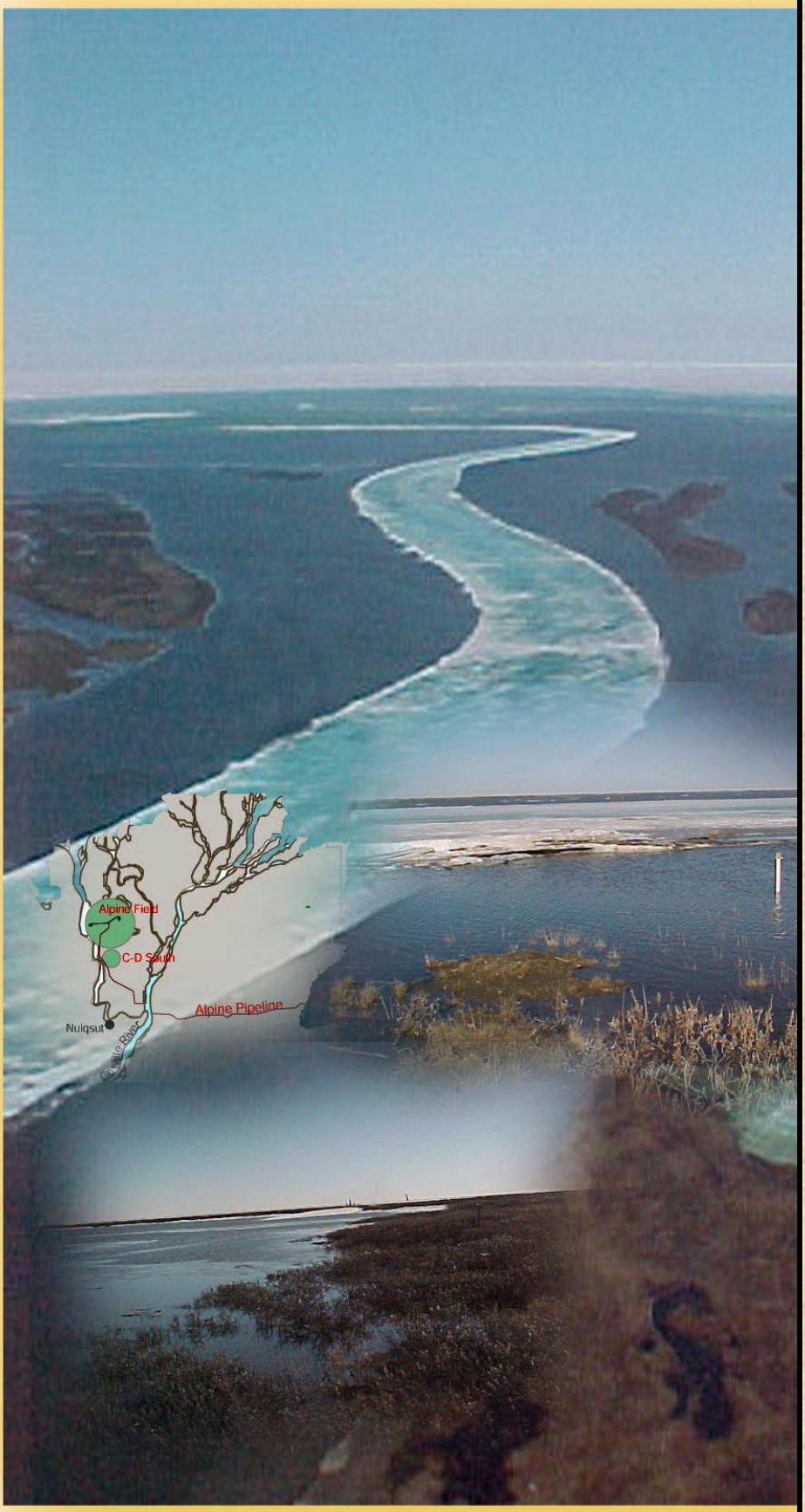
CD-South

Development Project

2002 Spring Breakup and Hydrologic Assessment



Submitted to

ConocoPhillips

By

Baker

Michael Baker Jr., Inc.
Anchorage, Alaska 99503
907-273-1600

November 2002

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1.0 Introduction

Breakup studies have been conducted on the Colville River Delta since 1992 in order to further the understanding of the hydrologic characteristics associated with spring breakup flooding events. Historical data for the Colville River Delta and the surrounding region are limited. Continued monitoring efforts are required in order to provide information needed for the design of oil field facilities that will be safe during large magnitude flood events.

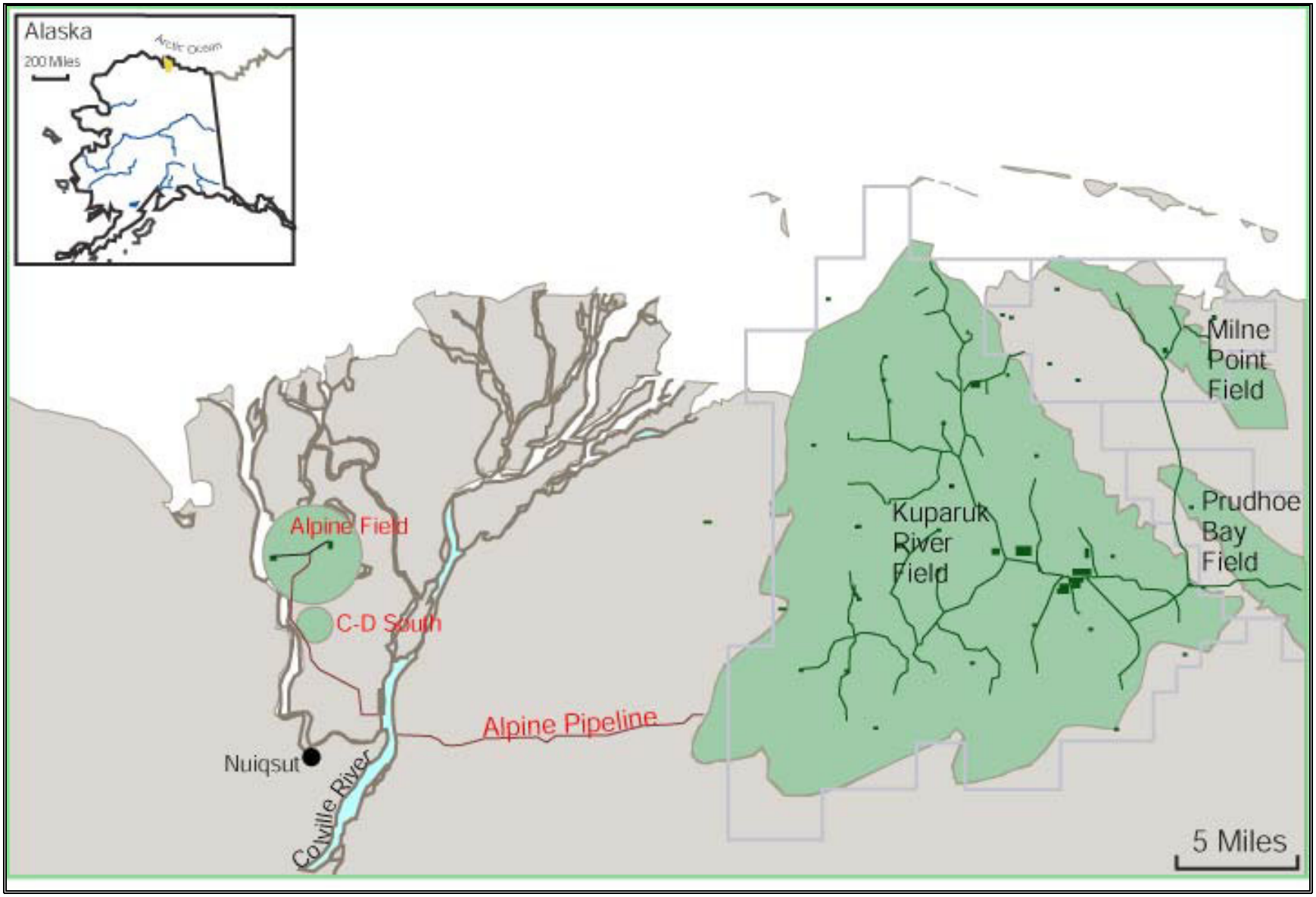
This report summarizes the observations and measurements made during the 2002 spring breakup of the Colville River Delta and its impact on the proposed CD-South satellite development site (Figure 1-1). Breakup field data for the CD-South development were collected in conjunction with those for a breakup study for the existing Alpine development (Michael Baker Jr., 2002a).

The proposed CD-South projects include a gravel pad for production facilities, an approximately 3.6-mile gravel road, and a pipeline to the existing Alpine facility. The pipeline follows the existing Alpine pipeline with the exception of a short spur from the proposed pad to the existing pipeline alignment.

Breakup data, observations, and analyses related to the head of the delta, and breakup observations that pertain to the delta as a whole are presented in Section 2 of this report. Breakup data, observations, and analyses related specifically to the CD-South site are presented in Section 3.

All elevations presented in this report are in feet and are referenced to British Petroleum Mean Sea Level (BPMSL) datum unless otherwise noted. All tables, figures, and photographs referenced within a given section are located at the end of that section.

Figure 1-1 Location of Proposed CD-South Satellite



2.0 Colville River

2.1 Water Surface Elevations and Observations at the Head of the Delta

Water surface elevations were monitored at the head of the Colville River delta at three monitoring sites, Monument 01, at temporary benchmark (TBM) 01U and TBM 01D. TBM 01U and TBM 01D were located approximately ½ mile upstream and downstream from Monument 01, respectively. Water surface elevations were measured from either direct observations of temporary staff gages at each monitoring site, high water marks left on the staff gages, or surveyed level loops of water levels or high water marks. The locations of the three monitoring sites at the head of the delta are shown on Figure 2-1. Measurements began on 23 May, the day flowing water was first observed near Monument 01. Measurements continued until 30 May at which time the water levels had receded considerably. All temporary staff gages were removed by 1 June. Water surface elevations and observation records for the temporary staff gages at the head of the delta are presented in Tables 2-1 through 2-3.

2.2 Peak Water Surface Elevation at the Head of the Delta

The peak water surface elevation at Monument 01 occurred in the early afternoon of 24 May at an elevation of 16.87 feet. Following the peak, the water levels receded rapidly and after 36 hours the water surface elevation had decreased to an elevation of 13.96 feet. Discharge at the time of the peak water surface elevation is estimated to have been 231,000 cubic feet per second (cfs). The channel at Monument 01 was free of intact low water channel ice at the time of the peak water surface elevation. Low water channel ice in the East and Nigliq channels was mostly intact (although floating) downstream from the divergence of these channels. Snow blockages were present in many of the smaller channels, however, much of the channel snow had melted and the exposed ice was rotten.

Measured peak water surface elevations at Monument 01 were compared to water surface elevations predicted by the two-dimensional surface water model developed for the Colville River Delta (Michael Baker Jr., Inc., 2002b, 2001a, 1998; and Shannon & Wilson, Inc., 1997). Based on a linear interpolation between the water surface elevations predicted for the 2- and 10-

year open water floods, it is estimated that the peak water surface elevations observed this spring at Monument 01 will likely be equaled or exceeded, on average, about once every 7 years. It should be noted that the difference in peak water surface elevation measured in 2001 versus 2002 is 0.5 feet and that estimated recurrence interval of 7 years (rounded to the nearest whole year) is the same.

2.3 Peak Discharge in the Colville River (Head of the Delta)

Discharge in the Colville River was estimated using the Slope-Area Method as defined by the United States Geological Survey (Dalrymple & Benson 1984). Water surface elevation and slope data were obtained from the measurements made at Monument 01 and TBM 01U and TBM 01D. Cross section geometry was based on three cross sections surveyed in July 2002 by Kuukpik/LCMF (Appendix A). Hydraulic roughness values were estimated based on a 1993-discharge measurement (Alaska Biological Research and Shannon & Wilson, 1994) and on-site investigations of the channel bottom using methods outlined by the United States Geological Survey (Arcement, and Schinder, 1989).

The peak discharge at the head of the Colville River Delta is estimated to have been 300,000 cfs, and to have occurred the afternoon of 27 May. It is estimated that this discharge will be equaled or exceeded, on average, approximately once every 4 years (Michael Baker Jr., Inc. and Hydroconsult, 2002). It should be noted that this estimate was based on limited data as weather prevented data collection on 28 and 29 May. The estimated discharge on 30 May is considerably lower than the estimate for 27 May, but the data are not sufficient to determine either the time when the peak discharge began to recede, or if a peak discharge of higher magnitude occurred during that period.

The estimated peak discharge in 2002 is the same as that estimated for 2001. and observations at Monument 01 and other areas of the Delta suggest that the discharges were very similar. Thus, the estimated peak discharge is considered a reasonable approximation based on the available data. A hydrograph of water surface elevation and discharge vs. time is presented on Figure 2-2.

2.4 2002 Observations Compared to 2001 Observations

At Monument 01 the peak water surface elevation approximates a 7-year recurrence interval when compared to the predictions of the two-dimensional surface water model. However, using the measured water surface slopes and Slope-Area Method, the magnitude of the peak discharge is estimated to have a recurrence interval of about 4 years (Section 2.2). These are the same conclusions made regarding recurrence intervals that were made for the 2001 spring breakup (Michael Baker Jr., 2001b).

Water surface elevation and flow pattern observations made in 2002 were very similar to those observed in 2001, although the two breakups exhibited uniquely different characteristics. For example, in 2002 breakup was preceded by warm sunny weather that caused a relatively rapid flood peak. At the head of the delta, the peak water surface elevation has occurred on average (since 1994) seven days after water was first observed on the delta. In 2002, the peak water surface elevation occurred only one day after water was first observed flowing, the fastest recorded time between observed flowing water and peak water surface elevation. In contrast, the 2001 breakup was preceded with cool cloudy weather that caused breakup to occur approximately two weeks later than average. Historically, the average date water has first been observed flowing at the head of the delta is 23 May. In 2001, flowing water was not observed until 5 June, with a peak water surface elevation occurring on 10 June.

Even though breakup occurred differently in 2002 and 2001, the magnitude of the flood peak discharge was estimated to be the same. Observed flow patterns were similar and comparisons to the two-dimensional model were similar. The differences in 2002 and 2001 flood peak recurrence intervals, when comparing estimations based on discharge versus estimations based on water surface elevations (interpolated from the two-dimensional model), are the same 4 year verses 7 year (rounded to the nearest whole year).

The two-dimensional surface water model was constructed to predict conditions during large flood events, i.e. 50-, 100-, and 200-year. It assumes open water, steady state conditions and does not take into account channel ice or ice jams. It was assumed that during a large flood event the presence of snow, ice, and ice jams would have little effect on the overall water surface elevations. This assumption is still valid, however, channel ice and ice jams are likely to always

occur to some extent during breakup in the Colville River Delta. Channel ice and ice jams will restrict flow and cause increases in water surface elevations during smaller flood events when flow is mainly confined to the channels. Thus, the water surface elevation predictions of the model will generally under-predict water surface elevations during small flood events when channel ice and snow are present in the delta. For this reason the water surface elevation return period is higher than the discharge return period during small flood events.

Table 2-1 Monument 01, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Observations
5/23/2002	8:15	11.00	Channel is 70% clear. Channel ice intact along the right bank.
5/24/2002	8:00	16.21	Channel ice has cleared. Open channel conditions with floating ice chunks.
High Water Mark		16.87	High water occurred on May 24 between 08:00 and 13:50.
5/24/2002	13:50	16.82	Ice chunks observed floating along right bank.
5/24/2002	14:20	16.63	Majority of floating ice is along right bank.
5/24/2002	14:50	16.21	
5/25/2002	12:19	13.96	Channel is free of ice.
5/26/2002	11:15	13.83	Channel is ice free with occasional small ice chunks flowing through. Reading taken in very windy conditions.
5/27/2002	15:15	13.94	Channel is free of ice.
5/30/2002	16:25	7.77	

Notes:

1. Elevations are based on an elevation of 27.74 feet BPMSL for Monument 01, established by Lounsbury & Associates in 1996.
2. The distance from Monument 01 to TBM 01U is 3,040 feet. The distance from Monument 01 to TBM 01D is 2,960 feet.
3. GPS coordinates for Mounument 01 are N70° 09' 58.3" W150° 56' 12.6" (NAD 27), surveyed by Loundsbury and Associates.

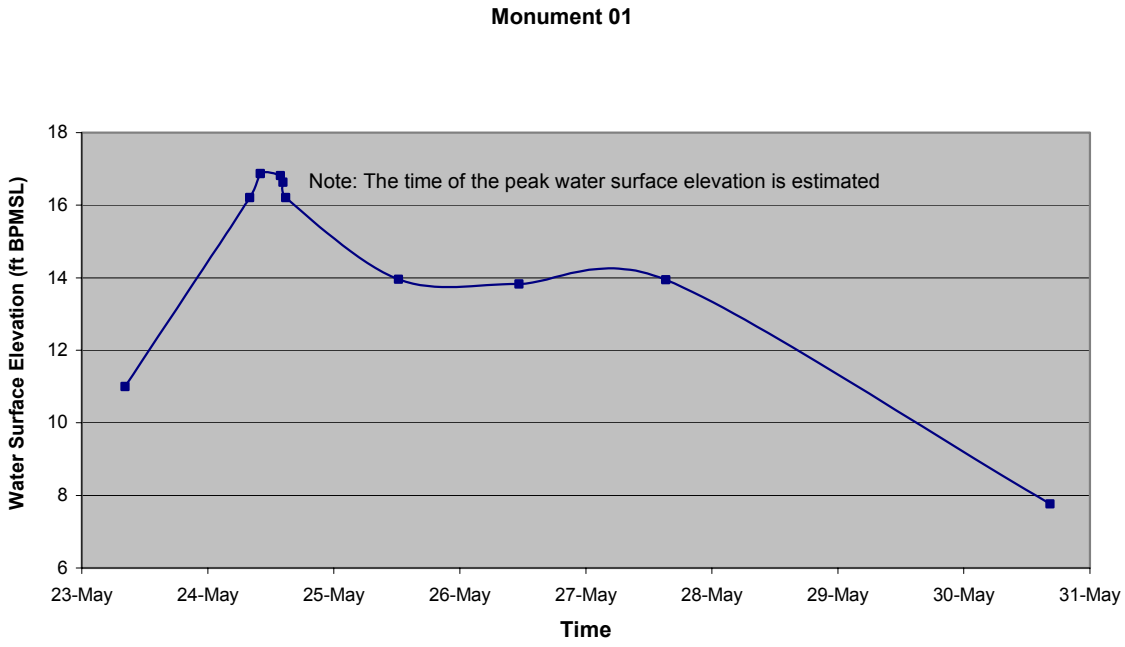


Table 2-2 Temporary Benchmark 01U, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Observations
5/23/2002	8:10	11.29	Channel is 70% free of ice. Channel ice intact along the right bank.
5/23/2002	15:25	12.77	Channel is 90% free of ice. Channel ice intact on right bank. Ice chunks floating in open water.
5/24/2002	7:55	16.32	Channel ice has cleared. Open channel conditions with numerous floating ice chunks.
High Water Mark		17.00	High water occurred on May 24 between 07:55 and 14:40.
5/24/2002	14:40	16.47	
5/25/2002	12:38	14.25	Ice chunks floating near left bank.
5/26/2002	10:30	14.16	Reading taken in very windy conditions.
5/27/2002	15:00	14.28	Channel is free of ice.
5/30/2002	15:10	8.13	

Notes:

1. Elevations are based on an elevation of 27.74 feet BPMSL for Monument 01, established by Lounsbury & Associates in 1996.
2. The distance from TBM 01U to Monument 01 is 3,040 feet.
3. GPS coordinates for TBM 01U are N70° 09' 31/4" W150° 56' 36.7" (NAD 27) which were obtained by a Garmin GPS III Plus hand-held global positioning system.

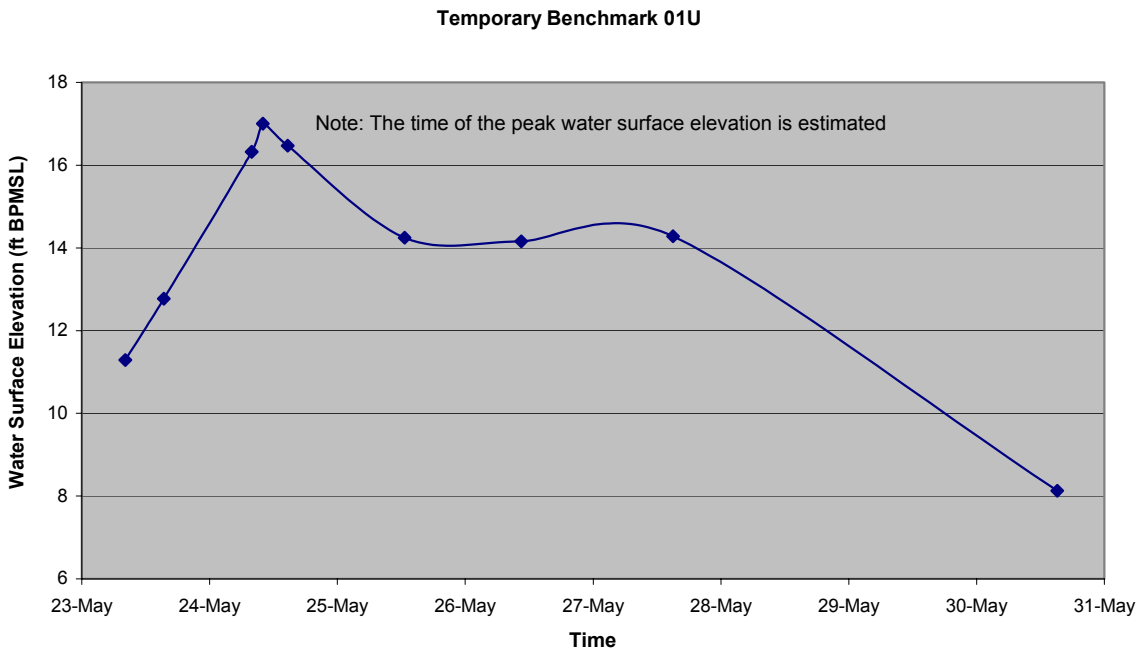


Table 2-3 Temporary Benchmark 01D, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Observations
5/23/2002	8:20	10.78	Intact channel ice along right bank. Ice breaking into rafts downstream.
5/23/2002	15:55	11.98	Ice chunks passing through channel.
5/24/2002	8:15	16.14	Channel ice has cleared. Open channel conditions with floating ice chunks.
High Water Mark		16.65	High water occurred on May 24 between 08:15 and 14:55.
5/24/2002	14:55	15.74	Stranded ice chunks visible on banks.
5/25/2002	12:52	13.59	Ice less than 5 feet in diamater floating in channel.
5/26/2002	11:20	13.41	Channel is open with occasional small floating ice chunks. Reading taken in very windy conditions.
5/27/2002	15:25	13.39	Channel is free of ice.
5/30/2002	17:57	7.59	

Notes:

1. Elevations are based on an elevation of 27.74 feet BPMSL for Monument 01, established by Lounsbury & Associates in 1996.
2. The distance from Monument 01 to TBM 01D is 2,960 feet.
3. GPS coordinates for TBM 01D are N70° 10' 26.6" W150° 56' 01.6", (NAD 27) which were obtained by a Garmin GPS III Plus hand-held positioning system.

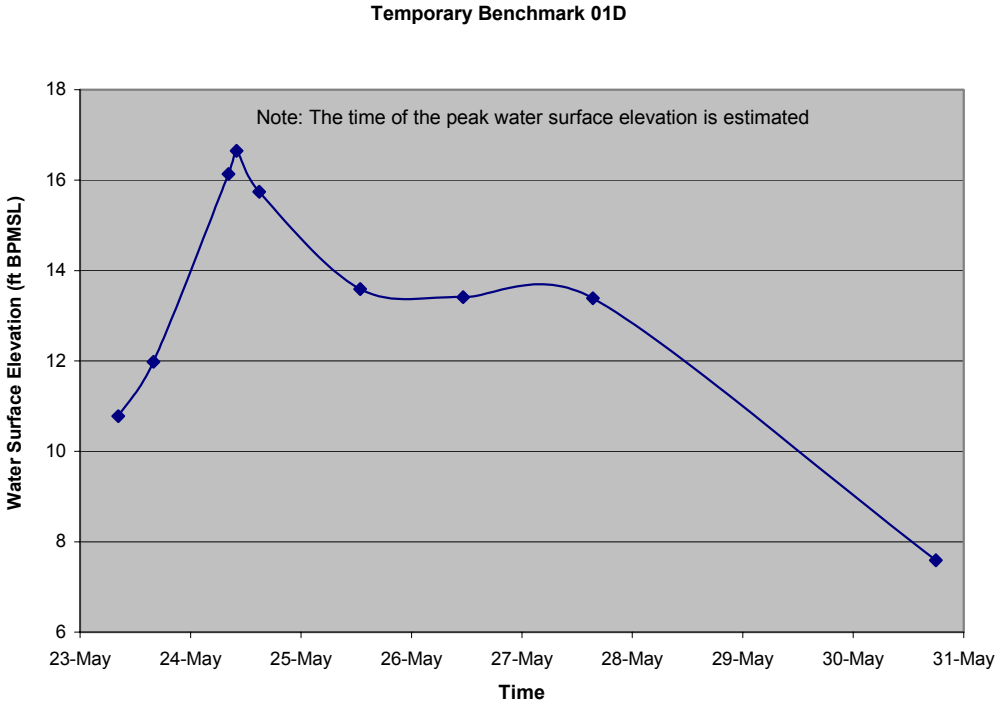


Table 2-4 Summary of Breakup Data Obtained at the Head of the Colville River Delta, 1962 - 2002

Year	Approximate Date Water Began to Flow	Peak Water Surface Elevation (ft)	Date of Peak Water Surface Elevation	Peak Breakup Discharge (cfs)	Notes
2002	23 May	16.87	24 May	300,000	1
2001	5 June	17.37	10 June	300,000	1, 2
2000	8 June	19.33	11 June	580,000	1, 3
1999	22 May	13.97	30 May	203,000	1, 4, 5
1998	21 May	18.11	29 May	213,000	1, 6
1997	20 May	15.05	29 May	177,000	1
1996	15 May	17.19	26 May	160,000	1, 7
1995	8 May	15.7	16 May	233,000	8
1994	16 May	13.0	25 May	159,000	8
1993	–	20.0	31 May	379,000	8
1992	–	14.7	2 June	188,000	8
1977	–	19.9	7 June	407,000	8
1973	25 May	–	8 June	–	8
1971	23 May	–	2 June	–	8
1964	28 May	–	3 June	–	8
1962	19 May	13.2	14 June	215,000	8

Notes:

1. Water surface elevations are based on monuments set by Lounsbury & Associates in 1996 and are based on British Petroleum mean sea level (BPMSL).
2. Data from Michael Baker, Jr., Inc., 2001, Alpine Facilities Spring 2001 Breakup and Hydrologic Assessment. Prepared for Phillips Alaska, Inc., Anchorage.
3. The peak breakup discharge was estimated to range between 570,000 to 590,000 cfs. Data from Michael Baker, Jr., Inc., 2000, Alpine Facilities Spring 2000 Breakup Monitoring and Hydrologic Assessment. Prepared for Phillips Alaska, Inc., Anchorage.
4. Data from Michael Baker Jr., Inc., 1999, 1999 Spring Breakup and Hydrologic Assessment, Colville River Delta, North Slope, Alaska. Prepared for ARCO Alaska, Inc., Anchorage, Alaska.
5. Water was flowing in the Colville River at Umiat on this day. It is not known if this was the first day of flow. Therefore, it is not known if water was flowing on the delta prior to this date.
6. Data from Michael Baker Jr., Inc., 1998, 1998 Spring Breakup and Hydrologic Assessment, Colville River Delta, North Slope, Alaska. Prepared for ARCO Alaska, Inc., Anchorage, Alaska.
7. Data from Shannon & Wilson, Inc., 1996, 1996 Spring Breakup and Hydrologic Assessment, Colville River Delta, North Slope, Alaska. Prepared for Michael Baker Jr., Inc., Anchorage, Alaska.
8. Data from Jorgenson et al., 1996, Geomorphology and Hydrology of the Colville River Delta, Alaska, 1995. Prepared for ARCO Alaska, Inc., and Kuukpik Unit Owners, Anchorage, Alaska. The water surface elevations presented in this report were based on an elevation of 41.99 feet for the USCGS monument “River.” In 1996 Lounsbury & Associates surveyed USCGS monument “River” and tied it to BPMSL. The elevation of “River,” based on BPMSL, is 41.83 feet. The values presented in this table are based on the elevation for “River” that is based on BPMSL.

Figure 2-1 Temporary Staff Gage Locations

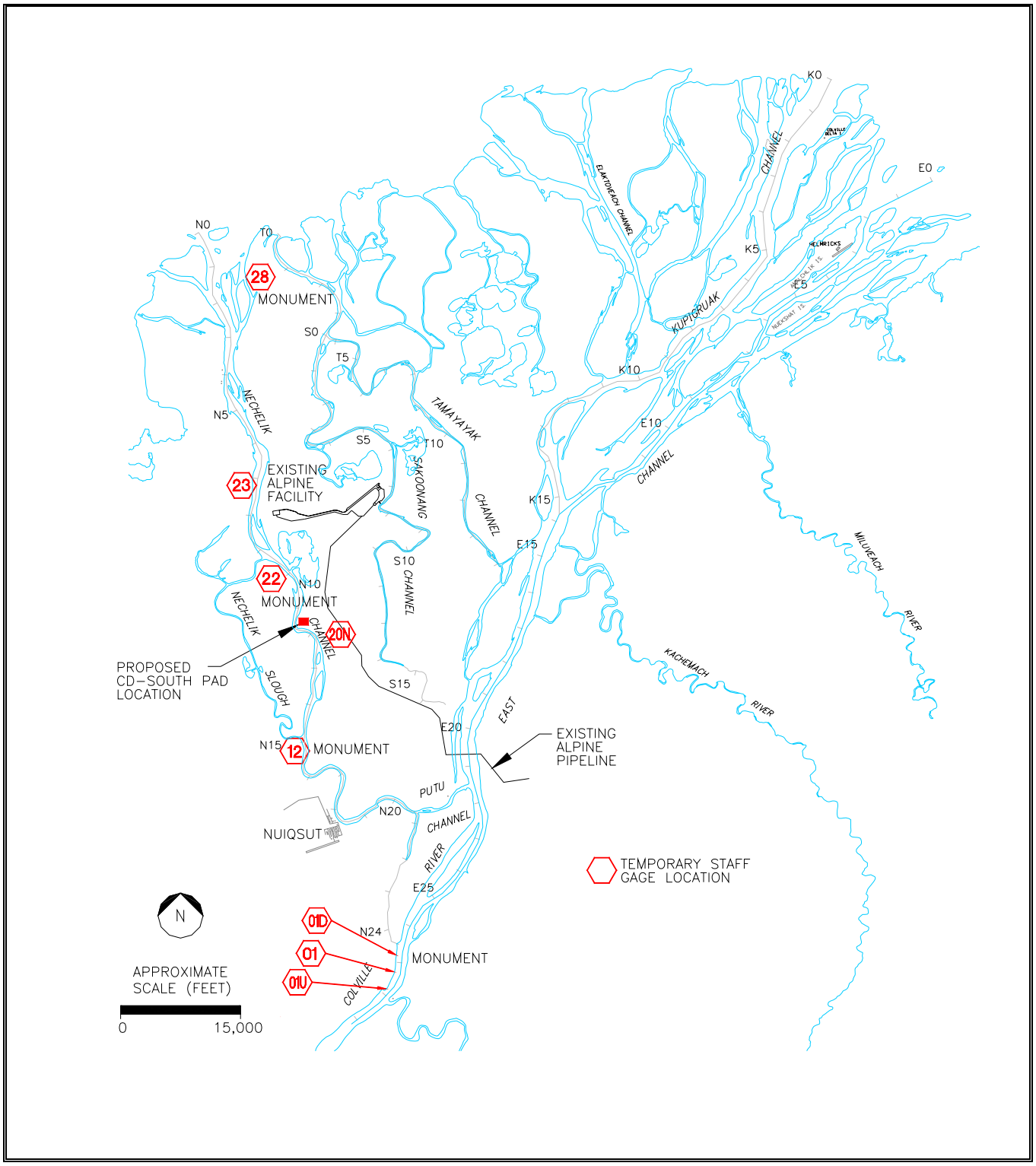
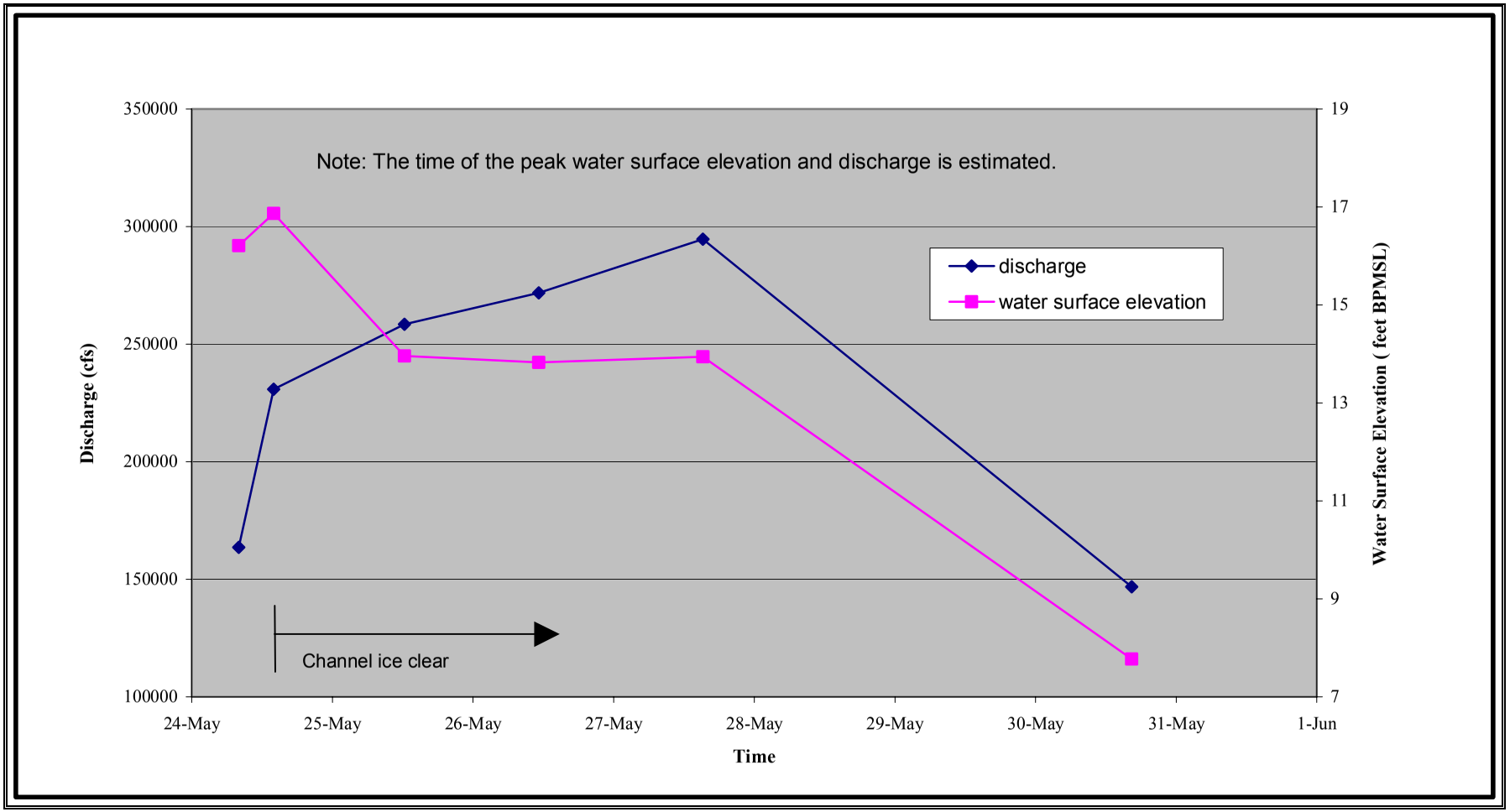


Figure 2-2 Discharge and Water Surface elevation vs. Time at Monument 01



3.0 CD-South

3.1 Water Surface Elevations and Observations

Water surface elevations were monitored along the Nigliq Channel at survey Monuments 12, 22, 23, 28, and at a temporary benchmark (TBM) established adjacent to the proposed CD-South pad location, approximately 1 mile downstream from Monument 20 and designated TBM 20N (Figure 2-1). Measurements began on 23 May, the day flowing water was first observed near Monument 01, and continued until 31 May when all temporary staff gages were removed. Water surface elevation and observation records for CD-South are presented in Tables 3-1 through 3-5.

In the Nigliq Channel near Monument 12, the peak water surface elevation occurred sometime between 3:00 p.m. on 24 May and 1:00 p.m. on 25 May at an elevation of 10.72 feet. The peak water surface at TBM 20N, Monument 22 and 23 occurred between 1:35 p.m. on 25 May and 2:05 9.m. on 27 May at elevations of 9.60 feet, 7.94, and 7.45 feet, respectively. The highest recorded water surface elevation at Monument 28 was 3.66 feet. The temporary staff gages at Monument 28 were destroyed by ice and high water marks were not available. However, based on the time of measurement on 26 May and the observed peak at other locations in the Delta the measurement of 3.66 feet is likely less than the peak water surface elevation.

Measured peak water surface elevations in the immediate vicinity of the proposed CD-South Development were compared to water surface elevations predicted by the two-dimensional surface water model developed for the Colville River Delta (Michael Baker Jr., Inc., 2002b, 2001a, 1998; and Shannon & Wilson, Inc., 1997). Based on a linear interpolation between the water surface elevations predicted for the 2- and 10-year open water floods, it is estimated that the peak water surface elevations observed this spring at the proposed CD-South site (TBM 20N) will likely be equaled or exceeded on average about once every 7 years. Estimated recurrence intervals at Monument 12 (upstream from CD-South) and Monument 22 (downstream from CD-South) are 7 and 8 years, respectively.

Observations at the time of the peak water surface elevation indicate large ice flows floating past the gages and much of the delta contained intact channel ice. The two-dimensional surface water model assumes open water conditions and does not take into account channel ice or ice jams. At

the time the model was constructed, it was assumed that during a large flood (such as the 50-, 100- and 200-year events for which the model was constructed), the presence of an ice sheet or ice jams would have little effect on the water surface elevation. However, channel ice and ice jams will restrict flow and cause increases in water surface elevation during smaller flood events when the flow is mainly confined within the channel banks. Thus, the water surface elevation predictions of the two-dimensional model will generally under-predict water surface elevations during small flood events when channel ice or ice jams are occurring in the delta. It is for this reason, that the return period estimated from predicted water surface elevations is higher than the return period estimated from discharge at the head of the delta. Discharge recurrence interval was previously discussed in Section 2.3.

3.2 Channel Ice Observations

Channel ice surveys began on 23 May when water was first observed at the head of the delta. Channel ice surveys were performed daily until 26 May when major channels of the delta were generally clear of channel ice and ice jams. The progression of the channel ice clearing and ice jamming is shown on a series of figures presented in Appendix B.

Unseasonable periods of warm and sunny weather characterized the early stages of breakup in the delta. Most of the snow cover in the delta had melted and many of the channels contained standing water with deteriorating channel ice. Channel ice in the main channels, East and Nigliq, showed signs of deterioration. Snow drifting that usually filled many of the smaller channels had melted, exposing areas of the channel bottom.

On the morning of 23 May, the first day of flowing water, the channel ice in the upper East and upper Nigliq channels was floating and beginning to break apart. Low water intact channel ice in all main channels was floating and becoming saturated by rising floodwaters. The Sakoonang Channel near Alpine was between 50 and 80 percent ice-free. Channel ice in the smaller channels in the lower portions of the delta was deteriorating rapidly as floodwaters rose and inundated these channels.

On the morning of 24 May, the East and Nigliq channels in the vicinity of Monument 01 were clear of all but broken and floating chunk ice. Ice that remained in the lower channels was, for

the most part, floating and rotten; however, the floating channel ice in the lower Nigliq was mostly intact

Channel ice in the East and Nigliq channels continued to clear on 25 May. In addition, the majority of the lower channels were clear or contained only floating broken chunk ice. The channel ice on the lower Nigliq was still intact and extended into Harrison Bay. With the exception of the East and Nigliq channels, all channels in the lower delta were either clear or contained only discontinuous sections of broken ice by 26 May.

The Nigliq channel adjacent to the proposed CD-South facility was 80% free of ice on 24 May, though numerous large ice floes were noted floating by the gages. The only significant ice jam observed in the vicinity of CD-South was in the Nigliq Channel at the sharp channel bend adjacent to the proposed pad location on 25 May. The ice jam spanned the entire width of the channel and appeared to be a surface ice jam only. Large ice floes (some measuring over 6 feet thick) had been driven onto both banks of the channel, however, backwater effects from this ice jam did not appear significant and no observable effects on water surface elevations up or downstream were noted. See Photos 3-11 to 3-13. On 26 May, grounded ice chunks, up to 50 feet in diameter, deposited by high water were observed on the channel bank adjacent to the proposed facility location.

Other ice jams were observed at various locations in the delta. A surface ice jam that formed above the village of Nuiqsut at the confluence of the Putu and Nigliq channels on 23 May grew in size on 24 May, but cleared by 25 May. Small ice jams were noted at the mouth of the Itkillik River, on the Sakoonang channel northeast of Alpine, and on portions of the Nigliq channel. All observed ice jams appeared to be surface ice jams rather that grounded jams. In no case did the observed ice jams appear to cause significant backwater, blockage, or diversions of flow.

3.3 Proposed CD-South Road Alignment

3.3.1 Field Observations

The proposed CD-South road alignment was monitored to document cross flow during the 2002 spring breakup and to assess the potential for cross flow during subsequent flood events. 2002 field observations of the flow paths, magnitudes of flooding, and recharge mechanisms along the alignment were very similar to field observations made in 2001 (Michael Baker Jr., 2001b).

No flow across the road alignment was observed during the 2002 spring breakup field monitoring.

The area east of the proposed road alignment was recharged by two breaches in the Sakoonang Channel. The first breach is located to the east of Lake M9525 where the Sakoonang Channel begins a "U" shaped bend (Figure 3-2, Location A). This breach was the primary mechanism for recharge to the east of the proposed alignment (Photos 3-8, 3-10, & 3-15).

The second breach is located to the east of the southern-most portion of Lake L9324 (Figure 1, Location B) at the 90° channel bend. Flow was observed through this breach into the adjacent shallow muddy lake, through Lake L9324, and into the Niqlig Channel (Photos 3-6, 3-7, 3-8, 3-9, 3-14, 3-15, and 3-16). Recharge contributions to the floodplains east of the proposed alignment from this second breach were negligible compared to the contributions observed from the breach located east of Lake M9525.

The area west of the proposed road alignment was recharged by a breach in the Nigliq Channel. The breach is located west of Nanuq Lake (Figure 3-2, Location C) and was the primary mechanism for recharge for the area west of the proposed alignment.

The area of the proposed CD-South drill pad and that portion of the proposed road that lies west of the paleochannel (Figure 3-2, Location D) is relatively high ground that will likely see flow only during large flood events. Local snowmelt was the only source of surface water noted in this area.

On the western edge of the paleochannel (Figure 1, Location D) a hydraulic connection between Lake L9324 and Lake L9323 was observed on 24 May. A similar connection was noted during the 2001 breakup field season. In 2002, flow through the connection was shallow and appeared to be moving from south to north (Photo 3-8). Water was again observed in the connection on 25 May, but the depth of water had decreased and flow was no longer apparent.(Photo 3-10). The proposed road realignment across Lake L9323 does not cross this paleochannel, and this observation is intended only to demonstrate similarities between 2001 and 2002 breakup characteristics in the vicinity of the proposed road.

A hydraulic connection was observed in the low area between Lake M9525 and Lake L9323 on 25 and 26 May (Figure 1, Location E, Photos 3-10 and 3-15). The direction of flow was from north to south and the source of the water was the Sakoonang Channel outlet at Location A. Again, this does not affect the proposed alignment, but is another similarity between 2001 and 2002.

No flowing water was observed at the potential crossing location on Lake L9323. Open water was observed around the edges of the lake; however, the lake ice remained intact throughout breakup.

3.3.2 Hydrologic Assessment

No changes were made to the hydrologic assessment of the proposed road alignment (Baker, 2001b) based on the observations made in 2002. The following assessments are reiterated:

Based on field reconnaissance and observations made during the spring of 2001 and 2002 breakup programs, the proposed CD-South road is located such that it will result in minimal impact to hydrologic systems in the vicinity of the project. Hydrologically, the proposed CD-South road is fundamentally different from the existing Alpine road in that the proposed CD-South road is aligned such that it is parallel to flow while the Alpine road is perpendicular to flow.

Based on field observations, it appears that cross flow over the proposed CD-South alignment is relatively infrequent. During the 2001 and 2002 breakups, recharge to the area east of the alignment originated in the Sakoonang Channel (via Location A) and recharge to the area west of

the alignment originated in the Nigliq Channel (via Location C). The proposed road alignment essentially follows a natural divide between these two areas.

3.4 Proposed CD-South Pad Location

3.4.1 Field Observations

The current location of the proposed pad was not impacted by either high water or grounded ice during the 2002 breakup. The lowest ground surface elevation in the vicinity of the pad is approximately 10.5 feet and the peak water surface elevation recorded at TBM 20N (adjacent to the proposed pad site) was 9.60 feet. Wet tundra caused by snowmelt was the only source of surface water noted in the immediate vicinity. Photographs 3-4 to 3-16 depict the CD South Pad and vicinity between 24 and 26 May 2002.

3.4.2 Hydrologic Assessment

No changes were made to the 2001 hydrologic assessment of the proposed pas location. based on observations made in 2002. The pad will be vulnerable to ice flows during extremely large flood events. During a 200-year flood event, a 5-foot thick ice floe could impact the pad, as the predicted depth of water is 5.8 feet. The ground will offer protection from ice flows during flood events smaller than the 200-year, but water could inundate low-lying portions of the gravel structures.

Table 3-1 Monument 12, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Observations
5/23/2002	8:45	7.02	
5/23/2002	16:05	7.61	
5/24/2002	8:30	9.58	Channel is about 50% free of ice. Ice, although intact, is rotten and cracked.
High Water Mark		10.47	High water mark occurred on May 24 between 08:30 and 15:15.
5/24/2002	15:15	9.75	Grounded rotten ice around gages. Large flow extends halfway across channel.
High Water Mark		10.72	Peak water surface elevation occurred between May 24 at 15:15 and May 25 at 13:10.
5/25/2002	13:10	10.64	Large ice floes floating in reach. Large ice jam noted upstream near Nuiqsut.
5/26/2002	11:35	9.15	Stranded ice chunks up to 30 feet in diameter on banks.
5/31/2002	10:45	3.49	

Notes:

1. Elevations are based on an elevation of 14.60 feet BPMSL for Monument 12, established by Lounsbury & Associates in 1996.
2. Staff gages were set on opposite bank from Monument 12.
3. GPS coordinates for Monument 12 are N70° 14' 58.3" W151° 01' 23.5" (NAD 27), surveyed by Lounsbury and Associates.

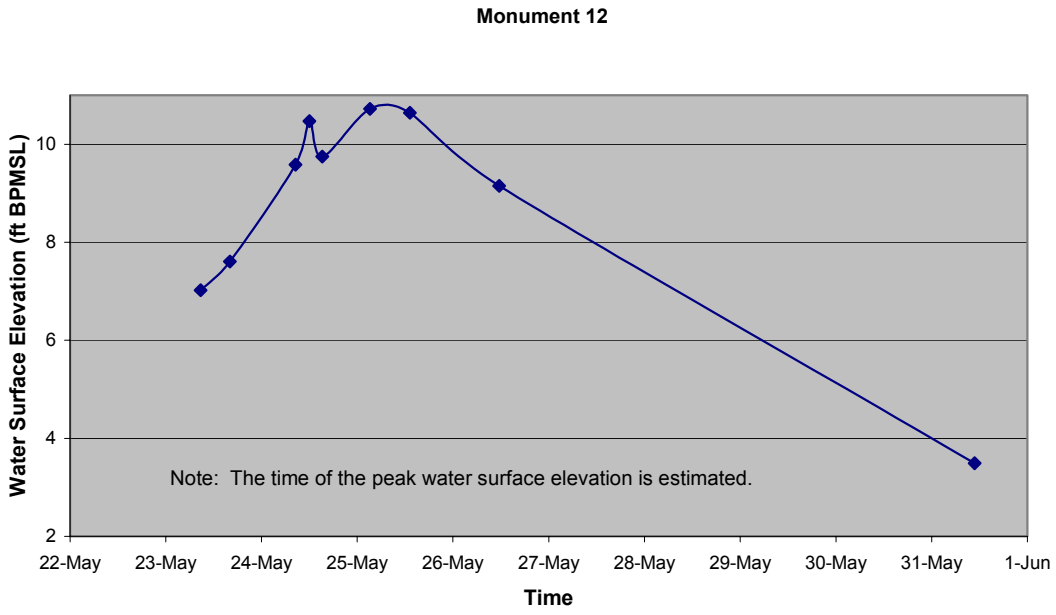


Table 3-2 TBM 20N Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Observations
5/23/2002	08:50	5.39	Channel approximately 80% free of ice. Ice still intact along right bank.
5/23/2002	16:10	6.23	Majority of ice along right bank has broken apart since last reading.
5/24/2002	08:40	7.79	Large ice floes noted in front of gages.
High Water Mark		8.91	High water mark occurred on May 24 between 08:40 and 15:40.
5/24/2002	15:40	8.29	Rotten ice chunks floating in channel.
5/25/2002	13:35	8.75	Significant ice jam across channel with numerous ice chunks driven onto shore.
High Water Mark		9.60	Peak water surface elevation occurred between May 25 at 13:35 and May 26 at 11:45.
5/26/2002	11:45	8.29	Ice jam has cleared channel free of ice. 50-foot diameter ice chunks on banks.
5/27/2002	14:25	7.55	Channel is free of ice. Ice chunks along right bank.

Notes:

1. Elevations are based on an elevation of 19.17 feet BPMSL for Monument 20, established by Lounsbury & Associates in 1996.
2. Gages were set on opposite bank and approximately 1 mile downstream (north) of Monument 20.
3. GPS coordinates for TBM 20N are N70° 17' 29.0" W150° 59' 57.8" (NAD 27), obtained with a Garmin GPS III Plus hand-held global positioning system.

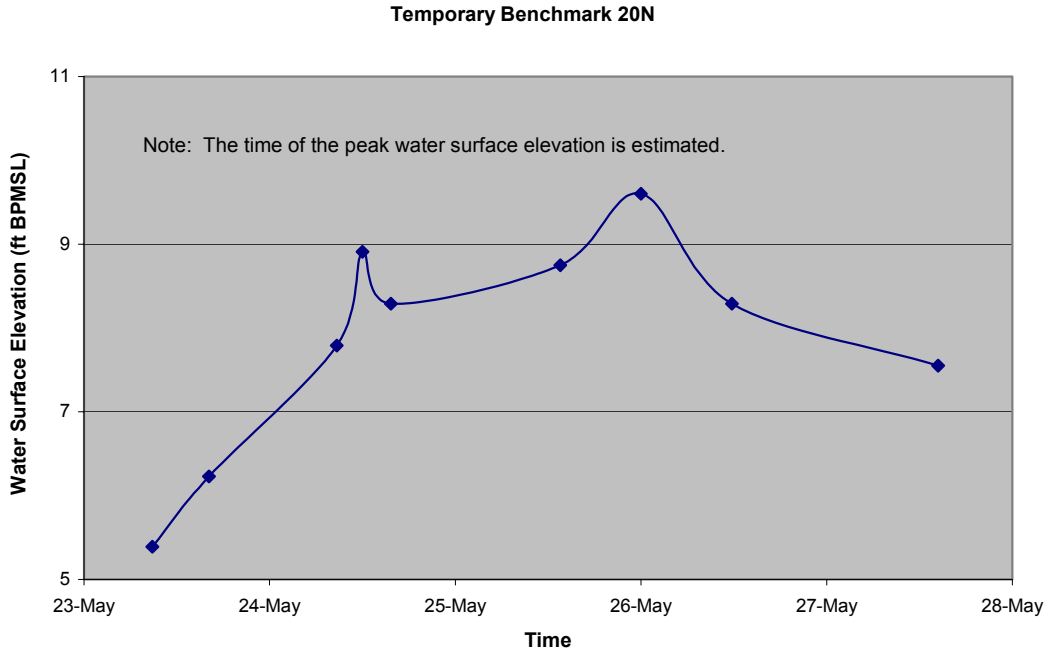


Table 3-3 Monument 22, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Observations
5/23/2002	08:45	4.11	Channel approximately 70% free of ice. Ice channel intact along right bank.
5/23/2002	16:15	5.19	Channel ice intact along right bank.
5/24/2002	9:00	6.47	Channel is 95% ice free. Large ice floe stranded in channel.
High Water Mark		7.06	High water mark occurred on May 24 between 09:00 and 15:50.
5/24/2002	15:50	6.92	
High Water Mark		7.27	High water mark occurred between May 24 at 15:50 and May 25 at 13:57.
5/25/2002	13:57	7.07	
High Water Mark		7.94	Peak water surface elevation occurred between May 25 at 13:57 and May 27 at 14:05.
5/27/2002	14:05	6.41	Left bank is choked with grounded and floating ice chunks.
5/31/2002	12:27	3.06	

Notes:

1. Elevations are based on an elevation of 10.13 feet BPMSL for Monument 22, established by Lounsbury & Associates in 1996.

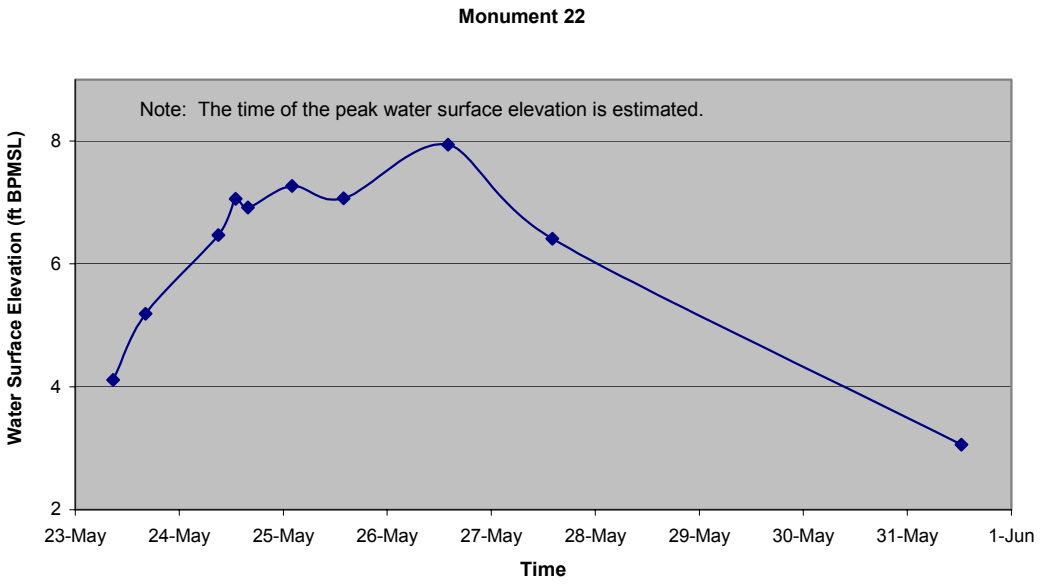


Table 3-4 Monument 23, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Observations
5/23/2002	9:10	3.65	
5/23/2002	16:25	4.49	
5/24/2002	9:10	5.64	Channel is 90% free of ice with small floes passing through reach.
High Water Mark		6.23	High water mark occurred on May 24 between 09:10 and 16:00.
5/24/2002	16:00	6.04	No visible ice floating in channel.
5/25/2002	14:15	6.15	Ice chunks moving through channel. Channel ice intact on left bank.
High Water Mark		7.42	High water mark occurred between May 25 at 14:15 and May 26 at 12:15.
5/26/2002	12:15	6.65	Large ice chunks stranded on both banks.
High Water Mark		7.45	Peak water surface elevation occurred between May 26 at 12:15 and May 27 at 12:45.
5/27/2002	12:45	5.62	Channel is free of ice. Grounded ice floes downstream on right bank.

Notes:

1. Elevations are based on an elevation of 8.76 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem support at Permanent Staff Gage #8. Elevations were established by Kuukpik/LCMF Incorporated.
2. GPS coordinates for Monument 23 are N70° 20' 30.6" W151° 03' 30.3" (NAD 27), surveyed by Lounsbury and Associates.

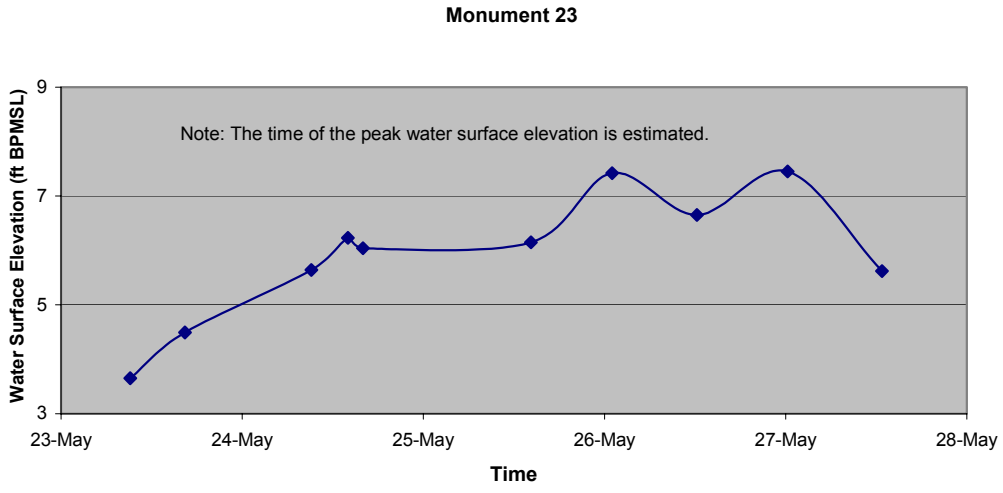


Table 3-5 Monument 28, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Observations
5/23/2002	9:20	1.91	No intact channel ice present in distributary where gages are located. Main Nigliq Channel has low water channel ice intact.
5/23/2002	16:35	2.14	
5/24/2002	9:30	2.67	
High Water Mark		3.00	High water mark occurred on May 24 between 09:30 and 16:10.
5/24/2002	16:10	2.90	No visible ice floating in channel.
5/25/2002	14:36	3.23	
5/26/2002	12:25	3.66	Staff gages destroyed. Nigliq channel ice still intact adjacent to gage location.

Notes:

1. Elevations are based on an elevation of 3.66 feet BPMSL for Monument 28, established by Lounsbury & Associates in 1998.
2. GPS coordinates for Monument 28 are N70° 25' 33.2" W151° 03' 49.6" (NAD 27), surveyed by Lounsbury and Associates.
3. Staff gages destroyed on May 26. No high water mark available. Reading on May 26 from Monument 28.

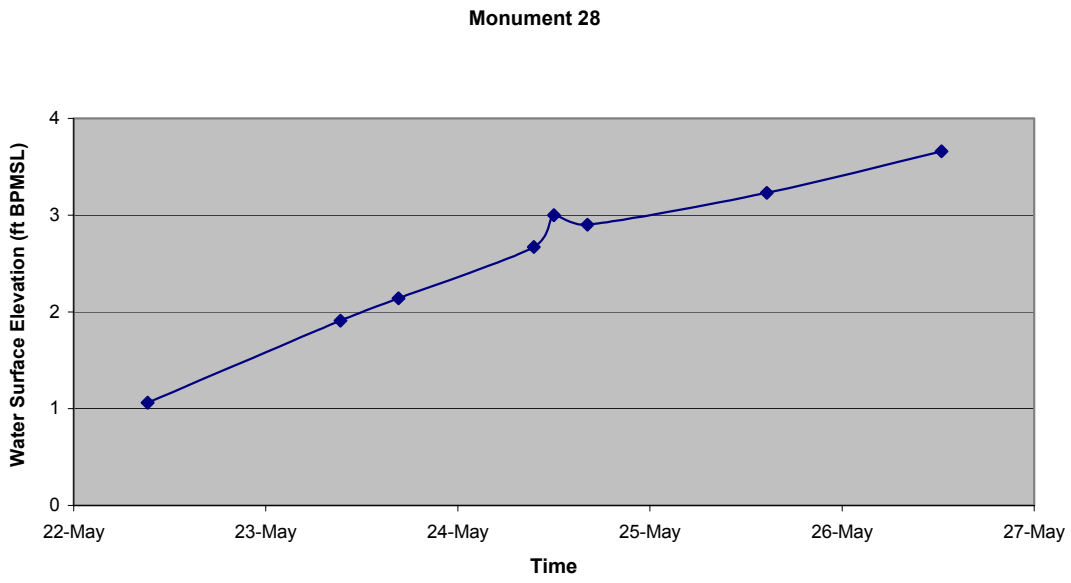


Figure 3-1 CD-South Project Location

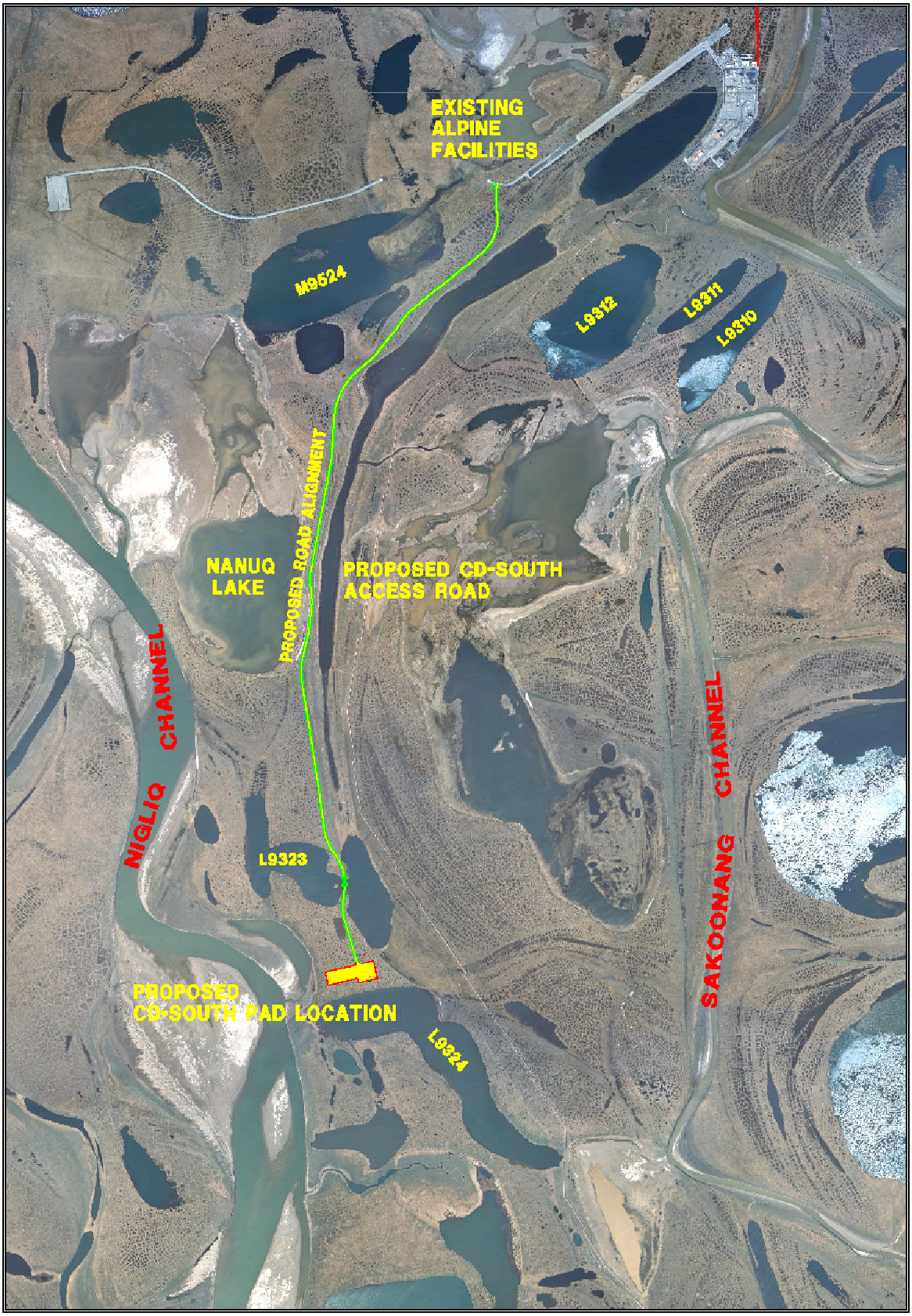
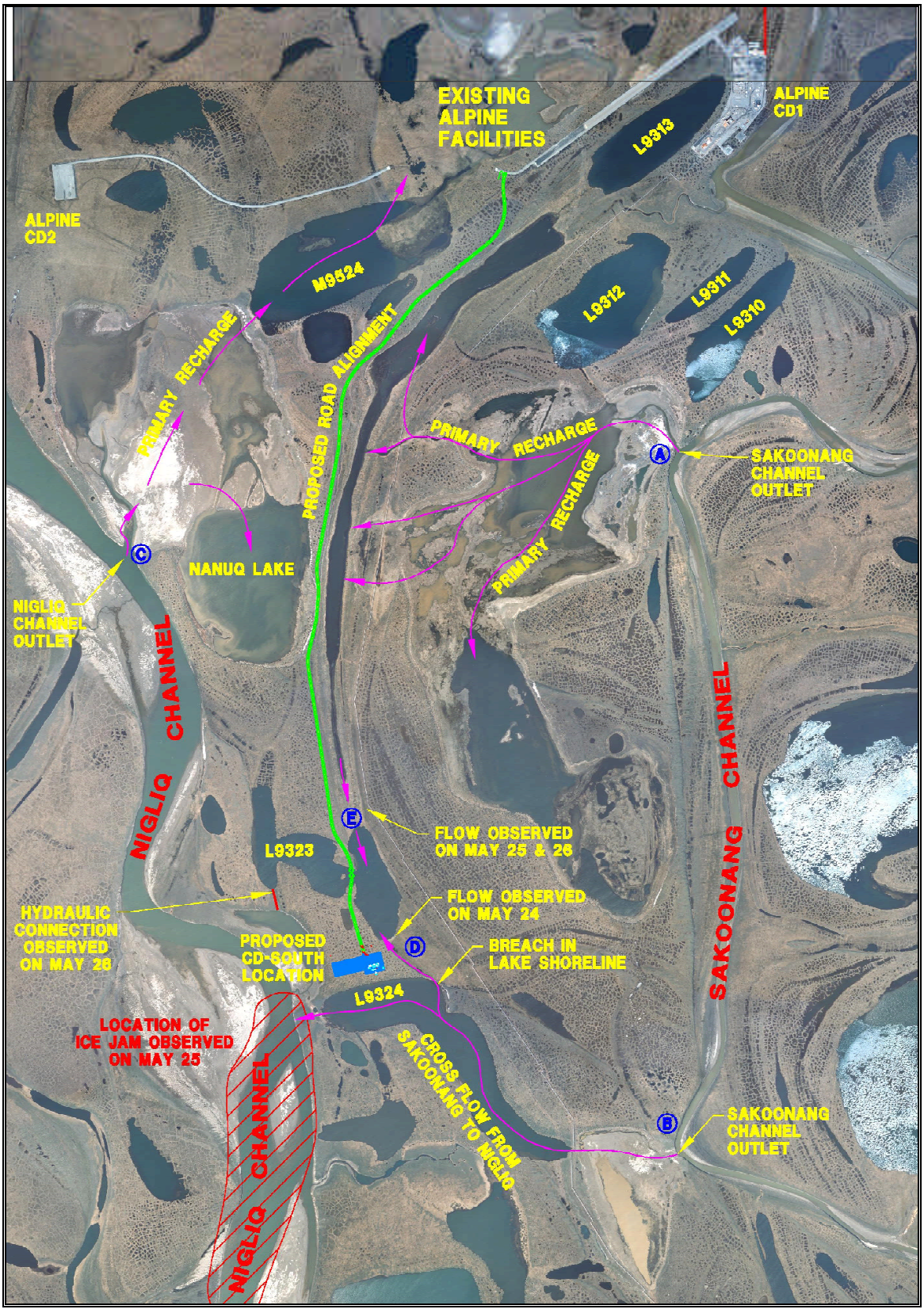


Figure 3-2 CD-South Road Alignment and Breakup Flooding 2002



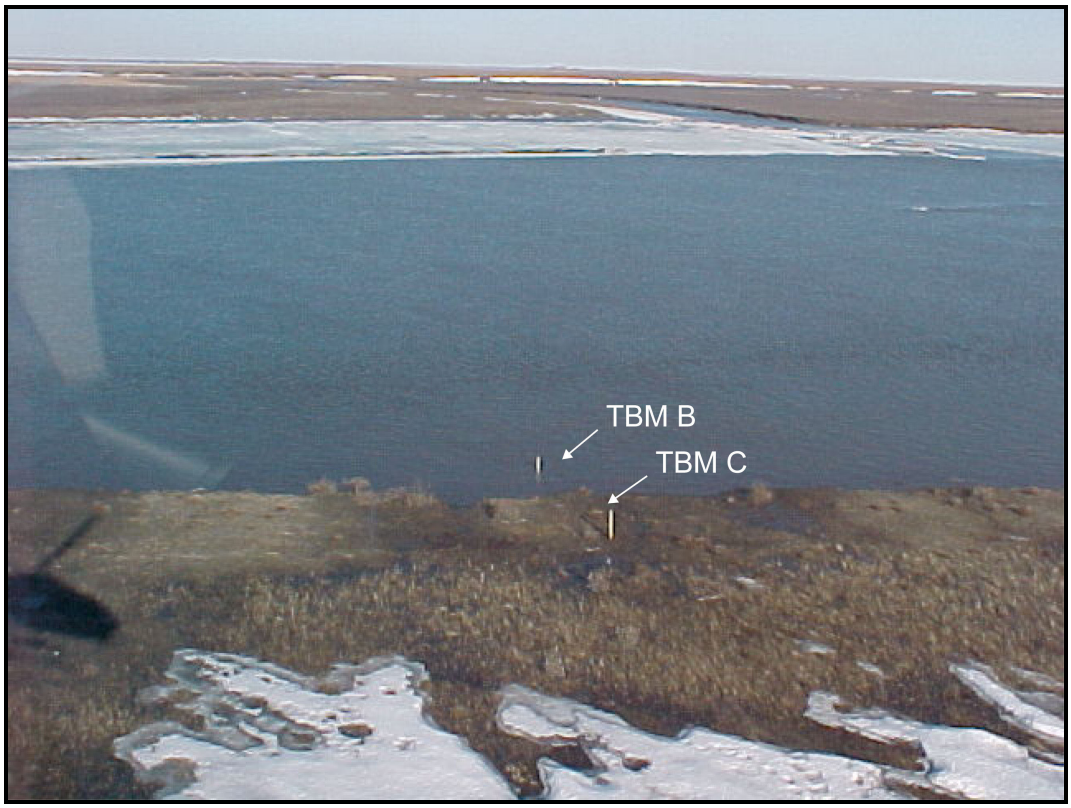


Photo taken May 23, 2002

Photo 3-1 Monument 12. Looking west across the Nigliq Channel.

Photo taken May 24, 2002

Photo 3-2 Monument 12. Looking west across the Nigliq Channel.

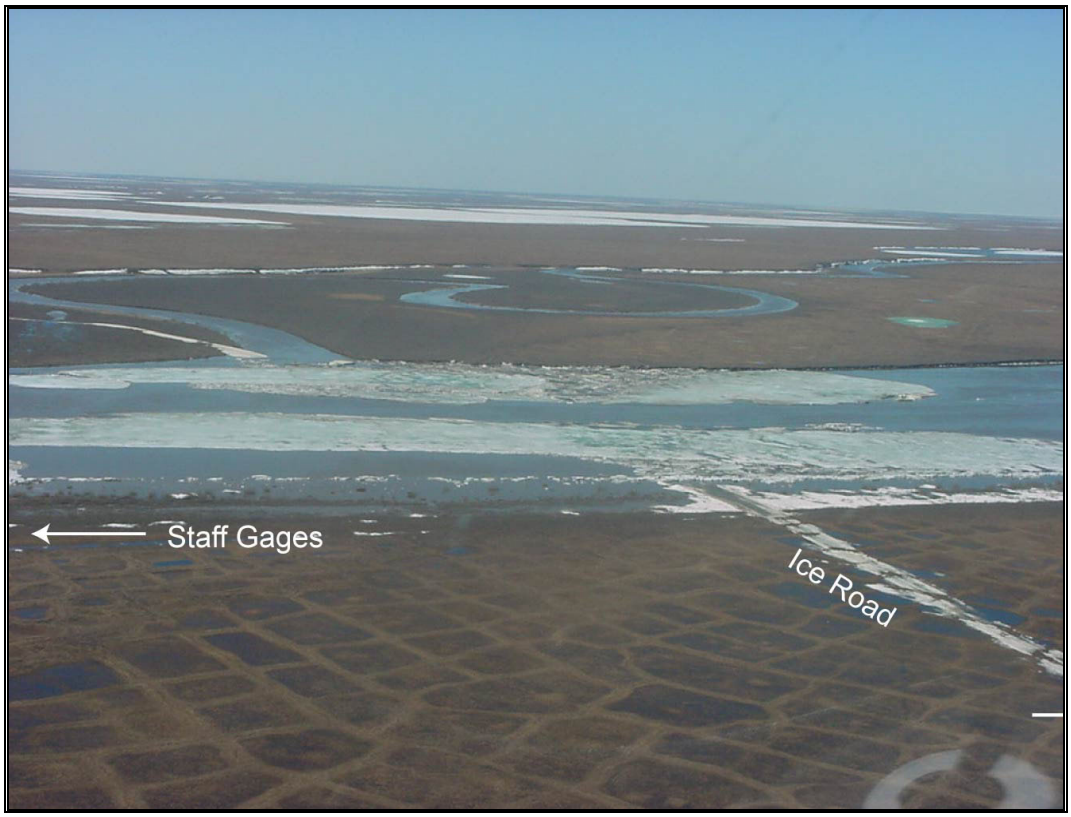


Photo taken May 24, 2002

Photo 3-3 **Looking west across the Nigliq Channel. Photo was taken just downstream from Monument 12. Note condition of ice road and channel crossing.**

Photo taken May 23, 2002

Photo 3-4 **Temporary Benchmark 20N. Looking west towards the Nigliq Channel.**

Photo taken May 23, 2002

Photo 3-5 **Looking north at the proposed CD-South pad location.**

Photo taken May 24, 2002

Photo 3-6 **Temporary benchmark 20N. Looking southwest at the Nigliq Channel and the proposed CD-South pad location.**

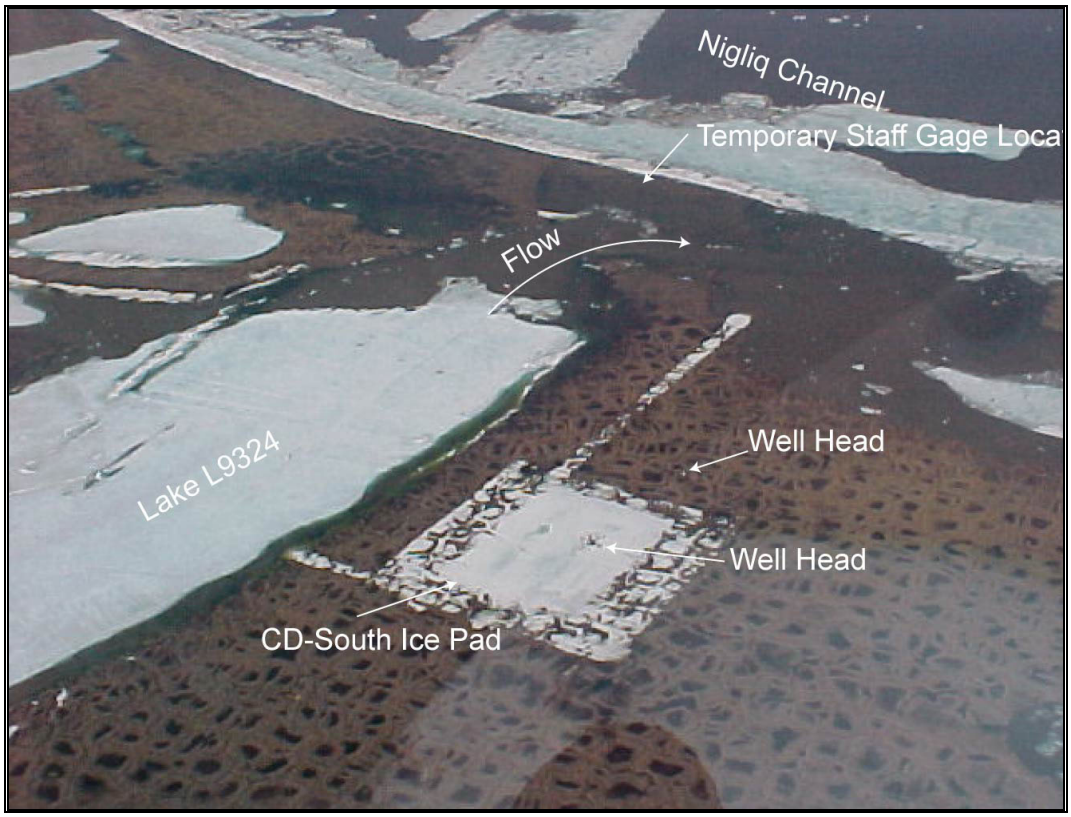


Photo taken May 24, 2002

Photo 3-7 **Looking southwest at the proposed CD-South pad location.**

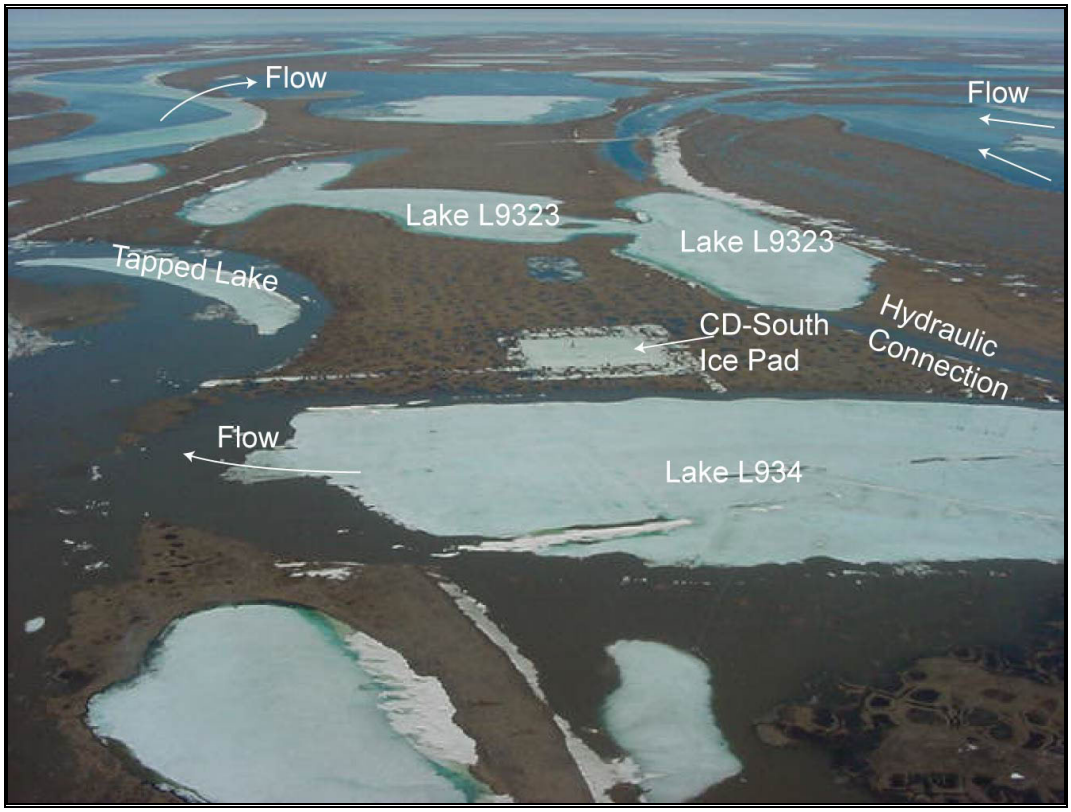


Photo taken May 24, 2002

Photo 3-8 **Looking north towards the proposed CD-South pad location.**

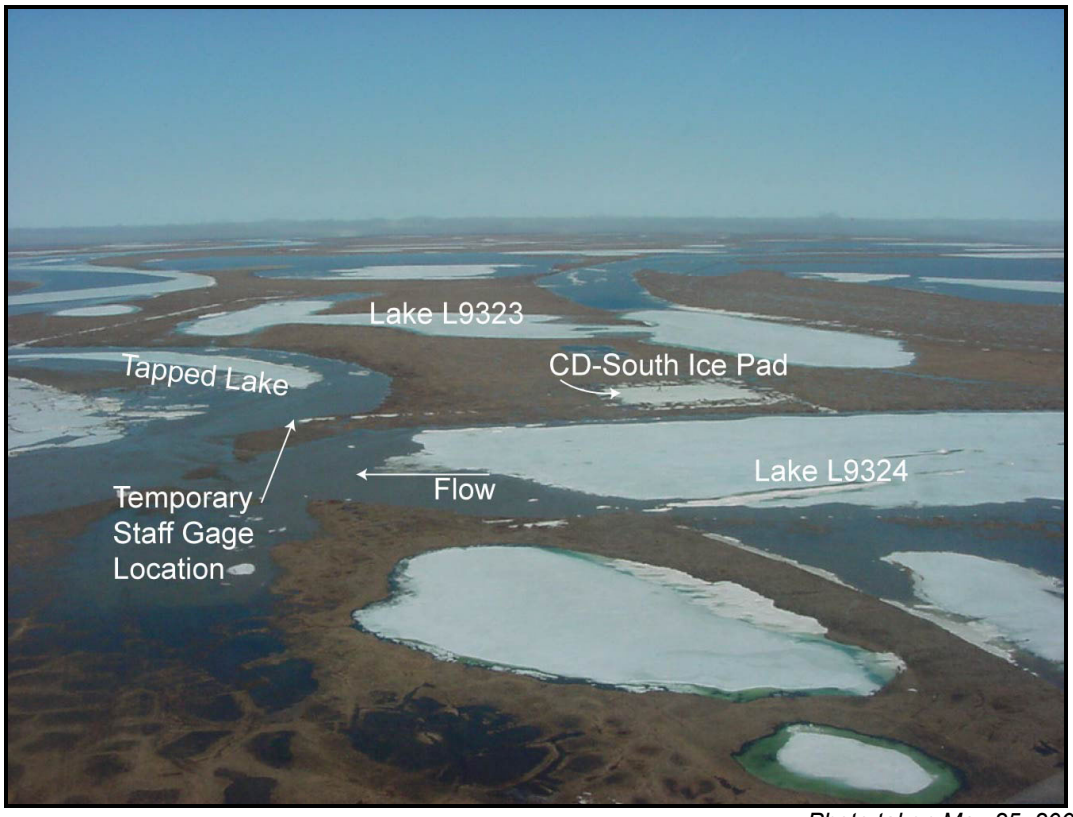


Photo taken May 25, 2002

Photo 3-9 **Looking north towards the proposed CD-South pad location.**

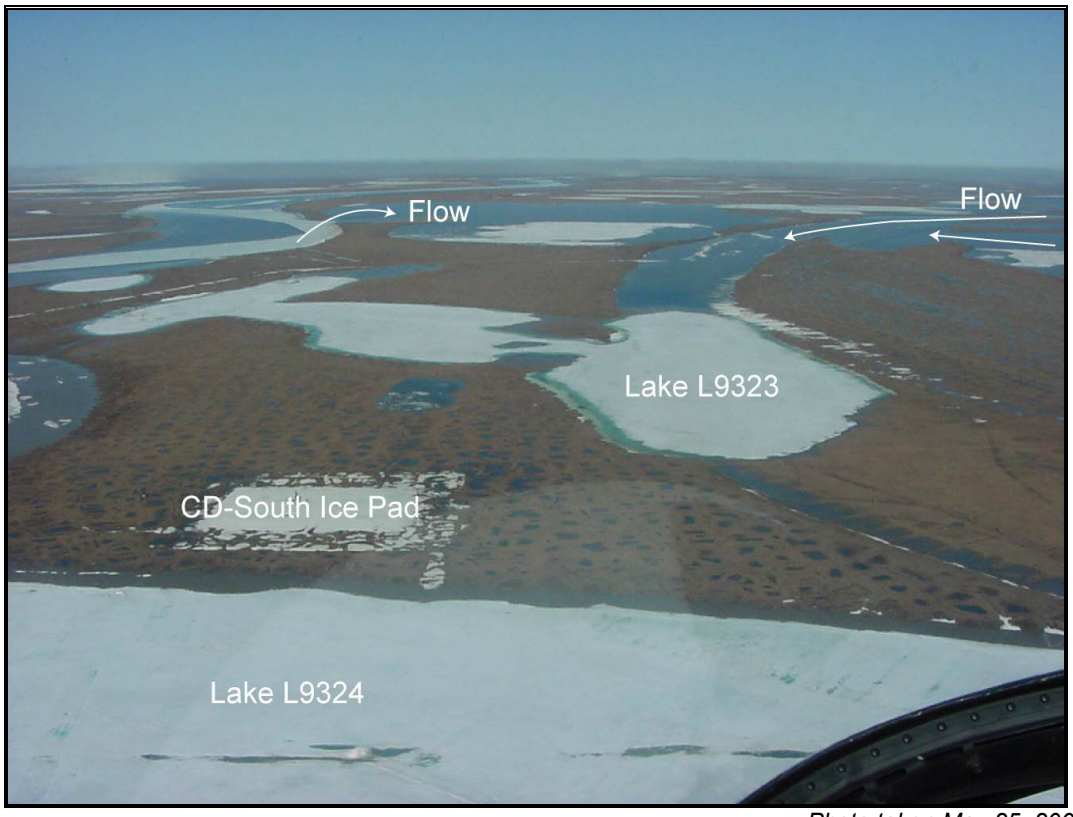


Photo taken May 25, 2002

Photo 3-10 **Looking north towards the proposed CD-South pad location.**

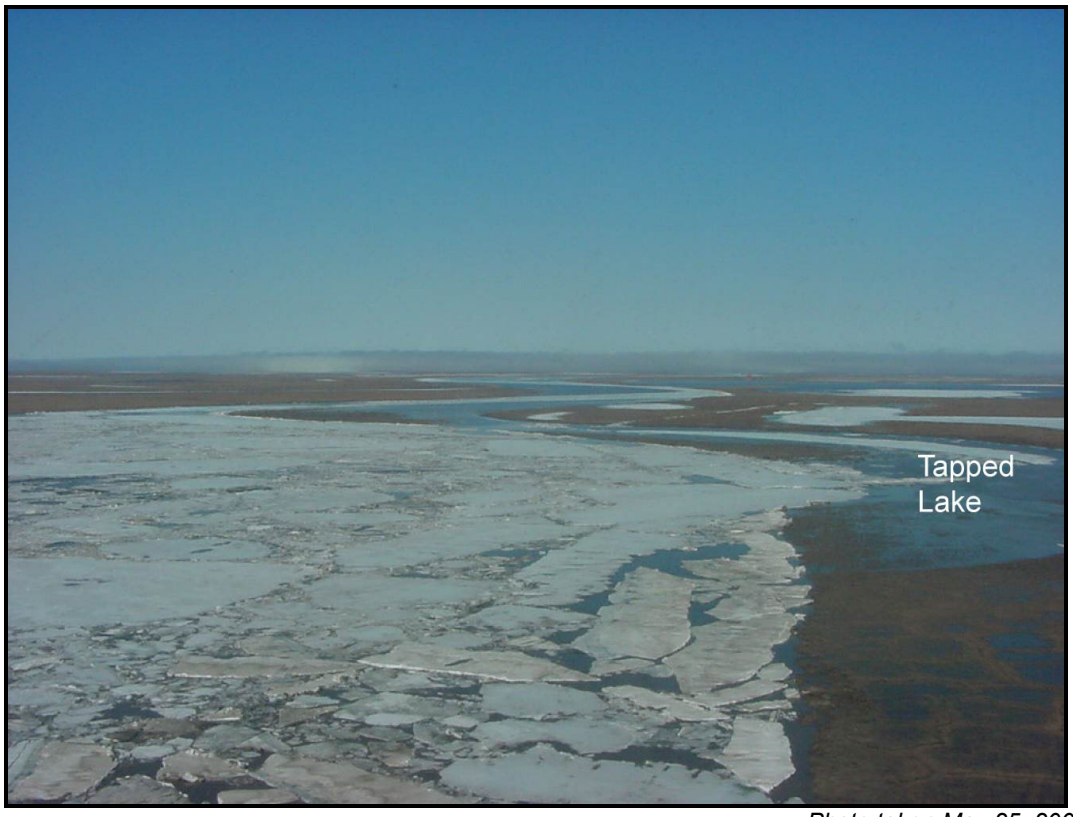


Photo taken May 25, 2002

Photo 3-11 **Looking north at an ice jam in the Nigliq Channel bend, directly west of the proposed CD-south pad location.**

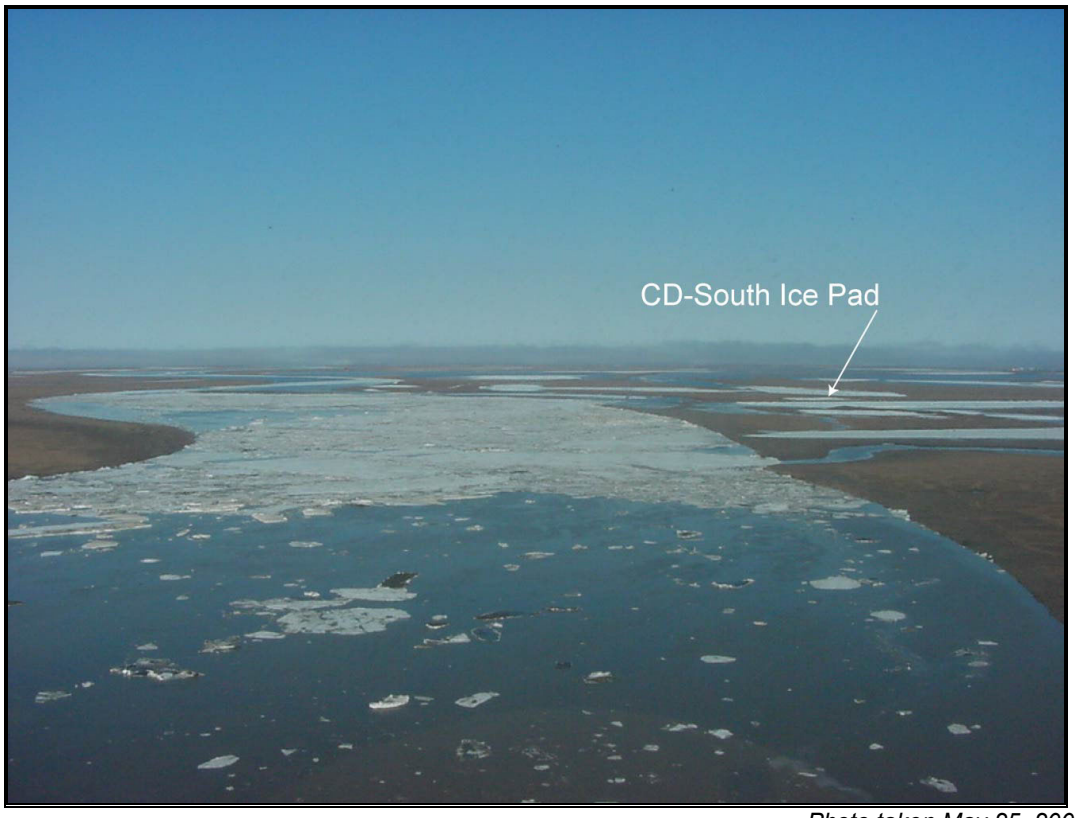


Photo taken May 25, 2002

Photo 3-12 **Looking north at the ice jam in the Nigliq Channel bend, west of the proposed CD-South pad location.**

Photo taken May 25, 2002

Photo 3-13 **Ice floes forced up onto riverbank as a result of the ice jam shown in previous photos.**

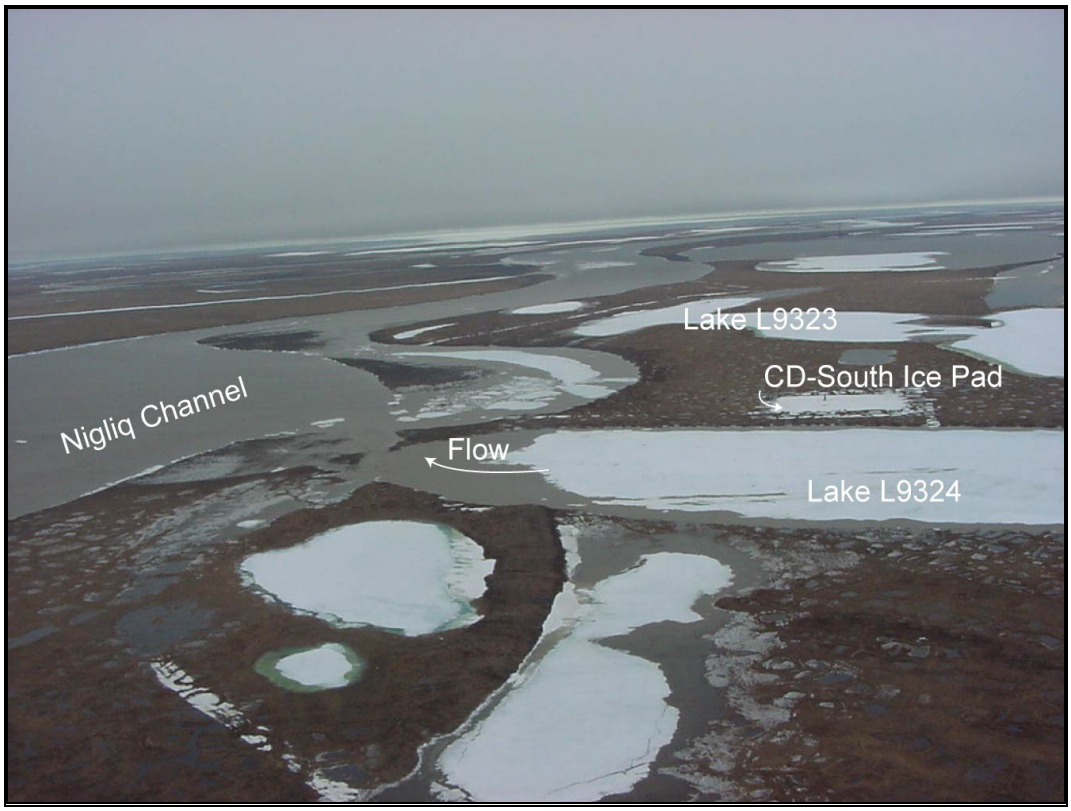


Photo taken May 26, 2002

Photo 3-14 **Looking north towards the proposed CD-South pad location. Note that the ice jam in the Nigliq Channel has cleared.**

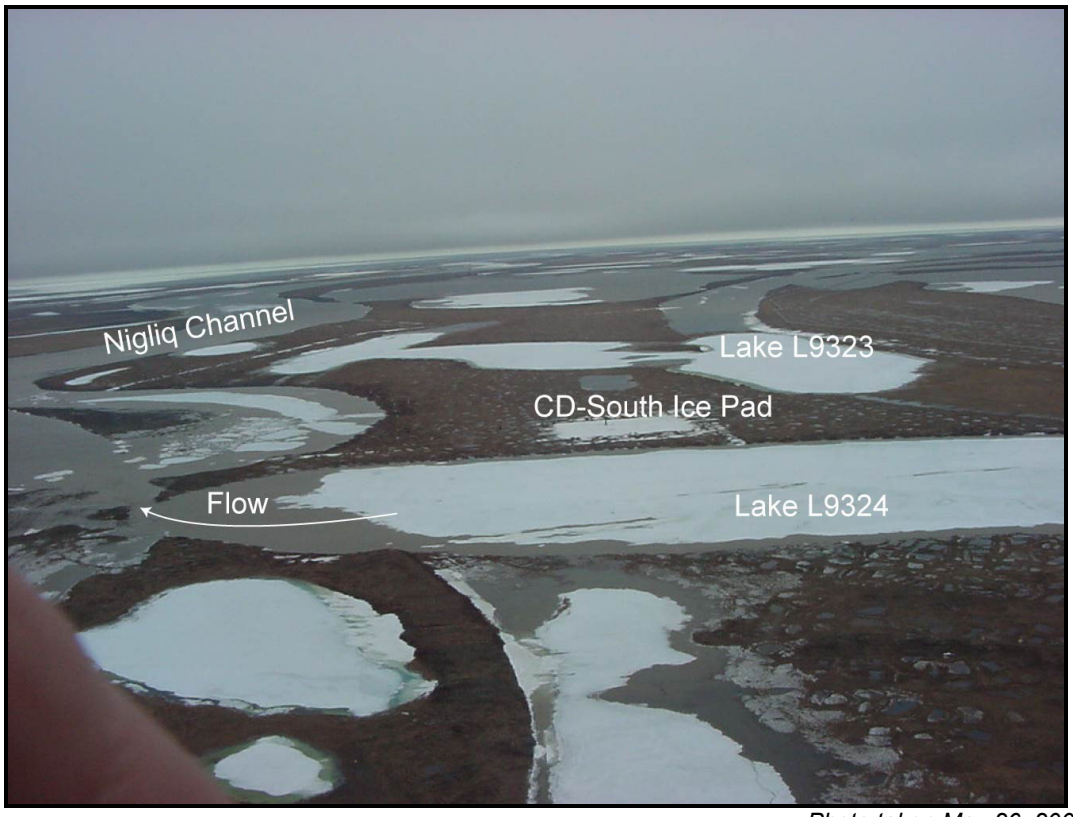


Photo taken May 26, 2002

Photo 3-15 Looking north towards the proposed CD-South pad location.

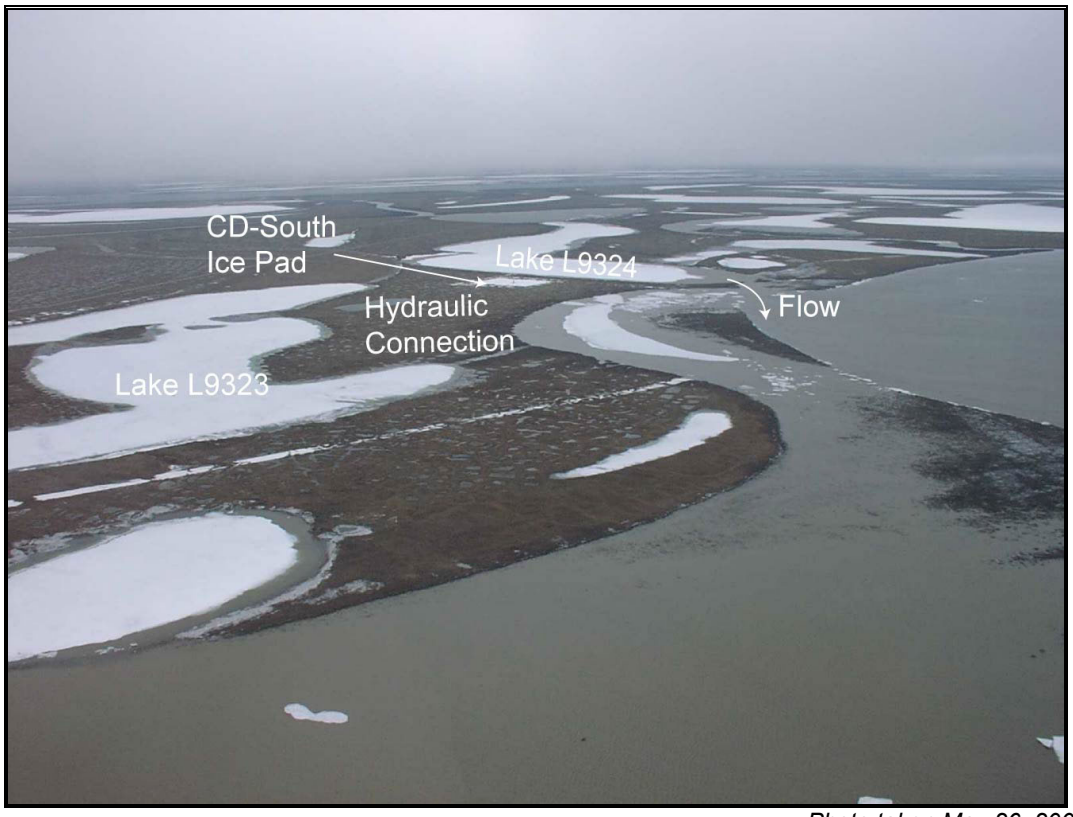


Photo taken May 26, 2002

Photo 3-16 Looking southeast towards the proposed CD-South pad location.

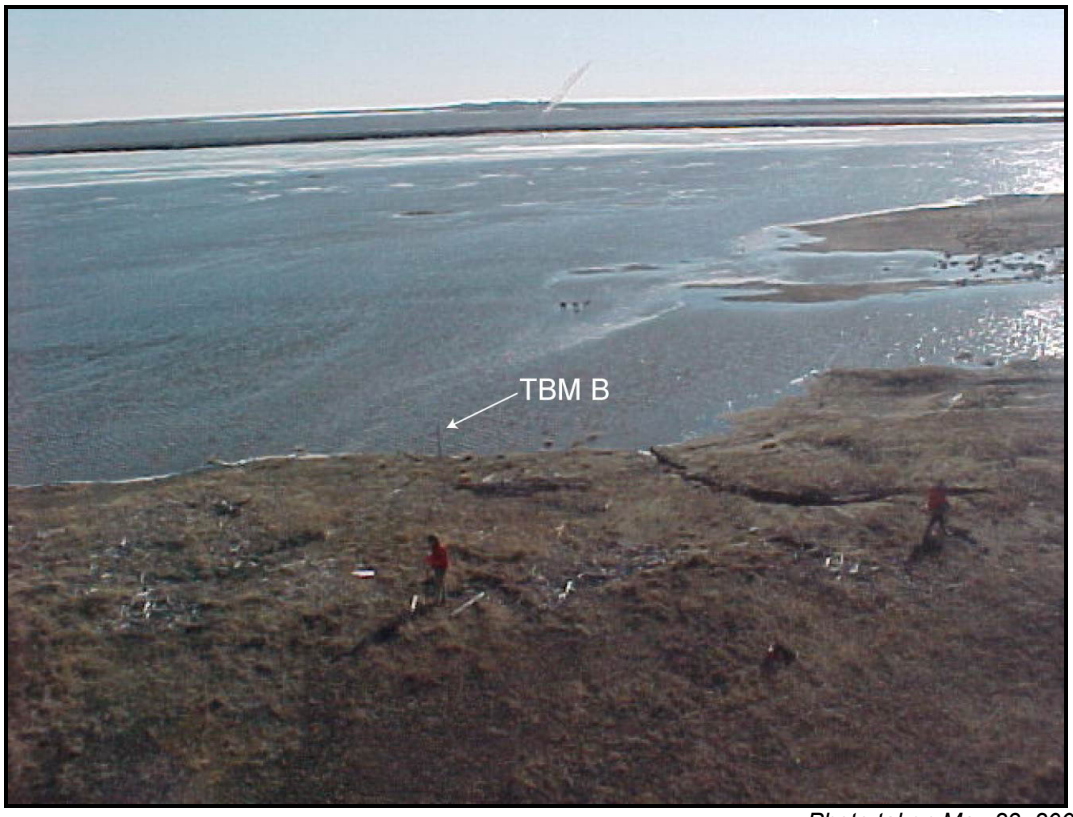


Photo taken May 23, 2002

Photo 3-17 Monument 22. Looking southeast across the Nigliq Channel.

Photo taken May 27, 2002

Photo 3-18 Monument 22. Ice grounded at temporary staff gage location. All staff gages have been destroyed by ice.

Photo taken May 23, 2002

Photo 3-19 **Monument 23. Looking northwest at the Nigliq Channel and the temporary staff gage location.**

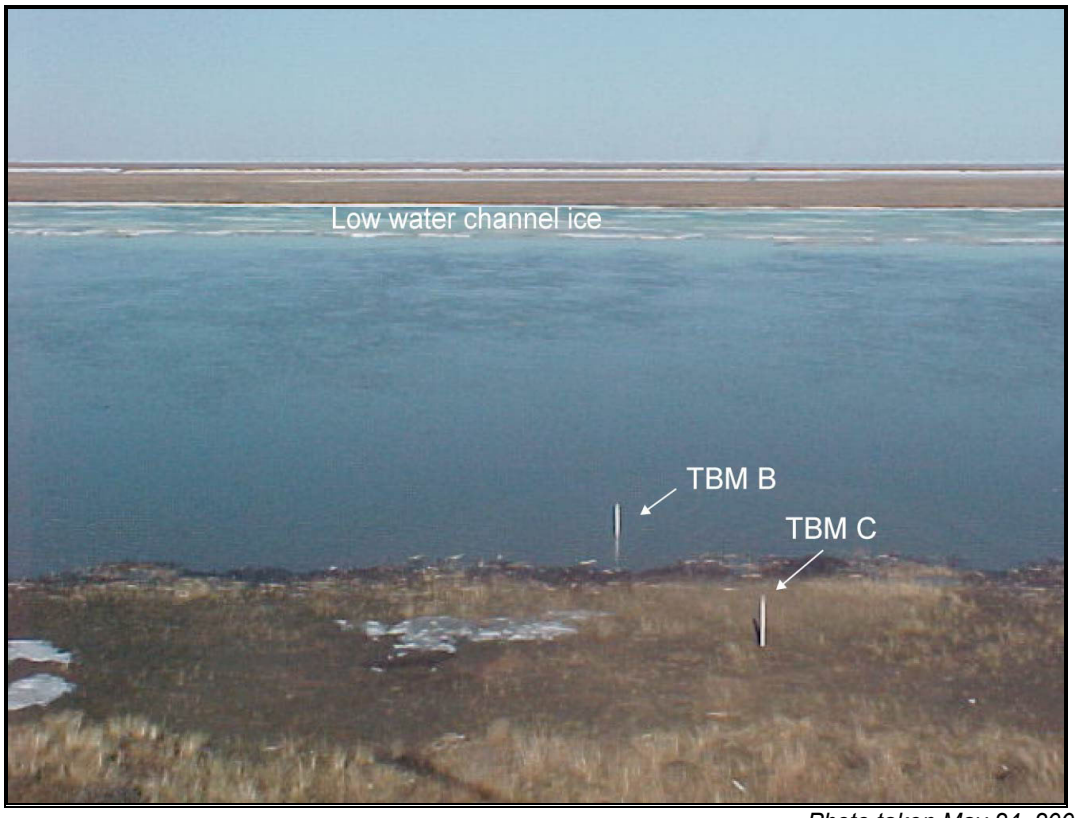


Photo taken May 24, 2002

Photo 3-20 **Monument 23. Looking west across the Nigliq Channel.**

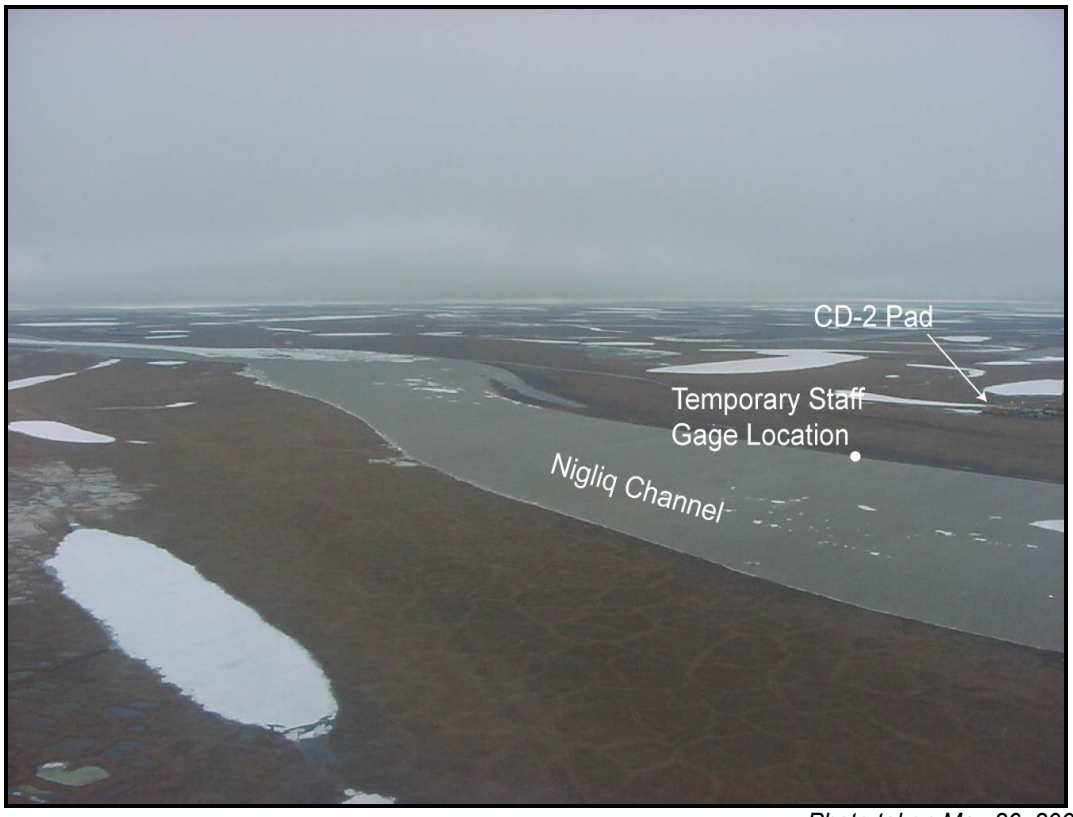


Photo taken May 26, 2002

Photo 3-21 Monument 23. Looking northeast at the Nigliq Channel.

Photo taken May 23, 2002

Photo 3-22 Looking north a the Nigliq Channel in the vicinity of Monument 28.

4.0 References

Alaska Biological Research and Shannon & Wilson, 1994. *Geomorphology and Hydrology of the Colville River Delta, Alaska, 1993*. Prepared for ARCO Alaska, Inc., Anchorage, Alaska

Arcement, G.J. & Schneider. 1989. *Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Floodplains*. U.S. Geological Survey Water Supply Paper 2339. U.S. Government Printing Office, Denver, Colorado.

Dalrymple and Benson. 1984. *Measurement of Peak Discharge by the Slope-Area Method.* Techniques of Water Resource investigations of the United States Geological Survey. U.S. Government Printing Office, Washington.

Michael Baker Jr., Inc. 2002a. *Alpine Facilities 2002 Spring Breakup and Hydrologic Assessment.* Prepared for Phillips Alaska, Inc., Anchorage.

——— 2002b. *Colville River Delta Two-Dimensional Surface Water Model, CD-Satellite Update.* Prepared for Phillips Alaska, Inc., Anchorage.

——— 2001a. *Colville River Delta, 2- and 10-Year Flood Models.* Prepared for Phillips Alaska, Inc., Anchorage, Alaska

——— 2001b. *CD-South Development Project 2001 Spring Breakup and Hydrologic Assessment.* Prepared for Phillips Alaska, Inc., Anchorage, November 2001.

——— 1998. *Colville River Delta, Two-Dimensional Surface Water Model, Project Update*. Prepared for ARCO Alaska, Inc., Anchorage, Alaska

Michael Baker Jr., Inc. and Hydroconsult. 2002. *Colville River Flood Frequency Analysis, Update.* Prepared for Phillips Alaska, Inc., Anchorage.

Shannon & Wilson. 1997. *Colville River Two-Dimensional Surface Water Model*. Prepared for Michael Baker Jr., Inc., Anchorage Alaska

Appendix A Cross Section Data — Head of the Delta

Project Note

To: Tony Hoffman, LCMF	Date: July 11, 2002
From: Jeff Baker	Project: Alpine and CD-Satellite Developments
Subject: Colville River Cross Sections	

We would like to have three cross sections of the Colville River near Monument 01 surveyed. The objective is to determine accurate channel geometry to assist with discharge estimates. The existing cross section data was taken in 1995 and I have attached it as a reference. We are requesting that three cross section measurements be made. One is at the same location as the 1995 cross section (x-sec Mon 01), one is upstream of this (x-sec Mon 01U), and one is downstream (x-sec Mon 01D), see attached figure.

Names and coordinates for the cross section end points are:

All coordinates in Alaska State Plane, Zone 4, NAD27

x-sec Mon 01D

x-sec Mon 01D-L	N5,912,928	E383,588
x-sec Mon 01D-R	N5,912,2104	E387,053

x-sec Mon 01

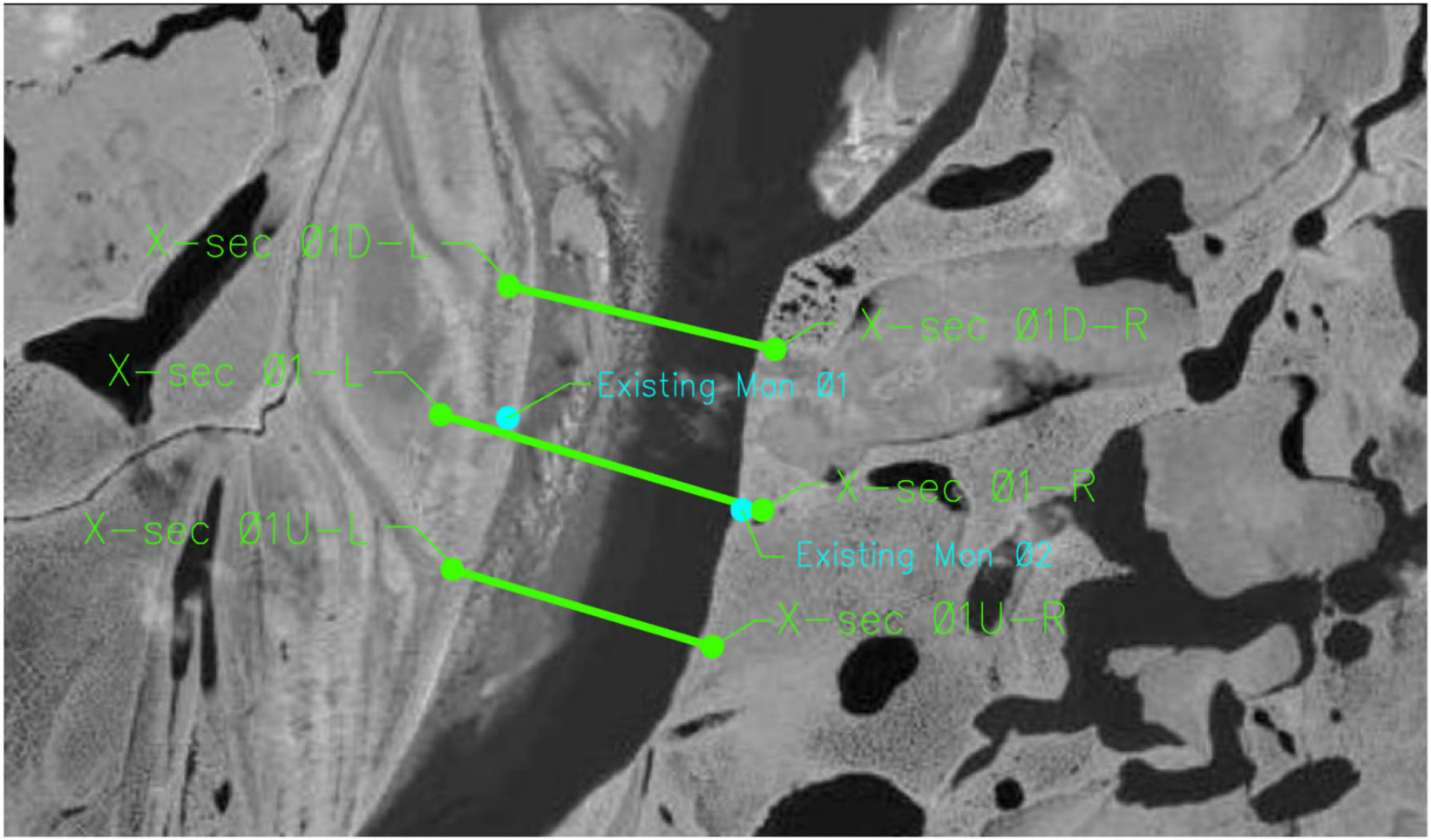
x-sec Mon 01-L	N5,911,257	E382,701
x-sec Mon 01-R	N5,910,016	E386,893

x-sec Mon 01U

x-sec Mon 01U-L	N5,909,245	E382,855
x-sec Mon 01U-R	N5,908,243	E386,240

Cross sections should be run from left bank to right bank (facing downstream). Points shall be taken at a maximum spacing of 50 feet (approximate) but in particular at all grade breaks or changes in soil/vegetation and at edges of water. Note the edge of water and the water surface elevation at the time of the survey. For each point please provide a station offset, ground/channel bottom elevation in BPMSL, northing/easting, and surface description (the same data as the 1995 example). In addition, install monumentation (monument cap with identification) at each cross section end point for future reference.

A spreadsheet file of the data and a description of the data collection procedure will be sufficient for a deliverable.



1000 0 1000 2000

SCALE IN FEET

Baker Michael Baker Jr., Inc.	TITLE: Colville River Monument Ø1 Cross Section Locations		
	FILE NAME: 25009C031	SCALE: As Shown	

Table B-1: Cross Section Data For Cross Section E27.09 (East Channel)

Station (ft)	Elevation (ft)	Northing (ft)	Easting (ft)	Soil Cover Complex
1000	18.4	5911257	382701	Grass covered
1022	18.1	5911251	382722	"
1092	18.6	5911231	382789	"
1133	19.4	5911219	382828	Sand dunes/ willow covered/ sparse grass
1385	23.3	5911148	383070	"
1511	25.2	5911112	383191	"
1708	26.6	5911056	383380	Sand dunes/ sparse willows
1751	30.7	5911044	383421	Top of dunes
1768	30.3	5911039	383438	Sand dunes/ sparse willows
1791	26.1	5911032	383460	"
1812	28.5	5911026	383479	"
1840	24.0	5911018	383507	"
1854	27.2	5911014	383520	"
1871	27.1	5911010	383536	"
1912	19.2	5910998	383576	"
1930	18.6	5910993	383593	"
1937	20.5	5910991	383600	"
1954	14.8	5910986	383616	Edge of dunes
2126	9.9	5910937	383781	Riverbed/sandbar
2429	9.2	5910851	384072	"
2771	7.9	5910754	384400	"
3098	6.3	5910661	384713	"
3321	4.3	5910598	384927	"
3463	2.5	5910558	385063	"
3624	-1.8	5910512	385218	"
3737	-4.2	5910480	385326	"
3842	-6.7	5910450	385427	"
3943	-8.2	5910421	385524	"
4007	-9.7	5910403	385585	"
4074	-10.7	5910384	385649	"
4145	-13.1	5910364	385717	"
4227	-16.0	5910341	385796	"
4318	-20.0	5910315	385883	"
4392	-23.7	5910294	385954	"
4472	-23.1	5910271	386031	"
4532	-22.7	5910254	386089	"
4591	-20.7	5910238	386145	"
4663	-19.2	5910217	386214	"
4719	-18.2	5910201	386268	"
4775	-15.7	5910185	386322	"
4839	-13.7	5910167	386383	"
4888	-13.2	5910153	386430	"
4929	-12.2	5910142	386469	"
4975	-1.9	5910129	386513	"
5001	6.3	5910121	386538	"
5006	9.2	5910120	386543	"

Table B-1: Cross Section Data For Cross Section E27.09 (East Channel)

Station (ft)	Elevation (ft)	Northing (ft)	Easting (ft)	Soil Cover Complex
5011	14.2	5910118	386548	
5016	17.9	5910117	386553	Low-centered polygons/ grass covered/ sparse willows
5022	19.4	5910115	386558	Top of bank
5030	20.1	5910113	386566	Low-centered polygons/ grass covered/ sparse willows
5061	19.4	5910104	386596	"
5080	17.9	5910099	386614	"
5121	18.1	5910087	386653	"
5140	20.3	5910082	386672	"
5200	18.6	5910065	386729	"
5213	18.8	5910061	386742	"
5238	20.1	5910054	386766	"
5370	19.7	5910017	386892	"
5371	19.6	5910016	386893	"

Notes:

1. Elevations are based on British Petroleum Mean Sea Level (BPMSL) datum, coordinate system AK State Plane Zone 4, NAD 27.
2. Ground profile was obtained using a level, theodolite, and sounding weight. The horizontal coordinates for the ends of the cross section were measured with DGPS.
3. In some previous reports, Cross Section E27.09 has been referred to as Cross Section 6.
4. The cross section was measured on 11 Jun 1995. The water-surface elevation on 30 May 1996 was 8.46 feet.

Colville River Channel Cross-Sections

Cross Section Mon 01 Upstream

Station	Offset	Northing	Easting	Elevation	Description
0+00	0	5909266.6	382894.5	27.2	MON-01-UL
0+49	0	5909252.1	382941.5	24.7	Scattered Grass and 3' Willows
0+66	0	5909247.1	382957.7	24.4	Top of Bank
1+12	0	5909233.6	383001.7	18.3	Tundra Ground Shot
1+64	0	5909218.4	383051.0	12.1	Tundra / Edge of Vegetation
2+17	0	5909202.7	383102.0	8.5	Toe of Bank
2+65	0	5909188.7	383147.4	7.4	Ground Shot / Sandy Beach
3+13	0	5909174.5	383193.4	7.1	Ground Shot / Sandy Beach
3+61	0	5909160.4	383239.2	6.8	Ground Shot / Sandy Beach
4+10	0	5909146.0	383286.1	6.6	Ground Shot / Sandy Beach
4+60	0	5909131.3	383333.7	5.6	Ground Shot / Sandy Beach
5+08	0	5909117.1	383380.0	5.4	Ground Shot / Sandy Beach
5+56	0	5909102.8	383426.2	5.4	Ground Shot / Sandy Beach
6+04	0	5909088.9	383471.4	5.1	Ground Shot / Sandy Beach
6+52	0	5909074.7	383517.5	4.6	Ground Shot / Sandy Beach
6+96	0	5909061.6	383560.1	4.9	Ground Shot / Sandy Beach
7+46	0	5909046.9	383607.8	4.7	Ground Shot / Sandy Beach
7+96	0	5909032.4	383655.0	4.6	Ground Shot / Sandy Beach
8+44	0	5909018.0	383701.5	4.0	Ground Shot / Sandy Beach
8+89	0	5909004.9	383744.2	4.1	Ground Shot / Sandy Beach
9+37	0	5908990.9	383789.7	4.7	Ground Shot / Sandy Beach
9+83	0	5908977.2	383834.3	4.8	Ground Shot / Sandy Beach
10+29	0	5908963.8	383877.6	5.3	Ground Shot / Sandy Beach
10+76	0	5908949.8	383923.1	5.1	Ground Shot / Sandy Beach
11+24	0	5908935.9	383968.3	4.9	Ground Shot / Sandy Beach
11+71	0	5908921.9	384013.8	5.1	Ground Shot / Sandy Beach
12+19	0	5908907.9	384059.2	5.1	Ground Shot / Sandy Beach
12+67	0	5908893.8	384105.1	5.2	Ground Shot / Sandy Beach
13+16	0	5908879.2	384152.3	4.9	Ground Shot / Sandy Beach
13+65	0	5908864.7	384199.3	4.2	Ground Shot / Sandy Beach
14+10	0	5908851.4	384242.4	4.1	Ground Shot / Sandy Beach
14+57	0	5908837.6	384287.3	3.5	Ground Shot / Sandy Beach
15+04	0	5908824.0	384331.4	3.1	Ground Shot / Sandy Beach
15+55	0	5908809.0	384380.4	2.4	Ground Shot / Sandy Beach
16+05	0	5908794.0	384428.8	1.4	Edge of Water
16+43	0	5908782.9	384464.9	0.6	River Bed
16+81	0	5908771.7	384501.3	-0.6	River Bed
16+90	4	5908765.2	384508.6	-0.5	River Bed
17+13	8	5908754.7	384529.2	-1.4	River Bed
17+14	0	5908762.0	384532.7	-1.6	River Bed
17+32	0	5908756.6	384549.5	-2.1	River Bed
17+42	0	5908754.0	384559.0	-2.1	River Bed
17+51	-2	5908752.8	384568.7	-2.9	River Bed
17+56	6	5908743.9	384570.5	-2.4	River Bed
17+73	1	5908744.2	384588.8	-3.7	River Bed
17+78	10	5908733.5	384591.0	-3.3	River Bed
17+89	-1	5908740.9	384604.7	-4.3	River Bed
18+01	3	5908733.1	384615.2	-4.4	River Bed
18+28	6	5908722.6	384639.2	-5.6	River Bed
18+47	11	5908712.1	384656.3	-6.5	River Bed

Colville River Channel Cross-Sections

Cross Section Mon 01 Upstream

Station	Offset	Northing	Easting	Elevation	Description
18+73	-3	5908717.8	384685.1	-7.4	River Bed
18+83	-11	5908722.8	384697.5	-7.2	River Bed
18+93	8	5908701.3	384701.1	-7.6	River Bed
19+19	-3	5908704.5	384729.9	-8.6	River Bed
19+45	14	5908680.2	384749.1	-9.5	River Bed
19+65	-9	5908696.5	384774.6	-10.8	River Bed
19+68	18	5908669.7	384769.7	-11.0	River Bed
19+91	12	5908669.4	384793.8	-10.8	River Bed
20+14	5	5908669.0	384818.0	-11.0	River Bed
20+28	-1	5908670.3	384833.3	-10.7	River Bed
20+40	8	5908658.5	384842.0	-10.6	River Bed
20+66	11	5908647.9	384866.0	-11.5	River Bed
20+81	1	5908653.1	384883.1	-12.2	River Bed
20+89	15	5908637.4	384886.6	-12.2	River Bed
21+12	8	5908637.1	384910.8	-13.6	River Bed
21+38	11	5908626.5	384934.8	-14.9	River Bed
21+58	5	5908626.2	384955.5	-15.1	River Bed
21+78	10	5908615.8	384972.6	-15.4	River Bed
22+04	13	5908605.3	384996.6	-16.5	River Bed
22+24	7	5908605.0	385017.4	-17.6	River Bed
22+43	12	5908594.5	385034.5	-18.3	River Bed
22+63	7	5908594.2	385055.2	-18.3	River Bed
22+89	10	5908583.7	385079.2	-18.4	River Bed
23+15	2	5908583.3	385106.8	-18.5	River Bed
23+48	14	5908562.5	385134.1	-18.4	River Bed
23+77	16	5908551.9	385161.6	-18.4	River Bed
24+03	19	5908541.4	385185.6	-18.3	River Bed
24+27	1	5908551.1	385213.4	-17.7	River Bed
24+59	2	5908540.5	385244.3	-16.5	River Bed
24+88	15	5908519.8	385268.2	-15.7	River Bed
25+14	18	5908509.3	385292.2	-15.2	River Bed
25+40	21	5908498.7	385316.2	-15.0	River Bed
25+70	12	5908498.3	385347.3	-14.9	River Bed
25+93	5	5908497.9	385371.5	-14.5	River Bed
26+20	8	5908487.4	385395.5	-14.3	River Bed
26+52	10	5908476.7	385426.4	-14.5	River Bed
26+82	12	5908466.2	385453.9	-15.1	River Bed
27+11	14	5908455.6	385481.4	-15.9	River Bed
27+37	17	5908445.0	385505.4	-17.0	River Bed
27+70	18	5908434.4	385536.3	-18.5	River Bed
27+93	11	5908434.0	385560.5	-19.3	River Bed
28+22	13	5908423.5	385587.9	-20.4	River Bed
28+52	15	5908412.9	385615.4	-22.4	River Bed
28+78	18	5908402.3	385639.4	-23.2	River Bed
29+04	21	5908391.8	385663.5	-23.2	River Bed
29+34	12	5908391.3	385694.5	-23.4	River Bed
29+66	13	5908380.7	385725.5	-23.0	River Bed
29+99	14	5908370.1	385756.4	-22.8	River Bed
30+35	14	5908359.4	385790.8	-19.2	River Bed
30+68	16	5908348.8	385821.7	-18.1	River Bed

Colville River Channel Cross-Sections

Cross Section Mon 01 Upstream

Station	Offset	Northing	Easting	Elevation	Description
30+88	10	5908348.4	385842.4	-17.2	River Bed
31+14	13	5908337.9	385866.4	-16.7	River Bed
31+37	6	5908337.5	385890.6	-15.9	River Bed
31+63	9	5908327.0	385914.6	-13.8	River Bed
31+84	21	5908309.3	385931.7	-7.2	River Bed
31+89	12	5908316.5	385938.6	-5.9	River Bed
32+05	18	5908306.1	385952.3	-2.0	River Bed
32+42	0	5908312.3	385993.0	1.4	Edge of Water
32+50	0	5908310.0	386000.1	1.6	Toe of Bank
32+54	0	5908308.7	386004.6	3.7	Gread Break
32+57	0	5908308.0	386006.8	9.0	Gread Break
32+64	0	5908305.8	386014.0	11.2	Gread Break
32+70	0	5908304.0	386019.7	15.4	Gread Break
32+75	0	5908302.4	386024.8	18.1	Top of Bank
33+25	0	5908287.7	386072.6	18.2	Tundra / Ground Shot
33+75	0	5908273.2	386119.6	19.7	Tundra / Ground Shot
34+24	0	5908258.7	386166.8	19.6	Tundra / Ground Shot
34+75	0	5908243.7	386215.4	19.8	Tundra / Ground Shot
35+08	0	5908234.0	386247.1	20.3	MON-01-UR
Notes:					

1. Elevations are British Petroleum Mean Sea Level Datum, based on the elevation of BM 1at 26.82'.
2. Horizontal Coordinates are Alaska State Plane Zone 4, NAD 27 Datum.
3. Ground profile was surveyed with a conventional total station. River bed depths were obtained with a Garmin GPS Depth Sounder, and spot checked with the total station and rod.
4. Rebar with Aluminum Caps were set at Cross-Section endpoints. Horizontal coordinates of the endpoints are based on found Benchmarks 1 and 2, per GPS survey performed in June 2002.
5. This cross section was surveyed on July 14, 2002. Water surface elevation at time of survey was 1.50' at 5:00 pm.

Colville River Channel Cross-Sections

Cross Section at Mon 01

Station	Offset	Northing	Easting	Elevation	Description
0+00	0	5911257.3	382698.4	18.5	MON-01-L
0+55	0	5911242.1	382751.6	17.6	Sandy Tundra w/ Grass
1+18	-1	5911224.9	382812.3	18.7	Sandy Tundra w/ Grass
1+73	-1	5911209.9	382864.8	18.4	Sandy Tundra w/ Grass
2+29	-1	5911193.7	382918.3	19.6	Sandy Tundra w/ Grass
2+86	-1	5911177.5	382972.6	19.4	Sandy Tundra w/ Grass
3+43	-2	5911162.5	383027.9	20.6	Sandy Tundra w/ Grass
4+00	-1	5911145.4	383082.7	22.7	Sandy Tundra w/ Grass
4+56	-1	5911129.6	383136.0	24.5	Sandy Tundra w/ Grass
5+14	-1	5911112.8	383191.3	24.1	Sandy Tundra w/ Grass
5+69	0	5911096.7	383244.6	23.4	Sandy Tundra w/ Grass
6+27	-1	5911081.3	383299.9	24.1	Sandy Tundra w/ Grass
6+85	0	5911064.0	383355.2	24.4	Sandy Tundra w/ Grass
7+40	0	5911048.3	383408.3	27.1	Sand Dunes w/ Scattered 2' Willows
7+53	0	5911044.6	383420.3	29.1	Sand Dunes w/ Scattered 2' Willows
7+70	0	5911040.1	383437.5	28.2	Sand Dunes w/ Scattered 2' Willows
7+82	0	5911036.7	383448.6	24.7	Sand Dunes w/ Scattered 2' Willows
7+97	0	5911032.0	383463.0	27.5	Sand Dunes w/ Scattered 2' Willows
8+16	1	5911026.2	383481.3	27.3	Sand Dunes w/ Scattered 2' Willows
8+30	0	5911022.6	383494.7	24.4	Sand Dunes w/ Scattered 2' Willows
8+47	0	5911017.7	383511.2	26.5	Sand Dunes w/ Scattered 2' Willows
8+53	-207	5911214.8	383574.5	26.8	BM-01
8+71	0	5911011.3	383534.1	26.2	Sand Dunes w/ Scattered 2' Willows
8+80	0	5911008.9	383542.6	24.4	Sand Dunes w/ Scattered 2' Willows
8+88	0	5911006.8	383549.8	26.1	Top of Bank
8+88	0	5911006.7	383549.9	25.3	Grade Break w/ Scattered Brush
9+08	0	5911000.8	383569.9	20.4	Grade Break w/ Scattered Brush
9+38	0	5910992.4	383598.6	19.2	Grade Break w/ Scattered Brush
9+54	0	5910988.0	383613.4	14.3	Edge of Vegetation
10+34	0	5910965.4	383690.4	9.0	Toe of Bank
10+82	0	5910951.9	383736.3	7.9	Ground Shot / Sandy Beach
11+32	0	5910937.9	383783.9	7.5	Ground Shot / Sandy Beach
11+79	0	5910924.4	383829.7	7.2	Ground Shot / Sandy Beach
12+26	0	5910911.1	383874.9	7.2	Ground Shot / Sandy Beach
12+76	0	5910897.1	383922.3	7.2	Ground Shot / Sandy Beach
13+25	0	5910883.1	383969.9	7.2	Ground Shot / Sandy Beach
13+74	0	5910869.4	384016.4	7.6	Ground Shot / Sandy Beach
14+23	0	5910855.5	384063.9	7.5	Ground Shot / Sandy Beach
14+73	0	5910841.4	384111.5	7.4	Ground Shot / Sandy Beach
15+22	0	5910827.8	384158.0	7.4	Ground Shot / Sandy Beach
15+71	0	5910813.9	384205.2	7.3	Ground Shot / Sandy Beach
16+21	0	5910799.8	384253.1	7.1	Ground Shot / Sandy Beach
16+70	0	5910785.9	384300.2	6.8	Ground Shot / Sandy Beach
17+18	0	5910772.3	384346.5	6.6	Ground Shot / Sandy Beach
17+68	0	5910758.1	384394.6	6.4	Ground Shot / Sandy Beach
18+18	0	5910744.1	384442.4	6.1	Ground Shot / Sandy Beach
18+67	0	5910730.2	384489.7	6.1	Ground Shot / Sandy Beach
19+17	0	5910716.1	384537.5	5.8	Ground Shot / Sandy Beach
19+66	0	5910702.2	384584.6	5.5	Ground Shot / Sandy Beach

Colville River Channel Cross-Sections

Cross Section at Mon 01

Station	Offset	Northing	Easting	Elevation	Description
20+16	0	5910688.3	384631.9	5.2	Ground Shot / Sandy Beach
20+66	0	5910673.9	384680.8	4.9	Ground Shot / Sandy Beach
21+17	0	5910659.8	384728.8	4.6	Ground Shot / Sandy Beach
21+64	0	5910646.3	384774.5	4.4	Ground Shot / Sandy Beach
22+11	0	5910633.0	384819.8	4.2	Ground Shot / Sandy Beach
22+59	0	5910619.7	384865.1	3.5	Ground Shot / Sandy Beach
23+06	0	5910606.4	384910.4	3.0	Ground Shot / Sandy Beach
23+52	0	5910593.2	384955.0	2.7	Ground Shot / Sandy Beach
23+92	0	5910582.1	384992.7	1.8	Edge of Water
24+28	0	5910571.8	385027.8	1.4	River Bed
24+69	0	5910560.2	385067.1	0.6	River Bed
25+02	0	5910551.0	385098.4	-0.1	River Bed
25+34	0	5910542.0	385129.2	0.5	River Bed
25+66	0	5910533.0	385159.8	-0.9	River Bed
25+73	-4	5910534.6	385167.5	-1.2	River Bed
25+76	-5	5910534.5	385171.0	-1.1	River Bed
25+83	-6	5910534.4	385177.9	-1.4	River Bed
25+92	0	5910525.6	385184.9	-2.0	River Bed
26+02	-1	5910524.0	385195.0	-1.8	River Bed
26+22	-7	5910523.7	385215.7	-1.7	River Bed
26+41	-2	5910513.3	385232.8	-2.0	River Bed
26+52	4	5910505.0	385241.0	-2.9	River Bed
26+61	-7	5910512.9	385253.5	-2.8	River Bed
26+81	-2	5910502.5	385270.6	-3.7	River Bed
27+01	-8	5910502.2	385291.3	-4.4	River Bed
27+23	-3	5910491.7	385311.9	-5.0	River Bed
27+34	4	5910481.6	385320.3	-5.3	River Bed
27+40	-8	5910491.5	385329.1	-6.2	River Bed
27+59	-3	5910481.0	385346.3	-6.4	River Bed
27+76	-7	5910480.8	385363.5	-6.8	River Bed
27+95	-2	5910470.4	385380.6	-6.2	River Bed
27+98	5	5910462.5	385381.1	-7.7	River Bed
28+12	-7	5910470.1	385397.9	-7.5	River Bed
28+25	9	5910451.1	385406.0	-8.2	River Bed
28+35	-3	5910459.6	385418.4	-8.3	River Bed
28+58	-9	5910459.2	385442.6	-8.3	River Bed
28+81	-5	5910448.8	385463.2	-8.1	River Bed
28+86	-10	5910452.5	385469.8	-8.4	River Bed
29+01	-10	5910448.5	385483.9	-9.1	River Bed
29+30	-8	5910437.9	385511.3	-9.3	River Bed
29+47	-13	5910437.6	385528.6	-8.7	River Bed
29+51	-17	5910440.3	385533.5	-8.5	River Bed
29+73	-9	5910427.1	385552.6	8.1	River Bed
29+95	-5	5910416.6	385573.2	-8.4	River Bed
30+05	-17	5910425.0	385585.6	-9.3	River Bed
30+19	-12	5910416.2	385597.3	-9.8	River Bed
30+35	-5	5910405.0	385610.7	-9.8	River Bed
30+61	-13	5910405.4	385638.6	-10.0	River Bed
30+87	-9	5910394.9	385662.6	-9.6	River Bed

Colville River Channel Cross-Sections

Cross Section at Mon 01

Station	Offset	Northing	Easting	Elevation	Description
31+04	-14	5910394.6	385679.9	-9.4	River Bed
31+23	-7	5910382.0	385696.1	-11.2	River Bed
31+43	-14	5910383.9	385717.7	-12.7	River Bed
31+63	-20	5910383.6	385738.4	-14.1	River Bed
31+82	-15	5910373.2	385755.5	-14.4	River Bed
32+05	-11	5910362.7	385776.1	-15.5	River Bed
32+22	-15	5910362.4	385793.3	-16.7	River Bed
32+41	-10	5910352.0	385810.5	-18.5	River Bed
32+61	-16	5910351.7	385831.2	-20.5	River Bed
32+80	-10	5910341.3	385848.3	-21.2	River Bed
33+00	-16	5910341.0	385869.0	-22.3	River Bed
33+26	-13	5910330.4	385893.0	-23.5	River Bed
33+43	-17	5910330.2	385910.3	-24.0	River Bed
33+56	-21	5910330.0	385924.1	-24.2	River Bed
33+86	-19	5910319.4	385951.5	-25.4	River Bed
34+25	-19	5910308.6	385989.4	-25.4	River Bed
34+61	-18	5910298.0	386023.7	-24.8	River Bed
34+87	-15	5910287.4	386047.7	-24.6	River Bed
35+04	-20	5910287.2	386065.0	-24.4	River Bed
35+24	-25	5910286.9	386085.7	-23.9	River Bed
35+44	-31	5910286.5	386106.4	-23.8	River Bed
35+60	-35	5910286.3	386123.7	-23.1	River Bed
35+83	-42	5910285.9	386147.9	-22.3	River Bed
36+03	-37	5910275.5	386165.0	-22.3	River Bed
36+29	-33	5910265.0	386189.0	-20.9	River Bed
36+42	-37	5910264.8	386202.8	-20.6	River Bed
36+61	-32	5910254.3	386219.9	-19.9	River Bed
36+75	-36	5910254.1	386233.7	-19.5	River Bed
36+94	-30	5910243.7	386250.8	-19.0	River Bed
37+11	-35	5910243.4	386268.1	-18.7	River Bed
37+33	-31	5910233.0	386288.6	-17.8	River Bed
37+56	-27	5910222.5	386309.2	-16.5	River Bed
37+79	-22	5910212.0	386329.8	-16.5	River Bed
37+95	-27	5910211.7	386347.0	-15.8	River Bed
38+13	-42	5910221.6	386367.9	-15.2	River Bed
38+49	-42	5910210.9	386402.3	-14.8	River Bed
38+65	-36	5910200.5	386415.9	-14.8	River Bed
38+87	-31	5910190.1	386436.5	-13.6	River Bed
39+07	-37	5910189.8	386457.2	-13.3	River Bed
39+30	-33	5910179.3	386477.7	-12.3	River Bed
39+49	-28	5910168.9	386494.9	-11.7	River Bed
39+69	-22	5910158.4	386512.0	-11.3	River Bed
39+78	-25	5910158.5	386521.8	-8.8	River Bed
39+85	-16	5910148.1	386525.6	-5.4	River Bed
39+99	-31	5910158.0	386543.0	-1.7	River Bed
40+02	0	5910127.6	386537.3	1.6	Edge of Water
40+10	0	5910125.3	386545.2	2.3	Toe of Bank
40+17	0	5910123.5	386551.7	4.8	Grade Break
40+24	0	5910121.4	386558.6	9.9	Grade Break

Colville River Channel Cross-Sections

Cross Section at Mon 01

Station	Offset	Northing	Easting	Elevation	Description
40+33	0	5910118.9	386567.1	9.7	Grade Break
40+35	0	5910118.1	386569.7	18.5	Top of Bank
40+84	0	5910104.4	386616.3	17.2	Tundra, Dense 3' Willow Brush
41+19	78	5910020.0	386627.7	20.5	BM-02
41+32	0	5910090.9	386662.0	19.1	Tundra, Dense 3' Willow Brush
41+80	0	5910077.3	386708.4	18.5	Tundra, Dense 3' Willow Brush
42+26	0	5910064.4	386752.0	19.7	Tundra, Dense 3' Willow Brush
42+73	0	5910050.8	386798.0	18.9	Tundra, Dense 3' Willow Brush
43+19	0	5910038.1	386841.3	18.7	Tundra, Dense 3' Willow Brush
43+69	0	5910023.9	386889.7	19.9	MON-01-R
Notes:					

1. Elevations are British Petroleum Mean Sea Level Datum, based on the elevation of BM 1at 26.82'.
2. Horizontal Coordinates are Alaska State Plane Zone 4, NAD 27 Datum.
3. Ground profile was surveyed with a conventional total station. River bed depths were obtained with a Garmin GPS Depth Sounder, and spot checked with the total station and rod.
4. Rebar with Aluminum Caps were set at Cross-Section endpoints. Horizontal coordinates of the endpoints are based on found Benchmarks 1 and 2, per GPS survey performed in June 2002.
5. This cross section was surveyed on July 15, 2002. Water surface elevation at time of survey was 1.60' at 4:40 pm.

Colville River Channel Cross-Sections

Cross Section Mon 01 Downstream

Station	Offset	Northing	Easting	Elevation	Description
0+00	0	5912947.6	383708.9	29.3	MON-01-DL
0+14	0	5912944.2	383722.7	26.3	Grade Break
0+26	0	5912941.3	383733.9	26.9	Grade Break
0+73	0	5912929.6	383779.2	25.7	Grade Break
0+92	0	5912924.7	383798.4	26.5	Grade Break
1+09	0	5912920.6	383814.1	23.4	Grade Break
1+55	0	5912908.9	383859.4	24.9	Grade Break
1+94	0	5912899.3	383896.8	24.4	Top of Bank
2+40	0	5912887.7	383941.2	17.9	Grade Break
2+89	0	5912875.4	383988.9	13.9	Grade Break
3+29	0	5912865.4	384027.7	12.5	Tundra / Edge of Vegetation
3+80	0	5912852.7	384077.3	10.7	Toe of Bank
4+32	0	5912839.9	384127.0	9.6	Ground Shot / Sandy Beach
4+85	0	5912826.6	384178.4	8.8	Ground Shot / Sandy Beach
5+36	0	5912813.9	384227.9	8.0	Ground Shot / Sandy Beach
5+87	0	5912801.2	384277.0	7.8	Ground Shot / Sandy Beach
6+38	0	5912788.5	384326.4	7.1	Ground Shot / Sandy Beach
6+87	0	5912776.2	384374.2	6.9	Ground Shot / Sandy Beach
7+38	0	5912763.6	384423.1	7.1	Ground Shot / Sandy Beach
7+87	0	5912751.1	384471.2	6.7	Ground Shot / Sandy Beach
8+35	0	5912739.2	384517.5	6.7	Ground Shot / Sandy Beach
8+84	0	5912727.0	384564.9	6.8	Ground Shot / Sandy Beach
9+33	0	5912714.8	384612.3	7.1	Ground Shot / Sandy Beach
9+84	0	5912701.9	384662.1	7.1	Ground Shot / Sandy Beach
10+36	0	5912689.1	384711.9	7.0	Ground Shot / Sandy Beach
10+86	0	5912676.6	384760.5	7.0	Ground Shot / Sandy Beach
11+36	0	5912664.0	384809.3	7.0	Ground Shot / Sandy Beach
11+88	0	5912651.1	384859.5	6.8	Ground Shot / Sandy Beach
12+39	0	5912638.3	384909.1	6.5	Ground Shot / Sandy Beach
12+90	0	5912625.6	384958.1	6.4	Ground Shot / Sandy Beach
13+41	0	5912612.8	385007.8	5.9	Ground Shot / Sandy Beach
13+90	0	5912600.6	385055.1	5.5	Ground Shot / Sandy Beach
14+38	0	5912588.7	385101.5	5.2	Ground Shot / Sandy Beach
14+87	0	5912576.6	385148.5	4.4	Ground Shot / Sandy Beach
15+37	0	5912564.0	385197.2	4.2	Ground Shot / Sandy Beach
15+86	0	5912551.7	385244.9	3.9	Ground Shot / Sandy Beach
16+32	0	5912540.3	385289.1	3.3	Ground Shot / Sandy Beach
16+81	0	5912528.2	385336.2	2.7	Ground Shot / Sandy Beach
17+24	0	5912517.3	385378.4	2.4	Ground Shot / Sandy Beach
17+56	0	5912509.3	385409.3	1.6	Edge of Water
17+94	0	5912499.8	385446.5	1.2	River Bed
18+32	0	5912490.3	385483.0	0.7	River Bed
18+69	0	5912481.1	385518.9	-0.2	River Bed
19+04	0	5912472.5	385552.3	-0.7	River Bed
19+35	0	5912464.8	385582.2	-1.1	River Bed
19+47	0	5912461.9	385593.9	-1.6	River Bed
19+62	0	5912457.8	385609.3	-2.1	River Bed
19+75	16	5912439.4	385617.6	-2.0	River Bed
19+95	11	5912439.0	385638.3	-2.3	River Bed
20+18	-1	5912445.2	385663.8	-3.7	River Bed
20+41	10	5912428.2	385683.0	-3.7	River Bed
20+67	15	5912417.7	385707.0	-5.3	River Bed

Colville River Channel Cross-Sections

Cross Section Mon 01 Downstream

Station	Offset	Northing	Easting	Elevation	Description
20+78	-2	5912430.8	385721.3	-5.8	River Bed
20+91	9	5912417.3	385731.1	-5.7	River Bed
21+11	4	5912417.0	385751.9	-6.6	River Bed
21+37	8	5912406.5	385775.9	-6.7	River Bed
21+41	-1	5912413.9	385782.4	-6.8	River Bed
21+59	13	5912396.0	385796.4	-8.0	River Bed
21+82	18	5912385.5	385817.0	-8.7	River Bed
22+05	13	5912385.1	385841.1	-7.8	River Bed
22+29	7	5912384.8	385865.3	-9.0	River Bed
22+53	-1	5912386.7	385890.7	-10.5	River Bed
22+58	10	5912374.2	385892.7	-10.2	River Bed
22+78	5	5912373.9	385913.4	-10.3	River Bed
22+96	-3	5912377.8	385932.8	-11.1	River Bed
23+04	10	5912363.3	385937.5	-11.4	River Bed
23+26	15	5912352.9	385958.0	-12.1	River Bed
23+47	10	5912352.6	385978.7	-11.4	River Bed
23+54	1	5912359.1	385988.0	-11.7	River Bed
23+72	14	5912342.0	386002.7	-12.7	River Bed
23+93	9	5912341.7	386023.4	-12.0	River Bed
24+18	13	5912331.2	386047.4	-12.3	River Bed
24+28	-3	5912345.0	386060.9	-12.9	River Bed
24+42	8	5912330.8	386071.6	-13.3	River Bed
24+64	13	5912320.3	386092.2	-13.7	River Bed
24+87	18	5912309.9	386112.7	-14.2	River Bed
25+10	12	5912309.5	386136.9	-15.0	River Bed
25+31	7	5912309.2	386157.6	-15.1	River Bed
25+54	1	5912308.8	386181.7	-15.8	River Bed
25+80	6	5912298.3	386205.7	-16.5	River Bed
25+97	2	5912298.0	386223.0	-16.9	River Bed
26+23	6	5912287.5	386247.0	-17.9	River Bed
26+45	11	5912277.0	386267.6	-18.3	River Bed
26+65	6	5912276.7	386288.3	-18.4	River Bed
26+91	10	5912266.2	386312.3	-19.5	River Bed
27+15	5	5912265.8	386336.4	-19.8	River Bed
27+35	0	5912265.5	386357.1	-20.0	River Bed
27+58	-6	5912265.2	386381.3	-20.0	River Bed
27+78	-11	5912264.8	386402.0	-20.8	River Bed
28+04	-7	5912254.3	386426.0	-21.5	River Bed
28+33	-3	5912243.7	386453.5	-22.2	River Bed
28+54	-8	5912243.4	386474.2	-22.8	River Bed
28+76	-3	5912233.0	386494.7	-22.9	River Bed
28+99	2	5912222.5	386515.3	-22.9	River Bed
29+25	-5	5912222.1	386542.9	-23.1	River Bed
29+60	8	5912201.3	386573.7	-23.5	River Bed
29+90	11	5912190.7	386601.1	-22.7	River Bed
30+32	11	5912179.9	386642.4	-22.3	River Bed
30+59	5	5912179.5	386670.0	-22.3	River Bed
30+82	10	5912169.0	386690.5	-21.4	River Bed
30+98	6	5912168.8	386707.8	-21.0	River Bed
31+31	8	5912158.1	386738.7	-19.0	River Bed
31+54	3	5912157.8	386762.9	-18.1	River Bed
31+77	8	5912147.3	386783.4	-17.1	River Bed

Colville River Channel Cross-Sections

Cross Section Mon 01 Downstream

Station	Offset	Northing	Easting	Elevation	Description
31+86	16	5912137.0	386790.2	-16.4	River Bed
31+99	23	5912126.7	386800.4	-15.6	River Bed
32+02	23	5912126.6	386803.8	-15.0	River Bed
32+23	-10	5912152.9	386832.3	-11.2	River Bed
32+33	5	5912136.3	386838.5	-9.0	River Bed
32+43	0	5912138.3	386848.9	1.7	Edge of Water
32+47	-1	5912138.5	386853.3	2.3	Toe of Bank
32+52	0	5912135.9	386858.1	6.2	Grade Break
32+57	0	5912134.7	386862.7	11.0	Grade Break
32+63	0	5912133.2	386868.9	13.8	Grade Break
32+65	0	5912132.8	386870.4	16.6	Top of Bank
33+10	0	5912121.6	386913.7	16.7	Tundra, Dense 3' Willow Brush
33+58	0	5912109.6	386960.3	17.1	Tundra, Dense 3' Willow Brush
34+06	0	5912097.4	387007.5	17.6	Tundra, Dense 3' Willow Brush
34+37	0	5912089.9	387037.1	17.8	MON-01-DR
Notes:					

1. Elevations are British Petroleum Mean Sea Level Datum, based on the elevation of BM 1at 26.82'.
2. Horizontal Coordinates are Alaska State Plane Zone 4, NAD 27 Datum.
3. Ground profile was surveyed with a conventional total station. River bed depths were obtained with a Garmin GPS Depth Sounder, and spot checked with the total station and rod.
4. Rebar with Aluminum Caps were set at Cross-Section endpoints. Horizontal coordinates of the endpoints are based on found Benchmarks 1 and 2, per GPS survey performed in June 2002.
5. This cross section was surveyed on July 15, 2002. Water surface elevation at time of survey was 1.60' at 4:40 pm.

Appendix B Channel Ice Observations

Figure B- 1 Low Water Channel Ice Survey, May 23, 2002.

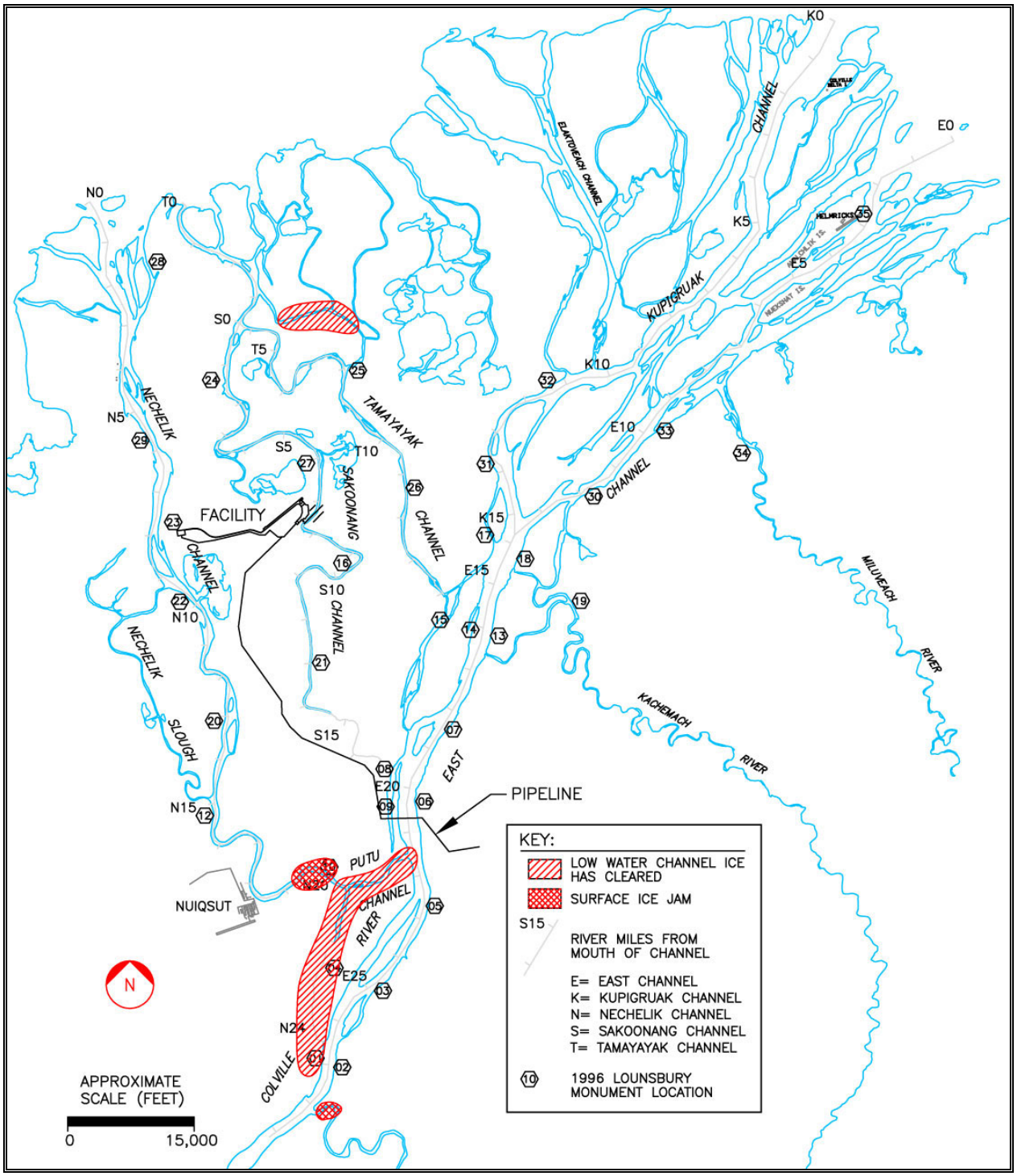


Figure B- 2 Low Water Channel Ice Survey, May 24, 2002.

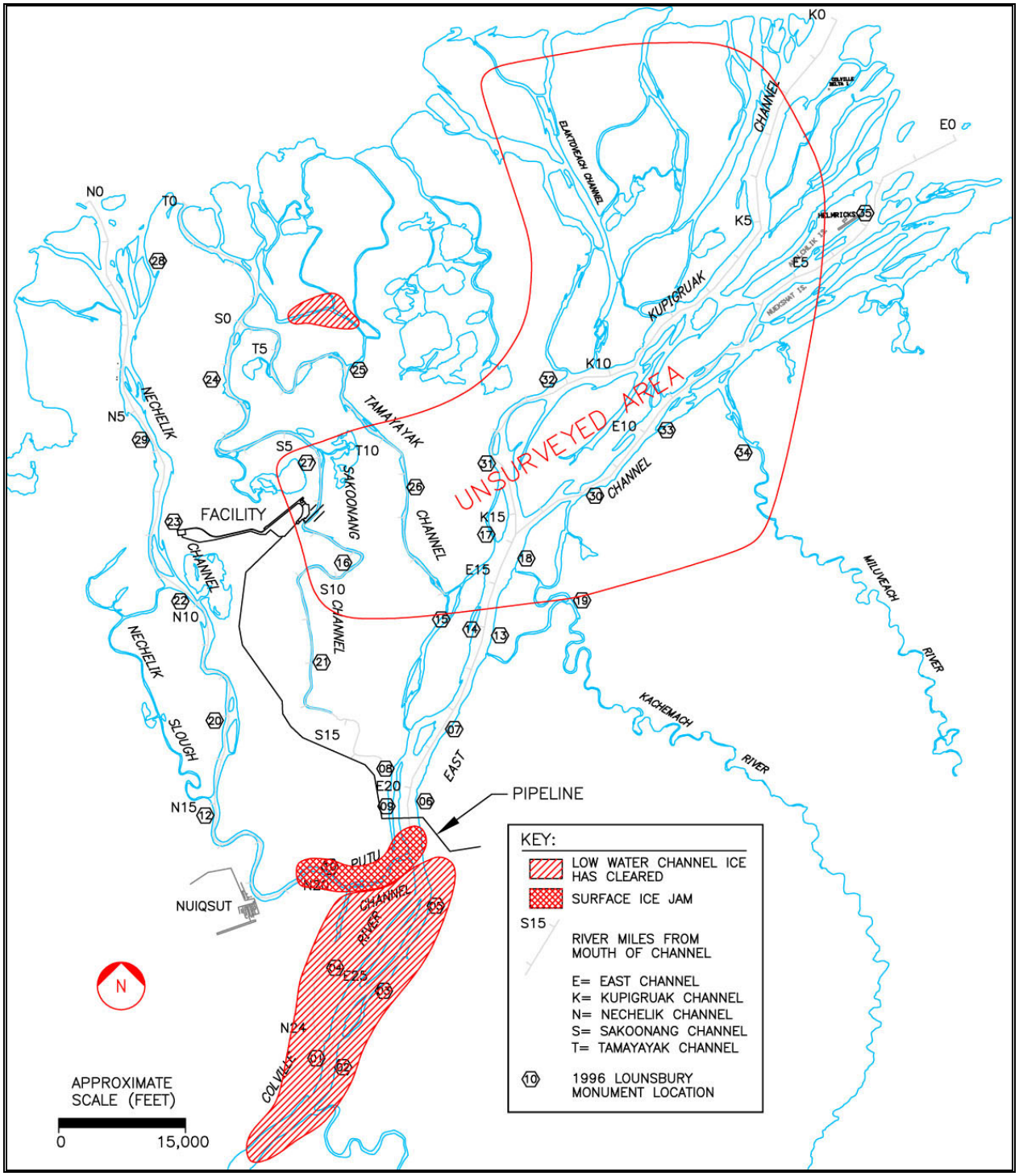


Figure B- 3 Low Water Channel Ice Survey, May 25, 2002.

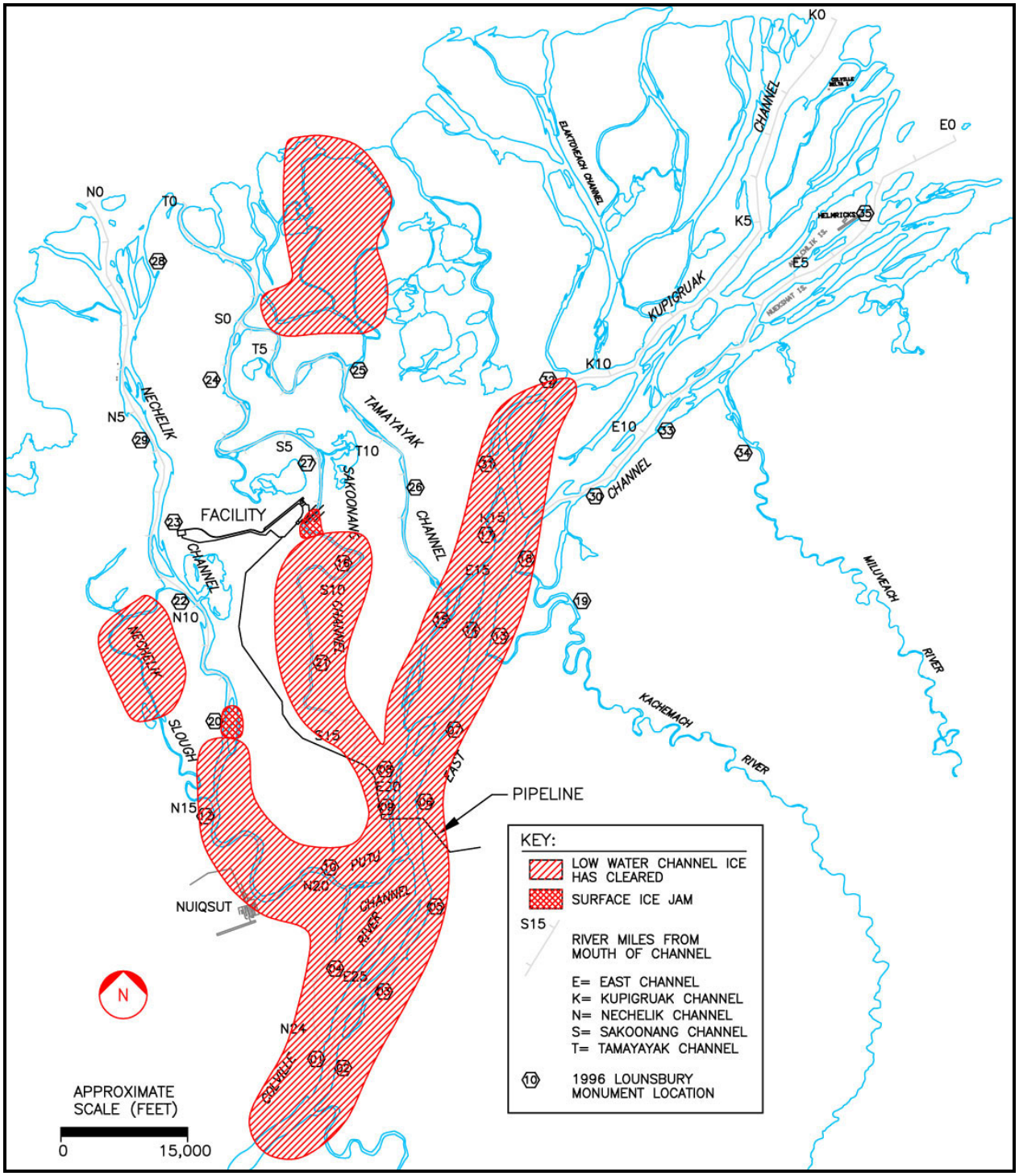
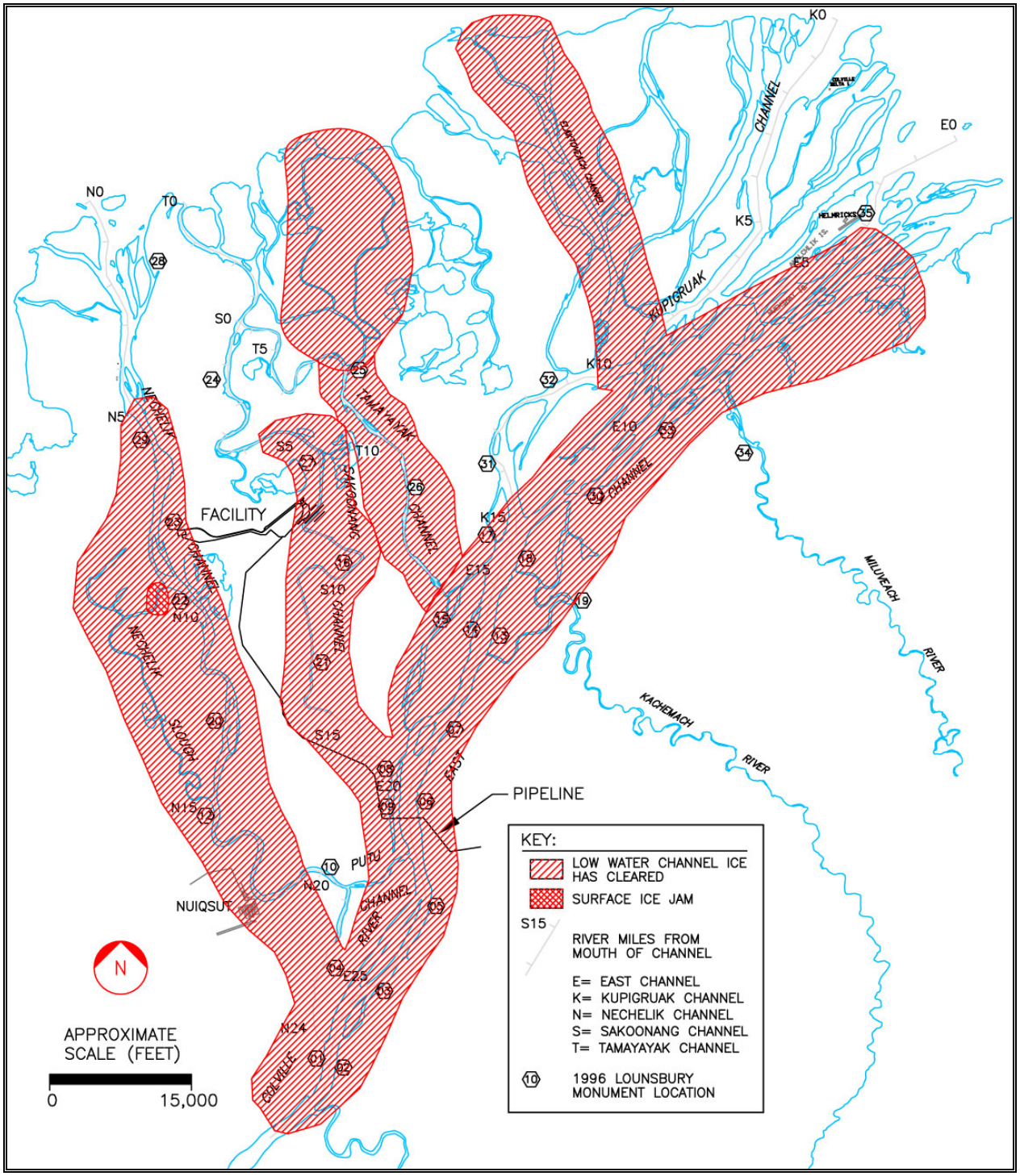


Figure B- 4 Low Water Channel Ice Survey, May 26, 2002.



CD-South 2002 Spring Breakup and Hydrologic Assessment
November 2002

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