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1892

## Proposed water works for Rolla

Frank L. Tyrrell

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Water Supply for Cities

U.S. HISTORICAL COLLECTION

In supplying a city with water there are two points to be considered. The quality of water and the cost of supply.

When water is used from our large rivers, it is pumped into basins, allowed to stand, settle, and is then passed to other basins where it undergoes some process or it is filtered by being passed through several feet of sand, gravel, and charcoal. Either of these methods are expensive and resorted to only in large cities, which cannot be supplied in other ways at a reasonable expense. Smaller cities and towns use other means, viz. hand-drawn, artesian wells and storage basins.

as localities demand.

A storage basin is an efficient way of supplying a city with water.

The ordinary manner of forming these basins consists of closing some valley by a dam of earth; it was not until recently that masonry was used for that purpose. This method seems to have been first adopted in Spain where large reservoirs were used for irrigation. It is however a dam is used extensively in this country consisting of a core wall of masonry extending to the desired height off the water, reinforced by earth embankments upon either side, generally standing on a slope of  $1\frac{1}{2}$  to 1. In choosing a location we are governed by the amount of water

we are required to supply, and up  
on the cost of supplying it.

The water depends upon the water  
shed, amount of rainfall, whether the  
surface is impervious or not, and  
whether the under strata of  
rock, if near the surface is inclin-  
ing toward, or from the valley  
crossing. The cost depends upon the  
value of the land, and expense of  
clearing, and making it suitable  
for the proposed purposes, also its  
distance from the city.

The city of Rolla can be cheaply  
supplied upon the storage basin  
plan. The site chosen for basin  
is in a small valley North of Rolla  
extending N & S and about three  
fourths of a mile distant. The

valley is narrow and has very steep sides, The West side is covered by a thick growth of timber which extends to water shed, The South side has a small clearing or shed extending down short way, the balance of South side has thick undergrowth, The East side has been cleared for pasture and contains yet many small trees and numerous stone fences.

The Water shed commenced at a point, at W. side of Rolla & Beckley road marked by a stone placed 10 feet E of junction of wire & rock fences, E of house North of Mr Merritt's, Line running N.  $56^{\circ}30'$  W 173.3, S  $13^{\circ}$  W. 501.4, S  $12^{\circ}$  E 512.7 thence deflecting  $46^{\circ}$  run 653.1, deflet.  $49^{\circ}20'$  967.8, deflet.  $18^{\circ}55'$  211.8, deflet.  $58^{\circ}3'$  run

1222.4, defct -  $58^{\circ} 5' 30''$ ,  $865^{\circ} 30' 8.8$   
to starting point.

The site for dam is in valley  
W. of Mr. Merwin's house at a pt  
where the valley is most narrow  
(shown in Plate I) and will extend  
in a line perpendicular to the  
center line of valley.

We are depending for the most  
part upon the rain fall, though  
not entirely, there being several  
springs which combined yield an  
about 5 thousand gal. per day, through  
several months of the year, and some  
last the year around.

The following are the statistics  
taken from the agricultural report  
of 1891 upon the same fall of Wisconsin  
and Illinois especially, for the last

10 years.

Report for Rolla

Jan.	2.34	July	5.16
Feb.	2.83	Aug.	3.46
Mar.	3.41	Sept.	3.27
Apr.	4.35	Oct.	2.42
May.	4.57	Nov.	2.28
June	4.03	Dec.	2.26

average 40.4

Each month was average for 10 years. The mean taken for 34 Stations throughout Missouri is 38.18 an yearly rain fall.

According to survey there are 57 acres of drainage, there will fall upon this area 61,892,975 gal. Allowing the reliable amount  $\frac{1}{10}$  for storage we have 37,135,785 gal. per year, 50% of this will be lost by

evaporation which will leave  
35,274,976 gallons per year for storage.

Records cover a large area in  
comparison with the low population,  
the main living in houses which  
contribute largely to their water  
supply, not mentioning of wells.

It is estimated that 30 gal  
per capita a day, would be suf-  
ficient with an assumed popu-  
lation of 3000,

This would make a daily  
supply of 90,000 gal.

At this rate a reservoir would be  
required to hold over 1700,000 gal.

The first step is to determine the  
height of dam. From a contour  
survey made of dam site Oct-1891  
Plate I, the following calculation



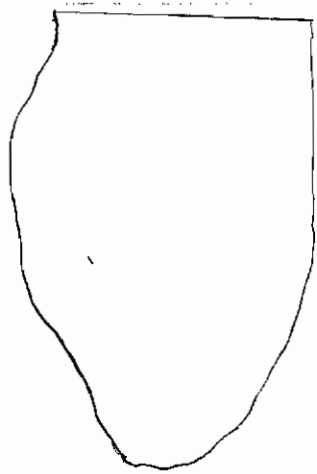
is made, drawing the flat ties  
across scale, the Plafometer was run  
around each contour commencing  
within the innermost circle, The reading  
of the Plafometer gave the area  
in sq. feet, which multiplied by  
the volume of water (2 feet) gave cub.  
contents enclosed within each  
contour, The operations were re-  
peated successively until the re-  
quired amount was reached.

The dam being in lowest pos-  
tion, its height is determined by  
the required column of water, which  
we find to be 22 feet; But we  
will design a dam 25 feet high.

It is required to design a  
water system from above data  
for the City of Rolla, from survey

made in April 1892, the traverse  
is as follows commencing at  
O. post fire driver flush with  
surface, at a point 105' due W. from  
N. E. Cor Main & 12 St. running  
N. 1650, reflecting 30°, 45', extends  
650' (Station 1). Then in stand pipe  
sili, shown on Plate I, deflecting  
60°, line runs direct to pump  
1200 feet. From station O. Main  
& 12 St., line extends S on Main to  
10<sup>th</sup>, E on 10<sup>th</sup> to Pine, thence South  
on Pine to Second St, a branch  
main to run W on 2<sup>nd</sup> St to Centre  
street, a branch to extend from  
10<sup>th</sup> south on Main to 4<sup>th</sup> St

Another to connect with Main  
on 8<sup>th</sup> & Pine, extend East on 8<sup>th</sup>  
to Olive, thence South to fourth



Mereweather

Pump

N

Rolla Vichy Road

1200

# Traverse Survey

60°

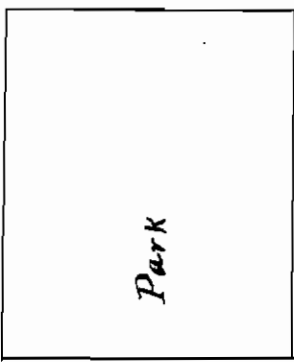
□ Baker

○ Stand Pipe

30.45

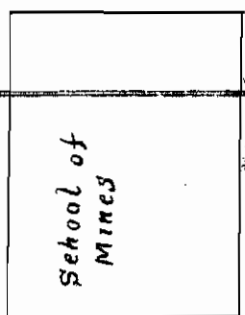
650'

Mrs. Smith



Park

1450



School of  
Mines

12th St

12th St

S 10

as shown in map. City of Rolla,  
Plate II

From Level Surveys made in  
April & May 1892, the profile was made  
(Plate III) by which the following eleva-  
tions were derived, taking the City's  
elevation from the Gulf of Mexico,  
(B.M. on Masonic door step 1100.05)

Station 0, 1134.95

Stand Pipe, 1179.69

Pump 1047.86

10<sup>th</sup> & Main Sts 1115.30

8<sup>th</sup> & Pine 1107.01

## Stand Pipe

When a city is supplied with water it is necessary to have head enough to force the water to every portion of the highest buildings. To do this the Engineer uses gravity as his power, by pumping to some high point and allowing the water to flow through pipes to the city. Where a city has no hills upon which to place a reservoir she erects a Stand Pipe.

This is variously constructed, though generally it is made of boiler iron, and can extend to any desired height, some going as high as 150 feet.

The City of Rolla has no hills high enough to give sufficient

pressure, but by putting a 50 ft stand pipe upon the highest neighboring hill a sufficient head can be obtained.

The diameter (10 ft) is taken so that it will act in a small way as a storage. The pipe will hold 29,377.6 gal. end

The calculation is as follows.  
From equation

$$Pd = 2St$$

where  $P$  - pressure,  $d$  - dia in in.  $S$  - strength of iron,  $t$  - thickness, or

$$21.7 \times 120 = 2 \times 8000 \times t, \therefore S = 8000$$

or  $t = \frac{1}{50}$ " = bursting thickness of plate, giving a safety factor of 10 to meet all resistances thickness is  $\frac{1}{50}$ ".

The first 25 feet of pipe is taken

at  $\frac{1}{4}$ ". 2nd. 25 feet at  $\frac{3}{16}$ "

Making allowance for lap in  
both directions and supposing  
plates of iron to be about 3' long  
and 3' wide we have

917 sq feet @  $\frac{3}{16}$ "

917 " " @  $\frac{1}{4}$ "

Rolls iron per sq ft  $\frac{3}{16}$  weighs 7.5<sup>#</sup>

" " " "  $\frac{1}{4}$  " 10<sup>#</sup>

917 -  $\frac{3}{16}$  @ 7.5 lbs = 6877

917 -  $\frac{1}{4}$  @ 10 " 9170

Total 16047

Kinds 500

or abt.  $8\frac{1}{4}$  tons, which at \$50. per  
ton = \$412.5

Excavation & Foundation 100.0  $\frac{2}{3}$

Surveys 100.

Total \$612.50

## Water Mains

Pipe for water mains is cast in lengths of 12 feet for all sizes from 3 in dia to 48" dia, and weigh from 15 lbs for 3 in to 5 to 7 hundred for a 48 in, per foot. There is a flange or socket upon one end, for sizes from 3 in to 10 in, this is 4 in, larger sizes increase proportionally to 5 in.

When the pipe is laid and each straight end fits well into the socket of the other, the joint is wrapped and filled with milled lead, this joint is capable of resisting great pressure.

Pipes from standard firms are tested by an hydraulic pressure of 300# per sq in.



## Pipe Line A.

Main A is 1200' long, extends from pump to stand pipe, difference of elevation 131.8'

The pipe will be designed to carry  $3\frac{1}{2}$  times as much as daily demand or 1 cu ft per second. By calculation a six in pipe is chosen.

6 in pipe weighs 35 lbs per lin. ft. An assumed price of \$23. per ton is taken, though the regular price will not vary far from this.

12 ft @ 35 = 420\*

420\* @ 1.15 per hund. = \$4.83

8" Lead @ 5 = 140

9 lb yarn = 30

Labour of felling = 10

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5.63

103 lengths @ 5.63 = \$579.89

Main B.

Main B. extends from stand pipe to 10<sup>th</sup> street, distance of 2800 feet, dif. of elevation 45.5, Stand pipe 50'0", Pot. 115.5 feet

It is designed to deliver at Main & 10<sup>th</sup> 403, 704 gal. per day or 1.25 cu ft. per sec. A 10 in pipe is adopted.

The Lost head is calculated as follows

$$\text{Lost head} = (h_1 + h_2 + h_3) - (1.5 + f \frac{l}{d}) \frac{v^2}{2g}$$

$$v = \frac{q}{A} = \frac{1.25}{.7854 \times (83)^2} = 2.3$$

$$L. h = (1.5 + 0.2 \frac{2800 \times 2.3}{83}) \frac{5.29}{64.32} \quad g = 32.16 \text{ - gravity}$$

Where  $l = 2800$ ,  $d = 10$ ,  $t = 0.2$ ,  $v = \text{velocity}$

The Pressure head at 10<sup>th</sup> is 110 feet.

10 in pipe 70# per foot = 840 @ 1.15 = 9.66

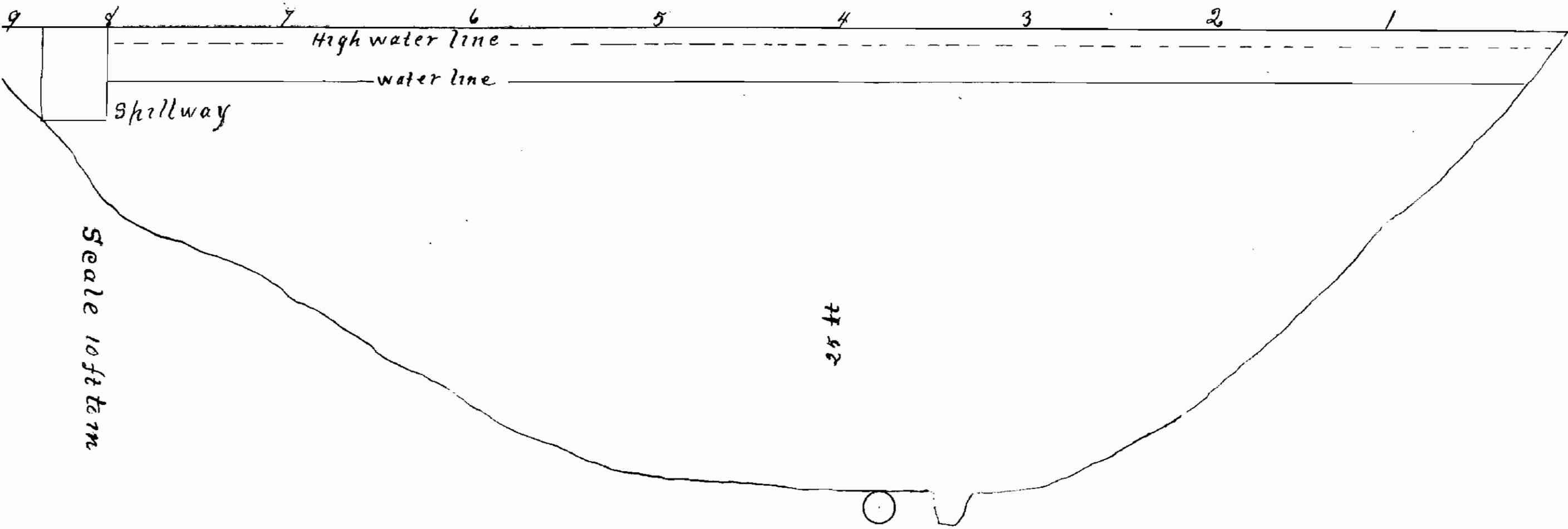
Lead per joint (45#) @ .5 = .75

Yarn & Labor = 10.94

240 lengths @ 10.94 = \$2630.40

PLATE IV

450 ft



Profile of Surface for Dam

Scale 50 ft to in

F. L. Tyrrell

June 1892

Main D.

Main D. extends from 10<sup>th</sup> & Main st  
to 8<sup>th</sup> & Pine as shown in Plan II  
a distance of 1155 feet; difference  
of elevation 8.33 feet; Lost head  
2.33 ft. or the pressure head at 8<sup>th</sup>  
and Pine street is 116 ft  
98 lengths @ 10.96 = \$1074.08

Main D.

Main D. extends South on Pine st  
to Second st distance 1900 feet  
Population 1500, Pipe to deliver,  
or be drawn from at all points.  
To deliver 141,596.6 gal per day or \*  
15 cu feet per sec.

16 in pipe gives a velocity of 2.6  
Lost head =  $f \frac{v^2 l}{2g}$  or 3 feet,  
Hgt. of elevation 35 ft. pressure height  
141.5 - 3 = 138'

\* Assume the value

Cost per length \$5.63

127 lengths @ 5.63 = \$715.00

Main C.

Main C is designed to deliver 193703 gal. per day or .3 cu ft per sec. and is located from junction at Pine & 8<sup>th</sup> street to Olive, South on Olive to 4 street a distance of 1800'. Elevation same as 8<sup>th</sup> & Pine, a pressure head is required of 110 ft.

Calculation of diameter

$$d = .479 \left( \frac{1}{3} \right)^{1/5} \left( \frac{193703}{h} \right)^{1/5}$$

or 4 in. is desired size

Weight per length = 24# per ft = 288#

288# at 1.15 = 3.31

Lead 4 1/2 lbs @ .5 = .22

Jam 7# = .17

Labor @ 2.50 \$ .10  
\$ 3.80

83 lengths @ 3.80 = \$315.40

Main A.

Main A extends from junction at  
Main & 40<sup>th</sup> St. S on main to 4<sup>th</sup>  
distance, 1400 ft, a 3 in pipe will  
be sufficient to meet all demands  
on this line, Required 500  
3 in pipe lengths per lin. ft - 15 lbs.

180 <sup>ft</sup> at 1/15 -	\$2.07
Lead 3/2 <sup>in</sup> at .5	.14
gum & Labor	<u>.25</u>

Total cost per foot, - \$2.46

130 lengths @ 2.45 = 318.5

Main B.

Main B. is branch running  
West on 2<sup>nd</sup> St forming Pine,  
It is one which will not be  
counted in this work.

## Engine & Pump

The engine & pump must have sufficient capacity to deliver in standard pipe 1 cu ft per second.

To do this it must not only be able to lift the weight of one cu ft. through 181.8 feet but must overcome all resistances, the greatest of these are loss of head at entrance & friction. Stated in formula

$$K = wqH + wqH(h' + h'')$$

$$K = wqH + wq \left( h_1 + f \frac{L}{d} \right) \frac{v^2}{2g}$$

$w = 62.5$ ,  $q =$  discharge (1),  $f$  coef. of friction .02

$h_1 = 0.5$ ,  $L = 1200$ ,  $d =$  dia of pipe  $= .5$ ,  $v =$  vel

$$K = 62.5 \times 1 \times 181.8 + 62.5 \times 1 \left( .5 + 0.2 \frac{1200}{.5} \right) \frac{13}{3216}$$

$$K = 11362.5 + 1225 = 12587.5 \text{ foot lbs}$$

$$H.P. = \frac{K}{55} = \frac{12587.5}{550} = 23, \quad v = 3.6$$

But will assume a 30 H.P. Engine & Pump

The probable cost of which will be  
\$1800.

## Dam

The side chosen for dam has at the depth of three feet a strata of blue clay, which seems to be more firmness to water. This is a good substitute for rock and is possible the calculated cost of the dam will depend the large quantities of material on each side of valley and close at hand afford the best of opportunities for a well built, and cheap structure.

The dam is 450 ft. top measurement 25 ft. high, with a core of puddled earth 5 ft. wide and extending entire length and height of dam. The sides slope at  $1\frac{1}{2}$  to 1. From survey made June 4 1892 there will be 2000 yds to be removed and puddled for foundation. There is about 900 cu yds of earth in entire dam, the estimated cost is \$71.



819 cu yds. in core wall.  
6400 " " " Side "

Removing 2660 yds @ 25	\$665.
Riddling 2660 " @ 20	<u>532.</u>
Total for foundation	\$1197.

Riddling interior wall @ 50 -	409.5
Hauling 6400 @ 35	<u>2240. -</u>
Total for Dam (cont.)	\$3846.5

The dam has a 20 ft spillway the bottom of which will have riprap for a distance of 20 feet each side of wall. Wall will be of stone masonry six feet high, the top coming even with general surface of dam. There will be two gates 3 ft. below average water line, to be opened in case of freshet. The entire opening is 6 x 20'

The Spill way will cost	\$ 325.
Clearing	3 846.50.
Total	\$ 4171.50

Land

It would be necessary to buy the land from which the water would drain. This is necessary for two reasons, 1<sup>st</sup> So that the City would never be without resource, 2<sup>nd</sup> It could clear and place it in the proper condition for a healthy supply of water. The valley above dam should be cleared of every thing of an organic nature, to make the water better, and to offer less resistance to flowing water.

shd. be covered by vegetation

There is about 30 acres of cleared land included within watershed. This would cost about \$15 per acre

The unleased land would cost about \$8 per acre. It would cost about \$7 per acre to clear the land for lines.

Estimate

27 acres (leased) @ \$7.	189.
30 " cost- 15.	450.
27 " " 8.	216.
General Clearing 57 @ 3	\$ 171.
Total for land.	1626.
The pipe line laid not less than three feet would cost as follows.	
4000 feet out of city @ 30 cts a yd.	270.
6455 Inside of city @ 40 cts	573.60
Sunds	<u>300.</u>
Excavating	\$ 1143.60

100 feet of 24" pipe with value \$257.  
This is placed as shown in profile to drain the lake.

Standard Metal	
Lands	\$ 1026
Mans	4171.50
3755 ft 10 in pipe	3704.48
3100 " 6 " "	1294.89
1800 " 4 " "	315.40
1600 " 3 " "	318.50
Engine	1800.00
Stand Pipe	612.50
Excavating	1143.00
100 ft 24 in Pipe	257.00
Lands	600.00
	<hr/>
	\$ 15,243.27

A comparison of the water rates of cities is one of the most accurate methods, that can be employed in judging the management of the different systems, since the main balance is largely met by the revenue derived from consumers.

This is more especially true when the works are owned by the City in which they are placed, as the only object is for the consumer to pay for the expense of operation.

Companies of course furnish water for profit, and therefore a comparison of their rates, with each other, and with those of public works is desirable, in order to ascertain whether they are furnishing water at reasonable figures.

Another advantage is of obtaining the relative advantages of public and private ownership. The Engineering News (1890) gives exhaustive tables of rates of 1000 Gallons, from all parts of the United States and Canada, and we find that the private concerns charge a few cents more to the 1000 Gal. than public, but it is affirmed that their plants are more costly.

The average for the whole U.S. show a cost of 102.07 for all public against 117.28 for private concerns.

A. L. Pyrell.