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This report is a continuation of the study on the three rivers and includes three additional sites. Two new sites were investigated on the St. Marys River (Dark Hole and Six Mile Point) and the location of the proposed new Peerless Sea Wall was added as a new site on the St. Clair River.

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HANOVER, NEW HAMPSHIRE

SUBMITTED BY: GEORGE R. ALGER, PHD
WATER RESOURCES CONSULTANT

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INTRODUCTION

This is the third in a series of annual reports to CRREL concerning ice related erosion within restricted waters which are utilized for commercial navigation. The first report was entitled 'Field Study of the Effect of Ice on Sediment Transport and Shoreline Erosion, Sault Ste. Marie, Michigan' November 1977, Volumes 1 and 2. The second report (Volume 3) dated November 1978 was expanded to include the St. Clair River and the Detroit River.

This report (Volume 4) is a continuation of the previous study effort on the three rivers and includes three additional sites. Two new sites were investigated on the St. Marys River (Dark Hole and Six Mile Point) and the location of the proposed new Peerless Sea Wall was added as a new site on the St. Clair River.

Site locations and baseline arrangement can be found in the previous reports unless otherwise noted.

A companion study was also initiated during the 1978-79 winter season on the St. Marys River under the auspices of the Great Lakes Basin Commission. This study (also performed by Dr. G. R. Alger) contains findings relevant to the material reported here under the existing CRREL contract. Therefore, the report to GLBC has been included as an appendix to this report. Those having interest in the material contained in this report should review the section in the Appendix, particularly the section on Summary and Conclusions and the Recommendation section.

THE ST. MARYS RIVER

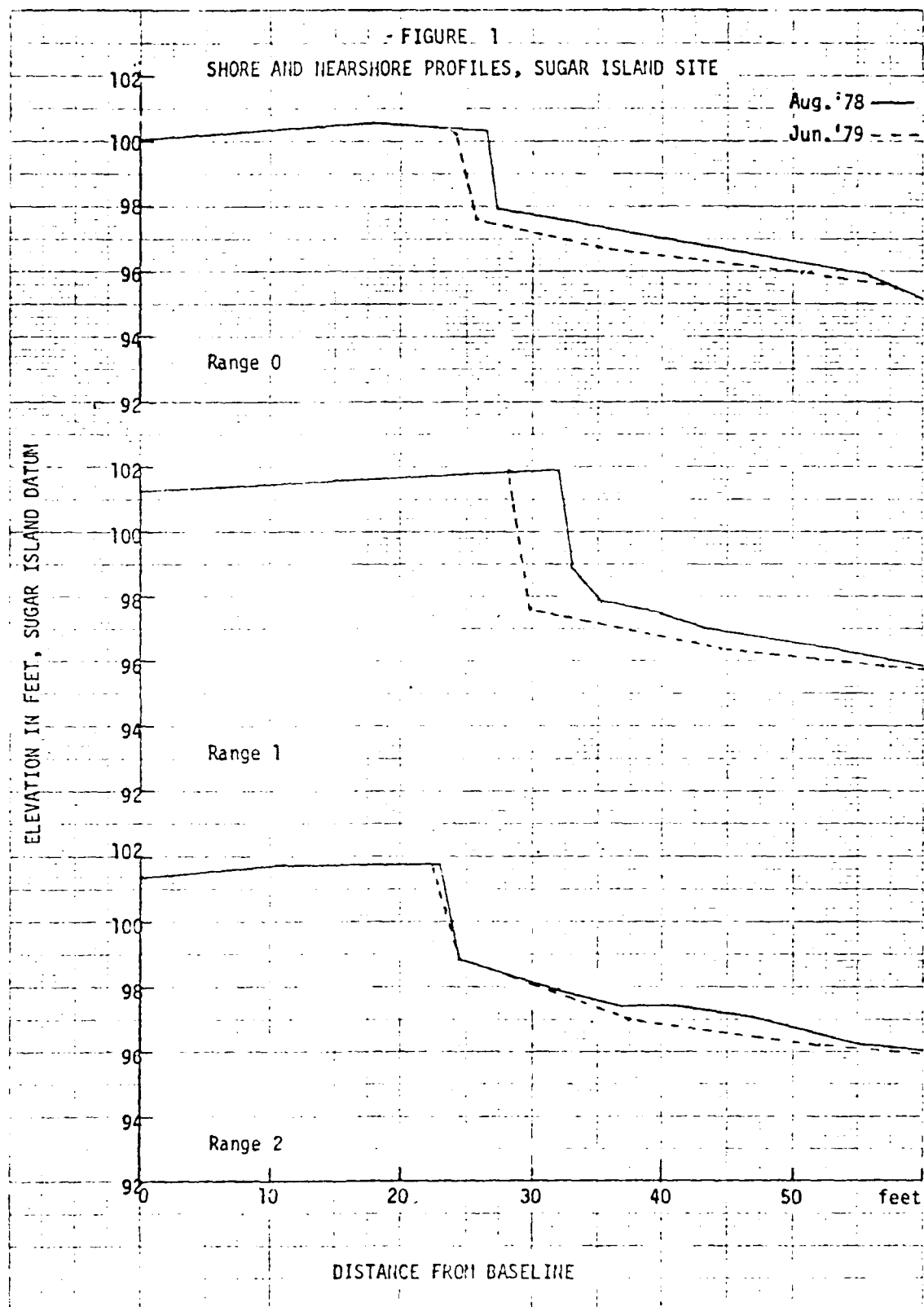
SUGAR ISLAND SITE

Details of site location and range line position may be found in the reports to CRREL of 1977 and 1978, Volumes 1, 2 and 3.

The shore and nearshore topography and bathymetry were determined in June of 1979 using a level and level rod. Similar measurements made at this site during previous years (Volumes 1, 2 and 3) beginning in August of 1976 have shown little or no change during the intervening period. However, the measurements made in June of 1979 under this contract show bluff recession along several of the ranges. This information is illustrated on Figures 1 through 6.

The river elevation (using the Sugar Island Site datum) was 98.44 ft., which is higher than any previous measurements done under this contract. As can be seen from the profiles this river elevation has submerged the lower part of the scarp face and consequently any wave action is transposed directly to the scarp face and would tend to localize such erosional forces there. As has been noted in previous reports the wave action generated by the passage of the many pleasure boats which utilize the river system is likely more detrimental than the waves generated by commercial vessels moving at regulated speed.

Offshore bathymetry for all ranges was also determined in June of 1979 using a boat equipped with a survey fathometer. A



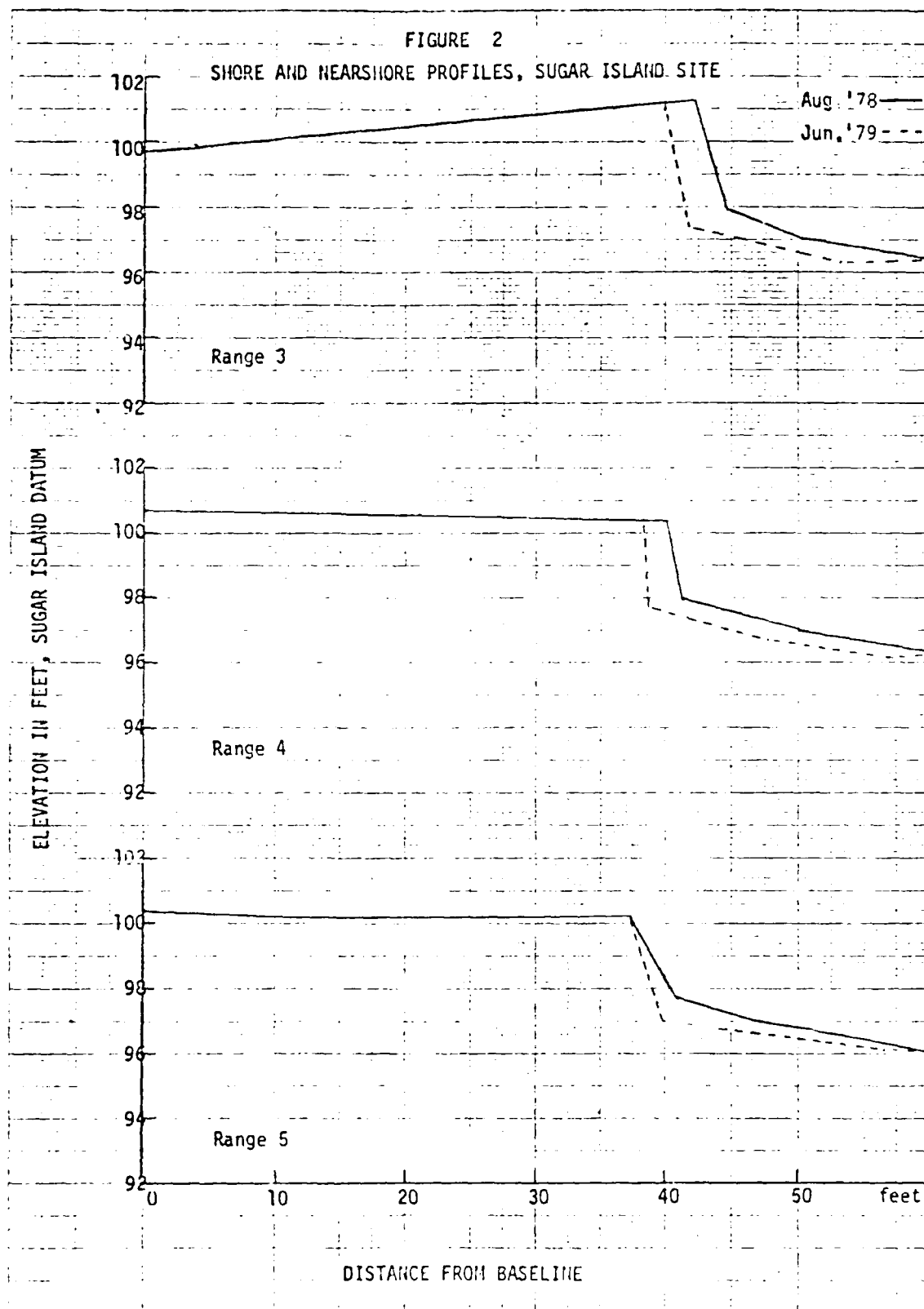


FIGURE 3

SHORE AND NEARSHORE PROFILES, SUGAR ISLAND SITE

Aug. '78 —

Jun. '79 - - -

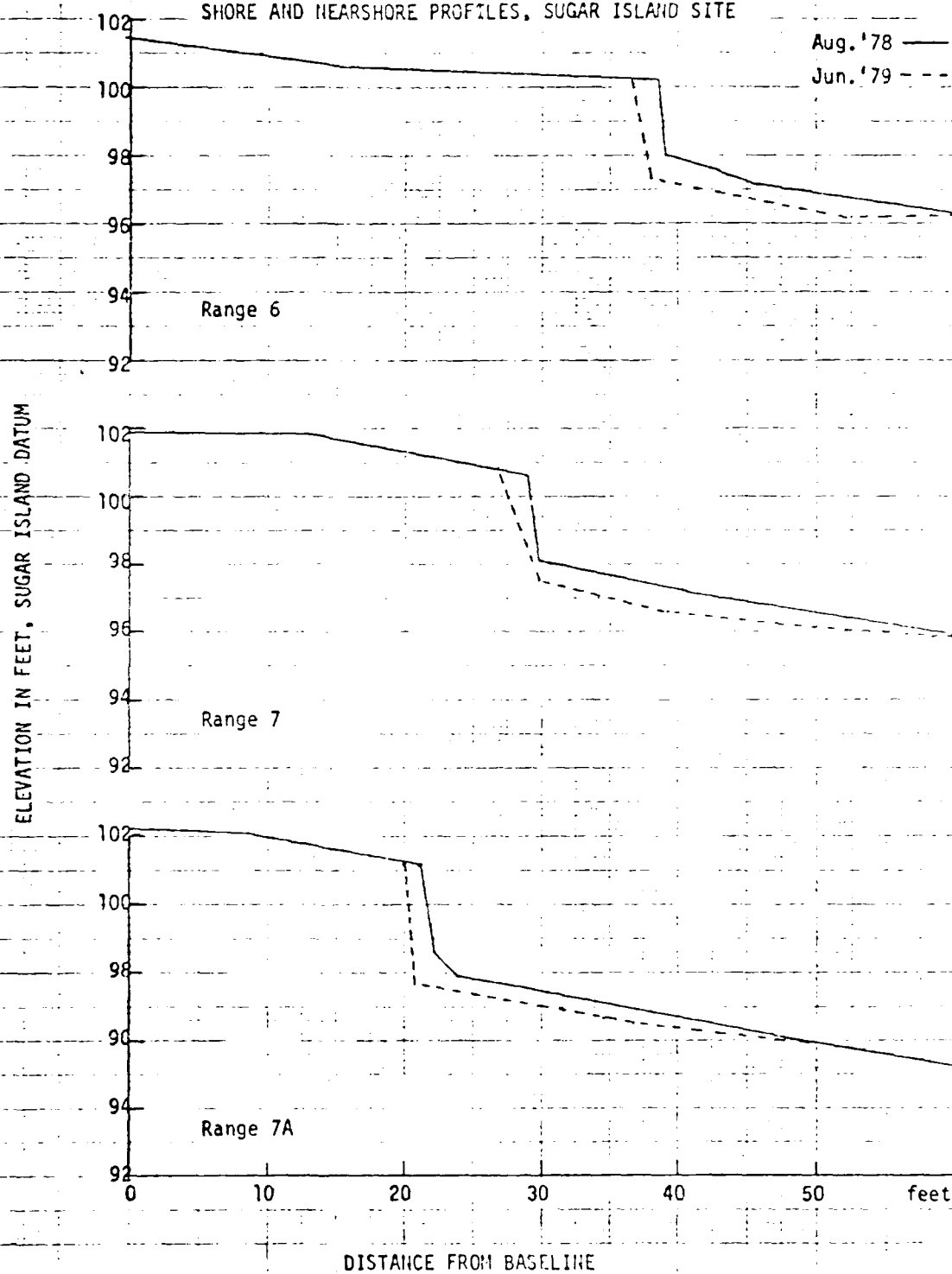
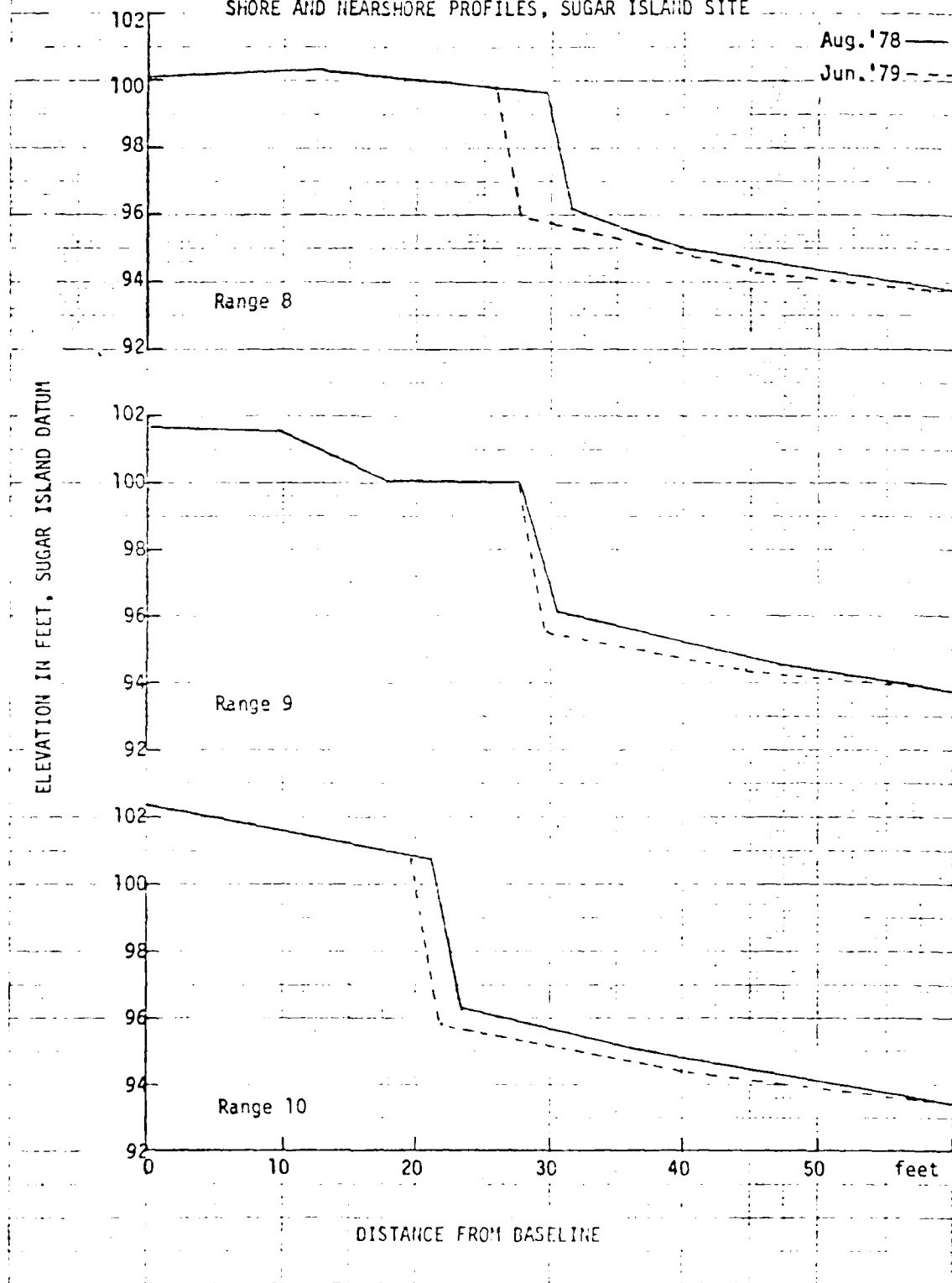


FIGURE 4

SHORE AND NEARSHORE PROFILES, SUGAR ISLAND SITE



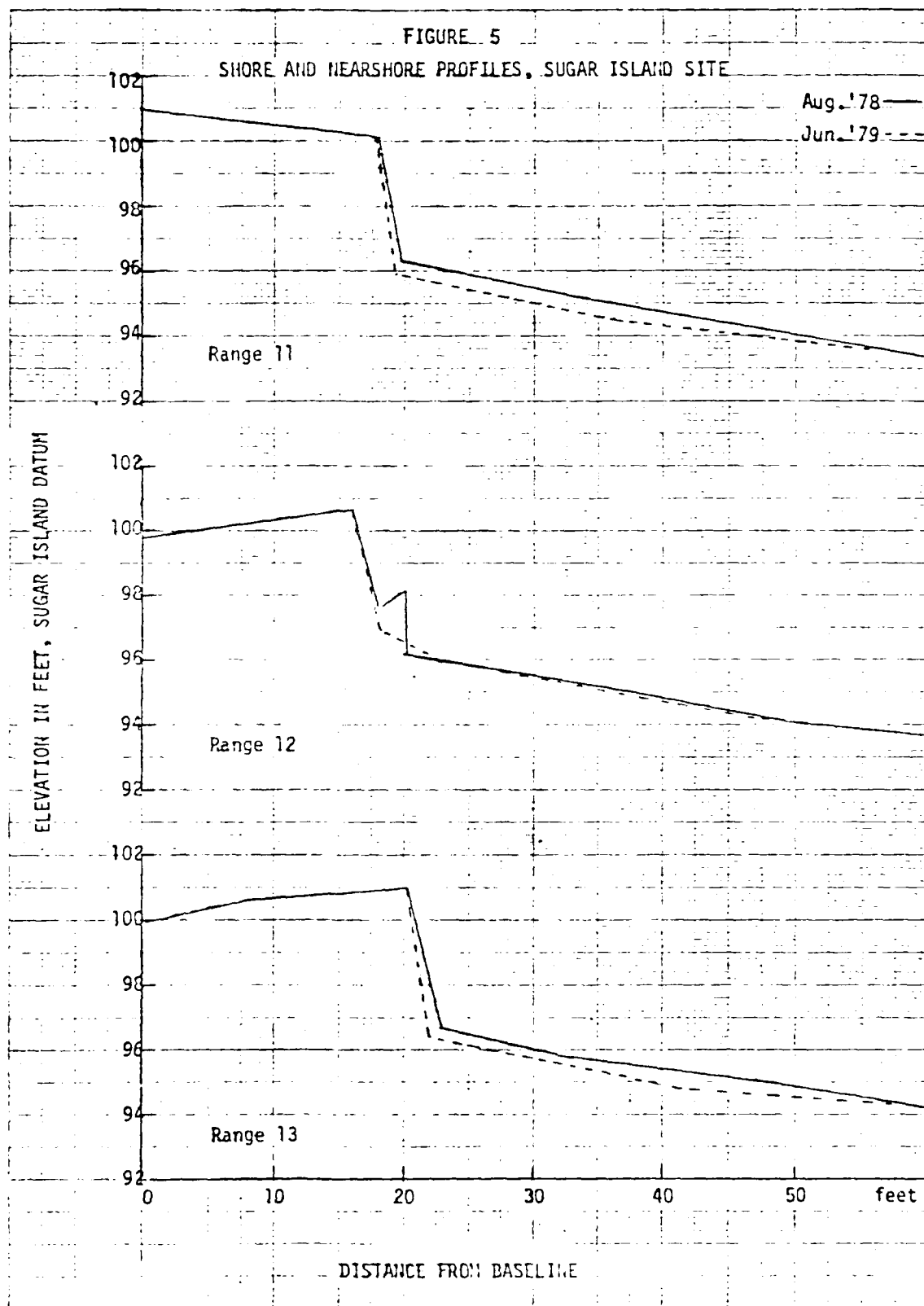
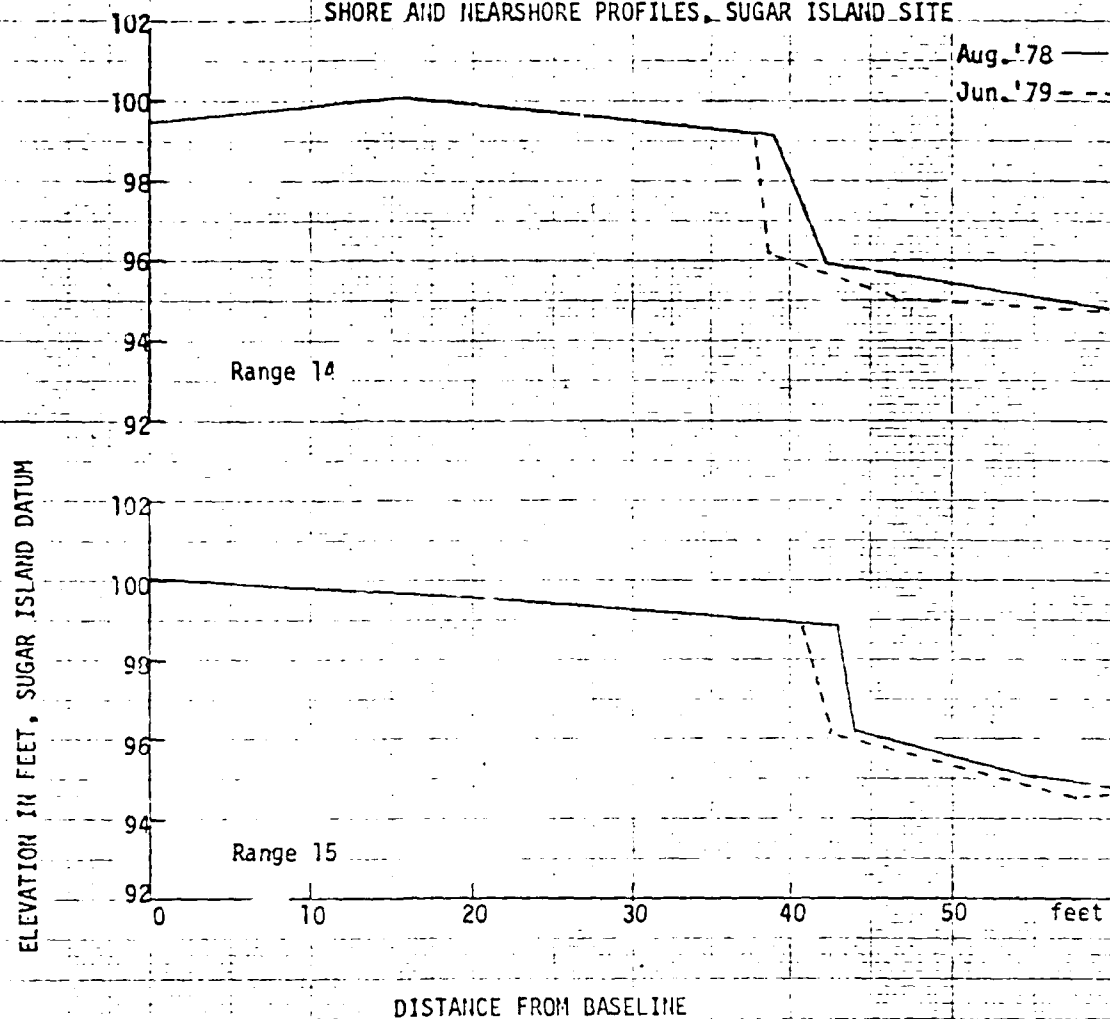


FIGURE 6
SHORE AND NEARSHORE PROFILES, SUGAR ISLAND SITE



comparison of these soundings with those done in previous years under this contract show no measurable change.

ADAMS SITE

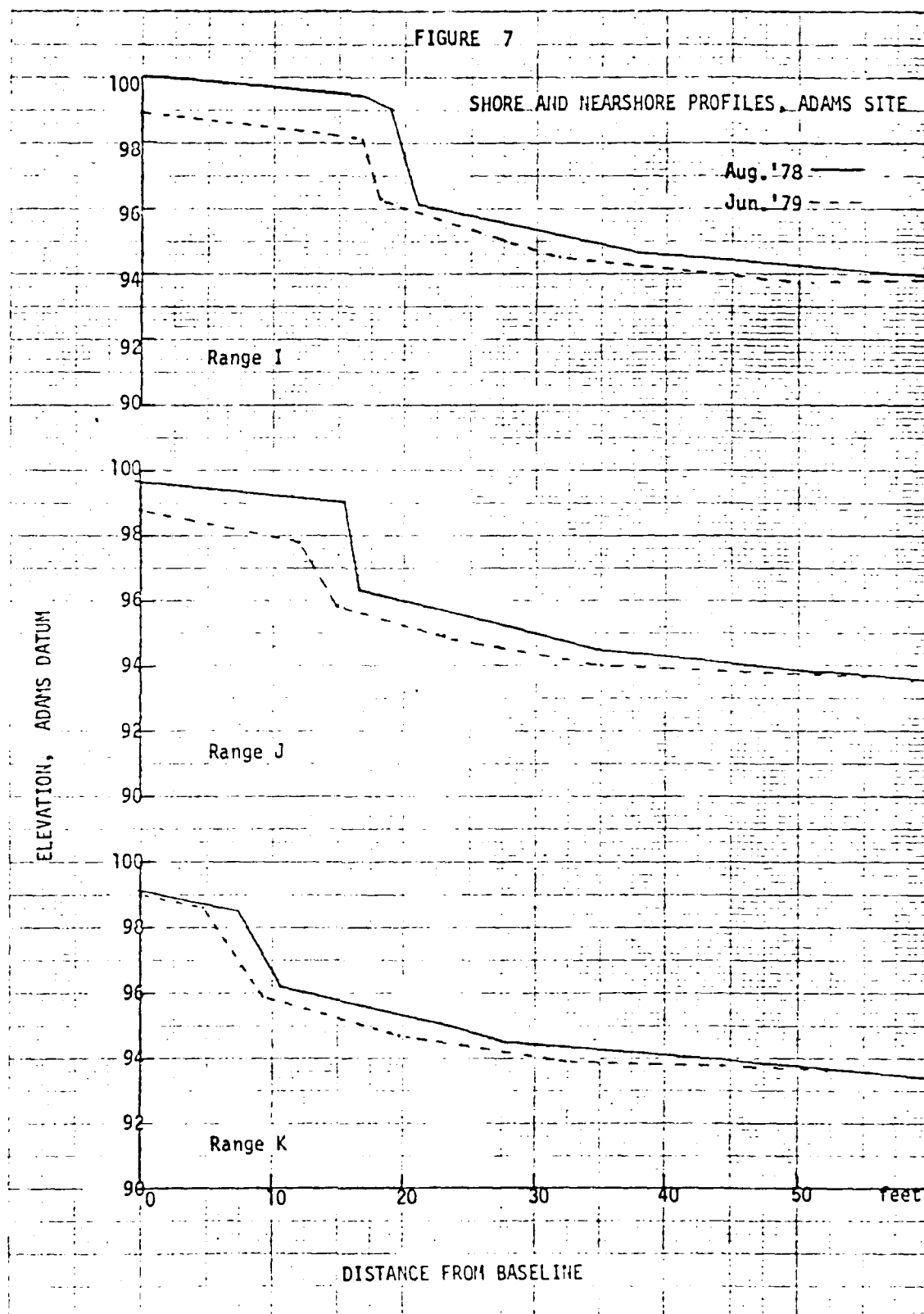
Details of site location and range line position may be found in the reports to CRREL of 1977 and 1978, Volumes 1, 2 and 3.

The shore and nearshore topography and bathymetry were determined in June 1979 using a level and level rod. Similar measurements made at this site during previous years (Volumes 1, 2 and 3) beginning in 1976 have shown little or no change during the intervening period. The results of the measurements made under this contract in June of 1979 again show no appreciable change except at Ranges I, J and K. A new home has been constructed in the area covered by these three ranges and the area between the home and rivers edge has been scraped in preparation for establishment of a new front lawn to the shore. This, in effect, has lowered the pre-construction shore elevation to some extent. This information is contained in Figure 7.

Soundings were also made offshore along all ranges utilizing a boat equipped with a survey fathometer. The results of these soundings were compared with those made in previous years under this contract and no apparent change is evident.

NINE MILE SITE

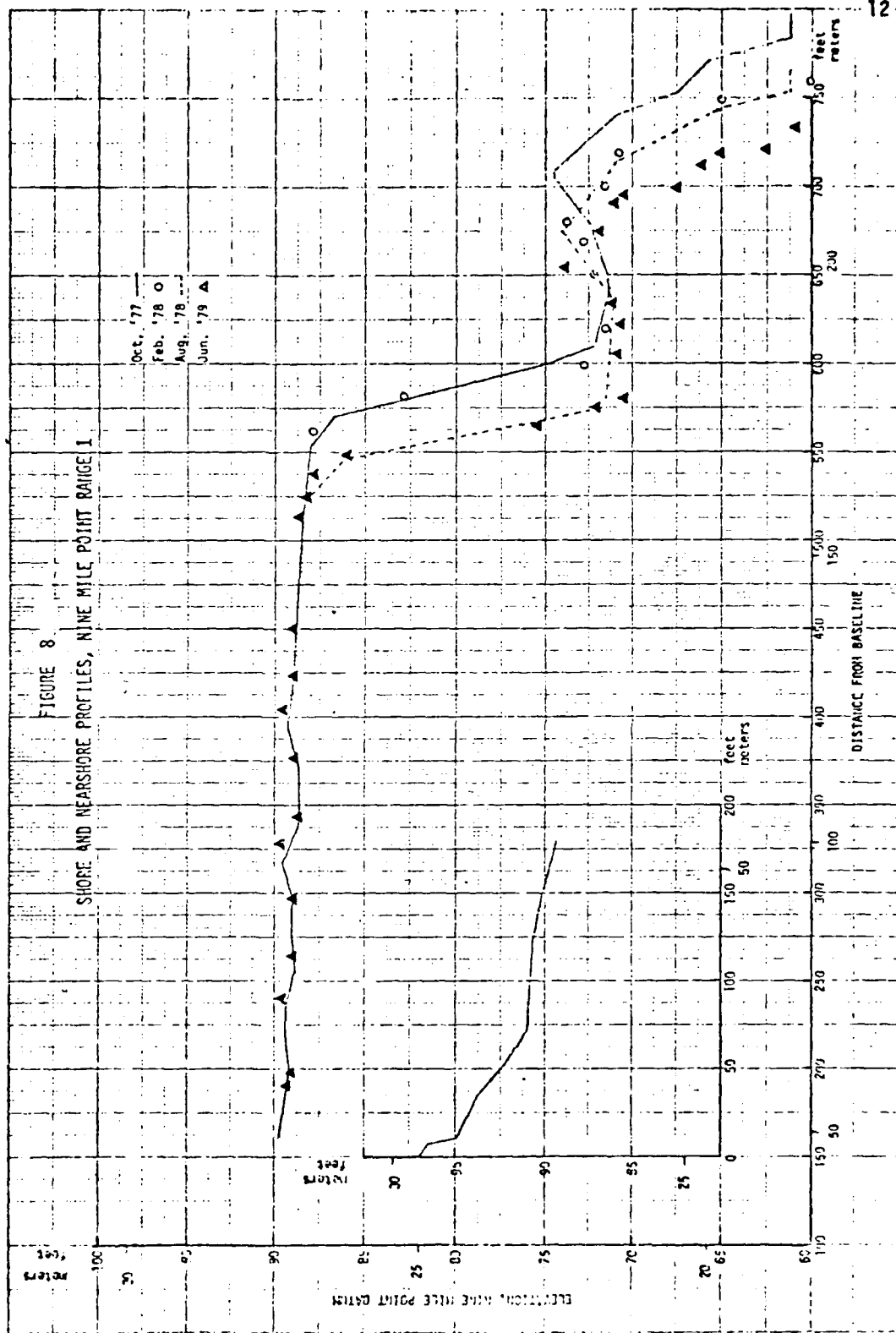
Details of site location and range line position may be found in the previous report to CRREL of 1978 (Volume 3).

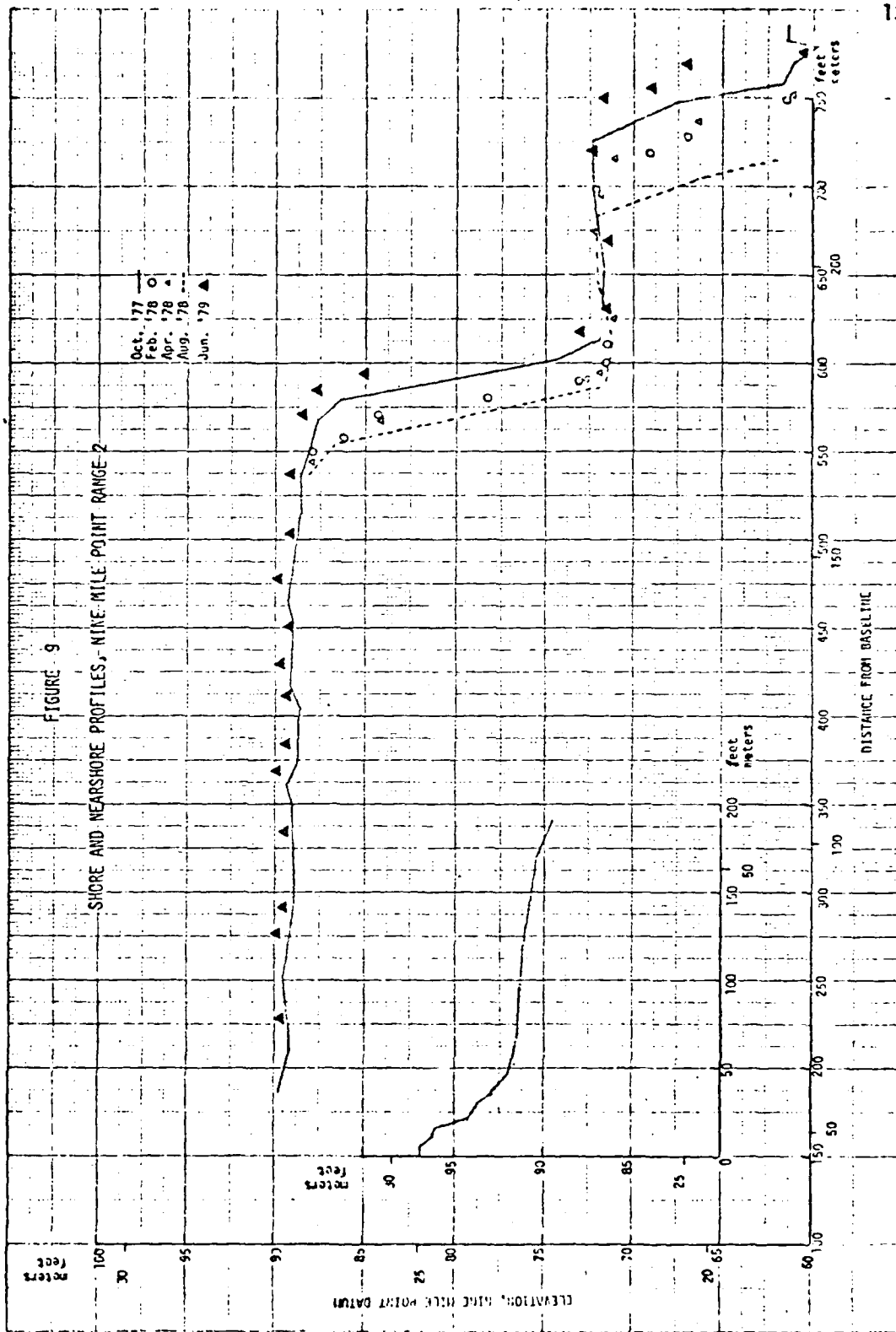


The shore and nearshore topography and bathymetry were determined in June of 1979 using a level and level rod. A comparison of these measurements with those presented in Volume 3 of 1978 show no measurable change except at range 5. As reported earlier there is a small sand berm along the shoreline at this location and it has a tendency to migrate in or offshore to some extent in response to changes in longer term river elevation fluctuation. It is not felt that the movement of this berm is materially effected by drawdown associated with passage of larger vessels.

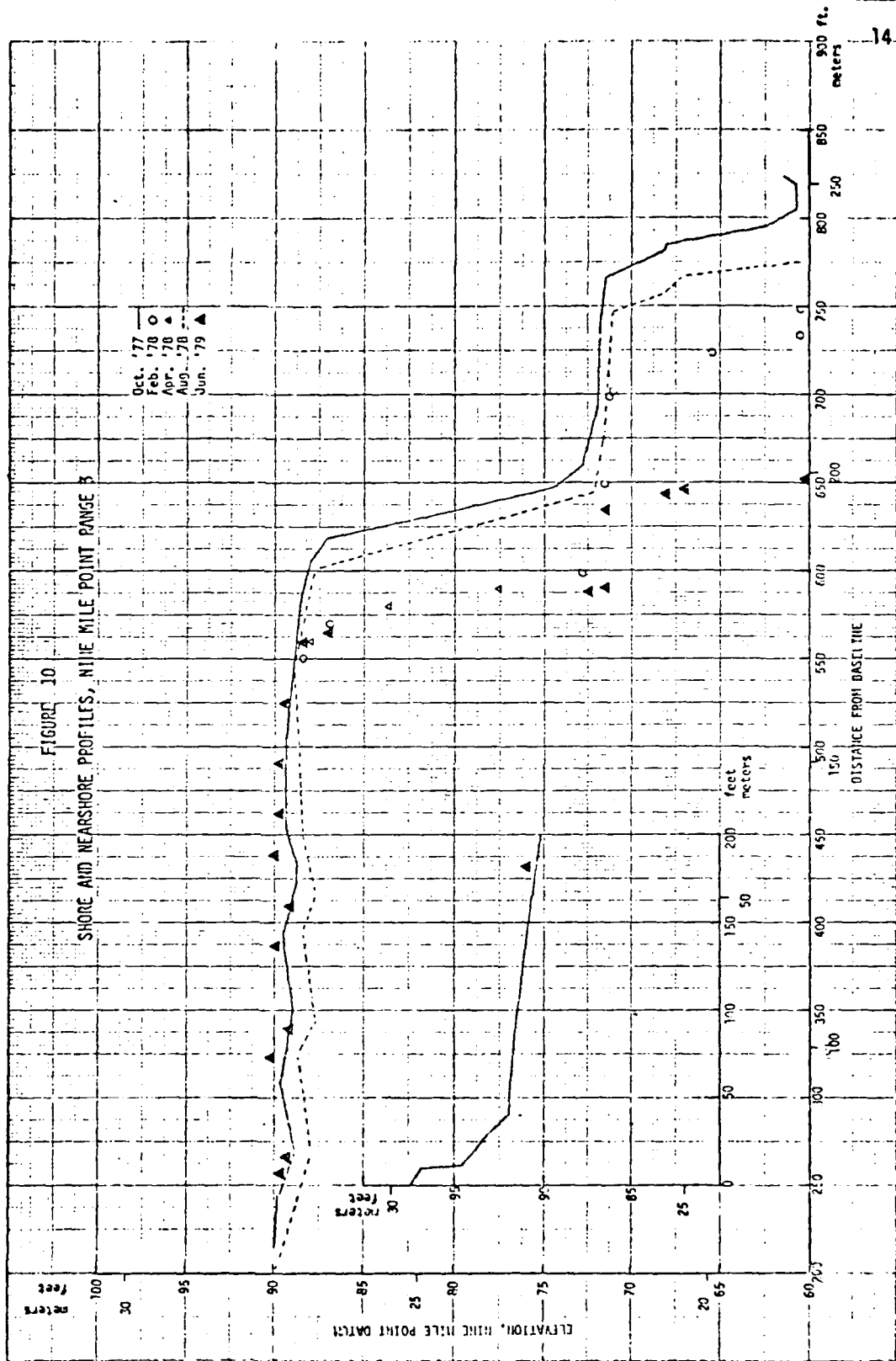
Offshore profiles were determined using a boat equipped with a survey fathometer. The boats position was determined by triangulation from shore.

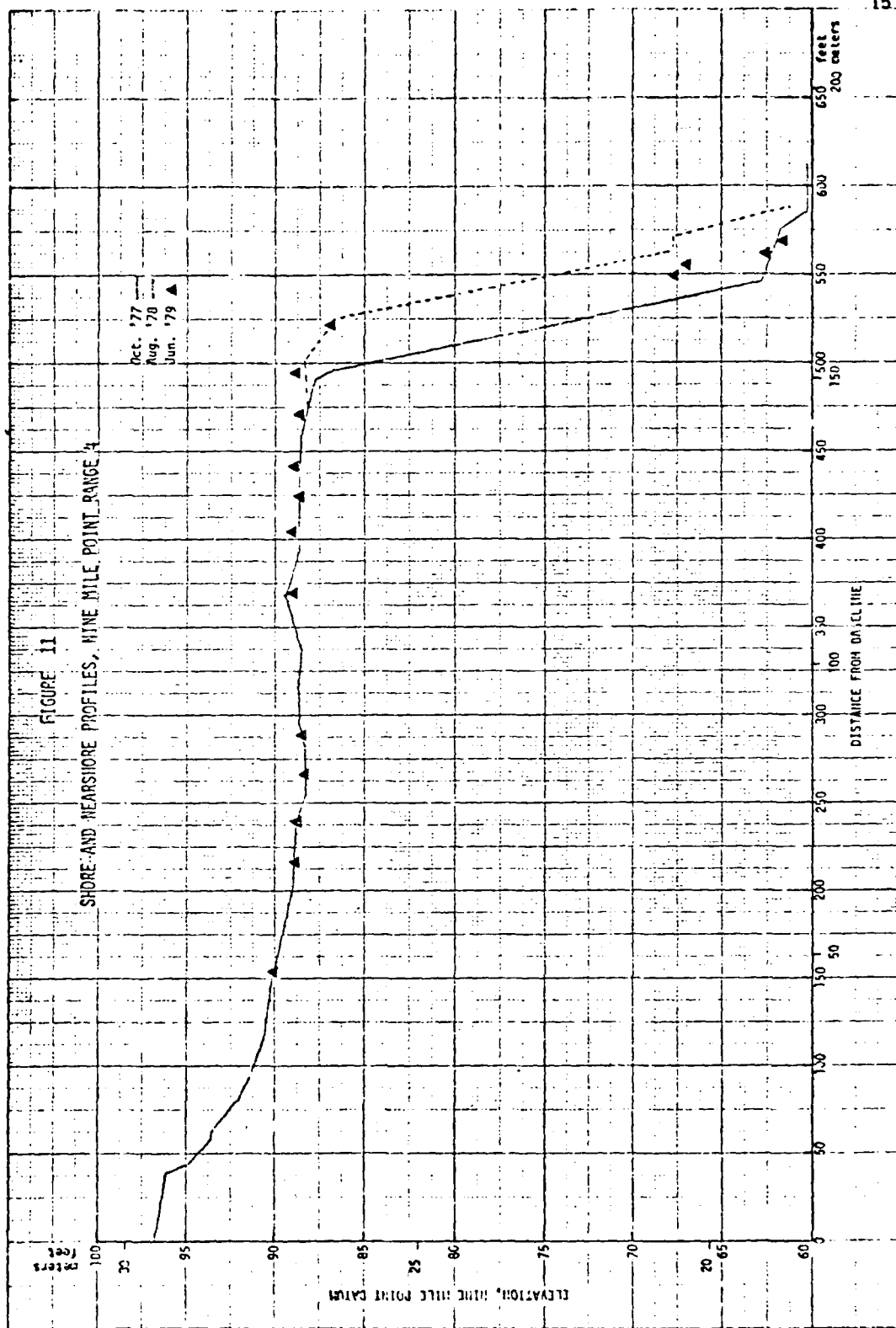
The results of these measurements have been plotted on Figures 8 through 14 along with measurements made in 1977 and 1978. Ranges 1, 2 and 3 on the north end of the study area appear to have filled slightly over the area shoreward of the navigation channel. The offshore depression noted earlier on range 5 at 100 m. from the baseline has remained filled. Ranges 6 and 7 show a further migration of the submerged offshore berm. As noted in the report of 1978 the offshore berm located on these two ranges is actively influenced by vessel drawdown. The apparent bottom movement near the navigation channel again appears to be quite erratic from range to range. The river current changes quite significantly from main river section to the region in shore. Thus the boat used for making the soundings experiences some change in speed as it attempts to move along the range. This greatly influences the measurements of boat location in

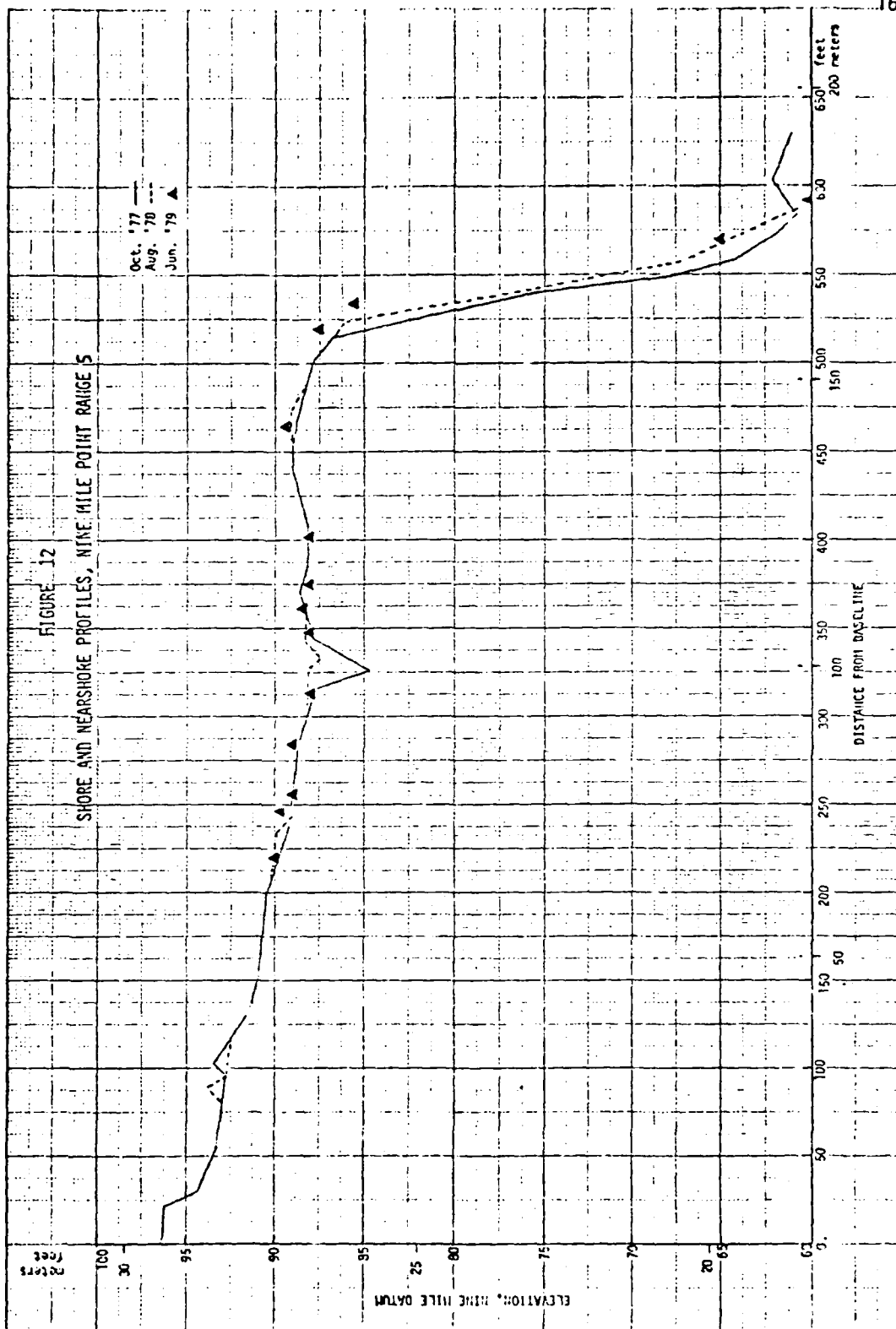


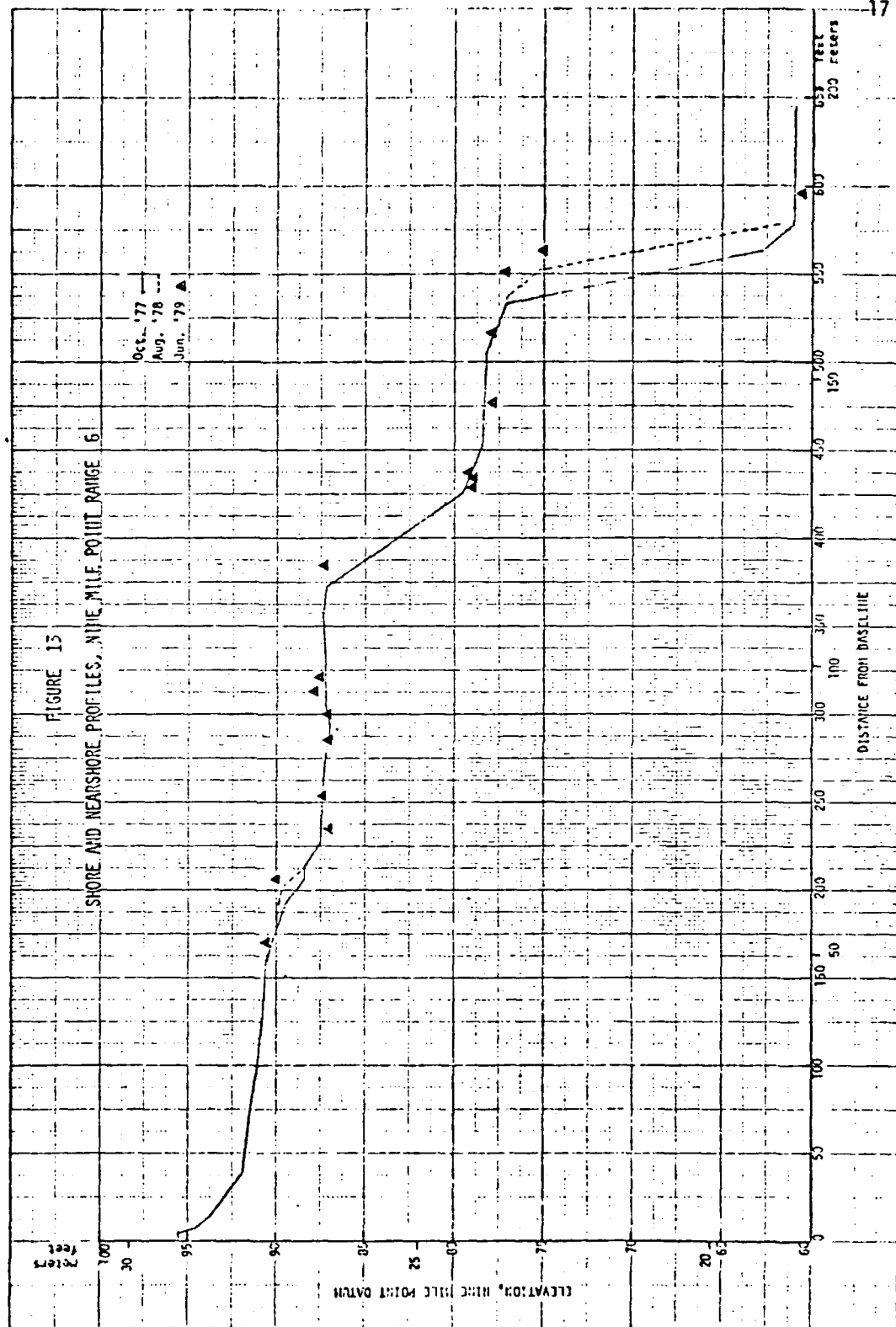


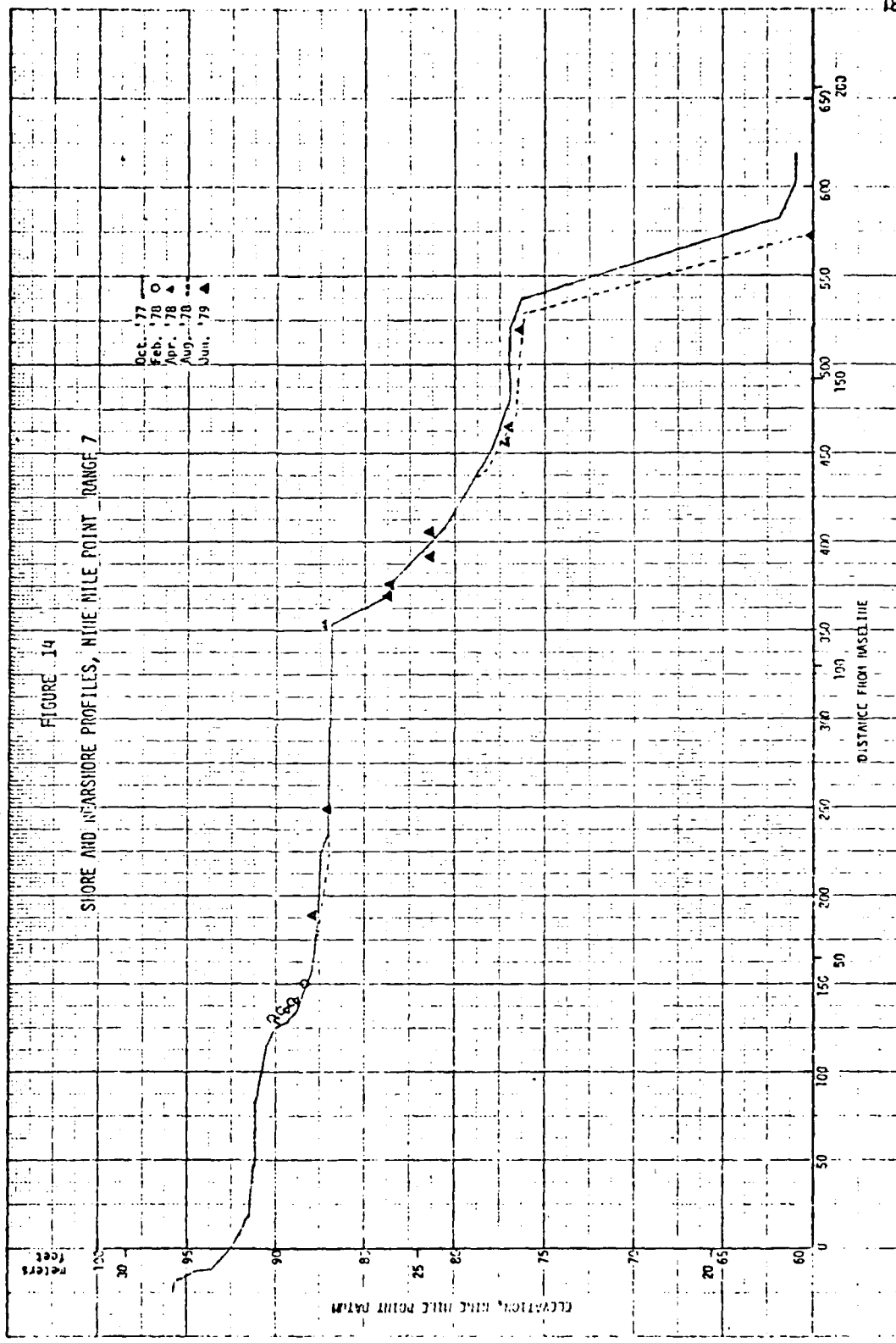
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the region where river velocity changes rapidly. It is likely then that much of the 'apparent' movement shown near the main river channel relates to the accuracy of measurement.

SIX MILE SITE

A special study was conducted along a reach of shoreline near Six Mile Point on the St. Marys River. The specific property is owned by a Mr. Cleary. Specific site detail and range line locations are available through CRREL. The investigation was undertaken on June 23, 1979.

Figure 15 is a photograph taken from the front lawn of the Cleary property looking generally in an easterly direction toward Sugar Island. Note the nearshore band of clouded water. Figure 16 is also taken from the Cleary property looking generally in a northerly direction and shows the small bay adjacent to the Cleary property. The cloudy nature of the water is quite evident in this photograph.

Three range lines had previously been established at this site by CRREL. Two of the ranges transected the river in the area covered by Figure 15. The third range transected the small bay shown in Figure 16. Only one of the ranges could be located during this field period, the one transecting the small bay (range A-A'). A shore profile was run on this range and the results compared with a previous run made by CRREL on May 24, 1978. This information is shown on Figure 17. There was no apparent change in the profile during these two periods. It should be noted that some attempt has been made to

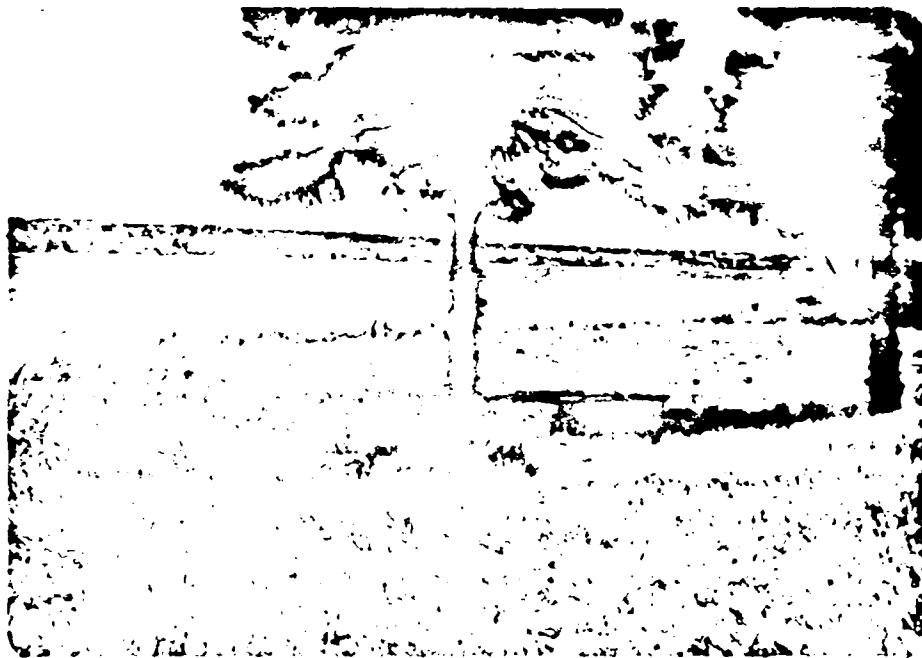


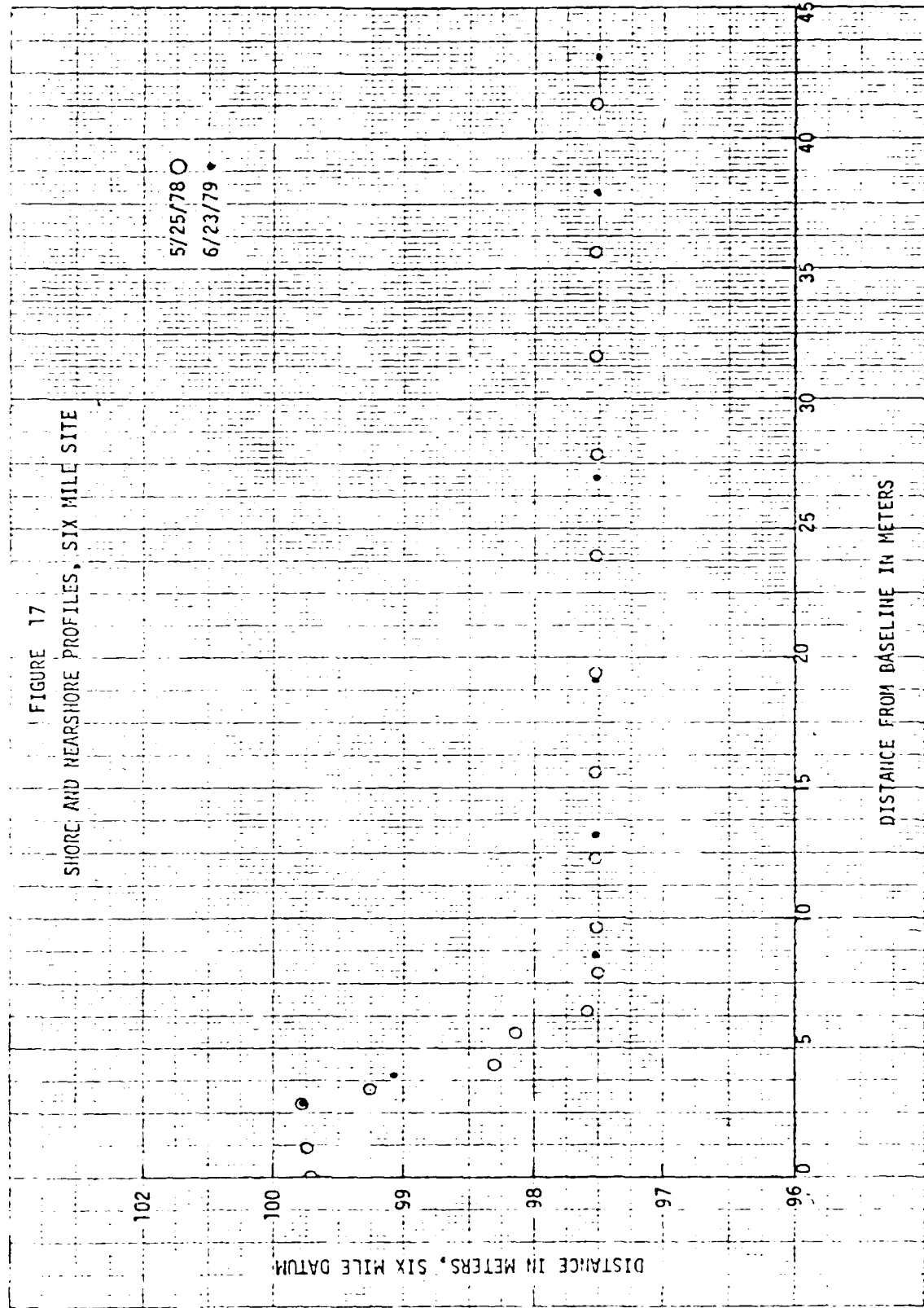
FIGURE 15 CLEARY PROPERTY - EAST



FIGURE 16 CLEARY PROPERTY - NORTH

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protect the shore in this area by placing large rock along the face of the bluff at range A-A'.

The site was observed for several days during the field period with expectations that the water clarity would improve in order that velocity measurements could be made for several ship passages. However this did not occur and only stage measurements could be made. Five vessel passages were noted on June 23, 1979. The observations made are shown in Table 1.

The sediment traps were positioned on the bottom of the small bay near range A-A' for 15 minutes under ambient conditions (no vessel passage). As would be expected from the cloudy nature of the water some sediment was collected in all traps.

The traps were also positioned for all vessel passages and the sediment collected for all vessel passages (except the St. Clair) did not appear to be materially different than would be expected from ambient conditions alone. The passage of the St. Clair caused the water in the bay to surge in and out several times causing an obvious bottom displacement at the head of the bay. The volume of material caught in the traps was also higher than would be expected under ambient conditions.

Three bottom soil samples were collected on June 23, 1979 (additional offshore soil information may be found in the Appendix). One sample from the small creek which enters the head of the bay (in a region influenced by the surge within the bay), the second nearshore along range A-A' and the third nearshore from the main river channel near range B-B'. The Phi distribution for these

TABLE 1

VESSEL PASSAGES - SIX MILE POINT 6/23/79

Vessel Name & Direction	Length & Beam (Meters)	Speed (kph)	Maximum Drawdown (cm)
L. E Block (upbound)	189.3 X 19.5	10.17	2.5
Ralph H. Watson (upbound)	186.5 X 18.3	missing	2.5
Arthur B. Homer (upbound)	251.8 X 22.9	11.05	2.5
J. Burton Ayers (upbound)	189.0 X 18.3	12.37	2.5
St. Clair (downbound)	234.7 X 28.0	13.41	13

samples is shown in the table below.

Site	μ_{ϕ}	σ_{ϕ}	α_{ϕ}
Creek	2.90	0.60	0.42
Range A	3.20	0.70	0.36
Range B	3.15	0.60	-0.17

As can be seen from the table the bottom material is generally a fine sand with slightly larger material on the creek bed due to transport of the finer fraction into the bay and river. There is also some skew toward the larger sizes along the main river shoreline.

This limited investigation does indicate that sediment translocation can occur due to vessel passage. This of course is highly dependent on vessel size and speed.

DARK HOLE SITE

A special study was conducted at the Dark Hole area on Neebish Island. The specific site is near Mirre Point on property owned by a Mr. Merchberger. Specific site detail and range line location are available through CRREL. This specific investigation was conducted on June 22 and 23, 1979.

Figure 18 is a photograph taken on the Merchberger property looking in an upriver direction and Figure 19 looking generally in a downriver direction. The eroding scarp is clearly evident in both photographs. Figure 18 also shows some damage to trees at the waters edge and Figure 19 shows the depositional section at the downstream end of the reach in the area of the offshore vegetation.



FIGURE 18 MERCHBERGER PROPERTY - NORTH

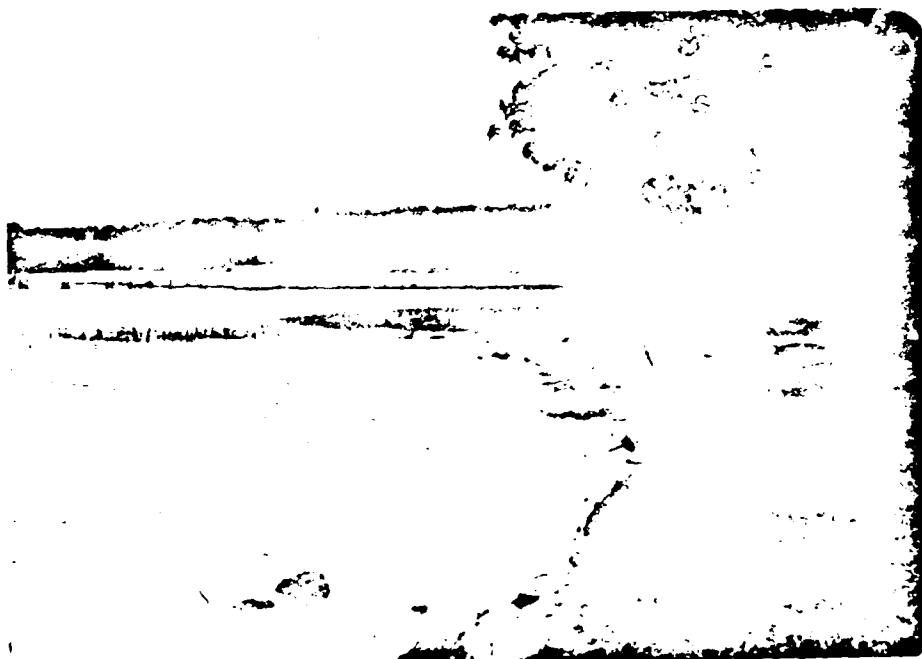


FIGURE 19 MERCHBERGER PROPERTY - SOUTH

Shore profiles were measured along the two ranges which had been previously established by CRREL. The results of these measurements are illustrated on Figure 20. Figure 20 also shows the results of similar measurements made by CRREL on May 24, 1978. There does not appear to be any material movement of the scarp along these two ranges over the period between measurements (over one year). The water level was 0.18 meters higher on 6/22/79 than on 5/24/78 which could account for the small differences shown at the base of the scarp.

The general configuration of the scarp along the reach was also measured on the above dates. A comparison of the results is shown in Table 2. Angles shown are those used by CRREL on 5/24/78. The data does indicate a general scarp recession at the upstream end of the study reach. It is likely that the accretion indicated by the last measurement in the table is a measurement or recording error on one of the two dates.

Measurements of stage, river velocity alteration, and sediment transport were also made for the passage of eight vessels. Table 3 lists the vessels, their size, speed, river velocity alteration and observed drawdown. The velocity and stage measurements were made near range A in 0.8 meters of water. The ambient near bottom river velocity (no vessel passage) at this location was approximately 10 cm/sec. The navigation channel carries only upbound traffic at this location during the regular navigation season. Thus all vessels observed were traveling upriver and in all cases river velocity changes were confined to changes in the ambient downstream compo-

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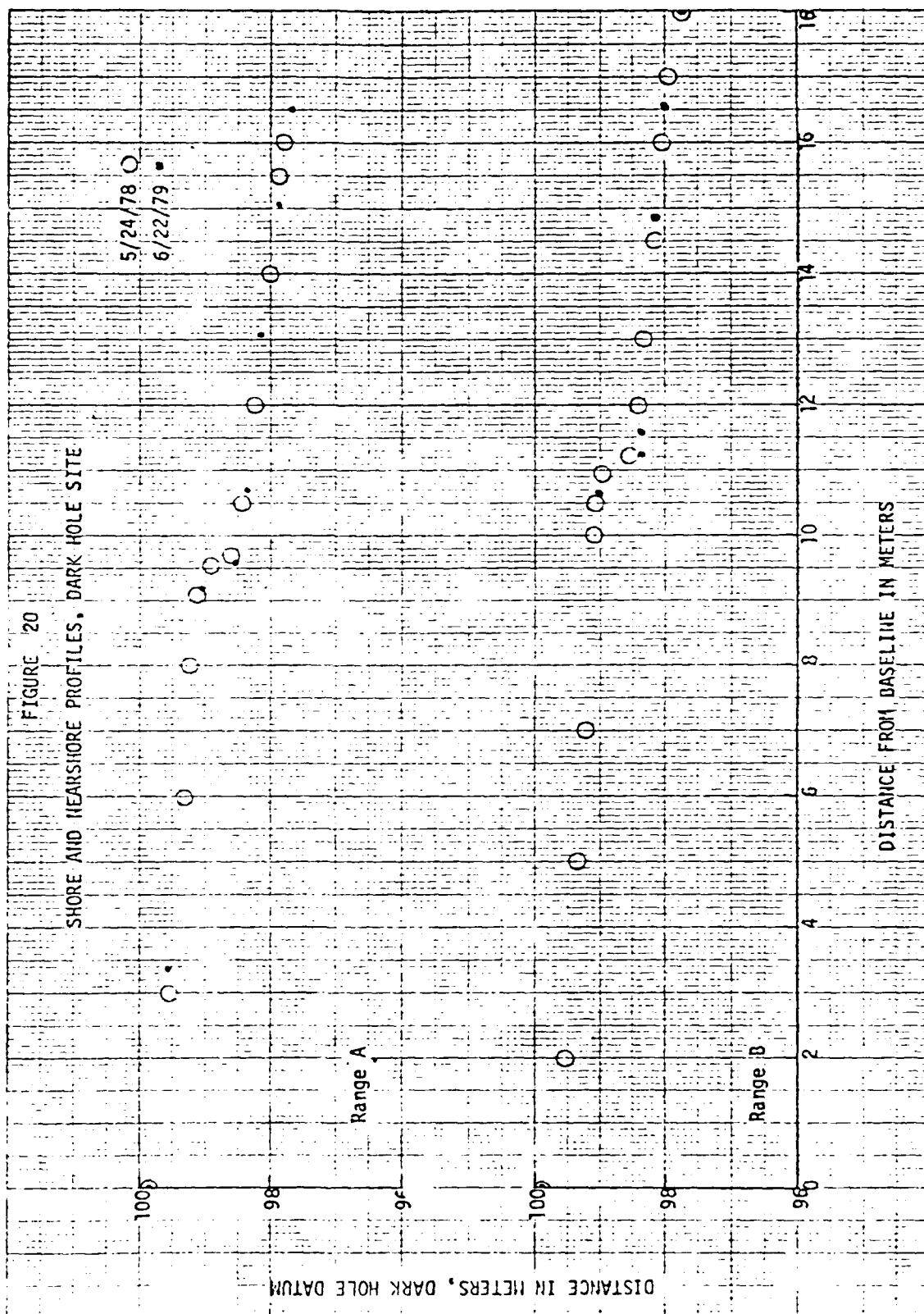
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TABLE 2

DARK HOLE SCARP LOCATIONS

(Distance in Meters)

Angle	5/24/78	6/22/79	Change
45°-52'	17.02	15.51	-1.51
45°-46'	16.31	15.51	-0.80
44°-37'	15.88	15.73	-0.15
45°-51'-30"	15.59	15.51	-0.08
47°-54'	15.77	15.70	-0.07
57°-09'	12.66	11.31	-1.35
55°-14'	11.35	10.55	-0.80
69°-25'	9.91	9.91	---
76°-27'	10.13	10.06	-0.07
79°-41'	9.60	9.69	+0.09
82°-29'	9.90	9.88	-0.02
92°-20'	9.75	9.85	+0.10
97°-45'	9.82	9.78	-0.04
99°-38'	9.66	9.72	+0.06
103°-40'	10.31	10.30	-0.01
116°-42'	10.86	10.88	+0.02
125°-11'-30"	11.81	11.80	-0.01
127°-06'	11.41	11.46	+0.05
143°-39'	13.64	15.03	+1.39

- recession

+ accretion

TABLE 3

VESSEL PASSAGES - DARK HOLE 6/22-23/79

Vessel Name	Length & Beam (meters)	Speed (kph)	Maximum Drawdown (cm)	Velocity Alteration (cm/sec)
Bella Marshe	not available		10.2	3.05 increase
Chemical Transport	118.9 X 16.8	12.97	2.5	slight stall
Howard F. Andrews	not available		2.5	"
Middletown	222.5 X 22.9	13.81	5.1	"
Red Wing	222.5 X 22.9	12.71	5.1	"
Merle M. McCurdy	183.2 X 17.7	12.92	3.8	"
Gulf Mackenzie	131.7 X 18.3	13.93	7.6	"
Paul H. Townsend	136.3 X 15.2	10.43	2.5	"

ment. In only one case, the Bella Marske, did the downstream component increase slightly. For all other passages shown there was a decrease in magnitude of downstream component for a brief period followed by a return to ambient conditions. In all cases monitored attendant drawdowns due to vessel passage were very slight.

The sediment traps were positioned on the river bottom near the location utilized for velocity measurements and left for one hour with no vessel passages. No sediment was collected under this ambient condition. The traps were also positioned for each vessel passage. No sediment was collected for any of the vessels monitored. A slight ripple pattern was evident on the river bottom at this location and this pattern was observed during each vessel passage. No ripple movement occurred for any of the passages.

Two soil samples were collected along range A-A', one near the shoreline and one at the drop off shown on Figure 20 at 9 meters from A'. An analysis of these samples is shown below.

Location	μ_{ϕ}	σ_{ϕ}	α_{ϕ}
Nearshore	1.80	0.60	0.08
At 9 meters	52.7 per cent passing the p200 sieve		

As can be seen from the table the material near the shoreline is a fine to medium sand which would be susceptible to movement due to erosive forces. The offshore material however possesses a large fraction of silt and clay sizes and in place is likely more stable relative to erosive forces.

A collective review of the above information suggests that little or no disturbance is caused by vessels of the class monitored which move at these moderate speeds. Based on similar measurements discussed in earlier reports it is likely that higher vessel speeds would cause greater effects in the nearshore zone. Some difference in effect may also occur during the winter navigation season when both upbound and downbound vessels make use of this navigation channel.

DETROIT AND ST. CLAIR RIVERS

CHRYSLER SITE

Shore, nearshore and offshore topography and bathymetry were measured in July of 1979. These measurements were compared with those presented in the 1978 report and no measurable changes were evident.

BELLE ISLE

Shore, nearshore and offshore topography and bathymetry were measured in July of 1979. These measurements were compared with those presented in the 1978 report and no measurable changes were evident.

Scarp location was also determined as described in the 1978 report. No changes were evident.

ALGONAC SITE

Shore, nearshore and offshore topography and bathymetry were measured in July of 1979. These measurements were compared with those presented in the report of 1978 and no measurable changes were evident.

Scarp location was also determined as described in the 1978 report. Table 4 shows the results of these measurements. It is evident that some recession has occurred.

RUSSELLS ISLAND

A field study was initiated on July 12, 1979 at the Russells Island Site. Details of site location and range line position may be found in Volume 3 of a previous report furnished to CRREL, November 1978. (A Study of Ice Related Sediment Transport and Shoreline Erosion). Figure 21 shows the historic shoreline changes measured during 1978 and 1979. Table 5 shows alterations in scarp position. Noticable recession is evident in the lower portion of the reach. Offshore profiling was also done by boat using a survey fathometer for all ranges. No measurable changes were noted in the offshore bottom profiles.

Measurements of drawdown and river velocity alterations due to vessel passage were also made for the passage of eight vessels. A summary of this data may be found in Table 6. In general upbound vessels tended to cause an increase in the downstream river velocity component while downbound vessels first caused the river velocity to shift in an upstream direction to be later followed by an in-

TABLE 4

ALGONAC STATE PARK SITE SCARP LOCATIONS
(Distance in Meters)

Angle	3/23/78	6/21/78	12/9/78	7/13/79	Total since 3/78
338°38'	32.06	32.40	31.49	32.43	0.37
334°31'	24.75	24.63	24.69	24.75	0.0
323°00'	19.67	19.69	19.60	19.39	-0.28
313°53'	16.43	16.46	16.43	16.37	-0.06
304°55'	15.36	15.42	23.90	14.90	-0.46
299°33'	13.52	13.17	13.29	13.17	-0.35
285°44'	11.93	11.98	11.98	11.89	-0.04
278°27'	11.92	11.92	11.73	11.83	-0.09
277°11'	12.08	12.07	11.95	11.95	-0.13
274°29'	11.68	11.70	11.69	11.64	-0.04
245°14'	12.94	13.11	13.11	13.11	0.17
243°06'	13.19	13.17	13.14	13.14	-0.05
240°54'	13.96	14.02	13.87	13.81	-0.15
232°04'	15.55	15.48	15.48	15.48	-0.07
217°42'	17.86	17.83	17.80	17.83	-0.03
212°25'	19.56	19.57	19.58	19.60	0.04
203°34'	25.76	25.82	25.63	25.60	-0.16
202°58'	26.00	26.00	26.00	25.97	-0.03
202°32'	26.75	26.82	26.47	26.24	-0.51

- indicates recession

FIGURE 21
SHORE AND NEARSHORE PROFILES, RUSSELLS ISLAND SITE

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WELLDYNE POST

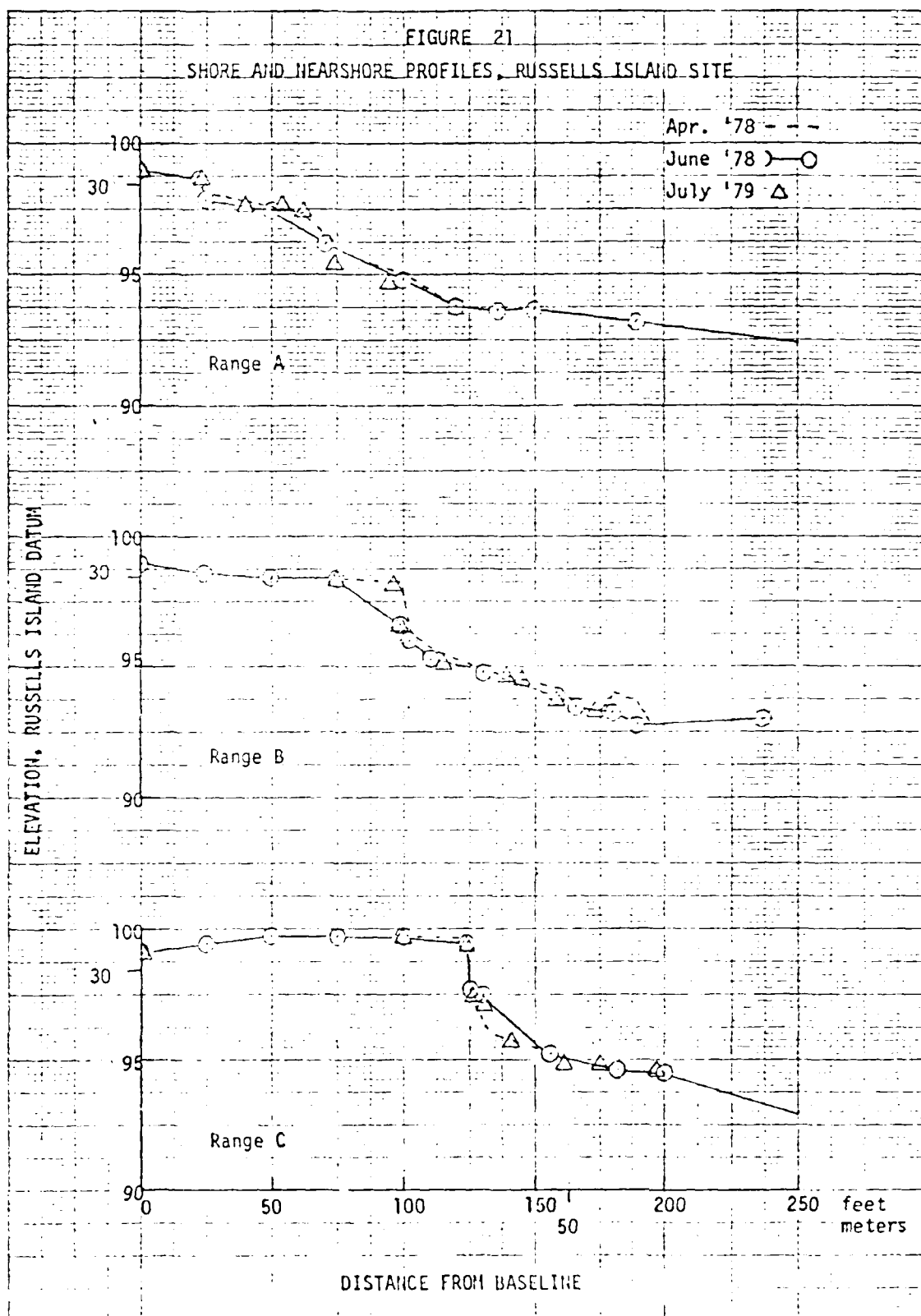


TABLE 5

RUSSELLS ISLAND SCARP LOCATIONS
(Distance in Meters)

Angle	4/14-15/78	6/22/78	12/9/78	7/12/79	Total since 4/14-15/78
59°	19.8	21.6	20.58	20.42	+0.62
63°	18.4	18.8	18.75	18.59	+0.19
70°	14.6	14.7	14.94	15.15	+0.55
75°	13.0	13.01	13.08	13.17	+0.17
80°	11.89	12.22	12.38	12.07	+0.18
85°	10.9	10.9	11.01	11.03	+0.13
90°	10.5	10.5	10.76	10.58	+0.08
100°	9.3	9.4	10.27	8.08	-1.22
110°	9.0	8.9	8.78	7.50	-1.50
120°	8.0	7.5	7.41	6.74	-1.26
130°	8.1	7.1	6.77	6.28	-1.82
135°	7.9	6.7	6.77	6.00	-1.90
145°	7.5	6.4	6.37	5.79	-1.71
155°	7.0	6.4	6.59	5.49	-1.51
165°	7.3	6.6	6.65	5.79	-1.51
175°	7.6	7.0	7.32	6.31	-1.29
185°	8.0	7.5	7.87	6.98	-1.02
195°	9.0	8.0	8.11	7.10	-1.90
205°	10.2	8.7	9.51	7.47	-2.73
210°	11.2	9.8	9.82	7.62	-3.58
220°	13.7	12.0	12.04	8.32	-5.38
230°	17.7	17.3	16.77	9.85	-7.85
235°	20.91	21.86	20.61	13.14	-7.77
238°10'30"	23.69		30.27		+6.58

- recession

+ accretion

TABLE 6

VESSEL PASSAGES - RUSSELLS ISLAND 7/12/79

Vessel Name & Direction	Length & Beam (meters)	Speed (kph)	Maximum Drawdown (cm)	Velocity Alteration (cm/sec)
Armco (upbound)	233.8 X 21.3	14.5	3.0	slight stall
Sennéville (downbound)	222.5 X 22.9	16.7	20.3	14 upriver 14 downriver
Kidric B. (upbound)	not available		7.6	20 downriver
Robert C. Norton (downbound)	189.3 X 18.3	17.5	7.6	14 upriver
Charles M. Beeghly (downbound)	245.7 X 22.9	18.1	17.8	8 upriver 8 downriver
Buffalo (upbound)	199.6 X 20.7	15.7	12.7	23 downriver
Paul Thayer (upbound)	192.0 X 20.7	16.9	7.6	10 downriver
Enders M. Voorhees (upbound)	195.1 X 20.4	16.3	7.6	10 Downriver

crease in downstream component. The shift to an upstream direction caused flow to pass around the tip of the island into the channel between the island and the United States mainland. This channel is not used for commercial navigation. This phenomena has been noted earlier in the report to CRREL of November 1978.

There were a considerable number of smaller pleasure craft utilizing the waterway during this field period. The surface waves generated by the passage of these vessels caused some difficulty in the determination of drawdown and river velocity alteration caused by the larger commercial vessels. Thus data shown in Table 6 should be viewed as approximate with perhaps only relative significance.

Attempts were also made to measure sediment movement due to vessel passage. For several of the passages shown in Table 5, the waves generated by pleasure craft passing at the same time caused the sediment traps to be rotated and partially filled with sediment. At other times such waves were noted to be causing sediment to move into the traps. It was impossible under these conditions to sort out material from the traps which may have only moved due to the passage of the larger vessels. These observations also indicate that during the summer months erosional forces near the shoreline may be greater due to the movement of the pleasure craft than those due to the passage of the larger commercial vessels.

PEERLESS SEA WALL

A new erosion control sea wall has been proposed extending along a reach of the St. Clair River on the United States side of the river. The wall would begin just downriver of the Blue Water Bridge to Canada along property owned by the City of Port Huron, Michigan. A baseline was established along the shoreline in the region to be protected by the sea wall and nearshore soundings were made at selected locations along the baseline. Figure 22 is a photograph showing the shoreline to be protected by the new sea wall.

Nearshore soundings were done in July of 1978 at selected points along the baseline. These soundings and the baseline descriptions may be found on the blue prints located in the map packet attached to the inside back cover of this report.

These profiles were checked again in July of 1979 and no changes were evident.



FIGURE 22 PEERLESS SEA WALL SITE

SUMMARY AND CONCLUSIONS

A field study examining the effects of vessel passage on sediment erosion potential has been continued at certain sites on the St. Marys River and the Detroit and St. Clair Rivers. This program was augmented by an auxiliary study under the auspices of the Great Lakes Basin Commission. The results of this auxiliary study may be found in the Appendix of this report.

Based on the results of the combined study and those of previous studies the following statements can be made.

- 1) The major ice crack patterns are generally parallel to the shore. The nearshore cracks are due to differential support between floating and grounded ice, and the offshore cracks are due to differential water pressure caused by mass water movements perpendicular to the shore due to vessel passage. These offshore cracks and the pressure differential occur at or near bathymetric transitions.
- 2) The near-bottom river velocity is temporarily altered in magnitude and direction by the passage of a vessel. The effect is dependent on the vessel's size, speed, and direction of travel for any particular river cross-section.
- 3) The temporary river level drawdown caused by vessel passage may be predicted analytically with good accuracy and demonstrate the interaction of vessel size, relative speed, and river cross-section.
- 4) River velocity profiles in the absence of vessel traffic shows differing velocity distribution between ice covered and

ice-free conditions.

- 5) There is no ambient sediment transport during the period of continuous ice cover.
- 6) Sediment transport occurs with the passage of a vessel when that vessel causes the occurrence of some critical combination of river velocity alteration and pore pressure response in bottom soils due to the rate of river level drawdown.
- 7) Once sediment transport is initiated by the vessel, all sediment sizes present are moved.
- 8) River level drawdown due to vessel passage appears to be little effected by the presence of an ice cover.
- 9) Waves generated by the passage of pleasure craft in the summer months appears to have a greater influence on shore and nearshore erosion than the regulated passage of the larger commercial vessels.
- 10) The results of the special studies undertaken at Dark Hole and Six Mile Point indicate that commercial vessels moving at regulated speeds cause little or no nearshore erosion at these sites under ice-free conditions.
- 11) Given that vessels are moving through the system at regulated speeds, no evidence collected to date from studies made under this contract would indicate erosional influences are greater with the presence of an ice cover.

RECOMMENDATIONS

The primary objective of this three-part study was to evaluate the measurable and predictable impacts on the biological community caused by water drawdown during winter navigation along the St. Marys River.

It has been established that sediment transport does occur under a combination of conditions. However the river velocity-pore pressure response relationship necessary to initiate sediment suspension and translocation is unknown. A combined theoretical and laboratory study is necessary to gain the ability to predict sediment movement. Only then will a rational method be available to provide vessel speed regulation or even the absolute prohibition of vessel movement in certain areas during periods of particular biologic activity.