THESIS

THE WATER SUPPLY SYSTEM
OF
LANSING, MICHIGAN

H. B. Huntley J. O. Gower

1924

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including

Investigation, estimates, and recommendations

by

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THE CITY OF LANSING:

Lansing, the capital of the State is located in the southcentral part of the southern peninsula of Michigan. It has a population according to the 1920 U.S. census returns of 57,327, nearly half of which has been acquired within the last decade. From the start up to 1900, the growth of Lansing has been slow and quite uniform. The recent growth is quite largely attributed to the rapid expansion of the automobile industry which is exerting a similar influence upon practically all of the important Michigan cities.

The city occupies an area which is practically square measuring approximately three miles east and west by three and one half miles north and south. The built-up portion of the city now includes all of the area within the city limits, except a narrow strip around the edge which has recently been annexed to the city and this is being rapidly developed along the south and west sides of the city.

The principal industries are the Olds and Reo Automobile Plants although many casting, truck, engine works, and similar allied industries contribute to the industrial stability of the community. Lansing is an important distributing point for south central Michigan on account of its excellent railroad facilities.

The principal commercials district lies in the center of the city and the industries in general are located along the Grand River and the railroads which pass through the heart of the city.

HISTORY OF WATER WORKS DEVELOPMENT AT LANSING:

A brief review will be made of the steps which have been taken from time to time to provide a more adequate or safe supply of water for the city.

The first water works plant in Lansing was constructed in 1885. The supply was drawn from an open well sunk in sand at the site of the present Cedar St. Plant. The original well, is still in existence but is now used for condensing water storage only.

The pumping equipment in the original plant consisted of two 1 1/2 million gallons Worthington duplex steam pumping engines taking suction from the open well and discharging into the distribution system and against a steel standpipe 16 ft. in diameter and 154 ft. in height. This standpipe is still in service.

A few years ago, in the early 90's the brick suction well was abandoned as a source of supply and twelve shallow wells were sunk in the station yard. The depth of these wells is not definitely known now but they probably did not exceed 50 ft. in depth. The water was drawn form the wells by direct suction through a 6" drop pipe suspended in each of the twelve wells.

About 1895 the pumping capacity was increased by the addition of a Holly pumping engine having five millions gallons daily capacity. About the same time the water supply was added to by sinking about twelve tubular wells 6" and 8" in size to a depth of 150 ft. These wells were drilled on the pumping station lot near the tile wells and were cased with wrought iron pipe down to the rock line.

In 1906 due partly to the break of the single force main under the Grand River near the pumping station and the consequent inability of the Cedar St. Station to supply the north part of the city with water for several days, it was decided to construct auxilliary pumping stations on the out skirts of the city which would draw their supply from wells drilled into the coal measure sandstones, and discharge directly into the distributing system. By this mehtod, it was also thought that the draft of the underground strata could be distributed and further that there would be material savings in the distribution by having water admitted to the mains at a number of points throughout the city rather than distributing the entire pumpage from one plant. The Townsend St. Station was the first auxilliary station built. Its equipment consisted of a motor driven Gould's Triplex Pump having a capacity of 1,800,000 gallons per day and taking suction from four 8"and one 12" wells about 350 ft. deep.

Proceeding upon this same program, the Seymour St. Station was built in 1908. Five wells were drilled at this station and a Gould's Triplex Pump of 1,380,000 gallons capacity per day at normal speed was installed. This pump was motor driven.

In the year following (1909) the Pennsylvania Ave. station was built. The original pump, which is still in use, was a Fairbanks Morse, motor driven, duplex, double acting crank

and flywheel pump with a rated capacity of 1,500,000 gallons per day. In 1911 a 10" Allis Chalmers motor driven centrifugal pump was added. It has a capacity of 3,000,000 gallons daily against the ordinary operating pressure.

Both pumps took suction through a long suction main directly attached to a system of wells about 350 ft. deep.

Plate No.1 shows the general location of the several pumping stations. The relative elevations, the depths of wells and similar data for each station are shown on Plate No.2.

The City of Lansing has been continually face to face with intermittent shortage of water. In 1911, it was determined to put down six additional 12"wells at the main station and about this time the shallow tile wells were abandoned on account of pollution due to the more compact residental development in the vicinity of the station.

In 1914 the Logn St. pumping station was built and the 20" wells drilled there was equipped with the first electrical driven deep well pump which had been in service in Lansing. All of the stations built prior to this had drawn the water fro from the wells by direct suction and the amount of water whcih was within reach of the suction lift machinery was therefore limited.

In 1917 a 20" well was drilled inside of the present central pumping station. This well was also equipped with a deep well pump of the American Well Work's manufacture and similar to that installed at the Logan St. station. At this time the 12" wells at the central station drilled in 1911 were abandoned.

In 1917 and 1918 the city constructed two 3 1/2 millions gallons reservoirs immediately south of the Cedar St. pumping station, and at the same time installed a 10 million gallon horizontal cross-compound Snow pumping engine in an extension to the Cedar St. station built for that purpose. The Snow pumping engine was installed for use during hours of peak consumption, and to funnish fire protection. This pump draws water from the seven million gallons held in storage in the two reservoirs. The reservoirs are replentished by bleeding from the mains durings hours of low consumption by direct discharge of the well in the station yard.

In 1919, one of the abandoned 12" wells immediately outside of the Cedar St. station was equipped with a 12" American deep well pump and a new 20" well was drilled near the north reservoir and approximately 1000 ft. from the Cedar St. station. An additional 20" well was also started during 1919 and is known as the Park Place well. This well approximately 1500 ft. from the Cedar St. station is equipped with a American deep well pump discharging directly into the distributing system.

In 1923 plans were laind for a new pumping station and 12 new wells located near the intersection of the Pere Marquete Railroad and the Red Cedar River. At the present time these wells and the pumping station are under construction. These wells will discharge directly into the distributing system and is connected to same by a 16" main laid parallel to the

P.M. railroad.

The Water Work's distribution system was also added to from time to time until by 1896 it included over 40 miles of cast iron pipe to which were connected over 2500 services, approximately 300 of which were metered. Ten years later five more miles of pipe had been added to the distribution system, and the total number of services had increased to nearly 4000, nearly half of which were metered. The consumption in 1905 was slightly less than a million five hundred thousand gallons per day or approximately the same as it was in 1895 when carrying less than two-thirds as many consumers.

At the present time the water work's system has increased until it is supplying approximately 66,000 people through nearly 12,000 services, practically all of which are metered. The average daily use at the present time is five million gallons or an average of slightly less than eighty gallons per capita. During seasons of heavy consumption the water supply is incapable of meeting the demands made upon it and the service is defficient in quantity and pressure. With the completion of the new wells and pumping station this condition will be releived, but as the City of Lansing continues to grow as it no doubt will, the supply of water will continue to decline in quantity and pressure.

POPULATION GROWTH

The growth of population and wealth in communities imposes greater demands for municipal improvements. Public works and utilities, usually adequate when placed in service become increasingly more deficient until the time arrives when some change must be made. At that time it is important to plan for the future in laying out the work to care for the present.

Inasmuch as the demands for water are quite largely dependent upon the population to be supplied, it is quite important in beginning an investigation of the future water supply for a community to investigate the past growth of the community and the factors which have influenced it and forecast as nearly as possible the conditions which will have a bearing upon the future growth of the community and its demands for water supply.

The rate of growth of population of the City of Lansing was very slow until after 1900. The population as taken from the U.S. census for each year from 1860 to 1920 inclusive are as shown below:

1860 -	3,047
1870 -	5,241
1880 -	8,319
1890 -	13,102
1900 -	16,485
1910 -	31,229
1920 -	57,327

It will be noticed that the population practically doubled in the last decade. Prior to the last decade, Lansing had been quite largely a resindential community dependent upon the surrounding agricultural district, and serving as a distribution center therefore, although some diversified manufacturing had been conducted there.

Within the last few years, Lansing has had a phenomenal growth which has been common to other Michigan cities in which the automobile industry has become established. The Oldsmobile and Reo Automobile factories together with allied industries have been quite largely responsible for the change in the rate of growth of Lansing.

Other factors which have a considerable bearing on the growth of Lansing are:

1st. Its railroad facilities. Lansing is on the main line of the Grand Trunk R.R. and on very important lines of the Michigan Central and the Pere Marquete. It is on a brance line of the Lake Shore and Mich. Southern R.R. These railroads provide exeellent shipping facilities.

2nd. The Grand River flows almost through the heart of the City of Lansing. It is paralleled by railroad lines. The availability of condensing water for use in large factories combined with railroad facilities is important for large industries.

3rd. The City of Lansing owns the water and electric light and power utilities and is in a position to furnish cheap water and cheap power to the manufacturing concerns desiring such service. It has not, however, at all times been able to meet these demands as it should, but it must do so if the city is to continue to grow industrially.

It is defficult matter to forecast the population of a city, the growth of which has been due to so great an extent to a specialized industry, the future of which is difficult of prediction. In such cases the future of the principal industry must also be considered. An illustration of this fact is furnished by the Mississippi River cities which had such remarkable growth from 1880 to 1900 when the northern lumbering was at its height but which experienced a marked depression for the next decade, from which they are just now beginning to recover.

One of the best means of forecasting the growth in population of a city is by comparing it with the growth of other cities now larger, whose growth has been influenced by conditions similar to those affecting the growth of the city for which the forecast is being made. In the comparison the cities are studied with reference to their growth, before and after the time at which their population was the same as that of the city being investigated.

On Plate No.3, we have shown the past grwoth of Lansing from 1860 to date, and have compared it with that of Detroit, Toledo, Des Moines, Grand Rapids, Columbus and Indianapolis, all referred to the time at which their populations were the same as that of Lansing at the present time, namely 57,327. It will be noticed from this diagram that in past growth, Lansing will probably continue at a relatively uniform rate for the next two or three decades, and will approximate 85,000 people by 1930, 115,000 by 1940, and 150,000 by 1950.

DIRECTION OF GROWTH:

In considering the development of a water supply system for the future, it is essential to know not only the probable extent of population frowth, but as well, the direction which that growth will take, so that improvements planned at the present time may be designed with a view to usefulness in the future plant.

The present population of Lansing is approximately 66,000 people. The are occupied is 11 square miles which gives an average density of population of 9.4 people per acre. It is probable that the density will not greatly increase within the next generation and accordingly we have assumed that the population in 1950 will be distributed over approximately 25 square miles of area or more than double that now occupied by the city.

Plate No. 1, shows the present City limits and our forecast of the City Limits for 1950. It will be noticed that it is considered that the greater part of the population growth of Lansing will be to the west and south except for a strip about a mile wide which will take in East Lansing.

DOMESTIC USES OF WATER:

As is usual in the experience of water work's plant when first constructed, the water supply at Lansing appears to have been ample for a few years and the consumers were furnished water on the "flat rate" basis. Within a few years, however, the growing demands made it necessary to conserve the supply and metering was adopted at gradually increasing proportions until at the present time all services are metered and waste restricted so carefully that it is apparent that the present deficiency must be met by increased supply rather than further economies in water use.

The records of water used in the past are very uncertain and are probably all based upon estimates. From the water work's directories which are available for the years 1896 and 1904 that the consumption at those times was approximately 1 1/2 millions gallons per day. From measurements which have been made of the maximum yield of the various well groups shows that the sonsumption now approximates 4,600,000 gallons per day, which up to the beginning of the Pennsylvania Ave. air lift installation was contributed by the several stations in approximately the following amounhts: (average for year)

	ave. rate		max. rate	
Cedar St. Main Station	1,640,000	to	1,640,000	gal.
Pennsylvania Ave. "	2,500,000	"	2,550,000	"
Townsend St. "	80,000	"	340,000	"
Seymour " "	320,000	"	490,000	"
Logan " "	100,000	"	400?000	"

During the summer of 1920 the water supply was materially increased by the installation of the air lift to the 19 wells at the Penn. ave. Station. The station building was increased to make room for two 1150 cubic feet free air capacity air compressors and a 3,000,000 gallon daily capacity motor driven centrifugal pump. The air is delivered from the compressors to the wells by a system of wrought iron pipes. The water flows from the wells to a receiving reservoir of 250,000 gallons capacity through the pipes which formerly served as suction mains. The wells as no equipped are capable of yielding about 5,000,000 gallons per day whcih increases the previous supply by about fifty percent.

FIRE REQUIREMENTS:

In addition to supplying the amounts of water required for domestic purposes a water work's system in all of its parts must be capable of successfully supplying the necessary quantities of water at adequate pressures at any time to combat any serious fire. Experience has shown that while what may be called a severe conflagration occurs only at long intervals, they do occur with sufficient frequency to demonstrate the wisdom fo supplying adequate water supply facilities to care for them when the emergency arises, and that city is wise which provides the necessary facilities in advance.

The amount of water required for fire protection varies with the size and importance of the community to be protected the character of its development and the importance of particular sections or industries to the welfare of the community.

The amount of water required for fire protection becomes proportionately smaller with larger population.

From the recommendations of the National Board of Fire Underwriters, Lansing should have water avaiable in various locations in the following amounts:

	1920	1930
Main commercial and Industrial	7,900,000 GPD	9,200,000 GPD
Closely built residnetial	4,0.0,000 "	4,600?000 "
Average " "	1,500,000 "	1,500,000 "
Sparsely settled " (1/3 lots occupied)	1,000,000 "	1,000,000 "

In Lansing the pressure for fire purposes is secured by use of fire pumping engines so that it is only necessary to deliver the water to the site of the fire under maximum draft conditions to that there will always be a pressure of from 10# to 20# in the mains which will enable the domestic consumers near the fire to have continous water service and insure the fire pumps operation without suction lift.

SUMMARY OF WATER REQUIREMENTS:

Table "B" shows a summary of both domestic and fire requirements. This table shows that the maximum demand during severe fire will be at the rate of 15,400,000 gallons per day in 1920; 20,700,000 in 1930 and 26,900,000 gallons per day in 1940. The water works in all of its parts should be able to meet these demands for a period of at least eight hours with any one unit of equipment of each type out of service for repairs or other reasons.

TABLE "A"

WATER REQUIREMENTS OF LANSING, MICH.

WATER IN MILLION GALLONS

Item	1920	1930	1940	1950
Average daily pumpage	5.2	7.7	10.8	14.2
Maximum days pumpage	8.3	12.3	17.3	22.7
Max. 8 hrs. of ave. day	7.8	11.5	16.2	21.3
Maximum fire rate	7.6	9.2	10.7	12.3
Max. demand rate during fire	15.4	20.7	26.9	33.5
Water required to supply above max. rate for 8 hr. period	100,000	6,900,000	9,000,000	11,200,000
Storage required for domestic peak	780,000	1,000,000	1,600,0000	2,100,000
*Storage avaiable for fire requirements	6,220,000	6,000,000	5,400,000	4,900,000
Storage required for 8 hr. fire	2,600,000	3,100,000	3,600,000	4,100,000

* 7 M.G. - Domestic Peak

TABLE "B"

PUMPAGE FORECAST

LANSING WATER WORKS

LANSING, MICH.

Year	Population	to Services	Services	Metered	per Service	MGD	MGD	MGD
1910	31,229	-			-	-	-	-
1911	32,300	4.7	6,892	54.5	-	-	-	-
1912	33,800	4.68	7,223	58.5	-	-	-	-
1913	33,800	-	-	-	-	-	-	-
1914	35,800	4.42	8,282	65.2	-	-	-	-
1915	38,700	4.39	8,805	74.2	-	-	-	-
1916	43,000	-	-	-	-	-	-	-
1917	49,000	-	-	-	-	-	-	-
1918	52,000	4.62	11,285	97.5	-	-	-	-
1919	55,500	4.65	11,700	96.0	*393	4.6	**-	-
1920	57,327	4.7	12,200	98.0	425	5.2	8.3	10.7
1925	70,000	4.7	14,900	100.0	425	6.3	10.1	13.1
1930	84,000	4.65	18,100	100.0	425	7.7	12.3	16.0
1935	98,000	4.55	21,700	100.0	425	9.2	14.7	19.1
1940	114,000	4.5	25,400	100.0	425	10.8	17.3	22.5
1945	133,000	4.5	29,600	100.0	425	12.6	20.2	26.3
1950	150,000	4.5	33,400	100.0	425	14.2	22.7	29.5

* Estimated

** Pressure not maintained during max. demand.

IMPBRTANCE OF RESERVOIRS FOR FIRE PROTECTION:

On account of the fact that fire protection service require water at high rates over compartively short periods it is frequently found economical to draw the water required for fire service from low service storgge rather than to develop the water supply resources to furnish these excessive demands which occur but rarely. It is usually considered adequate to provide water at a maximum rate for a period of eight hours, or one-third of a day. Accordingly, each million gallons held in storage is equivalent to 3,000,000 gallons daily capacity in water supply which would otherwise be necessary in addition to the development for domestic demands.

The Lansing Water Works system includes two 3 1/2 million gallons reinforced concrete reservoirs. These are available for use during the peak hours of the day and for supplying the water for fire protection purposes. That part of the total storage capacity whcih is not required to care for the daily vataations and hours of peak pumpage is available for fire protection purposes; this vaties from six million gallons in 1920 to four and one half million gallons by 1950. The amount of water required to fight an eight hour fire, i.e. the excess above the domestid rate will increase fnom 2.6 million gallons in 1920 to 4.1 million gallons in 1950. It is apparent, therefore, that the 7 million gallons of reservoir capacity is sufficient to provide for the peak hours of the day and furnish water required to successfully fight the most serious conflagrations resonable to be expected up to as late as 1950, provided the water supply is avaiable to keep them filled to capacity each day.

In all the projects considered herein for enlarging the Lansing Water Works System the storage in the present reservoirs has been utilized for peak rate and fire protection service and the development of water wupply made correspondingly smaller, being governed by the seasonal maximum rates of domestic service. The water required to replentish the reservoirs will be drawn from the three wells on the Cedar St/ lot, or from the mains during the hours of small use.

ADVISABILITY OF PROVIDING FOR FUTURE NEEDS:

Any municipal water works system should be built in advance of the demands which are made upon it, for only by so doing will the plant be able to meet the maximum demand which quick growth or unusual coincidence of demands may make upon it. Experience has shown that a plant enlarged only as necessity demands is always inadequate and exerts a serious retarding influence on the development of the community.

Certain parts of a water works plant must be built for a longer period in the future than others, on account of the fact that they are difficult of enlargement except in relatively larger units. This pertains particularly to water supply structures and pumping equipment. In Lansing it is believed advisable to provide a water supply capable of meeting the maximum demands which will be made upon it for the next ten years. This requires the ability to furnish a continous draft of 7,700,000 gallons per day and a draft of 12,300,000 gallons per day over a period of a month or more. Pumping station equipment should be provided so that the maximum demands can be met with one unit of any kind of equipment out of service.

The distribution system should be made adequate to transmit all of the water required for fire and domestic purposes at the present time with reasonable pressures (20# or more) at the hydrant. It should further be planned with regard to future enlargement from time to time in anticipation of the increased demands which the increased growth in population and property value make upon it.

AVAILABLE SOURCES FOR INCREASED WATER SUPPLY:

There are a number of means by which the water supply for the city of Lansing may be increase. Amoung these are:

1st. The filtration of Grand River water.

2nd. Increasing the present development from the coal measure sandstones utilizing either air lift or electric deep well pumps.

3rd. Development of shallow well supply from the drift overlying the sandstones.

Each of these methods have been considered, the practicability of its development investigated and estimates made of the cost of development, and the annual cost of operating.

FILTERED GRAND RIVER WATER:

One of the available sources of water supply for the City of Lansing is the Grand River, the water of which could be so purified as to render it satisfactory for use in the public water supply.

The Grand River has its source in the southern part of Jackson County, and flows in a general northerly direction toward Lansing, thence westerly to Lake Michigan.

The drainage area tributary to the Grand River above Seymour St/ Bridge in North Lansing, is 1238 square miles, of which 472 square miles is contributed by the Red Cedar, which unites with the Grand River within the City of Lansing. The drainage area of the Grand River above the City of Lansing is approximately 766 square miles.

The Grand River receives considerable urban pollution the most important source being the sewage from the City of Jackson, practically all of which at the present time discharges directly into the Grand River. During periods of low flow, the sewage at Jackson where the tributary drainage area of the Grand River is but 50 square Miles, is approximately fifty percent of the total runoff in the stream. Jackson is about fifty miles upstream from Lansing. The flow in the river is in general rather sluggish so that probably from two to four days is required for the flow period from Jackson to Lansing. Very little, if any sewage enters the Grand River between Jackson and Lansing.

By the time the Grand River reaches Lansing, its drainage area has increased from fifty square miles at Jackson to over 750 square miles and by virtue of the long travel of the polluted water, the stream has been subject to self-purification so that the water by the time it reaches Lansing is not grossly polluted by sewage. Its use, however would involve the construction of a mechanical filtration plant which must be carefully operated under the bacteriocogical control.

Numerous sites for a filtration plant are available, all of which provide excellent railroad facilities on account of the fact that the Grand Trunk Railroad parallel the Grand River for many miles upstream from Lansing. Pollution from the City of Lansing makes its advisable to locate the plant above the discharge of any of the sewers now built and sufficiently far upstream to enable future sewage improvements to be carried out without endangering the water supply or entailing unduly large cost for outlets downstream. The best location to meet the above requirements is at the present City Limits about one mile above the Logan St. bridge.

The flow in the Grand River is relatively uniform on account of the extensive swamp and marsh areas which are found in the upper parts of the drainage area, and which serve to store the runoff during rainy seasons, and release it gradually during the remainder of the year.

The U.S.Geological Survey maintained a gage at the Seymour St. Bridge in North Lansing from 1901 to 1906. Daily readings of the flow in the river were made during that period. The minium flow recorded was 122 cubic feet per second which was observed on but one day. The lowest aferage for any month was 265 cubic feet per second. As the City of Lansing uses at the present time only 7 cubic feet per second and probably will not exceed 25 cubic feet per second as late as 1950, it is apparent that the river is able to supply all of the water required for the City of Lansing indefinitely.

The records of the flow measurement of the Red Cedar River show that the minium flow of this stream during periods of drough is less than the use of the city. If the river was to be used as a source of supply, an impounding reservoir would be required. The Grand River offers many advantages over the Red Cedar as a source of supply.

TYPE OF PLANT CONSIDERED:

The tentative design of a filtration plant sufficient to supply the City of Lansing should be built now sufficiently large to take careof the season of heavy demand under 1930 conditions, which requires a filtration plant having a daily capacity of 12,000,000 gallons.

The plant includes a cast iron intake with suitable strainer set in the pool created by the old Michigan Power Company dam. Water would be drawn through this intake by low lift pumps discharging into a mixing chamber arranged with over and under and lateral baffling and providing a storage period of approximately 20 minutes. After the mixing of the chemicals with the water to be treated in the mixing chamber, the water would pass to a coagulating basin having three hours subsistence period.

From the coagulating basin, the water would flow by gravity to the filter units each of one million gallons daily capacity, based upon the ordinary water works rating of 2 gallons per square foot of filter area per minute. From the filters, purified water would be discharged into a clear water basin.

CEDAR ST. STATION TO FURNISH FIRE SERVICE ONLY:

In this plant the Cedar St. station would be used only for fire service emergency. New pumping equipment would be installed at the filtration plant for all domestic service. The estimates cover steam turbine driven centrifugal pumps, although equipment of the cross-compound type might be found more economical, the preference depending upon the relative costs and efficiency guarantees of the two types at the time bids are received.

The entire station would be designed for steam equipment which would necessitate the sinstallation of a 600 horsepower boiler plant, high and low lift pumps, stack, breeching and auxiliaries.

The filters should be washed by pressure supplied from a wash water tank.

The estimated cost of this plant is $528,000. The annual cost of this plant upon the 1930 pumpage is about $90,230, of which approximately one-half represents the interest and depreciation on the necessary investment, and the remainder represents the items of fuel, labor and coagulant, other items of operation being omitted as being comparable in all of the projects considered herein.

The estimated cost of a 15,000,000 gallon filter plant which with the emergency well wupply would be required to meet the forecasted demands for 1945. The estimated cost of constructing a 15,000,000 gallon plant is $768,000. The annual cost based upon an average pumpage of 12,000,000 gallons per day is estimated to be $126,880.

The filtered water would be sterlized and delivered to the mains clear, colorless, and pure. Its total hardness would probably average slightly over 200 parts per million. During warm weather there would be a possibility of some taste of odor in the water due to algae growths. These would be overcome by areation and other treatment. Temperature of the water would vary from 32 to nearly 80 degrees.

A filtered water supply at Lansing can be indefinitely enlarged at an expense practically i n direct proportion to the additional capacity desired. The annual cost of diltration per million gallons decreases with increased quantities of water treated. The annual cost for 1930 conditions is $32.10 per million gallons, decreasing to $27.80 per million gallons in 1945 with 60% more water treated.

SUPPLY FROM DEEP WELLS:

A second source of increased supply for the City of Lansing is a greater development of the underground supply which is now being used. Up to the first of Sept. 1921 the time when the emergency plant started operation, the City was able to secure about five millions gallons per day from a scattered system of about 25 wells, most of which are 6" in diameter, about 375 feet deep and pumped by direct suction. Four of the wells are 12" or 20" in diameter and are now equipped with deep well equipment.

FACTORS INFLUENCING WELL YIELDS:

The practicability of increasing the supply from deep wells in the vicinity of Lansing depends largely upon the extent of the gathering ground to the wells, the transmission capacity of the strata, the elevation of the static water level, and the depths to which it may practicably be lowered by pumping.

All ground water originates as rainfall. A part of the rainfall is evaporated from the surface of the ground, a part flows off without having been absorbed by the soil a part is taken up by vegetation, a part re-evaporated, and a large part sinks into the soil. It is that part which sinks into the soil which is of importance in the development of underground water supplies.

The rainfall absorbed by the soil usually travels slowly through the underground strata towards the nearest water courses reappearing in the streams through seepage or through springs where conditions are favorable or may be brought to the surface by pumping from wells penetrating the strata.

It may be conservatively estimated, based upon the gathering capacity of many watersheds for which data are available that from 20% to 40% of the rainfall reaches the subsoil. The average annual rainfall at Lansing is about 31" and it is therefore probable that at least one-third million gallons can be drawn from the coal measure sandstones daily through the year from each square mile of exposed area without depleting the amount of water in storage. A heavy draft concentrated in one locality may, however result ina lowering of the water level in that vicinity.

The yield of a system of wells is also dependent upon the amount which the static water level is depressed by pumping. In ordinary sandstones wells neglecting friction in the well, which for wells as shallow as those at Lansing is not large for sizes commonly used, the yield of the wells varies directly with the amount which the static water level is lowered by pumping, i.e., if a group of wells will produce 1000 gallons per minute with a lowering of the water level of 10 feet, the same group will produce 2000 gallons per min. if the water level is depressed 20 feet.

The normal passage of the water through the ground is very slow and the gradient correspondingly flat. Under pumping conditions, the velocity increases rapidly as the well is approached with a correspondingly increase in the slope of the gradient. This results in a depression of the ground water surface in the vicinity of the well which in shape somewhat resembles that of an inverted cone. Long continued pumping at high rates extends the limits of the area or the circle of influence affected by the increased rates of flow, and where the amount of water withdrawn is very large results in a permanent lawering of the static level.

GEOLOGICAL CONDITIONS AT LANSING:

The lower peninsula of Michigan may be compared geologically to a huge saucer. This refers both to the topography of the ground surface and of the underlying rocks as well.

The center part of the state extending from Bay City to Newaygo and from Jackson to Gladwin is occupied by the coal measure sandstones of the Jackson series. Lansing is located near the soughern part of this area which embraces altogether over 10,000 square miles. The surface of the rock in this area varies from 300 to 900 feet above sea level, and that of the ground from 700 to 1000 feet above sea level.

In approximately concentric rings outside of this area is found the Parma sandstones and the Marshall sandstones. Bordering the Marshall sandstones are found the shales and limestones.

On account of the superelevation of the rim of the saucer many flowing wells are found in the inner part of the saucer, more particularly along the inner line of the Marshall sandstone.

In the coal measure formation in which Lansing is located it is not difficult to secure wells most of which have a static water level slightly below the surface of the ground.

Wells drilled in this location yield moderate supplies of quite highly mineralized water.

Wells in the vicinity of Lansing are ordinarily drilled to from 350 to 400 feet deep. Wells at a greater depth have furnished saline water. The Marshall sandstones while furnishing a water of high quality at Jackson and at other places near the edge of its outdrop furnishes salty water near the center of the saucer. At Bay City and Saginaw which are about the same distance from the Marshall exposure as Lansing, the Marshall sandstones are the source of brines.

YIELD OF LANSING WELLS:

The last tests run on the well groups at Seymour St., Townsend St., Cedar St., and Pennsylvania Ave. stations in order to ascertain as closely as possible the facts with regard to local well yields which have so important a bearing upon the feasability of a more extensive development of the same source. The results of these tests and the principal data secured are shown on the following table.

The coal measure sandstones are not large water bearers in most sections and the Lansing wells are fair examples of wells in these strata. The specific capacities per well, or yield of water per foot of drawdown at Lansing when pumping the wells by groups was shown by tests to vary from 2.2 at Townsend St. to 3.7 at Pennsylvania Ave. One well at East Lansing showed a specific capacity of 7.7 on 48 hour test with three other wells within 800 feet being pumped simultaniously. The three easterly wells in the Potter Park

group have individual specific capacities of about 6.0 or nearly couble those of the other 16 wells of the same general locality.

So far as the local data are reliable they indicate that in the immediate vicinity of Lansing the yield of the coal measures probably increases towards the east. If this is the fact, the most favorable site for further grouhd water development will be found east of Potter Park, which is under development at the present time.

The following table is for the purpose of comparing the yield of the Lansing wells wihh those of other wells in cities where extensive deep well developments have been made.

Location		No. of wells	Ave. Specific Capacities Single wells Group pumping
Lansing-	Logan St.	1	2.3
	Seymour St.	5	3.2
	Townsend St.	5	2.2
	Cedar St.	3	3.8
	Penn. Ave.	19	3.7
East Lansing		4	7.7
Rockford Ills.		7	4.95
Elgin Ills.		4	6.25
Oak Park, Ills.		10	2.9
Madison, Wis.		4	21.5 #
Clearing Yards, Chicago		3	8.6
Mason City, Iowa		2	23.0

Very ample spacing - little interference.

A study of this table will show that the yield per foot of water level depression of the coal measures at Lansing are considerable lower there than in the other cities listed above. At Rockford, where the specific capacity is about a third to half greater than at Lansing, a large expenditure is now being made for additional grouhd water

development. Rockford has a population of about 65,000 and is located on the banks of Rock River which flows directly through the City.

At Madison, Wis. a commission of four engineers recommended the abandonment of wells and filtration of Lake Mendota water. The city has subsequently enlarged its well development. The Madison wells yield a copious supply of hard water.

TABLE "C"

SUMMARY

DEEP WELL TESTS

	Seymour St.	Townsend St.	Main Plant	Penn. Ave.
Static Water Level	106.3	116.2	106.0	112.0
Time Shut Down	8 hrs.	3 days	4 hrs.	8 hrs.
Pumpage Rate (Group)	** .489 MGD	*** .34 MGD	1.64 MGD	2.55 MGD
Drawdown	26.5	21.5	100.5	17.1
Specific Capacity (Group)	12.9 gal/min.	11.0 gal/min	11.5 gal/min	10.4 gal/min
Av. Specific Capacity per well	3.2 "	2.2 "	3.8 "	(a) 5.5 "
Specific Capacity (Single well)	-	-	4.07 "	-

*Enterpolated from 5 hrs.

** Trident Crest Meter

*** Pitometer

(a) This test was secured with pumps pperating by direct suction. Observed "drawdown" probably affected by connection with the gravel as "specific capacity" observed on air lift tests was but 3.7

CONCLUSIONS AS TO FUTURE WELL DEVELOPMENT AT LANSING:

From a study of the geological factors affecting the yield of wells in the coal measure sandstones at Lansing leads to the conclusion that it will be practicable to secure a supply from the sandstones which will be adequate for the city's needs for the next generation at least, and in fact, for the indefinite future if the development is made as to extend over a sufficiently extensive area. Up to the present time not more than about 2,000,000 gallons per day has been pumped from the sandstones at any one location in Lansing. However, for many years the municipal water works has been developing about 4,000,000 gallons daily from Penn. Ave., Cedar St. and Townsend St. locations all of which draw from the same collecting groundfrom the three stations all located within a square mile. So far as the records are avaiable they indicate no material recession of the static water level due to that pumping. With increased development, it is probable that some recession aill occur.

The experience at Chicago where about 15,000,000 gallons daily is drawn from the wells over an area of about 200 square miles has been that the water level has receded about four feet per year.

At the Stock Yards where from 5,000,000 to 10,000,000 gallons per day is pumped from an area less than a mile each way the recession has been about six feet per year.

At Rockford where wells have been in use for about 30 years the average drop in water level has been about .8 ft. per year. The pumpage is about the same as at Lansing but

from a very small area.

At Madison Wis. the supply is drawn from eight wells. Under a draught of about 2,500,000 gallons per day the static water level had dropped about 16 feet in 35 years or about 1/2 ft. per year. The wells extend over a large area.

It is probable that under heavier draughts the water levels at Lansing will drop due to the increased frictional resistance to flow occasioned by the higher velocities near the well area. As the well depths are limited by the brine in the deeper water, the available well yields and efficiency will decrease and the pumpage head increases.

There is no way of telling just how extensive a development the strata will maintain without dropping the water level to such an extent as to materially affect the problem. However, inview of the past experience at Lansing with a pumpage of about 4,000,000 gallons daily from a small area it will probably be practicable to pump from 5,000,000 to 10,000,000 gallons per day from a system of wells in one locality with the wells extending along a straight line at about 300 feet spacing. It has been predicted that the pennsylvania Ave., Cedar River locality is capable of supporting the 1930 pumpage of 7,000,000 gallons per day.

From the data already at hand it points to the strata as being porous from pennsylvania Ave. easterly. This location has been selected for the first development. A system of wells are now under construction along the East City Limits and the Red Cedar River which is believed will supply about 7,000,000 gallons per day. This amount with the Pennsylvania

Ave. supply will be sufficient to care for all 1930 needs.

There has been three methods considered of drawing the water from the sandstones and delivering it to the city.

(a) Drawing water from the wells by air lift, Steam pumps furnishing pressure to city.

(b) Motor driven deep well pumps with boosters operating against city pressure.

(c) Deep well pumps discharging into surface reservoir with steam pumps furnishing pressure to city.

All of these plans utilize the Pennsylvania Ave. group of wells developed by air lift. These wells, on account of being equipped with electric compressors and pumps and hence more costly to operate than the new steam station wells, will be used only in periods of heavy demand.

Of the three methods above mentioned the first has been chosen as the best because:

(a) Cheapest in annual cost.

(b) Most reliable.

(c) Most flexible under changing conditions of pumpage and water levels.

ADDITIONAL DEEP WELLS IN POTTER PARK AREA,
AIR LIFT PUMPS TO SURFACE RESERVOIR,
ELECTRIC PUMPS TO CITY MAINS

This plan contemplates the sinking of 12 new wells along the Red Cedar River upstream from the Pennsylvania Avenue group of wells. Wells would be approximately 450 feet in depth with a diameter of 12 inches, and placed on 300 ft. spacing. At the present time the 12 wells are down and nine are connected up with the air and drain pipes. It is expected to have them in operation within a few weeks so that water may be pumped into the City's mains.

Air for pumping the wells will be compressed by electrical driven air compressors located in the new pumping station on the north side of the Pere Marquette Railroad. A system of air piping delivers the air from the compressors to the wells. The water and air rising through the eduction pipes is discharged into a well head and tank located at such elevation above ground that the water would flow by gravity to a reinforced concrete suction reservoir located at the new pumping station.

The pumping equipment consists of electrical driven centrifugal pumps. The pumps take suction from the reservoir receiving the flow from the wells and discharge it into the city mains.

The estimated cost of this project is $400,000 and the annual cost including fixed charges and depreciation would be approximately $86,250 in 1930 and $70,000 in 1940.

--

QUALITY OF DEEP WELL WATER:

The water from the coal measure at Lansing is moderately hard (about 330 p.p.m.) and pure, provided the wells are properly constructed andmaintained. Lansing has in the past been visited by epidemics of dysentery which have apparently been attributable to the water supply. All water now pumped from the wells is being chlorinated for sterilization.

The Michigan State Board of Health has made elaborate investigations particularly of the 1919 epidemic and finds that the trouble is traceable in part at least to defective well head connections. It is also probable that many of the wells are improperly sealed into the rock. It was found in the installation of the emergency wells that a large number of the Pennyslvania Ave. wells were partially filled with sand and gravel which had probably entered the well at the bottom of the casing. Such a condition offers a possible source of contamination, for the wells located in the built-up area or along the rivers.

The supply is in itself pure and safe and can be drawn from the rock and delivered to the consumers in that condition with properly constructed and maintained wells.

SHALLOW GROUND WATER

The greater part of the State of Michigan is covered with glacial drift which in many places is water bearing. At Lansing the first water supply was drawn from this drift at the site of the present Cedar St. Station. It has been difficult for use to secure information concerning these wells and their yields. From the data avaiable it seems that the system originally consisted of 12-24" title wells sunk into the gravel from which the water was drawn through 6" drop pipes connecting with the steam pumping equipment.

This system of wells was adequate during a period when the average daily consumption was about 1 1/2 million gallons per day which would approximate 2 1/2 millions gallons with short periods of an hour or two when the rate would probably be as high as four million gallons per day.

Assuming these conditions as representing the fact the wells had a specific capacity of something less than 9 and possibly as low as 4 or 5 gallons per minute per well per foot of lowering the water level.

The surface topography and inspection of gravel pits in the vicinity of Lansing indicates that there might be a possibility of developing a considerable supply from the surface gravels in certain localities. For that reason we recommend the sinking of test wells,as that is the only satisfactory means of determining the practicability of such a development.

From all the information that can be obtained from test drilling and from the State Geoligical Survey it is plainly seen that it would be improbable that any system of shallow wells could be developed around Lansing which would be adequate for the city's growing needs.

DATA ON WELLS AT RIVERSIDE PUMPING STATION:

TABLE "D"

Well No.	Depth in ft.	12" casing in ft.	Ft. of 10" casing	Static level
1	426	79	108	12'
2	504	69	212	14'
3				
4	465	57	120	12
5	499	66	57	10
6	525	73	213	9
7	465	75	127	9
8	423	79	117	8
9	475	89	83	11
10				
11				
12				

Well No.	Draw-down	Work level with pump	G.P.M. with pump	Specific capacity
1	33'	45'	228	7
2	36	50	270	7.5
3				
4	11	23	170	15
5	17	27	166	9.7
6	14	23	292	20
7	7	16	213	29
8	37	45	197	5.4
9	15	26	255	17
10				
11				
12				

Well No.	Based on 100' total lift. permissible work level	G.P.M. at this level	G.P.M. with 35% interference
1	74	410	266
2	76	465	302
3	78		
4	80	600-53'	600-75'
5	82	685	445
6	82	600-50'	600-77'
7	83	600-308	600-41'
8	83	405	263
9	82	600-46'	600-65'
10	78		
11	78		
12	77		

Well No.	Op. press. lbs.	% of submer.	Based on 150' total lift. permissible work. level	G.P.M. at this level
1	81	65	124	745
2	81	65	126	840
3		65	128	
4	77	65	130	600-75'
5	81	65	132	920
6	77	65	132	600-77'
7	65	65	133	600-41'
8	81	65	133	675
9	67	65	132	600-65'
10			128	
11			128	
12			127	

Well No.	G.P.M. 25% interference	oper. press. lbs.	% of submergence
1	485	111	65
2	545	111	65
3			
4	600	95	70
5	600	114	65
6	600	84	67
7	600	60	70
8	440	114	65
9	600	85	70
10			
11			
12			

There are three air compressors in the new pumping station one of 2250 cubic feet capacity and two at 1750 cubic deet capacity.

THE DISTRIBUTION SYSTEM

The present distribution system consists of slightly over 100 miles of cast iron pipe, varying in sizes from 4" to 16". The propertion of the smaller sizes is very large, over 85% of the pipe being 4" and 6". This great preponderance of the smaller sizes of pipe results in excessive friction losses between the pumps and the consumers during periods of heavy draft, and makes the system unable to supply adequate fire protection to the major part of the city.

A system of feeder mains has already been strated with a view of connecting the main pumping station with the four substations located on the outskirts of the city. These substations have not been of a great deal of use in case of fire because their capacity was not large enough. A single 16" main, leading from Cedar St. station to the main mercantile district of the city, supplies practically the entire amount of the water for fire protection of that district.

HYDRANT PRESSURE REQUIRED:

The Lansing Water Works does not raise pressure during ordinary fires, the necessary increased nozzle pressure being furnished by fire engines. It is, therefore, only necessary to deliver the water to the hydrants during maximum fires at a minimum pressure of from 10 to 20 pounds and in the required quantities.

The system is capable of delivering water at a 7.6 millions gallons rate to a severe fire in the mercantile district in addition to supplying a domestic rate simultaneously of 7.8 millions gallons per day. The amount required in the resindential districts is from one-fourth to one-half as great.

The water required for fire protection, particularly in the mercantile district, should be supplied by the Cedar St. station, in which there is now installed a 10 million gallon Snow horizontal cross-compound pump, practically new and a 4 million gallon Holly pump, installed in 1885, but maintained in excellent operating condition. The utilization of the Cedar St. station for fire fighting purposes results in a marked economy in the distribution system on account of its central location. All of the plans that have been mentioned for water works improvements have taken advantage of the use of the Cedar St. equipment, and the 7 million gallons of storage held in reserve there.

The estimated cost of the mains at the present time is approximately $360,000. An additional sum of approximately $115,000 will be required to install the additional feeder mains required in 1930. Both of these estimates are based on pipe costing $65.00 per ton and labor prices as they are at present.

ESTIMATED COST OF
FUTURE FEEDER MAINS

Location On	From	To	Size	Length	Estimated Cost
Logan	Barnes	Mt.Hope	12"	1000'	$ 4,580
Mt.Hope	Logan	Wash.	12"	4000'	18,000
Logan	Saginaw	Franklin	12"	2300'	10,500
Franklin	Logan	Walnut	12"	2500'	11,450
Larch	Franklin	N.City Lim.	12"	3000'	13,750
N.City Lim.	Larch	Vermont	8"	2800'	7,580
Penn.Ave.	Sherdian	Franklin	12"	1500'	6,820
Franklin	Penn.Ave.	Vermont	12"	800'	3,860
Kalamazoo	Penn.Ave.	Clemens	12"	4000'	18,000
Clemens	Mich.Ave.	Kalamazoo	12"	1500'	6,820
Kalamazoo	Pine	Townsend	8"	1300'	3,520
Cedar	Saginaw	Franklin	12"	2400'	11,000

Total estimated Cost of Future Feeder Mains -$115,880

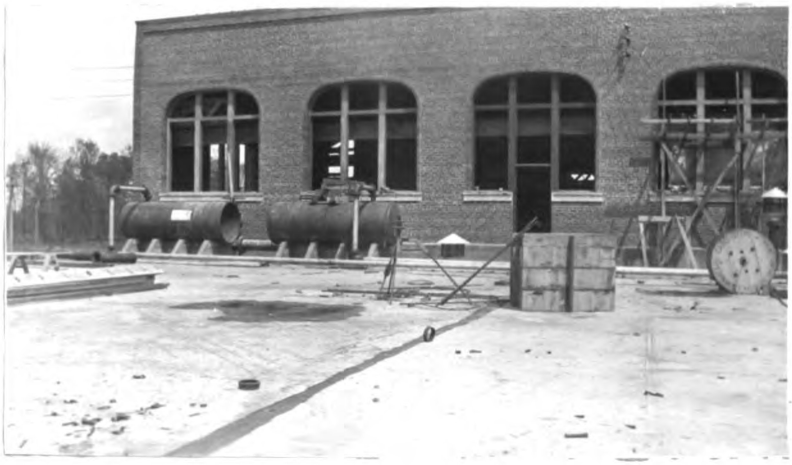
SUMMARY OF EXPENDITURES REQUIRED FOR IMMEDIATE REINFORCEMENT OF DISTRIBUTION SYSTEM

Location On	From	To	Size	Length	Estimated Cost
Isaac	Pumping	Logan	20"	4000'	$ 38,000
Main	"	Max.	20"	4000'	38,000
Huron	Main	Ionia	20"	3800'	36,100
Isaac	Logan	Washington	16"	4000'	32,000
Logan	Grand R.	Barnes	12"	1900'	8,702
Sycamore	Isaac	Ionia	12"	4600'	21,334
Ionia	Huron	Logan	20"	1100'	10,450
Ionia	Logan	Washington	16"	4100'	29,407
Walnut	Saginaw	Franklin	12"	2350'	13,500
Wash.	Ionia	Mich.	16"	900'	7,382
Mich.	Wash.	Cedar	24"	1800'	24,090
Mich.	Cedar	E.City Lim.	16"	4500'	55,500
Franklin	Walnut	Saginaw	12"	2650'	16,116

Total estimated Cost of Mains needed ------- $359,985

RIVERSIDE PUMPING STATION

New pumping station and reservoir under construction.



Air lift well ready for operation.

ESTIMATES AND RECOMMENDATIONS FOR THE LANSING WATER WORKS

The water works system of Lansing is now composed of the Main station at Cedar St.,the Pennsylvania Ave. station, the Seymour St. station, the Logan St. station, the Townsend St. station and the new Riverside station. The Main station and the Pennsylvania Ave. station at the present time are the two principle stations from which the water for Lansing is obtained. The Pennsylvania station is composed of nineteen air lift wells which will furnish about 4,000,000 gallons per day and the Main station will furnish about 2,000,000 gallons per day when worked at maximum capicity. With the three substations working at full capacity the total water available at the present time is about 8,000,000 gallons per day. This supply is adequate to supply the requirements of the present population as is shown on Plate No. 4, but it would be deficient within a very short period.

The new station located at the intersection of the Red Cedar river and the Pere Marquette railroad known as Riverside station is composed of twelve air lift wells and a one million gallon reservoir. This plant will be in operation within a few weeks and as the well drillers report shows on table(D) will be capable of furnishing 5,000,000 gallons per day. This plant was designed for Lansing for the estimated population of 1930. When this plant goes into operation the water available from this plant together with the supply from the Main station and Pennsylvania Ave. station will be about 12,000,000 gallons per day. From an investigation it is found that the operating costs of the Townsend, Seymour, and Logan St. stations are too much for the amount of water obtained and are now only used in case of emergency. For this reason these stations should be abandoned when the new Riverside station goes into operation. From table(A) will show that the amount of water required for 1930 is 12,300,000 gallons. There is a possibility that the new station can increase its supply by drilling more wells, thus making the Lansing Water Works System furnish an adequate supply for the needs of 1935 or 1940 without further reinforcements.

In case Lansing does take as rapid growth as has been estimated has a population of 150,000 in 1950 it is reasonable to expect that the present system will have to be reinforced at some future period which would be about 10 years hence. At this time the question will come up as to whether the system should be reinforced with an addition of deep wells or should a filtration plant system be substituted for the present system. If Lansing's growth should exceed our forecast and parallel that of Detroit or Toledo it would be wise to abandon the wells and substitute a filtration plant because of the economy of operating such a system. If the growth should be less rapid then additional wells would be advisable at such time when the present system is inadequate to supply the requirements which will be about 1935 as can be shown from Plate No.4. When this situation occurs it will necessitate the construction of a new group of wells, a reservoir and a pumping station at some location remote from the Potter Park well development. The Seymour Street station has been considered as a suitable location for these wells although conditions at that future date and observations of the wells prior to that time may alter the selection of the location at that time.

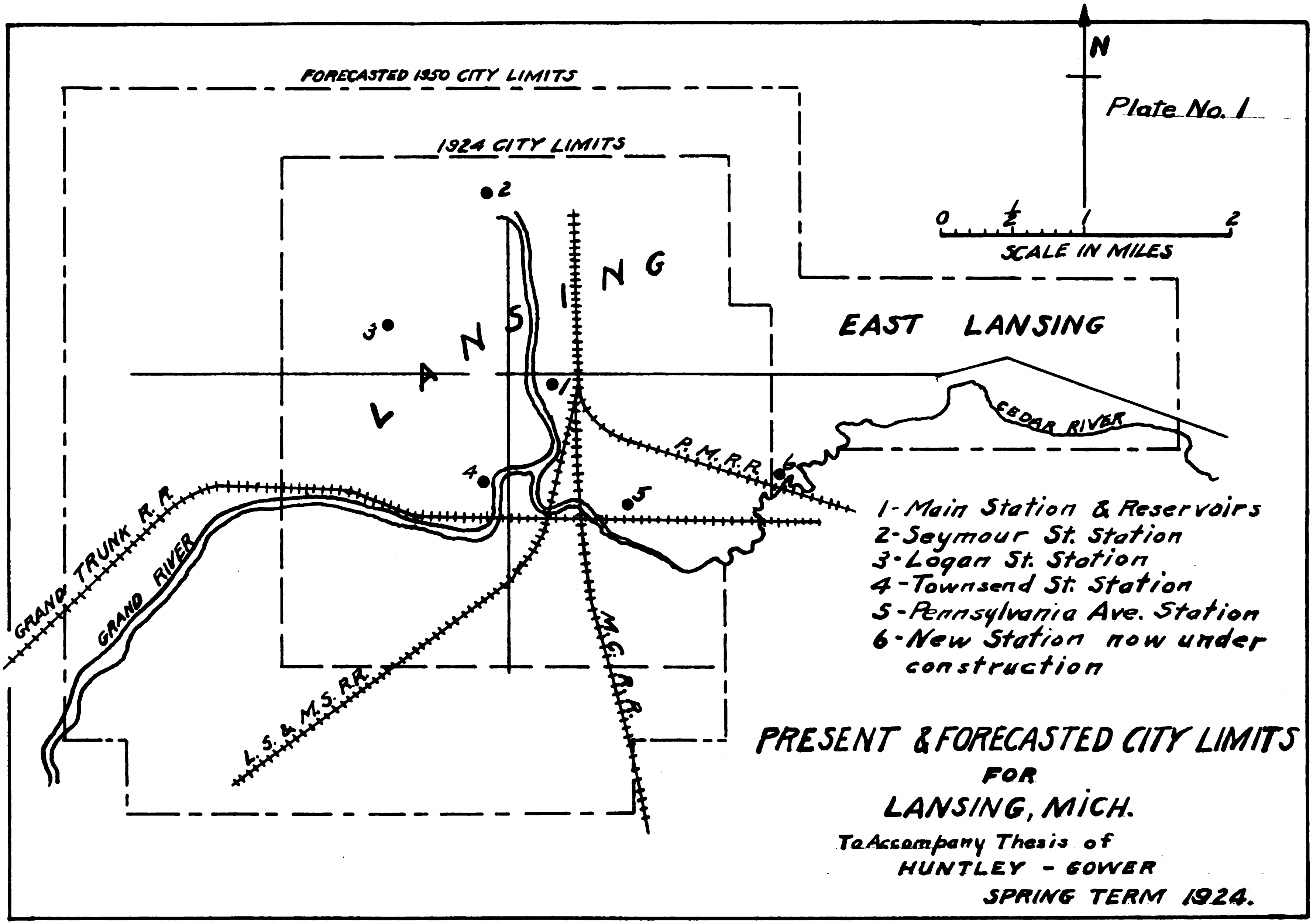
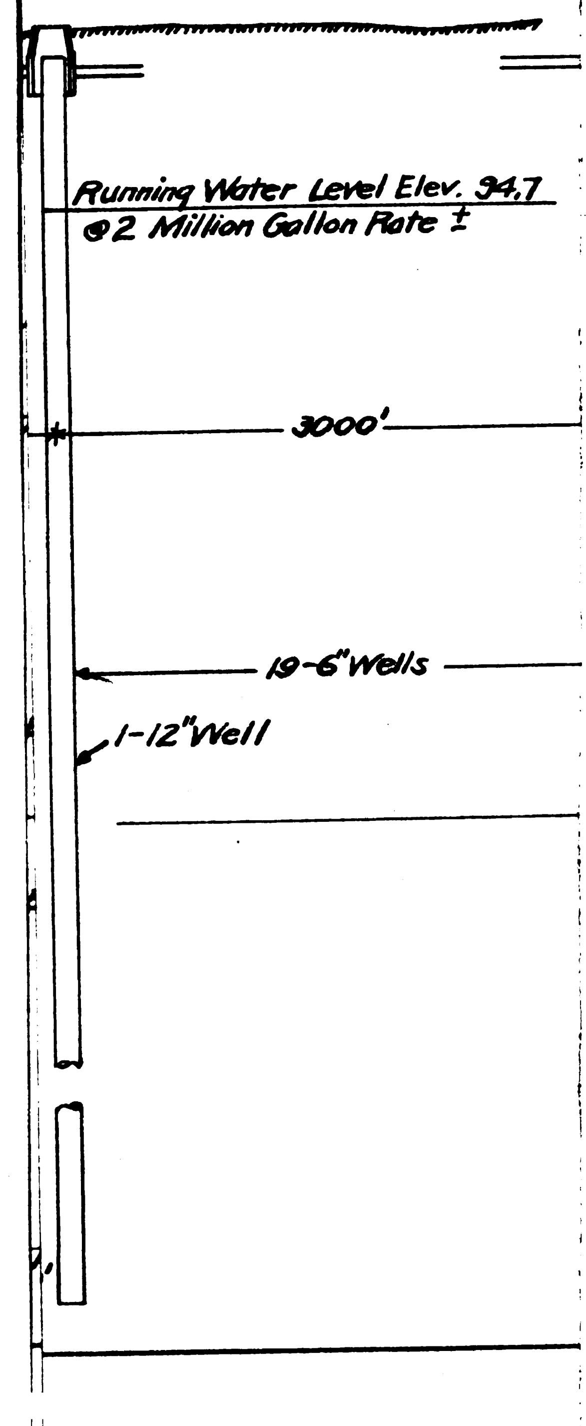


Plate No. 1
N
0 ½ 1 2
SCALE IN MILES
FORECASTED 1950 CITY LIMITS
1924 CITY LIMITS
LANSING
EAST LANSING
CEDAR RIVER
GRAND RIVER
GRAND TRUNK R.R.
P.M.R.R.
M.C. R.R.
L.S. & M.S. R.R.
1-Main Station & Reservoirs
2-Seymour St. Station
3-Logan St. Station
4-Townsend St. Station
5-Pennsylvania Ave. Station
6-New Station now under construction
PRESENT & FORECASTED CITY LIMITS
FOR
LANSING, MICH.
To Accompany Thesis of
HUNTLEY - GOWER
SPRING TERM 1924.

IA AVE. STATION

d by direct suction



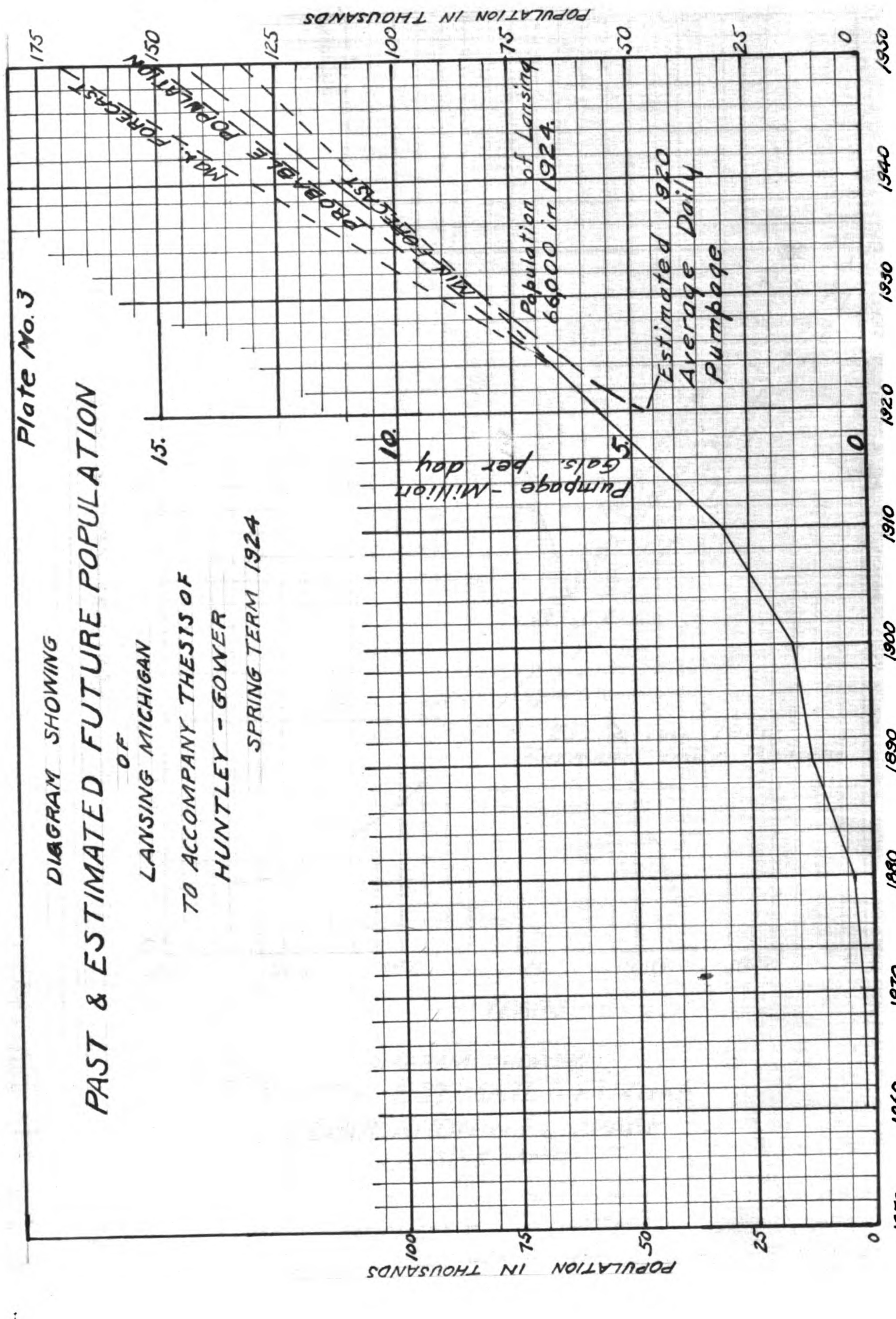


Plate No. 3
DIAGRAM SHOWING
PAST & ESTIMATED FUTURE POPULATION
OF
LANSING MICHIGAN
TO ACCOMPANY THESIS OF
HUNTLEY - GOWER
SPRING TERM 1924
POPULATION IN THOUSANDS
MAX. FORECAST
POPULATION
PROBABLE
FORECAST
MIN.
Population of Lansing
66000 in 1924.
Estimated 1920
Average Daily
Pumpage
Pumpage - Million
Gals. per day
15.
10.
5.
0
175
150
125
100
75
50
25
0
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950

PLATE NO. 4

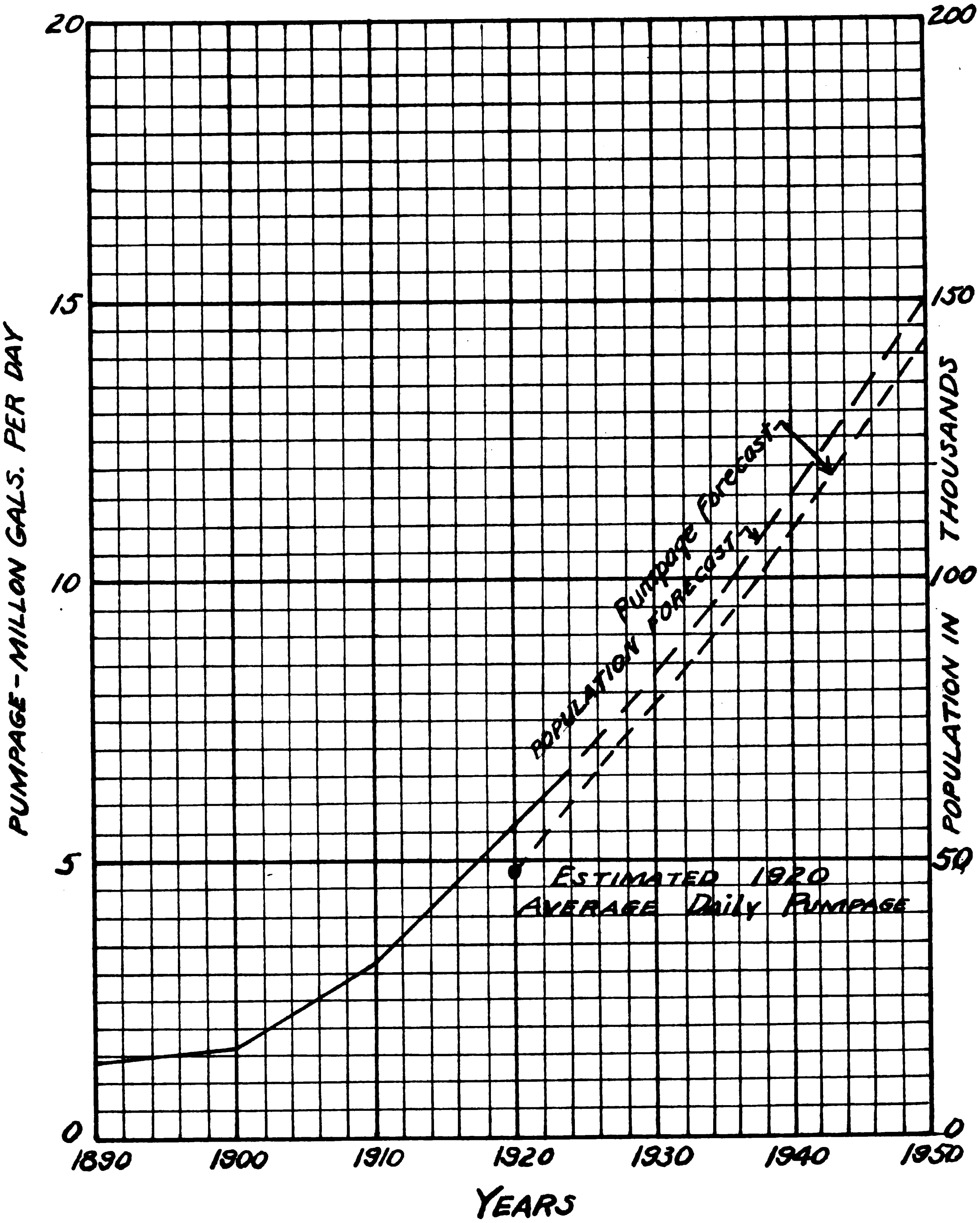


DIAGRAM SHOWING

PAST & ESTIMATED FUTURE POPULATION & PUMPAGE

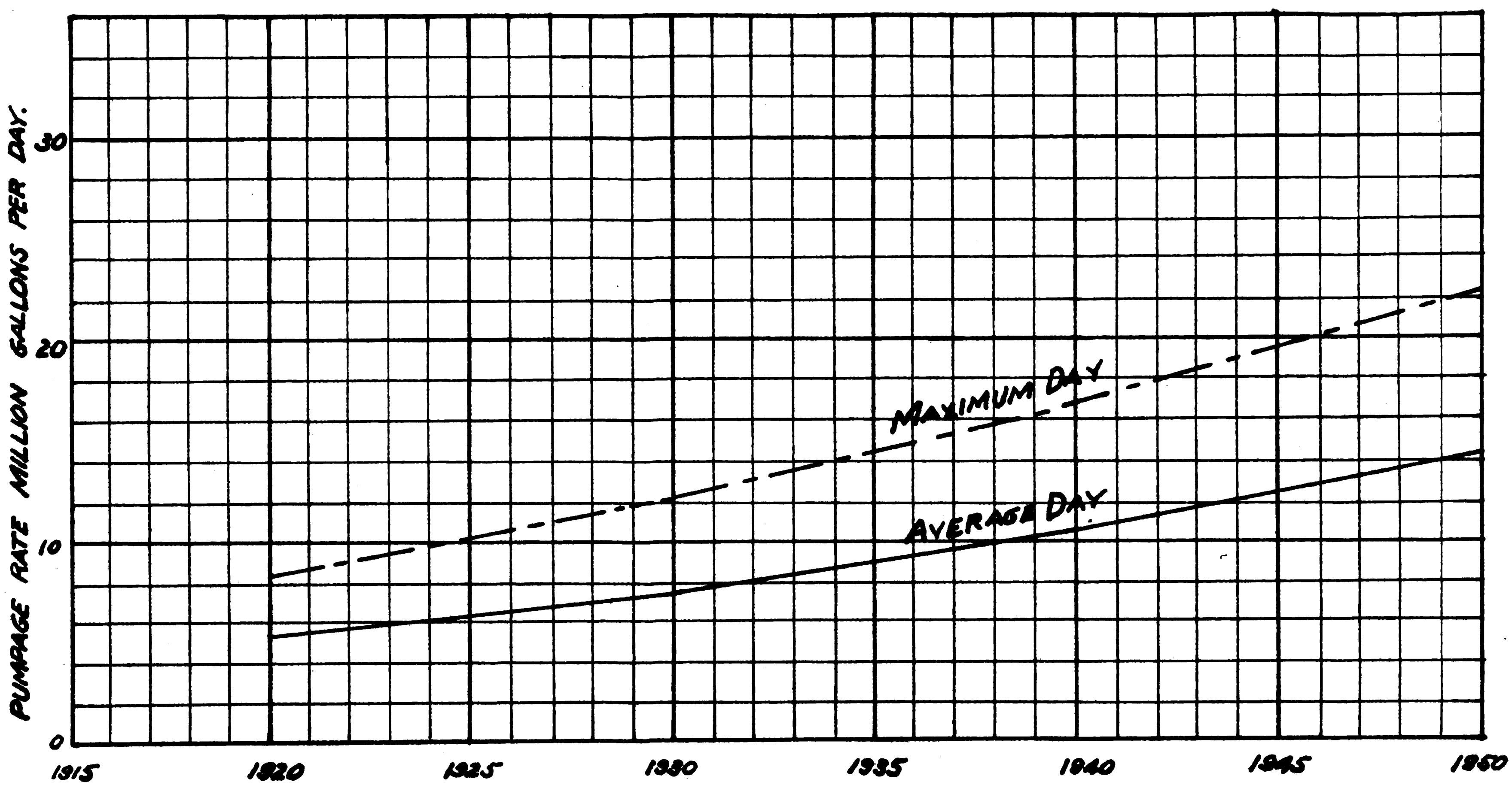
LANSING, MICH.

To accompany thesis of

HUNTLEY - GOWER

SPRING 1924.

PLATE NO. 4a



YEARS

DIAGRAM SHOWING

PAST & ESTIMATED FUTURE PUMPAGE RATES

LANSING WATER SYSTEM

TO ACCOMPANY THESIS of

HUNTLEY GOWER

SPRING 1924

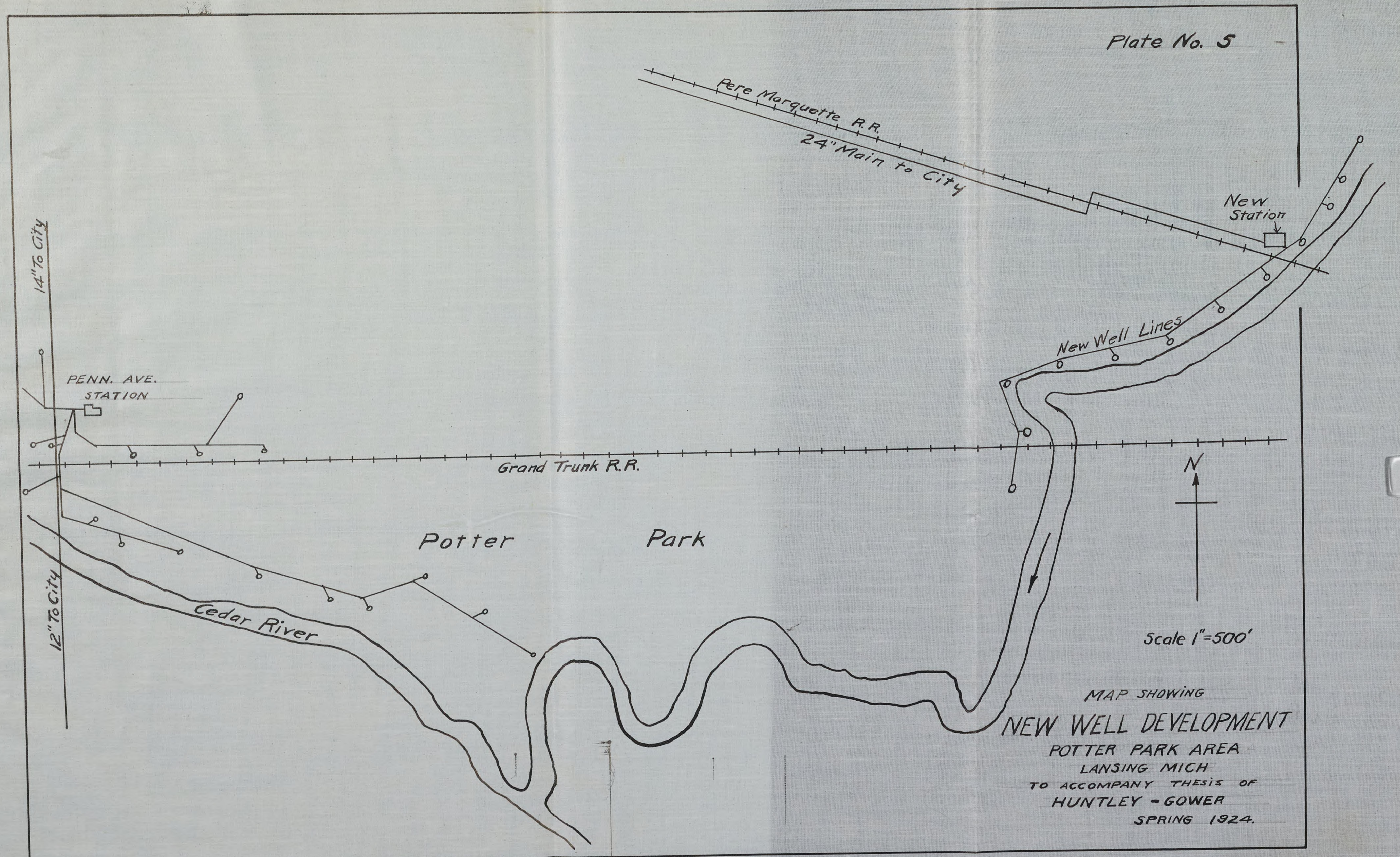


Plate No. 5
Pere Marquette R.R.
24" Main to City
New Station
New Well Lines
14" To City
PENN. AVE. STATION
Grand Trunk R.R.
N
Potter Park
Cedar River
12" To City
Scale 1"=500'
MAP SHOWING
NEW WELL DEVELOPMENT
POTTER PARK AREA
LANSING MICH
TO ACCOMPANY THESIS OF
HUNTLEY - GOWER
SPRING 1924.