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TO METER OR NOT TO METER.

By J. de Bruyn Kops, C. E., Savannah, Ga.

The question of metering or not metering the service pipes of water works plants is one that agitates the minds of water boards and city officials from time to time and, like Banquo's ghost, it will not down. The main point in discussion seems to be economy. The argument on the meter side is that the introduction of meters lessens the consumption by lessening the waste and consequently water plants, having less pumping to do, require less coal and other operating expenses. Also, they can be built on a smaller scale, requiring less outlay at the start. The anti-meter argument is, that by introducing meters you lessen the consumption of water as well as its waste and that to do so is not advisable on sanitary grounds, nor is it economical because in the long run the water board is less strenuous in its tax than the physician and the undertaker. The record of the past should give us facts by which to judge what the future may bring forth.

The number of "Engineering Record" for May 14, 1904, published an article on "Water Consumption at Pittsburg and the Probable Effect of Metering," in which appear some diagrams from data collected by Mr. Morris Knowles, Chief Engineer of the Bureau of Filtration, and it is this article, and particularly one of the diagrams accompanying it, that has given rise to the present article, because the conclusions reached did not seem to be fully warranted from the data, and besides a very obvious matter to the writer was not even mentioned. All data in the present article are taken from the above quoted diagram, which is reproduced here for convenient reference.

Arranging the cities in order of the largest initial consumption of water, we have tables A and B, the first seven columns of which contain the data taken from the diagram. The cities of Allegheny, Bridgeport, Philadelphia and Wheeling, which appear on the diagram, have been omitted from the table, because they showed no increase in the meters used and so were not germane to the present discussion.

An inspection of the diagram shows by the trend and location of the lines, also by the open space comparatively free from lines between 90 and 100 gallons daily consumption, that some sort of division occurs near this point. Table A has been prepared to show those cities having an initial consumption of water more than 100 gallons, table B showing those with an initial consumption of less than 100 gallons. There are thirteen cities in the first class, and fourteen in the second. The diagram also shows that sometimes the consumption of water increased when the percentage of meters increased, while sometimes it decreased, and so I have placed these two classes in separate columns. Columns 8 and 10 were obtained by subtracting the figures in column 4 from those in column 5; column 9 by subtracting column 7 from column 6 and column 11 by subtracting column 6 from column 7. Now in table A from column 8 and 10, we find that there were eight cities where a decrease in consumption followed an increase in meters and six cities where the reverse was the case, the city of Columbus being in both columns, having zero increase and zero decrease. Now by dividing the total under column 9 by the total under column 8 we find that the decrease for each 1 per cent of meters introduced in those eight cities was 1.63 gallons per inhabitant, while in the six cities an increase of 1 per cent of meters was followed by an increase of one gallon per inhabitant, so that as the average of the class of cities using an initial consumption of more than 100 gallons per inhabitant per day

WATER SUPPLY OF WORCESTER, MASS.

By F. A. McClure, Civil Engineer.

It was not until Worcester had grown into a town of some two thousand or more inhabitants that an effort was made to conduct water through pipes for the use of its people. The first attempt at procuring water of which record is found was in the year 1798, when, by legislative action, authority was granted to Daniel Goulding to convey water through pipes from a spring on his own land, for the use of himself and neighbors. By this act authority was also given the selectmen to take water from these pipes for the extinguishing of fires, and in this simple way water was brought through pipes into the streets of Worcester for the first time. The supply thus obtained, together with the wells and streams, seems to have answered their purpose many years, for we do not find that action was taken by the town to increase its water supply until the year 1842. By this time the population had grown to about 8,000 people, and the size and importance of its public and other buildings required better fire protection than the wells and cisterns then provided. At this time the town appointed a committee to consider measures for a further supply, and in the year following the selectmen were authorized to purchase what is now known as Bell Pond, as an addition to its water supply. This supply comprised about five acres originally, but was increased to a reservoir of eight acres.

The advantages of a town owning its supply of water were not at that time appreciated, and the selectmen, in their report on the matter, recommended that the town make certain propositions for the construction of an aqueduct. While this measure was being considered the Legislature, upon petition, granted to the inhabitants of the "Center School District" authority to construct and maintain an aqueduct to conduct water from Bell Pond for the use of the town. The school district mentioned comprised the territory in the neighborhood of what is now Thomas-st.

The petitioners being incorporated as the Worcester Aqueduct Company, effected organization in April, 1845, by the choice of a committee of managers, and under certain arrangements between the town and the aqueduct company the work was carried to a completion the same year. The advantages of an increased supply under pressure were soon apparent by its use in the extinguishment of two fires, and so much was its value appreciated that the selectmen, in their annual report, gave it as their opinion "that it will be more for the interest of the town to pay the district to retain the water for security than that it should be sold for profit."

Sime two years later, on the 29th day of February, 1848, Worcester became a city, the act of incorporation providing for the purchase, on behalf of the said city, of all the right, title and interest of the Worcester Aqueduct Company in and to the waters of Bell Pond.

At the first meeting of the City Council under its new charter, measures were taken to procure the rights and property of the water company, which were speedily followed by its purchase.

It was soon manifest that a more generous supply of water was needed, but nothing in the way of advance was done until the year 1854, when an engineer investigated the sources in or around the city from which an additional supply of water might be obtained. The report contained the opinion that the waters of Tatnuck Brook could "not be collected in sufficient quantity by the construction of reservoirs in this valley to supply the city of Worcester, and deemed it unnecessary to cause any survey to be made, either of the extent of country draining into the Tatnuck, or of a route into the city." Incidentally, it may be mentioned that this same stream has been the mainstay of the city's water supply for the past twenty years, and in abundance and quality is unsurpassed. Two large storage reservoirs have been constructed upon the Tatnuck Brook shed, sometimes known and spoken of as the "Holden" supply.

The insufficient supply was exemplified by the exhaustion of Bell Pond. The pumping from springs had to be resorted to. During this period the town pump was doing duty.

It was not until the year 1863, however, that the decisive steps were taken in answer to the people's petition "to procure an abundant supply of water for use of the inhabitants, and for the protection of the city against fire." At this time Worcester had grown to a population of about 28,000 people, only a fraction of whom were supplied with city water. It is stated in the reports of that period that 112 parties, mostly families, were provided with water from private aque-

ducts, and that the city was supplying 146 other parties when the water was not shut off because of an insufficient quantity in the reservoir. The total length of pipe controlled by the city was five and a quarter miles, with 112 hydrants.

The Lynde Brook dam and reservoir, the earliest of the city's sources of supply now in use, was so far completed in the year 1864 as to impound the water for general purposes, and on the 22d day of November was formally dedicated by the city government. Lynde Brook reservoir, when first built, stored, when full, about 230,000,000 gallons of water and covered an area of forty-eight acres. The number of water takers is reported as 175 at that time, but with the added supply this number was rapidly increased.

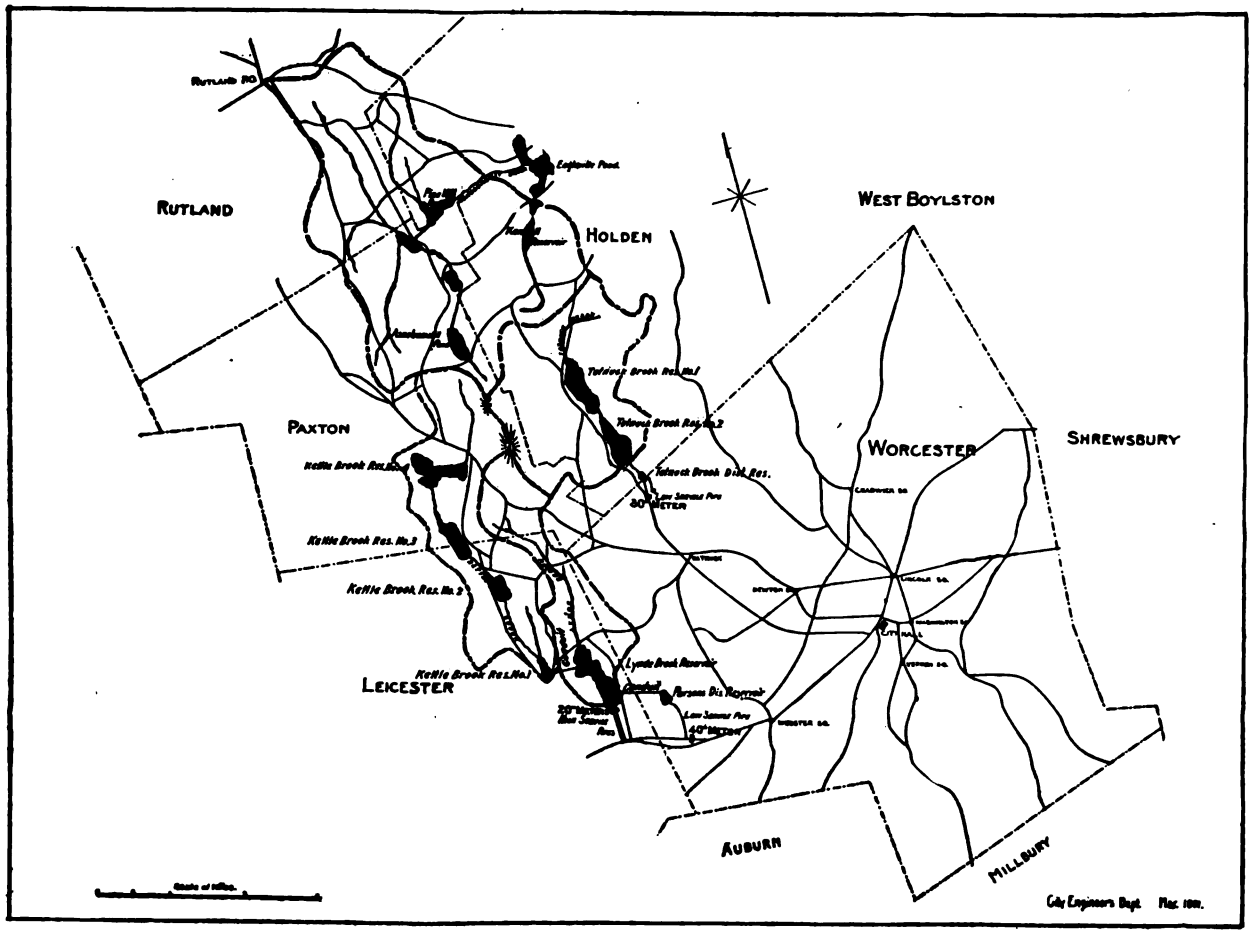
It was soon apparent that a still further storage of water was necessary, and in the year 1870-71 the dam was raised fifteen additional feet, increasing the storage to about 775,000,000 by the use of flashboards. In the meantime, it was evident that the aqueduct could not supply water to certain parts of the city, and as a measure of relief an independent main, utilizing the entire head from Lynde Brook reservoir, was laid and completed in the year 1873. This was the first introduction of what is known as our high service supply, and, with some improvements, is today our only means of furnishing water to the surrounding hills. An ordinance establishing water rates and the beginning of our meter system were important features settled upon during this period. The question of further supply seems to have been an ever-present one for within three years from the time the Lynde Brook dam was raised the city water committee advised the taking of Kettle Brook, and considered the advisability of taking North Pond as an additional source.

It was reported in the year 1874 that the daily consumption of water amounted to 3,000,000 gallons, and that the number of takers was 36,000 people. This would make a daily rate of eighty-three gallons a person, something considerably above the rate in use today. In the report of the city engineer of the same date it was stated that "a partial examination of Tatnuck Brook showed that its capacity as a source of supply may have been underrated" and suggested more extended surveys to determine its value. The following year Henshaw Pond and the Tatnuck Brook were surveyed and examined, and a report giving the results of the surveys was made to the City Council. No steps beyond that of investigation were taken, however, although the water committee of that year said in their report "that with more than a usual rainfall our only reservoir has not been filled for more than fifteen months, should excite apprehension, and should be kept prominently before the Council."

The year 1875 brought added difficulties by the discovery of increased leakage through the Lynde Brook reservoir embankment, in the vicinity of the "pipe arch." The leak, while of considerable volume, does not appear to have occasioned much alarm, for we find that in the following March the reservoir was not only allowed to fill, but that the water was permitted to overtop twelve-inch flashboards in addition. Five days later, or on March 30, the dam was breached, and the city, with a population of 50,000 people, was in dire necessity for water. Without going into the details of the trials and anxieties of the next few months, it is only necessary to add that the dam was immediately rebuilt, and so far advanced before the season was gone as to be of partial service.

Due to the increased use of meters, the daily consumption of water appears to have been considerably reduced, and except to investigate and report upon possible sources of supply, little was done until the year 1881, when legislative authority was procured to take the waters of Tatnuck Brook for the city's use. The low state of the reservoir during the previous months seems to have hastened this action, for we find in the report of the water commissioner for the year at one time "only 18,000,000 gallons or six days' supply, at 3,000,000 gallons per day, could be drawn." The boilers and pumps that were erected at Coes Pond, which had been used in previous times of stress, were overhauled and put in order to run, but a copious rainfall averted the necessity for using them at that time. The following year a shortage of water was again imminent, only to be followed a year later by actual failure. It was during this period of trial, or the season of 1883, that the Tatnuck Brook was added to the city's water supply, and the dam upon that stream was strengthened and made suitable for its new service. Due to the rapid growth of the city, it was soon apparent that additional storage was required, but the recommendations for this work were not heeded, however, until the year 1892, when the storage capacity of the Tatnuck Brook reservoir was increased twofold.

It is interesting to observe that during the nine years previous to this work the population had grown from 65,000 to 90,000



MAP OF WORCESTER, MASS., WATER SHED.

people. The effect of the increase in population was soon felt upon the high service supply, and in the two years after the work upon Tatnuck Brook had been completed the Lynde Brook reservoir failed, making necessary the procuring of a temporary supply from Kettle Brook. This was followed in the year 1895 by the permanent taking of Kettle Brook by the city and the immediate building of a conduit to divert its waters into the Lynde Brook reservoir. Since the taking of Kettle Brook there has been a gradual development of all the sources of supply, and today there exist in the general system seven storage reservoirs and two smaller basins used as distributers.

During the fifty-odd years since the city controlled its water supply, the storage capacity of the reservoirs has increased from 30,000,000 to 2,540,000,000 of gallons, and the number of water takers has advanced from 258 to 122,286. The distribution system has increased from five and a quarter miles to 185 miles of main pipe, and the number of hydrants from 112 to 1,902.

The use of water has become more general than formerly, and is employed for a variety of purposes that were not in practice during the earlier days, but there is greater economy in the strictly domestic consumption of water than was the case many years ago. This is due entirely to the excellent practice of placing meters on most of the pipes, but the record is not as good as it should be, because of the amount of unmetered water that is used. This is largely due to continuing an old practice of extending fire pipes wherever asked for, without being guarded by meters. Attention has been called to this condition from time to time, and from tests made by the water department it has been determined that improper use of water, in considerable volume, is being made in certain localities. The water for street sprinkling is also supplied without revenue to the city.

Since the year 1895 all the water entering the aqueducts has been measured, which has enabled us to keep constantly informed of the amount that is daily consumed. The following table will show to what an extent the consumption of water has increased during the past eight years.

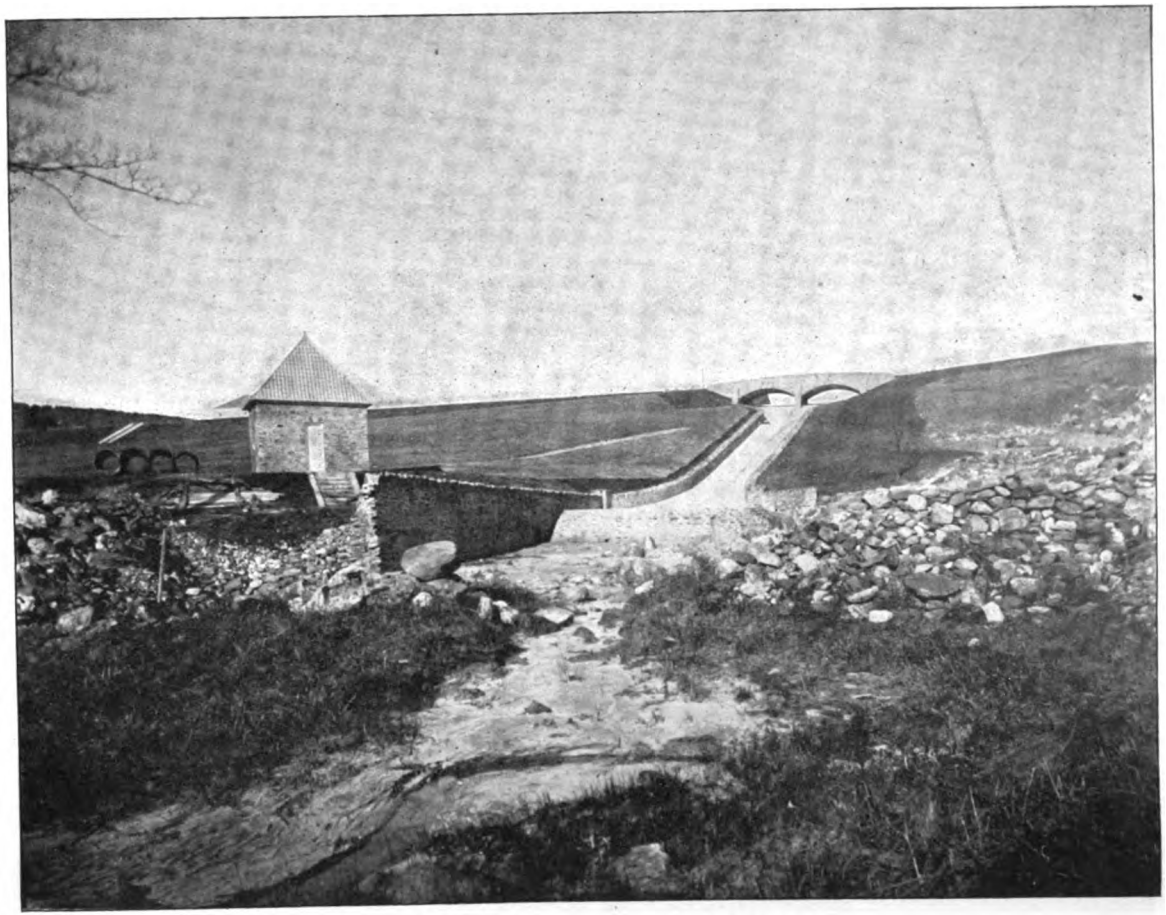
Year.	No. of water takers.	Av. Daily Consumption in Gallons. Total.	Av. daily Consumption in Gallons Per cap.
1896.....	100,586	6,125,630	60.9
1897.....	103,702	6,083,016	58.6
1898.....	105,963	6,795,578	64.1
1899.....	110,773	7,632,428	68.9
1900.....	113,217	8,152,373	72.0
1901.....	116,064	9,013,785	77.6
1902.....	119,331	8,211,878	68.8
1903.....	122,286	9,687,173	79.2

During the eight years given the number of water takers has increased 21.57 per cent, while the consumption of water has increased 58.1 per cent.

I think it has been the history of many cities that the increase in population is followed by an increase in the rate of consumption of water, but in this city, where the use of meters is so general, I do not attribute the cause altogether to the additions to the system, but in a great measure to the unmetered fire pipes to which I have referred. While the amount of water consumed may appear large for a community like ours, it is, nevertheless, a moderate and economical use, and Worcester has the distinction of being one of the few cities in the United States that economizes in the use of its public water supply. It may be of interest, and perhaps I ought to further explain that the rate of consumption given in the table is for the total amount of water consumed for all purposes, a considerable part of which is used for other than strictly domestic convenience. The rate for household uses averaged last year but fourteen gallons to the person. The amount of water used in different localities about the city also varies very much, and ranges from about twenty-five gallons to the person in the better residential parts to less than ten gallons to the person in dwellings of the poorer class.

In the manipulation of the reservoirs prior to 1897 there was no way to regulate the flow of water into the low service pipes, so that one source of the supply should not be drawn upon beyond its proper quota to the daily consumption. At that time a new distributing basin was built in the Parsons Brook valley, with a new conduit through which the Lynde and Kettle Brook reservoirs should supply their proper amount of water for the low service use. This distributing basin was constructed at an elevation about sixty feet higher than its corresponding reservoir on the Tatnuck Brook, and on the conduit leading to the city were placed regulating valves, by which the normal pressure could be increased or diminished at pleasure. By utilizing a portion of this difference in pressure, the water from the Parsons reservoir can be forced into the city, and, on the other hand, if the pressure is reduced, the water from the Tatnuck system enters the conduits more freely. This arrangement provides an absolute control of the different systems on the low service supply and in connection with the Venturi meters, which are placed on all the reservoir mains, furnishes both the requisite knowledge and means for intelligent operation of the system.

With regard to the total supply of water



OVERFLOW OF TATNUCK RESERVOIR WORCESTER WATER WORKS.

as it stands today, the situation is not as satisfactory, in my judgment, as it should be. We have, all told, a net catchment area of about eleven and one-half square miles, with a total storage of 2,540,000,000 gallons. Under the ordinary conditions there is no occasion for anxiety, but it is the extraordinary conditions that must be provided for, and which put a very different phase upon the question. Very few people, indeed, give any thought to the water supply further than to go to the tap and draw whatever amount they desire, so long as the quality holds good and there is no restriction in its use. They who have occasion to view the several storage reservoirs, and observe their seemingly generous capacities, often wonder what possible need there can be for such a provision. They frequently fail to appreciate the reduced amount of water that may be expected in periods of low rainfall, and that the consumption must be largely obtained from the storage when such condition exists. Some of our catchment areas are small, and when we fail to get the ordinary precipitation of rain the brooks dry up, and oftentimes the best of them do not furnish sufficient water to provide for the evaporation on the water surfaces. When we consider that during such periods the amount of the run-off often falls below one-half of the amount of water collected in an average year, it will readily be seen that if failure is to be guarded against a generous storage is a necessity.

These storage basins are the regulators, and are built for the very purpose of collecting and storing the water for use when little or nothing may be obtained from the streams. The amount of storage that should be given a catchment area is also one of limit, and this is another feature that often appeals to the visual notice of those who may visit the reservoirs in times of freshet. If water is being spilled or wasted at such a time many naturally infer that the dam should be raised, that little or no water may escape. Let me say that if such a course was to be pursued, there would be periods of many years that the reservoirs would be below high water mark, with a consequent injury to the quality of the water by reason of the growth of vegetation on the exposed surfaces. This is due to the unequal distribution of the rainfall, and for this reason the storage should be so proportioned that the reservoirs should not fail to fill for too long a period at a time. Our own reservoirs are rather overdeveloped in this respect, as they are designed with the expectation of being below high water mark for a period exceeding two years, which is a sufficient length of time to cause considerable injury.

I believe our several sources of supply are developed to all that should be expected of them, with due regard to the quality of water to be desired, and therefore am of the opinion that to provide for the rapid and expected growth of the city, an additional catchment area should be added at once. The city has been greatly favored by having at its very doors excellent water sheds, so situated as to give one of the finest gravity systems to be found. Our high service supply is something that causes wonderment amongst those conversant with water supply systems, and fortunately there are still further additions that can be made without departing from the method of gravity.—The Worcester Magazine.

SOME FEATURES OF THE WATER WORKS OF MADISON, WIS.

In the number of Municipal Engineering for September, 1903, vol. xxv, p. 162, was given a description of the installation of a Wood propeller pump for raising water from a deep well for increasing the water supply of the city of Madison, Wis. The pump consists of a series of propeller blades set at intervals of three to five feet along a shaft in the well tube, in this case about 120 feet long. It is run by electricity at a speed of about 1,200 revolutions a minute.

The pump described is located 3,990 feet from the storage basin at the pump house and must raise water about eighty feet in the well and force it through a 12-inch main against a head of twenty-six feet. The propeller shaft rests on a ball bearing at the bottom, on which the combined pressure of shaft, water lift and resistance is said to be about 3,630 pounds. As a result, the bearing must be replaced in from one to ten days, according to the duty required of the pump.

Another 7-inch pump of similar design put into the Blount-st. well during the past year, is 1,200 feet from the pumping station, of smaller dimensions and at present under less head. The ball-bearings of the shaft have therefore given better satisfaction.

Notwithstanding several difficulties in