14

# REPORTS

OF THE

# ENGINEERS

TO THE JOINT COMMITTEE OF ALDERMEN AND CITIZENS OF THE CITY OF SYRACUSE, NEW YORK,

## ON A SUPPLY OF WATER

FROM THE

# TULLY LAKES.

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JANUARY, 1871.

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1871.

# REPORT

OF

*with compliments of*

# J. J. R. CROES, CIVIL ENGINEER.

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Office of Croes, Church & Van Winkle,
Civil Engineers,
111 Broadway, New York City,
January 28, 1871.

*To the Honorable, the Joint Committee of Aldermen and Citizens of Syracuse, on the feasibility of procuring water from the Tully Lakes:—*

Gentlemen:—I have the honor to report the results of the investigations made under authority of a resolution of the Common Council of Syracuse passed September 12, 1870, for determining the feasibility of procuring a supply of water for the city of Syracuse from the Tully Lakes.

The examinations were begun on September 26, 1870, and have embraced the quality of the water procurable from the Lakes, the quantity which they may reasonably be expected to furnish, and estimates of the cost of its introduction into the city.

## I QUALITY OF THE WATER.

For comparison of the water of the Tully Lakes with that now furnished, and also with that proposed to be furnished by the Syracuse Water Company, six samples of water were sent to Professor C. F. Chandler, of the School of Mines of Columbia College in New York City, and were tested by him. The samples as sent to Professor Chandler were designated by numbers, and he did not know whence they were obtained. In the annexed copy of his report I have inserted the names of the sources from which I collected the waters.

No. 1 was taken from the Wilkinson Reservoir of the Syracuse Water Company after it had begun to fill from the Fall rains, and when the water surface was twelve feet below the high-water mark.

No. 2 was taken from the well which the Syracuse Water Company have been digging near the Onondaga Creek, a short distance south of the base-ball grounds, in the town of Onondaga. The water was taken at a time when the pumps had not run for over twenty hours, all grosser impurities had settled, and the water was perfectly limpid. The other four samples I took from the Tully Lakes at a time when they were very low, and the water was consequently in its least pure state. For comparison. Professor Chandler has added the analysis of the Croton Water.

## CERTIFICATE OF ANALYSIS.

"Laboratory of the School of Mines,
Columbia College, New York,
January 23, 1871.

*J. J. R. Croes, Esq.:*

Dear Sir:—"The samples of potable waters from Syracuse, marked Nos. 1, 2, 3, 4, 5 and 6, submitted to me for examination, contain in one U. S. wine gallon. (See Table 1.)

In order of purity and fitness for domestic use they rank as follows, beginning with the best:

No. 6 and No. 5—Extremely pure, remarkably so, equal to almost any city supply in America.

No. 3 and No. 4—Very good, pure enough for all practical purposes.

No. 1—Can be used, but only in case purer water is not available.

No. 2—A vile water, too impure for any purposes, except perhaps for navigation or water power; unfit for man or animals, steam boilers or manufacturing purposes. Yours respectfully,

C. F. CHANDLER, Ph, D."

## TABLE No. I.

| | No. 1. WILKINSON RESERVOIR. | No. 2. WELL DUG BY WATER COMPANY. | No. 3. BIG LAKE. | No. 4. GREEN LAKE. | No. 5. VAN HOESEN LAKE. | No. 6. CROOKED LAKE. | CROTON WATER. |
|---|---|---|---|---|---|---|---|
| | Grains. | Grains. | Grains. | Grains. | Grains. | Grains. | Grains. |
| Organic matter. | 0.47 | 3.38 | 0.93 | 0.70 | 0.93 | 0.58 | 0.67 |
| Inorgan. matter. | 14.46 | 64.02 | 7.23 | 9.21 | 2.57 | 2.92 | 4.11 |
| Total impurities. | 14.93 | 67.40 | 8.16 | 9.91 | 3.50 | 3.50 | 4.78 |
| Hardness. | 8°.58 | 34°.41 | 4°.83 | 5°.10 | 3°.22 | 2°.95 | 2°.68 |
| Sulphate of Lime | Considerable. | Large quantities. | Little. | Little. | None. | None. | Little. |
| Carbonate of Lime. | Considerable. | Large quantities. | Some. | Some. | Some. | Some. | Some. |
| Chloride of Sodium. | 0.59 | 1.49 | 0.44 | 0.44 | 0.28 | 0.44 | Some. |

The following table shows the amount of impurities in a gallon of the water furnished to a number of cities in this country:—

Table No. 2.

| *City.* | *Grains of Impurities in one gallon.* | *City.* | *Grains of Impurities in one gallon.* |
|---|---|---|---|
| New York | 4.78 | Detroit | 5.72 |
| Philadelphia | 5.76 | Baltimore | 5.85 |
| Boston | 3.37 | Troy | 7.77 |
| Albany | 4.72 | Jersey City | 7.44 |
| New Haven | 5.60 | Quebec | 6.75 |
| Cincinnati | 4.93 | Chicago | 8.01 |

Average of 12 cities 5.89.

From the following table, taken from analyses made by Professor Chandler, in the years 1865 and 1866, it appears that the water of the Tully Lakes is purer than any other water in the vicinity of Syracuse:

Table No. 3.

| *Locality.* | *Grains of Impurities in one gallon.* |
|---|---|
| Onondaga Creek, 1865 | 26.36 |
| Onondaga Creek, 1866 | 21.28 |
| Hydrant Syracuse Water Company, 1865 | 27.93 |
| Skaneateles Lake, 1865 | 23.85 |
| Owasco Lake, 1865 | 9.53 |
| Canandaigua Outlet, 1865 | 13.10 |
| Wilkinson Reservoir, 1866 | 13.94 |
| Butternut Creek, 1866 | 19.68 |
| Beaver Meadow Creek, 1866 | 20.40 |
| Geddes Pond, 1866 | 64.00 |
| Spring in Syracuse near Bridge | 26.00 |

The value of water for domestic purposes and for steam boilers, and many manufacturing uses, depends very much upon the degree of what is usually termed its *hardness*, which is caused by the presence of certain mineral salts. The relative hardness of waters is determined by the soap test, invented by Professor Clark, of Edinburgh, and now generally adopted by chemists.

In this test, the quantity of soap required to form a lather with various waters, furnishes the basis of comparison. The greater the amount of lime in water, the more soap is wasted, a certain amount being required to neutralize the lime, before a good lather can be formed.

The difference in the hardness of the waters of Green, Crooked, and Van Hoesen Lakes, and that of Wilkinson Reservoir, is such as to make a very great difference in the yearly cost of soap to families.

The waters of the three Lakes, combined in proportion to their drainage areas, have a hardness of 3.76 degrees, while that of Wilkinson Reservoir has 8.58 degrees. The latter would require 48 grains of soap for every gallon of water, more than the former. A family using only five gallons a day for purposes requiring soap, would therefore need 12½ lbs. more soap in a year by being compelled to use one water rather than the other, while if they had to use the water from the well near Onondaga Creek, they would use up 80 lbs. of soap yearly, more than if they had water from the Tully Lakes.

Considering the location of the well near Onondaga Creek, there is nothing surprising in the amount of impurities contained in its water. Well water is notoriously charged with impurities, and frequently that which is most sparkling to the eye and palatable to the taste, owes these very qualities to the germs of deadly diseases which it contains. Wells are now being bored in the city of New York, furnishing what was claimed to be superior water until Professor Chandler's analysis showed it to contain over 100 grains of impurities to the gallon. The water of Spring No. 1, in Lodi, contained 128 grains in a gallon. The analysis of the water of Wilkinson Reservoir, above given, furnishes by no means a fair sample of the water now furnished to your citizens, much of the latter being the yield of springs of great hardness which feed the lower reservoir. The hydrant water analyzed by Professor Chandler, and which was of 16 degrees of hardness, is nearer the average quality used in Syracuse. A careful estimate of the saving to families in the cost of soap, tea and coffee only, by the use of water of 3.76 degrees hardness instead of 16 degrees, based upon the actual annual consumption of these articles in a small and very economical family in Syracuse, the head of which kept for three years a very close account of his expenses, which account was procured by Mr. Sweet, enables me to give with confidence the actual money value of such saving, as at the very least $8.65 per annum, which, supposing that there are only 9,000 families in Syracuse, would make the aggregate annual saving $77,850, by introducing Tully water. There are 160 large steam boilers in the city, costing to run, for fuel alone, $480 per day, when clean and fed with pure water; while the incrustations from water charged with lime, such as is now furnished them, increase the cost of their fuel not less than $160 per day, or $48,000 per annum.

## II. QUANTITY OF WATER OBTAINABLE.

The Tully valley is situated about twenty miles south of Syracuse. At the head of the valley of Onondaga Creek, a natural dyke crosses the valley, and forms the divide between the waters flowing to the north and to the south. On the south side of this ridge, which is about a mile in width, lies what is called the "Tully Flats," a tract of land about two miles wide, nearly level from east to west, and sloping to the south at the rate of 13 feet to the mile. On each side it is bounded by steep and high hills, the summits of which are about four miles apart.

On the westerly side of this valley are several depressions in the surface, varying in size from half an acre to about 230 acres. Where the bottoms of these depressions are below a certain plane, they hold water for the whole year; when above that plane, water stands in them at certain seasons, but for a great portion of the year they are dry. This plane, or rather pair of planes, may be described as rising on each side of a north and south horizontal line through the main depression, at the rate of 29 feet to the mile. The four larger depressions, which are called the Tully Lakes, and the bottoms of which are from 30 to 80 feet below the plane spoken of, lie within a space ten thousand feet long, and eight thousand feet wide. Their areas and depths, at their ordinary water levels, are as follows:

| Name. | Area in Acres. | Elevation above Canal at Syracuse. | Extreme depth. | Location. |
|---|---|---|---|---|
| Big Lake.......... | 231.7 | 787 | 33 | S. end of main depression |
| Green Lake........ | 39.9 | 788 | 65 | N. " " " |
| Van Hoesen Lake... | 120.2 | 793 | 35 | 1000 feet west of Big Lake |
| Crooked Lake...... | 144.9 | 794 | 80 | 4000 " " Green " |

Green Lake was originally a portion of Big Lake, but the channel connecting them is now silted up, leaving only a small passage for the water which now flows into Big Lake and thence into Tioughneoga Creek No stream flows into Green Lake. It receives most of its supply of water from the gravelly plain extending about a mile to the east of it, nearly level, and forty feet higher than its surface.

A brook, rising three and a quarter miles north of Tully village, passes one mile east of Green Lake, and empties into Big Lake, near its southern extremity. This brook is dry in the Summer, the water from the hills passing under its bed, and into the lakes to the west of it. The shores of Green and Big Lakes are underlaid with a white limestone, at a depth of eight feet below the water surface.

The banks of Crooked and Van Hoesen Lakes are of gravel. Van Hoesen Lake has no visible inlet nor outlet. Crooked Lake is fed by two brooks which are dry in the Summer, the water sinking into the gravel and reaching the lake below the ground level. It has no natural outlet, but its waters have been for thirty-five years conducted to the north by an artificial channel. It is raised and lowered five feet by this draught.

The purity of the water of these two lakes is explained by the fact that the hill to the west of them is composed almost entirely of shale, and the shores are of gravel with no limestone visible, while a portion of the water of Big and Green Lakes passes over a limestone region to the eastward before reaching the gravel.

To obtain an approximate idea of the quantity of the water which these lakes can supply, a survey was made of the area of country drained by them. The topography of the region would show this area to be 13.72 square miles (8,783 acres). The water-shed of Van Hoesen Lake is 1.22 square mile, that of Crooked Lake 2.25 square miles, and that of Green and Big Lakes combined 10.25 square miles. To determine the exact proportion of this area which is tributary to Green Lake, is somewhat difficult. The area of that part which cannot possibly contribute to Green Lake is five square miles. Of the remainder, only one square mile is clearly tributary to Green Lake alone, leaving 4¼ square miles from which the water in heavy rains reaches Big Lake, while a portion of the flow from moderate rains, sinks into the gravel and reaches Green Lake.

A comparison of the flow from Green and Crooked Lakes during a given time, shows that the area drained by Green Lake is not less than 85-100 of that drained by Crooked Lake, or 1.91 square miles, and I assume this to be the available water shed of Green Lake. A comparison of the flow from both lakes for at least one year, would, however, be necessary for an exact determination of this point.

The amount of water to be obtained annually from a given water-shed differs very much in different localities. It bears a certain ratio to the rainfall, but this ratio varies with the elevation, the topography and geology of the district and the proportion of forest and cleared land. It must also vary at any one place with the amount of rainfall for the year, less water in proportion reaching the streams in seasons when there is little rain than when a large quantity falls. The quantity absorbed by vegetation is supposed to be nearly constant. By evaporation another portion varying with the season is lost, and still another portion is lost by percolation through strata lower than the bed of the streams within the water-shed, the most of this last water appearing in the stream below the point at which the flow is measured.

The following table shows the percentage of the annual rainfall which could be collected in the regions named, as determined by actual measurements. The observations on Madison and Eaton Brooks, in Madison County, in this State, and on Patroon's Creek, near Albany, are taken from a report by Mr. W. J. McAlpine. The results at Lake Cochituate are as given in the history of the Boston Water Works, and those on the West Branch of the Croton River are from observations made by myself.

Table No. 4.

TABLE OF PROPORTION OF ANNUAL RAINFALL WHICH CAN BE COLLECTED IN RESERVOIRS, AND USED FOR SUPPLY OF CITIES.

| Years. | Locality. | Area of water shed in square miles. | Rain fall in inches. | Percentage of rainfall flowing off. |
|---|---|---|---|---|
| 1835-36. | Eaton Brook, Madison County, N. Y. | 10.62 | 34.52 | 75.25 |
| 1835-36. | Madison Brook, Madison " " | 9.38 | 35.68 | 46.70 |
| 1850-51. | Patroon's Creek, near Albany, " | 4.06 | 47 36 | 56.03 |
| 1850-51. | Patroon's Creek, near Albany, " | 12 50 | 40.95 | 44 50 |
| 1859. | Lake Cochituate, Mass. | 17.81 | 49.02 | 78 |
| 1863. | " " " | 17.81 | 69.30 | 39 |
| 1864. | " " " | 17.81 | 42.60 | 40 |
| 1866. | " " " | 17.81 | 62.32 | 25 |
| | Mean of 14 years.................. | 17.81 | 50.93 | 46 |
| 1867-68. | West Branch Croton River, Putnam County.......................... | 20.37 | 53.36 | 72.73 |

The valley of Madison Brook agrees more closely in location, elevation, and its topographical and geological character, with the Tully Valley than any of the above named, and the proportion of flow to rainfall might, in the absence of measurements of the flow, be assumed to be that which would prevail around the Tully Lakes.

The following table of rainfall at Homer, for twenty years past, is compiled from the unpublished notes of Hon. E. C. Read, who kindly placed them at my disposal. This record, which has been kept with great care, is very valuable for our purpose, as Homer is in the continuation of the Tully Valley, and at nearly the same elevation above the sea as the lakes.

# TABLE 5.

TABLE OF MONTHLY PRECIPITATION OF RAIN AND MELTED SNOW, AT HOMER, CORTLAND COUNTY, N. Y.

| | 1850. | 1851. | 1852. | 1853. | 1854. | 1855. | 1856. | 1857. | 1858. | 1859. | 1860. | 1861. | 1862. | 1863. | 1864. | 1865. | 1866. | 1867. | 1868. | 1869. | 1870. | Means. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January, - - - | | 1.30 | 2.08 | 2.57 | 2.60 | 4.23 | 2.07 | 3.02 | 2.35 | 2.94 | 1.38 | 2.86 | 4.01 | 5.03 | 2.70 | 3 31 | 1.35 | 2.12 | 3.11 | 4.26 | 4.16 | |
| February, - - | | 5.77 | 1.89 | 4.49 | 4.46 | 2.20 | 1.02 | 2.05 | 2.22 | 1.82 | 1.04 | 3.30 | 2.92 | 3.02 | 0.33 | 3.46 | 3.17 | 2.27 | 1.83 | 3.66 | 4.28 | |
| March, - - - | | 1.94 | 3.38 | 2.90 | 3.34 | 1.43 | 1.99 | 2.58 | 1.17 | 4.71 | 4.01 | 3.01 | 4.92 | 2.20 | 1.15 | 5.45 | 3 04 | 2.59 | 4.30 | 3 59 | 4.40 | |
| April, - - - | | 4.22 | 3.67 | 4.41 | 5.84 | 5.35 | 2.85 | 6.78 | 2.70 | 5.54 | 2.79 | 4.99 | 1.78 | 2.66 | 2.86 | 1.91 | 1.86 | 9.21 | 2.82 | 2.31 | 1.05 | |
| May, - - - | | 5.41 | 4.71 | 4.69 | 2.33 | 4.01 | 4.06 | 4.38 | 5.01 | 3.85 | 3.53 | 5.02 | 1.79 | 5.13 | 4.10 | 3.54 | 3.26 | 5.01 | 5.54 | 3.64 | 2.74 | |
| June, - - - | | 4.94 | 3.78 | 4.00 | 3.31 | 8.69 | 3.41 | 12.55 | 3.28 | 5.54 | 5.56 | 1.79 | 4.64 | 5.64 | 2.38 | 5.37 | 4.80 | 2.30 | 3.65 | 6.84 | 3.90 | |
| July, - - - | | 5.51 | 7.52 | 2.28 | 2.19 | 6.27 | 3.85 | 2.39 | 5.09 | 5.07 | 6.43 | 5.88 | 7.00 | 8.43 | 2.42 | 4.51 | 3.43 | 4.97 | 4.05 | 4.35 | 3.62 | |
| August - - - | | 2.67 | 3.40 | 3.59 | 2.19 | 2.80 | 3.65 | 5.40 | 3.69 | 5.49 | 4.66 | 5.36 | 2.58 | 7.10 | 4.75 | 1.72 | 5.15 | 3.54 | 3.92 | 4.86 | 3.46 | |
| September - - - | 6.03 | 4.09 | 3.09 | 4.72 | 3.71 | 2.67 | 4.17 | 4.45 | 3.62 | 5.12 | 4.13 | 6.56 | 1.52 | 4.07 | 3.70 | 8.45 | 6.26 | 4.58 | 7.17 | 3.20 | 5.46 | |
| October, - - | 6.63 | 2.16 | 4.30 | 4.56 | 3.73 | 4.11 | 2.08 | 4.88 | 3.33 | 1.65 | 3.46 | 5.47 | 6.73 | 3.80 | 5.76 | 4.27 | 2.08 | 1 87 | 1.69 | 3.98 | 3.87 | |
| November, - - - | 4.20 | 5.60 | 4.56 | 3.15 | 3.07 | 3.39 | 2.98 | 3.48 | 3.93 | 3.77 | 3.75 | 2.32 | 3.34 | 5.47 | 3.97 | 3.75 | 5.64 | 1.57 | 6.76 | 4.36 | 1.57 | |
| December, - - | 4.39 | 3.01 | 3.98 | 1.76 | 3.13 | 3.91 | 2.30 | 3.29 | 4.93 | 4.06 | 2.42 | 1.95 | 2.87 | 4.05 | 3.51 | 2.25 | 3.68 | 2.68 | 2.87 | 4.10 | 2.81 | |
| First quarter, - - | | 9.01 | 7.35 | 9.96 | 10.40 | 7.86 | 5.08 | 7.65 | 5.74 | 9.47 | 6.43 | 9.17 | 11.85 | 10.25 | 4.18 | 12.22 | 7.56 | 6.98 | 9 24 | 11.51 | 12.84 | 8.74 |
| Second quarter, - | | 14.57 | 12.16 | 13.10 | 11.48 | 18.05 | 10.32 | 23.71 | 10 .9 | 14.93 | 11.88 | 11.80 | 8.21 | 13.43 | 9.34 | 10.82 | 9.92 | 18.52 | 12.01 | 12.79 | 7.69 | 12.79 |
| Third quarter, - - | | 12.27 | 14.01 | 10.59 | 8.09 | 11.74 | 11.67 | 12.24 | 12.40 | 15.68 | 15.22 | 17.80 | 11.10 | 19.60 | 10.87 | 14.68 | 14 84 | 13.09 | 15.14 | 12.41 | 12 54 | 13.30 |
| Fourth quarter, - | 15.22 | 10.77 | 12.84 | 9.47 | 9.93 | 11.41 | 7.36 | 11.65 | 12.19 | 9.48 | 9.63 | 9.74 | 12.94 | 13.32 | 13.24 | 10.27 | 11.40 | 6.12 | 11.32 | 12.44 | 8 25 | 10.90 |
| Yearly fall, - - - | | 46.62 | 46.36 | 43.12 | 39.90 | 49.06 | 34.43 | 55.25 | 41.32 | 49.56 | 43.16 | 48.51 | 44.10 | 56.60 | 37.63 | 47.99 | 43.72 | 44.71 | 47.71 | 49.15 | 41.30 | 45.51 |

It will be seen from this table that the average rain-fall for twenty years has been 45.51 inches, and that the least occurred in 1856, and was 34.43 inches. It also appears that in the year 1870, while twenty per cent. more rain fell than in the year of least rain, the fall was nearly 10 per cent. less than the average fall. The record of the quarterly rainfall shows that the year 1870 was an exceptional one, in that, while the rainfall in the first quarter, the greater portion of which reaches the streams directly, was far above the average, that for the second and fourth quarters, which usually furnish the supply for underground storage, was much less than usual; thus making the rain for the last nine months of the year, 22 per cent. less than the average, and less than for the same time in any year recorded at Homer. This corresponds with experience over the entire country, the last year having been an exceptional one, and the dryest on record. We may, with perfect safety, therefore, assume that the flow for the last nine months of 1870 is as small as can be expected at any time.

Gaugings of the flow of Green Lake were made by different persons during the Spring and Summer of 1870. The method pursued was not such as to insure very accurate results, but from the data furnished me of these gaugings, I have calculated the flow from March 23d to October 7th, making all the deductions that could be warranted.

Since October 7th the flow has been measured daily very accurately. The measurement of July 19th, by Mr. Sweet, was made with great care, and is probably as nearly correct as any measurement by floats in an irregular channel can be.

In the following table the result of the gaugings of Green Lake are given, the quantities, prior to October 7th, being obtained by averaging the flow between the days mentioned, while from October 7th to January 17th the sum of the actual daily gaugings is used.

Table 6. Flow from Green Lake :—

| Date. | C. feet per day. | No. Days. | Total cubic feet. |
|---|---|---|---|
| March 23d | 468,216 | | |
| | | 45 | 28,808,460 |
| May 7th | 812,160 | | |
| | | 45 | 22,003,650 |
| June 21st | 165,780 | | |
| | | 28 | 4,889,640 |
| July 19th | 183,480 | | |
| | | 41 | 5,524,340 |
| Aug. 29th | 86,000 | | |
| | | 39 | 2,167,269 |
| Oct. 7th | 25,824 | | |
| | | 10 | 164,088 |
| Oct. 17th | 5,376 | | |
| | | 10 | 100,560 |
| Oct. 27th | 10,848 | | |
| | | 10 | 327,376 |
| Nov. 6th | 23,040 | | |
| | | 10 | 310,584 |
| Nov. 16th | 35,568 | | |
| | | 10 | 481,780 |
| Nov. 26th | 50,352 | | |
| | | 10 | 567,128 |
| Dec. 6th | 74,008 | | |
| | | 10 | 1,011,176 |
| Dec. 16th | 94,620 | | |
| | | 10 | 1,017,060 |
| Dec. 26th | 100,850 | | |
| | | 10 | 960,500 |
| Jan. 5th | 111,940 | | |
| | | 12 | 1,706,262 |
| Jan. 17th | 171,432 | | |
| Total | | 300 | 70,039,873 |

Average daily flow, 233,466 cubic feet, or 1,746,326 gallons.

These gaugings show an increase of flow between March 23d and May 7th, due to the melting of the snow on the ground. From May 7th to June 21st, the flow diminished so rapidly as to lead me at first to doubt the accuracy of the gaugings, but I found that the ratio of decrease, as given by them, was fully sustained by observations made during the same period by myself on the west branch of the Croton River.

The flow continued to diminish until the middle of October, since which time it has gradually but steadily increased.

We, have then, as the flow from Green Lake for 300 days, an average of 233,466 cubic feet, or 1,746,326 U. S. gallons per day, during the dryest portion of an unusually dry year. If for the remaining 65 days, the flow averages only 120,000 cubic feet per day, the average for the year would be 213,260 cubic feet, or about 1,600,000 gallons per day. Gaugings have also been made since October 7th of the water flowing into Crooked and Van Hoesen Lakes. The quantity of water given by these gaugings agrees closely with that given from Green Lake in proportion to the drainage area.

The flow from Green, Crooked, and Van Hoesen Lakes would be at the same ratio of flow per square mile of drainage area as that given by the above measurements of Green Lake, about 4,500,000 gallons per day, a quantity amply sufficient for the supply of a city of 100,000 inhabitants, if proper care is exercised to prevent waste.

Comparing the quantity measured, with the rainfall during the same months, we find the flow from Green Lake, between March 23d and January 17th, to have been 52½ per cent. of the rainfall during that time.

As the flow during January, February and March is larger in proportion to the rain than during the rest of the year, the total proportion for the year may be taken at 55 per cent, which, assuming the least rainfall to be 34 inches, gives as the least available water to be expected from Green Lake an average of 1,700,000 gallons per day, or from Green, Crooked and Van Hoesen Lakes, 4,800,000 per day, while 46 per cent. of the average rain of 45.51 inches per annum would give as the yield of the three Lakes, 5,355,188 gallons per day.*

While the *mean* daily flow from these lakes is sufficient for the supply of Syracuse for many years to come, the actual daily flow for a large portion of the

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* The gaugings of Green Lake were continued to March 1st, 1871. The daily flow had then increased to 245,633 cubic feet. The average daily flow since March 23, 1870, had been 231,356 cubic feet, or 1,730,543 gallons. Rain fall during same time, 32.76 inches. Proportion of flow to rainfall 54.63 per cent.

year is less than is needed. To meet this deficiency, storage room must be provided. The observations for this exceptionally dry season show that for nine months, the daily flow averages $\frac{3}{8}$ of the mean flow of the year, leaving $\frac{5}{8}$ to be supplied from the stored water.

For this purpose ten feet in depth of the three Lakes, below the level of high water of Van Hoesen Lake, gives storage for 840,000,000 gallons.

In these estimates, no allowance has been made for evaporation and absorption, the calculations being based on the actual measured flow from the Lakes, which was independent of the loss from these sources.

## PLAN.

The plan proposed for collecting and storing the waters, is to dam the outlet of Green Lake, and raise its surface five feet, or to the level of Van Hoesen Lake, and to connect Green and Crooked Lakes, and Crooked and Van Hoesen Lakes by brick conduits thirty inches in diameter, low enough to draw the water down ten feet. Suitable guard gates to be placed at each end of the conduits.

The three lakes will thus form a combination of storage reservoirs, with an area, at high water, of 324 acres, and at ten feet below of 188 acres, and capacity of 112,012,462 cubic feet.

The following table shows the effect of a season similar to that of 1870 on the proposed resevoirs:—

Table 7. Table illustrative of the effect of an unusually dry season on storage reservoirs in Tully Valley, holding 840,000,000 U. S. gallons, and supplying 4,500,000 gallons per day.

| Date. | Flow into Reservoirs U. S. Gallons. | Draught from Reservoirs U. S. Gallons. | Quantity left in Reservoirs. |
|---|---|---|---|
| June 1, | | | 840,000,000 |
| | 120,000,000 | 135,000,000 | |
| July 1, | | | 825,000,000 |
| | 100,000,000 | 139,500,000 | |
| Aug. 1, | | | 785,500,000 |
| | 72,000,000 | 139,500,000 | |
| Sept. 1, | | | 716,000,000 |
| | 40,000,000 | 135,000,000 | |
| Oct. 1, | | | 621,000,000 |
| | 8,300,000 | 139,500,000 | |
| Nov. 1, | | | 489,800,000 |
| | 18,000,000 | 135,000,000 | |
| Dec. 1, | | | 372,800,000 |
| | 50,000,000 | 139,500,000 | |
| Jan. 1, | | | 313,300,000 |
| | 80,000,000 | 139,500,000 | |
| Feb. 1, | | | 253,800,000 |
| | 100,000,000 | 126,000,000 | |
| March 1, | | | 127,800,000 |
| | 300,000,000 | 139,500,000 | |
| April 1, | | | 388,300,000 |
| | 500,000,000 | 135,000,000 | |
| May 1, | | | 753,300,000 |
| | 300,000,000 | 139,500,000 | |
| June 1, | | | 840,000,000 |

and 73,000,000 wasted for want of storage room.

If, in the course of time more water is required than these lakes can furnish, an additional supply can be procured from Big Lake. A large portion of the water which falls on its natural water shed, does not reach this Lake, but percolates the gravel, reaching the stream some distance below the outlet of the Lake, This waste can be prevented, and large storage capacity afforded, by a trench filled with puddle across the outlet of the Lake, extending to the rock, which, at this point, lies not far from the surface, and a dam raising the water surface about five feet. A connection with one of the other lakes could be easily made. The supply would thus be doubled, at least, at a very small expense.

## CONDUIT.

For bringing the water to the northerly side of the ridge between the Tully Valley and the valley of Onondaga Creek two routes have been examined. The shortest and most direct is by a tunnel from the north end of Green Lake.

The other is by following the channel which has been cut to draw the water of Crooked Lake into Christian Hollow, and then along the north side of the dividing ridge.

The distance from the outlet of Crooked Lake to a point on the east side of the valley is 11,800 feet. The distance from Green Lake to the same point by a line partially in Tunnel is 5,900 feet, a difference of 5,900 feet in favor of the Tunnel line. This is the only advantage it possesses over the other. The cost of the Tunnel would be greater, even allowing that no rock or quicksand was encountered, and that the material was dry gravel. For 1,000 feet at the lake end, a hard rock overlaid with muck and wet gravel would be met; for 300 feet more the ground is wet, and there is every reason to anticipate quicksand, and at the north end of the Tunnel the material is treacherous. The time required to complete a tunnel of from 3,600 to 5,000 feet in length, according to the depth at which it was placed, is moreover a very strong argument against its construction. The three lakes being necessary for storage, it will be best to draw directly from the one which furnishes the purest and softest water, has the largest water shed, and the greatest capacity. The route from the outlet of the Crooked Lake is therefore adopted.

The size of conduit for bringing the water to the city should be sufficient to pass, at least, six millions of gallons per day, the increased cost of such an one being but little compared with the cost of one bringing a smaller quantity, and which would have to be duplicated hereafter. For the material of which it should be built, brick laid in hydraulic cement is recommended. The use of earthenware pipes for this purpose has been strongly urged by some of your citizens, but I do not think that in this case they have any special advantages over brick, and comparative estimates of the cost of a circular brick conduit, twenty-six and one half inches in diameter, and eight inches thick, and of earthen pipe twenty-four inches in diameter, show that the former would be cheaper, even supposing the pipe to be delivered on the ground free from all loss by breakage. In practice, the rugged and almost inaccessible nature of much of the ground over which the conduit passes, and the great weight and consequent difficulty of handling the sections of pipe, would probably cause a large per centage of breakage and consequent increase of cost of pipe. Wood is, from its lack of durability, unfit for use in so costly and extensive a work as this. Cement pipe is of doubtful durability. Iron pipe of the proper calibre would be too expensive.

The size of the conduit is determined by the grade adopted, which is in turn governed by the ground to be passed over. To save a long detour around Indian Hill, a summit near Lafayette must be crossed. This summit is the ruling point of the grade South of it, and to the North the same grade has been followed to avoid the outcropping of the limestone. The gradient is two feet in 1,000, or 10.56 feet to the mile.

From the outlet of Crooked Lake, the conduit line surveyed follows this grade for 77,200 feet, crossing three deep gulches by inverted syphons of iron pipe, and making two perpendicular drops of about fourteen feet each. Near the north line of the Indian Reservation a fall of 100 feet is made through an iron pipe delivering into an open chamber, from which the brick conduit is continued 5,700 feet to another fall of 125 feet. From the chamber, at the end of this pipe, it is proposed to use an 18-inch earthen pipe on a steeper gradient, to a point three-quarters of a mile east of Onondaga Valley and near Alvord's Lime-kiln, where a reservoir of eleven acres area, and depth of water of from 17 to 28 feet, containing 62,000,000 gallons, will be built. The flow line of this reservoir will be 270 feet above the canal. From this reservoir two lines of pipe will be laid; one to supply the higher portions of the city, the other 5,300 feet to supply another reservoir, to be built in a hollow in the hills one-half mile east of Brighton Corners. This, the distributing reservoir, will have a water surface of six acres, and a capacity of 34,612,500 gallons. The flow line will be 173 feet above the canal From this reservoir the main for supplying the city will be laid to the canal at Salina street, 15,000 feet.

No provision is made in the estimates for distribution through the city.

The conduit passes over very favorable ground, the alignment being good, and running, for most part of the distance, along hillsides where any desired elevation can be obtained by a slight change of line. The line is substantially that recommended by Mr. H. D. L. Sweet last Summer.

ESTIMATES.

The estimated cost of the works proposed for the present use of the city is as follows:—

| | |
|---|---|
| 1. For work at the Lakes, including dam at Green Lake, connecting conduits between Green and Crooked, and Crooked and Van Hoesen lakes, outlet chamber at Crooked Lake, land damages and compensation to mill owners | $134,722.00 |
| 2. For conduit from lake to storage reservoir, 89,600 feet, including also land damages | 474,682.10 |
| 3. For reservoir of 11 acres with lining of stone 18 inches deep, backing of broken stone, and bottom puddled, including land damages | 99,110.00 |
| 4. For connecting main between reservoirs | 17,264.00 |
| 5. For distributing reservoir of 6 acres | 57,327.00 |
| 6. For mains to the high service and to the canal at Salina street | 90,000.00 |
| Total | $873,105.10 |
| Add fifteen per cent, for contingencies, superintendence, engineering and office expenses | 130,965.77 |
| Total estimated cost | $1,004,070.87 |

In consideration of the great advantages to be derived from the introduction of pure and wholesome water in profusion, this cost is not excessive. The annual interest upon it would only be $1.56 for each person in a population of 45,000, even supposing the income from the water to only cover the expenses of maintenance of the works. The income, however, would undoubtedly be much in excess of this, and would soon, if not immediately, be sufficient to pay the interest and leave a balance annually for liquidating the debt.

In the above estimate of cost the brick are put at the highest current rates for the best selected hard brick. If, as is extremely probable, a large portion of them can be manufactured near the line of the conduit, the cost of the work would be diminished about $30,000.

All the other items have been estimated at very liberal prices, and I have no doubt that the work can be done within the cost named.

The following maps and plans accompany this report :—

1. Map of the water-shed of Tully lakes.
2. Map of the line of conduit from Tully to Syracuse.
3. Map of Big Lake.
4. Map of Green Lake.
5. Map of Van Hoesen Lake.
6. Map of Crooked Lake.
7. Plans of dam and connecting conduits and chambers at the lakes.
8. Details of conduits and syphon chambers and drop wells.
9. Plan of reservoirs and gate chambers.
10. Profiles of the Tully Valley.
11. Profile of conduit line from Tully to Syracuse.

In conclusion, I desire to express my obligations to members of the committee for information furnished, and assistance given by them, and to Mr. H. D. L. Sweet for his aid in the surveys, much valuable information concerning the topography and geology of the regions examined and the use of the notes of surveys of the county made by him in 1860. I wish also to acknowledge the assistance rendered by Mr. M. E.

Williams in the surveys, and the very efficient services of Mr. Walter S. Church, Jr., on the surveys and calculations, and of Mr. H. W. Clarke in the preparation of the maps.

Respectfully submitted,

J. J. R. CROES.

# REPORT

OF

# A. W. CRAVEN, CONSULTING ENGINEER.

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NEW YORK CITY, 38 BROADWAY,
January 28, 1871.

*To the Honorable, the Joint Committee of Aldermen and Citizens of Syracuse, on the Feasibility of Procuring a Supply of Water from the Tully Lakes :—*

GENTLEMEN : In the latter part of August last, I had the honor to be consulted by your committee as to the value of the Tully Lakes and their sources, in the important question of a supply of water for your city. After a general reconnoisance of the ground, and a consideration of such points of information as were obtainable, I recommended, in a brief report, which was submitted to your committee on the 10th of September, that accurate surveys and careful examinations be made, to ascertain not only the quality and quantity of the water which could be safely relied upon as the yield of that region, but the cost of properly constructed works, for bringing it into your city. At that meeting my suggestions were adopted, and a resolution was passed requesting me to act as consulting engineer, with a general supervision of all operations, and directing that all plans and estimates should be subject to my approval. At your meeting on the 22d of September, on my recommendation, Mr. J. J. R. Croes was appointed the engineer to conduct the investigations. This selection was made by me because my long continued personal knowledge of

Mr. Croes enabled me to rely upon his ability and fidelity. The surveys have been made—every point bearing upon the question before us has been carefully examined, and the results are set forth in the report of Mr. Croes, which, with this paper is now laid before you. From frequent personal examinations in the field during the surveys, and careful consultation over the results and subsequent plans and calculations, I am prepared fully to endorse the statement of facts, and approve the general plan of the work sketched out in this report.

As a *summary*, the details of this report establish the important facts—that, from what are called "the Tully Lakes," water most excellent in quality and sufficient in quantity for more than one hundred and fifty thousand inhabitants, can be brought to your city, and at a cost which, compared with the great benefits immediately and certainly accruing to persons and property, will be very moderate.

Although it will involve the repetition of much that is said in Mr. Croes' report, I deem it advisable to analyze this summary to a certain extent, in the hope of showing, perhaps more plainly to the non-professional reader, how clearly the details point to the deductions, and justify the opinions which I have formed, and here submit:—

## Quality.

The first question to be considered, in examinations of this kind, is the *quality* of the water; since, if water be impure, or for any reason unsuitable for its proposed uses, a calculation of the quantity procurable, or the cheapness of its introduction, would be of little value. The manifold advantages of *purity* and *softness* in water, for all domestic purposes, the salutary effect of such water upon the health of towns, its great value for steam boilers, and its power to attract to the city favored with its possession, bleaching, dyeing and other manufacturing establishments, in which pure water is requisite, are all well recognized, and universally admitted; but the actual pecuniary value of *softness* in water used for household purposes, is not so generally known. To show this in some degree, I take leave to quote from a report made to the Water Committee of Providence, in 1869, by Mr. J. H. Shedd, the engineer of the works now in progress for the supply of that city.

Mr. Shedd says: — "In household economy, besides the question of what is agreeable and wholesome to drink, and of what is easy to wash with, it is important to consider that the waste of materials which it is desired to infuse or dissolve, such as tea, coffee, soap, etc., is very great in hard water. The effect of hardness, or the presence of lime in water, is well understood as increasing the difficulty of washing with it; but the actual waste of soap in hard water, is greater than may be supposed. A certain quantity is expended in neutralizing the lime before the soap will dissolve freely and make a good lather. The loss is ten grains of soap to one grain of lime. One grain of lime in an imperial gallon of water, is called one degree of hardness. In water, then, from the softest well analyzed by Professor Appleton, of 4.90 degrees hardness, about 50 grains of soap must be wasted in each gallon of water; and in that from the hardest well, of twenty-two degrees hardness, two hundred and twenty grains.

At the Bolton-Union Workhouse, England, about five dollars per week, or about half the former cost, was saved in soap by changing from water of five degrees to water of two degrees hardness—that is, similar to the softest well in Providence tested by Prof. Appleton, to water similar to that of either of the neighboring rivers. Taking the English experiments of Prof. Clark and Mr. Donaldson, and assuming that each family in Providence uses, from the wells, only five gallons of water per day, for purposes requiring the use of soap, and that the saving in the city, by substituting river water for well water, would be equal to the difference between the average hardness of the well waters and river waters as ascertained by Prof. Appleton, we should have an annual saving of forty-two thousand dollars to the citizens, in the item of soap alone, by the public supply of river water. Writers upon this subject say the saving of wear and tear of clothes is fully equal to the saving of soap. In the making of tea, and other infusions of costly material, the loss is very great, from the fact that hard water will not readily absorb the flavor. Mr. Soyer concludes from his experiments, that the same quantity of tea will make five cups with soft water, and but three cups with hard water. He also finds great difference in favor of soft water, in the cooking of vegetables and meats, where it is desired to soften them, or to abstract their juices.

"No doubt the unsatisfactory quality of the well water in use in Providence and its vicinity, is as important a reason for a new supply as the want of a more abundant quantity."

That in the qualities of purity and softness, the water within the reach of the citizens of Syracuse is at the highest standard, is proved by recent analyses made by Professor Chandler, and embodied in table No. 1, of Mr. Croes' report. In table No. 2, Mr. Croes gives the degree of impurities in the waters at present supplied to twelve of our important cities. Of this number only two—Boston and New York—are favored with water as pure and soft as the water of Crooked and Van Hoesen Lakes, while those of Big and Green Lakes compare very favorably with the average of the ten remaining specimens, and are, in fact, not so hard as to be objectionable. The mixture of the waters of Van Hoesen, Crooked and Green Lakes, in the proportion of the quantity which would be yielded by each when all three were drawn upon at one time, gives a water of but 5.76 grains of impurity to the gallon. This is very nearly the average in the column of impurities for the twelve different cities referred to. It would be many years before your city would require a supply greater than would be furnished by the three lakes mentioned, and for that time you would be enjoying water, remarkable, even in a long catalogue, for purity and softness. Even when the entire flow of all the Tully lakes would be needed for your city, it would still have a supply, which, in the strictest comparison with a majority of the purest water sources from which our towns are supplied, would stand far above the average in quality.

Between the quality of this water, and of that with which your city is now partially supplied, a comparison need hardly be made. It seems, however, fair to add, that reasoning from the facts and experiments mentioned in the extract made from Mr. Shedd's report, the annual saving in the household expenses resulting from the difference in the hardness of the Tully water, and of that which is now brought into your city, would prove a very material offset to the annual interest on the cost of the works now proposed.

## QUANTITY.

The next consideration is the *quantity* of water obtainable.

The drainage area of the four Tully lakes, the flow from which could be made tributary to the supply of your city, is 8,783 acres, or 13.72 square miles—an area more than three-fourths of that supplying the 200,000 inhabitants of Boston.

In the general plan of the works proposed, it is designed to draw at the present only from the three smaller of the lakes, viz:—Green, Crooked and Van Hoesen. These three have a drainage area, or water shed of 5,443 acres, or 5.38 square miles. The annual rain fall on this area is shown by the observations made by Judge Reed, at Homer, (see table No. 5,) to equal an average depth, for the last twenty years, of 45.51 inches. The least rain-fall in any one year during that period, was

34.43 inches. The quantity which fell last year was 41.30 inches.

To ascertain the proportion of the rain of last year, which found its way to the lakes under consideration, gaugings of Green Lake were made at different times from March 23d to July 19th, by Mr. H. D. L. Sweet. These guagings were not intended to be perfectly exact—the method of making them not being such as is relied upon where minutely accurate results are required. They have, therefore, been tested by a comparison with observations and measurements by means of weirs, made with great care and accuracy, during the same period, in other parts of the country. This comparison would make the flow from Green Lake very much greater than the quantity calculated by Mr. Sweet; and, therefore, warrants the assumption that his results were substantially correct, and at least not in excess of the actual flow. For still further safety however, Mr. Sweet's results have been materially reduced, and only in this diminished volume have been taken into our present calculations.

From Oct. 7th until the present time, daily guagings have been made by means of wiers, the accuracy of which method is unquestionable.

The results of all these measurements are exhibited in Mr. Croes' report, (Table No. 6) and show an average daily flow from Green Lake from March 23d, 1870, to Jan. 17th, 1871, of 1,746,326 gallons. This is equal to 52 1-2 per cent. of the rain-fall during that period. If, for the remaining portion of the year, we assume 900,000 gallons per day as the flow, (which is less than observation gives us the right to expect) the average daily flow for the whole year would be 1,600,000 gallons. Gaugings made at Crooked Lake, and other examinations show that there can be collected from the drainage area of that lake and of Van Hoesen Lake,*

* Although Van Hoesen Lake has no visible outlet, its surplus waters, after reaching a certain elevation, pass off by percolation through the gravel which forms its margins and banks. Its margins are entirely free

the same quantity per square foot of surface as is yielded from Green Lake. From these three lakes combined, we should therefore, obtain 1,644,984,190 gallons as the aggregate flow of the year, or 4,506,806 (in round numbers 4,500,000) gallons per day. This would be 60 gallons per head, daily, to a city of 75,000 inhabitants; provided, the yearly aggregate could be equally distributed for daily consumption. But in all sources of water supply there are always portions of the year during which the daily flow is much less than the daily proportion of the year's aggregate. This has been the case to a peculiar degree, throughout the country, during the past year.

To provide for the deficiency during such periods, storage reservoirs are necessary; and in the lakes of the Tully Valley, we have them already made for our purpose. By a short dam at its outlet, Green Lake can be raised five feet, or to a level with Crooked and Van Hoesen Lakes. As the plan of our work makes the top of the conduit or aqueduct ten feet below the surface of the three lakes thus combined, we shall have then a storage reservoir 324 acres in area on its surface, 188 acres area at its lower plane, and having a depth of ten feet. Its capacity would be 840,000,000 gallons. This quantity, together with the daily flow as indicated by our gaugings, is shown in table No. 7, of Mr. Croes' report, to be sufficient to furnish a supply throughout the year of 4,500,000 gallons daily, and still leave the reservoirs full for the commencement of next year.

The above calculation is based upon a flow equal to 55 per cent. of the rain-fall, because our gaugings and other investigations justify the assumption that this proportion of the rain falling upon the particular region, or drainage area in question, can be collected. But for extreme safety, let us take the much lower

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from any aquatic vegetable growth and its water is of remarkable purity and sweetness Its surplus, now lost by percolation through its banks, will be diverted by the plan proposed, and thus added to the water of Crooked Lake, will be made available for our supply.

proportion measured in Madison Brook in 1835–6, namely, 46.70 per cent., and apply it to the lowest rain-fall for any year recorded at Homer, namely, 34.43 inches. This would give from the water-shed of the three lakes under consideration, an aggregate flow for the year, of 1,507,357,207 gallons, or, 4,129,740 gallons per day. This would furnish 60 gallons per head each day to 68,829 inhabitants, or 45 gallons per head for 91,772 inhabitants.

Partly because the facility for great waste is afforded mainly by introducing unmeasured water into several rooms in every building, and partly because recklessness and profusion in the expenditure of water only become excessive after long habituation to a profuse supply, it would be some years before your inhabitants would draw from the aqueduct, (whatever might be its capacity) 45 gallons; or, in other words, *a barrel and a half* of water every day for each man, woman and child of its inhabitants.

### EXTENSION.

All experience teaches us that the introduction of a copious supply of pure water into a city is always followed by an accelerated increase of the population. All considerations of prosperity, health and safety point to this result, and it should be provided for. When, by this increase, your city would require a greater quantity than can be obtained from the three lakes just described, there would still be remaining for an additional supply, Big Lake, with its extensive portion of the drainage area embraced in our system of works. That portion is 5,337 acres, or 8 34-100 square miles. The drainage area of Big Lake therefore, is, to that of the other three lakes as 8 34-100 to 5 33-100, or 1 55-100 times greater, and its capacity or yearly flow should be greater in the same proportion. If the works should be extended, therefore, so as to include Big Lake in the manner proposed, the entire flow for the year from the whole drainage area of 13 72-100 square miles, would be equal to a daily average of 10,530,837 gallons, or a daily supply of 60 gallons per head of 175,513 inhabitants.

That from the Tully Lakes, therefore, there can be drawn a supply of the purest water, sufficient, during a great many years to come, to meet most liberally and even profusely, every draught that your city can make upon it for domestic uses, for public health, for the extinguishment of fires, for public fountains and public baths, and for the numerous manufacturing establishments which will be rapidly attracted within its limits, seems to me to admit of no question.

### PLANS AND ESTIMATES.

As to the plan of the work, as proposed, it is submitted with my full endorsement and approval. The surveys have been made with great care and thoroughness, and should the work be undertaken, the labor to be performed in the final adjustment of the line, etc., for construction, will be less than usual.

The estimates have been made with careful and minute attention to, and consideration of, details, and on the assumption of the most liberal prices for material and labor; and I think you may safely assume that the actual cost of the work, on the plan proposed, would not exceed the estimate here presented.

Submitting these, as my well-considered opinions, I am, gentlemen,

Very respectfully,
Your obedient servant,
A. W. CRAVEN,
Consulting Engineer, &c.