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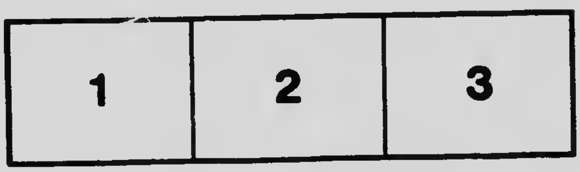

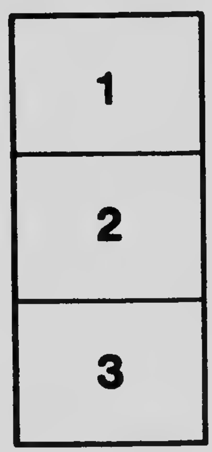

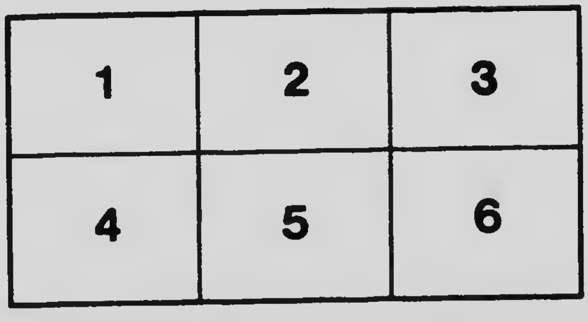

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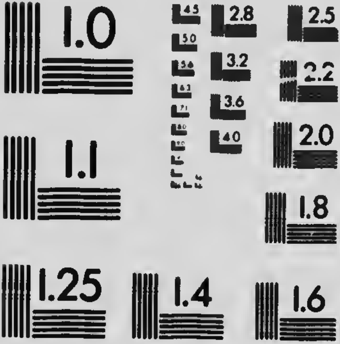

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GREATER WINNIPEG
WATER DISTRICT

Aqueduct Construction Scheme

What It Is
What It Means

Issued by authority of the Administration Board

ACCESSION NUMBER
17089

Greater Winnipeg Water District

AQUEDUCT CONSTRUCTION SCHEME

WHAT IT IS
WHAT IT MEANS

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1918

ACCESSION NUMBER
A7089

ORGANIZATION

Greater Winnipeg Water District

The affairs of the District are conducted by an Administration Board consisting of the Mayor of the City of Winnipeg, as Chairman, the members of the Board of Control, the Mayor and one member of the St. Boniface Council, the Mayor of Transcona and the Reeves of the Municipalities of St. Vital, Fort Garry, Assiniboia, East and West Kildonan.

Administration Board, 1918

F. H. Davidson (Mayor) Winnipeg, Chairman
J. W. Cockburn (Controller), Winnipeg.
C. F. Gray (Controller), Winnipeg.
A. W. Puttee (Controller), Winnipeg
J. J. Wallace (Controller), Winnipeg
H. Beliveau (Mayor), St. Boniface.
J. A. Cusson (Alderman), St. Boniface.
G. C. Jones (Mayor), Transcona.
Alex. Tod (Reeve), Mun. of St. Vital.
J. F. Feilde (Reeve), Mun. of Fort Garry.
C. L. Richardson (Reeve), Mun. of Assiniboia.
E. Partridge (Reeve), Mun. of West Kildonan.
S. R. Henderson (Reeve), Mun. of East Kildonan.
Clerk of the Corporation—M. Peterson

Board of Commissioners

R. D. Waugh (Chairman) J. H. Ashdown
[illegible]

Chief Engineer—W. G. Chace
Solicitor—J. G. Harvey, K.C.
Accountant—H. Russell
Cashier—J. R. Richardson
Purchasing Agent—R. Douglas Waugh
Railway Superintendent—J. A. Nelson
Auditors—Ronald, Griggs & Co.
Fiscal Agents and Bankers—The Bank of Montreal


WINNIPEG'S
FIRST WATER
DISTRIBUTION

CHAPTER I.

History of Winnipeg's Water Supply

The evolution in a few years of Winnipeg's water supply system from a few wells whose combined capacity was measured by barrels, to the very best and most modern system available, capable of delivering 85,000,000 gallons per day of the finest soft water, is another indication of the rapid growth of the City of Winnipeg and district, and an evidence of the faith which our people have in the future.

In the early days in Winnipeg the citizens obtained water from men who made deliveries from square tanks mounted on wheels or in the winter season from large barrels drawn on sleighs. The winter was taken from wells. There were several of these wells throughout the town, but two of the best known were the ones located on Water Street and on Logan Avenue.

Deliveries were made in this manner even after the installation of a systematized supply and were continued until a sufficient number of houses were fitted with piping as to make this form of delivery unprofitable. Some of the watermen obtained their supply from the Red River at the foot of Lombard Street, but by-laws prohibiting the distribution of this water as a supply for human consumption were eventually enacted.

WINNIPEG WATER WORKS CO.

The first water supply system was installed by a private corporation known as the Winnipeg Water Works Company. In 1880 they were given an exclusive franchise for the supply of water, covering a twenty year period, but did not commence commercial operations until 1882. The Assiniboine River was the source of supply and the intake and pumping station were located on Armstrong's Point, a few hundred feet downstream from the site of the present Maryland bridge. Operation of this system remained in the hands of the Water Company until April, 1899, when the City purchased their plant and distributing system for the sum of $237,650.00

Immediately upon taking over this system the City decided to change the source of supply and the present artesian well system was placed in operation in October, 1900.

This system has been gradually developed as necessity required until the pumping capacity is now about 14,000,000 gallons in 24 hours, and the combined capacity of the three reservoirs is about 24,000,000 gallons.

The average daily consumption of water at the present time (1918) is about 9,000,000 gallons.

PERMANENT VISIBLE SUPPLY OF SOFT WATER

The question of a permanent visible supply of soft water for the City of Winnipeg has been agitated with more or less vigor for many years, it having been realized that, if Winnipeg continued to grow as rapidly in manufacturing and commercial importance as it had done in the past ten years, it would not be long before the present well supply would be insufficient for the City's needs. The present supply, although pure and palatable, is very hard, ruinous to boilers, plumbing and heating apparatus, costly in soap and washing compounds, injurious to fabrics and unsuitable for many manufacturing industries which might be attracted to Winnipeg by the cheap hydro-electric power and a plentiful supply of soft water.

With these and other conditions in mind, the City Council in July, 1906, created, with the authority of the Legislature, The Water Supply Commission, of which Mr. J. H. Ashdown was chairman. This commission made an exhaustive report to the City Council in October, 1907, but as the City was then about to undertake the hydro-electric development, which has been such a boon to Winnipeg, the solution of the water problem was deferred. The conclusions of the 1907 report were, however, valuable in determining the permanent source of water supply and are quoted herein.

The Hydro-Electric plant being finished in 1911 and in operation, in 1912 the question of water supply became an urgent problem which could not be delayed; the issue then being to either extend and further develop, as an additional temporary necessity, the nearest local sources of supply at Poplar and Crystal Springs, or at once launch out on the larger project to go to the Winnipeg River or to Shoal Lake. The City Council were reluctant to undertake the larger scheme and passed, almost unanimously, a by-law to spend $1,800,000.00 on a development of the Poplar and Crystal Springs project.

POPLAR SPRINGS REJECTED

This project contemplated the operation and development of Poplar Springs (the waters of which are much softer than our present supply) to make available as a further temporary measure an estimated supply of 20,000,000 gallons per day from this and other then existing sources. This by-law was submitted to the qualified ratepayers on September 13th, 1912, and was defeated by a vote as follows:

For the by-law	1,029
Against	1,131

The majority of the ratepayers thus declared that they did not want any further temporizing.

SHOAL LAKE PROJECT

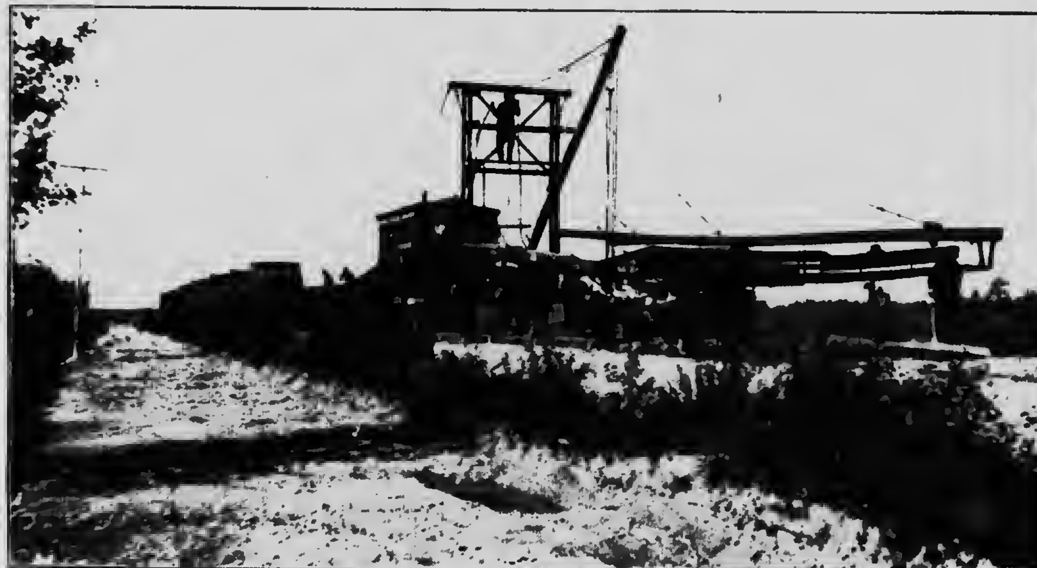
The Council had previously decided to ask Judge Robson, then Public Utilities Commissioner, to report on the question of water supply, which he did on September 6th, 1912. In his report Judge Robson says: "The object of the investigation was that there be laid before the ratepayers the facts in connection with the water supply, and the opinion of a qualified expert thereon. The facts have been fully elicited and made public. I urge that Professor Schlichter's recommendation be adopted and that the greater project be taken up immediately." (Professor Schlichter having recommended Shoal Lake as the source of supply). The conclusions and recommendations of Professor C. S. Schlichter, the expert retained by the Public Utility Commission, are quoted herein.

By the Act incorporating the Greater Winnipeg Water District, passed by the Legislature of the Province of Manitoba, the construction of the aqueduct and the expenditure incurred thereby was contingent upon the scheme being approved by the electors of the City of Winnipeg qualified to vote on money by-laws. The scheme itself was voted on by the electors on May 1st, 1913, with the following results:

In favor of the scheme	2,226
Against the scheme	369

Construction of the Falcon River Diversion Dyke

Built to prevent the mingling of dark-colored river water with that of Indian Bay, where the intake is located. The dyke is 7,000 feet long and contains 220,000 cubic yards of material.



A "Pioneer" Track-laying Machine at Work, 1911

The G.W.W.D. has 110 miles of standard gauge track, 60-lb. rails being used throughout.

FIRST REPORT

On May 20th, 1913, the Council of the City of Winnipeg passed the following resolution: "That the Board of Consulting Engineers be instructed to submit a report on the best means of supplying the Greater Winnipeg Water District with water from Shoal Lake, together with estimate of cost and general plan of the work."

The Board of Consulting Engineers referred to were appointed by resolution of the Council on April 7th, 1913, and consisted of Rudolph Hering and James H. Fuertes, of New York, and Frederic P. Stearns, of Boston, all eminent water supply engineers.

Their report, which was submitted on August 20th, 1913, briefly summarized its recommendations as follows: "To bring the water through a concrete aqueduct, approximately 85 miles in length, laid with a continuous down grade to a point about ten miles east of Winnipeg; and then in a five-foot steel pipe to the Red River and a five-foot pipe in tunnel to convey water under the Red River, thence by a four-foot cast iron pipe through the streets to McPhillips Street reservoir."

Subsequently, for economic reasons, the decision was made to use reinforced concrete pipe instead of the steel and the cast iron pipe, the substitution having been approved by the Board of Consulting Engineers.

The estimated total cost, not including the cost of the lands for right-of-way or the branch pipes for the different connections, and not including any allowance for water damages or for interest charges upon money obtained from the sale of bonds or otherwise for the construction of the works, was $13,045,600.00.

On the other hand the Engineers made no deduction from the estimate for the value of the railroad at the completion of the work or for any other equipment, buildings, plant, rolling stock or other assets remaining after the completion of construction.

The report of the Consulting Engineers was adopted by the Administration Board of the Greater Winnipeg Water District on September 6th, 1913, and on the same date a by-law was passed by the Administration Board to incur and create a debt of $13,500,000.00, by borrowing money and issuing debentures for the waterworks system.

On October 1st, 1913, the by-law creating the debt of thirteen and a half millions was also submitted to the vote of the legally qualified ratepayers of the City, with the following results:—

In favor of the by-law	2,951
Against the by-law	90

The first considerations of the various reports on Winnipeg's future water supply were of course quality and quantity.

The Consulting Engineers of the 1907 Water Supply Commission, namely, Messrs. James H. Fuertes, R. S. Lea, J. E. Schwitzer and George C. Whipple, state of the present city well supply:

"Chemically, the water is decidedly unsatisfactory. It is very hard and very saline, properties which make it unpleasant and expensive for domestic use, and unsuitable for use in boilers and many industrial processes.

"The use of hard water is not only a great inconvenience in the household, but is also expensive, as it necessitates the use of large quantities of soap and washing powders, with the consequent destruction of fabrics washed in the laundry.

The same Engineers say of Shoal Lake:

"Shoal Lake, in the north-west angle of the Lake of the Woods, has a drainage area of about 360 square miles, with a water surface of 107 square miles, and is connected with the main lake at Ash Rapids. The Lake of the Woods has a drainage area of about 27,700 square miles, and a water surface of about 1,500 square miles.

"The water is very soft in comparison with the water at present supplied to Winnipeg. The water, in the absence of unusual conditions may, therefore, be termed an excellent one for domestic, boiler and general manufacturing purposes.

"The water of Shoal Lake at Indian Bay is soft. Its chlorine is a negligible quantity. It is practically uncontaminated, as the entire region for miles around is uninhabitated. From the sanitary standpoint filtration is not now required, as the natural water is reasonably safe and wholesome.

"Considered from the standpoint of the quality of the water in its natural condition and taking into account the use of the water for all purposes, the Shoal Lake water is unquestionably the best source of supply."

SECOND REPORT

Of the present supply Professor Schlichter said:

"The present water supply of the City of Winnipeg from the well system is so highly undesirable and expensive, on account of its high mineral content, that it should be abandoned at the earliest possible date. The water is excessively hard and incrusting, and is corrosive and destructive to an unusual degree. The expense that this water now causes the citizens of Winnipeg by its destructive influence on plumbing, boilers, heating plants, etc., and increased cost of fuel, soap, compounds, and the destruction of woollens and other laundered articles, would well pay the interest on $15,000,000 to $20,000,000 as the City Engineer has tersely remarked in his printed report—'The water in its natural condition is much too hard for general domestic and boiler use.' The water is expensive to soften and after treatment it is still hard water, and more than that, still retains all of its corrosive qualities. The water is not only destructive of wealth, it is a handicap and a serious drawback to the proper operations of many industries, and a hindrance to the introduction of new industries. The following typical industries would be seriously handicapped by the present supply: meat-packing industries, canning industries, woollen mills, starch and kindred potato product industries, and industries, of which there are many, which require the use of live steam, or drying processes, or distillation, or kiln-dried material, or the application of heat for digesting or liquifying or combining a variety of commercial substances. There is no industry that would not be favorably affected by an abundance of pure soft water, and to many it is an absolute essential."

Of the Shoal Lake Supply he said:

"I visited Shoal Lake on August 24th, 1912, and inspected the various points in which intakes have been proposed. I also made comparative tests of the color and turbidity of the water at various points by sinking a white disk to invisibility; I also determined the temperature of the water at various places and at various depths, and took samples of water from these various zones. The date of my inspection was especially favorable, as I undoubtedly saw the lake at the time when the growth of algne, etc., is at the maximum. The amount of suspended matter in the water was surprisingly small. The amount of pelagic life in Shoal Lake is very small, due in part to the clean, rocky character of its shore, and of its water-shed. The clean Laurentian granite and schists have collected together a body of water of exceptional softness and purity.

"The water from Shoal Lake would require no treatment. No fear need ever be in mind that the sanitary quality of the water would be poor at any time in the future. The shores of the lake are hard rocks of the Laurentian series, entirely unfitted for agriculture, and the country thereabouts must remain in its present wild state indefinitely. There need be no fear of the growth of cities or towns upon the shore of Shoal Lake. The Lake of the Woods constitutes an enormous reservoir of clear, pure and soft water, situated 300 feet above the City of Winnipeg, within 100 miles of the city.

"As previously stated, the water of Shoal Lake would never require sanitary treatment.

"I would recommend that the water supply for the City of Winnipeg be taken from Shoal Lake, basing this judgment upon the fact that this is the very best supply available, and as near ideal as any city can expect to find.

"I recommend the Shoal Lake Supply solely for the reason that it is best. It is not the cheapest. I do not believe that it is necessary at this time to weigh too nicely the cost of such a project.

"The City of Winnipeg is no longer merely the supply point of the north-west prairies or merely the capital of a province. It has entered the class of world cities and has begun to direct the commerce and industries of a vast territory. Within the small group of cities of this class, pride as well as self-interest may well be appealed to. The city cannot afford to be committed to a temporizing or inadequate policy, or to permit further postponement of the settlement of the matter on a large and adequate basis."

THIRD REPORT

The report of Messrs. Rudolph Hering, Frederic Stearns and James H. Fuertes said of the Shoal Lake supply:

"The water of Shoal Lake was, when we examined it. of excellent quality for domestic and manufacturing purposes, being soft, practically free from contamination, without noticeable color, free from odors, and of an agreeable taste. The results of recent examinations of the Shoal Lake water, and all of the local conditions, indicate that the occurrence of bad tastes and odors in the water, from growths therein, should be infrequent, and may never occur at all. Should such trouble occur in the future the opportunity to correct them by suitable treatment may be availed of when necessary without interrupting the supply of water to the city or making expensive changes in the works as built."

The report on the laboratory investigations made by Mr. A. Blackie, city analyst, says:

"Shoal Lake water contains three parts of chlorine per million. The city's present supply and all water from well sources in the neighborhood of Winnipeg is very high in chlorine, the city wells giving about 250 parts and other wells running up as high as 500 parts per million. It is this chlorine in the water that causes the corrosion of steam fittings, etc. It s not possible by any known process to remove chlorine from water."

Thus Winnipeg secured the favorable opinion, contained in three reports, of no less than seven of the most eminent water supply engineers on the American continent, before undertaking the present Greater Winnipeg Water Supply scheme.

The Poplar Springs project having been defeated by the ratepayers' vote, and the Shoal Lake scheme having been approved by the vote of the ratepayers on two separate by-laws. and the quantity and quality of the water at Shoal Lake having been determined, it now only remained for the Water Board to proceed with the work.

The Administration Board, under the chairmanship of Ex-Mayor T. R. Deacon, who had been throughout an ardent advocate of Shoal Lake, proceeded with active construction vigorously.

The work was commenced on March 1st, 1914, and during that year the railway, with 105 miles of track, a telephone line, the clearing of the right-of-way, the construction of a dyke across Indian Bay, and the dredging of a channel for the diversion of water from the Falcon River, and the fencing of the right-of-way was carried out.

Just prior to the outbreak of the war tenders were invited for the construction of approximately 85 miles of the aqueduct from Shoal Lake to Deacon (about ten miles east of Winnipeg), and on September 25th, 1914, the contracts were let, on a unit price basis, amounting to approximately $6,200,000.00. The work was all allotted to Winnipeg contractors.

Work on the construction of the aqueduct was commenced on May 15th, 1915, and has been carried on continuously and vigorously during the summer working seasons up to the present time. According to the terms of the contract, 85 per cent. of the work between Shoal Lake and Deacon had to be completed at the end of 1917: 83 per cent. has been completed. Under the terms of all the contracts, the entire work must be completed before the end of 1918.

The system of works at present under construction follows the general plan for the undertaking outlined in the report of August 20th, 1913, by a Board of Consulting Engineers consisting of Messrs. Rudolph Hering, Frederic Stearns and James H. Fuertes.

General Features of Design

The complete designs for all the structures comprising the aqueduct are being made in headquarters office in Winnipeg. This work, which is being carried out by a staff of from five to ten men, involves the drawing up of general and detailed plans and specifications, the analysis and application of the results of all field tests made on structures and soils, and the laboratory work appertaining to the analysis and testing of cement, aggregate, concrete, etc.

The following is a brief description of the main features of the aqueduct and appurtenant structures as designed and as being built:

GRAVITY FLOW AQUEDUCT

The cut-and-cover section of the aqueduct, extending from Indian Bay to Deacon, a distance of 85 miles, is so designed that the water will flow the whole distance by gravity without quite filling the structure to the roof. This whole section of the aqueduct is arch shaped, resting on a floor or invert built as a flat inverted arch, both arch and invert being constructed of concrete. Where the foundation is yielding the invert is reinforced with steel. As the aqueduct follows in general the slope of the country traversed, the water will flow faster on the steeper slopes and slower on the flatter slopes. For this reason the aqueduct sections vary from a minimum section 6 ft. 4¾ ins. wide by 5 ft. 4¾ ins. high on the steepest slopes (between miles 23 and 32½) to a maximum of 10ft. 9 ins. by 9 ft. high where the slope is flattest (between mile 89 and Indian Bay, mile 98). In all there are eleven different gravity sections varying in size between the above mentioned limits. A crimped copper water stop is provided at contraction joints at 45-feet intervals.

Aqueduct Construction on Contract No. 33

Outside forms and carriers are shown, as well as the method of constructing the arches alternately.

Loading 66-inch Re-inforced Concrete Pipe for Contract No. 35

The pipe is constructed at manufacturing yards located in the town of Transcona, and is made in sections eight feet long; each section weighing approximately eight tons.

Transporting a Section of 66-inch diameter Re-inforced Concrete Pressure Pipe into place in the trench

This pipe is constructed under "lock joint pipe" patents and is made in 8-foot lengths.

Manholes and air vents have been provided at approximately one mile intervals throughout the length of the gravity section. The structure is heavily reinforced at all surveyed road crossings.

RIVER CROSSINGS

Where the aqueduct crosses the various rivers the structure is made circular in shape and depressed under the bed of streams, rising on each side in smooth curves to meet the gravity sections. These under-river siphons are made up of reinforced concrete pressure pipes approximately eight feet in diameter. The aqueduct section from mile 17 to Deacon, mile 13, is also circular reinforced concrete, being part of the sixteen mile inverted siphon crossing the Red River valley. Copper contraction joints are located at 30-feet intervals in this section.

OVERFLOWS AND BLOW-OFFS

At points where the aqueduct crosses under the rivers overflow structures are being provided just at the point where the line begins to dip under the stream. These overflow structures, built of reinforced concrete, are provided with adjustable overflow weirs leading through a gathering chamber to a well at one side of the aqueduct whence the water can be discharged through a covered concrete flume to the adjacent river. A concrete superstructure is placed above the overflow and a large opening is left in the floor through which a boat can be entered or withdrawn for the purpose of examining the condition of the aqueduct during operation. Bronze chains hung from this opening will permit access and egress. The purpose of the overflow structures which are provided with cross stop logs is to regulate the flow through the aqueduct and to permit emptying it in sections for the purpose of cleaning. The superstructures have all been designed of sufficient strength to permit backfilling with earth to a height of four feet above the roof in case it is found necessary on account of the action of frost. From observations made to date it is not anticipated that this backfilling will be required.

CULVERTS

For the purpose of furnishing free passage for country surface drainage from one side of the aqueduct to the other numerous rectangular culverts made of reinforced concrete are being provided. These culverts vary in size from a single 3 ft. by 4 ft. section to triple 6 ft. by 6 ft. 9 in. section, the latter being near mile 22 and discharging the water from a large government drainage ditch in that vicinity. The culverts are horizontal below the floor of the aqueduct, rising at each end on slopes of 45 degrees to the level of the drainage ditches. They are completely backfilled except for the entrances and exits, which are provided with stop plank grooves to permit the blocking off of water for the purpose of cleaning.

PRESSURE LINE, DEACON TO RED RIVER

From Deacon to the Red River crossing the water will flow under pressure in a 5 ft. 6 in. diameter lock-joint reinforced concrete pipe line, now under construction. This pipe will be duplicated when the demand for water requires it, but in connection with a booster pumping station at the Red River tunnel it will suffice for a supply of 50,000,000 gallons per day. The pipe is being built in pre-moulded sections eight feet in length at yards in Transcona and from there hauled to place and laid in the trench on a gravel bed. After laying to line and grade, a continuous concrete saddle is placed along the pipe and the whole structure is backfilled with six feet of earth.

The pipe dips under the Seine River in an inverted siphon and on account of the treacherous nature of the banks a heavy reinforced concrete mattress supported on piles driven to rock is being provided to carry the pipe line through the valley. In order to prevent a decrease in the flow due to the accumulation of air in the upper ends of the Seine siphon, air valves are being provided in small covered concrete chambers which will permit air to escape from the pipe without loss of any water. Manhole castings are being provided at approximately 1,000 feet intervals and these are completely backfilled, as it is not anticipated that access to the pipe will be required except at very rare intervals.

The pipe passes under several railroads in its course and at these points it is especially reinforced against the heavy loads which will come upon it.

RED RIVER TUNNEL AND SURGE TANK

The line will cross the Red River in a tunnel cut through the rock about 20 feet below the bed of the river and rising at each end in vertical shafts. The water will be conveyed through a 60-inch diameter cast iron pipe concreted solidly into the rock in the tunnel section. The shafts will be formed by sinking to rock reinforced concrete wells, 16 feet in diameter. Valves will be provided at the upper end of each shaft to allow for future outlet supply line and for controlling the flow. In St. Boniface property has been requisitioned adjacent to the east shaft for the erection of a future booster pumping station and also for a surge tank. This surge tank, which will be a circular reinforced concrete structure supported on concrete caissons carried to rock and provided with an outer masonry shell to serve as frost protection, is provided for the purpose of permitting regulation in the flow of the 5 ft. 6 in. pipe line, required on account of the varying demand for water. It will act as a storage supply while the velocity of water in the pipe line is accelerating to a required demand, or as a relief when the demand is reduced, excess water being discharged through an overflow to the Red River. The dimensions of the tank have been so figured that waste of water will be reduced to a minimum.

FORTY-EIGHT-INCH SUPPLY LINE IN WINNIPEG

From the west shaft of the tunnel to the McPhillips Street reservoir in Winnipeg the water will be conveyed through a reinforced concrete lock joint pipe, 48 inches in diameter, built in pre-moulded sections and laid in trench in the streets. The construction will be of a type similar to that of the 5 ft. 6 ins. pipe line between Deacon and the Red River, except that the pipe will be cast in lengths of ten feet instead of eight feet.

OUTLETS

For supplying water to the various municipalities comprising the Greater Winnipeg Water District outlets have been provided as follows:

A 36-inch outlet for Transcona from the 5 ft. 6 in. pipe at Plessis Road;

A 36-inch outlet for the City of St. Boniface and St. Vital from the 5 ft. 6 in. pipe where it passes through the pumping station yards of St. Boniface;

A 24-inch outlet for the Elmwood district and East Kildonan from the 5 ft. 6 in. pipe at Archibald Street;

36-inch and 24-inch outlets for the high pressure pumping station and for Fort Garry at west shaft of the Red River tunnel;

A 24-inch outlet for Kildonan from 48-inch pipe at King Street;

A 24-inch outlet for Assiniboia from 48-inch pipe at Arlington Street.

CHAPTER II.

General

DISTRICT ITSELF A CONTRACTOR

In order to supply aggregate for the manufacture of concrete the Water District has opened up two gravel deposits, a fine sand pit and a rock quarry. At first a gravel crushing, screening and mixing plant was erected at Mile 31 to supply the aggregate required for the manufacture of concrete. As the demand increased, gravel and fine sand pits were opened up at Mile 80, and a rock plant at Mile 95½ was built to add to the supply of the required material. The aggregate from the plant at Mile 31 is a feature of the work carried out by the District forces, being scientifically graded. This aggregate effected considerable economy in the cement quantities required for the manufacture of an impermeable concrete, and was easier for the contractors to handle than the separated materials.

The Portland cement for all the contracts was purchased by the District and furnished the contractors at cost. The District, under Contracts Nos. 30 to 35 and 55, 56, 69 and 65, is under obligation to the contractors for a continuous supply of tested and approved Portland cement. In obtaining supply for service to these contracto[illegible] must have from the cement manufacturers: (*a*) such formal and rea[illegible]ncial protection (in shape of a satisfactory bond) as would protect [illegible] against loss in the event of break in the continuity of that supply; (*b*) and must have from manufacturer, dealer or by the District itself such Winnipeg storage of manufactured and approved cement as would implement the unavoidable irregularities in manufacture, shipment and deliveries; (*c*) as well as from the manufacturer such mill storage as would ensure the continuous flow of shipments of tested and approved cement, even should occasional products of manufacture fail to pass the tests.

The cement used during the seasons of 1915, 1916 and 1917 was delivered from the Winnipeg mill of the Canada Cement Company. It was sampled by resident District inspectors, tested at engineering headquarters, and shipped upon approval had from the Chief Engineer. An important feature of this contract was the manufacture by the manufacturers of a forty or more days' supply in storage at all times. That company will also furnish the requirements of the District during 1918 under Contract No. 71.

There are only four other communities in the world that have gone a greater distance to secure their water supply than the Greater Winnipeg Water District. That the Greater Winnipeg Water supply ranks as a major undertaking is shown by the following tabulation:

Preliminary estimate of cost of undertaking, exclusive of land and interest during construction	$13,045.600
Source of supply	Shoal Lake, Ont.
Area of Shoal Lake	107 square miles
Area of Lake of the Woods, including Shoal Lake	1500 square miles
Drainage basin of Shoal Lake	360 square miles
Drainage basin of Lake of the Woods	27700 square miles

Total length of conduit	96.5 miles
Difference in elevation between Shoal Lake and the City of Winnipeg's reservoir surface	294 feet
Method of delivering supply	Gravity
Area of Greater Winnipeg Water District	92.03 square miles
Population of Greater Winnipeg Water District	250,000 inhabitants
Area of Greater Winnipeg Water District in 1913	91.67 square miles
Population of Greater Winnipeg Water District in 1913	214,691 inhabitants
Length of cut-and-cover concrete aqueduct with capacity of 85,000,000 imperial gallons per day	77.5 miles
Length of river siphons and pressure section of concrete aqueduct with capacity of 85,000,000 imperial gallons per day	7.1 miles
Length of reinforced concrete pressure pipe (lock joint type) with capacity of 50,000,000 imperial gallons per day	9.4 miles
Length of Red River Tunnel with 5-foot cast iron pipe lining	0.2 miles
Length of 48-inch concrete pipe, through streets of Winnipeg	2.3 miles
Date work commenced on undertaking	October 1st, 1913
Date set for completion	October 31st, 1918
Length of District railway, including sidings	110 miles
Maximum size of concrete cut-and-cover aqueduct	10'9"x9'
Minimum size of concrete cut-and-cover aqueduct	6'4½"x5'4½"
Maximum grade of concrete cut-and-cover aqueduct	1.537' per 1,000'
Minimum grade of concrete cut-and-cover aqueduct	0.110' per 1000'
Average grade for whole conduit	0.57' per 1000'

The following memoranda will give the citizens an idea of the magnitude of the works which the Water District have in hand in their preparation of structures for the furnishing of 85 million gallons of soft water per 24 hours to the population of the Greater Winnipeg Water District.

Eighty-five million gallons of water would fill Portage Avenue between the building lines from Main Street to Sherbrook Street to a depth of 20 feet; the contents of the reservoir which will be built at Deacon, ten miles east of the City of Winnipeg, combined with the contents of the reservoirs now owned by the City of Winnipeg, would fill this same area to a depth of 62 feet, or to the height of the fourth story windows.

The quantities of earth handled by the contractors and paid for by the District during the three seasons of aqueduct construction work would be sufficient to fill the Red River to the top of the banks for one and a third miles.

The quantities of concrete poured in the aqueduct structure and its appurtenances during the same period would provide 24 feet of pavement six inches thick over 134 miles of streets, or would provide a concrete walk six feet wide wherever there is now in Winnipeg a sidewalk of plank or of concrete.

The reinforcing steel used in the construction of aqueduct to date, if all rolled into rods five-eighths of an inch in diameter, would stretch from Montreal to Regina.

G.W.W.D. Regular Mixed Train standing at Deacon Station

Water Tank, Machine Shop and Roundhouse, Engineering and Railway Employees living quarters at Deacon

Pouring Insert Pads on Contract No. 30

The method of setting the forms for the pads is clearly shown. The sub-surface is carefully trimmed before concrete is poured upon it.

Pouring an Arch in Shallow Cut on Contract No. 30

The Portland cement consumed during the same period would fill a train of freight cars 18½ miles long and would weigh 4½ times as much as the entire population of the Water District.

DISTRIBUTION

Under the present scheme the Greater Winnipeg Water District will sell and deliver the water wholesale, and at the same price to all the municipalities, the price being based as near as possible on the cost of maintenance, operation and management of the main aqueduct. Each municipality will fix and collect its own water rates and have full control of the distribution within its boundaries.

RIGHTS SECURED

In order to make the District perfectly secure in its right to take water from the Lake of the Woods, which is partly in Manitoba, partly in Ontario and partly in the United States, an order of the International Joint Commission was secured in January, 1914. An act was also passed in June, 1913, by the Dominion Government and an Act passed by the Province of Ontario in 1916, confirming an order-in-council of the Ontario Government of October, 1913, enabling the City of Winnipeg to get water outside of the Province of Manitoba. In order that there may be no contamination of the water the Water District has purchased from the Dominion Government for a nominal sum the water area and a large portion of the land area surrounding the intake for the water supply.

RIGHT-OF-WAY

The Water District Corporation owns a right-of-way 300 feet wide for its railway, pipe line, and the necessary land for any future pipe line which may be required, from the lake to Deacon, eight miles east of the city. From Deacon to Winnipeg the right-of-way is one hundred feet wide.

FAIR WAGES

The specifications for all contracts contained the Fair Wage Schedule of the Province of Manitoba and wages paid for all classes of labor on the aqueduct construction are in accordance with the provisions of the Act. The District employs W. H. Lovatt as Fair Wage Officer, whose duty it is to see that the contractors satisfactorily carry out this part of their agreement. The specifications also require that good board and lodging be furnished to workmen at the rate of $5.00 per week.

CONTRACTORS

The contractors have all been anxious and have taken especial care to produce work of the best quality. The personell of the companies is as follows:—The Tremblay McDiarmid Company—J. P. Tremblay, J. H. Tremblay, Jas. McDiarmid, Ed. Cass. Thos. Kelly & Sons, Ltd.—L. C. Kelly, C. B. Kelly. Winnipeg Aqueduct Construction Company—Archibald Mackenzie, William H. Carter, A. H. Aldinger, Frank E. Halls, J. B. McLean.

DISTRICT RAILWAY OPERATION

The operation of the District railway is carried out by the District's own forces with headquarters at Deacon. Running rights obtained from the C.N.R. enables the District trains to operate over the Canadian Northern tracks from Paddington to the C.N.R. St. Boniface station. The use of the Union Stock Yards transfer tracks is arranged for on the basis common to the other railways.

A regular train service given by the District consists of a way freight mixed train, which leaves the C.N.R. St. Boniface station every Monday, Wednesday and Friday, and returns every Tuesday, Thursday and Saturday. This train carries passengers, supplies for the contractors and cement.

Gravel trains are operated so that a supply of aggregate for concrete is delivered each day to the contractors from the District gravel plant.

The following is a list of the District's rolling stock as at December 31st, 1917:

1	65-ton locomotive	$13,000.00
1	40-ton locomotive	1,600.00
4	52-ton locomotives	42,000.00
1	Dinky	3,200.00
40	20-cubic-yard air dump cars	58,000.00
25	16-cubic-yard hand dump cars	30,250.00
20	60,000-lbs. flat cars	10,500.00
10	60,000-lbs. box cars	4,200.00
4	Cabooses	2,500.00
1	Combination coach	2,600.00
3	Coaches	6,165.50
12	6-cubic-yard hand dump cars	2,370.00

The Railway has opened up a large area of wooded country from which Winnipeg can receive cordwood for years to come and already large quantities of cordwood and poles are being shipped. An extensive deposit of granite has also been discovered close to the railway and is being worked. Experts state that this is equal in quality to any found in America and compares favorably with the granite of Scotland.

It is the intention of the Administration Board to operate the Railway after the completion of the aqueduct. Settlers have located along the route and the produce from their farms will provide a considerable amount of freight. The cordwood camps are producing from 7,000 to 10,000 cords annually and the amount of granite to be carried will be fairly large. In addition the railway will aid the patroling of the aqueduct, and should repairs ever be necessary the material for these can be transported quickly by rail.

Recently rich deposits of molybdenite and rich veins of sheelite (tungsten) ore have been discovered at Falcon Lake in Eastern Manitoba, near the Lake of the Woods. This is in close proximity to the Greater Winnipeg Water District Railway, and if subsequent explorations being carried on by the Dominion Government establish the original prospection reports as correct, the District Railway will undoubtedly become an important ore transporting vehicle.

EXCURSIONS

During the past two years the Administration Board has run excursion trains over the District Railway on holidays to enable the public to see the construction of the aqueduct and the country through which the railway passes. Thousands of citizens have availed themselves of these cheap excursions, the round trip ticket costing $1.00 for a 200 mile trip. Excursions will be run during the coming summer, the first being on the 24th of May.

COLONIZATION AND DEVELOPMENT

In co-operation with the Dominion Government the Greater Winnipeg Water District has a colonization scheme well in hand. Nine townships of land traversed by the District have been reserved for colonization and development. Free homesteads of approximately forty acres each can be obtained along the Birch River and close to the railroad, on application to the Water District office. The land along the rivers is exceptionally rich and is being settled rapidly. In most cases the value of the wood cut more than pays for the clearing of the land. Many settlers are being attracted to this locality, partly because of the prominence given to the scheme and partly because the drainage done by the District is reclaiming large areas of land. Nor is the education of the settlers' children being neglected; already three schools have been opened and others will be erected as occasion arises.

For small farming, gardening, bee-keeping, poultry raising and other kindred occupations, the land along the river banks cannot be surpassed. Ready sale is found now on the construction work for all vegetables and produce, and later Winnipeg will supply an unfailing market at profitable prices. A highly commendable exhibit of grains, grasses and vegetables grown along the Water District Railway was made at the exhibition of the Winnipeg Garden Show last year.

MODEL FARM ON THE BIRCH RIVER

The Government of Manitoba and the Welfare Commission have unanimously decided to establish a model industrial farm of approximately 2,200 acres almost in the centre of the Water District colonization reserve. The soil has been carefully tested by experts, who state that it is particularly well adapted for the purpose of growing grains, small fruits, vegetables, and in fact everything which can be successfully grown in the Province of Manitoba. The location has been selected after a great deal of investigation. It is naturally beautiful, being traversed and drained by the Birch River. The Water District Railway crosses the farm and sidings will be located on it. The development of this district will proceed rapidly following the action of the Provincial Government.

CHAPTER III.

Progress in 1913

Immediately following the approval of the project by the citizens, in October, 1913, the Water Board appointed Samuel H. Reynolds as chairman of the Commission and James H. Ashdown, who since the inception of the scheme has given, as commissioner without remuneration, his valuable business experience; James H. Fuertes was appointed Consulting Engineer, and W. G. Chace Chief Engineer. Administration and engineering forces were at once organized and active work was commenced on the undertaking. Five field survey parties were placed in the field to complete the location of the aqueduct line.

Progress in 1914

In 1914 the progress made consisted in the completion of such works as were necessary to prepare the way for the construction of the 85 miles of concrete aqueduct. These works consisted in the completion of the location surveys, the clearing of the right-of-way, the construction of the telephone line, the putting up of the buildings for accommodating the staff, the purchase by the District of materials required to build the railway, the building of 105 miles of standard guage railway, yards and sidings, the construction of the Falcon River dyke and canal, the necessary preliminary work for the aqueduct contracts and the letting of these contracts.

LOCATION SURVEYS

The aqueduct location was chosen by March 1st, with the exception of certain short portions which were revised before the end of May. The general location is shown on page No. 35. Five field parties were engaged on this location survey.

CLEARING RIGHT-OF-WAY

The contract for the clearing of the right-of-way was awarded to E. J. Bawlf, of Winnipeg. This work commenced in March, 1914, and was practically all completed in three months time. The standard width cleared was 300 feet. Considerable quantities of cord wood, posts and poles were salvaged in this work.

CONSTRUCTION OF TELEPHONE SYSTEM

The construction of the telephone system was carried out by the Water District forces under the direction of the Chief Engineer, with C. J. Bruce as Superintendent. This work was commenced May 5th, 1914, and communication with Waugh was completed Oct. 22nd, 1914. In all 91 miles of line was put up, using No. 14 B. & S. copper wire. The total cost of the system to June 30th, 1916, was $32,505.23. This included the cost of building and removing necessary temporary stretches.

CONSTRUCTION OF THE WATER DISTRICT RAILWAY

In order to transport the supplies, machinery and construction materials required to build the 85 miles of concrete aqueduct from Deacon to the intake on Indian Bay, the Water District built, in 1914, a standard guage railway on the aqueduct right-of-way. Sixty-pound rails were used, and a well-ballasted roadbed was provided. The maximum grade is five-tenths of one per cent. and the standard curvature is four degrees. The railway was located parallel to the aqueduct centre line and at a distance therefrom of 110 feet.

The contract for the construction of the railway was awarded to the Northern Construction Company, of Winnipeg, at an estimated tender price of $556,974.50.

The actual amount expended on this contract was $689,107.57. Work was commenced on this contract in March, 1914, and the last spike was driven by Mayor T. R. Deacon at 10.30 a.m. Thursday, the tenth day of December, 1914.

CONSTRUCTION OF THE FALCON RIVER DYKE

The construction of the Falcon River dyke was carried out in order that the water near the intake might have an opportunity to become as clear as the waters of the main lake. This could only take place when opportunity was given to the natural agencies (sun, waves and wind) to act on the water near the intake, without allowing this water to be mixed with additional dark water from the Falcon River.

The contract for the construction of the dyke was awarded to Messrs. Tomlinson & Fleming, of Toronto. The actual cost of construction was $87,327.02.

CONTRACTS FOR THE CONSTRUCTION OF THE 85 MILES CONCRETE AQUEDUCT

The preparation of the drawings and specifications required for the aqueduct contracts was undertaken during the winter and spring of 1913-1914. The work was divided into five contracts and tenders were called requesting bids on each, any one or all of the five sections. The date of receiving tenders was September 19, 1914, and the contracts were awarded in October as follows:

Contract	Mile to	Mile	Successful firm	Originally estimated value
30	12.473	32.537	J. H. Tremblay & Co.	$ 945,945.00
31	32.537	50.302	Thos. Kelly & Sons	1,301,485.00
32	50.302	68.503	Wpg. Aqueduct Con. Co.....	1,268,680.00
33	68.503	84.592	Wpg. Aqueduct Con. Co.....	1,137,010.00
34	84.592	97.11	Wpg. Aqueduct Con. Co.....	1,489,520.00
				$ 6,142,640.00

By awarding these contracts in the fall of 1914 opportunity was given to the contractors to perfect their organization, to order material and forms, and during the winter season to thoroughly lay out their plans for the carrying out of the construction work during the whole of the working season of 1915.

Progress in 1915

The work in 1915 consisted principally of that done by the contractors and by the Water District's forces on the construction of the 85-mile concrete aqueduct section. The progress made by the contractors was as follows:

Contract	Camp	Length of contract	Ft. of arch built	Per cent.
30	2		6,525.	
	3	104,050 ft.	7,405.8	
Total			13,930.8 ft.	13.4
31	1		5,925.	
	2		1,800.	
	3	93,798 ft.	5,055.	
Total			12780. ft.	13.6
32	1		4,995.	
	2		8,925.	
	3	96,102 ft.	9,401.5	
Total			23,321.5 ft.	24.3
33	4		6,060.	
	5	84,950 ft.	4,033.	
Total			10,093. ft.	11.9
34	6	68,210 ft.	5,260.9	
Total			5,260.9 ft.	7.7
Grand totals		447,110 ft.	65,386.2 ft.	14.62
		84.7 miles	12.4 miles	

SETTLEMENT CRACKS

At the close of the construction season of 1915, a number of settlement cracks occurred in certain sections of the aqueduct. A Board of Consulting Engineers consisting of Messrs. J. G. Sullivan, R. S. Lea and Brigadier-General R. N. Ruttan, was appointed to make a special report to the Administration Board. After a careful investigation these gentlemen reported in September, 1916, and their conclusions were summarized:

"The practical questions to be answered in connection with the project are:

"1. When the aqueduct and its accessories are completed will the work be of such a character that they will satisfactorily perform the service for which they have been designed, namely: the delivery of Shoal Lake water to the City of Winnipeg and the surrounding municipalities in the quantities specified and without pollution on the way?

"2. Will the work as projected be of such a substantial and permanent character as to require only a reasonable charge for maintenance?

"3. Will the cost of the completed work be fair and reasonable?

"Subject to the careful carrying out of the work on the lines indicated in this report all the questions may be answered in the affirmative."

These cracks varied in width from 5-16 of an inch to hairline cracks only, and were caused by the settlement of the subsoil as it becomes adjusted to the imposed load. The results of this settlement were such that restoration of the surface was possible at a relatively small cost, and it is not anticipated that the utility of the aqueduct or the permanence of the structure will be affected. Hydrostatic tests were carried on at different points where the cracks had developed and had been repaired, and the leakage from these sections was carefully observed. The length of observation depended upon the observed leakage and in some cases extended over a period of several months.

The greatest leakage was 10,200 gallons per mile per day, and the least 375 gallons per mile per day. If, when the aqueduct is completed, the total average leakage from the structure when filled to the 85,000,000 gallons line should be equal to that from the portion in which the largest cracks had developed, the amount would be about seven-tenths of one per cent. of the water carried in the aqueduct. This is considerably lower than the quantity originally estimated as likely to be lost by seepage, etc. The loss when the aqueduct is delivering water will likely be much less than 6,000 gallons per mile per day.

If a standard section of aqueduct 8′9″ x 7′4½″ and 5,280 feet long, or a distance equal to that between the Assiniboine River and the City Hall, is considered as filled to the 85,000,000 gallons line, or to a depth of 6.14 feet, it would contain approximately 30,000 barrels of water of 50 gallons capacity each. From the above, the leakage would be found to be 210 barrels, or if considered on the basis of the minimum leakage, then only eight barrels out of 30,000.

In this connection a letter from R. S. Lea, of Montreal, Consulting Engineer, is quoted:—

R. S. & W. S. LEA
Consulting Engineers

Montreal, P.Q., June 26th, 1917.

R. D. Waugh, Esq., Chairman of Commissioners,
Greater Winnipeg Water District, Winnipeg, Manitoba.

Dear Sir,—Early in 1916, as you are aware, I was appointed a member of the Special Board of Consulting Engineers to examine and report upon the general question of the design and construction of the Shoal Lake Aqueduct. This was in consequence of certain defects which had developed in the previous (and first) season's work.

In this matter I was associated with Brigadier-General H. N. Ruttan, late City Engineer of Winnipeg, and Mr. J. G. Sullivan, Chief Engineer of the Canadian Pacific Railway.

As a result of our investigation, covering a period of about 6 months, we reported that the materials and workmanship employed in the construction of the concrete aqueduct were of the highest quality, that the work if carried out along lines indicated in the report would, when completed, satisfactorily fulfil the purpose for which they were designed, would be of a substantial and permanent character, and would cost a sum which would compare advantageously with that of similar works elsewhere.

The experience gained in connection with the 1916 and the present season's work, together with the lapse of a winter season, has served to confirm these conclusions and to indicate that the defects referred to in the first year's work can be effectively repaired at a comparatively small cost.

So far as my personal opinion is concerned I can say that I have never seen a better example of concrete construction, both as regards workmanship and materials. Very truly yours,

R. S. LEA.

Progress in 1916

The progress made by the contractor on the aqueduct contract during 1916 is shown in the following table:

Contract	Camp	Contract length	Feet of arch built 1916	Feet of arch built tot. to date	Percentage of length completed
30	1		9,295.	9,295.	
	2		14,298.5	20,825.	
	3		14,610.7	22,016.5	
	Total	104,050 ft.	38,204.5	52,135.0	50.1

Contract	Camp	Contract length	Feet of arch built 1916	Feet of arch built tot. to date	Percentage of length completed
31	1		4,171.2	10,096.2	
	2		4,560.	6,360.	
	3		6,870.5	11,925.5	
	Total	93,798 ft.	15,601.7	28,381.7	30.2
32	1		10,335.	15,330.	
	2		8,640.	17,565.	
	3		11,312.	20,713.5	
	Total	96,102 ft.	30,287.	53,608.5	55.8
33	4		11,393.9	17,453.9	
	5		5,155.	9,188.	
	Total	84,950 ft.	16,548.9	26,641.9	31.4
34	6		8,772.9	14,033.8	
	7		6,420.	6,420.	
	8		4,785.8	4,785.8	
	Total	68,310 ft.	19,978.7	25,239.6	37.0
Grand Total		447,110 ft.	120,620.5	186,006.7	41.6
		84.7 miles	22.8 miles	35.2 miles	

Progress in 1917

On all aqueduct contracts the progress made during 1917 exceeded that of any of the previous years. On Contracts 31, 33 and 34 the work completed during 1917 was in excess of that done in the two previous years. This improvement in the progress resulted from more efficient organization of the contractors' forces; a better knowledge of how to prosecute the work and lastly to the increase of plant in the form of new camps and added machinery. The latter followed as the result of orders issued to the contractors in January, 1917, by the Administration Board of the District on recommendation of the Commissioners and the Chief Engineer; that unless the organization on certain contracts was improved and additional camps and equipment provided it was quite probable that these contracts would not be completed according to schedule.

Accordingly two additional camps were established on Contract 31 and worn out equipment was replaced by new plant. On Contract 33 one new camp was opened at the beginning of the season and one late in the month of May, and on Contract 34 additions were made to the existing plant.

The following table shows the progress made on the aqueduct section during 1917 and also the total completed aqueduct on a percentage basis. By way of comparison the percentage of completed aqueduct for the period previous to 1917 is also given.

A Forty-five Foot "Pioneer" Arch on Continuous Invert

Inner forms still in place. Note the crimped copper expansion joint embedded in the arch and the wood-strip water-stop in the invert, also note narrow track for carriage for moving inner forms.

Pouring Invert "Pioneer" Pads on Contract No. 34

Note the method of transportation and the type of chute used for pouring the concrete.

A Section of Aqueduct completed except for Back-filling
This is a "Prairie Section" scene about 22 miles east of Winnipeg.

A Typical Contractor's Camp
The Falcon River is shown in the foreground. Note the marsh-like growths in the river.

Contract	Camps	Completed previous to 1917	Percentage of length completed 1917	Total completed aqueduct	Required
30	3	50.1%	37.03%	87.13%	85%
		52,135 ft.	38,529.7 ft.	90,664.7 ft.	88,442.5 ft.
31	5	30.2%	51.7 %	81.9 %	85%
		28,382 ft.	48,493.6 ft.	76,875.6 ft.	79,728.3 ft.
32	*2	55.8%	35.11%	90.9 %	85%
		53,608 ft.	37,741.4 ft.	87,349.4 ft.	81,686.7 ft.
33	†3	31.4%	46.5 %	77.9 %	85%
		26,641 ft.	39,501.9 ft.	65,142.9 ft.	70,220.7 ft.
34	3	37.0%	40.1 %	77.1 %	85%
		25,240 ft.	27,415.4 ft.	52,655.4 ft.	58,120.2 ft.

* 3 camps after Sept. † 4 camps after Sept.

Total length of aqueduct east of main reservoir site	447,277.0 ft.	84.7 miles
Total length completed in 1917	187,682.0 ft.	42.0%
Total length completed to date	372,688.0 ft.	83.3%

CONTRACT NO. 55

This contract was awarded on December 29th, 1916, to the Winnipeg Aqueduct Construction Company, who are working in conjunction with the Canada Lock Joint Pipe Ltd., and calls for the construction of a reinforced concrete pressure pipe line 5 feet and 6 inches in diameter, extending from Deacon to the Red River, approximately 9.3 miles. The joining of this line at its easterly end to the westerly end of the aqueduct section will be done by the contractor for Contract 30, while the westerly end will be joined to the Red River crossing works by the contractor for that contract.

Good progress was made with the manufacturing and fair progress with the laying of the pipe. The trench work, such as the excavation, the placing of foundation, of pipe and the jointing and backfilling, was done at two points on the contract, at Camps 55 and 56. During the season approximately 3.2 miles of pipe was laid, backfilled and jointed. Enough pipe was manufactured for four miles of the line.

The contractors built a standard guage tramway along the right-of-way of the pipe line and convenient to the centre line. The pipe was loaded on cars at the manufacturing plant and transported over the tramway to a point close to that to which the laying had progressed, it was there unloaded and lowered into the trench with a crane and carried into position by means of specially designed carriers running on a track laid in the trench.

CHAPTER IV.

A Study of the Approximate Saving to Residents of the Greater Winnipeg Water District by Using Shoal Lake Water Instead of the Present Supply, Based on Present Conditions

A study of the saving to be effected by substituting as a source of water supply, soft lake water for ground water which is excessively hard will naturally follow along the lines of the saving on the items affected, namely: softeners required to soften the hard water, the reduction in the maintenance and capital costs on such items as water fronts and water coils, water heaters, boilers, cisterns and soft water tanks and softening plant; the saving in fuel due to absence of scale in boilers, the saving in clothing now injured by necessary processes, and the improvement in private and public health.

The quantity of soaps, water softeners and water treatments will be greatly reduced and it is reasonable to expect that incrusting and pitting of steam and hot water pipes and fittings and of power boilers will be practically eliminated and thus a saving effected due to the greatly decreased maintenance and re[illegible]ement costs.

Cisterns are used in this locality for the purpose of storing rain water for domestic uses other than human consumption. As Shoal Lake water is excellent for domestic purposes such as laundering, etc., the need for the installation of cisterns will cease to exist, and as those already in use become worn out it is not likely that they will be replaced, and a saving may also be expected under this item.

The softening plants in use in Winnipeg do not reduce the hard water to a degree of hardness lower than Shoal Lake water and consequently their continued use is not anticipated. There will therefore likely not be any further capital expenditure in connection with water softening plant installation and the present operating costs can be used as a basis of the saving under this item.

The number of parts of hardness per million gallons in the present ground water supply averages about 476, whereas Shoal Lake water contains on the average less than one-tenth of this, or about 45 parts per million of "temporary" hardness only. The present population of the Greater Winnipeg Water District is 250,000 and the daily water consumption, including that used in power plants, laundries, bakeries, is 11,000,000 gallons. Authorities on the subject of water supply have established by observation and experiments that on public water services only a small portion of the water supplied is totally softened, the amount varying from one to ten gallons per capita. Because of the extreme hardness of the present Winnipeg water and in order to obtain conservative results, the assumption will be made that of all the water supplied to the residents of the district, only one gallon per capita is totally softened, or 250,000 daily. As stated above this quantity will include water supplied to the industries as well as the householders, and therefore, in addition to soap, such softeners as boiler compounds, washing powders, washing fluids and the like will be used as the softening medium. The price of these several commodities varies greatly, fancy toilet soaps being worth 50 cents per pound, while some of the cheaper grades of washing powders are quoted at ten cents per pound.

For purposes of calculation and based on confirmation from authentic sources the average price of water softeners may be placed at 15 cents per pound.

Hardness in water is not noticeable until the degree of hardness reaches 20 parts per million, and from experiment it has been proven that for each additional part of hardness per million parts of water the softening will require 240 pounds of soap per million gallons softened, worth 240 x $0.15, or $36.00. The well water now used is, on the average, 430 parts per million harder than Shoal Lake water, so that every million gallons softened costs 430 x $36.00—$15,480.00 for the extra degrees of hardness. Thus, by the use of Shoal Lake water the saving will be the present cost of softening 250,000 gallons, or $3,870.00 daily, amounting approximately to $1,161,000.00 annually.

WATER FRONTS AND WATER COILS (FOR HEATING DOMESTIC WATER)

There are in Winnipeg and the surrounding municipalities nearly 45,000 of these in use in the following proportions:

Water fronts	30,000
Water coils in furnaces....	15,000

Owing to the corroding and incrusting elements in the water as at present supplied the average length of service is five years and the cost of renewal $5.00, which includes the cost of the installation. The annual outlay in the District for new water fronts is thus approximately $30,000.00 To this sum add $10,000, which is the amount expended annually on repairs to water fronts, such as removal and cleaning, new lengths of pipe, etc., making a total annual expenditure of $40,000.00.

The length of service of a water heating coil is not more than one year and the average cost of renewal is $5.00; the cost for renewal of 15,000 water heating coils is thus $75,000. With the use of Shoal Lake water the duration of service of water fronts and coils should be extended almost indefinitely, and therefore the annual saving on these two items would be approximately $115,000.00

In addition to the above mentioned devices for heating water there are 8,000 water heaters with which gas is used as the fuel. These are divided into two classes:

(a) Automatic or instantaneous heater.
(b) Circulating heaters.

There are 1,000 automatic heaters in use. The lower portions of these need to be replaced annually because they become clogged by incrustants. As the cost of renewal is $13.00 the annual maintenance charge is $13,000.00. The length of service of the 7,000 circulating water heaters is about three years. Therefore, at $13.00, less $1.00 for each old coil returned, the cost of maintenance of these is $27,600.00 annually, or the combined annual cost amounts to $40,600.00. As far as the use of Shoal Lake water is concerned the length of service of these heaters should be indefinite, their life depending almost solely upon the ability of the metal of which the heaters are constructed to withstand the ordinary wear and tear to which they are subjected.

CISTERNS AND SOFT WATER TANKS

The size of the average soft water container in this district is about six feet in diameter and six feet high, having a capacity of approximately 30 barrels. In this locality rain water is stored for laundry and ablution purposes only, and when the water from Shoal Lake is obtainable their usefulness will cease, and therefore any monies which would be spent on the maintenance or replacing of those already in service may be set down as a direct saving.

It is estimated that there are about 10,000 of these in use. The average life is ten years and accordingly there would be about 1,000 renewals annually. The cost at the present time for cisterns of this size is $43.00, and therefore the cost for renewals annually is $43,000.00; to this add repairs $5,000.00 and cleaning, at $1.00 each, $10,000.00, making a total present annual expenditure of $58,000.00, or, as is stated above, this may be set down as an annual saving of $58,000.00.

The estimates in connection with soft water containers are very conservative and although it is not unreasonable to suppose that a certain sum will be spent annually on maintenance even after Shoal Lake water is in use, it is not likely that many renewals will be made. The present annual expenditure under this head is probably much greater than the sum set down and therefore, a saving of $58,000 may be considered as quite conservative.

BOILERS

According to records of inspections made by the Bureau of Labor for the Province of Manitoba there are 398 high pressure boilers in use in the Greater Winnipeg Water District. These differ in capacity but the average is about 100 h.p. The average size and number of tubes in these boilers is 3½ in. by 16 ft. and 70 tubes per boiler.

Owing to the excessive hardness of the present water supply the life of the tubes in boilers in this district is very short, and on the average a total renewal of tubes is necessary every five years. The price of boiler tubing is advancing rapidly, having increased over 25 per cent. between December, 1916, and October, 1917. The present price of 3½ inch tubes is $0.57 per foot.

At the present time there is about 16 x 70 x 398=445,000 lineal feet of boiler tubing in use in this district and one-fifth, or 98,000 feet of this is renewed annually, the cost being $51,000.00. Water which is not harder than 70 parts per million gallons is classed as good for power boilers, therefore Shoal Lake water, which is not much more than half as hard, or 45 parts per million gallons, is exceptionally good. Certainly it would be safe to assume that when the using of Shoal Lake water in boilers is begun the length of service of boiler tubes will be at least five times as long; and therefore, figuring on the present basis, the annual renewal costs would be not more than $10,000.00, and therefore there will be an immediate saving of $41,000 annually.

SOFTENING PLANTS

There are at present in operation in the District, privately owned softening plants for treating water, either from the municipal supply or from private wells, the water from either one of which is similar in quality. The amount of capital invested is approximately $60,000.00. The annual cost of chemicals and operation is about $7,200.00, and the interest and depreciation is 15 per cent. of the capital invested, or $9,000.00 annually.

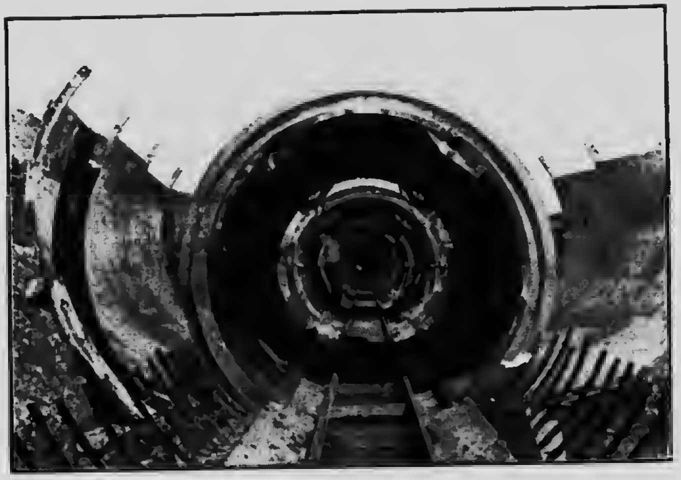
When the lake water is in use it will not be necessary to operate these plants, as in few instances do they reduce the hardness so as to make the supply as soft as the lake water. The direct sa[illegible] will be the operation cost of $7,200 annually, as it can be assum[illegible] that the interest and depreciation will be charged until the capi[illegible] debt is cancelled and need not be included as they would occur [illegible]respective of the water supply once the plant has been installed.

Typical Locomotive and Dump Cars

owned and operated by G.W.W.D. Cars dump mechanically by air pressure

School erected for Accommodation of Settlers' Children

There are three schools within the Districts Land Reserves.



Showing the Construction of the Circular Re-inforced Concrete, depressed section, where the Aqueduct approaches the Reservoir Site at Deacon

Aqueduct Dipping under a River

Backfilling over exposed position not completed. Note the boat-house structure at left of picture.

Another item to be dealt with is the saving of fuel which will be effected by the use of Shoal Lake water. With but few exceptions, in all steam power plants, trouble is experienced with scale in the boiler. Scale is the name given to the incrustants which form upon the tubes in boilers and is the result of precipitation of the carbonates and sulphates in the water when it is heated to above boiling point. This scale adheres to the tubes in layers, the thickness of which depends upon the nature of the water used, the treatment given to the water before it is used and the length of time between consecutive cleanings of the boiler. In any event even a slight scale upon the tubes acts as an insulator against the transmission of heat from the fuel to the water and a portion of the heat generated by the combustion of the coal is wasted in heating up and overcoming the effect of this insulating coat.

Once this scale is formed its removal is very difficult, as in many instances it withstands the action of strong chemicals. It can, however be removed by means of specially designed hammers operated by means of steam or compressed air, but this is a very slow and expensive process. Shoal Lake water is graded as excellent for boiler purposes and contains no elements which would form hard boiler scale, and when this water is used in power plants throughout the district trouble from scale should disappear. The loss of heat due to presence of scale is a real loss and amounts to from one per cent. to more than 45 per cent. of the total heat in the coal, depending upon the thickness of the scale.

Every citizen of Winnipeg who has had experience with scale in boiler and hot water tubes will realize how much heat, and consequently fuel, is now and has been wasted by the excessive corrosion in water heating, from the tea kettle up to the largest plant.

The figures presented below are a close approximation of the amount expended annually for fuel in the industrial plants and for domestic heating in the Greater Winnipeg Water District:

10,000 cords of wood	$ 75,000.00
140,000 tons of anthracite coal	1,750,000.00
50,000 tons Western bituminous coal	525,000.00
115,000 tons of bituminous coal	1,265,000.00
Total value	$ 3,615,000.00

Assuming that $1,115,000.00 is expended for fuel used in hot air furnaces, self-feeding coal stoves and similar heating apparatus, there would remain $2,500,000.00 as representing the amount expended for industrial power and heating plants and for residences heated either by steam or hot water systems.

Elwood Hendrick, an eminent analyst and chemical authority, says, in a recent publication: "We need not enter into a discussion of the nuisance that hard water is to boilers. The scale ruins the tubes and it is such a poor conductor of heat that it runs the coal consumption away up—*one-sixteenth of an inch of scale on boiler tubes doubles the consumption of fuel.*"

If, on the average, the scale in the tubes of boilers for power and heating throughout the Greater Winnipeg Water District was only thick enough to cause such a loss of heat as to increase the consumption 20 per cent., this would represent an over expenditure of $500,000.00.

With the advent of Shoal Lake water certainly no further formation of scale will occur, and the action of such water should remove a considerable portion of that already formed. If proper care is taken to remove such scale as exists when Shoal Lake water is first used, a considerable sum will be saved, as the heat hitherto wasted to overcome the insulating effect of the scale will be directly transferred to the water. The amount saved annually will probably exceed $500,000.00.

ANNUAL DIRECT SAVING

By summing up the above considerations the result obtained shows the annual direct saving. Against this, however, must be set the cost of the undertaking to the people of the Water District, the cost being made up of interest and sinking fund charges and the cost of the water to the consumer.

Approximate Saving on	
Soaps, boiler compounds, washing fluids, etc.	$1,161,000.00
Water fronts (in stoves)	40,000.00
Water coils (in furnaces	75,000.00
Automatic water heaters	13,000.00
Circulating water heaters	27,600.00
Soft water containers (cisterns)	58,000.00
Boilers (power)	41,000.00
Softening plants (chemicals)	7,200.00
Fuel	500,000.00
	$ 1,922,800.00

Approximate Cost	
Sinking fund	$ 153,000.00
Interest	825,000.00
Operating charges	313,000.00
	$ 1,291,000.00

Abstract	$ 1,922,800.00
	1,291,000.00
Apparent immediate annual net saving	$ 631,800.00

SAVINGS WILL INCREASE WITH POPULATION

It must be understood that the above figures are based on present conditions and that as the population increases the relative saving on the articles and commodities will increase, whereas the sinking fund and interest charges will remain practically the same. The operating cost may grow slightly greater owing to the increased amount of water used, but this growth will not be sufficient to offset the saving, which should be an increasing amount from year to year. In any event the annual saving effected by the citizens, although not perhaps a great amount individually, will collectively be sufficient to more than meet the annual indebtedness due to the construction of the aqueduct and in addition the residents of the District will have the benefit of the use of an inexhaustible supply of pure soft water.

The use of excessively hard water in the household is attended by real inconveniences. The thick unsightly scum formed on receptacles and the difficulty of obtaining a rich lather are due to insoluble compounds which have a deleterious effect on fabrics, reducing their strength and rendering them uncomfortable to wear.

The processes of dyeing of cloth and the tanning of leather require immense quantities of soft water, and both are carried on with more success and finer results when soft water is obtainable. Sugar refining requires pure soft water, and the manufacture of paper is impracticable, if not impossible, except where soft water is plentiful.

Those mentioned above are only a few of the industries which require soft water throughout the different processes of manufacture and which are likely to locate in the District when an abundant supply of soft water is available.

SHOAL LAKE WATER FOR HIGH PRESSURE PLANT

The High Pressure Fire System is located in the wholesale and business section of the City and the hydrants are so placed that if a fire has not gained too much headway before discovery the amount of water that can be thrown into it will prevent a spreading of the conflagration. Unfortunately, however, this water is pumped from the Red River which carries large deposits of sand and silt in suspension in its waters. This is deposited on merchandise and that portion not actually destroyed by fire is often rendered useless because of the layer of mud upon it, the cost of removing which would be greater than the amount of salvage, and all foodstuffs which have been exposed to this water must be destroyed as unfit for human consumption. It is the intention to use water from Shoal Lake for fire purposes and a branch connection is being built to the high pressure plant. The same water will then be used for fire fighting purposes as is used in the domestic mains, and then all foodstuffs not actually destroyed by water and all other articles such as clothing, leather, etc., can be salvaged profitably.

CLEAN STREETS AND SEWERS

In Winnipeg at present the cleaning of the streets by flushing with water is practically impossible because the supply of domestic water is not sufficient to permit this and the water from the high pressure system is not available because the health authorities will not allow it to be used for this purpose.

The sewers also cannot be flushed often enough because of lack of water. When Shoal Lake water is available there will be plenty of pure lake water for washing the streets and enough water at all time in every district in the city for systematic flushing of the sewers.

EXPERT TESTS AND EXPERIENCE

In connection with the above study, the following letters and extracts from letters are quoted, giving the opinion of those who, from the nature of their business, are able to set out the benefits to the citizens of the Greater Winnipeg Water District of water from Shoal Lake.

THE C.P.R. LAUNDRY

The following is quoted from a letter written to the Water District on January 11th by Mr. A. L. Scott, president of the C.P.R. Laundry, Ltd.—"The life of all goods washed in this Shoal Lake water will be lengthened to an incalculable extent. This also applies to all water heating and steam producing appliances. We can say most sincerely that we will welcome the advent of Shoal Lake water, both for our own sakes and that of our customers."

THE MODERN LAUNDRY

In a letter addressed to the District and dated April 27th, 1918, E. Edwards, Esq., managing director of the Modern Laundry & Dye Works Co., states:—"We find that it (Shoal Lake water) reduces the washing materials such as soap and soda just about 50 per cent."

RUMFORD SANITARY LAUNDRY LIMITED

Winnipeg, February 11th, 1918.

Mr. R. D. Waugh, Commissioner, Greater Winnipeg Water District, 501 Tribune Building, City.

My Dear Mr. Waugh,—It affords me great pleasure to report to you the results of the sample of water which you sent us. This water will be a godsend to the people of Winnipeg, if for no other reason than for washing clothes, as they come out so much softer and better than it is possible with the present city water.

As to the saving in cost of supplies, the sample which you sent us showed us a saving of exactly 50 per cent., but as I stated before, it is not altogether the saving in money as it is the results. The saving which we showed was against our own well supply, which is so much softer than the city water.

If we can be of any further service to you, at any time, we would be glad to have you call upon us. Yours truly,

RUMFORD SANITARY LAUNDRY LTD.,
L. J. Rumford, Vice-Pres. and Man. Dir.

THE NORTH WEST LAUNDRY, LIMITED

Winnipeg, February 6th, 1918.

Mr. R. D. Waugh, Commissioner, Greater Winnipeg Water District, 501 Tribune Building, City

Dear Sir,—Replying to your favor of 29th of January we duly received the sample of Shoal Lake water referred to, and have completed a laundering test with this water and with the same quantity of city water. We made the test with twenty-four soldiers' pure woollen undershirts, all of the same quality and manufacture, with the result that a saving of somewhere around 40 per cent. in soap was made with the use of Shoal Lake water compared with the City water. In addition to this the washing conditions were much better with the soft water than with the City hard water. As already referred to in a previous letter, in addition to the economy in washing materials which would result from the use of the soft water, there would also be a very considerable indirect advantage in the saving to machinery, particularly boiler flues. We think the test given was a fair one and are quite satisfied with the results. We hope, as stated in your letter, the soft water will be in commission by the end of the present year. Yours truly,

THE NORTH WEST LAUNDRY, LIMITED,
Per A. Davidson.

PATERSON & WAUGH
Adjusters of Fire Losses

301 Garry Building, Winnipeg, Man., Dec. 7th, 1917.

R. D. Waugh, Esq., Chairman of Commissioners, Greater Winnipeg Water District, Winnipeg.

Dear Sir,—We are in receipt of your favor of the 5th inst., asking as to the loss to property caused by the use of the water from the Red River in the high pressure system in fighting fires. While, of course, it is impossible to give comparative figures, there is no doubt that the damage in many instances has been heavily increased by this filthy water which an analyst has termed "Merely diluted sewage." Food stocks, except hermetically sealed goods, are almost invariably condemned by the Health Department, while many other classes of property are so stained as to be practically commercially valueless, and even where a salvage is made the extra cost of handling, cleaning, relabelling and packing caused by the mud makes a heavy additional loss.

Buildings, fixtures and furniture also suffer from the heavy deposit of what can only be described as putrid mud, which causes extra expense in cleaning and removal of debris.

It may also be pointed out that on several occasions deposits of mud and pebbles in the mains have clogged the hose and nozzles so that the Fire Department were delayed in their work with the natural results that the fire gained headway until this was remedied.

There is no question that the use of clean water in the high pressure service would much increase the salvage on all classes of property where it is used and in these times when the conservation of food products is of the greatest importance this might mean a heavy saving. Yours very truly,

PATERSON & WAUGH.

The Rock-Crushing Plant

Owned and operated by the G.W.W.D. Here is quarried trap rock, which is crushed and graded for incorporation in the concrete aggregate of certain sections of the Aqueduct. Rip-rap for all purposes is also obtained here.

Engineering Headquarters, Division No. 32

Typical of residences used by the G.W.W.D. for engineering staff, and in future to be occupied by patrol men.

A display of Vegetables, Grains and Grasses grown along the G.W.W.D. Railway line

CHAPTER V.

Financial

By agreement dated November 7th, 1913, the Bank of Montreal was appointed bankers and fiscal agents for the Greater Winnipeg Water District, for financing its undertaking during the period of construction.

The original scheme of financing for the water project was by the sale on the British market of inscribed stock, forty year term, bearing 4½ per cent. interest. A small amount of this long term stock was sold in the fall of 1914, prior to the war. The British market has been closed since the outbreak of the war, and our long term stock could not be sold. The Water District, on the advice of its fiscal agents, the Bank of Montreal, decided that the only available course was to issue short date debentures and sell them in the United States and Canada. This arrangement was of course necessitated by war conditions and will cause no additional obligation or expense to the Water District, except such as has been occasioned by war time financing.

Up to the present the District has issued securities as follows:

40-year stock sold in London before the war	$1,283,112.00
5-year 5% debentures sold in U.S. and Canada..	9,500,000.00
A total of	$10,782,112.00

Up to December 31st, 1917, the total amount expended for all purposes on the aqueduct project was $11,275,587.96. As previously stated, the estimated cost of the whole work (not including interest during construction nor the cost of lands for right-of-way) was $13,045,000.00 Notwithstanding unestimated and wholly unforeseen war conditions tending to increase the cost of the work, the actual construction will be completed very close to the original estimate and the only extra cost will be the extra cost of the land and the extra cost of money, borrowed on temporary debentures.

COST OF MONEY

The average cost of borrowed capital—funded and temporary—including all expenses, for the two years ended December 31st, 1915, was 5½ per cent. but for the next two years it had risen to slightly over 6 per cent. The average for the four years ended at December 31st last was a fraction under 6 per cent., but with present authorized and future anticipated borrowings at the prevailing higher rates, an increase in the average cost is inevitable.

SINKING FUND

The sum to pay interest and the sinking fund charges necessary to finally retire the debt will be levied in annual installments during a period of 36 years. *The tax will be on the land within the District and will be on an assessed value of the land only, excluding buildings and improvements. The assessment will be equalized by a board of experienced valuators appointed by the Public Utilities Commissioner.*

The sinking fund to redeem the outstanding debentures will be deposited in a chartered bank, to be designated by the Board, to be called "The Sinking Fund Account of the Greater Winnipeg Water District," and the same will be invested by three trustees, two of whom shall be appointed by the chief justice or any judge of the Court of King's Bench on application by the Board, and the third by the Board; from one of their number. Investments will be made in bonds, mortgages, or such other good safe securities as the trustees may think best.

The corporation is required by law to submit annually to the Public Utilities Commissioner and to each of th municipalities a statement of the affairs of the corporation.

Condensed Statement of Expenditures

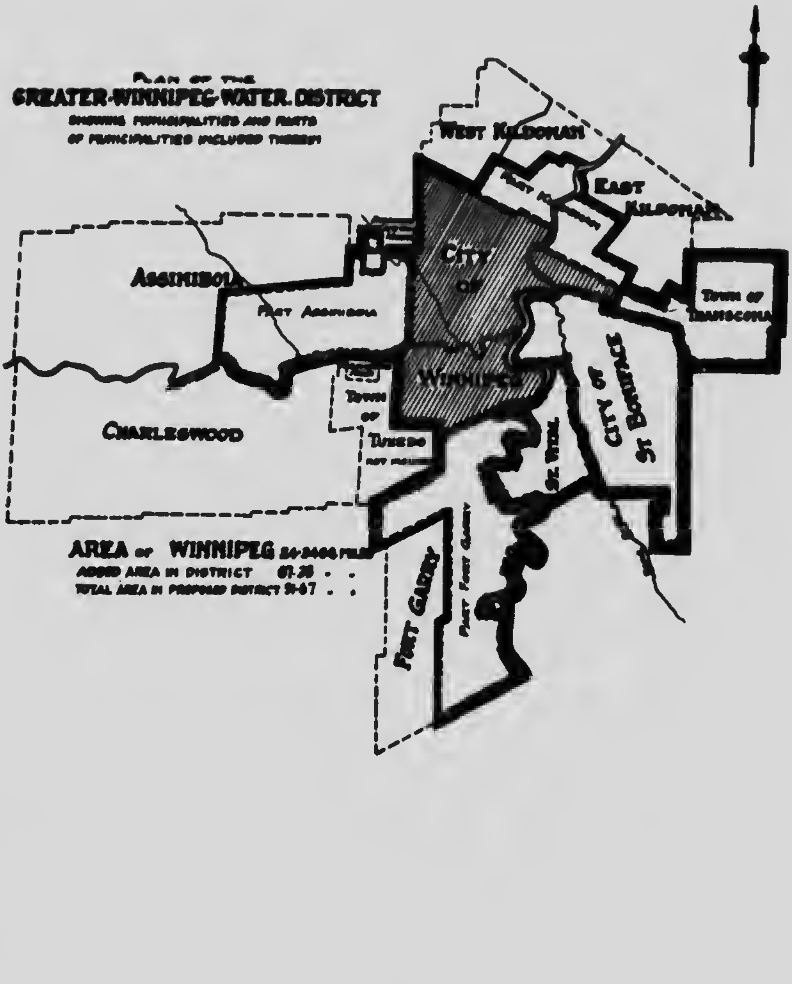
to December 31st. 1917

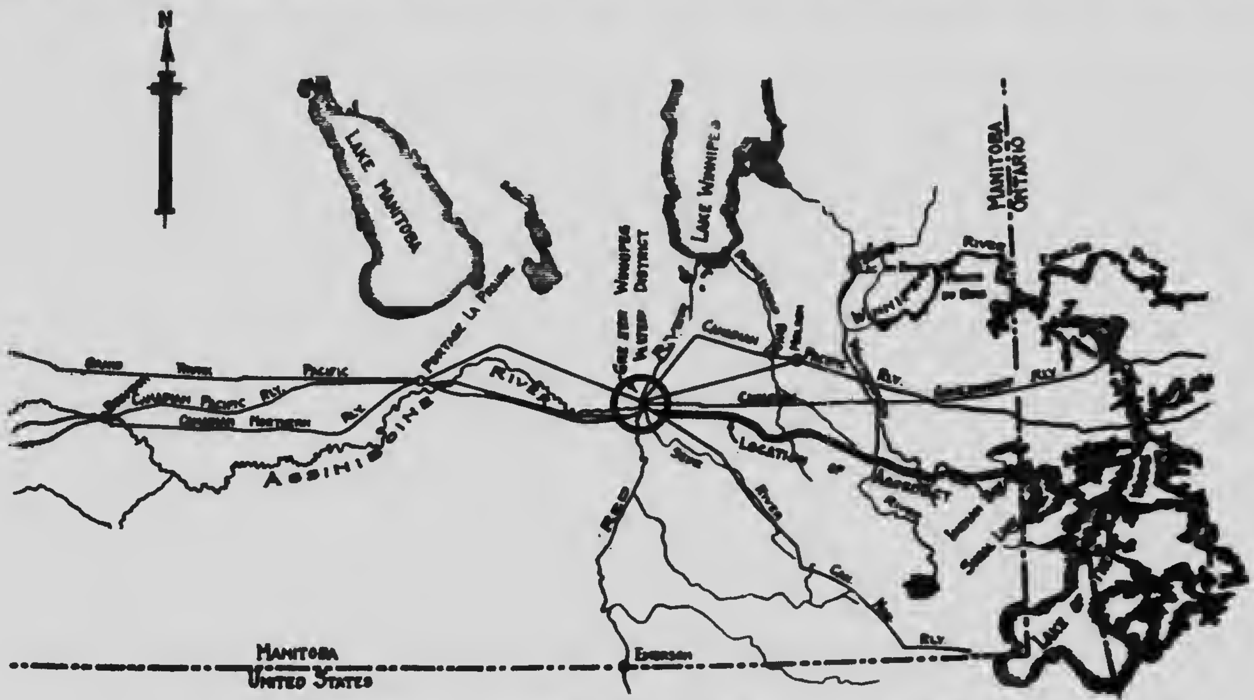
Aqueduct construction		$ 7,220,633.86
Falcon River Dyke and Diversion		143,302.62
Reinforced Concrete Pressure Pipe Line		791,206.40
Preliminary Expenditure on Future Construction—		
Intake	$ 2,182.85	
Red River Tunnel	6,669.05	
Concrete Mains, Red River to Reservoir	3,787.70	
		12,639.60
Constructional Railway	$ 1,430,961.25	
Constructional Railway Equipment	187,260.54	
		1,618,221.79
Constructional Telephone System		32,750.58
Screening Plant (Gravel Pit No. 1)		67,533.52
Government Pit (Gravel Pit No. 2)		4,596.69
Rock Crushing Plant		16,279.22
Buildings		81,283.44
Lands (for allocation in 1918)		12,547.06
Materials, Supplies and Equipment on hand		71,086.77
Charter and Organization Expenses		16,502.60
Field Organization and Preliminary Survey		99,069.43
Discount on Funded Debt and other Financial Charges		479,900.48
Colonization Expenditures		3,342.31
		$ 10,670,896.37
Less—		
Departmental Operating Accounts in Suspense—		
Constructional Railway Credit	$ 47,851.54	
Gravel Pit No. 1 Credit	9,443.85	
Gravel Pit No. 2 Credit	12,949.91	
Buildings Credit	7,752.50	
Cement Handling Credit	11,229.41	
	$ 89,227.21	
Rock Crushing Plant Debit	44,273.86	
		44,953.35
		$ 10,625,943.02

Liabilities

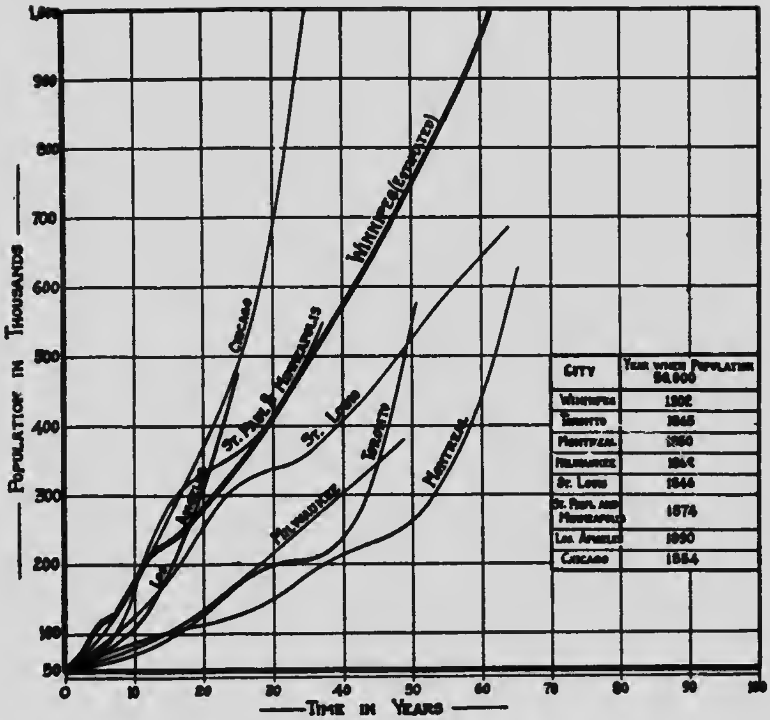
As at December 31st, 1917

4½% Inscribed Stock (£263,652 0s. 0d.)		$ 1,283,112.83	
5% Five-Year Debentures		7,500,000.00	
		$ 8,783,112.83	
Interest on above, accrued, not due		44,246.69	
			$ 8,827,359.52
Bank of Montreal—			
Bills Payable, secured by Treasury Bills		$ 840,000.00	
Overdraft		202,995.41	
			1,042,995.41
Sundry Creditors—			
Accounts Payable		$ 34,852.28	
December Payroll		10,689.98	
Contractors' Holdbacks	$596,838.48		
Contractors' Damages....	66,780.00		
		663,618.48	
			709,160.74
Contractors' Tender Deposits			30,090.00
Unpresented Interest Coupons			138,575.00
			$ 10,748,180.67
Deductions—			
Bank of Montreal, Coupon Account		$ 138,575.00	
Commissioners' Trust Fund		500.00	
Sundry Petty Cash Funds		320.00	
Sundry Accounts Receivable		7,842.65	
			147,237.65
Total Liabilities			$ 10,600,943.02
Item for Allocation—			
Winnipeg Aqueduct Construction Co. Bond Consideration (for allocation on Completion of Contracts 32-33-34)			25,000.00
			$ 10,625,943.02

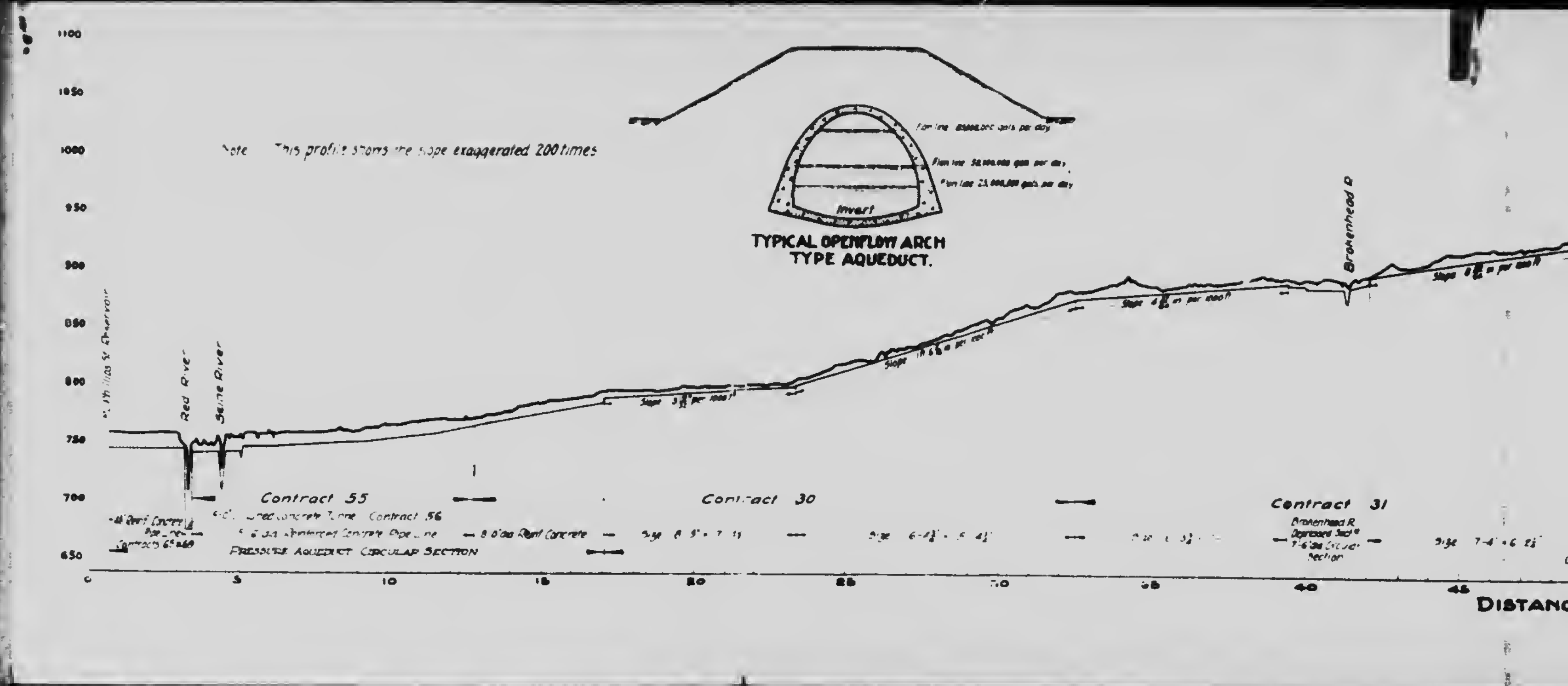

PLAN OF THE
GREATER WINNIPEG WATER DISTRICT
SHOWING MUNICIPALITIES AND PARTS
OF MUNICIPALITIES INCLUDED THEREIN
WEST KILDONAN
EAST KILDONAN
ASSINIBOIA
PART ASSINIBOIA
CITY OF WINNIPEG
TOWN OF TRANSCONA
CHARLESWOOD
TOWN OF TUXEDO
CITY OF ST BONIFACE
ST. VITAL
FORT GARRY
PART FORT GARRY
AREA OF WINNIPEG
ADDED AREA IN DISTRICT
TOTAL AREA IN PROPOSED DISTRICT



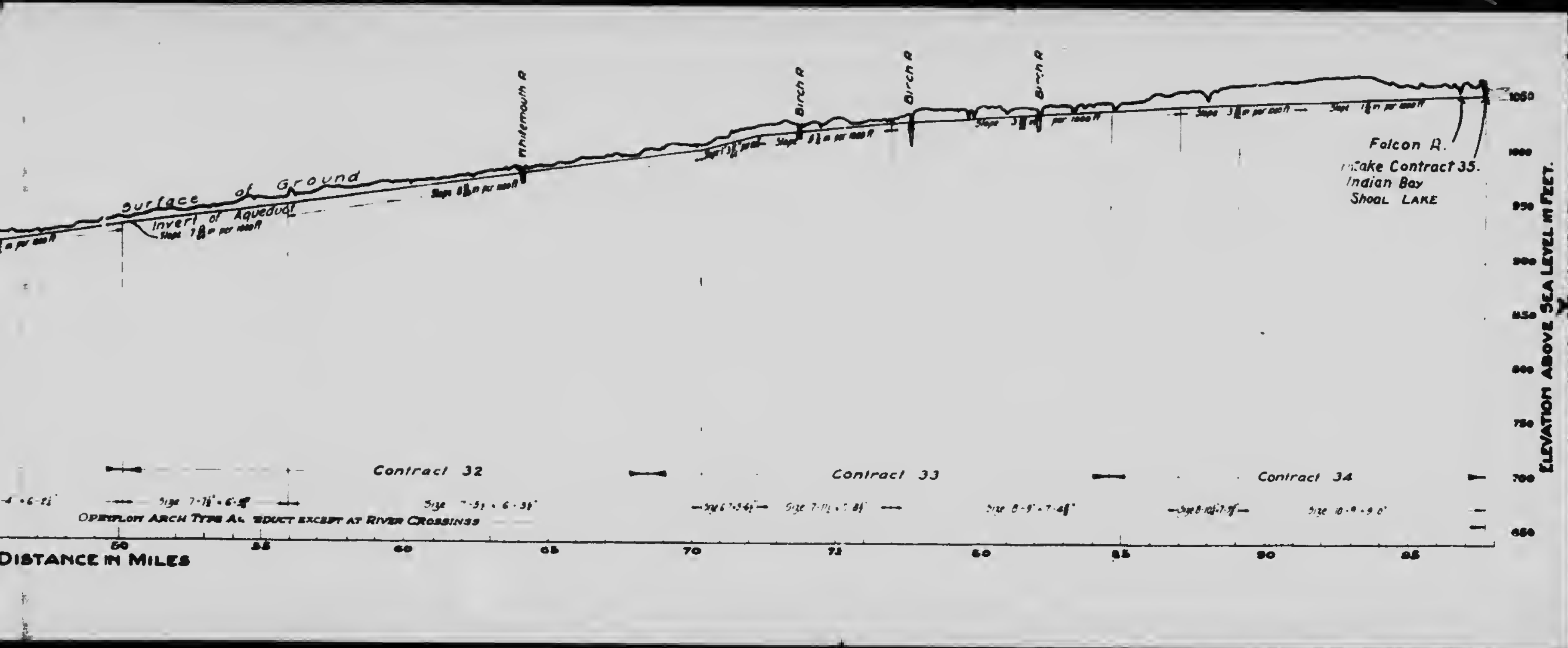
Map showing Location of Aqueduct



GROWTH IN POPULATION OF VARIOUS CITIES



1100
1050
1000
950
900
850
800
750
700
650
This profile shows the slope exaggerated 200 times
TYPICAL OPENFLOW ARCH
TYPE AQUEDUCT.
Invert
Red River
Seine River
Brokenhead R.
Contract 55
Contract 30
Contract 31
Contract 56
PRESSURE AQUEDUCT CIRCULAR SECTION
0
5
10
15
20
25
30
35
40
45
DISTANC



Surface of Ground
Invert of Aqueduct
Whitemouth R
Birch R
Birch R
Birch R
Falcon R.
Intake Contract 35.
Indian Bay
Shoal Lake
Contract 32
Contract 33
Contract 34
Overflow Arch Type Aqueduct except at River Crossings
Distance in Miles
Elevation above Sea Level in Feet.
1050
1000
950
900
850
800
750
700
650
50
55
60
65
70
75
80
85
90
95

GREATER · WINNIPEG · WATER · DISTRICT

1913