PROCEEDINGS

—OF THE—

CONNECTICUT

Civil Engineers and Surveyors

ASSOCIATION,

—AT ITS—

SUMMER MEETING,

—HELD AT—

WATERBURY, CONN., AUGUST 30, 1894,

—AND ITS—

ELEVENTH ANNUAL MEETING,

—HELD AT—

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NORWICH WATER WORKS.

BY C. E. CHANDLER, NORWICH, CONN.

Norwich, Connecticut, is supplied with water by simple gravity works, from an almost uninhabited watershed within about two and one-half miles from the centre of the city.

Its history and character are much like those of many other New England water works.

The city had a population of less than 12,000 when the works were built in 1868, and it was then supposed that forty gallons daily per capita was a sufficient supply.

The site selected was somewhat peculiar, in being at the head of two small streams running in opposite directions, the watersheds of which lapped by one another.

The area of the principal watershed, in which the reservoir was built was 394 acres, and the portion of the watershed of opposite valley diverted was 89 acres, a total of 483 acres.

The level of the summit of the principal watershed was fixed for height of water-line of the reservoir, so that the overflow discharges into the opposite valley below the point of diversion.

This simplified the construction of the dam, because no overflow was there needed.

It required, however, the settlement of land and water claims, with the riparian owners of both streams, not only on account of diversion from, but diversion into, each stream.

Regarding the character of the watershed, I quote from the original report by John T. Fanning, the engineer, as follows:

"About two-thirds of the surface of the watershed was arable land, and the remainder woodland, all with a considerable slope and with a nearly impervious clayey strata lying near the most of the surface, the whole being considered quite favorable for securing a large percentage of the rainfall."

I wish to call attention, in passing, to the fact that the watershed of the reservoir consists of the extreme upper portion of two watersheds, and to the idea that, other things being equal, a similar area of either of them would be likely to yield more than the combination.

The reasons I suggest for this belief are:

1. The periphery and least yielding portion of the watershed will form a greater proportion of the whole.

2. The loss from the water entering the ground, and appearing lower down the valley in the form of springs, will be greater than if a greater portion of either valley were included.

The dam is of blue gravel with masonry core wall. It is four hundred and sixty-eight feet long and twenty-five feet wide on top, and thirty-five feet in height at deepest place. The outer slope is one and one-half to one, soiled, and the inner slope two to one with eighteen inches of riprap. The priming wall was carried a part of of the way through shaley rock to solid rock, and is two feet thick at top and five feet thick at the bottom, and was grouted.

The well-house is of stone masonry, eight feet in diameter in the clear, and its bottom is twenty-five feet below level of overflow.

A special feature is the adjustable effluent pipe, which is a Y shaped casting, resting on the floor of the well-house, to which is joined the main sixteen-inch supply pipe. I again quote from original report:

"The arms of the Y casting are curved toward each other into heart form, and are flanged at their ends. These arms are of 14-inch diameter pipe. The adjustable pipe is of copper, sixteen inches in diameter. The foot of the adjustable pipe is made in ⊥ form, with the two arms flanged so as to make, when joined to the flanged arms of the Y casting, a flexible joint, allowing the pipe to move freely in a vertical plane. The flexible joint has gun metal flanges and rubbing surfaces. On the head of the adjustable pipe is a large perforated bulb, the sum of the perforations being double the sectional area of the pipe. The length of the adjustable pipe from the foot to the head is twenty-seven feet, so that when raised in a vertical position the bulb is accessible above water, from the platform on the top of the buttresses. In the curb of the well-house is set a shaft, on which is fixed a hand-wheel and pulley.

"The adjustable pipe is counter-weighted and retained in proper position by a copper wire weight cord, attached to the pipe near the bulb and passing over and around the pulley, and connected to the counter-weight suspended by it, in the interior of the well-house.

"A ratchet stop holds the shaft and pipe as adjusted. When the pipe is set in position the water enters the perforated bulb, passes through the copper pipe, and heart-shape pipe, into the main supply pipe. One man, with the aid of the adjustable machinery, can raise the bulb out of the water for cleaning, or quickly set it in any desired position between the surface of the water and the bed of the lake.

"This adjustable apparatus was suggested by, and constructed under the direction of Mr. Alba F. Smith, president of the board, and has continued to work admirably to the present time."

As there is no overflow at the dam the latter forms an unobstructive feature of the landscape.

The surface covered by the reservoir received an unusually thorough cleaning. Twenty thousand stumps from four to thirty-six inches in diameter were removed by two stump extractors. The entire bed of the lake was cleaned and all soil containing grasses or roots entirely removed. Forty thousand cubic yards of stone, exposed in the excavations, were used in building a bank wall extending entirely around the reservoir. The top of the wall is from two to four feet above the level of overflow.

Regarding this wall, I quote:

"The most important use of the enclosing wall, and riprap at its base, are to prevent washings of the steep slopes, when high winds dash the water upon them, to prevent the growth of aquatic plants, and to avoid shallow waters near the margin where the water might be raised in hot weather to a temperature sufficient to cause fermentation of any vegetable substance produced, or accidentally deposited there."

From the gutter, outside the roadway around the reservoir, forty-seven culverts were built beneath the roadway to lead the surface water to the reservoir.

While the wall is a pleasing feature in the appearance of the reservoir, and gives a considerable depth of water around the edges of the reservoir when full, there has been some trouble with the material outside the wall washing through it and making holes in the roadway.

In the ordinary use of the reservoir it is seldom full in the warm weather so that the advantage of the wall is more apparent than real, while riprap is a cheaper and more permanent form of protecting the edges.

The area of the reservoir is 66 acres, its greatest depth 24 feet, and capacity 333,000,000 gallons. Flash boards are used which increase the capacity to about 350,000,000 gallons.

The estimated capacity of the works was 50 per cent. of the average annual rainfall of 40 inches or about 262,500,000 gallons annually.

Unfortunately no actual measurements of the yield or consumption have been made. One can only say that the gates were closed October 23rd, 1868, and that the reservoir was full January 16th, 1870.

Comparison with the rainfall and estimated consumption during filling verified the engineers estimate of 50 per cent. as the amount of the rainfall available.

The reservoir remained full until May 15th, 1871. It furnished all the water used in Norwich until the spring of 1881 and practically no water wasted after the spring of 1871.

The population of Norwich in 1881 was 15,000.

In the absence of knowledge of the amount of water used it can only be said that a city of 12,000 to 15,000 people, where a good deal of water is used by manufacturing establishments, and where much water is known to have been wasted, were supplied from 417 acres of watershed exclusive of the 66 acres of reservoir from 1871 to 1881.

The level of overflow is about 220 feet above the ground on which the most important mills and business buildings stand, and about 100 feet above the ground on which the best residences are situated. A small portion of the city is nearly as high as the reservoir.

The works were built when cast-iron pipe was about $80 per ton, and wrought-iron cement-lined was recommended and used, because as by original report "In addition to the greatly increased cost of cast-iron pipes, the rapid incrustation and consequent diminished service capacity, the discoloration of the water by oxides, are found in practice, to be serious objections to their use."

Considering the fact that cement pipe then cost about half as much as cast-iron, and that the indebtedness had to be bonded at seven per cent. and long time, and the important fact that people did not then know what sizes were necessary for good service, the use of the cement was fortunate.

The main supply pipe has proved reliable for twenty-six years with no immediate prospects of failure. Its life may be considered thirty years. The life of the distributing pipes was about twenty years.

Had the pipes been cast-iron to begin with we should probably have been still struggling with mains so small that the people on the highest hills would have had to pump their water from the pipes.

The following table shows changes in sizes:

10,024	feet changed from	4-inch to	6-inch.
8,937	feet changed from	6-inch to	10-inch.
4,452	feet changed from	6-inch to	12-inch.
514	feet changed from	6-inch to	14-inch.
1,326	feet changed from	8-inch to	10-inch.
7,564	feet changed from	10-inch to	16-inch.

The total cost of the works, including distribution up to April 30th, 1870, was $267,669.12, of which the cost of the reservoir was about $137,000.

In 1880 an additional main of 16-inch cast-iron pipe was laid for the double purpose of increasing available pressure and of eliminating the risk of depending on a single main.

The new main cost $19,244.51.

The increasing use of city water, and the fact that the city had for ten years used all the water the works were able to supply, made an increase imperative.

A watershed of about 980 acres, lying westerly of and parallel with the reservoir already constructed, was selected as the source of an additional supply. 7,160 feet of 24-inch cast-iron pipe was used to connect this watershed with the existing reservoir with a fall of nine feet from bed of brook to full reservoir. The brook was diverted by simply repairing an ancient dam built to turn water for irrigation. The cost of this extension was $58,906.80.

The city did not first acquire the full use of the additional watershed, but only the right to use it at such times as there was a surplus in the Yantic river. As the mill privilege on the Yantic was fully developed the cities use of Meadow Brook was practically confined to two or three winter or spring months. In spite of this fact the addition kept our reservoir full on an average of five months in the year, from 1883 till 1893.

February 1st, 1893, the prospects for a water famine were altogether too favorable. There were 50,000,000 gallons in the reservoir only 24,000,000 gallons of which was practically available through both mains. The water was not lowering fast and the season of greatest yield was at hand. The danger was not that there would be a shortage soon, but that the reservoir might not fill, in which case another dry season would be fatal.

On February 6th, there was a rainfall of 1.30 inches; February 9th and 10th, 2.40 inches; February 13th, 1.41 inches, a total for the week of over five inches at just the most favorable time. The total rainfall for the month was 8.61 inches.

The result was that March 19th, the reservoir was full and remained full till July 2nd, 1893.

About that time full rights to the stream were secured but the city has used all the water of both watersheds since the last date, and the reservoir is now (January 1st, 1895,) only about one-half full.

The present population of the city is about 18,000, increasing slowly. It seems probable that the present works will answer for a number of years if average rainfalls favorably distributed occur.

There is an opportunity to build a reservoir in the new valley holding about 1,000,000,000 gallons. Such a reservoir, or even one of less capacity, would probably make available all the water collectable on the two watersheds.

Such a reservoir would be 35 feet higher than the present reservoir, and could be so connected with the mains as to form a high service of great advantage to a portion of the city.

The point of greatest difficulty is the treatment of the ground under proposed reservoir. Over 100 acres of it is meadow and swamp with a deep deposit of muck or peat, the removal of the whole of which would probably be impracticable.

The greatest danger to the water works is that of delaying the construction of this storage reservoir until increasing use of water and a dry season concur to cause a water famine.

The unusual expense incurred of cleaning bottom and building walls around our present reservoir could be justified only by it producing first-class water.

While for a long time and on the whole the water has been excellent, the fishy taste and odor which seems to occur at sometime in nearly all artificial reservoirs, was not wholly avoided, as will be seen from the following quotation from the report made by the superintendent, H. B. Winship at the end of the first five years:

"Considerable trouble has been experienced at various times, and it has been necessary to use very large quantities of water in flushing, emptying and refilling our mains, with the hope of removing the disagreeable taste and odor which at times, and in certain localities pervaded the water to a very unpleasant extent. I think full twenty per cent. of all the water drawn during such time was for this purpose; it was therefore a source of great care and anxiety, and I truly appreciated your order instructing me, to procure a thorough analysis, ascertain the cause, and if possible, how it could be permanently removed."

Prof. B. Silliman's report above referred to dated January 20th, 1873, compliments the manner in which the reservoir was constructed.

Among other things he says: "I may remark that this is an unusual degree of care and thoroughness in the preparation of ground for flowage. Many such works within my own knowledge, have been completed without any such needfnl care. The only additional precaution which could have been taken would have been the shingling of the scarfed surface with clean gravel and sand; and for this purpose the immediate vicinity of the reservoir offered no facilities, and the expenses involved would consequently have been very great."

Concerning complaints about the water, Prof. Silliman says: "All seemed to agree that the water in some localities was effected unpleasantly, and much less so in others, some localities never having made complaint. The nature of the objectionable flavor was as variously stated, but the most general statement was that the water had a 'fish-like' odor or flavor, while others simply compared it to bog-water or pond-water flavor. That there has been reason for these complaints cannot be doubted, but that the cause of complaint is no serious or irremediable one, I hope to show to the satisfaction of the most skeptical, nor is it by any means an unusual thing to find similar complaints from lakes and reservoirs comparatively newly built."

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"After hearing the testimony of various witnesses as to the character of the water in Norwich, on the 7th of January I made visits to several points, where all agreed it had been the most offensive, and certainly the reports were not such as to predispose even an unprejudiced judge in its favor! My surprise was therefore excited to find the water in no case where I examined it, as drawn from the taps, marked by any of the bad qualities of flavor or odor, which were reasonably to be expected. The color was slightly yellowish brown, and I fancied in one or two places that the flavor was a little marked by the vegetable extractive matter, which is the cause of the color.

"I was assured in all the places, which I visited, that some two weeks before there was no difficulty in finding the qualities which all, equally with myself, agreed were now sensibly absent. I make this statement, so much at variance with the general popular verdict, advisedly. But an appeal rests, after all, on the actual results of chemical and physical examination, which leaves no doubt, as you will see, that the water of your lake is of extraordinary purity, whether judged by the very minute quantity of foreign matter it contains, both absolutely, in grains per gallon, and comparatively, to other well-known and highly accredited waters.

"The only vulnerable point in the case, so far as given by chemical evidence, is seen in the fact that the proportion of the 'organic matter' to the 'mineral matter,' in the total solid contents of the water is too high, although it is considerably less in amount than the average of potable waters supplied in other cities, and with one or two exceptions it is smaller than any."

Regarding the trout and black bass placed and protected in the reservoir, Prof. Silliman says: "Too many large fish in a limited volume of water may certainly impair, rather than preserve its purity.

"I am, by no means, prepared to say that the 'fish-like flavor,' which some have detected in your water, is due to this cause. I have myself failed to detect the flavor in question, where others find it. But the comparative scarcity of animalcula suggest the inquiry whether the fish have devoured them, and thus impaired the balance of organic nature?"

The results of Prof. Silliman's analysis are shown in following table:

WEIGHTS OF IMPURITY IN GRAINS AND HARDNESS IN ONE STANDARD AMERICAN GALLON OF WATER SUPPLIED TO THE CITY OF NORWICH.

No.	Source.	Mineral Matter.	Organic and Volatile Matter.	Total Solids Impurities.	Hardness.
1.	22 feet from surface of Lake ..	1.166	0.700	1.866	0.560
2.	12 " " " " "	1.149	0.600	1.749	0.540
3.	Surface of Lake................	1.050	0.583	1.633	0.510
4.	Waste Pipe....	1.399	0.700	2.099	0.560
5.	Faucet at Mr. Richmond's.......	1.071	0.795	1.866	0.560
	Average	1.167	0.676	1.844	0.546

Prof. Silliman's conclusions are:

"1st. That the Norwich water, as compared to other city waters, is of exceptional purity.

"2nd. That remarkable care and good judgment have been exercised in preparing the lake, or reservoir, to secure cleanliness and freedom from objectionable circumstances, as well as to insure the delivery of the water from the turbidity of the lower stratum near the bottom of the lake.

* * * * * * * * * *

"5th. The complaints which have been made of the Norwich water by your citizens, in my judgment, are due to the small amount of vegetable matter, less than three-fourths of one grain, in a gallon of water.

"When the water is shut up in the mains, under a pressure of five or six atmospheres, the air dissolved in the water is greatly condensed, and with the pressure is relieved at the tap, the water rushing out force foams and sparkles with escaping air, carrying with it the peculiar odor of the vegetable matter. Hence it appears by such evidence, as I have been able to obtain, the annoyance is temporary.

"The water, at first offensive, allowed to stand a few hours, has lost all odor. I venture to predict that the evil will disappear as it came, without any assignable reason, and that your water will steadily gain favor with all classes of citizens."

It appears that there continued to be an unpleasant odor at times for several years, as Superintendent Winship's report for year ending March 7th, 1879, says: "Each year, when this unpleasant taste and odor has appeared, it is gradually less each time, and I have never doubted that with proper and intelligent care it may, to a great extent be avoided."

The writer has used the water continuously since June, 1881, and has never had any ground for complaint.