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ARTESIAN WATER RESOURCES

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October 26, 1937.

Dear Friend:

Enclosed herewith you will find a mimeographed copy of a report on the Artesian Water Resources of Mississippi. This summary was prepared by the Mississippi State Planning Commission in cooperation with the National Resources Committee and is to be part of the First Biennial Report of the Planning Commission, which will be submitted to the Mississippi Legislature in 1938. The aim of the completed report is to make a brief inventory of the resources of Mississippi, and, on the basis of these resources, to formulate a Master Plan for the future development of the State.

The report on Artesian Water Resources is largely based on Water Supply Paper 576, United States Geological Survey, "The Ground-Water Resources of Mississippi," which is no longer available for general distribution. The report is considerably more detailed than is generally necessary in publication of this type, but was purposely made so, in the hope that it can be used by industrialists seeking a location in which an adequate and dependable water supply may be obtained. This section of the report, therefore, should be considered as somewhat more than a summary, since it was designed to fill a definite need and to meet a specific demand. Your comments and criticisms on this section of the report will be appreciated.

Very truly yours,

V. M. Foster

V. M. Foster, Geologist,
Mississippi State Planning Commission

VMF:r

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Maps and Diagrams

Selected References

1. The Gr und-Water Resources of Mississippi
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ARTESIAN WATER RESOURCES

For the consideration of artesian water resources, Mississippi may be divided into four general regions, within each of which the conditions of water production are more or less uniform. In northeast Mississippi, including the Fall Line Hills, Black Prairie, Pontotoc Ridge and Flatwoods (See Physiographic Map), the major aquifers* are found in the Tuscaloosa, Eutaw and Ripley formations, all of which are Cretaceous in age. In north-central Mississippi, including the North Central Hills, the Jackson Prairie Region and the north-half of the Loess Bluffs Region, the major aquifers are in the Ripley Formation of the Cretaceous and the Holly Springs, Grenada and Lisbon formations of the Eocene. In the Mississippi Alluvial Plain the Grenada, Holly Springs and Lisbon formations all contain good aquifers, the two last named being by far the most important. In some parts of this district the Ripley formation is a possible undeveloped resource for production from deep wells. The River Alluvium, which is the surface formation thruout the Alluvial Plain, also contains abundant water. South Mississippi, which includes the Pine Hills Region, the Coastal Terraces and the southern part of the Loess Bluffs, derives an abundant water supply from the Catahoula, Hattiesburg and Pascagoula formations of Miocene age and the Citronelle formation of the Pliocene. In the southeastern counties of this area the water supply is especially ample, and copiously flowing wells are common.

*Aquifer: A porous, water-bearing and water-yielding bed of rock.

Since the production of artesian water is closely connected with

the geologic structure of the State and with the character of the sediments, frequent reference to the accompanying Geologic Map and structure sections will be made (for a general description of the various geologic formations see Columnar Section).

Much of the statistical information contained herein was obtained from Water Supply Paper 576, "The Ground-Water Resources of Mississippi", by Lloyd W. Stephenson, William N. Logan and Gerald A. Warring, published by the United States Geological Survey in 1928. This was supplemented by information contained in other publications of Federal and State Agencies, and by reports from Chambers of Commerce thruout the State.

Northeast Mississippi

The sediments which underlie this area consist of clay, sand, gravel, marl and chalk or limestone. All dip toward the west and southwest at a rate of approximately 30 feet to the mile, and outcrop in relatively narrow crescent-shaped bands extending from north to south (See Geologic Map). Three formations which bear abundant water are available in this territory: the Ripley, the Eutaw and the Tuscaloosa.

Tuscaloosa Formation

The Tuscaloosa Formation is practically undeveloped as a source of artesian water, except in that part of Mississippi lying east of the Tombigbee River. In that district it supplies many shallow wells, a number of which are flowing. In the counties lying west of the Tombigbee, and especially in the Black Prairie Belt, it forms an excellent potential supply. In commenting on the Tuscaloosa Formation as

a potential water producer in Clay County, Lloyd W. Stephonson says:

> "The whole county is therefore fortunate in possessing an excellent, practically inexhaustible and easily accessible supply of ground-water, which is being utilized by hundreds of wells, most numerous in the east, but also generally distributed thruout the remainder of the county."[1]

[1] Stephenson, Lloyd W., and others, "The Ground-Water Resources of Mississippi". U. S. Geological Survey, Water Supply Paper 576, Page 126; 1928.

This statement will apply to other parts of the area under consideration. The Tuscaloosa is composed of sands, gravels and clay, with coarse sand and gravel especially abundant in the basal of 175 or 200 feet. The formation varies in thickness from 200 feet in the northern part of Mississippi to about 400 or 500 feet in southern Noxubee County, and dips beneath younger beds toward the west at a rate of about 30 feet per mile. In Northeast Mississippi aquifers of Tuscaloosa age may be found at depths ranging from 30 feet or less in eastern Tishomingo, Itawamba and Monroe Counties to 1500 or 2000 feet, or more, in the Flatwoods district, and, since the water resources of the Tuscaloosa are largely potential thruout much of the area, further development for industrial uses would create little or no danger of damaging wells already in use. Furthermore, in those counties lying west of the Tombigbee Valley, there is no doubt that a water supply adequate to meet any reasonable demand can be obtained from wells of proper size, scientifically spaced and drilled. Unfortunately the artesian waters of this district do not have sufficient head to flow, except in a few of the deeper valleys, and even there the flow is slight. Therefore, any large scale water development must depend entirely on pumping.

An idea of the quantity and quality of the water may be gained from the following tables, adapted from "The Ground-Water Resources of Mississippi" mentioned above:

Table Showing Representative Wells of Northeast Mississippi Deriving Artesian Water from the Tuscaloosa Formation.

Location City	County	Depth	Diameter	Production Gals per Min.	Method of Production
West Point	Clay	790'	8"	60	Flows
Artesia	Lowndes	1300'	8"	400	Air Pump
Columbus	"	550'	3"	40	Flows
"	"	420'	--	130	"
Mayhew	"	815'	2"	35	"
Aberdeen	Monroe	450'	--	160	"
Amory	"	260'	4"	100	"
"	"	250'	---	200	"
Hamilton	"	120'	2"	15	"
Muldon	"	620'	6"	166	Air Pump
Brookville	Noxubee	1187'	6"	250	" "

[2]Average, Minimum and Maximum Quantities of Mineral Constituents in Waters from Tuscaaloosa Formation.

(Parts per million)

	Average	Minimum	Maximum
Silica (SiO_2)	18	9.4	35
Iron (Fe)	4.9	.08	20
Calcium (Ca)	7.8	1.4	13
Magnesium (Mg)	2.8	.7	4.8
Sodium (Na) Potassium (K)	18	3.2	67
Bicarbonate Radicle (HCO_3)	73	11	197
Sulphate Radicle (SO_4)	5.0	.4	16
Chloride Radicle (Cl)	4.5	1.0	8.0
Nitrate Radicle (NO_3)	.2	.00	.60
Total dissolved Solids	92	30	227
Total Hardness as ($CaCO_3$)	31	6	47

[2] Op. Cit.; Page 31.

Eutaw Formation

The Eutaw Formation, which overlies the Tuscaloosa, outcrops between that formation and the Selma Chalk (See Geologic Map), and con-

tains the aquifers from which the major water supply of the Flatwoods, the Pontotoc Ridge, the Black Prairie Region and the western part of the Fall Line Hills is derived. The Selma Chalk, which immediately overlies the Eutaw, is composed of massive and impervious chalk; it is not water producing but forms the cap-rock for the aquifers of the Eutaw formation west of their outcrop. The Eutaw consists of fine to medium-grained sand with subordinate marl beds in the upper, and clay beds in the lower portions. It dips to the west and southwest at a rate of about 30 feet per mile, and the top of the Eutaw is reached at a depth of about 1100 or 1500 feet along the western edge of the Flatwoods Region.

It is the Eutaw formation that forms the major source of water supply for domestic and municipal use, and for use in the existing industries of the area west of its belt of outcrop. In much of the district it is already well developed as a source of artesian water, and in other parts it is rapidly being developed. Therefore, it cannot be considered as a source for major industrial production to supply a future demand. The following tables illustrate the quantity and quality of water available from this formation:

Table Showing Representative Wells of Northeast Mississippi Deriving Artesian Water from Eutaw Formation.

Location				Production	Method of
City	County	Depth	Diameter	Gals per Min.	Production
Corinth	Alcorn	190'	8"	75	Steam Pump
"	"	100'	10"	50	" "
Houlka	Chickasaw	1087'	4"	50	Air Pump
Okolona	"	550'	10"	256	" "
Electric Mills	Kemper	1378'	6"	205	" "
Belden	Lee	300'	5"	40	Steam Pump
Tupelo	"	325'	6"	80	Pump
"	"	380'	10"	100	Air Pump

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Location City	County	Depth	Diameter	Production Gals. per Min.	Method of Production
Mayhew	Lowndes	357'	2½"	7½	Hand Pump
"	"	400'	1¾"	10	" "
Penn	"	720'	3"	10	Gas Pump
Aberdeen	Monroe	140'	4"	250	Air "
Amory	"	199'	2½"	25	Flows
Macon	Noxubee	875'	6"	85	Air Pump
"	"	595'	2"	12½	Flows
Shuqualak	"	960'	6"	25	Air pump
Starkville	Oktibbeha	910'	8"	175	" "
State College	"	1008'	6"	115	" "
Sherman	Pontotoc	300'	3"	3	Hand Pump
"	"	285'	4"	10	" "
Troy	"	704'	3"	10	" "
Baldwin	Prentiss	410'	4"	60	Electric Pmp
"	"	410'	5"	75	Steam Pump
Wheeler	"	385'	6"	350	Air Pump
Blue Springs	Union	400'	4"	20	Steam Pump

Mineral Analyses of Artesian Waters from Eutaw Formation, Northeast Mississippi.

(Parts per Million)

City -Corinth County-Alcorn	Okolona Chicka.	Electric M. Kemper	Tupelo Lee	Shuqualak Noxubee
Silica (SiO_2)------ 33	25	28	27	14
Iron (Fe)---------- 3.3	.05	.20	.05	1.2
Calcium (Ca)------- 71	8.1	3.7	30	8.5
Magnesium (Mg)----- 4.7	2.8	1.6	4.8	2.2
Sodium (Na)--------)				
Potassium (K)------) 12	106	443	44	611
Carbonate Radicle (CO_3)--- .0	38	30	6.7	17
Bicarbonate Radicle (HCO_3)--- 165	92	414	107	537
Sulphate Radicle (SO_4)----- 30	3.6	3.4	6.7	1.8
Chloride Radicle (Cl)----- 35	84	397	60	629
Nitrate Radicle (NO_3)---- 10	1.5	1.1	.33	.00
Total dissolved Solids--- 287	317	1114	243	1579
Total Hardness as ($CaCO_3$)--- 197	32	16	95	30

(Above table continued on Page 7)

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	City -Troy	Baldwin	Wheeler	Blue Springs
	County-Pontotoc	Prentiss	Prentiss	Union
Silica (SiO_2)	67	23	25	28
Iron (Fe)	18	.64	.50	.05
Calcium (Ca)	70	24	36	79
Magnesium (Mg)	22	6.6	6.8	9.5
Sodium (Na)				
Potassium (K)	206	28	19	12
Carbonate Radicle (CO_3)	.0	1.9	.0	.0
Bicarbonate Radicle (HCO_3)	220	130	145	280
Sulphate Radicle (SO_4)	329	10	18	29
Chloride Radicle (Cl)	128	20	15	2.1
Nitrate Radicle (NO_3)	.00	.52	.42	.40
Total dissolved Solids	957	181	188	304
Total Hardness as ($CaCO_3$)	265	87	118	236

Ripley Formation

The uppermost of the major aquifers, the Ripley, outcrops in the Pontotoc Ridge and supplies water to shallow wells of eastern Chickasaw, Pontotoc, Union and Tippah, and western Alcorn Counties. This formation varies in thickness from 400 feet in northern Tippah County to less than 100 feet in Noxubee County. It is composed predominantly of marine sands and marls interbedded with clays which form the local cap-rock of the artesian structure. In the southern part of its outcrop the sands grade into the Selma Chalk which outcrops in the Black Prairie Belt and in Clay, Oktibbeha and Noxubee Counties, the Ripley consists of marl and sandy chalk, distinguishable from the Selma only by fossil content. The marly and chalky portions are non water-bearing,

and, while the entire sandy phase produces potable water, by far the most important aquifer is the thick, massive bed of coarse, pure sand, the McNairy Sand Member, which is found near the center of the formation in the northern part of its outcrop. In northern Tippah County the McNairy Sand Member is estimated to be 225 to 250 feet in thickness. It tongues into the more typical Ripley of southern Alcorn and Tippah Counties, and sediments of a similar nature occur as thinner sand beds in the outcrops farther south. It is these beds which are most important as water producers, although, in this district, the larger wells are drilled to the Eutaw or Tuscaloosa. An idea of the quantity of water available from the Ripley, and its quality, can be gained from the following tables:

Table Showing Representative Wells in Northeastern Mississippi Deriving Artesian Water from the Ripley Sand.

Location City	County	Depth	Diameter	Production Gals. per Min.	Method of Production
Houlka	Chickasaw	400'	2½"	2	Hand Pump
Algoma	Pontotoc	141'	3"	5	" "
Pontotoc	"	102'	3"	4	Gas Pump
Blue Mtn	Tippah	105'	3"	7	Flows
" "	"	279'	3"	70	Gas Pump
Cotton Plant	"	461'	4"	30	" "
Falkner	"	140'	3½"	40	Steam Pump
Ripley	"	200'	3¼"	100	Flows
New Albany	Union	261'	6"	55	Air Pump

Mineral Analyses of Artesian Waters from Ripley Formation, Northeast Mississippi

(Parts per Million)

City	-Pontotoc	Blue Mtn.	Cotton Plt	Ripley	N.Albany
County	-Pontotoc	Tippah	Tippah	Tippah	Union
Silica (SiO_2)	14	29	20	34	11
Iron (Fe)	1.4	.07	.25	.09	1.1
Calcium (Ca)	57	46	6.1	48	11
Magnesium (Mg)	5.4	9.6	2.4	7.8	2.9

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	City -Pontotoc County-Pontotoc	Blue Mtn Tippah	Brownfield Tippah	Ripley Tippah	N.Al. Union
Sodium (Na)--------) Potassium (K)------)	17	14	60	10	59
Carbonate Radicle (CO_3)------	.0	4.8	14	2.4	.0
Bicarbonate Radicle (HCO_3)-----	217	179	135	189	171
Sulphate Radicle (SO_4)------	18	12	7.6	6.8	16
Chloride Radicle (Cl)-------	6.0	2.0	4.0	3.0	6.0
Nitrate Radicle (NO_3)------	.00	trace	1.2	trace	1.9
Total dissolved Solids at 180°C---	224	195	187	201	135
Total Hardness as ($CaCO_3$)-------	165	154	25	152	39

Conclusion

From the foregoing discussion it is obvious that:

(1) Over much of northeast Mississippi, the artesian waters potentially available for industrial uses are strictly limited.

(2) On the whole, the wells now producing do so in relatively small quantities, and the production of large volumes of water for local industrial use (measured in millions of gallons per day) would entail the expense of numerous large wells, fairly widely spaced.

(3) Any large scale development must depend entirely on pumping.

(4) In some parts of the area, the water resources are already highly developed, and attempts at greatly increased production would incur the risk of interfering with the yield from wells already in use.

(5) Thruout most the region, large undeveloped supplies are available only from that part of the Tuscaloosa formation which lies at depths of 1200 feet or more.

(6) The Black Prairie Belt, particularly in the southern half of its extent, offers the best possibility for development, since the full thickness of both the Eutaw and Tuscaloosa formations is present at depths sufficiently shallow to render them accessible without too great expense, sufficiently far from their outcrops to mask out the effects of abnormally dry years, and sufficiently undeveloped to minimize the risk of reducing production from wells which are already in use.

Recommendations

With these facts in mind, certain well-defined principles for the most economic use of artesian waters of northeast Mississippi become apparent:

(1) New industries, requiring moderately large amounts of water, should probably be concentrated only in the Black Prairie Belt, particularly in the southern half of its extent.

(2) Industries which require abnormally large quantities of water (for instance, large pulp mills) probably should not be located within this area.

(3) Industries should be well scattered or spaced over the area and care should be taken not to over-develop any one locality.

(4) Careful planning and selection of industries will be needed to utilize the available water resources to the optimum advantage.

(5) Before definitely selecting an industrial site a company which is to receive the contract for developing a water supply should be given an opportunity to make a careful hydrological survey to determine the available resources, the extent to which they are already developed and the cost of producing the required additional supply.

(6) Careful conservation of the limited water supply should be practiced.

North Central Mississippi

In the North Central Mississippi District, which includes the northern half of the Loess Bluffs Region and all of the North Central Hills and the Jackson Prairie Physiographic Unit (See Physiographic Map), the dominant bedrock consists of sands and sandy clays. Although only the western and southern parts of the district are important as water producing areas, North Central Mississippi is the catchment area for two of the State's most important water-bearing formations, the Holly Springs and Lisbon Sands, which outcrop within the area. These two important formations, together with less important or locally developed aquifers (Ackerman, Grenada, Tallahatta and Yegua) supply ample water for domestic and municipal use, but are only important for industrial purpose in the counties along the southern and western borders of the region and in the Mississippi Alluvial Plain. The Ripley Sands, underlying the northern quarter of the area at a depth of from 300 to 2500 feet, forms a potential, but as yet undeveloped, source of artesian water. Since the elevation of the

region as a whole is relatively high, an artesian head of sufficient strength to produce flowing wells is found only in the valleys of the larger streams (See map Areas of Artesian Flow). Hence, any development of industrial waters, to produce an adequate volume, must depend mainly on pumping, even in the lowlands.

Ackerman Formation

The Ackerman Formation, which is the oldest, and, therefore, underlies the other formations of the district (See Structure Sections), consists of 300 to 500 feet of stratified, gray, sandy clay, and includes many interbedded layers of lignite. A few layers of fine-grained sand are also interbedded with the clays, and these serve as aquifers for domestic and municipal waters. The quantity of water available from this source is not great, however; and it is usually rather highly mineralized with sulfate or carbonate of iron. The Ackerman formation, therefore, is generally unsuited to the development of industrial waters.

Holly Springs Formation

The Holly Springs Formation, which outcrops in a broad crescent-shaped band extending from the Tennessee State line in Marshall and Benton Counties to the Alabama State line in Lauderdale County, consists of highly cross-bedded sands, interbedded with subordinate clay lenses. It is about 300 feet thick and carries abundant water. This is by far the most important aquifer in North Central Mississippi because of its thickness, wide extent, large catchment area and uniformly porous character, and it is the formation into which most of the large wells

in the northwest quarter of the state are drilled. The Holly Springs formation dips gently toward the west and southwest at a rate of about thirty feet per mile, and since it is overlaid by the impervious clays of the Grenada, or the claystones and quartzites of the Tallahatta formation, excellent artesian conditions prevail west of its belt of outcrop. Thruout this district, the water-bearing sands of the Holly Springs can be reached at depths of less than 1500 feet, and, except in the extreme southwestern corner of the district, they lie less than 1,000 feet below the surface. Many large wells, therefore, derive water from this source, and, in the lowlands of the river valleys, flowing wells are not uncommon.

The following tables indicate the quantity and quality of the water which is available from this formation:

Representative Wells of North Central Mississippi Deriving Artesian Water from the Holly Springs Formation.

Location				Production	Method of
City	County	Depth	Diameter	Gals. per Min.	Production
Carrollton	Carroll	400'	4"	60	Flows
Vaiden	"	230'	3"	15	"
Dubard	Grenada	210'	2"	60	"
Grenada	"	400'	4"	30	"
Holcomb	"	355'	2"	40	"
Jackson	Hinds	1375'	8"	75	"
Durant	Holmes	850'	4"	350	"
Goodman	"	785'	4"	100	"
Lexington	"	900'	6"	175	"
Oxford	Lafayette	144'	12"	135	Electric Pump
Lauderdale	Lauderdale	168'	6"	115	Air Pump
Meridian	"	780'	8"	100	Steam Pump
"	"	375'	6"	300	Air Pump
Winona	Montgomery	400'	8"	60	Electric Pump
Union	Newton	350'	4"	400	Air Pump
Batesville	Panola	302'	4"	60	Flows
Savage	Tate	500'	2½"	85	Hand Pump
Water Valley	Yalobusha	80'	8"	750	Steam Pump
" "	"	1115'	4"	40	Gas Pump

[3] Average, minimum and maximum quantities of mineral constituents in waters from Holly Springs Sand[a].

(Parts per Million)

	Average	Minimum	Maximum
Silica (SiO_2)	29	8.4	56
Iron (Fe)	2.6	.16	17
Calcium (Ca)	12	1.3	45
Magnesium (Mg)	3.6	.7	8.8
Sodium (Na) and Potassium (K)	36	5.3	95
Bicarbonate Radicle (HCO_3)	126	16	295
Sulphate Radicle (SO_4)	8.9	.7	25
Chloride Radicle (Cl)	7.3	1.0	24
Nitrate Radicle (NO_3)[b]	1.7	.00	12
Total dissolved solids	163	35	296
Total Hardness as ($CaCO_3$)	44	6	149

[a]Based on results of 27 analyses, as follows: Grenada County, Nos. 6, 9, 20; Holmes County, No. 11; Lafayette County, No. 12; Lauderdale County, Nos. 8, 13; Marshall County, Nos. 3,4; Neshoba County, Nos. 1,2,3,4; Newton County, No. 19; Panola County, Nos. 3, 13; Quitman County, Nos. 1, 3, 4, 6; Tallahatchie County, Nos. 17, 19, 22; Tate County, No. 11; Yalobusha County, Nos. 13, 18, 19. For complete analyses see county descriptions.

[b]Based on 26 determinations.

[3]Op. Cit.; Page 47.

Grenada Formation

In Marshall, DeSoto, Tate, Panola, Tallahatchie, Yalobusha and Grenada Counties the Holly Springs is immediately overlaid by from 60 to 200 feet of lignitic clays and lignites to which the name of Grenada Formation has been applied. Locally, a few sand layers, interbedded with the clays, yield large quantities of artesian water. These aquifers are of greatest importance in DeSoto, Tate and Panola Counties where they constitute the water supply for several municipal-

ities. These clays correspond in characteristics and stratigraphic position to the Hatchetigbee Formation of Laudersale County and adjacent parts of Alabama, which also contains aquifers of minor importance. The sands of the Grenada and Hatchetigbee formations, however, are of restricted extent. The five wells listed in the following table serve to indicate the possibilities of local development.

Wells of North Central Mississippi Deriving Artesian Water from the Grenada-Hatchetigbee Formation.

Location City	County	Depth	Diameter	Production Gals. per Min.	Method of Production
Meridian	Lauderdale	230'	3"	30	Flows
Marion	"			20	"
Como	Panola	210'	8"	150	Steam Pump
Sardis	"	197'	8"	300	" "
Senatobia	Tate	120'	4"	120	Air Pump

Tallahatta Formation

The Tallahatta formation immediately overlies the Grenada-Hatchetigbee beds south of Grenada County, and between Montgomery and Lauderdale Counties it overlaps these clays, lying immediately on sands of the Holly Springs formation. It consists of interbedded claystone, sandstone and quartzite. The Tallahatta is quite thin thruout most of its extent, but thickens to about 250 feet in Newton and Clarke Counties where the soft sandstone layers are particularly prominent and form a locally important water resource.

Wells of Newton and Clarke Counties Deriving Artesian Water from the Tallahatta Formation.

Location City	County	Depth	Diameter	Production Gals per Min.	Method of Production
Enterprise	Clarke	400'	10"	250	Flows
"	"	200'	6"	75	"
Hickory	Newton	300'	$2\frac{1}{2}$"	34	"

Lisbon Formation

The Lisbon Formation consists of a series of coarse sands and sandstones, 400 feet or more in thickness and containing subordinate clay beds. The lower 300 feet, the Winona Sand Member, in particular, is abundantly water-bearing. Unfortunately the water which it contains is not under sufficient pressure to produce flowing wells except in lower portions of the major valleys. The Lisbon formation dips to the southwest at a rate of 20 to 25 feet per mile, and in the Jackson Prairie Belt, where it is overlaid by the impervious clays of the Yegua and Jackson formations, it is a most important source of artesian water. Thruout most of the district, water-bearing sands of the Lisbon may be encountered at depths of less than 500 feet and it is only in Hinds and southwestern Madison Counties that it reaches a depth of from 700 to 1500 feet.

The following tables indicate the adequacy and quality of water which is available from this source:

Representative Wells of North Central Mississippi
Deriving Artesian Water from the Lisbon Formation.

Location				Production	Method of
City	County	Depth	Diameter	Gals. per Min.	Production
Possomneck	Attala	160'	3"	20	Flows
McCarley	Carroll	160'	3"	8	"
Bolton	Hinds	1517'	6"	80	Steam Pump
Clinton	"	1125'	8"	75	Pump
Jackson	"	718'	6"	400	Air Pump
"	"	844'	6"	500	" "
Durant	Holmes	356'	6"	50	Steam Pump
Canton	Madison	1050'	6"	100	Air Pump
Flora	"	1304'	4"	100	" "
Newton	Newton	260'	4"	150	" "
Ophelia	Rankin	202'	3"	300	Gas Pump
Forest	Scott	398'	8"	350	Air Pump
"	"	361'	10"	400	" "

[4] Minimum and Maximum Quantities of Mineral Constituents in Waters from Lisbon Formation[a].

(Parts per Million)

	Minimum	Maximum
Silica (SiO_2)	11	60
Iron (Fe)	.20	4.3
Calcium (Ca)	1.4	68
Magnesium (Mg)	.4	22
Sodium and Potassium (Na K)	13	513
Bicarbonate Radicle (HCO_3)	63	1,235
Sulphate Radicle (SO_4)	0.0	130
Chloride Radicle (Cl)	4.5	72
Nitrate Radicle (NO_3)[b]	.00	4.0
Total dissolved solids	109	1,214
Total hardness as $CaCO_3$	5	230

[a]Based on results of 18 analyses, as follows: Clarke County, Nos. 21, 22; Covington County, No. 5; Holmes County, Nos. 12, 16, 32, 33, 37; Humphreys County, No. 9; Jasper County, Nos. 2, 3; Jones County, Nos. 9, 10; Newton County, No. 20; Sharkey County, Nos. 2, 3, 5; Smith County, No. 1. For complete analyses see county descriptions.

[b]Based on 15 determinations.

[4] Op. Cit.; Page 52.

Yegua Formation

A series of lignitic clay and lignite, which ranges in thickness from 40 feet in the southeast to about 400 feet in Madison and Yazoo Counties (the Yegua Formation), forms the caprock for the Lisbon artesian area. Although sand is not a prominent constituent of the Yegua, a few, locally developed, sand layers furnish an abundance of pure water in some places. The four wells listed below serve to demonstrate the possibilities of local production.

Wells Deriving Artesian Water from the Yegua Formation.

Location City	County	Depth	Diameter	Production Gals. per Min.	Method of Production
Canton	Madison	373'	10"	300	Air Pump
"	"	379'	6"	200	" "
Fannin	Rankin	325'	8"	400	Gas Pump
Satartia	Yazoo	588'	1"	14	Flows

Jackson Formation

The clays and marls of the Jackson formation contain no extensive beds of sand, and, hence, are unimportant as water producers. The lower 40 to 90 feet of the formation, however, consists of marly sand, and local wells derive a water supply adequate for domestic use from that source.

Vicksburg Formation

The Vicksburg formation consists of sand, clay, marl and limestone. The clay and sand are most prominent in the lower 70 feet of the formation and the marls and limestones in the upper 100 feet. Although all parts of the formation produce some water, the Forest Hill Sand, which lies at the bottom of the formation in Smith, Jasper, Clarke and Wayne Counties, is a locally prominent aquifer and is penetrated by many shallow wells.

Conclusions

It is obvious, therefore, that in North Central Mississippi the water resources are limited in area as well as in quantity.

(1) In the eastern half of the area, that belt in which the Ackerman and Holly Springs formations outcrop, the water is

sufficient for ordinary domestic and municipal uses, but the development of an abnormally large supply would require numerous wells and entail great expense.

(2) In the northern Loess Bluff Region, embracing parts of DeSoto, Tate, Panola, Tallahatchie, Yalobusha, Grenada and Carroll Counties, the entire thickness of the Holly Springs produces an abundance of artesian water.

(a) In much of that area, also, the Ripley formation is a deep lying and undeveloped, but potential, source of supply.

(b) Moderate artesian flows are not uncommon in major valleys of the Loess Bluffs Region.

(3) The most promising area for the development of large quantities of artesian water is included in Holmes, Yazoo, Madison, Hinds, Rankin, Scott, Smith, Jasper and Clarke Counties.

(a) In that area the Holly Springs and Lisbon formations produce abundantly.

(b) In the eastern counties the Tallahatta and Vicksburg formations yield large quantities of water.

(c) In the western counties the Yegua formation is an important producer, and locally the sands of the Jackson formation produce in moderate quantities.

Recommendations

(1) East of the Loess Bluffs area great care is needed to prevent over-development.

(a) Small, adequately spaced industries, or industries which do not require abnormally large quantities of water, are indicated for this area.

(b) Industries requiring abnormally large water supplies should be discouraged in order to insure most profitable use of available resources.

(c) Concentration of industries in any one locality should be avoided in order to prevent over-development of the water supply.

(d) Care is needed in drilling and spacing of wells in order to safeguard the yield of wells already in use.

(2) In those counties which border the region on the west, the water supply is adequate for normal industrial uses.

(a) Industries using moderately large quantities of water may be located in this area.

(b) However, concentration of industries requiring large quantities of water should be avoided.

(3) The Jackson Prairie Belt, plus Holmes and Clarke Counties, offers the best opportunities to industries in which availability of large quantities of water is the determining factor for successful operation.

(a) Care should be exercised to prevent over concentration, and hence, over-development of the water supply.

(4) Conservation measures are an immediate and imperative problem in the catchment areas of the aquifers.

(a) Steps should be taken to prevent rapid run off of rainwaters in order that enough may seep into the ground to insure a continuous supply.

The Mississippi Alluvial Plain

The third region in which an abundant water supply can be developed is the Mississippi Alluvial Plain, the so-called "Delta" region. The major artesian aquifers of the alluvial plain are the Lisbon Formation in the southern part, and the Holly Springs Sand in the northern part. In the northern third of this area, also, the Ripley Sands form a deep lying, but as yet undeveloped source of artesian water (see cross section).

Holly Springs Formation

The Holly Springs Sand is the middle formation of the Wilcox group of Eocene age. It is underlaid by clays and sandy clays of the Ackerman Formation, and it is overlaid by lignitic clays and sandy clays of the Grenada formation. Both of these bear locally important water-bearing sands, but cannot be considered for large scale and sustained water production. On the other hand, the clays form the impervious confining beds which, together with the abundantly water-bearing Holly Springs Sand, produce the artesian conditions for much of the state west of their outcrop. The Holly Springs Sand outcrops in a rather broad belt extending from Benton and Marshall Counties on the north to Neshoba and Kemper Counties on the south. It dips to the west and southwest at a rate of about 20 feet per mile and is encountered in wells at depths of 300 to 1,000 feet in the northern counties and at somewhat greater depths in the south. Waters of the Holly Springs show great variation as to quality and quantity. How-

ever, by regulating the number, size and depth of wells, almost any desired quality and quantity of water may be secured. The following tables indicate the importance of the Holly Springs Sand as a water-producer and the quality of water produced:

Table Showing Representative Wells of "Delta" Region Deriving Artesian Water from the Holly Springs Sand.

Location City	County	Depth	Diameter	Production Gals. per Min.	Method of Production
Boyles	Bolivar	1,555'	6"	225	Flows
Cleveland	"	1,500'	6"	230	"
Duncan	"	1,250'	4"	225	"
Gunnison	"	1,750'	6"	150	"
Shelby	"	1,565'	4"	250	"
Clarksdale	Coahoma	1,502'	6"	110	"
Clarksdale	"	1,000'	10"	1,000	Centrifugal Pmps
Lyon	"	975'	4"	150	Gas Pump
Cruger	Holmes	700'	2"	200	Flows
"	"	680'	2"	100	"
"	"	826'	4"	350	"
Greenwood	Leflore	835'	10"	1,000	"
Marks	Quitman	700'	$4\frac{1}{2}$"	75	"
Lambert	"	700'	$2\frac{1}{2}$"	100	"
Indianola	Sunflower	1,320'	4"	200	"
"	"	1,500'	$4\frac{1}{2}$"	300	"
Inverness	"	1,312'	2"	200	"
Glendora	Tallahatchie	650'		100	"
Leverett	"	380'	2"	150	"
Helm	Washington	1,601'	4"	160	"
Stoneville	"	1,850'	4"	160	"

[5] Average, Minimum and Maximum Quantities of Mineral Constituents in Waters from Holly Springs Sand[a].

(Parts per Million)

	Average	Minimum	Maximum
Silica (SiO_2)	29	8.4	56
Iron (Fe)	2.6	.16	17
Calcium (Ca)	12	1.3	45
Magnesium (Mg)	3.6	.7	8.8
Sodium and Potassium (NaK)	36	5.3	95

(Continued on Page 23)

(Continued from Page 22)

	Average	Minimum	Maximum
Bicarbonate Radicle (HCO_3)	126	16	295
Sulphate Radicle (SO_4)	8.9	.7	25
Chloride Radicle (Cl)	7.3	1.0	24
Nitrate Radicle (NO_3)[b]	1.7	.00	12
Total dissolved solids	163	35	296
Total hardness as $CaCO_3$	44	6	149

[a]Based on results of 27 analyses, as follows: Grenada County, Nos. 6, 9, 20; Holmes County, No. 11; Lafayette County, No. 12; Lauderdale County, Nos. 9, 13; Marshall County, Nos. 3,4; Neshoba County, Nos. 1, 2, 3, 4; Newton County, No. 19; Panola County, Nos. 3, 13; Quitman County, Nos. 1, 3, 4, 6; Tallahatchie County, Nos. 17, 19, 22; Tate County, No. 11; Yalobusha County, Nos. 13, 18, 19. For complete analyses see county descriptions.

[b]Based on 26 determinations.

5 Op. Cit.; Page 47

Lisbon Formation

The Lisbon Formation is separated from the Holly Springs Sand by about 500 feet of clays and sandy clays which belong to the Grenada Formation of the Wilcox group and the Tallahatta Formation of the Claiborne group. Both of these formations include minor beds and lenses of porous sand which yield abundant water locally, but cannot be considered as good prospects for sustained production of large quantities of water for industrial use. The Lisbon Formation, on the other hand, consists of a series of coarse sands and sandstones 400 feet or more in thickness and containing only subordinate clay beds. The lower 300 feet, the Winona Sand Member, in particular, is abundantly water-bearing, and yields artesian flows over much of the area under consideration. The following tables indicate the quantity and quality of the artesian waters from this source:

Table Showing Representative Wells Deriving Artesian Water from the Lisbon Sand.

Location City	County	Depth	Diameter	Production Gals. per Min.	Method of Production
Bee Lake	Holmes	675'	4"	500	Flow
Belzoni	Humphreys	771¼'	6"	294	"
"	"	658'	4"	100	"
Midnight	"	645'	4"	300	"
Silver City	"	735'	4"	130	"
Browning	Leflore	266'	2"	200	"
Shell Mound	"	426'	---	300	"
Minter City	"	437'	2"	50	"
Dockery	Sunflower	930'	2"	100	"
Drew	"	600'	6"	100	"
Moorhead	"	1300'	4"	300	"
Ruleville	"	864'	3"	100	"
Greenville	Washington	480'	8"	400	Air
"	"	520'	10"	1,000	"
"	"	575'	10"	500	Electric Pump
Hollandale	"	385'	6"	200	Air
Leland	"	527'	4"	100	Steam
Eden	Yazoo	800'	3"	200	Flow
Yazoo City	"	801'	8"	200	"

[6]Minimum and Maximum Quantities of Mineral Constituents in Waters from Lisbon Formation[a].

(Parts per Million)

	Minimum	Maximum
Silica (SiO_2)	11	60
Iron (Fe)	.20	4.3
Calcium (Ca)	1.4	68
Magnesium (Mg)	.4	22
Sodium and Potassium (NaK)	13	513
Bicarbonate Radicle (HCO_3)	63	1235
Sulphate Radicle (SO_4)	0.0	130
Chloride Radicle (Cl)	4.5	72
Nitrate Radicle (NO_3)[b]	.00	4.0
Total dissolved solids	109	1214
Total hardness as $CaCO_3$	5	230

[a]Based on results of 18 analyses, as follows: Clarke County, Nos. 21, 22; Covington County, No. 5; Holmes County, Nos. 12, 16, 32, 33, 37; Humphreys County, No. 9; Jasper County, Nos. 2, 3; Jones County, Nos. 9, 10; Newton County, No. 20; Sharkey County, Nos. 2, 3, 5; Smith County, No. 1. For complete analyses see county descriptions.

[b]Based on 15 determinations.

6 Op. Cit.; Page 52

Alluvium

The surface formation of the Mississippi Alluvial Plain consists of clays, silts, sands and gravels laid down as river alluvium. The lower half of these deposits is composed largely of porous sands and gravels which are saturated with hard water having a relatively high mineral content. L. W. Stephenson makes the following statement:

> "The alluvial deposits that underlie the Yazoo Delta to depths of 125 to 200 feet contain vast quantities of water, which may be regarded as practically inexhaustible even locally; a well of large diameter would probably yield from these deposits as high as 3,000 to 4,000 gallons a minute without seriously lowering the water level."[7]

7 Op. Cit.; Page 15

Since this water is not under pressure, it does not produce flowing wells. Therefore, it is usually cased-off from the local wells which are sunk to underlying beds of Eocene age, the Lisbon and Holly Springs aquifers.

Conclusions

It is obvious from the foregoing discussion that the entire Alluvial Plain Region of Mississippi will produce an abundant artesian water supply, a supply sufficient to meet the needs of any industrial development which is likely to be contemplated within the next decade. On the whole, the southern portion probably has the greater potential water supply since aquifers of both the Lisbon and Holly Springs formations are available and the latter is practically undeveloped at

the present time.

Recommendations

The Mississippi Alluvial Plain is recommended as an area for location of industries in which large quantities of artesian water are needed, since several abundantly producing aquifers are present at depths which render them available at moderate cost; yet, the area is located far enough from their zone of outcrop to insure a steady and continuous flow. Furthermore, the waters are under sufficient hydrostatic pressure to permit large flowing wells thruout the area. In order to conserve the present supply, however, and to prevent draining of adjacent areas in which artesian waters are not present in such abundance, careful regulation of wastage is recommended. This is especially imperative with regard to the flowing wells, many of which are permitted to flow continuously and unnecessarily.

South Mississippi

Another area recommended as satisfactory for development of a water supply of the magnitude needed for industrial development is in South Mississippi, particularly in the Gulf Coast Counties. South Mississippi includes two physiographic regions, the Coastal Terraces and the Pine Hills. The Coastal Terrace Region extends inland about 20 miles from the coast, and is practically co-extensive with the outcrop of the Coastal Terrace Formation (See attached maps). The topography ranges from gently rolling on the north to level on the south, and near the coast are large areas of poorly drained lowlands, swamps and marshes. In no part of the Coastal Terrace area does the elevation exceed 100 feet and in most places it is less than 50 feet.

The Pine Hills Region extends northward for a distance of 100 miles or more and is practically co-extensive with outcrops of the Citronelle Formation and the Catahoula Sandstone. The topography ranges from rolling to moderately rugged hills, and the elevation varies from less than 100 feet in the southeast to 500 feet or more in the northwest.

Catahoula Formation

The major artesian aquifers of southeast Mississippi are contained in the Catahoula, Hattiesburg, Pascagoula and Citronelle Formations (See Geologic Section attached), and the entire Pine Hills area constitutes the catchment basin for these aquifers. The coarse, porous sands and sandstones, which make up major portions of the Catahoula Formation are particularly well adapted as water bearers, and in South Mississippi the relatively few wells which reach the Catahoula indicate that it contains an abundant water supply which is as yet largely undeveloped. The Catahoula is of particular importance as a potential source of water in Marion, Lamar, Forrest, Perry, Greene, George and northeastern Stone Counties, in which areas all of the water-bearing beds of this formation should be encountered between 500 and 1,000 feet of the surface. Thruout most of this area, due to the altitude, water from this source would probably require pumping. However, flowing wells from the Catahoula Formation may be expected in lowlands of the major valleys such as those of the Leaf, Chickasawhay and Pascagoula Rivers. Along the coast the Catahoula Sandstone is too deeply buried to be considered as an aquifer for

ordinary domestic use. However, where large quantities of water are needed for industrial use, the Catahoula could be tapped at depths of from 1600 to 1800 feet and should yield strong flows of water. The following tables, showing wells drilled into the Catahoula Sandstone in South Mississippi, indicate the adequacy of the water supply:

Table Showing Representative Wells of South Mississippi Region Deriving Artesian Water from the Catahoula Formation.

Location City	County	Depth	Diameter	Production Gals. per Min.	Method of Production
Lumberton	Lamar	810'	8"	700	Air
Sumrall	"	370'		100	Pump
"	"	409'	6"	300	Air
Hattiesburg	Forrest	360'	8"	550	"
"	"	300'	8"	250	"
"	"	453'	6"	750	"
"	"	433'	8"	750 (300)	Gas (Flows)
Hattiesburg	Forrest	694'	6"	750 (300)	Steam (Flows)
Hattiesburg	Forrest	450'	6"	400	Flows
Columbia	Marion	600'	6"	600	"
Sandy Hook	"	852'	4"	70	"

[8]Average, Minimum and Maximum Quantities of Mineral Constituents in Waters from Catahoula Sandstone.

(Parts per Million)

	Average	Minimum	Maximum
Silica SiO_2)	32	9	69
Iron (Fe)	1.1	.00	4.5
Calcium (Ca)	6.2	.4	17
Magnesium (Mg)	2.4	.5	6.2
Sodium and Potassium (Na K)	49	2.8	225
Bicarbonate Radicle (HCO_3)	119	7.3	486
Sulphate Radicle (SO_4)	13	1.6	93
Chloride Radicle (Cl)	14	1.0	54
Nitrate Radicle (NO_3)	.36	.00	4.8
Total dissolved solids	177	24	578
Total hardness as $CaCO_3$	26	4	68

8 Op. Cit.; Page 56

Hattiesburg Formation

The Hattiesburg Formation, which overlies the Catahoula Sandstone, crops cut only on the lower slopes of deeper river valleys. Elsewhere, it is completely overlapped by the Citronnelle Formation. While the Hattiesburg is composed mostly of clays and sandy clays, it also contains a few beds of porous sand, some of which yield large quantities of water. It is the most feasible source of water supply for domestic and municipal use through a large portion of South Mississippi, and in the northern parts of Forrest, Perry and Greene Counties, it yields a strong flow of artesian water in the deeper valleys. Along the coast, also, the Hattiesburg is a potentially important water producer, and in Harrison County, where it is encountered at depths of 800 to 1200 feet, it yields strong flows of pure water. In Hancock and Jackson Counties water-bearing sands of Hattiesburg age have been reported at depths of between 1200 and 1600 feet. The following tables illustrate its importance as an aquifer:

Table Showing Representative Wells of South Mississippi Region Deriving Artesian Water from the Hattiesburg Formation.

Location City	County	Depth	Diameter	Production Gals. per Min.	Method of Production
Natchez	Adams	300'	8"	300	Air
"	"	275'	8"	300	"
Biloxi	Harrison	928'	8"	900	Flows
"	"	960'	6"	300	"
"	"	960'	4"	360	"
"	"	920'	6"	700	"
Gulfport	"	1173'	6"	400	"
"	"	862'	8"	450	"
Handsboro	"	836'	2½"	150	"
Columbia	Marion	495'	6"	800	"
"	"	500'	6"	600	"

[9] Average, Minimum and Maximum Quantities of Mineral Constituents in Waters from Hattiesburg Clay.

(Parts per Million)

	Average	Minimum	Maximum
Silica (SiO_2)	29	16	50
Iron (Fe)	.70	.07	1.5
Calcium (Ca)	2.5	.6	5.2
Magnesium (Mg)	1.5	.4	3.2
Sodium and Potassium (Na K)	43	4.6	90
Bicarbonate Radicle (HCO_3)	107	9.8	208
Sulphate Radicle (SO_4)	12	6.5	16
Chloride Radicle (Cl)	5.2	3.0	12
Nitrate Radicle (NO_3)	.12	.00	1.0
Total dissolved solids	144	29	230
Total hardness as $CaCO_3$	12	4	24

9 Op. Cit.; Page 57

Pascagoula Formation

The Pascagoula Clay, which overlies the Hattiesburg, varies in thickness from a feather-edge in the center of Lamar, Forrest, Greene and adjoining counties to approximately 400 feet in southern Hancock County. It crops out only on the lower slopes of deeper valleys and south of the Hattiesburg clay. Although composed mainly of clays and sandy clays, it contains a number of porous water-bearing sands, particularly in its southern extension. In the past, the Pascagoula has been the major water-producing formation of the Coastal counties where it is encountered between depths of 600 feet and 1200 feet. So far as known, this formation is not water-bearing in its northern extent, and furnishes only moderate quantities of water in Pearl River, Stone and George Counties. In the Coastal Counties, however, it yields

strong artesian flows and is probably the most important source of artesian water. The following tables indicate its importance as an aquifer in South Mississippi:

Table Showing Representative Wells in South Mississippi Region Deriving Water from the Pascagoula Formation.

Location City	County	Depth	Diameter	Production Gals. per Min.	Method of Production
Bay St. Louis	Hancock	1,000'	4"	250	Flows
" " "	"	1,000'	4"	350	"
" " "	"	1,036'	3"	300	"
" " "	"	860'	6"	500	"
Waveland	"	950'	4"	375	"
"	"	1,040'	4"	400	"
Biloxi	Harrison	670'	3"	175	"
Gulfport	"	650'	4"	250	"
"	"	670'	4"	300	"
Longbeach	"	840'	4"	400	"
Miss. City	"	915'	4"	475	"
Pass Christian	"	700'	3"	150	"
" "	"	900'	4"	400	"
Deer Island	Jackson	846'	4"	360	"
Moss Point	"	1,100'	4"	250	"
" "	"	793'	4"	100	"
" "	"	1,550'	6"	400	"
Ocean Springs	"	965'	4"	250	"
Pascagoula	"	875'	6"	300	"
McComb	Pike	615'	115/8"	750	Air
Magnolia	"	324'	8"	500	"

10

Average, Minimum and Maximum Quantities of Mineral Constituents in Waters from Pascagoula Clay.

(Parts per Million)

	Average	Minimum	Maximum
Silica (SiO_2)	33	11	53
Iron (Fe)	.22	.00	1.1
Calcium (ca)	2.4	.5	11
Magnesium (Mg)	.9	.1	2.5
Sodium & Potassium (Na K)	122	10	381
Bicarbonate Radicle (HCO_3)	232	30	531
Sulphate Radicle (SO_4)	6.7	.7	15
Chloride Radicle (Cl)	55	3.7	284

(Continued on Page 32)

(Continued from Page 31)

	Average	Minimum	Maximum
Nitrate Radicle (NO_3)	.25	.00	1.3
Total dissolved solids	338	49	979
Total hardness as $CaCO_3$	9	2	36

[10] Op. Cit.; Page 58

Citronelle Formation

The Citronelle Formation consists predominantly of sand, with considerable gravel and thin interbedded layers and lenses of clay. Because of its wide extent, large catchment area, and porous nature, the Citronelle has been a major water-producer for domestic use in much of South Mississippi. Thousands of shallow wells have been dug or bored to water-bearing sands of this formation thruout it's belt of outcrop. In Hancock, Harrison, and Jackson Counties the Citronelle Formation is overlaid by Coastal Terrace deposits of loams, sands and clays to a depth of 200 feet or more along the coast. In this area basal sands and gravels of the Citronelle form an important source of water, and wells drilled to this horizon give a small to moderately large flow. It would seem, however, that the Citronelle does not form an adequate source of water for large scale industrial development in much of the area under consideration. The following tables indicate its local importance as an aquifer:

Table Showing Representative Wells of South Mississippi Area Deriving Artesian Water from the Citronelle Formation.

Location City	County	Depth	Diameter	Production Gals. per Min.	Method of Production
Bay St. Louis	Hancock	500'	3"	15	Flows
Dillville	"	375'	3"	40	"

(Continued on Page 33)

(Continued from Page 32)

Location City	County	Depth	Diameter	Production Gals. per Min.	Method of Production
Kiln	Hancock	500'	3"	900	Flows
"	"	560'	6"	600	"
Logtown	"	750'	4"	200	"
Waveland	"	438'	3"	30	"
Biloxi	Harrison	440'	2"	30	"
Miss. City	"	537'	2½"	300	"
Pss Christian	"	450'	3"	50	"
Fontainebleau	Jackson	625'	2½"	60	"
Moss Point	"	560'	2½"	40	"
Ocean Springs	"	545'	4"	250	"
" "	"	535'	6"	250	"
Vancleave	"	229'	3	600	"
Fernwood	Pike	194'	10"	350	Air
McComb	"	100'	8"	300	"
Summit	"	110'	8"	113	Steam

[11] Average, Minimum and Maximum Quantities of Mineral Constituents in Waters from Citronelle Formation.

(Parts per Million)

	Average	Minimum	Maximum
Silica (SiO_2)	19	7.4	36
Iron (Fe)	.47	Trace	3.0
Calcium (Ca)	2.3	.4	4.1
Magnesium (Mg)	1.2	.3	3.1
Sodium and potassium (Na K)	31	5.7	92
Bicarbonate Radicle (HCO_3)	69	7.3	228
Sulphate Radicle (SO_4)	4.9	.8	15
Chloride Radicle (Cl)	9.5	4	21
Nitrate Radicle (NO_3)	2.7	.0	19
Total dissolved solids	105	23	270
Total hardness as $CaCO_3$	16	2	20

[11] Op. Cit.; Page 60

Coastal Terraces

The broad, flat, terrace plains of Hancock, Harrison and Jackson Counties, are underlaid by loam, clay and sand of Pleistocene age. The terrace deposits contain a number of sand beds that carry abundant water, but since this water is not under sufficient artesian head to

produce flowing wells, and since the water of these beds is likely to be of poor quality, they are not considered a good source of supply. Most wells, therefore, are drilled to deeper horizons.

Gulfport

A most interesting report on the artesian water supply of Gulfport, Mississippi, is contained in an unpublished manuscript, "Industrial Waters of Mississippi", by Ralph E. King, Engineer, Water Resources Division, Mississippi State Planning Commission. All of the Gulfport wells appear to derive their water from sands of the Pascagoula Formation. The complete report follows:

Gulfport, Harrison County*

"The City of Gulfport is supplied with artesian water from a great number of wells which range in depth from 600 to 800 feet. The output of the wells varies according to the size of the wells. During the past ten years there has been no noticeable decrease in either the pressure or output of these wells. Most of the industries in the city have their own water wells. The waters from these wells contain only an infinitesimal trace of iron and are slightly alkaline. There are no dissolved salts of lime or magnesium present, chemical analyses showing the water to have a hardness of zero. These waters are ideal for industrial uses. A chemical analysis of the underground water at Gulfport is given below. After analyzing a sample of this water, the firm of Hungerford and Terry, Inc., made the following statements:

> "'We have never, in our nearly 50 years of business experience and our analysis of many thousands of water supplies, found a natural water containing no hardness. We are almost inclined to believe that the sample of water sent us from Gulfport was taken from a zeolite water softenor machine which, of course, is capable of producing a water having this analysis. The sample of water sent us is indeed excellent and would be suitable for any textile requirement including the most rigid.'

Analysis of Water Supply at Gulfport

(Parts per Million)

Silica	30.82
Iron and Alumina Oxide	3.00
Calcium Oxide	8.00
Sulphate Tri-oxide	9.0
Magnesium Tri-oxide	21.4
Chlorine	140.38
Hardness	0.0

Date of Analysis March, 1936

*Information obtained from Gulfport Chamber of Commerce. Analysis by the firm of Hungerford and Terry, Clayton, New Jersey."

Conclusion

South Mississippi is capable of producing a larger sustained supply of artesian water than any other portion of the state. This is particularly true of the fifteen southernmost counties and over much of that area, except for the three coastal counties, the water resources are practically undeveloped. In the coastal counties, although enormous quantities are already being produced, there would appear to be no probability of serious over-development, provided reasonable conservation measures are adopted.

Recommendations

Practically the entire area is recommended as suitable for the establishment of industries in which the availability of moderate to large quantities of artesian water is the determining factor. In order to assure the most economic use of available resources and to insure against waste and depletion of these resources the following measures are suggested:

(1) There should probably be a greater concentration of water consuming industries in the southern part of the area than in the northern part.

(2) Steps to prevent rapid run off of rainwaters should be taken thruout the area.

(3) The production and use of water should be regulated to prevent the enormous waste at present prevailing, due to uncontrolled flow from numerous large, flowing wells, many of which are now abandoned.

Temperatures

In addition to quantity and quality of waters available for industrial uses, the temperature of the water may be a limiting factor in industrial development. The temperature of the water would, of necessity, be the same as that of the aquifer in which it is contained, and, since the temperature of the earth increases with depth, the temperature of artesian waters would also increase with the depth from which they are derived. In general, it may be stated that at any specific locality the temperature at a depth of thirty to sixty feet remains uniform thruout the year and corresponds, approximately, to the averave annual temperature at the surface. Below that depth the average rate of increase is 1°F for each 64 feet of increased depth (world average). It should be remembered, of course, that over large parts of the earth's surface the rate of increase deviates from that average, and that in unconsolidated Coastal Plain sediments, such as those which underlie the State of Mississippi, the increase of temperature with depth is likely to be much less than the average, while in regions of recent volcanic activity the increase in tempera-

ture is almost invariably much greater than the average.

Information upon which to base an accurate estimate of the temperatures of Mississippi's artesian waters is very meager as yet. However, based on the temperatures of some half-dozen or more scattered wells of known depth, it would appear that in the northern tier of counties the temperature increases with depth at a rate of approximately 1°F for each 100 feet. Farther south the rate of increase falls, and in the coastal counties it is only about 1°F for each 300 feet. It should be pointed out that all of the wells used as a basis for these estimates were relatively shallow (all were less than 1,000 feet in depth), and it is quite probable that at greater depths the rate of increase is slightly higher, particularly in the southern part of the state. However, use of these figures in conjunction with the average annual temperature (See Map of Average Annual Temperature), will yield a fairly accurate means of computing the temperature of water at any depth and locality in the state.

Résumé

The people of Mississippi are exceedingly fortunate in having at their disposal an easily available supply of ground water, pure enough and in sufficient quantities to yield abundantly for domestic purposes. They are doubly blessed in that this water supply is so widely distributed and so inexpensive to develop that there is practically no section of the state which cannot economically produce enough water to supply any domestic demand which may develop. Furthermore, artesian conditions prevail throughout the state, i.e., large quantities of water are held in subsurface beds of porous sand

(aquifers) under hydrostatic pressure sufficient to cause it to rise nearly to the surface where the aquifer is penetrated. In fact, over large areas, flowing wells and springs are not uncommon (See Map: Areas of Flowing Wells). The importance of an adequate supply of potable water is realized when it is remembered that in many sections of the United States the density of population is definitely limited by the scarcity of water available for domestic use or by the engineering difficulties and expense involved in developing a potential supply. Mississippi need have no fear of lack of potable waters if proper development and conservation are practiced.

Industrial Waters

The areas in which large quantities of artesian water are available for industrial uses, however, are somewhat more limited. It is obvious that the specific quantity of water available for sustained production is dependant upon the amount of rainwater which seeps into the ground in the area in which the aquifer outcrops and the freedom with which it percolates to replace the water which is being removed. The water supply, therefore, is not inexhaustible. It is one of the basic raw materials, the availability of which may be the determining factor in limiting the growth of industry. It is fitting, therefore, that the emphasis in the present report be placed on industrial waters.

In considering the development of a water supply of such magnitude as that necessary for industrial purposes, several factors must be taken into consideration. First in importance, of course, is the presence of water-bearing strata of sufficient capacity and porosity to supply the demand; second in importance is a consideration of the

cost of developing such a water supply; and, third, the extent to which development of available aquifers has already taken place--the extent to which the withdrawal of such large quantities of water would damage the wells already in use.

With these factors in mind, it is evident that large areas in Mississippi will produce artesian water in quantities sufficiently large to meet the demands of industrial use. Five general regions, may be recommended in particular; (1) The Black Prairie Belt; (2) the northern Loess Bluffs; (3) the Jackson Prairie Belt; (4) the Mississippi Alluvial Plain; and, (5) South Mississippi. Of these five areas development of the Black Prairie Belt would probably entail the greatest expense because of the following conditions: (a) The water-bearing strata lie at greater depths thruout most of the region; (b) partial consolidation of sediments in this area prevents the groundwater from circulating within the aquifer as freely as in the aquifers of other areas, and, consequently, more wells are required to produce the same volume of water; and (c) the artesian pressure is not sufficient to produce flowing wells over most of the region; and in those small areas in which flowing wells are possible, the flow is very slight, therefore, adding the expense of pumping.

In the northern Loess Bluffs and the Jackson Prairie Belt, also, flowing wells are limited to the relatively small areas of valley bottom, and, consequently, over most of the area, any large-scale water development must depend on pumping. However, thruout these areas several good aquifers are present and moderately large quantities of water can be secured without excessive cost.

Other conditions being equal, therefore, the Mississippi Alluvial Plain and the eleven southeastern counties of the State (particularly the coastal counties) seem the most logical areas for large-scale water development. The former has a slight advantage in one respect because of the abundance of water at shallow depths (the waters of the alluvial deposits), but the latter has the advantage of a greater number of aquifers from which to draw, of stronger flows and of somewhat less mineralized water.

Recommendations

For the development and utilization of the artesian water resources of the State it is recommended that the following principles apply:

(1) In developing a water supply for a new plant care should be taken to locate and space the wells so that the water supply from existing wells will not be decreased.

(2) Great care should be exercised in locating industries which require abnormally large quantities of water, and this type of plant should be discouraged for those areas in which the available supply is not especially abundant.

(3) The production and utilization of water should be regulated to prevent useless and large scale wastage from industrial plants and to prevent contamination of streams and groundwaters.

(4) The flow of water from flowing wells should be regulated to prevent useless waste, and abandoned wells should be capped.

(5) Conservation measures in the catchment areas of the state's aquifers should be encouraged. These measures should be designed to prevent rapid run-off of rainwater and to permit the seepage into the ground of sufficient water to replace that withdrawn at the wells. This is the only way in which a continuation of the supply can be assured. Encouragement of the following measures is especially recommended:

(a) Reforestation

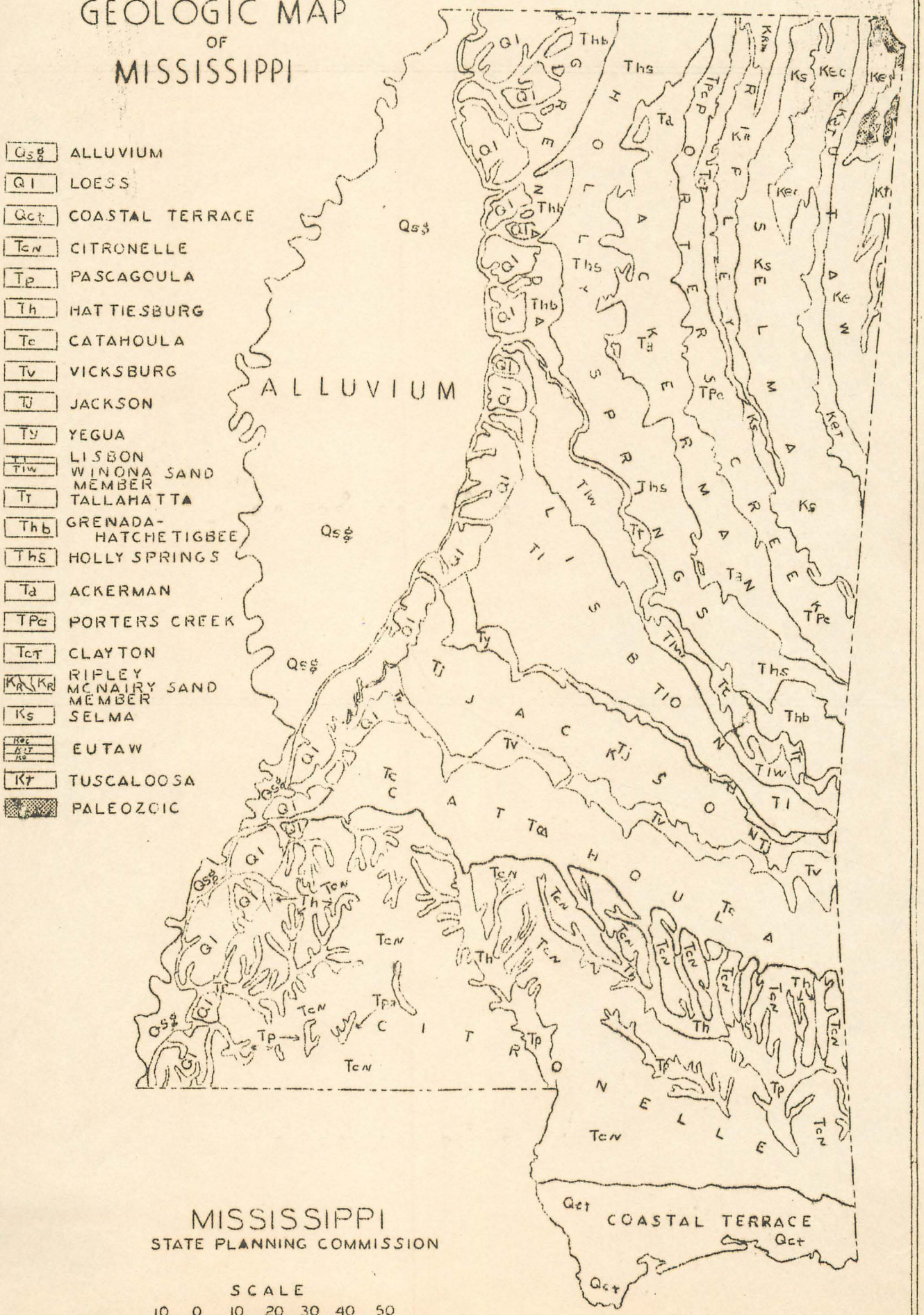
(b) Growing of cover crops

(c) Terracing of slopes

(d) Proper cultivation of arable land

(e) Other erosion control measures.

GEOLOGIC MAP OF MISSISSIPPI



MISSISSIPPI

STATE PLANNING COMMISSION

SCALE

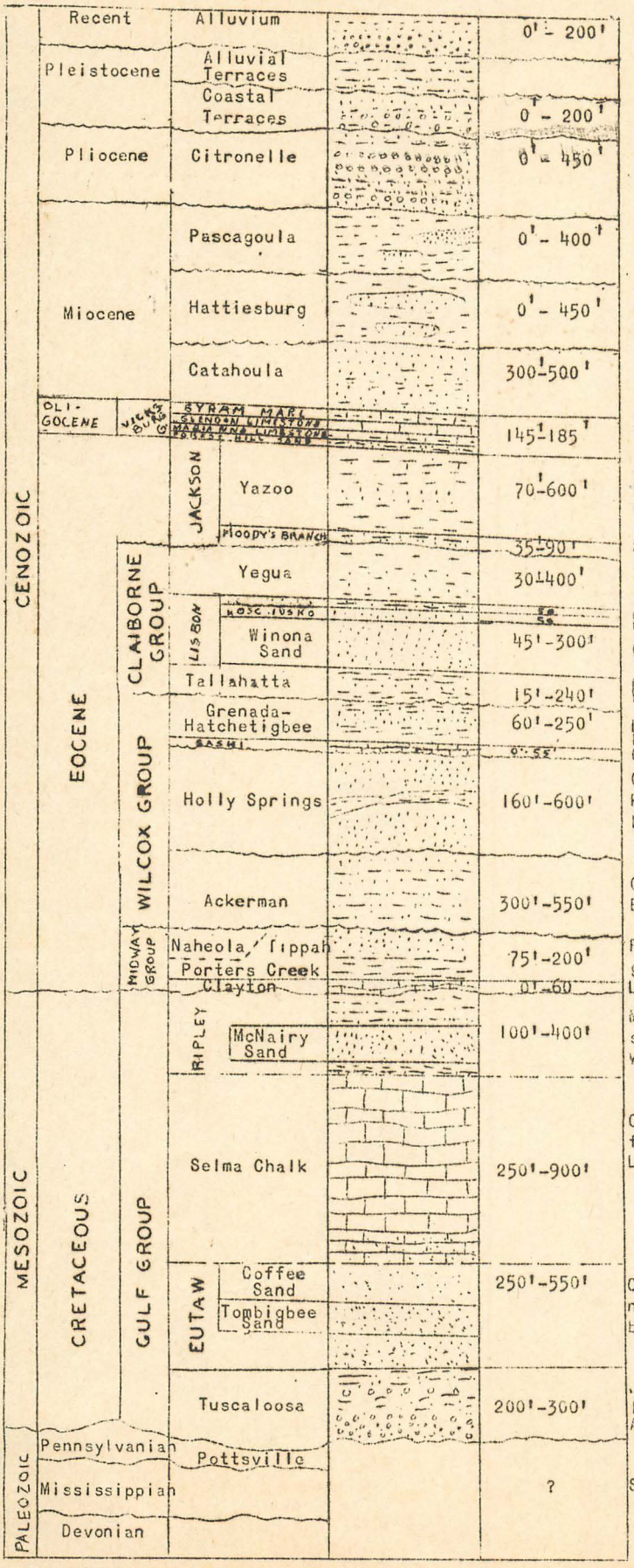
10 0 10 20 30 40 50

STATUTE MILES

AFTER: RECONNAISSANCE GEOLOGIC MAP OF MISSISSIPPI, PLATE 2, WATER-SUPPLY PAPER 576, U.S.G.S.

Generalized Geologic Columnar Section for Mississippi
Based on U.S.G.S. and State Publications

VERTICAL SCALE-
1 INCH = 2,000 FEET



Loam, Clay, Sand, Gravel; Abundantly water-bearing in Delta. Brick clays.

Sands, clays, silts, loess, some water, brick clays.

Sand, loam, clay, gravel. Water locally abundant but of poor quality; brick clay.

Sand, gravel, clay Abundantly water-bearing.

Clay, Sandy clay and sand. Abundantly water-bearing in places, particularly in Coastal Counties.

Blue and grey clay, claystone, lignite, sand Water locally abundant

Irregularly bedded sand, sandstone and clay. Abundantly water-bearing

Limestone, marl, clay, sand, water-bearing, especially from Forrest Hill sands. Bentonitic

Clay more or less calcareous with some sand and marl. Practically non-water bearing. Bentonitic

Shell marl and glauconitic quartz sand. Some water

Irregularly bedded, lignitic clay, lignite and some sand. Some water.

marl, little water

Coarse sand and sandstone water-bearing

Glauconitic sand, some clay. Abundantly water-bearing.

Diatomaceous claystone; some sand and sandstone Water-bearing

Lignitic clay, lignite some sand. Some water; some pottery clay

Glauconitic shell marl. Little water

Coarse, irregularly bedded sand with lenses of clay. Pottery clay lenses near center. Abundantly water-bearing.

Grey lignitic clay, lignite some sand. Some water Bauxite, "Baukite", Pottery clay; "paint rock".

Red sands locally developed resting on massive, dark grey Porters Creek clay, little water, brick clay

Limestone and marl, some water

Marl, limestone, clay, sand with extensive coarse sand layer (McNairy Member) near center. Abundantly water-bearing.

Chalk, argillaceous or sandy in places. Grades and fingers into Ripley above and Eutaw below. Little water.

Crossbedded, massive, Glouconitic sand with subordinate marl and laminated clay. Abundantly water-bearing. Bentonitic

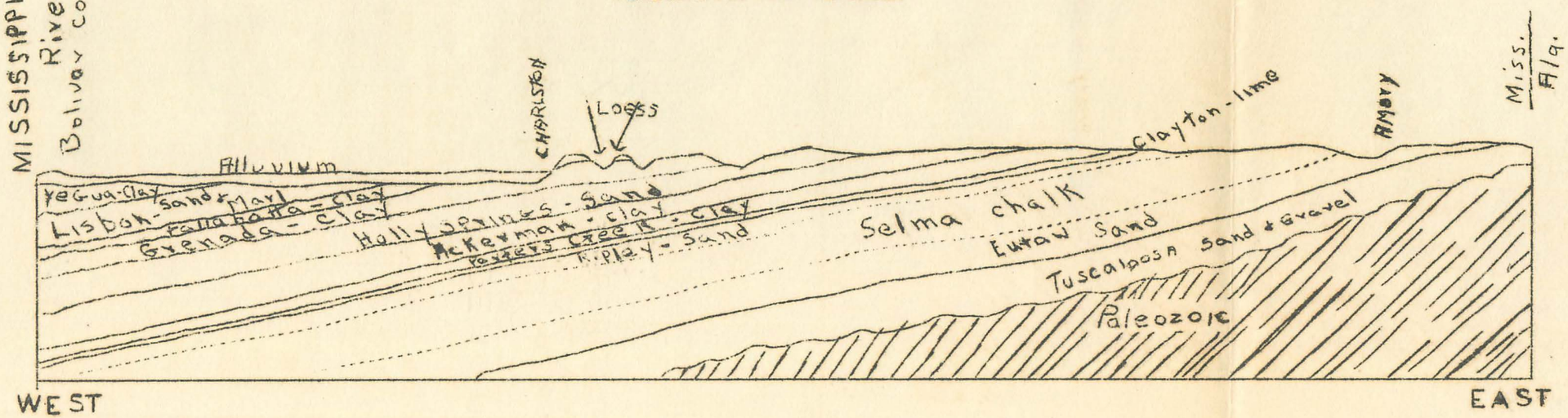
Irregularly bedded sand, clay, gravel and lignite Abundantly water-bearing. Pottery clay.

Sandstones, charts, limestones and shales.

MISSISSIPPI STATE PLANNING COMMISSION

GEOLOGIC SECTION FROM MONROE COUNTY TO MISSISSIPPI RIVER, BOLIVAR COUNTY

GENERALIZED AND IDEALIZED



VERTICAL SCALE 2000 FEET

HORIZONTAL SCALE

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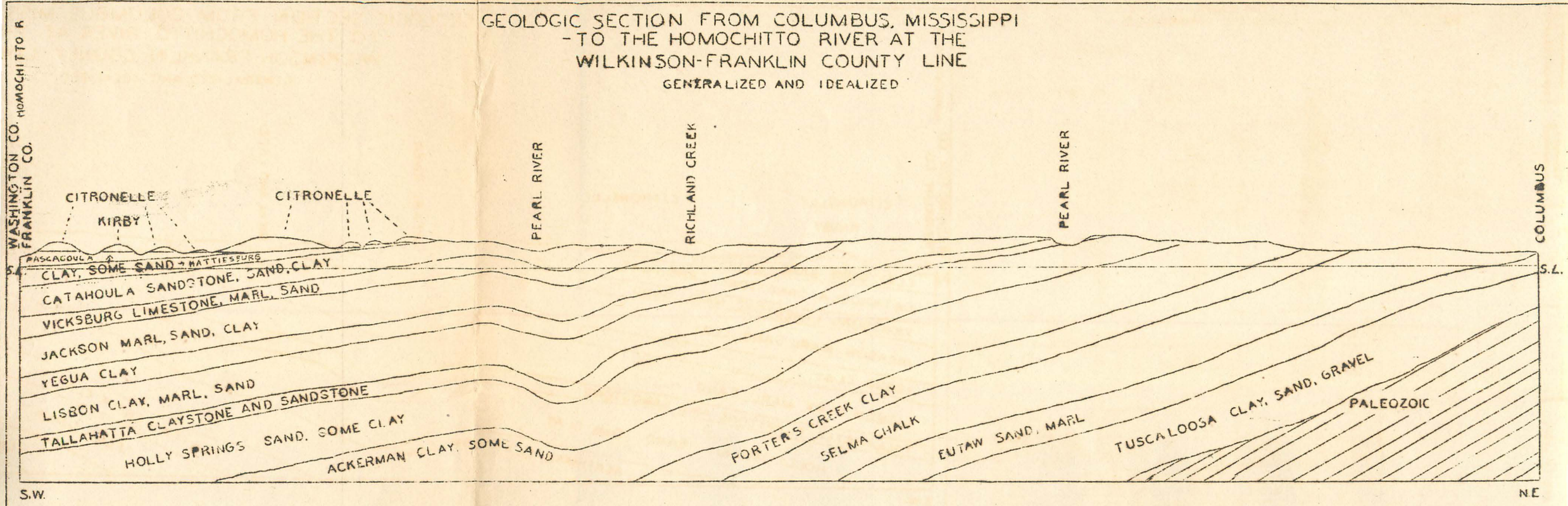
MILES

SOURCE: MISS. OIL AND GAS COMMISSION, MISS. GEOLOGICAL SURVEY, AND U.S.G.S.

MISSISSIPPI STATE PLANNING COMMISSION

GEOLOGIC SECTION FROM COLUMBUS, MISSISSIPPI - TO THE HOMOCHITTO RIVER AT THE WILKINSON-FRANKLIN COUNTY LINE

GENERALIZED AND IDEALIZED



VERTICAL SCALE 2000 FT.

HORIZONTAL SCALE

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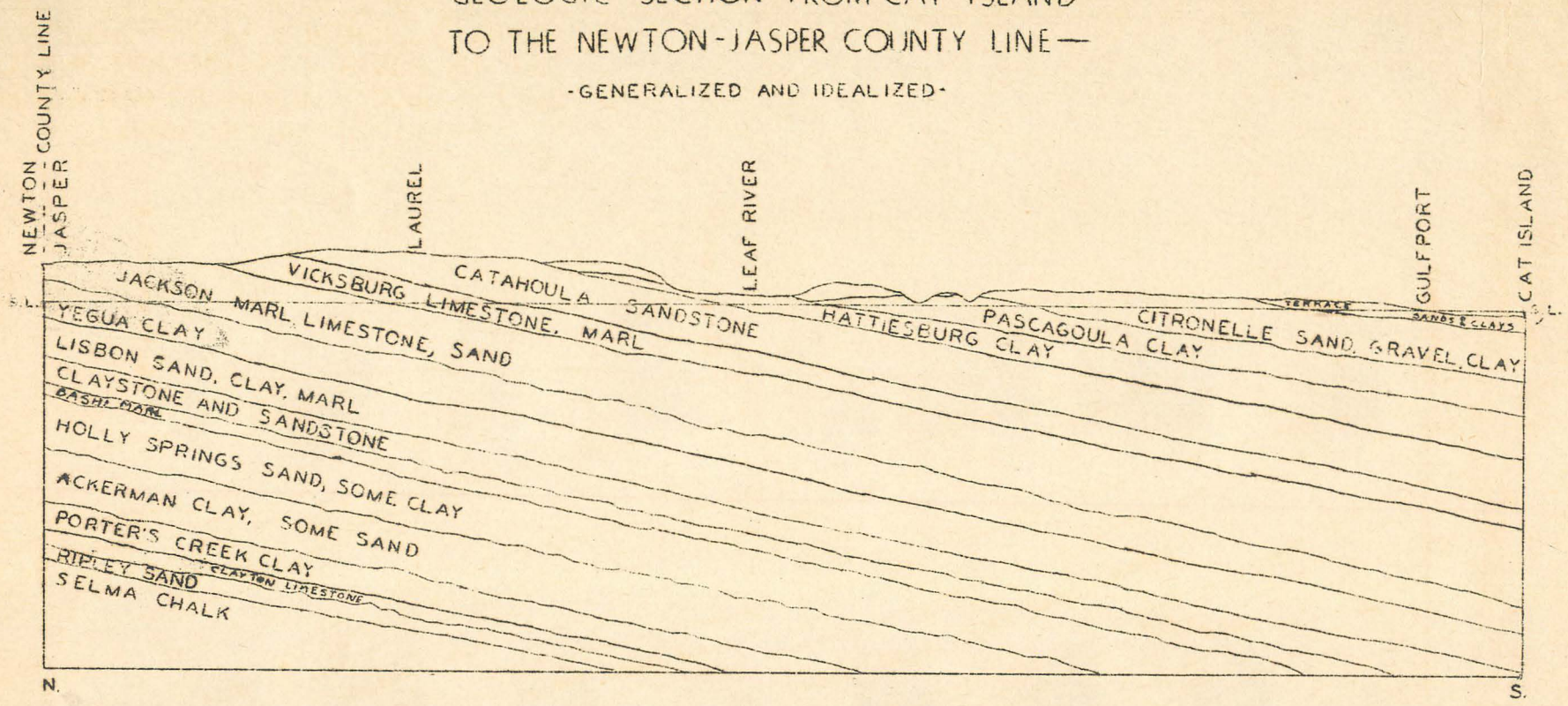
MISSISSIPPI STATE PLANNING COMMISSION

DATA FROM MISSISSIPPI OIL & GAS COMMISSION, MISSISSIPPI GEOLOGICAL SURVEY, AND U.S.G.S.

GEOLOGIC SECTION FROM CAT ISLAND TO THE NEWTON-JASPER COUNTY LINE—

-GENERALIZED AND IDEALIZED-



2000 FEET

VERTICAL SCALE

MILES

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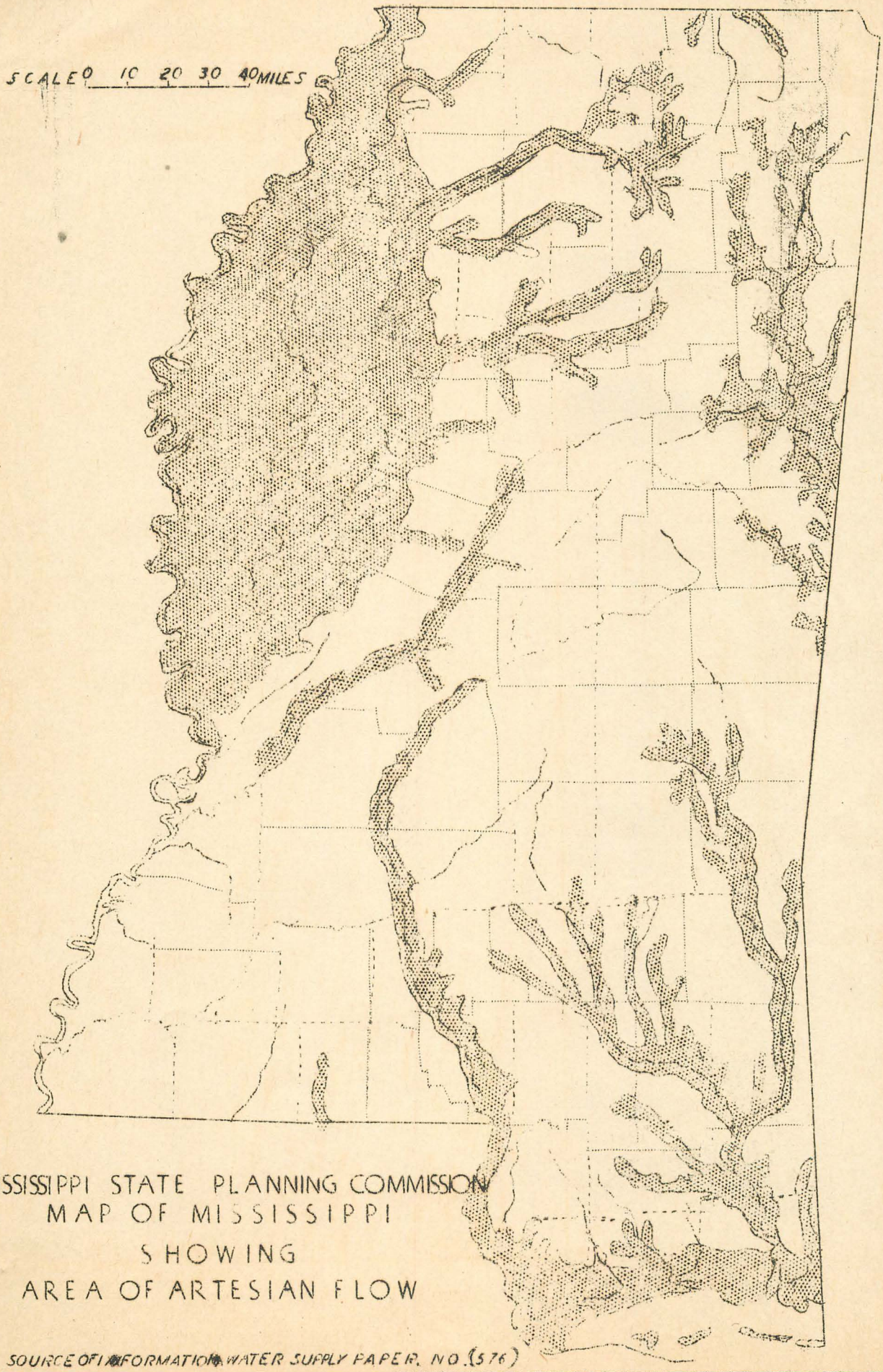
HORIZONTAL SCALE

MISSISSIPPI STATE PLANNING COMMISSION

SOURCE MISS. OIL AND GAS COMMISSION, MISS. GEOLOGICAL SURVEY AND U.S.G.S.



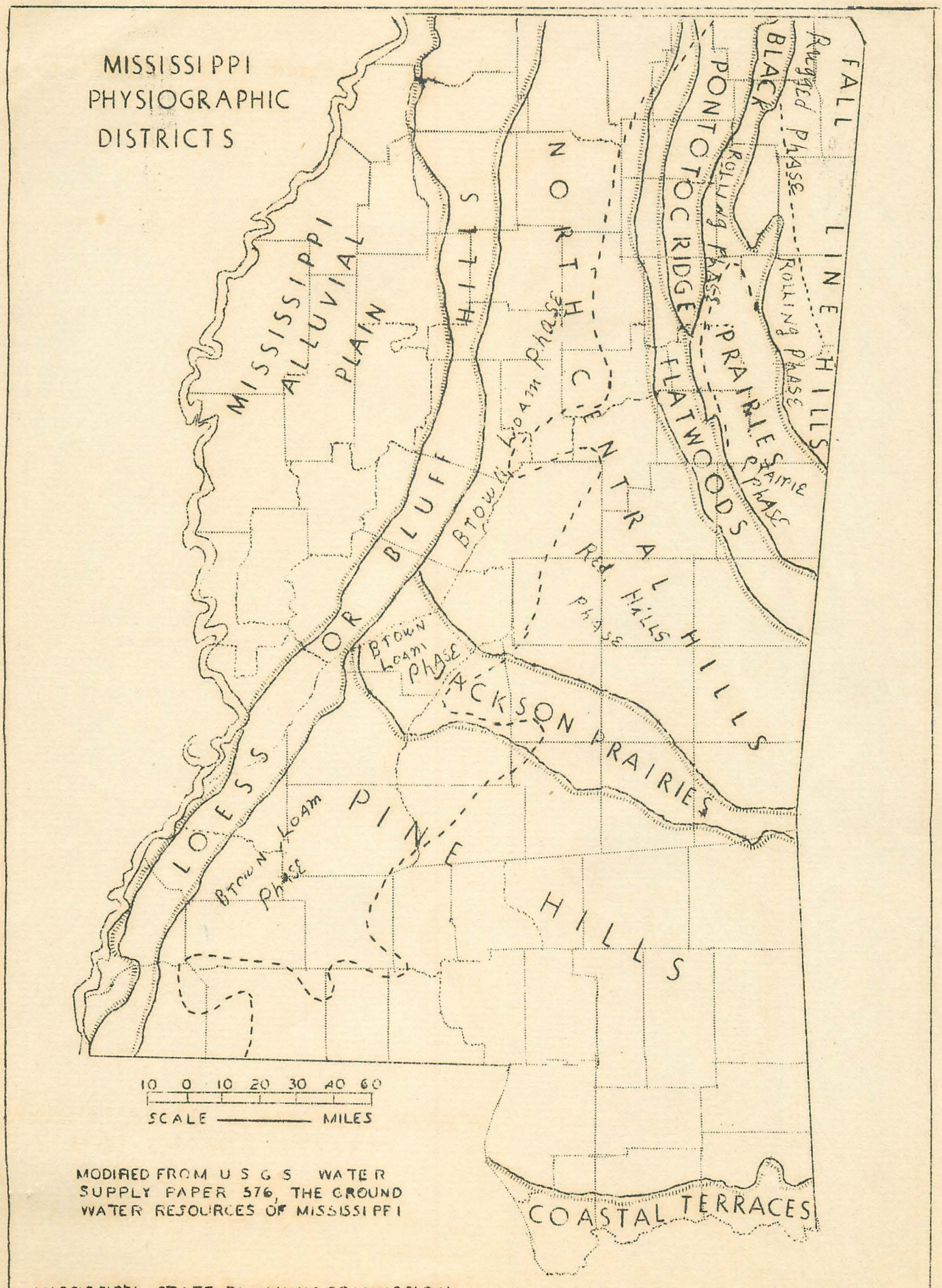
MISSISSIPPI STATE PLANNING COMMISSION

MAP OF MISSISSIPPI

SHOWING

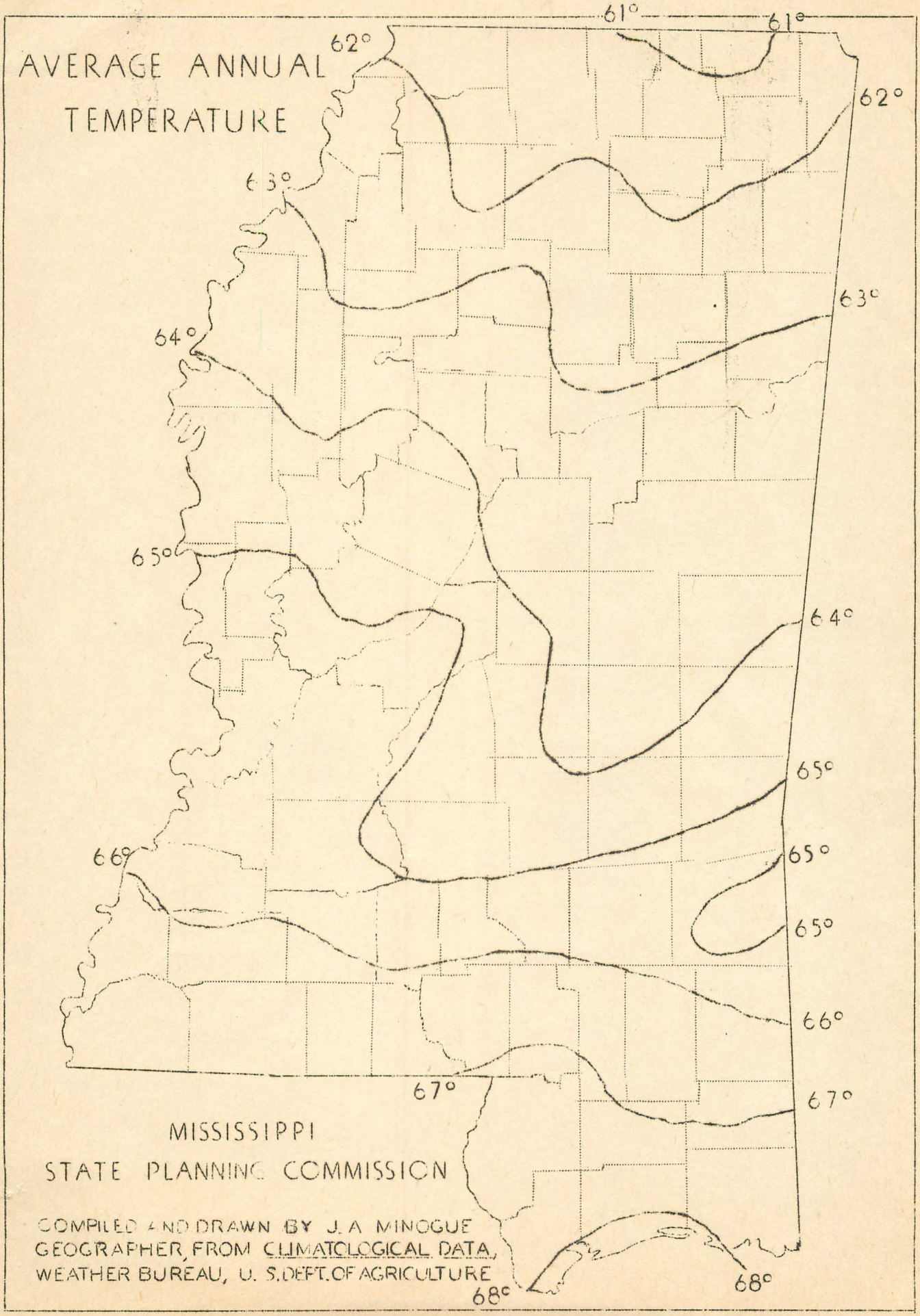
AREA OF ARTESIAN FLOW

SOURCE OF INFORMATION: WATER SUPPLY PAPER, NO. (576)



MODIFIED FROM U S G S WATER SUPPLY PAPER 576, THE GROUND WATER RESOURCES OF MISSISSIPPI

MISSISSIPPI STATE PLANNING COMMISSION


AVERAGE ANNUAL
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MISSISSIPPI
STATE PLANNING COMMISSION
COMPILED AND DRAWN BY J. A. MINOGUE
GEOGRAPHER, FROM CLIMATOLOGICAL DATA,
WEATHER BUREAU, U. S. DEPT. OF AGRICULTURE

MISSISSIPPI
STATE PLANNING COMMISSION
JACKSON, MISSISSIPPI