Alpine Facilities

2003 Spring Breakup and Hydrologic Assessment

Submitted to

ConocoPhillips

By

Baker

Engineering & Energy

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907-273-1600

September 2003

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1.0 Introduction – 2003 Alpine Breakup Overview

The 2003 breakup in the Alpine Development (Alpine) vicinity was characterized by cooler than normal temperatures that slowed regional melting and resulted in a protracted breakup process. The peak water surface elevation (peak stage) at Alpine, as measured at permanent staff gages #3 and #4, occurred in the afternoon or evening of 7 June or early on the morning of 8 June. As a comparison, the 2002 peak stage at Alpine occurred on 26 May, nearly 2 weeks earlier than in 2003. Additionally, the stage reached by breakup floodwaters at Alpine in 2003 was relatively low. The rise in water levels in the vicinity of the Alpine infield area was such that only one of the two CD-2 access road bridges and only two of the 26 CD-2 access road culverts saw measurable flow. Floodwaters did not rise high enough to reach permanent staff gages #6, #7, #8, or #9.

Spring recharge to Alpine drinking water lakes L9312 and L9313 was sufficient for the water surface elevations of the two lakes to reach bankfull stage in spite of the relatively low stage reached by breakup floodwaters. Floodwater recharge to Lake L9313 began on 8 June, and lasted approximately four days. Over that period, increases of the lake's water surface elevation of over one foot were measured at permanent staff gage #10. Breakup floodwaters did not rise high enough to reach Lake L9312, however, it was apparent from readings at permanent staff gage #9 that the lake was sufficiently recharged by local melt within its drainage basin for the lake's water surface elevation to reach bankfull stage.

A double peak stage was recorded in the Colville River near permanent survey Monument 01 (a short distance downstream from the confluence with the Itkillik River). The initial peak occurred at Monument 01 on either the afternoon or evening on 5 June or in the morning of 6 June, after which floodwaters began to recede. On 8 June, the stage at Monument 01 began rising again. The slow but steady rise continued until 11 June when the occurrence of the secondary peak was noted.

No significant erosion due to breakup flows was observed anywhere along Alpine's gravel pads and roads. In areas where inundation occurred, some minor settlement of fine-grained material was noted, however, no slumping or side slope deterioration was noted.

This breakup report represents the fifth of a 5-year Alpine breakup monitoring program that was stipulated under various state and federal permits.

2.0 Permit Stipulations

This report, summarizing hydrologic observations and measurements made during the 2003 spring breakup of the Colville River Delta in and around Alpine, was prepared in part to satisfy permit stipulations associated with the construction and operation of the Alpine facilities. Following are summaries of the relevant permit stipulations and, in parentheses, the applicable report section that addresses each.

U.S Army Corps of Engineers, Department of the Army Permit 2-960874, Colville River 18 (USACE 2-960874)

Page 2-A Item 6. *Aerial and ground photography shall be taken within 24 hours of peak flood discharge during spring breakup and any high water event that results in water passing through the infield facilities (subject to weather conditions and safety requirements)* (Section 3.0). *Monitoring shall continue weekly after the high water event until water is no longer ponded upstream of the road. The monitoring shall be done for the first five years after completion of construction and for high water events greater than the 10-year predicted floodwater surface elevation event. A monitoring plan shall be submitted to the District Engineer prior to completion of gravel placement for the infield facilities. The annual report shall contain: data and analysis related to the peak flow during the event* (Section 3.0)*; the relationship of the observed peak flow with the predictive model* (Section 4.0)*; water velocity along road and pad side slope corners* (Section 3.0)*; velocity and discharge rates through culvert and bridge openings* (Section 3.0)*; drawings showing the locations and extent of any erosion, scour, or gravel deposition greater than 20 cubic yards per 100 linear feet, a cross-section of each erosion area superimposed on the as-built cross-section of the area of concern, and an estimate of material eroded from each affected area* (Section 5.0).

Page 2-B, Item 7. *Remedial action plans (to include additional or modification of drainage structures) shall be developed, submitted for approval, and implemented when water surface elevation is equal to or greater than 0.5-foot* *higher than the downstream side water surface elevation one week after the peak discharge has occurred* (Section 3.0). *Remedial action measures (recovery, placement of additional erosion protection material, tundra restoration resulting from scour holes, revegetation, etc) shall also be developed when erosion of more than 20 cubic yards of gravel material occurs in any 100 linear feet of infield gravel fill placement. Any road washout area that occurs when water surface elevations are below the predicted 50-year flood event shall be further armored to withstand the predicted 100-year flood event water surface elevation* (Section 5.0).

State of Alaska, Office of Management and Budget Final Consistency Determination, State I.D. No. AK9703-03OG (AK9703-03OG)

<u>*Page 7, Item 6.*</u> *A photographic record shall be established of the flow around and through the gravel fill on the Colville River Delta during the first occurrence of a spring breakup that results in a flow between Q2 and Q10, and the first occurrence of a spring breakup that results in a flow greater than Q10. A report of the photographic records is due to DEC before December 31 of the year the documented flow event occurs* (Section 3.0).

<u>*Page 9, Item 24.*</u> *Each culvert and the culvert battery shall be monitored following installation. A report summarizing observations made (e.g., scour, erosion, water surface elevation differences and identifying remedial work (if needed) proposed shall be submitted to the DFG annually by July 1 following spring breakup. Note: If the monitoring indicates little or no change, the reporting requirements may be changed by permit amendment* (Section 3.0).

State of Alaska, Department of Fish and Game Fish Habitat Permit FG99-III-0051 (FG99-III-0051)

<u>*Page 2, Item 3.*</u> *ARCO Alaska Inc. shall monitor the water surface elevation of Lake L93-12 (U6.1) Water surface elevations shall be taken immediately after ice breakup and at least once a week for three weeks following breakup* (Sections

3.0 and 6.0). *Water surface elevations also shall be taken once each month until freeze-up.*

State of Alaska, Department of Fish and Game Fish Habitat Permit FG97-III-0190-Amendment #1 (FG97-III-0190-Amendment #1)

<u>*Page 2, Item 1.*</u> *ARCO Alaska Inc. shall monitor the water surface elevation of Lake L93-13 (T6.1). Water surface elevations shall be taken immediately after ice breakup and at least once a week for three weeks following breakup* (Sections 3.0 and 6.0). *Water surface elevations also shall be taken once each month until freeze-up.*

3.0 Breakup Summary

3.1 Water Surface Elevations and Observations

All elevations presented in this report are in feet and are based on the British Petroleum Mean Sea Level (BPMSL) datum unless otherwise noted.

3.1.1 2003 Peak Water Surface Elevations in the Alpine Vicinity

Observations of the permanent staff gages in the Alpine vicinity began on 29 May 2003. Water surface elevation measurements began when rising water levels were noted at the gages on 5 June. Measurements continued through 14 June at which point breakup flows had receded substantially. After 14 June, Alpine Environmental personnel made weekly readings at permanent staff gages located at drinking water lakes L9312 and L9313 for a five-week period. Staff gage locations are shown on Figures 3-1 and 3-2.

Peak water surface elevations in the Alpine vicinity at permanent staff gages #3 and #4 occurred in either the afternoon or evening of 7 June or the early morning of 8 June when measurements of 6.31 and 6.19 feet, respectively, were recorded. The peak water surface elevation at permanent staff gage #1 (Sakoonang Channel) occurred sometime in either the evening of 8 June or the early morning of 9 June when a measurement of 6.07 feet was recorded. The peak water surface elevation at permanent staff gage #10 (drinking water lake L9313) occurred on 9 June when a measurement of 7.12 feet was recorded. Floodwaters did not rise high enough to register on permanent staff gages #6, #7, #8, or #9. Permanent staff gage #9 (drinking water lake L9312), however, experienced a peak water surface elevation of 8.01 feet, occurring sometime between the afternoon of 8 June and the afternoon of 10 June, as a result of local melt within the lake's drainage basin. Water surface elevation and observation records for the Alpine permanent staff gages are presented in Tables 3-1 through 3-5. (No tables are provided for permanent staff gages #6, #7, and #8, which were not reached by floodwaters; permanent staff gages #2 and #5 no longer exist.)

Measurements indicate that during the 2003 breakup, the maximum difference between water surface elevations on either side of the CD-2 access road was 0.12 feet between permanent staff gages #3 and #4. This maximum difference was between recorded high water marks at the gages and, therefore, coincided with the occurrence of the peak water surface elevation. Differences in water surface elevations between the upstream and downstream sides of the road rapidly decreased as breakup floodwaters receded.

Breakup flooding conditions in the Alpine vicinity on 7 June (approximately 12 hours before the peak stage at permanent staff gages #3 and #4), and on 8 and 9 June (approximately 12 and 24 hours after the peak stage at permanent staff gages #3 and #4) are shown in Photos 3-1 through 3-6.

3.1.2 2003 Peak Water Surface Elevations in the Colville River Delta

A number of temporary staff gages were established prior to the 2003 breakup in order to monitor water surface elevations in the Colville River Delta. Temporary staff gage placement was concentrated in two general areas – in the vicinity of permanent survey Monument 01 at the head of the delta (the downstream-most point where the Colville River flows in a single channel, located a short distance downstream of the Itkillik River confluence), and along the northern half of the Nigliq Channel near permanent survey Monuments 22, 23, and 28 (see Figure 3-1).

Water was first noted flowing in the channel in the Monument 01 reach on 27 May, but did not rise high enough to reach any of the gages in that vicinity until 1 June. Temporary staff gage measurements in the delta began on 31 May when floodwaters first reached the gages near Monument 23 and continued until 13 June when the last of the temporary gages in the Monument 01 vicinity were removed. Water surface elevation and observation records for temporary staff gages in the Colville River Delta are presented in Tables 3-6 through 3-11.

A double peak stage was observed during the 2003 spring breakup at the Monument 01 monitoring site. The initial peak stage occurred in either the afternoon or evening of 5 June or in the morning of 6 June at a water surface elevation of 13.76 feet. A short period of receding water levels followed the initial peak. On 8 June, a slow steady rise in the water level was noted, and on 11 June a secondary peak water surface was recorded at an elevation of 13.30 feet. The floodwaters then receded a second time and by 13 June the stage had dropped to 11.13 feet. It should be noted that the timing and magnitude of the secondary peak stage is estimated. Strong winds that occurred between 10 and 12 June caused waves that prevented the recording of high water marks on the gages.

The initial peak stage was ice-affected, that is, water was flowing over and around ribbon ice (intact, partially floating, low water channel ice), resulting in a higher stage than would have occurred for the same magnitude of flow during ice-free conditions. Channel ice had cleared by the time the secondary peak occurred.

The peak stage at the Monument 22 and 23 monitoring sites occurred in either the afternoon or evening on 7 June or in the morning on 8 June at elevations of 7.02 and 6.07 feet, respectively. Definitive high water marks were not available at the Monument 22 site due to high winds; the peak stage at that location has therefore been estimated. At the Monument 28 monitoring site, the peak stage occurred in either the afternoon or evening of 8 June or in the morning on 9 June, at an elevation of 3.57 feet.

The double peak stage observed at Monument 01 was not clearly duplicated at the monitoring sites located along the northern half of the Nigliq Channel. At the Monument 22 monitoring site, a subtle secondary peak was recorded on 11 June. At the Monument 23 site, located approximately 10,000 feet downstream and to the north of Monument 22, there was a flat (static) segment on the hydrograph during this same period. At the Monument 28 monitoring site, located near the mouth of the Nigliq Channel and well to the north of Monuments 22 and 23, steadily dropping water levels were observed after the peak stage occurred on 8 or 9 June. There are a number of factors that either alone or in combination may have contributed to the lack of a clearly defined secondary peak being observed at the Nigliq Channel monitoring sites. These factors include natural attenuation of flood peaks as flows spread throughout the distributary channel system of the delta; changes in the proportions of flow carried by individual distributary channels as river stage changes and as bottomfast low water channel ice lifts and clears from channels; and high winds experienced during the time period of the secondary peak that affected the recording of good high water marks on gages.

3.2 2003 Peak Discharge in the Colville River Delta

Discharge in the Colville River during the 2003 spring breakup was estimated using Normal Depth computations. All discharge estimates are for the reach of river near Monument 01. Water surface elevation and slope data were obtained from the measurements made at Monument 01, and temporary benchmarks Monument 01 Upstream (TBM 01U) and Monument 01 Downstream (TBM 01D). Cross-section geometry was based on three cross-sections surveyed by Kuukpik/LCMF, Inc. in 2002 (Kuukpik/LCMF, Inc., 2002). The cross-sections are presented in 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 Schneider, 1989).

The initial (ice-affected) peak stage at Monument 01 occurred on either the afternoon or evening of 5 June or the morning of 6 June. The discharge at the time of the initial peak stage is estimated to have been approximately 255,000 cubic feet per second (cfs). The discharge associated with the initial peak stage is estimated to have a recurrence interval of between two and three years (the 2-year flood has an estimated magnitude of 240,000 cfs), based on the most recent Colville River Delta flood frequency analysis (Michael Baker Jr., Inc. and Hydroconsult EN3 Services, Ltd., 2002). In other words, the discharge associated with the 2003 initial peak stage has a 33-50% chance of being equaled or exceeded in any given year.

Based on aerial observations as far south as Umiat, the initial peak stage and associated discharge can likely be attributed to meltwaters from tributaries of the Colville River downstream of Umiat, including the Anaktuvuk, Chandler, Kogosukruk, and Kikiakrorak Rivers. These tributaries were flowing prior to any significant melt on the Colville River upstream of Umiat.

The 2003 spring breakup peak discharge at the head of the Colville River Delta is estimated to have been approximately 350,000 cfs, and to have occurred on 11 June, coincident with the secondary peak stage. The channel near Monument 01 was clear of ice at the time. The 2003 peak discharge is estimated to have a recurrence interval of between four and five years (the 5-year flood has an estimated magnitude of 370,000 cfs), based on the most recent flood frequency analysis (Michael Baker Jr., Inc. and Hydroconsult EN3 Services, Ltd., 2002). In other words, the 2003 spring breakup peak discharge has a 20-25% chance of being equaled or exceeded in any given year. A hydrograph of water surface elevation and discharge versus time is presented on Figure 3-3. A summary of breakup data obtained at the head of the Colville River Delta between 1962 and 2003 is presented on Table 3-12.

The secondary peak stage and associated peak discharge are attributed to meltwaters from the Colville River and its tributaries upstream of Umiat.

3.3 Alpine Facility Bridge and Culvert Observations

3.3.1 Bridges

Water levels in the vicinity of the Alpine infield were such that flow was observed through only one of the two bridges – the 452-foot bridge – on the CD-2 access road. As previously discussed, the peak water surface elevation in the Alpine vicinity at permanent staff gages #3 and #4 occurred sometime during either the afternoon or evening of 7 June or the morning of 8 June. A bridge discharge measurement was made on 8 June. The measured flow was approximately 420 cfs, with an average adjusted velocity of 0.9 feet per second (fps). The average adjusted velocity represents the average velocity normal to the bridge section. The maximum recorded water velocity at the bridge (not adjusted for flow direction) was 1.6 fps. Bridge discharge measurement notes are provided in Appendix B.

The peak flow through the 452-foot bridge is assumed to have occurred near the time of the peak stage at permanent staff gages #3 and #4, and is estimated to have been 730 cfs (see Table 3-13). At the time the discharge measurement was made, the ice in the vicinity of the bridge opening had cleared. Snow was observed upstream of the left abutment but was not affecting flow. Based on the water surface elevations and the timing of the discharge measurement, the conditions observed at that time can be considered to be reasonably representative of flow conditions at the bridge at the time of the estimated peak discharge.

3.3.2 Culverts

During the 2003 breakup, water was observed flowing at a measurable rate in only two of the 26 culverts – #23 and #24 – installed along the CD-2 access road. With the exception of culvert #22, which carried a very small amount of flow on 8 June, floodwaters did not rise high enough for flow to be carried by the remaining access road culverts. On the afternoon of 8 June, discharge measurements were made at culverts #23 and #24. Water velocity and depth data were collected using a Price AA current meter and wading rod. Depths of flow were 0.6 feet at the downstream inverts of both culverts. Velocities were 1.8 and 3.7 fps in culverts #23 and #24, respectively. Culvert water depths and velocities are provided in Table 3-13. Culvert discharge data are provided in Appendix B.

> ***Note:*** *Culverts on the CD-2 access road are numbered from west to east based on an as-built survey completed by Kuukpik/LCMF, Inc. on January 23, 2002. See Appendix C for detailed drawings of the culvert layout and numbering system.*

The peak flow through the two culverts is assumed to have occurred near the time of the peak stage at permanent staff gages #3 and #4, and is estimated to have been approximately 10 and 12 cfs at culverts #23 and #24, respectively (see Table 3-13). Based on the water surface elevations and the timing of the discharge measurements, the conditions observed at that time can be considered to be reasonably representative of flow conditions at the time of the estimated peak discharge.

Culverts were visually inspected on the afternoon of 13 June, approximately six days after the occurrence of the peak water surface elevation. Minimal flow through culverts #23 and #24 was still occurring but depths were not sufficient for measurement. Shallow standing water was observed on both sides of the road. No evidence of scour was observed at any of the culverts.

Water surface elevation differences on the upstream and downstream sides of the road were not greater than 0.5 feet seven days after the peak water surface elevation, thus meeting the requirements of USACE 2-960874, Page 2-A, Item 7, and AK9703-030G, Page 9, Item 24. No remedial planning measures to alter drainage structure design are required at this time.

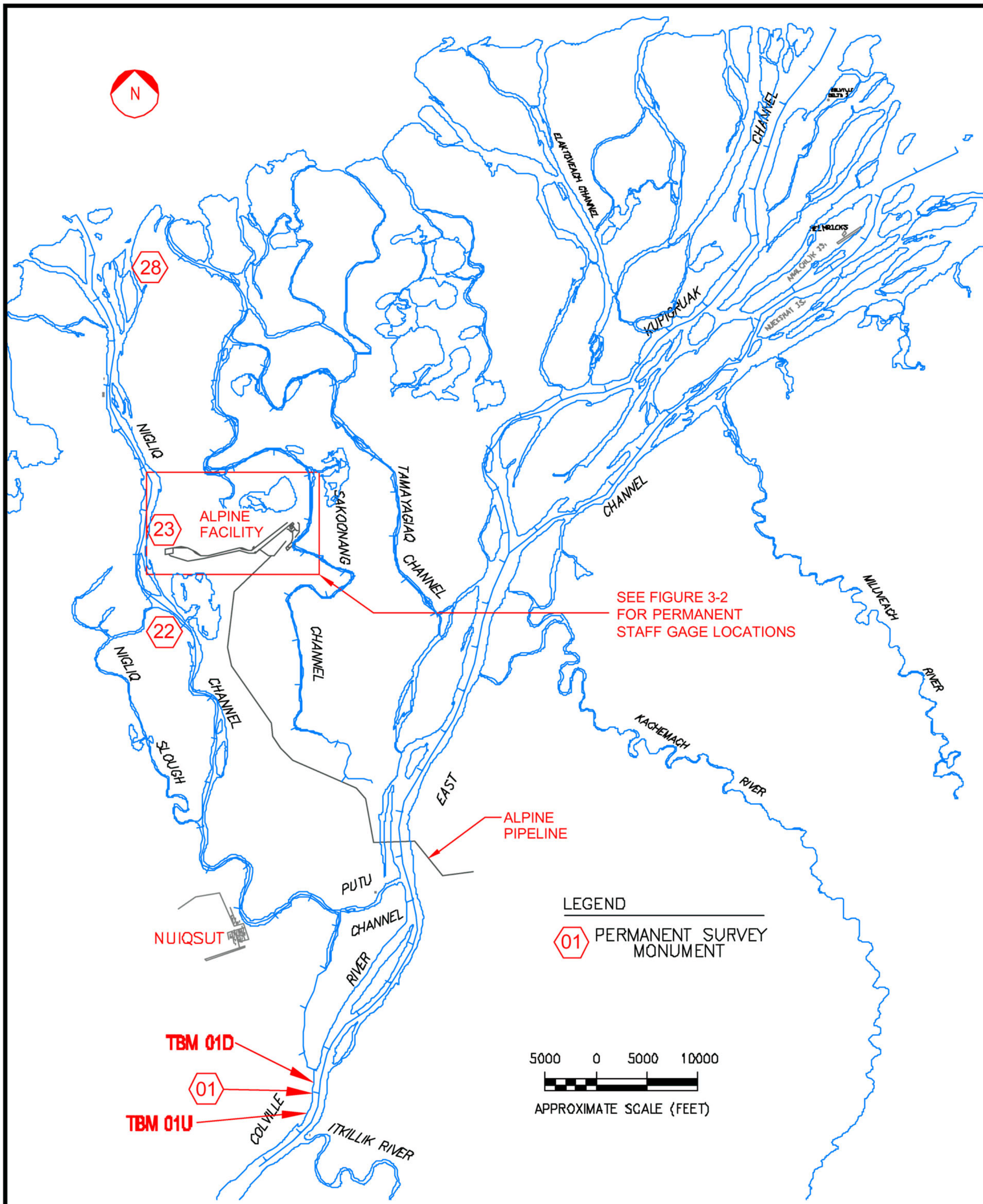

Figure 3-1

Temporary Staff Gage Locations

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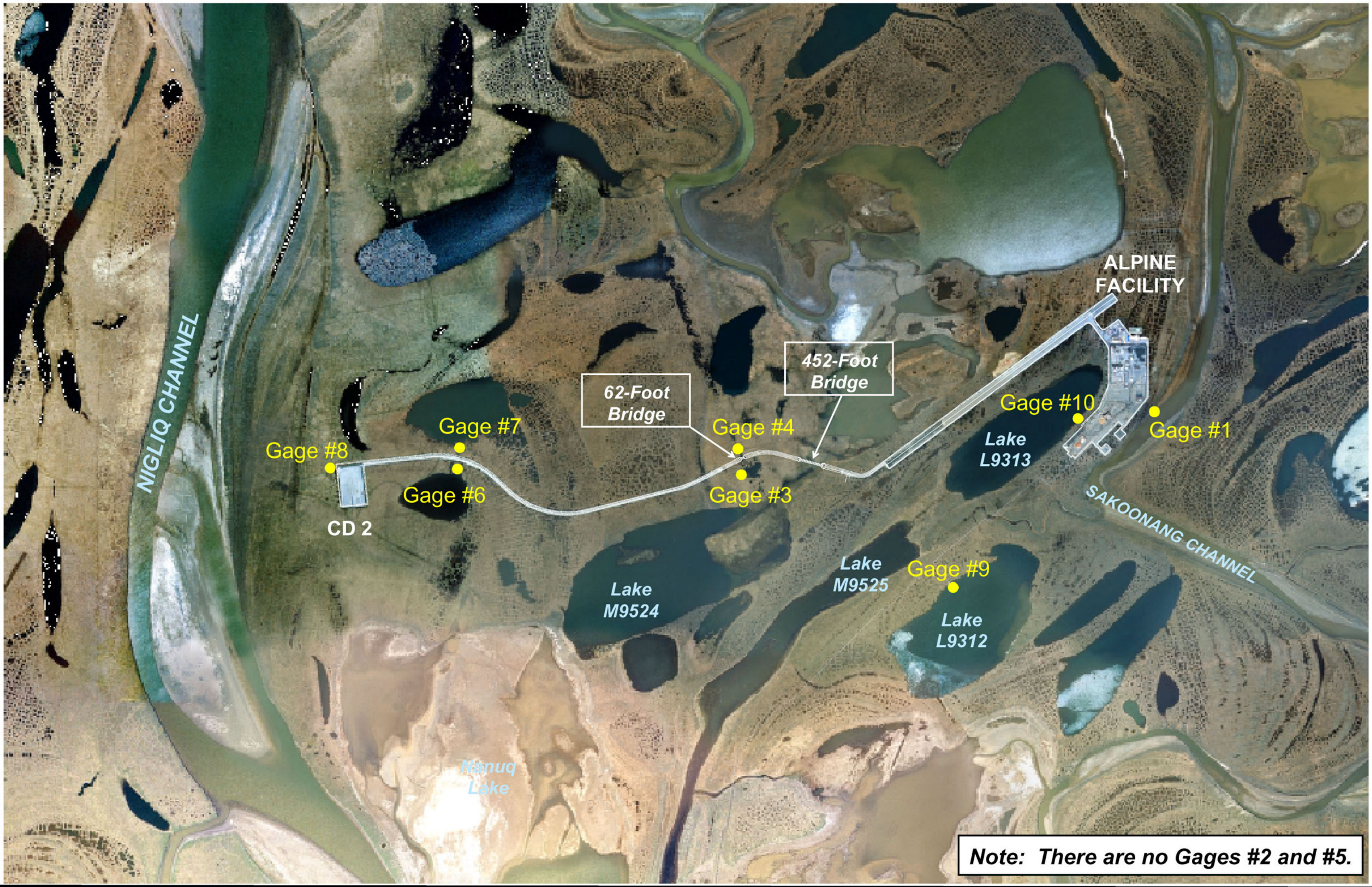

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Permanent Staff Gage Locations
Alpine Facility Vicinity

Figure 3-2

0 1,250 2,500 Feet

Baker

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09/2003

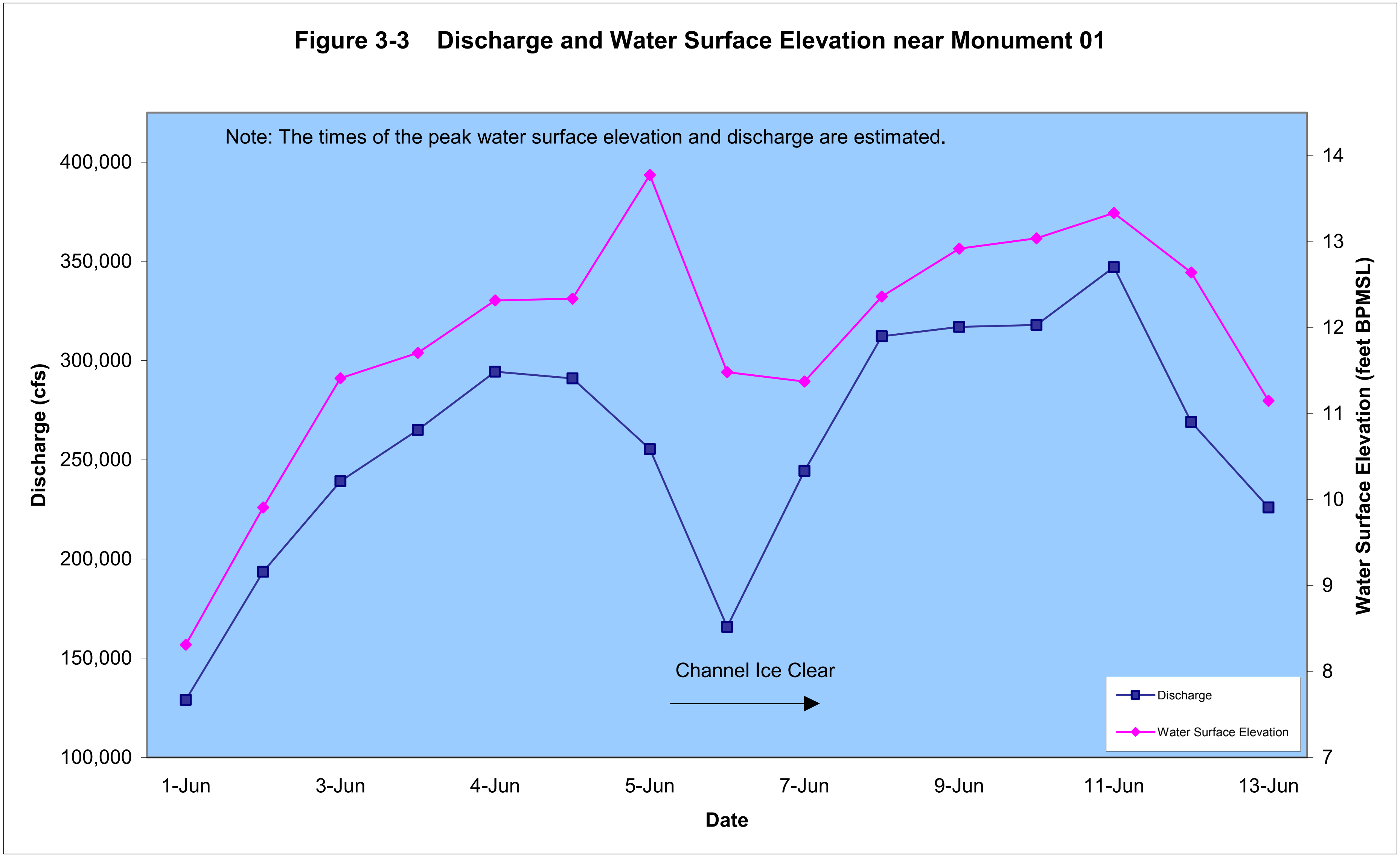


Figure 3-3 Discharge and Water Surface Elevation near Monument 01
Note: The times of the peak water surface elevation and discharge are estimated.
Discharge (cfs)
Water Surface Elevation (feet BPMSL)
400,000
350,000
300,000
250,000
200,000
150,000
100,000
14
13
12
11
10
9
8
7
Channel Ice Clear
Discharge
Water Surface Elevation
1-Jun
3-Jun
4-Jun
5-Jun
7-Jun
9-Jun
11-Jun
13-Jun
Date

Table 3-1 Permanent Staff Gage #1 - Sakoonang Channel, Water Surface Elevations and Observations

Date & Time	Water Surface Elevation (feet BPMSL)	Water Depth (feet)	Observations
6/5/03 9:00	3.92	3.02	Channel ice intact, few floating chunks
6/6/03 8:55	4.39	3.49	Channel ice intact
6/7/03 8:40	4.79	3.89	Channel ice intact, floating, beginning to deteriorate
6/8/03 9:15	5.43	4.53	Channel ice fractured, rotten
6/8/03 14:50	5.50	4.60	Reading taken prior to discharge measurement at 452-foot bridge
6/8/03 17:15	5.58	4.68	Reading taken after discharge measurement at 452-foot bridge
High Water Mark	6.07	5.17	Peak stage occurred late on 8 June or early on 9 June
6/9/03 6:45	5.84	4.94	Channel ice cleared overnight
6/10/03 8:45	4.99	4.09	Reading taken in approximately 20+ knot wind
6/11/03 8:40	4.77	3.87	Reading taken in approximately 25+ knot wind
6/12/03 8:10	4.64	3.74	Reading taken in approximately 15 knot wind
6/13/03 8:20	4.23	3.33	Reading taken in approximately 25 knot wind. Stage decreasing rapidly.

Notes
1. Elevations are based on an elevation of 2.31 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support. Elevations were re-established by Kuukpik/LCMF Inc. in 2003.
2. Water depths are based on ground elevations that were surveyed by Kuukpik/LCMF Inc. in 2002.

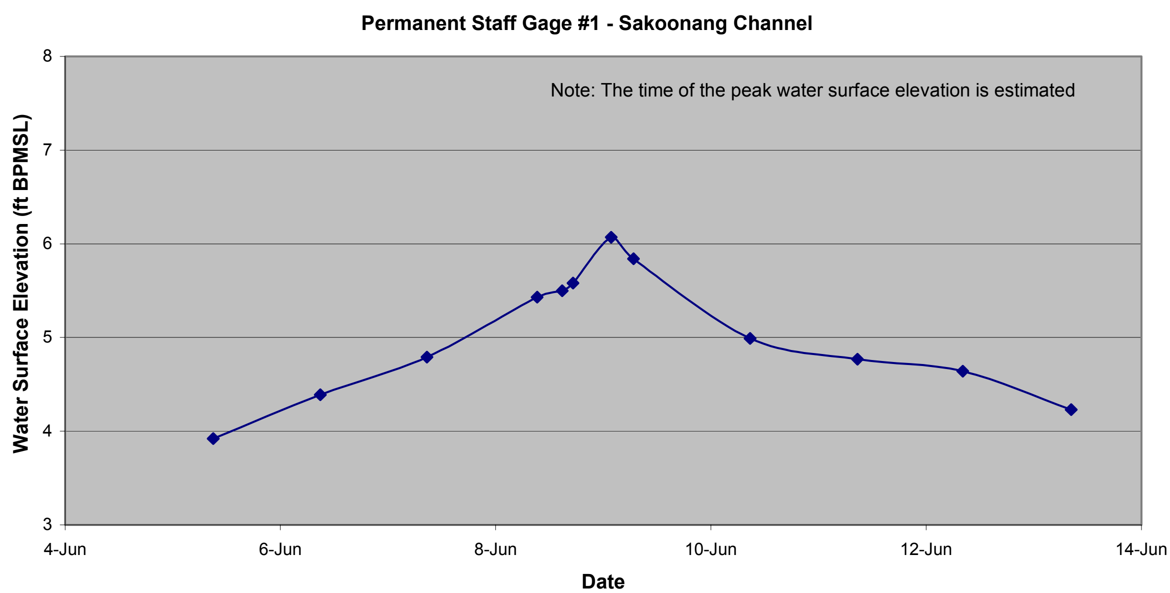


Table 3-2 Permanent Staff Gage #3, Water Surface Elevations and Observations

Date & Time	Water Surface Elevation (feet BPMSL)	Water Depth (feet)	Observations
6/6/03 9:10	5.46	0.56	Possible local melt
6/7/03 9:00	5.96	1.06	452-foot bridge flowing well, 62-foot bridge plugged w/ snow
High Water Mark	6.31	1.41	Peak stage occurred during the afternoon or evening on 7 June or early on 8 June
6/8/03 9:45	5.59	0.69	Stage at both bridges has dropped
6/8/03 15:10	5.49	0.59	Reading taken prior to discharge measurement at 452-foot Swale Bridge
6/8/03 17:00	5.47	0.57	Reading taken after discharge measurement at 452-foot Swale Bridge
6/9/03 8:00	5.41	0.51	Stage in vicinity of bridges dropping rapidly
6/10/03 9:10	5.38	0.48	Floodwaters no longer on gage, localized ponding

Notes
1. Elevations are based on an elevation of 5.93 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support. Elevations were re- established by Kuukpik/LCMF, Inc. in 2003.
2. Water depths are based on ground elevations that were surveyed by Kuukpik/LCMF, Inc. in 2002.

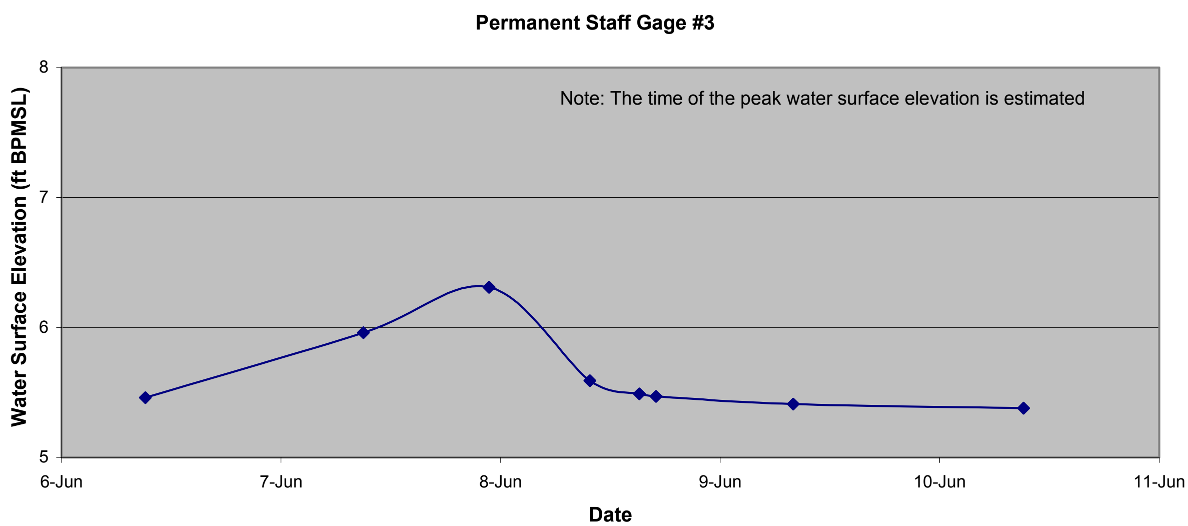


Table 3-3 Permanent Staff Gage #4, Water Surface Elevations and Observations

Date & Time	Water Surface Elevation (feet BPMSL)	Water Depth (feet)	Observations
6/6/03 9:10	5.45	0.45	Possible local melt
6/7/03 9:00	5.89	0.89	452-foot bridge flowing well, 62-foot bridge plugged w/ snow
High Water Mark	6.19	1.19	Peak stage occurred during the afternoon or evening on 7 June or early on 8 June
6/8/03 9:50	5.58	0.58	Stage at both bridges has dropped
6/8/03 15:10	5.54	0.54	Reading taken prior to discharge measurement at 452-foot Swale Bridge
6/8/03 17:00	5.47	0.47	Reading taken after discharge measurement at 452-foot Swale Bridge
6/9/03 8:00	5.40	0.40	Stage in vicinity of bridges dropping rapidly
6/10/03 9:10	5.37	0.37	Floodwaters no longer on gage, localized ponding

Notes:

1. Elevations are based on an elevation of 6.41 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support. Elevations were re-established by Kuukpik/LCMF, Inc. in 2003.
2. Water depths are based on ground elevations that were surveyed by Kuukpik/LCMF, Inc. in 2002.

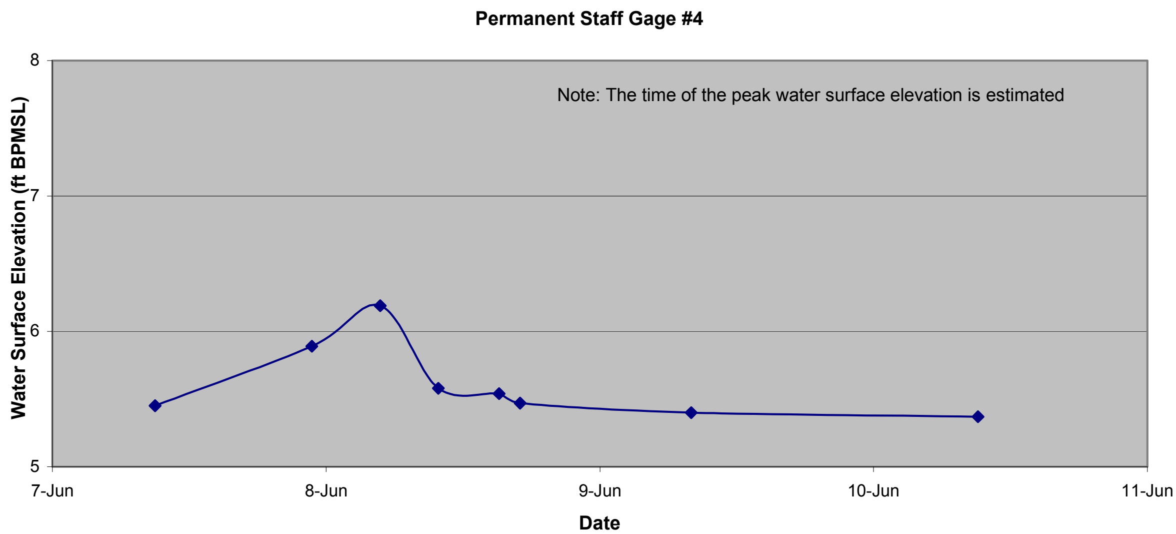


Table 3-4 Permanent Staff Gage #9 - Lake L9312, Water Surface Elevations and Observations

Date & Time	Water Surface Elevation (feet BPMSL)	Water Depth (feet)	Observations
6/4/03 11:05	7.93	2.83	Ice surrounding gage, good reading
6/5/03 11:03	7.98	2.88	Ice surrounding gage
6/8/03 14:55	8.00	2.90	Ice surrounding gage, no flood recharge occurring
6/10/03 16:45	8.01	2.91	Ice surrounding gage, no flood recharge occurring
6/12/03 10:00	8.01	2.91	Ice surrounding gage; verified gage plate placement; no flood recharge occurring
6/14/03 9:50	7.99	2.89	Ice surrounding gage, no flood recharge occurring
6/19/03 12:00	7.96	2.86	Reading taken by Alpine personnel, time is approximate
6/24/03 12:00	7.98	2.88	Reading taken by Alpine personnel, time is approximate
7/2/03 12:00	8.00	2.90	Reading taken by Alpine personnel, time is approximate
7/9/03 12:00	8.00	2.90	Reading taken by Alpine personnel, time is approximate
7/15/03 12:00	7.95	2.85	Reading taken by Alpine personnel, time is approximate

Notes:

1. Elevations are based on an elevation of 9.00 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support. Elevations were re-established by Kuukpik/LCMF, Inc. in 2003.
2. Water depths are based on ground elevations that were surveyed by Kuukpik/LCMF, Inc. in 2002.

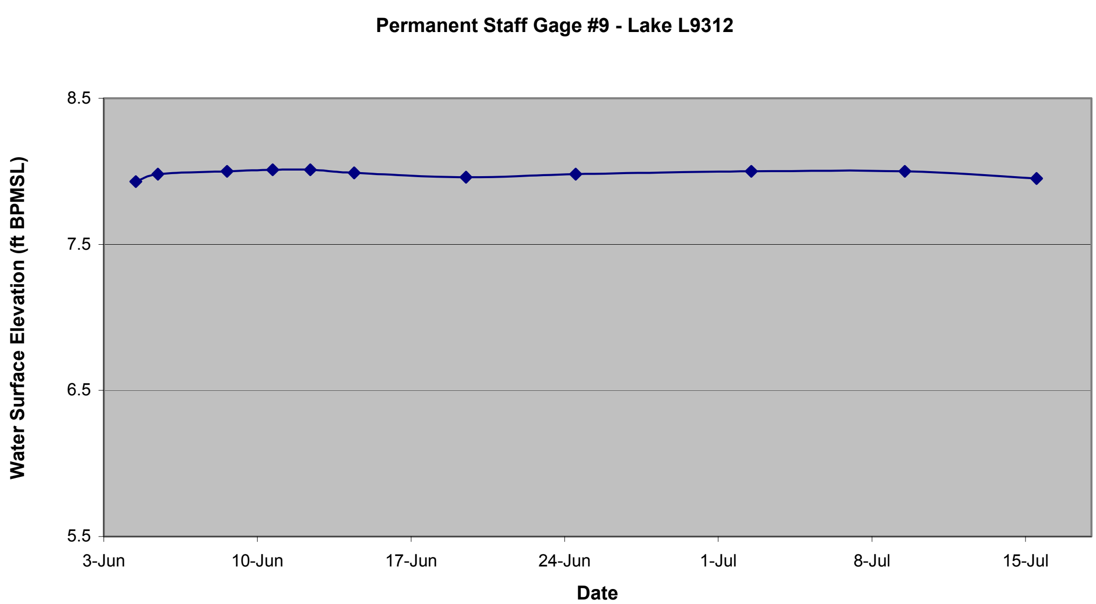


Table 3-5 Permanent Staff Gage #10 - Lake L9313, Water Surf. Elevations and Observations

Date & Time	Water Surface Elevation (feet BPMSL)	Water Depth (ft)	Observations
5/29/03 11:30	5.99	2.09	Ice surrounding gage, good reading
6/5/03 8:55	6.07	2.17	Lake still almost 100% ice covered
6/6/03 8:05	6.10	2.20	Lake still almost 100% ice covered
6/7/03 8:35	6.10	2.20	Lake still almost 100% ice covered
6/8/03 9:25	6.13	2.23	Some open water around edges, recharge waters have reached lake
6/8/03 14:55	6.27	2.37	Some open water around edges
6/8/03 17:25	6.37	2.47	Some open water around edges
High Water Mark	7.12	3.22	Peak stage recorded on 09 June at 6:40
6/10/03 8:35	6.83	2.93	Recharge slowing
6/11/03 8:30	6.65	2.75	Lake still about 80% ice-covered, recharge slowing
6/12/03 8:00	6.62	2.72	Lake level dropping noticeably
6/13/03 8:10	6.48	2.58	Water level dropping
6/24/03 12:00	6.24	2.34	Reading taken by Alpine personnel, time is approximate
7/2/03 12:00	6.14	2.24	Reading taken by Alpine personnel, time is approximate
7/9/03 12:00	6.14	2.24	Reading taken by Alpine personnel, time is approximate
7/15/03 12:00	6.15	2.25	Reading taken by Alpine personnel, time is approximate

Notes:

1. Elevations are based on an elevation of 13.64 feet (BPMSL) located at the punch mark on the 5-inch drill stem staff gage support. Elevations were re-established by Kuukpik/LCMF, Inc.in 2003.
2. Water depths are based on ground elevations that were surveyed by Kuukpik/LCMF, Inc. in 2002.

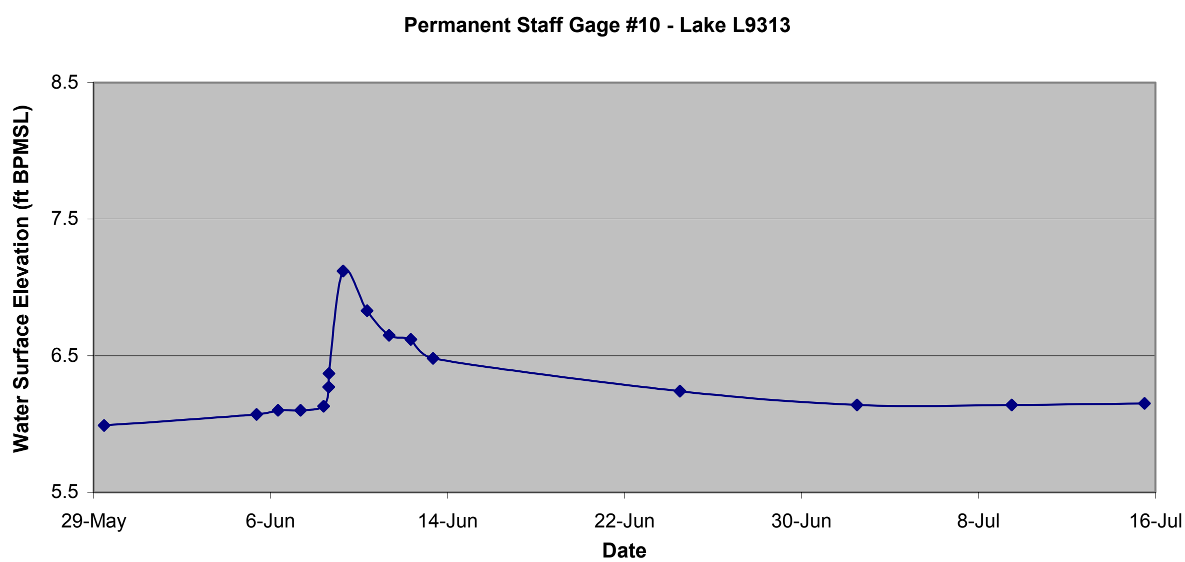


Table 3-6 Monument 01, Water Surface Elevations and Observations

Date & Time	Water Surface Elevation (feet BPMSL)	Observations
6/1/03 12:00	8.30	Flow over intact channel ice, right bank ice still above water level
6/2/03 9:00	9.89	Flow over intact channel ice, some pans floating thru section
6/3/03 9:35	11.39	Flow over mostly intact channel ice, some evidence of lift
6/4/03 9:36	11.68	Flow over mostly intact channel ice, significant lift
6/4/03 20:13	12.29	Channel ice floating and intact
6/5/03 9:14	12.31	Channel ice floating and intact
High Water Mark	13.76	Peak stage occurred in the afternoon or evening on 5 June or in the morning on 6 June
6/6/03 11:50	11.47	Channel clear of ice
6/7/03 12:50	11.35	Channel clear of ice, possible rise in stage
6/8/03 11:25	12.33	Noted significant rise in stage, channel clear
6/9/03 13:45	12.89	Rising stage
6/10/03 14:50	13.01	Stage continues to rise, 20+ knot winds
6/11/03 14:45	13.30	Secondary peak observed, readings made in 25+ knot winds
6/12/03 9:00	12.62	Stage dropping, approximately 15 knot winds
6/13/03 14:20	11.13	Significant decrease in stage

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. Coordinates for Mounument 01 are N70° 09' 57.1" W150° 56' 24.1" (NAD 83), surveyed by Lounsbury and Associates.

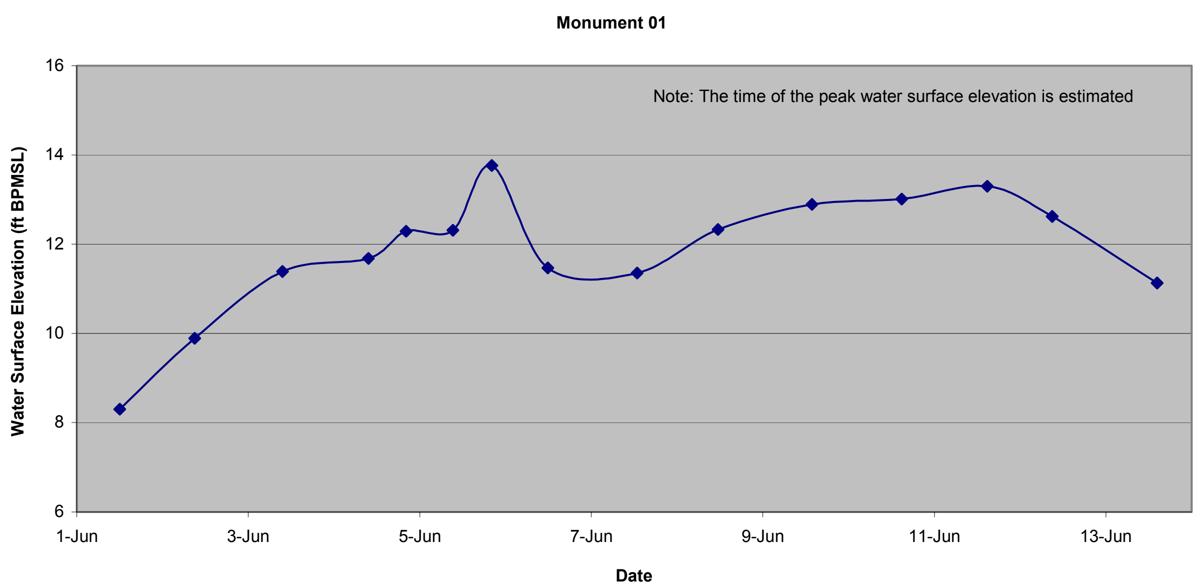


Table 3-7 Temporary Benchmark 01U, Water Surface Elevations and Observations

Date & Time	Water Surface Elevation (feet BPMSL)	Observations
6/1/03 12:00	8.41	Flow over intact channel ice, right bank ice still above water level
6/2/03 9:30	10.12	Flow over intact channel ice, some pans floating thru section
6/3/03 9:44	11.65	Flow over mostly intact channel ice, some evidence of lift
6/4/03 9:45	11.99	Flow over mostly intact channel ice, significant lift
6/4/03 20:04	12.60	Channel ice floating and intact
6/5/03 9:25	12.67	Channel ice floating and intact
High Water Mark	13.82	Peak stage occurred in the afternoon or evening on 5 June or in the morning on 6 June
6/6/03 12:15	11.59	Channel clear of ice
6/7/03 1:15	11.63	Channel clear of ice, possible rise in stage
6/8/03 11:30	12.69	Noted significant rise in stage, channel clear of ice
6/9/03 13:50	13.19	Rising stage
6/10/03 14:50	13.40	Stage continues to rise, 20+ knot winds
6/11/03 14:50	13.66	Secondary peak observed, readings made in 25+ knot winds
6/12/03 9:30	12.91	Stage dropping, approximately 15 knot winds
6/13/03 14:00	11.39	Significant decrease in stage

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. Coordinates for TBM 01U are N70° 09' 30.2" W150° 56' 48.1" (NAD 83), by Garmin III Plus GPS.

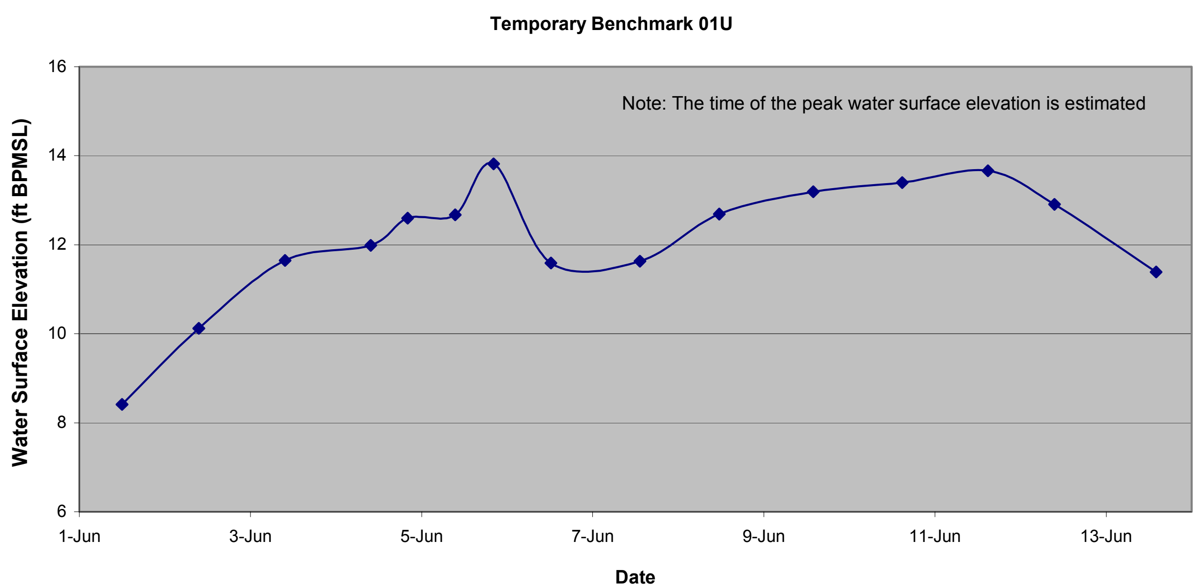


Table 3-8 Temporary Benchmark 01D, Water Surface Elevations and Observations

Date & Time	Water Surface Elevation (feet BPMSL)	Observations
6/1/03 12:00	8.12	Flow over intact channel ice, right bank ice still above water level
6/2/03 9:12	9.62	Flow over intact channel ice, some pans floating thru section
6/3/03 9:23	11.06	Flow over mostly intact channel ice, some evidence of lift
6/4/03 9:27	11.30	Flow over mostly intact channel ice, significant lift
6/4/03 20:24	11.83	Channel ice floating and intact
6/5/03 9:07	11.92	Channel ice floating and intact
High Water Mark	13.36	Peak stage occurred in the afternoon or evening on 5 June or in the morning on 6 June
6/6/03 11:20	11.31	Channel clear of ice
6/7/03 12:30	11.01	Channel clear of ice, possible rise in stage
6/8/03 11:20	11.83	Noted significant rise in stage, channel clear of ice
6/9/03 13:40	12.38	Rising stage
6/10/03 14:25	12.60	Stage continues to rise, 20+ knot winds
6/11/03 14:40	12.75	Secondary peak observed, readings made in 25+ knot winds
6/12/03 9:05	12.30	Stage dropping, approximately 15 knot winds
6/13/03 14:40	10.84	Significant decrease in stage

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. Coordinates for TBM 01D are N70° 10' 25.4" W150° 56' 13.0", (NAD 83), by Garmin III Plus GPS.

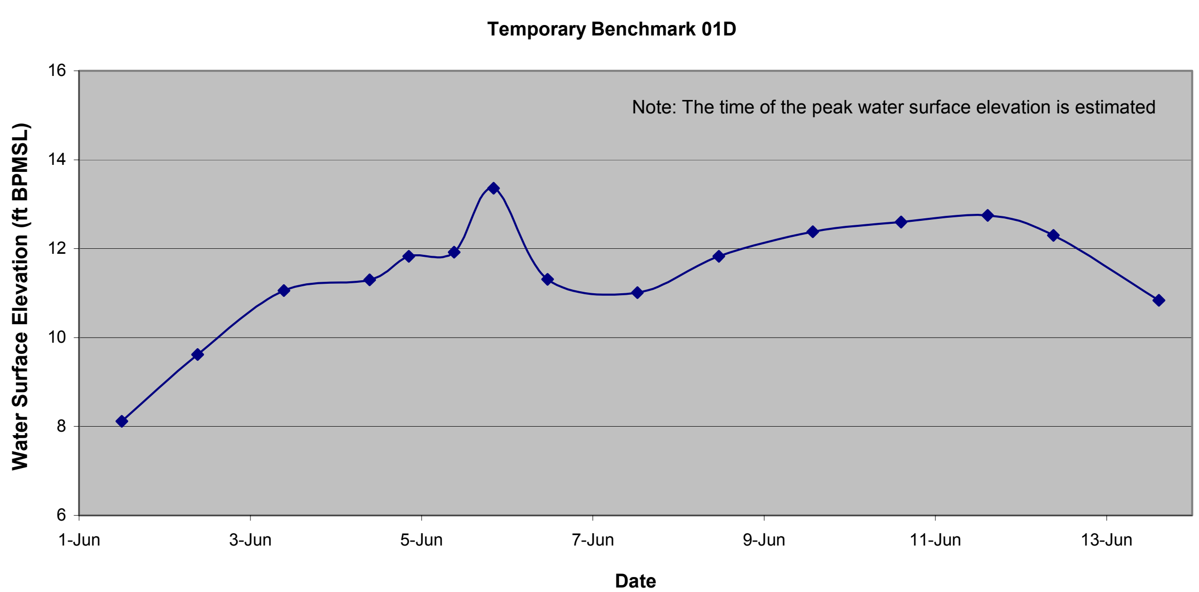


Table 3-9 Monument 22, Water Surface Elevations and Observations

Date & Time	Water Surface Elevation (feet BPMSL)	Observations
6/1/03 9:00	3.73	Snow surrounding gage but good hydraulic connection. Flow over intact channel ice
6/2/03 8:41	4.34	Snow surrounding gage but good hydraulic connection. Flow over intact channel ice
6/3/03 9:05	5.24	Flow over intact channel ice, some lifting
6/4/03 9:07	5.76	Channel ice lifting
6/5/03 8:50	6.13	Channel ice lifting
6/6/03 10:40	5.67	Channel ice lifting, ice becoming rotten
6/7/03 12:00	6.70	Channel clear of ice
High Water Mark	7.02	Estimated high water, see Note 3. Peak stage occurred in the afternoon or evening of 7 June or in the morning of 8 June.
6/8/03 10:55	5.78	Channel clear of ice
6/9/03 14:20	5.16	Channel clear of ice
6/10/03 10:55	5.09	Readings made in high wind (20+ knots)
6/11/03 13:48	5.24	Readings made in high wind (20+ knots)
6/12/03 9:40	4.97	

Notes:

1. Elevations are based on an elevation of 10.13 feet BPMSL for Monument 22, verified by Kuukpik/LCMF, Inc. in 2003.
2. Coordinates for Monument 22 are N70° 19' 05.2" W151° 03' 21.9" (NAD 83), by Garmin III Plus GPS.
3. Definitive high water marks were not available due to wind; the peak water surface elevation shown is an estimate.

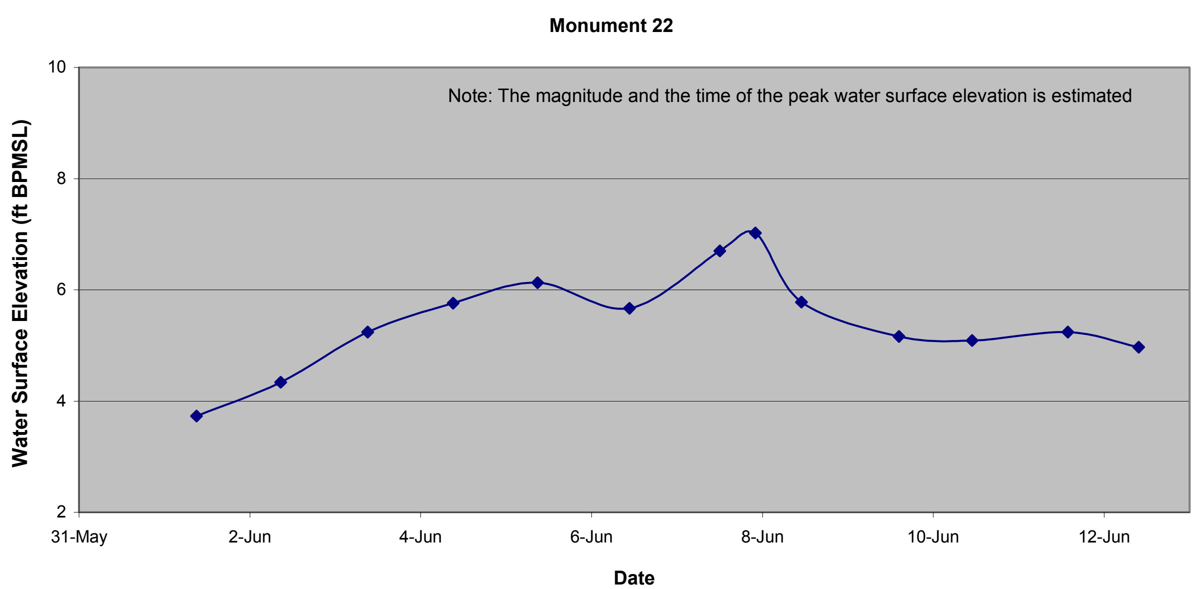


Table 3-10 Monument 23, Water Surface Elevations and Observations

Date & Time	Water Surface Elevation (feet BPMSL)	Observations
5/31/03 16:05	2.77	Snow surrounding gage but good hydraulic connection. Flow over intact channel ice
6/1/03 8:47	3.38	Snow surrounding gage but good hydraulic connection. Flow over intact channel ice
6/2/03 8:30	3.84	Flow over intact channel ice, some lifting
6/3/03 8:55	4.62	Channel ice lifting
6/3/03 17:30	4.83	Channel ice lifting
6/4/03 8:57	5.04	Channel ice lifting, ice becoming rotten
6/5/03 8:41	5.33	Ice lifted and in place
6/6/03 10:30	4.97	Ice lifted, in place and rotten
6/7/03 11:49	5.47	Ice lifted, in place and rotten
High Water Mark	6.07	Peak stage occurred in the afternoon or evening on 7 June or the morning on 8 June
6/8/03 10:30	5.11	Channel clear of ice
6/9/03 14:40	4.18	Channel clear of ice
6/10/03 10:50	4.02	Readings made in high wind (20+ knots)
6/11/03 14:00	4.01	Readings made in high wind (20+ knots)
6/12/03 9:45	3.93	

Notes:
1. Elevations are based on an elevation of 9.53 feet BPMSL for Monument 23, verified by Kuukpik/LCMF, Inc. in 2003.
2. Coordinates for Monument 23 are N70° 20' 40.1" W151° 03' 40.7" (NAD 83), by Garmin III Plus GPS.

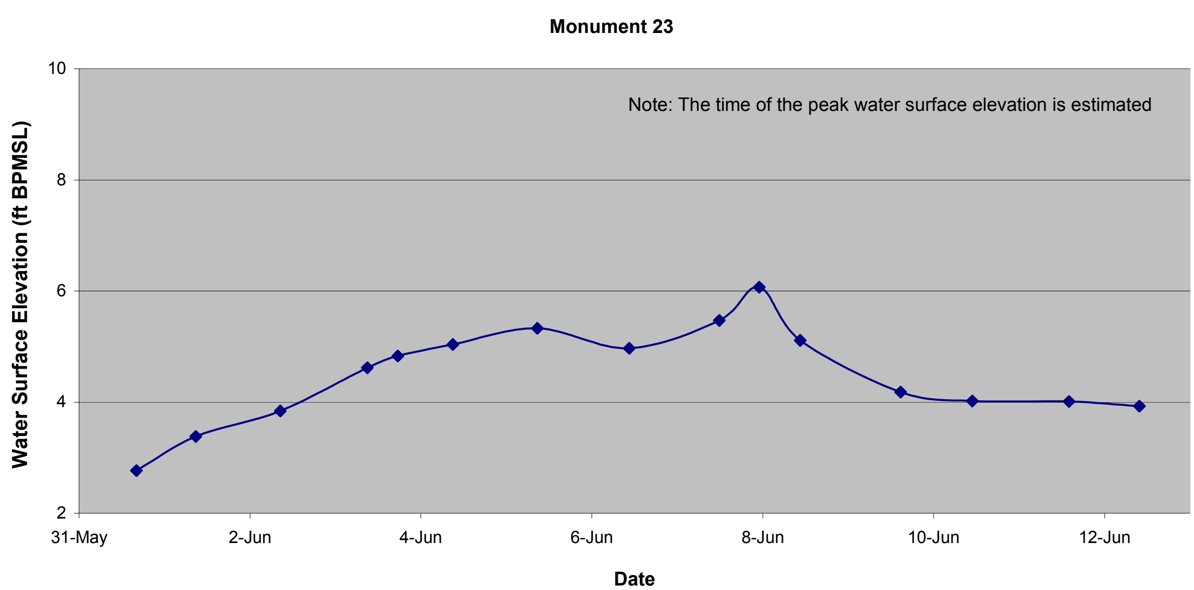


Table 3-11 Monument 28, Water Surface Elevations and Observations

Date & Time	Water Surface Elevation (feet BPMSL)	Observations
6/1/03 13:55	2.48	Snow surrounding gage but good hydraulic connection. Flow over intact channel ice
6/2/03 8:20	2.52	Snow surrounding gage but good hydraulic connection. Flow over intact channel ice
6/3/03 8:45	2.77	Flow over intact channel ice
6/4/03 8:43	2.81	Flow over intact channel ice
6/5/03 8:35	2.97	Flow over mostly intact channel ice, some lifting
6/6/03 10:17	2.84	Significant channel ice lifting, floating intact
6/7/03 11:30	3.32	Channel clear of ice
6/8/03 10:25	3.48	Channel ice cleared, chunks floating through section
High Water Mark	3.57	Peak stage occurred in the afternoon or evening on 8 June or in the morning of 9 June
6/9/03 14:40	2.45	Channel clear of ice
6/10/03 10:25	1.92	Readings made in high wind (20+ knots)
6/11/03 14:10	1.69	Readings made in high wind (20+ knots)
6/12/03 12:45	1.50	

Notes:
1. Elevations are based on an elevation of 3.66 feet BPMSL for Monument 28, verified by Kuukpik/LCMF, Inc.in 2003.
2. Coordinates for Monument 28 are N70° 25' 32.0" W151° 04' 01.2" (NAD 83), by Garmin III Plus GPS.

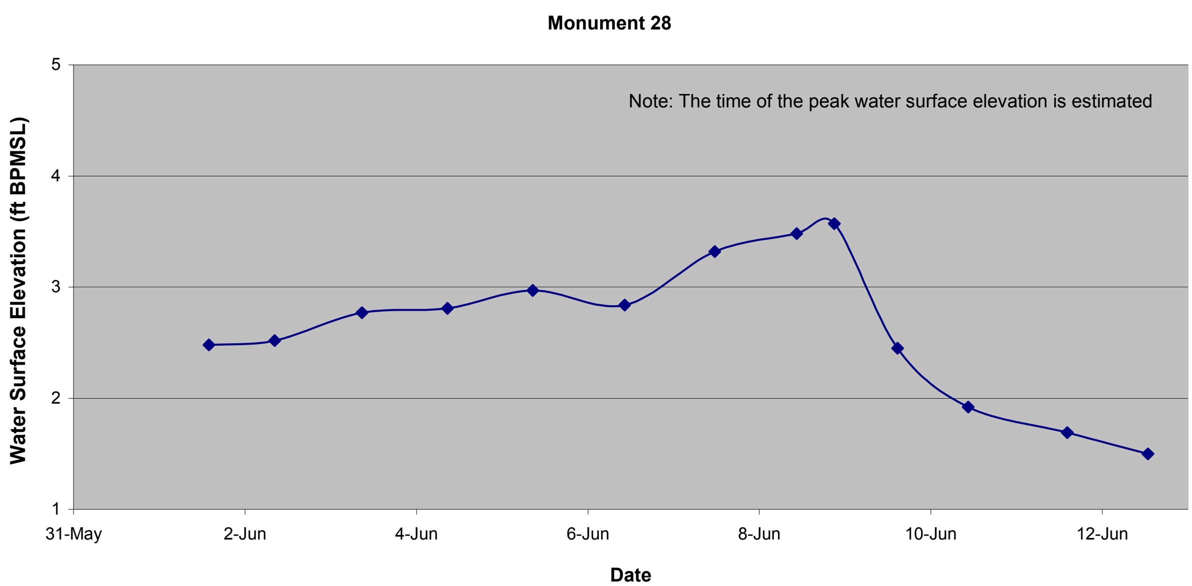


Table 3-12 Summary of Breakup Data Obtained at the Head of the Colville River Delta, 1962 – 2003

Year	Approximate Date of First Flowing Water	Peak Water Surface Elevation (ft)	Date of Peak Water Surface Elevation	Peak Breakup Discharge (cfs)	Notes
2003	27 May	13.76	5 June	350,000	1,10,11
2002	23 May	16.87	24 May	300,000	1,2,10,11
2001	5 June	17.37	10 June	300,000	1,3,10,11
2000	8 June	19.33	11 June	580,000	1,4,10,11
1999	22 May	13.97	30 May	203,000	1,5,6,10,11
1998	21 May	18.11	29 May	213,000	1,7,10,11
1997	20 May	15.05	29 May	177,000	1,10,11
1996	15 May	17.19	26 May	160,000	1,8,10,11
1995	8 May	15.7	16 May	233,000	9,10,11
1994	16 May	13.0	25 May	159,000	9,10,11
1993	–	20.0	31 May	379,000	9,10,11
1992	–	14.7	2 June	188,000	9,10,11
1977	–	19.9	7 June	407,000	9,10,11
1973	25 May	–	8 June	–	9,10,11
1971	23 May	–	2 June	–	9,10,11
1964	28 May	–	3 June	–	9,10,11
1962	19 May	13.2	14 June	215,000	9,10,11

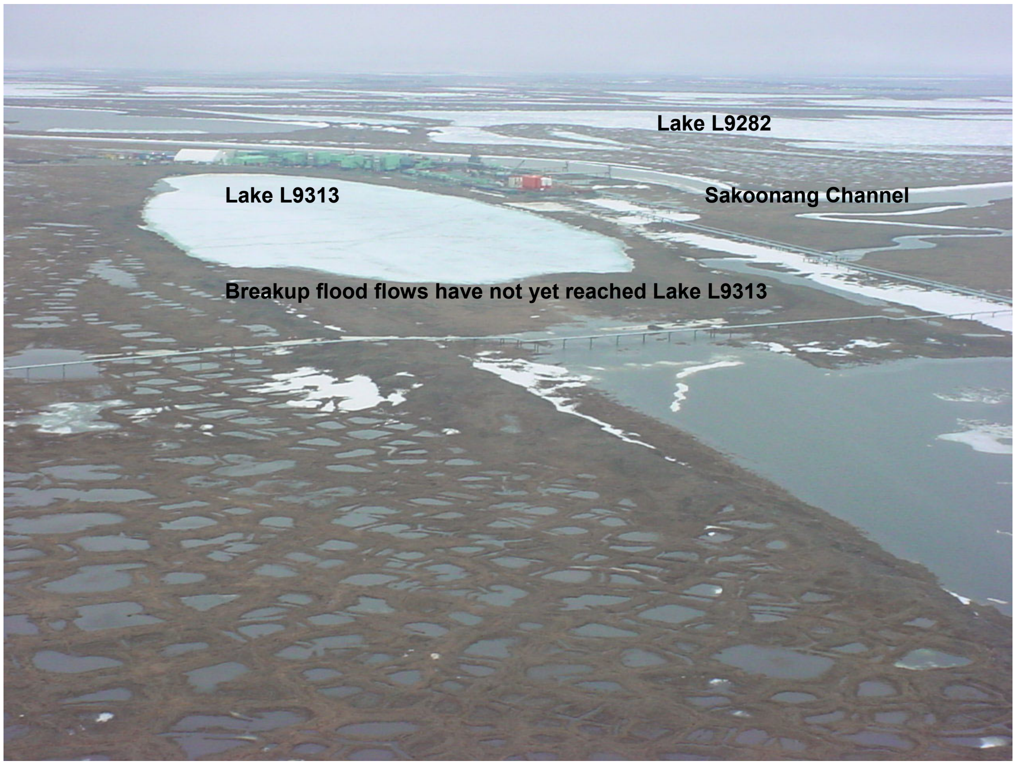
Notes:

1. Water surface elevations are based on monuments set by Lounsbury & Associates in 1996 and are based on the British Petroleum mean sea level (BPMSL) datum.
2. Data from Michael Baker, Jr., Inc., 2002b.
3. Data from Michael Baker, Jr., Inc., 2001.
4. The peak breakup discharge was estimated to range between 570,000 to 590,000 cfs. Data from Michael Baker, Jr., Inc., 2000.
5. Data from Michael Baker Jr., Inc., 1999.
6. 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.
7. Data from Michael Baker Jr., Inc., 1998.
8. Data from Shannon & Wilson, Inc., 1996.
9. Data from Jorgenson et al., 1996. 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.
10. The timing of the peak breakup discharge is not necessarily coincident with that of the peak breakup water surface elevation. It is not uncommon for the peak discharge to occur sometime after the peak water surface elevation, at a time when channel ice has lifted and cleared from the channel, increasing the channel's cross-section and flow-carrying capacity.
11. For the 2003 data, the date of first flowing water represents the first date on which water was noted to be flowing in the channel at the head of the delta (near Monument 01). In other years, the date of first water may indicate the first day that water reached temporary staff gages installed at the head of the delta. The timing of the two events – the day that water was first noted flowing in the channel vs. the day that water was first noted reaching temporary staff gages – will not necessarily be coincident in all years.

Table 3-13 Measured and Estimated Peak Discharge in Alpine Drainage Structures

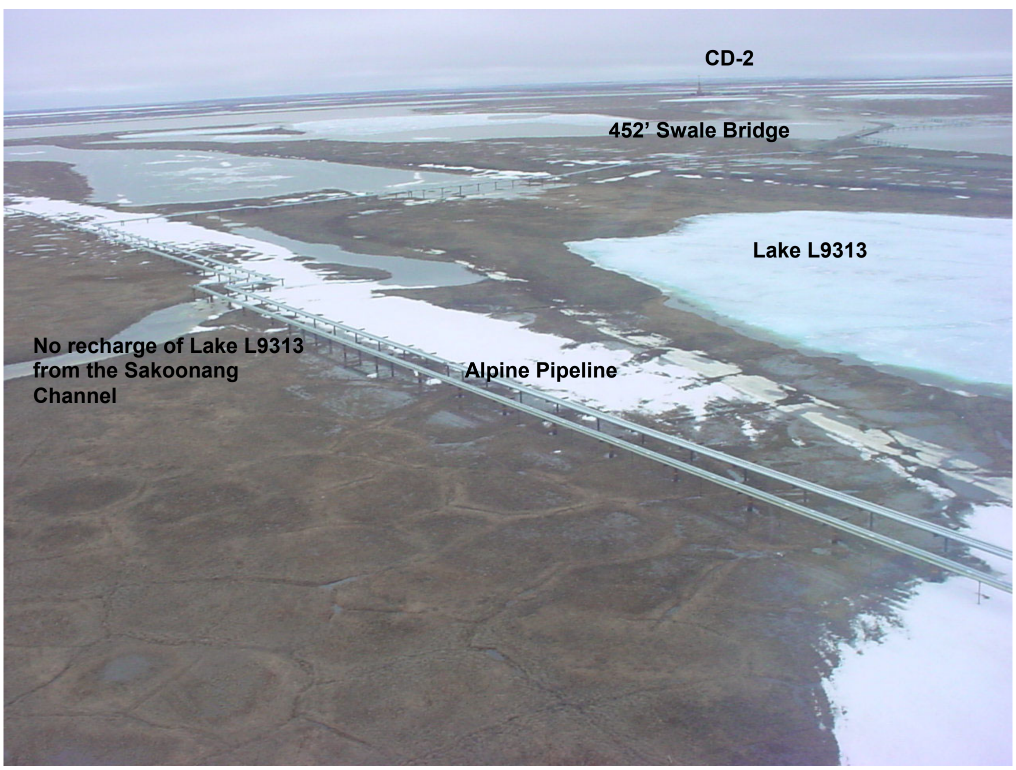
Structure	Field Measurement				Estimated Peak			
	Date	Water Depth (ft)	Average Velocity (ft/s)	Discharge (cfs)	Date	Water Depth (ft)	Average Velocity (ft/s)	Discharge (cfs)
62-ft Swale Bridge	6/8/03	No Flow			6/7/03	No Flow		
452-ft Swale Bridge	6/8/03	1.1 (ave.)	0.9	420	6/7/03	1.9 (ave.)	0.9	730
Culvert 1	6/8/03	No Flow			6/7/03	No Flow		
Culvert 2	6/8/03	No Flow			6/7/03	No Flow		
Culvert 3	6/8/03	No Flow			6/7/03	No Flow		
Culvert 4	6/8/03	No Flow			6/7/03	No Flow		
Culvert 5	6/8/03	No Flow			6/7/03	No Flow		
Culvert 6	6/8/03	No Flow			6/7/03	No Flow		
Culvert 7	6/8/03	No Flow			6/7/03	No Flow		
Culvert 8	6/8/03	No Flow			6/7/03	No Flow		
Culvert 9	6/8/03	No Flow			6/7/03	No Flow		
Culvert 10	6/8/03	No Flow			6/7/03	No Flow		
Culvert 11	6/8/03	No Flow			6/7/03	No Flow		
Culvert 12	6/8/03	No Flow			6/7/03	No Flow		
Culvert 13	6/8/03	No Flow			6/7/03	No Flow		
Culvert 14	6/8/03	No Flow			6/7/03	No Flow		
Culvert 15	6/8/03	No Flow			6/7/03	No Flow		
Culvert 16	6/8/03	No Flow			6/7/03	No Flow		
Culvert 17	6/8/03	No Flow			6/7/03	No Flow		
Culvert 18	6/8/03	No Flow			6/7/03	No Flow		
Culvert 19	6/8/03	No Flow			6/7/03	No Flow		
Culvert 20	6/8/03	No Flow			6/7/03	No Flow		
Culvert 21	6/8/03	No Flow			6/7/03	No Flow		
Culvert 22	6/8/03	No Flow			6/7/03	No Flow		
Culvert 23	6/8/03	0.6	1.8	2.1	6/7/03	1.7	2.0	10.1
Culvert 24	6/8/03	0.6	3.7	4.3	6/7/03	1.9	2.0	11.5
Culvert 25	6/8/03	No Flow			6/7/03	No Flow		
Culvert 26	6/8/03	No Flow			6/7/03	No Flow		

Notes:
1. Culvert numbering system is based on an Alpine Facilities as-built survey, prepared by Kuukpik/LCMF Inc., 1/23/2002. See Appendix B for culvert and bridge site plan.
2. Peak discharge and peak velocity occurred between the afternoon of June 7 and the morning of June 8.
3. Estimated peak discharge at the 452-foot bridge was calculated by increasing the water depth 0.82 feet (difference betweeen HWM and 7 June measurement at Staff Gage 3) and assuming a constant velocity.
4. The estimated peak discharge and velocity for the culverts are based on a clean culvert barrel and were calculated using Culvert Master Software.



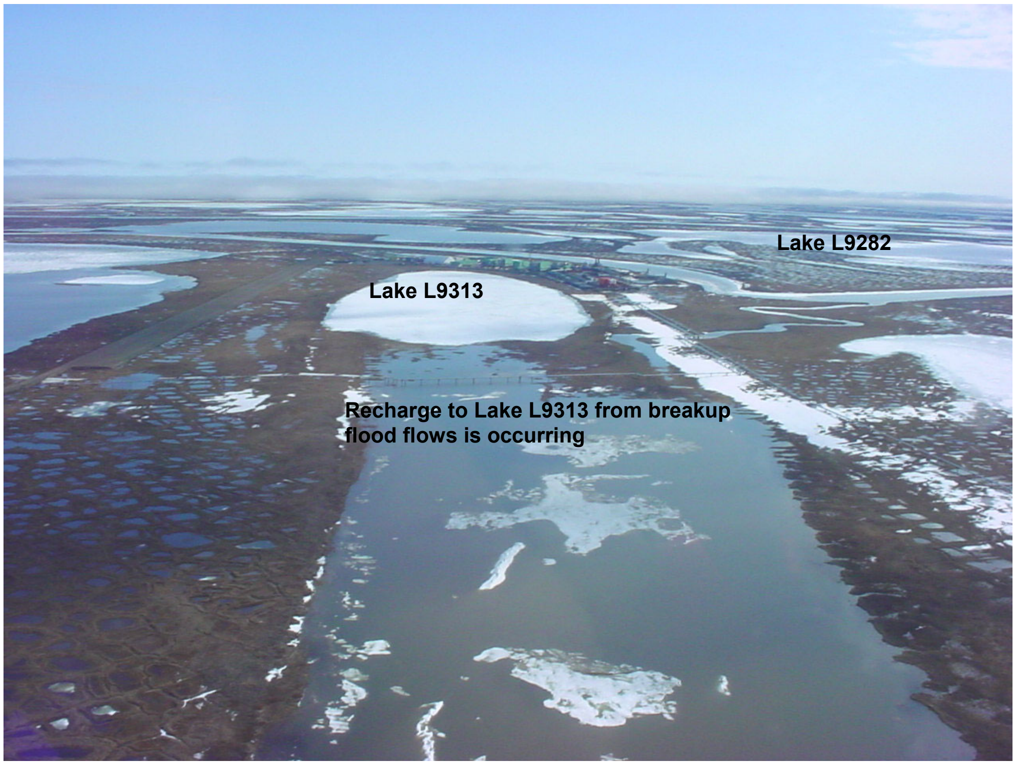
7 June 2003

Photo 3-1 Flooding conditions at Alpine approximately 24 hours prior to the peak flood stage. View looking east. Note that breakup flood flows have not yet reached Lake L9313.



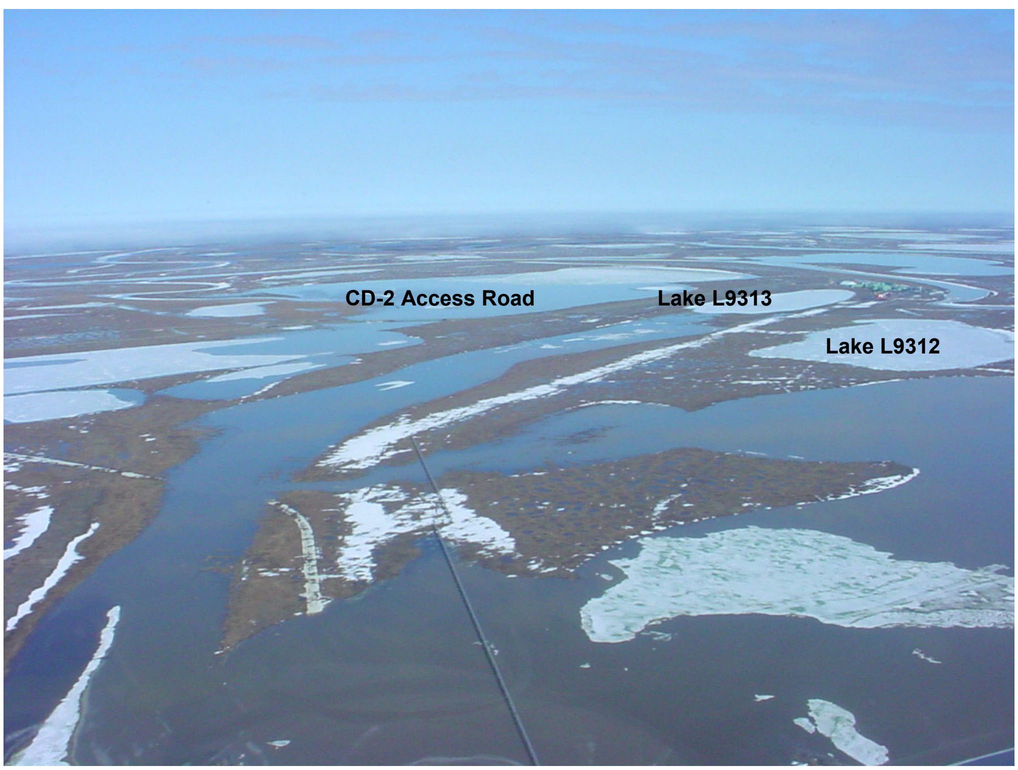
7 June 2003

Photo 3-2 Flooding conditions at Alpine approximately 24 hours prior to the peak flood stage. View looking west. Note that breakup flood flows have not yet reached Lake L9313.



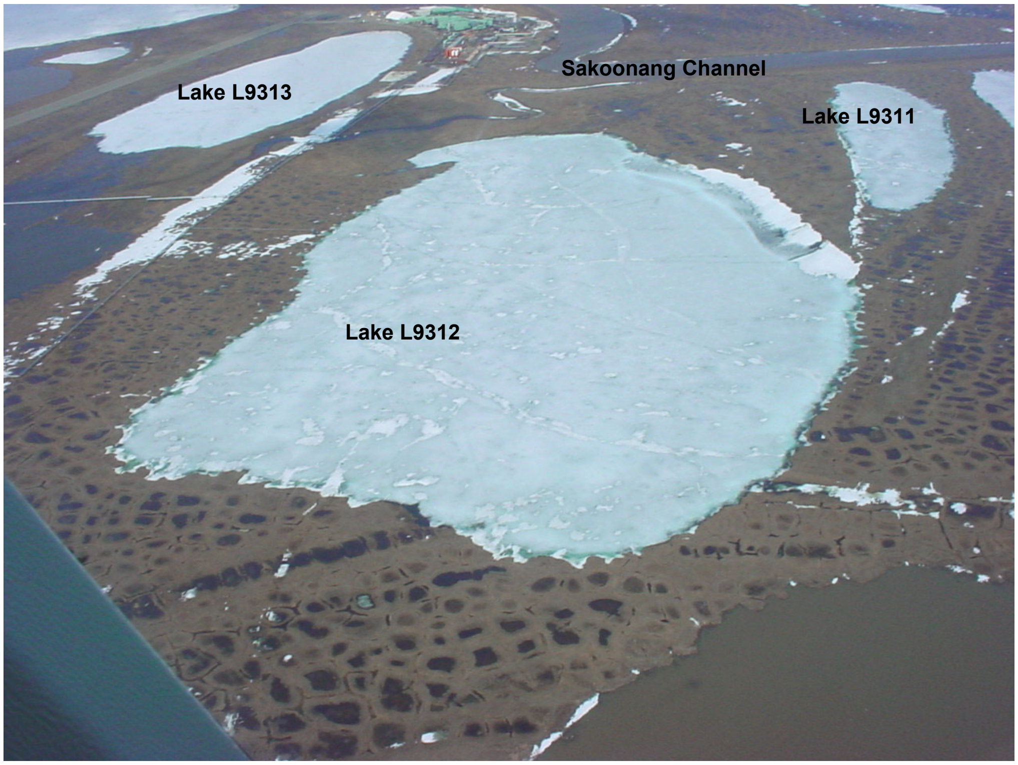
8 June 2003

Photo 3-3 Flooding conditions at Alpine approximately 12 hours after peak flood stage. View looking northeast. Note that breakup flood flows have reached Lake L9313 and recharge is occurring.



8 June 2003

Photo 3-4 Flooding conditions at Alpine approximately 12 hours after peak flood stage. View looking north. Note that Lake L9312 is not receiving recharge from breakup flood flows.



10 June 2003

Photo 3-5 Flooding conditions at Alpine approximately 24 hours after peak flood stage. Detail of Lake L9312. Note that there has been no apparent breakup flood flow recharge to the lake. Lake L9313 is still receiving breakup flood flow recharge.

10 June 2003

Photo 3-6 Flooding conditions at Alpine approximately 24 hours after peak flood stage.

4.0 Comparison of Predicted and Observed Water Surface Elevations

The 2003 peak water surface elevations in the immediate vicinity of Alpine were compared to water surface elevations predicted by the two-dimensional surface water model developed for the Colville River Delta (Michael Baker Jr., Inc., 2002a) in order to comply with USACE 2-960874, Page 2-A, Item 6. Peak water surface elevations at the head of the delta and along the Nigliq Channel were also compared to the predictions of the two-dimensional model. The comparisons are based on linear interpolations of observed water surface elevations between elevations predicted for the 2- and 10-year open water floods.

At or near the time that the peak water surface elevations within the delta were recorded, the discharge of the Colville River was estimated to be 255,000 cfs and to have a flood recurrence interval of two to three years. At the permanent staff gages near Alpine, flood recurrence intervals based on model predictions ranged from approximately two to five years. At Monument 01, the flood recurrence interval based on model predictions was approximately two years. At the Monument 22 and 23 monitoring sites along the Nigliq Channel, flood recurrence intervals based on model predictions were approximately five years. Comparisons of observed and predicted peak water surface elevations in the Colville River Delta are presented in Table 4-1.

The two-dimensional surface water model was constructed to predict conditions during low frequency, high magnitude flood events such as the 50-, 100-, and 200-year recurrence interval floods. The model assumes open water, steady state conditions and does not account for channel ice or ice jams. During the development of the model, it was assumed that during large flood events the presence of snow, ice, and ice jams would have little effect on the overall water surface elevations, and this assumption remains valid. However, channel ice and ice jams are likely to always be present to some extent during peak breakup floods in the Colville River Delta. Channel ice and ice jams will block and constrict flow to some degree, 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, model-predicted recurrence intervals for observed peak water surface elevations during small flood events are typically higher than the estimated recurrence interval based on field measurements.

Table 4-1 Comparisons of Observed and Predicted Peak Water Surface Elevations in the Colville River Delta

Observation Site	Observed 2003 Peak Water Surface Elevation (feet BPMSL)	Predicted 2-yr Water Surface Elevation (feet BPMSL)	Predicted 10-yr Water Surface Elevation (feet BPMSL)	Predicted 50-yr Water Surface Elevation (feet BPMSL)	Estimated Recurrence Interval of Observed Peak Water Surface Elevation (1) (years)
Staff Gage #1	6.07	5.5	8.4	11.2	4
Staff Gage #3	6.31	5.7 (2)	8.6	11.8	4
Staff Gage #4	6.19	5.1 (2)	7.6	9.9	5
Staff Gage #6	Dry (4)	Dry (3)	8.8	11.9	≤2
Staff Gage #7	Dry (4)	Dry (3)	8.6	9.8	≤2
Staff Gage #8	Dry (4)	Dry (3)	8.8	10.7	≤2
Staff Gage #9	Dry (4)	6.7 (2)	10.0	12.1	<2
Staff Gage #10	7.12	6.7 (2)	9.7	12.1	3
Monument 01	13.76	13.8	19.0	23.0	2
Monument 22	7.02	5.9	8.7	11.9	5
Monument 23	6.07	5.2	7.3	10.5	5

Specific Notes:

1. The estimated recurrence interval was interpolated between water surface elevations predicted with the two-dimensional surface-water model of the Colville River Delta (Michael Baker Jr., Inc., 2002, and Shannon & Wilson, Inc., 1997). The model considers open water conditions, therefore, the impact of an ice cover and/or ice jams is not considered in the model's predictions.
2. The finite element at the staff gage is turned off in the two-dimensional surface water model. The presented water surface elevation is the water surface elevation in the immediate vicinity of the staff gage.
3. The finite element at the staff gage is turned off in the two-dimensional surface water model. All elements in the immediate vicinity are turned off and the area is considered dry.
4. The observed 2003 peak water surface elevation is indicated to be "Dry" where floodwaters did not rise high enough to reach a particular gage.
5. Locations of monuments and gages are shown in Figures 3-1 and 3-2, respectively.
6. At or near the time of the observed 2003 peak water surface elevations, the discharge in the Colville River was approximately 255,000 cubic feet per second. This discharge is estimated to be a 2- to 3-year recurrence interval flood (the magnitude of the 2-year flood is estimated to be 240,000 cubic feet per second, as presented in Michael Baker Jr., Inc. and Hydroconsult EN3 Services, Ltd., 2002).

5.0 Erosion and Scour

5.1 Gravel Pad and Road Erosion

Alpine's gravel pads and roads were inspected for erosion on 13 June – approximately six days after the peak water surface elevation had occurred. The inspection was performed in order to determine if any erosion of the roads and pads had occurred as a result of contact with spring breakup floodwaters. No significant erosion due to breakup flows was observed anywhere along the gravel structures. At no location was the erosion of more than 20 cubic yards of gravel per hundred linear feet of infield gravel placement noted, thus the requirements of USACE 2-96087 are met and additional reporting or remedial action plans are not required at this time.

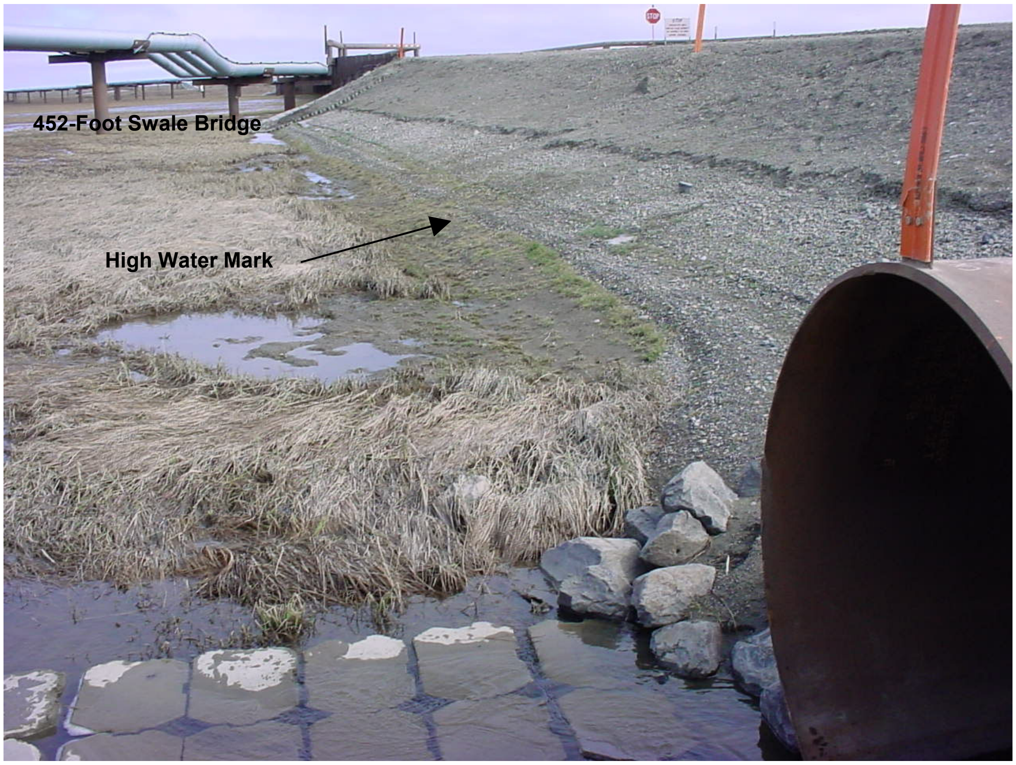
In areas where inundation did occur, some minor settlement of fine-grained material was noted, however, no slumping or side slope deterioration was noted. High water marks were noted on the gravel structures. Such marks were identified where grasses and other floating debris were stranded on the gravel side slopes, or where fine-grained materials had been washed from the gravel. High water marks along the CD-2 access road are presented on Photos 5-1 through 5-3.

13 June 2003

Photo 5-1 Looking west on the north side of the CD-2 access road from Culvert # 24.

13 June 2003

Photo 5-2 Looking west on the south side of the CD-2 access road from Culvert # 24.



13 June 2003

Photo 5-3 Looking east on the north side of the CD-2 access road from Culvert # 24.

6.0 Lake Recharge

Lakes L9312, L9313, L9282, and L9342 were monitored during breakup to assess recharge and the mechanisms causing recharge. Water surface elevations at Lakes L9312 and L9313 were measured with permanent staff gages #9 and #10, respectively. Water surface elevations at Lakes L9342 and L9282 were surveyed using temporary benchmarks installed by Kuukpik/LCMF, Inc. Summaries of field observations are provided below and in the accompanying tables and photographs. The monitoring of Lakes L9312 and L9313 was completed to comply with the following permits:

- AK 9703-030G, Page 8, Item 16
- FG99-111-0051, Page 2, Item 3
- FG97-111-0190-Amendment 1, Page 2, Item 1

6.1 Lake L9312

Prior to breakup, the water surface elevation in Lake L9312 was 7.93 feet, measured on 4 June. Breakup floodwaters did not rise high enough to reach Lake L9312, however, it was apparent from readings at permanent staff gage #9 that the lake was sufficiently recharged by local melt within its drainage basin for the water surface elevation to reach bankfull stage. A peak water surface elevation of 8.01 feet was recorded on 10 June at the lake. The water surface elevation remained static through 12 June and then showed minor fluctuations between elevations of 7.96 and 8.00 feet until receding to an elevation of 7.95 feet on 15 July. Water surface elevations for Lake L9312 are presented in Table 3-4. The lake is shown during breakup on Photos 3-4, 3-5, 3-6, and 6-1.

6.2 Lake L9313

Prior to breakup, the water surface elevation in Lake L9313 was 5.99 feet, measured on 29 May. On 8 June, floodwaters originating from the Sakoonang Channel began flowing into the lake. The floodwaters first flowed into Lake M9525, and then from Lake M9525 into Lake L9313 through the low divide separating the two lakes. The water surface elevation at Lake L9313 reached a peak of 7.12 feet on the morning of 9 June. The lake water surface elevation then began to gradually recede as water levels in the river dropped, reaching a lake water surface elevation of 6.14 on 2 July. The water surface elevation increase of 1.13 feet that occurred during breakup, coupled with the 0.98-foot recession following the peak stage indicates that the lake was recharged to above bankfull stage. Water surface elevations for Lake L9313 are presented in Table 3-5. Photos 3-1 through 3-6, and 6-1 through 6-3 show the lake during breakup and recharge to the lake from floodwaters.

6.3 Lake L9282

Prior to breakup, the water surface elevation in Lake L9282 was 8.72 feet, measured on 29 April. A water surface elevation of 9.08 feet was recorded on 12 June. Aerial observations of the channel connecting Lake L9282 and the Sakoonang Channel indicated that breakup flood flows did not reach Lake L9282. Evidence of this can be seen on Photos 6-4 and 6-5 taken on 6 June and 10 June, respectively. Recharge to Lake L9282 was therefore restricted to the melting of ice and snow within the lake's drainage basin. Water surface elevations for Lake L9282 are presented in Table 6-1.

6.4 Lake L9342

Prior to breakup, the water surface elevation in Lake L9342 was 8.78 feet, measured on 29 April. A water surface elevation of 9.09 feet was recorded on 12 June. No evidence of recharge from the Sakoonang Channel was observed. Recharge to Lake L9342 was therefore restricted to the melting of ice and snow within the lake's drainage basin. Water surface elevations for Lake L9342 are presented in Table 6-2.

Table 6-1 Lake L9282 Water Surface Elevations and Observations

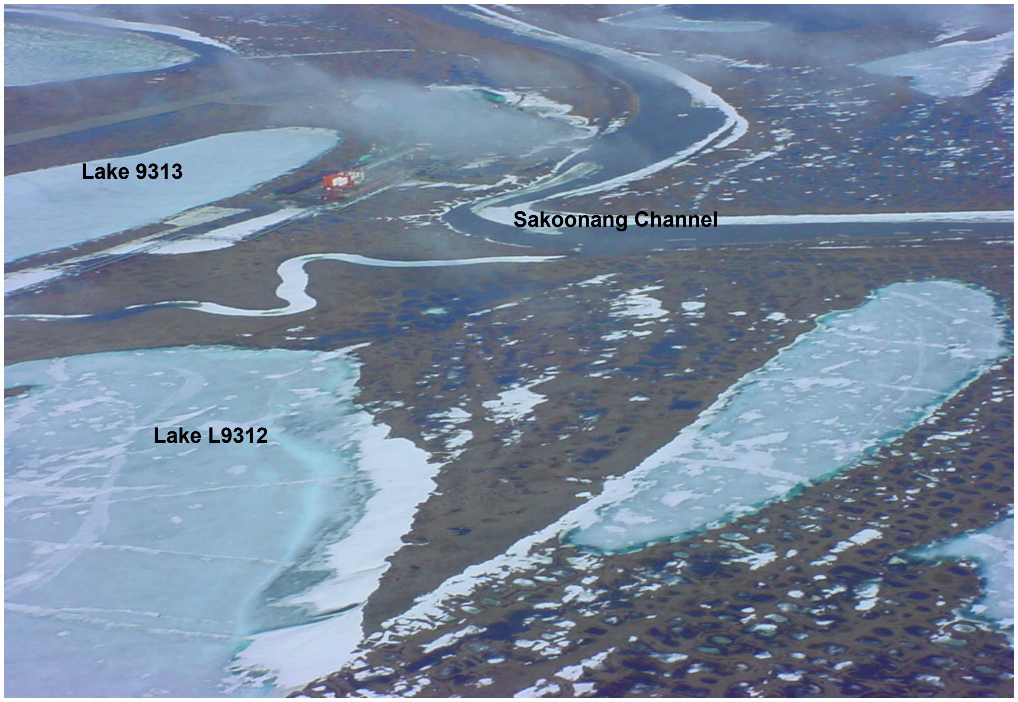
Date	Water Surface Elevation (feet BPMSL)	Observations
4/29/03	8.72	Lake is frozen. Water surface elevation surveyed by Kuukpik/LCMF, Inc. through a hole augered into the ice.
6/12/03	9.08	Lake is generally ice-covered with open water around the shoreline only.

Notes:
1. Water surface elevation measured by surveying from reference elevations of 13.70, 12.81, and 13.24 feet located on TBM 02-01-36 A, 02-01-37 J, and 02-01-37-K, respectively.
The TBM's and elevations were established by Kuukpik/LCMF, Inc. in April 2003.

Table 6-2 Lake L9342 Water Surface Elevations and Observations

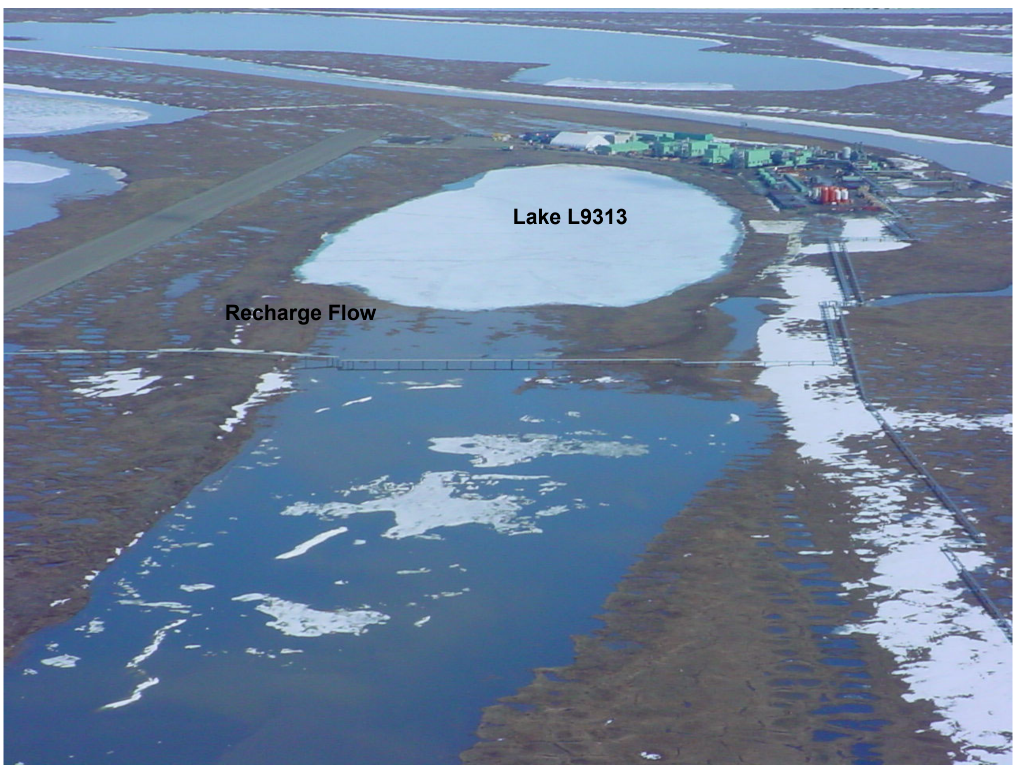
Date	Water Surface Elevation (feet BPMSL)	Observations
4/29/03	8.78	Lake is frozen. Water surface elevation surveyed by Kuukpik/LCMF, Inc. through a hole augered into the ice.
6/12/03	9.09	Lake is generally ice-covered with open water around the shoreline only.

Notes:
1. Water surface elevation measured by surveying from reference elevations of 13.70, 12.81, and 13.24 feet located on TBM 02-01-36 A, 02-01-37 J, and 02-01-37-K, respectively.
The TBM's and elevations were established by Kuukpik/LCMF, Inc. in April 2003.



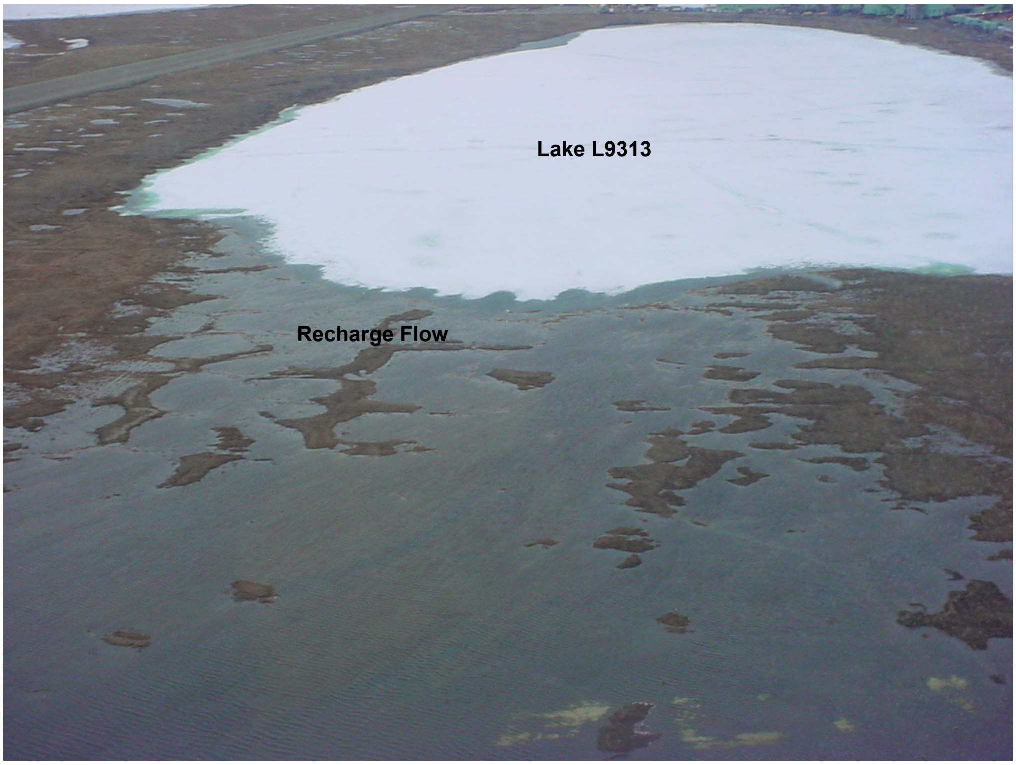
6 June 2003.

Photo 6-1 Lake L9312. View looking northeast. No breakup flood flow recharge from the Sakoonang Channel to the lake is occurring.



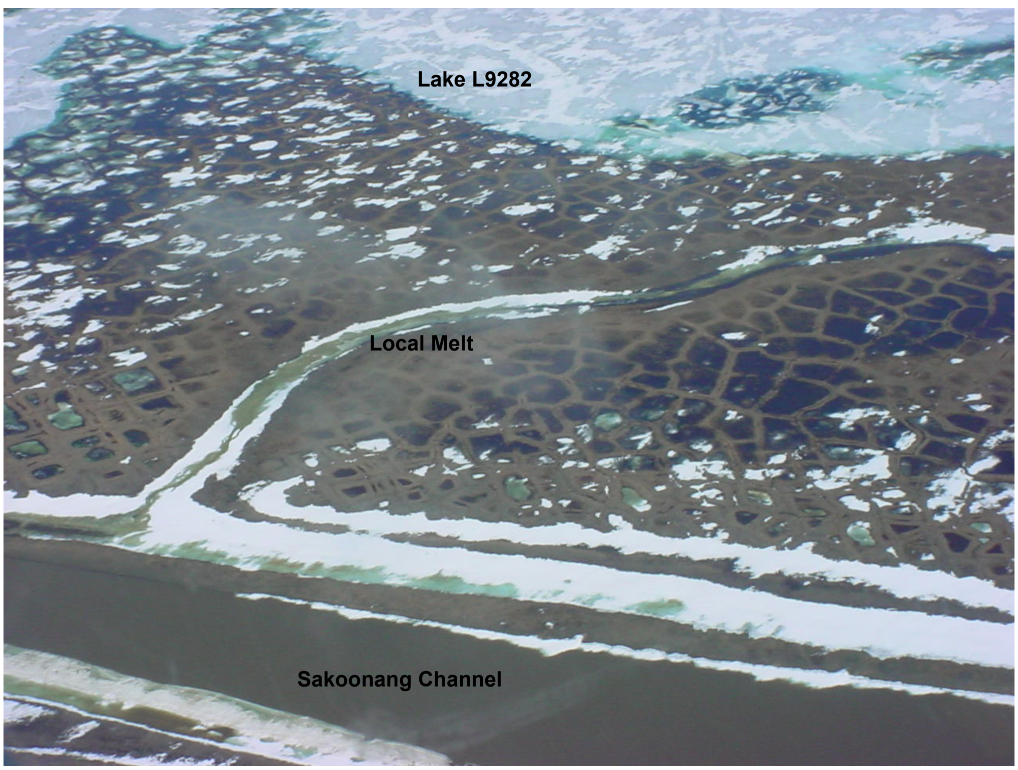
8 June2003.

Photo 6-2 Breakup flood flow recharge to Lake L9313. View looking northeast.



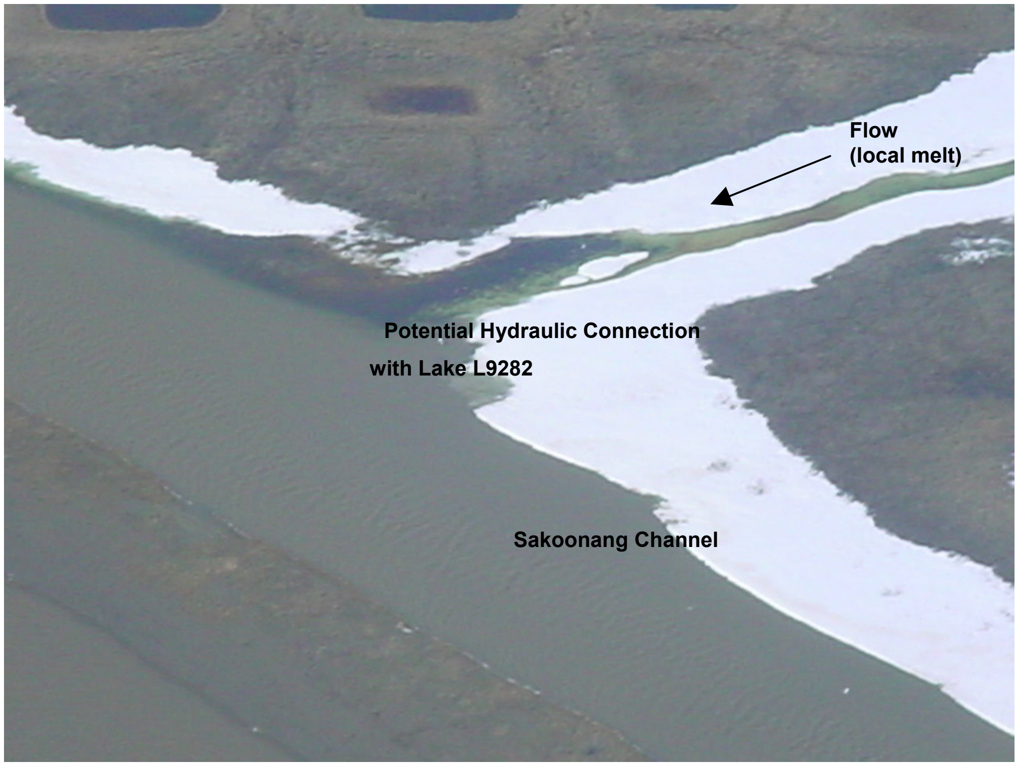
10 June 2003

Photo 6-3 Breakup flood flow recharge to Lake L9313. View looking northeast.



6 June 2003.

Photo 6-4 Lake L9282. View looking north. No breakup flood flow recharge from the Sakoonang Channel to the lake is occurring.



10 June 2003.

Photo 6-5 Detail of potential hydraulic connection between the Sakoonang Channel and Lake L9282. View looking north. No breakup flood flow recharge from the Sakoonang Channel to the lake is occurring.

7.0 Channel Ice Observations

Channel ice surveys began on 1 June when water first reached the temporary staff gages in the Monument 01 vicinity. Channel ice surveys were performed daily until 11 June when the secondary peak water surface elevation occurred at Monument 01. After 9 June, the major channels of the delta were essentially clear of channel ice and ice jams. The area covered by the surveys included the main channel of the Colville River north from a point approximately eight river miles upstream from Monument 01 to the head of the Putu Channel (the northern connection between the Nigliq Channel and the main channel of the Colville); the full length of the Nigliq Channel; and the Sakoonang Channel north from a point approximately two miles downstream of the head of the channel to approximately five river miles downstream of the Alpine facilities. Observations of ice jamming and the clearing of channel ice are shown on Figures 7-1 through 7-8, for the period 2 June through 9 June.

7.1 Channel Ice

Cool temperatures characterized the early stages of breakup in the delta. As noted previously, water was first noted flowing in the channel near Monument 01 on 27 May. As flows gradually increased over the next week, low water channel ice began floating and lifting in place in a roughly north to south progression. By 4 June, water in the main channel of the Colville near Monument 01 was flowing over and around ribbon ice (intact, partially-floating low water channel ice). By 6 June, after the occurrence of the initial peak water surface elevation, the rotting ribbon ice had broken up and floated downstream, leaving the main channel of the Colville free of ice.

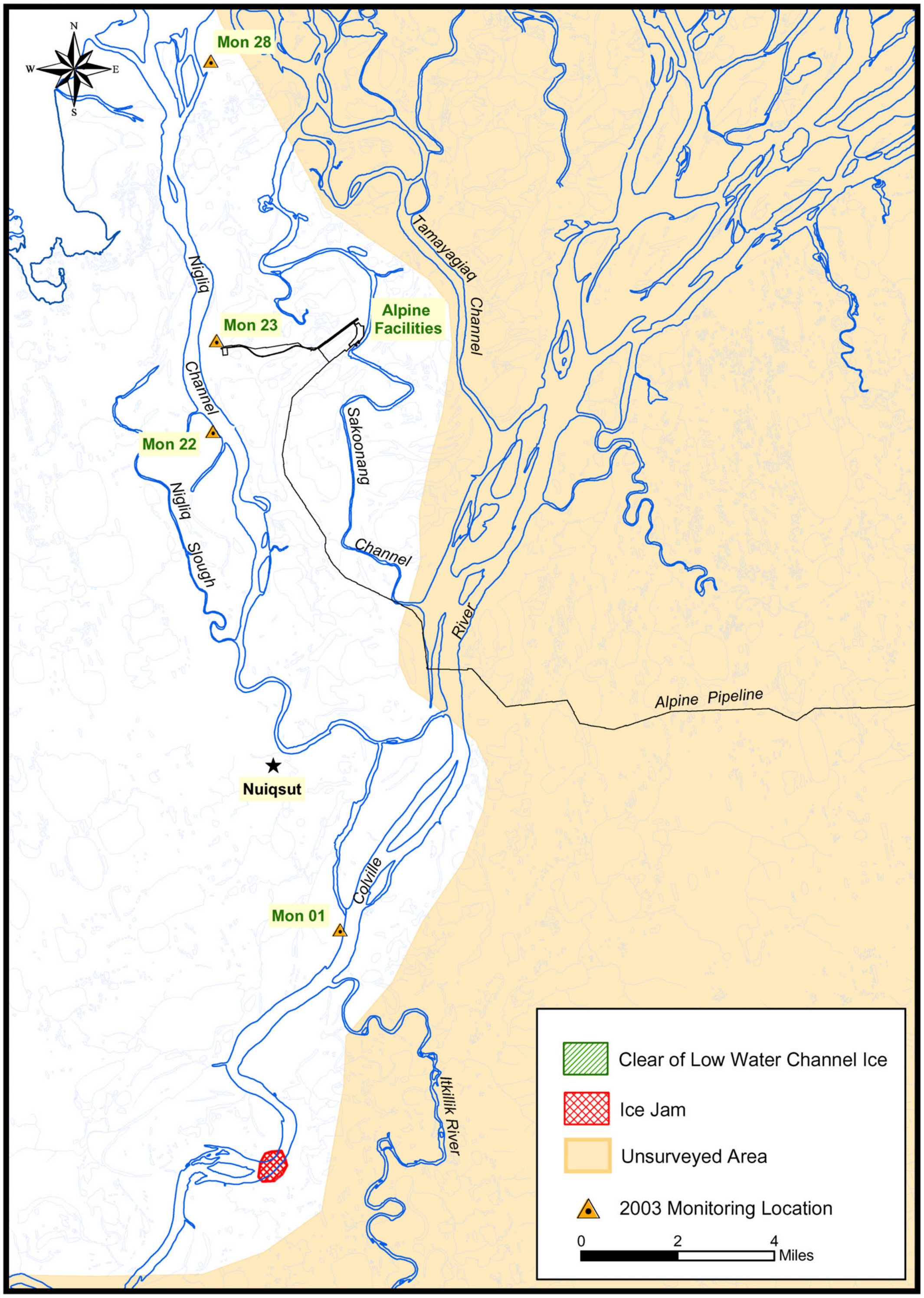
On the Nigliq Channel, by 3 June, water was flowing over and around ribbon ice from the head of the channel north to near CD-2. To the north of CD-2, low water channel ice had not yet lifted. By 5 June, the Nigliq channel was ice free from the head of the channel to a point just upstream of Nuiqsut, and the remaining intact low water channel ice had lifted, forming ribbon ice. Ice had cleared from the Nigliq Channel as far north as the CD-South (CD-4) area by 6 June. On 7 June, ice had cleared as far north as Monument 22, and the channel near Monument 28 was ice free. By 8 June, the entire Nigliq Channel was ice free.

In the Sakoonang Channel, turbid flow over intact low water channel ice was noted from near the Alpine facility north toward Harrison Bay on 2 June. By 4 June, the channel ice on the Sakoonang had lifted in place forming ribbon ice, and was becoming rotten. On 8 June, the Sakoonang Channel was ice free from near the head of the channel to just north of the Alpine facility. The ice was rapidly deteriorating and by 9 June, the Sakoonang Channel was clear of ice.

7.2 Ice Jams

Few ice jams were observed in the Colville River Delta in 2003. Small, short-lived ice jams were noted in the Nigliq Channel near Nuiqsut on 3 through 6 June. All of the Nigliq Channel ice jams were surface jams rather than grounded jams. As a result, they did not produce any notable effects on water surface elevations in the channel.

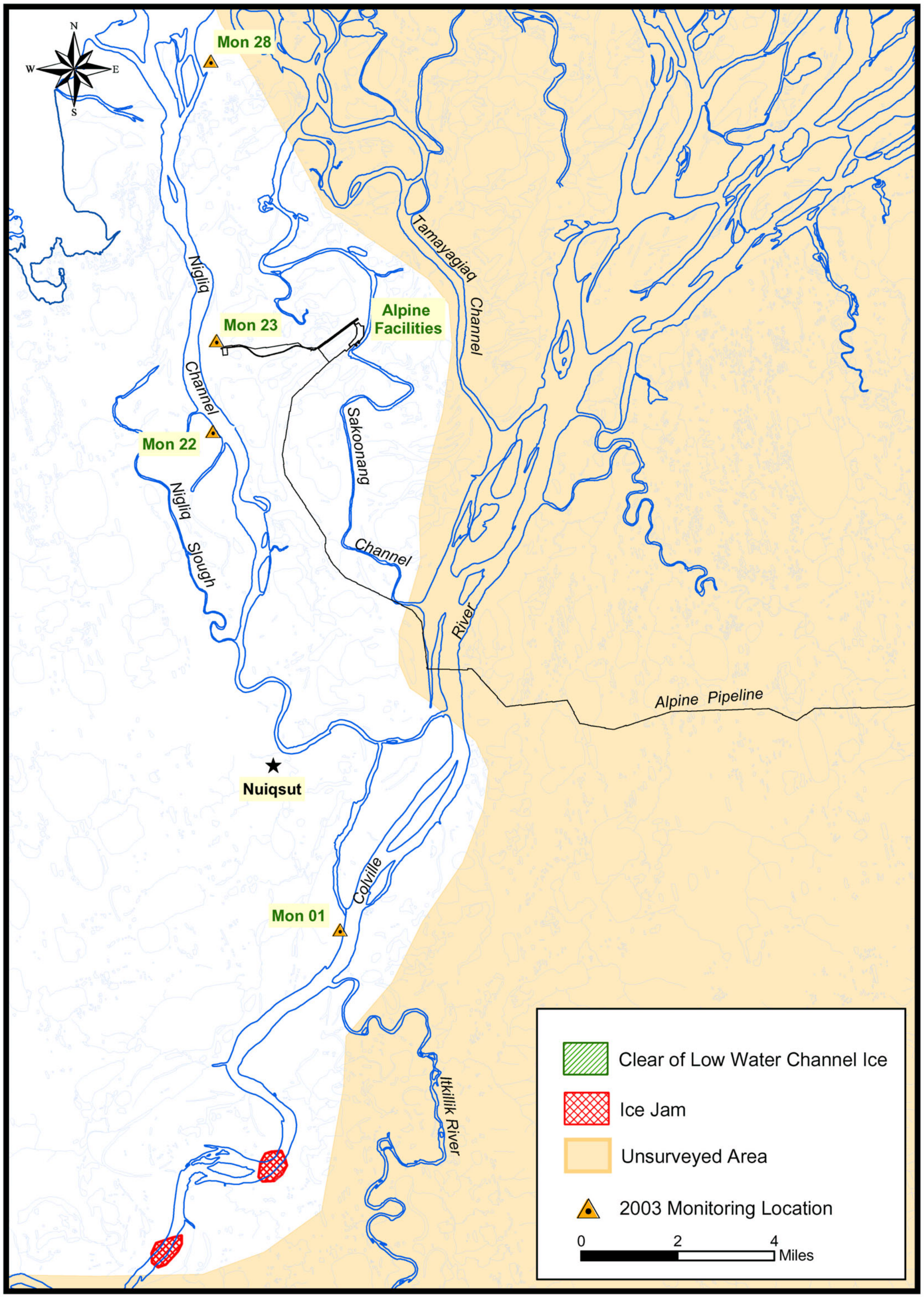
Ice jamming was more common in the main channel of the Colville River upstream and to the south of the delta. A surface ice jam was observed on 1 June approximately 17.5 river miles upstream from Monument 01. By 3 June the ice jam had moved downstream approximately three miles and was over one mile long. On 5 June the ice jam had broken apart and large pans of ice were noted flowing past the temporary staff gages at Monument 01. A small ice jam was also observed at the mouth of the Itkillik River on 5 June.



Alpine Colville River Area
Low Water Channel Ice Survey, June 2, 2003
Figure 7-1

ConocoPhillips

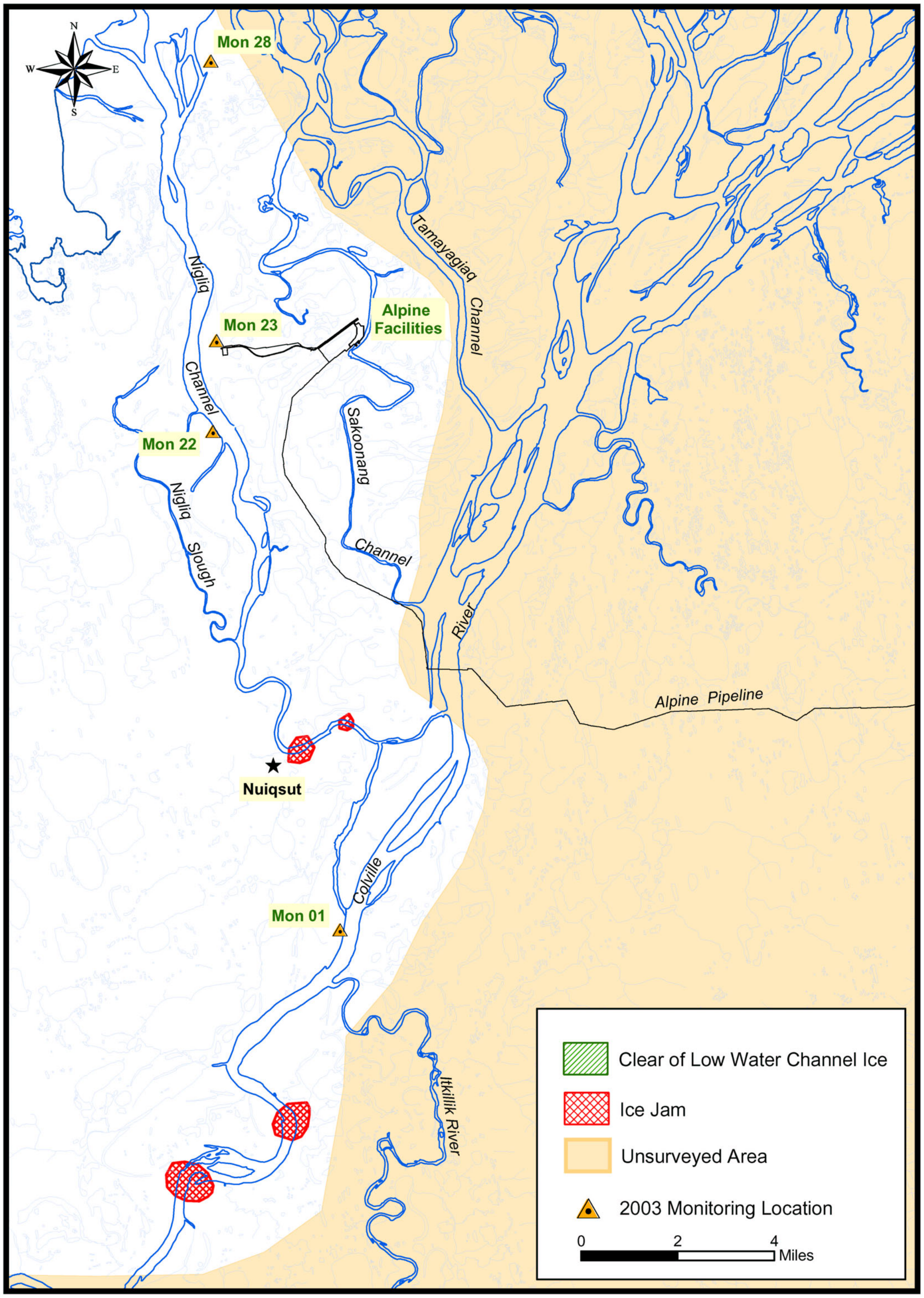
Baker



Alpine Colville River Area
Low Water Channel Ice Survey, June 3, 2003
Figure 7-2

ConocoPhillips

Baker

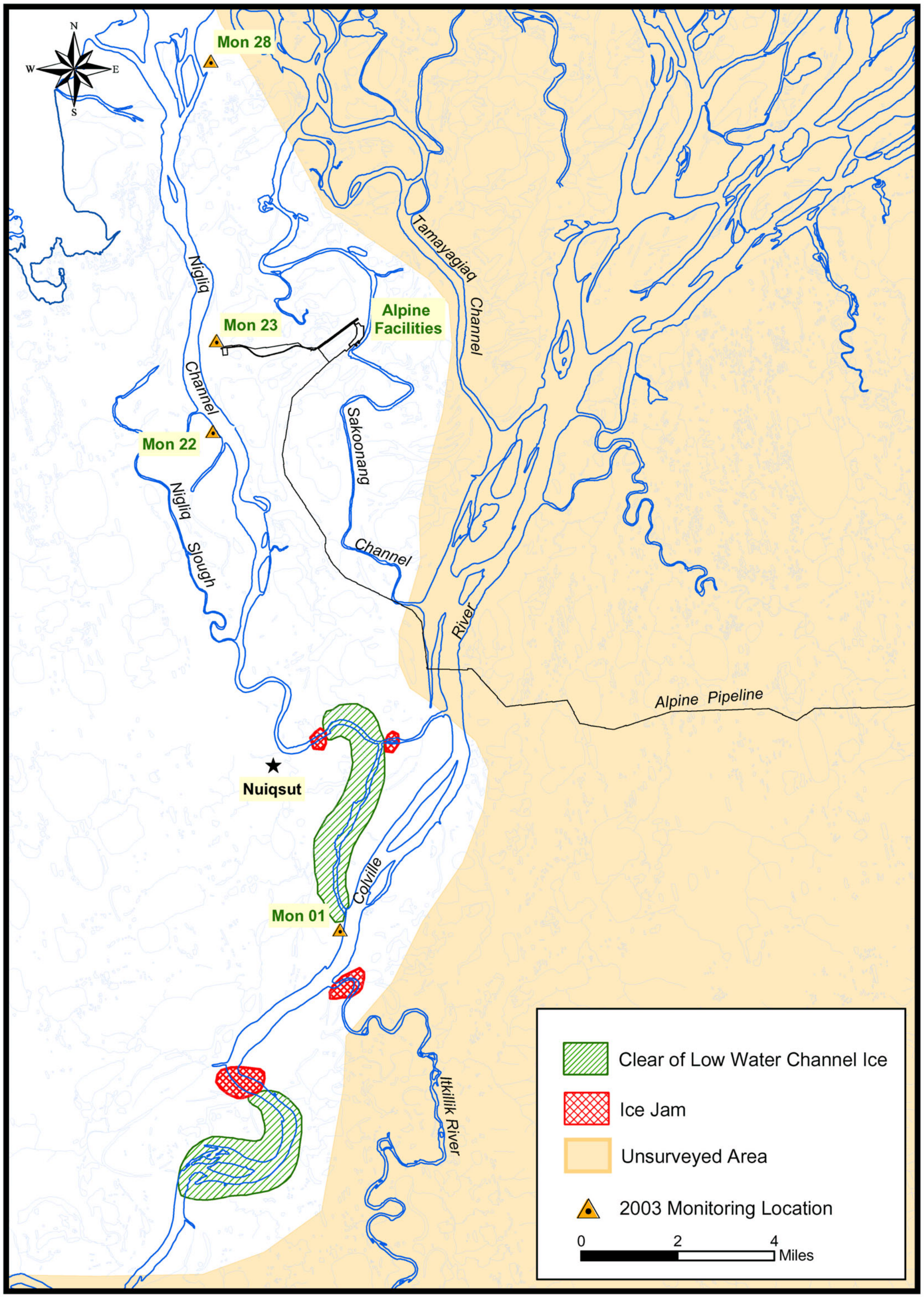


Alpine Colville River Area
Low Water Channel Ice Survey, June 4, 2003

Figure 7-3

ConocoPhillips

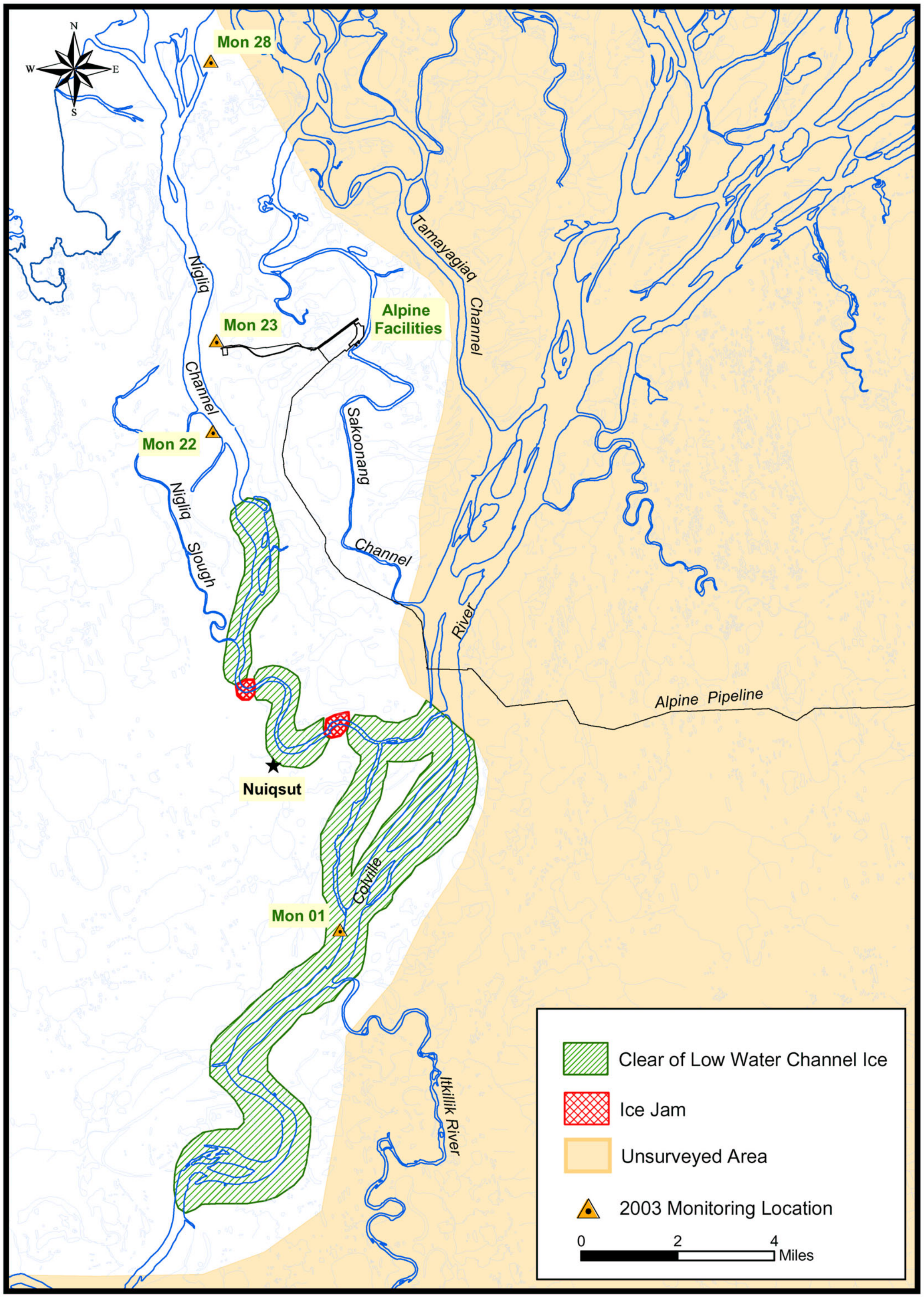
Baker



Alpine Colville River Area
Low Water Channel Ice Survey, June 5, 2003
Figure 7-4

ConocoPhillips

Baker

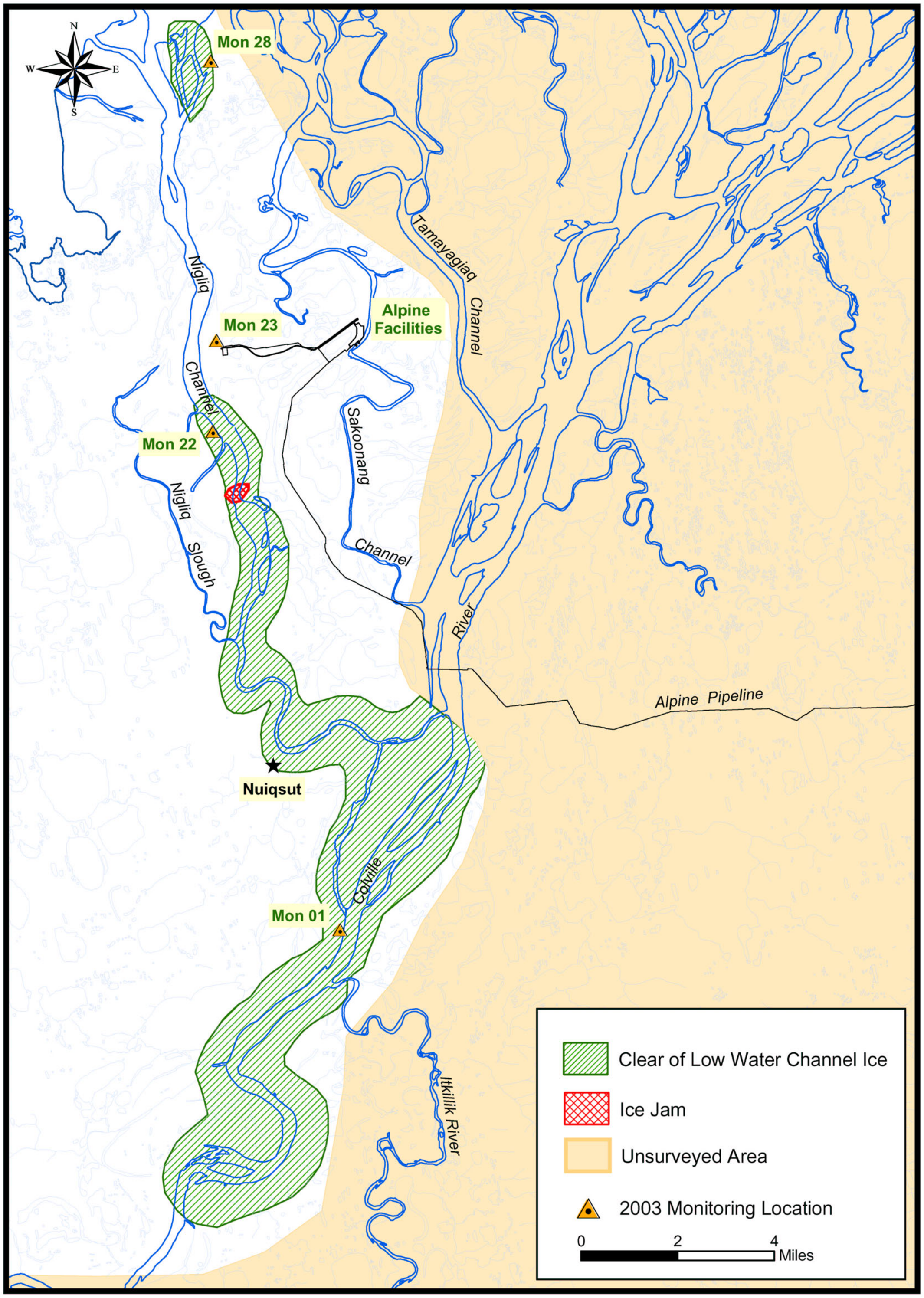


Alpine Colville River Area
Low Water Channel Ice Survey, June 6, 2003

ConocoPhillips

Figure 7-5

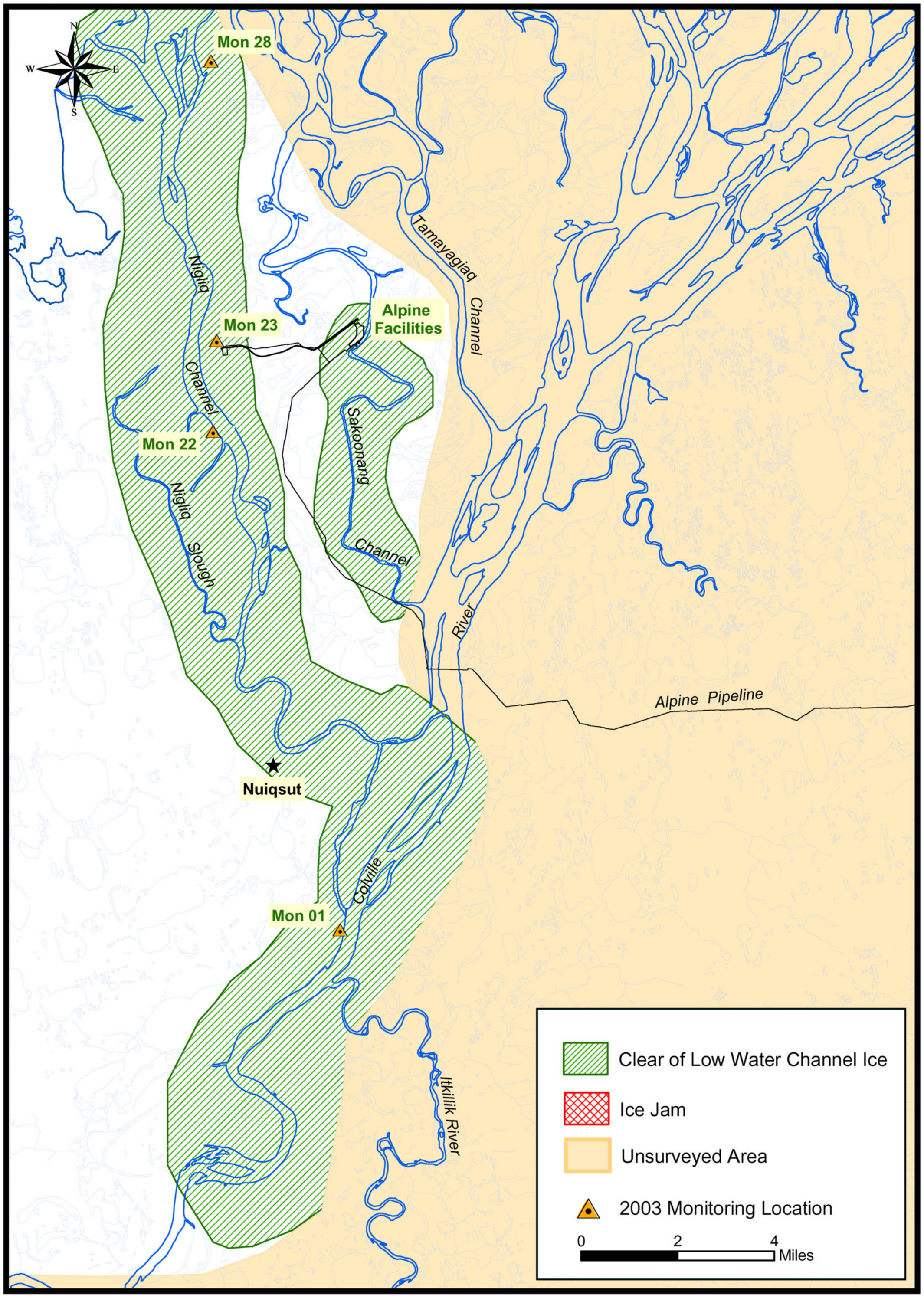
Baker



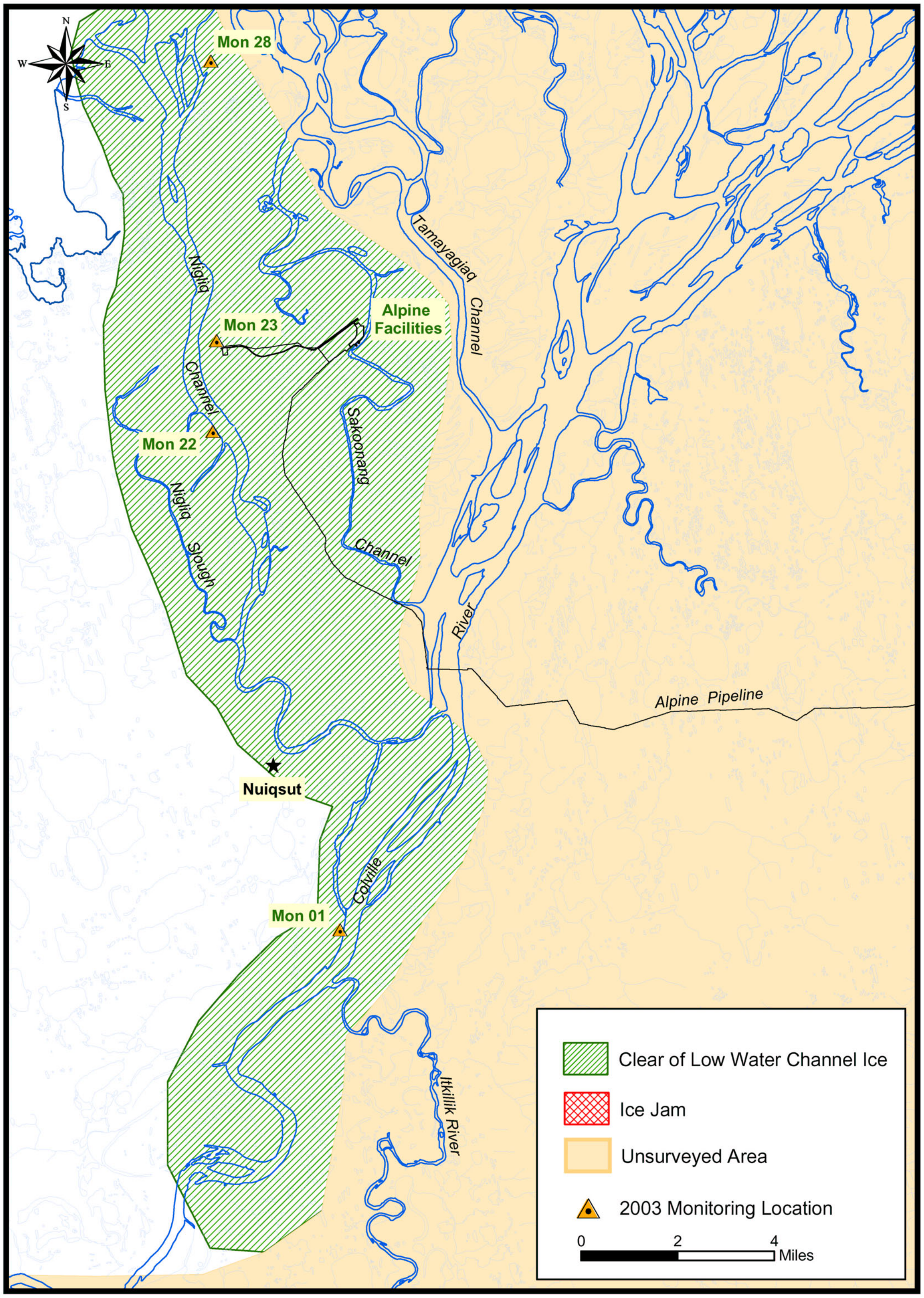
Alpine Colville River Area
Low Water Channel Ice Survey, June 7, 2003
Figure 7-6

ConocoPhillips

Baker



Alpine Colville River Area
Low Water Channel Ice Survey, June 8, 2003
Figure 7-7



Alpine Colville River Area
Low Water Channel Ice Survey, June 9, 2003
Figure 7-8

ConocoPhillips

Baker

8.0 References

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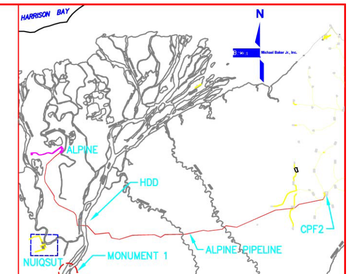
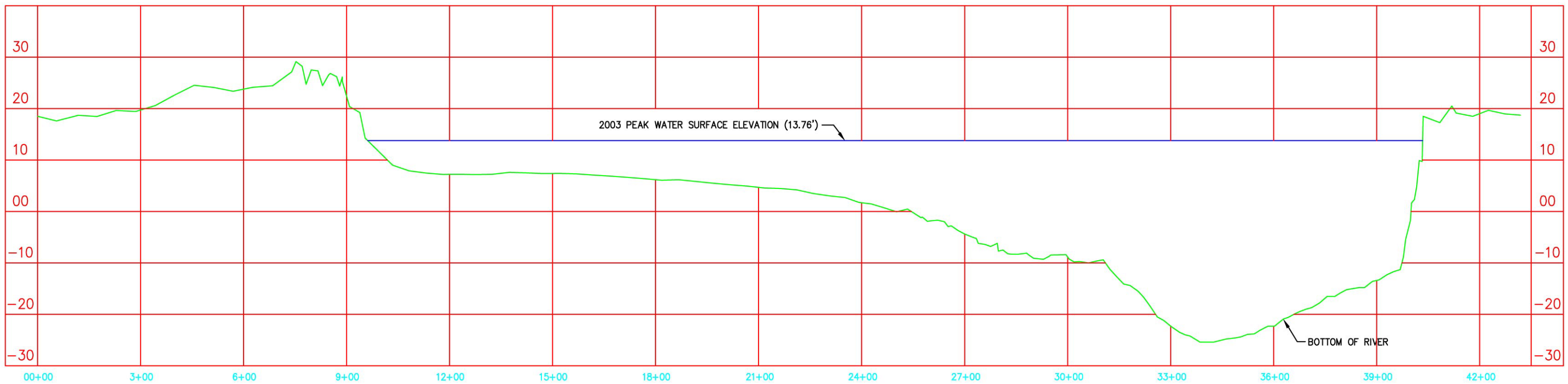
Appendix A Cross-Section Data — Head of the Delta

NOTES

1. CHANNEL PROFILE MEASUREMENTS COMPLETED JULY 17, 2002 BY KUUKPIK/LCMF INC.
2. ELEVATIONS SHOWN ARE REFERENCED TO BRITISH PETROLEUM MEAN SEA LEVEL DATUM.



LOCATION MAP
NOT TO SCALE



LEFT BANK

COLVILLE RIVER PROFILE AT MONUMENT 1

RIGHT BANK

10 0 10 20
VERTICAL SCALE IN FEET

150 0 150 300
HORIZONTAL SCALE IN FEET

Baker Michael Baker Jr., Inc.

ConocoPhillips

100876C002 07/28/03

REFERENCE DWG NO/SHT NO:	REV	DATE	REVISIONS	BY	CHK	ENGR	LEAD ENGR	PROJ ENGR	ENG MGR	PROJ MGR	CLIENT

FOR NO:	SCALE: AS NOTED	DRAWN: M. COX	
REDRAWN FROM:		DATE: 07/28/03	

CONSULTANT DRAWING NUMBER:
DO NOT SCALE — ABOVE SCALE FOR REFERENCE ONLY

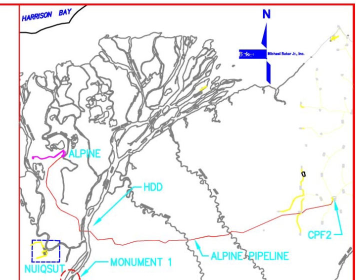
MODULE: COLVILLE RIVER MONUMENT 1 PROFILE JULY 15, 2002
UNIT:

JOB NO:	SUB JOB NO:	DRAWING NO.	SHEET:	REV:
100876		100876C002	1 of 1	

FORM: DBDR-ALP

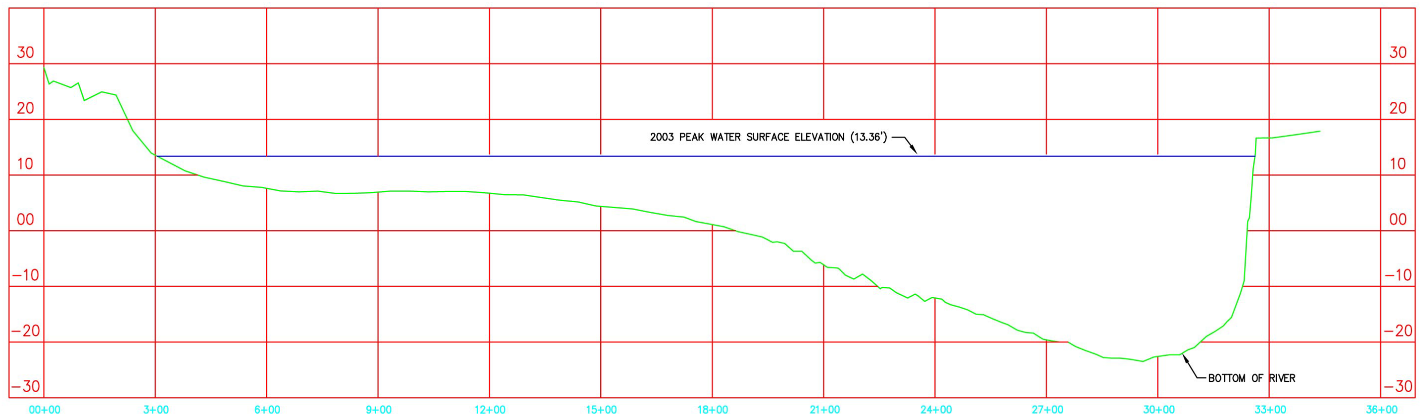
NOTES

1. CHANNEL PROFILE MEASUREMENTS COMPLETED JULY 17, 2002 BY KUUKPIK/LCMF INC.
2. ELEVATIONS SHOWN ARE REFERENCED TO BRITISH PETROLEUM MEAN SEA LEVEL DATUM.



LOCATION MAP

NOT TO SCALE



LEFT BANK

COLVILLE RIVER PROFILE AT MONUMENT 1 DOWNSTREAM

RIGHT BANK

VERTICAL SCALE IN FEET (10 0 10 20)

HORIZONTAL SCALE IN FEET (150 0 150 300)

Michael Baker Jr., Inc.

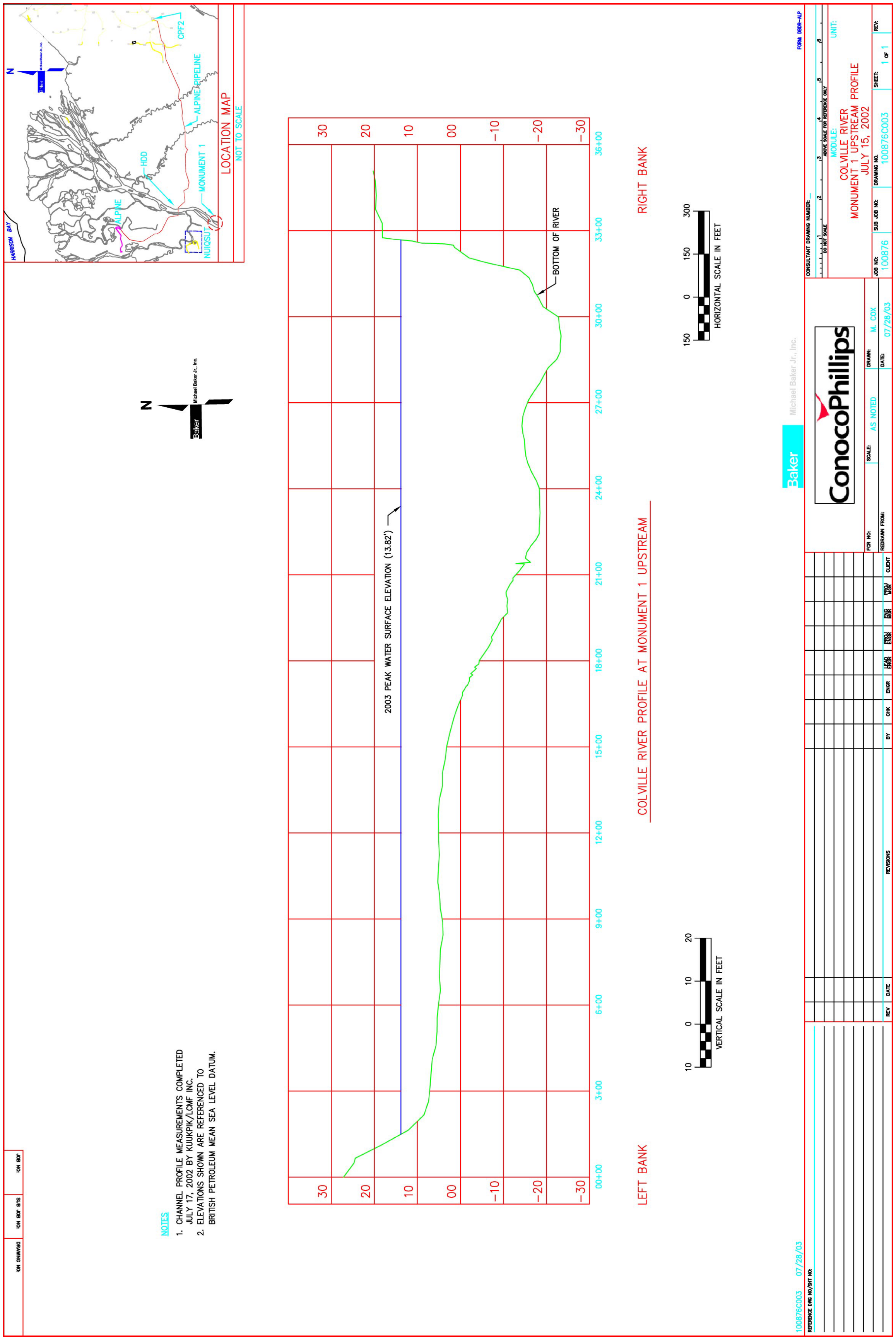
100876C004 07/28/03

ConocoPhillips

SCALE:	AS NOTED	DRAWN:	M. COX
REDRAWN FROM:		DATE:	07/28/03

MODULE: COLVILLE RIVER
MONUMENT 1 DOWNSTREAM PROFILE
JULY 15, 2002

JOB NO:	SUB JOB NO:	DRAWING NO.	SHEET:	REV:
100876		100876C004	1 OF 1	


NOTES
1. CHANNEL PROFILE MEASUREMENTS COMPLETED JULY 17, 2002 BY KUUKPIK/LCMF INC.
2. ELEVATIONS SHOWN ARE REFERENCED TO BRITISH PETROLEUM MEAN SEA LEVEL DATUM.
LOCATION MAP
NOT TO SCALE
HARRISON BAY
CPF2
ALPINE PIPELINE
HDD
MONUMENT 1
ALPINE
NUIQSUT
N
2003 PEAK WATER SURFACE ELEVATION (13.82')
BOTTOM OF RIVER
30
20
10
00
-10
-20
-30
00+00
3+00
6+00
9+00
12+00
15+00
18+00
21+00
24+00
27+00
30+00
33+00
36+00
LEFT BANK
COLVILLE RIVER PROFILE AT MONUMENT 1 UPSTREAM
RIGHT BANK
VERTICAL SCALE IN FEET
HORIZONTAL SCALE IN FEET
Baker
Michael Baker Jr., Inc.
ConocoPhillips
SCALE: AS NOTED
DRAWN: M. COX
DATE: 07/28/03
JOB NO: 100876
DRAWING NO. 100876C003
SHEET: 1 OF 1
COLVILLE RIVER
MONUMENT 1 UPSTREAM PROFILE
JULY 15, 2002
100876C003 07/28/03
FORM: DBDR-ALP

Appendix B Discharge Measurement Notes

DISCHARGE MEASUREMENT NOTES

LOCATION: Alpine 452-Foot Swale Bridge

Date: June 8, 2003 **Party:** Jon Wolf, Hans Arnett

Width: 444 **ft** **Area:** 477.5 **ft²** **Vel:** 0.88 **fps** **G.H.:** **Discharge:** 420 **cfs**

No Secs. **G.H. change:** **in.:** **hrs.:** **Susp.:**

Method coef.: **Hor. Angle coef.** **Sus. Coef.:** **Meter No.**

Gage Readings			
Time	**Recorder**	**Inside**	**Outside**
See Tables 2-1 though 2-8			
Weighted M.G.H.			
G.H. corrections			
Correct M.G.H.			

Type of meter: Price AA

Date rated:

Meter: 0.5 **ft. above bottom of weight.**

Spin before meas. 4 min 13 sec **after** 4 min 10 sec

Method:

Wading rod

Levels obtained: Yes, before and after

Measurement rated: Good

Rating based on following conditions:

Cross section: Fairly uniform channel

Flow: Uniform & steady

Weather: Sunny **Air Temp.** ~45 degrees F

Gage: **Water Temp.** ~36 degrees F

Other:

Record Removed: **Intake flushed:** N/A

Observer

Control Open channel flow. Bridge opening clear of ice and snow. No floating ice present in approaching flow.

Remarks Snow upstream of left abutment but not affecting flow.

G.H. of zero flow: **ft.**

Angle Coef. (deg)	Dist. From Initial Point (ft)	Width (ft)	Depth (ft)	Observ. depth (ft)	Revo-lutions	Time (sec)	VELOCITY At Point (fps)	VELOCITY Mean in-vertical (fps)	Adjust for Angle Coef.	Adjusted Velocity (fps)	Area (s.f.)	Discharge (cfs)	Description
20	1	14.5	1.3	0.6	29	40	1.6	1.6	0.94	1.5	18.1	27	LEW @ bridge abutment
5	30	29.5	1.3	0.6	8	40	0.5	0.5	1.00	0.5	38.4	17	
0	60	30.0	1.1	0.6	11	40	0.6	0.6	1.00	0.6	33.0	20	
0	90	30.0	1.0	0.6	7	40	0.4	0.4	1.00	0.4	30.0	12	pier at measurement location
0	120	30.0	1.0	0.6	18	40	1.0	1.0	1.00	1.0	30.0	30	
0	150	30.0	1.0	0.6	16	40	0.9	0.9	1.00	0.9	30.0	27	
0	180	30.0	0.8	0.6	15	40	0.8	0.8	1.00	0.8	24.0	20	
5	210	30.0	0.9	0.6	17	40	0.9	0.9	1.00	0.9	27.0	25	
5	240	30.0	1.4	0.6	19	40	1.1	1.1	1.00	1.1	42.0	44	
0	270	30.0	1.5	0.6	15	40	0.8	0.8	1.00	0.8	45.0	38	
0	300	30.0	1.3	0.6	19	40	1.1	1.1	1.00	1.1	39.0	41	
25	330	30.0	0.9	0.6	16	40	0.9	0.9	0.91	0.8	27.0	22	
25	360	30.0	1.2	0.6	14	40	0.8	0.8	0.91	0.7	36.0	26	
20	390	30.0	1.2	0.6	17	40	0.9	0.9	0.94	0.9	36.0	32	
0	420	27.5	0.8	0.6	16	40	0.9	0.9	1.00	0.9	22.0	20	
0	445	12.5	1.5	0.6	18	40	1.0	1.0	1.00	1.0	18.8	19	REW @ bridge abutment
TOTAL		**444.0**									**477**	**420**	**Page 2 of 2**

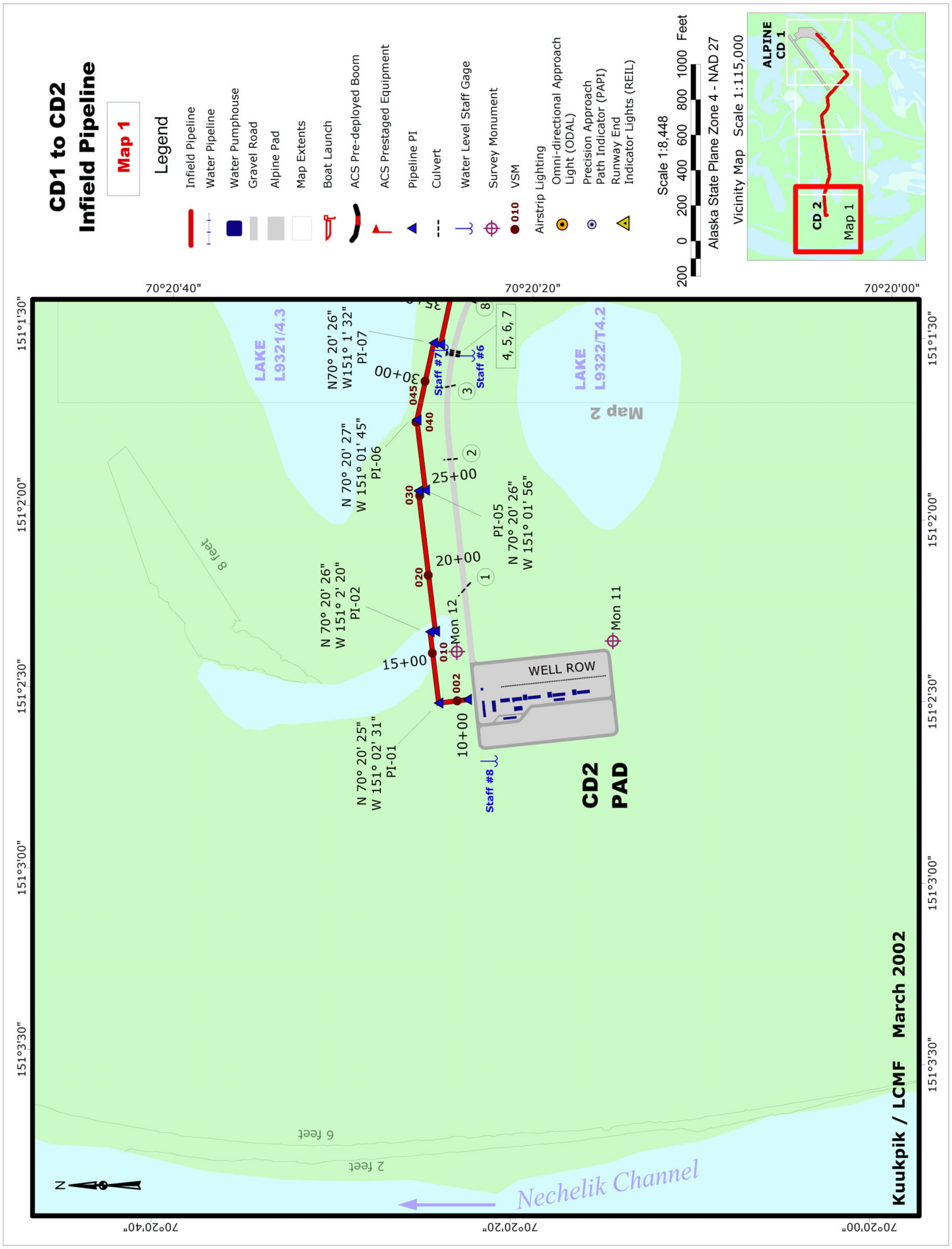
CD-2 Access Road, Culvert Discharge Measurements on June 8, 2003

Culvert Number	Time	Culvert Diameter (ft)	Water Depth (ft)	Observ. depth (ft)	Revo-lutions[1]	Time (sec)	VELOCITY At Point (fps)	VELOCITY Mean in-vertical (fps)	Area (s.f.)	Discharge (cfs)	Description
1	17:36										Localized melt only. No flow.
2	17:34										Localized melt only. No flow.
3	17:32										Localized melt only. No flow.
4	17:30										Localized melt only. No flow.
5	17:28										Localized melt only. No flow.
6	17:26										Localized melt only. No flow.
7	17:24										Localized melt only. No flow.
8	17:22										Localized melt only. No flow.
9	17:20										Localized melt only. No flow.
10	17:18										Localized melt only. No flow.
11	17:16										Localized melt only. No flow.
12	17:14										Localized melt only. No flow.
13	17:12										Localized melt only. No flow.
14	17:10										Localized melt only. No flow.
15	17:08										Localized melt only. No flow.
16	17:06										Localized melt only. No flow.
17	17:04										Localized melt only. No flow.
18	17:02										Localized melt only. No flow.
19	17:00										Localized melt only. No flow.
20	16:58										Localized melt only. No flow.
21	16:52										Localized melt only. No flow.
22	16:50										Localized melt only. No flow.
23	16:45	4	0.6	0.6	33	40	1.79	1.79	1.2	2.1	Breakup flood flow.
24	16:40	4	0.6	0.6	67	40	3.66	3.66	1.2	4.3	Breakup flood flow.
25	16:35										Localized melt only. No flow.
26	16:32										Localized melt only. No flow.
Total									**2.4**	**6.4**	

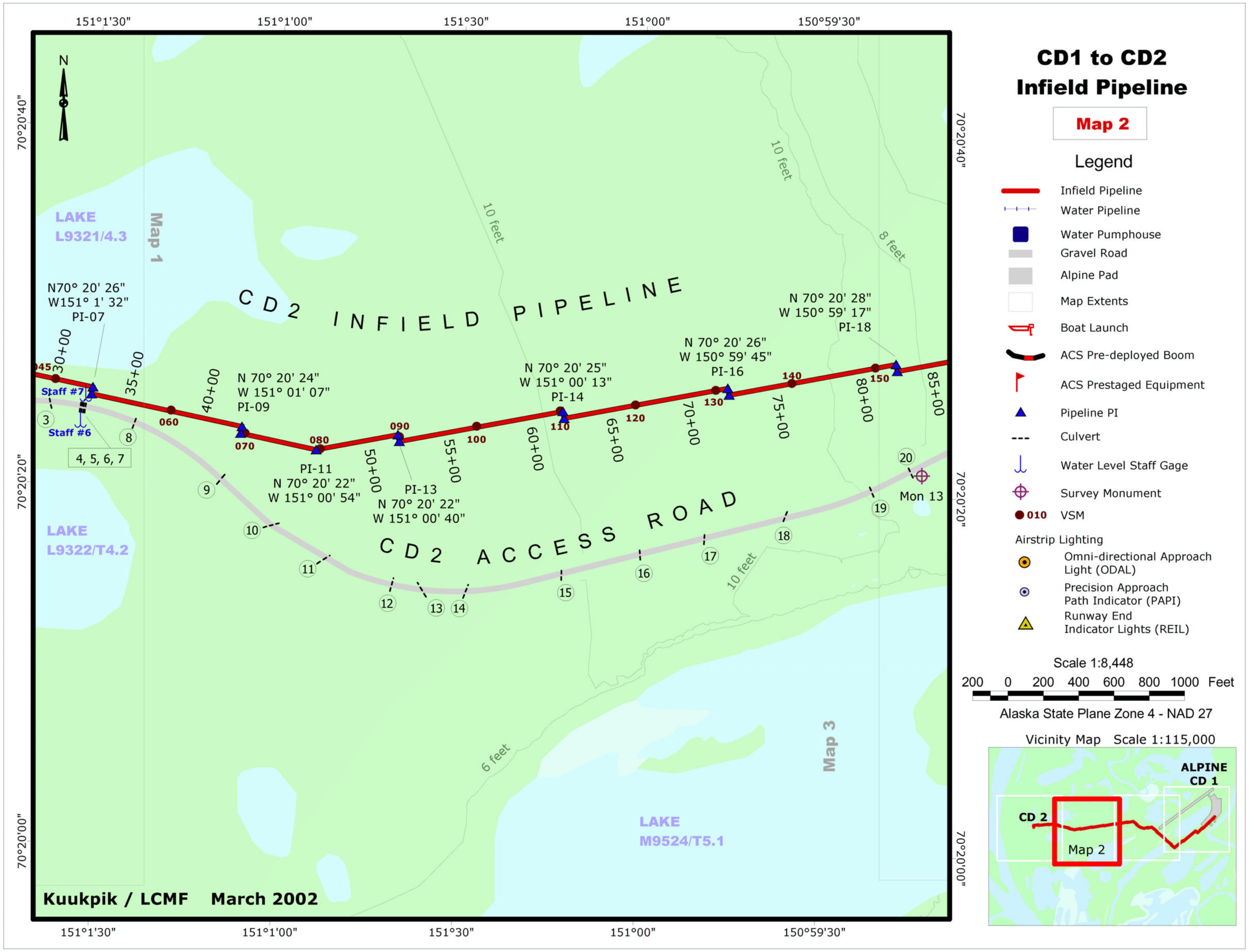
Notes:

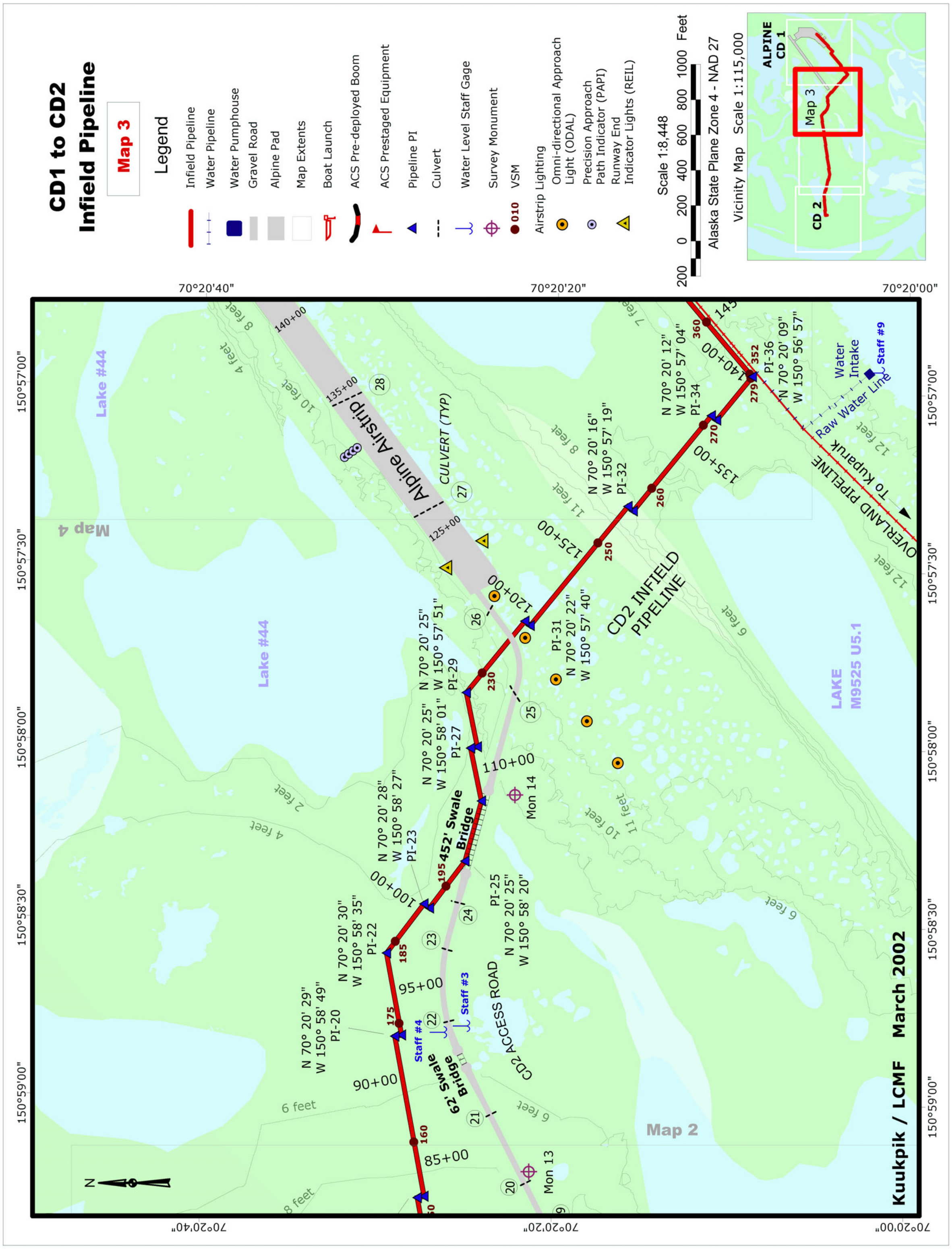
1 - A current meter digitizer was used.

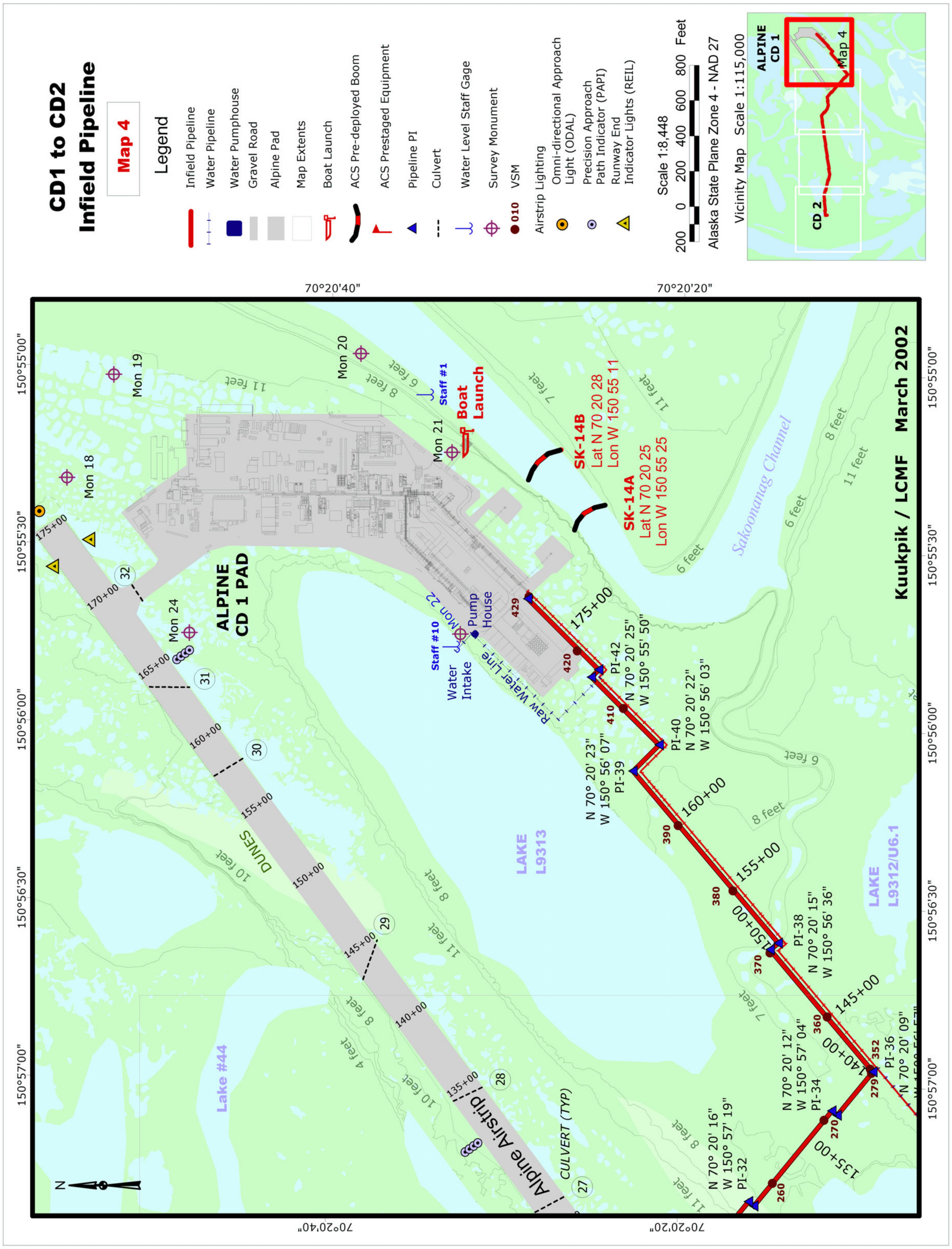
Appendix C Alpine Facilities Layout



CD1 to CD2
Infield Pipeline
Map 1
Legend
Infield Pipeline
Water Pipeline
Water Pumphouse
Gravel Road
Alpine Pad
Map Extents
Boat Launch
ACS Pre-deployed Boom
ACS Prestaged Equipment
Pipeline PI
Culvert
Water Level Staff Gage
Survey Monument
010 VSM
Airstrip Lighting
Omni-directional Approach Light (ODAL)
Precision Approach Path Indicator (PAPI)
Runway End Indicator Lights (REIL)
Scale 1:8,448
200 0 200 400 600 800 1000 Feet
Alaska State Plane Zone 4 - NAD 27
Vicinity Map Scale 1:115,000
ALPINE CD 1
CD 2
Map 1
LAKE L9321/4.3
LAKE L9322/T4.2
Map 2
CD2 PAD
WELL ROW
Nechelik Channel
Kuukpik / LCMF March 2002
N 70° 20' 25" W 151° 02' 31" PI-01
N 70° 20' 26" W 151° 2' 20" PI-02
PI-05 N 70° 20' 26" W 151° 01' 56"
N 70° 20' 27" W 151° 01' 45" PI-06
N70° 20' 26" W151° 1' 32" PI-07
10+00
15+00
20+00
25+00
30+00
Mon 11
Mon 12
Staff #6
Staff #7
Staff #8
4, 5, 6, 7
8 feet
6 feet
2 feet
N
70°20'40"
70°20'20"
70°20'00"
151°1'30"
151°2'00"
151°2'30"
151°3'00"
151°3'30"


CD1 to CD2
Infield Pipeline
Map 2
Legend
Infield Pipeline
Water Pipeline
Water Pumphouse
Gravel Road
Alpine Pad
Map Extents
Boat Launch
ACS Pre-deployed Boom
ACS Prestaged Equipment
Pipeline PI
Culvert
Water Level Staff Gage
Survey Monument
010 VSM
Airstrip Lighting
Omni-directional Approach Light (ODAL)
Precision Approach Path Indicator (PAPI)
Runway End Indicator Lights (REIL)
Scale 1:8,448
200 0 200 400 600 800 1000 Feet
Alaska State Plane Zone 4 - NAD 27
Vicinity Map Scale 1:115,000
ALPINE CD 1
CD 2
Map 2
CD2 INFIELD PIPELINE
CD2 ACCESS ROAD
LAKE L9321/4.3
LAKE L9322/T4.2
LAKE M9524/T5.1
Map 1
Map 3
N70° 20' 26" W151° 1' 32" PI-07
N 70° 20' 24" W 151° 01' 07" PI-09
PI-11 N 70° 20' 22" W 151° 00' 54"
PI-13 N 70° 20' 22" W 151° 00' 40"
N 70° 20' 25" W 151° 00' 13" PI-14
N 70° 20' 26" W 150° 59' 45" PI-16
N 70° 20' 28" W 150° 59' 17" PI-18
Staff #7
Staff #6
4, 5, 6, 7
Mon 13
10 feet
8 feet
6 feet
151°1'30"
151°1'00"
151°0'30"
151°0'00"
150°59'30"
70°20'40"
70°20'20"
70°20'00"
Kuukpik / LCMF March 2002


CD1 to CD2
Infield Pipeline
Map 3
Legend
Infield Pipeline
Water Pipeline
Water Pumphouse
Gravel Road
Alpine Pad
Map Extents
Boat Launch
ACS Pre-deployed Boom
ACS Prestaged Equipment
Pipeline PI
Culvert
Water Level Staff Gage
Survey Monument
VSM
Airstrip Lighting
Omni-directional Approach Light (ODAL)
Precision Approach Path Indicator (PAPI)
Runway End Indicator Lights (REIL)
Scale 1:8,448
200 0 200 400 600 800 1000 Feet
Alaska State Plane Zone 4 - NAD 27
Vicinity Map Scale 1:115,000
ALPINE CD 1
Map 3
CD 2
Kuukpik / LCMF March 2002
Alpine Airstrip
CD2 INFIELD PIPELINE
CD2 ACCESS ROAD
OVERLAND PIPELINE To Kuparuk
Raw Water Line
Water Intake
Lake #44
LAKE M9525 U5.1
Map 2
Map 4
452' Swale Bridge
62' Swale Bridge
CULVERT (TYP)
Mon 13
Mon 14
Staff #3
Staff #4
Staff #9
N 70° 20' 29" W 150° 58' 49" PI-20
N 70° 20' 30" W 150° 58' 35" PI-22
N 70° 20' 28" W 150° 58' 27" PI-23
PI-25 N 70° 20' 25" W 150° 58' 20"
N 70° 20' 25" W 150° 58' 01" PI-27
N 70° 20' 25" W 150° 57' 51" PI-29
PI-31 N 70° 20' 22" W 150° 57' 40"
N 70° 20' 16" W 150° 57' 19" PI-32
N 70° 20' 12" W 150° 57' 04" PI-34
PI-36 N 70° 20' 09" W 150° 56' 57"
85+00
90+00
95+00
100+00
110+00
120+00
125+00
135+00
140+00
70°20'40"
70°20'20"
70°20'00"
150°57'00"
150°57'30"
150°58'00"
150°58'30"
150°59'00"



CD1 to CD2
Infield Pipeline
Map 4
Legend
Infield Pipeline
Water Pipeline
Water Pumphouse
Gravel Road
Alpine Pad
Map Extents
Boat Launch
ACS Pre-deployed Boom
ACS Prestaged Equipment
Pipeline PI
Culvert
Water Level Staff Gage
Survey Monument
VSM
Airstrip Lighting
Omni-directional Approach Light (ODAL)
Precision Approach Path Indicator (PAPI)
Runway End Indicator Lights (REIL)
Scale 1:8,448
200 0 200 400 600 800 Feet
Alaska State Plane Zone 4 - NAD 27
Vicinity Map Scale 1:115,000
ALPINE CD 1
CD 2
Map 4
ALPINE CD 1 PAD
Alpine Airstrip
Lake L9313
Lake L9312/U6.1
Lake #44
Sakoonang Channel
SK-14B
Lat N 70 20 28
Lon W 150 55 11
SK-14A
Lat N 70 20 25
Lon W 150 55 25
Boat Launch
Pump House
Water Intake
Raw Water Line
DUNES
CULVERT (TYP)
Kuukpik / LCMF March 2002

Alpine Facilities 2003 Spring Breakup and Hydrologic Assessment
September 2003

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Anchorage, Alaska 99503
907-273-1600

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