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A WATER SUPPLY SYSTEM FOR A SMALL MINING
COMMUNITY

By
Paul Donovan Windsor

—
A
T H E S I S
submitted to the faculty of the
SCHOOL OF MINES AND METALLURGY
OF THE
UNIVERSITY OF MISSOURI
in fulfillment of the work required for the
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1926

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Approved by

C. V. Forbes

Professor of Mining.

A WATER SUPPLY SYSTEM FOR A SMALL MINING
COMMUNITY

TABLE OF CONTENTS

PART I - DISCUSSION OF WATER PURIFICATION

CHAPTER I - INTRODUCTION

CHAPTER II - WATER PURIFICATION IN GENERAL

CHAPTER III - SOURCE OF WATER SUPPLY

CHAPTER IV- SUMMARY OF PRECEDING CHAPTERS

PART II - DISCUSSION OF METHODS

CHAPTER I - METHODS OF PURIFYING WATER

CHAPTER II - MECHANICAL FILTRATION

CHAPTER III - CHEMICAL TREATMENT

PART III - EXPLANATION OF THE PLANS AND OPERATION
OF THE PLANT

CHAPTER I - GENERAL

CHAPTER II - THE SUCTION WELL

CHAPTER III - THE SUCTION LINE

CHAPTER IV - THE LOW LIFT PUMP HOUSE

CHAPTER V - THE DISCHARGE LINE

A WATER SUPPLY SYSTEM FOR A SMALL MINING
COMMUNITY
TABLE OF CONTENTS

PART III - EXPLANATION OF THE PLANS AND OPERATION OF
THE PLANT (Continued)

- CHAPTER VI - THE MIXING BASIN
- CHAPTER VII - THE SEDIMENTATION BASIN
- CHAPTER VIII - THE FILTERS
- CHAPTER IX - THE CLEAR WELL
- CHAPTER X - THE PUMP ROOM
- CHAPTER XI - THE OPERATING ROOM
- CHAPTER XII - OPERATION OF THE PLANT

PART IV - THE SPECIFICATIONS

PART V - CONCLUSION

- CHAPTER I - FINANCING THE PLANT
- CHAPTER II - CONCLUSION

PART VI - BIBLIOGRAPHY AND INDEX

(Drawings inserted in envelope inside rear cover)

LIST OF ILLUSTRATIONS

PLATES I AND II - Views of Plant Taken During course
of Construction

- Immediately preceding Page 20

PLATES III, IV AND V - Views of Completed Plant

- Immediately preceding Page 38

PART I - DISCUSSION OF WATER PURIFICATION

CHAPTER I - INTRODUCTION

CHAPTER II - WATER PURIFICATION IN GENERAL

CHAPTER III - SOURCE OF WATER SUPPLY

CHAPTER IV - SUMMARY OF PRECEDING CHAPTERS

CHAPTER I - INTRODUCTION

Water Purification and its attendant problems are, at first thought, supposed to be of a purely civil nature, and such as not to come to the attention of a mining engineer. This is true in many cases; however, it is an engineering subject which a mining engineer may, for various reasons, be called upon to use.

In many instances, mining development is undertaken in localities where no development of a cultural nature is present. It then devolves upon the mining engineer in charge of the development to provide suitable and sanitary living conditions, both for himself and his co-workers. These efforts for sanitation are of a necessity rather crude in the early stages of any mining development, but as the work progresses, they must be made more and more to conform with the principles of modern, up-to-date practice.

The fundamental basis of sanitary living conditions is a good water supply system, for without water it is impossible to dispose properly of human sewage and industrial wastes. By a "good water supply system" is meant a system of pipes that will deliver a pure, wholesome water at the necessary pressure.

Even in the older, fully developed and well established mining communities the demand for a good waterworks system is increasing, because of the laborers' demands for better living conditions. The mining companies are, for the most part, in favor of acceding to the demands of their employees in this respect, for besides raising the standard of living of the employee, and thereby making him a contented worker, a good water supply system enhances the value of property owned by the mine and gives them adequate fire protection. In fact, in many localities and small settlements that depend upon a mine for their existence, the question of water supply is quite often given the proper impetus by the mining companies, and in some cases such projects are financed and operated by them entirely.

The purpose of the foregoing paragraphs is to try to show that in these days of vastly improved living conditions the mining engineer must take cognizance of the fact that he must delve more and more into subjects which were heretofore thought to come only under the head of the civil engineering. It is a recognized fact that mining engineering profession needs for its ranks the most versatile of technically trained men. Therefore, it behooves the young mining engineer, who

wishes to be successful in his profession, to give some attention to civil engineering subjects, one of the most important of which is water purification.

This thesis deals with the problems met in solving the water supply question for a small coal mining community in southern Illinois. It will contain a brief general treatise on modern water purification with a discussion of the various methods and steps in modern practice, a set of drawings and specifications for a water supply system for this community together with an explanation of them.

CHAPTER II - WATER PURIFICATION IN GENERAL

Water purification may be defined as the art of removing foreign and polluting substances from solution and suspension in water. The object for which these impurities are removed naturally falls under two heads:

1. Removing organic matter and disease producing organisms from the fouled water or sewage of a community.
2. Treatment of impure water so as to make it hygienically safe for drinking, and suitable for industrial purposes.

Under the first of these heads comes the problem of sewage and sewage disposal. Since all matter is indestructible, it follows that water, which comprises a great portion of the earth's surface must undergo some sort of a cycle. This cycle includes precipitation from the clouds, ground filtration, use by man, disposal and evaporation. The uses to which water is put by man are varied; it is used for drinking and hygiene purposes, in industrial plants and as a means of disposing of sewage. Treatment of this water used as a transporting body for sewage is the subject included in the first of

the above heads. Modern engineering has devised methods for the treatment of these waters to make them pure, pure in the sense that they are hygienically and chemically clean. However, these waters are never purified, at that stage, to the degree necessary in drinking water. In general it might be said that sewage waters are purified only to the extent of making them pure enough not to cause stream pollution. This stage is primary in the process of water purification. After being discharged into streams and there being diluted, they are at some point again used and treated to make them fit for human consumption.

The purpose of this thesis, however, is to deal entirely with the problem presented under the second of the above heads, and with specific reference to the design and construction of a water supply system for a mining or industrial community of about 3500 inhabitants. It is true that it is possible to carry on water purification for industrial purposes independently of the more refined methods used for drinking purposes, and frequently this is done by large industrial concerns using large quantities of water and located where there is no adequate municipal supply. The increasing shortage of good water in the

past few years has made itself acutely felt by industrial plant owners and residents of southern Illinois, so the problem of furnishing a good, clean, wholesome water in sufficient quantities for both domestic and industrial purposes is one that is met and has to be solved frequently in this locality at this time.

CHAPTER III - SOURCE OF WATER SUPPLY

The source of water is primarily the same, that is, from precipitation out of moisture-laden clouds, but the collection and storage of this rainfall in the proper location and in suitable quantities for present consumption and a reserve supply during periods of drought is indeed an entirely different question. The impounding receptacles for the storage of water prior to its treatment may be divided into five general classes:

1. Wells, Deep wells and artesian wells.
2. Natural lakes.
3. Large streams.
4. Dammed streams.
5. Reservoirs.

Deep wells and artesian wells deliver a practically pure water and in many places this water is used without subsequent treatment, whereas in other places this water is prevalent with dissolved mineral matter and must be treated to remove such matter and disagreeable tastes and odors. Shallow wells are more apt to be polluted; it is a fact that small, shallow, domestic wells are often the media thru which various diseases are transmitted.

Natural lakes form a large source of water supply. The degree of purity of these waters depends upon the character of both the influent and effluent streams, size, character of the bottom, etc. It is in general necessary to purify lake water by some artificial means before it is fit for human consumption. Quite often, lake water is comparatively free from suspended matter, for the lake basin forms a natural settling reservoir; at other times it may be unusually muddy and turbid, depending upon the character of the bottom and the currents which disturb it.

Large streams are probably the greatest source of water supply in this country. Stream water is apt to be impure to a higher degree because most streams are at some point used as transporters for sewage. The degree of impurity depends upon the density of the population of the area thru which it flows. Yet from these streams comes water which is ultimately the finest drinking water that can be obtained. An example of this is the Illinois River. Into it flows the sewage of the entire Chicago district as well as that of some of the larger cities farther downstream. Peoria, Illinois obtains its water supply from this stream at a point where it is so polluted that at certain times of the year it is said that animal life is practically non-existent in it.

This water is treated in a modern plant and Peoria is supplied with a very good water. The Illinois River flows into the Mississippi River and altho it is diluted, it still retains a high degree of pollution when it reaches the vicinity of St. Louis, Missouri. The City of St. Louis obtains its water supply from this stream, treats it, and the result is a water that is noted for its purity. These are some extreme examples of stream pollution and what an adequate purification system will do. On the other hand, as in mountain streams, far removed from civilization, stream water is frequently used safely in its original condition, but this only in rare instances and seldom in quantities large enough for any considerable supply. In general, river water must be treated to make it safe and fit for human use.

In a great many instances, it is necessary to dam small streams so that a sufficient water reserve can be maintained for a given consumption. Reservoirs or merely the resultant basins formed by damming a small stream or several small streams. In this case the size of the reservoir depends upon the rate of consumption, the percentage lost thru evaporation and leaks. The possible size of the reservoir in any place depends upon the

existing topography and the extent of the water-shed feeding the reservoir.

CHAPTER IV - SUMMARY OF PRECEDING CHAPTERS

It has been the purpose of the foregoing chapters to show that practically all water must undergo some process of purification, for absolutely pure water is seldom found in nature, owing to the readiness with which it absorbs impurities from the air and soil. Even rain water contains a trace of ammoniacal salt; and the so-called "pure water" from natural springs is often impregnated to a great extent with soluble substances derived from the strata thru which it passes. Lake and pond waters are apt to be discolored and contain impurities of both a vegetable and organic nature. River water usually contains, in addition to the impurities already noted, sewage and refuse from industrial plants, which make it capable of transmitting typhoid and kindred diseases of a zymotic nature.

Aside from its sanitary importance, clean water is absolutely necessary in many industries; in fact, of such importance that an abundant natural supply of water formerly determined the location of many industrial plants. In the case of mines and such industries depending for development upon natural resources, the

the location of the mine or industry is fixed and the problem of getting to it an abundant supply of wholesome water must be solved.

PART II - DISCUSSION OF METHODS

CHAPTER I - METHODS OF PURIFYING WATER

CHAPTER II - MECHANICAL FILTRATION

CHAPTER III - CHEMICAL TREATMENT

CHAPTER I - METHODS OF PURIFYING WATER

Years of study and scientific research have narrowed the subject of water purification down to one thing, namely, mechanical filtration. Mechanical filtration has been fittingly called man's imitation of nature in the purification of water.

Of itself, mechanical filtration is essentially a straining and not a softening or chemical process, although these adjuncts are used frequently in connection with it. Under the general head of purification, other processes are sometimes employed - ozonation, chlorination, ultra-violet rays, water-softeners such as lime and soda, and the oxidation of iron by aeration and artificial zeolites. None of these processes takes the place of filtration, and with most of them filtration is required, either for preliminary or subsequent treatment to remove color and suspended matter.

In the plant described in subsequent chapters of this thesis, the principle of mechanical filtration is employed primarily, and it is that subject which lends itself into a brief discussion in the chapters immediately following.

CHAPTER II - MECHANICAL FILTRATION

All mechanical filters operate on practically the same principles. The water is passed thru a filtering medium which strains out the impurities. Natuarlly, the more dense the filtering medium, the finer the strainer, and therefore, the more perfect the filtration. During the development of mechanical filtration, there has been used excelsior, sponges, composition stone, cotton fiber, charcoal, coke, quartz and other materials, but it has finally resolved itself down to the use of layers of graded gravel and silica sand, and these are the media now generally employed.

The bed of filtering material is contained within a tank into which the water enters at the top, percolating down thru the bed, leaving the impurities within. The bed of filtering material is superimposed over a manifold strainer system which collects the water as it filters down thru the sand and gravel, and delivers it thru a system of piping to a storage chamber or clear well.

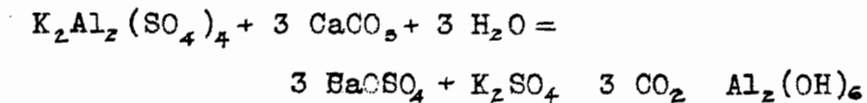
In filtration, the coarser, suspended matter is readily retained but particles smaller than the interstices between the grains of sand would slip thru if they were

not retarded. This is accomplished by the formation, on the filter bed, of an accumulation of the foreign matter removed from the water, which coagulates and forms a sludge of greater density than the filter itself. This coagulation is accentuated by the addition to the raw water of some chemical, and this subject is discussed in the next chapter.

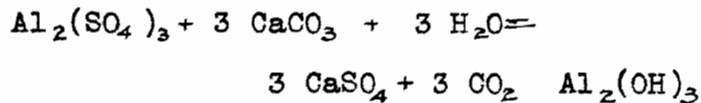
CHAPTER III - CHEMICAL TREATMENT

The first chemical treatment necessary in any raw water is the addition of some salt to aid in the formation of the coagulum which covers the filter bed. The chemical salts usually used are either Alum or Sulphate of Alumina, and the chemical reactions which result are as follows:

When alum is used:



When sulphate of alumina is used:



The coagulum thus formed is fittingly termed by the Germans, "Schmutzdecke."

A solution of the coagulant salt is added to the raw water when it first enters the filter plant. This is usually done in some sort of a mixing basin to insure the proper mixing of the raw water with the coagulant. It then passes into a sedimentation chamber, which is a tank large enough so that the water will be retained in it for a sufficient period and at a comparative state of quiet, so that coagulation can take place.

A common example of coagulation is the clarifying of coffee by the means of the white of an egg. The coagulum formed in water processes gradually aggregates together, precipitates or subsides thru the water, enveloping and dragging down such suspended matter and color with which it comes into contact, and after depositing the heavier portion in the sedimentation basin, finally rests in a greater or less degree upon the top of the filter beds. This coagulum in turn removes from the water particles of matter too fine to be caught by the sand. Eventually it becomes impervious and must be removed by washing.

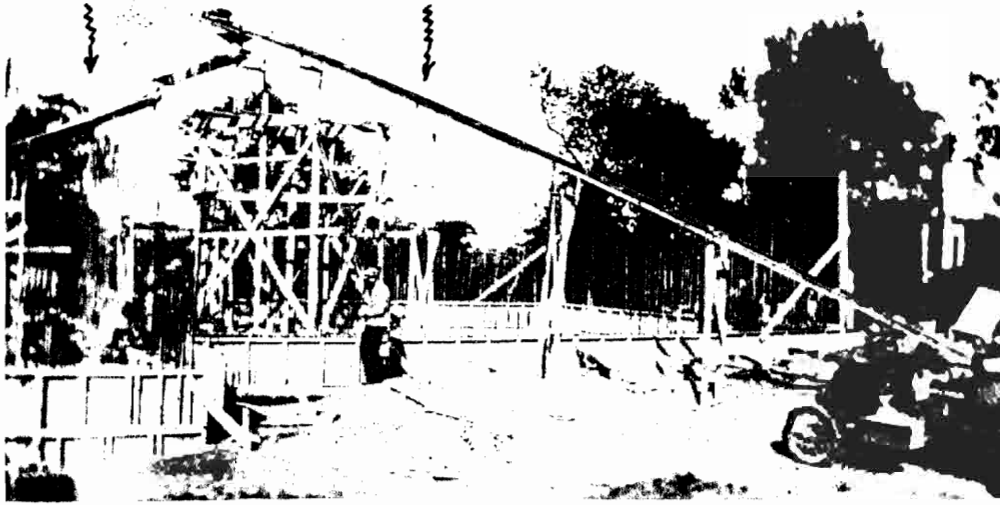
Another process used in the treatment of water is the addition of liquid chlorine in minute quantities to kill plant and animal organisms which have found their way thru the filters into the clear well. The ultra-violet ray is sometimes used to accomplish the same purpose, but chlorination is in more favor. The chlorine is either introduced into the clear well, or into the suction line of the pumps which remove the water from the clear well.

PLATE I

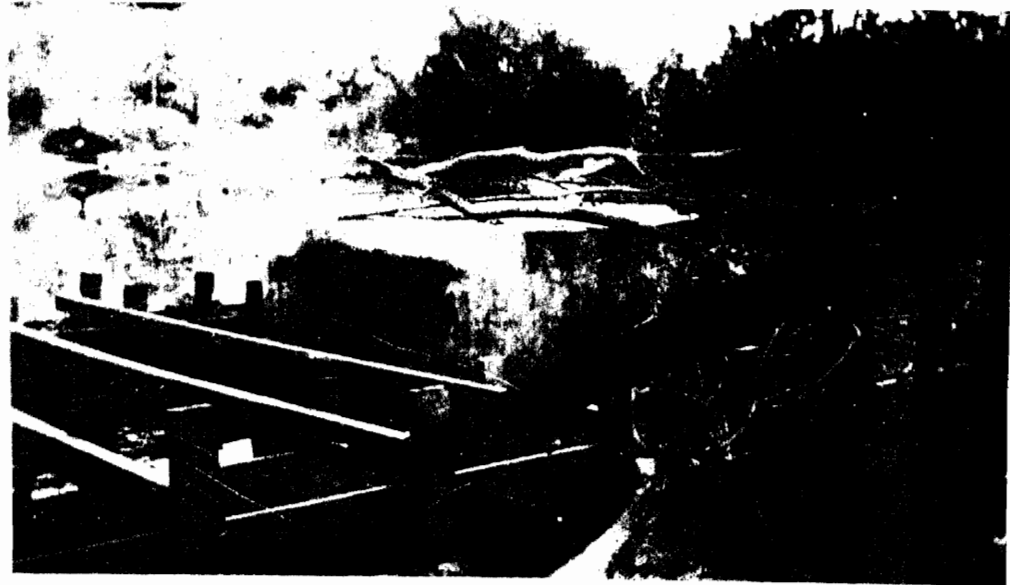
*VIEWS TAKEN DURING COURSE OF
CONSTRUCTION*

Clear Well

Sed. Basin



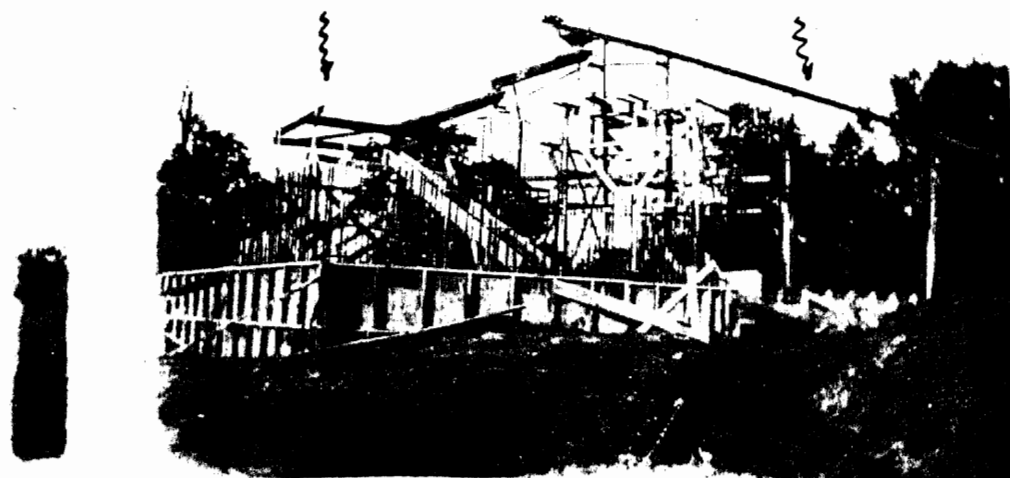
View from South
looking toward
Sedimentation
Basin



Suction Well

Clear Well

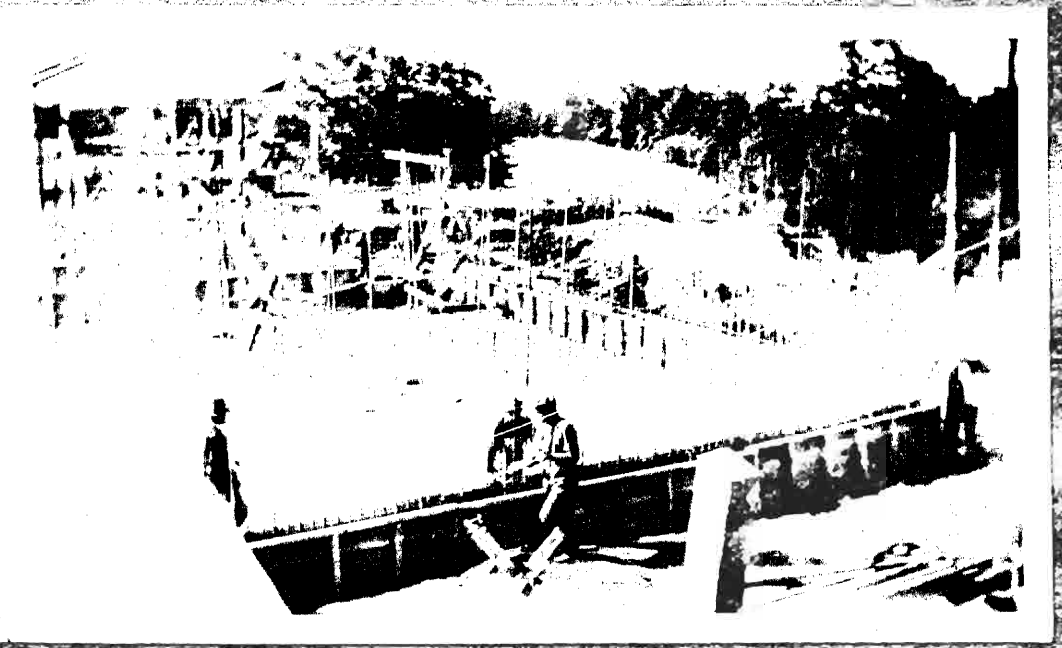
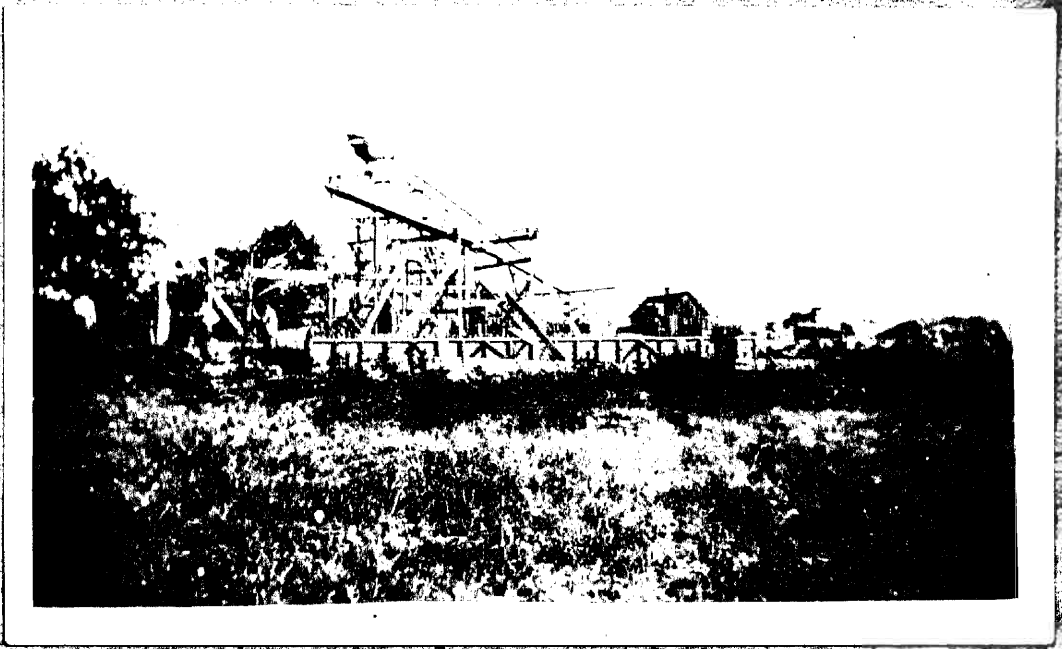
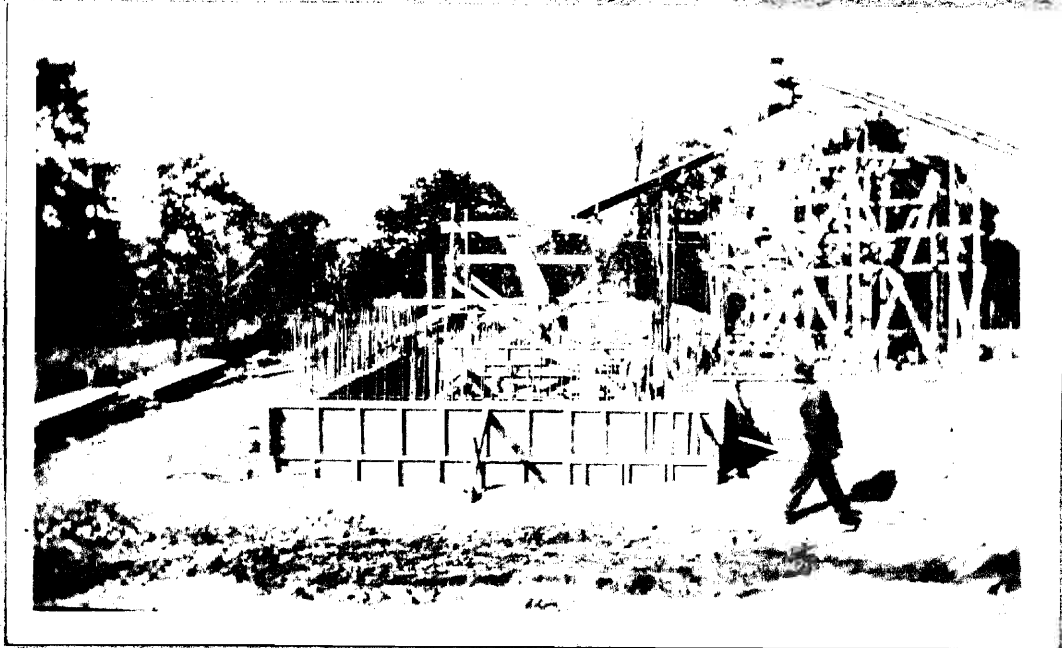
Sed. Basin



View from South
looking toward
Clear Well

PLATE II

*VIEWS TAKEN DURING COURSE OF
CONSTRUCTION*



PART III - EXPLANATION OF THE PLANS AND
OPERATION OF THE PLANT

- CHAPTER I - GENERAL
- CHAPTER II - THE SUCTION WELL
- CHAPTER III - THE SUCTION LINE
- CHAPTER IV - THE LOW LIFT PUMP HOUSE
- CHAPTER V - THE DISCHARGE LINE
- CHAPTER VI - THE MIXING BASIN
- CHAPTER VII - THE SEDIMENTATION BASIN
- CHAPTER VIII - THE FILTERS
- CHAPTER IX - THE CLEAR WELL
- CHAPTER X - THE PUMP ROOM
- CHAPTER XI - THE OPERATING ROOM
- CHAPTER XII - OPERATION OF THE PLANT

CHAPTER I - GENERAL

The filtration ^{plant} hereinafter described was designed to provide approximately 750,000 gallons of filtered water every twenty-four hours. For the present population of the city for which it was designed, it is necessary to keep it in operation only eight hours out of the twenty-four, the idea being to operate during the day-time and during that time to store a sufficient reserve to last thru the night. The plant was made large enough; however, to more than supply any estimated future demand owing to an increase in population or the location of new industries in the vicinity.

The plant is located on the bank of the Little Wabash River about seven miles from the city which receives the supply. It is pumped from there to the city thru standard water mains and many of the farmers enroute have taken the advantage of the system. Power for the motors is supplied from the municipally owned power plant in the city thru a high tension line to the filter. A number of the farmers have installed transformers and are also using this high line as a source of light and power.

The system was designed for a city that previously had installed water mains in its streets and was furnished

a raw water for fire protection purposes only. During the drought in that area during the entire year of 1925 the city decided to pipe to the river and there erect a modern filter, and thus be assured of an adequate supply of good water at all times. The reservoir went dry during this period and the need for water was acutely felt. Several fires had to go unchecked because of the scarcity of water and at one time water had to be shipped in for drinking and washing purposes.

The previous system depended for pressure upon a 60,000 gallon, 100 ft. elevated steel tank, and it is into this tank that the present water is pumped. There is about 100 feet of topographic relief between the city and the river, the tank is 100 feet high, and about 50 feet of head was lost due to friction in the seven miles of pipe line, making a total head of about 250 feet. The pumps at the filter were designed to take care of this head.

In discussing the plans of this filtration plant in the following chapters an effort will be made to follow the water from the time and point it is taken from the river, thru the various processes of purification, and until it is delivered to the consumer.

CHAPTER II - THE SUCTION WELL

The suction well for this system is a reinforced concrete masonry tank and was built to protect the end of the suction pipe and to form a sump for the collection of the water. It is circular in horizontal cross-section, 5'-0" in internal diameter, and 10'-6" deep. The size and shape was determined to a large extent by the character of the river. The river is one which passes thru large sections of timbered land, therefore it transports leaves, sticks, brush and even logs of a considerable size. A structure had to be designed which would offer the least obstruction to material of this nature, therefore the circular well. It was built in an excavation in the rock bed of the river so as to have formed a sump for the collection of water at all stages of the river. The water enters the suction well thru eleven vertical slots in the wall, each 4" X 3'-0". These slots are covered with 3/4" mesh screen to exclude leaves and small sticks. It was impossible to devise any means of finer filtration at this point; sand and small pebbles will enter the well and have to be removed periodically. This^{is} done, by gaining access to the inside of the well thru a trap door in the top, and ladders on both inside and outside walls. It will be noted from the Plans that the outside ladder was placed

on the downstream side, it having been remembered that such a thing would cause obstruction and be a lodging place for stream float.

CHAPTER III - THE SUCTION LINE

The suction line is an 8", bell and spigot cast iron pipe, at the lower end of which is placed an 8" foot valve. This is merely a valve which opens in a direction of flow toward the pumps, but automatically closes when the pumps are shut down, thus retaining the water in and above it. The suction line enters the low-lift pump house and is attached to the suction nozzles of the low-lift pumps.

CHAPTER IV - THE LOW-LIFT PUMP HOUSE

The low-lift pump house is situated on the bank of the river which is about fifteen feet above low water level and out of range of ordinary high water. It is a square concrete structure having an internal size of 10' X 10', and surmounted by a brick building. The entire structure is erected on eleven 12" diameter piles made of concrete and carried to bedrock. It has two floors, one just above the piles, and the other being the floor to the brick building. The pumps are located on the lower floor and are two 500 G. P. M. , Motor driven and designed for a head including friction and suction lift of 100 ft. They are connected in parallel, but by an arrangement of piping and valves, either can be operated independently of the other. The brick structure is used to house the transformers for the entire plant. A hatchway is left in the floor, of sufficient size to allow the admittance of the pumps, and for use as a man-hole for future inspection of the pumps. No provision was made for removing water from the floor around the pumps, but the building is so designed as to be higher than any high water record of previous years. Admittance is gained to the inside of the house by means of ladders on the inside and outside of the wall. The discharge of the pumps is connected to a 6" discharge line.

CHAPTER V - THE DISCHARGE LINE

The discharge line is a 6", bell and spigot, cast iron pipe. It is attached to the discharge of the low-lift pumps and is terminated in the mixing basin by a float-controlled valve. Near the point of entry into the mixing basin, a tee connection takes a 6" line into the flume off the sedimentation basin. This line is controlled by a 6" gate valve, and is used to by-pass the water around the mixing and sedimentation basins during the time those units are being cleaned.

CHAPTER VI - THE MIXING BASIN

The mixing basin is an integral part of the filter structure, a concrete tank, 21'-9" long, 6'-0" wide, and varying with the slope of the floor, from 11'-3" to 11'-9" deep. In it are placed cypress baffles, so arranged that the water must flow over one, under the next, etc. The flow of the water around these baffles insures its mixture with the coagulants which are introduced at the influent end of the mixing basin. The floor of this basin slopes to plug drain valve controlled, 8" vitrified tile sewer outlet, which when opened will drain the basin. The baffles slide in slots formed of channels of sheet metal so that they may be easily removed for repair and renewal. Openings are placed in the bottom of each baffle extending to the floor, and properly covered with flaps so that water will flow thru them towards the drain but will remain closed when the basin is in operation. The basin has a 9" freeboard and the float valve on the influent raw water line is regulated to close when this level is reached. The water leaves this basin thru openings at the end. These openings are arranged to take stop planks so that that the water can be made to flow either directly into the sedimentation basin, or by-pass the sedimentation basin and go directly to the filters.

CHAPTER VII - THE SEDIMENTATION BASIN

The sedimentation basin is a reinforced concrete tank, 36' X 48', and from 13'-9" to 14'-3" deep, depending upon the slope of the floor. Along its entire width runs a flume which connects with the settled water flume, in which are openings arranged to take stop planks. Thru the center of the basin runs a brick baffle wall extending to within 8 ft. of the sedimentation basin wall at its outer end. During normal operation the water enters the sedimentation basin from the mixing basin, and the stop planks in the flume are so arranged that it must pass around this baffle to get into the flume and the filters.

The capacity of the sedimentation basin is approximately 180,000 gallons or one-fourth the rated capacity of the plant for twenty-four hours. This means that the sedimentation basin has a retention period of about six hours, or in other words, from the time a particle of water enters from the mixing basin, six hours elapses before it is discharged from the sedimentation basin. During this time its shortest travel is some ninety feet, so it can be seen that while the water is in the sedimentation basin it is practically at rest. Owing to this

comparative state of rest, the heavier suspended matter settles out of the water to the floor of the basin.

A plug drain valve controlled, 8" vitrified tile outlet is placed at the low point in the floor of the sedimentation basin. This is necessary to facilitate the draining and cleaning of this unit.

CHAPTER VIII - THE FILTERS

The filters of this plant consist of two units, each 13'-6" X 9'-0" by 8'-8" deep. This gives a total filtering area of 243 square feet, so that when both units are operating they must filter approximately 2 gallons of water per square foot per minute, to fill the rated capacity of 500 gallons per minute. This is the usual amount of water which these filters can take care of.

In each unit is placed two wash water troughs, so designed as to carry the wash water, as it leaves the filters, into a 12", plug drain valve controlled, vitrified tile outlet. Under the gravel and sand is placed the cast iron manifold and strainer system. This consists of a 10" cast iron manifold from which extend to the sides of the filter, a series of 2" galvanized iron laterals, drilled with 5/16" holes. These manifolds are connected to the rate of flow controllers. They are also connected to the wash water pump by means of a tee connection.

The water enters the filters thru openings in the settled water flume, which are controlled by sluice gates. It trickles down thru the filtering material, is collected by the strainer system, and discharged into the clear wall thru the rate controllers.

CHAPTER IX - THE CLEAR WELL

The clear well is merely a basin for the storage of the filtered water. It is below and extends the entire length and width of the pump room and filters and is approximately 15 feet deep. It has a capacity of about 75,000 gallons. Access is gained to it thru a manhole in the pump room floor. Into it extend the filter effluent and high lift pump and wash water pump suction lines.

CHAPTER X - THE PUMP ROOM

The pump room is on the first floor of the filter building and houses the high lift and wash water pumps and motors. The high lift pumps are two 500 G. P. M. centrifugal pumps, one driven by an electric motor and the other by an automobile type gasoline engine. The engine driven pump is an auxiliary unit to be used when repairs are necessary on the motor driven unit. The wash water pump is a motor driven, 1900 G. P. M. centrifugal pump. The high lift pumps work against a head of 250 feet, and the wash water pump against a maximum head of about 10 feet.

CHAPTER XI - THE OPERATING ROOM

The operating room is on the second floor of the filter building and immediately above the pump room. Here are placed all floor stands which control valves in the piping of the pump room and filters. It also contains the solution tanks, loss of head guages, orifice tanks and chlorinator.

From this floor the operator can see the filter beds and watch their operation. He can also note the operation of the mixing basin from this floor.

CHAPTER XII - OPERATION OF THE PLANT

The plant is so designed that it can be operated entirely from the operating floor. The operator must make periodic tests of the raw water to determine the percentage of free chlorine, alkalinity, turbidity and color. The result of the last two determinations will inform the operator of the amount of coagulant to be added. The alum is mixed with water and placed in the solution tanks and from them flows into the orifice tanks. The orifice tanks are devices for regulating the flow of the coagulant solution into the mixing basin.

After the coagulant is added to the raw water the resultant liquid is thoroughly mixed in its passage around the baffles of the mixing basin. The operator must so arrange his stop planks that the water will flow into the sedimentation and around the brick baffle there, and not directly into the settled water flume.

The sluice gates in the settled water flume are left open during operation and the water passes thru them and the filters as explained elsewhere. The operator must keep the rate controllers regulated so as to deliver the rated quantity of water from the filters to the clear well.

Liquid chlorine is introduced into the suction piping of the high lift pumps by a Wallace & Tiernan chlorinator. This is a device which releases a drop of chlorine at periodic intervals, and can be regulated to give pulsations at any interval required. This ~~is~~ period of pulsation depends upon the amount of free chlorine in the raw water and is generally about one drop in from fifteen to twenty seconds.

As the filters are being used, they eventually clog up with the filtered matter taken from the water as it passes thru them, and they must then be washed. The point at which this is necessary is determined by loss-of-head gauges attached to the filters. When the filters are clean this head is a maximum, but as the filter operates and begins to clog the head drops off gradually, and at the point where the head reaches zero or nearly zero the filter must be washed. One unit is washed at a time. At this operation the operator reverses the flow of the water thru the manifold and strainer system by the following steps:

1. Closes the sluice gate for the unit being washed.
2. Opens the plug drain valve in the wash water sewer connecting with that unit

3. Closes gate valve in filter effluent line of that unit.
4. Opens gate valve in wash water discharge to that unit.
5. Starts wash water pump.

The operation of washing is then carried on automatically. The wash water pump takes filtered water from the clear well and forces it thru the manifold and strainer system, thence upward thru the filter beds where it collects the residue. When this water reaches the top of the filter bed it flows over into a concrete wash water troughs and out of the building thru a sewer. At a time when the unit is wash^{-ed} sufficiently, it can be again put in operation by a reversal of the above steps.

This plant is so designed that the raw water can be by-passed around either the mixing or sedimentation basins or both simultaneously. This is done by a system of piping, valves and stop planks, as will be seen by reference to the Plans. This is necessary, because at intervals these portions of the plant must be cleaned of settled material. These tanks are cleaned by the following steps.

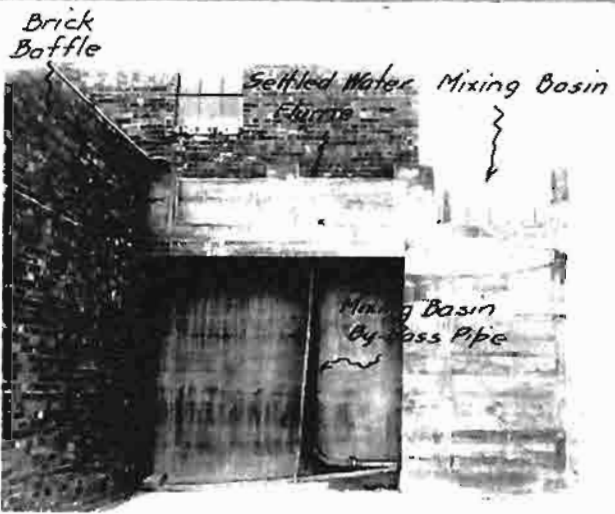
1. By-passing the water.
2. Opening plug drain valves.
3. Flushing with a pressure hose.

PLATE III

VIEWS OF COMPLETED PLANT

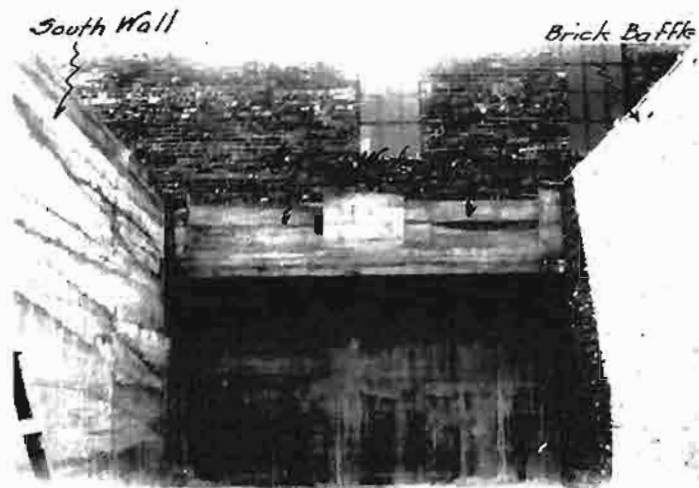


Settled Water Flume



Interior of Sedimentation Basin

Interior of Sedimentation Basin



Interior of Sedimentation Basin



PLATE IV

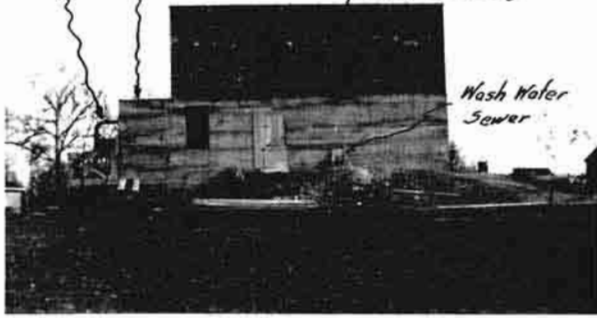
VIEWS OF COMPLETED PLANT

Raw Water Mixing Basin
Line

Filter Building

Wash Water
Sewer

West Elevation



Filter Building

Sed. Basin

View from Southeast



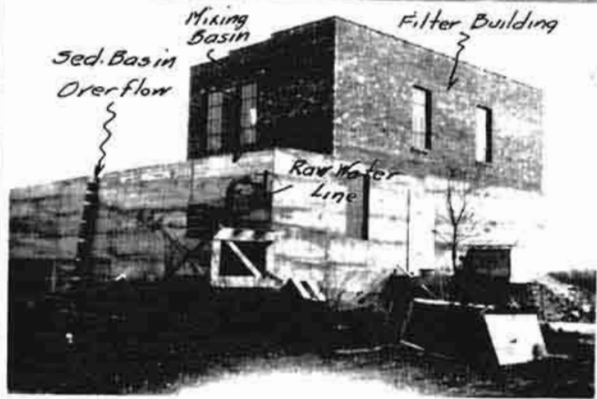
Mixing
Basin

Filter Building

Sed. Basin
Overflow

Raw Water
Line

View from Northwest



Sed. Basin

Mixing Basin

View from Northwest

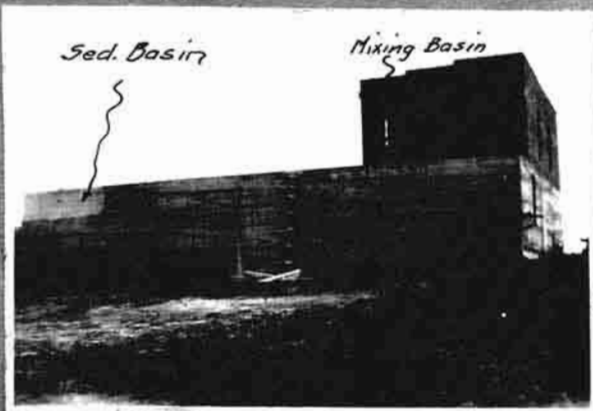
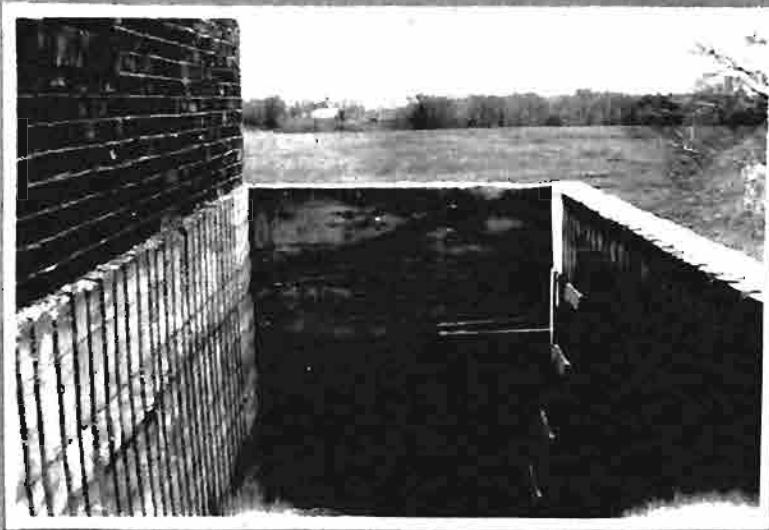


PLATE V

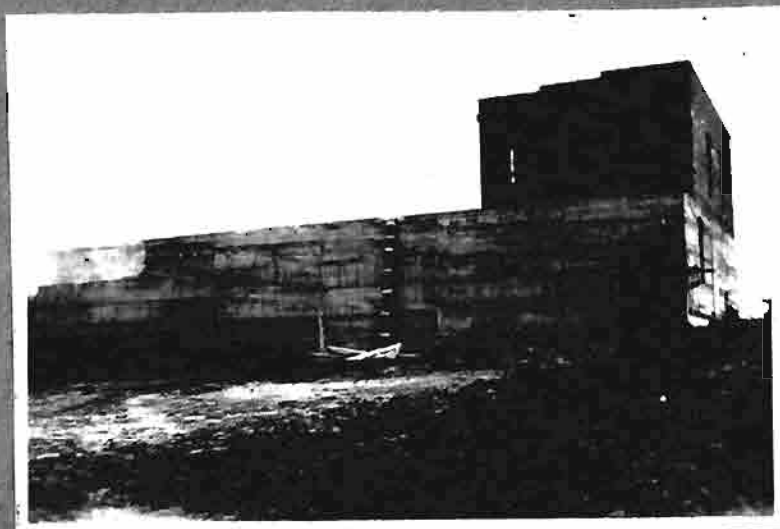
VIEWS OF COMPLETED PLANT



Mixing Basin



*Low-lift
Pump House*



*View from
North*

PART IV - THE SPECIFICATIONS

SPECIFICATIONS
FOR
A WATER SUPPLY SYSTEM
FOR THE
CITY OF _____

P. D. Windsor,
Belleville, Ill.

GENERAL INSTRUCTIONS TO BIDDERS

1. Attention of bidders is called to the fact that the estimate of quantities given below is believed to be correct, but is given only as a guide in checking such estimate as the bidder may make, and as a basis of calculation upon which the award of the contract may be made. In case any discrepancy appears between the figures enumerated and the quantities shown upon the Plans, or as determined by measurement of work actually done, the quantities obtained from the Plans or measurements shall prevail.
2. The bidder is expected to examine to his satisfaction the site of the proposed work, and also satisfy himself by such means as he may prefer, as to the quantities of work to be done.
3. All proposals must be filed with the City Clerk on or before the time specified in the "Notice to Contractors."
4. All proposals shall be in sealed envelopes endorsed, "Proposal for City of _____, Water Supply Construction," and shall be addressed to _____, Mayor, _____.
5. More than one proposal from an individual, firm, partnership, corporation or an association under the same

or different names will not be considered. Reasonable ground for believing that any bidder is interested in more than one proposal for the work contemplated will cause the rejection of all proposals in which such bidder is interested. Any or all proposals will be rejected if there is reason to believe that collusion exists among bidders.

6. No proposals will be considered unless accompanied by cash or a certified check, in a sum not less than 5% of the sum of the bid submitted, and proposals submitted to cover more than one section shall be accompanied by a certified check for each section, for the same sum as required for each section when proposals are submitted separately. In no case shall the sum of such cash or certified check be less than Three Hundred Dollars (\$300.00)

7. Checks shall be made payable to the order of the Mayor of the City of _____ and such check shall be held forfeited to the City as damages due to delay and other causes, should the successful bidder fail to enter into a contract and submit a bond acceptable to the City within ten (10) days after notice of acceptance of the bid.

8. Checks of unsuccessful bidders will be returned within ten (10) days of the time of the opening of the bids, to the respective bidders, except that the checks of the

three lowest bidders will be retained until the Contractor's Bond of the successful bidder is accepted and approved, at which time all checks will be returned to the respective owners.

9. No contract will be awarded except to responsible bidders capable of performing the class of work contemplated, and if requested by the City, bidders shall supply such information relating to previous experience in works of like character as shall permit the City to investigate their experience, skill and business standing. Failure of the bidder to supply such information will cause his bid to be rejected without further consideration.

10. Before entering into a contract, the bidder shall execute a bond in the form prescribed by law, in the penal sum of the contract, with a Surety Company, to be approved by the City, or shall furnish a bond of a form approved by the City and with sureties acceptable by the City, such bond to be conditioned that the bidder shall perform the work in accordance with the terms of the contract, and with the Plans, Specifications and Ordinance, and that he will commence and complete the work within the time prescribed in the contract.

Such bond shall also provide against any direct or indirect damages that may be suffered or claimed on account of such construction during the time thereof until the work is completed and accepted, and provide also that the full amount of said bond shall be conditioned also upon the payment, by the Contractor, of all sums of money due for any labor, materials, apparatus, fixtures or machinery furnished to the Contractor for the purpose of this construction. It is also understood that the full amount of the bond shall inure to the benefit of any person to whom money may be due for any labor, material, apparatus fixtures or machinery furnished, and suit may be maintained on such bond by any person for recovery of any money.

GENERAL SPECIFICATIONS

11. Whenever the term "City" is used in these Specifications, it shall be understood to mean the City of _____, party of the first part to this contract, acting in its official capacity thru its legal and authorized representatives.
12. Whenever the term "Contractor" is used it is understood to mean the person or persons who entered into this contract as party or parties of the second part, his or their heirs, administrators, executors, successors or assigns.
13. Whenever the term "Engineer" is used it is understood to mean the Engineer duly appointed by the City for this project, or his authorized representative.
14. Whenever the term "Plans" is used it is understood to mean all drawings or reproductions of drawings pertaining to the construction involved.
15. Whenever the term "Specifications" is used it is understood to mean the directions and requirements contained herein, together with all special provisions and written agreements made, or to be made, pertaining to the work involved. It is understood that all things contained herein

the "Notice to Contractors," Instructions to Bidders," "Proposal," the "Specifications," "Plans," "Contract," and "Contract Bond," together with any special provisions attached to or bound with any of the above, also any supplemental agreements, made or to be made are hereby made part of these Specifications and this Contract.

16. Whenever the word "Ordinance" is used, it shall be understood to mean and refer to the Ordinance providing for the improvement, passed by the City Council of the City of _____ on the _____ day of _____ A. D. _____ and approved on the _____ day of _____ A. D. _____.

17. Work to be done. The work to be done includes the furnishing of all materials, machinery, tools, labor and other means of construction, necessary to do all work in connection with the construction herein described, including any or all incidental work necessary to complete the construction in accordance with the Plans and all General and Detailed Specifications herein referred to, or hereto attached, and in accordance with the requirements of the Engineer under them.

18. Progress of the Work. The work shall begin not later than ten (10) days after the date of the Contract and shall be diligently prosecuted at such rate and in such manner

as, in the opinion of the Engineer, necessary to complete the construction within the time specified, it being understood that time is the essence of this Contract. The Contractor shall notify the Engineer in writing at least seven (7) days in advance of the time he expects to begin the work. The Contractor shall be charged for the salary of the Engineer from the date he shall set for beginning work until actual work is commenced. Should the Contractor fail to begin work at the proper time, or to maintain the necessary force and equipment, or if it becomes evident to the Engineer that the work is not being prosecuted with due diligence, or will not be completed within the contract time, it is hereby understood that the City shall have the right to call upon the bonding sureties to bring the work to a satisfactory completion in accordance with the terms of the Contract, or if agreeable to the bonding sureties, the City shall have the right to relet the remaining portion of the work, or employ such additional labor and purchase such additional tools and materials as may seem necessary to insure the completion of the work within the contract time. The total cost of the work so done, or materials, tools and labor so furnished, shall be deducted from any sums due the Contractor, or shall be covered by the bond for fulfillment of the Contract.

19. Additional Work or Deductions. It shall be the privilege of the City, under this Contract, to make such additions, deductions, or alterations in the work or quantities of work involved, as may be necessary for the proper completion of the work, and the Contractor shall agree to such conditions of addition, deduction or alteration, as in no wise invalidating this Contract, and if the Contractor shall perform such work or make such changes for the additive or subtractive consideration obtained by by applying the unit prices, as stated in the Proposal, to the quantities of the different items of work involved by the change.

20. Extra Work, Should it be necessary in the opinion of the Engineer to do work not covered by the Plans and Specifications, or for which no unit price had been agreed upon, the Contractor shall agree to do such work for the actual cost of same plus twenty per cent (20%). Actual cost, it is understood, and agreed, includes all necessary labor at the regular prices paid therefor, and the actual cost of all materials, as shown by authenticated bills. No charge shall be made by the Contractor for organization or overhead expense, nor shall any charge be made for superintendence unless authorized in writing by the Engineer.

21. Authority for Extra Work. No work shall be undertaken, or materials furnished, by the Contractor, except as specified in the Contract, unless authorized in writing by the Engineer and endorsed by the City.

22. Lines and Grades. During the construction the Engineer will furnish the Contractor with the necessary lines grades and measurements and if the Contractor, through wilfulness or carelessness removes, or causes to remove or be removed, such marks or stakes, before the prosecution of the work requires it, the replacing of the same shall be done at the expense of the contractor.

No allowance will be allowed for work done beyond the lines and grades shown upon the Plans.

23. Measurements and Quantities. All quantities shall be measured as indicated in the proposal submitted, and payment shall be made according to the gross sum thereto enumerated, or the gross sum as determined by measurements.

24. Interpretatin of Plans and Specifications. In the event of any discrepancy between any drawing and the figures written thereon, the figures shall betaken as correct. In case of a discrepancy between any drawing and the Specifications, the Specifications shall govern. In case of discrepancy among the several drawings, or in the Specifications themselves, such discrepancies will be interpreted and adjusted by the Engineer, and his decision shall be

final. Any doubts as to the true meaning and spirit of these Specifications, or any obscurity in the working thereof, shall be interpreted and explained by the Engineer.

25. Duties of the Contractor. The Contractor shall personally or thru an authorized representative, satisfactory to the Engineer and the City, constantly supervise the work from its beginning to its completion and final acceptance, and no part of the work shall be assigned or sub-let to any other person without the written consent of the City.

26. Engineer as referee. It is understood and agreed by both parties to this Contract, that the Engineer shall act as referee in all questions arising under the terms of this Contract between the parties thereto, and that the decision of the Engineer in such cases shall be binding upon both alike.

27. Liabilities of the Contractor. The Contractor shall assume all risk and liability for accident and damage that may accrue to persons or property during the prosecution of the work, by reason of negligence or carelessness of himself, his agents or employees, and shall assume all direct or indirect damages that may be claimed on account of the construction during the time thereof, and until the work is completed and accepted. He shall further assume all responsibility for damages that may arise, directly or indirectly, from fires or winds, or any other causes

until the work is finally accepted.

28. Workmen Employed. The Contractor shall , at all times, employ competent and capable workmen upon all parts of the work, and any workman or foreman employed by the Contractor, who, in the opinion of the Engineer, shall not perform his work in a proper and skillful manner, or who shall be disrespectful, disorderly or otherwise objectionable, shall, at the written request of the Engineer, be discharged at once and not re-employed on any portion of the work without the consent of the Engineer.

29. Equipment and Force Employed . The Contractor shall employ upon the work, a sufficient plant and equipment to meet the requirements of the work and to insure completion within the contract time.

The Contractor shall, at all times, employ such force as will, in the opinion of the Engineer, be necessary to complete the work within the contract time.

30. Patented Devices. The Contractor shall indemnify, keep, and save harmless the City from all liabilities, judgments or costs and expenses, which may in any wise come against the City on account of the infringement of any patent covering the use of any new design, material,

machinery, device or apparatus used by the Contractor in the performance of this Contract.

31. Permits and Licenses. The contractor shall be required to obtain all permits and licenses required to complete the work.

32. Sanitary Provisions. The Contractor shall provide and maintain in a sanitary condition, such accommodation for the use of his employees as may be necessary to comply with the requirements of the State and local Boards of Health. Public nuisance will not be permitted.

33. Defective Work or Material. All insufficient, defective or damaged work or material, when pointed out at any time shall be remedied immediately and made good, or removed and replaced, to conform with the Plans and Specifications, and any omission by the Engineer to disapprove or reject any such defective work or materials during construction shall not be deemed an acceptance of such work or materials, nor shall such omission on the part of the Engineer be construed as in any way releasing the Contractor from remedying, replacing or making good any defective work or material, so as to conform to the plans or Specifications. Any work done or materials used, without suitable supervision or inspection by the Engineer

or his authorized representative may be ordered removed and replaced at the Contractor's expense.

34. Penalty for Failure to Remove Defective Work. Should the Contractor fail to remove and renew any defective work within in the time specified in writing by the Engineer, such work may be removed and renewed at the Contractor's expense. Any expense incurred by the City in making such repairs, removals or renewals shall be paid out of the money due or which may become due the Contractor, or may be charged against the bond deposited

35. Failure to Complete Work. It is understood and agreed that if the Contractor shall fail to complete the work by the date named in the Proposal, the City may withhold from him such sums as may be due the Contractor under the terms of this Contract and amount equal to ten (10) dollars, for every day beyond the time so agreed necessary for the completion of such work, as damages for failure to complete the work within the time herein agreed.

It is further understood and agreed that the City may, in any event, permanently withhold from the Contractor the amount of engineering cost incurred after date of completion fixed in the Contract.

36. Extension of Time. Should the progress of the work be delayed by the City for any cause beyond the reasonable control of the Contractor, an extension of time shall be granted to the Contractor, to the extent of such delay,

provided the Contractor shall, in writing, demand such extension, and the right of the Contractor to have or not to have such extension, as decided by the Engineer, shall be final and conclusive. Any such extension of time granted to the Contractor shall not, in any manner affect the contract entered into, nor⁸relieve the Contractor from compliance with all provisions of the Contract, other than as to the time of completion, and that time shall be affected only to the extent of the extension of time allowed.

37. Annulment of Contract. For failure or neglect of the Contractor to begin the work within the time agreed upon after the date of the Contract, or for any failure or neglect to prosecute the work diligently, in such manner as will be in the opinion of the Engineer, necessary for the completion within the time specified, or for failure or neglect of the Contractor to keep and perform any of the agreements in this Contract specified, to be kept and performed by him, the City may, at its option, declare this Contract forfeited, and end and terminate all rights of the Contractor under it.

It is understood and agreed that after the Contract has been so declared forfeited by the City, the City may proceed to complete the work; and it is further understood that any excess cost for such completion of the work, over the original contract price, shall be charged to and paid for by the Contractor or his sureties.

38. Payments It is understood by the Contractor that the compensation provided for in the Contract is accepted as full payment for the furnishing of materials, labor, tools and equipment, and for the performing of the work contemplated and embraced under the Contract; also for all loss or damages arising out of the nature of the work, or from the action of the elements, or from unforeseen difficulties or obstructions which may arise or be encountered during the prosecution of the work; also for any expense incurred by or in consequence of the suspension or discontinuance of the work, as herein specified; or for any infringement of patent, trademark or copyright. The payment of any partial or final estimate shall in no way constitute an acknowledgment of the acceptance of the work, and such payments shall not prevent the City from investigating and correcting any errors in payment, or from causing any defective work or material to be removed, replaced or renewed.

39. Monthly Estimate. During construction the Engineer will, at the end of each month, measure or estimate the amount of work done and materials furnished by the Contractor during the month preceding, and certify to the City the sum due the Contractor for labor and materials so furnished. The City will then pay the Contractor eighty-five per cent (85%) of the estimated value of the work

done during the preceeding month, the remaining fifteen per cent (15%) be retained as a guarantee against poor workmanship and materials.

40. Final Acceptance. Upon the completion of the work, the Contractor shall notify the Engineer, in writing, and the Engineer shall inspect the work, and if completed as provided in the Plans and Specifications, shall so notify the City, and upon acceptance by the City of such work, the work shall be deemed completed and final payment made.

41. Final Payment. When final acceptance of the work shall have been made, then all money due the Contractor under this Contract shall be paid, excepting however, that no final payment will be made on account of this construction until it is shown by the Contractor that all sums of money due for any labor, materials apparatus, fixtures or machinery purchased for the purpose of this work shall have been paid for, or that the person or persons to whom the same may be respectively due, have consented to the final payment to such Contractor.

MATERIALS OF CONSTRUCTION.

42. Concrete. Unless otherwise specified, concrete shall be composed of one (1) volume of cement, two (2) volumes of sand or fine aggregate, and four (4) volumes of gravel or crushed stone or coarse aggregate.

If deemed advisable by the Engineer, the mixtures may be modified by changing the relative volumes of the various ingredients in order to produce a concrete in which the cement shall more than fill the voids in the sand, and the cement and sand shall more than fill the voids in the coarse aggregate.

43. Portland Cement. All cement used in this construction shall be of a standard brand of Portland Cement, which has been in practical use in public works and has given satisfactory service therein.

The Contractor, before furnishing the cement, shall notify the Engineer, in writing, as to the brand or brands to be used and before ordering shall receive the written approval of the Engineer as to the Brand selected. It is understood that such approval merely covers the selection of the brand, and that the cement itself may be rejected if it fails to meet the most recent standard specifications of the American Society for Testing

Materials, which specifications are hereby made part of these Specifications by reference.

The Contractor shall provide suitable means for storing the cement against dampness. No cement which has become caked shall be used, but shall be removed from the work.

All cement shall be delivered upon the work in the original packages with the name of the manufacturer marked thereon.

44. Sand. Sand or fine aggregate for concrete shall consist of clean, hard, durable uncoated particles of sand, preferably of a siliceous nature, free from clay or organic matter.

It shall not contain appreciable quantities of shale, lignite, slate or other soft grains.

It shall not contain more than three per cent (3%) by weight of clay and organic matter combined, or more than one per cent (1%) by weight of organic matter.

It shall be well graded from fine to coarse particles and not more than ten per cent (10%) shall pass thru a 100 mesh sieve, and not more than five per cent (5%) shall be retained on a $\frac{1}{4}$ " mesh screen.

45. Coarse Aggregate. Coarse aggregate shall be crushed stone or gravel. It shall contain clean, hard, tough, durable rock. It shall contain no shale, slate, coal or other materials which easily disintegrate. It shall be free from vegetable and other deleterious matter, and shall contain no soft, thin or elongated pieces.

It shall be well graded between the limits of $\frac{1}{4}$ " and $1\frac{1}{2}$ "

46. Water. Water used in mixing concrete shall be clean, free from oil and organic matter, and shall show a neutral reaction when tested.

47. Mixing Concrete. Concrete shall be mixed in a batch mixer of a type approved by the Engineer, and which shall insure a uniform distribution of the materials thru the mass, until the mixture is uniform in color and smooth in appearance. All of the materials, including water, shall be mixed for a length of time sufficient to produce a well mixed and homogeneous concrete.

No material for a batch of concrete shall be placed in the drum of the mixer until all the previous batch shall have been discharged. Retempering of mortar or concrete which has partially hardened, that is, mixing the concrete with additional materials or water, shall be prohibited.

Hand mixing shall not be resorted to except upon consent of the Engineer. When necessary to mix by hand, a watertight platform shall be used, the ingredients carefully measured and turned together until the entire

mass is uniform in color and appearance.

48. Consistency of Concrete. In mixing concrete, there shall be used such a quantity of water that the resultant mass is moderately wet and of a consistency to flow readily into the forms and around the reinforcement, and the water flush to the surface with light spading or trowelling. An excess of water, causing more than a slight accumulation above the concrete, or sufficient water to cause a separation of fine and coarse aggregates in transportation from the mixer to the forms, will not be permitted.

49. Placing Concrete. Concrete shall be placed in the structure immediately after mixing, and shall be thoroughly settled by spading, tamping or other means, to bring the mortar into thoro contact with forms and reinforcement.

Concrete placed in walls shall be placed in continual horizontal layers, so far as may be practicable. If at any time the work is interrupted so that the concrete already deposited has attained its initial set, the surface of such concrete shall be removed so as to expose the coarse aggregate, the loose material removed and the surface thoroughly wetted and flushed with a thin cement grout before concreting is resumed.

If the work is interrupted so that any layer of concrete is deposited more than twenty-four (24) hours before the next can be laid, and there are not sufficient reinforcing rods properly to bond the two surfaces, or it is necessary to produce a watertight joint, a timber of not less than 4" wide shall be laid the entire length of the course and bedded at least 2" in the concrete and allowed to remain until the concrete has set. When concreting is resumed the timber shall be removed and the surface of the concrete cleaned and flushed as above indicated.

Concrete placed in floors of tanks and subject to water pressure shall be placed for the full thickness and the entire floor placed in one operation.

50. Protection of Concrete while Curing. All concrete shall be protected from the direct rays of the sun by means of canvas, straw, or other means approved by the Engineer.

51. Concreting in Freezing Weather. No concrete shall be placed when the temperature is such that there is danger of freezing, except upon the express written consent of the Engineer, and then only in the manner approved by him.

52. Forms. The Contractor shall provide materials which shall be satisfactory to the Engineer, and the labor necessary for the erection of all forms for concrete masonry.

Forms shall be so constructed as to be held rigidly in place, line and elevation. If, at any point, after the concrete has been placed, the forms show signs of bulging or sagging, that portion of the concrete shall be immediately removed on notice by the Engineer, and the forms rebuilt and properly supported.

Forms shall remain in place until, in the opinion of the Engineer, it is safe to remove them.

53. Finish of Concrete. Immediately upon removal of the forms, all voids and crevices shall be neatly filled with a stiff 1 to 2 cement mortar, and if in the opinion of the Engineer the walls do not present a satisfactory appearance in harmony with the use to which they are to be subjected, the walls shall be brought to a smooth, neat surface by floating, or shall be given a brush coat of neat cement wash. Unless otherwise noted, on all walls and surfaces not exposed to view, no finishing will be required beyond a filling of all voids and crevices as above stipulated.

54. Reinforcing Steel. Unless otherwise specified, all steel for reinforcing concrete shall be mild or medium steel with an elastic limit of not less than 32,000 pounds per square inch. Steel bars shall stand bending

could within a radius equal to twice their diameter thru 180° without fracture.

All steel reinforcing bars shall have a sectional area equivalent to the area designated on the Plans.

Bars of different shapes than those called for by the Plans may be used, providing that an equivalent area of steel is used, and on condition that such substitution be plainly shown on a set of plans submitted to the Engineer for approval, before the steel is ordered.

The surface of all reinforcing bars shall be of corrugated, deformed or twisted type.

All bars shall be furnished to full lengths indicated on the Plans.

All bars, unless otherwise specified shall be of new stock, and shall be free from excessive rust or scale when placed in the work.

Steel reinforcing bars shall be placed in the concrete in the exact positions designated on the Plans, and in a manner approved by the Engineer. They shall be securely wired and otherwise fastened in place before the concrete is placed.

Adjoining bars at splices shall overlap at least 40 diameters, and shall be securely fastened together by wiring or clamps, and splices and laps shall be separated

and staggered as widely as is practicable.

Rerolled material or high carbon steel shall not be used except with the permission of the Engineer, and then only provided all stipulations of the Engineer as to bending the rods shall have been followed.

55. Vitrified Tile. All pipe and specials used in this construction shall be of standard length and pattern, first quality, vitrified pipe, salt glazed, well burned thruout its thickness, impervious to moisture, with smooth and well glazed inner and outer surfaces, free from cracks, flaws, blisters, fire checks and other imperfections. They shall be circular in bore, of the specified diameter and of uniform standard thickness. All pipe shall be of standard hub and spigot pattern with true and circular sockets concentric with the bore of the pipe.

All pipe and fittings shall be subject to inspection and approval or rejection by the Engineer, and any faulty or defective material shall be removed from the work at once.

VITRIFIED SEWER CONSTRUCTION.

56. Quality. All sewer pipe shall be of standard quality, full size, strictly first grade vitrified tile. Each pipe shall be straight and true, thorly and perfectly burned, we&l glazed, of homogeneous texture, and with smooth, hard, even surfaces.

Branches, wyes, bends or specials, where indicated on the Plans, or required, shall be of a quality equal to that of straight pipe, and shall be of standard dimensions.

57. Dimensions. The diameter of the pipe shall be as indicated on the Plans.

Straight pipe shall be at least $2\frac{1}{2}$ feet long, short or cut lengths being used only in making closures.

58. Joints. All joints shall be made properly by seating the end of each pipe in the bell end of the next adjoining pipe, and adjusting so as to provide a uniform space around the joint. The joint thus provided shall then be saulked with a hard, twisted jute gasket, thoroly rammed to the bottom of the socket, and the remaining space filled with a cement mortar composed of one (1) part of Portland cement and three (3) parts of sand, of a quality specified in Articles 43 and 44. Mortar for this purpose shall be mixed to a consistency suitable for the work,

and shall be used before the cement has attained its initial set.

59. Laying. All pipe shall be laid true to line and grade as shown on the Plans, or established by the Engineer. The inside of the pipe shall be kept clean and clear of all dirt, debris, cement, or other superfluous materials, as the work proceeds, by such means as will best accomplish the purpose. Proper means for the protection of pipe laid shall be resorted to when construction is temporarily stopped.

60. Defective Material. No piece of pipe known to be defective shall be laid, and any piece which is damaged in handling or laying shall be removed and replaced with good pipe, by the Contractor, at his expense.

61. Trench Excavation. Trenches for pipe, either cast iron or vitrified pipe shall be opened to the lines, depths and grades established by the Engineer, and of sufficient width to give convenient access to the pipe for laying and making of joints.

Sufficient shoring, sheeting and timbering must be employed to support the sides of the trench in a satisfactory manner.

Any water which may occur or accumulate in the trench shall be removed.

Care shall be taken to excavate under the bells of pipe lines sufficiently to afford a solid bearing for the pipe thruout its entire length.

In refilling trenches, the earth removed in excavation shall, so far as possible and suitable, be used. The refill placed under, around and over the pipe to a depth of 12" shall be carefully placed, and shall be thor^oly compacted and tamped with proper tools for the purpose.

So far as practicable, the same class of surface existing in streets before excavation shall be replaced, and in all cases the refilling shall be done in^a workman-like manner, approved by the Engineer.

CAST IRON PIPE AND FITTINGS.

BELL AND SPIGOT PIPE

62. Materials. Cast iron pipe employed shall be de Lavaud centrifugally cast iron pipe, of a strength sufficient to withstand an internal pressure of 250 lbs. per square inch. Fittings shall also be constructed to stand this pressure.

In the matter of the standard weights, dimensions and thicknesses of pipe and specials, and the allowable variations therefrom, of the quality of the iron and the method of casting of the pipe, of the cleaning of pipe and specials and the coating with coal-tar pitch varnish, and of the hydrostatic test of pipe, the Standard Specifications for Cast Iron Water Pipe of this particular class of the American Waterworks Association shall govern.

63. Lead and Jute. The best quality of lead and jute shall be used in making all joints.

64. Excavation and Backfilling. All trenches shall be dug to the line and grade indicated on the Plans or as established by the Engineer, and of such widths as to accommodate conveniently the laying of the pipe in a proper manner. They shall be of such depth that there

shall be at least two feet between the top of the pipe and the surface of the ground. Where the surface of the ground is above the usual grade, and in passing under existing sewers and other obstacles, a distance greater or less than two feet may be required for short distances.

In crossing streams the top of the pipe shall be at least eighteen inches below the bed of the stream, and the rise on either side to the usual grade shall be made by a gradual slope.

All excavated material shall be so placed as to be of as little inconvenience to public travel as possible. All sidewalks culverts, bridges, roads, etc. must be protected and restored to their original condition. Short tunnels will be permitted.

The Contractor shall furnish, put in place and maintain such sheeting and bracing as may be required to support the sides of the excavation and to prevent any movement which might delay the work or injure the work or adjacent property. He shall do all the necessary pumping to keep the trenches clear of water during the progress of the work.

The bottom of the trench shall have a uniform grade so that the entire length of pipe may be laid upon the bottom of the trench. Excavations shall be made under all bells and flanges. Blocking up of pipe will in general not be permitted.

All backfilling shall be done as soon as possible after the pipe is laid. Walks and roads shall be back-filled first. As backfilling progresses it shall be left with a smooth, rounding surface so as to be of as little obstruction to traffic as possible.

All surplus excavated material shall be the property of the City and shall be disposed of as directed.

65. Pipe Laying and Jointing. The pipe shall be unloaded and delivered on the streets by the Contractor and he shall protect the same from injury. They shall be placed, as much as possible, out of the way of public travel. Care shall be taken to keep pipe clean, and before laying and jointing each length of pipe shall be inspected and if necessary shall be thoroly cleaned. The coating of the pipe must be protected from injury, and if necessary shall be repainted with a good asphalt paint before laying.

Each pipe shall be laid on a firm bed and as straight as possible. The ends of the pipe shall abutt upon each other. Spigets shall be placed concentrically in the bells so as to give a uniform thickness of joint.

Joints shall be made by first calking in the jute for a depth of two inches and then pouring in enough lead so that it will stand flush with the end of the pipe after thoro calking. The jute shall be in length sufficient to reach around the joint and lap several inches, and the joints in successive layers shall be staggered. The jute must be calked tightly with the proper iron, care being taken not to drive it thru the joint nor to drive the iron thru the jute. When calked the jute must be even so as to admit a uniform depth of lead.

Lead shall then be poured in the joint and stand undisturbed until cool. The lead must be at the right temperature and each joint must be poured from a full ladle at one operation. After cooling, the joint shall be evenly and thorly calked with the proper irons and left flush with the end of the bell. The joint shall be repoured, if necessary, to leave a flush joint. Special care shall be taken with the under side of joints.

All yarning and calking of joints shall be done only by experienced men.

66. Valves and Valve Boxes. All valves shall be double gate valves, having an iron body with bronze mountings and hub ends. Valves shall be made to open by turning to the left. The waterway shall be at least equal to the diameter of the pipe on which the valves are to be placed.

They shall be tested and stand an internal water pressure of 300 lbs. per square inch. The valves to be furnished shall be approved by the Engineer.

Cast iron valve boxes shall be furnished for all valves. They shall be adjustable, preferably with screw extensions and shall have not less than a $\frac{1}{4}$ " shaft.

67. Testing Pipe Line. The pipe shall be tested by tank pressure by filling with water to the pressure specified by the Engineer. Any defective pipe, valves or hydrants or leaking joints must be immediately repaired. The test shall be continued until the line shall have remained under pressure for at least twenty-four hours and the line is tight. If impossible to do so with the city water system, a direct pressure of not more than eighty pounds per square inch shall be used instead of the ordinary working pressure.

The expense of all tests and repairs shall be paid by the Contractor, except if additional pumping equipment and labor is necessary to maintain the pressure of eighty pounds per square inch noted above, the City shall pay such additional cost.

FLANGED PIPE.

68. Quality. Flanged pipe and fittings shall be of a material and quality equal to that specified for Hub and Spigot pipe, and shall conform to all the requirements of the Standard Specifications of the American Waterworks Association, insofar as these Specifications may apply to this class of pipe.

All pipe and fittings shall be of the weight and class indicated on the Plans.

Flanges shall be cast solid with the pipe, unless otherwise specified by the Engineer, and shall be faced accurately at right angles to the axis of the pipe. Flanges shall conform strictly in dimensions and drilling to the American Standard.

69. Joints. All joints shall be made up with the best quality sheet rubber gaskets.

Joints shall be pulled tight by means of best quality mild steel bolts and cap screws. Bolts or cap screws shall be of the proper size for the pipe employed, shall have hexagonal heads and nuts, and threads sound and well cut.

70. Placing. Flanged pipe shall be placed as indicated on the Plans.

71. Test of Pipe Line. All flanged pipe lines, when completed, shall be tested by the Contractor in the manner indicated by the Engineer. All necessary labor and apparatus shall be furnished by the Contractor, who shall replace and repair, at his own cost, any defective pipe, casting, fittings or joints.

VALVES.

72. Quality. Gate valves shall be of a make approved by the Engineer, and shall be designed for the pressure indicated on the Plans.

They shall be of the double seated type, with non-rising stems, and with a circular waterway of the full diameter indicated.

They shall have an iron body, and all the wearing surfaces shall be bronze mounted or faced. They shall be of simple construction and all moving parts and surfaces in contact shall be accurately fitted to insure easy operation and perfect seating of the valves.

They shall be constructed so as to seat tight against a working pressure of 125 pounds on either side.

73. Placing. Gate valves shall be placed as indicated on the Plans, and shall be of a type suitable for for connection to the pipe in which they are employed.

SLUICE GATES AND PLUG VALVES.

74. Quality. Sluice gates shall be either of the circular or rectangular type, with clear openings of the size indicated on the Plans.

They shall have non-rising bronze stems.

They shall be so designed as to safely carry the maximum pressure to which they will be subjected in operation without bursting or springing.

They shall be of the iron body type, with flanges, frame and gates constructed of sound cast iron. Gates and frames shall be provided with non-corrosive bronze facings, securely fastened to the iron castings. The surface of flanges shall be machined and hand scraped to insure a water-tight bearing against pressure from either side of the valve. The construction of the flanges and gate shall be such that the gate shall remain in its proper position thruout the limit of its travel.

Cast iron surfaces shall be thor^oly cleaned and

painted with two coats of asphaltum varnish, or other coating approved by the Engineer. Bronze tool finished work shall be left bright.

75. Placing. Sluice gates shall be placed as indicated on the Plans, and securely fastened in a manner approved by the Engineer.

76. Plug Valves. Plug valves shall be of cast iron, bronze mounted and faced, with a clear opening of the size indicated on the Plans.

They shall have non-rising bronze stems.

All cast iron surfaces shall receive two coats of asphaltum varnish, or other acceptable coating.

77. Placing. Plug valves shall be placed as indicated on the Plans, and in a manner approved by the Engineer.

PUMPS AND PRIME MOVERS.

78. All pumps to be furnished shall be centrifugal pumps.

The casings of all pumps shall be horizontally divided along the center line of the shaft, with suction

and discharge nozzles in the lower half of the casting, permitting inspection and removal of the internal parts of the pump without disturbing main pipe connections. The casings are to be of close-grained cast iron of a sufficient thickness to withstand all strains incident to the service.

The bearings are to be of the ring oiled type, so designed that water cannot leak from the stuffing boxes into the bearings or oil reservoirs. The bearings shall be provided with a sufficient number of oil rings to efficiently lubricate them. The oil reservoirs shall hold an ample supply of oil and shall be provided with proper drains and oil sight gauges.

The impellers for all pumps shall be of bronze, carefully and accurately finished by hand.

The impellers for the low-lift pumps shall be of the double suction, open impeller type.

The impellers of the motor driven high lift pump and the engine driven high lift pump shall be of the enclosed single suction type.

The impellers for the wash pump shall be of the enclosed double suction type.

The pumps shall be provided with bronze wearing

rings, carefully and accurately finished to prevent leakage from discharge chamber into suction chamber.

The stuffing boxes shall be large and deep, capable of taking from 5 to 6 rolls of packing, and shall be provided with a bronze lantern water sealed ring. The bronze ring is to be placed in the bottom of the stuffing boxes to prevent packing from sticking to the stuffing boxes. The stuffing box glands are to be adjusted by bronze swing gland bolts.

The shafts shall be of high carbon forged steel, amply large in diameter for all strains incident to the service. There shall be provided on shafts a bronze sleeve which shall extend thru the stuffing boxes where the water touches the shaft. The shafts shall be accurately ground to guage.

There shall be furnished for connecting the pumps and prime movers, flexible couplings of the pin and rubber bushing type, so designed as to take care of any slight disalignment between pump and prime mover.

All pumps shall be mounted on substantial cast iron bedplates of the box type, and the pump and motor shall be doweled and bolted to the bedplate and accurately aligned.

79. Prime Movers. All motors shall be of the squirrel cage induction type, capable of carrying full load with a temperature rise not to exceed 40°C. The motors shall be capable of carrying a 25% overload for two hours with a maximum rise of 55°C. The motors shall be the Fairbanks Morse Company's type H and provided with ball bearings.

The low lift pump motors shall be not less than 20 H. P. and shall operate at a speed not to exceed 1800 R. P. M.

The high lift pump motors shall be not less than 50 H. P., and shall operate at a speed not to exceed 1800 R. P. M.

The wash pump motor shall be not less than 25 H. P., and shall operate at a speed not to exceed 1200 R.P.M.

All motors shall be provided with manually operated hand starting compensator, having overload and undervoltage protection devices.

There shall be furnished with the two low lift pump motors, two push button stations to be installed in the filter building, and inserted in undervoltage release circuit of the low lift motor starters, to permit stopping of low lift pumps from the filter building.

The engine driven high lift pump shall be directly connected to an automobile type gasoline engine of not less than 65 H. P., at 1400 R. P. M. The engine shall be equipped with all ignition devices, carburetor, governor, cooling system, electric starter, magneto, 15 gallon gasoline tank, force feed oiling system and other accessories required. The engine shall be complete and ready for operation. The engine shall be an EWE, Hercules, Buda, or equal.

EXCAVATIONS.

80. Earth Excavation. Excavation shall include the removal and satisfactory disposal of all materials taken from within the limits of the work contracted for, necessary for the preparation and construction of the various structures. It shall also include all necessary clearing and grubbing, and the necessary construction and compacting of all slopes and embankments, and backfilling to the required grade and lines shown upon the Plans.

Investigations on the site of the work indicate that the materials to be excavated will be loam, clay and sand to a depth of about twelve feet below the surface of the ground. It is expected, however, that the Contractor

will satisfy himself as to the probability of a quick-sand or bodies of water within the limits of the excavation.

Excavation shall consist of the excavation of all material within the limits of the lines and grades given by the Engineer, and shall also be all excavation and grading required for completing the structure, as indicated on the Plans.

It shall include the clearing of the site of the work and disposal of all brush, trees, logs, stumps and other perishable materials, and the removal and satisfactory disposal of structures and fences, as directed by the Engineer.

It shall include the placing and removal of all sheeting, shoring and bracing necessary for the proper completion of the work.

It shall include the draining and pumping and satisfactory disposal of any or all water which may occur in connection with the construction.

It shall include the proper backfilling and grading of the site of the work, in a manner satisfactory to the Engineer.

Whenever necessary or desirable, all trenches, pits and other excavations shall be properly sheeted and braced, in the manner directed by the Engineer. All bracing and sheeting shall be substantially constructed and so placed that it shall protect the completed work until the general construction of such work has proceeded far enough, or sufficient time shall have elapsed to provide sufficient strength to the completed work, Any structure, or portion of a structure, which may be injured by reason of settlement of earth, slides, water, or earth pressure, due to the lack or failure of proper shoring and bracing, shall be removed and replaced at the expense of the Contractor.

The Contractor, under this item, shall provide and maintain at all times during construction, adequate means and devices for the removal of all water occurring within the excavation. No masonry shall be laid in water, nor shall the water be allowed to rise sufficiently to cover work in place, until any mortar or concrete part of such work shall have set for at least twenty-four-hours.

Material excavated shall be disposed of by back-filling, and by providing the grades and slopes shown on the Plans, or ordered by the Engineer.

All excavated material shall be temporarily deposited on the site of the work, but in such a place and manner as not to interfere with the proper construction of other work.

Material not disposed of by use in backfills and embankments shall be disposed of by the Contractor at his expense.

Upon completion of the work, or part thereof, all lumber, shoring braces and rubbish shall be removed from around walls and other structures, as directed by the Engineer. All trenches, pits and excavations shall then be backfilled to the original surface of the ground, or to the grade indicated.

Backfill shall be thoroly wet down with water while being placed, and shall be done in a manner to prevent after-settlement.

Backfills shall not be placed until such a time as directed by the Engineer.

Excavation for structures will be measured between vertical planes passing thru the outside of the structure and from the surface of the ground to the neat lines of the bottom of the structure, as shown on the Plans, or to such greater depth as the Engineer may direct.

81. Rock Excavation. Rock excavation will include the removal and satisfactory disposal of all material taken from the limits of the excavations indication, and the preparation of the excavation to receive the structure to be built in or upon it.

Foundations on rock shall be carried to a firm, solid stratum, and all loose, broken or disintegrated materials removed.

Trenches in rock shall be constructed true to line and grade, and where constructed to receive pipe shall be backfilled with earth to provide a uniform bearing for the pipe.

Payment for rock excavation shall be made as stipulated in Article 20 of these Specifications.

DETAILED SPECIFICATIONS.

INTAKE TOWER AND LOW LIFT PUMP HOUSE.

82. The work to be done under this heading includes the construction on the site indicated of an intake well and pump house, with connecting pipe, all as indicated on the Plans.

Concrete masonry shall be as specified in Article 42 of these Specifications.

Pipe connecting intake well and pump house shall be Class "A" 8" pipe as specified in Article 62 with bell and spigot ends, laid partly in earth and partly in rock excavation trenches.

The low lift pump house shall be constructed of concrete masonry, having two floors and being covered by a brick structure, as shown.

This superstructure shall be constructed of vitrified shell brick, known as No. 2 Paver, or of a hard common red brick, laid in Portland Cement mortar, and the walls covered by a standard 9" vitrified coping tile.

Sash shall be of steel, with ventilator sash, and glazed with double strength clear glass.

The door shall be of the size indicated. It shall be solid, No. 1 quality, 1-3/4" in thickness, hung in a wood frame and provided with a suitable lock.

Door frame and sash shall receive two coats of white lead and oil of a color approved by the Engineer.

The roof shall be constructed as shown on the Plans, and covered with first quality five-ply composition roofing, properly flashed.

Pipe rail as indicated on the Plans, constructed of $1\frac{1}{4}$ " iron pipe shall be constructed. After construction, all pipe rail and ladders shall be given two coats of a suitable protective coating.

In the pump house there shall be installed two centrifugal pumps each capable of delivering 500 G. P. M. against a head of 100 feet including suction lift. Each pump shall be driven 1800 R. P. M. by a 220 volt, 3 phase, 60 cycle electric motor, as elsewhere specified, equipped for manual control, and also equipped with a stop push button to enable operator to shut off motors from filter building.

Connections of intake and discharge piping in the pump house shall be substantially as shown on the Plans.

Electric power and light wiring shall be as specified in Article 96 of these Specifications.

For delivering water to filters there shall be constructed a pipe line of cast iron pipe, bell and spigot

joints to the mixing basin of the filter, terminating in a float-controlled outlet valve of sufficient size, and of a make approved by the Engineer.

FILTER SUBSTRUCTURE AND SUPERSTRUCTURE

83. The work to be done shall consist of the erection, complete in place, of all concrete masonry necessary for the construction of the Clear Well, Sedimentation Basin, Mixing Basin, Filters, Operating Floor and Stairs, as the same are shown on the Plans, including the construction of all forms, the mixing, placing and finishing of all concrete, the placing of all reinforcing steel, the testing of the structure for water tightness, and repairs and alterations, if any.

The work shall also include the furnishing and placing, in a manner approved by the Engineer, of the vitrified tile and elbows and overflow, shown on the Plans, and the furnishing complete in place, with extension stems, stem guides, brackets and handwheels, the plug drain valves as indicated. The valves to be furnished shall consist of plug drain valves, of a make approved by the Engineer, having openings of the full size specified, and being substantially constructed, so as to

afford a watertight seat. Extension stems, guides and handwheels shall be of a standard make and quality, and approved by the Engineer.

The work shall also include the furnishing and erection of the mixing basin wood baffles indicated on the Plans. These baffles shall be spaced as shown, and shall occupy the position, extend for the full width of the mixing basin and for the length shown on the Plans.

They shall be constructed of material 1" in thickness, to be of cypress or some material equally as resistant to alternate wetting and drying and immersion in water.

These baffles shall be held in place by channels of 20 guage sheet metal placed within the concrete wall at the time of placing the concrete. These channels shall be placed so as to properly space the baffles, and shall be $1\frac{1}{2}$ " deep.

Care shall be taken in placing the baffles and guides, that the clean out openings are staggered as shown.

Baffles will be so constructed as to be readily removable.

This work shall also include the construction of cypress or equal stop planks, as indicated on the plans. These planks shall be constructed of the same kind of material as the baffles, shall be solidly constructed with iron straps, and provided with lifting handles.

This work shall also include the placing in the position indicated on the Plans, of the cast iron raw water inlet pipe, thru the wall of the mixing basin.

This work shall also include the placing in the clear well wall, of the cast iron filtered water pipe, as indicated on the Plans. It shall also include placing within the clear well and filter tank walls of the waste water sewer. It shall also include the furnishing, complete in place, the waste water sewers indicated on the Plans.

This work shall also include the placing of the cast iron strainer manifold system in the walls of the filter tanks.

This work shall also include the placing of all pump suction and filter effluent pipes in the floor of the pump room, and the necessary base plates or foundations for loss of head gauges.

This work shall also include the construction, in the pump room floor, of a manhole, giving access to the clear well. This manhole shall be located as directed by the Engineer. It shall have a substantial cast iron frame, with a clear opening of not less than 24", and shall be provided with a substantial, close fitting,

solid cast iron lid. The construction and placing of the frame and lid shall be such, that when the lid is properly placed and locked, it shall be impossible for any water to enter the clear well thru or around the frame and opening.

84. All concrete for work done under these items shall be as indicated.

All basins, tanks or structures which will be used for storing liquids or water, or shall be subject to a seepage of ground water, shall be constructed as nearly a monolith as possible, and particular care shall be taken with all necessary joints to make them watertight and impervious to moisture. Great care shall be taken also that at all points where pipes or castings pass thru floors or walls, a perfectly watertight joint is secured.

Upon completion of the structure, or part thereof, the structure or tank shall be filled with water, and the Contractor shall, at his own expense, repair all cracks, voids or imperfections, which cause the fall of 1" or more in the surface of the water in 24 hours. All places which show appreciable seepage from any of the tanks or basins on the inside of the filter house or pump room,

shall be made perfectly watertight, even if the structure fulfills the requirements for watertightness as above specified.

With proper materials, and care in mixing and placing, watertight walls should be secured with the materials and proportions specified herein. The Contractors may, with approval of the Engineer, incorporate a waterproofing material in the concrete, No additional payment will be made for such waterproofing material.

No special finishing of the walls will be required, except as specified in Article 53.

The floors of the clear well, sedimentation basin, and mixing basin shall be screeded to a smooth, hard, even surface.

The operating floor, pump room floor and stairs shall be floated to a smooth surface with a wood float.

The sides of the filter tanks shall be given a rough finish by brushing or sanding, so as to make a satisfactory joint between the filter sand and gravel and the sides of the tank.

As specified herein, the Contractor, under this item, shall place all pipe, fittings, castings or base plates. These pipes, castings, etc. shall be set in position before the concrete thru which they pass, is poured, and shall be securely anchored in the proper position for making closures in connecting pipe lines.

It shall be discretionary with the Contractor as to whether the pipes and castings shall be placed ~~as~~ the concrete is poured, or whether the openings shall be left in the structures, the pipes set and securely grouted in place.

It is the intention of these Specifications to obtain watertight joints and any method may be employed by the Contractor in obtaining such joints, as is approved by the Engineer.

There shall be erected, complete in place, the filter superstructure, including all concrete work, brick work, mortar, sills, lintels, roof sheeting and roofing, flue, flashing, door and door frame, window sash and glass, and painting necessary for the construction of the filter superstructure as indicated on the Plans.

Brick shall be No.2 Pavers or hard-burned redbrick and shall be uniform in size, straight and true. Samples of the brick to be used shall be submitted to the Engineer, and his approval as to size, quality and type shall be obtained before ordering the brick. Bricks shall be laid in regular bond, with every fifth course a full course of headers, unless otherwise ordered by the Engineer. Brick shall be laid on a level bed, with all vertical joints straight and true, and the bond must be

well preserved. Outside joints are to be pointed with a concave tool, and the inside struck with a trowel. Equal care is to be exercised in finishing both sides of the wall as no interior finish is to be applied. Bricks shall be laid with a shove joint, and all joints shall be entirely filled with mortar.

After the roof rafters have been set, the walls shall be continued to a height indicated on the Plans, and the wall finished by capping with a standard 9" vitrified clay coping tile, with necessary angle tile. Joints shall be uniform in width and not exceed 3/8" in width.

All necessary lintels, anchors, dowels or clamps for securing door frames and window sash shall be placed as the work progresses.

Upon completion of the walls, the Contractor shall thoroughly wash down both sides of all brick walls, remove all mortar from the brick, and repoint all defective joints. Joints around window sash and door frames shall be filled with mortar and pointed.

Mortar for the brick work specified under this item shall be composed of one part Portland Cement, and three parts of sand by volume. Hydrated lime, or well slacked lime putty, in a volume not to exceed 10% of the cement, may be added to the mortar.

Mortar shall be mixed in mortar boxes, with clean water. No mortar shall be mixed on the ground or floors of the structure.

Steel lintels, composed of two $3\frac{1}{2}$ " X $3\frac{1}{2}$ " X $\frac{5}{16}$ " structural steel angles, placed back to back against a 1" thick plank and bolted together, shall be placed over each window opening in the walls. The lintels shall have at least 6" of bearing on the walls.

The roof of the filter building shall consist of 1" No.1 yellow pine, $\frac{7}{8}$ " by 8" tongue and groove or ship-lap sheathing placed on 2" X 10" roof joists on 16" centers.

All exposed surfaces of sheathing and underside joists shall be surfaced. Sheathing shall be securely nailed to the joists.

The roof shall then be covered with a five-ply coal tar pitch felt and gravel roof, to be constructed according to standard specifications.

All walls shall be flashed to make a wtertight job, and the flashings shall be coated with roof pitch.

There shall be constructed at the point indicated on the Plans, or where indicated by the Engineer, a brick flue, 8"X 12" in cross section, extending the full height of the brick walls and properly capped.

All sash shall be of steel, of a make and type approved by the Engineer. They shall be of stock size, as indicated, glazed with double strength, clear glass, and shall have a ventilator of the type and size shown, and made weathertight by use of putty especially adapted to use in steel sash. Sash shall be placed in the walls in the best manner suitable to the make and type of sash. Ventilators shall be equipped with cam latch and stay bar, or other equally satisfactory operating device. All sash shall receive one shop coat of red lead and oil.

Sash glazing shall be protected by the Contractor during construction, and any glass damaged or broken shall be replaced by him at the completion of the contract. When the contract is completed, the Contractor shall clean the glass of all oil, putty, or other defacement, and shall wash and clean it, leaving it in perfect condition.

Steel sash shall be given one coat of mineral paint after erection.

The door required under this item shall be of the size indicated. It shall be solid, No. 1 quality, shall have styles of Michigan stock pine or cypress 1-3/4" in thickness, paneled and moulded. Wood panels shall be

of Georgia pine or equal. Styles and rails shall be mortised, tenoned and securely wedged and glued. Glazing shall be of double strength clear glass, and in the manner indicated on the Plans. Glass indoors is to be held in place by wood moulding set in putty.

The door frame shall be rabbited to the full thickness of the door, and it shall be 1-7/8" thick, and shall be of white pine or cypress. The frame shall be set plumb, well braced, and secured to the concrete masonry with three anchor bolts on each jamb. The door shall be hung to clear the floor, but no threshold shall be provided. Door and frame shall receive two coats of white lead and oil in colors approved by the Engineer. Wood work shall be cleaned and sanded and all nail holes and irregularities puttied before painting.

Hardware shall be provided as required for hanging doors and windows. Door shall be hung on three loose pin hinges and shall be provided with mortise cylinder lock, knobs and escutcheons.

All exterior and interior wood work, including the under side of the roof sheathing, and the rafters shall be given two coats of white lead and oil, in colors approved by the Engineer.

Window sills shall be of concrete. They shall be constructed and reinforced in a manner approved by the Engineer. Sills shall have sufficient length to afford proper bearing on the jambs, shall be set to wash and drip, and shall project 1 1/2", with a 5" face.

There shall be furnished and installed on the inside of the filter building, where directed by the Engineer, a solid bronze tablet of satisfactory design, not less than 14" X 26" in size, and having on it, in suitable, neat, raised letters, the names of the Mayor, Aldermen, Engineer and Contractor, and the date of completion.

There shall be constructed and erected on the operating floor and stairs, the pipe hand and guard rail, shown on the Plans. This rail shall be of standard pipe of the size indicated, fastened in place and connected with standard galvanized flanges and fittings. All rail shall be set straight and plumb, and all connections and construction done in a neat and workmanlike manner.

HIGH LIFT PUMPS AND PIPING.

84. There shall be installed in the filter building high lift pumps and piping substantially as shown on the Plans. However, such changes in arrangement as are necessary to accommodate various types of equipment can be made, but no changes shall be made unless plans of such changes are submitted to the Engineer and approved by him.

Pumps and prime movers shall be as specified in Articles 78 and 79.

Pumps as follows shall be furnished and erected complete in place :

Motor Driven High Lift Pump:

Number of units - 1

Service - High lift pumpin service, pumping from clear well to elevated storage tank.

Type - Horizontal, multi-stage, centrifugal.

Capacity - 500 G. P. M.

Total dynamic pumping head - 250 Feet.

Prime mover - Electric motor.

Electric current characteristics - 2200 volt, 3 phase, 60 cycle.

Engine Driven High Lift Pump.

Number of units - 1

Service - High lift pumpingservice, pumping from clear well to elevated storage tank.

Type - Horizontal, multi-stage, centrifugal.

Capacity - 500 G. P. M.

Total dynamic pumping head - 250 feet.

Prime mover - Automobile type gasoline engine.

Piping shall be as indicated, suction piping being Class "A" and discharge piping Class "C".

The discharge pipe shall be connected to the supply line at a point about two feet outside the filter building.

Discharge line valves shall be of the type specified in Article 72, with flanged body, and constructed to withstand a pressure of 300 pounds per square inch on either side.

Suction line valves shall be as specified in Article 72 and tested to 100 pounds pressure.

The suction pipe shall be equipped at its lower end with a foot valve of sufficient size and of a make approved by the Engineer.

Proper priming pipe lines shall be provided for each pump.

WASH WATER PUMP

85. There shall be installed as indicated on the Plans, a wash water pump for delivering a high velocity water wash to the filter beds.

This pump and motor shall be as specified in Articles 78 and 79. This pump shall be as follows:

Number of units - 1

Service - Filter wash service, pumping from clear well thru filter wash system.

Type - Horizontal, single-stage, centrifugal.

Capacity - 1900 G. P. M.

Total dynamic pumping head - 35 feet.

Prime mover - Electric motor.

Electric Current Characteristics - 220 volt
3 phase, 60 cycle.

Piping connections for the wash water pump shall be as indicated. Pipe shall be flanged, Class "A". All valves shall be standard gate valves, with flanged body, as specified in Article 72, tested to 100 pounds.

FILTRATION PLANT EQUIPMENT.

86. The equipment to be provided is to consist of the mechanical equipment for the two filter units as shown on the Plans, and is to consist of the following:

Strainer system, wash water troughs, beds of sand and gravel, loss of head gauges, effluent controllers, wall castings, pipe connections, sluice gates, plug valves, chemical apparatus, filter piping and chlorinating apparatus.

87. Strainer System. The strainer system shall be constructed substantially as shown on the Plans. The manifold shall consist of a good grade of cast iron pipe with flanged ends and of the weight specified. The laterals shall be of extra heavy, galvanized wrought iron pipe, which shall be capped with an extra heavy galvanized cap, and drilled as shown on the Plans. All joints between manifold and laterals shall be watertight against a pressure of 25 pounds per square in ch. No brass strainers or ferrules will be required.

Alternate plans for strainer systems may be employed, providing they do not change the general con-

struction of the system and shall be capable of handling a 24" to 27" wash.

88. Filter Piping and Fittings. The work to be done will be the furnishing and erecting, complete in place, of all cast and wrought iron piping, with all necessary special castings, fittings, valves and appurtenances, within the filter building.

The work will include the construction of the effluent lines from the filters, the construction of the wash water line, the construction of the waste water and rewash lines, the filtered water lines from the pumps to the outside wall of the filter building, together with the furnishing of all special castings, fittings, valves, extension valve stems and floor stands as indicated.

The work will also include the furnishing and erection of the filter troughs shown on the Plans.

The work will also include the furnishing and erection, complete in place, of plug drain valves and sluice gates, as indicated on the Plans and specified in Articles 72 to 77. All valves and sluice gates shall be equipped with extension stems, brackets and floor stands, as indicated on the Plans.

The work shall also consist of furnishing and erecting all pump suction lines, complete in place, together with all special castings and foot valves. Foot valves furnished shall be of standard make and quality, approved by the Engineer.

The work shall also consist of the furnishing and erecting all necessary stirrups, saddles, rods, or wrought iron columns necessary for the proper support of pipe lines.

Wrought iron pipe specified for the rewash line shall be galvanized and extra heavy, Byers make, or equal.

The arrangement of piping shall be of the general plan shown, but some rearrangement will be permitted to facilitate different types of equipment. The Contractor shall submit detailed plans for the approval of the Engineer, of any modification he proposes to make in the piping plan, showing dimension of all lines, valves and fittings and their connection with pumps and rate controllers, but no work shall be undertaken without the written approval of the alternate plan by the Engineer.

89. Effluent Rate Controllers. There shall be furnished complete in place, two rate controllers of the Venrurá

tube type, one on the effluent line from each filter, with all connections, apparatus and appurtenances.

The controllers furnished shall be of the enclosed type of make which has been in successful use for at least three years.

The controllers shall be capable of maintaining constantly any desired rate of flow, between the limits of 250,000 gallons and 425,000 daily, without any pounding or surging under the varying heads resulting in the operation of the filters, and the actual rate of flow shall not vary at any time more than 3% from the mean rate for which the controller is set. When the water is passing thru the controller the maximum total head required shall not be more than 12" for the rate above specified.

Each controller shall be provided with a plainly readable device for setting at any desired rate of flow within the limits specified.

After installation and under the direction of the Engineer, each controller shall be carefully tested by the Contractor, accurately calibrated and put in satisfactory running order.

All wearing surfaces, threats, orifices and stuffing boxes shall be of bronze or suitably faced with bronze. The indicating device shall be nickel-plated and all the auxiliary piping, valves and cocks shall be of bronze.

The outlet of each controller shall be provided with a suitable trap and all the necessary water connections shall be provided and installed.

90. Loss of Head Guages. There shall be furnished and installed, complete in place, at each filter an indicating loss of head guage, of a type approved by the Engineer. This guage shall be complete with all the necessary float tubes, counterweights, cords and other apparatus necessary to accurately indicate the loss of head in the corresponding filter. The guage shall be of the differential float type and shall register loss of head from zero to twelve feet maximum. The connections from the filters and the effluent pipes shall be of galvanized wrought iron with a brass nipple thru the concrete wall of the filter. Proper provision shall be made to prevent the entrance of wash water or sand into the float chamber. The mechanism of the guage shall be of brass and enclosed in a strong, neatly finished nickel-plated or

japanned brass case arranged on a pedestal mounting and to be readily accessible.

91. Filter Sand and Gravel. There shall be furnished filter sand and gravel, graded as herein specified and of the quality specified.

Filter gravel shall consist of hard, durable, rounded particles of material, of a relatively high specific gravity. It shall be free from contaminating material. It shall be screened and washed free from all sand, clay, loam or any organic impurity, and then placed in layers, as herein specified, immediately over the strainer system.

Before placing the gravel, the filter tanks shall be thoroly cleaned, and ^{no} dirt or foreign matter of any kind shall be allowed to enter the filter tank after beginning to place the gravel. Failure of the Contractor to observe the proper precaution will result in the removal and disposal of any contaminated gravel, and its replacement with clean gravel, at the expense of the Contractor.

Care shall be taken in placing the gravel, that the strainer system is not injured, and to avoid mixtures of gravels of different sizes. Gravel so mixed shall be removed and replaced at the expense of the Contractor.

The gravel shall be carefully placed by careful spreading, and shall not be dropped from any appreciable height.

Gravel shall be placed in layers of the size and thickness indicated in the following table:

Layer	Depth. Inches	Diameter in circular ring inches	
		Thru which gravel will pass	Upon which gravel will be retained
Bottom			
2nd	6	2	1
3rd	4	1	3/4
4th	3	3/4	1/2
5th	3	1/2	1/4
	2	1/4	1/10

92. Filter Sand. Filter sand shall be composed of pure quartz and with hard, durable grains, sharp or rounded, free from clay, loam, dirt or organic matter, and relatively free from micaceous particles.

Filter sand shall have an effective size of not less than 0.38 of a millimeter, nor more than 0.44 of a millimeter, and a uniformity coefficient of not more than 1.65. Not more than 2/10 % shall be finer than 0.2 of a millimeter, and not more than 1% shall be finer than 0.25 of a millimeter, and at least 90% shall be finer than 0.8 of a millimeter. The diameters of sand gross shall be

computed as the diameters of spheres of equal volume and all percentages calculated by weight..

The Contractor may place in the filter tanks sand which does not strictly conform to the Specifications for effective size and uniformity coefficient, provided that he shall, after placing, thoroly wash the sand by means of wash water introduced by the strainer system at a satisfactory rate, and he shall remove the fine sand remaining upon the surface of the filter after washing, by scraping if necessary. He shall repeat this process until the sand remaining is of the required size, depth and uniformity.

Especial care shall betaken in the transportation and placing of filter sand to prevent contamination of any sort, and sand which may have become dirty, either before or after placing in the filters shall be removed and replaced by clean sand in a satisfactory manner. All sand contaminated by organic matter shall be rejected. After sand is placed in the filters, it shall be washed at least ten times, with the washing devices connected with the filters, and fine sand appearing at the surface shall be removed by scraping. Sufficient sand shall be placed in each filter to secure a layer at least thirty inches in depth after the sand has been washed and scraped, and conforming to the sizes above shown.

After the sand has been placed in the filters, the Contractor shall protect it as may be necessary from dirt or other contamination.

The Contractor shall furnish for tests, samples of sand, consisting of not less than one quart, taken under the direction of the Engineer. Each sample shall be labeled, stating whether it has been washed or screened, or both, and the place from which it is taken. All samples shall be furnished in mason jars or similar tight receptacles. The same will be carefully tested by the Engineer to determine its conformity with the Specifications.

93. Floor Stands. There shall be furnished ten floor stands, one for each valve in the filter piping. These stands shall be of cast iron provided with extension stems for connection to the valves. They shall have a handwheel 12" in diameter, and shall have on them plates or raised letters indicating the purpose to which they are to be used and the direction of opening.

They shall be securely fastened to the concrete floor.

94. Chemical Feed Apparatus. There shall be furnished and erected, complete in place, with all valves, fittings, connections and pipe, on the operating floor, two constant

level chemical feed orifice tanks. These orifice tanks are to be built of cast iron, of suitable size, with the interior porcelain enamel lined, and are to be rigidly supported on a metal support or framework, at such a height above the floor as will provide a gravity feed from the tanks to the point of application of the solution.

These orifice tanks shall be provided with a balanced float valve, with a hard rubber or glass float, which float valve shall be constructed to control the level of the solution within the tanks at a fixed height.

These tanks shall be provided with an adjustable orifice, constructed of a suitable durable material, and the size of the orifice shall be adjustable by a suitable means, so that tanks may be set to feed from 0 to 500 gallons of solution per 24 hours.

There shall be provided piping of 1" iron pipe size from each tank to the orifice tanks, as indicated on the Plans, and provided with acid-resisting bronze valves as shown. There shall also be provided a pipe of 1" iron pipe size from each orifice tank to the point of application of the solution in the mixing basin. All solution piping shall be in straight lines and is to be made up of plugged tees, crosses or wyes, where changes of direction are made, to facilitate rodding.

Solution piping shall be placed so as to be easily accessible for renewal, and suitable wall pieces shall be provided where solution pipes pass thru walls of the solution tanks and building walls.

All materials used, including valves, shall be of a special acid-resisting composition that will not be attacked by the action of the chemical used.

There shall be provided by the Contractor a line of 3/4" galvanized wrought iron pipe, extending from the filtered water high pressure line in the pump room to a point above each solution tank. Above each solution tank shall be placed an outlet and valve for supplying filtered water to each tank.

There shall be provided means for making a pressure connection between the water lines and the solution lines for the purpose of flushing the solution line thruout its entire length.

95. Chlorinator. There shall be furnished and installed, complete in place, and ready for operation, one Wallace and Tiernan, manual control, solution feed chlorinator, with all necessary piping and connections from the apparatus on the operating floor to point of application of solution in suction pipes of high lift pumps.

The apparatus is to be furnished complete, with all necessary equipment, tools, instructions and operating charts.

There shall also be furnished one tank, containing 100 pounds of liquid chlorine, also one platform scale having a capacity of 500 pounds.

95. Laboratory. There shall be constructed by the Contractor, in the location indicated on the Plans, an office and laboratory. This laboratory shall be equipped with a cast iron enamelled sink with connection to a soil pipe leading to the wash water sewer, and a 3/4" galvanized pressure pipe line with a faucet. There shall also be furnished a small table with unfinished top not less than 30" X 60" in size.

There shall also be provided a wooden cabinet approximately 18" square and 7 feet high, having three drawers each 12" in depth, the remainder of the cabinet to be equipped with shelves, with double doors and cabinet latch.

There shall also be furnished laboratory equipment of Wallace and Tiernan manufacture, designated as their Ortho-Tolidin Water Testing Outfit, Outfit "C", also Outfits designated Outfits "D" and "E", or if the Contractor so elects he may furnish such articles as are required by the regulations of the State Department of Public Health for making tests for alkalinity, color, turbidity and free chlorine.

HIGH TENSION TRANSMISSION LINE

96. There shall be constructed from a designated point in the City a 6600 volt, 3 phase power line, extending in an easterly direction along State Route 15 a distance of 36,000 feet to the east line of the filter site.

This line shall be constructed in a right-of-way procured by the City, and shall terminate and connect with the filter building as more fully described below.

The work shall consist of all labor, hauling, and materials to erect the line complete in operating condition according to underwriter, City and State regulations and the approval of the Engineer.

Transmission line is to carry a potential of 6600 volts, 3 phase, 60 cycle.

The pole line shall consist of 36 foot northern white cedar poles with butt treatment, drilled and galvanized at the job for proper size cross-arms and hardware.

Poles shall be set five to six feet in the ground and shall be spaced on centers of 150 feet with one pole at the filter plant coming close to the building to carry 2200 volt 3 phase service connections for motors in that building and then continue down to pump building at river's edge to transformers in that building.

Each pole shall have crossarms of fir long enough for proper spacing of 6600 volt conductors. Pins and insulators shall be of large type, insulators of high voltage test vitreous porcelain.

All carriage bolts, machine bolts, lag screws, cross arm braces, guy thimbles, cable clamps, ground anchors, etc., necessary to properly install line shall be galvanized/

Line shall be rigidly guyed at both ends and doubly guyed at two intervals to each mile of pole line, also at any turns in the line. Guy lines shall be of heavy strand guy wire with strain insulators in between and fastened to ground with an approved deep seating ground anchor having thimbles, clamps and moused ends.

Wire to be used shall be 3 No. 6 B&S gauge hard drawn bare copper between point of service and filter plant, and 3 No. 6 B&S gauge triple braid weatherproof wires between filter plant and pump house.

An additional six pin cross arm shall be bolted to each pole between the filter building and pump house to carry secondary wires as follows: 4 No. 12 B&S gauge weatherproof wires for pilot lines to

compensators in pump building, and 2 No. 10 B&S guage weatherproof wires for 110 volt lighting service in filter plant from transformers in pump building.

At point of service in the City, at point of service to filter building, and again outside of pump building, sets of multigap, compressed chamber lightning arrestors shall be installed and grounded to ground rod at base of pole with No. 6 insulated wire and soldered connections.

All lines shall be tied to insulators with regulation tie. Two sets of fusible plug disconnects shall be placed, one in each line at point of service in the City, and another set just ahead of filter plant connection.

A service drop of 3 No. 6 triple braid weatherproof wires shall be tapped off and dropped to insulator brackets on wall of filter building at location of service conduits.

At the pump house the 3 No. 6 weatherproof conductors shall be brought to insulator brackets on wall at service conduit. The 3-6600 volt feeders shall be carried thru the wall in this conduit with three No. 6-6600 volt rubber covered wires and connected to primary of transformers set on the upper floor of the pump house. The secondary and pilot lines shall terminate on wall insulator brackets on buildings at both ends where conduits are

located for same.

There shall be furnished and connected as designated two 6600 volt primary to 220 volt secondary oil cooled transformers with intermediate tap for 110 volt for lights from one transformer and 3 phase 20 volts for power from both connected. These transformers are to be complete with fusible cutouts, oil, etc.

The line shall be completed in a workmanlike manner according to modern practice, and shall be cut in and put in service at the direction of the Engineer and left in proper operating condition.

The conduits for service connection in each of the two buildings covered is specified in Article 97.

97. Power Wiring Filter and pump station shall be wired in a galvanized conduit for power and light service as hereinafter more fully described.

All work shall be done in compliance with Underwriters, City and State regulations.

All cables for power shall be double braid rubber covered 6600 volt with all terminals properly soldered to heavy copper lugs, with all splices outside conduits or in junction boxes wiped with solder, and taped with rubber, varnished cambric, and friction tape and then coated with insulating paint.

Type and dimensions of the buildings in which this work is to be done are shown upon the Plans.

Two motors and compensators are to be wired for and connected in the filter building, one to be 50 HP, and another 25 HP, both operating on 220 volts, 3 phase, 60 cycles. Both of these motors will be on the pump room floor with one compensator on this floor, and another on the operating floor, suspended in a manner approved by the Engineer.

A conduit not smaller than $1\frac{1}{2}$ " with proper pothead or conduit shall be installed where service wires enter the filter building; into this conduit there shall be pulled 3 No. 6 rubber covered 2500 volt wires. Inside the building these wires shall be connected to a 3 pole, 60 amp., 2500 volt main oil switch, with overload and under-voltage releases. Carry 3 load side wires from this oil switch to two smaller switches of smaller amperage, one ahead of each motor compensator to be used as a safety and disconnecting switch.

All wiring between oil switches and compensators, and between compensators and motors shall be in conduit and all conduits shall be linked together and grounded in an approved manner. Oil switches, compensators and motor frames shall also be grounded. All oil switches and

starters shall be filled with oil and regulated and left in proper operating condition.

The Contractor shall connect on the wall of the filter building 2 single pole momentary switches from wires brought to the building from the pump building, to be used as stopping devices for the two low lift pump motors.

Low lift pump house shall be wired in galvanized conduit for two 20 HP, 220 volt, 3 phase motors and compensators as follows: Connect three No.2 RCDB 600 volt wires in $1\frac{1}{2}$ " conduit from 3 phase 220 volt secondary wires of transformer on upper floor and run same to one 3 pole, 200 amp., 250 volt main switch. At each side of this safety switch mount a 3 pole, 100 amp., 20 volt fused safety switch as a safety disconnect, and from each of these switches connect compensators and 20 HP motors. Connect from push stop buttons on each compensator a pair of No. 14 rubber covered wires in $\frac{1}{2}$ " conduit to outside conduit where pole line runs from same to filter plant.

All conduits, switch cabinets, starters and motor frames in this building shall be properly grounded,

All fuses for proper operation shall be installed and one extra fuse of each size furnished and left in

each cabinet.

The entire power installation in both buildings shall be left in complete working order.

98. Light Wiring. Both pump and filter houses shall be wired for 110 volt electric lights, in galvanized conduit with rubber covered wire as follows:

At transformers in pump station connect 110 volt, 2 wire tap to a 30 amp., 125 volt, 2 circuit combination safety switch and circuit fuse cabinet; from one circuit run two wires out thru conduit from connection to pole line, covered elsewhere separately in these Specifications. From the other circuit wire in for lights in pump house one 220 watt outlet on each floor, each with snapswitch, lamp and large industrial porcelain enamel reflector.

In filter building wire for lights as follows: Run conduit out to connect to 110 volt wires from pole line and down into fuse block in sheet iron cabinet. From this fuse block run to four 200 watt outlets for lights in ceiling of operating floor, and to two wall receptacles in operating room. Run wire to four light outlets on ceiling of pump room.

Each floor shall have a separate snapswitch, and all light outlets shall have lamp and enameled industrial reflector

All light wiring shall be left complete with all the necessary fuses in place. All conduits shall be grounded in an approved manner and all wires shall be free from grounds and short circuits. The light wiring shall be left in a satisfactory operating condition.

HEATING.

99. Heating of the filter building shall be by a stove connected to the 8" X 8" X 12" flue indicated on the Plans.

Stoves shall be of the type known as the heavy cannon stoves, and shall have a firepot not less than 18" in diameter. Before purchasing this stove the Contractors shall submit specifications of it to the Engineer for approval.

The stove shall be erected complete in place with all necessary smoke piping.

WATER SUPPLY LINE

100. There shall be constructed a cast iron pipe line, 10" in internal diameter, connecting with high lift pump discharge at the filter building and with present city mains at Main and E. Fourth Streets.

This pipe line is approximately 35,400 feet in length and shall be located upon the right of way of State Route 15 as designated by the engineer of the Department of Public Works and Buildings, Division of Highways.

The line shall be constructed of pipe of quality specified in Article 62 of these Specifications, and shall be laid and jointed as specified in Articles 63 to 67, inclusive.

There shall be installed in the pipe line, automatic air valves, lever and float type, installed in brick or concrete manholes $3\frac{1}{2}$ feet in internal diameter, and provided with cast iron manhole frame and cover, as indicated on the Plans.

Connection to the present city mains shall be done in a manner approved by the Engineer, and any fittings or special castings shall be approved by the Engineer.

PART V - CONCLUSION

CHAPTER I - FINANCING THE PLANT

CHAPTER II - CONCLUSION

CHAPTER I - FINANCING THE SYSTEM

One of the greatest problems met in the construction of a water supply system like the one described in this thesis is the question of finances. As has been stated before, in localities or towns where the energies of the entire working population ~~is~~^{are} bent toward the development of a mine or some industry, that mining company or industrial concern quite often furnishes the capital necessary in a project of this nature. This, however, is the exception rather than the rule, so it is almost imperative that the engineer be familiar with this phase of the work as well as those of a purely technical nature.

The laws of the State of Illinois give municipalities three different ways in which to raise money for works of a public improvement nature. They are as follows:

1. By bond issue
2. By special assessment
3. Certificates of indebtedness

The bond issue system is one which is not very often used in works of this nature. The amount to which a city or village may bond itself is set by

law, and is a very small percentage of the total assessed valuation of the property in that town. In towns of the size for which this water supply system was constructed this limit of bonded indebtedness is rather small and would represent but a small portion of the money needed. Then, too, quite frequently such towns are already bonded to their limit and it is impossible to, legally issue more bonds.

The special assessment method is one used more frequently in financing waterworks systems. In this method the system is paid for by levying a special tax against the property owner being benefited, and he pays in proportion to the benefits he derives from the improvement. It would seem, at first that, that it would be impossible to finance a waterworks fby this method for this reason: The amount necessary must be assured before the plant can be started. The number of consumers is necessarily small at the start but increases from year to year. It would be obviously unfair to levy a special assessment against the initial users of the water, and to allow users to tap on to the mains later without sharing in the initial cost of the plant. This difficulty is gotten around by financing the construction

of the distribution system alone by special assessment and financing the remainder of the system by different means. In this case the cost of the water mains, tank, fireplugs, etc. is pro-rated among the property owners which they benefit and the property owner pays his portion of that cost whether he becomes a consumer immediately or waits until a later date to start using the water. Under this plan the mains may at any time be extended and the new owners benefited according to the cost and the benefits derived. In the city referred to in this thesis, water mains were laid several years ago under this plan, so it was not necessary to levy a special assessment against the individual property holders.

This plant was financed by the third of the above, namely, by issuing certificates of indebtedness or water certificates. An explanation of what water certificates are can best be had by reference to an act of the ^{State} Illinois General Assembly of 1899, entitled, "An act authorizing cities, towns and villages to build, purchase or extend water works systems for public and domestic use and to provide for the cost thereof," which reads as follows:

Section 1. Every city, incorporated town and village in this State, is hereby authorized to acquire water works for supplying water for public use, and domestic use of its inhabitants by building or purchasing water works system or enlarging or extending an existing system. In payment of such building, purchase or enlargement such municipality may issue certificates of indebtedness limited in their payment solely to the water fund hereinafter provided for; such certificates may bear interest at a rate not to exceed six per centum per annum, payable semi-annually, and shall only be issued at not less than par value in payment for the building, purchase or extension of a water works system.

Section 2. Any such municipality desiring to avail itself of the provisions of this act shall first pass an ordinance fixing in a general way the capacity of the water works system it is proposed to acquire, and referring to the plans and specifications therefor which shall be open to the inspection of the public; which said ordinance shall fix the rates at which the water is to be supplied

for all private purposes, and said rates so fixed, shall not thereafter be reduced until the certificates issued for the acquiring or enlarging the water works, and the interest thereon, are fully paid. Which said ordinance shall be published in a newspaper published in such municipality at least once in each week for three successive weeks. And if no petition shall be filed with the clerk of such municipality as hereinafter provided, within twenty-one days after the first publication of said ordinance, then corporate authorities may proceed to carry out the provisions of the ordinance. But if within said period of twenty-one days there shall be filed with the clerk of such municipality a petition, signed by twenty per cent of the number of voters voting for the presiding officer of the legislative body of such municipality at the next preceding city, town or village election, asking that the question of acquiring or enlarging a water works system be submitted to a vote. It shall then be the duty of the legislative body of such municipality to call a special election in the manner provided by law to vote upon such question, and if

it appear that a majority of voters voting upon such question at such election vote in favor of acquiring or enlarging the waterworks, then said ordinance shall be in full force and effect and the corporate authorities may proceed to carry out the provisions thereof, but if a majority of the votes are cast against such acquiring or enlarging, then said city, incorporated town or village shall proceed no further for the period of six months next ensuing.

Section 3. Whenever any such municipality shall avail itself of the provisions of this act, the entire proceeds arising from the operation of the water works thereof shall be paid into a fund known as the "water fund" and which fund shall be and remain inviolate until the certificates issued under the terms hereof and the interest thereon is fully paid, and the treasurer of such municipality shall not pay any warrants drawn on said fund unless the same be drawn in payment of the necessary operating expenses of such water works system, or in payment of the certificates issued hereunder or the interest thereon.

Section 4. In order to secure in the most ample manner the payment of the water certificates authorized as aforesaid, any such municipality may convey by mortgage or deed of trust the water works so acquired or enlarged which said mortgage or deed of trust shall be acknowledged and recorded in the same manner as mortgages of real property, and which mortgage or deed of trust shall contain such provisions and conditions as are reasonably necessary to fully secure the payment of said water certificates.

Section 5. Whenever, and as often as default shall be made in the payment of water certificates issued as aforesaid, and such default shall continue for the space of ninety days, it shall be lawful for said mortgagee or trustee to declare the whole of the principal and interest of such certificates at once due and payable, and proceed to foreclose the same in any court of competent jurisdiction, and in any decree to be rendered in such suit of foreclosure there shall be included a reasonable solicitor's fee for the complainant's solicitor, and such decree shall fix reasonable rates for water furnished from said

water works system for public uses during the time that such municipality shall be deprived of the possession thereof as hereinafter provided, and upon any sale under such decree of foreclosure the person or corporation offering to satisfy said decree for the rents, incomes and profits of said water works system for the least number of years not exceeding fifty, shall become the purchaser thereof, and on satisfying said decree shall be let into the use, occupation and enjoyment of said waterworks system during the time for which the same were sold, and during such period such purchaser or assigns shall be entitled to receive and collect for water furnished for private purposes the rates prescribed in the ordinance provided for in Section 2 of this act, and shall be entitled to receive and collect the reasonable rates fixed for the public uses of water in such decree. At the end of said period said purchasers or assigns shall deliver said waterworks system to such municipality in as good condition as when the same was received, ordinary wear and tear excepted.

Section 6. During the time when the purchaser at such foreclosure sale shall be entitled to the use and enjoyment of said waterworks system, it shall not be competent for such municipality to construct or authorize any person or corporation to construct a competing system of water works, nor shall it be competent for the purchaser at such foreclosure sale, or assigns, to extend the water works system so purchased, except on such terms as such municipality may authorize.

Section 7. This act shall be deemed and construed to confer powers in addition to, but not limiting those now existing.

In brief, the water works certificate act is merely a law which allows cities and villages to extend their bonding limit to cover waterworks systems. The only difference between municipal improvement bonds and water certificates is that whereas the principal and interest of the former are paid from general taxation, the latter are retired from the income of such water works system. In addition to furnishing this money to retire the bonds, the ^{rates} for water must be sufficiently large to take care of all current expenses, repairs, depreciation, etc.

It is obvious that this act is a boon to small towns and villages that have a low bonding limit. The law has been used with great success in Illinois, and with the exception of a few rare cases, the towns availing themselves of its use have not had to default on the payment of the bonds. The bonds are generally issued in blocks of one, three, five, ten and twenty year maturities, and in several instances the towns have been able to retire all the bonds in as little as ten years.

In the City described herein, water certificates to the amount of \$150,000 were issued. The entire issue was taken up by a reliable title and trust company who made cash payments to the contractor, discounting the bonds about fifteen points. This company in turn has sold many of the bonds to its clients; it holds a mortgage deed of trust on the entire system, receives a certain quarterly income from the plant, and interest and principal of the bonds are paid to the bond-holders at its office. In case the City should default upon any payments, the trust company is empowered by the act to foreclose the mortgage, and either take over its operation or employ a competent person or corporation to do so. From the first few months of the operation of this plant it became quite evident that there would be no danger of defaulting on any payment;

in fact, by basing calculations on the first two months' income of the plant, plus a conservative figure for an increase in revenue, it has been estimated that all the bonds will be retired in from ten to fifteen years.

CHAPTER II - CONCLUSION

It has been the purpose of this thesis to present and show the methods of solving the problems encountered in planning a water works system for a small mining community. The question of water purification is one that every mining engineer ought to understand; the greater portion of this thesis deals with but one of the many specialized problems coming under that head. That this thesis covers this phase of the problem thoroly and accureately cannot be doubted, for the detailed subject matter covers a water works system which is in actual successful operation in a small mining town in southern Illinois.

PART VI - BIBLIOGRAPHY AND INDEX

INDEX

(Numbers refer to pages)

Bidder	
General instructions to	40
Bond of	42
Clear Well	32
Cast Iron Pipe, Lines (Ball and Spigot)	
Excavation and backfill	67
Lead and Jute	67
Materials	67
Pipe Laying and Jointing	69
Testing of	71
Valves and Valve Boxes	70
Cast Iron Pipe Lines (Flanged)	
Joints	72
Placing	72
Quality	72
Test of	73
Valves in	73
Chemical Treatment	18
Chlorination	15 - 19
Chlorinator	110

Contract	42
Annulment of	53
Contractor	
Defined	44
Duties of	49
Employees of	50
Liability of	49
Concrete	
Consistency of	59
Finish of	63
Forms	60
In Freezing Weather	60
Mixing of	58
Placing of	59
Protection of	60
Excavation	
Earth	79
Rock	83
Filter	31
Materials	16
Coagulation	17
Containers	16
Sludge	17
Filter Building	
Substructure and superstructure	80

Filter Equipment	
Chemical Apparatus	108
Floor Stands	108
Loss of Head Guages	104
Pipe and Fittings	101
Rate Controllers	102
Sand and Gravel	105
Strainer system	100
Filtration, mechanical	15
Filtration Plant	21
Finance	121
Heating	119
High Lift Pumps	97
Intake Tower	84
Low lift Pumps	26
Low Lift Pump House	84
Materials of Construction	
Concrete	56
Cement	56
Gravel	58
Reinforcing steel	61
Sand	57
Vitrified Tile	63
Water	58

Operating room	34
Operation of Plant	35
Patented Devices	50
Payments	54
Permits	51
Plans and Specifications	
Interpretation of	48
Power	
High Tension Line	21-112
Light and Power Wiring	21
Light Wiring	118
Transformers	21
Wiring	115
Pumps and Prime Movers	75
Pump, Washwater	99
Sedimentation Basin	28
Specifications - Detailed	84
Specifications - General	
City defined	44
Contractor defined	44
Engineer defined	44
Plans defined	44
Ordinance defined	45
Specifications defined	44

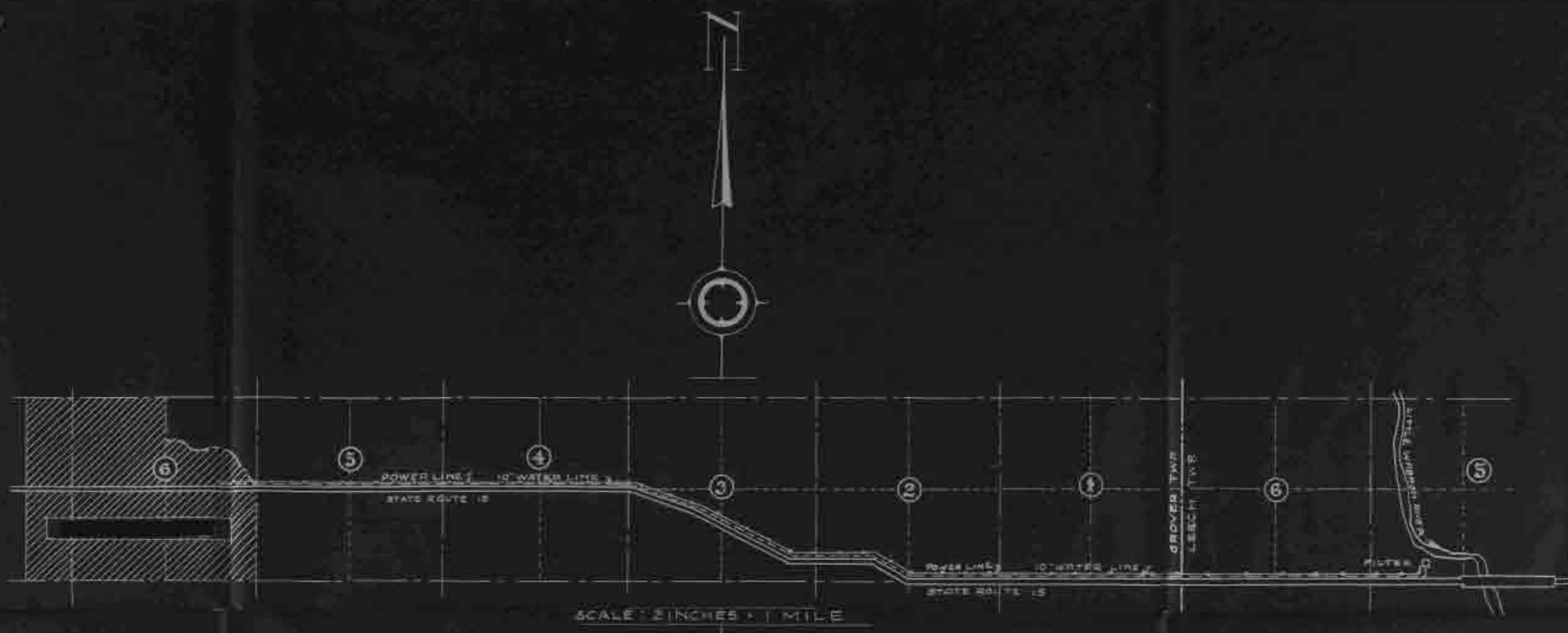
Sanitary Provisions	51
Sewage Disposal	5
Sluice gates and Plug valves	74
Suction Well and Line	23
Water	
Mains	21 - 119
Tank	23
Water Purification	
Diseases	12
Impurities	12
Methods of	15
Work	
Acceptance of	55
Failure to Complete	52
Failure to remove defective	52
Final Acceptance of	55

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Machinery Co.
Bulletins and specifications of the Fairbanks Morse Co.
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Carnegie Handbook of Steel
REINFORCED CONCRETE CONSTRUCTION - Vol. 1, Hool
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TEXT-BOOK ON HYDRAULICS, Russell
Handbook of Electrical Engineering
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Co. and Iowa Valve Co.
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INDEX TO PLANS

TITLE	PAGE	NW	Index
SHEET NO. 1	-		General Layout
SHEET NO. 2	-		Filter Building
SHEET NO. 3	-		Filter Building Layout
SHEET NO. 4	-		Clear Well
SHEET NO. 5	-		Mixing basin Details
SHEET NO. 6	-		Filter Details
SHEET NO. 7	-		Operating Floor Layout
SHEET NO. 8	-		Pump & Piping Details
SHEET NO. 9	-		Low Lift Pumps and Suction Well
SHEET NO. 10	-		Intake Pump Building
SHEET NO. 11	-		Mixing & Sedimentation Basin Reinforcing
SHEET NO. 12	-		Pipe Line

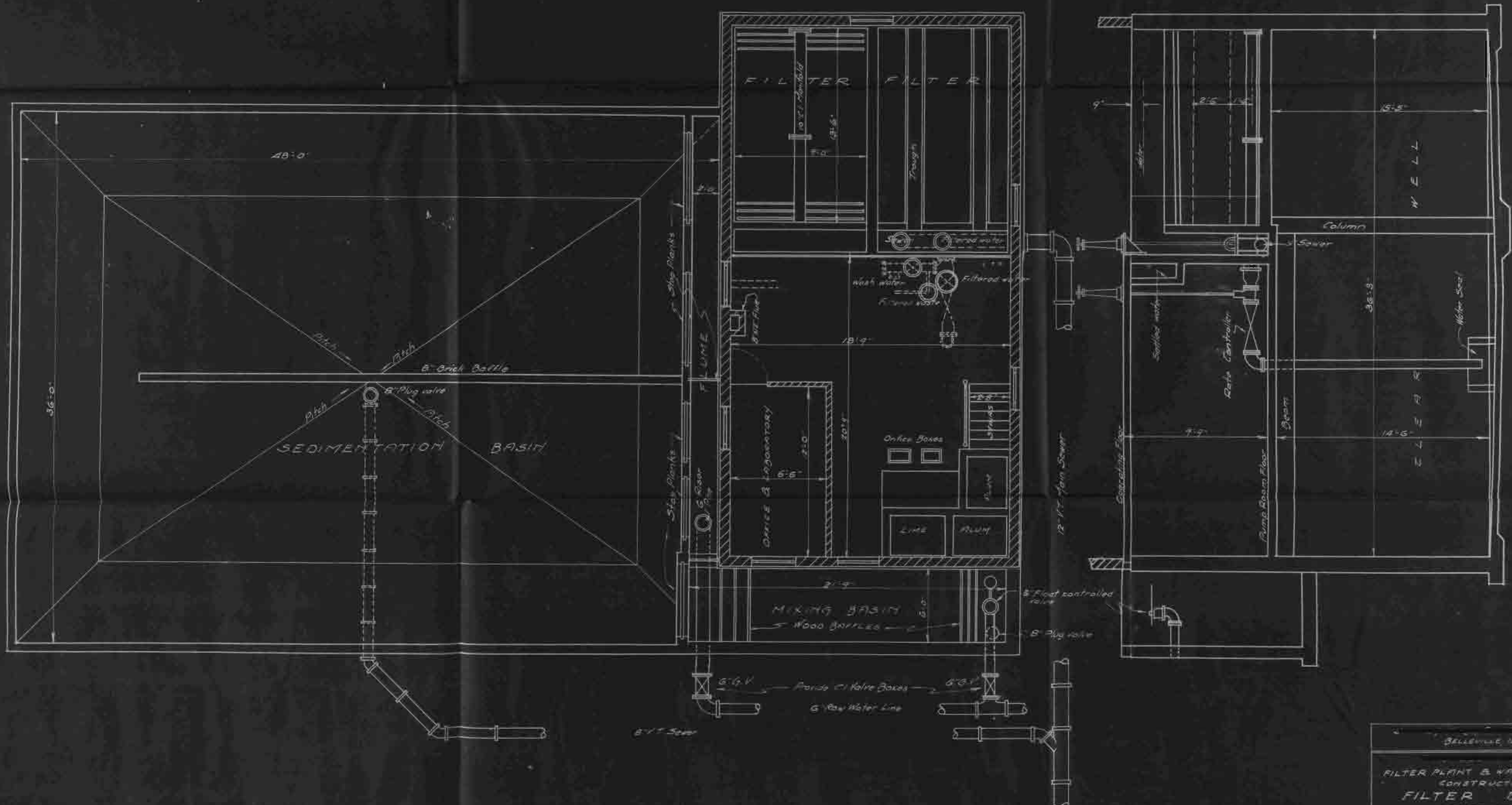


CITY OF
ILLINOIS.

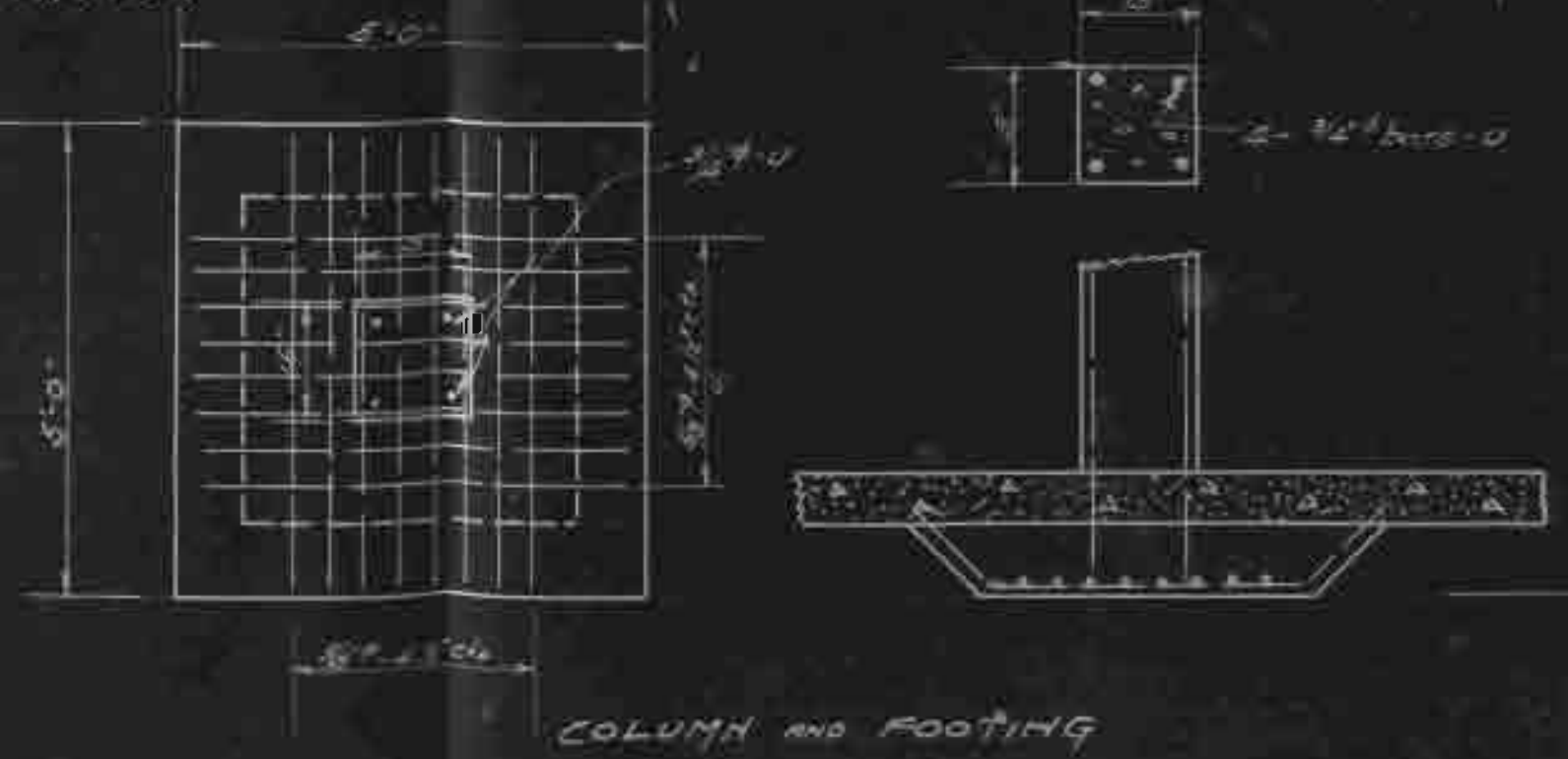
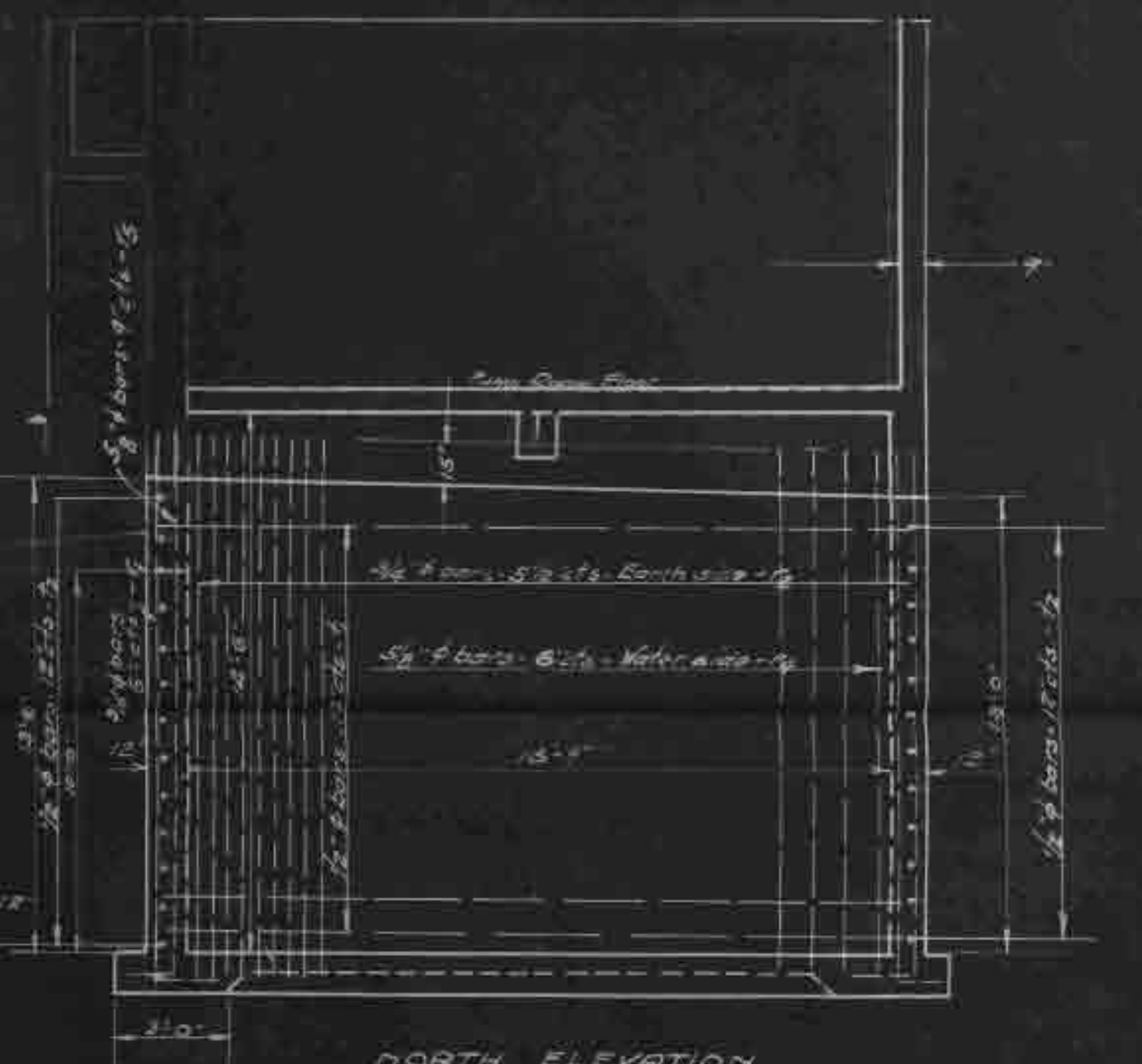
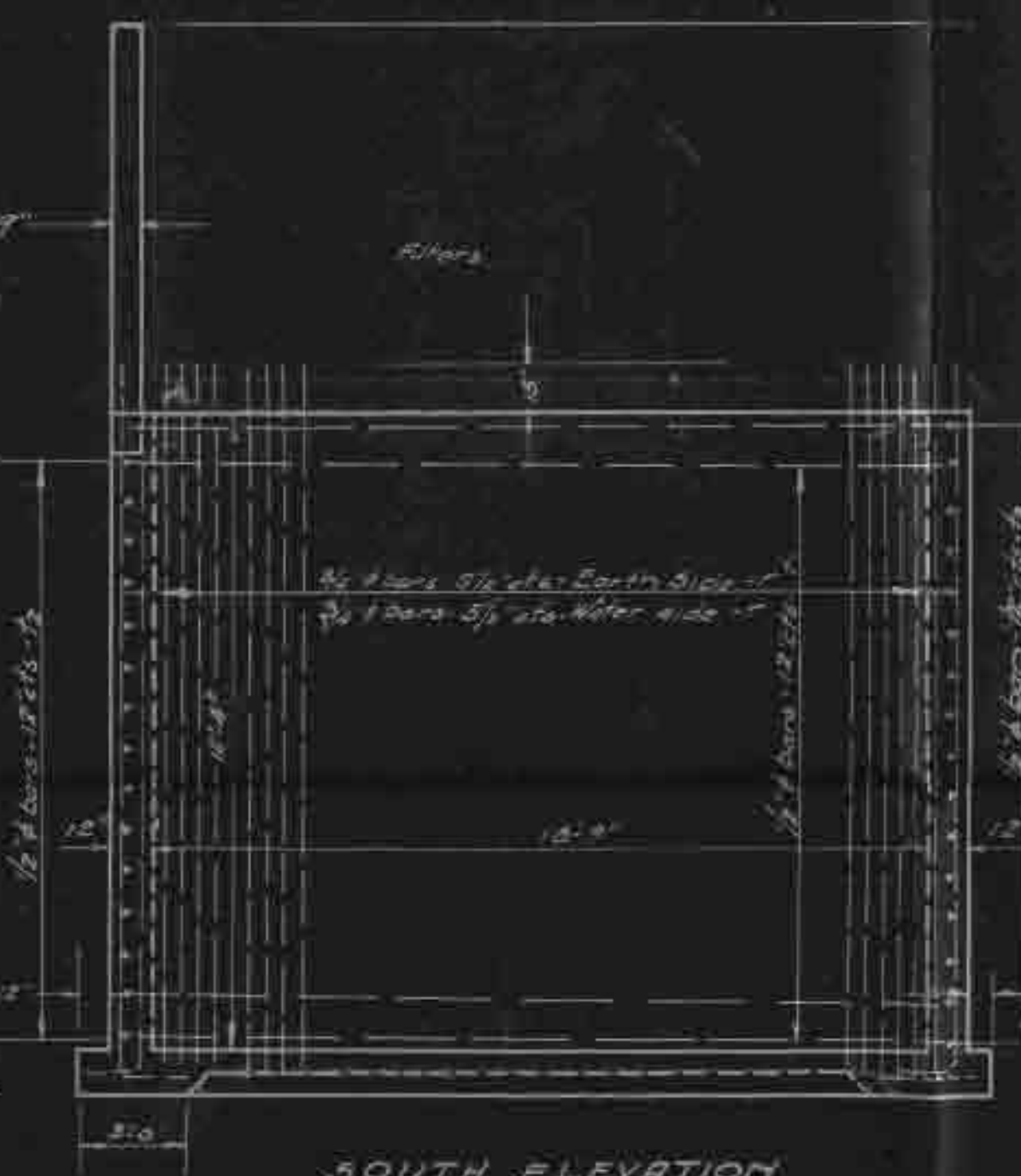
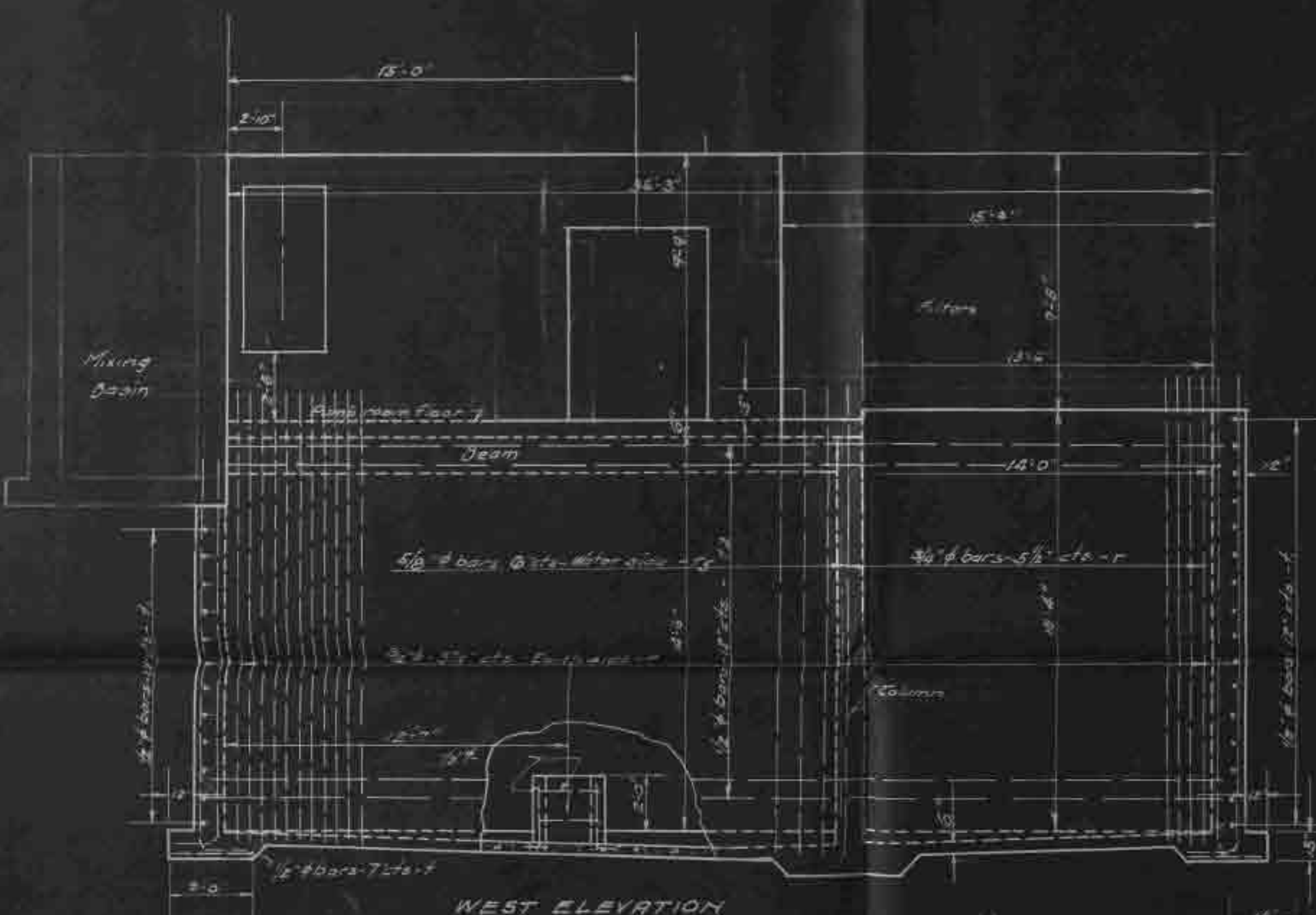
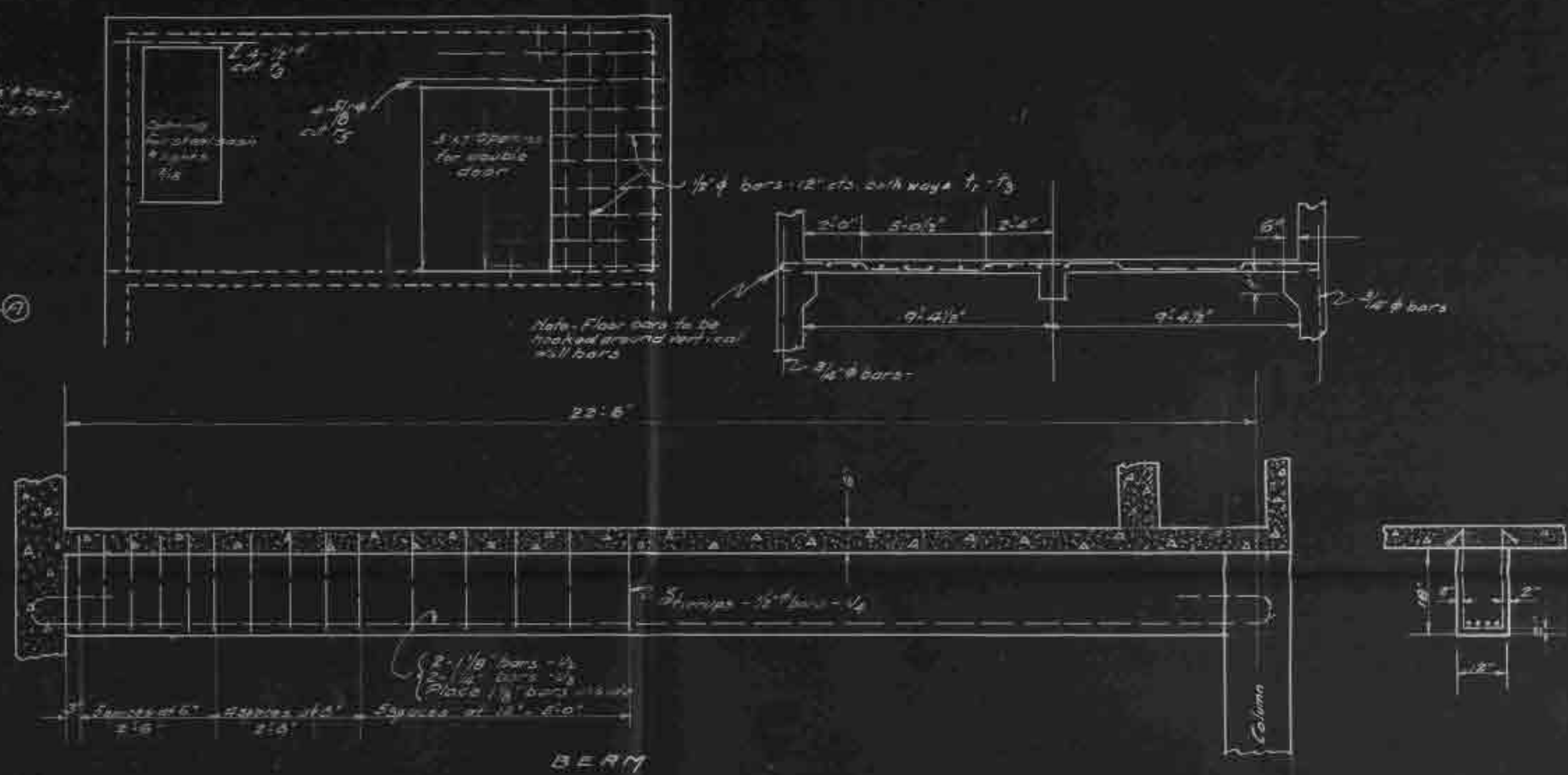
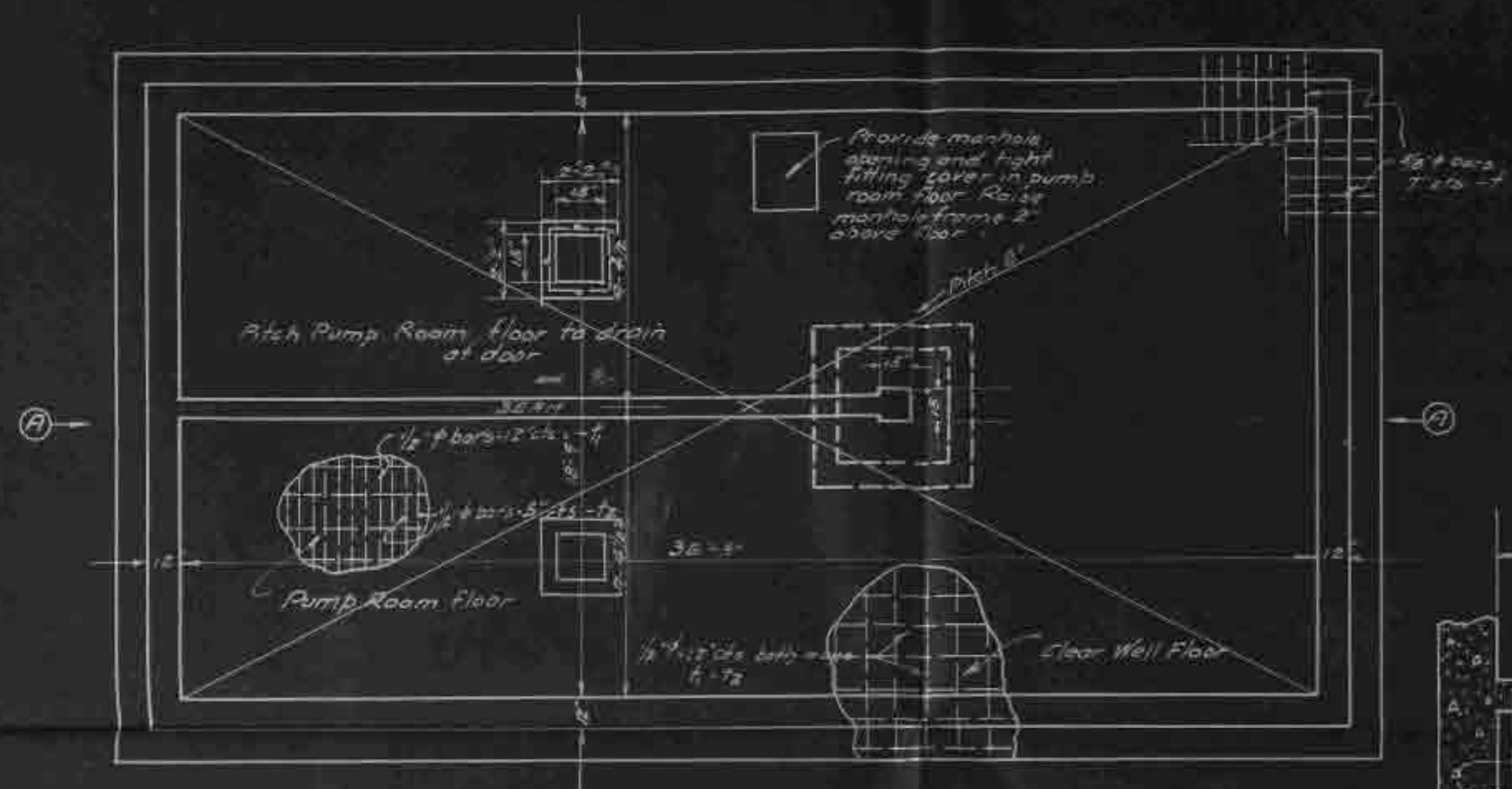
WATER SUPPLY CONSTRUCTION

INDEX TO DRAWINGS

- SHEET N°1 - GENERAL LAYOUT
- SHEET N°2 - FILTER BUILDING
- SHEET N°3 - FILTER BUILDING LAYOUT
- SHEET N°4 - CLEAR WELL
- SHEET N°5 - MIXING BASIN DETAILS
- SHEET N°6 - FILTER DETAILS
- SHEET N°7 - OPERATING FLOOR LAYOUT
- SHEET N°8 - PUMP & PIPING DETAILS
- SHEET N°9 - LOW LIFT PUMPS & SUCTION WELL
- SHEET N°10 - INTAKE PUMP BUILDING
- SHEET N°11 - MIXING & SEDIMENTATION BASIN REINFORCING
- SHEET N°12 - PIPE LINE



BELLEVILLE, MO.
 FILTER PLANT & WATER SUPPLY
 CONSTRUCTION
 FILTER BLDG.
 LAYOUT
 Scale 1/8" = 1'-0" Revised
 Drawn
 Traced G-25-25 P.W. Sheet No. 8

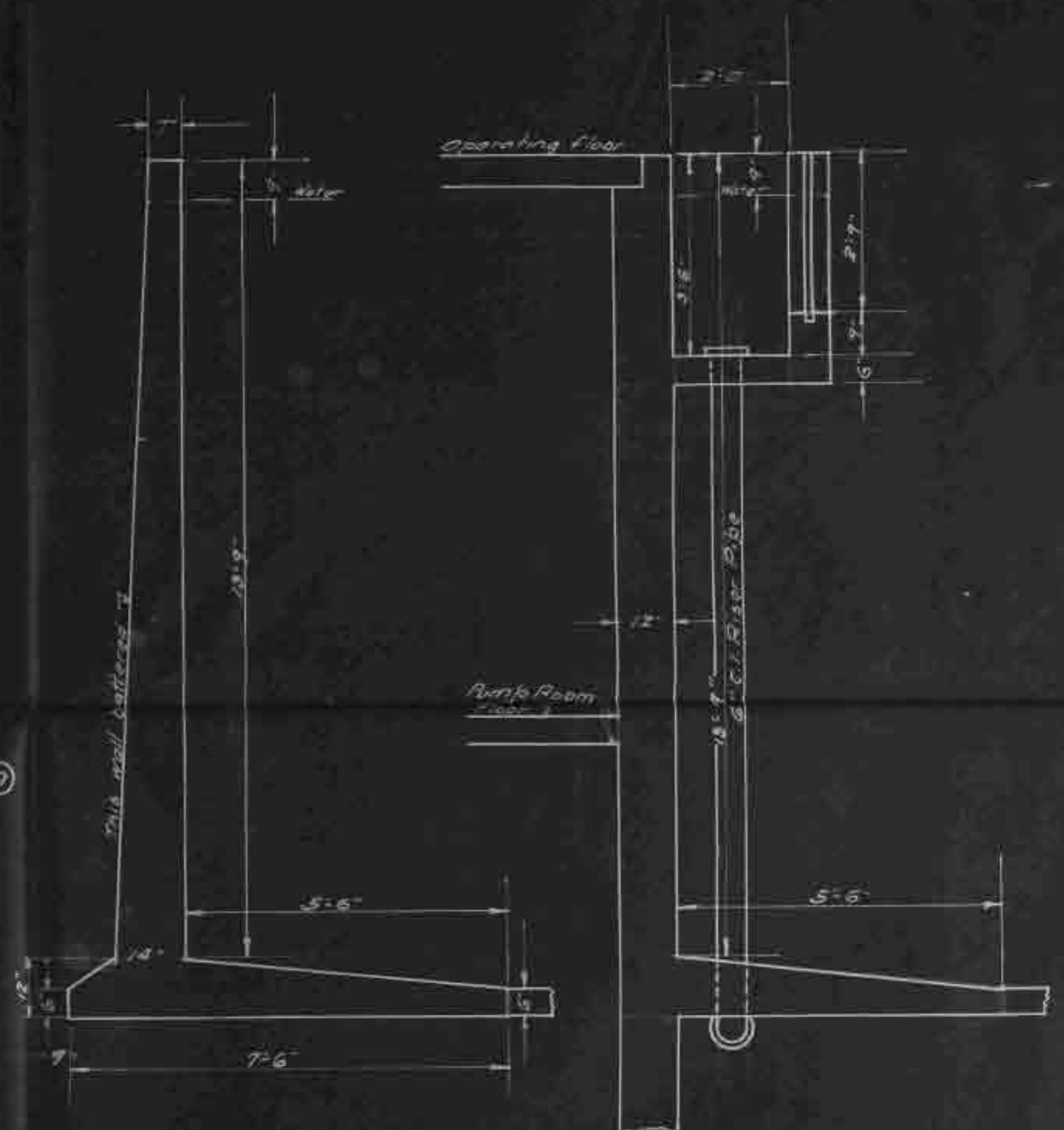
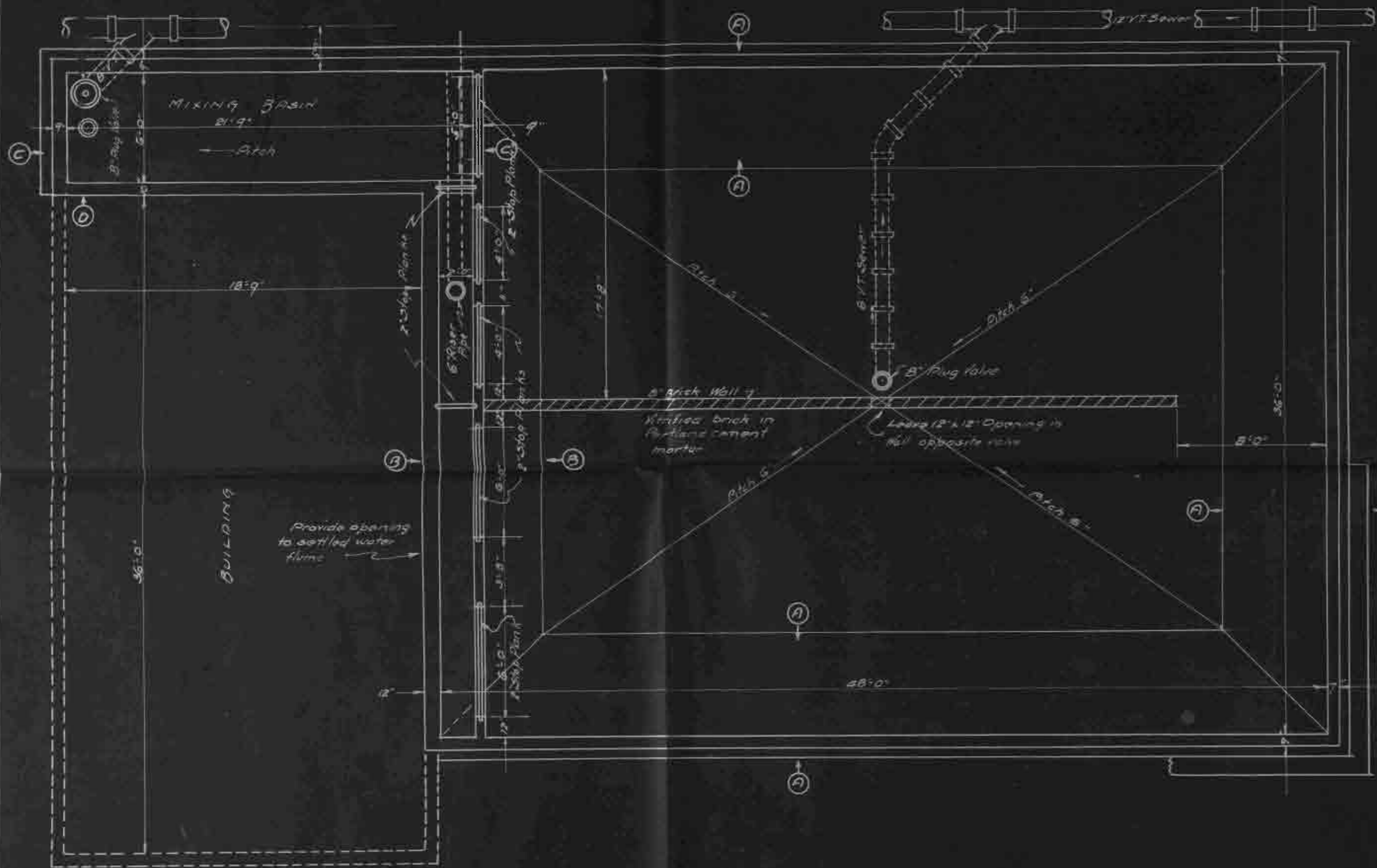


Bill of Material

Ref.	Qty	Size	Length
1	12	3/4"	18'-3"
2	23	3/4"	15'-3"
3	23	3/4"	15'-9"
4	27	5/8"	15'-2"
5	27	5/8"	16'-9"
6	28	5/8"	18'-3"
7	172	5/8"	18'-0"
8	6	5/8"	16'-3"
9	126	1/2"	20'-9"
10	22	1/2"	10'-9"
11	4	1/2"	15'-4"
12	16	5/8"	15'-6"
13	2	1/2"	20'-0"
14	2	1/2"	20'-0"
15	29	1/2"	4'-3"

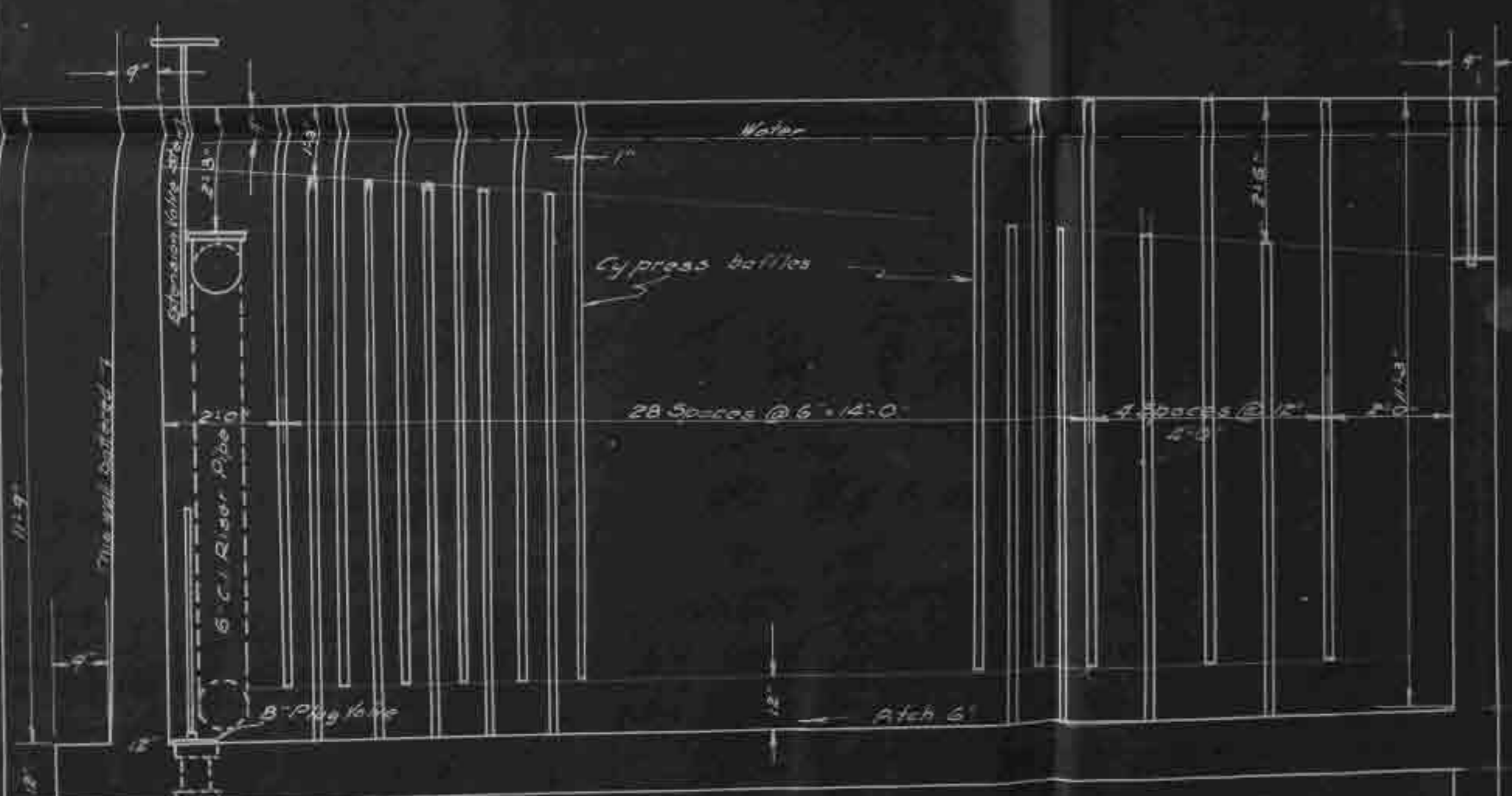
Check of Conc. - 92.30 Cu Yds
Steel - 14,700 lbs

BELLEMEILLE, ILL.
 FILTER PLANT & WATER SUPPLY
 CONSTRUCTION
CLEAR WELL
 Jack & Co. Inc. REVISED
 Drawn
 Traced
 Sheet No. 4

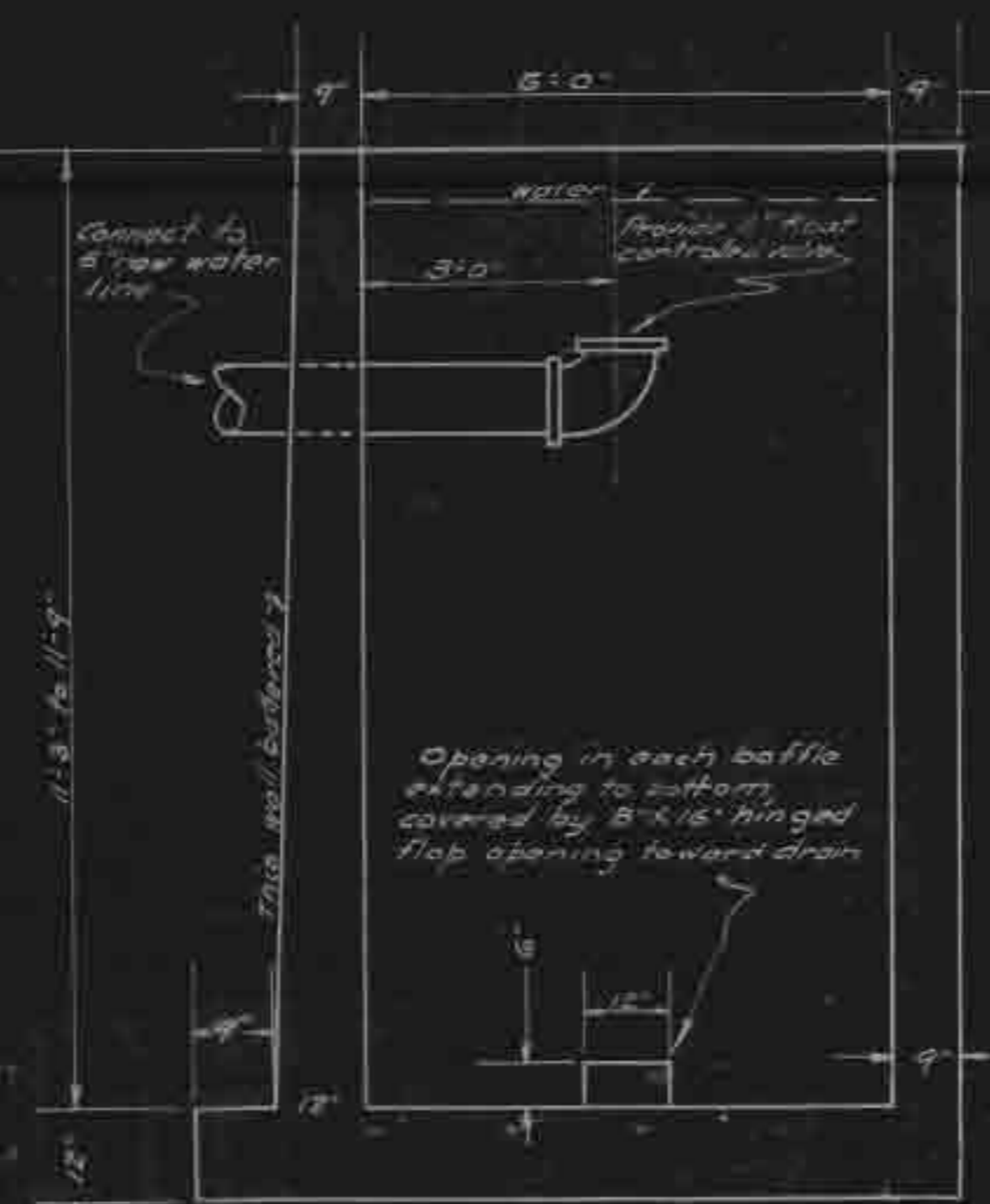


SECTION A-A
Scale 1/2" = 1'-0"

SECTION B-B
Scale 1/2" = 1'-0"

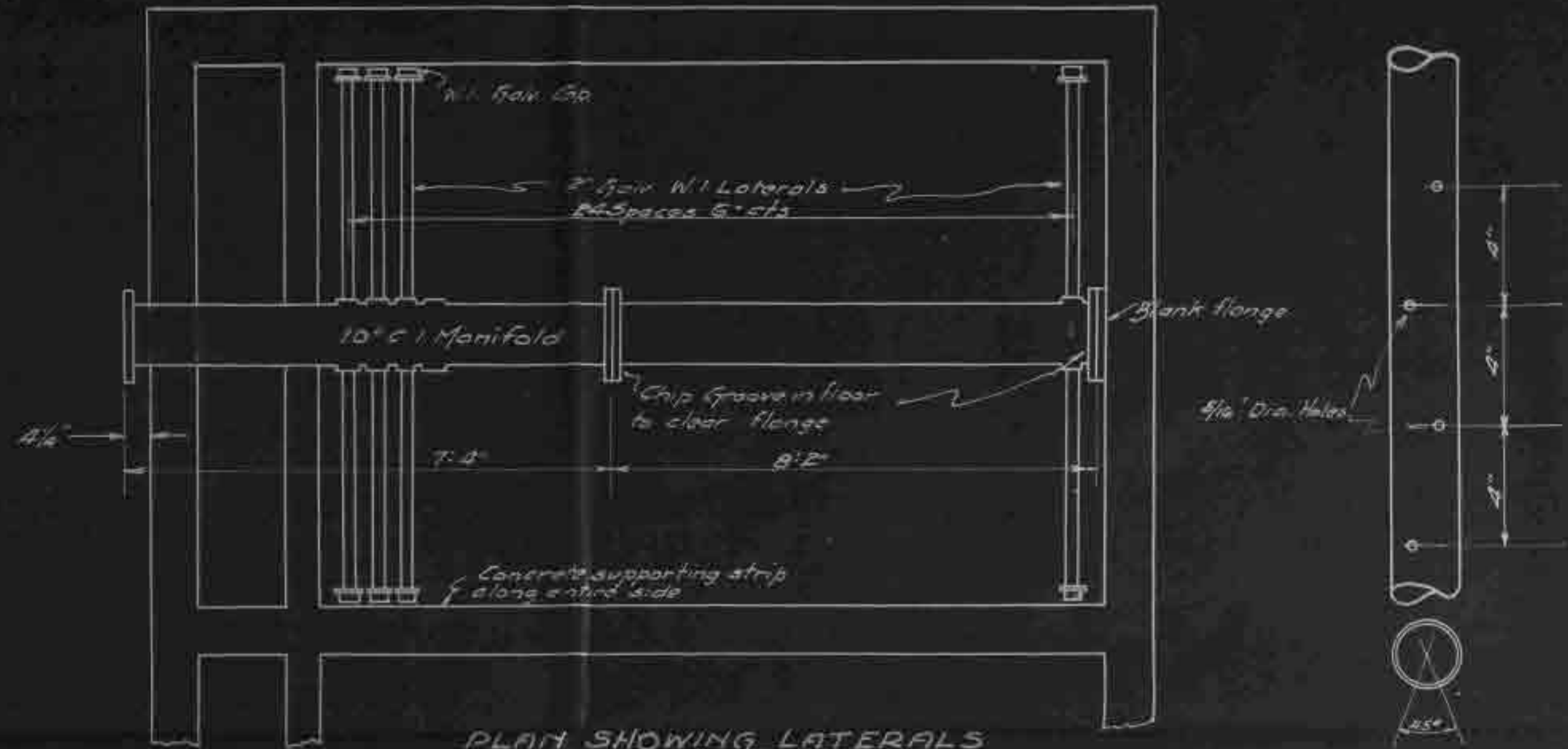
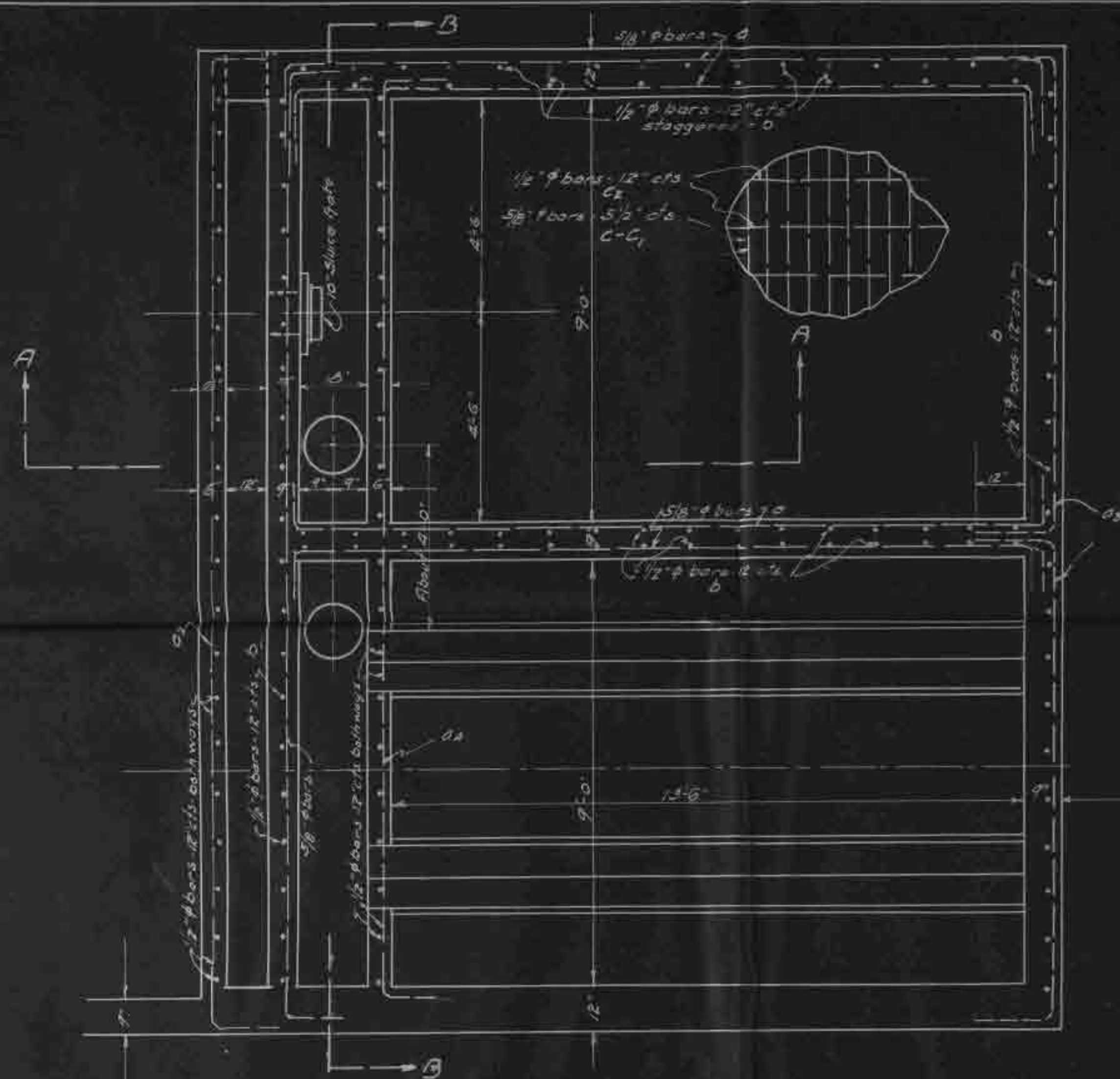


SECTION C-C
Scale 1/2" = 1'-0"



SECTION D-D
Scale 1/2" = 1'-0"

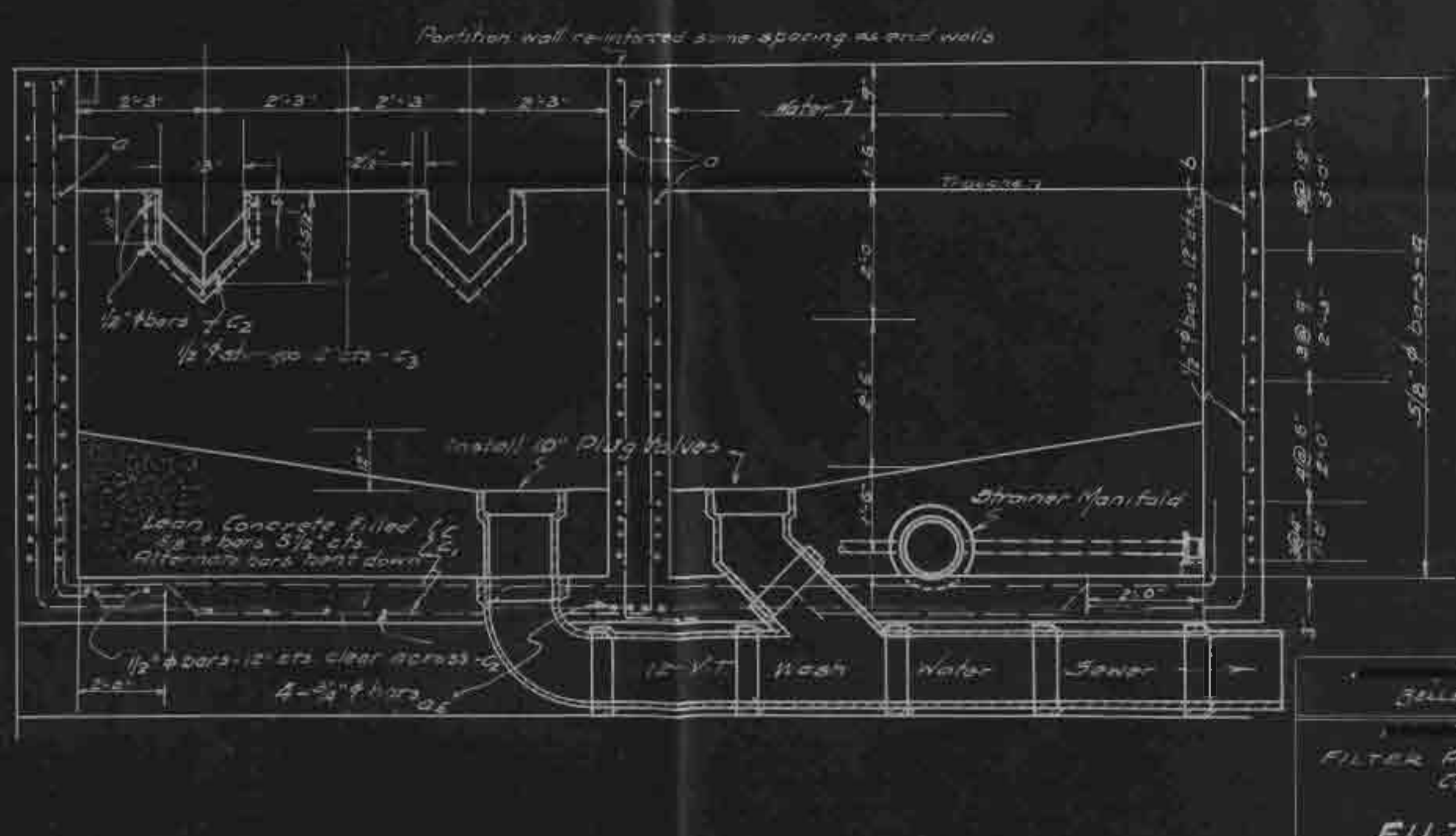
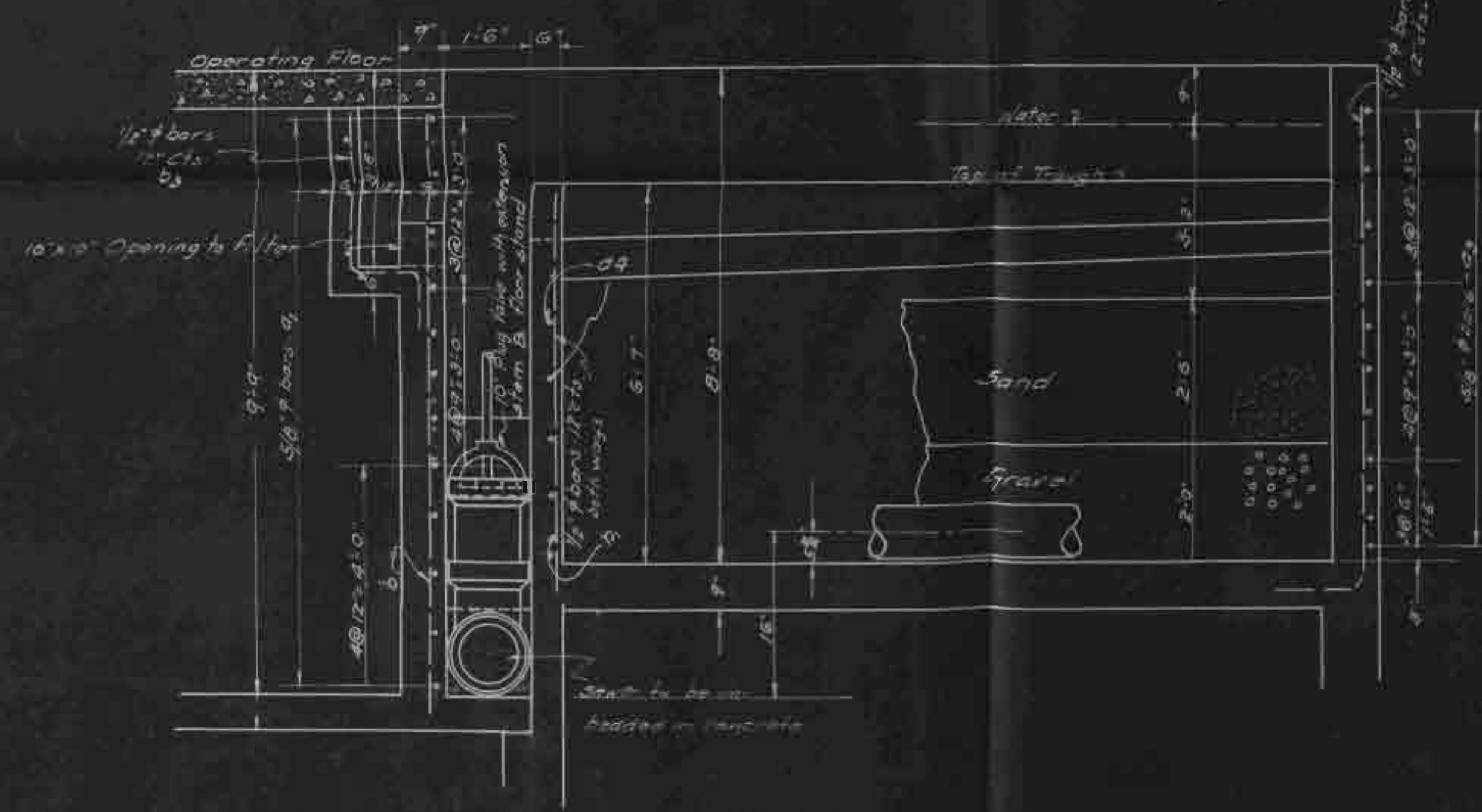
BELLVILLE, ILL.
 FILTER PLANT & WATER SUPPLY
 CONSTRUCTION
**MIXING BASIN
 DETAILS**
 Scale: As shown
 Drawn: 6-21-25 PMW
 Revised: [blank]
 Sheet No. 5



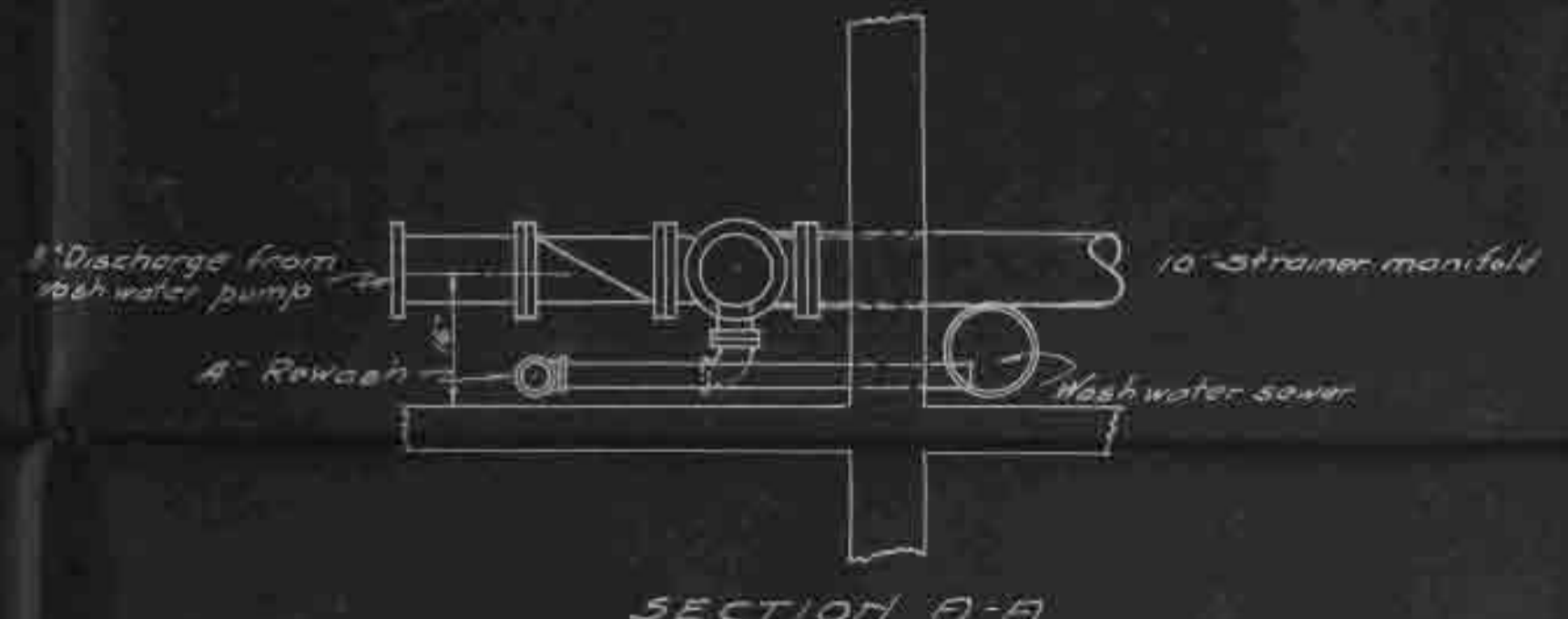
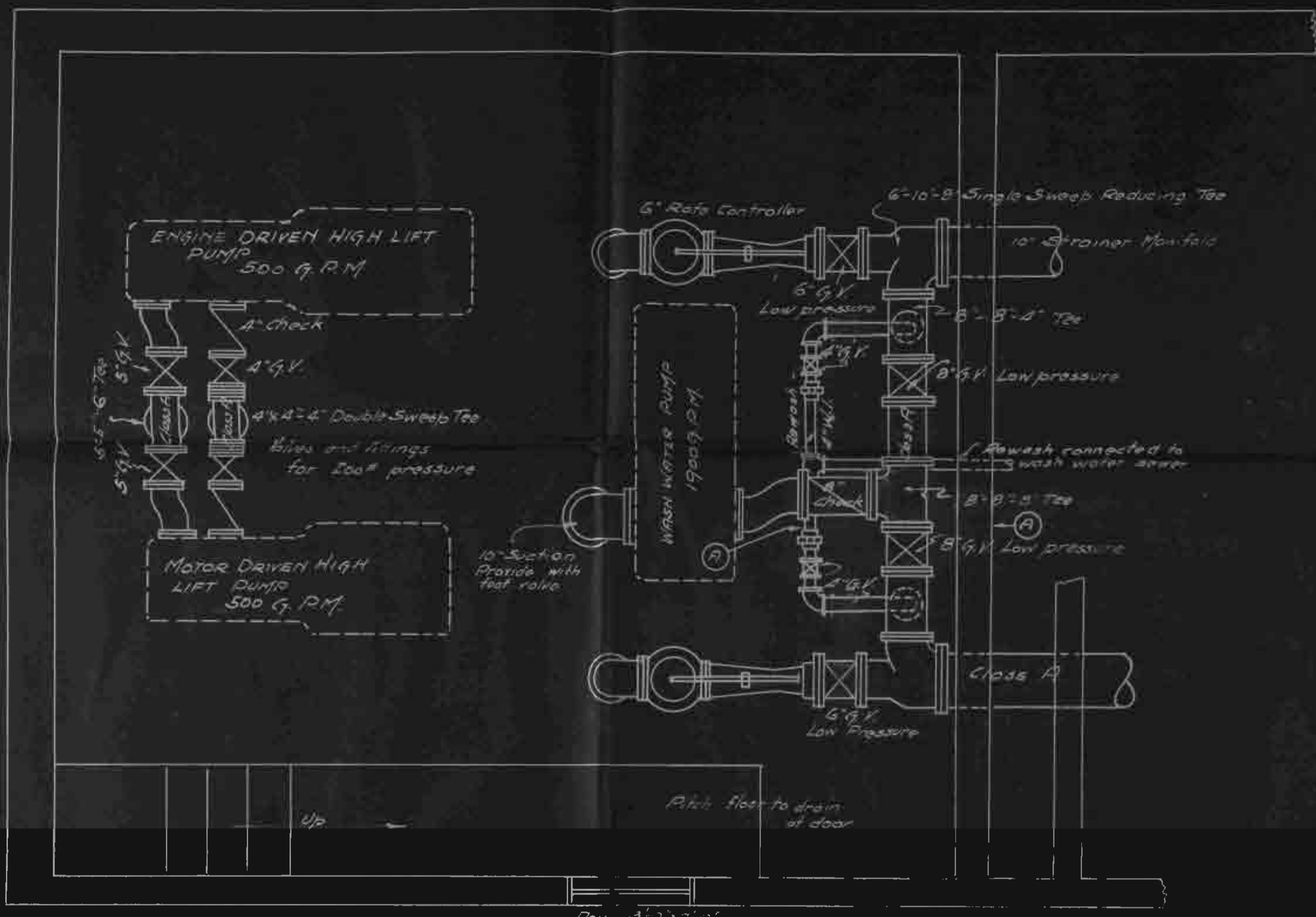
BILL OF MATERIAL

Letter	No.	Size	Length
c	70	5/8"	18'-6"
c ₁	12	3/8"	22'-6"
c ₂	4	1/2"	23'-6"
c ₃	22	3/8"	13'-6"
c ₄	5	1/2"	22'-6"
c ₅	4	3/8"	19'-6"
b	104	1/2"	10'-0"
b ₁	20	1/2"	7'-0"
b ₂	20	1/2"	5'-6"
c	15	5/8"	22'-2"
c ₁	15	3/8"	25'-2"
c ₂	39	1/2"	14'-0"
c ₃	52	1/2"	3'-9"
Steel	4320	lbs	
Class A Conc	5720	cu yds	Lean Conc. 2 1/2 cu yds

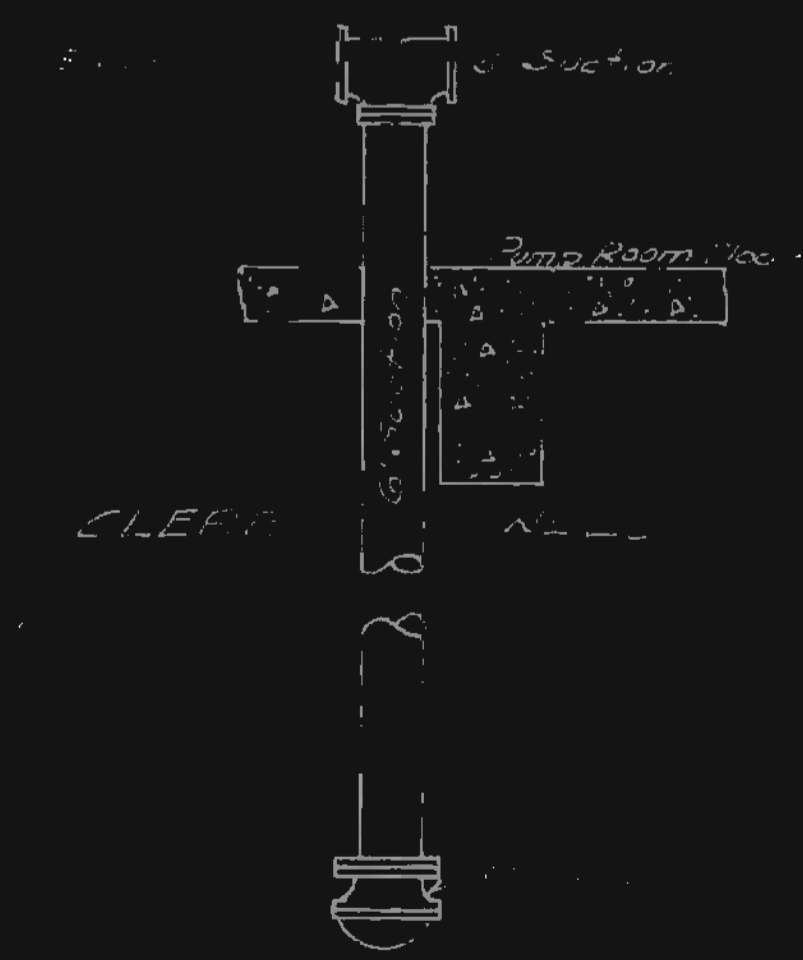
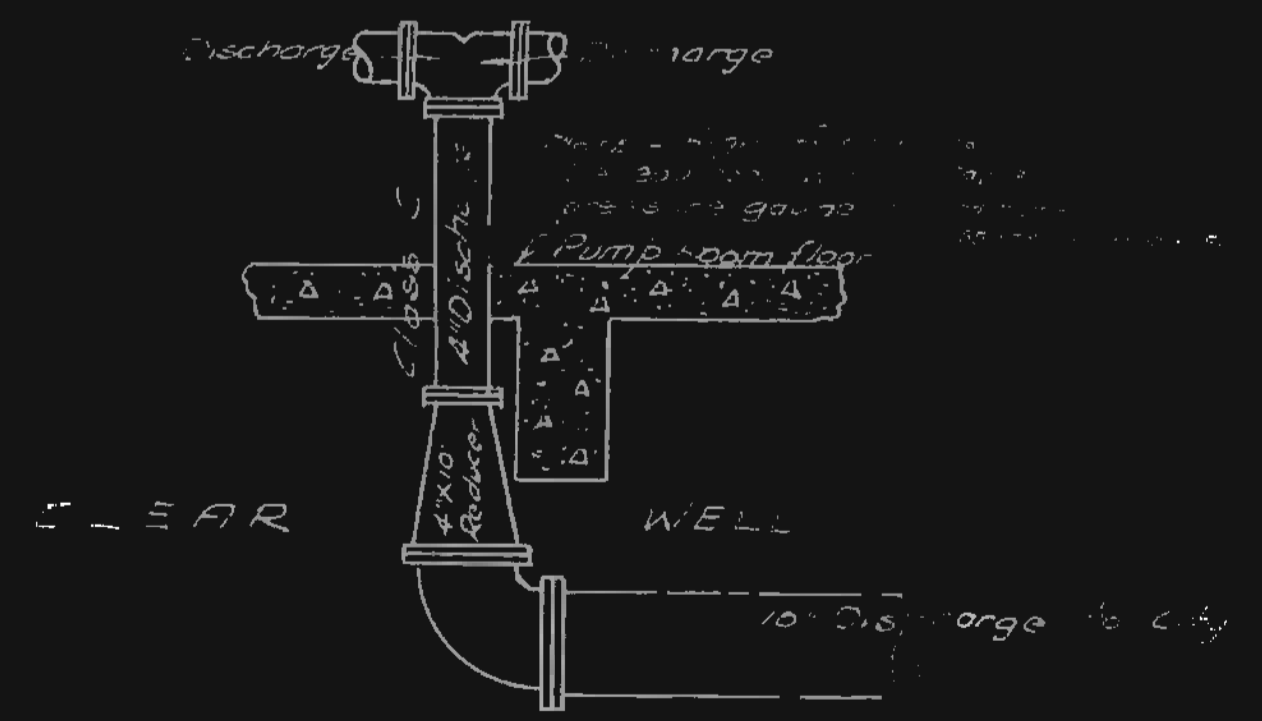
DRILLING OF LATERALS



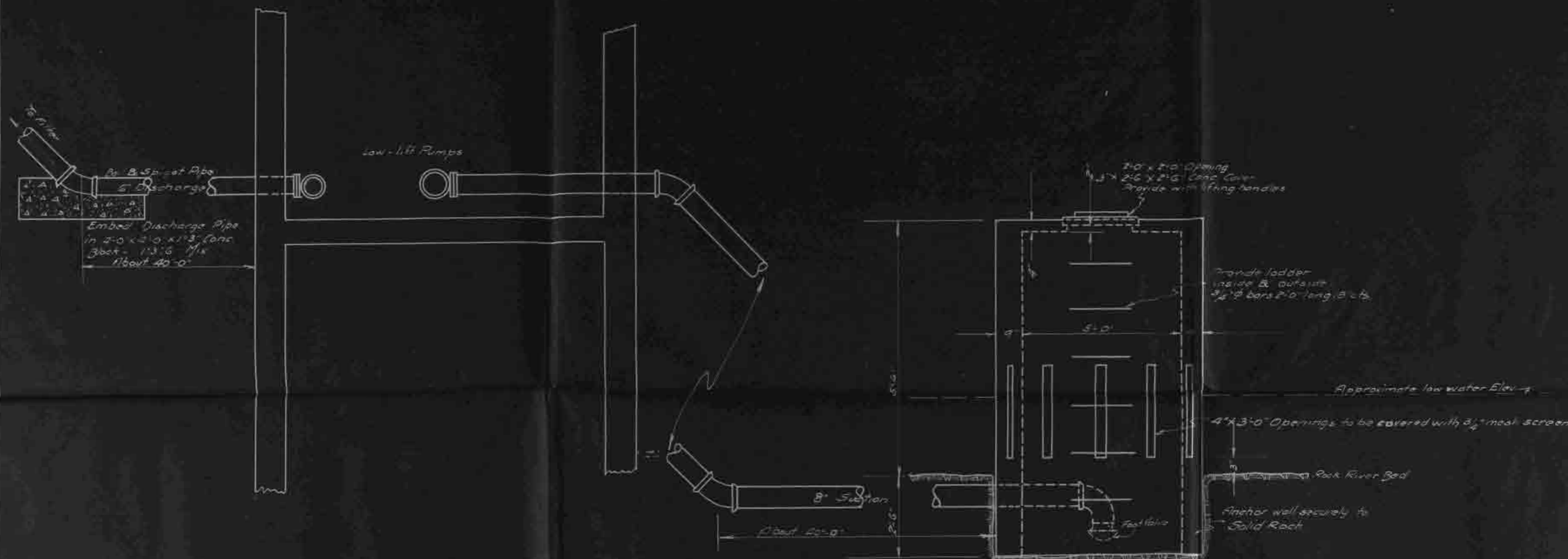
BULEVILLE, ILLINOIS
 FILTER PLANT & WATER SUPPLY
 CONSTRUCTION
 FILTER DETAILS
 Scale 1/2" = 1'-0" Revised
 Drawn
 Traced 6-13-28 Sheet No. 6



P A N

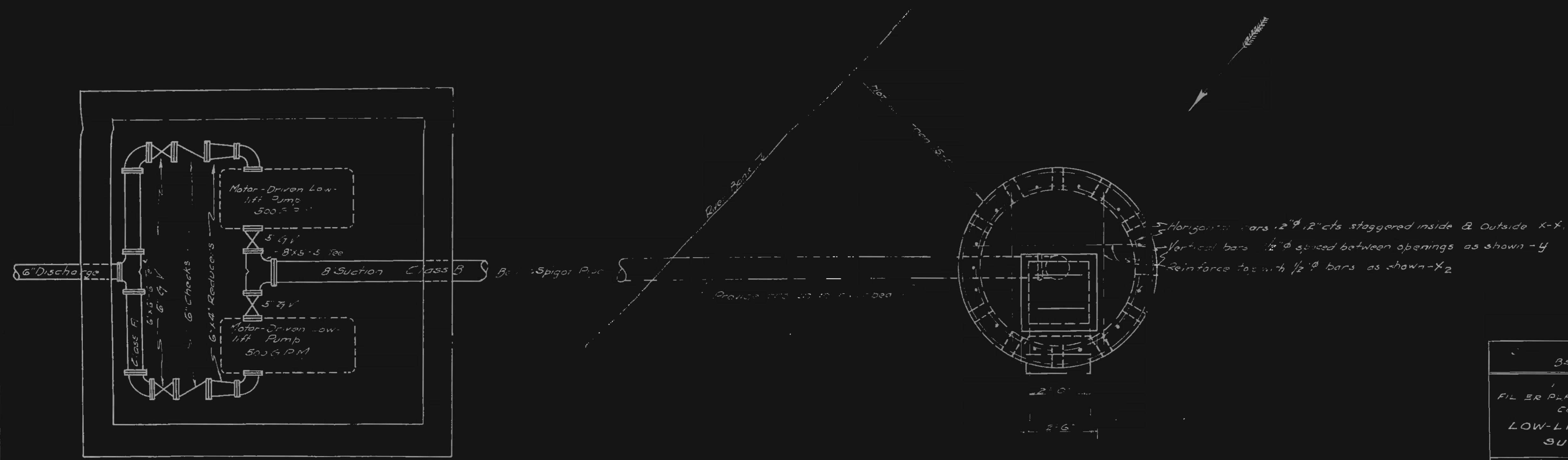


BELLEVEILLE, ILLINOIS
 FILTER PLANT & WATER SUPPLY
 CONSTRUCTION
 PUMP & PIPING
 DETAILS
 Scale 1/2" = 1'-0"
 Drawn 6-1-24 S.K.
 Check 6-1-24 P.W. Shear



BILL OF MATERIAL

Letter	No	Size	Length
X	4	1/2" φ	20'-0"
X ₁	4	1/2" φ	17'-6"
X ₂	3	1/2" φ	5'-6"
Y	13	1/2" φ	8'-6"
Ladders	11	3/4" φ	2'-0"
Steel	260 lbs.		
Conc Class B	5.2 Cu Yds		



BELLEVILLE, IL

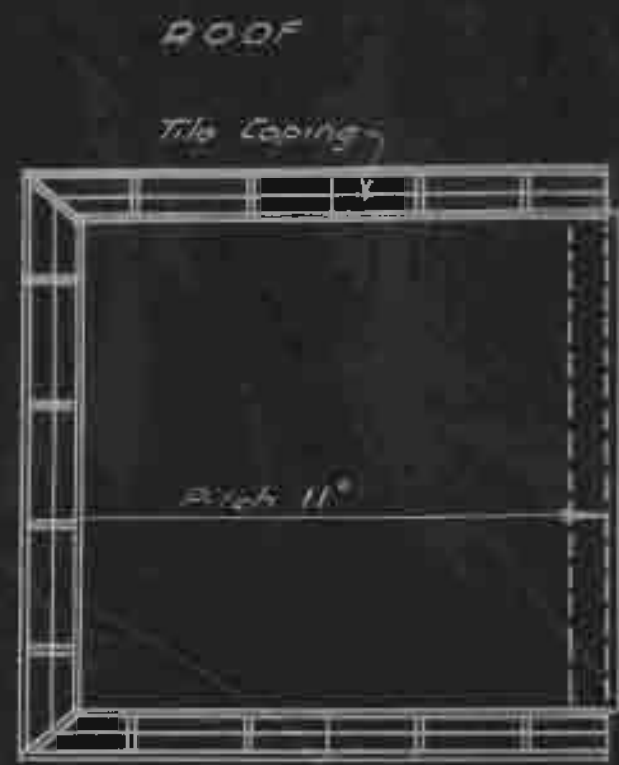
FILTRATION PLANT & WATER TREATMENT CONSTRUCTION

LOW-LIFT PUMPS & SUCTION WELL

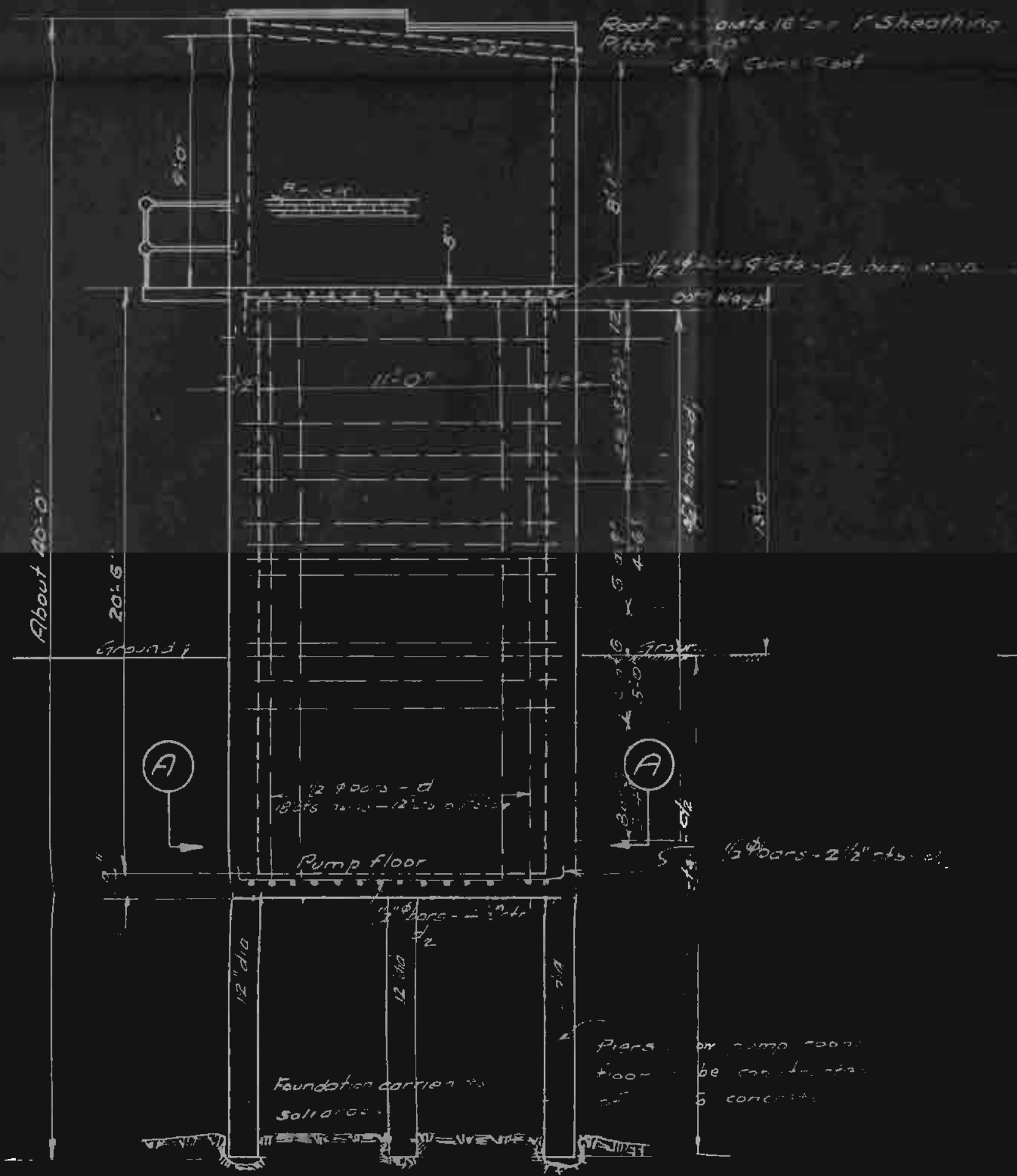
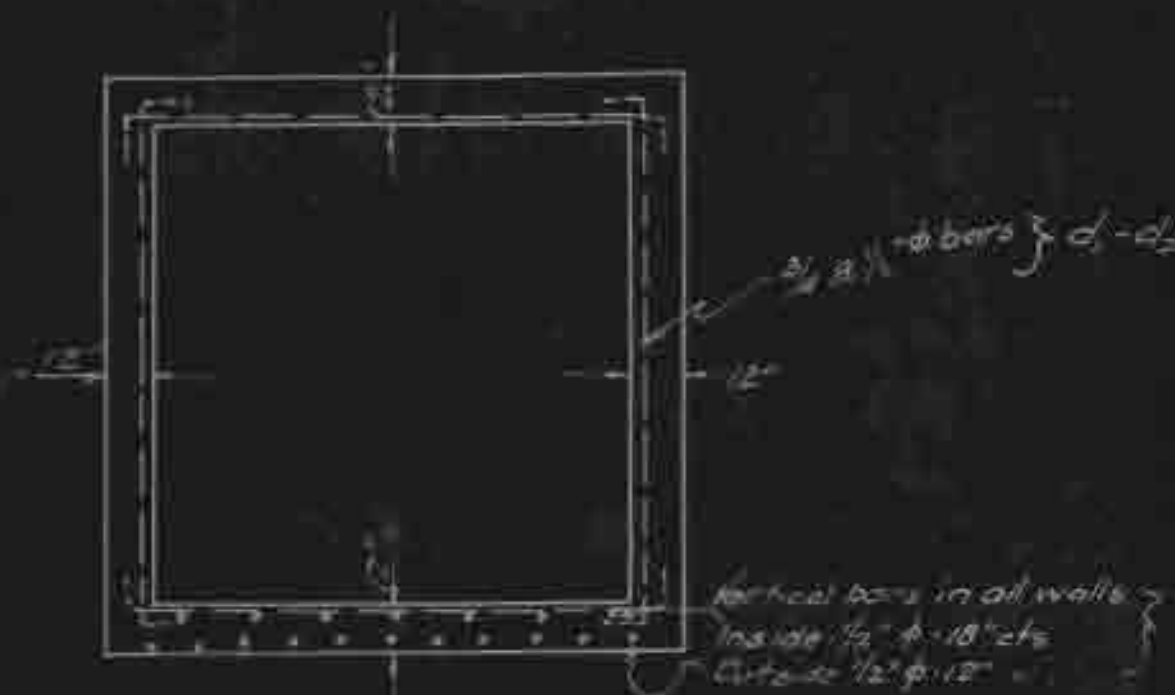
Scale 1/2" = 1'-0"

Drawn 2/25/64

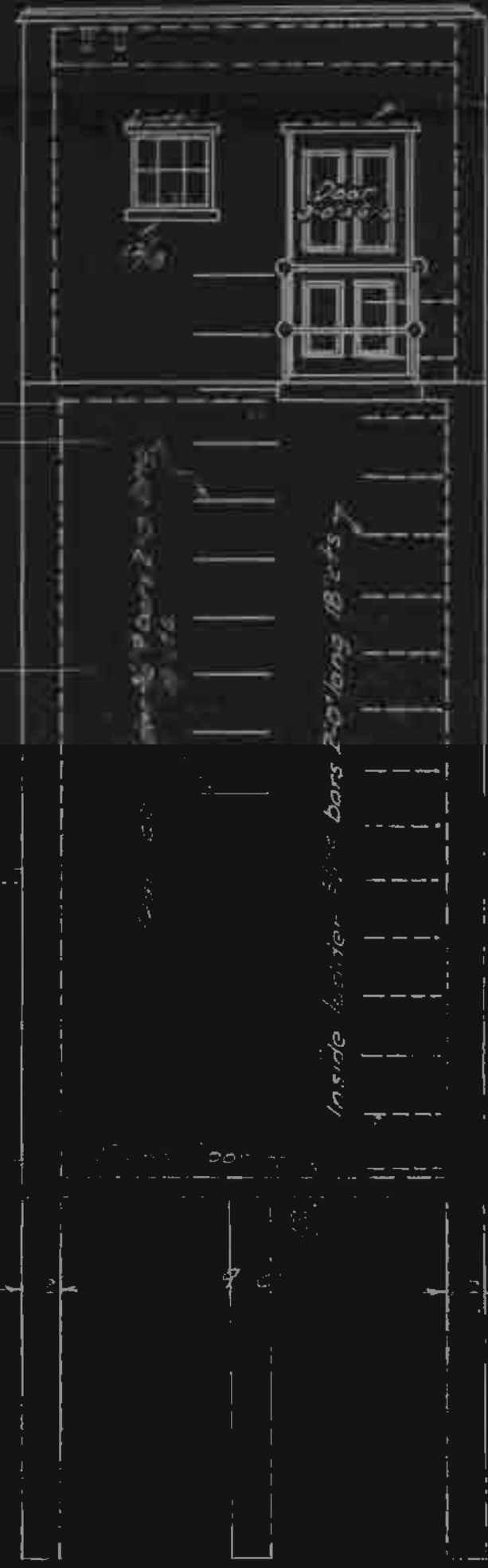
Checked 5/10/64



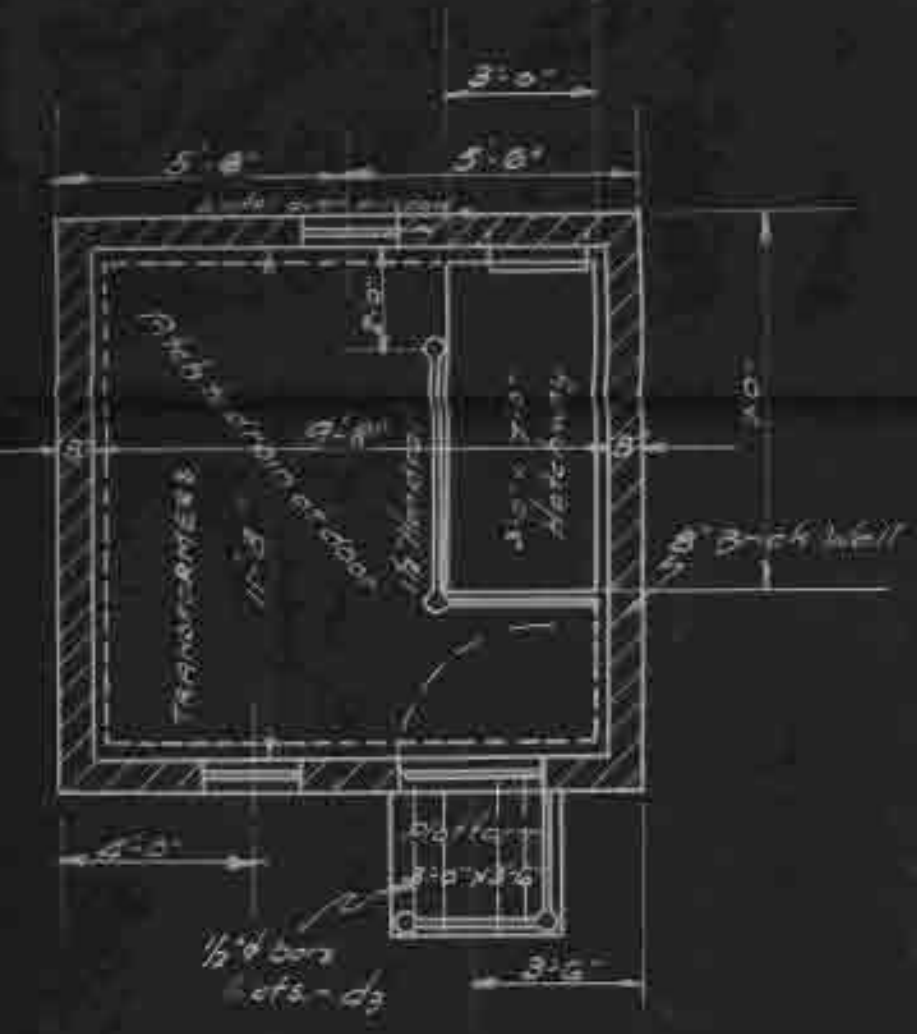
SECTION AT A-A



SOUTH ELEVATION



EST. ELEVATION



OPERATING FLOOR PLAN

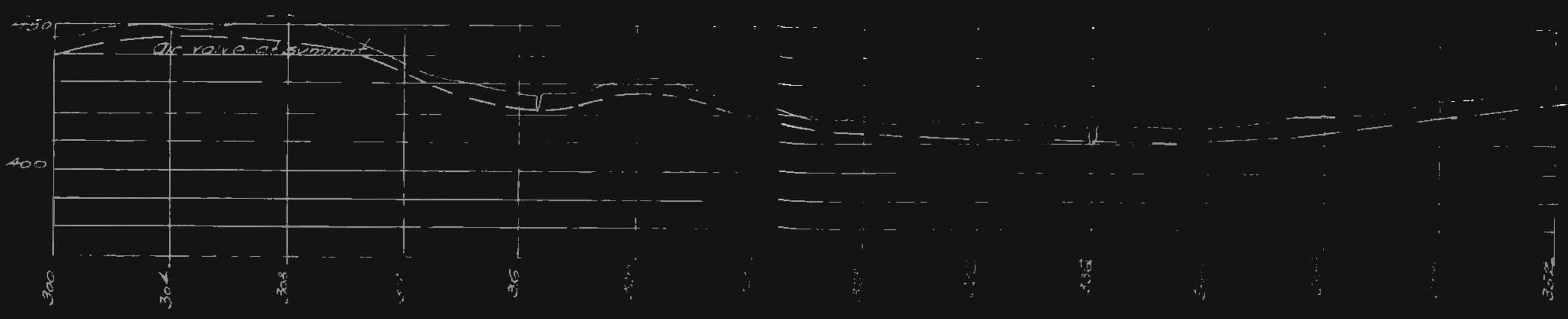
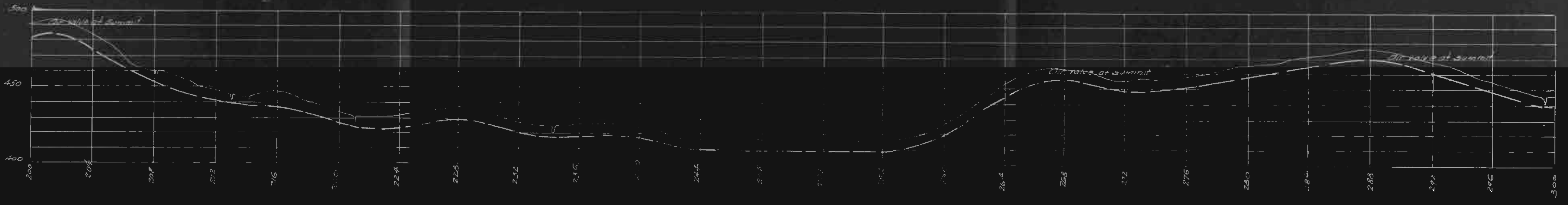
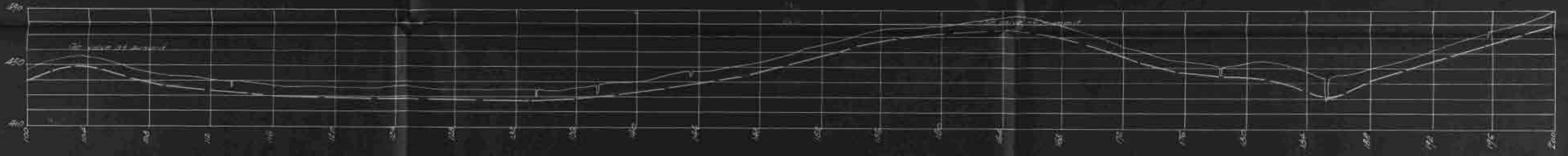
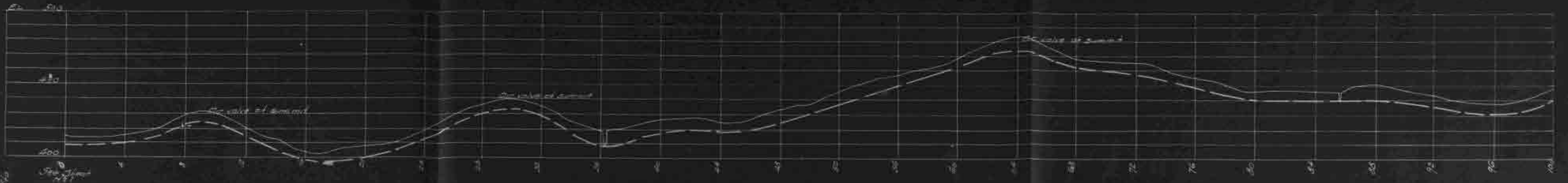
BILL OF MATERIAL

Letter	Qty	Size	Length
d	72	1/2" φ	30'-0"
d ₁	62	3/4" φ	13'-6"
d ₂	94	1/2" φ	12'-9"
d ₃	5	1/2" φ	4'-0"
Ladders	23	3/4" φ	4'-0"
Steel	2775.0 lbs		
Conc	53.75 Cu Yds Class 4		

311
JELLENVILLE, ILL.

FILTER PLANT & WATER SUPPLY
CONSTRUCTION
INTAKE PUMP BLDG.
DETAILS

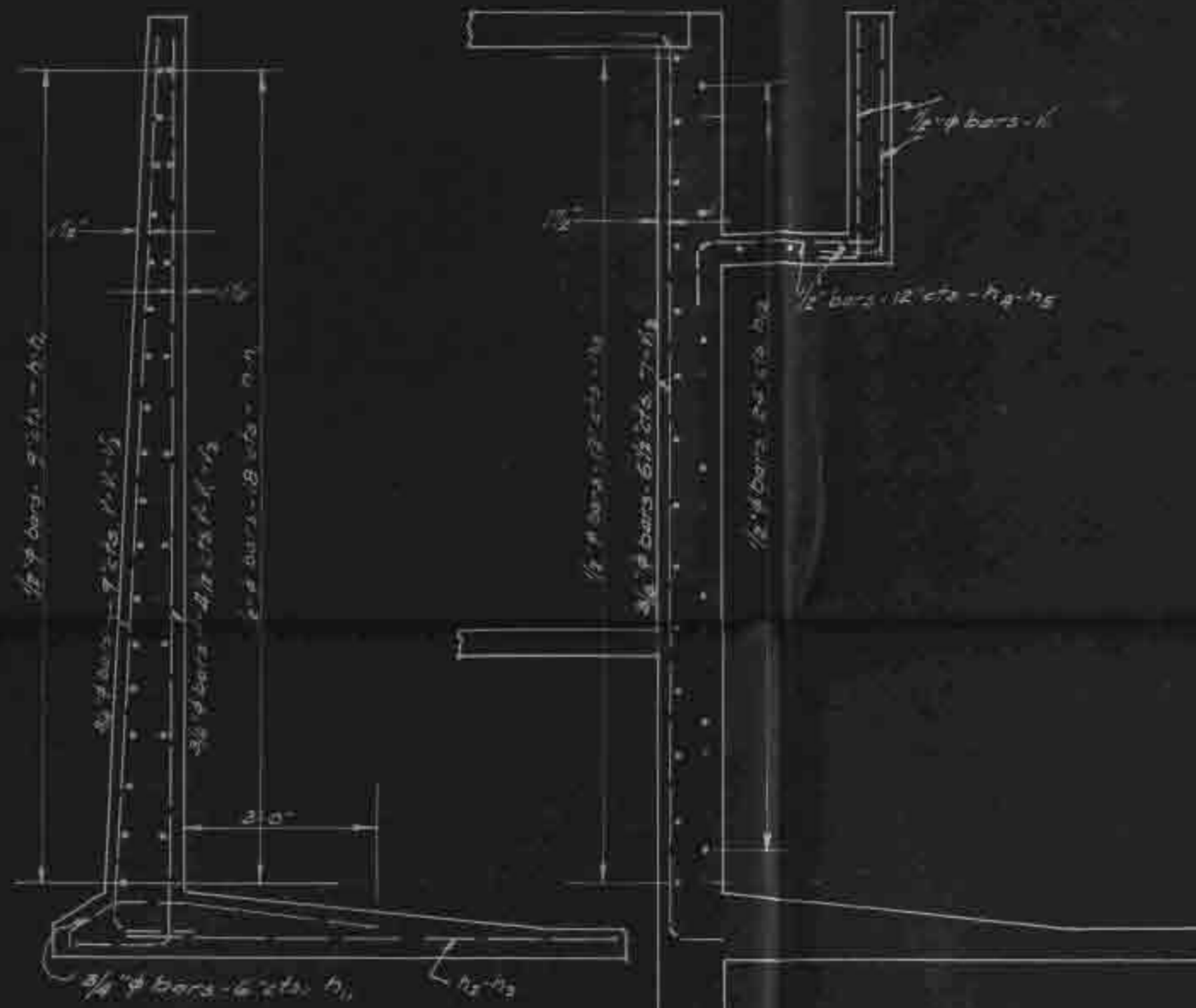
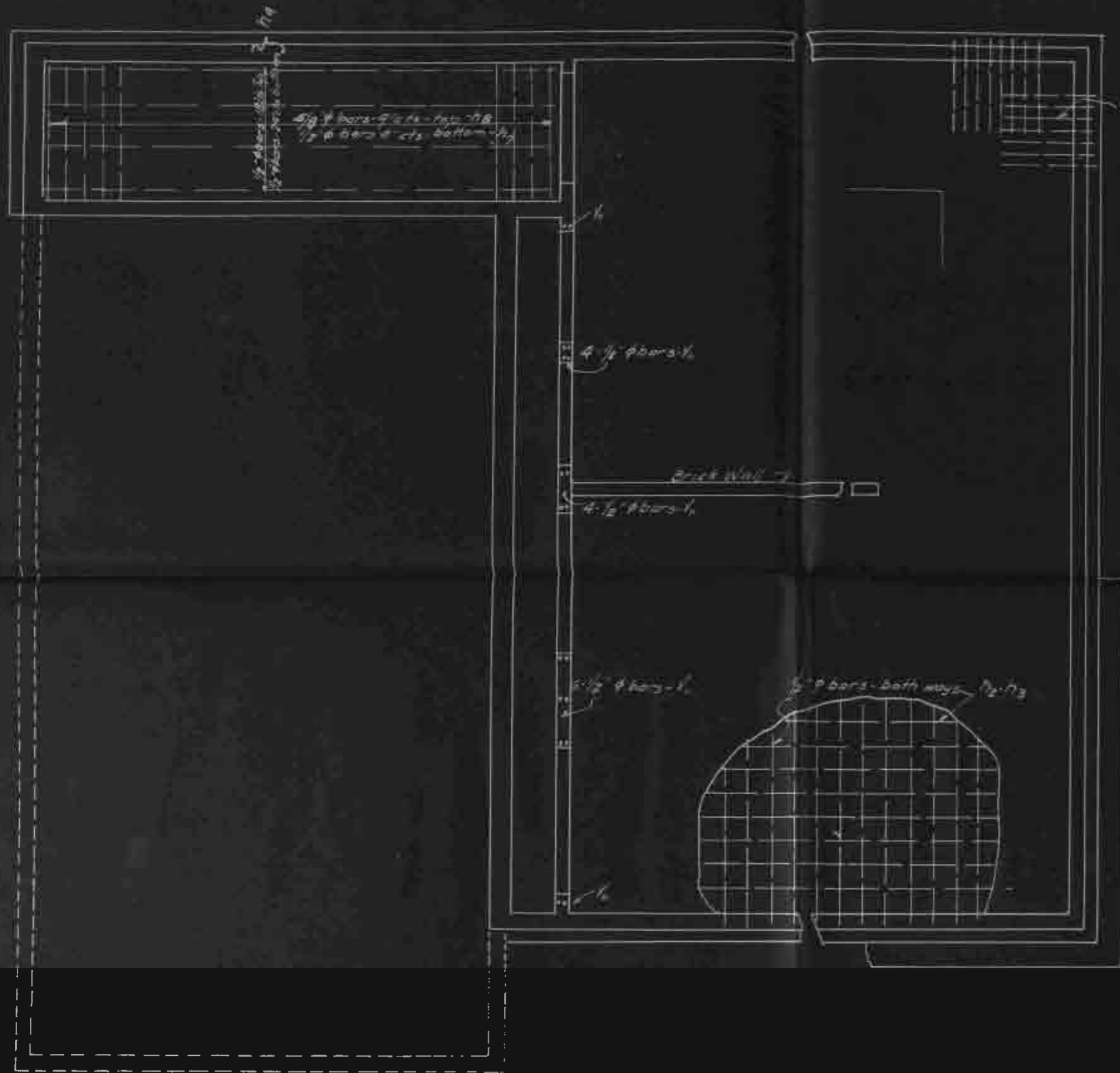
Scale 1/4" = 1'-0" K. J. ...
Drawn G. J. ...
Fixed 6-1-23



1. The profile of the summit is shown by a solid line.
 2. The profile of the ground is shown by a dashed line.
 3. The profile of the proposed pipe line is shown by a dotted line.

One in the ground is shown by a solid line.
 Estimated by Engineer. Existing
 drainage structure and channels
 to be left intact.

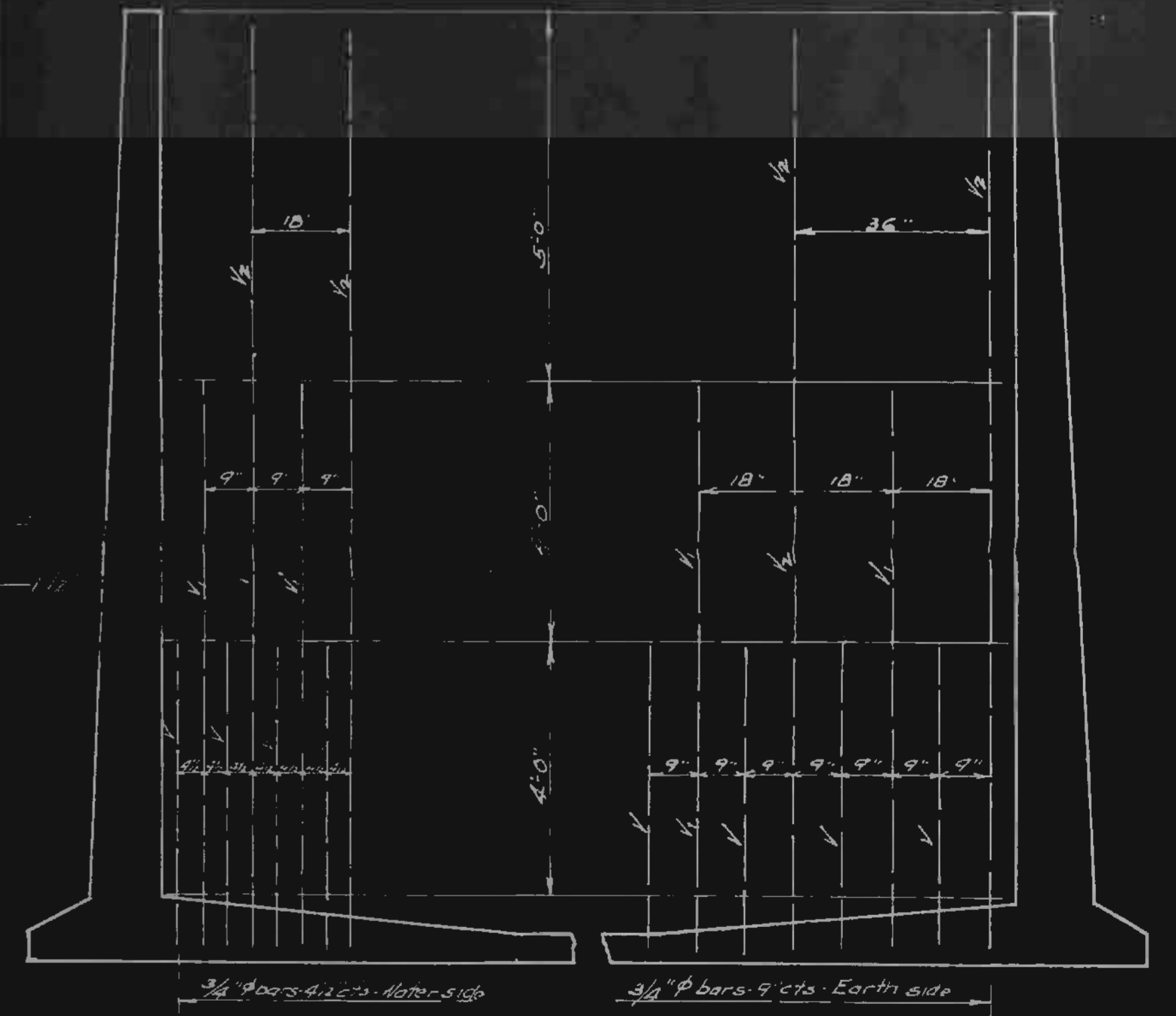
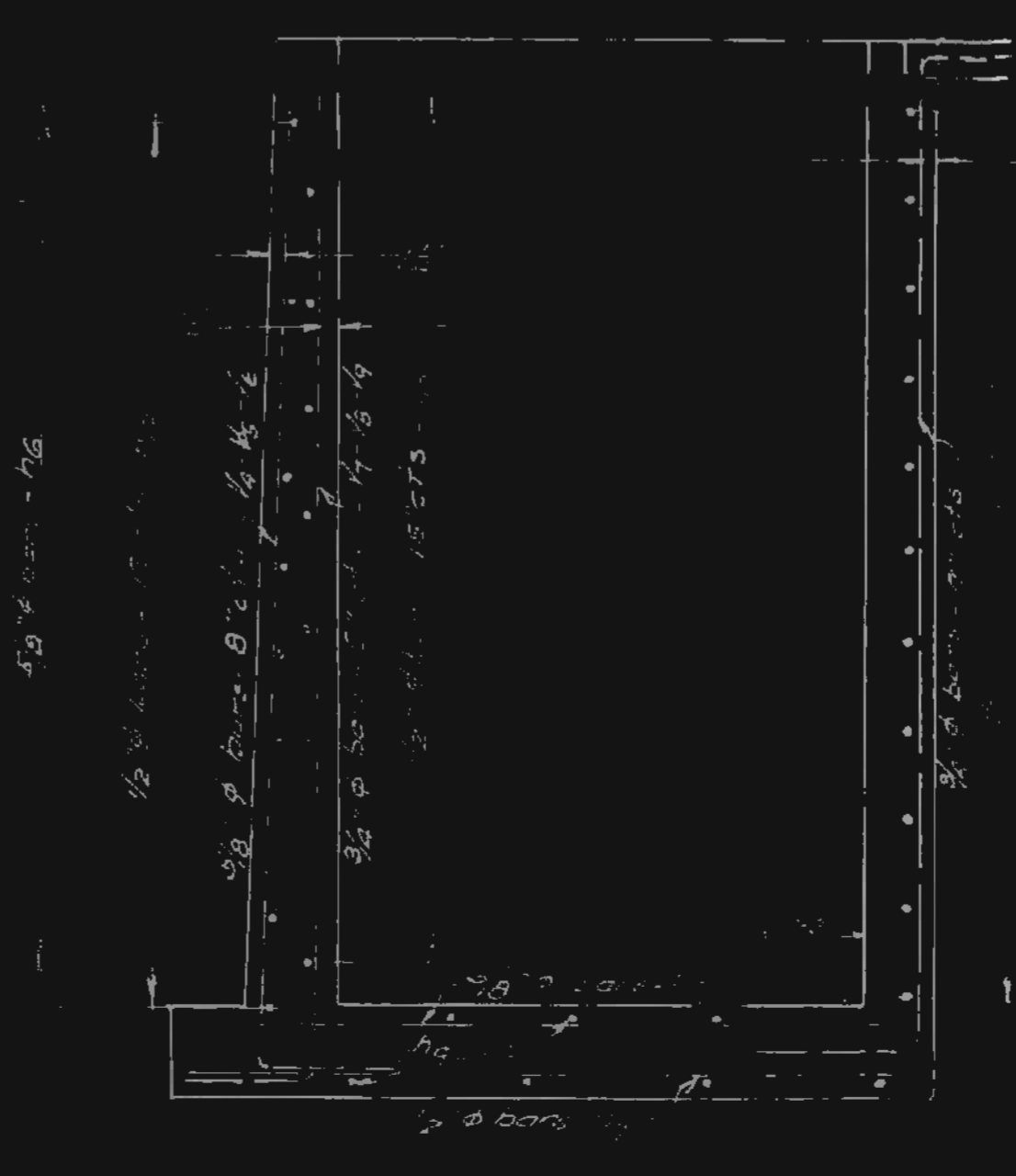
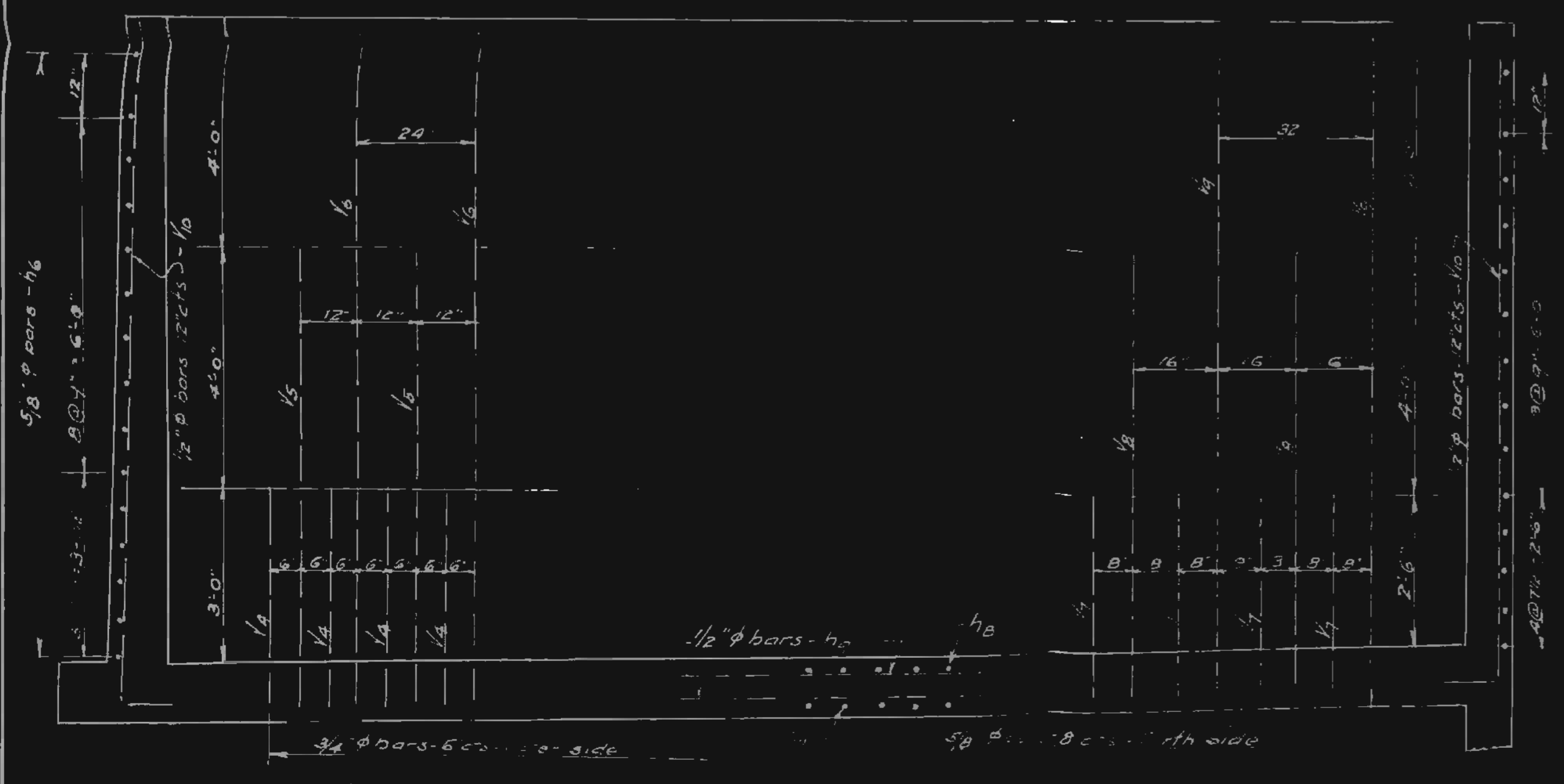
Kelleysville, Ind.
 FILTER PLANT & WATER SUPPLY
 CONSTRUCTION
 PIPE LINE
 500 = 0.50 in. Revised
 Drawn 5-2-16
 Traced
 Sheet No. 12



BILL OF MATERIAL

Letter	No.	Size	Length
V	264	3/4"	5'-0"
V1	132	3/4"	10'-0"
V2	132	3/4"	18'-9"
V3	40	3/4"	16'-6"
V4	22	3/4"	5'-0"
V5	11	3/4"	4'-0"
V6	11	3/4"	12'-6"
V7	16	3/4"	5'-0"
V8	8	3/4"	4'-0"
V9	8	3/4"	12'-6"
V10	12	1/2"	12'-6"
V11	18	1/2"	5'-0"
V12	29	3/4"	14'-6"
V13	55	1/2"	16'-0"
H	54	1/2"	39'-6"
H1	54	1/2"	26'-6"
H2	48	1/2"	37'-0"
H3	36	1/2"	49'-0"
H4	29	1/2"	4'-0"
H5	3	1/2"	30'-0"
H6	29	5/8"	8'-6"
H7	29	1/2"	6'-6"
H8	29	5/8"	6'-6"
H9	8	1/2"	22'-0"
H10	31	1/2"	24'-0"
H11	262	3/4"	4'-0"
H12	21	1/2"	32'-0"

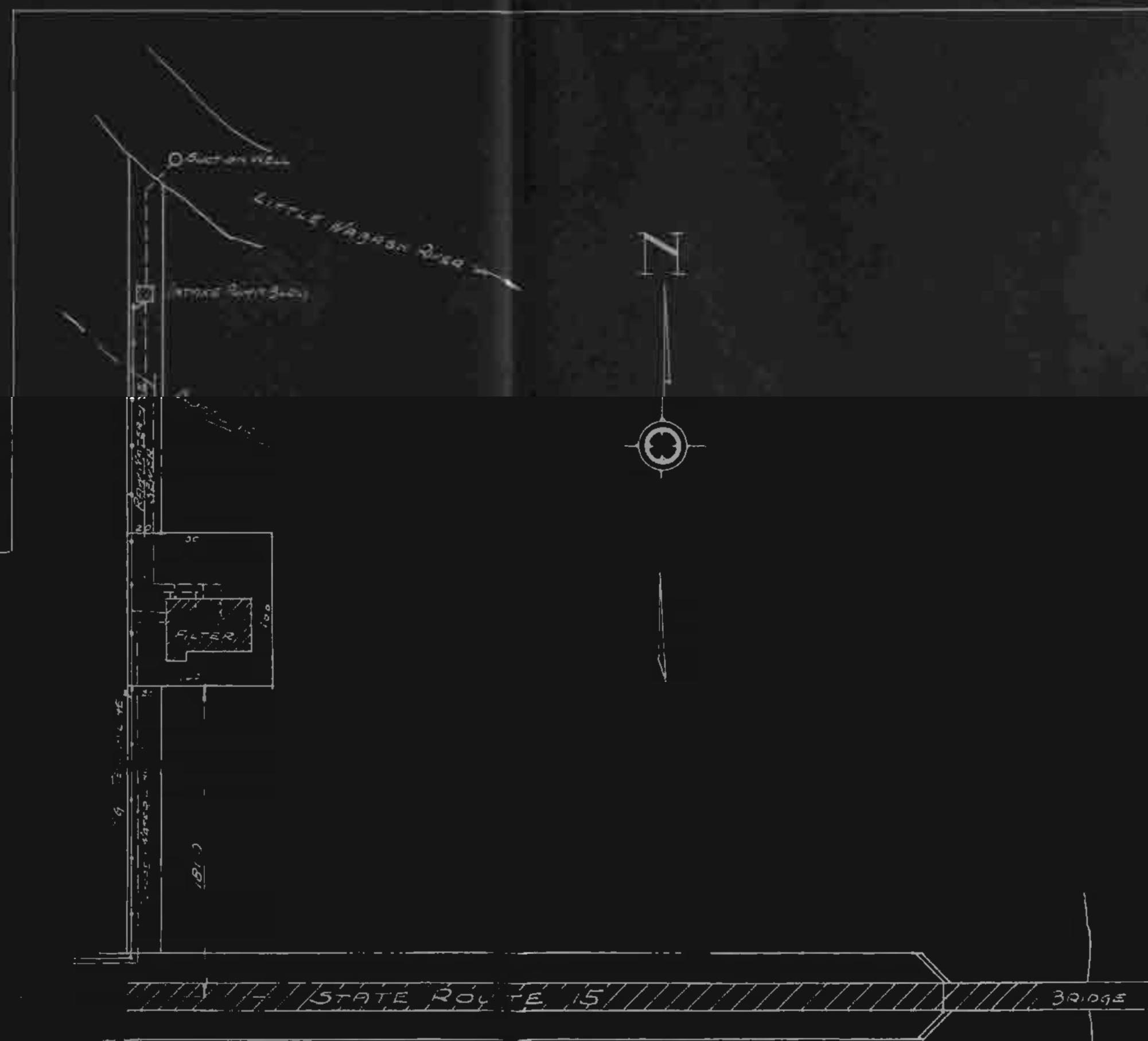
18 200 lbs Steel
1517 Cu Yds Class A Conc.



BELEVILLE, ILL
 FILTER PLANT & WATER SUPPLY
 CONSTRUCTION
 MIXING & SEDIMENTATION BASIN
 REINFORCING
 Scale: 1/4" = 1'-0"
 Date: 10-2-1914
 Sheet No. 1



FILTER LAYOUT
Scale 1"=10'



PLAN & PROFILE OF FILTER SITE
Site Elevation 437.75' - 442.0'

BELLEVILLE, ILL.
 FILTER PLANT & WATER SUPPLY
 CONST. PROJECT
GENERAL LAYOUT
 Scale 1"=50' (Plan) 1"=10' (Profile)
 Date 3-27-25
 3-27-25
 Sheet No. 1