US Army Corps
of Engineers
North Central Division

Great Lakes Update

No. 117 APRIL 5, 1995

The Welland Canal
Gateway to the Interior

The Great Lakes - St. Lawrence River system allowed European adventurers and fur traders to discover and tap the rich natural resources of the upper Great Lakes. Initially, furs and later grain, iron, lumber and many other products of this region could become accessible to the world via this lake and river system. The chief obstacle in what was to be an uninterrupted waterway into America's heartland was the falls and rapids of the Niagara River.

Until 1829, the only route from Lake Ontario to Lake Erie included a lengthy portage from Queenston, Ontario, below the falls, to Chippewa Creek, Ontario, above the falls. This led to what is known today as the Welland Canal. With its eight locks, it is able to provide easy access between Lake Ontario and Lake Erie thus circumventing nature's barrier.

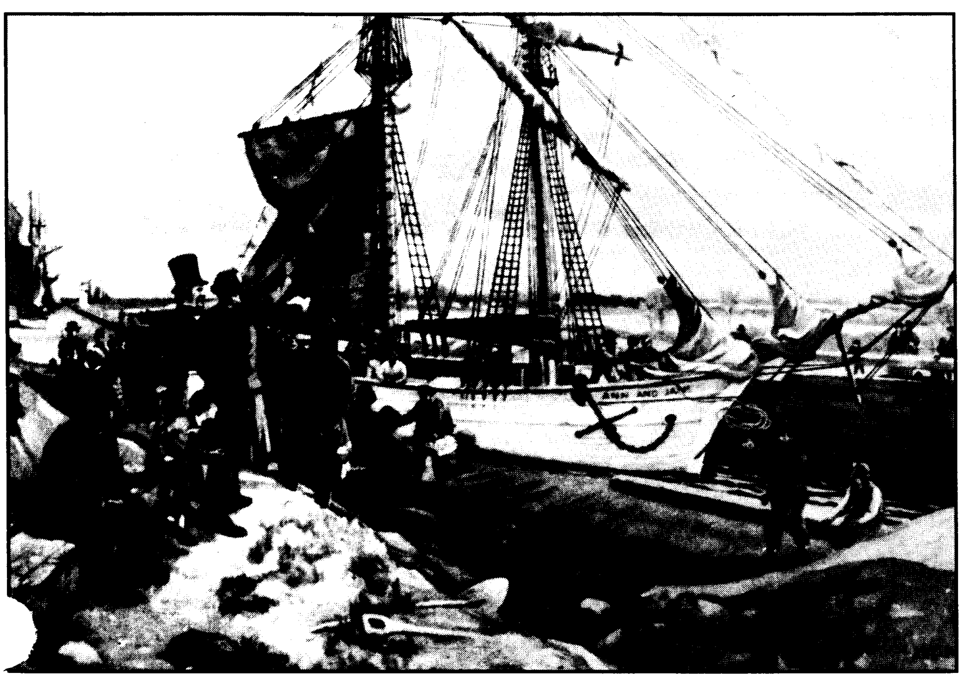

Figure 1. The schooner "Ann and Jane" of Toronto entering Lock One, at Port Dalhousie, as dignitaries look on. (Painting by J. D. Kelly)

Today's Welland Canal is the fourth in a series of canals to be constructed, reflecting the evolution of the North American shipping trade during the past 166 years.

1829-1844: The First Welland Canal

In 1824, in search of a continuous supply of water to power his mills, William Hamilton Merritt, an enterprising businessman of the then Province of Upper Canada, came to recognize the potential for a canal joining Lakes Erie and Ontario. He envisioned this canal with a series of locks, which would allow vessels to scale the 100-meter Niagara Escarpment, thus providing a direct trade route across the Niagara Peninsula.

Financed by government and private sources, Merritt formed the Welland Canal Company in 1824. The first sod was turned November 30, 1824 at Allanburg.

Overcoming the gigantic tasks of earth excavation and marine construction with the limited tools available at the time, the Welland Canal Company pressed on and five years later, on November 29, 1829, the schooner "Ann and Jane" completed the first upbound transit, a two-day voyage. Commissioned by the Confederation Life Association, a J. D. Kelly painting *"Ann and Jane"* commemorated this event (See Figure 1).

In constructing the canal, natural waterways were used wherever possible. From Port Dalhousie, on Lake Ontario, the first leg of the canal followed the route of Twelve Mile Creek through St. Catherines to Merritton, and up the escarpment to Thorold (See Figure 2). The canal terminated 5 miles south of Thorold, at Port Robinson on the Welland River. Ships then proceeded east on the Welland River to Chippawa and then south up the Niagara River to Lake Erie. In 1833, work was completed to extend the canal from Port Robinson directly to Gravelly Bay, now Port Colborne on Lake Erie. The first Welland Canal was 27 miles long with 40 wooden locks, the smallest being 110 feet long by 22 feet wide and 8 feet deep.

1845-1886: The Second Welland Canal

Maintenance of the wooden locks was expensive and toll revenues were not sufficient to cover the cost. Government assistance was sought and in 1839, the Government of Upper Canada voted to purchase the privately held company stock. The purchase was completed in 1841 and soon plans were drawn for an improved canal.

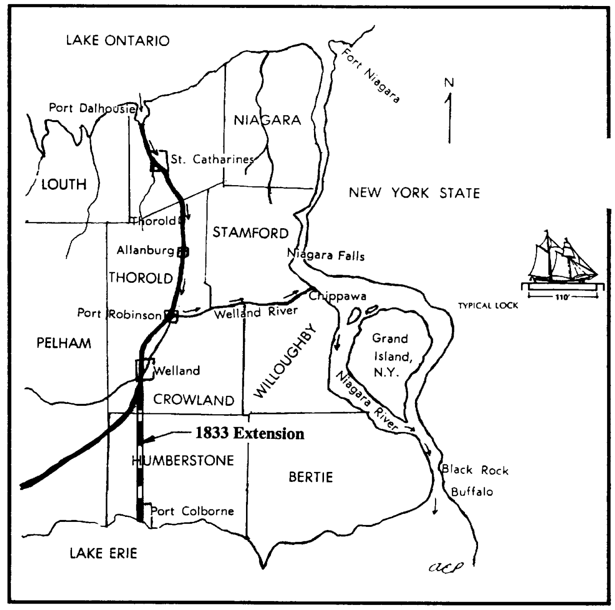

Figure 2. Routes of the First Welland Canal and the 1833 extension. (By Jean and Allen Pritchard)

The route of the revamped Welland Canal paralleled the first, using the channels and locks of the original canal as control weirs for the new works (See Figure 3). Depth for the new canal was increased to 9 feet and the number of locks reduced to 27. The new locks were masonry structures 150 feet long and 26.5 feet wide. Concurrently, a canal of similar depth was completed between Montreal and Lake Ontario, and by 1848, navigation was possible from Lake Erie to the lower St. Lawrence River.

1887-1931: The Third Welland Canal

Sailing vessels were rapidly being replaced by larger steam powered ships. In 1870, a Commission appointed by the Canadian Government recommended substantial canal improvements, stating in its report that "wheat, lumber, copper and iron from the Upper Lakes would pass through the Welland Canal in increasing amounts were it not for the fact that the larger boats cannot go through". It was further pointed out that three quarters of the tonnage currently sailing the lakes could not use the existing locks.

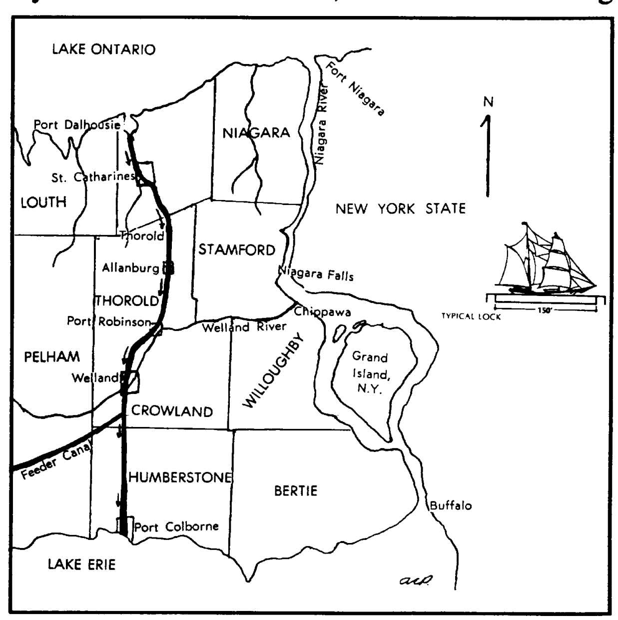

Figure 3. Route of Second Welland Canal. (By Jean and Allen Pritchard)

Following the same route as the second canal from Lake Erie to a point 3 miles above the escarpment, the third Welland Canal left Twelve Mile Creek and followed a more direct line to Port Dalhousie (See Figure 4). The third canal consisted of 26 cut stone locks, each 270 feet long

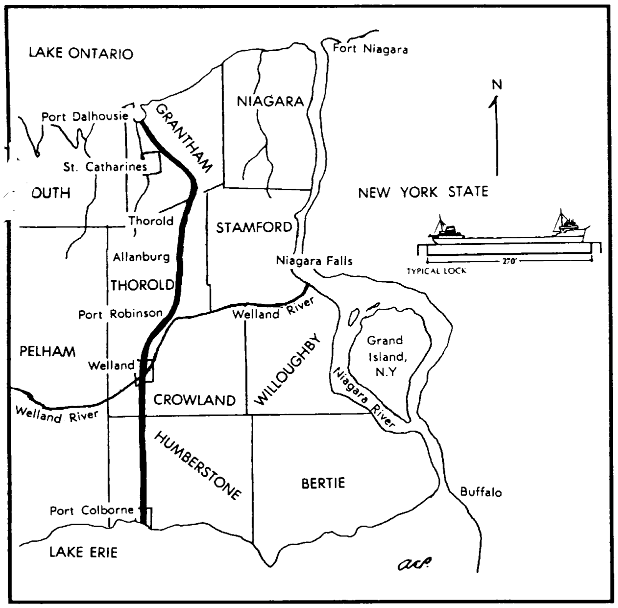

Figure 4. Route of Third Welland Canal. (By Jean and Allen Pritchard)

and 45 feet wide. Originally, the depth was to be 12 feet, but was increased to 14 feet during construction. Partially operational in 1881, it was not until 1887 that the 14-foot depth was available throughout. In 1889, nearly 2,000 vessel transits were recorded, 820 steamships and 1,141 by sailing vessels.

The inland canal system led to the development of a distinctive type of vessel, the Great Lakes "canaler". This was a bulk carrier that was literally a self-propelled barge. The machinery was located in the stern and the navigating bridge up forward, with a long, almost box-shaped, hold in between. "Canalers" using the third Welland Canal, had a maximum length of 262 feet and could carry as much as 3,000 tons.

1931 - 1973: The Fourth Welland Canal

By the turn of the century, larger ships with cargo capacities up to 15,000 tons were sailing the upper lakes. To allow for transit to the lower lakes, it was necessary to transfer their cargo to several small "canalers" at Port Colborne. It soon became evident that the larger vessels must be able to move between the upper and lower lakes.

Between 1907 and 1912, plans were made to enlarge the canal once more. It was decided to build larger locks and to also reduce the number of locks. The Lake Ontario connection was moved to Port Weller, 3 miles east of Port Dalhousie. The Lake Erie connection remained at Port Colborne. Since no natural harbor existed at Port Weller, embankments were extended 1.5 miles into Lake Ontario to create an artificial one. Construction, which started in 1913, was interrupted by World War I. It was resumed in 1919 and continued until 1932.

On August 6, 1932, the Governor General of Canada, the Rt. Hon. Earl of Bessborough, turned a lever releasing the guard fender at the upper end of the flight locks as he spoke the words "It is a privilege to dedicate this canal to the trade of the world. I hereby declare the Welland Canal open to the commerce of the world." Hundreds of colorful flags strung from her masts and her holds filled with some 530,000 bushels of wheat, the S.S. "LEMOYNE", then the largest freighter (633 feet long with a 70-foot beam) on the Great Lakes, moved into the lock

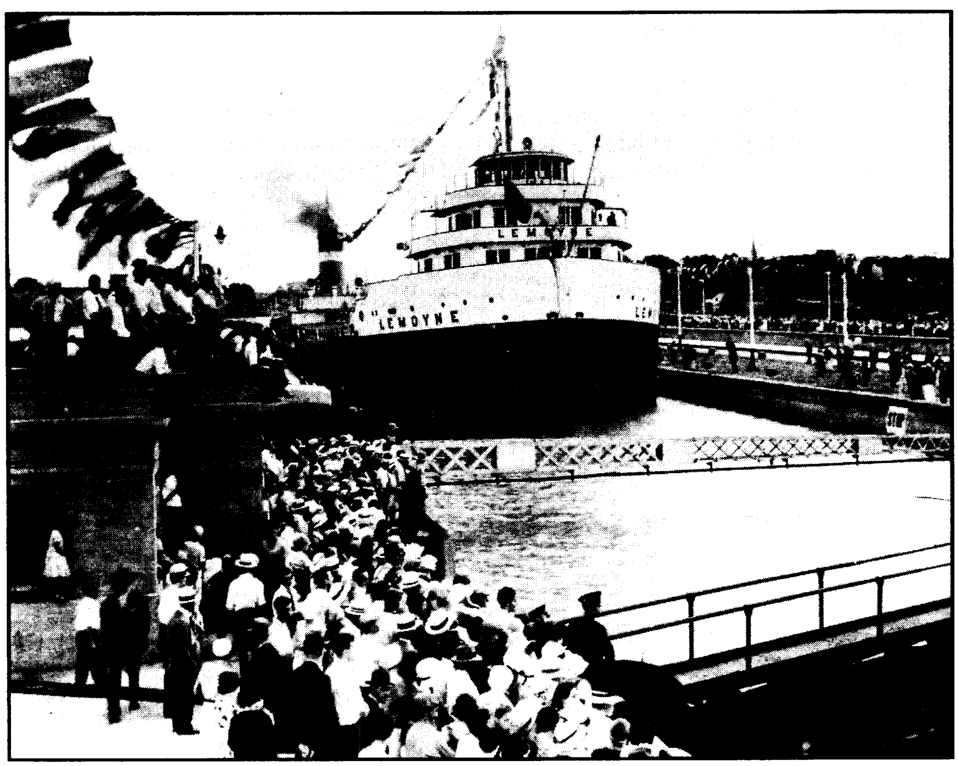

Figure 5. The S.S. LEMOYNE , then the largest freighter on the Great Lakes entering the upper end of the flight locks to open the canal on August 6, 1932.

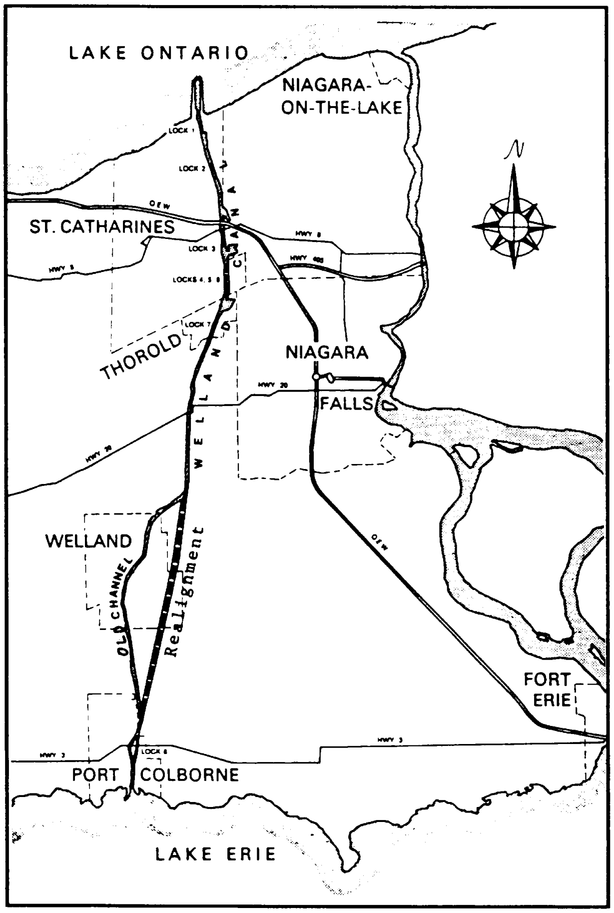

Figure 6. The fourth and present Welland Canal Route showing the Realignment or "By-Pass".

chamber. The fourth Welland Canal was officially opened (See Figures 5 and 6).

Eight locks and 27 miles of canal overcome the 326.5-foot elevation difference between Lakes Ontario and Erie. Seven of the locks have an average lift of 46.5 feet. Each is 766 feet long by 80 feet wide. The depth of water is 30 feet over the sill and 27 feet in the channels. They are located in the 7.2-mile section of the canal between Lake Ontario and the top of the Niagara escarpment. Three of the locks (Locks 4, 5 and 6) are called the "flight locks" because no canal separates them and they are twinned to allow for two-way traffic (See Figure 7). A 17.3-mile man-made channel runs through level ground to Lock 8 at Lake Erie. Lock 8 serves as a control lock with a shallow lift varying between 1 and 4 feet to make the final adjustment to the prevailing lake level (See Figure 8).

Improvements

Completion of the St. Lawrence Seaway in 1959 resulted in increased ship traffic. The Welland Canal section of the Seaway system became the cause of delays due to the complexities of transiting the older canal. Unpredictable arrival rates, combined with unfavorable weather conditions, often resulted in backups while transit demand was at times dangerously close to the capacity limit of the canal.

By 1964, delays were a chronic problem and a program improve operations was initiated. A sophisticated traffic control center, using closed circuit television and telemetry, improved scheduling and substantially reduced both cycle and round trip travel times. Other improvements included variable intensity lighting along the southern half of the canal, automation and centralization of controls at Locks 1, 2, 3, 7 and 8, extension of lock approach walls, widening of several canal sections, modification to lock hardware, and installation of navigation signal light displays.

The most beneficial improvement to the Canal was the construction of the Realignment or "By-Pass". Ship captains had long complained about the stretch of the Welland Canal which bisected

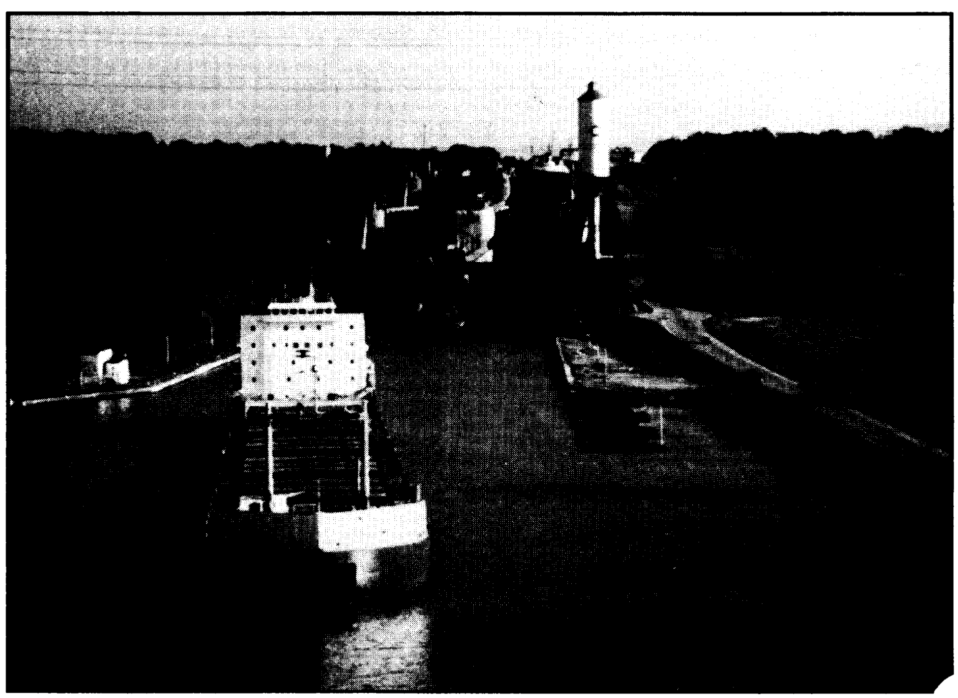

Figure 7. The Welland Canal Twinned Flight Locks.

WELLAND CANAL PROFILE

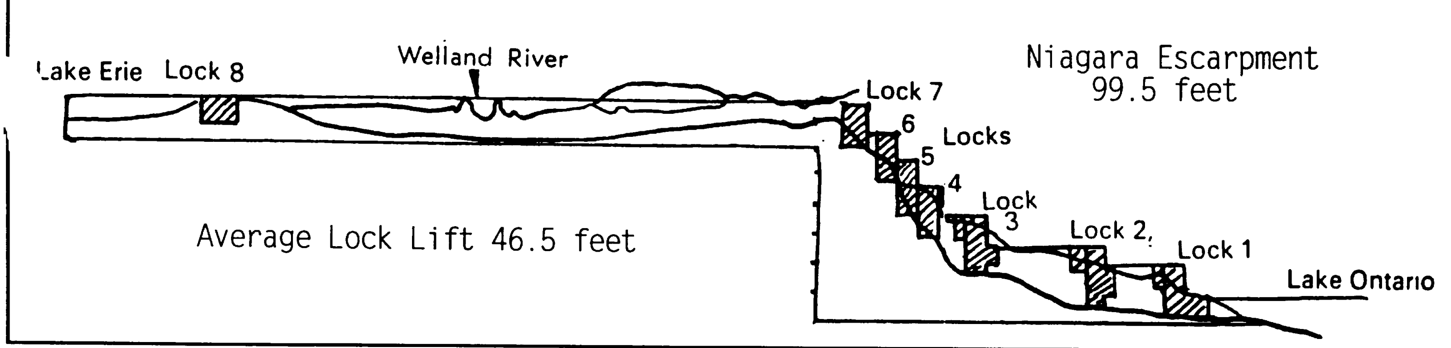

Figure 8. Welland Canal Profile.

the City of Welland (See Figure 6). This section, with its numerous bridges, insufficient width and sharp curves, presented dangers to navigation, especially to the growing number of maximum size vessels inching their way through it. One railway bridge was hit six times in one season. The center pier of this bridge limited the 75-foot wide ships to two narrow navigable lanes, 92 feet wide on one side and 102 ·t on the other, a situation ıich brought considerable risks to the ships and their crews. At the same time, relief was needed from land traffic congestion and tie-ups at the four vertical lift bridges.

Starting in May 1966, land was acquired and by March 1973, after 65 million cubic yards of earth, clay, rock and silt removal, the Welland Canal Realignment, or "By-Pass", was opened to provide safe, fast and economical transit to ship traffic. This comparatively straight new channel replaced a 9.1-mile section of the canal that bisected the City of Welland. An important part of the realignment project involved ·he diversion of the Welland ·er under the new channel. This required construction of a 638-foot long, 94-foot wide four-tube reinforced concrete siphon with a maximum capacity of 12,000 cfs.

Needless to say, the construction of the "By-Pass" required major relocation and new construction of roads, tunnels, rail facilities, water, electric, gas, telephone and sewer lines. Overhead obstructions, such as bridges, were eliminated. A modern lighting system was strung along the sides of the new channel to allow safe transit after dark. When viewed from the air, this luminous strip is an imposing sight. A new 1,000-foot dock capable of handling the largest lakers and ocean vessels was constructed by the Seaway Authority to replace several docks that were on the old canal.

In 1986, a new Traffic Control Center was inaugurated which incorporated the latest monitoring, display and computer assisted information processing techniques. That year also saw the start of a seven-year $175 million Welland Canal Rehabilitation Program funded by the Canadian Government to provide a major civil engineering refit to all the primary facilities of the canal.

Important Trade Artery

With the opening of the St. Lawrence Seaway in 1959, the Welland Canal assumed its rightful position as a vital part of our great inland water route. Vessels up to 730 feet long loaded to a 26-foot draft, travel back and forth between the Lake Superior lakehead ports of Duluth, Minnesota and Thunder Bay, Ontario and the Lower St. Lawrence River carrying cargoes of iron ore, wheat, corn, barley, soybeans, coal, petroleum products, other bulk products, and manufactured and packaged goods. Cargo tonnage traveling through the Welland Canal in 1959 was 27.1 million tons. In 1994, 43.7 million tons were carried through the canal.

It is almost impossible to quantify the benefits contributed by the Welland Canal to the economy and general prosperity of our continent's interior. Throughout its history, however, one fact has stood out clearly: the Welland Canal continues to be a vital artery connecting the major industrial areas of the North American heartland, thus providing a valuable link with the world's trading nations.

Operation of the Welland Canal

The Welland Canal is owned and operated by the St. Lawrence Seaway Authority, a federal agency of Canada under the Ministry of Transport. Commercial vessels transiting the Welland Canal pay tolls based upon the gross registered tonnage (13¢/ton), the tonnage of cargo being carried (varies from 55-83¢/ton), and a charge per lock ($440 loaded; $325 in ballast). For example, a typical 700-foot vessel loaded with grain has a gross registered weight of about 18,000 tons and carries about 28,000 tons of grain. The tolls for a one-way transit would be:

	18,000 x $0.13
+	28,000 x $0.55
+	$440 x 8 locks
	$ 21,260

All commercial vessels, U.S., Canadian, and foreign, pay the same tolls. Pleasure craft pay a toll of $10/lock. Other vessels pay $15/lock. All of these are in Canadian dollars.

For further information on the Welland Canal, write to:

St. Lawrence Seaway Authority
Constitution Square
360 Albert Street
Ottawa, Ontario K1R 7X7

Or, you may call Mr. Harley Smith at (905) 641-1932.

Acknowledgments

Many thanks to the St. Lawrence Seaway Authority, Ottawa, Ontario, Canada for the use of materials from its 1993 publication *"The Welland Canal Section of the St. Lawrence Seaway"* on which this Update article is based.

The painting of the schooner *"Ann and Jane"* by J. D. Kelly, as commissioned by the Confederation Life Association shown in Figure 1; the Welland Canal routes shown in Figures 2, 3 and 4, as prepared by Jean and Allen Pritchard; and, the remaining Figures 5, 6, 7 and 8 have been reproduced courtesy of the St. Lawrence Seaway Authority.

Do You Know?

The answer to last month's query is: A waterbody up to ten feet deep would result if the conte[nts] of the Great Lakes were spre[ad] over an area equal to that of the continental United States.

This month's question is: What percentage of the total volume of surface water in the United States is contained in the Great Lakes?

(a) Up to 50 percent

(b) Up to 90 percent

(c) Up to 99 percent

The Answer will be provided in the next Update.

RICHARD W. CRAIG
Colonel, EN
Commanding

Table 1

Possible Storm Induced Rises (in feet) at Key Locations on the Great Lakes April 1995

	Degrees of Possibility				
	20%	10%	3%	2%	1%
LAKE SUPERIOR					
Duluth	0.8	1.0	1.1	1.3	1.4
Grand Marais	0.5	0.7	0.9	1.0	1.2
Marquette	0.8	0.9	1.1	1.3	1.4
Ontonagon	0.7	1.2	2.0	2.8	3.5
Point Iroquois	0.9	1.0	1.2	1.4	1.6
Two Harbors	0.6	0.7	0.9	0.9	1.0
LAKE MICHIGAN					
Calumet Harbor	1.5	1.7	2.0	2.1	2.3
Green Bay	2.1	2.5	3.1	3.5	3.9
Holland	0.9	1.0	1.2	1.3	1.4
Kewaunee	0.8	0.9	1.0	1.1	1.2
Ludington	0.9	1.0	1.1	1.2	1.3
Milwaukee	1.0	1.1	1.2	1.3	1.4
Port Inland	1.1	1.3	1.5	1.6	1.8
Sturgeon Bay	0.9	1.0	1.1	1.2	1.3
LAKE HURON					
Detour Village	0.5	0.6	0.7	0.8	0.8
Essexville	1.9	2.3	2.8	3.1	3.5
Harbor Beach	0.7	0.8	1.0	1.1	1.2
Harrisville	0.5	0.5	0.6	0.7	0.7
Lakeport	1.2	1.4	1.6	1.8	2.0
Mackinaw City	0.7	0.8	0.9	1.0	1.1
LAKE ST. CLAIR					
St. Clair Shores	0.6	0.7	1.0	1.1	1.3
LAKE ERIE *					
Barcelona	1.7	2.2	2.7	3.1	3.5
Buffalo	3.4	4.3	5.5	6.3	7.1
Cleveland	1.1	1.3	1.6	1.8	1.9
Erie	1.6	2.2	2.8	3.4	3.9
Fairport	0.9	1.1	1.4	1.6	1.9
Fermi Power Plant	2.0	2.4	3.0	3.4	3.9
Marblehead	1.5	1.8	2.1	2.4	2.7
Sturgeon Point	2.7	3.6	4.8	5.8	6.7
Toledo	2.7	3.3	4.0	4.5	5.1
LAKE ONTARIO					
Cape Vincent	0.8	0.9	1.1	1.2	1.4
Olcott	0.5	0.6	0.7	0.8	0.9
Oswego	0.7	0.8	0.9	1.0	1.1
Rochester	0.7	0.8	0.9	1.0	1.1

* The water surface of Lake Erie has the potential to tilt in strong winds, producing large differentials between the ends of the lake.

Note: The rises shown above, should they occur, would be in addition to the still water levels indicated on the Monthly Bulletin. Values of wave runup are not provided in this table.

Great Lakes Basin Hydrology

During the month of March precipitation on each Great Lakes basin was below average. For the year to date, precipitation is about 5% below average for the entire Great Lakes basin. The net supply of water to each of the Great Lakes in March was below average. Table 2 lists March precipitation and water supply information for all of the Great Lakes.

In comparison to their long-term (1918-1994) averages, the March monthly mean water level of Lake Superior was 3 inches below average, Lakes Michigan-Huron, St. Clair, Erie and Ontario were 5, 7, 9 and 2 inches above average respectively. Shoreline residents are cautioned to be alert whenever adverse weather conditions exist, as these could cause rapid short-term rises in water levels. Should the lakes approach critically high levels, further information and advice will be provided by the Corps of Engineers.

TABLE 2
GREAT LAKES HYDROLOGY[1]

PRECIPITATION (INCHES)								
BASIN	MARCH				YEAR-TO-DATE			
	1995[2]	Average (1900-1991)	Diff.	% of Average	1995[2]	Average (1900-1991)	Diff.	% of Average
Superior	1.6	1.8	-0.2	89	5.0	5.2	-0.2	96
Michigan-Huron	1.8	2.2	-0.4	82	5.6	6.0	-0.4	93
Erie	1.8	2.8	-1.0	64	6.9	7.3	-0.4	95
Ontario	1.4	2.7	-1.3	52	6.8	7.7	-0.9	88
Great Lakes	1.7	2.2	-0.5	77	5.8	6.1	-0.3	95

LAKE	MARCH WATER SUPPLIES[3] (CFS)		MARCH OUTFLOW[4] (CFS)	
	1995[2]	Average (1900-1989)	1995[2]	Average (1900-1989)
Superior	44,000	45,000	60,000	66,000
Michigan-Huron	180,000	184,000	190,000[5]	170,000
Erie	52,000	72,000	212,000[5]	193,000
Ontario	51,000	75,000	264,000	233,000

[1]Values (excluding averages) are based on preliminary computations.
[2]Estimated.
[3]Negative water supply denotes evaporation from lake exceeded runoff from local basin.
[4]Does not include diversions.
[5]Reflects effects of ice/weed retardation in the connecting channels.

CFS = cubic feet per second.

For Great Lakes basin technical assistance or information, please contact one of the following Corps of Engineers District Offices:

For NY, PA, and OH:
COL Walter C. Neitzke
Cdr, Buffalo District
U.S. Army Corps of Engineers
1776 Niagara Street
Buffalo, NY 14207-3199
(716) 879-4200

For IL and IN:
LTC Robert E. Slockbower
Cdr, Chicago District
U.S. Army Corps of Engineers
111 North Canal Street
Chicago, IL 60606-7206
(312) 353-6400

For MI, MN, and WI:
COL Randolph O. Buck
Cdr, Detroit District
U.S. Army Corps of Engineers
P.O. Box 1027
Detroit, MI 48231-1027
(313) 226-6440 or 6441