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A TENTATIVE DESIGN FOR A
COMBINED SEWER FOR TOURAINE
SUB-DIVISION AND IN IMMEDIATE
LOCALITY OF SEWER IN
EAST LANSING, MICHIGAN

Thesis for the Degree of B. S.
MICHIGAN STATE COLLEGE
Seymour J. Ryckman
1938

THESIS

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**SUPPLEMENTARY
MATERIAL**
IN BACK OF BOOK

A Tentative Design for a Sewer for
Taurine Sub-Division and in Immediate
Locality of Sewer in West Lansing
Michigan

A Thesis Submitted to
The Faculty of
MICHIGAN STATE COLLEGE
of
AGRICULTURE AND MECHANICAL ENGINEERING

by

Seymour J. Richardson

Candidate for the Degree of
Bachelor of Science

D. C., 1922

THESIS

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A C K N O W L E D G E M E N T

The author wishes to express his thanks and indebtedness to Prof. Frank R. Theroux who helped make this thesis possible by his valuable suggestions and contributions afforded by his experience in the field of Engineering.

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Present Conditions:

At the present time the sanitary sewage and storm water from the four block area shown on the map is East of the included North of Grand River Ave. between Lansing St. and North Cowley Ave. and several short lots which extend outside of the district, is all collected in one main at the intersection of Park Blvd. and Grand River Ave. This main then crosses Grand River and thence the untreated sewage along with the storm water finds its way to the river.

General Description of Plan.

If the above conditions were allowed to continue a public nuisance would soon develop, if it already does not exist at the present. In order to remedy this nuisance it is proposed to install an intercepting sewer which will take the sewage from the main at the intersection of Grand River Ave. and Park Blvd. and take it to the East Lansing Sewage Disposal Plant.

After consideration it was decided to lay the sewer along Grand River, down Park St. and Michigan Ave. At Michigan Ave. the sewer intercepts an 18" storm sewer from Cowley Ave. This sewer then crosses a Michigan Ave. and follows East to Julia St. It follows Julia St. South until it comes to the Red Cedar River. Here an inverted syphon forms a part of the line and carries the sewage to an

interceptor and direct into one of the existing plants.

Justification of location.

It was decided to lay the line down the street because it would be less expensive to lay the line along an unimproved street and there also is no apartment building being built on the street which will be served. The line then goes across to the street, then to the street and then to the street. The streets were chosen because these streets are adjacent to those already served by the West Branch sewer system. In addition, these streets at present are unimproved.

It was necessary to provide here less to drain the sewer so that it could be directly as possible to the disposal plant. The possibility of carrying on a sewer through the sewerage system. Invert elevation was impossible due to the high elevation of that point.

From Manhole	To Manhole	Location of Sewer	Length in (ft.)	Area in Sq. In. Scale - 1" = 200'	Increment Run-off (c.f.s.)	Total Flow & Run-off (c.f.s.)	Population Increment (cap)	Population Increment (cfs)	Total Q (cfs)	Dia. of Sewer in inches	% of Slope of Sewer	Vel. in ft/sec.	Surface Elev. at Upper end.	Fall in (feet)	Invert Elev. at Upper end	Cut in feet at Upper end
Above	1	Gr. River		36.6	33.90	33.9	292	.05	34.0	--	.26	--	843.5	1.16	843.5	---
1	2	Gr. River	60	---	---	34.0	---	---	34.0	36	.26	4.8	851.5	.16	43.29	8.2
2	3	Br. River	240	1.0	.93	34.9	40	.006	35.0	36	.35	4.8	851.0	.63	43.13	7.9
3	4	New St.	630	5.2	4.82	39.8	48	.007	39.9	36	1.01	5.8	853.0	.21	42.50	10.5
4	5	New St.	490	4.29	4.55	44.5	40	.006	44.5	36	.46	9.8	852.6	.45	40.29	11.7
5	6a	Oak Rdg.	231	.9	.84	45.4	20	.003	45.5	36	.48	6.7	842.0	1.05	34.84	7.2
5a	6	Oak Rdg.	250	1.4	1.30	46.8	30	.004	46.9	36	.60	6.8	845.0	1.20	33.79	12.2
6	7	Highland	555	5.4	5.00	51.9	40	.006	52.0	36	.73	7.5	858.0	.33	32.59	25.4
7	8	Ave.	553	4.1	3.80	55.8	40	.006	55.9	36		8.3	837.0	.04	29.26	7.7
8	9	Mich. Ave.	153	20.7	19.20	75.1	--	---	75.1	54	.14	4.8	831.0	.26	25.22	6.8
9	9a	Mich. Ave.	509	---	---	75.1	20	.003	75.1	54	.14	4.8	831.0	.71	25.00	6.0
9a	10	Mich. Ave.	509	---	---	75.1	20	.003	75.2	54	.14	4.8	836.0	.71	24.29	11.7
10	11	Judd St.	500	---	---	75.1	40	.006	75.3	54	.14	4.8	837.0	.70	23.57	13.4
11	12	Judd St.	400	---	---	75.1	40	.006	75.4	54	.14	4.8	831.0	.56	22.87	8.1
12	13	Judd St.	350	---	---	75.1	--	---	75.4	54	.14	4.8	829.0	.49	22.31	6.7
13	14	C. River	104	---	---	---	--	---	---	--	---	---	828.0	.50	21.82	---
14	15	to Plant	49	---	---	---	--	---	---	88	.12	4.9	828.0	.06	21.32	6.7
													830.0		21.26	8.7

TABLE I-A

Computations for sewer

1. Determination of run-off coefficient for steel:

When an inspection of 19001 was made, the following was found: the maximum rate of fall for a period of 2.3 years was found to be 1.53" per 1/4 hour.

Materials and size gave values for run-off coefficient which varied from .75" for sparsely settled districts and .50" for densely settled districts. In past drainage is neither of these and probably will not be densely settled. If took an average of the statistics is .775". The run-off was computed on the heavy basis is 1.5 times .75 = 1.13 in./hr.

2. Assumed values used in this design:

For sewers up to 48" in diameter the maximum spacing between man-holes was taken as 100 ft. A man-hole was placed in it each change of grade or direction of the sewer.

The minimum size of tile sewer to be used was taken as 15 inches.

Except where it is possible to design otherwise, the minimum depth of crown of conduit below the surface was taken as 6 feet. In case where it is possible to design otherwise, owing to available slope, this article was conformed to as closely as possible. Of course the minimum depth is not so necessary if the sewer does not go under any heavily traveled roads.

For tables on Computation of flow, Kutter's formula was used. The gauging on pages 10 and 129 in the text-book "Sewers and Sewage Disposal" by Kutter and Eddy were used. The value of $n = .015$ was used for vitrified tile and smooth concrete.

concrete over 75 in. in dia at p. For concrete less than 75 in. in dia: $k = .015$ was used.

The cover was used for a minimum value of 2 ft./sec. over flowing spill. Care was taken to avoid all velocities above 10 ft./sec.

3. Computation for flow from Corley Ave.

This is a storm sewer which follows along Fielden Ave. west of Corley Ave. For several blocks and finally empties into an open drain which empties into the Mississippi River. The present 18" dia storm drain along Fielden Ave. does not adequately serve the catchment area conditions along Fielden Ave. and much more than is required. It was therefore decided to intercept this drain and to convey the drainage directly to the river.

This catchment area extends along Corley Ave. to the river, and includes the area between Corley and Webster Hill parking. These areas are readily seen from an inspection of the topographic map of the east side of St. Louis.

The area as described by the engineer was found to be 23.7 sq. in. on a 1" = 200' scale. The constant to obtain cubic feet per second (c.f.s.) from sq. in. of area is .197. This is the result of 1" = 200' ft. of minimum run-off of ^{.08} ft. per hour. This constant develops into $23.7 \times .197 = 4.67$ c.f.s.

4. Computation for flow at in-lets (c. 1.)

The contributing area was located on the river on the

South, the 101 St. elevation line north of 30 ft. on the
 east, city lot line on the west, and 101 St. on the
 West.

$$Area = 75.5 \text{ sq. ft.}$$

$$75.5 \times .927 = 69.9 \text{ c.f.s. in at } .11.1$$

6. Details of the size of cover, slope, amount of flow,
 velocity in, etc. may be found in table I-A.

6. Design of sewer line 1.1. 1 - 1.1. 2.

This does not require sewerage and thus there isn't any
 additional contribution for sewerage in the area.

Design upon a 10" vitrified tile (V.T.) conduit with
 a slope of .011

7. Design from 1.1. 2 - 1.1. 3

It was necessary to make extra slope from 1.1. 4 and 5
 due to a rise in elevation.

8. Design from 1.1. 3 - 1.1. 11.

Below 1.1. 10 no additional drain or sewer was required
 because when the above flows are flowing through run-off the
 crest of the 101 St. is high and this area doesn't signifi-
 cantly contribute to the flow.

It was necessary to allow the sewer to be closer to the
 closer to the surface than the allowed depth of the
 available head was and it impossible to put the sewer lower

in the point.

The 54 in. pipe line is made of reinforced concrete cast in place.

Computation for Inverted Siphon

Total available head from upper end of siphon to river is .55 ft.

If .35 were allowed for head loss from lower end of siphon to air seal, there would remain an available head loss in the siphon of .50'.

Computation for Flow Conditions

Conditions of flow	Pop. No.	Increment c.f.s.	Infiltration c.f.s.	Total Q (c.f.s.)
Min. flow	800	.110	.42	.14
Max. Dry weather flow	700	.240	.14	.26

I. Infiltration in 5100 gal. per mil./hr.

Run off for ordinary water 1/16 inch per hour or about 1/16 of that computed for average flow.

$$75.1 \times 1/16 = 4.7 \text{ c.f.s.}$$

It is desirable that one maintain a 5 ft./sec. velocity in all pipes and not use any smaller than 6" unless screened.

II. Determine size of pipe elevation of water and cover maximum flow from siphon.

Quantity in 4" pipe with 5 ft./sec. velocity.

$$\frac{3.1416 \times 4^2 \times 5}{4} = \frac{3.1416 \times 4}{8 \times 1} = .785 \text{ c.f.s.}$$

Actual velocity in 4" pipe with Q = .14 c.f.s.

$$.14 \times 50 = 1.6 \text{ ft./sec.}$$

The screen is not liable to clog if this velocity of 1.5 ft./sec. is maintained and the inlet is provided with a screen to prevent larger objects from getting into the system.

Check Head Loss -

fairly smooth 4" C.I. pipe

(table page 232 in Hydraulics by Choudhry and Dawson)

$$h_f/1000 \text{ ft.} = 4' \quad \text{with } Q = .14 \text{ c.f.s.}$$

$$h_f \text{ for } 104' = \frac{4 \times 104}{1000} = .416'$$

$$\text{Vel.} = 1.5' / \text{sec.}$$

Available Capacity of 4" pipe-

$$\text{Head loss} = .5'$$

$$H_f/1000 = \frac{.5 \times 1000}{104} = 5.9'$$

$$Q = .17 \text{ c.f.s.}$$

Try a 5" C.I. pipe - $H_f/1000 = 4.9'$ or .5' in 104 ft.

$$Q = .5 \text{ c.f.s.} \quad \text{Vel.} = 2.5' / \text{sec.}$$

which values are maximum as no entrance losses are assumed but as the velocity is very small the entrance loss could also be very small.

III. From an inspection of the above data and computation, one may conclude that a 4" pipe will be required to meet the minimum flow conditions. As the velocity is low it is considered that the maximum flow will raise the velocity to or above 7.0 ft./sec. during the dry run thus no depositing or settling out will occur. At present time, the 4" C.I. pipe will take care of both the min. and max. dry weather flows but there should be provided another conduit

which will take care of the storm water to the disposal plant. It will, therefore, be both a 4" and a 6" C.I. will be used.

Elevation of Invert. = 321.2

Check with flow in 6" sewer, assuming length of 4'.

Assume the flow conditions then will:

$$Vel. = .72 \quad Discharge = .14$$

$$Q = V \times A = .14 \text{ c.f.s.} \quad Vel. = \frac{Q}{A} = \frac{.14}{.075} = 1.87 \text{ ft.}$$

Will be the elevation of water which controls flow into the second pipe 6" above invert of 6" sewer. This will increase the head on the 4" pipe and increase its flow to some extent before the second pipe comes into use.

The elevation of this weir will then be:

$$321.22 + .42 = 322.24$$

The elevation at the second weir which will control the overflow to the river will be 6" above the first.

$$\text{This elevation will be } 322.24 + .75 = 322.99.$$

At this elevation of 322.99 the sewage will begin to overflow into the river. The overflow will be placed

a short distance down the river in order to prevent,

to some extent, the backing up of sewage in the syphon.

The syphon will be arranged so that the small pipe will be nearly in line with the axis of the 6" sewer, the 6" pipe will be to one side and the overflow will be out on the other side of the 6" pipe as shown by drawing of north side of syphon. This will divert the flow across

the mouth of the two pipes and will carry out those objects which have been prevented from going through the screen by the screen.

A small ledge will be provided so that if necessary the screens may be cleaned.

Using above data check flow through system -

Use an 18" vertical tile conduit at the lower end.

Check capacity of 4" system. With an 18" head at

the head of the 4" pipe. Assume flow in 18" pipe

is 1.5" deep. Friction loss available = $14.3 \frac{\text{ft}}{1000} = 14.3 \frac{\text{ft}}{1000}$

Entrance loss = 1.5" Loss = .12 c.f.s.

To check: $\frac{Q_1}{Q} = \frac{.29}{.4} = .65$ $d_1 d = .13 \times 10^3 = 2.7 \frac{\text{ft}}{1000}$

$V_1 = 2.7$

The flow in the 4" pipe just before overflow will be .17 c.f.s.

To check flow in 3" pipe when ready to overflow:

total head available = 15"

Friction Loss (Assumed) = 2.5"

Depth of flow in 18" sewer (assumed) = 3"

Available loss in 3" pipe = 3.0"

$\frac{Q_1}{Q} / 1000 = \frac{.3 \times 1000}{12 \times 10^3} = 4.2$ $Q = .50$

$\frac{Q_1}{Q} = \frac{.75}{.4} = .19$ $d_1 d = .50 \times 10^3 = 1.4$

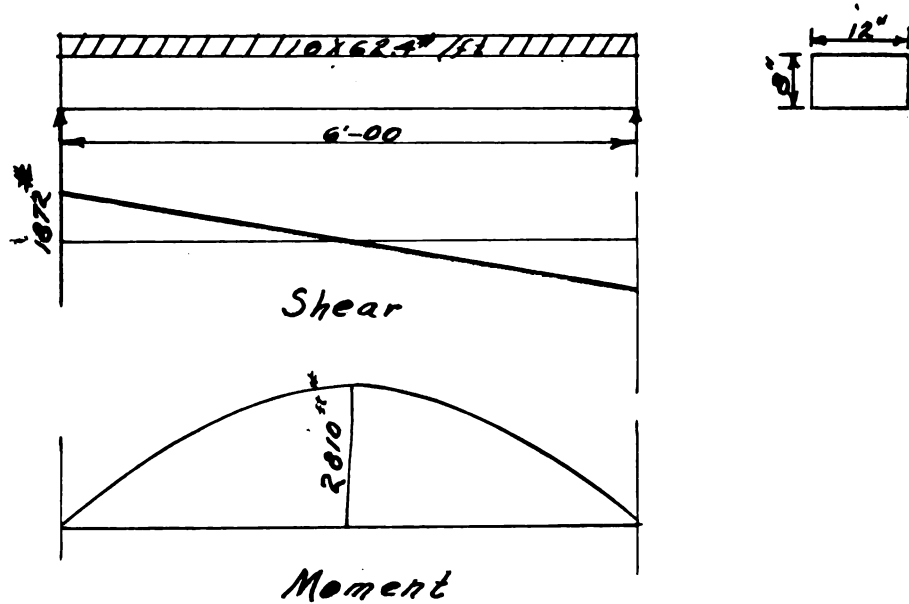
Fr. loss ready to go over the overflow = .35

Flow capacity = 3.0" Total Q of system = .3 + .5 = .7 c.f.s.

The size of sewer from the system to the river is justified, for requiring a large conduit not so much as is required to give the required flow out in this way will

constant load of 100 lbs per sq ft. in the portion in the center of column clear.

IV. Design of Steel:



Determine amount of steel in 10' or foot:

$$\text{Max. Shear} = \frac{wL}{2} = \frac{68.4 \times 6}{2} = 1872 \#$$

$$\text{ex. Moment: } \frac{1872 \times 6}{2} = 2010 \text{ ft.}\#$$

ex. concrete stress 1500 Joint Standard Building Code (A.C.I.)-1928: for 2000" concrete (Art. 200)

Extreme fiber stress of concrete:

$$f_c = .45 f'_c = 900 \text{ p.s.i.}$$

Shear from A.C.I. (as above)

$$V = .33 f'_c = 400 \text{ p.s.i.}$$

per A.C.I. - 1928 Joint Standard Building Code Art. 200

$f_s = 20,000 \text{ p.s.i.}$ allowable stress in steel

$$\text{required } a = \frac{\sqrt{\frac{M}{Kb}}}{\sqrt{\frac{f_s}{f_c}}} = \frac{\sqrt{\frac{1872 \times 12}{157 \times 12}}}{\sqrt{\frac{11.9}{3.45}}} = \sqrt{11.9} = 3.45$$

Will use a finished floor wall of 9".

Use cov. steel with a 1" layer of concrete

$$d = 9" - 1" = 8"$$

Use neutral axis x curves online to design stresses of

$f_c = 900$ p.s.i. and $f_s = 80,000$ p.s.i. equals:

$$k = \frac{1}{1 + \frac{f_s}{n f_c}} = .408 \quad j = \frac{-k}{2} = .37$$

$$i = \frac{1}{6k^2} = \frac{1372 \times 12}{19 \times 10^6} = .69$$

From plot 3 (p. 454) in Reinforced Concrete Structures by Huseby (for footnote)

$$p = .0093 \quad f_c = 450 \text{ p.s.i.}$$

From plot 1 (p. 454) using $p = .0093$ and $n = 15$

$$j = .915$$

Analysis of wall of 9" is satisfactory for bending moment require mts.

to check for shear.

$$\frac{V}{b_d} = \frac{1372}{1' \times .87 \times 3} = 80 \text{ p.s.i.} \quad \text{This is satisfactory as allowable stress is } 40 \text{ p.s.i.}$$

Area of steel:

$$A_s = \frac{2.16 \times 1'}{80,000 \times .915} = .002 \text{ sq.in./ft.}$$

Will use 3" extra bars from 3" floor concrete to develop at the bottom.

At one-third distance from bottom will develop steel

to 9" walls will use a 1" space from top end of wall to 9"

Footnote: This textbook is used as reference through out the design of the walls and floor slab.

Vertical 12-11

A 12" round vertical pipe was used .9' to .4' of area of concrete.

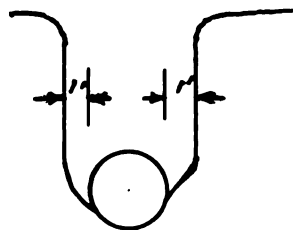
$$.911 \times \pi \times .09 = .249 \text{ sq. in. area of steel/ft. of pipe}$$

A 12" round bar lives on area of .91 sq. in. All 12" round bar spaced at 12" center to center.

Estimated Cost of the Project

I. Estimate cost of everything to be built.

a. Typical tunnel:



Cost of pipe and excavation and fill

Location ft. to ft.	Average diam. (ft.)	Area sq. ft.	gross-section sq. ft.
1-2	3.1	30	12.0
2-3	9.7	246	85.0
3-4	10.1	320	103.0
4-5	3.0	281	100.9
5-5a	3.0	281	77.1
5a-6	10.0	281	170.0
6-7	17.0	300	110.0
7-8	3.7	353	117.0
50" pipe used to here			total 1177.0 sq. ft.
8-9	3.0	153	54.0
9-9a	3.0	219	150.5
9a-10	11.0	309	154.1
10-11	10.0	500	100.0
11-12	3.0	400	119.0
12-13	7.1	150	91.0
54" pipe was used to here			total 1840 sq. ft.

$$\text{Vol.} = 1177 \times 5 + 345 \times 0.5 = 11,740 \text{ cu. yds.}$$

An estimate cost of \$2.10 per cubic yard for excavation and backfill is used. This value is used as it is not likely that a road will be used, therefore no allowance is made for the cost of backfilling.

I. Cost of excavation and backfill =

$$11,740 \times 2.10 = \underline{\underline{24,654.00}} \quad 24,654.00$$

II. Cost of Water Line =

$$\text{Length of 12" sewer} = 2500 \text{ ft.}$$

$$\text{Length of 6" sewer} = 2691 \text{ ft.}$$

$$\text{Estimated cost per ft. of vitrified tile} =$$

$$1.30$$

$$\text{Cost of 12" V.T. sewer} =$$

$$2500 \times 1.30 = \underline{\underline{3,250.00}} \quad 3,250.00$$

$$\text{Estimated cost of 6" Concrete sewer} =$$

$$1.00 \text{ per ft.}$$

$$\text{Cost of 6" Concrete sewer} =$$

$$2691 \times 1.00 = \underline{\underline{2,691.00}} \quad 2,691.00$$

III. Cost of Manholes =

\$75.00 is the average estimated cost of one manhole, 3 ft. in depth. For manholes above 3 ft.

a cost of 15.00 per ft. is added.

Manhole	Depth in ft.	Cost
1	3	70.00
2	3	70.00
3	2	70.00
4	9	80.00
5	4	70.00
6a	9	80.00
6	2'	210.00
7	3	70.00
8	4	70.00
9	4	70.00
9a	9	70.00
10	9	80.00
11	3	70.00
12	3	70.00
13	Inverted siphon here	
14	Inverted siphon here	
15	3	70.00
	total	<u>2050.00</u>

2050.00

IV. Estimate cost of inverted siphon and conduit
from H. 15 to Disposal plant.

a. Concrete in siphon:

Vol. of Concrete = 35.3 cu.yd.

Estimated cost of reinforced concrete

in place = \$23.00 per cu.yd.

Cost of concrete =

35.3 x 23.00 = 810.00 810.00

b. Manholes:

4-2' opening for C.I. manhole frames and
cov. pt. (A-480, Reverse City Iron type)

at \$45.00 each. 180.00 180.00

c. Cost of C.I. pipe:

(Class A pipe- Reverse City Iron for c)

93 ft. 4" C.I. pipe at 2.00 per ft. 186.00

98 ft. 3" C.I. pipe at 2.00 per ft. 196.00

(Average cost per pound laid = .10)

d. Valves:

2-4" sliding stem valves at \$27.50 =	55.00
2-6" sliding stem valves at 42.75 =	85.50
4-8" globe valves at 17.50 =	70.00

e. Bar steel:

2" x 1/2" at 7" centers = 115.00	15.00
----------------------------------	-------

f. Wall castings:

4-4"x16" wall castings at 18.00 =	72.00
4-6"x16" wall castings at 15.10 =	60.40

g. Laterals:

2-4" standard C.I. laterals at 12.00 =	24.00
2-6" standard C.I. laterals at 12.25 =	24.50

h. 45° elbows:

2-4"-45° elbows at 10.00 =	20.00
2-6"-45° elbows at 9.65 =	19.30

i. Steps:

Galvanized steel steps	15.00
------------------------	-------

j. Pipe:

58'-2 1/2" galvanized pipe at 1.10/ft.	63.80
--	-------

k. Sewer Pipe:

25'-54" concrete at 1.50/ft.	81.00
40'-18" V.P. at \$1.75/ft.	70.00

l. Excavating and fill:

121 cu. yd. at 2.00/cu.yd.	242.00
----------------------------	--------

Total Art. IV

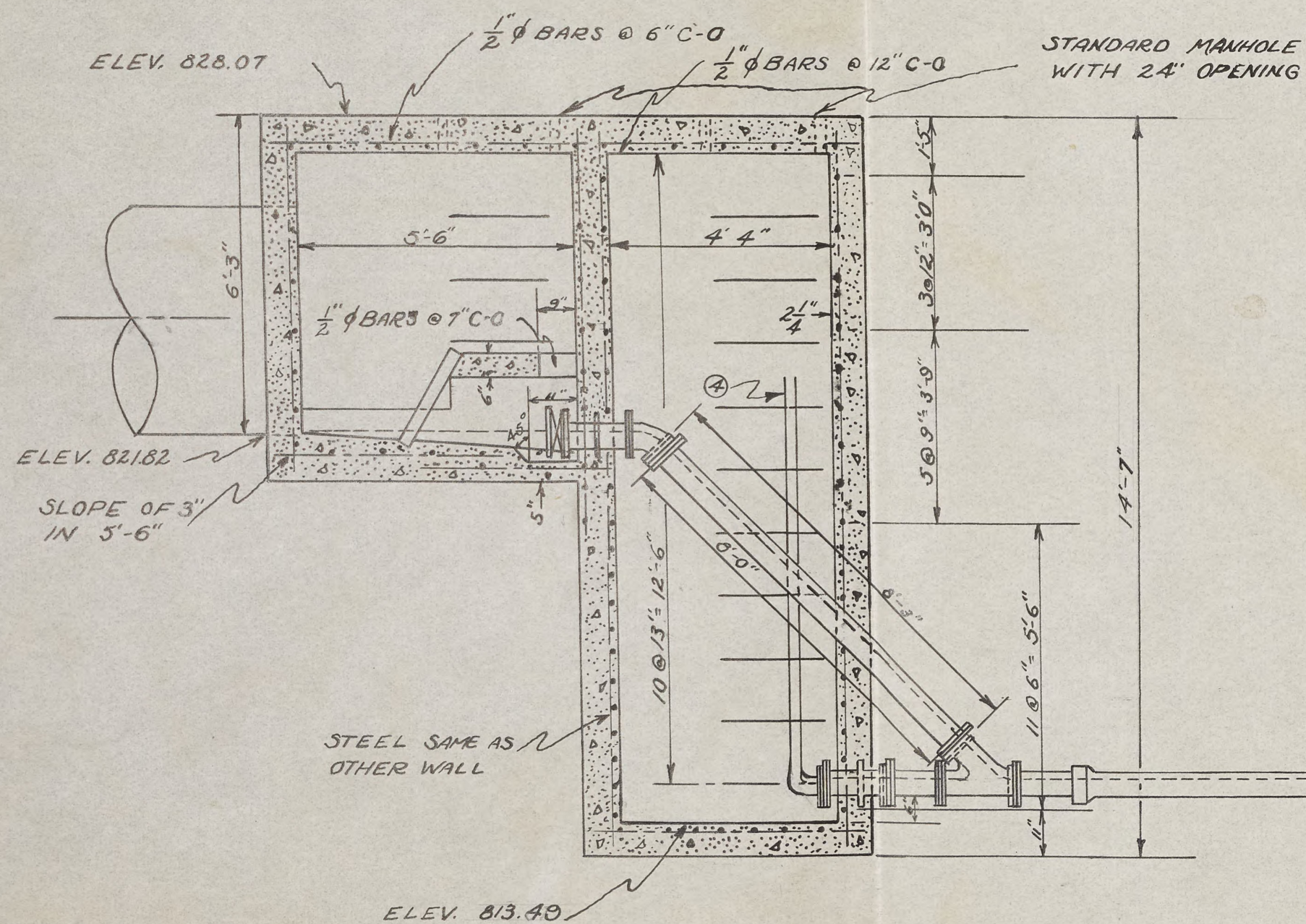
943.00

V. Gross total of estimated cost of project:

Excavation and backfill.....	12775.00
36" V.C. cover.....	7500.50
54" Concrete cover.....	2357.50
Manholes.....	8990.00
Syphon.....	<u>2457.50</u>
total.....	\$25275.00

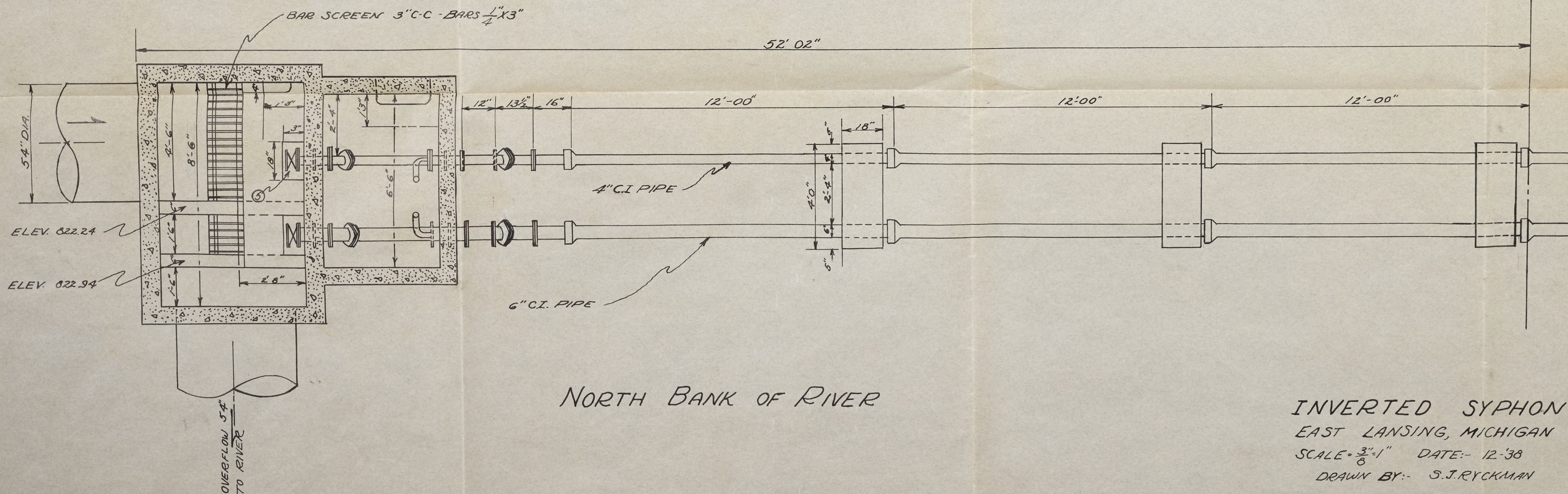
10% of total cost is added for miscellaneous

fees and engineering fees.....	<u><u>2,707.50</u></u>
Gross total.....	\$25,602.50



NOTE:-

- ① ALL WALLS 8" IN THICKNESS EXCEPT WHEN DIMENSIONED
- ② WALL CASTINGS - 15" LONG
- ③ STEPS - 3" ϕ BARS GALVANIZED STEEL - 2 FT. WIDE
- ④ 2" GALVANIZED PIPE WITH 2" GLOBE VALVE AT TOP AND FITTED FOR CONNECTION TO A 2" HOSE - PIPE LENGTH 8'-0"
- ⑤ SLIDING STEM VALVE A205 TRAVERSE CITY IRON WORKS

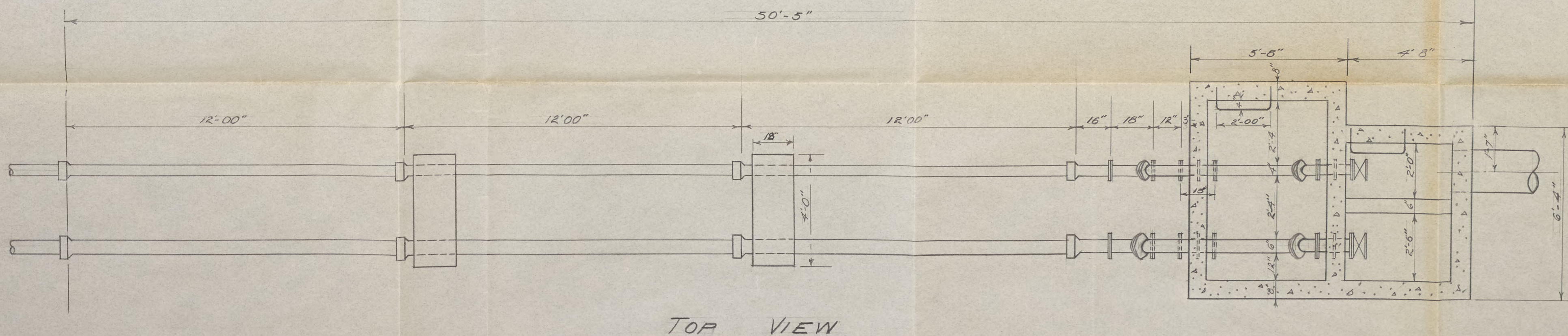
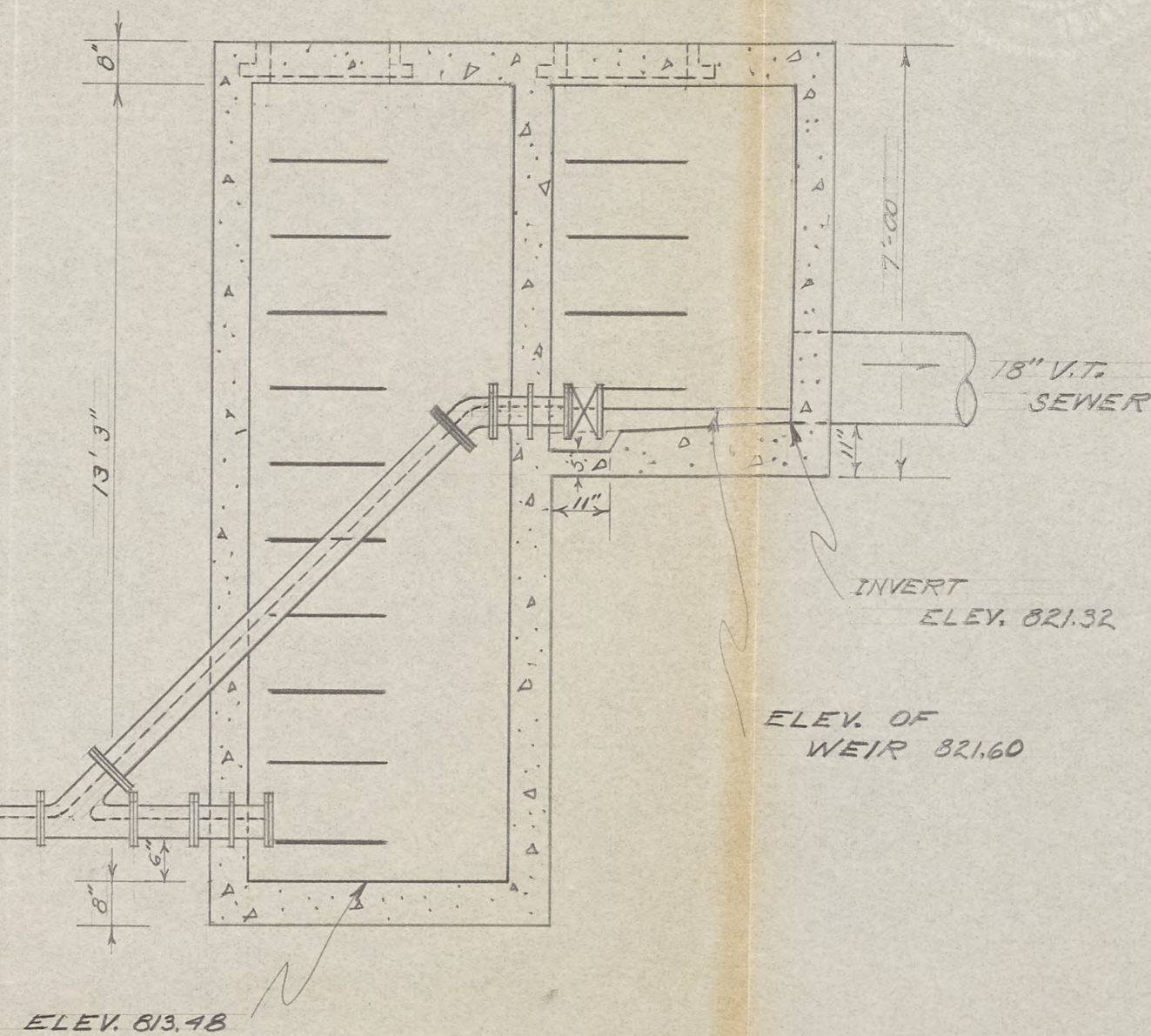
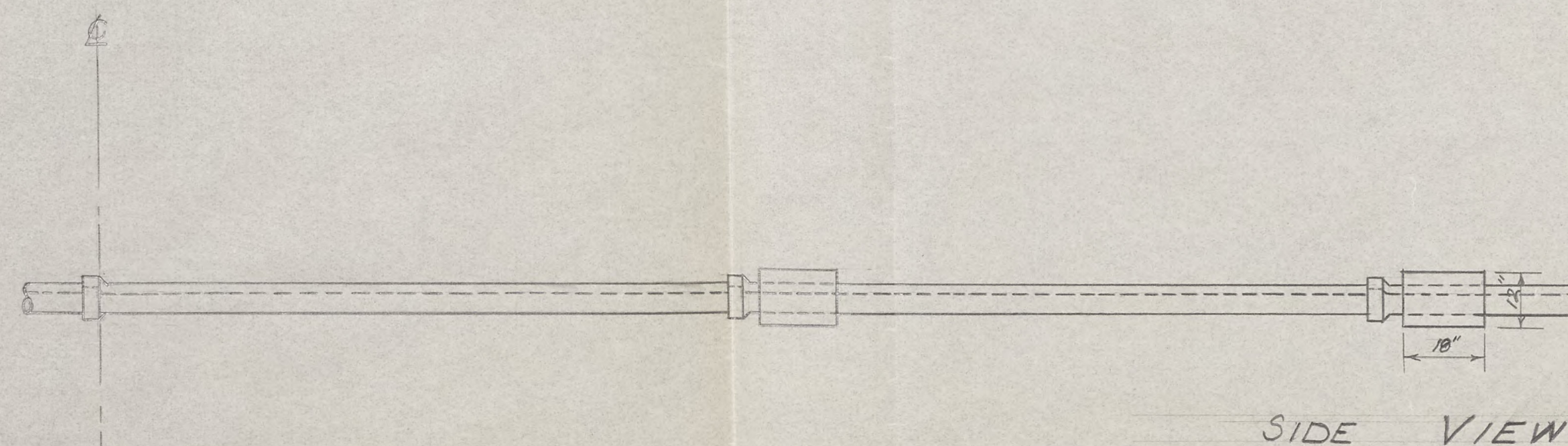


NORTH BANK OF RIVER

INVERTED SYPHON
 EAST LANSING, MICHIGAN
 SCALE = $\frac{3}{8}$ " = 1" DATE:- 12-'38
 DRAWN BY:- S.J. RYCKMAN

NOTE:-

STEEL PLATE SAME AS SHOWN ON
NORTH BANK
STEPS TO BE SAME AS FOR OTHER END
MANHOLE CENTERS 1'3" FROM INSIDE OF WALL



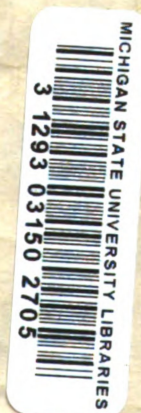
SOUTH BANK OF RIVER

INVERTED SYPHON
EAST LANSING MICH.
SCALE: $\frac{3}{8}'' = 1'$ DATE: 12-38
DRAWN BY: S.J. RYCKMAN



NOTE BOOK	DATE	BY	DATE	BY	DATE
PROFITE	BY	DATE	BY	DATE	BY
PROFITE	BY	DATE	BY	DATE	BY

SUPPLEMENTARY
MATERIAL



124
118
TAS
Plan 2

Note- Not to scale

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