AN ESTIMATED COST OF CONSTRUCTION OF THE PROPOSED FISH REARING PONDS AT ARGENTINE MICHIGAN, AND AN EXPERIMENTAL STUDY OF THE SOIL FOR IMPERVIOUSNESS

THESIS FOR THE DEGREE OF B. S.

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1931

THESIS

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An Estimated cost of construction of the Proposed Fish Rearing Ponds at Argentine Michigan, and an experimental study of the soil for imperviousness

A Thesis Submitted to

The Faculty of

Michigan State College

of

Agriculture and Applied Science

By

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Candidate for the Degree of

Bachelor of Science

June 1931

Acknowledgement

The author wishes to gratefully acknowledge the suggestions and assistance offered by C. M. Cade, C. A. Miller and C. A. Allen; also the various departments of the Conservation Department, and the Bridge Department of the State Highway Department. Reference was made to the text "Concrete Practice" by Hool and Pulver

George A. Granger

This view was taken from the dam just above the island on North Ore Creek. It shows the high bank on the left side of the island.

The topic on which I am writing my thesis is a project which was proposed by the Department of Fisheries of the Conservation Department of Michigan. Professor Cade of the Civil Engineering Department of Michigan State College and one other man and myself worked on the survey of this project in June 1930. We took the topography of the land, ran property lines, and set monuments, also we made tests on the soil over the entire property to determine the depth of muck and loam.

Although this project may never come into existance it is worthy of some further study. It furnishes an excellent opportunity to study watershed areas, the soil and its imperviousness to water.

In this thesis I hope to show the estimated cost of construction of the proposed rearing ponds, also to obtain and show some valuable knowledge as to the imperviousness of the soil. As far as I have been able to find out no experimental data has ever been published on the imperviousness of soils. This subject alone would furnish sufficient material for a thesis. But I shall experiment only on the soil common to this piece of property. I will show a cross-section of the proposed dike and a method to prevent erosion of the dikes. I will also show a design for a concrete spillway and its estimated cost of construction.

All blue prints contained herein were obtained from the Department of Fisheries. The topographical maps were obtained from the State Geological Survey Department. The Photographs herein were taken by Mr. Yarger, a senior civil engineer, and myself.

This project is located on North Ore Creek in the north east quarter of section 34 of Argentine township, Genesee County. The piece of land on which the proposed rearing pond No. I is to be built is a small island of about 3½ acres foımed by North Ore Creek.

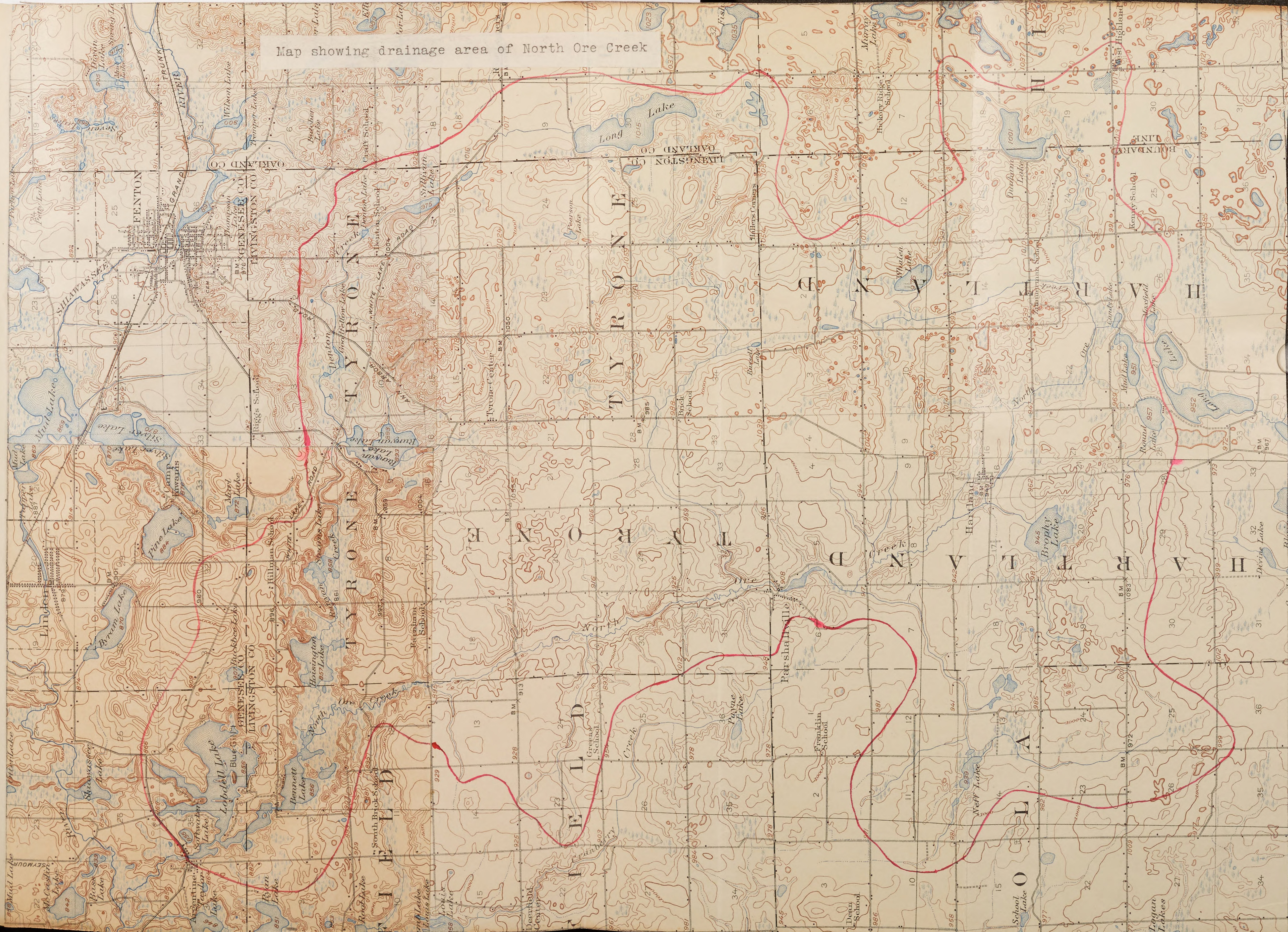
Some years ago a dam was built across North Ore Creek about 100 feet upstream from the island. Thus backing the creek and its tributaries forming a lake. Formerly North Ore Creek flowed between high banks at the point where the dam was built,thus making its construction very practical and quite simple. This dam is an earthen dam of about 18 feet high and between 150 and 200 feet long. Just last year the State Highway Department completed a concrete structure across North Ore Creek. This structure serves as a bridge and also a dam. No emergency spillways were provided for and there is always the danger of failure from flood. Provision for the passage of water was made by two manually operated gates under the bridge.

The lake Formed by the waters of North Ore Creek being impounded is known as Lobdell Lake. This lake covers about half of sections 35 and 36 of Argentine township. The present elevation of the lake is 856 feet above sea level. The water from this lake at one time was used to furnish power for a flour mill located on the bank of the creek.

The island which is directly down stream from Lobdell lake is quite level with a slight rise towards the center. Its general elevation is about 846 feet and contains about 3½ acres of land. The island lies in such a position that if the dam above it ever failed or if a flood should ever occur any construction work on the island would be in great danger of being washed away.The island lies in a narrow valley about 400 feet across making it in the direct path of flood waters.

The watershed area of North Ore Creek comprises an area of 83.25 square miles. Many large lakes and swamps are included in this area so that considerable storage of flood waters can be expected. The area not covered by such swamps and lakes is very rugged and slopes are steep so that run off from the highlands is very rapid.

The soil in this location is an alluvian containing sand, gravel, marl, and clay with 6inches of loam on the surface where the land has been cultivated. This is true for the upper pond in entirety and it will be necessary that the land to be occupied by the dikes be plowed and the surface loam removed. The upper pond or pond No.1 will enclose only the island as can be seen from the blue print of the project. The lower pond or pond No. 2 will enclose an area of about 5.11 acres on the left hand bank of North Ore Creek.
A portion of the lower pond has a bottom muck which varies in depth from 1 to 4 feet. This must all be removed from the area to be occupied by the dike before construction is commenced.



Map showing drainage area of North Ore Creek

Wharves | Breakwater and jetties | Bridges | Footbridges

City, village or borough line | Small park or cemetery line | Triangulation or traverse point

Shaft | Mine tunnel | Lighthouse

WATER
printed in blue

Creeks or ditches | Aqueducts | Aqueduct tunnels

UNITED STATES

the smaller ... gradually away and forms an ... crossed by a few shallow gullies ... feature is represented ... sketch, by contour lines.

City or village | Roads and buildings | Church | Cliff dwelling | Metaled road | Private or poor road | Trail or path

Dam | Canal lock | U.S. township and section lines and located corners | State line | County line

Cemeteries | Tanks and oil reservoirs | Oil well

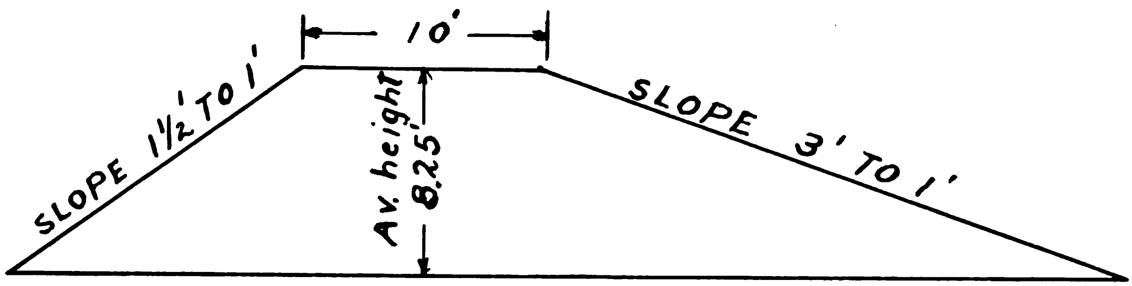
RELIEF
printed in brown

Figures | Contours | Depression contours | Levee

Construction of embankment

Due to the topographic condtions of the land along North Ore Creek, it will be necessary to build dikes only on the north and west sides of the proposed ponds. All sod, muck, and loam should be stripped from the surface, both under the dike and the barrow. The top elevation of the dike will be 853.25 feet and it is to be 10 feet wide on top so that a roadway may be constructed. The inside slope of the dike will be 1 foot vertical to 3 feet horizontal, the outside slope will be 1 foot vertical to $1\frac{1}{2}$ feet horizontal except for the portion directly below the spillway of the dam. This portion will have an inside and outside slope of 1 foot vertical to 3 feet horizontal. The earth for the dikes should be placed in 1 foot layers and rolled with a cultipacker.

After the dikes are built they should be well sodded on the outside slope to prevent erosion from rain. The slopes given above will work very well under normal conditions, but in case of flood that portion of the dike which is directly below the spillway of the dam will be subject to very rapid erosion. To prevent this the outside slope of the dike at that point and for a distance of about 250 feet downstream should be built on a slope of 1 foot vertical to 3 feet horizontal and this covered with broken stone and gunited with cement mortor. As a further precaution against flood about 50 feet of the dike on the down stream side of pond No. 2 should be left permanently 6 inches lower than the remainder to form a fuse plug. Then in case of a flood this portion of the dike would wash away before the water reached the top of the rest of the dike. Thus sacrificing 50 feet of dike to save the greatest portion of it. This method is standard in earthen dams. Below is a typical cross-section of the proposed dike.



Earthwork

The earthwork for the dikes was computed by the end area method. That is the proposed dike was layed off in 50 foot stations and the end area of each station computed.The end areas of two successive stations were averaged and the result multiplied by the distance between stations. Following are the computations for the earthwork on pond No. 1

Station	Cross-section area	Cu. Yd. earth
0	0	0
1	246.5	223.0
2	164.5	381.0
3	133.1	275.5
4	173.0	283.0
5	120.1	272.0
6	120.1	222.0
7	149.3	249.5
8	120.1	249.5
9	117.5	219.5
10	181.1	276.0
11	191.8	345.0
12	272.6	428.0
13	213.4	450.0
14	181.0	364.0
15	168.0	323.0
16	167.3	310.0
17	174.0	316.0
18	104.9	258.0
19	76.2	167.0

Station	Cross-section area	Cu. Yd. earth.
20	83.9	143.0
21	103.4	173.5
22	101.2	189.0
23	56.0	145.0
23+20	0.0	56.0
		6308.0cu.yd.

The average width of the dike is 40 feet and its total length is 1170 feet with a 6 inch depth of muck and loam under 585 feet of it which must be removed.

$\frac{585 \times 40 \times \frac{1}{2}}{27} = 432\frac{1}{2}$ cu.yd. to be removed and refilled or a total pay yardage of 865 cu.yd.

The yardage for pond No.2 was computed in the same manner as for pond No.1

Yardage for pond No.2.

Dike fill ------- ----------------------5774 cu.yd.

Muck to be removed and refilled --------1160 ' '.

Total 6834 cu.yd.

Estimated cost of earthwork for dikes.

Mr. Oaks of the State Highway Department gives a price of .40¢ a cu.yd. for excavating work.

Pond No.1

Yardage above present surface -------- -6300 cu.yd.

Surface soil to be removed and refilled 865 ' ' .

@ .40¢ a yd. 7165 cu.yd.

Total cost of earthwork on pond No.1 is $2866.00

Pond No.2

Fill above present surface ------------5774 cu.yd.

Muck to be removed and refilled -------2320 cu.yd.

Total 8094 cu.yd.

Total cost of earthwork on pond No.2 is $3237.60

Both upper and lower ponds must have an intake pipe and valve to control the flow of water into the ponds.

Pond No.1

60 feet of 12 inch iron pipe ---------$200.00

1 valve ---------------------------$100.00

Installing $175.00

$475.00

Pond No.2

Intake pipe -------------------------$ 35.00

1 valve ---------------------------$100.00

$135.00

Total cost of construction thus far including earthwork and rip-rap on dikes, pipe and valves, and 10% allowed for contractors profit.

Earthwork on pond No.1 ---------------$2366.00

Earthwork on pond No.2 ---------------$3237.60

Pipe, valve, and installation --------$ 475.00

Pipe and valve -----------------------$ 135.00

Cost of rip-rap ----------------------$ 400.00

$7113.60

10% for contractors profit -----------$ 711.36

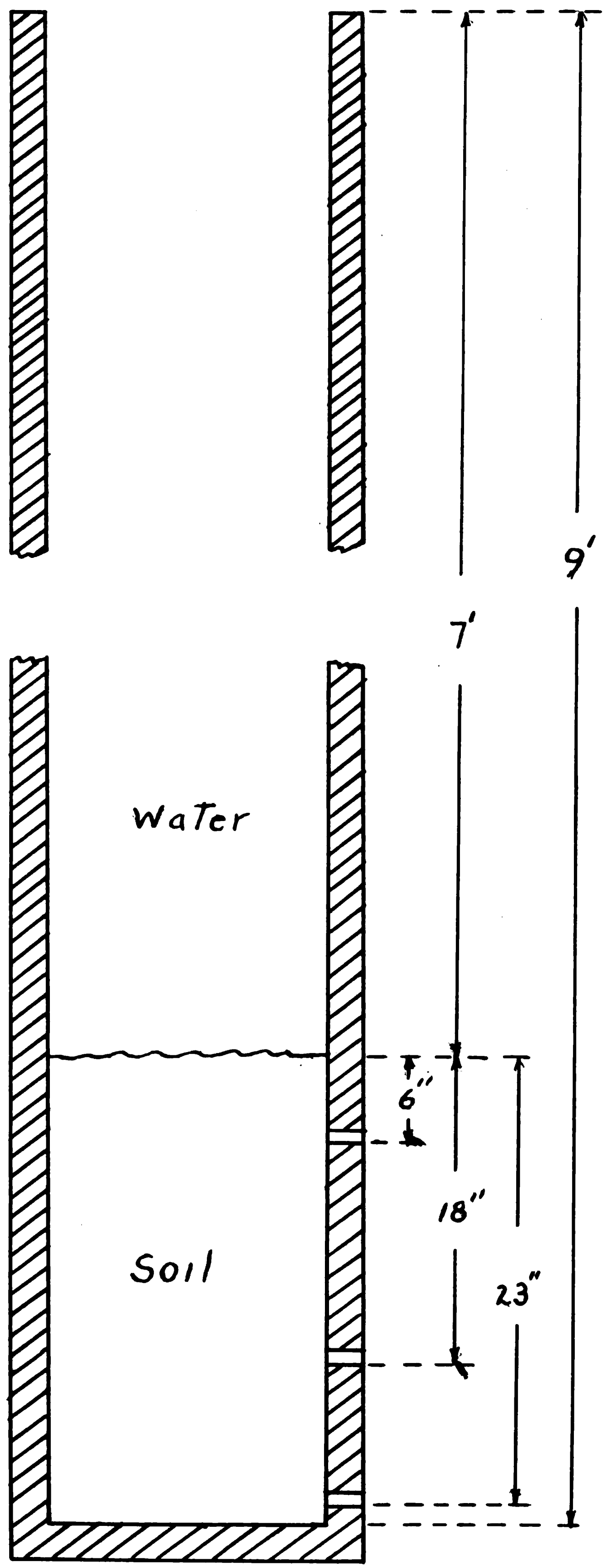
$7824.96

An experimental study of a soil sample for its imperviousness to water.

To obtain more information and some possible working data on the soil of this location I have performed a test on a sample of soil taken from the island and which seems to be a sample that is common to the project. I have constructed a tank with a cross-section of one square foot and a depth of 9 feet and as nearly water tight as possible. On the next page is a drawing showing a cross-section of the tank and the method I used to test the imperviousness of the soil.

The soil was placed in the bottom of the tank to a depth of two feet. Three, one inch holes were drilled in one side of the tank. One 6 inch below the top of the soil, one 18 inches below, and the other 23 inches from the top of the soil.The soil when placed in the tank was puddled with a little water and then tamped with a rod, this was done so that the soil would be as nearly as possible under the same conditions in the tank as it would be in the dike.

After the soil was placed a seven foot head of water was placed on top of it. The depth of the water in the ponds will be seven feet. After the soil had been under these conditions for an hour I made my first observation and observed that the water was seeping through the 6 inch depth of soil. At a depth of 18 inches there wasn't any seepage, at the end of three hours I made anther observation and noticed that the seepage at the 6 inch depth was practically the same. At the 18 inch depth the soil was slightly damp. At the 23 inch depth there wasn't any seep-

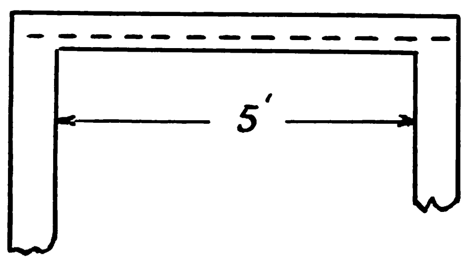

Water
Soil
7'
9'
6"
18"
23"

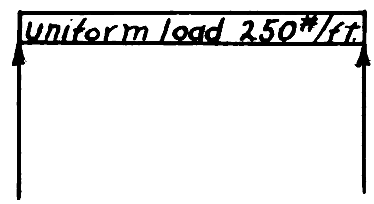
age. At the end of 13 hours I examined the soil again and found the conditions practically the same as at the end of 3 hours. After leaving the experiment stand for 3 days I made another observation and found that the soil was in practically the same condition as it was at the end of 3 hours.

This experiment shows that this soil is quite impervious to water and that it would make a very good material for a dike or an earthen dam. This experiment alone could be worked up into a very good thesis. Different types of soil could be tested, also different aggregates, such as sand, clay, and gravel could be mixed in various proportions and tested thus giving some very useful information relative to the construction of puddled walls for dikes and earthen dams.

The design of the spillway.

The greatest wheel load that will come on this structure will be about 3000 pounds. The Bridge Department of the State Highway Department of Michigan gives the following data on such structures. The equivalent uniform load per foot for a 5 foot span on which there is a wheel load of 3000 pounds is 250 pounds.





For the design of this structure a 2000 pound concrete will be used. For these conditions $f_s = 16000$#/sq. in. $f_c = 500$#/sq.in. $p = 0.0107$; $k = 0.429$; and $j = 0.857$ assume the weight of a slab 12 inches wide to be 70#/lin.ft. This data applies to the floor slab of the spillway which is being designed as a beam supported at both ends.

$$M = \frac{wl^2}{8} = \frac{320 \times 5 \times 5 \times 12}{8} = 12000 \text{ inch pounds.}$$

$$bd^2 = \frac{12000}{.0107 \times 16000 \times .857} = 84$$

$$d^2 = \frac{84}{12} = 7.0 \text{ in.}$$

$$d = 2.62 \text{ in. say } 3 \text{ inches}$$

$$v = \frac{V}{bjd} = \frac{320 \times 5}{12 \times 7/8 \times 3} = 51\#/\text{sq.in.}$$

Area of cross-section, $bd = 12 \times 3 = 36$sq.in.

$A_s = 36 \times 0.0107 = .39$sq.in.

Select 2 - 5/8 in. round bars. Perimeter is 1.964 inches.

$$\text{Bond } u = \frac{1600}{1.964 \times 5 \times 7/8 \times 3} = 62\#/\text{sq.in.}$$

Weight of designed beam $= \frac{5 \times 12 \times 150}{12 \times 12} = 63$ #

Minimum distance from end of beam to edge of support.

$\frac{320 \times 5 \times 2}{12 \times 500} = .54$ in. Minimum allowable is 6 in. use 6 inches. Reviewing beam design.

$$f_s = \frac{12000}{.612 \times .857 \times 3} = 7620\#/\text{sq.in.}$$

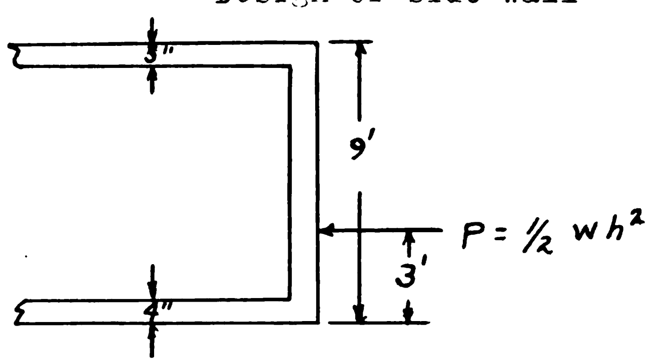
$$f_c = \frac{2 \times 7620 \times .0107}{.492} = 380\#/\text{sq.in.}$$

Spacing of stirrups.

$x_1 - 2/3 \times 5\frac{(51 - 40)}{51} = .72$ feet from center of support

spacing $s = .45d = 1.35$ inches

Design of side wall



In this design the side wall will be designed as though it were a partly continious beam. An equivalent liquid pressure of 25 pounds will be used. The weight of the beam can be neglected because its weight will fall on the ground and not on the supports.

$$M = \frac{wl^2}{10} = \frac{100 \times 9 \times 9 \times 12}{10} = 9720\text{in.-lb.}$$

$$bd^2 = \frac{9720}{.0107 \times 16000 \times .857} = 67.5$$

$$d^2 = \frac{67.5}{12} = 5.7 \text{ in.}$$

d = 2.4 in. say 3 inches.

$$v = \frac{V}{bjd} = \frac{100 \times 9}{12 \times 7/8 \times 3} = 28.6\#/\text{sq.in.}$$

Area of cross-section, bd = 3 x 12 = 36sq.in.

$A_s = 36 \times .0107 = .39$sq.in.

select 2 - 5/8 inch round bars. Perimeter, 1.964 inches.

$$\text{bond } u = \frac{900}{1.964 \times 9 \times 7/8 \times 3} = 19.4\#/\text{sq.in.}$$

Add 3 inches to d to provide a 6 inch bearing for the floor slab.

$$\text{The weight of the beam} = \frac{6 \times 12 \times 150}{12 \times 12} = 75\#$$

Minimum distance from end of beam to edge of support.

$$\frac{100 \times 9 \times 2}{12 \times 12} = .3 \text{ inches.}$$

The top floor slab is 5 inches thick so support is O.K.

Reviewing design of beam.

$$f_s = \frac{9720}{.612 \times .857 \times 3} = 6350\#/\text{sq.in.}$$

$$f_c = \frac{2 \times 6350 \times .0107}{.429} = 326\#/\text{sq.in.}$$

The bottom floor slab will need to be only about 4 inches thick because the wall slab needs only a .3 inch bearing support and the slab itself supports no weight . It is there to prevent the washing of the earth.

Investigating the wall slab as a column to see if it will carry the weight from the floor slab.

Load on wall from floor slab 2.5 x 320#	=	800#
Weight of the wall itself 9 x 75#	=	675#
	total	1475#

The earth will carry 5000# per sq.ft. Wall is 12 in. wide by 6 in. thick or ½ sq.ft. ½ x 5000 = 2500# earth will with stand. Therefore this wall is safe and will not need a footing.

The joint committee gives the following unit stress for lateral reinforced columns. $.20f'_c$ where f'_c is a 2000# concrete. In this case unit stress is 400#/sq.in. The wall under consideration when taken as a column will be like a column supported at both ends. When computing the h/R ratio of a column of this type only ½ of the length of the column is used for h. The column is 103 inches long and 6 inches thick by 12 inches wide.

Then $\frac{h}{R} = \frac{51.5}{\sqrt{\frac{1/12 \times 12 \times 6^3}{72}}} = 17\ 1/3$ therefore this

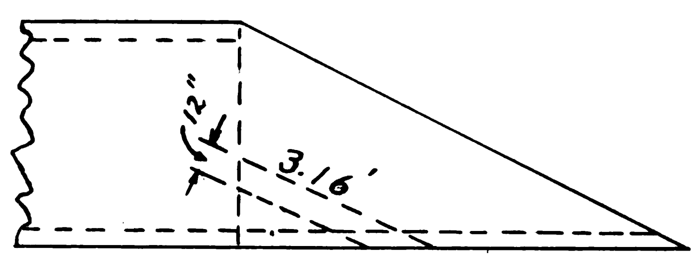
column is a short column. The necessary cross-section area for the column equals the total load on it + weight of the column itself, divided by 1.28 x 400.

$\frac{1475}{1.28 \times 400} = 2.9$ sq.in area needed.

We have 72 sq.in the column.

The steel needed = .02 x 2.9 = .058. We all ready have .39 sq.in. of steel in the column therefore the wall is safe as a column and will support the load on it.

The design of the sloped part of the side wall.



This part of the wall is designed as a partly continious beam. A section 12 inches wide will be taken near the bottom of the wall so that the maximum stress in the wall can be obtained.

$M = \frac{wl^2}{10}$ $P = \frac{1}{2}wh^2$, where w = 25#, and h = 8 ft.

Then P = 815#/ lin. ft. of beam.

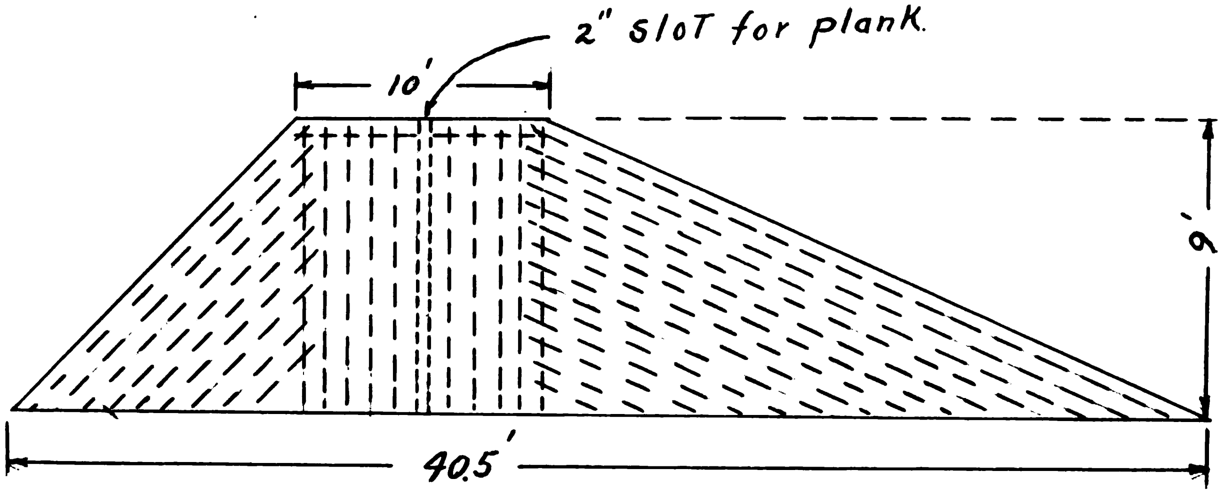
$\frac{815 \times 3.16 \times 3.16 \times 12}{10} = 9800$ in.-lb.

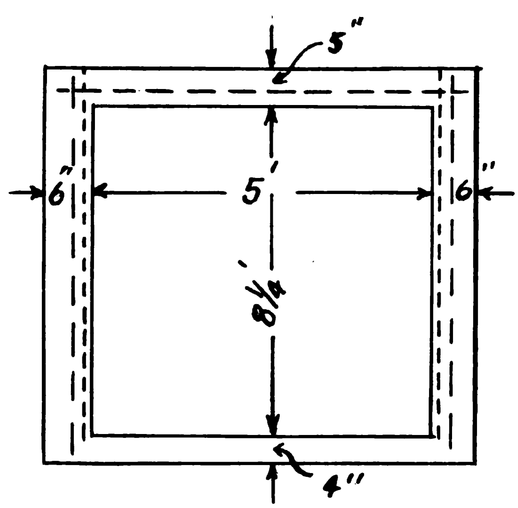
$bd^2 = \frac{M}{Q}$ $\frac{9800}{.0107 \times 16000 \times .857} = 68$

$d^2 = \frac{68}{12} = 5.8$ in.

$d = 2.41$ in. say 3 inches.

From here on this beam is designed exactly the same and will give the same results as the beam designed for the side wall under the floor slab. Theoretically this wall could be decreased in thickness towards the top but it will not be economical to do so. Therefore all side walls will be 6 inches thick with reinforcement of 2 - 5/8 inch round bars per foot of wall. Following is a drawing showing the all dimensions and steel in place.





Estimated cost of spillway.

The Bridge Department of the State Highway Department gives the following prices on materials that will be used in this structure.

Steel in place ------------------------ $.04½ per lb.

Fine aggregate -------------------------$1.50 cu.yd.

Coarse " -------------------------$2.00 cu.yd.

Cement -------------------------$1.90 bbl.

Hool and Pulver recomend a 1:2:4 mix for a 2000# concrete at 28 days. The cost will be computed on this data. The struvture will contain 93 cu.yd. of concrete. Hool and Pulver give the following materials for a 2000# concrete of 1:2:4 mix.

Cement ----------------------6 sack or 1½ bbl.

Fine aggregate ----------------------.445 cu.yd.

Coarse " ----------------------.89 cu.yd.

Cost for a cu.yd. of concrete.

Cement @ $1.90 a bbl.------------------$2.75

Fine agg. @ $1.50 cu.yd. ---------------$ .67

Coarse ". @ $2.00 " " ---------------$1.78

$5.20 a cu. yd.

Total cost of concrete 93 x $5.20 = $483.60

Steel required for structure, 1243 feet. @ 1.04 lbs. per ft. @ 4½¢ per lb. in place = $57.20

Total cost of structure = $483.60 + $57.20 = $54080

Cost for two spillways 2 x $540.80 = $1081.60

Total estimated cost of dikes and spillways.

$7824.96 + $1081.60 = $8906.56