NECHELIC CHANNEL INVESTIGATIONS
1994

A Report on Field Investigations from
June 16 to July 3, 1994 and
Subsequent Laboratory Analyses
for the North Slope Borough
Under Contract No. 94-305

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Baton Rouge, LA
December 1994

NECHELIC CHANNEL INVESTIGATION--1994

PREFACE

The field season (6/16-7/3/94) in the Colville Delta was devoted primarily to an examination of the Nechelic dredge channel at Nuiqsut. While at the delta, data were also obtained for 1. bluff erosion at Nuiqsut, 2. bank retreat at two other locations in the delta, 3. water depths at several tapped lake entrances, and 4. bar building at Putu and at other locations.

All of the surveys follow on and add to field examinations made in the delta during a number of years since 1960 and especially since 1981. Selected references are included at the end of this report.

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1. INTRODUCTION

The Drainage Basin of the Colville River is about 53,200 km^2 (20,550 mi^2) in area. About 1/90th (appx. 600 km^2) of this area is its delta which extends some 45 km (28 mi) from the mouth of the southern most distributary to the Arctic Ocean.

During the summer of 1994, 10 days of field work provided the opportunity to examine a number of locations in the delta not visited in several years. At these locations it was possible to make some measurements and take some samples to add to the delta collection that has been accumulating since 1961.

The map (Fig. 1) shows those locations visited that are discussed in this report. The photographs included show some of the major recent changes that have occurred in the delta. The earliest vertical aerial photographs, made in 1948-9, have been compared with some made in 1992 and ilustrate the rapidity of sedimentation within parts of the delta and especially in those parts that impact the residents of Nuiqsut.

One of the major problems facing them relates to boat transportation. Therefore, emphasized in this report--in addition to the dredge channel itself--is Putu Channel and the head-water area of Nechelic Channel.

Bank erosion, like sedimentation, varies greatly around the delta. It can also impact heavily on human activities as is well illustrated by the bluff erosion that forced the movement of the

Wood's house at Nigilik near the mouth of the Nechelic Channel.

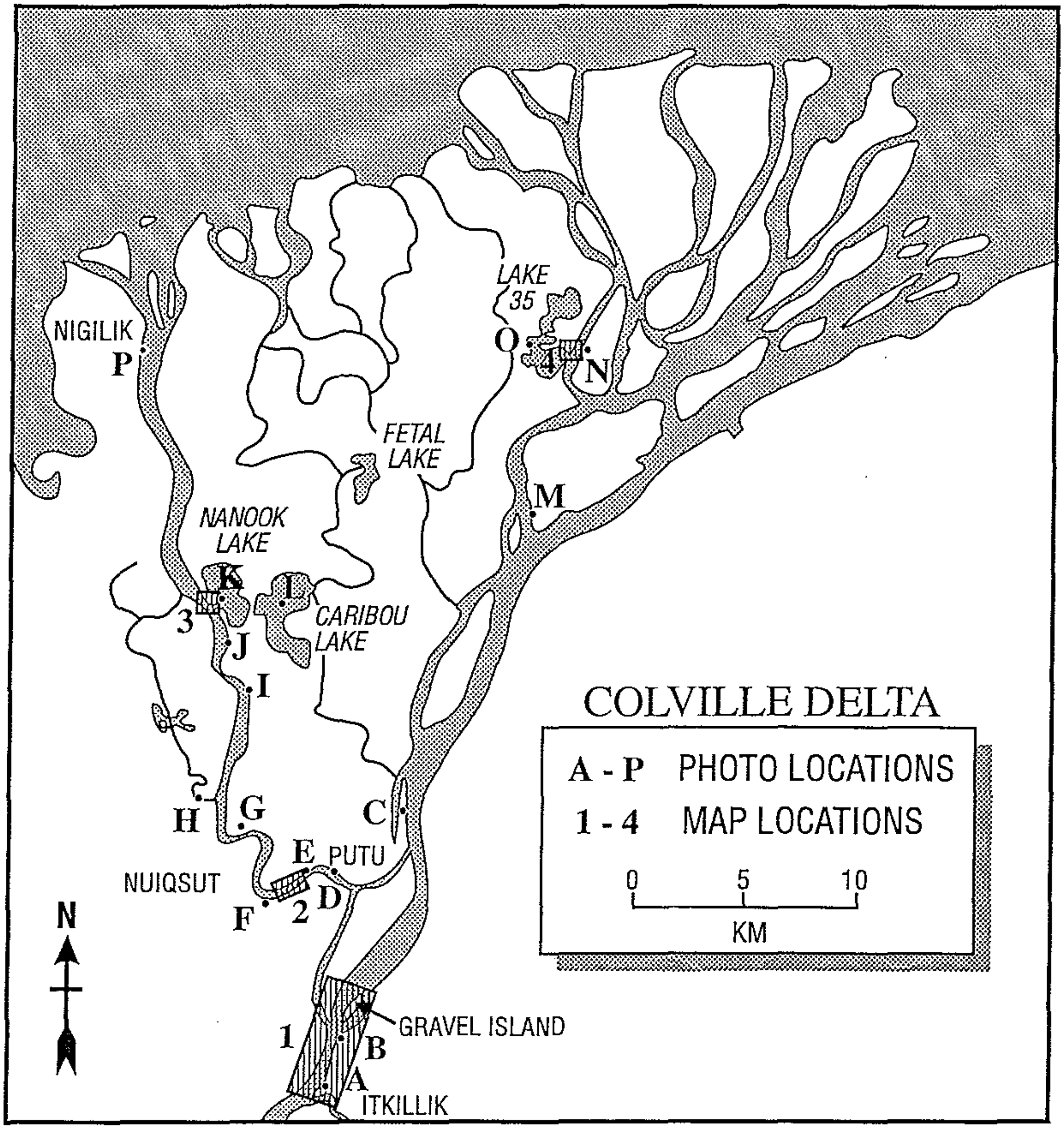

Figure 1. Colville Delta location map

2. THE NECHELIC DREDGE CHANNEL AND ITS BOTTOM MATERIAL

The Dredge Channel

River dredging on the North Slope was begun in Nechelic Channel just upstream from Nuiqsut in 1982. It was later extended to other locations including sites at Kaktovik, Barrow, Atkasuk, Wainwright and Point Lay (Walker 1994).

Prior to dredging in Nechelic Channel, profiles had been obtained from many Colville River locations including the section of the river adjacent to where Nuiqsut is now located. However, it was the profiling done in 1981 that established a base line for future measurements (Fig. 2). Following the 1981 base line study, profiles were made in 1982, 1983, 1985, 1987, 1989, 1991, and 1994. The cross-sections from these profiles are shown in Figures 3 and 5 and the maps derived from them are shown as Figures 2, 4, and 6.

Prior to doing the echosounding, river levels were measured. The bench mark used is located near the bank at Nuiqsut and the elevations of the river were recorded in vertical distance below it (Fig. 7). During the eight years, the level of the water varied by 1.2 m (4 ft) being highest in 1983 and lowest in 1985. In general this range represents about the variation that occurs during most of the summer.

During the period between 1982, when original dredging began, and 1992, when additional dredging was commenced, the deeps created in the channel aggraded rapidly (Figs. 2 & 3).

The depths of over 15m (50 ft) reached in 1983 were reduced to about 9 m (30 ft) by 1989, a change that represents a fill of some

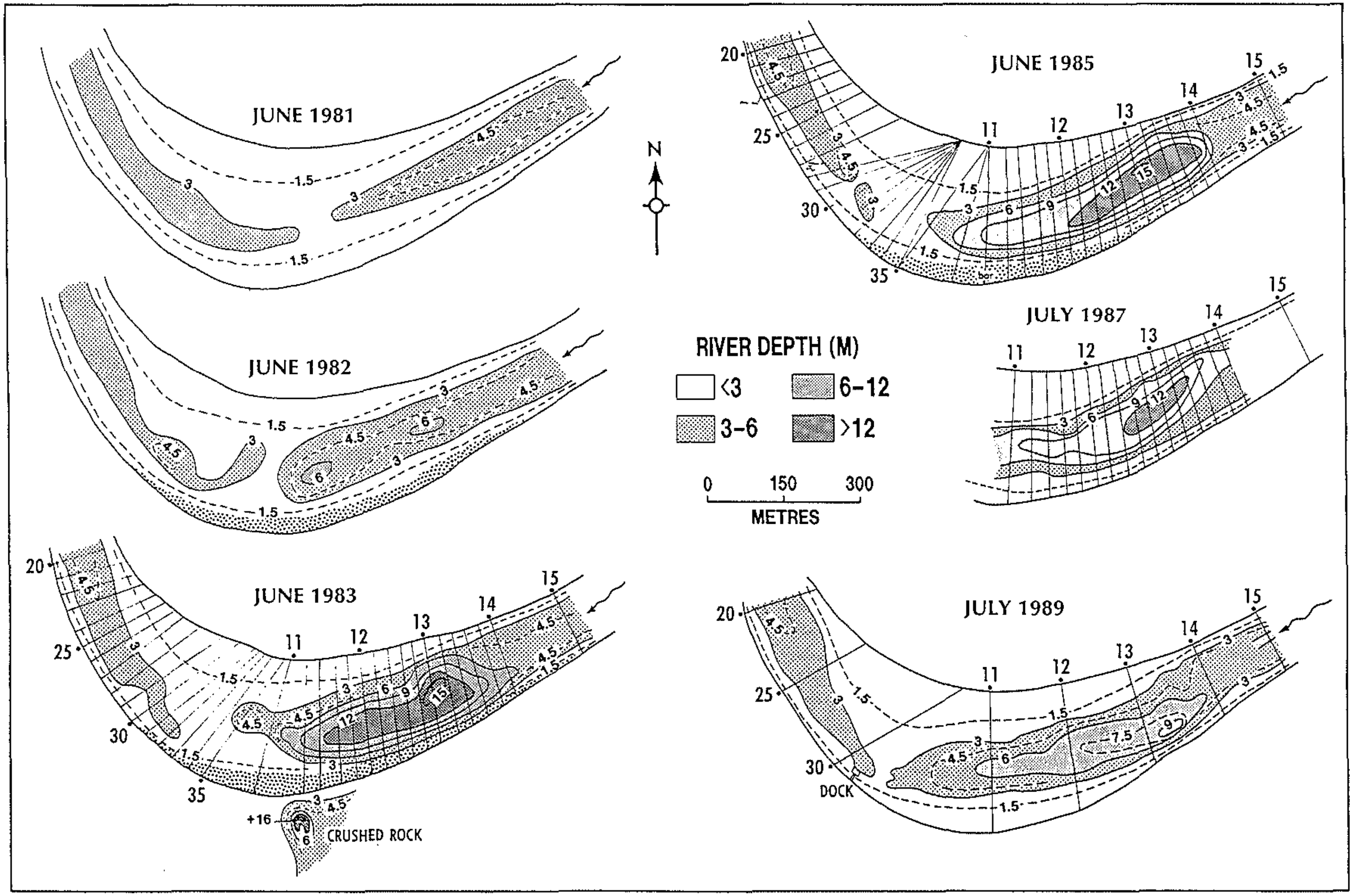

Figure 2. Dredge channels (1981-1989)

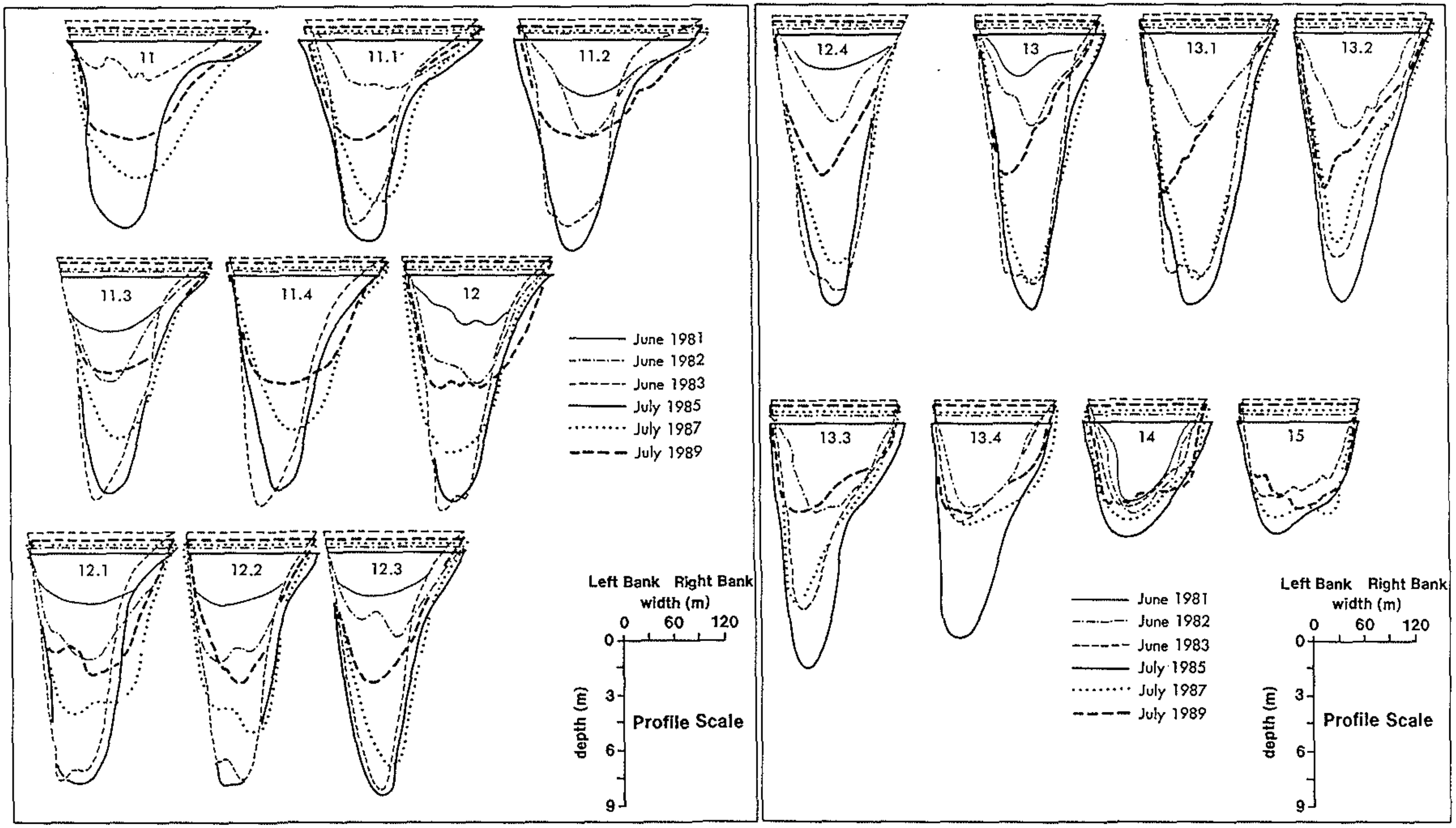

Figure 3. Cross-section surveys of the Nechelic dredge channel

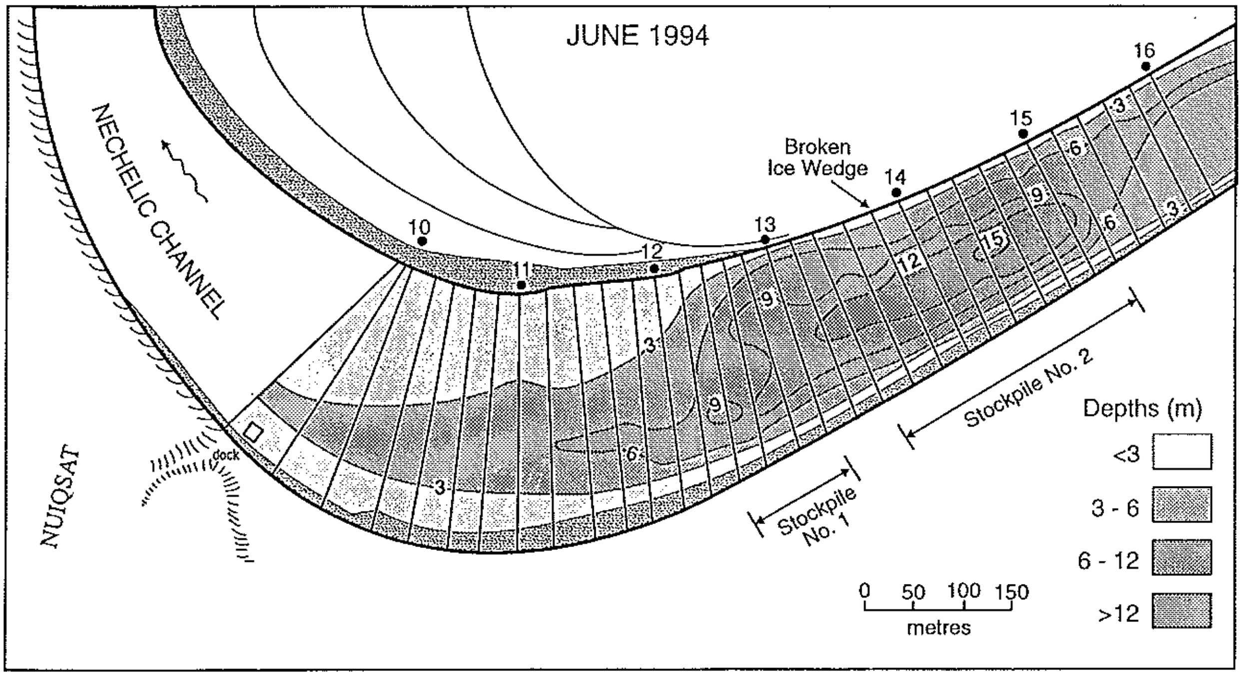

Figure 4. Dredge channel in June 1994

6 m (20 ft) in six years. Fill was somewhat selective in that the thalweg portion migrated gradually toward the left bank (Sections 13 to 13.3, Fig. 3). However, by 1991, these sections had filled sufficiently more to approach the pre-dredge position.

Dredging in 1992 and 1993 extracted part of the old dredge-channel fill (Sections 12.4 to 13.4, Fig. 5) and extended up stream into previously undredged material (Sections 14 to 15.1, Fig. 5). Figure 6 illustrates the location of the greatest dredged depths during 1983 and 1994. The deepest portion in 1994 was located about 250 m upstream from its 1983 counterpart.

Although the exact depths of the channel immediately prior to 1992-1993 dredge seasons are unknown, profiles from 1989 and 1991

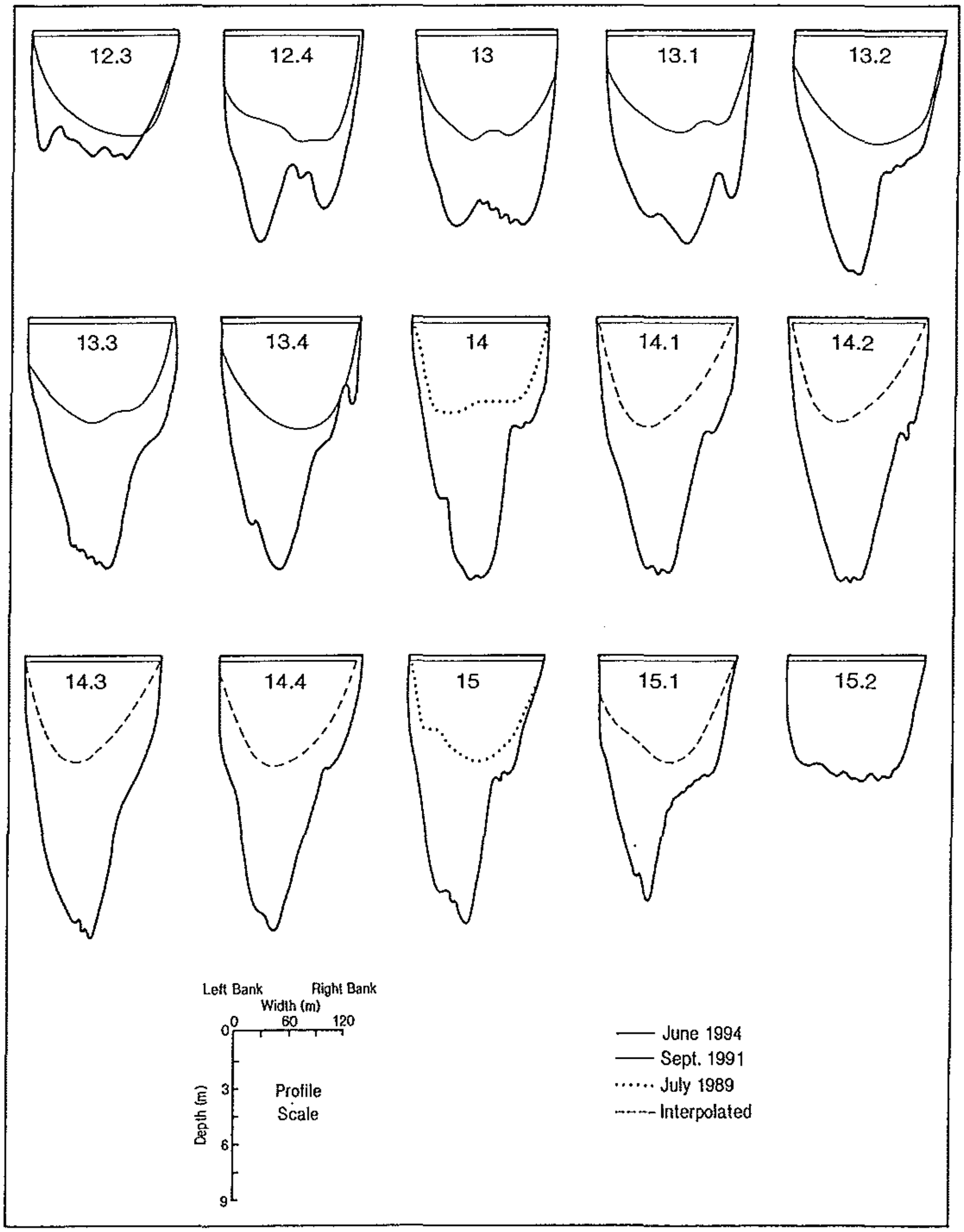

Figure 5. Cross-section surveys of 1992-1993 dredge channel

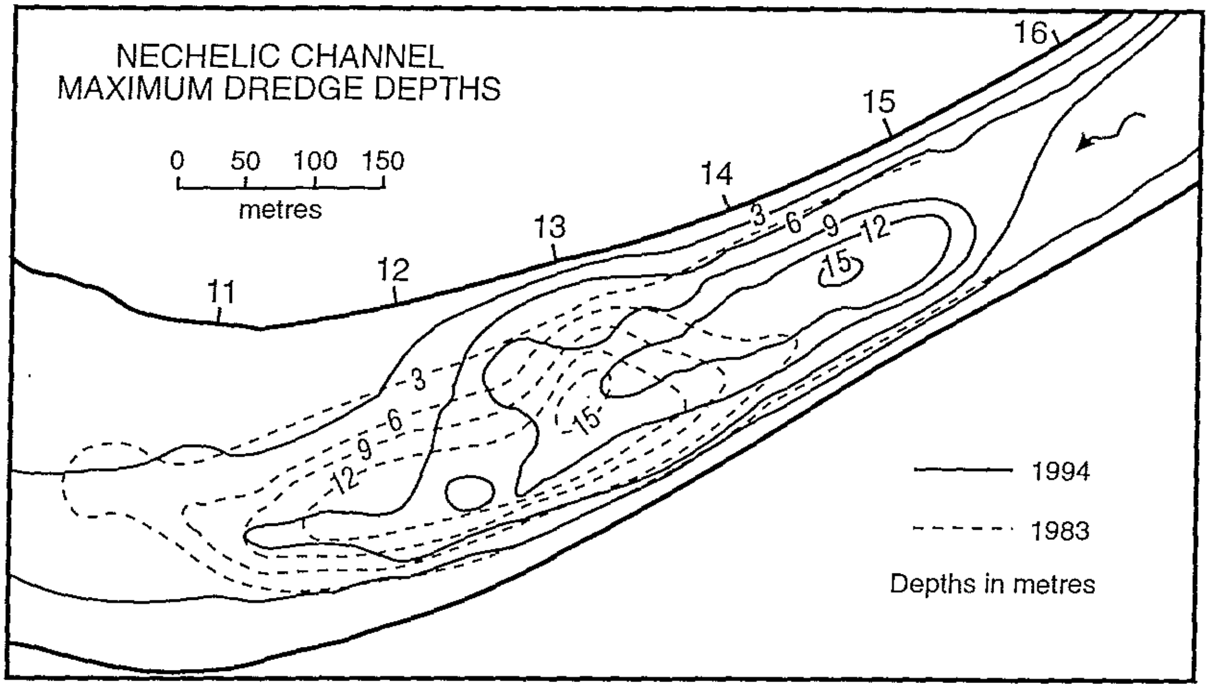

Figure 6. Map showing the shift upstream of dredging operations between 1983 and 1994

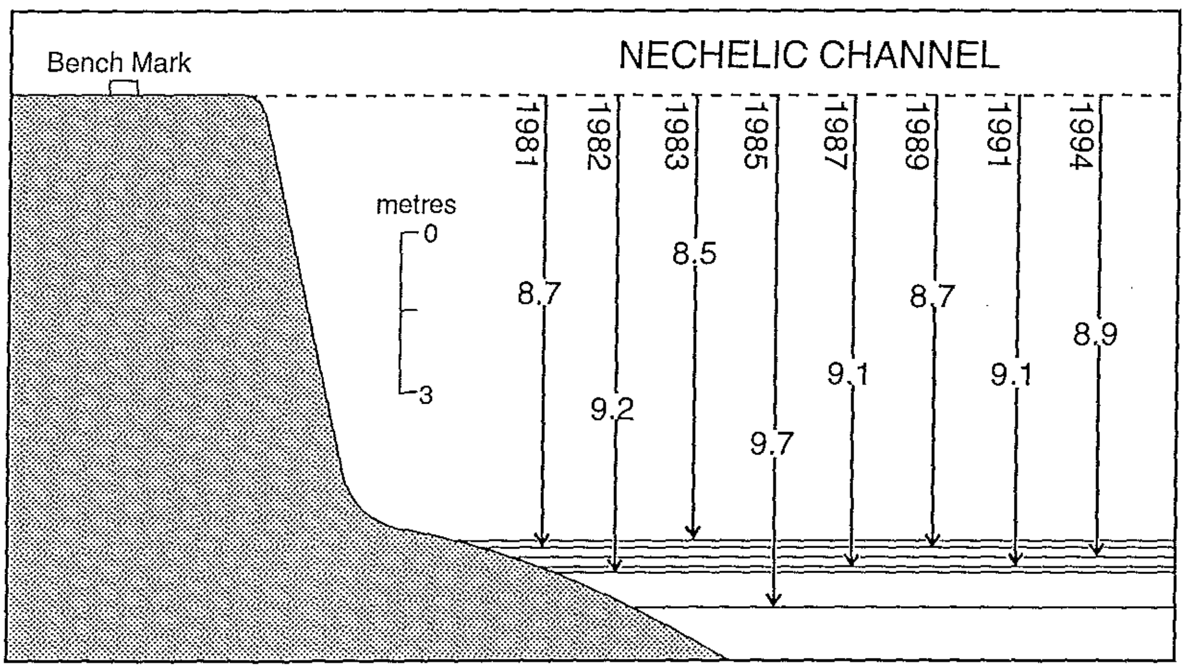

Figure 7. Stages of Nechelic Channel (1981-1994)

(Fig. 5) must approximate the pre-dredge position. They have been used in calculating the volume of material removed during the two dredge seasons. The total volume based on these calculations is 270,000 cu m or 360,000 cu yds.

The amount determined by measuring the volume of the stock pile (pers. corr. Len Nelson) was about 400,000 cu yds which is 40,000 cu yds more than obtained by dredge channel calculations. Much, if not all, of this discrepancy can be considered to be the volume of material that was deposited between the end of the 1992 season and the beginning of dredging in 1993 at which time it was removed plus the amount of deposition that occurred between the end of 1993 dredging and the initiation of echosounding in 1994.

Bottom Materials

During the 1994 field season a number of bottom samples were obtained, 17 of them from Nechelic channel (Fig. 8), three each from sections 12, 13, 14, and 15.4. These samples were taken from depths ranging from 3 m to 14 m. Their textures are shown in Table 1 and Figure 9.

All samples contained organic matter, especially peat shreds. One (Sample 20) contained a large clump of peat. Only one (Sample 16) included pieces of gravel. Most of the material collected is finer than fine sand (FS); some contained large amounts of silt and clay. These fines ranged to as much as 60% in sample 18. In only one sample (17) was there as much as 75% medium sand (MS) to coarse sand (CS).

The one general trend that appears in all cross sections is

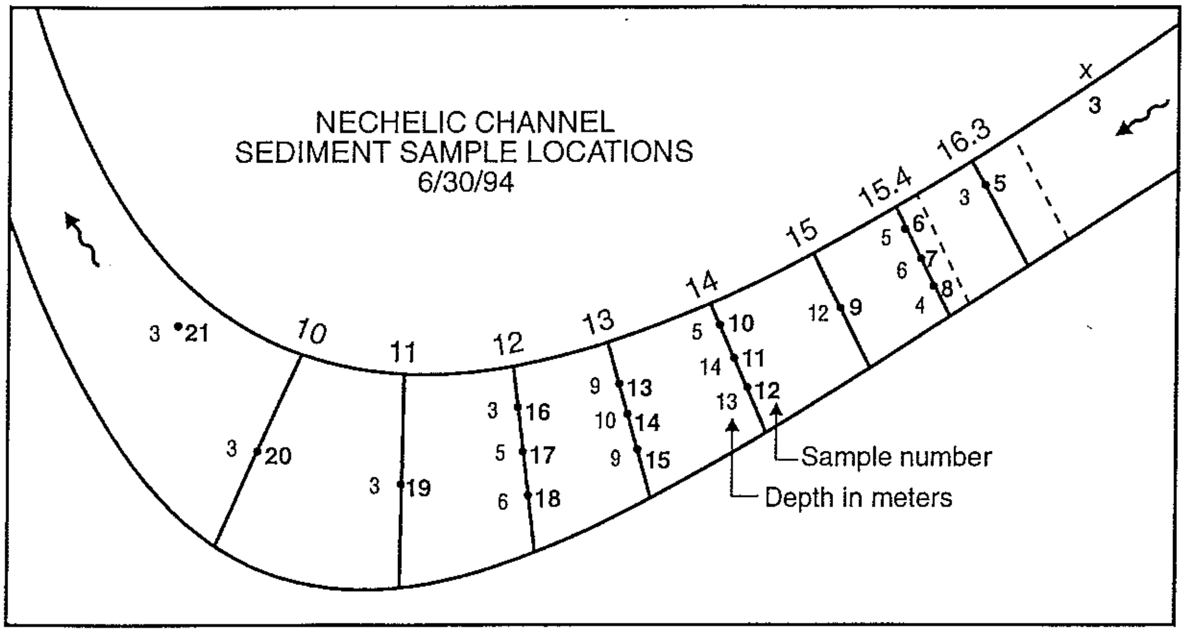

Figure 8. Bottom sediment sample locations (1994)

Table 1. Grain Size: Colville River Samples--1994

Sample no	% finer (mm) 2.00	1.00	0.50	0.25	0.125	0.063
1	100	100	100	98.39	78.79	65.63
2	100	100	99.2	37.04	14.31	6.81
3	99.4	99.2	99.1	97.9	86.1	42.7
4	no sample					
5	99.5	98.8	97.3	21.2	18.6	10.7
6	99.8	99.7	96	59.6	33.5	30.3
7	100	100	99.8	78.7	46.2	20.8
8	100	100	100	99.29	77.29	25.29
9	100	100	99.4	95.9	80.1	31.8
10	99.8	99.5	98.9	45.7	18.5	11.3
11	100	99.83	99	97.33	71	26.5
12	100	100	100	100	70.98	43.38
13	100	100	99.88	92.63	68.25	44.25
14	100	100	99.7	95.5	80.3	53.69
15	100	100	100	97.67	94.64	47.62
16	100	100	100	98.29	59.01	31.92
17	97.4	93.3	79.8	25.5	18.2	14.9
18	100	99.9	99.9	99.6	77.6	61.5
19	99.8	99.8	99.7	54	21.4	5.6
20	96.4	96.1	95.2	75.5	50	29.5
21	99.8	99.8	92.5	9.6	6.6	5.35

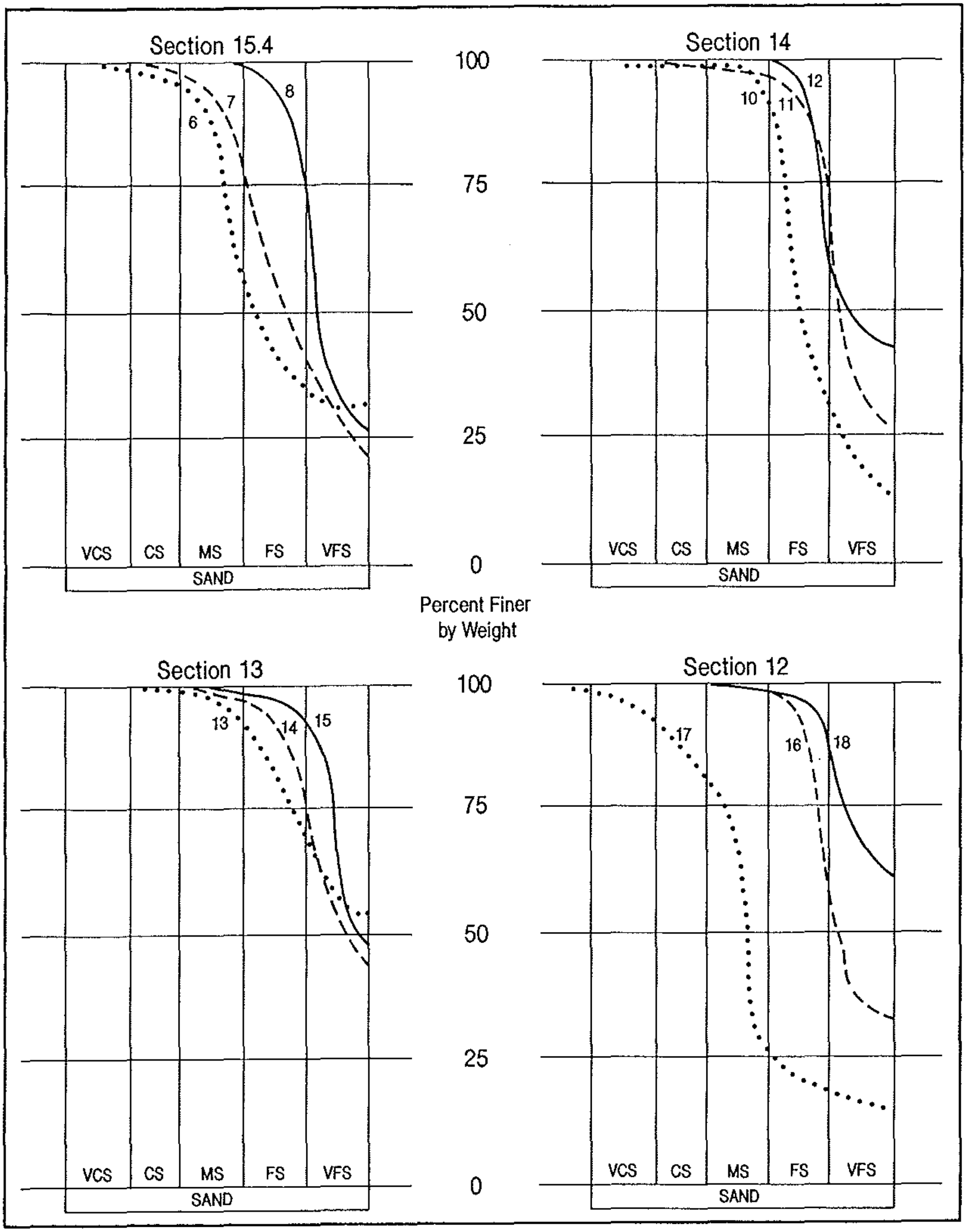

Figure 9. Texture analysis of dredge-bottom material

that the texture becomes coarser in moving from the right bank across to the thalweg portion, although the coarsest material collected (Sample 17) was in the middle of channel.

All of these samples were collected from the bottom by grab bucket and, on the whole, represent only the finest material deposited during the flood season. The coarsest material, i.e. the first to be deposited as breakup flooding began to subside, is buried beneath these finer materials.

Other sediment samples from the delta that were analyzed include materials from a sand dune, a collapsed block, an overflow deposit and four other locations (Fig. 10). The samples with the

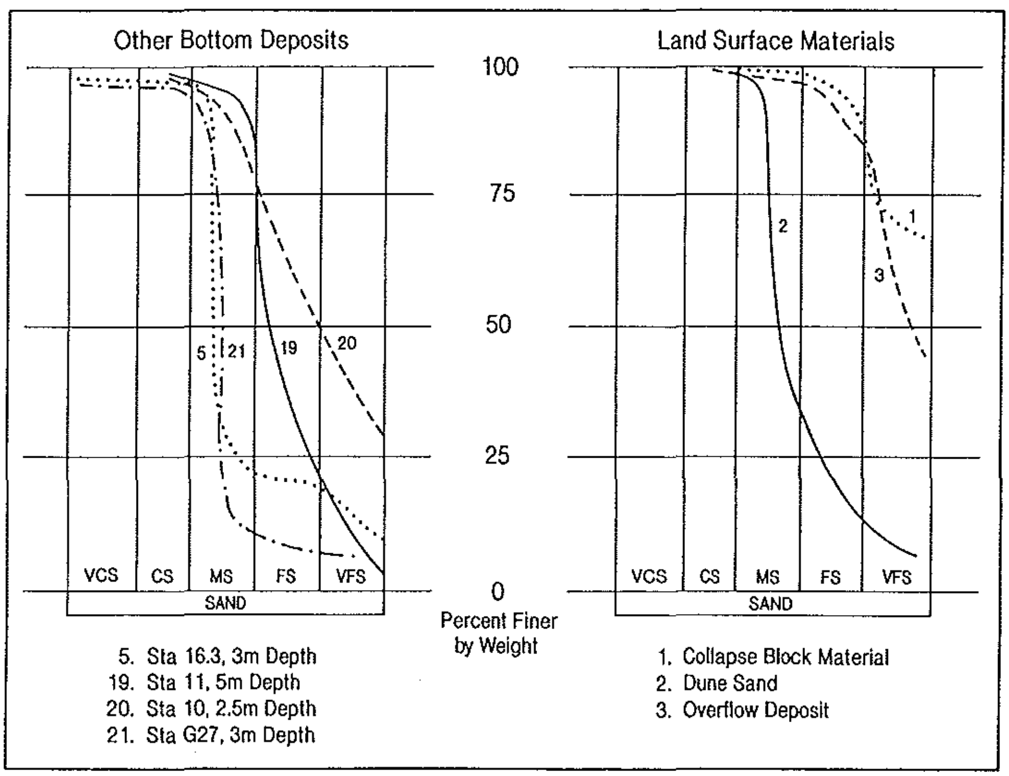

Figure 10. Texture analysis of seven samples from other Colville Delta locations

coarsest materials are from a sand dune (Sample 2), the head of the dredged trench (Sample 5) and from a spot adjacent to the point bar opposite Nuiqsut (Sample 21). In all three sediments are predominantly (up to 85 %) medium sand (MS) or coarser.

DELTAIC EROSION

Nuiqsut-Gubik Formation

The town of Nuiqsut is located on Gubik Formation materials (Black 1964). The Nechelic Channel at several locations is cutting into the Gubik causing bluff retreat. One of the most rapid rates of retreat in the Gubik is occurring on the bluffs just downstream (north) of the town site (Fig. 11). The erosion along this stretch

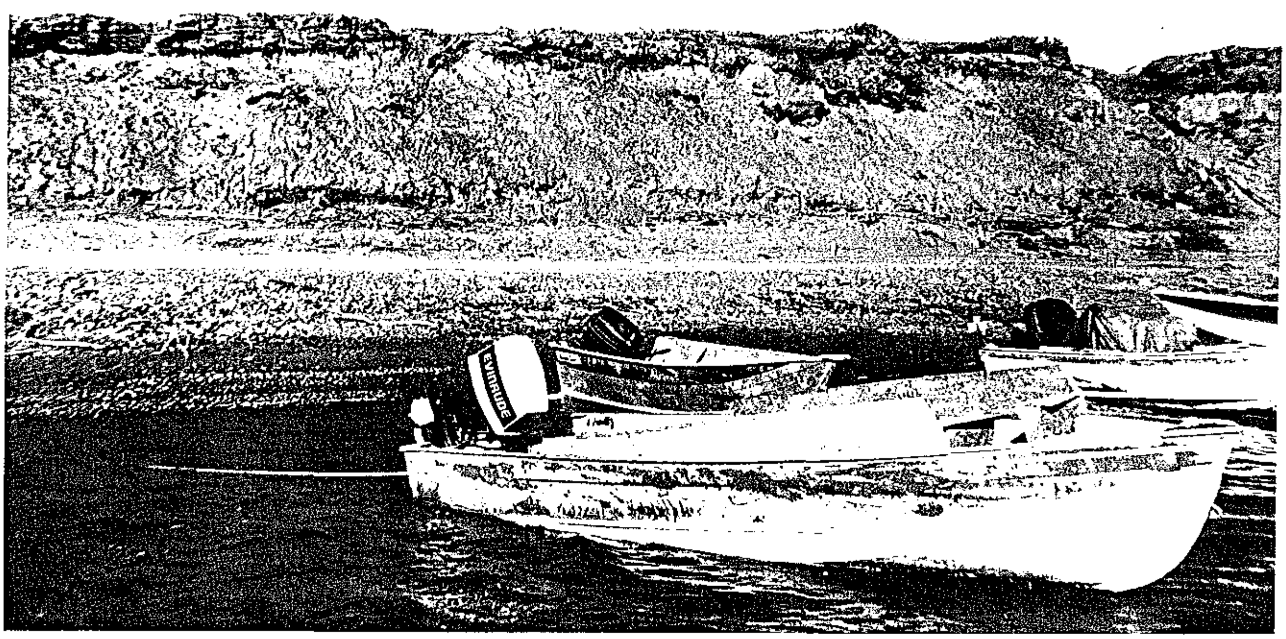

Fig. 11. The Gubik bluff at Nuiqsut (94-A-5-36)

(about 1065 m (3500 ft) has been monitored periodically since 1962. The base line of 1962 had been established after the amount of erosion that had occurred between 1949 (the year the first aerial photographs of the area were taken) and 1962 had been determined (Walker and Arnborg 1966). Then, subsequently since 1982, when a new set of survey stations was established, bluff retreat rates were measured in 1983, 1985, 1987, 1989 and 1994. This retreat has been the subject of a number of papers including "Riverbank erosion in the Colville Delta, Alaska" (Walker et al 1987).

Table 2, Gubik Bank Retreat--1982-1994, provides data for most of the 21 bank-retreat stations and gives the amount of total retreat as well as the average rates. During that period of time, total retreat has varied from a low of 1.9 m (6.2 ft) to 8.6 m (28.2 ft) for the 13 stations where markers had not been destroyed. One other station (11) which was not recovered in 1994, had a retreat of 10.9 m (35.8 ft) in one season (Spring 1983) because of block collapse (Table 2). Subsequent retreat of that portion of the bank was minimal because of the protection provided by the collapsed block. The only retreat for several years at that location was during the establishment of an angle of repose of the bluff from the vertical face that block collapse formed.

Other Delta Locations

There are several other locations in the Colville delta where bank erosion is a common occurrence. Most of these other locations are on meander bends or along straight reaches where the adjacent channel is relatively deep. The amount of erosion varies with the

Table 2. Gubik Bank Retreat -- 1982-1994
(in metres -- avg. also in feet)

Sta.	82/83	83/85	85/87	87/89	89/94	Total	avg/yr m	avg/yr ft
1	3.0	0.0	0.0	1.5	1.3	5.8	0.48	1.6
2	7.0	1.2	*	*	2.0	3.2	0.27	0.9
3	4.1	0.5	0.0	0.3	*	--	--	--
4	7.0	0.0	0.9	0.0	0.7	8.6	0.7	2.2
5	5.8	1.2	0.3	*	*	--	--	--
6	5.0	3.2	0.3	0.9	*	--	--	--
7	0.0	0.3	0.0	0.6	1.0	1.9	0.16	0.5
8	4.2	0.6	0.3	*	0.0	5.1	0.43	1.5
9	0.8	0.8	0.0	0.6	1.3	3.5	0.29	1.0
10	3.6	0.9	1.0	0.3	1.0	6.8	0.57	1.9
11	10.9	1.2	0.3	2.1	*	--	--	--
12	0.3	4.2	1.0	0.6	0.6	6.7	0.58	1.8
13	2.2	3.3	0.0	0.3	*	--	--	--
14	3.3	1.5	0.1	0.6	0.6	6.1	0.51	1.7
15	2.4	0.0	0.0	0.6	0.3	3.3	0.28	0.3
16	3.4	0.5	0.4	1.5	0.3	6.1	0.51	1.7
17	7.8	1.5	*	*	*	--	--	--
18	*	*	*	*	*	--	--	--
19	0.0	1.5	0.3	0.6	*	--	--	--
20	0.6	0.0	1.5	*	0.6	2.1	0.18	0.6
21	1.0	0.0	0.2	0.9	0.0	2.1	0.18	0.6
Avg (m)	3.6	1.1	0.36	0.8	0.75	4.7	0.39	--
Avg (ft)	11.8	3.6	1.2	2.5	2.4	15.5	--	1.28

composition of the bank as well as with its position in relation to the erosional capabilities of the flowing water (Walker and Morgan 1964). Especially vulnerable are sand dunes (Fig.12) and silt banks (Fig.13), both of which are composed of very friable materials when in a non-frozen state.

These two types of bank (sand and silt) are easily undercut by the relatively warm flowing water that is especially erosive during periods of flood. Notch formation (Fig. 12) may progress to such a position beneath the bluff that collapse occurs (Fig. 13).

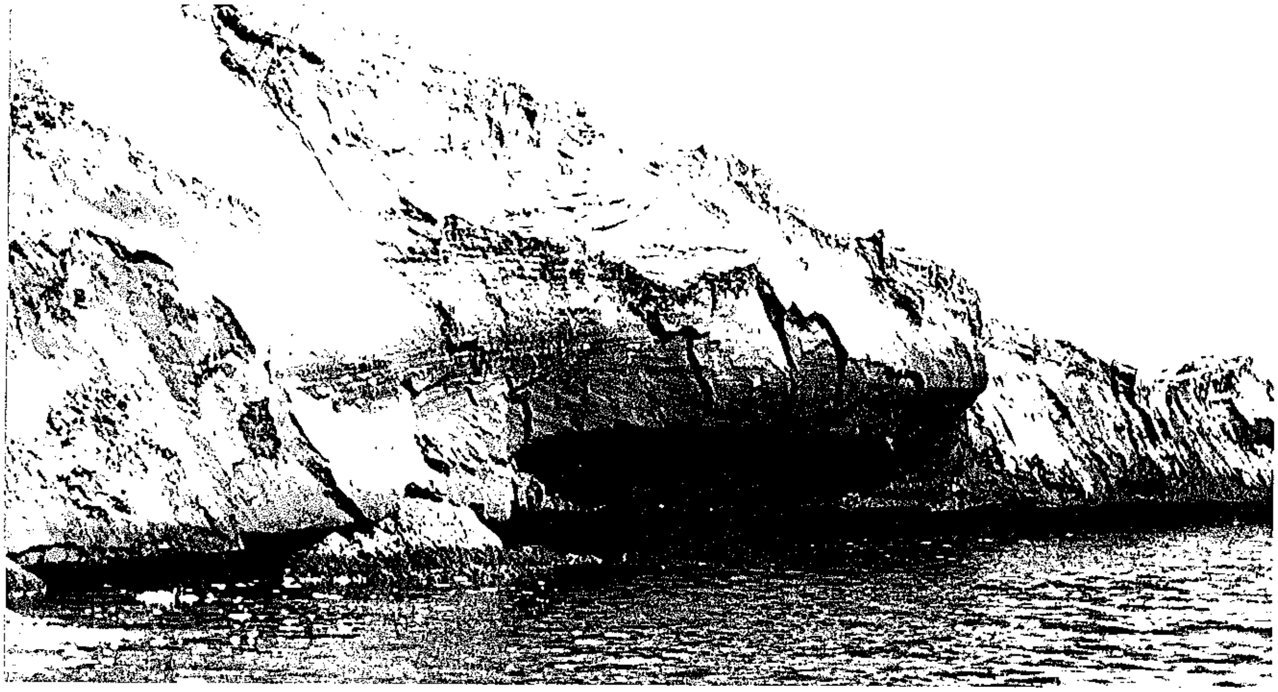

Figure 12. Thermoerosional niche at M, Fig. 1 (94-A-3-32)

Figure 13. Bank collapse at G, Fig. 1 (94-A-6-11)

Peat banks have quite different erosional characteristics than those banks composed primarily of mineral matter. Ice wedges are major elements in areas of peat in the Colville Delta. In some locations, especially along the right bank of the main channel, ice wedges occupy as much as 30% of the upper 3 to 4 m (10 to 13 ft) of the top surface materials.

When the river impacts on such a combination (peat and ice wedge), ice wedges respond to the thermo-erosional processes more rapidly than the surrounding peat resulting in a much more rapid rate of retreat (Fig. 14). This more rapid rate of retreat is due

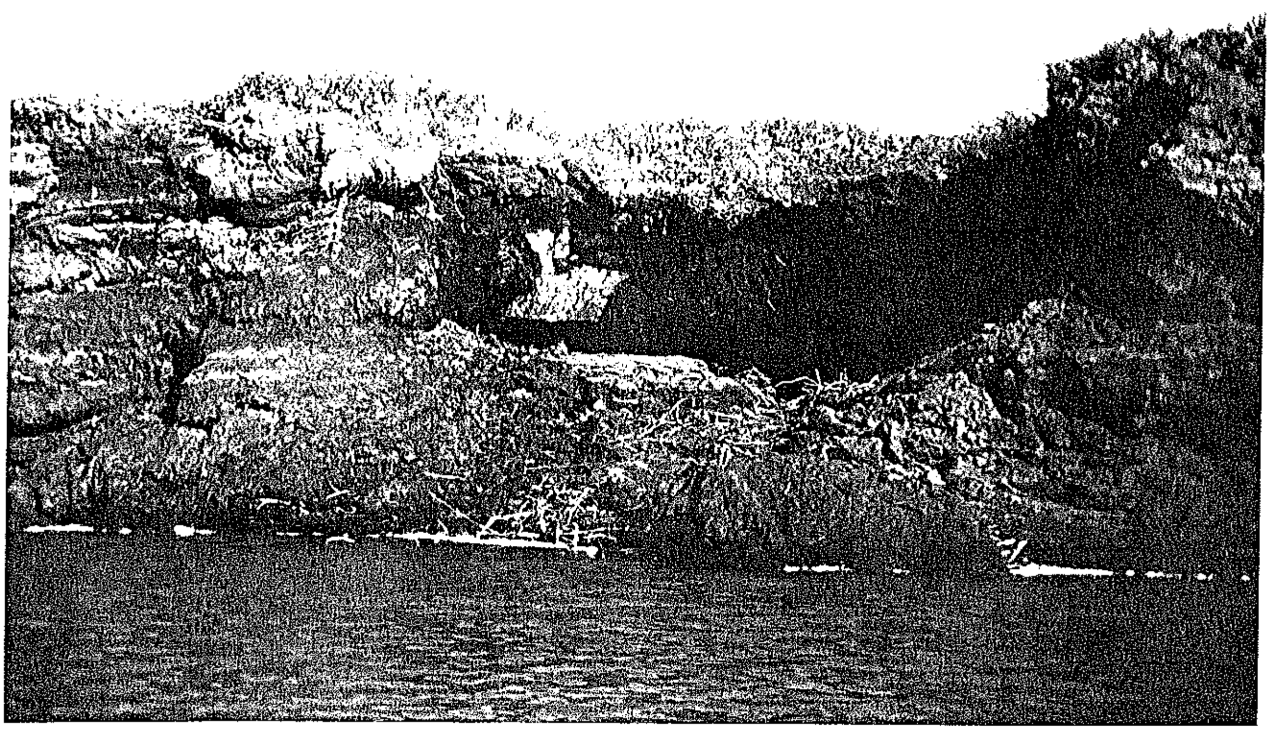

Figure 14. Ice wedge erosion in peat at E, Fig. 1 (94-A-9-21)

to a combination of thermoerosion from water contact (Fig. 15) and subsequent atmospheric heating and melting of the ice. Retreat may be such that whole peat polygons are isolated (Fig. 16). However, the rate of wedge retreat slows as indentation (both vertical and horizontal) progresses because the ice surface becomes protected by the material that is sloughed from adjacent banks, is deposited by the river, or is draped over the wedge from overtopping peat (Fig. 17).

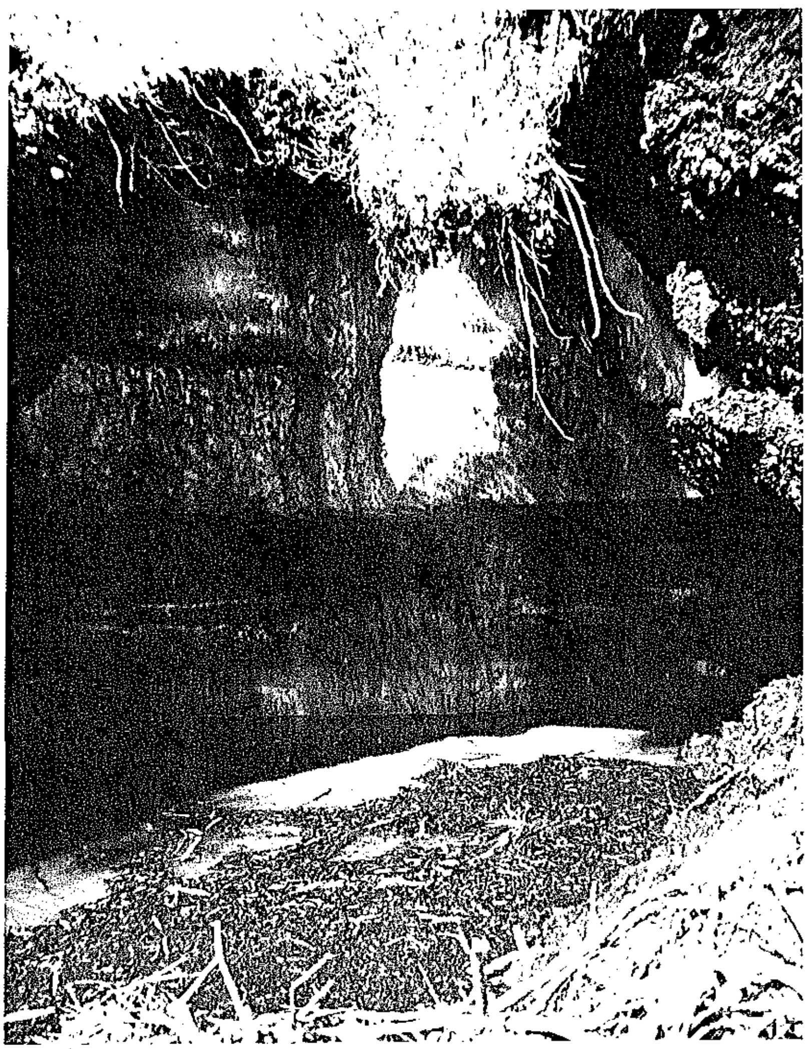

Figure 15. Thermoerosion of ice wedge at E, Fig. 1 (94-A-11-4)

One of the areas that has been monitored periodically is located at Nigilik (the Wood's camp) at the mouth of Nechelic Channel. Bank retreat was so severe that in 1985 it became necessary to move the Wood's house inland. During the last 45 years 58 m (190 ft) of retreat has occurred along this portion of the Nechelic Channel. With an average of 1.3 m/year (4.2 ft/yr) its rate of retreat is greater than

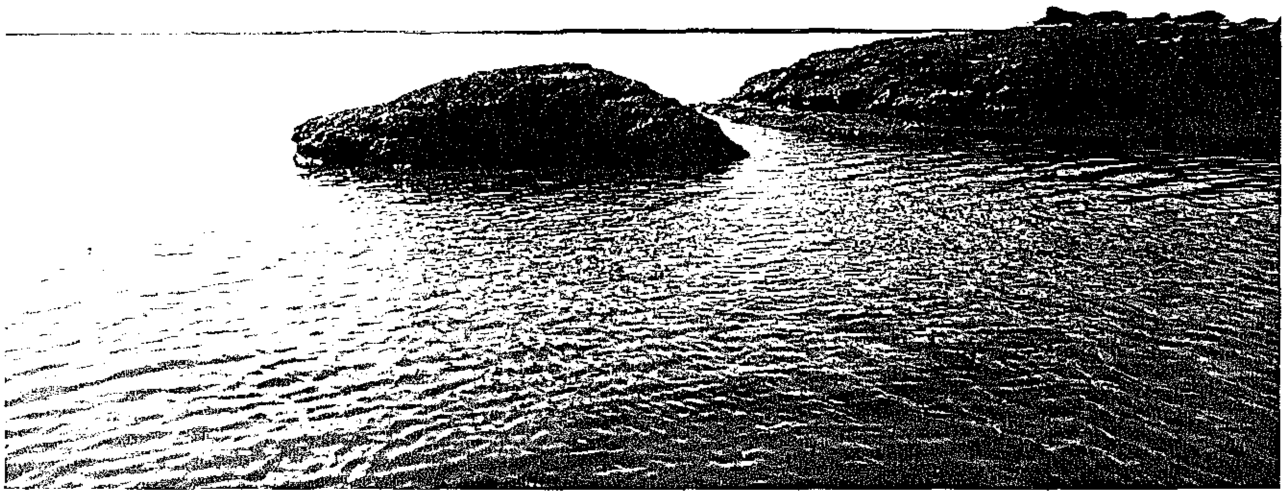

Figure 16. Isolated peat block at O, Fig. 1 (94-A-3-20)

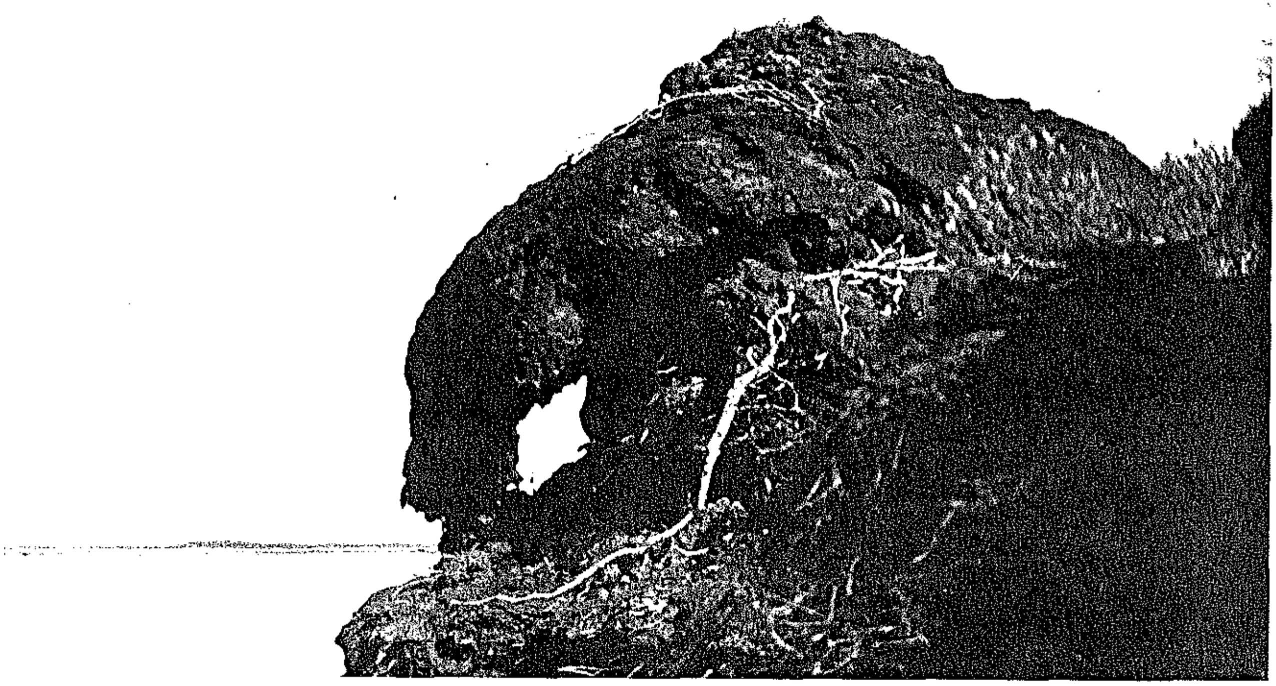

Figure 17. Draping of peat at B, Fig. 1 (94-A-10-28)

that for the Gubik at Nuiqsut. In addition to the loss of land by erosion, many cultural remains, some dating back to the days of trading between the Anaktuvuk Pass and Point Barrow residents, have been destroyed or submerged at the bottom of the migrating channel.

Bank retreat frequently impacts more than just the immediate bank itself. One of the most conspicuous changes that occurs in the delta takes place when the river erodes the bank to such an extent that lakes are tapped. Such tapping causes lake drainage and the incorporation of the lake into the flooding regime of the river and subsequent filling (Walker 1978).

In addition to large lakes, small ponds, such as those occurring in low-centered polygons, are frequent casualties. Figure 18, which is of the right bank upstream from Nuiqsut, shows such drainage. In 1981, a photo taken in connection with the dredging operation, shows that the pond is intact. By 1992, erosion into the two adjacent ice wedges caused its drainage so that today it is dry (Fig. 18).

COLVILLE RIVER CROSS-SECTIONS

During 1962 over 300 sections were made across the various channels in the Colville Delta. In 1994, in addition to re-echosounding the dredge channel area of the Nechelic Channel, echo-sounding was also done at several other locations including some in the main channel and some at the entrances to tapped lakes.

Itkillik Entrance to First Distributary

The section of the Colville River, from the mouth of the last

Figure 18. Drained low-center polygon at E, Fig. 1 (94-A-9-35)

distributary before reaching the delta's first distributary (as it is today), is about 3.6 km (2.2 mi) long. It is a very important stretch in the river because it carries more than 99% of the flow that enters the delta. There is minimal addition from the tundra into the delta itself.

The main channel is quite deep with the thalweg portion ranging to as much as 14 m (45 ft) in depth near the mouth of the Itkillik. This thalweg portion tends to favor the right side of the channel until about half way between the Itkillik River and the distributary by which location it had begun to move gradually toward the bar on the left side of the river (Sections 2, 3, 4 in

Fig. 19). Several changes occurred between 1949 and 1992 as can be seen in a comparison of Figures 20a and 20b. The main difference is in the position of the inlet to the first distributary. It has shifted about 1.1 km (0.7 mi) to the north. This shift, as discussed below under the section on deposition, has had a major impact on the navigability of this Nechelic Channel mouth.

Tapped Lake Entrances

One of the major changes that occurs in the delta is the tapping of lakes by migrating river channels (Walker 1978). Lakes on the North Slope are often enlarged by lake shoreline erosion, a process that occurs in the delta as well. However, the major factor resulting in tapping in the delta is river channel migration toward a lake.

Once tapping occurs, which is usually along an ice wedge between polygons, drainage progresses rapidly. Because most of the lakes, prior to tapping, are some 2 m (6 ft) above the main river channel at its normal stage outflow is rapid and scour pools occur near the channel entrance. Some of the deepest locations in the delta's channels are such scour pools.

Once tapped, lake levels fluctuate along with river levels. Thus, during river flooding, lakes fill and as flood levels subside they drain. The current velocity at the entrance can be quite high as the lake drains and the scour hole formed during tapping is maintained at least to some extent.

The depths at the entrance to two (Nanook and Lake 35) of the many tapped lakes were echosounded in 1994 and are illustrated in

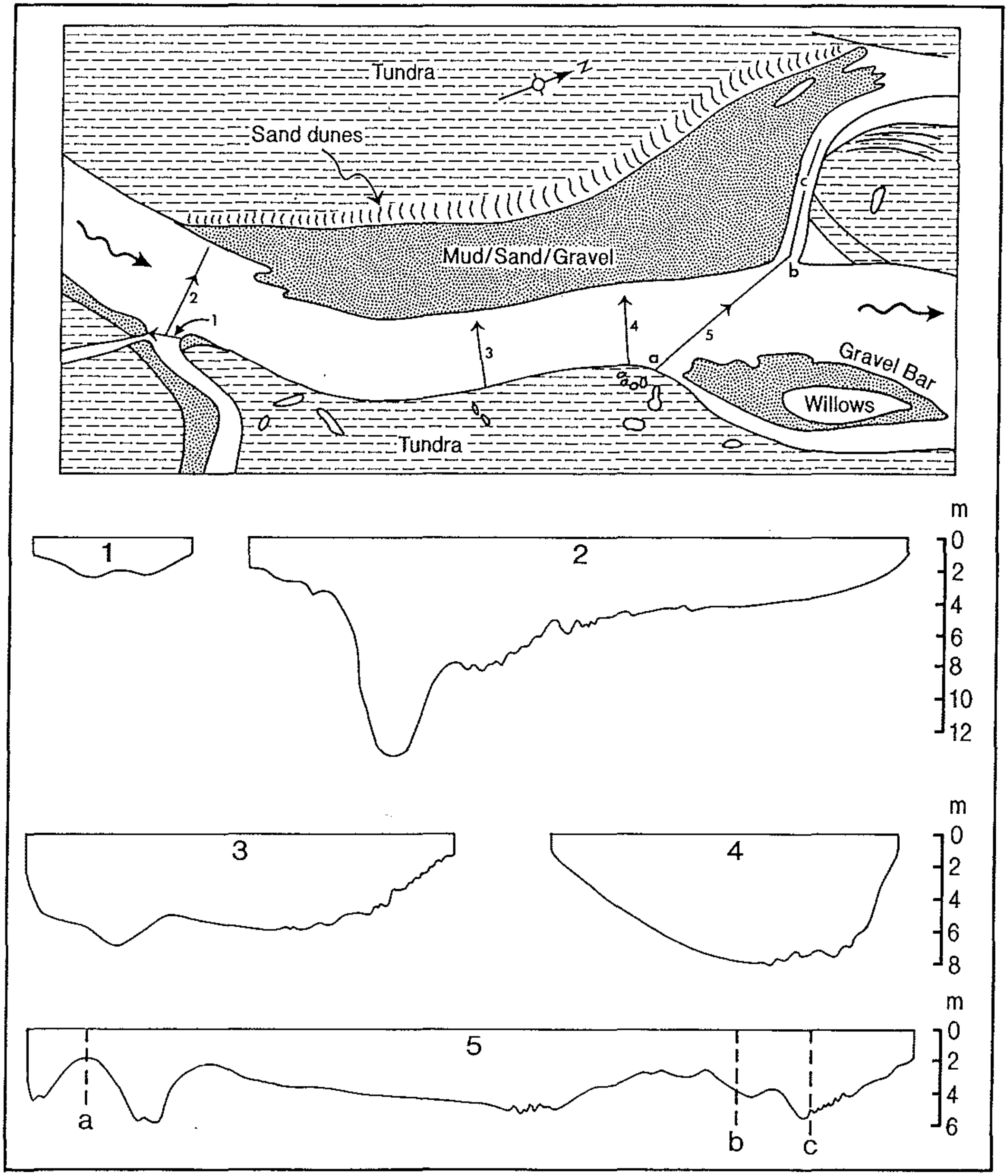

Figure 19. Channel cross-sections between the Itkillik River mouth and the delta's first distributary

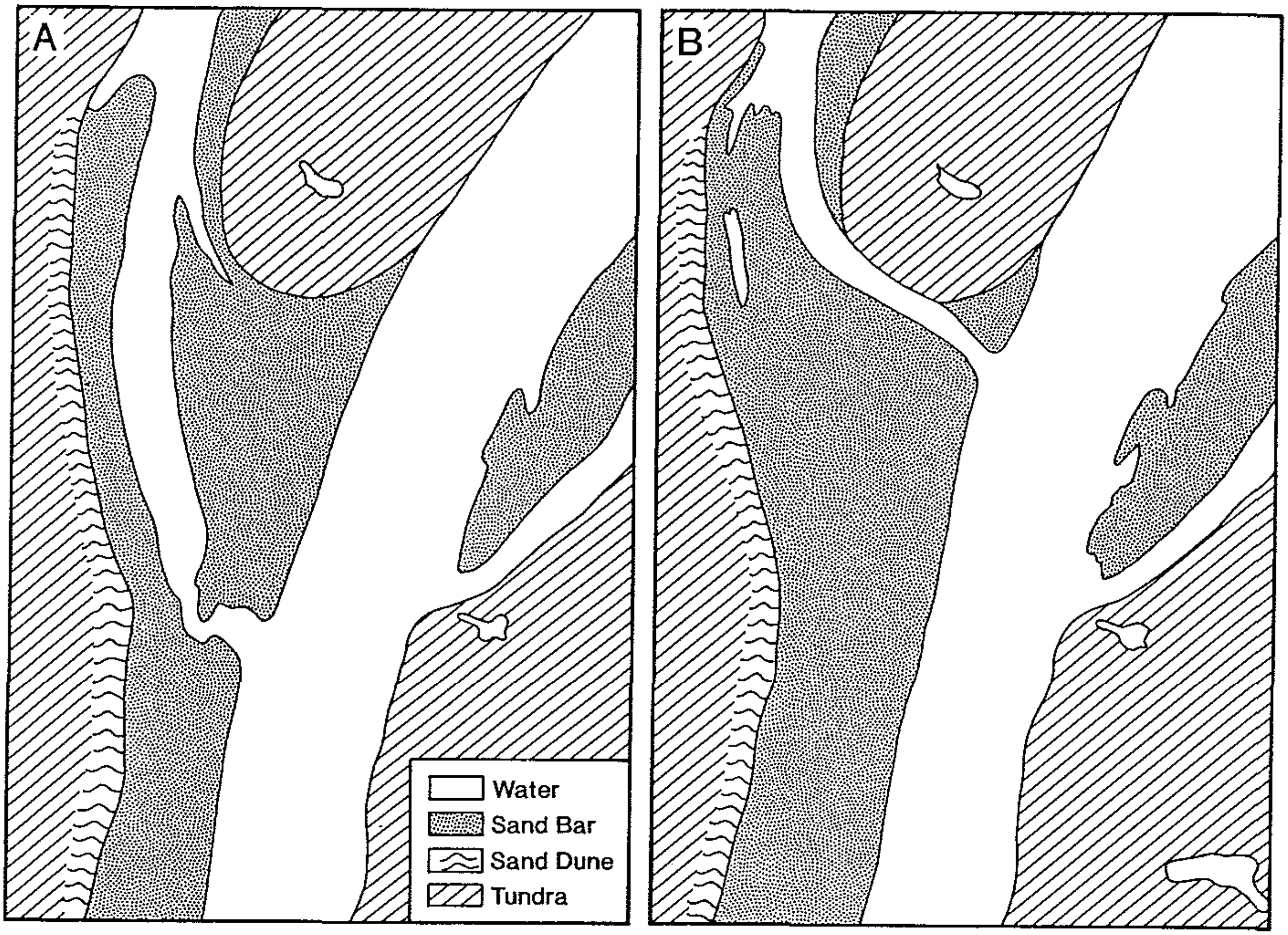

Figure 20. Shift of the mouth of the delta's first distribtary

a = 1949, b = 1992

Figures 21 and 22. Lake Nanook (Fig. 1) on the Nechelic Channel, was tapped in the late 1940s (Pers. corr. Nannie Woods). The first echosounding of the lake entrance showed the depth of the scour hole to be nearly 10 m (33 ft). In 1994, the maximum depth recorded was 8.5 m (28 ft). It appears that the scour hole is filling. If so it is probably because Lake Nanook itself has gradually filled to such an extent that its total water capacity has decreased

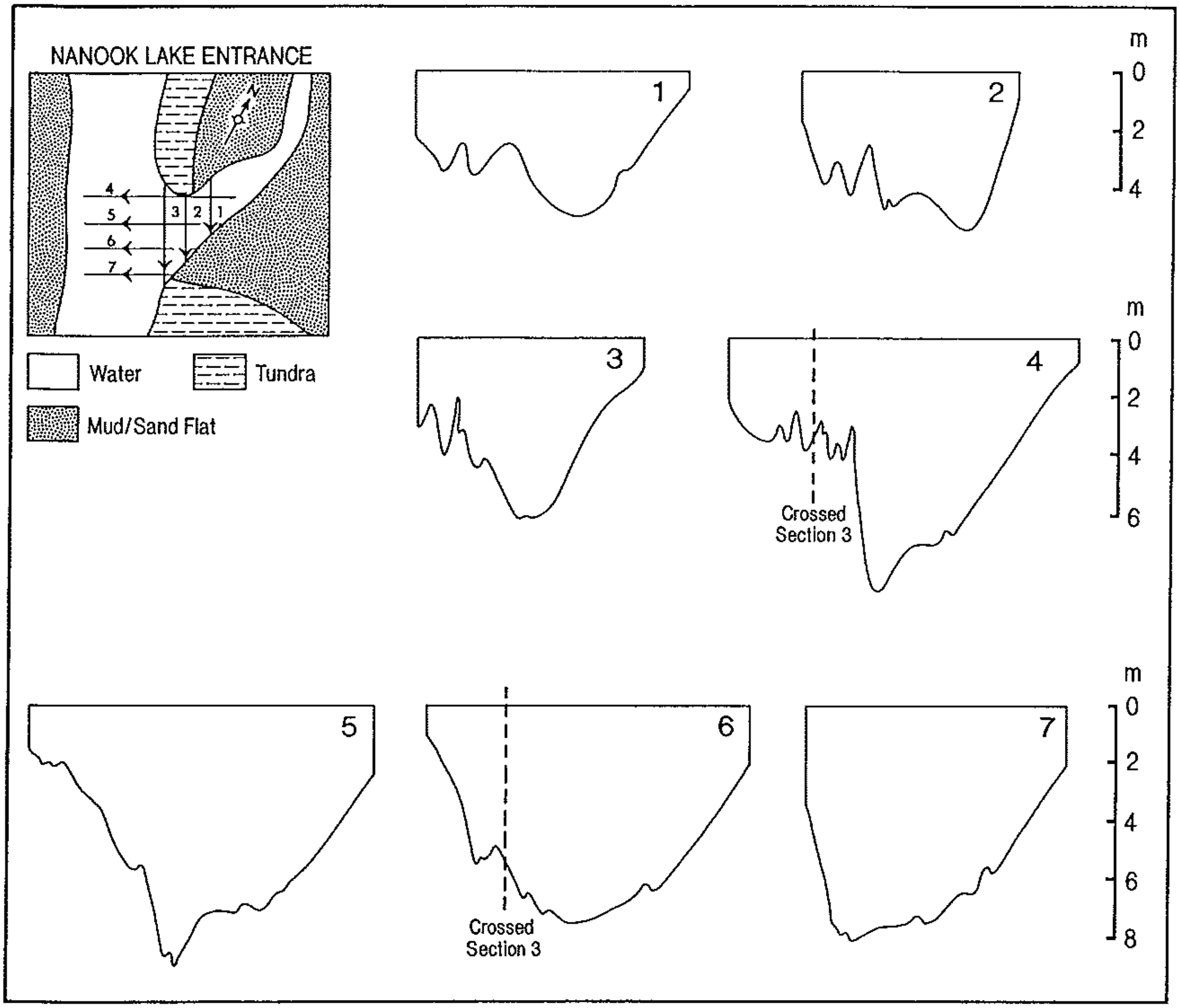

Figure 21. Cross sections of Lake Nanook entrance (1994)

sufficiently to reduce exit turbulence substantially. The widening of its mouth through the 45+ years of opening would also tend to reduce its draining turbulence. Further, the 1994 soundings show that the greatest depths are gradually moving from near the entrance of the former lake out toward the center of the channel.

Lake 35 (Figs. 1 & 22), which was tapped between 1956 and 1960, has not filled to the extent of Nanook and today possesses

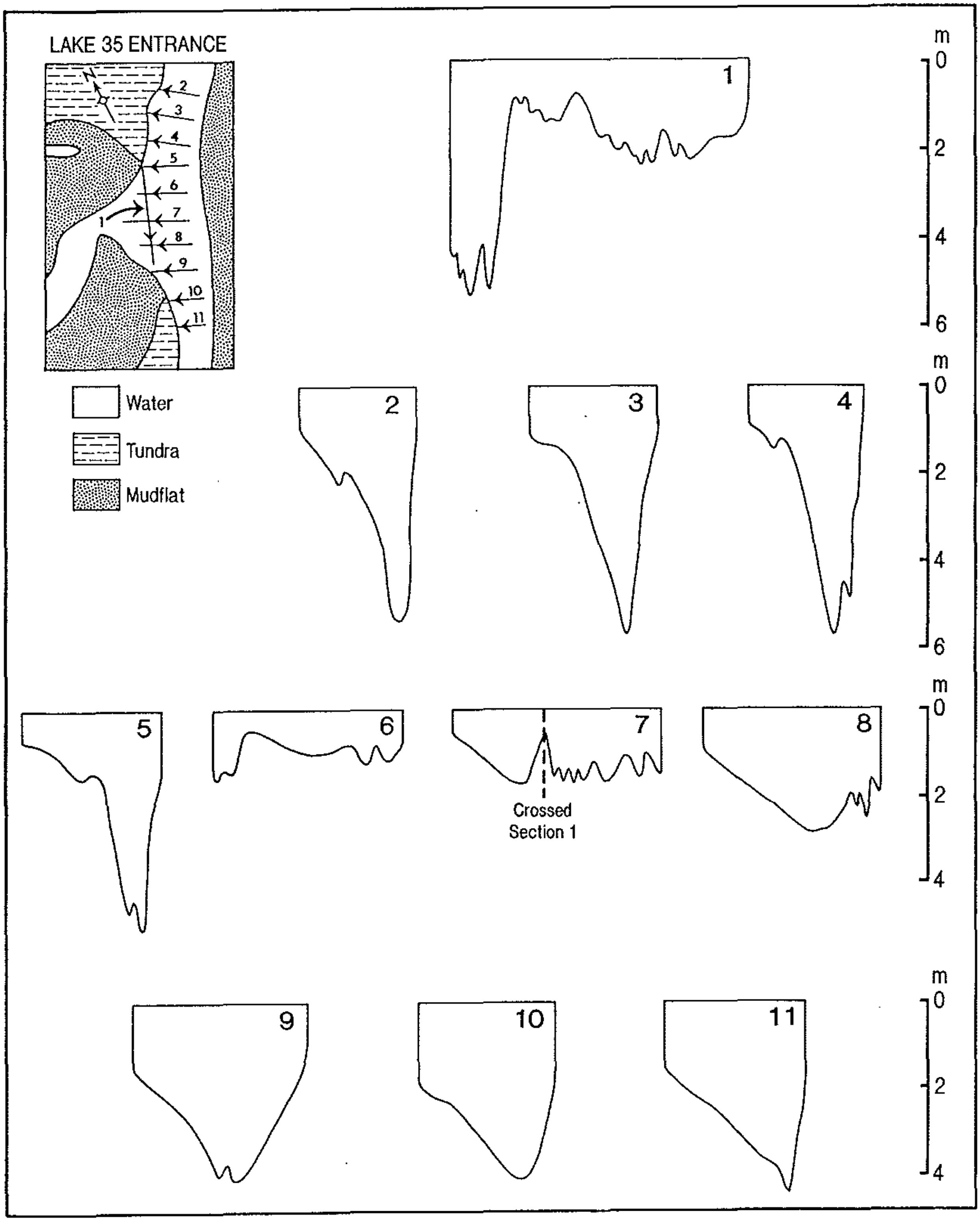

Figure 22. Cross sections of Lake 35 entrance (1994)

a scour hole of 5.8 m (19 ft) which is comparable with the 5.5 m (18 ft) originally recorded.

SAND BAR DEVELOPMENT

First Distributary Entrance

As noted above, the entrance channel of the first distributary, at normal stage, has shifted north with time (Figs 20a & 20b). During flood periods it is quite wide because the sand/gravel bar at its entrance is submerged beneath floodwaters.

At normal stage (all but about 2 to 3 weeks of the hydrologic year--i.e., mid-May to mid-October) relatively little of the Colville discharge enters this distributary. However, during flood period as much as 25% enters it and flows down the Nechelic Channel (Arnborg et al 1966).

Because it is a location where the discharge (and its mineral and organic load) diverges, velocity reduces and sediment is deposited. It is at this location where most of the transported gravels are deposited. It should be noted that the gravel (and boulder bars) occurring along the Gubik banks in the Nechelic Channel are from the Gubik Formation and not from present day river flow.

As flood waters subside, this distributary entrance location continues to be one of deposition which results in a quite shallow channel and therefore causes difficulty in traversing by boat. This is a natural process that will continue into the future.

The Putu Channel Area

The Putu Channel, a connection between the main channel and Nechelic Channel, has also been subjected to rapid sedimentation. During the 1960s it was traversable easily even during low stage. During the 1970s, some difficulty was encountered and, by the early 1990s, it became impossible to use it at low stage as a route between Nuiqsut and the main channel.

Putu Channel is one of those channels in which the water reverses direction with stage, a situation that enhances deposition and hastens its filling. Figure 23 illustrates this reversal with stage. The normal flow (i.e., when the stage is below about 2 m (6 ft)) is from east to west. However, as the stage approaches that level, velocity decreases to zero at which level stage reversal occurs and the flow is toward the east (i.e., from the upper part of Nechelic Channel to the main channel). This direction of flow continues until the stage again drops below about 2 m (6 ft).

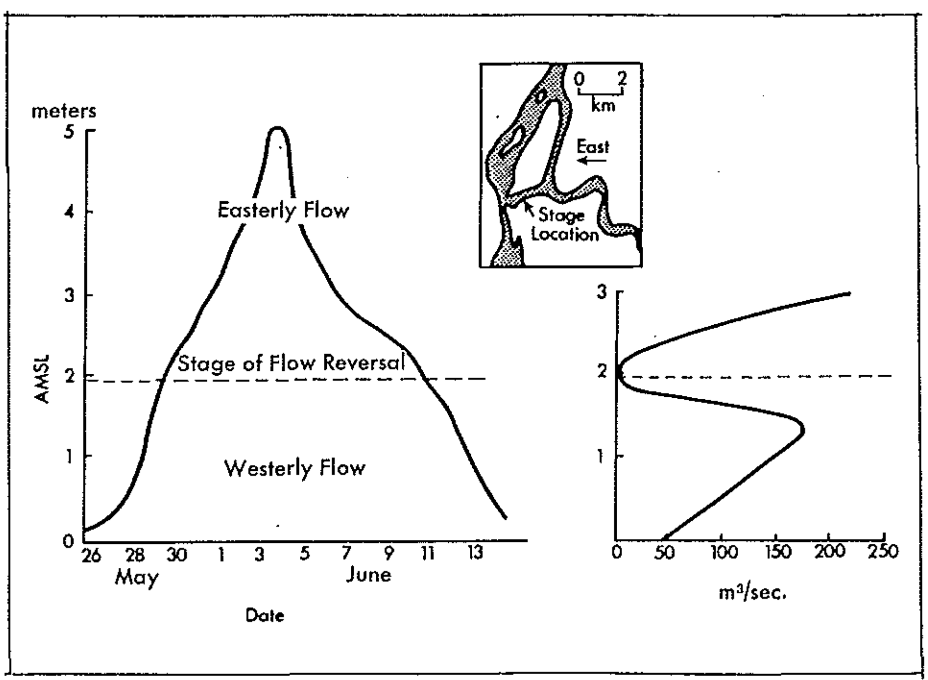

Figure 23. Reversal of flow in Putu channel

At least twice during the season there is still-stand of the water in Putu Channel which results in large amounts of suspended material being deposited. It is not surprising--given this type of stage reversal--that Putu Channel has become so shallow. Indeed, in July, 1994 it was completely blocked at its main channel location.

Not only has Putu Channel shallowed drastically, but the east entrance, at normal stage, has migrated northward almost 3 km (1.0 mi) (Figs. 24a & 24b).

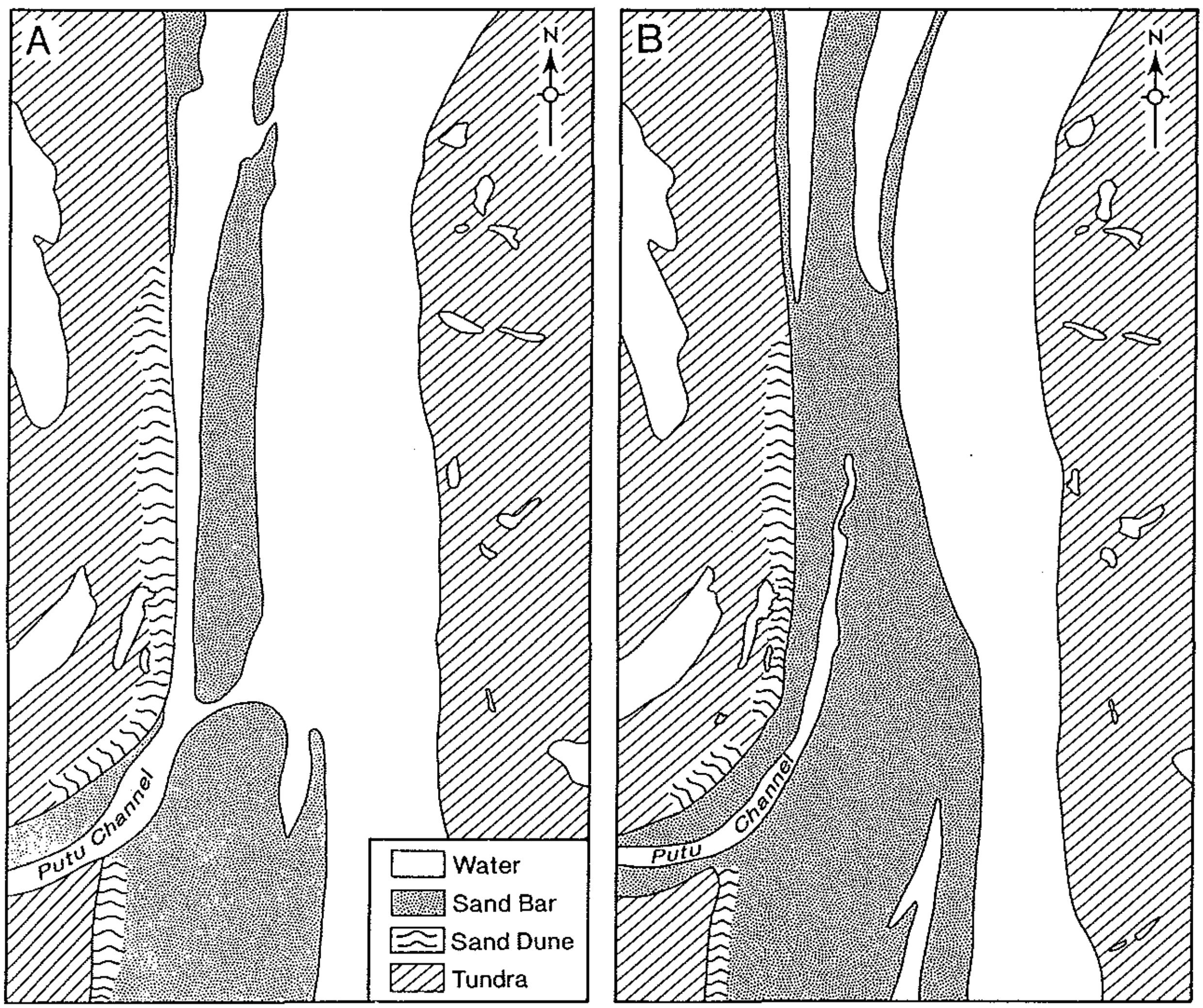

Figure 24. Migration north of Putu Channel mouth. a = 1949, b = 1992

In addition, the area of the Nechelic Channel just downstream from Putu Channel is also undergoing increased sedimentation. In 1994, the channel opposite the band of dunes north west of the western end of Putu Channel was sufficiently shallow in early July that some boats could not pass through it (Fig. 25).

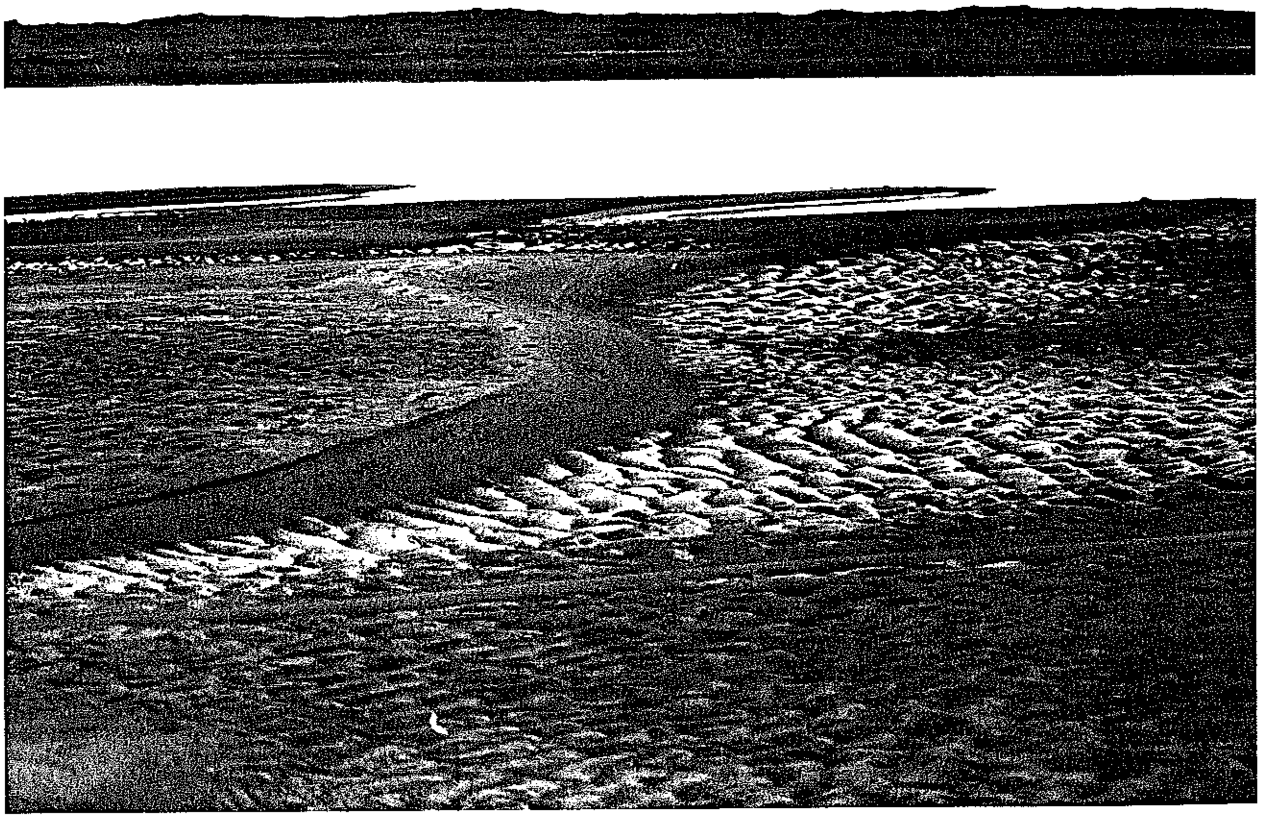

Figure 25. Bar formation at D, Fig. 1 (94-A-9-13)

<u>Tapped lakes</u>

One of the most rapid sedimentation rates occurring with the delta is in tapped lakes. During river flooding, flood waters with their high suspended loads enter these former lake basins and become trapped until the stage of the river lowers. Large amounts of sediment are deposited in the lakes such that they rapidly fill. Fetal Lake (Fig. 1), which was tapped many years before the first aerial photos (1948-49) were made, is nearly filled. Lake Nanook (Fig. 26) has filled to such an extent that it has been divided into three separate parts.

Although deposition in tapped lakes does not impact Nuiqsut residents like deposition in the river channels, it does help illustrate the dynamism of the forces the river exerts on the delta and its formation.

Figure 26. Lake Nanook in 1992 showing bar that formed since original tapping 45 years ago

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