

COLVILLE RIVER DELTA NORTH SLOPE, ALASKA

October, 1998



Baker

Baker

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**1998 SPRING BREAKUP AND HYDROLOGIC ASSESSMENT
COLVILLE RIVER DELTA
NORTH SLOPE, ALASKA**

1.0 INTRODUCTION

This report describes the observations and measurements made during the 1998 spring breakup monitoring of the Colville River Delta. Both distributary channels and lakes were monitored.

Fieldwork for the 1998 monitoring was performed between 21 May and 6 June. During that time, water surface elevations were measured at the head of the delta and on the East, Nechelik, and Sakoonang Channels (Figure 1, Appendix B). Water surface elevations were also measured immediately before and after the breakup flood at lakes 92-82, 93-10, 93-11, 93-12, 93-13, 93-15, 93-21, 93-22, 95-09, 96-05, 96-07, and 96-08 (Figure 2, Appendix B).

1.1 1998 Breakup Summary

The ice cover began to break up on 27 May 1998. At the head of the delta the peak water surface elevation occurred during the night of 28-29 May, and probably occurred in conjunction with a downstream ice jam. The discharge at the time of the peak water surface elevation is estimated to have been approximately 175,000 cfs. In the vicinity of the proposed facility the peak water surface elevation probably occurred during the morning of 29 May. At the head of the delta, the peak discharge occurred on 3 June and is estimated to have been on the order of 213,000 cfs.

It is likely that the 1998 spring peak discharge will be equaled or exceeded in somewhat more than 5 out of 10 years. It is likely that the 1998 spring peak water surface elevation will be equaled or exceeded between 1 and 5 times in a 10-year period.

1.2 Lake Recharge Summary

The water surface elevation rose in all of the lakes between the pre- and post-breakup measurements. In general the increase in water surface elevation was between 0.1 and 0.5 feet (Table 20, Appendix A). Most of the lakes, with the exception of L92-82, L96-05 and L96-07, where flooded by either the East or Nechelik Channels (Figure B, Appendix B).

2.0 COLVILLE RIVER DELTA BREAKUP MONITORING

2.1 Survey Control

Water surface elevation monitoring was performed using 12 survey monuments placed in 1996, 2 monuments placed near the proposed facility in 1997, and several temporary bench marks (TBM). The location and elevation associated with each of the monuments, and the year in which the elevation was established, are presented in Table 1 (Appendix A). The location and elevation associated with each of the TBM, and the monument used to establish the elevation, are presented in Table 2 (Appendix A).

2.2 Breakup Observations

Water surface elevations, water temperatures, and observations by time and date at each of the monitoring locations are presented in Tables 3 through 21 (Appendix A). Monument and TBM locations are presented in Figure 1, and the locations of the lakes monitored for this project are presented in Figure 2. A daily description of the events occurring during the 1998 spring breakup is presented below.

2.2.1 May 27, 1998

Breakup of the ice cover began in the afternoon of 27 May, at approximately 3:58 PM, when the low-flow-channel ice in the East Channel at the head of the delta broke loose and began floating downstream (Photo 1, Appendix C). Observers at Monument 3 and TBM 1U observed a rapid rise in water surface elevation at these locations. At Monument 3, the water level increased 1.11 ft in the 34 minutes between 3:51 PM and 4:25 PM.

The low-flow-channel ice in the Sakoonang Channel was floating in place on 27 May and remained floating in place throughout the breakup event (Photo 2, Appendix C). There was little change in the Sakoonang over the course of the day. Water surface elevations rose 0.18-feet between 11:49 AM and 5:49 PM at Monument 16 and rose 0.07-feet between 5:25 PM and 8:45 PM at Monument 27.

By evening, water had begun to pass through the swale in the facility area, connecting Nanuk Lake to the first lake north of the airstrip. The water was continuing to rise, and a floating ice jam was present in the vicinity of Monument 1 (Photos 3 and 4, Appendix C). The surface jam extended bank to bank, with floes completely covering the gravel bar on the west side of the river.

2.2.2 May 28, 1998

Weather conditions on 28 May began as overcast, with a mild wind. However, the cloud cover lifted during the course of the day and sunny skies developed. Air temperatures rose into the mid-40s.

A surface ice jam was still present in the East Channel by the morning of 28 May. The jam began at an island located at approximately mile 19 on the East Channel and extended south to just upstream of the Putu Channel. The limits of the surface jam remained approximately the same throughout the day (Photo 5, Appendix C). The low-flow-channel ice remained in place on the East Channel to a point approximately 2 miles upstream from the jam, and extended across the entrance to the Sakoonang Channel.

By the afternoon of 28 May, there was a surface ice jam at the entrance of the Nechelik Channel. However, the East Channel was free of ice at the head of the delta (Monument 1). Water was moving through the swale in the facilities area at an estimated 2.3 fps. The water temperature in the swale was 35.6° F. The air temperature was 41° F.

Conditions in the East Channel remained basically the same into the evening. The surface jam at the entrance of the Nechelik Channel dissipated, but approximately 30% of the surface area of the Nechelik Channel was covered with floating ice.

By evening, Lakes 93-21 and 93-22 were completely inundated by floodwaters. Water was just beginning to flow from the East Channel into Lake 95-09, and from Nanuk Lake into Lake 93-15. Lake 96-08 was also receiving floodwaters from the Nechelik Channel.

2.2.3 May 29, 1998

The morning of 29 May began as sunny with little to no wind. Lake 93-13 was receiving floodwaters from the Nechelik Channel. The ice jam in the East Channel was at the same location as the night before. By afternoon, however, the upstream limit of the jam had moved downstream to approximately the entrance of the Sakoonang Channel (Photo 6, Appendix C).

At the head of the delta (Monument 1), the water surface elevation in the East Channel peaked between 8:17 PM on 28 May and 9:10 AM on 29 May. However, the water surface elevation continued to rise in the Nechelik and Sakoonang Channels, and in the facilities area, during the morning of 29 May.

The low-flow-channel ice continued to float, and melt, in-place in the Sakoonang. The water surface elevation recorded at the Alpine Facility Monument 2 (Table 19, Appendix A), and the available mapping, indicates that the water may have passed from the Sakoonang Channel into the lake north of the proposed airstrip on the afternoon of 29 May (Photos 7, 8, 9, 10 and 11, Appendix C). Although flow was not observed, the water surface elevation is consistent with the expected water surface elevation in the Sakoonang Channel at this location.

Ice blocks were floating in the swale at the proposed facility. Some were grounded on a high area across from TBM 100U (Photos 12 and 13, Appendix C). Others were passing through. After the water in the swale had receded (31 May 1998), one of the ice blocks was measured as being 5.2 ft thick.

Wind velocities increased during the evening hours. Flooding expanded into Lake 93-10 and water was observed spilling from Lake 93-13 into Lake 93-12.

2.2.4 May 30, 1998

By the morning of 30 May, the ice jam in the East Channel had partially cleared. The channel on the east side of the island near River Mile 19 was approximately half open, and the low-flow-channel ice had broken free. However, the ice jam was still present in the channel on the west side of the island and partially obstructed the entrance to the Sakoonang Channel (Photo 14,

Appendix C). Water surface elevations in the Nechelik and Sakoonang Channels had peaked by the morning of 30 May, and the water surface elevations continued to drop throughout the day (Photo 15, Appendix C). The ice jam in the East Channel had completely cleared by evening.

2.3 Peak Water Surface Elevation And Discharge

Peak water surface elevations were recorded based on high water marks (Photos 16 and 17, Appendix C) and periodic water surface elevation measurements at selected locations within the delta. The elevations are based on British Petroleum Mean Sea Level (BPMSL) and the data are summarized in Tables 3 through 19 (Appendix A).

Normal depth computations were used to estimate the 1998 spring peak discharge. Water surface elevation and slope were based on measurements made during the 1998 spring breakup at Monument 1 and temporary benchmarks 1U and 1D. Cross section geometry was based on a 1996-surveyed cross section at E27.09 (at Monument 1), and hydraulic roughness values were estimated based on a 1993-discharge measurement (Shannon & Wilson, 1996).

At the head of the delta (at Monument 1), the peak water surface elevation occurred during the night of 28-29 May, at an elevation of 18.11. The discharge at the time of the peak water surface elevation is estimated to have been approximately 175,000 cfs. At the time of the peak water surface elevation, an ice jam was located in the East Channel at about mile 19. The jam extended upstream to approximately the Putu Channel.

The peak discharge at the head of the delta occurred on 3 June and is estimated to have been on the order of 213,000 cfs. This discharge equates to slightly less than a 2-year frequency event. The ice jam on the East Channel had dispersed several days prior to this date, and therefore, was not a factor at the time of the peak discharge.

After reviewing the data collected during the 1998 spring breakup event, it is thought that the ice jam in the East Channel probably caused more water to be diverted into the Nechelik and Sakoonang Channels than has been observed during events with similar discharges in the recent past. Although the formation of an ice jam at about mile 19 in the East Channel is thought to be a

common occurrence, it is concluded that ice from the ice road in the vicinity of the proposed pipeline crossing may have caused the jam to be thicker than usual. A thicker than usual ice jam would allow less water to pass beneath the jam, and cause a greater than usual percentage of the water to pass down the Nechelik and Sakoonang Channels.

Additionally, it is likely that a spring peak discharge equal to or greater than the 1998 spring peak discharge will occur in somewhat more than 5 years out of 10. However, a spring peak water surface elevation equal to or greater than the 1998 spring peak water surface elevation, near the proposed facility and at the head of the delta, will probably occur only 1 to 5 times in a 10-year period. This difference between the water surface elevation and discharge frequency of occurrence is common in streams that experience ice jams.

2.4 Lake Recharge

Water surface elevations in Lakes 92-82, 93-10, 93-11, 93-12, 93-15, 93-21, and 93-22 were measured both immediately before and after the 1998 spring peak water surface elevation. Water surface elevations in Lakes 92-82, 93-10, 93-11, 93-12, 93-15, 93-21, and 93-22 were measured relative to TBMs placed earlier in the year by Lounsbury & Associates. The TBMs placed by Lounsbury & Associates had elevations based on BPMSL. Lakes 95-09, 96-05, 96-07, and 96-08 were measured relative to temporary benchmarks (1/2 inch diameter rebar) placed by Michael Baker Jr., Inc. on 23 May 1998. All temporary benchmarks were assigned an arbitrary elevation of 100.00 feet. A summary of the data collected is presented in Tables 20 and 21 (Appendix A).

Lake water levels were first measured on 23 May 1998. On this date, all of the lakes investigated for this project were covered with ice. The thickness of the ice varied among lakes and was between 4.5 and 6 feet thick (Table 20, Appendix A). Snow covered the areas surrounding the lakes. In general, the area that drained to each of the lakes appeared to be little more than the area in the immediate vicinity of the lake.

After the flooding associated with the river channels had subsided, the water surface elevation on the lakes was re-measured. The second set of measurements was taken between 31 May and 5 June 1998. For all of the lakes except Lake 96-05, the snow within the drainage basin had melted

and the lake ice that remained was detached from the shore. The relative increase in water surface elevation at each of the lakes is presented in Table 20 (Appendix A).

As can be seen in Table 20 (Appendix A), the water surface rose in all of the lakes between the pre- and post-breakup measurements. In general, the increase in water surface elevation was between 0.1 and 0.5 feet.

In the case of Lake 96-05, it was difficult to determine a water surface elevation prior to breakup. Four holes were drilled through the ice. The distance between the holes and the western shoreline ranged from 50 to 150 feet. In all cases, the auger encountered soil and water at the same time. Water rose very slowly in each of the auger holes and the water surface elevations ranged from 85.24 to 85.31 (Table 20 in Appendix A reflects the average water surface elevation in the 4 holes). It is speculated that the water surface elevations measured on 23 May 1998 may have been somewhat lower than the free water surface elevation due to the headloss resulting from the water passing through the soil into our hole. It is also possible that the pre-breakup water surface elevation measured in the holes was unrelated to the free water surface elevation in the lake. Snow and ice were still attached to the banks of the lake at the time of the post-breakup monitoring (5 June 1998). Obtaining access to the lake's water surface during the post-breakup monitoring was also difficult. For these reasons, plus the problem encountered during the pre-breakup water surface monitoring, the increase in water surface elevation at this lake is suspect.

While the water surface elevation in most of the lakes was measured only once before and after breakup, it was measured twice in Lake 93-13. The water surface elevation was measured first on 31 May and again on 5 June, due to a noticeable decrease in the water surface elevation. The water surface in Lake 93-13 dropped 0.94 feet between 31 May and 5 June. The drop in water surface elevation was the result of water leaving the lake by flowing between the tussocks. Due to the relatively flat terrain, water leaving the lakes in this manner is not immediately obvious. It is possible that some of the other lakes may have also experienced a similar decrease. Therefore, where an increase in water surface elevation of more than about 0.5 feet is shown in Table 20 (Lakes 93-22, 96-05 and 96-07), the increase should probably be considered somewhat suspect.

3.0 REFERENCES

Shannon & Wilson, Inc. 1996. *1996 Colville River Delta Spring Breakup And Hydrologic Assessment, North Slope, Alaska*. Prepared for: Michael Baker Jr., Inc., Anchorage, Alaska.

APPENDIX A

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Table 1: Reference Monuments Used In 1998 Break-Up Study

Monument	Elevation (feet,BPMSL)	Year Elevation Established	Coordinates	
			Latitude	Longitude
MON01	27.74	1996	70° 09' 58.348"	150° 56' 12.638"
MON03	20.66	1996	70° 11' 14.475"	150° 52' 15.516"
MON08	26.69	1996	70° 15' 43.559"	150° 51' 34.384"
MON09	25.03	1996	70° 14' 41.738"	150° 51' 18.416"
MON10	17.42	1996	70° 13' 41.312"	150° 55' 06.068"
MON16	12.17 (1)	1998	70° 19' 27.857"	150° 53' 16.801"
MON22	10.13	1996	70° 19' 06.352"	151° 03' 10.342"
MON24	8.40	1996	70° 23' 15.471"	151° 00' 01.007"
MON27	11.12 (2)	1998	70° 21' 38.452"	150° 54' 44.298"
MON28	3.66 (3)	1998	70° 25' 33.209"	151° 03' 49.587"
MON29	8.03	1996	70° 22' 19.472"	151° 04' 50.879"
MON35	5.57	1996	70° 25' 58.142"	150° 22' 49.055"
Alpine Facility Monument 2	10.17	1997	70° 20' 59.176"	150° 55' 37.576"
Alpine Facility Monument 5	24.52	1997	70° 20' 16.190"	150° 57' 32.887"

Notes:

1. Monument 16 had an elevation of 12.12 when established in 1996.
2. Monument 27 had an elevation of 10.66 when established in 1996.
3. Monument 28 had an elevation of 3.68 when established in 1996.

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Table 2: Temporary Bench Marks (TBMs) Used In 1998 Break-Up Study

Temporary Bench Marks	Elevation (4)	Coordinates		
		Latitude	Longitude	
TBM's Used For Water Surface Elevation Monitoring Within Channels And The Proposed Facility				Reference Monument
1D	28.34 (1,2)	70° 10' 12.3"	150° 56' 07.6"	1
1U	23.87 (1,2)	70° 09' 21.7"	150° 56' 49.2"	1
28HWM	5.73 (1,2)	70° 24' 52.2"	151° 03' 57.9"	28
100	6.75 (1,2)	70° 20' 23.0"	150° 57' 58.5"	Alpine Facility Monument 5
100HWM	8.92 (1,2)	70° 20' 31.6"	150° 57' 09.3"	Alpine Facility Monument 5
100U	10.05 (1,2)	70° 20' 13.1"	150° 58' 19.8"	Alpine Facility Monument 5
TBM's Used For Water Surface Elevation Monitoring At Lakes				Lake
L98-9-37-1	10.89 (2)	70° 20' 37.3"	150° 53' 14.3"	Lake 92-82
L98-9-40-1	10.73 (2)	70° 19' 51.0"	150° 55' 47.4"	Lake 93-10
L98-9-40-1	10.73 (2)	70° 19' 51.0"	150° 55' 47.4"	Lake 93-11
L98-9-39-1	8.52 (2)	70° 20' 08.0"	150° 56' 24.1"	Lake 93-12
L98-9-39-2	8.39 (2)	70° 20' 08.0"	150° 56' 24.1"	Lake 93-12
L98-9-38-1	12.77 (2)	70° 20' 37.7"	150° 56' 21.9"	Lake 93-13
L98-9-38-2	11.01 (2)	70° 20' 37.7"	150° 56' 21.9"	Lake 93-13
L98-9-44-1	6.62 (2)	70° 20' 54.9"	151° 02' 18.5"	Lake 93-15
L98-9-42-2	7.29 (2)	70° 20' 28.4"	151° 02' 07.0"	Lake 93-21
L98-9-42-3	7.58 (2)	70° 20' 11.5"	151° 01' 42.9"	Lake 93-22
MB 9509	100.00 (3)	70° 14' 42.8"	150° 48' 41.6"	Lake 95-09
MB 9605	100.00 (3)	70° 13' 16.0"	150° 31' 26.7"	Lake 96-05
MB 9607	100.00 (3)	70° 14' 41.9"	150° 51' 54.8"	Lake 96-07
MB 9608	100.00 (3)	70° 14' 13.2"	150° 56' 05.4"	Lake 96-08
Notes:				
1. All of the TBMs used for water surface elevation monitoring within the channels and the proposed facility were established in 1998. The elevation of each of the TBMs is based on the elevation of the reference monument listed.				
2. The elevation of the TBM is in feet and based on British Petroleum Mean Sea Level (BPMSL).				
3. The elevation of the TBM is in feet and based on an assumed datum.				
4. All of the TBMs used for water surface elevation monitoring at the lakes, which have elevations based on BPMSL, were established by Lounsbury & Associates, Inc. All of the other TBMs used for water surface elevation monitoring at the lakes were established by Michael Baker Jr., Inc. during the 1998 spring break-up.				

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Table 3: Observations In East Channel At Monument 1

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/21/98	13:10			Some flow in river. There is shallow flow over approximately 1/3 of the gravel bar on the west side of the river. Low-flow-channel ice floating in place.
5/25/98	15:45 15:52	7.27 7.27		Low-flow-channel ice floating in place. A few ice blocks floating in river.
5/26/98	15:33 15:37	9.09 9.11		Low-flow-channel ice floating in place.
5/27/98	8:45 9:56 9:59 15:58 16:36 17:57 20:28	 11.12 11.13 12.35 12.54 12.83	 33.1	Low-flow-channel ice floating in place. Ice bridges do not appear to have any impact on flows at this point. Low-flow-channel ice floating in place. Water nearly covering all of the gravel bar. Ice over low-flow-channel broke loose and began moving downstream.
5/28/98	9:10 9:44 15:00 15:10 15:15 15:53 21:09	 17.42 17.77 17.78 17.80 17.87 18.03		Floating ice jam in vicinity of Monument 1 (bank to bank). Ice floes blocked over main channel - surface jam. Flow over bar on west bank. Low-flow-channel (East Channel) ice still floating in place across from entrance to Sakoonang Channel and upstream approximately 1 to 2 miles. Ice jam occurring in East Channel from approximately 1 mile downstream of the entrance to the Sakoonang Channel to approximately 2 miles downstream of the entrance to the Nechelik Channel. River is free of ice at this location. No floating ice. Ice blocks can be seen across the entrance to the Nechelik Channel (in the Nechelik Channel). All surface ice.
1998 High Water Mark		18.11		River has scattered ice upstream of Nechelik Channel. A maximum of 5 - 10% of the surface area is covered with ice. Most of the ice is near the shoreline.
5/29/98	8:51 9:17	 17.56		Surface ice jam still in East Channel. Backed up to Putu Channel.

Table 3: Observations In East Channel At Monument 1 (continued)

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/29/98	17:06			Upstream limit of ice jam in East Channel has moved downstream to approximately the Sakoonang Channel. Ice jam still in East Channel. No real change.
	19:27			
	20:03	15.21		
5/30/98	9:00			Ice jam at mile 19 in the East Channel has partially cleared. Channel east of the sand bar is approximately half open. Low flow channel ice has broken free. West side of the sand bar is still jammed. Jam partially obstructing entrance to Sakoonang Channel. There are other jams on the East Channel located downstream from mile 19 on the East Channel.
	12:10	12.19		
	12:11	12.23		
	16:47	12.17		
	16:50	12.15		
	17:00			
5/31/98	11:52	12.15	41.5	East Channel is completely open in area of original ice jam.
	11:54	12.15		
	19:21	12.10		
	19:24	12.08		
6/1/98	9:48	12.03	41.5	Channel is clear of ice.
	16:40	11.93	51.1	
6/2/98	9:55	12.03	44.4	
	16:09	12.18	47.3	
	16:12	12.17		
6/3/98	10:27	12.44		
	10:31	12.41		
	16:15	12.39		
	16:19	12.40		
6/4/98	15:02	9.87		
	15:04	9.86		
6/5/98	11:32	7.28		
	11:39	7.30		

Table 4: Observations In East Channel At TBM IU

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/26/98	9:54	8.32	32.0	
	10:03	8.34		
5/27/98	10:54	11.55	33.7	Low-flow-channel ice floating in place. Approx. 3.5 ft thick ice blocks lodged on gravel bar. Low-flow-channel ice broke loose and is moving downstream.
	10:57	11.54		
	16:00			
	16:31	12.70		
	16:52	12.68		
	17:00	12.83		
	17:10	12.88		
	17:15	13.08		
	17:25	13.13		
	17:30	13.23		
	17:40	13.33		
	18:01	13.32		
5/28/98	9:30	17.52		Floating ice jam in vicinity of Monument 1 (bank to bank). River has scattered ice upstream of Nechelik Channel. A maximum of 5 - 10% of the surface area is covered with ice. Most ice is near shore.
	16:06	18.03		
	21:17	18.11		
1998 High Water Mark		18.22		
5/29/98	9:10	17.68		Channel clear of ice at this location.
	20:11	17.48		
5/30/98	12:21	12.58		
	12:23	12.60		
	17:02	12.56		
	17:04	12.54		
5/31/98	11:35	12.64	39.6	
	11:38	12.60		
	19:35	12.60		

Table 4: Observations In East Channel At TBM IU (continued)

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/31/98	19:38	12.58		
6/1/98	9:36	12.45		Channel is clear of ice.
	16:25	12.35		
6/2/98	15:55	12.63		
	15:58	12.65		
6/3/98	10:47	12.88		
	10:51	12.90		
	16:02	12.87		
	16:06	12.86		
6/4/98	14:50	10.12		
	14:52	10.12		
6/5/98	12:20	7.37		
	12:25	7.40		
6/6/98	11:41	5.69		
	11:45	5.71		

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Table 5: Observations In East Channel At TBM 1D

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/27/98	9:10 9:17	10.87 10.91	34.3	Low-flow-channel ice floating in place. Air temperature 49° F.
5/28/98	10:02 10:05 10:27 15:30 21:00	17.40 17.41 17.45 17.79 18.03	32.9	Air temperature 46.6° F. River has scattered ice upstream of Nechelik Channel. A maximum of 5-10% of the surface area is covered with ice. Most ice is near shoreline.
1998 High Water Mark				
5/29/98	9:25 5:02	18.00 17.46 14.78	36.0	Channel clear of ice at this location.
5/31/98	12:06 12:09	11.98 12.00		
6/1/98	10:00 16:50	11.84 11.75		Channel is clear of ice.
6/2/98	16:20 16:23	11.98 11.98		
6/3/98	10:09 10:15 16:28 16:31	12.22 12.25 12.19 12.18		
6/4/98	15:13 15:15	9.83 9.88		

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Table 6: Observations In East Channel At Monument 3

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/27/98	15:43	10.84		Ice over low-flow-channel broke loose and began moving downstream.
	15:51	10.85		
	15:58			
	16:25	11.96		
5/28/98	9:40	17.24		Air temperature 39° F.
	9:53	17.27		
	10:05	17.29		
	10:15	17.32		
	10:30	17.34	32.4	
5/29/98	9:13	17.43		Broken ice blocks floating in East Channel at this location.
	9:18	17.42		
	9:24	17.35		
	9:27	17.32		
5/31/98	12:25	11.60		
	12:31	11.59		
6/3/98	16:44	11.79		
	16:47	11.79		

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Table 7: Observations In East Channel At Monument 9

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/27/98	14:14 14:19	7.29 7.28		Low-flow-channel ice floating in place but appears to be beginning to break-up.

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Table 8: Observations In East Channel At Monument 35

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
6/6/98	9:42	0.73		
Notes:				
1. 1998 peak water surface elevation was estimated to be between 4.16 and 4.27 feet (BPM SL) based on debris lines observed on 6 June 1998.				

file: table8.xls

Table 9: Observations In Nechelik Channel At Monument 10

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/29/98	20:54	13.03		
	20:57	12.99		
5/30/98	15:23	10.20		
	15:29	10.22		
5/31/98	14:36	9.84		
	14:39	9.86		
Notes:				
1. The 1998 spring peak water surface elevation was approximately 16.21 feet (BPMSL), based on a debris line observed on 30 May, 1998.				

file:table9.xls

Table 10: Observations In Nechelik Channel At Monument 22

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/27/98	17:15	5.51		Low-flow-channel ice intact in places.
	21:13	5.70		
5/28/98	14:30	7.74		Ice blocks can be seen across the entrance to the Nechelik Channel. All surface ice. Nechelik still has approximately 30% of surface area covered with ice. Low-flow-channel ice floating in place for majority of the reach from the inlet of the Nechelik Channel to Monument 22 including the area in front of the entrance to Nanuk Lake.
	15:15			
	19:57	8.24		
	21:34			
5/29/98	8:51			Surface ice jam still in East Channel. Extending up to Putu Channel.
	9:50			
	10:20	8.90	36.2	Low-flow-channel ice floating in place.
	10:50	8.95		
	10:57	8.96		
	11:05	8.99		
	11:10	9.01		
	21:15	9.94		
1998 High Water Mark		10.20		A high water mark on Crest Gage 93-13 @ Lake 93-13 had an elevation of 10.31.
5/30/98	9:00			Ice jam at mile 19 in the East Channel has partially cleared. Channel east of sand bar is approximately half open. Low-flow-channel ice has broken free. West side of sand bar is still jammed. Jam partially obstructing entrance to Sakoonang Channel. There are other jams located downstream from mile 19 in the East Channel. Nechelik Channel is open to ocean.
	15:00			
5/31/98	17:00	6.43		East Channel is completely open in area of original ice jam.
	14:13	3.56		
	14:16	3.57		

file: table10.xls

Table 11: Observations In Nechelik Channel At Monument 28

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
6/5/98	20:30	0.59		

file: table11.xls

Table 12: Observations In Nechelik Channel At TBM 28 HWM

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
6/5/98	20:03	0.84		
Notes: 1. TBM 28 HWM is located approx. 0.78 miles upstream from Monument 28. 2. The 1998 peak water surface elevation was estimated to be between 4.18 and 4.84 feet (BPMSL) based on debris lines observed on 5 June 1998.				

file:table12.xls

Table13: Observations In Sakoonang Channel At Monument 16

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/26/98	14:35	0.90	31.8	Low-flow-channel ice intact. Water flowing over top of ice.
	14:40	0.94		
5/27/98	11:49	3.03	42.0	Low-flow-channel ice floating in place. Water temperature was taken at the edge of water, near the bank.
	11:53	3.04		
	17:44	3.26		
	17:49	3.21		
5/28/98	11:27	4.94		Low-flow-channel ice floating in place.
	16:17	5.47		
	20:35	5.93		
5/29/98	9:57	7.71		Low-flow-channel ice deteriorating (melting in place).
	10:33	7.86		
	10:36	7.88		
	15:38	9.16		
	16:30	9.30		
1998 High Water Mark		10.01		
5/30/98	11:37	8.49		Channel is clear. Low-flow-channel ice has broken free and is jammed at a curve approximately 1000 ft downstream.
	15:50	8.13		
5/31/98	12:45	7.44		
	19:07	6.46		
6/1/98	9:14	6.00		Channel is clear of ice.
	16:10	5.83		
6/2/98	9:14	5.46		Channel is clear of ice.
	16:40	5.43		
	16:42	5.42		
6/3/98	9:42	5.35		
	9:45	5.34		
	15:41	5.32		
	15:43	5.32		

Table 13: Observations In Sakoonang Channel At Monument 16 (continued)

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
6/4/98	14:32	4.89		
	14:33	4.83		
6/5/98	10:47	3.78		
	10:51	3.80		
6/6/98	10:30	2.63		
	10:33	2.48		
6/8/98	14:01	1.22		
	14:06	1.20		
6/15/98		2.05		

file:table13.xls

Table 14: Observations In Sakoonang Channel At Monument 24

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/26/98	17:00	2.88		Low-flow-channel ice floating in place. Water Surface Elevation determined from Staff Gage located within snow bank. Water Surface Elevation may not reflect channel conditions.
	17:15	2.87		Water Surface Elevation determined from Staff Gage located within snow bank. Water Surface Elevation may not reflect channel conditions.
5/27/98	12:07	3.00		Water Surface Elevation determined from Staff Gage located within snow bank. Water Surface Elevation may not reflect channel conditions.
	12:49	3.02		Low-flow-channel ice floating in place. Water Surface Elevation determined from Staff Gage located within snow bank. Water Surface Elevation may not reflect channel conditions.
	17:24	3.18		Low-flow-channel ice intact. Water Surface Elevation determined from Staff Gage located within snow bank. Water Surface Elevation may not reflect channel conditions.
	21:01	3.32		Low-flow-channel ice intact. Water Surface Elevation determined from Staff Gage located within snow bank. Water Surface Elevation may not reflect channel conditions.
5/28/98	14:36	4.08		
	16:30	4.30		
	20:16	4.66		Low-flow-channel ice floating in place but melting. Pockets of water on the ice.
5/29/98	10:19	5.57		Low-flow-channel ice deteriorating (melting in place).
	16:02	5.91	35.1	Low-flow-channel ice deteriorating (melting in place). Some snow on bottom of channel at this location.
	16:40	5.94		
	16:45	5.95		
	21:28	6.18		
1998 High Water Mark		6.65		
5/30/98	9:00			Ice jam in East Channel still partially blocking entrance to Sakoonang Channel.

Table 14: Observations In Sakoonang Channel At Monument 24 (continued)

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/30/98	11:15	5.48	33.1	Low-flow-channel ice is gone. Ice jam occurring approximately 0.5 miles downstream of this location in the Sakoonang Channel. Channel is clear of ice. Ice jam in East Channel has cleared by this time. Entrance to Sakoonang Channel is open.
	16:12	5.19		
	17:00			
5/31/98	13:09	4.38		
	13:17	4.32		
	13:22	4.32		
	18:45	4.25		
6/1/98	8:50	3.66	36.1	Channel is clear of ice.
	15:40	3.41	38.9	Channel is clear of ice.
6/2/98	8:50	2.84	39.3	Channel is clear of ice.
	17:20	2.60		
	17:22	2.60		
6/3/98	9:11	2.39	39.3	
	9:15	2.42		
	15:10	2.40		
	15:14	2.30		
6/4/98	14:04	2.05		
	14:06	2.05		

file: table14.xls

Table 15: Observations In Sakoonang Channel At Monument 27

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/27/98	17:25	3.08	32.8	Low-flow-channel ice floating in place. Low-flow-channel ice broke loose on the East Channel approximately 1 hour ago.
	17:32	3.09		
	20:45	3.15		
5/28/98	11:32	4.38	34.0	Some low-flow-channel ice still in place. Low-flow-channel ice floating in place. Air temperature 44.2° F.
	11:38	4.39		
	11:50	4.41		
	12:00	4.43		
	12:10	4.46		
	12:20	4.48		
	12:30	4.49		
	12:37	4.51		
	16:25	5.06		
	20:27	5.72		
5/29/98	10:07	7.37	37.4	Low-flow-channel ice floating in place. Low-flow-channel ice deteriorating (melting in place).
	10:44	7.38		
	15:48	8.12		
	15:52	8.12		
	16:28	8.24		
	16:36	8.26		
	16:37	8.27		
	16:41	8.26		
	16:45	8.28		
1998 High Water Mark		9.02		
5/30/98	11:49	7.30		
	16:00	7.09		
5/31/98	12:57	5.15		
	12:59	5.14		
	18:55	4.85		
	18:57	4.85		

Table 15: Observations In Sakoonang Channel At Monument 27 (continued)

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
6/1/98	9:03	5.00		Channel is clear of ice.
6/2/98	9:00	4.32		Channel is clear of ice.
	16:55	4.21		
	16:58	4.20		
6/3/98	9:27	4.05		
	9:31	4.04		
	15:26	4.01		
	15:30	4.02		
6/4/98	14:19	3.68		
	14:22	3.66		
6/5/98	10:34	2.76		
	10:36	2.75		
6/6/98	10:50	1.64		
	10:53	1.63		
6/8/98	12:52	0.73		
	12:53	0.75		
6/15/98		1.10		

file:table15.xls

Table 16: Observations Near Proposed Facility At TBM 100

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/27/98	17:00			Water is just barely flowing overland between Nanuk Lake and the first lake north. In the vicinity of the proposed road, it is not clear if water is flowing into the lake on the north side of the proposed road. Water may be flowing between the tussocks.
	21:13			
5/28/98	13:24	4.92	35.6	Water is now flowing through the swale. The flow rate is probably small, maybe not measurable, but there is a connection the whole way.
	13:27	4.92		
	20:46	6.05		
5/29/98	15:05	7.56		Water is moving quickly through swale. Air temperature 40.4° F.
1998 High Water Mark		8.02		
5/30/98	10:58	4.21		
	11:01	4.19		
	15:00	5.26		
5/31/98	13:44	3.94		
	13:47	3.99		
6/1/98	15:25	3.53		

file:table16.xls

Table 17: Observations Near Proposed Facility At TBM 100 HWM

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/30/98	10:27	5.91		
	15:45	5.17		

file: table17.xls

Table 18: Observations Near Proposed Facility At TBM 100 U

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/29/98	14:20			Ice blocks getting stuck on high ground immediately across from TBM.
	15:35	8.14		

file:table18.xls

Table 19: Observations Near Proposed Facility At Alpine Facility Monument 2

Date	Time	Water Surface Elevation (ft)	Water Temperature (°F)	Observations
5/29/98	15:20 15:25	8.62 8.64		

file: table19.xls

Table 20: Lake Recharge Data

Lake ID	Pre-Breakup		Post-Breakup		Increase in Water Surface Elevation (ft)	Primary Recharge Source	Ice Thickness (ft)
	Date	Water Surface Elevation (ft)	Date	Water Surface Elevation (ft)			
92-82	5/23/98	8.84 (1)	6/1/98	9.13 (1)	0.29	Local Snowmelt	
93-10	5/23/98	8.88 (1)	6/1/98	9.06 (1)	0.18	Nechelik Channel	5.90
93-11	5/23/98	9.83 (1)	6/1/98	9.96 (1)	0.13	Nechelik Channel	5.95
93-12	5/23/98	7.94 (1)	5/31/98	8.35 (1)	0.41	Nechelik Channel	5.10
93-13	5/23/98	6.07 (1)	5/31/98	7.35 (1)	1.28	Nechelik Channel	4.50
			6/5/98	6.41 (1)	0.34		
93-15	5/23/98	5.88 (1)	6/1/98	6.14 (1)	0.26	Nechelik Channel	
93-21	5/23/98	7.02 (1)	6/4/98	7.1 (1)	0.08	Nechelik Channel	
93-22	5/23/98	6.89 (1)	6/1/98	7.41 (1)	0.52	Nechelik Channel	
95-09	5/23/98	96.52 (2)	6/3/98	96.72 (2)	0.20	East Channel	5.80
96-05	5/23/98	85.27 (2,3)	6/5/98	86.47 (2,3)	1.20	Local Snowmelt	
96-07	5/23/98	99.03 (2)	6/4/98	99.66 (2)	0.63	Local Snowmelt	5.20
96-08	5/23/98	99.12 (2)	6/3/98	99.45 (2)	0.33	Nechelik Channel	4.80

Notes:

1. Water surface elevation is based on British Petroleum mean sea level (BPMSL).
 2. Water surface elevation is based on an assumed datum.
 3. Difficulties were encountered during both the pre- and post-breakup measurements which made the measurement suspect.
- See Section 2.4 of this report for details.

file: table20.xls

Table 21: Lake Flooding Observations

Lake	Date	Time	Observation
92-82	5/28/98	21:40	Lake is frozen. Some snowmelt in drainage swale leading from Sakoonang Channel to Lake 92-82. However, there is no flow from the Sakoonang Channel. Lake north of 92-82 looks like it may spill over into 92-82 soon.
	5/29/98	8:51	Lake is frozen. No flow from Sakoonang Channel.
	5/30/98	16:12	No flooding.
93-10	5/28/98	19:53	Lake is frozen. No flooding.
	5/29/98	16:57	Flood waters from Nechelik Channel flowing into Lake 93-10.
93-11	5/28/98	19:53	Lake is frozen. No flooding.
	5/29/98	16:57	No flooding.
93-12	5/28/98	19:53	Lake is frozen. No flooding.
	5/29/98	16:57	Water spilling from Lake 93-13 to 93-12.
93-13	5/28/98	19:53	Lake is frozen. No flooding.
	5/29/98	8:51	Water from Nechelik Channel flooding is right at edge of Lake 93-13. Ice still on top of lake.
	5/29/98	12:14	Water spilling from Nechelik Channel flooding into Lake 93-13. Depth approximately 6 to 12 inches across ridge at southwestern edge of lake. Larger sheets of ice (approx. 6 ft X 10 ft) floating in from Nechelik and becoming grounded at edge of lake.
	5/29/98	16:57	Water spilling from Lake 93-13 to Lake 93-12.
	6/5/98		High water mark on Crest Gage 93-13 determined to be at elevation 10.31 feet.
93-15	5/28/98	19:57	Water just beginning to flow from Nanuk Lake to Lake 93-15.
93-21	5/28/98	19:56	Lake is completely inundated by flooding from a swollen Nanuk Lake.
93-22	5/28/98	19:56	Lake is completely inundated by flooding from a swollen Nanuk Lake.
95-09	5/28/98	19:32	Water just starting to flow into lake from East Channel.
96-07	5/28/98	19:37	Lake still frozen. No water from East Channel.
96-08	5/28/98	19:43	Lake flooded. Water spilling to east from Nechelik Channel at approximately River Mile (RM) 17 and flooding lake. Lake also connects, via a channel, to the Nechelik Channel south of the lake at approximately RM 19.

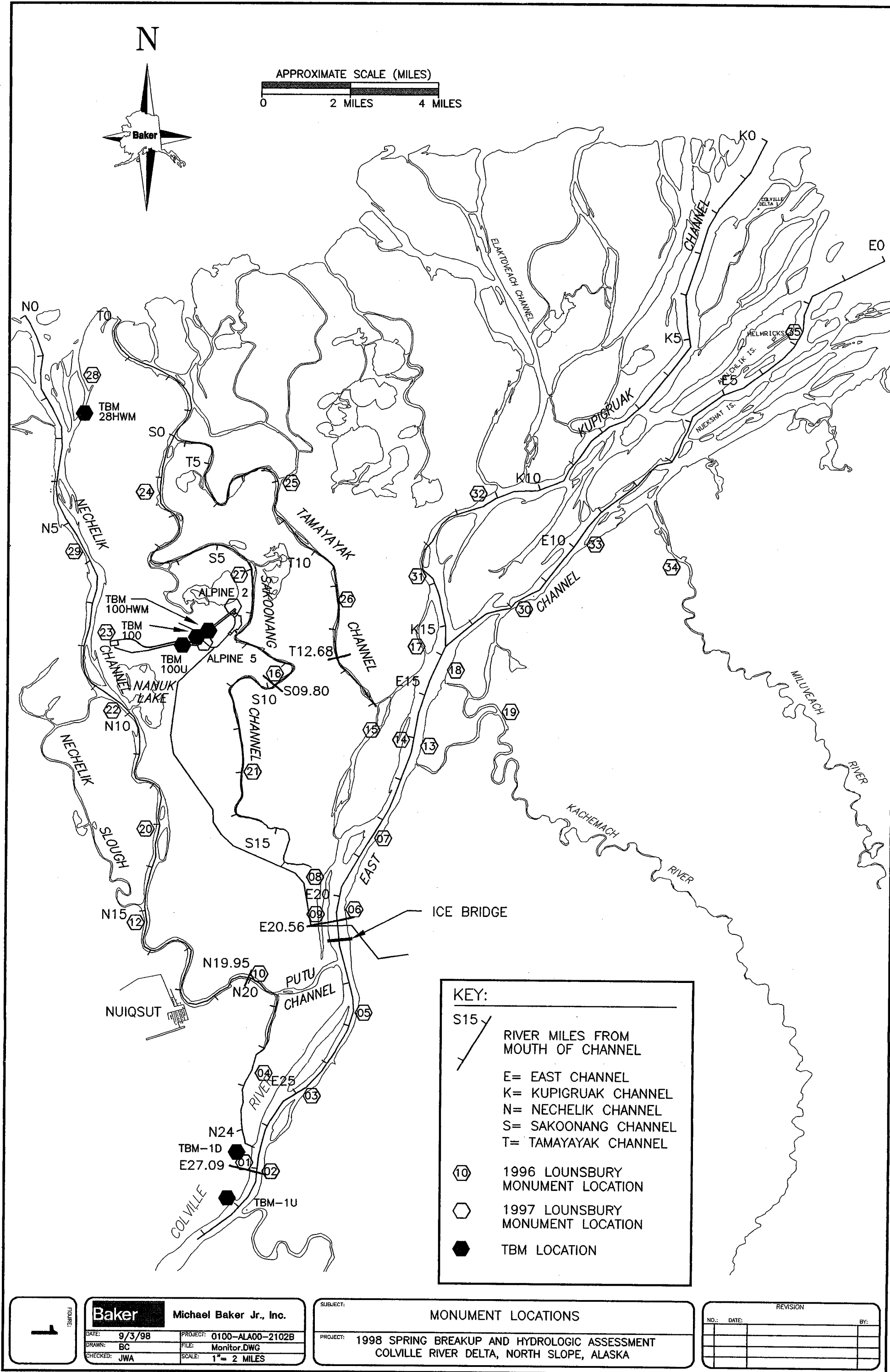
file: table21.xls

APPENDIX B

LIST OF FIGURES

Figure 1: Monument Locations

Figure 2: Lake Locations



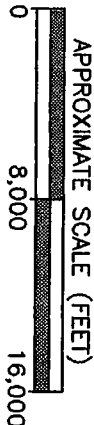
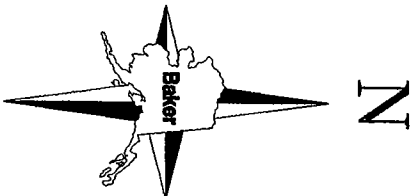
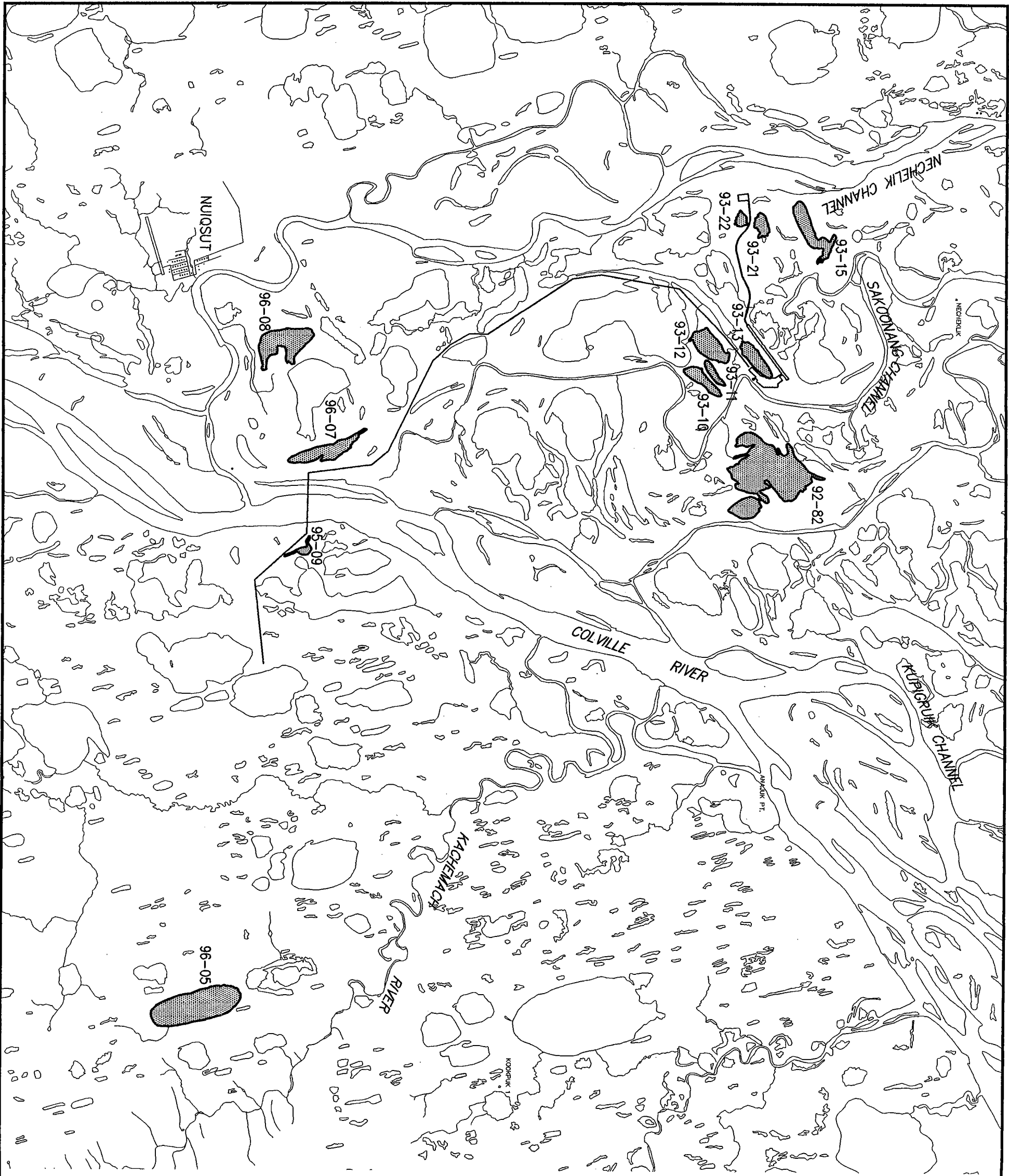


FIGURE:
2

Baker Michael Baker Jr., Inc.	
DATE: 9/3/98	PROJECT: 0100-ALA00-2102B
DRAWN: BC	FILE: LakeLoc.DWG
CHECKED: JWA	SCALE: 1" = 8,000'

SUBJECT:	LAKE LOCATIONS
PROJECT:	1998 SPRING BREAKUP AND HYDROLOGIC ASSESSMENT COLVILLE RIVER DELTA, NORTH SLOPE, ALASKA

REVISION		
NO.:	DATE:	BY:

APPENDIX C

LIST OF PHOTOS

- Photo 1: Looking downstream from Monument 3 on the East Channel, at the time the low-flow-channel ice broke loose. (5/27/98 16:00)
- Photo 2: Looking downstream from the staff gage at Monument 24 on the Sakoonang Channel. Low-flow-channel ice floating in place. (5/27/98 12:45)
- Photo 3: Staff Gage 20 at Monument 1 at the head of the Colville River Delta. (5/27/98 20:30)
- Photo 4: Looking upstream on the East Channel, from just below the entrance to the Sakoonang Channel. (5/27/98 20:41)
- Photo 5: Looking upstream from below the surface ice jam on the East Channel. The ice jam extends above the Putu Channel. The low-flow-channel ice is floating in place in the vicinity of the jam. (5/28/98 21:43)
- Photo 6: Looking downstream at the surface ice jam in the East Channel. The entrance to the Sakoonang Channel is on the left edge of the photo. The low-flow-channel ice is present in the vicinity of the jam. (5/29/98 19:26)
- Photo 7: Looking northwest across the swale. Ice blocks are getting stuck on the high ground in the center of the photo. TBM 100 U is in the foreground. (5/29/98 14:20)
- Photo 8: Looking north across the proposed airstrip and facility. Lakes 93-13, -12, -11, and -10 are all inundated by floodwaters. The Sakoonang Channel is in the foreground. (5/29/98 approx. 20:00)
- Photo 9: Looking south across the proposed airstrip. The Sakoonang Channel is in the foreground, the low-flow-channel ice is floating in place. (5/29/98 approx. 20:00)
- Photo 10: Looking east toward the proposed facility. (5/29/98 approx. 20:00)
- Photo 11: Looking northeast at the proposed airstrip. (5/29/98 approx. 20:00)
- Photo 12: Looking northwest across the swale. Note the ice floes deposited in the swale. (6/1/98 15:25)

- Photo 13: Ice floes deposited in the swale near the proposed facility.
- Photo 14: Looking downstream on the East Channel. The entrance to the Sakoonang Channel is on the left. The low-flow-channel ice has broken loose in the East Channel. The ice jam has cleared on the eastern side of the East Channel but is still present on the west side of the sand bar. (5/30/ 9:03)
- Photo 15: Looking northeast across the proposed airstrip. (5/30/98 9:21)
- Photo 16: Surveying high water marks at TBM 28HWM. Looking west. (6/5/98 20:00)
- Photo 17: Looking at debris line near Monument 35. (6/6/98 9:40)



Photo 1: Looking downstream from Monument 3 on the East Channel, at the time the low-flow-channel ice broke loose. (5/27/98 16:00)



Photo 2: Looking downstream from the staff gage at Monument 24 on the Sakoonang Channel. Low-flow-channel ice floating in place. (5/27/98 12:45)

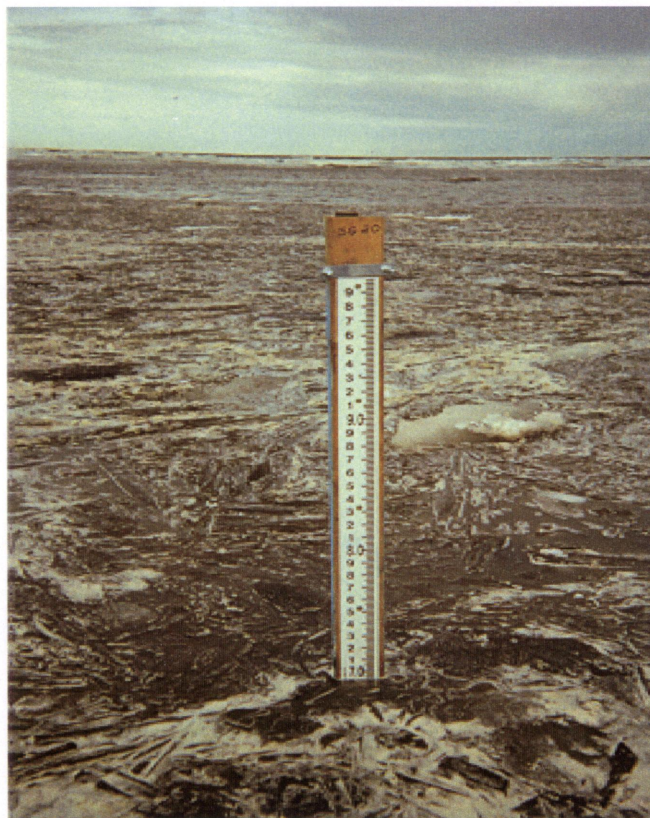


Photo 3: Staff Gage 20 at Monument 1 at the head of the Colville River Delta. (5/27/98 20:30)

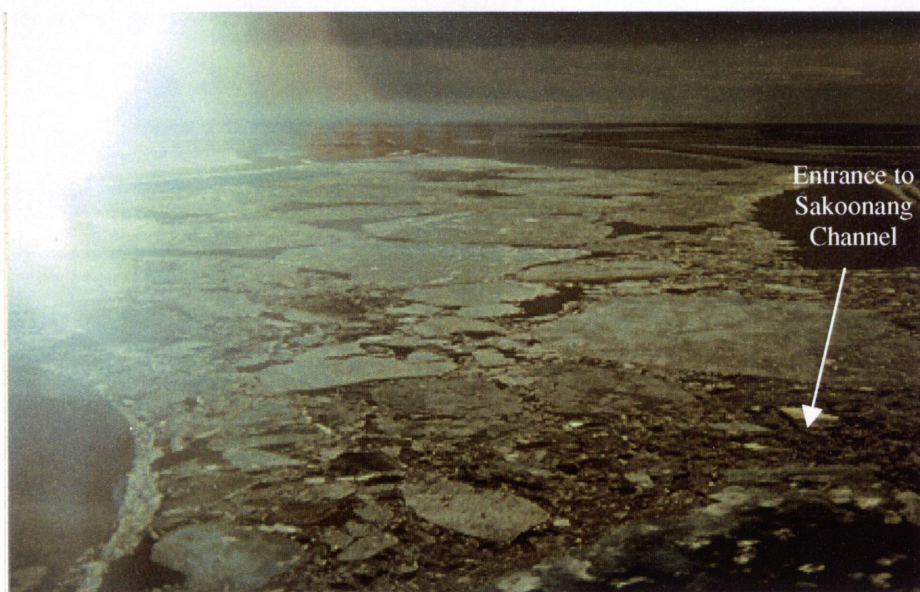


Photo 4: Looking upstream on the East Channel, from just below the entrance to the Sakoonang Channel. (5/27/98 20:41)

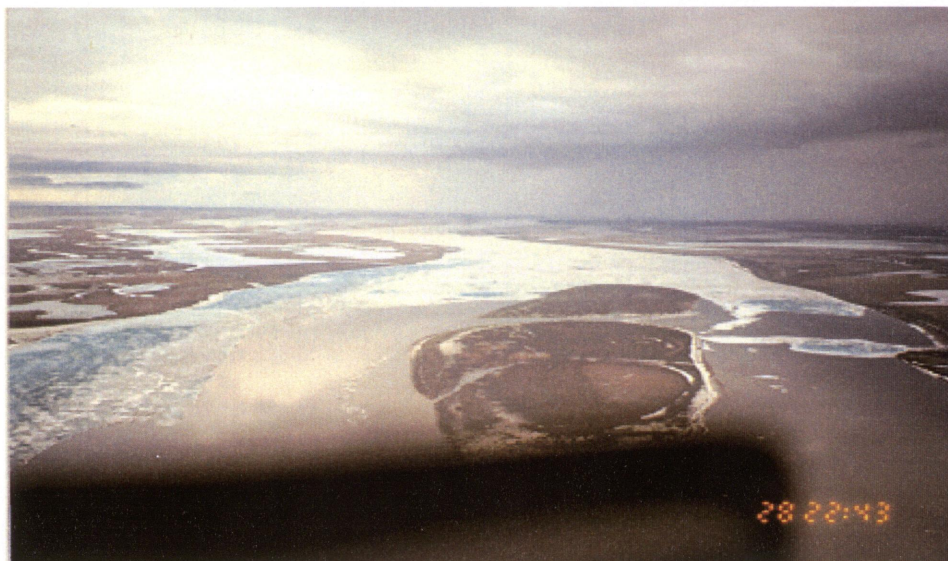


Photo 5: Looking upstream from below the surface ice jam on the East Channel. The ice jam extends above the Putu Channel. The low-flow- channel ice is floating in place in the vicinity of the jam. (5/28/98 21:43)

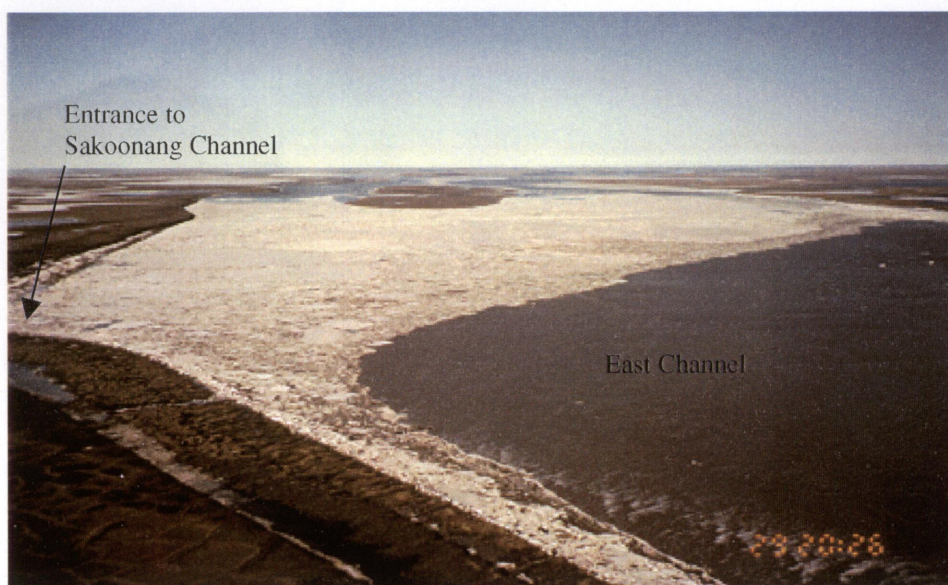


Photo 6: Looking downstream at the surface ice jam in the East Channel. The entrance to the Sakoonang Channel is on the left edge of the photo. The low-flow-channel ice is present in the vicinity of the jam. (5/29/98 19:26)

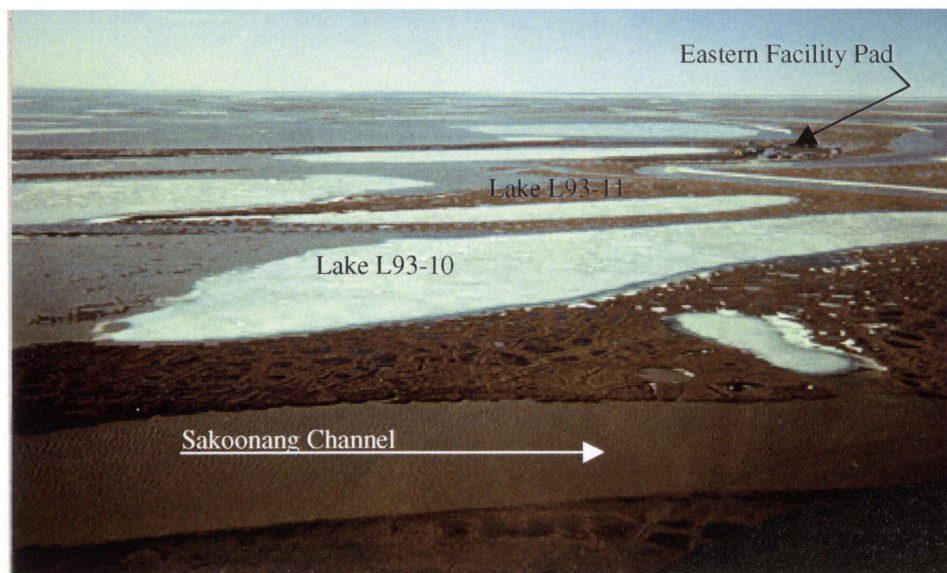


Photo 7: Looking northwest across the swale. Ice blocks are getting stuck on the high ground in the center of the photo. TBM 100 U is in the foreground. (5/29/98 14:20)



Photo 8: Looking north across the proposed airstrip and facility. Lakes 93-13, -12, -11, and -10 are all inundated by floodwaters. The Sakoonang Channel is in the foreground. (5/29/98 approx. 20:00)



Photo 9: Looking south across the proposed airstrip. The Sakoonang Channel is in the foreground, the low-flow-channel ice is floating in place. (5/29/98 approx. 20:00)

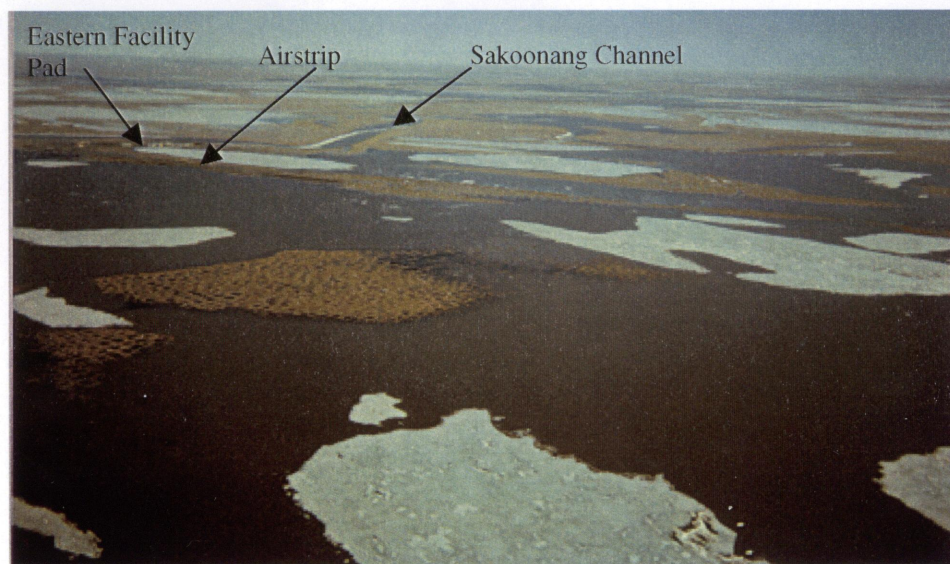


Photo 10: Looking east toward the proposed facility (5/29/98 approx. 20:00)

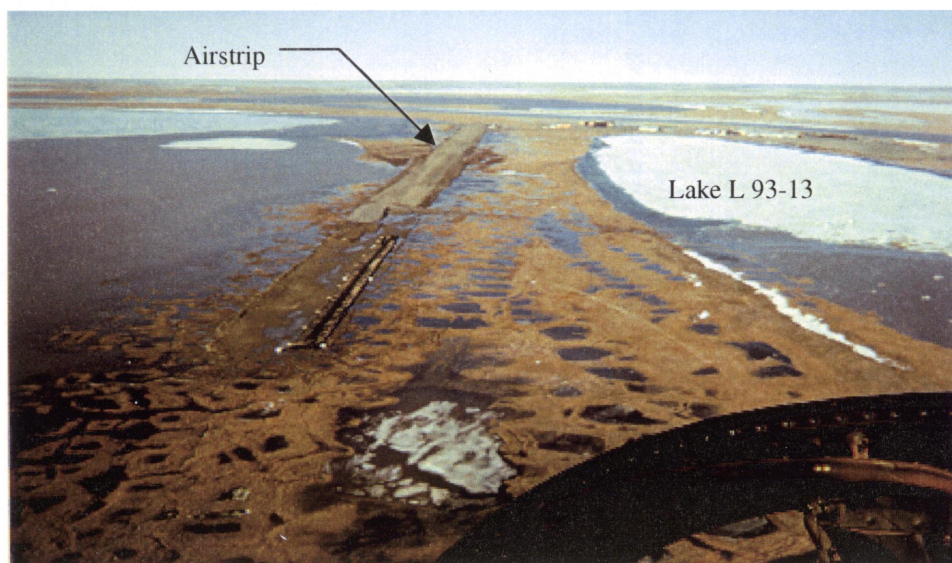


Photo 11: Looking northeast at the proposed airstrip. (5/29/98 approx. 20:00)



Photo 12: Looking across the swale. Note the ice floes deposited in the swale. (6/1/98 15:25)

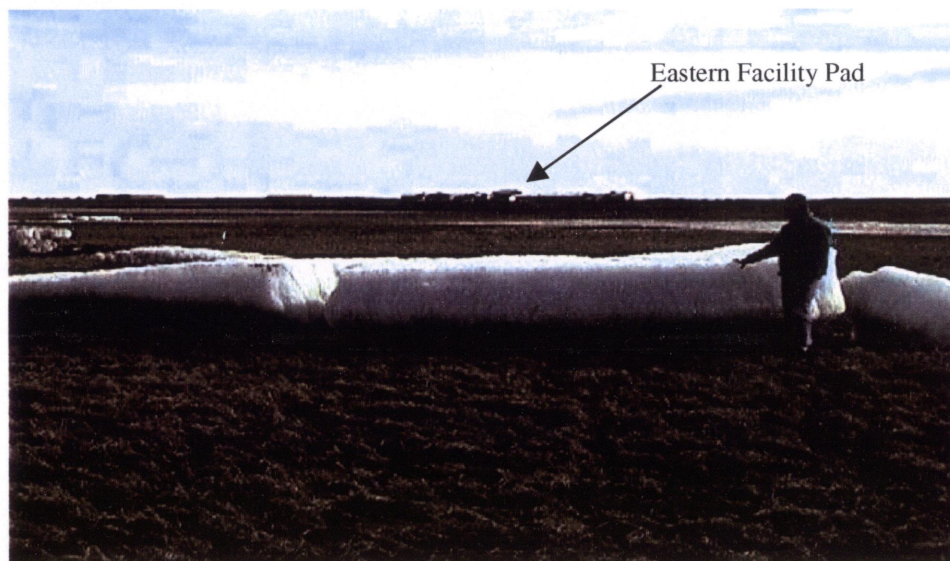


Photo 13: Ice floes deposited in the swale near the proposed facility.



Photo 14: Looking downstream on the East Channel. The entrance to the Sakoonang Channel is on the left. The low-flow-channel ice has broken loose in the East Channel. The ice jam has cleared on the eastern side of the East Channel but is still present on the west side of the sand bar. (5/30/98 9:03)



**Photo 15: Looking northeast across the proposed
airstrip. (5/30/98 9:21)**



**Photo 16: Surveying high water marks at TBM 28HWM. Looking west. (6/5/98
20:00)**



**Photo 17: Looking at debris line near Monument 35.
(6/6/98 9:40)**