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CHARLES D. WALCOTT, DIRECTOR

THE NATURAL FEATURES AND ECONOMIC DEVELOPMENT

OF THE

SANDUSKY, MAUMEE, MUSKINGUM, AND MIAMI DRAINAGE AREAS IN OHIO

BY

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AND

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., October 8, 1903.

SIR: I have the honor to transmit herewith a manuscript for a Water-Supply paper treating of the four principal drainage areas of the State of Ohio and describing the economic development that has taken place within each.

The greater part of this manuscript was written by the late Benjamin H. Flynn, who for some years prior to his death was employed by the United States Geological Survey as field assistant in charge of stream measurements in the State of Ohio. After the death of Mr. Flynn the manuscript was completed by his widow, Margaret S. Flynn, who for several years had taken an active part in his professional work, especially in connection with his duties as engineer for the Ohio State board of health.

This paper treats of the natural features and development of the areas drained by the Maumee, Sandusky, Miami, and Muskingum rivers and contains valuable data with reference to the flow of these streams and the natural advantages they offer with reference to water power and domestic water supply. Of particular interest is that part of the paper which deals with the early history of the water powers, their general relation to the canal systems of Ohio, and the decline in value that has taken place since the establishment of modern methods of manufacturing, trade, and transportation.

The chapter dealing with public water supplies comprises unusually complete information with reference to the sources, equipment, and value of the systems that were installed during the latter part of the last century.

This paper is one of a proposed series dealing with hydrographic matters in the several States of the Union and showing the advantages that the various river systems offer and the manner in which they have been developed, from an economic standpoint.

Very respectfully,

F. H. NEWELL,
Chief Engineer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

THE NATURAL FEATURES AND ECONOMIC DEVELOPMENT OF THE SANDUSKY, MAUMEE, MUSKINGUM, AND MIAMI DRAINAGE AREAS IN OHIO.

By BENJAMIN H. FLYNN and MARGARET S. FLYNN.

INTRODUCTION.

The data for the following paper were gathered during what might be called a sanitary survey of the drainage areas of Ohio rivers, made for the State board of health. In the original reports of this work an attempt was made to give complete information regarding the sanitary condition of these areas, but little was said concerning the hydrography except in connection with public water supplies. This statement applies especially to the Sandusky and Maumee basins, as they were taken up first, and data concerning the water resources could receive but little attention, owing to the extra time required to plan the work. In connection with the work in the Muskingum and Miami basins, during the next two years, more attention was paid to the gathering of this information, though it was, of necessity, subordinate to the sanitary survey.

The Sandusky and Maumee drainage areas were inspected during the latter half of 1898, the Muskingum in 1899, and the Miamis in 1900. In the summer of 1903 letters were sent out to various cities and villages asking for information in regard to certain statistics which are subject to variation. From the mass of details in the original reports and from these letters there have been assembled fairly complete data concerning the hydrography of these areas, so far as this is given, and the more salient facts concerning their sanitary condition.

GENERAL DESCRIPTION OF DRAINAGE AREAS.

Four separate drainage areas are described in this report—the Sandusky, the Maumee, the Muskingum, and the Great and the Little Miami.[a] Their general locations are shown in fig. 1.

LOCATION.

The Sandusky basin is situated in the central part of the northern half of the State, and its waters drain to Sandusky Bay, an arm of Lake Erie. The Maumee basin occupies the northwest corner of

[a] For general purposes the Miami and Little Miami drainage basins may be treated as one area.

Ohio and small portions of the adjacent States of Indiana and Michigan, and its waters empty into Maumee Bay, at the western end of Lake Erie. The Muskingum basin occupies a large section of the eastern part of the State south of the Lake Erie drainage divide, and its run-off is to Ohio River. The Miami basins occupy a large portion of the southwestern part of Ohio and a considerable area of the south-eastern part of Indiana. The Little Miami basin lies east and south

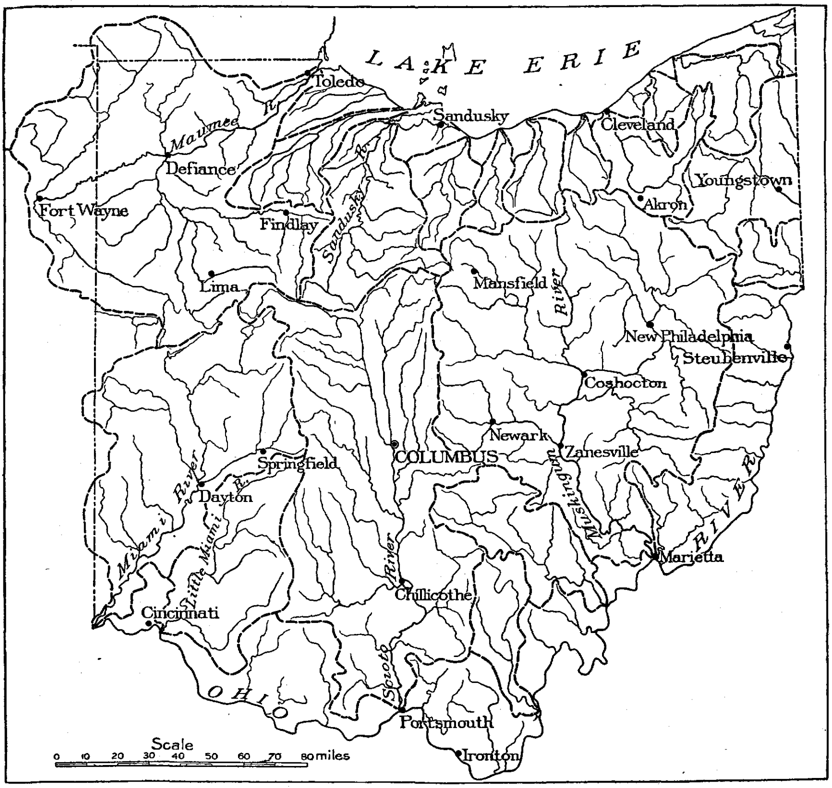

FIG. 1.—Map of Ohio, showing drainage basins.

of that of the Great Miami and west of the basin of Scioto River. The waters from its southern border are carried by short, turbulent creeks directly to the Ohio.

AREA.

In point of size the Muskingum ranks first, with an area of 7,797 square miles, nearly one-fifth of the area of the State. The Maumee is next in size, with an area of 6,344 square miles, of which 4,702 square miles are in Ohio, 1,303 in Indiana, and 339 in Michigan. The total area of the Great Miami basin is 5,247 square miles, of which 1,355 square miles are in Indiana and the remainder in Ohio. The Little Miami basin has an area of 1,709 square miles, all of which is in Ohio. The Sandusky basin has an area of 1,581 square miles, being almost exactly one-fourth as large as the Maumee. These areas were computed with a planimeter from the best available map of the State and are fairly accurate.

POPULATION.

According to the Twelfth Census, the population of the Sandusky drainage area is 126,591, of which 49,370 may be considered as urban and the remainder, 77,221, as rural. In explanation of these terms, it may be said that all cities or villages with an estimated population of 1,000 or more are classed as urban, while those below this figure are included with the rural population. This low figure is assumed in order to bring into the urban classes all the towns that have public water supplies or sewerage systems and to keep in the rural class all the villages not so provided.

On a similar basis of classification the Maumee basin is estimated to have a total population of 640,128, of which 339,268 are classed as urban and the remainder, 300,860, as rural. Of the above total population, Ohio has 478,078; Indiana, 141,899, and Michigan, 20,151. The total population of the Great Miami basin is 520,698, of which 258,859 are classed as urban and 261,839 as rural. Of the total population, 89,814 are in Indiana, divided as follows: Urban, 32,062, and rural, 57,752. The total population of the Little Miami basin is 120,959, of which 39,645 are urban and 81,314 rural. The Muskingum basin has a total population of 612,784, of which 229,794 are urban and 382,990 rural.

The following statement shows the population per square mile of each district:

Population per square mile of drainage basins of Ohio streams.

	Rural.	Urban.	Total.
Sandusky	49	31	80
Maumee	47	53	100
Great Miami	53.6	59.5	113.1
Little Miami	47.6	23.2	70.8
Muskingum	49	29	78
Average	49	39	88

In the small area of 216 square miles lying between the two Miami basins and tributary to Mill Creek and to Ohio River there is a total population of 375,571, of which 350,894 are urban and 24,677 rural. This gives an average population per square mile of 1,739. A large part of this area is occupied by the city of Cincinnati, which accounts for the unusually large urban population, amounting to 1,625 per square mile, against 114 per square mile of rural.

The slight excess in the average of the rural population of the Muskingum basin is due principally to the large number of small mining settlements scattered over the coal regions of that basin. Its agricultural population in much of its area is probably below the average, but the latter is brought up by the mining communities.

TOPOGRAPHY AND SOILS.

In general topography the Sandusky and Maumee are much the same. Both lie in glaciated areas and have the level plains and rolling elevations characteristic of such districts. The Sandusky basin is generally more rolling than the Maumee, especially the Ohio portion of that area. The large central area of the Maumee basin is taken up by a fertile, level plain, while the outer edges of this fan-shaped district are more hilly, especially to the north and west.

The Sandusky drainage area consists of ordinary agricultural land interspersed with small patches of timber. There is practically no waste land in the whole district, except a small marshy area around the mouth of the stream. Corn and wheat form the staple crops, with the usual admixture of hay and oats.

In the Maumee basin agriculture is not so far advanced and there are large tracts of land still covered with brush and shrubbery, but little good timber remaining. The extensive hard-wood forests of this region were a profitable field for the operation of stave and heading factories, and as a result of the extent to which these industries were carried on there is now much waste land here. In the cleared areas of the central and southern portions of this area corn is the staple and almost the only crop, but farther north the dairy and stock-raising interests are large and much land is kept in pasture, with a good per cent under cultivation for feed.

With reference to surface configuration, the Miami basins occupy a place between the Maumee and Sandusky basins on one hand and the Muskingum on the other. In this district there are greater extremes of elevation than in any other portion of the State, but the slopes are more uniform and the surface is more rolling than in the Muskingum basin, and there is none of the level prairie that is found in the northwestern part of Ohio.

The northwestern part of the Great Miami basin and the northeastern part of the Little Miami consist of comparatively level elevated areas, marked, however, with rolling glacial moraines. Between these two districts and connecting the extremes of elevation—425 feet above sea level at the confluence of the Great Miami and Ohio rivers and 1,540 feet just east of Bellefontaine—there is a wide strip of hilly and heavily rolling land with a rather steep slope to the southwest. A narrow strip of high land running lengthwise through this area forms the dividing line between the Great and Little Miami basins.

As the entire area of both basins has been glaciated, the surface presents the smoothed-over appearance that characterizes such districts, and no abrupt changes are to be found except where the streams have cut out their valleys in the soft drift.

The surface is covered with wide areas of heavy limestone soil, crossed by narrow stretches of loamy and gravelly soil. Some of the stream valleys contain extensive alluvial deposits, which form very fertile areas. Much of the clay subsoil of the southern part of the Little Miami drainage area is covered with loam, forming on the level uplands excellent farming districts.

As the whole district is essentially an agricultural one, the timber was rapidly cleared off and but small isolated wood lots now remain over the tillable portion. Along the steep hillsides and the streams there are still found stretches of forest, much of which is scrub or young growth, all the merchantable timber having been cut out.

The lower and rougher portions of the Little Miami basin contain the most heavily wooded areas to be found in either basin. Here, on the steep hills bordering the streams, there are still to be found many good tracts of timber, the inaccessibility of which has so far prevented their destruction.

Corn, wheat, and tobacco are the staple crops, the last being important in both districts. In and around Cincinnati extensive dairy interests have been built up. Good roads cover nearly all of both basins, indicating better than anything else that they are rich districts, inhabited by a prosperous and enlightened people.

The Muskingum drainage area is entirely different from the others under discussion. The terminal moraine passes diagonally across this district from northeast to southwest, leaving the northern and western part glaciated and the large central and southern portion unglaciated. The glaciated region is level in but few portions, but the rising, rolling ground makes an excellent agricultural district. The soil is here composed of glacial drift, and is usually deep and fertile. It is especially adapted to the raising of wheat, and large crops of this cereal are harvested annually. In the lowlands corn is also a flourishing crop. At one time, it might be added, these districts supported a large amount of stock, but the decline in prices has practically done away with grazing, especially with the raising of sheep for wool. It is to be supposed that the present increase in price will reestablish this industry.

The eastern, central, and southern parts of the Muskingum drainage area, or the unglaciated portions, are very hilly and rough, and the streams run in deep valleys cut in the bed rock. Here the soil is of a poorer quality, as it is formed by the disintegration of the native rock, and not as good a field is offered for agriculture except in the stream valleys, where there are long strips of alluvial deposit, which yield enormous crops of corn. The unglaciated section also corresponds roughly to the mining district, a fact which has tended to decrease the agricultural value of much of the land.

The fertile fields of the northwestern part of the area and the hills of the southeastern part have been stripped of timber, the former to make room for agriculture and the latter for use in the mines; and as a result nearly all the timber left standing is to be found between the agricultural and mining sections.

GEOLOGY.

The Sandusky and Maumee basins lie, respectively, east and west of the Cincinnati axis or anticline, so that in the Sandusky basin the formations occur successively in long, narrow strips running nearly north and south. Starting at the east, the ages are as follows: Carboniferous, including only the Mississippian limestone and the Waverly; Devonian, including the Ohio shale, the Black shale, the Hamilton, and the upper Helderberg; finally, Silurian, with only the lower Helderberg, Rondout waterlime, Niagara, Clinton, and Medina appearing. In the Maumee basin these appear in reverse order, but in less regular strips and trending to the northwest instead of due west.

In a few localities in both basins where the drift was thin it has been removed for stone quarrying, but the industry could not be called an important one.

As stated before, the Great and Little Miami areas have both come under the influence of the glacial action which covered the original strata with a layer of drift that varies in thickness from 5 to more than 100 feet. Practically all the bed rock belongs to the Silurian system; the Hudson River group, the Utica shale, and the Trenton limestone covering the entire southern portion of both basins, while to the north and east there is a wide band of Niagara, Clinton, and Medina, and to the extreme northeast is found the lower Helderberg and Rondout waterlime.

On the high elevation east of Bellefontaine there appear small areas of both the Devonian groups, the Hamilton and upper Helderberg, and the shales. Near Dayton and in the valleys of the Stillwater at Covington and Mad River below Springfield there are extensive limestone quarries. At the latter place and at Cedarville, on Massicks Creek, a considerable quantity of limestone is taken out to be burned for lime.

In the Muskingum drainage area sedimentary deposits of only one age appear, the Carboniferous, with the following groups: Coal Measures, conglomerate, Mississippian limestone, and the Waverly. The first two of these occupy the large eastern and central section of the watershed, and the last two the western part. The Coal Measures contain many excellent veins of coal, which are extensively mined over a considerable area of this watershed. The above-named strata also furnish fire clay, limestone, and some building stone.

DRAINAGE.

SANDUSKY RIVER.

The Sandusky basin contains but one important drainage line, namely, the Sandusky River proper, which rises in the extreme eastern part of its drainage area and flows at first westward then northward to Sandusky Bay. Into this main stream there flow a large number of small creeks, among which are Broken Sword, Tymochtee, Sycamore, Honey, Wolf, Muskalong, and Green, the latter entering the river almost at its mouth.

Sandusky River is 115 miles long and has an average fall of 6.41 feet per mile. Its headwaters have an elevation of 1,282 feet above sea level, or 709 feet above Lake Erie. Near its headwaters the fall per mile is about 28 feet, but this is reduced to 7 feet between Bucyrus and Upper Sandusky, and thence the fall decreases gradually to 2.5 feet per mile below Fremont. Above Fremont the river has a steady flow, but below that town it becomes sluggish, winding in and out through low, flat, and in many places marshy land, until it reaches Sandusky Bay, where it spreads out over a broad plain covered with grass and lilies. Originally the headwaters of this river were situated at several springs $4\frac{1}{2}$ miles east of Crestline, but since the water from these has been appropriated for the supply of that city little or none of the flow reaches the river. The headwater streams are now West Branch and "Stink" Creek, both of which are fed to a small extent by spring water, but to a much larger extent by the sewage of Crestline.

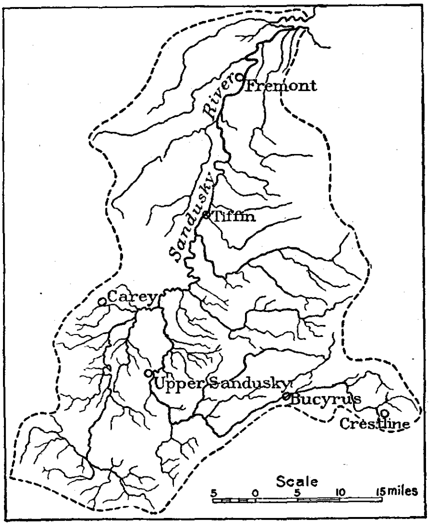

FIG. 2.—Map of drainage basin of Sandusky River.

MAUMEE RIVER.

Maumee River is formed by the junction of St. Joseph and St. Mary rivers at Fort Wayne, Ind. Its main drainage line starts at the extreme western edge of the drainage area and runs northeastward to the bay of Toledo. To this main line, Maumee River proper, there are four important tributaries, Tiffin and St. Joseph rivers on the north and Auglaize and St. Mary on the south. The Tiffin and Auglaize join the Maumee at Defiance, and a very symmetrical drainage basin would be formed were it not for the fact that the Tiffin is much smaller than the Auglaize. The last-named stream has itself two large tributaries, Blanchard and Ottawa rivers, which enter it from the east.

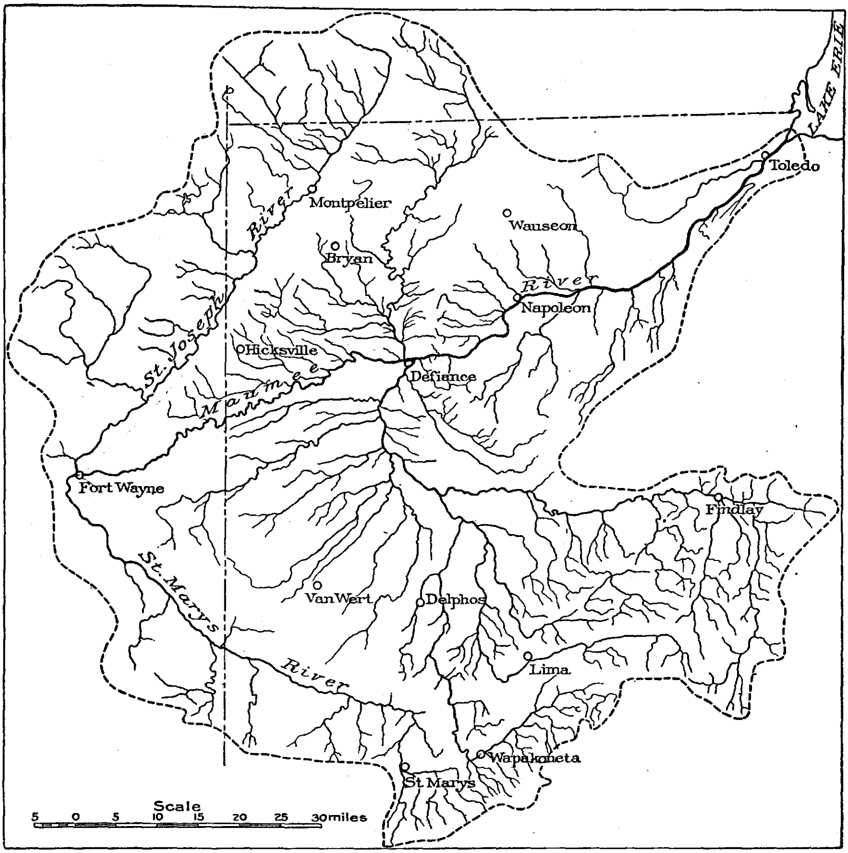

FIG. 3.—Map of drainage basin of Maumee River.

Length and fall of Maumee River and tributaries.

Stream.	Length in miles.	Total fall in feet.	Fall per mile in feet.
Maumee	150	164	1.1
Tiffin	65	293	4.5
St. Joseph	100	313	3.1
Auglaize	74	325	4.4
St. Mary	100	238	2.4

GREAT AND LITTLE MIAMI RIVERS.

The main drainage line of the Great Miami basin starts in its extreme northeastern part and runs southwestward, joining Ohio River at the Ohio-Indiana State line. Until Dayton is reached it occupies the central portion of the basin, but from that point down it lies very close to the eastern edge of its drainage area. Below Dayton its tributaries, not considering Whitewater River, consist of Indian, Sevenmile, and Twin creeks, each of which drains a long and narrow strip of territory. At Dayton the main stream receives two large tributaries—Mad River from the east and the Stillwater from the west.

In the Little Miami basin the main drainage line rises in the extreme northern part of the district and flows southwest, keeping close to the western boundary for its whole length, and finally joining the Ohio a few miles above Cincinnati. Its principal tributaries, all flowing in from the east, are the east branch of the Little Miami, Todds Fork, Cæsars Creek, and Massicks Creek, the first named being the most important.

The length, total fall, and fall per mile of the main streams and tributaries in both basins are shown in the following table:

Approximate gradient of Miami rivers and tributaries.

Stream.	From—	To—	Distance in miles.	Total fall in feet.	Fall per mile in feet.
Great Miami River	Ohio River	Hamilton	33	145	4.4
Do	Hamilton	Dayton	44	160	3.6
Do	Dayton	Piqua	33	110	3.3
Do	Piqua	Degraff	27	120	4.4
Do	Degraff	Headwaters	26	90	3.5
Do	Ohio River	do	163	625	3.8
Stillwater River	Dayton	Covington	30	150	5
Do	Covington	Headwaters Greenville Creek.	36	240	6.7
Do	do	Headwaters Stillwater River.	32	165	5
Do	Dayton	Headwaters Greenville Creek.	66	390	5.9
Do	do	Headwaters Stillwater River.	62	315	5.1
Mad River	do	Springfield	23	170	7.4
Do	Springfield	Headwaters	35	300	8.6
Do	Dayton	do	58	470	8.1
Twin Creek	Great Miami River	do	48	450	9.4
Sevenmile Creek	do	do	34	510	15
Little Miami River	Ohio River	Milford	13	66	5.1
Do	Milford	Waynesville	35	180	5.1
Do	Waynesville	Headwaters	46	450	9.8
Do	Ohio River	do	94	696	7.4
East branch Little Miami River.	Little Miami River	Batavia	12	105	8.8
Do	Batavia	Williamsburg	19	200	10.5
Do	Williamsburg	Headwaters	42	300	7.1
Do	Little Miami River	do	73	605	8.2

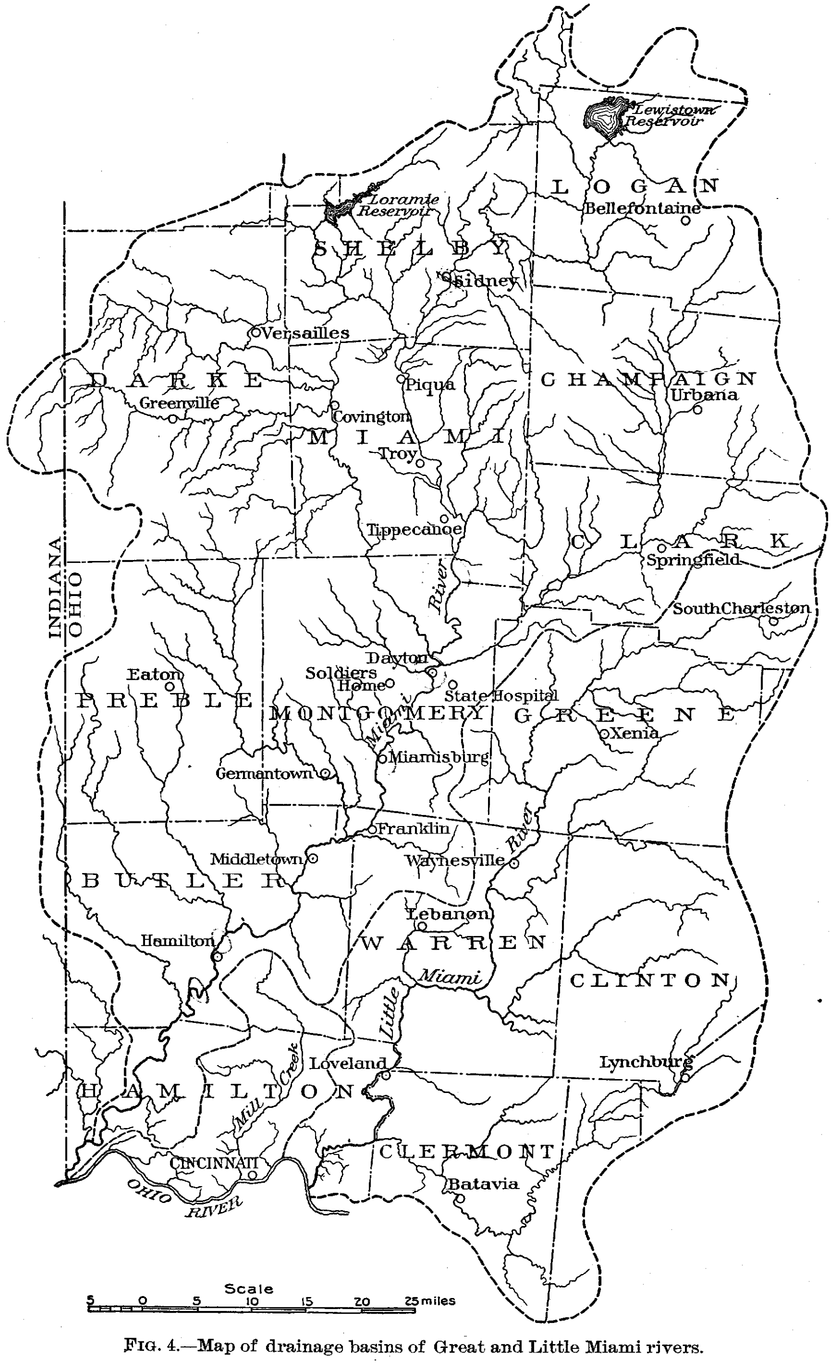

FIG. 4.—Map of drainage basins of Great and Little Miami rivers.

It is evident at once from this table that all the streams of the Miami basin flow at very rapid rates. Even the lowest average gradient, 3.3 feet per mile, found between Dayton and Piqua, is sufficient in a large stream to give a swift current. The gradient of the Great Miami is very uniform throughout its entire course, more so than is usual in so long a stream. Mad River also has a very uniform but a much steeper gradient. Sevenmile and Twin creeks, coming down from the high land near the Indiana line, have a very high gradient, the highest in either of the two basins. The upper part of Little Miami River and the east branch of the same stream also have high rates of flow, induced by steep gradients. At one time the excellent water powers on these streams were utilized by numerous mills, but now many of these have been abandoned. A discussion of available water powers is given later in connection with the descriptions of water powers still in use.

Owing to the general use of the land for agricultural purposes no extensive tracts of swamp land remain unreclaimed. Many large areas have been ditched and tiled, and much that was formerly waste land has been turned into exceptionally fertile fields.

The valley of Mad River between Dayton and Springfield, except immediately below the latter city, is low and swampy, much of it being so low that it can with difficulty be drained for use. Along this stream in Champaign County there are large areas of low, wet, peaty land which have not yet been successfully drained.

MUSKINGUM RIVER.

The main drainage system of the Muskingum basin consists of Muskingum River and its four principal tributaries, namely, Licking Creek, Wills Creek, Walhonding Creek, and Tuscarawas River, the two last-named streams uniting at Coshocton to form the Muskingum proper. The three streams designated creeks are large and could very properly be called rivers.

Tuscarawas River and Walhonding Creek drain the eastern and western parts of the upper portion of the drainage basin, and Wills Creek and Licking Creek, together with Muskingum River, drain the eastern, western, and central parts of the lower portion. Tuscarawas and Muskingum rivers could very properly be considered as one stream, forming the central drainage line of the watershed.

The pre-Glacial drainage of this area was along lines entirely different from the present ones. It is claimed that Muskingum River turned westward at Dresden and flowed through Licking Creek Valley to the Scioto. It is also believed that the Scioto flowed eastward through this same valley, then northward through the Muskingum, Tuscarawas, and Cuyahoga basins into Lake Erie. It seems to be established that the Muskingum did not have its present outlet. Some of the facts that have led to this opinion are, the traces of a large channel through the Licking Valley, the small size and recent excavation of the present Muskingum River channel south of Zanesville, and the deep channel of the Tuscarawas to the north, where in many places the bed rock is lower than that in the Muskingum Valley to the south.

The following table shows the approximate gradient of the main streams and their more important tributaries:

Approximate gradient of principal streams of Muskingum drainage basin.

Stream.	From—	To—	Distance in miles.	Total fall in feet.	Fall per mile in feet.
Muskingum	Mouth	Zanesville	70	106	1.5
Do	do	Coshocton	99	180	1.8
Do	Zanesville	do	29	74	2.6
Muskingum and Tuscarawas.	Mouth	Headwaters	211	530	2.5
Tuscarawas	Coshocton	Canal Dover	47	110	2.4
Do	do	Headwaters	112	350	3.1
Stillwater	Mouth	Tippecanoe	16	23	1.4
Do	do	Headwaters	47	392	8.6
Licking	Zanesville	Newark	23	134	5.8
Do	Newark	Headwaters	33	399	12
Do	Zanesville	do	56	533	9.5
Wills	Mouth	Cambridge	46	69	1.5
Do	Cambridge	Headwaters	35	201	5.7
Do	Mouth	do	81	370	4.5
Walhonding	Coshocton	Headwaters of Killbuck	54	230	4.3
Do	do	Headwaters of Black Fork.	92	635	6.9
Do	do	Headwaters of Kokosing.	62	365	5.9

From the above table it is seen that the fall per mile along the main drainage line, the Muskingum and Tuscarawas, is very small and the flow sluggish. This is especially true of Muskingum River and the lower part of the Tuscarawas. The fall per mile of the lower part of both Stillwater and Wills creeks is in keeping with their lack of current, but the fall is so great in the hills which form their headwaters that the average for the whole stream is brought up to a rather high figure.

This same feature is shown, but in a less marked degree, in all the streams, and no doubt it is gradually increasing as the water cuts back into the hills at the headwaters and spreads débris out over the valleys below. This general silting up of the lower channels is greatly prevented by the great number of dams in the streams, each one of which holds back from every flood a large amount of sediment that would have been distributed along the whole channel. Tiling also has decreased the amount of sediment reaching the streams. In the hilly portions of the basin many good farms have been ruined, and in some of the abandoned mining districts, where the timber has been cut away and the ground exposed, the hills have been cut into by such enormous gullies that it seems as if it would be impossible ever to reclaim them. Nature will require many years to restore these waste lands unless she is intelligently assisted by man.

In the northern and western parts of the drainage basin the fields are well tiled and ditched. In fact, nearly all the swamp land has been

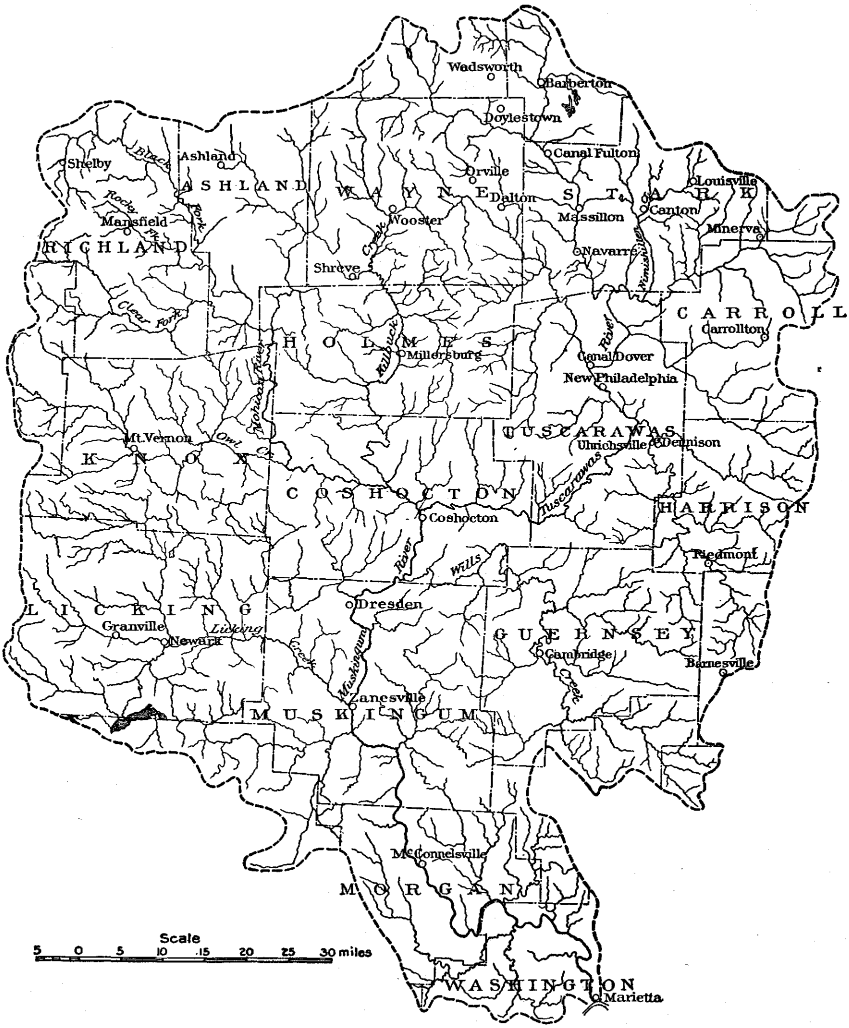

FIG. 5.—Map of drainage basin of Muskingum River.

reclaimed, the only extensive area still in existence being a strip along Killbuck Creek between Wooster and Shreve. All through the drainage basin there are areas that are swampy in wet years, but as a rule the drainage of the basin is good—too good, in fact, for the preservation of the summer flow of the streams.

FLOW OF STREAMS.

In connection with the United States Geological Survey, the Ohio State board of health established gages for reading the daily height of the streams at Mexico and Fremont, on the Sandusky, and at Waterville, on the Maumee; but owing to changes in the stream bed and certain obstructions to the flow, it was not possible to work up the discharge of the Sandusky at Fremont, and the flow of this stream at Sandusky and of the Maumee at Waterville only are given.

SANDUSKY RIVER.

The daily gage-height readings of Sandusky River at Mexico extend from November, 1898, to November, 1900, when the gage was destroyed

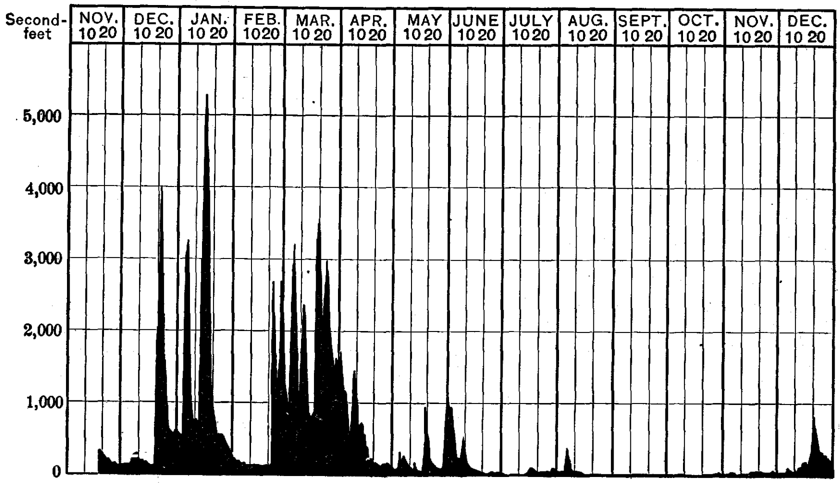

FIG. 6.—Diagram showing discharge of Sandusky River at Mexico in 1898–99.

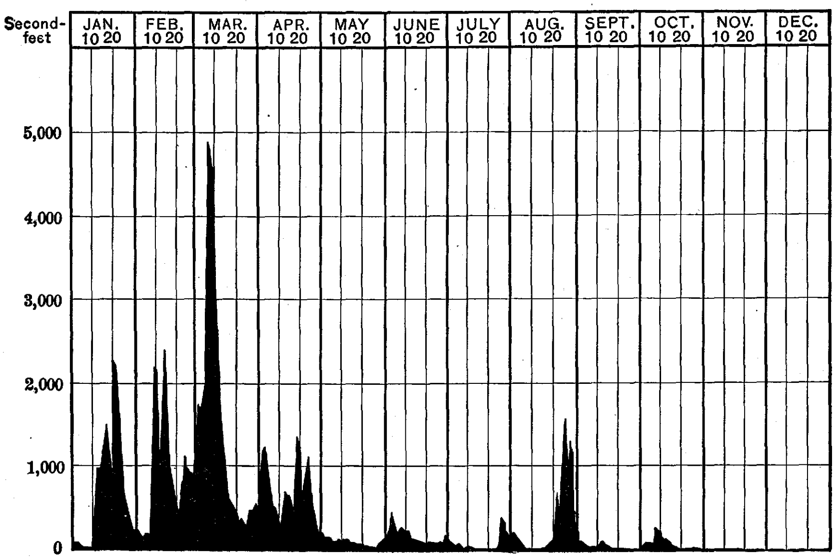

FIG. 7.—Diagram showing discharge of Sandusky River at Mexico in 1900.

and the station abandoned. Owing to lack of facilities, it was impossible to estimate the rainfall by any means except that of averaging the monthly records of the various stations in and near the drainage basin. For the basin above Mexico six stations are used, and in the same table there are given two other stations, with a separate average of the eight for use at such time as it is possible to get the discharge at the Fremont station.

Monthly discharge of Sandusky River at Mexico, 1898–1900.

[Drainage area, 776 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.			
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	Rainfall in inches.	Ratio.
1898.								
December	4,035	100	727.4	44,726	0.950	1.090	2.65	0.411
1899.								
January	5,410	240	1,515.6	93,222	1.953	2.253	3.29	.684
February	2,725	100	636.4	35,344	.820	.854	2.21	.386
March	3,580	795	1,871.1	115,049	2.424	3.714	4.84	.767
April	1,730	100	600.2	35,714	.773	.856	1.44	.594
May	1,145	45	626.6	13,933	.292	.334	4.55	.073
June	935	6	207.5	12,347	.267	.297	2.95	.100
July	100	4	31.7	1,949	.040	.040	4.82	.008
August	375	3	43.9	2,699	.056	.066	1.86	.035
September	6	2	2.9	173	.003	.003	2.34	.001
October	30	2	8.9	547	.011	.011	2.22	.005
November	45	12	23.9	1,422	.030	.030	2.28	.013
December	655	30	170.8	10,502	.220	.230	3.20	.072
Year	5,410	2	496.6	322,901	.640	8.688	36	.241
1900.								
January	2,245	8	655.5	40,581	.844	.974	2.22	.439
February	2,380	125	888.9	49,367	1.145	1.192	4.18	.285
March	4,870	270	1,407	86,513	1.813	2.093	2.64	.793
April	1,355	180	686.2	40,832	.884	.984	2.84	.340
May	180	20	88.4	5,436	.114	.134	2.57	.521
June	445	80	161.5	9,610	.208	.228	3.94	.578
July	410	6	78.7	4,839	.101	.121	4.72	.256
August	1,560	4	242.6	14,917	.312	.362	4.76	.076
September	125	4	38.3	2,279	.049	.058	2.04	.028
October	270	8	70.1	4,310	.090	.100	2.53	.039

The mean monthly rainfall shown in the next to last column was obtained from the following table, the data for which were obtained from the reports of the United States Weather Bureau:

Rainfall in Sandusky drainage basin, 1898–1900.

	1898.	1899.													1900.												
	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Bucyrus	1.25	-----	-----	-----	1.33	5.71	2.95	5.01	0.40	3.88	-----	-----	-----	------	0.60	2.85	2	-----	3.27	4.64	3.40	4.63	2.10	1.75	1.03	0.73	------
Findlay	2.51	3.19	1.50	4.57	1.77	3.31	2.30	5.08	.79	1.61	1.91	1.71	3.06	30.80	1.70	5.19	1.52	1.99	2.86	1.60	5.84	6.27	1.50	3.16	3.10	.08	35.61
Kenton	3.04	3.46	2.11	4.90	1.21	4.65	1.05	3.28	2.25	1.32	2.05	3.04	2.93	32.25	3.11	4.29	2.31	2.30	1.39	5.04	3.67	3.41	1.52	3.67	4.66	1.01	36.38
Mansfield	4.30	3.61	2.31	5.55	1.75	4.60	6.42	4.75	1.60	4.55	3.20	2.40	3.39	44.13	2.89	4.75	4.30	4.85	3.50	4.15	7.88	4.65	2.23	2.15	4.63	1.62	47.60
Marion	1.65	2.97	1.68	4.71	1.45	3.05	2.42	4.73	3.47	1.39	1.79	2.29	3.02	32.97	3.35	3.86	2.74	3.12	1.33	5.64	3.13	4.52	2.99	1.84	3.45	1.31	37.01
Upper Sandusky	3.14	3.20	2.44	4.48	1.14	5.96	2.55	6.08	2.67	1.30	2.16	1.95	3.60	37.53	2.69	4.14	3.25	2.20	3.05	2.57	4.37	5.06	1.98	2.62	2.57	1.35	35.85
Mean for Mexico station	2.65	3.29	2.21	4.84	1.44	4.55	2.95	4.82	1.86	2.34	2.22	2.28	3.20	36.00	2.22	4.18	2.64	2.89	2.57	3.94	4.72	4.76	2.04	2.53	3.24	1.15	36.88
Tiffin	3.30	3.72	2.20	5.06	2.64	5.42	2.10	4.56	.90	1.53	2.15	1.84	3.27	35.39	2.19	4.91	2.14	2.55	1.21	3.80	7.55	4.39	.91	1.91	2.90	.92	35.38
Vickery	2.43	3.23	1.49	4.87	.82	5.27	1.96	3.25	1.38	.85	1.98	1.71	2.18	28.99	1.74	3.94	1.68	1.72	2.36	3.36	5.89	2.72	1.03	1.46	2.58	.57	29.05
Mean for Fremont station	2.70	3.34	2.10	4.88	1.51	4.75	2.72	4.59	1.68	2.05	2.18	2.13	3.06	34.99	2.16	4.24	2.46	2.68	2.36	3.85	5.22	4.46	1.77	2.32	3.12	1.05	35.69

Above Mexico Sandusky River has a drainage area of 776 square miles. The country consists of rolling farm land in a high state of cultivation. There remain very few tracts of timber of large size, and the fields are fairly well drained by ditches and tile.

There are six small dams in the river above the gaging station, but they store very little water and seem to have no perceptible influence on the flow at Mexico.

MAUMEE RIVER.

The gaging station on this stream was placed at Waterville, the first available place above the influence of backwater from Maumee Bay, in November, 1898, and was abandoned early in 1902. The mean monthly rainfall in this basin was obtained by averaging the depth reported from 21 stations within or neighboring to the basin.

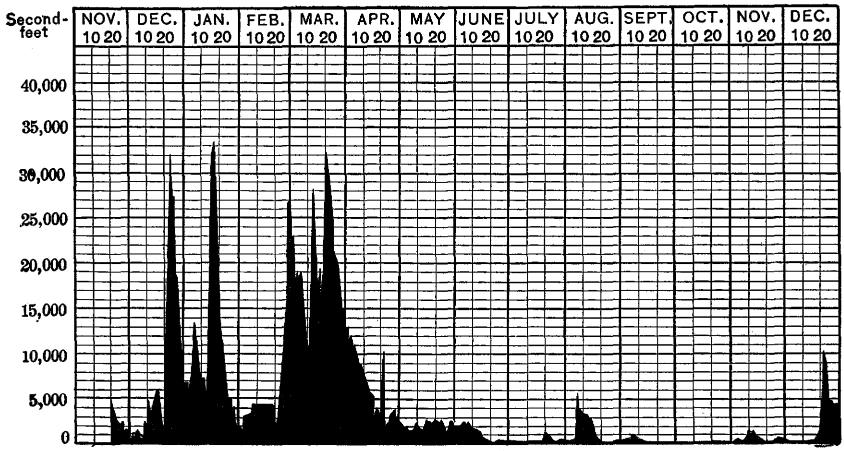

FIG. 8.—Diagram showing discharge of Maumee River at Waterville in 1898-99.

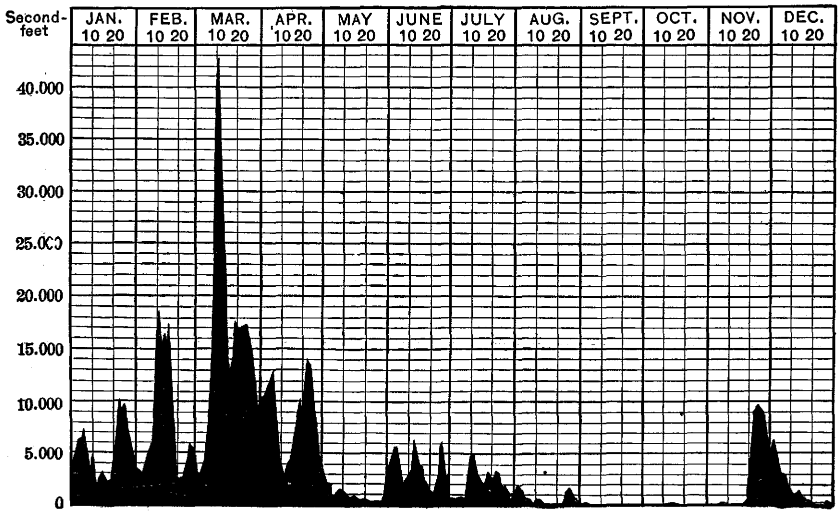

FIG. 9.—Diagram showing discharge of Maumee River at Waterville in 1900.

Monthly discharge of Maumee River at Waterville, 1898–1900.

[Drainage area, 611 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.			
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	Rainfall in inches.	Ratio.
1898.								
December	32,120	680	8,203.4	504,407	1.325	1.525	2.41	0.632
1899.								
January	33,250	780	10,979	675,072	1.796	2.070	2.60	.796
February	26,765	1,310	6,301.2	349,950	1.080	1.070	2.14	.500
March	32,100	8,700	19,431.4	1,194,790	3.180	3.660	4.39	.833
April	12,960	1,800	6,027.5	358,661	.986	1.095	1.11	.986
May	2,750	1,200	1,990	352,360	.325	.375	3.66	.102
June	2,450	150	1,057.3	62,814	.173	.203	1.88	.108
July	1,200	3	285.3	17,536	.046	.046	4.36	.011
August	4,940	70	1,362.2	43,758	.223	.253	2.09	.121
September	990	20	259	15,411	.042	.042	2.40	.018
October	150	5	48.1	2,955	.007	.007	2.51	.003
November	1,310	40	521	31,001	.085	.085	2.12	.040
December	9,950	10	2,323.2	142,847	.380	.450	3.08	.146
Year	33,250	3	5,211.7	3,017,155	.689	9.356	32.34	.227
1900.								
January	10,200	1,200	5,053.9	310,752	.827	.947	1.25	.757
February	18,985	2,450	7,943.9	441,180	1.300	1.342	4.50	.298
March	42,750	2,600	15,609.7	959,803	2.554	2.942	2.13	1.381
April	13,965	2,600	8,149.1	484,904	1.330	1.480	2.40	.617
May	3,050	200	937.7	57,657	1.530	1.760	2.65	.664
June	6,320	680	3,443.6	204,907	.563	.623	4.30	.145
July	5,120	300	2,093.5	128,724	.342	.392	4.89	.080
August	1,930	5	562.7	34,598	.092	.104	3.56	.029
September	250	5	26.8	1,596	.004	.004	1.45	.003
October	250	5	40.6	2,499	.006	.006	2.80	.002
November	9,700	10	2,619	155,840	.428	.478	3.89	.123
December	6,320	70	1,508.7	92,766	.246	.286	.83	.344
Year	42,750	5	4,665.7	2,275,226	7.635	10.364	34.65	.299

Rainfall in Maumee

	1898.	1899.										
	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
Angola	2.17	3	3.17	4.17	0.65	4.43	1.02	4.04	2.77	3.21	3.32	2.27
Auburn	1.77	2.03	2.01	3.02	.69	3.62	2.02	4.73	3.73	2.17	3.27	1.80
Bluffton	2.12	2.60	1.99	4.96	.97	3.31	2.02	4.61	2.12	1.59	2.60	3.28
Fort Wayne	2.33	2.34	2.35	5.01	.70	2.83	2.29	4.28	6.06	3.49	2.30	2.75
Adrian	1.85	1.91	2.06	3.87	.59	5.57	3.35	6.08	2.10	3.24	2.74	1.85
Hillsdale	1.89	2.44	2.02	4.01	.87	6.65	3.02	3.81	1.26	3.13	3.24	2.01
Benton Ridge	3.51	3.70	1.31	5.18	1.48	2.44	1.97	4.21	.66	.96	1.74	1.91
Bowling Green	1.57	2.17	2.39	4.59	1.21	3.24	2.33	4.33	.75	2.01	2.47	1.84
Celina	1.85	2.76	1.88	3.67	.70	2.92	1.67	4.06	------	------	2.01	2.03
Defiance	2.40	2.08	2.21	3.99	2.49	3.05	1.64	4.22	1.77	3.71	2.63	2.06
Findlay	2.51	3.19	1.50	4.57	1.77	3.31	2.30	5.08	.79	1.61	1.91	1.71
Hedges	2.50	2.88	1.54	------	------	2.37	------	------	------	------	------	------
Kenton	3.04	3.46	2.11	4.90	1.21	4.65	1.05	3.28	2.25	1.32	2.05	3.04
Leipsic	2.58	2.57	1.82	4.62	.56	------	1	------	2.50	1.50	2.80	1.63
Montpelier	2.55	2.09	2.01	3.41	1.92	3.65	2.05	------	------	------	------	------
Napoleon	3	1.25	2.52	4.39	1.56	2.68	1.51	5.19	.85	3.60	2.24	1.63
New Bremen	------	------	------	------	------	------	------	------	------	------	------	------
Ottawa	2.48	2.84	1.58	4.52	1.45	2.94	1.65	3.25	2.85	1.86	2.36	1.88
Swanton	------	------	------	------	------	------	------	------	------	------	------	------
Van Wert	2.25	2.25	1.70	4.76	.44	------	1.80	6	------	2.35	------	------
Wauseon	3.28	3.90	4.52	5.47	1.19	4.53	1.11	4.52	.84	2.70	2.50	2.17
Total	45.71	49.46	40.69	79.11	19.95	62.21	33.80	71.69	31.30	38.45	40.19	33.86
Mean	2.41	2.60	2.14	4.39	1.11	3.66	1.88	4.36	2.09	2.40	2.51	2.12

basin, 1898–1900, in inches.

1899.		1900.												
Dec.	Total.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
3.31	35.65	1.37	5.23	2.88	2.21	2.23	4.60	8.02	3.68	1.50	4.35	5.58	0.65	42.48
1.92	31.01	.76	5.05	1.89	1.98	2.44	5.61	5.29	3.87	1.39	2.44	4.45	.45	35.62
2.92	32.47	.83	3.95	1.92	2.92	3.34	5.01	3.03	4.15	1.87	2.74	3.88	.93	34.57
3.16	37.56	.86	5.11	1.87	2.26	3.40	6.05	3.52	------	1.84	2.83	------	------	------
2.39	35.75	.72	3.26	2.91	1.85	3.33	3.15	7.04	2.50	2.12	2.83	3.90	.27	33.88
2.77	35.23	.79	4.09	2.55	2.22	2.35	4.49	8.42	1.80	1.55	2.99	4.80	.43	36.48
3.39	28.95	1.67	5.50	2.81	2.72	2.42	2.54	4.45	4.69	1.66	3.05	3.66	1.18	36.35
2.70	30.03	.97	3.36	1.33	2.45	2.95	3.80	3.76	4.24	.85	2.95	3.32	1	30.98
4.01	------	1.58	4.99	2.21	2.05	2.17	4.07	2.33	4.18	1.51	1.87	2.43	1.33	30.72
3.50	33.35	1.20	4.41	1.81	3.17	3.21	5.36	6.03	2.58	1.07	3.07	3.76	.59	36.26
3.06	30.80	1.70	5.19	1.52	1.99	2.86	1.60	5.84	6.27	1.50	3.16	2.10	.88	35.61
------	36.26	------	3.11	1.14	2.35	2.89	4.22	4.75	2.85	.92	2.78	4.10	.72	------
2.93	32.25	3.11	4.29	2.31	2.30	1.39	5.04	3.67	3.41	1.52	3.67	4.66	1.01	36.38
------	------	------	------	------	------	------	------	4.80	2.45	.70	1.55	------	.75	------
------	------	.96	4.44	2.39	2.23	2.09	6.61	6.35	2.16	1.63	3.62	3.92	.57	36.97
3.48	30.90	.65	4.33	2.79	2.50	2.30	5.47	3.48	2.80	1.34	2.62	3.61	.95	32.84
------	------	1.12	------	------	1.74	2.28	3.91	2.37	4.09	1.84	2.19	4.22	1.09	------
3.26	30.44	1.42	4.55	1.67	2.21	2	2.89	3.88	3.10	1.11	2.03	3.37	1.05	29.34
------	------	------	------	------	------	------	------	------	------	------	------	3.32	1.03	------
------	------	------	------	------	------	------	------	------	5.74	1.55	2.12	3.37	------	------
3.36	36.81	1.50	5.57	2.17	4.04	4.12	3.01	5.71	2.97	1.61	3.09	4.48	.93	39.38
46.16	------	21.21	76.43	36.17	43.19	47.77	77.43	92.74	67.71	29.08	55.95	73.93	15.81	------
3.08	32.34	1.25	4.50	2.13	2.40	2.65	4.30	4.89	3.56	1.45	2.80	3.89	.83	34.65

The rainfall table for 1901 gives the mean annual rainfall for the basin as 30.89 inches, which is 1.45 inches less than the rainfall for 1899 and 3.76 less than for 1900. This lower rainfall is accompanied by a falling off in the run-off, the figure being 19.9 per cent, as against 22.7 per cent and 29.9 per cent for 1899 and 1900, respectively.

To prevent overvaluation of these results, it must be noted that the canal system takes a small amount of water from above the gaging station and returns some of it below this station. On the extremely low flows this may have some influence, but it is not believed that it is extensive.

Monthly discharge of Maumee River at Waterville in 1901.

[Drainage area, 6,111 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.			
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.	Rainfall in inches.	Per cent.
January	6,110	480	2,389.7	146,937	0.391	0.451	1.90	23.7
February	9,450	580	3,716.8	206,421	.608	.633	1.45	43.6
March	27,600	2,240	11,207.9	689,147	1.834	2.114	2.58	81.9
April	8,160	1,020	3,646.3	216,970	.596	.658	2.18	30.2
May	22,750	530	3,147.9	193,557	.515	.594	3.90	15.3
June	15,220	660	3,599	214,155	.589	.657	3.84	17.1
July	14,215	80	2,503.1	153,910	.410	.473	3.06	15.5
August	140	5	47.7	2,935	.008	.009	2.74	.3
September	80	10	42	2,499	.007	.008	1.35	.6
October	1,020	10	246.1	15,132	.040	.046	2.73	1.7
November	180	60	98	5,831	.016	.018	1.53	1.2
December	11,200	110	2,585.8	158,995	.423	.488	3.63	13.5
Year	27,600	5	2,771.2	2,006,489	.453	6.149	30.89	19.9

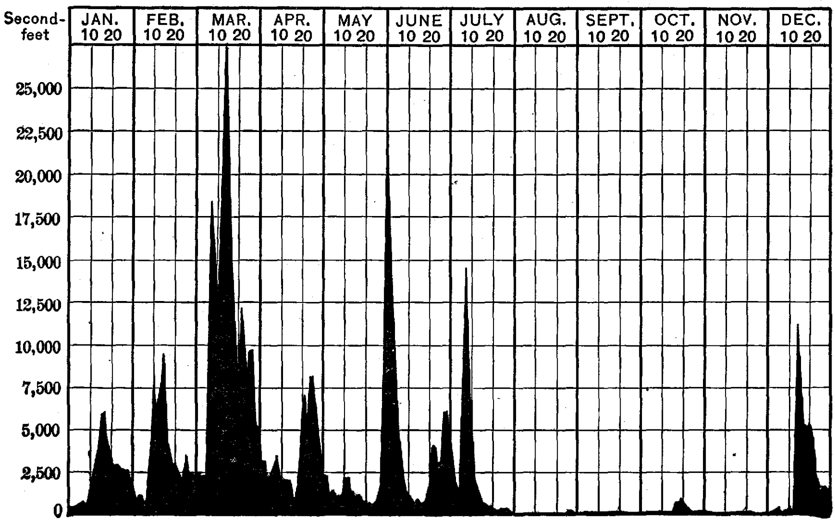

FIG. 10.—Diagram showing discharge of Maumee River at Waterville in 1901.

Rainfall in Maumee basin in 1901, in inches.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Angola	3.19	1.93	3.26	2.54	2.75	4.10	5.95	4.58	0.87	6.15	1.81	3.47	40.60
Auburn	1.58	1.44	1.15	1.94	2.45	2.87	1.38	3.71	1.30	3.71	1.15	1.57	24.25
Bluffton	1.17	.93	2.76	2.34	4.16	3.29	1.23	4.79	1.12	3.40	1.50	4.01	30.70
Fort Wayne	1.49	1.74	------	------	------	------	------	------	------	------	------	------	------
Adrian	2.12	1.31	2.37	1.33	2.53	2.23	1.75	2.05	.97	3.46	1.89	2.91	24.92
Coldwater	2.79	1.75	2.71	2.18	1.78	4.96	4.67	4.10	.73	6.56	1.82	3.25	37.30
Hillsdale	2.53	2.63	2.95	1.98	2.64	3.55	2.68	2.20	.93	5.63	2	3.12	32.84
Benton Ridge	1.42	2.10	3.15	2.03	3.70	3.59	2.66	2.02	1.82	.24	------	3.59	------
Bowling Green	2.57	1.30	2.86	2.23	4.91	3.98	4.42	4.38	1.32	1.15	2.33	4.21	35.66
Celina	1.74	.80	3.14	2.27	4.79	3.98	3.24	1.86	1.95	.94	.95	3.58	29.24
Defiance	1.10	1.07	2.35	1.87	3.93	3.47	6.08	2.16	1.54	2.63	1.41	4.14	31.75
Findlay	1.46	1.45	3.30	2.46	4.65	2.79	1.36	2.96	1.85	.86	.94	3.87	37.95
Hedges	1.12	1.03	3.02	2.19	5.28	3.26	1.89	2.25	1.76	2.27	1.35	4.03	29.45
Kenton	2.61	------	------	------	------	------	------	------	------	------	------	------	------
Leipsic	1.33	1.70	2.20	1.81	3.95	3.95	3.20	2.14	------	1.22	1.01	4.43	------
Montpelier	3.30	1.70	2.44	2.82	3.52	4.01	5.07	2.45	.82	4.09	1.71	3.10	35.03
Napoleon	1.58	1.25	2.51	2.01	4.03	5.10	2.98	2.53	.64	1.73	1.27	3.02	28.65
New Bremen	1.28	.77	1.26	2.11	4.67	5.14	1.68	2.11	1.44	1.09	1.25	3.75	26.55
Ottawa	1.64	1.26	2.60	2.34	4.32	2.46	3.32	2.61	1.61	.59	1.64	2.25	27.64
Swanton	2.01	1.44	2.05	2.12	3.58	6.68	3.71	2.55	1.32	1.36	1.92	3.88	32.62
Vanwert	1.68	1.46	2.04	2.11	6.63	2.32	1.63	1.50	1.74	2.24	1.28	4.64	29.27
Wauseon	2.10	1.38	3.57	2.99	3.67	5.15	2.33	1.93	1.95	2.88	1.61	5.73	35.32
Total	41.81	30.44	51.69	43.67	77.94	76.88	61.26	54.28	25.68	51.96	29.14	72.55	------
Mean	1.90	1.45	2.58	2.18	3.90	3.84	3.06	2.74	1.35	2.73	1.53	3.63	30.89

? This much at Waterville.

The Maumee basin has an area of 6,111 square miles, portions of which are in Indiana and Michigan. The central and southern parts of the district are rather level, while the northern part is rolling. In portions of the basin, notably the central part, there are still extensive areas of scrub-timber land; but by far the largest part is under cultivation or cleared for grazing.

MUSKINGUM RIVER.

No gaging station was established on Muskingum River, but a method by which the discharge could be approximately determined was found and used for one year. In fact, an accurate gaging of this stream with a reasonable expenditure of time and money would be very difficult. Below Zanesville slack-water navigation is maintained by ten fixed dams. Boats are locked through these from pool to pool or from level to level, as in a canal system. This effectually prevents the use of a current meter on the main portion of the river and makes it necessary to go to the tributaries for such work. To do this would involve the maintenance of a large number of gages and the making of innumerable meter measurements. This plan not being practicable, it was determined to approximate the flow by computations of

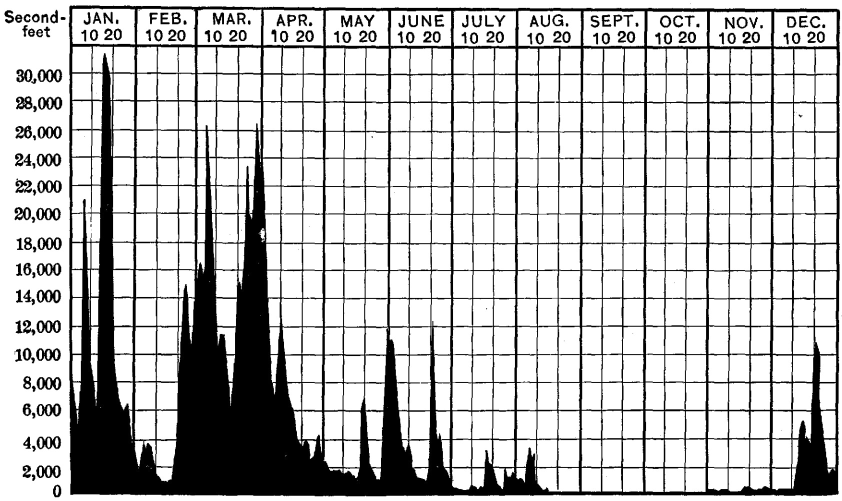

FIG. 11.—Diagram showing discharge of Muskingum River at Eagleport in 1899.

the discharge over one of the dams. Owing to the irregularity in the crest of these dams, to leakage, waste through locks, and other causes, it was found impossible with the time at hand to do as good work as the method would warrant.

Dam No. 8, at Eagleport, was selected as affording the best opportunity for success. The pool levels both above and below this dam, together with plans and other valuable information, were obtained through the courtesy of Mr. Edmund Moeser, United States resident engineer, Zanesville, Ohio. From the pool levels, which were read from one to six times daily, the daily average height of the water above the dam was computed. A formula for the flow over this dam was obtained from the Rafter experiments at Cornell University. Owing to the high water, it was impossible to survey a low place in the crest, and the effect of this lowered portion was estimated from the water powers both above and below this dam.

Estimated monthly discharge of the Muskingum River at Eagleport, Ohio.

[Drainage area, 6,849 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.		Mean rainfall in inches.
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.	
1899.							
January	31,590	2,670	11,466	705,008	1.98	1.67	2.61
February	14,970	720	5,137	341,368	.78	.75	1.83
March	26,530	5,640	15,898	978,546	2.68	2.32	4.52
April	22,570	2,530	7,146	425,213	1.16	1.04	1.81
May	12,020	1,060	2,789	171,501	.47	.41	4.76
June	12,370	720	3,945	234,742	.64	.58	4.00
July	3,520	251	960	59,007	.16	.14	4.35
August	3,500	171	709	43,612	.12	.10	1.47
September	194	171	175	10,483	.03	.03	3.30
October	348	171	181	11,141	.03	.03	2.12
November	476	194	322	19,183	.05	.05	1.60
December	11,120	220	2,711	166,724	.46	.40	3.05
The year	31,590	171	4,286	3,166,528	8.51	.627	35.42

The mean monthly rainfall as shown in the last column was obtained from the following table, the data for which were obtained from the reports of the United States Weather Bureau:

Rainfall on Muskingum basin in 1899, in inches.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Ashland	2.16	1.24	2.71	0.69	4.50	3.67	3.92	1.13	3.13	2.63	1.71	3.10	30.59
Bangorville	3.68	1.64	4.38	1.01	4.38	6.33	5.45	2.43	3.24	2.59	1.98	2.98	40.09
Canton	2.12	1.72	4.86	4.45	5.52	2.85	4.69	1.14	3.26	1.83	2.14	3.56	38.15
Green Hill	1.88	1.72	3.58	2.41	6.04	3.20	5.19	1.38	3.43	1.88	1.51	3.36	35.58
Wooster	3.29	1.04	3.95	1.28	4.42	1.95	3.73	.53	5.56	2.21	1.59	2.78	32.93
Cambridge	2.17	2.05	4.59	1.36	4.55	4.76	4.66	1.05	2.60	2.21	1.44	3.17	34.61
Canal Dover	3.28	2.18	4.53	2.17	6.84	2.89	3.53	1.28	3.61	1.65	1.90	3.59	37.45
Carrollton	2.13	2.54	4.17	2.69	5.92	3.92	4.15	1.03	......	......	......	......	......
Granville	2.41	1.84	5.60	2.44	3.15	4.72	5.47	1.95	2.62	......	1.99	3.19	......
Gratiot	2.53	2.21	5.48	1.67	3.53	4.12	3.64	1.16	2.59	1.74	1.41	3.08	33.16
Milfordton	2.93	1.98	4.52	1.25	3.74	2.55	3.87	1.45	2.54	2.44	1.37	2.78	31.42
Killbuck	3.15	.89	4.51	1.35	4.74	2.82	3.20	.82	3.23	1.81	1.25	2.38	30.15
Pataskala	2.39	1.97	5.38	2.15	3.40	7.68	4.83	1.16	2.43	2.44	1.68	3.10	38.61
Philo	2.03	2.16	4.55	.96	4.45	5.08	4.71	1.39	4.37	2.40	1.10	2.86	36.06
Warsaw	3.06	1.70	5.01	1.22	6.17	3.44	4.27	4.08	3.58	1.76	1.26	2.70	38.25
Total	39.21	27.48	67.82	27.10	71.35	59.98	65.31	22.01	46.19	27.59	22.33	42.63	......
Mean	2.61	1.83	4.52	1.81	4.76	4.00	4.35	1.47	3.30	2.12	1.60	3.05	35.42

The fifteen stations given here are scattered over the whole drainage area above Eagleport, and the mean of the rainfall at these stations will give a fair average for the basin.

Even if the computations for the discharge of this stream were accurate, it would be impossible to make a proper study of the run-off of this drainage basin, as the canal system diverts a portion of the flow of the northern tributaries to the Cuyahoga River and of the southwestern tributaries to the Scioto River. From the data at hand it is impossible to state the extent of this diversion and the effect it should have on the run-off, but it should be more noticeable in the low flows than in the higher ones, as a larger per cent of the former is used.

From the above causes the figures in the preceding table showing the run-off are of secondary value. It is shown that 8.51 inches of rainfall, or 21.2 per cent, constituted the run-off. In the survey of the canals of the State by the United States Engineering Department, in 1895, estimates were made of the run-off of this river at Zanesville. The average per cent of run-off for eight years (1888–1895) was 33, or 11.8 per cent above the estimate for 1899. The average for three dry years, 1889, 1894, and 1895, was 22 per cent, or 0.8 per cent above that for 1899. These comparisons show that the figure for 1899 is probably too low.

From the middle of August until the last of October the water never rose above the true crest of the dam, and the constant flow shown in the chart is due to the flow over the depressed crest, leakage, locking of boats, etc. The methods used in the work would not admit of great refinement in the estimate of these low flows, so an average figure was obtained for them from the water-power ratings, as mentioned above.

DAMS AND WATER POWER.

The traveler through the older portions of Ohio has his attention arrested by the desolateness of the old water-power mills. On every hand there are to be found the ruins of some once busy mill, its dam broken and its race clogged and overgrown with weeds. At no very distant time these small mills entered very largely into the daily life of a good portion of the people, not from the importance of the mills themselves, but from the fact that they supplied the daily necessities of life, especially in the more isolated districts. The usual grist and saw mill was here supplemented by small woolen mills, cooper shops, an occasional machine or wagon shop, and rather numerous cider presses and cane mills.

As would be expected, this method of obtaining power was of more importance in the hilly eastern section of the State than in the more level district of the north and west. At one time in the Muskingum basin water powers were to be found on many small streams, the backwater of one dam reaching to the tailrace of the power above. These numerous dams made the flow of the stream more uniform than ever, and frequently gave steady power throughout the year. Evidence of the general use of water power is not to be found in any of the other three drainage areas, though the flow of Sandusky River proper was formerly well utilized. In the Muskingum, Maumee, and Miami drainage basins the canal system furnished considerable water power.

Within the last few decades there has been a decline in the amount of water power, for several reasons. The most important of all, of course, has been the increasing lack of uniformity in the run-off of the streams, due to the rapid deforesting of the tributary areas and the ever-increasing amount of tiling and ditching of agricultural land. From this cause alone many mills that formerly gave full power for twelve months in the year can be used now for but six or eight months.

In this state of affairs it has become unprofitable to tie up capital in a plant from which no certain return can be expected, and many owners were led either to abandon their water powers altogether and put in steam plants or, if the power were still good for short periods, to put in an auxiliary steam plant to tide over seasons of low water. The gradual reduction in price of coal made this scheme more and more economical. Another cause of the disuse of water power is probably to be found in the decline of water transportation, which deprived many of the mills of their raw material and of a market for their produce. This applies especially to the canal powers of the Muskingum and Maumee basins. Just as a decline in water transportation was inimical to these mills, so was the increase in rail transportation. The cheapening of this latter method of transportation made it possible for large concerns to underbid in the local markets the products of the local mills.

The many unfavorable features to be contended with in the operation of a water-power mill have tended to prevent the expenditure of money for the repairs needed, and these properties have gradually run down to such an extent that they can no longer be operated.

The silting up of the pond areas has also worked against the successful operation of many of the mills.

On the other hand, there have appeared in the last few years conditions which will in time increase the amount of water power developed, probably not at numerous small plants, but at large central stations. The transmission of power by electricity, in connection with a general rise in the price of coal, will tend more and more to bring about the larger use of water power. Even now there are four plants in these drainage areas installed for the development of electrical power, one each in the Sandusky and Muskingum and two in the Maumee drainage basin.

SANDUSKY BASIN.

All the water power in this drainage area is to be found on Sandusky River proper. Its tributaries are too small to furnish profitable power.

Following is a list of the dams on this stream, with notes as to their use. No information is at hand as to the amount of power furnished:

Table showing dams on Sandusky River.

No.	Name.	Distance from mouth of river.	Approximate location.	Use.	Width in feet.	Height in feet.	Length of backwater in miles.	Pond area in acres.
1	McMickles	96	1½ miles above Bucyrus	Watering stock	60	2.5	3	20
2	Waterworks	95	Just above Bucyrus	Water supply	50	1.5	1	8
3	do	94½	In Bucyrus	do	70	2.5	.5	4
4	Gas works	94	do	Gas works	70	.4	.25	3
5	Waterworks	70	In Upper Sandusky	Water supply	70	2.5	.1	.6
6	Indian Mill	68	Below Upper Sandusky	Grist mill	60	.7	1	6
7	St. Johns	45	9 miles above Tiffin	do	175	.3	1	20
8	Waterworks	38	Just above Tiffin	Water supply	175	5.5	4	80
9	Pioneer Mills	37	In Tiffin	Grist mill	250	7	1	45
10	Spec	36½	do	do	225	8	.3	14
11	Beckley	36	Just below Tiffin	do	250	4	.5	15
12	Bakers	34½	2 miles below Tiffin		250	4	(a)	
13	Umsted	32½	3½ miles below Tiffin	Grist mill	200	6	1	25
14	Fort Seneca	28	8 miles below Tiffin	Tile mill	200	5	1	25
15	Ballville	18	2½ miles above Fremont	Grist mill	300	14	1.1	30
16	First dam	17	1½ miles above Fremont	Electric power	300	14	.5	15

a Broken out.

The St. Johns, Pioneer Mills, Spec, and Ballville dams furnish power for feed and flour mills. Enough power is furnished to run nearly the year round, especially for the lower mills.

The Tiffin waterworks dam supplies power enough to run a 1,500,000-gallon pump, working against about 115 feet head, for eight or ten hours each day.

The "First dam," above Fremont, furnishes an extensive and reliable power for practically the whole year.

MAUMEE BASIN.

The dams in this basin are confined to two on Maumee River, for the supply of the Miami and Erie Canal; one on Blanchard River, to impound water for Findlay, and a few on St. Joseph River, in Indiana, for water power. The first State dam is at Grand Rapids. It is 1,610 feet long, 5½ feet high, and backs up the water to Napoleon, 19 miles above. The second is below Defiance. It is 400 feet long, 7 feet high, with flashboards 1 foot high, and backs the water up into Defiance, 5 miles above.

The dam at Findlay is 200 feet long, 8 feet 3 inches high, and backs up the water 3 miles. It is used to divert the water of Blanchard River to a filtering basin, from which it is pumped by steam for public supply.

The Miami and Erie Canal furnishes power to run a flour mill and sawmill at Waterville, and a flour mill, paper mill, and two electric-power houses at Maumee. The fall is obtained between the canal and Maumee River.

MIAMI BASINS.

The decline in the dams in the Little Miami drainage basin is only apparent in the smaller number of mills, as the horsepower in use has diminished but little owing to the more complete development of some of the larger powers, especially the one at Kings Mills.

The data concerning the Miami dams and water powers were obtained by personal inspection and from reports of the owners and operators. The estimates on the pond areas are crude and are given only as a guide to the amount of storage available. The areas of tributary drainage basins were obtained by planimeter measurements from the State board of health maps of Ohio.

Dams and water power

Number.	Stream.	Dam.						
		Approximate location.	Character.	Height in feet.	Length in feet.	Condition.	Length of backwater in miles.	Approximate pond area in acres.
1	Great Miami River	New Baltimore						
2	Fourmile Creek	Oxford	Log and slabs	2½	100	Poor	¼	3
3	Sevenmile Creek	Sevenmile	Pile and frame	8	140	Fair	¼	4
4	Great Miami River	Hamilton	Brush, stone, and timber.	4	2,000	Fair	1	200
5	do	Woodsdale	Timber frame	6	600	Good	1	70
6	do	Middletown	do	11	450	Fair	2	100
7	Twin Creek	South of West Alexandria.	Log and timber	2½	150	Good	¼	2
8	do	West Alexandria	Timber frame	5	225	Fair	¼	6
9	do	Lewisburg	Log and stone in 3 section.	3	342	Good	⅛	5
10	Great Miami River	Franklin	Timber	6	600	Fair	1½	75
11	do	West Carrollton	Timber frame	10	300	Good	1½	50
		Miamisburg						
		do						
		do						
12	Mad River	Dayton	Pile and frame	4	250	Poor	¼	6

of Great Miami basin.

Area of tributary watershed in square miles.	Use of dam; if water power, kind of mill.	Water power. Average head available.	Kind of wheels.	Total horsepower claimed.	Approximate time available.	Remarks.	Number.
					Mos.		
3,734	Flour mill	4		30			1
70	Feed and saw mill	10	2 turbines	20	8	Little used	2
139	Planing mill	14	One 25-inch Victor turbine.	30	8		3
3,521	Paper mill	26		200	11	Auxiliary steam.	4
	Foundry	26	1 turbine	25	11		
	Marble works	26	Overshot	25	11		
	Agricultural implements.	18	Turbine	12	11	Auxiliary steam.	
	Bending works	18	do	12	11	do	
	Planing mill	18	do	12	11		
	Turning shop	13	Overshot	50	11	Auxiliary steam.	
	Printing shop	18	Turbine	50	11		
	Planing mill	18	do	12	11		
	Machine shop	18	do	12	11	Auxiliary steam.	
	do	13	do	12	11	do	
	do	13	do	12	11	do	
3,508	Sawmill	9	50 and 37 inch turbines	75	10	Little used	5
	Flour mill	9	Two 42 and 50 inch turbines.	100	10	do	
3,060	Canal feeder and hydraulic waterworks.	$17\frac{1}{2}$	One 56-inch American turbine.	85	12	Auxiliary steam.	6
	Paper mill	$17\frac{1}{2}$	Two 36-inch Hercules turbines.	300	11	do	
	do	17	One 36-inch Leffel turbine.	112	11	do	
	Flour mill	17	One 28-inch American turbine.	50	11	do	
	Machine shop	17	One 28-inch turbine	21	11	do	
	Paper mill	18	One 32-inch Victor turbine.	90	11	do	
160	Flour mill	8	One $26\frac{1}{2}$ and one 35 inch turbine.	27	8	do	7
155	do	$8\frac{1}{2}$	Two 36 and one 40 inch turbine.	50	8		8
90	do	9	2 turbines	35	6	Auxiliary steam.	9
2,677	Paper mill	$14\frac{1}{2}$	5 turbines	100	11	do	10
	Planing mill	14	2 turbines	25	11		
2,610	Canal feeder and hydraulic.						11
	Paper mill	$17\frac{1}{2}$	36 and 17 inch Victor turbines.	160	10	Auxiliary steam.	
	do	17	One 35-inch Victor turbine.	150	10	do	
	Planing mill	17	One 20-inch turbine	20	10		
640	Canal feeder					Supplies some water for hydraulic.	12

Dams and water power of

Number.	Stream.	Dam.						
		Approximate location.	Character.	Height in feet.	Length in feet.	Condition.	Length of backwater in miles.	Approximate pond area in acres.
13	Mad River	Dayton	Stone fill	6	150	Fair	$\frac{1}{4}$	4
14	do	Harshmanville	Stone fill, 3 sections.	5	350	Fair	$\frac{3}{4}$	30
15	Spring Run	Fairfield	Earth					2
16	Mad River	Osborn	Timber	5	170	Fair	$\frac{1}{2}$	10
17	do	Durbin	Brush and stone	3	100	Poor	$\frac{1}{8}$	2
18	do	Springfield	Stone fill	4	75	Poor	1	8
19	Buck Creek	do	Cut stone	7	150	Fair	$\frac{1}{2}$	8
20	do	do	do	4	75	Fair	$\frac{1}{4}$	3
21	do	New Moorefield	Stone fill	1	30	Poor	$\frac{1}{20}$	
22	Mad River	Springfield	do	6	70	Fair	$\frac{1}{2}$	4
23	do	Below Tremont	do	$1\frac{1}{2}$	150	Fair	$\frac{1}{4}$	6
24	Chapman Creek	Tremont	Brush, stone, and plank.	3	60	Poor	$\frac{1}{4}$	2
25	do	West of Tremont	Plank	3	50	Fair	$\frac{1}{4}$	2
26	Mad River	South of Urbana	Log and stone	3	125	Poor	$\frac{1}{4}$	4
27	Kings Creek	Kings Creek	Creek diverted three-fourths mile above.					
28	Great Miami River	Dayton	Log and stone	8	630	Poor	1	70

Great Miami basin—Continued.

Area of tributary watershed in square miles.	Use of dam; if water power, kind of mill.	Water power.				Remarks.	Number.
		Average head available.	Kind of wheels.	Total horsepower claimed.	Approximate time available.		
					Mos.		
633	Paper mill	16	Overshot	130	10	Auxiliary steam	13
	Cereal mill	16	do	30	10	do	
	Linseed-oil mill	16	do	25	10	do	
	Flour mill	16	1 turbine	15	10		
	Plow works	16	Overshot	6	10		
	Flour mill	16	do	9	10		
	Flax mill	16	do	9	10		
	Plow works	16	do	6	10		
	Flour mill	10	One 22-inch turbine	6	10	Auxiliary steam.	
	Tag works	10		30	10		
	Scale works	10		35	10	Auxiliary steam	
	Flour mill	10	3 overshots, 10-foot diameter.	30	10	do	
	Linseed-oil mill	10		16	10		
	Brewery	10		12	10	Auxiliary steam.	
	Foundry and machine shop.	8	One 45-inch American turbine.	25	10	Auxiliary steam (canal to river).	
625	Corn shelter	8	One 48 and one 36 inch turbine.	50		Little used	14
	Grain elevator	8	One 48-inch turbine	25		do	
	do	8	One 8-foot reaction	20		do	
	Shoe factory	7	Three 48 and 30 inch turbines.	130	12	Only 40 horsepower used.	
	Sawmill	8	Four 36-inch turbines	75		Little used	
8	Feed mill	12	One 30-inch turbine	15		do	15
575	Flour mill	8	One 72-inch Leffel turbine.	76	11	2 short stone sections to dam.	16
	do	8	One 35-inch Leffel turbine.	35	8	Auxiliary steam.	
483	Not used						17
447	Flour mill	8	Turbines	40	8	Little used	18
150	do	24	One 42-inch Leffel turbine.	100	9	Auxiliary steam	19
	Machine shop	22	do	80	12	do	
	Not used for power						20
82	Feed and flour mill	10	One 32-inch Leffel turbine.	23	6		21
290	Feed mill	8	Two 6-foot reaction	20	10		22
	Flour mill	8	Two 24 and 32 inch turbines.	40	10		
276	do	7	One 48 and one 40 inch turbine.	50	9		23
24	do	16	Overshot; 16-foot diameter, 5½ breast.	30	6	Little used	24
18	Feed mill	14	Overshot; 14-foot diameter, 8-foot breast.	25	6	do	25
165	do	4	2 turbines	20	6	do	26
27	Feed and flour mill	14	Overshot and 20-inch turbine.	50	9		27
1,811	Machine shop	8	3 Stillwell-Bierce turbines.	90	9	Auxiliary steam.	28

Dams and water power of

Number.	Stream.	Dam.						
		Approximate location.	Character.	Height in feet.	Length in feet.	Condition	Length of backwater in miles.	Approximate pond area in acres.
29	Stillwater Creek	$3\frac{1}{2}$ miles south of West Milton.	Stone fill and timber.	5	150	Poor	1	15
30	Weimer Branch	3 miles south of West Milton.	Earth	$5\frac{1}{2}$	----	Fair	----	$\frac{1}{4}$
31	Cedar Branch	$1\frac{3}{4}$ miles south of West Milton.	do	10	75	Fair	----	4
32	Vore Branch	One-half mile south of West Milton.	Timber and stone	4	140	Fair	$\frac{1}{8}$	2
33	Rutledge Branch	West Milton	Earth	----	----	----	----	1
34	Stillwater River	Above West Milton	Stone fill	3	150	Poor	$\frac{1}{4}$	4
35	do	North of Ludlow Falls.	Timber	5	100	Fair	$\frac{1}{2}$	6
36	do	Sugar Grove	Timber frame	5	125	Fair	1	12
37	Painter Creek	do	do	12	50	Fair	1	4
38	Stillwater River	Covington	Stone fill and concrete.	3	100	Good	1	9
39	Greenville Creek	do	Timber frame	12	125	Good	1	12
40	do	West of Covington	do	6	120	Fair	$\frac{1}{2}$	6
41	do	Gettysburg	Stone fill	4	125	Poor	$\frac{1}{4}$	3
42	do	New Harris	Timber frame	6	200	Good	$\frac{1}{2}$	8
			Frame and stone	----	180	Fair	----	----
43	do	Above Greenville	Log and stone	5	100	Fair	$\frac{1}{2}$	40
44	Stillwater River	Covington	Timber	$1\frac{1}{2}$	100	Fair	$\frac{1}{8}$	2
45	Spring Branch	2 miles east of Troy	----	----	----	----	----	----
46	Great Miami River	Troy	Timber frame	5	200	Good	1	15
47	do	Below Piqua	do	$2\frac{1}{2}$	250	Poor	$\frac{1}{2}$	10
48	do	Above Piqua	Timber	4	250	Fair	1	25
49	do	Below Sidney	do	3	200	Fair	1	20
50	Mosquito Creek	Sidney	Stone fill	2	50	Poor	$\frac{1}{8}$	1
51	do	Pasco	do	2	50	Poor	$\frac{1}{8}$	1
52	Great Miami River	Port Jefferson	Timber frame	$8\frac{1}{2}$	240	Good	4	100
53	do	Quincy	Stone fill	4	150	Fair	$2\frac{1}{2}$	35

Great Miami basin—Continued.

Area of tributary watershed in square miles.	Use of dam; if water power, kind of mill.	Water power.				Remarks.	Number.
		Average head available.	Kind of wheels.	Total horsepower claimed.	Approximate time available.		
					Mos.		
613	Flour mill	8	2 turbines	40	9	Little used	29
4	do	10	1 turbine	12	8		30
6	do	56	One 10-inch Leffel turbine.	20	8		31
3	do	20	Overshot; 20-foot diameter, 3-foot breast.	12	8		32
2	Woolen mill	18	One 6-inch turbine	10	8	Little used	33
573	Flour mill	4	One 48-inch turbine	21	9	do	34
471	Plaster mill	6	One 40-inch Victor turbine.	25	10		35
456	Flour mill	6	One 30-inch and one 25-inch turbine.	35	12		36
	Sawmill	12	Two 35-inch turbines	70	8	Little used	37
433	Saw and feed mill	6	One 40-inch and one 35-inch turbine.	45	12	do	38
197	Electric-light plant	28	Two 21-inch Victor turbines.	80	12		39
192	Feed mill	6	One 48-inch Leffel turbine.	20	10		40
173	do	6	One 23-inch and one 48-inch Leffel turbine.	25	10	Little used	41
157	Flour mill	7	One Leffel turbine	40			42
110	Flour mill	5	One 40-inch turbine	20	6	Auxiliary steam	43
233	do	16	2 Victor turbines	50	8		44
	Corn sheller	16	1 turbine	25	8		
3	Sawmill	29	Turbines	25	6	Little used	45
910	Flour mill	12	One 44-inch Eclipse turbine.	75	12		46
876	Not used						47
578	Canal feeder						48
550	Flour and feed mill	11	2 Leffel turbines	50	9	Auxiliary steam	49
60	Electric-light plant	41	One 20-inch Leffel turbine.	61	10	Auxiliary gas	50
56	Flour mill	25	Four 15-inch turbines	60	8		51
452	Canal feeder						52
397	Flour mill	$5\frac{1}{2}$	One 45 and one 35 inch Leffel turbine.	45	12		53

Dams and water power of

CANAL WATER POWER.

Number.	Stream.	Dam.						
		Approximate location.	Character.	Height in feet.	Length in feet.	Condition.	Length of backwater in miles.	Approximate pond area in acres.
1	Miami and Erie Canal.	Hamilton						
2	do	Excello						
3	do	Amanda						
4	do	Middletown						
5	do	Franklin						
6	do	Miamisburg						
7	do	West Carrollton						
8	do	North of West Carrollton.						
9	do	do						
10	do	Tippecanoe						
11	do	Below Piqua						
12	do	do						
13	do	Piqua						
14	Hydraulic from canal.	do						

Great Miami basin—Continued.

CANAL WATER POWER.

Area of tributary watershed in square miles.	Use of dam; if water power, kind of mill.	Water power.				Remarks.	Number.
		Average head available.	Kind of wheels.	Total horsepower claimed.	Approximate time available.		
					Mos.		
-------	Knitting mill	4	1 turbine	20	11	Auxiliary steam	1
-------	Paper mill	8½	2 Hercules turbines	100	11	----do	2
-------	----do	4⅝	Two 54 and one 36 inch American turbines.	75	11	----do	3
-------	----do	9	2 turbines	20	10	----do	4
-------	----do	12	One 48-inch American turbine.	50	10	----do	5
-------	Flour mill	7	One 36 and one 42 inch American turbine.	40	10	----do	6
-------	Paper mill	8	One 32 and one 30 inch Victor turbine.	70	11	----do	7
-------	Flour mill	6	One 36 and one 42 inch Victor turbine.	50	11		8
-------	----do	7	1 turbine	25	11		9
-------	----do	9	50-inch and 21-inch turbines.	40	11		10
-------	----do	9	1 turbine	25	11		11
-------	Elevator	11	Overshot, 9 feet diameter, 12 feet breast.	20	11	Little used	12
-------	Flour mill	9½	One 36-inch Victor turbine.	60	10	Auxiliary gas	13
-------	Waterworks	20	25-inch and 30-inch Victor turbines.	210	12		14

Dams and water power

Number.	Stream.	Dam. Approximate location.	Dam. Character.	Dam. Height in feet.	Dam. Length in feet.	Dam. Condition.	Length of backwater in miles.	Approximate pond area in acres.
1	Little Miami River	Plainville	Timber	3½	300	Poor	¾	25
2	East Branch, Little Miami.	Above Batavia	Log and stone fill	4½	75	Fair	¾	6
3	do	Williamsburg	Natural riffle					
4	Little Miami River	Symmes	do					
5	do	Loveland	Log	4	300	Poor	1	30
6	do	Fosters	Timber	5	300	Fair	1	30
7	do	Kings Mill	do	6	900	Good	1	100
8	do	Morrow	Brush and stone	6	300	Fair	¾	20
9	do	Hammel	do	4	260	Poor	½	10
10	do	Freeport	Timber frame	4	310	Good	1½	40
11	do	Above Freeport	Brush and stone	2	150	Poor	½	6
12	Cæsars Creek	Harveysburg	Plank and log	4	100	Poor	½	4
13	Little Miami River	Waynesville	Timber and stone	3½	150	Fair	1	15
14	Gladys Run	Spring Valley	Timber	4	35	Fair	¼	1
15	Little Miami River	Bellbrook	Log	3	150	Poor	1	15
16	Beaver Creek	Alpha	Stone fill	6	150	Fair	⅛	2
17	Little Miami River	Trebeins	Timber frame	9	230	Fair	1	25
18	do	Old Town	do	6	80	Good	½	5
19	Massicks Creek	Cedarville	Cut stone	24	30	Good	1	4
20	Little Miami River	Goes	Timber frame	6	90	Good	½	5
21	do	Above Goes	Timber and stone	4	75	Fair	½	4
22	do	South of Yellow Springs.	Timber	4	80	Fair	¼	3
23	Branch of Little Miami River.	Yellow Springs	Cut stone	10	50	Fair	¼	3
24	Little Miami River	Clifton	do	15	100	Good	¾	10

of Little Miami basin.

Area of tributary watershed in square miles.	Use of dam, if water power; kind of mill.	Water power.				Remarks.	Number.
		Average head available.	Kind of wheels.	Total horsepower claimed.	Approximate time available.		
					Mos.		
1,665	Flour mill	7	1 reaction, 2 turbines	25	10	Little used	1
353	Flour and feed mill	8	One 36-inch Leffel turbine.	25	8	Auxiliary steam.	2
245	Flour mill	20	Overshot, 20 feet diameter, 4 feet breast.	25	6	Little used	3
1,114	do	8	Two 48 and one 40 inch turbines.	40	10	do	4
1,106	Not used					Mill burnt	5
798	Flour mill	8	2 turbine	80	10		6
	Sawmill	8	One 20-inch turbine	30	10		
792	Powdermill	20	One 50 and two 56 inch Leffel turbines.	700	9	Auxiliary steam.	7
682	Flour mill	9	Two 48-inch Leffel and one 44-inch Victor turbines.	60	9		8
675	Feed mill	8	1 turbine	20	9	Little used	9
658	Flour mill	8	Three 36-inch Victor turbines.	100	8		10
	Sawmill	8	One 36-inch Victor turbine.	30	8		
653	Flour mill	7	40, 50, 60 inch turbines	35		Little used	11
201	Feed mill	8	One 40 and one 28 inch turbine.	40	8	do	12
410	Flour mill	8	2 turbines	75	8		13
	Sawmill	8	1 reaction	20	8		
22	Flour mill	24	1 American turbine	17	6	Auxiliary steam, 140 horsepower.	14
306	Sawmill	7	One 36-inch Victor turbine.	40	8	Little used	15
	Flour mill	7	One 40-inch Victor turbine.	50	8	do	
35	Feed mill	8	Overshot, 8 feet diameter, 15 feet breast.	25	6	do	16
246	Flour mill	11	One 48-inch American turbine.	40	8	Auxiliary gas	17
224	do	12	One 30-inch Victor turbine.	65	10	Auxiliary steam.	18
62	do	24	2 new American turbines, two 36-inch American turbines.	50	9	do	19
120	Powdermill	8½	One 30-inch Leffel turbine.	40	8	do	20
113	Flour and feed mill	9		40	9	Little used	21
109	Feed mill	6	One 48-inch Leffel turbine.	16	9		22
4	Not used						23
97	Flour mill	26	2 Leffel turbines, 26 and 15 inches.	50	9	Little used	24
	Sawmill	20	1 Leffel turbine, 26 inches	25	9	do	

In the Great Miami basin there are 53 dams, only 2 of which are not in use. Five divert water for the supply of the Miami and Erie Canal, and 48 furnish water power, 2 dams supplying both the canal and water power. The 48 dams furnish about 89 mills with a total horsepower of 4,158, or an average of 47 horsepower per mill. In 1880, according to the United States census, there were in the Great Miami basin 218 mills, using about 7,191 horsepower, or 33 horsepower per mill. In twenty years there was a decline of 59 per cent in the number of mills, but only of 42 per cent in the total horsepower in use.

In the Little Miami basin the table gives 24 dams, 2 of which are not in use, and the 22 remaining supply power for 28 mills, using 1,803 horsepower, or 64 horsepower per mill. In 1880 there were 59 mills, using 1,956 horsepower, which is 33 per mill. This is a decline of 52 per cent in the number of mills, but only 8 per cent in the total horsepower in use.

On the Miami and Erie Canal, within the Great Miami drainage basin, there are given 14 mills using 860 horsepower, or 61 per mill. In 1880 there were 48 mills using 2,011 horsepower from the canal. If the above figures are correct, there was a decline in twenty years of 70 per cent in the number of separate powers and of 57 per cent in the total horsepower in use.

The decline in the use of water power on the canal is no doubt mainly due to the falling off of navigation, which left many of the mills without sufficient means of obtaining supplies or of disposing of their product. The general tendency to use the more reliable steam power in preference to water power and the increase of competition were also factors in the abandonment of the small water powers.

In the water powers supplied from the streams direct the principal and almost only cause in a number of places was the decrease in run-off from the tributary drainage basin and the increase in the variation of this flow. This is a cause which has been expounded at such length that there is no further need for discussion here. It is altogether too true that the rapid deforesting of the State has seriously affected the regularity of the flow of the streams. Where there was formerly a fairly constant stream of water flowing there is now a variable one, dry in summer and with frequent floods in the spring.

The other factors which enter into the question of the decline in the use of water power are the filling up of the reservoirs and impounding areas and the natural deterioration of the plants.

The first of the above is one which can not be avoided and one which requires radical treatment to remedy the evil effects. With the greater variation in the flow of the streams and with a rapidly decreasing storage capacity the water power available was most seriously affected. Instead of being able to store the night flow for use during the day, it is necessary to depend upon the average daily flow of the stream.

The natural wearing out of the plants from long use, coupled with lack of means for repair and renewal, is causing many of the smaller plants to be abandoned. The old-school millers are dying off and the younger men, failing to find the operation of a small isolated mill remunerative enough, abandon it and seek other fields for employment.

The water power is employed in both these drainage areas for a much greater variety of work than in the other drainage areas. The isolated powers are still mainly used in flour, feed, and saw mills, but the power developed by the "hydraulics" in Dayton, Middletown, and Hamilton is used in a number of different industries. The large paper mills of the two last-named places derive at least some of their power from this source. In a few cases where the water power is not sufficient, steam has been substituted and the water of the privilege used for boiler supply, washing purposes, etc.

The Hamilton "hydraulic" supplies some 12 mills and factories with 434 horsepower. The water is brought from the river by a race 5 miles long and is distributed to the various powers in such a way that some have the full head of 26 feet from race direct to the river, a few have a 13-foot head between the race and a tailrace, emptying into the old river bed, the remainder having 18 feet head from a second level to the river. The full head of this last group is not used at present, there being 7½ feet fall between the first and second levels.[a]

The next important power is found at Middletown, where the State dam sends a part of the flow of the river to a "hydraulic" or waterway, which now supplies 658 horsepower to 6 plants, including the city waterworks. The fall is obtained directly between the waterway and the river, and varies from 17 to 18 feet, according to the location of the power. This power is good for from ten to twelve months in the year and is one of the best in the district.

At Miamisburg about 330 horsepower is furnished to 3 mills by a dam in the Great Miami River at West Carrollton. In consideration of supplying a certain amount of water to the canal the waterway is used as a race for a portion of its length.

At Dayton a waterway from Mad River supplies 15 manufacturing establishments with 384 horsepower, not all of which is in use, however. The fall is obtained between different levels of the waterway, between these and the canal, and between the latter and the river. The water is not sufficient at all times for the power rented, and all of the latter is not used.

Above Dayton, at Harshmanville, Mad River furnishes about 300 horsepower to a number of small mills, but at the present time only 40 horsepower is used.

At Piqua a waterway, supplied principally from the canal, at one time furnished power to a large number of mills. At the present time, however, it furnishes only about 210 horsepower to the city waterworks.

In the Little Miami drainage basin by far the most important power is that developed at Kings Mills by the King Powder Company. At first the water was conducted through a long race to a number of isolated mills scattered along the river bank for 2 miles or more. Now it is conveyed to a central power plant, where it is used to generate electricity, which is in turn conveyed to the isolated mills necessary in the manufacture of powder.

MUSKINGUM BASIN.

As would be expected from its topography, this district was much more favorable to the development of water power than either of the other two.

The following table has been prepared to show the number and character of the dams still standing and the nature and amount of water power derived from them and also from the canal system:

[a] From Fifteenth Report Ohio State Board of Health, p. 569.

Dams and water power

Number.	Watershed and water course.	Approximate location of dam or water power.	Dam.						
			Character.	Condition.	Height in feet.	Length in feet.	Length of backwater in miles.	Approximate pond area in acres.	Approximate area of tributary watershed in square miles.
	MUSKINGUM RIVER.								
1	Muskingum River	Marietta	Timber frame	Good	12	480	5½	250	7,797
2	do	Devols	do	Good	10	588	8	500	7,783
3	do	Lowell	do	Good	11	848	10	900	7,736
4	Wolf Creek	Watertown	do	Fair	9½	90	1½	20	69
5	do	Wolf Creek	do	Poor	4	75	1	15	125
6	do	Pattons Mills	do	Poor	4	60	1	10	119
7	Muskingum River	Beverly	do	Good	10	705	8	600	7,473
8	do	Luke Chute	do	Good	11	546	6	350	6,931
9	do	Stockport	do	Good	11	482	9	500	6,915
10	do	McConnelsville	do	Good	11	472	8	400	6,889
11	do	Eagleport	do	Good	11	515	10	600	6,849
12	Salt Creek	Near Sundale	do	Poor	8	75	½	2	4
13	Muskingum River	Taylorsville or Philo.	do	Good	9	736	9	700	6,646
14	Jonathan Creek	Powells	do	Poor	8	296	1	40	183
15	do	White Cottage	Cut stone	Good	9	108	1	20	158
16	Muskingum River	Zanesville	Timber frame	Good	8	514	10	600	5,850
17	Dresden Side Cut Canal.	Dresden							
18	Wakatomika Creek	Below Bladensburg	Log and stone	Poor	3	100	¼	2	28
19	do	Above Bladensburg	Log	Poor	5	75	½	2	27
20	Ohio Canal	Adams Mills							
	LICKING CREEK.								
1	Licking Creek	Zanesville	Timber frame	Good	7	325	3	120	753
2	South Fork Licking Creek.	Kirkersville	do	Fair	1½	75	¼	1	48
3	North Fork Licking Creek.	Utica	do	Good	4½	170	1	20	117
	WILLS CREEK.								
1	Wills Creek	Plainfield	Timber frame	Poor	7	135	3	50	735
2	do	Linton Mills	Timber and stone.	Poor	8	150	4	70	706
3	do	Kimbolton	Timber	Fair	8	50	5	25	648
4	Salt Fork	Clio	Log and stone	Poor	8	50	4	20	83
5	Wills Creek	Below Cambridge	Log	Fair	7	60	4	20	464
6	do	Senecaville	Timber	Fair	5½	50	2	10	128

of Muskingum basin.

Water power.					Remarks.	Number.
Use of dam or water power.	Head in feet.	Number and kind of water wheels.	Horsepower claimed.	Approximate time available (months per year).		
Navigation, flour mill	12	Three 50, 52, and 66 inches	180	12		1
do	10	Three 48-inch turbines	80	12		2
Navigation, planing mill	13	One 42-inch turbine	85	12		3
Flour mill	13	One 48-inch turbine, one 54-inch reaction.	50	12		
Flour and feed mill	9½	One 30-inch turbine	45	9		4
Not used					Mill abandoned	5
Feed mill	4	Turbine	10		Very little used	6
Navigation, flour mill	10	Two 60-inch reaction	50	12		7
do	10	42 and 54 inch turbine	45	12		
Sawmill	10	One 48-inch turbine	55	12		
Planing mill	10	One 58-inch reaction	35	12		
Navigation						8
Navigation, flour mill	11	72, 72, and 60 inch reaction	50	12		9
do	11	Six 54-inch reaction, two 60-inch reaction.	120	12		10
Navigation						11
Feed and saw mill	8	3 turbines, 35, 28, and 24 inches.	30	6		12
Navigation, flour mill	9	One 60-inch turbine, two 54-inch turbines, three 48-inch turbines.	135	12		13
Feed and flour mill	8	6 reaction	20		Little used	14
do	9	One 42-inch turbine, three 48-inch reaction.	40	9		15
Navigation, flour mill	8	Two 60-inch turbines	50	12		16
Coffin factory	13	One 35-inch turbine	55	12		
Furniture factory	14	do	60	12		
Ice factory	16	do	50		Little used	
Woolen mill	22	One 22-foot overshot, 6-foot breast.	25	7	Canal to river	17
Feed mill	12	Turbines	15	8	Little used	18
do	6	do	10	8	do	19
Flour mill	22	One 36-inch turbine	96	12	Canal lock	20
Flour mill	7	Two 40-inch turbines	100	12		1
Canal feeder, saw and feed mill.	11	Turbine	30		Little used	2
Flour mill	9½	Two 35-inch turbines	30	6		3
Not used					Mill abandoned	1
Feed mill	8	1 turbine, 1 reaction	30		Little used	2
Flour and saw mill	8	Turbines	25			3
Not used					Mill standing	4
Saw and flour mill	7	48-inch turbine	37	8		5
Flour mill	5½	One 48-inch turbine	20	6		6

Dams and water power of

Number.	Watershed and water course.	Approximate location of dam or water power.	Dam. Character.	Condition.	Height in feet.	Length in feet.	Length of backwater in miles.	Approximate pond area in acres.	Approximate area of tributary watershed in square miles.
	WALHONDING CREEK.								
1	Walhonding Feeder	Roscoe							
2	Walhonding Creek	Above Coshocton	Timber	Good	4	275	$\frac{1}{2}$	15	2,148
3	Deughty Fork	Below Clarks	Log	Fair	5	80	$\frac{1}{8}$	1	46
4	do	Above Clarks	Stone and timber frame.	Fair	$6\frac{1}{2}$	150	$\frac{3}{4}$	15	31
5	do	Becks Mills	Timber frame	Fair	9	100	$\frac{1}{8}$	1	15
6	do	East of Saltillo	do	Fair	14	100	1	10	12
7	do	Northeast of Saltillo.	Stone and timber.	Fair	11	80	$\frac{1}{10}$	1	10
8	do	3 miles south of Berlin.	Timber frame	Poor	14	100	$\frac{1}{4}$	8	8
9	Killbuck Creek	Killbuck	Timber	Fair	6	50	2	10	421
10	Point Creek	Point Valley	do	Poor	5	25	$\frac{1}{4}$	1	16
11	Salt Creek	Fredericksburg	do	Fair	3	25	$\frac{3}{4}$	3	11
12	Run to Killbuck	Near Mill Brook	Earthen	Poor			$\frac{1}{4}$	1	1
13	Apple Creek	East of Wooster	Timber frame	Fair	6	30	$\frac{1}{2}$	1	29
14	Apple Creek, North Branch.	Northeast of Wooster.	do	Fair	4	30	$\frac{1}{2}$	2	12
15	Killbuck Creek	Burbank	do	Poor	18	100	$\frac{1}{4}$	3	42
16	Beaver Run	Shannon	Earthen	Fair	7	360	$\frac{1}{10}$	3	2
17	Kokosing River	Millwood	Log	Fair	$4\frac{1}{2}$	200	$\frac{1}{8}$	7	449
18	Big Schench Creek	Monroeville	Timber	Fair	5	75	$\frac{1}{8}$	1	26
19	Kokosing River	Gambier	Timber frame	Good	5	233	$\frac{3}{4}$	20	304
20	do	Mount Vernon	do	Good	6	150	1	12	188
21	do	Fredericktown	Log and gravel	Poor	7	75	$\frac{1}{2}$	2	71
22	do	Above Fredericktown.	Timber frame	Fair	$4\frac{1}{2}$	115	$\frac{1}{4}$	3	39
23	do	Ankenytown	Timber	Poor	3	65	$\frac{1}{8}$	1	20
24	Mohican River	Brinkhaven	do	Good	$5\frac{5}{8}$	270	$1\frac{3}{4}$	50	949
25	Run to Jerome Fork	Above McZena	Earthen	Poor					1
26	do	Mohicanville	Timber frame	Fair	11	30	$\frac{1}{2}$	1	3
27	do	Southeast of Springville.	do	Fair	10	20	$\frac{1}{4}$	1	2
28	do	Springville	Earthen	Poor				1	1
29	Jerome Fork	Jeromeville	Timber	Fair	8	45	$\frac{1}{2}$	1	123
30	Clear Fork	Below Butler	Stone	Poor	2	50	$\frac{1}{10}$	1	150
31	do	Above Butler	Timber frame	Fair	$3\frac{1}{2}$	75	$\frac{1}{4}$	2	133

Muskingum basin—Continued.

Water power.					Remarks.	Number.
Use of dam or water power.	Head in feet.	Number and kind of water wheels.	Horsepower claimed.	Approximate time available (months per year).		
Flour mill	14	One 36-inch turbine	50	12	Canal to creek	1
Sawmill	12	Turbine	25	12	do	
Flour mill	22	One 22-foot overshot, one 26½-inch turbine.	93	12	Feeder to canal	
Woolen mill	18	One 32½-inch turbine	25	12	do	
Canal feeder						2
Flour mill	8½	One 40-inch turbine	20	8		3
Sawmill	7	One 30-inch turbine	12	7	Little used	4
Woolen mill	9	One 18-inch turbine	8	7	do	
Sawmill	8	One 30-inch turbine	20	6	do	5
Flour and feed mill	14	14-foot overshot, 4-foot breast.	10	6	do	
Woolen mill	16	One 12-inch turbine	6		do	6
Sawmill	12	One 48-inch turbine	25		do	7
Flour and feed mill	15	One 22-inch turbine	37	6		8
Flour and saw mill	6	3 turbines, 3 reaction	80	9		9
Saw, cider, and feed mill.	20	One 13-inch turbine	10	6		10
Woolen mill	14	14-foot overshot, 3-foot breast.	12			11
Feed and cider mill			12		Very little used	12
Flour and feed mill	12	Turbine	25	10		13
Cider mill	8		10		Very little used	14
Not used					Mill burned	15
Feed, cider, and saw mill	18½	18½-foot overshot, 4-foot breast.	12	6		16
Flour mill	5	2 turbines, 35 and 48 inches	25	12		17
do	18	One 18-inch turbine	35		Little used	18
do	12	2 turbines, 40 and 26½ inches.	80	12		19
do	12	Turbines	115	8	50 horsepower year around.	20
do	7½	One 32-inch turbine	32	8		21
Sawmill and cider press	15	Turbine	20		Little used	22
Feed mill	12	One 20-inch turbine	10	4		23
Flour mill	8	3 turbines, 40, 44, and 50 inches.	130	12	Only 80 horsepower used.	24
Saw and cider mill	10		6		Little used	25
Flour and feed mill	22	22-foot overshot, 4½-foot breast.	20	8		26
Saw and cider mill	20	20-foot overshot, 1⅝-foot breast.	24	12		27
Feed mill	10	Turbine	10		Little used	28
Flour and feed mill	8	do	40	6		29
Saw and flour mill	10	Reaction and turbine	57		Little used	30
Flour and feed mill	10	10-foot overshot, 16-foot breast.	25			31

Dams and water power of

Number.	Watershed and water course.	Approximate location of dam or water power.	Dam. Character.	Condition.	Height in feet.	Length in feet.	Length of backwater in miles.	Approximate pond area in acres.	Approximate area of tributary watershed in square miles.
	WALHONDING CREEK—continued.								
32	Clear Fork	Bellville	Stone and brush.	Poor	2	70	$\frac{1}{4}$	1	112
33	do	3 miles above Bellville.	Log and frame	Poor	2	75	$\frac{1}{4}$	1	60
34	Black Fork	Above Loudonville	Timber frame	Good	5	330	2	50	340
35	do	Perrysville	Log and stone	Poor	8	150	3	10	305
36	Run to Rocky Fork	Lucas	Earth and frame.	Poor	3	100	$\frac{1}{2}$	2	4
37	Rocky Fork	Below Mansfield	Timber	Poor	8	60	$\frac{3}{4}$	2	42
	TUSCARAWAS RIVER.								
1	White Eyes Creek	Avondale	Stone fill	Poor	6	42	$\frac{1}{2}$	1	36
2	Ohio Canal	New Comerstown							
3	do	Port Washington							
4	do	Lock Seventeen							
5	Tuscarawas River	West of Uhrichsville	Timber frame	Fair	5	400	$1\frac{1}{2}$	70	2,237
6	Big Stillwater	Above Uhrichsville	Log	Poor	2	100	1	10	355
7	do	Tippecanoe	Cut stone	Good	10	125	5	70	193
8	Tuscarawas River	South of Midvale	Loose stone	Poor	2	300	$\frac{1}{2}$	10	1,760
9	Ohio Canal	Blakes Mills							
10	Tuscarawas River	New Philadelphia	Stone fill	Fair	6	250	2	50	1,656
11	Sugar Creek	Canal Dover	Timber frame	Poor	5	250	1	10	345
12	do	Strasburg	Loose stone	Poor	$3\frac{1}{2}$	175	$\frac{1}{4}$	5	313
13	South Fork Sugar Creek.	Dundee	do	Fair	7	70	$\frac{1}{2}$	2	66
14	do	Barrs Mills	do	Fair	6	40	$\frac{1}{2}$	1	59
15	One Leg Creek	Sherodsville	Log	Poor	7	75	2	10	142
16	Tuscarawas River	Zoar	Timber	Poor	5	150	2	15	1,005
17	Nimishillen Creek	Sparta	do	Fair	6	75	1	6	166
18	do	Howenstine	Log	Poor	4	150	$\frac{1}{2}$	2	158
19	do	Below Canton	Timber frame	Fair	5	100	$\frac{1}{2}$	5	134
20	Nimishillen Creek, West Branch.	Above Canton	do	Good	$1\frac{1}{2}$	30	$\frac{1}{4}$	1	43
21	Sandy Creek	Magnolia	do	Good	5	203	$1\frac{1}{2}$	30	251
22	do	Malvern	do	Good	8	400	1	40	135
23	do	Oneida	Log	Good	6	100			133
24	Wolf Creek	North of Loyal Oak	do	Poor	6	20	$\frac{1}{2}$	1	30
25	Tuscarawas River	Millheim	Earth and frame.	Fair	7	35	$\frac{1}{2}$	5	15

Muskingum basin—Continued.

Water power.					Remarks.	Number.
Use of dam or water power.	Head in feet.	Number and kind of water wheels.	Horsepower claimed.	Approximate time available (months per year).		
Flour and feed mill	7½	Turbine	25	8		32
Feed mill	6	do	10		Little used	33
Flour mill	8	do	75	6		34
Not used						35
do						36
Feed mill	8	Turbine	15		Little used	37
Feed mill	6	One 40-inch turbine	15		Little used	1
Flour mill	7½	2 turbines, 36 and 40 inches	50	12	Canal lock	2
do	6½	One 48-inch turbine	30	12	do	3
do	9	One 35-inch turbine	45	12	do	4
Canal feeder, flour mill						5
Not used					Mill abandoned	6
Flour mill	10	1 new turbine, 2 old turbines	30	9	Just remodeled	7
Not used					Mill abandoned	8
Flour mill	11	2 turbines	70	12	Canal lock	9
Electric power house	10	Two 56-inch turbines, one 45-inch turbine.	300	8		10
Canal feeder, flour mill	14	Turbines	75		Feeder to canal	11
Flour mill	7	do	50		Canal to river	
Sawmill	12	One 44-inch turbine	30	12		12
Flour and feed mill	7	Turbine	11	6		13
Flour, feed, and cider mill.	6	do	20	8		14
Saw and feed mill	7	do	15		Little used	15
Canal feeder, saw and flour mill.	5	5 turbines	80	12		16
Flour mill	19	3 turbines	50	10		17
Sawmill	4		10		Little used	18
Flour mill	9	5 turbines	40			19
Canton water supply						20
Flour mill	10½	Turbine, two 10½-foot overshots, 12-foot face.	80	10		21
do	15	Turbines	25	12		22
Flour mill and railroad water.					Under construction.	23
Feed mill	6		10		Little used	24
do	10	Overshot	15		do	25

The information contained in the above table was secured in nearly every case from the mill owners. The data in reference to the backwater could be obtained by actual measurement in but few cases, and much of it is therefore only approximate. The areas given for the tributary watersheds were obtained by planimeter measurements.

The table shows 90 water powers, as against 253 reported by Prof. Dwight Porter in the Tenth Census report as in existence in 1880. Owing to the large area covered it is probable that a few unimportant powers have been overlooked, but their number can not be great, as special inquiry was made on this subject. Considering the large number of powers that have been abandoned in the last ten years, this reduction of 65 per cent is not hard to believe. Throughout this district there are streams which only a few years ago supported seven or eight powers and which now have but one or two. This decline in the number of water powers is brought out in another light by the following: In 1880 the total horsepower given was 7,066, while in the above table there is listed 3,960, a reduction of 44 per cent. This is due to some extent to the fact that the small powers escaped notice. These powers, located on small creeks, have been first to suffer from the lack of uniformity in the flow of the streams. Many of the creeks that formerly maintained a good flow throughout the year are now dry in summer and fall, and at flood height during short periods in winter and spring, thus leaving but a few months in the latter seasons during which power could be obtained.

There are 84 dams described, 8 of which are not in use at all; 10 were built for the slack-water navigation of the Muskingum, 4 for canal feeders, and the remaining 62 were put in for power purposes alone. There is a small dam in Tuscarawas River near its headwaters which diverts water to the canal reservoirs and feeders, and there is a waste dam in the same stream where the canal crosses it above Clinton, which, together with several small temporary dams, have not been given in the table.

All the dams given in the table as in poor condition and the mills marked as being little used have not been repaired for years, and the next decade will probably see them abandoned if present conditions hold.

The greatest power in the drainage area is obtained from the canal system and from the slack-water navigation system in Muskingum River. Those at Adams Mills, New Comerstown, Port Washington, Lock Seventeen, and Blakes Mills are on the Ohio Canal proper and utilize the fall at a lock, or, in the case of Adams Mills, at a double lock. The water supply for these mills is usually sufficient to operate the wheels at full gate. In fact, the decline of navigation has in a way increased the amount of water available at the mills, as a smaller quantity is required in the operation of locks. At times during the winter ice blocks the canal and cuts off the supply for a short time, but the water seldom fails in dry seasons.

The mill at Dresden is located on the "Dresden side cut," and obtains its head from the fall between the canal and Muskingum River. This side cut carries off much of the surplus water of the canal between the Licking and the Portage summits, and an excellent power is available for development.

Two of the mills at Roscoe use the water from the Walhonding feeder as it passes to the canal proper, and two take water from the canal and conduct it to the creek. These powers are of great value, and much more could be obtained from them by a modern installation. The power on the Kirkersville feeder is of but slight importance and can be developed but little, as the tributary drainage area is too small to secure a steady supply.

Sugar Creek at Canal Dover should furnish an excellent water power, but the works have been neglected and are now in poor condition. The water is used both as it goes from the feeder to the canal and from the canal to the river. These water privileges were granted to the owners in payment for the diversion of Sugar Creek for canal purposes.

At the old town of Zoar there is a combination of water powers, listed as one in the table, which use water from the Zoar feeder dam and conduct it back to the river. These were also granted in payment to former riparian owners for the diversion of part of the flow of the Tuscarawas to the canal.

The fourteen water powers now in use at the eight Government dams, as shown in the table, were granted when the supply of water was plentiful, for the purpose of promoting industries along the river. Thus the amount of navigation on the slack-water system, which was then not under Government control, was increased. Now the amount of water is not sufficient for both navigation and power, and the latter has become subordinate to the former. Many of the leases were granted for long periods and at low rates and have become very valuable. The one at McConnellsville, given in perpetuity as payment for a diverted water right, guarantees to the present owners, free of cost, a supply of about 17,000 cubic feet of water per minute at a head of 11 feet. The lease provides for "enough water for 10 run of 4-foot 5-inch stones."

Of the powers derived from the dams built for this purpose alone the best are those at Zanesville, on Licking Creek; at Killbuck, on Killbuck Creek; at Gambier and Mount Vernon, on Kokosing River; at Brinkhaven, on the Mohican; at Magnolia, on Sandy Creek, and at New Philadelphia, on Tuscarawas River. The last-named plant is provided with modern wheels, well installed, and is a good though variable power. An important cause of interruption at this power site is backwater during freshets and floods. The dry-season flow is usually sufficient.

As an indication of the generally low estimate of the value of these water powers, it may be well to state that by conversation with a large majority of the mill owners it was found that the powers were for sale at a low figure. The future may find many of these plants offering a profitable field for the investment of capital.

PUBLIC WATER SUPPLIES.

NUMBER AND EXTENT.

Within the drainage areas here described 104 cities and villages, having a total population of 771,128, are provided with public water-supply systems. In the Sandusky basin are 8, comprising a population of 35,988; in the Maumee are 5, with a population of 287,633; in the Miami are 34, with a population of 246,499, and in the Muskingum 37, with 201,008 inhabitants. Eighteen of these towns, with a population of 11,627, are each below 1,000 and are not classed as urban, thus leaving 86 cities and urban towns, with a total population of 759,501, having public water-supply systems. These towns represent 61 per cent of the total number of urban towns and 91 per cent of the urban population.

In the Sandusky drainage area there are no urban towns without water supplies, while the Maumee has 22, with a total population of 35,562. In the Great Miami basin there are 10, with a population of 16,314, and in the Little Miami 8, with a total population of 28,199. In the Muskingum are 6, with a population of 8,169, only 6,969 of which, however, is within the drainage area, the corporate limits of some extending over into other basins.

In a few communities, by prohibiting the construction of vaults and requiring the use of boxes or dry earth closets, and especially by compelling these to be properly cleaned, the soil and subsoil have been kept clean, and potable water is provided from wells.

In a few instances it has been found that the private well supply is obtained from a stratum whose water is but little influenced by surface pollution. That these cases are not more numerous is probably due to the great expense usually attached to obtaining the deep-seated water. Nearly every village has one or more wells which reach desirable water, but only a favored few can afford these, and the majority must use the more easily obtained but less potable subsurface supply.

Five of the public water-supply systems of the Maumee basin are in Indiana and Michigan, which leaves for that area in Ohio 20 waterworks in towns having a total population of 224,260. No recent information is available except for the Ohio water supplies, and the details of these only will be given.

Following is a list of the water-supply systems, grouped according to the drainage areas, showing the name of the city or town, its estimated population, and the source of supply.

Source of water supply of cities and towns in Sandusky, Maumee, Miami, and Muskingum drainage basins.

SANDUSKY BASIN.

City or town.	Population.	Source of supply.
Attica	694	Wells and galleries.
Bucyrus	6,560	Sandusky River.
Carey	1,816	Wells.
Crestline	3,282	Wells and springs.
Fremont	8,439	Sandusky River, wells, and galleries.
Sycamore	853	Wells.
Tiffin	10,989	Sandusky River and wells.
Upper Sandusky	3,355	Sandusky River.
Total	35,988	

MAUMEE BASIN.

City or town.	Population.	Source of supply.
Ada	2,576	Wells.
Bluffton	1,783	Do.
Bryan	3,131	Do.
Columbus Grove	1,935	Do.
Continental	1,104	Do.
Defiance	7,579	Maumee River.
Delphos	4,517	Wells.
Findlay	17,613	Blanchard River.
Hicksville	2,520	Wells.
Lima	21,723	Lost Creek and wells.
Montpelier	1,869	Wells.
Napoleon	3,639	Maumee River.
New Bremen	1,318	Wells.
Paulding	2,080	Do.
Rockford	1,207	Do.
St. Marys	5,359	Do.
Toledo	131,822	Maumee River.
Van Wert	6,422	Wells.
Wapakoneta	3,915	Do.
Wauseon	2,148	Do.
Total	224,260	

Source of water supply of cities and towns in Sandusky, Maumee, Mami, and Muskingum drainage basins—Continued.

MIAMI BASIN.

City or town.	Population.	Source of supply.
Batavia	1,029	East branch of Little Miami.
Bellefontaine	6,649	Wells.
Blanchester	1,788	Impounding reservoir and wells.
Dayton	85,333	Wells.
Eaton	3,155	Gallery and wells.
Evanston	1,716	Ohio River.
Franklin	2,724	Wells.
Greenville	5,501	Do.
Hamilton	23,914	Do.
Harrison	1,456	Do.
Hyde Park	1,691	Ohio River.
Lebanon	2,867	Wells.
Lynchburg	907	Do.
Madisonville	3,140	Do.
Middletown	9,215	Do.
New Vienna	805	Do.
Norwood	6,480	Do.
Oakley	528	Ohio River.
Oakwood	342	Do.
Osborn	948	Wells.
Oxford	2,009	Do.
Piqua	12,172	Miami and Erie Canal.
Pleasant Ridge	953	Ohio River.
Sidney	5,688	Wells.
Springfield	38,253	Gallery and Buck Creek.
Tippecanoe City	1,703	Wells.
Trotwood	220	Do.
Troy	5,881	Do.
Urbana	6,808	Do.
Versailles	1,478	Do.
Waynesville	723	Do.
West Alexandria	740	Do.
West Carrollton	987	Do.
Xenia	8,696	Impounding reservoir, springs, surface water, and wells.
Total	246,499	

Source of water supply of cities and towns in Sandusky, Maumee, Miami, and Muskingum drainage basins—Continued.

MUSKINGUM BASIN.

City or town.	Population.	Source of supply.
Ashland	4,087	Wells.
Barberton	4,354	Do.
Canal Dover	5,422	Do.
Canton	30,667	Nimishillen Creek and wells.
Cambridge	8,241	Wills Creek.
Carrollton	1,271	Wells.
Coshocton	6,473	Do.
Dalton	666	Well.
Dennison	3,763	Big Stillwater Creek.
Freeport	690	Wells.
Granville	1,425	Do.
Lewisville	170	Do.
Loudonville	1,581	Do.
Mansfield	17,640	Do.
Massillon	11,944	Slipper Creek and wells.
Marietta	13,348	Ohio River.
McConnelsville	1,825	Wells.
Millersburg	1,998	Do.
Minerva	1,200	Do.
Mount Vernon	6,633	Do.
Mineral City	1,899	Springs.
Mineral Point	1,220	Do.
Newark	18,157	Licking Creek and wells.
New Comerstown	2,659	Wells.
New Philadelphia	6,213	Do.
Orrville	1,901	Do.
Perrysville	513	Do.
Piedmont	275	Springs.
Scio	1,214	Wells.
Shreve	1,043	Well.
Shelby	4,685	Wells.
Uhrichsville	4,582	Big Stillwater Creek.
Wadsworth	1,764	Springs and wells.
Waynesburg	613	Springs.
Wooster	6,063	Christmas Run, Apple Creek, and wells.
Zanesville	23,538	Muskingum River.
Total	201,008	
Grand total	771,128	

Dennison and Uhrichsville have the same supply, furnished by a private water company, so that in the Muskingum drainage basin 36 waterworks supply 37 cities and villages.

CLASSIFICATION.

For convenience in discussing the various supplies, they have been divided, according to the source from which the water is obtained. The divisions made are based upon the origin of the water, whether from surface or ground. A second division classifies the ground water as subsurface or deep-seated. The subsurface class include all ground waters found in porous beds near the surface and of recent surface origin, while the deep-seated class includes those waters found in deeper strata and of a more remote surface origin; in other words, in the first class are put all waters the purity of which is easily affected by surface pollution, and in the second class those waters which are so far removed from direct connection with the surface that they are not easily influenced by surface pollution.

All the large towns are supplied either entirely or in part with surface water. It has seemed almost impossible, with a reasonable expenditure, to procure in these drainage areas sufficient ground water for even the larger villages. The only city of any size in the "ground" division is Mansfield, which, by the expenditure of an enormous amount of money, has been able to procure enough ground water for the supply of the city. Mansfield has the second most expensive plant of the 104 named, being surpassed by Toledo only, a city with six times the population.

None of the surface-water supplies are fit for domestic use unless they are artificially purified, as in the case of the supply for Dennison and Uhrichsville. Ten towns of the 16 supplied with surface water are provided with water that is so objectionable that only for short periods can it be considered at all fit for drinking purposes. This condition is generally recognized by the inhabitants of these towns, and better water is being sought for in several of these places. Bucyrus is now impounding a new surface supply from a small drainage area, Cambridge is seeking ground water, Findlay and Toledo are agitating the question of better supplies, and Zanesville is investigating the relative cost of filtering the water it now gets or of obtaining a ground water.

In the last main division, "Surface and ground supplies," there are 10 towns—Blanchester, Lima, Springfield, Wooster, Xenia, Canton, Massillon, Tiffin, Fremont, and Crestline—which were originally supplied with surface water. Owing to the objectionable character of the water, they have tried to procure ground water, but failed to obtain enough to allow them to abandon their surface supplies. In justice to Massillon it must be stated that all the water for domestic use is obtained from wells and is of excellent quality, and that the surface water is retained for industrial use only.

Newark started with ground water, but, owing to the insufficiency of the supply, was compelled to use some surface water, and with little detriment, as the water is of good quality.

The small villages located in the glaciated area of the State usually have no difficulty in obtaining plenty of water either from the drift or from the rock under it. This rock water is of course available in the unglaciated portion also, but, unfortunately, in this section it is frequently so highly impregnated with mineral matter as to be objectionable.

In many localities in the Maumee drainage basin flowing wells can be obtained, which usually furnish water that is excellent for domestic use, but not so desirable for industrial purposes, because of dissolved incrusting salts. This region of flowing wells, or "fountains," as they are locally called, extends up into Michigan, where several towns obtain public supplies from wells of this kind.

DETAILED DESCRIPTION OF WATERWORKS.[a]

Following are detailed descriptions of the public water supplies of the four drainage areas.

SURFACE SUPPLIES.

Batavia.—A public water-supply system was installed in 1900 by Batavia (population, 1,029), and has cost to date $38,000, including the electric-light plant. The supply is obtained from the East Branch of Little Miami River, at a point just above the village and above all local pollution. As may be seen from the description of the drainage basin, the East Branch drains a hilly farming country, and receives no notable pollution until Lynchburg, 42 miles above, is reached, at which place a large distillery winters some 1,000 head of cattle, the filth from which directly enters the stream. Before this source was approved filtration was required by the State board of health. The village first presented plans for a rather crude system of slow sand filtration, which were here hardly satisfactory, and finally plans for mechanical filtration by the Wefugo process, which were approved. The water is pumped from the river by a low-service pump to two sedimentation tanks situated on the side hill back of the filter house and pumping station. From these tanks the water flows by gravity onto the filter, and through it to a clear-water well, from which it is pumped to a supply reservoir situated on the high ground north of the village.

The filtration process involves the use of a coagulant—sulphate of aluminum in this case—which is admitted to the water as the latter passes to the sedimentation basins. The coagulant solution is pumped

[a] Many of the facts reported under this head have been published by the Ohio State board of health.

from the coagulant tanks by a small piston pump actuated by the low-service pumps, so that a constant ratio is maintained between the amount of solution and the amount of water pumped. The actual amount of coagulant used must be varied by changing the strength of the solution; it is usually 1 grain per gallon. At times of high turbidity in the stream it is necessary to increase this amount in order to get perfect clarification.

The sedimentation tanks are two in number and consist of open wooden tubs, each 20 feet in diameter and 13½ feet high, with an effective height of 10 feet, giving a capacity of 23,660 gallons each, or 47,320 gallons for both. These tanks are exposed to the weather, with no protection whatever. As the water enters the tanks it falls over the sides of a pan secured to the discharge pipe of the pump, and receives more or less aeration. The tanks are used alternately, an automatic device admitting the water to first one and then the other, thus securing a longer period of quiet sedimentation. The outlet from these tanks is supplied with a skimmer float, so as to procure at all times the clearest water for the filters. The tanks are supplied with suitable pipes for flushing out the collected sediment.

The filter consists of an 8-foot cypress tank, 8 feet deep, fitted with a double bottom, the upper bottom being fitted with brass strainers supplied with phosphor-bronze screens. The openings in the screens are approximately three-fourths by one one-hundredth of an inch. In the bottom of the strainer is placed a brass ball, so arranged as to throttle the downward flow but to allow a free upward flow of the wash water. On the screens rests a 2-foot 9-inch bed of sand, composed of crushed quartz. The compartment between the bottoms is for the collection of the clear water, and to this is connected the discharge pipe of the filter, which is fitted with a regulator, so that the rate of filtration is kept uniform, irrespective of the condition of the bed. The inlet pipe is controlled by means of a float, so that a uniform level is maintained on the bed. A positive head of 4 feet is maintained on the filter and a suction head of 7 feet, making a total of 11 feet.

The filter is washed by reversing the flow through the sand and at the same time stirring it with a revolving mechanical agitator. The wash water is carried off by an annular trough fastened inside of the filter tank.

The total filtering area is 50 square feet, or 0.0012 of an acre, giving, at the standard capacity of 120,000,000 gallons a day, a rate of filtration of 100,000,000 gallons a day per acre.

The clear well is 42 feet in diameter and 16 feet deep, with a capacity of 165,000 gallons.

The low-service pump is of the horizontal duplex McGowan type, of 500,000 gallons capacity. The water is drawn from the clear well to the reservoir by two horizontal duplex McGowan pumps of 750,000 gallons capacity each. The pressure at the station is 95 pounds per square inch, and the average on the mains is somewhat less than this. The reservoir is 30 feet in diameter and 17 feet deep, its capacity being 84,000 gallons. Both this reservoir and the clear well have brick walls laid in cement and concrete bottoms, but neither is covered. There are 3½ miles of mains, which serve about 95 per cent of the people. There are 140 service taps, all of which are in use and none metered. The average daily consumption is 25,000 gallons for the total population, equal to 24 gallons per capita of the population, or 25 gallons per consumer. The water after filtration is clear and seems to be of excellent quality, and should displace the private wells, many of which are badly contaminated.

Bucyrus.—The public water-supply system of Bucyrus (population, 6,560) was established by a private company in 1883 and has cost to date about $125,000. The supply is taken from Sandusky River and forced through mechanical filters directly to the mains. Owing to the small amount of water flowing in the river in the summer, it is necessary to impound some to tide over this season. This is done by three small dams across the river, one 1½ miles above Bucyrus, one just above the city, and one at the pumping station. The dam at the station is constructed of timber and is 70 feet long, 2½ feet high, and impounds about 2,000,000 gallons of water. The one above this is a temporary structure of brush and stone, but is so favorably located as to hold back nearly 2,000,000 gallons of water. The third dam is constructed of timber, is 30 feet long, 2½ feet high, and impounds a large expanse of water, as the river has but little fall above. This dam flooded so much land that the water company has been compelled by the courts to abandon it.

The water flows from the backwater of the dam at the station into a large covered well, which serves as a pump well, but which was first put in as an infiltration basin in a vain attempt to furnish ground water to the city. This well is constructed of brick, is 30 feet deep, and 50 feet in diameter.

The water is pumped from this by a compound duplex Holly pump of 1,500,000 gallons capacity and a compound duplex Walker pump having a capacity of 1,000,000 gallons. Before reaching the consumers the water goes through two Hyatt pressure filters, which were erected in 1886. They are the old-style vertical filter, 10 feet in diameter, and contain 2½ feet of crushed granite and 1½ feet of coke. They are washed by reversing the flow through them once or twice a day, as the condition of the water may require. Alum is used as a coagulant when the water is very muddy, but not continuously enough or in quantities large enough to be constantly effective. The filters serve merely as strainers and give no protection from the dangerous ingredients of the water.

Sandusky River is badly polluted with the sewage of Crestline, only 16 miles above Bucyrus. This fact has led the company to seek a new supply. A large impounding reservoir 2½ miles up the river, east of the city, has just been constructed, which holds the run-off of a small tributary to the river. This tributary has a drainage area of only about 3 square miles, so that a large reservoir was necessary in order to impound sufficient water. This reservoir was formed by building across the lower end of the run an earthen embankment with a masonry waste weir, the embankment being made of clay and soil stripped from the area to be flooded. The reservoir has an area of about 60 acres and holds 166,000,000 gallons of water, which stands at an average depth of 8 feet, though over much of the area it is very shallow. The water flows by gravity through a 16-inch pipe to the present pumping station and is forced directly to the mains, the filters being abandoned.

About 12 miles of mains have been laid, which supply water to about 70 per cent of the people. There are 500 service taps connected, of which 325 are in use and 175 are metered. The average daily quantity of water pumped is 622,000 gallons, but owing to the waste at the filters not more than 550,000 gallons is sent to the mains. This is 65 gallons per capita for the total population, or 280 gallons for each consumer.

Cambridge.—A system of public water supply was established by Cambridge (population, 8,241) in 1896 and has cost to date about $63,000. The supply is taken directly from Wills Creek, which is a very sluggish, muddy stream, draining a hilly mining country. Its waters are polluted by filthy surface drainage from mining communities and by the drainage from the mines themselves. The water is so objectionable that it is not employed for domestic purposes, for which private wells are used. A ground-water supply is now being developed, which, if sufficient in amount, will be preferable.

The water is pumped from the creek to a standpipe by two horizontal compound duplex Laidlaw-Dunn-Gordon pumps of 1,500,000 gallons capacity each. The standpipe is located on a hill between the pumping station and the city, and when full gives an average pressure of 70 pounds per square inch in the mains. It is 60 feet high, 25 feet in diameter, and has a capacity of 200,000 gallons.

There are 12 miles of mains, to which 70 per cent of the people have access. There are 400 services connected, of which 140 are in use and 130 are metered. The large number of idle services is due to the fact that a number of streets have just been paved, and all the services have been put in to the curb line to avoid tearing up the new pavement. The average daily consumption is claimed to be 400,000 gallons, which is 57 gallons per capita of the city and 440 gallons per capita of the population actually supplied. This large figure is due to the general waste of the water and to its extensive use for industrial purposes.

Defiance.—A system of public water supply was installed at

Defiance (population, 7,579) by a private company in 1887 and had cost to August, 1898, about $200,000.

The supply is taken directly from the Maumee River at a point above all local contamination from sewage, but within the influence of that of Fort Wayne, only 54 miles above. The water is pumped from the river to a standpipe by two horizontal compound duplex Blake pumps, each of 2,000,000 gallons capacity. The standpipe is 140 feet high and 20 feet in diameter and has a capacity of 329,000 gallons. It furnishes an average pressure on the mains of 55 pounds per square inch. Eighteen miles of mains have been laid, which supply about 75 per cent of the population with water. Seven hundred services have been connected, of which 500 are in use, 40 of which are metered. The average daily consumption is about 1,100,000 gallons, or 145 gallons per capita of the total population and 193 gallons per capita of the population actually supplied.

The water is not used for domestic purposes because of its muddiness during six months of the year.

Dennison, Uhrichsville.—The twin cities of Dennison (population, 3,763) and Uhrichsville (population, 4,582) are supplied with water from a plant put in by the Dennison Water Supply Company in 1888. The cost to October 31, 1902, was $312,121.45.

Until recently the supply was taken directly from Big Stillwater Creek and with but a slight preliminary sedimentation was pumped to a small distributing reservoir. Big Stillwater Creek is an exceedingly sluggish and turbid stream, carrying much objectionable surface and mine drainage, and the water taken from it was almost unusable for domestic purposes. In January, 1900, the water company put in a mechanical filter plant, and an excellent supply has since been furnished the city. The raw water is admitted from Stillwater Creek to a settling basin of about 400,000 gallons capacity, flows from here to a small suction well, where the coagulant is applied, and is then pumped onto the filters by a horizontal duplex Worthington pump of 1,000,000 gallons nominal capacity, but of greater capacity now on account of the low head. There are four standard 16-foot Jewell gravity filters, each of which has a filter bed 15 feet in diameter and 4½ feet deep, composed of natural sand from Red Wing, Minn. The area of each filter is 176.7 square feet, making 706.8 square feet, or 0.016 acre for the four filters, which will give them a combined capacity of 1,920,000 gallons per day. The coagulant used is crushed block alum or aluminum sulphate. The average amount used is 0.75 grain per gallon, which amount is sufficient to produce clear effluent.

From the filters the water flows through a concrete flume to a clear-water well, from which it is pumped to the distributing reservoir by a horizontal compound duplex Holly pump of 2,000,000 gallons capacity. The reservoir is located on a hill between the pumping station and Dennison and gives an average pressure of 100 pounds. It is an open reservoir, its sides being lined with brick and its bottom puddled with clay, and has a capacity of 3,000,000 gallons.

There are about 17 miles of mains in both cities, supplying with water 95 per cent of the inhabitants of Dennison and 75 per cent of those of Uhrichsville. Altogether there are 1,235 service taps in use, only one of which is metered. The average daily consumption is 1,700,000 gallons, or 170 gallons per capita of the total population, and 422 gallons per capita of the population actually supplied. Railroad shops and tanks consume 50 per cent of this, other manufacturing and commercial plants about 10 per cent, leaving for domestic use about 68 gallons per capita daily.

Evanston, Hyde Park, Oakley.—Cincinnati supplies with Ohio River water the suburbs of Evanston (population, 1,716), Hyde Park (population, 1,691), and Oakley (population, 528). They are supplied as a portion of the city proper, with a slight modification of rates, compensation for fire protection, etc. No separate data are available at this time as to the extent of the system in each village or the number of services in use in each.

Findlay.—The public water-supply system of Findlay (population, 17,613) was installed by the city in 1889 and has cost to date $440,250.

The supply is derived from a basin located at the side of Blanchard River and filled from that stream by seepage through a wall of filtering material. Just below the basin a dam has been built across the river in order to keep up its level in times of low water. This dam is constructed of stone and is 200 feet long, 8 feet 3 inches high, and backs the water up about 3 miles. The filtering material consists of 10 feet of gravel and charcoal placed in openings between the arches of a masonry bridge or dam built across the end of the reservoir. This wall is 295 feet long, and the supports for the arches take up 116½ feet, leaving 178½ feet for the length of the filter proper. As the filter is 6 feet deep its area is 1,071 square feet. The gravel is kept in place by screens extending across the openings of the arches, and a mass of charcoal forming a V-shaped wedge is placed between the banks of gravel. Thus but a small amount of charcoal lies at the bottom of the filter and the resistance to the flow of water is therefore less here, so that most of the water passes through gravel only and receives but little purification. The filter is cleaned three times a year by pumping water through it. The rate of filtration is controlled by gates that can be raised or lowered over the openings. The filter was designed to free the water from mud, and it does this to some extent, but the filtering media become so thoroughly impregnated with filth that, in the absence of any adequate method of cleaning, the whole operation must be looked upon with distrust. The water in the basin never appears to be muddy, but during low water a scum gathers on its surface, and it has a disagreeable odor. The reservoir is cleaned biennially by draining out the water and flushing and scraping out the mud.

The present source of supply is very much polluted by waste from the oil fields and glycerine factories that abound along the banks of the river. At present a new conduit is being built to a ridge 9 miles east of town, where an abundance of good water is found.

The water is pumped from the reservoir directly to the mains by two horizontal compound duplex Gordon pumps, each of 2,500,000 gallons capacity. There are 29 miles of mains laid, which supply 80 per cent of the population with water. There are 2,137 service taps installed, of which 1,262 are in use, and 314 of these are metered. The average daily consumption is 900,000 gallons, or 45 gallons per capita of the total population, and 140 gallons for each consumer. During the summer, when the reservoir is low, the public water supply is not generally used for domestic purposes, resort being then had to private wells.

Marietta.—The public water-supply system of Marietta (population, 13,348) was established by the city in 1890, and has cost to date $267,145.67. The supply is taken directly from Ohio River, above the town, through three intake pipes, each 275 feet long, and 8, 16, and 18 inches in diameter, respectively. When the plant was first put in it was intended to obtain a ground water from a large well near the river, but the quantity thus obtained was too small and was also objectionable owing to an excess of iron. The lower portion of this large well was filled and in the remaining portion was set a horizontal pump, so as to bring it within reach of the low stages of the river.

The nearest serious sewage pollution of Ohio River above the intake is received from the cities of Bellaire, Wheeling, Martins Ferry, and Bridgeport, about 75 miles above. A number of villages below these send some sewage to the river, but the amount is small.

The water is pumped from the river to two tanks by a 750,000-gallon horizontal duplex Gordon pump, a 1,000,000-gallon vertical compound duplex Gordon pump, and a new 3,000,000-gallon vertical compound duplex Snider-Hughes pump. The tanks are located on a hill back of the city at such an elevation as to give a pressure of 85 pounds at the pumping station. They consist of two open steel tanks, each 66 feet in diameter and 30 feet high, having a combined capacity of 1,500,000 gallons. There have been 28½ miles of mains laid, to which 95 per cent of the total population have access; 2,340 service taps have been connected, of which 2,250 are in use, and 75 of these are metered. The great quantity of sand suspended in the water cuts out the meters in a short time and they become inaccurate.

The average daily consumption is estimated at 2,700,000 gallons, or 202 gallons per capita of the total population, and 213 gallons per capita of the population actually supplied. The public water supply is in general use, but there is a great deal of complaint on account of its muddy condition during the greater part of the year. Very little relief in this respect can be expected with the present reservoir, owing to its small storage capacity, for it requires a long time to enable the mud to settle. A new reservoir, with a capacity of 20,000,000 gallons, is being constructed, which will afford about 125 pounds pressure.

Napoleon.—The public water-supply system of Napoleon (population, 3,639) was installed by the village in 1895, which, with an electric-light plant, put in at the same time, cost $59,589. The cost to date has amounted to $103,000.

The supply is taken from Maumee River at a point opposite the upper end of the town and the backwater of the Grand Rapids dam. The water is in danger of contamination from sewage emptying just below the intake, especially when the wind is upstream, and it is always polluted by the sewage of Defiance, only 18 miles above.

The water is pumped to a standpipe by two vertical compound Smith-Vaile pumps of 1,000,000 gallons capacity each. The standpipe is 125 feet high and 20 feet in diameter, and has a capacity of 290,000 gallons. The mains are 8 miles long and supply 85 per cent of the population with water. There are 494 service taps connected, 454 of which are in use, and 111 of which are metered. The average daily consumption is 282,191 gallons, or 77 gallons per capita of the total population, and 91 gallons for each consumer. The water of the public supply is not used to any extent for domestic purposes.

Piqua.—The waterworks at Piqua (population, 12,172) were put in by the city in 1876. The waterworks proper have cost the city to date $131,838.59, and the hydraulic canal $269,000.

The supply is from the "hydraulic," a branch and feeder of the Miami and Erie Canal. This branch leaves the main canal at Lockington and joins it again below Piqua, gathering up much surface drainage on the way and furnishing a supply of water to Piqua; also the power to pump it and to run several manufacturing plants. Just above the waterworks the canal broadens into three reservoirs, in all about 100 acres in area. The reservoirs and the canal are badly overgrown with weeds and moss, as the sides and bottom are not paved in any manner. The water is pumped from the branch directly to the mains by two power pumps. One of these is a Flanders pump of 2,000,000 gallons capacity and the other a Gordon-Maxwell pump of 1,500,000 gallons capacity.

Though the waterworks trustees have developed a ground supply which secured the approval of the Ohio State board of health, owing to local jealousies and difficulties this water has not been substituted for that of the "hydraulic."

The trustees put down twenty-three 4-inch wells in the bed of Great Miami River north of the city and in the valley of Ross Creek adjoining. These wells were from 48 to 134 feet deep, driven through various strata of soil, clay, gravel, and sand. A good flow of water was found in fourteen of the wells, and these were reserved for the public supply. While there are certain local conditions which might interfere with the continued purity of the water, they are so unimportant and so easily overcome that the well supply should be utilized at once, for it is vastly superior to the water from the "hydraulic."

The secretary of the waterworks, Mr. W. B. Mitchell, in his last report gives figures on the original cost of the plant and "hydraulic" and the cost of additions:

Original cost of "hydraulic"	$268,911.64
Original cost of waterworks	56,896.84
Total	325,808.48
Additional cost of waterworks	63,896.84
Total cost of plant complete to May 1, 1900	389,705.32

In addition to the above the new wells cost $2,861.71, all of which came from the revenue of the plant. The total cost of operating the plant, maintenance of "hydraulic," etc., exclusive of interest, was $5,144.32 for the last year.

There have been 24.5 miles of mains laid, giving about 90 per cent of the people access to the water. There are 1,400 services connected, of which 1,320 are in use and none metered. The average daily consumption is estimated at 1,500,000 gallons, which is 1,136 gallons per service, 227 per consumer, and 123 per capita of the total population. This large consumption is due to the general industrial use of the water and to excessive wastage, brought on by the absence of meters and the poor quality of the water.

The city water is not used for domestic purposes to any extent, the main dependence being placed on private wells. About two-thirds of these are shallow dug ones, from 15 to 30 feet deep, getting their water in a bed of gravel. The others are drilled and go 10 to 12 feet into the limestone, which is about 25 feet below the surface.

Toledo.—The public water-supply system of Toledo (population, 131,822) was put in by the city in 1872, and it is estimated that the plant has cost to date $1,979,408.78.

The supply is now, and always has been, taken from Maumee River at a point opposite the upper end of the city. Owing to the objectionable character of this water, from mud and sewage, it has been proposed a number of times to obtain a new supply or filter the present one. One of the most feasible schemes presented is to collect the underflow of the river in a number of galleries or wells placed in a large sandy bar or island opposite the present works.

At the present time the water is led directly from the river through a 5-foot steel conduit to a pump well, and from there is raised to a regulating standpipe by four Worthington and one Knowles pumps, having in all a total pumping capacity of 45,000,000 gallons. Two horizontal compound duplex Worthington pumps of 5,000,000 gallons capacity were put in in 1873. The Knowles is a horizontal compound duplex pump of 5,000,000 gallons capacity, and was installed in 1886.

The other Worthington pumps are vertical compound duplex high-duty pumps of 15,000,000 gallons capacity each, one of which was erected in 1893 and the other in 1898. The standpipe consists of a steel tank inclosed in a brick tower. The former is 225 feet high, 5 feet in diameter, and has a capacity of 42,000 gallons.

About 183 miles of mains have been laid, which give 75 per cent of the total population access to the water. There are 13,961 service taps in use, of which 7,200 are metered. The average daily consumption is 9,074,900 gallons, or 70 gallons per capita of the total population, and 92 gallons per capita of the population actually supplied.

The public water supply is not used so extensively as it should be in a city of this size, and it probably will not be until water of a better quality is supplied. Many use the small house filters, but these afford but little relief from the objectionable features of the water.

Upper Sandusky.—The public water-supply system of Upper Sandusky (population, 3,355) was put in by a private company in 1889, and to July, 1898, had cost about $70,000.

The supply is taken directly from Sandusky River at a point just above the village. When it reaches here the river has received the combined sewage of Bucyrus and Crestline, 24 and 40 miles above, respectively. This long flow has caused all visible traces of sewage to disappear, but it has by no means completely purified the water.

At the waterworks the river is intercepted by a small dam, which forms an impounding reservoir having a capacity of about 500,000 gallons. From this backwater the intake pipe leads to a small sand filter that is connected by a bypass directly with a pump well, which furnishes by far the most of the water used. It is claimed that the direct connection to the river is used only when the stream is at a good stage, and that when the water is muddy it is pumped to a reservoir, allowed to stand a certain length of time, then passed to the filter, and then to the pump well.

The storage reservoir was built in 1895, and is 325 feet long, 180 feet wide, and will hold 2,288,000 gallons. It is formed by throwing up earthen embankments around a piece of low ground and is not lined or paved in any way. All the surface drainage, except that from the immediate vicinity of the basin, is diverted by a ditch dug along the hill above.

The filter box is 11 by 20 feet and contains 3 feet of fine gravel. It is cleaned monthly by scraping off the top layer, and twice a year by washing all the gravel. It acts as a strainer only, and can improve the water but little, except as regards appearance.

The pump well, which is walled up with rough stone, is 85 feet in diameter and 12 feet deep. At first this well supplied the village with ground water, but the supply soon fell short and it was necessary to use river water. Now the river water is used almost entirely, this well supplying a small proportion only.

The water is pumped to an elevated tank by two horizontal duplex Blake pumps, each of 1,500,000 gallons capacity. This tank is constructed of wood, and is 24 feet high and 28 feet in diameter, with a capacity of 95,000 gallons. It is supported on a brick tower 75 feet high.

There have been 11 miles of mains laid, which supply practically the whole village with water. There are 500 service taps connected, of which only 350 are in use, and 30 of these are metered. The average daily consumption is about 350,000 gallons, amounting to 70 gallons per capita, or 104 gallons per consumer. The water is not used to any extent for domestic purposes, wells and springs supplying the drinking water.

Zanesville.—A public water supply was put in by Zanesville (population, 23,538) in 1840, and has cost to date $800,000. The first supply was taken direct from Muskingum River at a point which is now within the limits of the city. As most of the city's growth was upstream, the water entering the old intake became contaminated, and in 1873 the pumping station was moved to the present site above the city.

The water is pumped directly from the river to a reservoir and standpipe, and a second reservoir is filled from the first by gravity, thus giving three levels, which are necessary on account of the extreme range in the level of the city. The first reservoir built is now abandoned; the second, built by the side of it on Harvey Hill, is still in use, supplying the lowest service in the city. It has a capacity of 2,000,000 gallons, and is filled by gravity from the new reservoir on Blandy Hill, which supplies the middle service and has a capacity of 2,500,000 gallons. The high service is supplied by a standpipe built in 1894 on the same hill. The standpipe is 100 feet high, 25 feet in diameter, and has a capacity of 367,000 gallons. It is now filled directly from the river, but was formerly supplied from the new reservoir by a 1,000,000-gallon Knowles pump.

The reservoirs are completely lined with brick laid in cement, and are carefully protected for surface drainage. Owing to the large amount of sediment carried by Muskingum River, the reservoirs have to be cleaned at least twice a year.

The pumping station contains three pumps—an old-style single-acting Worthington, installed in 1873, but since remodeled and compounded, now giving a daily capacity of 3,500,000 gallons; a horizontal compound duplex Holly pump of 5,000,000 gallons capacity, put in in 1873; and a horizontal compound duplex Gordon pump of 4,000,000 gallons capacity, installed in 1895.

There are 66.5 miles of mains, which supply 90 per cent of the population with water. There are 6,500 service taps recorded in the books of the water department, the high number being due to a peculiar method of numbering, some families having several services. Of this number 125 are metered. The average daily consumption is 4,500,000 gallons, or 191 gallons per capita of the population of the city and 216 gallons for each consumer. The water is in general use for domestic purposes, except in times of high water, when the large amount of mud makes it undesirable. The use of a large amount of water for industrial purposes accounts for the extraordinary consumption.

GROUND SUPPLIES.

SUBSURFACE.

Ashland.—The public water-supply system of Ashland (population, 4,087) was installed by the village in 1895, and has cost to date $70,000. The supply is derived from two wells situated in low land lying between the branches of Jerome Fork, about one-half mile east of the corporation limits. One of the wells is 30 feet in diameter and 16 feet deep; the other is 36 feet in diameter and 18 feet deep. Both are constructed of brick, roofed over, and fully protected from surface drainage. The smaller well was dug in 1895, when the works were first put in, but it soon failed to furnish enough water, and the larger well was dug the next year.

The water is obtained from a bed of gravel which is found just below the surface soil. During wet seasons the water rises to the surface, but in dry seasons it falls to within a few feet of the bottom of the wells. The water is pumped from the wells through the village to a standpipe beyond by two horizontal compound duplex Smith-Vaile pumps of 1,000,000 gallons capacity each.

The standpipe is 20 feet in diameter and 75 feet high, and has a capacity of 176,000 gallons. The average pressure on the street main is 75 pounds and at the station 122 pounds.

There have been 15 miles of mains laid, giving 80 per cent of the inhabitants access to the water.

There are 600 service taps connected, of which 500 are in use, and 250 of these are metered. The average daily consumption is 204,350 gallons, or 50 gallons per capita of the population of the village, and 62½ gallons per capita of the persons actually supplied.

Attica.—The public water-supply system of Attica (population, 694) was installed by the village in 1895, and has cost to date $17,147. The supply is from a well 28 feet in diameter and 25 feet deep, fed by an 8-inch tile collecting gallery 300 feet long and laid in an extensive bed of gravel. The well is lined with brick and covered with a board roof. The well and gallery are removed from local pollution and seem to furnish an excellent and abundant water supply.

The water is pumped to an elevated tank by a Gordon pump of 500,000 gallons capacity, operated by a Hicks gasoline engine. The tank, which stands on a brick tower 40 feet high, is 20 feet in diameter and 25 feet high, and has a capacity of 59,000 gallons.

There are 2½ miles of mains laid, which supply water to about 95 per cent of the population. There are 100 service taps connected, all of which are in use, and 67 of these are metered. The average daily consumption is 10,000 gallons; the average consumption per capita of the village is 14 gallons, and the average per consumer is 15 gallons.

Barberton.—The public water-supply system of Barberton (population, 4,354) was put in by the village in 1892, and has cost to date $45,000. The cost represents mains and hydrants only, as the water is purchased by the city from three large manufacturing establishments, which not only furnish the water but also supply the pressure. These plants have one well each, all of which are about 14 feet deep and 16 feet in diameter. They are located in beds of gravel near the canal.

The water is pumped directly to the mains by four pumps located in the various factories, one of which maintains the pressure, the others being held for use in emergency. The pumps consist of a horizontal compound Worthington of 640,000 gallons capacity, a Hooker pump of 320,000 gallons capacity, and two others of 512,000 gallons each, making a total daily capacity of 1,984,000 gallons.

There have been 9 miles of mains laid, to which 60 per cent of the people have access. There are 425 services connected, all of which are in use and none metered. It is impossible to estimate the average daily consumption, but it is not important, as this supply is not used at all for domestic purposes. A potable water supply is projected, and it is highly desirable that such a supply be obtained.

Bellefontaine.—A system of public water supply was put in by Bellefontaine (population, 6,649) in 1882, and has cost to date $140,000. The water is obtained from four 8-inch wells located just south of the village, in the valley of a small stream. The wells are 160 feet deep and go through 80 feet of gravel and clay and 80 feet into limestone. The supply has always been sufficient, but it is intended to put down a number of shallow wells in the gravel for an additional supply. There is no local pollution of the ground, and even if there were it is a question whether it would affect the deep wells.

The water is pumped direct from the wells to a reservoir by two horizontal compound duplex Gordon pumps of 750,000 gallons capacity each. A new vertical compound duplex Snow pump of 2,500,000 gallons capacity is to be installed soon for reserve in case of accident to the present pumps. The reservoir is located on high ground to the east of the village, and gives a pressure of 80 pounds at the station and an average of 60 pounds over town. It is an open basin, 206 by 106 by 20 feet, holding 2,000,000 gallons, with sloping sides built of brick laid in cement. The whole is surrounded by a high barbed-wire fence for protection from contamination.

There are 17 miles of mains in, to which about 95 per cent of the people have access. There are 956 services, of which 900 are in use and only 18 are metered. It is intended to increase the number of meters very soon, so as to cut down waste, as the consumption is very large for a village of this size. The average daily consumption is 642,000 gallons, which is 714 gallons per service, 143 per consumer, and 94 per capita of the total population.

Canal Dover.—A public water-supply system was installed by Canal Dover (population, 5,422) in 1895, and has cost to date $40,152.10. The water is obtained from six 6-inch driven wells, ranging from 51 to 61 feet deep, penetrating a large bed of sand and gravel, located in the southern part of the village on the bank of Tuscarawas River. Four of the wells were dug when the plant was installed, in 1895, and two more were added in 1897. The water rises to within 10 feet of the surface when the wells are not being pumped, and it is lowered but little by pumping.

The water is pumped to a standpipe by two horizontal compound duplex Worthington pumps of 750,000 gallons capacity each. The standpipe is 100 feet high and 16 feet in diameter, giving a capacity of 150,000 gallons and a pressure, when full, of 60 pounds per square inch at the station.

There are 10 miles of mains laid, to which 87½ per cent of the people have access. There are 742 service taps connected, of which 700 are in use and 8 are metered. The average daily consumption per capita of the village is 27 gallons and per consumer 31 gallons. This supply is of good quality, but is not in general use.

Columbus Grove.—A public waterworks has been installed at Columbus Grove (population, 1,935). The supply is obtained from wells drilled into the limestone found a short distance below the surface. The water is pumped from the wells to a reservoir of 60,000 gallons capacity by a McGowan compound duplex pump of 75,000 gallons capacity. About 4¾ miles of mains have been laid, to which 85 per cent of the population have access. Thirty service taps have been connected, all of which are in use and metered. As the plant has just been installed, it is impossible at this time to estimate the daily consumption.

Coshocton.—A public water-supply system was put in by Coshocton (population, 6,473) in 1892, and has cost to date $100,000. The supply is from twenty-two 6-inch wells, driven from 31 to 32 feet into the sandy point between Walhonding Creek and Tuscarawas River. The level of the water in the wells is the same as that in the streams, usually about 8 feet below the surface, and it is lowered but little during pumping. The water is pumped directly from the wells to a covered brick reservoir of 324,000 gallons capacity, which is located on a hill east of the town, of such height as to give a pressure of 115 pounds. The pumps in use are a vertical compound duplex Hughes of 1,250,000 gallons capacity and a horizontal compound duplex Hughes of 600,000 gallons capacity.

There are 16 miles of mains laid, giving 90 per cent of the people access to the water. There are 1,000 service taps connected, all of which are in use, and 25 are metered. The average daily consumption is 1,500,000 gallons, or 232 gallons per capita of the village and 257 gallons per consumer.

Dayton.—In 1869 a public water-supply system was installed by Dayton (population, 85,333), which has cost to date $1,811,618.47 for construction alone. The total expenditure of the waterworks department for thirty years was $2,108,721, of which $745,429 was for maintenance. The total income for the same period was $1,248,638, showing the net cost of the plant to be $860,083, a figure much below the present value of the works. The construction account for 1900 was heavy, as a new suction was put down, also new wells, and a large pump is to be put in, which will require extensive changes in the pumping station.

The first supply was directly from Mad River, but this was abandoned in 1887, when the first of the present extensive system of wells were put down. There are now eighty-seven 8-inch wells, driven 30 to 60 feet in the bed of Mad River in the upper portion of the city. During the last year twenty-four of the old wells were replaced by twenty additional new ones, bringing the total to the figure named above.

The bed of Mad River consists of a porous gravel which carries a large amount of water, the subsurface flow of the stream. The normal level of the water in the wells coincides with the river level except when the stream is at very low stages, when it rises above the surface water level. On a test one well gave 400 gallons per minute, the level being lowered only 5 feet. At this same test a well 50 feet away was lowered only 4 inches. The wells extend up and down the river 2,000 feet each way from the pumping station, and until this year were reached by a 30-inch suction line going down the river and by a 20-inch and 30-inch going up. A new 5-foot suction line is being put in up the river to replace the small lines, and also, in time, to extend above them as new wells are added.

While the site of the wells is above all sewage pollution, the water does not escape all manufacturing refuse, especially that from a strawboard works. Except in times of extreme low water it is doubtful whether any of this refuse would influence the subsurface water, but at such dry times some of it would soak into the gravel bed, where, if the filtration were not perfect, it would pollute the water of the wells.

The water is pumped directly to the mains by a 4,000,000-gallon quadruplex Holly pump, installed in 1873; a 10,000,000-gallon horizontal compound duplex Holly pump, erected in 1899, and a 15,000,000-gallon pump of the same pattern, installed in 1895. A new 10,000,000-gallon vertical triple-expansion Holly is now being put in.

The domestic pressure averages 60 pounds. About 130 miles of mains have been laid, giving about 90 per cent of the total population access to the water. There are 14,800 service taps connected, and 12,500 in use, and 8,800 of these are metered, about 60 of which are for hydraulic elevators. The average daily consumption is 7,000,000 gallons, which is 91 gallons per consumer, and 82 gallons per capita of the total population. The water is of excellent quality, and has come into general use, to the gradual exclusion of local wells.

Eaton.—Waterworks were put in by Eaton (population, 3,155) in 1891, and have cost to January, 1903, $91,200.47. The supply is from wells and springs near Sevenmile Creek. The well water is furnished by ten driven wells, ranging in depth from 74 to 89 feet and all 6 inches in diameter. They go through 55 feet of hardpan into a bed of gravel, which furnishes the water. The wells flow when not pumped, and the water can be lowered 35 feet during dry weather. The springs are one-fourth mile west of the waterworks, at the foot of a hill just across Sevenmile Creek. The water is collected by a sewer-pipe gallery and is brought by gravity through a tile pipe to the station. Near the works this pipe line empties into a silt well, 13 feet in diameter and 15 feet deep, which frees the water from the heavier sediment before it reaches the pumps. It is estimated that the wells can supply 150,000 gallons per twenty-four hours and the springs 200,000 gallons. A covered reservoir of 100,000 gallons capacity is just being built, into which the water of the wells and springs may flow when the pumps are not running. The reservoir is 110 feet long, 12 feet wide, 12 feet deep, and will be built of brick laid in cement. Direct connection can be made to the creek for use in case of fire. The water is pumped to a standpipe by three pumps—two horizontal compound Gordons of 1,000,000 gallons capacity each and one small Hughes pump of 500,000 gallons capacity. The first pumps were put in with the works, and the latter in 1898. The standpipe consists of a tank 20 feet in diameter and 80 feet high, placed on top of a stone tower 50 feet high. It has a capacity of 185,000 gallons.

Franklin.—The public water-supply system for Franklin (population, 2,724) was put in by the village in 1887, and has cost to date $57,000. The supply is obtained from six 6-inch wells driven 65 feet into a clay, sand, and gravel bed, bordering the Miami and Erie Canal in the lower part of the village. The water stands normally 22 feet below the surface and is lowered but little by ordinary consumption. There is direct connection with the canal for use in cases of emergency.

The water is pumped directly from the wells to the mains by two horizontal compound duplex Holly pumps of 750,000 gallons capacity each. The pumps are set 18 feet below the surface, so as to keep the water well within the suction limit. The station pressure carried is 60 pounds and the average on the mains is 55 pounds.

There are 8 miles of mains laid, giving about 90 per cent of the people access to the water. There are 410 services connected, of which 340 are in use, and 24 of these are metered. The average daily consumption is estimated at 300,000 gallons, which is 882 gallons per service, 172 per consumer, and 110 per capita of the total population.

The large consumption is due chiefly to the extensive use of the water by the various paper mills, but in some measure to the large amount of leakage claimed to be caused by the deterioration of the pipes from electrolysis.

Granville.—A public water-supply system was installed by Granville (population, 1,425) in 1884, and has cost to date $15,000. The supply is from three 4-inch wells driven 45, 50, and 55 feet into a bed of gravel located south of the village, in the valley of Raccoon Creek. The water is pumped directly from these wells to an elevated tank by a horizontal compound duplex Knowles pump of 350,000 gallons capacity.

The tank is 32 feet in diameter, 20 feet high, and has a capacity of 100,000 gallons. It is constructed of wood and is placed on a frame trestle located on a hill just northwest of the village. The domestic pressure is 80 pounds.

There have been 6¾ miles of mains laid, giving 80 per cent of the people access to the water. There are 206 services connected, all of which are in use, and 6 are metered. The average daily consumption is 50,000 gallons, which is 28 gallons per capita of the village and 40 gallons for each consumer. The water is in general use throughout the village.

Greenville.—In 1893 waterworks were put in by Greenville (population, 5,501), and have cost to date $110,000. The original supply was derived from nine wells 6 inches in diameter and from 50 to 57 feet in depth; but lately six new 8-inch wells, averaging in depth from 46 to 54 feet, were added as a safeguard against the failure of the first set. The wells go through gravel and clay into a bed of gravel. The water rises nearly to the surface when the wells are not being pumped, and during a test it was lowered 18 feet, at which depth pumping at the rate of 900,000 gallons per day failed to lower the water farther. The waterworks are west of town, on Greenville Creek, to which direct connection can be made in case of fire, but this connection has not been used since August, 1895. There is a milldam on Greenville Creek, 1½ miles above the waterworks, which controls the amount of water in the creek during dry weather. It is 6 feet high, 40 feet long, and backs the water up about 1½ miles.

The water is pumped directly from the wells to a standpipe by two horizontal compound duplex condensing Hughes pumps of 1,500,000 gallons capacity. The standpipe consists of a tank 60 feet high and 20 feet in diameter, placed on a brick tower 70 feet high. It has a capacity of 141,000 gallons.

Thirteen miles of mains have been laid, which supply 80 per cent of the population with water. There have been 961 services connected, 811 of which are in use, and 540 of these are metered. The average daily consumption is 400,000 gallons, which is 91 per consumer and 73 per capita of the whole population.

Hamilton.—A public water-supply system was installed in 1884 by Hamilton (population, 23,919), and has cost to date $365,000. The first supply was derived from a large well or basin situated in the low land north of the city, lying between the Great Miami River and an abandoned channel of the same stream. The basin was 500 feet long, 100 feet wide, and 15 feet deep, dug into a large bed of gravel.

The supply from this source was unsatisfactory, and in 1889 a number of deep wells were driven in the basin, and these, with additions, have furnished the supply since that time. Now there are nineteen 6-inch and three 8-inch wells, driven from 75 to 135 feet into the bed of gravel.

The water flows from the wells at the river level and is conducted about 1,000 feet to a receiving basin set 13 feet below mean low water in the river. The receiving well is a closed brick chamber 28 by 13 by 33 feet deep, with a capacity of 90,000 gallons.

The water is pumped from this basin to a supply reservoir by a vertical compound duplex Gordon-Maxwell pump of 3,000,000 gallons capacity. The average domestic pressure is 90 pounds. The reservoir is situated on the high ground west of Great Miami River, and is reached by two mains, a 20-inch main laid in the bed of the river and a 10-inch main crossing on a bridge. It is an open basin, with sides paved with brick in cement, and is 200 by 270 by 24 feet deep, with a capacity of 7,000,000 gallons. As first constructed the reservoir was not cemented and there was trouble frequently with vegetable growths of various kinds. Since the sides were cemented, however, no trouble has been reported.

There are 40 miles of mains laid, giving about 95 per cent of the population access to the water. The mains even extend outside of the corporation in order to supply several manufacturing plants. There are 3,295 services in use, and 827 of these are metered. The average daily consumption is 1,818,000 gallons, which is 569 gallons per service, 103 per consumer, and 76 per capita of the total population. It will be noted here that the pumping capacity is less than twice the average daily consumption, a rather perilous condition for a pumping plant, notwithstanding the very fair reservoir capacity.

Lynchburg.—A public water-supply system was installed in 1896 by Lynchburg (population, 907), and had cost to January, 1901, $18,000. The first supply was obtained from a dug well 16 feet in diameter and 20 feet deep, which enters a bed of gravel just above the rock. This well soon failed to supply enough water, and a 4-inch suction line was run to a large basin from which a distillery obtains its water supply.

This basin consists of a trench 120 feet long by 15 feet wide, with an 18-foot well at each end, all excavated 15 feet deep in a bed of sand and gravel. The sides of this basin are planked, and the whole is covered with a flat plank roof at the ground level. It occupies a low swale and is easily accessible to surface drainage, as the well is situated nearly in the center of the village. In 1900 the 4-inch suction line to the distillery basin was replaced by a 5-inch line.

As the distillery required the entire yield of this basin, the village was compelled to seek a new supply. Application was made to the State board of health for the approval of three springs, only one of which could be approved, namely, the "sulphur" spring, located 1¼ miles northeast of the village, in low land near a small run. With proper care this spring ought to be able to provide at least 20,000 gallons of potable water a day. It is at such a height that the water could be conducted by gravity to a pump well at the present station.

The water is pumped from the well and basin to an elevated tank by a horizontal duplex Laidlaw-Dunn-Gordon pump of 250,000 gallons capacity. The tank is 16 feet in diameter, 20 feet high, with a capacity of 30,000 gallons, and is placed on a trestle 89 feet high. The average pressure on the mains is 40 pounds.

There are 4½ miles of mains in use, to which all the people have access. There are 135 services in, of which 122 are in use, and none is metered. The average daily consumption is estimated at 25,000 gallons, which is 53 gallons per consumer. The water is not in general use for domestic purposes.

McConnelsville.—A public water-supply system was installed in 1899 by McConnelsville (population, 1,825), and has cost to date $30,000. The supply is from four 6-inch wells, 42 feet deep, located in the river bottom just above the village. The wells go through 18 feet of loam, sand, and gravel and a thin layer of hardpan, then into the water-bearing gravel. The normal level of the water in the wells is 17 feet below the surface, and it is lowered but little by pumping. The water is pumped directly from the wells to an open brick reservoir by horizontal duplex Stillwell-Bierce Smith-Vaile pumps of 750,000 gallons capacity. The reservoir is placed on a hill back of the village, where it gives a pressure of 100 pounds.

There are 3¾ miles of mains laid, to which 80 per cent of the people have access. There are 200 services connected, of which 175 are in use, and none is metered.

Middletown.—A public water-supply system was installed in 1874 by Middletown (population, 9,215), and has cost to date $450,000. The supply is obtained from a large well 20 feet in diameter and 35 feet deep, dug in a gravel bed in the upper part of the city, near Great Miami River. The normal level of the water is 16 feet below the surface, and it is lowered about 11 feet by ordinary consumption in the dry season. The supply has always been sufficient except in 1893, when it failed during a period of exceptionally dry weather.

The water is pumped directly from the well to the mains by a quadruplex Holly power pump, installed in 1874. The pump has a capacity of 1,250,000 gallons per day and is operated by a 56-inch American turbine, operating under a 17-foot head of water, secured from the Middletown ditch or "hydraulic."

In 1885 two horizontal compound duplex Smith-Vaile steam pumps of 1,500,000 gallons capacity each were installed. These are for reserve and for use in case of fire, steam being kept at low pressure in one boiler all the time. In cases of emergency the water from the "hydraulic" can be admitted to the well.

Enough water power to supply the domestic pressure is obtained from the "hydraulic" at an annual rental of $260, certainly a very economical method of pumping. A pressure of 45 pounds is maintained at the station, and the average on the mains is 40 pounds.

There have been 20 miles of mains laid, to which about 87 per cent of the people have access. There are 1,337 services in, of which 1,300 are in use, and 62 of these are metered. The average daily consumption is 1,500,000 gallons, 187.5 per consumer, and 163 per capita of the total population. The large consumption is due to some extent to the general use of the water for industrial purposes, also to an extensive waste, induced by cheapness of the water.

Millersburg.—A public water-supply system was installed in 1895 by Millersburg (population, 1,998), and has cost to date $27,000. The water is obtained from a well 30 feet in diameter and 28 feet deep, located just west of the village, in bottom land, 50 feet from Killbuck Creek. The well is walled up with brick and is covered with a conical board roof. It goes through loam and muck into a bed of gravel, where the water is found. The normal level of the water is above that in the creek, varying from 15 to 24 feet from the surface, and is seldom lowered below the latter figure. The water is pumped directly from the well to a covered reservoir by two horizontal compound duplex Stillwell-Bierce pumps, each of 750,000 gallons capacity. The reservoir is constructed of brick and covered with a tin roof, and has a capacity of 150,000 gallons. It is located on a hill just east of the village, and gives an average pressure of 80 pounds.

There are 6 miles of mains laid, to which 95 per cent of the people have access. There are 400 services connected, all of which are in use, and 5 are metered. The average daily consumption is 500,000 gallons, which is 250 gallons per capita of the total population and 263 gallons for each consumer.

Mineral Point.—A public water-supply system was installed in 1899 by Mineral Point (population, 1,200), and has cost to date $12,000. The water is obtained from four springs, is impounded in a reservoir of 169,000 gallons capacity, and is supplied to the village by gravity at a pressure of 80 pounds. The reservoir is 60 feet in diameter, 8 feet deep, and is built of brick and covered with a slate roof. The springs are located under steep hills rising in a thinly settled farming district about 1 mile northeast of the village. For fire purposes a reserve supply is stored in an open reservoir of 88,000 gallons capacity, which is located in the village. The pressure is obtained by a horizontal duplex Battle Creek pump of 720,000 gallons capacity.

There are 3 miles of mains installed, giving 90 per cent of the people access to the water. There are 100 service taps, all of which are in use, and none is metered. It is impossible to estimate the amount of water used.

Minerva.—A public water-supply system was installed in 1886 by Minerva (population, 1,200), and has cost to date $16,000. The supply was first obtained entirely from Clear Fork of Sandy Creek; then from an infiltration well placed at the side of this creek in the upper part of the village; then this supply was supplemented by driving a 6-inch well 55 feet deep into sand and gravel. The infiltration well is 9 feet square, boarded up with plank, and 10 feet deep. The water enters it through quicksand at the bottom. At times the creek covers this well and the deep well is used entirely. Normally each well supplies about half of the water. When not pumped, the water stands 6 feet from the surface, or a little above the creek level, and by pumping is easily lowered to the suction limit. The water is pumped directly from these wells to an elevated tank by a horizontal duplex Smith-Vaile pump of 250,000 gallons capacity and by a horizontal compound duplex Worthington pump of 600,000 gallons capacity. The tank is 20 feet high and 24 feet in diameter, giving a capacity of 65,000 gallons, and is placed on a frame trestle located on a hill north of the village, where it gives a pressure of 50 pounds.

There are 5½ miles of mains laid, giving 90 per cent of the population access to the water. There are 250 services connected, all of which are in use, and none is metered. The average daily consumption is 201,000 gallons, which is 167½ gallons per capita of the village and 170 for each consumer. The public supply is in general use and seems to be of good quality.

Mount Vernon.—A public water-supply system was installed in 1882 by Mount Vernon (population, 6,633), and has cost to date $115,000. The original supply was from two large wells—one 20 feet in diameter and the other 7 feet, and both 21 feet deep. The larger of these wells has been filled up until it is now only 10 feet deep and is used as a receiving well. The smaller is used as a pump well, the water flowing from the receiving well to it by gravity.

The supply is now obtained from 21 driven wells, which have been put in from time to time as the consumption increased. These consist of nine 6-inch, four 4-inch, eleven 2-inch, and two 3-inch wells, which are from 60 to 90 feet in depth, the average being 73 feet. The wells go through a surface layer of sand and gravel, then through a layer of hardpan and into water-bearing gravel. The wells were all artesian and the natural flow only is utilized; five, however, have now ceased to flow. The sand found through the gravel stops the flow in a comparatively short time and the wells have to be blown out to keep the flow constant. The supply is now just about equal to the demand, and it is intended to sink more wells.

The water is pumped to a standpipe by a horizontal compound duplex Worthington pump of 750,000 gallons capacity and a horizontal compound duplex McGowan pump of 1,000,000 gallons capacity. The standpipe is 25 feet in diameter and 57 feet high, has a capacity of 209,290 gallons, and furnishes an average pressure of 100 pounds.

There are 20 miles of mains laid, giving 80 per cent of the people access to the water. There are 1,100 services connected, of which 1,025 are in use, and none is metered. The average daily consumption is 1,000,000 gallons, which is 151 gallons per capita of the village and 188 for each consumer. The wells are located in the western part of the village, in the bottom land of the Kokosing River, a large area of which is under the control of the village and is laid out for a public park, so as to protect the water supply.

New Philadelphia.—The public water-supply system of New Philadelphia (population, 6,213) was put in by a private company, the New Philadelphia Water Company, in 1886, and has cost to date about $100,000.

The supply was first taken from an infiltration well at the edge of Tuscarawas River, just south of the town. In 1892 eight 6-inch wells, 30 feet deep, were put down in a large gravel deposit in the lowland along the river and near the old infiltration well. In 1896 six 6-inch wells, 80 feet deep, were put down in the same vicinity, and in 1898 two more of the same kind were put in. The normal level of the water is 11 feet below the surface, and it is lowered 15 to 18 feet by pumping.

The old infiltration well is now connected directly with the river, and can be drawn upon in case of fire. The water is pumped directly from the driven wells to a reservoir by two horizontal duplex Blake pumps of 1,000,000 gallons capacity each and by one horizontal compound duplex Laidlaw-Dunn-Gordon pump of 2,000,000 gallons capacity. The reservoir is located on a hill east of the village, at such a height as to give a pressure of 100 pounds. It is oval in shape, 200 by 100 feet, is 13 feet deep, and has a capacity of about 1,250,000 gallons. The bottom of the reservoir is lined with a mixture of cement and clay, the sides are riprapped, and the whole is covered with a board roof.

There have been 15 miles of mains laid, to which 90 per cent of the people have access. There are 600 service taps, 575 of which are in use, and 8 are metered. The average daily consumption is 600,000 gallons, which is 96 gallons per capita of the village and 175 gallons per consumer. The wells are removed from any local pollution and furnish good water.

Osborn.—A public water-supply system was established in 1895 by Osborn (population, 948), and has cost to date, including the electric-light plant, $30,000. The supply is obtained from four 6-inch wells in the northern part of the village. The wells are driven 50 feet through a thin stratum of clay and into a large bed of gravel. The normal level of the water is from 15 to 18 feet below the surface, and it is lowered but little by pumping.

The water is pumped directly from the wells to a standpipe by a horizontal compound duplex Laidlaw-Dunn-Gordon pump of 500,000 gallons capacity. The standpipe is 10 feet in diameter, 125 feet high, and has a capacity of 70,000 gallons. The station pressure is 60 pounds and the average on the mains is 50.

There are 3 miles of mains in use, to which about 80 per cent of the people have access. There are 100 services connected, of which 97 are in use, and none is metered. The average daily consumption could not be obtained.

The water seems to be of good quality, but it is not yet in general use for domestic purposes.

Oxford.—A public water-supply system was installed by Oxford (population, 2,009) in 1896, and has cost about $45,000. The supply is obtained from a large well dug in the sand and gravel bed near Fourmile Creek, some distance northeast of the village. The well is 20 feet in diameter and 35 feet deep. It is walled up with brick laid in cement and arched over so as to prevent flooding during high water, which overflows the well site. The top of the well is provided with a ventilator above high water. The normal level of the water is 9 feet from the surface, but it is frequently lowered to 24 feet by pumping.

The water is pumped directly from the well to the mains by two horizontal compound duplex Smith-Vaile and Stillwell-Bierce pumps of 750,000 gallons capacity each. The pressure on the mains varies from 45 to 65 pounds.

There are 7 miles of mains laid, which give about 95 per cent of the people access to the water. There are 234 services connected, of which 211 are in use, and 9 are metered. The daily average consumption is 30,000 gallons, which is 142 gallons per service and 15 gallons per capita of the village. The total number of consumers is hard to estimate, owing to the fact that three large institutions are supplied, but the consumption per consumer can not be far from 25 gallons.

Piedmont.—A public water-supply system was put in at Piedmont (population, 275) by a private company, the Piedmont Water Supply Company, in 1894, and has cost to date $1,450. The supply is obtained from two springs located on the neighboring hills, the water from which is impounded in a reservoir and conducted to the village by gravity. The reservoir consists of a vaulted stone cistern, with a capacity of 12,500 gallons, and is at such a height as to give a pressure of 55 pounds on the streets.

There are 2 miles of mains in, which give about 60 per cent of the village access to the water. There are 45 services, of which 40 are in use, and none is metered. Owing to the nature of the supply, it was impossible to estimate the consumption. The springs emerge from a bed of shaly sandstone in the side of the hills, and the water appears to be of good quality.

Shelby.—The public water-supply system of Shelby (population, 4,685) was put in by a private company, the Shelby Water Company, in 1897, and has cost to date $140,000. The supply is from twelve 6-inch wells, 46 feet deep, located in lowland lying northwest of the village and bordering Black Fork. The wells go through clay and sand, gravel, and blue clay, into a stratum of gravel, in which the water is found. The normal level of the water in the wells is 5 feet from the surface, and the supply has been so abundant that the level is seldom lowered more than a foot by the pumps. The creek at times overflows the land occupied by the wells, but it is claimed the turbidity of the well water does not increase during such times, showing no intimate connection between the surface water and that obtained from the wells.

The water is pumped directly from the wells to a standpipe by two horizontal compound duplex McGowan pumps of 2,000,000 gallons capacity each. The standpipe is 16 feet in diameter and 145 feet high, giving a capacity of 218,000 gallons and an average pressure of 1,000 pounds.

There are 15 miles of mains in use, giving 95 per cent of the people access to the water. There are 710 services connected, 640 of which are in use, and 4 are metered. The average daily consumption is 750,000 gallons, or 160 gallons per capita, or 170 gallons per consumer. The water is rather highly impregnated with iron, and on this account is objectionable to many for domestic use.

Tippecanoe City.—A public water-supply system was put in by Tippecanoe City (population, 1,703) in 1897, and has cost to date, together with the electric-light plant, $28,000. The supply is obtained from driven wells located in the eastern part of the village, near the Miami and Erie Canal. There are five 8-inch wells, driven 80 feet deep into a bed of sand and gravel. Only three of the wells are in use. The normal level of the water is 10 feet below the surface, and this is lowered by pumping to a depth of from 17 to 35 feet, according to the season.

The wells are surrounded by scattered houses, and will in time suffer pollution unless steps are taken to drain off all objectionable refuse.

The water is pumped directly from the wells to the mains by two horizontal duplex Smith-Vaile pumps of 500,000 gallons capacity each, and at a pressure of 60 pounds, which is decreased to 55 on most of the mains.

There are 6 miles of mains, which supply about 95 per cent of the population with water. There are 345 services, 310 of which are in use, and 18 are metered. The average daily consumption is 75,000 gallons, which is 281 gallons per service, 56 per consumer, and 44 per capita of the total population.

Trotwood.—The smallest village—or rather community, as it is not incorporated—in the State that has a public water supply is Trotwood (population, 214). The plant was put in in 1899 by a stock company, formed of nearly all the citizens, to provide primarily for fire protection only, and has cost to date $4,000. The installation of the system was occasioned by a very disastrous fire the year previous.

The water supply is procured from two 8-inch wells, driven 26 feet through clay and hardpan and into a bed of gravel. The water stands in the wells 12 feet below the surface, and the level was lowered but little by pumping at the rate of 120 gallons per minute. The water is pumped directly from the wells to a horizontal steel tank by a vertical duplex power pump run by a gasoline engine. The tank, engine, pump, and wells are all within the confines of a neat stone building situated at the edge of the village.

The pump was made by C. O. Lucas, of Greenville, Ohio, and is fitted with a device by which a certain amount of air can be pumped with the water to the tank, and there, under pressure, force the water through the mains when the pump is not running. The pump is a double-acting one, with a capacity of 175,000 gallons in twenty-four hours, working under a pressure of from 40 to 80 pounds, the limits allowed in the tank. This tank is 24 feet long, 5 feet in diameter, and holds 5,000 gallons. It is fitted with a blow-off cock for the regulation of the pressure and the amount of air above the water.

There are 3,900 feet of mains, to which about 90 per cent of the people have access. There are 38 services connected, 30 of which are in use, and none is metered.

The water is of good quality, but it is not yet in general use for domestic purposes. On account of the few services and the wide range of pressure allowed in the tank—from 40 to 80 pounds—the pump is run for a short time only each day, and the water in the tank is not so fresh as it would be with a larger consumption.

Troy.—The public water-supply system of Troy (population, 5,881) was installed in 1884, and has cost to date $125,000. The first supply was obtained from a large well, 25 feet in diameter and 31 feet deep, dug in the sand and gravel that underlies this whole section. This failed to supply the increasing consumption, and in 1891 another large well was dug, which was later filled by a flood and not reopened. As the consumption increased, five 8-inch wells were driven 20 feet in the bottom of the first large well, and the flow considerably increased for a time, but the water soon ran low and they are not of much use now. In 1898 three wells were driven near the old large wells, but they were of no value. In the same year five 8-inch wells were driven along the street south of the plant, and considerable water was found at from 38 to 51 feet below the surface. In 1899 eight 8-inch wells were driven just east of the plant to a depth of from 38 to 54 feet. The last two sets of wells, 13 in all, furnish the bulk of the water.

The water is pumped directly from the wells by two horizontal compound duplex Laidlaw-Dunn-Gordon pumps of 1,700,000 gallons capacity each. Until March, 1898, nearly all of the water was pumped by two Smith-Vaile power pumps of 1,000,000 gallons capacity each, actuated by a 15-inch and 28-inch Victor turbine supplied with water under 16 feet 8 inch head from the "hydraulic," a ditch fed from the Miami and Erie Canal and a little local territory, which furnished satisfactory power until March, 1898, when a flood washed out the embankment, damaged the power house, and filled up one of the wells, as noted above. The average domestic pressure carried is 60 pounds.

There are 14 miles of mains in use, to which about 90 per cent of the people have access. There are 1,002 services connected, of which 994 are in use, and 78 of these are metered. The average daily consumption is 503,000 gallons, which is 506 gallons per service, 101 gallons per consumer, and 86 gallons per capita of the total population.

The waterworks is located in the northern part of the city, where the wells are subject to but little local pollution, and the water seems to be of good quality.

Urbana.—The waterworks at Urbana (population, 6,808) were put in by a private company in 1878. The supply is from one large well 20 feet in diameter and 23 feet deep, walled up with rough stone and covered with a conical board roof, and from eight 6-inch wells averaging 40 feet in depth. The large well goes through about 4 feet of soil, 2 feet of blue clay, and then through layers of gravel and sand, finding water in a layer of fine gravel 23 feet down. The small wells go through the same strata and obtain their water in an extensive bed of gravel, which continues downward for 150 feet, when bed rock is struck.

A reservoir 175 by 80 by 13 feet deep, with a capacity of 140,000 gallons, is used to store water in case of emergency. It is claimed it has not been used for a year at least. The sides and bottom of the reservoir are carefully cemented, and practically no surface drainage has access to it. The reservoir is cleaned three or four times a year to remove moss and other vegetable growths.

The water is pumped from the large well directly to the mains by a quadruplex Holly pump of 1,500,000 gallons capacity, installed in 1878, and a horizontal compound duplex Holly pump of 2,000,000 gallons capacity, put in about 1889. There are 8.4 miles of mains in, giving nearly all the city access to the water. There are 900 services in use, of which 40 are metered. The average daily consumption is about 1,000,000 gallons, and the average per consumer is 185 gallons.

The private water supply is from dug and driven wells ranging from a few feet to 60 feet in depth. These wells obtain their water from a large bed of gravel which underlies the whole city. This bed is composed of alternate layers of gravel, sand, and blue clay. The clay is not continuous, but is very much broken, especially in the western part of the city. In the eastern half the layers of hardpan and clay are more extensive, making several water-bearing strata, one above each layer of hardpan. This large gravel bed supplies an abundance of water, and would furnish a water of good quality if it were protected from pollution. Urbana has no sewers whatever. The surface drainage is to Dugan Creek and its branches, through surface drains and gutters. Dugan Creek is a tributary of Mad River. Many houses have water-closets that drain to cesspools, which are put down into the gravel, so that the water will drain off and not fill up the cesspool so quickly. As soon as they become full, new ones are dug and the old ones are covered over. Vaults are also dug down into the gravel, so as to require less frequent cleaning, or in this case renewal, as very few vaults are ever cleaned. This practice has loaded the ground water with filth, and would make well water absolutely unfit for use if it were not for the filtering action of the gravel and sand. The water is at the present time a potable one.

There are now 20 miles of mains laid, giving about 85 per cent of the people access to the water. There are 1,137 services connected, of which 1,000 are in use, and 60 of these are metered. The average daily consumption is 1,170,000 gallons, which is 1,286 gallons per service, 257 gallons per consumer, and 186 gallons per capita of the total population.

Versailles.—On November 1, 1900, Versailles (population, 1,478) obtained the approval of the State board of health for a public water supply to be obtained from three 8-inch wells located on the banks of Swamp Creek, near the center of the village, though not in the immediate neighborhood of many houses. The wells are driven 30 feet deep through a bed of clay and into gravel, and could furnish an excellent water but for contamination from the surrounding population. The water is not of the best, but as it is all that can be had, and is so much better than the private well water, its use was permitted. The plant has just been put in, and has cost to date $38,000. Three and one-half miles of mains have been laid, 90 per cent of the population having access to them, and 126 services have been connected, all of which are in use, and none is metered. The average daily consumption is 200,000 gallons, which is 135 gallons per capita of the total population, or 150 gallons per consumer.

Wadsworth.—A public water-supply system was put in at Wadsworth (population, 1,764) by a private company in 1881, and has cost to date about $12,000. The supply was first obtained by gravity from three springs, two situated on the high ground just north of the village and one on a hill to the east, the average elevation of the three being about 80 feet above the village streets. The springs are walled up and roofed over, and fairly well protected from surface washings, though not so well as their surroundings require. Analyses have shown that these springs are not yet seriously polluted.

These springs failed in time to give enough water, and in 1898 three 6-inch wells were drilled 40 feet deep, going 28 feet into sandstone. These wells are in the valley of a small run northwest of the village and are removed from serious contamination. The water rises practically to the surface when the wells are not being pumped, and it is lowered about 15 feet by the pumps.

The water is pumped directly from the wells to the main by a 150,000-gallon horizontal duplex Worthington pump, the surplus going to the spring basins.

There are 6½ miles of mains laid, to which 80 per cent of the population of the village have access. There are 350 services connected, of which 340 are in use, and none is metered. It was impossible to estimate the consumption, as no record has ever been kept either of the flow of the springs or of the amount pumped from the wells.

Waynesburg.—The public water-supply system at Waynesburg (population, 613) was put in by a private company, the Waynesburg Water Company, in 1857, and has cost to date $1,300. The water is obtained by impounding the run-off of two springs located in the upper part of the village, and the supply is carried to the mains by gravity. The reservoir consists of a basin 16 by 33 feet and 5 feet deep, built of brick and covered with a board roof. It has a capacity of about 16,000 gallons and is located at such a height as to give an average pressure of about 20 pounds. The springs emerge from the side of a hill which is used as a pasture. One of them comes from an abandoned coal bank. There has been 0.75 mile of mains laid, giving 40 per cent of the people access to the water; 55 services have been connected, all of which are in use, and none is metered. The daily consumption could not be even estimated.

Waynesville.—On November 1, 1900, Waynesville (population, 723) obtained the approval of the State board of health for a public water supply to be obtained from a number of 6-inch drilled wells located south of the village and near the Little Miami River. The wells are from 40 to 50 feet deep, are drilled through various strata of sand and gravel and into limestone, just above which the water is found.

The wells are practically free from local pollution, and the small amount existing can easily be removed, so that they should furnish an excellent water—much better than the private well supply. Bonds for $30,000 were sold, and a combined electric-light and water plant has just been put in.

The water is pumped to a standpipe having a capacity of 92,000 gallons by two duplex McGowan pumps of 750,000 gallons pumping capacity each. About 3¾ miles of mains have been laid, and 125 services are connected, 123 of which are in use, and none is metered.

West Carrollton.—The public water-supply system of West Carrollton (population, 987) was put in by the village in 1895, and has cost to date $8,500. The supply is obtained from two 8-inch wells drilled in the lowland along the Miami and Erie Canal. The wells are 65 feet deep and go through gravel, hardpan, and into a deep bed of sand, in which the water is found. The normal level of the water is about 10 feet from the surface, and it is lowered to about 30 feet by the highest consumption.

The water is pumped directly to the mains by a horizontal duplex McGowan pump of 750,000 gallons capacity. The average pressure is 60 pounds. The pump is located in the mill of the G. H. Friend Paper and Tablet Company, which has a ten-year contract with the village, under which the company furnishes steam for the pump and keeps it in repair for its use and for the use of the water from the wells. The consumption of water in the village is small, but a large amount is used by the paper mill.

There are 4 miles of mains in, giving about 90 per cent of the people access to the water. There are 128 services connected, of which 120 are in use, and 3 are metered. The well water seems to be of good quality and is used for domestic purposes.

DEEP-SEATED.

Ada.—The village of Ada (population, 2,576) is furnished with water by the Ada Water, Heat and Light Company, which derives its supply from four 8-inch wells, drilled 152 feet deep through 25 feet of clay and soil, 5 to 6 feet of gravel, and the remaining distance in limestone. The wells are located in the eastern part of the village, fairly well removed from local influences. The water is pumped directly to the mains by two horizontal compound duplex Deane pumps of 750,000 gallons capacity each and one Dunn-Gordon of 75,000 gallons capacity. The heating plant has, also, two horizontal compound duplex Laidlaw-Dunn-Gordon pumps of the same capacity, which can also be used on the water supply if necessary. There have been 3 miles of mains laid, to which 75 per cent of the population have access; 150 services have been connected, of which 100 are in use, and 15 are metered. The average daily consumption is 300,000 gallons, which is 116 gallons per capita of the entire population, or 155 gallons per consumer. The supply has just been installed, and the above estimates are therefore not very reliable.

Bluffton.—A public water-supply system was put in by Bluffton (population, 1,783) in 1896 at a cost of $17,000, and has cost to date $24,000. The supply is derived from 8 wells, 8 inches in diameter and from 35 to 50 feet in depth. Only 6 of these wells, however, are now connected with pumps.

The limestone lies within a few feet of the surface, and the water is obtained in this rock. It rises nearly to the surface when it is not pumped, but can easily be lowered to the suction limit of the pumps. The supply of water has always been sufficient so far, but for use in cases of emergency an 8-inch intake pipe has been run to an old stone quarry near the waterworks. This quarry contains about 3½ acres, and the water is from 3 to 20 feet deep, only the upper 5 feet of which, or 4,000,000 gallons, can be drawn off by the pumps. This emergency intake is infrequently used.

The well water is pumped to an elevated tank by a horiziontal simple duplex Stillwell-Bierce-Smith-Vaile pump of 750,000 gallons capacity. The tank is 20 feet in diameter, 30 feet high, with a capacity of 70,000 gallons, and is placed on a steel-frame tower 82 feet in height, which gives an average pressure of 35 pounds on the main streets.

There have been 4 miles of mains laid, giving 80 per cent of the population access to the water. There are 300 services connected, of which 250 are in use, and only 1 is metered.

The average daily consumption is about 120,000 gallons, or 68 gallons per capita of the population of the village and 81 gallons for each consumer.

Bryan.—A public water-supply system was put in by Bryan (population, 3,131) in 1893–94, and had cost to January, 1899, $45,000. The supply is derived from thirteen wells, eight of which were put down in 1893, and, in the fear that these might not furnish enough water, five more were sunk later. The wells are 4½ inches in diameter, from 95 to 112 feet deep, and go through hardpan, cement, gravel, quicksand, and into loose gravel, where the water is found. When not pumped all the wells flow, and they have always furnished enough water, the level never going below the suction limit of the pumps. The water flows from the wells to a common main, to which the suction pipe is attached, and to which it is directly pumped by two horizontal compound duplex Hughes pumps of 1,000,000 gallons capacity each.

There have been 6 miles of mains laid, which give 75 per cent of the people access to the water. There are 436 services connected, of which only about one-half are in use the year round, the rest being used in summer only for sprinkling. Of these services 55 are metered. The average daily consumption is 176,000 gallons, or 56 gallons per capita of the total population, and 74 gallons per consumer.

Carey.—A public water-supply system was put in by Carey (population, 1,816) in 1894, and has cost to date $30,000. The supply is from a group of five wells west of the village, where the limestone is only 14 feet below the surface. The wells are 5⅝ inches in diameter, from 50 to 60 feet deep, and the water stands normally only 13 feet from the surface, and its level is lowered but 1 foot by ordinary pumping.

The water is pumped directly from the wells to a standpipe by two horizontal compound duplex Laidlaw-Dunn-Gordon pumps of 500,000 gallons capacity each. The standpipe is 16 feet in diameter, 115 feet high, and has a capacity of 173,000 gallons. There are 7 miles of mains laid, which give 80 per cent of the population access to the water.

There are 250 services connected, all of which are in use, and 6 are metered. The average daily consumption is estimated to be 160,000 gallons, or 88 gallons per capita of the total population, and 110 gallons for each consumer.

Carrollton.—A public water-supply system was put in by Carrollton (population, 1,271) in 1895, and has cost to date $66,000. The water is taken from five 8-inch drilled wells, which are 100 feet deep and go through 17 feet of loam and shale and 83 feet into sandstone. The normal level of the water is 8 feet below the surface, and it is lowered to 27 or 28 feet during pumping.

The water is pumped directly from the wells to a standpipe which is 16 feet in diameter and 73 feet high, giving a capacity of 103,000 gallons and a domestic pressure of 60 pounds. The pumps consist of two horizontal compound duplex Worthingtons, of 750,000 gallons capacity each.

There are 4½ miles of mains, giving 85 per cent of the people access to the water. There are 255 services connected, all of which are in use, and 2 are metered. The average daily consumption is 85,000 gallons, which is 67 gallons per capita, and 78 gallons per capita of the population actually supplied. This supply is in general use for domestic purposes.

Continental.—A public water-supply system was put in by Continental (population, 1,104) in 1894, and has cost to date about $10,000. The supply is from three 8-inch wells 75 feet deep, which strike the limestone at a depth of 48 feet. The water is pumped to a standpipe by a deep-well pump of 100,000 gallons capacity. The water rises in the well to within 13 feet of the surface, but the pump cylinder is placed 20 feet down, so that if necessary the water can be lowered about 45 feet; but it has never reached this limit yet, as the well has always supplied enough at a higher level.

The standpipe is 10 feet in diameter, 100 feet high, and has a capacity of 40,000 gallons. For ordinary service the deep-well pump keeps the standpipe full, but in case of fire a 100,000-gallon duplex Stillwell-Bierce pump draws from the standpipe and pumps directly to the main.

There are 2¼ miles of mains in use, which give about 75 per cent of the population access to the water. There are 110 services connected, of which 84 are in use, and 4 of these are metered. The average daily consumption is 45,000 gallons, or 41 gallons per capita of the population of the village, and 154 gallons for each consumer.

Dalton.—A public water-supply system was put in by Dalton (population, 666) in 1895, and has cost to date $8,000. The water is obtained from a well 200 feet deep, drilled in sandstone all the way. The well was drilled 6 inches in diameter for a part of the way, then sent down to the above depth only 4 inches in diameter. The water is pumped by a deep-well pump operated by wind power to a reservoir located at the side of the well, and then flows by gravity to the town to the east. The pump cylinder is 150 feet below the surface, and the water can be lowered to the suction limit below this. The normal level of the water is 40 feet below the surface. The deep-well pump was formerly operated by steam, but owing to the fact that the well is on a high hill, where good wind power can be developed, the change was made. The wind wheel is of the self-adjusting compound pattern, and requires no attention beyond occasional setting and oiling. With this power the pump can handle about 10,000 gallons daily. The reservoir is a circular brick well, covered with a tin roof, and holding 140,000 gallons. In addition to the well supply, the run-off of a spring located in the town has been impounded in a reservoir of 36,000 gallons capacity, which is used only when the well supply is shut off for repairs or for lack of wind.

There are 2½ miles of mains laid, which give 85 per cent of the people access to the water. There are 42 service taps connected, of which 36 are in use, and 8 are metered. Only 3 of the taps are for house use, the others being for sprinkling and stable use only. The average daily consumption is about 3,900 gallons, which is 5 gallons for each person in the village, and 20 for each consumer. This supply is not used at all for domestic purposes.

Delphos.—A public water-supply system was put in by Delphos (population, 4,517) in 1896, and has cost to date $82,000.

The supply is from seven 8-inch wells, ranging from 191 to 300 feet deep, which obtain water from the Onondaga limestone, the top of which is only 20 feet below the surface. Six of the wells flow to a receiving well, and one of them is pumped to this by a Stillwell-Bierce air lift. This one well furnishes nearly all the water, which flows naturally at the rate of 56,000 gallons a day and can be pumped at a rate of 185,000 gallons.

The receiving well is 40 feet in diameter, 37½ feet deep, and has a capacity of 235,000 gallons. It is excavated partly in rock, its sides are lined with brick, and it is roofed over, so that it furnishes an excellent receptacle for a reserve supply of water.

Before the air lift was installed the water was almost unusable from the amount of sulphur present, but the aeration afforded by the lift has overcome this objection, and by the time the water reaches the mains it is free from the taste and smell of sulphur. A strong odor of sulphur is noticeable, however, in the receiving well.

The water is pumped from this well to a standpipe by two horizontal compound duplex Laidlaw-Dunn-Gordon pumps, each of 1,000,000 gallons capacity. The standpipe is 20 feet in diameter, 130 feet high, and has a capacity of 305,000 gallons, which, with the receiving well, gives an ample reserve supply of water.

There are 15.38 miles of mains in use, giving 90 per cent of the population access to the water. There are 615 service taps, of which 600 are in use, and 52 of these are metered. The average daily consumption is 300,000 gallons, which is 66 gallons per capita of the total population, or 74 gallons per consumer.

Lebanon.—A public water-supply system was installed in 1896 by Lebanon (population, 2,867), and has cost to date $52,000. A light plant has recently been established in the same building at a cost of $20,000. The supply is obtained from six 6-inch wells driven from 96 to 104 feet through alternating strata of clay, sand, and gravel. The wells are located a short distance west of the village, in the low ground bordering a small tributary of Turtle Creek.

The water from the wells is siphoned to a receiving well, from which it is pumped to a standpipe by two horizontal compound duplex Still-well-Bierce and Smith-Vaile pumps of 750,000 gallons capacity each. The supply from the wells is such that the water in the receiving well can be lowered only 10 feet by the present pumping capacity.

The receiving well consists of a brick cistern covered with a tin roof, and is 40 feet in diameter and 25 feet deep, with a capacity of 235,000 gallons. The standpipe is 80 feet high and 25 feet in diameter, with a capacity of 300,000 gallons. The average pressure on the mains is 70 pounds.

There are 12 miles of mains in use, to which at least 95 per cent of the people have access. There are 538 services connected, of which 512 are in use, and 15 of these are metered. Two of the meters are on the lines to the County Infirmary and Children's Home, respectively.

The average daily consumption is 103,000 gallons, or 40 gallons per consumer and 36 gallons per capita of the total population. The water seems to be of excellent quality and is in general use for domestic purposes.

Lewisville.—A water-supply system was installed in 1894 by Lewisville (population, 1,374), and has cost to date $18,000. The supply is obtained from two 8-inch wells, which were drilled 110 feet deep, going through soil and shale into a bed of gravel. The normal level of the water is from 8 to 10 feet below the surface, and it has never been lowered to the suction limit.

The water is pumped directly from the wells to a standpipe by two horizontal duplex Boisard pumps of 500,000 gallons capacity each. The standpipe is 16 feet in diameter and 100 feet high, and has a capacity of 150,000 gallons. The domestic pressure varies from 45 to

50 pounds in the main streets. There are 3½ miles of mains, which give 90 per cent of the people access to the water. There are 165 services connected, of which 159 are in use, and none is metered. The average daily consumption is 40,000 gallons, which is 25 gallons per capita for the village and 42 gallons per capita of the population actually supplied. The water is of good quality, and is used for domestic purposes by those who have access to it.

Madisonville.—A public water-supply system was installed in 1892 by Madisonville (population, 3,140), and has cost to date, together with an electric-light plant, $80,000. The waterworks alone cost about $35,000. The supply is from one 6-inch well and two 8-inch wells, each 150 feet deep and drilled through various strata of clay, quicksand, and gravel down to the rock. The wells are located just west of the village, in the low valley of a branch of Duck Creek. The normal level of the water is 21 feet from the surface.

At first the wells were pumped by direct suction, but this method failed to supply enough water, and in 1895 three deep-well pumps were put in. The wells are only 12 feet apart and within the walls of the pumping station, conditions favorable to the installation of deep-well pumps. All the pumps are the double-acting Laidlaw-Dunn-Gordon type, two having a capacity of 500,000 gallons each and the third 350,000 gallons. The pump cylinders are placed 120 feet from the surface.

The water is pumped by the deep-well pumps to a receiving tank and from this directly to the mains by two horizontal compound duplex Laidlaw-Dunn-Gordon pumps of 1,000,000 gallons capacity each. The receiving chamber consists of a covered steel tank 20 feet in diameter and 15 feet high, with a capacity of 55,000 gallons. The pressure at the station is 80 pounds and the average on the mains is 50 pounds.

There are 10 miles of mains laid, giving 90 per cent of the people access to the water. There are 350 services connected, of which 340 are in use, and 2 are metered. The average daily consumption is estimated to be 110,000 gallons, or 160 gallons per consumer and 35 gallons per capita of the total population. The water seems to be of excellent quality and is in general use for domestic purposes where it is available.

Mansfield.—A public water-supply system was installed in 1870 by Mansfield (population, 17,640), and has cost to date $566,000. The supply is from three groups of wells—one near the pumping station in the northern part of the city, near Rocky Fork; another one-fourth of a mile above this, near the Pennsylvania Railroad, and the third on Bloom street, near the central part of the city.

The station wells were the original supply and were drawn upon until the water in this section was exhausted; then, in 1889 and 1896, the gang one-fourth of a mile above was put in, and in 1896 the Bloom street wells were drilled. In the group near the station there are ten 4-inch wells and one 10-inch well, which range in depth from 150 to 210 feet and are all in a bed of quicksand. This gang is pumped to a receiving well by a horizontal duplex Blake pump of 750,000 gallons capacity, and supplies about 375,000 gallons daily.

The group one-fourth mile above the station consists of five 5-inch wells and one 10-inch well, all 180 feet deep. These wells penetrate soil and gravel and 60 feet into sandstone rock. The water from them flows to the receiving well by gravity. A centrifugal pumping plant will shortly be installed here, which, it is claimed, will increase the capacity of the group to 2,000,000 gallons daily.

There are two wells in the Bloom street group, each 10 inches in diameter and 180 feet deep. They go through the surface soil, gravel, and clay into a bed of quicksand. The water flows by gravity from these wells directly to the station. The pump well is 35 feet in diameter and 30 feet deep and is walled up with stone and housed over. The water is pumped from this well directly to the mains by two horizontal compound duplex Gordon pumps of 2,000,000 and 1,750,000 gallons capacity, respectively. By closing down the valve in one supply main two pressures are maintained, one of 125 pounds and the other of 80.

There are 60 miles of mains in use, which supply about 70 per cent of the population with water. There are 3,000 services connected, all of which are in use, and 43 are metered. The average daily consumption is about 3,000,000 gallons, which is 170 gallons per capita of the city and 243 for each consumer. The water is in general use by all those able to obtain it.

Montpelier.—A public water-supply system was installed in 1895 by Montpelier (population, 1,869), and had cost to January, 1899, about $44,000. The supply is from three 8-inch drilled wells 113 feet deep, only two of which are now in use. The wells go through clay, fine sand, and into gravel, in which the water is found. The water rises to within 28 feet of the surface; and as the wells were to be pumped by direct suction, the pumps had to be placed 20 feet below the surface, from which place they can lower the water about 45 feet below the surface.

The water is pumped to a standpipe by two horizontal compound duplex Worthington pumps of 750,000 gallons capacity each. The suction pipe is 6 inches in diameter and goes down 36 feet into the well casing.

The standpipe is 12 feet in diameter, 110 feet high, and has a capacity of 93,000 gallons.

There are 4½ miles of mains, which supply about 80 per cent of the people with water. There are 420 services connected, all of which are in use, and none is metered. The average daily consumption is 390,000 gallons, or 209 gallons per capita of the total population and 261 gallons per consumer.

New Bremen.—The village of New Bremen (population, 1,318) will be supplied with water from three 6-inch wells drilled about 100 feet deep through 76 feet of clay and gravel into limestone.

New Comerstown.—On July 22, 1901, a franchise was granted to the New Comerstown Water Company for furnishing a public supply to this village (population, 2,659). The plant was put in operation in the summer of 1902, the supply being obtained from six 6-inch wells driven from 35 to 37 feet deep through clay and loam into a bed of sand and gravel lying along the Tuscarawas River, three-quarters of a mile east of the village.

The water is pumped directly to the mains and reservoir by two horizontal compound duplex Laidlaw-Dunn-Gordon pumps of 1,000,000 gallons capacity each. The reservoir is constructed of concrete or puddle, not covered, and has a capacity of 1,125,000 gallons. It is located on a hill east of the village, at such an elevation as to give a pressure of 107 pounds on the streets. There have been about 6½ miles of mains laid, giving practically the entire population access to the water. It is reported that there are 137 services in use, 6 of which are metered. The average daily consumption is 250,000 gallons, or 85 gallons per capita and 366 gallons per consumer. The industrial use of the water is very large. It is reported that the plant complete cost $149,000, a per capita cost of $56.41. It is hard to see where the money was placed, as this is certainly a large sum to spend for a plant of this character.

New Vienna.—This village (population, 805) has just completed a new waterworks at a cost of $20,000. The supply is obtained from four wells driven 60 feet through gravel and Niagara limestone into the shale that lies below this rock. This water was struck in the southeastern portion of the city by an old gas well. When not pumped the water flows with a small head. A compound duplex John McGowan pump raises the water to the reservoir, which has a capacity of 60,000 gallons.

Four miles of mains have been laid, to which 90 per cent of the population have access. There are 25 services connected, and it is reported that the daily consumption is 2,500 gallons, but the plant is so new that it is impossible to estimate it accurately.

Norwood.—This village (population, 6,480) is on the divide between Duck Creek and Mill Creek, and only about half of its population is tributary to the former, or the Little Miami drainage area.

A public water-supply system was put in by the village in 1894, and has cost to date $154,138. A light plant was installed in the same building, costing, completed, $34,501. The supply was originally derived from six drilled wells, 235 feet deep and 6 and 8 inches in diameter. These wells began to fail and two 10-inch wells were drilled 260 feet deep through clay, gravel, and sand and into the limestone rock a few feet. These have furnished the whole supply since September 1, 1900. The normal level of the water is 110 feet from the surface, and it is lowered but little by pumping. The wells are located in the eastern part of the village, but the water will not be greatly liable to pollution, on account of the depth at which it is found, 240 feet, and the general introduction of sewers, which has prevented the construction of vaults. A third well is being put down so as to insure an ample supply.

The water is pumped to a receiving basin by air lifts and thence to a standpipe by two horizontal compound duplex Laidlaw-Dunn-Gordon pumps of 750,000 gallons capacity each. Compressed air is supplied by a Rand Drill Company's compressor and by a new Ingersoll-Sergeant compressor, the former being held in reserve. A 3-inch air line is carried down 240 feet in the well, and the water is forced up between this and the casing.

The receiving basin is an open oval-shaped cistern, 15 by 20 by 8 feet deep, with a capacity of 14,000 gallons. The standpipe is 60 feet high, 40 feet in diameter, with a capacity of 537,000 gallons, and is placed on a hill of such height that the station pressure is 112 pounds, standpipe full, and the pressure on the mains varies from 104 to 142 pounds.

There are 35 miles of mains laid, giving about 95 per cent of the people access to the water. There are 974 services connected, of which 874 are in use, and 140 of these are metered. Owing to the changes in the plant the consumption could not even be estimated.

Oakwood.—During 1902 the citizens of Oakwood (population, 342) installed a complete water-supply system at a cost of $10,000, or a per capita cost of $40. The supply is obtained from one 6-inch well driven 50 feet into drift, the water being obtained from a stratum of sand and gravel.

The water is pumped to an elevated tank holding 50,000 gallons by a power pump of 350,000 gallons capacity, operated by a gasoline engine; 1.61 miles of mains have been laid and 26 services have been connected, 24 of which are in use, and none is metered. The average daily consumption is 10,000 gallons, or 40 gallons per capita and 91 gallons per consumer.

Orrville.—A public water-supply system was installed in 1894 by Orrville (population, 1,901), and has cost to date $25,000. The supply is derived from four 8-inch wells, which vary from 114 to 121 feet in depth. The wells went through from 10 to 16 feet of soil, then struck the rock, which is a conglomerate of the Waverly group. The water rises above the surface when the wells are not being pumped, and it is lowered only from 10 to 12 feet during the hardest pumping. The supply is pumped directly from the wells to the mains, and a domestic pressure of 70 pounds is maintained by two horizontal compound duplex Laidlaw-Dunn-Gordon pumps of 1,500,000 gallons capacity each. There are 6 miles of mains laid, which furnish 90 per cent of the people with water. There are 268 services connected, 260 of which are in use, and none is metered. The average daily consumption is 141,858 gallons, which is 71 gallons per capita of the total population and 91 gallons per capita of the population actually supplied. The water is in general use and is of good quality, both for domestic and manufacturing uses. A good deal of water is used by the railroads that pass through the town.

Paulding.—A public water-supply system has just been installed at Paulding (population, 2,080) at a cost of $38,000. The supply is taken from three 8-inch wells from 320 to 616 feet deep. The water is obtained from the limestone found just below the drift. The wells are located in the northern part of the village, at a point free from local pollution, and the rock is well protected by about 25 feet of clay. The water is pumped from the wells to a reservoir by two horizontal compound duplex McGowan pumps of 750,000 gallons capacity each.

Four miles of mains have been laid, to which 70 per cent of the population have access. There are 95 services connected, all of which are in use, and none is metered. The average daily consumption is 80,000 gallons, or 38 gallons per capita of the total population, or 55 gallons per consumer.

Perrysville.—A public water-supply system was installed in 1894 by Perrysville (population, 513), and has cost to date $8,000. The supply is derived from one 6-inch well 93 feet deep, 53 feet of which is sandstone rock. The well is located just north of the village, far away from all source of pollution. The water is pumped to a small reservoir by a Smith-Vaile deep-well pump of 112,000 gallons capacity. The normal level of the water is 25 feet below the surface, and the well can be pumped dry, as the water cylinder is 75 feet down.

The reservoir, which is of 54,000 gallons capacity, consists of a brick cistern covered with a shingle roof, and is located on a hill back of the pumping station at such height as to give a pressure of 75 pounds in the village.

There are 3 miles of mains in use, supplying 75 per cent of the people with water. There are 60 services connected, 45 of which are in use, and 25 are metered. The average daily consumption is 12,600 gallons, which is 25 gallons per capita of the village and 35 per consumer. The water is in very general use in the village, to the exclusion of private wells. The absence of baths and water-closets keeps the consumption very low.

Rockford.—The public water-supply system of Rockford (population, 1,207) was put in by the village in 1897, and has cost to date about $17,000, which is a per capita cost of $14.08.

A private company owns and operates an electric-light plant in the waterworks pumping station and obtains its power from the waterworks boilers. This arrangement, it is said, pays the waterworks enough annually to cover the cost of pumping the entire supply for the village.

The supply is obtained from two 6-inch wells, drilled 109 and 111 feet, respectively, into an extensive bed of gravel. The normal level of the water is from 11 to 16 feet from the surface, and it is lowered but little in one and some 50 feet in the other by ordinary pumping.

These wells are pumped by two Laidlaw-Dunn-Gordon deep-well pumps of 150,000 gallons capacity each, which discharge into a receiving well, from which the water is pumped to a standpipe by a horizontal compound duplex Laidlaw-Dunn-Gordon pump of 500,000 gallons capacity.

The receiving well is 24 feet in diameter and 14 feet deep and has a capacity of 50,000 gallons. It is constructed of brick and covered with a tin roof. The standpipe is 107 feet high and 12 feet in diameter, has a capacity of 94,000 gallons, and furnishes an average pressure on the mains of 40 pounds.

There are 3½ miles of mains laid, which give about 90 per cent of the people access to the water. There are 52 services connected, all of which are in use, and 10 are metered. The average daily consumption is about 23,000 gallons, which is 442 per service, 38 per consumer, and 19 per capita of the village's population.

The wells are located in the northwestern part of the village, far away from any source of serious pollution, and the water seems to be of good quality.

There are a number of private wells still in use. These are usually dug about 35 feet deep, going through clay and hardpan into the gravel below.

St. Marys.—In 1895 a public water-supply system was put in by St. Marys (population, 5,359), and had cost to December, 1898, about $57,500. The supply is derived from four 8-inch drilled wells, which range from 262 to 272 feet in depth. The wells strike the limestone at 125 feet, and from this stratum obtain a very hard water, which contains some sulphur and iron.

The wells flow to a covered receiving well, 38 feet in diameter and 28 feet deep, that holds 237,000 gallons. From this well the water is pumped directly to the mains by two horizontal compound duplex Smith-Vaile pumps, each of 750,000 gallons capacity.

There are 12½ miles of mains laid, which give 75 per cent of the population access to the water. There are 280 services connected, of which 275 are in use, and 7 of these are metered. The average daily consumption is about 100,000 gallons, or 28 gallons per capita of the population of the village and 60 gallons per consumer.

Scio.—The water-supply system at Scio (population, 1,214) was put in by a private company, the Scio Water Supply Company, in 1899, and has cost to date about $35,000. The plant was originally designed to protect the village against the great danger from fire on account of the oil industry. The water is obtained from five 8-inch wells 105 feet deep. Four of the wells go through quicksand into sandstone rock, and one goes through rock into a broken stratum of rock and clay. The normal level of the water is 2 feet below the surface, and it is lowered but little by pumping. The wells are located in the valley of Conotton Creek, just below the village, and would be badly polluted by drainage if they were not carefully cased in. The water is pumped directly from the wells to two elevated tanks by a Smith-Vaile triplex double-action pump of 1,000,000 gallons capacity. The tanks are constructed of steel, each 18 feet in diameter and 25 feet high, and have a combined capacity of 95,000 gallons. They are placed on a hill back of the pumping station and at such height as to give an average pressure of 100 pounds.

There are 4 miles of mains, which give 95 per cent of the people access to the water. There are 120 services connected, and 110 are in use, of which 1 is metered. The average daily consumption is 31,500 gallons, which is 17 gallons per capita of the village and 150 gallons per consumer.

Shreve.—The public water-suply system of Shreve (population, 1,043) was put in by the village in 1893, and has cost to date $11,000. The water is obtained from an 8-inch well 142 feet deep, located in the upper part of the village. The rock is very near the surface at this point, and the well required but little casing. The water is pumped by a Laidlaw-Dunn-Gordon deep-well pump, of 100,000 gallons capacity, to a small brick cistern, from which it is pumped to a reservoir by a horizontal duplex Miller pump of 150,000 gallons capacity. The cistern holds 3,300 gallons and the reservoir 88,200 gallons. The reservoir, which is constructed of brick and is covered over, is 30 feet in diameter and 16 feet deep. It is located on a hill north of the village, at such height as to give a pressure of 80 pounds. It is cleaned every year, and no trouble has been given by vegetable growths.

There are 2½ miles of mains laid, which supply 90 per cent of the people with water. There are 122 services connected, all of which are in use, and all are metered. The average daily consumption is about 54,000 gallons, which is 51 gallons per capita of the total population and 106 gallons for each consumer. The water is of good quality and is used for domestic purposes by everyone having access to it.

Sidney.—Waterworks were first established by Sidney (population, 5,688) in 1874. The old plant cost $50,000 and the new one, put in in 1889, has cost to date $107,500. The first source of supply was Mosquito Creek. This was abandoned in 1889, and water was then taken from Miami River. The water was filtered through two American pressure filters of 225,000 gallons capacity each, and later a New York horizontal pressure filter of 500,000 gallons capacity was put in. In 1895 wells were drilled and water enough to supply the town was found. Now these form the sole source of supply, and the creek water is not used at all, though the intake is intact and the water could be drawn on in case of emergency. The filters were also put out of use as soon as the well supply was developed. The present supply is derived from six wells, 120 feet deep and 8 inches in diameter, located near the pumping station. The wells are all artesian; they flow at the rate of 1,000,000 gallons in twenty-four hours during favorable seasons, and are lowered only 10 feet by the pumps. They go through a bed of gravel 20 feet thick and then strike the Niagara limestone, in which they find water which is of excellent quality except for its hardness. The water is pumped directly from the wells to a standpipe situated on a hill back of town. The two pumps in use, put in in 1889, are vertical compound duplex Gordon pumps of 1,500,000 gallons capacity. The standpipe is 25 feet in diameter, 86 feet high, and has a capacity of 300,000 gallons. It gives a pressure of 70 pounds at the station.

There are 13 miles of mains laid, giving about 90 per cent of the population access to the water. There are 700 services connected, of which 685 are in use, and 60 of these are metered. The average daily consumption is 639,000 gallons and the average per consumer is 183 gallons, or 112 per capita.

Sycamore.—The public water-supply system of Sycamore (population, 853) was put in by the village in 1898–99, and has cost to date, together with the electric-light plant, $25,000.

The supply is obtained from two 6-inch wells, one 204 and one 198 feet deep, located at the eastern edge of the village. The wells go through 100 feet of drift and then strike the limestone bed rock, in which the water is found. The normal level of the water is about 23 feet below the surface of the ground, and it is lowered but little by the severest pumping.

At first the whole supply was obtained from these wells by a Snider-Hughes air lift, but in June, 1900, a Hill deep-well pump of 75,000 gallons capacity was installed in one well for fear of the failure of the air lift. Both the air lift and the deep-well pump discharge to a covered brick cistern of 40,000 gallons capacity, from which the water is pumped to an elevated tank by a horizontal compound duplex Snider-Hughes pump of 500,000 gallons capacity. The water tower consists of a 40,000-gallon steel tank on a steel tower 80 feet high, giving a total height of 100 feet.

About 7 miles of mains have been laid, giving about 80 per cent of the people access to the water. There are 250 services connected, of which 140 are in use, and one of these is metered for the supply of a local railroad. The average daily consumption is 90,000 gallons, which is 105 gallons per capita, or 132 gallons per consumer.

Van Wert.—The public water-supply system of Van Wert (population, 6,422) was put in by the village in 1891, and has cost to date $130,000. The supply is from nine 6-inch wells 200 feet deep, which strike the limestone in which the water is found at 40 feet. The water rises to within from 12 to 18 feet of the surface and is pumped down about 40 feet, the pumps being set 20 feet below the surface.

The water is pumped directly from the wells to the mains by two horizontal compound duplex Holly pumps of 1,500,000 gallons capacity each. An open reservoir, 165 feet square and 18 feet deep, holding 3,000,000 gallons, is used to store water for an emergency. It is kept full all the time and is drawn on by the pumps only in case of fire, when the wells would be exhausted by so sudden an increase in consumption.

There are 19 miles of mains in use, which give about 75 per cent of the population access to the water. There are 1,035 services connected, of which 650 are in use, and 205 of these are metered. The average daily consumption is 300,000 gallons, or 47 gallons per capita of the total population, or 62 gallons per consumer.

Wauseon.—The public water-supply system of Wauseon (population, 2,148) was installed by the village in 1897, was first operated in April, 1898, and had cost to January, 1899, $25,000. The supply is from one of two 8-inch wells 185 feet deep, which are sunk through shale and fine gravel into coarse gravel, in which the water is found. The water comes to within 30 feet of the surface, and is pumped to a receiving well by a 400,000-gallon Downey deep-well pump, so set up as to be able to lower the water to 75 feet from the surface if necessary. During ordinary pumping the well not in use, which is 150 feet away, is lowered 6 feet. The receiving well, which is covered with a tin roof, is 19 feet deep, 30 feet in diameter, and has a capacity of 100,000 gallons. The water is pumped from this basin to a standpipe by a horizontal compound duplex Smith-Vaile pump of 750,000 gallons capacity. The standpipe is 12 feet in diameter, 120 feet high, and has a capacity of 100,000 gallons.

There are 7½ miles of mains laid, giving 90 per cent of the population access to the water. There are 301 services in use, of which 275 are metered. The average daily consumption is 45,000 gallons, or 20 gallons per capita of the total population, or 60 gallons per consumer.

West Alexandria.—The public water-supply system of West Alexandria (population, 740) was installed in 1897, and has cost to date $25,643.65. The supply is obtained from four artesian wells located in the southwestern part of the village. The wells are 6 inches in diameter; two of them are 132 feet deep, one is 95 feet deep, and one is 65 feet deep, and all go through alternate layers of clay, gravel, and hardpan. It is claimed that the wells will flow with a head of 16 feet above the surface.

Only the natural flow of the wells is utilized, the water being conducted to a receiving basin, from which it is pumped to the standpipe by two horizontal duplex Smith-Vaile pumps of 1,000,000 gallons capacity each. The basin consists of a covered brick well, 20 feet in diameter, 24 feet deep, having a capacity of 7,500 gallons. The standpipe consists of a steel tank 40 feet high and 10 feet in diameter, holding 60,000 gallons, placed on a brick tower 60 feet high. The average pressure on the mains is 40 pounds.

There are 3 miles of mains in, to which all of the people have access. There are 131 services in, all of which are in use, and all are metered. The average daily consumption is estimated to be 26,767 gallons, or 36 gallons per consumer, and 36 gallons per capita of the village's population.

SUBSURFACE AND DEEP-SEATED.

Hicksville.—The public water-supply system of Hicksville (population, 2,520) was put in by the village in 1890, and has cost to date about $25,000. The supply is obtained from seven wells, four of which are 32 feet deep and 6 inches in diameter, two are 132 feet deep and 6 inches in diameter, and one is 132 feet deep and 3 inches in diameter.

The wells go through a mixture of clay and sand, the deeper ones reaching a layer of sand and gravel found just above the Ohio black shale, 130 feet down. All the wells flow with a head of 4 feet when not pumped, but do not supply enough water in dry season without pumping. The water from six of the wells is pumped directly to the mains by two horizontal duplex Hughes pumps of 750,000 gallons capacity each. The flow of the seventh well goes to a small reservoir, 100 feet square, holding 387,000 gallons, which is kept on hand as a reserve in case of fire.

There are 4.5 miles of mains in use, which give about 75 per cent of the population access to the water. There are 290 services connected, of which 260 are in use, and none is metered. The average daily consumption is 90,000 gallons, or 36 gallons per capita of the total population and 47 gallons for each consumer.

Wapakoneta.—A public water-supply system was put in by Wapakoneta (population, 3,915) in November, 1895, and had cost to April 1, 1903, $63,109.76. The supply is from nine 6-inch drilled wells, eight 35 feet deep and one 142 feet deep, and from a large dug well 30 feet deep and 20 feet in diameter. Only one of the shallow wells is pumped. The water collected by the other shallow wells now flows through tile directly to the large well, which acts as a collecting well and also as a pumping well. The shallow wells obtain their water from a bed of gravel found at the level of Auglaize River. The deep well goes through clay and gravel into limestone, which is found at a depth of 135 feet. The water is pumped directly to the mains in summer and to a standpipe in winter by two horizontal compound duplex McGowan pumps of 1,000,000 gallons capacity each. The standpipe is 125 feet high and 25 feet in diameter, and has a capacity of 459,000 gallons.

There are 12.75 miles of mains in, giving about 90 per cent of the population access to the water. There are 475 services connected, of which 469 are in use, and only 15 are metered. The average daily consumption is 198,000 gallons, which is 51 gallons per capita of the total population, or 56 gallons per consumer.

SURFACE AND GROUND.

SURFACE AND SUBSURFACE.

Blanchester.—The public water-supply system of Blanchester (population 1,788) was put in by the village in 1896, and has cost to date $34,000. An electric-light plant costing $10,000 is in the same building. The supply was to be obtained from three wells 6 feet in diameter and 50 feet deep, but they soon failed, and the village was without water, as there were no funds available for a new supply. In 1899 a private company was formed among the citizens of the village for the purpose of securing a supply of water for fire protection at least. A franchise was obtained from the village, under which the company was to supply the water, the village to provide pumps and pay the cost of pumping, and the company to have the privilege of collecting the private water rents.

As ground water was not available and there were no streams nearby of sufficient size to afford a supply, a reservoir was excavated in the valley of a small run having a drainage area of 1,400 acres, and a surface supply was thus impounded. The reservoir has an area of about 3 acres and an average depth of 6 feet, giving a capacity, when full, of about 5,000,000 gallons. The sides and bottom of the reservoir are not paved or protected in any way, and the water is very muddy for a long period after each rain. In the spring of 1900 a heavy rain caused a flood, too large for the wasteway, and the reservoir banks were overflowed and a portion was broken out. The wasteway is 10 feet long and can carry a flow 5 feet deep before the reservoir banks will overflow. This would require a rainfall of $\frac{1}{4}$ inch per hour over the entire watershed of such duration as would allow the water from the most remote section to reach the river; it would also have to fall on a soil that would be impervious from continual rain or freezing. The reservoir, with connections, cost $6,000.

The water from the reservoir flows by gravity through an 8-inch pipe to the old wells, in which the suction of the pumps is placed. The water in the wells will rise to within 7 feet of the surface when pumping is suspended for some time, and the reservoir line will not flow until the wells have been lowered to 12 feet, so that a small amount of well water is supplied, but it is a very small proportion of the total consumption and can hardly be considered.

The water is pumped directly from the suction wells to an elevated tank by two horizontal compound duplex McGowan pumps of 750,000 gallons capacity each. The pressure is 50 pounds at the station and averages 45 pounds on the mains.

There are 11 miles of mains laid, to which 90 per cent of the people have access. There are 150 services connected, 140 of which are in use, and 12 are metered. The average daily consumption is about 15,000 gallons, which is 333⅓ gallons per service, 35 gallons per consumer, and 28 gallons per capita of the village.

The water is not used for domestic purposes at all, and is not fit for such use without filtration.

Lima.—The public water-supply system of Lima (population, 21,723) was put in by the city in 1885–1887, at a cost of $387,000. Many extensions and additions have been made since that time, and the cost to date is much more than the sum stated. The original supply was from an impounding reservoir on Lost Creek, a small stream that enters the Ottawa River just east of Lima. A timber dam, 10 feet high and 30 feet long, was built across the creek, forming a reservoir 6 acres in area and having a capacity of about 10,000,000 gallons. This reservoir is dirty, overgrown with weeds, very shallow in many places, and is dry all summer except for a few stagnant pools.

The winter and spring rains fill the reservoir and the water is run to a receiving well, from which it flows by gravity to two storage reservoirs, situated side by side, and having a combined area of 21 acres, a depth of 17 feet, and a capacity of 120,000,000 gallons. The sides and bottom of these basins are of natural clay, but no trouble has been experienced from vegetable growths, except during one year, though they have been cleaned but once. Formerly these reservoirs had to be filled during freshets or hard rains, and the water was then supplied to the city until another rain came. If the water was low, the first part of the rain had to be caught and used, and the first washings of the small drainage area were especially foul, as they brought in the waste from a number of oil wells within the area. There was soon considerable complaint about the water, and in 1894 eight wells were put down at the head of the impounding reservoir in an endeavor to find ground water enough to supply the city.

The wells are all 8 inches in diameter and are from 150 to 200 feet deep. They are pumped to the receiving well by a 1,000,000-gallon pump operated by an electric motor furnished with power from the central station. The water in the wells is lowered below the suction limit in a short time by pumping, as they are placed too close together.

In 1897 a 10-inch well was put down north of this group and an abandoned oil well also was appropriated. These are pumped to the receiving well by machinery similar to that used on the first group. It is estimated that all the wells supply 1,250,000 gallons a day, which allows better water to be obtained from the surface source.

The water is pumped from the storage reservoir directly to the mains by two horizontal compound duplex Holly pumps of 3,000,000 gallons capacity each. There are 45 miles of mains laid, giving about 80 per cent of the population access to the water. There are 3,705 connections in use, of which 300 are metered. The average daily consumption is 1,624,805 gallons, which is 61 gallons per capita of the total population, or 120 gallons for each consumer.

Since the above information was obtained Lima has had more trouble from shortage of water and further additions will probably be made to the ground supply.

Newark.—The public water-supply system of Newark (population, 18,157) was put in by a private company, the Newark Water Company, in 1886, and has cost to date about $250,000. The water was first obtained from two brick-lined wells, 21 feet deep and 20 feet in diameter, dug in a gravel bed about a mile north of the city, near the north branch of Licking Creek. Later these wells were supplemented by twenty-four 4-inch Cooke driven wells located at the same place. The supply still being short, a small brush-and-stone dam was put in the creek and the water was thus diverted to one of the large wells, which serves as a pump well. All the wells are in sand and gravel, the deeper ones just reaching a layer of hardpan below this bed. The normal level of the water is about 10 feet below the surface and it is lowered 4 or 5 feet by pumping.

The pumps are attached directly to the Cooke wells and to one of the large wells, the other flowing to this one through a siphon. The water is pumped to an open reservoir by two horizontal compound duplex Gordon-Maxwell pumps of 2,500,000 gallons capacity each. The reservoir is about 250 by 60 feet, and 12 feet deep, with an available capacity of 850,000 gallons. It is located on a hill across the creek from the pumping station, at such a height as to give a pressure of 114 pounds. It is excavated in the top of the hill, and the sides are formed of earthen embankments, puddled and roughly paved. No trouble has been experienced from vegetable growths.

There are 27 miles of mains laid, to which 80 per cent of the people have access. There are 1,900 services connected, of which 1,600 are in use, and 450 are metered. The average daily consumption is 1,545,000 gallons, which is 85 gallons per capita of the city and 105 gallons for each consumer. The water is not in general use in the city, but its quality is good, much better than that of private well water. The surface water is used only when the water of the creek is clear, and in this way is not very objectionable, though the run-off is derived from a thickly settled farming district and is rather impure. The large average daily consumption per consumer is due to the use of the water by one of the railroads.

Springfield.—Waterworks were put in by Springfield (population, 38,253) in 1881, and have cost to date $666,402. The first supply was from a filter gallery. This soon failed, and two years later a reservoir was built just above the junction of Beaver and Buck creeks, at the site of the present pumping station. This reservoir is 350 feet long, 200 feet wide, and 18 feet deep, giving a capacity of about 8,000,000 gallons. The bottom and sides are only graveled and are badly covered with weeds and moss. The reservoir is filled by the seeping in of ground water. In order to raise the level of the ground water and keep the reservoir full, a dam was built about 300 feet below the junction of the creeks. This dam is 50 feet long and 4 feet high, and backs the water up past the reservoir. This reservoir and the old gallery supplied the city until 1894–95, when the new station and gallery were put in and the old station was abandoned. The new gallery is 200 feet long, 32 inches wide, and 48 inches high, and lies 20 feet below the surface, in an extensive gravel bed, which is situated under and between the two creeks at their junction. The gallery leads to a covered pump well 30 feet in diameter and 21 feet deep. This gallery supplies an excellent water and, so far, plenty of it. The reservoir is connected to the pump well by a 36-inch main, to be used in cases of emergency only.

The old station contains a 2,500,000-gallon Cope and Maxwell pump that can be used to pump the water from the old gallery to the new pump well in case of failure of the new supply due to continued drought. The new station contains a horizontal compound duplex Holly pump of 5,000,000 gallons capacity and a vertical triple-expansion Allis pump of 7,000,000 gallons capacity. The Holly pump was brought from the old station, but has been remodeled, and is in good condition now. The Allis pump is a new one, put in in 1895. The water is pumped to a standpipe 30 feet in diameter and 112 feet high, having a capacity of 592,000 gallons.

On account of the extremely dry weather of 1899 it was necessary to use water from the wells and galleries of the old station, the former source of the total supply. The water from this source was pumped by the engine left at the old station to the reservoir near the new station and allowed to flow from there to the pump well. Even this increase in the supply was not sufficient for all purposes, and Springfield was left without adequate protection from fire.

To overcome this danger the trustees, in the early part of the summer of 1900, tapped the old 20-inch main leading from the old station to the reservoir at Buck Creek and put in a 12-inch pipe, so that the creek water can flow directly to the reservoir. The intention was to keep the reservoir full in this way and to allow the water to seep through into the gallery and pump well and only use the water directly in case of fire. This reservoir is 250 by 500 by 15 feet deep, and as it is excavated in a rather porous gravel bed, normally its water level is equal to and varies with the height of the ground water.

It was thus the intention to reenforce the ground water with seepage from this reservoir supplied from the creek, and such use would not be objectionable; but as the reservoir puddled very soon with turbid creek water, this seepage was slow, and it was necessary on a few occasions to run the creek water directly to the pump well by way of the reservoir and a 36-inch pipe from the reservoir to the pump well.

There are local as well as sanitary difficulties regarding the use of Buck Creek water, in the nature of suits for diverting the water from the mills below, etc.

There are now 66 miles of mains in use, giving some 90 per cent of the people access to the water. There are 5,000 services in, of which 5,000 are in use, and 280 of these are metered. The average daily consumption is 3,250,000 gallons, which is 194 per consumer, and 85 per capita of the total population.

Wooster.—A public water-supply system was installed in 1875 by Wooster (population, 6,063), and has cost to date about $280,000. The first water was supplied by gravity from the Redick reservoir, which is formed by a dam across Christmas Run, just north of Wooster. The run above the dam has a drainage area of 8 square miles, on which are located a number of farm houses and the County Children's Home, an institution with 64 inmates and officers, part of whom use closets sewered direct to the run, at a point only three-fourths of a mile above the reservoir. This reservoir will hold 8,000,000 gallons, with an average depth of 18 feet. Its sides are roughly paved, but no provision is made to prevent soil and clay from washing in from its slopes. On account of the small drainage area, it is necessary to fill the reservoir during freshets, when the water is at its worst stage. A few springs send a small quantity of excellent water to this reservoir.

Need was soon felt for a better and more abundant supply and also greater pressure, for the reservoir is only 114 feet above the streets. In 1881 a well 47 feet deep and 33 feet in diameter was dug northeast of the village and a quantity of good water was obtained; not enough, however, to allow the Redick reservoir to be abandoned; so about one-half of the people must still use the old supply.

The water from the well is pumped by a 750,000-gallon horizontal duplex Worthington pump directly to a new reservoir located on high land to the north. When not being pumped the well contains 13 feet of water, which is pumped out in about five hours, and then the well is allowed to fill again.

The reservoir is circular, 1 acre in area, and holds 4,000,000 gallons when filled to a depth of 13 feet. Its sides are carefully paved and no surface drainage can enter it. It is 160 feet above the pumping station and 248 feet above the main streets, and so furnishes ample pressure. This part of the supply would be without objection if the ground water were not exposed in an open reservoir where growths are developed which give it a very bad odor and taste.

Combined, these supplies have failed during dry seasons, and it has been necessary to use water from Apple Creek. A horizontal duplex Worthington pump, with a capacity of 500,000 gallons an hour, is used to pump the creek water directly to the mains in the dry summer months.

There are 11.75 miles of mains laid, to which 80 per cent of the people have access. There are 487 services connected, of which 390 are in use, and 47 are metered. The average daily consumption is about 700,000 gallons, half of which is supplied from each reservoir. The average daily consumption per capita of the total population is 115 gallons, and the per capita of the population actually supplied is 142 gallons. Very little water is used for domestic purposes, most of the above quantity being used for sprinkling, water-closets, and industrial purposes.

Xenia.—The public water-supply system of Xenia (population, 8,696) was put in by a private company in 1887 and has cost to date, as claimed, $203,000. The company now operates under the name of The Xenia Water Company.

The first supply was obtained by impounding the run-off of a number of springs located 1½ miles north of the city. The flow from these is collected in an open reservoir, formed by an earthen embankment, with sheet-piling core wall, thrown across a small valley and forming a basin 1½ acres in area. Through the center of the reservoir there is a dividing wall for convenience in cleaning. This, as well as the inner side of the dam, is roughly paved. Much of the surface drainage to the reservoir is diverted, but some of it is used. Later, near this reservoir, a large well, 75 feet square, was dug 25 feet deep through a bed of clay and hardpan into gravel. The water from this is pumped by a 1,000,000-gallon horizontal duplex Worthington pump to a large stone pump well, 40 feet in diameter, built in the dividing wall of the reservoir. The combined water of the well and reservoir is then pumped through the mains to a standpipe by two horizontal compound duplex Gordon-Maxwell pumps of 1,500,000 gallons capacity each. It is estimated that the springs will supply 300,000 gallons daily and the well 100,000.

In 1896 these sources were supplemented by an additional ground supply secured from six 6-inch wells and three 8-inch, located southwest of the city, just out of the corporation limits. These wells are from 28 to 40 feet deep, and go through a bed of clay and into gravel. The normal level of the water is 6 to 8 feet from the surface, and it can easily be lowered to the suction limit, indicating a rather weak vein at the above depths. A test well is now being put down into the rock, which is found at 60 feet, in the hope of securing a more abundant supply.

The water from this last set of wells is pumped by a 1,000,000-gallon horizontal compound duplex Deane pump directly to the mains and standpipe. This station supplies about 175,000 gallons a day for a few days each week in summer and fall, and is not used in winter.

The standpipe is 115 feet high by 20 feet in diameter, with a capacity of 270,000 gallons, and furnishes, when full, an average pressure on the mains of 55 pounds.

There are 20 miles of mains laid, to which almost all of the people have access. There are 1,200 services in, of which 1,100 are in use, and 50 of these are metered. The average daily consumption is 500,000 gallons, which is 57.7 gallons per consumer, or 57.5 gallons per capita of the total population.

SURFACE AND DEEP-SEATED.

Canton.—The public water supply of Canton (population, 30,667) was put in by the city in 1869, and has cost to date about $800,000. The first supply was taken from the west branch of the Nimishillen Creek, which was the sole source until 1888, when the supply was increased and improved by the addition of water from a number of wells.

The water from the creek is diverted to a race by a small dam 35 feet long and 1 foot high, located 1.3 miles above the pumping station. The western branch has above the dam a drainage basin 48 square miles in area, on which there are several small villages and one public institution. This last, the Stark County Infirmary, is located just above Canton, and sends its sewage to a gravel swale, from which some of it may be washed into the creek by heavy rains. A public ford just above the dam is also the source of some objectionable pollution. This surface water is one of the few in Ohio that is highly colored at times from organic matter.

In 1888 26 wells were put down in the park adjoining the pumping station, and these have been added to until there are now 36 in all. These wells vary from 4 to 8 inches in diameter and from 225 to 365 feet in depth. The water is possibly obtained from a bed of sandstone, into which most of the wells go after passing through an irregular stratum of limestone. The normal level of the water is near the surface, but is easily lowered from 25 to 30 feet by direct pumping.

The wells are pumped by a 2,000,000-gallon Gordon pump to an open well, into which the water from the race flows by gravity. The mixed waters are then pumped directly to the mains by two horizontal compound duplex Worthington pumps of 2,000,000 gallons capacity each, and one horizontal compound duplex Holly pump of 8,000,000 gallons capacity.

The average domestic pressure maintained is 80 pounds. There are 65 miles of mains in use, giving 60 per cent of the people access to the water. There are 5,200 services connected, of which 4,700 are in use, and 198 of these are metered. The average daily consumption is 4,000,000 gallons, of which about 1,200,000 gallons is supplied by the wells and the remainder directly from the creek. A number of new wells are now being put in and the amount of surface water used will probably soon be decreased. The average daily consumption per capita of the population is 130 gallons and the per capita of those actually supplied 217 gallons.

Massillon.—This city (population, 11,944) has been supplied with water from various sources since 1854, and always by private companies. In 1881 the run-off of Sippo Lake and Sippo Creek was impounded and the city was supplied entirely with this water. The quality was not satisfactory, and in 1893 a new supply for domestic use was procured from six drilled wells. The old surface supply is used for industrial purposes and street sprinkling. It is furnished by gravity from a reservoir having a capacity of about 30,000,000 gallons.

The wells from which the domestic supply is procured are located in the river valley, in the upper part of the city. They are 6 inches in diameter and average 200 feet in depth, going through clay and gravel into sandstone. Four of the wells flow when not pumped, and in the other two the water rises very near the surface; average pumping lowers the level about 15 feet. The water is pumped directly from the wells to a standpipe by three pumps—a horizontal compound duplex Blake of 2,000,000 gallons capacity, installed in 1887 at the old station and removed in 1893 to the present one; a horizontal compound duplex Deane pump of 1,500,000 gallons capacity, and a horizontal compound duplex Worthington pump of 500,000 gallons capacity, the last two installed in 1893.

A small covered reservoir 18 feet deep, 30 feet in diameter, and holding 100,000 gallons is used as a reserve supply for the wells. The standpipe was erected in 1883 for use on the surface supply. It is 150 feet high, 25 feet in diameter, and has a capacity of 550,000 gallons. A horizontal compound duplex Blake pump of 2,000,000 gallons capacity stands in the old pumping station at the reservoir and can be used to pump this water to the standpipe in cases of emergency.

The average pressure for the gravity supply is 26 pounds; that for the domestic supply is 90 pounds. There are 2 miles of mains laid for the surface water and 24 miles laid for the well water. About 90 per cent of the total population are within reach of the domestic service. There are 1,300 services in, all of which are in use, and 75 are metered. The average daily consumption for the domestic supply is only 650,000 gallons, or 54 gallons per capita of the total population and 60 gallons per capita of the population actually supplied. These figures are of special interest, as they represent the amount of water actually used for the domestic supply of a city. The amount of water used on the gravity supply could not be obtained.

Tiffin.—The waterworks at Tiffin (population, 10,989) were put in by a private company in 1879. The cost of the plant could not be learned. The supply was originally taken entirely from Sandusky River, but this source was supplemented later with water from a number of wells. The river water is badly polluted with the sewage of Crestline, Bucyrus, and Upper Sandusky, the latter village being 34 miles above.

The waterworks are at the upper end of the village, and 400 yards above this is a dam that diverts the water to a small reservoir, from which it is pumped, and to a race which furnishes power for a portion of the time. The dam is constructed of timber, is 175 feet long and 5½ feet high, and backs the water 4 miles up the river.

There are seven drilled wells, each 10 inches in diameter and from 200 to 268 feet deep, all in the Onondaga limestone, which outcrops in this locality. The wells extend in a line up and down the river valley and are from 200 to 300 feet apart. The pump suction is connected directly to the well casing, and the water is lowered about 24 feet by ordinary pumping. It is claimed that these wells supply all the water except in cases of emergency, and that a better method of pumping will be put in, so that no river water will be needed. These claims are hardly realized, however, as the river water is used daily.

Direct pressure is furnished by three Holly pumps. One, put in in 1879, is run by water power and has a capacity of 1,500,000 gallons; the other two are steam pumps, put in in 1882 and 1895, and have capacities of 3,000,000 and 4,000,000 gallons.

There are 26 miles of mains, which give about 90 per cent of the people access to the water. There are 1,300 services connected, of which only 900 are in use, and 175 are metered. The average daily consumption is estimated at 1,000,000 gallons, being 91 gallons per capita of the total population, or 101 gallons for each consumer. The supply is not satisfactory owing to the constant use of the river water.

SURFACE, SUBSURFACE, AND DEEP-SEATED.

Fremont.—A public water-supply system was put in by Fremont (population 8,409) in 1883, and had cost to July, 1898, $203,766.96. The supply is obtained from Sandusky River at a point above the city, from wells, and from galleries. Above the place where the water is taken from the river it receives the sewage of Crestline, Bucyrus, Upper Sandusky, and Tiffin, the latter only 21 miles above.

The river water is admitted through three 10-inch pipes to a reservoir excavated in the solid rock below the river level. This basin is also supplied to some extent by three lines of vitrified tile, 6 to 9 inches in diameter, having a total length of 1½ miles, which are laid in gravel beds along the river bottom. The reservoir is 200 feet long by 150 feet wide, and the water stands from 6 to 8 feet deep in it, or at the river level, giving a capacity of from 1,400,000 to 1,800,000 gallons. Large quantities of sand and mud collect in the reservoir, which have to be removed by buckets, as the bottom is too low for flushing.

Five 10-inch wells, 300 feet deep, were drilled in 1897. These are pumped by airlifts and supply about 230,000 gallons daily. The machinery for pumping these wells is inadequate and it is intended to install better, so as to increase the supply, though at present the water is lowered from 40 to 125 feet in the wells.

The water is pumped to a standpipe by two Knowles pumps, one a 3,000,000-gallon compound duplex, and the other a 1,000,000-gallon duplex. The standpipe is located in the center of the village and is 100 feet high, 25 feet in diameter, and has a capacity of 365,000 gallons. There are 23 miles of mains in use, which give 75 per cent of the total population access to the water. There are 1,115 services connected, of which 905 are in use, and 428 of these are metered. The average daily consumption is 942,516 gallons, or 112 gallons per capita of the total population of the village and 149 gallons of the population actually supplied. This large consumption can be explained only by the extravagant use of water in public fountains, watering troughs, and for flushing sewers, and by the habit of allowing the water to run constantly when it is muddy.

Crestline.—The public water-supply system of Crestline (population, 3,282) was put in by the village in 1871, and had cost to July, 1898, $225,000. The supply was first obtained from springs 4½ miles east of the village, but these failed to furnish enough water, and in 1895 three wells were drilled to help out. Two reservoirs have been built near the springs to impound the flow from them and from a small area around them. This tributary area is about 3½ square miles in extent, but some of the drainage is diverted from the reservoirs by ditches. One reservoir was built in 1871 and a second in 1888, both having been formed by throwing up earthen embankments across and around the valley of a small run. Only the first reservoir, with a capacity of 1,295,000 gallons, is in use, the second still being very foul from vegetable growths of various kinds, due, no doubt, to an improper stripping of the flooded area. The first reservoir is full of growths also, but here they are due to the exposure of ground water in an unlined open basin. These growths nearly fill the reservoir to the top of the water, and below the living part is a foot or more of thick black mud, formed by the decomposition of moss. The authorities are trying to have this reservoir cleaned, paved, and covered over, so as to do away with the only objectionable feature of the supply.

The wells are 6 inches in diameter and 140, 170, and 180 feet deep. The water flows from them at a rate of 150,000 gallons a day, and it is necessary to pump forty-eight hours a week to keep up the supply. This pumping is done by a 750,000-gallon duplex Worthington pump, installed in 1896. The wells flow and are pumped to the first reservoir, which is 127 feet above the streets of Crestline, and supplies the mains by gravity through an 8-inch wooden-pipe line 4½ miles long. This pipe furnishes an inadequate supply, especially in case of fire, and it is intended to put in a 16-inch cast-iron line. The water seems to reach the consumers clear and tasteless, but it must sooner or later be affected by the bad condition of the reservoir.

There are 10 miles of mains laid, giving about 90 per cent of the people access to the water. There are 445 services connected, of which 400 are in use, and 68 of these are metered. The average daily consumption is 200,000 gallons, or 61 per inhabitant, and 70 per consumer.

DISCUSSION OF WATER SUPPLIES.

From the mass of details contained in the above descriptions of the public water supplies there can be gathered a few interesting facts.

OWNERSHIP.

Of the 104 waterworks 82 are owned and controlled by the city or village, 21 by private corporations, and 1 is under joint private and municipal ownership and direction. Five of the public water supplies are of such poor quality that unless steps are taken for their betterment by the corporations in control the citizens of the towns interested will probably endeavor to purchase the plants and franchises of the companies and procure a good supply under their own management. Even a carelessly conducted municipal plant will usually give better service than most of those under private direction. Under municipal ownership it is much easier to make the changes necessary to the improvement of the quality of the water, though some private companies are far-sighted enough to see that it pays to furnish a potable water. Also, as a rule, the water rates are higher under private than under municipal ownership.

Following are brief outlines of the franchises and contracts under which the private companies operate:

Ada.—The waterworks were put in by the Ada Water, Heat and Light Company, operating under a franchise granted in 1902 and running for twenty-five years. The city may purchase the plant at the end of fifteen years if it so desires. The contract does not specify the kind of water to be furnished.

Blanchester.—The first waterworks were put in by the village, but the supply of water from wells failed almost immediately and the village was without water for nearly two years, as there were no more funds available to seek a new supply.

In order to get fire protection a private company was formed and a franchise secured from the village, according to which the company agreed to furnish a supply of water for the pumps, in return for which they were to collect all the private water rents. This company, the Blanchester Water and Light Company, put in the impounding reservoir at a cost of $6,000. The franchise is to run for fifteen years from 1899, and the village can purchase at the expiration of the franchise only. The water rates are fixed by the franchise, which also specifies that the water shall be taken from the reservoir.

Bucyrus.—The waterworks were put in by the Bucyrus Water Company, operating under a franchise granted in 1883, but it now operates under a new one, granted March 11, 1895, to run fourteen years. Nothing is stated concerning the method by which the city may secure control of the plant before the expiration of the franchise. The contract specifies that the "running" water of the Sandusky River shall be impounded in a reservoir of 60,000,000 gallons capacity, and "filtered" before it is admitted to the mains. Until this year the water was passed through two pressure filters without previous impounding, but now the supply will be the impounded waters of a small stream tributary to Sandusky River. The water will not be filtered unless filtration is required by the State board of health.

Canal Fulton.—Waterworks were installed in 1902 under a franchise granted March 3 of that year, to run for twenty years. Nothing is stated concerning the method by which the city may secure control of the plant before the expiration of the franchise, and the water company is the sole arbiter as to the kind of water to be furnished and the price to be charged for it.

Defiance.—Waterworks were put in by the Defiance Water Company, operating under a franchise granted in 1887, to run for thirty years. The city may purchase the plant at the end of ten years, or at the end of each five-year period thereafter. The rates are subject to regulation by the city. The franchise provides that "the water shall be taken from such point as is free from all sewage contamination, and shall at all times be a good, wholesome water, fit for all purposes of domestic and manufacturing use." The sewage of a city of 50,000 inhabitants enters Maumee River 54 miles above the point where the water is taken.

Dennison.—Waterworks were put in by the Dennison Water Supply Company, operating under a franchise granted September 5, 1887, to run for twenty years. The village may purchase the plant complete at any time after fifteen years. Rates are fixed by franchise. The franchise provides that the water shall be taken from filter galleries and wells adjacent to Big Stillwater Creek, and that there shall be a direct connection with the creek, to be used in case of emergency. The water was used directly from the creek until January, 1900, at which time mechanical filters were put into operation.

Uhrichsville.—The same company that furnishes Dennison with water supplies Uhrichsville. Here it works under a twenty-year franchise, granted March 6, 1887. The village may purchase at the end of fifteen years such part of the plant as is within the corporate limits of Uhrichsville. The rates are fixed by the franchise, which also provides that the company furnish a good, wholesome water, suitable for domestic use, to be taken from Big Stillwater Creek, or the Tuscarawas River, through wells or galleries, with an auxiliary pipe to the creek or river, for use in cases of emergency. The same water has been furnished that is supplied to Dennison, as noted above.

Massillon.—The first waterworks were put in by a private company in 1854, but the present works are operated by the Massillon Water Supply Company, working under a franchise granted June 7, 1886, and running for twenty years. The city might have purchased the works at the end of ten or fifteen years. The rates are subject to regulation by the city. The franchise states that the water is to be taken from Sippo Lake, led to an impounding reservoir, filtered, and pumped to a standpipe. A well water is now furnished for domestic use.

Harrison.—A franchise was granted in 1891, to run twenty years, to the Harrison Water and Light Company. It contains no provision for purchase by the city, and the kind of water to be supplied is not stated.

Newark.—The waterworks were put in by the Newark Water Company, working under a franchise granted May 4, 1885, and extending for twenty years. The city may purchase at any time after ten years. Rates are fixed by the franchise. "The water shall be obtained from Berkham Spring, or such other source as may be approved by city council. It shall be clear water, suitable for culinary and drinking purposes, and not detrimental to the health of those who use it." Well water, supplemented by surface water, is now used.

New Comerstown.—The waterworks were put in in 1902 under a franchise granted to the New Comerstown Water Company on July 22, 1901, the franchise to run for twenty years.

The company is to provide "a sufficient supply of good, wholesome water, suitable for domestic, manufacturing, and fire purposes, the same to be obtained from open or driven wells, as long as a sufficient quantity can be obtained."

The water rates are fixed in the franchise, and the city can purchase the plant at the end of ten years, and every five years thereafter, from the date of the passage of the ordinance.

New Philadelphia.—Waterworks were put in by the New Philadelphia Water Company, working under a franchise granted June 3, 1886, to extend for fifteen years. The village may purchase the plant at the end of ten years. The rates are required to be as low as the average for Ohio companies. The franchise requires that the water shall be taken from filtering galleries or wells adjacent to Tuscarawas River.

Piedmont.—As this village is not incorporated, the Piedmont Water Company secured in 1894 a 99-year lease on the springs and the right of way. The lease contains no requirements concerning purchasing rates or kind of water to be supplied.

Oakwood.—The waterworks were put in in 1902 under a franchise granted March 27, 1902, to the Oakwood Water and Light Company, the franchise to run for twenty-five years.

The company is to furnish a "sufficient supply of good water for domestic purposes." This water is obtained from wells.

There is no purchasing clause included in the franchise, and the rates are fixed by the company.

Scio.—The plant was put in by the Scio Water Supply Company, operating under a franchise granted February 18, 1899, to extend for ninety-nine years. The village may purchase the plant at the end of each five-year period after the completion of the works. The rates are required to be the same as those at Bridgeport, Ohio. The franchise specifies that the water shall be the best obtainable from driven wells.

Shelby.—Waterworks were put in by the Shelby Water Company, operating under a franchise granted February 5, 1896, and extending for twenty years. The village may purchase at the end of ten or fifteen years. The rates are fixed by the franchise, which also requires that the water shall be a good, potable water, free from all obnoxious and injurious elements, and that it be procured from such suitable place as will guarantee its purity, and that the source shall be protected from future encroachments and pollution. Surface water shall not be used.

Tiffin.—Waterworks were put in by the Tiffin Waterworks, operating under a franchise granted December 1, 1879, to run for twenty-five years. The franchise does not regulate the rates or provide for purchase by the city. It states that the water can be taken from such points as best subserve the object and purposes of the company.

Trotwood.—Waterworks were put in by a stock company formed of citizens of the village. This company has no franchise, as the village is not incorporated and none could be granted. The plant was put in by sufferance alone. The mains are in the county and township roads, the verbal permit of the commissioners and trustees having been obtained.

Upper Sandusky.—Waterworks were put in by the Upper Sandusky Waterworks Company, operating under a twenty-year franchise granted April 23, 1889. The village may purchase the plant at the end of ten or fifteen years. Rates are not regulated in any way. The franchise states that the water shall be taken from wells sunk in the gravel banks of Sandusky River or it shall be "river water dispossessed of earthy matter by settling pools." The well water shall be carefully protected from pollution and shall be increased from time to time as the consumption warrants. A separate suction pipe may be run to the river, to be used in cases of great emergency only. The river water is used practically direct nearly all the time.

Urbana.—The franchise of the Urbana Waterworks Company expired in 1899, and no new one has been secured since that time. There has been considerable friction between the city and the company, and the terms of the settlement are uncertain. The company still supplies water for the citizens and collects the water rent, and this condition may hold for some time.

Wadsworth.—Waterworks were put in by the Wadsworth Waterworks Company, operating under an unlimited franchise granted September 20, 1881. Under the first grant the village could purchase at the end of ten years, but this grant was amended July 6, 1892, and the right of purchase given up. It is practically a perpetual franchise. Rates are fixed by the franchise.

Waynesburg.—In 1857 the Waynesburg Water Company was granted the use of the village streets for a free water trough and one fire plug. The grant states nothing regarding the purchasing of works, regulation of rates, or kind of water to be supplied.

Xenia.—This city is supplied with water by the Xenia Water Company, operating under a twenty years' franchise granted July 19, 1886. The city may purchase the plant at any time after the expiration of the first ten years. Rates are fixed by the franchise. The water is to be taken from wells or filtering galleries near Little Miami River or Cæsars Creek, with direct connection to either stream for fire protection only. As a matter of fact neither stream is used, but the water is procured from another source.

Lack of potable water.—It is unfortunate that in many cases a nonpotable water is supplied, even when the franchise specifically requires a water that is of good quality, or that is derived from a source that would furnish a potable water. In so many communities the desirability of a good water has not been so realized by those in authority as to impel them to take the steps necessary to enforce the provisions of the waterworks franchises. When the present franchises expire, if it is not possible to purchase the works outright, it would be well for the interested towns to see that the new franchises contain a very definite clause in reference to the kind of water to be supplied.

DATE OF INSTALLATION OF WATERWORKS.

The following table shows the decades in which water supplies were introduced in the various towns:

Basin.	1840-1850.	1850-1860.	1860-1870.	1870-1880.	1880-1890.	1890-1900.	1900-1903.
Sandusky				2	3	3	
Maumee				1	3	11	5
Miamis			1	4	6	16	7
Muskingum	1	2	1	2	7	18	6
Total	1	2	2	9	19	48	18

This shows that $66\frac{2}{3}$ per cent of the plants have been put in since 1890 and that about 86 per cent have been put in since 1880, confirming the general fact that public sentiment requiring better water than that furnished by a private well is of very recent growth. In many cases, however, a demand for fire protection has been almost the sole reason for the introduction of a public supply. The number of old plants in the Muskingum drainage basin accords very well with the fact that it is a portion of the State that was developed at a very early period.

METHOD OF SUPPLYING WATER.

A study of the methods used in the various drainage basins to supply the water shows the general nature of the country as to levelness almost as well as a topographic map. In the Sandusky basin there is 1 gravity supply, 2 direct pumping, and 5 pumping to standpipes or elevated tanks. The Maumee basin, with its broad, level plains, has not developed a single supply that does not involve pumping; 8 direct and 12 by pumping to standpipes or elevated tanks. The Miami basins also have no gravity supplies, but in 13 cases the pressure is obtained by direct pumping, in 16 cases by pumping to standpipes and tanks, and in 3 cases only by pumping to reservoirs. On the other hand, the rather hilly Muskingum district has 4 gravity supplies, 4 in which the water is furnished by gravity and pumping to reservoirs, 1 by gravity and pumping to a standpipe, 11 by pumping to reservoirs, 1 by pumping to reservoirs and a standpipe, 13 by pumping to standpipes, and only 4 supplied by direct pumping.

The safety and convenience of a gravity supply from a reservoir, or a supply from a reservoir filled by pumping, are generally recognized, and wherever the topography will permit these methods are used.

The 5 gravity supplies of the basins are small and unimportant—in fact, all the surface supplies that depend upon impounding reservoirs are not large. In general, Ohio cities are content to seek a ground water, if they are not near a large river whose water may be used directly, rather than to go to the expense of impounding the run-off of the smaller streams and protecting the basin from pollution. The excessive turbidity of these small streams is also an important factor which works against the use of this water, and it is turbidity that makes all the surface supplies objectionable for a good part of the year.

The present industrial supply for Massillon is obtained, as was the old supply, from an impounding reservoir which has an estimated capacity of 30,000,000 gallons.

Bellefontaine has an impounding reservoir of about 2,000,000 gallons capacity, Blanchester one of 5,000,000 gallons, Hamilton one of 7,000,000 gallons; Wooster has one of about 8,000,000 gallons, and Crestline two of about 1,000,000 gallons capacity each. These, together with 21 storage and distributing basins, constitute the reservoirs of the four drainage areas. Uhrichsville and Dennison, Lebanon, New Philadelphia, Springfield, and Zanesville have good storage reservoirs of large capacity for this class of work.

MILES OF MAINS AND POPULATION ACCESSIBLE.

In the 104 towns there are 1,601.6 miles of mains, or an average of 15.4 miles for each place. On an average, 85 per cent of the total population of each town has access to the water; the various percentages range from 50 to 95. Considering the towns as a whole, 601,480 people have access to the public water supplies; this is 78 per cent of the total population (771,128) of the towns supplied. The remaining 169,648 people, or 22 per cent, must still depend upon private wells until such time as the officials in charge shall see fit to extend the mains.

POPULATION ACTUALLY SUPPLIED.

The number of people actually using the water has been estimated from the number of services in use at 393,275 for the four drainage areas, divided as follows: Sandusky, 18,280; Maumee, 102,695; Miamis, 138,740; Muskingum, 132,560. Of the total population the above number who use the water constitute only 51 per cent, and but 66 per cent of the population accessible to the water. Thus, while 22 per cent of the population of towns with public water supplies do not use the water from lack of access, 34 per cent of those who can use it do not do so, some of these from lack of means, but many from false ideas as to the purity and potability of the water obtained from private wells. Unfortunately, it is necessary to add that in too many cases the public supply is of no better quality than the water from the private wells.

USE OF METERS.

Of the 80,467 services in use, only 12,875, or 16 per cent, are metered. Leaving out Toledo, with its 13,961 services and 7,200 meters, only 8.5 per cent of the services in use are metered. Of the 104 public supplies, 25 have not a single meter in use and 27 others have 10 or fewer. Shreve has all of its 85 services metered, West Alexandria all of its 131, and Cambridge 130 of its 140 services. Attica, Bucyrus, Dayton, Eaton, Greenville, Hamilton, Norwood, Toledo, and Wooster have more than one-fourth of their services metered. These towns, with Shreve, West Alexandria, and Cambridge, comprise all the towns where meters are used to any extent for domestic services. In the remaining places meters are used, as a rule, only for manufacturing establishments, livery stables, etc.

PUMPING CAPACITY.

It might be well to call attention to the large reserve pumping capacity at hand, as so many of the towns are supplied directly or by small reservoirs and standpipes. This excess is found to vary from 2 to 23 times the average daily consumption. The high figures occur in new plants, where the consumption is not yet great and a large allowance has been made for future growth. There is only one supply in the four basins where water power is used in public waterworks. Tiffin utilizes the water of the Sandusky River to run a 1,500,000-gallon Holly pump, which usually supplies the pressure during the night only.

AVERAGE DAILY CONSUMPTION.

In 84 of the 104 supplies it was possible to estimate the average daily consumption. In a number of cases accurate daily records of the pumps are kept and the results have some weight, but in others merely the crudest estimate can be made.

Considering the 84 towns in which the consumption could be estimated, the average daily consumption per capita of the total population is 70 gallons, and per consumer, or per capita of the population actually supplied, it is 125 gallons. In individual towns these figures run from 150 gallons as the average daily consumption per consumer and 17 gallons per capita of the total population to 106 and 100 gallons, respectively. The minimum average daily consumption is found in the small places, especially in those where there are no sewers. There are not enough metered supplies to show the effect of meters on the consumption. The maximum normal consumption is found in those towns where the supply is of poor quality, especially if it is turbid; for example: Cambridge, 442 gallons; Dennison and Uhrichsville, 442; Waynesville, 218; Wooster, 210; Zanesville, 259; Defiance, 300; Bucyrus, 280, and Fremont, 350. Shelby had an average daily consumption per consumer of 330 gallons, but this was due to the construction and flushing of a complete new sewer system.

The variation of the consumption throughout the year was carefully determined from the monthly pumping records of ten supplies in the Muskingum basin—Ashland, Canal Dover, Canton, Carrollton, Dennison and Uhrichsville, Massillon, Mount Vernon, Newark, Orrville, and Zanesville—in all, about 450 monthly records. With the average monthly consumption equaling 100, the following gives the variation:

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
104.8	99.0	95.2	88.7	91.3	102.9	102.6	113.4	104.1	103.9	95.9	98.0

The increase in the consumption in the cold months is due to the fact that hydrants are permitted to run to prevent freezing, and the increase in the summer is due to the sprinkling and general free use of water. The increase in consumption from year to year is well shown in the following 18-year record for Mount Vernon:

Yearly variation in consumption at Mount Vernon.

Year.	Average daily consumption.	Estimated population.	Estimated population using water.	Average daily consumption per capita.	Average daily consumption per consumer.
1884	213,774	5,540	3,270	39	65
1885	280,346	5,620	3,300	50	85
1886	281,271	5,680	3,360	50	84
1887	346,622	5,780	3,420	60	101
1888	361,247	5,860	3,480	62	104
1889	339,676	5,940	3,780	57	90
1890	354,672	6,027	3,960	59	90
1891	399,386	6,088	4,200	66	95
1892	500,091	6,149	4,550	81	110
1893	598,066	6,209	4,800	96	125
1894	636,662	6,270	5,100	101	125
1895	732,932	6,331	5,400	116	136
1896	688,311	6,392	5,580	108	123
1897	794,898	6,452	5,820	123	137
1898	814,567	6,513	6,000	125	136
1899	858,510	6,574	6,150	130	140
1900	926,157	6,663	6,335	139	146
1901	1,000,000	6,694	6,500	149	154

Where this increase will stop is a problem hard to solve. That a great deal of the increase is due to waste is undoubted, but it is difficult to determine just how much is due to legitimate increase of use. In a few places, by the general introduction of meters, and by carefully watching for leaks, the consumption per capita has been greatly decreased and then held to a low rate of increase. As the population increases it becomes difficult to supply an abundance of potable water, and no doubt it will soon be necessary in many places to take stringent steps to check waste.

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