PROPOSED CHANNEL FOR THE RED CEDAR RIVER

THESIS FOR THE DEGREE OF B. S.

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1934

Red Cedar river

Title

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Proposed Channel for the
Red Cedar River

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By

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Dedication

This thesis is respectfully dedicated to the Civil Engineering Department of Michigan State College.

A.J.K. J.C.H.

Contents

Forward

The Red Cedar River, between Kalamazoo Street and the Pere Marquette Railroad bridge at the outskirts of Lansing, is so winding that more than a mile and a half of river is contained in somewhat more than a half mile of distance. During the spring flood time, this land is inundated to such an extent that the property is practically valueless for agriculture or other purposes. In the past the city of Lansing has acquired some of this property for the purpose of someday converting it into a park with a river drive and picnic grounds.

Before this can be done, however, some means must be provided to take care of the excess water during flood time so that it would be pratical to build the drive. To enable the water of the Red Cedar to flow more directly and thus reduce the frequency of floods through this area, the proposed channel has been designed.

Description of the Red Cedar River

The country bordering along the river is flat or moderately rolling, with much of the land marshy. The river, which is a small stream and sluggish at low stages, makes numerous bends. The river floods its banks each spring and whenever there is an intense precipitation for a short time or a longer period of several days.

The drainage area of the Red Cedar is 528 square miles above the Grand River. The length of the river is approximately 40 miles, and the fall over this length is about 115 feet. The average low water depth is one foot, and the width of the river at this stage is 50 feet. The bankful stage is six feet deep, with a width of 150 feet. The depth of the river at the flood stage is eight feet or over.

Description of Land under Consideration

The land through this section is very level and low, not varying in elevation more than three feet throughout the entire area. It is composed chiefly of a sandy loam which erodes easily, the main factor of the constant changing of the river's course. There are a few spots which tend to be marshy during heavy rains.

The high water line extends back from the river distances varying from 50 to 1000 feet. During flood time the river rises up over the streets, causing much inconvenience and greatly hampering the growth of this district as a residential section. On the east side of the river, the water floods the fields of the farmer and destroys productive value.

Aerial View of Section

under Consideration

Formulas Used for the Computations

One of the most widely used formulas for computing the flow of water in channels is that derived by Manning. This has been used in computing the flow in the proposed channel for the Red Cedar River.

The Manning formula is as follows:

$$V = \frac{1.486\,(r)^{\frac{2}{3}}\,(s)^{\frac{1}{2}}}{n}$$

V= velocity in feet per second

r= hydraulic radius or area of cross-section divided by the wetted perimeter

s= the slope or fall per foot

n= a coefficient depending upon all the characteristics of a channel which cause retardation of flow, such as roughness of material in the bed and sides, irregularity in cross-section and profile, vegetation, obstructions, etc.

To computate the quantity of flow through the proposed channel, the discharge formula, which follows, was used.

Discharge formula:

$Q = AV$

Q= discharge in cubic feet per second

A= cross-section area of a river in square feet

V= velocity in feet per second

CHANNEL CROSS SECTION DETAIL

AREA OF CROSS SECTION	750 SQ. FT.
FULL BANK CAPACITY	3000 CU. FT./SEC.
VALUE OF n	0.02
DEPTH OF WATER AT NORMAL FLOW	1.5

SCALE 1" = 10'

JUNE 1, 1934

Data and Values Used for the Computations

Length of river----------------------------8800 feet

Fall in above distance---------------------- 3.96 feet

Length after the proposed improvements--- 3400 feet

Proposed channel-------

Width of bottom--------------------------50 feet

Depth-------------------------------------10 feet

Slope of banks-------------------------- $2\frac{1}{2}$ to 1

Cross-section area --------------------750 sq. ft.

The velocities of flow will vary from a few tenths to four feet per second, depending upon the discharge.

R. E. Horton's value of $n = 0.02$ in Manning's formula will be assumed for the uniform earth channel.

Greatest maximum discharge: 5000 c.f.s., March 15, 1918

Average maximum discharge: 2000 to 3000 c.f.s.

Minimum discharge: 6.1 c.f.s., July 25 & 26, 1933

Results of Computations

Assumed coefficient of roughness n = .02

Assumed maximum velocity 4 ft./ sec.

$$s = \left(\frac{Vn}{1.486(r)^{2/3}}\right)^2 = \left(\frac{4(.02)}{1.486(7.2)^{2/3}}\right)^2 = .00021$$

With n and s as constants, new values for V and Q were computed for various depths of flow.

Depths Ft.	Hydraulic radius	Velocity Ft./sec.	Area Sq. Ft.	Discharge C.F.S.
10	7.2	4.0	750.0	3000
9	6.6	3.8	652.5	2480
8	6.0	3.5	560.0	1960
7	5.4	3.3	472.5	1560
6	4.8	3.0	390.0	1170
5	4.1	2.8	312.5	880
4	3.3	2.4	240.0	576
3	2.6	2.0	172.5	345
2	2.1	1.8	125.0	225
1	0.95	1.1	52.5	57.8
0.75	0.78	0.91	39.0	35.5
0.5	0.49	0.66	26.0	17.2
0.25	0.25	0.41	13.1	5.4

Comparison of Flow Data in Present and Proposed Channels

Location	Velocity Ft./sec.	Quantity C.F.S.	Area Sq. Ft.
Bend 1	1.17	108	92.5
Bend 5	0.402	108	269.0
Bend 6	0.620	108	174.0
Bend 8	0.580	108	185.0
Bend 16	0.610	108	175.5
Proposed Channel	1.38	112	80.6

The present river channel is so irregular in size and shape of cross-section and contains such obstructions as snags, logs, sand-bars, and growths of various kinds that there is a considerable variation in the velocity of the river at different points.

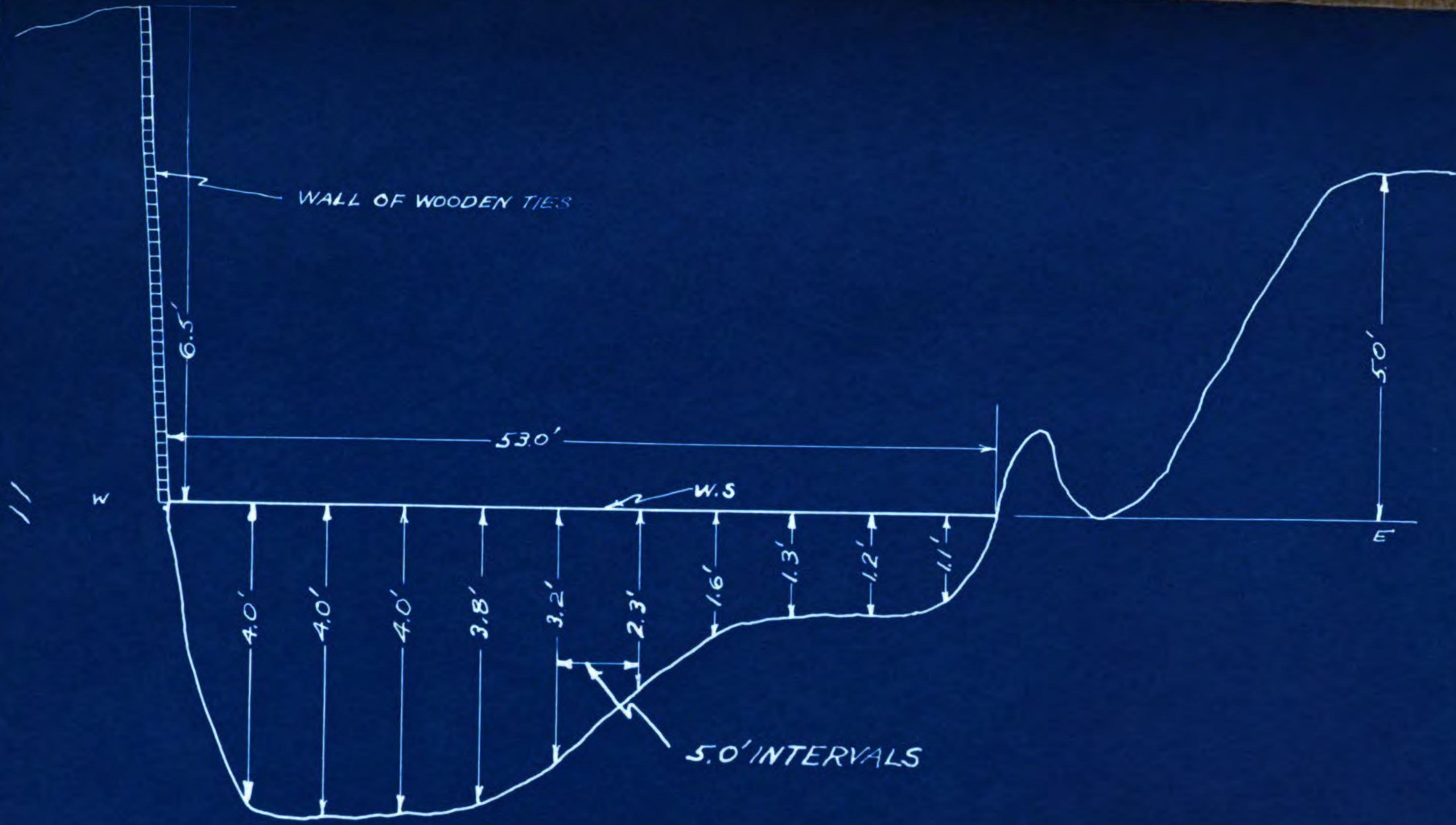
A comparison of the quantity flow in the present course with the flow in the proposed channel, whose depth would be 1.5 feet, was made. It was found that the quantity flow was four cubic feet per second more in the proposed channel, and that the velocity of the latter was also much greater than in the present channel for a quantity flow approximately equal to that of the present.

View of River Showing First Bend

View of River Showing Fifth Bend

View of River Showing Eighth Bend

View of River Showing Sixteenth Bend



CROSS-SECTION
AT BEND 1

DATE:-5-2-34
AREA:-92.5 SQ.FT
QUANTITY OF FLOW= 108 C.F.S.
VELOCITY=1.17 FT/S
SCALE:- HOR. 1"=10'
VERT. 1"=2'

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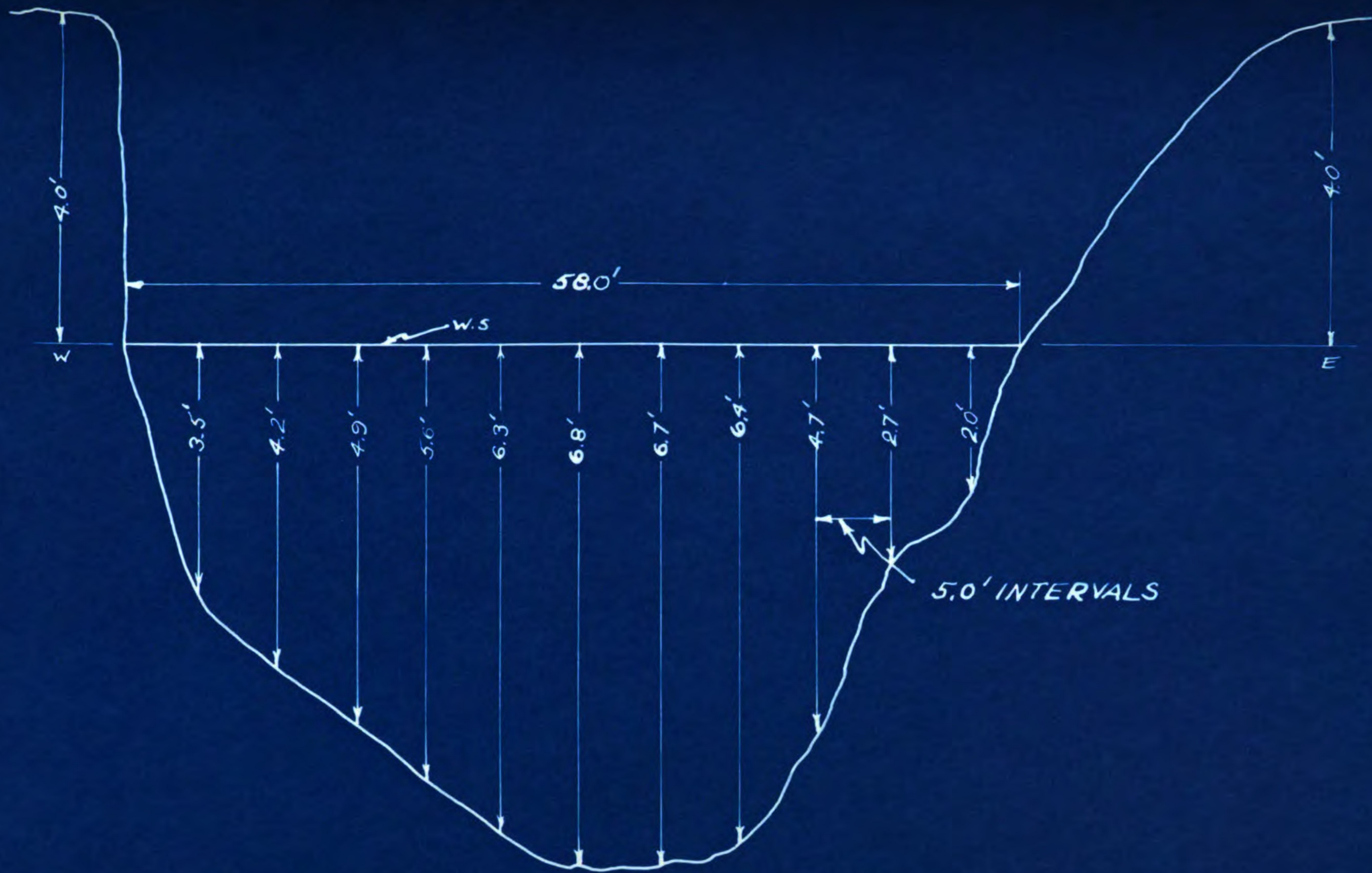
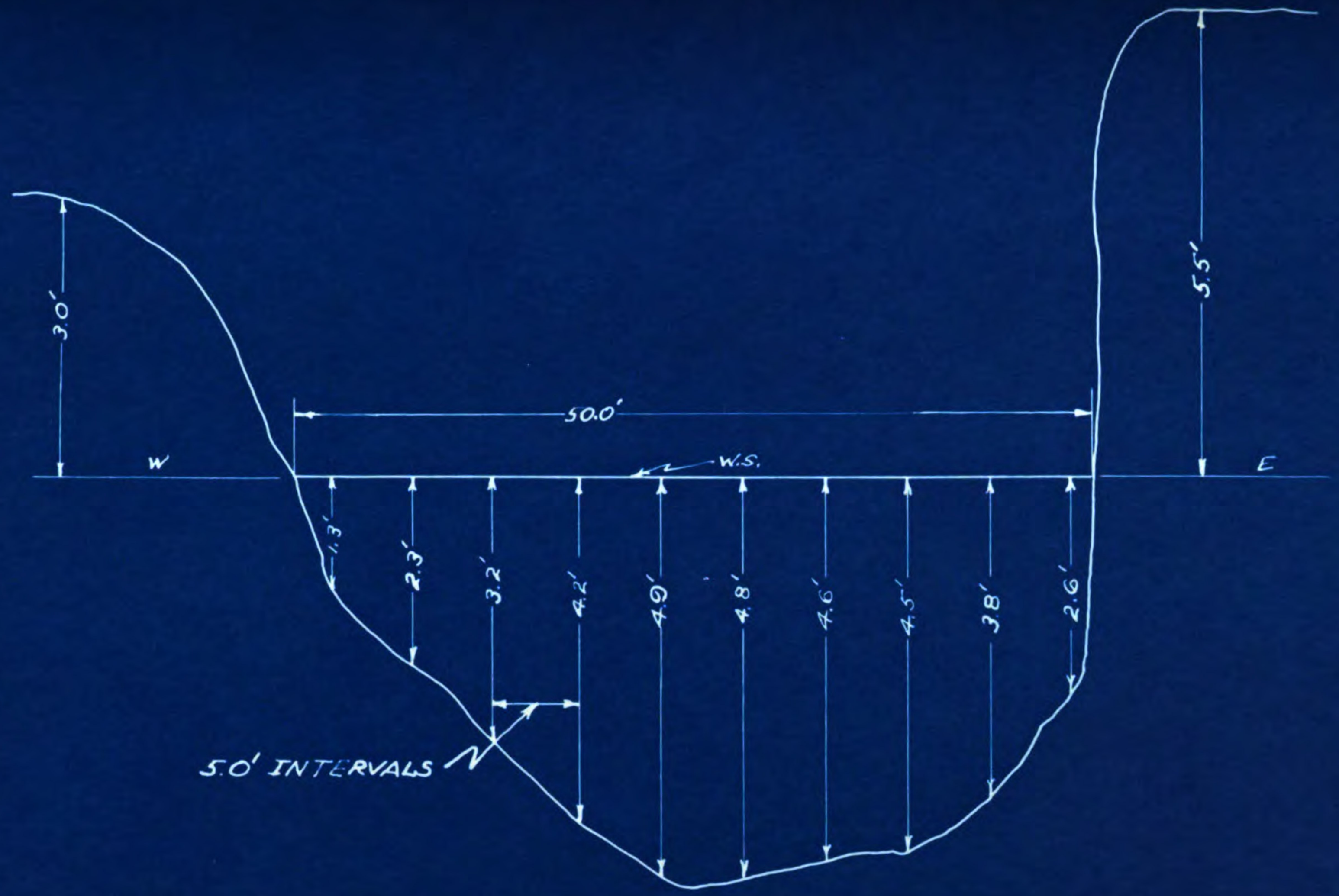


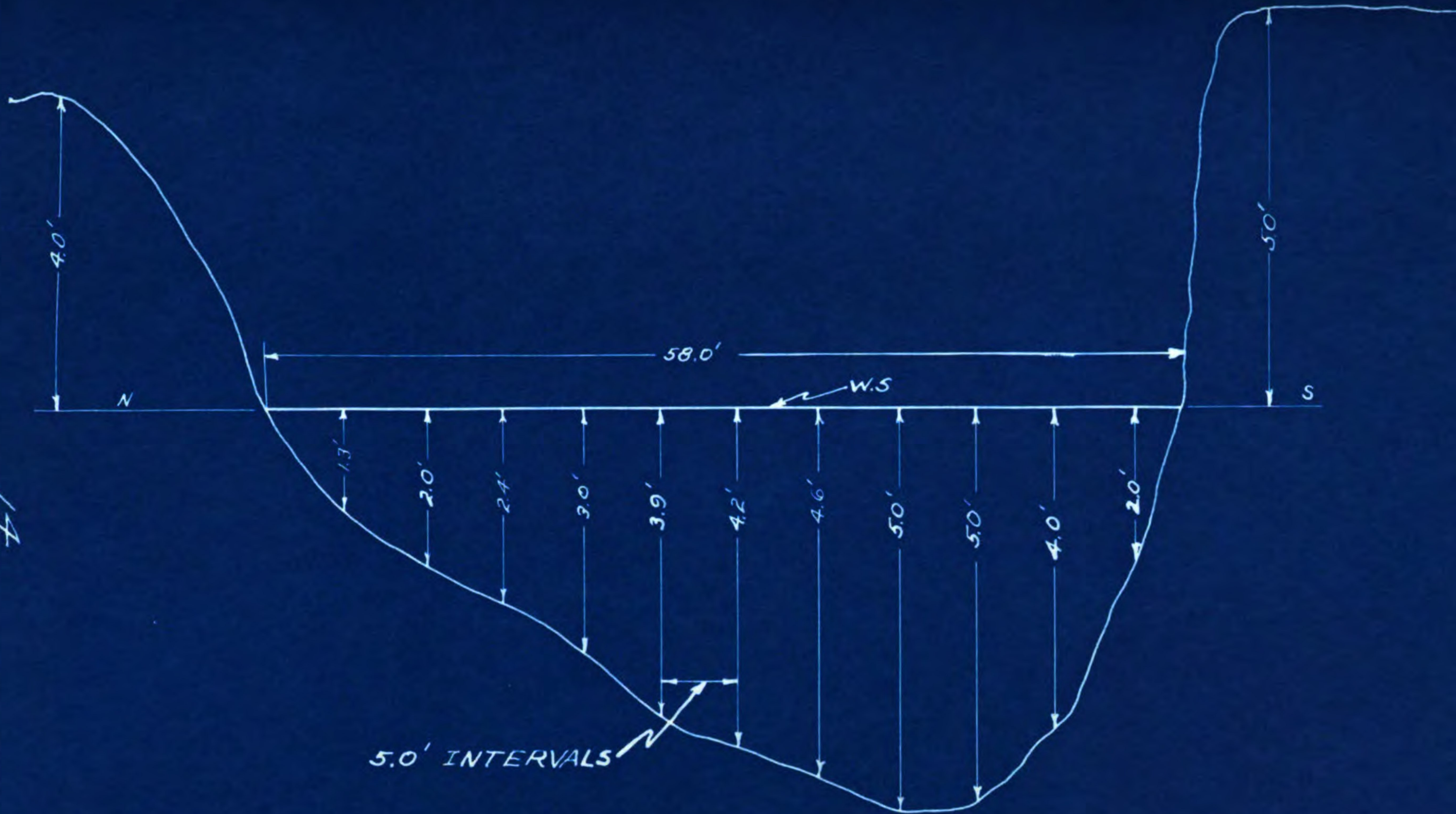
CROSS-SECTION
AT BEND 5

DATE:–5-2-34
AREA:–269.0 SQ.FT.
QUANTITY OF FLOW= 108 C.F.S
VELOCITY= 0.402 FT/S.
SCALE:– HOR.–1"=10'
VERT.–1"=2'



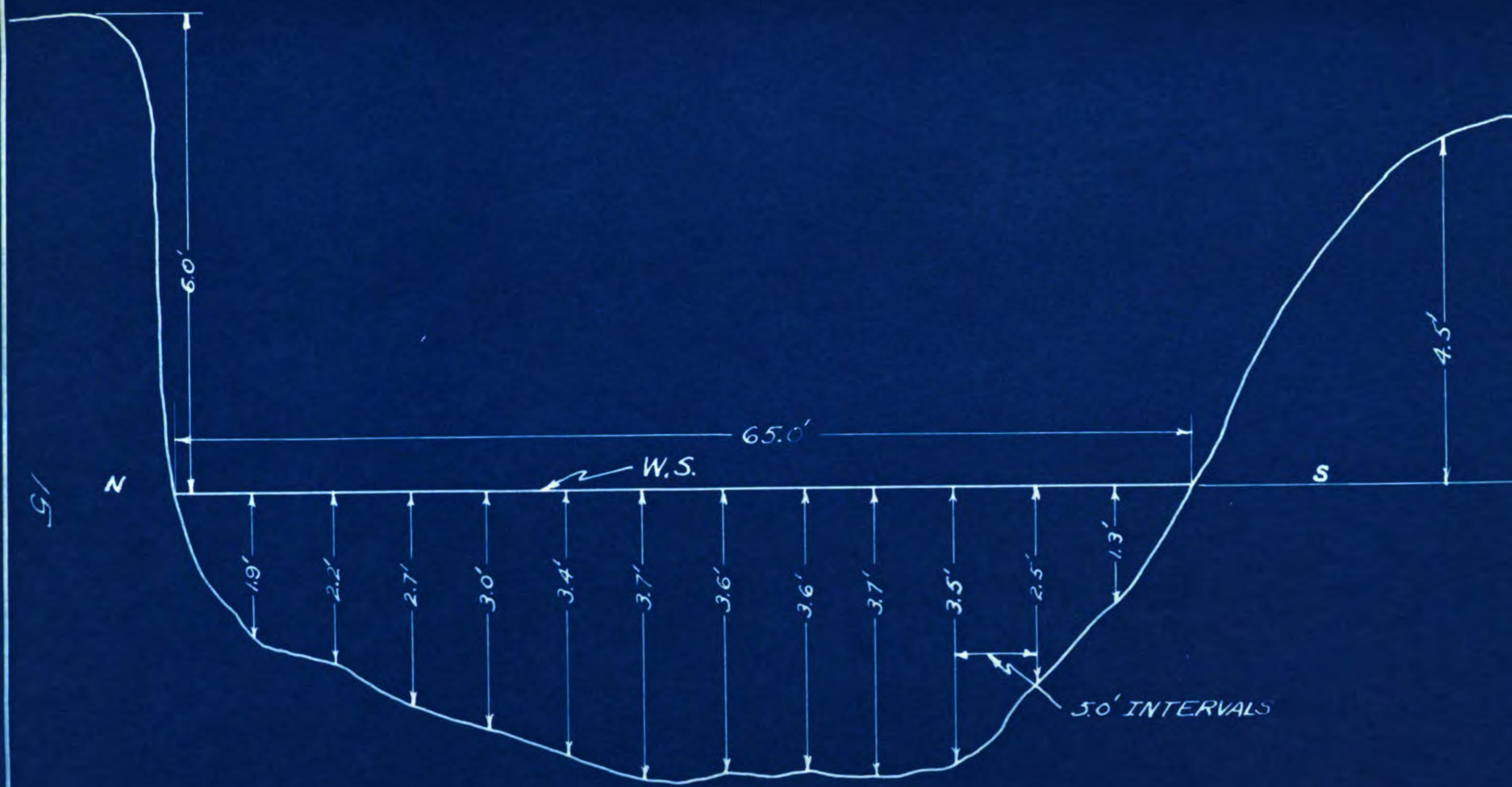
CROSS - SECTION
AT BEND 6

DATE:-5-2-34
AREA - 174.0 SQ. FT.
QUANTITY OF FLOW = 108 C.F.S.
VELOCITY = 0.62 FT./S.
SCALE:- HOR.-1" = 10'
VERT.-1" = 2'



CROSS-SECTION
AT BEND 8

DATE:- 5-2-34
AREA - 185.0 SQ. FT.
QUANTITY OF FLOW = 108 C.F.S.
VELOCITY = 0.58 FT./S
SCALE:- HOR. - 1" = 10'
VERT. - 1" = 2'



CROSS-SECTION
AT BEND 16

DATE– 5-2-34
AREA – 175.5 Sq. FT.
QUANTITY OF FLOW = 108 C.F.S
VELOCITY = 0.61 FT./S
SCALE:- HOR. – 1" = 10'
VERT – 1" = 2'

The Proposed Channel

From an economical point of view it would be entirely impractical to run a straight channel from the Kalamazoo Street bend of the river to the Pere Marquette Railroad bridge. A channel of this sort would make it necessary to re-drill two of the wells of the city of Lansing. It would also cause an added expense, because such a channel would cut through Howard, Harton and Detoit streets, making bridges over or re-routing of these streets necessary. In view of these facts, and since the property is some day to be converted into a park, the project has been divded into three separate channels, by so doing eliminating all of these difficulties. At the same time, this plan will provide a short route for the river through this district which would be straight enough to answer our purpose.

The first of these channels is about 750 feet in length, extending from the first bend of the river near Kalamazoo Street to the center of the fifth bend, about 150 feet east of Howard Street. From this point the river would be allowed to pursue its present course to the center of the sixth bend, a distance of approximately 350 feet.

The second cut would begin at this point and end at the center of the eighth bend. The length of this cut would be about 500 feet. Beginning at the center of the eighth bend and ending at the sixteenth bend would be the third and final cut. These three cuts would form a new channel for the river having only two small bends throughout its entire length in addition to those at the beginning and end of the channel. From the standpoint of cost, this is probably the most practical solution of the problem.

It is recommended that the banks of the channel be sodded for a distance of sixteen feet from the top.

Erosion Control on the New Channel

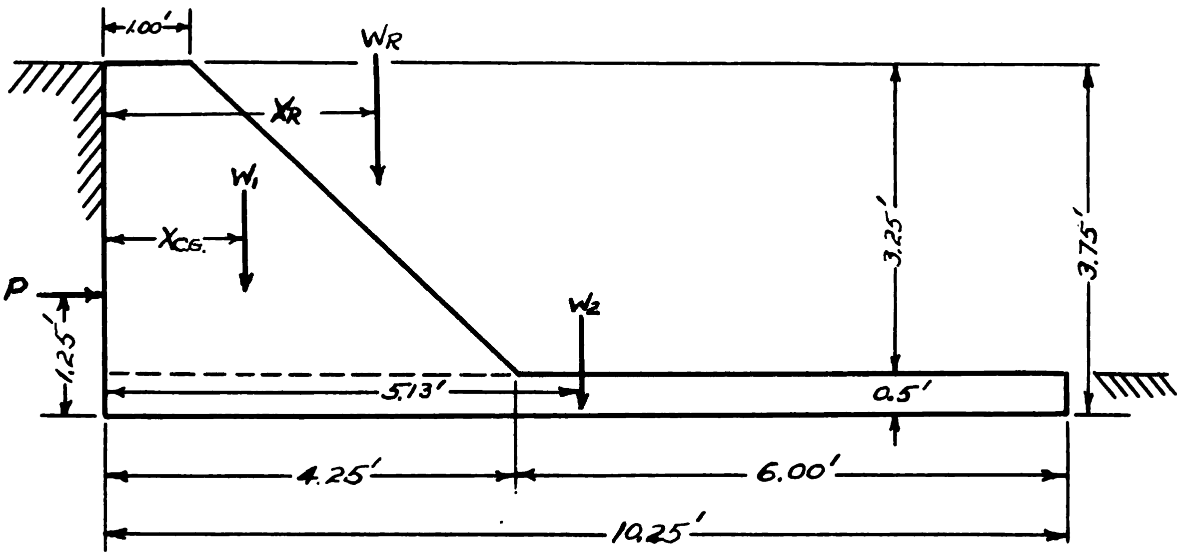
The velocity of the river in its present course varies from 0.5 to 1.0 feet per second. With the new conditions of slope and channel resulting from the proposed cut, the velocity would be increased to about nine feet per second. If this were to be the velocity, the river would soon eat away its banks and be back in its present condition. So great a quantity of water would be carried through the new channel in this manner that it would flood the land at the lower end of the cut.

In order to take care of this situation it would be necessary to place a concrete cataract at the beginning of the channel. This cataract would allow the water to fall a distance of three feet three inches and would reduce the slope so that the velocity, at full bank, would be only about four feet per second, which would be quite safe with such a straight cut.

By using a cataract or waterfall instead of a dam, the necessity of backing up water at the beginning of the channel would be eliminated.

The cataract, as designed, would be a concrete retaining wall of the gravity type, sixty feet long, which would allow the ends to be embedded two feet in the banks at each end. It is recommended that either concrete or stone work be placed along the bank for a distance of about ten feet above the cataract and twenty-five feet below to prevent erosion by the rapids.

Concrete Cataract for Velocity Control Calculations



$$X_{cg} = \frac{a^2 + ab + b^2}{3(a+b)} = \frac{\overline{1.00}^2 + 4.25 + \overline{4.25}^2}{3(1.00 + 4.25)} = 1.48 \text{ feet}$$

This wall would tend to be the most unstable when the river was at low flow. Disregarding back pressure due to water, the following formula was used to show the earth pressure on the concrete cataract:

$$P = \tfrac{1}{2}\, wh^2 = \tfrac{1}{2}(100)(3.75)^2 = 703.13$$

$$W_1 = \frac{1.00 + 4.25}{2}\,(3.25)(150) = 1283$$

$$W_2 = 10.25(0.5)(150) = 770$$

$$W_R = 770 + 1283 = 2053$$

$$770(5.13) + 1283(1.48) - 2053X_R = 0$$

$$X_R = 2.85 \text{ feet}$$

Factor of safety from overturning

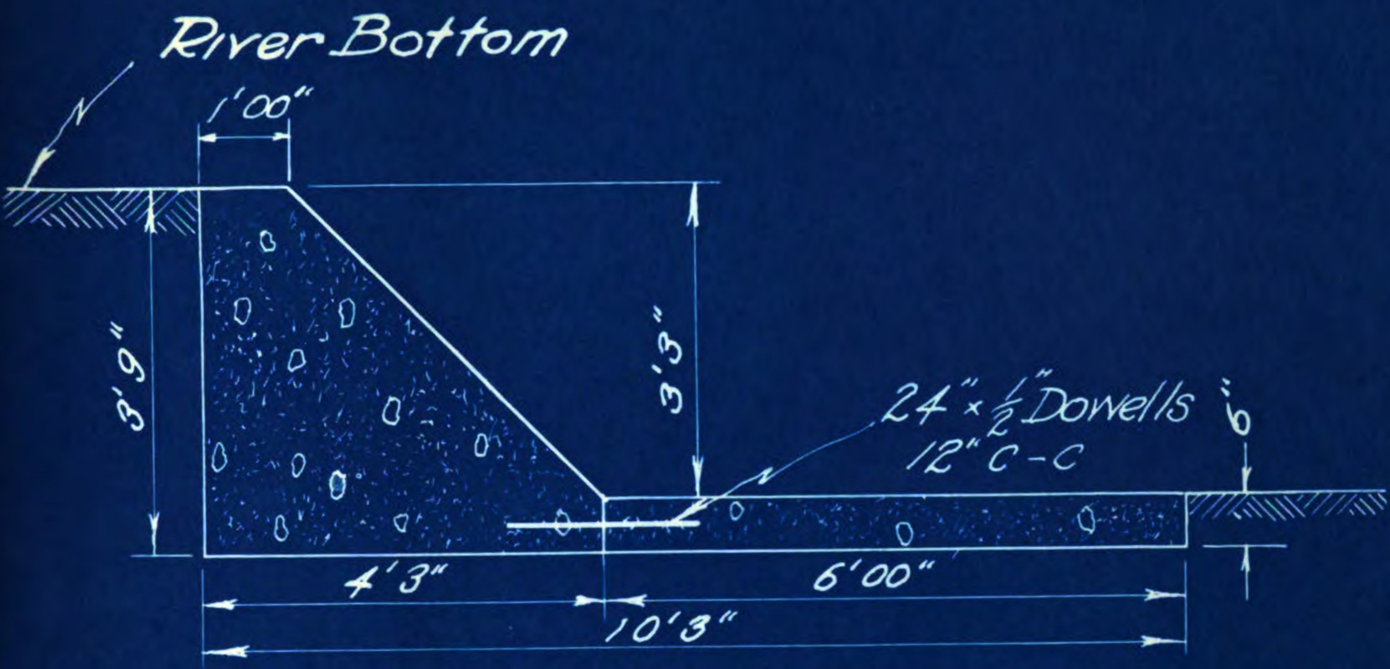
$$\frac{(2053)(4.25+2.85)}{(703)(1.25)} = 3.26$$

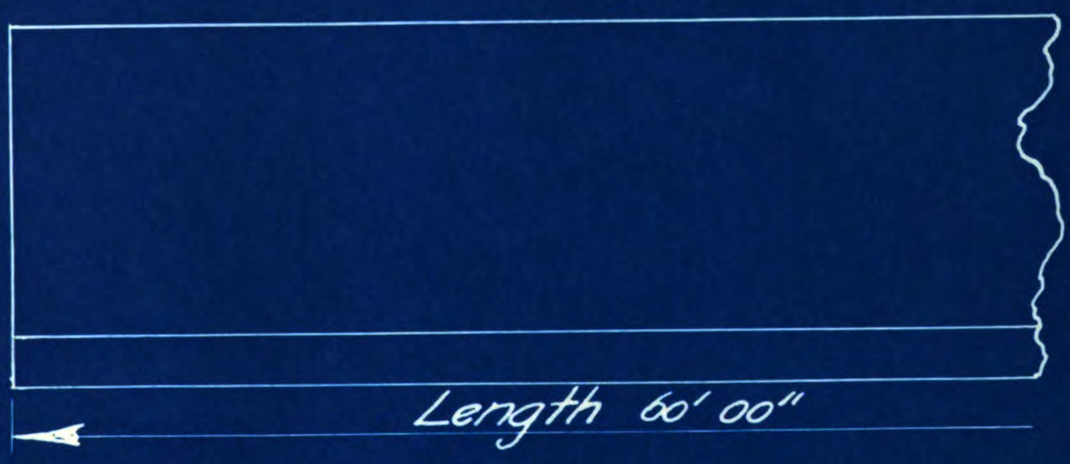
Factor of safety from sliding

Coefficient 0.05

$$\frac{(2053)(0.05)}{703} = 1.47$$

Pressure on soil $\frac{2053}{(10.25)(1)} = 200$ pounds per square foot





CONCRETE CATARACT
FOR VELOCITY CONTROL

SCALE 1"=2'

JUNE 1, 1934

J C Hogle

A J Korney

Proposed Channel Bends

Bend A:	Degree of curve	16°
	Radius	359.26 feet
	Length of bend	375 feet
Bend B:	Degree of curve	7° 15'
	Radius	790.81 feet
	Length of bend	550 feet
Bend C:	Degree of curve	18°
	Radius	319.62 feet
	Length of bend	400 feet
Bend D:	Degree of curve	18°
	Radius	319.62 feet
	Length of bend	350 feet

Estimated Cost

Excavation, 85,350 cu. yds. @ $0.35/cu. yd.	$29,872.50
Concrete cataract, 30.4 cu. yds. @ $15/cu. yd.	456.00
Extending sewer 270 feet @ $15/linear foot	4,050.00
Stonework or concrete, 70 sq. yds.	300.00
Sod, 12,240 sq. yds. @ $0.08/sq. yds.	979.20
Labor, 20 men for 12 weeks	
40 hour week @ $0.50 per hour	4,800.00
	$40,457.70
Engineering and contingencies, 10%	4,045.77
Total	$44,503.47

Property owners are willing to grant right of way without cost for the benefits that they would derive from the new channel.

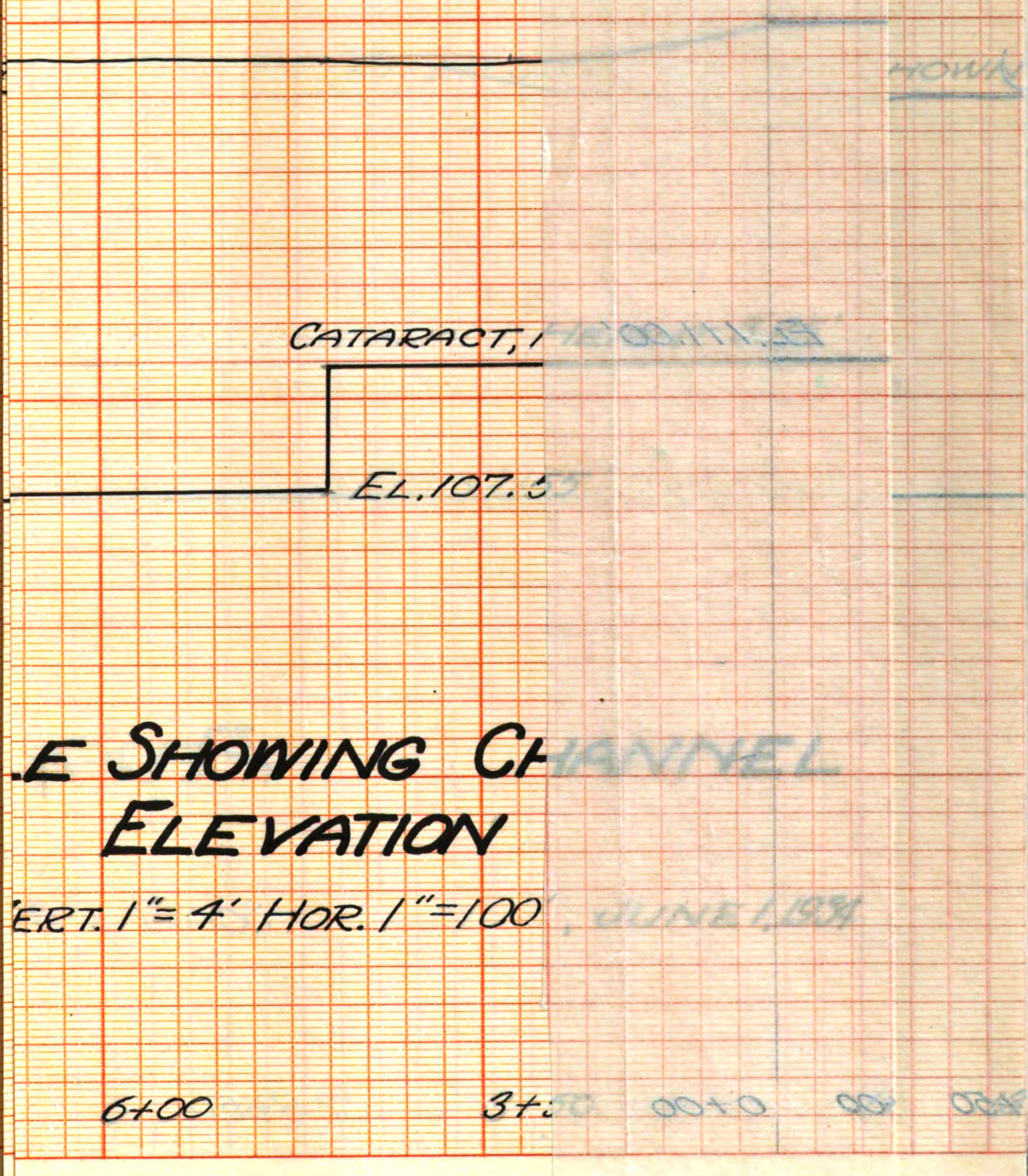
Conclusion

The completed channel would take care of three thousand cubic feet of water per second at the bankful stage. Floods over three thousand cubic feet per second have occurred about once every six years for the past twenty years, and in each case these have been of less than a day's duration. Such periods of high water, since they are so short, would cause no severe damage. The river in its present condition floods every spring, the length of these floods varying from two weeks to a month.

The high water period usually occurs during the spring planting season so that the fields which are below the water line are useless to their owners. This condition affects about a mile and a half of land along one bank of the river. On the other side of the river the value of the property to home owners is about one half what it would be if this flooding could be eliminated. If the channel were constructed, it would undoubtedly be possible to convert the city owned property into a park as well as turning this section bordering the river into a fine residential district. Building the channel would result in an increase in value of the surrounding property.

City of East Lansing uses the Red Cedar River for sewage disposal purposes, and because of this the river at high water constitutes a health menace to the residents of this district. The sewage ladened water rises into the streets and in many cases enters the basements of the homes. When the river recedes, pools of water are left which quickly become stagnant and afford a breeding place for mosquitoes. This condition would likewise be eliminated.

These are the points which must be considered in determining the advisability of the new channel.



.E SHOWING CH
ELEVATION

'ERT. 1" = 4' HOR. 1" = 100'