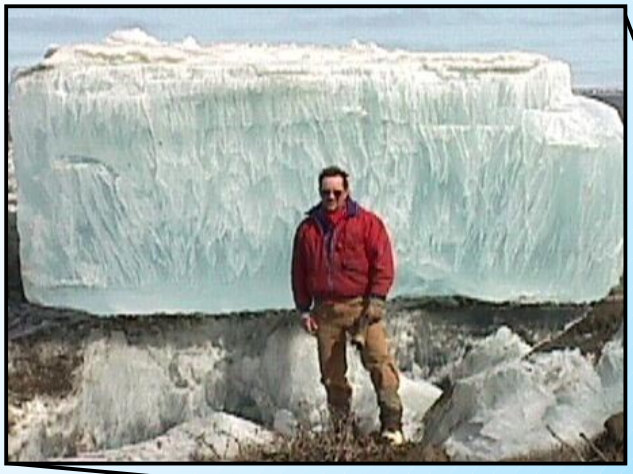
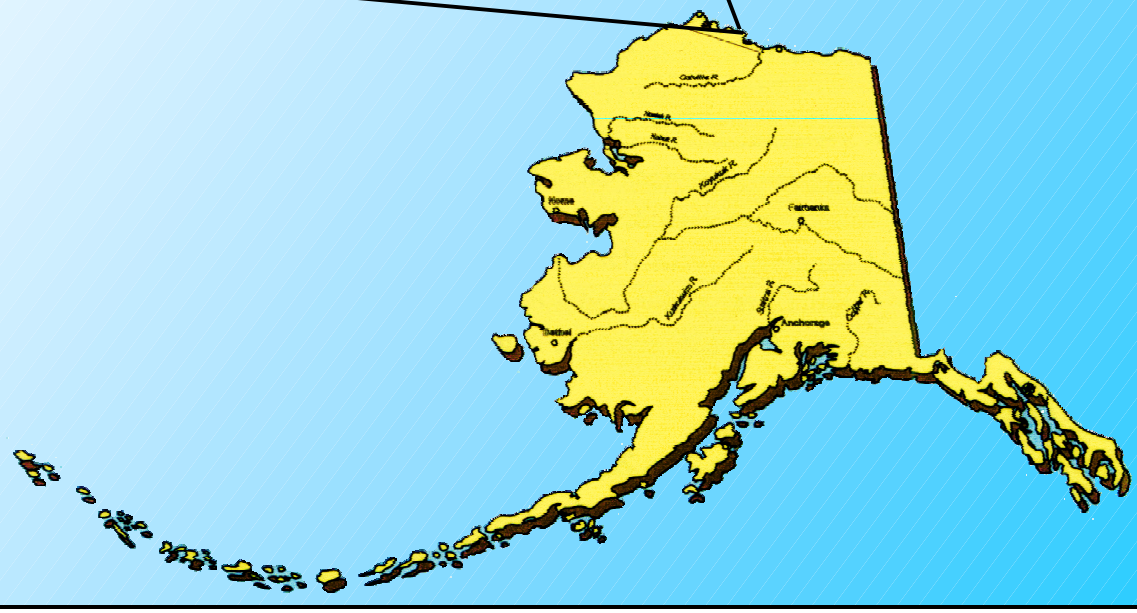
Alpine Facilities
Spring 2000 Breakup Monitoring
Alpine Development Project
COLVILLE RIVER DELTA
NORTH SLOPE, ALASKA

2000 SPRING BREAKUP AND HYDROLOGIC ASSESSMENT



November 2000



Prepared for:

PHILLIPS Alaska, Inc.
A Subsidiary of PHILLIPS PETROLEUM COMPANY

By:

Michael Baker Jr., Inc.
100 Cushman Street, # 201
Fairbanks, AK 99701
907-455-8073
4601 Business Park Blvd., # 42, Anchorage, AK 99503

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Michael Baker Jr., Inc.
4601 Business Park Blvd., # 42
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November 21, 2000

24540-MBJ-RPT-001

Contents

Appendices

1.0 Introduction

This report summarizes the observations and measurements made during the Spring 2000 breakup of the Colville River Delta in and around the Alpine Development.

Fieldwork for the Spring 2000 breakup monitoring was performed between 28 May 2000 and 22 June 2000. Water surface elevations were monitored at six permanent staff gages located adjacent to the Alpine Facility and at four other locations within the Colville River Delta. Discharge measurements were made at the two bridges and at selected culverts along the roadway connecting the CD-1 and CD-2 pads. Channel ice observations were made on the main channels of the delta to document the clearing of the low water channel ice sheet and the location of ice-jams. Photo documentation of the flooding around the Alpine Facility was also obtained.

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

2.0 Breakup Summary

2.1 Photographic Documentation

Photographic documentation of the flow around the Alpine Facility was obtained on 10 June and 12 June 2000, and is presented in Appendix A.

2.2 Water Surface Elevations and Observations

Water surface elevation measurements began on 4 June 2000 when standing water was first observed around the permanent staff gages. The peak water surface elevation in the immediate vicinity of the Alpine Facility was 9.6 feet and was recorded at Staff Gage 6 (Figure B-2, Appendix B). The peak water surface elevation occurred sometime between the morning of 12 and 13 June 2000. The peak water surface elevations recorded at the five remaining permanent staff gages ranged from 8.75 to 9.48 feet. The water surface elevation and observation records for these locations are presented in Tables B-1 through B-6, Appendix B.

To monitor water surface elevations in the Nechelik Channel upstream from the Alpine Facility and at the head of the delta, temporary staff gages were established at selected locations (Figure B-1, Appendix B). At the head of the delta (Monument 1), the water surface elevation peaked during the night of 9-10 June 2000, at an elevation of 19.33 feet. In the Nechelik Channel (Monuments 12 and 22), the water surface elevation peaked sometime after the morning of 11 June and prior to 15 June 2000. It seems most likely that it occurred between the morning of 12 and 13 June, based on the measurements at other locations. The peak water surface elevations recorded at Monuments 12 and 22 were 13.26 and 9.58 feet, respectively. In the lower East Channel (Jim and Tina Helmricks' house, near Monument 35), the water surface elevation peaked on 11 June at approximately 12:30 hours, at an elevation of 7.39 feet. The peak water surface elevation at the Helmricks' house was caused by an offshore ice-jam. The water surface elevation and observation records for these locations are presented in Tables B-7 through B-10, Appendix B.

Water surface elevations measured immediately upstream and downstream of the gravel road between CD-1 and CD-2 (Staff Gages 3 and 4 and Staff Gages 6 and 7) indicate that the greatest difference between the water surface elevation on either side of the gravel road was 0.8 feet. This difference occurred on 9 June 2000, on the rising limb of the hydrograph, between permanent Staff Gages 3 and 4.

2.3 Peak Discharge in the Colville River Delta

The peak discharge at the head of the Colville River Delta was approximately 580,000 cubic feet per second (cfs). It is estimated that at the head of the delta this discharge will be equaled or exceeded, on average, approximately once every 25 years (Michael Baker Jr., Inc. et. al, 1998). Discharge on the night of 9 June, on 11 June, and on 12 June 2000 was probably within 5 to 10 percent of the estimated peak discharge. The available data does not support a quantitative estimate of the discharge on 10 June 2000.

2.4 Channel Ice Observations

Ice floe observations were begun on 6 June 2000, when the ice cover within the Colville River Delta began to breakup. By 12 June 2000 all of the major channels of the Colville River Delta had cleared of channel ice and ice jams, with the exception of the Nechelik Channel. The Nechelik had cleared to approximately river mile N7, about one mile north of CD-2. The progression of the channel ice clearing and ice jamming is shown on a series of figures presented in Appendix C.

2.4 Comparison of Observed and Predicted Water Surface Elevations

The peak water surface elevations in the immediate vicinity of the Alpine Facility were compared (Table 2-1) to the elevations predicted by the two-dimensional surface water model developed for the Colville River Delta (Michael Baker Jr., Inc., 1998 and Shannon & Wilson, Inc., 1997). Based on a linear interpolation between the water surface elevations predicted for the 10- and 30- year open water floods, it is estimated that the peak water surface elevations experienced this spring might be equaled or exceeded on average about once every 19 years. At individual staff gages located in the immediate

vicinity of the Alpine Facility (permanent Staff Gages 1, 3, 4, 6, 7, 8 and the temporary staff gage at Monument 22), the estimate of the recurrence interval varied from 16 to 24 years.

Table 2-1: Comparison of Observed and Predicted Water Surface Elevations

Observation Site	Observed Peak Water Surface Elev. (ft)	Predicted 10-yr Water Surface Elev. (ft)	Predicted 30-yr Water Surface Elev. (ft)	Predicted 50-yr Water Surface Elev. (ft)	Approximate Recurrence Interval of Observed Peak Water Surface Elevation (1) (yrs)
Staff G. 1	9.1	8.4	10.2	11.2	18
Staff G. 3	9.48	8.6	10.8	11.8	18
Staff G. 4	8.75	7.6	9.2	9.9	24
Staff G. 6	9.64	8.8	10.9	11.9	18
Staff G. 7	8.84	—	9	9.8	N/A (2)
Staff G. 8	9.11	8.8	9.9	10.7	16
Mon 01	19.33	19	21.7	23	25 (3)
Mon 12	13.26	12	14	14.9	23
Mon 22	9.58	8.6	10.7	11.8	19
Mon 35	7.39	4.5	5.2	5.4	Over 200 (4)

Notes:

1. The recurrence interval was estimated based on water surface elevations predicted with a two-dimensional open-water surface-water model of the Colville River Delta (Michael Baker Jr., Inc., 1998 and Shannon & Wilson, Inc., 1997). Thus, the impact on the recurrence interval of an ice cover and/or ice jams has not been considered. The larger the recurrence interval, the less likely it will be that an ice cover and/or ice jams will significantly affect the recurrence interval associated with a particular water surface elevation.
2. An estimate of the water surface elevation in the immediate vicinity of Staff Gage 7 is not available. The finite elements within the immediate vicinity of Staff Gage 7 are turned off in the two-dimensional surface water model of the 10-year open water flood.
3. The recurrence interval was estimated from the computed peak discharge and the flood frequency relationship developed for the head of the delta (Michael Baker Jr., Inc. and Shannon & Wilson, Inc., 1998).
4. The peak water surface elevation was caused by a downstream ice-jam.
5. The locations of the monuments and staff gages are shown in Appendix B, Figures 1 and 2, respectively.

At Monument 12, located approximately half way between the Alpine Facility and Monument 1 at the head of the delta, the Spring 2000 peak water surface elevation has an average expected recurrence interval of 23 years. At Monument 1, the Spring 2000 peak discharge has an average expected recurrence interval of 25 years.

The reason the recurrence interval is higher at the head of the delta than at the Alpine Facility may be related to temporary floodwater storage within the delta. As a flood moves through the delta, the peak is attenuated due to the filling of depressions and backwater areas (i.e., temporary floodwater storage). The two-dimensional surface water

model, on the other hand, assumed that steady-state conditions existed at the time of the peak discharge (i.e., no attenuation of the discharge). Thus, the two-dimensional surface water model may somewhat over-estimate the water surface elevation within the lower reaches of the delta due to attenuation of the flood peak discharge. The magnitude of this possible over-estimation is likely to be on the order of inches and to be of about the same magnitude as the difference in water surface elevation between the 19- and 25-year floods.

It should also be noted that the two-dimensional surface water model does not consider the impact of an ice sheet or ice jams on the water surface elevation. At the time the model was constructed, it was assumed that during a large flood (such as the 50-, 100-, and 200-year floods for which the model was constructed) the presence of an ice sheet or ice jams would have little effect on the water surface elevation. At the time of the Spring 2000 peak water surface elevation at the Alpine Facility, there were ice jams at the coast in several of the channels. The extent to which these ice jams impacted the water surface elevation at the Facility cannot be quantitatively assessed, but after reviewing all of the data, it is thought that they probably had only a small to minor impact on the peak water surface elevation.

At Monument 35, it is estimated that the peak water surface elevation was approximately 2.5 feet higher than the estimated 25-year flood water surface elevation based on the 10- and 30-year open water flood profiles developed with the two-dimensional surface water model. Thus, the probable effect of the offshore ice jam was to raise the water surface elevation more than 2.5 feet. This value should be used cautiously. Monument 35 is located close to the downstream boundary of the two-dimensional surface water model and therefore the water surface elevation estimates at this location are subject to considerably more error than those at the Alpine Facility.

In assessing the recurrence interval associated with the flood peak discharge and the peak water surface elevation at the head of the delta, an ambiguity was found. Based on the 10- and 30-year open water flood profiles developed with the two-dimensional surface water model, the average recurrence interval of the Spring 2000 flood peak water surface

is estimated to be about 12 years. However, using normal depth computations to estimate the magnitude of the flood peak discharge and the flood frequency relationship developed for the delta (Michael Baker Jr., Inc. and Shannon & Wilson, Inc., 1998) the flood peak discharge is estimated to have an average recurrence interval of about 25 years. The reason for this difference is unexplained at this time. Therefore, until the reason for this difference can be confirmed, it will be important to continue to measure both water surface slope and water surface elevation at the head of the delta whenever an estimate of total discharge is required.

2.5 Alpine Facility Bridge and Culvert Observations

Water surface elevations at the ends of the culverts were recorded three to six days after the peak water surface elevation. Differences in water surface elevation between the south and north ends of the culverts varied from –0.53 to 0.55 feet (Tables D-2, D-3 and D-4, Appendix D). Culverts C-4 and C-9 were the only culverts with a difference of more than 0.50 feet, approximately six days after the peak water surface elevation. Both culverts C-4 and C-9 had snow and ice in the culverts six days after the peak water surface elevation. The snow and ice was responsible for the majority of the difference in the water surface elevation at both culverts. Thus, the installation of the culverts does not appear to be a problem.

Depressions in the ground surface at the ends of the culverts were documented to provide a baseline for scour monitoring (Tables D-2 and D-3, Appendix D). All of the depressions, with the exception of CS-10 and CS-11, appear to have been caused by the culvert construction effort and did not appear to be the result of water scour. Observations at CS-10 and CS-11 indicated that water scour may have caused some of the depression. Water surface elevations and other observations made at the culverts are presented in Tables D-1, D-2, and D-3, Appendix D. The difference between the water surface elevation at each end of each culvert is summarized in Table D-4, Appendix D.

Water velocity was measured at the two bridges and at selected culverts along the road between CD-1 and CD-2. At the East bridge (large bridge), the maximum discharge

passing through the bridge during the Spring 2000 breakup is estimated to be 7100 cubic feet per second (cfs). The average velocity at the time of the maximum discharge is estimated to be 3.6 feet per second. At the West bridge, (small bridge), the maximum discharge passing through the bridge during the Spring 2000 breakup is estimated to be 975 cubic feet per second (cfs). The average velocity at the time of the maximum discharge is estimated to be between 4.0 to 4.6 feet per second. Summaries of the discharge measurements are presented in Appendix D. The maximum discharge estimates are based on these measurements and the water surface elevations recorded on either side of the bridges.

Water velocity measurements were also made in selected culverts along the road between CD-1 and CD-2. The highest recorded discharge and associated velocity, along with the maximum likely peak discharge and associated velocity, are presented in Table 2-2. The maximum likely peak discharge and associated velocity are computed based on a clean culvert barrel. In some cases (Appendix D), there was snow and ice still remaining in the culvert barrel after the flood had passed. It is estimated that the peak discharge occurred on 12 June 2000, in conjunction with the peak water surface elevation. Summaries of the discharge measurements are presented in Appendix D.

Table 2-2 Measured and Maximum Likely Peak Discharge and Velocity in Alpine Drainage Structures

	Highest Field Measurement (2)			Maximum Likely Peak (4)		
Structure (1)	Date	Discharge (cfs)	Average Velocity (ft/s)	Date (3)	Discharge (cfs)	Average Velocity (ft/s)
East Bridge	6/9/00	3780	3.27	6/12/00	7085	3.55
West Bridge	6/10/00	577	3.30	6/12/00	975	4.62
Culvert C-1	6/10/00	28.1	2.78	6/12/00	57.1	4.54
Culvert C-2	6/10/00	36.9	3.79	6/12/00	57.3	4.56
Culvert C-3	6/11/00	26.6	3.22	6/12/00	55.5	4.75
Culvert C-4	6/10/00	24.3	3.87	6/12/00	52.9	4.57
Culvert C-5	6/11/00	15.4	3.57	6/12/00	37.9	4.79
Culvert C-6	N/A	N/A	N/A	6/12/00	9.4	4.50
Culvert C-7	N/A	N/A	N/A	6/12/00	16.2	4.95
Culvert C-8	N/A	N/A	N/A	6/12/00	5.7	3.92
Culvert C-9	N/A	N/A	N/A	6/12/00	3.8	3.53
Culvert C-10	N/A	N/A	N/A	6/12/00	37.1	5.51
Culvert C-11	N/A	N/A	N/A	6/12/00	52.0	4.54
Culvert C-12	N/A	N/A	N/A	6/12/00	18.7	3.83
Culvert C-13	N/A	N/A	N/A	6/12/00	57.5	4.61
Culvert C-14	N/A	N/A	N/A	6/12/00	38.8	4.12
Culvert C-15	N/A	N/A	N/A	6/12/00	39.0	4.61
Culvert C-16	N/A	N/A	N/A	6/12/00	34.8	4.72
Culvert C-17	6/11/00	21.2	3.37	6/12/00	46.4	5.06
Culvert C-18	N/A	N/A	N/A	6/12/00	56.4	4.85
Culvert C-19	N/A	N/A	N/A	6/12/00	56.4	4.78
Culvert C-20	N/A	N/A	N/A	6/12/00	56.6	4.91
Culvert C-21	6/11/00	23.8	2.53	6/12/00	56.4	4.76
Culvert C-22	6/10/00	24.2	3.62	6/12/00	51.0	4.85
Culvert C-23	6/10/00	19.7	4.57	6/12/00	42.1	5.2
Culvert C-24	6/10/00	17.9	4.15	6/12/00	43.5	5.47

Notes:

1. See Figure D-1, Appendix D for culvert and bridge site plan.
2. The highest measured data was not recorded at the time of the flood peak.
3. It is estimated that the peak discharge and velocity occurred between the morning of 12 and 13 June 2000.
4. The maximum likely peak discharge and velocity estimate for the culverts is based on a clean culvert barrel. In actuality, some culverts were still blocked by snow and ice after the flood peak had receded (Appendix D).

2.6 Gravel Pad and Road Erosion

Visual inspection of the road and pads revealed the presence of a high water mark (Appendix E). The high water mark appeared to have been caused by either the settlement of the gravel embankment below the flood peak water surface or the removal of fines from the gravel embankment. However, no material was observed deposited in significant quantities along the toe of the embankment.

3.0 References

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

Michael Baker Jr., Inc. and Shannon & Wilson, Inc. 1998. *Colville River Flood-Frequency Analysis, North Slope, Alaska.* Prepared for: ARCO Alaska, Inc., Anchorage.

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

Appendix A

Photographs of Flooding

List of Figures:

June 10, 2000 **(1 of 6)**

Baker **Michael Baker Jr., Inc.**			
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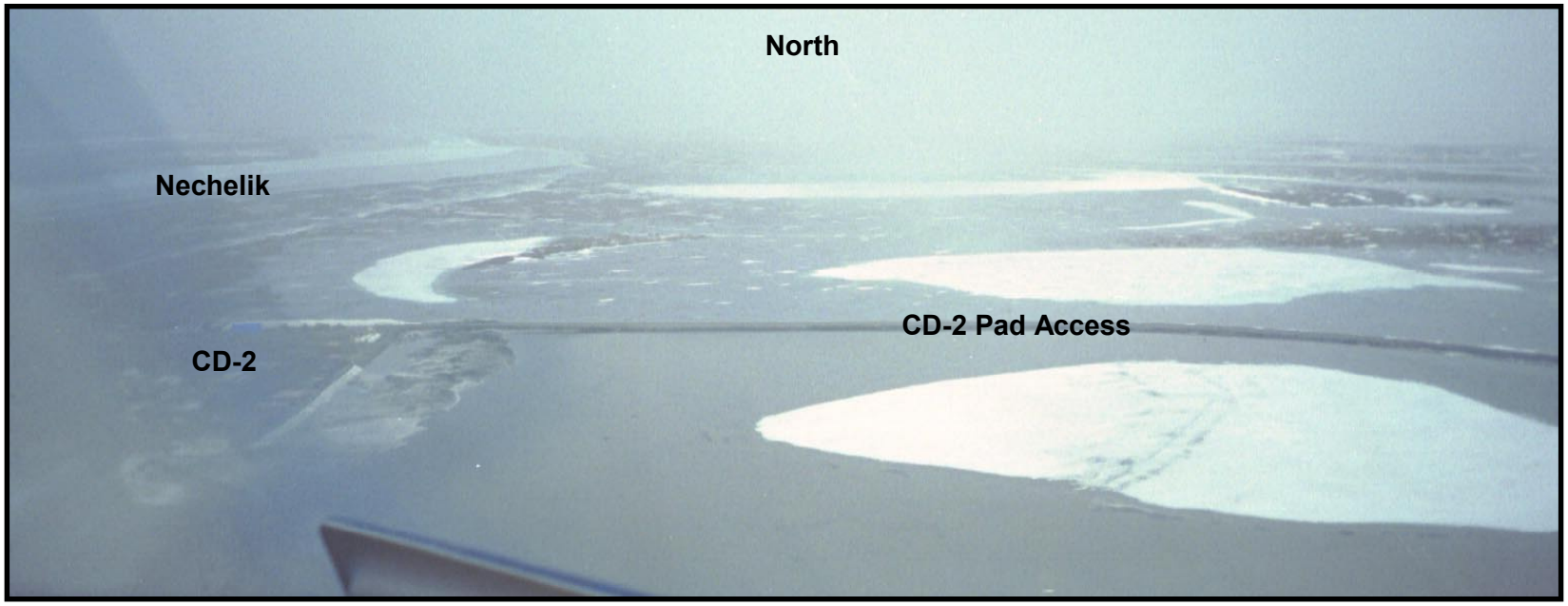
2000 SPRING BREAKUP
COLVILLE RIVER DELTA
FLOODING NEAR ALPINE FACILITIES

Figure
A-1
Sheet 1 of 6



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2000 SPRING BREAKUP
COLVILLE RIVER DELTA
FLOODING NEAR ALPINE FACILITIES

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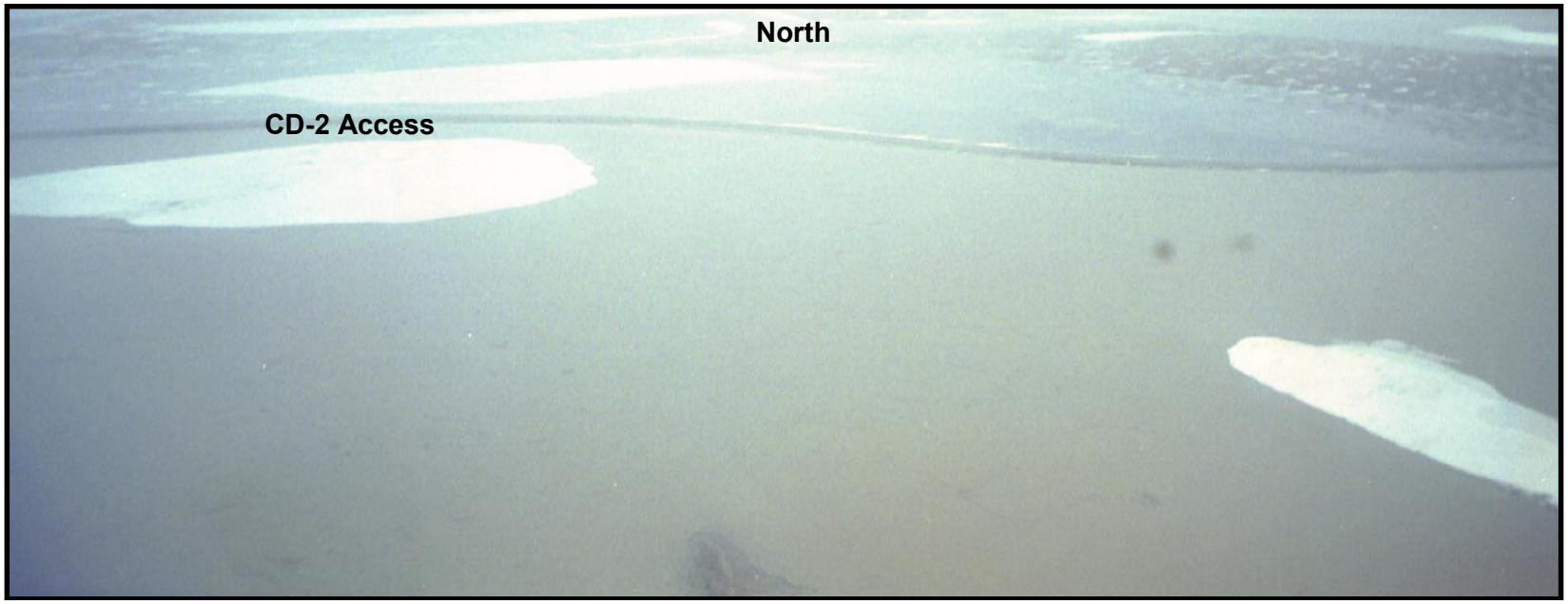
Sheet 2 of 6



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COLVILLE RIVER DELTA
FLOODING NEAR ALPINE FACILITIES

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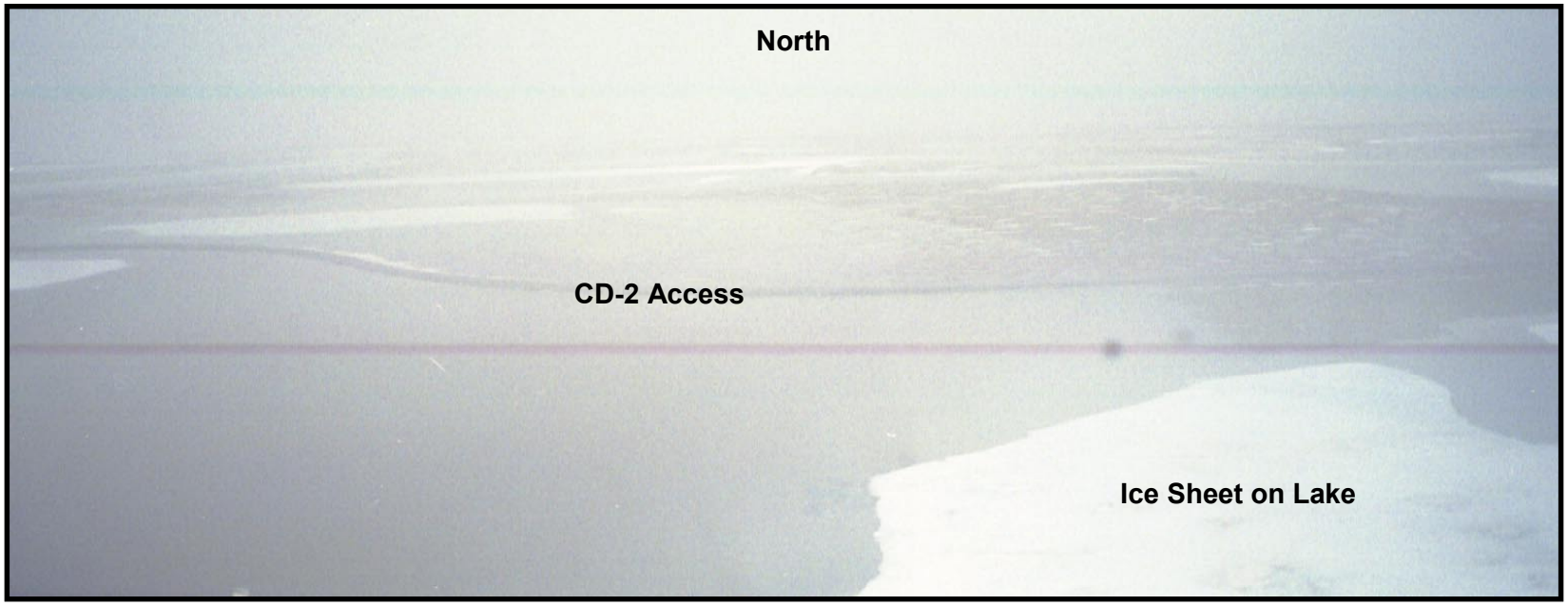

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2000 SPRING BREAKUP
COLVILLE RIVER DELTA
FLOODING NEAR ALPINE FACILITIES

Figure
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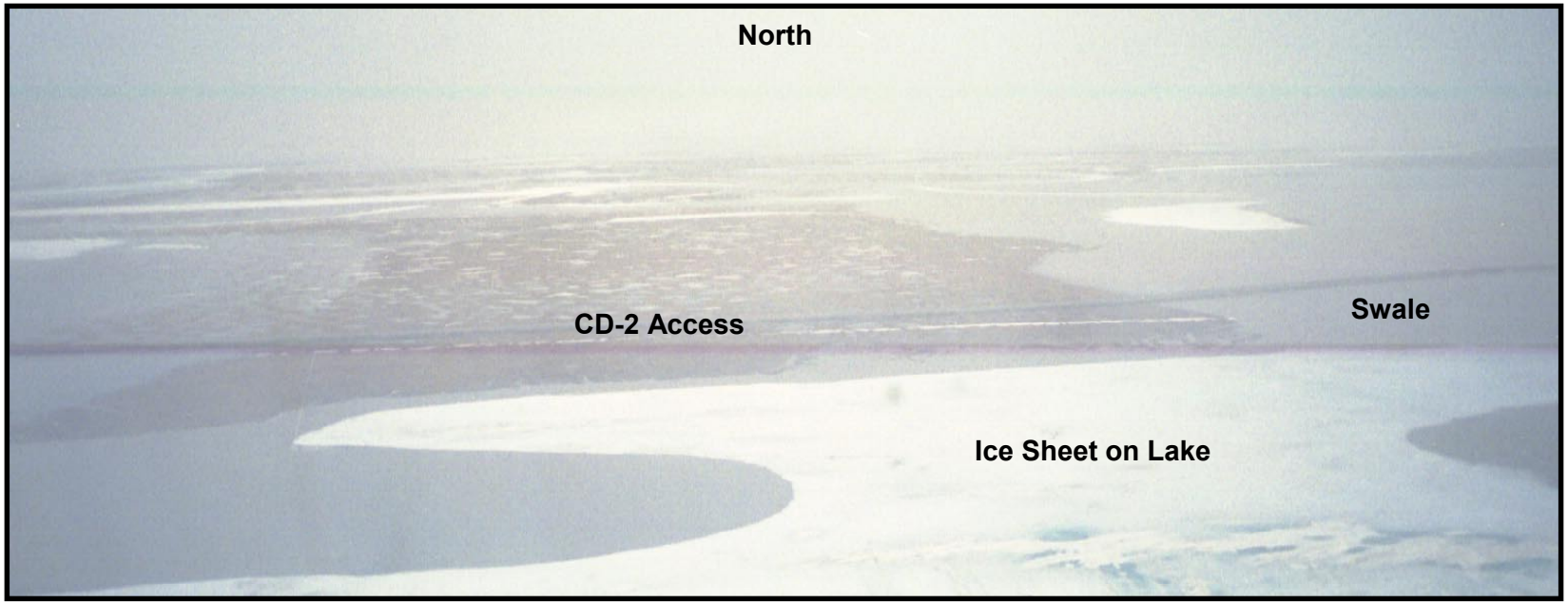
Sheet 4 of 6



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COLVILLE RIVER DELTA
FLOODING NEAR ALPINE FACILITIES

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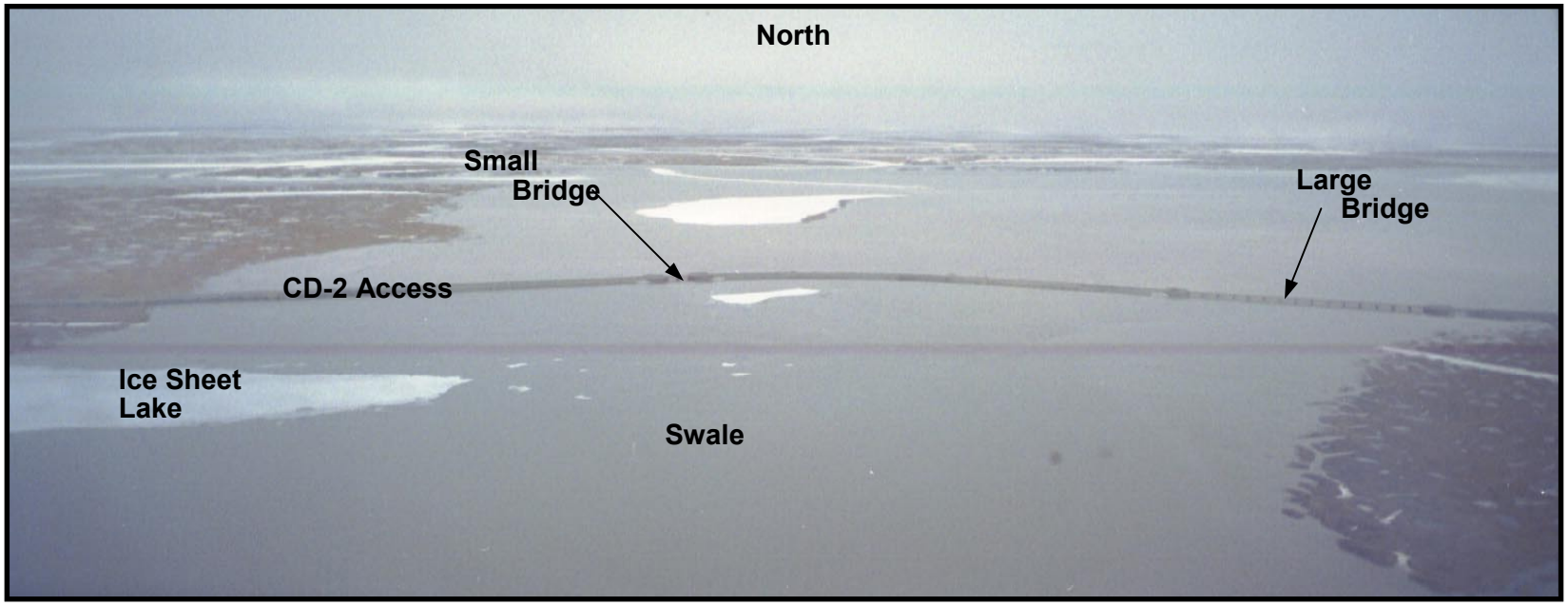

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2000 SPRING BREAKUP
COLVILLE RIVER DELTA

FLOODING NEAR ALPINE FACILITIES

Figure
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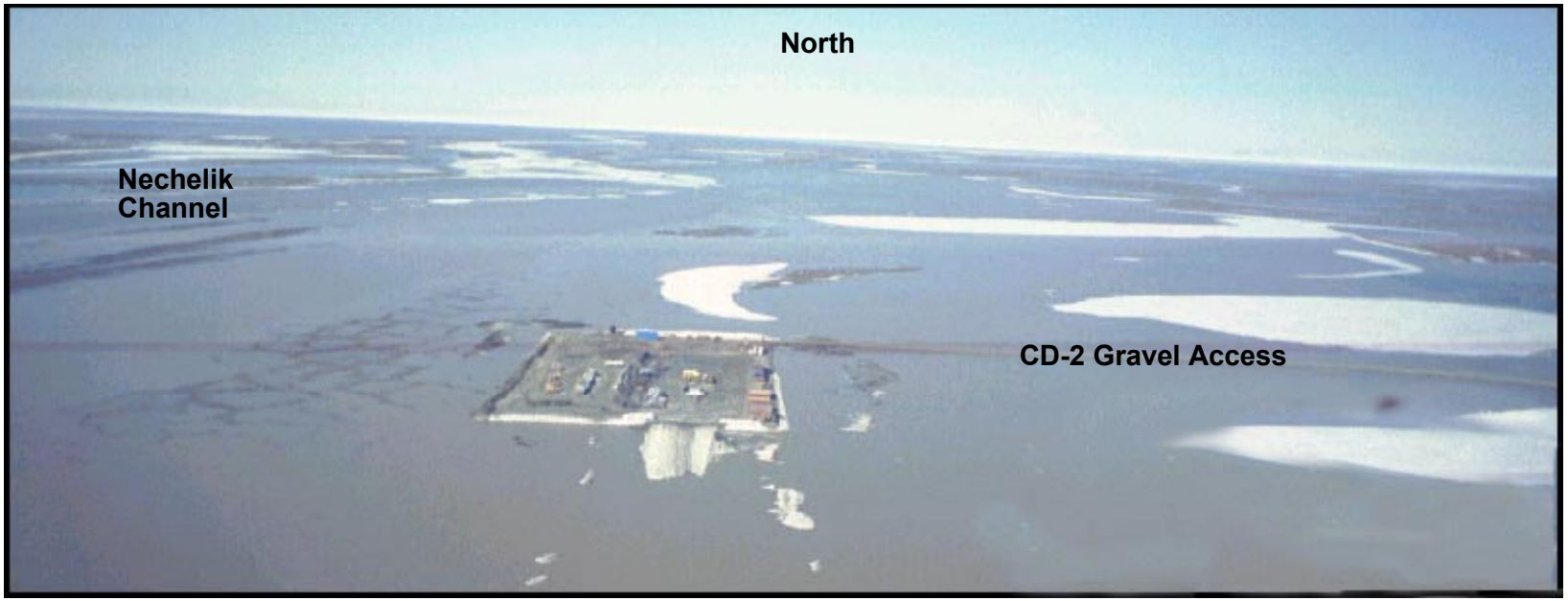

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2000 SPRING BREAKUP
COLVILLE RIVER DELTA

FLOODING NEAR ALPINE FACILITIES

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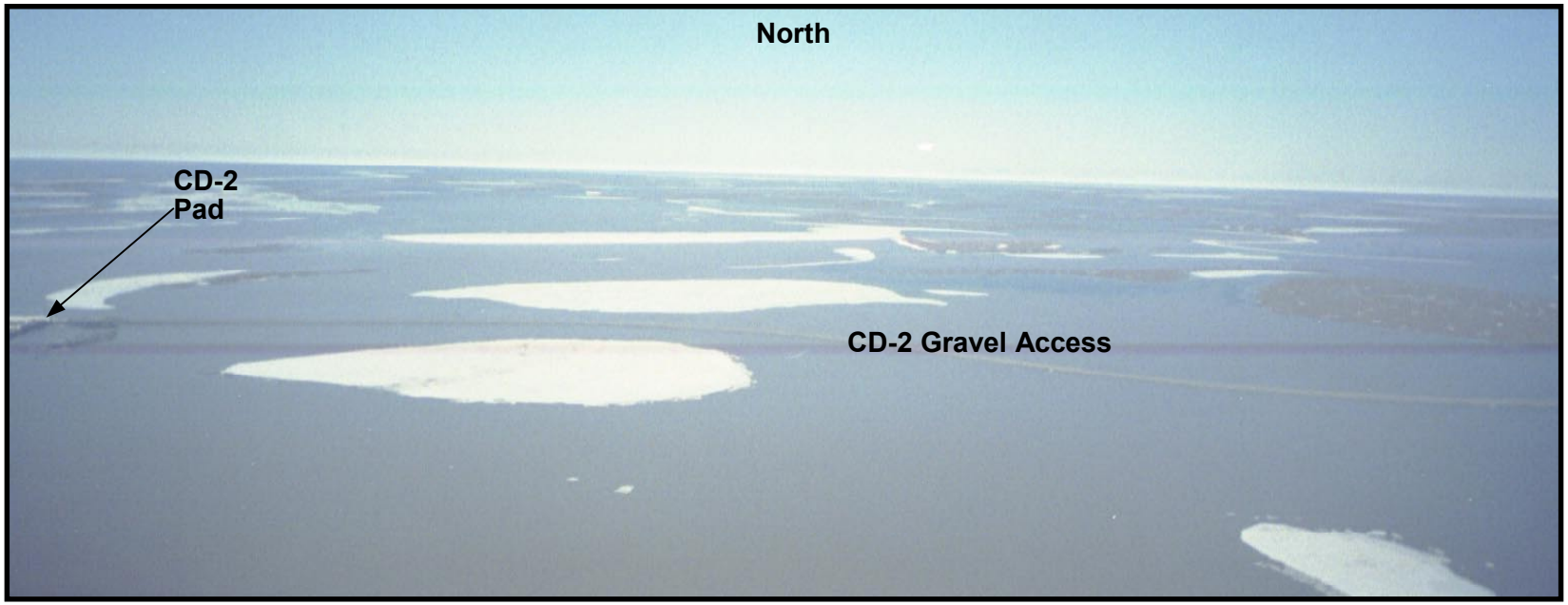

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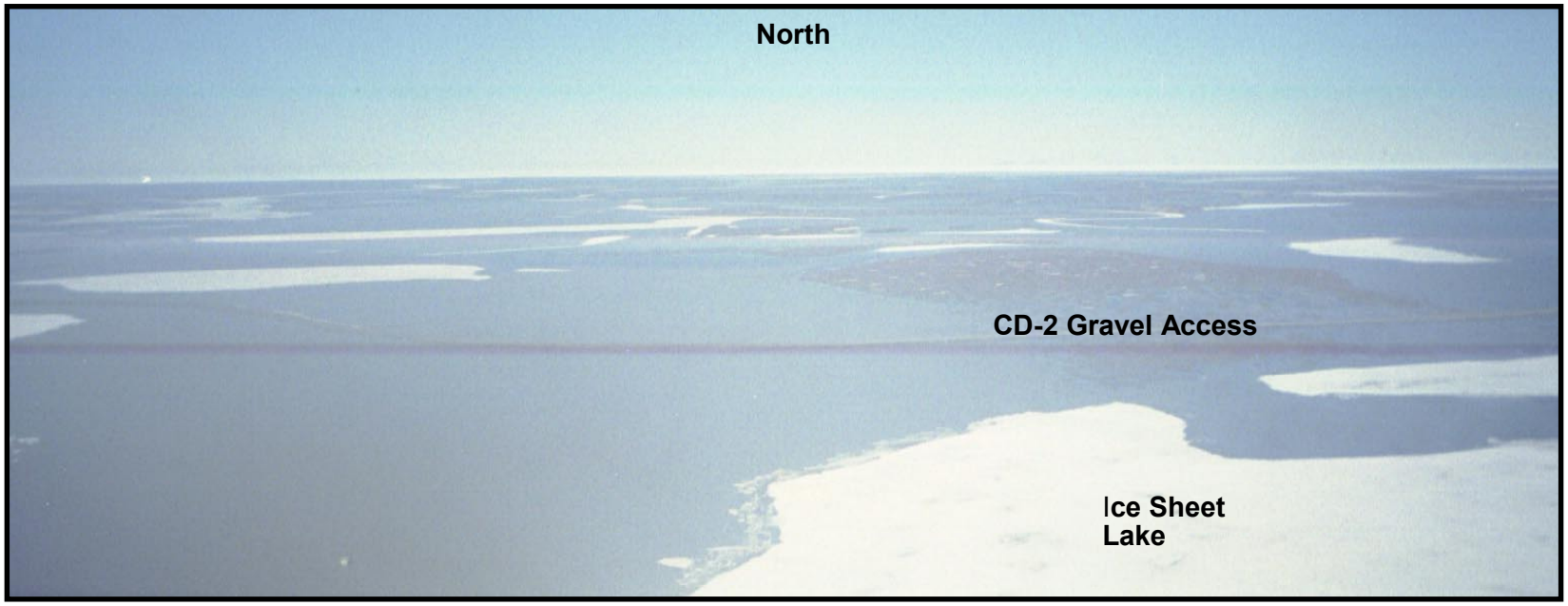
2000 SPRING BREAKUP
COLVILLE RIVER DELTA

FLOODING NEAR ALPINE FACILITIES

Figure
A-2
Sheet 2 of 5



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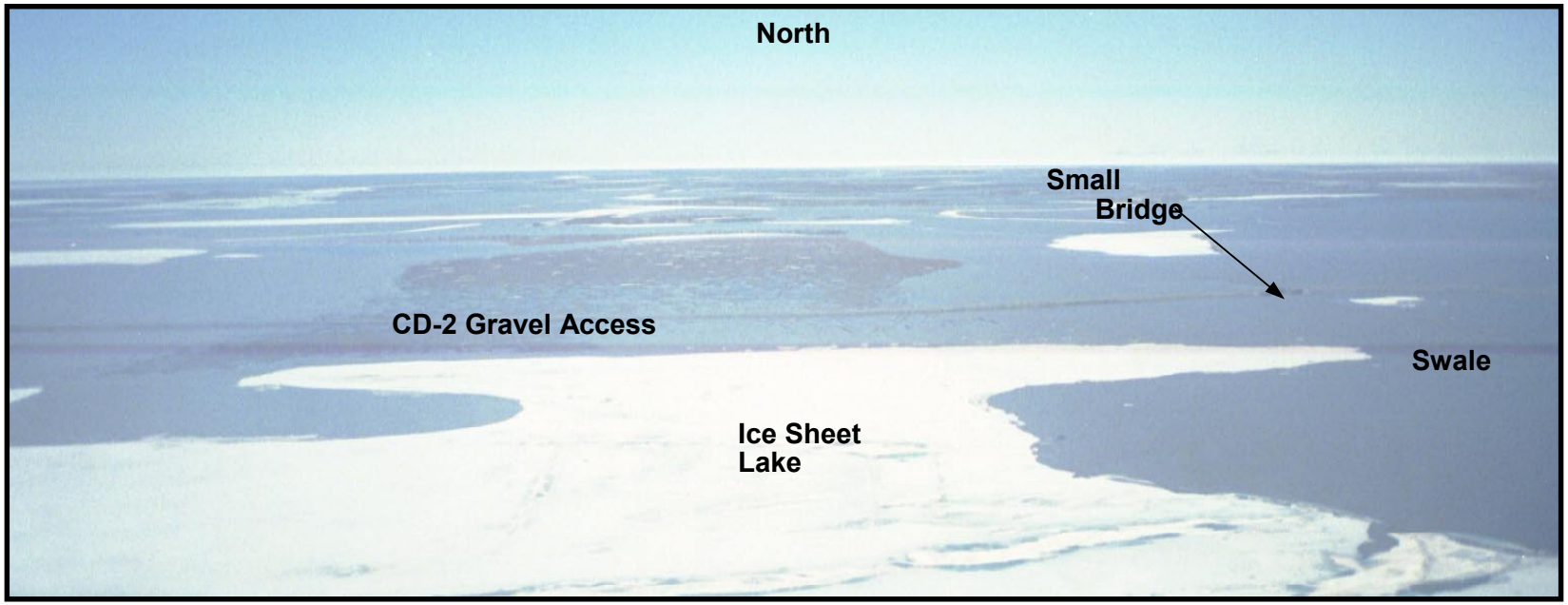
2000 SPRING BREAKUP
COLVILLE RIVER DELTA

FLOODING NEAR ALPINE FACILITIES

Figure
A-2
Sheet 3 of 5



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2000 SPRING BREAKUP
COLVILLE RIVER DELTA

FLOODING NEAR ALPINE FACILITIES

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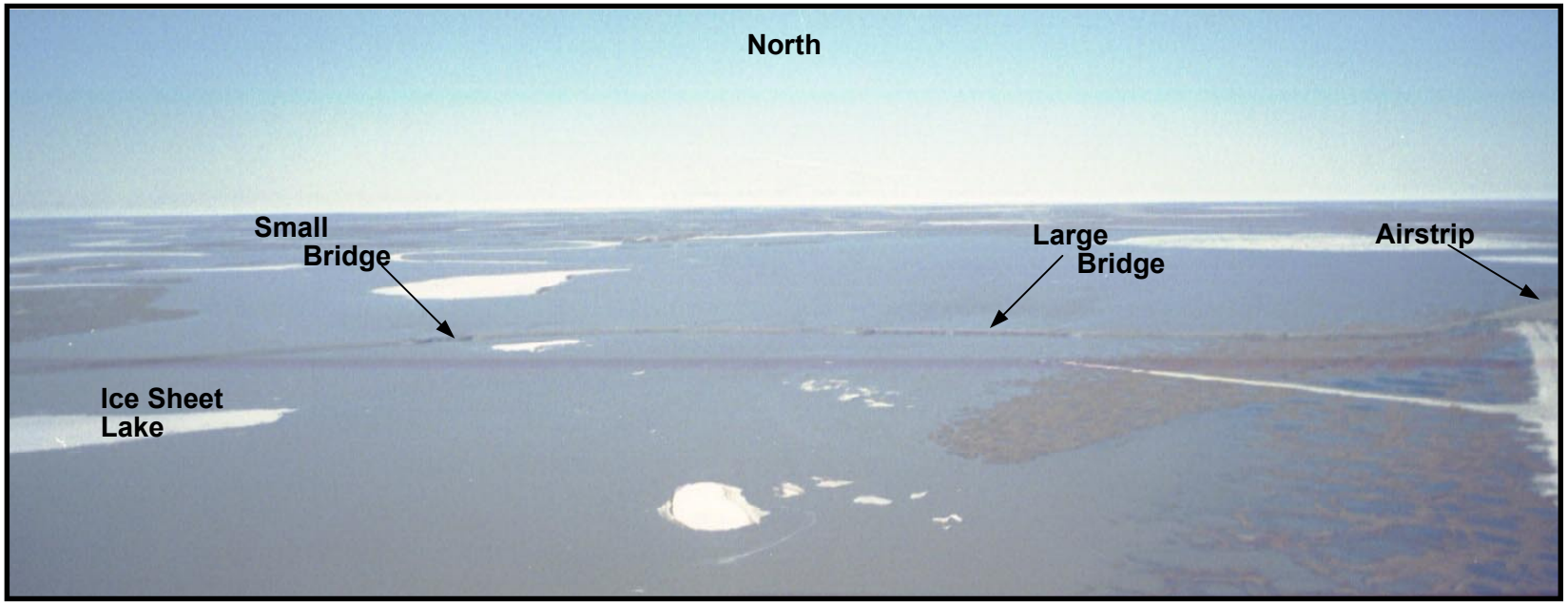
A-2
Sheet 4 of 5



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2000 SPRING BREAKUP
COLVILLE RIVER DELTA

FLOODING NEAR ALPINE FACILITIES

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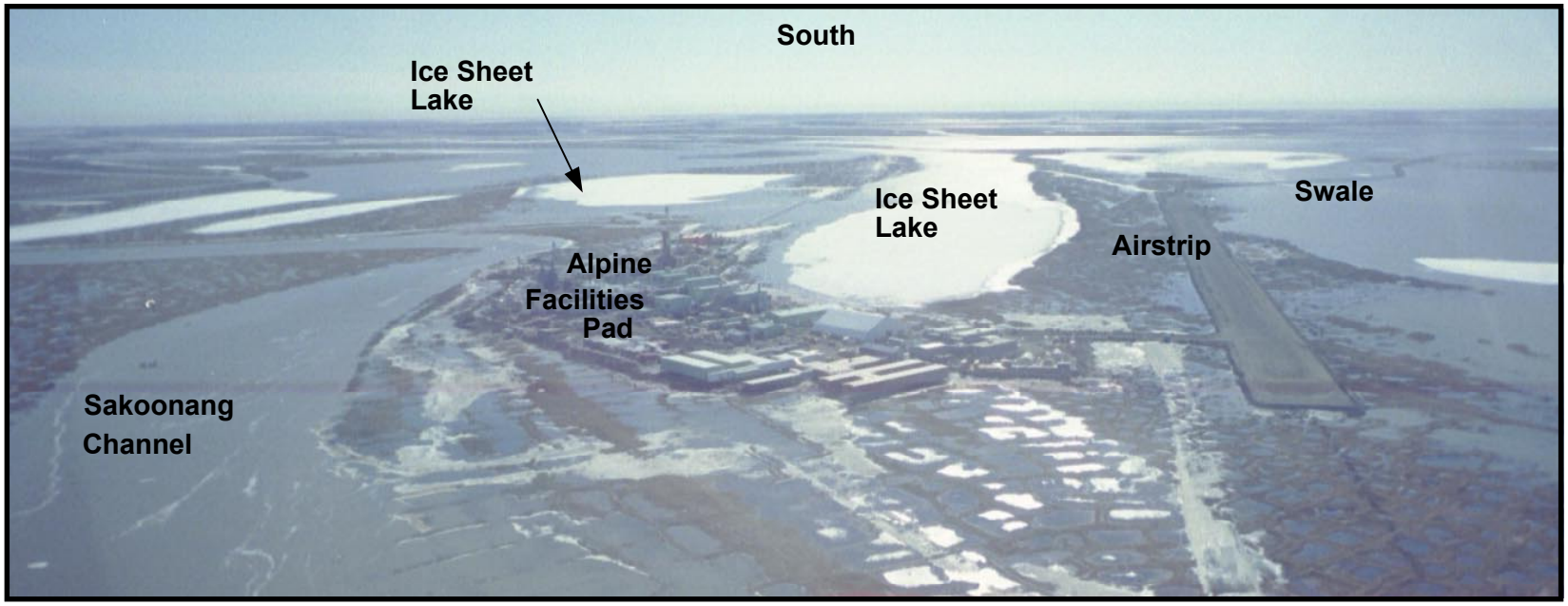
A-2
Sheet 5 of 5



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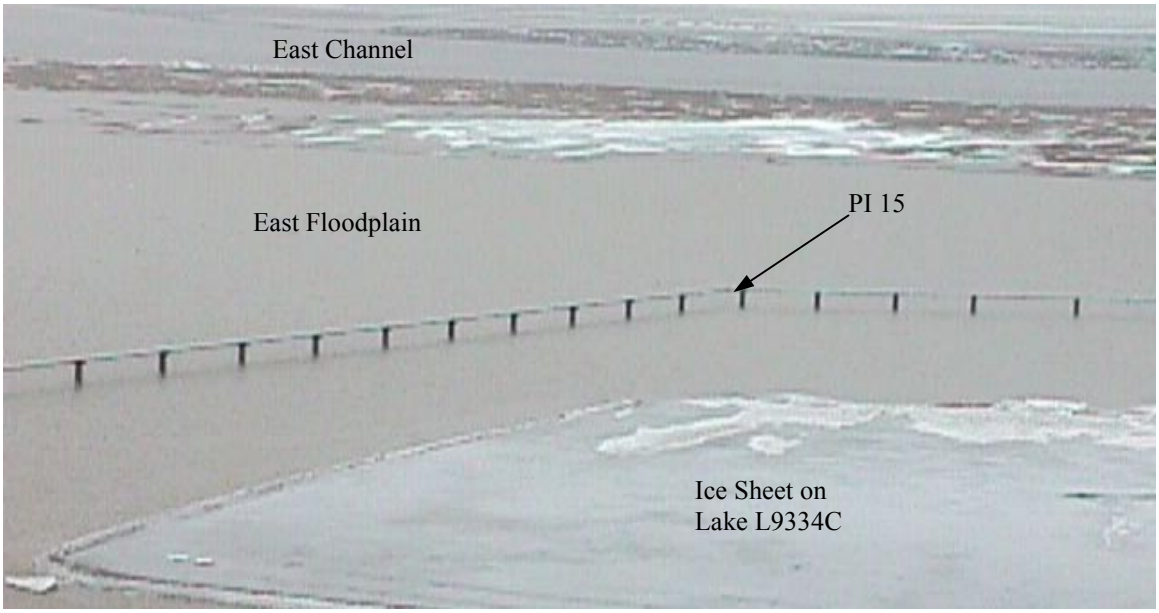
2000 SPRING BREAKUP
COLVILLE RIVER DELTA
FLOODING NEAR ALPINE FACILITIES

Figure
A-3
Sheet 1 of 1

Looking Southwest at the East Floodplain of the East Channel (6/10/00)



Looking Southwest at the East Floodplain of the East Channel (6/10/00)

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2000 SPRING BREAKUP
COLVILLE RIVER DELTA

FLOODING NEAR EAST CHANNEL PIPELINE CROSSING

FIGURE:

A-4

Rafted 5.8’ thick ice pan, 15’ to 20’ on a side. (6/09/00)

Rafted 5.9’ thick ice pan, 15’ to 20’ on a side. (6/09/00)

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2000 SPRING BREAKUP
COLVILLE RIVER DELTA

RAFTED ICE NEAR HEAD OF NECHELIK CHANNEL

FIGURE:

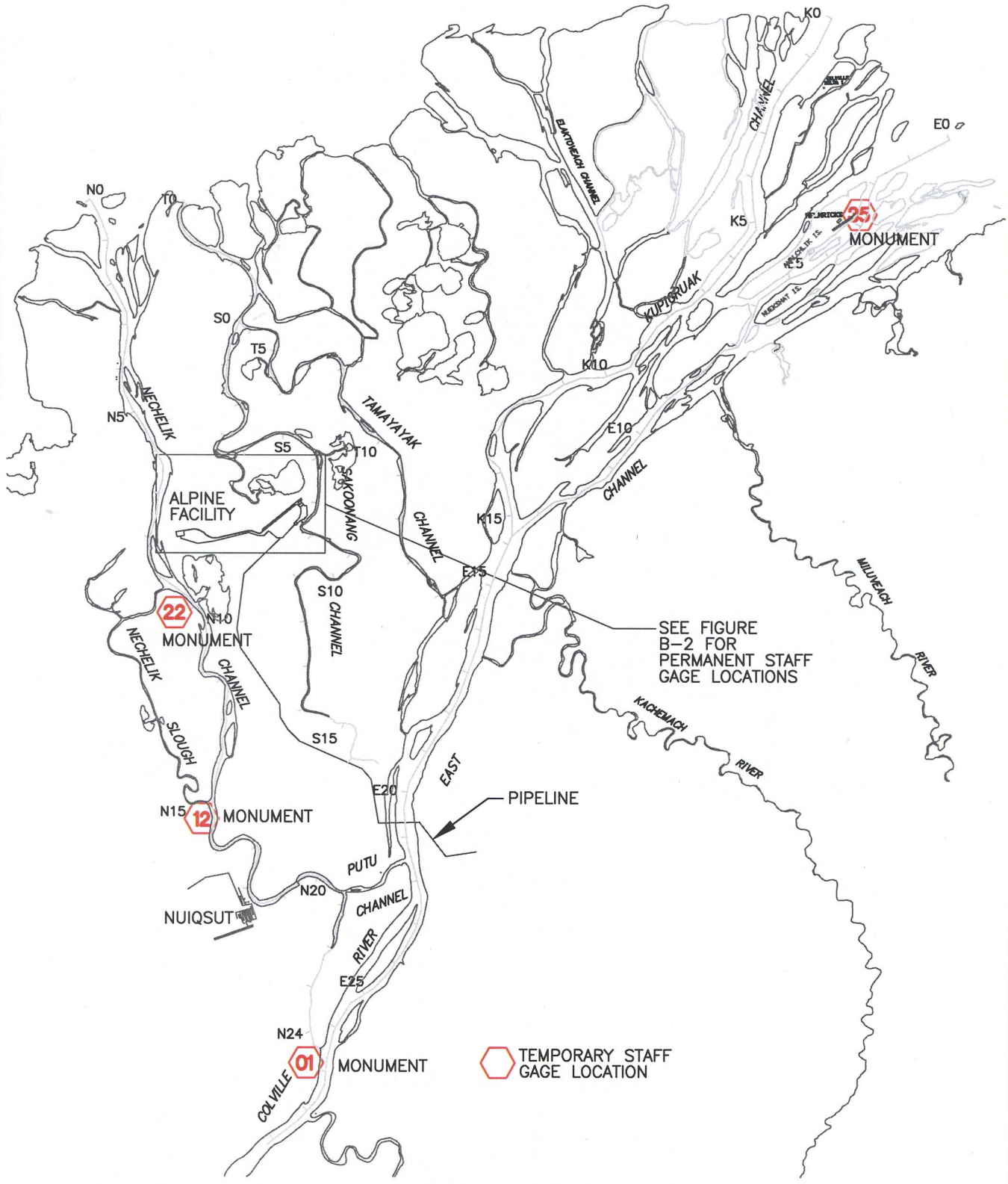
A-5

Appendix B

Water Surface Elevations and Observations

List of Figures:

List of Tables:



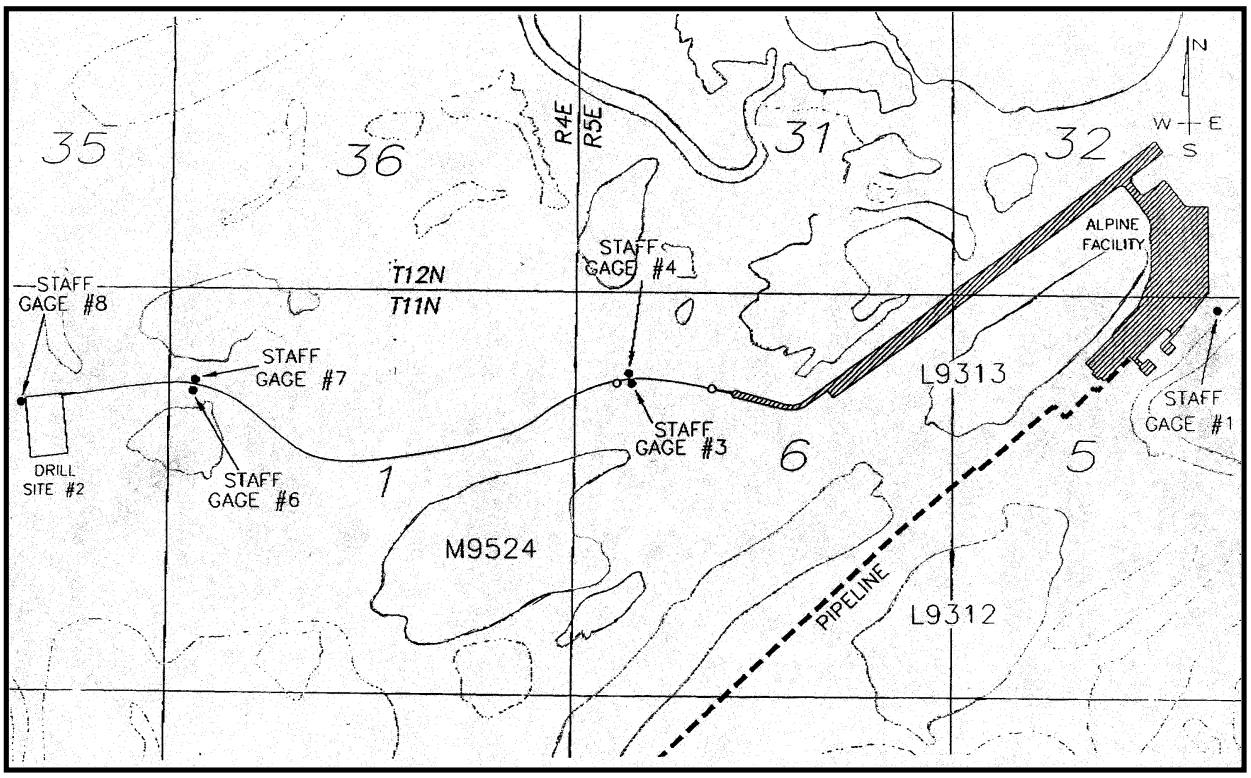
24540B-1.dwg

Baker	Michael Baker Jr., Inc.		
DATE: 11/07/00		PROJECT: 24540	
DRAWN: WAE		FILE:	
CHECKED: TAR		SCALE: NOT TO SCALE	

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

TEMPORARY STAFF GAGE LOCATIONS

FIGURE:
B-1



Baker	Michael Baker		
Date	20-Sep-00	Project:	24540-157-0000
Draw	TAR	File	Appendix B
Checked:	TAR	Scale:	

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

PERMANEMT STAFF GAGE LOCATIONS

Figure
B-2
Sheet 1 of 1

Table B-1: Water Surface Elevations and Observations at Permanent Staff Gage #1

Date	Time	Water Surface Elevation (feet)	Observations
06-02-00			Set faceplate on Staff Gage #1 from 1.48 to approximately 15.00 feet.
06-03-00	10:11	1.49	
06-08-00	13:40	~1.00	Water does not quite touch staff gage at this point. No continuous ice either upstream or downstream of gage.
06-09-00	11:18	3.22	± 0.02 feet
	18:08	3.47	± 0.02 feet
06-10-00	08:35	5.80	± 0.03 feet
	18:20	7.05	± 0.05 feet
06-11-00	08:24	7.95	± 0.01 feet
	20:58	8.31	± 0.02 feet. Ice floes are present in channel. Intermediate high water mark of 8.46 recorded.
06-12-00	07:23	8.80	± 0.05 feet. Ice floe 6 inches upstream of gage. Could not see chalk line due to ice floe. Ice floes still present, with some beached about 300 feet downstream of gage on left bank.
High Water Mark		9.10	± 0.05 feet
06-13-00	09:25	7.00	± 0.03 feet
	17:25	6.36	± 0.01 feet
06-14-00	09:05	5.32	± 0.01 feet. Ice floes still present in channel.
	20:05	4.80	± 0.01 feet
06-15-00	08:37	4.19	± 0.03 feet
	21:27	3.77	± 0.01 feet
06-16-00	08:14	3.40	± 0.05 feet. Faceplate is slightly bent between 3.0 and 5.0 feet.
	17:55	3.05	± 0.05 feet
06-17-00	08:07	2.62	
	20:07	2.24	± 0.02 feet
06-18-00	10:39	1.83	± 0.02 feet
06-19-00	16:20	1.29	± 0.02 feet. Straightened staff gage faceplate.

Notes:

1. Coordinates for Staff Gage #1 are longitude 5975948.0, latitude 386920.3 and are Alaska State Plane, Zone 4, NAD 27.
2. Elevations are based on an elevation of 2.16 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support, which was surveyed by LCMF Incorporated.

Table B-2: Water Surface Elevations and Observations at Permanent Staff Gage #3

Date	Time	Water Surface Elevation (feet)	Observations
06-03-00	14:12	5.39	Placed staff gage faceplate from 6.67 to 15.07 feet. Standing water in hole at staff gage
06-04-00	14:39	5.37	Standing water around staff gage
06-08-00	10:59	5.34	Intermediate high water mark of 5.40 feet recorded
06-09-00	09:33	6.70	± 0.01 feet
	13:27	7.21	± 0.02 feet
	17:09	7.20	± 0.02 feet
	23:08	7.38	± 0.03 feet
06-10-00	10:40	7.61	± 0.02 feet
	14:23	7.77	± 0.03 feet
	15:34	7.87	± 0.04 feet
	17:20	7.87	± 0.03 feet
	18:45	7.89	± 0.02 fee.
06-11-00	08:57	7.87	Intermediate high water mark of 7.96 feet recorded
	12:08	7.92	± 0.01 feet
	14:26	7.97	± 0.02 feet
	15:42	7.96	± 0.02 feet.
06-12-00	08:00	9.18	± 0.02 feet
High Water Mark		9.48	± 0.02 feet
06-13-00	07:59	6.57	± 0.03 feet
	14:50	6.00	± 0.02 feet
06-14-00	09:48	5.36	Standing water. No flow.
	17:54		No flow.

Notes:

1. Coordinates for Staff Gage #3 are longitude 5975040.8, latitude 379259.2 and are Alaska State Plane, Zone 4, NAD 27.
2. Elevations are based on an elevation of 6.00 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support which was surveyed by LCMF Incorporated.

Table B-3: Water Surface Elevations and Observations at Permanent Staff Gage #4

Date	Time	Water Surface Elevation (feet)	Observations
06-03-00			Placed staff gage faceplate from 6.67 to 13.32 feet.
06-04-00	14:54	5.46	Standing water around gage.
06-08-00	10:53	5.42	
06-09-00	09:31	6.28	± 0.01 feet
	13:28	6.47	± 0.03 feet
	17:09	6.46	± 0.02 feet
	23:09	6.60	± 0.02 feet
06-10-00	10:41	7.01	± 0.02 feet
	14:24	7.17	± 0.03 feet
	15:36	7.26	± 0.03 feet
	17:22	7.34	± 0.03 feet
	18:46	7.38	± 0.02 feet
06-11-00	08:58	7.55	± 0.01 feet. Intermediate high water mark of 7.71 recorded.
	12:07	7.65	± 0.01 feet
	14:27	7.71	± 0.02 feet
	15:43	7.71	± 0.03 feet
06-12-00	08:01	8.48	± 0.02 feet
High Water Mark		8.75	± 0.02 feet
06-13-00	08:00	6.47	± 0.02 feet
	14:51	5.96	± 0.01 feet
06-14-00	09:48	5.34	Standing water. No flow..
	17:54		No flow.

Notes:

1. Coordinates for Staff Gage #4 are longitude 5975173.9, latitude 379222.5 and are Alaska State Plane, Zone 4, NAD 27.
2. Elevations are based on an elevation of 6.47 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support which was surveyed by LCMF Incorporated.

Table B-4: Water Surface Elevations and Observations at Permanent Staff Gage #6

Date	Time	Water Surface Elevation (feet)	Observations
06-03-00	15:24	7.20	Placed staff gage face plates from 9.99 to 15.0 feet. Standing water at staff gage.
06-04-00	15:29	7.20	Standing water at gage.
06-08-00	10:06	7.24	Standing water at staff gage. Intermediate high water mark of 7.27 recorded.
06-09-00	08:59	7.26	
	17:23	7.37	± 0.02 feet. There is water flowing, but it is not passing through the road at this location due to snow/ice blocked culverts.
06-10-00	10:19	7.84	± 0.02 feet. There is water flowing, but it is not passing through the road at this location due to snow/ice blocked culverts.
	19:11	8.07	± 0.03 feet
06-11-00	09:15	7.89	Intermediate high water mark of 8.16 recorded.
	17:11	8.00	± 0.02 feet
06-12-00	08:35	9.25	± 0.04 feet
High Water Mark		9.64	± 0.02 feet
06-13-00	08:18	7.47	± 0.01 feet
	15:07	7.38	± 0.01 feet
06-14-00	10:30	7.22	Standing water. No flow.
	17:45		No flow.

Notes:

1. Coordinates for Staff Gage #6 are longitude 5974982.6, latitude 373555.5 and are Alaska State Plane, Zone 4, NAD 27.
2. Elevations are based on an elevation of 7.30 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support which was surveyed by LCMF Incorporated.

Table B-5: Water Surface Elevations and Observations at Permanent Staff Gage #7

Date	Time	Water Surface Elevation (feet)	Observations
06-03-00			Placed staff gage faceplate from 13.32 to 9.99 feet.
06-08-00	10:03	7.17	Standing at staff gage.
06-09-00	08:58	7.17	
	17:23	7.25	
06-10-00	10:22	7.23	No indication of flow through culverts.
	19:13	7.47	± 0.01 feet
06-11-00	09:21	7.68	Intermediate high water mark of 7.76 recorded.
	17:09	7.77	± 0.01 feet
06-12-00	08:33	~8.50	Could not determine exact elevation due to unsafe wading conditions.
High Water Mark		8.84	
06-13-00	08:20	7.48	± 0.01 feet
	15:09	7.36	± 0.01 feet
06-14-00	10:32	7.18	Standing water. No flow.
	17:45		No flow.

Notes:

1. Coordinates for Staff Gage #7 are longitude 5975132.9, latitude 373586.4 and are Alaska State Plane, Zone 4, NAD 27.
2. Elevations are based on an elevation of 7.81 feet (BPMSL) located at the top of the 1-inch angle iron welded on the 5-inch drill stem staff gage support which was surveyed by LCMF Incorporated.

Table B-6: Water Surface Elevations and Observations at Permanent Staff Gage #8

Date	Time	Water Surface Elevation (feet)	Observations
06-03-00			Placed staff gage faceplate from 9.99 to 15.07 feet.
06-08-00	09:40	8.06	Standing water at staff gage. Intermediate high water mark of 8.12 recorded.
06-09-00	08:43	8.06	Standing water at staff gage.
	17:30		Standing water at staff gage.
06-10-00	10:14		Standing water at staff gage.
06-11-00	09:26		Standing water at staff gage.
06-12-00	08:45	8.84	Water flowing around CD-2 pad. No high water mark at this time.
High Water Mark		9.11	
06-13-00	08:32		Standing water at staff gage.
06-14-00	10:48	8.06	Standing water at staff gage.
	15:48		Standing water at staff gage.

Notes:

1. Coordinates for Staff Gage #8 are longitude 5974854.9, latitude 371261.2 and are Alaska State Plane, Zone 4, NAD 27.
2. 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 staff gage support which was surveyed by LCMF Incorporated.

Table B-7: Water Surface Elevations and Observations at Survey Monument #1

Date	Time	Water Surface Elevation (feet)	Observations
6-8-00	08:23	11.26	Ice sheet over the channel is continuous and about 1000' across.
	09:42	11.64	Ice sheet over the channel is continuous and about 1000' across.
	11:51	11.75	Ice sheet over the channel is continuous and about 1000' across.
	15:40	12.24	Ice sheet over the channel is continuous and about 1000' across.
6-9-00	06:50	15.68	Ice sheet over the channel is continuous and about 1000' across. Non-moving ice rubble exists for the other 2000'.
	14:37	18.98	Ice sheet over the channel is only along the east bank and about 35' across.
High Water Mark		19.33	
6-10-00	15:20	18.61	Ice sheet over the channel is only along the east bank and about 35' across.
	19:20	18.18	
6-11-00	10:57	15.94	
6-12-00		15.54	
6-13-00		13.21	

Notes:
1. Elevations are based on an elevation of 27.74 feet (BPMSL) for Monument 1, which was established by Lounsbury & Associates in 1996.
2. GPS coordinates for Monument 1 are N 70º 09’ 58.3” W 150º 56’ 12.6” (NAD 27). The GPS coordinates were obtained with a Garmin GPS II global positioning system.
3. The distance along the flow path from Monument 1 to TBM01D is approximately 2134 feet.
4. The distance along the flow path from Monument 1 to TBM01U is approximately 2010 feet.

Table B-8: Water Surface Elevations and Observations at Temporary Bench Mark 01D

Date	Time	Water Surface Elevation (feet)	Observations
6-8-00	08:27	N/A	Water level had not reached first gauge. Ice sheet over the channel is continuous and about 1000' across.
	09:45	N/A	Water level had not reached first gauge. Ice sheet over the channel is continuous and about 1000' across.
	11:53	N/A	Water level had not reached first gauge. Ice sheet over the channel is continuous and about 1000' across.
6-9-00	07:21	15.49	Ice sheet over the channel is continuous and about 1000' across. Non-moving ice rubble exists for the other 2000'.
	00:29	15.82	Ice sheet over the channel is continuous and about 1000' across. Non-moving ice rubble exists for the other 2000'.
	14:40	18.87	Ice sheet over the channel is only along the east bank and about 35' across.
High Water Mark		18.87	
6-10-00	15:23	18.43	Ice sheet over the channel is only along the east bank and about 35' across.
6-11-00	11:00	N/A	All gages are dry or destroyed.

Notes:
1. The elevations are based on an elevation of 28.62 feet (BPMSL) for TBM01D, which was established by Michael Baker Jr., Inc. in 2000. The elevation of TBM01D was based on an elevation of 27.74 feet (BPMSL) for Monument 1, which was established by Lounsbury and Associates in 1996.
2. The distance along the flow path from Monument 1 to TBM01D is approximately 2134 feet.
3. The distance along the flow path from Monument 1 to TBM01U is approximately 2010 feet.

Table B-9: Water Surface Elevations and Observations at Temporary Bench Mark 01U

Date	Time	Water Surface Elevation (feet)	Observations
6-8-00	08:21	11.46	Ice sheet over the channel is continuous and about 1000' across.
	09:40	11.88	Ice sheet over the channel is continuous and about 1000' across.
	11:45	11.97	Ice sheet over the channel is continuous and about 1000' across.
6-9-00	06:46	16.61	Ice sheet over the channel is continuous and about 1000' across. Non-moving ice rubble exists for the other 2000'.
	09:21	17.56	Ice sheet over the channel is continuous and about 1000' across. Non-moving ice rubble exists for the other 2000'.
	14:34	19.23	Ice sheet over the channel is only along the east bank and about 35' across.
High Water Mark		19.88	
6-10-00	15:15	18.53	Ice sheet over the channel is only along the east bank and about 35' across.
6-11-00	10:55	17.51	
6-12-00	17:15	16.38	

Notes:
1. The elevations are based on an elevation of 28.03 feet (BPMSL) for TBM01U, which was established by Michael Baker Jr., Inc. in 2000. The elevation of TBM01U was based on an elevation of 27.74 feet (BPMSL) for Monument 1, which was established by Lounsbury and Associates in 1996.
2. The distance along the flow path from Monument 1 to TBM01D is approximately 2134 feet.
3. The distance along the flow path from Monument 1 to TBM01U is approximately 2010 feet.

Table B-10: Water Surface Elevations and Observation at Survey Monument #12

Date	Time	Water Surface Elevation (feet)	Observations
6-8-00	08:32	7.02	Ice sheet over the channel is continuous and about 600' across.
	09:50	7.31	Ice sheet over the channel is continuous and about 600' across.
	12:06	7.62	Ice sheet over the channel is continuous and about 600' across.
	07:29	9.64	Ice sheet over the channel is continuous and about 500' across.
6-9-00	14:49	10.24	Ice sheet over the channel is continuous and about 500' across.
6-10-00	15:41	10.68	Ice sheet over the channel is continuous and about 200' across.
6-11-00	11:07	10.82	
6-12-00			
High Water Mark		13.26	The peak water surface elevation probably occurred between the morning of 6/12 – 6/13 based on local observations.
6-15-00			

Notes:

1. Elevations are based on an elevation of 10.13 feet (BPMSL) for Monument 12, which was established by Lounsbury & Associates in 1996
2. GPS coordinates for Monument 12 are N 70º 14’ 58.3” W 150º 01’ 23.5” (NAD 27) which were surveyed by Lounsbury and Associates.

Table B-11: Water Surface Elevation and Observations at Survey Monument #22

Date	Time	Water Surface Elevation (feet)	Observations
6-8-00	08:40 09:50 12:11	4.08 4.26 4.54	Ice sheet over the channel is continuous and about 300' across. ± 0.02 ft. Ice sheet over the channel is continuous and about 300' across. ± 0.02 ft. Ice sheet over the channel is continuous and about 300' across.
6-9-00	07:41	6.79	± 0.02 ft. Ice sheet over the channel is continuous and about 200' across.
6-9-00	15.06	7.47	± 0.05ft. Ice sheet over the channel is continuous and about 200' across.
6-10-00	15:58	7.94	± 0.05 ft. Ice sheet over the channel is continuous and about 175' across.
6-11-00	11:30	7.85	
6-12-00 High Water Mark 6-15-00		9.58	The peak water surface elevation probably occurred between the morning of 6/12 – 6/13 based on local observations.

Notes:

1. Elevations are based on an elevation of 10.13 feet (BPMSL) for Monument 22, which was established by Lounsbury & Associates in 1996.
2. GPS coordinates for Monument 22 are N 70º 19’ 06.3” W 151º 03’ 10.4” (NAD 27) which were surveyed by Lounsbury and Associates.

Table B-12: Water Surface Elevations and Observations near Survey Monument #35

Date	Time	Water Surface Elevation (feet)	Observations
6-10-00	22.45	6.26	
6-11-00	01:20	6.30	
	03:30	6.34	
	05:45	6.93	
	06:12	7.01	
	06:45	7.09	
	07:05	7.18	
	07:30	7.26	
	07:50	7.18	
	08:15	7.18	
	08:30	7.26	
	09:00	7.30	
	09:21	7.34	
	10:15	7.34	
	11:30	7.34	
High Water Mark	12:35	7.39	
	13:50	7.32	
	14:30	7.22	
	15:45	7.01	
	18:10	7.09	
	19:30	7.01	
	20:15	6.93	
	21:40	6.84	

Table B-12 (continued): Water Surface Elevations and Observations near Survey Monument #35

Date	Time	Water Surface Elevation (feet)	Observations
6-12-00	00:30	6.68	
	06:30	6.26	
	08:00	6.09	
	13:30	5.76	
	16:00	5.59	

Notes:

1. Elevations are based on an elevation of 5.57 feet (BPMSL) for Monument 35, which was established by Lounsbury & Associates in 1996..
2. GPS coordinates for Monument 35 are N 70º 25' 58.1" W 150º 22' 49.1" (NAD 27) which were surveyed by Lounsbury and Associates.
3. Observations made by Jim & Tina Helmricks on the south side of their residence.

Table B-13: Summary of Breakup Data Obtained at the Head of the Colville River Delta, 1962 – 2000

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

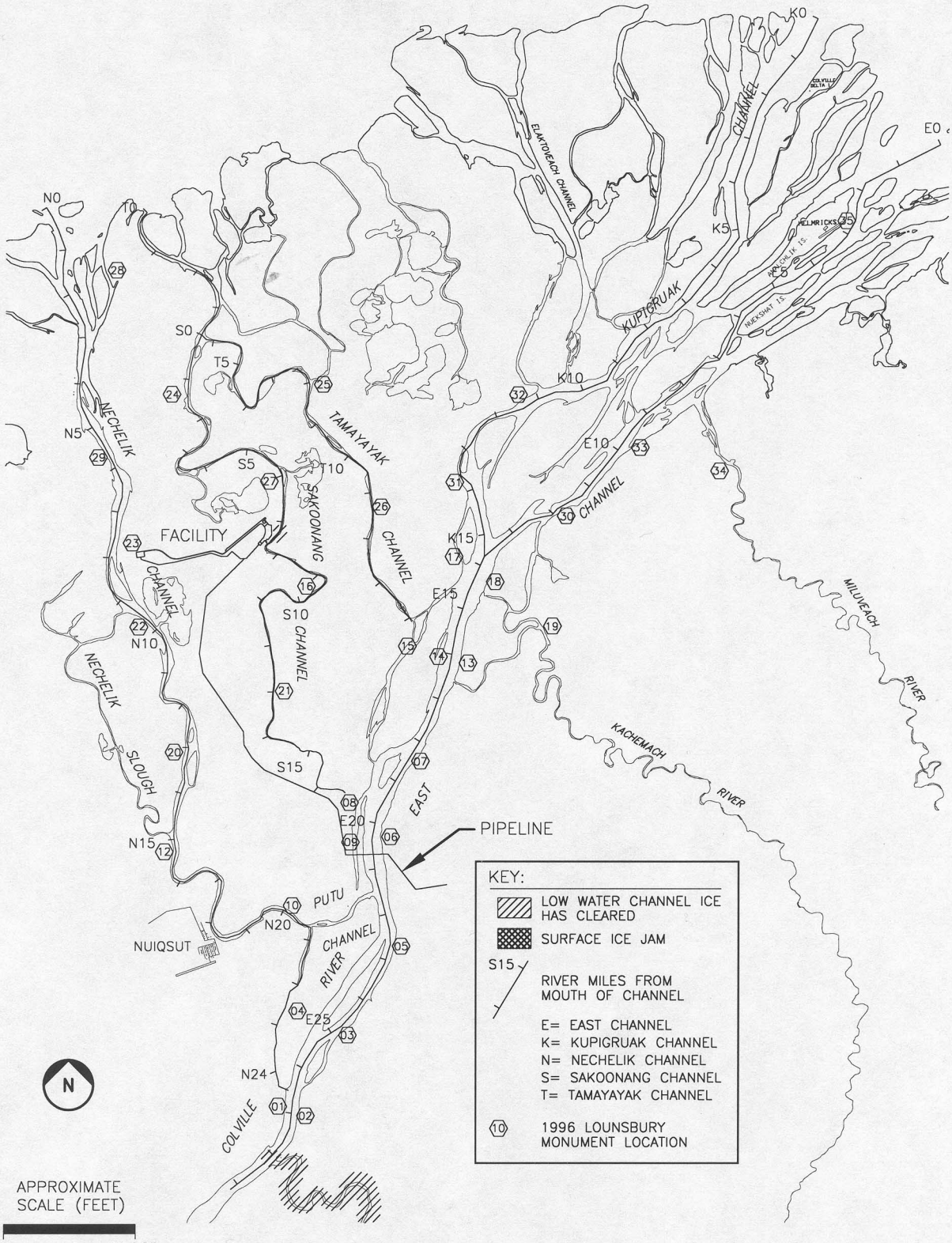
Notes:

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. The peak breakup discharge was estimated to range between 570,000 to 590,000 cfs.
3. 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.
4. 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.
5. 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.
6. 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.
7. 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.

Appendix C

Channel Ice Observations

List of Figures:



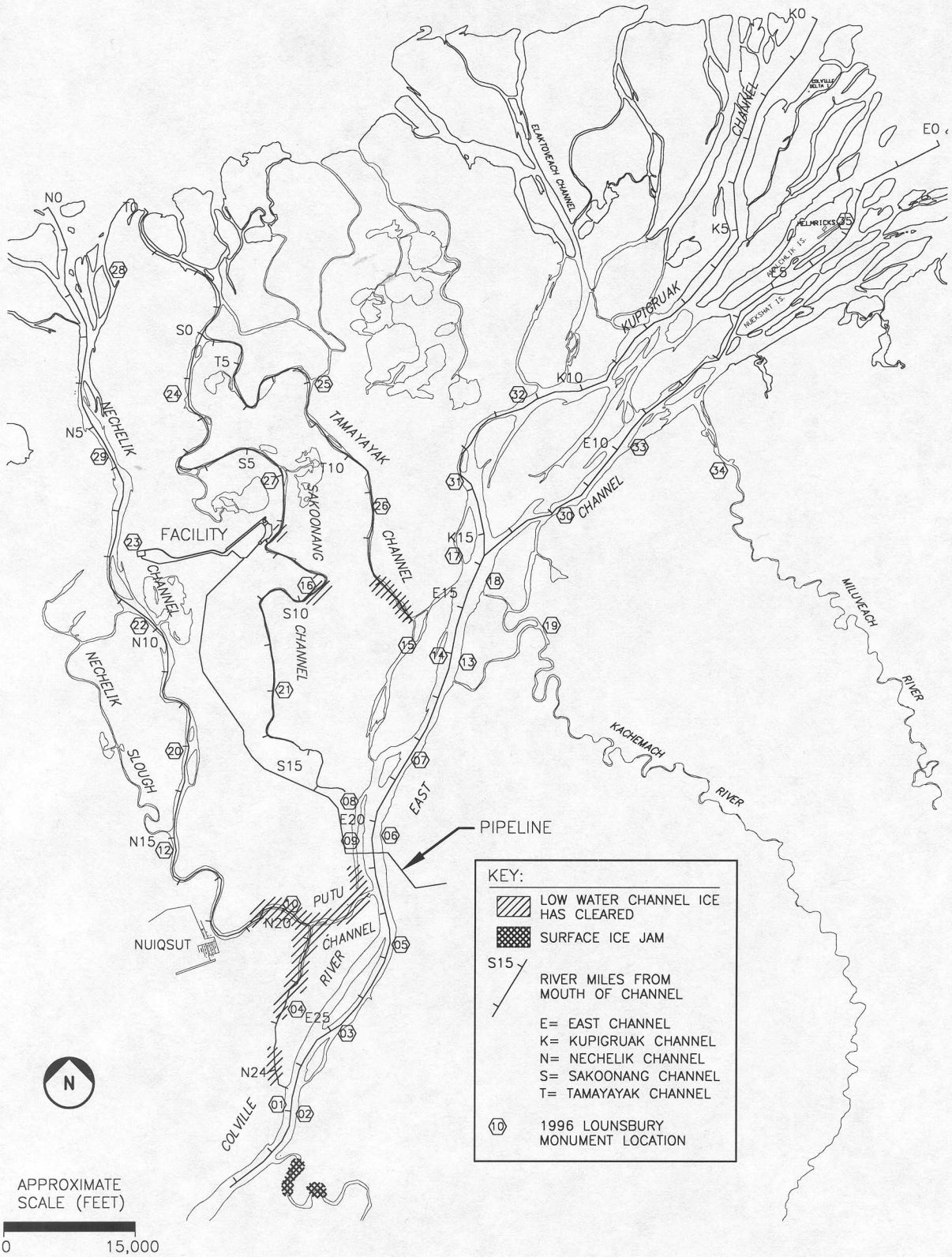
24531M01.dwg

Baker — Michael Baker Jr., Inc.	
DATE: 8/1/00	PROJECT: 23100-020-0101
DRAWN: TM	FILE:
CHECKED: JWA	SCALE: AS NOTED

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

LOW WATER CHANNEL ICE SURVEY
JUNE 6, 2000 AT 15:00 HOURS

FIGURE: C-1



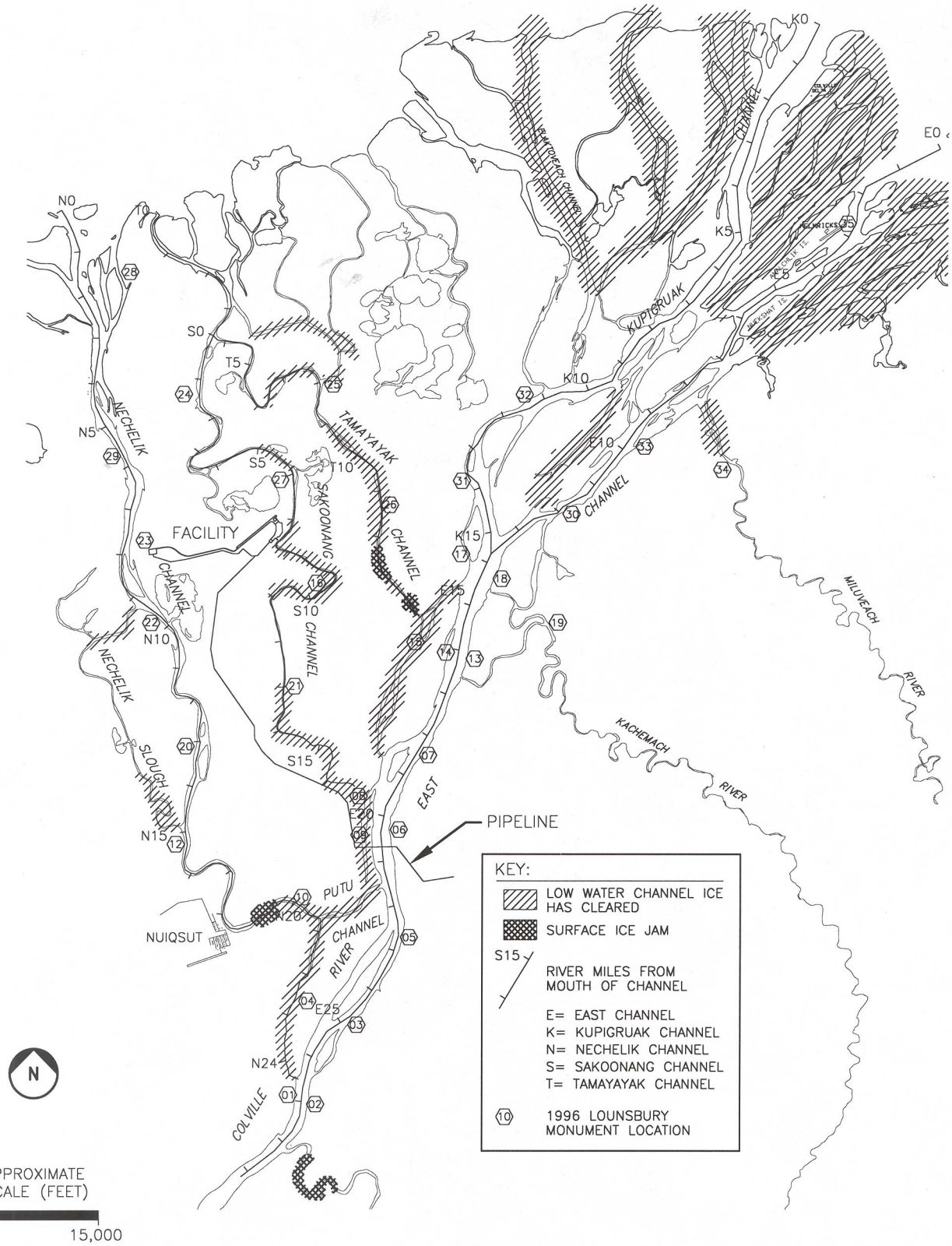
24531M02.dwg

Baker	Michael Baker Jr., Inc.
DATE: 8/1/00	PROJECT: 23100-020-0101
DRAWN: TM	FILE:
CHECKED: JWA	SCALE: AS NOTED

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

LOW WATER CHANNEL ICE SURVEY
JUNE 7, 2000 AT 10:00 HOURS

FIGURE:
C-2



KEY:

- LOW WATER CHANNEL ICE HAS CLEARED
- SURFACE ICE JAM
- S15 — RIVER MILES FROM MOUTH OF CHANNEL
- E= EAST CHANNEL
- K= KUPIGRUAK CHANNEL
- N= NECHELIK CHANNEL
- S= SAKOONANG CHANNEL
- T= TAMAYAYAK CHANNEL
- (10) 1996 LOUNSBURY MONUMENT LOCATION

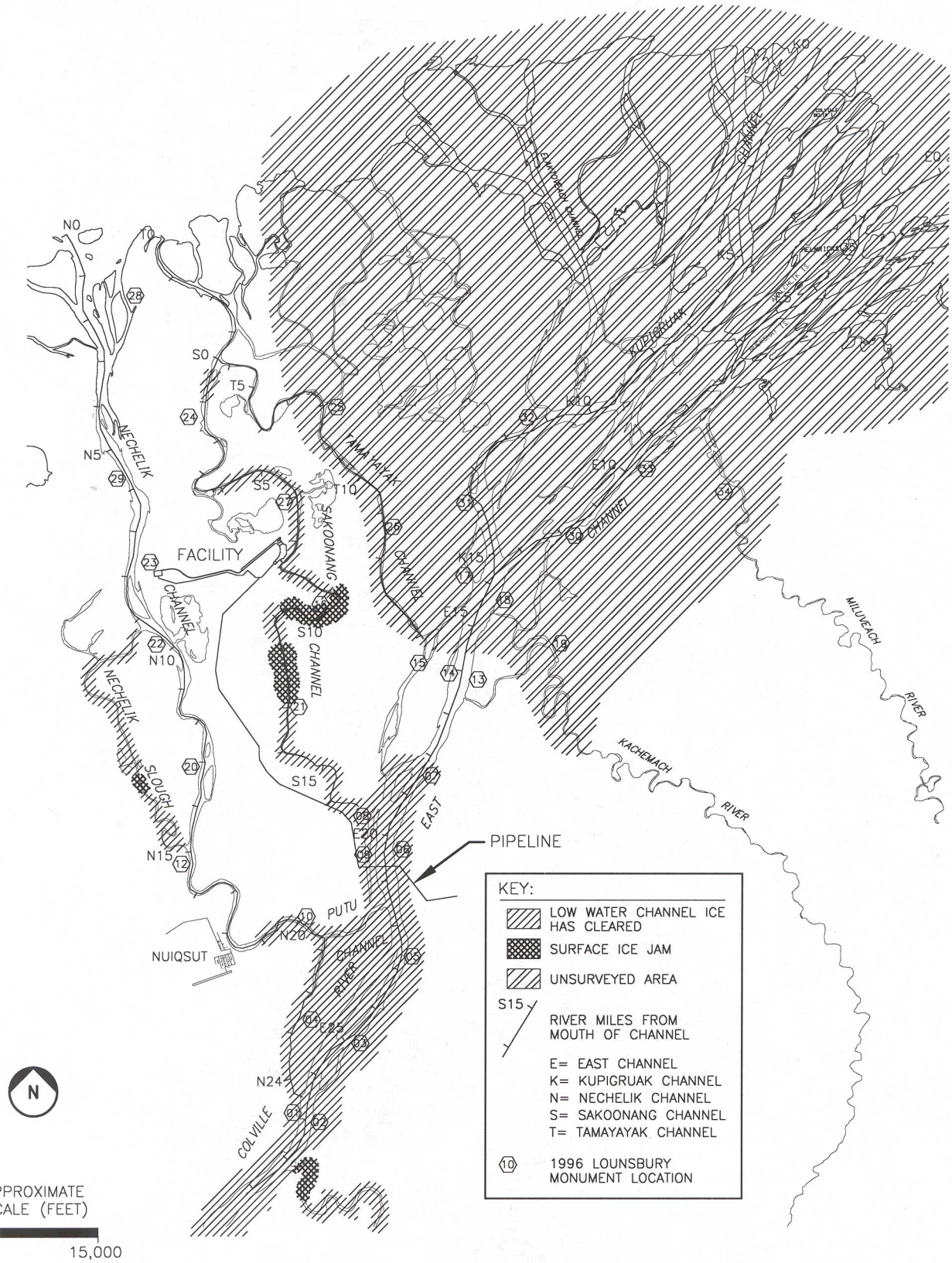
24531MØ3.dwg

Baker	Michael Baker Jr., Inc.		
DATE:	8/1/00	PROJECT:	23100-020-0101
DRAWN:	TM	FILE:	
CHECKED:	JWA	SCALE:	AS NOTED

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

LOW WATER CHANNEL ICE SURVEY
JUNE 8, 2000 AT 15:43 HOURS

FIGURE:
C-3



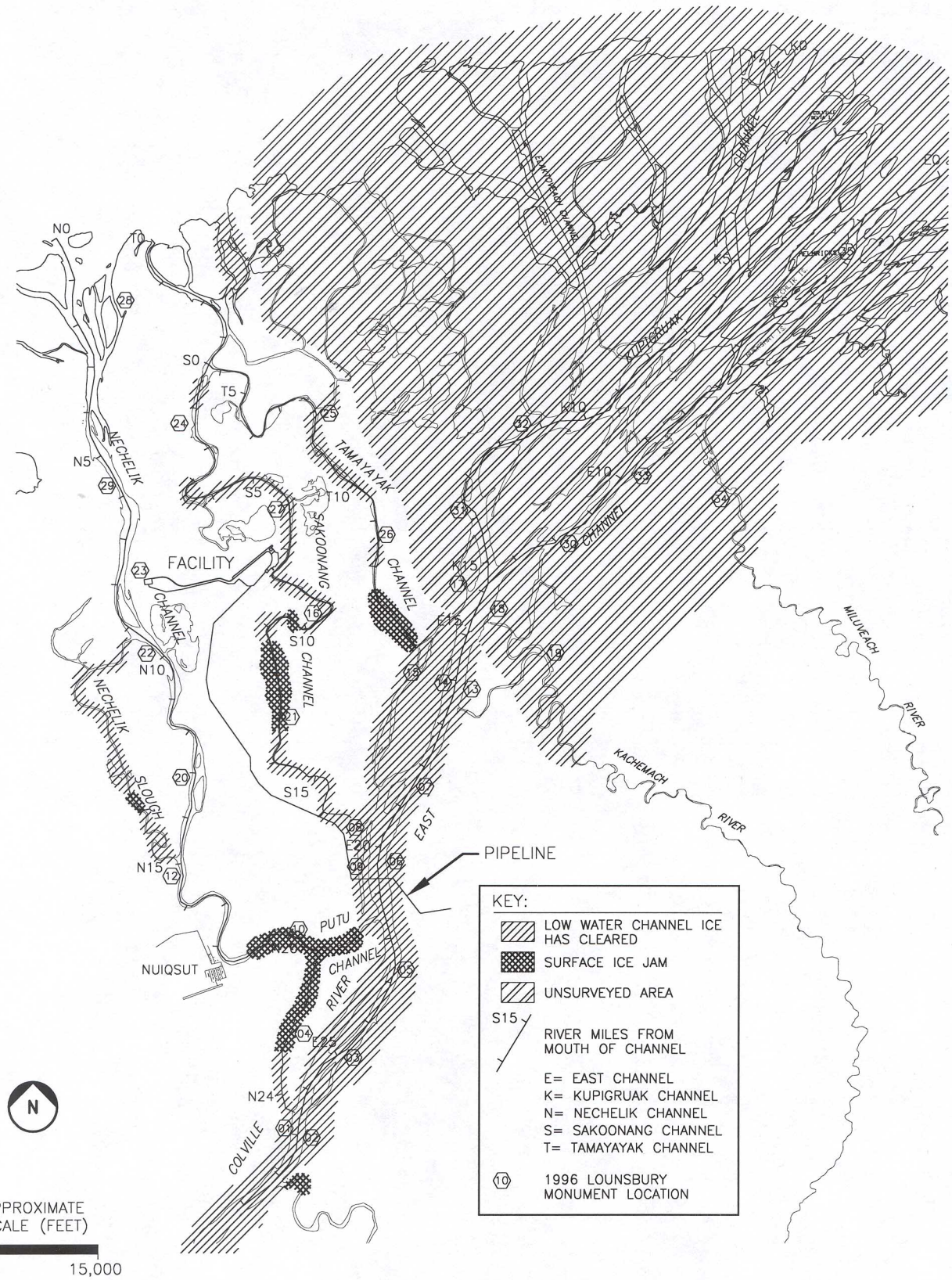
24531M04.dwg

Baker	Michael Baker Jr., Inc.
DATE: 8/1/00	PROJECT: 23100-020-0101
DRAWN: TM	FILE:
CHECKED: JWA	SCALE: AS NOTED

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

LOW WATER CHANNEL ICE SURVEY
JUNE 9, 2000

FIGURE:
C-4



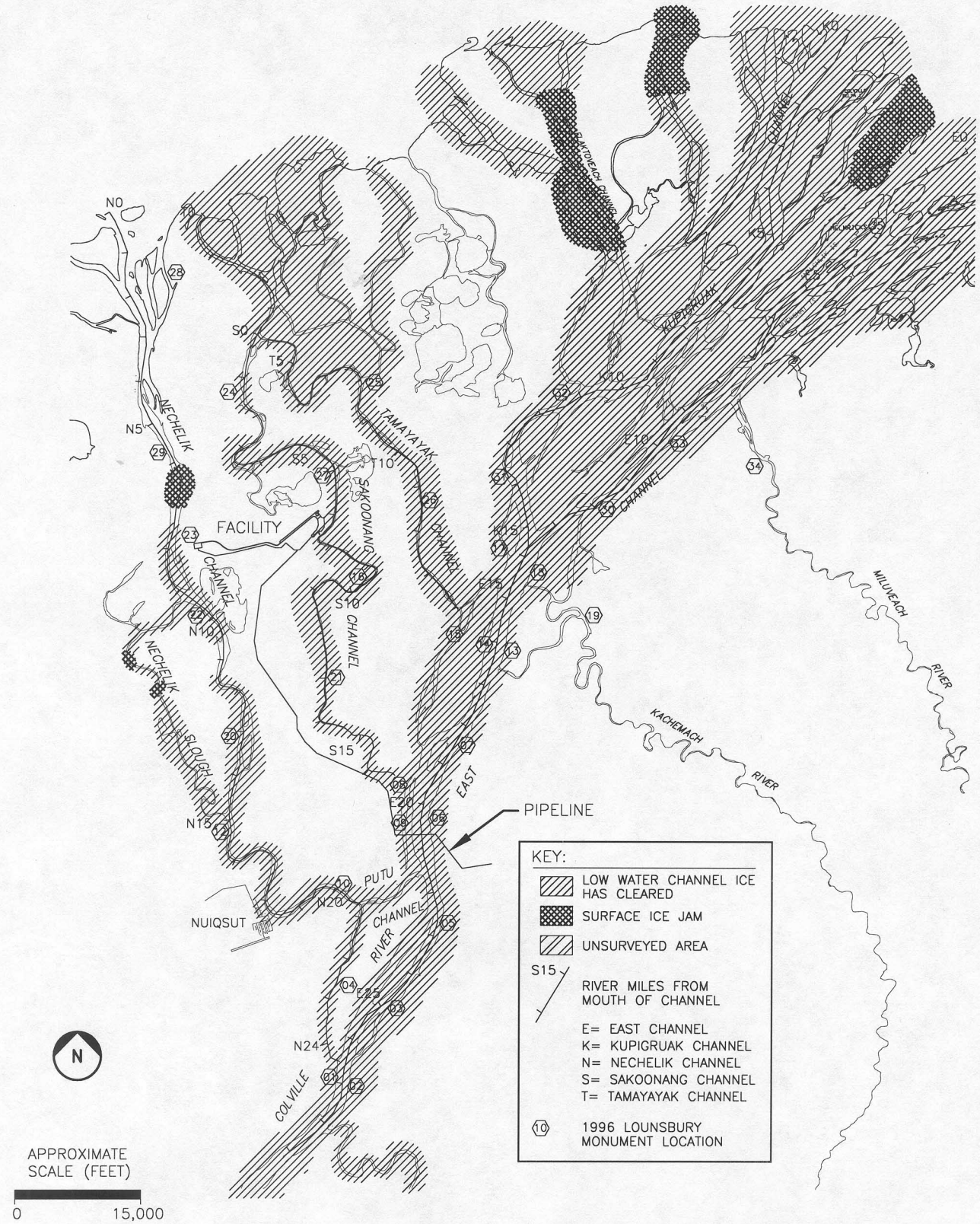
24531MØ5.dwg

Baker	Michael Baker Jr., Inc.
DATE: 8/1/00	PROJECT: 23100-020-0101
DRAWN: TM	FILE:
CHECKED: JWA	SCALE: AS NOTED

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

LOW WATER CHANNEL ICE SURVEY
JUNE 10, 2000 AT 18:00 HOURS

FIGURE:
C-5



24531M07.dwg

Baker	Michael Baker Jr., Inc.
DATE: 8/1/00	PROJECT: 23100-020-0101
DRAWN: TM	FILE:
CHECKED: JWA	SCALE: AS NOTED

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

LOW WATER CHANNEL ICE SURVEY
JUNE 12, 2000 AT 15:30 HOURS

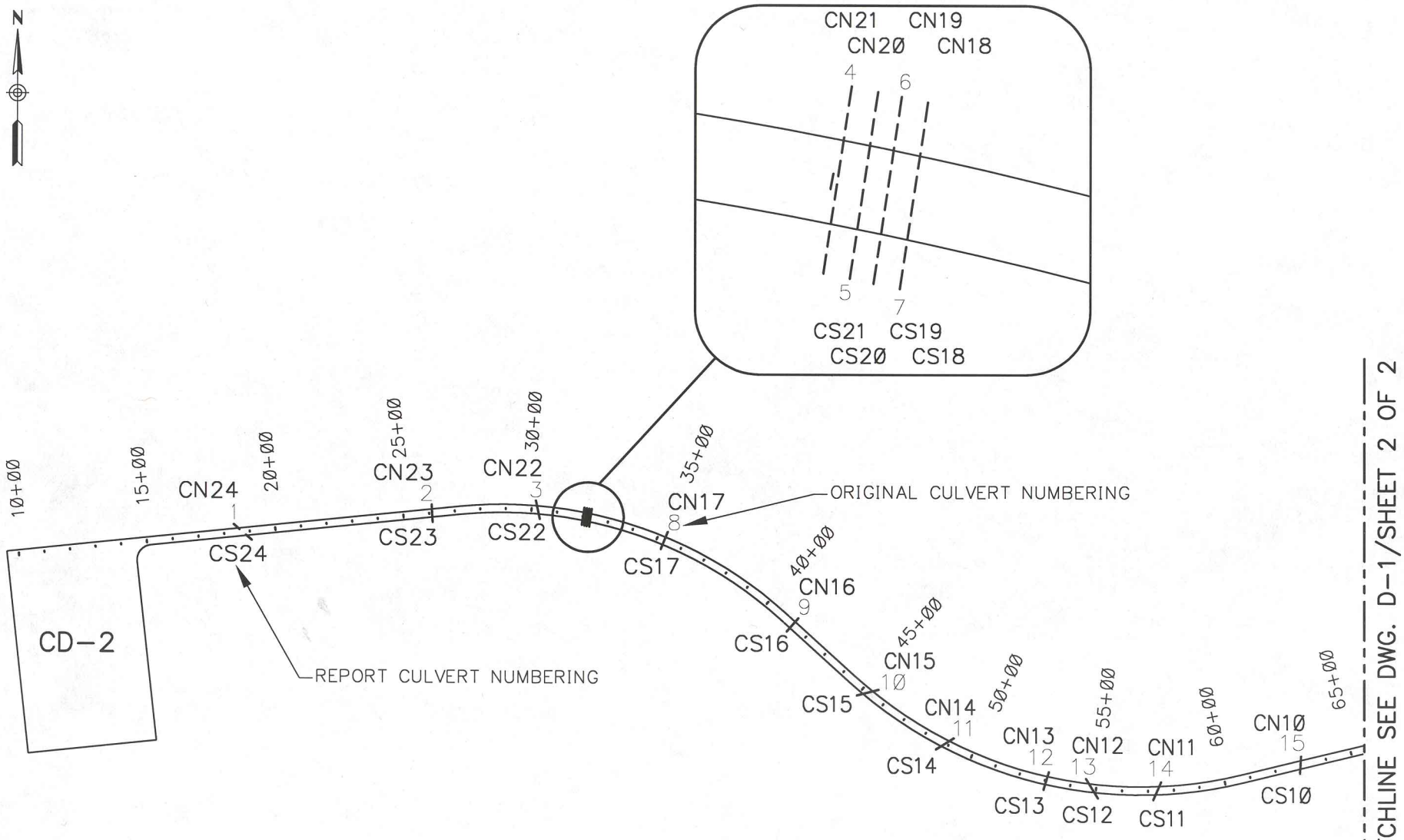
FIGURE:
C-6

Appendix D

Observations at Culverts and Bridges

List of Figures:

List of Tables

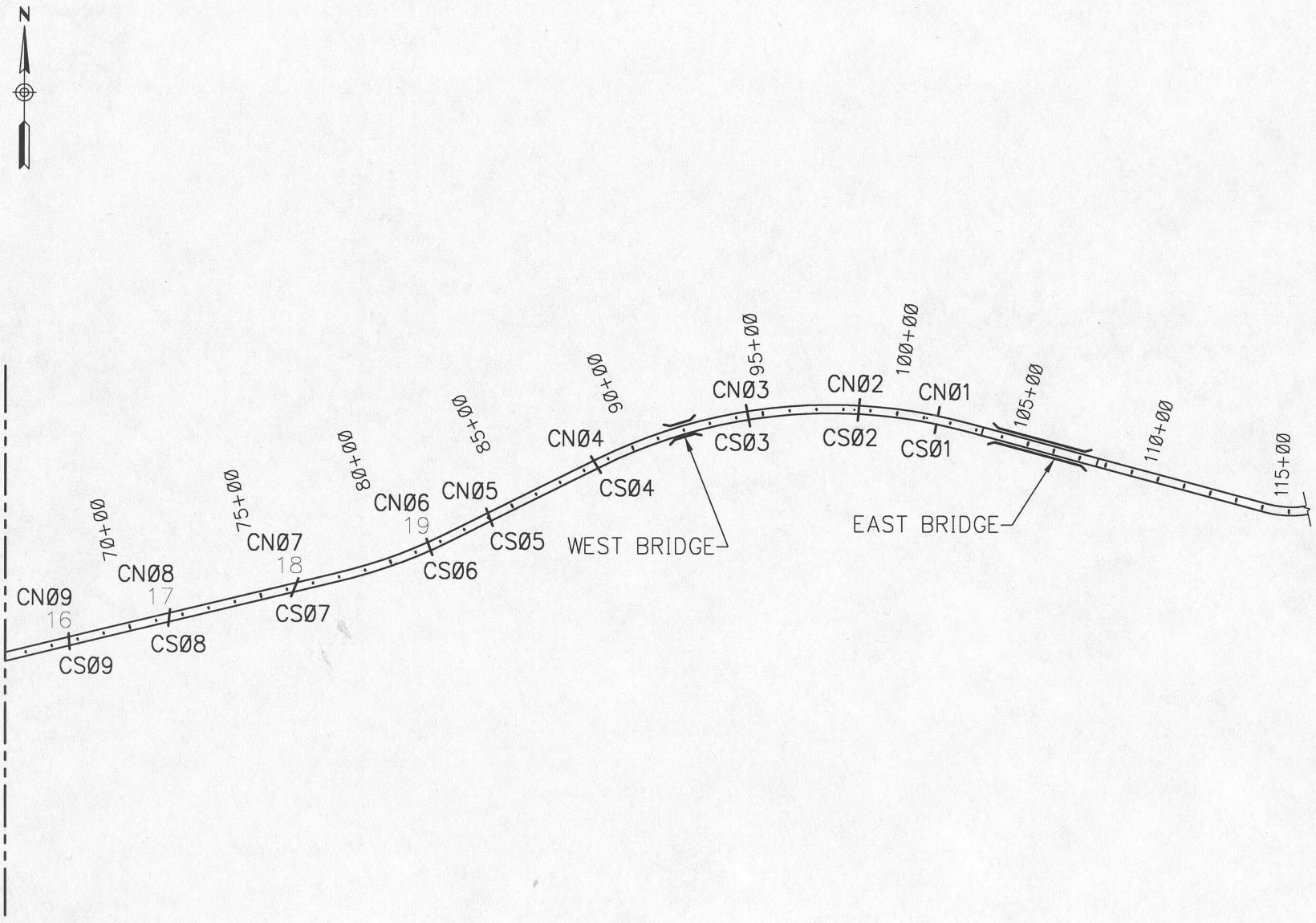


Baker	Michael Baker Jr., Inc.		
DATE:	10/25/00	PROJECT:	24540
DRAWN:	WAE	FILE:	24540C001.DWG
CHECKED:	JAB	SCALE:	NONE

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

ALPINE FACILITY CULVERT LOCATIONS
AND NAMING CONVENTION

FIGURE:
D-1
SHEET 1 OF 2



Baker	Michael Baker Jr., Inc.		
DATE:	10/25/00	PROJECT:	24540
DRAWN:	WAE	FILE:	24540C002.DWG
CHECKED:	JAB	SCALE:	NONE

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

ALPINE FACILITY CULVERT LOCATIONS
AND NAMING CONVENTION

FIGURE:
D-1
SHEET 2 OF 2

Table D-1: Flow Observations at Culverts

Date	Time	Culvert #	Observations
06-04-00		C-1	Water from Nanuk Lake on south side of culvert, cannot pass to north side due to snow/ ice blockage.
		C-2	Water from Nanuk Lake on south side of culvert, cannot pass to north side due to snow/ ice blockage.
		C-3	Water from Nanuk Lake on south side of culvert, cannot pass to north side due to snow/ ice blockage.
		C-4	Water from Nanuk Lake on south side of culvert, cannot pass to north side due to snow/ ice blockage. Standing water from melting on north side of culvert.
06-09-00	09:20	C-4	Water flowing from south to north through culvert. No apparent snow or ice blockage in culvert.
	09:36	C-3	Water flowing from south to north through culvert. No apparent snow or ice blockage in culvert.
	09:42	C-2	Water flowing from south to north through culvert. No apparent snow or ice blockage in culvert.
	09:58	C-1	Water flowing from south to north through culvert. No apparent snow or ice blockage in culvert.
06-10-00	10:10		Most culverts on south side of road near CD-2 have water in them. Some have flow completely through, while others are still blocked by snow/ ice on the north side of the road.
	19:13	C-21	Water flowing from south to north through culvert.
			The staff gage #6 reading is representative of the water surface elevation on the south side of culverts C-17, 21-24.
			The staff gage #7 reading is representative of the water surface elevation on the north side of culverts C-17, 21-24.
06-11-00	09:18	C-20	Water flowing from south to north through culvert.
06-12-00	08:02	C-1, 2, 3	South side of culvert is completely under water.
	08:35	C-18 - 21	South side of culvert is completely under water and there is flow through all culverts.
06-13-00	08:04	C-1 - 4	Water is still flowing from south to north but the depth of flow is less than on 6/12.
	08:07	C-5	No flow through culvert.
	08:09	C-11 - 21	Flow has changed direction such that flow is now from north to south. C-15 had no flow.
	08:29	C-22, 23, 24	Minimal flow through culverts. The direction of flow is now from north to south.
06-14-00	09:48	C-1 - 5	No flow through culverts. Standing water on south side.
	10:17	C-11 - 14	Direction of flow is from north to south.
	10:17	C-15	No flow is present and there is standing water on both ends of the culvert.
	10:17	C-16	Minimal flow through culverts. The direction of flow is now from north to south.
	10:17	C-17 - 21	No flow through culverts.
06-15-00		C11 - 24	These culverts are on the west side of a high point in the Swale area. During initial flooding stages, the water coming from the Nanuk Lake area passed from south to north. But once the water started to recede, the flow changed direction and began flowing from north to south through the culverts.

Table D-2: Depressions in Tundra Adjacent to North Side of Culverts

Observation Date	New Culvert Number	Old Culvert Number	Invert Elevation (ft)	Water Depth (ft)	Water Surface Elevation (ft)	Depression at Inlet			See Note
						Max Depth from Culvert Invert (ft)	Max Width (ft)	Max Length (ft)	
06-15-00	CN-24	1	6.42	0.97	7.39	1.03	12	11	1, 2
06-15-00	CN-23	2	6.38	0.97	7.35	0.83	21	12	1, 2
06-15-00	CN-22	3	5.72	1.64	7.36	0.76	20	5	1, 2
06-17-00	CN-21	4	5.27	2.06	7.33	1.04	17.9	13.6	1, 2, 3
06-17-00	CN-20	5	5.39	1.92	7.31	0.98	9.2	11	1, 2, 4
06-17-00	CN-19	6	5.28	2.10	7.38	1.2	10.5	11.5	1, 2, 4
06-17-00	CN-18	7	5.35	1.98	7.33	0.52	14.4	11	1, 2, 3
06-17-00	CN-17	8	6.10	1.28	7.38	0.72	24.3	6	1, 2
06-17-00	CN-16	9	6.83	0.36	7.19	0.84	16.5	6.8	1, 2
06-17-00	CN-15	10	6.61	0.46	7.07	2.54	29.4	21.4	1, 2
06-17-00	CN-14	11	6.42	0.56	6.98	2.24	22.2	14.5	1, 2
06-17-00	CN-13	12	6.12	1.06	7.18	0.34	8.7	9	1, 2
06-18-00	CN-12	13	6.17	0.72	6.89	1.68	23.2	15.3	1, 2
06-18-00	CN-11	14	6.01	0.98	6.99	0.82	25.8	11.6	1, 2
06-18-00	CN-10	15	6.73	0.66	7.39	1.14	22.6	7.7	1, 2
06-18-00	CN-9	16	8.59	-0.36	8.23	1.36	17.1	8.1	1, 6
06-18-00	CN-8	17	8.42	0.26	8.68	0.54	15	4	1, 2, 6
06-18-00	CN-7	18	7.52	0.98	8.50	1.32	21.5	15.5	1, 2
06-18-00	CN-6	19	8.07	-0.59	7.48	1.09	16	6.8	1, 2, 6
06-18-00	CN-5	N/A	6.34	0.18	6.52	-	-	-	1, 2, 7
06-18-00	CN-4	N/A	5.28	0.22	5.50	-	-	-	1, 2, 7
06-18-00	CN-3	N/A	5.24	0.00	5.24	-	-	-	1, 2, 6, 7
06-18-00	CN-2	N/A	4.57	0.20	4.77	-	-	-	1, 2, 7
06-18-00	CN-1	N/A	4.38	0.00	4.38	-	-	-	1, 2, 7

Notes:

1. Depression appears to be from construction effort.
2. No measurable flow present in culvert.
3. Width of depression is equal to the distance from the edge of vegetation to mid-distance between culverts.
4. Width of depression is equal to mid-distance to mid-distance between culverts.
5. Maximum depression depth may be due to scour, rather than construction efforts.
6. Ice/snow is present in the culvert.
7. An articulated concrete mat is present at the end of the culvert.

Table D-3: Depressions in Tundra Adjacent to South Side of Culverts

Observation Date	New Culvert Number	Old Culvert Number	Invert Elevation (ft)	Water Depth (ft)	Water Surface Elevation (ft)	Depression at Inlet			See Note
						Max Depth from Culvert Invert (ft)	Max Width (ft)	Max Length (ft)	
06-15-00	CS-24	1	5.86	1.66	7.52	0.44	11.0	7.0	1, 2
06-15-00	CS-23	2	6.23	1.24	7.47	0.96	17.0.	6.0	1, 2
06-15-00	CS-22	3	5.82	1.72	7.54	0.58	20.0.	12.0	1, 2
06-17-00	CS-21	4	5.52	1.94	7.46	1.26	13.7.	27.2	1, 2, 3
06-17-00	CS-20	5	5.40	1.92	7.32	1.48	10.3	27.6	1, 2, 4
06-17-00	CS-19	6	5.50	1.90	7.40	1.4	9.7	28.5	1, 2, 4
06-17-00	CS-18	7	5.46	1.98	7.44	1.42	16.2	30.7	1, 2, 3
06-17-00	CS-17	8	6.02	1.36	7.38	1.34	24.2	22.8	1, 2
06-17-00	CS-16	9	6.79	0.46	7.25	1.54	24.0	21.0	1, 2
06-17-00	CS-15	10	6.49	0.78	7.27	1.22	26.4	20.2	1, 2
06-17-00	CS-14	11	6.72	0.39	7.11	2.21	24.0	29.6	1, 2
06-17-00	CS-13	12	6.16	0.98	7.14	1.12	45.0	21.8	1, 2
06-18-00	CS-12	13	6.53	0.52	7.05	1.38	26.0	35.3	1, 2
06-18-00	CS-11	14	6.02	0.99	7.01	0.81	25.0	26.0	1, 2, 5
06-18-00	CS-10	15	6.40	1.00	7.40	1.1	23.0	14.6	1, 2, 5
06-18-00	CS-9	16	8.46	0.32	8.78	0.68	20.4	18.3	1, 2, 6
06-18-00	CS-8	17	8.20	0.60	8.80	0.8	25.0	15.5	1, 2, 6
06-18-00	CS-7	18	7.56	0.98	8.54	1.02	20.6	17.0	1, 2
06-18-00	CS-6	19	7.96	-0.48	7.48	1.98	24.5	20.0	1, 2, 6
06-18-00	CS-5	N/A	6.32	0.32	6.64	1.08	33.0	33.0	1, 2
06-18-00	CS-4	N/A	5.47	-0.50	4.97	1	10.6	5.3	1, 2, 6
06-18-00	CS-3	N/A	5.09	0.08	5.17	0.72	12.3.	5.0	1, 2
06-18-00	CS-2	N/A	4.34	0.42	4.76	0.28	14.8	4.0	1, 2
06-18-00	CS-1	N/A	4.20	0.20	4.40	0.5	10.3	2.6	1, 2

Notes:

1. Depression appears to be from construction effort.
2. No measurable flow present in culvert.
3. Width of depression is equal to the distance from the edge of vegetation to mid-distance between culverts.
4. Width of depression is equal to mid-distance to mid-distance between culverts.
5. Maximum depression depth may be due to scour, rather than construction efforts.
6. Ice/snow is present in the culvert.
7. An articulated concrete mat is present at the end of the culvert.

Table D-4 Difference in Water Surface Elevation Between Inlet and Outlet of Culverts

Date	Culvert North Side	Water Surface Elevation (feet)	Culvert South Side	Water Surface Elevation (feet)	Water Surface Elevation Difference
6/15/00	CN-24	7.39	CS-24	7.52	0.13
	CN-23	7.35	CS-23	7.47	0.12
	CN-22	7.36	CS-22	7.54	0.18
6/17/00	CN-21	7.33	CS-21	7.46	0.13
	CN-20	7.31	CS-20	7.32	0.01
	CN-19	7.38	CS-19	7.40	0.02
	CN-18	7.33	CS-18	7.44	0.11
	CN-17	7.38	CS-17	7.38	0.00
	CN-16	7.19	CS-16	7.25	0.06
	CN-15	7.07	CS-15	7.27	0.20
	CN-14	6.98	CS-14	7.11	0.13
	CN-13	7.18	CS-13	7.14	-0.04
6/18/00	CN-12	6.89	CS-12	7.05	0.16
	CN-11	6.99	CS-11	7.01	0.02
	CN-10	7.39	CS-10	7.40	0.01
	CN-9	8.23	CS-9	8.78	0.55
	CN-8	8.68	CS-8	8.80	0.12
	CN-7	8.50	CS-7	8.54	0.04
	CN-6	7.48	CS-6	7.48	0.00
	CN-5	6.52	CS-5	6.64	0.12
	CN-4	5.50	CS-4	4.97	-0.53
	CN-3	5.24	CS-3	5.17	-0.07
	CN-2	4.77	CS-2	4.76	-0.01
	CN-1	4.38	CS-1	4.40	0.02

Table D-5: CD-2 Access Road, Culvert Discharge Measurements on June 10, 2000

DISCHARGE MEASUREMENT NOTES

LOCATION: Culverts on downstream side of flow between CD-1 and CD-2.

Date: **June 10, 2000** **Party:** J. Abrams, J. Charton, J. Aldrich

Width: **ft** **Area** 53.9 **ft^2** **Vel**: 3.58 **fps** **G.H.:** **Disch.:** 192.8 **cfs**

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

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

Gage Readings

Time	**Recorder**	**Inside**	**Outside**
17:20	S.G. # 3 (U/S)		W.S.E. = 7.87 +/- 0.03
17:22	S.G. # 4 (D/S)		W.S.E. = 7.34 +/- 0.03
Weighted M.G.H.			
G.H. corrections			
Correct M.G.H.			

Type of meter: Price AA

Date rated: Factory

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

Spin before meas. 2 min 2 sec **after** 1 min 25 sec

Method: wading rod

0.4 depth measurements

Levels obtained:

Measurement rated: **Rating based on following conditions:**

Cross section:

Flow: **Weather:** **Air oF@:**

Gage: **Water oF@:**

Other:

Record Removed: **Intake flushed:**

Observer

Control

Remarks **Water surface elevations are relative to BPMSL.** Discharge measurements taken at the outlet of the culverts

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

Table D-5 (continued): CD-2 Access Road, Culvert Discharge Measurements on June 10, 2000

Culvert #	Time	Culvert Dia. (in.)	Depth (ft)	Observ. depth	Revo-lutions	Time In seconds	VELOCITY		Area (s.f.)	Discharge (cfs)	Description
							At Point (fps)	Mean in-vertical (fps)			
CN-4	18:00	48"	2.0	0.4	80	42	4.16	3.87	6.3	24.3	
CN-5	18:05	48"	1.0	0.4	N/A	N/A		0.00	0.0	0.0	Standing Water, Culvert full of snow.
CN-3	18:18	48"	2.2	0.4	80	44	3.98	3.70	7.1	26.2	
CN-2	18:27	48"	2.9	0.4	80	43	4.07	3.79	9.8	36.9	
CN-1	18:32	48"	3.0	0.4	60	44	2.99	2.78	10.1	28.1	
East Bridge	18:38		2.7	0.4	80	48	3.65			0.0	
CN-17	19:05	48"	0.8	0.4	60	43	3.06	2.85	3.1	8.7	Bottom of culvert is filled with ice. Top of ice is 2.60 and 2.90 feet below top of culvert at inlet and outlet respectively.
CS-17		48"	1.0	N/A	N/A	N/A	N/A				
CN-21	19:21	48"	0.6	0.4	60	41	3.21	2.99	2.3	6.8	Bottom of culvert is filled with ice. Top of ice is 2.20 and 1.70 feet below top of culvert at inlet and outlet respectively.
CS-21	19:17	48"	1.2	N/A	N/A	N/A	N/A				
CN-22	19:28	48"	2.1	0.4	80	45	3.89	3.62	6.7	24.2	Bottom of culvert is ice covered at inlet. Top of ice is 3.93 feet below top of culvert. There is no ice at the outlet.
CS-22	19:24	48"	2.6	N/A	N/A	N/A	N/A				
CN-23	19:34	48"	1.5	0.4	90	40	4.91	4.57	4.3	19.7	No ice at inlet or outlet.
CS-23	19:32	48"	2.1	N/A	N/A	N/A	N/A				
CN-24	19:40	48"	1.5	0.4	100	49	4.46	4.15	4.3	17.9	
CS-24	19:38	48"	2.3	N/A	N/A	N/A	N/A				
Total									**53.9**	**192.8**	**Page 2 of 2**

Table D-6: CD-2 Access Road, Culvert Discharge Measurements on June 11, 2000

DISCHARGE MEASUREMENT NOTES

LOCATION: Culverts on downstream side of flow between CD-1 and CD-2.

Date: **June 11, 2000** **Party:** J. Abrams, J. Packer

Width: **ft** **Area:** 75.2 **ft^2** **Vel**: 2.84 **fps** **G.H.:** **Disch.:** 213.3 **cfs**

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

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

Type of meter: Price AA

Date rated: Factory

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

Spin before meas. 2 min 20 sec **after** 2 min 29 sec

Method: wading rod

0.6 depth measurements

Gage Readings

Time	Recorder	Inside	Outside
15:42	S.G. # 3 (U/S)		W.S.E. = 7.96 ± 0.02
15:43	S.G. # 4 (D/S)		W.S.E. = 7.71 ± 0.03
Weighted M.G.H.			
G.H. corrections			
Correct M.G.H.			

Levels obtained:

Measurement rated: **Rating based on following conditions:**

Cross section:

Flow: **Weather:** **Air oF@:**

Gage: **Water oF@:**

Other:

Record Removed: **Intake flushed:**

Observer

Control

Remarks **Water surface elevations are relative to BPMSL.** Discharge measurements taken at the outlet of the culverts

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

Table D-6 (continued): CD-2 Access Road, Culvert Discharge Measurements on June 11, 2000

Culvert #	Time	Culvert Dia. (in.)	Depth (ft)	Observ. depth	Revo-lutions	Time In seconds	VELOCITY		Area (s.f.)	Discharge (cfs)	Description
							At Point (fps)	Mean in-vertical (fps)			
CN-1	16:30	48"	3.3	0.6	40	56	1.58	1.58	11.1	17.5	
CN-2	16:25	48"	3.2	0.6	60	49	2.69	2.69	10.8	29.0	
CN-3	16:17	48"	2.5	0.6	72	49	3.22	3.22	8.3	26.6	
CN-4	16:37	48"	2.5	0.6	60	46	2.86	2.86	8.3	23.6	
CN-5	16:44	48"	1.5	0.6	80	49	3.57	3.57	4.3	15.4	
CN-17	16:57	48"	2.0	0.6	80	52	3.37	3.37	6.3	21.2	No ice at outlet
CN-20	17:06										Could not measure due to snow over outlet
CN-21	17:05	48"	2.8	0.6	60	52	2.53	2.53	9.4	23.8	No ice at outlet
CN-22	17:16	48"	2.3	0.6	60	42	3.13	3.13	7.5	23.4	No ice at outlet
CN-23	17:23	48"	1.6	0.6	80	49	3.57	3.57	4.7	16.8	No ice at outlet
CN-24	17:29	48"	1.6	0.6	80	51	3.43	3.43	4.7	16.1	No ice at outlet
Total									**75.2**	**213.3**	

Table D-7: East Bridge Discharge Measurement on June 9, 2000

DISCHARGE MEASUREMENT NOTES

LOCATION: Alpine Development - East Bridge

Date: **June 9, 2000** **Party:** J. Aldrich, J Abrams

Width: 437.4 **ft** **Area:** 1218.0 **ft^2** **Vel:** 3.27 **fps** **G.H.:** **Disch.:** 3979.5 **cfs**

No Secs. 15 **G.H. change:** 0.08 **in.:** 1.42 **hrs.:** **Susp.:**

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

Type of meter: Price AA

Date rated: Factory

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

Spin before meas. 2 min 6 sec **after** 1 min 40 sec

Method: Suspension - hand line with 15 lbs sounding weight

0.2, 0.4, 0.8 depth measurements

Gage Readings

Time	Recorder	Inside	Outside
21:17	S.G. # 3 (U/S)		W.S.E. = 7.30 ± 0.03
21:15	S.G. # 4 (D/S)		W.S.E. = 6.53 ± 0.03
21:35 Start Meas.			
23:00 End Meas.			
23:08	S.G. # 3 (U/S)		W.S.E. = 7.38 ± 0.03
23:09	S.G. # 4 (D/S)		W.S.E. = 6.60 ± 0.02
Weighted M.G.H.			
G.H. corrections			
Correct M.G.H.			

Levels obtained:

Measurement rated: Fair **Rating based on following conditions:**

Cross section: Very Uniform

Flow: Very Uniform **Weather:** Foggy **Air oF@:**

Gage: **Water oF@:**

Other:

Record Removed: **Intake flushed:**

Observer

Control Bridge Opening

Remarks **Water surface elevations are relative to BPMSL.** Bridge has sheet pile abutments, and 14 pile bents on 30-foot centers supporting the center of the bridge. Each pile bent consists of four 30-inch diameter piles on 8-foot centers (oriented in the flow direction). Immediately downstream from the bridge, there remained some ice that had not been eroded. There may have been ice under the bridge (and water surface) from the ice pad that had been built during the winter. Velocity behind the piles is estimated based on the June 10, 2000 measurement on the West bridge.

G.H. of zero flow:

Table D-7 (continued): East Bridge Discharge Measurement on June 9, 2000

Angle coef.	Dist. From Initial point (ft)	Width (ft)	Depth (ft)	Observ. depth	Revo-lutions	Time In seconds	VELOCITY		Area (s.f.)	Discharge (cfs)	Description
							At Point (fps)	Mean in-vertical (fps)			
	0										R.E.W.
0.9781	12	21.8	2.76	0.2	90	42	4.68	3.94	60.0	236.3	
				0.8	80	52	3.37				
	23	2.5	2.78					2.30	7.0	16.0	Behind 30-inch pile
0.9336	38	27.5	2.80	0.2	100	43	5.08	3.71	77.0	285.4	
				0.8	60	46	2.86				
	53	2.5	2.76					2.07	6.9	14.3	Behind 30-inch pile
0.9272	68	27.5	2.71	0.2	100	53	4.12	3.18	74.5	237.0	
				0.8	70	56	2.74				
	83	2.5	2.70					1.87	6.7	12.6	Behind 30-inch pile
0.9272	98	27.5	2.68	0.2	80	42	4.16	3.04	73.7	223.8	
				0.8	50	46	2.39				
	113	2.5	2.90					1.72	7.3	12.4	Behind 30-inch pile
0.9272	128	27.5	2.90	0.2	80	44	3.98	2.85	79.8	227.0	
				0.8	50	51	2.16				
	143	2.5	2.90					1.72	7.3	12.5	Behind 30-inch pile
0.9272	158	27.5	2.90	0.2	80	41	4.26	2.87	79.8	228.9	
				0.8	50	57	1.93				
	173	2.5	3.03					1.73	7.6	13.0	Behind 30-inch pile
0.9272	188	27.5	3.15	0.2	80	42	4.16	2.86	86.6	247.4	
				0.8	50	55	2.00				
	203	2.5	2.84					1.89	7.1	13.4	Behind 30-inch pile
0.9272	218	27.5	2.52	0.4	100	55	3.98	3.43	69.3	237.8	
	233	2.5	2.56					2.07	6.4	13.2	Behind 30-inch pile
0.9272	248	27.5	2.60	0.4	80	44	3.98	3.43	71.5	245.4	
	263	2.5	2.60					2.07	6.5	13.4	Behind 30-inch pile
0.9272	278	27.5	2.60	0.4	80	44	3.98	3.43	71.5	245.4	
	293	2.5	2.70					1.99	6.8	13.4	Behind 30-inch pile
0.9272	308	27.5	2.80	0.2	100	49	4.46	3.18	77.0	244.5	
				0.8	50	46	2.39				
	323	2.5	2.75					2.03	6.9	14.0	Behind 30-inch pile

Table D-7 (continued): East Bridge Discharge Measurement on June 9, 2000

Angle coef.	Dist. From Initial point (ft)	Width (ft)	Depth (ft)	Observ. depth	Revo-lutions	Time In seconds	VELOCITY		Area (s.f.)	Discharge (cfs)	Description
							At Point (fps)	Mean in-vertical (fps)			
0.9272	338	27.5	2.70	0.2	100	48	4.55	3.56	74.3	264.4	
				0.8	60	42	3.13				
	353	2.5	2.85					2.13	7.1	15.2	Behind 30-inch pile
0.9272	368	27.5	3.00	0.2	100	45	4.85	3.52	82.5	290.3	
				0.8	60	48	2.74				
	383	2.5	3.00					2.15	7.5	16.1	Behind 30-inch pile
0.9205	398	27.5	3.0	0.2	100	42	5.20	3.63	82.5	299.2	
				0.8	50	41	2.68				
	413	2.5	2.80					2.44	7.0	17.1	Behind 30-inch pile
0.9063	425.5	23.2	2.6	0.4	100	41	5.32	4.48	60.2	269.9	
	437.4										L.E.W.
Total:		**437.4**							**1218.0**	**3979.5**	**Page 3 of 3**

Table D-8: East Bridge Discharge Measurement on June 11, 2000

DISCHARGE MEASUREMENT NOTES

LOCATION: Alpine Development - East Bridge Swale Area

Date: **June 11, 2000** **Party:** J. Aldrich, J. Abrams, J. Packer

Width: 437.4 **ft** **Area:** 1672.7 **ft^2** **Vel:** 1.71 **fps** **G.H.:** **Disch.:** 2854.0 **cfs**

No Secs. 15 **G.H. change:** 0.05 **in.:** 1.88 **hrs.:** **Susp.:**

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

Type of meter: Price AA

Date rated: Factory

Meter: 1 **ft. above bottom of weight.**

Spin before meas. 2 min 17 sec **after** 2 min 20 sec

Method: Bridge reel w/ 30 lb sounding weight

0.2, 0.6, 0.8 depth measurements

Gage Readings

Time	Recorder	Inside	Outside
12:07	S.G. # 3 (U/S)		W.S.E. = 7.92 ± 0.01
12:08	S.G. # 4 (D/S)		W.S.E. = 7.65 ± 0.01
12:24 Start Meas.			
14:17 End Meas.			
14:26	S.G. # 3 (U/S)		W.S.E. = 7.97 ± 0.02
14:27	S.G. # 4 (D/S)		W.S.E. = 7.71 ± 0.02
Weighted M.G.H.			
G.H. corrections			
Correct M.G.H.			

Levels obtained:

Measurement rated: Fair to Good **Rating based on following conditions:**

Cross section: Uniform

Flow: Uniform **Weather:** Overcast, **Air oF@:**

Gage: Fog **Water oF@:**

Other:

Record Removed: **Intake flushed:**

Observer

Control Bridge Opening

Remarks **Water surface elevations are relative to BPMSL.** Bridge has sheet pile abutments, and 14 pile bents on 30-foot centers supporting the center of the bridge. Each pile bent consists of four 30-inch diameter piles on 8-foot centers (oriented in the flow direction). Velocity behind the piles is estimated based on the June 10, 2000 measurement at the West bridge.

G.H. of zero flow:

Table D-8 (continued): East Bridge Discharge Measurement on June 11, 2000

Angle coef.	Dist. From Initial point (ft)	Width (ft)	Depth (ft)	Observ. depth	Revo-lutions	Time In seconds	VELOCITY		Area (s.f.)	Discharge (cfs)	Description
							At Point (fps)	Mean in-vertical (fps)			
	0		3.90								R.E.W.
1.000	12	21.8	3.80	0.2	50	47	2.34	2.16	82.7	178.1	
				0.8	50	56	1.97				
	23	2.5	3.79					1.23	9.5	11.6	Behind 30-inch pile
0.966	38	27.5	3.78	0.2	50	49	2.24	1.92	104.0	199.3	
				0.8	50	64	1.73				
	53	2.5	3.78					1.09	9.5	10.3	Behind 30-inch pile
0.883	68	27.5	3.78	0.2	50	49	2.24	1.69	104.0	175.3	
				0.8	30	42	1.58				
	83	2.5	3.69					1.03	9.2	9.5	Behind 30-inch pile
0.848	98	27.5	3.60	0.6	40	43	2.05	1.74	99.0	172.1	
	113	2.5	3.79					0.99	9.5	9.4	Behind 30-inch pile
0.848	128	27.5	3.98	0.2	40	40	2.20	1.56	109.5	170.3	
				0.8	30	45	1.47				
	143	2.5	3.88					0.98	9.7	9.5	Behind 30-inch pile
0.866	158	27.5	3.78	0.2	50	48	2.29	1.69	104.0	175.5	
				0.8	40	55	1.61				
	173	2.5	4.19					0.93	10.5	9.7	Behind 30-inch pile
0.875	188	27.5	4.60	0.2	50	49	2.24	1.39	126.5	176.0	
				0.8	30	71	0.941				
	203	2.5	4.13					0.97	10.3	10.0	Behind 30-inch pile
0.891	218	27.5	3.65	0.6	40	43	2.05	1.83	100.4	183.3	
	233	2.5	3.65					1.11	9.1	10.1	Behind 30-inch pile
0.866	248	27.5	3.65	0.6	40	41	2.15	1.86	100.4	186.9	
	263	2.5	3.65					1.10	9.1	10.0	Behind 30-inch pile
0.866	278	27.5	3.65	0.6	40	43	2.05	1.78	100.4	178.2	
	293	2.5	3.70					1.08	9.3	10.0	Behind 30-inch pile
0.819	308	27.5	3.75	0.2	50	42	2.61	1.82	103.1	188.0	
				0.8	40	48	1.84				
	323	2.5	3.77					1.06	9.4	10.0	Behind 30-inch pile
0.755	338	27.5	3.78	0.2	50	41	2.68	1.69	104.0	175.7	

Table D-8 (continued): East Bridge Discharge Measurement on June 11, 2000

Angle coef.	Dist. From Initial point (ft)	Width (ft)	Depth (ft)	Observ. depth	Revo-lutions	Time In seconds	VELOCITY		Area (s.f.)	Discharge (cfs)	Description
							At Point (fps)	Mean in-vertical (fps)			
				0.8	40	49	1.80				
	353	2.5	3.89					1.06	9.7	10.3	Behind 30-inch pile
0.743	368	27.5	4.00	0.2	60	45	2.92	1.81	110.0	199.5	
				0.8	40	45	1.96				
	383	2.5	3.95					1.10	9.9	10.9	Behind 30-inch pile
0.719	398	27.5	3.90	0.2	60	42	3.13	1.85	107.3	197.9	
				0.8	40	44	2.00				
	413	2.5	3.76					1.12	9.4	10.5	Behind 30-inch pile
0.695	425.5	23.2	3.62	0.6	50	41	2.68	1.86	83.8	156.0	
	437.4		3.45								L.E.W.
TOTAL		**437.4**							**1672.7**	**2854.0**	**Page 3 of 3**

Table D-9: West Bridge Discharge Measurement on June 10, 2000

DISCHARGE MEASUREMENT NOTES

LOCATION: Alpine Development - West Bridge

Date: **June 10, 2000** **Party:** J. Aldrich, J Abrams, J. Charton

Width: 46.8 **ft** **Area:** 174.8 **ft^2** **Vel:** 3.30 **fps** **G.H.:** **Disch.:** 576.8 **cfs**

No Secs. 13 **G.H. change:** 0 **in.:** 1.55 **hrs.:** **Susp.:**

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

Type of meter: Price AA

Date rated: Factory

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

Spin before meas. 1 min 45 sec **after** 1 min 38 sec

Method: Bridge reel w/ 75 lb sounding weight

0.2, 0.4, 0.8 depth measurements

Gage Readings

Time	Recorder	Inside	Outside
15:34	S.G. # 3 (U/S)		W.S.E. = 7.87 ± 0.04
15:36	S.G. # 4 (D/S)		W.S.E. = 7.26 ± 0.03
15:42 Start Meas.			
17:15 End Meas.			
17:20	S.G. # 3 (U/S)		W.S.E. = 7.87 ± 0.03
17:22	S.G. # 4 (D/S)		W.S.E. = 7.34 ± 0.02
Weighted M.G.H.			
G.H. corrections			
Correct M.G.H.			

Levels obtained:

Measurement rated: Fair to Good **Rating based on following conditions:**

Cross section: Uniform

Flow: Uniform **Weather:** Overcast **Air oF@:**

Gage: **Water oF@:**

Other:

Record Removed: **Intake flushed:**

Observer

Control Bridge Opening

Remarks **Water surface elevations are relative to BPMSL.** Bridge has sheet pile abutments, and a pile bent supporting the center of the bridge. The pile bent consists of four 30-inch diameter piles on 8-foot centers (oriented in the flow direction).

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

Table D-9 (continued): West Bridge Discharge Measurement on June 10, 2000

Angle coef.	Dist. From Initial point (ft)	Width (ft)	Depth (ft)	Observ. depth	Revo-lutions	Time In seconds	VELOCITY		Area (s.f.)	Discharge (cfs)	Description
							At Point (fps)	Mean in-vertical (fps)			
	0		4.50								R.E.W.
1.000	4	6.0	4.60	0.2	80	45	3.89	3.55	27.6	98.0	
				0.8	60	41	3.21				
1.000	8	4.0	4.60	0.2	100	55	3.98	3.78	18.4	69.5	
				0.8	80	49	3.57				
1.000	12	4.0	4.50	0.2	80	47	3.72	3.52	18.0	63.3	
				0.8	80	53	3.31				
1.000	16	4.0	4.40	0.2	80	49	3.57	3.50	17.6	61.6	
				0.8	80	51	3.43				
1.000	20	2.8	4.10	0.2	60	44	2.99	3.12	11.3	35.2	Turbulence around pile
				0.8	80	54	3.25				
1.000	21.5	1.2	4.10	0.2	50	60	1.84	2.26	4.9	11.1	Behind Pile
				0.8	50	41	2.68				
1.000	22.4	1.8	4.10	0.2	25	45	1.23	1.81	7.2	13.0	Behind Pile
				0.8	50	46	2.39				
0.951	25	3.3	3.60	0.2	80	50	3.50	3.36	11.9	39.9	Turbulence around pile
				0.8	70	43	3.56				
0.927	29	4.0	3.70	0.2	80	48	3.65	3.31	14.8	49.1	
				0.8	80	50	3.50				
0.927	33	4.0	3.80	0.2	60	41	3.21	2.45	15.2	37.3	
				0.8	50	53	2.08				
0.985	37	4.0	2.80	0.4	80	50	3.50	3.21	11.2	35.9	
0.998	41	3.5	2.2	0.4	80	43	4.07	3.78	7.7	29.1	
0.995	44	4.3	2.1	0.4	80	43	4.07	3.76	9.0	34.0	
	46.8										L.E.W.
TOTAL		**46.8**							**174.8**	**576.8**	**Page 2 of 2**

Table D-10: West Bridge Discharge Measurement on June 11, 2000

DISCHARGE MEASUREMENT NOTES

LOCATION: Alpine Development - West Bridge Swale Area

Date: **June 11, 2000** **Party:** J Abrams, J. Packer

Width: 46.8 **ft** **Area:** 193.5 **ft^2** **Vel:** 2.29 **fps** **G.H.:** **Disch.:** 443.1 **cfs**

No Secs. 11 **G.H. change:** 0 **in.:** 1 **hrs.:** **Susp.:**

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

Type of meter: Price AA

Date rated: Factory

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

Spin before meas. 2 min 17 sec **after** 2 min 20 sec

Method: Bridge reel w/ 30 lb sounding weight

0.2, 0.4, 0.8 depth measurements

Gage Readings

Time	Recorder	Inside	Outside
14:26	S.G. # 3 (U/S)		W.S.E. = 7.97 ± 0.02
14:27	S.G. # 4 (D/S)		W.S.E. = 7.71 ± 0.02
14:40 Start Meas.			
15:37 End Meas.			
15:42	S.G. # 3 (U/S)		W.S.E. = 7.97 ± 0.02
15:43	S.G. # 4 (D/S)		W.S.E. = 7.71 ± 0.03
Weighted M.G.H.			
G.H. corrections			
Correct M.G.H.			

Levels obtained:

Measurement rated: Fair to Good **Rating based on following conditions:**

Cross section: Uniform

Flow: Uniform **Weather:** Overcast **Air oF@:**

Gage: **Water oF@:**

Other:

Record Removed: **Intake flushed:**

Observer

Control Bridge Opening

Remarks **Water surface elevations are relative to BPMSL.** Bridge has sheet pile abutments, and a pile bent supporting the center of the bridge. The pile bent consists of four 30-inch diameter piles on 8-foot centers (oriented in the flow direction). Velocity behind the pile is estimated based on the June 10, 2000 measurement.

G.H. of zero flow:

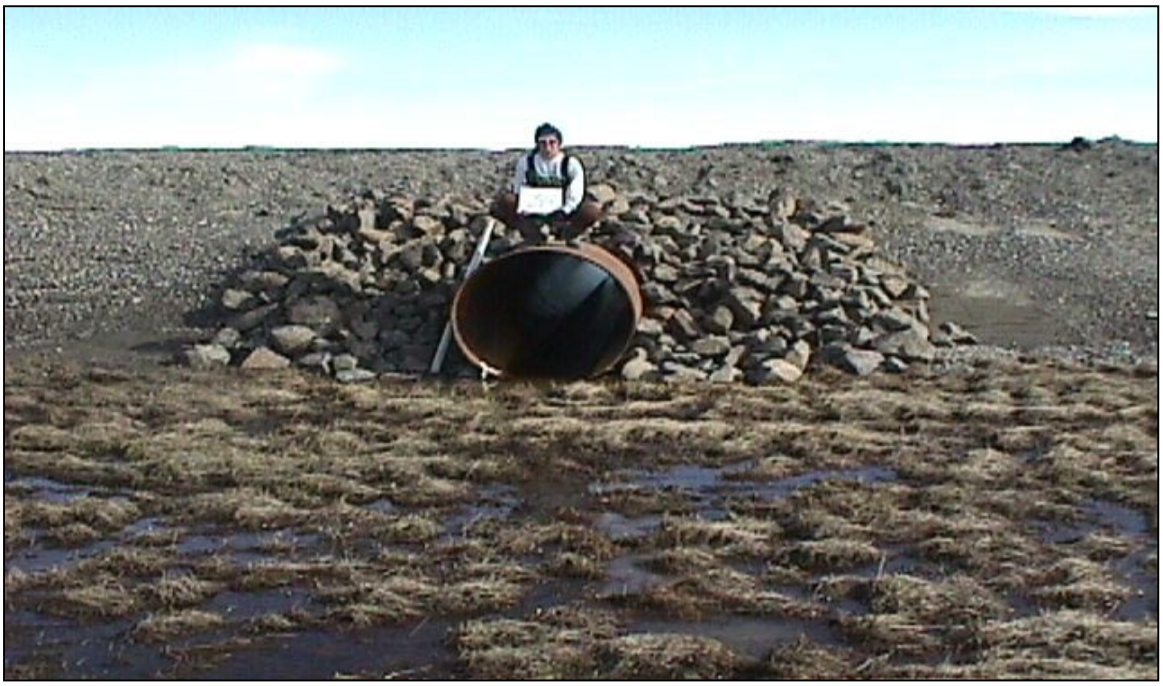
Table D-10 (continued): West Bridge Discharge Measurement on June 11, 2000

Angle coef.	Dist. From Initial point (ft)	Width (ft)	Depth (ft)	Observ. depth	Revo-lutions	Time In seconds	VELOCITY		Area (s.f.)	Discharge (cfs)	Description
							At Point (fps)	Mean in-vertical (fps)			
	0		5.23								R.E.W.
0.940	4	6.0	4.95	0.2	60	45	2.92	2.38	29.7	70.7	
				0.8	40	41	2.15				
1.000	8	4.0	4.85	0.2	50	40	2.74	2.71	19.4	52.6	
				0.8	50	41	2.68				
0.995	12	4.0	4.70	0.2	50	41	2.68	2.40	18.8	45.2	
				0.8	40	41	2.15				
0.974	16	4.0	4.62	0.2	50	41	2.68	2.52	18.5	46.6	
				0.8	50	44	2.5				
0.998	20	3.3	4.55	0.2	50	42	2.61	2.44	14.8	36.1	
				0.8	50	48	2.29				
	22.5	2.5	4.43					1.48	11.1	16.4	Behind 30" pile
0.982	25	3.3	4.30	0.2	50	41	2.68	2.46	14.0	34.4	
				0.8	50	47	2.34				
0.940	29	4.0	4.10	0.2	50	42	2.61	2.30	16.4	37.8	
				0.8	50	48	2.29				
0.899	33	4.0	4.70	0.2	40	43	2.05	1.65	18.8	31.0	
				0.8	30	41	1.62				
0.961	37	4.0	3.10	0.4	40	42	2.10	1.73	12.4	21.4	Instrument swaying
				0.6	40	54	1.64				
0.951	41	3.5	2.80	0.4	60	48	2.74	2.49	9.8	24.4	
				0.6	50	41	2.68				
0.970	44	4.3	2.30	0.4	60	46	2.86	2.68	9.9	26.5	
				0.6	60	46	2.86				
	46.8		2.63								L.E.W.
TOTAL		**46.8**							**193.5**	**443.1**	**Page 2 of 2**

CN-1: Looking north at the north end of the culvert. (6/18/00)

CN-1: Looking south at the north end of the culvert. (6/18/00)

Baker **Michael Baker Jr.,**		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE:
Date: 6/20/00	Project: 24540-157-0000		D-2
Drawn: JDA	File: C1.doc	ALPINE FACILITY – CULVERT C-1	SHEET 1 OF 2
Checked: JWA	Scale:		



CS-1: Looking north at the south end of the culvert. (6/18/00)

Baker **Michael Baker Jr., Inc.**		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE:
Date: 6/20/00	Project: 24540-157-0000		
Drawn: JDA	File: C1.doc	ALPINE FACILITY – CULVERT C-1	D-2 SHEET 2 OF 2
Checked: JWA	Scale:		

CN-2: Looking north at the north end of the culvert. (6/18/00)

CN-2: Looking south at the north end of the culvert. (6/18/00)

Baker **Michael Baker Jr.,**		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE:
Date: 6/20/00	Project: 24540-157-0000		D-3
Drawn: JDA	File: C2.doc	ALPINE FACILITY – CULVERT C-2	SHEET 1 OF 2
Checked: JWA	Scale:		

CS-2: Looking north at the south end of the culvert. (6/18/00)

Baker **Michael Baker Jr.,**		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE:
Date: 6/20/00	Project: 24540-157-0000		D-3
Drawn: JDA	File: C2.doc	ALPINE FACILITY – CULVERT C-2	SHEET 2 OF 2
Checked: JWA	Scale:		

CN-3: Looking north at the north end of the culvert. (6/18/00)

CN-3: Looking south at the north end of the culvert. (6/18/00)

Baker **Michael Baker Jr.,**		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE:
Date: 6/20/00	Project: 24540-157-0000		D-4
Drawn: JDA	File: C3.doc	ALPINE FACILITY – CULVERT C-3	SHEET 1 OF 2
Checked: JWA	Scale:		

CS-3: Looking north at the south end of the culvert. (6/18/00)

Baker Michael Baker Jr.,	
Date: 6/20/00	Project: 24540-157-0000
Drawn: JDA	File: C3.doc
Checked: JWA	Scale:

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

ALPINE FACILITY – CULVERT C-3

FIGURE:

D-4

SHEET 2 OF 2

CN-4: Looking north at the north end of the culvert. (6/18/00)

CN-4: Looking south at the north end of the culvert. (6/18/00)

Baker Michael Baker Jr., Inc.		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE: D-5 SHEET 1 OF 2
Date: 6/20/00	Project: 24540-157-0000	ALPINE FACILITY – CULVERT C-4	
Drawn: JDA	File: C4.doc		
Checked: JWA	Scale:		

CS-4: Looking north at the south end of the culvert. (6/18/00)

Baker Michael Baker Jr.,		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE:
Date: 6/20/00	Project: 24540-157-0000		
Drawn: JDA	File: C4.doc	ALPINE FACILITY – CULVER C-4	D-5 SHEET 2 OF 2
Checked: JWA	Scale:		

CN-5: Looking north at the north end of the culvert. (6/18/00)

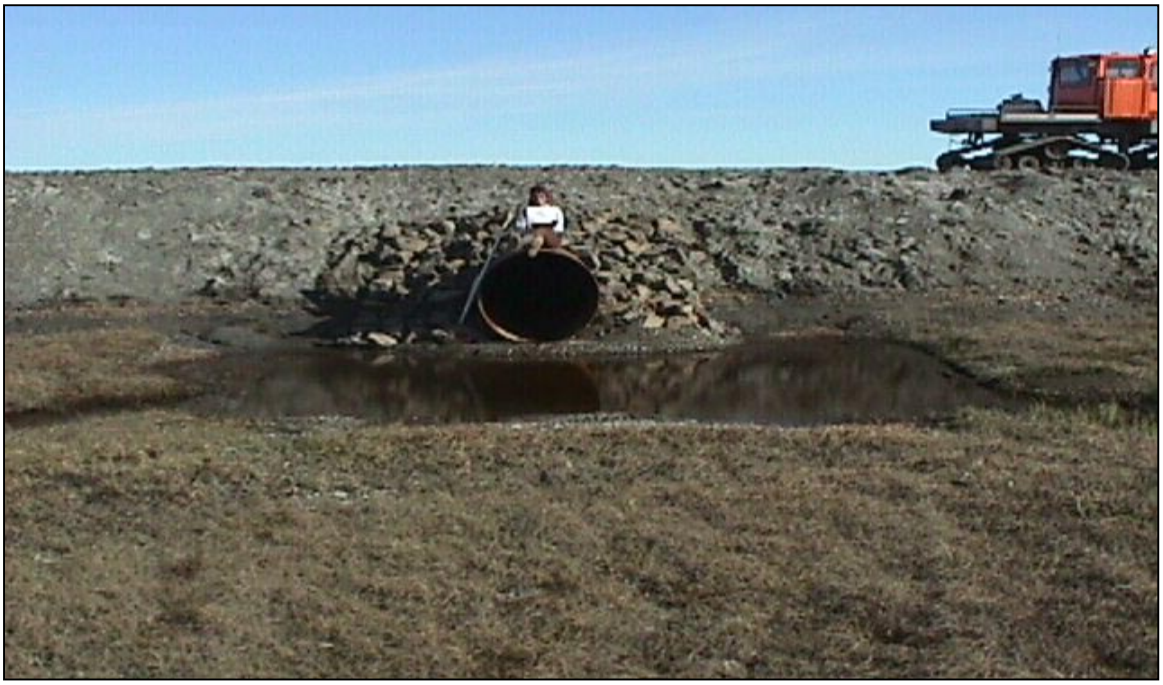
CN-5: Looking south at the north end of the culvert. (6/18/00)

Baker Michael Baker Jr.,		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE::
Date: 6/20/00	Project: 24540-157-0000		D-6
Drawn: JDA	File: C5.doc	ALPINE FACILITY – CULVERT C-5	SHEET 1 OF 2
Checked: JWA	Scale:		

CS-5: Looking north at the south end of the culvert. (6/18/00)

Baker Michael Baker Jr., Inc.		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE::
Date: 6/20/00	Project: 24540-157-0000		D-6
Drawn: JDA	File: C5.doc	ALPINE FACILITY – CULVERT C-5	SHEET 2 OF 2
Checked: JWA	Scale:		

CN-6: Looking south at the north end of the culvert. (6/18/00)



CS-6: Looking north at the south end of the culvert. (6/18/00)

Baker **Michael Baker Jr.,**		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE: D-7 SHEET 1 of 1
Date: 6/20/00	Project: 24540-157-0000		
Drawn: JDA	File: C6.doc	ALPINE FACILITY – CULVERT C-6	
Checked: JWA	Scale:		

CN-7: Looking south at the north end of the culvert. (6/18/00)

CS-7: Looking north at the south end of the culvert. (6/18/00)

Baker **Michael Baker Jr.,**	
Date: 6/20/00	Project: 24540-157-0000
Drawn: JDA	File: C7.doc
Checked: JWA	Scale:

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

ALPINE FACILITY – CULVERT C-7

FIGURE:
D-8
SHEET 1 OF 1

CN-8: Looking south at the north end of the culvert. (6/18/00)

CS-8: Looking north at the south end of the culvert. (6/18/00)

Baker Michael Baker Jr., Inc.		2000 SPRING BREAKUP COLVILLER RIVER DELTA	FIGURE: D-9 SHEET 1 OF 1
Date: 6/20/00	Project: 24540-157-0000		
Drawn: JDA	File: C8.doc	ALPINE FACILITY – CULVERT C-8	
Checked: JWA	Scale:		

CN-9: Looking south at the north end of the culvert. (6/18/00)

CS-9: Looking north at the south end of the culvert. (6/18/00)

Baker **Michael Baker Jr.,**		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE::
Date: 6/20/00	Project: 24540-157-0000		D-10
Drawn: JDA	File: C9.doc	ALPINE FACILITY – CULVERT C-9	SHEET 1 OF 1
Checked: JWA	Scale:		

CN-10: Looking north at the north end of the culvert. (6/18/00)

CN-10: Looking south at the north end of the culvert. (6/18/00)

Baker **Michael Baker Jr.,**		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE:
Date: 6/20/00	Project: 24540-157-0000		D-11
Drawn: JDA	File: C10.doc	ALPINE FACILITY – CULVERT C-10	SHEET 1 OF 2
Checked: JWA	Scale:		

CS-10: Looking south at the south end of the culvert. (6/18/00)

CS-10: Looking north at the south end of the culvert. (6/18/00)

Baker Michael Baker Jr.,		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE:
Date: 6/20/00	Project: 24540-157-0000		D-11
Drawn: JDA	File: C10.doc	ALPINE FACILITY – CULVERT C-10	SHEET 2 OF 2
Checked: JWA	Scale:		

CN-11: Looking south at the north end of the culvert. (6/18/00)

CS-11: Looking north at the south end of the culvert. (6/18/00)

Baker **Michael Baker Jr.,**		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE: D-12 SHEET 1 OF 1
Date: 6/20/00	Project: 24540-157-0000		
Drawn: JDA	File: C11.doc	ALPINE FACILITY – CULVERT C-11	
Checked: JWA	Scale:		

CN-12: Looking south at the north end of the culvert. (6/18/00)

CS-12: Looking north at the south end of the culvert. (6/18/00)

Baker Michael Baker Jr.,		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE: D-13 SHEET 1 OF 1
Date: 6/20/00	Project: 24540-157-0000	ALPINE FACILITY – CULVERT C-12	
Drawn: JDA	File: C12.doc		
Checked: JWA	Scale:		

CN-13: Looking south at the north end of the culvert. (6/17/00)

CS-13: Looking north at the south end of the culvert. (6/17/00)

Baker Michael Baker Jr.,		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE: D-14 SHEET 1 OF 1
Date: 6/20/00	Project: 24540-157-0000		
Drawn: JDA	File: C13.doc	ALPINE FACILITY – CULVERT C-13	
Checked: JWA	Scale:		

CN-14: Looking south at the north end of the culvert. (6/17/00)

CS-14: Looking north at the south end of the culvert. (6/17/00)

Baker Michael Baker Jr.,		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE: D-15 SHEET 1 OF 1
Date: 6/20/00	Project: 24540-157-0000		
Drawn: JDA	File: C14.doc	ALPINE FACILITY – CULVERT C-14	
Checked: JWA	Scale:		

CN-15: Looking south at the north end of the culvert. (6/17/00)

CS-15: Looking north at the south end of the culvert. (6/17/00)

Baker Michael Baker Jr.,		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE:
Date: 6/20/00	Project: 24540-157-0000		D-16
Drawn: JDA	File: C15.doc	ALPINE FACILITY – CULVERT C-15	SHEET 1 OF 1
Checked: JWA	Scale:		

CN-16: Looking south at the north end of the culvert. (6/17/00)

CS-16: Looking north at the south end of the culvert. (6/17/00)

Baker **Michael Baker Jr.,**	
Date: 6/20/00	Project: 24540-157-0000
Drawn: JDA	File: C16.doc
Checked: JWA	Scale:

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

ALPINE FACILITY – CULVERT C-16

FIGURE:
D-17
SHEET 1 OF 1

CN-17: Looking south at the north end of the culvert. (6/17/00)

CS-17: Looking north at the south end of the culvert. (6/17/00)

Baker Michael Baker Jr.,		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE:
Date: 6/20/00	Project: 24540-157-0000		D-18
Drawn: JDA	File: C17.doc	ALPINE FACILITY – CULVERT C-17	SHEET 1 OF 1
Checked: JWA	Scale:		

CN-18, CN-19, CN-20, CN-21: Looking south at the north end of the culverts. Staff gage #7 is on the right side of the picture. (6/19/00)

CS-21, CS-20, CS-19, CS-18: Looking north at the south end of the culverts. Staff gage #6 is on the left side of the picture. (6/19/00)

Baker Michael Baker Jr.,	
Date: 6/20/00	Project: 24540-157-0000
Drawn: JDA	File: C18_21.doc
Checked: JWA	Scale:

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

ALPINE FACILITY – CULVERTS C-18, C-19, C-20, C-21

FIGURE:
D-19
SHEET 1 OF 1

CN-22: Looking north at the north end of the culvert. (6/15/00)

CN-22: Looking south at the north end of the culvert. (6/15/00)

Baker **Michael Baker Jr.,**		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE: D-20 SHEET 1 OF 2
Date: 6/20/00	Project: 24540-157-0000		
Drawn: JDA	File: C22.doc	ALPINE FACILITY – CULVERT C-22	
Checked: JWA	Scale:		

CS-22: Looking north at the south end of the culvert. (6/15/00)

Michael Baker Jr.,		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE: D-20 SHEET 2 OF 2
Date: 6/20/00	Project: 24540-157-0000		
Drawn: JDA	File: C22.doc	ALPINE FACILITY – CULVERT C-22	
Checked: JWA	Scale:		

CN-23: Looking south at the north end of the culvert. (6/15/00)

CS-23: Looking north at the south end of the culvert. (6/15/00)

Baker **Michael Baker Jr.,**	
Date: 6/20/00	Project: 24540-157-0000
Drawn: JDA	File: C23.doc
Checked: JWA	Scale:

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

ALPINE FACILITY – CULVERT C-23

FIGURE:
D-21
SHEET 1 OF 1

CN-24: Looking south at the north end of the culvert. (6/15/00)

CN-24: Looking north at the south end of the culvert. (6/15/00)

Baker **Michael Baker Jr.,**		2000 SPRING BREAKUP COLVILLE RIVER DELTA	FIGURE: D-22 SHEET 1 OF 1
Date: 6/20/00	Project: 24540-157-0000		
Drawn: JDA	File: C24.doc	ALPINE FACILITY – CULVERT C-24	
Checked: JWA	Scale:		

Up-stream side of the Small (West) Bridge taken from the East abutment on the CD-2 access road looking Northwest, on 10-Jun-00.

Up-stream side of the Small (West) Bridge taken from the East abutment on the CD-2 access road looking Northwest, on 12-Jun-00.

Baker Michael Baker Jr.,	
Date: 20-Sep-00	Project: 24540-157-0000
Drawn: TAR	File: Brid01.doc
Checked: TAR	Scale:

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

ALPINE FACILITY – WEST BRIDGE

FIGURE:

D-23

Up-stream side of the Large (East) Bridge taken from the West abutment on the CD-2 access road looking Northeast, on 12-Jun-00.

Down-stream side of the Large (East) Bridge taken from the West abutment on the CD-2 access road looking East, on 12-Jun-00.

Baker Michael Baker Jr.,	
Date: 20-Sep-00	Project: 24540-157-0000
Drawn: TAR	File: Brid02.doc
Checked: TAR	Scale:

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

ALPINE FACILITY – EAST BRIDGE

FIGURE:

D-24

Appendix E

High Water Line at Alpine Facilities

List of Figures

Photo 1: Looking east along the north side of the embankment on the road to CD-2 near culvert CN-24. (6/15/00)

Photo 2: Looking east along the south side of the embankment on the road to CD-2 near culvert CS-24. (6/15/00)

Baker Michael Baker Jr.,	
Date: 6/20/00	Project: 24540-157-0000
Drawn: JDA	File: embankmt.doc
Checked: JWA	Scale:

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

ALPINE FACILITY – HIGH WATER LINE

Figure:
E-1
SHEET 1 OF 3

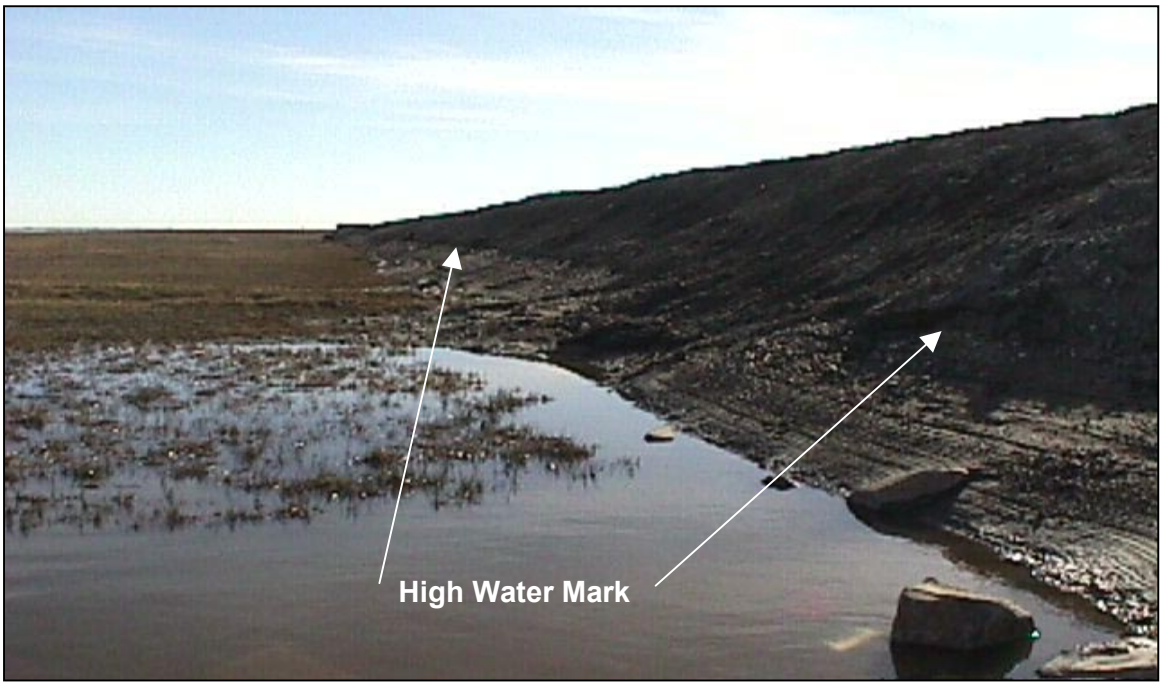


Photo 3: Looking east along the north side of the embankment on the road to CD-2 near culvert CN-5. (6/18/00)

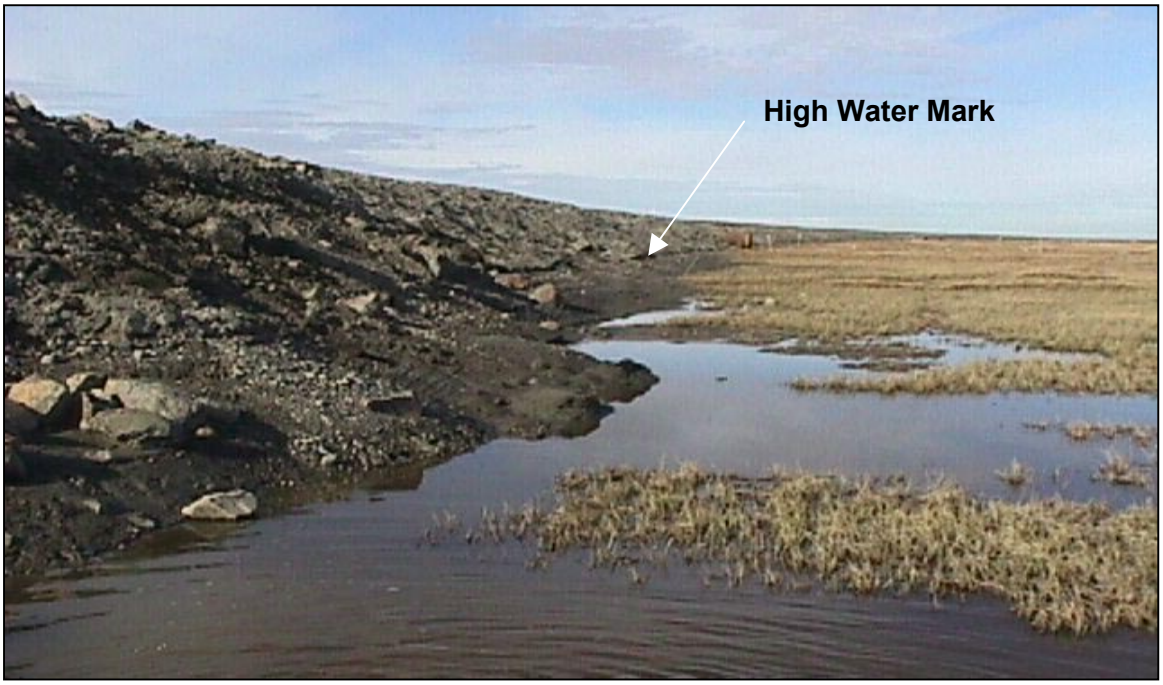


Photo 4: Looking west along the north side of the embankment on the road to CD-2 near culvert CN-5. (6/18/00)

Baker Michael Baker Jr.,		2000 SPRING BREAKUP COLVILLE RIVER DELTA	Figure: E-1
Date: 6/20/00	Project: 24540-157-0000	ALPINE FACILITY – HIGH WATER LINE	SHEET 2 OF 3
Drawn: JDA	File: embankmt.doc		
Checked: JWA	Scale:		

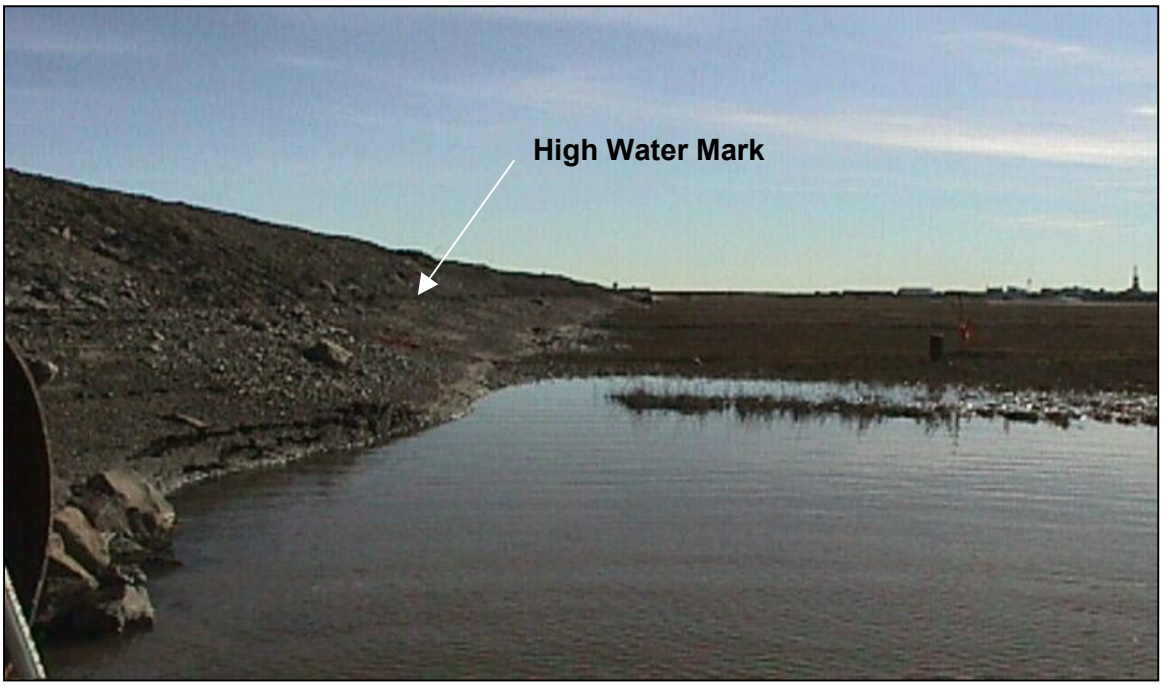


Photo 5: Looking east along the south side of the embankment on the road to CD-2 near culvert CS-5. (6/18/00)

Baker Michael Baker Jr.,		2000 SPRING BREAKUP COLVILLE RIVER DELTA	Figure: E-1
Date: 6/20/00	Project: 24540-157-0000		
Drawn: JDA	File: embankmt.doc	ALPINE FACILITY – HIGH WATER LINE	SHEET 3 OF 3
Checked: JWA	Scale:		