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WATER RESOURCES OF THE ST. LOUIS AREA, MISSOURI AND ILLINOIS

By J. K. Searcy, R. C. Baker, and W. H. Durum

UNITED STATES DEPARTMENT OF THE INTERIOR
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GEOLOGICAL SURVEY
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PREFACE

This report is one of a series concerning water resources of certain selected areas of strategic importance and is intended to provide information of value for national defense and related purposes. The series is sponsored by and prepared with the guidance of the Water Utilization Section in the Water Resources Division of the U. S. Geological Survey, which is under the general supervision of C. G. Paulsen, chief hydraulic engineer.

This report was prepared by J. K. Searcy, hydraulic engineer, under the supervision of H. C. Bolon, district engineer in Missouri (Surface Water); R. C. Baker, district geologist, Arkansas (Ground Water); and W. H. Durum, chemist, under the supervision of P. C. Benedict, regional engineer, Missouri River basin (Quality of Water).

The data summarized in this report have been collected over a period of many years by the U. S. Geological Survey in cooperation with Federal, State, and local agencies in connection with investigations for other purposes. Surface-water investigations have been carried on by the U. S. Geological Survey in Illinois under the direct supervision of J. H. Morgan, district engineer, and in Missouri under the direct supervision of H. C. Bolon, district engineer.

The St. Louis and Kansas City Districts of the Corps of Engineers furnished data for river profiles, flooded areas, and records of historical floods.

The Missouri Division of Geological Survey and Water Resources supplied information about probable yields and quality of water to be expected from wells in the Missouri part of the St. Louis area.

Information on pollution in the Missouri and Mississippi Rivers was furnished by the Missouri Division of Health.

The Illinois State Geological Survey Division supplied information about alluvial deposits in American Bottoms, well logs, and a bedrock-surface contour map of the State of Illinois.

The Illinois State Water Survey Division furnished information on water levels in wells in the American Bottoms, estimates of pumpage, records of wells, and analyses of the mineral quality of waters from wells and streams in the area.

Special acknowledgment is due E. L. Clark and J. G. Grohskopf, Missouri Division of Geological Survey and Water Resources; M. M. Leighton, G. E. Eckblaw, Arthur Bevan, F. C. Foley, and J. W. Foster, Illinois State Geological Survey Division; A. M. Buswell, Max Suter, H. E. Hudson, Jr., H. F. Smith, and T. E. Larson, Illinois State Water Survey Division; L. E. Ordelheide, director, Bureau of Public Health Engineering, Missouri Division of Health; G. J. Hopkins, U. S. Public Health Service; T. J. Skinker, commissioner, City of St. Louis Water Department; C. M. Roos, manager, East St. Louis and Interurban Water Co.; W. O. Theiss, foreman, City of Kirkwood Water Department; F. H. King, manager, Alton Water Co.; J. D. Kerr, Jr., St. Louis Chamber of Commerce; E. F. Smith, Layne Western Co.; and G. J. Vencill and C. F. Hoffman, Union Electric Co.

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INTRODUCTION

The water used for all purposes in the St. Louis area is less than 1 percent of its available surface-water supply. When the potential ground-water supply and the unconsumed water that is returned to the streams and ground-water reservoirs are considered, the present water requirements of the area become only a few tenths of 1 percent of the water available.

The quantity of water flowing in the Mississippi River at St. Louis ranges from a minimum of 27,600 cfs (cubic feet per second) to a maximum of 1,300,000 cfs. The average flow is 168,500 cfs.

The total rate of ground-water pumpage in the American Bottoms, lying along the Mississippi River in Illinois, was estimated to be about 100 mgd (million gallons per day) in 1950. The potential supply is much greater. Ground-water supplies in other parts of the area have been only slightly developed.

The adequacy of service provided by a public utility corporation and the chemical quality of the water supplied determine to a large degree the use that can be made of that supply. In the St. Louis area seven principal water plants treat water and deliver to diversified users a product that meets rigid health requirements, is free of turbidity, and has a temperature of less than 60 F for about 6 months of the year.

The purpose of this report is to provide information on the water resources of the St. Louis area that may be useful for initial guidance in the location or expansion of water facilities for defense and nondefense industries and for the municipalities upon which the industries are dependent.

The report was written to answer many of the questions that might be asked about the water resources of the St. Louis area. It summarizes the available streamflow data in the St. Louis area and evaluates the ground-water supply insofar as information is available. It furnishes data on chemical quality and turbidity of water supplies, gives information on the magnitude and frequency of floods, shows flood profiles of the major streams, and delineates the areas protected from the floods. This report does not attempt to present all the water-resources data necessary for the development of this area. However, it does provide information for defense planning and for industrial development of the area. It also shows the enormous water-supply potential of the area.

Water in sufficient quantity, of suitable quality, and at a price commensurate with its value to the finished product is essential to most industries. Considering the average daily flow of nearly 108 billion gallons in the Mississippi River at St. Louis and East St. Louis, one might suppose that the development of the water resources of the area need not be planned, but even under these favorable conditions planning is necessary. The removal of silt and other objectionable substances from the river water is costly. Thus the availability of ground water becomes important when quality and cost of the water supply are considered. A large river with its navigation possibilities and ample water supply has the attendant evil of damaging floods. A knowledge of the frequency and magnitude of floods and the protection afforded from them is a vital consideration in industrial development.

DESCRIPTION OF AREA

Physical Description

The area considered in this report is about 42 miles long from north to south and 28 miles from east to west and is roughly centered on the city of St. Louis (see pl. 1). The Mississippi River flows southward across the area passing along the eastern edge of St. Louis. The Missouri River crosses the northwestern part of the area and empties into the Mississippi River a short distance north of St. Louis. The Meramec River crosses the southwestern part of the area and empties into the Mississippi River about 11 miles south of St. Louis.

The principal streams in the area are bordered by alluvial flood plains along most of their courses. The flood plains reach a maximum width of about 11 miles and are at an altitude of about 400 to 450 ft. They are crossed by many low, broad ridges and valleys which, together with oxbow lakes or swamps, mark the former courses of the streams. Parts of these alluvial plains are flooded at times of high water.

The ground surface rises abruptly at the edges of the flood plain onto a gently rolling upland which ranges from 550 to 700 ft in altitude. Most of the city of St. Louis is on this upland.

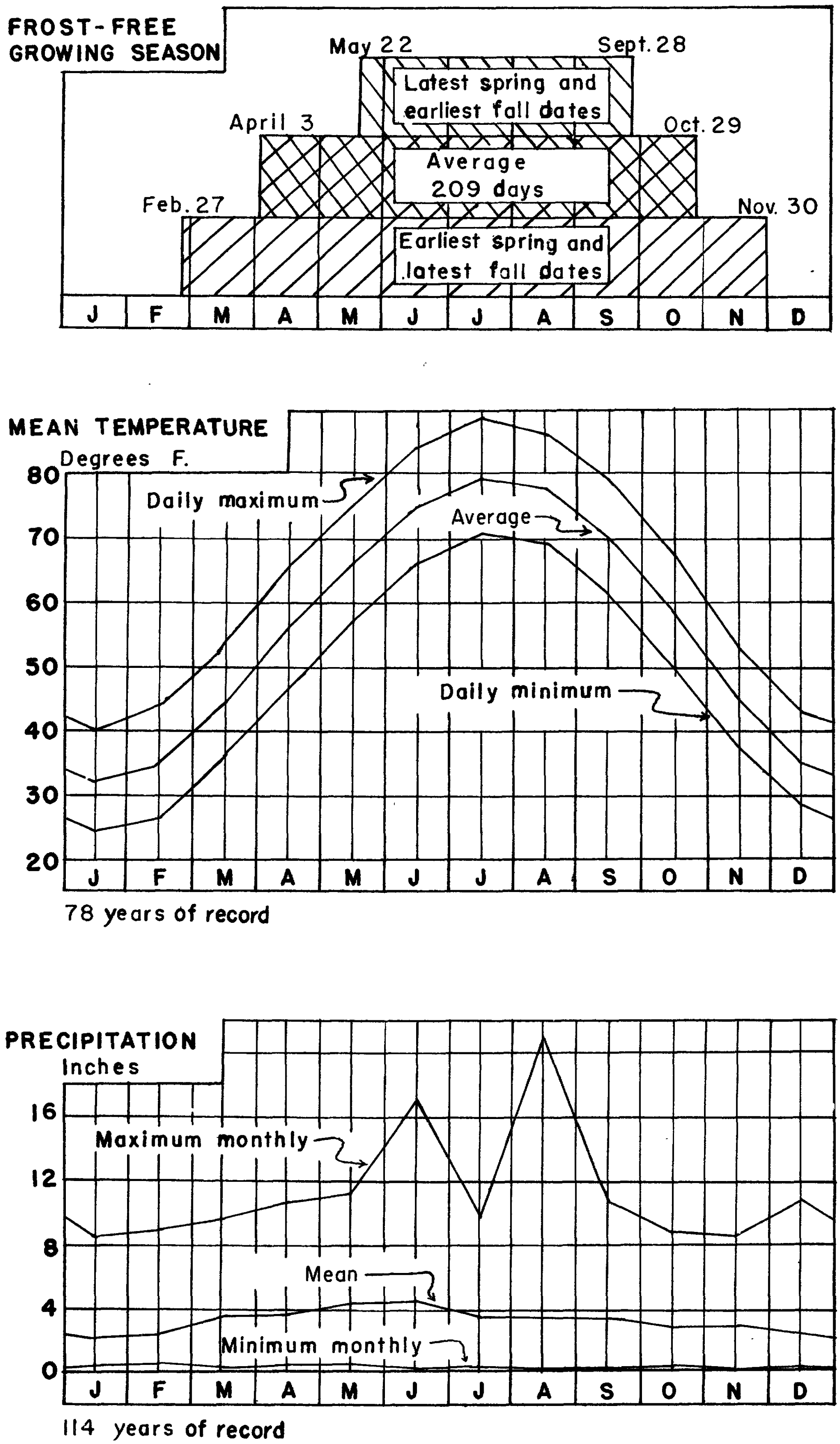

Figure 1.—Selected climatological data for St. Louis.

Climate

The climate at St. Louis is about average for the United States. Extremes of heat or cold rarely occur and long rainy periods or protracted droughts are uncommon. The average annual precipitation is about 39 in., according to more than 100 years of record collected by the United States Weather Bureau. Extremes for the past 50 years ranged from 23.23 in. in 1930 to 57.12 in. in 1946. The precipitation is fairly well distributed throughout the year as shown by figure 1. The average snowfall is 17.4 in. and ranged from 0.7 in. in 1931-32 to 67.6 in. in 1911-12.

The average annual temperature is about 56 F. Temperatures above 90 F occur on about 35 days a year and temperatures of 0 F or lower occur about 2 days a year. The average, maximum, and minimum mean daily air temperatures for each month are shown in figure 1. The average frost-free growing season is about 209 days (see fig. 1). The average percent of possible sunshine is 59.70; the average relative humidity is 64 percent; and the average wind velocity is 10.9 mph.

Importance of the Area

The St. Louis area is one of the great industrial centers in the Nation. Among the major industrial areas it ranks ninth in dollars added by manufacturing. Its industry is diversified; it is the largest market in the country for raw furs, wool, lumber, and drugs; it is also important in the production of machinery and metal products. St. Louis, eighth largest city in the United States, is served by 18 trunkline railroads and is one of the Nation's largest railroad centers. Five major passenger airlines serve it. Its products can be transported by water to the entire Mississippi Valley and the Great Lakes. It is a major distribution center, having 5 million people living within a radius of 150 miles. Factors contributing to the importance of the St. Louis area are its proximity to sources of raw material and the availability of fuel, water, transportation, and power.

SOURCES OF WATER

Precipitation is the source of all fresh water. When water falls upon the earth's surface as precipitation, part of it soaks into the ground, part flows into surface streams, and part is returned to the atmosphere by evaporation or by transpiration from vegetation. The part of the precipitation that soaks into the ground, moves downward to the water table, and then slowly moves to places of discharge from the ground where it may return to the atmosphere or may become streamflow. This discharge of ground water maintains the flow of streams at times when there is no surface flow from precipitation. This circulation of water from the atmosphere to the earth and back to the atmosphere is called the hydrologic cycle. The significance of the hydrologic cycle is that water is a renewable resource. Water available today, whether used or not, follows the cycle and will become available again. However, unlike most other natural resources, large quantities of water cannot be held in reserve for future use. Examination of the cycle also shows the close interrelationship between ground water and surface water.

Streams, lakes, and reservoirs of underground water are the most important sources of water for use by man. Water in streams, and to a lesser extent that in lakes, is subject to variations in amount, quality, and temperature and may contain sediment or harmful bacteria. Impounding of the streams tends to reduce the fluctuations in quantity and the quality of the water. Ground water generally is less subject to large fluctuations in quantity, quality, and temperature; and also it rarely contains sediment or bacteria. Ground-water reservoirs generally contain a large amount of water in storage but the reservoirs will become depleted if water is withdrawn faster than it is recharged into them.

Not all the fresh water in the St. Louis area comes from local precipitation. The water in small streams and in most of the ground-water reservoirs comes largely from precipitation falling in and near the area, but most of the water in the large streams comes from precipitation falling on the river basins upstream from and outside the area.

The Mississippi and Missouri Rivers are a source of large quantities of surface water. Other sources of surface water are the Meramec River, Cahokia and Indian Creeks, Canteen Creek, Long Lake, and the smaller lakes and streams in the area. The alluvial material underlying the flood plains of the Mississippi and Missouri Rivers is an important source of ground water. The alluvial deposits in the valley of the Meramec River are also capable of yielding a large amount of ground water. The locations of these sources are shown on plate 1.

SURFACE WATER

The presence of the Mississippi, Missouri, and the Meramec Rivers provides an almost unlimited quantity of surface water for waste disposal, water supply, and navigation. The problem for most areas near the rivers is that of protection from floods rather than availability of water.

The drainage area of the Mississippi River at Eads Bridge is more than 23 percent of the total area of continental United States. The length of the Mississippi River within the area considered by the report is about 62 miles, and that of the Missouri River about 28 miles.

The Mississippi River has played an important part in the growth of St. Louis. The romantic era of steamboating has faded since 1870 when the "Robert E. Lee" and the "Natchez" raced from New Orleans to St. Louis for river supremacy, but the tonnage moved on the river has increased to proportions undreamed of by the early settlers of St. Louis. Plans are under way to make St. Louis a port of call for seagoing vessels. The traffic through the Port of St. Louis during recent years is shown in table 1.

The 1949 annual report of the Chief of Engineers contains information on the tonnage of several commodities passing through the Port of St. Louis and

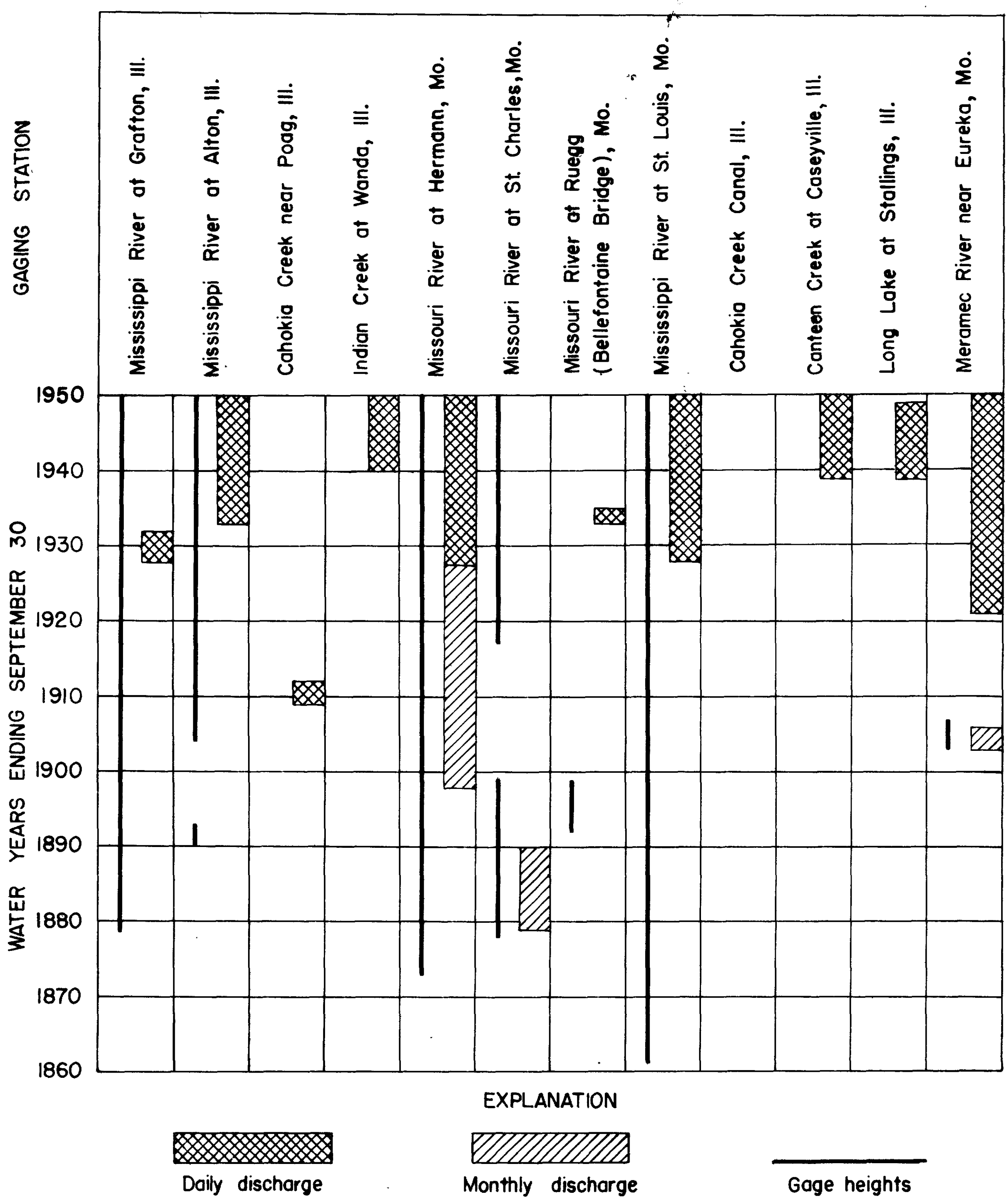

Figure 2.—Duration of published records at gaging stations in the St. Louis area.

Table 1.—Traffic through Port of St. Louis, 1939-48

[From annual report of the Chief of Engineers, U. S. Army, 1949]

Year	Total traffic (tons)	Passengers
1939	1,167,787	870,537
1940	1,302,614	1,011,356
1941	1,377,272	1,098,320
1942	1,115,652	1,197,530
1943	980,544	543,228
1944	1,361,565	484,686
1945	1,395,769	-
1946	1,839,482	996,900
1947	2,259,894	874,492
1948	4,032,657	899,292

other statistical information pertaining to traffic through the port and on the adjacent rivers.

A comparison of gage heights and concurrent discharges for different years on the Mississippi or Missouri Rivers should be made with caution. In common with other streams having low gradients and alluvial beds, the gage height and discharge are not directly related to each other. Owing to changes in stream slope, effect of channel scour and fill, variable backwater conditions (particularly at Alton, Ill.), ice conditions, and other effects, the maximum discharge usually does not coincide with the maximum stage. Sometimes the yearly maximum discharge and the highest yearly stage occur in different floods which may be months apart.

Records Available

The Geological Survey is now operating stream-gaging stations on the Mississippi River at Alton, Ill., and at St. Louis; on the Missouri River at Hermann, Mo.; on the Meramec River at Eureka, Mo.; and on several tributaries of Cahokia Creek. The duration of streamflow records published in either the water-supply papers on the U. S. Geological Survey or the publications of the Mississippi River Commission are shown in figure 2. Records of gage heights also have been collected at several places in the area. Discharge measurements and gage heights for two sites on the Meramec River near Fenton, Mo., for 1903 have been published in the Geological Survey water-supply papers.

Records of chemical analyses were collected by the water-supply companies at the following locations: Mississippi River at Alton, Ill., and Chain of Rocks; the Missouri River at Howards Bend; and the Meramec River at Kirkwood, Mo.

Mississippi River Above Missouri River

The Mississippi River at Alton, Ill., 7.7 miles above the mouth of the Missouri River, has a drainage area of 171,500 sq mi; its length above Alton is 1,163 miles. The upper Mississippi drains parts of the States of Minnesota, Wisconsin, Michigan, Iowa, South Dakota, Illinois, Indiana, and Missouri. Average annual rainfall in the basin ranges from about 41 in. in the lower part of the basin to about 24 in. in the northwestern part, and average annual runoff ranges from about 10 in. in the lower part of the basin to about 3 in. in the northwestern part. The upper part of the basin contains many lakes which have an equalizing effect on the flow. Flow is further regulated by navigation dams and reservoirs.

Navigation.—The upper Mississippi is navigable to Minneapolis, Minn. A channel 9 ft deep is maintained by 26 navigation dams and locks. Six reservoirs near the headwaters of the Mississippi River have a total operating capacity of 1,455,750 acre-ft and are operated to benefit navigation.

A water connection with the Great Lakes at Chicago is available by way of the Illinois Waterway (Illinois and Des Plaines Rivers, Chicago Sanitary and Ship Canal, and the Chicago River or the Calumet-Sag Channel, Little Calumet, and Calumet Rivers). The Great Lakes connection accommodates vessels drawing 9 ft of water.

The navigation season between St. Louis and Rock Island, Ill., usually lasts from March 1 to December 1, and that above Rock Island from March 15 to November 15. Severe winters may cause the navigation season to be as much as $1\frac{1}{2}$ months shorter than normal. The Illinois Waterway is ordinarily open to navigation throughout the year.

The volume of river traffic on the Mississippi River between Minneapolis and the mouth of the Missouri River has increased from a total of 2,411,151 tons in 1939 to 8,648,980 tons in 1948. The traffic on the Illinois Waterway between Lockport, Ill., and the Mississippi River has increased from 3,115,595 tons to 10,779,074 tons during the same period.

Discharge.—The average discharge of the Mississippi River at Alton, Ill., for the 15 yr of record (1933-37, 1939-50) is 94,900 cfs. The maximum, minimum, and average monthly discharges are shown in figure 3.

The minimum discharge of record is 7,960 cfs November 7, 1948. It was affected by regulation from the navigation lock and dam. The corresponding daily discharge was 16,600 cfs.

Floods.—Records of flood stages at Alton include that of 1844 and are continuous from December 1890 to September 1893, and since January 1904. The maximum elevation known was 432.42 ft, present datum, in June 1844. Major floods are listed in table 2 and a flood-stage frequency graph based on continuous records is shown in figure 4.

Table 2.—Major floods on the Mississippi River at Alton, 1844, 1904-51

Date	Altitude (feet)	Date	Altitude (feet)
June 1844	432.42	June 8, 1935	424.4
April 29, 1904	424.4	May 24, 1943	429.91
June 18, 1908	425.08	April 30, 1944	429.33
July 15, 1909	425.18	April 28, 1947	424.6
April 19, 1922	427.08	July 2, 1947	429.40
April 25, 1927	426.7	July 21, 1951	429.47
April 28, 1929	425.6		

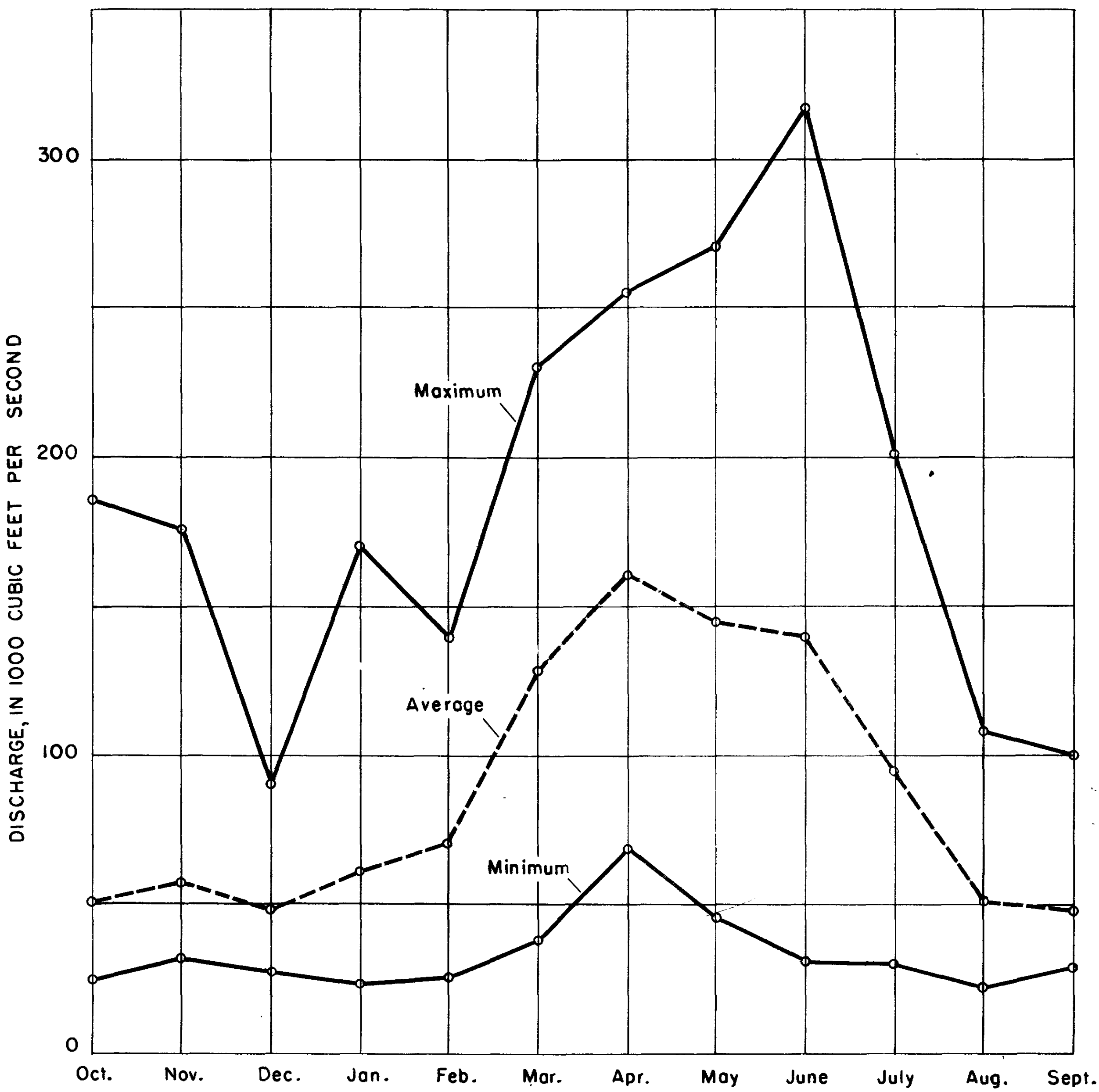

Figure 3.—Maximum, minimum, and average monthly discharge of the Mississippi River at Alton, 1933-38, 1939-50.

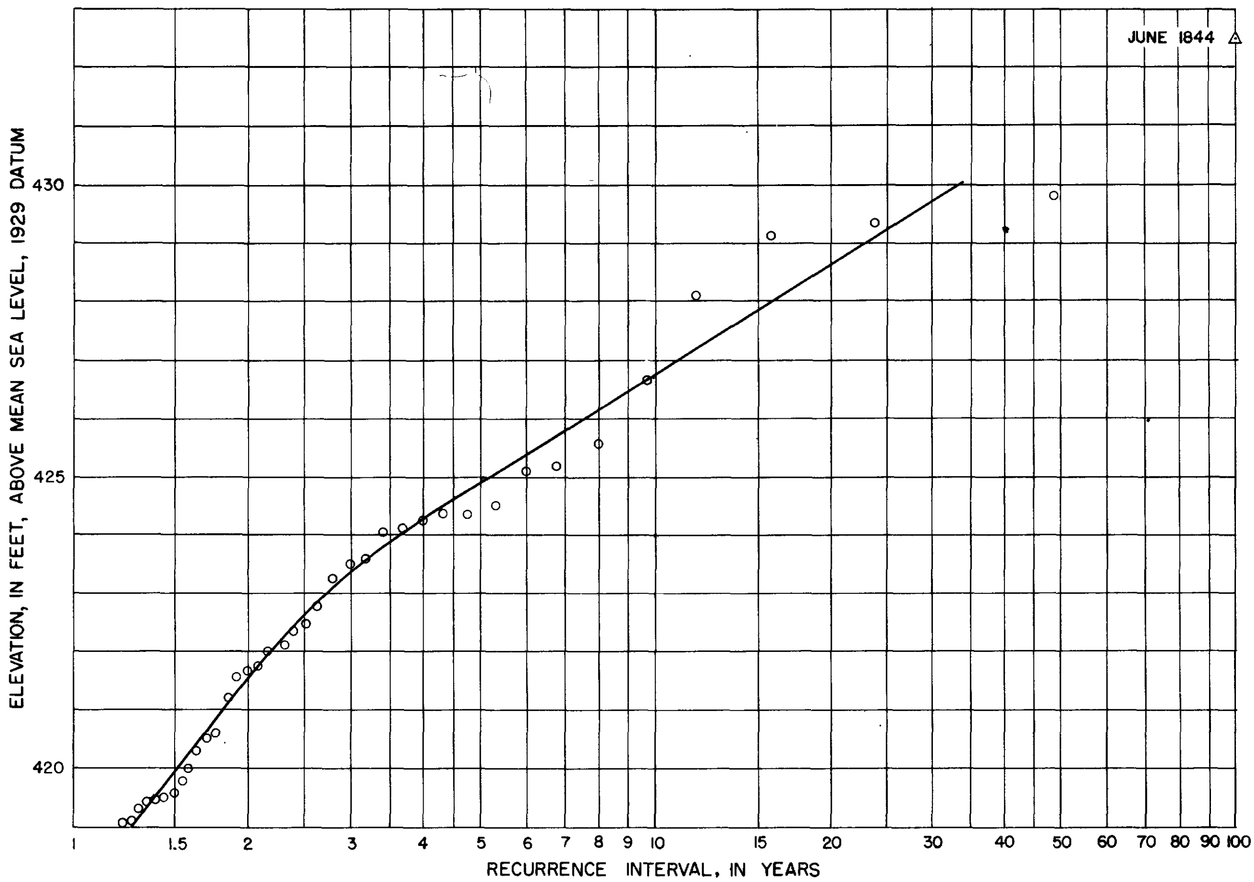

Figure 4.–Flood frequencies on the Mississippi River at Alton, Ill., 1844, 1904-50.

The highest stage in any year can be expected in any month but it is most likely to occur in June. The highest stage in each year of record at Alton occurred as shown in figure 5.

A water-surface profile of the reach from Alton through St. Louis to Waters Point, Mo., for selected floods is plotted in figure 6. Areas inundated by the flood of July 1951 are shown on plate 1.

Quality.–Chemical-quality records for the Mississippi River above the Missouri River are available from the Alton Water Co., which treats river water for industrial, commercial, and domestic uses in the general Alton area. Table 3 summarizes the hardness of treated and untreated waters and the temperature of the treated water. Hardness of the untreated water for the 10-yr period, 1940-49, averaged 200 ppm (parts per million) and hardness of the treated water averaged 108 ppm—an average reduction in hardness of about 92 ppm. The highest average monthly water hardness was 253 ppm during January 1942, and the lowest 150 ppm during September 1941. The highest monthly water temperature was 85 F during August 1947 and the lowest 32 to 33 F in each January and February during the period. Ranges in chemical and physical characteristics of daily samples of untreated and treated water collected at Alton in 1950 are shown in table 4.

Table 3.–Mean monthly temperature and hardness of Mississippi River water at Alton, Ill., 1940-49

[Analyses by Alton Water Co.]

Month	Temperature of treated water (°F)	Hardness as $CaCO_3$	
		Untreated water (ppm)	Treated water (ppm)
January	34	218	113
February	34	212	108
March	41	201	106
April	54	214	109
May	64	214	110
June	74	197	110
July	81	186	109
August	82	183	105
September	75	180	106
October	63	181	107
November	50	198	109
December	38	214	110

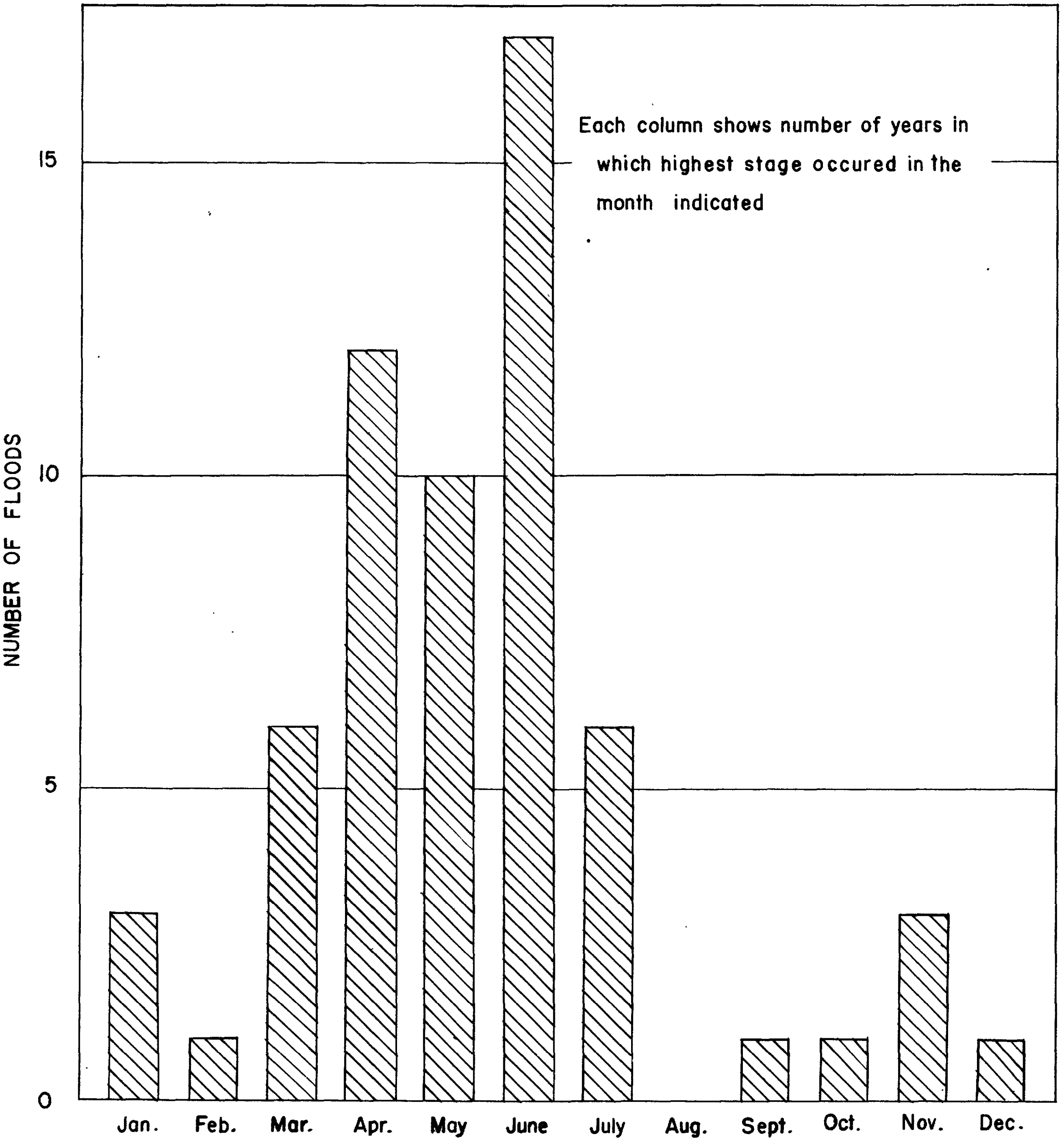

Figure 5.–Month of occurrence of 61 annual stages (1884, 1858, 1880, 1881, 1888, 1896-1951) on Mississippi River at Alton, Ill.

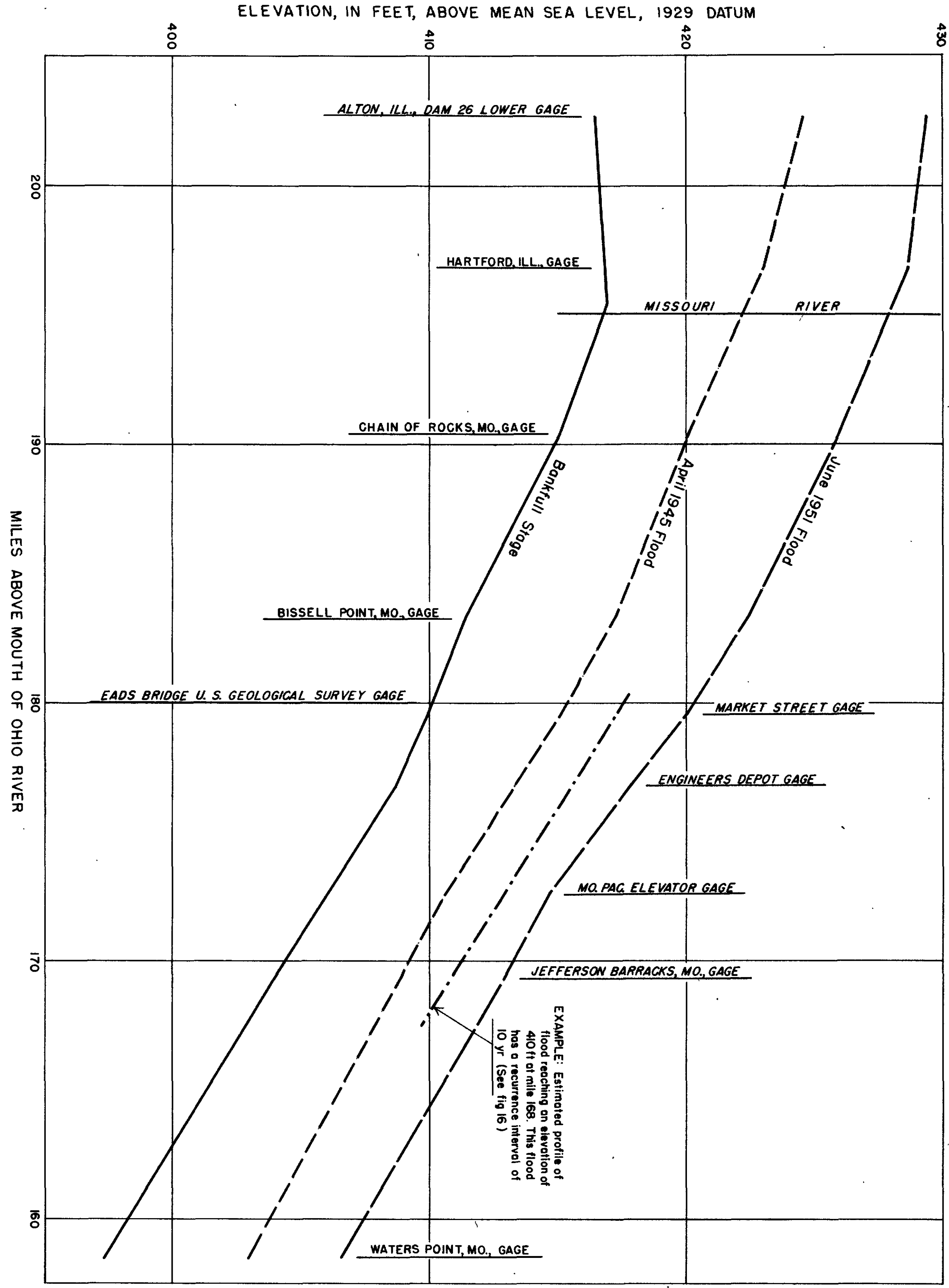

Figure 6. —Water-surface profile for selected floods on the Mississippi River, Alton, Ill. to Waters Point, Mo.

Table 4.—Selected chemical and physical characteristics of water from the Mississippi River at Alton, Ill., 1950

[Analyses by Alton Water Co.]

Characteristics	Untreated water	Treated water
Alkalinity as $CaCO_3$ (ppm):		
Average	151	52
Maximum	191	90
Minimum	97	29
Hardness as $CaCO_3$ (ppm):		
Average	205	117
Maximum	252	150
Minimum	127	90
pH:		
Average	7.7	9.3
Maximum	7.9	10.2
Minimum	7.4	7.9
Turbidity:		
Average	218	0
Maximum	1,228	0
Minimum	25	0
Temperature (°F):		
Average	57	-
Maximum	81	-
Minimum	33	-

Missouri River

The Missouri River at the Hermann gage, about 97 miles above its mouth, has a drainage area of 528,200 sq mi. The drainage area above Hermann constitutes 99.8 percent of the total drainage area of the river, and for most purposes the flow at Hermann can be considered as equivalent to the flow of the Missouri River at its mouth.

The Missouri River is formed by the confluence of the Jefferson, Madison, and Gallatin Rivers at Three Forks in southwestern Montana. From Three Forks the river flows through a part of the Northern Rocky Mountains province, then enters the Great Plains province and flows a total of 2,466 miles to join the Mississippi River 15 miles above Eads Bridge in St. Louis. The Missouri River drains all or part of the States of Montana, Wyoming, North Dakota, South Dakota, Nebraska, Colorado, Kansas, Minnesota, Iowa, and Missouri.

Precipitation over the drainage basin ranges from less than 8 in. in the upper part of the basin to more than 40 in. in the lower part. Annual runoff ranges from less than one-half in. in the headwaters to about 10 in. in the lower part of the drainage basin.

The normal regimen of the stream is low flows during the winter months, owing to the low temperatures of the northern and western parts of the basin; a minor rise in April, owing to melting of the snow blanket over the Interior Plains area; and a much greater rise in June, owing to the melting of snow and ice in the upper part of the basin and to the May and June rains in the lower part. Reservoirs modify the regimen to some extent.

Navigation.—The Missouri River has a project depth of 9 ft from Sioux City, Iowa, to its mouth. At present the controlling depth below Kansas City is 6 ft throughout the navigation season, which is from March 15 to November 30. The present controlling depth decreases from 6 ft at Kansas City to 3½ ft at Sioux City; the navigation season is from April 1 to November 15. The annual river traffic between 1939 and 1948 has ranged from a low of 322,345 tons in 1944 to a high of 797,214 tons in 1948.

Discharge.—The average discharge of the Missouri River at Hermann, for the 22 yr of Geological Survey record (1928-50) is 71,290 cfs. The average discharge for the period 1898 to 1950 (1898 to 1927 estimated) is 81,760 cfs. The maximum, minimum, and average monthly discharges for the period of record (1928-50) are shown in figure 7. The minimum discharge of record is about 4,200 cfs January 10-12, 1940.

Floods.—Records of flood stages at Hermann include the 1844 flood and are continuous since 1873. The maximum stage known was 35.5 ft in June 1844. Major floods are listed in table 5 and a flood-stage frequency graph based on continuous records is shown in figure 8.

The highest stage during the year has occurred one or more times in every month except January. The highest stage during each year of 80 yr of record at Hermann occurred as shown in figure 9. A water-surface profile for selected floods on the Missouri River in the reach from Weldon Springs, Mo., to the mouth is plotted in figure 10. Areas inundated by the flood of July 1951 are shown on plate 1.

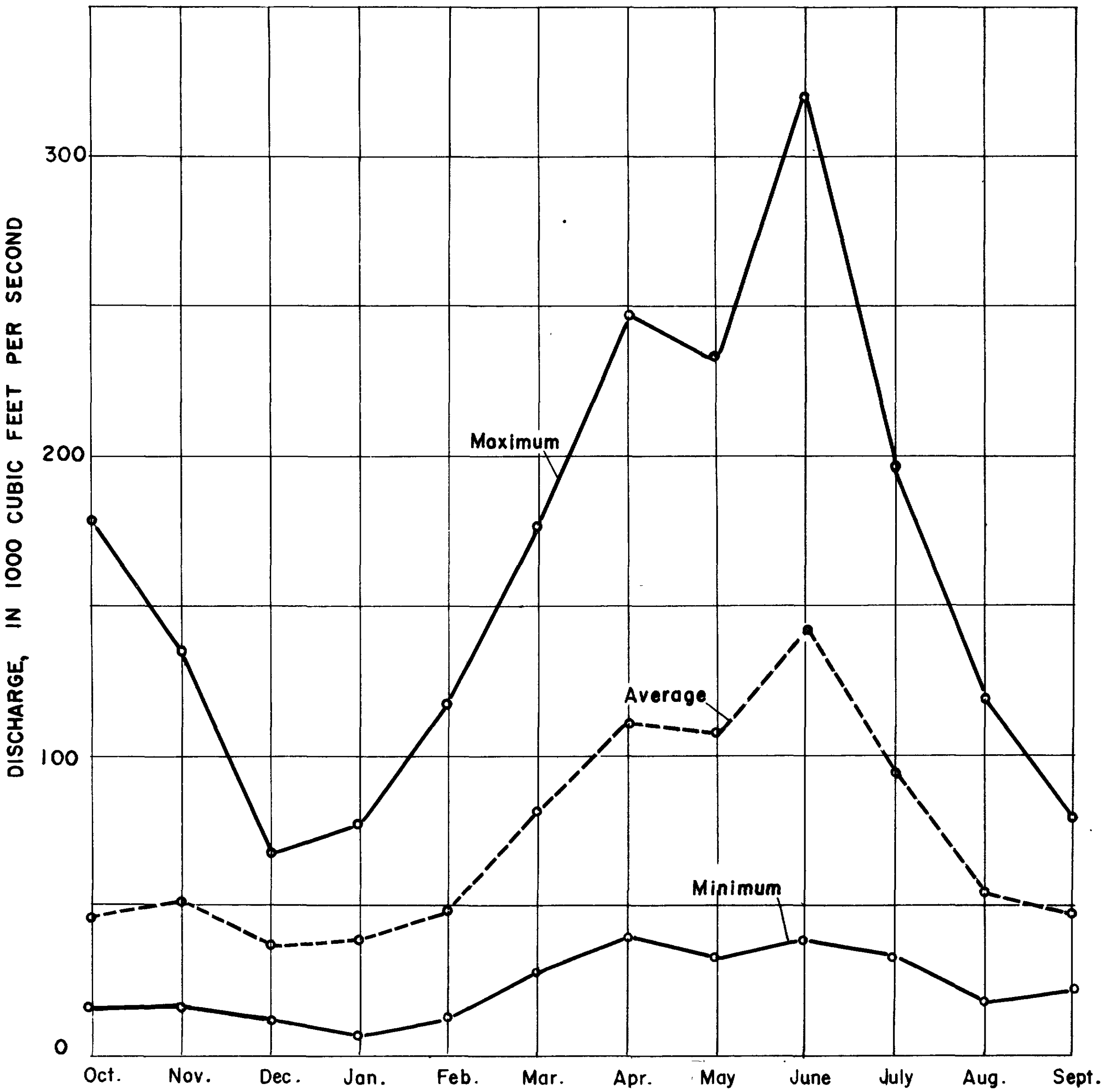

Figure 7.—Maximum, minimum, and average monthly discharge of the Missouri River at Hermann, Mo., 1928-50.

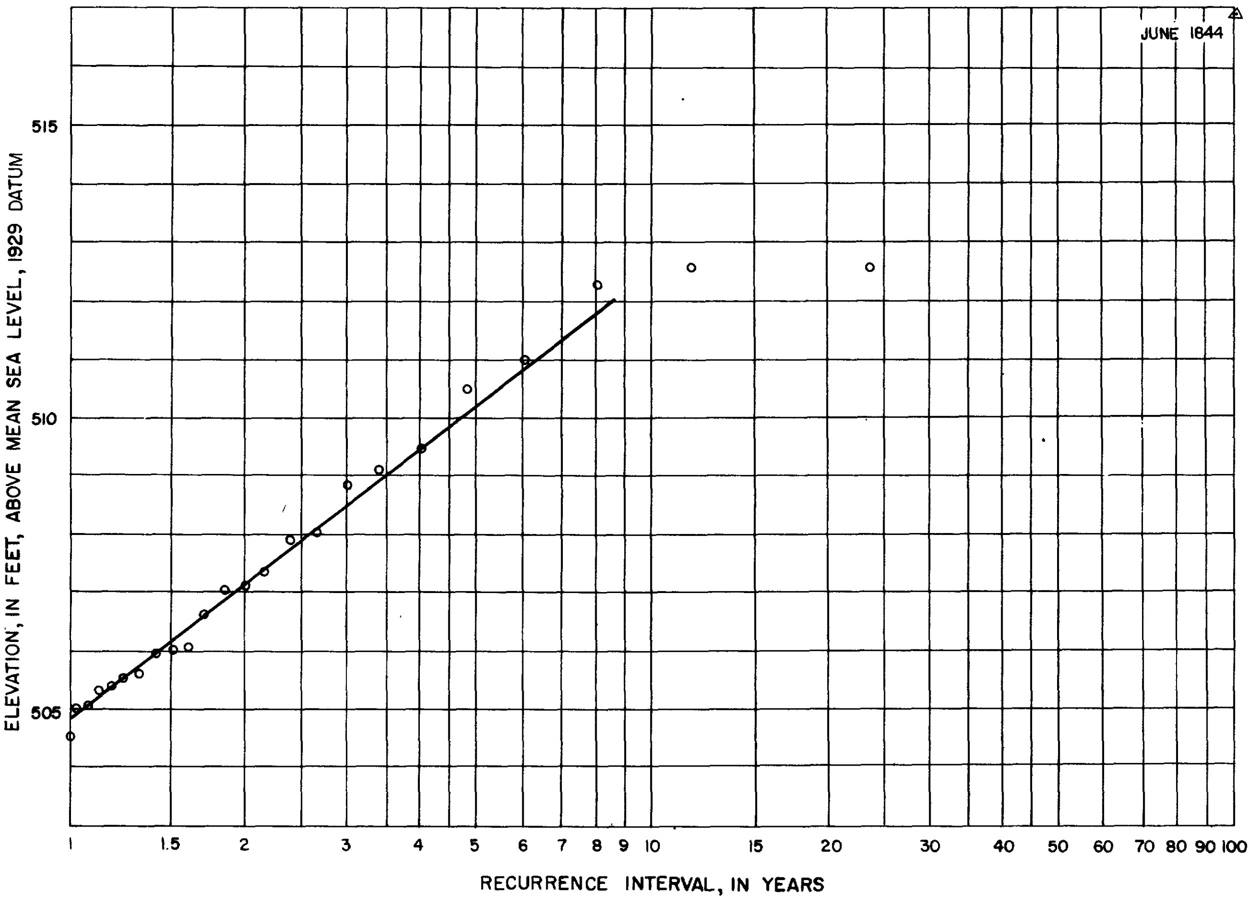

Figure 8.–Flood frequencies on the Missouri River at Hermann, Mo., 1928-50.

Table 5.–Major floods on the Missouri River at Hermann, Mo., 1844, 1873-1951

[Gage height plus 481.40 equals elevation above mean sea level, datum of 1929]

Date	Gage height (feet)	Elevation above msl (feet)
June 1844	35.50	516.90
June 7, 1903	29.40	510.80
Apr. 24, 1927	26.9	508.3
June 7, 1935	29.15	510.55
June 28, 1942	29.62	511.02
May 21, 1943	31.20	512.60
June 24, 1943	28.12	509.52
Apr. 28, 1944	30.90	512.30
Apr. 20, 1945	27.74	509.14
June 22, 1945	26.65	508.05
Apr. 26, 1947	26.54	507.94
June 13, 1947	27.50	508.90
June 29, 1947	31.20	512.60
July 19, 1951	33.33	514.73

Quality.–The consistently high turbidity of untreated Missouri River water except during winter makes the use of untreated river water undesirable. In the St. Louis area, three large water plants treat water from the Missouri River. These are the city of St. Charles plant, city of St. Louis Howard Bend plant, and the St. Louis County Waterworks plant, which is situated near the Howard Bend plant. Daily records of chemical and physical characteristics of the treated and untreated water are made at these plants.

Annual averages of the more important chemical constituents in the treated and untreated waters at the Howard Bend plant for the 10-yr period 1940-49 are presented in table 6. The 10-yr average for dissolved solids in the untreated water was 365 ppm. The average hardness of the untreated water, 190 ppm, was nearly identical to that at the Chain of Rocks plant, which is on the Mississippi River below the confluence of the Missouri River. The range in daily hardness from 82 to 326 ppm was also similar to that at the Chain of Rocks plant.

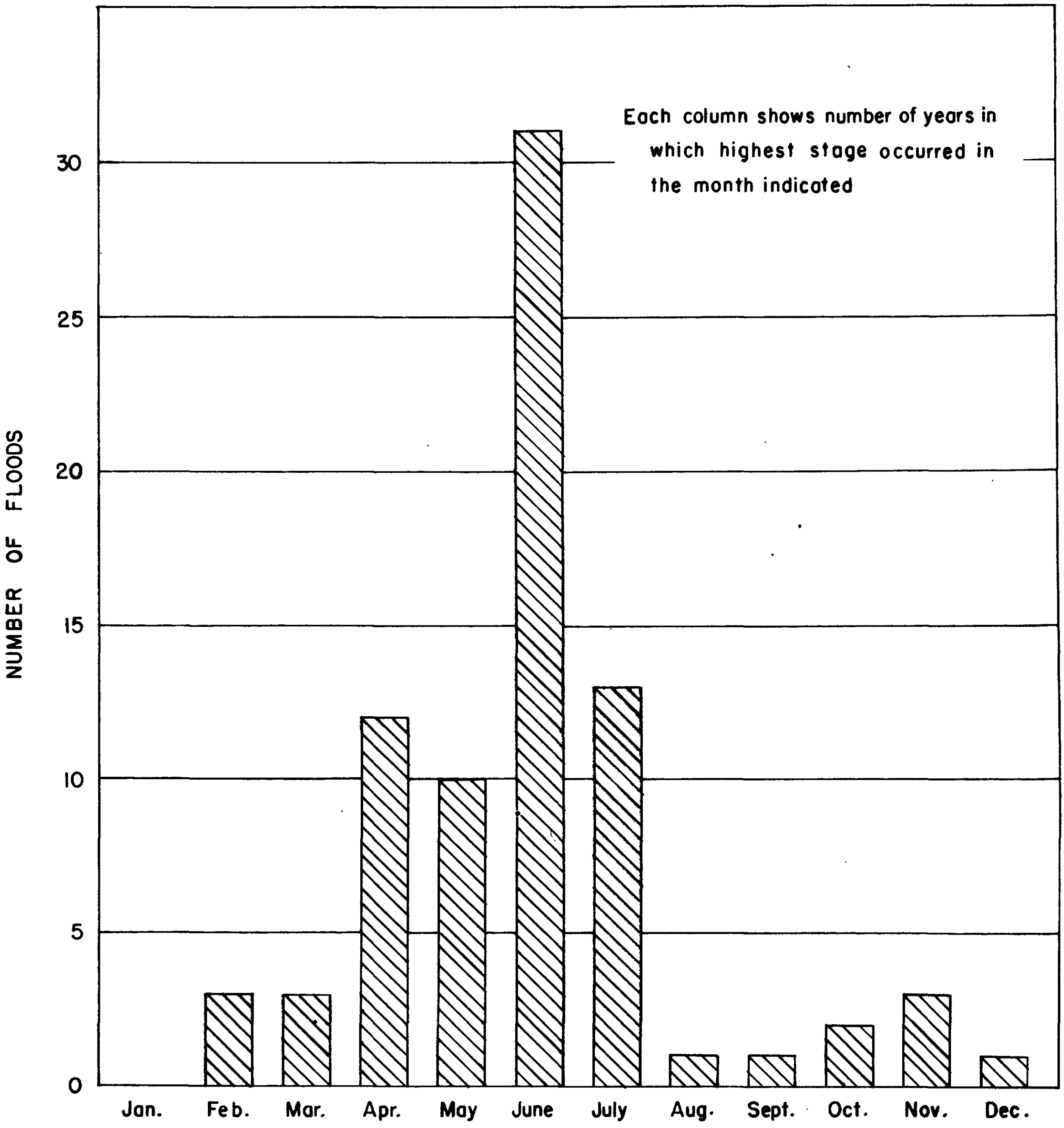

Figure 9.—Month of occurrence of highest stage in each year (1844, 1873-1951) on the Missouri River at Hermann, Mo.

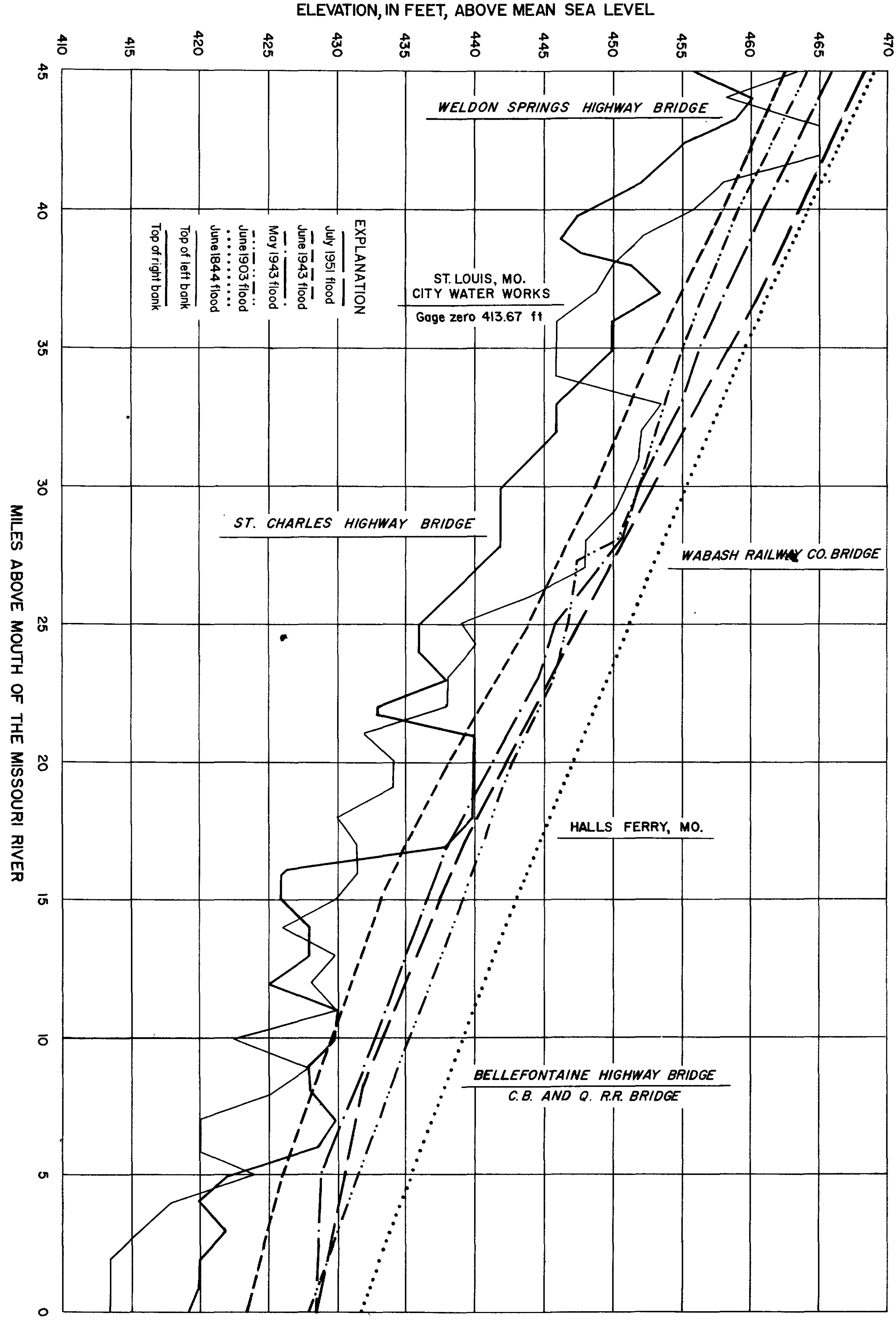

Figure 10. —Water-surface profile for selected floods on the Missouri River, Weldon Springs, Mo., to mouth.

Table 6.—Chemical quality of Missouri River water at Howard Bend treatment plant, St. Louis, 1940-49

[In parts per million except temperature and pH; analyses by city of St. Louis]

Annual average for year ending March 31	1940		1941		1942		1943		1944		1945	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
Silica	12.5	9.9	11.0	7.9	11.3	7.4	11.5	8.0	10.9	9.1	12.2	9.7
Iron and aluminum oxide	.9	2.9	1.3	3.4	1.0	4.0	1.2	3.8	.8	3.1	.4	2.1
Calcium	56.0	22.4	50.5	22.7	48.6	24.7	53.3	23.3	52.0	22.2	54.7	25.1
Magnesium	16.1	12.5	14.2	9.8	12.6	7.7	14.0	9.4	14.6	10.3	14.9	10.6
Sodium and potassium	62.8	58.0	51.8	46.9	41.8	37.8	42.7	39.4	46.7	44.7	44.8	42.3
Carbonate	1.2	14.4	.6	12.9	.2	12.3	1.2	13.3	1.2	14.8	.0	13.0
Bicarbonate	186.1	31.7	163.9	21.3	151.7	19.5	166.2	21.2	168.8	20.7	164.4	21.7
Sulfate	121.6	128.8	113.1	120.5	93.3	103.9	94.8	110.3	113.4	121.9	120.5	125.6
Chloride	24.8	24.5	21.6	21.8	19.7	19.7	21.8	21.8	22.0	21.8	20.0	19.8
Nitrate	1.5	1.4	5.1	5.5	5.2	5.1	3.7	4.0	3.3	3.1	4.0	3.7
Dissolved solids	399	294	367	267	348	240	361	252	363	267	380	276
Alkalinity as $CaCO_3$	154	50	135	39	124	37	138	40	141	41	135	40
Hardness as $CaCO_3$	206	107	185	97	173	93	191	97	190	98	198	106
Color	17	8	19	7	22	8	21	8	19	8	20	9
Turbidity	1,600	.09	1,900	.08	2,100	.08	1,610	.08	1,250	.09	1,800	.07
pH	8.01	9.24	8.01	9.26	8.08	9.38	8.04	9.25	8.09	9.40	8.05	9.33
Temperature °F	57	61	57	61	59	62	57	61	57	61	57	62

Maximum and minimum measurements; untreated water

	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Hardness as $CaCO_3$	324	107	259	114	306	88	311	93	299	86	326	97
Turbidity	7,800	18	7,800	130	[illegible],200	80	9,300	65	4,000	52	9,000	100
Temperature °F	86	32	86	32	86	33	85	31	85	33	83	32

Table 6.—Chemical quality of Missouri River water at Howard Bend treatment plant, St. Louis, 1940-49—Continued

Annual average for year ending March 31	1946		1947		1948		1949		Average 1940-49	
	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
Silica	11.7	9.1	13.6	10.3	12.6	9.4	11.0	8.7	11.8	8.9
Iron and aluminum oxide	.5	1.6	.5	1.4	.5	1.6	.7	1.8	.8	2.6
Calcium	50.4	22.7	52.4	24.7	53.2	24.2	49.5	24.2	51.8	23.6
Magnesium	14.4	10.4	15.8	11.3	15.5	11.6	14.1	9.6	14.6	10.3
Sodium and potassium	38.7	36.8	46.2	44.5	44.4	42.2	42.4	42.2	46.2	43.5
Carbonate	.4	12.6	.3	12.5	.0	13.5	.0	13.5	.5	13.3
Bicarbonate	167.3	24.4	169.8	25.8	168.4	22.0	157.3	17.8	166.4	22.6
Sulfate	94.2	104.4	118.3	126.8	120.5	130.5	114.1	124.4	110.4	119.7
Chloride	20.8	20.9	20.3	20.8	18.7	19.3	17.7	18.2	20.7	20.9
Nitrate	5.0	4.5	6.7	6.2	5.8	5.4	4.9	4.6	4.5	4.4
Dissolved solids	329	241	378	276	371	274	355	258	365	264
Alkalinity as $CaCO_3$	137	41	140	42	138	41	129	36	137	41
Hardness as $CaCO_3$	185	99	196	108	197	67	182	100	190	97
Color	17	7	21	9	24	10	22	8	20	8
Turbidity	1,520	.06	2,000	.06	1,278	.05	1,600	.05	1,670	.07
pH	8.01	9.33	8.00	9.26	7.99	9.30	8.03	9.30	8.03	9.31
Temperature °F	57	61	58	62	56	61	57	61	57	61

Maximum and minimum measurements; untreated water

	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Hardness as $CaCO_3$	308	101	323	96	309	82	290	101	306	96
Turbidity	6,900	30	8,400	110	6,300	90	6,000	115	7,270	79
Temperature °F	82	32	84	32	84	32	83	34	84	32

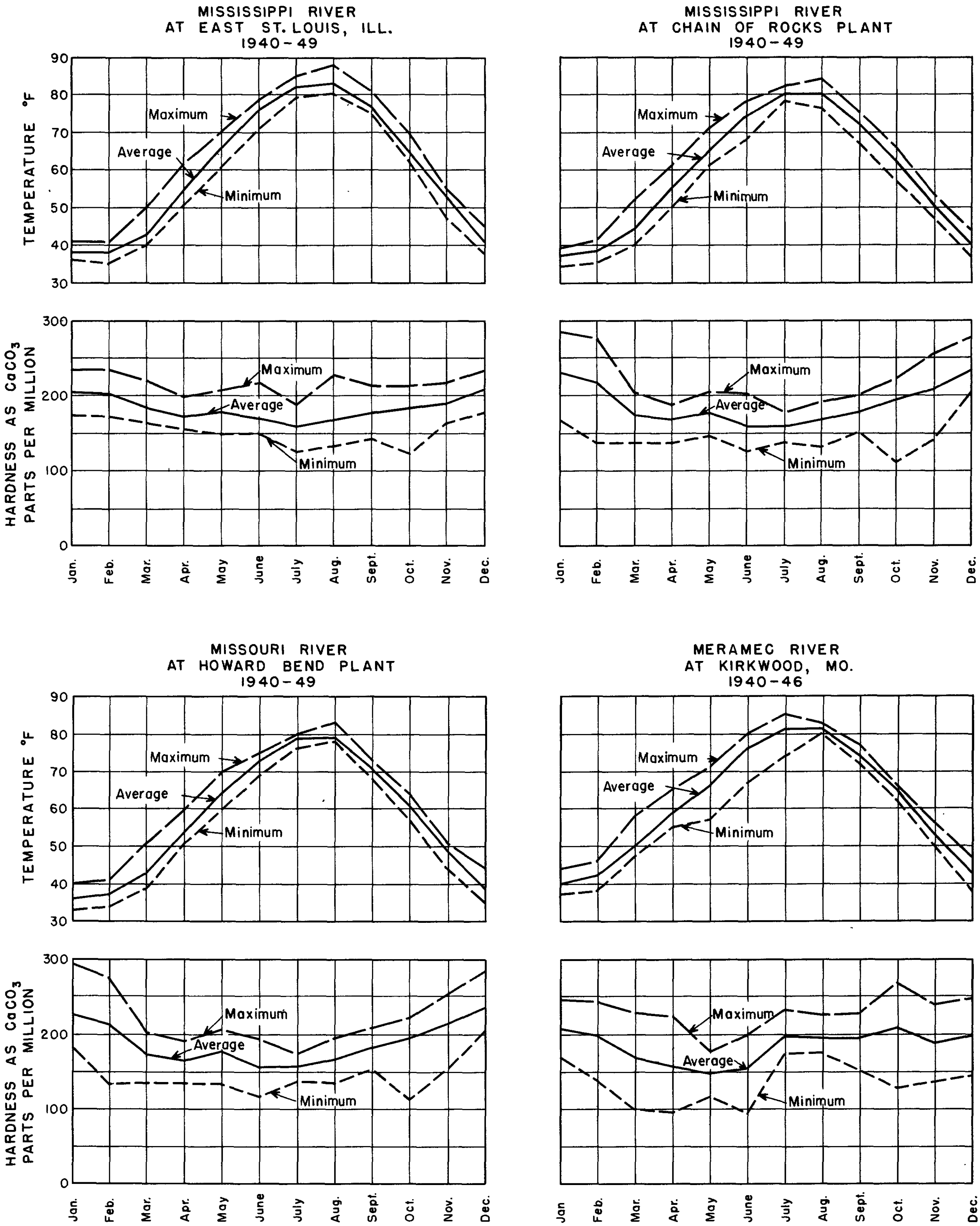

Figure 11.–Maximum, minimum, and average monthly temperature and hardness of river water, St. Louis area.

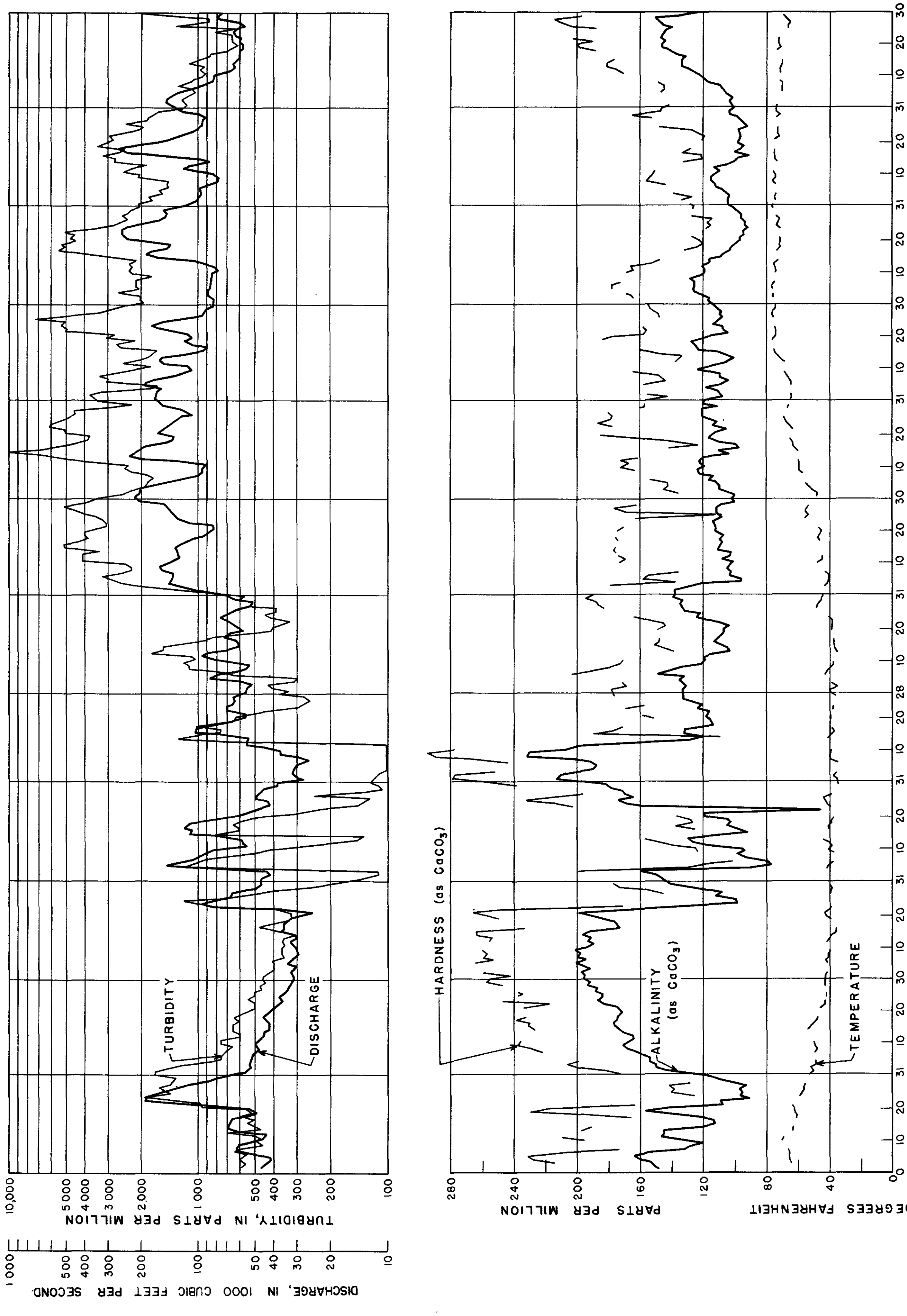

Figure 12. —Relation between streamflow and selected chemical and physical characteristics of Missouri River water at Howard Bend plant, St. Louis, 1949-50.

Table 7.—Average monthly chemical and physical characteristics of untreated Missouri River water at Howard Bend treatment plant, 1940-49

[Analyses by city of St. Louis]

Month	Temperature (°F)	Turbidity	Alkalinity as $CaCO_3$ (ppm)	Hardness as $CaCO_3$ (ppm)	Dissolved solids (ppm)
January	36	357	180	239	415
February	37	552	155	212	390
March	43	1,445	123	172	306
April	54	1,790	118	165	304
May	64	2,480	124	177	345
June	73	2,960	113	156	319
July	79	3,240	114	157	320
August	79	2,050	123	166	338
September	71	1,875	127	182	371
October	61	1,220	137	196	401
November	49	1,120	150	214	413
December	39	563	175	234	410

Turbidity concentrations were noticeably higher in this reach of the river than in the Mississippi River at Chain of Rocks. The average turbidity was 1,670 ppm, and daily turbidity during the 10-yr period ranged from 18 to 9,300 ppm. The maximum daily turbidity exceeded 7,000 ppm in 7 of 10 yr at the Howard Bend plant. The chemical quality of untreated Missouri River water is summarized as monthly averages in table 7. Figure 11 shows a comparison of temperature and hardness of untreated Missouri River water with other surface water in the area.

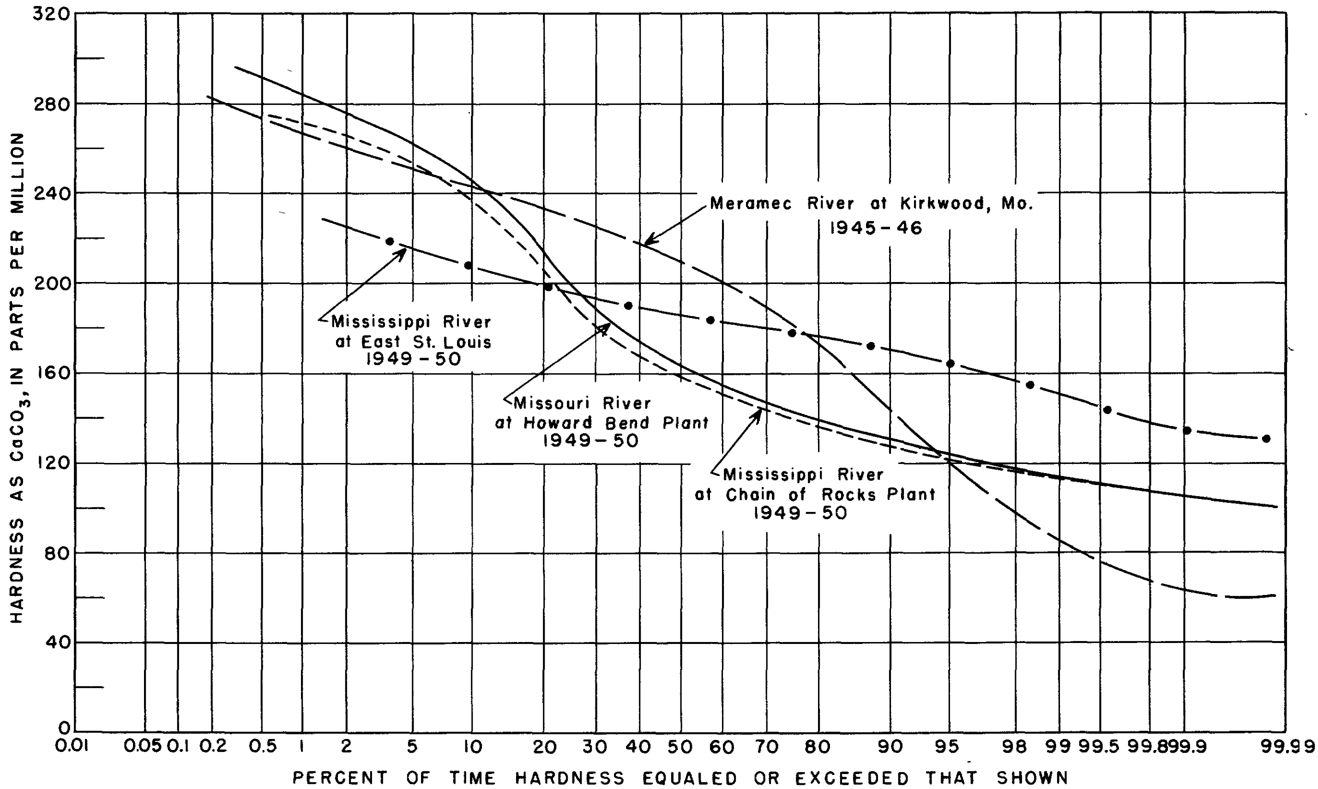

Figure 13.—Hardness-duration curve of Missouri, Mississippi, and Meramec Rivers.

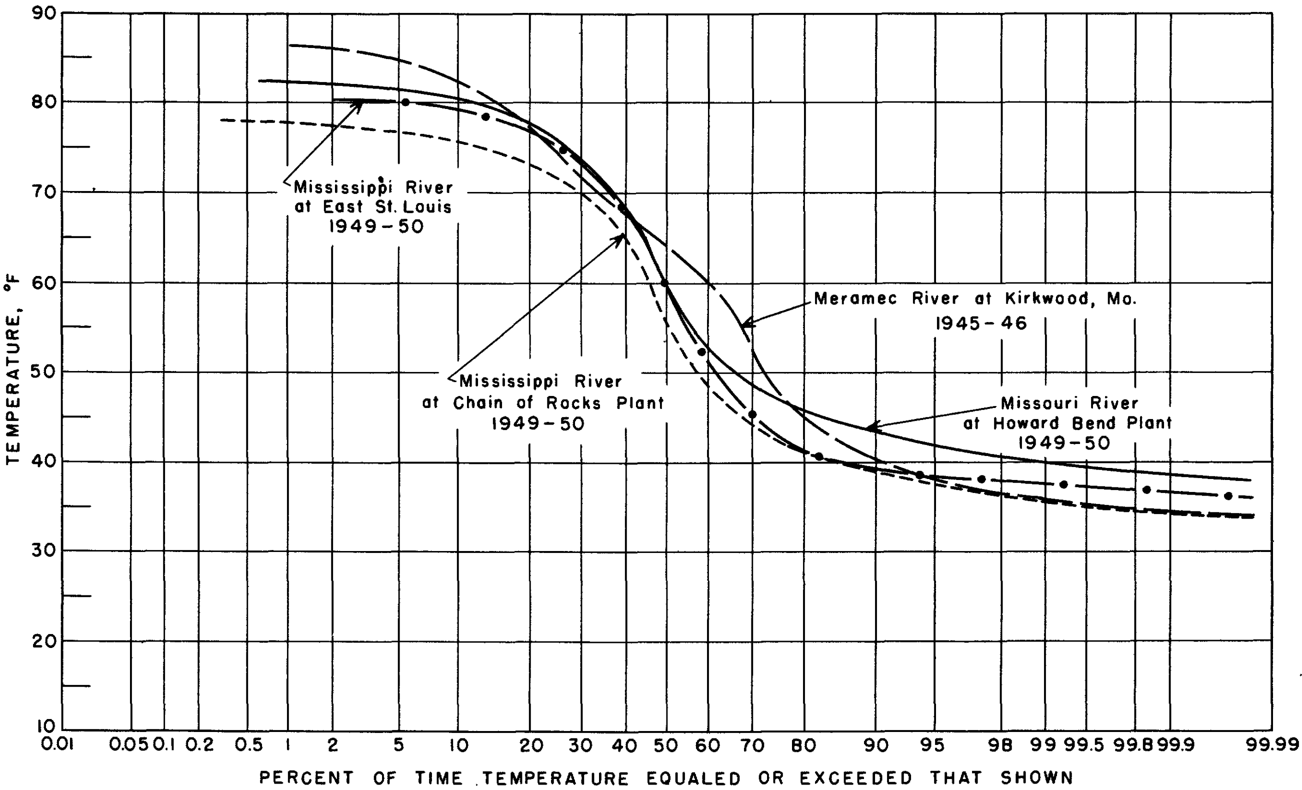

Figure 14.–Temperature-duration curve, Missouri, Mississippi, and Meramec Rivers.

The relation between streamflow and several chemical and physical characteristics of Missouri River water during the 1949-50 water year is shown in figure 12. The discharge data are from records at Hermann, Mo.

Turbidity was consistently above 1,000 ppm from April to August and for the first 10 days in September. Hardness exceeded 200 ppm on several days in September, October, January, and February, and during most of November and December. The hardness-duration curve for untreated water at the Howard Bend plant rather closely parallels the curve for the Chain of Rocks plant; hardness as $CaCO_3$ exceeded 245 ppm on about 10 percent of the days and was less than 130 ppm for about the same percent of days (see fig. 13). The median hardness, that which is equaled or exceeded 50 percent of the time, is about 164 ppm at the Howard Bend plant. During the period 1940-49 the average temperature at the Howard Bend intake was 57 F and reached a maximum temperature of 86 F in the 3-yr period. During the water year 1949-50 temperature equaled or exceeded 60 F on 50 percent of the days, exceeded 80 F on about 10 percent of the days, and was less than 44 F on about 10 percent of the days (see fig. 14). The treated water from Howard Bend plant averaged about 4 F higher than the river water.

Sediment measurements are not being made in this reach of the Missouri River; however, the Corps of Engineers measures sediment at Hermann.

Wastes from the St. Louis metropolitan area discharged into the Missouri River represent a relatively minor part of the total for the area, the major part being discharged into the Mississippi River.

The Missouri Division of Health reports that much of the heavy upstream organic pollution and the moderate pollution discharged into the lower reaches of the Missouri are assimilated in the 360-mile reach between the Kansas City metropolitan area and the mouth, through the self-purification capacity of the river. However, bacterial pollution remains above desirable levels at the mouth of the Missouri River.

A tentative summary of analyses showing pollution during 1950 at three points on the Missouri River in the vicinity of St. Louis is given in table 8. The collection of samples and analyses were performed by the Missouri Division of Health as a part of a survey of the lower Missouri River undertaken cooperatively by five State health departments and the U. S. Public Health Service.

Table 8.—Tentative summary of analyses showing pollution, Missouri River near St. Louis, 1950

[Analyses by Missouri Division of Health]

Distance from mouth (miles)	Sampling periods	Number of samples		Temperature °F	Dissolved oxygen ppm	Dissolved oxygen Saturation (percent)	BOD1/ 5-day (ppm)	Coliform (mpn per 100 ml)2/	Enterococci (mpn per 100 ml)2/	pH	NO_2 (ppm)	NO_3 (ppm)	NH_4 (ppm)
St. Louis County water plant intake													
36.0	June-Sept.	6	Average	72	7.5	85	1.5	-	-	7.9	0.015	0.783	0.187
			Maximum	75	8.4	90	2.1	43,000	430	8.2	.024	2.900	.500
			Minimum	66	6.9	79	.9	420	15	7.7	.010	.200	.080
	Dec.-Feb.	6	Average	37	12.0	89	1.8	-	-	7.9	.068	.452	.368
			Maximum	46	13.1	92	3.7	15,000	1,500	8.1	.140	.580	.400
			Minimum	32	10.7	86	1.3	60	3.0	7.5	.020	.230	.280
	Intermediate	7	Average	54	9.8	89	2.9	-	-	7.7	.033	.360	.278
			Maximum	64	11.7	94	3.4	93,000	150	8.0	.130	.720	.800
			Minimum	36	8.6	84	2.0	4,300	3.0	7.6	.008	.180	.040
Ruegg Bridge in St. Louis County3/													
8.3	June-Sept.	6	Average	73	7.2	83	2.1	-	-	7.8	-	-	-
			Maximum	79	8.0	91	3.7	93,000	430	8.0	-	-	-
			Minimum	64	6.2	71	1.3	3,600	9.1	7.5	-	-	-
	Intermediate	-	Average	57	9.2	87	3.0	-	-	7.9	-	-	-
			Maximum	64	11.4	96	4.6	93,000	230	8.0	-	-	-
			Minimum	46	8.0	82	1.9	4,300	15	7.8	-	-	-
At light marker near mouth of river4/													
1.4	Dec.-Feb.	5	Average	39	11.7	88	1.6	-	-	7.8	-	-	-
			Maximum	46	12.6	91	2.9	4,300	930	8.0	-	-	-
			Minimum	34	10.8	40	.9	2,300	3.0	7.5	-	-	-

1/ Biochemical oxygen demand.
2/ Most probable number per 100 milliliters.
3/ No samples taken December to February.
4/ No samples taken June-September or intermediate periods.

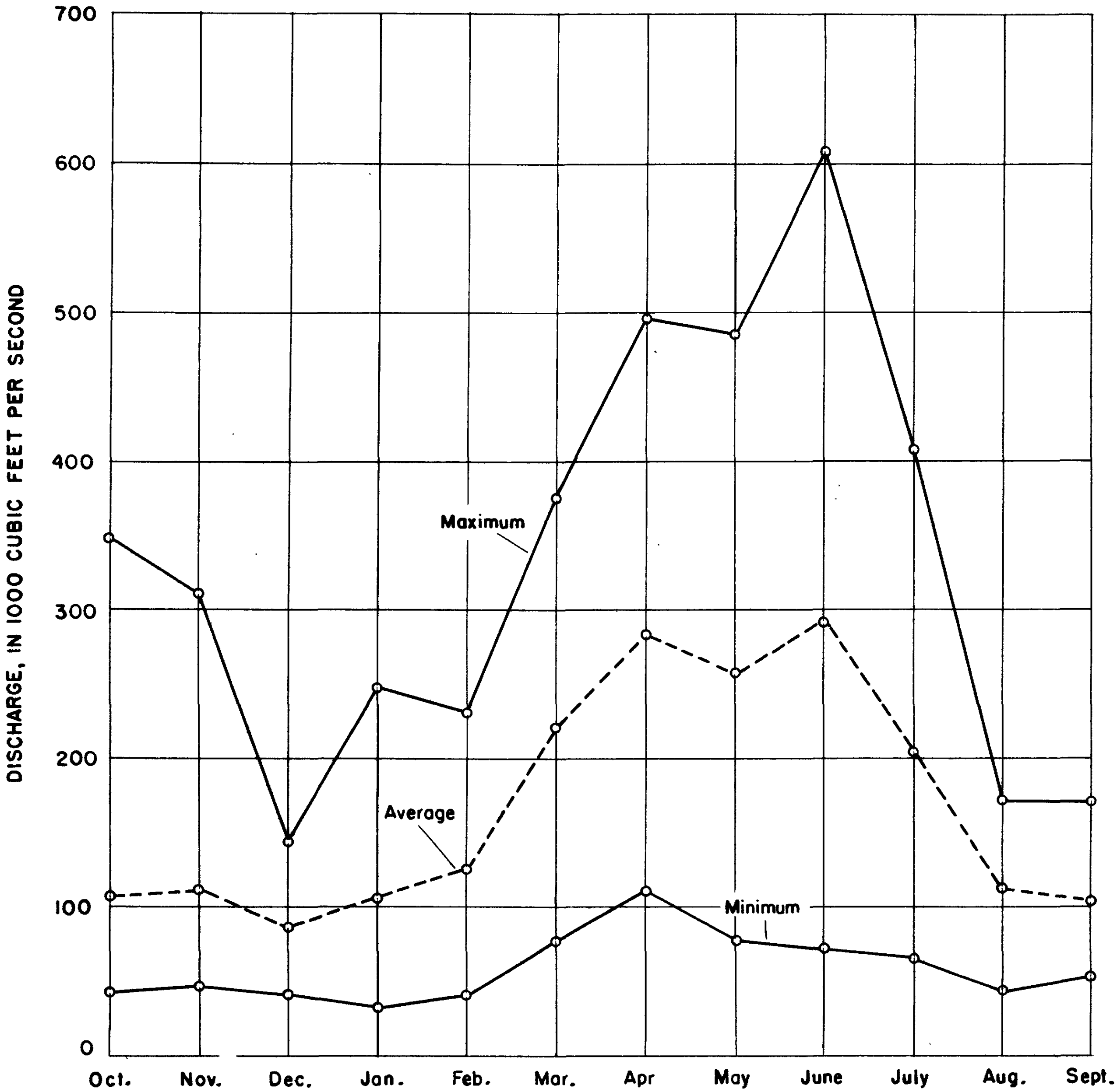

Figure 15.—Maximum, minimum, and average monthly discharge of the Mississippi River at St. Louis, 1933-50.

Mississippi River Below Mouth of Missouri River

The Mississippi River at Eads Bridge in St. Louis has a drainage area of 701,000 sq mi. The general features of the drainage basin were discussed in the paragraphs for the Missouri River and for the Mississippi River above the mouth of the Missouri River.

Navigation.—The controlling depth of the Mississippi River from the mouth of the Missouri River to the mouth of the Ohio is 9 ft, but at low stages depths may be no more than 6 to 6½ ft in parts of the rock ledge in the Chain of Rocks reach immediately above St. Louis, and less than 9 ft for short periods on infrequent occasions in other reaches. The navigation season extends throughout the year except for short periods of floating ice. During the period 1939 to 1948 the total annual river traffic, not including car ferry, ranged from a low of 2,536,513 tons in 1939 to a high of 9,464,196 tons in 1948 (U. S. Department of the Army, 1949).

The traffic through the Port of St. Louis is shown in table 1.

Discharge.—The average discharge of the Mississippi River at St. Louis, for the 17 yr of Geological Survey record (1933-50) is 168,500 cfs. The maximum, minimum, and average monthly discharges are shown in figure 15. The minimum discharge of record is 27,600 cfs, December 12, 1937.

Floods.—Records of flood stages at St. Louis include the year 1785 and are continuous since 1861. The maximum stage known was in April 1785 when the river reached a stage reported to be 42 ft. The maximum stage known with a greater degree of reliability was 41.32 ft on June 27, 1844. Some of the major flood stages are listed in table 9. A flood-stage frequency graph based on continuous records (1933-50) is shown in figure 16.

The highest stage during a 12-month period has occurred one or more times in every month. The highest stage during each year of 103 years of record at St. Louis (1785, 1838, 1843-46, 1849, 1851-53, 1856, 1858, 1861-1951) occurred as shown in figure 17. A water-surface profile of the reach from Alton through St. Louis for selected floods is shown in figure 6.

The frequency of damage by floods in areas along the river may be estimated from figures 6 and 16. For example, suppose that a manufacturing plant is to be built along the river 12 miles downstream from Eads Bridge (mile 168 above the Ohio River). The altitude at the plant site is 410 ft. Levees are not to be built to protect the area. The frequency of flooding at the plant may be estimated as follows: Plot elevation 410 ft at mile 168 (see example, fig. 6). Draw an estimated flood profile approximately paralleling the profile for the 1951 and 1945 floods and passing through elevation 410 ft at mile 168. This estimated profile shows that a flood whose crest elevation is 410 ft at mile 168 could be expected to have a crest elevation of about 417.5 ft at mile 180 (U. S. Geological Survey gage). A flood with a crest of 417.5 ft at the U. S. Geological Survey gage has a recurrence interval of 10 yr (fig. 16). Therefore, there will be an average interval of 10 yr between damaging floods at the plant site. The plant site will not be flooded at regular intervals of 10 yr but during a long period of time the average interval between floods exceeding 410-ft elevations would be 10 yr. That is, the plant site would be flooded about 10 times in 100 yr. Areas inundated by the flood of July 1951 are shown on plate 1. Inundated areas of previous floods have only historical value because of the increase in flood protection in the area.

Table 9. — Major floods on the Mississippi River at St. Louis

[Gage height plus 379.94 equals elevation above mean sea level, datum of 1929]

Date	Gage height (feet)	Elevation above msl (feet)
April 1785	42.0 (approx.)	421.9 (approx.)
1828	36.4	416.3
June 27, 1844	41.32	421.26
June 10, 1851	36.61	416.55
1855	37.1	417.0
June 15, 1858	37.21	417.15
May 19, 1892	36.0	415.9
June 10, 1903	38.00	417.94
June 16, 1909	35.25	415.19
April 26, 1927	36.1	416.0
May 24, 1943	38.94	418.88
June 26, 1943	35.17	415.11
April 30, 1944	39.14	419.08
June 13, 1945	35.30	415.24
July 2, 1947	40.26	420.20
July 22, 1951	40.28	420.22

Quality.—The water of the Mississippi River below the Missouri River is harder and more turbid than that above the Missouri River. The flow from the Missouri River increases the turbidity of the Mississippi River, especially during periods of high runoff in the Missouri River. During the 10-yr period, 1940-49, analyses were made of water samples taken at the East St. Louis Water Co. intake, about 2 miles below the mouth of the Missouri River during the low-flow periods the two waters do not mix completely, and the clearer water of the Mississippi River predominates at the intake.

Yearly averages of several physical characteristics and chemical constituents of untreated Mississippi River water at the East St. Louis Water Co. plant for the 10-yr period, 1940-49, are shown in table 10. Annual turbidity ranged from 128 to 451 ppm and averaged 292 ppm; the minimum and maximum occurred at the beginning and end of the period, respectively. Hardness as $CaCO_3$ ranged from 163 ppm in 1941 to 210 ppm in 1947 and averaged 183 ppm. The maximum turbidity occurred during the week ending June 11, 1949, and averaged 3,100 ppm for the week. The maximum hardness occurred during

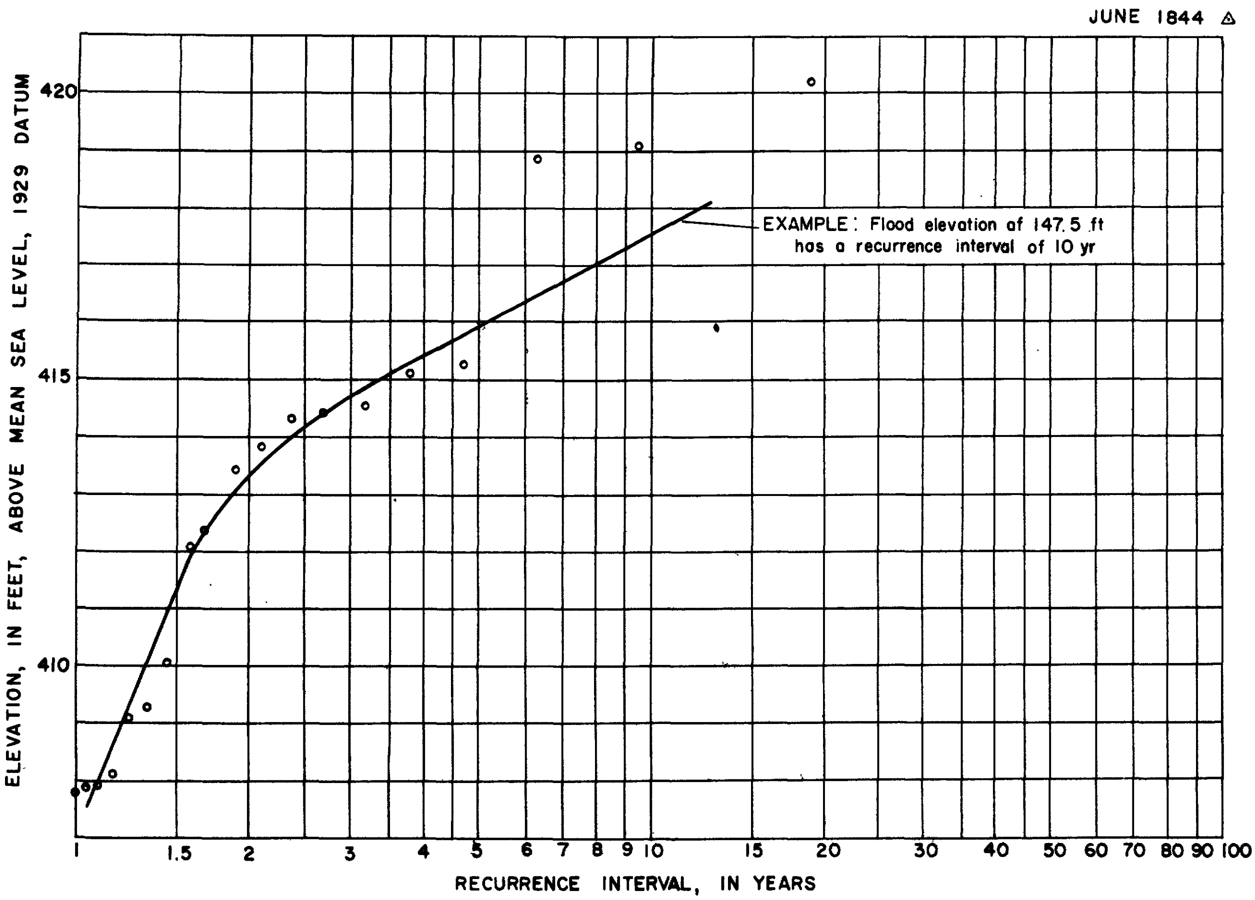

Figure 16.—Flood frequencies on the Mississippi River at St. Louis, 1933-50.

Table 10.—Average annual chemical and physical characteristics of untreated Mississippi River water at East St. Louis Water Co. plant, 1940-49

[Analyses by East St. Louis Water Co.]

Calendar year	Temperature (°F)	Turbidity (ppm)	pH	Alkalinity as $CaCO_3$ (ppm)	Hardness as $CaCO_3$ (ppm)
1940	59	128	7.6	121	164
1941	60	241	7.6	121	163
1942	60	270	7.7	134	176
1943	59	247	7.7	139	176
1944	60	374	7.9	147	184
1945	59	292	7.7	145	187
1946	61	306	7.7	147	191
1947	60	200	7.7	164	210
1948	60	407	7.7	158	199
1949	61	451	7.8	134	179
Average	60	292	7.7	141	183

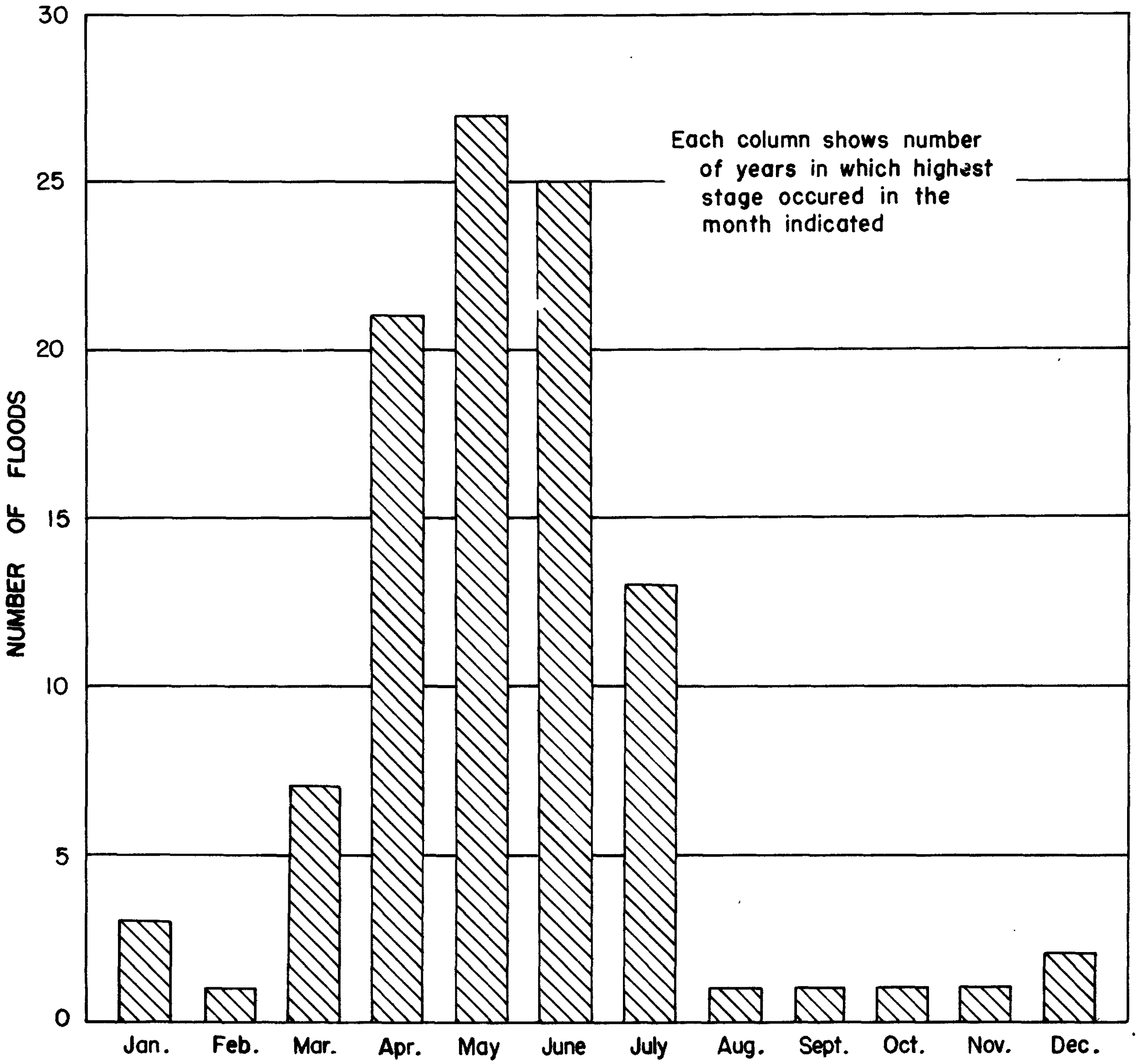

Figure 17.—Month of occurrence of highest stage in each year on Mississippi River at St. Louis (103 years of record).

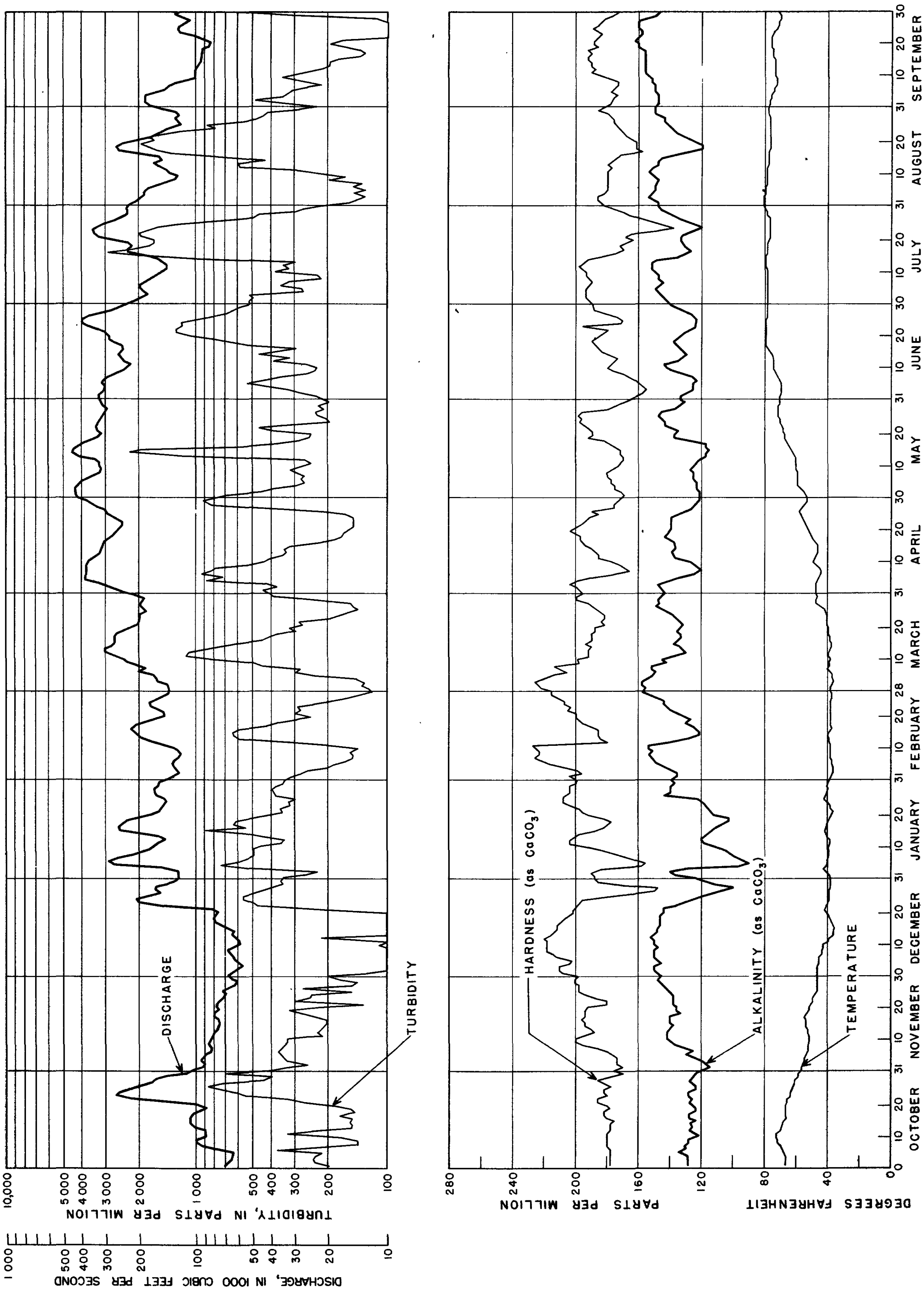

Figure 18. --Relation between streamflow and the chemical and physical characteristics of the water, Mississippi River at East St. Louis, 1949-50.

the week ending January 11, 1947, and averaged 241 ppm for the week. Average monthly turbidity, hardness, and other physical and chemical characteristics of untreated Mississippi River water at the East St. Louis Water Co. plant are given in table 11. Maximum, minimum, and average monthly hardness are shown in figure 11.

Figure 18 shows the relation between streamflow and chemical and physical characteristics of Mississippi River water at East St. Louis, and that turbidity fluctuates widely from day to day. It also shows that fluctuations in turbidity follow fluctuations in discharge rather closely. The lowest average turbidity occurred in October, November, and December, and the highest average turbidity occurred from March through August.

Hardness in excess of 200 ppm occurred in the months of December through March and fluctuated generally between 160 and 200 ppm during the rest of the year. The hardness-duration curve for the Mississippi River at East St. Louis (see fig. 13) for the 1949-50 water year shows that the hardness of untreated water exceede 210 ppm on about 10 percent of the days and was less than 180 ppm on about 10 percent of the days. The range in hardness of the Mississippi River at East St. Louis was considerably less than that for other streams shown in figure 13.

One of the two municipal water plants of the city of St. Louis is operated at Chain of Rocks, about 5 miles downstream from the mouth of the Missouri River. Excellent quality control records are maintained at the plant during various stages of treatment, and a compilation of the more important constituents for the untreated and treated water for the period 1940-49 is given in table 12.

Untreated water at the Chain of Rocks intake is of moderately high mineral content; the dissolved solids are composed principally of bicarbonates and sulfates of calcium and sodium. The 10-yr average for dissolved solids was 340 ppm, and the yearly averages were uniform. The average hardness of 188 ppm is only 5 ppm greater than that at the East St. Louis intake, but within any one year the fluctuation is much greater at the Chain of Rocks intake on the Missouri side of the stream (see fig. 13). For the 10-yr period, the range in daily hardness was from 80 to 303 ppm.

Hardness in excess of 200 ppm occurred at the Chain of Rocks plant throughout most of November and December and the first 2 weeks of February. As illustrated in the hardness-duration curve (fig. 13), hardness exceeded 235 ppm on about 10 percent of the days. The hardness-duration curve for water at the Chain of Rocks plant closely follows that for the Howard Bend plant. The range in hardness is much greater at the Chain of Rocks plant than at the East St. Louis plant. Monthly averages for hardness and several physical characteristics and chemical constituents are shown in table 13.

The most noticeable difference in the water on opposite sides of the river is the turbidity, which averages 1,325 ppm for the 10-year period at Chain of Rocks. This is about four times the average turbidity observed at the East St. Louis intake. Daily turbidity ranged from 27 ppm in January 1940 to 8,500 ppm in July 1942.

Figure 19 shows that wide fluctuations in turbidity occur from day to day and that during the period April through August 1950 the turbidity remained consistently above 1,000 ppm.

Daily temperatures at intakes on opposite sides of the river differed somewhat, although the 10-yr average was 60 F at East St. Louis and 57 F at Chain of Rocks. In the water year 1949-50 the temperature of the river water exceeded 55 F for about 50 percent of the days at Chain of Rocks, and exceeded 60 F for about 50 percent of the days at East St. Louis (see fig. 14). The treated water from the Chain of Rocks plant averaged about 4 F higher than the untreated water.

Daily measurements of the sediment load in the Mississippi River are being made by the U. S. Geological Survey in cooperation with the Corps of Engineers, U. S. Army. As previously described, the flow at the St. Louis gage is a combination of upper Mississippi River water and Missouri River water whose widely different concentrations of sediment have not become thoroughly mixed. Figure 20 shows the variation in maximum, minimum, and average sediment concentration at selected points at Eads Bridge.

Table 11.—Average monthly chemical and physical characteristics of untreated Mississippi River water at East St. Louis Water Co. plant, 1940-49

[Analyses by East St. Louis Water Co.]

Month	Temperature (°F)	Turbidity (ppm)	Alkalinity as $CaCO_3$ (ppm)	Hardness as $CaCO_3$ (ppm)
January	38	107	159	205
February	38	153	154	201
March	43	377	139	181
April	55	309	128	170
May	66	271	136	178
June	76	555	130	170
July	82	609	125	159
August	83	375	135	168
September	77	274	139	177
October	65	235	139	181
November	53	143	146	189
December	41	88	158	208

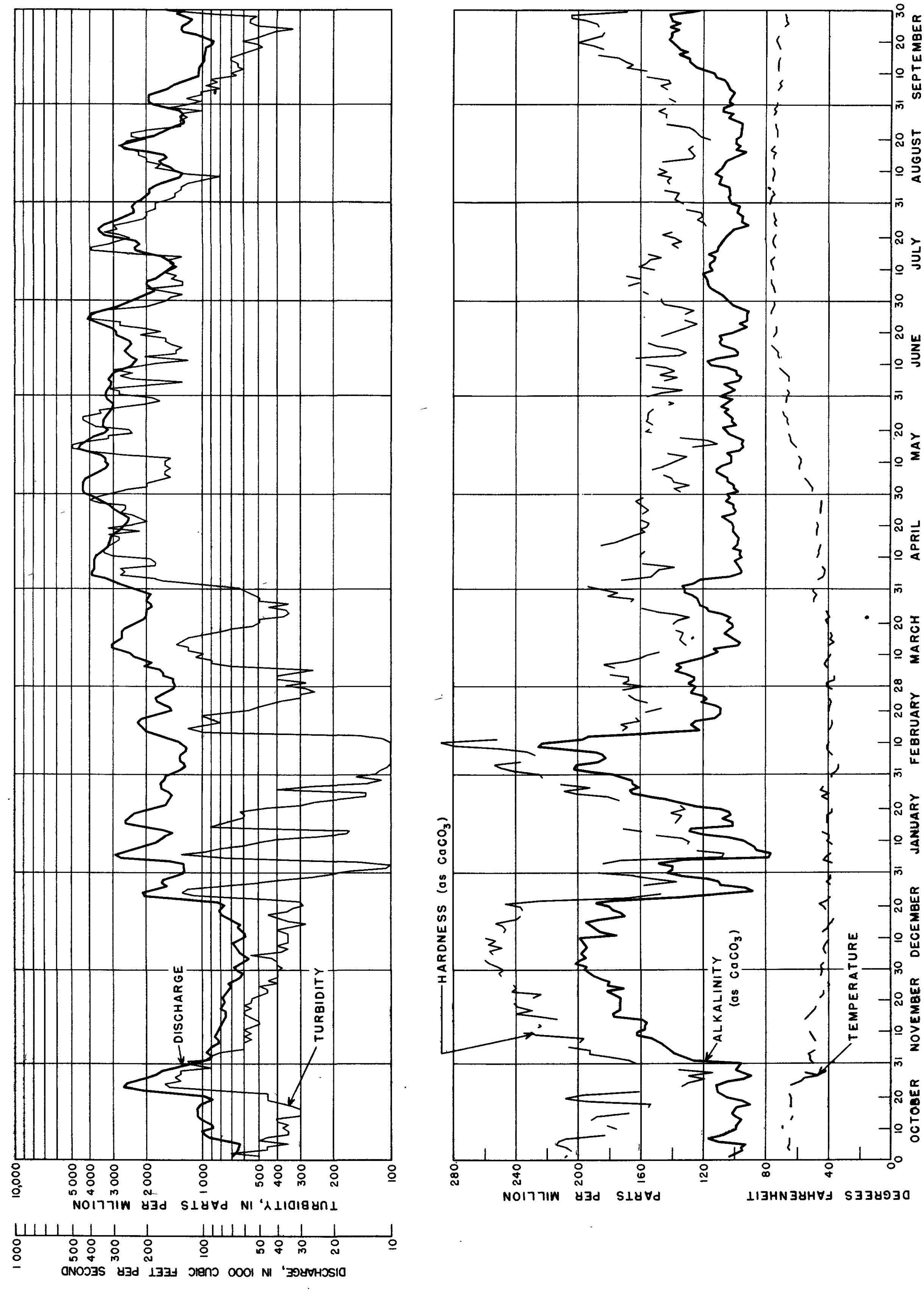

Figure 19. —Relation between streamflow and chemical and physical characteristics of the water, Mississippi River at Chain of Rocks plant, 1949-50.

Table 12.—Chemical quality of Mississippi River water at Chain of Rocks Treatment Plant, St. Louis, Mo., 1940-49

[In parts per million except temperature and pH; analyses by city of St. Louis]

Annual average for year ending March 31	1940 Untreated	1940 Treated	1941 Untreated	1941 Treated	1942 Untreated	1942 Treated	1943 Untreated	1943 Treated	1944 Untreated	1944 Treated	1945 Untreated	1945 Treated
Silica	11.4	9.3	10.5	8.6	11.6	8.4	12.4	9.3	11.6	8.9	14.2	9.6
Iron and aluminum oxide	.2	.7	.2	.9	.2	.8	.2	1.2	.2	1.2	.3	1.2
Calcium	55.0	23.1	49.3	23.9	48.6	29.8	52.8	24.1	52.6	20.5	54.3	23.2
Magnesium	14.2	11.0	12.9	9.5	11.4	7.4	13.7	9.8	14.5	11.5	15.0	11.4
Sodium and potassium	56.5	55.0	46.2	45.5	36.1	36.0	38.0	38.3	41.1	40.4	40.4	39.5
Carbonate	1.8	14.4	1.2	13.2	1.2	11.4	1.2	13.2	1.2	12.6	1.2	10.7
Bicarbonate	179.3	32.9	156.2	22.0	147.6	29.3	164.7	20.7	164.7	22.0	163.5	21.0
Sulfate	110.7	116.4	103.6	113.2	91.0	98.9	96.6	106.2	103.4	110.9	110.9	121.8
Chloride	21.8	21.7	19.2	19.3	16.8	17.3	19.8	20.1	18.2	18.3	18.0	18.5
Nitrate	4.2	4.5	5.8	6.1	5.4	5.6	6.0	6.4	6.0	6.0	6.4	6.6
Dissolved solids	369	272	331	254	301	240	338	247	342	250	361	266
Alkalinity as $CaCO_3$	150	51	130	40	123	43	137	39	137	39	136	35
Hardness as $CaCO_3$	196	103	176	99	168	105	188	100	191	98	197	105
Color	14	7	15	8	22	9	20	11	19	8	20	8
Turbidity	1,100	.15	1,463	.12	1,946	.14	1,500	.13	1,026	.13	1,472	.14
pH	8.1	9.0	8.1	9.1	8.0	9.0	8.0	9.1	7.9	9.0	7.90	9.04
Temperature °F	58	-	58	-	61	-	58	-	58	-	59	-

Maximum and minimum measurements; untreated water

	1940 Max.	1940 Min.	1941 Max.	1941 Min.	1942 Max.	1942 Min.	1943 Max.	1943 Min.	1944 Max.	1944 Min.	1945 Max.	1945 Min.
Hardness as $CaCO_3$	302	105	235	107	292	80	275	94	283	82	317	102
Turbidity	5,200	27	6,250	125	8,500	80	7,000	90	4,000	45	5,000	90
Temperature °F	86	32	87	34	88	32	86	33	86	34	85	34

Annual average for year ending March 31	1946 Untreated	1946 Treated	1947 Untreated	1947 Treated	1948 Untreated	1948 Treated	1949 Untreated	1949 Treated	Average 1940-49 Untreated	Average 1940-49 Treated
Silica	12.8	9.1	13.3	9.9	12.9	9.7	12.0	8.5	12.3	9.1
Iron and aluminum oxide	.4	1.3	.5	1.4	.4	1.4	.7	1.7	.3	1.2
Calcium	50.5	21.9	52.8	25.7	52.3	23.8	50.0	23.3	51.8	23.9
Magnesium	14.8	11.3	15.8	11.6	15.9	12.2	14.6	10.2	14.3	10.6
Sodium and potassium	34.7	34.8	40.7	39.7	41.4	39.3	41.2	39.8	41.6	40.8
Carbonate	1.2	9.0	1.2	10.2	1.2	12.0	1.2	12.1	1.3	11.9
Bicarbonate	158.6	26.8	165.9	25.6	163.5	22.0	153.7	18.3	161.8	24.1
Sulfate	92.3	101.2	108.8	118.0	117.1	127.8	112.6	121.4	104.7	113.6
Chloride	19.1	19.3	19.3	19.8	17.6	18.3	18.3	18.1	18.8	19.1
Nitrate	6.2	6.4	6.3	6.6	5.6	5.6	5.1	4.8	5.7	5.9
Dissolved solids	320	231	349	261	348	262	343	249	340	253
Alkalinity as $CaCO_3$	132	37	138	38	136	38	128	35	135	40
Hardness as $CaCO_3$	187	101	197	107	196	110	185	100	188	103
Color	19	8	19	9	17	8	16	6	18	8
Turbidity	1,223	.14	1,300	.11	1,020	.09	1,200	.07	1,325	.12
pH	7.95	9.02	7.91	8.98	7.91	9.08	7.84	9.16	7.96	9.05
Temperature °F	58	-	58	-	57	62	57	62	58	-

Maximum and minimum measurements; untreated water

	1946 Max.	1946 Min.	1947 Max.	1947 Min.	1948 Max.	1948 Min.	1949 Max.	1949 Min.	Average 1940-49 Max.	Average 1940-49 Min.
Hardness as $CaCO_3$	302	103	295	105	303	104	284	110	289	99
Turbidity	4,800	60	5,000	100	5,200	85	5,000	130	5,595	83
Temperature °F	84	33	85	33	85	32	85	34	86	33

Table 13.—Average monthly chemical and physical characteristics of untreated Mississippi River water at Chain of Rocks plant, 1940-49

[Analyses by city of St. Louis]

	Temperature (°F)	Turbidity (ppm)	Alkalinity as $CaCO_3$ (ppm)	Hardness as $CaCO_3$ (ppm)	Dissolved solids (ppm)
January	37	346	177	230	386
February	38	559	156	216	374
March	44	1,267	123	172	288
April	55	1,560	115	167	288
May	65	1,875	122	175	317
June	74	2,410	110	158	284
July	80	2,579	111	158	300
August	80	1,447	118	168	312
September	72	1,454	124	177	351
October	62	1,001	134	194	371
November	50	864	146	208	394
December	40	520	174	232	401

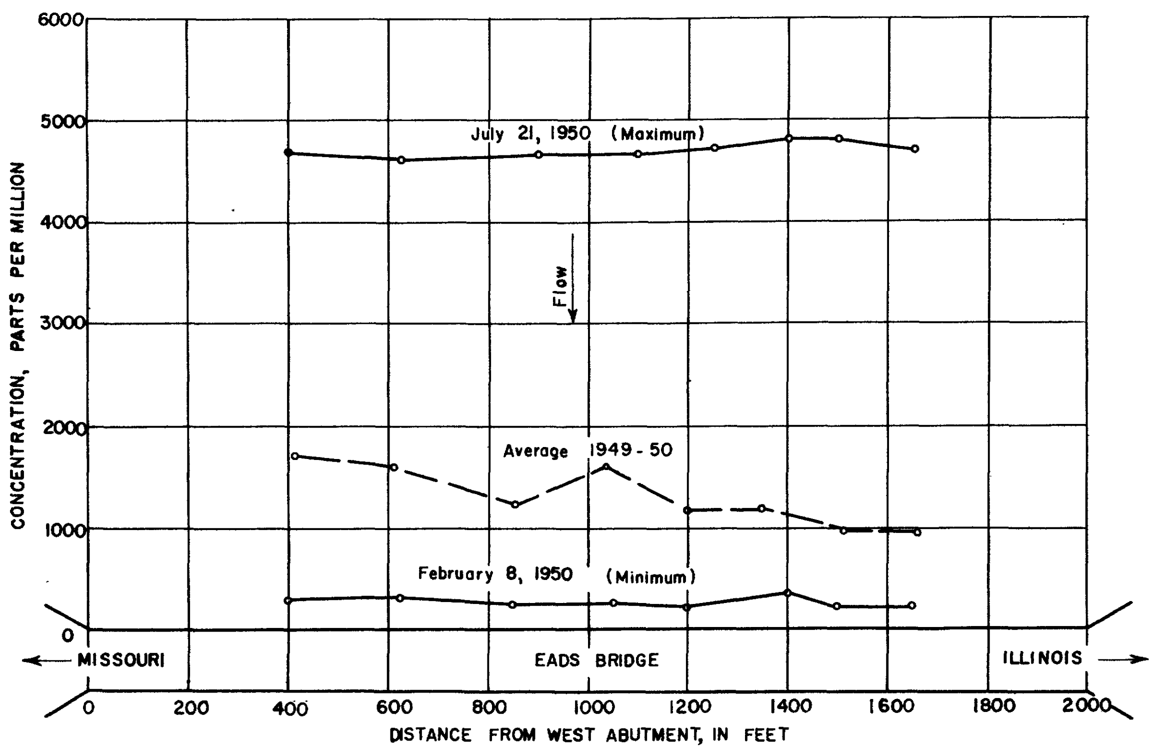

Figure 20.—Maximum, minimum, and average sediment concentration, Mississippi River at St. Louis, 1949-50.

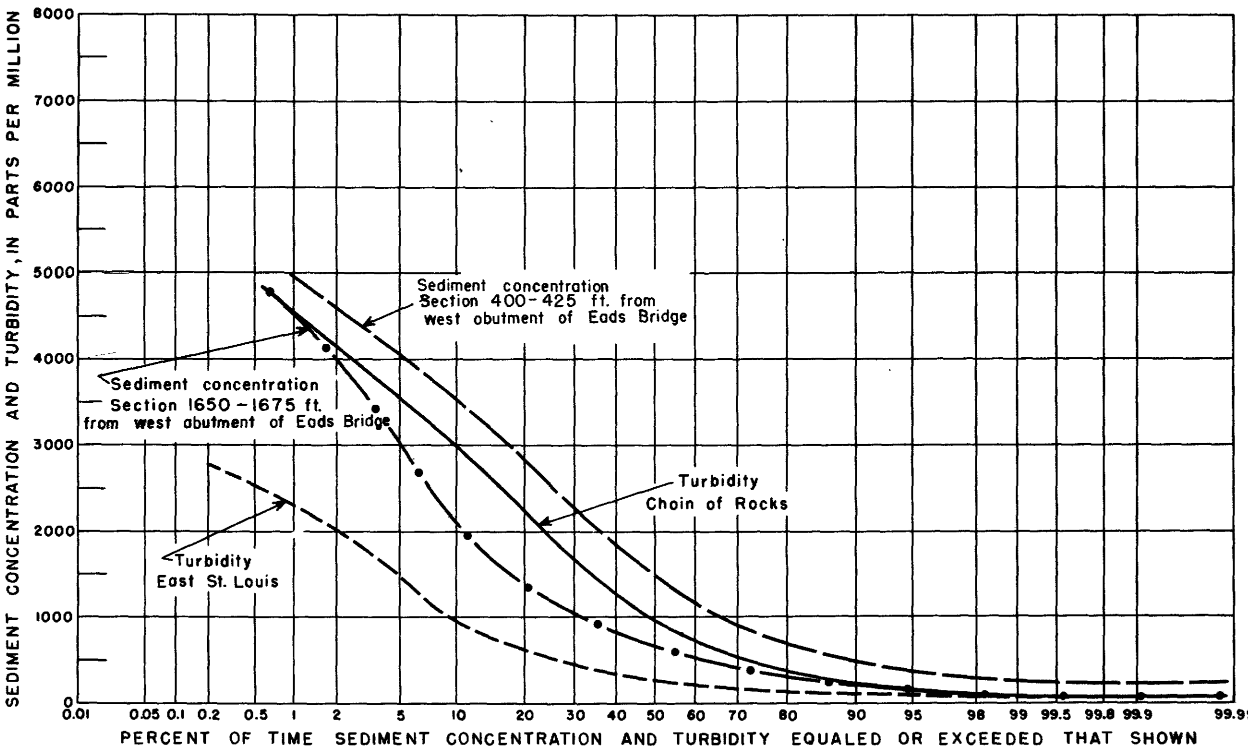

Figure 21. –Duration curve of sediment concentration and turbidity, Mississippi River at St. Louis, 1949-50.

Duration curves of the suspended-sediment concentrations obtained during the period October 1949 to September 1950 at sections 400 to 425 ft and 1650 to 1675 ft from the west abutment of Eads Bridge are compared in figure 21 with turbidity at the East St. Louis and Chain of Rocks intakes.

Very little sewage is treated in the area, most municipalities discharge untreated sewage directly into the Mississippi River. Discharging waste into open channels is prohibited in Illinois. Noncorrosive, nontoxic effluent that is only oxygen deficient can generally be discharged into sewers. At least one refinery in the Wood River area controls releases of phenol-contaminated waste by use of retention ponds.

Pollution studies of the Mississippi River from Alton to Jefferson Barracks are being conducted as a joint investigation by the U. S. Public Health Service, Illinois Sanitary Water Board, Missouri Division of Health, the U. S. Fish and Wildlife Service, and the Bi-State Development Agency. A survey has been made of the water and pollution situations in St. Louis (Conservation Foundation and the National Association of Manufacturers, 1950). Of 39 plants that returned questionnaires, 9 stated that the pollution problem in the St. Louis area was serious, and 8 considered pollution to be moderate.

Meramec River

The Meramec River drains the northeastern portion of the Ozark Plateaus and the rough, heavily wooded foothills of the Ozark border region. Many sinkholes are found near the headwaters of the Meramec, and many large springs maintain the low flow of the Meramec and its smaller tributaries.

The rainfall over the basin averages about 40 in. and runoff averages 10 to 12 in. The drainage area above the gaging station at Eureka, Mo., is 3,788 sq mi. It is 95.2 percent of the total drainage area of the basin.

Discharge.—The average discharge of Meramec River near Eureka, Mo., for the 29 yr of record (1921-50) is 3,225 cfs. The minimum discharge of record, 196 cfs, occurred on August 27, 31, and September 1, 1936. The low-flow characteristics of the Meramec River are shown by the flow-duration curve, figure 22, and by the curve showing the maximum period of deficient discharge without storage, figure 23. The flow-duration curve shows the percentage of time that a specified daily discharge in cubic feet per second or millions of gallons per day has been equaled or exceeded. It may be considered a probability curve and used to estimate the probability of occurrence of a specified discharge. It can be used to solve problems of plant location and operation. For example, suppose that it is desired to locate a manufacturing plant on the Meramec River in the vicinity of Eureka. Construction of a storage dam is not contemplated. A flow of 220 mgd is required to operate the plant. It is necessary to know the average number of days each year that there will be a shortage of water. Figure 22 shows that the daily flow near Eureka is 220 mgd or more 99 percent of the time. In an average year there would be sufficient water 99 percent of 365, or 361 days, and a shortage for only 4 days. It may be possible to operate the plant for short periods on less than 220 mgd. Therefore, it is necessary to know the maximum number of consecutive days, even in unusual years, that the flow will be less than 220 mgd. The flow near Eureka may be expected to be less than 220 mgd for not more than $1\frac{1}{2}$ consecutive months (fig. 23, maximum period of deficient discharge). Figure 23 also shows that the average flow for any 3-month period will not be less than 220 mgd.

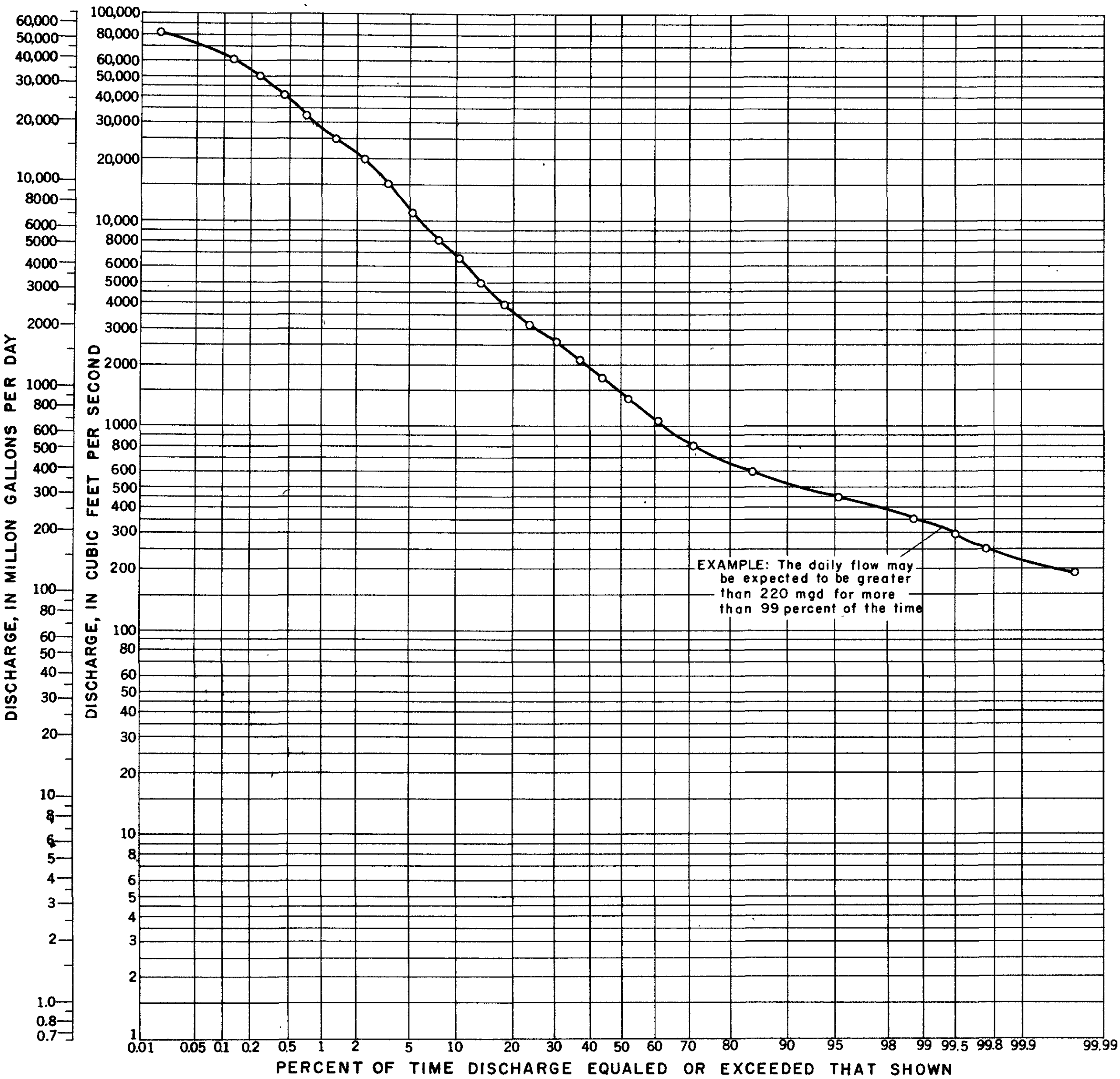

Figure 22.—Duration of daily flows, Meramec River near Eureka, Mo., 1921-50.

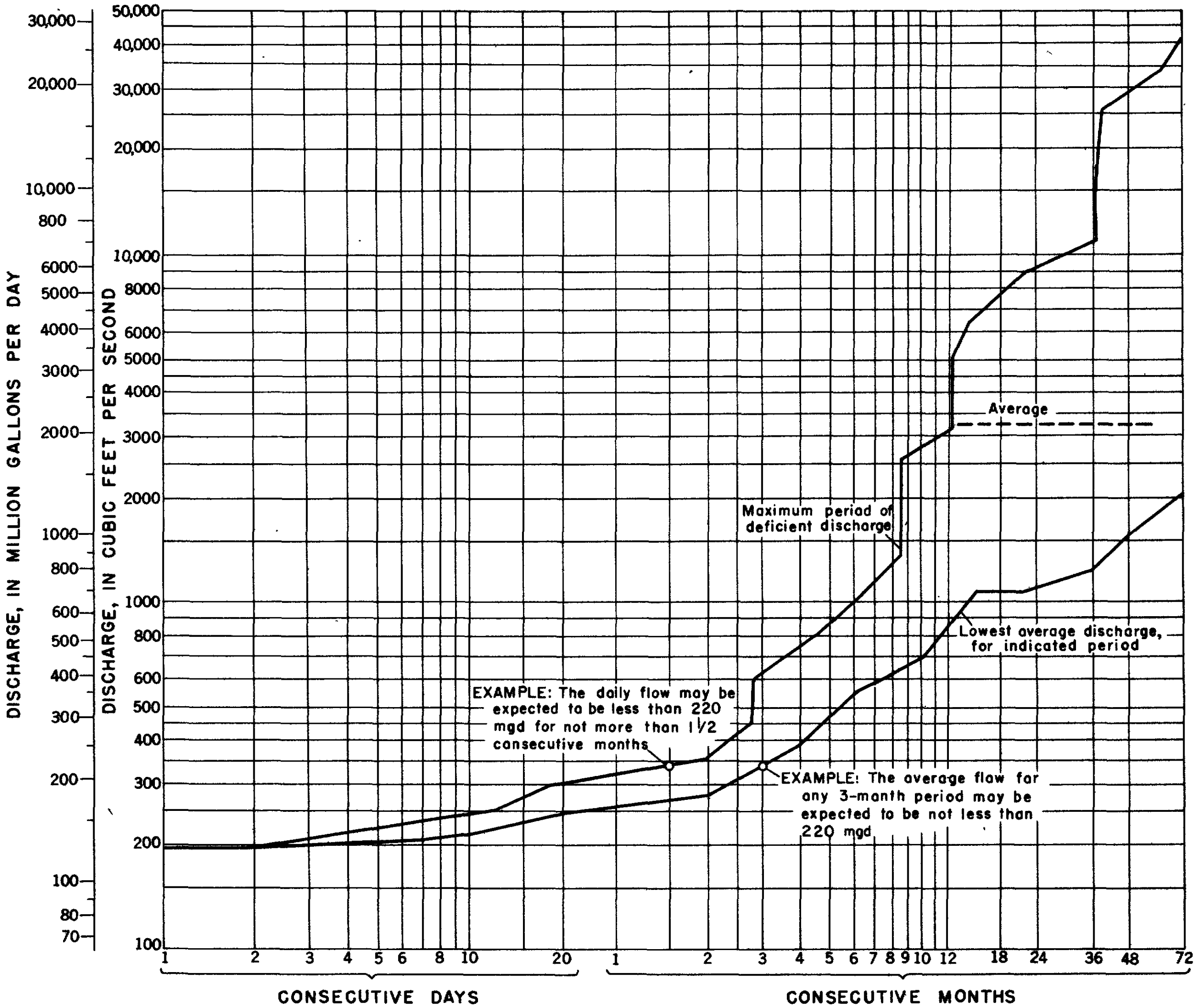

Figure 23. –Discharge available without storage, Meramec River near Eureka, Mo., 1921-50.

Floods.—Records of flood stages near Eureka include the floods of 1915 and 1916 and are continuous from August 1903 to July 1906 and since October 1921. Gage-height records have been obtained on the Meramec River at Valley Park since October 1916 by the U. S. Weather Bureau with a gage whose zero is 393.58 ft above mean sea level. The maximum stage known at Eureka is 40.2 ft (446.4 ft above mean sea level) on August 22, 1915. Major floods at Eureka are given in table 14 and the frequencies of flood stages for 1915, 1916, and 1921-50 are shown in figure 24. A profile of the water-surface during selected floods in the reach from Eureka to the mouth are shown in figure 25. Areas inundated in the St. Louis area during the July 1951 flood are shown on plate 1.

Table 14.—Major floods on the Meramec River near Eureka, Mo., 1915, 1916, 1921-50

[Gage height plus 406.18 equals elevation above mean sea level, datum of 1929]

Date	Gage height (feet)	Elevation above msl (feet)
Aug. 22, 1915	40.2	446.4
Feb. 1, 1916	37.0	443.2
Apr. 3, 1927	29.47	435.65
May 17, 1933	30.72	436.90
Mar. 14, 1935	30.89	437.07
Apr. 19, 1939	29.71	435.89
Dec. 30, 1942	31.78	437.96
Apr. 2, 1945	28.98	435.16
Apr. 17, 1945	32.13	438.31
June 11, 1945	36.94	443.12
Apr. 27, 1947	31.15	437.33
Jan. 6, 1950	33.01	439.19

Quality.—The waters of the Meramec River at Kirkwood, Mo., are as hard as the waters of the Mississippi River into which it flows, slightly higher in alkalinity, and not nearly so turbid. Annual averages for several physical and chemical properties of the river water are shown in table 15 for each year during the period 1940-46. Turbidity averaged 92 ppm for the period and ranged from a monthly average of less than 10 ppm in December 1944 and January 1945 to a maximum monthly average of 319 ppm in April 1944. The average hardness was 185 ppm, and the monthly average ranged from 93 ppm in June 1942 to 269 ppm in October 1942. Average monthly physical characteristics and chemical con-

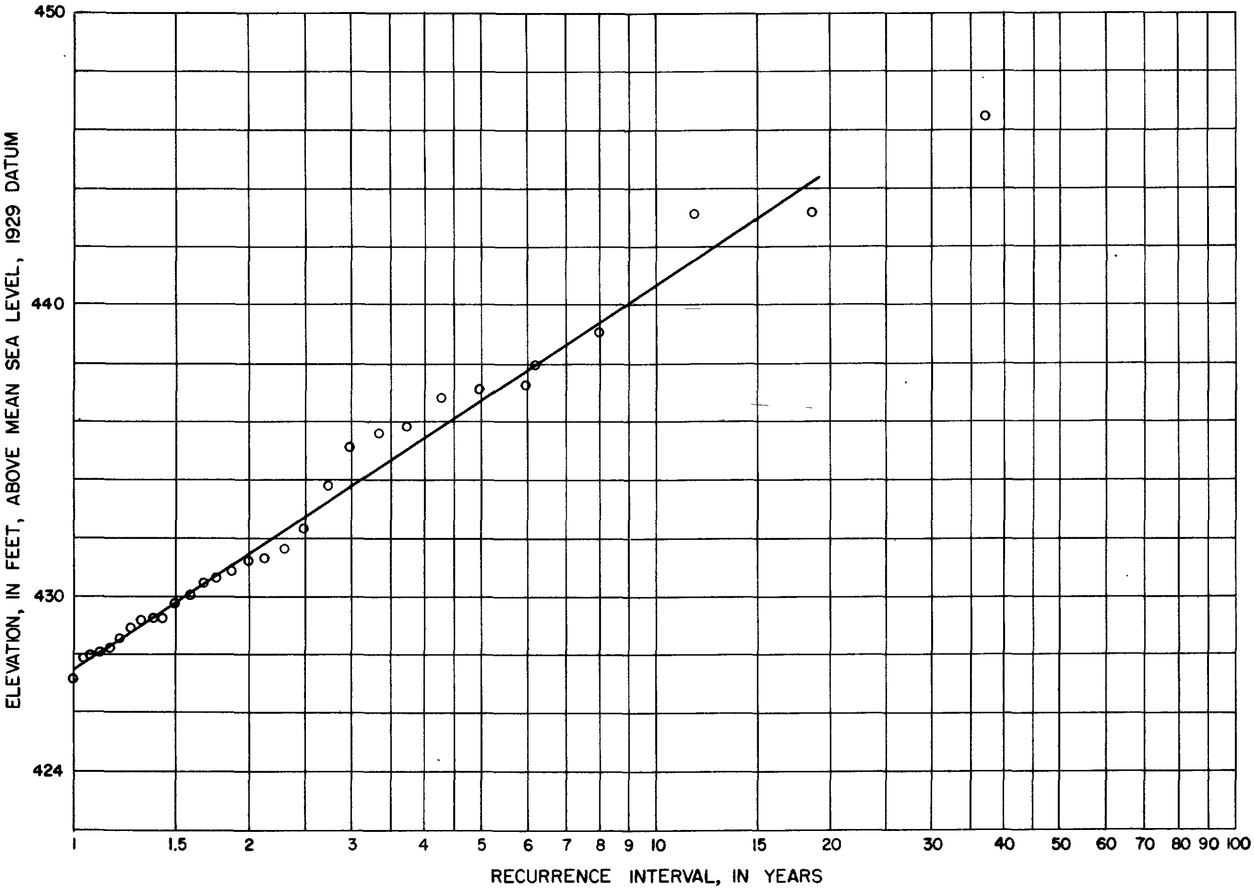

Figure 24.—Flood frequencies on Meramec River near Eureka, Mo., 1915, 1916, 1921-50.

stituents are given in table 16. Maximum, minimum, and average monthly hardness and temperatures are shown in figure 11.

As previously demonstrated in other streams, the turbidity increases and decreases with increase and decrease in streamflow (see fig. 26). Maximum turbidity, which seldom exceeded 1,000 ppm, occurred in the months from January to March and in August.

Total hardness fluctuated rapidly with changes in streamflow; hardness in December 1949 averaged more than 240 ppm, whereas hardness in May 1950 averaged somewhat less than 180 ppm.

A hardness-duration curve of Meramec River water is shown in figure 13. Daily analyses of the river water were discontinued in 1947. At that time the city of Kirkwood began using a radial-type well as the source for the municipal water supply. In the 1946 water year, the hardness of the river water exceeded 140 ppm on about 90 percent of the days and 240 ppm on about 10 percent of the days (see fig. 13).

Table 15.—Average annual chemical and physical characteristics of untreated Meramec River water at Kirkwood, Mo., 1940-46

[Analyses by city of Kirkwood]

Calendar year	Temperature (°F)	Turbidity (ppm)	pH	Alkalinity as $CaCO_3$ (ppm)	Hardness as $CaCO_3$ (ppm)
1940	60	66	8.0	159	184
1941	63	73	8.0	142	174
1942	61	137	8.0	140	178
1943	62	87	8.1	156	196
1944	61	83	-	162	188
1945	58	112	7.9	147	179
1946	62	89	7.9	148	194
Average	61	92	8.0	150	185

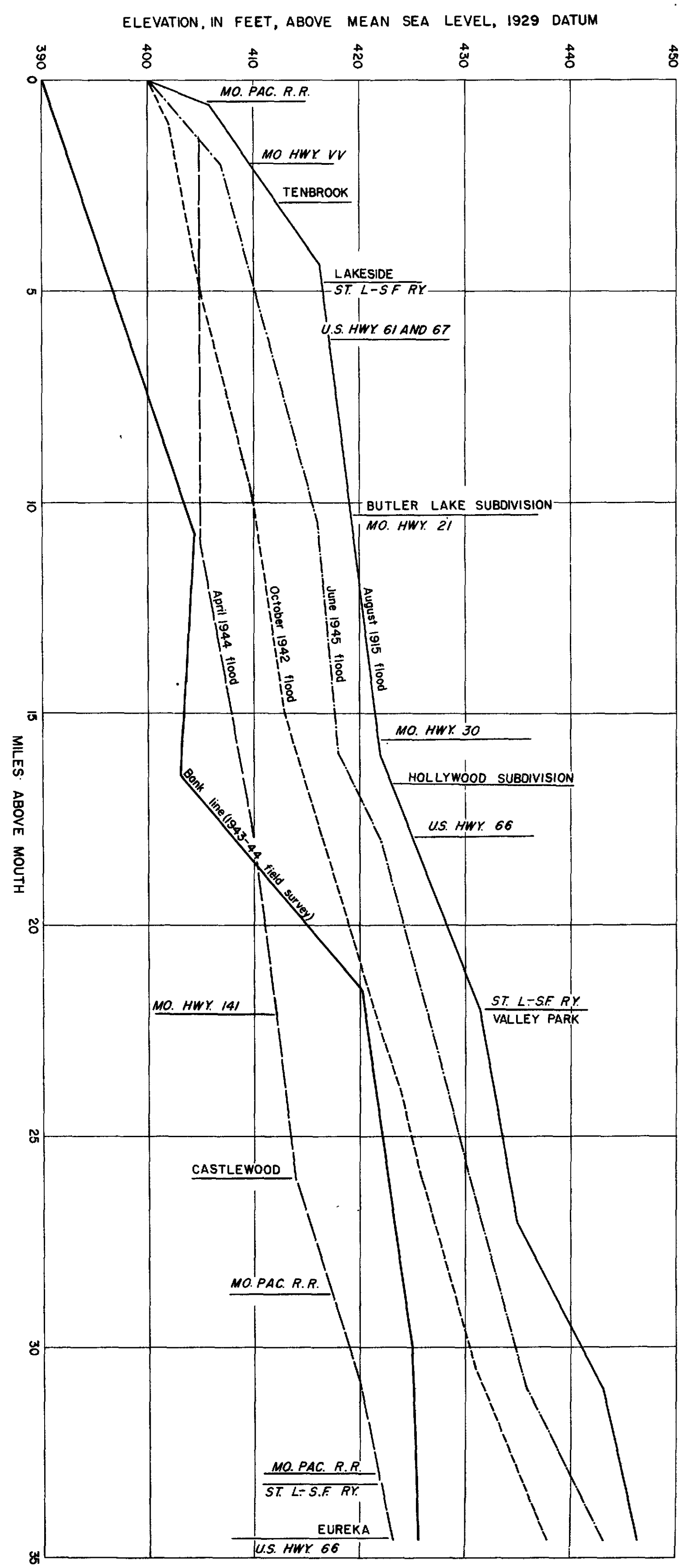

Figure 25. —Water-surface profile for selected floods on the Meramec River, Eureka to mouth.

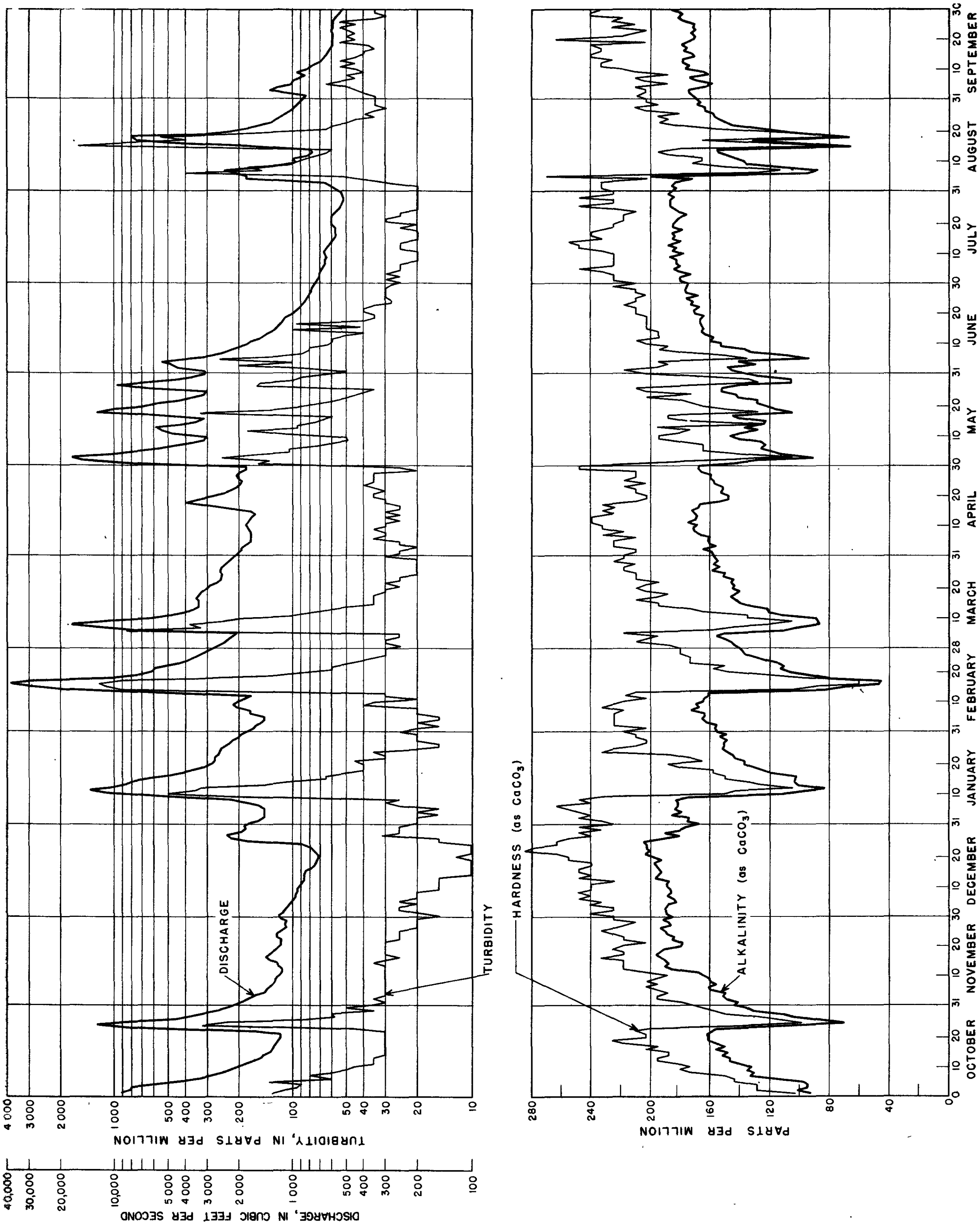

Figure 26. –Relation between streamflow and chemical and physical characteristics of the water, Meramec River at Kirkwood, Mo., 1945-46.

Table 16.—Average monthly chemical and physical characteristics of untreated Meramec River water at Kirkwood, Mo., 1940-46

[Analyses by city of Kirkwood]

Month	Temperature (°F)	Turbidity (ppm)	Alkalinity as $CaCO_3$ (ppm)	Hardness as $CaCO_3$ (ppm)
January	40	42	169	207
February	42	86	152	199
March	50	109	134	169
April	59	143	130	158
May	66	163	124	149
June	76	170	129	154
July	81	54	159	196
August	81	75	158	193
September	74	67	161	195
October	65	56	167	208
November	53	74	158	189
December	43	69	168	198

During the 1946 water year, the water temperature was less than 64 F on about 50 percent of the days but exceeded 82 F on about 10 percent of the days (see fig. 14). The average temperature of 61 F for 1940-46 period was about 4 F higher than the average for the Missouri River at the Howard Bend plant for a comparable period.

Cahokia Creek Basin

Cahokia Creek rises in Montgomery County, Ill., and follows a tortuous course to a point west of Edwardsville where the flow is diverted through the Cahokia diversion channel to the Mississippi River. This diversion was made April 7, 1912. The upper part of the drainage area is moderately rough and undulating and is crossed by a chain of bluffs just north of Poag. The old creek channel below the point of diversion has been improved somewhat and named Cahokia Canal.

Indian Creek enters Cahokia Creek above the point of diversion. The topography of the drainage basin is rolling. Stream channels become narrow and deep as they cut through the high bluffs bordering the flood plain. Some channel improvement and levee construction have been made near the mouth to protect 600 acres. The drainage area above the station at Wanda is 37.0 sq mi.

Canteen Creek enters Cahokia Canal which empties into the Mississippi River just below Eads Bridge. The topography of the drainage basin is somewhat rougher than that of Indian Creek. Some channel improvement and levee construction have been done near the mouth to protect 1,640 acres. The drainage area above the station at Caseyville is 22.5 sq mi.

Long Lake is one of several lakes in the American Bottoms. The drainage basin is flat and swampy and totals 5.0 sq mi above the station at Stallings. The lake drains into Cahokia Canal through Elm Slough.

Discharge.—The average discharge of Indian Creek at Wanda for the 10-yr of record (1940-50) is 32.7 cfs. No flow occurred on many days in 1940, 1941, 1944, and 1948.

The average discharge of Canteen Creek at Caseyville for the 11 yr of record (1939-50) is 19.5 cfs. The minimum discharge of record, 0.04 cfs, occurred August 22, 1941.

The average discharge of Long Lake at Stallings for the 10 yr of record (1939-49) is 2.31 cfs. No flow occurred during the 1941 water year and during long periods of other years. The station was discontinued September 30, 1949.

A streamflow station was operated on Cahokia Creek near Poag from December 13, 1909, to April 6, 1912. The average discharge for the calendar years 1910 and 1911 was 192 cfs. No unusual extremes were noted during the period of operation.

The low-flow characteristics of Indian and Canteen Creeks are shown by a flow-duration curve (fig. 27). The flow-duration curve shows the percentage of the time that a specified daily discharge in cubic feet per second or millions of gallons per day has been equaled or exceeded. It may be considered a probability curve and used to estimate the probability of occurrence of a specified discharge.

Unit hydrographs have been prepared for Indian Creek at Wanda and Canteen Creek at Caseyville (Mitchell, 1948).

Floods.—Records of floods in the Cahokia Creek basin cover the period of streamflow records. The maximum flood of record on Indian Creek at Wanda, for the years 1940-50 was 9,340 cfs on August 15, 1946 (gage height 18.41 ft; 449.93 ft above mean sea level, datum of 1929) and that for Canteen Creek at Caseyville for the years 1939-50 was 10,000 cfs on August 16, 1946 (gage height, 20.54 ft). The maximum flood of record at Long Lake at Stallings occurred on August 18, 1946; the gage height of 7.40 ft (416.53 ft above mean sea level) and the discharge was 121 cfs. This low-peak discharge is partly due to the level terrain and the presence of Long Lake in the area, but is also due to the fact that at high stages part of the runoff from the area spills over the rim of the basin into adjoining basins.

Table 17.—Chemical quality of water from Indian Creek at Wanda, Ill., 1945-50

[In parts per million except flow and temperature; analyses by Illinois State Water Survey Division]

	Flow (cfs)	Temperature (°F)	Turbidity	Iron (Fe)	Manganese (Mn)	Silica (SiO_2)	Ammonium (NH_4)	Sodium (Na)	Calcium (Ca)	Magnesium (Mg)	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Alkalinity as $CaCO_3$	Hardness as $CaCO_3$	Residue
1945																
Oct. 11	5.3	56	30	1.2	0.2	15.0	0.1	5.8	70.7	31.2	6	102.9	5.4	198	306	374
Nov. 18	3.2	48	25	.8	.3	18.5	.0	9.2	72.4	33.2	7	108.4	3.0	212	318	395
Dec. 18	1.4	33	10	.3	.1	18.0	.1	30.6	103.1	49.1	9	150.8	6.3	352	460	582
1946																
Jan. 20	14.6	34	33	.1	.3	13.5	.1	17.7	72.5	33.6	8	125.1	6.1	212	320	409
Feb. 13	860	40	2,000	92.4	.5	11.0	.6	.2	22.7	8.5	3	36.0	2.7	50	96	124
Mar. 4	10.0	54	27	.7	.2	13.5	Tr	18.6	80.6	38.1	7	133.9	6.3	244	358	451
Apr. 11	7.0	49	25	.3	.3	8.0	.1	19.3	77.1	39.5	7	131.4	3.5	248	356	426
May 16	12.2	63	105	1.6	.3	17.8	Tr	24.2	68.9	34.6	9	124.7	6.9	220	315	426
June 17	1.9	82.3	108	2.5	Tr	15.1	Tr	15.4	68.7	34.0	8	102.4	4.0	224	312	406
July 11	.26	79.5	61	1.1	.8	12.5	.1	12.7	74.2	33.9	7	84.5	2.9	252	325	384
Aug. 1	.09	79.5	46	1.1	.9	14.8	.3	7.4	59.0	23.9	5	64.0	1.2	188	246	300
Sept. 6	2.0	74	30	.4	.2	15.7	.1	9.9	73.7	34.8	6	94.2	2.8	240	328	385
Oct. 7	.39	61	75	.5	.3	16.3	.2	2.1	80.0	37.7	6	80.0	1.3	268	356	386
Nov. 4	55	57	130	4.1	.3	20.4	.1	13.3	55.5	22.5	5	89.5	6.0	156	232	302
Dec. 9	18.2	52	65	.5	.2	16.7	.1	12.4	76.4	35.8	5	121.4	4.7	228	338	414
1947																
Jan. 6	9.7	32	30	.5	.2	19.2	.2	22.3	81.7	37.7	8	135.6	5.2	252	360	474
Feb. 3	20	34	51	3.2	.2	19.2	.1	16.6	75.7	32.1	8	123.0	8.0	212	322	411
Mar. 10	8.3	35	29	.8	.3	12.9	.1	14.0	69.2	32.2	6	124.0	3.9	196	306	383
Apr. 7	30	50	205	3.7	.3	17.6	.1	17.7	68.2	27.8	7	118.9	7.9	184	285	393
May 5	20	57	185	1.5	.2	18.5	.1	18.4	70.7	33.3	6	124.9	4.9	212	314	402
June 13	2.8	70	70	1.2	.2	14.4	Tr	10.8	76.4	38.8	7	123.4	4.1	232	351	425
July 2	12.6	69	233	5.6	.5	23.2	.1	9.0	54.8	20.9	6	87.2	9.6	136	223	292
Sept. 16	.0	-	140	3.6	2.1	17.3	.1	7.3	55.4	27.2	6	45.3	4.3	208	251	291
Oct. 5	.0	68	90	2.0	1.2	14.1	.1	3.7	41.4	18.0	3	45.5	3.2	132	178	199
Nov. 8	.19	48	98	2.1	1.0	18.5	Tr	11.3	53.7	22.8	6	83.1	2.6	156	229	293
Dec. 9	.88	38	56	1.4	.4	16.9	Tr	11.0	68.4	31.0	6	106.8	3.6	200	299	385
1948																
Jan. 12	3.0	38.5	Tr	.3	.3	16.9	.1	20.9	73.7	27.4	8	125.1	7.0	196	297	415
Feb. 9	.44	31.5	Tr	.2	.5	17.8	Tr	22.8	84.9	35.5	8	122.8	5.4	264	359	479
Feb. 27	13.8	46	98	2.6	.3	19.7	Tr	23.0	66.7	26.5	8	125.7	6.7	176	276	386
May 18	8.0	65	90	1.4	.4	18.3	Tr	19.8	72.9	30.4	8	138.0	9.2	188	308	428
June 8	1.0	75.5	110	2.9	.9	13.3	.3	7.4	55.0	23.3	8	76.1	5.1	160	233	298
July 10	.49	76	132	2.5	1.0	19.4	.1	9.2	58.0	21.6	5	76.9	4.6	164	234	318

Table 17.—Chemical quality of water from Indian Creek at Wanda, Ill., 1945-50—Continued

	Flow (cfs)	Temperature (°F)	Turbidity	Iron (Fe)	Manganese (Mn)	Silica (SiO_2)	Ammonium (NH_4)	Sodium (Na)	Calcium (Ca)	Magnesium (Mg)	Chloride (Cl)	Sulfate (SO_4)	Nitrate (NO_3)	Alkalinity as $CaCO_3$	Hardness as $CaCO_3$	Residue
1948																
Aug. 19	1.4	77	279	6.7	.5	10.1	Tr	.9	33.1	11.8	6	40.7	3.0	80	-	164
Oct. 4	.01	57	100	1.7	1.8	14.8	Tr	16.3	70.4	27.1	6	67.5	.5	244	288	376
Oct. 13	.39	-	190	2.4	.4	14.4	.2	10.4	41.1	16.1	7	57.2	2.9	122	169	249
Nov. 24	3.5	35	5	.4	.4	18.4	.1	12.2	69.1	30.5	6	109.4	3.8	200	299	369
Dec. 15	9.4	55	306	6.8	.9	10.2	.0	20.2	158.4	22.7	8	106.3	2.2	160	240	335
1949																
Jan. 13	32.	37.5	35	1.4	.0	18.3	.2	12.7	62.6	25.7	7	116.2	8.1	156	265	340
Feb. 11	18.6	38	27	1.2	.4	17.4	.1	6.2	67.9	30.0	6	109.3	6.7	180	293	361
Mar. 9	12.6	43	11	.4	.2	15.7	Tr	20.9	77.7	34.6	8	133.1	5.5	228	337	437
Apr. 21	8.0	51	19	1.0	.4	14.7	Tr	20.5	76.5	35.1	8	141.5	1.7	220	336	455
May 16	2.7	69	34	.3	.4	19.2	Tr	7.4	79.9	37.1	7	111.5	3.3	240	352	394
June 4	2.5	69	66	5.7	.6	16.1	Tr	9.7	85.0	33.9	8	96.9	3.5	232	352	406
June 30	16.3	79	343	6.7	.7	17.9	Tr	12.9	44.9	15.4	8	63.6	3.2	124	176	253
Aug. 2	115	71	950	.7	7.1	10.4	.5	11.3	22.9	7.5	9	24.7	.4	76	88	125
Sept. 6	.30	76	13	.7	1.0	16.2	.4	16.8	69.9	25.2	7	59.6	1.3	240	276	349
Sept. 6	2.2	73	40	1.5	0.0	18.4	0.1	10.4	53.1	20.5	9	73.6	4.5	148	218	271
Nov. 7	3.2	49	9	.8	.2	17.4	Tr	7.6	78.0	35.2	6	109.6	1.8	232	340	394
1950																
Jan. 9	409	40	710	24.9	1.6	9.2	Tr	3.2	26.1	7.5	3	40.7	6.1	52	97	124
Feb. 1	15	37	10	.8	.2	23.8	Tr	8.1	82.4	34.7	6	126.3	8.3	220	349	432
Mar. 9	8.7	34	46	.1	—	19.3	.0	15.0	81.7	34.4	10	128.8	7.5	224	346	429
Apr. 13	16.3	47.5	33	1.1	.3	20.2	.0	19.3	76.2	32.7	14	124.4	7.5	212	325	410
May 4	11.8	69	15	1.4	.2	15.3	.0	19.3	77.9	32.7	7	133.1	3.6	220	330	431
June 8	4.1	75	41	2.1	.3	21.4	Tr	14.5	73.9	31.2	8	103.7	6.8	220	314	405
July 7	1.2	72.5	47	2.4	.7	17.1	Tr	11.0	66.3	30.7	8	85.8	3.7	212	292	365
Aug. 1	.81	78	40	1.0	.7	16.4	Tr	12.7	68.2	34.9	7	77.6	3.4	248	314	382
Sept. 11	2.2	73	106	2.6	.5	17.4	.1	26.7	49.9	19.8	6	59.2	3.3	192	206	312

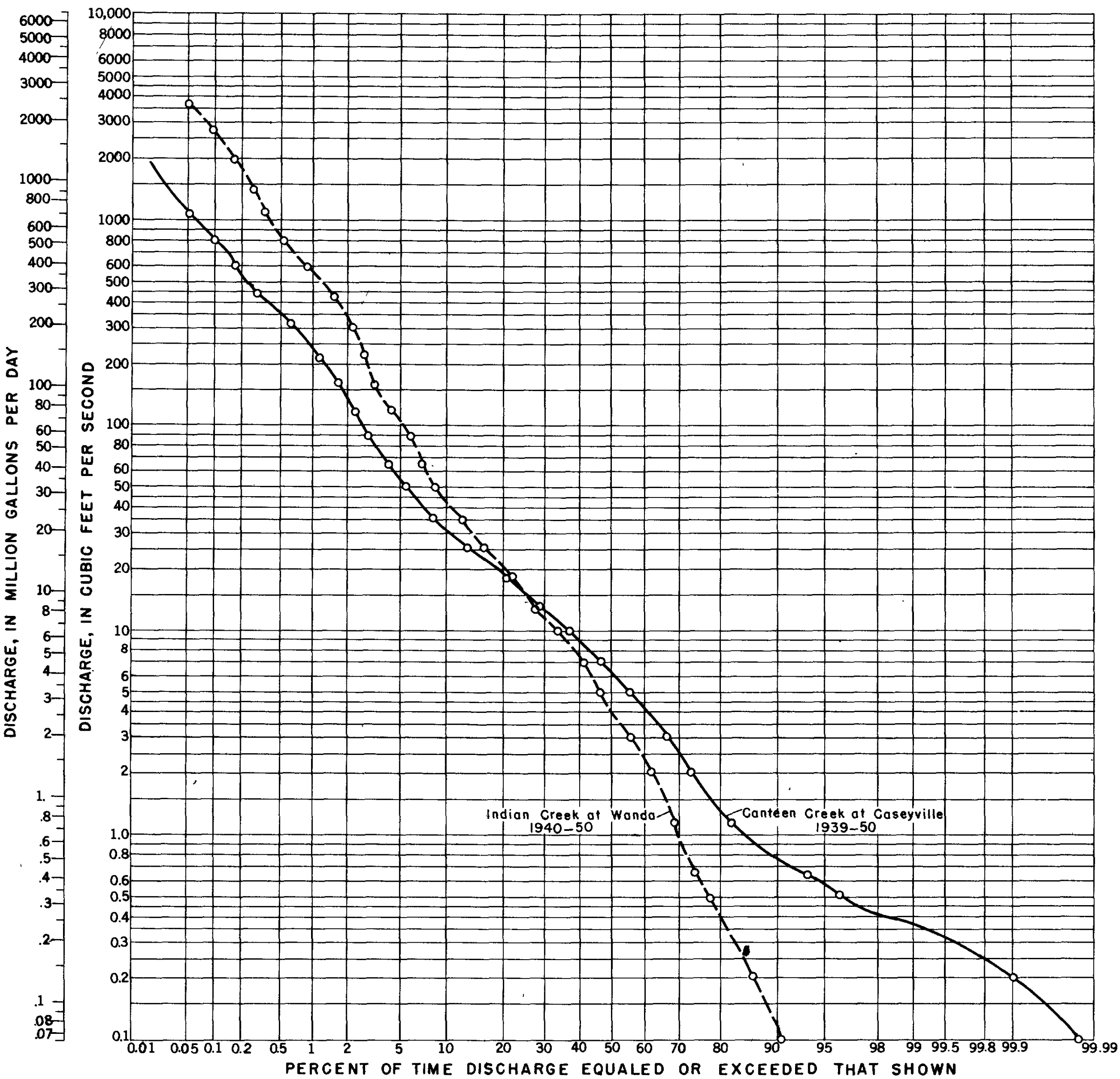

Figure 27.–Duration of daily flows, Cahokia Creek basin.

Quality.–The chemical quality of the waters of Indian Creek at Wanda are probably representative of natural streams that drain the bluffs surrounding the American Bottoms (see table 17). The content of dissolved solids fluctuated through a comparatively narrow range. During the period of October 1945 to September 1950, the dissolved solids (residue) in samples collected monthly ranged from a minimum of 124 ppm at 860 cfs flow on February 13, 1946, to a maximum of 582 ppm at 1.4 cfs flow on December 18, 1945. The hardness of the water was principally of a calcium and magnesium bicarbonate type throughout all creek stages, and the sulfate content was high. During normal and low flows the water was extremely hard and at times exceeded 450 ppm, a figure considerably greater than that observed for the principal rivers in the area. The quantities of chloride and nitrate were low, but the iron and manganese together usually exceeded 1 ppm; and at periods of high runoff, when turbidities were as great as 2,000 ppm or more, the iron content of unfiltered water reached 92.4 ppm.

Water temperatures during the period ranged from near freezing to about 82 F.

Other Streams

Streamflow and chemical-quality data are not available for several small streams in the area.

Among these, in Illinois, are Wood River, tributary to the Mississippi River, 3 1/4 miles below the Alton dam; Schoenberger Creek, a tributary to Cahokia Creek; and Prairie du Pont Creek (canalized) which flows into Cahokia chute at Arsenal Island.

In Missouri, Creve Coeur Creek, draining a rural area, is tributary to the Missouri River near St. Charles. Coldwater Creek draining a mixed rural and suburban area flows into the Missouri River 1 3/4 miles below the Lewis and Clark Bridge. River Des Peres skirts the western and southern edge of the city of St. Louis and flows into the Mississippi River at the southeastern corner of the city. River Des Peres drains an urban area and in its upper reaches the stream flows through a large conduit. It has been canalized below the crossing of the St. Louis-San Francisco Railway. Deer Creek is a tributary to River Des Peres just above the point where canalization begins. Gravois Creek rises in the city of Kirkwood and flows into River Des Peres Canal 1 1/4 miles above the mouth of the canal. An indirect measurement was made of the flood which occurred the night of August 15-16, 1946, on Gravois Creek. The peak discharge at the bridge on Union Road was 6,000 cfs for this 15.6 sq-mi area. There are a few other small streams in the area.

Lakes

Several lakes once existed in the American Bottoms area in Illinois. Some were formed by former river channels. Many of the lakes have been decreased in size or obliterated through drainage or by filling of low areas. Long Lake in the Cahokia Creek basin is probably representative of the larger lakes in the American Bottoms.

In Missouri, Creve Coeur Lake lies on the western edge of the area, and several very small lakes are scattered throughout the area.

In the Alton Lake area are remnants of two oxbow lakes, Maries Temps Clair and Marais Croche.

GROUND WATER

Ground water occurs throughout the St. Louis area, but it is not available everywhere in such quantity or quality as to be an important resource. The nature and relationship of the geologic formations exert an important control over the occurrence, quantity, and quality of ground water.

The entire St. Louis area is underlain by relatively old consolidated rocks (bedrocks). These rocks crop out at a few places in the uplands but generally they are covered by a mantle of fine sand and silt, deposited mostly by the wind. In the alluvial flood plains the consolidated rocks are overlain by alluvium deposited by the streams. This alluvial material in the valleys of the larger streams is the only important source of large quantities of ground water in the St. Louis area.

Consolidated Formations

The consolidated rocks in the St. Louis area consist of layers of limestone, sandstone, and shale. These layers dip in a general northeasterly direction about 50 to 60 ft per mile. The rocks have been compacted and cemented, and have been fractured by earth forces.

Wells in the St. Louis area tapping the consolidated rocks at depths less than 1,000 ft generally yield less than 50 gpm. Deeper wells may yield as much as several hundred gallons per minute. The quality of water from the consolidated rocks differs from place to place. Fresh water is available from shallow depths but information by Gleason (1935) indicates that water from depths more than 1,000 ft will not be suitable for most uses. One well more than 800 ft deep yields salt water having more than 16,000 ppm of dissolved solids. Because of these limitations on quantity or quality of water the consolidated rocks are not considered an important source of good water in the St. Louis area.

Unconsolidated Deposits

Wind-blown deposits.— The upland areas are mantled with unconsolidated deposits chiefly of wind-blown origin. These deposits may be as much as 50 ft thick on the bluffs near the Mississippi and Missouri Rivers but rapidly decrease in thickness away from these streams. The material in the deposits near the Mississippi and Missouri Rivers tends to be coarsest, grading into finer material farther from the streams. Also, the material in the bottom part of the deposits tends to be coarser than that in the upper part.

Many small-capacity wells in the St. Louis area, put down chiefly for domestic use, tapped the more permeable material in the lower part of these deposits. Most of these wells have now been abandoned, particularly at places where water is available from the public supply. These deposits are not important as sources of large quantities of ground water.

Alluvial deposits.—There are five general areas in the vicinity of St. Louis in which the alluvial deposits are of importance as sources of ground water. These areas (see fig. 28) are the American Bottoms, Columbia Bottoms, Alton Lake bottoms, Missouri Valley bottoms, and Meramec River bottoms. There is extensive use of ground water only in the American Bottoms and this is the only area in which there is much detailed information about the nature of the deposits and the occurrence, quantity, and quality of the contained water. The other areas are probably similar in nature to the American Bottoms except as noted.

Natural recharge.—Under natural conditions and during most of the year, recharge to the alluvial deposits is directly from precipitation on the flood plains and on nearer parts of the adjacent uplands. This recharge suffices to keep the water table above stream level and the water moves slowly to the

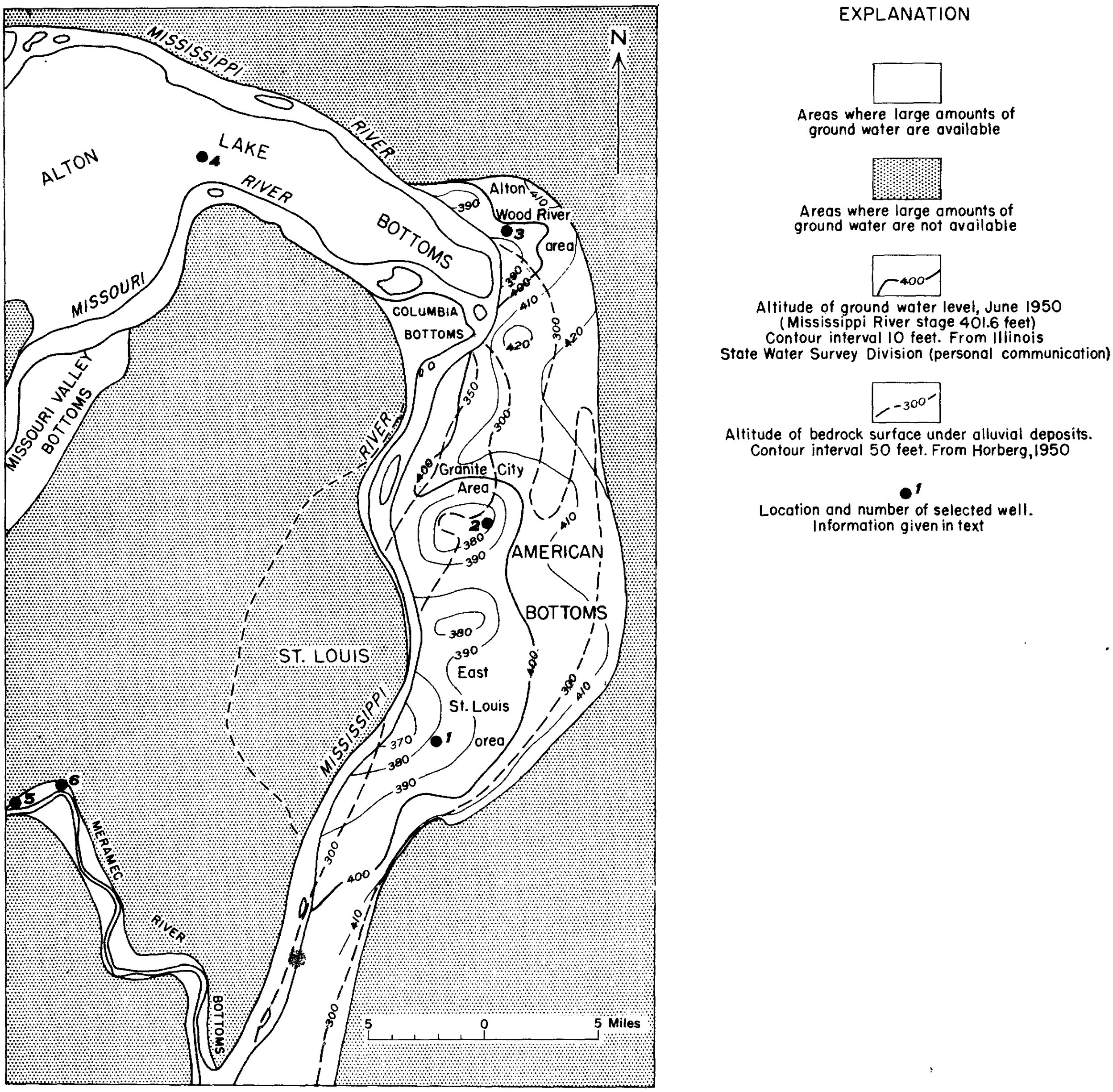

Figure 28.—Map showing areas where large amounts of ground water are available, and other information.

streams and seeps into them. During floods, however, the stream level rises above the adjacent water table and large quantities of water enter the alluvium, especially in areas where the land surface is flooded. Climatic, topographic, and geologic conditions are such that the alluvial deposits in the St. Louis area receive abundant recharge from precipitation and streamflow.

When ground water is withdrawn through a well the water level near the well is lowered. This lowering of the water level causes ground water to move towards the well and tends to increase the amount of water recharged into the material and to decrease the amount of water discharged naturally from it. In addition to the abundant natural recharge from precipitation, recharge may be induced by altering the natural conditions.

Induced recharge.—If large-capacity wells in permeable deposits near major streams, such as in the alluvial deposits near the Mississippi, Missouri, or Meramec Rivers, are pumped heavily, the water level may be lowered so that the natural ground-water flow toward the stream is reversed and water moves from the stream through the deposits to the wells. Under favorable conditions the amount of increased recharge, induced from the stream, may be very large and increase the total yield of the deposits tremendously. When water moves from the stream to the wells, the water from the wells may eventually become similar in chemical quality to the water in the stream. The temperature of the well water will fluctuate more than under natural conditions, but it generally will fluctuate considerably less than the stream temperature. Natural filtration by the material between the stream and the well generally removes all suspended matter and bacteria and some of the objectionable tastes and odors.

This principle of locating large-capacity wells in permeable material near large streams and inducing infiltration from the stream has been used successfully at many places and has been particularly successful in the Ohio River Valley. In the American Bottoms recharge induced from the Mississippi River probably maintains the yields of some of the large-capacity wells. In the Meramec River bottoms the large-capacity well at Kirkwood probably receives water from the Meramec River. Geologic conditions indicate that this procedure would be successful in maintaining large yields from wells in the alluvial deposits near the Mississippi, Missouri, and Meramec Rivers.

American Bottoms.—The American Bottoms is in Illinois, across the Mississippi River from St. Louis (see fig. 28). It is an elongated area bordering the east bank of the river and extending from Alton, Ill., southward beyond the boundary of the area considered in this report. The average width is about 6 miles and the maximum width is about 11 miles. The American Bottoms is the former flood plain of the river. Available data show that its surface is fairly flat but has a slight general slope to the south. Contours on the bedrock under the alluvium indicate that the bedrock floor under the bottoms is fairly flat but that it has more relief than the present surface. The alluvial deposits in the American Bottoms average about 115 ft thick and have a maximum thickness of about 180 ft.

The alluvial material was deposited largely by the Mississippi River and consists of clay, silt, sand, and gravel. Over a considerable part of the bottoms the material near the surface consists of fairly impermeable clay and silt, but at some places the upper material consists of fairly permeable silt and sand. The underlying material down to bedrock consists of beds of fairly well sorted sand and gravel interbedded with layers of silt and clay. The material in the lower part of the deposit generally is quite permeable and the more permeable deposits seem to be interconnected.

Selected well logs, believed to show typical alluvial material in the American Bottoms, are given in table 18. The locations of these wells are shown in figure 28.

The earliest wells in the American Bottoms were probably shallow dug wells. However, in the early 1900's, as industrial development began, cased wells with strainers were put down to depths as great as 170 ft. In 1907 there were about 70 industrial wells and by 1950 there were about 250. The depths of the industrial wells range from about 70 to 177 ft. Yields of tubular wells range from 100 to 2,000 gpm, depending on size, construction, location, and age. Special wells having slotted pipes projecting radially from the bottom of a caisson have reported yields as large as 7,000 gpm (10 mgd).

The total rate of pumping of ground water in the bottoms is estimated to have been 90 mgd in 1944. The rate in 1950 is estimated by the Illinois Water Survey Division to have been about 100 mgd. Most of the water is obtained from three centers of pumping in the American Bottoms. They are the Alton-Wood River area near the northern end of the American Bottoms, having a daily rate of pumping of about 30 million gallons; the Granite City area, having a daily rate of about 25 million gallons; and the East St. Louis–Monsanto area just across the river from St. Louis, in which the daily rate of pumping is about 35 million gallons. The general locations of these areas are indicated on figure 28.

Before 1905 the water level was near the land surface, its position depending on the local topography and the condition of the surface drainage. The hydraulic gradient was toward the river, except during floods. Subsequently, water levels in much of the area have been lowered as a result of land drainage. Also, local cones of depression have appeared in the main areas of pumping where the water levels have been lowered as much as 20 or 30 ft. Contours, showing the altitude of the water level on June 1, 1950, and showing these cones of depression, are shown on figure 28. Available information shows that there has not been a significant lowering of the water level in the last 5 or 6 yr, even though the rate of pumping is reported to have increased by about 10 mgd. The direction of ground-water flow is still toward the Mississippi River except at some places between the areas of heavy pumping and the river.

The relation between the water level in the alluvium (well 3, fig. 28) and river stage is shown in figure 29. The relationship for the years 1946-47 is particularly important because it shows that there is a hydraulic connection between the alluvium and the river and that water can move from the alluvium into the river or in a reverse direction.

The present rate of pumping in the American Bottoms certainly is much less than the maximum that can be obtained from this area, although there are so many unknown factors and possible variations of conditions that an estimate of the maximum yield cannot be made at this time.

Considerable quality-of-water data are available for wells in the American Bottoms between Dupo and Alton. The quality of water obtained from these wells differs greatly from place to place. The concentration of dissolved solids for samples collected chiefly in 1943 and 1944 ranged from 246 ppm to more than 3,300 ppm, and hardness ranged from 157 ppm to more than 2,980 ppm. Hardness and dissolved solids for 80 representative waters in the area are illustrated in figure 30. No particular quality grouping is observed, and more than 20 percent of the wells yield water that exceeds 800 ppm in hardness. The concentration of dissolved solids in approximately 30 percent of the plotted samples equaled or exceeded 1,000 ppm. Troublesome quantities of iron are usually found in the untreated ground water. With few ex-

Table 18.—Logs of selected wells in the St. Louis area

Well 1

[Location: Valley Junction, Ill. Source of data: Illinois State Geological Survey Division]

	Thickness (feet)	Depth (feet)
No samples (probably alluvial silt)	5	5
Sand, gray, medium, well-sorted, clean, calcareous	21	26
Sand, fine, and silt, yellow-gray, very organic, dirty, calcareous	4	30
Sand, yellow, medium-coarse, clean, slightly calcareous	8	38
Same as preceding, and fine gravel, noncalcareous	10	48
Sand, yellow, fine to medium, sorted, clean, calcareous	6	54
Sand, yellow-gray, medium to coarse, poorly sorted, dirty, calcareous, interbedded with silt	9	63
Sand, yellow-gray, medium-coarse, mostly clean, calcareous, interbedded with noncalcareous silt	14	77
Sand, yellow, medium to coarse, clean, partly calcareous	3	80
Sand, yellow, medium, well-sorted, and granule gravel, clean, calcareous	6	86
Gravel, yellow, fine to medium, clean, calcareous	14	100
Gravel and sand, yellow, pebbles as large as $1\frac{1}{2}$ in.; sand, coarse, very clean, calcareous	6	106
Top of limestone estimated at depth of 110 to 120 ft		-

Well 2

[Location: Granite City, Ill. Source of data: Illinois State Geological Survey Division]

	Thickness (feet)	Depth (feet)
Cinders	1.5	1.5
Gumbo	1.5	3
Clay, yellow	4	7
Sand, yellow	7	14
Sand, blue, fine (water level)	3	17
Clay, blue	5	22
Sand and clay	11	33
Sand, blue	18	51
Clay, blue	4	55
Sand, coarse	17	72
Sand, fine	6	78
Sand and boulders	2	80
Sand, coarse, and boulders	21	101
Sand and gravel	7	108
Sand, coarse, and boulders	3	111
Sand, gravel, and boulders	3	114

Well 4

[Location: Machens, Mo. Source of data: St. Louis Chamber of Commerce]

	Thickness (feet)	Depth (feet)
Open pit	3	3
Sand, clean, brown	11	14
Sand, fine, mucky	26	40
Sand, some gravel	12	52
Sand, coarse, and gravel	11	63
Sand, fine, gray	3	66
Sand and some coarse gravel	10	76
Sand, coarse, and gravel	9	85

Well 5

[Location: Valley Park, Mo. Source of data: Layne Western Co.]

	Thickness (feet)	Depth (feet)
Surface fill	7	7
Soil, black	4	11
Clay, yellow	14	25
Clay, sandy, blue	13	38
Gravel, coarse	6	44
Sand, medium	1	45
Sand, coarse and extremely coarse gravel	18	63

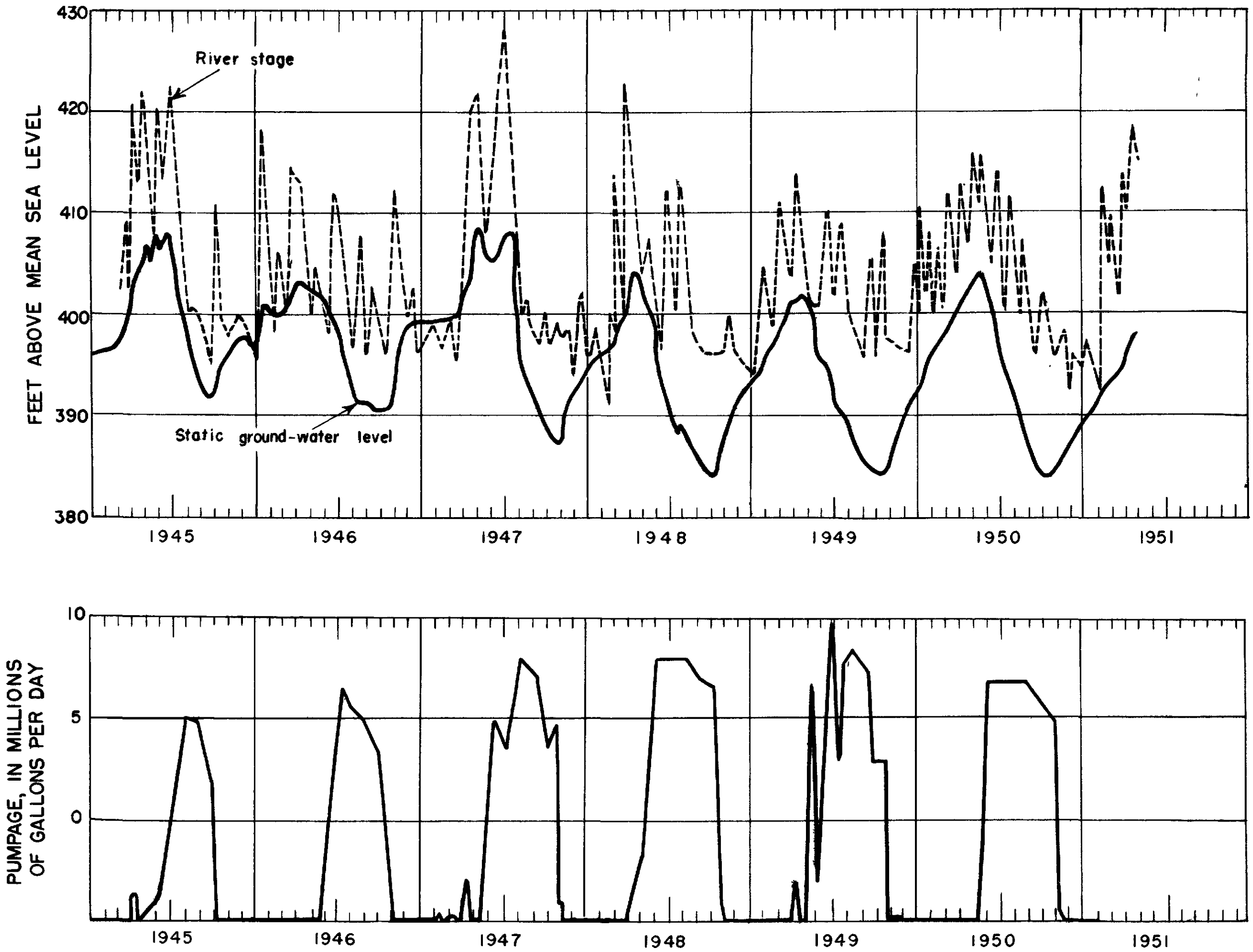

Figure 29.—Relation between ground-water levels in well 3 and Mississippi River stage and pumpage at Standard Oil Co. plant at Wood River, Ill.

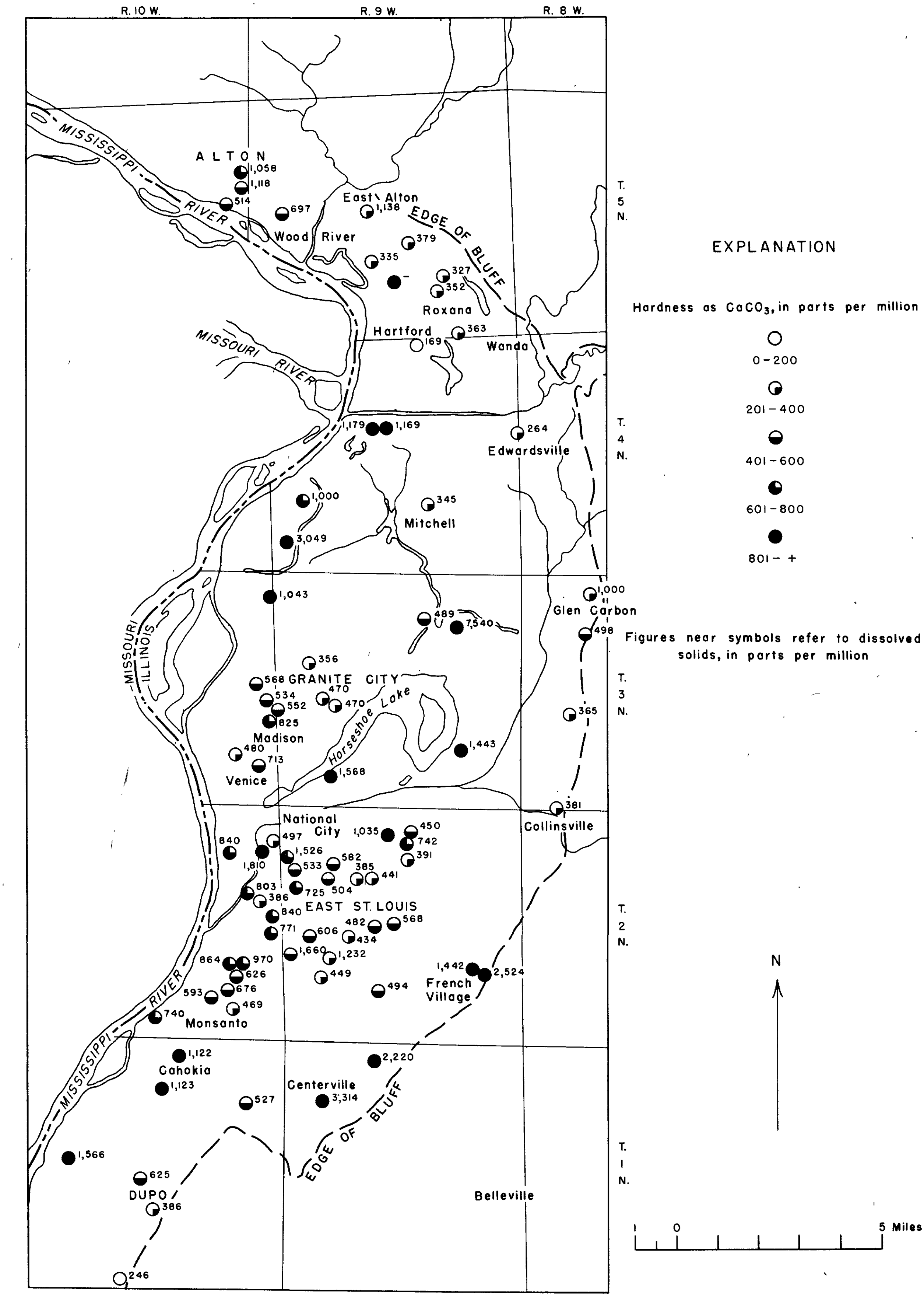
R. 10 W.
R. 9 W.
R. 8 W.
T. 5 N.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
MISSISSIPPI RIVER
MISSOURI RIVER
MISSOURI ILLINOIS
EDGE OF BLUFF
ALTON
East Alton
Wood River
Roxana
Hartford
Wanda
Edwardsville
Mitchell
Glen Carbon
GRANITE CITY
Horseshoe Lake
Madison
Venice
Collinsville
National City
EAST ST. LOUIS
French Village
Monsanto
Cahokia
Centerville
DUPO
Belleville
1,058
1,118
514
697
1,138
379
335
327
352
363
169
1,179
1,169
264
1,000
345
3,049
1,043
489
7,540
1,000
498
356
568
534
552
825
470
470
365
480
713
1,443
1,568
381
497
1,035
450
742
840
1,526
582
391
1,810
533
385
441
803
725
504
386
840
482
568
771
606
434
1,660
1,232
864
970
626
1,442
2,524
593
676
449
494
469
740
1,122
2,220
1,123
527
3,314
1,566
625
386
246
EXPLANATION
Hardness as CaCO3, in parts per million
0-200
201-400
401-600
601-800
801- +
Figures near symbols refer to dissolved solids, in parts per million
N
1 0 5 Miles

Table 19.—Chemical quality of selected municipal ground-water supplies in the American Bottoms

[In parts per million except temperature and odor; analyses by Illinois State Water Survey]

	Collinsville, Ill. 1/	Edwardsville, Ill. 2/	Glen Carbon, Ill. 3/	Hartford Village, Ill. 4/	
				Untreated	Treated
Silica (SiO_2)	29.8	27.1	23.8	36.4	-
Iron (Fe)	.3	2.8	3.0	10.3	0.1
Manganese (Mn)	.3	.3	.2	.6	-
Calcium (Ca)	103.5	59.9	162.8	131.6	-
Magnesium (Mg)	39.3	15.0	69.1	32.9	-
Sodium (Na)	7.6	-	22.5	11.5	-
Ammonium (NH_4)	Tr	.1	.2	.3	-
Alkalinity (HCO_3)	288	144	352	352	88
Sulfate (SO_4)	123.6	51.8	337.1	114.8	-
Chloride (Cl)	11	5.0	27	13	15
Fluoride (F)	.4	.5	.4	.2	.4
Nitrate (NO_3)	6.1	8.1	.2	.5	-
Dissolved solids	521	264	867	566	255
Hardness as $CaCO_3$)	421	211	691	464	204
Color	0	0	0	0	0
Turbidity	2	13	30	94	0
Temperature °F	-	57.5	57.5	57	-
Odor	0	0	0	0	-
Date of collection	12-3-48	12-3-48	12-3-48	12-7-48	

1/ Composite of wells 1, 2, and 4; no treatment.
2/ Well 2; water chlorinated.
3/ Treatment plant not in operation.
4/ Well 2; water is aerated, softened, and chlorinated.

ceptions, iron exceeds 1.0 ppm. Temperatures generally ranged from 55 to 62 F. The quality of ground water in the area is shown by analyses of water from the municipal wells serving Collinsville, Edwardsville, Glen Carbon, and Hartford Village (table 19).

Columbia Bottoms.—Columbia Bottoms is an 8 sq-mi area, roughly square, lying north of St. Louis, west of the Mississippi River, and south of the Missouri River at the confluence of the two streams (see fig. 28). A narrow strip of bottom land, averaging less than a mile in width, extends from the Columbia Bottoms southward along the west bank of the Mississippi River for a distance of about 10 miles.

There are few wells in the relatively undeveloped Columbia Bottoms, and information about the water-bearing material and ground-water conditions is very meager. The information indicates that the alluvial material is about 115 ft thick. The material probably is very similar to that in the American Bottoms.

Alton Lake bottoms.—Alton Lake bottoms is used in this report to designate the flood-plain area north of St. Louis and lying between the Mississippi River and the Missouri River (see fig. 28). The Alton Lake bottoms extend from the confluence of the Mississippi and Missouri Rivers westward beyond the limit of the area of this report.

Only a few wells have been developed in this area. The log of a railroad company well at Machens, Mo., (see fig. 28) is given in table 18.

The available information shows that the alluvial material is similar to that in the Columbia Bottoms and the American Bottoms. There is variability from place to place in the thickness and the permeability of the alluvial deposits.

Available quality-of-water data for the Alton Lake bottoms are limited to a single analysis of the railroad company well at Machens. An abridged analysis of that water is as follows:

Temperature	69 F
Specific conductance at 25° C	468 micromhos
Iron (Fe)	.08 ppm
Sulfate (SO_4)	41 ppm
Total hardness as $CaCO_3$	221 ppm
Dissolved solids	286 ppm

It is expected that the excessive hardness and iron observed in untreated water from shallow wells in the American Bottoms will also characterize most shallow ground water in this area.

Missouri Valley bottoms.—The Missouri Valley bottoms is the alluvial flood-plain area bordering the Missouri River west of St. Louis. Only the eastern end of this area is shown on figure 28, but the area extends westward for many miles. There are no large-capacity wells in the St. Louis area but at Weldon Springs, which is north of the mouth of the Missouri River and about 11 miles west of St. Charles, there are 13 large-capacity wells in a 344-acre tract which supply water from the alluvium at a rate of more than 44 mgd. It is reported that a constant water level was maintained in the wells tested after an initial drawdown of slightly more than 2 ft.

The scant geologic evidence available indicates that the alluvium of the Missouri Valley bottoms is similar in thickness and character to that in the Alton Lake bottoms.

Analyses of water from several wells at the Weldon Springs Ordnance Plant reveal the characteristically hard, iron-bearing water observed in other alluvial deposits in the St. Louis area. Well 4 at the ordnance plant yields water of the following concentration of constituents:

	ppm
Silica (SiO_2)	35
Iron, soluble (Fe)	6
Manganese (Mn)	0.5
Calcium (Ca)	133
Magnesium (Mg)	13.2
Sodium (Na)	6.5
Bicarbonate (HCO_3)	585
Sulfate (SO_4)	0
Chloride (Cl)	5
Fluoride (F)	0.5
Hardness as $CaCO_3$	386
pH	7.2

Meramec River bottoms.—The Meramec River bottoms are a band of alluvial deposits in the valley of the Meramec River a few miles southwest of St. Louis. The river crosses and recrosses these deposits dividing them into a series of bottom-land areas. These areas are considerably smaller than the bottom-land areas of the Mississippi and Missouri Rivers. Also, in general, the alluvial deposits of the Meramec River Valley are not as thick. The log of a well showing the type of material in the alluvial deposits of the Meramec River is given in table 18 (see fig. 28).

A radial-screened well in the Meramec River Valley at Kirkwood (well 6 on fig. 28) has a dependable capacity estimated at 8 mgd. However, it is believed that wells in the Meramec River Valley probably will not have yields as large as those of similar wells in the alluvium of the Mississippi or Missouri Rivers.

Table 20.—Chemical quality in treated and untreated water from Meramec River bottoms

[In parts per million except color, pH, and conductance; analyses by city of Kirkwood]

	Untreated	Treated
Silica (SiO_2)	11	9.2
Iron (Fe)	.03	.02
Manganese (Mn)	.00	.00
Calcium (Ca)	65	21
Magnesium (Mg)	26	18
Sodium (Na)	21	20
Potassium (K)	1.8	1.0
Carbonate (CO_3)	0	18
Bicarbonate (BCO_3)	239	36
Sulfate (SO_4)	61	65
Chloride (Cl)	41	31
Fluoride (F)	.0	.1
Nitrate (NO_3)	1.3	1.0
Dissolved solids	420	244
Hardness as $CaCO_3$:		
Total	267	128
Noncarbonate	71	68
Color	2	2
pH	7.2	9.5
Specific conductance (micromhos at 25 C)	585	373
Turbidity	3	.2
Date of collection	4-14-51	4-14-51

Table 21.—Chemical quality of untreated and treated waters, Meramec River bottoms

[Untreated water except as noted. Analyses by city of Kirkwood]

Year	Temperature (°F)	Turbidity	Alkalinity as $CaCO_3$ (ppm)	Hardness as $CaCO_3$ Untreated (ppm)	Hardness as $CaCO_3$ Treated (ppm)	pH Untreated	pH Treated
1948	58	1.4	200	278	165	6.6	9.0
1949	-	3.2	217	330	153	6.7	9.1
1950	58	1.8	206	278	120	6.6	9.4

Water pumped from the radial-type well owned by the city of Kirkwood is clear and cool and generally is somewhat harder than the river water. The turbidity of the untreated water is seldom more than a few parts per million, and the temperature ranges from 55 to 61 F during the year. The alkalinity and hardness remain fairly uniform throughout the year except during the spring and summer, at which time the hardness of the untreated water tends to decrease somewhat. Analyses of the untreated and treated water are shown in table 20.

A summary of averages for treated and untreated water at Kirkwood for the period of operation 1948-50 is given in table 21.

PUBLIC WATER-SUPPLY SYSTEMS

St. Louis Municipal Supply

About two-thirds of the water supply of the city of St. Louis is obtained from the Mississippi River and about one-third from the Missouri River. Plants are located at Chain of Rocks on the Mississippi and Howard Bend on the Missouri (see fig. 31). The total filtration capacity of the two plants is 240 mgd. The pumping capacity is somewhat higher. Average daily water consumption has increased from about 63 mgd in 1900 to 157 mgd in 1950. Per capita consumption has changed from about 110 gpd to 175 gallons per day during the same period. The percentage of the total water metered at the manufacturer's rate varied from 18.6 to 23.6 percent and averaged 21.5 percent for the period 1944 through 1950.

The treatment at the Howard Bend plant includes presedimentation, softening with lime, coagulation with iron sulfate, sedimentation, coagulation with aluminum sulfate, primary disinfection with ammonium hydroxide and chlorine, filtration, and final disinfection with chlorine. This treatment accomplishes a a remarkable reduction in average turbidity to less than 0.1 ppm and an average reduction in hardness to about 100 ppm (see table 6).

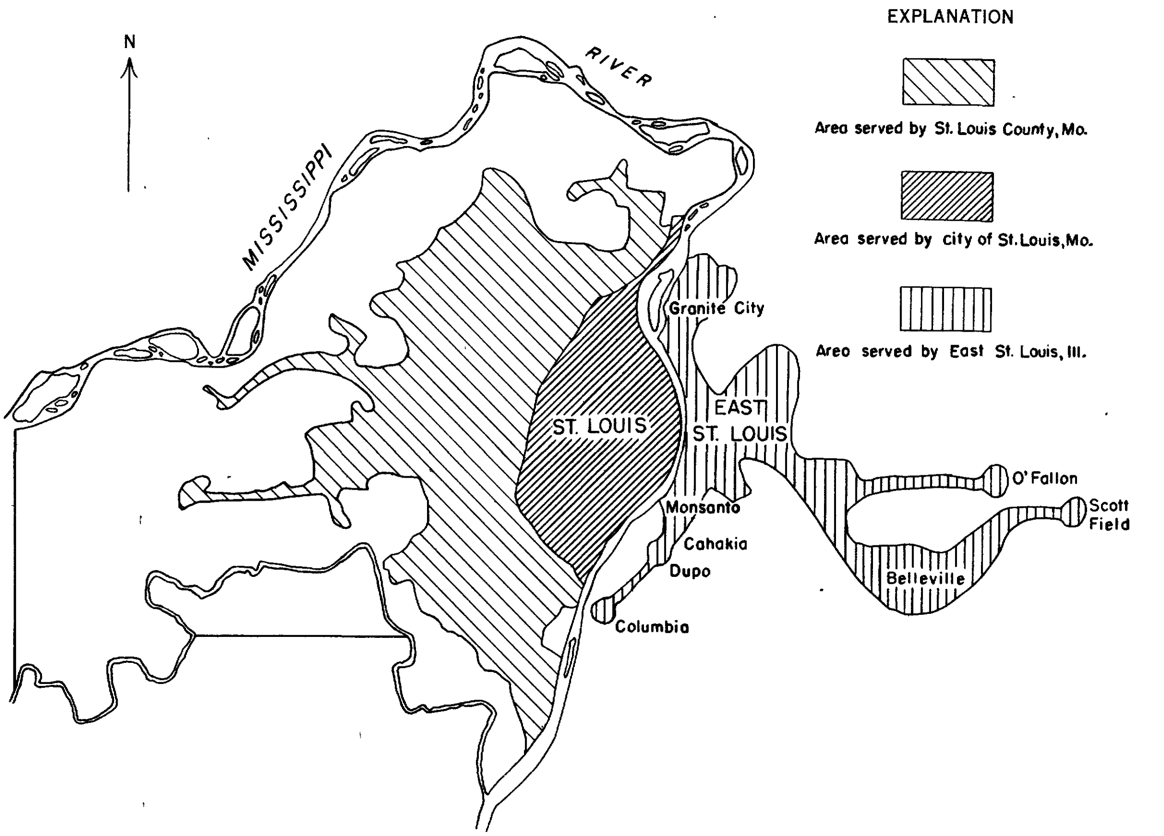

Figure 31. -Territory served by the major water-supply systems in the St. Louis area.

St. Louis County, Mo.

The St. Louis County Water Co., University City, Mo., supplies water to a large part of St. Louis County (see fig. 31). The 80 incorporated municipalities served include all of the municipalities in St. Louis County except the cities of St. Louis, Kirkwood, and Valley Park. A large amount of unincorporated territory is also served by the St. Louis County Water Co. The total population served is approximately 350,000.

The St. Louis County Water Co. obtains its water from the Missouri River at a point 14 miles west of the city of St. Louis. The capacity of the filtration plant is about 45 mgd. The average daily plant output of the St. Louis County Water Co. and its predecessor (prior to 1926), the West St. Louis Water and Light Co., has increased from about 1 1/4 mgd in 1909 to more than 27 1/4 mgd in 1950. The per capita consumption in 1949 was about 74 gpd. It is estimated that approximately 15 percent of the total water supply is used for industrial purposes. The river water is completely treated including removal of about half of the hardness present in the river water. The treatment differs somewhat from that at the Howard Bend plant, but the hardness, alkalinity, turbidity, and temperature characteristics of the treated water are similar.

Kirkwood, Mo.

The city of Kirkwood obtains its water from a well having slotted pipes projecting radially from the bottom of a caisson. The well is about 60 ft north of the north bank of the Meramec River. It collects some infiltrated river water and a larger percent of ground water. The plant capacity is 2.3 mgd. There is no industrial water use in the city. The average daily plant output has increased from 0.463 mgd in 1932 to 1.343 mgd in 1950. The 1950 per capita water consumption is about 72 gpd. Treatment consists of aeration, softening with quick lime, prechlorination, mechanical flocculation, sludge removal, settling, filtration, and postchlorination.

St. Charles, Mo.

The city of St. Charles obtains its water from the Missouri River. The plant output was 1 1/4 mgd in 1950 and the plant capacity is 2.2 mgd. About 18 percent of the municipal supply is used for industrial purposes. The treatment differs somewhat from that at the Howard Bend plant, but the hardness, alkalinity, turbidity, and temperature characteristics of the treated water are similar.

Valley Park, Mo.

The city of Valley Park obtains its water from wells. The plant output is 75,000 gpd and the plant capacity is 720,000 gpd. The water is purified and disinfected.

East St. Louis and Interurban Water Co.

The East St. Louis and Interurban Water Co. supplies most of the treated water used by industrial plants and communities in the American Bottoms. It serves East St. Louis, Alorton, Belleville, Brooklyn, Cahokia, Fairmont City, Granite City, Madison, Monsanto, Nameoki, National City, Swansea, Venice, and Washington Park and sells water wholesale to Caseyville, Columbia, Dupo, O'Fallon, Pearl Harbor, Shiloh, and Scott Field (see fig. 31).

The East St. Louis and Interurban Water Co. obtains its water from the Mississippi River at Chouteau Island almost opposite the Chain of Rocks intakes of the St. Louis municipal supply. River water enters settling tanks where most of the sediment is removed. Suspended materials are removed by coagulation with lime alum, and the water is disinfected by prechlorination, filtration, ammoniation, and postchlorination. The water is not treated for hardness. The filtration capacity of the plant is 38 mgd. The average daily plant output has increased from slightly more than 20 mgd in 1927 to about 29½ mgd in 1950. About 54 percent of the total water supply is used for industrial purposes.

Alton, Ill.

The city of Alton receives its supply from the Mississippi River. The average plant output was 6.66 mgd in 1950. Treatment at the Alton plant consists of coagulation with alum, softening with lime and soda ash, rapid sand filtration, and postchlorination.

Collinsville, Ill.

Collinsville obtains an estimated 1.7 mgd from three wells in the American Bottoms about 1 1/4 miles west of Collinsville. The water is not treated.

Edwardsville, Ill.

Edwardsville obtains an estimated 0.9 mgd from three wells in the American Bottoms. All water is chlorinated.

Wood River, Ill.

Wood River obtains an average of 0.69 mgd from four wells and has a fifth well for emergency use. The water is chlorinated but not otherwise treated.

Roxana, Ill.

Roxana uses an average of about 0.60 mgd from three wells. The water is treated for iron removal.

East Alton, Ill.

East Alton uses an average of 0.321 mgd from wells owned by the Western Cartridge Co. The water is chlorinated.

Hartford, Ill.

Hartford uses an average of 0.085 mgd from two wells. The water is aerated, softened, and chlorinated.

Glen Carbon, Ill.

Glen Carbon uses an average of 0.012 mgd from one well in the American Bottoms about 1 1/4 miles southwest of Glen Carbon. The water receives intermittent treatment.

WATER DEMANDS

The area provides many places where a combination of surface and ground water might be advantageously used for cooling purposes. Surface water might be used during the cooler months and ground water during the summer months to provide large quantities of cool water. This combination is used by one of the refineries in the area.

The principal surface-water supplies in the area are those of the city of St. Louis, the East St. Louis and Interurban Water Co., the St. Louis County Water Co., the city of Alton, Anheuser-Busch, Inc., the Western Cartridge Co., and the city of St. Charles. The Western Cartridge Co. supplies water for the city of East Alton from its ground-water supply.

Ground-water supplies are used by many industrial plants in the Illinois part of the area and by the municipalities of Kirkwood and Valley Park, Mo., and East Alton, Hartford, Edwardsville, Collinsville, Glen Carbon, Roxana, and Wood River, Ill. Ground water is used also for rural supplies and by residents of some of the smaller communities not having water systems.

Public Water Supplies

More than 97 percent of the water used for public supplies is from surface sources; however, ground-water sources are used by far more than half of the public supplies. The areas served by the major water companies are shown in figure 31. Table 22 shows the use of water for public supplies:

Table 22.–Use of water, in million gallons per day, for public supplies in the St. Louis area (1950)

Surface sources:	
St. Louis city	157
St. Louis County	27.2
St. Charles	1.25
East St. Louis	29.5
Alton	6.66
Total	221.61
Ground-water sources in Missouri:	
Kirkwood	1.34
Valley Park	.075
Total	1.415
Ground-water sources in Illinois:	
Collinsville	1.7
Edwardsville	.9
Wood River	.69
Roxana	.6
East Alton	.321
Hartford	.085
Glen Carbon	.012
Total	4.308
Total ground-water sources	5.723
Grand total	227.333

Private Industrial Water Supplies in Missouri

Most of the water used by industry on the west bank of the Mississippi River is purchased from either the city of St. Louis or the St. Louis County Water Co. In the year ending April 10, 1950, the largest consumer in St. Louis at regular rates used an average of 1.195 mgd and the largest consumer at the manufacturing rate used an average of 4.69 mgd.

Only four private industrial supplies are found in the Missouri part of the St. Louis area. Anheuser-Busch, Inc., has a filter plant and obtains water from the Mississippi River for boiler-feed water, washing, cooling, and other plant purposes to supplement water purchased from the city of St. Louis. The plant capacity is about 7 mgd and the average daily pumpage since 1938 has ranged from about 2½ mgd in 1940 to more than 5 mgd in 1950.

The Union Electric Co. uses an average of 36 mgd of untreated Mississippi River water for condenser cooling in its Ashley Street steam-power plant and an average of 44 mgd in its Mound Street plant.

Near the western edge of the area the American Car and Foundry Co. at St. Charles withdraws an average of about 0.5 mgd from the Missouri River.

Private Industrial Water Supplies in Illinois

Several private industrial supplies have been developed in the American Bottoms. Most of these supplies are obtained from wells. The Granite City Steel Co. completed a 13-ft-diam high-capacity well at Granite City in 1948. This well has a capacity of 20 mgd and the normal withdrawal is about 10 mgd. Another plant uses several wells to obtain a supply in excess of 8½ mgd.

The Standard Oil Co.'s Wood River refinery uses 7 to 15 mgd of Mississippi River water during about 6 months of the year to conserve its ground-water supply. The Western Cartridge Co. at East Alton pumps an average of 1.095 mgd from wells and since July 1941 has operated a 6-mgd filter plant using Mississippi River water. East Alton's water supply is included in the pumpage given for the Western Cartridge Co.

Several steam-power plants in the area use cooling water, as follows: The Cahokia plant at Monsanto uses an average of 300 mgd of untreated Mississippi River water. The water is returned to the river after use.

Venice plants 1 and 2 at Venice use an average of 570 mgd of untreated Mississippi River water, which is returned to the river after use.

The Granite City plant, Granite City, uses an average of 8.6 mgd. The water is obtained from wells and about 8 mgd is discharged to the river after use.

Rural Water Supplies

Much of the rather small rural population of the area is supplied by the developed water supplies previously described. Other demands are readily met by ground water, except for some places in St. Louis County, where only small and inadequate supplies of fresh ground water are available. In some places the ground water of St. Louis County is too highly mineralized for domestic use.

Recreation

Streams utilized for recreation are the Mississippi River, particularly in the navigation pool above Alton, Ill., and the Meramec River. Opposite the Chain of Rocks are many sand bars that entrench clear water and are popular bathing places for residents on both sides of the river.

The Meramec River is navigable for small craft for about 21 miles above its mouth. It was once considered navigable for 182 miles above the mouth. The Meramec River Valley has become increasingly popular for vacationers, picnickers, and water-sports enthusiasts. In recent years a large number of cabins and homes have been built along the stream. Recreational demands do not conflict with other demands except as they might raise the stream sanitary classification and thereby reduce the amount of waste that may be discharged to the stream.

POTENTIALITIES

Surface Water

The St. Louis area uses for all purposes less than 1 percent of its average available surface-water supply. A large part of the water demand is for cooling purposes in the steam-power plants of the area. Cooling water used by the power plants is immediately returned to the river with only a slight rise in temperature and is available for reuse. Exclusive of the water demand for steam-power plants, the water demand of the St. Louis area is less than 0.4 percent of the available surface supply. Part of the surface water used for purposes other than power production is returned to the streams in the sewers and the discharge from industrial plants. The minimum daily flow of the Mississippi River at St. Louis, on December 12, 1937, was 16.6 percent of the average flow. On this day, after supplying almost all of the consumptive surface-water needs of the area, the flow was 27,600 cfs. The current needs of the three major water-supply systems, St. Louis, St. Louis County, and East St. Louis, are for 332 cfs. The minimum flows occur during the winter because most of the precipitation falls as snow and therefore does not become part of the streamflow until spring. The winter is also the time of minimum water demand. Thus an almost unlimited water demand can be met from the available surface-water sources.

Much additional demand for surface water can be met without expanding existing facilities. For example, the capacity of the St. Louis municipal water supply exceeds present demands by about 80 mgd; that of the St. Louis County Water Co. exceeds present demands by about 18 mgd; and that of the East St. Louis and Interurban Water Co. exceeds present demands by about 8½ mgd. The three major water systems in the area have always been expanded to meet their growing needs before the increased demand created a critical situation.

The Meramec River has been used little except for recreation. Its entire potential is available for use although opposition might arise if the proposed use interfered with the recreational use of the stream.

Some surface water is available from the tributary streams crossing the American Bottoms; however, the availability of ample ground water in the American Bottoms will make development of surface-water supplies unattractive for most users.

Ground Water

The ground-water potential of the St. Louis area is very large. Alluvial deposits bordering the Mississippi, Missouri, and Meramec Rivers contain the most important ground-water resources. These deposits cover about one-third of the St. Louis area. The deposits are quite permeable and wells having large yields can be developed in them. In the American Bottoms about 100 mgd is taken from the alluvial deposits; the largest reported capacity of a single well is 10 mgd. There is relatively little use of ground water in the Columbia Bottoms, Alton Lake bottoms, Missouri Valley bottoms, and Meramec River bottoms; however, the available information indicates that these bottoms are comparable with the American Bottoms in occurrence, quality, and quantity of ground water, except that the Meramec River bottoms may be slightly less productive. In the St. Louis area the ground-water potential of the wind-blown deposits and of the bedrock probably is not large and is relatively unimportant because of limitations of quality or of yield.

The total ground-water potential in the St. Louis area cannot be estimated. In the American Bottoms, for which the most information is available, an estimate of the maximum yield is not possible, but it certainly is much larger than the present use of 100 mgd. In the St. Louis area the factor that probably will limit the maximum dependable yield is the amount of water that is recharged into the alluvial deposits. Under favorable conditions recharge may be induced from streams nearby, thus increasing the yield of the deposits tremendously. Judging from the geologic conditions and from the yield of existing wells, induced recharge could be successful in maintaining very large yields from wells in the alluvial deposits near the Mississippi, Missouri, and Meramec Rivers. The available supplies decrease with distance from the rivers, as induced recharge becomes less effective and a greater part of the water must be derived from infiltration of precipitation. Local overdevelopment could occur if wells of large yield were spaced too closely. Here again, the potential depends upon the nearness to or remoteness from the rivers.

WATER LAWS

The principal sources of surface-water supply in the St. Louis area are the three navigable streams, the Mississippi, the Missouri, and the Meramec Rivers. Use of these waters and other water in the area is regulated to some extent by municipal, State, and Federal legislation. The principal legislation affecting water use in the area will be discussed briefly. This discussion is not intended to be all-inclusive or to preclude the need for legal advice in the final determination of plant location.

Federal Laws

Navigable streams are under the jurisdiction of Congress through its constitutional powers to "***regulate commerce *** among the several States." This power extends to nonnavigable tributaries of navigable streams if the navigable capacity of the navigable waterway or interstate commerce is affected. Flood control is also recognized as a Federal responsibility.

A riparian owner under the laws of either Missouri or Illinois may hold title to a part of the bed of a navigable stream, but he has no claim to compensation if his interests conflict with the exercise of the navigation powers of Congress, other than payment for the fair value of land inundated by reservoirs.

Control of navigable waters has been generally exercised by the Corps of Engineers, U. S. Army. The district office of the Corps of Engineers having jurisdiction of the navigable stream affected should be consulted when any encroachment on a navigable stream is contemplated.

Deposit of refuse matter in a navigable stream "***other than that flowing from streets and sewers and passing therefrom in a liquid state***" is prohibited if navigation is affected. This prohibition extends to the nonnavigable tributaries if the refuse may be washed into the navigable stream.

Missouri Law

Permission must be obtained from the Missouri Conservation Commission to impound any flowing stream. The State Division of Health has limited control over stream pollution.

Illinois Law

A Sanitary Water Board was created by act of the Illinois State Legislature in the summer of 1951. An older act of 1929 for similar purposes was repealed by the new act. The Sanitary Water Board is empowered to prescribe and enforce rules and regulations to prevent the pollution of surface and underground waters. The Board's regulations should be consulted if the waste from a proposed plant might contaminate the waters of the State.

Illinois prohibits the discharge of wastes into open channels.

A 1951 act of the State Legislature provided for the establishment of water authorities to function at local levels in regulating the use of water, particularly the withdrawal of ground water. In areas where water authorities have been established a provision of the act permits a continued withdrawal of water from the same source equal to "***the rated capacity of the equipment used to divert or obtain water at the time of the establishment of the water authority having jurisdiction over the water source."

Interstate Streams

The middle of the main channel of the Mississippi River forms the boundary between the States of Missouri and Illinois. Thus projects which affect the interests of both States would require the consent of both.

Municipal Laws

Municipal laws affecting water use are found in the city codes; they are generally concerned with regulation of the municipal water supplies and sanitary provisions.

SUMMARY

The surface-water supply available to the area far exceeds the requirements for any forseeable industrial expansion. Untreated Mississippi River water is used for cooling purposes at several plants. Two private industrial filter plants use in excess of 5 mgd of Mississippi River water each. One industrial plant uses an average of about 0.5 mgd of Missouri River water.

Almost all the industrial plants in the Missouri part of the area purchase their water from either the St. Louis municipal supply or the St. Louis County Water Co. The largest consumer at the manufacturer's rate purchased an average of more than 4.5 mgd. Both water supplies can furnish a sizable additional supply without increasing present facilities.

Maximum turbidities of 9,300 ppm in the Missouri River were measured at the Howard Bend treatment-plant intake (see table 23). The daily average turbidity

Table 23.—Ranges in selected chemical and physical characteristics of untreated river water, St. Louis area

Location	Temperature (°F)	pH	Hardness as $CaCO_3$ (ppm)	Turbidity (ppm)	Dissolved solids (ppm)
Mississippi River at Alton, Ill., 1950	33-81	7.4-7.9	127-252	25-1,228	-
Missouri River at Howard Bend, Mo., 1940-49	32-86	7.6-8.8	82-326	18-9,300	a/200-519
Mississippi River at East St. Louis, Ill., 1949-50	36-81	7.2-7.8	138-228	35-3,000	-
Mississippi River at Chain of Rocks, Mo., 1940-49	32-88	7.6-8.3	80-303	27-8,500	a/152-504
Meramec River at Kirkwood, Mo., 1945-46	35-87	7.4-8.3	60-285	8-1,200	-

a/ Monthly averages; all other figures are for daily observations.

for the period 1940-49 of 1,670 ppm was about 340 ppm higher than the average turbidity in the Mississippi River at the Chain of Rocks intake below the Missouri River. Treatment at both plants reduced turbidity to a fraction of 1 ppm. A maximum hardness of 326 ppm was measured at the Howard Bend plant, but the average daily hardness was 190 ppm. The average hardness at Chain of Rocks was similar. Treatment at both plants reduces the average hardness to about 100 ppm.

The temperature of the untreated water at Howard Bend and Chain of Rocks averaged about 57 F and ranged from near freezing to 88 F. Treated water averaged about 4 F higher than the river water.

The turbidity of the untreated water at the Chain of Rocks plant averaged more than four times the turbidity at the East St. Louis intake on the opposite side of the river. The 10-yr averages for hardness and alkalinity at the two plants were nearly identical, but significant differences in the yearly averages were observed. The hardness of the Mississippi River at the East St. Louis intake fluctuates through a much smaller range than at the Chain of Rocks intake.

The Meramec River is little used except for recreation. At Kirkwood, Meramec River water is equally hard, slightly higher in alkalinity, but not nearly so turbid as water from the Missouri and Mississippi Rivers.

Surface-water supplies in the Illinois part are undeveloped except for use of Mississippi River water. The East St. Louis and Interurban Water Co. serves a large area. About 54 percent of the total water supply of the company is used for industrial purposes.

Ground water is used extensively in the American Bottoms on the east bank of the Mississippi River. The potential ground-water supply is much greater than the current use of 100 mgd. A single well in the area has a reported capacity of 10 mgd. Ground water in the American Bottoms is of variable quality. The concentration of dissolved solids in shallow wells in the bottoms ranged from less than 300 ppm to more than 3,000 ppm. The water is generally very hard and much of it contains troublesome quantities of iron.

Little ground water is found within the city of St. Louis or St. Louis County except in the alluvium along the Missouri and Meramec Rivers. The city of Kirkwood draws water from the alluvium in the Meramec River bottoms and reduces an average hardness of about 290 ppm to about 120 ppm. The iron and manganese in the untreated water are negligible. The potential ground-water supply in the alluvium along the Missouri River in the area has not been developed.

Two other areas of large potential ground-water supply are the Columbia Bottoms south of the Missouri River near its mouth and the Alton Lake bottoms between the Missouri and the Mississippi Rivers north of the Missouri River. Both these areas are undeveloped, owing in part to the lack of flood protection.

No laws exist that restrict the use of the water resources of the area except in regard to pollution. Legislation has been enacted in Illinois that will permit control of the use of ground water in the American Bottoms, when such control becomes necessary, without decreasing the amount of ground water being used when the controls become effective. No problem of overwithdrawal of ground-water supplies exists in the area.

The facts presented in this report support the statement that the water resources of the St. Louis area are capable of supporting all the industry that the strategic location, the excellent land, water, and air transportation, and the many other advantages of the area might attract.

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