SECTION 2

REGIMEN CHANGES ON THE GREAT LAKES CONNECTING CHANNELS AND THE INTERNATIONAL SECTION OF THE ST. LAWRENCE RIVER

2.1 St. Marys River.

The St. Marys River (Figure 2-1) is the outlet channel from Lake Superior. From Whitefish Bay on Lake Superior, the river flows in a general southeast direction approximately 60 miles to Lake Huron and falls about 22 feet. The river consists of an upper reach and a lower reach. The upper reach begins in the lower end of Whitefish Bay on Lake Superior, above Pte. aux Chenes, and extends approximately 15 miles to the St. Marys Rapids. This reach is broad and deep. Widths vary between 25,000 feet, at the mouth of the river, to about 2,000 feet at Brush Point, the narrowest point above the Rapids. Natural depths average about 20 feet.

Most of the fall in the river occurs in the area of the St. Marys Rapids. When the river was first surveyed in 1855, the outflow from Lake Superior was naturally controlled by the St. Marys Rapids, which acted as a free over-fall weir with a fall of about 20 feet over a distance of about a 1/4 of a mile. The rapids area consisted of the St. Marys Falls and a group of small islands north of the falls, which extended nearly to midstream, separated by narrow channels. Many changes have since been made in this area of the river, including the construction of powerhouses, navigation locks, a compensating structure (see Figure 2-6) and a fishery remedial wall in the rapids. The outflow from Lake Superior has been fully regulated since 1921.

The lower St. Marys River runs from the foot of the St. Marys Rapids to Point DeTour on Lake Huron, a distance of about 45 miles. The river in this reach is broken by islands into several channels, and was, in its natural state, interrupted by rapids. After leaving Soo Harbor, below the St. Marys Rapids, the river splits around Sugar Island. The Lake George Channel runs east of the island and the main navigation channel is to the west, through Little Rapids Cut and Lake Nicolet. Below Sugar Island the channel splits around Neebish Island, flows into Lake Munuscong, past Round and Lime Islands and then out through DeTour Passage, between DeTour Point and Drummond Island, into Lake Huron. The fall in the lower river originally was between two and three feet and now, due to channel improvements for navigation, averages about 1-1/4 feet. Because of the very moderate slope in the lower river, water levels at the foot of the rapids near Sault Ste. Marie are strongly influenced by Lake Huron levels.

The natural regime of the St. Marys River was first disturbed by man in 1797 when the Northwest Fur Company built a shallow 38 foot long lock on the Canadian side of the St. Marys Rapids in one of the small natural channels. This lock was destroyed by U.S.

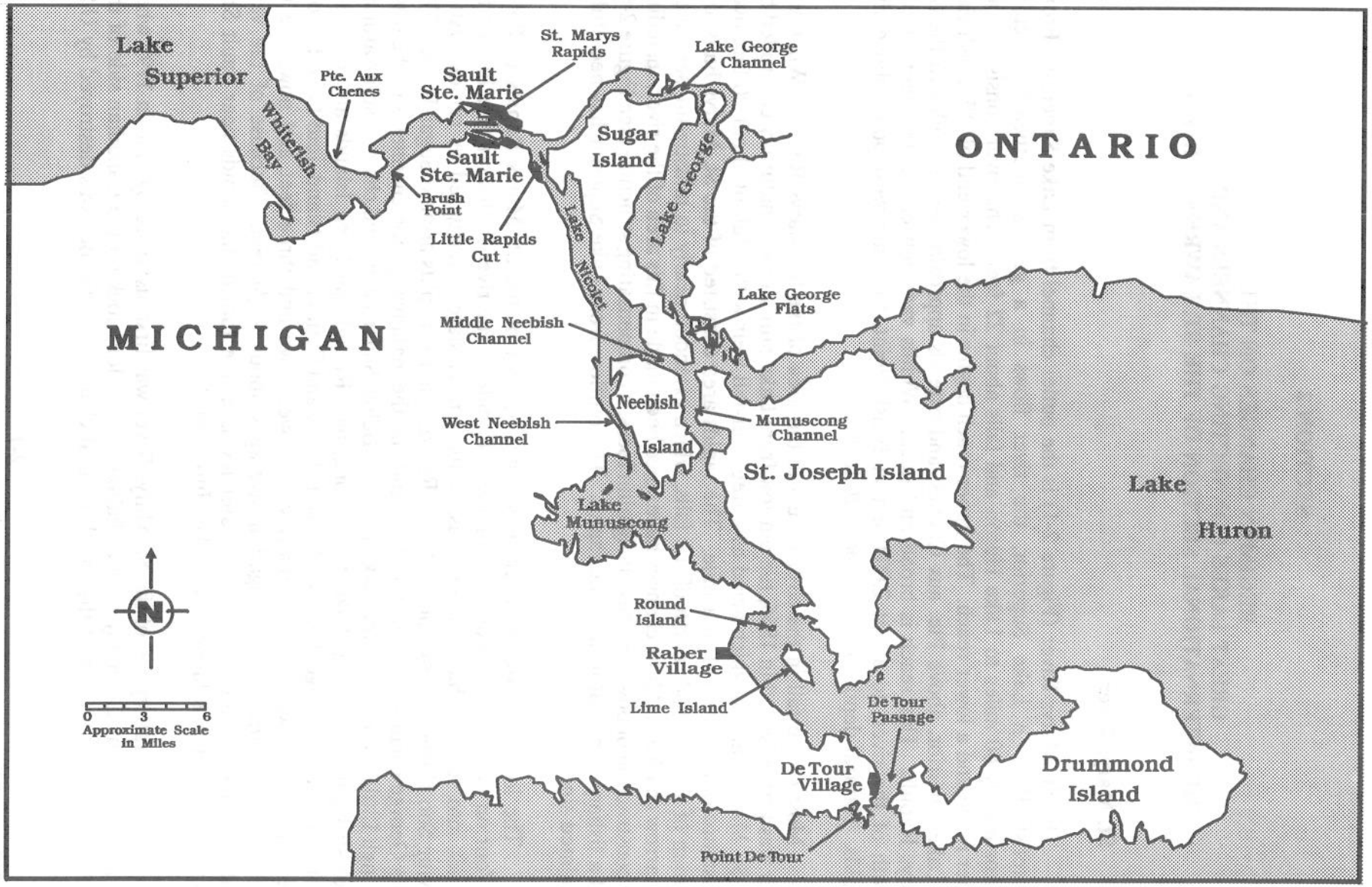


Figure 2-1

St. Marys River

troops in 1814, during the War of 1812. The first U.S. ship canal built to by-pass the St. Marys Rapids was completed in 1855. Owned by the State of Michigan, the system included two 350-foot locks in tandem. This system was designated the State Lock. In 1873 the U.S. Government began construction of the Weitzel Lock, parallel to and on the south side of the State Lock. The Weitzel Lock became operational in 1881, the same year the State Lock came under Federal control. In 1895, the present 900-foot long Canadian Lock was completed on the north side of the rapids. A year later the U.S. Government finished work on the 704-foot long Poe Lock. This lock was built on the site of the old State Lock. As commerce increased, additional locks were built. The Davis and Sabin Locks were completed in 1914 and 1919, respectively. World War II brought increased shipping demands and the use of larger ships. This led to the construction, in 1943, of the MacArthur Lock, which replaced the shallow and aging Weitzel Lock. The most recent lock construction was intended to replace the old Poe Lock. This lock, which is also named the Poe, was finished in the fall of 1968. The Canadian lock was closed in 1987, due to a major structural failure in the southwest wall of the lock. No plans have been made to reopen this lock. A chronologic summary of lock construction is given in Appendix B.

Dredging throughout the entire length of the St. Marys River, to widen and deepen navigation channels and to remove shoals and obstructions, has been ongoing almost continuously since the 1850s. Early navigation was through the Lake George Channel, although the naturally available depth was only 4 to 5 feet. The other channels inhibited navigation, because of sloping rapids.

In 1857, dredging of a 300-foot wide, 12-foot deep channel through the west channel of Lake George Flats was begun by the United States. Dredging in this channel was abandoned the next year in favor of the Middle Channel. Also around this time, excavation was underway in the East Neebish Rapids area by the Canadian Government. By 1870, when dredging in the Lake George Channel ended, due to lack of funds, the Middle Channel had been excavated to a depth of 14 feet and a minimum width of 150 feet. Dredging operations in the East Neebish Rapids were suspended in 1881.

In the 1880s and 1890s, dredging of the Middle Neebish Channel and the Little Rapids Channel provided channels with navigable depths of 20 feet and minimum widths of 300 feet. In 1893, to compensate for the increased cross sectional area, which resulted from the dredging of the navigation channel, compensating dikes were built: one was between Sugar Island and Island No. 1, at the head of Little Rapids Channel and the other was in the Middle Neebish Channel, projecting from Sugar Island. When the initial improvements of these channels were completed, the Lake George Channel was abandoned for use by commercial navigation. Dredging continued into the early 1900s, to improve and maintain the navigation channels of the St. Marys River to a minimum depth of 20 feet. Between 1902 and 1909, excavations to widen channels were done in two reaches of the river. Little Rapids Cut was completed in 1907. The channel had a minimum width of 600 feet and was dredged to a depth of 21 feet. Completed in 1909, Rock Cut in the West

Neebish Channel was excavated to a width of 300 feet for a distance of 13,300 feet and a depth of 22 feet.

In 1932, dredging commenced to further deepen certain reaches in the navigation channels to at least 25 feet. By the mid-1960s, all of the major navigation channels of the St. Marys River were being maintained at a minimum depth of 27 feet below chart datum (low water datum). Removal of shoals in the channels and canal approaches is an on-going maintenance project. A chronologic summary of dredging and miscellaneous construction in the St. Marys River is given in Appendix B.

The first utilization of St. Marys River water for power production began in 1822-23, when a raceway and saw mill were built by the U.S. Army at Sault Ste. Marie, Michigan. The first hydroelectric power plant was built on the United States side of the rapids by the Edison Sault Light and Power Company and was completed in 1888. This plant was later taken over by the Chandler-Dunbar Water Power Company, and is now known as the U.S. Government Plant. In 1889, the Ontario Water, Light and Power Company began excavation of a powerhouse headrace on the Canadian side of the Rapids. This canal was completed in 1895 by the Lake Superior Power Company. In 1887, the St. Marys Falls Water Company began excavation for a canal through Sault Ste. Marie, Michigan. This company encountered financial trouble and the development was completed by the Michigan Lake Superior Company. In 1903, the first water was diverted through this canal, now the Edison Sault Power Canal. In the spring of 1979, the Great Lakes Power Limited (Canada) began construction of a new powerhouse to replace the old Lake Superior Power Company plant. The new plant was fully operational early in 1983. This new plant had an increased capacity of 22,000 cubic feet per second (cfs).

Man first began to somewhat regulate the flow in the St. Marys River as a result of the Rivers and Harbors Act of 1902. This act required the U.S. Secretary of War to approve the operation of the early U.S. power canal diversions. That approval included restrictions on diversions when Lake Superior water levels rose or fell outside specified limits. Limits were set based on levels at the canal above the locks at Sault Ste. Marie. The total range in allowable levels was 2.0 feet. If the lake level fell below the threshold limit, diversions had to be reduced; if levels remained below the threshold for five consecutive months or dropped below the absolute minimum allowable level, all diversions had to cease. If the lake rose above the maximum allowable level, the power company was required to operate their canals at maximum capacity; if levels remained above the upper limit for six consecutive months, alteration of the canals to enable more flow was required.

The Canadian Pacific Railroad steel truss bridge, known as the International Railroad Bridge, was the first significant man-made change to affect the amount of water available for flow through the St. Marys River. Built in 1887-88 across the river at the head of the Rapids (see Figures 2-2 and 2-3), this structure resulted in a 9% decrease in the discharge capacity of the St. Marys River, due to the obstruction of the channel by the bridge piers and approaches. Between 1888 and 1892, the largest of the small channels among the

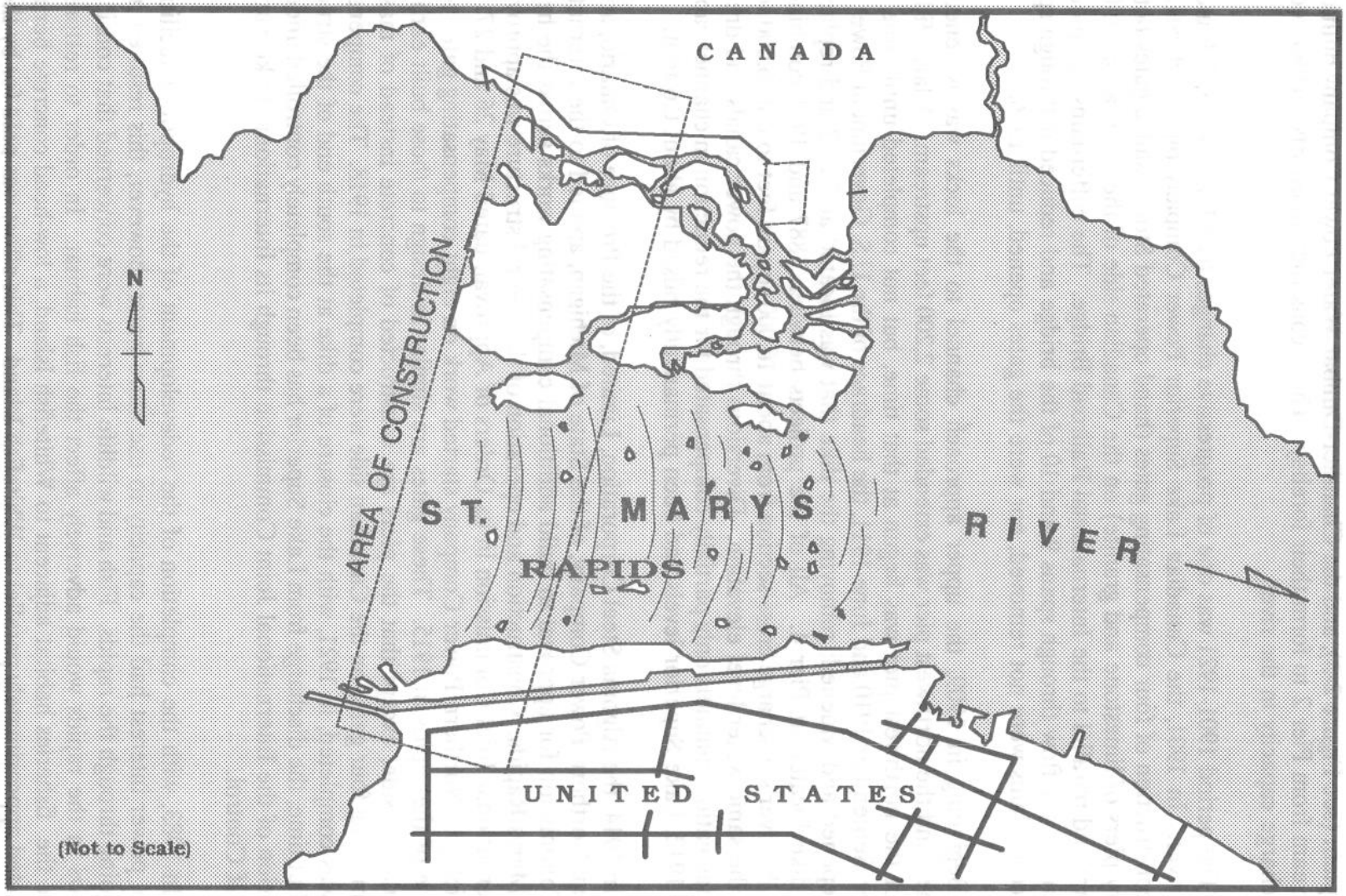


Figure 2-2

St. Marys Rapids, 1860-1888

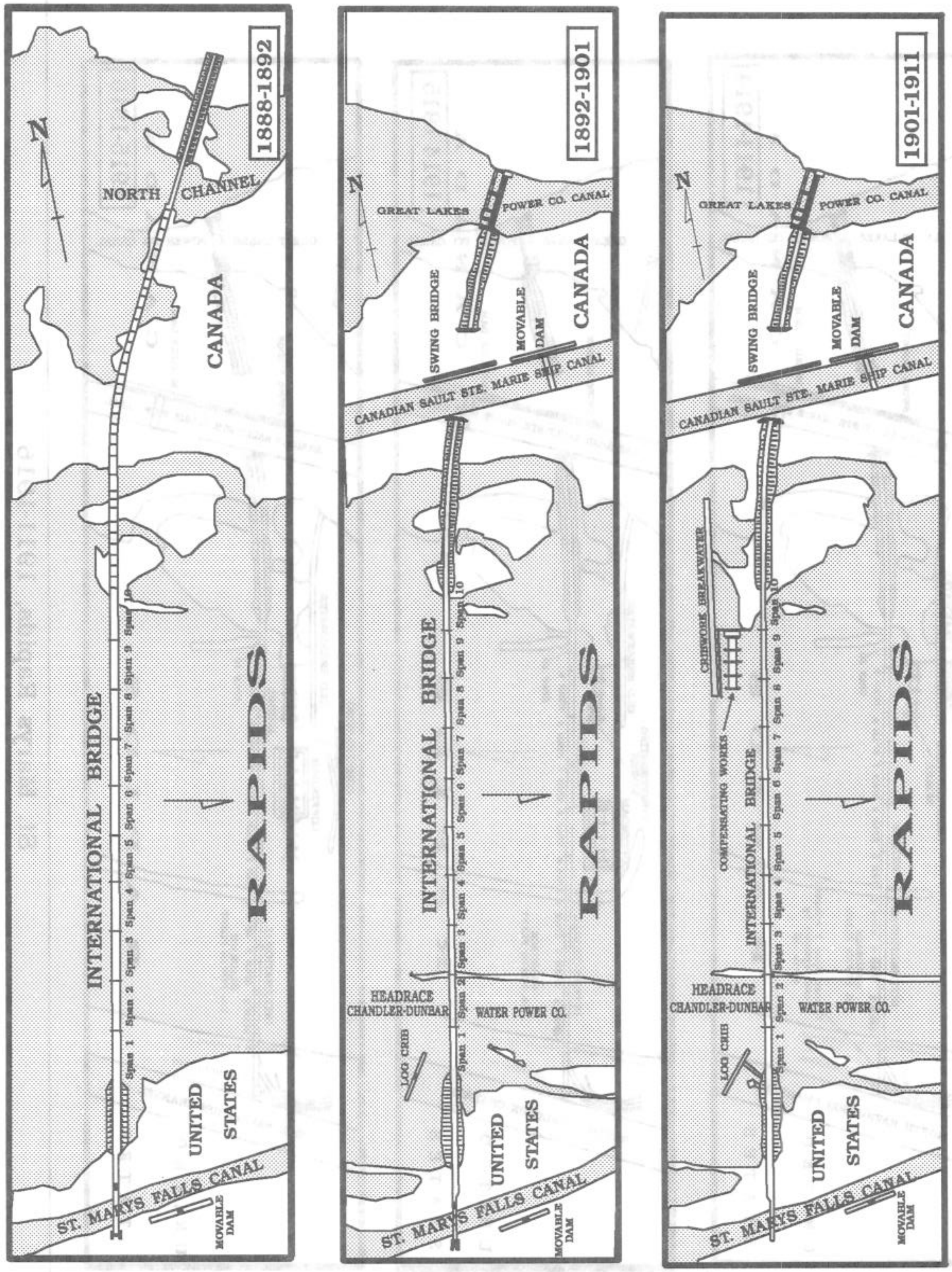
islands north of the rapids was closed for the construction of the head race for the Canadian power plant (see Figure 2-3), and the Chandler-Dunbar Water Power Company built a dike downstream from Pier 2 to form their forebay. These construction efforts further reduced the discharge capacity in the river.

The period 1901-1921 was one of progressive changes (see Figures 2-3, 2-4 and 2-5) in the river. In 1901, the Canadian Lake Superior Power Company built cofferdams to begin construction of four compensating gates (hand operated Stoney sluice gates between masonry piers of limestone and granite) on the Canadian side of the river, about 150 feet upstream and parallel to the International Railroad Bridge. The cofferdams completed in 1905, cut off the flow through spans 9 and 10 of the bridge and reduced it through span 8. These cofferdams were not removed, nor were the gates opened, until 1916.

Beginning in 1909, the upper approach channel to the locks was widened and deepened and the northwest pier was extended some 2,200 feet upstream. A large fill lying north of the northwest pier was begun at that time, but not completed until June 1914. Between September 1910 and June 1911, the headrace of the U.S. Government Power Plant was deepened and widened; removing the dike that was located at Pier 2 and replacing it with a dike located at Pier 4. All of the projects between 1887 and 1911 combined to reduce the river's discharge cross-section from about 16,000 square feet to only 6,000 square feet at the same water level elevation. Diversions through the power canals and dredging of the navigation channels only partially compensated for the reduction in channel capacity, and by 1912, Lake Superior levels had been permanently raised by about 0.6 foot.

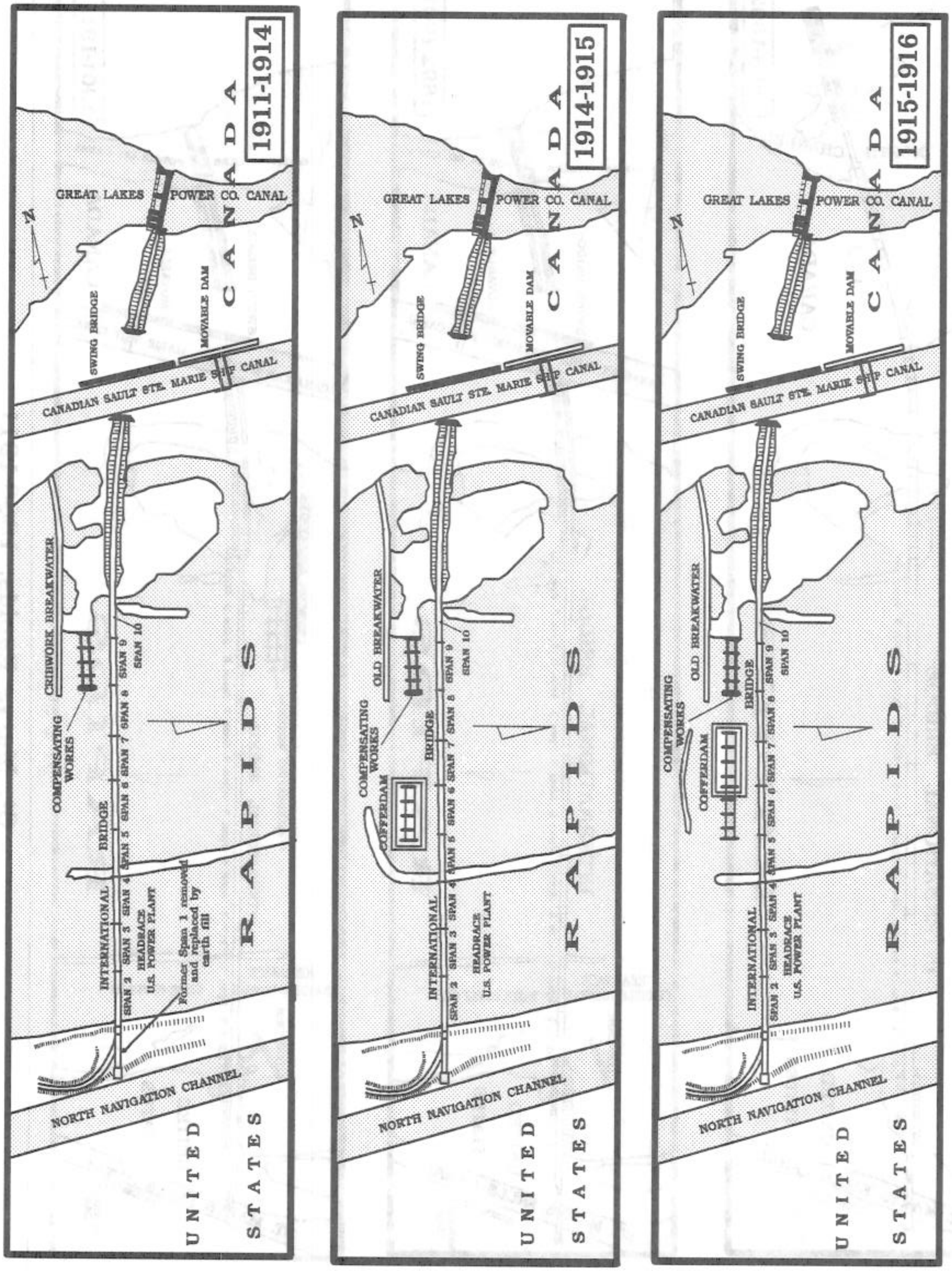
In 1914, the Algoma Steel Corporation, Limited, of the Province of Ontario, and the Michigan Northern Power Company, of the State of Michigan, applied to the International Joint Commission for approval to build additional compensating works across the head of the St. Marys Rapids. Construction and operation of the control structure was approved by the International Joint Commission in its Orders of Approval, dated May 26 and 27, 1914. The Michigan Northern Power Company started work on eight compensating gates on the U.S. side of the rapids in 1915. These gates are similar in design to those built earlier on the Canadian side, except that the piers are constructed of concrete instead of masonry. The remaining four gates on the Canadian side were completed in 1918. The compensating works was completed, in 1921, with the closure of a dike at the south end of the structure. Since that time, the discharge from Lake Superior has been completely controlled under the supervision of the International Joint Commission through its International Lake Superior Board of Control.

In 1983, with the completion of the redevelopment of the hydropower facilities in Canada, power interest had the capacity to use more water; however, this resulted in less water going through the rapids. Fish and wildlife interests were concerned that consistently low flows in the rapids would adversely affect the fish habitat. In order to restore and enhance the fisheries habitat adjacent to Whitefish Island, a low-head concrete berm was constructed approximately parallel to Whitefish Island. This effort was paid for by the two



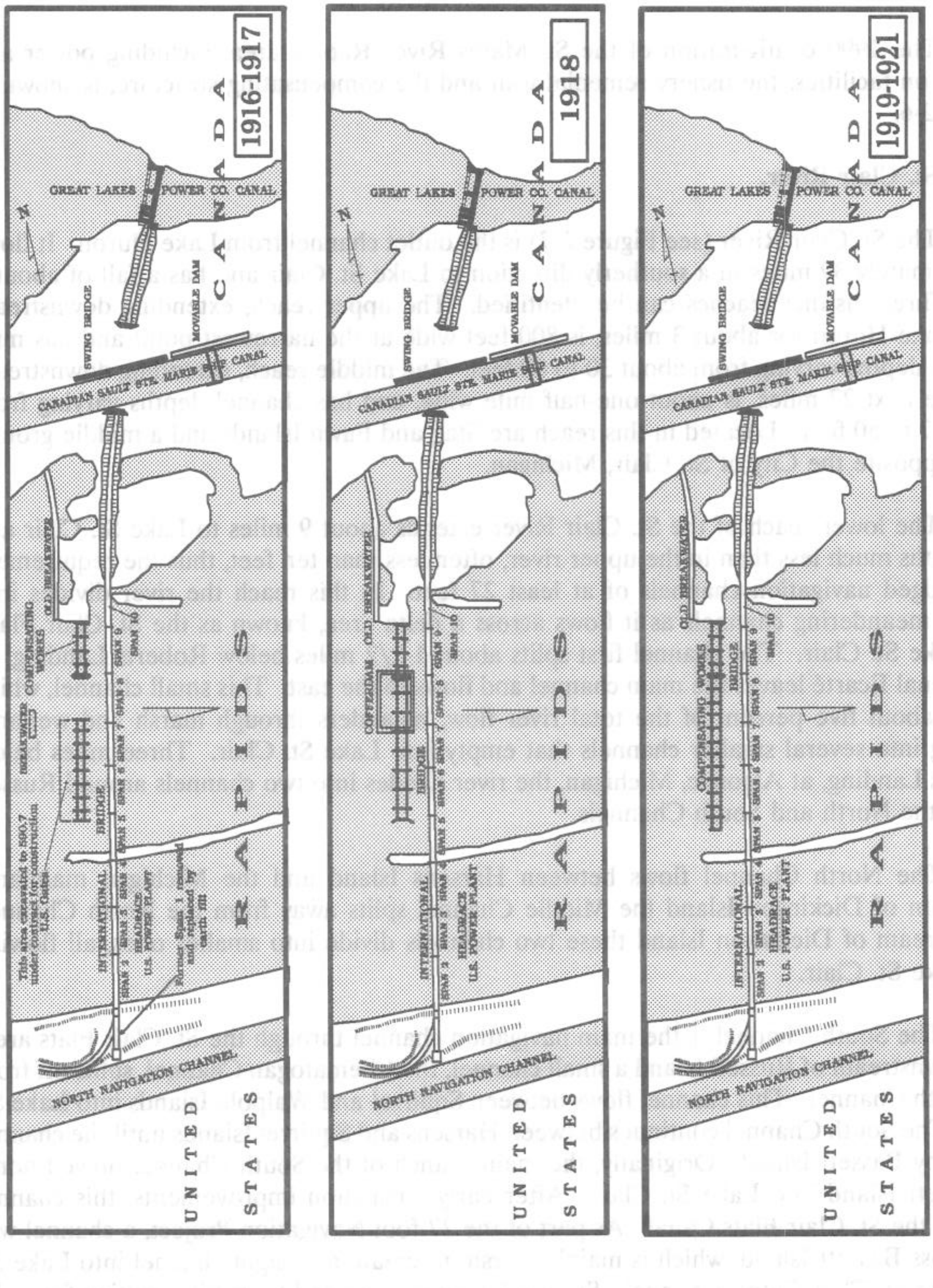
St. Marys Rapids, 1888-1911

Figure 2-3



St. Marys Rapids, 1911-1916

Figure 2-4



St. Marys Rapids, 1916-1921

Figure 2-5

private power entities, Great Lakes Power Limited and Edison Sault Electric Company, and was sponsored by the Ontario Ministry of Natural Resources. This remedial work was completed in the Summer of 1985.

The 1990 configuration of the St. Marys River Rapids area, including power and navigation facilities, the fishery remedial wall and the compensating structure, is shown in Figure 2-6.

2.2 St. Clair River.

The St. Clair River (see Figure 2-7) is the outlet channel from Lake Huron. It flows approximately 39 miles in a southerly direction to Lake St. Clair and has a fall of about 5 feet. Three distinct reaches can be identified. The upper reach, extending downstream from Lake Huron for about 3 miles, is 800 feet wide at the narrowest point and has mid-channel depths varying from about 30 to 60 feet. The middle reach, extending downstream over the next 27 miles, is about one-half mile wide, and has channel depths varying from about 27 to 50 feet. Located in this reach are Stag and Fawn Islands and a middle ground shoal opposite the City of St. Clair, Michigan.

The lower reach of the St. Clair River extends about 9 miles to Lake St. Clair and has depths much less than in the upper river, often less than ten feet, thus the requirement for dredged navigation channels of at least 27 feet. In this reach the river divides into several meandering channels as it flows across a delta area, known as the St. Clair Flats, into Lake St. Clair. The channel first splits about 1-1/2 miles below Roberts Landing, as the Chenal Ecarté leaves the main channel and flows to the east. This small channel, which carries about five percent of the total river flow, meanders through marsh and wetland, splitting into several smaller channels that empty into Lake St. Clair. Three miles below Roberts Landing, at Algonac, Michigan, the river divides into two channels around Russell Island, the North and South Channels.

The North Channel flows between Harsens Island and the Michigan mainland. Upstream of Dickinson Island the Middle Channel splits away from the North Channel. Downstream of Dickinson Island these two channels divide into smaller ones, all flowing into Lake St. Clair.

The South Channel is the main navigation channel through the St. Clair Flats area. Just downstream of Russell Island a small channel, the Chematogan Channel, splits off from the South Channel. This channel flows between Squirrel and Walpole Islands into Lake St. Clair. The South Channel continues between Harsens and Squirrel Islands until the channel is split by Bassett Island. Originally, the main branch of the South Channel flowed north of Bassett Island into Lake St. Clair. After early navigation improvements, this channel became the St. Clair Flats Canal. As part of the 27-foot Navigation Project, a channel was cut across Bassett Island, which is mainly marsh, to create a straight channel into Lake St. Clair, the St. Clair Cutoff Channel. Seaway Island was created from fill resulting from the

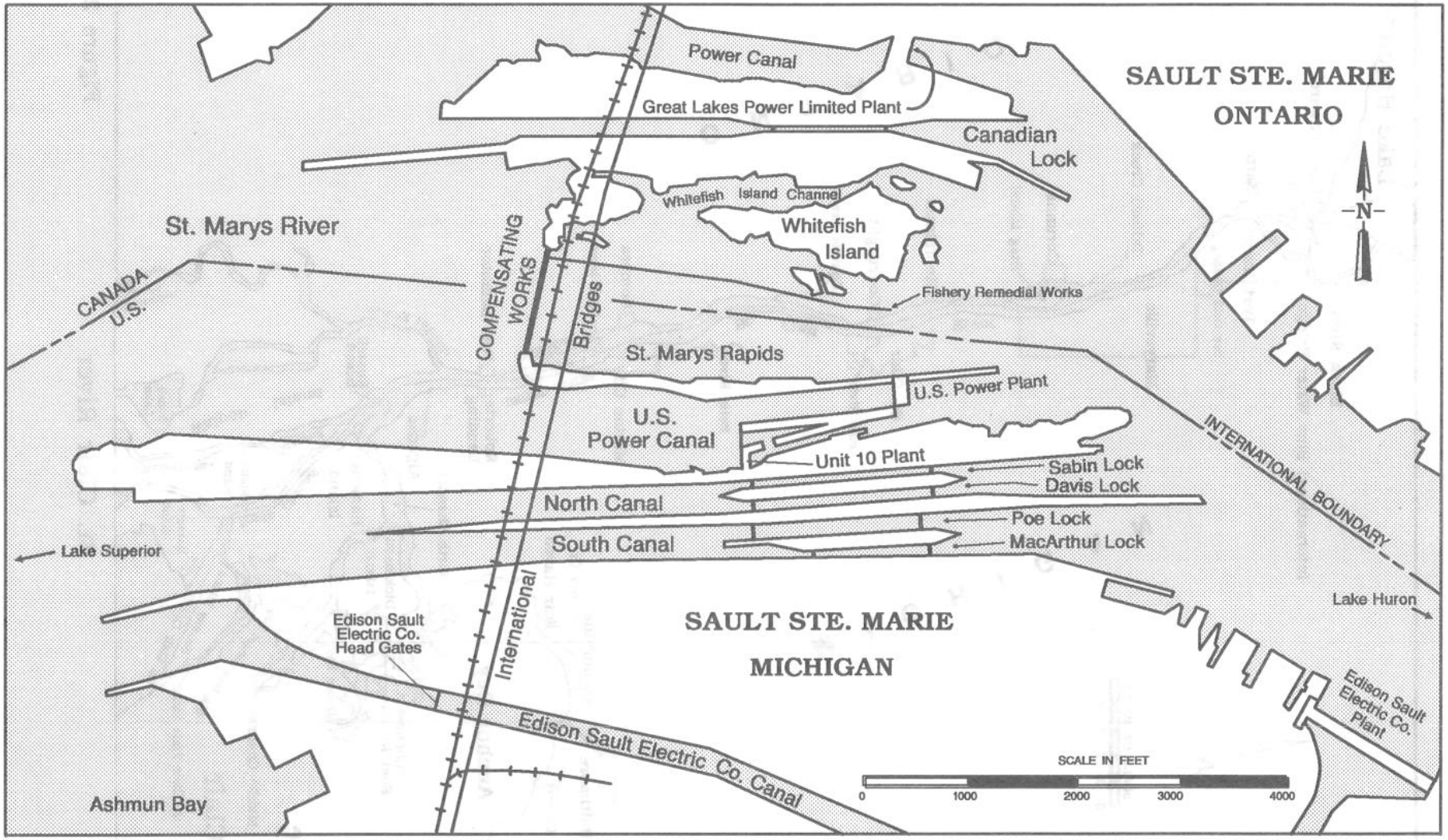
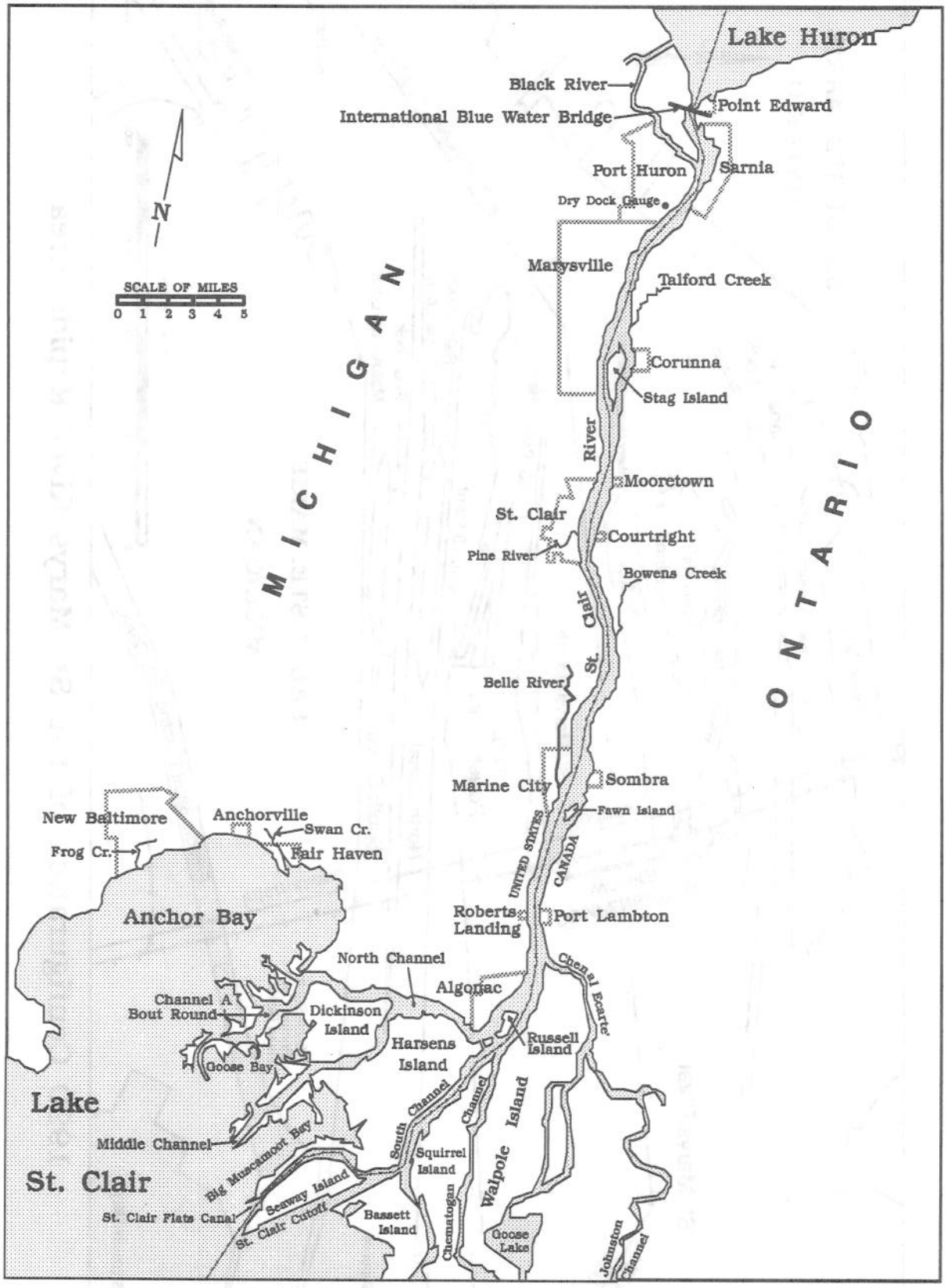


Figure 2-6

1990 Configuration of the St. Marys River Rapids Area



St. Clair River

Figure 2-7

dredging for the St. Clair Cutoff. The construction of the St. Clair Cutoff Channel caused a major change in the distribution of flow among the several channels in the St. Clair Flats.

In its natural state, the main channel of the St. Clair River had depths of 20 feet or more, while the channel depths in the St. Clair Flats region averaged only about 4 to 6 feet. Improvements in the South Channel, including construction of the St. Clair Flats Canal, began in 1855. In 1906, the east and west channels through the canal were opened. By the beginning of the present century, a least depth of 20 feet was generally available along the entire river, and essentially prevailed until 1930.

On August 4, 1900, the steamer Fontana was wrecked in the narrows at the head of the river; on September 22 of the same year, the steamer Martin was wrecked at the same point. Only the superstructures and machinery of these vessels were removed. The hulls remained on the bottom near the west shore, buried in sand. These wrecks decreased the cross section of the river at its narrowest point, and thus affected the capacity of the river until their removal during later dredging operations.

Commercial sand dredging in the river dates back to 1890, when large quantities of sand were removed from the North Channel downstream of Algonac. This dredging continued until 1922. However, it had little effect on the outflow of the river, because the flow in the North Channel was largely controlled by sand bars across the outlet. In 1909, commercial interests began to remove sand and gravel from the head of the river. Between 1909 and 1925, it has been estimated that these interests removed 3-1/2 million cubic yards of material from the river, most of it above the Dry Dock gauge. During the same period, dredging was also being done to improve the navigation channel. This work consisted mainly of removal of isolated shoals along the river, the largest of which was the Black River shoal (1920-1922). The removal of sand and gravel for commercial purposes, together with the dredging to increase depths in the navigation channels, significantly increased the discharge capacity of the river, resulting in a lowering of Lake Huron levels. A 1926 report of the Joint Board of Engineers, entitled "St. Lawrence Waterway," attributes about 0.3 foot of lowering of Lake Huron levels to commercial dredging of gravel from the reach of the St. Clair River in the vicinity of Point Edwards, Ontario. In 1925, sand and gravel dredging was prohibited in United States waters, and shortly thereafter in Canadian waters.

Two major regimen changes have been made on the St. Clair River since 1933. The first resulted from dredging for a 25-foot deep navigation channel. The second major change was due to a 27-foot navigation project. Dredging for the 25-foot project began in June 1933 and was completed in October 1936. The deposition of dredged materials into deeper sections of the river constituted the only compensation made for the increase in depth. The 27-foot project was started in April 1960 and was completed in 1962. As stated earlier, this project involved significant excavation in conjunction with the dredging of a new cut-off channel, which bypassed the Southeast Bend in the lower South Channel. Spoil material from this project was used to create the large island between the Southeast Bend and the new cut-off channel, partially compensating for the increase in depth.

Compensation works were authorized as part of the 27-foot project, but were never constructed. The uncompensated lowering of Lake Huron levels, due to dredging after 1933 for the 25-foot navigation project, plus the uncompensated lowering, due to dredging for the 27-foot project, is estimated to be 0.59 foot. Figures 2-8 and 2-9 show the extent of the dredging in the St. Clair River for the 25-foot and 27-foot navigation projects, respectively. Included in Appendix B is a chronologic summary of construction and dredging in the St. Clair River.

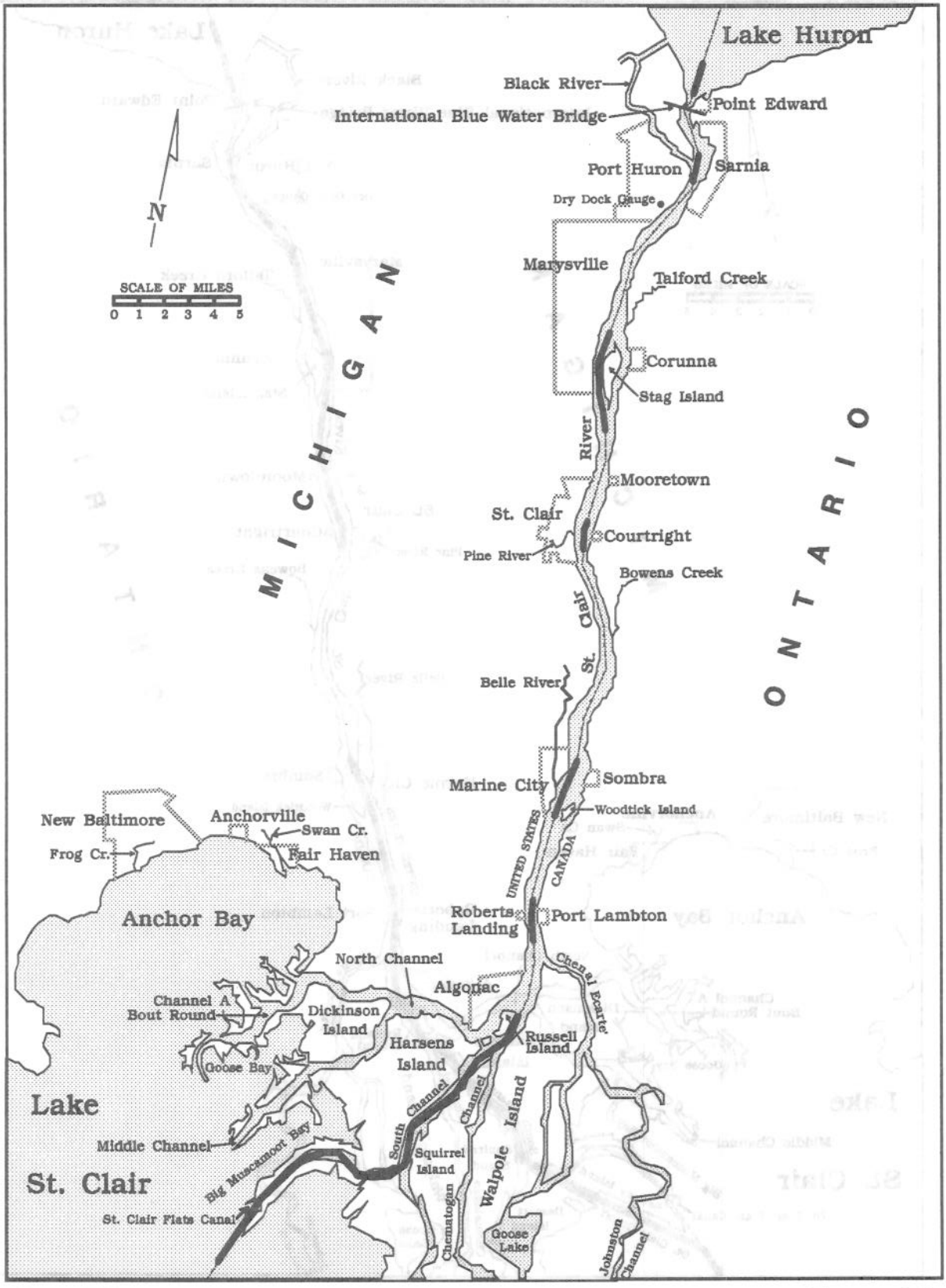
2.3 Detroit River.

The Detroit River (see Figure 2-10) flows in a southerly direction and falls about 3 feet between Lakes St. Clair and Erie. It is about 32 miles long from its head at the Windmill Point Light to its mouth at the Detroit River Light in Lake Erie. The river is characterized by two distinct reaches. The upper reach extends downstream from Lake St. Clair to the head of Fighting Island, about 13 miles. In this reach, the river consists of a single, wide and deep channel, except at its head, where it is divided by two islands. The lower reach is broad, with several islands and many shallow expanses.

As water flows out of Lake St. Clair, it divides as it passes Peach (Peche) Island. The channels on both sides of this island are relatively deep, but the main navigation channel from Lake St. Clair lies north of this island. Just below Peach Island lies Belle Isle. The main river channel, the Fleming Channel, runs to the south of this island. The channel north of Belle Isle is divided by the Scott Middle Ground, over which depths vary from 1 to 6 feet. The channels on either side of the Scott Middle Ground are quite deep (19 to 30 feet), but are only used by small craft.

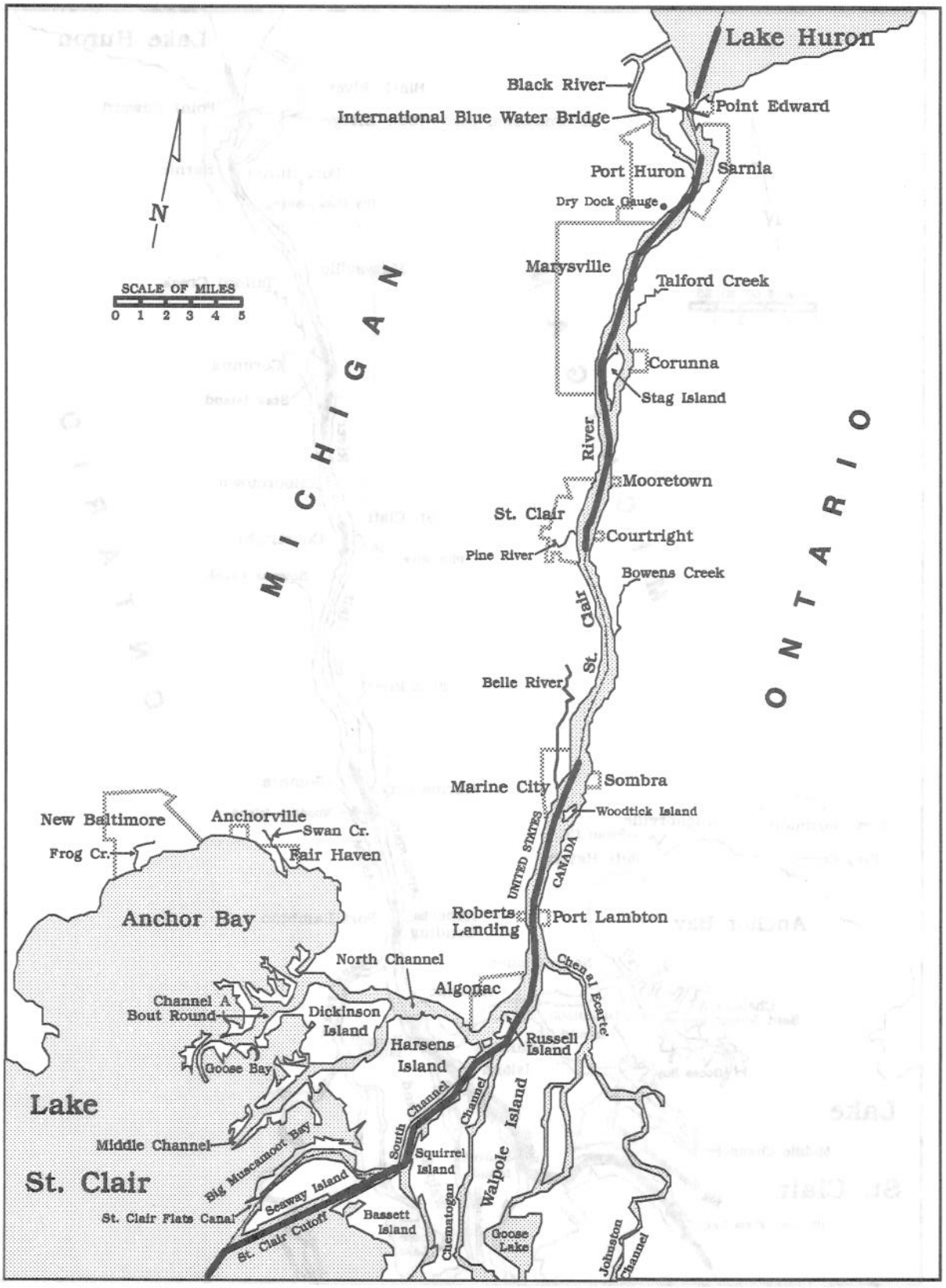
From the foot of Belle Isle to the head of Fighting Island, the channel is generally broad and deep. Its bottom consists of sand and clay and its banks are quite steep. The river, in this reach, averages about 2,400 feet in width and has depths of 35 to 50 feet. The deepest areas are found in the vicinity of the Ambassador Bridge, where the river slightly narrows to a width of about 1,900 feet for a distance of 1-1/2 miles.

At the head of Fighting Island, the river divides into three channels; east and west around the island and an extensive middle ground further to the west. The middle channel, known as the Fighting Island Channel, is the main navigation channel. The channel on the Canadian side of Fighting Island (east) is divided by Grass and Turkey Islands before it rejoins the main channel below Fighting Island. The west-most channel (along the U.S. shore), which was originally narrow and crooked, has been straightened by a cut across the upper end of the middle ground. This channel divides around Grosse Ile. The channel west of Grosse Ile is the Trenton Channel. The other channel rejoins the main (middle) channel at the foot of the middle ground. River depths at the south end of the Trenton Channel are less than 10 feet and do not permit navigation of deep-draft vessels. Turning basins in this channel allow deep-draft vessels to re-navigate into the Detroit River. The Trenton Channel below Gibraltar is divided by Celeron Island.



St. Clair River **Figure 2-8**

Extent of 25-Foot Dredging Project



St. Clair River **Figure 2-9**

Extent of 27-Foot Dredging Project

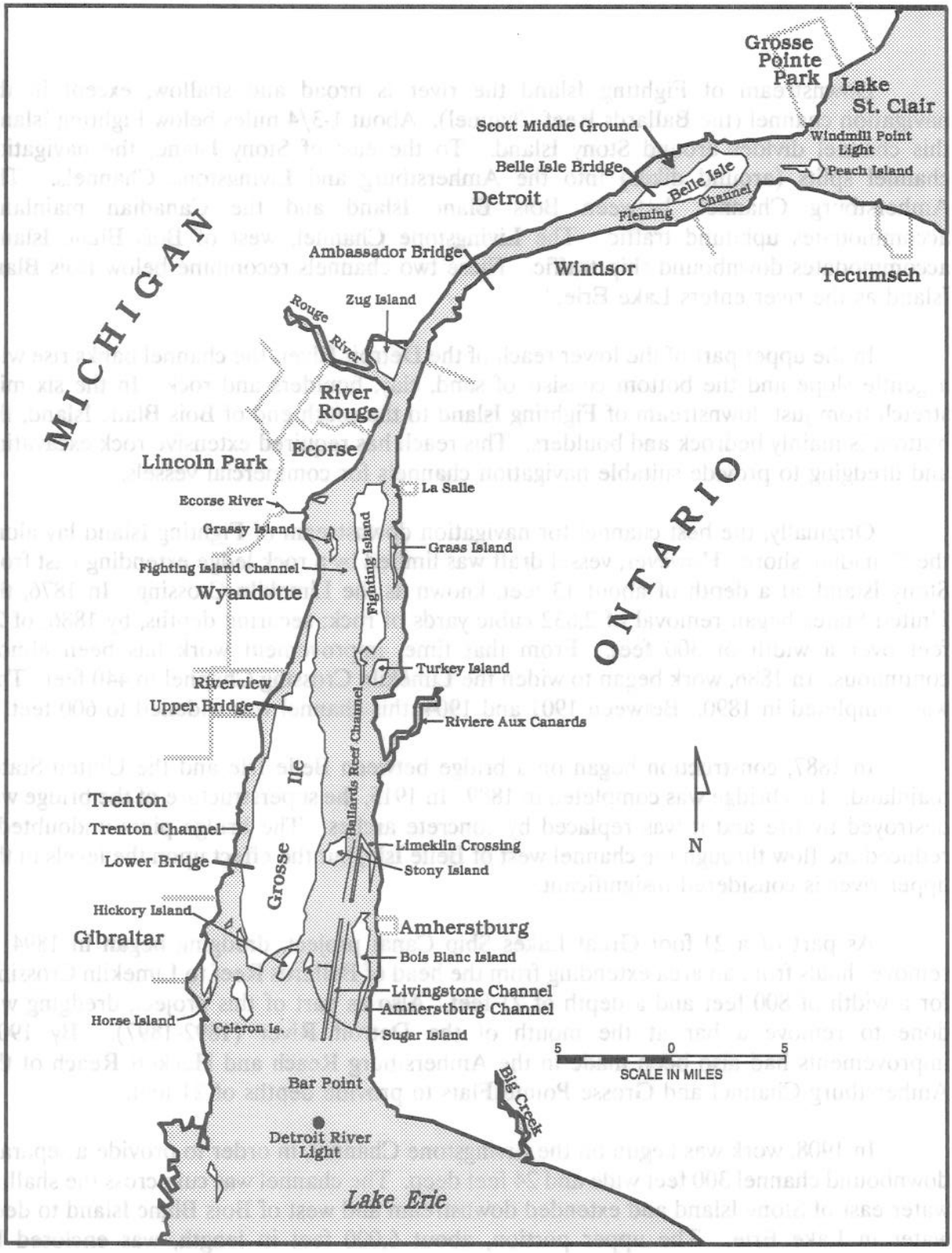


Figure 2-10

Detroit River

Downstream of Fighting Island the river is broad and shallow, except in the navigation channel (the Ballards Reef Channel). About 1-3/4 miles below Fighting Island, this channel divides around Stony Island. To the east of Stony Island, the navigation channel splits (around dikes) into the Amherstburg and Livingstone Channels. The Amherstburg Channel, between Bois Blanc Island and the Canadian mainland, accommodates upbound traffic. The Livingstone Channel, west of Bois Blanc Island, accommodates downbound ship traffic. These two channels recombine below Bois Blanc Island as the river enters Lake Erie.

In the upper part of the lower reach of the Detroit River, the channel banks rise with a gentle slope and the bottom consists of sand, clay, boulders and rock. In the six mile stretch from just downstream of Fighting Island to the south end of Bois Blanc Island, the bottom is mainly bedrock and boulders. This reach has required extensive rock excavation and dredging to provide suitable navigation channels for commercial vessels.

Originally, the best channel for navigation downstream of Fighting Island lay along the Canadian shore. However, vessel draft was limited by a rock ledge extending east from Stony Island, at a depth of about 13 feet, known as the Limekiln Crossing. In 1876, the United States began removal of 2,632 cubic yards of rock; securing depths, by 1886, of 20 feet over a width of 300 feet. From that time, improvement work has been almost continuous. In 1886, work began to widen the Limekiln Crossing Channel to 440 feet. This was completed in 1890. Between 1901 and 1904, this channel was widened to 600 feet.

In 1887, construction began on a bridge between Belle Isle and the United States mainland. This bridge was completed in 1889. In 1915, the superstructure of the bridge was destroyed by fire and it was replaced by concrete arches. The bridge piers undoubtedly reduced the flow through the channel west of Belle Isle, but the effect upon the levels in the upper river is considered insignificant.

As part of a 21-foot Great Lakes Ship Canal project, dredging began in 1894 to remove shoals from an area extending from the head of Ballards Reef to Limekiln Crossing, for a width of 800 feet and a depth of 21 feet. Also as part of this project, dredging was done to remove a bar at the mouth of the Detroit River (1892-1897). By 1900, improvements had also been made in the Amherstburg Reach and Hackett Reach of the Amherstburg Channel and Grosse Pointe Flats to provide depths of 21 feet.

In 1908, work was begun on the Livingstone Channel, in order to provide a separate downbound channel 300 feet wide and 24 feet deep. The channel was cut across the shallow water east of Stony Island and extended downstream and west of Bois Blanc Island to deep water in Lake Erie. The upper portion, about 6,000 feet in length, was enclosed by cofferdams and dewatered. When work was completed in 1912, the cofferdams were left as a form of compensation. Openings were made at each end of the cofferdam enclosure, 300 feet in width. The openings were widened to 450 feet in 1915. Between 1920 and 1922, the Livingstone Channel was widened to 450 feet over its entire length. During the same

period, the construction of a dike on the west side of the lower part of the channel and the dumping of dredged material, was completed.

Before the construction of the Livingstone Channel, little if any attention was given to the effect of channel improvements upon lake levels. However, all of the material excavated from the river was strategically placed in other locations in the river. This balance of materials undoubtedly provided some compensation. There had also been some encroachment on the river by wharfs along the water front, and the extensive filling at the head and foot of Belle Isle, by the City of Detroit. Sherman Moore, with the U.S. Lake Survey District, Corps of Engineers, wrote in 1935 that"....it appears fairly certain that in spite of the large amount of dredging in the interests of navigation, including the breaching of the rock ledge at the Limekiln Crossing, there has been no measurable change in the capacity of the Detroit River as a whole between 1859 and 1932....While the capacity of the river as a whole has been unchanged, the capacity of certain reaches has been slightly increased while that of other reaches has been diminished....the capacity of the reach (from Stony Island to below Bois Blanc Island) has been increased while the capacity of the reach between Windmill Point and Fort Wayne has been reduced by filling above and below Belle Isle, and by encroachment of the dock lines at Detroit."

A 24-foot Navigation Project was begun in 1932. This project required further deepening of the channels in the lower river and some dredging near the head of the river. To further deepen the Livingstone Channel, it was enclosed by a cofferdam from 1932 to 1935. In 1935, the upstream and downstream ends of the cofferdam were removed. The sides were left in place to compensate for the increased depth of the channel. An additional compensating dike, extending westerly from the west dike of the Livingstone Channel towards Sugar Island, was constructed in 1936.

In 1940, the deepening of the Trenton Channel was begun. The project provided for a turning basin 1,700 feet downstream of the lower Grosse Ile Bridge and a 250 feet wide, 21 foot deep channel from the main navigation channel to the turning basin. In 1964, additional dredging was completed to provide for a 300 foot wide, 27 foot deep channel from the main navigation channel to the Upper Grosse Ile Bridge; and for a 300 foot wide, 28 foot deep channel extending about 6,000 feet downstream of the bridge, to and including an upper turning basin 28 feet deep and 15 acres in area, outside the channel limits.

Between 1957 and 1962, dredging was again instituted in the river, this time to accommodate a 27-foot Navigation Project. The majority of the work was done in the Amherstburg Channel. This work was completed in August 1959. To compensate for the additional channel capacity, two dikes were constructed. One dike was an enlargement of an existing dike at the junction of the Amherstburg/Livingstone and Ballards Reef Channels. Construction of this dike was started in May 1957 and was completed in August 1959. The dike is along the west side of the Amherstburg Channel and extends 10,000 feet downstream of the Upper Entrance Light. The second dike was built downstream of the lower end of Bois Blanc Island, parallel to and 100 feet west of the Amherstburg Channel. The

construction of this dike, 6,200 feet in length, was started in January 1958 and was completed in May 1959.

Since 1962, dredging in the Detroit River has consisted only of that necessary to maintain the present project depth of 27 feet. Included in Appendix B is a chronologic summary of construction and dredging in the Detroit River.

2.4 Niagara River.

The 36-mile long Niagara River (see Figure 2-11) flows from Lake Erie over and through the Niagara Escarpment and into Lake Ontario, 326 feet below Lake Erie. The river leaves Lake Erie at Buffalo, New York. It immediately narrows to a width of 1,500 feet and depth of 17 feet as it reaches a rock ledge, which naturally controls its outflow. This constricted channel is spanned by the Peace Bridge (see Figure 2-12), with three piers which further restrict the channel. About 1-1/2 miles below the Peace Bridge is the International Railway Bridge. This bridge has eight piers surrounded by protective masses of large rock.

Located between the Peace and International Bridges is Squaw Island. Extending upstream of this island is Bird Island Pier, which proceeds south under the Peace Bridge and out into Lake Erie. The channel east of Squaw Island and the Bird Island Pier is known as the Black Rock Canal. At the north end of this channel, just downstream of the International Bridge, is the Black Rock Lock. The Black Rock Canal and Lock allow for passage of commercial vessels around the shallow and fast moving waters at the head of the river. The depth in this canal is 21 feet. In the first 4 miles of its course the river falls about 5 feet. The level in the canal is maintained near the level of Lake Erie and the lock raises and lowers ships over the 5-foot difference.

In the next 18 miles, the river flows more slowly, falls only about 4 feet and widens to 2,400 feet. Within this 18 mile reach, about three miles downstream of the Black Rock Lock, the river divides into two channels around Grand Island, the Chippawa Channel to the west of the island and the Tonawanda Channel to the east. Both channels are navigable. The Chippawa Channel has minimum depths of 10 feet below Chart Datum. The Tonawanda Channel has been improved to a depth of 21 feet extending as far as Niagara Falls, New York.

Downstream of Grand Island, the river rejoins to form the Chippawa-Grass Island Pool. At this point, the river is shallow and about 7,000 feet in width; however, the steep slope and rapid current in the area make the term "pool" a misnomer. Both the United States and Canada divert water out of the river from this pool for power generation. To maintain optimum water levels in the pool for power production, a control structure (see Figure 2-13) was built just above the first of the cascades above the falls. This gated structure extends half way across the river.

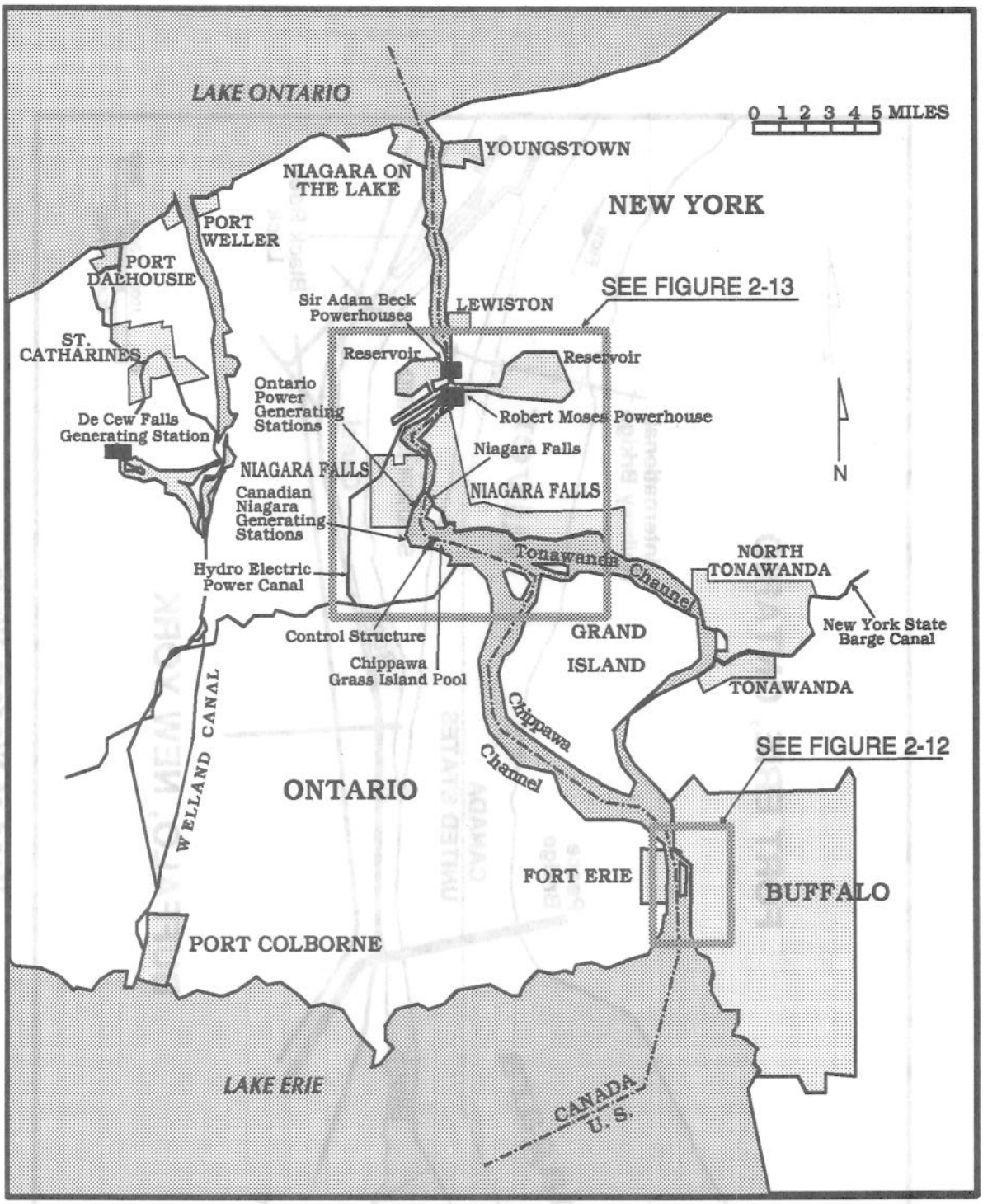


Figure 2-11

Niagara River

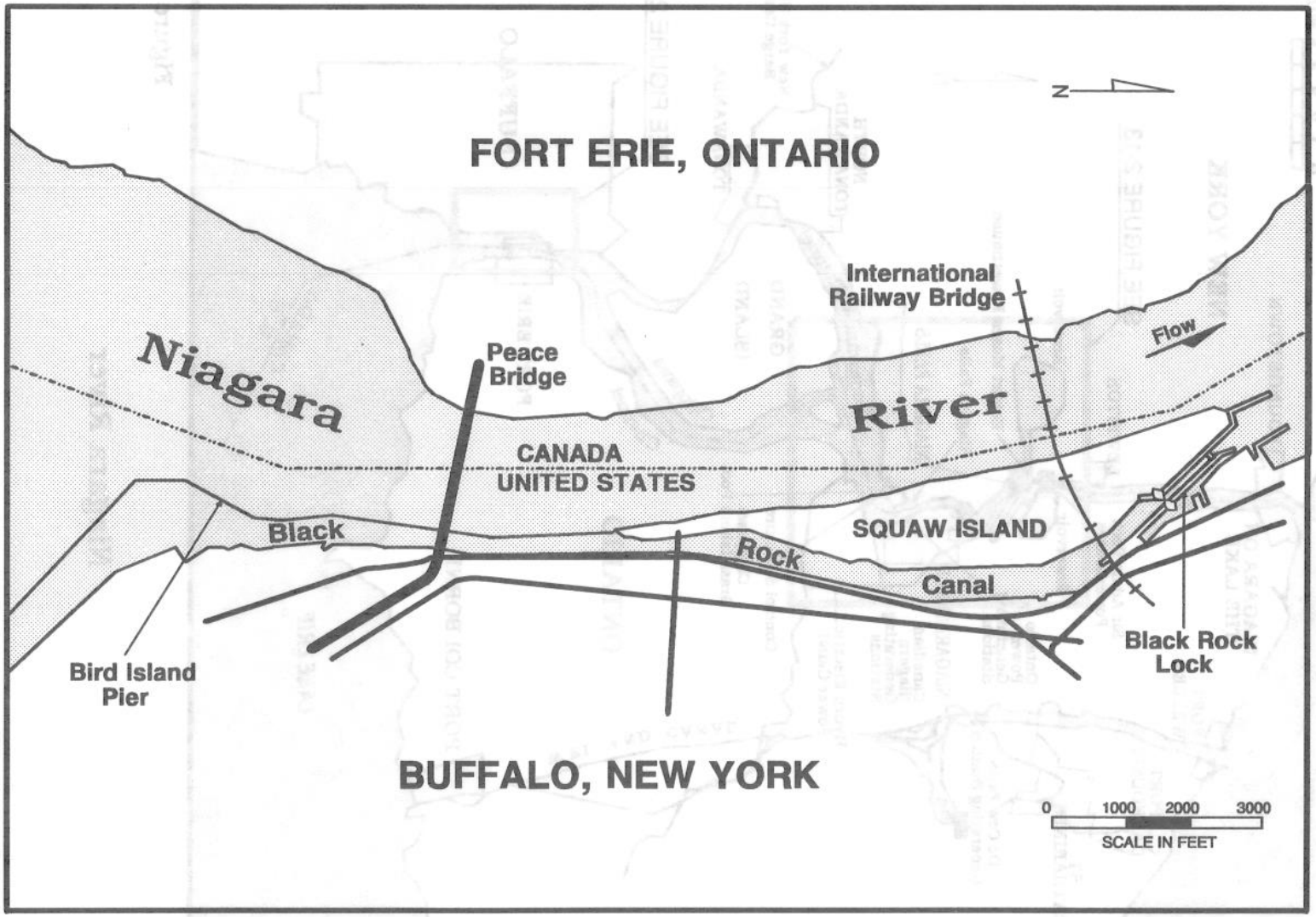
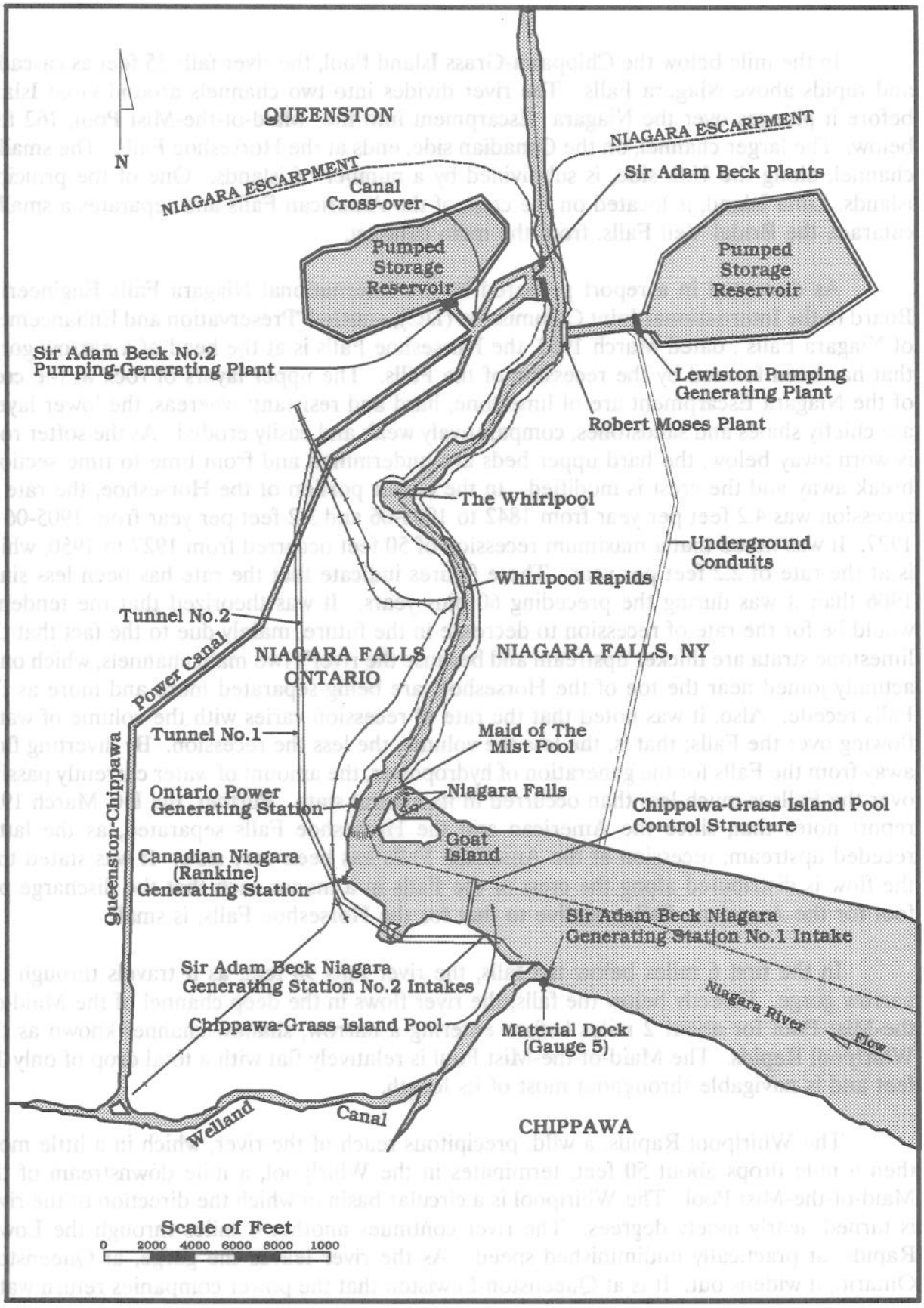


Figure 2-12

Head of Niagara River



Present (1990) Configuration of
U.S. and Canadian Hydropower Facilities

Figure 2-13

In the mile below the Chippawa-Grass Island Pool, the river falls 55 feet as cascades and rapids above Niagara Falls. The river divides into two channels around Goat Island before it plunges over the Niagara Escarpment into the Maid-of-the-Mist Pool, 162 feet below. The larger channel, on the Canadian side, ends at the Horseshoe Falls. The smaller channel, along the U.S. side, is subdivided by a number of islands. One of the principle islands, Luna Island, is located on the crest of the American Falls and separates a smaller cataract, the Bridal Veil Falls, from the main cataract.

As discussed in a report prepared by the International Niagara Falls Engineering Board to the International Joint Commission (IJC), entitled "Preservation and Enhancement of Niagara Falls", dated March 1953, the Horseshoe Falls is at the head of a narrow gorge that has been formed by the recession of the Falls. The upper layers of rock at the crest of the Niagara Escarpment are of limestone, hard and resistant; whereas, the lower layers are chiefly shales and sandstones, comparatively weak and easily eroded. As the softer rock is worn away below, the hard upper beds are undermined and from time to time sections break away and the crest is modified. In the center portion of the Horseshoe, the rate of recession was 4.2 feet per year from 1842 to 1905-06 and 3.2 feet per year from 1905-06 to 1927. It was noted that a maximum recession of 50 feet occurred from 1927 to 1950, which is at the rate of 2.2 feet per year. These figures indicate that the rate has been less since 1906 than it was during the preceding 60 plus years. It was theorized that the tendency would be for the rate of recession to decrease in the future, mainly due to the fact that the limestone strata are thicker upstream and because the river's two main channels, which once actually joined near the toe of the Horseshoe, are being separated more and more as the Falls recede. Also, it was noted that the rate of recession varies with the volume of water flowing over the Falls; that is, the less the volume, the less the recession. By diverting flow away from the Falls for the generation of hydropower, the amount of water currently passing over the Falls is much less than occurred in its natural state. Further, the IJC March 1953 report notes that, since the American and the Horseshoe Falls separated, as the latter receded upstream, recession at the American Falls has been very slow. It was stated that the flow is distributed along the crest of the Falls in a manor such that the discharge per foot for the American Falls, relative to that for the Horseshoe Falls, is small.

In the first 6 miles below the falls, the river falls 96 feet, as it travels through the narrow gorge. Directly below the falls, the river flows in the deep channel of the Maid-of-the-Mist Pool for about 2 miles before entering a narrow, shallow channel known as the Whirlpool Rapids. The Maid-of-the-Mist Pool is relatively flat with a total drop of only 1.4 feet and is navigable throughout most of its length.

The Whirlpool Rapids, a wild, precipitous reach of the river, which in a little more then a mile drops about 50 feet, terminates in the Whirlpool, a mile downstream of the Maid-of-the-Mist Pool. The Whirlpool is a circular basin in which the direction of the river is turned nearly ninety degrees. The river continues another 4 miles through the Lower Rapids, at practically undiminished speed. As the river leaves the gorge, at Queenston, Ontario, it widens out. It is at Queenston-Lewiston that the power companies return water

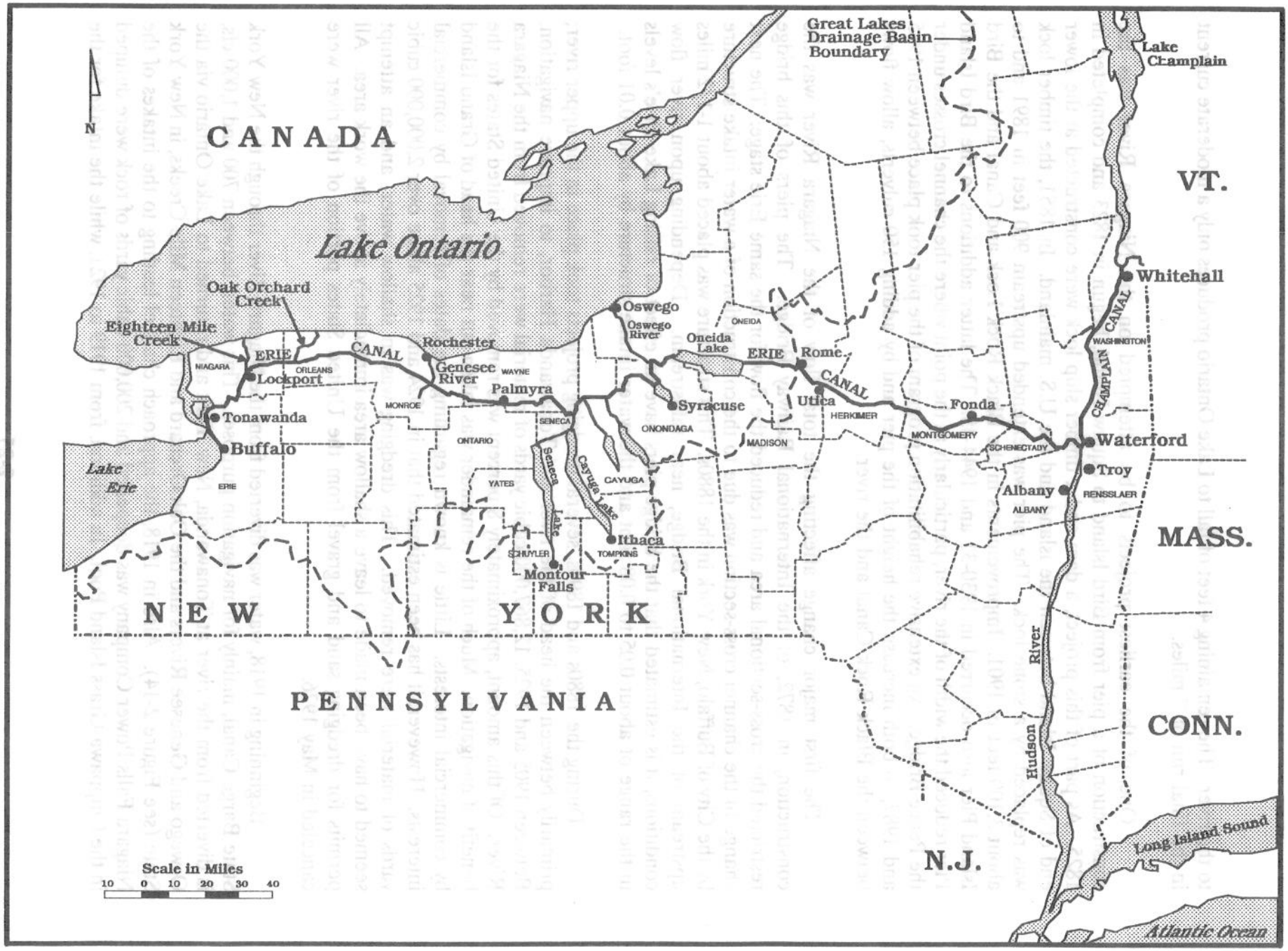
to the river. The remaining 4 feet of fall to Lake Ontario produces only a moderate current in the final run of 7 miles.

One of the earliest projects to be attempted on the Niagara River was the construction of a pier from Bird Island to Squaw Island, begun in 1823 and completed in 1825. As part of this project, a dam and a timber ship lock were constructed at the lower end of Squaw Island between the island and the U.S. mainland. In 1851, the timber lock was replaced by a stone lock. The pier was extended upstream 900 feet in 1891 and to about 3,100 feet in 1901. Improvements in the Black Rock Lock and Canal and the Bird Island Pier also occurred in 1930-31 and 1944-45. The latter additions to the Bird Island Pier reduced the width of the river, particularly at the point where the channel crosses under the Peace Bridge. An extensive rehabilitation program of the pier took place between 1985 and 1987, to both increase the height of the pier and by adding 150 culverts, allow flows between the Black Rock Canal and the river.

The first major change affecting the total flow of the Niagara River was the construction, in 1872, of the International Railway Bridge. The piers of this bridge restricted the cross-sectional area and reduced the flow for the same Erie stage. The next change in the channel cross-section was due to the construction of a water intake structure by the City of Buffalo, New York in the 1880s. This structure was placed about 1-1/2 miles upstream of the International Bridge, near midstream. Depending upon river flow conditions, it is estimated that the bridge piers have an effect of raising Lake Erie's levels in the range of about 0.05 to 0.08 foot and the water intake structure by about 0.01 foot.

During the 1880s and 1890s, several dredging projects took place in the upper river; primarily between the head of the river and Tonawanda Harbor, to improve navigation. Between 1905 and 1925, 12,867,000 cubic yards of material were removed from the Niagara River. Of this amount, approximately 8 percent was removed by the United States for the benefit of navigation. Much of the remainder was taken out near the head of Grand Island by commercial interests. Little is known regarding the dates of removal by commercial interests. However, it has been estimated that in 1924 and 1925 alone over 2,000,000 cubic yards of material were removed. This dredging was in shallow water, and an attempt seemed to have been made to leave a shallow area immediately above the work area. All permits for dredging sand and gravel from the United States portion of the river were canceled in May 1926.

Beginning in 1918, water was diverted from the Niagara River through the New York State Barge Canal, mainly for navigation purposes. This water, between 700 and 1,000 cfs, is diverted from the river at Tonawanda, New York and returned to Lake Ontario via the Oswego and Genesee Rivers and the Oak Orchard and Eighteen Mile Creeks, in New York State (see Figure 2-14). Also in 1918, the approach channel leading to the intakes of the Niagara Falls Power Company was deepened and 200,000 cubic yards of rock were dumped in the Chippawa-Grass Island Pool. In addition, from 1919 to 1921, while the intake for the



New York State Barge Canal System

Figure 2-14

Queenston Power Plant was under construction, large quantities of earth and rock were dumped in the pool below the intake.

In 1925-26, the Peace Bridge was constructed across the narrowest part of the head of the river. The piers of this bridge had a considerable retarding impact on the river flow by reducing the already constricted controlling point of flow from Lake Erie. The impact on Lake Erie water levels is of about the same order of magnitude as that of the International Railway Bridge.

In the 1930s and 1940s, construction of Mather Park at Fort Erie, Ontario, took place along the shore of the Niagara River in the vicinity of the Peace Bridge and upstream thereof. The park construction involved placement of fill material in the Niagara River and the building of a seawall. This construction had a limited effect on the flow in the river, because the fill was placed in fairly shallow water in an area which often was above water.

The placement of fills downstream of Mather Park at Nicholl's Marine and its adjacent areas at Fort Erie, Ontario, took place at various times until the early 1970s. These fills are located in the river at its narrowest point and have a relatively significant impact on Lake Erie levels, compared to other fills in the area. Fills below the International Bridge on the Canadian shore have also affected the flow in the river, but to a much lesser extent than fills closer to the head of the river. Depending upon river flow conditions, it is estimated that these fills have a combined effect of raising Lake Erie's levels in the range of about 0.04 to 0.08 foot.

The first recorded use of the Niagara River for power purposes was in 1725, with the utilization of the rapids above the Falls. The first attempt to develop power from the actual Falls was made in 1853. The first production of electrical power dates from 1877. Since then, there has been a continuous growth, which is now limited only by the control imposed by the Niagara Treaty of 1950. This Treaty, between the Governments of Canada and the United States, requires a minimum flow over the falls of 100,000 cfs between the hours of 8:00 a.m. and 10:00 p.m., E.S.T., from April 1 through September 15, and between the hours of 8:00 a.m. and 8:00 p.m. from September 16 through October 31 (tourist hours). A minimum flow of 50,000 cfs is required at all other times (non-tourist and night hours).

In 1853, the Niagara Falls Hydraulic Company was incorporated and construction commenced on a canal 70 feet wide, 10 feet deep and 3/4 mile long. Starting at a point about 1 mile above the Falls, on the U.S. side, this canal terminated in a basin about 1/2 mile long located at the edge of the gorge below the Falls. Water was drawn into the canal in 1855 and the canal was considered complete in 1861. It was anticipated that mills would be situated on the edge of the cliff drawing water from the basin and spilling the used water over the cliff. The Civil War brought the project to a stand still and only one mill was established. This mill developed 150 horsepower under a head of 25 feet.

In 1877, the above property was bought by the Niagara Falls Hydraulic Power and

Manufacturing Company (later known as the Hydraulic Power Company). By 1880, two additional mills were using water from the Niagara River for mechanical power. In 1881, the company installed electric generators and sold electric power to various manufacturers and to the village of Niagara Falls, New York.

In 1886, a competing company was organized, the Niagara Falls Power Company. This company cut a tunnel through solid rock under the City of Niagara Falls; the tunnel, above the Falls, leading to a vertical shaft. Water passed through the tunnel, dropped into the shaft, through wheels at the bottom of the shaft and through a long tunnel with an outlet below the Falls. A powerhouse was constructed and was called the Edward Dean Adams Station. Power was first delivered from the station in 1895. The Station is no longer standing.

Prompted by the example of the Niagara Falls Power Company, in 1892 the Hydraulic Power Company enlarged its canal and constructed a second power plant; completed in 1901. In 1904, a new and larger plant was begun; it was finished in 1914. The old tenants of the company were gradually induced to surrender their old water power rights and accept supplies of electric power. The various U.S. power companies on the Niagara River came together in 1918 to form the Niagara Falls Power Company, in order to improve the use of water and increase efficiency to meet increasing demands for electricity. In 1956, the southern two-thirds of the Company's Schoellkopf Plant was destroyed by a rockfall.

The first diversion of water from the Niagara River, by Canada, for power production was in 1893, when a small generating plant was built which diverted water from just above the Falls and discharged it through an outlet in the cliff at the flank of the Horseshoe Falls. The operating head was 62 feet. At the beginning of the 20th century, three large hydroelectric powerhouses were begun, the Ontario Power Company (1901), the Canadian Niagara Power Company (1902) and the Electrical Development Company (1903), today known as the Toronto Power Plant. This plant was retired in about 1975. The Canadian Niagara Power Company is now owned by Niagara Mohawk Power Corporation of Buffalo, New York. In 1900, diversions from the Niagara River, above the Falls, for power purposes, totaled about 6,000 cfs; by 1922, the total amount diverted, by both the U.S. and Canadian plants, was approximately 50,000 cfs.

The first of the high-head plants, the Canadian Queenston Plant (later renamed the Sir Adam Beck No. 1) was completed in 1926, and a further 14,000 cfs bypassed the Falls. During the Second World War, an increase of this diversion, by Canada, was permitted. In 1954, units of the Sir Adam Beck No. 2 Plant came into service. This plant reached full capacity in 1958, bringing the maximum diversion through the Beck development to 66,000 cfs. Both plants divert water from the Chippawa-Grass Island Pool and return it to the Niagara River about a mile upstream of the village of Queenston, Ontario.

The Robert Moses Niagara Plant, on the United States side of the river, came into service in January 1961 and reached full capacity in 1962. It has a design capacity of 83,000

cfs, but on occasion has diverted up to 105,000 cfs. This plant also diverts water from the Chippawa-Grass Island Pool, and returns it to the river about two miles upstream of Lewiston, New York. Figure 2-13 depicts the present configuration of the U.S. and Canadian hydropower facilities on the Niagara River.

In about 1900, in order to facilitate the flow of water into their intake canals and to reduce trouble caused by ice, the Niagara Falls Power Company (U.S.) cut a channel across a shoal area above their intake. This lowered the elevation of the Chippawa Pool. In constructing their intake works in 1903-05, the Ontario Power Co. closed off a portion of the First Cascade with coffer dams. This raised the level of the water above, but the change was temporary. Removal of the dams, in 1905, permitted the water to fall to its original level. In 1918, coincident with the construction of a new intake tunnel, the Niagara Falls Power Company deepened the cut across the shoal and, as previously mentioned, dumped some 200,000 yards of rock into the Chippawa-Grass Island Pool. At about the same time, construction of the Queenston canal began. Much of the dredge material from this construction, mostly earth, was also dumped into the Pool. These dumpings somewhat compensated for the effects of the increased diversions by power, but this material was gradually eroded away.

In 1929, a Special International Niagara Board recommended construction of a submerged weir at the lower end of the Chippawa-Grass Island Pool, to facilitate the diversion of water for power generation, without lowering the level of Lake Erie. Before 1941, the total allowable diversion of water from the Niagara River for power purposes was 56,000 cfs. During 1941, this limit was increased to 82,500 cfs. This increase in diversion highlighted the need for such a weir. Construction of this weir took place between 1942 and 1947. The weir raised the level of the Chippawa-Grass Island Pool, which had been lowered by the power diversions, and improved the flow over the American Falls and in the vicinity of the Three Sisters Islands. However, the weir caused a small decrease in the flow over the Horseshoe Falls, thus making the conditions at the flanks of the Horseshoe somewhat less satisfactory.

In 1953, work began on remedial works to replace the submerged weir. The Chippawa-Grass Island Pool Control Structure was completed in 1957, with additions made in 1961-1963. The structure, consisting of 18 movable gates, extends 2,200 feet out from the Canadian shore about a half mile upstream of the Horseshoe Falls. This structure serves to maintain pre-project levels in the Chippawa-Grass Island Pool, so as to provide proper flow over the Falls, while allowing for diversions for power purposes.

2.5 St. Lawrence River, International Section.

The St. Lawrence River, the outlet from Lake Ontario, flows 530 miles in a northeasterly direction to the Gulf of St. Lawrence, with a fall of about 245 feet. The major portion of this fall, some 227 feet, occurs between Lake Ontario and Montreal Harbor, 183 miles from the lake.

The International Section of the river (see Figure 2-15) extends for a distance of 115 miles from Lake Ontario to St. Regis, New York, where it passes entirely into Canadian territory (see Figure 2-16). After leaving Lake Ontario, for 63 miles the river is wide and deep, with little current. In the first 50 of these miles, the channel is filled with what is known as the "Thousand Islands." The fall from Tibbetts Point at Lake Ontario to Ogdensburg, New York, is only about 1 foot. Beginning about a mile upstream of Brockville, Ontario, and continuing to downstream of Ogdensburg, New York, a distance of about 13 miles, the channel is nearly straight, approximately one mile in width and some sixty feet in depth. About 6 miles below Ogdensburg is Galop Island. Most of the improvements and changes made in the river were made at and below this point.

The 55 mile stretch of river, from the head of Galop Island to the international boundary in Lake St. Francis, used to be a swift-flowing section with a drop of over 90 feet. The Galop Rapids, which flowed around Galop Island, were removed when the channels were widened and deepened, in the 1950s, for the St. Lawrence Seaway and Power Project. A dam below Galop Island, near Iroquois, Ontario, now controls the levels in this reach. The Iroquois Lock is used by ships to navigate past this dam.

The reach below Iroquois, which once consisted of many narrow channels filled with rapids, is now a reservoir impounded by the Long Sault Dam and the Moses-Saunders Powerhouses. This man-made lake, known as Lake St. Lawrence, covers some 100 square miles of land area. The difference in elevation between this reach and the next is overcome by the U.S. Eisenhower and Snell Locks at Massena, New York.

Downstream of the Powerhouses, the river divides into two channels around Cornwall Island and then widens to form Lake St. Francis. With the exception of a small area at the upstream end of the lake, about 3 miles of United States shoreline, Lake St. Francis and the downstream St. Lawrence River lie entirely within Canada.

The natural regime of the outlet from Lake Ontario has undergone changes, at least since 1825. By 1850, work in the St. Lawrence River provided a minimum channel depth of 9 feet from the Atlantic Ocean to Lake Ontario. The natural control of Lake Ontario outflows was at the Galop Rapids, located, as previously discussed, on either side of Galop Island, approximately 70 miles downstream from Kingston, Ontario. Man-made changes to the natural control began in 1876, with dredging in the Canadian Galop Rapids channel (completed in 1888). Changes continued with the realignment of the Galop channel (from 1897 to 1901), improvements to the North Channel and construction of the Gut Dam (from 1903 to 1908). Gut Dam was removed in January 1953. Dredging was begun in 1890 to remove a series of 12 shoals between Three Sisters Islands and Brockville, Ontario. This work was completed in 1901.

Between 1884 and 1905, a canal building program, undertaken by the Government of Canada, enabled ships with a 14-foot draft to navigate from the Atlantic to Lake Superior. In 1918, a submerged weir was built in the St. Lawrence River near Massena,

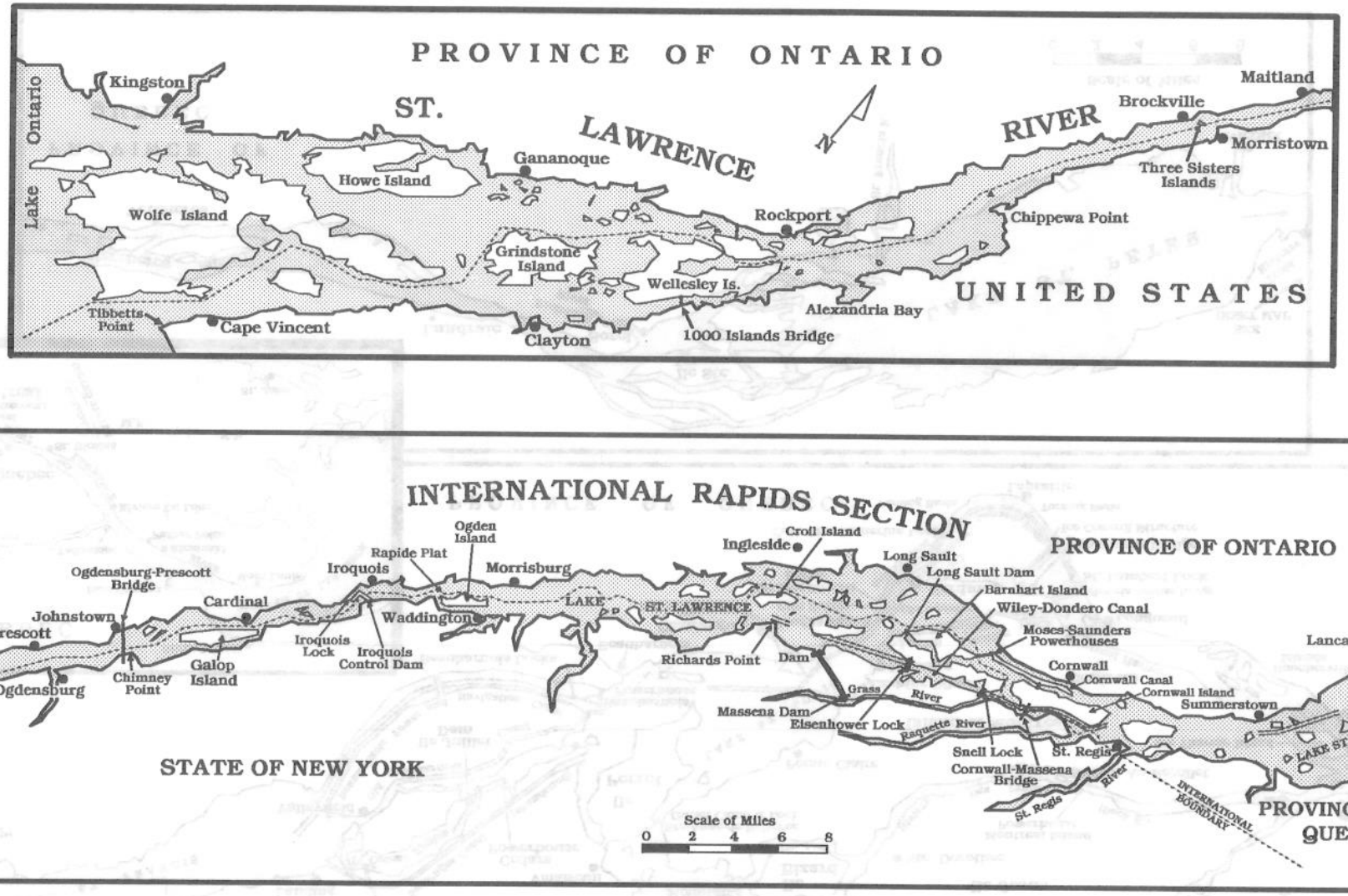


Figure 2-15

International Section of the St. Lawrence River

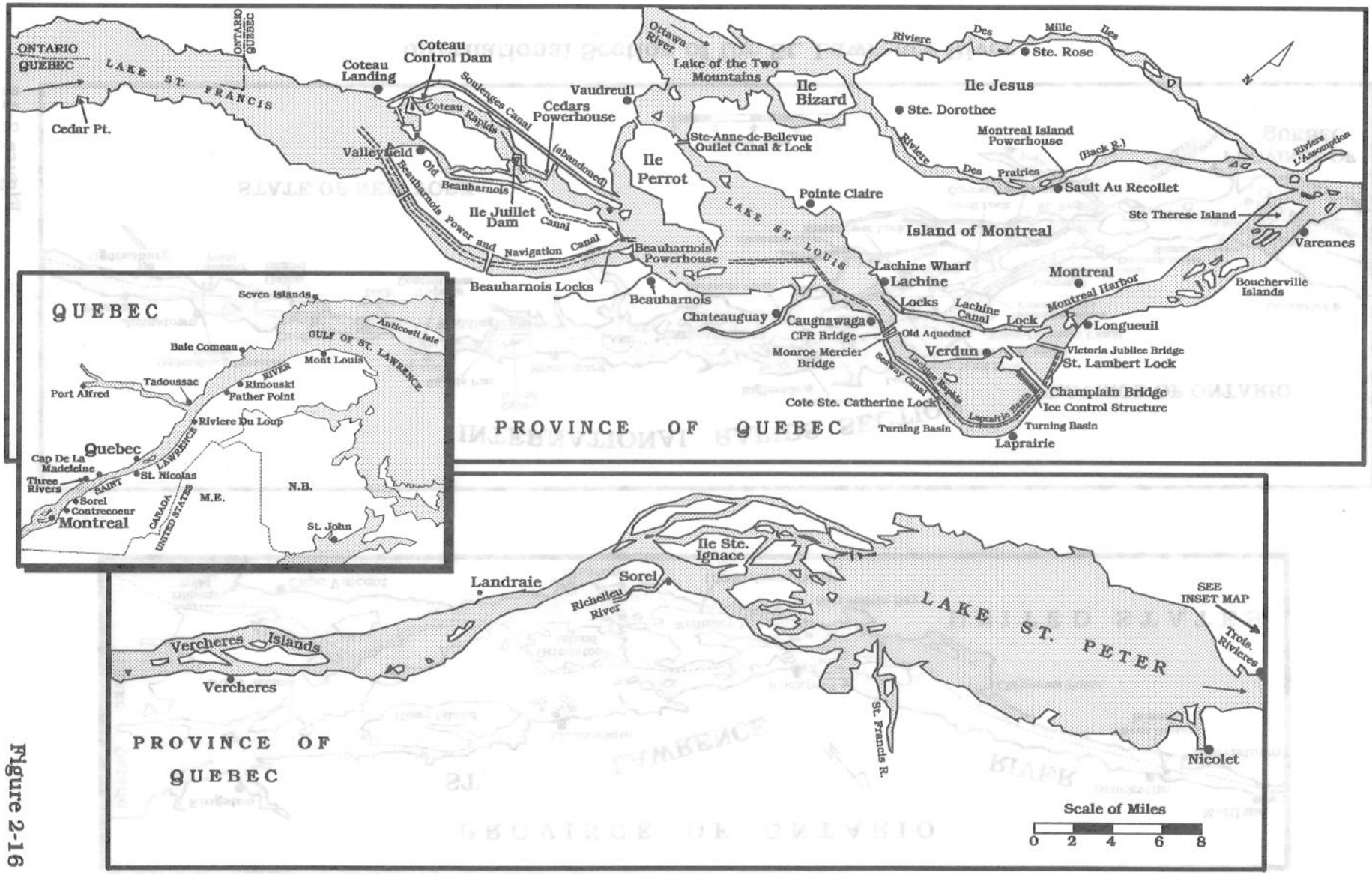


Figure 2-16

St. Lawrence River in Quebec

New York, to facilitate the diversion of water for the generation of power. In 1934, the Cornwall Canal was started to allow navigation around the Long Sault Rapids.

Prior to construction for the St. Lawrence Seaway and Power Project, the character of the St. Lawrence River was significantly different than it is today. The Galop Rapids flowed on either side of Galop Island; the water broke over a rock ledge and fell about 14 feet in 8 miles; the channel south of Galop Island, known as the American Galops, or Red Mills Rapids, entered a relatively quiet pool from which water rejoined the main river through several passages among a group of Islands.

Paralleling the Galop Rapids on the Canadian side was the Galop Canal, with two locks, Lock 27 at the upper end and Lock 25 at the lower end. The canal, at one time, followed the river closely and its lower portion formed the waterfront and harbor at Cardinal, Ontario. A new deep cut canal was constructed to pass behind the village of Cardinal.

Downstream of Lock 25, for a distance of 4 miles, the river, although swift, was navigable. It then entered the Rapide Plat, with a fall of 12 feet in 4 miles. Originally, the river in this location flowed in two channels, one on either side of Ogden Island. At an early date a dam for power purposes was constructed across the American channel at Waddington. Above the dam, this channel was known as the Little River. There was no perceptible current, although a small amount of leakage was observed through the dam.

The Rapide Plat Canal carried navigation past these rapids. There were two locks in this canal, Guard Lock 24 at its head and Lock 23 at its foot at Morrisburg, Ontario. About ten miles below Lock 23, in the Canadian channel, at the head of Croil Island, were the Farran Point Rapids and the Farran Point Canal, with a single lock (No. 22) having a lift of about 4 feet. The canal was about 1-1/4 miles long. The American channel, to the foot of Croil Island, was wide and deep.

Between the foot of Croil Island and the head of Long Sault Island was a channel called the Sny. South of Long Sault Island was the South Sault Rapids, while north of the Island the channel was relatively deep and wide for nearly 2 miles to the head of the Long Sault Rapids. The St. Lawrence River Power Company (U.S.) constructed a dam across the South Sault Rapids and diverted water by a canal through its power plant to the Grass River.

The river, as it entered the Long Sault Rapids, was broken into several channels by islands; the hydraulic conditions were rather complex. Navigation past these rapids was by way of the Cornwall Canal, 11 miles in length and with a total lift of 48 feet using 6 locks. Lock 21 was at the head of the canal and Lock 15 at its foot at Cornwall, Ontario. Below Cornwall the river entered Lake St. Francis and no further critical sections occurred until after it ceased to be an international boundary water, at St. Regis, New York.

In 1952, the Governments of Canada and the United States applied to the International Joint Commission for approval to construct certain works for the development of power in the International Rapids Section of the St. Lawrence River. The construction, maintenance and operation of the proposed works were approved subject to a number of conditions established by the Commission in it's Orders of Approval of 1952, which was amended in 1956. The resulting project is known as the St. Lawrence Seaway and Power Project.

Construction of the Seaway began in 1954 and was completed: after five years and the dredging of over 360 million tons of rock; after the resettlement of thousands of people and entire towns; after changing river channels and the homes and habits of thousands of its inhabitants; after the construction of seven new locks (three in the international section) and after the construction of the world's largest joint power facility.

The Moses-Saunders Dam and Powerhouses, the Long Sault Dam, which is a spillway capable of passing the total flow of the St. Lawrence River, and the Iroquois Dam were completed in August 1958. The extensive channel enlargements, to widen and deepen the navigation channel to 25 feet for the entire length of the river, were completed and the Seaway was opened for navigation in 1959. The channel enlargements significantly increased the outflow capacity of Lake Ontario; control dams were designed to cope with the worst known (as of 1955) floods and droughts, as well as to compensate for the increased flow capacity.

Since 1960, the outflow from Lake Ontario has been completely controlled as directed in the International Joint Commission's Orders of Approval. The Commission established the International St. Lawrence River Board of Control to ensure compliance with the provisions of the Orders. Since October 1963, Plan 1958-D has been the operational regulation plan controlling Lake Ontario outflows.