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INVESTIGATION OF THE WATER SUPPLY SYSTEM OF JACKSON, MICHIGAN WITH RECOMMENDATIONS FOR FUTURE IMPROVEMENTS

William C. Johnson Carl M. Waltz

1924

THESIS

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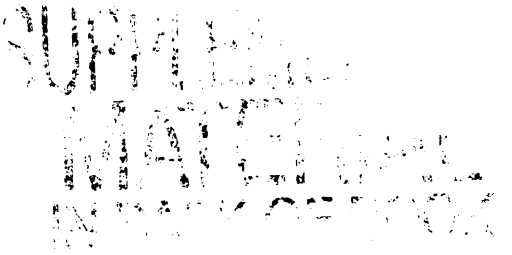

INVESTIGATION OF THE WATER SUPPLY SYSTEM OF JACKSON, MICHIGAN, WITH RECOMMENDATIONS FOR FUTURE IMPROVEMENTS.

A Report Submitted to the Faculty

of

MICHIGAN AGRICULTURAL COLLEGE

By

William C. Johnson

Carl M. Waltz

Candidates for the Degree of

BACHELOR OF SCIENCE.

June, 1924.

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PART I.

Introduction.

The investigation of the water supply system of Jackson, Michigan, was undertaken with the idea of showing just what the conditions are at the existing water works plant, and with a view of determining its adequacy and efficiency. It is proposed to criticise favorably or otherwise and to recommend improvements if they are deemed necessary.

Criticisms, recommendations and conclusions are based on references taken from treatises of good water supply methods as presented by recognized authorities. The authority in most cases being:

1. Public Water Supply, - Turneaure and Russell,

2. Hydraulics, - Hughes and Safford,

3. History of Jackson County, - G. A. Morton.

The authors wish to thank H. K. Vedder, Professor of the Civil Engineering Department, who permitted us to write a report on the "Water Supply System of Jackson, Michigan".

To Dr. Town of the Public Department of Health, Superintendent Hatch of the Water Works Department, and to Professor H. C. Woods of the M. A. C., gratitude is expressed for the helpful suggestions and time spent on this investigation.

History of Jackson Water Works.

During the early days, the people of Jackson Michigan obtained their supply of water from the Grand River. But as this water was very poor for drinking purposes, a meeting of the Citizens was called in December of 1869 for the purpose of voting a sum of money for the construction of a system of water works. The result of this meeting was the formation of a company to take the enterprise in hand, as the charter terms opposed such an investement on the part of the city. During March and April of the year 1870 contracts were made for engines, pipes, hydrants, machinery and buildings. The erection of the water works house was begun April 26 1870 and finished August 1, 1870. At this time the water was taken from the Grand River and passed through large filters. But some time about 1890 steps were taken to obtain the supply of water from the ground.

The first wells that were drilled yielded a supply of water under a head sufficient to cause over flow at ground surface. And at this time these wells were connected direct to the suction lines of the main pumps. After a short period of use the ground water head was considerably depressed, however, so much that additional wells were found necessary. Within a few years following the first drilling, the level of the ground water continued to be depressed to such an extent, that it was found necessary to construct a suction well from which the pumps might draw their supply, and into which the several drilled wells might be discharged through siphonic action. At varying intervals up to the present time, there have appeared recurring evidences of the gradual and steady depression of the ground water table in the vicinity of the Municipal Water Works. In 1901 a pump was installed on the siphon lines to increase the yield; in 1916 a storage reservoir of about 50,000,000 gallons capacity was built to carry the peak loads of the plant; in 1917 & 1918 an additional supply was developed in the area south of the Grand River and west of Losey Avenue.

By the establishment of these water-works the city has been singularly benefited. A supply of artesian water is brought into the very homes of the people, and hydrants at regular intervals are ready to offer opposition to the fire fiend. This artesian water is known to be of the very best quality and is said to equal that which is obtained from the celebrated artesian wells of Europe. But through out the years since the first construction was undertaken, there appears never to have been a time, when there was assured an adequate supply of water for any great time in the future.

PART II.

Description of Present Plant.

The present high-service plant is located on the small strip of land lying between the Grand River and Water street. An area of approximatelly 2.25 acres in extent. The engine house is built of brick and was designed by J. F. Coots. It is rectangular in shape being 76 feet long and 56 feet wide. It is 20 feet high with a tower 45 feet, rising from the main building, and close by the lofty octagonal chimney shaft rising to a height of 78' The roof is a mansard, slated and tastefully ornamented after the french style of architecture. Adjacent to the main building we have the suction well and the ½ million gallon reinforced concrete reservoir built in 1916.

The machinery comprises one 6 Mil. gal. per. da. Holly Gaskell pumping engine; one 10 Mil. gal. per. da. Holly Gaskell pumping engine; and one 8 Mil. gal. per. da. Snow pumping engine. The boiler equipment consists of two batteries of two boilers each, with usual auxiliaries, such as boiler feed pump, air pumps, etc.

The design of the three engines is to vary the supply of water according to the demand, only two being needed for the ordinary supply, and the other in case of fire. An extra supply is commanded by simply opening a hydrant and be it ever so far away, this action acts automatically on the machinery, giving fresh impetus to the pumps, supplying the increased force necessary for the extra flow in a few seconds. At the same time an alarm is sounded to warn the engineer, so that the accessory engine may be set in motion. The water is forced through a 24 inch main, and thence through smaller pipes leading to the less populous districts of the city.

Losey Avenue Pumping Station.

The recent constructed low service pumping station near Losey Avenue, consists of a brick and concrete building, 18 feet square, and extending to a depth of approximately 15 feet below the ground surface and having one story above ground. This station house at present has a 12 inch motor driven centrifugal pump. To this pump is connected the suction line from four 12 inch drilled wells in the adjacent area. The water from these wells is lifted and pumped through a 20 inch wooden force main into the receiving well at the main pumping station.

General Character and Condition of Existing Plant.

Practically all of the equipment at main pumping station, with exception of Snow pumping engine is in a very depreciated condition. The two Holly pumping engines, have expended practically all of their useful life and little justifcation can be found for their further operation. The Snow pumping engine is a comparatively new piece of machinery, and has evidently been well handled, as it appears to be in excellent condition. The advance in the art of pumping stations and the design of pumping equipment, alone has rendered many of the elements of the old plant obsolete, even if they were not worn out. The available area at the site of the main pumping plant is so limited, that there is no opportunity at this site for an expansion, such as will be necessary in order to furnish the city of Jackson a sufficient water supply in future years.

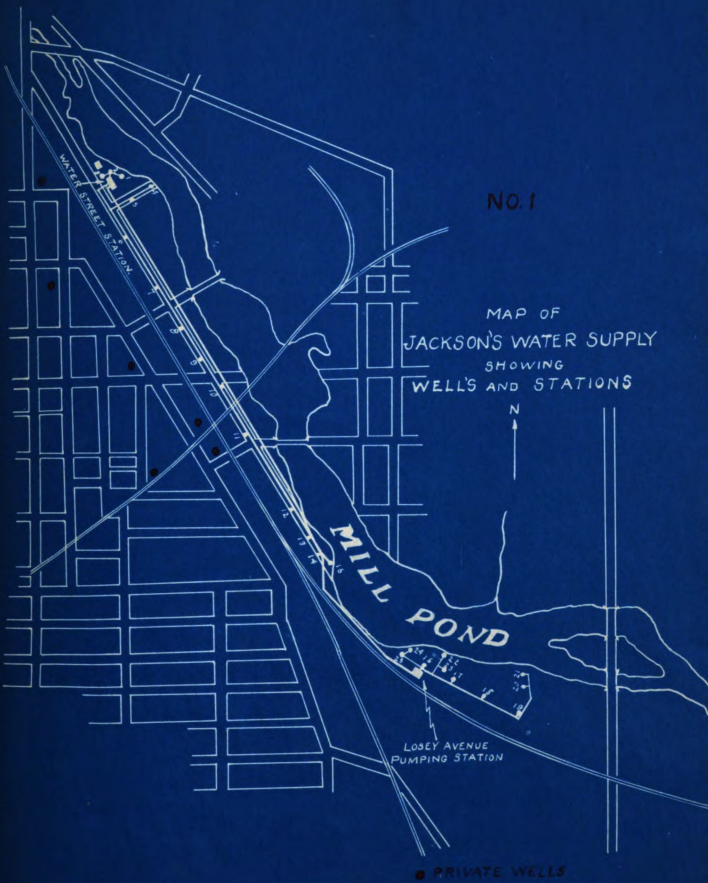
Geological Considerations Affecting Ground Water.

It has been stated by some investigators, that the municipal supply of the city of Jackson is drawn from the Marshall sandstone stratum underlying this region. A careful study of geological records indicate that this is probably not the case, however, as it is generally accepted that the Marshall sandstone under Jackson is found at a depth of somewhere around I,000 feet. While the municipal wells are in general drilled to a depth of about 350 feet. It is more probable that the city supply is taken from the Parma sandstone stratum. It may be possible that the water origanally comes from the Marshall sandstone, and is forced by artesian head into wells which reach only into the overlying formations. It is probable that the catchment area for the water which reaches these wells, is in the table lands lying south of Jackson some 25 to 30 miles, and that the ground water flow is general from south to north.

Present Development of Ground Water Supplies in Jackson.

Drawing number I. of this report is a map of the location of some of the larger water supplies, which are taken from the ground in the city of Jackson. A number of the industrial plants in city depend almost entirely upon this source for their boiler supply. It will be noted that most of the wells are located along the course of the Grand River, and it is possible that some of the supplies are taken from the ground water flows in the drift, comparatively near the surface. Others of the supplies, however, go down several hundred feet and draw their water from the underlying rock formation. It has been estimated that the normal amount of water taken from the ground by private supplies, independent of the municipal water works system, will reach a total of about 3 Mil. gal. per. da. This is a little more than half the amount used by the municipal supply on the average day of the year. On reference again to the map it will be noted that some of the municipal wells (indicated in black) are located well within the area, in which are many of the large private supplies. The private wells are shown in red. At the present time there is noted a marked interference between these supplies. During certain pumping tests which were made some four or five years ago, at which time the city was drawing heavily from the ground water strata, a number of private well supplies failed entirely. Others of them were very noticeably reduced. The general lowering of the ground water table, due to heavy pumping of municipal wells, broke the suction in some plants, where the equipment was not arranged for such deep pumping.

It is very apparent from a consideration of the facts at hand, that if the city attempts to develop the ground water supply near the present main pumping plant by air lift pumping or any other means, which will further lower the ground water table. It will result in the failure of many of the large private supplies now in ues in the city. It appears to be incontrovertible that the central area of the city is at the present time almost completely developed so far as ground water is concerned.


NO. 1
MAP OF
JACKSON'S WATER SUPPLY
SHOWING
WELL'S AND STATIONS
N
WATER STREET STATION
MILL POND
LOSEY AVENUE
PUMPING STATION
PRIVATE WELLS

Available Sources of Supply.

There is no question concerning the fact that the city of Jackson must by some means develope a more adequate and dependable water supply. The present wells could probably be made to yield a slightly greater quantity than is at present drawn from them, by air lifting or some other means, which would cause a further depression of the ground water table. The amount of water which could be obtained by any such method however, would not justify the effort.

There are two possible sources of water supply which are available. The ground water supply at and near the city of Jackson is by no means depleated, even though there may be a local depression in the immediate area of present development. There is also a possibility of developing a supply from the many available lakes, streams and other surface sources near the city. Through a carefully designed and properly operated filter plant, a water supply from the latter sources would prove entirely satisfactorly for municipal use.

The area in and around Jackson is underlain with water bearing strata, which can be made to yield great quantities of water of fairly good quality, although containing a considerable amount of iron. This abundance of ground water has lead to a development of supplies from this source to a rather unusual extent.

Water Main Construction in Jackson Michigan.

From the available data shown below, and attempt has been made to show by graph, the number of miles of water mains constructed each year in the city of Jackson. Also along with this, the total number of miles of mains up to and including last year. The first water mains were laid in the year I870 but no complete record for the numbers of miles of mains lain each of the preceding years up to the year I908. But the total number of miles of mains laid was shown to be 67.2 miles. Below is shown the number of miles of mains laid each year from I908-I924. Also the total number of miles which is II7.I56.

Years.	Miles of mains constructed Each year.
I908	3.00
I909	2.78
I9I0	4.25
I9II	2.60
I9I2	.50
I9I3	4.25
I9I4	2.72
I9I5	2.I0
I9I6	8.50
I9I7	2.30
I9I8	2.60
I9I9	.636
I920	.89
I92I	.56
I922	2.00
I923	5.07

From an investigation of the graph it is seen that very little construction work was done during the years I9I9,-I920-I92I. This was just at the closing part of the world war when there was little growth in the city of Jackson. And at that time labor and the material for construction work were very expensive. But in I922 construction work begain to pick up a little and in I923 a total of 5.07 miles of water mains were lain. In I924 there will probably be still a greater number of mains constructed because of the extension of the city limits of Jackson and also due to the new reservoir and pumping station which is now under construction.

Size of Mains.

Length of 4"	I3I,543 Ft.	24.9I Miles.
" " 6"	374,908 "	7I.I0 "
" " 8"	26,666 "	5.05 "
" " I0"	34,870 "	6.60 "
" " I2"	44,444 "	8.4I "
" " I6"	3,040 "	.575 "
" " I8"	300 "	.057 "
" " 20"	2,020 "	.387 "
" " 24"	380 "	.072 "

Form 91

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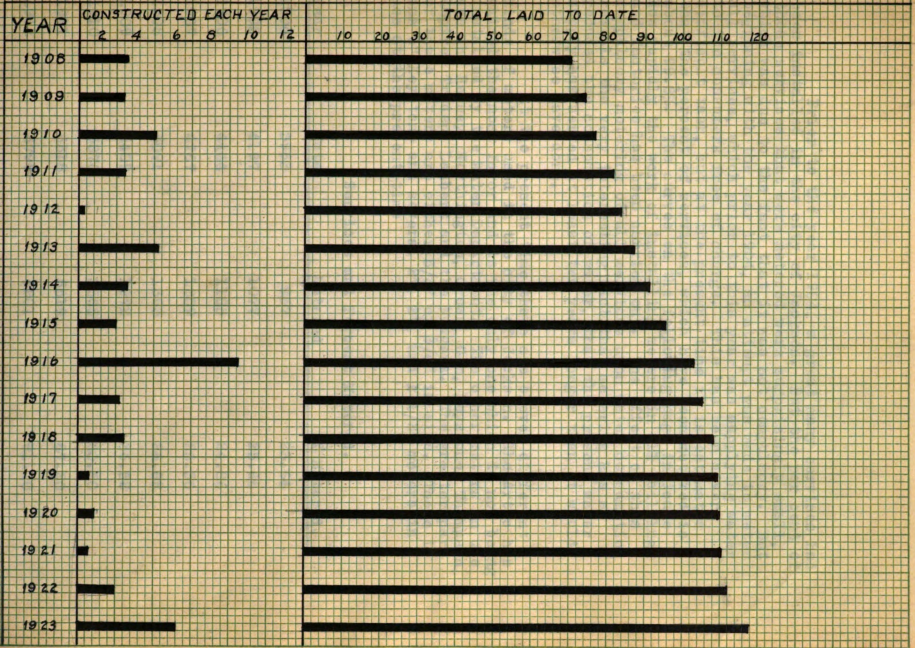
MILES OF MAINS



DEPARTMENT OF MATHEMATICS

Prior to the year 1904, a great many services had been installed in the city of Jackson. But the per cent of these services that were metered were surprisingly small, which was due to the fact that it was not compulsory. But beginning with the year 1904, an attempt was made to meter all services, which prior to this year was supplying water to the consumers free of charge. This has been a very difficult task, but at the present time it is estimated that the percent of services, which have been metered is about 99.8%. The curves on the following page indicate how rapidly the work of installing meters in all buildings and factories has been carried out. The effect of this compulsory metering of all services upon water consumption reveals the very interesting fact that metering has so reduced the consumption of water, that the present water supply has served at least ten years longer than it would otherwise have done.

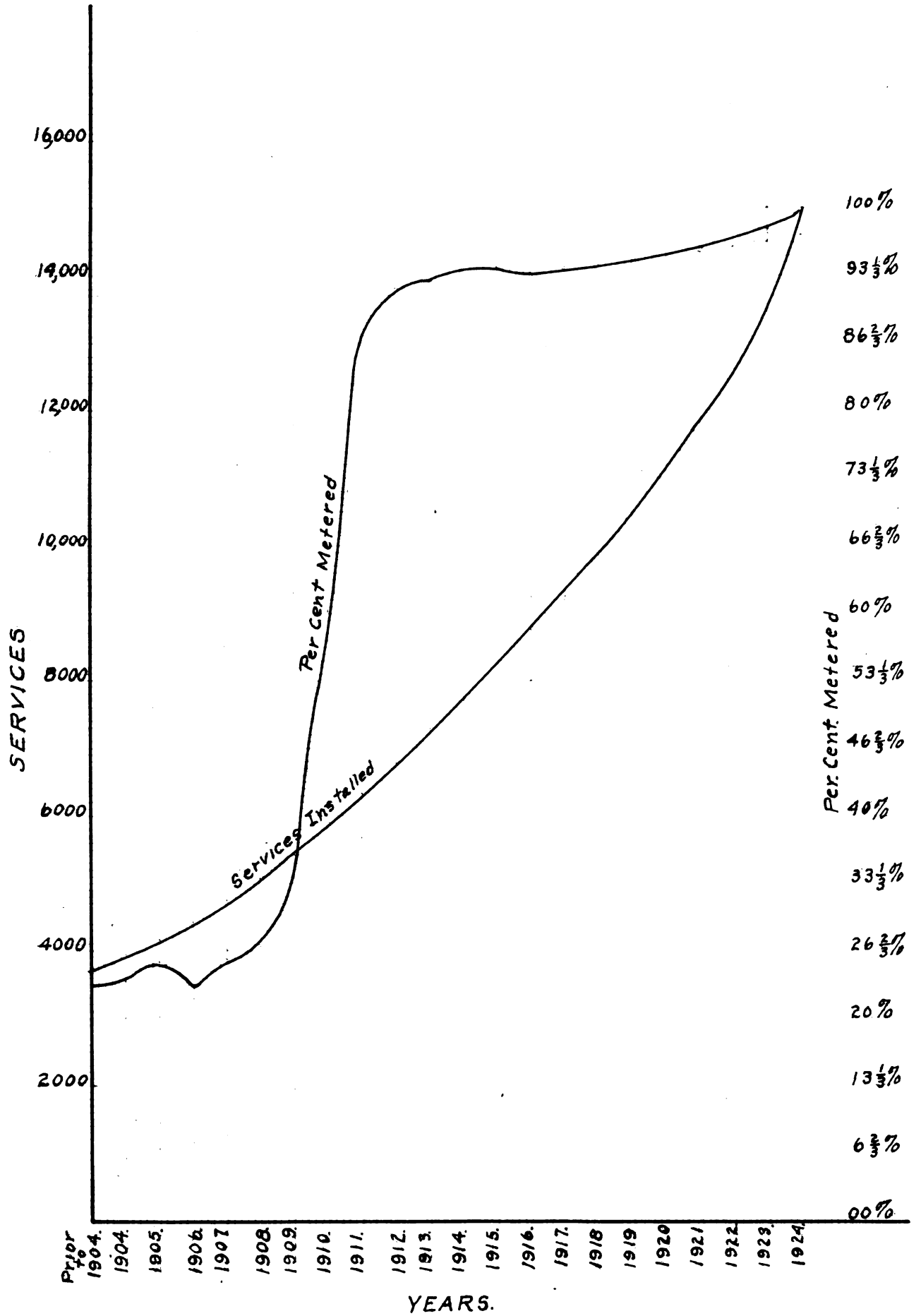
At the present time there are eleven different kinds of meters used in the city of Jackson. The Artic has gained the most favor and is the only one which is now being installed by the Water Department. The other meters in use are the Hersey, Worthington, Crown, Gem, Keystone, Thompson, Empire, Tryden, Lambert and the Niagara. The greater part of these meters are either 5/8" or 3/4" in size. There is one 6" Keystone and several 2", 3", and 1 1/2" meters in use at the present time

Services and Percent Metered.

Year	Total	Metered	% Metered.
1904	3963	937	23.64
1905	4197	1077	25.66
1906	4444	1105	24.86
1907	4767	1209	25.36
1908	5091	1363	26.82
1909	5409	1972	36.52
1910	5876	3565	60.50
1911	6318	5519	87.20
1912	6797	6201	91.10

Services and Percent Metered.

Year	Total	Metered	% Metered.
1913	7288	6754	92.50
1914	7700	7230	93.80
1915	8069	7675	95.00
1916	8758	8192	93.60
1917	9255	8717	94.20
1923	15000	14998	99.80

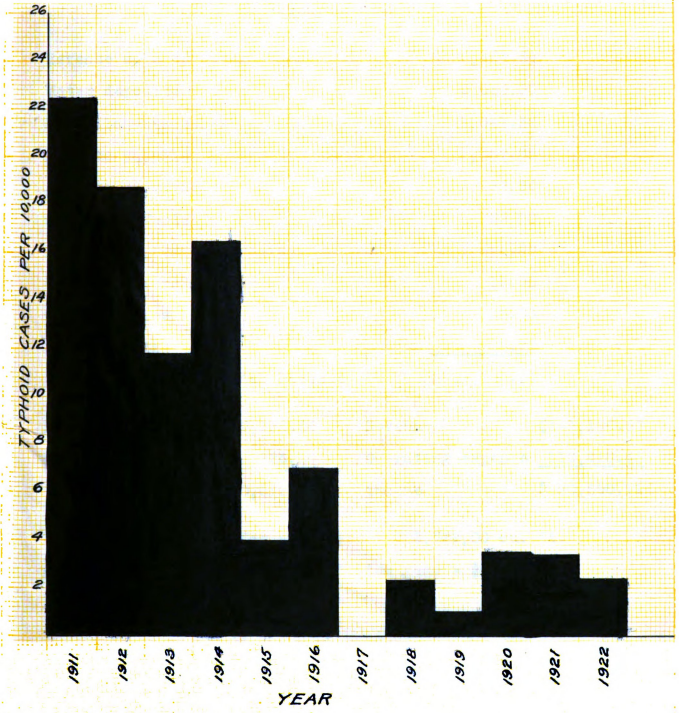

16,000
14,000
12,000
10,000
8000
6000
4000
2000
SERVICES
100%
93⅓%
86⅔%
80%
73⅓%
66⅔%
60%
53⅓%
46⅔%
40%
33⅓%
26⅔%
20%
13⅓%
6⅔%
00%
Per. Cent. Metered
Per Cent Metered
Services Installed
Prior to 1904.
1904.
1905.
1906.
1907
1908
1909
1910
1911.
1912.
1913.
1914.
1915.
1916.
1917.
1918
1919
1920
1921
1922
1923.
1924.
YEARS.

A study of the death-rate or case-rate of typhoid fever in the city of Jackson for the past number of years, illustrates in a striking way, the relation that exists between this disease and the general character of the public water supply. From the data shown below, it is easy to see that the number of typhoid fever cases about the year 1911 was rather high. According to Dr. Town of the Health Department of Jackson, the water at that time did not give very favorable results on being tested. But since that time more precautions have been taken and the number of typhoid cases have diminished fairly rapidly. But in 1920 and 1921 we find that the number of typhoid cases increased somewhat. On investigating the cause of these cases, it was found that some of the private wells, of which there are several in Jackson, were in a very bad condition, and that the majority of the people who were sick with typhoid fever, had been using water from these wells. The use of water from these wells was then prohibited and the number of cases at once became fewer. The water supply of Jackson is from the best artesian wells in the country, and so there should be very few typhoid fever cases in Jackson at any one time.

Data.

Years	Cases	Deaths
1911	75	8
1912	66	5
1913	44	4
1914	65	7
1915	17	1
1916	30	6
1917	0	0
1918	10	1
1919	4	0
1920	17	4
1921	20	3
1922	12	2
1923	3	0

GRAPH SHOWING TYPHOID CASES PER 10,000



Comparison of Pumping Statistics for the Years 1922-1923.

1922.

Revenue sale of water	$130,402.54
Meter deposits	3,080.00
Miscellaneous sales	1,041.32
Amounts payable	1,187.35
Amounts receivable	3,587.36
Gas Meter Tests	36.00
Earnings (service repairs)	1,665.00
Testing meters	16.00
Gas penalties	25.00
Show permits	60.00
Total Revenue	$141,100.57

Expenses	$119,136.56	Revenue	$141,100.57
Capital account	8,926.10	Operating expense	110,210.46
Operating expense	$110,210.46	Income	$ 30,890.11

Total amount pumped for year 1922 = 222,722,00 cu. ft.

Cost of pumping per 1000 cu. ft. for year = $0.4948

1923.

Revenue sale of water	$147,628.24
Meter deposits	4,222.00
Earnings (service repairs)	1,564.47
Accounts receivable	489.60
Miscellaneous sales	405.44

Show permits	60.00
Gas penalties	28.50
Gas meter tests	15.00
Pumping rental	16.00
Testing meters	7.00
Total Revenue	$154,436.25

Expenses	$113,943.46	Revenue	$154,436.25
Capital account	7,853.40	Operating expense	106,090.56
Operating expense	$106,090.56	Income	$ 48,345,69

Total amount pumped for year 1923 = 241,843,000 cu. ft.

Cost of pumping per 1000 cu. ft. for year = $0.438

Reduction per 1000 cu. ft. for year 1923 over 1922 was $0.056

The Water Department does not charge for fire service, but for domestic and manufacturing purposes, they charge $1.00 a 1000 for the first 5000 cu. ft. consumed in a month, and 75¢ for all above 5000 cu. ft. The gas is tested every three hours, and if it falls below 540 B.T.U. at any one time, the Gas Company is fined $25. The amount of chlorine used is about .4 parts per million.

PART III.

Population Studies and Estimates.

The population of the city of Jackson from the date of the earliest United States Census, up to the present time is given in the following table.

Table 1.

Population of Jackson, Michigan, by U. S. Census Returns.

Year	Population
1850	2,363
1860	4,799
1870	11,447
1880	16,105
1886	18,919
1887	19,388
1888	19,858
1889	20,328
1890	20,798
1891	21,236
1892	21,674
1893	20,112
1894	22,550
1895	22,988
1896	23,426
1897	23,864
1898	24,303

Year	Population
1899	24,742
1900	25,180
1901	25,805
1902	26,430
1903	27,055
1904	27,680
1905	28,305
1906	28,930
1907	29,555
1908	30,181
1909	30,807
1910	31,433
1911	33,394
1912	35,355
1913	37,316
1914	39,277
1915	41,238
1916	43,200
1917	47,500
1920	48,474
1922	50,000

These records indicate a steady, but not unusual gain over the whole life of the city. From the curve it can be seen that during the World War, the increase in polulation was very small. But as soon as the soldiers returned from

the war and the factories began working under normal conditions, the population has increased more rapidly.

An effort has been made to estimate the future growth in population for the city of Jackson, up to, and including the year 1950. Curve Number 1 of this report is a past, and probable future increase in population for the year 1950. This estimation for the future was made by percent increase per decade.

Estimated Future Population of Jackson, Michigan.

Year	Population.
1930	65,000
1940	95,000
1950	118,000

To attain a population, which has been estimated in this forecase, the city of Jackson will not be required to experience any unusual growth, but just a normal increase, such as may reasonably be expected of any Michigan city.

Water Consumption Studies and Estimates.

The records of the Water Works Department of the city of Jackson have yielded some valuable information concerning the average daily quantity of water consumed for recent years. The following table gives the data which is available for the years 1910 - 1922.

Table 2.

Data Concerning Water Consumption at Jackson, Michigan, For Years 1910 - 1922.

Average Consumption Rate in Million Gallons per Day.

Year	For Year	For Maximum Day	For Minimum Day	For Maximum Hour
1910	2.92	7.70	1.84	
1911	2.71	4.97	1.85	
1912	2.90	4.96	2.04	
1913	2.89	6.17	2.13	
1914	2.95	5.45	1.73	
1915	2.55	4.13	1.92	
1916	3.11	5.66	2.13	
1917	3.73	7.46	2.16	
1918	4.12	6.94	2.40	
1919	4.23	8.33	2.23	13.62
1920	4.51	7.42	2.89	13.57
1921	4.36	8.35	3.05	15.34
1922	4.56	7.90	3.10	15.00

Table 3.

Ratios in Per Cent.

Max. Da. To Average	Min. Da. To Average	Max. Hr. To Average
264	63	
183	68	
171	70	
213	74	
185	59	
162	75	
182	68	
200	58	
168	58	
197	53	322
165	64	300
191	70	330
173	68	338

The following table is a record of daily average gallons, and daily consumption per capita in the city of Jackson, for years 1886 - 1923. While these figures might be taken to show that the per capita consumption might be expected to continue to be about 90 gallon per. It is shown by curve Number 2 that for the year 1950, it will be about 108 gallons per capita. This curve was constructed from the following data, and the estimation for the future was made by per cent increase per decade.

Table 4.

Year	Daily Average Gallons	Daily Consumption Per Capita.
1886	1,730,000	92.5 gallons
1887	1,600,000	83 "
1888	1,650,000	84 "
1889	2,010,000	100 "
1890	1,805,000	90 "
1891	1,770,000	84.5 "
1892	1,730,000	80.5 "
1893	1,953,000	89 "
1894	2,342,000	104.5 "
1895	2,330,000	102 "
1896	1,945,000	83.5 "
1897	2,180,000	92 "
1898	2,460,000	101.5 "
1899	2,290,000	93 "
1900	2,200,000	87.8 "
1901	2,240,000	87 "
1902	1,855,000	70.5 "
1903	2,130,000	79 "
1904	2,150,000	78 "
1905	2,120,000	75.5 "
1906	2,610,000	90 "
1907	2,255,000	76.5 "
1908	2,605,000	87 "

Year	Daily Average Gallons	Daily Consumption Per Capita.
1909	2,410,000	78.5 gallons
1910	2,760,000	88 "
1911	2,770,000	83 "
1912	2,720,000	77 "
1913	2,785,00	75 "
1914	2,745,000	70.5 "
1915	2,445,000	59 "
1916	3,055,000	67 "
1917	3,750,000	78.5 "
1918	3,800,000	79 "
1919	3,960,000	84.5 "
1920	4,105,000	93.5 "
1921	4,210,000	89 "
1922	4,600,000	91.5 "

Basis of Design for Future.

As a basis upon which a design for an improved water works for the city of Jackson may be carried forward, the following conclusions have been reached.

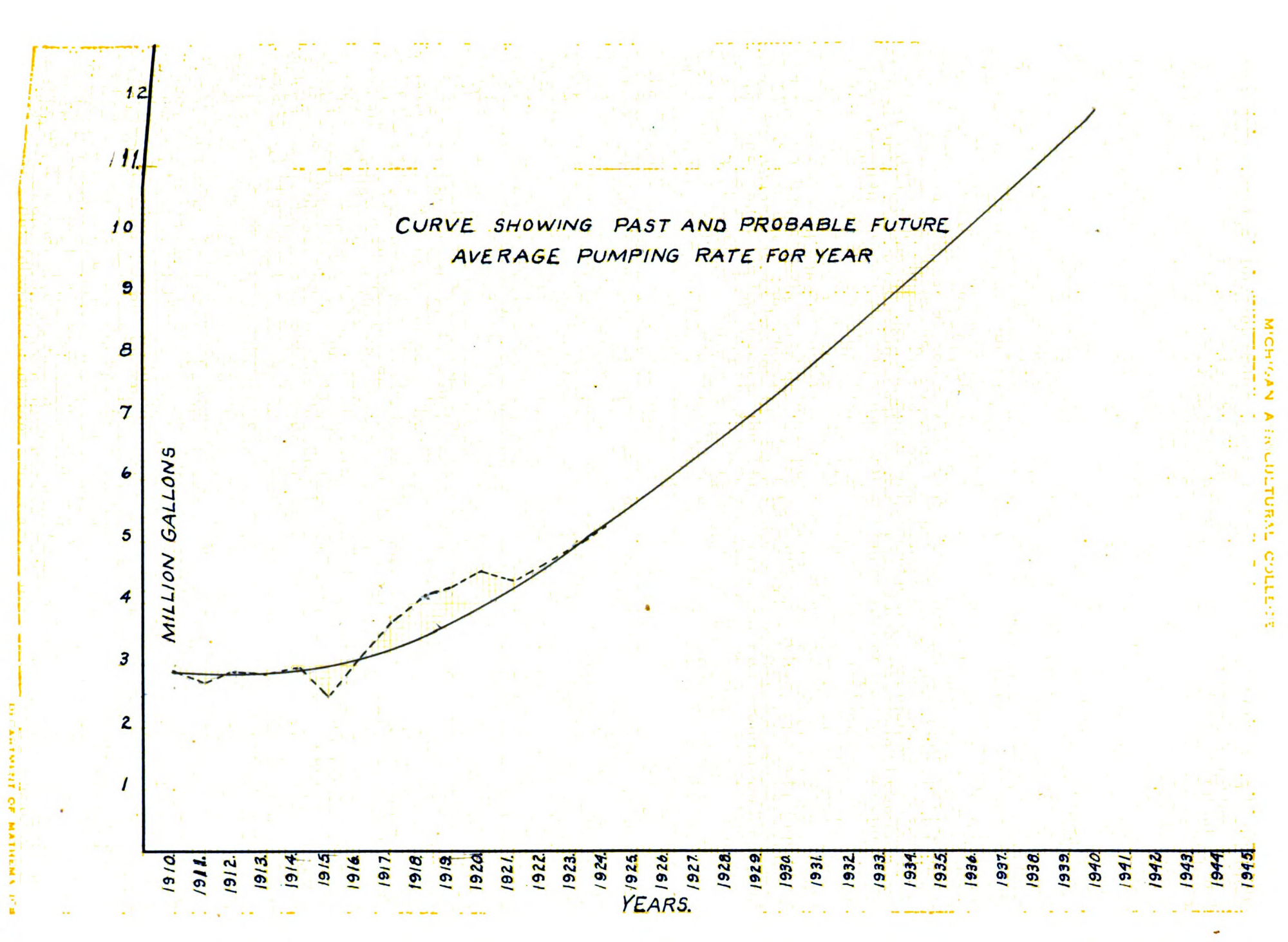
That the general features of the plans should be designed to adequately serve a population of approximately 118,000 persons, which population should be attained about the year 1950.

That an average consumption of 108 gallon per capita per day should be provided for.

That the ratio of consumption rate during maximum hour to the average, be taken as 320 per cent.

That the ratio of consumption during maximum day to that of the average day, be taken as 180%.

That the design should provide for an average pumping rate of 12,000,000 gallons per day.


CURVE SHOWING PAST AND PROBABLE FUTURE
AVERAGE PUMPING RATE FOR YEAR
MILLION GALLONS
12
11
10
9
8
7
6
5
4
3
2
1
1910
1911
1912
1913
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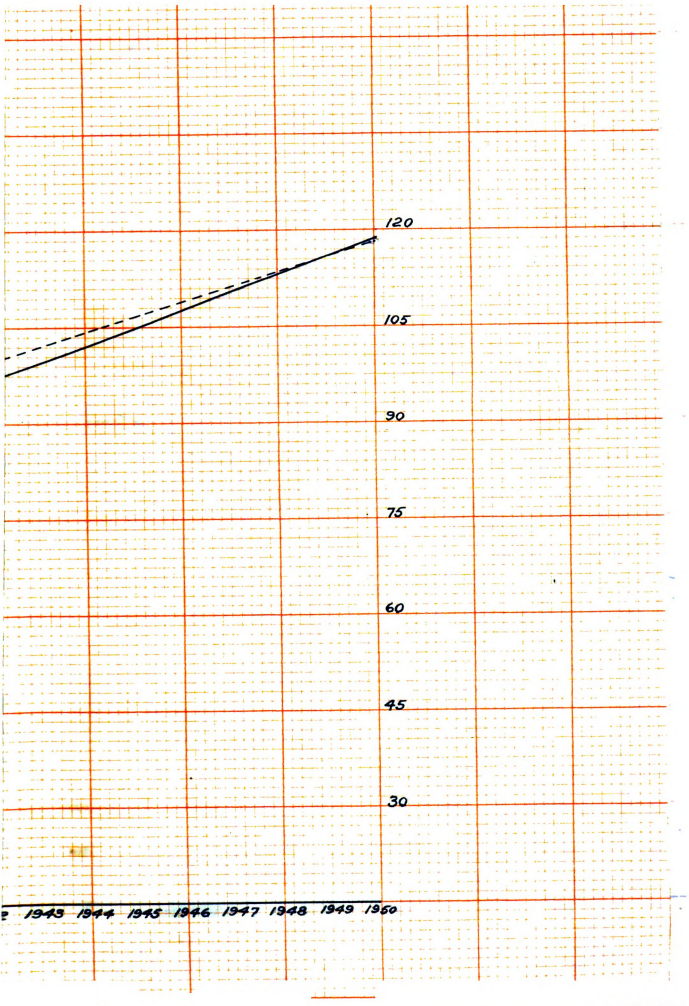
YEARS.


120
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60
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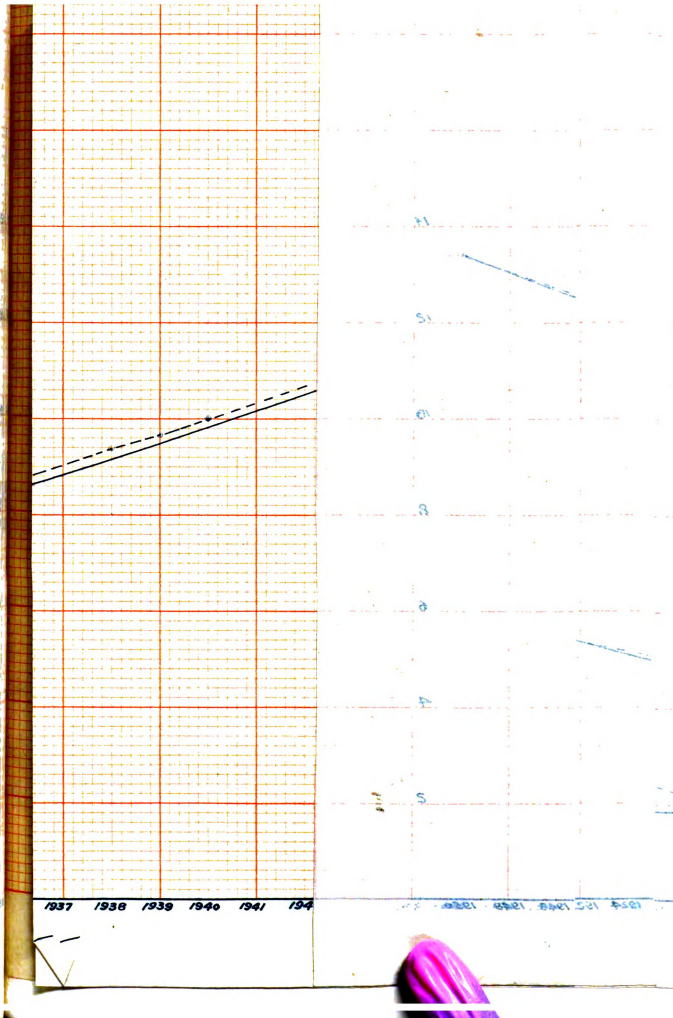
30
1943 1944 1945 1946 1947 1948 1949 1950


1937
1938
1939
1940
1941

PART IV.

"Ella Sharp Park Project"

It has been apparent to the people of Jackson, that the present system of obtaining water to supply the city of Jackson, will be adequate for only a few more years. In the minds of some people there exists the thought that the Ella Sharp Park is a desirable place for a water supply development for the city of Jackson Michigan. Reference to this is also found in the report of Mr. S. G. Pollard, who acted as consultant to the city of Jackson upon water works improvement in the years 1917 & 1918. It appears from Mr. Pollard's report that some little thought and investigation was given to this question at that time.

In the present investigation of the water supply system of Jackson, attention is again drawn to Ella Sharp Park, as a suitable place for a future water supply development for the city of Jackson. The Ella Sharp Park is situated on either side of 4 th street just south of the southern limits of the city of Jackson. It is a beautiful tract of rolling land which under the terms of its bequest to the city, has been atristically landscaped. It will be a very valuable asset to the city of Jackson, if continued in a restricted use as a public park.

According to the available records the highest point in the park is about elevation 1010. This heighth of land coupled with the presence of small flows of spring water, in the lower levels, has prompted the suggestion for a water supply development at the park. Onecareful investigation, a water supply development in this area may be along two different plans. The water supply might be taken from the ground water underlying the park, and be pumped to a reservoir located on the high land, from which it would flow by gravity into the city. Another plan might be is to obtain the water from some of the present wells and pump it across the city to a reservoir located in the park, from which it would flow by gravity down into the city as under the other scheme. In the study of these possiblities such calculations have been made which show conclusifly, that neither one of these two plans can be worked out satisfactorily.

In the working of this problem it was necessary to determine which part of the city not only was the center of the business district, but also contained the tallest building. This being necessary because under either of the plans previously mentioned, there would have to be enough pressure to force the water to the top of the tallest building. If this is not possible, under the present conditions in the city of Jackson, there is little need of fostering either of the plans, because Jackson is growing rapidly and will be constructing buildings, which are taller than those already existing.

The center of the business section of the city is taken at the intersection of Michigan Avenue and Mechanic St. At this place, is also situated the Peoples National Bank building, which is eight stories in heighth. At this point the elevation of the ground surface is 935 feet. The distance from the reservoir site in the park to the latter point is about I3,750 feet. Calculations as to the desirable size of main from the reservoir to the city, indicates that there should be at least a 30 inch main from the park in as far as High St. From that point it may be reduced to 24 inches on account of possible cross connections with the existing destribution system. A study of the consumption rates which have been obtained in the past in the city of Jackson, indicates that the maximum hourly rate of consumption has already reached I5 Mil - gal - per - da. A rate of I3 mil - gal - per - da has occured several times in the past few years. Reference to an earlier page of this report indicates that any proposed development, should be made on the basis of a probable maximum daily consumption rate of I8 Mil - gal - per - da. And a maximum hourly rate of 30 Mil - gal - per - da these figures being calculated for about the year I940.

The following table brings together some of the results determined in a calculation of the friction loss in a 30 inch main, from a reservoir site in the park to the intersection of Michigan Avenue and Mechanic St.

Table 5

Data Concerning an Available Water Pressure Resulting from a Reservoir Located in the Ella Sharp Park.

Rate of water Consumption in Gal.per.da.	Friction loss between Mechanic St. and Michigan Ave. In feet.	Elevation of water in reservoir. In feet.
I0,000,000	28	I0I0
I5,000,000	66	I0I0
I8,000,000	79	I0I0
30,000,000	I29	I0I0

Elevation of Hydraulic Gradient at Mechanic St. and Michigan Ave. In feet.	Elevation of ground surface at Mechanic St. and Michigan Ave. In feet.	Heighth to which water will rise at ground surface at Mechanic St. and Michigan Ave. In feet
982	935	47' above.
944	935	9' "
931	935	4' below.
880	935	55' "

In order to determine the friction head for the data given in table 5 the formulae $hf = f \frac{LV2}{D2g}$ and $V = \frac{Q}{A}$ were used.

L= the length in feet of the pipe measured on its axis.

D= the internal diameter in feet of the pipe.

V= the mean velocity of flow in feet per second.

h = the acceleration due to gravity, taken as 32.16.

The results of these calculations will be considered in the light of the service, which would be rendered to a water consumer under the conditions previously stated. Now it is possible to determine just how high the water would rise in the Peoples National Bank building due to gravity pressure.

The elevations of the different floors are as follows.

Floor.	Elevation.
First.	935
Second.	951
Third.	962
Fourth.	973
Fifth.	984
Sixth.	995
Seventh.	1006
Eighth.	1017

The roof elevation is about elevation 1028. At a time of a consumption rate of 10 Mil. gal. per. da. The water would rise in this building to a point 47 ft. above ground floor or just to the level of the fifth floor. At the time of a consumptive rate of 15 Mil. gal. per. da. the water would rise in the building to a point 9 feet above the ground floor, not quite to the second floor. At the time of a consumption rate of 18 Mil. gal. per. da the water would rise to a point 4 ft. below the first floor. Even under a static condition, where no flow at all would be possible, the water would rise in a piping system of the building only to a point 75 feet above the ground surface, which is about 4 feet above the seventh floor. And under these conditions it would be impossible, without some additional pumping to get water to the eighth floor.

Q = the discharge in cubic feet per second.

A= the cross - sectional area of the pipe in feet.

f= the friction factor, which with new cast iron pipes ranges from .02 to .05.

Mr. L. Arnold, City Engineer of Jackson, states that they have found that the friction factor .035 is best suited for all computations concerning new cast iron pipe.

For a rate of water consumption of 10 Mil. gal. per. da. through a 30 inch pipe for a distance of 13,750 feet, the following results are obtained.

Q= 10,000,000 ÷ 646317 = 15.4 discharge cubic feet per second.

Area of a 30 inch pipe 5.02 feet. .

V= 154 ÷ 5.02 = 3.1 mean velocity of flow in feet per second.

$$hf = f.\frac{LV^2}{D2g} = .035.\ \frac{13,750\ (3.1)^2}{2.5\ \ 64.3} = 28.$$ friction loss.

For a rate of water consumption of 15 Mil. gal. per. da through a 30 inch pipe, for a distance of 13,750 feet, the following results are obtained.

Q= 15,000,000 ÷ 646317 = 23.2 discharge cubic feet per. second.

Area of 30 inch pipe = 5.02 ft.

V= 23.2 ÷ 5.02 = 4.6 mean velocity of flow in feet per. second.

$$hf = f.\ \frac{LV^2}{D2g} = .035.\ \frac{13{,}750\ \ (4.6)^2}{2.5\ \ 64.3} = 66 \text{ friction loss.}$$

For a rate of water consumption of 18 Mil. gal. per. da for a 30 inch pipe, for a distance of 13,750 feet, the following results are obtained.

$Q = 18{,}000{,}000 \div 646317 = 29$ discharge cubic feet per second.

Area of a 30 inch pipe = 5.02 feet

$V = 29 \div 5.02 = 5.8$ mean velocity of flow in feet per second.

$$hf = f.\ \frac{LV^2}{D2g} = .035.\ \frac{13{,}750\ \ (5.8)^2}{2.5\ \ 64.3} = 79 \text{ friction loss.}$$

For a rate of water consumption of 30 Mil. gal. per. da through a 30 inch pipe, for a distance of 13,750 feet, the following results are obtained.

$Q = 30{,}000{,}000 \div 646317 = 46.4$ discharge cubic feet per. second.

Area of a 30 inch pipe is = 5.02 feet.

$V = 46.4 \div 5.02 = 9.28$ mean velocity of flow in feet per. second.

$$hf = f.\ \frac{LV^2}{D2g} = .035\ \ \frac{13{,}750\ \ (9.28)^2}{2.5\ \ 64.3} = 129 \text{ friction loss.}$$

For a consumption rate of 10 Mil. gal. per. da.
1010 − 28 = 982 feet.
982 − 935 = 47 feet above ground surface.

For a consumption rate of 15 Mil. gal. per. da.
1010 − 66 = 944 feet.
944 − 935 = 9 feet above ground surface.

For a consumption rate of 18 Mil. gal. per. da.
1010 − 79 = 931 feet.
931 − 935 = 4 feet below surface.

For a consumption rate of 30 Mil. gal. per. da.
1010 − 129 = 880 feet.
880 − 935 = 55 feet below ground surface.

In a business district a desirable water pressure is about 60 lbs. per. square inch or I38 ft of pressure head. In order to provide such a pressure at ground surface of Michigan Ave. and Mechanic street, during the time when the water consumption rate reached IO Mil. gal. per. da it would be necessary that the reservoir be located on the high hill in the park, be elevated to a point 90 feet above ground surface. And with a rate of I5 Mil. gal. per. da ,the elevation of the reservoir would have to be at least I30 feet above the ground surface. While for a consumption rate of I8 Mil. gal. per. da, which will soon be reached in the city of Jackson. The reservoir would have to be at least I42 feet above the ground surface.

In order that the reservoir can satisfactorily meet the fluctuations in consumption, its volume should be about 3 million gallons. An ecommically proportioned reservoir of this volume to be built at the ground surface would be I75 feet square, with a water depth of I4 feet. To construct a reservoir of this volume at an elevation of I00 feet or more above the ground surface, would be impracticable from any stand point; and the cost of such a structure would be very high, and so prohibitive.

In view of the fact that this land was given to the city of Jackson as a pleasure park and as it has already proven itself to be very valuable, it will not be feasible to construct a water supply system in Ella Sharp Park. It has also been shown by calculations, that a water supply system situated in the Park will never give satisfactory service over the whole city of Jackson.

PART V.

Recommended Plan for the Development of a New Water Works Plant.

A definite and final conclusion has been reached, that it is not practicable to consider any further development, or enlargement of the municipal water works plant at its present site, between Water Street and Grand River. An investigation of the quantity of water, which might be available from the area now partly developed by wells near Losey Avenue and from adjacent areas in this vicinity bordering on the Grand River, indicates that there can be obtained from this area, sufficient water to meet the needs of the city of Jackson. No other site, which is available to the city of Jackson, offers the possibilities approximating those, which may be had in a development in the Losey Avenue area. This being partially due to its nearness to the present plant, and the ease with which the two systems can be joined together.

General Plan.

Drawing 2. of this report shows a general plan of a possible arranging of structures, necessary in the development of a water works pumping plant in the above mentioned area. While this plan shows a definite location for the several structures comprising the plant, it is not to be understood that this particular arrangement will be final in all respects. The topography is such that the general relations of the several structures may be kept alike, even though the location and orientation of the plant as a whole be changed.

At the present time the water works structures situated in this area consist of the four I2 inch wells, and the small electrically operated low service pump station, which forces the water from the wells to the present high service plant situated along Water Street. Under the proposed development, six new I2 inch wells will be drilled in the area adjacent to existing wells already drilled. These wells will be connected with the present line leading to the existing low lift pumping station. The present pumping equipment consists of a I2 inch motor driven centrifugal pump supplemented by a new I5 inch motor driven centrifugal pump. These pumps will draw water from the wells and discharge it through appropiate piping connections into a new storage reservoir, to be located south of the New York Central tracks.

The proposed storage reservoir will be of approximately 3 million gallon capacity. This reservoir will be of sufficient size to meet the demands of the maximum hourly rate on that day of the year, which has the maximum consumption. The use of such a reservoir will make it possible

to draw on the wells at practically a constant rate during the night time, and at other periods of low demands for water, the water from the low service pumps will go into storage in the reservoir. During sprinkling hours and other periods of high demand, the water from the low service pumps will go directly to the high service pumps and this supply will be further augmented by that volume stored in the reservoir.

A new high service pump building, which when completed will replace the Water street station will be located on the land lying between the New York Central and Cincinnati tracks. This pump building with the adjacent boiler house will be given an architectural treatment, which will make these structures different from the usual factory type of construction, and which will enhance the value of any park or landscape development which may follow.

The high service pumping equipment to be housed in this building, will consist of the present 8 Mil. gal. per. da. Snow Cross compound high duty pumping engine, now in place at the Water street station; one new 8 Mil. gal. per. da. cross compound high pump engine; and one new 8 Mil. gal. per. da. turbin driven centrifugal pump. In the pump room there will also be housed two 100 K. V. A. turbo-generator sets, which will be used to supply electrical energy for the low surface station. A connection will also be made with the commercial electrical power service for use if required. Necessary switch boards and other auxiliary equipment will of course, be provided.

The boiler plant equipment will consist of 3 160 H. P. boilers with their necessary feed-water heaters, fuel pumps and other auxaliaries. The coal supply for the boilers will be brought in over a spur track from the New York Central lines. This track will be elevated from the coal pit in such a manner, that hopper cars may dump their loads directly on to the coal pile. The high service pumps will take their suction from the low service discharge line or storage reservoir. They will discharge into a supply main leading from the plant to Beldon Avenue and continued through the public streets to a connection with the existing distribution system at Milwaukee and Otsego streets.

The following tabulation presents an estimate of cost of those parts of the recommended water works development, which should soon be under taken. This amount of construction will provide a thoroughly adequate supply, equal in quality to that at present enjoyed and much less liable to contamination. It will provide pumping capacity sufficient to meet the maximum demands upon the water supply system for the next twenty years. It will provide the nucleus of a plant,

Provisions for Plant Expansion.

Chemical analysis of the water from Losey Avenue wells and from other deep wells in Jackson, show a hardness of about 275 parts per million. While it is probably true that the people of the city of Jackson are accustomed to a water of this hardness and may not at present feel the need of softening it; yet a consideration of this contingency is most important at this time. When the city of Jackson will have completed and placed in operation an adequate water works plant, supplying sufficient quantities of water, it will doubtless be found that many of the industeries now obtaining their supplies from private scources, will revert to the municipal supply as being cheaper and more reliable. These consumers will demand a supply reasonably soft and suitable for steam purposes. The public in general, is taking an increasing interest in the quality of their public water supply, and it is only a question of time when the domestic consumers also will appreciate and demand the advantages of a softened and filtered water.

With these considerations in mind, the general plan has been so laid out, that it will allow of a development for softening and filtering the water when this may be desired. Drawing 2. indicates in light lines, those structures and parts of the plant, which may be developed at such time as a softened supply becomes desirable.

Under such a completed design the operation of works will be essentially as follows; The low service pumping station will take its supply, as at present, from the several wells, but will pump through a low service main to the chemical building, where the water in its flow will be treated with the required softening chemical. From this point it will continue on to a sedmentation basin,which may be located on the high - land a little way south and east of the main plant. In this basin the resulting precipates from the chemical softening reactions, and other foreign matter will be settled out. From the sedimentation basin the supply will be carried through a pipe line into the filter building and on to the filters, where a further purification will be effected. The effluent from the filters will be carried over and stored in a large reservoir. From the storage reservoir the softened and filtered water will be drawn by suction into the high service pumps, from which it will be discharged through the pump main into the distribution system.

which may at a latter date be expanded and developed into a thoroughly complete softening and filteration works.

The time which has been available for these studies has not allowed the making of plans complete in all their details, nor as to the investigation as to the actual cost of many of the parts and pieces of equipment. It has, however, shown conclusivelythat these works may be constructed at a very reasonable figure.No allowance being made in these estimates for such lands, or right-of-ways as may be necessary in the development.

Preliminary Estimate of Cost of Recommended Water Works Improvement for City of Jackson Michigan.

Wells.

Consisting of six new I2 inch drilled wells. The wells are approxmately 400 feet deep. Total cost $I2,000.

Low Service Station Improvement.

Consisting of necessary piping connecting with wells; a new I5 inch motor driven centrifugal pump with valves and piping; and a 24 inch Class A cast iron pipe main peading to the high service pumping station. $I6,000.

Storage Reservoir.

One covered concrete reservoir of 3 million gallon capacity $65,000.

High Service pumping Station Building.

Consisting of pump room, boiler room stack, coal storage area, spur railroad track, trestle, roadways and general grading and ground improvement. $94,000.

High Service pumping Equipment.

Consisting of the resetting of the present 8 Mil. gal. per. da. Cross compound pumping engine; one 8 Mil. gal. per. da. turbin driven centrifugal pumping unit; two I00 K. V. A. turbin generator sets; 3-I60 H.P. turbin boilers and other necessities. $I28,000.

Connecting Main.

From the high service pumping building to connect with present city distribution system. $85,000.

The total cost of recommended immidiate construction, not including rights-of-way is $4000,000.

PART VI.

CITY OF JACKSON, MICHIGAN.

Report on

TESTING OF NEW CITY WELLS

Summary of Tests

Well No. 1 was tested Oct. 9th and 10th with the following results:

Minimum rate of pumpage	171,000	Gal./Da.
Maximum " " "	565,000	" "
Average " " "	420,000	" "
Lowering corresponding to min. rate pumpage	1.18	ft.
" " " max. " "	3.20	"
" " " Aver. " "	1.705	"

Well No. 2 was tested Oct. 5th and 6th with the following results:

Minimum rate of pumpage	522,000	Gal./Da.
Maximum " " "	942,000	" "
Average " " "	719,000	" "
Lowering corresponding to Min. rate pumpage	4.86	ft.
" " " Max. " "	5.27	ft.
" " " Aver. " "	4.375	"

Well No. 3 was tested Dec. 5th and 6th with the following results:

Minimum rate of pumpage	502,000	Gal./Da.
Maximum " " "	726,000	Gal./Da.
Average " " "	662,500	" "

Lowering corresponding to Min. rate pumpage 5.17 ft.

" " " Max. " " 8.40 "

" " " Aver. " " 7.08 "

Well No. 4 was tested Nov. 2nd and 5th with the following results:

Minimum rate of pumping 406,000 Gal./Da.

Maximum " " " 942,000 " "

Average " " " 660,000 " "

Lowering corresponding to Min. rate pumpage 5.60 ft.

" " " Max. " " 5.90 "

" " " Aver. " " 4.678 "

Well No. 5 was tested Oct. 26th and 27th with the following results:

Minimum rate of pumpage 464,000 Gal./Da.

Maximum " " " 1,000,000 " "

Average " " " 701,000 " "

Lowering of head corresponding to Min. rate pumpage 4.41 ft.

" " " " " Max. " " 6.41 "

" " " " " Aver. " " 4.10 "

Well No. 6 was tested Nov. 21st and 22nd with the following results:

Minimum rate of pumpage 407,500 Gal./Da.

Maximum " " " 1,051,000 " "

Average " " " 690,000 " "

Lowering of head corresponding to Min. rate pumpage 2.00 ft.

" " " " " Max. " " 8.16 "

" " " " " Aver. " " 4.285 "

COMPARISON OF PUMPING

1922 & 1923.

	Max. Day (Pumping)		Min. Day (Pumping)	
	1922	1923	1922	1923
Jan.	5,036,200	4,570,800	3,200,600	3,490,500
Feb.	4,923,100	5,200,000	3,710,000	3,276,100
Mar.	4,695,600	5,291,000	3,544,800	3,785,600
Apr.	4,760,100	5,715,500	3,560,000	3,617,400
May	5,174,000	7,103,000	3,263,900	3,316,000
June	7,528,500	8,225,600	3,661,000	3,874,000
July	7,864,500	7,207,000	4,420,000	4,019,100
Aug.	7,104,000	6,642,100	3,597,100	4,001,400
Sept.	6,593,600	7,667,400	3,435,900	3,601,000
Oct.	5,214,300	5,454,600	3,240,900	3,711,500
Nov.	4,751,600	5,566,600	3,186,800	3,466,000
Dec.	4,631,900	5,021,000	3,257,900	3,360,000

Daily Average (Month)

	1922	1923
Jan.	4,311,250	4,268,800
Feb.	4,079,820	4,607,290
Mar.	3,946,650	4,776,620
Apr.	4,161,550	4,833,360
May	4,411,000	4,650,460
June	5,406,260	6,303,490
July	5,916,000	6,052,300
Aug.	5,447,000	5,242,990
Sept;	4,564,000	4,960,470

	Daily Average (Month)	
	1922	1923
Oct.	4,267,000	4,965,820
Nov.	4,060,900	4,499,090
Dec.	4,117,000	4,253,710
Average	4,560,700	4,952,590

Maximum of water pumped in one day, 1922 - 7,904,000 Gal.
" " " " " " " 1923 - 8,223,800 "

Minimum amt. of water pumped in one day, 1922 3,166,800 Gal.
" " " " " " " " , 1923 3,316,000 "

Average daily amount for year, 1922 4,560,700 Gal.
" " " " " 1923 4,952,590 "

Average daily increase of 1923 over 1922 391,890 Gal.

Per Capita Consumption 1923 99 Gal.

Total amt. of water pumped 1922 - 1,666,987,700 Gal. or
241,843,275 cu. ft.

Total amt. of water pumped 1923 - 1,808,947,850 Gal. or
222,720,301 cu.ft.

Increase pumpage of 1923 over 1922 - 141,959,850 Gal.

	Water Pumped 1923		Coal Used		Chlorine Used			
	Daily Aver. (Gal.)	Total (Gal.)	Daily Aver. (Tons)	Total (Tons)	Daily Aver. Lbs.	Oz.	Total Lbs.	Oz.
Jan.	4,266,800	132,272,800	5.86	181.68	12	7	384	14
Feb.	4,607,290	129,004,400	6.79	190.14	17	0	476	2
Mar.	4,776,620	148,074,600	6.59	204.50	17	12	551	12
Apr.	4,833,360	145,002,000	6.22	186.69	16	16	569	14
May	4,650,460	144,164,300	6.57	205.60	19	7	602	5
June	6,303,490	189,105,000	9.22	279.46	20	6	612	2
July	6,053,300	187,652,300	8.81	273.07	19	12	611	15
Aug.	5,242,990	162,529,900	7.47	231.47	19	0	589	2
Sept.	4,960,470	149,415,000	6.63	199.02	16	1	481	4
Oct.	4,962,520	153,868,500	6.49	201.37	15	13	469	14
Nov.	4,499,090	134,972,000	6.59	197.67	14	0	426	8
Dec.	4,253,710	131,864,700	6.47	200.44	18	14	585	4

Daily Average water pumped	4,952,590	Gal.
Total Water Pumped	1,808,987,700	"
Aver. coal to pump 1 Mil. Gal.	1.41	Tons
Total Coal consumed	2,549.54	"
Total Chlorine used	6,392	lbs.
Average parts per Mil. Chlorine	.43	

REPORT ON

TESTING OF NEW CITY WELLS

The contract with The Artesian Well and Supply Co., which consisted of drilling six twelve-inch wells for the City of Jackson, has been completed. Each well, upon completion, was tested by pumping, measuring the lowering of the ground water and recording the discharge. There are two important reasons for testing the wells; first, the cleaning of the wells, and second, to determine the probable yield of the wells.

The tabulation below gives the depth of casing, the amount of uncased wall, and total depth.

Well No.	Length Cased	Length Uncased	Total Depth
1	70' - 1/2"	329' - 11 1/2"	400' - 0"
2	63' - 9 1/2"	334' - 8 1/2"	398' - 6"
3	58' - 1"	325' - 11"	384' - 0"
4	68' - 6"	324' - 0"	392' - 6"
5	73' - 1 1/2"	312' - 10 1/2"	386' - 0"
6	63' - 9"	326' - 7"	390' - 4"
	397' - 3 1/2"	1954' - 1/2"	2,351' - 4"

The deepest well is 400 ft. and the shallowest 384 ft. The longest casing is 73' - 1 1/2" and the shortest is 58 ft. 1 in. The source of supply of these wells is from The Marshall Sandstone strata which is first encountered about 300 ft. below the surface of the ground. The direct pumping method will be used.

From the above data it was possible to work out a head-discharge curve or to obtain a curve which would give the probable yield for one foot lowering of the ground water.

In conclusion it would seem reasonable to believe that by lowering the ground water eight feet the six wells would yield 6,000,000 Gal. in 24 hours and by lowering the ground water 10 feet, the yield of ten wells would be 7,000,000 Gal. in 24 hours.

STATISTICAL DATA

for

HEAD-DISCHARGE CURVE

Average Pumping

Well No.	Lowering	Rate
1	1.705 ft.	420,000 Gal.
2	4.375 "	719,000 "
3	7.080 "	662,500 "
4	4.678 "	660,000 "
5	4.100 "	701,000 "
6	4.265 "	690,000 "

Equation of Curve - r = 162,900 h.

Minimum Pumping

Well No.	Lowering	Rate
1	1.18'	171,000 Gal.
2	4.86'	522,000 "
3	5.17'	502,000 "
4	5.60'	408,000 "
5	4.41'	464,000 "
6	2.80'	407,000 "

7 Equation of curve - r = 121,850 h.

Maximum Pumping

Well No.	Lowering	Rate
1	3.20'	585,000 Gal.
2	5.27'	942,000 "
3	8.40'	726,000 "

Maximum Pumping (Continued)

Well No.	Lowering	Rate
4	5.90'	942,000 Gal.
5	6.41'	1,000,000 "
6	8.16'	1,021,000 "

DATA FOR HEAD-DISCHARGE CURVE AT VARIABLE RATES.

Rate	Head Lowering
240,000 Gal.	1.06'
325,000 "	1.13'
464,000 "	2.51'
502,000 "	4.43'
544,000 "	4.00'
600,000 "	4.18'
621,000 "	5.51'
675,000 "	5.09'
727,000 "	4.25'
775,000 "	4.19'
830,000 "	4.34'
885,000 "	5.07'

Equation of Curve, r = 156,500 h

DATA FOR SUMMARY HEAD-DISCHARGE CURVE

Maximum Pumping

Well No.	Lowering	Rate
1	3.20'	885,000 Gal.
2	5.27'	942,000 "
3	8.40'	726,000 "
4	5.90'	942,000 "
5	6.41'	1,000,000 "
6	8.10'	1,011,000 "

Minimum Pumping

Well No.	Lowering	Rate
1	1.10'	171,000 Gal.
2	4.60'	522,000 "
3	5.17'	502,000 "
4	5.30'	406,000 "
5	4.41'	464,000 "
6	2.00'	407,500 "

Average Pumping

Well No.	Lowering	Rate
1	1.705'	420,000 Gal.
2	4.375'	719,000 "
3	7.080'	662,500 "
4	4.673'	666,000 "
5	4.100'	701,000 "
6	4.285'	690,000 "

Well No. 1

(Continued)

Discharge (h) Start at 5:00 P.M.	Elev. of Water Start at 5.15 P.M.	Discharge	Elev.
.55	916.12	.60	913.9
.52	913.3	.60	914.2
.47	913.3	.60	914.1
.41	914.4	.60	914.1
-	915.2	.59	914.3
-	913.3	.60	914.3
.64	913.3	.60	914.3
.64	913.2	.60	914.3
.64	913.1	.62	916.4
.66	913.3	.68	918.3
.61	913.1	.64	918.1
.62	913.8	.61	915.4
.63	913.4	.60	916.1
.62	913.2	.59	915.4
.66	913.3	-	916.0
.66	912.9	.60	916.1
.67	913.0	.54	914.6
.67	913.0	.54	915.5
.67	912.9	.54	915.6
.64	913.0	.55	915.6
.65	913.9	.48	915.9
.64	913.2	.54	915.7
.64	913.1	.54	915.5
.60	913.8	.54	915.7

(Continued)

Discharge (h)	Elev. of Water	Discharge (h)	Elev. of Water
.54	915.5	-	913.8
.54	915.5	.43	913.8
.52	916.0	.50	914.2
.53	915.8	.50	915.2
.45	916.5	.43	914.9
.46	916.1	-	914.9
.44	916.7	-	913.8
-	916.7	-	914.8
-	916.6	-	914.8
-	916.4	.49	915.0
-	916.3	-	915.2
-	916.3	-	915.1
-	916.1	-	914.4
-	916.5	-	914.6
-	916.6	-	913.4
-	-	-	913.4
-	-	.42	913.4
-	915.6	.50	914.9
-	-	.57	915.1
-	-	.57	915.1
-	-	.55	
-	915.4		
-	915.4		
-	915.4		
-	914.2		

Well No. 2

Discharge (h) Start at	Elev. of Water Start at	Discharge (h)	Elev. of Water
10:15 A.M.	10:00 A.M.	.62	911.8
.77	916.57	.68	911.7
.76	911.7	.66	"
.76	911.9	.64	"
.75	911.9	-	"
.74	912.0	.68	"
.74	912.0	.75	"
.74	911.9	.74	915.0
.74	"	.73	914.2
.74	"	.74	912.7
.71	"	.74	912.6
.70	"	.72	912.3
.71	"	.75	912.0
.67	"	.74	"
.67	"	.76	"
.68	"	.73	"
.68	"	.76	"
.66	"	.76	"
.67	"	.76	912.1
.62	"	.72	912.1
.67	"	.78	912.0
.66	"	.78	911.9
.65	911.8	.78	914.3
.65	911.8	.76	916.2

(Continued)

Discharge (h)	Elev. of Water	Discharge (h)	Elev. of Water
.80	917.0	.73	912.4
.77	916.9	.74	912.3
.80	917.6	.73	912.6
.79	917.8	.70	912.5
.77	918.0	.74	912.6
.77	917.4	.72	912.6
.76	917.4	.73	912.4
.75	913.4	.73	912.7
.75	912.6	.72	912.8
.75	912.5	.73	912.4
.75	912.4	.73	912.8
.73	912.3	.73	912.3
.74	912.2	.72	912.1
.74	912.4	.72	912.1
.74	912.2	.72	912.1
.73	912.2	.72	912.1
.71	912.1	.74	911.8
.74	912.3	.73	911.5
.70	912.2	.73	911.4
.74	912.4	.79	911.3
.74	912.1	.76	911.2
.74	912.4	.78	911.5
.74	912.3	.72	911.7
.74	912.3		911.6
.74	912.4		912.1
.75	912.4		913.8

Well No. 5

Discharge (h)	Elev. of Water
Start at 8:45 A.M.	
.64	917.4
.62	912.4
.62	912.4
.62	911.9
.72	911.9
.72	911.9
.72	911.9
.72	911.9
.70	911.9
.70	911.9
.70	911.9
.70	909.4
.69	909.1
.70	909.1
.70	909.3
.69	909.8
.69	909.8
.69	909.4
.69	909.7
.69	909.4
.69	909.5
.69	909.5
.68	910.0
.68	909.4
.68	909.6
.71	909.6
.70	910.4
.68	909.9
.68	909.7
.65	910.8
.69	909.4
.69	909.0
.69	909.4
.67	909.4
.66	909.9
.70	909.2
.69	909.2
.70	909.0
.68	909.5
.70	909.1
.68	909.9
.69	909.3
.67	909.9
.69	909.4
.66	910.7
.70	-

(Continued)

Discharge (h)	Elev. of Water	Discharge (h)	Elev. of Water
.70	-	.67	910.7
.70	909.4	.66	911.2
.70	909.4	.68	911.9
.70	909.9	.69	910.8
.69	909.7	.70	911.1
.68	909.6	.70	910.6
.64	910.2	.70	910.9
.69	911.4	.71	910.2
.69	910.2	.71	910.7
.67	910.1	.71	910.5
.67	910.2	.70	910.2
.69	910.6	.70	910.2
.69	909.6	.69	910.8
.68	909.6	.69	910.8
.69	910.2	.69	910.8
.70	910.4	.69	910.9
.69	910.2	.69	911.1
.69	910.2	.67	910.5
.69	910.1	.67	
.69	910.1	.67	
.68	910.8	.67	
.67	910.9	.68	
.69	911.1	.67	
.69	910.4	.68	
.66	910.6	.67	
.69	911.9	.66	
		.67	

Well No. 4

Discharge (h) Start at	Elev. of Water Start at	Discharge (h) -	Elev. of Water -
2:45 P.M.	2:30 P.M.	.74	-
.58	917.04	.72	917.0
.68	914.0	.70	914.4
.66	912.4	.72	912.0
.57	911.3	.68	912.2
.62	911.4	.74	912.4
.62	911.6	.72	912.2
.68	911.7	.71	912.0
.62	911.1	.75	912.0
.62	911.4	.70	912.1
.61	911.3	.64	912.1
.65	911.5	.68	911.7
-	911.4	.71	911.4
-	-	.78	911.4
-	-	.74	911.4
-	-	.74	911.7
.67	-	.72	912.0
.68	911.6	.70	912.2
.66	911.6	.72	912.4
.67	911.1	.68	913.0
-	911.1	.68	913.4
-	911.1	.68	914.2
-	-	.66	915.0
-	-	.66	-

(Continued)

Discharge (h)	Elev. of Water	Discharge (h)	Elev. of Water
-	-		
.80	-		
.72	914.0		
.70	913.0		
.72	"		
.74	"		
.72	"		
.72	"		
.70	"		
.70	913.2		
.71	913.4		
.72	913.8		
.70	914.0		
.68	914.0		
.70	914.0		
.72	913.8		
.70	913.4		
.72	913.7		
.74	914.0		
.72	913.5		
.72	912.0		

Well No. 5

Discharge (h) Started at 4:45 P.M.	Elev. of Water Started at 6:30 P.M.	Discharge (h)	Elev. of Water
.72	916.66	.76	913.7
.67	912.3	.70	915.8
-	912.3	.70	917.8
.72	912.6	-	917.8
.71	912.5	.74	918.3
.73	911.3	.74	917.4
.77	912.1	.70	916.3
.71	911.1	.80	917.3
.74	-	.82	916.3
.64	912.6	.78	-
.66	912.8	.76	-
.72	911.3	.76	916.3
.70	910.8	.74	915.4
.60	918.3	.76	-
.66	-	.60	910.8
.62	912.8	.74	911.2
.69	912.8	.76	911.8
.78	912.8	.76	911.3
.76	-	.76	911.8
.80	-	.76	911.3
.78	912.1	-	-
.80	-	.68	-
.78	911.7	.74	911.8
		.76	911.3

(Continued)

Discharge (h)	Elev. of Water	Discharge (h)	Elev. of Water
.68	911.8	.66	911.2
.70	911.9	.72	911.2
.70	911.9	.70	911.2
.76	911.9	.65	910.6
.72	911.8	.68	910.4
.74	911.8	.66	910.4
.72	912.0	.70	910.4
.74	912.0	.66	910.4
.72	912.4	.69	910.6
.76	912.9	.70	910.6
.74	912.9	.69	910.6
.74	912.8	.72	910.5
.74	912.4	.71	910.5
.68	912.2	.70	910.5
.70	911.8	.70	
.72	911.1	.71	
.67	911.2	.69	
.66	911.9	.68	
.69	911.6	.69	
.72	911.5	.69	
.71	911.3	.70	
.61	911.3	.70	
.77	911.4		
.72	911.4		
.73	911.3		
.66	911.2		

Well No. 6

(Readings taken every 15 minutes)

Discharge (h)	Elev. of Water	Discharge (h)	Elev. of Water
Start at		.69	913.4
5:00 P.M.		.68	913.9
.65	910.52	.67	913.4
.69	912.40	.66	913.4
.62	913.90	.65	913.4
.605	-	.62	914.4
.59	914.4	.65	914.9
.61	914.4	.71	914.4
.62	-	.69	913.9
.63	913.1	.68	-
.63	913.1	.76	914.4
.61	913.4	.74	913.8
.61	913.4	.74	912.8
.63	912.9	.79	913.4
.63	913.3	.73	913.4
.65	913.4	-	914.0
.66	912.9	-	913.4
.67	914.5	-	-
.67	911.9	.77	913.3
.70	911.8	.76	913.2
.68	913.4	.76	914.4
.66	912.3	.77	914.4
.67	-	.62	912.2
.66	913.4	.76	913.9
.67	913.4	.77	914.1

(Continued)

Discharge (h)	Elev. of Water	Discharge (h)	Elev. of Water
-	-	.73	911.1
-	-	.69	911.3
.63	-	.66	911.5
-	-	.65	909.1
-	914.4	.79	909.0
-	913.9	.70	909.2
.83	-	.76	908.4
.77	914.9	.77	908.7
.-	914.4	.77	908.5
-	-	.77	908.9
.74	-	.75	909.5
-	-	.79	909.4
-	914.4	.68	909.5
-	913.9	.67	909.6
.65	-	.67	-
.67	-	-	-
-	-	-	908.6
-	-	.77	908.6
-	-	.77	908.5
-	-	.68	
-	-	.76	
-	-	.77	
-	914.1	.76	
-	910.3	.82	
.61	911.1		
.69	910.2		
.68	910.0		

Probable Available Yield of Ground Water at Losey Avenue Site.

From the curves which have just been shown in this report, we are able to make some estimates as to the quantity of water which might be expected at the Losey Avenue site. These curves show the tests that were made upon the six new wells drilled in 1923. The following conclusions have been drawn after a study of this available data, and after a personal investigation of conditions at the new pumping station.

That the available yield of one of a number of 12 inch wells spaced 300 feet apart in the Losey Avenue area, would be at least one million gallons per day, and probably would amount to nearer one and one half million gallons per day.

In the area at the Losey Avenue site, there could be developed as many as ten 12 inch wells spaced 300 feet apart.

That such a development would have very little effect if any, upon any existing ground water development in the down town section of the city.

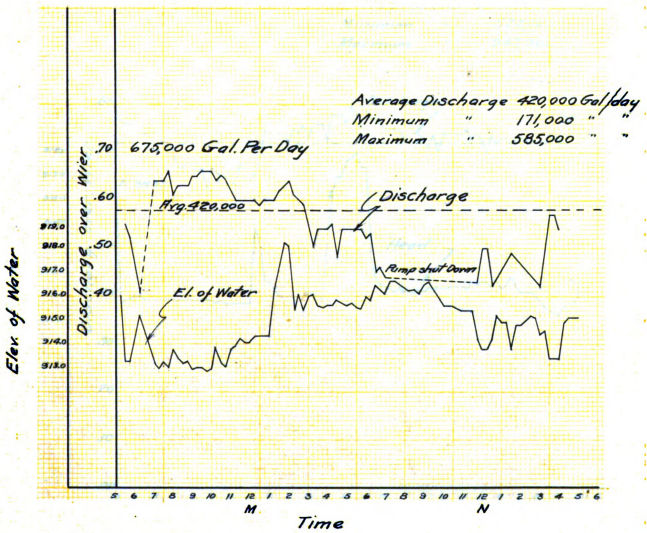
That such a scheme of development might be continued in adjacent areas, south of the Losey Avenue site.

That in lowering the six wells eight feet, there would be a yield of six million gallons.

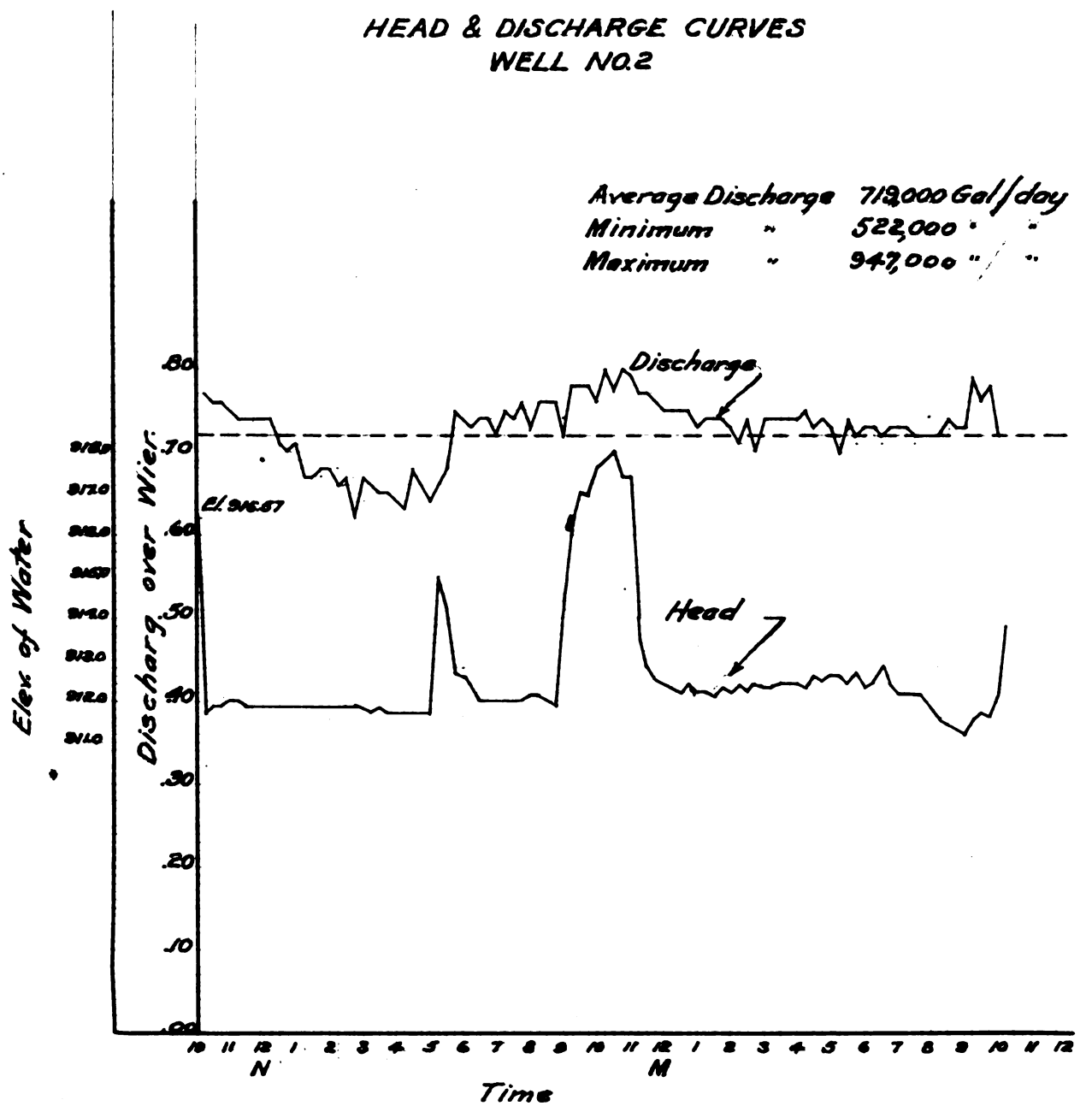
It would appear that there might be developed an average daily rate of 10 to 15 million gallons of water in the immediate vicinity of Losey Avenue, and that this amount could probably be increased during the hours of greatest demand.

According to Superintendent Hatch the six new wells will be connected to the existing pumping system some time in June of this year. He also says, that contracts have been let for pumping machinery and boilers for the new plant, which will be of the latest and most efficient type. The work on the storage reservoir with a capacity of three million gallons is well under way at the present time. If there are no delays in the construction work, the new station will be in operation early in the year 1925. This will give the city of Jackson a water system, along with adequate supply of water, which will serve an estimated population of 118,000 in 1950.

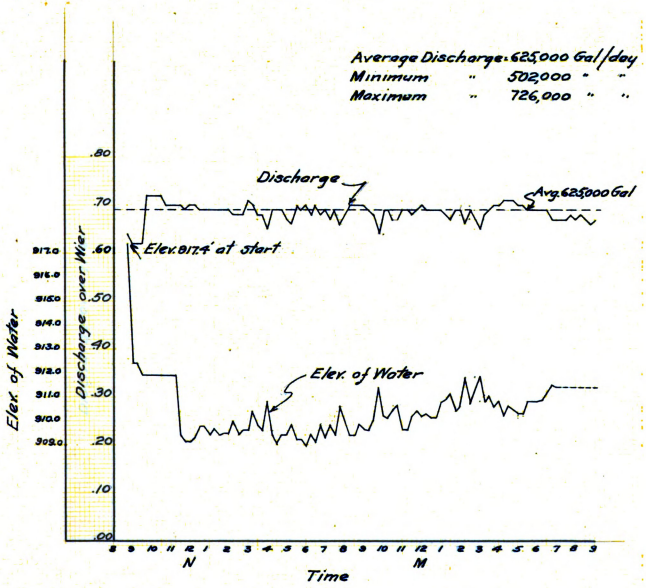
HEAD & DISCHARGE CURVES
WELL NO. 1.

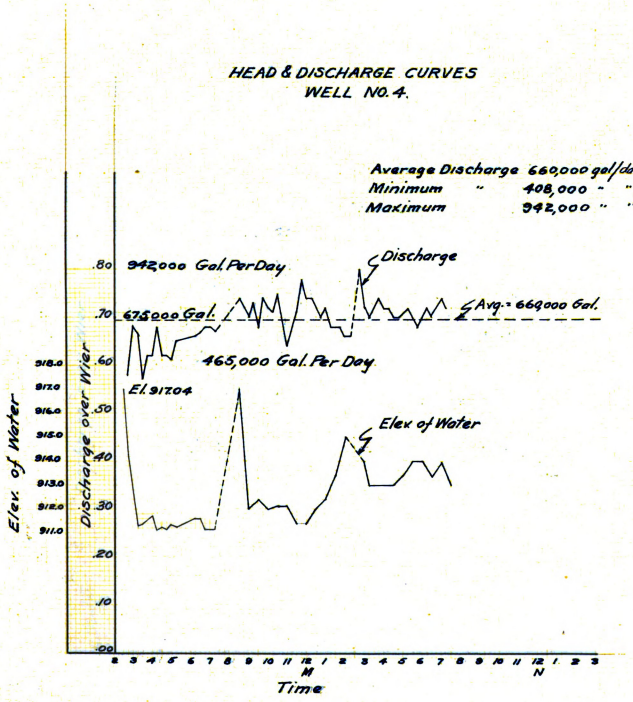


DEPARTMENT OF MATHEMATICS

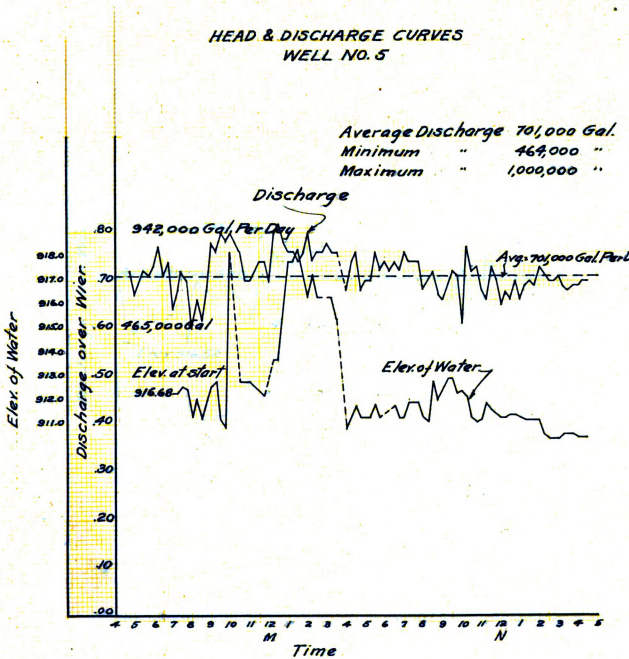

HEAD & DISCHARGE CURVES
WELL NO.2
Average Discharge 713,000 Gal/day
Minimum " 522,000 " "
Maximum " 947,000 " "
Discharge
Head
El. 946.67
Elev of Water
Discharg. over Wier
.80
.70
.60
.50
.40
.30
.20
.10
.00
946.0
945.0
944.0
943.0
942.0
941.0
10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
N
M
Time

HEAD & DISCHARGE CURVES
WELL NO.3



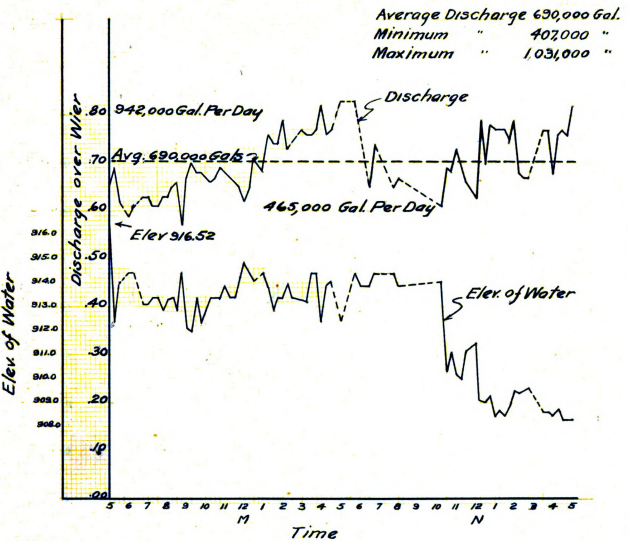


DEPARTMENT OF MATHEMATICS

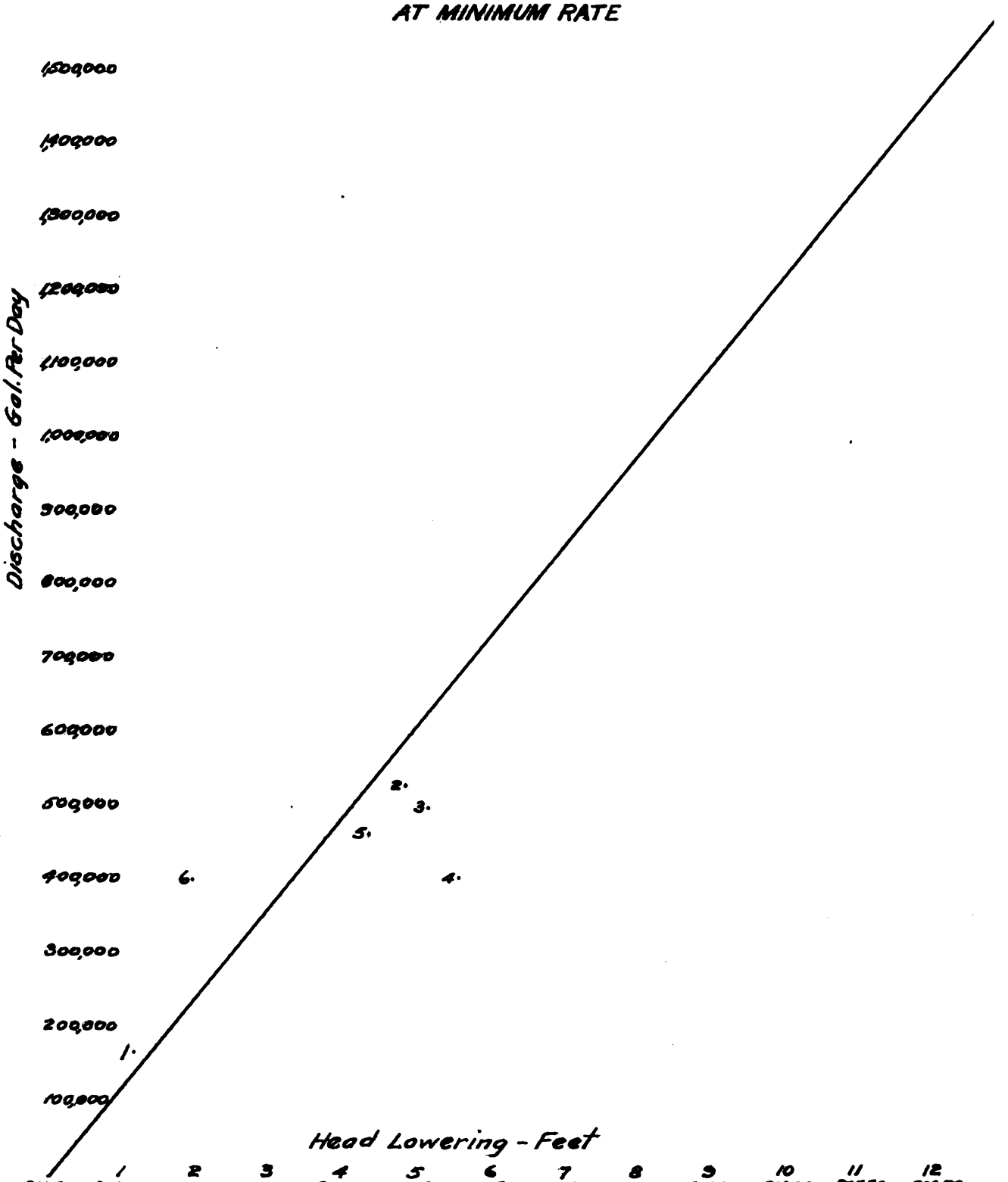


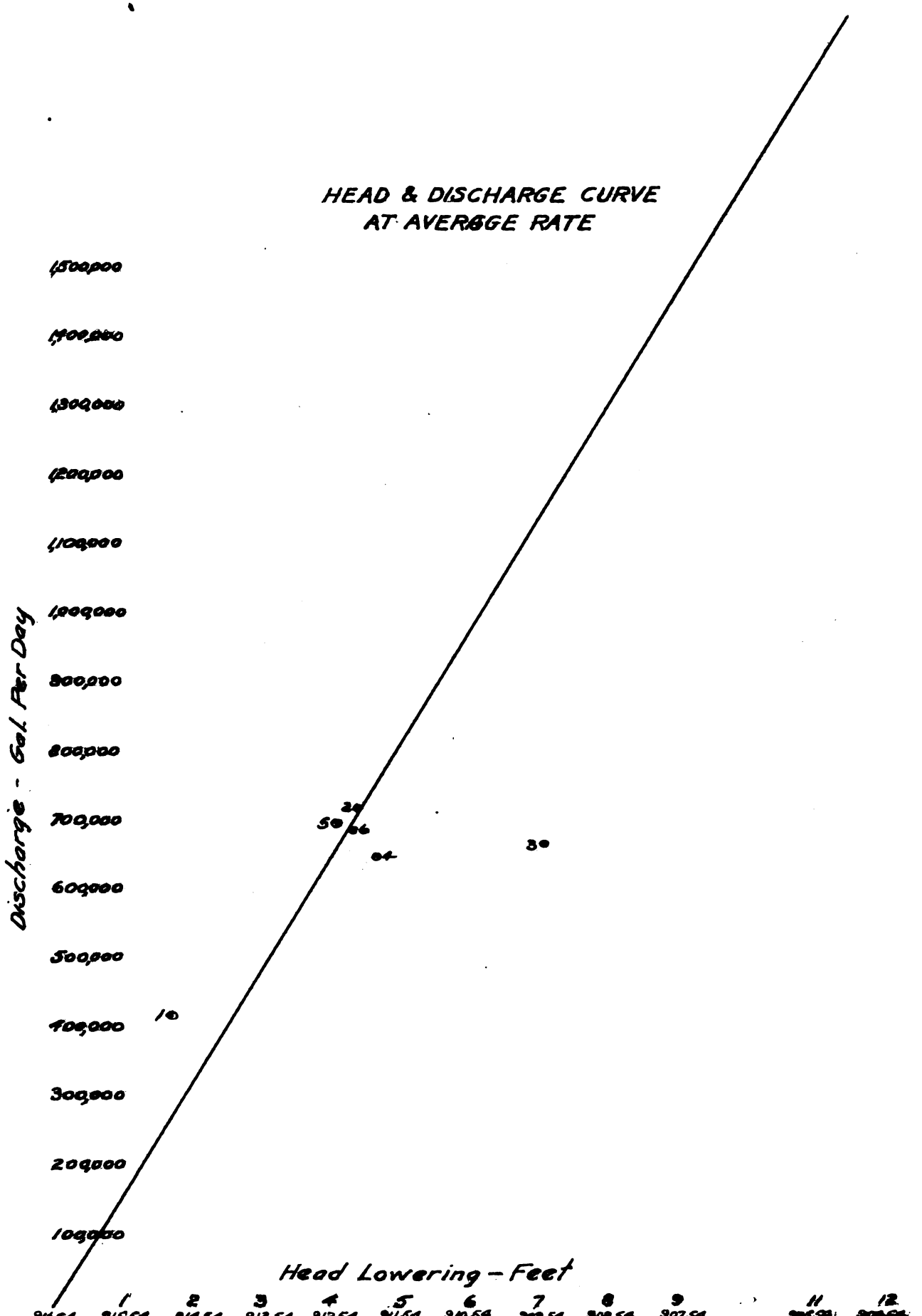
DEPARTMENT OF MATHEMATICS

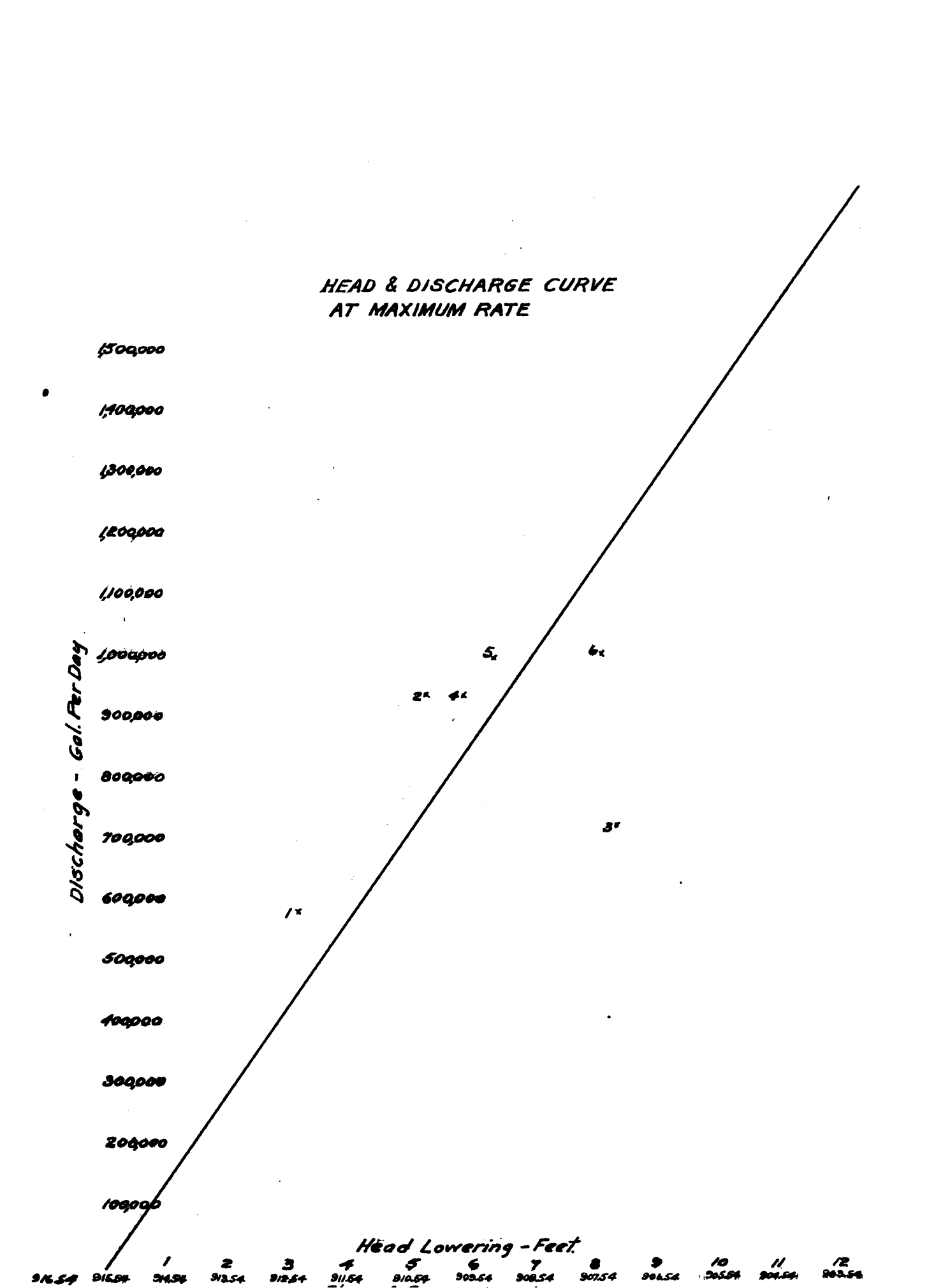
HEAD & DISCHARGE CURVES
WELL NO. 6.

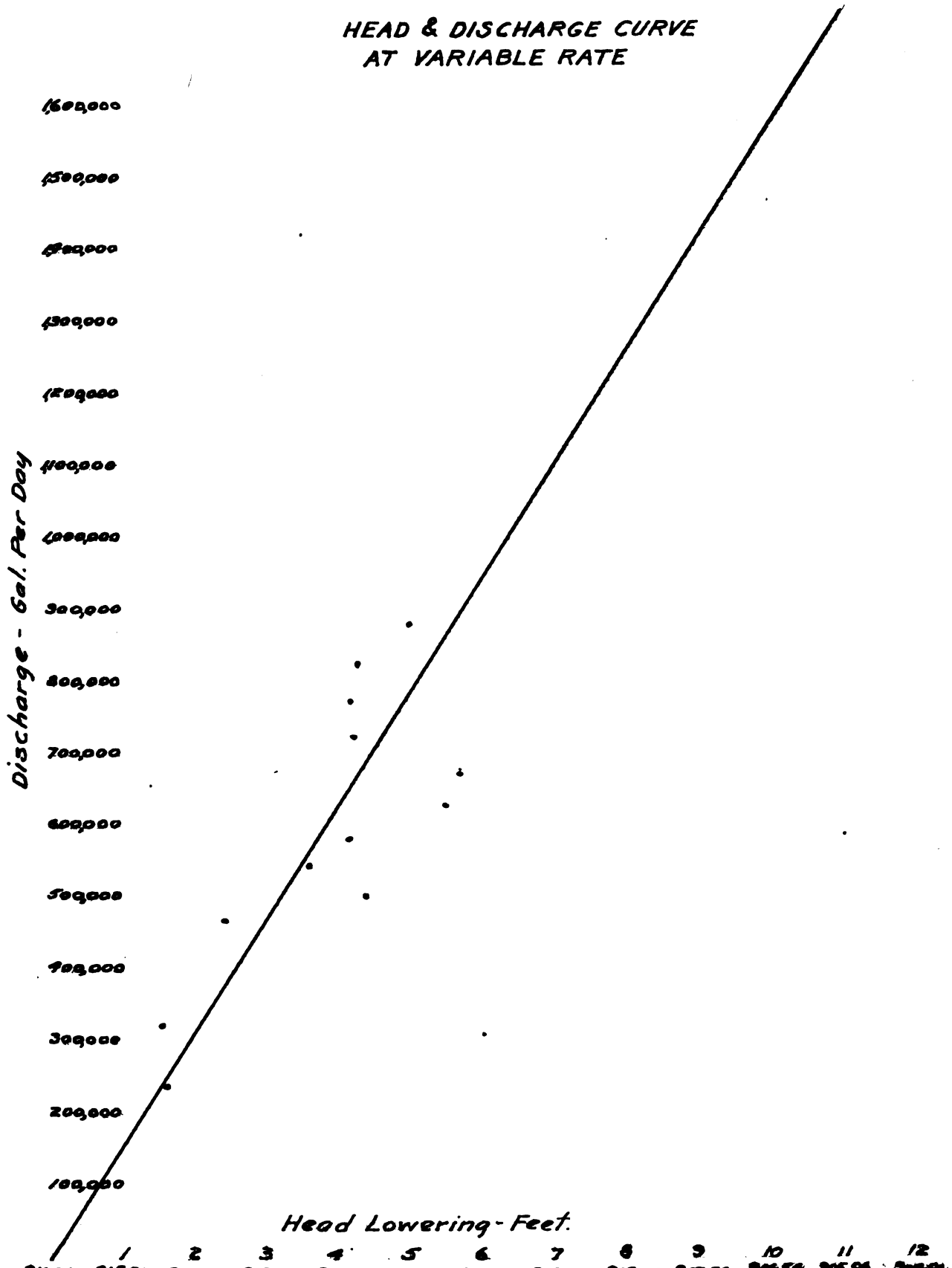


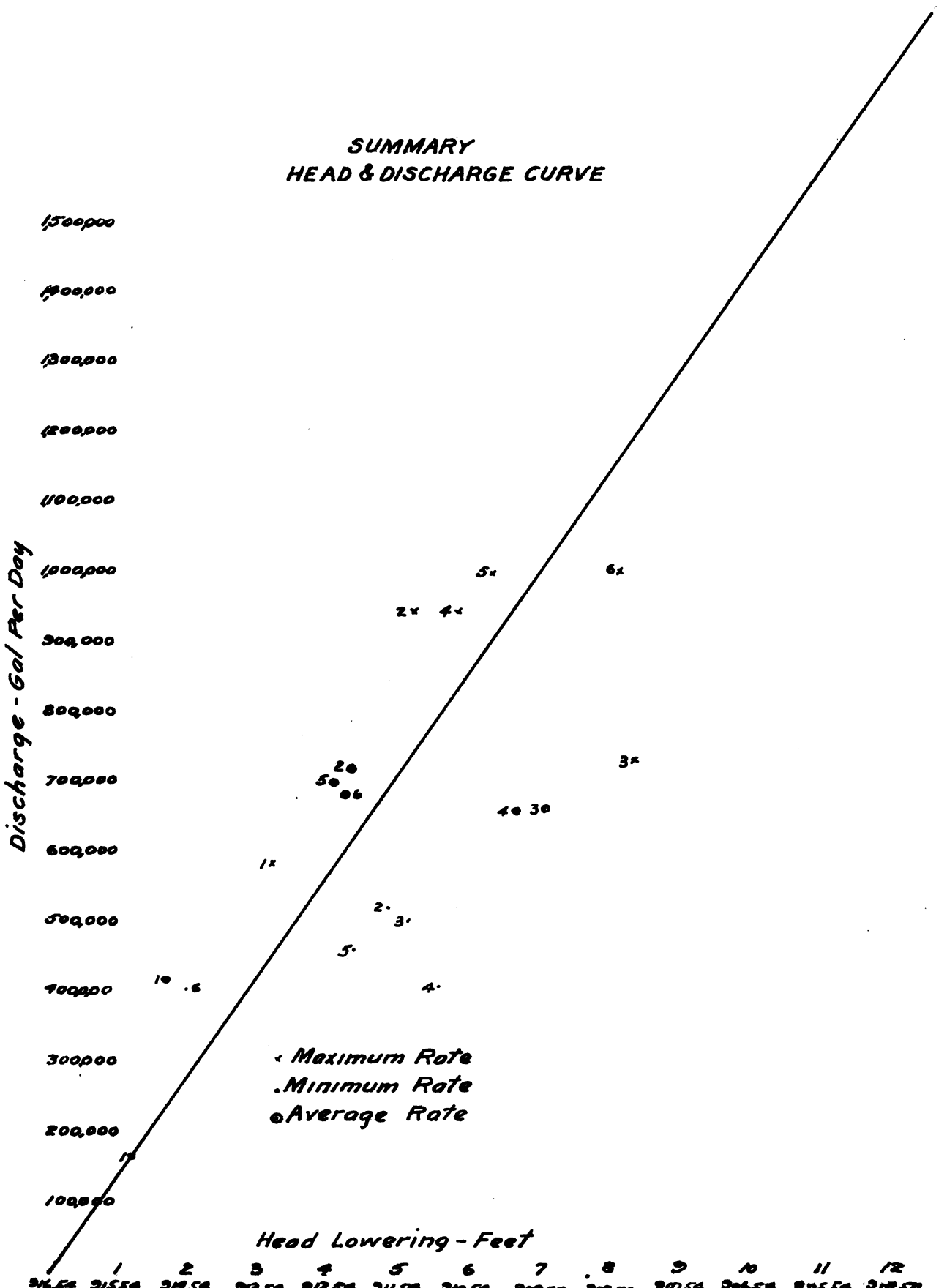
HEAD & DISCHARGE CURVE AT MINIMUM RATE

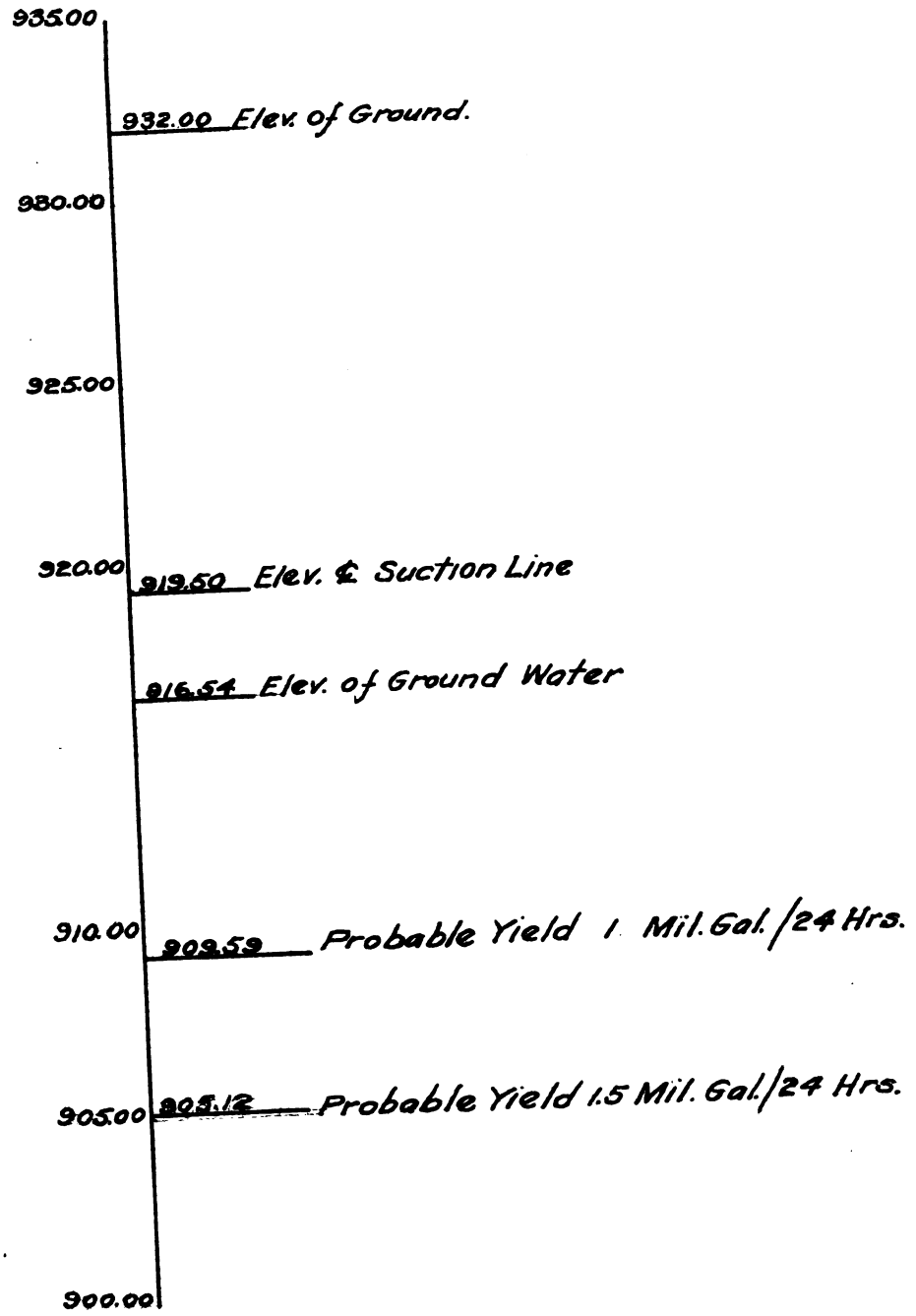


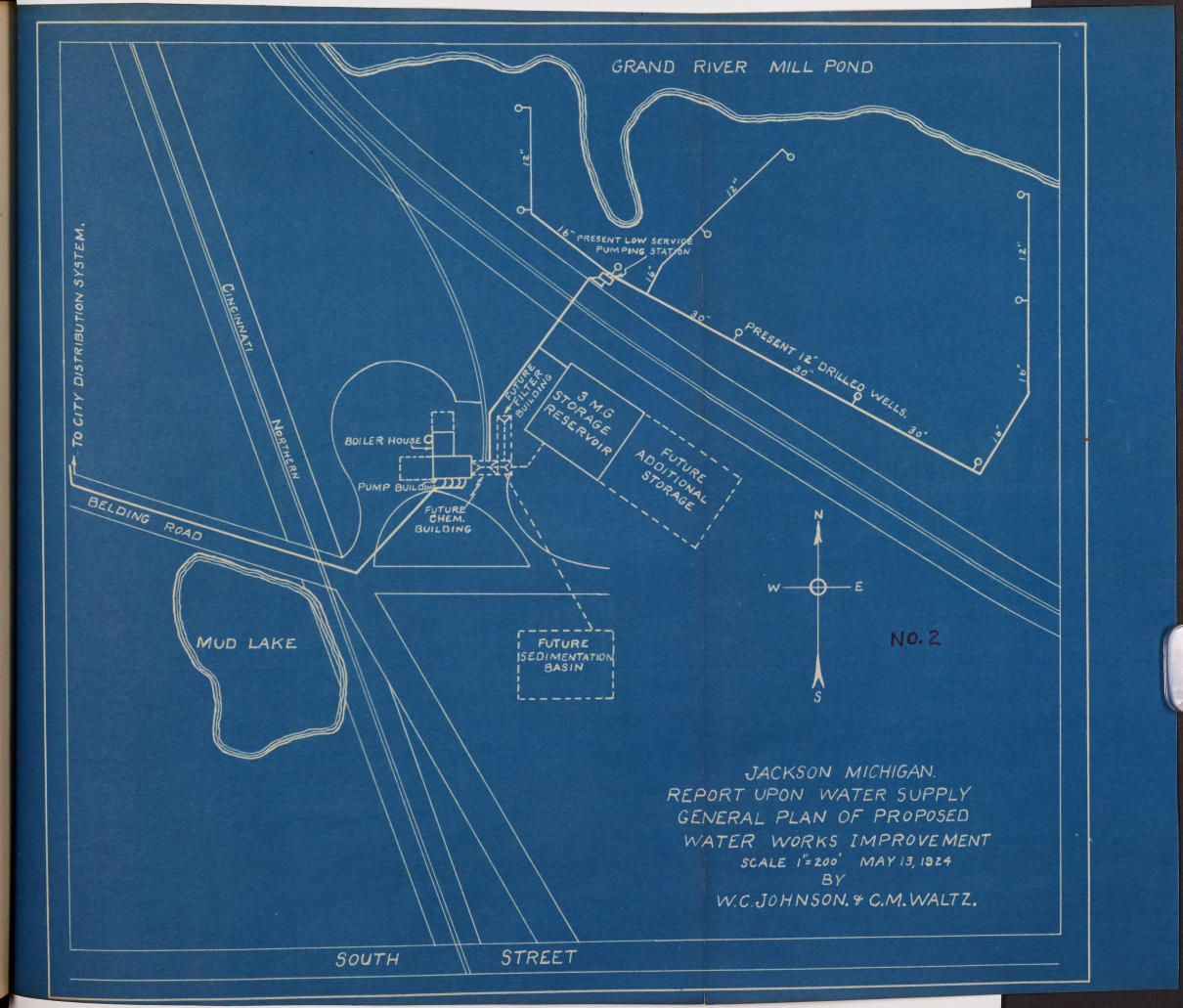

HEAD & DISCHARGE CURVE
AT AVERAGE RATE
Discharge - Gal. Per Day
1500000
1400000
1300000
1200000
1100000
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
Head Lowering - Feet
1
2
3
4
5
6
7
8
9
11
12
916.54
915.54
914.54
913.54
912.54
911.54
910.54
909.54
908.54
907.54
10
50
24
66
64
30


HEAD & DISCHARGE CURVE
AT MAXIMUM RATE
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
Discharge - Gal. Per Day
1x
2x
3x
4x
5x
6x
Head Lowering - Feet.
916.54
1 915.54
2 914.54
3 913.54
4 912.54
5 911.54
6 910.54
7 909.54
8 908.54
9 907.54
10 906.54
11 905.54
12 904.54
903.54

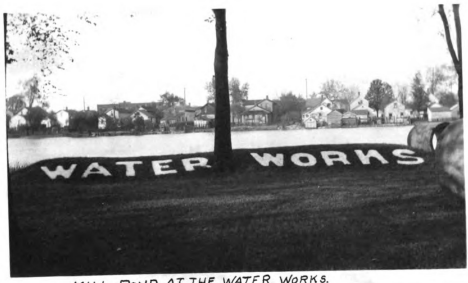

HEAD & DISCHARGE CURVE
AT VARIABLE RATE
Discharge - Gal. Per Day
Head Lowering - Feet.
916.54
1
915.54
2
914.54
3
913.54
4
912.54
5
911.54
6
910.54
7
909.54
8
908.54
9
907.54
10
906.54
11
905.54
12
904.54


SUMMARY
HEAD & DISCHARGE CURVE
Discharge - Gal Per Day
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
Head Lowering - Feet
1
2
3
4
5
6
7
8
9
10
11
12
916.54
915.54
914.54
913.54
912.54
911.54
910.54
909.54
908.54
907.54
906.54
905.54
904.54
× Maximum Rate
. Minimum Rate
◎ Average Rate

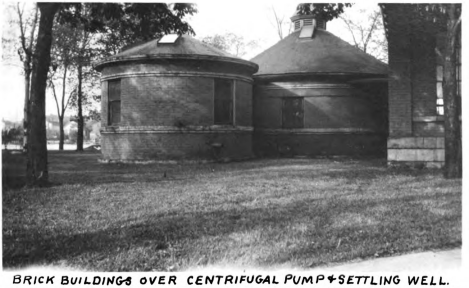

935.00
932.00 Elev. of Ground.
930.00
925.00
920.00
919.50 Elev. ℄ Suction Line
916.54 Elev. of Ground Water
910.00
909.59 Probable Yield 1 Mil. Gal./24 Hrs.
905.00
905.12 Probable Yield 1.5 Mil. Gal./24 Hrs.
900.00


GRAND RIVER MILL POND
12"
16" PRESENT LOW SERVICE PUMPING STATION
12"
16"
30"
PRESENT 12" DRILLED WELLS
30"
30"
12"
16"
12"
TO CITY DISTRIBUTION SYSTEM.
CINCINNATI NORTHERN
FUTURE FILTER BUILDING
3 MG STORAGE RESERVOIR
FUTURE ADDITIONAL STORAGE
BOILER HOUSE
PUMP BUILDING
FUTURE CHEM. BUILDING
BELDING ROAD
MUD LAKE
FUTURE SEDIMENTATION BASIN
N
W
E
S
NO. 2
JACKSON MICHIGAN.
REPORT UPON WATER SUPPLY
GENERAL PLAN OF PROPOSED
WATER WORKS IMPROVEMENT
SCALE 1"=200' MAY 13, 1924
BY
W.C. JOHNSON. & C.M. WALTZ.
SOUTH STREET

PUMPING STATION ON WATER STREET



MILL POND AT THE WATER WORKS.



BRICK BUILDINGS OVER CENTRIFUGAL PUMP + SETTLING WELL.

½ MIL-GAL RESERVOIR ON WATER STREET

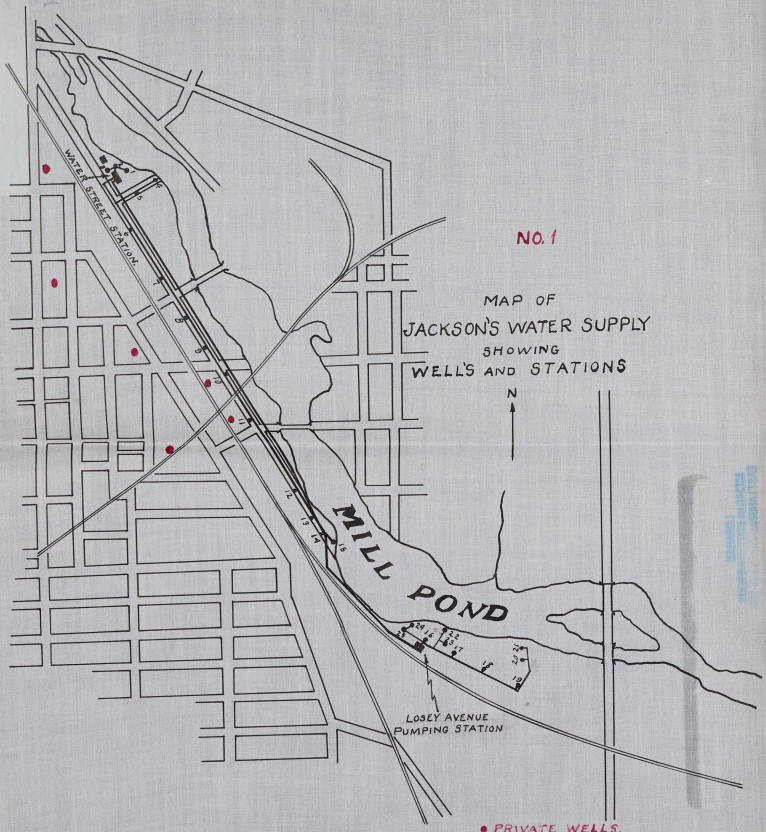
[redacted]

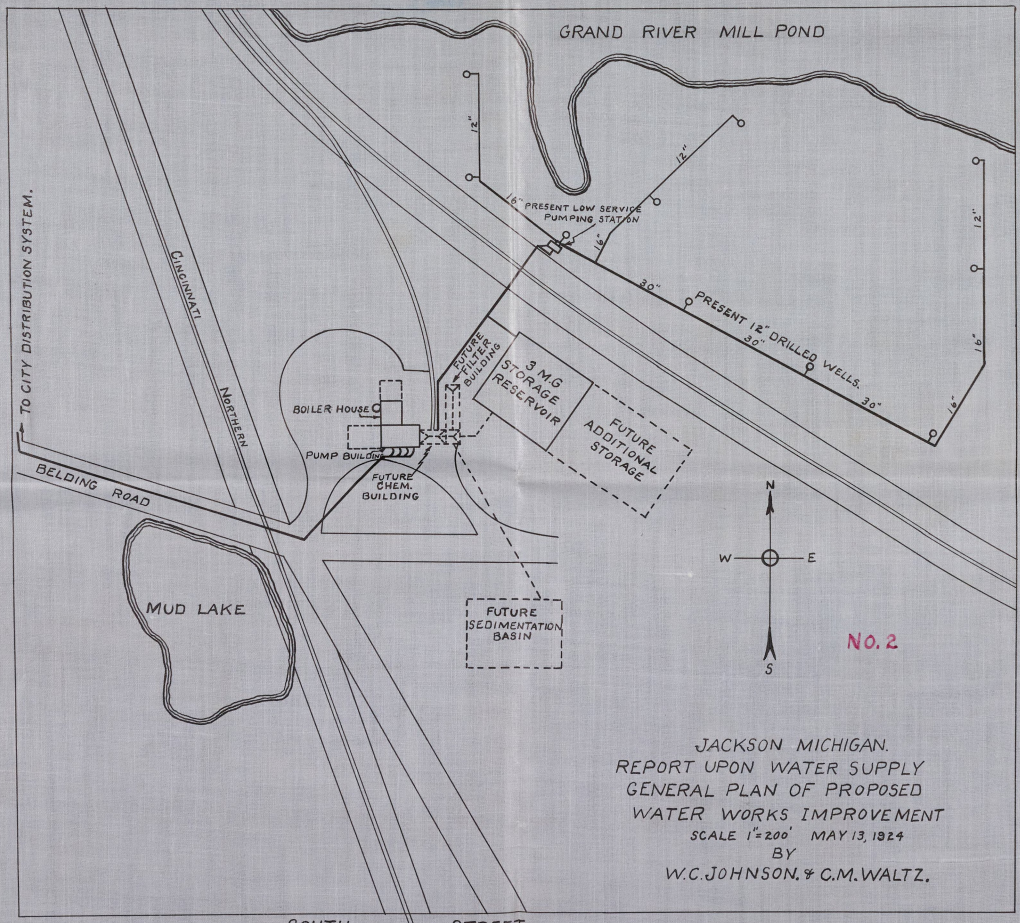
Pocket Atlas:

CONTENTS OF POCKET.

1. Map of Jackson with Water Mains
1. Tracing of Plan of Pumping Station
1. Map of New Pumping Station NO. 2
1. Map of Present Wells NO. 1
4. Negatives

SUPPLEMENTARY MATERIAL




GRAND RIVER MILL POND
TO CITY DISTRIBUTION SYSTEM.
CINCINNATI
NORTHERN
BELDING ROAD
MUD LAKE
SOUTH
STREET
12"
16"
PRESENT LOW SERVICE PUMPING STATION
12"
16"
30"
PRESENT 12" DRILLED WELLS.
30"
30"
12"
16"
16"
FUTURE FILTER BUILDING
3 MG STORAGE RESERVOIR
FUTURE ADDITIONAL STORAGE
BOILER HOUSE
PUMP BUILDING
FUTURE CHEM. BUILDING
FUTURE SEDIMENTATION BASIN
N
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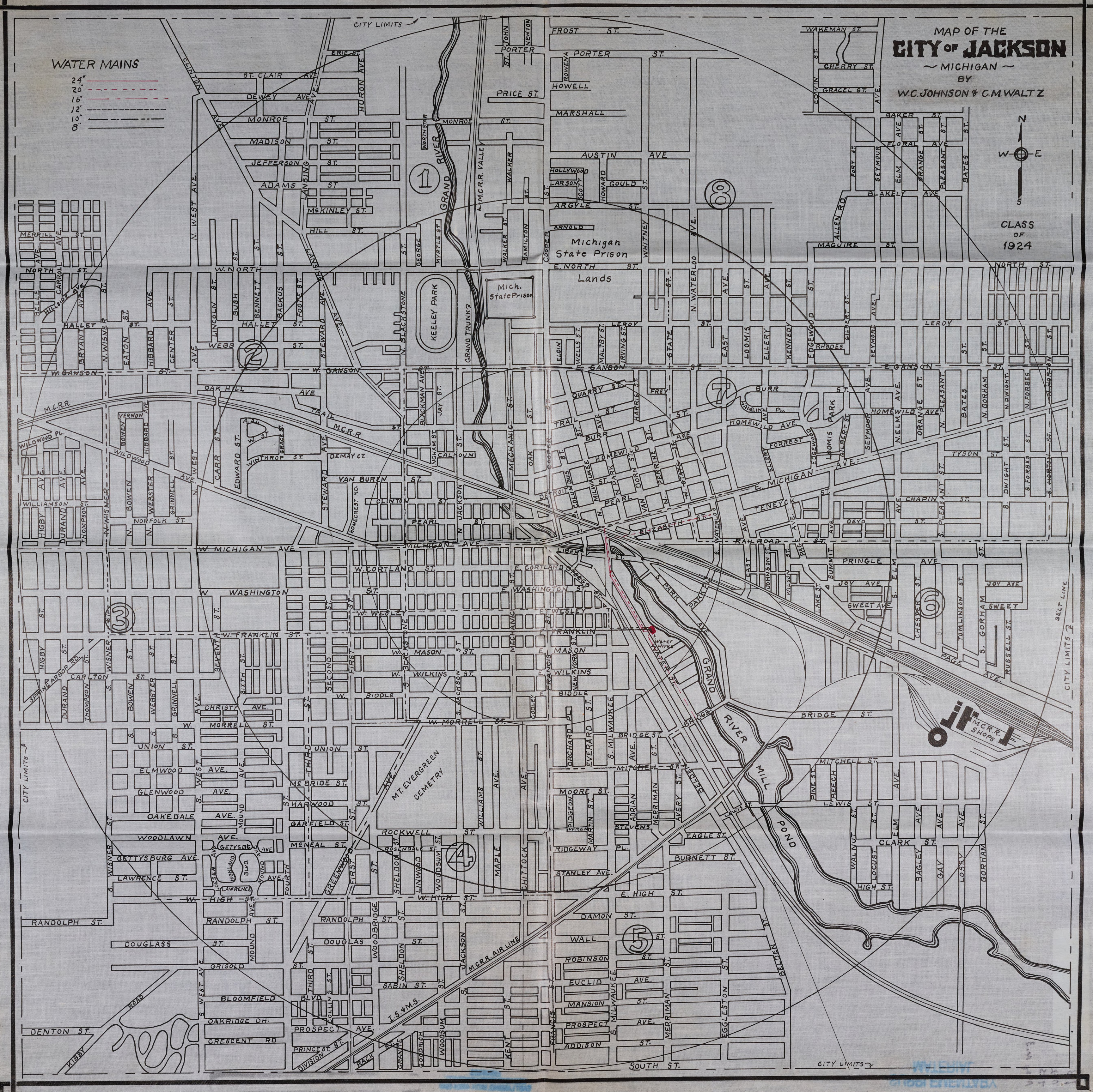
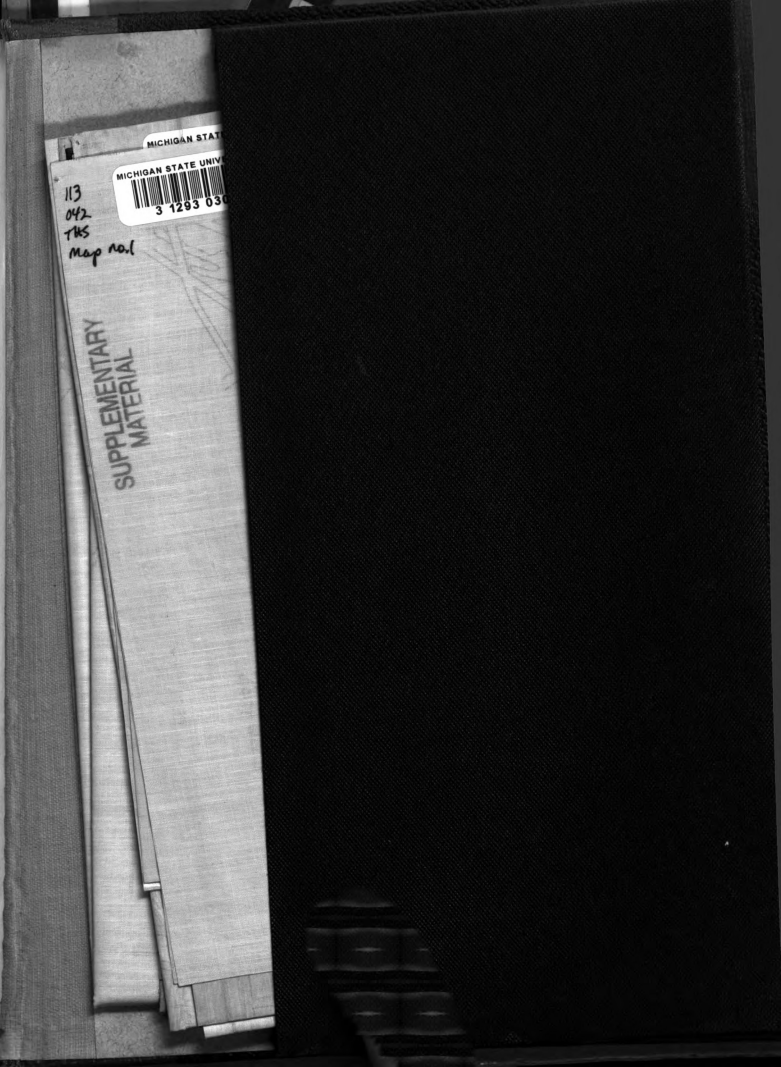

MAP OF THE
CITY OF JACKSON
~MICHIGAN~
BY
W.C. JOHNSON & C.M. WALTZ
CLASS OF 1924
WATER MAINS
24"
20"
16"
12"
10"
8"
N
W
E
S
CITY LIMITS
Michigan State Prison
Mich. State Prison
E. NORTH Lands
KEELEY PARK
MT. EVERGREEN CEMETERY
M.C.R.R. SHOPS
GRAND RIVER
MILL POND
BELT LINE
M.C.R.R.
GRAND TRUNK
M.C.R.R. AIR LINE
L.S.&M.S.
M.C.R.R. VALLEY
W. MICHIGAN AVE.
E. MICHIGAN AVE.
W. GANSON
E. GANSON
W. NORTH
WASHINGTON
W. FRANKLIN ST.
W. MORRELL ST.
W. HIGH ST.
E. HIGH ST.
RANDOLPH ST.
DOUGLASS
BLOOMFIELD
OAKRIDGE DR.
CRESCENT RD
PROSPECT AVE.
DENTON ST.
SOUTH ST.
FROST ST.
PORTER ST.
PRICE ST.
HOWELL
MARSHALL
AUSTIN AVE
ARGYLE
MONROE ST.
MADISON ST.
JEFFERSON ST.
ADAMS ST.
McKINLEY ST.
DEWEY AVE.
ST. CLAIR AVE.
HILL ST.
HALLET ST.
WEBB
OAK HILL AVE
VAN BUREN
CLINTON
PEARL ST.
W. CORTLAND ST.
W. WESLEY
W. MASON ST.
W. WILKINS ST.
BIDDLE
UNION ST.
ELMWOOD AVE.
GLENWOOD AVE.
OAKDALE AVE.
WOODLAWN AVE.
GETTYSBURG AVE.
LAWRENCE ST.
ROCKWELL
MENEAL ST.
GARFIELD ST.
HARWOOD
McBRIDE ST.
MOORE ST.
STEVENS
RIDGEWAY PL.
STANLEY AVE.
DAMON ST.
WALL
ROBINSON
EUCLID AVE.
MANSION
ADDISON
BRIDGE ST.
MITCHELL ST.
LEWIS ST.
CLARK ST.
EAGLE ST.
BURNETT ST.
PRINGLE AVE.
JOY AVE
SWEET AVE.
PAGE AVE.
CHAPIN
TYSON
TENEYCK
ELIZABETH ST.
BURR ST.
HOMEWILD AVE.
LEROY
RHODES
MAGUIRE ST.
E. NORTH ST.
BAKER ST.
FLORAL AVE.
BLAKELY AVE.
WAKEMAN ST.
CHERRY ST.
GRACEL ST.
N. WATERLOO AVE.
WHITNEY
N. WEST AVE.
S. WEST AVE.
LANSING AVE.
STEWARD AVE.
N. BLACKSTONE
N. JACKSON
S. JACKSON
MECHANIC ST.
S. MILWAUKEE
FRANCIS
COOPER ST.
N. GORHAM
S. GORHAM
N. ELM
S. ELM
PLEASANT
BATES
ORANGE ST.
SEYMOUR
KIBBY ROAD
HIGBY
DURAND
WISNER
BOWEN
WEBSTER
GRINNELL
MERRIMAN
EGGLESTON ST.
FOURTH
SECOND
FIRST
THIRD
WOODBRIDGE
SHELDON ST.
LINWOOD
WOODSUM ST.
MAPLE AVE.
WILLIAMS AVE.
1
2
3
4
5
6
7
8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Map no.1
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