THESIS

DESIGN OF SEWAGE DISPOSAL PLANT FOR THE CITY OF EAST LANSING

Howard F. Hollenbach

LaVerne J. Hendryx

1924

Sewage

DESIGN OF SEWAGE DISPOSAL PLANT

FOR THE CITY OF

EAST LANSING.

A Report Submitted to the Faculty

of the

MICHIGAN AGRICULTURAL COLLEGE.

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Candidates for the Degree of

BACHELOR OF SCIENCE.

June, 1924.

INTRODUCTION

REPORT

DESIGN OF SEWAGE DISPOSAL PLANT

FOR

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INTRODUCTION.

Sanitary conditions at East Lansing are similar to those existing in many other cities. The sewage at present is discharged into the Red Cedar River, and is sarisfactorily handled by the river. However, this state of affairs is not permanent.

The Michigan Agricultural College expects to double its enrollment in a few years. East Lansing is attracting increasing numbers of residents, so that the time can be foreseen when sewage disposal will be more serious. A disposal plant would make the Red Cedar a potential source of water supply, not to mention the esthetic side of the question. Also hydro-electric developments by the college would be easier to obtain, the present contamination being a strong drawback.

The City of Lansing is considering installing a disposal plant for its sewage. When this happens it will be quite likely that strong pressure will be brought to bear on East Lansing to quit polluting the Cedar, and hence the Grand River.

PRELIMINARY CONSIDERATIONS.

The present East Lansing sewerage system has not been changed. There are two sewers east of Bogue street, one across the college campus, one west of Beal street, and the outlet from the collecting manholes at Harrison Avenue, that empty into the river. An interceptor will run from the Bogue street sewers along the river to the manhole at Harrison and Michigan, where now the system empties into the river. A larger manhole will be put in here, and the interceptor run to the plant from here.

This permits tapping into the interceptor, or extending it on up the river, and practically cares for all territory east of Harrison Avenue. Should subdivisions grow up to the west of Harrison Avenue, a system of sewers coming from the west into the screen and grit chambers would be easy to install.

Topographic considerations of themselves chose the site - no other land in necessary amount was available, and the low elevation of the inverts at the Harrison Avenue sewers made low land a necessity.

This low head was also responsible for the need of pumps. By no system could the sewage be treated without pumping at some stage.

A sanitary survey of the Red Cedar river was made. The object was to gain some idea of how badly the river was contaminated at present.

Sample numbers 1 and 2 came from Farm Lane bridge; numbers 3 and 4 from the Railroad bridge; numbers 5 and 6 from the athletic bridge; numbers 7 and 8 from the Harrison Avenue bridge.

The averages of these tests were as follows:

PLAIN AGAR.

INCUBATED 24 HOURS AT 25°C.

SAMPLE	DILUTIONS.		
	1 - 10	1 - 100	1 - 1000
1 and 2	53	6	1
3 and 4	53	5	0
5 and 6	400	41	2
7 and 8	130	13	1

Figures are total number of colonies on a petri dish.

LITMUS LACTOSE AGAR.

INCUBATED 24 HOURS AT 37° C.

SAMPLE	DILUTIONS. 1 - 10	1 - 100	1 - 1000
1 and 2	(3) 28	(1) 15	1
3 and 4	(1) 20	(1) 10	0
5 and 6	(100) 214	(15) 34	3
7 and 8	(22) 61	(3) 4	1

Figures in parenthesis are B. Coli, count. Others, total count.

GELATIN.

INCUBATED 3 DAYS AT ICE BOX TEMPERATURE.

SAMPLE	DILUTIONS. 1 - 10	1 - 100	1 - 1000
1 and 2	(7) 15	(2) 3	
3 and 4	(6) 12	(0) 0	
5 and 6	(12) 44	(3) 7	
7 and 8	(13) 37	(0) 1	

Figures in parenthesis are liquefiers. Others total count.

LACTOSE BROTH FERMENTATION TUBES.

INCUBATED 24 HOURS AT 37°C.

SAMPLE	DILUTIONS.				
	1 - 1000	1 - 100	1 - 10	1	10 - 1
1 and 2	0	1/2	7	12	32
3 and 4	0	0	4	15	40
5 and 6	5	15	31	45	90
7 and 8	6	15	13	35	77

Figures are % of gas formed in tube.

In analyzing the results the most common indicator of sewage pollution, B. Coli will be of most importance. Prescott & Winslow state that if isolated in a large number of cases from 1 c.c. of water, serious pollution is a warranted conclusion. The differential count as given by the litmose lactose agar shows from 10 to 1000 B. Coli per c.c. along the river.

Taking the results as a whole, it is noticeable that 3 and 4 show lower counts than 1 and 2, in the distance from Farm Lane to the Railroad bridge the river purifies itself a little. Numbers 5 and 6 were taken just below all the campus sewers and they show very high courts, indicating that the stream is pretty well saturated with sewage, The counts for Harrison Avenue show a marked degree of purification in the space between the last two bridges.

While these tests are only rough estimates, yet they show that the river is fairly well polluted, but not dangerously so. A stability test showed very nearly 100%, indicating that the river is having no trouble handling its sewage.

Available stream flow records were very scarce. Complete data for 1903 showed a flow in cu. ft. per second by months, averaged from daily readings, as follows:

January - 337,	February - 571,	March - 959,
April ---- 860,	May ------- 143,	June -- 134,
July ----- 132,	August ---- 172,	September - 423,
October - 173,	November - 152,	December - 103,

The lowest flow, 103 cu. ft. per second could handle approximately 10 cu. ft. per second of sewage. Flow at present is not greatly at variance with the 1903 records, so we might assume that 10 cu. ft. per second would be our highest sewage flor allowable. This is well over present flow, leaving dilution as a satisfactory means until conditions are ready for installing a plant.

Having decided on our interceptor, all that remained before considering design was a rough topographical survey. The proposed site lies west of Harrison Avenue and south of Michigan Avenue. It is fairly level and at average flood water is submerged from 1 to 3 feet generally. The soil is loam and clay and offers no problems.

DESIGN OF PLANT.

Considering present population, future growth and probable size at time of construction, it was felt that to design for 10,000 persons would be most economical and satisfactory in the end. The flow was estimated at 200 gallons per capita per day. This is ample for a purely residential district, such as East Lansing is.

Next came a decision as to what form of treatment. Sprinkling filters were ruled out on account of the impossibility of isolation. Sand filters were not suitable - the low head obtainable, lack of suitable materials, large area needed, all counted against them. Contact beds were decided upon because of clean operation, good results, small space and simplicity.

Screen and grit chambers were of course included, and separate sludge digestion was selected for initial treatment. This is simpler than an Imhoff tank and results being obtained by recent installations highly recommended them.

Sludge beds were provided, and from the contact beds the effluent ran into the river.

The designers started their interceptor from the collecting manhole at Harrison and Michigan Avenues, with invert elevation 827,50. As to linking up the system of stream, that is properly a job for the East Lansing City Engineer. There are no sewer elevations, no street elevations, to work by. Moreover, to forecast by guess where to place an intercepting sewer 5 or 10 years hence, with no idea where all connections will be, was considered useless.

Using, then, an 18" interceptor laid on an .004 grade and 1000' to the grit chamber entrance, a maximum capacity of flow of 3,550,000 gallons per day was secured, with a velocity of 3.2' per second flaming full.

SCREENS.

The interceptor discharged into the screen and grit chambers. Screens were provided in duplicate. A swinging gate at the head of the partition allows either channel to be used, or both, if the flow is heavy. The screens are to be cleared by raking. A wooden platform 4 ft. wide and stretching across the channels and by passes can be laid back of the screens for footing when removing debris.

GRIT CHAMBERS.

At the head of each of the two partitions in the grit chambers are swinging gates, allowing the flow from either channel to take either of the two chambers in its course.

Using Bagin's New Formula, for a channel 3' wide, grade .002, depth of flow 1/2', V = 3.66' which gives Q = 5.5 cu. ft. per second, which is the discharge of the interceptor running full.

Using the same fomula, for a 2 m.g.d. flow the velocity would be 3.24'. For a 1 m.g.d. flow the velocity would be 2.33'. Since 1' per second is the minimum velocity to prevent deposition of solids, there is no danger of this even with low flow.

Drainage of the beds is effected by a channel across the bottom covered with an iron plate as shown, a drain pipe from each chamber going to the contrifugal pump outside. The plate is lifted when draining a chamber and the valve in the pump pit opened. The water and what grit comes with it is pumped into the by pass, when the chamber is then cleaned by hand.

With a flow of 2 cu. ft. per second, there is a 24 minute storage volume in the sump and one channel up to the mouth of the interceptor. With a 2 m.g.d. flow, a 13 minute storage to the same level. With interceptor flaming full, a 9 minute storage period to same level, and a 14 minute period to top of chamber.

Two pumps are installed, each of 2 m.g.d. capacity. The discharge pipe connects with the by-pass at one end and the sludge digestion tanks at the other. Included in the pump house is an air compression for the sludge air lifts.

SEPARATE SLUDGE DIGESTION TANKS.

The tanks number 12 - 6 separating and 6 sludge. Diagonal pairs are connected. The retention period is 2 hours. The tanks have a liquid capacity of 31,000 gallons up to the flow line. With a 2 hour retention period, 2' of scum and about 11' of sludge, average conditions, one tank could care for 286,000 gallons of sewage per day.

The sludge pipe leading to the sludge tank has a valve outside, operated from the deck. On opening this, the hydrostatic pressure forces the sludge thru the pipe. An extension projects up thru the wall and ends in a gate valve. This is to permit rodding out the sludge pipe should it get clogged. The sludge is taken out with an air life and flows by gravity down a concrete channel to the sludge beds.

The separating tanks have radial flow thru a 12 inch pipe tapped from the 18 inch main from the pumps. Scum wires are placed between adjacent tanks allowing the scum to be drawn off into the sludge tanks.

The longitudinal and cross decks give access to every tank, and valves are all controlled from here.

SLUDGE BEDS.

Sludge beds in area to the extent of 2 1/4 sq. ft. per capita are provided.

Stop boards control influent. The effluent is collected by the underdrains and flows into the river. Track is laid on the bed for removal of sludge, this being the quickest and most satisfactory method. Vitrified tile laid with open joints furnish the best type of underdrainage for this work and so are used here.

The top of the sludge beds is at elevation 830. This is about ordinary high water or a little higher. Fill from the grit and sludge chamber excavations could be used to bring the beds to this height. Should it prove necessary, an addition to the walls could be made, but it is the designer's belief that unless proven necessary, higher walls are not advisable.

CONTACT BEDS.

In studying contact beds as various authorities dealt with them it was a concensus of opinion that double contact beds were less likely to clog, handled more sewage per area and often gave better effluents. Filling from underneath was also approved as reducing the nuisance and liability of clogging. For these reasons double contact beds filled from below were chosen.

A frequent complaint of contact beds operating in the past has been that too fine material was used. The designers specify for the primary beds, crushed stone of good grade, between 1 inch and 2 inches in size, and for secondary beds, crushed stone between 1/4 inch and 1 inch in size. These sizes are believed to give as great freedom from clogging as can be determined with present knowledge.

Underdrains are provided by half round 6 inch tile laid with open joints on a slope of 1.6 to 100. Channels around the lower sides help collect the water and serve as runways for the pipe exits.

The pipes thru the wall are covered on the inside end by stop boards operated from the top of the wall. The object of putting exits so close is, first, to drain the bed quickly, and second, to reduce to a minimum the piping system in the bed, as the sewage standing in pipes and drains does not get well purified.

With drawing of the stop boards the primary bed discharges into the concrete chamber between it and the secondary bed. Here four siphons are arranged to discharge when the chamber and bed are half full. As the siphons operate, the level in bath bed and chamber falls and a continuous flow is maintained until the bed is emptied.

Each siphon runs direct to the underdrains of the secondary bed, which in distribution and collection of sewage is identical with the first. The effluent from the secondary bed runs into the river thru a concrete bhannel.

It will be seen that particular attention has been paid to underdrainage, filling and emptying. With the underdrains as here designed, it is believed any accumulation of sludge or slime on the bottom of the beds will be prevented, a big step in itself towards keeping the beds open.

Using larger sizes of rock quicker drainage and filling times can be obtained. Should the beds empty too fast, the stop boards or the inlet pipes permit throttling the flow.

Quick filling, while not a vital point, is desirable when possible.

The dosing tanks, located between the two sets of beds, are two in number. The effluent from the sludge digestion tanks flows into the circular pan and thru the opening in it to one tank. When the tank reaches a pre-determined height of fill, an electric motor starts the pan revolving, being stopped after 180° revolution.

Thus the two chambers are filled alternately. Siphons discharge into the primary bed underdrains in a manner similar to those of the secondary bed.

A gear and shaft connection with the revolving pan also turns the siphon outlet 180° with each half revolution of the pan, so the beds on either side of the chamber are dosed alternately with successive fillings of the same chamber.

Should it be desired, an electrical time clock system could be installed for emptying the primary and secondary beds, and the entire plant could be automatic in operation.

The designers recommend that 30 minutes after the bed is full, emptying be commenced. This might be lengthened to 45 minutes in case the secondary beds are necessary.

The contact beds as here designed form a unit capable of handling from 2 m.g.d. to 3 m.g.d.

Moreover, additional beds of same design can be added with perfect harmony. The design permits of expansion to any degree.

The cost of such a plant is indefinite for 5 years ahead. In general, about $35,000 per acre for contact beds of this type may be allowed.

Figuring $10 per cu. yd. for concrete work on sludge beds, screen and grit chambers, and $15 per cu. yd. for the sludge digestion tanks, the concrete will cost about $122,000. Allowing $25,000 for piping, and $13,000 for pumps, compressor and valve fittings, the total, including sludge beds, is $440,000. A $450,000 bond issue should cover the cost of the plant. The cost computations were based on authoritative estimates and engineering - News Record Quotations.

Under flood conditions, two courses are open. Use the plant, making screen and grit chamber walls above the water, and pumping the effluent from the secondary tanks, or running the sewage into the river and giving the plant a rest.

The designers advocate the latter. First, the expense of operating the plant during high water is considerable. Second, the river will have several times its normal volume and can very easily dispose of all the sewage emptied in. The 1903 records show a 6 to 8 fold increase at flood time. Moreover, the river is muddy at such a time and the sewage would not be much of a contamination. A short by pass from the collecting manhold at Harrison Avenue to the river, controlled by gate valve, is all that is needed.

CONCLUSION.

This system for the disposal of sewage represents the combined recommendations of the foremost authorities in sanitary lines, - Metcalf, Eddy, Fuller, Engineering News Record articles and others. Credit is due the Michigan Department of Health for the splendid help given. Major Rich, Mr. Hearn, Mr. Sheppard and an unknown young engineer rendered very practical and welcome assistance.

The point of chief concern is the contact beds. In these, the designers aimed for non-clogging, good under drainage, a long life, simple operation as quickly carried out as possible.

They believe that this plant will operate as designed, but in view of the very unsettled state of knowledge on sanitary disposal in general, an actual test is the only means of determination.

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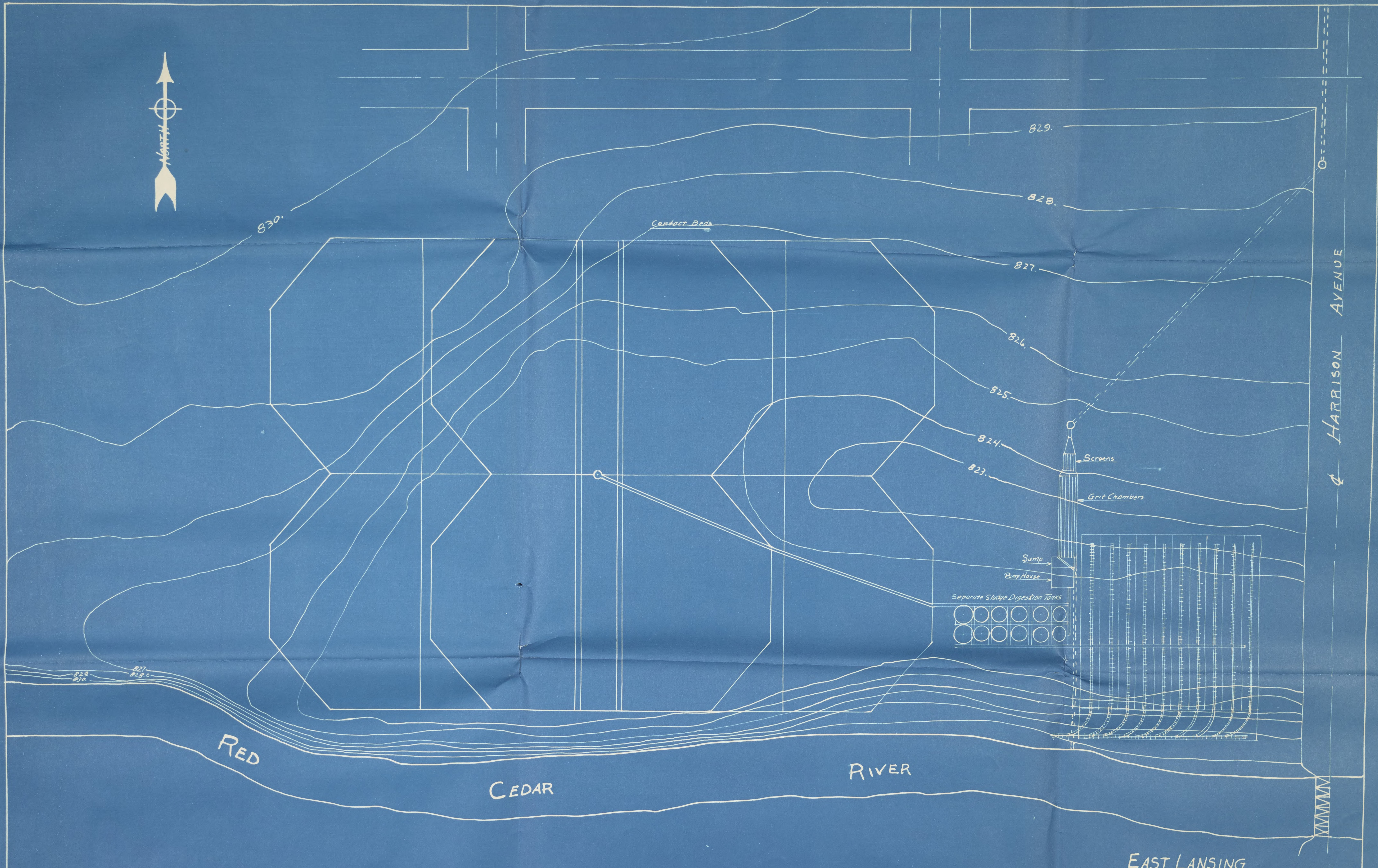


East Lansing
Michigan Agricultural College
Sewage Disposal Plant

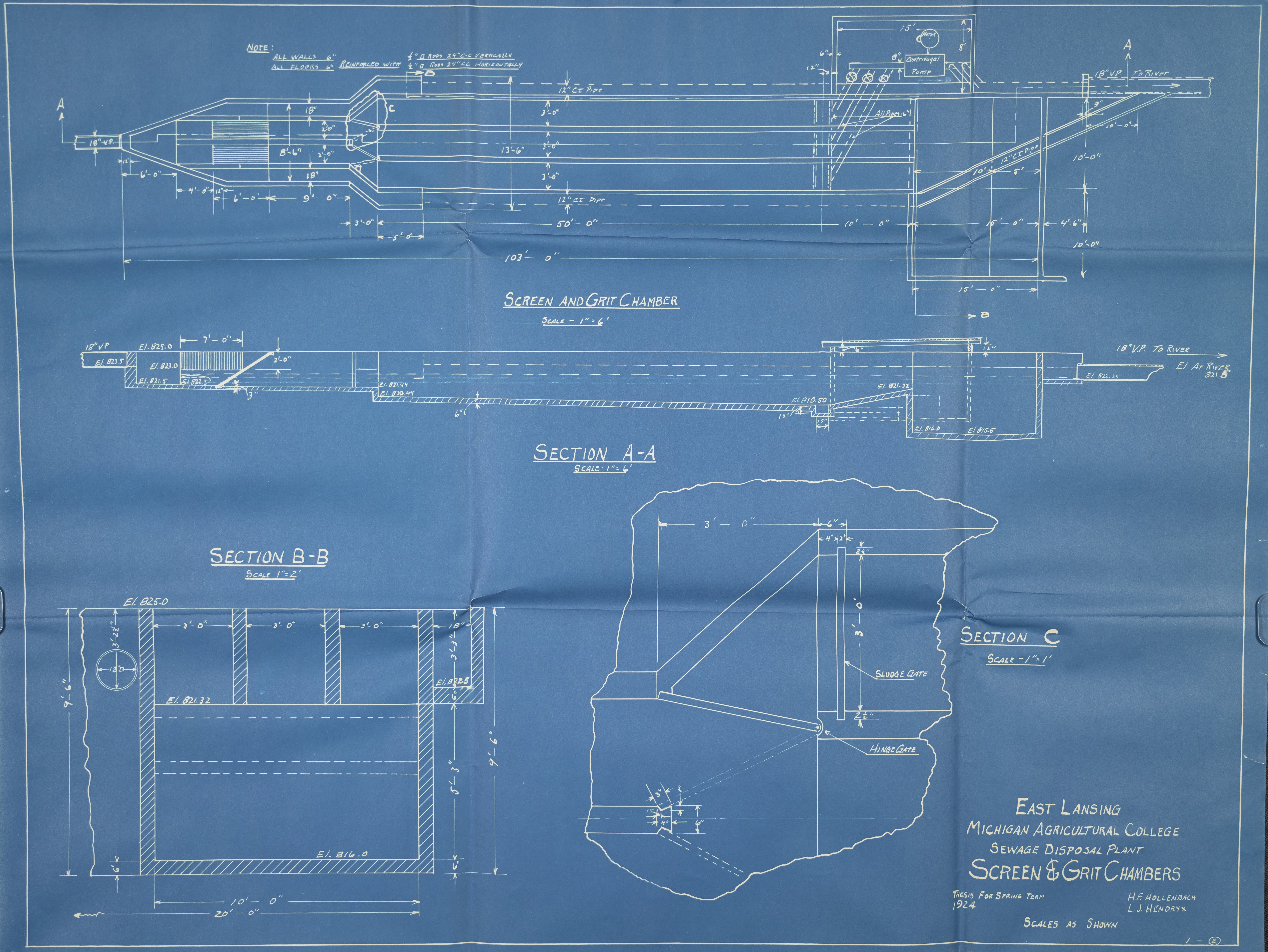
Topography & Layout

Thesis for Spring Term
1924

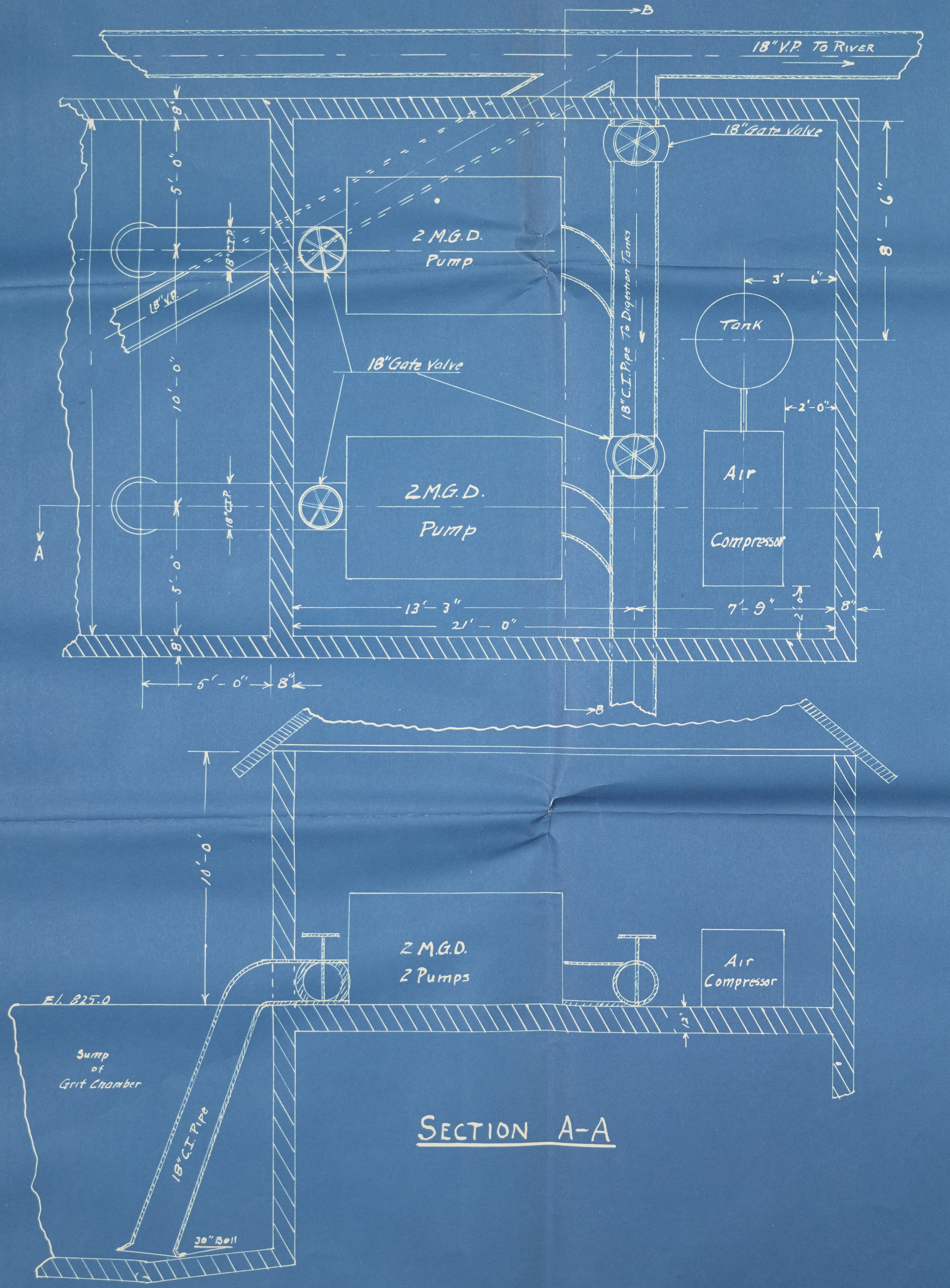
H.F. Hollenbach
L.J. Hendryx

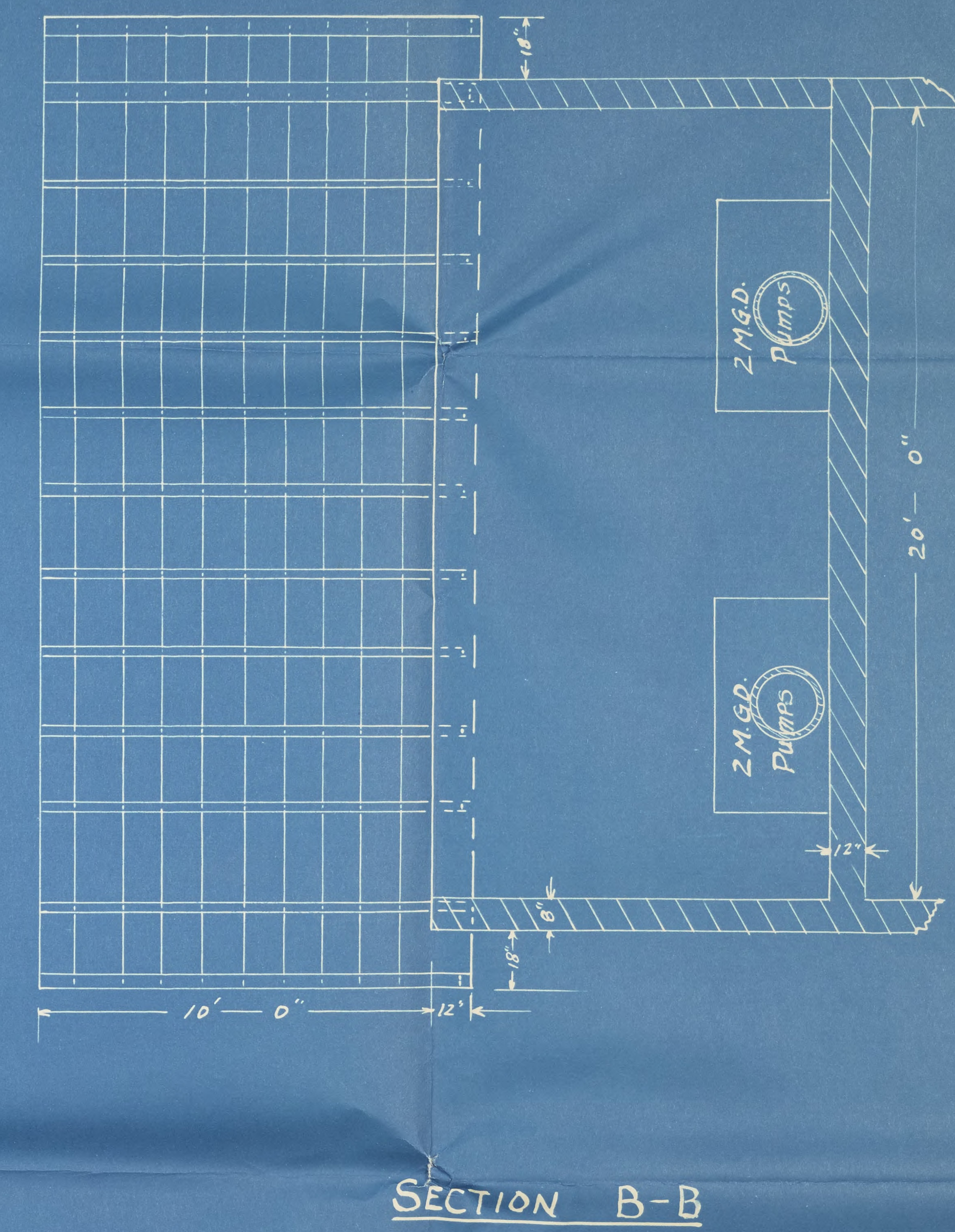
Scale - 1" = 50'

1 - 0



NOTE:
ALL WALLS 6"
ALL FLOORS 6" REINFORCED WITH 1/2" Ø RODS 24" C-C VERTICALLY
1/2" Ø RODS 24" C-C HORIZONTALLY
Motor
Centrifugal Pump
12" C.I. Pipe
18" V.P. To River
All Pipes 6"
12" C.I. Pipe
18" V.P.
103' - 0"
50' - 0"
SCREEN AND GRIT CHAMBER
Scale - 1" = 6'
18" V.P.
El. 825.0
El. 823.5
El. 823.0
El. 821.5
El. 822.5
El. 821.44
El. 820.44
El. 819.50
El. 821.32
El. 816.0
El. 815.5
18" V.P. To River
El. At River 821.5
El. 822.25
SECTION A-A
Scale - 1" = 6'
SECTION B-B
Scale 1" = 2'
El. 825.0
El. 821.32
El. 822.5
El. 816.0
18" D
10' - 0"
20' - 0"
SECTION C
Scale - 1" = 1'
Sludge Gate
Hinge Gate
EAST LANSING
MICHIGAN AGRICULTURAL COLLEGE
SEWAGE DISPOSAL PLANT
SCREEN & GRIT CHAMBERS
Thesis For Spring Term
1924
H.F. HOLLENBACH
L.J. HENDRYX
SCALES AS SHOWN
1 - 2





East Lansing

Michigan Agricultural College

Sewage Disposal Plant

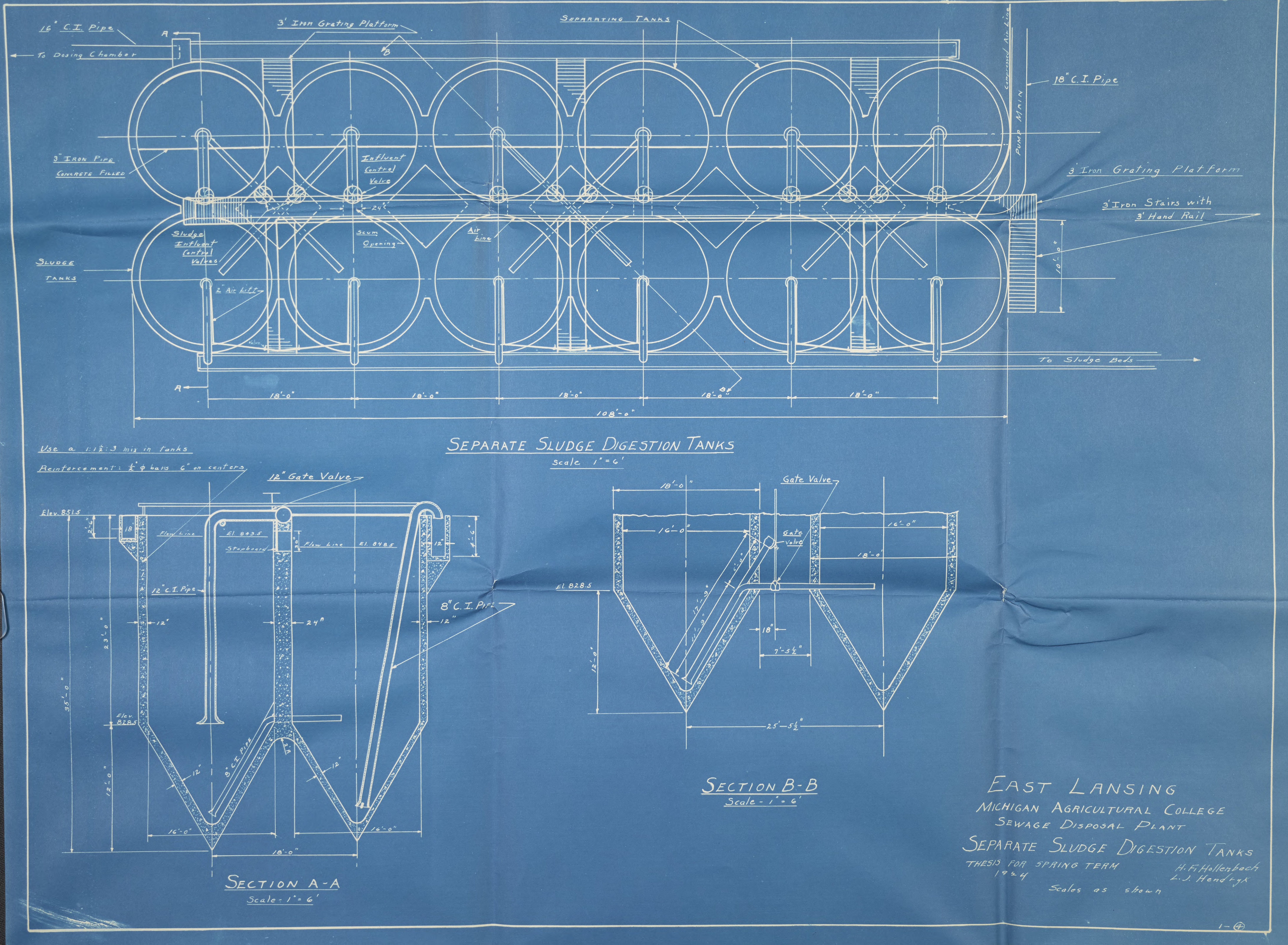
Pump House

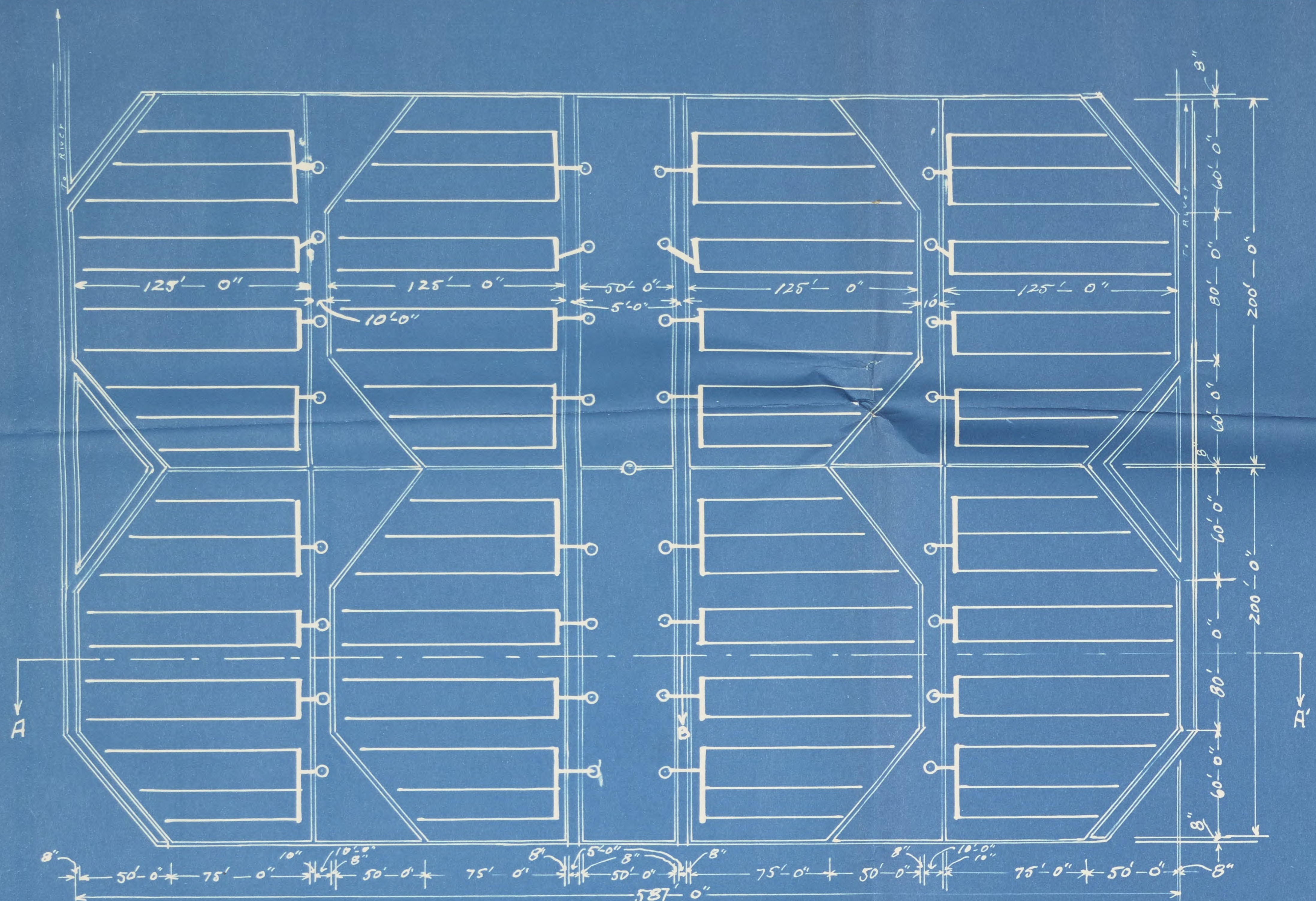
Thesis For Spring Term 1924

L. J. Hendryx
H. F. Hollenbach

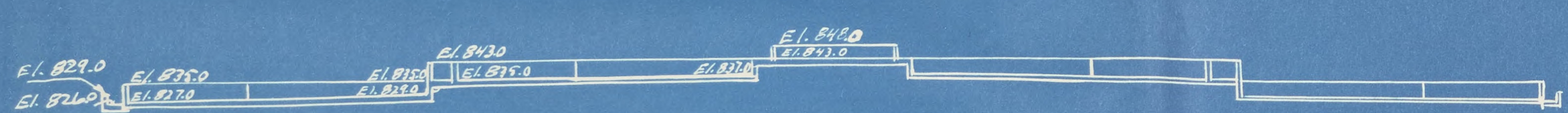
Scale - 1" = 3'

1-3

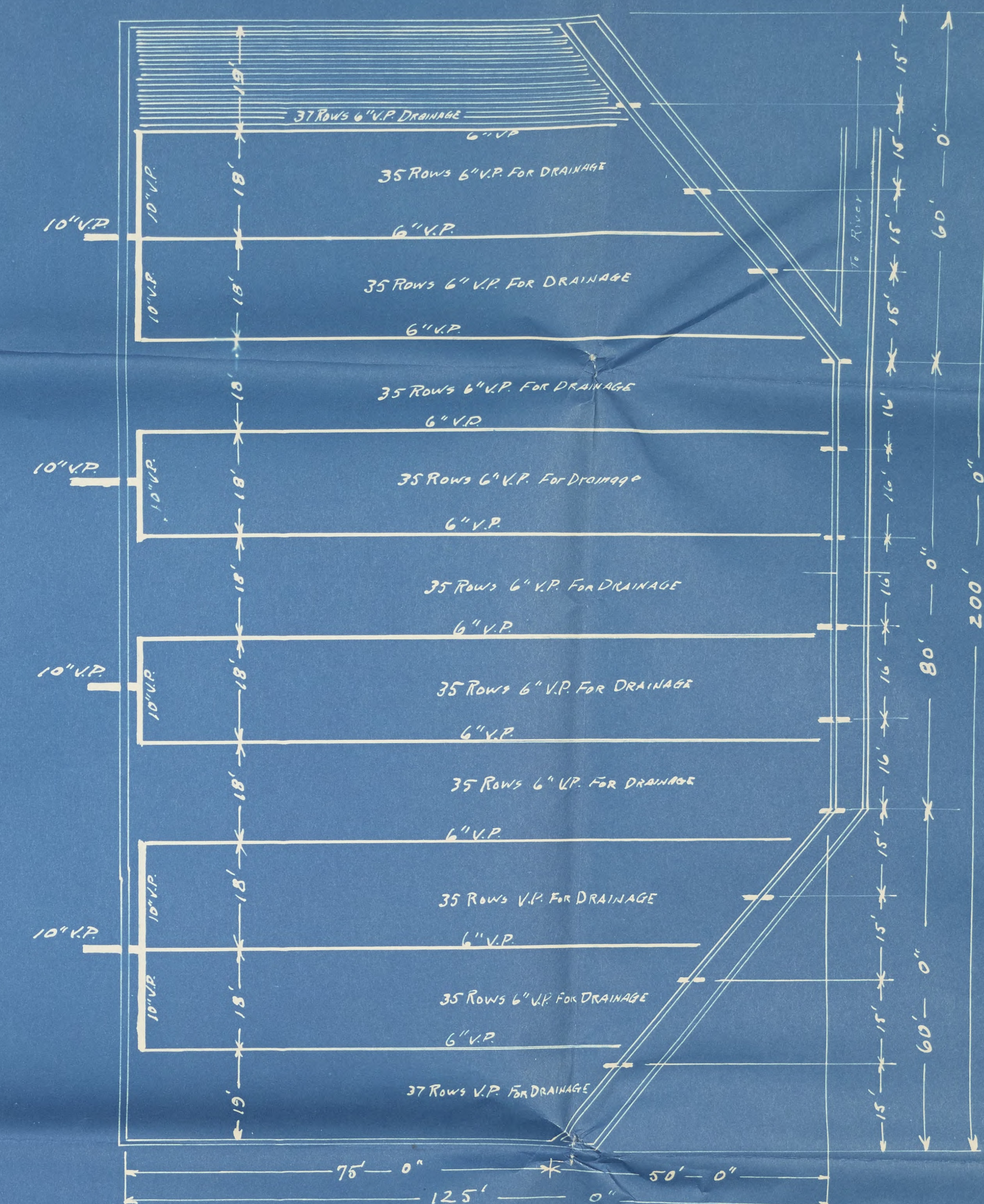

16" C.I. Pipe
To Dosing Chamber
3' Iron Grating Platform
Separating Tanks
Compressed Air Line
18" C.I. Pipe
Pump Main
3" Iron Pipe
Concrete Filled
Influent Control Valve
3' Iron Grating Platform
3' Iron Stairs with 3' Hand Rail
Sludge Influent Control Valves
Scum Opening
Air Line
Sludge Tanks
2" Air Lift
To Sludge Beds
18'-0"
108'-0"
10'-0"
SEPARATE SLUDGE DIGESTION TANKS
Scale 1" = 6'
Use a 1:1½:3 mix in tanks
Reinforcement: ½" φ bars 6" on centers
12" Gate Valve
Elev. 851.5
Flow Line
El. 849.5
Stopboard
Flow Line El. 848.5
12" C.I. Pipe
8" C.I. Pipe
Elev. 828.5
35'-0"
23'-0"
12'-0"
16'-0"
18'-0"
24"
12"
SECTION A-A
Scale - 1" = 6'
Gate Valve
El. 828.5
7'-5½"
25'-5½"
SECTION B-B
Scale - 1" = 6'
EAST LANSING
MICHIGAN AGRICULTURAL COLLEGE
SEWAGE DISPOSAL PLANT
SEPARATE SLUDGE DIGESTION TANKS
THESIS FOR SPRING TERM
1924
H. F. Hollenbach
L. J. Hendryx
Scales as shown
1-4



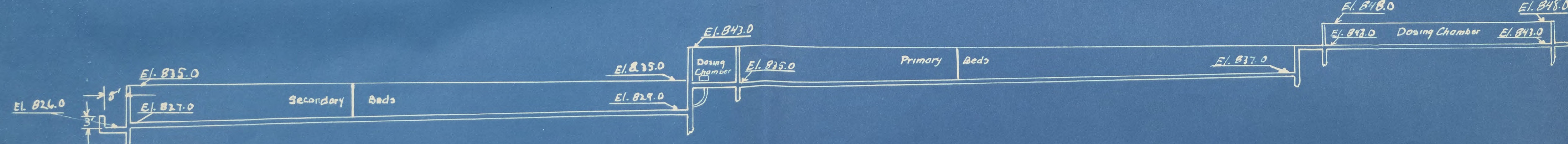
CONTACT BEDS
SCALE - 1" = 60'



SECTION A-A'
SCALE - 1" = 60'



DISTRIBUTION & DRAINAGE SYSTEMS
SCALES - 1" = 20'



SECTION A-B
SCALE - 1" = 20'

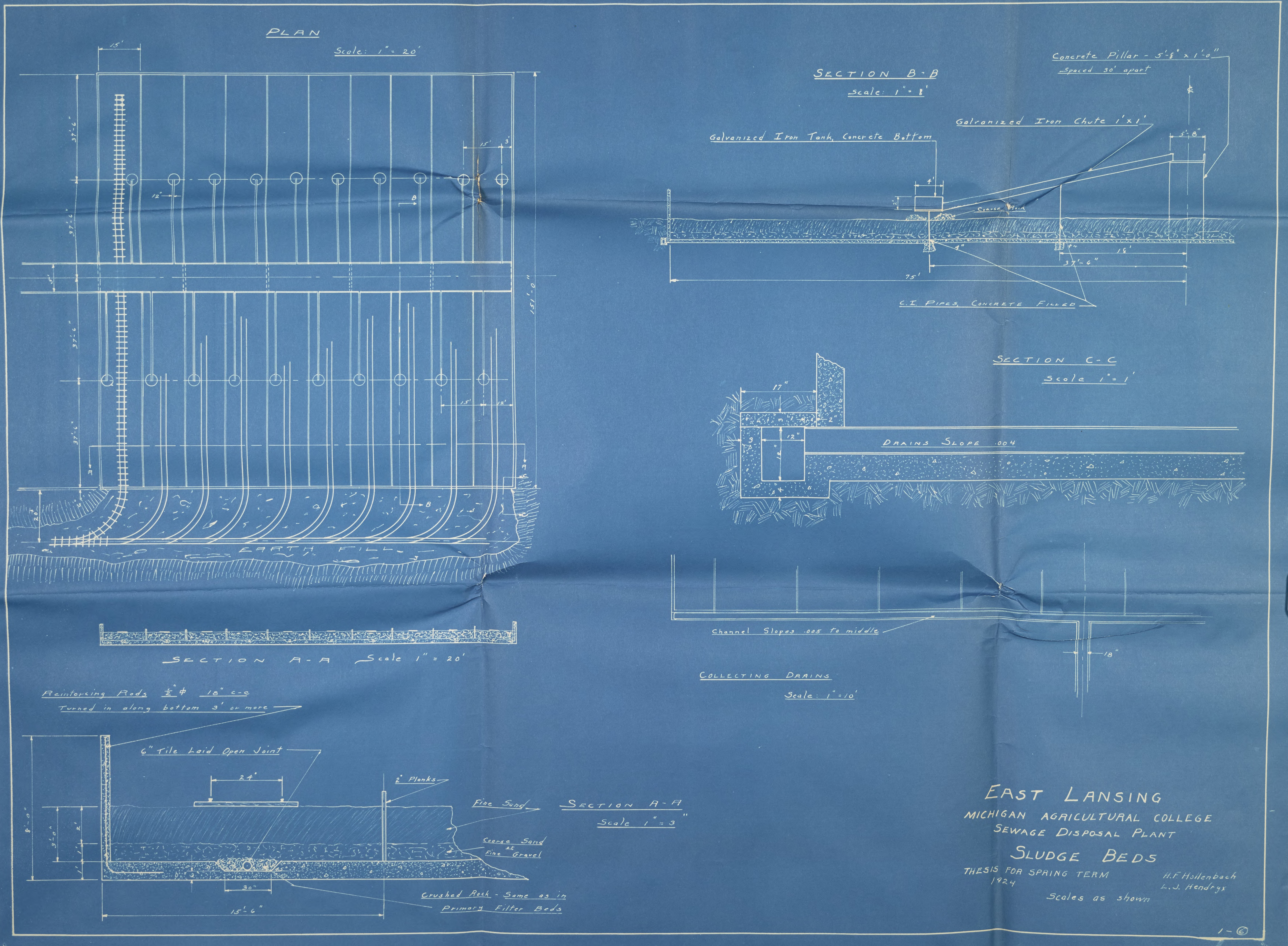
EAST LANSING
MICHIGAN AGRICULTURAL COLLEGE
SEWAGE DISPOSAL PLANT
DOUBLE CONTACT BED FILTERS

THESIS FOR SPRING TERM 1924

H.F. HOLLENBACH
L.J. HENDRYX

SCALES - AS SHOWN

1 - 5


PLAN
Scale: 1" = 20'
15'
37'-6"
15'
3'
12"
B
151'-0"
37'-6"
37'-6"
15'
12'
20'
EARTH FILL
SECTION B-B
Scale: 1" = 8'
Concrete Pillar - 5'-8" x 1'-0"
Spaced 30' apart
Galvanized Iron Chute 1' x 1'
Galvanized Iron Tank, Concrete Bottom
5'-8"
4'
16'
37'-6"
75'
C.I. Pipes Concrete Filled
SECTION C-C
Scale 1" = 1'
17"
12"
2
Drains Slope .004
Channel Slopes .005 to middle
18"
Collecting Drains
Scale: 1" = 10'
SECTION A-A Scale 1" = 20'
Reinforcing Rods ½" ɸ 18" c-c
Turned in along bottom 3' or more
6" Tile Laid Open Joint
24"
2" Planks
Fine Sand
Coarse Sand & Fine Gravel
8'-0"
3'-0"
30"
15'-6"
Crushed Rock - Same as in Primary Filter Beds
SECTION A-A
Scale 1" = 3"
EAST LANSING
MICHIGAN AGRICULTURAL COLLEGE
SEWAGE DISPOSAL PLANT
SLUDGE BEDS
THESIS FOR SPRING TERM
1924
H.F. Hollenbach
L.J. Hendrys
Scales as shown
1-6