A STUDY OF THE WATER SUPPLY OF ST. JOSEPH, MICHIGAN

THESIS FOR THE DEGREE OF B. S.

J. Donaven Wells

1933

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A Study of the Water Supply

of

St. Joseph, Michigan

A Thesis Submitted to

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MICHIGAN STATE COLLEGE

of

AGRICULTURE AND APPLIED SCIENCE

By

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Candidate for the Degree of

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THESIS

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Preliminary Investigation:

Before the present pumping station and filtration plant was constructed, the city of St. Joseph, Michigan was rated as 7th class under the National Board of Fire Underwriters' Grading Schedule. The various gradings placed by that schedule previous to March, 1932, were as follows: Water Supply, 6th class; Fire Department, 7th class; Fire Alarm System, 9th class; Building Laws, 8th class; Hazards, 9th class; and Structural Conditions, 5th class; averaging 7th class protection.

The water supply of the city is obtained from Lake Michigan. The following figures prove conclusively that the raw water is polluted and needs purification:

"	Daily Av.	Daily Max.	Daily Min.	
Presumptive Bacillus Coli	543	827	286	
Confirmed Bacillus Coli	378	823	83	" 1.

Lake Michigan, near the shore line at this location, is, of course, always polluted to some extent. The cause of excessive pollution of the raw lake water is the location of the St. Joseph River which is approximately one mile north of the intake. On days when the lake currents carry the river water in the direction of the pumping station, the water is highly polluted and contains a high percentage of solids; the turbidity being raised in excess of that of the average day.

The former plant of the city was constructed in 1892 and, by the standards of that time, was well designed. The plant and equipment consisted of the following: a single 16" intake extending from a point 1500

1. Taken from Supt.'s annual report.

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feet off shore at a depth of 25 feet in Lake Michigan to a suction well at the shore. It is to be noted here that this same intake line is still used although an entirely new suction well, which will be discussed in detail later, has been constructed. Two steam pumps, each having a rated capacity of 1,500,000 g.p.d., drew the water from the suction well and discharged it into a 12" main. Two boilers, each 85 horse power, were used to supply the steam for the pumps and auxiliaries. A coarse screen in the suction well which served to keep fish and other aquatic life out of the distribution system was the only means by which the water was protected against dirt or foreign matter. A standpipe erected at a high point on State Street provided some small storage at a usable elevation.

In addition to the pumping equipment, a gas producer, gas engine, and generator produced sufficient electrical energy to take care of a portion of the street lights. The remainder of the lights were served by purchased current.

It was, of course, not to be expected that this thirty-eight-year old plant would be of sufficient size or proper design to meet present day requirements. Today the users of water expect, and have the right to expect, that water furnished them shall be clear, sparkling, and free from objectionable odors and tastes, and shall be furnished in whatever quantity they may demand and at an adequate pressure. Then, too, it is further required that the supply be adequate not only for domestic service, but for fire fighting purposes. From the standpoint of good business, the pumping equipment should be of efficient design so that the operating expenses may be kept a minimum.

The former plant fulfilled none of the requirements just stated. With no purification other than sterilization by means of Chlorine, the water was frequently dirty and at times carried so much sand and clay that it stopped up water meters. With the former size and arrangement of the pumping equipment, a rate of 4,000,000 g.p.d. was approximately the highest that could be maintained, and that supply proved insufficient at times, during the summer of 1929 to supply the demand for water except at a reduced pressure. Another thing to be considered here is the fact that there was no reserve available for fire fighting purposes during periods of maximum demand. Then, too, the cost of pumping was very high in comparison with modern plant costs.

In view of these facts, it was recommended to the city that it construct a new modern purification plant and pumping station.

In considering proposed improvements to any plant, it is necessary to make a forecast of what the future demands on the plant will be. In the case of a water plant this is done by estimating the growth in population and determining from past records what the per capita consumption of water has been under various conditions and then estimating the future consumption from these figures. Recognizing the fact that the population of St. Joseph is greatly increased in the summer months, the per capita consumption figures of the engineer's preliminary report were referred to the population shown by the census. This estimation follows:

" The growth of population since 1890 was as follows:

Year	Population	Percent Increase
1890	3733	
1900	5155	38.1
1910	5936	15.2
1920	7251	22.2
1930	8363	15.3

Assuming 18% increase per decade, or approximately the same rate of growth as in the last thirty years, it is estimated that the 1940 population would be 9868 and the 1950 population 11,644.

Water Consumption

Present: The water consumption for the past eight years as estimated from the revolution counters on the two steam pumps follows:

Year	Gallons
1922	352,883,417
1923	364,007,237
1924	376,181,208
1925	391,541,595
1926	362,805,641
1927	359,322,291
1928	379,144,645
1929	405,886,448

The actual pumpage is somewhat less than that shown, because of the pump slippage which occurs in all pumps of this type.

The per capita consumption, based on census populations and on assumed uniform growth from 1920-1930 follows:

Year	Assumed Population	May	June	July	Aug.	Sept.	Other 7 Mos.	Av. for Year
1922	7473	118	143	158	175	163	115	129
1923	7583	123	177	137	143	140	121	131
1924	7695	115	127	162	155	142	129	134
1925	7806	137	178	181	140	114	128	137
1926	7917	117	127	130	150	132	121	126
1927	8028	108	137	151	168	143	109	123
1928	8139	138	136	167	165	142	111	127

Year	Assumed Population	May	June	July	Aug.	Sept.	Other 7 Mos.	Av. for Year
1929	8250	126	142	175	188	155	119	135
Average		123	146	158	160	141	119	130 *1.

The maximum day's pumpage in the years 1929-1930 was 2,225,088 gallons on August 21, 1929, or a per capita consumption of 270 g.p.d. The maximum three days' pumpage during the two years was on July 17, 18, and 19, 1930, when a total of 6,264,684 gallons was pumped, or an average of 2,088,228 g.p.d. This is equivalent to a per capita consumption of 250 g.p.d. The maximum hourly pumpage was at the rate of 4,000,000 g.p.d., or a per capita rate of 478 g.p.d.

While these rates seem high in comparison with per capita rates in general, it must be remembered that the census population has been used rather than the actual population at the times of consumption.

" Future: Based on the foregoing figures, the estimated future consumption for 1940 and 1950 follows:

Av. Daily Cons.	1940	1950
May (123)	1,213,764	1,432,212
June (146)	1,440,728	1,700,024
July (158)	1,559,144	1,839,752
Aug. (160)	1,578,880	1,863,040
Sept. (141)	1,391,388	1,641,804
Other 7 Mos. (119)	1,174,292	1,385,636
Entire Yr. (130)	1,282,840	1,515,720
Max. Daily (270)	2,664,360	3,143,880

1. From report by Gordon and Bulot, Chicago.

Av. Daily Cons.	1940	1950
Av. Max. 3 Days (250)	2,467,000	2,911,000
Max. Hourly	4,716,900	5,565,832 "[1].

The National Board of Fire Underwriters has compiled and uses a standard grading schedule for determining the classification of cities and towns for insurance rate purposes. For a city of 10,000 population, the standard grading schedule requires an available fire flow of 3,000 g.p.m. for a period of ten (10) hours. This is in addition to the domestic consumption which is assumed to be equivalent to that of the maximum day. The Michigan Inspection Bureau follows the grading of the National Board of Fire Underwriters in recommending a fire flow of 3,000 g.p.m. and in their 1930 report on St. Joseph, recommended the construction of a filter plant having a capacity of at least 4,000,000 g.p.d.

The only storage available in the old plant was that afforded by the standpipe. This has a total nominal capacity of 132,190 gallons. However, only that portion of the water which is stored in the upper part of the standpipe is at a sufficient elevation to provide adequate pressures. Because of this fact, the National Board of Fire Underwriters' grading schedule considers only the storage in the top 25ft. of a standpipe is available. In the case of St. Joseph, this is equivalent to 33,050 gallons. During the winter months, however, even this amount may be reduced by the formation of ice within the standpipe and the difficulty of carrying the standpipe full.

In arriving at the storage requirements, it is desirable to consider the needs of future years in order that a plant constructed at the

1. Ibid.

present time will not be outgrown within a period of a few years. The engineers, therefore, in their preliminary survey, considered what storage will be necessary to serve the city for a period of at least 20 years. Their estimation and recommendation follow:

"

	Gallons
Estimated Max. Daily Cons. (1950)	3,143,880
Req'd. Fire Flow 10 hr. per. @ 3,000 g.p.m.	1,800,000
Total Quantity Required	4,943,880
Filter Plant Capacity	4,000,000
Total Storage Req'd.	943,880
Storage Available @ Adequate Press	33,050
Additional Storage Req'd.	910,830

We would recommend that additional storage of 1,000,000 gallons be provided by the construction of a reinforced concrete covered reservoir at the pumping station." 1.

Many years ago filtration became the standard method of treating water for the removal of turbidity and the production of a water of a high sanitary quality. The process consists of adding chemicals to the water which, upon agitation, will produce a floc, then passing the water through a sedimentation basin, where the greater part of the suspended matter is carried to the bottom by the floc which has been formed, and then allowing the water to flow downward through the sand filter bed and into a storage reservoir. It is then ready to be pumped to the distribution system. When a filter becomes clogged so that it will no longer operate

1. Ibid.

at its rated capacity, it is washed by forcing water into the underdrainage system under pressure and up through the gravel and sand bed. The dirty water is carried off by washwater troughs placed with their tops some distance above the sand.

Several chemicals can be used in the treatment of water to produce a floc, but aluminum sulphate or lime and iron are the most commonly employed. Practically all of the plants treating Lake Michigan water use aluminum sulphate.

The filter beds ordinarily consist of a system of underdrain piping with a graded layer of gravel placed above the piping and above this a layer of filter sand which serves as the filtering medium. Rectangular concrete tanks are usually used for the filter units.

The process of washing in a well designed and well operated plant should not be needed oftener than once in every 24 hours, although microscopic plant organisms may cut down this period materially at times. The length of time required for washing will ordinarily vary from two to five minutes and the quantity of wash water should not exceed five per-cent of the total amount of water filtered, and many plants operate on as little as two percent.

Lake Michigan water is comparatively soft, the total hardness being about 130 p. p. m. There is little necessity, therefore, for softening the water. The turbidity varies greatly throughout the year, but the average turbidity will run around 10 p. p. m.

The engineer's estimated initial cost and operating cost and recommendations for a pumping station and filtration plant for St. Joseph follow:

" The estimate of cost of the proposed pumping station and filtration plant has been made from preliminary plans prepared after a study of local conditions. The best location for the plant was determined from a consideration of the topography, and a site was selected to the north of the present station. " [1]

Plate 1 is a plan showing the present location with respect to the old location. This location is well adapted to the topography and permits extension room.

" The pumping equipment would include three low service pumps (motor-driven centrifugals) of one, two, and three m.g.p.d. capacity respectively, two high service motor-driven centrifugals having a capacity of one and two m.g.p.d.; and two motor-driven centrifugals for fire service, having a capacity of one and seven-tenths and three m.g.p.d. respectively. One of the motor-driven pumps for fire service would also be provided with a gasoline engine so that it could be operated in case of complete failure of power. In addition to these pumps a pump would be provided to supply washwater for the filters. " [2]

The low service pumps are used to lift water from the suction well to the mixing tanks where the chemicals are added. The water flows from this point through the coagulation basins and filters by gravity. From the clear water reservoir it is pumped into the distribution system with the high service pumps. The fire pumps are used when it is desired to raise the pressure on the distribution system, or they may be used to supplement the high service pumps if required. Likewise, the high service pumps may

1. From report by Gordon and Bulot, Chicago

2. Ibid.

be used to supplement the fire pumps. Because of the nature of the operating characteristics of a motor- driven centrifugal, the capacities of the high service pumps when used to pump water at fire pressures would be materially reduced.

"   The following is an estimate of the cost of the improvements recommended:

Buildings and Structures		
Building, inc. heating, lighting and plumbing		$61,360
1,000,000 gal. Clear water Reservoir		20,500
Coagulation basin		18,000
Equipment		
Filter Equipment.		
Underdrains, washwater troughs		
Sand and gravel	5,200	
Operating tables	4,100	
Rate of Flow Controllers	1,620	10,920
Pumping Equipment		15,424
Switchboard, Transformers, etc.		8,700
Dry Feed Machines		1,050
Meters and Gauges		1,000
Aerating and Mixing Equipment		4,500
Valves and Piping		
Within Building	13,500	
Outside	3,760	17,260
Total		158,714

	158,714
Add 10% for Engineering and Contingencies	15,871
Total	$174,585 [1]

The above estimate did not include the cost of changing over the Edgewater and downtown circuits, so that current may be supplied them from the pumping station. The cost of this change was estimated by the City Engineer to be about $2,500.00.

[1] The estimated cost of operation of the proposed plant, using the 1929 figures on Water Consumption and power required for street lighting is as follows:

Cost of Power		
Estimated K.W.H. req'd. per m.g. pumped	955	
Total Pumpage (1929)	405,886,000 gal.	
Pumping K.W.H.	387,621	
Street Lighting K.W.H.	295,200	
Total K.W.H.	682,821	
682,821 K.W.H. @ 1.5¢		10,242
Labor:		
Chief Engineer	1920	
Ass't. Engineers	4680	6,600
Chemicals		
Alum	610	
Chlorine	100	710
Oil and Waste		50
Miscellaneous		300

1. Ibid.

Maintenance and Repairs

Machinery and Equipment	$58,854 @ 1%	$588		
Building	$61,360 @ .5%	307		895
Total Operating Expense				$18,797

" The actual cost of operation of the old plant for 1929 was as follows:

Light Dept. & Water Works			
Labor		$1565.75	
Materials			
Coal	$1,158.64		
Freight	1,240.87		
Unloading Coal	225.60		
Oil and Grease	285.16		
Repairs	284.11		
Incidentals	43.56	3,237.94	
Current Purchased		4,508.54	$9,312.23
Water Dept.			
Labor (Operation and Repairs)		$5,330.05	
Supplies			
Coal	$2,030.98		
Freight	3,615.87		
Unloading Coal	1,060.58		
Chlorine	167.28		
Oil and Grease	198.68		
Pump and Boiler Repairs	492.49		
Miscellaneous	460.64	$8,032.52	13,362.57
Total			22,674.80

" From the above comparison it will be noted that the estimated saving in operating expenses for one year of the proposed new plant over the existing plant, based on the 1929 pumpage and street lighting load, is in excess of $3,800.00.

Charges for interest and depreciation on the proposed plant are estimated as follows:

	Int.	Dep'n.	Total	Amount
Machinery and Equip.				
$58,854	5%	2.4%	7.4%	$4,355
Buildings and Structures				
$99,860	5%	0.8%	5.8%	$5,792
Eng. and Contingencies				
$15,871	5%	0.8%	5.8%	$ 921
Total				$11,068

The total operating expenses and fixed charges for the proposed new plant would therefore be:

Operating Exp.	$18,797
Fixed Charges	11,068
	$29,865

This is only $7,190 more than the charge for operating expenses alone of the existing plant for the year 1929. This difference represents an increased cost of $17.71 per 1,000,000 gallons assuming the 1929 pumpage, or less than 1.8¢ per 1,000 gallons.

" Conclusions and Recommendations

1. The existing pumping station is inadequate and incapable of furnishing water of a satisfactory quality.

2. The capacity of the intake under existing conditions is not

sufficient to take care of the maximum demands for water during periods of high consumption.

3. The boilers and pumping equipment are 38 years old and are expensive to operate and maintain.

4. No reserve is available for fire fighting purposes during periods of high consumption.

5. A new pumping station and filtration plant having a capacity of 4,000,000 gallons per day should be constructed.

6. This new plant and all street lights should be operated with purchased current.

7. The cost of operation of the new plant, including filtration and the cost of street lighting, will be at least $3,800.00 per year less than under the existing method of operation.

8. The estimated cost of the proposed plant is $175,000.

9. Charges for interest and depreciation on the new plant will add less than 1.8¢ per 1,000 gallons to the present cost of pumping water." [1]

1. From report by Gordon and Bulot, Chicago

Intake and Suction Well:

As previously stated, the old intake is still in use and is primarily the same as before the construction of the new plant. It consists of a 16" pipe, so constructed as to form an inverted U, that runs from the shore line to a point 1500' out in Lake Michigan. The pipe is held in place at the intake end by a wooden crib filled with broken rock. The crib is built up on piles and thoroughly anchored to the spot. The only change is that a 20" x 16" reducer was installed near the location of the old suction well and a 20" line continues from this point to the new suction well which is located in the southwest corner of the pumping station.

The suction well consists of a circular shaft 10' inside diameter which extends downward 32.58'. At elevation 585 there is a floor and above the floor the well is rectangular in cross-section. The circular portion of the suction well was constructed prior to the construction of the pumping station building or of the low lift pump pit.

The low lift pump pit, also circular in design, houses the pumps required to place the water at the necessary elevation for adding the coagulent and settling. This pit has an inside diameter of 20' and was constructed in a similar manner to the suction well. However, well points and pumping equipment were installed inside the pit to hold the ground water level below the bottom of the pit while the concrete floor was placed. While this water level was being maintained, the 16" suction was installed between the low lift pump pit and the suction well, and was concreted in place. The opening in the wall of the low lift pump for the suction pipe has a copper strip set in concrete which provides a water-tight joint between the wall of the pit and the concrete placed around the pipe. The low lift pump pit is used for housing the following pumping equipment:

Pump	H.P. of Motor	Type of Motor
1-Low Service	10	Squirrel Cage
1-" "	20	" "
1-" "	25	" "

Mixing Chambers:

The mixing chambers, two in number, are octogonal in outline and are fed from a triangular chamber thru 16" sluice gates. When the water is pumped from the low lift pump pit, it passes into a triangular chamber, which is directly connected to the mixing chambers, where the chemicals are added and from this chamber the water may be fed to either or both of the mixing chambers thru two sluice gates. At this stage the water is stirred by two motor driven coagulent mixers which consist of vertical paddles attached to a central vertical shaft, which is guided at the bottom by a line guide bearing supported above the drain opening at the center of the tank. The shaft is supported from a steel base plate by means of ball thrust bearings, and is driven by a 3-phase, 60-cycle, 440-volt motor of the variable speed.type directly connected to a vertical worm gear speed reducer. Each coagulent mixer is capable of imparting horizontal velocities to the water of from 1½' per second to 3' per second.

After mixing, the water flows over a weir and into the sedimentation basins. The water is passed through these basins, also two in number, by means of gravity alone and tests have shown that the required time for the water to pass thru is approximately five hours. The tanks are horse-shoe in shape and have a vertical baffle passing down thru the center around which the water must circle before leaving the chamber. The two tanks may be run in parallel or in series. However, it is very seldom necessary to run the water thru both tanks before allowing it to go to the filters as the water of Lake Michigan is not of such a turbidity to demand it. Upon leaving the chambers, the water again passes over a weir into the opposite ends of a trough and from this trough is fed to the filters.

Filters and Equipment:

The filtration equipment of the water supply system of St. Joseph consists of four filter tanks each having a capacity of one and a half million gallons per day with a total overload capacity of about seven and a half million gallons per day.

The filter underdrainage system consists of a concrete box channel on the center line of each filter and located immediately below the filter floor, together with pipe manifolds, each consisting of a cast iron vertical nipple embedded in the concrete forming the top of the box channel previously referred to. This box channel, with the exception of the slab forming its top, was poured at the same time that the floor of the filters was poured. After the concrete had set up, the inside forms were removed from the sides of the box channel, and the slab which forms the top was poured. However, before pouring the slab, the cast iron tee, laterals, and the short length of cast iron pipe which is embedded in the concrete were made up and set in their final positions. The cast iron pipe has an inside diameter of 3" and, according to specifications, may not have a wall thickness of less than ½". These pipes were reamed to remove all burrs. Each lateral pipe is drilled with 3/8" holes, in the bottom, staggered on two gauge lines 60 degrees apart and having a pitch of 5". The end of each lateral adjacent to the wall of the filter is closed with a cast iron disk, welded to the pipe so as to make a water tight joint. All the pipes and castings of the underdrainage system were coated on the inside and out with coal tar pitch varnish. According to the job specifications, this coating was required to fulfill the specifications of the American Water Works Association for coating standard cast iron water pipe. The cast iron laterals were screwed into the tees using white lead. The laterals are supported at the proper elevation by a small block of concrete as shown in the accompanying drawing (Plate lVa).

Following are the job specifications for the filter gravel: " All gravel shall consist of hard rounded pebbles with high specific gravity, free from sand, loam, clay, dirt, and organic impurities, and from splinters and flat pieces. It shall be durable and of such a nature that when digested for 24 hours with warm, strong hydrochloric acid, at least 95% shall remain insoluble. "

The gravel was screened and placed in the filter tanks in four separate layers. The following table gives the grading of the gravel and the depths of the layers in the order in which they were placed:

Layer No.	Thickness Inches	Passing Screen Size	Retained on Screen Size
1	8	2"	1"
2	6	1"	½"
3	4	½"	3/16"
4	3	3/16"	10-mesh

The gravel was deposited in the filter tank very carefully, the first layer being placed by hand around the laterals of the underdrainage system and so as not to cover or partially cover the perforations in the pipes. After the gravel was placed, it was carefully protected from any disturbance until the filter sand was placed over it.

The job specifications for the filter sand were as follows:
" Filter sand shall be free from clay, loam, dust or organic matter, and

flat or laminated particles. Special care shall be taken in handling and transporting the sand to prevent contamination of any sort, and sand which may be found dirty or contaminated by organic matter will be rejected. The sand shall be composed of hard, durable grains which will not disintegrate, and shall contain not less than 95% silica calculated as $Si\ O_2$. When a sample of sand, crushed and powdered, is digested for 24 hours in strong, warm hydrochloric acid at least 95% shall remain insoluble. The sand shall not contain more than 1½% calcium and magnesium taken together and calculated as calcium carbonate ($Ca\ CO_3$). Not more than 2% of the powdered sand shall be lost on ignition. The sand shall have an effective size of preferably forty-five hundredths of a millimeter, but not less than forty-three or more than forty-eight hundredths of a millimeter and a uniformity coefficient of not more than one and five-tenths. "

The sand bed as placed is 27" thick and was placed in the filter tanks with great care to avoid any disturbance of the filter gravel.

The wash water troughs, semicircular in cross-section with a 10" radius, are placed with their edges 27" above the top of the filter sand or a height of 6'-6" above the floor of the filter tank. These are so constructed that they all drain into a common channel at the back of the filters. There are three wash water troughs for each filter with a distance of 5'-3" between their centers. Each of the troughs is supported in place by vertical rods from the cross walk above the filters and by bolts projecting thru sleeves set in the baffle wall.

Each filter is equipped with a filter effluent rate of flow controller. The controllers are actuated by means of a venturi tube. The normal rating of each controller is one and a half million gallons per day, but the controllers are adjustable and permit flows varying as much as 25% either above or below normal. The accuracy of regulation is within

4% of the indicated setting when delivering with the water in the reservoir up to Elevation 592.0. The controllers are so arranged that when the head of water in the reservoir rises above Elevation 592.0, the rate of flow is gradually diminished until Elevation 594.0 is reached, when the flow is practically stopped.

All of the water supply and drain piping for the operation of the hydraulic valves is of genuine wrought iron with malleable screwed fittings. Each filter is equipped with a rate of flow gauge and an indicating loss of head gauge. Each of the rate of flow gauges is so constructed that it is connected with the venturi meter of the rate controller. The gauges are graduated from 0 to 15 mg / 24 hrs. The control wires are enclosed in small sized pipe. The loss of head gauges are graduated from 0 to 12 feet. These gauges are actuated by the difference in pressure head of the water above the sand in the filter and the water in the lateral effluent line between the effluent gate valves and the rate controller.

Clear Wells and Reservoir:

Underneath the filters are two clear wells, one of which is under three of the filters and the other of which is under the remaining filter. The concrete floors of the two clear wells were poured without construction joints. However, stub bars and a 20 gauge copper strip 6" wide were placed at the construction joint between the floor and the walls before the pouring of the floor slab. The outside walls of the two clear wells, and the interior wall that separates them, were also poured without any construction joints. The two inlets to the clear wells and the filtered water conduits were poured at the same time the walls were poured.

The inlets to the clear wells are provided with tight covers. The inlet under the three filters has a steel frame and cover while the inlet to the clear well under the one filter has a wood frame and a plate glass cover.

From the clear wells below the filters the water passes thru a filtered water channel into the million gallon reservoir which is at the same elevation as the clear wells so that the water in the two will be at the same level. The construction of the reservoir was carried out in much the same manner as the clear wells; the floor slab was poured first, using a minimum number of construction joints. The vertical steel for the side walls and a form for the construction joint at the wall were set in place before the slab was poured. In this case as in the other, a 20 gauge copper strip 6" wide was placed vertically on the center line of the wall to insure a water proof joint. This strip was so placed that half of it was embedded in the slab and half in the wall. A similar copper strip was used at all construction joints in the floor slab, roof and walls. The walls were poured with two construction joints made in the following manner: The joints are a stepped type of joint, consisting of a vertical joint from the roof to a point 5' below the under side of the roof, then a horizontal joint for a distance of 10', and then a vertical joint from this point to the floor. The wall between these construction joints was poured continuously from footing to roof. The floor of the valve vault was poured at the same time that the wall footing forming part of it was poured. The walls of the valve vault were poured continuously with the pouring of the side wall of the reservoir.

The pipe connections in the reservoir consist of a 16" inlet connection, a 16" outlet connection, a 12" overflow, and an 8" drain. The drain consists of an 8" flanged and spigot pipe, inserted in the sleeve in the wall of the reservoir, and an 8" gate valve.

Miscellaneous Equipment:

Other equipment in the plant consists of a washwater meter, a 1" automatic water jet eductor, chemical feed machines, an oil burner for heating, and an exhaust fan in the chlorine room.

The washwater meter is of the electrically operated type, and consists of a flow nozzle, a sending element, and two indicating gauges, and one recording and one integrating gauge. The orifice nozzle is located in the vertical run of the 16" discharge from the washwater pump at a point 18" below the flange of the 16"-90° ell. The sending element is located immediately back of the nearest column in the pipe gallery. The two indicating gauges are of the flush type and are mounted on the two washwater control panels. The recording gauge and the integrating gauge are mounted on the gauge board located on the Pump Room floor. Each indicating gauge has graduations ranging from 0 to 30, and are so calibrated that the 30 graduation represents a delivery of 7,854 g.p.m. thru the meter nozzle and the other graduations represent proportional amounts. The ordinary flow thru the meter is approximately 5,250 g.p.m.

A 1" automatic water jet eductor is located in the sump in the Low Lift Pump Pit. This eductor has a suction capacity of 500 gallons per hour and is provided with a ball float which operates the pressure water connection to the eductor. It is also provided with a foot valve strainer.

There are two chemical feed machines in the plant, each of which has a range of feed in pounds per 24 hrs. of 50 to 2,000. The machines are complete with scales and are arranged with a water connection and with discharge connections which convey the solution from each machine to the following points: The 16" inlet to the triangular chamber between the mixing chambers and each 16" sluice gate leading to each mixing tank. These connections are so arranged that each location may be fed directly from either machine by changing pipe connections at the machine itself. A 1-½" copper pipe is used for conveying the chemical solution to the points designated. The capacity of the hopper of each machine is 3.5 cubic feet. Each machine is furnished with a single phase, 60 cycle, 110 volt motor, with the switch mounted on the machine.

The oil burner used for heating the plant has a continuous electrical ignition while the oil is being sprayed into the fire box and is positively controlled in its operation so that if anything occurs to affect the safe operation of the burner, it will automatically stop and not operate until started manually. The oil pump is directly connected to the motor and is of sufficient capacity to supply oil of any gravity between Baume' 25° and 45° for the full capacity and lifts the oil directly from the underground tank without auxiliary equipment. The oil used, however, is as heavy as will flow without heating either the flow lines or the storage tank. The storage tank is one of 2,000 U.S. gallons capacity and is made of open hearth steel with all seams welded and caulked. The entire tank is buried about 2'-0" below the regular grade. The entire oil burner system is automatically controlled to meet the following emergencies and conditions:

1. Failure of power supply.
2. Short circuiting or ignition failure.
3. Excessive motor current.
4. Lack of oil in tank.
5. Excessive water in tank.
6. Stoppage in oil lines.

7. Failure of combustion.

The exhaust fan in the Chlorine Room has a 12" blade and is so designed as to deliver approximately 1,400 cubic feet of air per minute. The fan is installed back of a grille and the motor is of the totally enclosed type.

Conclusion:

During the first ten months of operation of the new plant, a total of 256,434,500 gallons was pumped, giving a daily average of 844,500 gallons. A total of 264,325,340 gallons of water was filtered during this period, of which 10,612,900 gallons were used for washing the filters. The washwater expressed as a percent of the total amount filtered gives a monthly average of 3.69%, a monthly maximum of 6.07%, and a monthly minimum of 1.0%. The monthly average chemical application to the raw water was as follows: Alum, 1.10 grains per gallon; Ammonia, .14 p.p.m.; Chlorine to raw water, .39 p.p.m.; Chlorine to filtered water, .33 p.p.m. The high service discharge after treatment showed a B-Coli count of 0.0 and a residual chlorine of .17 p.p.m.

The total cost of plant operation for this same period was $10,765.08 or a daily average of $35.19. This is equivalent to a cost of $41.81 per m.g. pumped as compared with a cost of $55.90 per m.g. in the old plant and the estimated cost of $46.30 per m.g. that was given in the engineer's preliminary report. There are, however, two elements that enter into the difference in the estimated cost and the actual pumpage cost in the new plant. The estimated cost was based on the 1929 pumpage which was much greater for the same period of time than the 1932 pumpage. On the other hand, the engineer's estimate was based on a plant having a capacity of 4,000,000 g.p.d., while the existing plant has a capacity of 6,000,000 g.p.d.

The number of organisms in water is known as the "bacterial count", and is the actual number of organisms present in a small amount of water tested. Beginning with the raw water, analyses are made wherever a change is induced in the water, either by chemical application or by physical operation. The percentage of bacteria reduction from the raw to the finished product is one index of the purification efficiency of the plant. As shown under laboratory analysis, the monthly bacterial count of the raw water was 32 organisms per 1c.c., and the average bacterial count on the finished water was 2.2 per 1c.c. This is a 93.7% reduction. Besides the constant endeavor to reduce the number of bacterial organisms present in the water, special attention is given to analysis for the purpose of determining the presence of the "bacillus coli", more commonly known as "B-Coli". The number of B-Coli organisms in 100c.c. of water is referred to as the "B-Coli" index. This index furnishes a method of rapid comparison of water. Comparing the St. Joseph index number with those listed in the State Department of Health report, one finds that the St. Joseph supply ranks with the best of those using surface water supply; also, the finished water "B-Coli" index, which was zero (100% reduction), ranks at the head of the list with four other plants in the state of Michigan.

The new plant has improved the water supply in a good many ways, but chief among these are the following: 1. The doing away, to a great extent, with the chlorine taste in the water. Before the new plant was built, sterilization by chlorination was the only means of purification and consequently the water generally had a very high amount of residual chlorine and at practically all times had a disagreeable taste; 2. The addition of a filtration plant which eliminates the turbidity of the water and gives a water which is clear, sparkling, and free from any foreign matters, odors, or tastes; 3. The reduction in operating cost of the plant; 4. The addition of extra storage space by the building of a million gallon reservoir to supply the city in the event of a breakdown of the plant; and 5. The capacity to supply the maximum domestic and fire fighting demand at an adequate pressure.

[redacted]

6 Plates

POCKET CONTAINS:

PLATE I - GENERAL LAYOUT

" II - DETAIL OF SUCTION WELL

" III - SEDIMENTATION BASINS

" IV - SECTION THRU FILTER

" IVa - " " "

" V - RESERVOIR

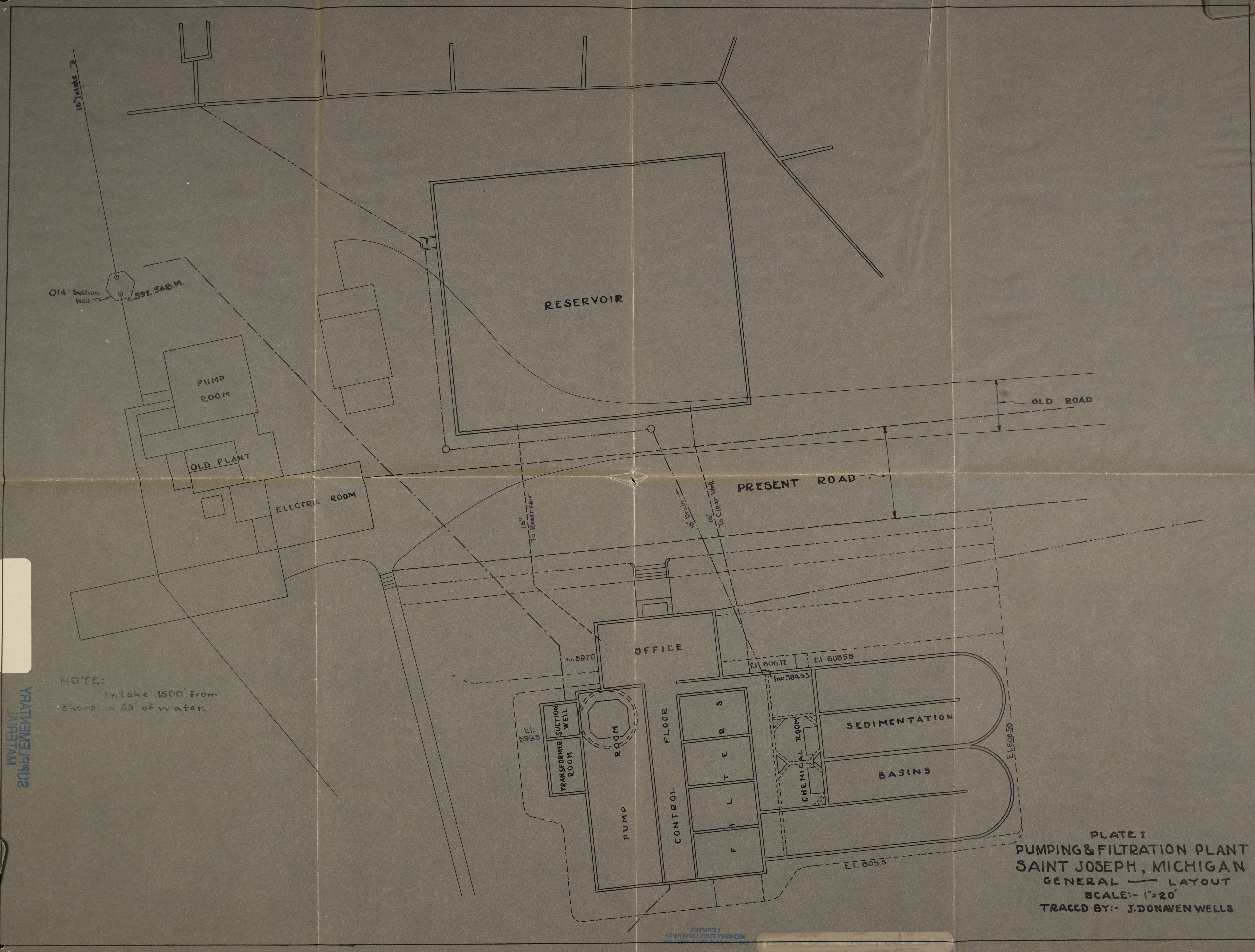


PLATE I
PUMPING & FILTRATION PLANT
SAINT JOSEPH, MICHIGAN
GENERAL — LAYOUT
SCALE:- 1" = 20'
TRACED BY:- J. DONAVEN WELLS

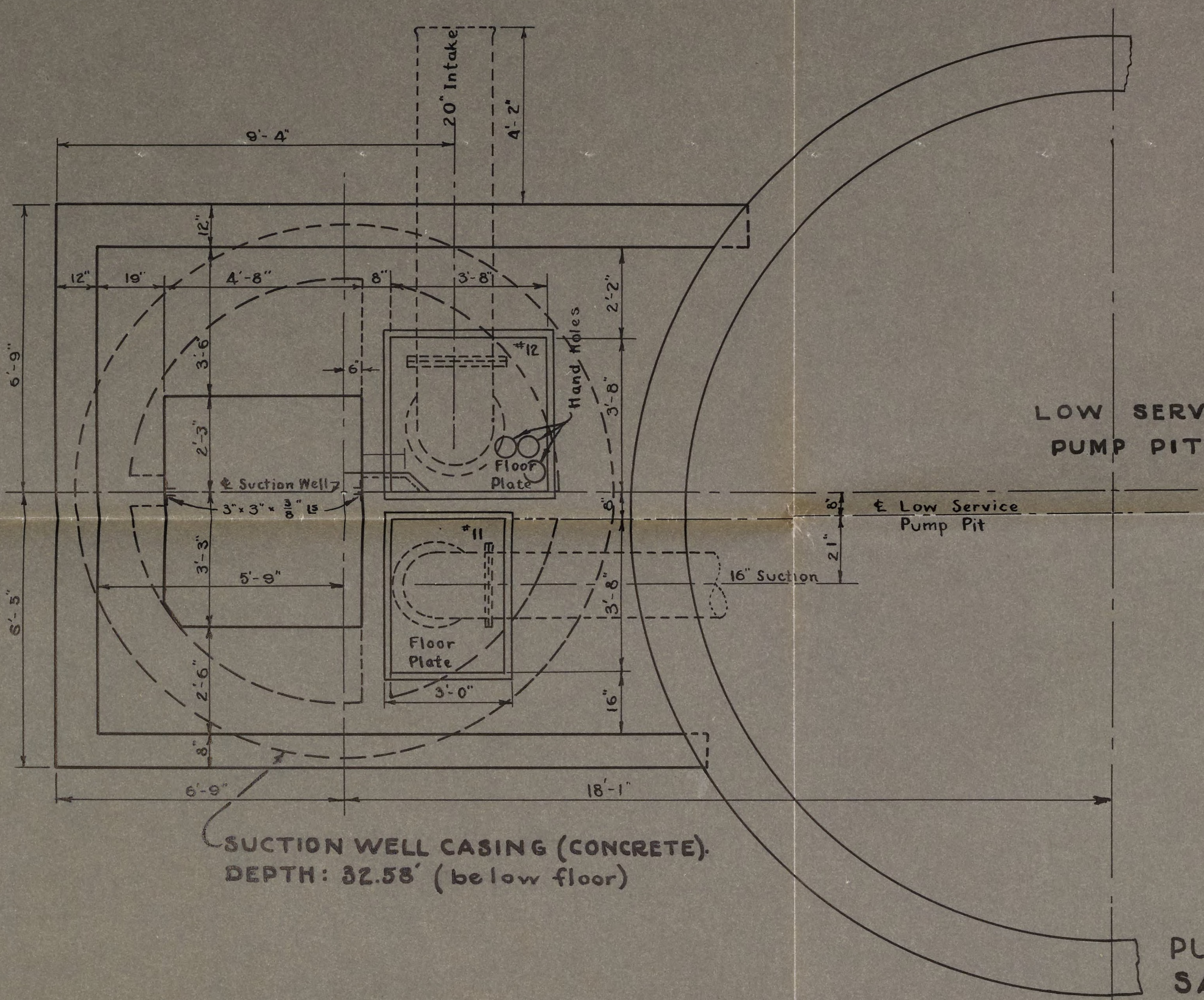


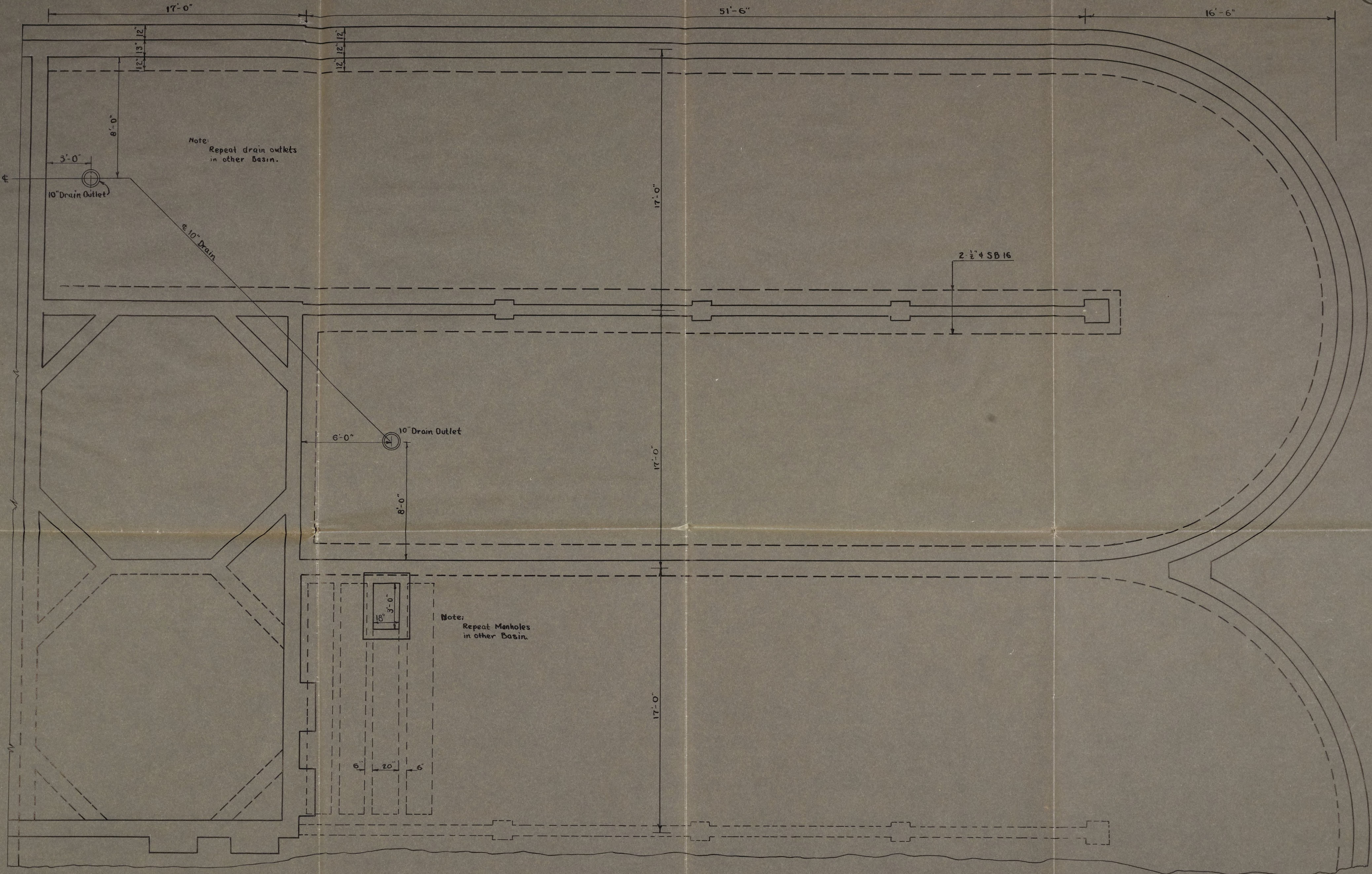
PLATE II

PUMPING & FILTRATION PLANT SAINT JOSEPH, MICHIGAN

DETAIL OF SUCTION WELL

SCALE: 3/8" = 1'-0"

TRACED BY — J. DONAVEN WELLS



GENERAL LAYOUT.

PLATE III

PUMPING & FILTRATION PLANT

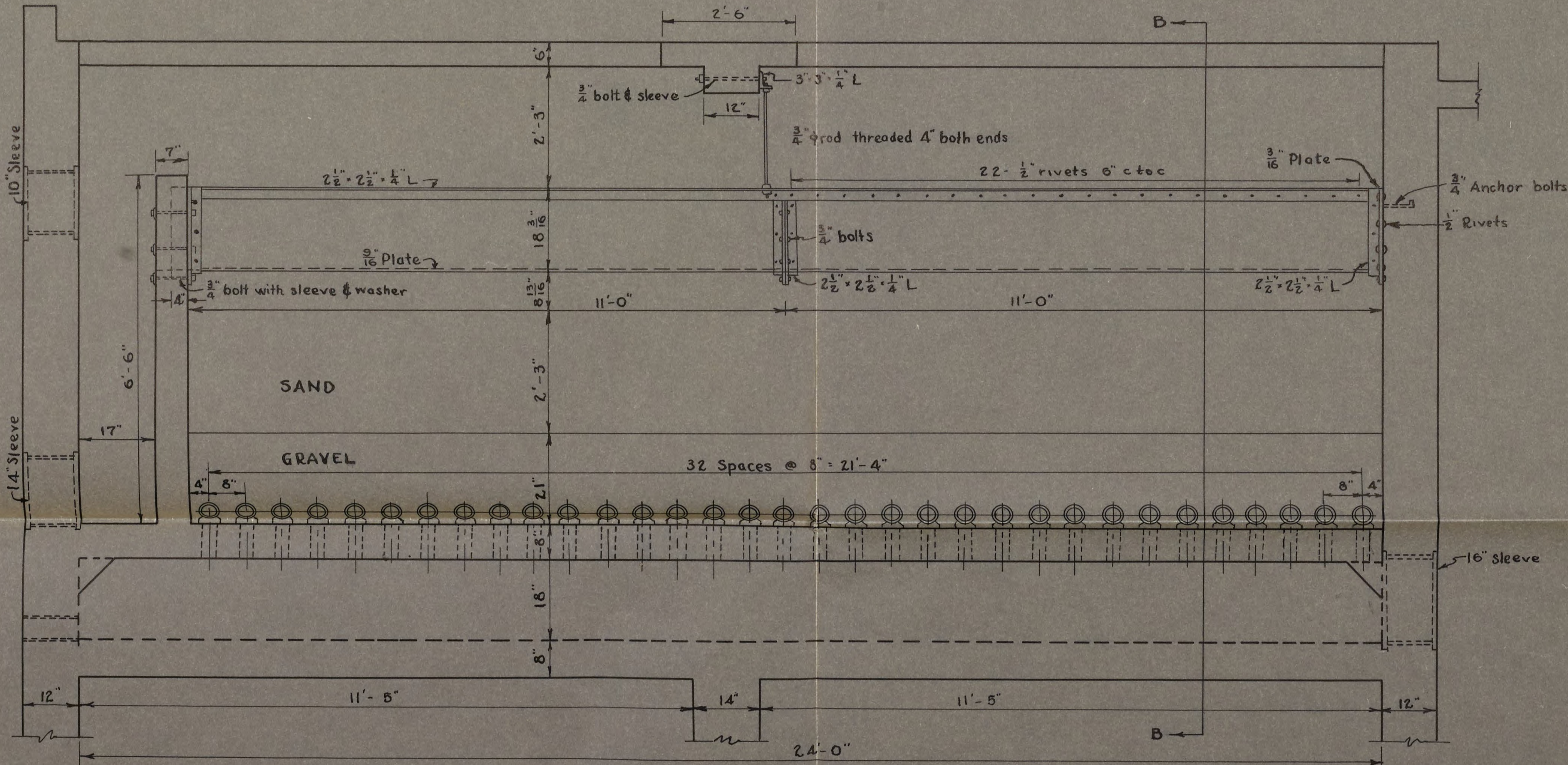
SAINT JOSEPH, MICHIGAN

SEDIMENTATION BASINS

SCALE $\frac{1}{4}$" = 1'-0"

TRACED BY: J. DONAVEN WELLS

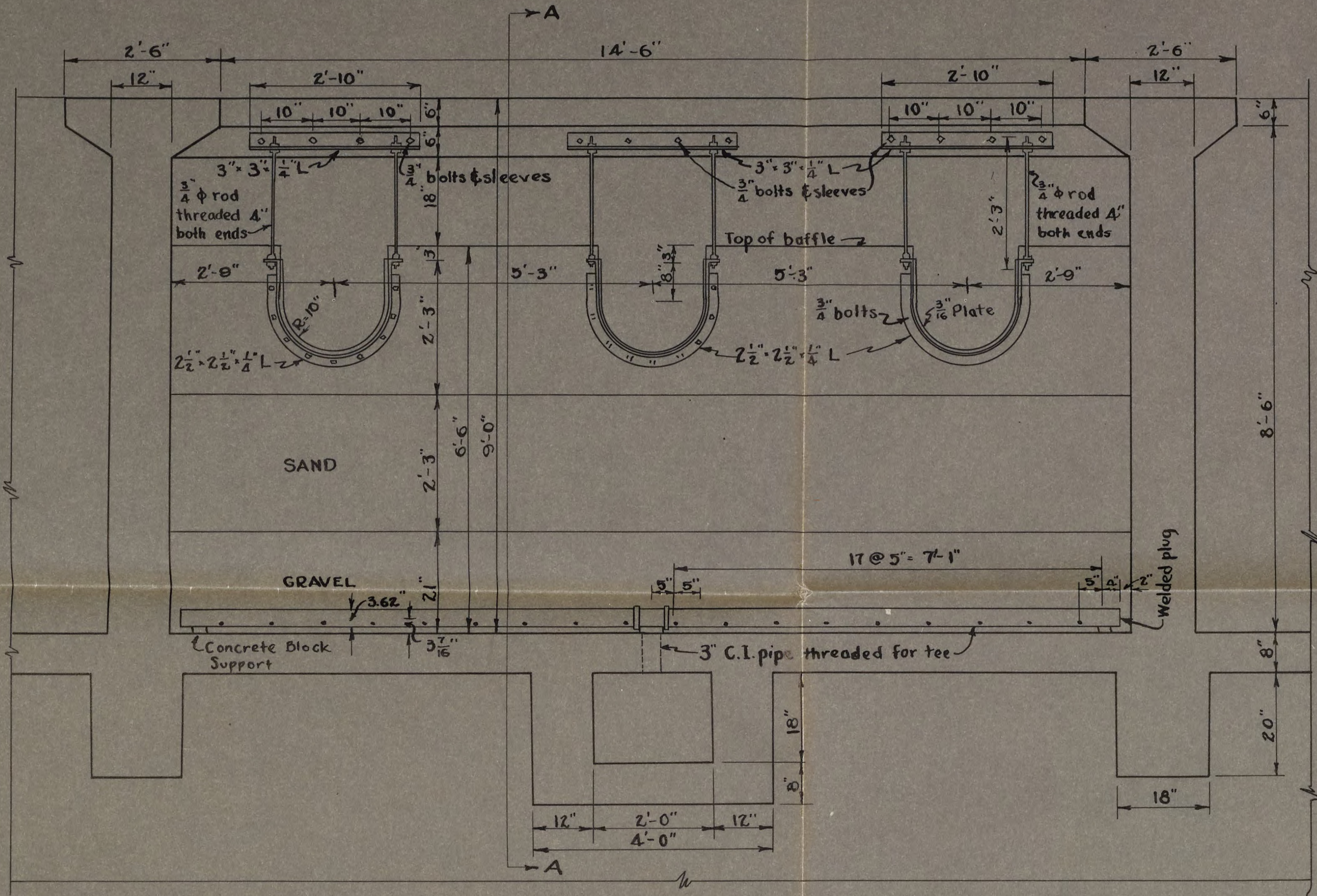
SUPPLEMENTARY MATERIAL



SECTION A-A

PLATE IV

PUMPING & FILTRATION PLANT
SAINT JOSEPH, MICHIGAN
SECTION THRU FILTER
SCALE: 1/2" = 1'-0"
J. DONAVEN WELLS



SECTION B-B

PLATE IVa

PUMPING & FILTRATION PLANT

SAINT JOSEPH, MICHIGAN

SECTION THRU FILTER

SCALE: 1/2" = 1'-0"

J. DONAVEN WELLS

SUPPLEMENTARY MATERIAL

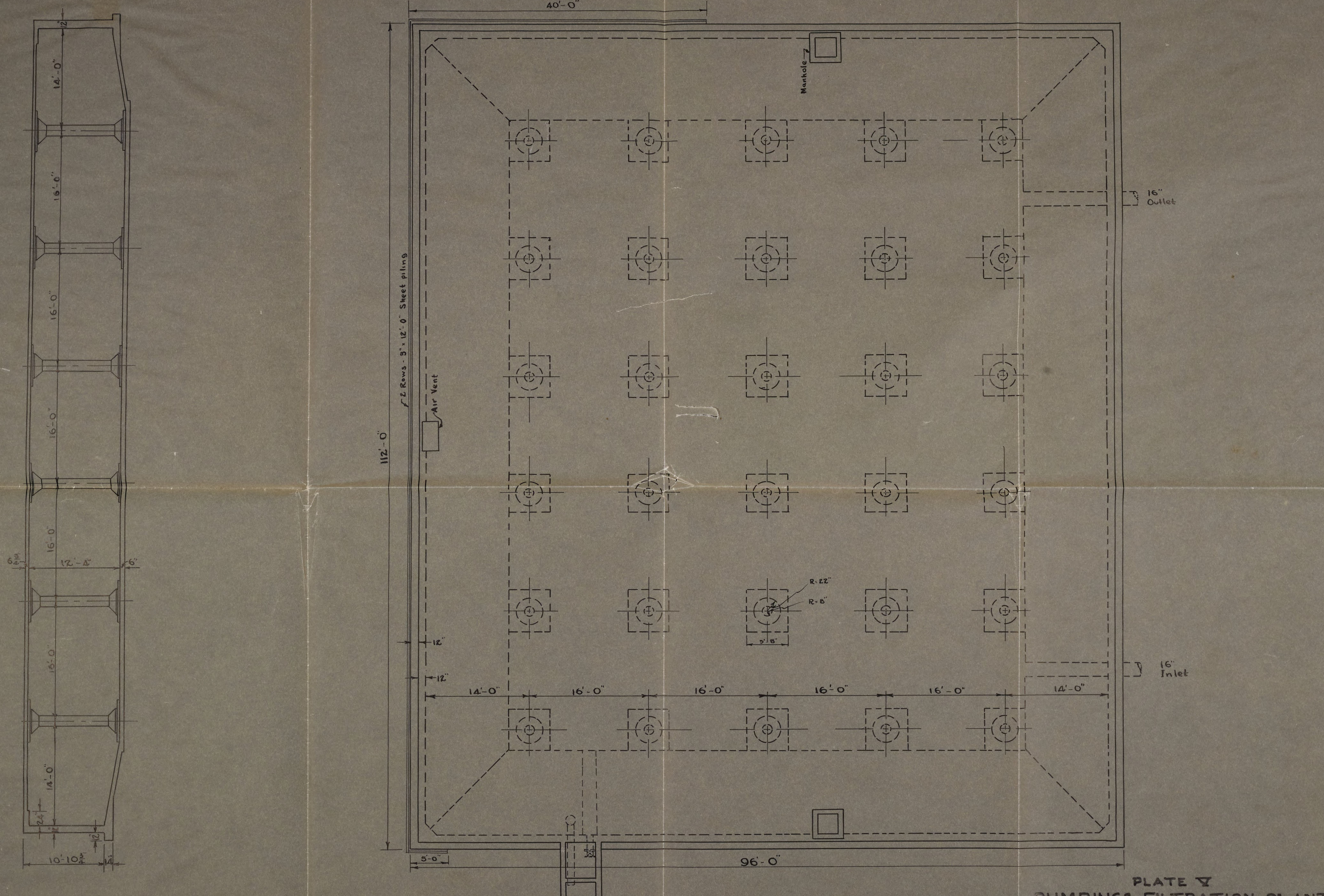


PLATE V
PUMPING & FILTRATION PLANT
SAINT JOSEPH, MICHIGAN
RESERVOIR
SCALE: 1/8" = 1'-0"
TRACED BY: J. DONAVEN WELLS

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