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REPORT ON THE ST. MARYS RIVER-LITTLE RAPIDS CUT
ICE BOOM AND ITS EFFECTS ON LEVELS AND FLOWS
IN THE SOO HARBOR AREA

AD-A213 745

WINTER OF 1979-80

BY

U.S. ARMY ENGINEER DISTRICT, DETROIT
DETROIT, MICHIGAN

AUGUST 1980

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**REPORT ON THE LITTLE RAPIDS CUT ICE BOOM
AND ITS EFFECTS ON LEVELS AND FLOWS
IN THE SOO HARBOR AREA**

Winter of 1979-80

INTRODUCTION

The St. Marys River has always been considered one of the key links in the Great Lakes-St. Lawrence Seaway transportation system. Both the United States and Canadian governments, as well as commercial concerns, have made considerable investments to insure safe and economic transportation of goods and materials through the St. Marys River, especially in the Sault Ste. Marie area. Besides its involvement in building four of the five navigation locks, which bridge the 20 plus feet of fall at the St. Marys Rapids, and in erecting powerhouses and a compensating works in the same area, the United States Government has constructed the Little Rapids Cut, which is a 600-foot-wide channel between Sugar Island and the mainland of Michigan. Prior to the winter of 1975-76, experience had shown that winter ship traffic produced some restriction of normal travel and commerce between Sugar Island and the mainland. These restrictions were caused by broken, floating ice entering Little Rapids Cut from the harbor at Sault Ste. Marie (Soo), Michigan and Ontario causing ice build-up in the Cut. Periodically, this would hinder normal ferry operations. To help alleviate this problem and to act as an aid to winter navigation, an ice boom with a 250-foot-wide navigation opening was installed for the winter of 1975-76 at the outlet of Soo Harbor to stabilize the ice cover in the harbor. This boom has been deployed each winter since. The location of the ice boom is shown in Figure 1.

Authority and Purpose

The Little Rapids Cut Ice Boom was first installed as part of the Great Lakes-St. Lawrence Seaway Navigation Season Extension Program. This program ended after the 1978-79 winter season, but because the boom has utility independent of winter navigation, a decision was made to reinstall the system for subsequent winters for an indefinite time. Authority was given to the Soo Area Office, Detroit District, Corps of Engineers to make the installation part of its regular winter operations.

The boom system has been of value in stabilizing the ice cover in Soo Harbor, reducing the extent of ice accumulation in Little Rapids Cut and reducing the amount of ice in the Sugar Island ferry crossing. These benefits occur whether there is winter navigation or not, as the harbor ice usually breaks up due to wind and weather several times a year.

By lessening the possibility of ice jams in the Cut, the boom has decreased the chances of flooding in Soo Harbor along with possible power

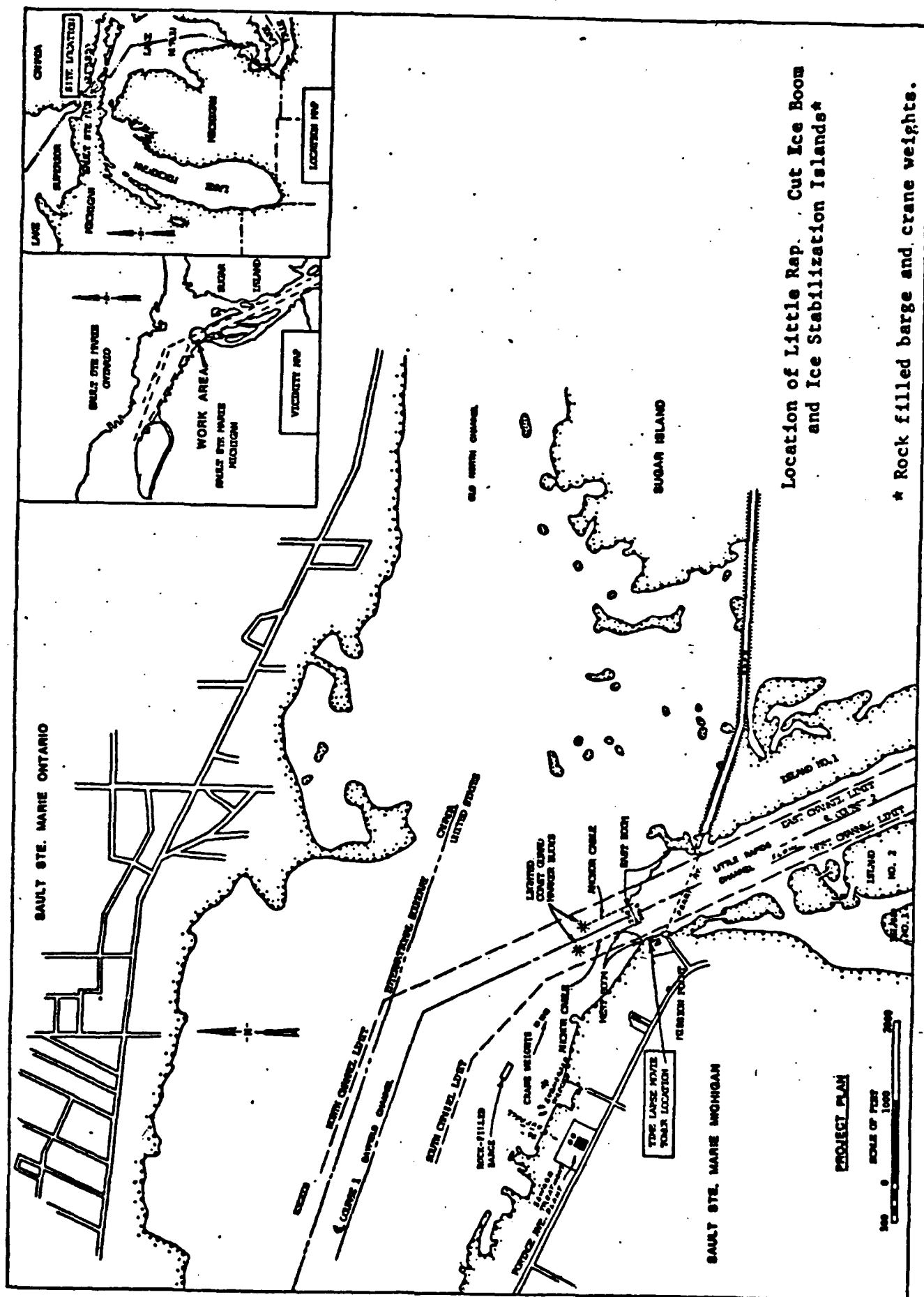


Figure 1

losses at the hydropower plants. By reducing the adverse effects of natural ice conditions on the Sugar Island ferry, it has contributed to more reliable transportation between Sugar Island and the mainland.

The effect of the Little Rapids Cut Ice Boom on water level and flow patterns in Soo Harbor and the local St. Marys River have been investigated and monitored by the Corps of Engineers each winter since its initial deployment in December 1975. In the past, these investigations were a part of the Great Lakes-St. Lawrence Seaway Navigation Season Extension Program. This season, monitoring continued as part of the operation and maintenance of the boom. As with previous investigations, some of the data analyzed in this report were acquired in the implementation of the Soo Harbor-Little Rapids Cut Monitoring and Emergency Operations Plan, a program instituted to prevent or reduce flooding in case of an ice jam in the Little Rapids Cut.

This report documents the field observation program and analyzes the collected data to evaluate the effectiveness and reliability of the ice boom in stabilizing Soo Harbor ice and water levels.

Winter Synopsis

The east and west arms of the floating timber ice boom at the head of the Little Rapids Cut were installed on 26 and 30 November 1979, respectively. The boom's configuration and location remained the same as in the previous years of deployment (Figure 1). Positioned just upstream of the Sugar Island ferry crossing, the boom is composed of a west arm, which extends 400 feet out from the mainland, and a longer east arm which extends out from Mouse Island about 1,000 feet into the river. Mouse Island is a small island just upstream of the Sugar Island ferry slip on the east shore of the Little Rapids Cut. The configuration of the boom provides a 250-foot opening in the center of the navigation channel for ship passage. As in each winter since the winter of 1976-77, a rock-filled barge and crane weights were positioned near the edge of the shipping channel upstream of the west arm of the boom. These measures have been effective in stabilizing the ice field from the U.S. shore out to the edge of the shipping channel.

The winter of 1979-80 was the warmest winter experienced in the Sault Ste. Marie area since the ice boom was first placed in December 1975. It was also the third warmest winter of the last ten years (Table 1). Above normal temperatures combined with below normal precipitation resulted in little snow accumulation. The maximum depth of snow on the ground was 17 inches, compared to a maximum snow depth of 32 inches during the previous winter. The total 1979-80 winter snowfall was only 90.5 inches, as compared to a total snowfall during the 1978-79 winter of 160.1 inches.

Table 1

Average Air Temperature
Sault Ste. Marie, Michigan
(°F)

	<u>December</u>	<u>January</u>	<u>February</u>	<u>March</u>	<u>Winter Average (Dec-Mar)</u>
1970-71	17.3	9.5	13.1	20.3	15.1
1971-72	22.0	13.8	10.7	19.0	16.4
1972-73	18.7	19.2	14.6	35.0	21.9
1973-74	19.3	14.3	9.6	21.9	16.3
1974-75	24.1	16.2	17.9	20.9	19.8
1975-76	19.8	10.4	18.8	22.9	18.0
1976-77	9.4	5.3	14.3	28.6	14.4
1977-78	19.8	10.8	11.1	20.4	15.5
1978-79	17.9	8.9	5.2	27.1	14.8
1979-80	24.0	15.0	12.4	22.5	18.5
10-year ave.	19.2	12.3	12.8	23.9	18.4
NWS 30-year average	20.1	14.2	15.2	24.0	-

ON
8-1980

The best conditions for ice formation in Soo Harbor and the upper St. Marys River existed during the last ten days of January and first ten days of February, and during the last week in February. Between 22 January and 10 February the average maximum daily temperature was about 16°F and the average minimum daily temperature was about -4°F. During this period Soo Harbor was nearly 100% ice covered and both arms of the ice boom retained a 100% solid ice cover. The last week in February was the coldest period of this winter season, with mean daily temperatures averaging about 5°F, or about 13 degrees below normal. The lowest temperature recorded for this winter season, -17°F, was reached twice during this period. The ice cover, after destabilization and some melting in mid-February, began to resolidify during this period, but it never reached the extent realized in early February. Little Rapids Cut remained ice free throughout the winter. The Lake Nicolet ice field remained at least 3/4 of a mile below the Sugar Island ferry crossing.

Commercial vessels navigated through the boom until the Soo locks was officially closed at midnight on 15 January 1980. Limited Coast Guard vessel traffic continued throughout the winter. The first of the U.S. locks was reopened for the official navigation season on 20 March 1980 and the first ship of the season transited the lock on 24 March. No problems due to ice were experienced by the Sugar Island Ferry at any time during the winter.

The west arm of the ice boom was removed on 25-26 March 1980. At that time, the only ice in Soo Harbor was a small amount of frazile ice behind the boom. With the removal of the west arm of the boom this ice passed uneventfully downstream. The east arm was removed on 2 April 1980, at which time very little ice remained in Soo Harbor and open water existed downstream into Lake Nicolet.

Monitoring Program

The monitoring program for the winter of 1979-80 was patterned after the procedures used in prior years. Some significant items of the program are listed below.

1. Continuous daylight field observations of ice conditions in Soo Harbor and Little Rapids Cut were recorded using three time-lapse, super-8mm, movie cameras.

- a. Two cameras were installed in the U.S. Coast Guard observation tower at Mission Point, located at the head of the Little Rapids Cut on the Michigan mainland, as shown in Figure 1. The cameras were positioned to record ice conditions in the vicinity of the Sugar Island Ferry crossing and the ice boom. Camera No. 1 recorded the Sugar Island ferry crossing

and the downstream conditions in the Little Rapids Cut. Camera No. 2 recorded the ice boom passageway, including the outer end of each boom arm. Both cameras were in operation during the daylight hours throughout the ice season, from mid-December through mid-March, and were set to record approximately one frame per minute.

b. Camera No. 3 was installed in the Administration Building of the Soo Locks to record the movement of vessels through the Locks and their effect on the ice cover. Set to record approximately one frame per minute, Camera No. 3 was positioned in mid-December 1979 to monitor the east or downstream approach to the Poe Lock. On 23 March 1980, Camera No. 3 was realigned to record ice conditions and the movement of vessels in both the upper harbor and upstream approach to the locks. This camera was removed on 25 April 1980.

2. Commencing on 3 January 1980 and continuing through 31 March 1980, a series of nine oblique aerial photography flights were flown to document the ice conditions in the St. Marys River and, in particular, the Soo Harbor area.

3. Ice thicknesses above and below the boom were measured at six points along the St. Marys River, as shown in Figure 2. These measurements were made weekly, beginning on 18 January 1980 and continued until 21 March 1980.

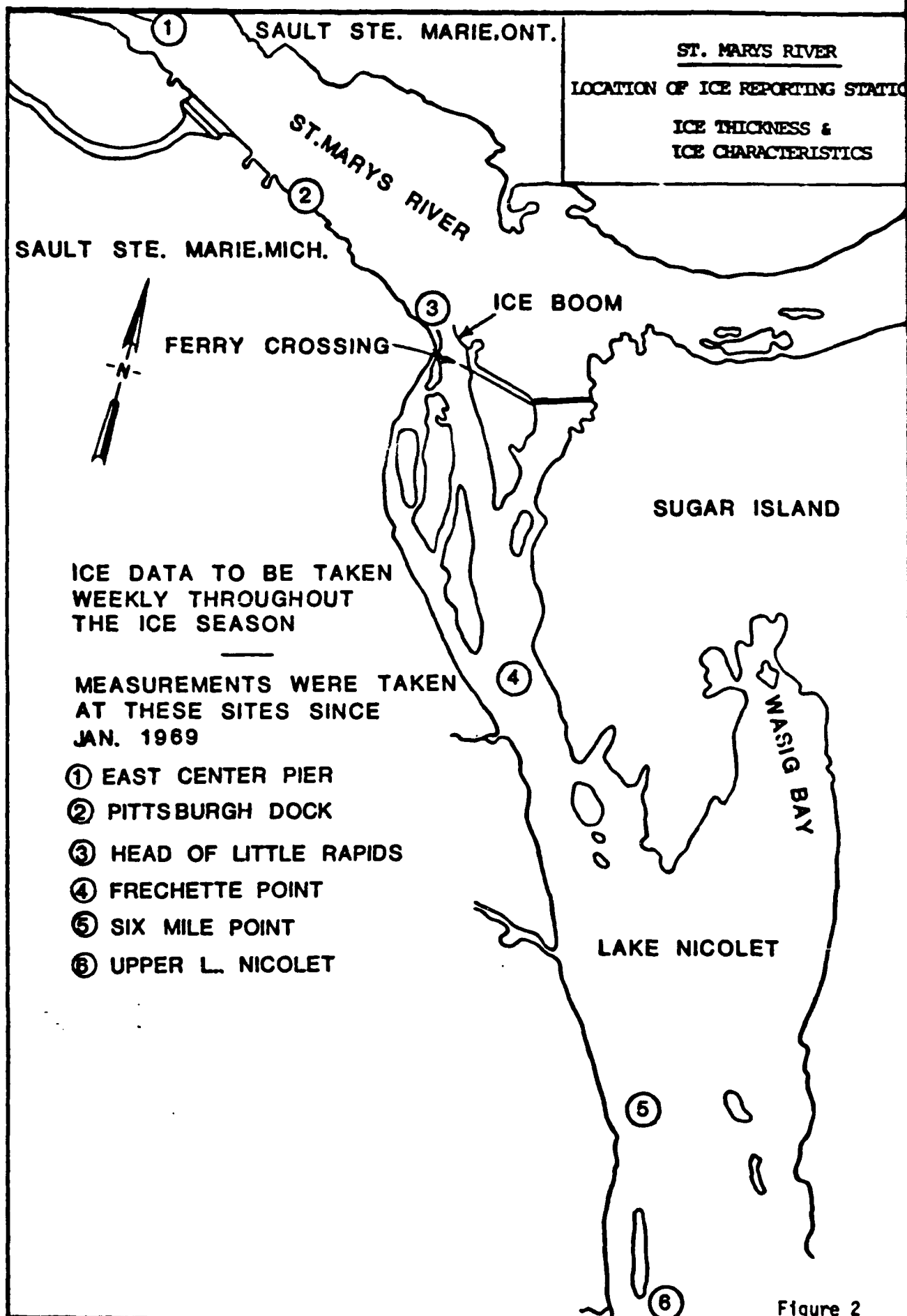
4. As part of the Soo Harbor-Little Rapids Cut Monitoring and Emergency Operations Plan, the water level gage network in Soo Harbor, Little Rapids Cut, and the lower St. Marys River was reestablished (Figure 3) and closely monitored. The information gathered from this network is used to determine, among other things, what effect, if any, the ice boom has on water levels above and below the boom.

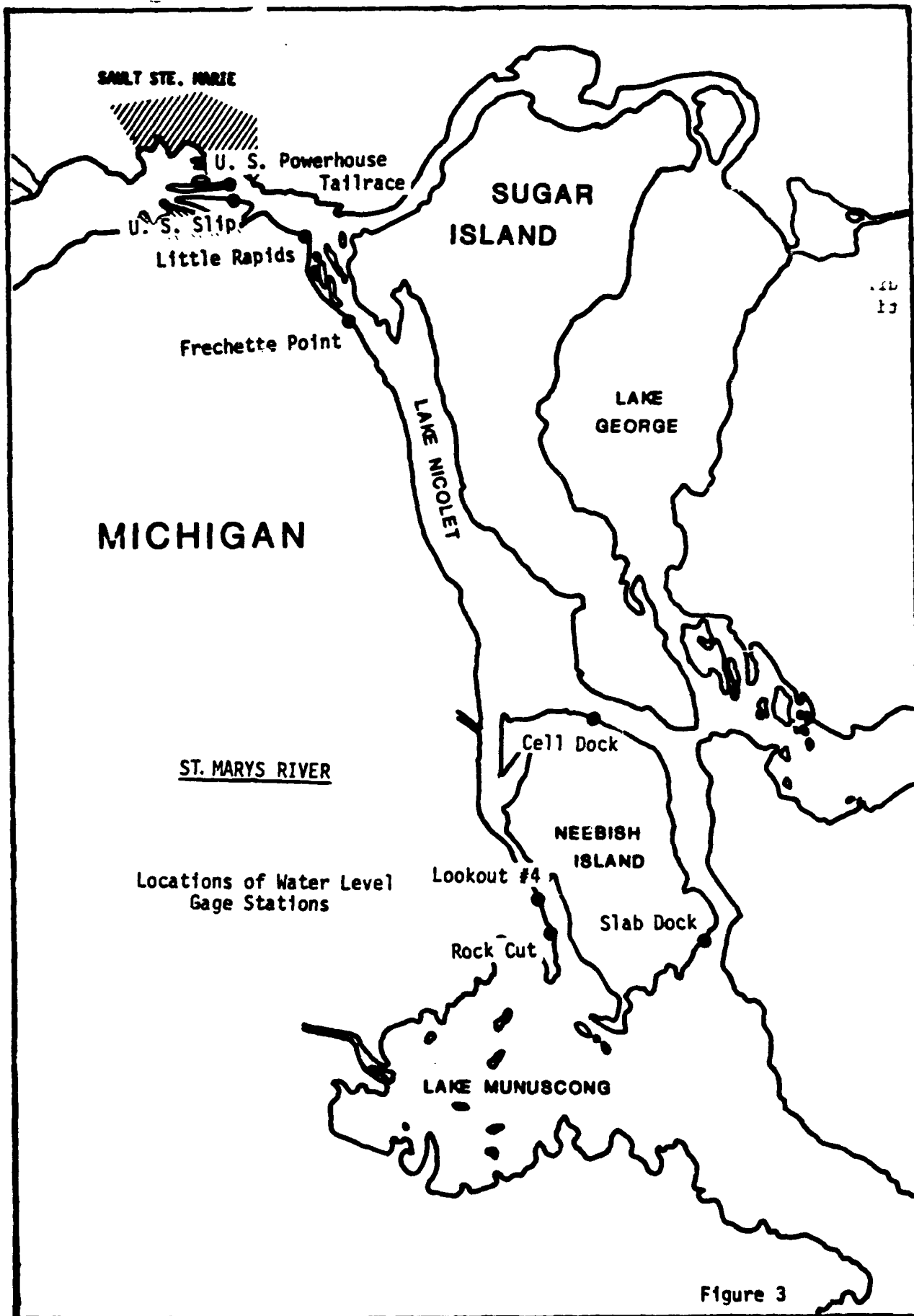
5. Throughout the winter season, ice conditions in and around the Soo Harbor-Little Rapids Cut area were visually monitored and recorded daily by the Soo Area Office. This was also part of the Soo Harbor-Little Rapids Cut Monitoring and Emergency Operations Plan. These records include observations on prevailing and forecasted weather conditions, ice conditions and ship movements throughout the length of the St. Marys River system, as well as icebreaker activities and ferry operations.

Results and Analysis

I. Ice Conditions.

The time-lapse movies taken of the ice boom area were reviewed and used to prepare an appendix to this report entitled "Appendix A:





Inventory of Ice through the Little Rapids Cut Ice Boom and Other Boom Events, 1979-80 Season." Appendix A summarizes the daily film record of ice passage through the boom opening and the stability of the ice cover behind the boom arms. This appendix also relates ice conditions to prevailing meteorological conditions. The record thus generated by the time-lapse movies is quite helpful in determining the chronology of ice conditions during the winter.

The low altitude oblique aerial photograph program yielded, from a different perspective, information on the ice cover similar to that of the time-lapse movies. The aerial photographs give a wide field of view and provide a reasonable perspective on the amount of ice in and around Soo Harbor at the time of the flights. A separate appendix entitled, "Appendix B: Aerial Photographic Record at the Little Rapids Cut Ice Boom, Winter of 1979-80," documents the ice conditions in the ice boom area, as seen from the aerial photos.

Visual on-site observation reports supplemented the time-lapse films and aerial photos by providing an on-site description of the ice cover, often noting causes and effects. These daily observations of the ice cover, supplemented with information on weather conditions, water levels, powerhouse flows, and lock and ferry operations, proved to be especially informative. The record of these observations is part of the Soo Harbor-Little Rapids Cut Monitoring and Emergency Operations Program and may be found in the Great Lakes Hydraulics and Hydrology Branch Archives, file number GLHH 80-3.

As documented by the time-lapse movies, aerial photos and on-site observations, the first ice formed in Soo Harbor on the night of 3-4 January 1980. The most extensive ice cover of the season existed during the end of January and beginning of February, with nearly 100% ice coverage in the harbor and behind the boom. After much in-place melting and large ice movements in mid-February, ice began to resolidify and stabilize by the end of February, but coverage never again reached its previous extent. At the end of the first week in March the ice field in the harbor and behind the boom began its spring break-up. By mid-March, Soo Harbor, below the compensating works, was essentially ice free. When the west arm of the boom was removed on 26 March the only ice in the harbor was a small amount of broken ice behind the west boom arm. The remainder of the boom was removed on 2 April 1980. The Lake Nicolet ice field did not enter Little Rapids Cut during the 1979-80 winter season, but remained at least 3/4 of a mile below the Sugar Island ferry crossing.

Appendix C, entitled, "Summary of Ice Thickness Measurements on the St. Mary River, Winter of 1968-69 to Present," outlines the data acquired over the last 12 winter seasons on ice thickness and characteristics at six selected stations. These stations are located adjacent to the navigation channel between the Soo locks and Lake Nicolet, as shown in Figure 2. These six sites were the same sites where the Regulatory Works

Subcommittee of the International Great Lakes Levels Board Working Committee conducted ice thickness and ice characteristic measurements during the winter periods from 1968-69 through 1971-72. These measurements were a part of a program to determine the feasibility of operating the Lake Superior Regulatory Works during the winter.¹ The observations continued under the Great Lakes-St. Lawrence Seaway Navigation Season Extension Program in an attempt to determine whether winter ship passage and, later, ice boom placement had an effect on ice thickness. This season, observations were made to provide a continuous record of the ice season over the last 12 years.

Over the last six winters, the East Center Pier station has proven to be of little use as a sampling station because unsafe ice conditions often made measurement impossible. The same problem has plagued the Little Rapids station for the entire 12 winter seasons. (For further details see Appendix C.) Because the data at these two stations are so sparse, little can be gained from them and thus they will not be considered in the analysis of ice conditions.

Table 2 is a comparison of the maximum ice thickness measured during each winter from 1968-69 to 1979-80 at the four selected sites, as well as the dates of these observations. Comparing the averages of these observations from the preboom and postboom periods indicates that all sites, except for the Lake Nicolet station, had an average maximum ice thickness for the postboom winters greater than that for the preboom seasons. Part of this can be accounted for by the colder than normal temperatures experienced during four of the five years in which the boom has been in place. The maximum ice thicknesses measured at the four stations during the 1979-80 winter season were the lowest recorded in the 12 years of measurement, even though this was only the third warmest winter of the last ten years.

Since there is only one reliable sampling station above the ice boom, any comparative effort to evaluate the ice boom's effect on ice thickness upstream is very difficult. With the sparse data available and the colder than normal temperatures experienced during most of the winters since the boom was installed, it cannot be concluded that the ice boom has caused the thicker ice cover.

II. Water Levels.

To analyze the possible effects of the ice boom on water levels, historical water level records were examined for the period December 1968 to March 1980. The U.S. Slip, Little Rapids and Frechette Point gages were chosen for this analysis because of their location (Figure 3).

¹Regulatory Works Subcommittee, International Great Lakes Working Committee, "Winter Operations at the Lake Superior Regulatory Works, Sault Ste. Marie, Winter of 1968-69," and supplements of the same title for "Winter of 1969-70," and "Winter of 1970-71."

TABLE 2

Maximum Ice Thickness
as Measured, in Feet, at Selected Sites*

	Pittsburgh Dock	Frechette Point	Six Mile Point	Lake Nicolet
1968-69	1.16 (03/03)	1.48 (02/12)	1.26 (02/17)	1.41 (02/26)
1969-70	0.95 (02/05)	0.90 (02/12)	1.30 (02/19)	1.35 (02/05)
1970-71	1.50 (03/04)	1.75 (02/25)	1.92 (04/01)	2.00 (04/01)
1971-72	1.75 (03/27)	1.65 (03/27)	1.90 (03/13)	1.60 (04/11)
1972-73	1.05 (02/27)	1.00 (02/21)	1.30 (02/21&27)	1.70 (02/27)
1973-74	0.96 (02/14)	1.04 (02/14&28)	1.38 (02/28)	1.80 (02/28)
1974-75	0.00 (O.W.)	0.83 (02/13&20)	1.21 (03/06&13)	1.62 (03/10&13)
1975-76	N/A	1.67 (03/18)	1.92 (03/18)	1.79 (03/04)
1976-77	0.75 (01/10&17)	2.25 (03/07)	1.62 (03/07)	1.83 (02/22)
1977-78	1.42 (01/30)	1.75 (02/21)	2.33 (03/13)	1.79 (03/28)
1978-79	1.66 (02/20)	1.54 (02/26)	1.75 (02/14)	1.67 (03/13)
1979-80	N/A	0.58 (02/01)	0.96 (02/08)	1.12 (02/08)

Preboom average

(1968/69-
1974/75)

1.05

1.24

1.47

1.64

Postboom average

(1975/76-
1979/80)

1.28

1.56

1.72

1.64

(O.W.) - All observations were open water.

N/A - Not averaged due to insufficient data (usually open water or unsafe cover).

* Date of occurrence in parenthesis.

The U.S. Slip gage represents the levels in Soo Harbor above the boom, while Little Rapids gage records levels immediately downstream of the boom. The Frechette Point gage gives the water level below Little Rapids Cut. These three gages should reflect the effects on water levels, if any, of the boom, accumulated ice in Little Rapids Cut and ice in Lake Nicolet.

Figure 4 shows plots of actual monthly mean levels at the three gages, averaged over two time periods: preboom, December 1968 to November 1975, and postboom, December 1975 to March 1980. Figure 5 shows Lake Superior levels at Marquette and Lake Michigan-Huron levels at Harbor Beach, averaged over the same periods. Comparing these figures it can be seen that there is definitely some form of flow retardation occurring in the region of the Little Rapids Cut during the winter months. (Flow retardation has the effect of raising upstream levels and lowering downstream levels.) The retardation that is occurring appears to be a natural winter phenomenon in this reach, having occurred during both pre- and postboom winters. The water level at Frechette Point begins to reflect the formation of ice in Lake Nicolet in late December. The retardation caused by this ice field is also seen in the levels at Little Rapids and U.S. Slip gages. Ice retardation is also occurring in Little Rapids Cut, and can be seen by the increased levels recorded at the U.S. Slip and Little Rapids gages during the winter months. It should be noted that the monthly mean averages do not show any significant variations between the pre- and postboom level patterns at Little Rapids and U.S. Slip gages. Such an anomaly would indicate possible ice retardation conditions due to the ice boom.

Figure 6 shows a plot of the average differences between U.S. Slip and Frechette Point levels and between U.S. Slip and Little Rapids levels for pre- and postboom periods. These plots are based on average weekly levels, with the months divided in the same manner as used for the ice thickness measurements in Appendix C. The ice retardation occurring in Little Rapids Cut can be seen by the increase in the difference between U.S. Slip and Frechette Point levels during midwinter. The plot of the U.S. Slip-Little Rapids level differences still show no significant evidence of ice retardation between the two gages due to the ice boom. The postboom plot of the U.S. Slip-Little Rapids differences is based on only four winter seasons, as compared to seven preboom winters, and so is only of limited value. The 1976-77 winter season was not included in the comparison because Little Rapids gage data was missing during much of that season. The winter of 1976-77 was designated by the National Weather Service to have been the fifth coldest winter in the last 200 years of official record,² and, therefore, would have made a good benchmark winter for comparative purposes if more complete level data had been available.

²NOAA Technical Memorandum ERL GLERL-20, "SUMMARY OF GREAT LAKES WEATHER AND ICE CONDITIONS, WINTER 1976-77."

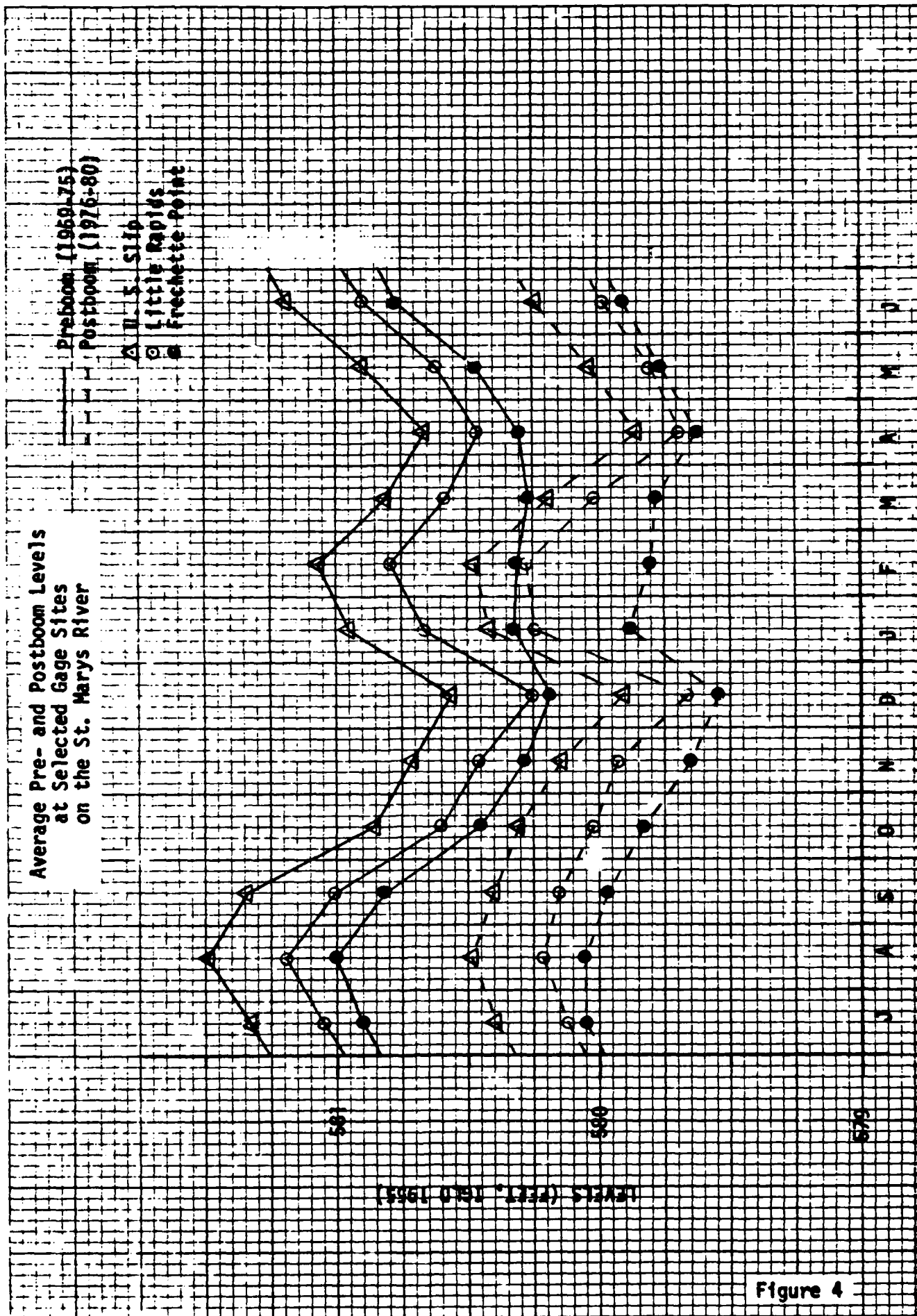
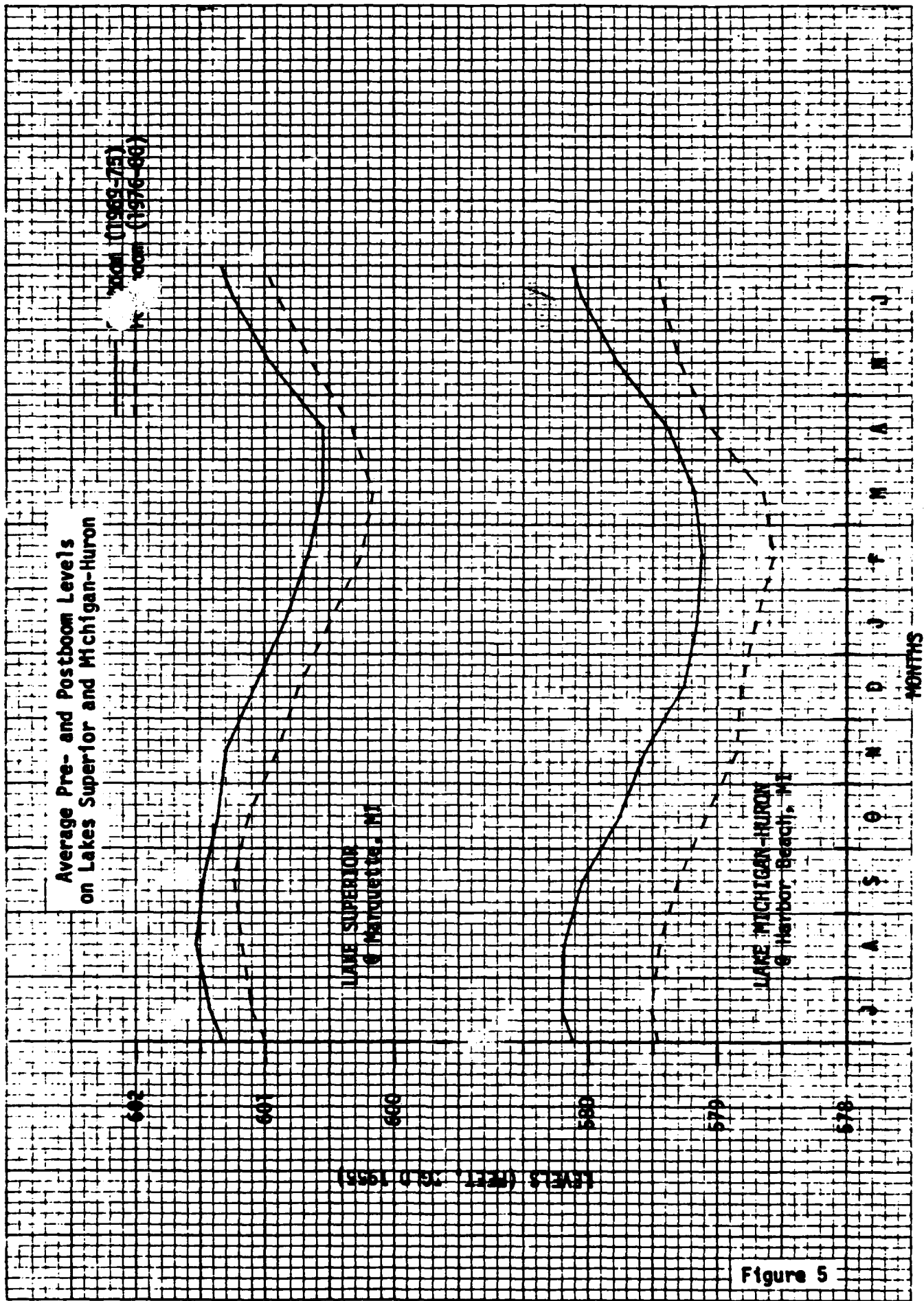
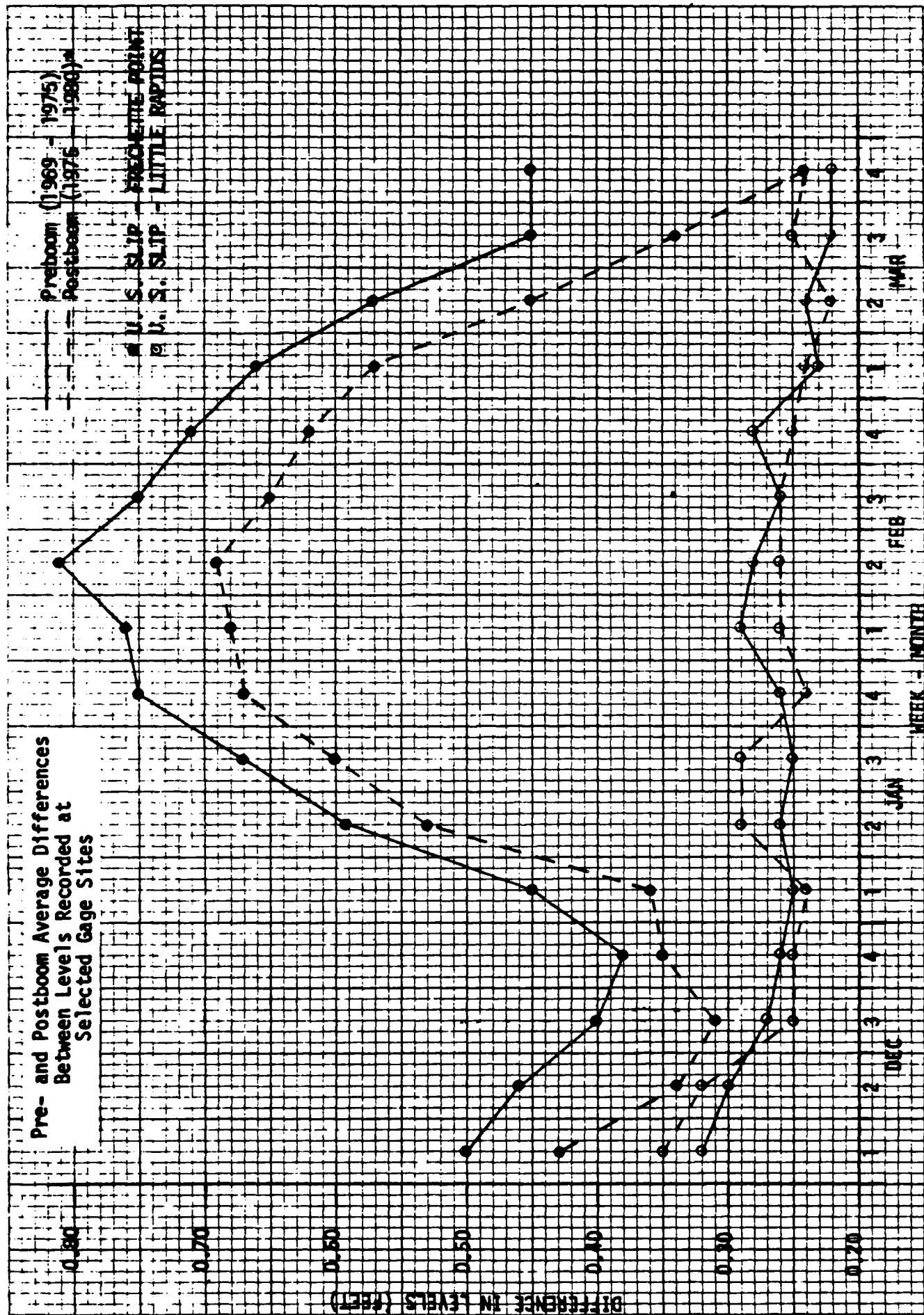


Figure 4





*Does not include 1976-77 winter season.

To evaluate the 1979-80 winter season the data in Table 3 was plotted in Figure 7, parts A and B. As mentioned previously, this past winter season was a comparatively mild one, with above normal temperatures and relatively little ice formation. Part A of Figure 7, a plot of the December 1979 to March 1980 monthly means at the three gages of concern, shows that while retardation of flow did occur below Frechette Point, little or no retardation occurred in the Cut. It must be remembered that Little Rapids Cut was essentially ice free during the entire winter season.

Figure 7, Part B is a more detailed look at the levels for the 1979-80 winter season based on weekly average levels. Again, there is the problem of incomplete data at the Little Rapids gage. Looking at the period with the most reliable data, the last three weeks in January and first two weeks in February, it appears that some retardation may have occurred at the head of Little Rapids, during the last week in January, possibly caused by ice accumulation behind the boom. A 100%, solid, stable ice cover existed behind the boom from 24 January until about 9 February. A few days prior to the 24th of January the ice field had been slowly resolidifying after a period of melt and breakup. On 23 January, with a 50 to 90% ice cover behind the boom, a continuous moderate to heavy flow of broken skim ice from Soo Harbor passed through the boom opening. The flow of broken ice, combined with the ice field behind the boom, created a degree of blockage at the head of the Cut. Although the ice field remained solid and stable into the second week in February, the indicated variation between the levels at U.S. Slip and Little Rapids was temporary. The blockage appears to have been quickly taken care of by the natural flow of water. Whether a similar situation would have occurred without the boom cannot be ascertained due to the scarcity of historical data on the day to day ice conditions at the head of the Cut.

In summary, there is no evidence to indicate that the ice boom has had any effect on the levels in Soo Harbor or downstream in Little Rapids Cut.

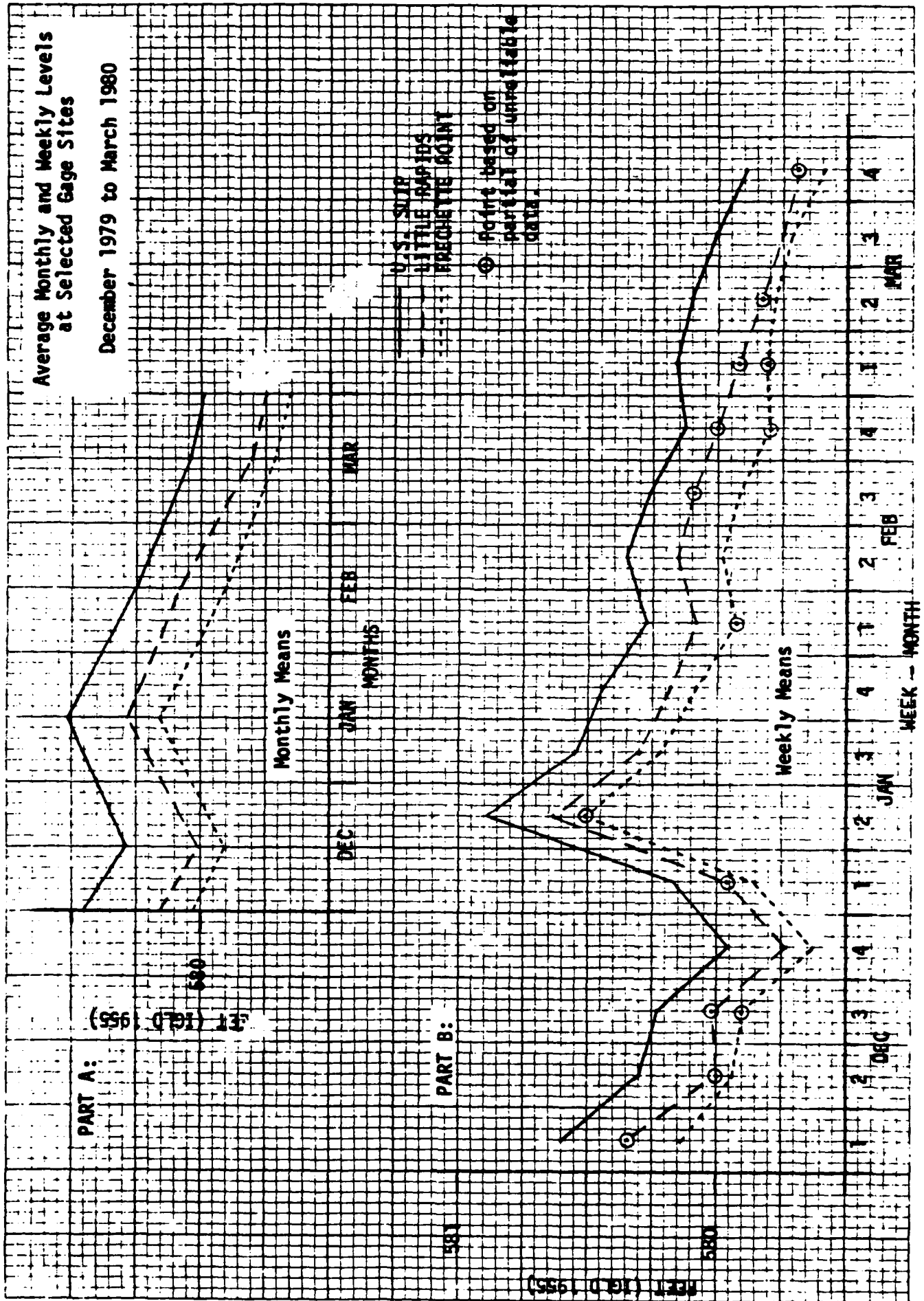
TABLE 3
SOO HARBOR - LITTLE RAPIDS
CUT WATER LEVEL COMPARISONS
WINTER OF 1979-80

Month- Week	U.S. Slip Weekly Ave. (A)	Little Rapids Weekly Ave. (B)	Stage Diff. Ft. (A-B)	Frechette Weekly Ave. (C)	Stage Diff. (A-C)	Stage Diff. (B-C)
December - 1st	580.60	580.34*	0.26	580.14	0.46	0.20
2nd	580.30	580.00*	0.30	579.94	0.36	0.06
3rd	580.23	580.02*	0.21	579.90*	0.33	0.12
4th	579.95	579.73	0.22	579.63	0.32	0.10
January - 1st	580.17	579.96*	0.21	579.86	0.31	0.10
2nd	580.88	580.63	0.25	580.51*	0.37	0.12
3rd	580.54	580.30	0.24	580.22	0.32	0.08
4th	580.44	580.18	0.26	580.08	0.36	0.10
February - 1st	580.27	580.08	0.19	579.93*	0.34	0.15
2nd	580.35	580.15	0.20	579.98	0.37	0.17
3rd	580.26	580.09*	0.17	579.92	0.34	0.17
4th	580.13	580.00*	0.13	579.80*	0.33	0.20
March - 1st	580.16	579.92*	0.24	579.81*	0.35	0.11
2nd	580.10	579.83*	0.27	579.78	0.32	0.05
3rd	580.00	579.75	0.25	579.71	0.29	0.04
4th	579.89	579.69*	0.20	579.59	0.30	0.10
Monthly Average						
December	580.28	580.01*	0.27	579.91*	0.37	0.10
January	580.51	580.28*	0.23	580.16*	0.35	0.12
February	580.25	580.08*	0.17	579.90*	0.35	0.18
March	580.04	579.81*	0.23	579.72	0.32	0.09

*Based on partial data.

Average Monthly and Weekly Levels at Selected Gage Sites

December 1979 to March 1980



Conclusions

1. The Little Rapids Cut Ice Boom and the rock-filled barge and crane weights were effective in stabilizing Soo Harbor ice throughout the 1979-80 operating period, with no major problem being encountered. It should be noted that significant ice formations were non-existent in the Soo Harbor area for most of the 1979-80 winter operations period.
2. The placement of the ice boom, rock-filled barge and crane weights has had no distinguishable effect on the ice thickness in Soo Harbor and in the Little Rapids Cut.
3. There appears to be a natural flow retarding effect caused by ice in Soo Harbor and in the Little Rapids Cut, even when the ice boom is not deployed. This retardation occurs regularly in the first or second week of January each year and is maintained through the third or fourth week of March, and causes an increase in the water levels in Soo Harbor of about half a foot. The presence of the ice boom has had no discernable effect on Soo Harbor levels or on the levels downstream of the ice boom.

Recommendations

1. Since the ice boom placed at the head of Little Rapids Cut has been effective in stabilizing Soo Harbor ice and reduced the possibility of ice jams in Little Rapids Cut, it is recommended that the boom be reinstalled each winter. The rock-filled barge and crane weights should also be retained, as an effective supplemental measure, until they can be replaced with permanent rock structures.
2. A monitoring program similar to this past season's activities should be continued next winter, whether the ice boom is reinstalled or not. Greater emphasis should be placed on the analysis of the characteristics and amount of ice being held by the boom and the ice passing the boom structure. If the ice boom is not reinstalled the information gathered in this type of monitoring program could be useful in analyzing the effect the boom had on ice conditions by providing more data similar to the preboom data, and also data not affected by winter navigation.
3. The ice thickness and characteristic measurements in their present form have been of little use in analyzing the effect of the ice boom, and the other stabilization measures, on the thickness of the ice in the harbor and cut areas. If measurements are conducted next winter, it is recommended that new sites be selected in Soo Harbor, where safe access can be more readily obtained. Also a more detailed description of the ice conditions at and around the stations would be helpful.

APPENDIX A

INVENTORY OF ICE THROUGH THE
LITTLE RAPIDS CUT ICE BOOM
& OTHER BOOM EVENTS

1979-80 SEASON

INVENTORY OF ICE THROUGH ST. MARYS -- LITTLE RAPIDS ICE BOOM AND OTHER BOOM EVENTS
1979-1980 SEASON

<u>Date</u>	<u>Air Temperature (°F)</u>		<u>Average Wind Speed (MPH) and Direction</u>	<u>Ice Behind Booms</u>	<u>Ice Passing Into Little Rapid Cut</u>		<u>Other Comments</u>
	<u>Max.</u>	<u>Ave.</u>					
15 Dec	38	27	15	SSW	None	None	
16 Dec	26	13	-1	NNW	None	None	
17 Dec	17	9	0	W	None	None	
18 Dec	16	8	-1	E	None	None	
19 Dec	22	16	10	E	None	None	
20 Dec	31	25	19	ESE	None	None	
21 Dec	34	28	22	SE	None	None	
22 Dec	35	34	33	SE	None	None	
23 Dec	37	35	33	ENE	None	None	
24 Dec	36	32	28	NE	None	None	
25 Dec	29	24	18	N	None	None	
26 Dec	26	23	20	W	None	None	
27 Dec	34	-5	16	NW	None	None	
28 Dec	38	34	29	WNW	None	None	

Date	Air Temperature(°F)		Average Wind Speed (MPH) and Direction		Ice Behind Booms	Ice Passing Into Little Rapid Cut	Other Comments
	Max.	Ave.	Min.				
29 Dec	37	35	32	13.2 WNW	None	None	
30 Dec	36	32	28	10.1 NW	None	None	
31 Dec	38	34	30	8.1 WNW	None	None	
1 Jan	31	26	20	7.3 NW	None	None	
2 Jan	20	14	8	7.5 N	None	None	
3 Jan	15	8	0	5.2 N	None	None	
4 Jan	20	11	1	4.6 E	West boom - 50% East Boom - None West boom new skim ice mostly stable.	Small amount of skim and slush ice passing into Little Rapids Cut throughout the day. Vessel movement had no influence on the ice flow.	First ice formation of the season occurred on the night of 3-4 Jan, creating 50% coverage behind the west boom and skim ice in Soo Harbor. Day was partly sunny.
5 Jan	22	15	7	6.0 E	Morning West Boom - 50% East Boom - None Evening West Boom - 20% East Boom - None West boom ice unstable and flowing.	Small amount of skim and slush ice passing between boom arms from Soo Harbor and over and under the west boom arm. Vessel movement did not affect the ice flow.	Sunshine.
6 Jan	28	19	9	12.9 ESE	Morning West Boom - 50% East Boom - None Evening West Boom - None East Boom - None Most of the ice loss was the result of in-place melting.	Small amount of ice passed over and under the west boom arm. No flows from Soo Harbor.	Cloudy and foggy.

<u>Date</u>	<u>Air Temperature (°F)</u>		<u>Average Wind Speed (NPH) and Direction</u>		<u>Ice Behind Booms</u>	<u>Ice Passing Into Little Rapid Cut</u>	<u>Other Comments</u>
	<u>Max.</u>	<u>Ave.</u>	<u>Min.</u>	<u>Dir.</u>			
7 Jan	28	21	13	WSW	None	None	No ice apparent anywhere.
8 Jan	15	7	-2	W	West Boom - 50% thin East Boom - None Slightly unstable.	Upbound vessel late in the day brought down a small amount of ice from behind the west boom, which was the only ice movement of the day.	Partly sunny.
9 Jan	10	3	-5	WSW	West Boom - 80% East Boom - 70% Stable.	A moderate amount of skim ice passed through the boom opening, continuously, throughout the early part of the day. Later in the day the flow ceased.	Considerable ice formation occurred behind both booms on the night of 8-9 Jan. Sunshine.
10 Jan	32	15	-2	SE	West Boom - 100% East Boom - 90% Stable.	One upbound ship brought a moderate size ice flow, which was the only ice movement of the day.	All of Soo Harbor covered, except for open ship track and boom opening. Mostly cloudy.
11 Jan	44	23	1	SW	West Boom - 95% East Boom - 80% Stable.	One episode of moderate ice flow.	Cloudy.
12 Jan	17	9	1	W	Unchanged from eleventh. Stable.	No apparent ice flow.	A snowstorm impaired visibility throughout the day and so observations are questionable.
13 Jan	34	25	15	SE	West Boom - 90% East Boom - 80% Ice behind west boom cracked and destabilized by two ship movements.	Small flow in early morning.	Mostly cloudy.

Date	Air Temperature (°F)		Average Wind Speed (MPH) and Direction	Ice Behind Booms	Ice Passing Into Little Rapid Cut	Other Comments
	Max.	Ave.				
14 Jan	34	25	15	11.2 WNW	West Boom - 100% East Boom - 90% Stable.	Ice formation continued on the night of 13-14 Jan. An ice field from the harbor moved into the boom opening, blocking it, and remained there throughout the day. Sunny.
15 Jan	29	24	18	13.4 ESE	West Boom - 100% East Boom - 95% Stable.	Ship movement cleared out the ice blockage at the head of the boom opening.
16 Jan	35	32	29	16.1 ESE	West Boom - 100% East Boom - 80% Stable.	Cloudy.
17 Jan	36	35	33	6.9 ESE	West Boom - 100% East Boom - 90% Stable.	Cloudy and foggy.
18 Jan	36	33	29	13.4 WNW	West Boom - 100% East Boom - 75% Some destabilization with slight movement behind both booms in morning - unrelated to navigation.	Mostly cloudy. Most of upper harbor is open water and most of lower harbor is ice covered.
19 Jan	30	27	24	13.8 WNW	West Boom - 50% East Boom - None The entire ice field behind the east boom was cleared out on the night of 18-19 Jan. Ice behind the west boom was unstable. Some flow over and under the boom arm.	Melt day. Mostly cloudy.

<u>Date</u>	<u>Air Temperature (°F)</u>		<u>Average Wind Speed (MPH) and Direction</u>		<u>Ice Behind Booms</u>	<u>Ice Passing Into Little Rapid Cut</u>	<u>Other Comments</u>
	<u>Max.</u>	<u>Ave.</u>	<u>Min.</u>	<u>Dir.</u>			
20 Jan	25	19	12	10.1 WNW	West Boom - 50% East Boom - None Stable.	Later in the day, a moderate flow of skim ice passed down from the harbor.	Cloudy.
21 Jan	28	21	14	6.5 S	West Boom - 75% East Boom - None Stable. Ice beginning to re-solidify behind west boom.	None	Partly sunny.
22 Jan	29	18	6	12.2 W	West Boom - 75% East Boom - None Stable.	None	Cloudy.
23 Jan	6	1	-5	11.5 N	West Boom - 90% East Boom - 50% Stable ice resolidifying behind both boom arms.	Moderate to heavy continuous flow of skim ice through boom opening throughout the day.	Partly sunny.
24 Jan	10	-1	-11	4.5 E	West Boom - 100% East Boom - 100% Stable.	None	All visible portions of Soo Harbor (including boom opening) were ice covered. Sunny.
25 Jan	14	4	-6	5.9 N	West Boom - 100% East Boom - 100% Stable.	None	Entire harbor completely ice covered. The only open water was in Little Rapids Cut, below the boom. Sunny.
26 Jan	21	14	7	5.2 W	Unchanged -- Same as 25 Jan	None	
27 Jan	22	17	11	4.5 SSW	Unchanged -- Same as 25 Jan	None	
28 Jan	18	9	-1	5.3 W	Unchanged	None	Partly sunny to partly cloudy.

Date	Air Temperature(°F)			Average Wind Speed (MPH) and Direction		Ice Behind Booms	Ice Passing Into Little Rapids Cut	Other Comments
	Max.	Ave.	Min.					
29 Jan	11	4	-3	7.2	NNW	Unchanged	None	Partly sunny to partly cloudy.
30 Jan	9	-3	-14	7.1	N	Unchanged	None	Partly sunny to partly cloudy.
31 Jan	10	-1	-12	7.3	NNW	Unchanged	None	Partly sunny to partly cloudy.
1 Feb	10	-3	-16	6.5	NNW	Unchanged	None	Partly sunny to partly cloudy.
2 Feb	9	-3	-15	5.3	NW	Unchanged	None	Fog in morning, sunny later.
3 Feb	13	0	-13	8.5	NW	Unchanged	None	Partly cloudy.
4 Feb	12	2	-8	6.9	NW	Unchanged	None	Sunny.
5 Feb	14	3	-8	3.7	ENE	Unchanged	A small to moderate amount of ice from between the booms was released into Little Rapids Cut as a result of a vessel passing through the booms.	Lead at the head of Little Rapids Cut increased in length, extending upward into the area between the booms. Sunny.
6 Feb	18	10	1	5.5	NE	East Boom - 100% West Boom - 100% Afternoon passage of vessel slightly shifted field behind west boom, otherwise stable.		Sunny.
7 Feb	24	14	4	6.0	N	Unchanged -- Same as 6 Feb.	None	Sunny.
8 Feb	20	11	1	2.9	WSW	Ice behind booms and in Soo Harbor generally remained unchanged.	Very small amount (trivial) from the area between booms.	The lead of open water from the head of Little Rapids upward to the area between the booms increased in length by gradual melting and trivial ice movements. Sunny.

Date	Air Temperature (°F)		Average Wind Speed (MPH) and Direction	Ice Behind Booms	Ice Passing Into Little Rapid Cut	Other Comments
	Max.	Ave.				
9 Feb	21	11	0	3.2 NNE	The areas behind the booms and generally throughout Soo Harbor remained completely 100% ice covered.	The area between the booms became almost completely ice free during the night of 8-9 February. Sunny.
10 Feb	21	10	-2	9.1 ESE	West Boom - 95% East Boom - 75% Both boom arms lost ice to melting and ice movement past the arms during the day.	Light to moderate flow of ice from behind both boom arms during the day. Cloudy.
11 Feb	26	21	16	5.3 NNE	West Boom - 85% East Boom - 50% Gradual in-place melting and small ice losses over both booms throughout the day.	Small amounts of ice passed from behind both booms throughout the day. Cloudy.
12 Feb	24	16	8	6.9 W	West Boom - 80% East Boom - 50% More in-place melting.	A moderate size ice sheet passed from the harbor into the boom opening. Some chunks broke off of this sheet, creating a light flow of ice into Little Rapids Cut. Partly cloudy.
13 Feb	24	20	15	7.2 WSW	Morning West Boom - 50% East Boom - 30% Late West Boom - 100% Afternoon East Boom - 80% Increased in-place melting early in the day led to general deterioration. Late in the day, ice movement from Soo Harbor brought down a large amount of ice, much of which was retained behind the booms.	As a result of ice movement from the harbor, a fairly large amount of ice passed over and under the boom arms and through the boom opening. As a result of the ice movement, the head of the boom opening was again closed off by ice. Cloudy.

<u>Date</u>	<u>Air Temperature (°F)</u>		<u>Average Wind Speed (MPH) and Direction</u>		<u>Ice Behind Booms</u>		<u>Ice Passing Into Little Rapid Cut</u>	<u>Other Comments</u>
	<u>Max.</u>	<u>Ave.</u>	<u>Min.</u>	<u>Dir.</u>	<u>Max.</u>	<u>Ave.</u>		
14 Feb	22	17	11	5.5 W	Morning West Boom - 100% East Boom - 80% Late West Boom - 90% Afternoon East Boom - 90% The ice which had been behind the booms was totally replaced by broken ice coming down from the harbor. A large amount of ice also passed from behind the east boom into North Channel.		A massive ice movement pushed a great deal of ice over and under the boom arms, and through the boom opening into Little Rapids channel.	Continued melting throughout the day induced a massive ice movement from the upper Soo Harbor. Most of the ice was removed from the upper harbor. Cloudy.
15 Feb	22	16	10	5.5 WNW	Morning West Boom - 80% East Boom - 80% Continued melting deteriorated the ice fields behind both booms.		No ice movements in morning. During afternoon a very small amount of ice flowed from the harbor.	Upper harbor ice free. Sunny.
16 Feb	14	9	4	7.8 NW	West Boom - 50% East Boom - 80% Some ice cleared from behind the west boom on the night of 15-16 Feb leaving a weak 50% cover. The cover behind the east boom was essentially unchanged from that of 16 Feb.		Circumstantial evidence indicates that there was some ice flow from behind the west boom on the night of 15-16 February. There was no ice movement during the day.	Partly cloudy with snow flurries in the morning.
17 Feb	20	11	2	4.3 NNW	Unchanged.		None	Cloudy.

Date	Air Temperature (°F)			Average Wind Speed (NPH) and Direction	Ice Behind Booms	Ice Passing Into Little Rapid Cut	Other Comments
	Max.	Ave.	Min.				
18 Feb	31	17	2	8.5 SW	Unchanged through the early part of the day. In the afternoon, severe deterioration of the ice field behind the west boom caused large pieces of ice to break off and pass over and under the west boom arm.	Light to moderate flow of ice from behind the west boom was the only ice movement of the day.	Cloudy with light snow.
19 Feb	34	32	30	7.1 S	Due to continuous movement of ice, throughout the day, coverage behind booms varied from near zero to nearly 100% at times. At the end of the day, coverage was about 80% behind the west boom and near zero behind the east boom.	Large amounts of thin ice passed almost continuously over and under the boom arms and through the boom opening, throughout the day.	Cloudy.
20 Feb	36	34	32	6.2 SSW	Morning West Boom - 90% thin East Boom - 20% thin Ice conditions behind the booms changed continuously throughout the day. Evening West Boom - 90% East Boom - 70%	Large amounts of thin and broken ice passed over and under the boom arms and through the boom opening. The overall flow, while large, was not as great as that of 19 February.	Cloudy and foggy.
21 Feb	34	26	18	8.8 E	West Boom - 80% East Boom - 50% Thin, stable ice fields.	None	Cloudy

Date	Air Temperature (°F)		Average Wind Speed (NPH) and Direction		Ice Behind Booms	Ice Passing Into Little Rapid Cut	Other Comments
	Max.	Ave.					
22 Feb	35	27	18	E	West Boom - 60% East Boom - 50% During the day, moderate ice movement past the west boom arm reduced coverage there to about 40%. The east boom field remained stable.	One small passage of ice by the west boom arm.	About 40% of Soo Harbor was covered with broken ice. Little Rapids Cut was ice free. Partly cloudy.
23 Feb	34	29	24	W	West Boom - 75% East Boom - 60% The ice field behind the booms appeared thicker than on the previous evening, but was broken into large pieces.	A small ice field blocked the head of the boom opening early in the day but was broken up later and passed down into Little Rapid Cut. This was the only movement of ice.	Cloudy.
24 Feb	27	22	16	W	Morning West Boom - 50% East Boom - 20% Evening West Boom - 50% East Boom - None	Downstream passage of remaining east boom ice was the only movement of the day. This was only a small flow of ice.	Cloudy and foggy.
25 Feb	17	9	0	N	West Boom - 100% East Boom - None Ice field behind the west boom was solidified by extensive freezing this day.	Very thin skim ice passed by the east boom and through the boom opening throughout the day.	Sunny.
26 Feb	18	1	-17	SSE	West Boom - 100% East Boom - 60% Solidification and thickening behind both booms.	Passage of skim ice from Soo Harbor continued throughout the day and represented the only ice flow this day. Light to moderate overall passage.	Partly sunny.

Date	Air Temperature(°F)		Average Wind Speed (MPH) and Direction	Ice Behind Booms		Ice Passing Into Little Rapid Cut	Other Comments
	Max.	Ave.		Min.			
27 Feb	18	12	6	12.2	NW	Morning West Boom - 100% East Boom - 75% Evening West Boom - 100% East Boom - 20% Ice was fairly well stabilized behind both booms throughout the morning. Later in the day, melting resulted in the breakup and deterioration of the ice field behind the east boom.	The only ice flow this day resulted from the breakup of the ice field behind the east boom. Sunny.
28 Feb	8	-2	-12	9.2	N	West Boom - 100% East Boom - 60% Ice solidifying behind both booms.	Light flow of newly formed skim ice from the harbor. Sunny.
29 Feb	4	-7	-17	11.8	NNW	West Boom - 90% East Boom - 80% Solidification behind both booms. Small open pool in the field behind the west boom.	Small passage of skim ice from Soo Harbor. Only open water in harbor was within the opening between the booms. Sunny.
1 Mar	8	-2	-11	8.1	NNW	West Boom - 90% East Boom - 100% Solid, stable.	None Boom opening freezing over.
2 Mar	26	14	1	6.2	SW	Unchanged.	None Partly sunny.
3 Mar	26	13	-1	6.6	SSE	Unchanged.	Piece of ice broke off from the ice field between the booms and passed down into Little Rapids Cut. Mostly cloudy.

Date	Air Temperature (°F)		Average Wind Speed (MPH) and Direction	Ice Behind Booms		Ice Passing Into Little Rapid Cut	Other Comments
	Max.	Ave.					
4 Mar	29	23	17	9.1	WNW	West Boom - 90% East Boom - 100% Some melting, but still stable.	Partly sunny.
5 Mar	17	13	8	11.2	NW	Morning West Boom - 75% East Boom - 90% Variable ice movement previous night, continued throughout the day. Evening West Boom - 90% East Boom - 50%	Above the boom opening the harbor retained a complete and stable ice cover. Mostly sunny.
6 Mar	21	9	-3	7.3	SSW	West Boom - 80% East Boom - 30% Ice fields behind the boom had further deteriorated during previous night. A moderate size pool of open water developed near shore behind the west boom. Small degree of in-place melting.	Fragile ice bridge at the head of the boom opening broke up and passed downstream through the Cut. Sunny.
7 Mar	30	15	-1	3.5	ESE	Morning West Boom - 80% East Boom - 30% In the late afternoon, a moderate to large ice movement cleared all of the ice from behind the east boom, taking with it ice from the harbor just above the booms. The field behind the west boom was reduced to about 75% cover.	A moderate volume of thin ice passed into the Cut as a result of the late afternoon ice movement above the booms. Sunny.

Date	Air Temperature (°F)		Average Wind Speed (MPH)	Direction	Ice Behind Booms	Ice Passing Into Little Rapid Cut	Other Comments
	Max.	Ave.					
8 Mar	31	18	5	5.0 NW	Morning West Boom - 100% (thick) East Boom - 60% (thin) During the night a considerable movement of ice from Soo Harbor restored coverage behind both booms and filled in the boom opening with thick ice. Variable ice movements during the day left the west boom with a solid 75% ice cover at days end. The east boom had a 75% cover of broken ice. The opening between the booms was filled with broken ice.	Three separate ice movements during the day brought down large to moderate amounts of ice. Major passages were over and under the east boom arm and through the boom opening.	Sunny.
9 Mar	32	18	3	5.0 S	Morning West Boom - 100% East Boom - 60% Early in the day, solidification was taking place behind both booms. With warming in the afternoon, ice behind the east boom began to deteriorate and pass downstream, both over and under the boom arm and into North Channel. Except for in-place melting, ice behind the west boom was unaffected. Evening West Boom - 100% East Boom - 5 to 10%	Throughout the morning, a light to moderate flow of skim ice passed through the boom opening. Later, the breakup of the field behind the east boom produced a moderate flow of ice over and under the east boom arm.	Sunny.
10 Mar	39	26	19	16.5 W	The only ice in the vicinity of the booms was a 60% cover of unstable, broken ice behind the west boom. During the day, small amounts of this broken ice did pass over and under the boom arm, but this was compensated by ice flowing into the west boom field from Soo Harbor.	There was a light flow of ice from the field behind the west boom early in the day. In the afternoon there was a light continuous flow of broken ice passing down from the harbor through the boom opening.	Fog.

<u>Date</u>	<u>Air Temperature (°F)</u>		<u>Average Wind Speed (MPH) and Direction</u>		<u>Ice Behind Booms</u>		<u>Ice Passing Into Little Rapid Cut</u>	<u>Other Comments</u>
	<u>Max.</u>	<u>Ave.</u>	<u>Min.</u>		<u>Max.</u>	<u>Ave.</u>		
11 Mar	19	14	8	18.3 NW	West Boom - 100% East Boom - None Ice reformed and solidified behind west boom, with no movement.		Small continuous flow of skim ice from Soo Harbor.	Sunny.
12 Mar	17	2	-13	8.1 ESE	West Boom - 100% East Boom - None Stable.		A continuous, light to moderate, flow of skim ice from Soo Harbor.	Sunny.
13 Mar	25	18	11	13.5 ESE	West Boom - 100% East Boom - 25% Stable.		None	Partly cloudy.
14 Mar	27	21	14	13.8 WNW	Morning West Boom - 100% East Boom - 25% The entire east boom field deteriorated and passed downstream, both over and under the boom and into North Channel. No movement behind the west boom.		Ice passages included a light flow of skim ice from Soo Harbor and ice from the break-up of the east boom field.	U.S. side of Soo Harbor almost ice covered. Most of Canadian side ice free. Cloudy.
15 Mar	23	14	5	7.9 ESE	West Boom - 100% East Boom - None Stable.		Nearly continuous light flow of skim ice from Soo Harbor.	Sunny.
16 Mar	35	27	19	17.4 SE	Morning West Boom - 100% (solid) East Boom - None Ice movements during the day broke up the field behind the west boom and resulted in the loss of about 25% of the ice cover there.		Light flow as a result of the breakup of the west boom field.	Partly sunny.

Date	Air Temperature(°F)			Average Wind Speed (MPH) and Direction	Ice Behind Booms	Ice Passing Into Little Rapid Cut	Other Comments
	Max.	Ave.	Min.				
17 Mar	35	30	25	17.5 NW	Morning West Boom - 75% East Boom - None Ice movement behind the west boom caused moderate passage of ice over and under the boom arm. Some ice from above the boom passed behind the west boom, and by evening there was 100% cover of broken ice. The east boom still retained no ice.	Ice movement behind and above the west boom released a moderate flow of ice, both over the boom and through the boom opening, throughout the day.	Partly cloudy.
18 Mar	26	20	14	9.6 WNW	Morning West Boom - 100% East Boom - None Deterioration of field behind west boom reduced coverage there to 60% by late afternoon.	One small passage of ice over the west boom arm.	Partly cloudy.
19 Mar	51	33	15	10.6 ESE	West Boom - 75% East Boom - None Some movement behind the west boom, with small movements of ice over the boom and into the boom area.	Small amounts of ice flowed over the west boom arm.	Sunny.
20 Mar	44	37	30	8.8 W	Morning West Boom - 50% East Boom - None Passages of ice over the boom reduced the west boom field to about 10% cover by evening.	Small to moderate ice passage over the west boom, throughout the day.	Sunny.
21 Mar	33	31	28	18.6 NW	West boom retained a 50% cover of stable frazil ice.	None	Soo Harbor mostly ice free except for ice behind the west boom. Sunny.

Date	Air Temperature (°F)		Average Wind Speed (MPH) and Direction		Ice Behind Booms		Ice Passing Into Little Rapid Cut		Comments
	Max.	Ave.	Max.	Min.					
22 Mar	28	24	19	13.1	NW	West Boom - 75% frazil ice East Boom - None Stable.	None		
23 Mar	33	28	22	6.0	ESE	Unchanged.	None		
24 Mar	34	27	20	7.3	NNW	Unchanged.	None		
25 Mar	33	28	23	11.1	NW	Morning West Boom - 75% fragile ice East Boom - None Part of the west boom was re-moved, resulting in passage of the remaining ice field downstream into Little Rapids Cut.	One moderate ice flow as a result of the removal of the lower portion of the west boom.		
26 Mar	42	28	14	4.0	W	None	None		Remainder of west boom removed this day.
27 Mar--									
1 Apr						None	None		
2 Apr						None	None		East boom completely removed.

APPENDIX B

AERIAL PHOTO RECORD
AT THE LITTLE RAPIDS CUT
ICE BOOM

WINTER OF 1979-80

AERIAL PHOTO RECORD AT THE ICE BOOM

3 January - Soo Harbor was ice free. There was no ice behind the booms or in Little Rapids Channel or Upper Lake Nicolet.

15 January - The portion of Soo Harbor above the Edison Sault Powerhouse was completely ice free. The lower portion of Soo Harbor was about 50% covered. Open sections of the lower harbor included the Edison Sault Powerhouse tailrace, the ship track between the booms and the section immediately above the booms. Covered areas of the harbor included the area behind the booms and the area immediately above the head of North Channel. Cover was 100% behind the West Boom except for a crack that had developed between the ice field and the American shore. Coverage was almost complete behind the East Boom, but a small open pool existed between the base of the boom and the Mouse Island shore. Little Rapids Cut was open as far as Frechette Point.

29 January - The only open sections of Soo Harbor were the area below the compensating works including the rapids and the U.S. Powerhouse head and tail races, which merged with an open section along the Canadian shore. The Edison Sault Power Canal was ice free. All lock approaches, the ship track, and the area behind both booms were completely ice covered. Little Rapids Cut was open from the booms to Frechette Point.

6 February - Ice behind the booms appeared to be thinner and a small lead had developed in the old ship track just above the booms, but otherwise, coverage was the same as on the previous flight.

25 February - Except for the lock approaches and behind the booms, Soo Harbor was entirely ice free. A small ice field remained behind the East Boom. The West Boom retained a larger field, which was only about as wide as the boom arm and extended only a few hundred feet upstream into Soo Harbor. This field had broken away from the U.S. shore just above the boom, and directly behind the West Boom was broken ice. Little Rapids Cut was open well into Lake Nicolet.

6 March - Except for the lock approaches, which were completely covered, the harbor was open to just downstream of the Edison Sault Powerhouse. Below this the harbor was covered by broken patches of skim ice, with some areas of substantial cover. A considerable ice field existed behind the East Boom, but with open areas directly behind the boom. The West Boom was retaining broken ice from the ice cover along the American shore. Little Rapids Cut was open through to Lake Nicolet.

19 March - Soo Harbor was completely ice free except for a small field of broken ice behind the lower portion of the East Boom and another field of broken ice immediately behind the West Boom. Little Rapids Cut was open into Lake Nicolet.

24 March - Unchanged from 19 March except that the ice field behind the East Boom was further reduced in size and both boom fields were even more broken than had been the case on the earlier date.

31 March - Soo Harbor was almost completely ice free. There was broken ice in the upstream lock approaches and above the compensating works. Small amounts of broken drift ice were also present below the rapids and locks. Small amounts of very broken ice remained behind the East Boom. The West Boom was removed on 26 March. Little Rapids Cut was ice free.

APPENDIX C

SUMMARY OF ICE THICKNESS MEASUREMENTS
ON ST. MARYS RIVER

WINTER OF 1968-69 TO PRESENT

The ice thickness and characteristic data acquired during the past 12 winter seasons are included in this appendix. The format chosen for the presentation of this data includes a breakdown for each station covering approximate weekly time periods from the second week of December through the third week of April. These approximate weekly periods were chosen to be:

December - 1-8, 9-16, 17-24, and 25-31;
January - 1-8, 9-16, 17-24, and 25-31;
February - 1-7, 8-14, 15-21, and 22-28
 (except leap years - 22-29);
March - 1-8, 9-16, 17-24, and 25-31; and
April - 1-8, 9-15, 16-23, and 24-30.

All values are given in feet with the dates of the measurements given in parenthesis following the observed values.

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 1 - EAST CENTER PIER

SEASON	2ND WK. DEC. (9-16)	3RD WK. DEC. (17-24)	4TH WK. DEC. (25-31)	1ST WK. JAN. (1-8)	2ND WK. JAN. (9-16)	3RD WK. JAN. (17-24)
68-69	---	---	---	---	---	0.65 90%-SN (1/20)
69-70	---	---	---	---	0.35 100%-SN (1/15)	0.68 100%-BI (1/22) OW
70-71	---	---	---	---	---	(1/22) UC
71-72	---	---	---	---	---	(1/21) OW
72-73	---	---	---	---	(1/9), (1/16)	(1/23)
73-74	---	---	---	OW (1/3)	OW (1/10)	OW OW (1/17), (1/24) OW
74-75	---	---	---	---	---	(1/23) UC
75-76	---	---	---	---	(1/15) UC	(1/22)
76-77	OW (12/13)	OW (12/22)	OW (12/27)	OW (1/3)	(1/10)	1.08 62%-BI (1/17)
77-78	---	---	---	OW (1/3)	OW UA, UC (1/11), (1/16) UA	UA, UC (1/23)
78-79	---	---	---	---	(1/16)	(1/23) OW
79-80	---	---	---	---	---	(1/18)

KEY: OW=OPEN WATER; UC=UNSAFE COVER; UA=UNSAFE ACCESS;
BI=BLUE ICE; SN=SNOW ICE
---NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 1 - EAST CENTER PIER

SEASON	4TH WK. JAN. (25-31)	1ST WK. FEB. (1-7)	2ND WK. FEB. (8-14)	3TH WK. FEB. (15-21)	4TH WK. FEB. (22-28)	1ST WK. MAR. (1-8)
68-69	0.84 50X-SN (1/27)	0.94 40X-SN (2/3)	1.19 1.19 1.20 10X-SN 84X-BI 83X-BI (2/10), (2/12), (2/14)	1.23 1.21 81X-BI 74X-BI (2/17), (2/19)	1.29 1.31 1.30 85X-BI 84X-BI 85X-BI (2/24), (2/26), (2/28)	1.29 1.21 1.32 78X-BI 74X-BI 76X-BI (3/3), (3/5), (3/7)
69-70	0.80 100X-BI (1/29)	1.15 78X-BI (2/5)	1.15 65X-BI (2/12)	1.20 71X-BI (2/19)	1.30 73X-BI (2/26)	1.35 63X-BI (3/5)
70-71	UC (1/29)	UC (1/4)	1.00 85X-BI (2/12)	1.10 68X-BI (2/18)	1.20 67X-BI (2/25)	1.40 50X-BI (3/4)
71-72	UC (1/28)	0.75 67X-BI (2/4)	1.10 86X-BI (2/11)	1.10 82X-BI (2/27)	1.44 69X-BI (2/25)	1.28 76X-BI (3/4)
72-73	UC (1/30)	OW (2/6)	0.43 100X-BI (2/13)	0.86 100X-BI (2/21)	0.75 100X-BI (2/27)	0.90 89X-BI (3/6)
73-74	---	UC UC (2/1), (2/7)	0.88 100X-BI (2/14)	---	1.08 100X-BI (2/28)	---
74-75	OW (1/30)	OW (2/6)	OW (2/13)	OW (2/20)	OW (2/27)	OW (3/6)
75-76	UC (1/29)	UC (2/6)	UC (2/13)	UC (2/19)	OW (2/27)	OW (3/6)
76-77	1.17 50X-BI (1/25)	1.33 94X-BI (2/1)	1.75 1.75 81X-BI 89X-BI (2/8), (2/14)	---	1.42 1.83 88X-BI 55X-BI (2/22), (2/28)	1.42 41X-BI (3/7)
77-78	UA, OW (1/30)	UA, UC (2/7)	UA, UC (2/13)	UA, OW (2/21)	UA, OW (2/27)	OW (3/6)
78-79	UA (1/30)	UA (2/7)	UA (2/14)	UA (2/20)	UA (2/26)	OW (3/6)
79-80	UA (1/25)	UA (2/1)	UA (2/8)	UA (2/15)	OW UA (2/22), (2/29)	---

KEY: OW-OPEN WATER; UC-UNSAFE COVER; UA-UNSAFE ACCESS;
BI-BLUE ICE; SN-SNOW ICE
---NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 1 - EAST CENTER PIER

SEASON	2ND WK. MAR. (9-16)	3RD WK. MAR. (17-24)	4TH WK. MAR. (25-31)	1ST WK. APR. (1-8)	2ND WK. APR. (9-15)	3RD WK. APR. (16-23)
68-69	1.32 1.45 1.39 83X-BI 83X-BI 792-BI (3/10), (3-12), (3/14)	1.40 1.25 0.00 792-BI 100Z-BI (3/17), (3/20), (3/24)	0.00 (3/27)	---	---	---
69-70	1.40 100Z-BI (3/12)	OW (3/19)	---	---	---	---
70-71	1.45 48Z-BI (3/11)	1.50 1.62 50Z-BI, 57Z-BI (3/18), (3/24)	---	1.60 50Z-BI (4/1)	---	---
71-72	1.78 49Z-BI (3/13)	1.49 70Z-BI (3/20)	1.60 25Z-BI (3/27)	UA (4/4)	OW (4/11)	---
72-73	OW (3/14)	---	---	---	---	---
73-74	OW (3/14)	OW (3/21)	OW (3/28)	OW (4/4)	---	---
74-75	OW (3/13)	OW (3/20)	OW (3/27)	OW (4/3)	OW (4/10)	---
75-76	UC (3/11)	UC (3/18)	OW (3/26)	OW (4/2)	---	---
76-77	OW (3/15)	OW (3/22)	OW (3/29)	---	---	---
77-78	OW (3/13)	OW (3/21)	OW (3/28)	OW (4/3)	---	---
78-79	OW (3/13)	OW (3/20)	OW (3/27)	OW (4/3)	OW (4/10)	---
79-80	OW (3/10)	OW OW (3/17), (3/21)	---	---	---	---

KEY: OW-OPEN WATER; UC-UNSAFE COVER; UA-UNSAFE ACCESS
BI-BLUE ICE; SN-SNOW ICE
--NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT

ST. MARYS RIVER
ICE THICKNESS (feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 2 - PITTSBURGH DOCK

SEASON	2ND WK. DEC. (9-16)	3RD WK. DEC. (17-24)	4TH WK. DEC. (25-31)	1ST WK. JAN. (1-8)	2ND WK. JAN. (9-16)	3RD WK. JAN. (17-24)
68-69	---	---	---	---	---	0.31 100%-SN (1/20)
69-70	---	---	---	---	UC (1/15)	0.60 100%-BI (1/22) OW
70-71	---	---	---	---	---	(1/22) UC
71-72	---	---	---	---	---	(1/21) OW
72-73	---	---	---	---	UC OW (1/9), (1/16)	(1/23) OW OW
73-74	---	---	---	OW (1/3)	(1/10)	(1/17), (1/24) OW
74-75	---	---	---	---	---	(1/23) UC
75-76	---	---	---	---	OW (1/15)	(1/22)
76-77	OW (12/13)	UC, UA (12/22)	UC, UA (12/27)	OW (1/3)	0.75 61%-BI (1/10) OW UA, UC (1/11), (1/16)	0.75 78%-BI (1/17) UA, UC (1/23) UA
77-78	---	---	---	OW (1/3)	---	(1/23) OW
78-79	---	---	---	---	(1/16)	(1/23) OW
79-80	---	---	---	---	---	(1/18)

KEY: OW-OPEN WATER; UC-UNSAFE COVER; UA-UNSAFE ACCESS;
BI-BLUE ICE; SN-SNOW ICE
---NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 2 - PITTSBURG DOCK

SEASON	4TH WK. JAN. (25-31)	1ST WK. FEB. (1-7)	2ND WK. FEB. (8-14)	3RD WK. FEB. (15-21)	4TH WK. FEB. (22-28)	1ST WK. MAR. (1-8)
68-69	0.46 75X-SN (1/27)	0.70 100X-SN (2/3)	0.95 75X-BI 80X-BI 82X-BI (2/10), (2/12), (2/14)	1.12 80X-BI 80X-BI (2/17), (2/19)	1.10 73X-BI 74X-BI 76X-BI (2/24), (2/26), (2/28)	1.16 78X-BI 71X-BI 75X-BI (3/3), (3/5), (3/7)
69-70	0.55 100X-BI (1/29)	0.95 58X-BI (2/5)	0.65 54X-BI (2/12)	0.90 69X-BI (2/19)	0.80 50X-BI (2/26)	0.20 50X-BI (3/5)
70-71	UC (1/29)	0.83 52X-BI (2/4)	1.05 57X-BI (2/12)	1.15 48X-BI (2/18)	1.40 54X-BI (2/25)	1.50 33X-BI (3/6)
71-72	UC (1/28)	0.68 85X-BI (2/4)	0.88 72X-BI (2/11)	1.12 68X-BI (2/17)	1.21 67X-BI (2/25)	1.15 63X-BI (3/4)
72-73	UC (1/30)	UC (2/6)	0.76 87X-BI (2/13)	0.98 85X-BI (2/21)	1.05 86X-BI (2/27)	0.95 58X-BI (3/6)
73-74	---	UC UC (2/1), (2/7)	0.96 100X-BI (2/14)	---	0.92 100X-BI (2/28)	---
74-75	OW (1/30)	OW (2/6)	OW (2/13)	OW (2/20)	OW (2/27)	OW (3/6)
75-76	UC (1/29)	UC (2/6)	UC (2/13)	UC (2/19)	OW (2/27)	OW (3/4)
76-77	UA (1/25)	UA (2/1)	UA, UC 0.67 50X-BI (2/8), (2/14)	---	UA UA (2/22), (2/28)	UA (3/7)
77-78	1.42 94X-BI (1/30)	1.00 98X-BI (2/7)	1.12 89X-BI (2/13)	1.21 90X-BI (2/21)	1.00 92X-BI (2/21)	1.08 100X-BI (3/6)
78-79	UA (1/30)	1.08 38X-BI (2/7)	1.42 59X-BI (2/14)	1.67 60X-BI (2/20)	1.50 44X-BI (2/26)	1.08 69X-BI (3/6)
79-80	UA (1/25)	UA (2/1)	UA (2/8)	UA (2/15)	OW OW (2/22), (2/29)	---

KEY: OW-OPEN WATER; UC-UNSAFE COVER; UA-UNSAFE ACCESS;
BI-BLUE ICE; SN-SNOW ICE
---NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 2 - PITTSBURG DOCK

SEASON	2ND WK. MAR. (9/16)	3RD WK. MAR. (17-24)	4TH WK. MAR. (25-31)	1ST WK. APR. (1-8)	2ND WK. APR. (9-15)	3RD WK. APR. (16-23)
68-69	0.93 1.05 1.02 542-BI 572-BI 592-BI (3/10), (3/12), (3/14)	0.77 0.00 0.00 652-BI (3/17), (3/20), (3/24)	0.00 (3/27)	---	---	---
69-70	0.40 1002-SN (3/12)	OW (3/19)	---	---	---	---
70-71	1.35 332-BI (3/11)	1.25 1.16 202-BI 222-BI (3/18), (3/24)	---	1.10 232-BI (4/1)	OW (4/9)	---
71-72	1.25 642-BI (3/13)	1.00 642-BI (3/20)	1.75 342-BI (3/27)	UA (4/4)	OW (4/11)	---
72-73	OW (3/14)	---	---	---	---	---
73-74	UC (3/16)	OW (3/21)	OW (3/28)	OW (4/4)	---	---
74-75	OW (3/13)	OW (3/20)	OW (3/27)	OW (4/3)	OW (4/10)	---
75-76	UC (3/11)	UC (3/18)	OW (3/26)	OW (4/2)	---	---
76-77	OW (3/15)	OW (3/22)	OW (3/29)	---	---	---
77-78	UA (3/13)	OW (3/21)	OW (3/28)	OW (4/3)	---	---
78-79	UA (3/13)	OW (3/20)	OW (3/27)	OW (4/3)	OW (4/10)	---
79-80	OW (3/10)	OW OW (3/17), (3/21)	---	---	---	---

KEY: OW=OPEN WATER; UC=UNSAFE COVER; UA=UNSAFE ACCESS;
BI=BLUE ICE; SN=SNOW ICE
--NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 3 - HEAD LITTLE RAPIDS

SEASON	2ND WK. DEC. (9-16)	3RD WK. DEC. (17-14)	4TH WK. DEC. (25-31)	1ST WK. JAN. (1-8)	2ND WK. JAN. (9-16)	3RD WK. JAN. (17-24)
68-69	---	---	---	---	---	0.00 (1/20) UC
69-70	---	---	---	---	UC (1/15)	(1/22) OW
70-71	---	---	---	---	---	(1/22) UC
71-72	---	---	---	---	---	(1/21) OW
72-73	---	---	---	---	OW OW (1/9), (1/16)	(1/23) OW UC
73-74	---	---	---	OW (1/3)	OW (1/10)	(1/17), (1/24) OW
74-75	---	---	---	---	---	(1/23) UC
75-76	---	---	---	---	OW (1/15)	(1/22) OW
76-77	OW (12/13)	OW (12/22)	OW (12/27)	OW (1/3)	OW OW (1/10)	(1/17)
77-78	---	---	---	OW (1/3)	OW OW (1/11), (1/16)	(1/23) OW
78-79	---	---	---	---	UA (1/16)	(1/23) OW
79-80	---	---	---	---	---	(1/18)

KEY: OW-OPEN WATER; UC-UNSAFE COVER; UA-UNSAFE ACCESS;
BI-BLUE ICE; SN-SNOW ICE
--NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 3 - HEAD LITTLE RAPIDS

SEASON	4TH WK. JAN. (25-31)	1ST WK. FEB. (1-7)	2ND WK. FEB. (8-14)	3RD WK. FEB. (15-21)	4TH WK. FEB. (22-28)	1ST WK. MAR. (1-8)
68-69	SKIN (1/27)	UC (2/3)	0.93 0.93 1.00 100%-BI 100%-BI 100%-BI (2/10), (2/12), (2/14)	1.10 1.00 100%-BI 100%-BI (2/17), (2/19)	UC UC UC (2/24), (2/26), (2/28)	UC UC UC (3/3), (3/5), (3/7)
69-70	UC (1/29)	0.85 41%-BI (2/5)	UC (2/12)	0.90 69%-BI (2/19)	1.00 70%-BI (2/20)	OW (3/5)
70-71	UC (1/29)	OW (2/4)	UC (2/12)	UC (2/18)	UC (2/25)	UC (3/4)
71-72	UC (1/28)	UC (2/4)	1.26 52%-BI (2/11)	1.27 44%-BI (2/17)	1.52 52%-BI (2/25)	1.37 41%-BI (3/6)
72-73	OW (1/30)	UC (2/6)	0.65 62%-BI (2/13)	0.82 88%-BI (2/21)	0.75 87%-BI (2/27)	UC (3/6)
73-74	---	OW UC (2/1), (2/7)	0.75 89%-BI (2/14)	---	0.79 95%-BI (2/28)	---
74-75	OW (1/30)	OW (2/6)	OW (2/13)	OW (2/20)	OW (2/27)	OW (3/6)
75-76	UC (1/29)	UC (2/6)	UC (2/13)	UC (2/19)	UC (2/27)	OW (3/4)
76-77	OW (1/25)	UC, OW (2/1)	OW OW (2/18), (2/14)	---	OW OW (2/22), (2/28)	OW (3/7)
77-78	UA, OW (1/30)	OW (2/7)	UA, OW (2/13)	UA, OW (2/21)	UA (2/27)	UA, OW (3/6)
78-79	OW (1/30)	OW (2/7)	OW (2/14)	OW (2/20)	OW (2/26)	OW (3/6)
79-80	OW (1/25)	OW (2/1)	OW (2/8)	OW (2/15)	OW OW (2/22), (2/29)	---

KEY: OW=OPEN WATER; UC=UNSAFE COVER; UA=UNSAFE ACCESS;
BI=BLUE ICE; SN=SNOW ICE
--NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 3 - HEAD LITTLE RAPIDS

SEASON	2ND WK. MAR. (9-16)	3RD WK. MAR. (17-24)	4TH WK. MAR. (25-31)	1ST WK. APR. (1-8)	2ND WK. APR. (9-15)	3RD WK. APR. (16-23)
68-69	UC UC 0.00 (3/10), (3/12), (3/14)	0.00 0.00 0.00 (3/17), (3/20), (3/24)	0.00 (3/27)	---	---	---
69-70	OW (3/12)	OW (3/19)	---	---	---	---
70-71	UC (3/11)	OW OW (3/18), (3/24)	---	OW (4/1)	OW (4-9)	---
71-72	1.40 292-BI (3/13)	0.92 352-BI (3/20)	UA (3/27)	UA (4/4)	OW (4/11)	---
72-73	OW (3/14)	---	---	---	---	---
73-74	OW (3/14)	OW (3/21)	OW (3/28)	OW (4/4)	---	---
74-75	OW (3/13)	OW (3/20)	OW (3/27)	OW (4/3)	OW (4/10)	---
75-76	UC (3/11)	UC (3/18)	OW (3/26)	OW (4/2)	---	---
76-77	UC, OW (3/15)	OW (3/22)	OW (3/29)	---	---	---
77-78	UA, OW (3/13)	OW (3/21)	OW (3/28)	OW (4/3)	---	---
78-79	OW (3/13)	OW (3/20)	OW (3/27)	OW (4/3)	OW (4/13)	---
79-80	OW (3/10)	OW OW (3/17), (3/21)	---	---	---	---

KEY: OW=OPEN WATER; UC=UNSAFE COVER; UA=UNSAFE ACCESS;
BI=BLUE ICE; SN=SNOW ICE
---NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 4 - FRECHETTE POINT

SEASON	2ND WK. DEC. (9-16)	3RD WK. DEC. (17-24)	4TH WK. DEC. (25-31)	1ST WK. JAN. (1-8)	2ND WK. JAN. (9-16)	3RD WK. JAN. (17-24)
68-69	---	---	---	---	---	0.29 100%-SN (1/20)
69-70	---	---	---	---	UC (1/15)	0.49 100%-BI (1/22) UC
70-71	---	---	---	---	---	(1/22) UC
71-72	---	---	---	---	---	(1/21) UC
72-73	---	---	---	---	UC UC (1/9), (1/16)	(1/23) 0.50 0.62 33%-BI 33%-BI (1/17), (1/24) UC
73-74	---	---	---	UC (1/3)	0.38 82%-BI (1/10)	0.33 100%-BI (1/22) 1.33 81%-BI (1/17) UA, UC
74-75	---	---	---	---	---	(1/23) 0.33 100%-BI (1/22) 1.33 81%-BI (1/17) UA, UC
75-76	---	---	---	---	OW (1/15)	(1/23) 0.33 100%-BI (1/22) 1.33 81%-BI (1/17) UA, UC
76-77	UC (12/11)	UC (12/22)	OW, UC, UA (12/27)	UC (1/3)	1.19 90%-BI (1/10) OW UA, UC (1/11), (1/16)	(1/23) 0.96 100%-BI (1/23) OW
77-78	---	---	---	OW (1/3)	---	(1/23) 0.96 100%-BI (1/23) OW
78-79	---	---	---	---	0.92 100%-BI (1/16)	(1/23) 0.96 100%-BI (1/23) OW
79-80	---	---	---	---	---	(1/18)

KEY: OW-OPEN WATER; UC-UNSAFE COVER; UA-UNSAFE ACCESS;
BI-BLUE ICE; SN-SNOW ICE
--NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 4 - FRECHETTE POINT

SEASON	4TH WK. JAN (25-31)	1ST WK. FEB. (1-7)	2ND WK. FEB. (8-14)	3RD WK. FEB. (15-21)	4TH WK. FEB. (22-28)	1ST WK. MAR. (1-8)
68-69	0.85 50%-SN (1/27)	1.06 75%-SN (2/3)	1.38 1.48 1.17 71%-BI 74%-BI 68%-BI (2/10), (2/12), (2/14)	1.30 1.34 69%-BI 67%-BI (2/17), (2/19)	1.11 1.00 1.00 63%-BI 60%-BI 60%-BI (2/24), (2/26), (2/28)	1.00 1.01 0.94 60%-BI 59%-BI 53%-BI (3/3), (3/5), (3/7)
69-70	0.49 80%-BI (1/29)	0.80 50%-BI (2/5)	0.90 56%-BI (2/12)	0.55 27%-BI (2/19)	0.55 27%-BI (2/26)	OW
70-71	UC (1/29)	1.35 85%-BI (2/4)	1.50 87%-BI (2/12)	1.70 76%-BI (2/18)	1.75 74%-BI (2/25)	1.70 59%-BI (3/4)
71-72	UC (1/28)	1.02 65%-BI (2/4)	1.31 62%-BI (2/11)	1.21 77%-BI (2/17)	1.20 67%-BI (2/25)	1.48 53%-BI (3/6)
72-73	UC (1/30)	UC (2/6)	0.95 73%-BI (2/13)	1.00 80%-BI (2/21)	0.92 62%-BI (2/27)	UC (3/6)
73-74	---	0.92 0.88 27%-BI 19%-BI (2/1), (2/7)	1.04 32%-BI (2/14)	---	1.04 40%-BI (2/28)	---
74-75	UC (1/30)	0.58 29%-BI (2/6)	0.83 55%-BI (2/13)	0.83 50%-BI (2/20)	UA (2/27)	UA (3/6)
75-76	0.92 91%-BI (1/29)	1.21 72%-BI (2/6)	1.25 73%-BI (2/13)	1.25 80%-BI (2/19)	1.33 63%-BI (2/27)	1.33 34%-BI (3/4)
76-77	1.29 77%-BI (1/25)	1.90 62%-BI (2/1)	1.58 1.75 66%-BI 60%-BI (2/8), (2/14)	---	1.58 1.67 63%-BI 55%-BI (2/22), (2/28)	2.25 37%-BI (3/7)
77-78	1.38 100%-SN (1/30)	1.69 94%-SN (2/7)	1.79 72%-SN (2/13)	1.75 60%-BI (2/21)	1.42 53%-BI (2/27)	1.33 31%-BI (3/6)
78-79	0.92 53%-BI (1/30)	1.17 71%-BI (2/7)	1.33 78%-BI (2/14)	1.42 65%-BI (2/20)	1.34 65%-BI (2/26)	1.33 50%-BI (3/6)
79-80	UA (1/25)	0.58 14%-BI (2/1)	0.25 100%-BI (2/8)	OW (2/15)	OW 0.42 30%-BI (2/22), (2/29)	---

KEY: OW-OPEN WATER; UC-UNSAFE COVER; UA-UNSAFE ACCESS;
BI-BLUE ICE; SN-SNOW ICE
---NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 4 - FRECHETTE POINT

Season	2ND WK. MAR. (9-16)	3RD WK. MAR. (17-24)	4TH WK. MAR. (25-31)	1ST WK. APR. (1-8)	2ND WK. APR. (9-15)	3RD WK. APR. (16-23)
68-69	0.77 0.85 0.67 52½-BI 47½-BI 75½-BI (3/10), (3/12), (3/14)	0.61 UC 0.00 66½-BI (3/17), (3/20), (3/24)	0.00 (3/27)	---	---	---
69-70	OW (3/12)	OW (3/19)	---	---	---	---
70-71	1.55 1.45 48½-BI 31½-BI (3/11)	1.50 1.45 33½-BI 31½-BI (3/18), (3/24)	---	0.60 0½-BI (4/1)	OW (4/9)	---
71-72	1.25 48½-BI (3/13)	1.10 45½-BI (3/20)	1.65 18½-BI (3/27)	UA (4/4)	UC (4/11)	---
72-73	OW (3/14)	---	---	---	---	---
73-74	0.33 10½-BI (3/14)	OW (3/21)	UC (3/28)	OW (4/4)	---	---
74-75	UA (3/13)	UA, UC (3/20)	UC (3/27)	UC (4/3)	OW (4/10)	---
75-76	1.58 32½-BI (3/11)	1.67 50½-BI (3/18)	OW (3/26)	OW (4/2)	---	---
76-77	UA (3/15)	OW (3/22)	OW (3/29)	---	---	---
77-78	1.17 36½-BI (3/13)	UC (3/21)	OW (3/28)	OW (4/3)	---	---
78-79	1.17 79½-BI (3/13)	OW (3/20)	OW (3/27)	OW (4/3)	OW (4/10)	---
79-80	OW (3/10)	OW OW (3/17), (3/21)	---	---	---	---

KEY: OW=OPEN WATER; UC=UNSAFE COVER; UA=UNSAFE ACCESS;
BI=BLUE ICE; SN=SNOW ICE
--NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 5 - SIX MILE POINT

SEASON	2ND WK. DEC. (9-16)	3RD WK. DEC. (17-24)	4TH WK. DEC. (25-31)	1ST WK. JAN. (1-8)	2ND WK. JAN. (9-16)	3RD WK. JAN. (17-24)
68-69	---	---	---	---	---	0.65 100%-BI (1/20)
69-70	---	---	---	---	UC (1/15)	0.79 100%-BI (1/22)
70-71	---	---	---	---	---	0.95 84%-BI (1/22)
71-72	---	---	---	---	---	UC (1/21)
72-73	---	---	---	---	0.65 0.61 75%-BI 92%-BI (1/9), (1/16)	0.81 88%-BI (1/23)
73-74	---	---	---	UC (1/3)	0.71 100%-BI (1/10)	0.75 0.88 100%-BI 71%-BI (1/17), (1/24)
74-75	---	---	---	---	---	UC (1/23)
75-76	---	---	---	---	UC (1/15)	0.54 85%-BI (1/22)
76-77	UC (12/13)	0.62 87%-BI** (12/22)	0.42 100%-SN** (12/27)	0.83 60%-BI (1/3)	1.08 75%-BI (1/10)	1.08 54%-BI (1/17)
77-78	---	---	---	ON (1/3)	UC 0.88 100%-SN (1/11), (1/16) (5)	1.58 95%-SN (1/23)
78-79	---	---	---	---	1.00 92%-BI (3/16)	1.00 75%-BI (1/23)
79-80	---	---	---	---	---	ON (1/18)

KEY: ON-OPEN WATER; UC-UNSAFE COVER; UA-UNSAFE ACCESS;
BI-BLUE ICE; SN-SNOW ICE
--NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

**READINGS TAKEN 200' OFFSHORE ON 12/22/76 AND 400' OFFSHORE ON 12/27/76

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 5 - SIX MILE POINT

SEASON	4TH WK. JAN. (25-31)	1ST WK. FEB. (1-7)	2ND WK. FEB. (8-14)	3RD WK. FEB. (15-21)	4TH WK. FEB. (22-28)	1ST WK. MAR. (1-8)
68-69	0.87 100%-BI (1/27)	0.95 90%-BI (2/3)	1.15 1.10 1.16 87%-BI 86%-BI 86%-BI (2/10), (2/12), (2/14)	1.26 1.20 87%-BI 83%-BI (2/17), (2/19)	1.23 1.23 1.15 73%-BI 73%-BI 78%-BI (2/24), (2/26), (2/28)	1.07 1.09 1.05 75%-BI 73%-BI 67%-BI (3/3), (3/5), (3/7)
69-70	0.54 100%-BI (1/29)	1.20 58%-BI (2/5)	1.20 58%-BI (2/12)	1.30 62%-BI (2/19)	0.95 63%-BI (2/26)	1.00 40%-BI (3/5)
70-71	1.30 65%-BI (1/29)	1.35 74%-BI (2/4)	1.32 77%-BI (2/12)	1.70 65%-BI (2/18)	1.65 58%-BI (2/25)	1.75 66%-BI (3/4)
71-72	0.88 33%-BI (1/28)	0.81 38%-BI (2/4)	1.10 64%-BI (2/11)	1.11 38%-BI (2/17)	1.36 41%-BI (2/25)	1.22 57%-BI (3/6)
72-73	0.89 100%-BI (1/30)	1.15 87%-BI (2/6)	1.25 86%-BI (2/17)	1.30 73%-BI (2/21)	1.30 85%-BI (2/27)	1.25 84%-BI (3/6)
73-74	---	1.04 1.17 60%-BI 79%-BI (2/1), (2/7)	1.08 62%-BI (2/14)	---	1.38 70%-BI (2/28)	---
74-75	0.33 50%-BI (1/30)	0.71 59%-BI (2/6)	0.74 45%-BI (2/13)	1.04 28%-BI (2/20)	0.96 26%-BI (2/27)	1.21 14%-BI (3/6)
75-76	0.79 68%-BI (1/29)	1.17 71%-BI (2/6)	1.00 83%-BI (2/13)	1.08 85%-BI (2/19)	1.42 53%-BI (2/27)	1.33 47%-BI (3/4)
76-77	1.21 66%-BI (1/25)	0.92 73%-BI (2/1)	1.50 1.29 53%-BI 55%-BI (2/8), (2/14)	---	1.54 1.42 41%-BI 29%-BI (2/22), (2/28)	1.62 18%-BI (3/7)
77-78	1.33 69%-BI (1/30)	1.73 64%-BI (2/7)	1.92 74%-BI (2/13)	2.04 73%-BI (2/21)	1.21 79%-BI (2/27)	2.17 80%-BI (3/6)
78-79	1.08 62%-BI (1/30)	1.33 66%-BI (2/7)	1.75 81%-BI (2/14)	1.25 67%-BI (2/20)	1.58 58%-BI (2/26)	1.25 80%-BI (3/6)
79-80	UA (1/25)	0.83 70%-BI (2/1)	0.96 61%-BI (2/8)	0.92 73%-BI (2/15)	UA 0.58 29%-BI (2/22), (2/29)	---

KEY: OM=OPEN WATER; UC=UNSAFE COVER; UA=UNSAFE ACCESS;
BI=BLUE ICE; SN=SNOW ICE
---NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 5 - SIX MILE POINT

SEASON	2ND WK. MAR. (9-16)	3RD WK. MAR. (17-24)	4TH WK. MAR. (25-31)	1ST WK. APR. (1-8)	2ND WK. APR. (9-15)	3RD WK. APR. (16-23)
68-69	1.13 1.18 1.02 71X-BI 76Z-BI 69X-BI (3/10), (3/12), (3/16)	0.99 0.61 0.00 88Z-BI 100Z-SN (3/17), (3/20), (2/24)	OW (3/27)	---	---	---
69-70	0.75 13Z-BI (3/12)	0.55 100Z-SN (3/19)	---	---	---	---
70-71	1.80 67Z-BI (3/11)	1.90 1.92 53Z-BI 53Z-BI (3/18), (3/24)	---	1.60 44Z-BI (4/1)	UC (4/9)	---
71-72	1.90 32Z-BI (3/12)	1.08 29Z-BI (3/20)	1.10 55Z-BI (3/27)	1.05 + (4/4)	1.83 33Z-BI (4/11)	---
72-73	UC (3/14)	---	---	---	---	---
73-74	0.83 20Z-BI (3/14)	0.33 100Z-SN (3/21)	0.25 100Z-SN (3/28)	UC (4/4)	---	---
74-75	1.21 34Z-BI (3/13)	1.00 21Z-BI (3/20)	0.83 25Z-BI (3/27)	0.79 11Z-BI (4.3)	0.54 100Z-SN (4/10)	---
75-76	1.50 67Z-BI (3/11)	1.92 52Z-BI (3/18)	1.67 55Z-BI (3/26)	UC (4/2)	---	---
76-77	0.50 100Z-SN (3/15)	UA (3/22)	OW (3/29)	---	---	---
77-78	2.33 79Z-BI (3/13)	UA (3/21)	1.79 77Z-BI (3/28)	UA (4/3)	---	---
78-79	1.58 53Z-BI (3/13)	UA (3/20)	UA (3/27)	OW (4/3)	OW (4/10)	---
79-80	0.88 24Z-BI (3/10)	UA UA (3/17), (3/21)	---	---	---	---

KEY: OW=OPEN WATER; UC=UNSAFE COVER; UA=UNSAFE ACCESS;
BI=BLUE ICE; SN=SNOW ICE
---NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

+PERCENTAGE OF BLUE ICE NOT AVAILABLE

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 6 - UPPER LAKE NICOLET

SEASON	2ND WK. DEC. (9-16)	3RD WK. DEC. (17-24)	4TH WK. DEC. (25-30)	1ST WK. JAN. (1-8)	2ND WK. JAN. (9-16)	3RD WK. JAN. (17-24)
68-69	---	---	---	---	---	0.60 100%-BI (1/20)
69-70	---	---	---	---	0.50 100%-BI (1/15)	0.90 100%-BI (1/22)
70-71	---	---	---	---	---	0.86 81%-BI (1/22)
71-72	---	---	---	---	---	0.65 55%-BI (1/21)
72-73	---	---	---	---	0.88 1.05 100%-BI 90%-BI (1/9), (1/16)	0.90 100%-BI (1/23)
73-74	---	---	---	UC (1/3)	0.75 100%-BI (1/10)	0.83 100%-BI (1/17)
74-75	---	---	---	---	---	0.25 67%-BI (1/23)
75-76	---	---	---	---	UC (1/15)	0.75 67%-BI (1/22)
76-77	0.50 100%-BI (12/13)	0.54 85%-BI** (12/22)	0.42 20%-BI** (12/27)	0.92 73%-BI (1/3)	0.88 67%-BI (1/10)	1.17 79%-BI (1/17)
77-78	---	---	---	UC (1/3)	UC 0.54 100%-SN (1/11), (1/16)	0.83 75%-BI (1/23)
78-79	---	---	---	---	1.08 77%-BI (1/16)	1.17 79%-BI (1/23)
79-80	---	---	---	---	---	UA (1/18)

KEY: OW=OPEN WATER; UC=UNSAFE COVER; UA=UNSAFE ACCESS;
BI=BLUE ICE; SN=SNOW ICE
--NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

**READINGS TAKEN 1500' OFFSHORE ON 12/22/76 AND 12/27/76

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 6 - UPPER LAKE NICOLET

SEASON	4TH WK. JAN. (25-31)	1ST WK. FEB. (1-7)	2ND WK. FEB. (8-14)	3RD WK. FEB. (15-21)	4TH WK. FEB. (22-28)	1ST WK. MAR. (1-8)
68-69	0.80 75% BI (1/27)	1.00 80% BI (2/3)	1.08 1.14 1.27 82% BI 82% BI 87% BI (2/10), (2/12), (2/14)	1.35 1.38 89% BI 87% BI (2/17), (2/19)	1.33 1.41 1.35 83% BI 85% BI 89% BI (2/24), (2/26), (2/28)	1.35 1.35 1.40 89% BI 80% BI 79% BI (3/3), (3/5), (3/7)
69-70	0.85 65% BI (1/29)	1.35 70% BI (2/5)	1.20 54% BI (2/12)	1.10 55% BI (2/19)	1.05 43% BI (2/26)	1.40 57% BI (3/5)
70-71	1.06 86% BI (1/29)	1.53 82% BI (2/4)	1.45 86% BI (2/12)	1.60 75% BI (2/18)	1.80 67% BI (2/25)	1.80 50% BI (3/4)
71-72	0.64 100% BI (1/28)	0.76 47% BI (2/4)	1.15 84% BI (2/11)	1.10 64% BI (2/17)	1.53 80% BI (2/25)	1.50 81% BI (3/6)
72-73	1.06 100% BI (1/30)	1.41 96% BI (2/6)	1.53 97% BI (2/13)	1.62 100% BI (2/21)	1.70 100% BI (2/27)	1.50 93% BI (3/6)
73-74	0.83 80% BI (1/24)	1.17 1.12 75% BI 78% BI (2/1), (2/7)	1.42 74% BI (2/14)	---	1.62 69% BI (2/28)	---
74-75	0.75 100% BI (1/30)	0.79 100% BI (2/6)	0.92 50% BI (2/13)	1.25 67% BI (2/20)	1.46 43% BI (2/27)	1.42 51% BI (3/6)
75-76	0.96 74% BI (1/29)	1.12 93% BI (2/6)	1.25 90% BI (2/13)	1.33 91% BI (2/19)	1.33 69% BI (2/27)	1.79 65% BI (3/4)
76-77	1.21 66% BI (1/25)	1.50 80% BI (2/1)	1.42 1.42 65% BI 68% BI (2/8), (2/14)	---	1.83 1.71 41% BI 51% BI (2/22), (2/28)	1.71 45% BI (3/7)
77-78	1.08 85% BI (1/30)	1.25 82% BI (2/7)	1.62 90% BI (2/14)	1.50 89% BI (2/20)	1.62 87% BI (2/26)	1.71 85% BI (3/6)
78-79	1.08 85% BI (1/30)	1.25 83% BI (2/7)	1.33 81% BI (2/14)	1.58 79% BI (2/20)	1.50 72% BI (2/26)	1.25 93% BI (3/6)
79-80	0.83 100% BI (1/25)	0.92 100% BI (2/1)	1.12 100% BI (2/8)	1.08 85% BI (2/15)	0.75 0.96 100% BI 57% BI (2/22), (2/29)	---

KEY: O=OPEN WATER; U=UNSAFE COVER; U=UNSAFE ACCESS;
BI=BLUE ICE; SN=SNOW ICE
---NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

ST. MARYS RIVER
ICE THICKNESS (Feet)
CORPS OF ENGINEERS - SOO AREA OFFICE
STATION NO. 6 - UPPER LAKE NICOLET

SEASON	2ND WK. MAR. (9-16)	3RD WK. MAR. (17-24)	4TH WK. MAR. (25-31)	1ST WK. APR. (1-8)	2ND WK. APR. (9-15)	3RD WK. APR. (16-23)
68-69	1.38 1.41 1.37 80%-BI 78%-BI 80%-BI (3/10), (3/12), (3/14)	1.40 1.17 1.13 79%-BI 68%-BI 100%-SN (3/17), (3/20), (3/24)	0.90 100%-SN (3/27)	---	---	---
69-70	1.10 36%-BI (3/12)	1.20 29%-BI (3/19)	---	---	---	---
70-71	1.90 61%-BI (3/11)	1.90 1.65 53%-BI 45%-BI (3/18), (3/24)	---	2.00 60%-BI (4/1)	1.65 UC 55%-BI (4/9), (4/15)	---
71-72	1.41 79%-BI (3/13)	1.12 76%-BI (3/20)	1.40 43%-BI (3/27)	1.55 + (4/4)	1.60 38%-BI (4/11)	---
72-73	UC (3/14)	---	---	---	---	---
73-74	1.38 73%-BI (3/14)	1.33 50%-BI (3/21)	1.21 79%-BI (3/28)	1.08 77%-BI (4/4)	---	---
74-75	1.62 56%-BI (3/13)	1.58 55%-BI (3/20)	1.54 46%-BI (3/27)	1.58 45%-BI (4/3)	1.62 23%-BI (4/10)	---
75-76	1.50 72%-BI (3/11)	2.17 42%-BI (3/18)	1.75 67%-BI (3/26)	UC (4/2)	---	---
76-77	1.04 44%-BI (3/15)	0.42 100%-SN (3/22)	UC (3/29)	---	---	---
77-78	1.58 89%-BI (3/13)	1.67 90%-BI (3/21)	1.79 79%-BI (3/28)	1.58 89%-BI (4/3)	---	---
78-79	1.67 60%-BI (3/13)	1.33 62%-BI (3/20)	1.46 71%-BI (3/27)	UA (4/3)	OW (4/10)	---
79-80	1.08 85%-BI (3/10)	0.79 UA 68%-BI (3/17), (3/21)	---	---	---	---

KEY: OW=OPEN WATER; UC=UNSAFE COVER; UA=UNSAFE ACCESS;
BI=BLUE ICE; SN=SNOW ICE
--NUMBERS IN PARENTHESES ARE THE DATES OF THE MEASUREMENT.

+PERCENTAGE OF BLUE ICE UNAVAILABLE