring post office, Shannon County, about 10 miles north of Eminence. The spring rises in a circular basin which is about 80 feet in diameter and which contains a maximum depth of water of about 55 feet (plate XVII-A). The wall of the basin, or sink, is about 30 feet high and is almost vertical except on the east side, where the wall is breached and a path leads down to the water edge. The calm water in the basin is without visible sign of current. it is usually clear or of a milky blue color, although after some heavy rains it becomes quite turbid. The water escapes from this basin through a subterranean passage about 80 feet long and emerges at the foot of a small bluff, from which it flows quite swiftly in the spring branch a distance of 800 feet to Current River.

The spring and the park can be reached readily by driving on State Highway 19, which is only a few yards west of the spring. The spring is of a unique type and the surroundings are beautiful. The wooded park grounds are maintained well; stone hearths for cooking, picnic tables, and suitable camping sites are provided by the State Park Board; and boating, fishing, and swimming may be enjoyed in Current River. The drive on State Highway 19 from the spring to Eminence is along one of the most scenic routes in the State.

Round Spring basin presents a graphic example of the result of a cavern roof collapse. The deep, circular, vertical-walled pool is well named; and it obviously represents a portion of a former near-surface, underground channelway which has been exposed to view by the falling of its arched roof, some 80 feet back from the spring outlet, in the former cavern. The country rock at the spring is the relatively pure and soluble dolomite of the Eminence formation.

It is possible that the underground course of at least some of the water of the spring flows in solution-widened channels in the Eminence dolomite—channels which may represent the enlargement of narrow fractures that were originally mere joint cracks in the dolomite. Evidence of the direction of former underground water routes, which were originally controlled by joint patterns in the relatively homogeneous bedrock, may be seen in some of the caves of southern Missouri; and there is a cavern which is thought to be joint-controlled, located about half a mile west of Round Spring. Part of the course of this cave, Round Spring Cavern, has been explored. It is a comparatively narrow, linear opening which can be followed easily for several thousand feet. Starting at the western end of that portion of the main cave route which is now easily accessible to exploration on foot, one follows a course for more than a quarter of a mile which is almost due east or a little north of east. Then the narrow passage turns abruptly to a course which is a little west of north, thus changing its direction through an angle of more than 90 degrees. The northerly course may then be followed for more than a quarter of a mile, when the linear passageway makes another right-angled turn to follow a direction which is due east. This pattern of alignment of the elongation of this cavern suggests that its main course originally was directed by a pattern of major jointing in the bedrock, before excavation of the cavern by flowing subsurface water solution work. Round Spring Cavern is well above the present level of Round Spring, for the spring pool is approximately 50 feet below the elevation of the cave entrance. The cavern is an attraction of the area which fascinates many of the visitors to Round Spring.

The source of the spring is believed to include portions of the drainage basin of Spring Valley which lies to the southwest of the spring outlet. Heavy rains in the upper part of that basin appear to produce increased flow in the spring. Except for short periods after heavy rains there is little flow in Spring Valley basin—much less than in the nearby Sinking Creek in proportion to the relative sizes of their drainage areas.

During the period that a gaging station was operated on the spring (from 1928 to 1939), appreciable changes in the stage and discharge were observed that could not be accounted for by changes in rainfall. The thought occurred that these changes in stage and discharge might be caused by changes in the atmospheric pressure. W. L. Doll, of the Geological Survey, made a brief study of this subject by using the pressures indicated by the iso-baric lines on the daily weather map of the U. S. Weather Bureau. His studies, although not very detailed or conclusive, indicated a tendency for the stage of the spring to increase somewhat with a drop in the barometric pressure, and to decrease with a rise in the pressure. The relation between the elevation of the water surface and the barometric pressure have been noted by enginers and geologists in many wells, especially those in which the water is under artesian pressure.

Records of the flow of the spring have been collected from October 1928 to September 1939. During this period the flow was as follows:

Date	Second-feet	Gallons per day
Maximum.... May, 1933............	520	336,000,000
Minimum..... December, 1937.......	10	6,460,000
Average...... 1928-39...............	41	26,500,000

A hydrograph of the mean monthly flow over a period of several years is shown on plate V. Records of the daily flow may be had upon request.

RYMER SPRING (also called Ebb-and-Flow-Spring) is located in NW¼ sec. 35, T. 28 N., R. 6 W., Shannon County, near Rymer's Ranch, 6 miles northeast of Birch Tree. It issues from the base of a high hill in the Gasconade dolomite, about 10 feet from the water edge of Jacks Fork. It is used as a water supply for a fishing club and for Rymer's Ranch, a pleasure resort. Owing to the periodic fluctuations in its flow, it is what is known as an "ebbing-and-flowing" spring. On July 29, 1923, the flow at the highest stage was partly measured and partly estimated as 22 second-feet, or 14,000,000 gallons per day, and at the lowest stage it was estimated as 5 second-feet, or 3,200,000 gallons per day. On December 17, 1936, the flow was measured as 0.66 second-foot, or 427,000 gallons per day. A reproduction of a recording gage graph showing the variations in stage of the spring over a period of several weeks is shown as plate VI. More complete information upon this spring is given under the heading, "Ebb and Flow Spring on Jacks Fork of Current River"; Bulletin 1, Volume 7, p. 20, Missouri School of Mines and Metallurgy, "Ebb and Flow Springs in the Ozarks" by Josiah Bridge (1923).

A general description of ebbing-and-flowing springs and the probable cause of their periodic action is given on pages 44 and 45 of this report.

SAND SPRING.—See Conn Spring.

SANTA FE SPRING is located in Arrow Rock State Park in sec. 36, T. 50 N., R. 19 W., Saline County, about a quarter of a mile east of the historic Arrow Rock Tavern. The spring rises in a basin about 3 feet in diameter and 3 feet deep, surrounded by a rock curb over which an open spring house has been constructed. The water flows from this basin about 200 feet to a swimming pool, and, when the quantity is sufficient, it falls over a natural rock spillway and flows three-quarters of a mile to the Missouri River. During early days, Indian trails crossed near the spring, and later it was used as a watering place for stage coaches that stopped at the tavern. The place can be reached readily by driving over State Highway 41.

On May 7, 1937, the flow was measured as 0.09 second-foot, or 60,000 gallons per day, and the water was rather muddy as a result of recent rains. The discharge at that time was too small to cause any flow over the spillway of the swimming pool.

SCHLICHT SPRING is located in sec. 30, T. 37 N., R. 12 W., 7 miles northwest of Waynesville, Pulaski County. The water flows from the foot of a rock ledge into a mill pond created by a small dam in the spring branch where power was developed formerly to operate a grist mill and to furnish electric power for lights. On September 12, 1935, the flow was 1.0 second-foot, or 650,000 gallons per day.

SEQUIOTA SPRING is located in NW¼ sec. 9, T. 28 N., R. 21 W., at the Sequiota State Hatchery, 7 miles southeast of Springfield, Greene County. It issues from a cave at the base of a limestone ledge of the Burlington formation (Mississippian) and flows one mile into James River. A part of the spring flow is utilized by the State Conservation Commission to supply the fish hatchery which consists of seven rearing pools, five large trout pools, a three-acre lake for rearing bass, and several buildings. The place is quite interesting and picturesque. It is adjacent to U. S. Highways 60 and 65.

The spacious cavern from which the spring flows can be explored by boat for about a quarter of a mile. In general, the cross section of the narrow cavern is seen to have the shape of a section through a mushroom—its greatest width is at or just above the water level, and the low roof in many places along the route is broadly arched with its greatest height near the midline of its course. The opening is apparently developed along joint planes in the bedrock—incipient openings in the limestone which have been enlarged by the solution work of underground water which found easiest passage along joint cracks. A compass course along this small subterranean stream shows that the linear direction of the narrow, low passage are roughly east, then north, then east; thus making nearly rectangular turns every few hundred feet. Observation of the joint cracks in the limestone outside of the cave, near its mouth, shows that there are two sets of prominent joints which trend roughly east-west and north-south.

This cavern, which can be explored easily by boat for 1,600 feet along its angular course, has a width which rarely exceeds 30 or 40 feet and which in most places is nearer 10 feet. As noted, the width of this arched subterranean passage is greatest at and near the present water level, indicating obvious widening of the narrow passage by solution work attending lateral corrosion of the spring stream in the course of its flow through the cavern. At places in the cave, the stream is artificially confined by broad, low, loose masonry platforms built out from the walls on the floor of the cave. These low benches are near the water level and are covered with soil and clay which formerly supported mushroom beds.

Just outside the cavern, and only a few feet from its mouth, are two prominent tubular openings which reach back into the low limestone bluff (plate VII-B). The larger of these presents a bell-shaped outline and is some 12 to 15 feet high from the center of its roof to its floor. It is floored with red clay and the width of the floor at its entrance is about 8 or 10 feet. The smaller of the two openings is nearly circular in general cross section, perhaps 4 or 5 feet in diameter; and with a prominent notch in its floor—a notch which is 10 or 12 inches deep. These openings are now dry, but they evidently have been subterranean water conduits at some time in the geologic past, when the water table was at an appreciably higher level and before the floor of the valley was cut down to its present elevation. The floors of these two tubes are about 5 feet above the present outlet of Sequiota Spring. The size of these dry openings can be contrasted with that of the spring cave, for the latter is some 30 or 40 feet wide at its mouth.

The country rock which makes up the bluff in which Sequiota Cave has been formed is crystalline limestone and somewhat cherty limestone of the Burlington formation (Osage Group) of Mississippian age. The gently undulating upland surface of the Springfield Plateau in the vicinity of Sequiota is poorly drained in many places, where its subsurface drainage is indicated by many large sinkholes which serve as catchment areas for rainfall that would otherwise run off in surface streams. The Burlington limestone, at least at shallow depths immediately beneath the soil and residuum in this area, is thus inferred to be traversed by the solution channels, crevices, and cavernous openings which are known to be present in many limestone areas where sinkholes and springs are found.

Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 28, 1936	17.1	11,100,000
November 12, 1942	7.70	4,980,000

SHANGHAI SPRING (also called Blue Spring) is located in SW¼ sec. 24, T. 36 N., R. 11 W., 7 miles east of Waynesville, Pulaski County. It is located at the foot of a high, wooded, and rocky cliff and issues in a circular basin about 25 feet in diameter, surrounded by a layer of stones. It flows over a small rocky riffle and empties into Big Piney River at a distance of 500 feet. An attractive house and landscaped grounds adjoin the spring. The place can be reached readily by driving about half a mile over a county road from U. S. Highway 66. A view of the spring and the picturesque surroundings can be obtained from the county road, but their beauty may be appreciated more fully if permission is obtained from the owner to enter his grounds and get a nearer view of the spring.

Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
March 24, 1925	22	14,200,000
June 21, 1925	12	7,760,000
June 27, 1932	9.6	6,200,000
October 12, 1932	7.8	5,040,000
August 3, 1934	7.7	4,980,000
August 18, 1934	34.2	22,100,000
October 14, 1934	11.8	7,620,000
November 17, 1940	10.2	6,590,000

SHIRLEY SPRING.—See Racing Spring.

SLABTOWN SPRING is located in sec. 15, T. 33 N., R. 10 W., 9 miles northwest of Licking, Texas County. It emerges from the side of a steep, rocky hill, flows over a small rock dam, and empties into Big Piney River about 1,000 feet away. The outlet is never flooded by the river. The place can be reached by driving from Licking. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
July 21, 1925	13	8,400,000
October 18, 1932	8.7	5,620,000
August 14, 1934	12.6	8,140,000

SLATER SPRINGS are located in NE¼NE¼ sec. 1, T. 28 N., R. 4 W., 1½ miles southeast of Eminence, Shannon County. These four springs rise within 3 or 4 feet of each other, have wooden or concrete boxes around the outlets, and flow in a single channel to a creek 100 feet away. They are of historic interest in connection with the early copper mining industry of the region. On November 19, 1942, the combined flow of the springs was 0.10 second-foot, or 65,000 gallons per day.

STEELVILLE SPRING is located in SE¼SE¼ sec. 33, T. 38 N., R. 4 W., just south-west of the public square in the city of Steelville, Crawford County.

Estimates of the flow have been made as follows:

Date	Second-feet	Gallons per day
January 4, 1936	1.5	970,000
May 3, 1936	2.5	1,600,000
July 23, 1936	.05	32,000
August 1, 1936	0	0

STONE MILL SPRING is located in sec. 21, T. 35 N., R. 10 W., Pulaski County, 2 miles southwest of Spring Creek post office, and 11 miles southeast of Waynesville. It issues from the base of a rock ledge and flows 100 feet into Big Piney River. A private clubhouse is located nearby. The spring and its surroundings are attractive, but the place is quite inaccessible.

Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 12, 1925	23	14,900,000
October 20, 1932	18.0	11,600,000
August 2, 1934	16.8	10,900,000

SWEET SPRING.—See Blue Spring near Eldridge.

THOMASSON MILL SPRING is located in sec. 16, T. 22 N., R. 2 W., a quarter of a mile east of the "Knife-Edge" divide between Frederick Creek and Eleven Point River known as

"The Narrows", near the mouth of Frederick Creek; and 14 miles southeast of Alton, Oregon County. The spring rises in a small lake formed by a dam about 8 feet high, where power was developed formerly to operate a small grist mill. The spring branch flows a quarter of a mile into Eleven Point River. The small lake is quite full of aquatic growth, and the surroundings are very pretty; it is an excellant place for picnics and outings. The spring is only a mile from Oregon County Highway "D", and can be reached readily by driving over county roads from Thayer or Alton. Thomasson Mill Spring is half a mile northeast of Blue Spring, one of the larger springs of the Ozark area, which rises at the base of the 60-foot bluff of "The Narrows". Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 12, 1925	26	16,800,000
June 10, 1926	50	32,300,000
October 25, 1932	14	9,050,000
September 14, 1933	35	22,600,000
August 17, 1934	23.8	15,400,000
July 18, 1935	57.5	37,200,000
August 13, 1936	24.3	15,700,000

TORONTO SPRING is located in SW¼ sec. 30, T. 38 N., R. 14 W., three-quarters of a mile southeast of Toronto, Camden County. It rises in a gravel bed and flows 1,000 feet into Wet Auglaize Creek, which must be forded in order to reach the spring outlet. The spring branch contains an abundance of aquatic vegetation. On November 19, 1942, the flow was 6.94 second-feet, or 4,490,000 gallons per day.

TORONTO SPRING, LITTLE.—See Little Toronto Spring.

TURNER MILL SPRING is located in sec. 3 T. 24 N., R. 3 W., 10 miles northeast of Alton, Oregon County. The water flows from a small cave, is carried 250 feet in a wooden flume to a 26-foot, steel, overshot waterwheel which is used to develop power to operate a saw mill, sorghum mill, and flour mill.

Turner Mill Spring is of a type which is of interest to students concerned with these surface manifestations of the flow of underground water. The flow here issues from a low-roofed, bedding-plane cavern in a vertical bluff of the Gasconade cherty dolomite and dolomite. The wall of the bluff rises vertically for more than 50 feet above the spring and then slopes steeply to the top of the ridge. The spring outlet is aptly described as a "hole in the bluff", approximately 35 feet above the normal stage of Eleven Point River. Such cavernous, tubular openings may be seen at many places in the dolomite bluffs which border the flood plains of the larger Ozark streams, but they usually are dry, abandoned channels which were left above the ground-water table after the surface streams had cut their valleys to lower levels. Most of the large springs of the Ozarks emerge at or near the water level of the major stream valleys in which they occur, whereas Turner Mill Spring is an outlet well above Eleven Point River, into which it flows at a distance of about 300 feet. Attention may be called here to the great Greer Spring, which is located only 4 miles northwest of Turner's Mill. Although Greer Spring rises in the bottom of a narrow tributary gorge 1¼ miles from the bank of Eleven Point River, its elevation is approximately 60 feet above normal stage of the river.

Turner's Mill is in a beautiful woodland setting in the deep, steep-walled valley of the swift, clear Eleven Point River. Well known to fisherman in this part of Missouri, the mill is a landmark on the river. It has been in almost continuous operation for about 60 years. The present mill operator reports that variations in the spring flow seem to be independent of rises and falls on Eleven Point River, and, though the spring becomes turbid or murky after prolonged or heavy rainfall, it never become truly "muddy."

Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 8, 1924	2.3	1,500,000
August 13, 1925	2.4	1,600,000
October 25, 1932	1.7	1,100,000
August 12, 1936	1.85	1,200,000

WARNER BAY SPRING is located in sec. 9, T. 31 N., R. 2 E., 8 miles southeast of Centerville, Reynolds County. The water issues from several openings in a cave in a rocky cliff and flows a quarter of a mile before entering Black River. The rugged surroundings are picturesque, but the place is quite inaccessible. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
July 31, 1925	16.0	10,300,000
August 6, 1936	16.3	10,500,000

WAYNESVILLE SPRING.—See Roubidoux Spring.

WELCH SPRING is located in sec. 14, T. 31 N., R. 6 W., 3 miles southeast of Cedar Grove, Shannon County. The water issues from a cave at the base of a high wooded hill of Eminence dolomite, about 75 feet below the top of the formation. It flows into a small lake formed by a low rock dam containing two outlet gates; and then empties into Current River through two separate channels about 100 feet and 400 feet long. A house built over the mouth of the cave from which the spring issues is air-conditioned with air drawn from the cave (plate XVIII-B). The place is very scenic and picturesque, and can be reached readily by driving one mile over a good county road after leaving State Highway 19.

The source of the spring is believd to include a rather large area lying to the north of the outlet—perhaps extending northward as far as the town of Salem—which contains little well-established surface drainage. Welch Spring, like Montauk, Cave, Pulltight, Round, Blue, and Big Springs is an important contributor to the flow of the spring-fed Current River.

This is the fifth largest spring of the Ozark region of Missouri and Arkansas. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
October 2, 1923	115	74,300,000
June 22, 1924	331	214,000,000
October 14, 1932	77	49,800,000
August 21, 1936	78	50,400,000
October 11, 1938	86	55,600,000
July 15, 1942	117	75,600,000

WESTOVER SPRING is located in SE¼ sec. 14 and NE¼ sec. 23, T. 37 N., R. 3 W., at Westover, 8 miles southeast of Steelville, in Crawford County. The water emerges from several sources within an area of several acres in the dry, gravel-bottomed valley of Dry Creek, is diverted by a ditch to a trout hatchery, and empties into Dry Creek. The place can be reached readily by driving from Steelville. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
August 23, 1926	13	8,400,000
June 22, 1932	10	6,460,000
October 11, 1932	6.3	4,070,000

WET GLAIZE SPRINGS and CAMP GROUND SPRING are located in SW¼ sec. 25, T. 37 N., R. 15 W., Camden county, 7 miles north of Stoutland. The several outlets of Wet Glaize Springs are from gravel beds in Mill Creek valley and are now partly submerged by pools created by a number of earthen dams, which also form many other similar pools with a total area of about 65 acres. Camp Ground Spring also issues from a gravel bed at the edge of the pools, and its flow is piped into them. The pools are used by the Ozark Fisheries Company to rear large numbers of goldfish that are shipped to markets in several states. The discharge from the pools was formerly carried in a flume to a small hydroelectric plant. The pools, the large numbers of goldfish, the special equipment for rearing them, and the landscaped surroundings make the place interesting for the visitor to this unusual type of hatchery. At the hatcheries the valley of Mill Creek has cut down into the lower portion of the Roubidoux formation. The rearing pools are approximately 730 feet above sea level.

It is not practicable to measure the flow of these springs separately. Measurements of the combined flow have been made as follows:

Date	Second-feet	Gallons per day
May 25, 1938	12.7	8,210,000
November 18, 1942	8.55	5,530,000

WILDER SPRING (also called Breakup Spring) is located in sec. 14, T. 23 N., R. 11 W., on the Kelly-Wilder ranch, 5 miles north of Elijah, Ozark County. It issues from the base of a low rock bluff in the channel of Spring Creek. During dry weather it forms the source of the creek. The place is quite inaccessible, is privately owned, and is not open to the public. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
September 5, 1925	6	3,900,000
August 28, 1926	20	12,900,000
August 18, 1934	9.0	5,810,000
August 17, 1936	5.76	3,720,000

WILKINS SPRING is located in S½SE¼ sec. 17, T. 36 N., R. 9 W., 7 miles southwest of Newburg, Phelps County. It rises in a 2-acre lake formed by an earth dam, flows down the valley 1,000 feet, and empties into Mill Creek. The spring site can be reached easily by driving from Newburg. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
January 4, 1927	7.2	4,650,000
October 13, 1932	4.8	3,100,000
July 21, 1934	4.3	2,780,000
August 18, 1934	9.1	5,880,000
July 27, 1936	5.4	3,490,000

WINOKA SPRING is located in NW¼NW¼ sec. 22, T. 28 N., R. 21 W., 1 mile southeast of Galloway, Greene County. It issues from the side of a wooded hill and flows 300 feet into James River, at a point about 200 feet upstream from State Highway 65. Winoka Lodge, located nearby, uses the spring for a water supply.

Winoka Spring is an interesting example of spring flow which emerges from a number of openings along a single bedding plane in a sequence of limestone beds. The spring normally has 8 or 10 such outlets, in a horizontal distance of about

100 feet, along a bed in the Burlington (Mississippian) formation. These outlets and seepage vents obviously make an interconnecting network of small solution channels and tubes, perched well up the side of the valley wall of the small ravine which carries the spring water to James River. The probable source of the spring no doubt includes subsurface water which goes underground through the sinkhole depressions on the upland to the south and east. The wide-mouthed Winoka Cave is located several hundred feet east of the spring in the steep side of James River Valley. This cave, which is practically dry at the present time, is about 15 or 20 feet above Winoka Spring. The cave is probably an abandoned underground channel which formerly was a waterway; and local residents state that, after heavy rains, rushing water can be heard by one who is in the cave. It is not improbable that water which formerly emerged from the mouth of Winoka Cave has more recently been diverted to lower outlets such as the present Winoka Spring, 500 feet west of the cave. The limestone bed from which Winoka Spring flows is underlain, at the spring, by a relatively impermeable stratum of cherty limestone which has "perched" the local water table at that level—some 25 or 30 feet above James River.

Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
October 20, 1932	0.23	150,000
March 7, 1937	3.52	2,270,000

WOODLOCK SPRING is located in NE¼ sec. 30, T. 36 N., R. 2 W., at Davisville, Crawford County. The spring issues from several outlets in a pool and adjoining marshy ground in a recess at the foot of a hillside, flows about 600 feet in a channel with a low rock wall on each bank, passes through a culvert under the road, flows several hundred feet to an abandoned over-shot water-wheel, and then empties into a nearby creek. The spring water is used as a domestic supply by a nearby school, store, and residence. For nearly a century the spring was used to operate a grist mill, until the mill was washed out by a torrential rain in about 1930. Then the present overshot water-wheel was installed, and was used for several years to develop electricity for the Woodlock resort. On October 6, 1943, the flow of the spring was 2.0 second-feet, or 1,300,000 gallons per day.

YANCY MILL SPRING is located in SW¼ sec. 32, T. 36 N., R. 8 W., at Yancy Mill post office, Phelps County, 13 miles south of Rolla. The spring bubbles up in a gravel bed surrounded by a rock wall, flows into a one-acre lake formed by a concrete dam which was formerly used to develop power to operate a grist mill, and empties into Little Piney Creek about 400 feet downstream. It is an excellant place for outings and picnics, and can be reached readily by driving over U. S. Highway 63. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
July 24, 1925	1.5	969,000
October 20, 1932	3.0	1,940,000
August 2, 1934	1.0	646,000

ZANONI SPRING is located in sec. 7, T. 23 N., R. 12 W., at Zanoni post office, Ozark County, 9 miles northeast of Gainesville. It issues from the sides of a high hill, flows through a flume to a mill, and empties into Pine creek at a distance of half a mile. Measurements of the flow have been made as follows:

Date	Second-feet	Gallons per day
October 18, 1932	0.3	194,000
August 18, 1936	.35	226,000

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