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DREDGING, HYDRAULIC AND WATER QUALITY ASPECTS OF THE ST. MARYS RIVER NEAR SAULT STE. MARIE

- A Review of Existing Documentation -

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Ontario Region
Région de l'Ontario

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WATER PLANNING AND MANAGEMENT BRANCH
INLAND WATERS DIRECTORATE
ONTARIO REGION

December 1982

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1. INTRODUCTION

1.1 Background

Dredging for purposes of navigation in the St. Marys River was initiated in the 1850's and has been conducted periodically up to the present. The most recent extensive dredging program which was begun in 1957, was 98% complete by 1972. Maintenance dredging continues to the present time on an on-going basis.

Concern has recently been expressed by Parks Canada at Sault Ste. Marie and the Sault Ste Marie Region Conservation Authority about the impacts that have resulted from the dredging of the river. The areas of concern include Lake George and the Lake George Channel (North Channel) of the St. Marys River (Figure 1.: Location Map). Specific concerns pertain to shoreline changes and water quality degradation in the Lake George Channel, caused by changes in flow distribution around Sugar Island. The change is considered to be the result of repeated dredging in the channel west of Sugar Island, thereby reducing the flow entering the Lake George Channel.

The United States, under international agreement consisting of exchanges of notes with Canada, has taken the initiative on dredging in the St. Marys River. In addition, flow distribution around Sugar Island has not been of serious concern in early years. As a result, Canada has limited information on the history of the dredging and its impacts. This lack of technical information base formidably weakens Canada's ability to argue or take appropriate mitigative procedures in response to future requests from the United States for further dredging. Further dredging is likely because of the increasing size of bulk carriers using this connecting waterway. Problems of manoeuverability in channel turns have already been experienced.

As a result of discussions between the above-mentioned concerned agencies, and the Canadian member of the International Lake Superior

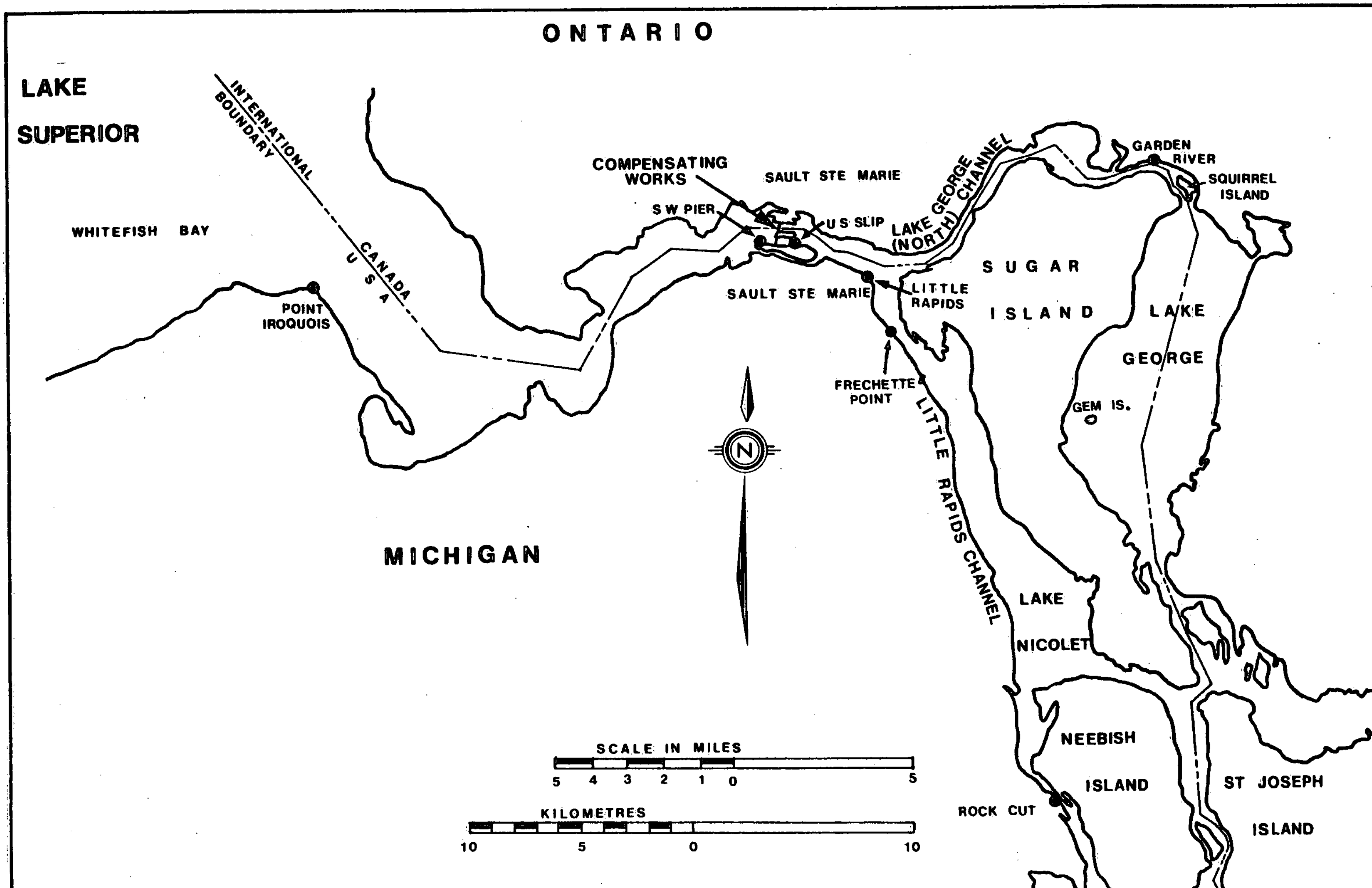

Figure 1. Map of the Upper St. Marys River

Board of Control, it was advocated that a study be undertaken (by appropriately mandated federal and provincial agencies) to determine the impact of past modifications to the St. Marys River on flows and the implications of future development for the river environment. A data collection program was also recommended to establish a data base on flow distributions around the major islands in the lower St. Marys River to monitor any further changes in the river, and to provide the much needed information for any future studies. Prior to the implementation of such a data collection program, however, the need for a review of related historical data and documents was identified and the task was referred to the Water Planning and Management Branch, Inland Waters Directorate, Ontario Region.

1.2 Purpose and Scope

This report addresses the issue of changes in flow distribution around Sugar Island, water quality and sedimentation patterns in the Lake George Channel of the St. Marys River, as they may be related to dredging and dredge-spoil disposal activities.

Most of the structural and physical modifications in the St. Marys River were made at a time when environmental considerations received little attention. As a result, hydraulic and environmental baseline data which otherwise might have been collected are generally not available. This lack of historical data from pre-dredging times unfortunately, effectively precludes any quantitative and factual comparison with present conditions and limits the current understanding of the effects that dredging may have had on the river system.

This review provides a summary of dredging activities, flow characteristics, sedimentation patterns and water quality observations during the post-dredging period. It also suggests what could be done in relation to future dredging projects, and outlines a program of data collection for future studies. It should be noted that the United States tentative long-term plans for navigation in the St. Marys River include extensive dredging (U.S. Army Corps of Engineers, July 1982).

This review has been undertaken to address the environmental and engineering concerns expressed by local interests. Socio-economic effects of changes in the river system were not dealt with at this time since such evaluation was considered premature and of limited value pending the identification and evaluation of the full range of environmental issues.

2. ST. MARYS RIVER: HISTORICAL AND PRESENT CONDITIONS

2.1 General River Characteristics and Flows

The St. Marys River forms the outlet of Lake Superior. From Whitefish Bay in the southeast corner of Lake Superior, the river flows in a general southeasterly direction over a distance, depending on route traversed, of 98 km (61 mi), 101 km (63 mi), or 121 km (75 mi) to Lake Huron and falls about 7 m (23 ft) in elevation. In the upper 22 km (14 mi) the river falls about 0.06 m (0.2 ft); then at the St. Marys Rapids (having a reach of 1.2 km or 0.75 mi), it falls approximately 6.1 m (20 ft). The rest of the fall (0.6 m or 2 ft) takes place gradually over the very mild slope of the remaining length of the river to Lake Huron. The rock ledge at the head of the rapids at Sault Ste. Marie is the natural control of the St. Marys River's outflows separating the upper and lower river. Water levels at the foot of the rapids, in the vicinity of Sault Ste. Marie, are affected by the levels of Lake Huron.

The natural regime of the St. Marys River was first disturbed by man in 1797 when the Northwest Fur Company built a 11.6 m (38 ft)- long lock on the Canadian side of the St. Marys Rapids. This lock was destroyed by U.S. troops in 1814 during the War of 1812. Nothing was again constructed in the river until 1822 when the U.S. Army built a raceway and sawmill at Sault Ste. Marie, Michigan. Since then the regime of the St. Marys River has undergone continuous change, particularly in the region of the St. Marys Rapids.

Presently, the flow of the St. Marys River is used by a number of facilities: the Great Lakes Power Company's power plant, the Canadian ship canal, the U.S. Government power-house, two U.S. ship canals, and the power-house of the Edison Sault Electric Company. Part of the river flow also discharges through the Lake Superior Compensating Works, which was constructed to offset the effects of various man-made diversions. Outflows of Lake Superior are completely regulated by these structures, under plans of regulation established by the International Lake Superior Board of Control.

The current regulation plan, Plan 1977, was developed to comply with the regulation objectives and criteria contained in the IJC's Order of Approval for Regulation of Lake Superior, dated May 26-27, 1914, as well as the new objectives contained in the Commission's 1973 Interim Report. The main objective of Plan 1977 is to provide more desirable lake level conditions on Lake Superior, as well as Lakes Michigan and Huron. During the period from 1900-1980, the outflow of Lake Superior has averaged 2120 m^3s (75,000 cfs) and has ranged from a maximum monthly discharge of 3600 m^3s (127,000 cfs) to a minimum of 1160 m^3s (41,000 cfs).

Approximately 4 km (2.5 mi) downstream of the rapids, the river flow divides into two channels which pass around Sugar Island (Figure 1). These channels are commonly known as Lake Nicolet (west channel) and Lake George (also known as Old North Channel or east channel). Downstream of Sugar Island, the flow separates further into: the West Neebish Channel (between Neebish Island and U.S. mainland), the

Munuscong Channel (between Neebish and St. Joseph Islands), and the St. Joseph Channel (between St. Joseph Island and the Canadian mainland). Commercial navigation in the river is limited to Lake Nicolet, the West Neebish Channel (down-bound) and the Munuscong Channel (up-bound), all of which have been dredged to a project depth of 8.2 m (27 ft).

The distribution of flow around Sugar Island does not seem to follow any well established relationship. Discharge measurements to determine flow distributions were carried out over a period from 1965 to 1979. During the open water seasons, it was found that the percentage of total river flow occurring in the west channel ranged from 70 to 77 percent, while during the winter season when river flows were low, the values ranged from 64 to 70 percent. Since the characteristics of ice covers vary from season to season, flows during the winter months can be expected to be highly variable.

Over the past 100 years, man-made alterations have been made intermittently to the various channels of the St. Marys River for navigation and power purposes. Most of these alterations took place in the St. Marys Rapids area. At the present time, the river is capable of passing ships with lengths up to 305 m (1,000 ft) and a draft up to 7.8 m (25 1/2 ft) at Low Water Datum between Lake Superior and Lakes Michigan-Huron. In the upper river, a navigation channel with a minimum depth of 8.5 m (28 ft) and a minimum width of 336 m (1,200 ft) is maintained. In the lower river, a navigation channel with a minimum depth of 8.2 (27 ft) is maintained. Several dredging projects, for the purpose of widening some of the bends in the existing navigation channels of the lower river were carried out in recent years. These projects have no effects on the outflows of Lake Superior since the outflows are being regulated. However, they have affected the flow characteristics in the lower river. The Lake George route has not been dredged this century and consequently has adequate depth for small recreational craft only. The assessment of the adequacy of water depths in the Lake George Channel remains a subject of considerable local concern.

2.2 Summary of Riverine Construction and Dredging Activities

The first ship canal built to by-pass the St. Marys rapids was completed in 1855. Owned by the State of Michigan, the State Lock system included two 107 m (350 ft) locks in tandem. 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, and in the same year the State Lock came under Federal control. During 1895, the present 274 m (900 ft)- long Canadian Lock was completed on the north side of the St. Marys Rapids. A year later, the U.S. finished work on the 215 m (704 ft)- long Poe Lock which was built on the site of the old State Lock. As commerce increased the Davis and Sabin Locks were completed in 1914 and 1919, respectively. World War II brought on increased shipping demands and the use of larger ships, which in turn led to the construction of the MacArthur Lock in 1943 (replaced the shallow and aging Weitzel Lock). The latest construction to take place on the locks was the building of a new lock to replace the old Poe Lock. This new Poe Lock was finished in the fall of 1968.

The Canadian Pacific Railway steel truss bridge, known as the International Railway Bridge, was built across the river at the head of the rapids and completed in 1887. This structure causes restriction of the river flow and could be considered the first major man-made impact on flows of the river.

The first power canal (U.S. Power Canal) was completed on the U.S. side of the rapids in 1893. The Great Lakes Power Canal in Canada was built around the same time by the same company and commenced diverting water in 1895. A second U.S. canal, now known as the Edison Sault Power Canal, was built through the City of Sault Ste. Marie, Michigan, and finally completed in 1902. These were built prior to the Boundary Waters Treaty of 1909 which established the International Joint Commission (IJC). The United States hydroelectric plant was completed later in the

1950's. Redevelopment of the Great Lakes Power Company's hydro-power facilities commenced in the late 1970's and was virtually complete by the end of 1982. Some dredging was carried out in the power canals upstream and downstream of the power houses to increase their capacities. While the Great Lakes Power Company applied and obtained approval from the IJC for its redevelopment, the U.S. hydroelectric plant was built without any application to the Commission, and in effect, without any IJC approval.

The power canals described above increased the discharge capability of the St. Marys River. Man-made restrictions such as the bridge piers, approaches, and navigation canals were insufficient to offset the effects of the power diversions. To compensate for these effects, the Lake Superior Power Company, as early as 1902, built four compensating gates on the north side of the river, about 45 m (150 ft) upstream and parallel to the International Railway Bridge. Later, in 1914, the Algoma Steel Corporation Limited of Ontario and the Michigan Northern Power Company of Michigan applied to and received approval from the International Joint Commission (IJC) to divert water for power purposes and to complete the compensating works across the head of the St. Marys Rapids. With the completion of these works by 1919 and the closure of the dyke at the south end of the structure in 1921, the discharge from Lake Superior could be controlled and came under the supervision of the IJC through its International Lake Superior Board of Control. All facilities of the Soo are used to discharge the required regulation plan outflows.

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 1850's. The first dredging was carried out in the Lake George Middle Channel to provide a 4.3 m (14 ft) deep channel with a minimum width of 45.7 m (150 ft). In the late 1800's and early 1900's dredging was in progress to improve and maintain the navigation channels of the St. Marys River to a minimum depth of 6.1 m (20 ft). Between 1902 and 1909 excavation was undertaken in two reaches of the river to cut wider channels. Little Rapids Cut, located west of Sugar Island, was completed in 1907. It had a minimum width of 183 m (600 ft) throughout the length of the Little Rapids Channel and was dredged to a depth of 6.4 m (21 ft). Rock Cut, completed in 1909 in the West Neebish Channel, was excavated to a width of 91.4 m (300 ft) for a distance of 4 km (2.5 mi) and had a depth of 6.7 m (22 ft). In 1932 dredging commenced to deepen certain reaches in the navigation channels to at least 7.6 m (25 ft). In 1933 alone, 5.2 million m^3 (6.8 million yd^3) of material was dredged from the St. Marys River, the largest volume dredged in a single year. By the early 1970's all of the major navigation channels of the St. Marys River were being maintained at a depth of 8.2 m (27 ft). Removal of shoals in the channels and canal approaches is a continuously on-going project.

Detailed records of dredging projects conducted prior to 1933 were not kept and, as a result, very little information is available on locations and quantities dredged. Site specific data for dredging completed after 1933 are not readily available; however, some data have been compiled on total quantities dredged under authorization of the U.S. Army Corps of Engineers. Table 1 and figure 2 provide a summary of this information for the St. Marys River.

The Dredging Subcommittee of the IJC Great Lakes Water Quality Board recently began to maintain a register of commercial dredging operations on the Great Lakes and their interconnecting channels. A fairly accurate record of dredging projects, including data on location, quantity dredged, dates, material type, equipment type, disposal method, cost and sediment quality parameters, is available from 1975 to the present. While this register is of limited use in this particular review, it will be useful in the assessment of long term plans for future modifications (physical or structural) to the St. Marys River.

TABLE 1

SUMMARY OF DREDGING ACTIVITIES IN THE ST. MARYS RIVER
QUANTITY DREDGED, MILLIONS OF M^3

YEAR	U.S.	CANADA	YEAR	U.S.	CANADA
1933*	5.2		1957	0.0	
1934	1.4		1958	1.6	
1935	0.5		1959	1.3	
1936	0.2		1960	3.8	
1937	0.2		1961	0.9	
1938	0.7		1962	3.0	0.04
1938	0.8		1963	1.3	0.02
1940	1.1		1964	0.1	0.02
1941	0.0		1965	0.7	
1942	0.1		1966	0.1	
1943	0.1		1967	1.3	
1944	0.04		1968	**	
1945	0.0		1969	**	
1946	0.0		1970	**	
1947	0.0		1971	**	
1948	0.0		1972	**	
1949	0.0		1973	**	
1950	0.04		1975	0.0	
1952	0.1		1976	0.2	Great Lakes
1953	0.04		1977	0.0	
1954	0.04		1978	0.0	Dredging Register
1955	0.04		1979	0.0	
1956	0.0				

* no record found prior to 1933
** no data

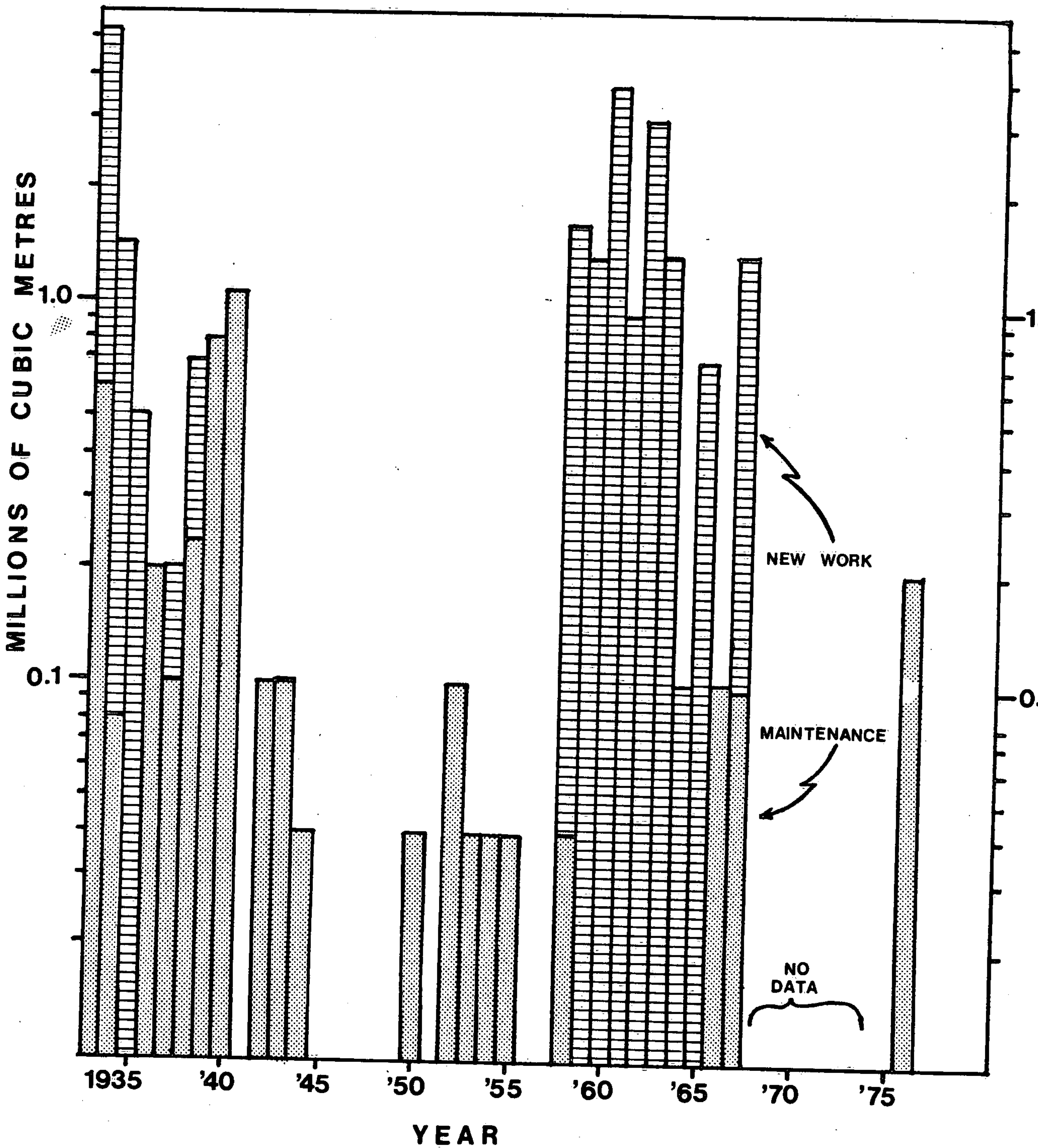

FIGURE 2. DREDGING IN THE ST. MARYS RIVER BY THE U.S. ARMY CORPS OF ENGINEERS.

The on-going maintenance dredging results in an annual average quantity of 29,800 m^3 (39,000 yd^3) of material dredged (U.S. Army Corps of Engineer, 1975). Navigation channels in the upper river (Gros Cap Shoals to and including Lake Munuscong) are dredged by derrick boat on an annual basis. The lower river between Lake Munuscong and Lake Huron is dredged approximately every third year. About every five years, navigation channels are dredged by hopper dredge to remove soft shoals which have developed. Generally, the volume and frequency of maintenance dredging depend on the extent and rate of shoaling.

Dredging operations normally begin in April/May at the Soo Locks; June/July in upper navigation channels; and proceed downstream, August to October, along east and west sides of Neebish Island. By November/ December, operations return to work on the Soo Locks approaches.

Most of the dredge spoil from St. Marys River dredging operations has been dumped in open water adjacent to the navigation channels. Disposal sites utilized during the 1960's dredging program are identified on National Oceanic and Atmospheric Administration navigation charts No's 14882, 14883, and 14884. Several dredge spoil islands have also been created, but due to the lack of protection many have been severely eroded by water and ice.

2.3 Water Quality Conditions

The water quality of the St. Marys River has been described by the Ontario Ministry of the Environment (MOE) as generally satisfactory. Impaired water quality, however, is found along the Canadian shoreline downstream from industrial and municipal sewage outfalls (Figure 3). Algoma Steel, for example, withdraws water from the St. Marys River at a rate of 0.58 million m^3/day (127.2 million imperial gallons/day) and discharges 0.55 million m^3 (121.7 million gal) of industrial sewage per day. This waste contains a variety of contaminants and includes phenols

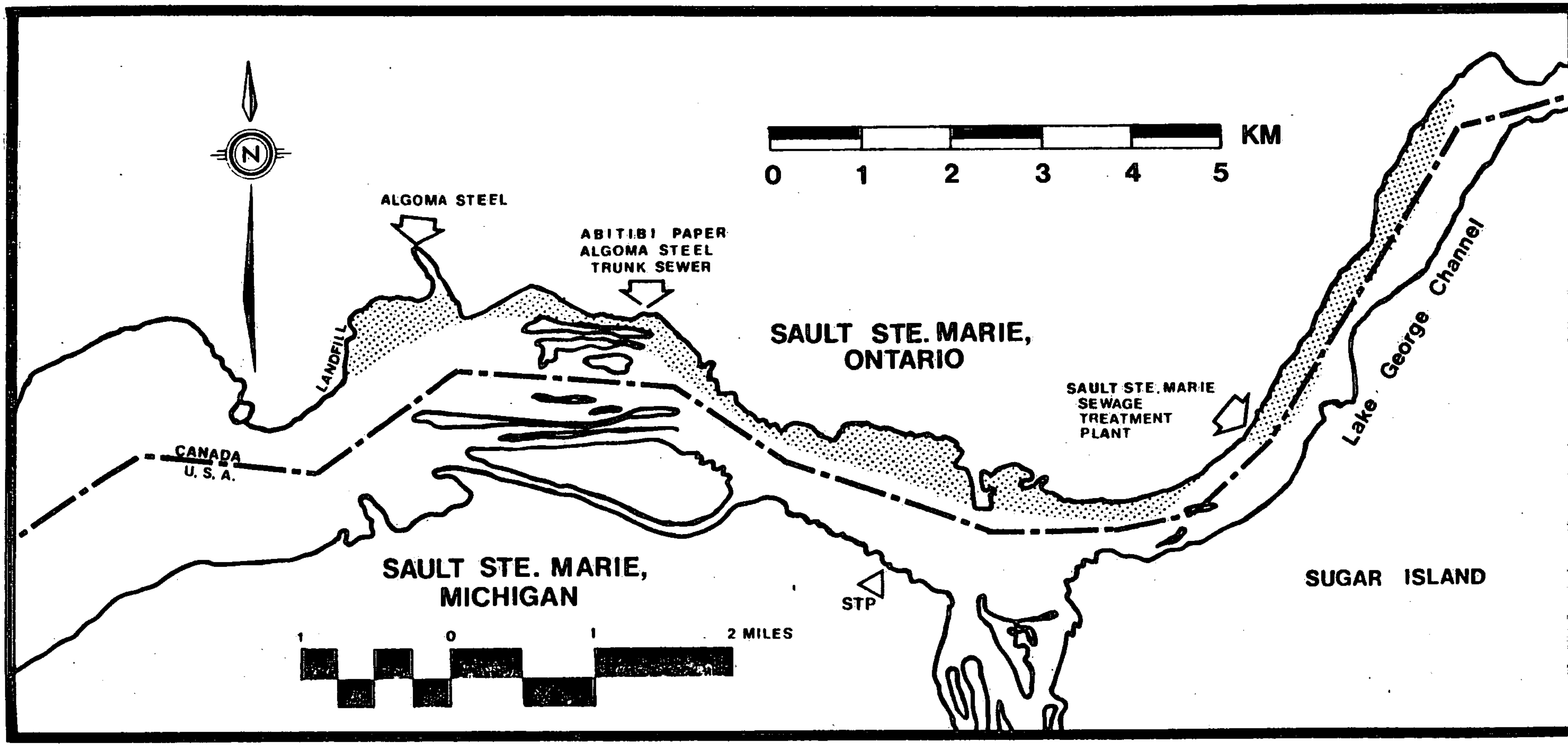

Figure 3. General water quality and sediment quality problem areas.

ammonia, cyanide, heavy metals, oil and suspended solids. Abitibi Paper also withdraws about 65000 m^3 (14.3 million gal) of water per day and discharges 69000 m^3 per day (15.2 million gal) of industrial sewage which contains dissolved and suspended solids and phenols. Municipal wastewaters are discharged at rates of 51800 m^3/day (11.4 million gal/day) and 14700 m^3/day (3.2 million gal/day) from sewage treatment plants at Sault Ste. Marie, Ontario, and Sault Ste. Marie, Michigan, respectively. Both cities have primary sewage treatment plants (STP's) with chlorination facilities. In addition to bacterial contamination, effluents from the Ontario plant are tainted with phenols (loading of 25 kg/day) from Domtar Chemical which discharges its wastewater into the sanitary sewer system. There are no major industrial waste discharges to the river from Sault Ste. Marie, Michigan.

Since the channels around Sugar Island are immediately downstream from major municipal and industrial outfalls, they are susceptible to water quality degradation. The distribution of pollutants is a function of discharge location, shoreline configuration and channel hydraulics. Water quality impairment within a narrow band of water adjacent to the Canadian shoreline is thus the result of heavier upstream pollutant loadings, much lower river flows along the Canadian side, and the lateral discharge of water from the Edison Soo power plant which further confines pollution to the Canadian shore. Partial recovery of water quality is achieved in the Lake George Channel. However, further pollutant loadings from the Sault Ste. Marie STP into the channel delay any more complete recovery of water quality to natural background levels.

The concentration of phenols in the river steadily decreases downstream from the Algoma outfall to an average value of 10 mg/l in the Lake George Channel. At the outlet of Lake George, phenol concentrations are comparable to background levels of 2 mg/l. This, nevertheless, is still above the maximum acceptable level of 1 mg/l (ie. MOE water quality objectives). Therefore, high concentrations of phenols are a problem in Canadian waters, including the Lake George Channel and Lake George.

Average ammonia concentrations decrease from 0.4 mg/l immediately downstream from the Algoma outfall to 0.2 mg/l at the Lake George Channel. Downstream of the sewage treatment plant which discharges 700 kg of ammonia/day into the channel, levels increase to 0.4 mg/l. High ammonia levels are also a problem in the area since the maximum acceptable level for protection of aquatic life is 0.02 mg/l.

Cyanide concentrations follow a similar pattern in that high concentrations (0.28 mg/l) just downstream of the Algoma outfall decrease to 0.06 mg/l at a point about 1 km downstream. Concentrations further decrease in the Lake George Channel to 0.03 mg/l, still in exceedance of the 0.005 mg/l objective level. Levels of iron at the Algoma outfall are near the objective level of 0.3 mg/l but decrease to about 0.1 mg/l in the Lake George Channel.

Phosphorus levels in the St. Marys River are generally comparable with background concentrations of 0.011 mg/l. Elevated (0.04 mg/l) levels are found in the Lake George Channel downstream of the city sewage treatment plant, however. The Ontario MOE characterizes Lake George as being eutrophic, although this status is not solely a function of the effluent discharged with the river. Lake George is naturally shallow and the settling of suspended sediments is augmented by low current velocities.

With the exception of periodically high concentration levels along the Canadian shoreline, bacterial contamination is not usually regarded as a problem in the St. Marys River. Elevated levels of total coliform, fecal coliform, and fecal streptococci are common during summer and fall months, especially downstream from storm sewers and the Sault Ste. Marie STP. Storms sewers have been identified as a definite source of contamination in the waters adjacent to the urban areas of Sault Ste. Marie, Ontario and Michigan. In the Lake George Channel bacterial contamination in the form of pseudomonas aeruginosa has been found in densities of 15 organisms/100 ml, compared to typical background concentrations of 4 organisms/100 ml. Levels of 20-30 organisms/100 ml were found in waters adjacent to storm sewer discharges on the Canadian side. Measurements of bacteria in the Lake Nicolet Channel, on the other hand, were within water quality objectives.

In terms of other forms of visible water pollution encountered in the area, oil slicks present in waters adjacent to the Algoma docking slip have been a persistent problem. Mats of oily, fibrous material and wood chips can be observed on the water surface extending downstream from the locks into the Lake George Channel and through Lake George. Such mats have extended 90 to 180 m (300-600 ft) from the Canadian shore.

In summary, it can be said that water quality of the Sugar Island Channels is a function of the distribution of pollutants from upstream industries and sewage treatment plant discharges. With flow conditions such as they are in the St. Marys River, pollutants are primarily confined to the Canadian shoreline in the channel immediately downstream of the locks and in the Lake George Channel. Phenols, ammonia, cyanide, bacterial contamination, and oil slicks continue to degrade the water quality in this area.

The St. Marys River has been identified as an area of environmental and human health concern in every report of the IJC's Water Quality Board since 1974. While no significant improvements have been observed, increased efforts are being made to control water pollution. Several of the major polluting industries in Sault Ste. Marie, Ontario, are now under court orders to comply with effluent standards established by the Ministry of the Environment. For example, in June 1982, Ontario MOE served Algoma Steel with a Control Order to limit discharges of sulphides, cyanides, and ammonia, and to install filtration and treatment systems to reduce ether solubles, suspended solids, and phenols. On May 20, 1982, an agreement was signed among the federal, provincial, and municipal governments in Sault Ste. Marie, Ontario, which provides for the funding of a second municipal sewage secondary treatment plant to serve the western section of Sault Ste. Marie. The first phase of this STP is expected to be completed and operational by 1985 (Great Lakes Water Quality Board, 1982).

2.4 Sedimentation Characteristics

Some information has been accumulated regarding sedimentation sources and processes in the St. Marys River. Erosion and sedimentation processes are principally natural processes as well as phenomena. These processes are at times accelerated through physical changes brought about by man. Considered among sources of sediments are tributaries such as Big and Little Carp Rivers, where for the Little Carp River in particular, large sediment loads have been observed (severe bank erosion, due to sand and gravel mining operations). Still other sources include storm sewers, river sand and gravel extraction (e.g., A.B. Maclean for federal airport construction), Algoma Steel landfilling operations, and Great Lakes Power Company's recent power redevelopment. However, the relative significance of these sources to the sediment load of the St. Marys River is not known.

Erosion and accretion along points of the river are primarily determined by water flow, shoreline composition, orientation, and characteristics. Transport of sediments is either by suspension in water (referred as suspended load) or along the bottom (bed load) or both, depending on flow parameters such as velocity and sediment characteristics. When sediment transport capacity of the river exceeds the supply of sediment available for transport, river scour results. When sediment supplies exceed transport capacities or when water velocity is reduced below the point where it can transport sediment, sedimentation or settling takes place. Erodable materials along the shoreline also add to the sediment load of the river. The shore adjacent to the inlet of the Lake George Channel is believed to be subject to constant changes such as described above.

Deepening of the navigation channels has created artificially steep banks in many reaches of the river (U.S. ACE, 1975), thus accelerating scour and erosion. Sediment laden waters have been observed to occur in the high flow sections, down the middle of shipping channels. These sediments tend to be carried over great distances and dispersed over wide areas. Dredging and disposal operations release materials into the waterway and also contribute to the sediment loading.

Recreational boat and commercial ship movements also contribute to increased shore erosion as well as to sediment transport. Aerial photographs, for example, taken of the wake of an ore carrier revealed that even when the surface water appears clear, sediment-laden waters move with the current underneath the clear surface water (U.S. ACE, 1975). Much of the problem in some areas along the waterway is the result of high water levels inundating low-lying areas. Waves generated by passing vessels during high water levels cause more erosion than during normal or low water levels. In some cases, the disposal of dredged materials has created barrier reefs or islands that protect the neighbouring mainland shore from the wave wash of passing vessels; however, because these have not usually been adequately protected themselves, many have been severely eroded and no longer afford protection.

Sediments upstream of the industrial outfalls in the St. Marys River are composed of sands interspersed with gravel patches in faster flowing portions of the river. Sediments in the vicinity of the Algoma slip outfalls are characterized by silty clays, while a band of silty sands extends downstream along the Canadian shore for about 3 km (1.9 mi). In the U.S. portion of the river generally sands are found; an exception being the St. Marys Rapids where gravel predominates.

Sediment composition in the section of the river between the rapids and the entrance to Lake George appears to be strongly related to flow velocities and depth contours, both of which vary greatly in the area (Ontario MOE, 1978). The resultant patchy sediment pattern largely obscures any effects of effluents on sediment composition. In the Lake George Channel and downstream from the Sault Ste. Marie STP sediments are predominantly silt/silty sands as far as Little Lake George. Sands predominate again at the entrance to Lake George. Sediment composition in Lake Nicolet and Lake George is characterized by clays in the upper portions and clays/sand mixtures in the lower reaches.

As in the case of existing water quality patterns, contamination of sediments by heavy metals, organics and inorganics, and nutrients is most evident in areas confined to the Canadian shore. Concentrations of zinc and iron in Whitefish Bay (10 mg/kg and 0.5%, respectively) are typical background levels for sediments classified as non-polluted (Environmental Protection Agency interim guidelines for Great Lakes sediments). The highest levels of zinc are observed in the bay adjoining the Algoma landfill (1110 mg/kg), in the Algoma slip (680 mg/kg) and in the embayment near the entrance to Little Lake George (550 mg/kg). These sediments are considered to be heavily polluted with zinc, according to EPA guidelines (ie. levels greater than 200 mg/kg). The distribution of zinc in sediments downstream from the Algoma main trunk sewer suggests that zinc which is discharged at this location is bound to fine grain materials which remain in suspension in the fast moving portion of the river and deposit some distance away from the source in sheltered embayments. This is further evidenced by the fact that only moderate zinc contamination is found immediately downstream of the trunk sewer where there is a high flow velocity. Some transboundary movement of zinc is shown by the fairly high concentrations found at the inflow to Lake Nicolet and in the Lake George Channel.

Sediment contamination by iron and inorganics, such as cyanide, are similarly patterned, more or less, after the distribution of zinc in sediments. Almost the entire Canadian side of the river is highly contaminated by oil and grease (ether solubles) in sediments from just downstream of the Algoma complex as far as the entrance to Little Lake George. No evidence of comparable contamination is found in Lake Nicolet or downstream from the entrance to Little Lake George. Heavy accumulations of wood chips in sediments are also largely confined to the Canadian shore, although some transboundary movement is found.

In terms of sediment nutrient levels, these generally exceed EPA guidelines in slow moving portions of the river, especially in embayments where fine-grained materials are deposited. The distribution of phosphorus and nitrogen in sediments do not appear to be attributed to point sources entering the river. An exception is downstream of the Sault Ste. Marie STP discharge where elevated levels are found. Total phosphorus levels throughout the river are typically within MOE guidelines (1 mg/g). Nitrogen levels, however, exceeded these guidelines throughout most of the Lake George Channel (levels range from 1.7-7.2 mg/g), and drop to moderate levels (averaging 1.2 mg/g) in Lake George and Lake Nicolet.

3. EVALUATION OF AVAILABLE DATA AND DREDGING IMPACTS

3.1 Existing Data

As previously noted, there are very little data and information available which are specific to the impact of dredging on the St. Marys River. It was neither common practice nor a requirement in the past, to collect environmental data on pre- and post-dredging activities and major dredging efforts were essentially completed by the early 1970's; at a time when the importance of environmental considerations was not fully appreciated. For example, a water level gauge was installed in the Lake George Channel in 1973, only as a result of the International Great Lakes

Levels Board study which pointed out the requirement to study flow distributions around Sugar Island. With increasing emphasis on the environment, even maintenance dredging work conducted by the Army Corps of Engineers now requires an environmental impact statement. The current information base for the St. Marys River is thus expanded somewhat.

As noted in earlier sections of this report, the most recent dredging project of significance in the St. Marys River was completed in 1972. The limited amount of pre-1972 data which have been used to evaluate the effects of dredging on water levels and flows (and thereby also water quality and sedimentation) in the channels around Sugar Island do not go very far in providing any firm or conclusive understanding of what is happening in the St. Marys River, let alone attributing the cause of existing problems solely to dredging.

3.2 Analysis of Flow Data - Flow Distribution

During the period 1965-1979, current meter measurements were carried out by the United States Army Corps of Engineers in both the Little Rapids Channel and the Lake George Channel. These measurements provide information on the flow distribution around Sugar Island. A summary of the measurements is shown in Table 2.

Figure 4 shows a plot of the percentage of total St. Marys River flow in the Little Rapids Channel versus total river flow, based on the above-mentioned measurements. As shown in the figure, there is no well-defined relationship between the two. During the open-water seasons, the flow in the Little Rapids Channel represented 70-77 percent of the total St. Marys River flow. The river flows during these measurements ranged from 1980 to 3400 m^3/S (70,000 to 120,000 cfs).

Measurements were also carried out over several winters when ice cover existed. Lake Superior outflows during the winter months are usually cut back according to regulation plans. There are two reasons

TABLE 2

SUMMARY OF FLOW DISTRIBUTION MEASUREMENTS AROUND SUGAR ISLAND
1965-1979

Date	Flow in Little Rapids (cfs)	Flow in L. George Channel** (cfs)	Total St. Marys River Flow (cfs)
Sept. 14-18, 1965	87,800	30,600	118,400
Sept. 21-Oct. 6, 1965	80,000	28,900	108,900
Sept. 18-27, 1969	72,900	27,500	100,400
Oct. 16-21, 1969	52,100	19,700	71,800
Dec. 10-15, 1971	86,800	35,400	122,200
Feb. 2-8, 1972* ice	50,800*	22,400*	73,200*
Feb. 17-21, 1973 ice	43,900	19,600	63,500
Feb. 24-27, 1976 ice	45,400	25,000	70,400
Sept. 6, 1978	89,700	27,900	117,600
Feb. 27-Mar. 3, 1979 ice	51,600	25,700	77,300
June 13-16, 1979	78,100	33,300	111,400

* not measured, figures shown are estimates.
**at Garden River.

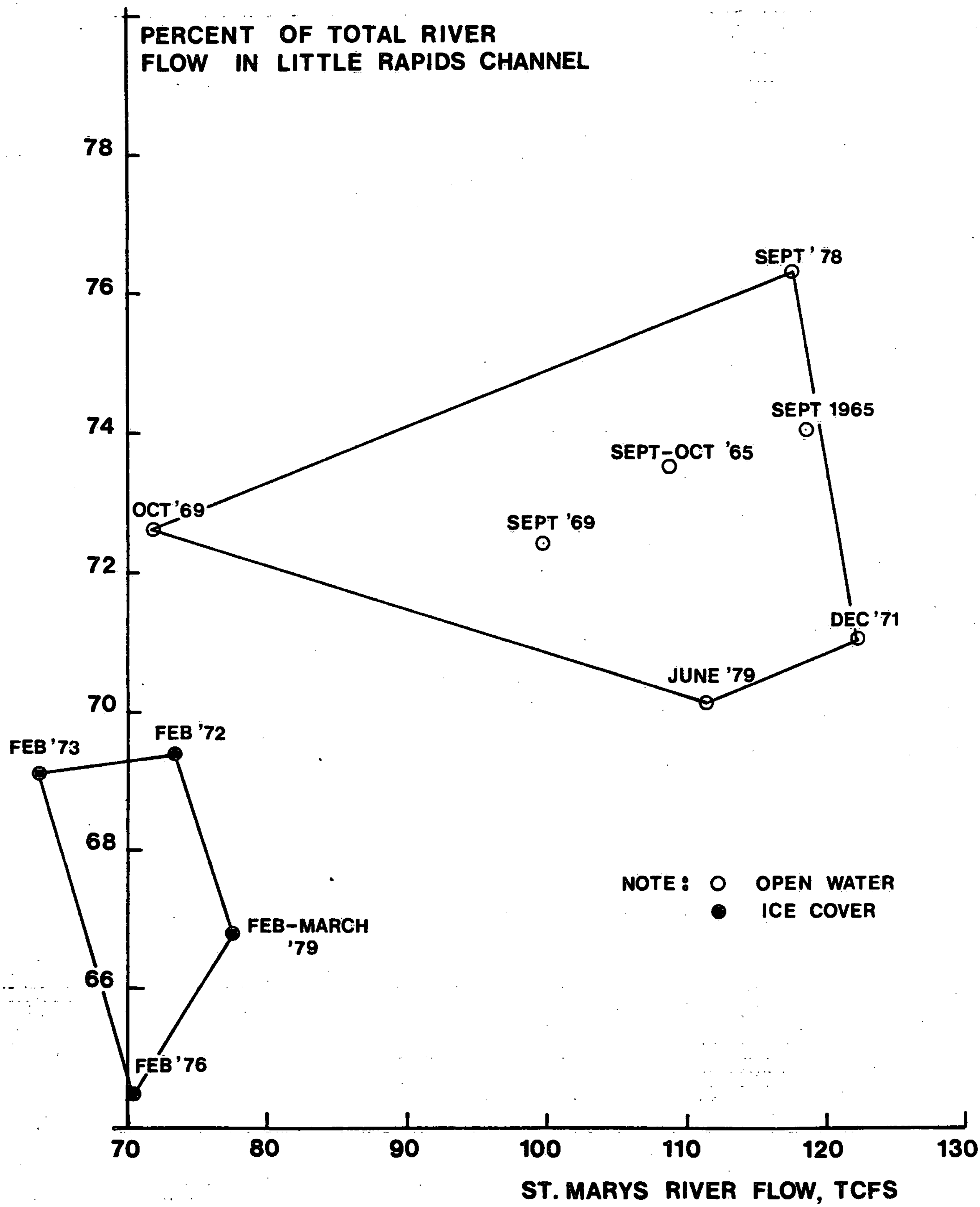

Figure 4. Percent of Total River Flow in Little Rapids Channel vs Total River Flow

for doing so. One is that water supplies to Lake Superior are low during the winter. The other reason is that high flows in the winter could cause unstable ice cover and thus ice jamming in the lower river.

Figure 4 shows that with the total river flow ranging from 1980 - 2180 m^3/S (70,000 - 77,000 cfs), the percentage of flow occurring in the Little Rapids Channel ranged from 64 to 70 percent. Again, there is no well defined relationship between the two.

Gauge records were also examined. The gauging station located near Garden River was installed in 1973. Table 2 shows that current meter measurements were carried out under open water conditions in 1978 and 1979. The two measurements show that flows in the Lake George Channel are directly proportional to the water level measured at the Garden River gauge. However, additional stage-discharge measurements would be required to define the existing stage-discharge relationship.

3.3 Comparison of Historical and Current Hydrographic Charts

A number of historical charts of the lower St. Marys River were examined to identify any progressive changes that have been taking place in the past. Particular emphasis was placed on identifying trends in sedimentation in the Lake George area. Changes examined included shoreline features, navigation channel depths and widths, and general channel profiles.

It should be reiterated that historical hydrographic changes are the result of many factors, such as the natural process of erosion and deposition, and man-made changes, especially dredging for navigation purpose. It is very difficult to make a distinct separation between man-made changes and those caused by natural factors. Also, old charts, as well as the current ones, often rely on data from surveys and soundings taken much earlier which may have been incorporated into

TABLE 3

LIST OF HISTORIC CHARTS EXAMINED IN THE STUDY

Chart	Year Published/Agency	Datum	Surveys Taken
No. 2	1898 Corps of Engineers	Mean tide, New York	1853-4, 1893-1896
No. 2	1924 Corps of Engineers	Mean sea tide, 1903	1853-6, 1894-1897
Sheets 2-10	1936 Corps of Engineers	U.S. Coast and Geodetic survey, 1935	1853, 1854, 1895, 1935, 1910
No. 62	1970 Corps of Engineers	IGLD (1955)	
14883	1980/NOAA	IGLD (1955)	

earlier versions of the charts. Therefore, it is not possible to identify the exact timing of hydrographic changes. The examination of the charts did reveal a number of changes that have occurred since earlier surveys. A list of the charts reviewed is shown in Table 3.

The first chart examined was that published in 1898. It was based on surveys carried out in 1853-54, and 1893-96. In the channel west of Sugar Island (Little Rapids Channel), a navigation channel extended from the Sault Ste. Marie harbour area to the northern part of Lake Nicolet. The channel had a minimum depth of 6.4 m (21 ft) and a width of about 122m (400 ft). There was no dredging in the central portion of Lake Nicolet since the natural depth in that area was adequate for the vessels in use at the time. Towards the southern portion of Lake Nicolet, a navigation channel with a minimum depth of 6.4 m (21 ft) ran between Sugar Island and Neebish Island. The channel width was about 122 m (400 ft).

Along the Lake George Channel (North Channel) which extends from the Soo Harbour to the head of Lake George, there was probably some dredging carried out in the shallow areas in the late nineteenth century but this dredging is not likely to have been very extensive. The northern half of Lake George is characterized by depths in the range of 7-17 m (22-55 ft) along the International Boundary. A navigation channel had been dredged in the southern half of Lake George. This channel extends southward from a point about 1.5 km (1 mi) east of Gem Island for a distance of about 4 km (2.5 mi) with a depth of about 6 m (20 ft).

The next chart examined was that published in 1924, which incorporated survey data collected between 1894-1897. Comparison with the earlier chart, shows that the navigation channel west of Sugar Island had been widened to about 183 m (600 ft). In addition, a downbound navigation channel, having a width of about 91 m (300 ft) and a depth of 6 m (20 ft) was dredged west of Neebish Island. The chart also shows dredged disposal areas immediately adjacent to the West Neebish Channel, and a partial dam which extended from the U.S. mainland and from the west shore of Neebish Island. The dam placement could have been intended to offset some of the effects of the dredging.

No additional dredging could be identified in the 1924 chart. As soundings in this chart were also based on the earlier surveys in 1894-97, no discernible differences were identified in the Lake George bottom contours.

Charts published in 1936 showed that the navigation channels west of Sugar Island had been dredged to a minimum of 8 m (26 ft). Both charts published in 1970 and 1980 show little or no change. The channel, however, now has a minimum depth of 8.2 m (27 ft).

In order to identify the effect of sedimentation on Lake George, a comparison was made of the lake's bottom profile extracted from the 1898 chart and the most up-to-date (1980) chart. The profile starts at a point just west of Squirrel Island, located at the north-eastern part of Sugar Island, and follows generally in a south-ward direction along the International Boundary. Examination of the two profiles revealed some sediment deposition on Lake George since 1898, particularly in the central portion of the lake. It is not possible to identify exactly the magnitude of the deposition.

Shoreline features of Lake George were also compared. No significant changes could be observed between the 1898 chart and the 1980 chart.

3.4 Analysis of Water Quality Data - Water Quality Trends

Much of the information summarized earlier in Section 2.3 was derived from an MOE study of water quality in the St. Marys River during 1973-74 (Hamdy et al. 1978). MOE water quality data for six stations over the period of 1976-1980 were also examined (figure 5). These included sampling locations (Canadian side) near the mouth of Big Carp River, just downstream of Algoma Steel, at the inlet to Lake George Channel and in the Lake George Channel near the inlet to Little Lake George. One station was also located in the U.S. side, opposite the Canadian stations near Algoma.

The water pollution patterns and problem water quality parameters which were identified previously (i.e., ammonia, phenols, cyanide, iron, zinc) were found to have changed relatively little from the 1973-74 survey. Above-objective levels of ammonia (ranging from 0.038 - .082 mg/l), phenols (1-7 μg/l), and iron (0.54 - 1.8 mg/l) were entering the St. Marys River from Big Carp River. Downstream of the Algoma outfall, levels for all these parameters and, in addition cyanide and zinc, continued to remain excessively high. On the Sault Ste. Marie, Michigan side levels of these pollutants were substantially lower, with the exception of phenols (at or slightly above the objective levels of 1 μg/l). As during the 1973-74 survey, concentrations of ammonia, phenols,

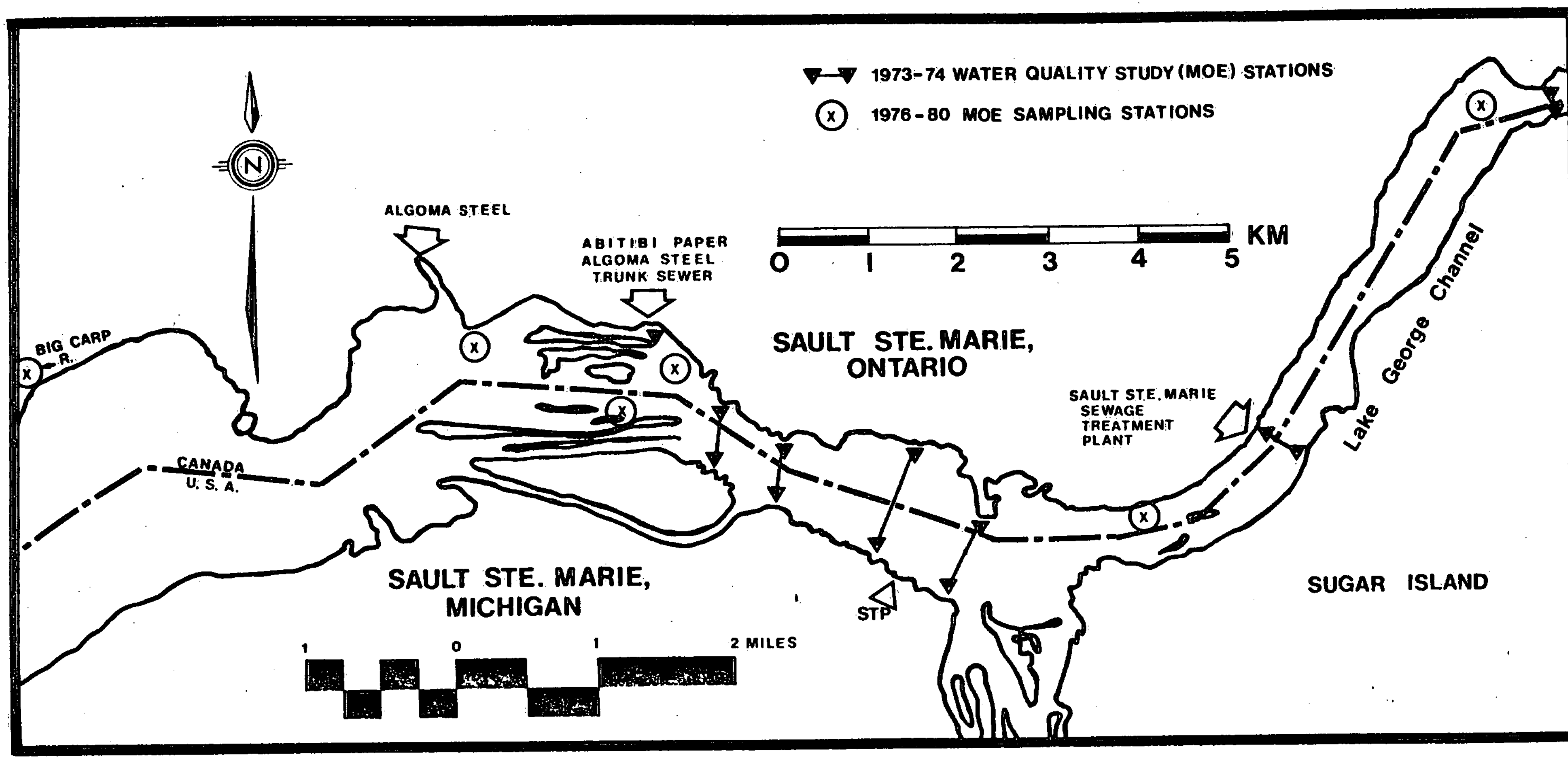

Figure 5. Locations of MOE sampling stations for water quality data reviewed.

iron, cyanide and zinc decreased somewhat at the entrance to the Lake George Channel and very little recovery was evident even as far as Little Lake George. Overall, the recent water quality data may show that there is a slight gradual decline in levels of these substances, although still significantly above acceptable water quality criteria. It would be difficult to substantiate, in view of the paucity of data regarding pre- and post-dredging flow distribution and comparable water quality data, whether or not dredging has played a major role in the degradation of water quality in the St. Marys River, and particularly, the Lake George Channel. Increased water flow to the Lake George Channel may provide additional dilution to further reduce pollution loadings present in the channel. However, it is not known how beneficial this would be considering that many of the prime problem substances are found in contaminated sediments throughout the Channel, which are susceptable to resuspension in the water column. It would seem that the major effort should be to reduce pollutant loadings from the already well-known industrial and municipal sources in Sault Ste. Marie, Ontario, if any water quality improvements in this portion of the St. Marys River are to be realized. The Province of Ontario has apparently taken some steps in this direction (particularly with Algoma Steel); however, the more recent water quality monitoring data tend to indicate only slight resultant effects.

The contribution of dredging activities to water quality degradation lies in its disturbance of potentially contaminated bottom sediments leading to their further resuspension and redistribution to downstream locations. Such disturbances are generally of short-term duration, whereas the water quality problems prevalent along the Canadian shoreline appear to be fairly long-term. A recent study of dredging in Lake Nicolet and the Middle Neebish Channel (Liston et al. 1980) has indicated that contaminants found in sediments of these areas can be attributed to industrial and municipal sources of the Upper St. Marys River (Sault Ste. Marie). It also determined that the fine-grained nature of sediments prevalent in the St. Marys River made them highly susceptable to resuspension and contributed to sustained periods of turbidity in the water.

For maintenance dredging proposals, the U.S. Army Corps of Engineers has already submitted environmental impact assessment documents which consider the quality of sediments to be disturbed according to U.S. EPA classifications of non-polluted, moderately polluted, and heavily polluted. This constitutes the basis for determining whether open-water disposal is acceptable. Past practices of open-water disposal in the St. Marys River have increasingly come under criticism due to the lack of erosion protection given to such sites. Unless erosion protection is provided, it would be unlikely that future dredging spoils will be permitted for disposal in open waters.

3.5 Further Data Collection/Study Requirements

This review of existing data and dredging documentation for the St. Marys River underscores the fact that the available information is insufficient for the purpose of ascertaining in any conclusive manner the effects of past dredging operations on flow distributions and attendant water quality and sedimentation conditions. A long-term data collection program would be required and to obtain a better understanding of the flow characteristics around Sugar Island. This information would be essential in order to properly evaluate future dredging activities and to identify remedial works that may be required to compensate for the possible effects of dredging.

In general, a data collection program should include the maintenance of the water level gauge located near Garden River (Canadian Department of Environment) and water level gauges at Frechette Point and Little Rapids (now operated by the U.S. Army Corps of Engineers). The program should also encompass current-metre measurements in the Lake

George and Little Rapids Channels to monitor flow distributions around Sugar Island. A detailed record of gate openings at the Compensating Works, as well as other water uses by facilities at the Soo, should be kept during current-metre measurements so that accurate stage-discharge relationship can be developed.

Water quality should continue to be monitored at existing stations with some additional sampling conducted, perhaps, to coincide with flow measurements. Sediment movement measurements may also be beneficial to better establish sedimentation rates and characteristics. Dredging activities and operations should be subject to comprehensive documentation.

4. SUMMARY AND CONCLUSIONS

Since the 1850's, dredging of the St. Marys River to provide for and maintain commercial navigation use has become almost an integral part of the river environment. The St. Marys River, moreover, has been subjected to many other man-induced changes such as flow regulation, water diversion, and industrial pollution which all become factors in establishing the existing conditions and characteristics of the river.

Particular concern has been expressed about the effects of dredging on water flows in channels around Sugar Island, specifically the Lake George Channel in regard to channel sedimentation, water quality and sediment quality. This review has encompassed available dredging records, hydraulic data, water quality and sediment information for purposes of ascertaining whether any effects of past dredging activities are evident.

Due to the lack of pre-dredging data on flows around Sugar Island and incomplete nature of past dredging records, no quantitative or factual conclusion is possible with respect to changes in flows in the

Lake George Channel and Little Rapids Channel. Flow measurements conducted during and following completion of the last major dredging work in the St. Marys River indicated that some 23-30% of the total river flow passed through the Lake George Channel, although no clear relationship was evidenced between the flows around Sugar Island.

Water quality degradation is most acute along the Canadian shore and in the Lake George Channel. While problems of poor water quality and sediment quality are enhanced to a degree by river flow conditions as they are, this is directly attributable to the high industrial and municipal pollutant loadings from Canadian sources. Data records are insufficient to establish any water quality effects which may have resulted from dredging in the St. Marys River.

Historical hydrographic charts were examined and compared with recent charts to identify changes in shoreline features and sedimentation in Lake George. No significant shoreline alterations were found to have occured since the earliest 1898 chart. Some sediment build up in Lake George was observed. Since erosion and sedimentaion are naturally occurring processes in the St. Marys River, it was not possible to distinguish changes in water depths due to sedimentation in the Lake George area that could be attributable solely to dredging.

It would appear from this review that the limited and incomplete data available at present is not sufficient to draw any firm conclusions about the possible effects of past dredging activities in the St. Marys River. Since further dredging operations are anticipated in the future, a program of data collection is warranted to allow a more knowledgeable evaluation of the effects of dredging and identification of possible remedial actions to compensate for any effects.

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