THESIS

DESIGN OF A

SEWAGE DISPOSAL SYSTEM

FOR LANSING MICH.

F. J. RICHARDS E. W. TAPPAN

1911

THESIS

Sewage Disposal

This thesis was contributed by

Mr. E. W. Tappan

under the date indicated by the department stamp, to replace the original which was destroyed in the fire of March 5, 1916.

Civil Engineering Surveying Department

- T H E S I S -

THE DESIGN

of a

SEWAGE DISPOSAL SYSTEM

for

The City of Lansing, Mich.

F. J. Richards. E. T. Tarpan.

Mich. Agr. College.

-1911-

THESIS

The object of the work required by this thesis is to investigate the necessity, the probable cost and the feasibility of a sewage disposal system for the city of Lansing, Michigan.

Lansing, like many other cities today disposes of its sewage by dilution. Practically the entire sewage flow of the city is discharged into the waters of the Grand and Cedar Rivers. A very considerable amount of this sewage enters these rivers at various points along their courses in the southern and western parts of the city, and mixed with their waters, flows thru the center of the city for its entire length. This is not all however, for from the time these rivers enter the city from the south until they leave it at the north, they have intercepted a total of thirty-two sewer openings discharging very close to five million five hundred thousand gallons of house sewage into them each day. We have not in our possession the results of chemical or bacteriological analysis of the water below the city or at different places within its limits, and consequently are not in a position to state definitely the degree of pollution caused by sewage. It would seem, however, that it must be considerable. Considered from the stand-point of appearance to the casual observer, one has but to stand on one of the bridges, the Kalamazoo Street bridge, e. g. for a few minutes to hear such remarks as this, "My but that river looks dirty," or, "I wonder what makes that scum on the water?"

In a discussion of the subject with Mr. Eddy, the assistant city engineer, he said that a sewage disposal system was considered unnecessary because the ripples in the river below the city caused sufficient aeration to take place to remove from the water practically all of the impurities due to sewage

pollution. This may be true, nevertheless that does not facilitate matters within the limits of the city where contamination can prove most dangerous, and it appeals to us that some method of disposal other than dilution should be provided, for the welfare of the citizens and the beauty of Lansing.

In order to install a sewage disposal plant the present sewer systems will necessarily have to be so changed that the sewage can be delivered to the plant. In our investigation of the topography of the city of Lansing, we found that without a large amount of pumping it would be impossible to carry all the sewage to one location. Consequently more than one plant will be necessary.

The material slope on the west side of the Grand River is north and south from Main Street. On the east side the slope is in general toward the river and north and south from Joseph Street. From this it is quite apparent that two disposal plants will be the more feasible, one located in the southern part of the city and the other located in the northern part. With this in view we have selected the following locations: For the plant in the southern part, a portion of land situated south of the Grand Trunk Railroad and north of the Grand River, now owned by The Seager Engine Works; for the one in the northern part, the vacant territory north of Willow and west of Symour Streets fronting the Grand River on the north. These locations seem to us to be the most favorable because of accessability, or in other words, because the present sewer systems can be utilized to the greatest advantage and will necessitate the smallest amount of redesign and reconstruction to carry the sewage to the plants.

In our estimate of cost of a sewage disposal system we have made many assumptions which are based upon various authorities selected only after a careful consideration of the subject along the different lines.

In a search for information concerning the cost of construction of sewers we have done considerable reading and held interviews with different parties. The contractor who is at present constructing a large sewer in the southern part of the city stated that he had done a large amount of trenching in Lansing and had observed that the river seemed to be a sort of dividing line. On the west side the soil is mostly clay while on the east it is moist sand necessitating the use of sheathing even in shallow trenches. With this as a basis we began to look for something general concerning the cost of excavating, back-filling and sheathing in such material. We wrote to several companies advertising trenching machines asking them for information concerning the cost of such work, but very little information was gained from this source. Then we consulted Gillette's Handbook of Cost Data. Although there was considerable data contained therein concerning the cost of sewer construction, practically none of it was general nor could any example similar to Lansing be found. In the sixth edition of Folwell's "Sewerage" page 324, Table No. 21, can be found the data that we finally selected for the estimate of cost, of excavating, back-filling and sheathing. Although this does not exactly fit our conditions it is the most nearly general of anything we have been able to find.

For the cost of sewer pipe we have taken the values given in Engineering News for April 6, 1911. The cost of laying the

pipe has been estimated by using Table No. [illegible], page [illegible] of Folwell's "Sewerage." We have based our estimate of cost of brick sewer work on the following information obtained from Gillette's Handbook of Cost Data.

Labor	$[illegible].4[illegible]
Brick @ $[illegible].[illegible] per M. ([illegible]-[illegible] per yd.)	5.[illegible]
Sand	.4[illegible]
Natural Cement	1.[illegible]
Centers	.[illegible]
Miscellaneous	.[illegible]
Total per cu. yd.	$11.[illegible]

The amount of masonry in brick sewers was also taken from Gillette's Handbook of Cost Data as follows:

Dimensions.	Cu. yds. per lineal foot. 2 ring.	3 ring.
[illegible]	.[illegible]97	
[illegible]	.[illegible]	
[illegible]x4[illegible]	.3[illegible]	
[illegible]	.341	
[illegible]	.[illegible]74	
[illegible]x54	.[illegible]	
[illegible]	.[illegible]	
[illegible]x[illegible]7	.[illegible]	.[illegible]46

For estimating cost of manholes we constructed a diagram similar to one found in Gillette's Handbook. The diagram is for a 4 foot manhole and is used as follows:

For a 15 foot manhole follow the vertical 15 foot line to intersection with brick curve, thence horizontally to the left and read [illegible],[illegible]. From the intersection of the last horizontal line with the sand, mortar, and cement curves respectively, read vertically above 1.[illegible] cu. yds. of sand, [illegible].[illegible] cu. yds. of mortar, and 65 bbls. of cement. To ascertain the cost follow the vertical 15 foot line from bottom to intersection with cost curve and read horizontally to right, cost plus 15%, $[illegible], of which cost of labor is $1[illegible].60 as shown by the labor curve.

The curves allow for a double layer of brick in the bottom

and the outside of the manhole to be well plastered.

DESIGN OF SEWERS.

PRELIMINARY WORK: As a preliminary to our redesign of the sewer system we obtained from the City Engineer's office the elevation of each street intersection. This gave us a pretty good idea of the topography of the city. Then we sketched upon a map the location of the principle sewers of the city and designated their size. We also designated the grade of those sewers which we expected to use as a basis for our computations.

DESIGN: In our redesign we have established grades convenient to the topography and then made the computations necessary to determine the size of sewers required to carry the sewage which can be carried by the present sewers with their size and grade.

The formulae used to determine size of pipe and egg shaped sewers were respectively:

$$d = 1.45 \left(\frac{q}{c\sqrt{s}}\right)^{\frac{2}{5}}$$

$$d = 1.21 \left(\frac{q}{c\sqrt{s}}\right)^{\frac{2}{5}}$$

in which d = diameter in feet, q = quantity in cubic feet per second, c = a constant obtained from Kutter's formula, and s = the slope.

For locations, sizes and grades of sewers see profiles and maps showing the redesigned sewer system.

As an example we will show our procedure with the Barnes Avenue sewer.

The design of this sewer consists in computing the sizes necessary to care for the sewage that is at present being cared

for by the owners of this district.

The present sewer on Bonds from Real Ave., to Bradley Ave., is a 18" pipe, consequently we will use the same size pipe. The present Bradley Ave. main intercepting sewer has a grade of .033 and a 24" pipe at outlet and will discharge 10.50 cu. ft. per second. The size of sewer necessary to carry this sewage is

$$d = 1.71 \left(\frac{10.50}{33 \cdot .04}\right)^{\frac{3}{8}} = 1.5' = 20"$$

therefore a 20"x30" egg sewer will be used from Bradley Ave. to Todd Ave.

There is at present an 8" pipe sewer have a grade of .033 beginning at Todd Ave. and running east to Washington Ave., then south to Baker. Its capacity is 1.43 cu. ft. per second making the total amount of sewage to be taken care of from Todd Ave. to Baker St. equal to 10.73 cu. ft. per second. The size of sewer necessary to take care of this sewage is

$$d = 1.71 \left(\frac{10.73}{33 \cdot .04}\right)^{\frac{3}{8}} = 1.53' = 22.8"$$

therefore a 24"x36" egg sewer will be used from Todd Ave. to Baker St.

-Cost-

Excavation, back-filling and sheathing.

18"	800'	@	$1.65 per ft.	$1320.00
20"x30"	800'	@	3.00 " "	2400.00
24"x36"	800'	@	4.70 " "	4320.00
21"x30"	450'	@	3.25 " "	1462.50
24"x36"	400'	@	4.00 " "	1600.00

Pipe.

18"	800'	@	1.00 per lin. ft.	165.34

Laying pipe.

18"	800'	@	.021 per lin. ft.	16.80

Forward £10710.66

Lay sewers.

6"x33 - 339' @ .327 x £11.00 per lin. ft. £3421.54
4"x30 - 1330' @ .256 x 11.00 " " " 4387.75

Manholes.

Location.	Depth.	Cost.	
Portion and Road	11.5	£10.00	
Adlington	11.0	11.00	
Pemsley	10.0	09.00	
Levin	11.0	11.00	
Town	10.0	10.00	
Cobham	7.0	07.00	
Twilight A	8.0	10.00	
Twilight and Otaraw	11.0	41.00	644.25
		Total	£[illegible]

All others sewers have been computed similarly to above example and their cost is as follows:

BUCK STREET SEWER.

Excavating, back-filling and breaking.

12"			
15" - 870' @ 1.21 per lin. ft.			£1052.70
24" - 810' @ 1.37 " " "			1109.70
30x15" - 67' @ 2.11 " " "			141.37
24x21" - 370' @ 2.11 " " "			780.70
24x24" - 3' @ 2.2 " " "			6.60

Piles.

12" - 870' @ 1.320		171.70
24" - 810' @ .515		417.15

Laying pipe.

12" - 870' @ 1.000		53.40
24" - 810' @ .140		113.40

Lay sewers.

30x15" - 470' @ .541 x £11.00 per lin. ft.		2799.37
24x21" - 1350' @ .371 x 11.00 " " "		7119.67
24x24" - 3' @ .396 x 11.00 " " "		16.20

Manholes.

Location.	Depth.	Cost.	
Baker and Lloyd	11.0'	£10.00	
Cooke	7.0'	07.00	
Pentant	11.0'	10.00	
Platt	11.0'	10.00	
-	10.0'	10.00	537.00
		Total	£[illegible]

Forward $ 4773.00

Manholes.

Location.	Depth.	Cost.	
Baker and Washington	7'.0'	42.00	
Washington and Island	11.0'	41.00	
G.T.P.R.R.	10.0'	41.00	
Foot of Ann	8.0'	33.00	157.00
	Total		$4930.00

RIVER STREET SEWER.

Excavation, back-filling and sheeting.

8"	- 700' @ $1.21	per lin. ft.	$847.00
12"	- 700' @ 1.13	" " "	791.00
15"	- 400' @ .65	" " "	260.00
18"	- 500' @ .75	" " "	375.00
15"	- 900' @ 1.04	" " "	936.00

Pipe.

8"	- 700' @ $.222	155.54
12"	- 700' @ .333	233.10
15"	- 400' @ .450	180.00
18"	- 500' @ .613	306.50
15"	- 900' @ .850	765.00

Laying Pipe.

8"	- 700' @ $.100	70.00
12"	- 700' @ .143	100.10
15"	- 400' @ .225	90.00
18"	- 500' @ .311	155.50
15"	- 900' @ .390	351.00

Manholes.

Location.	Depth.	Cost.	
Main and G. T. P. R. R.	10.50'	42.00	
Beach	11.00'	44.00	
Beach and Spring	14.00'	56.00	
Spring and Cedar	7.00'	34.00	
River	7.00'	34.00	
River and Main	7.00'	34.00	
St. Joseph	7.00'	34.00	
Hillcrest	7.00'	34.00	
Lorraine	7.00'	34.00	
Edmonton	13.00'	52.00	384.00

Reservoir.

50'x50'x20' 2500 cu. yds. concrete @ $2.00 5000.00

Pumping Plant.

6" Centrifugal pump	200.00
4 H. P. motor	200.00
Total	$400.00

CEDAR STREET SEWER.

Excavation, back-filling and sheathing.

8"	- [illegible]'	@ [illegible]	per lin. ft.	$ [illegible]
10"	- [illegible]'	@ 1.70	" " "	[illegible]
24x36"	- 1[illegible]'	@ 2.31	" " "	[illegible]
30x42"	- 1[illegible]'	@ 3.43	" " "	[illegible]
36x48"	- 1[illegible]'	@ 4.00	" " "	[illegible]
48x72"	- [illegible]'	@ 1.52	" " "	[illegible]

Pipe.

8"	- [illegible]'	@ [illegible]	[illegible]
10"	- [illegible]'	@ 1.50	[illegible]

Laying pipe.

8"	- [illegible]'	@ [illegible]	[illegible]
10"	- [illegible]'	@ .17½	[illegible]

Fire stops.

24x36"	- 1[illegible]'	@ [illegible]	x 11.00	per lin. ft.	[illegible]
30x42"	- 1[illegible]'	@ .3[illegible]	x 11.00	" " "	[illegible]
36x48"	- 1[illegible]'	@ .4[illegible]	x 11.00	" " "	[illegible]
48x72"	- [illegible]'	@ .6[illegible]	x 11.00	" " "	[illegible]

Manholes.

Location.	Depth.	Cost.	
Cedar and Ft. Joseph	11.0'	[illegible]	
"	11.0'	[illegible]	
"	10.[illegible]'	[illegible]	
Kalamazoo	8.0'	[illegible]	
"	[illegible]'	[illegible]	
Michigan	16.0'	[illegible]	
"	16.0'	[illegible]	
Kilwaukee	16.0'	[illegible]	
Kilwaukee and Larch	13.75	[illegible]	
"	13.0'	[illegible]	
Larch and Turner	11.0'	[illegible]	
Eighth and Cedar	7.0'	[illegible]	
Center	4.0'	[illegible]	
Center and Monroe	3.0'	[illegible]	
Elliott	[illegible]'	[illegible]	
at River	[illegible]'	[illegible]	[illegible]
		Total	[illegible]

MICHIGAN AVENUE SEWER.

Excavation, Back-filling and Sheathing.

8" - [illegible]' @ $1.[illegible] per lin ft.	733.40
10" - [illegible]' @ 1.4[illegible] " " "	1[illegible]7.[illegible]
1[illegible]" - [illegible]' @ 3.[illegible] " " "	[illegible]
1[illegible]" - 47[illegible]' @ 4.[illegible] " " "	[illegible]
1[illegible]" - 1[illegible]5 @ [illegible].[illegible] " " "	[illegible]
1[illegible]" - [illegible]' @ 4.[illegible] " " "	[illegible]1.[illegible]
1[illegible]" - [illegible]' @ [illegible] " " "	[illegible]4.[illegible]
[illegible]" - [illegible]' @ [illegible] " " "	[illegible]7.[illegible]
1[illegible]" - [illegible]' @ [illegible] " " "	1[illegible]
1[illegible]" - 47[illegible]' @ [illegible] " " "	1[illegible]

Pipe.

[illegible]" - [illegible]' @ [illegible] per lin. ft.	[illegible].7[illegible]
10" -157[illegible]' @ .1[illegible] " " "	[illegible]4.[illegible]
1[illegible]" - [illegible]7[illegible]' @ .1[illegible] " " "	[illegible]
1[illegible]" - [illegible]' @ .[illegible] " " "	[illegible]

Laying pipe.

8" - [illegible]' @ [illegible] per lin. ft.	[illegible]
1[illegible]" - 1[illegible]' @ .[illegible] " " "	[illegible]
1[illegible]" - [illegible]75' @ .[illegible] " " "	[illegible]
1[illegible]" - [illegible]' @ .[illegible] " " "	7[illegible]

Manholes.

Location.		Depth.	Cost.	
Michigan Ave. and	City Lt's.	7.0	[illegible].00	
	R[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	1[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	1[illegible]	[illegible]	
	Ferguson	[illegible]1.[illegible]	47.[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	1[illegible]	
	J[illegible]	[illegible]	1[illegible]	
	[illegible]	[illegible]1.[illegible]	1[illegible]	
	[illegible]	[illegible]	[illegible]	
	Pennsylvania	[illegible]	17[illegible]	
	[illegible]	[illegible]	[illegible]	
	Hill	[illegible]	1[illegible].50	
	[illegible]	[illegible]	[illegible]	
	Larch	1[illegible]	[illegible]	1[illegible].75
	Total			[illegible].25

GRAND STREET SEWER.

Excavation, back-filling and sheeting.

8"x27" - 1[illegible]' @ [illegible] per lin. ft. [illegible]
8"x17" - [illegible]' @ 1.05 " " " 247.50
8"x17" - 1[illegible]' @ 1.00 " " " [illegible]

Pipe Sewer.

8"x27" - 3000' @ $.043 x 11.[illegible] per lin. ft. $[illegible]

Manholes.

Location.		Depth.	Cost.	
Grand Street and	Jefferson	[illegible]1.0	[illegible]	
	Newburn	11.6	41.50	
	Eagle	10.5	[illegible]	
	Franklin	11.5	46.00	
	Willow	8.0	31.00	
	-	[illegible]8.0	[illegible]	
	Seymour	15.0	61.00	
	-	11.0	42.00	412.00
		Total		$[illegible]

SEPTIC TANK.

The area of the territory tributary to the south end reaches is approximately [illegible] acres. Assuming a population of 10 per acre, the territory population is 5[illegible]0. Assuming the average sewage flow at 50 gallons per capita per day, the total flow would be [illegible] x 50 = [illegible],000 gallons per day.

It has been found that from 6 to 12 hours is the best length of time for sewage to remain in a septic tank, consequently for fresh sewage the tanks should have a capacity equal to about 12 hours flow or 334,000 gallons.

Assuming the tanks to be 70 feet long and 10 feet deep and letting W = the width, if we use two tanks we have

$$2 \times 70 \times 10 \times 7.48 \times W = 334{,}000$$

$$W = 25 \text{ feet}$$

Therefore at the south end we will use two tanks 70'x25'x10'.

The area tributary to the north end sewers is 5,011 acres and similarly to the preceding if we assume the tanks to be 150' long and 15' deep, if we use four tanks we have

$$4 \times 150 \times 15 \times 7.48 \times T = 1,130,450$$

$$T = 75 \text{ feet}$$

therefore at the north end we will use four tanks 150'x75'x15'.

COST.

Owing to the topography the septic tanks will have to be practically built on the surface and have the sewers pumped to them, so we have taken no account of the excavation, but have estimated the cost of the concrete work which is as follows:

South End Tanks.

Cross sectional area of walls 16.75 sq. ft.	
Total length of wall [illegible] ft.	
Total number cu. yds. of concrete 1365.	
Cost at $[illegible] per cu. yd.	$1170.00

North End Tanks.

Cross sectional area of wall 12.75 sq. ft.	
Total length of wall 675 ft.	
Total number cu. yds. concrete 675	
Cost at $8.00 per cu. yd.	$5440.00

FILTER BEDS.

The filters are to consist of a layer of crushed stone 1' thick, then a layer of coarse gravel 1' thick, then a layer of sand 3' thick. They are to be 100' wide by 300' long and of such depth that a head of 6' may be maintained if necessary. Five filter beds will be used at the south end and eleven at the north end. The general arrangement of filter beds and septic tanks can be seen by referring to blue print in pocket, also the arrangement of distributors and under-drains.

C[illegible]T.

[illegible] Unit.
Dams No. 1 to 5 Inclusive
Cross sectional area of walls 7 sq. ft.
Total length of wall 34[illegible] ft.
Total number of cu. yds. concrete [illegible]

Cost at [illegible] per cu. yd.	[illegible]
[illegible] cu. yds. crushed stone @ $1.[illegible]	[illegible]
[illegible] cu. yds. gravel @ [illegible]	[illegible]
[illegible] cu. yds. sand @ [illegible]	[illegible]

[illegible]
[illegible]' - 4" pipe at [illegible] per ft.	[illegible]

[illegible]
[illegible]' - [illegible]" pipe @ [illegible] per ft.	[illegible]
1[illegible]' - 14" square at [illegible] per ft.	[illegible]

Pumping plant.
[illegible]" Centrifugal pump	1[illegible]
[illegible] H. P. Motor	[illegible]
Land for location	[illegible]
Total	[illegible]

[illegible]
Dams No. 1 to 11 Inclusive
Cross sectional area of wall 7 sq. ft.
Total length of wall [illegible] ft.
Total number cu. yds. of concrete 17[illegible]

Cost at [illegible] per cu. yd.	1[illegible]
17[illegible] cu. yds. crushed stone @ $1.[illegible]	[illegible]
[illegible] cu. yds. gravel @ [illegible]	[illegible]
[illegible]7[illegible] cu. yds. sand @ [illegible]	[illegible]

[illegible]
[illegible]' - 4" pipe @ [illegible] per ft.	[illegible].75

[illegible]
[illegible]' - [illegible]" pipe @ [illegible] per ft.	[illegible]
[illegible]' - 14" square @ [illegible] per ft.	[illegible]

Pumping plant.
[illegible]" Centrifugal pump	[illegible]
[illegible] H. P. Motor	[illegible]
Land for location	1[illegible]
Total	[illegible]

SUMMARY OF COST.

Sewers.	
Bonney Ave..	$ [illegible]
Baker St.	[illegible]
River St.	[illegible]
Cedar St.	[illegible]
Michigan Ave.	[illegible]
Grand St.	[illegible]
Septic Tanks.	
South end	117[illegible].00
North end	[illegible]
Filter Beds.	
South end	[illegible]47.00
North end	[illegible]
total	[illegible]

In view of the probability that laws will be enacted requiring sanitary disposal of sewage, it would be apparently feasible for any city to install a disposal system, and the sooner the better, because the longer it is postponed, the greater will be the expense when the time does come, for sewers are continually being constructed which would be thrown out of use in the event of a disposal system. E. g. the sewer which is at present being constructed in the southern part of the city of Lansing at a cost of about $50,000 cannot be used as a portion of the disposal system as designed by us.

Of course the cost of the system as designed by us is considerable and the proposition would undoubtedly fail in presented to the voters of Lansing, as would also the politicians presenting it. It seems to us however, that something at least should be done with the sewage entering the rivers in the southern part of the city. We would therefore recommend that, if the entire system be considered unfeasible, the system designed for the south end

be minimal. It would be approximately [illegible] which should be well [illegible]. In our estimation the cost of such a system should be borne by the city at large [illegible] the result would be mutually beneficial.

et has:
l Suppl.