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LOCATION OF

BARGE CANAL AND HARBOR

AT ROCHESTER, N. Y.

REPORT BY LYMAN E. COOLEY.

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INTRODUCTION.

I came to Rochester on May 9, and received the written instructions of the Mayor, Hon. James G. Cutler, by E. A. Fisher, City Engineer, a copy of which is appended. I went back to Chicago on the evening of the 11th and secured some data bearing upon the problem in hand, returning to this city on the 23rd; and my time has been devoted to the question at issue up to date.

I have had extended conferences with city, state and county officials, and in company with same have examined the several propositions on the ground. I have gone through the voluminous literature on the subject, and have been furnished with special data from official sources. I have heard many interested citizens, and received statements in writing. The Engineering Department has made special studies of suggested solutions.

I was familiar with Rochester and interested in canal questions in early life when my home was in this part of the state. As a member of the International Deep Water-ways Commission I gave special study to the New York canal situation in 1895-7. In 1898, I acted as Advisory Engineer to Governor Black's Committee of Investigation under the "Nine Million Act," and spent a couple of weeks in examining canal conditions at Rochester and vicinity. In 1899, I made an elaborate study of transportation by water and rail between the West and the eastern seaboard. All this has enabled me to grasp the situation at Rochester much more quickly and certainly than would otherwise be possible in the time.

The data available are sufficient to indicate the proper solution, and the general treatment and the details can be left to those who are specially charged with the carrying out of the work.

GENERAL CONSIDERATIONS.

Whatever difference of opinion may exist as to the practical utility of the barge canal, all will agree that the canal, with its harbor, should be so located as to best serve commercial and industrial interests, if the city is to realize the greatest benefit through its development as a traffic route. Railways everywhere seek the commercial and industrial core; and no one should question the propriety in other means of transportation.

The statistics (appended) of canal traffic in recent years are significant. The through business has shrunk and the local business has expanded until it is about 60 per cent of the total. The business of Rochester is about 10 per cent of the local and about 6 per cent. of the total, while the proportion of taxation for Monroe county is about 2.4 per cent of that for the whole state. Such facts reinforce the policy of a domestic waterway. Indeed, if the Great Lakes some time are to be developed as an arm of the sea, as available as the Gulf of Mexico, then the future history of the barge canal will be as a

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domestic waterway. In Europe the policy of domestic waterways is well established, and there is a growing belief in such waterways of some minimum capacity in this country as necessary to its fullest development with growing density of population. The western half of New York is well formed for a domestic waterway system.

Every one will concede that the works should be located and designed as to assist, rather than to accentuate, the solution of local problems. Aside from their transportation value, the works then become an integral factor in the commercial welfare. It is no argument against the expenditure of a dollar that it may incidentally contribute to another public purpose.

It will also be agreed that the present need should be served along lines that can develop progressively to the conditions of the future.

What benefits Rochester most, is of greatest interest to the state, for the common welfare is the aggregate of local and individual good.

THE SEVERAL ROUTES.

Several alternative routes and variations have been considered for passing Rochester, originating one mile east of South Greece and closing at Fairport. The crossing of the Irondequoit valley is a governing factor; the present location, known as the "Ox-bow," being some 12 miles around from Brighton to Fairport, while the direct distance is six miles. Three locations follow the "Ox-bow" in whole or in part, two at present canal level and one 14.5 feet lower. Two locations are direct from Brighton to Fairport and at the lower level. The low level locations propose to cut down the Fairport-Macedon snmmit to the Palmyra-Newark canal level. All comparative estimates are therefore between South Greece and Macedon.

The present location and through the city of Rochester and by the "Ox-bow," seems to have been estimated for purposes of comparison. It has few partisans, and has not been seriously entertained. Certain stretches of the old canal are used in the several projects.

A variation of what is known as the "South Route" leaves the present canal line near Pittsford, crossing the Irondequoit valley to Fairport south of the West Shore Railroad, as a low level line. This route seems also to have been eliminated.

The "North Route" is seriously advocated by a number of influential people, although the state has confirmed its decision in favor of that part of the "South Route" to the west of the city by letting the contract for work between the junction east of South Greece to the crossing of the New York Central & Hudson River Railroad (Buffalo line.)

This route leaves the present canal about four miles west of Rochester at the Four-Mile Grocery Bridge and crosses the Genesee River about one-half mile north of the Driving Park Avenue bridge on a steel aqueduct 1,050

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feet long and 215 feet above the bed of the river. It then skirts the city on the north and east to near Brighton, crossing the Irondequoit valley on the low level line directly to Fairport south of the New York Central & Hudson River Railroad and north of the highway. It is proposed to improve the present canal from the junction of Lyell Avenue as a harbor for the western division of the city. A harbor for the eastern division of the city would necessitate locking back to the "wide waters" and retaining the existing canal, or some substitute, as a feeder.

This location is urged as permitting a higher declivity (12.66 feet is suggested) in the reach between Rochester and Lockport, thus giving a larger flow of water; as facilitating a connection with Irondequoit Bay at some future time, and as avoiding complications due to the pool crossing of the Genesee River on the South Route.

The State project for this route did not contemplate a channel of large declivity. The conformation of the supporting ground does not lend itself to such treatment, and the object can be better accomplished by a larger prism and with substantial betterment to navigation. Irondequoit Bay can be readily reached from near Brighton on one of the routes hereinafter discussed. A treatment of the pool crossing is recommended which will avoid the criticisms that have been made, and at the same time accomplish other wise purposes.

The proposed crossing of the Genesee gorge is truly heroic. It involves a monumental structure in steel which cannot be regarded as having a permanent life. The Northern Route would be justified if there was no alternative. The relative advantages of this location are not manifest.

THE TWO ALTERNATIVES.

The South Route (defined by statute) originates one mile east of South Greece, and takes a southerly course near the Belt Railway on the west of the city and sweeps around southeasterly to a crossing of the Genesee River in Genesee Valley Park; thence a direct course to the turn in the present canal west of Pittsford; thence along the canal to the turn east of Carterville; thence directly across the Irondequoit valley, avoiding the detour by Bushnell Basin, and along the canal and a new location behind Fairport,—keeping the present level of the "Ox-bow" through to Macedon.

The canal on the outskirts of the city, and well on towards Pittsford, is in deep cutting, and will be available for through business only. The little low-lying land near the Genesee River is for the most part within park limits. It is proposed to control the pool level by a regulating dam at the site of the present state dam, and to develop the feeder with a basin at the junction with the present canal for harbor purposes.

The alternative route is spoken of as the "Bond, or Middle Route," and leaves the South Route between the crossing of the Buffalo, Rochester

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& Pittsburg Railway and Brooks Avenue, crossing the river in a pool north of Brooks Avenue and the State dam, thence by the feeder and a new canal from south of Clarissa Street to the present canal at Goodman Street, thence along the present canal to Brighton, thence by low level line already described direct to Fairport and through to Macedon.

The length of the two routes is practically the same, but the Middle Route will be somewhat shorter if the South Route omits the Fairport cut-off, as has been suggested.

THE RIVER HARBOR.

It is sound waterway practice to utilize natural channels. The canalization of streams usually aims to lift the low water plane without accentuating flood effects.

The city has expended from its core around the river. The river compels respect; it insists on its right of way and man encroaches at his peril. Bridges are not needlessly built over it. It occupies the only land that cannot be put to other than waterway uses. A river harbor will substitute a fair dock line of masonry for unsightly river banks, and make valuable property of the foreshores. It will solve the flood problem for the length of the harbor, and improve the water power.

Careful attention has been given to the topography in the vicinity of the river upstream from the canal aqueduct. It is practicable to locate controlling works immediately above Court Street bridge and below the Johnson & Seymour dam. Such works at this locality will not be affected by backwater, and the greatest floods may be passed at the normal pool level. Experience on the controlling works of the Chicago drainage canal at Lockport shows that regulation is effective for a very small fraction of a foot. If the ordinary fluctuations are controlled within limits of one foot throughout the length of this harbor during the season of navigation, it will be sufficient.

It is proposed to fix the normal pool surface at or about elevation 251 feet, city datum, (512.26 feet above mean tide as used by barge canal) which is 9.1 feet above crest of Johnson & Seymour dam. The river should be bottomed out for a depth of 18 feet below pool surface and for a width of 400 feet for about two miles up to the juncture of the Middle Route below the state dam. The dock walls should be carried three feet above normal pool surface, or to elevation 254 feet, city datum, and the forshores filled in to a grade rising back for a distance from the river. The greatest known floods can be passed though the two miles without going over the dock walls.

The Middle Route can approach from the west parallel to Brooks Avenue and near to Barton Place, and enter the harbor parallel to the current. It can leave the harbor near the junction of Clarissa Street and Mount Hope Avenue, going east between Sanford and Gregory Streets to a

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junction with the present canal at Goodman Street. The harbor will constitute about 1 1-4 miles of the through route.

The dockage throughout the length of the harbor on the east side can be developed at once. The lands between the river and South Avenue, Mt. Hope Avenue and Wolcott Street, on the east, are largely occupied by the present canal and feeder and by the Lehigh Valley Railroad, the area remaing being very poor property. The railroad is largely on state property under revocable lease. It seems practicable to shift Wolcott Street to the foot of the bluffs, to place the railroad adjacent to the streets and to fill in and reclaim the feeder and canal from the state dam to the aqueduct.

The Middle Route enables the present canal to be suppressed from the crossing of the New York Central & Hudson River Railroad on the west to Goodman Street on the east, and as soon as the route partially under contract, can be developed from South Greece to Goodman Street. It would be possible for the Lehigh Valley Railroad to change its terminals to the abandoned canal line between the junction point and the feeder, coming into the city by the gap west of Pinnacle Hill, thus freeing the entire east river front. Such a solution would be ideal.

The western river front does not lend itself so readily to immediate treatment. To give this side the best development it would be desirable to shift Exchange Street inland near Clarissa Street and put the Erie Railroad back from the river front. This is a matter that can be taken up later, and and worked out gradually as may seem expedient when the demand for dock room is better developed.

OTHER HARBOR FACILITIES.

East from Goodman Street to Brighton, and throughout the wide waters, the route can be almost continuously developed as a harbor for industrial purposes. These facilities should be valuable to the east side with its two-thirds of the city population. Some changes in levels are contemplated which will facilitate bridging. This stretch of canal cannot be utilized in connection with the South Route, and it seems a pity to waste so fine a site, now devoted to canal uses, and one so well located to meet the growing needs of the city.

The interests on the west side are well satisfied if the present canal is retained from South Greece to the crossing of the New York Central and Hudson River Railroad (main line.) This will conserve the situation until vested interests have worked themselves out and the future demands are more clearly defined. A guard or low-lift lock will be required near South Greece junction, and some connection with the river or sewer at the dead end for circulating the water.

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FLOODS.

The effect of the improvement on the regimen of the river and especially that of floods, is a matter of prime concern. The pool crossing of the Genesee River in conjunction with the long and gentle declivity from Lockport demands guard locks with possible interruptions by floods in the season of navigation, unless the pool be radically improved and its fluctuation controlled within narrow limits. Such control can only be effected by works with a free fall in extreme flood, and these are practicable only as the aqueduct is approached. The radical improvement of the two miles between the controlling dam and the junction of the Middle Route is justified for harbor purposes, but the extension of another mile to the South Route crossing in the park is costly in rock excavation, and the range of fluctuation is increased.

An improvement that meets the requirements of navigation is a radical solution of the flood problem; in fact disposes of that question throughout the length of the harbor. Such requirements are, that the velocity shall not exceed four feet per second (so fixed for river improvent on barge route) during the floods of the navigation season, and that the fluctuations where the canal enters shall not exceed one foot, thus permitting unobstructed flow.

The "Report of Special Committee on Flood Conditions in the Genesee River," presented to the Mayor, April 15, 1905, is a digest of all that is known, and has been invaluable to this investigation. The flood frequency is much the same as on other rivers under similar climatic conditions. Two or three times in a century occurs the flood of tradition or of the "oldest inhabitant." Two or three times in a generation occurs the flood upwards of half the extreme volume that is recalled by those who have long lived in the vicinity of the river. The ordinary expectation is about one-third the extreme, and in half the years this will not be reached.

The flood limit is estimated by the "Special Committee" at 60,000 cubic feet per second. The slope has been computed for this volume, and also for one-half and one-third, from the controlling dam, 200 feet above center line of Court Street bridge, to the junction of Middle Route, 11,000 feet, and of South Route in the park, 16,000 feet. The results are as follows:

Cubic Feet Per Second	Controlling Dam.	Middle Route 11,000 Feet.	South Route 16 000 Feet.
20,000	0.00	0.51	0.71
30,000	0.00	1.09	1.41
60,000	0.00	3.43	4.47

Cross-section, 400x18 at normal level.

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The two greatest floods of early times are, that of March 18, 1865, the greatest known and estimated at 45,000 to 54,000 second-feet, and that of October 23, 1835, estimated at 36,000 second-feet. The pool level at the Johnson & Seymour dam is somewhat below the flood level of 1865. General I. F. Quinby, in his report to the flood commission of 1866, gives the elevation of the two floods as follows (referred to normal pool level):

	1865.	1835.
Near Clarissa Street	2.56	(-0.50)
Above state dam	9.30	6.35
Between Black creeks	14.40	12.60

The improvement would reduce the flood elevation of 1865 by over six feet, and that of 1835 by over four feet, in the vicinity of the state dam, and conditions would be mitigated for some miles upstream.

From 1866 to 1892, inclusive, the record is as follows:

1867,	February	20,000-25,000
1873,	March	30,000-35,000
1875,	March	30,000-35,000
1879,	March	20,000
1889,	June 1-3	20,000

Only one of these floods occurred in the season of navigation.

A gauge record has been kept at the Johnson & Seymour dam since February, 1893, and the record is complete to date. The following is a list of floods of 20,000 second feet and over:

1894,	May 23	25,000
1896,	April 1	33,000-36,000
1901,	April 24	20,000
1902,	March 3	35,000-38,000
1902,	July 9	20,000
1904,	March 28	20,000
1905,	March 27	25,000

In thirteen years are six flood years with seven floods, two of which occurred in the season of navigation. Neither of these would have interferred with the normal working of the canal.

The report of the "Special Committee" gives in profile the following elevations of floods at the state dam (reduced to pool level):

THE LOCKPORT-ROCHESTER SLOPE.

The following data are taken from a manuscript report to Henry C. Allen, Special Deputy State Engineer, loaned for this investigation:

The standard cross-section is uniformly 12 feet deep with a bottom width of 75 feet and a surface width of 123 feet, the area being 1,188 square feet. In rock, bottom 94 feet wide and vertical sides.

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The volume is taken at 1,237 cubic feet per second at Lockport decreasing to 709.6 feet at Genesee River, the velocity decreasing from 1.04 feet per second to 0.60 feet. The volume reaching the river is assumed to pass on to feed the canal to the Seneca River level at Savannah.

The distance from Lockport to the Genesee River is 59.55 miles, and the slope is computed by the Kutter formula with 0.030 for the value of (n). The slope varies and the total for the distance is given as 2.59 feet for normal flow.

Approximate data on the earth sections of the Chicago canal with a mean depth more than double give a value for (n) in Kutter of about 0.025, which would indicate that slopes have been figured on a conservative basis with some allowance for deterioration, etc. A special formula* for open channels based on an exhaustive collection of data made for the determination of the slope in the Chicago channel and interpreting the experience therewith, gives a slope of 4 05 feet and this agrees closely with Kutter with 0.030 for the value of (n) when the slope function is omitted in computing the value of (C). In large open channels, the validity of the slope function in the Kutter formula is questionable.

If a specific slope is to be given this channel, I think it should be based on an actual determination in a channel of similar proportions and depth, and with similar declivities. The state officials with whom I have talked seem to recognize this, and I presume that it will be done. Aside from the question of volume, a higher slope say four feet, would make a more stable stream, less "limber" or changeable under extraneous conditions, and less affected by pool changes at Rochester.

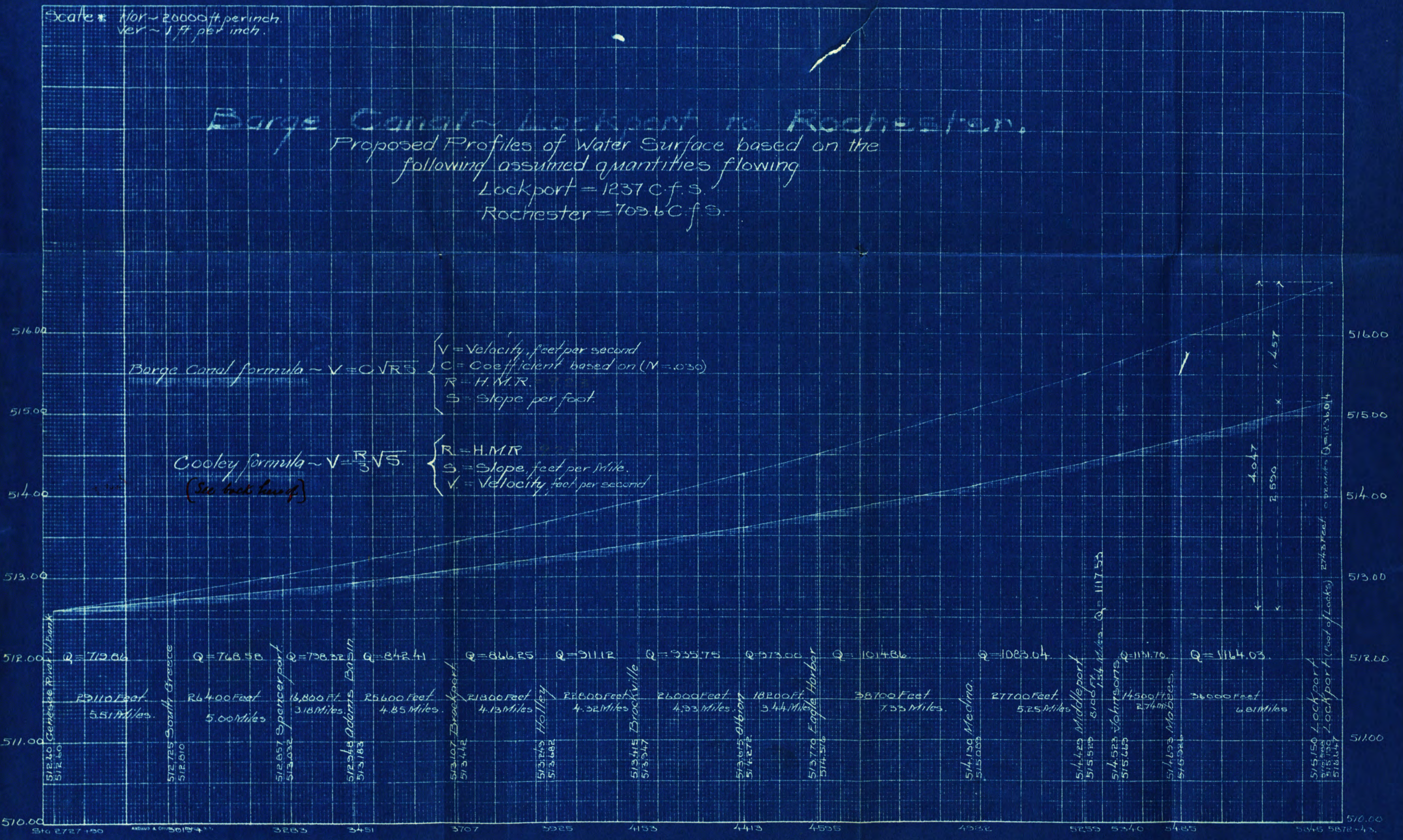
The entire range of ideas can be covered by giving the channel a bottom slope of two feet and sufficient freeboard so as to permit a surface slope of four or five feet. The increase in depth will more than compensate for the increased current due thereto, so far as concerns the movement of boats.

Experience shows that west-bound boats go light or partly loaded, and are capable of better speed. An easterly current favors navigation, and within the limits of a mile per hour in a restricted channel of this capacity and with suitable boats, the time of a round trip should not be increased. Such flow of water as may incidentally be had wlthout undue cost, is a contribution to the resources of the state.

In order to meet variations in the level of the harbor-pool it would be well to conform canal grade to a pool level one-half foot below the normal.

I can see no reason why the minimum flow of the Genesee River should be diverted eastward, and I can see how it may be usefully stimulated on many occasions. The fact that the canal crosses by pool adds to to the possibilities.

* Cooley's formula is $v = \frac{r}{3}\sqrt{S_1}$, where S_1 = fall in ft. per mile or $S_1 = 5280 . S_0$, where $S_0 = \frac{h}{l}$ = sine of surface slope. Writing the expression like the Chezy formula, we have $v = \alpha\sqrt{r S_0}$, where $\alpha = \frac{\sqrt{5280\, r}}{3} = 24.2212\sqrt{r}$.


Scale: Hor ~ 20000 ft per inch.
Ver ~ 1 ft per inch.
Barge Canal ~ Lockport to Rochester.
Proposed Profiles of Water Surface based on the following assumed quantities flowing
Lockport = 1237 C.f.s.
Rochester = 703.6 C.f.s.
Barge Canal formula ~ V = C√RS
V = Velocity, feet per second
C = Coefficient based on (N = .030)
R = H.M.R.
S = Slope per foot.
Cooley formula ~ V = R/3 √S.
R = H.M.R
S = Slope feet per Mile.
V = Velocity feet per second
(See back hereof)
516.00
515.00
514.00
513.00
512.00
511.00
510.00
Q = 719.86
Q = 768.58
Q = 798.32
Q = 842.41
Q = 866.25
Q = 911.12
Q = 935.75
Q = 973.00
Q = 1014.86.
Q = 1083.04.
Q = 1131.70.
Q = 1164.03.
Q = 1175.5
29110 Feet. 5.51 Miles.
26400 Feet 5.00 Miles
16,800 Ft. 3.18 Miles.
25600 Feet 4.85 Miles.
21800 Feet 4.13 Miles
22800 Feet 4.32 Miles
26000 Feet 4.93 Miles.
18200 Ft. 3.44 Miles
38700 Feet 7.33 Miles.
27700 Feet. 5.25 Miles
8100 Ft. 1.54 Miles.
14500 Ft. 2.74 mi.
36000 Feet 6.81 Miles
2743 Feet
Genesee River W. Bank 512.60 512.60
South Greece 512.725 512.810
Spencerport 512.857 513.032
Adams Basin 512.948 513.183
Brockport 513.107 513.442
Holley 513.249 513.682
Brockville 513.415 513.947
Albion 513.615 514.272
Eagle Harbor 513.779 514.516
Medina 514.130 515.089
Middleport 514.429 515.529
Johnsons 514.523 515.669
Mabees 514.693 515.926
Lockport 515.150 515.190 516.647
Lockport (Foot of Locks)
4.047
3.590
.457
Sta 2727+90
3019+4
3283
3451
3707
3925
4153
4413
4595
4982
5259
5340
5485
5845
5872+43.

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Cobley's formula: $v = \frac{r}{3}\sqrt{S_1}$ ‖ S_1 = fall in feet per mile = 5280. S_0. Said to be based on observations on Chicago Drainage Canal.

S_0 = " " per foot = $\frac{h}{l}$ = sine of slope

whence: $v = \frac{r}{3}.\sqrt{5280.S_0} = \frac{\sqrt{5280}.r}{3}.\sqrt{rS_0} = \frac{72.6636}{3}.\sqrt{r}.\sqrt{rS_0} = 24.2212\sqrt{r}.\sqrt{rS_0} = \alpha\sqrt{rS_0}$ ‖ $\log \alpha = 1.8667978$

This corresponds to Chezy formula: $v = C\sqrt{rS_0}$, where (C) is replaced by $(\alpha) = 24.2212\sqrt{r}$

For $r = 9.23'$, we have $\sqrt{r} = 3.0381$ and $\alpha = 73.58643$
This is a very small value for so large a channel.

$\log(n = 0.030) = -2.4771213$
$+ \sqrt{r} = 0.4826008$
$\therefore \frac{n}{\sqrt{r}} = 0.0098746 = -2.9945205$

$\log(r = 9.23) = 2|0.9652017$
$\log\sqrt{r} = 0.4826008$

Compare this value of (α) with that of (C) in Kutter formula with $n = 0.030$ & $r = 9.23$ viz: $C = \frac{41.66 + \frac{1.811}{n} + \frac{0.00281}{S}}{1 + \left(41.66 + \frac{0.00281}{S}\right)\frac{n}{\sqrt{r}}}$

$\frac{1.811}{n} = 60.3667$
$\frac{n}{\sqrt{r}} = 0.00987462$

Assume (S_0) for mean section from Holley to Albion, which is 9¼ miles = 48,840 ft. with fall of 0.366, as per Barge Canal profile & 0.590 as per Cooley's profile.

These two slopes are $S_0' = \frac{0.366}{48840} = 1/133443$ & $S_0'' = \frac{0.590}{48840} = 1/82780$ } mean = 1/108111 say $S_0 = \frac{1}{110000}$, whence $\frac{0.00281}{S} = 309.1$

Whence $C = \frac{41.66 + 60.37 + 309.10}{1 + (41.66 + 309.10).0.00987462} = \frac{411.13}{1 + \frac{(350.76 \cdot 0.00987462)}{3.46362}} = \frac{411.13}{4.46362} = 92.1073$, as against $\alpha = 73.5864$
($\log = 1.9642939$) ($\log = 1.8667978$)

By hypothesis, the values of (v) from the two formulas are equal;
or $v = C\sqrt{rS_0} = \alpha\sqrt{rS_0}$, whence we should have $C = \alpha$; this is not so,
as the values of (S_0) are different in the two expressions; hence

we have: $C\sqrt{rS_0'} = \alpha\sqrt{rS_0''}$, or $\frac{C}{\alpha} = \sqrt{\frac{S_0''}{S_0'}}$, or $\frac{S_0''}{S_0'} = \left(\frac{C}{\alpha}\right)^2 = \left(\frac{92.1073}{73.5864}\right)^2 = (1.2517)^2 = 1.5667$

hence on the average we have S_0''(Cooley) = 1.5667 . S_0'(Kutter).

The distribution of (Q) from Lockport to Rochester is peculiar: —

	Dist. miles	Q_1 — Q_2	$Q_1 - Q_2$	Cfs per mile
viz:— Lockport to Mabees	6.81 m	1236.04 — 1164.03	72.01	10.58
Mabees — Johnson's	2.74	1164.03 — 1131.70	32.33	11.80
Johnson's — Middleport	1.54	1131.70 — 1117.53	14.17	9.19
Middleport — Medina	5.25	1117.53 — 1083.04	34.49	6.57
Medina — Eagle Harbor	7.33	1083.04 — 1014.86	68.18	9.30
Eagle Harbor — Albion	3.44	1014.86 — 973.00	41.86	12.17
Albion — Brockville	4.93	973.00 — 935.75	37.25	7.55
Brockville — Holley	4.32	935.75 — 911.12	24.63	5.69
Holley — Brockport	4.13	911.12 — 866.25	44.87	10.86
Brockport — Adams Bas.	4.85	866.25 — 842.41	23.84	4.92
Adams Bas. — Spencerport	3.18	842.41 — 798.32	44.09	13.86
Spencerport — S. Greece	5.00	798.32 — 768.58	29.74	5.95
S. Greece — Rochester	5.51	768.58 — 719.86	48.72	8.84
	59.03	1236.04 — 719.86 = 516.18	516.18	

average per mile = $\frac{516.18}{59.03} = 8.74$ cft/sec

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WATER POWER.

The difference in level between the crest of the Johnson & Seymour dam and the top of the flash board at the dam immediately above the falls is 19.5 feet, and this is the possible head at the present time. The new pool level will add 9.1 feet, or nearly 50 per cent., and there will be this increase in the power possibilities above the falls.

The present pond of the Johnson & Seymour dam has an area of some 40 acres, and in low water the fluctuation ranges through a couple of feet due to the variable demand for power. An ample pond is a valuable asset in meeting the requirements of a variable load, as for lighting, transportation and daylight factories. The new pool will set back to Scottsville, and in its various ramifications will have a probable area of 1,000 acres. An inch on such a pond is the equivalent of two feet on the pond above Court Street bridge ; and there is no reason why several inches should not be available. This pond is not only valuable to the water power interests, but it is a valuable adjunct to the canal as a regulator of the feed eastward. It will, moreover, be appreciated by the pleasure seeker and the sportsman.

The water for power can be taken through closed flumes of reinforced concrete, laid beneath the surface, thus doing away with unsightly races. Were it not for the Court Street bridge the pool could be extended to a controlling dam at the aqueduct site, which would facilitate the water power treatment and bring the harbor to its last limit in the heart of the city.

ICE.

Rapids are ice-making machines, and the rapid below the State dam is no exception. A deep pool produces sheet ice and is not liable to gorge. The controlling dam can be so manipulated as to assist in freeing the pool from ice before the spring break-up. Sheet ice should be so broken in passing the dam as not to be liable to engorgement below. The correction of ice conditions is a species of insurance.

SOUTH PARK CROSSING.

The South Route proposes to pass directly across the Genesee River in South Park at normal elevation of 251.34 feet, city datum. The low water is to be raised about 4.6 feet by a regulating dam at the site of the old State dam, such dam to give a free flow when the natural stage is equal to pool level. Above such stage the fluctuations will be uncontrolled, and guard locks on either side are provided for such conditions.

The equivalent stage at the Johnson & Seymour dam has been estimated for a stage of 251 feet at Elmwood Avenue by gauge relations in 1904–5. The volume in the river at this stage is estimated at 9,600 second-feet. In the twelve years, 1893–1904, inclusive, the stage ranged above pool level ;

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from April to November inclusive, (navigation season), a total of 181 days, varying from 1 to 33 days and averaging 15 days per year. For this length of time, therefore, the flow through the canal will be complicated and the guard locks called into use. The matter is further complicated by the proposed use of the feeder for harbor purposes, requiring also a guard-lock at its head.

If the river is to be used as a harbor reaching the heart of the city, then work must be done in the river bed to give the necessary depth and to prevent accentuating the flood conditions at the canal crossing. The complete remedy is to carry the pool depth of 18 feet up to this crossing, or 5,000 feet further than necessary for the Middle Route.

The direct crossing of the river will be vexatious to navigators, and in this respect does not compare with the Middle Route as developed in conjunction with the harbor.

HARBOR ESTIMATES.

The quantities involved in treating the river as proposed have been approximately estimated from the data available.

For channel 18 feet deep below elevation 251 feet, city datum, and 400 feet wide between dock walls of masonry carried to elevation 254 feet, and for a length of 11,000 feet between controlling dam and canal entrance below state dam—Middle Route.

Rock, 826,000 cubic yards; earth, 318,000 cubic yards; masonry dock wall, 64,000 cubic yards; superstructure of Clarissa Street bridge to be changed to a through bridge without change of grade; controlling dam 200 feet above center line of Court Street bridge.

The treatment omits guard locks, avoids land damages and many complications, and considering the results obtained, the cost will compare most favorably with any other project.

If the same treatment is extended 5,000 feet to the South Route it will add quantitles as follows:

Rock, 666,000 cubic yards; earth, 240,500 cubic yards; wall, 20,000 cubic yards.

This extension is without special advantage for harbor purposes, though important as a betterment of flood conditions and of the canal crossing.

DISCUSSION OF ROUTES.

Whether the Middle Route or the South Route be taken, it is obvious that the river should be developed as the harbor, differing only in the length of treatment required.

The use of the wide waters on the east side for industrial purposes will not be practicable in conjunction with the South Route without retaining the canal west of Goodman Street and connecting the same with the river

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harbor. opposite the Feeder junction; and the future connection with Irondequoit Bay that has been advocated will not be practicable.

The South Route is three miles from the heart of the city by the river, one mile of which is unavailable, while the Middle line enters at the head of dock territory and leaves near the middle; thus keeping the commerce of the canal more in touch with the city.

Strenuous obection is made by the park officials to the location of the canal through the park, and the making of the same the junction point for the local traffic to and from the city. This is largely a matter of point of view. The treatment is bound to recognize the conditions as a measure of damage. The canal itself and its accessories can be artistically planned so as to add to the landscape effects, and such is the view of the state officers who have come to Rochester to aid in this investigation. The objection reduces largely to one against the presence of traffic, and this seems irreconcilable. A line entirely south of the park has been suggested, but this accentuates the engineering difficultfes, is farther out and less available, and it would not avoid the local traffic passing through the park by the river.

That part of the Middle line between the river and Goodman Street is also strenuously objected to by interested property owners. This section can, and should, be treated artistically as a mere channel of passage, and thus handled cannot be objectionable on account of its physical presence. This property is not of the highest class, and the development due to harbor facilities both east and west may appreciate rather than depreciate values.

IRONDEQUOIT VALLEY.

The crossing of Irondequoit valley has conditioned largely the selection of route. The South Route is directly located via Pittsford, so as to avail of the "Ox-bow" in part and keep the old canal level with the minimum of change. The Middle Route crosses directly from Brighton to Fairport at a level 14.5 feet lower, and involves two formidable embankments across Allen creek and Irondequoit creek and a cutting through the swamps between Fairport and Macedon.

I think it will be admitted that the northern or low-level crossing of the valley will be much the best when it has been produced, and in this connection the level should be cut down as much as economy will permit in view of the possibility of utilizing natural channels east from Macedon. The actual canal bank in the air will be less by the northern line, and ground water should contribute to the water supply of the canal east of Fairport, thus diminishing the feed water required east of Rochester.

No rock has been found between Fairport and Macedon in the range of any probable canal horizon, and the material favors excavation. It is believed that an exhaustive study of all the physical conditions and the

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resources of engineering construction will develop conditions and methods which will make the Middle line compare favorably in cost with that to the south. The advantages of the Middle line would then be obvious. To my mind they are so obvious as to justify a large increase in cost, should that be necessary.

THE MAYOR'S QUESTIONS.

The questions asked by the Mayor in instructions of May 9th, have been fully covered and may now be answered categorically.

1. The objects sought by the several locations are substantially covered in two routes with their collateral works. These are the only lines which have received serious consideration by the state.

2. Of the two routes, that known as the Bond, or Middle Route, treated as herein proposed, is altogether for the best interests of the city in both the present and future development.

3. The water power interests are not necessarily predjudiced by the proposed pool crossings. Treated in the manner herein recommended they would be decidedly benefited.

4. I question the proposed grade between Lockport and the Genesee River, and suggest that it should be based on actual experimental data with similar elements; or better, that the bottom be given a minimum slope and the banks sufficient free-board so that the surface slope may be largely increased.

5. A pool crossing as proposec need not affect flood conditions, but treated as herein recommended in connection with a local harbor, the flood conditions would be remedied between Court Street and the state dam, and ameliorated indefinitely up stream.

6. I recommend that the river be developed as a harbor between the state dam and Court Street bridge; that the wide waters on the East Side be reserved for harbor development and that the canal west of the main line of the New York Central & Hudson River Railroad be retained for the use of the shippers thereon until the future needs of the West Side are more apparent.

7. I would suppress the old canal from the crossing of the main line of the New York Central & Hudson River Railroad on the west to Goodman Street on the east, and remove the aqueduct as soon as the state can work out the line from South Greece to Goodman Street and divert the traffic thereto.

The letter of the Mayor and statistical data by Houston Barnard, Assistant Superintendent of Public Works, are appended.

Respectfully submitted,

LYMAN E COOLEY,

To Hon. James G Cutler, Mayor.
Through E A. Fisher, City Engineer.
Rochester, N. Y., June 3, 1905.

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DATA RELATING TO CANAL TONNAGE RECEIVED AT AND SHIPPED FROM PORT OF ROCHESTER.

Year.	Receipts by Erie Canal at Port of Rochester, Tons.	Shipments by Erie Canal at Port of Rochester, Tons.	Total tons. All canals.	Way freight. All canals.
1893	136,744	238,479	4,331,047	1,694.735
1894	108.359	215,178	3,941,671	1,611,431
1895	144,418	216,329	3,497,920	1,785,654
1896	137,008	199,765	3,712,848	1,455,269
1897	219,967	165,426	3,618,341	1,882,042
1898	162,820	136,518	3,359,643	1,786,497
1899	246,862	214,755	3,686,020	1,992,509
1900	255 757	212,785	3,345,941	1,982,560
1901	197,694	194,131	3,420,613	2,108,087
1902	181,242	233,611	3,274.610	2,172,620

ANALYSIS OF CANAL BUSINESS OF THE CITY OF ROCHESTER.

Total average yearly tonnage for the five years, 1898-1902—407,235 net tons at Port of Rochester.

Port of Rochester includes territory, generally speaking, between Medina and Clyde.

Average yearly receipts for the five years at the Port of Rochester, 208,875 net tons.

Average yearly receipts at Rochester, (city), 160,000 net tons.

Average yearly shipments from Rochester, (city), 160,000 net tons.

Average yearly shipments for five years from Port of Rochester, 198,360 net tons. 1898-1902.

Total average yearly tonnage of all New York State canals for five years, 3,417,365 net tons. 1898-1902.

Total average yearly way freight tonnage of all New York State canals for same period. 2,008,455 net tons. 1898-1902.

Way freight equals 58 per cent. of total tonnage; for the three years, 1900-1902, 62 per cent. Rochester tonnage equals about 10 per cent. of total.

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Average tonnage of the various commodities delivered by canal within the City of Rochester :

Wheat, 45,000 tons.
Lumber, 23,375 tons.
Barley, 3,020 tons.
Clay, 9,500 tons.
Coal, 15,000 tons.
Stone, lime and paving materials, 43,000 tons.
Roofing materials, 600 tons.
General merchandise, 21,000 tons.
Shipments from Rochester :
Bituminous coal, 75,000 tons.
Anthracite coal, 30,000 tons.
Salt, 29,000 tons.
General merchandise, 23,000 tons.

Rochester, N. Y., May 9, 1905.

Mr. Lyman E. Cooley, C. E., Consulting Engineer, 21 Quincy Street, Chicago, Ill.

Dear Sir—In the matter of the location of the proposed barge canal in the vicinity of Rochester in which we desire your opinion, I would be glad to have you consider the general question in all its bearing that occurs to you as affecting the city, and would call your attention specifically to the following questions :

1. How would the various lines suggested in the barge canal report affect the business interests of the city and its future development ?

2. Taking all things into account, which line would you prefer, considering primarily the interests of the city ?

3. If the river is crossed in a pool or at the water level, would the water power interests of the city be adversely affected ?

4. What do you say as to the sufficiency or otherwise of the gradient proposed from Lockport to the Genesee River with reference to the flow of water in the canal ?

5. What do you say as to the possible effect on the flood conditions in this city of a pool crossing in the Genesee River ?

6. What recommendations would you make with reference to a harbor or harbors for local business in the city ?

7. If the line you consider preferable is adopted, what would you recommend as to the old canal within the city ?

Very truly yours,

JAMES G. CUTLER,
Mayor.

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