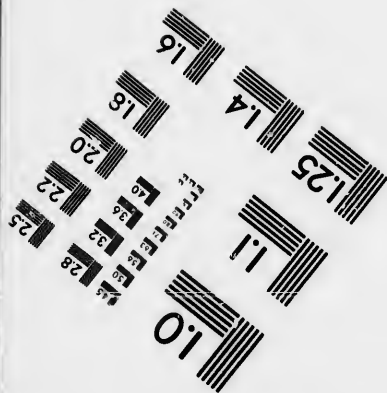
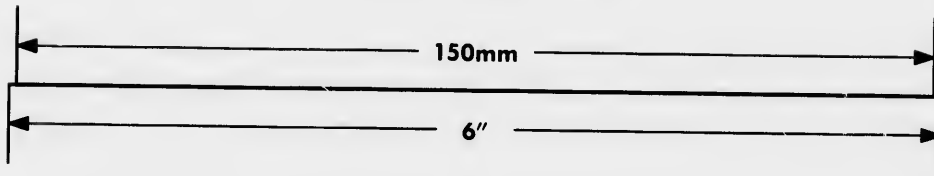
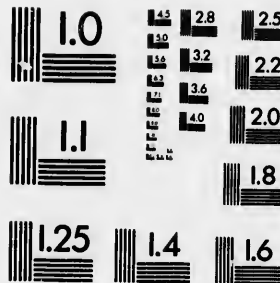
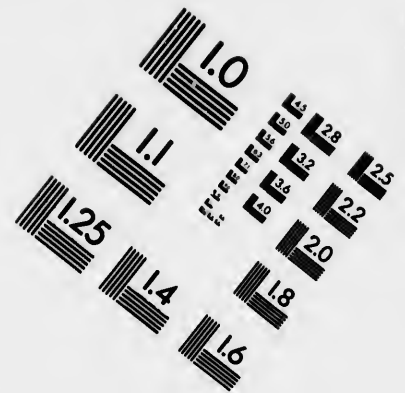
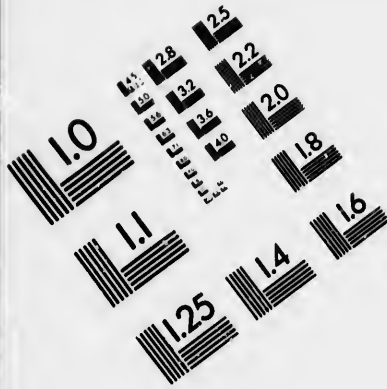
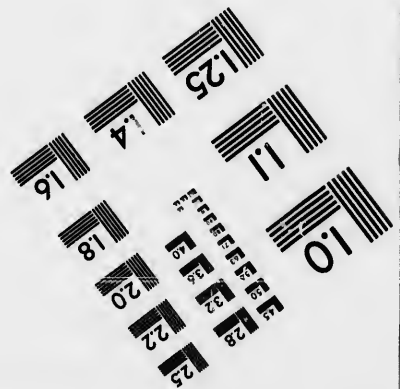


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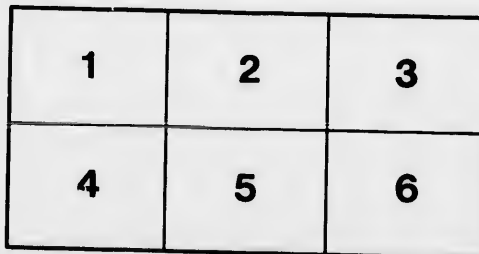
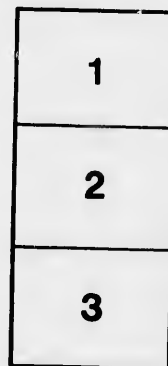
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WELLAND CANAL ENLARGEMENT.

REPORT OF THE COMMISSIONERS,

ALSO,

REPORT OF THE CHIEF ENGINEER THEREON.

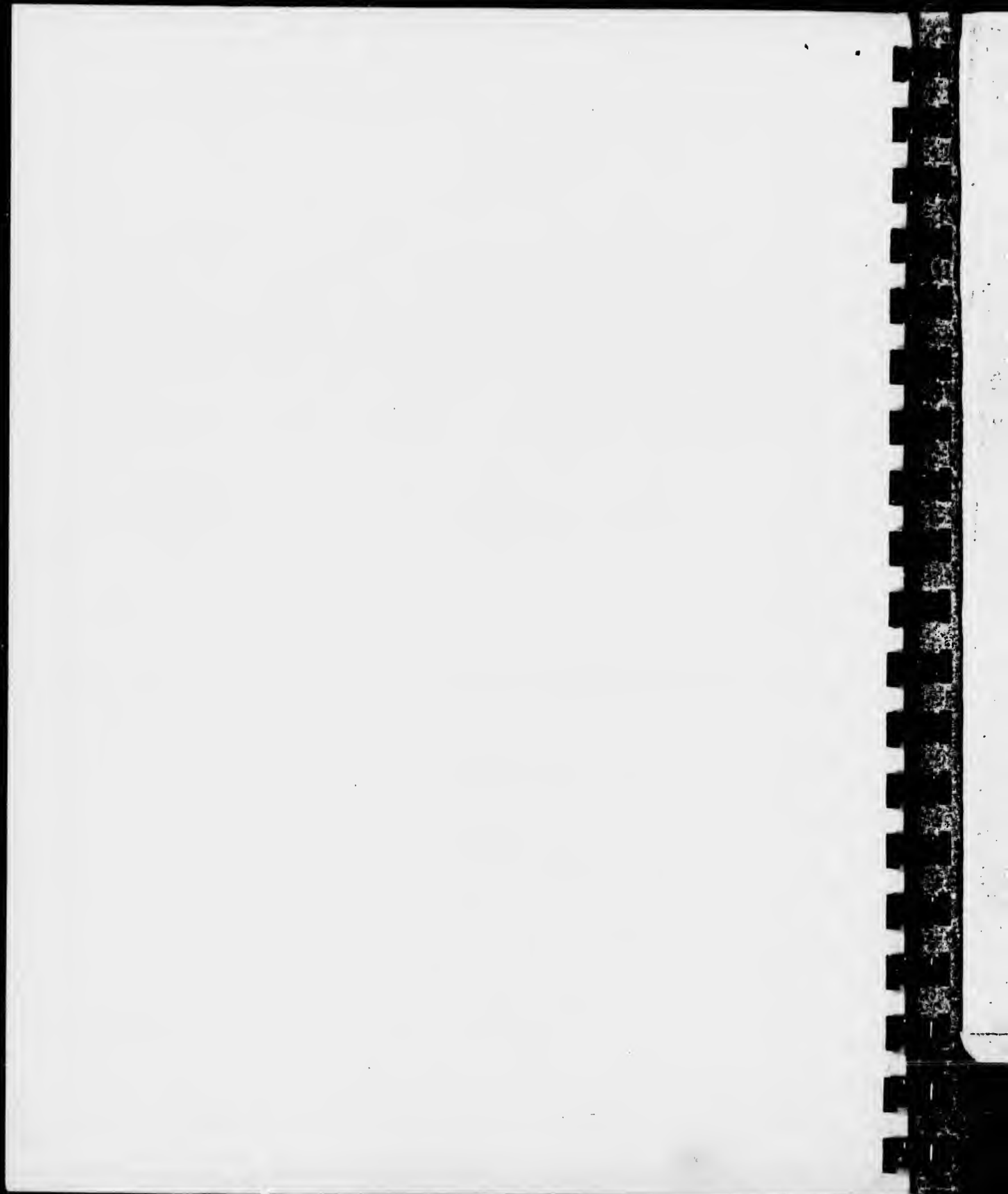
PRINTED BY ORDER OF PARLIAMENT



OTTAWA

PRINTED BY W. TAYLOR, 25 & 23 E. BEAU STREET

1873



WELLAND CANAL ENLARGEMENT.

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REPORT OF THE COMMISSIONERS;

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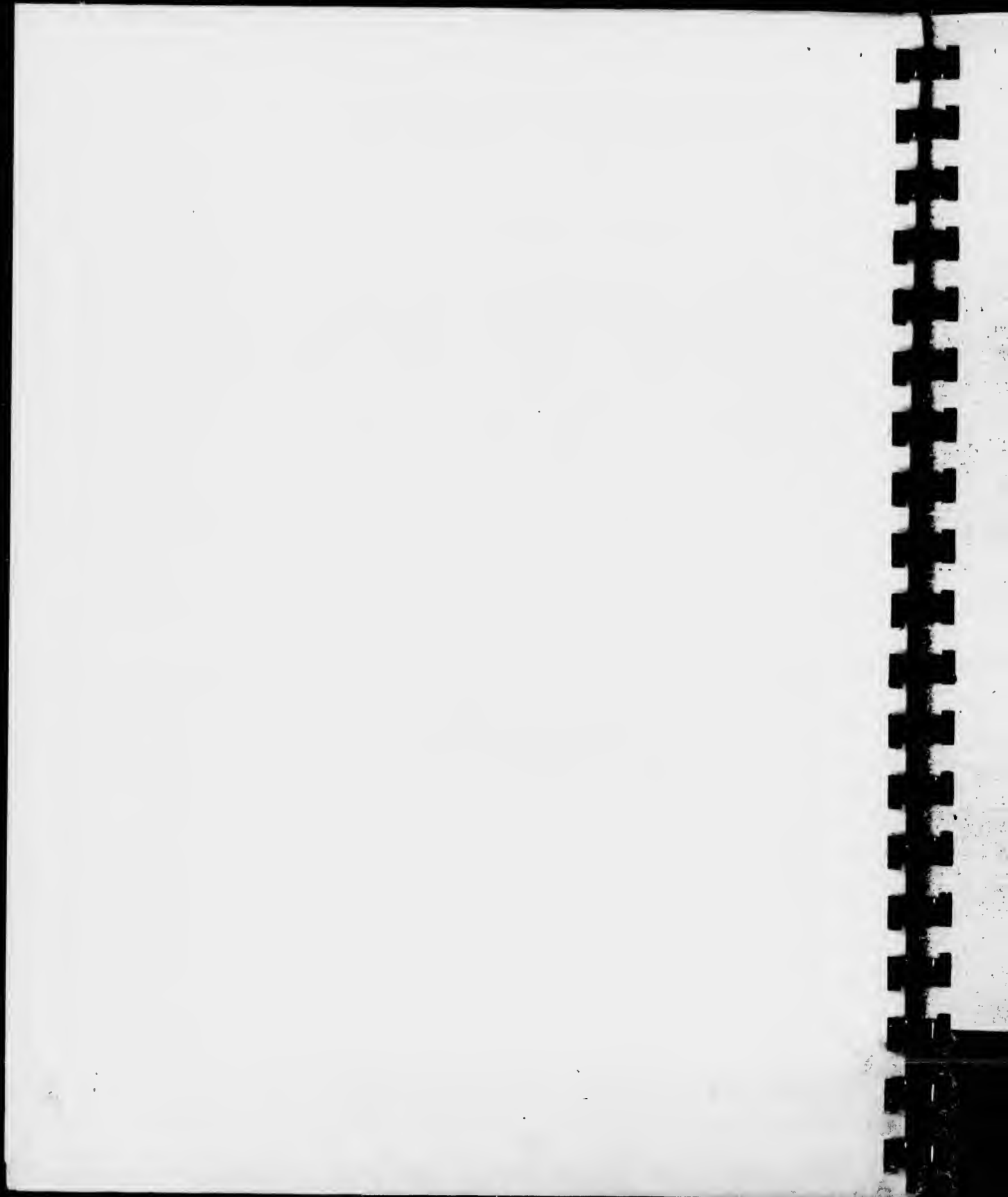


OTTAWA:

PRINTED BY I. B. TAYLOR, 29 31 & 33 RIDEAU STREET

1873.





## RETURN

To an Address of the HOUSE OF COMMONS, dated 9th April, 1873 ; For a Copy of the Report of the late Commissioners appointed to consider the different routes for the Welland Canal Enlargement ; also, the Report of the Chief Engineer thereon

By command.

J. C. AIKINS,  
*Secretary of State.*

DEPARTMENT OF THE SECRETARY OF STATE,  
21st April, 1873.

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No. 19,069. Subj. 2,986. Ref. 29,858.

OTTAWA, April 19th 1873.

Sir,—I am directed to transmit the accompanying return in reference to the Welland Canal Enlargement—called for by the enclosed address of the House of Commons of the 9th instant.

I have the honor to be,  
Sir,  
Your obedient servant,

F. BRAUN,  
Secretary.

E. PARENT, Esq.,  
Under Secretary of State.

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### LIST OF DOCUMENTS.

1. Report by John Page, Chief Engineer, dated 29th April, 1872, on the Enlargement of the Canal, together with the Report of the Engineer intrusted with the survey thereof, in Report of Minister of Public Works, for year ending 30th June, 1872.
2. Letter of Minister of Public Works to Messrs. Gzowski and Keefer, referring the above, dated 3rd January, 1873.
3. Report of Messrs. Gzowski, Keefer and McAlpine, dated 14th February, 1873, on the proposed route for said Canal.
4. Report of John Page, Chief Engineer, on the above, dated 14th March, 1873.
5. Letter to Messrs. Gzowski and Keefer, submitting the above for remarks, dated 22nd March, 1873.
6. Reply of Messrs. Gzowski and Keefer to preceding, dated 26th March, 1873.
7. Letter to Messrs. Gzowski and Keefer, for further remarks, dated 28th March, 1873.
8. Reply of Messrs. Gzowski and Keefer to preceding, dated 31st March, 1873.
9. Order in Council, dated 10th April, 1873, approving of line recommended by Chief Engineer.



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No. 1.

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*Report of the Chief Engineer of Public Works on the Enlargement of the Welland Canal, together with the Report of the Engineer intrusted with the survey thereof.*

OTTAWA, 29th April, 1872.

THE SECRETARY OF PUBLIC WORKS :

SIR,—On receiving your letter, No. 7961, (dated August 17th, 1870), relative to the contemplated enlargement of the Welland Canal, I at once took steps to have proper instrumental surveys made of the various lines and localities that presented anything like a favourable appearance, or had been suggested as suitable for that purpose; and of having such data collected, as would enable the whole matter to be fully and clearly laid before the Department.

These surveys and examinations extended over a large area of country, and in some cases had to be of a minute nature, consequently they occupied a considerable length of time. Plans, profiles, &c., of the several lines being, however, now prepared, I have the honor to submit for consideration the following report on the subject;—

The agricultural resources of the vast region lying contiguous to the western lakes of this Continent, are doubtless without a parallel as regards extent; and the rapidity with which they have been developed, is wholly unprecedented.

In 1825 the completion of the Erie Canal, first opened up a practicable route for western immigrants; but it was not until about 15 years later that the interior regions were brought so far under cultivation as to permit of the export of surplus produce to any considerable extent. Since that time, however, the growth of trade has been such, that the receipts of grain alone, of all kinds, in 1871, at the five different receiving ports on the lakes, amount to over *one hundred and forty millions of bushels*.

This of itself is a formidable mass to transport; but it is greatly augmented by other agricultural products—immense quantities of lumber and timber from the forests on the shores of Lakes Huron and Michigan, and minerals from Lake Superior; all of which form a volume of trade that now presses upon every available avenue of communication.

The establishment of routes likely to cheapen the carriage of such immense masses of what, for the most part, are bulky articles, is therefore a question which has gradually forced itself into a prominent position in the public mind, and affords an almost inexhaustible theme, both for reports of scientific men, and the deliberation of those corporated bodies who represent the commercial wealth and business intelligence of the country.

The extent of territory lying between the regions of production, and eastern centres of distribution, either for consumption, or export, fortunately presents no serious obstacles to the construction of land routes; whilst the great lakes themselves, form a line of water communication, which although for part of the distance very circuitous, is of almost boundless capacity.

Between the head of Lake Michigan, and the eastern end of Lake Erie, the distance by water is about one thousand miles; by land it is only about five hundred miles; but even this advantage has not enabled the land routes to compete successfully with that by water for the carriage of those heavy articles which constitute the main items of export.

It is nevertheless true that flour, animal food, and such other kinds of freight, as either require to be conveyed speedily to market, or the value of which will bear higher transport rates, are now frequently carried by rail.

During the season when navigation is closed, the movements by the land routes lightens the pressure on the water lines in the open season. Still, the producing powers

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The keen competition which exists for this vast carrying trade, has induced the State of New York to reduce the tolls on her canals, 50 per cent, with a view to regaining the large business which has deserted them.

This was done in the early part of 1870; but although the eastward movement of the Erie Canal has increased considerably since that time, it is quite probable that a large portion of this is due to the fact that the crop for exportation in 1871, was much larger than that for 1870.

Strenuous efforts are now being made to introduce steam power on this route, with a view of diminishing the time necessary to pass through it, and thus lessen the contrast in this respect, between it and the railways. A very large premium has lately been offered by the State authorities, for any design that can be judiciously brought into use for this purpose.

The great length and limited capacity of this canal, has enabled the railways to take from it a portion of heavy freights, the carriage of which it formerly monopolized, so that it is questionable whether even the entire abolition of tolls, and the successful application of steam power, would do more than partly restore the traffic which it has lost.

In this connection it may be observed that all the leading lines of communication in the United States, east of the Mississippi River, from the producing regions of the West to the Atlantic sea-board, cross the Alleghany range at some point, with the exception of the Erie Canal and the New York Central Railway, which are carried through a break in the chain, forming the valley of the Mohawk River.

This being the best possible route for a canal in that direction, gives it an advantage, for the Western trade, over all other water channels in the United States; still it does not present a continuous downward lockage towards tide-water; the long level at Rome being higher than those to the East and West of it—and although its draft of water is comparatively small, the supply is maintained with great difficulty during dry seasons.

There cannot be a doubt but that there will always continue to be a considerable competition, between railways and canals, for the carrying trade Eastwards from the foot of Lake Erie; but from the Westward to that point, the water route, although twice the length of that by land, will in all probability keep the lead.

This may safely be inferred from the known characteristics of the navigation, and the large class of vessels employed on it, some of which draw about twelve feet of water and are capable of carrying from 40 to 50,000 bushels of wheat.

This, together with the rapidity with which vessels can be unloaded, and allowed to proceed on their return voyage, and the attractions of the commercial port of New York, must, to the extent of these advantages, have a tendency to throw the stream of trade towards Buffalo.

To the Westwards of this point the route to the heads of Lake Michigan and Superior, is common to all; so that the rivalry between the New York State Canals, and those on the St. Lawrence for the carrying trade to the sea-board, may very properly be said to commence at the foot of Lake Erie.

If vessels of the capacity above mentioned could proceed downwards without breaking bulk, until alongside the ocean-bound ship, a great object would be achieved, and a route established which might reasonably be expected to defy successful competition for the cheap and rapid transport of the heavy and bulky articles of agricultural produce.

For several years after the present Welland Canal was opened, (1845), all the vessels engaged in the grain trade of the upper lakes could pass through it, but ten years afterwards there were at least twenty propellers on Lake Erie that could not use the canal; and at the present time there is fully three times that number engaged in the traffic to Buffalo, which cannot descend to Lake Ontario.

From the best information that could be obtained, there appears to be over one-half (some competent authorities say about three-fourths) of the tonnage employed in the

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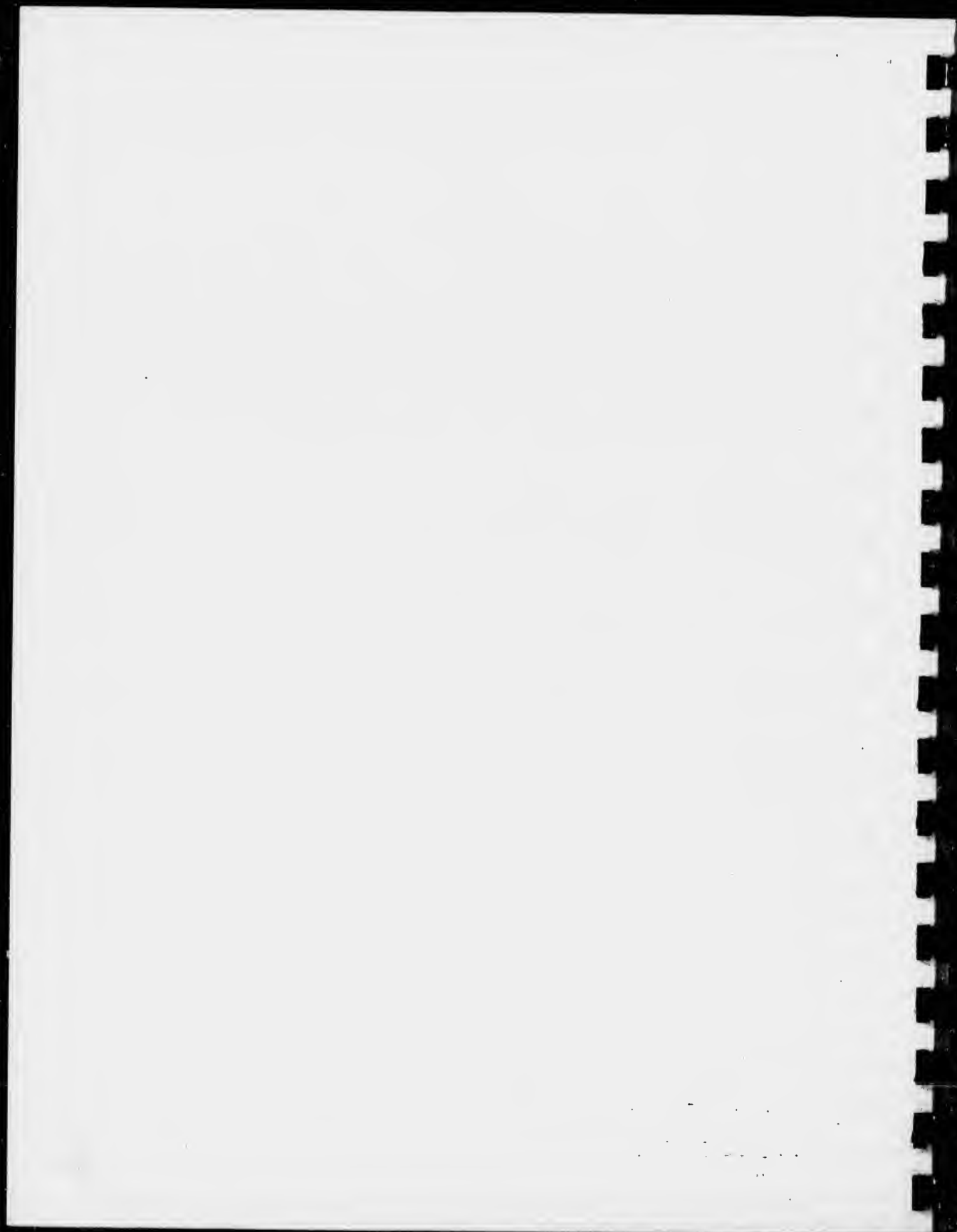
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Western trade which cannot descend lower than the foot of Lake Erie; consequently, while this state of matters exists, freight can be delivered cheaper there than at any other point.

The Eastward movement of all classes of freight from Buffalo, by the Erie Canal, was for the past two years as follows:—

	Tons.	No. of Boats.	Average Cargo of each Boat.
1870 ... ..	1,303,394 .. ..	6790 .. ..	192 tons.
1871 ... ..	1,742,157 .. ..	8795 .. ..	189 ..

In the year 1862, when the greatest volume of freight was sent Eastward from Buffalo of any previous or subsequent year, 1,980,982 tons, the average of each boat was 177 tons cargo.

The downward movement of freight of all kinds from Port Colborne through the Welland Canal, was, for the past two years as follows:—

	Tons.
1870.....	867,085.
1871.....	962,565.

It is considered proper here to submit a few remarks relative to the nationality and tonnage of vessels which pass through this Canal, so as to correct some erroneous statements which lately appeared in reference to this matter.

Up to the early part of the season of 1871, it was the practice to issue a let-pass each trip to the tugs engaged between Port Colborne and Alburgh.

These vessels being owned in Canada, swelled the number of Canadian steamers that passed through the canal. Thus in 1870 there were issued at Port Colborne, 3275 let-passes, from which should be deducted 1012 given to tugs, and 150 to scows and rafts, or 1162; leaving 2113 as the number granted to vessels actually engaged in the trade. In 1871 this system was changed, and a season let-pass was issued to each tug; the whole number of let-passes issued at Port Colborne that year being 2767; of these 105 were for tugs, and 89 for scows and rafts, or 194 to be deducted, leaving 2573 for vessels with cargo.

This shows an increase of 460 eastward bound vessels last year, and an addition to the tonnage as above stated.

The Canal Commissioners in their letter, dated 24th February, 1871, to the Honorable the Secretary of State, appear to have mistaken the tugs used on the Canal for freight vessels passing through it, as on page 36 the following statement is made:—

“It is also equally noteworthy that the American steamers passing through the Welland, though less in number than the Canadian steamers, are of a larger class—in fact, of the largest capacity of the Canal. For instance, the number of American steamers going through in 1870, was only 878, whilst those belonging to Canada amounted to 1169. But the tonnage of the former was in the aggregate, more than double that of the latter.”

An examination of the records kept at Port Colborne of the down trade for 1871, shows, on the contrary, that the average load carried by American steamers and steam barges through the Canal, was 392 tons, and that of the Canadian steamers was fully 424 tons; whilst the proportion of the Canadian steamers carrying from 400 to 510 tons cargo far exceeded that of the American steamers. (?)

As no great change took place in these respects in the season of 1870 or 1871, it is quite clear that the statement referred to, cannot be accepted as fairly representing the relative tonnage capacity of the Canadian and American vessels engaged in the trade.

It may also be observed, that in making comparisons between the traffic from the West on the Erie Canal with that on the Welland, it is obvious that reference should



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be had to Buffalo and Port Colborne only; and as the trade on the New York State Canal embrace the whole internal movement of the country, it would be manifestly unfair to contrast it with the downward business done either on the Welland or St. Lawrence Canals.

The largest aggregate movement on the New York State Canal was in 1868, but as already stated, the largest eastward trade from Buffalo, was in 1862, whilst the traffic by way of the Welland Canal continues gradually to increase.

The requirements of trade and its active competition have rendered it imperative that the cost of transport between the producer and consumer, should be reduced to the least possible rates, and for the most part a very slight difference in this respect will soon determine the course which business will take.

It is well known that large vessels can carry freight profitably, at less rates than smaller ones, still, although large propellers can go to Buffalo to better advantage than others of less size can go to Oswego, yet, the latter, by being able to continue their course about 170 miles further without breaking bulk, enables the port of Oswego to compete with that of Buffalo on nearly equal terms, even after a reduction of 50 per cent. has taken place on the tolls of the State Canals.

This fact of itself indicates not only what may reasonably be expected from enlarging the lines of communication between Lakes Erie and Ontario, but to some extent what may be fairly anticipated from increasing the capacity of the canals between Prescott and Montreal.

The St. Lawrence being the natural outlet of the great lakes, and the only route by which a channel can be formed, with a continuous descent connecting them with the ocean, the removal of all impediments to its safe and fullest available navigation should be a matter of the greatest solicitude to those through whose territory it passes.

It has been frequently and doubtless truly stated, that the benefits resulting from commerce with foreign nations, or even between different parts of the same country, are not confined to the sale, purchase, or exchange of commodities, a large and profitable part of it being the actual carrying trade itself, besides other and numerous advantages which follow in its wake.

No stronger proof of a full belief in these statements can be found than in the arguments of the originators of the Erie Canal, who constantly affirmed that the western trade should by no means be permitted to descend to Lake Ontario, if it were possible to avoid it. They concluded with rare foresight that once on that level it would be likely to find its way through the St. Lawrence to the seaboard, and therefore urged that no pains or expense should be spared to establish a line of navigation direct from Lake Erie to the Hudson River.

These views are still held by many prominent men, and New York has consequently been always antagonistic to any canal scheme for uniting Lakes Erie and Ontario, even by a route through the territory of the United States.

If this trade is considered of so much importance by a shrewd, far-seeing people, ever alive to their own interests, there is good reason to believe that it would be at least equally beneficial to the people of Canada to secure and retain the control of it.

To enable this to be done, there can scarcely be a doubt but that the outlay required for the further improvement of the St. Lawrence route would be amply justified, especially as it is capable of being enlarged to such dimensions as would in all probability place it beyond the reach of successful competition.

On turning to the map of Canada, it will be seen that the eastern extremity of Lake Erie overlaps the west end of Lake Ontario, in such a manner as to leave only a comparatively narrow peninsula between them, the distance across which in a north and south direction is, at one point, barely 22 miles.

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The Niagara River, forming the eastern side of this peninsula, as also the boundary line between the State of New York and Canada, falls about 324 feet from the upper to the lower lake in a distance of a little over 31 miles.

To the eastward of this river [American side] the space between the lakes increases rapidly, and the land is high, and continues for a long distance in a north-easterly direction without a break or ravine of any considerable extent occurring in it. No surveys made on that side have as yet led to any suitable route being found for a ship canal of the ordinary kind; and even if a practicable line were discovered, it is quite probable that the influence of eastern cities, as well as that of Buffalo, would prevent it being brought into use.

The Canada side on the contrary is almost in every respect advantageously situated, and presents all the facilities for the construction of a canal that could reasonably be expected, when the nature and extent of the undertaking is considered.

The present line of connection between the lakes is probably the shortest that, under the circumstances, could have been selected,—the whole length of the main line being 27½ miles, or about 25 per cent over that of the most direct line.

In its location the principal difficulty experienced was not so much the height to be overcome by lockage as the comparatively short distance in which it had to be done, nearly the whole ascent having unavoidably to be made within a few miles.

The brow of the so-called "Mountain" is, in this vicinity, only about six miles from the shore of Lake Ontario. This remarkable geological feature can be traced for many miles into the northern part of the State of New York, at the side of the Niagara River at Queenston, and in a western direction to Hamilton, where it sweeps to the north and continues until it forms the promontory known as Cabot's Head on Lake Huron.

Where this escarpment is traversed by the deep chasm through which the Niagara River flows, or wherever its face is exposed, a series of layers of limestone rock, shale, &c., are presented, the upper strata of which, for the most part, yield excellent stone for building purposes; and a lower stratum can be manufactured into a superior class of hydraulic cement—materials which will doubtless be of at least equal importance for the projected works, as they were found to be in the construction of those now in use.

Towards Lake Ontario the land has a gentle inclination, and the drainage of the surrounding country flows in that direction through numerous channels, the largest of which in this vicinity is the Twelve Mile Creek,

Advantage was taken of the valley of this stream to form a line for the present canal; and by a dam and lock at the outlet it has been converted into a deep water basin of considerable area, the level of which extends 3½ miles up to the town of St. Catherine's.

The line continues through the valley of this Creek, and along the eastern branch of it up to the 10th lock, where the bottom of the Canal is very little below the natural surface of the ground, and the sides consist principally of embankments.

From this point up to the 21st lock, the canal for fully one-half the distance ascends in a line nearly parallel with the northern face of the high ground forming the upper plateau, and from the head of one lock to that of another the distance varies from 586 to 800 feet.

Through the village of Thorold the distance between the locks is greater, there being from 1163 to 1350 feet from the head of one to that of another up to the 25th, which is situated fully 9 miles above the northern outlet of the canal, and the water level above it is about 318 feet over the mean surface level of Lake Ontario.

This level is continued for a distance of 3½ miles to Allanburg, where the greatest height is reached by a lock of fifteen feet lift: the bottom width of the canal for this stretch varies from 26 to 40 feet.

The present water supply is furnished from the Grand River, raised nearly 9 feet by a dam thrown across it at 5 miles above its outlet, which at ordinary times gives a

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general depth of 9 feet in the feeder, and admits of the level of the canal being maintained at about 8 feet over that of Lake Erie.

This feeder is fully 21 miles in length from the town of Dunville to its junction with the main line (about six and a-half miles from Port Colborne), and at about five miles from its upper end a branch one mile and three-quarters long leads off to Port Maitland.

The summit level, supplied as above mentioned, extends from Allanburg to Port Colborne, a distance of nearly 144 miles. At the latter place there is a lock down from it of 8 feet. At the town of Welland, about 7 1/2 miles from Port Colborne, where the canal is carried over the river by an aqueduct, there is another lock down of about 17 feet; and at Port Robinson there is a second descent to the Welland River of 17 feet.

These three outlets, together with that of the principal line itself, require a volume of water which the Grand River, under presents arrangements, can barely supply during dry seasons.

It may be said that the canal has three different entrances on Lake Erie; one being at Port Colborne, the upper terminus of the main line; another 17 miles to the westward at Port Maitland, the mouth of the Grand River, which is connected by way of the feeder with the main canal at a point about six and a-half miles from Port Colborne; the third 18 miles to the eastwards, is by the Niagara River to Chippawa, thence along the Welland River to Port Robinson, a place nearly midway between the lakes.

One of the most troublesome questions connected with this undertaking, from the outset up to the present time, has been the instability of the banks of what is called the "Deep Cut," an excavation formed through the highest ridge of land on the line, and near the northern end of the summit level. It is about 1 1/2 mile in length, and the present line assumed for the bottom is for a considerable distance fully 60 feet under the top of the banks on either side; but the depth below the natural surface of the ground is not more than 45 feet, the upper 15 feet consisting of material excavated from the channel when it was first formed.

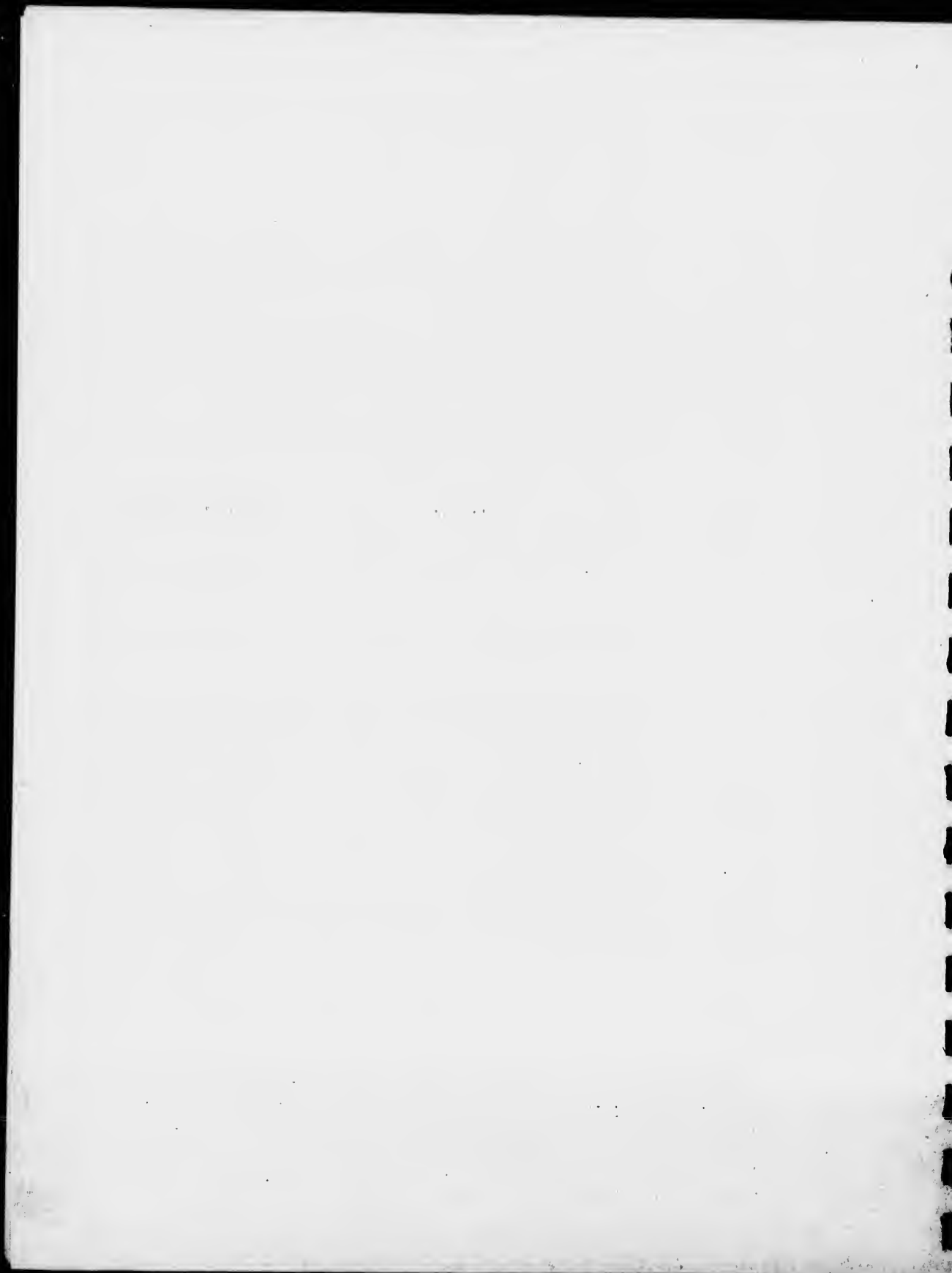
The extensive slides and movement of the banks that occurred on this part of the line, in 1828, first led the "Welland Canal Company" to abandon their original design of drawing the water supply from the Welland River, and to resort to the plan of using the Grand River as a feeder.

By the adoption of this course it was thought that the channel would be elevated above all interruptions from the slides that had occurred, and placed beyond the risk of similar casualties for the future.

For many years this appears to have been the case; but during the enlargement of the channel to its present dimensions, and the lowering of the bottom, so as to give the proper depth of water at the level of Lake Erie, there have been slides in the banks at several places and at various times, still none of them were of such an extent as to impede navigation on the higher level. The most recent of these were in January, 1867, and in May, 1870. At the latter time they were larger and more numerous than on any previous occasion. It is remarkable that some of them have occurred suddenly at places where no indications were before observed, and also that where a heavy slide has taken place, although the prism of the canal has been subsequently fully cleared out, it is seldom that a slide again occurs at that place:

A circumstance which leads to the impression that, when the yielding materials which form the lower part of the cut are displaced to a sufficient depth by the tenacious clay of the sides, there is a probability that the bottom may remain undisturbed and the subsidence of the banks cease.

If this view of the matter be correct, there should always be kept on hand sufficient dredging power and equipment to remove, as expeditiously as possible, any slides that may occur.



There is good reason to believe that the only mode that could be adopted with any prospect of success, to guard against such casualties, is to lighten the banks on both sides of the Cut.

This, if not an entire preventative, would at least reduce them to the minimum; besides, it would be much less expensive to remove the materials from the top than to be under the necessity of dredging the bulk of them from the bottom.

From Allanburg to the "Rock Cut" below Stone Bridge, the canal is for the most part 50 feet bottom width at the level of the sills of Port Colborne lock; and, for the lower one-third of that distance, the depth is about one foot below the top of the sills; the bottom of the upper two-thirds is nearly down to the lock sills.

From Port Colborne northwards for fully one and a-half miles, the canal is from 56 to 58 feet in width, and the bottom from 15 to 18 inches higher than the lock sill. This Cut for the full depth is in rock of a hard class, with many seams and fissures in it, through which water enters freely; and, there being no good drainage in the vicinity, the unwatering of this section is likely to be attended with unusual difficulty.

The expenditure on the present works, since 1842, amounts in the aggregate to \$5,066,702, a sum which would not now pay for over three-fifths of a like extent of work.

It has been considered proper to submit the foregoing brief sketch of the canal, and such matters connected with it, as may be of service in enabling a decision to be arrived at on several important questions about to be brought under notice.

In the letter of instructions handed me, dated 22nd July, 1871, the scale for the enlarged navigation is fixed for locks 270 feet long and 45 feet wide, with 12 feet water on the sills.

This is understood to be the dimensions recommended by the Canal Commission as the proper size for locks, &c., from Lake Superior to tide water. It should, however, be borne in mind that there are *three* Canadian paddle-wheel steamers (two built in 1871), now plying between Collingwood and the head of Lake Superior, that could not pass through the Sault St. Mary canal, if it were made of the dimensions above given.

It may also be stated that the Canal on the American side at this place has a depth of 12 feet on the sills; but a survey was recently made with a view to the construction of another tier of locks, made so as to have 14 feet of water on the sills.

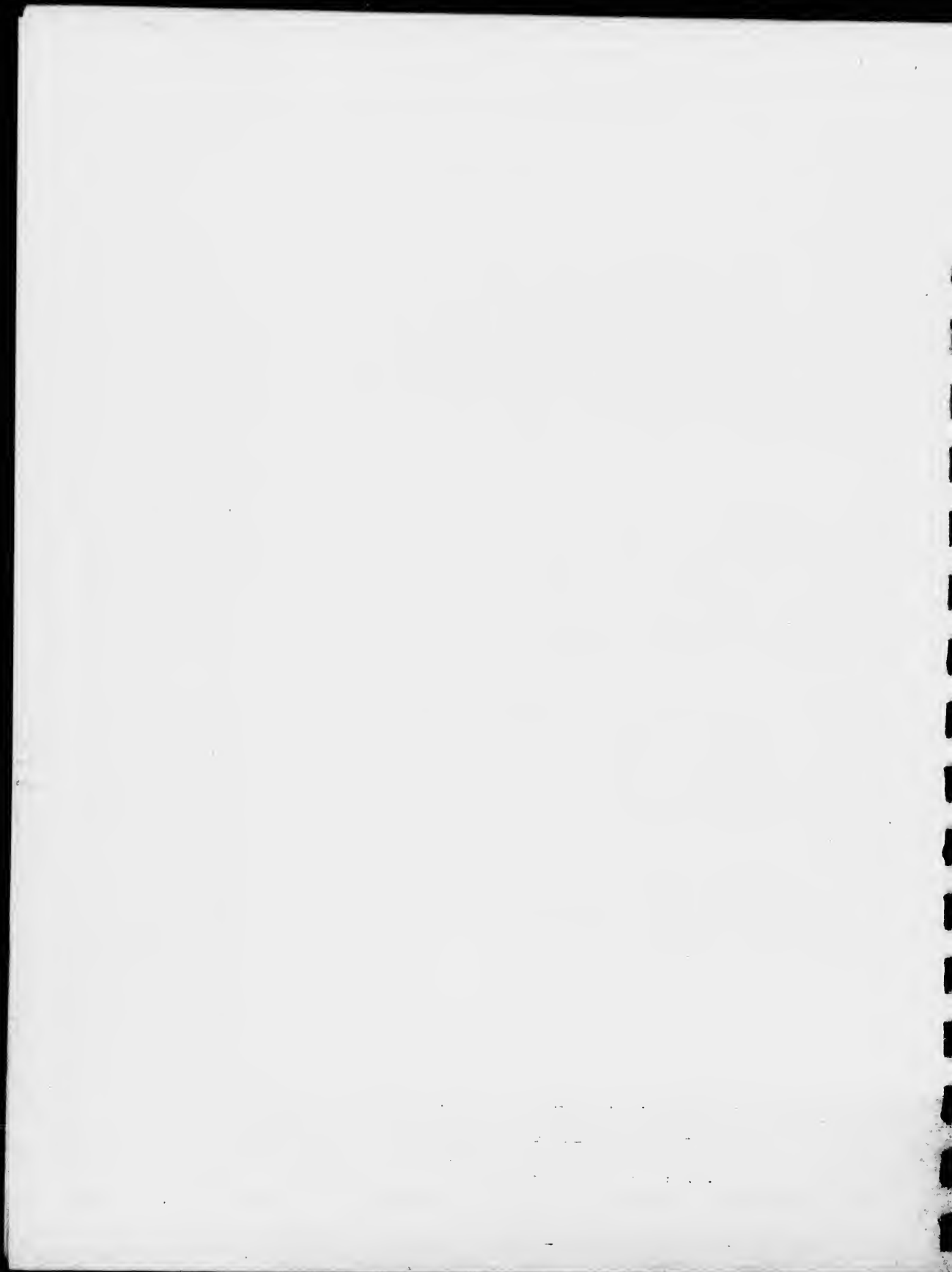
These facts may, however, not possess any great degree of importance when the St. Lawrence and Lake navigation are looked upon and considered as a whole; still, if the class of vessels engaged on the Lake Superior trade are necessary, it will be evident they could not pass through that part of the Canadian route.

The draft of water contemplated for the Welland Canal is, nevertheless, fully as much as the river between Prescott and Montreal will warrant; still, as it would enable vessels to pass of the size now considered most serviceable and profitable for both lake and river trade, no reasonable efforts should be spared to effect an object likely to prove so beneficial.

It is quite probable that at all important places on the lakes where there is not enough water at present to admit vessels of that draught, the harbours would very soon be sufficiently deepened for that purpose.

The United States Government has already taken a step in that direction by forming a deep water channel through the "Flats" of Lake St. Clair; and the Refuge harbours on Lakes Huron and Erie, now in course of construction by the Dominion, will admit vessels of fully the draught stated.





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With a view, if possible, of avoiding repetition, the principal matters relating to the enlargement of that part of the canal below Port Robinson will, in what is to follow, be kept separate from those having reference to the part above that place.

In carrying out the contemplated improvements, it will be obvious that economy would be consulted by utilizing as much as possible of the existing works, consistent with the requirements of the enlarged scale of navigation.

This can be done generally along the upper parts of the canal; but from Thorold downwards it has long been understood that a new line, either in part or as a whole, must be formed.

The short distance between the locks known as the "Mountain Range," or indeed between those from the 10th to the 21st locks, renders it impossible to build detached structures, on the same line, of dimensions at all suited to the present or probable future wants of the trade.

It is true that if at intervals two or more locks were combined, there might be a fair space left between the head of one set and the foot of another; but such an arrangement on a line of navigation of this nature and importance would, it is believed, be so decidedly objectionable as to warrant a very considerable outlay being incurred to avoid it.

This opinion is based not only on the detention that would continually be caused to vessels by locks in combination, but the fact that, if an accident occurred at such places, it would in all probability be of a more serious nature than if the locks were some distance apart.

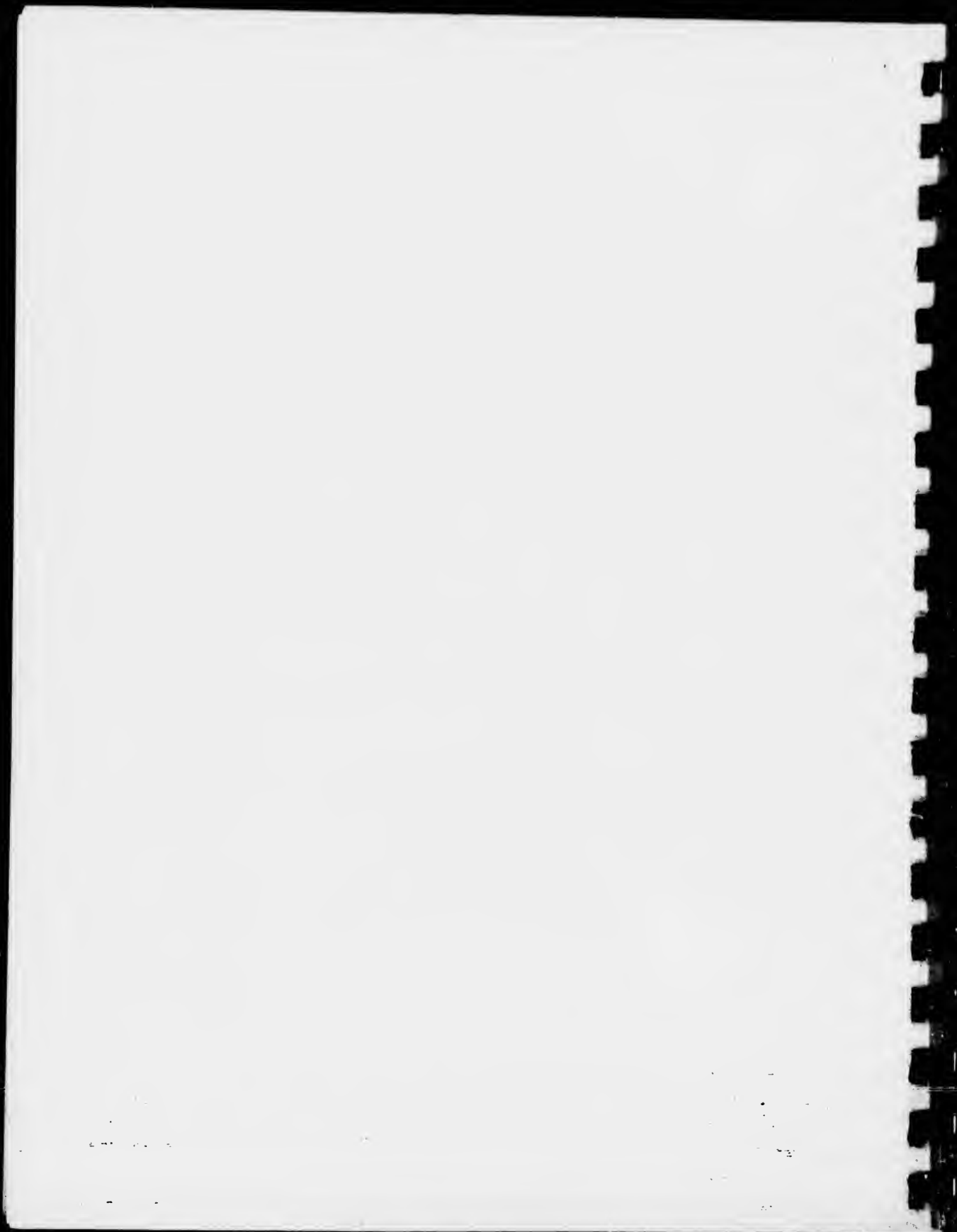
Representations having been made that a favorable line for improvement might be found to the westward of the present canal, and although a cursory examination did not bear out such statements, it was nevertheless considered best to have lines of level run along the valley of the Twelve Mile Creek from St. Catharines upwards, and along the different eastern tributaries of that stream. These lines of levels were continued until they intersected the canal at different points, and one was also carried fully a mile and a half to the eastward of the line between Allanburg and Port Robinson; the result of all of which shews that the ridge of high land traversed by the "Deep Cut" rises gradually to the westwards, and continues all but level on top in an easterly direction, leading to the conclusion that the canal has been located in as favorable ground as could have been selected in that vicinity.

These levels also shew that the ascent towards the south, from the canal level at St. Catharines by way of the western branch of the Twelve Mile Creek, is at some point on all the lines very abrupt, so that there appears to be nothing like a practicable line for reaching the summit on that side.

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In 1851, a survey was made, for the Town Council of Niagara, of the ground lying to the eastward of the present canal, from Thorold downwards, striking off from the foot of the mountain towards the Niagara River. This was for what is known as the "Lateral Cut," the chief points in the location of which may be briefly stated as follows:—

The survey line connected with the present canal above lock 25, at the village of Thorold, and ran into a ravine formed by the head waters of the Ten Mile Creek.— Descending this to Brown's Cement Quarry, it was continued by a series of easy curves to the Great Western Railway, and crossed it a little to the east of the culvert through which the Ten Mile Creek passes. Thence the line swept to the north-west, and was continued in a straight course to the town of Niagara; being altogether  $12\frac{1}{2}$  miles long, with a fall of 318 feet, which it was proposed to overcome by twenty-five locks, varying in lift from 9 to 14 feet.



The place selected for an outlet on the Niagara River was in a little bay near Old Fort George, adjoining which an ascent of 55 feet was to be made by four locks combined. At the Thorold end of the line there were to be three distinct flights of combined locks, two of which embraced three locks each, and one included two locks; at all other places the locks were to be detached and have good-sized reaches between them, except locks 11 and 12, which were also to be combined.

On the route there was, therefore, five different sets of locks "in combination," embracing in the aggregate fourteen locks, or more than half the number stated to be necessary to overcome the fall.

According to this arrangement, there would have been a deficiency of nine reaches or reservoirs at the proper height for regulating the supply, and of course an equal number of places where vessels could not pass each other between the locks.

This was admitted to have been an objectionable feature in the location, which, in a report on the subject, it was assumed would apply "equally" to any other possible route "from Thorold to the Lake;" a statement which, it is presumed, was meant to apply fully as much to the topography of the country as to the actual construction of the canal.

The line from the Thorold levelled down to, at least, the point where the Great Western Railway is crossed, being common to any route east of the present canal, and having been examined in connection with a trial line leading to Port Dalhousie, it will be referred to under that head.

At Niagara, the outlet of the proposed canal being situated in a bend of the river, there is less current in its immediate vicinity than is generally met with at other places.

Deep water was found close to the shore, and at 100 and 150 feet out, the respective depths were 45 and 51 feet, with a sand bottom.

A careful examination of the west bank of the river, with numerous levels taken along and over the space to be occupied by the four combined locks proposed to be built there, leads to the conclusion that the latter cannot be avoided without incurring a very heavy expenditure in forming a long artificial descent, something like a natural ravine extending from the table land downwards to the water surface.

It was many years ago stated, in reference to the same place as an entrance for a canal, "that the current is too swift for a safe harbour above, and below it would be exposed to the swell of the lake."

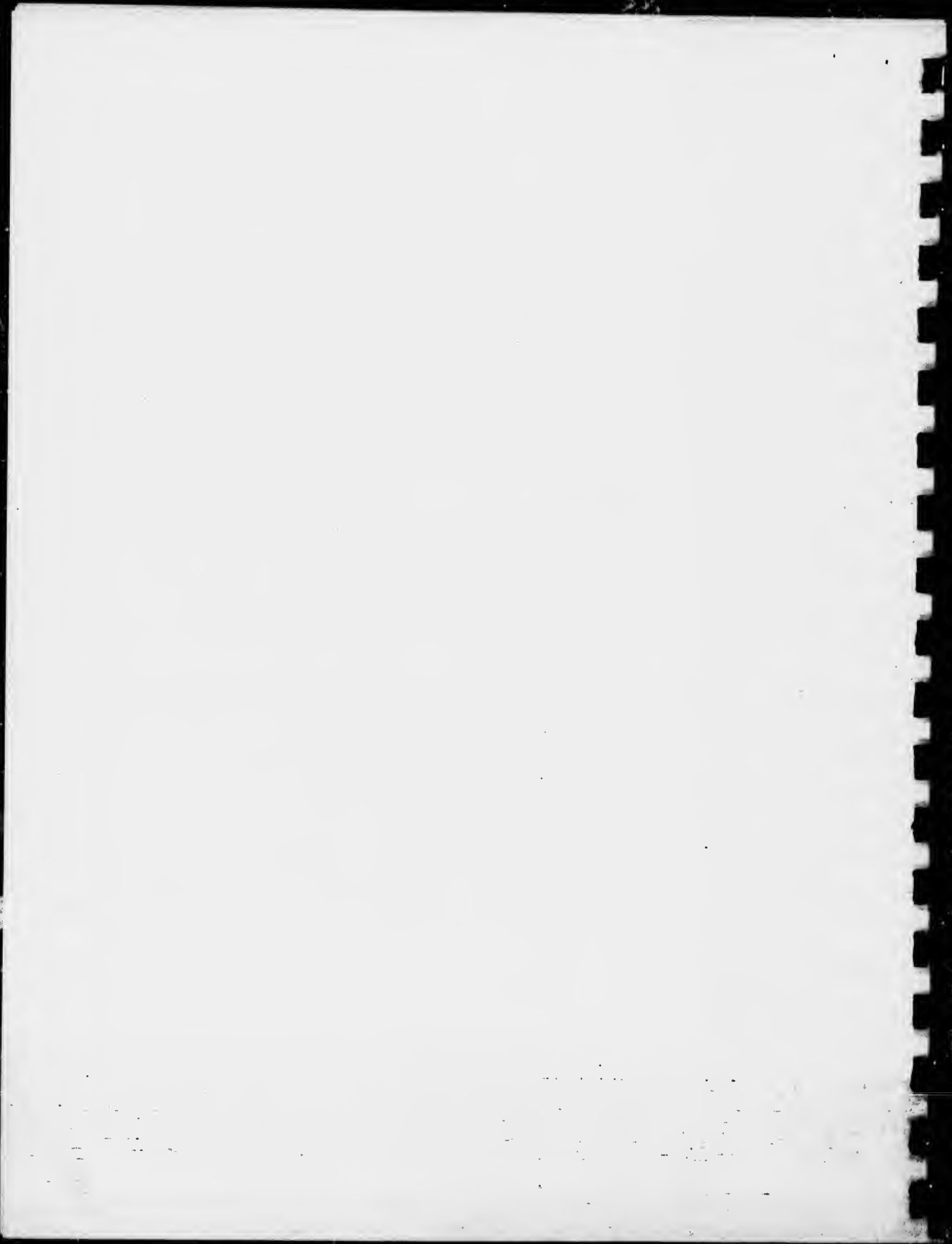
The river is fully half-a-mile wide, and has a current of from 3 to 4 miles an hour, and in the middle part there is a depth of from 70 to 90 feet; outside, in a continuous line with the centre of the stream, the depth is about 24 feet.

A sand shoal extends out in a northerly direction from Port Niagara, on which, at  $\frac{1}{2}$  of a mile from the shore, 12 feet of water is marked on the chart; and at about  $\frac{1}{4}$  miles to the north-east of the same fort a rocky shoal is shown, with 15 water over it. These shoals, lying not far from the track of vessels bound to or from the eastward, might in stormy or thick weather be dangerous to those drawing 12 feet water.

The banks of the river are high and bluff, and, although forming in certain winds shelter to the harbour, would present a formidable obstacle to the formation of an entrance to a canal approaching the river at nearly right angles, and where the current is so swift a short distance from shore.

The above will give a general idea of the line proposed for the "Lateral Cut," in 1854, and its outlet at Niagara,—matters which will again be referred to in a subsequent part of this Report.

In order to obtain correct information as to whether a route could be found that would admit of the locks being judiciously placed at such distances apart as would enable the largest class of vessels suited to the navigation to pass each other freely between them, several trial lines were run, and the ground thoroughly examined to the eastwards of the present canal, from Thorold to Port Dalhousie.



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The least distance from the head of one lock to that of another was assumed at 1000 feet; and the shortest line, requiring the least outlay for construction, was to be projected on a plan and a profile of it prepared.

When doing this, it had to be constantly borne in mind that the track of the Welland Railway had to be crossed twice, and that of the Great Western Railway once, without interfering with their present grades, especially as any change whatever in that respect would in either case inflict a serious and permanent injury on the road.

After a time it was ascertained that, by leaving the present canal at what is called "Marlatt's Pond," a short distance above the village of Thorold, the Welland Railway could be crossed at a fair angle, and at a place where the track is nearly level, and about nine feet over the surface of the pond.

From this point, the quantity of excavation on the proposed line would be about the same as if a divergence was made lower down, and the canal enlarged up to that point, and the necessity would be obviated of crossing the railway at an unusually oblique angle on a grade from eighty to ninety feet to the mile. It would also admit of the supply for the new line being drawn from a large area of water, an advantage which under the peculiar circumstances should not be overlooked.

The proposed line, after crossing the Welland Railway at the place above referred to, sweeps to the north, and continues in that direction until it passes through the deep rocky ravine of the Ten Mile Creek before mentioned. From the rapid inclination of the surface on this part of the route, a much larger quantity of rock will have to be excavated in order to secure a suitable distance between the locks, than if they were placed close together or combined; still the advantages to the navigation of having detached locks, it is believed, would fully warrant all the additional outlay, or even more were it required to effect that object.

Through this ravine the railway track should be moved to the westward, so that the place which it now occupies can be used for the canal.

The line, as laid down, then follows obliquely along the sloping ground past the old church and cemetery of Thorold, crossing the Great Western Railway about 2 miles to the eastward of the present canal, and at a distance of nearly  $2\frac{1}{2}$  miles from the starting point.

The descent in this distance can be overcome by eight detached locks of 14 feet lift each, arranged so that there will be at least 1000 feet from the head of one to that of the next adjoining lock.

This distance might, however, be still further increased by throwing the line back towards the front of the mountain.

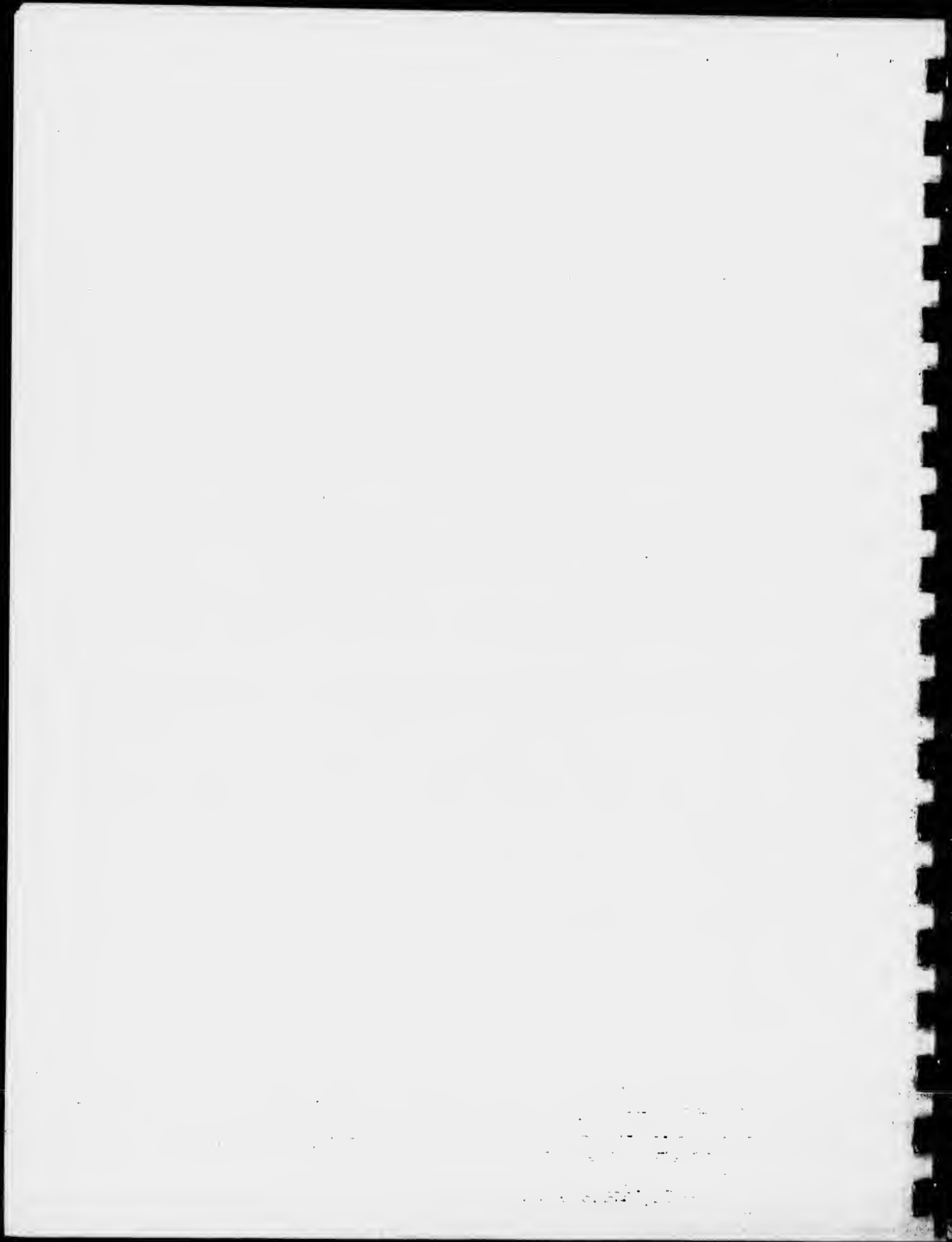
From this railway-crossing, the line is continued all but straight to near the western angle of St. Catharine's cemetery, a distance of two miles.

Thence it curves round to a north-westerly direction for  $2\frac{1}{2}$  miles to where it crosses the Welland Railway for the second time, and then follows towards the head of the north branch of an arm of the Twelve Mile Creek, known as May's Ravine, down which it is carried until joining the present canal at about half-a-mile from the entrance lock at Port Dalhousie.

From the crossing of the Great Western Railway downwards to the outlet, the distance from the head of one lock to that of another varies from 1200 to 7000 feet.

The principal difficulty likely to be experienced at this end of the route would be that of again crossing the Welland Railway, the track of which for some distance is very little over the surface of the adjacent ground, thus rendering indispensable either a change of grade or change of line, otherwise a considerable depth of cutting for a long reach of the canal.

From the place where this line leaves the canal above Thorold to where it intersects it near Port Dalhousie, the whole distance is  $8\frac{1}{2}$  miles, or about  $\frac{1}{2}$  of a mile less than by following the course of the present canal between the same points.



The first lock upwards might be located on the prominent point immediately east of the present waste weir, where the road to St. Catharines ascends the bank. At this place there is reason to believe that a good foundation would be obtained at the proper depth; but, to secure this at any other place between that point and the present lock, it is to be feared would be attended with a vast deal of trouble and expense.

By the adoption of this site for the lock, the line would be more direct than any other that could be selected, and it would admit of all the present water-covered space between the inner end of the piers and waste weir being used as part of the harbour.

A route for the enlargement was also carefully examined along an easterly branch of the Twelve Mile Creek to where it enters the present canal at what is called "Collier's Bend," a short distance below the fifth lock. The head of this branch creek is near the place where the line just described passes the west corner of the St. Catharine's cemetery, and from that point to the canal the distance is 7,100 feet, the difference of level between the adjoining reach on the Port Dalhousie trial line and that below the fifth lock of the present canal being 7,479 feet.

This ascent could be made by means of 6 locks, which would give a distance of fully 1,100 feet from the head of one lock to that of another.

The gully, near its junction with the canal, is about 50 feet wide at bottom and 400 feet at top, and the banks are over 50 feet high.

It has a south-easterly course for 1,600 feet from the canal, and for about two-thirds of that distance the stream through it is on the same level as that of the canal surface.— From the point above mentioned it takes a course all but due east for 800 feet; thence continues in a south-easterly direction, gradually diminishing in both width and depth, until it runs out at the place above stated.

The excavation for the canal and side channel necessary to pass the supply for the proper maintenance of the different levels would require to have an average width of 160 feet throughout at bottom, and at the lower end the depth would be at least 52 feet.

It is stated that the nature of the material is unfavourable for the foundation of structures, or to form the sides of the canal prism.

The present canal is about 800 feet from where this line connects with it; sweeps round and takes a south-westerly course to about 500 feet below the 4th lock; thence for about 600 feet its direction is nearly west. It then turns sharply to a course almost due south for 1,500 feet to the outlet of the Twelve Mile Creek.

The 3rd lock is situated on this stretch; and its line is such that a downward-bound vessel, when passing through it, points in an opposite course to one leading direct to the harbour of Port Dalhousie.

From the outlet of the Twelve Mile Creek for 2,100 feet, the canal again runs about due west; thence it follows a north-west course for 1,700 feet; then tends more to the west, and continues on that line for nearly half-a-mile, or to about 900 feet below the 2nd lock, from which point the line leads generally in a direction towards the outlet on Lake Ontario.

In this connection it may be said that, as Port Dalhousie lies a little to the west of north from the 4th lock, it will be evident from the bearings above given that the canal, where it passes through the town of St. Catharines, must be extremely tortuous in its course.

The banks of the ravine through which it is carried are nearly on the same level at the west end of St. Catharines as the table land at "Collier's Bend," but the descent of the two locks in the intervening distance makes them fully 70 feet high over water surface at the former place.

Between the 5th and 4th locks the reach is of a good width; thence downward the channel is at many places narrow, and the adjoining banks liable to slide.





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The north wall of the third lock, a few years after the opening of the present canal, was forced in so much by the bank on that side that part of it had to be taken down and rebuilt.

It is therefore to be feared that, were the banks further encroached upon by the cutting necessary for the enlargement, there would be a greater tendency to slide, and that the lowering of the bottom 2 feet would be likely to increase the difficulty; whilst to raise the water levels so as to give the required depth would cause great injury to a large amount of valuable private property.

The 4th and 3rd locks might, however, be widened towards the south; but this would not diminish the existing curvature, which at places is so sharp as to render it difficult for vessels of the dimensions now in use to enter a lock or pass freely; besides, it would destroy the dry-lock property at the 3rd lock.

To build structures of the dimensions proposed (nearly double the length and width of those now in use), either at the place occupied by the present locks or in the vicinity, or indeed at any other place that could be selected between the 5th lock and the outlet of the Twelve Mile Creek, there is good reason to believe would not accommodate the class of vessels contemplated by the enlargement, and even be to some extent a hindrance to the passage of those now in use.

It is, therefore, questionable whether a proper line of navigation of the scale now proposed can be successfully formed along the valley of such a deep, comparatively narrow and winding ravine, through which flows the drainage of a large extent of country, that at certain seasons form rapid streams, occasionally carrying with them considerable quantities of detritus, which are eventually deposited in the still waters of the canal.

Besides, in heavy freshets the large body of water thus suddenly brought down sometimes threatens to destroy the works, and is at times very difficult to control.

When the canal was first made, and subsequently enlarged, it was no doubt necessary to follow the ravine on the line adopted; but although judicious at that time, it does not follow that the same route is adapted to a line of navigation of the scale now under consideration.

From the point where the trial line intersects the present canal above Thorold, along the route by way of "Collier's Bend," and the existing canal to Port Dalhousie, the distance is 10½ miles; and the estimated cost of construction is \$5,350,000.

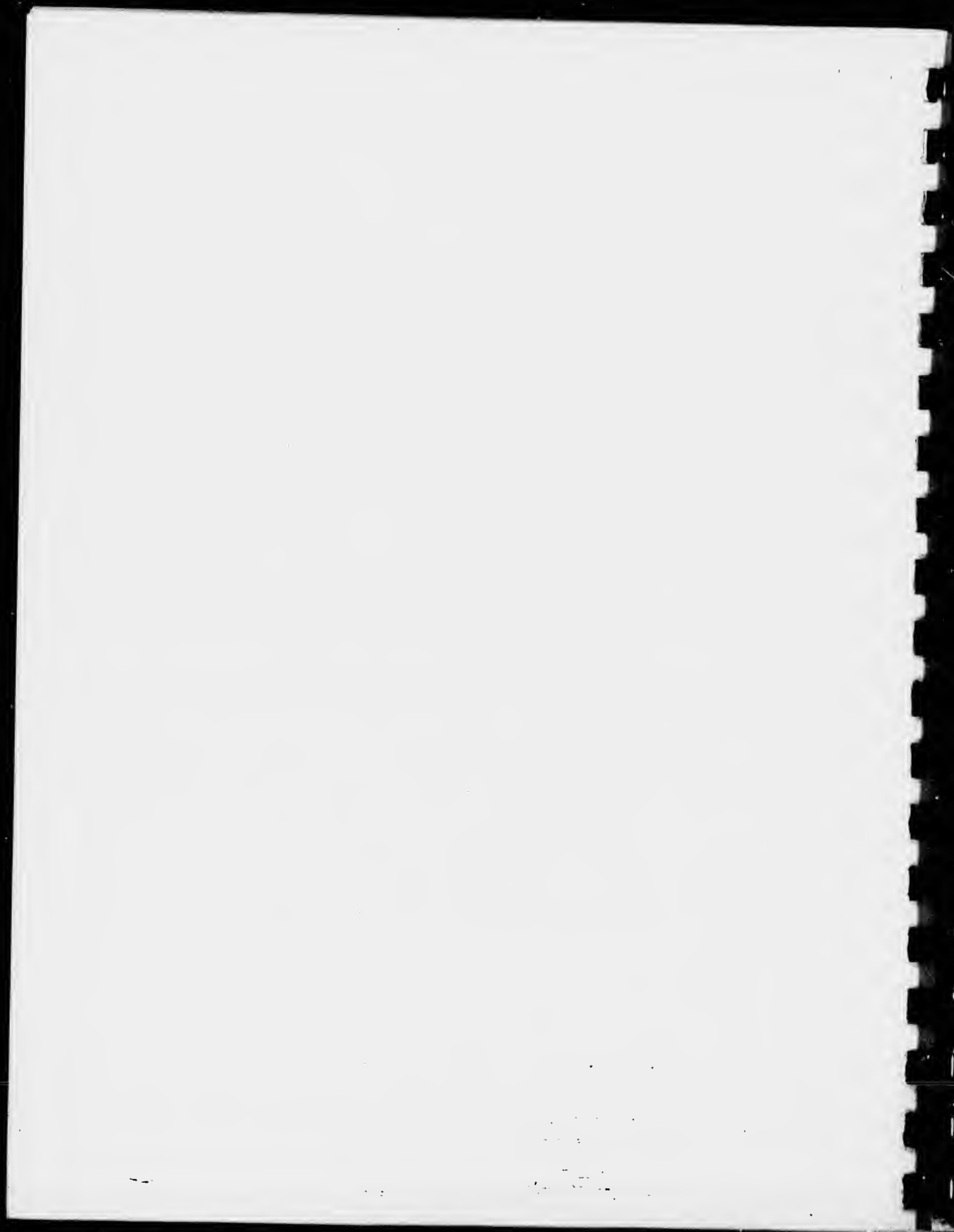
By following the more direct route (previously described) between the same points, the distance is 8½ miles; and the probable cost of the work, &c., connected with the construction of the canal is estimated at \$5,180,000.

Both estimates are prepared on the same basis, and at prices believed to be the fair value of the works, with a proportionate allowance in both cases for contingencies, superintendence, &c.

It has been assumed that the quantity of excavation necessary to deepen and enlarge the old channel, would cost 33½ per cent. more than on other parts of the line; and that the enlargement of the 2nd, 3rd and 4th locks during the winter would be attended with fully as much additional expense, as the materials now in them would amount to for the purpose of rebuilding.

From the foregoing it will be seen that the direct line to Port Dalhousie is fully two miles shorter, and can be made at \$170,000 less cost, than by following the "Collier's Bend" line, and the old canal to Port Dalhousie.

The latter, it may be again observed, has the following objectionable and unavoidable features, namely, of being situated in a deep ravine, at some places extremely crooked and narrow, where the banks are liable to slide, and of having at times a large body of water [unconnected with the navigation] charged with soil from the adjoining country thrown into it, and thereby either impeding it or endangering the works.



There is also on the lower part of it considerably over a mile of floating tow-path, which is inconvenient to the trade, and expensive to maintain.

On the direct line, although the distance is shorter, its physical peculiarities are such that the locks could be spread over a much greater extent, and the canal made wholly unconnected with the drainage of the surrounding country. The banks would, for the most part, be of such dimensions as could judiciously be made from the material excavated from the prism of the canal.

At Port Dalhousie the line would be in such a position as to admit of a much larger area of harbour accommodation being formed and brought into use.

Moreover, the surplus water along it could be made more serviceable for manufacturing purposes, than if it passed through a narrow valley where the space was insufficient to apply the power at the proper level.

In fact the water that could be discharged from it by way of a ravine, so frequently mentioned, might be advantageously used for a series of mills or factories, if they were required.

It therefore, appears to me, after fully considering the subject in all its known bearings, that even were the old canal below "Collier's Bend" enlarged to the dimensions before stated, there would nevertheless be so many objections found to it as a navigable route for vessels of the class contemplated, that there is reason to believe the results would be so unsatisfactory, as would either lead to its abandonment, or to an immense expenditure to render it in a limited degree serviceable.

On the other hand, what has been called the direct line, is not only free from many of these objections, but it presents numerous facilities for the construction of a canal of the full dimensions, at the minimum of cost, and such as would possess all the advantages that could reasonably be expected on a line of artificial navigation of the nature and extent proposed.

The Lake Ontario Harbor of this canal is situated at the natural outlet of the Twelve Mile Creek, near the village of Port Dalhousie. Its entrance is formed by means of two parallel piers, placed 200 feet apart, running in a north and south direction, nearly 2,100 feet into the Lake. The space included between them is about  $9\frac{1}{2}$  acres area, and the general depth throughout at ordinary low water level is from  $11\frac{1}{2}$  to 12 feet—bottom, indurated clay. Between the inner end of the entrance piers and the first lock, the basin has an area of fully 7 acres, which can be increased to 17 acres when required. All the materials to be removed for that purpose, consist of silt and soft clay.

The works connected with deepening the entrance channel to 14 feet, and the basin to  $13\frac{1}{2}$  feet at the inner end of the piers, and 13 feet at the lock, over an area of about 10 acres, are now under contract.

The harbor is easy of access and egress in almost any wind. There is no perceptible current to contend with, and inside it is well sheltered by the high lands on the east and west sides.

There are no shoals or any outlying dangers to be apprehended for miles to the east or west of the entrance.

Above the first lock, which has generally a lift from 12 to 13 feet, a spacious inner harbor or basin has been formed by the damming back of the water, over a large area of which there is a depth of—feet and upwards.

This basin or reach is entirely beyond the influence of storms on the Lake, being for all practical purposes completely land-locked, and capable of accommodating safely a large number of vessels.

In the preceding pages will be found an outline sketch of the survey made in 1854, for a Branch Canal, extending from Thorold to the town of Niagara, and the main features of the river outlet at the latter are also described.

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In further reference to this project, it may at once be stated that the construction of the Welland Railway has produced such changes in the vicinity of Thorold, as to prevent the adoption at that place of the line then proposed.

This will be evident when it is born in mind, that the railway passes through the Ten Mile Creek Ravine with an inclination of from 80 to 90 feet to the mile, and that from its position it would have to be crossed by the canal, which on such a grade would be inadmissible.

A circumstance which lead to the selection of a point for diverging from the present canal that would admit of crossing the railway at a place where the track is nearly level as before stated.

This point is about half a mile further up than that at which the "Lateral Cut" line joins the present canal, but from it for about ¼ of a mile along the proposed route through "Marlatt's Pond," there is a depth of fully 6 feet of water; consequently the formation of the new line, although longer, would not involve much, if any, additional expense over that required for enlarging the existing channel between the points mentioned.

The amount estimated for this is about \$108,000, a sum that should be either deducted from the estimate of the Port Dalhousie trial line, or added to that of the "Lateral Cut" line, for the purpose of comparison.

The construction of the proposed canal, together with all the works and expenses connected with it, from the starting point at Thorold to its debouchure on the Niagara River, was at that time estimated at £989,625, or say \$4,000,000.

This being taken as the value of all the necessary works, etc., in 1854, it will be evident that at least forty per cent. should now be added to it, in order to arrive at anything like a fair estimate of its cost at the present day. This would make the sum of \$5,600,000 as the estimated probable cost, an amount which there is reason to believe is rather under than over, what would be required.

If the southern end of the Port Dalhousie trial line was followed for the "Lateral Cut" as far down as to where these two lines cross each other [3¼ miles from the starting point above Thorold], detached locks could be substituted for the three upper flights of combined locks on the "Lateral Cut" line; but it would augment its cost at least \$450,000, and thus rise the estimate to \$6,050,000.

To be enabled to dispense with the two other flights of combined locks on this line would involve an expenditure of at least \$450,000 more, which would make the total approximate estimate for the "Lateral Cut" line with detached locks, \$6,500,000, or as, above stated with combined locks, the cost is estimated now at \$5,600,000.

The line from Thorold to Port Dalhousie, with locks placed at such distances apart along the whole route as will admit of vessels passing each other in the reaches between them, including all necessary harbor improvements, is, as before stated, estimated at \$5,180,000.

In order to admit of a fair comparison being made between these lines, it has been considered best to estimate for both as having detached locks, in as much as on a navigation of the character contemplated, combined locks would be so decidedly objectionable as to warrant even a larger expenditure to avoid them, than what could be required to effect that object in either case.

It will, however, be observed that the "Lateral Cut" line, with five different flights of combined locks, would cost \$420,000 more than that by Port Dalhousie, with detached locks throughout.

But to make detached locks on the "Lateral Cut" would increase the cost of that line to \$1,320,000 more than that required to be expended in the Port Dalhousie route.

It should also be born in mind that the Port Dalhousie line is the shortest by about four miles—a fact which, apart from the question of first cost and maintenance, is of the greatest importance to the trade, inasmuch as it would necessarily lengthen the time of transit through the canal, and increase the towage expenses of vessels.



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Having thus drawn attention to some of the main questions connected with these lines, it is now proposed to submit a few further remarks in relation to the respective harbors.

It is doubtless quite true that the mouth of the Niagara River affords ample space for a large fleet of vessels, and that in certain winds good shelter can be obtained in it, still there are serious objections to its being selected for an entrance to a canal, for the passage of vessels of the size and class now contemplated, some of which may be stated as follows:—

1st. There is a rapid current in the river, (3 to 4 miles an hour), which in case of southerly winds, would render it very difficult for a vessel to approach the canal in such a manner as to enter it. The employment of tugs, it is true, would in some measure obviate the difficulty; but, it should be borne in mind that both vessel and tug would have to cross the current in making the entrance.

2nd. When Lake Erie opens in the spring, all the ice must pass out by the mouth of the Niagara River, where everything in its course is attacked with great force, and during easterly winds it is driven across to the westerly side of the river, rendering it almost impossible to maintain any pier projecting even slightly into the stream.

At times when northerly winds prevail, large masses of ice are kept floating about in the offing long after other ports on Lake Ontario are open.

This would, of course, continue to be the more felt the greater the extent of trade, and from its diminishing the already comparatively short navigable season, could not fail to be objectionable to Niagara River being selected as a route leading towards a canal, the navigation of which, at the earliest period each year, is of such vital importance to the commercial interests of the Dominion.

3rd. The shoals, previously mentioned, as lying to the north and north-east of Fort Niagara, would, doubtless, in northerly winds be dangerous to vessels entering the river in thick weather, especially as they extend out so far as to be near the track that would, in all probability, be followed either to or from ports at the lower end of the lake.

This is irrespective of whether the bar at the entrance is of a permanent or shifting nature.

4th. Although the mouth of the Niagara River is a comparatively well sheltered roadstead; it nevertheless, at no place forms such a harbor as is necessary at the entrance of a canal; whilst the banks and shore are very unfavourable for the construction of one in the position and of the capacity required.

On the other hand there is no appreciable current in the harbor of Port Dalhousie—the ice leaves it early in the spring, and without injury to any of the works—generally before the ice on Lake Erie breaks up, and always long before the outlet of the Niagara is clear.

There are no shoals or obstructions of any kind in the offing, so that vessels can run for it safely from any point in the lake; and further, there is as above stated, a harbor already formed at this place capable of accommodating a large number of vessels, and which at a moderate outlay [included in the estimate], can be enlarged to afford ample space for the trade of the projected canal.

These facts, together with the shortness of the route previously described—the advantages it will possess, the lesser amount required for its construction, and the suitability of the harbor, all, in my opinion, lead to the conclusion that the direct line to Port Dalhousie is the best route that could be selected for the enlargement.

From the junction of Port Dalhousie branch line southwards, the enlargement can generally be made along the line of the existing canal, and in order to obviate the necessity of lowering the bottom of the reach below Allanburg, it is proposed to raise the water level two feet.

The land damages that would be caused by doing this, it is believed, would be small in comparison with the costs of deepening the channel, and it would render unnecessary

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From Hurst's Bridge to that of Marlatt's, a distance of  $\frac{1}{2}$  of a mile, the channel is for the most part through a pond, which at some places is of considerable width, but of very little depth.

In certain winds vessels experience great difficulty in passing here, as they are not unfrequently driven over and grounded on the bank, and occasionally have to remain for some time before they can get off, otherwise they must come to a complete stop above or below the pond until the wind changes.

To guard against this, an embankment should be formed along the east side, with openings through it, so that the full benefit of the storage capacity of the pond may still be retained. This bank could be used for a second towing path, which from the peculiar sweep of the wind there, would at all times be of great service.

From Marlatt's Bridge upwards, the canal for a distance of about 1600 feet, through the valley of the Beaver Dams Creek, is bound chiefly by embankments under which the water of the creek is passed by a stone culvert with two arches.

Thence upwards to Allanburgh, the channel is for the most part in cutting, with a bottom width not exceeding 40 feet; on this stretch is another branch of the Beaver Dams Creek, which is passed under the canal by what is called Davis' Culvert.

From Marlatt's Pond to the swing bridge at Allanburgh, the distance is about  $2\frac{1}{2}$  miles—the channel along this part of the route is at many places winding, and varies from 26 to 40 feet in width at the bottom; but the most objectionable parts are through the pond already mentioned and near Allanburgh.

At the latter place the channel is so crooked, that it would be very difficult for large vessels to pass, unless the line is improved, and as a new lock will have to be built, it should be located in a position that would admit of the line being changed, as well as of the work being executed during summer, when its cost would be less than if placed either where water would have to be contended with, or the masonry laid in water.

The present 26th lock is situated opposite the village of Allanburgh, is suited to Grand River level, and has a lift of 15 feet, when the summit is maintained at the proper height.

A guard lock has been constructed at about 500 feet above the lift lock, for the purpose of enabling the water in the "Deep Cut" to be kept at a uniform height; an arrangement which it was considered might be the means of preventing to some degree the recurrence of slides in the banks.

From the guard lock for 1,800 feet southwards, the bottom is from 45 to 80 feet in width, and sunk a little lower than the mitre still at Port Colborne lock.

The part next in order is the cutting through the highest ridge of land on the route, and known as the "Deep Cut." It is upwards of nine thousand feet long, and a mean width of 50 feet at bottom; the lower parts of the sides are, however, somewhat irregular from the slides which have occurred, and the necessity of having to remove the material by means of dredges.

Attention having been previously drawn to some of the difficulties which on various occasions have been experienced in connection with this part of the works, it is not considered necessary in a report of this general nature to enter further into the subject.

It may, however, be stated that the work of removing a continuous strip along the front side of the east bank of this cut, for an average width of 50 feet, and down to within two feet of ordinary water surface, is now under contract.

In order that the bottom of the summit level can be made of the width, and to the depth proposed, it will be necessary to lighten the west bank to a like extent as is now being done on the east side.

This is the more necessary as the west bank, which has stood well for many years, now shows indications of settlement.



From the south end of this "cut" to the guard lock at Port Robinson, the distance is about 2,500 feet, and the channel from 50 to 80 feet in width, follows for the most part along the west side of what is at present a long pond; the area of which will, however, be very much diminished when the water is lowered to the level of Lake Erie.

The guard gates, although seldom used, are now in a dilapidated condition, and not at a depth suited to the enlargement.

To admit of the channel above this place being laid dry without emptying the part below, new guard gates should be built as near the south end of the "Deep Cut," as a proper foundation for the structure can be obtained.

On the easterly side of this pond or basin, a branch canal has been formed for fully one-third of a mile in length, which connects the Welland River with the present main line by means of a lock, 17 feet lift.

In continuation of this line, a cut was many years ago made through a point at the mouth of the Welland River, with a view of giving the navigable channel an upward direction, where at the village of Chippawa it connects with the strong current of the Niagara River.

For a number of years steamboats were engaged on this route, between Port Robinson and Buffalo, *via* Chippawa; but since the construction of railways along the sides of the Niagara River, passenger boats have ceased to run between these places.

It may also be stated, that although the lock at Port Robinson is the same size as others on the main line of canal, and that the Welland and Niagara Rivers form a deep water line of communication with Lake Erie, this route is seldom if ever used by vessels engaged in the lake trade.

From Port Robinson upwards for fully 4 miles, the canal continues on the west side of the Welland River. For the greater part of this distance it is in through cutting; but towards both ends, one side of it is formed by an embankment of considerable height, which at some places is so situated that piles had to be driven along the slope to prevent encroachment on the bed of the river.

The additional width for the prism should generally be taken off the west side, except at a few points where the banks are high, and the line can be improved by widening on the east side.

It is believed proper to remark that part of the material to be excavated about midway of the distance above stated, consist of unusually hard clay.

At the south end of an stretch just mentioned, the canal is carried over the Welland River by means of the aqueduct, formed of a heavy class of well built ashlar masonry. This structure is so arranged, that the present bottom of the canal is one foot under the ordinary surface of the river, and also that the undersides of the centre portions of the arches over the waterway of the stream are fully five feet below its surface.

It will therefore be evident that it is to a certain extent a dam, through which a siphon culvert [on a large scale] has been formed of a sectional area sufficient to allow the necessary volume of water to pass.

Previous to the erection of the structure, that part of the bed of the river to be occupied by it was laid dry, and a channel formed for the temporary diversion of the stream. The foundations were then well piled, and the masonry carried up before the water was allowed to resume its original course.

The aqueduct is 316 feet long, and the trunk 45 feet wide between the side walls, which is carried up to a height suited to the Grand River level.

It is supported by 4 arches, each 40 feet span and 7 feet rise, the voussoirs of which are 2½ feet in depth, and the spandril filling is of masonry and concrete, brought fully up to the crown of the arches. Transverse timbers were then laid and secured between the side walls, over which a floor of plank was subsequently placed. On this there is a depth of 18½ feet, when the summit water is at its full height, or 20 feet over the level of the present mitre sill of Port Colborne lock.



When Lake Erie forms the source of supply, the summit will be lowered 8 feet, which will leave only 10½ feet in the aqueduct, but by removing the wooden floor above mentioned, there would be the same depth as on the present lock sill at Port Colborne.

During seasons of very low water there are, however, occasionally for short periods, less than 12 feet of water on the present lock sills at Port Colborne. It is therefore proposed, when increasing the length of that structure, or building another one, to lower the sills, say 12 inches.

The contemplated depth at the aqueduct can be obtained by cutting down the crown of the arches, from 10 to 12 inches, for a space of about 20 feet in the centre of the channel through it.

This can be done without injuring the stability of the structure, if strong bands of wrought iron are let into the stone—extended down into the haunches of the respective arches, and throughout well fastened to the masonry.

The space above mentioned might then be covered between the abutments with heavy plate iron, well fastened to hands and bearers, and otherwise secured so as to prevent displacement from any cause whatever.

By adopting this course the present aqueduct can be made available for the passage of vessels of the full draught of the enlarged canal, and in this way, one of the chief difficulties in carrying out the enlargement at this important point will be obviated at a very moderate outlay.

Means must, however, be provided for supplying a larger volume of water for canal service than could pass through the aqueduct.

For this purpose another, and separate water way will have to be formed across the river, a connection with which could be made above and below the present aqueduct.

From the relative levels of the river and canal, it is quite evident that a structure, such as the existing one, could not be built to the westward of the canal without interrupting the navigation, an idea that could not, under any circumstances, be entertained.

The only place that could be selected for the site of an aqueduct suited to the enlarged canal, is to the eastward of the present one, where the course of the river could be temporarily changed, and the bed of the stream unwatered until the foundations were properly formed and secured, and the masonry laid.

This would necessitate the formation of a canal around the town of Welland, that would cross several streets where bridges would be required—destroy a large extent of valuable property, and be attended with a very great outlay.

To avoid such an expenditure, it is proposed to form a channel solely for the purpose of passing the necessary supply, which might be so arranged that its bottom would be about the level of the river surface.

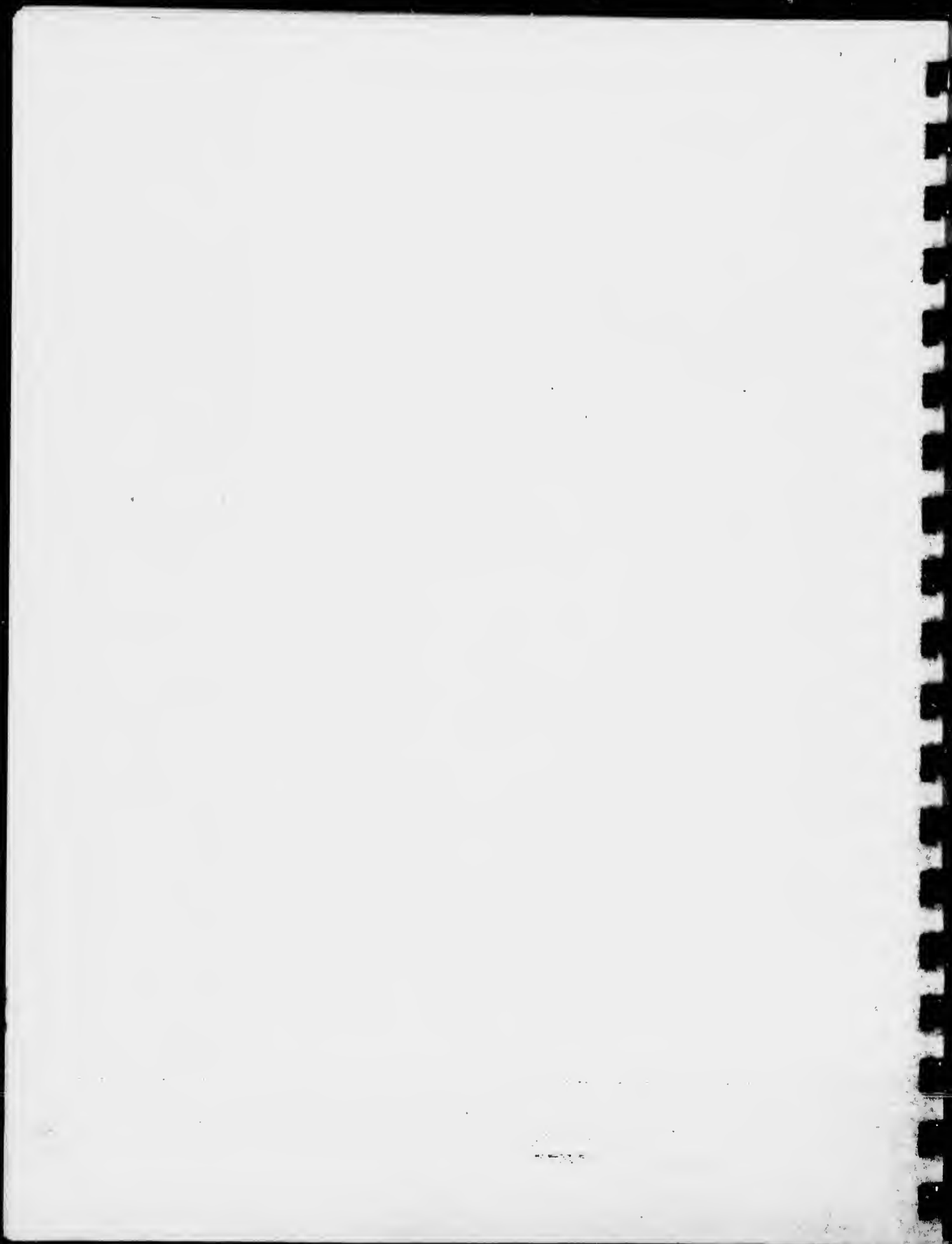
It might be constructed of iron, or even of wood, resting on stone abutments, and on such centre piers as would form little obstruction to the water of the stream.

If this water way was made on the western or up-stream side of the aqueduct, the lock down the Welland River would be rendered useless; consequently, if this branch of navigation had to be maintained, another lock would have to be constructed.

But by making the supply channel on the east, or down stream side, there would be little or no interference with the existing works, whilst the saving that would be effected in this respect, would pay for all the property necessary to be purchased, and leave a considerable amount to be applied to the execution of the works.

From the aqueduct to the junction of the feeder with the main line, the distance is fully one and a-quarter mile, and the bottom for the most part is 50 feet, but at some places is 100 feet in width.

The east side of the canal between the points above mentioned, is generally formed of a heavy embankment, so that the prism must be widened, on the west side. In doing



this, part of the banks of the old canal, which now forms a race-way to the mills at Welland, will have to be cut away, which will render it necessary to make a new water course at these places.

A short distance below the road bridge at the junction, the Canada Southern Railway Company have built a swing bridge for the purpose of carrying their track over the canal, with the distinct understanding that a permanent structure will be substituted by them when notified to do so by the Government.

The enlargement of the canal—construction of new work, and alterations to others—the purchase and drainage of land along the main line, from the upper end of the Port Dalhousie route in Marlatt's Pond, to the Feeder Junction, is estimated to cost \$1,840,000.

From the Junction southwards for 23,500 feet, the canal is formed through clay excavation; thence for 2,238 feet it is in rock; when for 2,200 feet it is again in clay, at the south end of which the principal rock cutting commences, and continues for a distance of 6,347 feet, or to 460 feet south of the entrance lock.

The total distance from the Junction to the south end of the Port Colborne lock being about  $6\frac{1}{2}$  miles.

On this part of the line the bottom is 50 feet wide in clay excavation, and from 56 to 58 feet through rock cutting; the latter being from  $1\frac{1}{4}$  to  $1\frac{1}{2}$  feet higher than the present sills of the entrance lock.

As the sides of this rock cutting will be all but vertical, it should be made of such a width as will give the prism of the canal through it at least a like sectional area as those parts in earth excavation.

At the place where the entrance lock is situated, the streets of the village of Port Colborne run parallel with the line of the canal on each side, and are not more than 147 feet apart.

It will therefore be indispensable that a considerable extent of valuable property should be purchased, otherwise that the position of the lock should be changed. The latter, there is good reason to believe, would be the most judicious course to adopt.

In order to have the means of admitting a full supply at the entrance during periods of low water in the lake, the works should be of sufficient extent, and arranged so as to have openings available for that purpose, nearly equal to the sectional area of the canal.

As previously stated there are times when the depth on the lock sills is less than 12 feet. This is, however, of short duration, and occurs only at intervals, in seasons of very low water, and after a continuance of northerly winds. To be prepared for such occurrences, the bottom of the enlarged or new lock should be kept about 12 inches lower than that of the present one.

The Buffalo and Lake Huron Railway crosses the canal at 150 feet below the present entrance lock, so that a new swing bridge to carry this line over the enlarged channel must be built at some place in the vicinity.

The Lake Erie entrance to the canal at Port Colborne is formed by means of piers extending out into the lake, which on the westerly side run in a south-westerly direction 1,600 feet beyond the line of the shore, and on the eastern side the pier has a southerly course, and is only 500 feet long.

At the shore line they are 150 feet apart, and from that point to the head of the lock, the distance is 2,300 feet. The present basin is 1,475 feet in length, and has an average width of 265 feet, containing an area of about 9 acres, with a depth of fully one foot below the level of the mitre sills of the entrance lock.

The west pier is built chiefly on a ledge of flat rock, which at about 1,000 feet from the shore is found slightly beyond the line of the pier, at the level of two feet below the lock mitre sill, and at this depth it can be traced round until nearly opposite that part of the pier which opens to the southwest, where it is 160 feet out.

Near the angle referred to, for a distance of 250 feet, and a width of 26 feet along-side of the pier, the rock stands from one to two feet over the mitre sill of the lock.



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The works of enlarging the basin 725 feet, in a southerly direction, and to a depth throughout of 18 inches below the mitre sill of the lock, together with that of making the entrance channel at other places fully two feet under the level of the lock sills, are now under contract.

When these works are completed, the basin will be 2,200 feet long, and have an area of 11½ acres.

The harbor has a good width of entrance, and is generally easy of access; there are no dangers to be apprehended in approaching it from the west, but in a direction S. E. by E., 800 feet from the lighthouse on the head of the west pier, there is a reef, on the outer end of which, at low stages of the lake, the depth is only 8½ feet.

From a point on the shore, 1,500 feet in an easterly direction from the east pier, this reef runs out in a southwesterly course 2,000 feet, to where it terminates at the point first mentioned.

It is proposed to construct a breakwater alongside of this reef for its entire length; and by this means form an outer harbor, that will be upwards of forty acres area. This, together with the inner basin would, there is reason to believe, not only accommodate the trade of the enlarged canal, but afford shelter to all such vessels as may seek refuge there in rough weather. The main light, with some distinguishing characteristic, could then be placed on the outer end of the breakwater, and a smaller one built on the head of the present pier, so as to guide vessels into the harbor at night.

The probable cost of enlarging the canal from the junction southwards, including culverts, lock, supply weir, harbor, and all the works connected with them, is estimated at about \$2,220,000.

The mouth of the Grand River being well known as the only natural harbor at the lower end of Lake Erie, on the Canadian side, it was considered proper that such surveys and examinations should be made as would enable a line, *via* the Feeder, to that place, to be compared with the route to Port Colborne.

From the junction upwards, the Feeder has a southwesterly course for 16½ miles, to where it is joined by the Port Maitland Branch at Broad Creek; it then takes a more westerly direction, and continues in a winding course 4½ miles to Dunnville.

From opposite Stromness a line was run along the bed of what is called "Broad Creek" to opposite a rocky point on its eastern side, thence it continued through the marsh, parallel with the Port Maitland Branch, to the Grand River, which it strikes at 7,250 feet from the starting point; making the total distance from the Junction to the Grand River, 17½ miles.

The Feeder, from the junction upwards, passes through a flat marshy section of country, the upper part of which, for a depth of from 3 to 4 feet, is a light vegetable mould, and underneath a deep deposit of blue clay. It has generally been formed by a cutting from 6 to 7 feet in depth below the natural surface of the ground, and depositing the material excavated along both sides. In the spring of 1845, it had a bottom width of 26 feet, with side slopes, for the most part, of 2 horizontal to 1 vertical, and a depth of fully 9 feet.

There were then a number of places where, for a short distance at each, the bottom had been made from 35 to 40 feet in width to allow vessels to pass freely, during the time it was intended to be used as the main navigable route; but from slips in the banks, silt, and other partial obstructions, the channel is not now of these dimensions.

Its water level, when at the proper height, is eight feet over what was formerly assumed as the low water surface of Lake Erie; but records of the rise and fall of the Lake show that at times it falls from 6 to 10 inches below that level. The bottom of the summit reach has therefore been assumed at 22 feet below the surface of the feeder, or two feet under the top of the present sills at Port Colborne lock.

The following table shows the results of the experiment. The first column shows the number of trials, the second column shows the number of correct responses, and the third column shows the percentage of correct responses.

Trial	Correct	Percentage
1	1	100%
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This would make the average depth of cutting for the proposed canal about 21 feet from the junction to the Port Maitland Branch, which may be taken for that depth and width irrespective of the present channel, the material excavated from which having been placed along the sides, one-half of it would have to be removed, no matter on what side the enlargement was made, and the formation of back ditches, lock, culverts, pits, &c., would amount to fully as much as the other half.

At the upper end of the line, numerous borings were made through the creek and marsh, all of which showed that the materials to be removed were soft mud and clay, for the full depth (14 feet) of necessary cutting.

To excavate a channel from the Junction upwards, of like dimensions as estimated for other parts of the line, together with lock and culvert pits, ditches, &c., would require the removal of fully 10,000,000 cubic yards of material. This would form a bank about 500 feet wide and 6 feet high, for the entire length of the cutting; deposit ground for which, together with that for other purposes, would require the purchase of at least 1,300 acres of land.

A guard lock would have to be constructed at some point near the Grand River together with the means of admitting and regulating the supply to the canal, and a lift lock would be required near Stormness, so as to keep up the navigation of the feeder to Dannville.

New culverts would have to be built in the vicinity of those at present under the Feeder, and new road bridges constructed. A bridge to carry the line of the Buffalo and Lake Huron Railway would also have to be built.

The trial line strikes the Grand River about one mile above the outlet of the present branch canal, and  $1\frac{1}{2}$  mile above the entrance pier at Port Maitland. The stream at that place has a width of about 300 feet, between 12 feet on one side to the same depth on the other side, and in the centre it is 30 feet deep; these depths and this width continue down to near the entrance of the present canal; but opposite Moss' Wharf, about 400 feet downward, 17 feet of water was found in the centre of the stream, and 400 feet further the depth was 15 feet. From this the channel diminishes to from 12 to 13 feet in depth opposite a wharf in the centre of the village, where it is for some distance both narrow and crooked. Outwards the depth gradually increases to 18 feet opposite the north end of the west pier; thence towards the Lake there is a depth of from 19 to 20 feet in the centre of the channel.

The entrance is formed by means of piers, having a south-westerly course, placed 180 feet apart, and so that the one on the west side extends 400 feet further into the lake than that on the east side; the latter is 1,400 feet long, the inner, 1,000 feet of which runs in a S. S. W. course from the shore, and forms a breakwater on that side.

The west pier is 1,600 feet long, and the inner 600 feet, run all but one south from the shore.

Inside the area is large, but with the exception of a comparatively narrow channel, it is for the most part shoal, so that there is at present no accommodation for large vessels, until north of the entrance of the present canal.

The mouth of the Grand River is easy of access from the Lake, and has the advantage of being open earlier in the spring than places to the eastward of it on Lake Erie. It could doubtless be made an excellent harbor, capable of accommodating a large business.

But notwithstanding all the natural advantages it possesses, it is quite evident that economy would not be consulted, or the interest of the navigation duly considered, in its being selected as the Lake Erie terminus of the projected enlargement, inasmuch as it would involve the necessity of making what is equivalent to an entirely new line of canal  $17\frac{1}{2}$  miles long, requiring an enormous extent of excavation, all of which would have to be wasted, whereas an available line only  $6\frac{1}{2}$  miles long, is already formed to fully one-half the necessary dimensions.



To make the enlarged canal along the line of the feeder, and through the marsh to the Grand River, together with all necessary works, harbor improvements, &c., would cost at least \$4,260,000.

It is, however, important that the feeder should be thoroughly cleared out, the bottom lowered about two feet, and some additional passing places made.

By doing this, it is believed that a much greater volume of water could be drawn from the Grand River at its low stages even in dry seasons, and in this way the difficulties hitherto arising from short supply would doubtless, in a great degree, be obviated. In case of a wet season occurring during the enlargement of the main line, the deepening of the feeder would admit of the trade passing temporarily by that route, as was done when the construction of the present canal was in progress.

By adopting this course, it is probable that the work connected with the rock cutting below Port Colborne, instead of being confined to the winter months of several years, might be carried on at least one year continuously, which would greatly facilitate the operations, and enable the pressing demands of the trade to be met at the earliest possible period.

The various important matters connected with the enlargement of this canal, having been, I believe, fairly placed before the Department, and at the same time as fully as could be done within the limits of an ordinary report, it is now considered proper to give a brief *resumé* of the principal reasons which led to the selection of the route recommended.

1st. It is the shortest practicable route across the peninsula, being only 26½ miles in length, a matter of vast importance in a ship canal between the two great lakes, where the time occupied in passing through it is often of the utmost consequence.

2nd. It is the cheapest line of navigation that can be formed of the capacity to answer fully all the objects contemplated.

3rd. The harbors at either end are easily accessible, free from attacks of ice, and have none of the objectionable currents, bars, shoals, &c., which are almost invariably found at harbors situated near the mouths of large streams. They are open early in the season, and continue so, long after navigation closes, and can be made at a reasonable outlay fully capable of accommodating the trade of the enlarged canal.

The probable cost of the contemplated works from Port Colborne to	
Thorold, will, as previously stated, amount to.....	\$4,060,000
From Thorold to Port Dalhousie <i>via</i> the new and direct line now recommended .....	5,180,000
Total .....	9,240,000

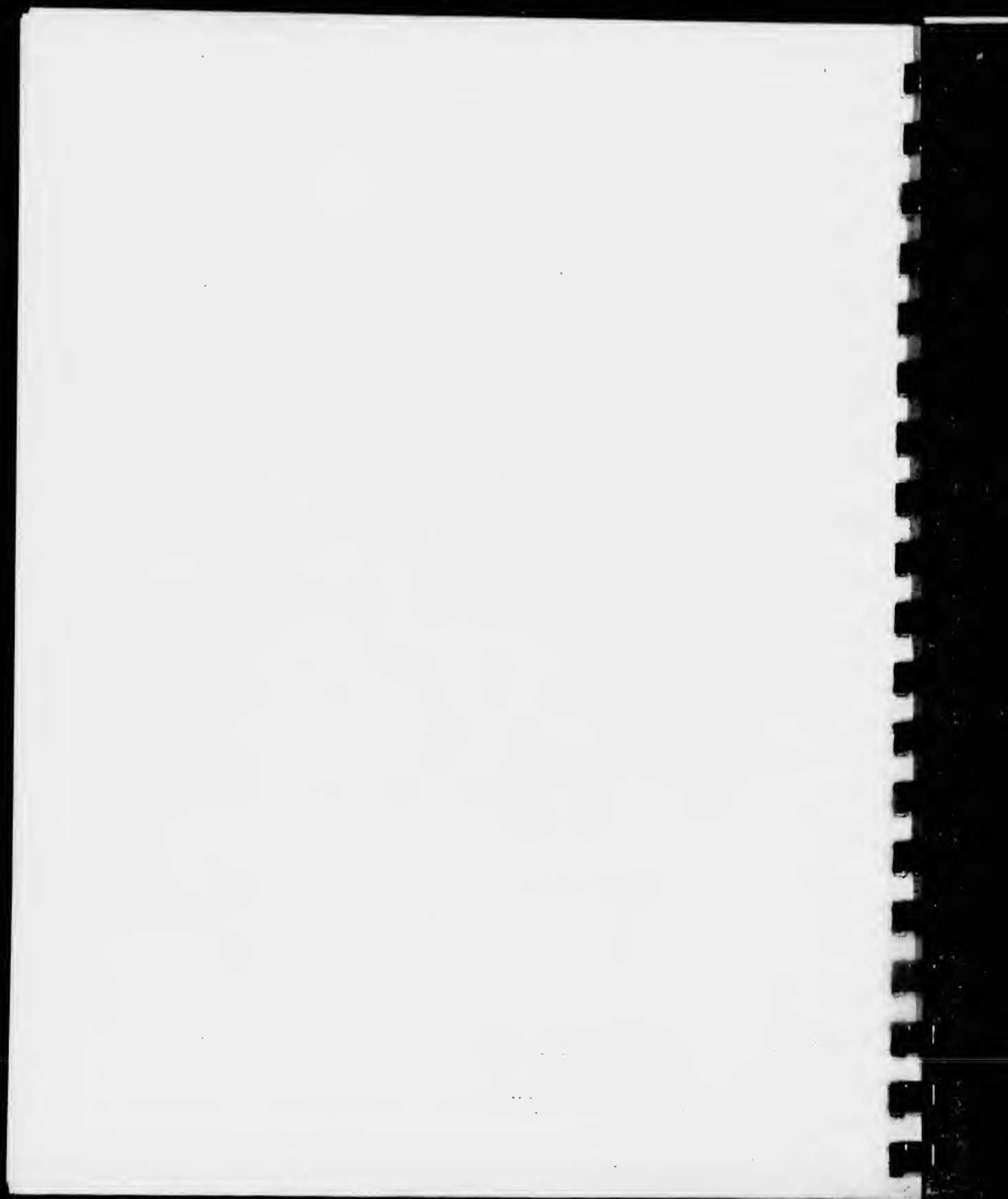
The carrying out of this extensive undertaking would, under any circumstances, occupy from three to four years, a period not unlikely to be protracted by the scarcity of men accustomed to that class of labor, unless there may be a large influx of workmen from other countries.

It is important that the summit level should be maintained, as nearly as possible at its usual height, until at least one-half the additional width is obtained, when it can be lowered to that of Lake Erie.

The canal can then be made the full width, without the operations interfering with the passage of vessels.

In the prosecution of this work, such a number of excavator dredges can be employed as will enable the widening to be proceeded with as expeditiously as circumstances will warrant.

From the nature and extent of the undertaking, it is believed that it can be carried out in a more satisfactory and economical manner by letting the work in sections than in any other way that could be adopted.



It is also important that, in every case, it should be placed in the hands of thoroughly competent contractors, and at such prices as will fairly represent its value. Unless some such course as this be followed, no one can give anything like a reliable opinion as to the time likely to be required to carry out the contemplated enlargement.

The survey was entrusted to Mr. Thos. Monro, whose Report is hereunto appended. To this gentleman I desire to express my thanks for the zealous and energetic manner in which his duties have been discharged, and the assistance he has rendered me in this matter.

I have the honor to be,

Sir,

Your obedient servant,

(Signed,)

JOHN PAGE,

Chief Engineer, Public Works.

### REPORT OF OFFICER ENTRUSTED WITH SURVEY.

OTTAWA, January 23rd, 1872.

JOHN PAGE, Esq.,

Chief Engineer, Public Works.

SIR,—As instructed by you, I have made such surveys and examinations of the various routes proposed for the enlargement of the Welland Canal as will, I trust, enable a decision to be arrived at as to the most eligible line for the improvement of this great public work; and I have now the honor to submit for your information the general result of my labors, embodied in the following Report, and shown on the accompanying plans, sections, &c., &c.

It being your frequently expressed desire, during the progress of the surveys, that they should be made as comprehensive as possible, so that all the data necessary in the full and fair discussion of the relative merits of the several projects should be correctly supplied, I beg to prefix a list of the principal examinations and measurements which have been made.

1. A general survey and topographical map of the country between Thorold and Port Dalhousie.
2. A survey of the present canal, from Thorold to Port Colborne, with cross sections at about 500 feet apart throughout this length.
3. Measurements, levels and borings along the Feeder, and *via* Broad Creek to Port Maitland.
4. A survey of the Twelve Mile Creek and its eastern tributaries, together with longitudinal sections of the same; lines being run from the head waters to connect with the present canal near the town of Welland.
5. An examination and part survey of the proposed "Lateral Cut" to Niagara;—also soundings of the mouth of the river, &c.

According to your directions at the outset, the surveys were made with a view of obtaining a practicable line for enlargement, with detached locks throughout. When the work was well advanced, you informed me that the scale recommended by the Canal Commissioners for the proposed navigation was for a channel 100 feet bottom width, having side slopes of 2 to 1 in. clay; locks 270 feet in length between quoins, and 45 feet wide, with twelve feet on the mitre sill,—canal depth being 13 feet. The quantities have been estimated for a canal of these dimensions.

1. It is evidently impossible to enlarge the present canal to any considerable extent along its northern end, chiefly because numbers of the "mountain locks" are so close together that they could not be lengthened without throwing many of them into combination—an arrangement very objectionable in a navigation of the character contemplated.—





A new line had therefore to be sought for by which the descent between Thorold and Lake Ontario could be made by detached locks, with a sufficient length of reach between them to enable vessels of a large class to pass each other without difficulty.

My examinations were, accordingly, first directed to this matter as being of vital importance to the whole question; and in order to render the results intelligible, I shall endeavour briefly to describe the leading topographical features of the vicinity.

The Niagara escarpment (here called the "mountain") runs in a general direction west of Queenston Heights to Hamilton, and at a distance from six to eight miles from the shore of Lake Ontario, with a summit level of 350 to 360 feet over the surface of the latter, near Thorold. This is one of the most formidable obstacles to be surmounted in the construction of a canal connecting Lakes Ontario and Erie.

Although at many places it presents a nearly perpendicular face, yet there are valleys or indentions which break the general regularity of its outline, and where the slope is much less steep. Down these the streams that drain the northern part of the upper plateau find their way to the plain below.

Advantage has been taken of the bed of one of these water-courses, in the construction of the existing canal.

The Twelve Mile Creek, which has its sources amongst the "Short Hills," about half way across the peninsula, dividing Lakes Ontario and Erie, runs into the former at the village of Port Dalhousie, where the lower entrance of the canal is situated.

By damming the mouth of this creek, its waters were set back to the second lock, in the town of St. Catharines, about three miles inland. At the third lock, the canal leaves the main stream, and runs up to a crooked branch of it to the foot of the "mountain," which is reached at the fifteenth lock from Lake Ontario. The face of the slope is then ascended obliquely by a series of six locks, known as the "Mountain Range," at the head of which the canal curves sharply to the south, and is continued along the western side of the incline until the level of 318 feet over the lower lake is attained at lock 25, in the village of Thorold.

An examination of that portion of the line between Thorold and what is known as "Collier's Bend" clearly showed that all the ground available there for canal purposes was occupied by the existing work, together with its reservoirs, mill sites, &c., &c., and that it would be as impossible to locate another line alongside of it as it was admitted to be to enlarge the existing one to the required dimensions.

This being the case, attention was directed to the ground on the east side of the valley of the Ten Mile Creek, as it seemed to offer the easiest descent towards Lake Ontario.

This creek rises about the centre of the northern part of the township of Stamford, and on the plateau above the Niagara formation. Its course is almost due west for about four miles to Peter Hoover's farm, on lot 15 of Thorold township, and immediately in rear of the village.

Here the stream (which is quite small) turns sharply to the north, at right angles to its previous direction, and, running down a ravine of about half-a-mile in length, deeply worn into the clay, falls over a ledge of rock which marks the edge of the "mountain," at Brown's Cement Quarry.

The fall occurs at the mouth of the ravine, where the banks of the latter are about forty feet high. The level of the stream below is about eighty feet under that of the plateau. This place may be described as the southern point or head of a deep valley, up a portion of the western slope of which the present canal is carried, as above referred to.

Where the ravine opens out into this valley, the banks are, as above stated, high, and from thence the ground inclines downwards along the base of the cliff towards the north-east, exposing more and more of its rocky face until the eastern points of the valley are reached, where it shows an almost perpendicular height of over 100 feet.



In following the foot of the slope, the Great Western Railway is met at about a mile and a-quarter from the mouth of the ravine. As this forms a governing feature in the location, its course in the vicinity may be briefly described as follows:—

The line crosses the present canal at Lock No. 12, about two miles below Thorold.— It then runs in a general direction a little south of east towards the Suspension Bridge, traversing the Ten Mile Creek about one and a-quarter miles from Thorold Station, and entering the long cutting by which the "mountain" is ascended at about a mile further to the west. The grade is here 38.54 to the mile, and in the valley of the creek there is a considerable curve in heavy embankments.

Thus, looking northward from the mouth of the ravine at the Cement quarry, a sort of triangular-shaped area presents itself, formed by the line of the Great Western Railway and the east and west sides of a deep indentation in the line of the "mountain," converging to the point referred to. Down the centre of this space the Ten Mile Creek runs northward to the lake, crossing the railway as above described. Its mouth is about three miles to the east of Port Dalhousie.

The whole of the eastern slope between the ravine and the railway has been carefully surveyed and covered with a network of levels. The cross sections were also continued to the north of the latter, until the ground ceased to present any difficulty in projecting a canal line.

As it was soon apparent that, if the large natural excavation of the ravine described could be utilized, a practicable route might be formed for connection with the present canal above the village of Thorold, this gully was measured and closely levelled throughout; and the ground between the bend referred to on Hoover's Farm and Marlatt's Pond was also cross-sectioned over an area of about three-quarters of a mile in length by half-a-mile in width.

The result of these operations has been that a fair location can be had between Marlatt's Pond and the Great Western Railway, which is the most difficult part of the route from Thorold to Port Dalhousie.

I shall now proceed to describe this more particularly, submitting my reasons in favor of the projected line.

The difficulty of choosing a proper point for divergence from the present canal has been greatly increased by the construction of the Welland Railway.

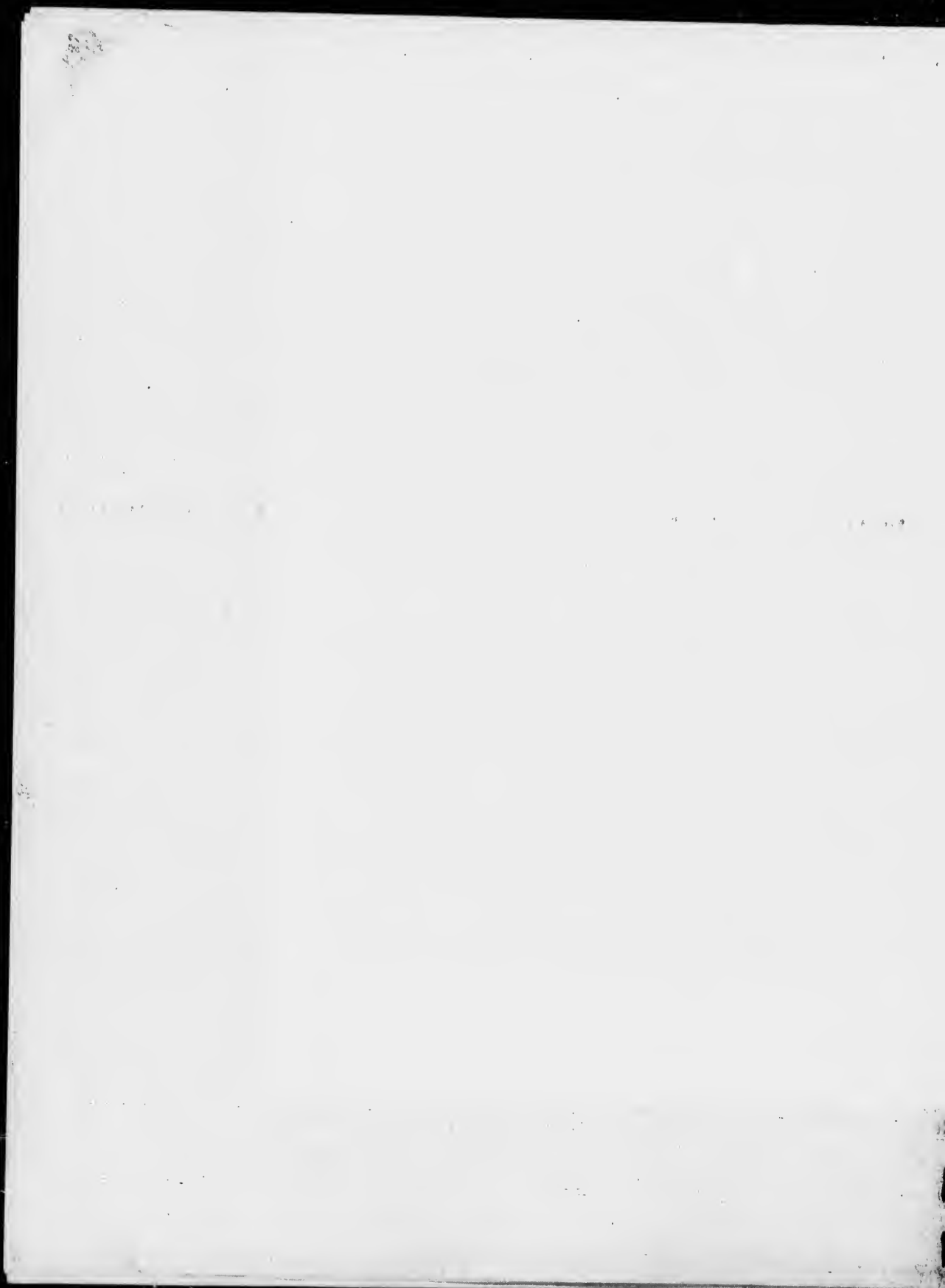
This line runs from Port Colborne to Port Dalhousie, on the eastern side of the canal. Behind Thorold it is located in the ravine formed by the Ten Mile Creek (previously described), this being obviously the best way of reaching the lower level. The grade down the ravine is, nevertheless, between 80 and 90 feet to the mile, and this rate of inclination is continued for nearly three miles. It is manifestly desirable to utilize as much of the existing canal as possible, and in this view the new line should begin at as short a distance above the mountain locks as could judiciously be done. At the same time, it is clear that the ravine affords the best line for enlargement by reason of the great saving in excavation consequent upon its adoption.

A trial line was therefore run, diverging from the middle of the "Little Deep Cut," and striking for the ravine as directly as its position would permit. This would be a short and cheap line between these points.

But after careful examination it was considered inadvisable to adopt it, inasmuch as the railway would have to be crossed at a great angle of skew, between the banks of a narrow gully, and at a point where the grade of the track is from eighty to ninety feet per mile.

To avoid this it became necessary to diverge further south than the Little Deep Cut; and, after a careful survey of the ground, Marlatt's Pond seemed, under all the circumstances, to be the best place for the purpose.

By continuing the general line of the reach south of Hurst's Bridge across the road to Allanburg and the Welland Railway, the latter can be crossed at a fair angle and where the grade is nearly level. The height of the rails being about 9 feet over the



present surface of the pond is also favorable for the construction of a swing bridge at this point.

There is, in addition, an evident advantage in drawing from such a large body of water as the long reach below Allanburg, for the supply of the proposed canal as well as for that of the existing one.

The trial line, after crossing the railway, sweeps to the north by a curve of 1000 feet radius, and enters the ravine at the bend on Hoover's Farm.

Advantage has been taken of a small branch of Marlatt's Pond, and also of the shape of the ground, to reduce the amount of excavation as much as possible. Still it is very considerable, as the ridge already traversed by the "Little Deep Cut" has again to be cut through. The distance from the point of divergence to the 24th lock from Lake Ontario, as shewn, is 5,130 feet. About 2,630 of this is in the cutting; the remaining 2,500 being through Marlatt's Pond, where there is from five to nine feet water.

From the 24th lock to the mouth of the ravine the distance is 2,400 feet. Down the gully, it is proposed that the centre line of the new canal shall be the same as that of the present railway, the latter to be shifted about 120 feet to the westward.

Although the work here will be heavy, and a great portion of it through rock, yet it is believed this is the best line that can be had under the circumstances. The railway can in this way be relaid on precisely the same grade as at present, and the turn out to the line in its new position can be made by an easy reversed curve just north of Thorold Station; the tangent down the ravine being, as before stated, run 120 feet parallel to and west of its present location, so as to join the existing line a short distance from the Cement quarry, thus straightening a portion of the track at that place, which is now curved. In short, it may be said that the traffic of the line need not in any way be interfered with by the proposed arrangement.

Lock 21 is placed on the slope north of the mouth of the ravine, the reaches between it and No. 24 being shown as 630 feet each.

The rock in the cutting will consist of the upper layers of the Niagara limestone, amongst them being the bed from which the well-known "Thorold cement" is manufactured.

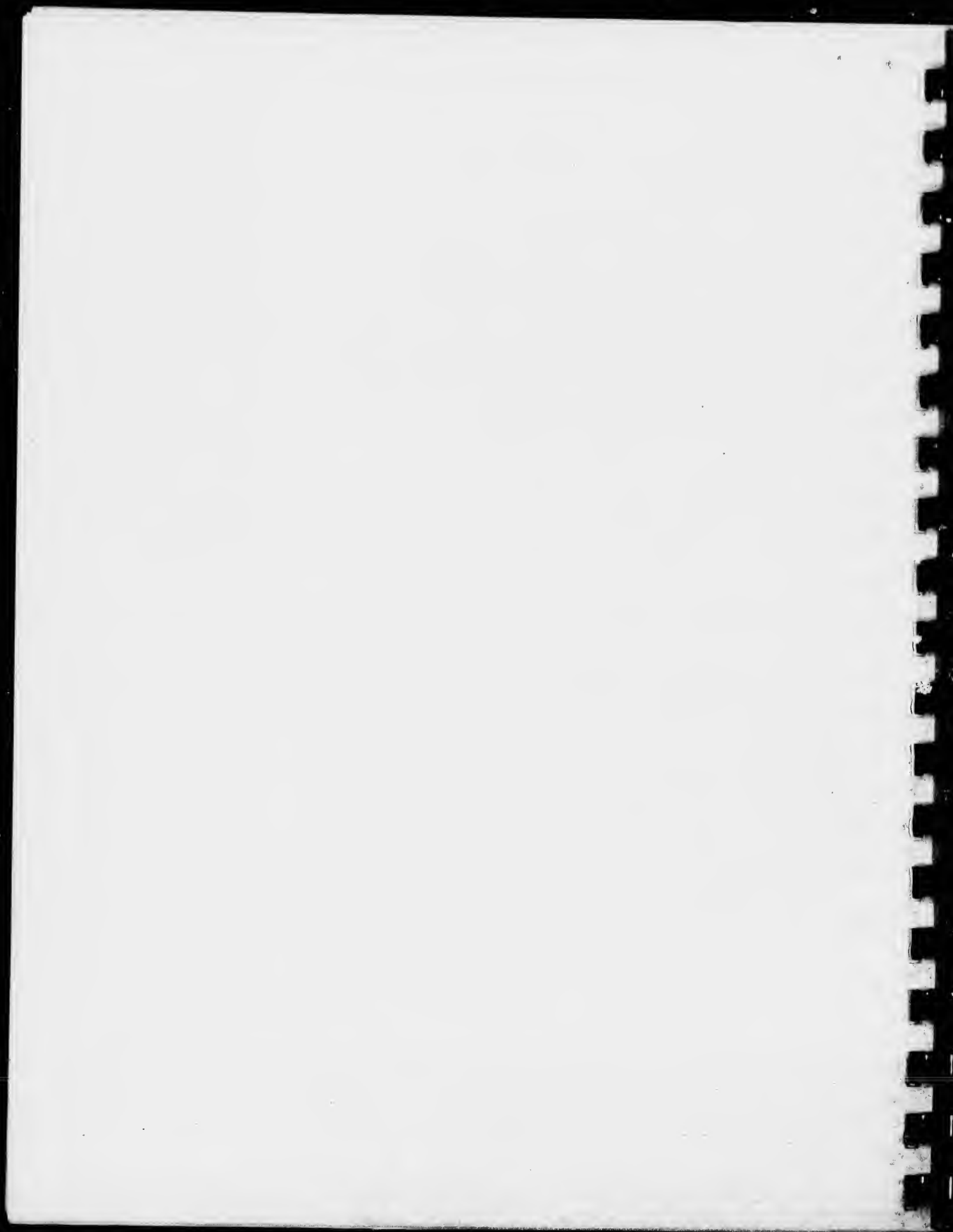
From the mouth of the ravine to the crossing of the Great Western Railway, the line gradually descends the slope, passing close by the north end of the Thorold cemetery, and near the old (and now abandoned) stone church. At the railway the distance from the starting point is 2.40 miles.

Nearly the same arrangement as to locks and reaches is preserved from Lock 24 to Lock 17, which latter it is proposed to connect with the abutments of the swing-bridge to be built at the crossing of the Great Western Railway; that is to say, a lock and reach occupy together from 1,000 to 1,100 feet; from which, deducting the length of the lock, leaves from 630 to 730 feet in the reaches, the latter being nearly three times the length of the largest vessel which could navigate the enlarged canal. The lift of all these locks is 14 feet each; the level above 24 being 320 feet, and at the Great Western Railway above 16,260 feet above datum of mean water surface above Lake Ontario.

As before stated, the ground along the eastern slope was carefully examined and levelled, so that, if there is no objection to the adoption of locks of 16 feet lift, another line can easily be laid down on that basis and estimated for. In such case the length of lock and reach might be increased to nearly 1,300 feet; and one lock could be omitted, the descent being accomplished by seven locks instead of eight, as shown.

Even with locks of 14 feet lift, it is, however, possible to obtain a greater length of reach by throwing the line up nearer the "mountain," and making it more circuitous with the same, or, if required, less fall.

As the Great Western Railway ascends towards the east by a grade of nearly 40 feet to the mile against its outward and principal freight traffic, it is evident that no interference with this rate of incline, by which it would be increased, is admissible. The level of the rails will, therefore, govern that of the surface of any canal at the crossing.



A glance at the map will show that the nearer any line from the mouth of the ravine to the railway runs to the centre of the valley of the Ten Mile Creek, the less will be the distance between these points; and, as above stated, the railway rises rapidly to the eastward, there must necessarily be a greater fall, or, in other words, more lockage to do and less space to do it in.

Thus, where the railway crosses the creek its rails are 198 feet above datum, whereas at the proposed point of crossing for the canal line they are 216½ feet above the same plane.

This part of the line has been particularly described, inasmuch as it will hereafter be referred to in connection with the projected "Lateral Cut" to Niagara. The difficulties of location, do not, however, cease when the railway is passed. To the north the ground is still steep for over a mile, and had to be carefully examined to obtain a practicable line.

Near the railway crossing it becomes necessary to curve a good deal to the west, in order to run as straight as possible for May's Ravine, which, upon being closely surveyed and levelled, seemed to be the best place for descending to the reach above Lock No. 1, at Port Dalhousie.

The position of the swing-bridge is accordingly shown on a short tangent between two curves to the west, each of 1000 feet radius.

The line then runs nearly straight to 3.62 miles, taking advantage of a spur of high ground between two small tributaries of the Ten Mile Creek.

This avoids throwing the canal into heavy embankment. On the length of 1.32 miles beyond the railway, locks Nos. 16, 15 and 14 (each 14 feet lift), lock No. 13 (13 feet lift), and locks 12 and 11 (each 10 feet lift), are shown. All these have reaches of from 630 to 850 feet between them.

The trial line then curves slightly to the west, and runs towards the western end of the St. Catharine's cemetery, crossing the Ten Mile Creek where the banks are very low, at 3.92 miles.

It is noticeable that all the branches of the "Ten" have, in the vicinity of the Great Western Railway, high banks; but at about three-quarters of a mile to the north of it these valleys run out, and the streams are nearly on a level with the surrounding country. Advantage has been taken of this feature to cross the Ten Mile Creek at a favorable place.

The cemetery corner is reached at 4.56 miles, and the road from St. Catharines to Homer, &c., is here crossed. The present line is shown on the map as curving slightly to the east, for the purpose of shortening the cut through the gravel ridge on which the road runs, and in order to get a crossing as nearly at right angles to the latter as possible.

From this point the trial line bends a little to the west, and runs straight past where the Niagara road intersects the side line between lots 14 and 15 of Grantham. There are five roads meeting here, which can be served by one bridge. The long tangent shown is produced some distance further, and then by a slight reversed curve the trial line crosses the Welland Railway, for the second time, at 7.01 miles, and immediately south of the curve near the head of the grade to Port Dalhousie.

It may be remarked that from lock No. 11 to the point of intersection with the Welland Railway, the general direction of the line is north-westerly and the ground presents no difficulty. A curve is shown to the north of the cemetery for the purpose of avoiding valuable private property, houses, &c. A straight line can, however, be had without involving more excavation than on that now projected.

From the second crossing of the Welland Railway the line runs to the head of the North branch of May's Ravine, and down it to the present canal, the centre of which is reached at 8.66 miles from the point of divergence above Thorold.

To the south of the railway the maximum lift of lock is 14 feet, and the reaches vary from 830 to 7,000 feet in length. The line will be easily constructed between locks 11 and 5, the latter being close to the railway.



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From this point to the head of May's Ravine the work will be heavy, if the grade of the railway be taken as governing the canal levels. It may perhaps hereafter be considered advisable to alter the location or grade of the track, or both.

The level of the rails from St. Catharines to the head of the grade descending to Port Dalhousie does not differ very much from that of the ground adjacent; hence the canal surface must be entirely in cutting, in order to pass under the present line, giving at the same time the necessary height to construct the turning apparatus, &c., of a swing bridge.

It follows that the sooner the railway can be reached from the head of the Ravine, the lighter the canal work can be made, as immediately after crossing the track, the water surface can be thrown up out of cutting, as shown on the profile. To make this clear it will be necessary to describe the trial line at the outlet of May's Ravine.

The present canal level above lock No. 1, at Port Dalhousie, is taken at 12 feet above datum of mean surface of Lake Ontario. By placing the second lock above the lake in the point of the south side of the entrance to the ravine, and damming the water back, a reach can be obtained above it of 1,350 feet in length, and generally of a good depth. Lock No. 3 might be located a little to the west of the main road from Port Dalhousie to St. Catharines. The reach between it and No. 2 would then be about 1,000 feet, and the surface level of the canal 44 feet above datum. Lock No. 4 could be placed near the point where the north branch of the ravine runs out—the surface above it being about 60 feet over datum. This would give a suitable height to pass under the present grade of the Welland Railway, which at the point of crossing is 68 feet over the same place.

It is quite practicable to divide the 48 feet, thus proposed to be overcome, by 3 locks, into four lifts if required. In this case, it would perhaps be better to adopt the south branch of the ravine, as a site for the canal. This would lengthen the whole distance only some 500 or 600 feet. The calculations are, however, now made for the line down the north branch.

As before stated, the trial line joins the existing canal in the reach above lock No. 1.

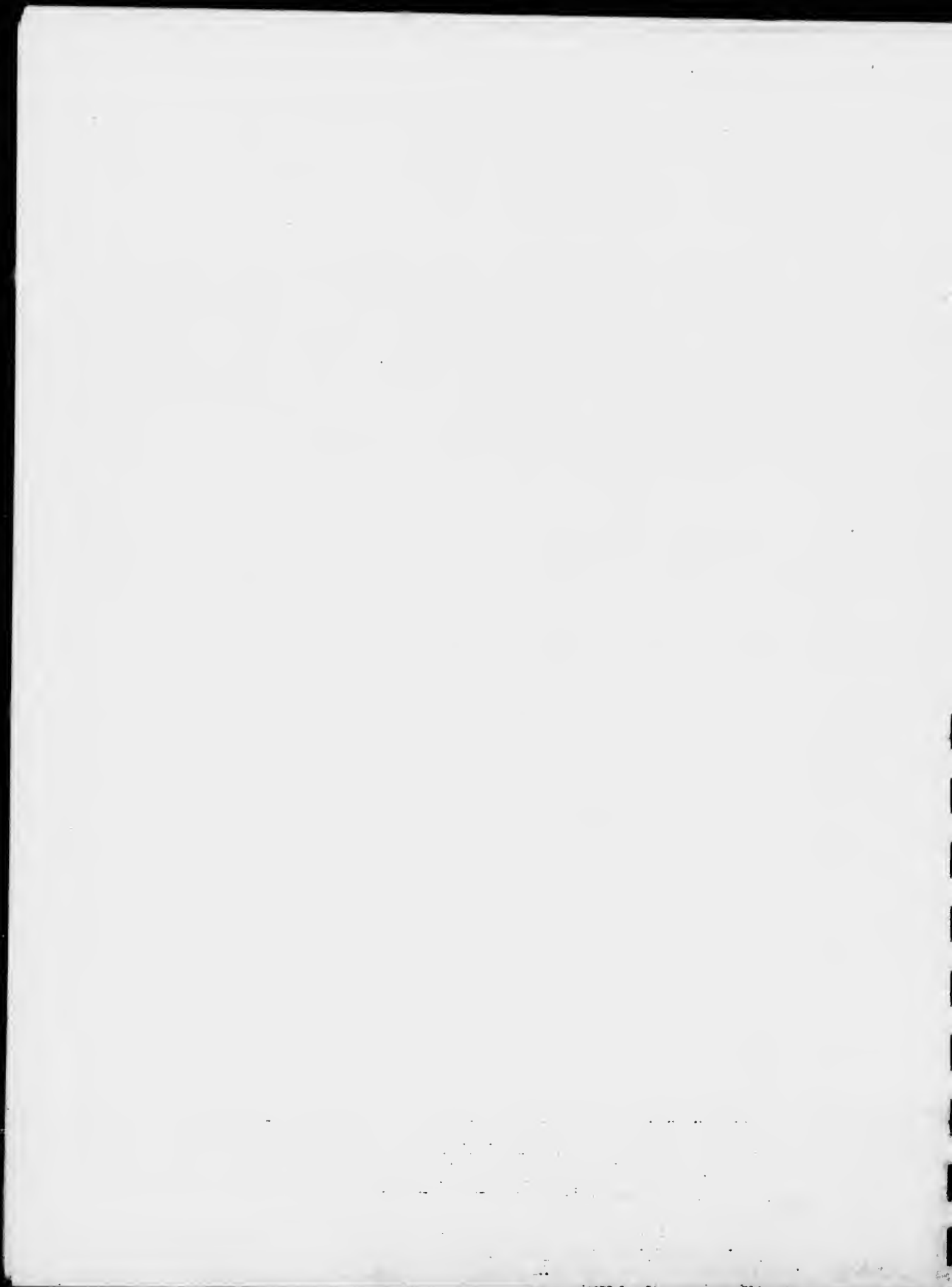
Between this point and Port Dalhousie, there is a large bay on the east side of the canal with an area of 40 acres, in which there is at present from 12 to 15 feet water, with a mud bottom. This forms a capacious inner basin, for the accommodation of a large number of vessels. It is almost completely land locked, so that all those likely to be detained from going out into the lake during stormy weather, might safely lie there without interfering in any way with the upper bound traffic.

Soundings were taken over the area—between the entrance piers to the harbor—and for some distance out into the lake. Cross sections were also taken on the east side of the present lock, at Port Dalhousie, where it seems the enlarged lock should be constructed.

The general depth from the lock to the end of the piers (a distance of 3,200 feet,) is with 12 feet on the lower mitre sill, from 10½ to 12 feet. A portion of the material forming the bottom is hard; but there is no reason to believe that to obtain the necessary depth for a canal of the proposed dimensions, any extraordinary difficulty will be encountered. A part of this work is now under contract. The water gradually deepens lakeward from the head of the piers, and there are no shoals or other dangers in the approach to this harbor from any direction.

All the information obtained during the period of the surveys and examinations, from captains of vessels and others practically acquainted with the requirements of the trade of the canal, proved clearly that Port Dalhousie is one of the best ports on Lake Ontario. So that by an increase of depth and area it can be made fully adequate to the wants of the proposed enlargement, and this can be accomplished at a reasonable outlay.

Trial lines were run from the projected route above described to another ravine on the right bank of the present canal, on lot No. 21 of Grantham (IV Con.), and about one mile below lock No. 2. A general examination of the banks on this side was made with a view of finding some place which might improve the proposed location. The results prove that the point selected for entering the canal is decidedly the best.



The foregoing description will show the general features of the proposed line for enlargement between Thorold and Port Dalhousie. It is about three-quarters of a mile shorter than via the present canal between the same points—and there are no objectionable curves at any place along it; whilst about 60 per-cent. of the whole distance of 8½ miles is straight line, or nearly so. Ample space can be had between locks to permit of vessels passing each other freely, and the Railway crossing can be so arranged as not to interfere with existing grades, whilst at the same time, the efficient working of the proposed canal can be fully secured. If the line recommended should, in the main, be adopted for construction, the relative levels of the old and new canals will be such that a large milling and manufacturing power can be created on channels discharging from the latter into the former at various points. The nature of the soil through which the line runs is generally so favorable for the construction of water-tight banks and sides, that the loss from leakage and infiltration (often a serious item), will probably be reduced to a minimum, whilst, in the execution of the work, the proximity of large quarries of excellent building stone, together with an abundance of first class cement, will prove a great and obvious advantage. Finally, the Lake Ontario terminus of this line can, as before stated, easily be made capable of accommodating the largely increased trade, which will, beyond all doubt, follow this route upon its completion to the scale now contemplated.

Near where the trial line to Port Dalhousie passes the west corner of the St. Catharines Cemetery, it runs close to the head of a branch of the Twelve Mile Creek, which enters the present canal at what is known as "Collier's Bend," a short distance below lock No. 5.

It is doubtless practicable to descend by this ravine, and form a connection with the present work; but the line would be crowded in between high banks, where it would be difficult to locate the required waste weirs; and the channel would be crooked and unsuitable to the navigation of the character contemplated.

This line would interfere with the existing hydraulic race by which the water is now supplied to the several mills in St. Catharines, and would cross the Welland Railway where there is a very heavy embankment, necessitating a formidable bridge. It is also said that the character of the soil in the gully at some depth below the surface is, in places a sort of quicksand unsuitable for the foundations of the locks.

But it seems to me that the chief objection to this route, and one that would outweigh all ordinary considerations of economy is, that it leads into the tortuous channel of the existing canal, where the traffic of both would be thrown together, and where in some places it would be almost if not quite impossible to obtain a line adopted to the requirements of the enlarged canal.

In my humble opinion the lines of traffic when divided at Thorold, should not again be united in the same channel until the inner basin of Port Dalhousie is reached, where there is ample room for both without danger of interruption to either. For these reasons the present canal has not been surveyed from Collier's Bend to Port Dalhousie, although information can readily be provided from existing documents, on which to base an approximate estimate of cost, should the proposition of enlarging by this route be entertained. The profile shows the lockage and longitudinal section down the ravine, which has been measured and cross-sectioned closely throughout.

2. From Thorold to Port Colborne the existing canal has been accurately surveyed and cross-sectioned at distances, of 500 feet apart, so as to afford sufficient accurate data to make an approximate estimate of the cost of the enlargement.



As instructed by you, the quantities between Thorold and Allanburgh, have been calculated on the arrangement that the water in the reach between these points will be raised two feet, instead of lowering the bottom to obtain the requisite depth.

Up to the bend below the Allanburgh bridge, at the Holland road crossing the present line is generally followed throughout. At this point, however, the very objectionable approach to the lock from the lower level, may be avoided by adopting a new line for enlargement. This would permit of the necessary works being constructed, without interruption to the business of the existing canal.

The ground in the vicinity of Allanburgh, has been closely cross-sectioned, to enable the new line at this place to be located on the west side in the most favorable position.

Between Allanburgh and Port Robinson, sections were carefully taken through the "Deep cut," and the calculations for the enlargement of this formidable excavation, are made for the same bottom width as the other parts of the projected canal, namely 100 feet.

From Port Robinson to Welland the canal is, in some places, close to the left bank of the Chippawa River, and in considerable embankment on the side next the stream. The enlargement is therefore at such place, projected on the side next the land, to avoid any interference with the banks, which are now rendered solid by repairs, and the time they have been built.

At the town of Welland, numerous cross-sections and soundings of the river were taken, with a view of obtaining a line for a new aqueduct, in case it should be considered necessary to build one. Between Welland and the junction of the feeder, the excavation is calculated for on the west side of the canal. Beyond this, on the long straight line to Ramney's Bend, the enlargement is also intended to be on the same side. The tow path is at present on the east side of the canal, and also the road from Welland to Port Colborne.

Through the rock cut above Ramney's Bend, and that from below Stone bridge to Port Colborne, the quantities are taken out for the east side, the west bank being covered with large heaps of soil arising from the excavation of the present canal.

At Port Colborne the harbour was carefully surveyed and sounded, together with the entrance, and for some distance outside the lighthouse on the end of the west pier.

The result of these measurements showed that there is a considerable area of rock lying inside the west pier, which it will be necessary to excavate to the required depth for the entrance when the canal is enlarged.

The work is, I believed, now under contract.

An additional lock will probably have to be provided at Port Colborne of the size and depth required for the proposed canal, the present one being only 230 feet, long between quoins.

During calm weather, and at ordinary level of the lake, neither of these locks would have any lift when Lake Erie level is introduced. But as the sudden fluctuations caused by storms have rendered it necessary that the present lock should be provided with two sets of gates opening in opposite directions, a similar arrangement will, it is presumed, be made for the new lock. This will enable a higher level to be resumed temporarily for the summit, should this at any time prove advisable.

It is quite evident that at no time would it be possible to pass through the gates of these locks the large body of water required for the supply of the new canal as well as that for the present canal below Thorold. It will therefore be necessary to construct a large weir for the purpose. This might be built on the east side of the inner basin, and a channel excavated from it to join the canal a short distance north of the locks, passing under the Grand Trunk Railway. The swing bridge at the crossing of this line will, of course, have to be rebuilt. With reference to the supply for both canals below Thorold, if the prism be made through rock cutting of the dimensions estimated for, an ample volume can pass through it without creating an objectionable current. A slight current downwards and in the direction of the heaviest traffic would be an obvious advantage to the trade.



From observations made when sounding Port Colborne Harbor, and from the information obtained there, it appears certain that the mitre sill of the present lock is at least one foot too high. On several successive days of calm weather last fall there was only a little over 12 feet on the sill, whilst a slight wind off shore would lower the water suddenly five or six inches.

In the month of October last there were 11 days on which the register kept by the Lockmaster shewed less than 12 feet on this sill, when his usual measurement was taken at noon of each day. There were also 12 other days in the same month when the depth did not exceed twelve feet three inches. This shows conclusively that the mitre sill of the Port Colborne Lock should be lowered at least one foot to admit of a twelve foot navigation. It is to be remarked, however, that last fall the level of Lake Erie was very low.

The level of the floor of the present aqueduct at Welland is 1.47 feet higher than that of the mitre sill at Port Colborne. If this floor were removed, the backs of the arches would be about level with the sill referred to. But it has been shewn that the latter is at least one foot too high, and it would be well to give the bottom of the enlarged canal a slight inclination northward in order to ensure the full delivery of the necessary supply of water for both lines at the lower end.

Even were the floor of the aqueduct made low enough to give the required depth of 12 feet, it is evident that when the summit is reduced to Lake Erie level the structure would not afford sufficient area to pass the water required for both canals except at such velocity as would prove an obstruction to the navigation.

It will therefore be necessary to construct a channel for the supply of this volume, alongside of the present canal.

The above description will, I trust, draw attention to all the chief points connected with the enlargement between Thorold and Port Colborne. The whole of the traverses and triangulated parts of the surveys, were checked on a base line measured between Lakes Erie and Ontario, having a total length of over 23 miles.

From the junction of the feeder with the main line of canal to the Port Maitland branch at Stromness, a survey line was run and level taken. The results show that the distance between these points is nearly 16½ miles; and the average cutting for a canal to Lake Erie level would be a little over 21 feet.

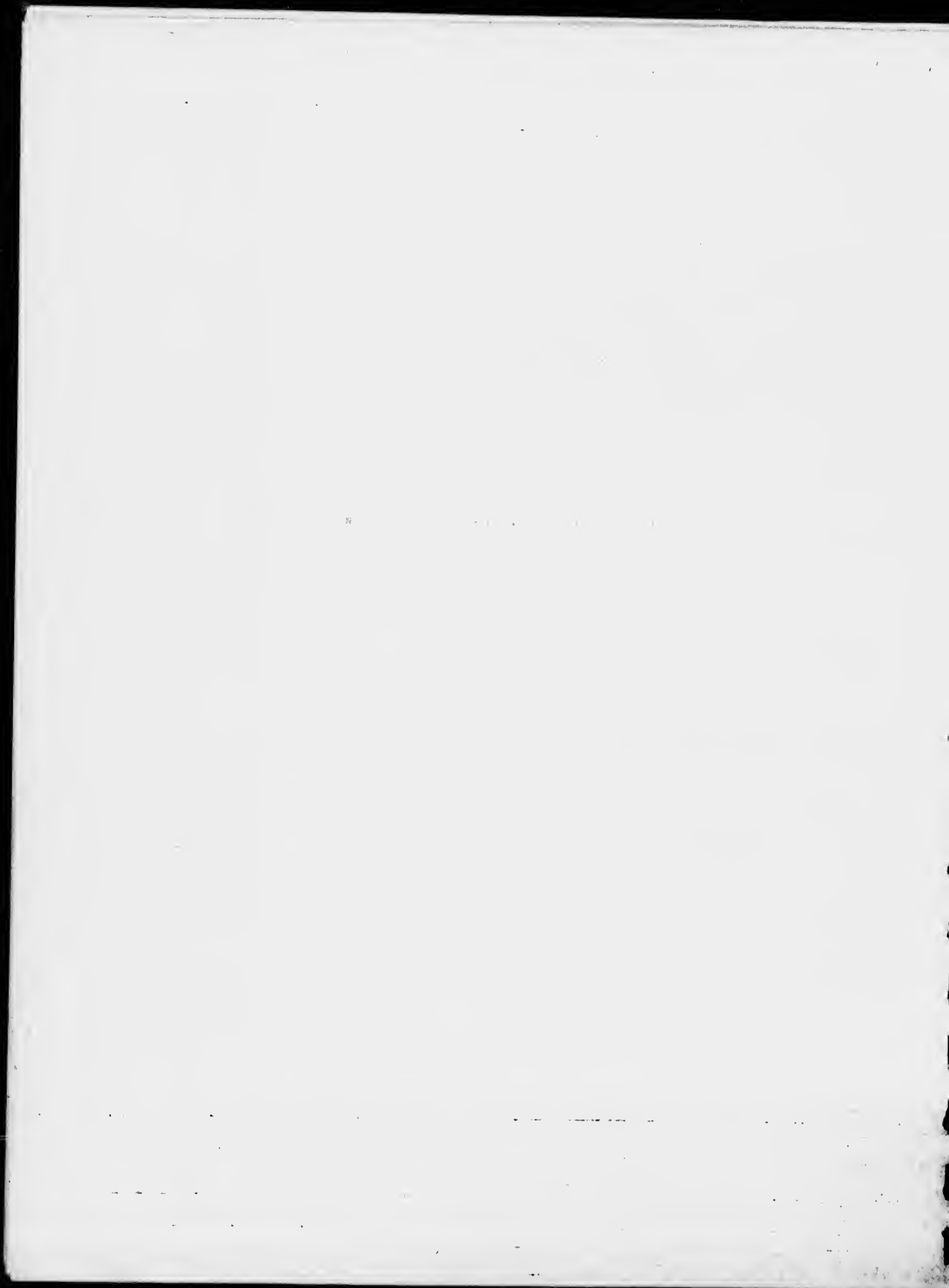
The country traversed by the feeder is very flat, and the borings taken at several points along it shewed a surface deposit of from three to four feet of peat or vegetable mould, underlying which blue clay was found in every case.

At the branch to Port Maitland, Broad Creek crosses the feeder. This creek was roughly surveyed, and borings taken in its bed for about three-quarters of a mile in the direction of the Grand River, into which it flows about two miles above Port Maitland. These soundings shewed no rock—noting but mud and stiff clay down to and below the bottom line of the projected canal.

Judging from the ground in the vicinity, it appears as if the Carboniferous limestone (through a ridge of which the present branch to Port Maitland has been partly cut) falls off abruptly on the eastern bank of Broad Creek, about a quarter of mile to the west of the existing canal—at all events, we found no rock in the bed of the creek close to the eastern shore, nor on a straight line from a point at the "Quarry" to a junction with Grand River.

From Stromness to the latter, the distance is 7,250 feet, on which there would be an average depth of at least 14 feet of mud and clay cutting. From the point where the survey line strikes the Grand River, the distance down it to the mouth of the Port Maitland branch is one mile; and to the piers at the entrance to the harbor, 3,250 feet farther, making the total distance to this point from the feeder junction near Welland to be about 19½ miles.





The excavation necessary in the formation of this line, from the junction to Grand River would be fully 10,000,000 cubic yards.

Through the river, in the direction of the piers, from Broad Creek, the soundings showed nearly 30 feet in the centre, until about opposite to the entrance of the present canal. The stream is about 400 feet wide for this distance. From thence the channel shoals to a point near the centre of the village, where there is a sort of sand bar with from 12 to 13 feet of water on it. After this is passed it deepens quickly, carrying nearly 20 feet through the entrance and out into the lake.

The width between the outer part of the piers is 180 feet. When they were built the plans showed that there were only nine or ten feet water between them. The present depth demonstrates the effect of scour on a shifting bottom during spring freshets, at which time it is stated that the current of the Grand River is objectionably strong.

From the foregoing it will be seen that the route *via* the feeder to Port Maitland from the junction with the main line of canal, would be 19½ miles in length, whilst the distance from the same point to Port Colborne Harbor by the present canal is but 6.27 miles, showing a difference in favor of the latter of 12.50 miles. These lengths are measured in both cases to the entrance piers of the harbors.

There are, however, other considerations which present themselves in connection with this matter which I shall briefly refer to.

Port Maitland is easily accessible in stormy weather—has, as already shown, a deep water entrance—and from the nature of the river bed, is capable of enlargement at a reasonable outlay. This harbor is now frequently used by vessels as a haven of refuge, and is stated to be one of the safest on Lake Erie. It has the additional advantage of being generally clear of ice much sooner than either Port Colborne or Buffalo. It is also well known that towards the eastern end of Lake Erie great fluctuations of the surface are caused by storms—the maximum effect from this cause being often productive of serious inundations at Buffalo. This is mainly owing to the rapid convergence of the north and south shores, and the fact that the city is situated at the extreme end of the lake.

These changes are neither so sudden nor so great to the westward. It is said that a S. W. gale which produces a rise of four or five feet at Buffalo, does not lower the surface at Cleveland more than a foot.

If this is substantially correct, it is clear that Port Maitland would be more advantageously placed in this respect than the present terminus of the canal on Lake Erie; and an entrance built at the former place could be more easily worked.

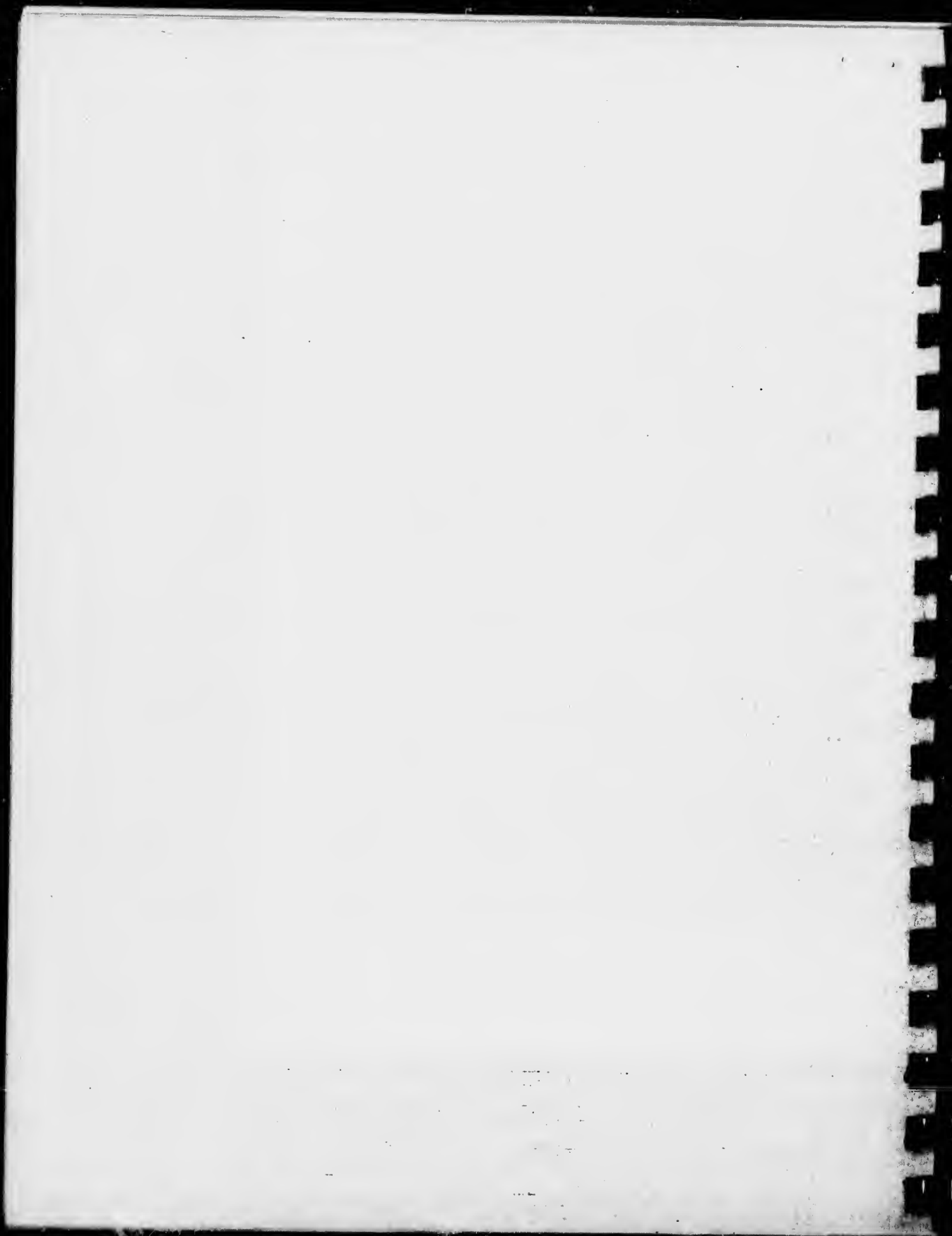
On the other hand, there are the important facts that in order to reach Port Maitland, about 10 additional miles of canal would have to be constructed and maintained—a greatly increased cost for towing would be entailed upon vessels, and the time of transit between the lakes would certainly be lengthened.

The enormous mass of materials arising from the excavation of the feeder route would chiefly have to be deposited on its sides, at some distance from the edge of the cut, necessitating the purchase of about 1,500 acres of land for this purpose.

Large ditches will also have to be formed to take the water of the marsh from the rear of the spoil banks, and the under culverts would have to pass the canal at a great depth below the surface, unless some arrangements could be made to receive the drainage of the surrounding country into the new channel.

A guard lock with double sets of gates would have to be built near the Grand River, and a lift lock, near Stromness, to keep up the feeder navigation to Dunville. One railway bridge would have to be built, together with several road bridges; the harbor extended, piers rebuilt, &c., &c. Taking all the circumstances of the case into consideration, it does not, in my opinion, appear advisable to adopt the Feeder Route for the enlarged Welland Canal.

4. With a view of determining whether a practicable line could be obtained up the valley of the Twelve Mile Creek, from its junction with the present canal at St. Cath.



arines, and from its head waters near Fonhill, across to the town of Welland, surveys were made and levels taken along both the main stream and its principal eastern tributaries. The general result of these operations may be stated in a few words.

No lower summit than that at the present canal at the "deep cut" was found. The ground to the west of Allanburg is nearly flat, or slopes up gently towards the basis of the steep rise on which Fonhill is situated.

Besides the valley of the Twelve Mile Creek, at St. Johns, has such a quick descent, that it would be impossible to avoid having several locks in combination in the vicinity, whilst all the eastern tributaries are at some point quite precipitous.

The level of the rock met in these examinations is not so high any where as that found in the ravine behind Thorold; and in the plateau to the east and west of the "deep cut," the soil seems to be similar to that formidable excavation—namely, clay resting on and merging into a sort of quicksand, which, when reached by the wells affords a supply of water.

There is no rock on the higher levels. The depth to which the aqueduct foundation were driven into the bed of the Welland River, without encountering anything but clay, seems to shew that it dips southward from Thorold, and is not again met until the strata of a higher formation appear near the shores of Lake Erie.

The valley of the Twelve Mile Creek is winding, and the stream is liable to violent freshets, whilst its waters is at such times charged with the clay swept from its banks. These are objectionable features, and generally there does not seem to be any good argument in favour of adopting this as a canal route.

5. The practicability of obtaining a line for the enlarged canal down the mountain slope at Thorold, without resorting to combined locks, being clearly demonstrated—a connection was subsequently made between the proposed route and that of the "Lateral Cut" to Niagara, at a point about a mile to the north of the Great Western Railway, inasmuch as it appeared that even if this scheme was adopted, the location now shown would be the best for its southern end.

At the town of Niagara, the line was run back from the bank at the ruins of Fort George, for about a mile inland and levelled. The ground for some distance to the north and south of the projected terminus of the canal was also surveyed, and cross sections taken at several places.

The river was also sounded for some distance in the vicinity.

The result of these examinations shew that the line marked on Mr. Stanley's plan is, doubtless, the best which could be found in this locality.

The banks of the river are generally from 40 to 50 feet high, and so steep as to offer but little choice of ground for the site of the combined locks. Advantage has, however, been taken of a bend in the stream a little to the south of Fort George, to locate the entrance, where the current is not so swift as above the Ferry Point, and where, in calm weather, the ice would have a direction towards the opposite shore.

By the kind permission of the gentlemen in charge at Fort Niagara, we made a copy of their carefully prepared chart of the mouth of the river, with soundings in the lake for some distance to the north and south of this point, and also for a considerable length up stream. An examination of this document will shew that in the centre of the river inside (which is here about half a mile wide), the water is very deep; the soundings shewing 70.80, and in some places 90 feet with a sand bottom.

The depths increase very rapidly from the west shore towards the centre of the stream. At 150 feet from the beach, measured on the line of the "Lateral Cut" produced, we found 51 feet water; and this was also shewn (at the same distance out) for several hundred feet above and below this point.

Outside the river mouth the water is not so deep, as on a line in the general direction of the centre of the stream, lakeward there is for some distance about 14 feet water.

To the north of Fort Niagara, and for a distance nearly three-quarters of a mile from the shore, there is a sand shoal with only 12 feet of water at its extremity. There is

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also a small rocky shoal with 15 feet water on it, shown about  $1\frac{1}{2}$  mile N.E. of the Fort, in the lake. These dangers would doubtless prove serious to vessels making the harbor in stormy or thick weather, as they lie in the general direction taken by those trading to or from ports at the eastern end of Lake Ontario.

Notwithstanding this objection, it is however evident that Niagara is a fine natural roadstead, capable of affording shelter to a very large fleet of vessels; and in certain winds it is easily accessible.

Still, if adopted as the lower entrance to the canal, it will necessitate the construction, maintenance and navigation of four miles of additional canal beyond that required to reach Lake Ontario from Thorold, via the proposed line; and there appears to be no way of avoiding four locks in combination where it enters the Niagara River, except by incurring a very large additional outlay.

Adopting about  $3\frac{1}{2}$  miles of the Port Dalhousie line for the south end of the "Lateral Cut" line, the distance by the latter from Mariatt's Pond to Niagara is 12.66 miles.

The water is so very deep in shore near Fort George, that it would be unfavourable for the construction of entrance wharves or piers where vessels could tie up when awaiting their turn to enter the canal, whilst works in such a position would be liable to destruction by the attacks of ice borne along by a rapid current. It is true that basins might be constructed on the flat to the north of the proposed entrance, but a large amount of excavation, docking, &c., would be required. It seems therefore clear that Niagara cannot be so improved as to form a harbor suitable for a large canal trade, without very considerable outlay, whilst its approach is not free from danger.

On the other hand, from all I could learn from ship captains and others practically acquainted with the requirements of navigation, as well as from actual observation during a period of one whole season, it is certain that the harbor of Port Dalhousie is one of the best on Lake Ontario, being easily accessible, and having no shoals outside in any direction.

Although the depth between the entrance piers is not at present sufficient for the draught of the proposed canal, it can be made so at a moderate outlay, whilst the existence of a capacious inner basin above lock No. 1, affords good shelter for a large number of vessels.

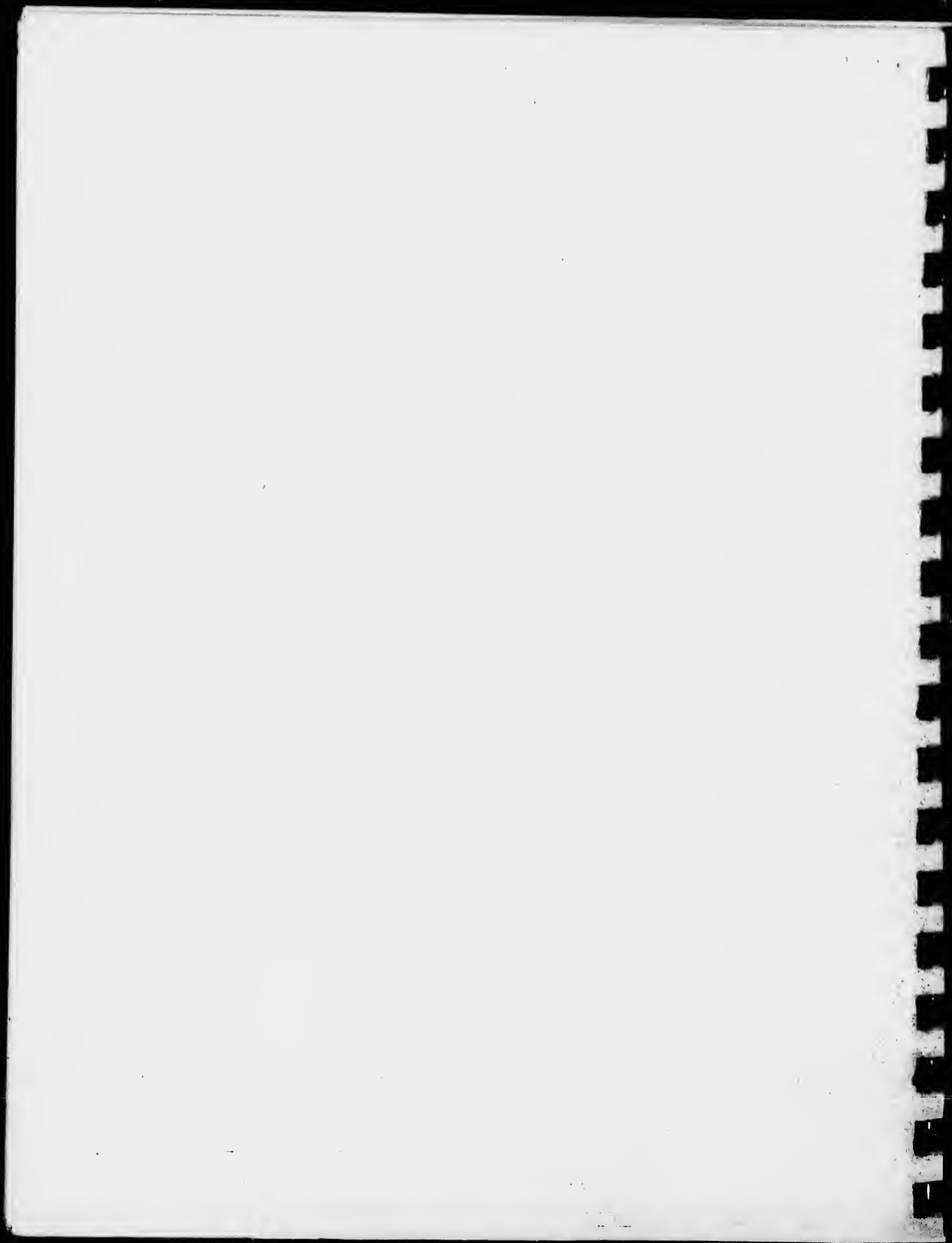
The rapid increase of propellers on the upper lakes, will in all probability render it quite unnecessary to provide very extensive harbor accommodation for the trade of a canal, such as the Welland, where no transshipment takes place at either end. At present, vessels frequently arrive in fleets, and require considerable room to receive them; but if it prove true, as is very generally believed, that steam will eventually supersede sail in the lake trade, arrivals and departures will be more continuous; the harbors will be less crowded, and the proposed canal will in all likelihood be worked to very great advantage.

As regards the mouth of Niagara River, it may be remarked, in conclusion, that this place is often blocked up with ice for weeks after Port Dalhousie is open. This seems reasonable to expect; as of course all the ice which comes down from Lake Erie has to pass here in a comparatively narrow space; whilst, should northerly winds prevail at these periods, they have the effect of keeping the ice in the river, or off the entrance for some time after it has disappeared from other ports on Lake Ontario.

The above are the principal facts in reference to the roadstead at the mouth of the Niagara River; and, unless I am quite mistaken, they point to the conclusion (especially when considered in connection with the additional cost of constructing a canal to this point), that the circumstances do not warrant the abandonment of Port Dalhousie as the Lake Ontario terminus of the Welland Canal, or of the enlarged canal now contemplated.

It may not be considered out of place to close this Report with a few remarks respecting the trade of the Welland Canal, as compared with that of its rival the enlarged Erie.

The idea has been widely promulgated, in reports and other documents, that the business of the Canadian canal is quite insignificant when compared with that of the



American one. This conclusion has sometimes been arrived at by incorrect comparisons, as, for example, contrasting the business of the whole of the New York State canals with that of the Welland alone.

It is clear, however, that to institute a proper comparison in this matter the shipments east and west by canal, at Buffalo, should alone be contrasted with the trade both ways at Port Colborne.

In this view of the case, it will be found that, although the business of the Erie Canal is in the aggregate very much greater than that of the Welland, yet in the chief items of Western produce which pass down it, there is not such a difference as might have been expected.

From the Buffalo Board of Trade Reports, for the years ending 31st December 1870 and 1871, it appears that the shipments east, by canal, of the following articles were as under:—

	1870.	1871.
Wheat .....		
bushels.	16,738,613	19,028,316
Corn.....	5,911,668	20,695,305
".....	5,572,254	6,649,439
Oats.....		
".....	163,204,218	141,648,046
Lumber.....		
ft. B. M.	12,880,000	6,725,000
Timber.....		
cub. feet.		

The returns at Port Colborne, kindly furnished by the Collector, Mr. Rooth, have enabled me to compile a statement of the trade of the Welland Canal for the year ending 31st December, 1871; and I have obtained that for the season of 1870 from the Inland Revenue Office. The chief items are as follows:—

	1870.	1871.
Wheat.....		
bushels.	12,838,749	12,828,005
Corn.....	3,280,329	8,389,658
".....	Not given.	309,008
Oats.....		
".....	46,812,600	54,994,491
Lumber.....		
ft. B. M.	2,489,900	3,421,439
Timber.....		
cub. feet.		

Only a small proportion of flour is carried by either canal, that article being now chiefly transported by rail. It may be said that, in addition to the above movement east at Port Colborne, the Welland Railway carried outwards nearly three millions of bushels of grain; making the total downward trade by canal and rail at that point, during 1871, over 24½ millions of bushels.

Trusting that the foregoing statements and conclusions will meet with your approval.

I have the honor to be,

Sir,

Your obedient servant,

(Signed,)

THOMAS MONRO,

Civil Engineer.



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S MONRO,  
Civil Engineer.

No. 17,6910.

QUEBEC, 3rd January, 1873.

GENTLEMEN,—The enlargement of the Welland Canal is such a large work and of such an importance for the future of Canada, that the Government of the Dominion wish to obtain the best advice they can procure from Engineers of eminence in this country and even in the United States. I have therefore requested you to examine the proposed enlargement, as indicated on the plans and in the specifications prepared by our Engineer, Mr. Page, and I am sure you will not object to consult with Mr. McAlpine, whose knowledge and experience are well known. I have, therefore, the honor to inform you, on behalf of the Government, that you are hereby authorized to communicate with Mr. McAlpine, and to ask for his professional counsel and advice in this matter—you should not limit yourselves to the above plan and specifications, but you should also consider any other plan or scheme which has been suggested to the Government, and may be found in my Department. The report we expect from you should state whether the proposed Plan of Mr. Page should, in your opinion, be modified, and in what particular, and the object of such modifications, adding any other remark or recommendation you would think proper.

Messrs. C. S. Gzowski and }  
Keefer.

H. L. LANGOEVIN,  
Minister of Public Works.

Copy of No. 28,600.

OTTAWA, 14th February, 1873.

To the Honorable HECTOR LOUIS LANGOEVIN, C.B.,  
Minister of Public Works, &c., &c., &c.

SIR,—In compliance with a desire expressed in yours of the 3rd January, that we should examine the proposed enlargement of the Welland Canal as indicated in the Plans and Specifications prepared under the directions of the Chief Engineer of your Department.

We lost no time in making the necessary arrangements for entering upon that duty and beg now to submit the following report as the result of our labors:—

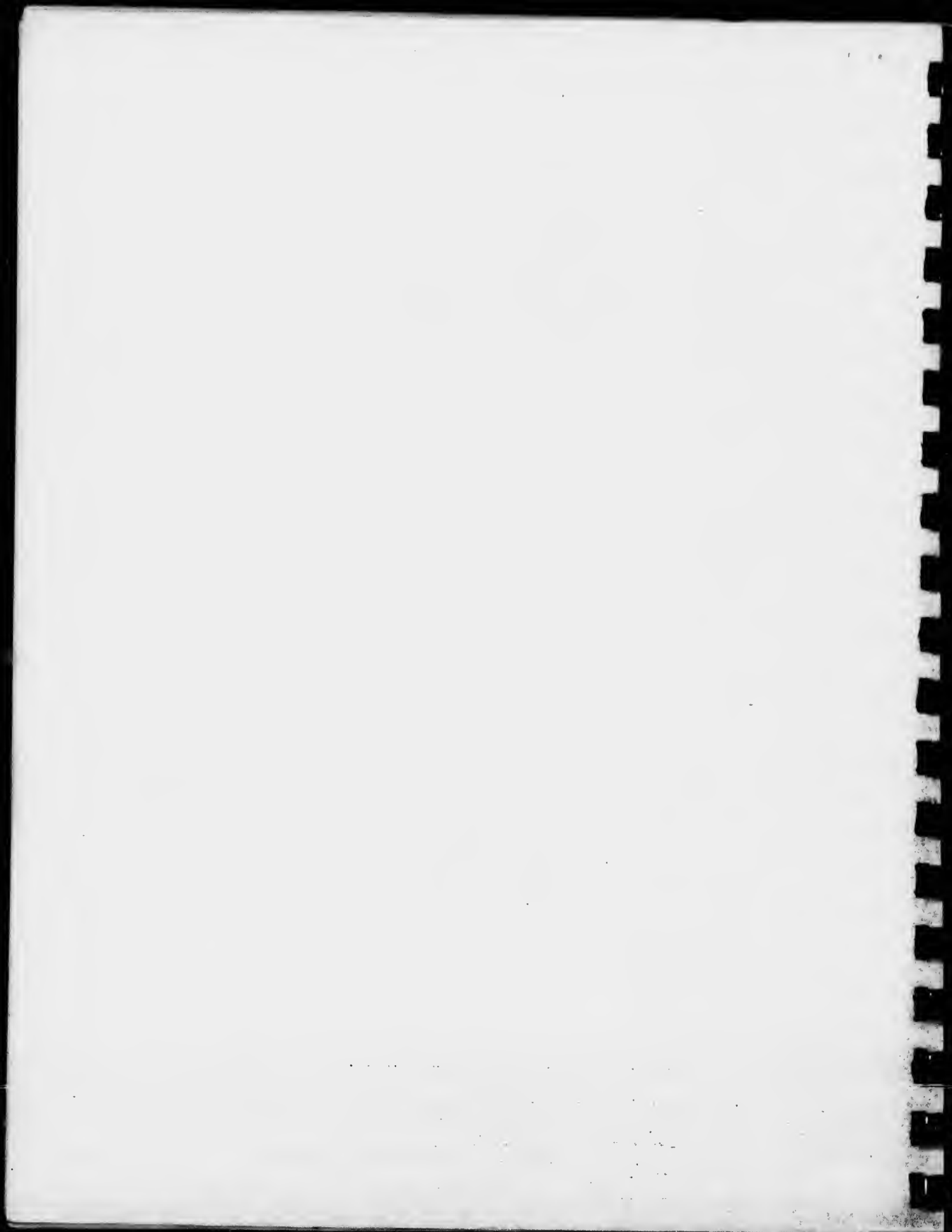
After a preliminary conference in Toronto, we addressed a communication to your Chief Engineer inviting him to meet us and give us the benefit of the information which is of official connection with the plans and surveys so well qualified him to do. (Copies of our letter and his reply are appended.)

In arrive at a satisfactory conclusion on the merits of the several projected routes described in the memorials and documents referred to us, it was considered necessary to make a personal examination of that portion of the peninsula between Lakes Erie and Ontario. We therefore visited nearly the entire line of the present canal, making more special examinations of the localities near St. Catharines, Thorold, the Deep Cut, Port Colborne and the line proposed by Mr. Grenville.

We have also visited Chippawa, Drummondville, Quebec and Niagara.

The intimate acquaintance with the several localities named and of that section of the country generally, by one of our number, with the general knowledge of its geological character by all of us, removed most of the difficulty caused by the ground, at the time of our examination, being covered with snow.

Although your instructions refer more particularly to the examination of plans and specifications already prepared, we believe that our statement, on this head, will be more clear and better understood if we, in the first place, express our opinion briefly on the several alternative lines, and conclude our report with the recommendations we are prepared to make in regard to the located line.



The first of these alternative lines is that proposed by Mr. Grenville, and supported by the St. Catherine's Board of Trade, and some others; its chief features are, 1st, the descent of the mountain range by two flights of combined locks, located in a straight line; and, 2ndly, the saving of distance in the new line to be constructed.

Mr. Grenville's proposed line commences at a point on the located line on Marlatt's Pond, and connects with it again near the junction of the Twelve Mile Creek with the canal, making the distance three and two-thirds miles, as against the located line of eight and two-thirds miles.

The difference of level between these points is proposed to be overcome by two flights of double combined locks, one combination of fifteen locks, and the other of six combined locks.

Examination of the ground on this route reveals its peculiar features, which are a rocky ridge with an abrupt declivity, covered with the debris or drift from the solid formation of the rocky plateau.

The larger number of the combination of fifteen locks are placed on the face or scarpment of this plateau, partly in rock and partly in clay and debris.

The very great difficulty, in our opinion, of obtaining a safe and uniform foundation for the locks so located, the danger from slides and infiltration that cannot always be successfully guarded against, even with a largely increased cost in construction, and the impossibility, from the general features of the rocky formation in that vicinity, of finding any other line to meet the proposed arrangements of combination of locks, precludes our entertaining the project of entering further into the discussion of its merits and demerits.

We may, however, add, that were the natural features favourable for such a location and arrangement of lockage, the cost of construction being nearly double that of the located line, would, in itself, be sufficient reason for not recommending its adoption.

The next alternative line is the Chippawa, St. Davids and Niagara, or Queenston line.

This involves heavy cutting of rock and clay through the summit, and combined double locks for descending the mountain at St. Davids and at Queenston, or Niagara, there being no way avoiding them.

The length of the summit cutting, from Chippawa to St. Davids on the line indicated in the memorials and pointed out to us, is nearly seven miles. The depth of cutting at the summit, according to levels we had taken, would be 120 feet, and the average nearly 65 feet.

A lower summit can be found on the plateau below Drummondville, where the deepest cutting would be about seventy feet, and the average depth not exceeding fifty feet, but with an increased amount of rock cutting.

The length of canal to build from Chippawa to Queenston would be about ten miles, to Niagara about fifteen miles.

The magnitude of excavation for either of these lines is one of the chief objections—but there are still others. The termini of the canal at Chippawa, or at a point indicated a short distance above are objectionable on account of the current in the Niagara River, which is due to the fall of nearly eleven feet between its head near Fort Erie and Chippawa, but varied by the conformation of its banks, and in several places increasing to upwards of five and a half miles per hour. Such a current must call for constant service of tugs for all sailing crafts, and thereby increasing the cost of transport.

The proximity of Chippawa terminus to the very rapid current above the Niagara Falls; is another serious objection; any slight derangement in the machinery or steering gear of steam vessels passing into or out of the canal, or to the tug boat towing a sailing craft, would expose them to great danger of being carried down the rapids. Another serious objection to this route is the construction of the International Bridge below Buffalo and Fort Erie, compelling all vessels to pass through a draw.

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The already powerful and growing railway interests in the United States and Canada striving daily to increase the facilities of communication between the great producing west and the eastern consuming markets, will, before long, require additional bridge accommodation across Niagara River, to carry the trade. Other bridges will, undoubtedly, be built; and that would still further increase the difficulties of navigation in that route, and must be considered as another objection to the adoption of Chippawa as the terminus of the canal.

Another projected route is called the Niagara Lateral Cut.

This line commences at some point on the present canal near Thorold and terminates near the mouth of the Niagara River, and if constructed would increase the length of canal nearly four miles.

The construction of the works essential to a terminus for a canal on the enlarged scale of the Welland, with the best selection of the most convenient point in the river, must involve very large money outlay.

The river is too narrow and too deep to permit the construction of works which would still further reduce its width and increase the existing current (already sufficiently strong to call for the service of tugs for all sailing vessels) to a dangerous extent, but if so built the works would also be exposed to danger from ice which passes in large quantities in the spring of the year. The entrance, wharves, piers, docks, &c., would therefore have to be built in part on the level bank above the river in deep cutting, causing very large amount of excavation.

The construction of three or four combined locks to make the descent to the river is unavoidable, and as such combination of locks has been generally admitted to be objectionable the necessity of having them at Niagara forms a strong objection to making that port the terminus of the canal.

The accumulation of ice in the spring of the year, held in and near the mouth of the river by northerly winds is another objection, and is one from which the existing harbour at Port Dalhousie is quite free.

No valid complaints, we are informed, have been made against Port Dalhousie harbour as the terminus of the Welland Canal. We do not therefore see any good ground for recommending the construction of a new line to the mouth of Niagara River, fraught with the objections of increased distance of nearly four miles of canal;—difficulty and great expense of constructing the necessary terminal works; necessity of having combined locks; tugs for the use of all sailing craft, and liability of detention by ice.

THE WELLAND CANAL PROPER.

No better harbours can be found either on Lake Erie or Lake Ontario as termini for a canal uniting these two Lakes than Port Colborne and Port Dalhousie.

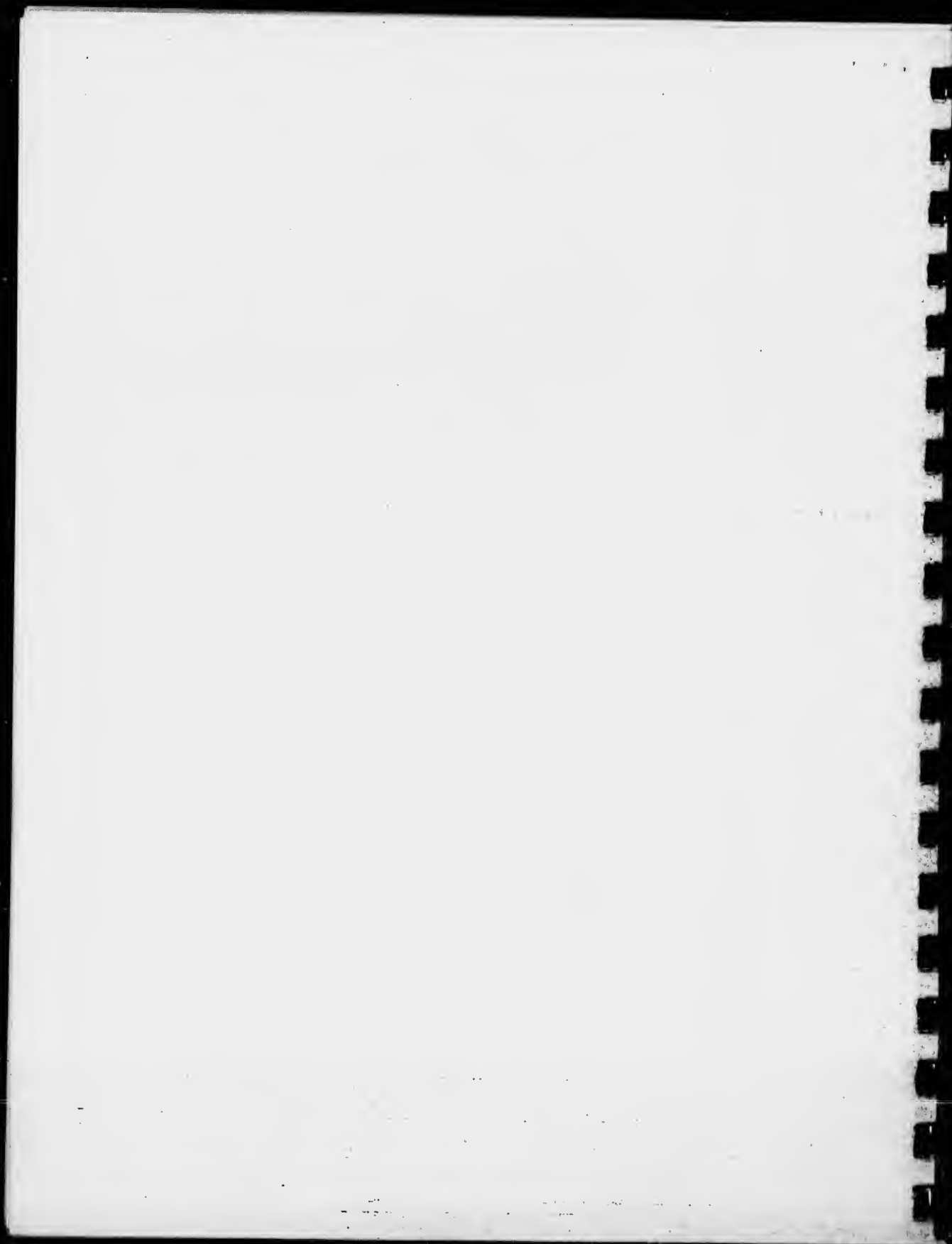
They have answered the purpose of ports of entry ever since the canal was opened, without any complaint, and they can now at moderate expense be improved to meet all the necessities of the enlargement.

No better line for uniting these two ports can be found than the line of the existing canal except that a departure from it is inevitable for overcoming the descent from the upper to the lower plateau from Thorold to Port Dalhousie, for the reasons pointed out in the report of the Canal Commission of 24th February, 1871.

Here a loop line has been traced out between these points under the direction of your engineer, nearly corresponding with the line indicated in that report.

In making the enlargement there can of course be no departure from the existing line between Port Colborne and Thorold, and so far as the plans have been prepared for the enlargement of the prism of the canal, they meet our approval.

We have not seen any plans, if they are prepared, for the admission of the water at Port Colborne, nor for passing more at the aqueduct, and therefore make no reference to them.



The length of this deviation line, from the point of departure from the old canal in Marlatt's pond, above Thorold, to the point of intersection at lock No. 1, Port Dalhousie, is  $8\frac{3}{4}$  miles, or  $\frac{1}{4}$  mile less than by the old line between the same points. The difference of elevation to be surmounted in this distance is 320 feet.

According to the plans submitted to us this is to be accomplished by 24 locks, 23 of which are on the loop line. Of these there are three of 16 feet lift, thirteen of 14 feet, one of 13 feet, two of 12 feet, one of 11 feet, and three of 10 feet lift. Of the reaches between the locks there are six of 630 feet, five of 730 feet, two of 830 feet, and the remainder varying from 1,120 to 6,930 feet in length.

We consider this arrangement of locks objectionable.

Where the conditions are such as to permit the adoption of nearly uniform lifts, as they certainly do here, we think so much diversity of lifts should be avoided. For the practical working of the canal—for the economical use of the water—for convenience of supplying reserve gates in case of accident—it is desirable that nearly uniform lifts should be maintained, unless they involve too much excavation.

We recommend that the difference of elevation should be overcome by 20 locks instead of 24, and to make the lifts chiefly 16 and a few 17 feet, so as to meet the conditions.

By this arrangement four locks will be saved, the reaches lengthened, and the time of transit shortened; while the levels of the long reach between locks seven and eight and that at the Great Western Railway crossing between locks sixteen and seventeen will remain unchanged, and the altered position of the locks will afford a better crossing of the Ten Mile Creek; and avoid making a siphon culvert for it under the canal.

While the sloping ground from Thorold to Port Dalhousie presents the only possible route for a single line of distributed locks, with ample basins between them, very serious difficulties have been interposed to the selection of a proper line by certain chartered rights which have been conceded by Parliament, since the existing canal was constructed.

These are the three railway crossings:—Two of the Welland, and one of the Great Western Railway—the latter being on a gradient of nearly forty feet to a mile.

Under all the circumstances we think your engineer has selected the best crossing that can be made of the Great Western Railway; but his treatment of the Welland Railway involves his line through the gorge at Thorold in very serious difficulties.

There are two reaches here where it is impossible to have outside basins except at very large cost in deep rock cutting; and where the canal surface is so limited that a single lockage would have the effect of lowering the water thirteen inches in one and twenty inches in the other; and where in the order to prevent grounding the vessels, it would be necessary to run a large body of water through the waste weirs outside the locks.

Allowance must be made in all the reaches for a fluctuating surface level, generally of only a few inches where ample basins can be made; but here it would be necessary to sink the mitre sills and bottom levels from one to two feet in order to provide for the lockages.

To avoid this complication of the navigation, we suggest that the line for the enlargement shall follow that of the existing canal through the little deep cut to Thorold and after descending into the first basin between the two upper locks to sweep round to the north of the village, and unite with the proposed line somewhere below Brown's Cement Quarry. On this line there is a guard lock lock already built and half the excavation made through the ridge of the little deep cut—the ridge that must inevitably be crossed by any deviation line starting from above Thorold. There will be reaches between the locks from one thousand to twelve hundred feet in length and facilities for obtaining a sufficient water surface for the working of the canal, will be by suitable arrangement of the locks and levels, and by shifting the line of the Welland Railway a little to the east, without altering the gradient, a good crossing of that railway can also be obtained.

Looking at this question in its engineering and commercial aspects, we consider this the best line for the enlargement, and if the Railway Company is obliged to have a draw



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bridge on its maximum gradient, this is not deemed an insuperable objection, but in view of the general interests of trade, it would be an inconvenience that must be submitted to as unavoidable.

It is true that this line involves changes of street crossings and purchase of some mill privileges, but we are of opinion that its cost will not exceed that through the gorge, while it will be much better for the navigation in every respect. And as regards the re-arrangement of the locks as we suggest, we do not think there will be any material difference in the cost, while we are clearly of opinion that it will afford greater facilities to the navigation than the one on which the plans have been prepared.

We do not think it necessary to construct the road culvert under the canal near the crossing of the Great Western Railway. It will be much better and save considerable expense to carry the road over the canal, by a swing bridge placed on the extended walls of the lock and on a sloping embankment forming the approaches to it.

We have examined the general plan of a lock which has been submitted to us with the other plans.

We observe that no provision has been made for filling the chamber of the lock through the lock walls, and that consequently the chamber must be filled entirely through the gates. We consider this a defect that ought to be remedied.

Means should be provided for filling, both through the gates and through the lock walls, so as to shorten the time of passing vessels, and also to prevent the surging when water is admitted in only one direction.

There are some minor points respecting which modifications might be suggested, but we consider that they will naturally occur to the engineer who will be charged with the duty of carrying out the recommendations we have made.

It may be well to observe, that the time occupied in the examination of this subject, to arrive at the conclusions we have communicated to you, has not in our opinion delayed the progress of this important work, for, in addition to the advantages gained, whatever they may prove to be in directing to its final location fresh and disinterested minds, the short postponement of the date (the 25th of January inst.) for receiving proposals cannot practically be considered as a delay. The winter, in that section of country, by the 25th of January, may be considered as well over, and it would not have been advisable to allow the quarrying of stone for the locks, about the only work that might have been attempted, till the season of severe frosts had passed. No other preparation for carrying on the work could have been advantageously made before spring.

After a careful consideration of the whole subject we are unanimously of opinion:— That no line for a canal suitable to the existing and anticipated trade between the western chain of lakes and the waters of Ontario and eastward, can be obtained on the Canadian Peninsula, which is better adapted to the required purposes than that which has already been recommended by the Canal Commission;

That the best entrance and exit from and to such a canal, is at the ports of Colborne and Dalhousie;

That combined locks should not be introduced on such a channel of international navigation, but that they should be separated by basins of sufficient capacity to allow the traffic vessels to pass each other with the least inconvenience. And finally, that the line from near Thorold to Port Dalhousie, with the modifications we have recommended, combines all the requirements of such traffic better than any of those which have been suggested to us, or which have occurred to us during our examination.

We have the honor to be, Sir,

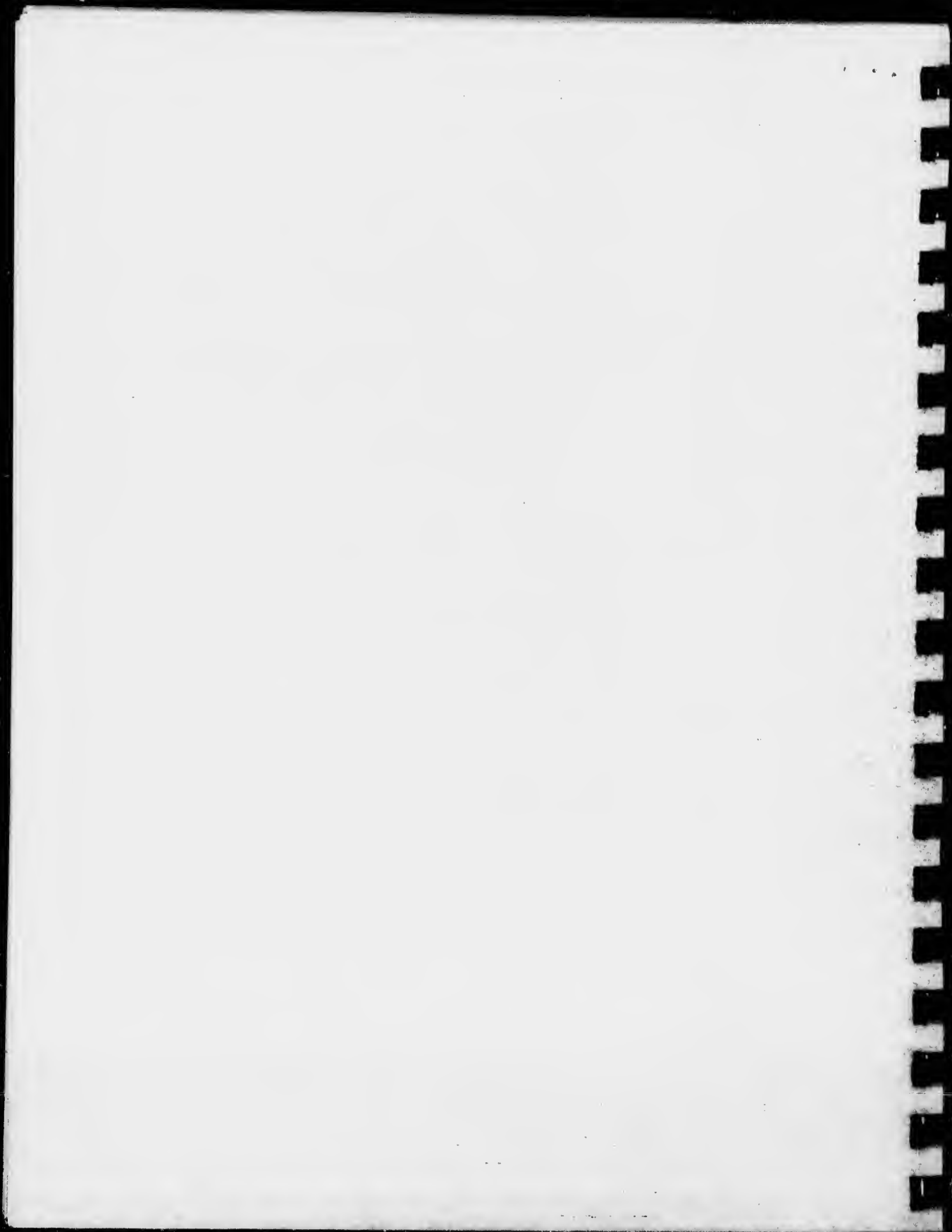
Your obedient servants,

(Signed,)

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C. S. GZOWSKI,  
SAMUEL KEEFER,  
WM. McALPINE.



*(Copy of letter to the Chief Engineer, Public Works.)*

SIR,—As the engineers appointed by the Government to examine and report on plans for the enlargement of the Welland Canal, as well as certain schemes for the accomplishment of the same object, we have just met in this city to consider the matters referred to us. Before visiting the canal to enter upon our duties, we think it due to you, in your position as the Chief Engineer, under whose directions the surveys have been conducted and the plans prepared, to invite you to meet us at the canal. We shall proceed thither on Friday, the 30th inst., and if it is convenient for you to join us there, shortly after, we shall be glad to have the benefit of the information which, by your official connection with the plans and surveys, you are so well qualified to give.

We have the honor to be, Sir,

Your obedient servants,

(Signed,)

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C. S. GZOWSKI,  
SAMUEL KEEFER,  
W. J. McALPINE,

Mr. JOHN PAGE,  
Chief Engineer, Public Works Dept.,  
Ottawa.

*(Copy of Letter from the Chief Engineer, Public Works.)*

GENTLEMEN,—I have just received your letter of the 29th instant, stating that "as the engineers appointed by the Government to examine and report on the plans for the enlargement of the Welland Canal, as well as certain schemes for the accomplishment of the same object," you invite me to meet you at the canal.

In reply, I beg to inform you that I cannot attend. Allow me, however, to forward a printed copy of my general report of the 29th April, 1872, on the scheme of canal enlargement, which I was officially notified (by a letter dated 21st June, 1872) the Government had adopted, and obtained from Parliament an appropriation towards carrying out the work.

I beg also to enclose printed copies of the several specifications of works, accordingly advertised, and for which tenders have been received.

I have the honor to be, Gentlemen,

Your obedient servant,

(Signed,)

JOHN PAGE.

Messrs. Gzowski and Keefer,  
and the Hon. W. J. McAlpine.

(No. 18,298.)

DEPARTMENT OF PUBLIC WORKS,

OTTAWA, February 27, 1873.

SIR,—I am directed by the Honorable the Minister of Public Works to send you herewith the report of Messrs. Gzowski, Keefer and McAlpine, on an examination recently made by them of the several routes proposed for the enlargement of the Welland Canal. The Minister wishes your attention to be given to the subject, and especially to that portion of the report which refers to the line between Thorold and Port Dalhousie, inasmuch as those gentlemen suggest a different arrangement from that it was the intention of the Department to carry into effect.

(to Works.)

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The Minister, before giving final instructions in the matter, desires to have your views, and will be glad to receive them at as early a date as possible.

I have the honor to be, Sir,  
Your obedient servant,  
(Signed) F. BRAUN,  
Secretary.

John Page, Esq.,  
Chief Engineer, Public Works,  
Ottawa

OTTAWA, 12th March, 1873,

The Secretary of Public Works :-

SIR,—I duly received your letter of the 27th ult., enclosing a Report from Messrs. Gzowski, Keefer and McAlpine, on an examination recently made by them of the several routes proposed for the enlargement of the Welland Canal, relative to which the Hon. the Minister desires to have my views before arriving at a final decision on the subject.

In order to enable this request to be complied with, I have carefully read over the report above mentioned, and have now the honor to submit, for the information of the Department, the following remarks in reference thereto.

It appears that the conclusions arrived at by these gentlemen are principally as follows :—

- 1st. That after an examination of the different localities, the Lake harbors at both ends of the present canal are considered the best for the enlarged channel, and that the main features of the line as located between Thorold and Port Dalhousie have also received their approval.
- 2nd. That detached locks are considered the most suitable for an important line of navigation like the Welland Canal, and consequently that locks in combination are not approved of, therefore any route on which their introduction is necessary has been condemned.

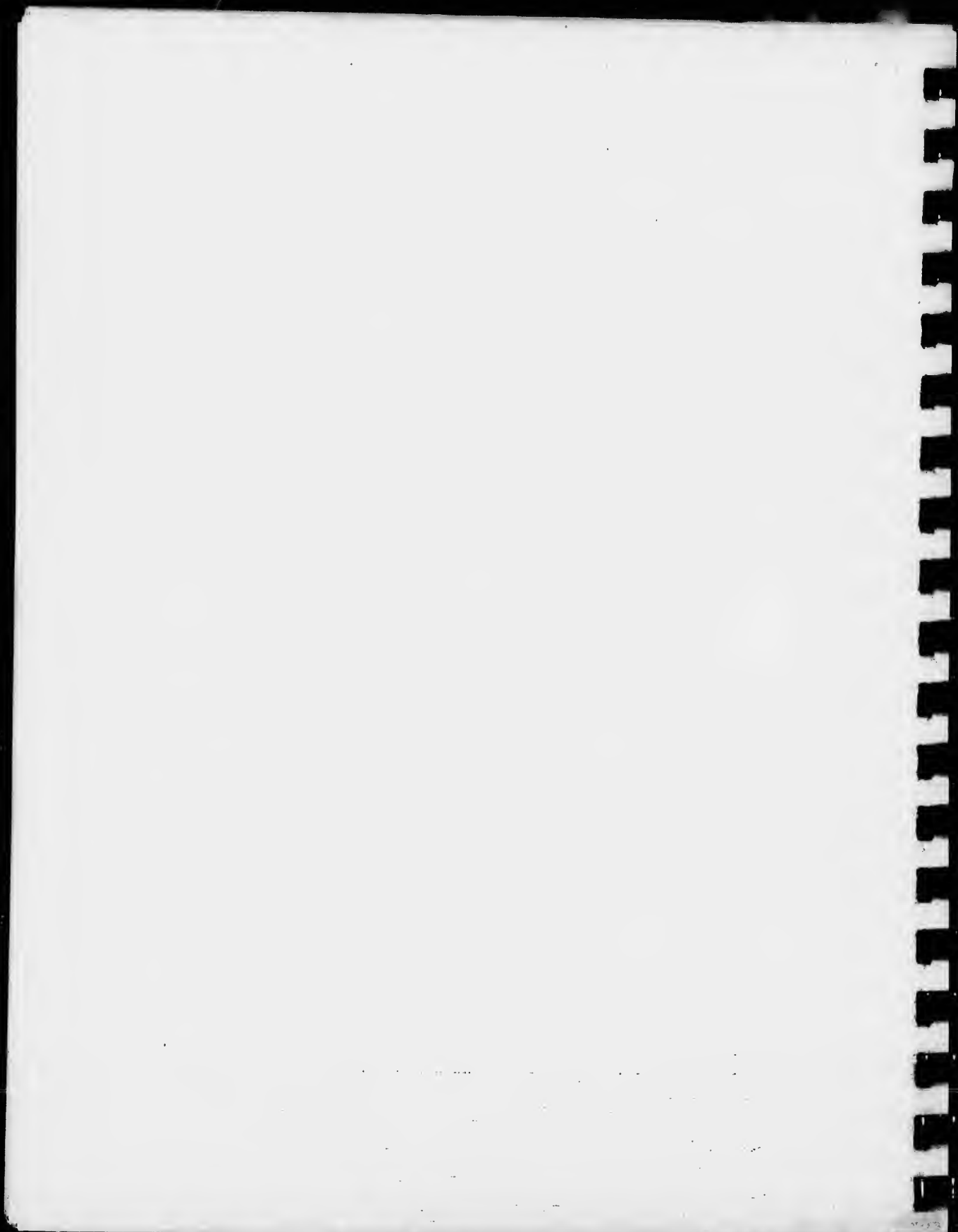
3rd. They recommend that the southern end of the new line be changed, so that the enlarged canal can pass through the Village of Thorold—and also that the locks be made from 16 to 17 feet lift throughout, so that there may be only 20 locks between Thorold and Port Dalhousie, instead of 24 as on the line marked out on the ground, and for a part of which tenders have been received.

4th. They recommend that means should be provided for filling the locks "both through the gates and through the lock walls, so as to shorten the time of passing vessels," &c., &c.

Referring to the several matters in the order above shown, it may be stated :—that the reasons for the selection of the located line are fully set forth in my report on the 29th April, 1872; in which will also be found a description of each of the harbors that have been proposed as entrances to the canal on Lakes Erie and Ontario.

In reference to the roadstead at the mouth of the Niagara River, the "Engineers" remark that the construction of entrance works to a canal terminating at this point would have a tendency to dangerously augment the already rapid current of the stream, which they describe as being "too narrow and too deep" to permit of this being judiciously done.

The river at the place where the line known as the "Lateral Cut Line" enters it, is about half a mile wide, and in the centre from 70 to 90 feet in depth. It is, therefore, difficult to understand how the construction of entrance piers could produce any sensible effect on a stream of this volume, or how its so called narrowness can be viewed as reasonable objection to its forming the inlet to a canal.



It is considered proper to correct at the outset, a statement made by the "Engineers" in their report, to the effect that the line as located is nearly that indicated by the Canal Commission.

The records of the Department show that the surveys were commenced in August 1870; and I may add that the rapidity with which the examinations were made, enabled the principal features of the route to be determined about the latter end of October following.

When called before the Canal Commission about the end of November of that year, I informed them that the new line would start from a point above Thorold, and continue downwards to Port Dalhousie. The information thus given admitted of their shewing the general direction of the proposed line on the map, which followed their report in 1871.

Generally when Engineers are invited to a consultation relative to large public works, their attention is given to the discussion of leading principles, questions of detail being seldom introduced. The only proper object being to arrive at right conclusions, based upon facts and experience; matters are usually presented fairly and fully without reserve.

But in this case the discussion of general principles has been avoided, while matters of detail occupy an exceptional degree of prominence.

In short, there is throughout the report a number of peculiarities unusual in documents of this kind, as will be clearly shewn farther on.

2nd. I agree with the "Engineers" in rejecting the introduction of combined locks on a navigation of this importance, and of the character contemplated; and also, that the building of double locks is not now necessary or advisable.

In their report, however, no reasons are given why they have arrived at these conclusions. It may therefore be well to state briefly, for the information of the Department, my views on both these questions.

There is no instance on record of a line favorable for detached locks on a ship canal having been ignored, and in its stead another chosen where the locks had of necessity to be combined.

On the contrary, every effort is made to ascertain where nature affords the best facilities for passing from a higher to a lower level, and to follow this, should it even considerably increase the length of the canal to be formed.

Combined locks have been found to answer tolerably well on a line of boat navigation, but even for that purpose, and with a double range of them, they are less serviceable, and more expensive to construct and maintain than locks separated by reaches of moderate length.

They are also liable to accidents of a serious nature by which the navigation on an entire range might for a time be destroyed, and much damage done to vessels in the locks below.

This, I am credibly informed, has occurred several times at Lockport, on the Erie Canal, and to my own knowledge a similar accident took place a few years ago on the Rideau Canal, which resulted in a vessel being sunk in the lower lock of a range, and led to a vast deal of expense and delay.

As such casualties occur on boat canals, it will at once be evident that the risk would be greatly augmented by having combined locks on a ship canal, on which the future traffic will doubtless be so enormous as that of the Wolland.

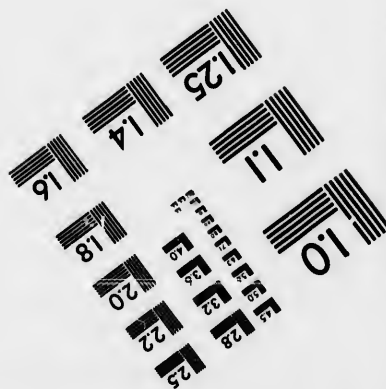
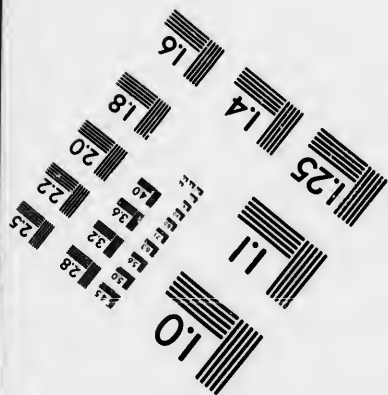
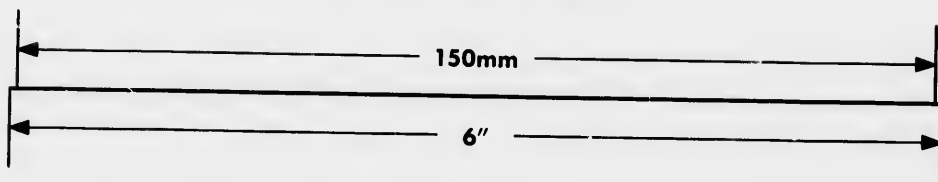
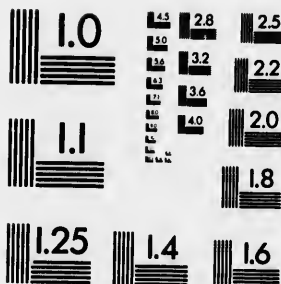
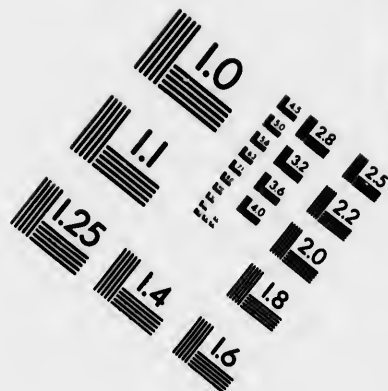
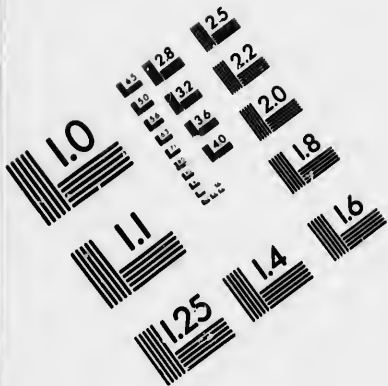
It will, of course, be readily admitted by any person practically acquainted with the requirements of navigation, that if the locks are combined two ranges of them would have to be built. This would necessitate an immediate outlay of at least double the money that would be required for the construction of one line of detached locks, whilst the latter could be doubted at any future time when called for by the trade, and that at a less aggregate cost than would be required in the first instance to construct a double range of combined locks.

It was not therefore deemed advisable to recommend double locks of any kind at present, inasmuch as they are not now required, whilst the large additional outlay which





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their construction would involve, together with the interest on that amount, and the future maintenance of the structures, would be at least as much, if not more, than their first cost before they might be required, besides the property itself by that time might be considerably deteriorated.

The downward trade on the present canal amounts in round numbers to a million of tons moved annually; and that carried by the Erie Canal from Buffalo is about twice as much; or in all about three millions of tons are annually moved eastwards by both these water routes.

A moderate estimate of the carrying capacity of the enlarged canal with single detached locks, double towing paths, and such other arrangements as have been proposed, is at least nine millions of tons annually in one direction, or about three times that of the trade now offering to both the Welland and Erie Canals.

3rd. At the southern end of the line as located, the "Engineers" suggest a change so that the enlarged canal shall pass through the village of Thorold. The principle reasons given for this being that they consider the arrangement of locks objectionable, this they represent to be as follows:—

"According to the plans submitted to us, this (difference of water level) is to be accomplished by 24 locks—23 of which are on the Loop line. Of these are 3 of 16 feet lift, 13 of 14 feet lift, 1 of 13 feet, 2 of 12 feet, 1 of 11 feet, and 3 of 10 feet lift. Of the reaches between the locks there are 6 of 630 feet, 5 of 730 feet, 1 of 830 feet, and the remainder varying from 1,120 to 6,930 feet in length."

On a profile of a new trial line, some such arrangement as that above described may have been shown as best suited to the levels of the country through which it passes, but the whole of the 24 locks are nevertheless intended to be made 12 and 14 feet lift. This is clearly and distinctly shewn on the plans exhibited to contractors for those parts of the works for which tenders have been received. These plans were placed in the hands of the "Engineers" at Ottawa, and they closely examined duplicates of them at Thorold.

It, therefore, seems strange that when the correct documents were before them, they could inadvertently make such a mistake as to produce a medley like that above quoted, and represent it to be the design contemplated.

In speaking of the three railways crossings which unavoidably occur on the line, these gentlemen notice the fact that the Great Western Railway has a gradient of forty feet to the mile, and that the best crossing of it has been selected; but that the "treatment of the Welland Railway involves his (the) line through the gorge at Thorold, in "very serious difficulties."

The fact, however, is suppressed, that at the two places where the Welland Railway is crossed, the track is all but level.

At the point to which one of these crossings would be transferred, if the recommendations of the "Engineers" were acted upon, the grade is 83 feet to the mile, another fact which these gentlemen have neglected to mention.

They have also ignored the fact, evident to anyone acquainted with such matters, that a drawbridge on the gradient or inclination stated, would so seriously interfere with the working of the railway as to render it practically useless.

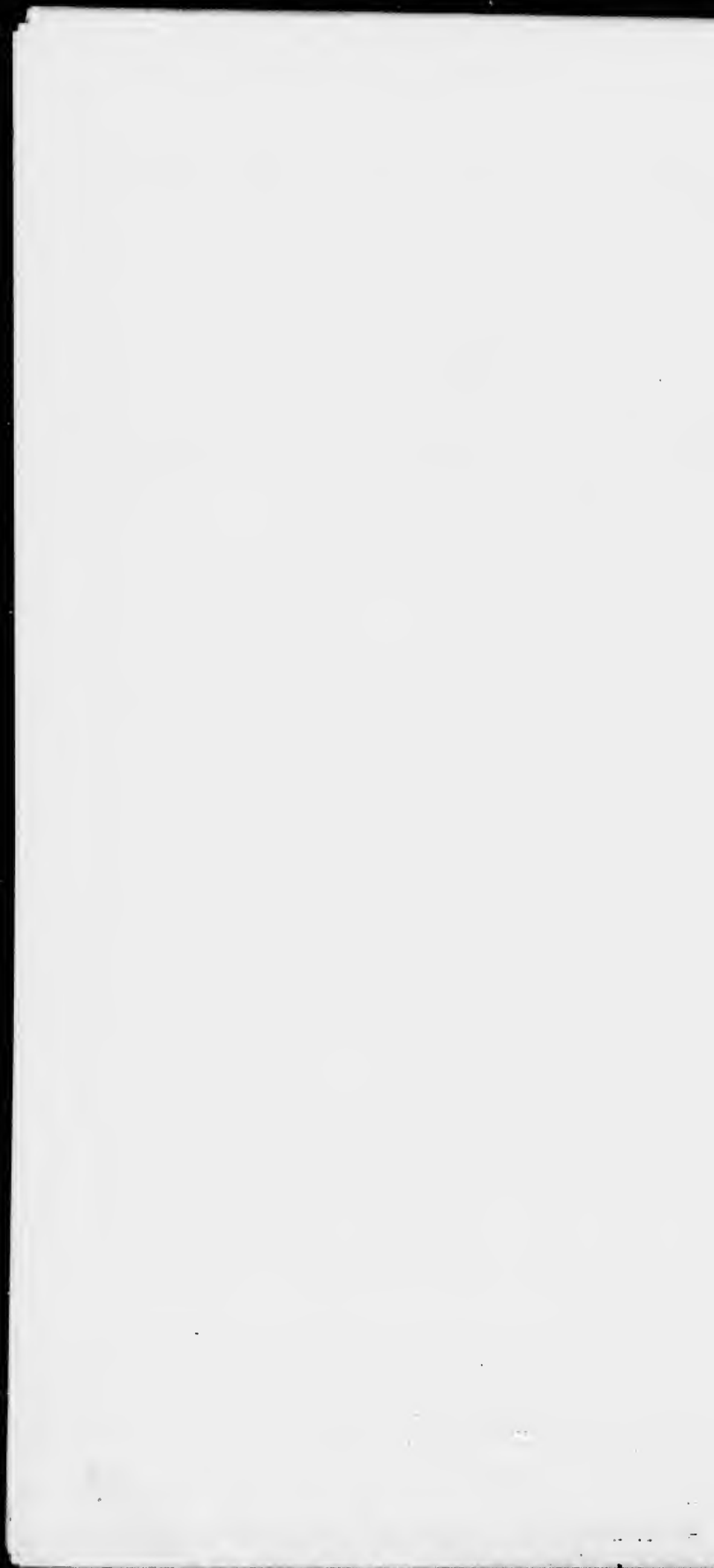
Both canals and railways, being highways, which essentially benefit the public, the reasons must, in reality, be strong, that would warrant the serious injury of either one or the other.

But even this might be justifiable if the object to be effected were of greater public importance than the interests that had to be sacrificed.

To follow such a course, however, where no necessity for it exists, would be decidedly wrong, whilst to advocate it under the guise of a public improvement, as in the case under consideration, appears, to say the least of it, a manifest absurdity.

It may further be said that by following the course suggested by these gentlemen there would have to be at least five mills purchased, and quite a number of private houses and village lots acquired.

In short, forming a canal of the dimensions contemplated would, in twisting through the village of Thorold, dig the very heart out of the place, cross the principal street at





such an angle as would necessitate its being cut off from the main line of travel, and thereby inflict a great injury on the inhabitants.

It would also throw the point of divergence of two important lines of navigation into the centre of the village, where the traffic would be cramped up in a comparatively small space, a difficulty that would be constantly growing in extent as the trade of the canal increased.

In this connection it may be stated that the traffic of the Great Western Air Line now passes over the Welland Railway, which, together with its own large grain business during the summer months, renders it a road of very great importance to the public, and therefore no hasty or inconsiderate action that might have a tendency in any way to impair its usefulness should be entertained. (See copy of Managing Director's letter hereunto appended.)

One of the greatest difficulties met with in fixing on a location in this vicinity was to avoid all injurious interference with existing lines of traffic, and at the same time secure the most practicable route for the new part of the canal.

To enable this to be done intelligently, the country was carefully and closely examined, many trial lines run, and all such information collected as would be likely to assist in arriving at right conclusions on these essential points.

It was found that the Welland Railway could be crossed at a fair angle in what is called Marlatt's Pond, about half a mile from the head of the grade, at a point where the track is nearly level, and the rails about ten feet over the present canal surface.

Here a long wide water space presents the best point for a divergence of the new from the old canal, and where ample deep water basins can be formed at the minimum of cost, in which a considerable number of vessels can lie, should this at any time be found necessary.

If a point to the north of this had been selected for leaving the present canal, it would have involved the crossing of the Welland Railway on the 83 feet grade, and between the bank of a ravine, a fact which alone was considered sufficient to condemn any such location.

In 1854, W. Shanly, Esq., when surveying a line for the "Lateral Cut" to Niagara, diverged from the old canal at a point about midway of the "Little Deep Cut." He, however, draws attention to the fact, that a direct line to Marlatt's Pond can be formed if required; but he does not propose to turn out below any of the locks in the Village of Thorold, even at a time when there was no Welland Railway in existence.

On referring to the reaches between the locks, at the southern end of the new line, the "Engineers" state, as previously remarked, that there are:—

"6 of 630 feet, 5 of 730 feet, 2 of 830 feet," &c., whilst the fact is, as shewn on the plans exhibited to intending contractors, which were also seen by the "Engineers," that there are 1 reach of 660 feet, 5 between 700 and 800 feet, and 7 between 800 and 900 feet.

It is also stated "that there are two reaches where it is impossible to have outside basins, except at very large cost, in deep rock cutting.

This is also a mistake. There is only one reach without an outside basin, namely, that between the twenty-third and twenty-fourth lock, as shewn on plans. This reach is, however, about 780 feet in length, and nearly 160 feet in width at bottom—in fact, it is a basin of itself.

From these mis-statements deductions have been drawn which lead to very erroneous conclusions, and to which it is considered necessary to direct attention here.

If the supply to all parts of a great line of water communication, such as that under consideration, were not uniformly maintained, evaporation, leakage, &c., would very soon empty it, independently of the demand for lockage purposes.

When the water is drawn from Lake Erie, it is intended that the inclination of the bottom of the canal shall be sufficient to admit of a mean velocity equal to about five-eighths of a mile an hour at the summit level, and that such other arrangements shall be made as will allow of this current being continuous, if required.

The passage of this large volume of water will be secured throughout by a series of



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ured throughout by a series of

regulating weirs placed generally in raceways, a short distance from the respective locks.

These weirs are to have such a width of spill-way, and area of sluice openings as to fully effect the object in a manner suited to the position and circumstances.

Thus a volume of water from three to six times greater than that required for lockage purposes, will at all times be passing into each reach or level between the different locks.

It will therefore be evident, that calculations based on a theory that deals with the question as if the canal consisted of a series of still water ponds, liable to be drawn down by every lockfull of water required for navigation, are for all practical purposes utterly worthless.

The time occupied in filling a lock, is not over one-fourth of that required by a vessel to pass from one level to another; whilst the water is flowing constantly through, and over the weirs at a rate fully as rapidly as it could be judiciously discharged into a lock.

This being the case, there is not even the remotest probability of the levels being drawn down; but on the contrary care will be required to regulate the discharge so as to guard against the reaches getting too high, if there be any considerable length of time between the lockages.

In working the present canal, the levels are seldom, if ever, drawn down below navigation height, unless on reaches where the means of controlling the supply for milling purposes are defective.

There is, however, a vast difference between drawing as at present from a limited uncertain source of supply, and the time when the canal bottom will be at such a level as to admit of Lake Erie being tapped. Then the volume of water need only be limited by the current that can be judiciously permitted in the prism of the canal.

It is, of course, desirable to have basins adjoining reaches of moderate length, when they can be obtained at reasonable outlay; but to secure one on a level nearly 160 feet in width, would scarcely warrant the destruction of a great public highway like the Welland Railroad.

Especially as after this had been done the traffic of both the old and new lines, would be thrown into a channel in which even the width above stated could barely be obtained.

Moreover, when one-fifteenth part of the probable outlay required to make so destructive a change would form a basin between the 23rd and 24th locks, if it should at any time be wanted, which there is no reason to believe will, under the circumstances, be required.

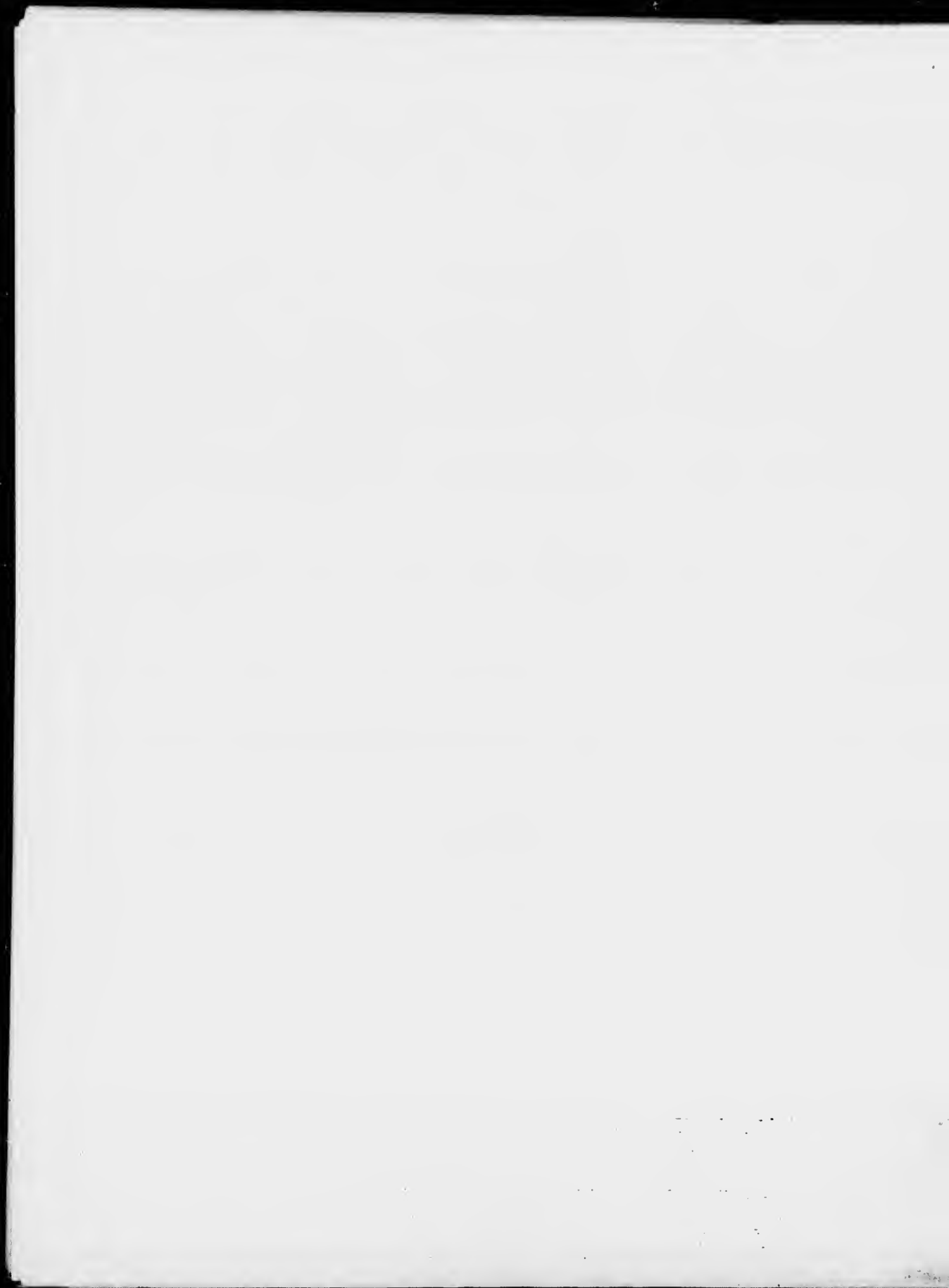
The recommendation of the "Engineers" that the difference of elevation should be overcome by 20 locks instead of 24, and to make the lifts chiefly 16 and a few 17 feet," is so much at variance with precedent even on boat canals of comparatively little width, that it is necessary to consider carefully such an unusual proposition.

It has been already shewn that the locks on the line are intended to be 12 and 14 feet lift, and that the gentlemen had an opportunity of knowing this fact; their advocacy of uniform lifts, as if it were something new, is therefore, to say the least of it, quite superfluous.

Their suggestion relative to increasing the lift of the locks has doubtless mainly in view the lengthening of the reaches between them, and admitting of the line passing through the village of Thorold.

It has already been shewn what would be the effect of carrying out the latter change on the village property, as well as on the Welland Railway, so that it is unnecessary again to refer to these matters.

Still it is proper to bring under notice the fact, that by following the suggested line through Thorold, the curvature would be greatly increased at the places where the locks would be situated, and that the water would have to be drawn off for one or more winters from the present canal during the progress of the works—a matter which of itself would be attended with serious consequences.



If the lift of the locks were increased, their number of course could be diminished, and this would to some extent lessen the quantity of masonry, but it would largely increase the amount of excavation to be done, and as a whole would considerably augment the cost of the work; besides the risk to the gates and foundations would be greater.

When fixing on the height of the different levels, the question of the lift of the locks was carefully considered in all its different phases, and every effort made to arrive at right conclusions.

All accessible written authorities were consulted, and the arrangement of lockage on most of the canals on this continent, as well as in Europe, was studied. This information, together with my own experience in the construction and practical working of canals, led to decisions on all leading points, which, after a careful review, I feel confident are right.

Along the quickly sloping ground at the base of the mountain, the locks are shewn with lifts of 14 feet, an arrangement best suited to the levels, and other controlling circumstances.

This, it is believed, is the highest that could be judiciously introduced on a line of navigation like this, where the gates are wide, and where it is at the same time of the greatest importance that they should be expeditiously worked, and no unnecessary risk invited.

On the extensive system of boat canals of New York State, where the locks are only 18 feet wide, the perpendicular lifts are all less than 12 feet, except in two or three cases at the river outlets, where in one instance there is a lift of about 15 feet at periods of extreme low water.

On the canals in Great Britain, the lift of locks seldom exceeds 11 feet, but is often considerably less. The lift of the locks on the St. Lawrence Canals is generally from 9 to 10 feet, except at the lower end of the Lachine Canal where the lift is 13 feet.

On the present Welland Canal, where the locks are 26½ feet wide, there are some of them 14 feet lift; the rest are 12½ feet and under, except at Port Robinson and Welland. The locks at the latter two places are 26½ feet wide, and have at present lifts of 17 feet, but when the summit level is lowered to that of Lake Erie they will each have only 9 feet lift.

When submitting a plan for the Caughnawaga Canal, Mr. John B. Jarvis proposed to have locks of about 12½ feet lift, and Mr. Walter Shanly, in his report on the Niagara Lateral Cut, fixes the minimum lift of the locks on that line at 14 feet.

On other projected lines of a similar character in this Province, the locks are generally placed at from 10 to 12 feet lift.

There is no case on record, as far as I know, in which an experienced Engineer, after due consideration, has advised the construction of locks 17 feet lift on a line of navigation of such dimensions as that of the Enlarged Welland Canal, and where the gates require to be so expeditiously worked.

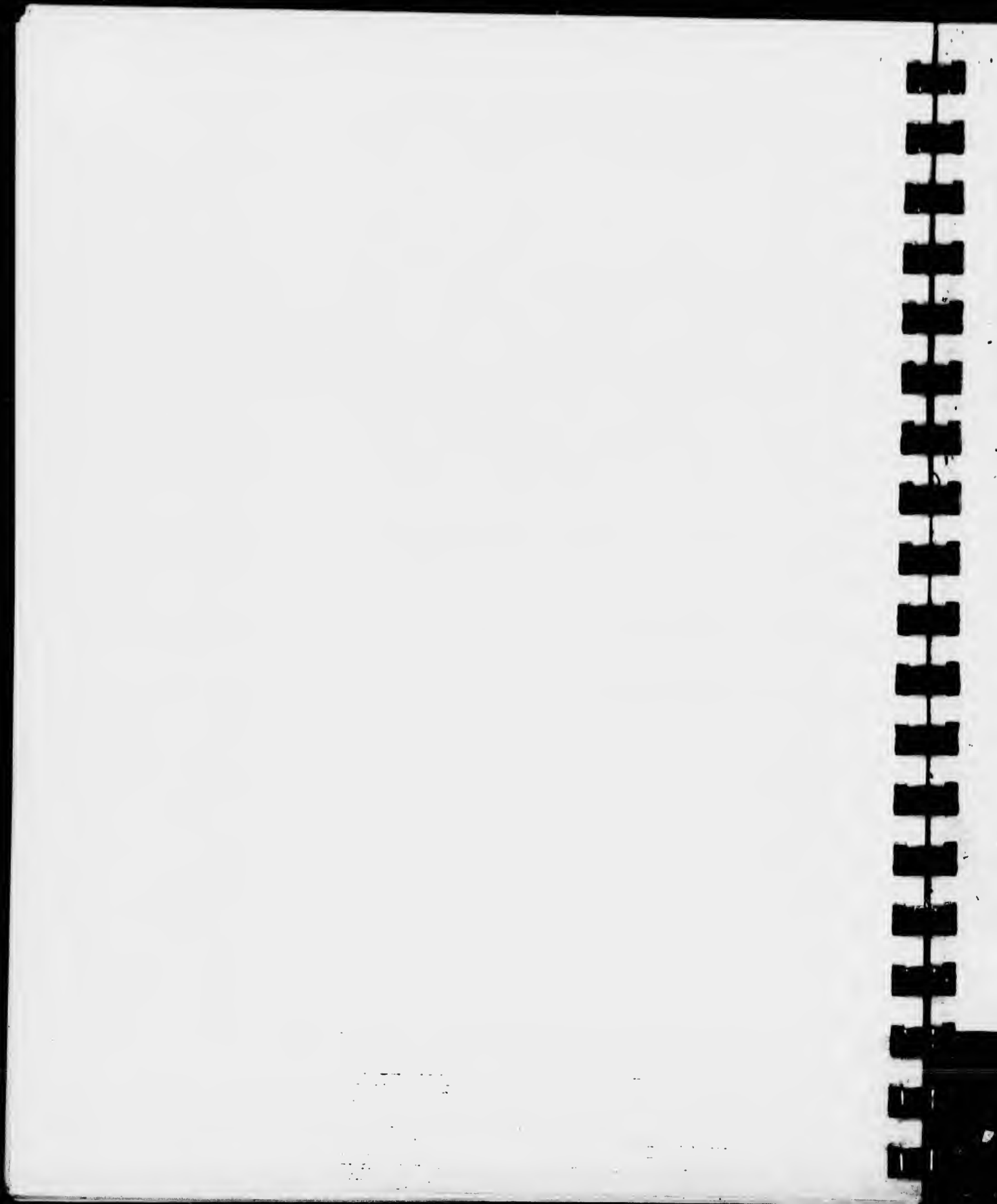
4th. The "Engineers" advised that "means should be provided for filling <sup>locks</sup> through "the gates and through the lock walls so as to shorten the time of passing vessels" &c.

In the practical working of canals, the mode of filling and supplying the locks has of course occupied considerable attention, and numerous plans have been tried to effect this in an expeditious and satisfactory manner. These may generally be classed under the following heads:—

1st. By passing the water around the gates, through sluice-ways formed in the masonry of the side walls.

2nd. By building a culvert parallel to the side wall of the lock for the passage of the water, admitting and discharging it through tunnels formed at one or more points, as was done by Sir William Cubitt, many years ago when carrying out the improvements of the Severn Navigation.

3rd. By sluices of various kinds, constructed in the gates themselves.



The plan first mentioned was adopted in the locks on the Ottawa Canals, upwards of forty years ago; but it was found that the action of the water, together with that of frost, injured the walls to such an extent, that in order to save them from being entirely destroyed, it became necessary to fill up the tunnels, and introduce the water through sluices placed in the gates. Although tunnels no doubt answer well in some countries, they are nevertheless found to be quite objectionable where the action of frost is so trying and severe as in Canada.

On the St. Lawrence and Welland Canals, which were constructed long after those above referred to were in use; the water for filling or emptying the locks is passed wholly through sluices in the gates. This mode of effecting the object has been found to answer a very good purpose, besides possessing the advantage of being rapidly overhauled and repaired.

The time generally occupied in filling or emptying a lock on the Lachine Canal, by means of the quadrant valves now in use, is from four to five minutes—this, as before stated, is only a small part of the time necessary to pass a vessel from one reach to another.

The enlarged locks on the Welland Canal of 14 feet lift, can, however, by means of an improved kind of valves, intended to be used, be filled, if necessary, in  $3\frac{1}{2}$  minutes; but although provided with the means of fully effecting this, I do not think it would be judicious to do it in less than about five minutes.

Previous to arriving at a decision as to the mode of filling and emptying the locks, all the different plans that were known to have been previously in use were carefully considered with a view of endeavoring to modify, improve or adapt them to the circumstances.

Tunnels formed of masonry alone, whether immediately around the gates or parallel with the side walls, it will be seen, are objectionable for the reason above stated.

These difficulties, it might be supposed, would be met by lining the tunnels with cast, or even wrought iron, or by introducing a number of large iron pipes embedded in concrete, with branches at various points leading into the lock chamber, but the rapid oxidation of such a large surface of metal, together with the unavoidable difficulty of access to such conduits for the purposes of repairs, would, in case of accident when the canal was open, be likely to cause serious interruption to the navigation.

Moreover it was considered, on thoroughly investigating the matter, that the risk of failure to the working equipment, the probable damage to the walls, &c., by this mode of introducing and regulating the water, would more than counterbalance any possible advantage that could be gained, or time saved, by its adoption.

On again reviewing the subject, there appears to be no reason to alter the conclusions arrived at, especially when it is borne in mind that introducing the tunnel system would involve a greatly increased annual cost for maintenance, and necessitate at present an additional outlay or from forty to fifty thousand dollars at each lock, or in all considerably over (\$1,000,000) *one million of dollars for that purpose alone.*

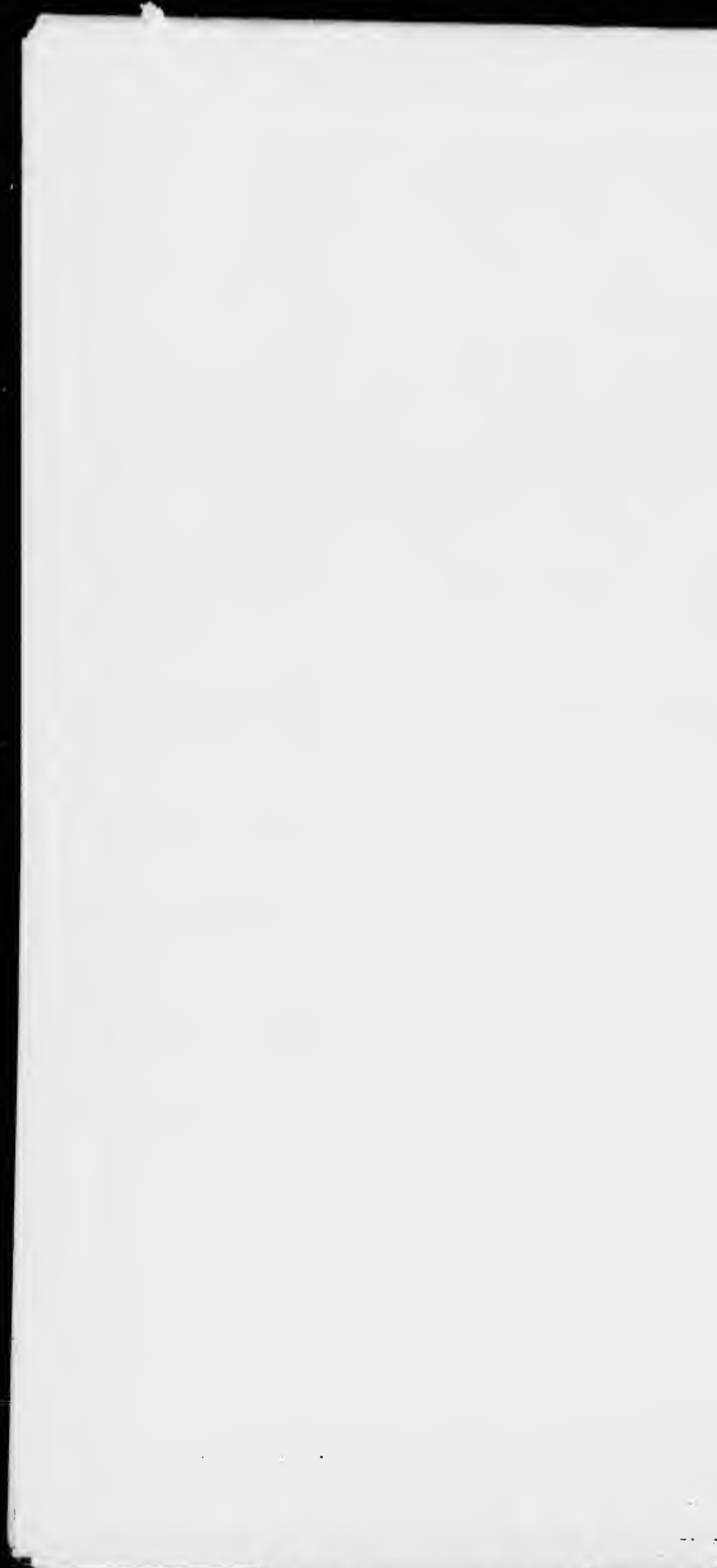
In conclusion, it is deemed proper to submit a brief summary of the reasons why, in my opinion, the line selected for the enlargement should be adhered to, and to repeat a few of the principal reasons why I believe the suggestions contained in the "Engineers" report should not be entertained.

1st. The line as located is the best that can be obtained between the wide part of the canal above Thorold and Lake Ontario.

2nd. It passes through the country in rear of the village of Thorold and town of St. Catharines, where the land damages will involve no great outlay; whilst the water power subsequently available will render the land acquired valuable.

3rd. The interests of both the land and water routes are as well secured as circumstances will permit.

4th. The length of the reaches, arrangement of basins, lifts of the locks, and the means of emptying and filling them, are such as to secure the efficient and expeditious working of the canal, without incurring unnecessary risk; whilst economy has been fully consulted.







On the other hand, it may be stated with reference to the changes proposed by the "Engineers,"

1st. That to throw the point of separation between the old and the new canals into the heart of the Village of Thorold would lessen the efficiency of both channels of trade, and would add considerably as well as unnecessarily to the cost of the works.

2nd. That by crossing the Welland Railway near the middle of its maximum grade, the traffic would be so interfered with as to render the road practically worthless as a means of safe communication.

3rd. That by increasing the lift of the locks, the risk of accident, as well as the cost of the work, would also be increased without any benefit to navigation that would warrant such a course.

4th. That the filling and emptying of the locks in the manner suggested is not necessary or required, as it can be done as expeditiously as circumstances will warrant, without entailing upon the navigation the risk inseparably connected with tunnels and their equipment.

In short no advantage could be gained by adopting any of the suggestions of the "Engineers," but on the contrary there is good reason to believe that if they were followed a less efficient canal would be constructed, and that too at an additional cost of full (\$2,000,000) *two millions of dollars.*

I therefore beg respectfully to advise that the line from Marlatt's Pond to Port Dalhousie, as located on the ground, be adopted, and that the works be carried out agreeably to the design contemplated, and for which Tenders have been publicly invited and received.

I have the honor to be, Sir,  
Your obedient servant,

JOHN PAGE,  
*Chief Engineer, Public Works.*

OTTAWA, 6th March, 1873.

MY DEAR SIR,—I learn that the Canal Commissioners recommend a deviation from the Government line at the village of Thorold, which will cross the Welland Railway at about the centre of its eighty-four feet grade. If this is so it will be perfect destruction to the road, as the grade is nearly three miles long, and the difficulty, and at many times impossibility of stopping trains in descending would seriously reduce its capacity for carriage of freight and render it dangerous to the life of passengers; and in ascending, it is found that when a train is once stopped great power is lost in getting under way again.

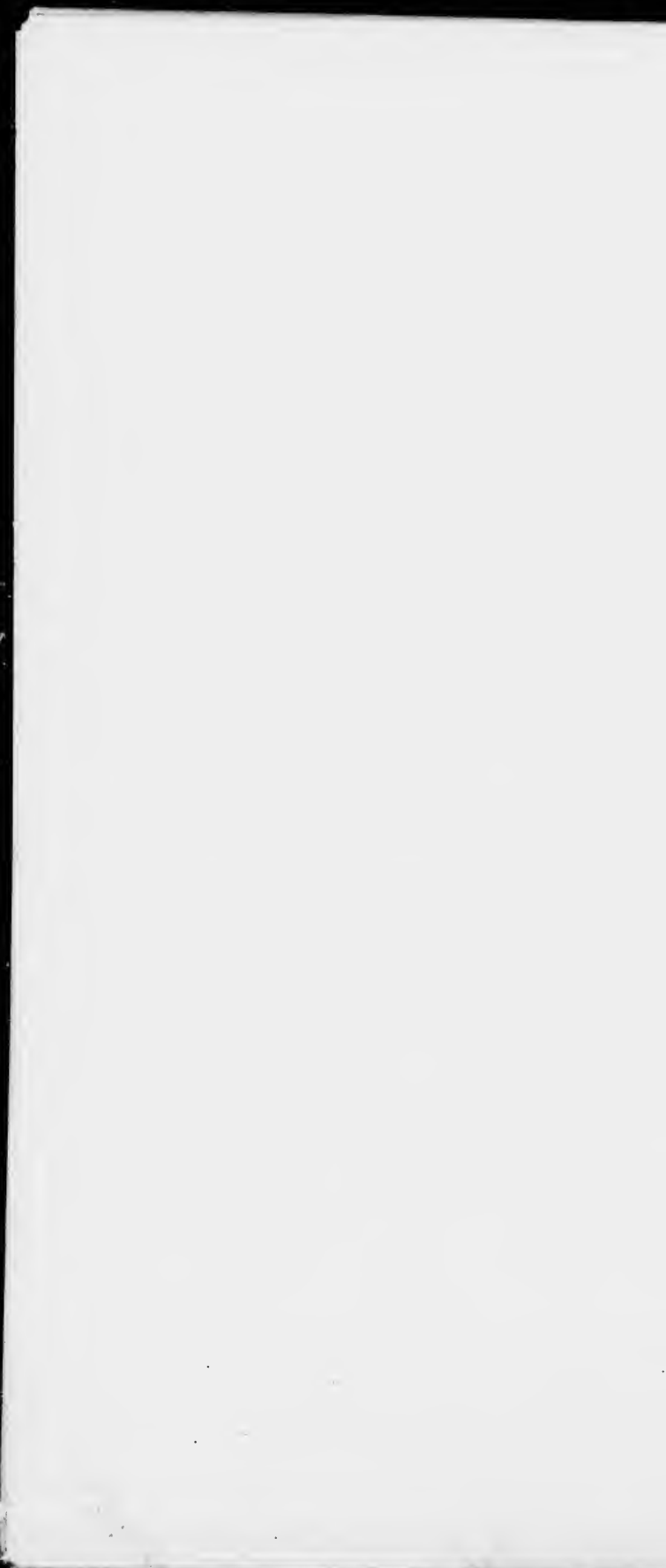
The Great Western now use the Welland between its Main and Air Lines, and at the present moment fourteen regular trains pass over that portion daily, besides specials; during the season of navigation the number will be much greater.

I feel it my duty, as Manager of the Welland, to bring this matter officially before you, and respectfully beg, that before adopting the proposed change, you will well consider the damage the road will sustain by it.

Yours truly,

THOS. R. MERRITT,  
*Chairman.*

Hon. H. L. LANGEVIN,  
Minister of Public Works.





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Chairman.

(No. 18656.)

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GENTLEMEN,—Your report  
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Engineer of the Department to  
wish you with the accompanying  
such remarks as you may deem

Messrs. Gzowski and Keefer,  
Civil Engineers,  
Ottawa.

SIR,—We yesterday received  
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(No. 18656.)

## DEPARTMENT OF PUBLIC WORKS.

OTTAWA, March 22nd, 1873.

GENTLEMEN,—Your report on an examination of the several routes proposed for the enlargement of the Welland Canal, dated the 14th ulto., having been referred to the Chief Engineer of the Department to obtain his views in regard thereto—I am directed to furnish you with the accompanying extract from his report, with request that you will offer such remarks as you may deem necessary in the matter.

I have the honor to be, Gentlemen,

Your obedient servant,

(Signed,)

F. BRAUN, Secretary.

Messrs. Gzowski and Keefer,  
Civil Engineers,  
Ottawa.

RUSSELL HOUSE,

OTTAWA, March 26th, 1873.

SIR,—We yesterday received a letter from the Secretary of your Department, dated the 22nd inst., accompanied by an extract from Mr. Page's report on the changes suggested by the Board of Engineers, in his plans for the Welland Canal, and requesting us to offer such remarks as we may deem necessary in the matter.

It is to be regretted that Mr. Page did not accept the invitation of the Board of Engineers to meet them at the Welland Canal, where the different questions treated of in these extracts might have been fully discussed, and by so doing saved the delay which has occurred.

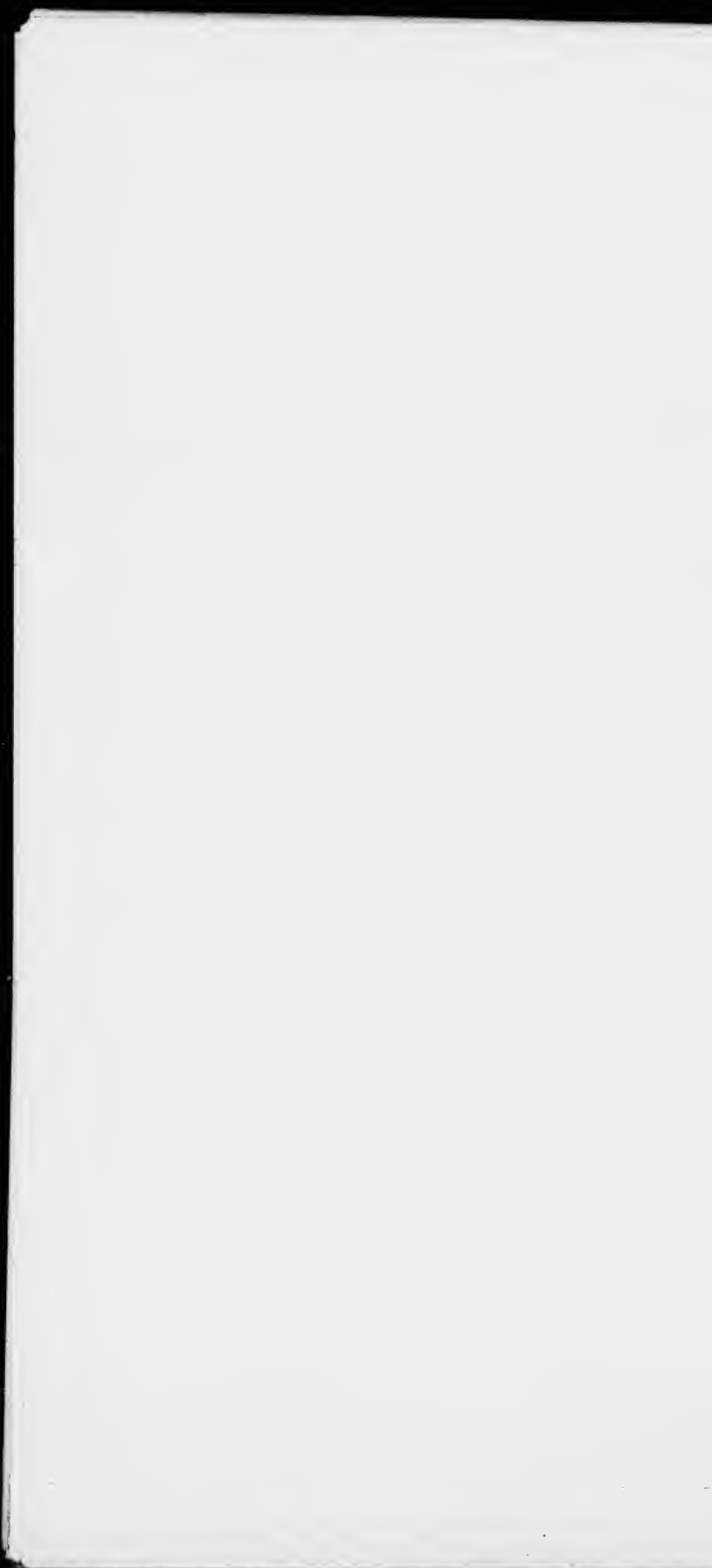
We cannot enter into any discussion with Mr. Page. But having read the extracts from his report, and again referred to that of the Board of Engineers, and speaking for ourselves only, we have to state that we see nothing in his remarks to induce us to alter in any particular.

We adhere to the recommendation to have uniform lifts for all the locks as far as practicable, and that these lifts should be mostly 16 feet, and a few of 17 feet to answer the conditions. That provision should be made for filling the chamber of the lock both through the walls and through the lock-gates. That the reaches between the locks should be made as long as possible, and that there should be ample basins on every reach—and that as the only possible means of attaining these objects, it is necessary to make the deviation recommend through the village of Thorold. That instead of building an expensive road-culvert under the canal for the Queenston road, the traffic should pass over a wing-bridge placed on the extended wings of the nearest lock; and finally, that the position of the locks and levels should be such as would avoid making the culvert, for the Ten Mile creek, a siphon culvert, and provided for in Mr. Page's specifications. These last two suggestions are not referred to in the extracts from Mr. Page's report.

We are still of opinion that a careful and impartial estimate would shew that the cost of constructing the canal, according to the report of the Board of Engineers, would not exceed that of the present (Mr. Page's) plans.

In this age of active railway competition, the saving of time in the transit of freight is an important element in determining the course it will take. To economize the time as much as possible, the Board recommended lifts of 16 and 17 feet for the locks as perfectly safe, and the filling of the locks both through the gates and through the lock walls.

We may remark, that at the combined locks on the Rideau Canal in this city, we have an example of filling through the walls, which has been in use ever since their first construction.





We do not think that Mr. Page's plans are such as the magnitude and importance of our system of navigation demand: while the statements by which he endeavours to support them are some of them incorrect, and some exaggerations, both we fear only calculated to mislead.

In conclusion we beg to state, that if the report submitted to you by the Board of Engineers in reference to the enlargement of the Welland Canal, be not adopted, we hope there will be no objections to our making that fact publicly known, as justice to ourselves requires that we should be relieved from all responsibility connected with it, if this great work is executed on Mr. Page's plans, which we have, after careful examination, considered insufficient.

We have the honor to be,

Your obedient servants,  
(Signed,)

C. S. GZOWSKI.

SAMUEL KEEFER.

Hon. Hector L. Langevin, C. B.,  
Minister of Public Works,  
Ottawa.

(No. 18739.)

DEPARTMENT OF PUBLIC WORKS,

OTTAWA, 28th March, 1873.

GENTLEMEN,—I am directed to acknowledge the receipt of your letter of the 26th inst., containing remarks on Mr. Page's report on the changes suggested by the Board of Engineers, in his plans for the Welland Canal, as called for by my letter of the 22nd inst.

The Minister desires me to call your attention to that portion of Mr. Page's report which refers to the crossing of the Welland Railway on an 83 feet grade, and to which no allusion is made in your remarks. The Government would like to have also your opinion on that particular subject.

I have the honor to be, Gentlemen,

Your obedient servant,  
(Signed,)

F. BRAUN,

Secretary.

Messrs. Gzowski and Keefer, C.E.

OTTAWA, 31st March, 1873.

SIR,—In compliance with your request of the 28th instant, we will now add the following remarks in reference to the crossing of the Welland Railway, by way of supplement to our letter of the 26th instant.

A swing bridge upon any line of railway is an inconvenience to the traffic, yet with a well constructed bridge, and properly equipped railway, and a compliance with the statute regulating the passage of trains over such bridges, their can be no danger to life and property, and but very little inconvenience.

Mr. Page's plan is to cross the Welland Railway where the grade is level, at an angle of 64 degrees. The line through Thorold would cross it at its maximum gradient of 83 feet in a mile, and with a slight alteration, without changing the grade, it would cross it at a right angle, the most favorable angle for the purpose; so that as regards the horizontal angle of this crossing the line through Thorold is much more favorable than the line through the gorge.



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8th March, 1873.

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With regard to the inclination or gradient of the railway, Mr. Page proposes to cross the Great Western Railway where the inclination is something like 38½ feet per mile. The very heavy traffic of the Great Western Railway at this point will be much more difficult to control on this gradient than the light and comparatively unimportant traffic of the Welland on the steeper one.

It is difficult to assign a limit to the gradient at which it would be impossible to have a safe crossing, and we believe that it is quite possible to construct a safe crossing at the point proposed for the Thorold line.

No railway company has a right to adopt a gradient on its line on which the force of gravity exceeds the power of the brakes on its engine and cars; in other words, every railway company is bound to have sufficient brake-power on its trains to bring them to a stand at any point on any of its grades.

The Baltimore and Ohio Railway, as well as the Boston and Albany Railway, two of the most important roads in the United States, each carrying an immense traffic, have gradients of 85 feet to the mile and upwards.

They find no practical difficulty in controlling their trains at all points on these gradients.

Practically it is easy to protect the trains on the Welland Railway by semaphores, therefore, without adopting any more than the usual precautionary measures, we feel sure the crossing can be made quite safe.

I have the honor to be, Sir,

Your obedient servant,

(Signed,)

C. S. GZOWSKI,  
SAMUEL KEEFER.

The Honorable H. L. Langevin, C.B.  
Ottawa.

P.S.—The undersigned considers it material to add that there is a level crossing of the Welland Railway on the Thorold and Queenston road, near the place where the swing bridge would be, at which the trains of the road are any day liable to be brought to a stand on its maximum gradient.

(Signed,)

SAMUEL KEEFER.

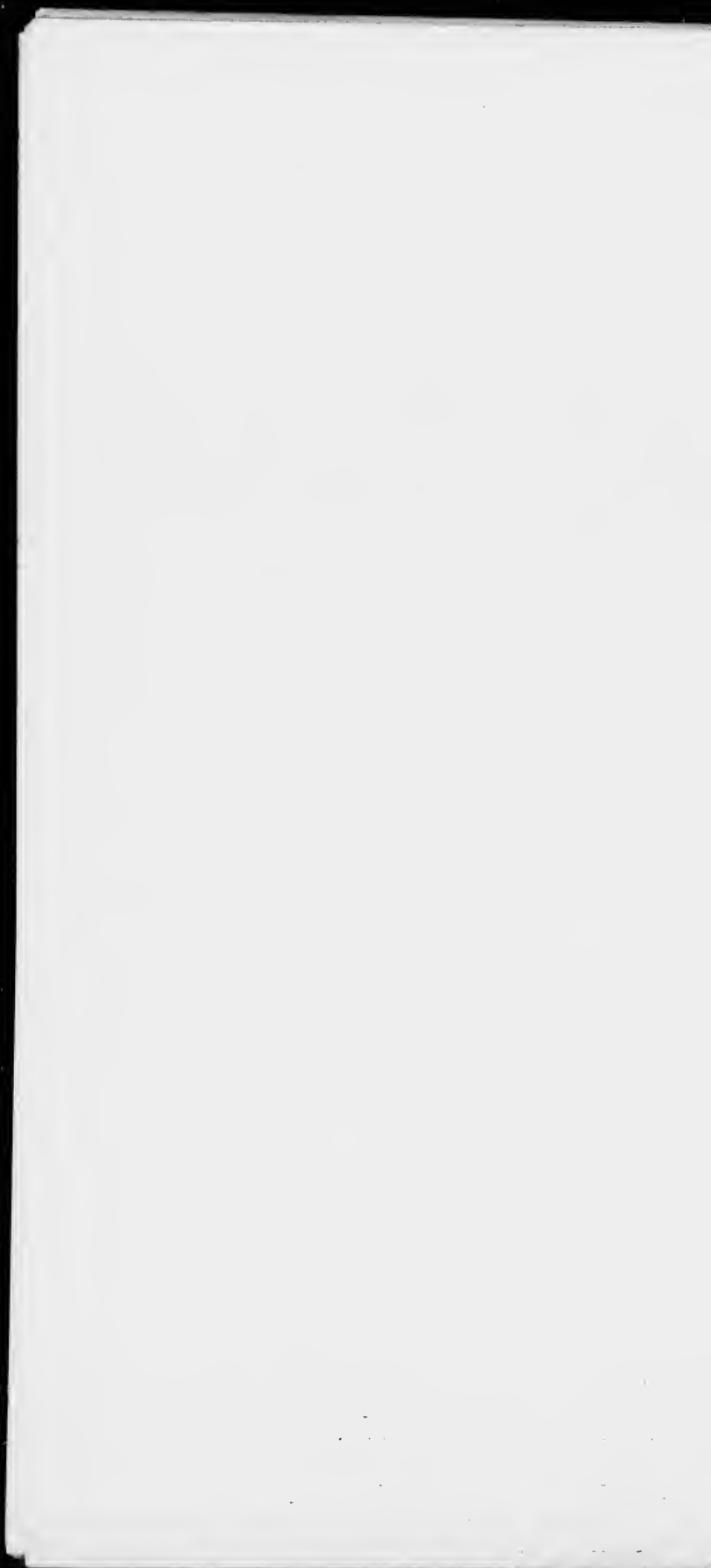
*Copy of a Report of a Committee of the Honorable the Privy Council, approved by His Excellency the Governor General in Council on the 10th April, 1873.*

On a report dated 7th April, 1873, from the Hon. the Minister of Public Works, stating that on the 17th August, 1870, the Chief Engineer of his Department (Mr. Page) was instructed to have such surveys and examinations made as would enable the best course to be adopted for the enlargement of the Welland Canal.

That on the 29th April, 1872, Mr. Page submitted a comprehensive report on the mode of effecting this object, advising that the harbor of Port Colborne should be adopted as the entrance from Lake Erie, and that the present line of canal downwards should be followed to a point above Thorold, thence a new line should be formed to Port Dalhousie, the present outlet on Lake Ontario.

That the cost of the works necessary to secure a canal of 12 feet available depth, and 100 feet in width at bottom, with locks 270 feet long and 45 feet wide, he estimated at \$9,240,000, and stated that it would require about four years to execute the works under the most favorable circumstances.

That this report was laid before Parliament and an appropriation was granted towards carrying out the undertaking, and that the Chief Engineer was subsequently directed to make the necessary arrangements for carrying out the works, and to have part of them placed under contract at the earliest possible period.





That in November, 1872, the plans and specifications were sufficiently advanced to warrant tenders being invited, and that the 25th January was the date fixed for receiving them.

That during this time certain persons in the section of country through which the canal passes were favorably impressed with a project for shortening the line, and to effect this object, to make the locks in combination.

That the continuation of the line to Niagara was again revived, and the question of the formation of a canal from the village of Chippawa to Queenston was also urged.

That it was therefore considered proper to refer these various projects to other engineers for their opinions as to the best course to adopt.

That for this purpose Messrs. Gzowski and Keefor were asked to consider the subject and to associate with them the Honorable J. W. McAlpine, an engineer of eminence in the United States.

That these gentlemen having visited the various localities and examined the plans, etc., prepared under the directions of Mr. Page, reported in favor of the main features of the line previously recommended to and adopted by the Department.

That they objected to any route on which combined locks were necessary, but suggested a modification of the line at the village of Thorold, as well as some changes relative to the locks.

That their report was subsequently referred to Mr. Page, who entered fully into the questions raised by those gentlemen, and that an extract from Mr. Page's reply having been sent to them, they adhered to their former opinions.

The Minister of Public Works states, that having fully considered the matter, he recommends that the design previously submitted by Mr. Page and adopted by the Department be approved, and that authority be given to carry the same into effect.

The Committee submit the report of the Minister of Public Works for your Excellency's approval, and advise that Mr. Page's design be sanctioned and authority given to carry the same into effect, as recommended.

Certified.

(Signed,)

W. A. HINSWORTH,  
Clerk, Privy Council.

