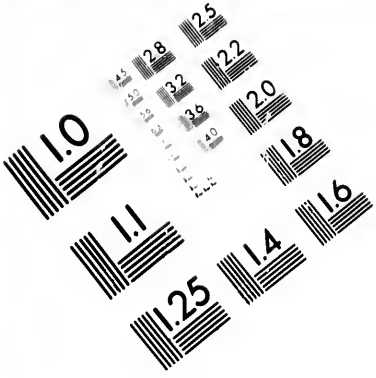

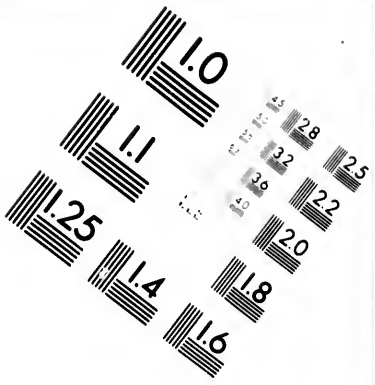

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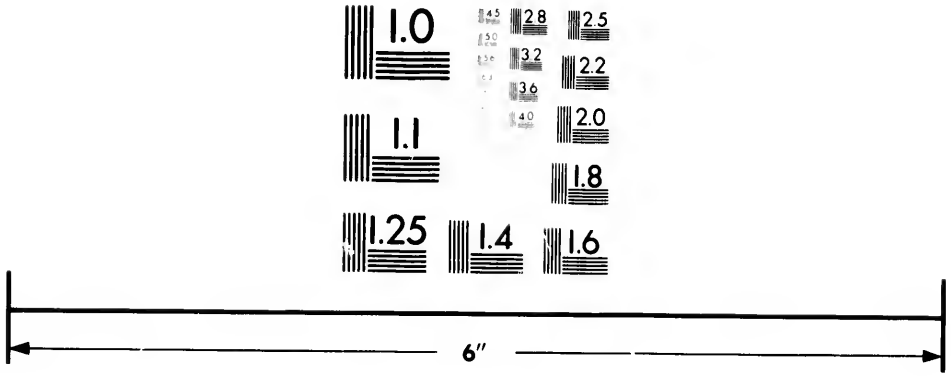

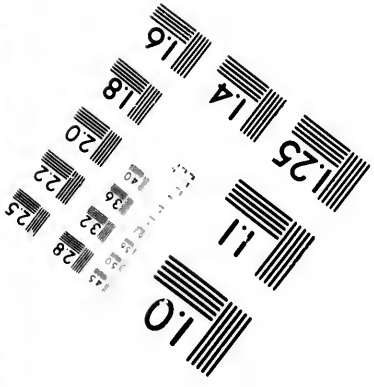

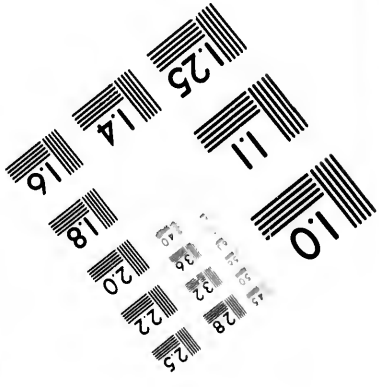

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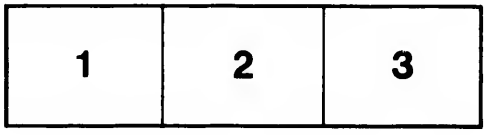

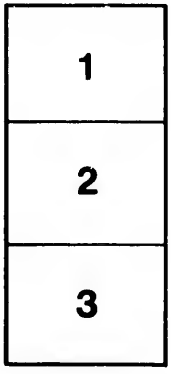

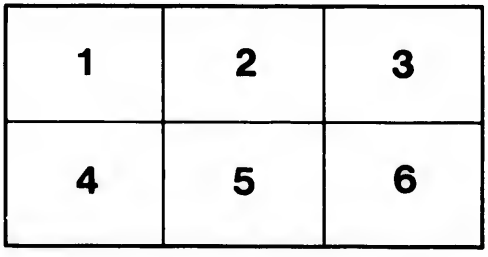

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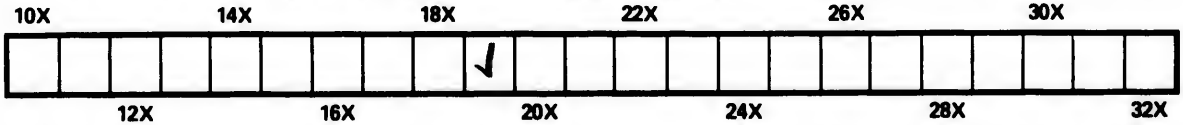


B. E. Walker, Esq.
General Manager,
The Canadian Bank of Commerce,
Toronto

with the Author's Compts,
May 10/95

COMMERCE

AND

PHYSICAL FEATURES OF THE GREAT LAKES.

BY

MAJOR HENRY A. GRAY, M. INST. C. E., M. CAN. SOC. C. E.

Engineer in Charge, Public Works of Canada, District of Western Ontario.

COMMERCE AND PHYSICAL FEATURES
OF THE
GREAT LAKES.*

BY MAJOR HENRY A. GRAY, C.E.

The constantly increasing importance of the Great Lakes for the purpose of commerce having recently caused considerable public attention on both sides of the Atlantic, it is thought that this paper on the commerce and physical features of these waters, prepared from notes and observations made from time to time during the past fifteen years, and from information gathered, during that period, by the writer, while filling the position of engineer in charge of the Public Works of Canada in the lake district, will be of interest. The average season of navigation on the lakes is about 220 days. In order to give an idea of the extent of the commerce on these lakes, it is shown that the annual average net tonnage for the last five years of the Suez Canal—a world's channel of commerce, and open every day in the year—was 6,983,167 tons; the annual average net tonnage of the lock and canal, at Sault Ste. Marie, for the same period—open only an average of 220 days in the year—was 6,821,062. The registered American tonnage of the lakes, June 30th, was 1,154,878 tons; 1,592 steam vessels, representing 736,751 tons, and 2,008 sail, 418,118 tons. The tonnage has more than doubled in the last five years, the increase being almost exclusively in steel steamships of 1,500 to 2,500 tons register. The number of Canadian vessels on the lakes is 647, tonnage 132,971; valuation, $3,989,130. The total of coast and inland shipping registered in Canada is 7,153 vessels, of 1,040,481 tons register, valued at $31,213,430.

The sailing vessel has almost disappeared from the lakes. The square-rigged ship is no longer seen, and only a few of the great cargo-carrying schooners are left. The sailing fleet was succeeded by the "propeller," as it is known locally, with its tow of one or

*Presented before the Canadian Society of Civil Engineers.

more consorts, and it, in turn, is giving way to the modern steamer, maintained at little more than one-half the cost, while having a carrying capacity quite as great, a speed double that of the propeller and consort, and making two or three round trips for one of the tow. Of large capacity and great power, regardless of wind or weather, the steamers of the prevailing type bear their cargoes to and from ports a thousand miles apart, with the precision of railroad trains, each of them transporting at once more than ten ordinary freight trains.

The work of this lake shipping is given approximately by the United States census report, 1890. The freight movement in 1889 on all the lakes was estimated by that report at 53,424,432 tons. The tonnage put afloat since then has increased this movement to 63,240,514 tons. Estimates only can be given, because at one point only on the lakes, Sault Ste. Marie, is there an official record made of tonnage movement. The movement through the Detroit river alone, in 1889, was estimated at 36 203,586 tons. The total entries and clearances, foreign and coastwise, for the port of London that year (1889), were 19,245,417 tons; of Liverpool, 14,175,200 tons. The estimate of the tonnage movement through the Detroit river, in 1889, was 3,000,000 tons above the combined foreign and coastwise tonnage of the ports of London and Liverpool.

The rapid growth, too, of steam transportation, and the competition of lake lines with the railways, have caused continued reductions in the cost of transportation. The cost per ton per mile of carrying freight, an average distance of eight hundred miles, was one and one-half mill in 1889. The value of all the cargoes—27,500,000 tons—carried on the lakes during that year was over $315,000,000. Had this been carried at railway rates, the cost to the public would have been over $143,000,000; by the lake rates it was about $23,000,000 only; so that transportation on the lakes saved to the public about $120,000,000 in one year. But, as to a large portion of this tonnage, any possible cost on wheels would not have permitted it to move at all. In such a case, its production at the point of origin would, of course, have been impossible. That, in turn, would have halted the pioneer emigrant this side of the richest areas of the continent.

The average distance for which freight on the lakes is carried is 566 miles. From this, the Census Bureau estimates the ton mileage for the season of 1889 to be 15,518,360,000 tons miles. The aggregate ton mileage of railways for the year ending June 30th, 1889, was 68,727,223,146, which shows the ton mileage of the lakes is nearly one-fourth of the total ton mileage of railways in the United States. In no other way could the relative importance of lake commerce be more effectively shown.

During the season of 1879, grain was shipped from Chicago to Liverpool for 17 cents per bushel, a rate but little greater than was paid for transportation by canal from Buffalo to New York, only ten years before, that is in 1869. In 1890, grain was shipped from Chicago to Liverpool for 9¾ cents per bushel.

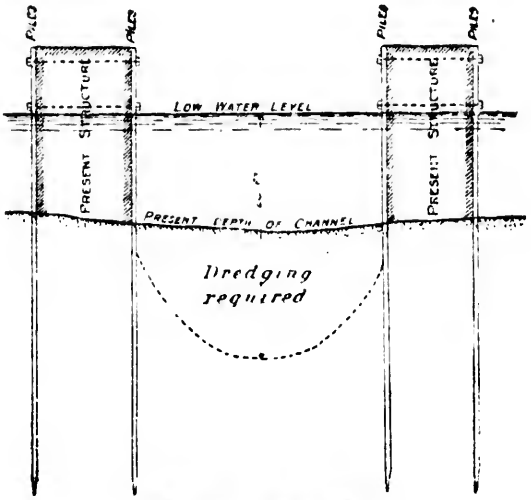
The extraordinary growth in shipbuilding and commerce on the lakes implies corresponding changes of conditions as to population and production along the thousands of miles of their shores and in the tributary country. Such equipment and use of these waters mean industrial activity and large advance in population.

	1880.	1890.
Four cities on Lake Superior had population	5,528	64,147
Four cities on Lake Huron and Lake St. Clair	181,610	304,863
Twelve cities on Lake Michigan	734,196	1,502,663
Seven cities on Lake Erie	420,685	675,310
	1,342,019	2,546,983

An increase of population in ten years of 85 per cent.

The Government of Canada has expended a large amount o money, in some instances assisted by the municipalities, on these lakes in constructing breakwaters, piers, wharves, and in dredging out approaches to harbors and channels entering same, as well as inner basins for vessels to lie in, both for commercial purposes and refuge. Up to the time of Confederation the amount expended by the Public Works Department of Canada for the above purposes was $890,699.25, and from that period until the 30th June, 1893, the expenditure was $3,439,364.63, making a total of $4,330,063.88. This does not include the construction of a dry dock at Kingston, nor the Canadian canal and locks at Sault Ste. Marie. Owing to the low stage of water in the lakes during the past two

seasons of navigation, considerable demand has been made upon the Department of Public Works of Canada for dredging out channels at the entrance to many of the harbors, and also for a continuation of the dredging inside the harbors, to enable vessels to enter for the purpose of loading and unloading. Care had to be exercised in directing these operations, from the fact that when the present piers and other works were constructed at the several harbors, some years ago, these structures were considered quite safe, and as serving all purposes for which they were intended, if extended and built in from 10 to 13 feet of water, as vessels drawing these depths were the largest afloat. Recent years have developed a much larger capacity in vessels trading upon the upper lakes, and, consequently, a deeper draught. To accommodate this increased size and draught, and even to give access to those of less tonnage during the low stage of water, the dredging required was, in many cases, lower than the foundation of the structures. To obviate the difficulties and danger to the present structures—where the increased depth is required—it has become necessary to protect the piers, etc., by driving sheet-piling along the sides and ends; this method is the least expensive. The sketch below shows the method adopted:—



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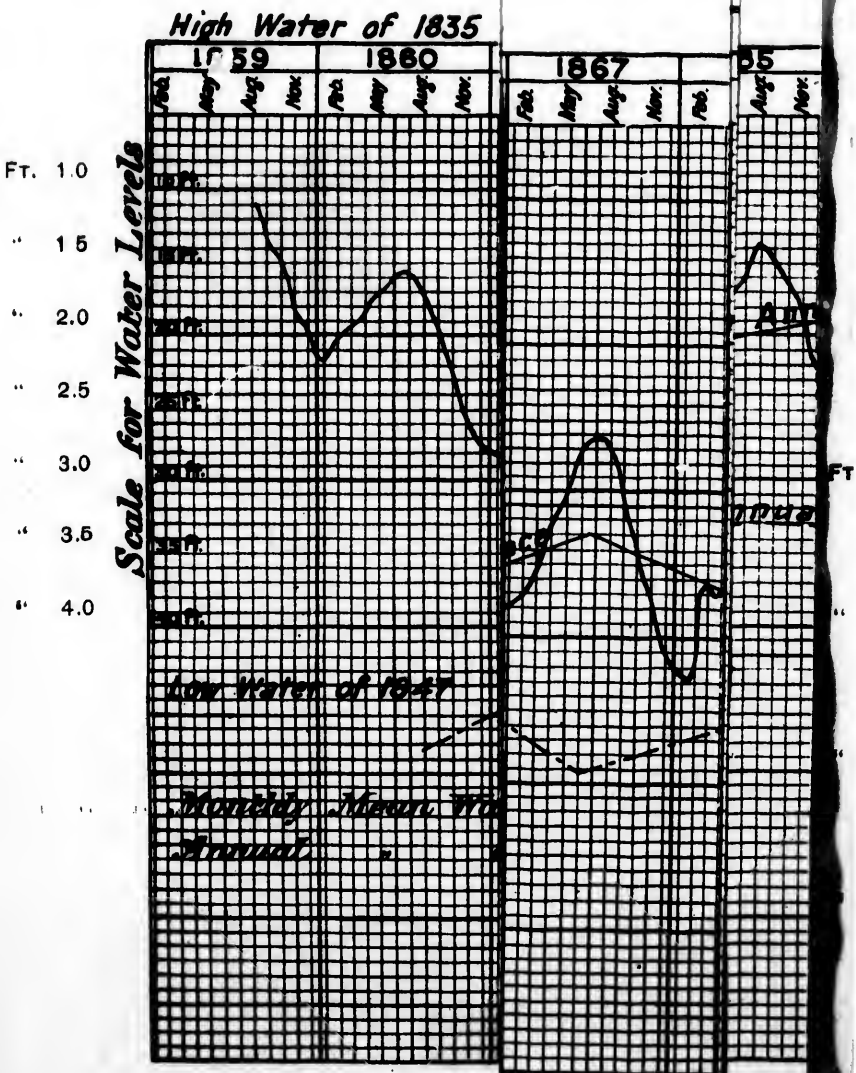
High Water of 1835
1859
1860
1867
Feb.
May
Aug.
Nov.
Scale for Water Levels
Ft. 1.0
" 1.5
" 2.0
" 2.5
" 3.0
" 3.5
" 4.0
Low Waters of 1847
Monthly Mean Wa
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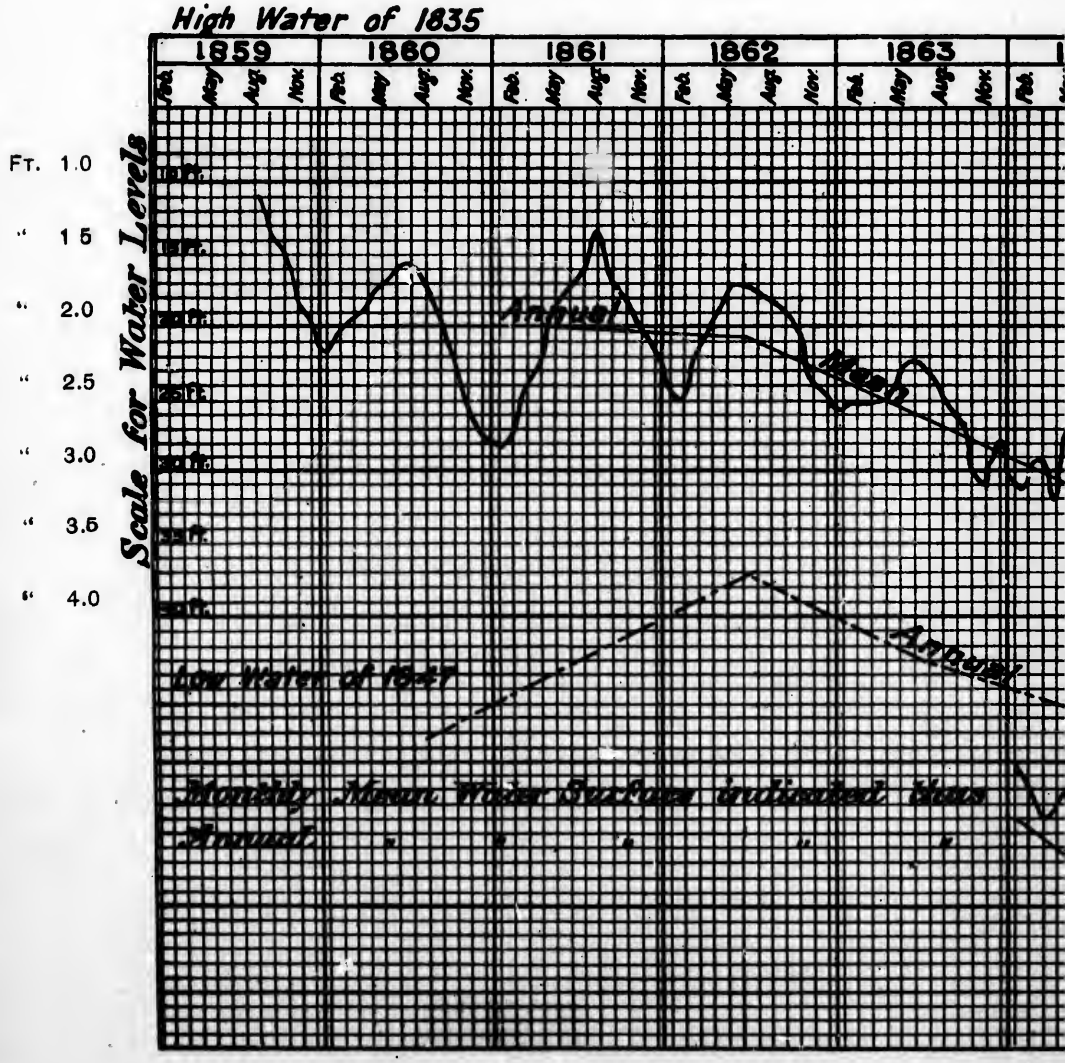
Henry A. Gray


High Water of 1835
1859
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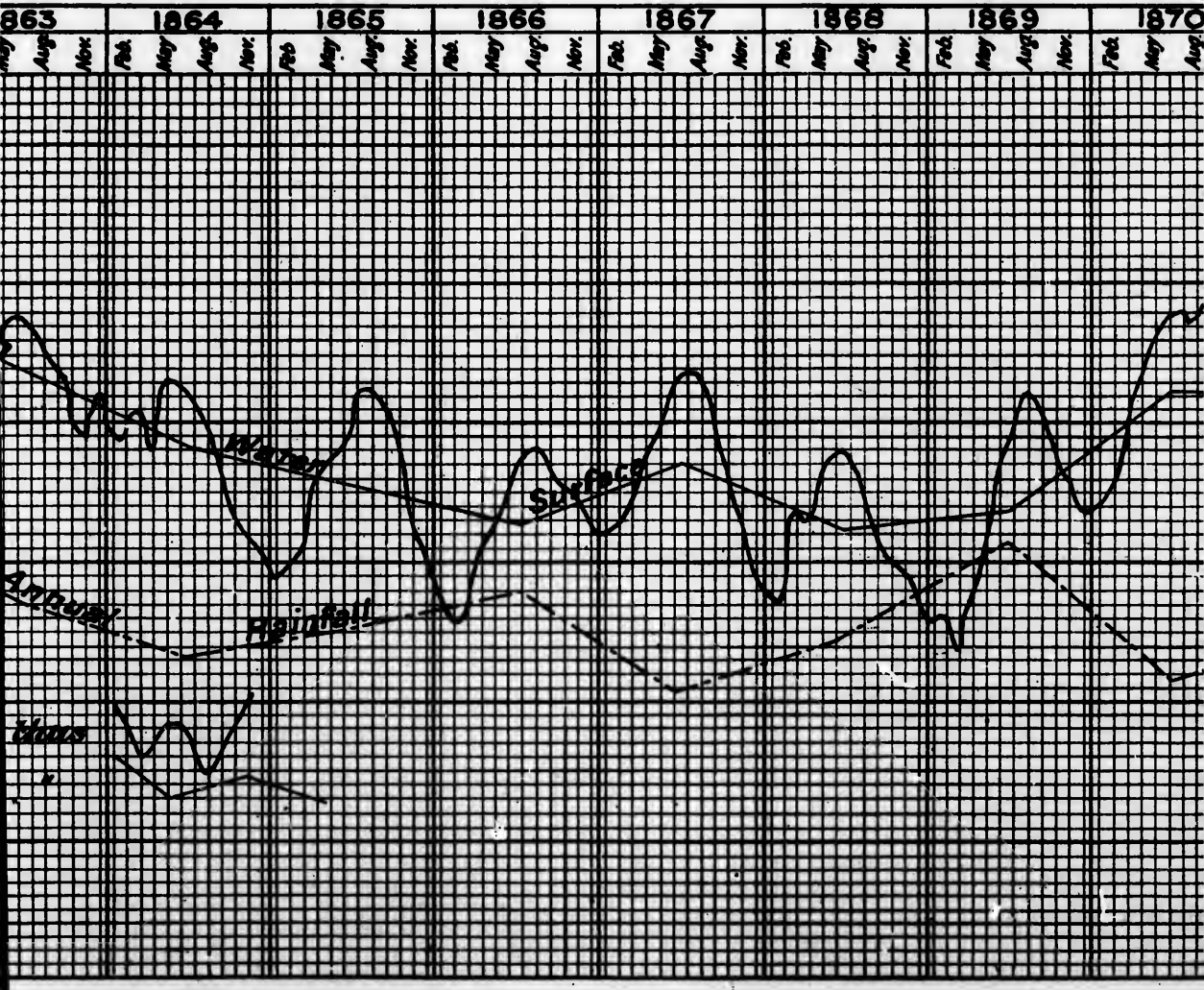
A. Gray


1863
1864
1865
1866
1867
1868
1869
1870
Feb.
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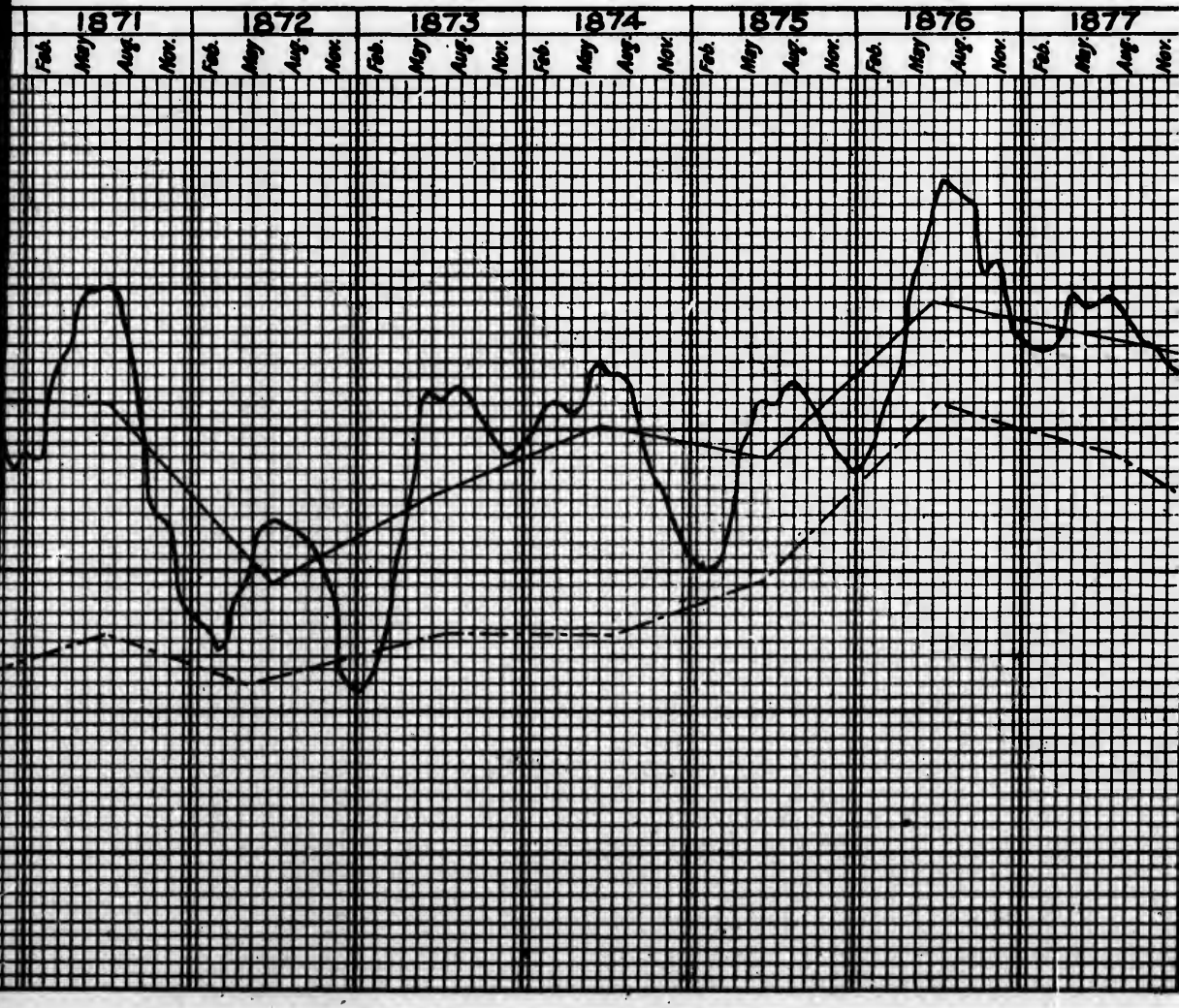
LAKES MICHIGAN A



SHOWING

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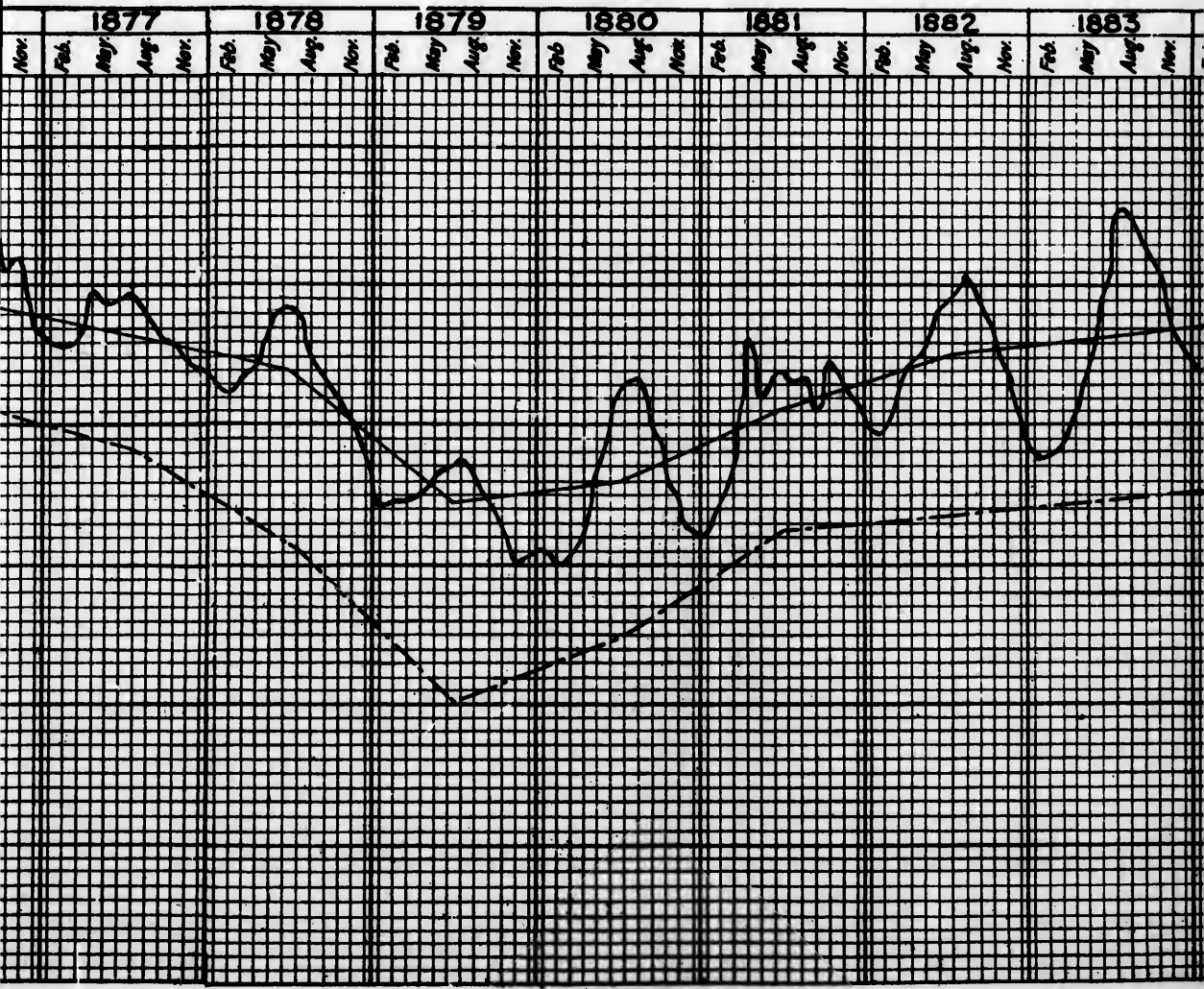
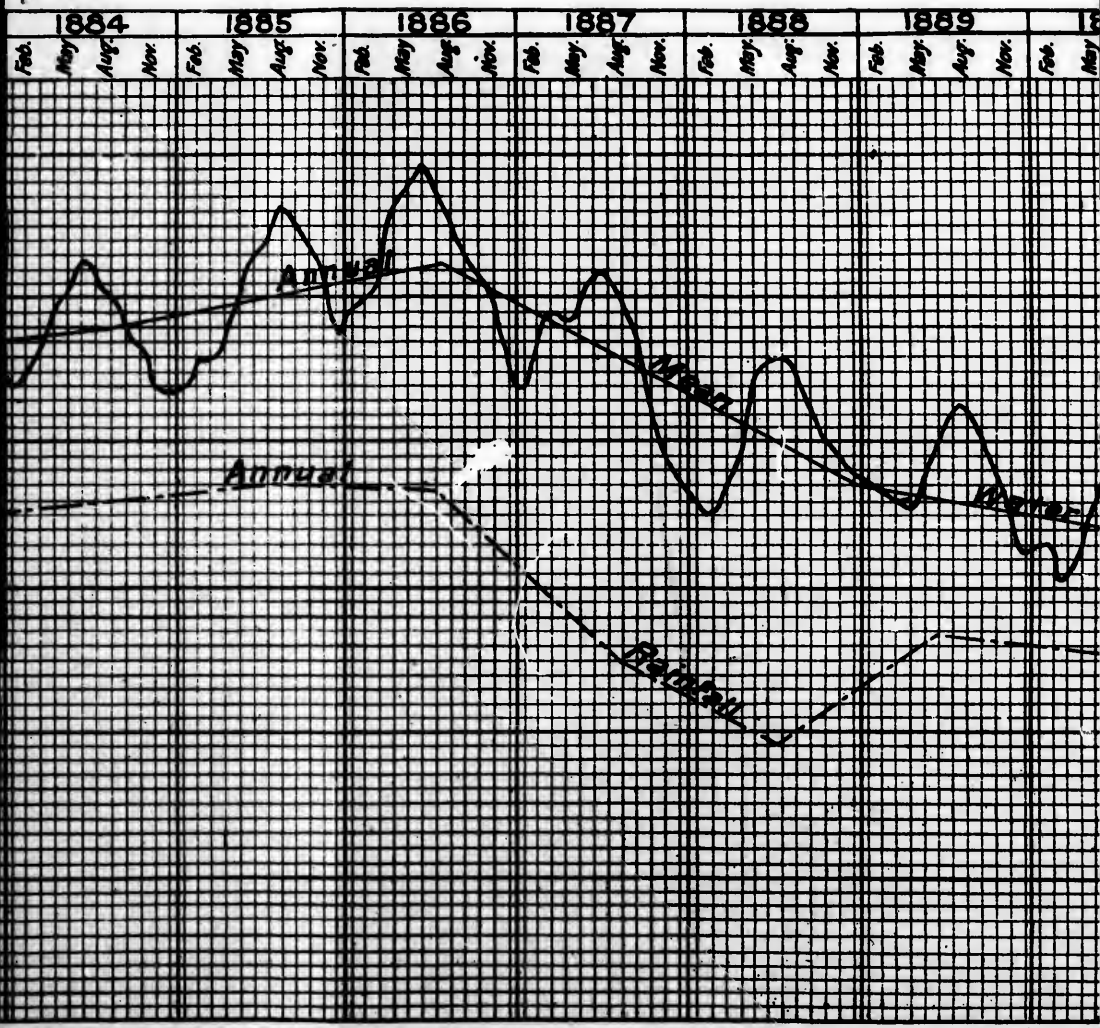



1884
1885
1886
1887
1888
1889
Feb.
May.
Aug.
Nov.
Annual
Annual
Rainfall

TRANSACTIONS CAN. SOC. C. E.
VOL IX. PLATE V.

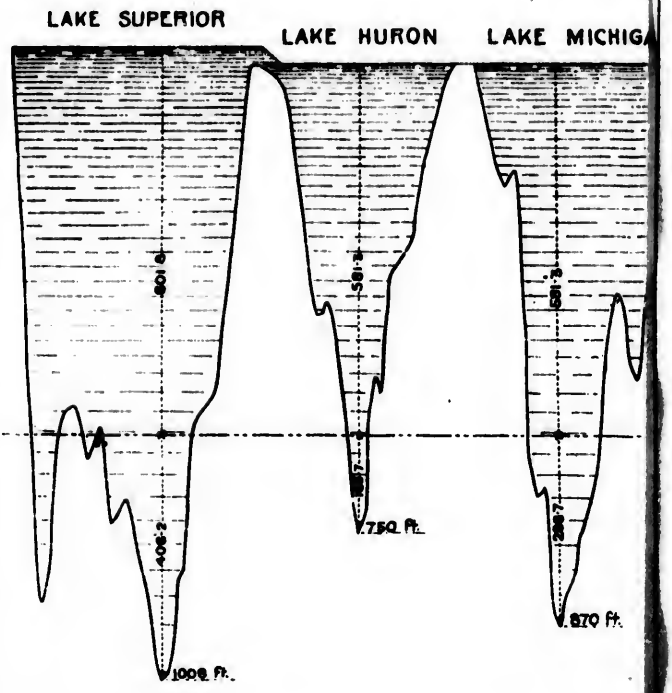
With respect to the low stage of water in the lakes, referred to above as having caused the Department of Public Works of Canada considerable attention and expenditure of money for dredging purposes during the past two seasons, various theories have been advanced to account for the several changes in the water level of the lake; it is, however, well established that the fluctuations are due to the variations in rainfall, as the lake levels approximate closely to those of rainfall and snow. The highest known level occurred in 1838, when Michigan and Huron rose 26 inches above ordinary high stage, and Erie and Ontario 18 inches. The lowest level was in 1819, when Erie fell 3½ feet below its usual plane. Since the highest water in 1838, there have been alternate periods of descension and ascension of the levels, either five, seven, or eight years in lengths, the seven year period being most frequent. In order to show the fluctuations of the water surface, rainfall, etc, as stated above, the accompanying chart of Lakes Huron and Michigan has been prepared, copied from information compiled from official data, obtained from the U. S. Lakes Survey, and tabulated by Mr. Chas. Crossman, U. S. Engineer at Milwaukee. The chart embraces a period from 1861 to 1894. A careful examination will show that from 1882 to 1888 the surface of Lakes Michigan and Huron was considerably above the mean level. The water, at the present time, is about the average of the period from 1882 to 1887, and judging the future by the past, it is probable that for several years to come there will be no permanent increase in depth. By this chart, the relation between the rainfall and the stage of the lake can be perceived unmistakably in the spring, autumn, and summer of 1876, the remarkable rise of water, culminating in September 1876, corresponding with a period of heavy rainfall. This period was followed by a few months of light rainfall, during which the water fell rapidly. From this time until December, 1879, the rain, fall was, as a general thing, less than the mean, and the water surface had a downward tendency. In January, 1880, began a period of heavy rainfall and a rise in the water. From June to August, 1881, the rainfall was light and the stage of water a falling one. In September there was the heaviest rainfall known for many years, accompanied by a correspondingly rapid rise in the water.

While there is every reason to believe that a winter of continually freezing weather, by retaining the snowfall until the thawing weather of April or May, will tend to raise the summer level of the lake at the expense of the winter level, it is not confirmed to any great degree. The explanation of this is not difficult. A single week of warm weather in the winter, causing the melting of the greater part of the snow, might be preceded and followed by extremely cold weather, giving a low mean temperature for the month; so that a cold winter does not necessarily imply the impounding until spring, in the form of snow, of the winter rainfall. Vessel owners and captains state that the water in the several lakes must have decreased and fallen, as it is now found more difficult to enter the several harbors and navigate the channels. Others have remarked that the deepening of some of the channels lying between the chain of lakes has caused a drainage and lowering of the water in the lakes; others, that the wearing away of the crest of the rock at Niagara Falls has lowered the water above that point.

In making these and other assertions and statements, these persons seem to forget entirely that the vessels used now are larger, and draw from six to ten feet more water than they did some few years ago, and, consequently, require a corresponding greater depth of channel and harbor accommodation. General Poe, Lieut.-Col. of Engineers, U. S. Army, in charge of the Lake District for the American Government, writing upon this subject, states: – "There is no indication anywhere that the waters in the lakes have mysteriously fallen. The long continued series of observation, now available, show that since 1838 the water level has fluctuated within limits somewhat less than 6 feet, and that these fluctuations were due to the greater or less rain and snowfall. It may be considered, as a fact established, that the lakes are simply great pools forming part of the course of a river, and that they conform to all the laws governing the rise and fall of rivers."

In 1881, it was stated by the Toronto newspapers that the level of Lake Ontario had been lowered by work done at the Galops Rapids, in the St. Lawrence river, and that the harbor of Toronto had been damaged by it. It was proved, however, that thirty years before the deepening of the Galops channel was begun, the water

Henry A. Gray.



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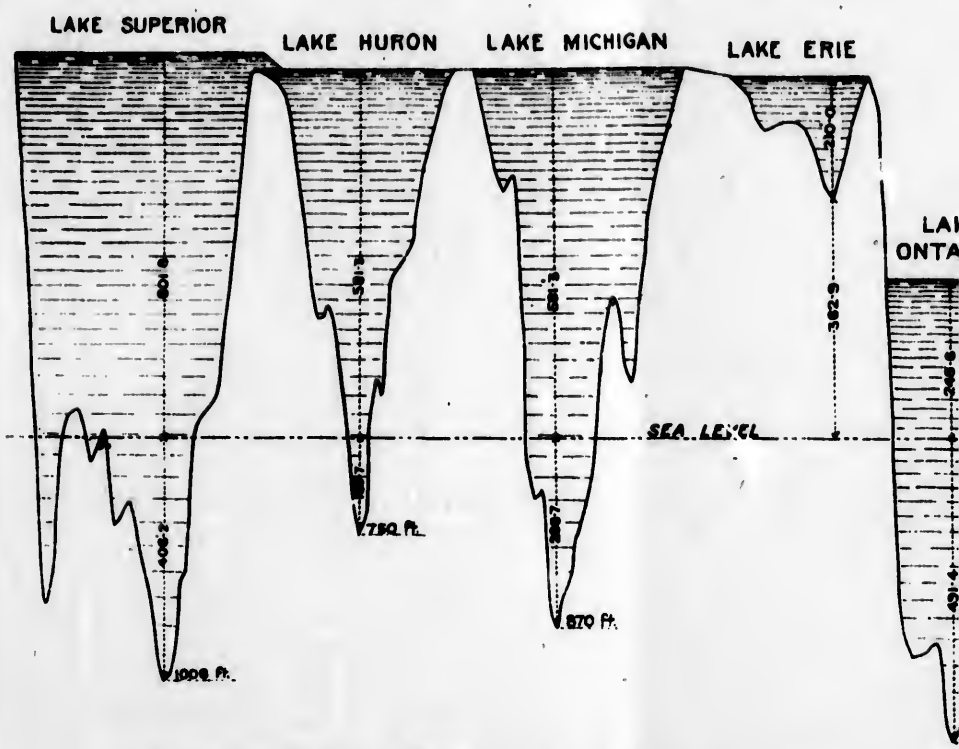
Henry A. Gray.



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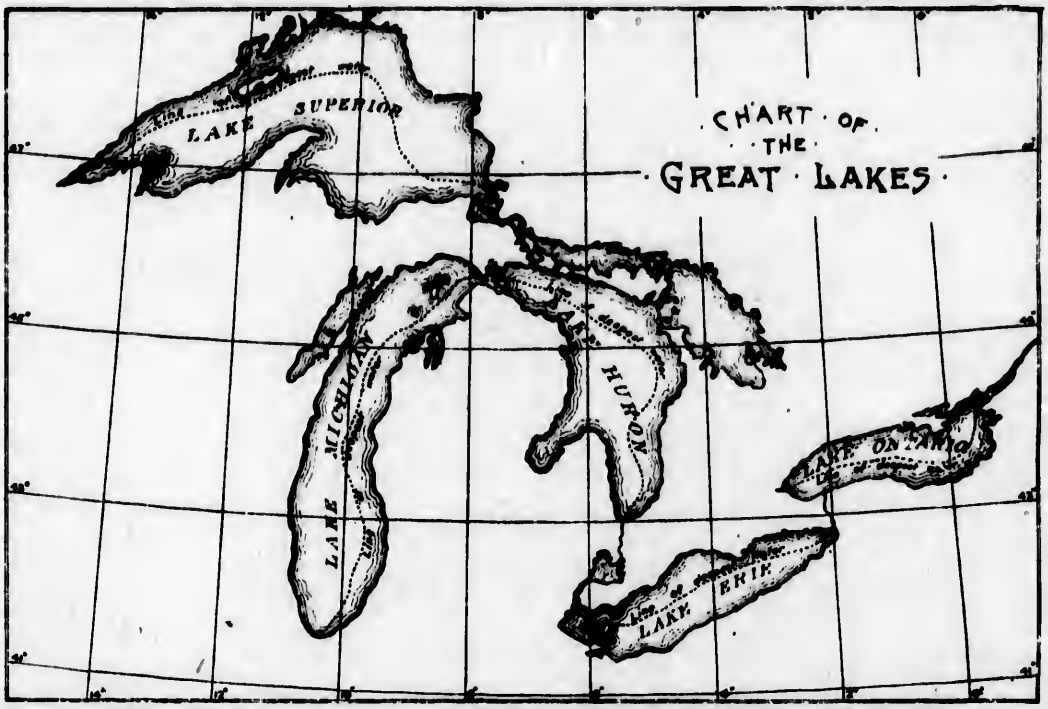
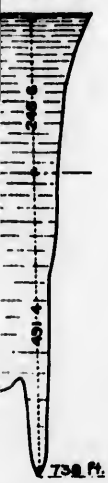




	Area of Water surface	Area of watershed	Aggregate area of basin
	SQ. MILES.	SQ. MILES.	SQ. MILES.
Lake Superior	31,200	51,600	82,800
Lake Huron	23,800	31,700	55,500
Lake Michigan	22,450	37,700	60,150
Lake Erie	9,960	22,700	32,660
Lake Ontario	7,240	21,600	28,840

was as low in Lake Ontario as it was in 1881. The best authorities on hydraulics show that no harm can result from deepening the several channels, for it is a theory of permanent motion that a change of *regimen* being made at any point of a river, its effect is extended up and down stream, decreasing as it goes until points are reached where it disappears entirely, and the river remains unaffected.

In the following it is endeavored to give a part of the latest and most reliable information relating to the Great Lakes. The lately completed lake surveys made by the United States have reduced to exactness much that was previously only approximate.

The water surface of the Great Lakes, with the land draining into it, presents the total drainage basin of over 270,000 square miles, assembled as follows:

	Area of Water Surface, Square Miles.	Area of Water Shed, Square Miles.	Aggregate Area of Basin, Square Miles.
Lake Superior	31,200	51,600	82,800
St. Mary's River	150	800	950
Lake Michigan	22,450	37,700	60,150
Lake Huron and Georgian Bay.....	23,800	31,700	55,500
St. Clair River	25	3,800	3,825
Lake St. Clair.....	410	3,400	3,810
Detroit River.....	25	1,200	1,225
Lake Erie	9,960	22,700	32,660
Niagara River	15	300	315
Lake Ontario.....	7,240	21,600	28,840
	95,275	174,800	270,075

The combined areas of the lakes exceed the area of England, Wales and Scotland.

The accompanying figure is a carefully drawn chart of the lakes, and compilations showing area of water surface, water shed and aggregate areas of basin; line of greatest depth and longitudinal sections on that line, with heights and depth referred to sea level. The length of shore line of the lakes and their connecting rivers is about 5,400 miles. The elevation of the mean surface of the lakes above mean sea level is as follows:—

Lake Ontario ....$246\frac{6}{10}$ feet.
Lake Erie..... .....$572\frac{9}{10}$ "
Lakes Huron and Michigan.....$581\frac{3}{10}$ "
Lake Superior.....$601\frac{8}{10}$ "

The difference of 20½ feet between Lake Superior and Huron occurs in the rapids of St. Mary's river; the 8 1/10 feet between Lakes Huron and Erie, mainly in Detroit river. The difference of 326 feet between Lakes Erie and Ontario occurs in the vicinity of Niagara Falls, and is principally assembled as follows :—100 feet in the five miles of rapids between Lewiston and the lower Suspension Bridge, 10 feet in the rapids between the Bridge and the Falls, 160 feet at the Falls, 50 feet in the rapids immediately above the Falls, and 6 feet in the upper Niagara river. The mean depth of Lake Superior is about 475 feet; the deepest point marks a depth of 1,008 feet, or 406 feet below the level of the sea. Lake Huron has a mean depth of 250 feet and a maximum depth of 750 feet. Lake Erie is comparatively shallow, having an average depth of less than 70 feet and a maximum of 210 feet. Lake Ontario has a mean depth of about 300 feet and a maximum of 738, or nearly 500 feet below the level of the sea. The channel of the rivers connecting the lakes seldom exceeds the depth of 50 feet. If the lakes could be drained to the level of the sea, Lake Erie would disappear, Lake Huron reduced to quite insignificant dimensions, Lake Michigan to a length of about 100 miles, with a width of 25 or 30 miles, Lakes Ontario and Superior, although with diminished areas, would still preserve the dignity of their present titles as Great Lakes.

A chemical analysis of water taken from the deepest part of Lake Superior failed, under the application of delicate tests, to indicate the presence of salt. The beds of the lakes away from the vicinity of the shore lines, and at depths exceeding 100 feet, are almost invariably covered with clay. Specimens from the deep soundings of Lake Superior were invariably soft clay, varying in color from red to yellow and blue. In the deepest parts, the drabs and bluish tints predominate. The temperature at the deepest points varies little from the mean annual temperature of the surrounding air. The temperature of Lake Superior at depths exceeding 200 feet varies but slightly from 39° F. In Lake Huron, at depths of about 300 feet, the temperatures in the months of June and August were 52° F., while, at a depth of 624 feet, the temperature was 42° F., the surface temperature being 52° F., and the air 64° F. The mean annual rain and melted snowfall of the several lake

basins is as follows : Lake Superior, 29 inches ; Lake Huron, 30 inches ; Lake Michigan, 32 inches ; Lakes Erie and Ontario, 34 inches. This is about equal to 31 inches on the entire lake basin. The following represents the average discharges at the outlets of the lakes : —

Lake Superior, at St. Mary's River.....	86,000	cubic ft per sec.
Lakes Michigan and Huron at St. Clair River.....	225,000	" "
Lake Erie, at Niagara	265,000	" "
Lake Ontario, at St. Lawrence River.....	300,000	" "

If the average discharge of the lakes passed through a river one mile wide with a mean velocity of one mile per hour, such river would have a depth of 40 feet from shore to shore.

The volume of water in the lakes is about 6 000 cubic miles, of which Lake Superior contains a little less than one-half. Perhaps a better idea of this volume may be obtained when it is said that it would sustain Niagara Falls in its present condition for about 100 years.

The principal changes in the elevation of the lake surface are those due to the wind and to rainfall.

During protracted autumn gales, waves have been observed which, through reliable means, measured from 15 to 18 feet above the normal surface. The second class of variation are those due to rainfall, as before stated. The last ten years show a tendency to irregularities which may be due to changes in rainfall and water-shed, produced by the rapid destruction of the forests which, ten years ago, covered the basin of the upper lakes. Observations made by the U.S. Survey have established the existence of small tides which, at Chicago, had an amplitude of 1½ inches for the neap tide and about 3 inches for the spring tide. There is still another class of oscillations called *seiches*, which have been already observed in the Swiss lakes, and for which a solution, in all respects satisfactory, has not been offered. Whenever the lakes are sufficiently free from the disturbing action of wind to permit observation, a quite regular series of small waves, or pulsations, can be detected, which have an interval of about ten minutes from impulse to impulse. These pulsations seem to occur almost without cessation on Lake Superior. Besides having tides in common with

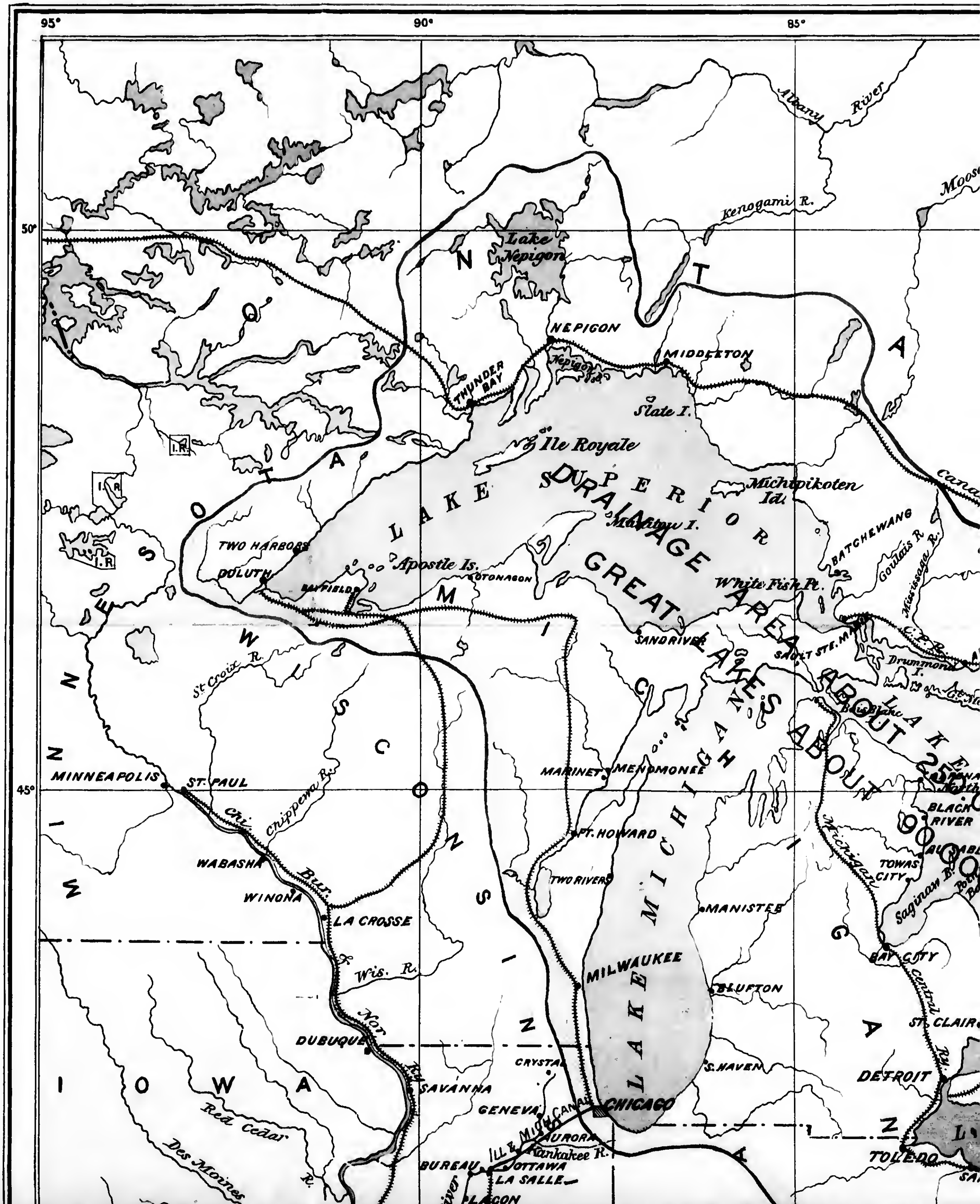
the ocean, the lakes have well-defined land and lake breezes, the breeze from the lakes landward commencing in summer at 8 or 10 o'clock a.m., and continuing until sunset, and the breeze from the land lakeward from 9 or 10 p.m. until sunrise.

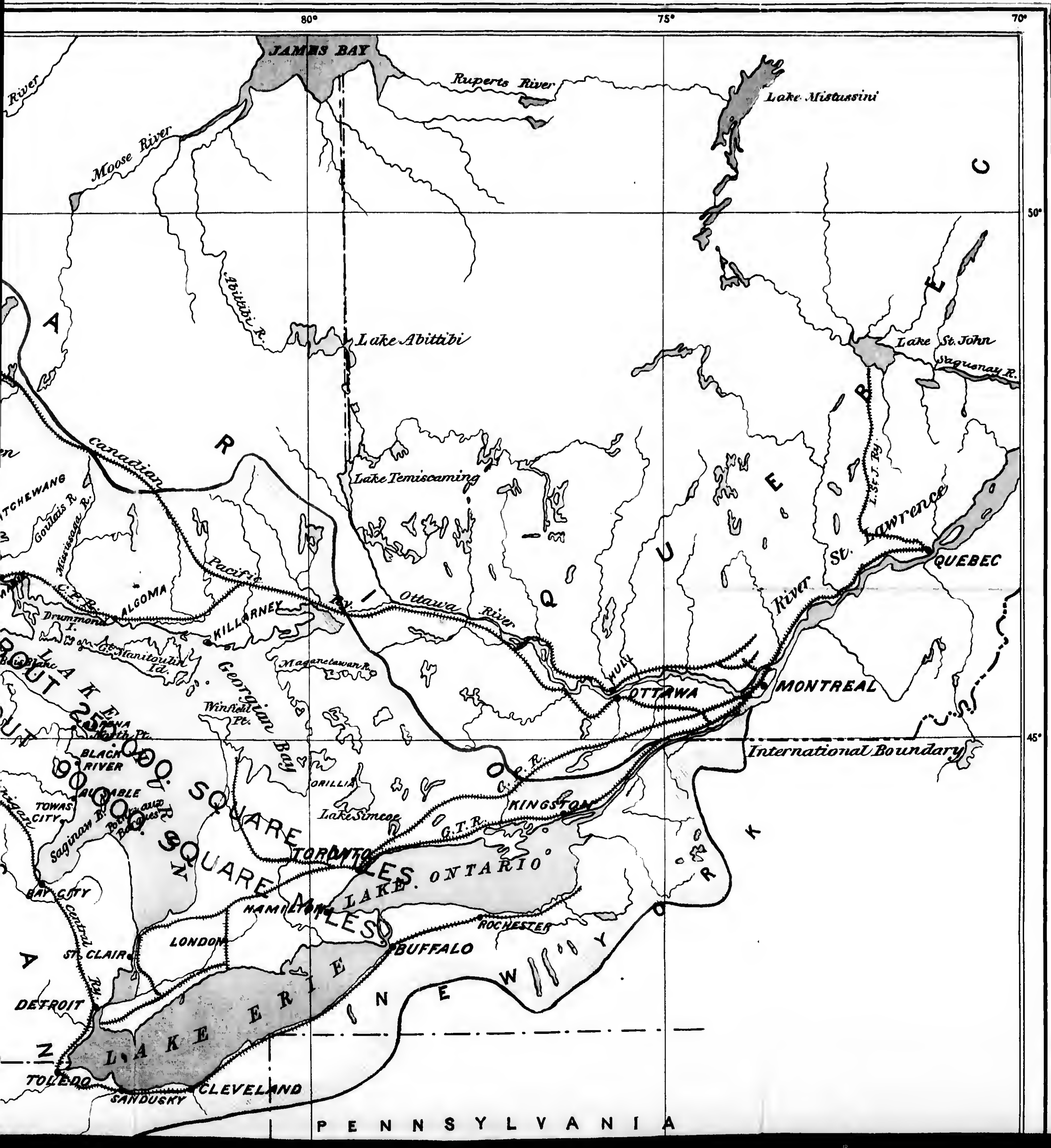
For about one-half the distance across the continent the waters of the St. Lawrence system divide the Dominion of Canada from the United States. The boundary line, beginning on the St. Lawrence in latitude 45 degrees, passes through the middle of Lake Ontario, Erie, St. Clair, Huron, the St. Mary's River and Lake Superior, to a point on its north shore, 124 miles east of Duluth and Superior, the western end of Lake Superior. Lake Michigan is wholly within the territory of the United States. These great lakes contain more than one-half the area of all the fresh water of the globe. They make up the largest system of deep water inland navigation on the globe. No other inland water may bear upon its bosom so vast a commerce, or touches, as this does, the vital interests ot so many millions of men. Lying, in general direction, east and west between the 41st and 47th parallels, they penetrate the tide water on the St. Lawrence. The western extremity of the system, the head of Lake Superior, is 1,700 miles only from the waters of the Pacific. It is 2,384 miles from Belle Isle, at the mouth of the St. Lawrence, and 4,618 miles from Liverpool.

The range of this water system, it will be observed, is entirely within the limits of the north temperate zone, on the line on which population has most freely moved westward, where final settlement is most compact, and where climatic conditions insure the largest returns to capital and labor. Lake Superior, the head of the system, alone receives the waters of 200 rivers. One hundred and fifty miles northwest of Port Arthur and Duluth are the fountains of three of the great drainage systems of the continent. Physical conditions there send flowing waters northward to the ocean through Hudson's Bay; southward, through the Mississippi Valley and the Gulf of Mexico, and eastward, through the lakes and the St. Lawrence. For commercial purposes, the northern drainage system has not yet been utilized; but flowing water will forever be a potent instrument of commerce, southward and eastward, between the interior and the Atlantic coast.

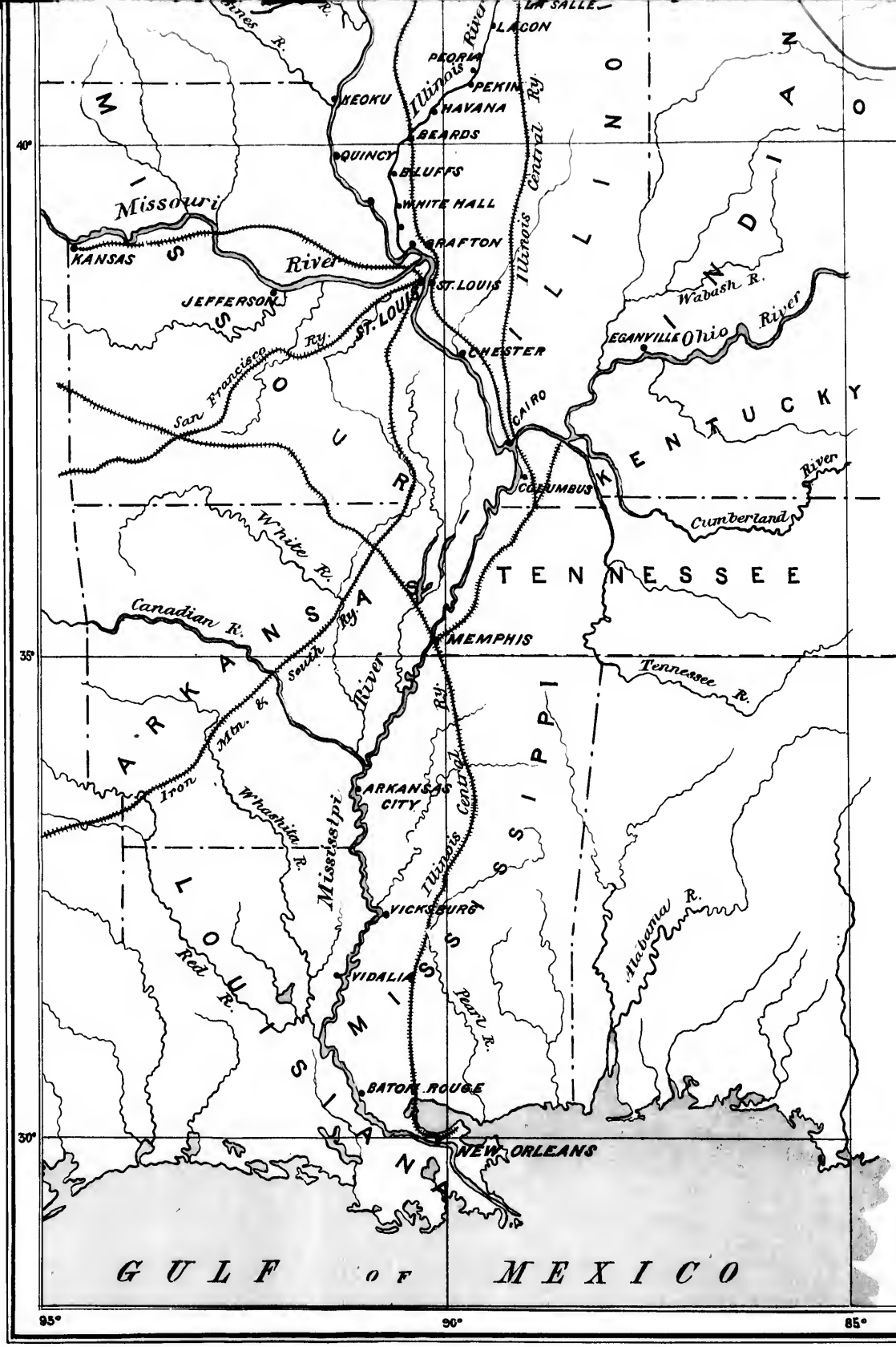
Such are the peculiar and the favoring physical conditions under which two great peoples of English tongue occupy, side by side, the North American continent from ocean to ocean, using in common this continental water-way, and by treaty stipulations interchanging with each other the use of improvements inside their respective boundary lines. From both sides, then, of this continental boundary line, inevitably and forever, will come here for transit into the world's commerce, the products of the vast plains and the mountain region of the far Northwest. On this line, also, to a large extent, will be made the commercial exchanges of the Pacific Slope, Australia, China and Japan.

SHEET, NO. 6.


95°
90°
85°
50°
45°
Albany River
Moose
Kenogami R.
Lake Nepigon
NEPIGON
MIDDLETON
THUNDER BAY
Nepigon
Slate I.
Ile Royale
Michipikoten Id.
LAKE SUPERIOR
GREAT LAKES DRAINAGE AREA ABOUT 250,000
TWO HARBORS
DULUTH
BAYFIELD
Apostle Is.
ONTONAGON
White Fish Pt.
BATCHEWANG
Goulais R.
Missisaga R.
SAND RIVER
SAULT STE. MARIE
C.P.R.
Drummond I.
St Croix R.
MINNEAPOLIS
ST. PAUL
Chippewa R.
MARINETTE
MENOMONEE
FT. HOWARD
BLACK RIVER
TOWAS CITY
Saginaw B.
WABASHA
WINONA
LA CROSSE
TWO RIVERS
MANISTEE
BAY CITY
Wis. R.
MILWAUKEE
BLUFTON
Central Ry.
ST. CLAIR
DUBUQUE
CRYSTAL
S. HAVEN
DETROIT
SAVANNA
GENEVA
CHICAGO
ILL. & MICH. CANAL
AURORA
Kankakee R.
Red Cedar R.
Des Moines R.
BUREAU
OTTAWA
LA SALLE
LACON
TOLEDO
LAKE MICHIGAN
Michigan
ONTARIO
MINNESOTA
WISCONSIN
MICHIGAN
IOWA
I.R.



80°
75°
70°
50°
45°
JAMES BAY
Ruperts River
Lake Mistassini
Moose River
River
Abittibi R.
Lake Abittibi
Lake Temiscaming
Lake St. John
Saguenay R.
L. St. J. Ry.
Q U E B E C
O N T A R I O
Canadian Pacific Ry.
C.P.R.
Goulais R.
Mississaga R.
ALGOMA
KILLARNEY
Drummond I.
Gt. Manitoulin Id.
Georgian Bay
Maganetawan R.
Winfield Pt.
ORILLIA
Lake Simcoe
Ottawa River
HULL
OTTAWA
MONTREAL
QUEBEC
River St. Lawrence
International Boundary
KINGSTON
G.T.R.
TORONTO
HAMILTON
LAKE ONTARIO
ROCHESTER
BUFFALO
LONDON
ST. CLAIR
DETROIT
LAKE ERIE
TOLEDO
SANDUSKY
CLEVELAND
BAY CITY
Central Ry.
BLACK RIVER
AU SABLE
Saginaw B.
N E W Y O R K
P E N N S Y L V A N I A



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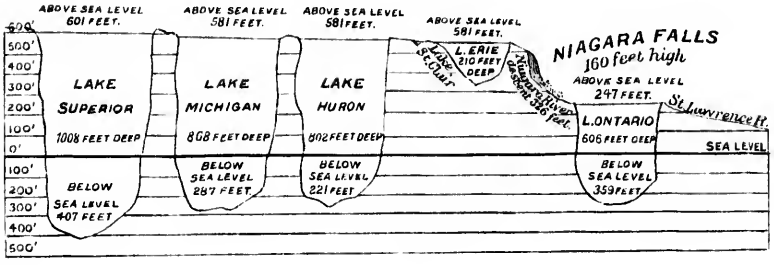
Ottawa, Ont., Canad

J.L.P

PENNSYLVANIA

80° 75° 70° 40° 38° 30°

LONGITUDINAL SECTION
OF THE GREAT LAKES AND CONNECTING RIVERS.



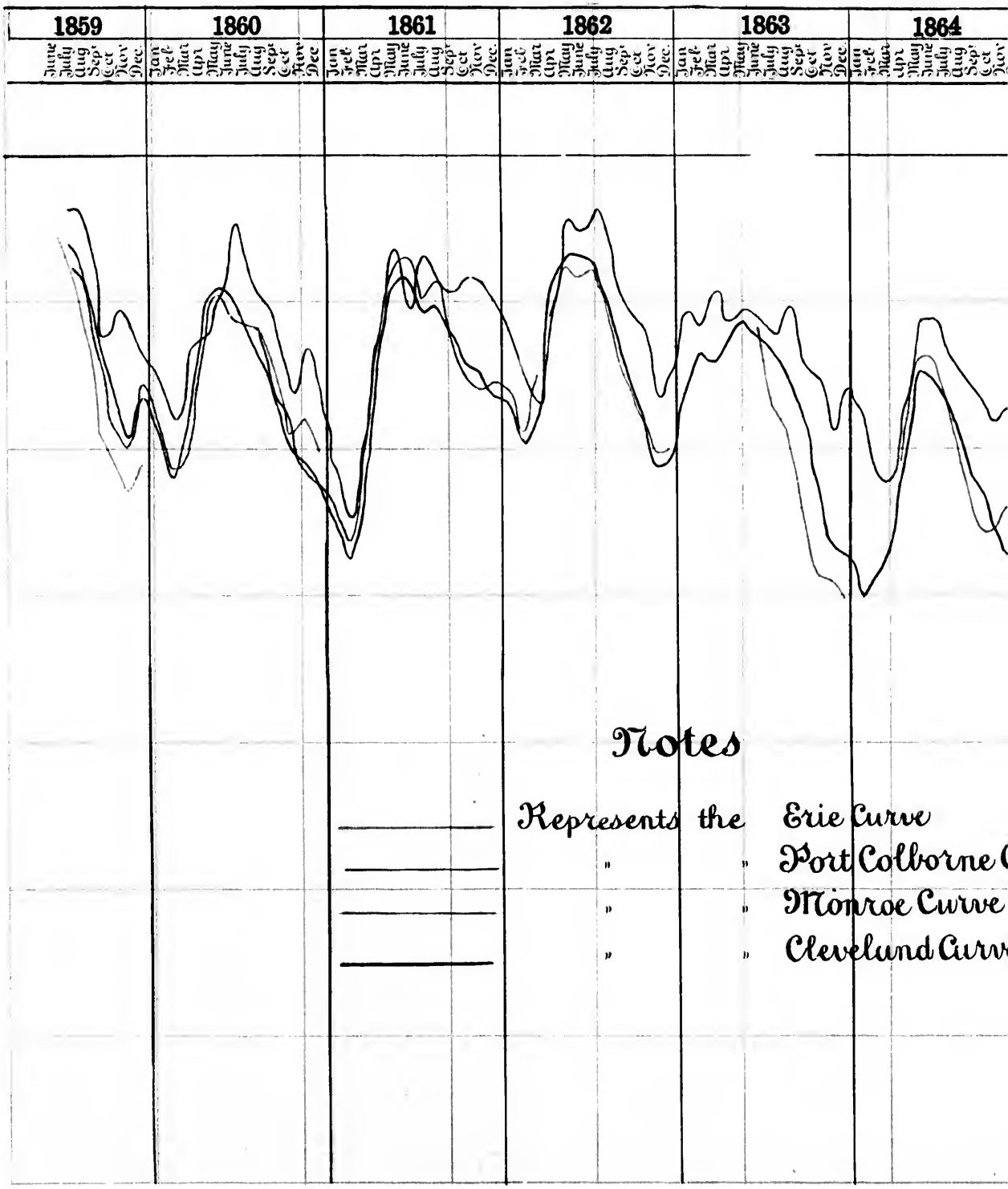
To accompany report on "Effect of Chicago Drainage Canal on levels of Great Lakes and connecting Rivers" by order of

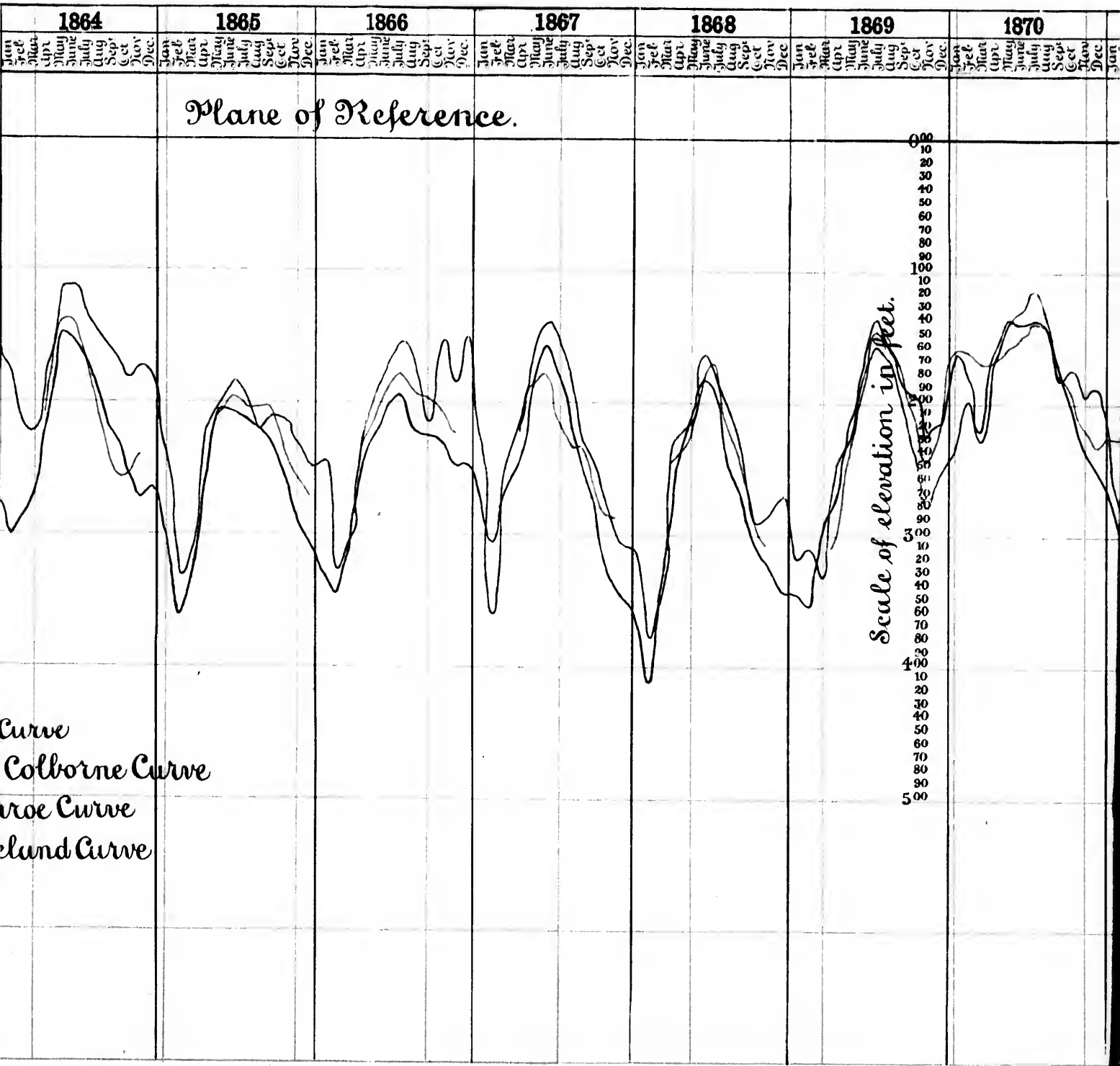
HONORABLE JOHN COSTIGAN,
Minister of Marine and Fisheries
Canada.

Map Showing
The Drainage Basin of the
GREAT LAKES
— with the —
Des Plaines Illinois and Mississippi Rivers.

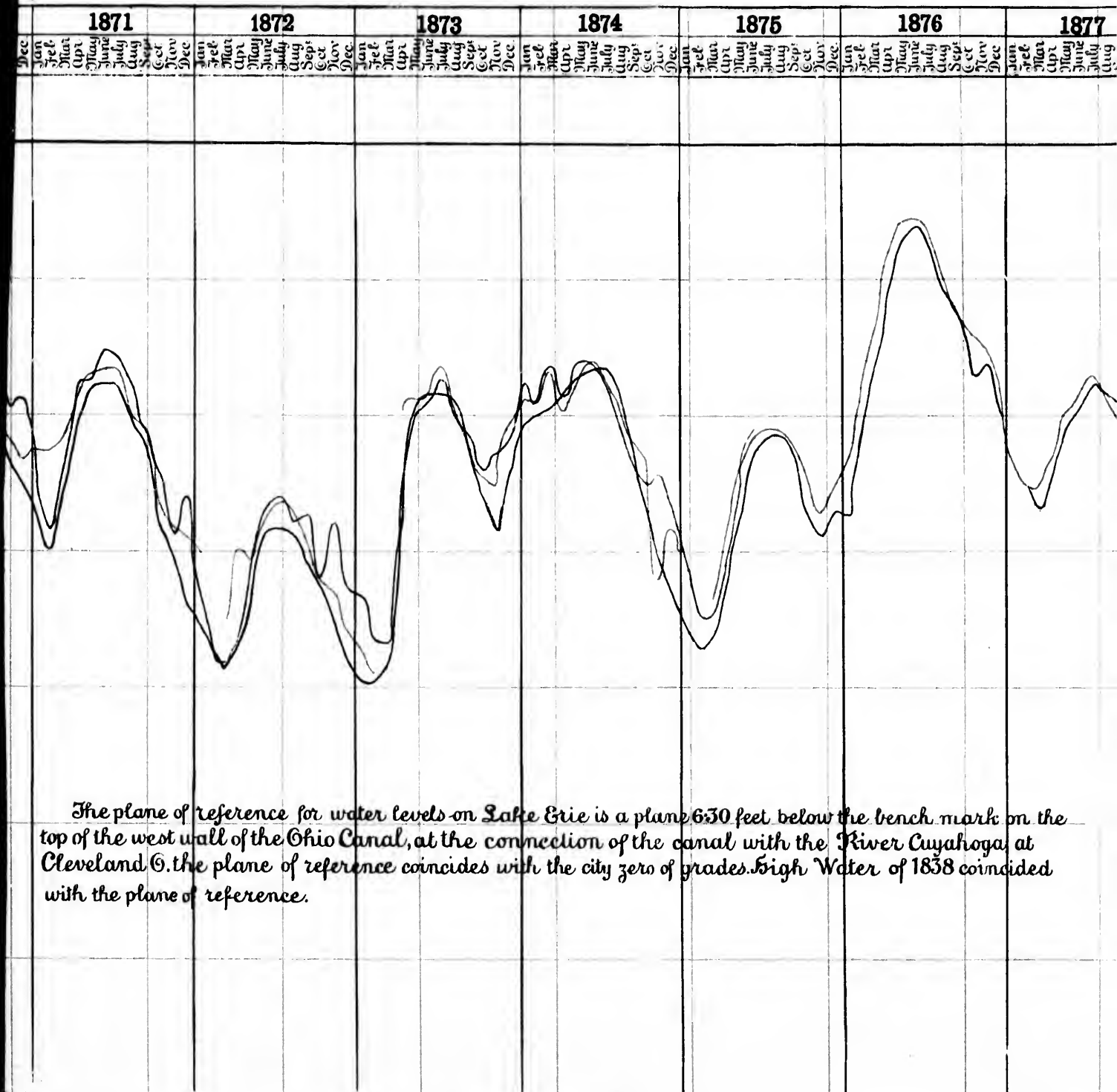
Ont., Canada, April 1896.
J. L. P. O'HANLY, C.E.

SHEET, NO. 2.


1859
1860
1861
1862
1863
1864
June July Aug Sep Oct Nov Dec.
Jan Feb Mar Apl May June July Aug Sep Oct Nov Dec
Notes
Represents the Erie Curve
" " Port Colborne
" " Monroe Curve
" " Cleveland Curv

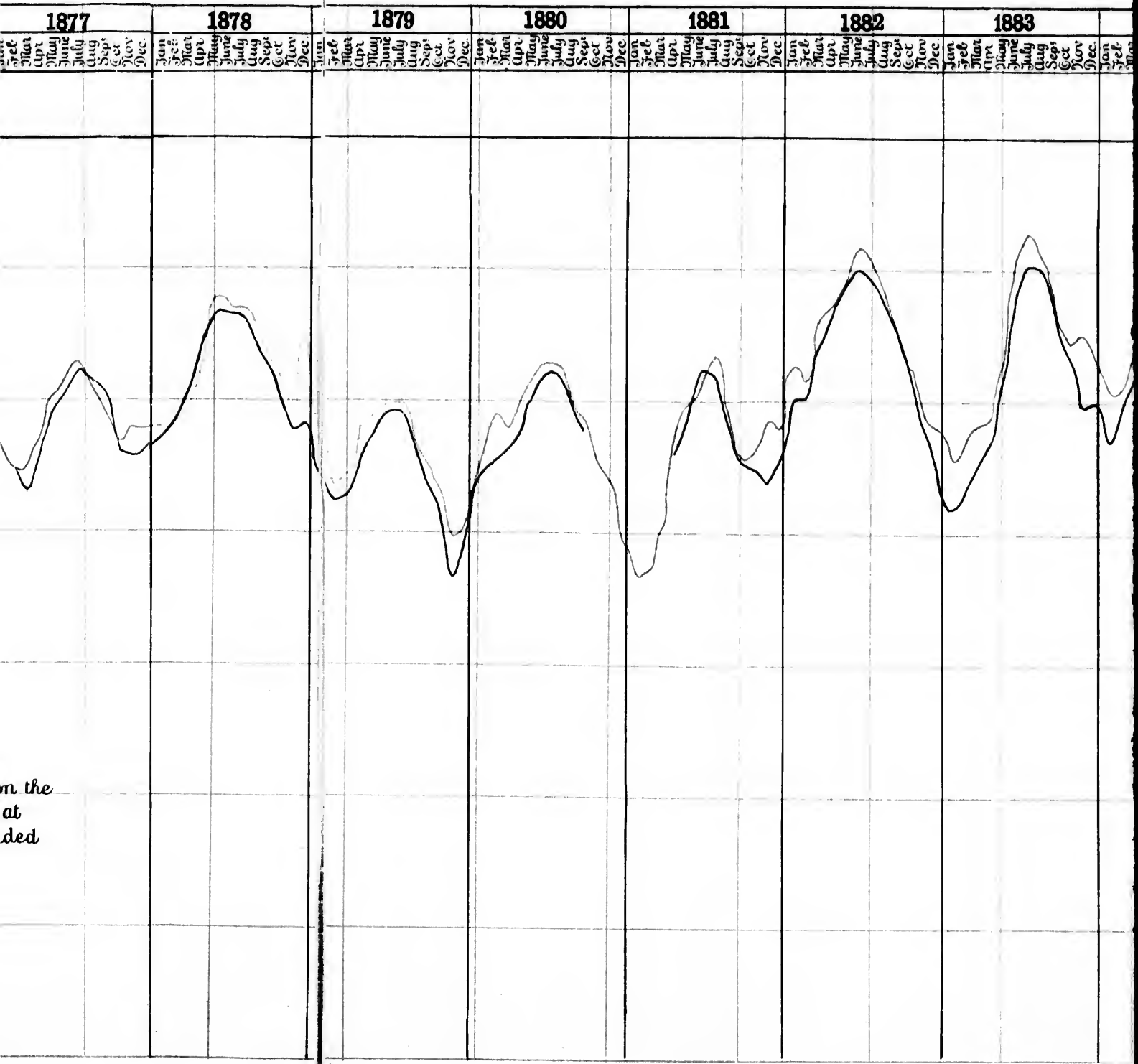

1864
1865
1866
1867
1868
1869
1870
Jan Feb Mar Apr May June July Aug Sep Oct Nov Dec
Plane of Reference.
Scale of elevation in feet.
0
100
200
300
400
500
Curve
Colborne Curve
roe Curve
land Curve

Annual Water Level Curves Lak



The plane of reference for water levels on Lake Erie is a plane 6:30 feet below the bench mark on the top of the west wall of the Ohio Canal, at the connection of the canal with the River Cuyahoga, at Cleveland O. the plane of reference coincides with the city zero of grades. High Water of 1838 coincided with the plane of reference.

Lake Erie.



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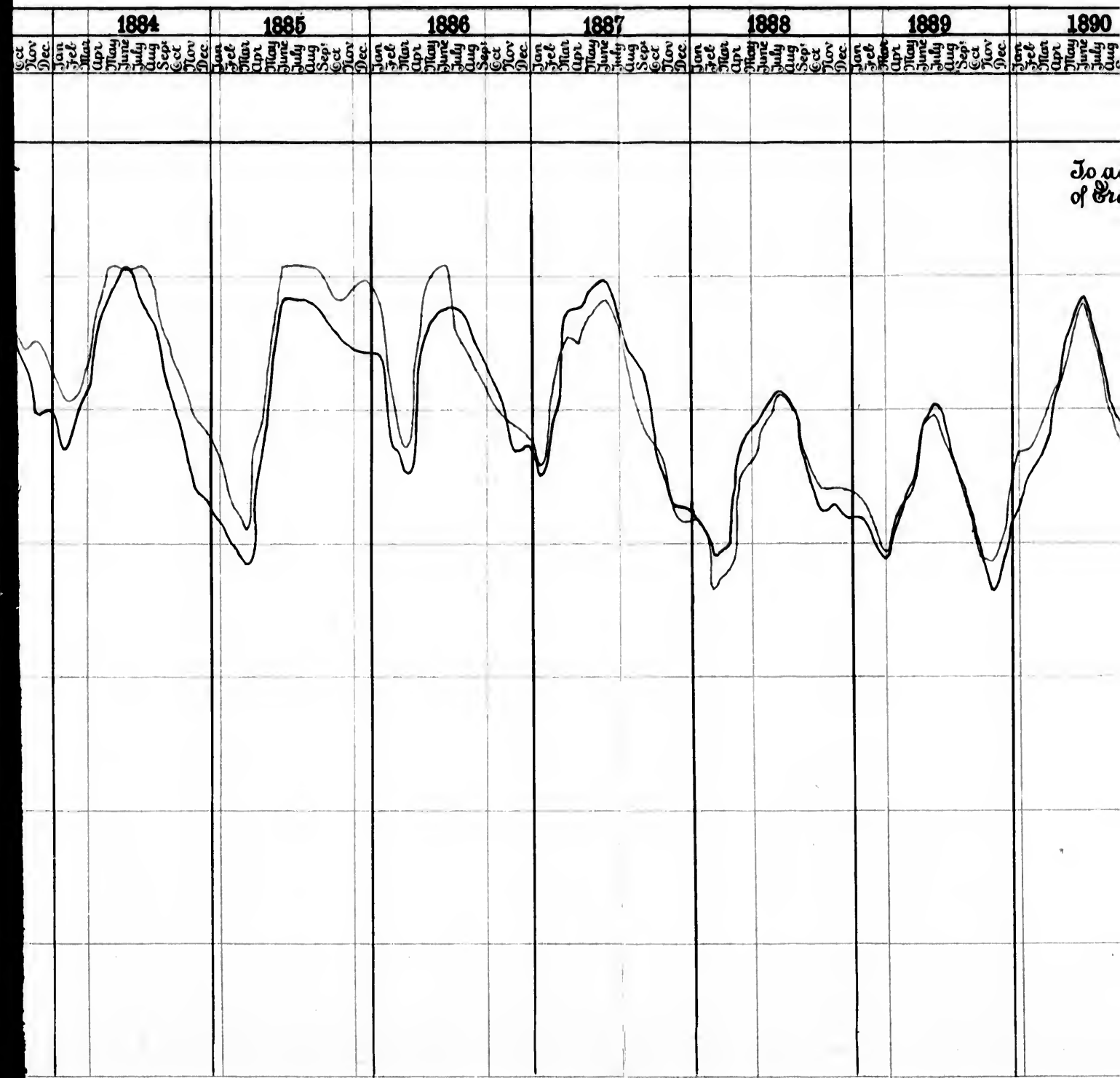
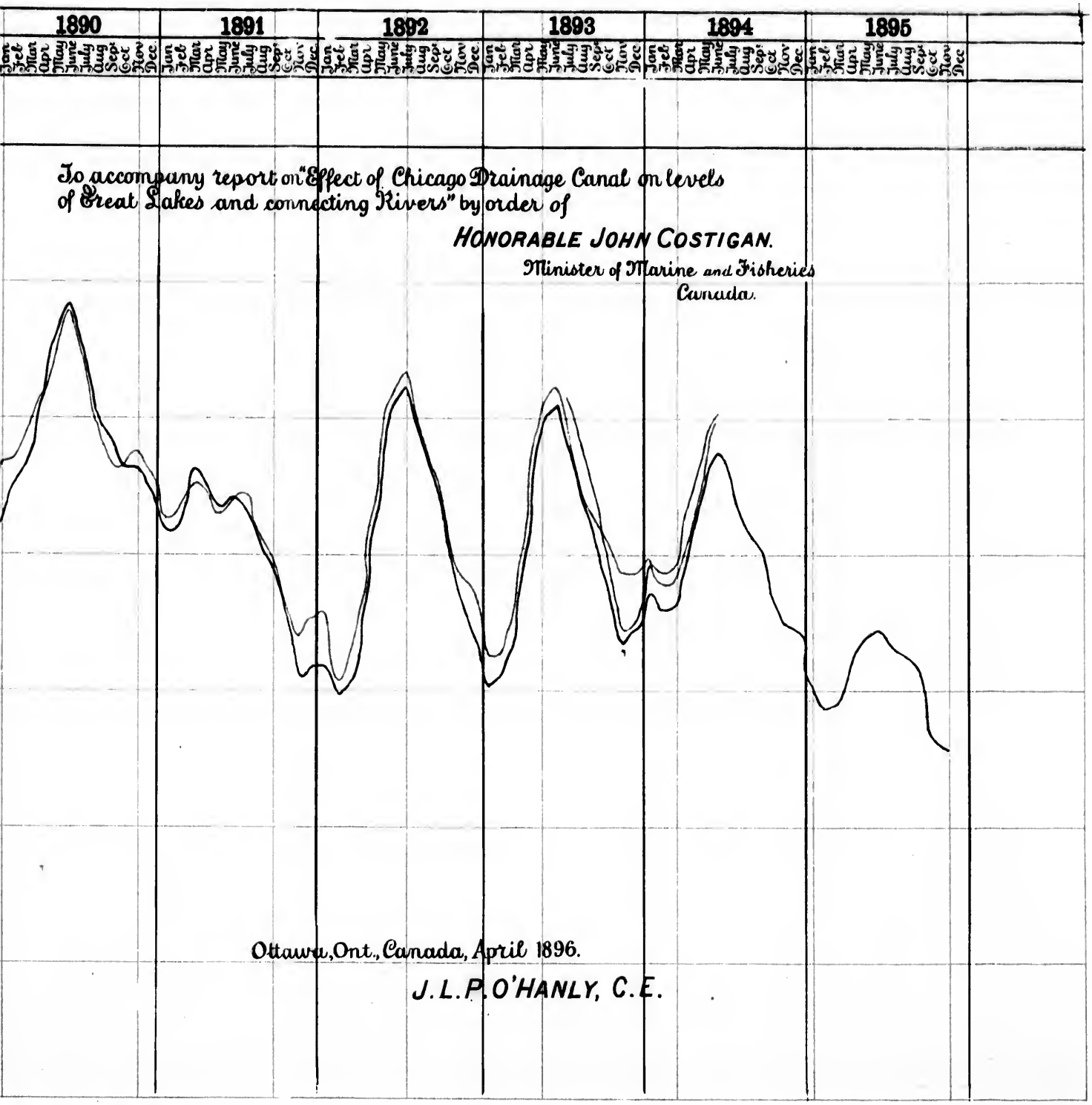

1884
1885
1886
1887
1888
1889
1890
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec



To accompany report on "Effect of Chicago Drainage Canal on levels of Great Lakes and connecting Rivers" by order of

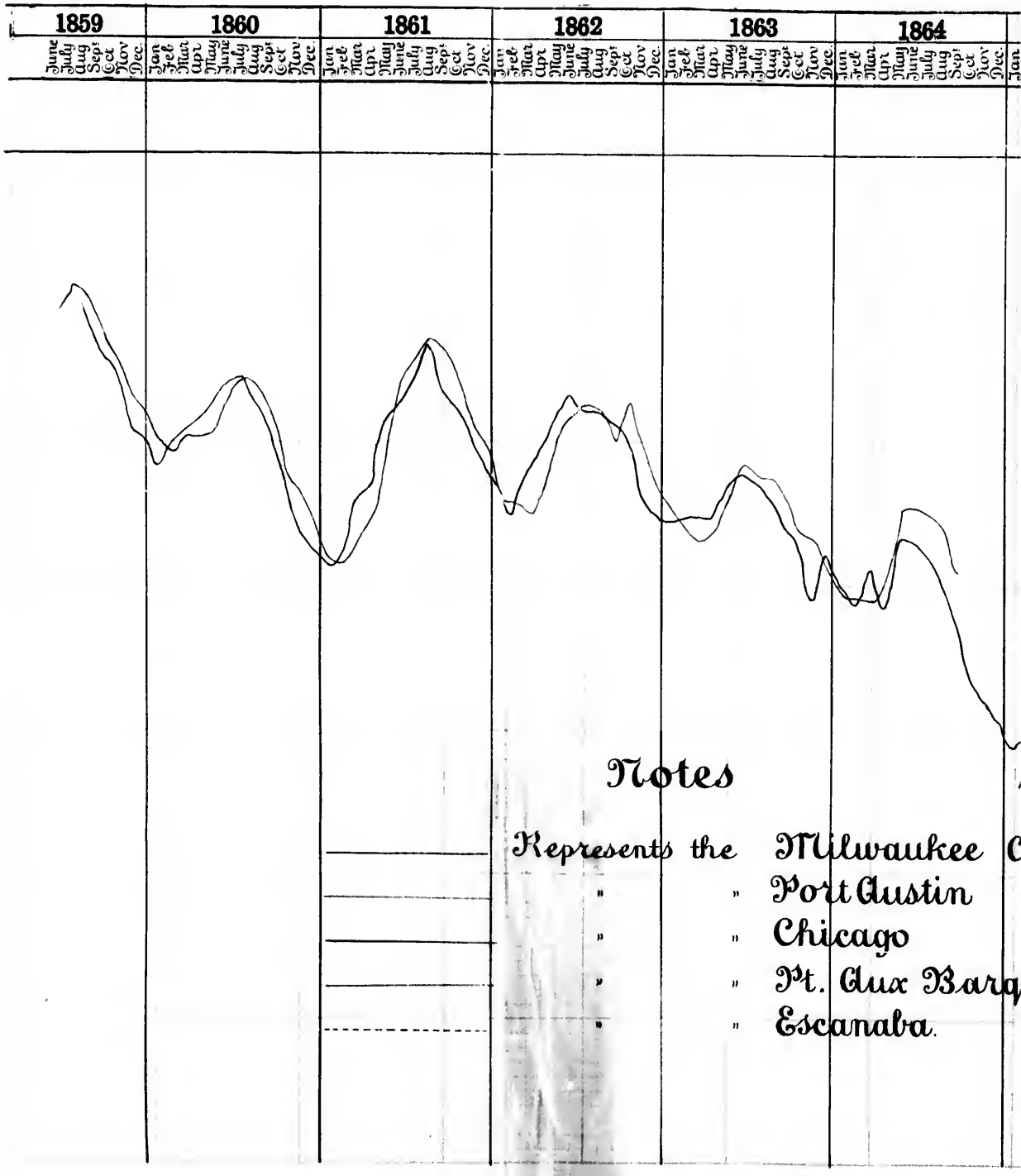
HONORABLE JOHN COSTIGAN.

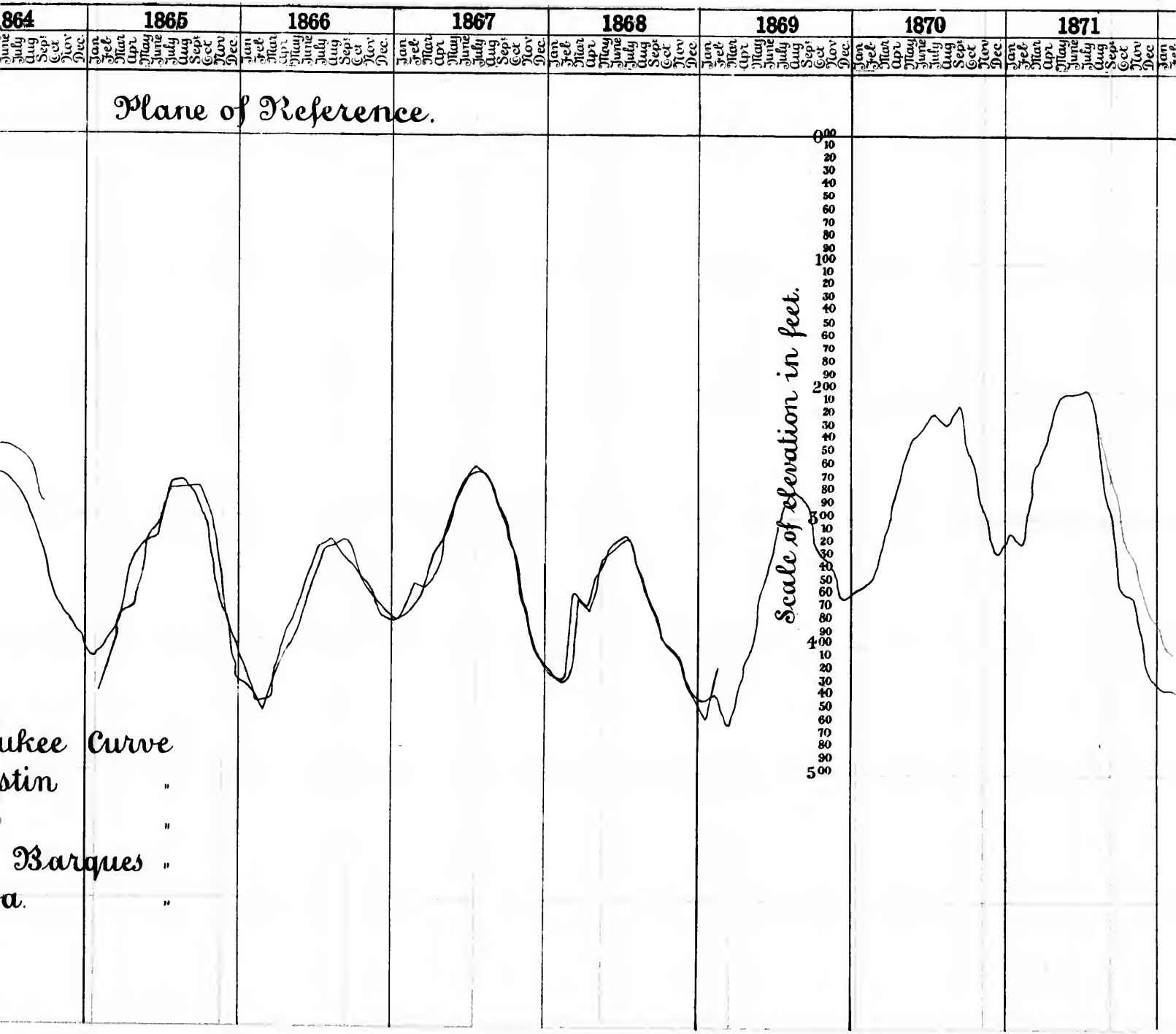
Minister of Marine and Fisheries Canada.

Ottawa, Ont., Canada, April 1896.

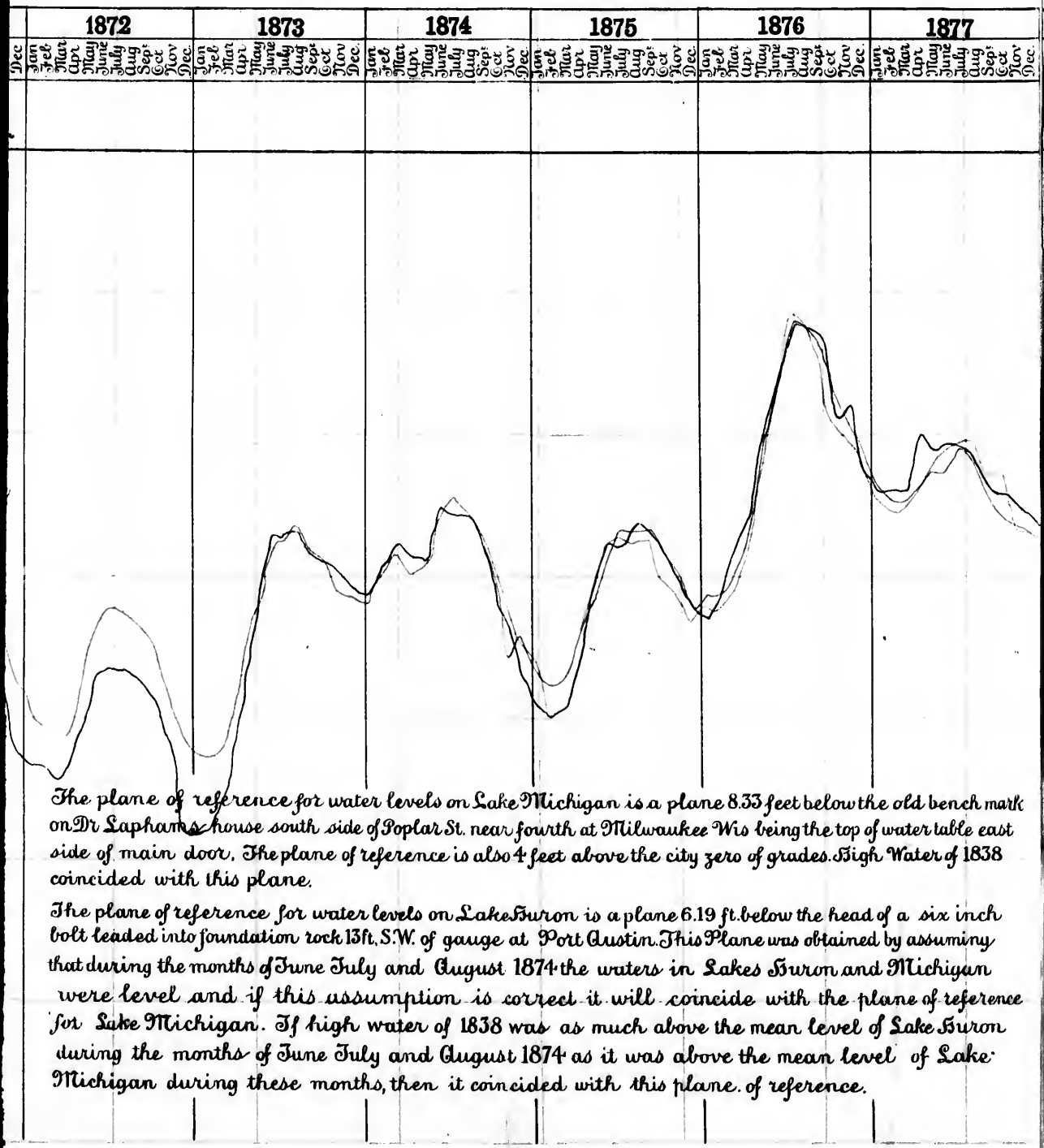
J. L. P. O'HANLY, C. E.

SHEET, NO. 1.


1859
June July Aug Sept Oct Nov Dec
1860
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec
1861
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec
1862
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec
1863
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec
1864
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec
Jan
Notes
Represents the Milwaukee C
" " Port Austin
" " Chicago
" " Pt. Aux Barq
" " Escanaba.


1864
1865
1866
1867
1868
1869
1870
1871
Plane of Reference.
Scale of elevation in feet.
ukee Curve
stin "
"
Barques "
a. "

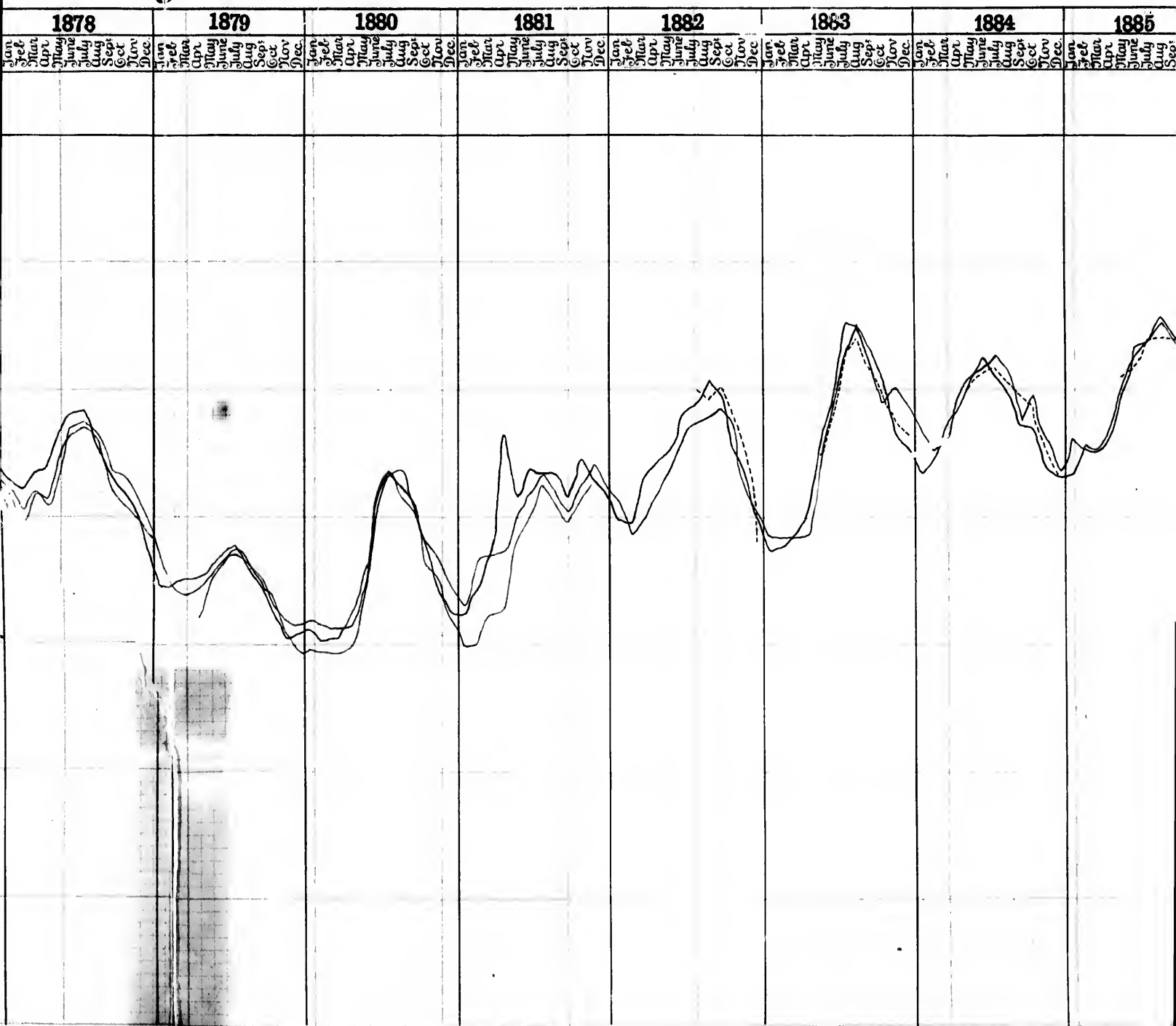
Annual Water Level Curves Lakes Mic

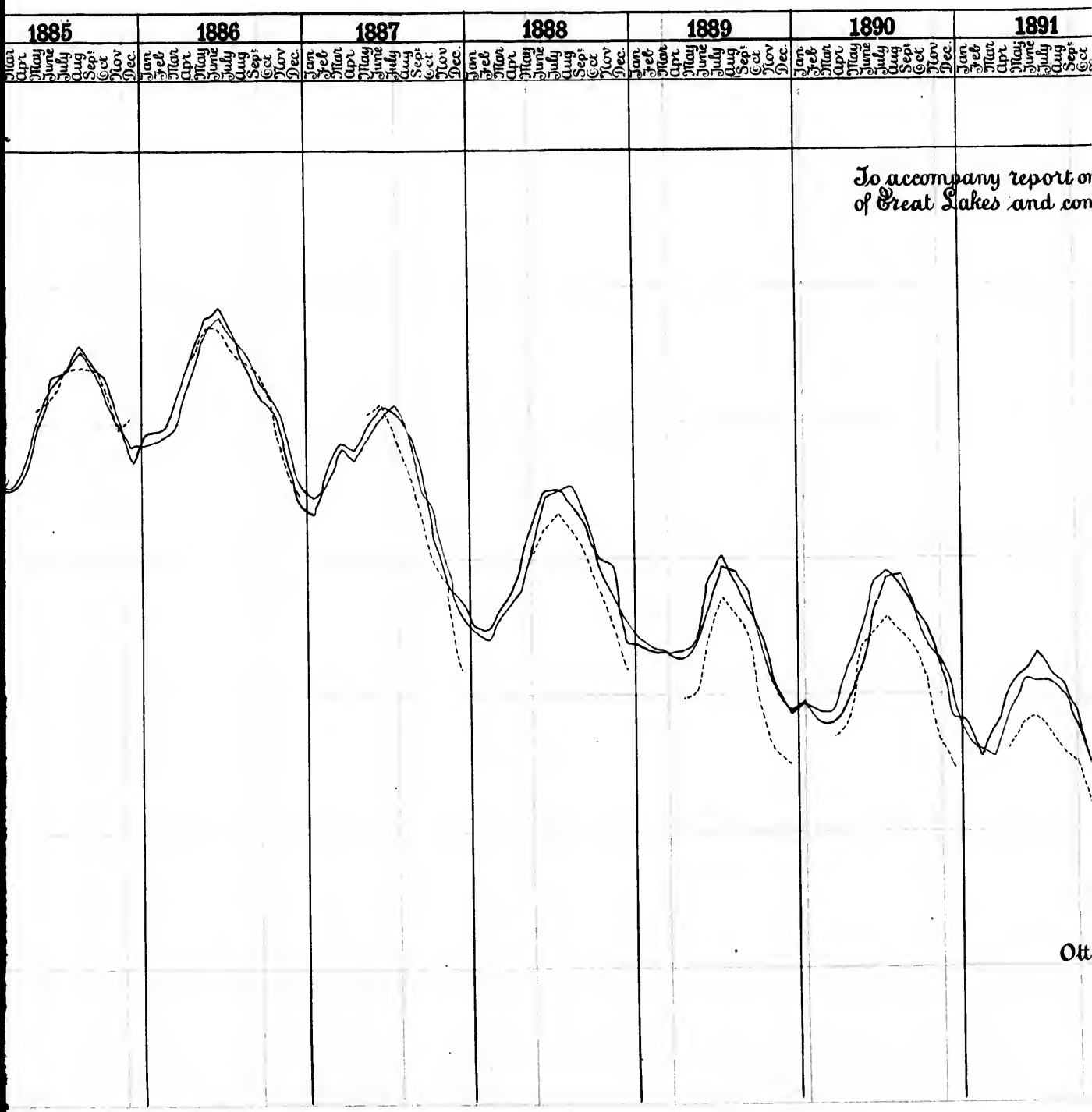


The plane of reference for water levels on Lake Michigan is a plane 8.33 feet below the old bench mark on Dr Lapham's house south side of Poplar St. near fourth at Milwaukee Wis being the top of water table east side of main door. The plane of reference is also 4 feet above the city zero of grades. High Water of 1838 coincided with this plane.

The plane of reference for water levels on Lake Huron is a plane 6.19 ft. below the head of a six inch bolt leaded into foundation rock 13 ft. S.W. of gauge at Port Austin. This Plane was obtained by assuming that during the months of June July and August 1874 the waters in Lakes Huron and Michigan were level and if this assumption is correct it will coincide with the plane of reference for Lake Michigan. If high water of 1838 was as much above the mean level of Lake Huron during the months of June July and August 1874 as it was above the mean level of Lake Michigan during these months, then it coincided with this plane of reference.

Michigan and Huron




1885
1886
1887
1888
1889
1890
1891
To accompany report on
of Great Lakes and con
Ott

	1891	1892	1893	1894	1895	
Nov Dec.	Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec.	Jan Feb Mar Apr May June July Aug Sep Oct Nov Dec.	Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec	Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec.	Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec.	

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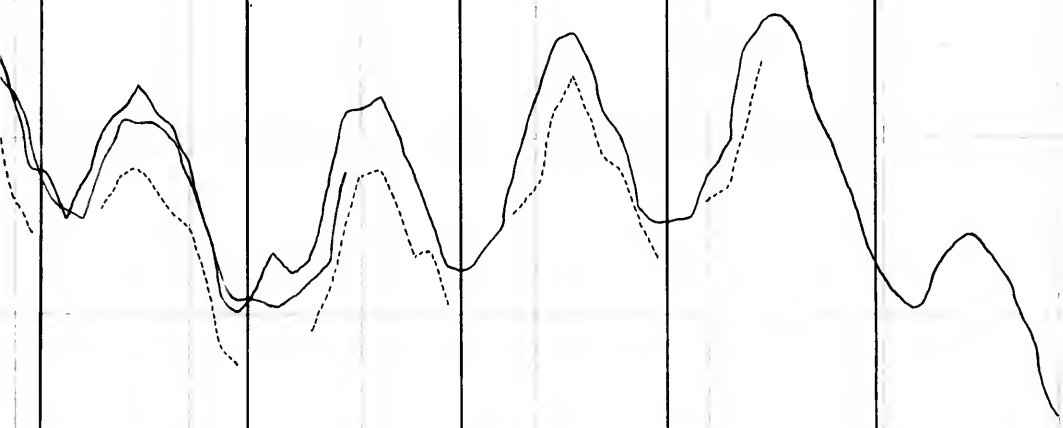

Ottawa, Ont., Canada, April 1896.

J. L. P. O'HANLY, C.E.