DESIGN OF A SECONDARY SEWAGE TREATMENT PLANT
EAST LANSING, MICHIGAN

Thesis for the Degree of B. S.

Milton O. Lehnhardt

1937

Sewage disposal
Title

Civil engineering - Sanitary engineering

DESIGN OF A SECONDARY SEWAGE TREATMENT PLANT

EAST LANSING, MICHIGAN

A THESIS SUBMITTED TO

THE FACULTY OF

MICHIGAN STATE COLLEGE

OF

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BY

MILTON O. LEHNHARDT

CANDIDATE FOR THE DEGREE OF

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JUNE, 1937

THESIS

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INTRODUCTION:

The purpose of this thesis is to submit a design of a Trickling Filter which can be used as a Secondary Treatment of Sewage for East Lansing and Michigan State College.

ACKNOWLEDGEMENT:

The author wishes to thank Professor Frank H. Theroux for his advice and help in preparing this thesis.

General Information and Present Conditions

Sewer System: East Lansing is served with a combined sewer system which delivers the sewage to an interceptor adjacent to the Red Cedar River. The sewage from Michigan State College is added to the East Lansing flow in the interceptor. The interceptor is provided with overflow chambers so that in time of excessive storm water run-off, part of the flow is diverted directly into the river.

Sewage Treatment Plant: The interceptor sewer terminates at the sewage treatment plant located near the west city limits of East Lansing, about one-quarter mile below Harrison Street Bridge, on the south bank of the Red Cedar River. The plant consists of a pumping station, a bar-rack screen, an Imhoff tank, and a sludge bed. The effluent from the Imhoff tank discharges into the Red Cedar River at the plant site.

The present plant was placed in operation in 1923. It secures the removal and treatment of only a portion of the suspended solids. The balance of the suspended solids and all those in solution discharge to the river in the plant effluent. A plant of this kind effects only about one-third of the organic solids in the sewage. Thus two-thirds of the organic solids pass to the river unchanged. It is the organic solids in sewage which are the causes of offensive conditions from the sewage. The principle objective of sewage treatment plants is to change the organic matter, both suspended and dissolved, into sufficiently inocuous, more stable compounds so that the plant effluent may be discharged into a diluting body of water without causing objectional conditions. The degree to which these changes need be carried out depends on the diluting body of water, its volume of flow, the uses to which it may be placed, and its location. This plant does not appreciably effect the bacterial content of the sewage, and thus the river is grossly contaminated by the present plant discharge.

River Conditions: The flow in the Red Cedar River is generally very low during several months of the year and entirely inadequate to avoid offensive conditions and gross contamination of its waters, due to the sewage load it now receives from the East Lansing Sewage Treatment Plant. (Table I) The result is that the river is in a very objectionable condition from the point at which it receives the plant effluent, down to its entry into the City of Lansing.

The location of this stretch of river, through a residential and recreational area, makes it desirable to maintain it in its natural condition. The river just passes adjacent to the Lansing Red Cedar Municiple Golf Course, then adjacent to or near a residential development contiguous to Lansing, thence through Potter Park, a municiple park of the City of Lansing, and thence through a portion of the City of Lansing to its junction with the Grand River.

Detailed Information

It is recognized that a river has a certain digestive capacity to take care of sewage without offense. In order to determine the conditions which may result from the variable river flow, the flow records have been tabulated below on a basis of time.

Surface Elev. 0 gage = 821.76'

Max. high flood = 833.00'

Ord. " " = 829.00'

Low water = 821.00'

Table No. I

Average monthly Red Cedar River flows, according to occurrence

Percent of Time	No. of Months	Gage Heights Max.	Gage Heights Min.	Gage Heights Ave.	Water Surface Elev. Max.	Water Surface Elev. Ave.
5	5	1.1	1.0	1.04	822.86	822.8
10	10	1.1	1.0	1.08	822.86	822.84
15	16	1.3	1.0	1.10	823.06	822.86
20	21	1.4	1.0	1.19	823.16	822.95
25	26	1.5	1.0	1.25	823.26	823.01
30	31	1.6	1.0	1.29	823.36	823.05
40	41	1.7	1.0	1.52	823.46	823.28
50	52	1.9	1.0	1.58	823.66	823.34
75	78	3.4	1.0	1.92	825.18	823.68
100	104	6.3	1.0	—	828.00	—

Design Basis

Population:

Pop. of E. Lansing

1910 - 902	1920 - 1889	1930 - 4380

Enrollment of M. S. C.

1910 - 1508	1920 - 2036	1930 - 4428

Total E. Lansing and M. S. C.

1910 - 2470	1920 - 3925	1930 - 8717

From Graph I, the estimated population of East Lansing and Michigan State College is 15,000 in 1960. My Design Basis is 15,000 population.

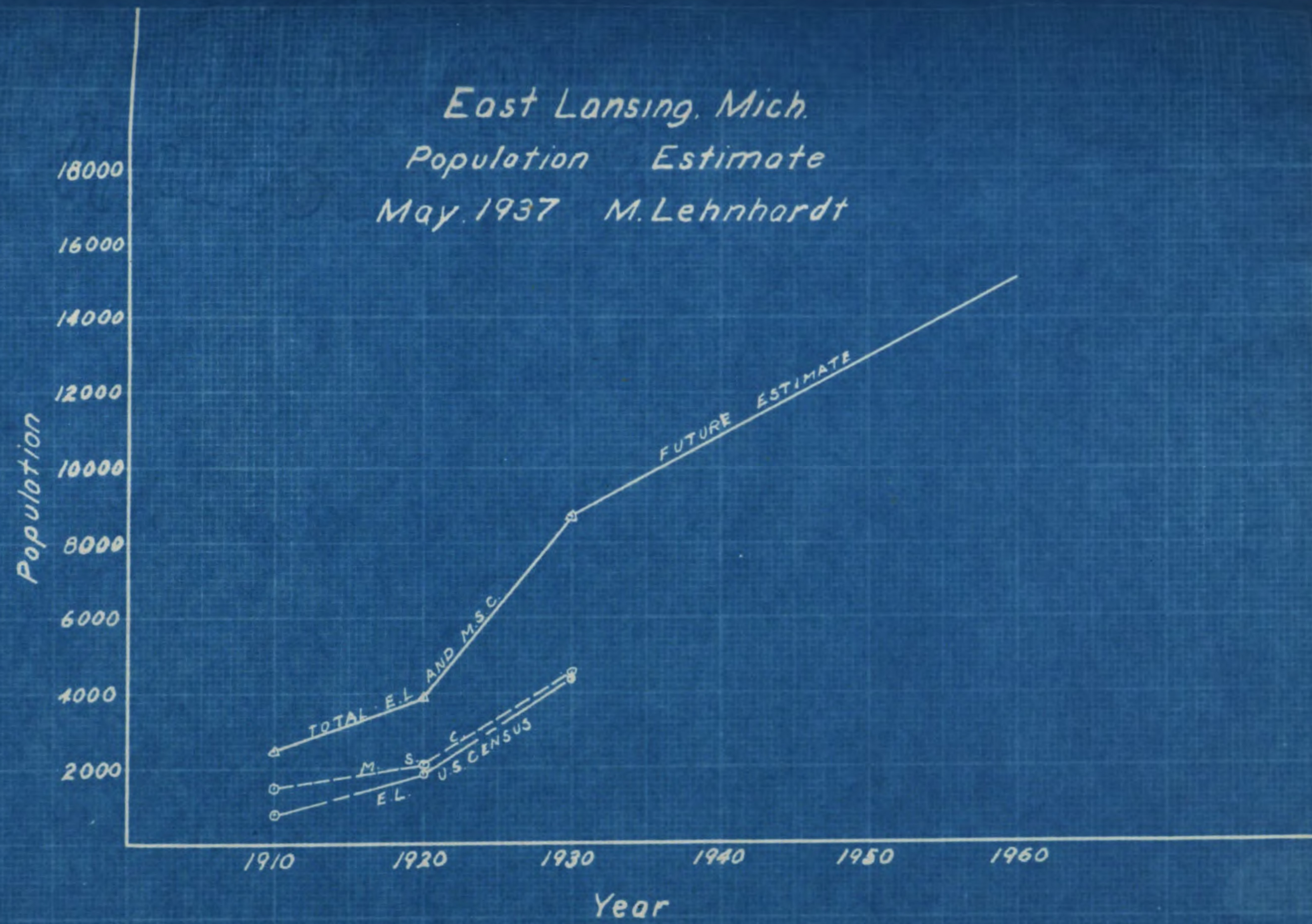
Flow: Assume sewage flow of 125 g. c. d. which will be excessive and on safe side. Also it will allow for any extra flow that comes during freezing weather with taps running.

Design basis = 125 x 15,000 = 1,875,000 gallons per day.

In writing this thesis I wish to contribute a design of a Trickling Filter which operates from the Imhoff Tank effluent. It is a Secondary System of treatment which will remove enough of the organic solids left in the Imhoff Tank effluent to make its own effluent unobjectionable.

The Trickling Filter will consist of a dosing tank, and a circular stone bed which is fed by four revolving arms, that move by the force of water coming out of the orifices. The sewage trickles through the stone bed and the effluent passes to the river by gravity flow.

For a detention of two hours in the Imhoff Tank sedementation


East Lansing, Mich.
Population Estimate
May. 1937 M. Lehnhardt
18000
16000
14000
12000
10000
8000
6000
4000
2000
Population
FUTURE ESTIMATE
TOTAL E.L. AND M.S.C.
M. S. C.
U.S. CENSUS
E.L.
1910
1920
1930
1940
1950
1960
Year

GRAPH I

channels, the capacity is as follows:

Volume of channels = $3(6.5 \times 7.33 + \frac{3.5 \times 6.75}{2})80 = 16280$ cu. ft.

Flow for 24 hours = $\frac{24}{2} \times 16280 \times 7.5 = 1,460,000$ gallons

In 1930 a daily flow curve was plotted (Chart I) and the flow was 1,000,000 gallons average for 24 hours. Since the flow was measured in April, this can be expected to be high due to infiltration. At the present time, due to increased enrollment at M. S. C. and population of E. Lansing, the flow is probably above 1,000,000 g. d.

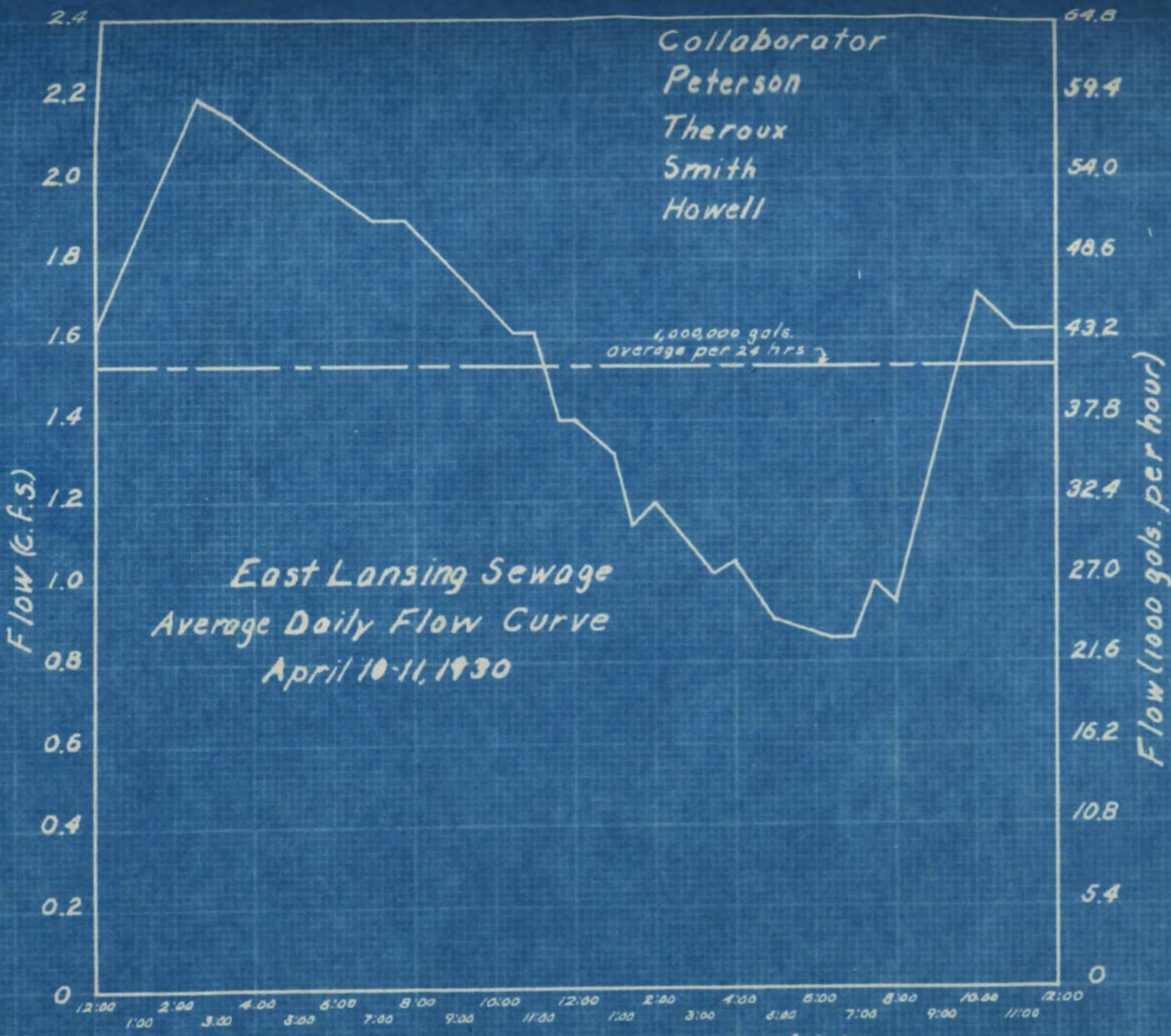

Collaborator
Peterson
Theroux
Smith
Howell
East Lansing Sewage
Average Daily Flow Curve
April 10-11, 1930
1,000,000 gals. average per 24 hrs.
Flow (c.f.s.)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
Flow (1000 gals. per hour)
64.8
59.4
54.0
48.6
43.2
37.8
32.4
27.0
21.6
16.2
10.8
5.4
0
12:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00
P.M.
HOUR
A.M.

CHART I

Dosing Tank

Design basis of 1,875,000 g. d. = 2.9 c. f. s. average

Use one dosing tank with 3 - 14" siphons to dose the filters in succession for 8 minute periods each.

Design for a draw-down of 24" for best operation of filters.

At 2.9 c. f. s. for 8 minutes = 8 x 60 x 2.9 = 1392 cu. ft.

Size of tank = $\frac{1392}{2}$ = 696□' - use 20' x 35' tank = 700□'

The present flow is now around 1,000,000 g. d. = 1.54 c. f. s.

Using this same dosing tank the dosing periods would be

$$\frac{1392}{60 \times 1.54} = 15 \text{ minutes}$$

Design of Filter Tank

Design basis = 1,875,000 g. d.

At 400,000 g. A. d/foot depth and 6' depth, the capacity of the filters will be 6 x 400,000 g. A. d.

Area required for 1,875,000 g. d. = $\frac{1,875,000}{2,400,000}$ =

0.78125 A = 34145.44□'

Use 3 filters, each = $\frac{34145.44}{3}$ = 11381.81□'

Dia. of each = $\sqrt{\frac{11381.81}{.7854}}$ = 118' say 120'

Area of each = $.7854 \times \overline{120}^2 - .7854 \times \overline{10}^2$ (area of well)

= 11231.22□'

Volume of ballast = 3 x 11231.22 x 6 x $\frac{1}{27}$ = 22,462.44

yds. for 3 filters

Area 3 filters floor drainage system = 33693.66□'

B. O. D. load:

For 5 day B. O. D. per cap. of 1.167# per day per person

Design pop. = 15,000

Sewage 5 day B. O. D. = 15,000 x 0.167 = 2505#/day

Cu. ft. of ballast per lb. 5 day B. O. D. = $\frac{6 \times 33693.66}{2505}$ =

80.70 Cu.

Design of Filter Tank (Cont'd.)

Design of Footing:

Wt. of stem - 150 x 1 x 1 x 6.5 = 975#

Estimated footing wt. = <u>300</u>

total =1275#

Soil pressure = 2000#/□'

Area of footing = $\frac{1275}{2000}$ = .6375□'/ft. length

This will give a footing smaller than the wall it supports, therefore increase the footing to 12" x 24".

The bond between the footing and the stem will be taken by the 4" key as shown in sketch. Also the vertical stem from the stem will give extra bond.

Reinforcement for side walls of tank

Hoop tension

1. Foot

5.5 x 62.5 x 60 = 20,600 # tension

As = $\frac{20,600}{16,000}$ = 1.29□"

use 3-¾" round bars = 1.32□"

2. Foot

4.5 x 62.5 x 60 = 16,900# tension

As = $\frac{16,900}{16,000}$ = 1.05□"

use 1-¾" round bars = 0.44□"

" 2-5/8" " " = <u>0.62□"</u>

1.06□"

3. Foot

3.5 x 60 x 62.5 = 13,100 # tension

Design of Filter Tank (Cont'd.)

Design of Footing:

Wt. of stem - 150 x 1 x 1 x 6.5 = 975#

Estimated footing wt. = <u>300</u>

total = 1275#

Soil pressure = 2000#/□'

Area of footing = $\frac{1275}{2000}$ = .6375□'/ft. length

This will give a footing smaller than the wall it supports, therefore increase the footing to 12" x 24".

The bond between the footing and the stem will be taken by the 4" key as shown in sketch. Also the vertical stem from the stem will give extra bond.

Reenforcement for side walls of tank

Hoop tension

1. Foot

5.5 x 62.5 x 60 = 20,600 # tension

As = $\frac{20,600}{16,000}$ = 1.29□"

use 3/4" round bars = 1.32□"

2. Foot

4.5 x 62.5 x 60 = 16,900# tension

As = $\frac{16,900}{16,000}$ = 1.05□"

use 1-3/4" round bars = 0.44□"

" 2-5/8" " " = <u>0.62□"</u>

1.06□"

3. Foot

3.5 x 60 x 62.5 = 13,100 # tension

Design of Filter Tank (Cont'd.)

Reinforcement for side walls of tank (Cont'd.)

3. Foot (Cont'd.)

$$As = \frac{13,100}{16,000} = 0.875''$$

use 3-5/8" round bars = 0.93 "

4. Foot

2.5 x 60 x 62.5 = 9,370 # tension

$$As = \frac{9370}{16,000} = 0.586''$$

use 3½" round bars = 0.59 "

5. Foot

1.5 x 60 x 62.5 = 5,620 # tension

$$As = \frac{5,620}{16,000} = 0.35''$$

use 2½" round bars = 0.39 "

6. Foot

0.5 x 60 x 62.5 = 1875 # tension

$$As = \frac{1875}{16,000} = 0.117''$$

use 1½" round bar = 0.197 "

Amount of steel for side walls of tank

$$c = \pi D = 120\pi = 377'$$

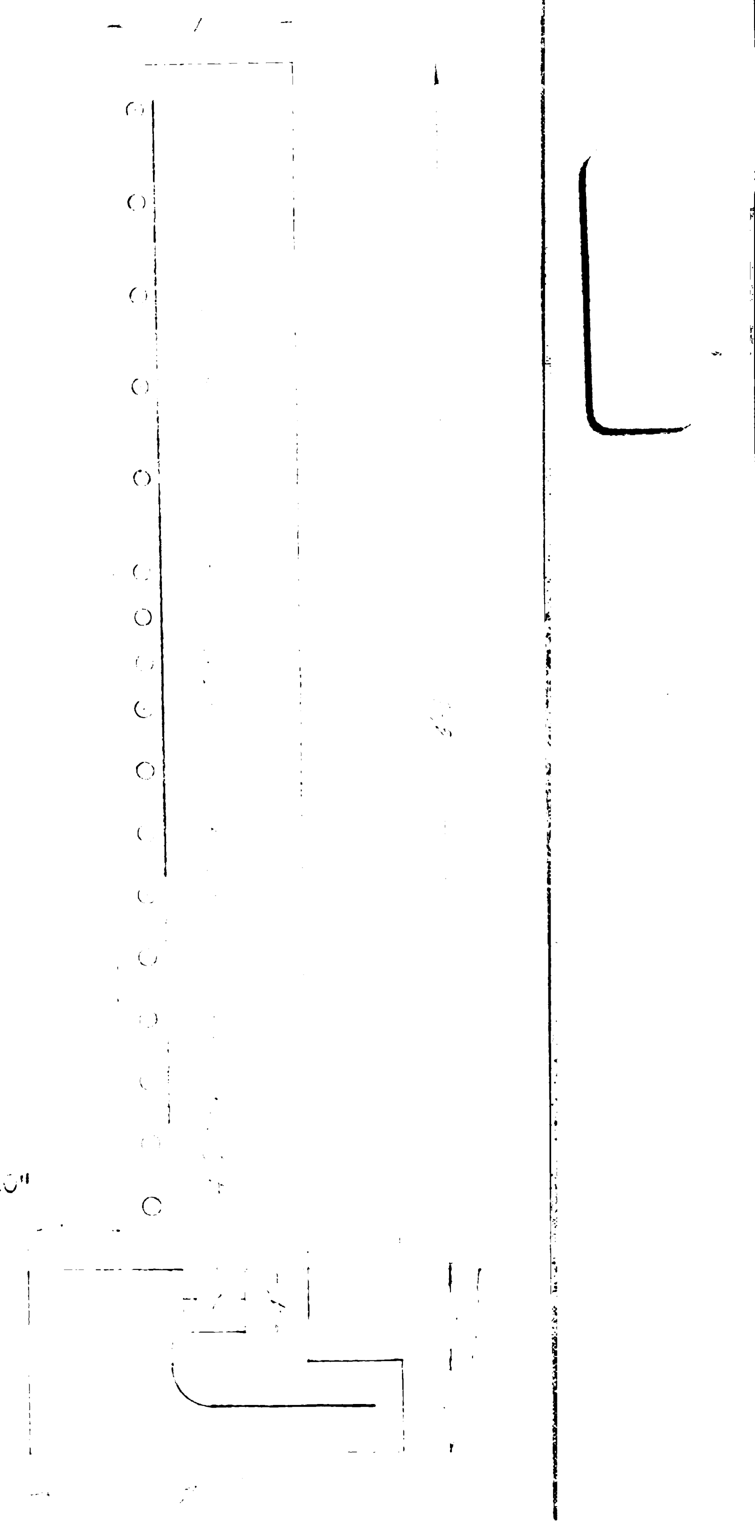
steel coming in 20 feet lengths

$$\frac{377}{20} = 19 \text{ lengths}$$

at 40 dia. per length for bond - ¾" round = 30"

length of steel = 377 + 19 x 2½ = 425'

¾" round steel	= 425 x 4 =	1700'
5/8" " "	= 425 x 5 =	2125'
½" " "	= 425 x 8 =	3400'
		7225'



Vertical steel - ½" round and 7' length @ 20'

$\frac{377}{20}$ = 19 lengths

19 x 8 = 152' of ½" round

Wt. of steel - one tank

½" rd. = 3552 x 0.668 = 2370#

5/8" rd. = 2125 x 1.043 = 2220 #

¾" rd. = 1700 x 1.502 = 2550 #

7140

7140 x 3 = 21,420 # for 3 tanks

$\frac{21,420}{2000}$ = 10,710 tons

No. of blocks for bottom of filter (one tank)

each block - 5" x 10" x 12" with ½" mortar on sides = 10½" x 12½"

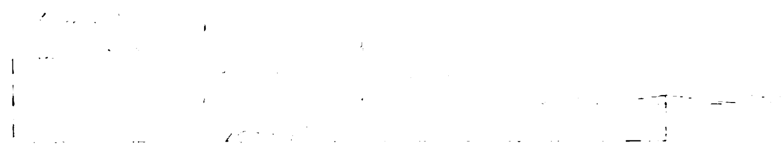
10 blocks 1 sq. yd.

no. of blocks required = $\frac{A \times 10}{9}$

$= (\quad \times \overline{20}^2 - \quad \times \overline{10}^2 = \frac{11231.02 \times 10}{9} = 12479$ blocks

for 3 filters = 3 x 12479 = 37437 blocks

Design of Trickling Filter Arm



Design flow = 1,875,000 g. d. = 2.9 c. f. s.

V_{14} = 2.71 ft/sec. $\frac{2.9}{A} = 0.725$

try 4" arm

entrance loss out of dosing tank = $\frac{V^2}{2g}$ =	0.114'
friction loss 100' - 14"	0.300'
two elbows ¼ vel. hd. each	0.057'
frict. loss 38'-4" arms (175 x ¼ x 0.9)	0.020'
entrance loss to arm = 1½ vel. hd.	0.171'
total loss of head	0.662'

Average head at orifice = 4.0 - 0.662 = 3.338'

try ½" orifice with 3.338' head C = 0.6, ½" = 0.00137"

Q = 0.6 x 0.00137 x 8.02 3.338 = 0.00123 c. f. s.

no. of orifices needed = $\frac{2.9}{.00123}$ = 240 orifices

Therefore: use 4-4" distributing arms with 60½" orifices each

Spacing of Orifices in Filter Arms

Distances are from center of well

Arm 1	Arm 2	Arm 3	Arm 4
11'-6"	12'-1"	12'-8"	13'-2"
13'-8"	14'-2"	14'-8"	15'-2"
15'-8"	16'-2"	16'-8"	17'-2"
17'-8"	18'-1"	18'-6"	18'-11"
19'-4"	19'-9"	20'-2"	20'-7"
21'-0"	21'-4"	21'-8"	22'-0"
22'-4"	22'-8"	23'-0"	23'-4"
23'-8"	24'-0"	24'-4"	24'-8"
25'-0"	25'-8"	26'-0"	26'-4"
26'-7"	26'-11"	27'-3"	27'-7"
27'-11"	28'-3"	28'-6"	28'-9"
29'-0"	29'-3"	29'-6"	29'-9"
30'-0"	30'-3"	30'-6"	30'-9"
31'-0"	31'-3"	31'-6"	31'-9"
32'-0"	32'-3"	32'-6"	32'-9"
33'-0"	33'-3"	33'-6"	33'-8½"
33'-11"	34'-1½"	34'-4"	34'-5½"
34'-8"	34'-10½"	35'-1"	35'-3½"
35'-6"	35'-8½"	35'-11"	36'-1½"
36'-4"	36'-6"	36'-8"	36'-10"
37'-0"	37'-2"	37'-4"	37'-6"
37'-8"	37'-10"	38'-0"	38'-2"
38'-4"	38'-6"	38'-8"	38'-10"

Spacing of Orifices in Filter Arms (Cont'd.)

Arm 1	Arm 2	Arm 3	Arm 4
39'-0"	39'-2"	39'-4"	39'-6"
39'-8"	39'-10"	40'-0"	40'-2"
40'-4"	40'-6"	40'-8"	40'-10"
41'-0"	41'-2"	41'-4"	41'-6"
41'-8"	41'-10"	42'-0"	42'-2"
42'-4"	42'-6"	42'-8"	42'-10"
43'-0"	43'-2"	43'-4"	43'-6"
43'-8"	43'-10"	44'-0"	44'-2"
44'-4"	44'-6"	44'-8"	44'-10"
45'-0"	45'-2"	45'-4"	45'-6"
45'-8"	45'-10"	46'-0"	46'-2"
46'-4"	46'-8"	46'-10"	47'-0"
47'-2"	47'-4"	47'-6"	47'-8"
47'-10"	48'-0"	48'-1¾"	48'-3½"
48'-5¼"	48'-7"	48'-8¾"	48'-10½"
49'-0¼"	49'-2"	49'-3¾"	49'-5½"
49'-7¼"	49'-9"	49'-10¾"	50'-0½"
50'-2¼"	50'-4"	50'-5¾"	50'-7½"
50'-9¼"	50'-11"	51'-0¾"	51'-2½"
51'-4"	51'-5½"	51'-7"	51'-8½"
51'-10"	51'-11½"	52'-1"	52'-2½"
52'-4"	52'-5½"	52'-7"	52'-8½"
52'-10"	52'-11½"	53'-1"	53'-2½"
53'-4"	53'-5½"	53'-7"	53'-8½"
53'-10"	53'-11½"	54'-1"	54'-2½"

Spacing of Orifices in Filter Arms (Cont'd.)

Arm 1	Arm 2	Arm 3	Arm 4
54'-4"	54'-5½"	54'-7"	54'-8½"
54'-10"	54'-11½"	55'-1"	55'-2½"
55'-4"	55'-5½"	55'-7"	55'-8½"
55'-10"	55'-11½"	56'-1"	56'-2½"
56'-4"	56'-5½"	56'-7"	56'-8½"
56'-10"	56'-11½"	57'-1"	57'-2½"
57'-4"	57'-5½"	57'-7"	57'-8½"
57'-10"	57'-11½"	58'-1"	58'-2½"
58'-4"	58'-5½"	58'-7"	58'-8½"
58'-10"	58'-11½"	59'-1"	59'-2½"
59'-4"	59'-5½"	59'-7"	59'-8½"

Bibliography

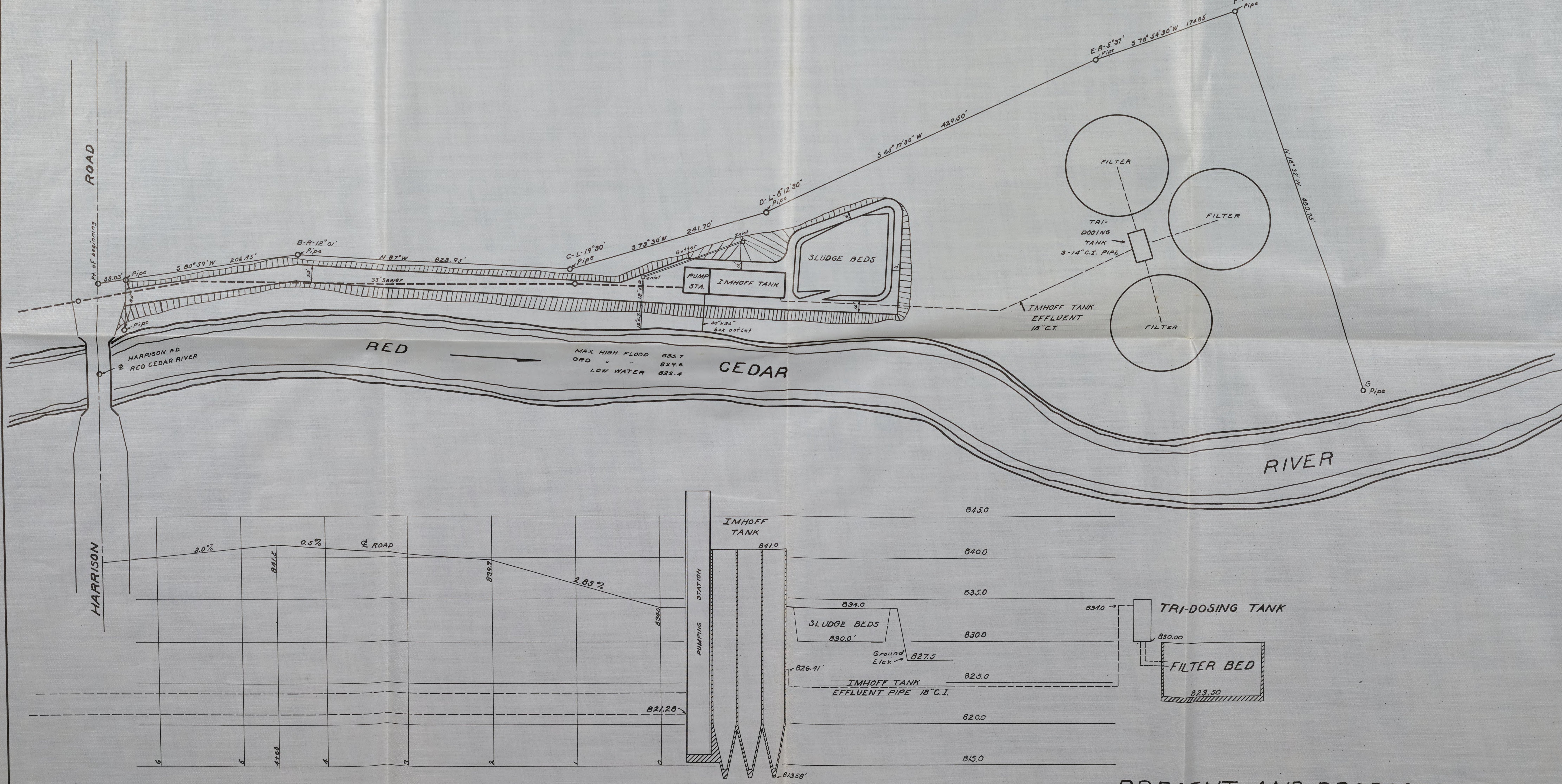
Sewerage and Sewage Disposal - Metcalf and Eddy

Hydraulics - Schoder and Dawson

Reinforced Concrete Structure - Peabody

[redacted]

[redacted]

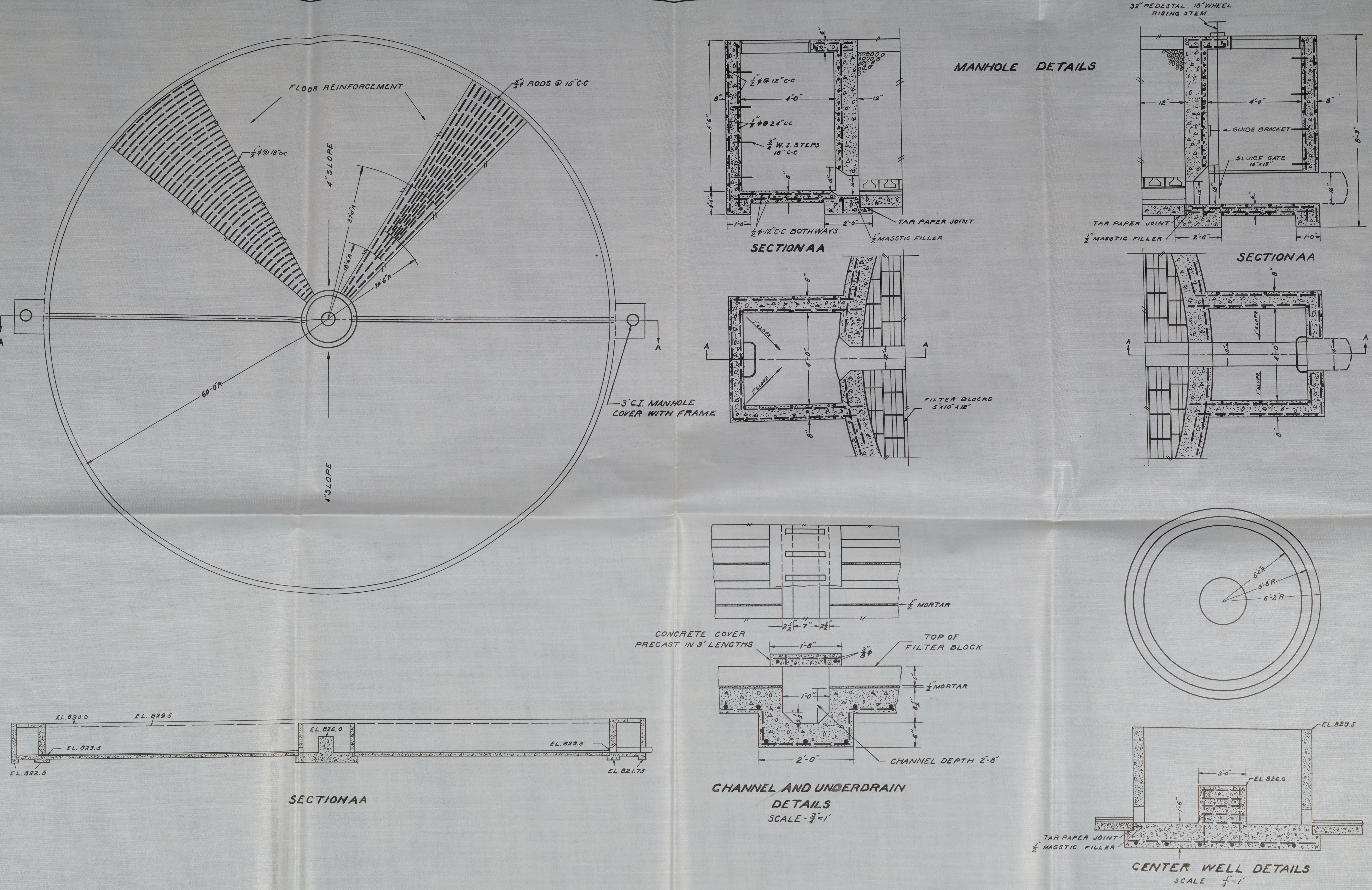


GENERAL PLAN AND PROFILE
SCALE HOR. 1" = 80' VERT. 1" = 8'

PRESENT AND PROPOSED SEWAGE TREATMENT PLANT EAST LANSING MICHIGAN

SCALE AS SHOWN JUNE 4, 1937

M. O. LEHNHARDT



FILTER DETAILS
SEWAGE TREATMENT PLANT
EAST LANSING MICHIGAN

SCALE AS SHOWN JUNE 11, 1937

M.O. LEHNHARDT