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CONTENTS.

[The letters in parentheses preceding the titles are those used to designate the papers for advance publication.]

ILLUSTRATIONS.

TEMPERATURE OF WATER AVAILABLE FOR INDUSTRIAL USE IN THE UNITED STATES.

By W. D. Collins.

INTRODUCTION.

The importance of water supply as a limiting factor in industrial development is becoming more evident each year. The limitation in a particular instance may be the quantity of water available, the quality determined by the mineral matter in solution or in suspension or by organic pollution, or the temperature of the water. Generally it is a combination of two or more of these factors.

Many publications of the Geological Survey give data in regard to the quantity of surface water and ground water obtainable at different points. Other publications of this Survey and of other organizations give data on the quality of waters available for industrial use. The temperature of these waters is discussed in the present report.

Data in regard to ground water have been obtained from Geological Survey water-supply papers, from the publications indicated in footnotes, and from an unpublished compilation of temperature records prepared by C. E. Van Orstrand, of the Geological Survey, in connection with studies of deep earth temperature. Data on temperature of surface water have been obtained mainly from officials of waterworks, as noted in the accompanying table. Data on air temperature have been obtained from reports of the United States Weather Bureau. The maps showing temperature of ground water and surface water (Pls. VIII and IX) are taken directly from Weather Bureau charts of temperature distribution.

GROUND WATER.

The temperature of water in the ground at any place is in general about the same as the mean annual air temperature. Near the surface the temperature of the water follows the changes in air temperature; at greater depths the water has a higher temperature corresponding to the increase of the earth temperature with increasing depth.

The annual range in temperature of the ground decreases rapidly in the first few feet. Results of measurements of earth temperature

in Japan cited by Tamura[1] show annual ranges of 51° F. at the surface, 34° at a depth of 2 feet, 9.4° at 10 feet, and only 0.7° at 23 feet. Data by Spence[2] show a similar decrease of range with depth in North Dakota. With an extreme variation in air temperature of 133° F., as given in the Weather Bureau report, the range in earth temperature was 80° at a depth of 1.2 feet, 42° at 3.7 feet, 25° at 6.6 feet, and 18° at 9.0 feet. A curve showing these results indicates that at about 30 feet the annual range would not be more than 1°. From a study of over 3,000 records of temperature of ground water C. E. Van Orstrand has computed that under normal conditions the temperature of ground water obtained at a depth of 30 to 60 feet will generally exceed by 2° or 3° the mean annual air temperature. In exceptional localities the excess may amount to 5° or 6°.

After careful examination of the available data relating to increase of earth temperature with depth a committee of the British Association for the Advancement of Science adopted as the most probable average rate an increase of 1° F. for each 64 feet of depth.[3] On this basis water from a depth of 640 feet would have a uniform temperature of 10° F. above the temperature at 30 or 60 feet. At 200 feet the increase would be only 3°.

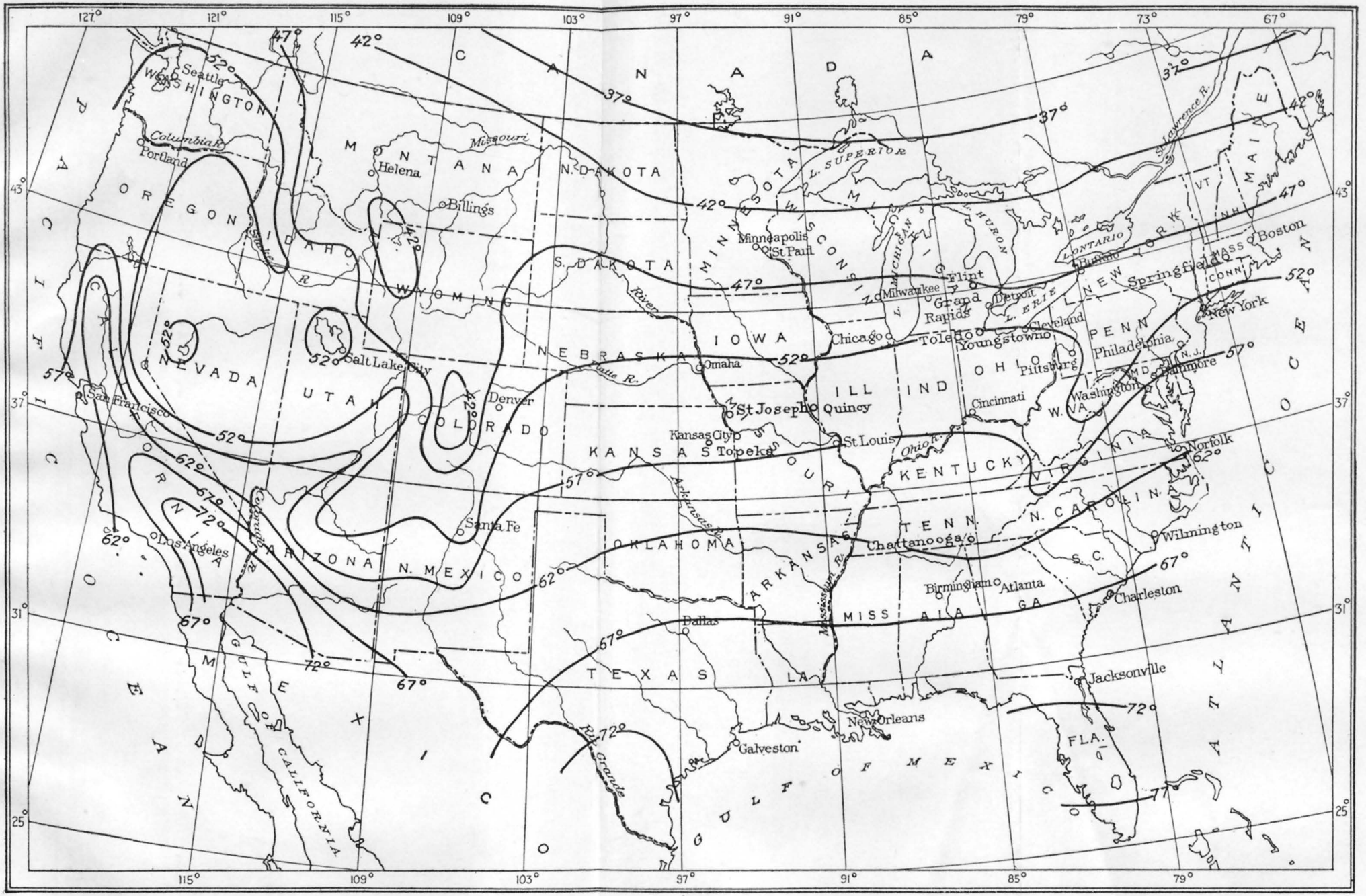
It may be stated, then, for practical purposes that a ground-water supply obtained at any depth from 20 to 200 feet will have a uniform temperature ranging from about 3° to 6° F. above the mean annual air temperature. If the supply comes from a depth more than 300 feet the difference in temperature due to increased depth must be taken into account.

The map that shows the probable temperature of ground water in the United States at depths of 20 to 60 feet (Pl. VIII) is based on the map of the United States Weather Bureau showing normal annual air temperature. It is necessarily generalized. Closer approximation to the ground-water temperature at any place can be obtained from the detailed data in reports of the Weather Bureau, which give the normal temperatures at individual stations.

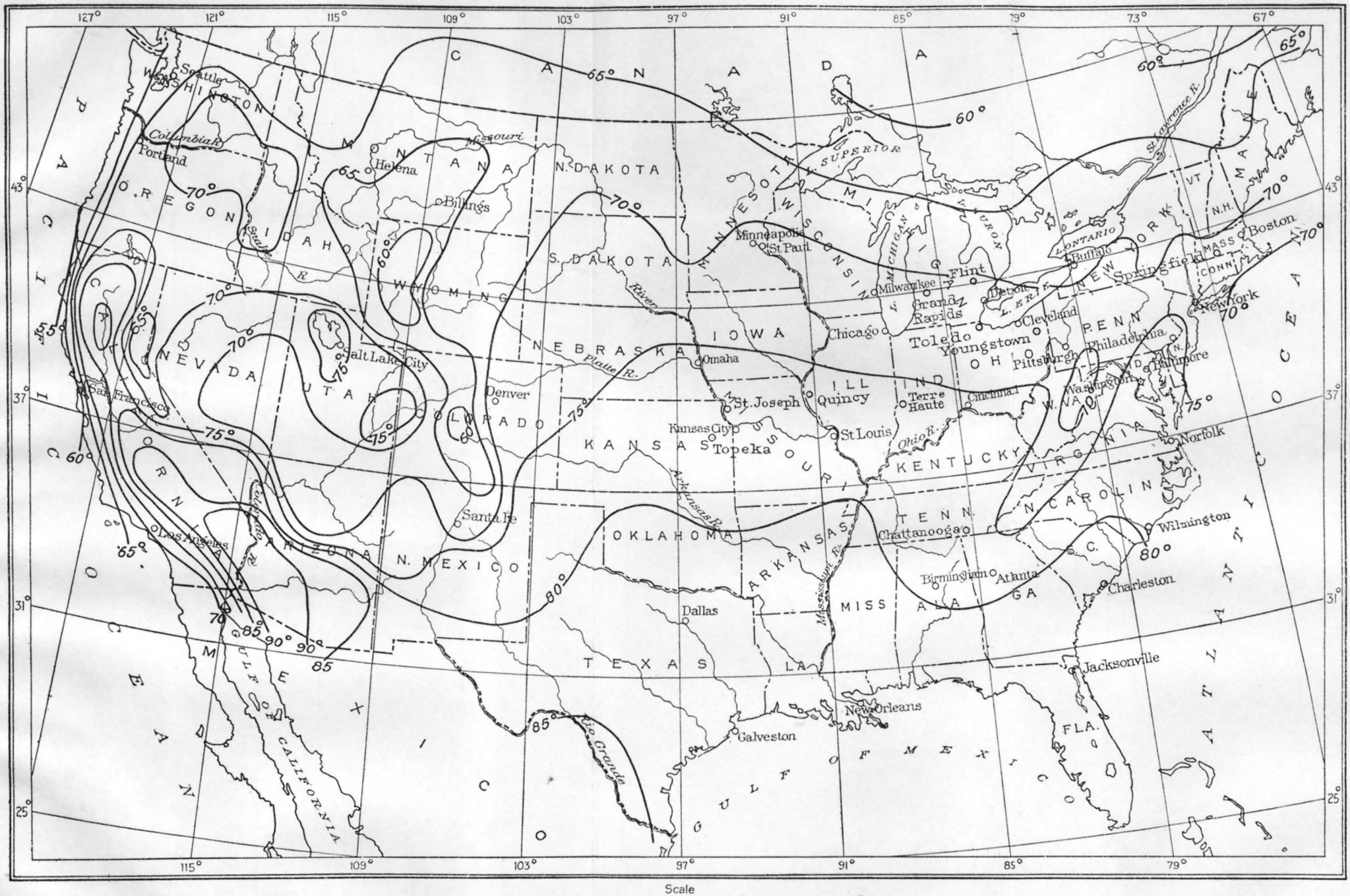
SURFACE WATER.

The relation between surface-water temperature and air temperature is much more variable than the relation between ground-water temperature and air temperature. Obviously the range in temperature of surface water will be considerable, but it is much less than the range in air temperature. Reports of the Weather Bureau give daily, mean monthly, and mean annual temperatures of the air. Of

[1] Tamura, S. T., Monthly Weather Review, 1905, p. 296.
[2] Spence, B. J., North Dakota Univ. Quart. Jour., vol. 8, pp. 233–238, 1918.
[3] British Assoc. Adv. Sci. Rept. Fifty-second Meeting, p. 88, 1882.



APPROXIMATE TEMPERATURE OF WATER FROM NONTHERMAL WELLS AT DEPTHS OF 30 TO 60 FEET



APPROXIMATE MEAN MONTHLY TEMPERATURE OF WATER FROM SURFACE SOURCES FOR JULY AND AUGUST

these the mean monthly temperature is evidently the best for comparison with the temperature of water in a river or lake.

The records of water temperature given in the table were obtained from the sources indicated. Those of air temperature were taken from the Monthly Weather Review. Information was not obtained as to the types of thermometers used to measure the water temperature, or the exact conditions prevailing when the measurements were made—factors which might affect the reliability of the figures. For the purposes of this report an error of 1° or 2° would not have much significance. There is no reason to believe that any of the figures given are in error by more than 2°, and it is doubtful if many errors exceed 1°. The water and air temperatures given are all rounded off to the nearest whole degree.

Comparisons of the mean monthly water temperature and air temperature at certain places are shown in Plates X and XI, which also show the maximum water temperature. It can be seen that during the warm months the mean monthly water temperature is generally within 3° above or below the mean air temperature and the maximum water temperature is rarely more than 4° above the mean monthly water temperature.

It is not possible to give a map showing the probable surface-water temperature as closely as the probable ground-water temperature is indicated in Plate VIII, but Plate IX gives a basis for estimating probable maximum monthly surface-water temperature. The map is the United States Weather Bureau map showing normal July temperature. It is quite certain that during July and August the surface water at most places will have a temperature not much below the mean monthly air temperature. On the average the water temperature will be within 3° above or below the mean monthly air temperature in July and from 2° to 5° above the mean in August. From the data in the table and in Plates X and XI it appears that at some places the surface-water temperature shows much more than the average difference from the mean monthly air temperature. The reasons for these departures are not hard to find.

The minimum recorded water temperature will be from 32° to 34° F. during the coldest months. As the monthly air temperature rises the water temperature is likely to rise more slowly. Early in the spring melting ice may keep the water considerably below the air temperature.

Water in a lake or large reservoir is slow in warming up to the summer air temperature. The upper 25 feet of water follows the air temperature the same as a river water. The temperature of the water below this depth rises very slowly throughout the summer, and that of the water below 75 or 100 feet may rise to only a few degrees above the temperature corresponding to the maximum density of

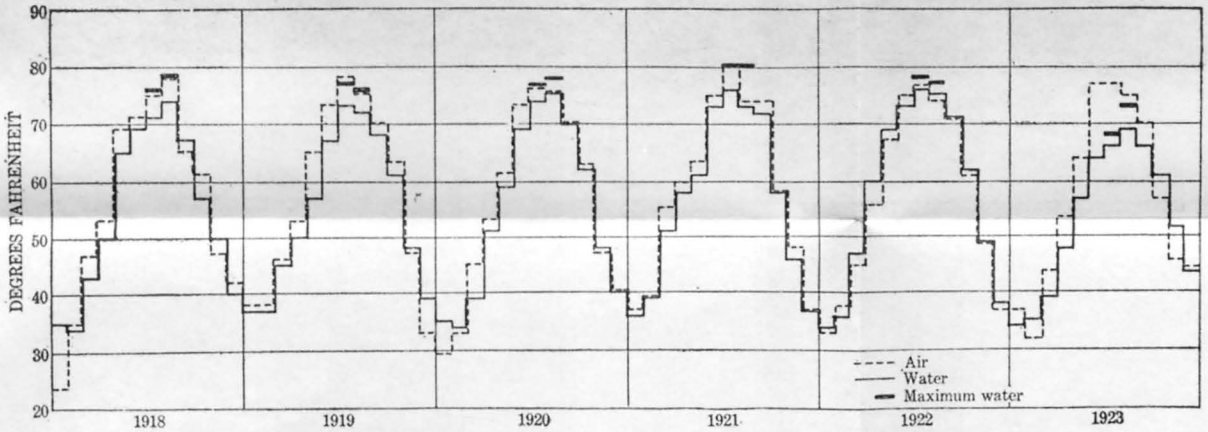
water. This effect can be noted in the records of temperature at Baltimore, Md., shown in Plate X, *A*. The height of the waterworks dam at Baltimore was raised to make a large increase in reservoir capacity between the summers of 1922 and 1923. The difference between water temperature and air temperature from 1918 to 1922 was about 3° in July and 1° in August; in 1923 the water was 11° cooler than the mean air temperature in July and 6° in August. A similar lag in warming of the water is shown in the table for Lake Erie water at Cleveland, Ohio.

Mountain streams, which may be formed largely from melting snow and may flow quickly into plains where the temperature is high, will have a temperature much below the mean monthly air temperature in the plains. This effect is not confined to mountain streams, although it is most pronounced in them.

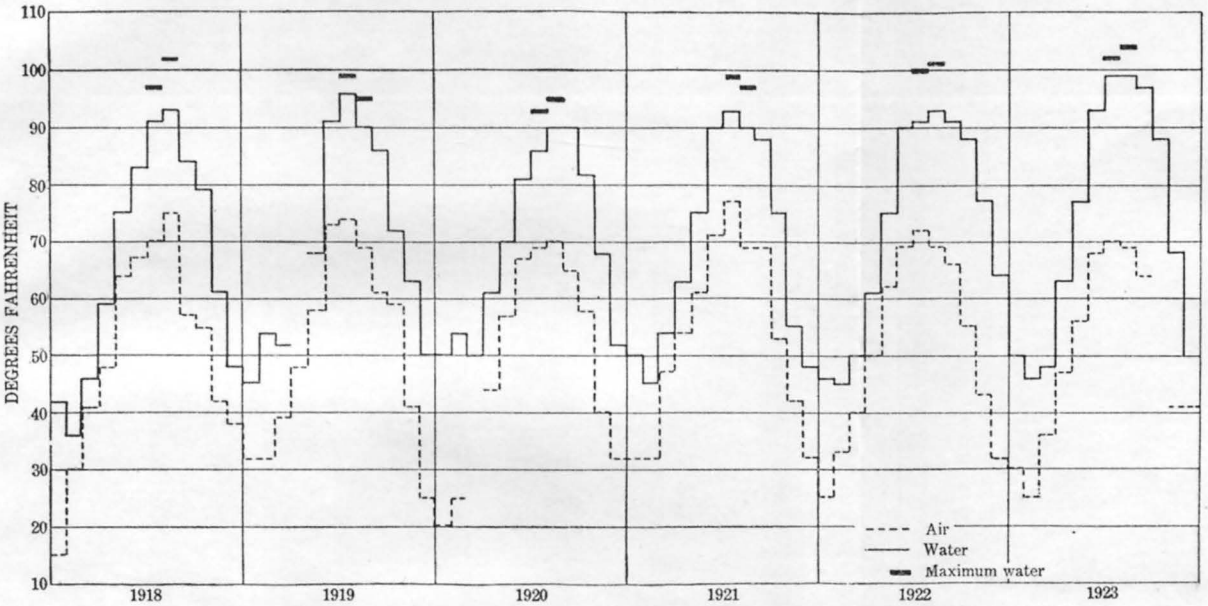
Mississippi River at New Orleans, La. (Pl. XI, *A*), shows the effect of large volumes of cold water brought a long distance. The normal January air temperature at Minneapolis, Minn., is 41° F. below the normal air temperature at New Orleans. From a point a little above Cairo, Ill., northward the normal January air temperature is below freezing. Thus a large part of the water reaching New Orleans comes from much colder places, and because the discharge is great early in the spring the colder water does not have a chance to be warmed to the air temperature of New Orleans. In summer, however, the air temperature in the upper Mississippi and Ohio basins is not so much below the temperature at New Orleans. The normal July temperature at Minneapolis is only 10° below that at New Orleans. The discharge of the river is smaller in summer. There is less water to be warmed, it moves less rapidly and therefore has more time to be warmed, and as it enters the lower Mississippi at a temperature nearer that of the air at New Orleans it requires less warming to approach that temperature than the water brought down by the river in winter and spring.

In Plate X, *C*, the characteristic changes in temperature at different places on Mississippi River are shown from the data for 1923 at four points. In general the water temperature lags behind the air temperature as it changes from month to month. The water temperatures at Quincy and St. Louis are close together, as would be expected, and follow the air temperature during the cold months more closely than those at Minneapolis or New Orleans.

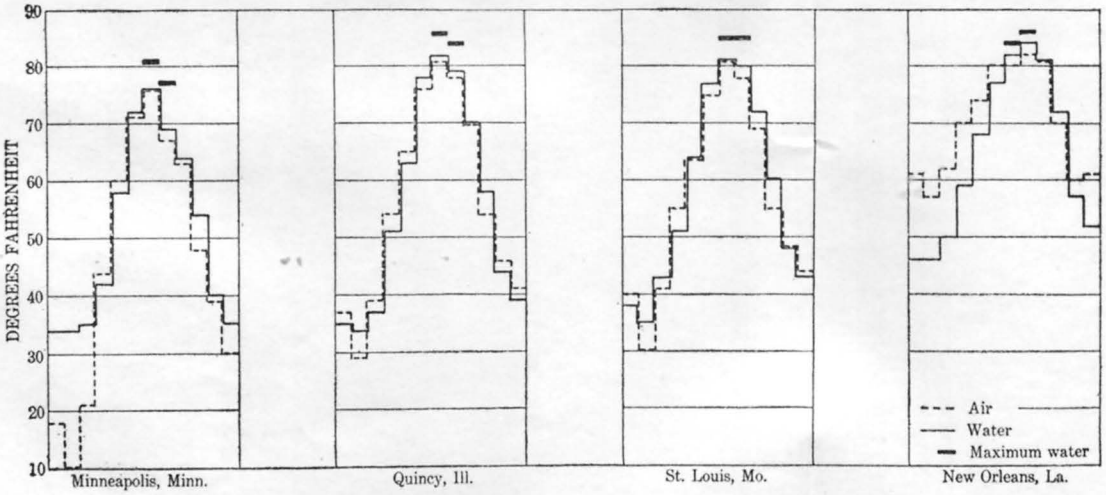
The greatest departure of water temperature from air temperature shown in the table is at Youngstown, Ohio (Pl. X, *B*). The temperatures recorded represent filtered water and must be slightly below the temperature of water in the river. The high temperature of the river water results from its use for cooling at industrial plants above Youngstown. This use raises the temperature of the water



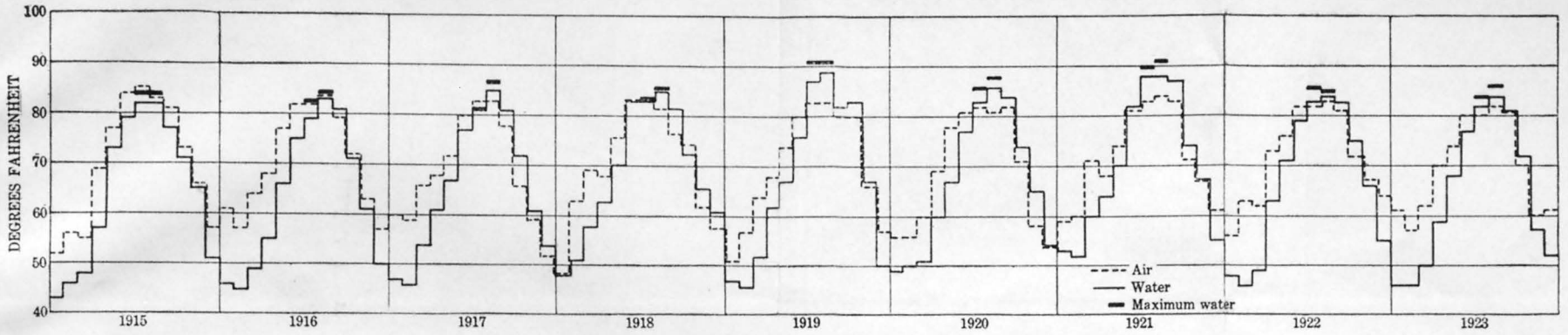
A. TEMPERATURE OF SURFACE WATER AND OF AIR AT BALTIMORE, MD.



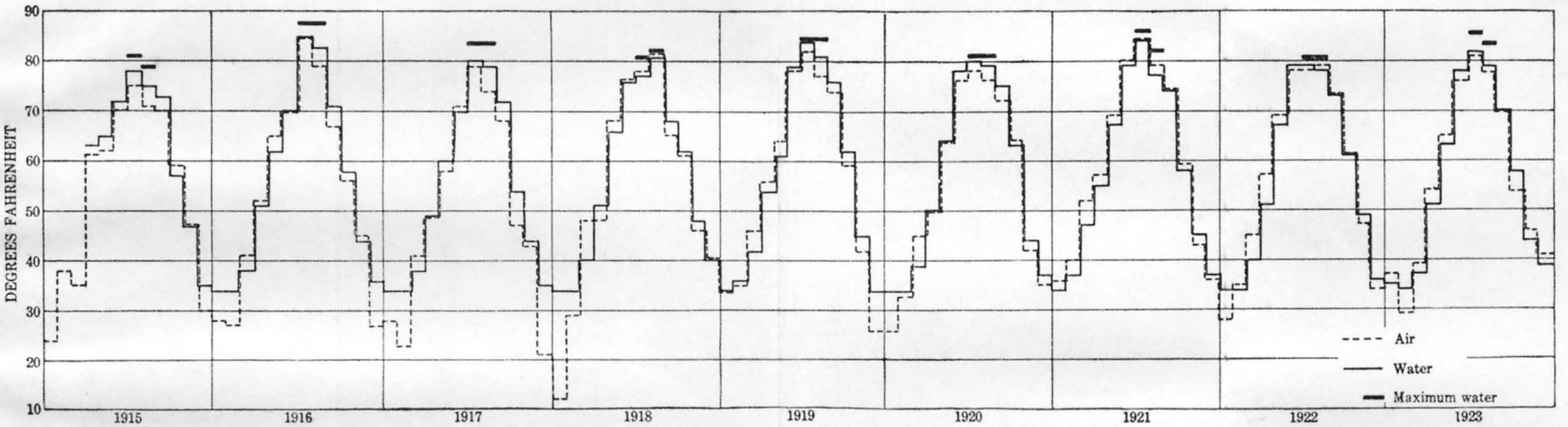
B. TEMPERATURE OF SURFACE WATER AT YOUNGSTOWN AND OF AIR AT WARREN, OHIO



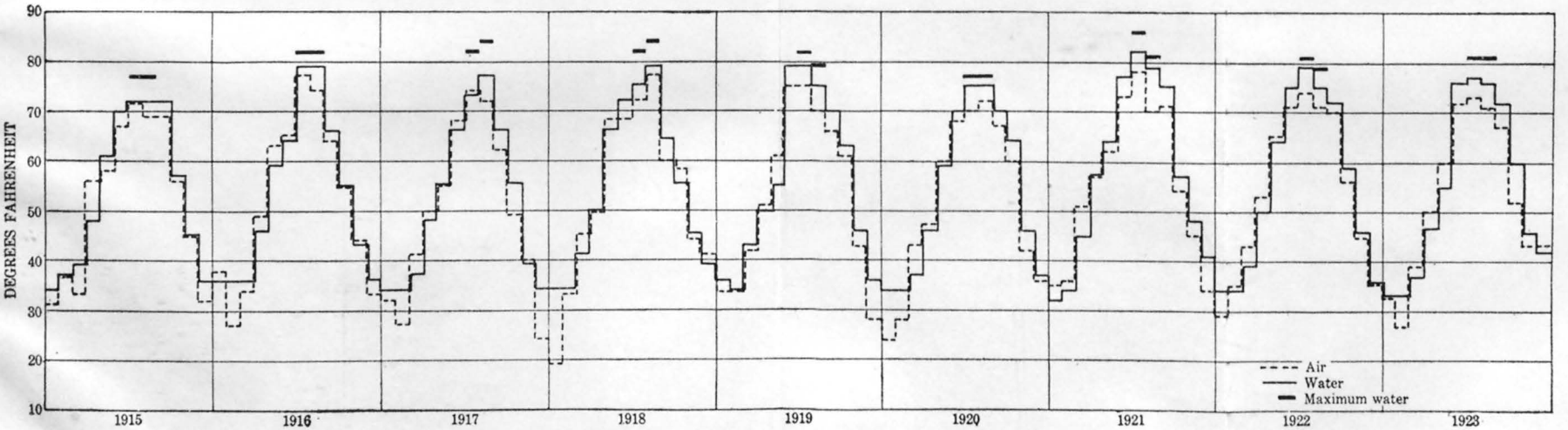
C. MEAN MONTHLY TEMPERATURE OF WATER AND OF AIR AT POINTS ON MISSISSIPPI RIVER AND MAXIMUM WATER TEMPERATURE IN JULY AND AUGUST



A. TEMPERATURE OF SURFACE WATER AND OF AIR AT NEW ORLEANS, LA.



B. TEMPERATURE OF SURFACE WATER AND OF AIR AT QUINCY, ILL.



C TEMPERATURE OF SURFACE WATER AND OF AIR AT PITTSBURGH, PA.

approximately 20° F. above the temperature a normal surface water would be expected to have at Youngstown in July and about 25° F. above the normal temperature for August. Industrial use of river water undoubtedly accounts for the higher temperature of Monongahela River water at Rankin (12b in the table) as compared with air temperature. Allegheny River at Colfax (12a) shows little increase over the air temperature, and Ohio River at Brunot Island (12c) is between the two branches in the relation of water temperature to air temperature.

The conditions outlined above cause the temperature of surface water to vary from mean monthly air temperature at many places, but the results presented in the table show that unless some easily noted influence affects a surface water its mean monthly temperature is quite likely to be within a few degrees of the mean monthly air temperature for each month that the air temperature is above the freezing point.

SUMMARY.

The temperature of ground water available for industrial supplies is generally from 2° to 3° F. above the mean annual air temperature if the water is between 30 and 60 feet below the surface of the ground. At a depth of 10 feet the temperature may range from 10° above to 10° below the mean annual temperature. An approximate average for the increase in temperature with depth is about 1° F. for each 64 feet.

The mean monthly temperature of a surface water at any place is generally within a few degrees of the mean monthly air temperature when the air temperature is above the freezing point. The maximum water temperature in any of the warmer months is usually from 2° to 6° higher than the mean monthly water temperature.

Mean monthly temperature of surface water and of air and maximum daily temperature of water at certain localities.

[Water temperatures (W) furnished by municipal or private waterwo rks officials except as noted. Air temperatures (A) from published reports for U. S. Weather Bureau stations at cities listed or at near-by points.]

Locality.	Year.	Mean monthly temperature.																						Maximum daily temperature of water.	
		January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.			
		W	A	W	A	W	A	W	A	W	A	W	A	W	A	W	A	W	A	W	A	W	A	W	A	July.	Aug.
1. Baltimore, Md	1918	35	24	34	35	43	47	50	53	65	69	69	71	71	75	74	78	67	65	57	61	50	47	40	42	76	78
	1919	37	38	37	38	45	46	50	53	57	65	67	73	73	78	72	75	68	70	61	63	48	47	39	33	77	76
	1920	35	29	34	33	39	45	51	53	59	61	69	73	74	76	75	75	70	70	62	63	48	47	40	40	77	78
	1921	36	37	39	39	51	55	58	59	61	63	73	75	76	80	73	74	72	74	58	58	46	48	37	37	80	80
	1922	34	33	36	38	47	45	60	56	69	67	73	75	76	77	75	74	71	71	62	61	49	49	38	37	78	77
	1923	34	37	35	32	39	44	48	54	57	64	64	77	66	77	69	75	66	70	61	57	52	46	44	45	68	73
2. Birmingham, Ala	1923	48	52	47	46	51	54	58	62	67	69	72	77	80	78	81	78	78	76	69	64	63	52	53	53	------	------
3. Chattanooga, Tenn	1923	49	47	49	42	52	51	58	59	65	65	73	75	77	77	79	77	76	73	69	61	56	50	52	49	------	------
4. Cincinnati, Ohio	1923	39	36	37	28	43	40	52	52	64	61	79	72	81	76	82	74	75	68	64	54	50	44	44	44	------	------
5. Cleveland, Ohio	1923	36	30	33	24	36	35	40	46	47	54	59	71	66	71	69	69	68	65	65	52	52	42	43	40	68	72
6. Detroit, Mich	1918	32	13	32	24	32	40	37	45	45	62	60	67	67	71	70	75	60	57	55	56	46	42	38	36	------	------
	1919	33	31	32	29	35	36	41	46	51	57	----	74	71	75	70	70	66	67	59	56	44	39	33	23	------	------
	1920	32	17	----	23	----	38	----	41	49	56	64	69	68	70	69	69	66	66	59	59	44	39	37	33	------	------
	1921	32	30	32	30	36	43	44	53	49	62	----	----	----	----	----	----	----	----	----	----	----	----	----	----	------	------
7. Flint, Mich	1920	34	12	34	19	38	----	45	----	59	56	71	69	71	69	68	69	66	64	60	57	41	36	38	31	79	75
	1921	35	29	35	27	42	40	55	52	69	61	74	71	81	78	74	68	69	67	58	50	46	36	40	28	85	80
	1922	38	20	40	26	40	34	51	47	63	64	74	69	77	71	74	69	68	64	56	51	46	39	35	27	79	79
8. Grand Rapids, Mich	1923	34	26	34	20	35	29	47	45	60	57	75	72	76	73	72	68	65	63	54	50	42	40	38	37	78	79
9. Minneapolis, Minn	1923	34	18	34	10	35	21	42	44	58	60	72	71	76	76	69	67	64	63	54	48	40	39	35	30	81	77
10. New Orleans, La	1915	43	52	46	56	48	55	57	69	73	77	79	84	82	85	82	83	77	81	71	73	65	66	51	57	84	84
	1916	46	61	45	57	49	64	55	68	66	77	75	82	79	82	83	83	81	79	71	72	61	63	50	57	82	84
	1917	47	60	46	59	54	66	61	68	67	72	77	80	82	83	85	83	81	78	72	66	61	59	54	52	82	87
	1918	48	48	51	63	58	69	63	68	70	76	82	83	83	83	85	82	82	77	73	75	66	62	61	58	84	86
	1919	47	51	46	57	52	64	62	68	67	74	76	80	87	83	89	83	82	80	83	80	67	66	50	57	91	91
	1920	49	56	50	56	51	60	60	69	67	78	77	81	83	82	86	81	84	82	74	71	65	58	54	54	86	88
	1921	53	59	52	60	60	71	64	68	70	74	82	81	88	83	88	84	87	83	74	71	67	67	55	61	90	91

	1922	48	56	46	63	49	62	63	73	71	76	79	82	83	82	84	83	83	81	75	72	66	67	55	64	86	85
	1923	46	61	46	57	50	62	59	70	68	74	77	80	82	80	84	82	81	81	72	70	57	60	52	61	84	86
11. Pittsburgh, Pa	1912	-----	20	34	25	36	35	48	53	61	64	70	68	75	73	70	69	68	69	57	56	45	44	36	36	81	75
	1913	37	40	34	29	39	43	46	52	61	61	70	70	75	74	77	73	68	65	59	54	46	45	39	36	81	81
	1914	34	34	36	24	37	37	46	49	59	63	75	71	77	74	75	73	68	64	61	58	45	43	37	30	79	77
	1915	34	31	37	37	39	33	48	56	61	58	70	67	72	72	72	69	72	69	57	56	45	45	36	32	77	77
	1916	36	38	36	27	36	34	46	49	59	63	64	65	79	77	79	74	66	64	55	55	43	44	36	33	82	82
	1917	34	32	34	27	37	41	48	50	55	55	66	68	73	74	77	72	66	62	55	49	39	40	34	24	82	84
	1918	34	19	34	33	41	45	50	49	66	68	72	68	75	72	79	77	64	60	55	58	45	44	39	41	82	84
	1919	36	34	34	34	43	42	50	51	55	61	79	75	79	75	75	70	70	66	63	61	46	43	36	28	82	79
	1920	34	24	34	28	37	43	46	47	59	60	70	68	75	70	75	72	70	67	64	60	46	42	37	36	77	77
	1921	32	35	34	36	45	51	57	57	64	62	77	73	82	78	79	70	75	71	57	54	48	45	41	34	86	81
	1922	34	29	34	35	39	43	50	53	64	65	75	71	79	74	75	71	72	70	59	56	46	45	36	36	81	79
	1923	33	33	33	27	37	39	47	50	55	60	76	72	77	73	76	71	72	67	60	52	46	43	42	43	81	81
12. Pittsburgh region:																											
a	1923	35	33	38	27	41	39	48	50	60	60	74	72	76	73	75	71	69	67	58	52	44	43	41	43	------	------
b	1923	40	33	40	27	45	39	52	50	64	60	78	72	79	73	80	71	77	67	71	52	54	43	46	43	------	------
c	1923	36	33	36	27	38	39	48	50	60	60	74	72	76	73	77	71	72	67	62	52	48	43	42	43	------	------
13. Quincy, Ill	1913	34	29	34	25	36	37	51	54	64	65	74	77	80	82	80	83	71	70	58	54	46	49	40	38	82	82
	1914	35	34	34	23	37	39	50	54	66	68	77	79	80	82	79	79	70	69	-----	60	-----	45	-----	24	84	81
	1915	-----	24	-----	38	-----	35	63	61	65	62	72	70	78	75	75	71	73	70	57	59	47	47	35	30	81	79
	1916	34	28	34	27	38	41	51	52	62	65	70	70	85	85	83	79	71	67	58	56	44	45	36	27	88	88
	1917	34	28	34	23	38	41	49	49	60	58	70	71	80	79	79	74	72	68	54	47	44	43	35	21	84	84
	1918	34	12	34	29	40	48	51	48	66	68	76	76	77	78	81	82	68	65	62	61	48	46	40	41	81	82
	1919	34	34	36	35	42	46	54	56	61	64	79	78	84	82	81	77	76	74	62	59	45	42	34	26	84	84
	1920	34	26	34	33	39	45	50	50	64	64	78	76	80	78	79	76	75	72	63	64	44	42	37	35	81	81
	1921	34	36	37	40	47	52	55	57	67	69	79	80	84	84	77	79	74	74	58	59	45	43	37	36	86	82
	1922	34	28	34	35	40	45	51	57	67	69	79	78	79	78	78	79	73	73	61	61	49	47	36	34	81	81
	1923	35	37	34	29	37	39	51	54	63	65	78	76	82	81	79	78	70	70	58	54	44	46	39	41	86	84
14. St. Louis, Mo	1921	-----	-----	-----	-----	-----	-----	57	58	68	68	80	78	85	83	80	78	74	74	61	60	49	47	39	39	87	83
	1922	34	30	36	36	44	46	55	58	68	69	78	78	79	79	80	79	74	74	61	62	51	49	38	37	83	83
	1923	38	40	35	30	43	41	51	55	64	64	77	75	81	81	80	78	72	69	60	55	48	48	43	44	85	85
15. St. Joseph, Mo	1923	34	37	34	29	34	37	48	54	64	62	72	74	78	79	77	76	68	69	61	52	43	45	36	37	------	------
16. Springfield, Mass	1920	33	19	33	24	33	35	37	45	48	56	59	66	64	70	64	72	59	58	54	-----	42	-----	36	-----	66	66
	1921	33	27	33	30	36	42	44	53	52	58	58	-----	66	74	65	-----	65	-----	54	53	43	40	36	-----	69	68
	1922	33	-----	33	29	34	38	39	-----	51	-----	61	-----	66	74	65	72	61	68	52	57	42	43	35	37	70	67
	1923	33	23	33	23	33	34	39	48	50	57	60	68	65	69	65	68	63	63	52	50	40	39	37	40	66	66
17. Terre Haute ,Ind	1919	-----	34	-----	34	-----	44	-----	54	-----	61	81	76	84	80	81	74	75	71	66	60	-----	42	-----	27	88	86
	1920	-----	24	-----	31	-----	44	52	48	66	63	73	72	77	75	73	73	70	71	61	62	-----	42	-----	34	82	79
	1921	-----	36	-----	38	-----	51	54	57	66	67	79	78	81	81	75	74	70	72	55	57	-----	46	-----	37	86	81
	1922	-----	27	-----	34	-----	44	52	56	63	68	70	75	72	76	73	76	66	72	54	59	-----	46	-----	34	75	77
	1923	-----	36	-----	27	-----	40	48	52	63	62	75	73	72	78	73	74	70	67	54	54	-----	45	-----	43	86	82
18. Toledo, Ohio	1917	33	26	33	22	40	38	50	45	54	53	69	66	75	73	76	71	67	62	49	46	42	39	34	22	82	84
	1918	34	14	34	28	40	42	49	46	66	65	74	68	74	72	78	76	62	58	56	56	46	43	39	38	79	80
	1919	33	33	32	31	40	37	49	47	58	57	77	74	77	76	73	71	70	68	60	57	44	40	34	24	80	77
	1920	34	18	34	25	39	40	45	42	59	57	71	70	74	71	73	70	70	67	60	61	44	40	38	33	77	77

Mean monthly temperature of surface water and of air and maximum daily temperature of water at certain localities—Continued.

Locality.	Year.	Mean monthly temperature.																						Maximum daily temperature of water.	
		January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.			
		W	A	W	A	W	A	W	A	W	A	W	A	W	A	W	A	W	A	W	A	W	A	W	A	July.	Aug.
18. Toledo, Ohio	1921	34	32	34	32	46	45	54	54	64	62	77	73	82	79	74	71	73	70	56	53	43	40	37	32	88	79
	1922	34	24	34	31	38	38	51	49	65	63	74	70	76	72	75	71	71	68	58	55	46	43	36	30	79	79
	1923	34	30	34	23	36	34	47	47	58	55	76	72	76	73	73	70	68	65	56	51	44	41	39	39	79	79
19. Topeka, Kans	1923	42	39	31	30	58	39	52	54	71	62	71	74	82	79	82	77	77	70	68	53	39	46	37	37	------	------
20. Wilmington, N. C	1923	49	50	48	46	58	57	63	61	72	68	81	77	84	78	84	79	80	74	68	62	57	53	51	54	86	86
21. Youngstown, Ohio	1918	42	15	36	30	46	41	59	48	75	64	83	67	91	70	93	75	84	57	79	55	61	42	48	38	97	102
	1919	45	32	54	32	52	39	-----	48	68	58	91	73	96	74	90	69	86	61	72	59	63	41	50	25	99	95
	1920	50	20	54	25	50	-----	61	44	70	57	81	67	86	69	90	70	90	65	82	58	68	40	52	32	93	95
	1921	50	32	45	32	54	47	63	54	75	61	90	71	93	77	90	69	88	69	75	53	55	42	48	32	99	97
	1922	46	25	45	33	50	40	61	50	75	62	90	69	91	72	93	69	91	66	88	55	77	43	64	32	100	102
	1923	50	30	46	25	48	36	63	47	77	56	93	68	99	70	99	69	97	64	88	-----	68	41	50	41	102	104

1. Gunpowder River impounded for public water supply of Baltimore, Md.
2. Cahaba River impounded for public water supply of Birmingham, Ala.
3. Tennessee River at waterworks intake, Chattanooga, Tenn.
4. Ohio River at waterworks intake, Cincinnati, Ohio.
5. Lake Erie at waterworks intake, Cleveland, Ohio.
6. Detroit River at waterworks intake, Detroit, Mich.
7. Flint River at waterworks intake, Flint, Mich.
8. Grand River at waterworks intake, Grand Rapids, Mich.
9. Mississippi River at waterworks, Minneapolis, Minn.
10. Mississippi River at Carrollton filtration plant of municipal waterworks, New Orleans, La.
11. Allegheny River at Aspinwall filtration plant of municipal waterworks, Pittsburgh, Pa.
12. a, Allegheny River at Colfax, Pa.; b, Monongahela River at Rankin, Pa.; c, Ohio River at Brunot Island. Water temperature furnished by the Philadelphia Co. of Pittsburgh, Pa., from records at plants of the company. Air temperature at Pittsburgh, Pa.
13. Mississippi River at waterworks intake, Quincy, Ill.
14. Mississippi River at waterworks intake, St. Louis, Mo.
15. Missouri River at waterworks, St. Joseph, Mo.
16. Westfield Little River impounded for public water supply of Springfield, Mass.
17. Wabash River at waterworks, Terre Haute, Ind.
18. Maumee River at waterworks, Toledo, Ohio.
19. Kansas River at waterworks, Topeka, Kans.
20. Cape Fear River at waterworks, Wilmington, N. C.
21. Mahoning River at waterworks, Youngstown, Ohio. Temperature of filtered water. Air temperature at Warren, Ohio.