2019 Colville River Delta
Spring Breakup Monitoring & Hydrological Assessment

Michael Baker International
3900 C Street Suite 900
Anchorage, AK 99503

ConocoPhillips Alaska

MSA Contract No. 296937

EXECUTIVE SUMMARY

This report presents the observations and results from the 2019 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment conducted by Michael Baker International for ConocoPhillips Alaska. In the Colville River Delta, the breakup and downstream movement of river ice typically occurs during a three-week period in May and June. The spring breakup event historically produces flooding resulting from the rapid rise and fall of stage often attributed to ice jam formations and releases. Annual study and reporting of spring breakup is required by U.S. Army Corps of Engineers Permits 2-960874 Special Condition #6, POA-2004-253 Special Condition #17, and POA-2005-1576 Special Conditions #1 and #17 and Alaska Department of Fish and Game Permits FH04-III-0238, FG97-III-0260, FG99-III-0051, and FG97-III-0190. The analyses provide data to support design, permitting, and operation of oilfield development.

The 2019 monitoring and hydrological assessment is the 28th consecutive year of spring breakup investigations and the 33nd year of historical breakup monitoring in the Colville River Delta. Water surface elevations were monitored throughout the delta at locations of hydrologic importance, including near infrastructure. Discharge was measured, and peak discharge was calculated at key locations. The entire breakup event was documented with visual observations and photography from a helicopter and from roadways. Following breakup, roads, pads, and drainage structures were assessed for erosion and damage.

This year's spring breakup flood was characterized as a short-duration, low-magnitude event. Initial floodwater arrived in the delta on May 20 and reached the coast by May 21. On May 21, ice jams were observed approximately 7 and 13 river miles upstream of MON1. These jams released, progressed downstream through the MON1 reach and into the Colville East Channel on May 23. Ice jams and intact channel ice were flushed from the Colville East Channel by May 28. Overall, ice jamming effects in the CRD were minimal, as was associated backwater.

Peak conditions throughout the delta occurred between May 24 and May 26. Peak stage at MON1C occurred on May 24 and was 16.19-ft British Petroleum Mean Sea Level having an estimated recurrence interval of less than 2.0-years. Peak discharge at MON1C occurred on May 24 and was estimated at 305,000 cubic-ft per second having an estimated 3.5-year recurrence interval.

During peak conditions, floodwater in the delta was generally confined within channels, lakes, and swales and did not reach most infrastructure (roads/pads) in the delta. Measured pier scour at the CD5 bridges was minimal. Post-breakup visual inspections of all roads and pads found no evidence of erosion or damage.

Table of Contents

Figures

Tables

Graphs

Photos

Appendix D Photos

ACRONYMS & ABBREVIATIONS

2D	Two-dimensional
ABR	Alaska Biological Research
ADF&G	Alaska Department of Fish and Game
Baro PT	barometric pressure sensors
BPMSL	British Petroleum Mean Sea Level
CD	Colville Delta
CFDD	cumulative freezing degree days
cfs	cubic-ft per second
CPAI	ConocoPhillips Alaska, Inc.
CRD	Colville River Delta
FEMA	Federal Emergency Management Agency
fps	feet per second
ft	feet
gage	hydrologic staff gage
GPS	Global positioning system
HDD	Horizontal directional drill
HWM	High water mark
Michael Baker	Michael Baker International
MON	Monument
MP-AMS	Monitoring Plan with an Adaptive Management Strategy
NOAA	National Atmospheric and Oceanic Administration
NRCS	Natural Resources Conservation Service
NPR-A	National Petroleum Reserve of Alaska
PT	pressure transducer
RM	river mile
RTFM	Real-Time Flood Monitoring
SAK	Sakoonang
TAM	Tamayayak
ULAM	Ulamnigiaq
UMIAQ	Umiaq, LLC (UMIAQ)
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VSM	Vertical support member
WSE	Water surface elevation

1. INTRODUCTION

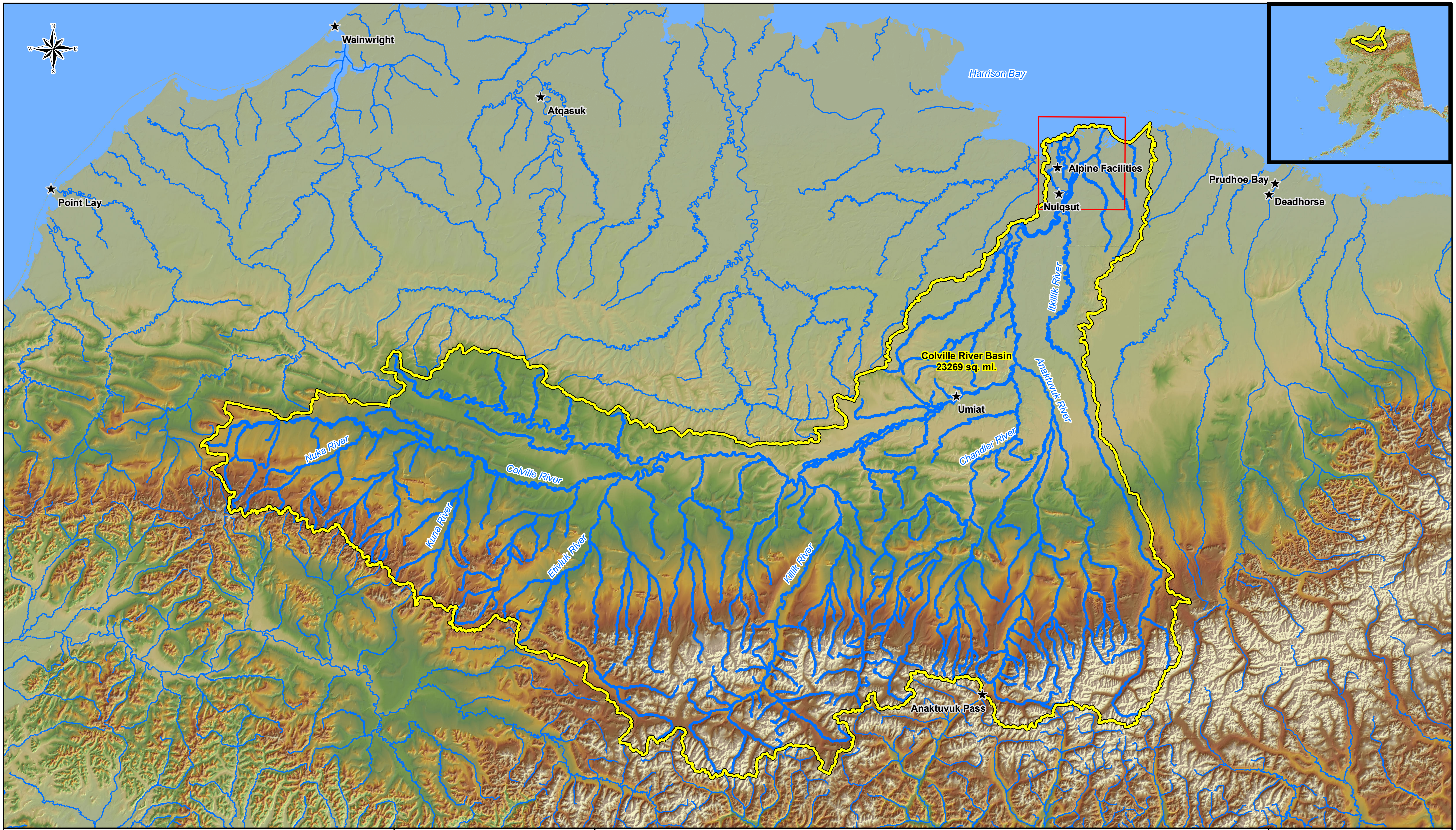
The Colville River is the largest river on the North Slope, initiating in the DeLong Mountains on the north side of the Brooks Range, running north and east through the Arctic Coastal Plain, and forms the Colville River Delta (CRD) where the river empties into the Beaufort Sea. The Colville River drainage basin is approximately 23,270 square miles and includes a large portion of the western and central areas north of the Brooks Range (Figure 1.1). Spring breakup commences with the arrival of meltwater in the delta and progresses with a rapid rise in stage which facilitates the breakup and downstream movement of river ice. The CRD spring breakup is generally considered to be the largest annual flooding event in the region and typically occurs during a three-week period in May and June. Spring breakup monitoring is integral to understanding regional hydrology and ice effects, establishing appropriate design criteria for proposed facilities, and maintaining the continued safety of the environment, oilfield personnel, and existing facilities during the flooding event.

The CRD Spring Breakup Monitoring and Hydrological Assessment supports the ConocoPhillips Alaska, Inc. (CPAI) Alpine Development Project and the Alpine Satellite Development Plan. The Alpine facilities are owned and operated by CPAI. Alpine facilities include the Colville Delta (CD) 1 processing facility (Alpine) and the CD2, CD3, CD4, CD5, and Greater Moose's Tooth 1/Moose's Tooth 6 (GMT1/MT6) pads, access roads, and pipelines. A new drill site, Greater Moose's Tooth 2/Moose's Tooth 7 (GMT2/MT7), is in construction and will be connected to the Alpine facilities by road and pipeline.

Colville River breakup monitoring has been ongoing since 1962. The timing and magnitude of breakup flooding has been determined consistently since 1992 by measuring stage and discharge at established locations throughout the delta. The program was expanded to include additional Alpine facilities in 2004 and the CD5 development area in 2009. The 2019 monitoring and hydrological assessment is the 28th consecutive year of CRD spring breakup investigations.

The 2019 field program took place from April 19 to June 5. Spring breakup setup began on April 19 and concluded on May 7. Spring breakup monitoring began on May 7 and concluded on June 5. Primary field tasks included documenting the distribution of floodwater and measuring water levels and discharge at select locations. Observations of lake recharge, ice jams, ice road crossing degradation, and floodwater effects on infrastructure were also recorded. Hydrologic observations were documented at all Alpine facilities, roads, and drainage structures, and relevant waterbodies within the CRD.

Umiaq, LLC (UMIAQ), CPAI Alpine Field Environmental Coordinators, Alpine Helicopter Coordinators, and Soloy Helicopters, LLC provided support during the field program and contributed to a safe and productive field season.



ConocoPhillips Alaska

Miles 0 12.5 25 50

Date:	11/14/2019	Project:	171385
Drawn:	BTG	File:	Figure 1.1
Checked:	GCY	Scale:	1 in = 25 miles

Legend

- ★ Place Name
- Stream
- Study Area
- Colville River Basin

Michael Baker INTERNATIONAL

Michael Baker International
3900 C. Street Suite 900
Anchorage, AK 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 SPRING BREAKUP COLVILLE RIVER DELTA
Drainage Basin

FIGURE: 1.1

(SHEET 1 of 1)

1.1 Monitoring Objectives

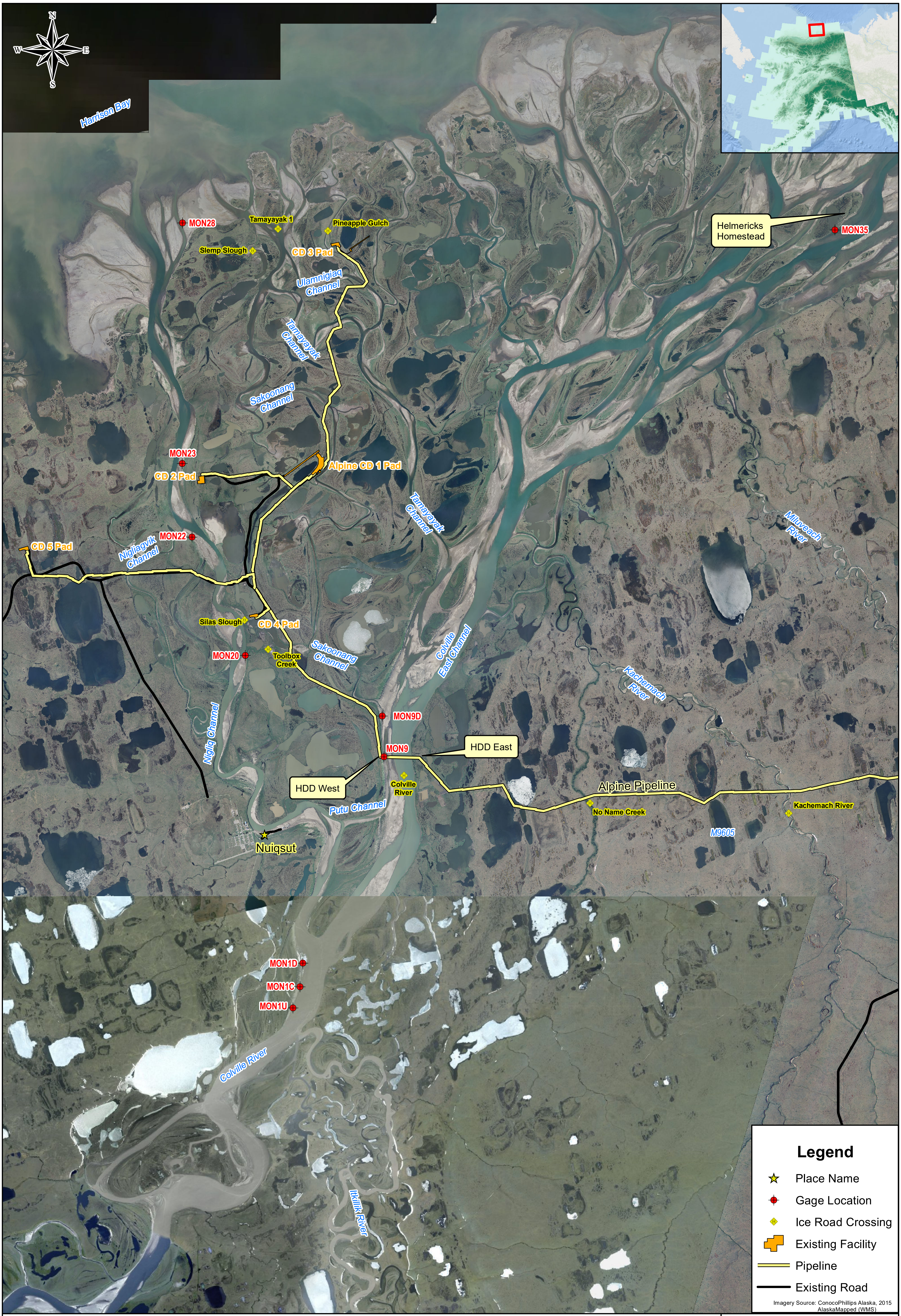
The primary objective of CRD spring breakup monitoring and hydrological assessment is to monitor and estimate the magnitude of breakup flooding within the CRD in relation to Alpine facilities. Water surface elevations (WSE, or stage, used interchangeably in this report), discharge, and observations are used to validate design parameters of existing infrastructure, for planning and design of proposed infrastructure, and to satisfy permit requirements. Data collection supports refinement of the CRD flood frequency, two-dimensional (2D) surface water model, and stage frequency analyses.

The CRD spring breakup monitoring satisfies permit stipulations by the U.S. Army Corps of Engineers (USACE) and the Alaska Department of Fish and Game (ADF&G).

Permit stipulations for USACE Permits 2-960874 Special Condition #6, POA-2004-253-2 Special Condition #17, ADF&G Fish Habitat Permit FH04-III-0238, and USACE Permit POA-2005-1576 Special Conditions #1 and #17 require monitoring Alpine facilities during spring breakup. Permit stipulations include documentation of annual hydrologic conditions, direct measurements and indirect calculations of discharge through drainage structures, and documentation of pad and road erosion caused by spring breakup flooding. USACE Permit POA-2005-1576 Special Condition #1 requires the *Monitoring Plan with an Adaptive Management Strategy* (MP-AMS) (Michael Baker and Alaska Biological Research [ABR] 2013) which includes monitoring channel sedimentation and erosion specific to the CD5 development. Observations of functionality and flooding effects to the CD2 road bridges are recorded to satisfy ADF&G permit FG97-III-0260-Amendment #3. The ADF&G permits FG99-III-0051-Amendment #8 and FG97-III-0190-Amendment #1 require monitoring of recharge to lakes L9312 and L9313, respectively. Alpine facilities rely on water withdrawal from these lakes for daily operations; the volume of which is dictated in part by annual spring recharge. The information presented in this report encompasses the data required by the permits.

1.2 Monitoring Locations

The 2019 monitoring locations and gage stations are the same as those studied in 2018 (Michael Baker 2018). Most gage stations are adjacent to major hydrologic features and were selected based on topography, importance to the historical record, and proximity and hydraulic significance to existing or proposed facilities or temporary infrastructure. Figure 1.2 shows the CRD monitoring locations and gage stations denoted with a MON prefix. Monitoring locations and gage stations specific to Alpine facilities are shown in Figure 1.3. The location descriptions for each gage station are listed in Table 1.1. Gage and culvert geographic coordinates and associated vertical control are provided in Appendix A.



ConocoPhillips
Alaska

Miles
0 1 2

Date: 11/13/2019		Project: 171385	
Drawn: BTG		File: Figure 1.2	
Checked: GCY		Scale: 1 in = 2 miles	

Michael Baker
INTERNATIONAL

Michael Baker International
3900 C Street, Suite 900
Anchorage, AK 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 SPRING BREAKUP
COLVILLE RIVER DELTA

Monitoring Locations

FIGURE: 1.2

(SHEET 1 of 1)

Mile
0 0.5 1

ConocoPhillips Alaska		Michael Baker INTERNATIONAL Michael Baker International 3900 C Street, Suite 900 Anchorage, AK 99503 Phone: (907) 273-1600 Fax: (907) 273-1699	2019 SPRING BREAKUP ALPINE AREA FACILITIES Monitoring Locations
Date: 11/13/2019	Project: 171385		
Drawn: BTG	File: 2019_Facilities_11x17P_Fig1_3		FIGURE: 1.3
Checked: GCY	Scale: 1 in = 1 mile		(SHEET 1 of 1)

Table 1.1: Monitoring & Gage Station Locations

Monitoring Location	Monitoring Location Description	Gage Station	Gage Station Description
CRD Monitoring Locations			
Colville River	Head of the CRD	MON1U	West bank, farthest downstream confined reach of the Colville River, conveying approximately 22,500 square miles of runoff in a single channel
		MON1C	
		MON1D	
Colville River East Channel	East Channel Bifurcation	MON9	West bank, adjacent to horizontal directional drill (HDD) West, downstream of Nigliq Channel bifurcation
		MON9D	West bank, downstream (north) of HDD West, upstream of Sakoonang Channel bifurcation
		MON35	East side of Helmericks Homestead, Kupigruak Channel just upstream of the coast line, farthest downstream gage station
Nigliq Channel	Nigliq Channel Bifurcations	MON20	East bank, upstream (south) of CD4 pad, upstream of Toolbox Creek
		MON22	West bank, upstream of Nigliagvik Channel tributary
		MON23	East bank, downstream of Nigliagvik Channel tributary, downstream (northwest) of CD2 pad
		MON28	Eastern tributary channel at Harrison Bay, farthest downstream gage station
Alpine Facilities Monitoring Locations			
CD1 Pad & Drinking Water Lakes	Lake L9312	G9	Northwest side of lake, southwest of CD1 pad
	Lake L9313	G10	East side of lake, adjacent to CD1 pad
	CD1 Pad	G1	West bank of Sakoonang Channel, east side of CD1 pad
CD2 Pad & Road	Long Swale Bridge	G3	South side of road, downstream of Lake M9524
		G4	North side of road, downstream of Lake M9524
	Short Swale Bridge	G3	South side of road, downstream of Lake M9524
		G4	North side of road, downstream of Lake M9524
	Culverts	G3	South side of road, downstream of Lake M9524
		G4	North side of road, downstream of Lake M9524
		G6	South side of road, between Lake L9322 and Lake L9321
		G7	North side of road, between Lake L9322 and Lake L9321
		G12	South side of road, downstream of Nanuq Lake
		G13	North side of road, downstream of Nanuq Lake
	CD2 Pad	G8	Northwest side of CD2 pad, adjacent to Nigliq Channel
CD3 Pad & Pipeline	Pipeline Crossings	SAK	South side of Sakoonang Channel, downstream of pipeline bridge #2
		TAM	South side of Tamayayak Channel, downstream of pipeline bridge #4, downstream of Ulamnigiaq Channel bifurcation
		ULAM	North side of Ulamnigiaq Channel, downstream of pipeline bridge #5, upstream of East and West Ulamnigiaq Channel bifurcation
	CD3 Pad	G11	South side of CD3 pad, adjacent to north side of East Ulamnigiaq Channel
CD4 Pad & Road	Culverts	G15	East side of road, between Lake L9323 and Lake M9525
		G16	West side of road, between Lake L9323 and Lake M9525
		G17	North side of road, between Sakoonang Channel and Lake L9323
		G18	South side of road, between Sakoonang Channel and Lake L9323
		G40	West side of road, between Lake M9525 and Nanuq Lake
		G41	East side of road, between Lake M9525 and Nanuq Lake
		G42	West side of road, between Lake M9525 and Nanuq Lake
		G43	East side of road, between Lake M9525 and Nanuq Lake
	CD4 Pad	G19	South side of CD4 pad, north side of Lake L9324
		G20	West side of CD4 pad, east side of Tapped Lake
CD5 Road	Culverts	G30	South side of road, east of Lake L9341
		G31	North side of road, east of Lake L9341
		G34	South side of road, west of Lake L9341
		G35	North side of road, west of Lake L9341
		G36	South side of road, east of Nigliagvik Channel
		G37	North side of road, east of Nigliagvik Channel
		S1	South side of road, between Oil Lake and Lake MB0301, outside of the CRD
		S1D	North side of road, between Oil Lake and Lake MB0301, outside of the CRD
	Lake L9323 Bridge/ CD5 Bridge #1	G24	Northeast side of Lake L9323, 200-ft upstream of bridge centerline
		G25	Northeast side of Lake L9323, 310-ft downstream of bridge centerline
	Nigliq Bridge/ CD5 Bridge #2	G28	West side of Nigliq Channel, 2,600-ft upstream of bridge centerline
		G26	East side of Nigliq Channel, 200-ft upstream of bridge centerline
		G27	East side of Nigliq Channel, 160-ft downstream of bridge centerline
		G29	West side of Nigliq Channel, 2,300-ft downstream of bridge centerline
	Lake L9341 Bridge/ CD5 Bridge #3	G32	West side of Lake L9341, 180-ft upstream of bridge centerline
		G33	West side of Lake L9341, 300-ft downstream of bridge centerline
	Nigliagvik Bridge/ CD5 Bridge #4	G38	East side of Nigliagvik Channel, 350-ft upstream of bridge centerline
		G39	East side of Nigliagvik Channel, 300-ft downstream of bridge centerline

2. METHODS

2.1 Observations

The U.S. Geological Survey (USGS) operates a hydrologic gage station on the Colville River at Umiat, approximately 90 river miles (RM) upstream of the CRD. Real-time stage data and photos from this site were used during spring breakup monitoring to help forecast the arrival of floodwater and timing of peak conditions in the CRD study area. A helicopter reconnaissance flight was also conducted to Ocean Point and towards the Anaktuvuk River and the Chandler River confluences to track the progression of the floodwaters.

Field data collection and observations of breakup progression, discharge distribution, bank erosion, ice events, scour, lake recharge, and interactions between floodwaters and infrastructure were recorded in field notebooks (Photo 2.1). Photographic documentation of breakup conditions was collected using digital cameras with integrated global positioning systems (GPS). Each photo was geotagged with the latitude and longitude, date, and time. The photo location is referenced to the World Geodetic System of 1984 horizontal datum. Additional photos were collected via game cameras installed at MON9 (Photo 2.2) and the Nigliq Bridge. These were programmed to record every 15 minutes, providing time-lapse observations of the Colville East and Nigliq Channels in the vicinity of the HDD crossing and Nigliq Bridge respectively.

UMIAQ provided Hägglund track vehicle support to access gage stations during setup and before a helicopter was onsite at Alpine. Soloy Helicopters, LLC provided helicopter support to access CRD gage stations, and Alpine Environmental Coordinators provided a pickup truck to access Alpine facilities monitoring locations.

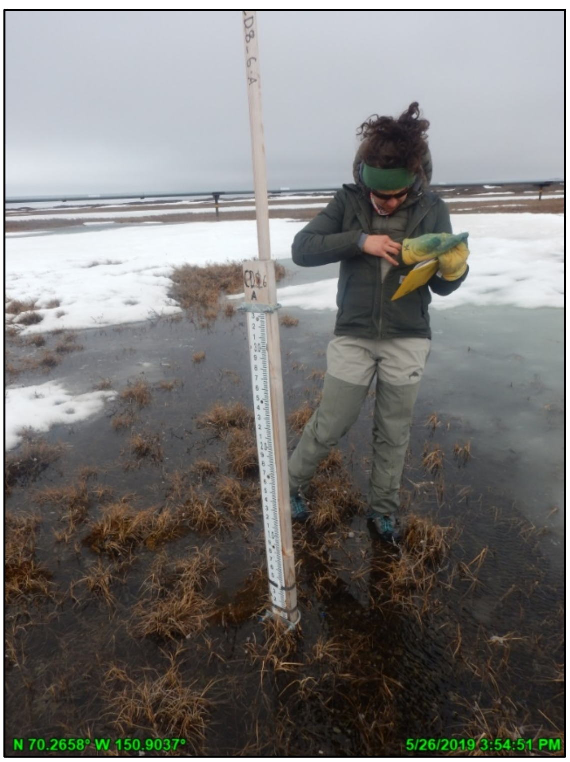


Photo 2.1: Field crew recording observations at staff gage; May 26, 2019

Photo 2.2: Game camera at MON9; May 1, 2019

2.2 Stage

HYDROLOGIC STAFF GAGES

Stage data was collected using hydrologic staff gages (gages) and pressure transducers (PTs). Site visits were performed as needed and as conditions allowed. The field methodologies used to collect hydrologic data on the North Slope of Alaska during spring breakup are proven safe, efficient, and accurate for the conditions encountered.

Gages were installed or rehabilitated as needed in the previous fall and re-surveyed prior to spring breakup using standard differential leveling techniques.

Two types of gages were used:

1) **Direct-read gages** directly correspond to a British Petroleum Mean Sea Level (BPMSL) elevation and were surveyed by UMIAQ. The survey is used to determine if correction factors must be applied to adjust elevations during flooding conditions. Adjustments are made annually by UMIAQ during ice-free conditions to correct for jacking or settlement induced by the freeze-thaw cycle. The gages consist of metal gage faceplates attached to drill stems permanently driven into the ground (Photo 2.3) or attached to pipeline vertical support members (VSMs).
2) **Indirect-read gages** do not directly correspond to a BPMSL elevation. The gage elevations were surveyed relative to a known benchmark elevation to determine a correction. The correction is applied to the gage reading to obtain the elevation in-ft (ft) BPMSL.

Indirect-read gage stations consist of one or more gage assemblies positioned perpendicular to the waterbody or road. Each indirect-read gage assembly includes a standard USGS metal faceplate mounted on a wooden two-by-four. The two-by-four is attached with U-bolts to a 1.5-inch-wide angle iron post driven into the ground. The faceplate is graduated and indicates water levels every 0.01 feet between 0.00 to 3.33-ft (Photo 2.4).

Photo 2.3: Direct-read gage G7 along the CD2 road; May 5, 2019

Photo 2.4: Indirect-read gages at G20; May 25, 2019

Alpine facilities gage stations were established at pads and along roads adjacent to infrastructure and at drinking water source Lakes L9313 and L9312. Paired gages along the access roads captured water levels on the upstream and downstream side of drainage structures to determine stage differential.

The CRD gage stations were established throughout the delta at locations of hydrologic importance. The number of gage assemblies per station is dependent upon site specific conditions: primarily slope of the channel bank and overbank. In locations where terrain elevation varied by more than 3 feet, multiple gages were installed linearly from the edge of the low water channel up to the overbank. The gages were installed at elevations overlapping by approximately 1 foot. Individual gage assemblies were identified with alphabetical designations beginning with "A" representing the location nearest to the stream. High water marks (HWMs) were measured by applying chalk on the angle iron gage supports or VSMs and measuring the wash line (Photo 2.5).

Photo 2.5: Measuring a high water mark on gage MON20-D; May 26, 2019

PRESSURE TRANSDUCERS

Pressure transducers were used at select gage stations to supplement gage measurements and provide a continuous record of WSEs (Photo 2.6). The PTs are designed to collect and store pressure and temperature data at discrete pre-set intervals. The PTs were programmed to collect data at 15-minute intervals from May 1 to August 30. Each PT was housed in a small perforated galvanized steel pipe and secured to the base of the gage assembly nearest to the channel. By sensing the absolute pressure of the atmosphere and water column above the PT, the depth of water above the sensor was calculated. Atmospheric pressure was accounted for using barometric pressure sensors (Baro PT, Photo 2.7) at two locations in the CRD. During data processing, the PT measurements were adjusted to WSEs recorded at the staff gages.

Secondary PTs were installed to validate and backup the primary PT data at locations where discharge is calculated. The PT setup and testing methods are detailed in Appendix B.

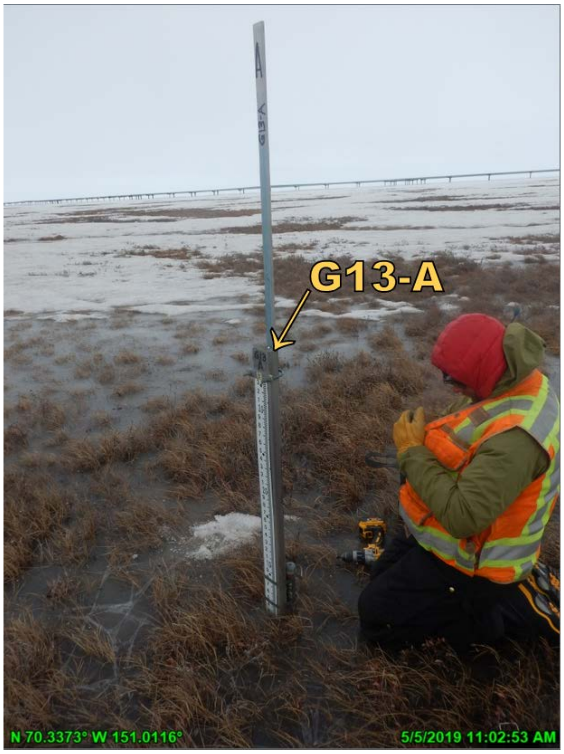


Photo 2.6: Installation of PT on staff gage G13; May 5, 2019

Photo 2.7: Baro PT at MON9/East Channel HDD; May 1, 2019

2.3 Discharge

MEASURED DISCHARGE

Discharge was measured as close to observed peak stage at the following drainage structures:

- Nigliq Bridge/CD5 Bridge #2
- CD2 Road Short Swale Bridge
- CD2 Road Long Swale Bridge
- CD2, CD4, and CD5 road culverts observed conveying flow

Discharge was not measured at MON1 because of helicopter mechanical issues and the potential for interference with Nuiqsut subsistence hunters during peak conditions. Discharge was not measured at the Lake L9323 Bridge/CD5 Bridge #1 or the Lake L9341 Bridge/CD5 Bridge #3 because floodwater at the bridges was either backwater or local melt and not flowing. Discharge was not measured at the Nigliagvik Bridge/CD5Bridge #4 because the presence of ice at the bridge didn't allow for equipment to be placed in the channel.

Flow depth and velocity were measured at the CD2 Road Long Swale and Short Swale bridges using a Price AA current meter suspended by cable with a sounding weight following USGS midsection procedures (USGS 1982) (Photo 2.8). Culvert flow depth and velocity were measured using a Hach flow meter attached to a wading rod following USGS velocity/area procedures (USGS 1968 [Photo 2.9]). Discharge at the Nigliq Bridge was measured using a boat mounted acoustic doppler current profiler (ADCP) following USGS ADCP measurement procedures (USGS 2006). Measured discharge methods are further detailed in Appendix C.

Photo 2.8: Measuring discharge at the Long Swale Bridge; May 25, 2019

Photo 2.9: Measuring discharge at a culvert along the CD2 road; May 25, 2019

PEAK DISCHARGE

Peak discharge was calculated using indirect methods and observed WSEs. When possible, results were calibrated with a direct discharge measurement. Under open channel conditions, peak discharge typically occurs at the same time as peak stage; however, discharge in the CRD is typically affected by ice and snow during peak conditions. This often yields a lower discharge than an equivalent stage under open water conditions.

Peak discharge was calculated at the following locations:

- Colville River (MON1)
- Colville River East Channel (MON9)
- Nigliq Bridge/CD5 Bridge #2
- CD2 Road Long Swale Bridge
- CD2 Road Short Swale Bridge
- CD2 road culverts associated with gages G3/G4
- CD4 road culverts associated with gages G17/G18

Drainage structures not listed above were either dry, did not have discernable flow, had ice present in the water body during peak conditions, or experienced monitoring equipment malfunction. Peak discharge results are estimates based on conditions at the time of data collection. These conditions often include ice and snow effects, which are highly dynamic and challenging to quantify. Ice and snow conditions can affect channel geometry, roughness, energy gradient, and stage, all of which are used to calculate discharge indirectly. In consideration of these conditions, calculations of peak discharge are presented with quality ratings, as described in Table 2.1. Detailed peak discharge methods are presented in Appendix C.

Table 2.1: Peak Discharge Quality Ratings

Quality Rating	Description
Good	Open channel/drainage structure free of ice and snow, no backwater effects from downstream ice jamming, uniform channel/drainage structure through reach
Fair	Some ice floes and/or snow in the channel/drainage structure, some backwater effects, fairly uniform conditions through reach
Poor	Significant quantities of ice and snow in the channel/drainage structure, significant backwater effects from downstream ice jamming, non-uniform conditions through channel/drainage structure reach

2.4 Post-Breakup Conditions Assessment

Alpine facilities roads, pads, and drainage structures were assessed immediately following breakup flooding. A systematic inventory was completed to document the effects of flooding on infrastructure with a focus on erosion. Both sides of the roads were photographed from the ground and the condition of the fill material was described.

2.5 CD5 Pier Scour, Bank Erosion, & Bathymetry

Monitoring described in this section supports additional requirements specific to the CD5 development per USACE Permit POA-2005-1576 Special Condition #1 which requires the MP-AMS (Michael Baker and ABR 2013).

PIER SCOUR

The objective of measuring pier scour was to determine maximum pier scour depths during flood conditions and to determine post-breakup pier scour depths. Pier scour measurements satisfy the requirement for annual pier scour measurements during spring breakup and other large flood events at the Nigliq Bridge and Nigliagvik Bridge (Michael Baker and ABR 2013). Maximum scour occurring under the influence of peak velocities is often greater than the final scour measured after flood recession due to sediment deposition in the scour hole associated with lower flow velocities. For this reason, real-time soundings are collected during peak flood conditions.

The Nigliq Bridge is supported by two bridge abutments, abutments 1 and 9, and seven bridge piers, piers 2 through 8, numbers increasing west to east. Each bridge pier contains five piles labeled A through E, with pile A being the most upstream pile. Piles A and B support the ice breaker, while piles C, D, and E support the bridge. Bridge piers 2 through 5 are located within the main portion of the Nigliq Channel.

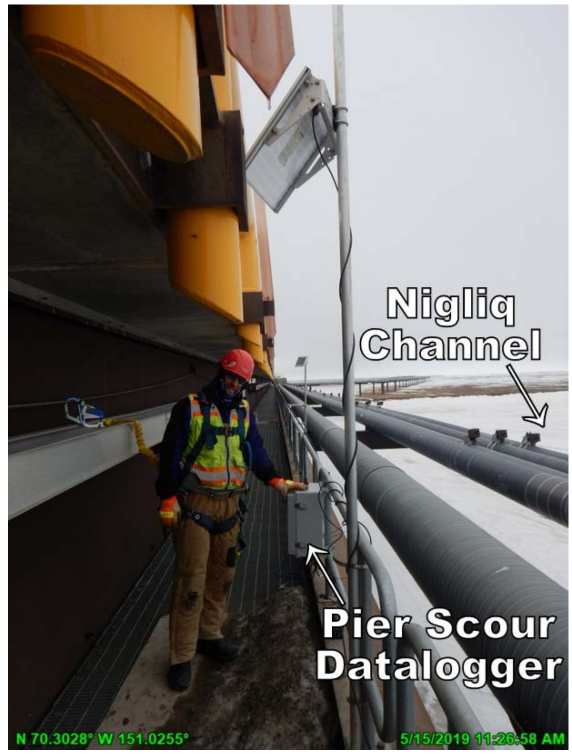


Photo 2.10: Installation of real-time pier scour equipment on the Nigliq Bridge; May 15, 2019

The Nigliagvik Bridge is supported by two bridge abutments, abutments 1 and 5, and three bridge piers, piers 2 through 4, numbers increasing west to east. Each bridge pier contains two piles labeled A and B, with pile A being the upstream pile. Bridge piers 3 and 4 are located within the main portion of the Nigliagvik Channel. Appendix E presents a plan view of each bridge (UMIAQ 2019a).

A real-time pier scour monitoring system was installed on bridge piers that are the most susceptible to scour (Photo 2.10). These include piers 2 through 5 of the Nigliq Bridge, installed in the spring of 2016, and pier 3 of the Nigliagvik Bridge, installed in the spring of 2015. Scour depths were measured using a single beam sonar installed inside a steel pipe casing welded to the downstream side of pile E on the Nigliq Bridge and pile B on the Nigliagvik Bridge. Sonar measurements were recorded with an on-site datalogger. The sonar system was programmed to measure depths and record data at 30-minute intervals. A telemetry system, using cellular communication, provided remote access to the sonar measurements. A post-breakup survey of the scour holes at the base of all piles at bridge piers within the main channel of the Nigliq Bridge and Nigliagvik Bridge were also completed and contour plots around the piers are provided in Appendix E.

BANK EROSION

The objective of the bank erosion study is to monitor bank migration upstream and downstream of the Nigliq Bridge and Nigliagvik Bridge. This work supports the requirements for visual inspection and documentation of tundra as well as bank erosion monitoring. A detailed edge-of-bank delineation was surveyed in 2013 to establish pre-construction baseline data. Post-construction bank surveys were performed in 2016, 2017, 2018, and again this year (UMIAQ 2016, 2017c, 2018, 2019). Maximum and average rates of erosion between 2013 and 2018 were determined for each bank.

BATHYMETRY

A. Bathymetry at Bridges

Topographic and bathymetric baseline post-breakup surveys upstream and downstream of the Nigliq Bridge, Nigliagvik Bridge, and Lake L9341 Bridge were performed by UMIAQ in August 2013, prior to construction of the bridges. The pre-construction survey included two transects surveyed upstream and two transects surveyed downstream of the Nigliq Bridge (Transects 8-11), the Nigliagvik Bridge (Transects 25-28), and the Lake L9341 Bridge (Transects 36-39). These transects have been surveyed annually since 2013 (Michael Baker and ABR 2013).

B. Channel Bathymetry

Topographic and bathymetric baseline post-breakup surveys of the Nigliq Channel and Nigliagvik Channel were performed by UMIAQ in August 2013, prior to construction of the bridges. The pre-construction survey included 15 transects surveyed along the Nigliq Channel upstream and downstream of the Nigliq Bridge (Transects 1-15) and 20 transects surveyed at the Nigliagvik Channel upstream and downstream of the Nigliagvik Bridge (Transects 16-35). These transects were surveyed post-construction in 2016 and annually through 2019. After 2019, the transects will be surveyed every five years (Michael Baker and ABR 2013).

2.6 Ice Road Crossings Breakup

Aerial observations of the hydraulic effects of winter ice road crossings during breakup were documented at the following ice road crossings:

- Colville River East Channel at HDD
- Kachemach River
- No Name Creek
- Pineapple Gulch
- Silas Slough
- Slemp Slough
- Tamayayak Channel 1 near coast
- Toolbox Creek

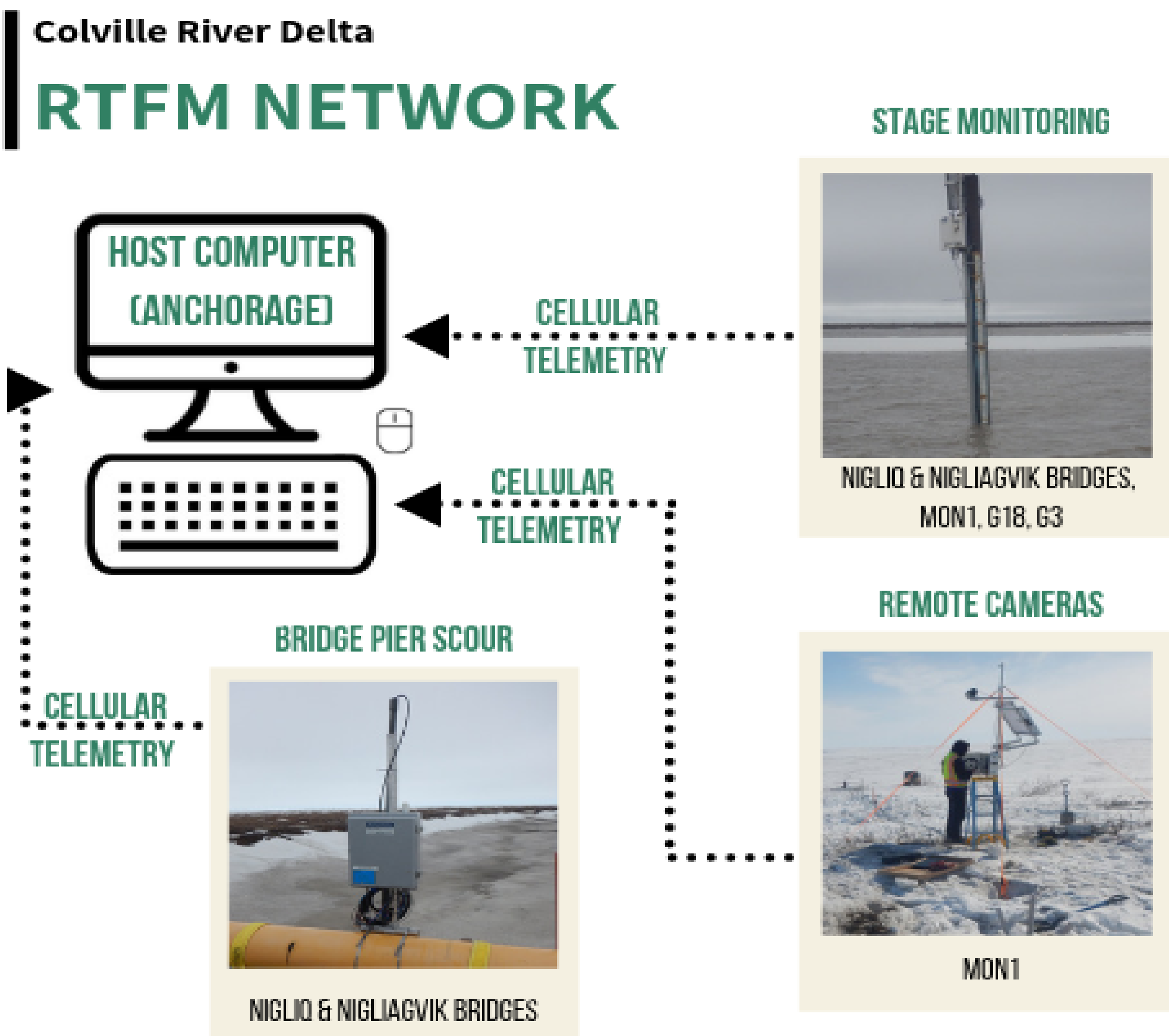
2.7 Real-Time Flood Monitoring Network

The objective of the Real-Time Flood Monitoring (RTFM) Network is to remotely monitor stage and pier scour at select monitoring locations during spring breakup flooding (Table 2.2). The RTFM Network has the following components: remote cameras to monitor stage and river conditions, sensors to monitor stage, barometric pressure and real-time bridge pier scour discussed in Section 2.5, dataloggers and telemetry systems to collect and transmit data, and a host computer to receive the transmitted data (Figure 2.1). The ability to remotely monitor stage and scour helps reduce helicopter traffic in the CRD, allows for round-the-clock monitoring of conditions, and provides an interactive tool for the hydrologic data when helicopter travel is restricted because of weather, maintenance, or other issues. In addition, a network of real-time monitoring stations at critical locations around Alpine infrastructure helps guide facilities operations preparedness, and helps hydrologists deploy resources during peak conditions when critical measurements are required.

Table 2.2: RTFM Network Stations

Monitoring Location	Gage Station	Real-Time Data
Colville River	• MON1U • MON1C • MON1D	Stage River conditions and staff gage measurements via remote camera images
Alpine Drinking Water Lakes	• L9312 (G9) • L9313 (G10)	Stage
CD2 Road Swale Bridges	• G3	Stage
CD4 Road/CD4 Pad	• G18	Stage Barometric pressure
CD5 Road	• Nigliq Bridge • Nigliagvik Bridge	Stage Pier scour

Figure 2.1: RTFM Network Schematic



REMOTE CAMERAS

Remote camera systems were installed at the MON1 monitoring locations (Photo 2.11). A high-resolution digital camera was programmed to take pictures at 15-minute intervals. The camera collected wide-angle photographs of the Colville River to document conditions and monitor ice jam formation and releases in the MON1 reach. Additionally, the cameras' zoom capabilities allowed hydrologists to remotely read staff gages for validating PT data. This proved extremely valuable during peak stage when hydrologists were unable to land at the MON1 monitoring locations due to helicopter mechanical issues and local subsistence hunting.

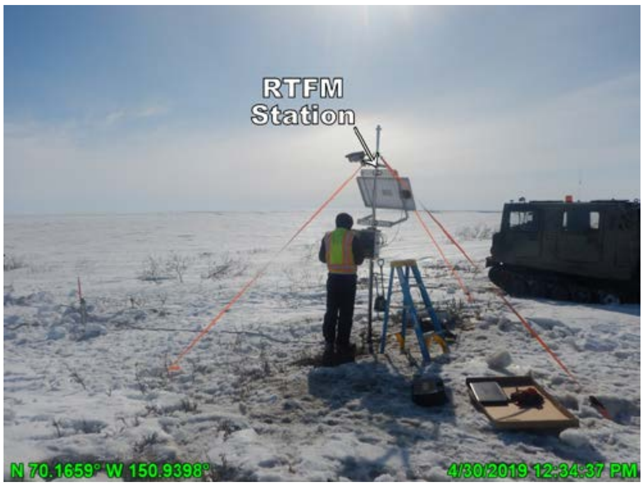


Photo 2.11: Remote camera setup at MON1D; April 30, 2019

SENSORS

Pressure transducers were programmed to read and record water levels and barometric pressure at 15-minute intervals. The RTFM PTs were installed at the head of the CRD (MON1), along the CD2 and CD4 road (G3 and G18), at the Nigliq and Nigliagvik Bridges (G45 and G46), and at the Alpine drinking water lakes (G9 and G10 [Photo 2.12]). Real-time pier scour sensors were also installed on the Nigliq and Nigliagvik Bridges. Pier scour was measured using single beam sonars (Photo 2.13) at 30-minute intervals.

Photo 2.12: Remote stage monitoring equipment at Lake L9313 (G10); May 15, 2019

Photo 2.13: Pier scour sonar equipment; May 16, 2019

DATALOGGERS & TELEMETRY

Onsite dataloggers were programmed to interface with the PTs and sonars. Data was uploaded to the datalogger via a data cable and stored internally. The dataloggers were programmed to interact with telemetry equipment to transmit data. Data was transmitted using an onsite cellular modem and TCP/IP communication where each cellular modem has a unique static IP address. To conserve power, cellular modems were programmed to power-on every

15 minutes for data transmission. Systems were powered with 12v DC batteries and charged with onsite solar panels (Photo 2.14).

Photo 2.14: Field install of telemetry and solar/battery RTFM equipment; April 15, 2019

HOST COMPUTER, DATA ACCESS, & NOTIFICATIONS

A host computer monitored the cellular modem IP addresses offsite and received data from the dataloggers once the connection was established. Real-time stage was processed using downloaded stage and barometric pressure data. Real-time stage was periodically compared with field-observed stage data for quality assurance. Real-time stage and pier scour were plotted on graphs and updated in tables as data was received. Alarms were set to notify Alpine operations personnel if stage or pier scour reached the 50- or 200-year predicted values at any of the monitoring locations. If alarms were triggered, notifications would automatically be sent by email and text message to the Michael Baker project manager and Alpine Operations personnel for immediate assessment.

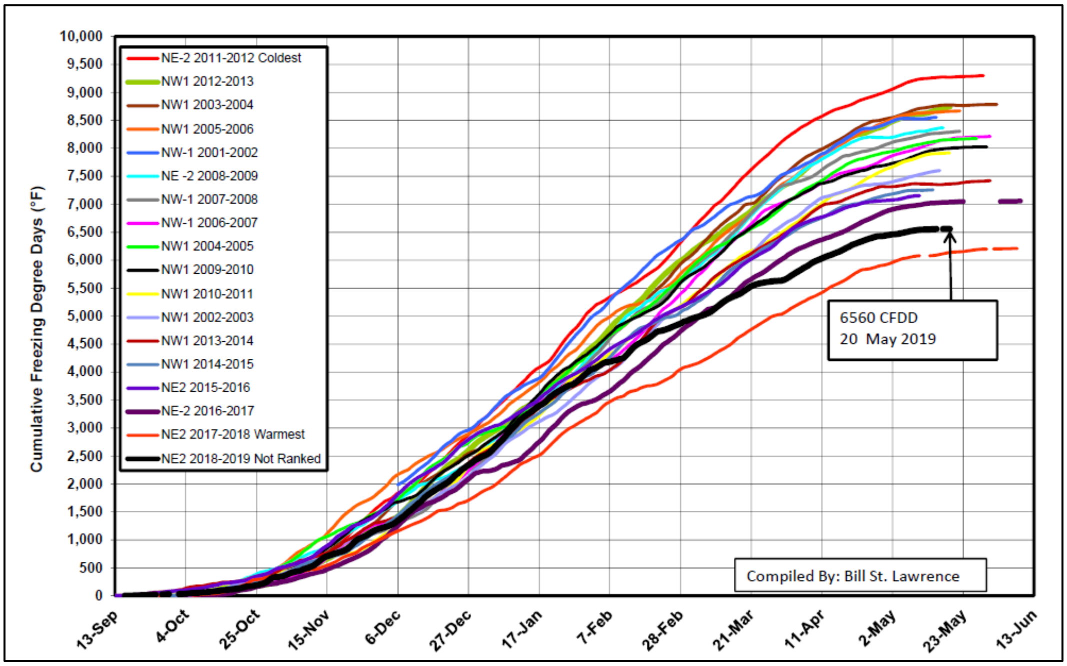
2.8 Flood & Stage Frequency Analyses

Peak discharge at MON1 is assigned a flood recurrence interval annually based on current design criteria. The flood recurrence interval provides an estimate of the magnitude of annual breakup flooding entering the CRD. A flood recurrence interval was assigned to the peak discharge at MON1 based on the results from the basis of design flood frequency analysis (Michael Baker 2018). Peak stage at select monitoring locations was compared with historical stage data and results from the 2D model and assigned a stage recurrence interval.

3. OBSERVATIONS

3.1 General Climatic Summary

According to cumulative freezing degree-days (CFDD) measured at the National Petroleum Reserve Alaska (NPR-A) tundra monitoring station, the 2018-2019 (September – May) winter was the second warmest on record for the past 18 years (Graph 3.1, ICE 2019).



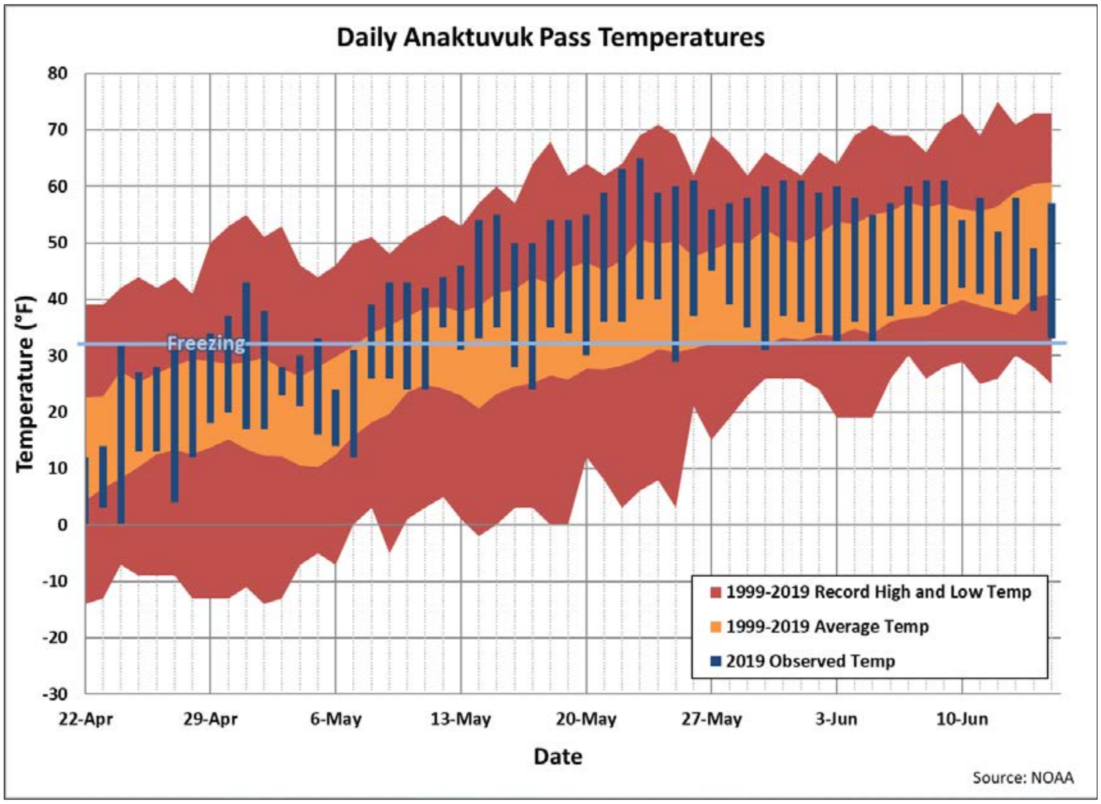
Graph 3.1: NPR-A N. Tundra Monitoring Station, CFDD, Winters 2002-2019 (ICE 2019)

No North Slope snowpack data is currently available for the 2018-2019 winter season through the Natural Resource Conservation Service, but general observations indicate snowpack was at or above normal levels in the Colville River drainage basin.

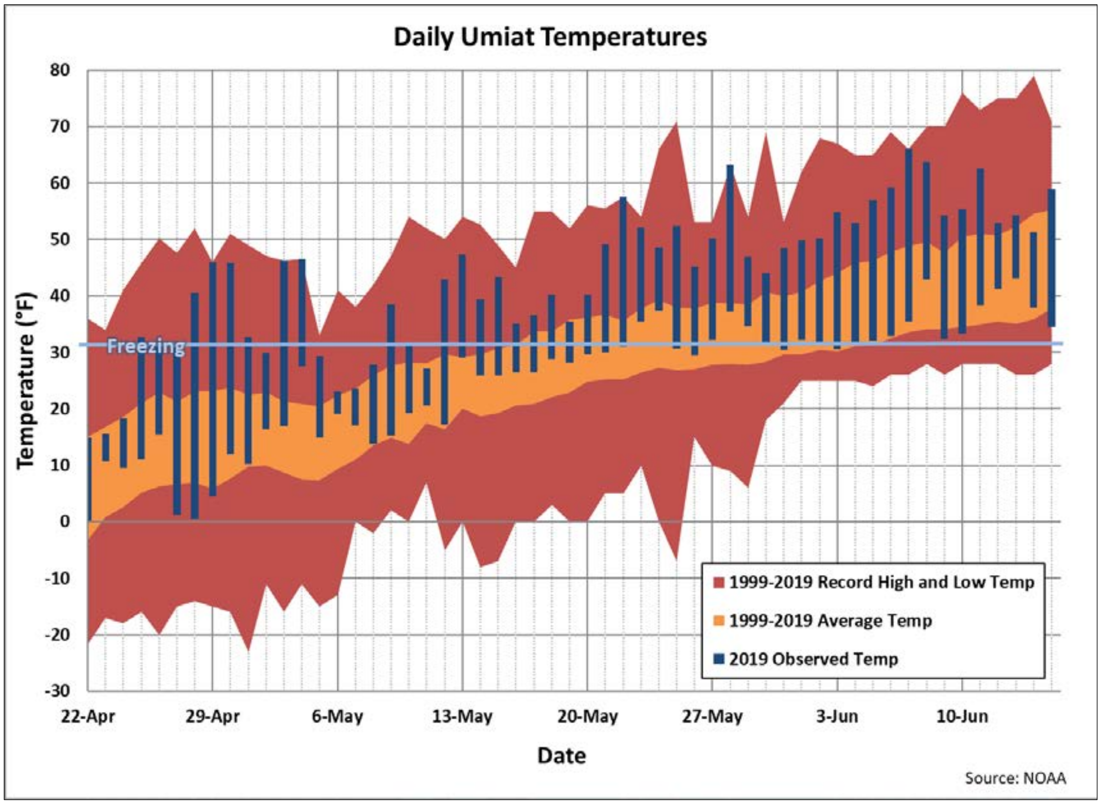
Air temperatures were generally higher than average throughout the Colville River drainage during the spring breakup season. At the southern-most, furthest extent of the drainage (at Anaktuvuk Pass in the Brooks Range), a brief warm period in late April and early May saw temperatures reach 45 degrees which initiated runoff in the upper reaches of the watershed. After a short cooling period between May 3 and May 7, the spring warming trend began; high temperatures averaged in the mid 50s throughout the rest of the monitoring period. The spring warming trend in the central Colville River watershed (at Umiat in the Brooks Range foothills) started April 25. This region also experienced a brief cooling period during early May. Daily maximum temperatures began to exceed freezing on May 12 and daily minimum temperatures began to regularly exceed freezing on May 23.

Temperatures for the CRD in the Alpine area are available from the Nuiqsut weather station, located approximately 9 air miles south (upstream) of Alpine facilities. Daily maximum temperatures at Nuiqsut exceeded freezing from April 29 to May 4, followed by a cooler period with sub-freezing temperatures. Daily high temperatures consistently exceeded freezing on May 16 and continued through the breakup monitoring period. Daily minimum temperatures generally remained below freezing through the breakup monitoring period. The leading edge of flowing meltwater in the Colville River arrived at MON1 on May 20, two days before the average arrival date.

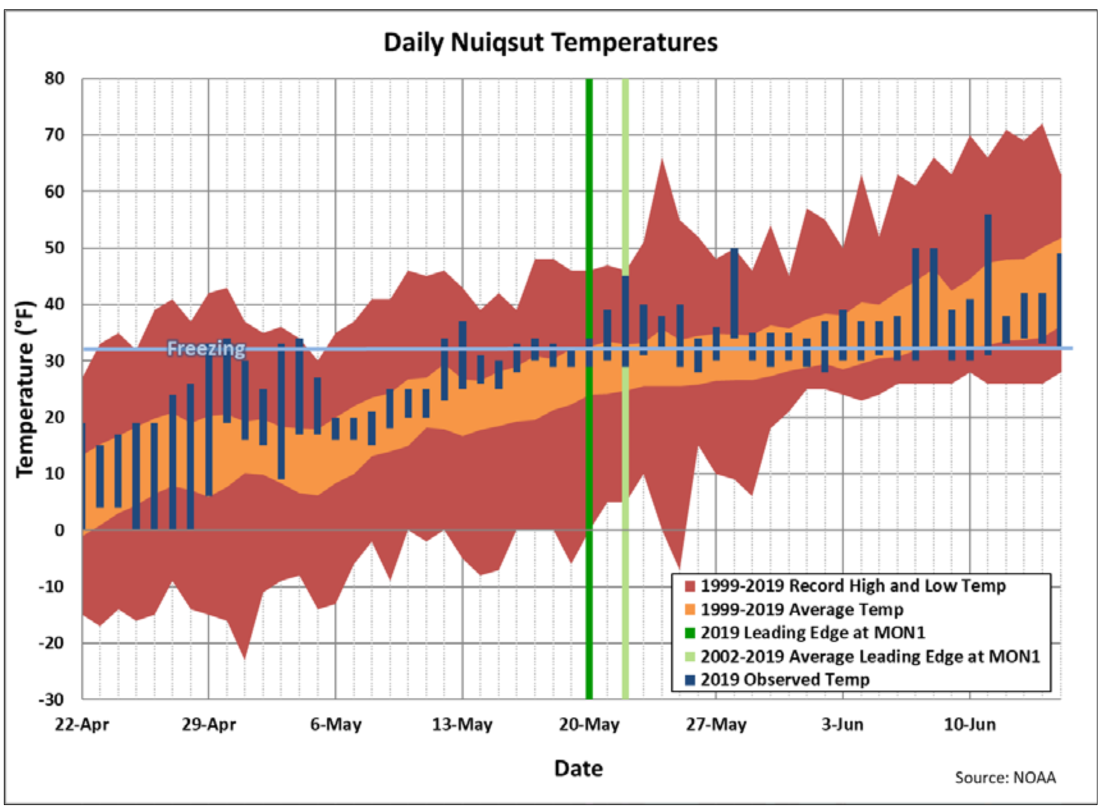
Graph 3.2, Graph 3.3, and Graph 3.4 illustrate daily high and low ambient air temperatures recorded in Anaktuvuk Pass, Umiat, and Nuiqsut, respectively, superimposed on the average and record daily highs and lows during the breakup monitoring period (National Oceanic and Atmospheric Administration [NOAA] 2019).



Graph 3.2: Anaktuvuk Pass Daily High and Low Ambient Air Temperatures



Graph 3.3: Umiat Daily High and Low Ambient Air Temperatures



Graph 3.4: Nuiqsut Daily High and Low Ambient Air Temperatures and MON1 Leading Edge

3.2 General Breakup Summary

Crew members began reconnaissance flights toward the headwaters of the Colville River drainage on May 18. On May 18, a well-defined leading edge of floodwater in the Colville River was observed approximately 28 RM south (upstream) of MON1 (Photo 3.1). Visible flow was observed within a couple miles upstream of the leading edge. Local melt was also observed around Alpine facilities and in distributary channels.

On May 20, the leading edge of floodwater passed through the MON1 reach. At that time, lifted, intact channel ice was observed in the MON1 reach (Photo 3.2).

Photo 3.1: Approximate leading edge of observed flowing water, looking north (downstream); May 18, 2019

Photo 3.2: Lifted channel ice through the MON1 reach, looking south (upstream); May 20, 2019

On May 21, a 10-mile-long ice jam was observed near Ocean Point with the downstream extent approximately 12 RM south (upstream) of MON1 (Photo 3.3). No substantial backwater was visible and water levels remained below bankfull stage behind the jam.

Another ice jam, approximately 2 miles in length, was observed near the horseshoe bends, about 4 RM south (upstream) of MON1 (Photo 3.4). The leading edge of this ice jam was situated at the furthest upstream extent of intact channel ice. The furthest upstream extent of intact channel ice is referred to hereafter as the “breakup front” and is a common location for ice jam formation. Between the two ice jams, the channel was predominantly clear of ice (Photo 3.5).

Lifted channel ice was observed downstream of the breakup front at the horseshoe bends and throughout the main channels in the CRD. Daily satellite imagery indicated that floodwater from the Nigliq and East Channel had reached the coast and was flowing over top of shorefast sea ice (Photo 3.6). The ice jams had not substantially moved by May 22, although increasing backwater below bankfull stage was observed upstream of Ocean Point, about 14 RM upstream of MON1.

Photo 3.3: Ice jam on the Colville River approximately 12 RM upstream of MON1, looking northeast (downstream); May 21, 2019

Photo 3.4: Full extent of Horseshoe Bend ice jam, including the breakup front, on the Colville River approximately 6 RM upstream of MON1, looking north (downstream); May 21, 2019

Photo 3.5: Open reach between the two ice jams, looking north (downstream); May 21, 2019

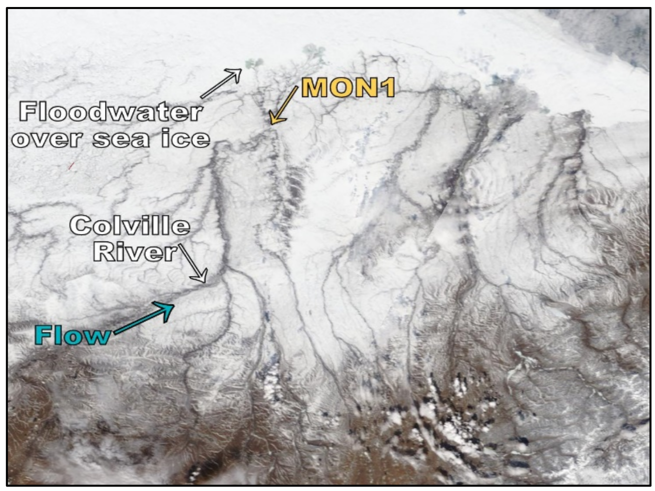


Photo 3.6: MODIS imagery of North Slope; May 21, 2019 (Source: National Aeronautics and Space Administration 2019)

Stage continued to rise around the CRD and Alpine facilities on May 23. Aerial observations were limited at this time due to helicopter maintenance. By May 24, the ice jams had converged and progressed to near the Itkillik River confluence, just upstream of MON1. Some backwater flooding was observed in low-lying areas and tributary channels, including the Itkillik River (Photo 3.7). Open channel conditions were observed upstream of the jam. By late evening on May 23, RTFM images revealed the breakup front passing through the MON1 reach, followed by peak stage conditions. Channel ice on the Nigliq Channel was intact but visibly deteriorating. Near Alpine facilities, flow into Nanuq Lake had connected to Lake M9524 and was passing through the Long and Short Swale Bridges.

On the morning of May 25, the progression of ice jams formation and release cleared the MON9 reach of ice. Stage steadily declined in the East Channel but rose in the Nigliq channel and around the Alpine facilities. An ice jam was observed in the East Channel at the Elaktoveach bifurcation downstream of MON9. Floes were stranded at MON9D, indicating stage had receded (Photo 3.8). Channel ice remained intact throughout the Nigliq channel and stage was near bankfull.

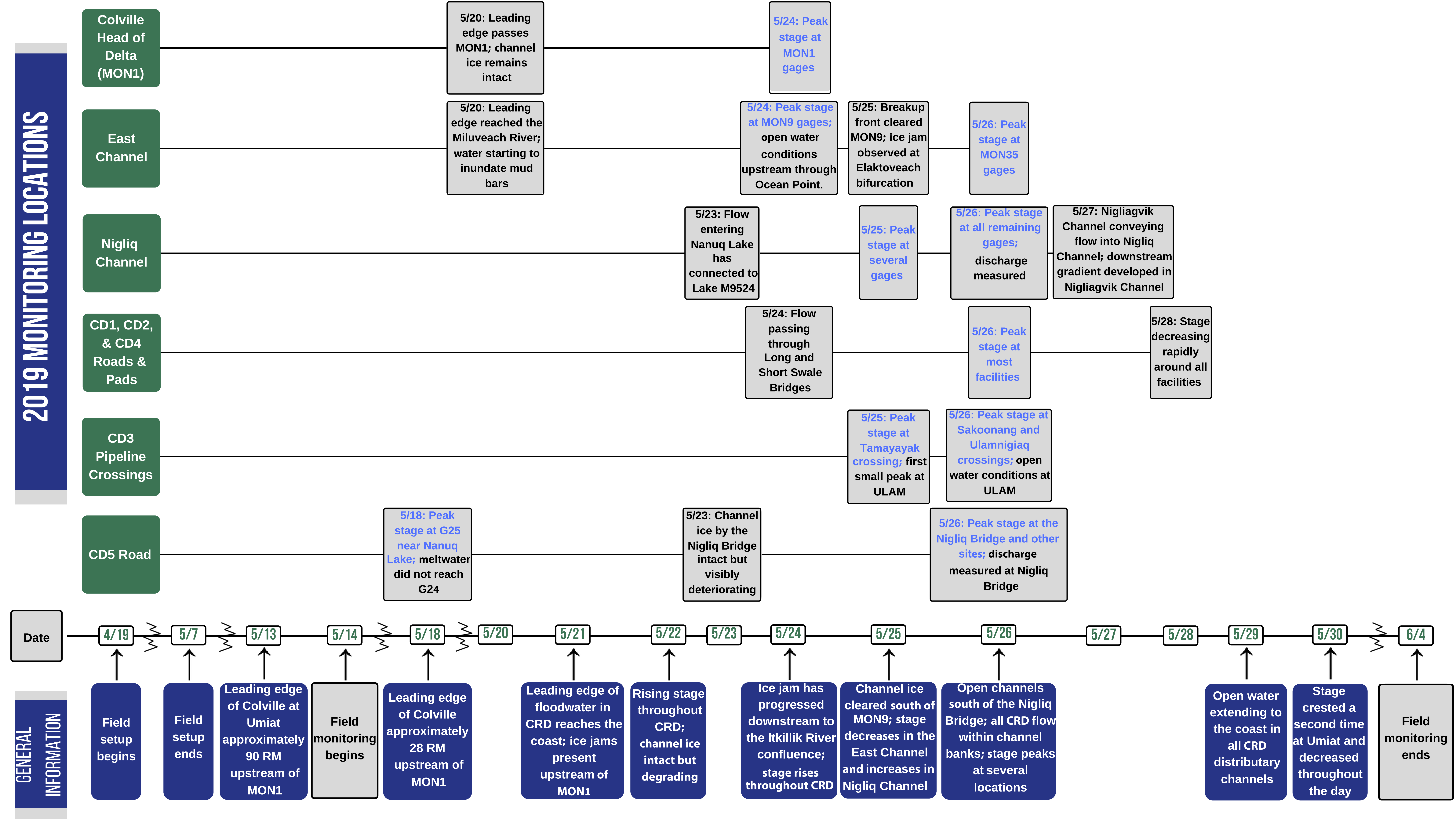
The Nigliq channel at the CD5 bridge and most Alpine facilities experienced peak stage on May 26. Discharge was measured in the Nigliq Channel mid-morning on May 26, after the channel ice cleared. On May 27, the Nigliagvik Channel was conveying flow into the Nigliq Channel as stage in the Nigliq receded and a downstream gradient developed in the Nigliagvik Channel. Stage continued to decrease across the CRD through the rest of the monitoring period. Open water extending to the coast in all distributary channels was confirmed on May 29 (Photo 3.9).

In general, peak stage conditions were observed around the CRD and Alpine facilities from May 24 to May 26. During peak conditions, stage generally remained below bankfull levels, however, many typical hydraulic connections between lakes and channels were established, including the recharge of both Lake L9312 and L9313. Lake L9312 was not connected to floodwater and recharged by local melt only. Overall, ice jamming effects in the CRD were minimal, as was associated backwater and flooding. Further information on drinking water lake recharge at Alpine facilities is found in Section 8.4.

Photo 3.7: Colville River backwater in the Itkillik River, looking northwest; May 24, 2019

Photo 3.8: Stranded ice at MON9D indicating receding stage, looking southeast (upstream); May 25, 2019

Photo 3.9: Open channel in Nigliq Channel to coast, looking north (downstream); May 28, 2019


2019 MONITORING LOCATIONS
Colville Head of Delta (MON1)
5/20: Leading edge passes MON1; channel ice remains intact
5/24: Peak stage at MON1 gages
East Channel
5/20: Leading edge reached the Miluveach River; water starting to inundate mud bars
5/24: Peak stage at MON9 gages; open water conditions upstream through Ocean Point.
5/25: Breakup front cleared MON9; ice jam observed at Elaktoveach bifurcation
5/26: Peak stage at MON35 gages
Nigliq Channel
5/23: Flow entering Nanuq Lake has connected to Lake M9524
5/25: Peak stage at several gages
5/26: Peak stage at all remaining gages; discharge measured
5/27: Nigliagvik Channel conveying flow into Nigliq Channel; downstream gradient developed in Nigliagvik Channel
CD1, CD2, & CD4 Roads & Pads
5/24: Flow passing through Long and Short Swale Bridges
5/26: Peak stage at most facilities
5/28: Stage decreasing rapidly around all facilities
CD3 Pipeline Crossings
5/25: Peak stage at Tamayayak crossing; first small peak at ULAM
5/26: Peak stage at Sakoonang and Ulamnigiaq crossings; open water conditions at ULAM
CD5 Road
5/18: Peak stage at G25 near Nanuq Lake; meltwater did not reach G24
5/23: Channel ice by the Nigliq Bridge intact but visibly deteriorating
5/26: Peak stage at the Nigliq Bridge and other sites; discharge measured at Nigliq Bridge
Date
4/19
5/7
5/13
5/14
5/18
5/20
5/21
5/22
5/23
5/24
5/25
5/26
5/27
5/28
5/29
5/30
6/4
GENERAL INFORMATION
Field setup begins
Field setup ends
Leading edge of Colville at Umiat approximately 90 RM upstream of MON1
Field monitoring begins
Leading edge of Colville approximately 28 RM upstream of MON1
Leading edge of floodwater in CRD reaches the coast; ice jams present upstream of MON1
Rising stage throughout CRD; channel ice intact but degrading
Ice jam has progressed downstream to the Itkillik River confluence; stage rises throughout CRD
Channel ice cleared south of MON9; stage decreases in the East Channel and increases in Nigliq Channel
Open channels south of the Nigliq Bridge; all CRD flow within channel banks; stage peaks at several locations
Open water extending to the coast in all CRD distributary channels
Stage crested a second time at Umiat and decreased throughout the day
Field monitoring ends

4. STAGE & DISCHARGE

Table 4.1 contains a summary of peak stage, measured discharge (in cubic ft per second [cfs]), and peak discharge at each gage station.

Table 4.1: Peak Stage, Measured Discharge, and Peak Discharge Summary

Monitoring Location	Monitoring Location Description	Gage Station	Peak Stage		Measured Discharge			Peak Discharge		
			Stage ft BPMSL	Date & Time	Discharge cfs	Stage[1] ft BPMSL	Date & Time	Discharge cfs	Stage ft BPMSL	Date & Time
Colville River	Upstream of Anaktuvuk & Chandler River Confluences	Umiat[3]	56.36	5/24, 11:15pm	118,000	55.48	5/29, 2:30pm	135,000	56.35	5/25, 12:30am
CRD Monitoring Locations										
Colville River	Head of the CRD	MON1U	16.44	5/24, 6:15pm	Not measured because of access restrictions			305,000	16.44	5/24, 6:15pm
		MON1C	16.19	5/24, 6:30pm					15.86	
		MON1D	15.99	5/24, 6:45pm					15.69	
Colville River East Channel	East Channel Distributary	MON9	14.23	5/24, 11:15pm				249,000	12.70	5/24, 6:30pm
		MON9D	14.50	5/24, 11:00pm					12.22	
		MON35	3.98	5/26, 8:00am						
Nigliq Channel	Nigliq Channel Distributary	MON20	10.19	5/25, 5:30pm	See Nigliq Bridge Below			See Nigliq Bridge Below		
		MON22	8.59	5/26, 3:15pm						
		MON23	7.12	5/26, 10:00am						
		MON28	2.95	5/26, 6:30am						
Alpine Facilities Monitoring Locations										
CD1 Pad & Drinking Water Lakes	Lake L9312	G9	8.09	5/23, 7:15pm						
	Lake L9313	G10	8.72	5/26, 5:15am						
	CD1 Pad	G1	7.83	5/26, 6:30am						
CD2 Pad & Road	Short Swale Bridge	G3	7.64	5/25, 10:45pm	244	7.27	5/26 1:00pm	252	7.32	5/25, 4:45pm
		G4	7.49	5/26, 6:45am		7.28			6.97	
	Long Swale Bridge	G3	7.64	5/25, 10:45pm	2,795	6.84	5/25 12:15pm	2,998	7.32	5/25, 4:45pm
		G4	7.49	5/26, 6:45pm		6.59			6.97	
	Culverts	G3	7.64	5/25, 10:45pm	69	6.84	5/25, 12:45pm	91	7.32	5/25, 4:45pm
		G4	7.49	5/26, 6:45am		6.61			6.97	
		G6	7.96	5/26, 12:00am	No flow observed			Not calculated		
		G7	7.91	5/26, 6:30am						
		G12[4]	7.92	5/25, 11:00pm	No flow observed			Not calculated		
		G13[4]	7.80	5/26, 3:00am						
	CD2 Pad	G8	Dry	--						
CD3 Pad & Pipeline	Pipeline Crossings	SAK	7.33	5/26, 6:30am						
		TAM	8.36	5/25, 7:45pm						
		ULAM	7.97	5/26, 5:00am						
	CD3 Pad	G11	Dry	--						
CD4 Pad & Road	Culverts	G15[4]	8.73	5/26, 4:45am	No flow observed			Not calculated		
		G16[4]	8.80	5/26, 4:45am						
		G17	10.39	5/25, 5:00pm	7	10.38	5/25, 4:30pm	70	10.18	5/25, 3:00pm
		G18	11.15	5/25, 2:45pm		10.93			11.14	
		G40	Dry	--	No flow observed			Not calculated		
		G41	Dry	--						
		G42	Dry	--	No flow observed			Not calculated		
		G43	Dry	--						
	CD4 Pad	G19	Dry	--						
		G20[2]	unk	5/25, 5:30pm						
CD5 Road	Culverts	G30	Dry	--	No flow observed			Not calculated		
		G31	Dry	--						
		G34	Dry	--	No flow observed			Not calculated		
		G35	Dry	--						
		G36	Dry	--	No flow observed			Not calculated		
		G37	Dry	--						
		S1	unk	water below PT	3	21.08	5/25, 5:45pm	Not calculated		
		S1D	unk	water below PT		19.88				
	Lake L9323 Bridge (CD5 Bridge #1)	G24[4]	8.49	5/29, 1:15pm	No flow observed			Not calculated		
		G25[4]	9.07	5/18, 3:00pm						
	Nigliq Bridge (CD5 Bridge #2)	G28	9.30	5/25, 3:45pm	37,888	7.14	5/26, 7:00pm	95,000	9.23	5/25, 8:00pm
		G26	9.16	5/26, 12:15am		7.02			8.67	
		G27	9.10	5/25, 11:45pm		7.01			8.67	
		G29	9.02	5/25, 11:00pm		6.94			8.52	
	Lake L9341 Bridge (CD5 Bridge #3)	G32	8.63	5/26, 1:30am	No flow observed			Not calculated		
		G33	8.71	5/26, 1:30am						
	Nigliagvik Bridge (CD5 Bridge #4)	G38	9.30	5/26, 5:00am	Not measured because of ice in channel			Not calculated		
		G39	unk	PT malfunction						

Notes:
1. Stage prior to discharge measurement
2. Peak stage date estimated
3. Data obtained from USGS Umiat gage station 15875000 and referenced to NAVD88 vertical datum
4. Peak stage from ponded local melt

Gray cells indicate that measured and calculated discharge at that location are not included within the scope of the program

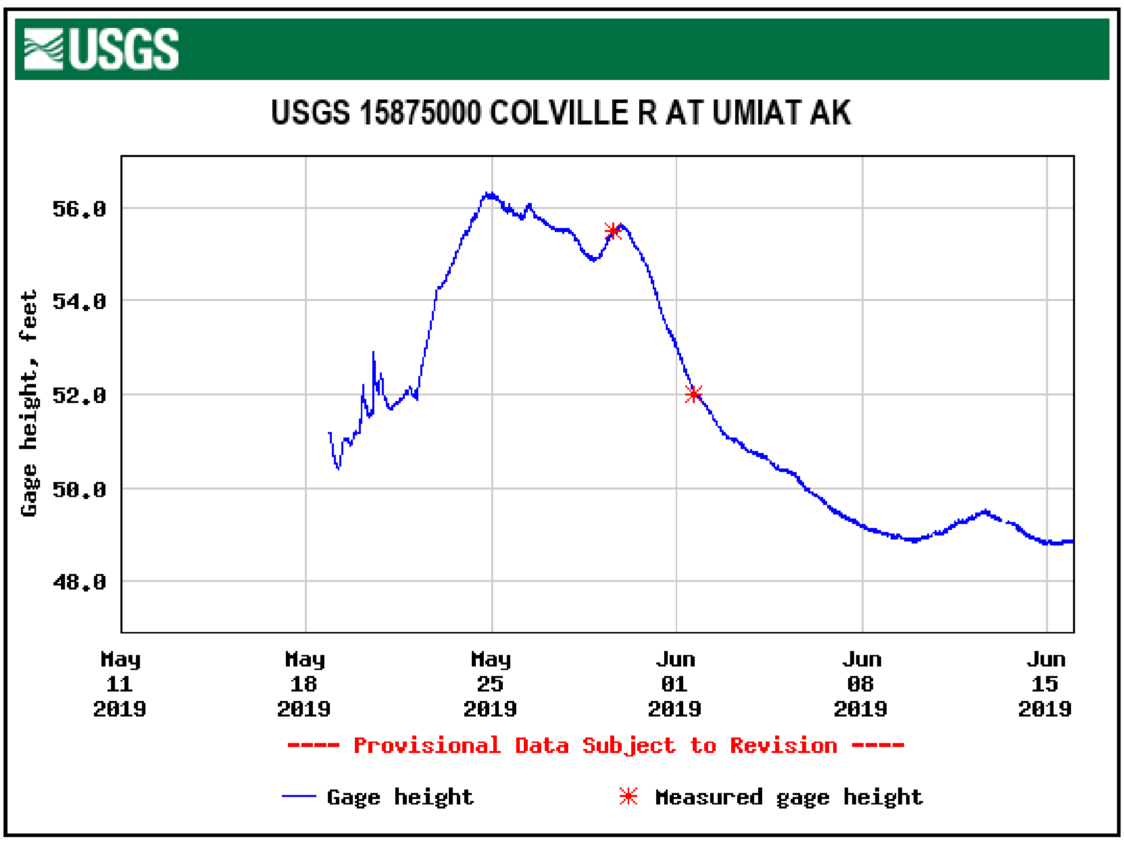
4.1 Colville River

UMIAT

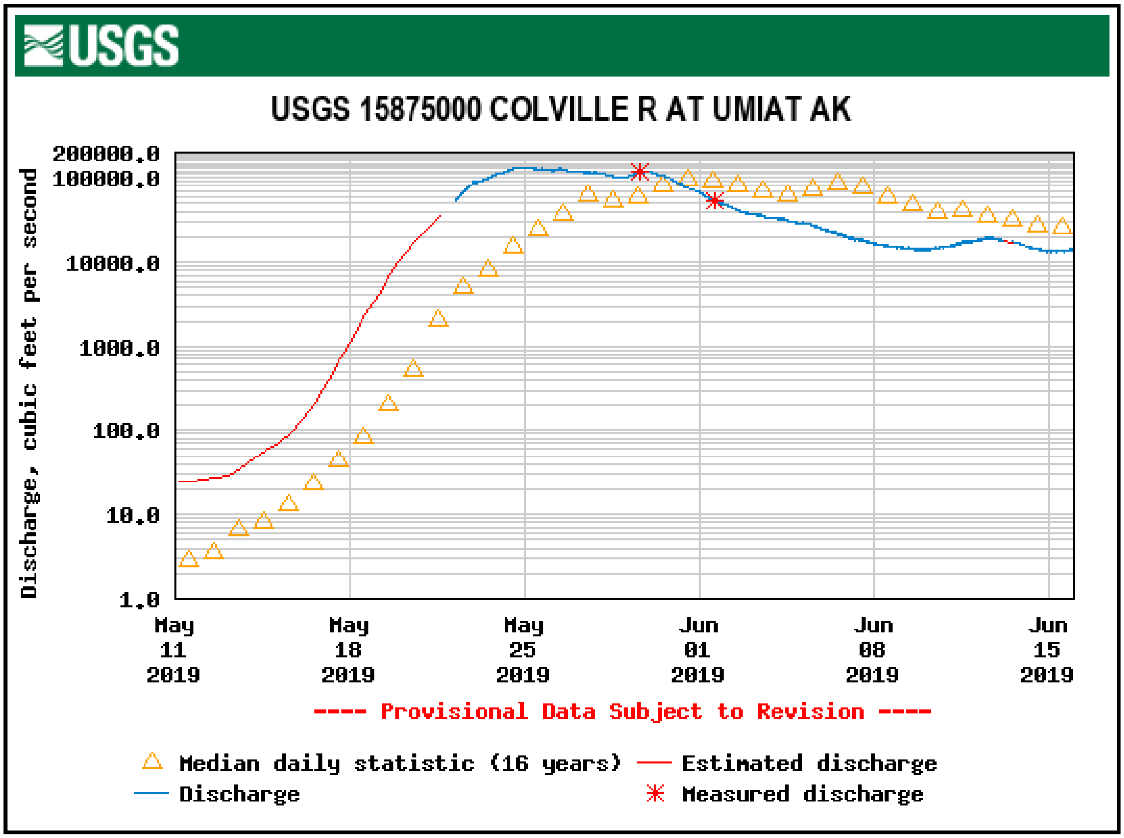
The USGS Umiat gage station 15875000 is located approximately 90 RM upstream of the CRD and is monitored throughout breakup to help predict the timing of floodwater and flood crests in the CRD. Umiat is upstream of the Chandler and Anaktuvuk River confluences and Umiat gage data does not account for the contribution from these two major tributaries. Because of local ice effects, distance, and streamflow additions between Umiat and the CRD, the magnitude of flooding at Umiat and in the CRD do not necessarily correlate.

The leading edge of floodwater in the Colville River reached Umiat on May 18, based on the initial gage height reporting date. Stage peaked on May 25 at 56.3 ft NAVD88. This is below the National Weather Service established flood stage of 59.0 ft NAVD88. A slightly lower crest of 55.6 ft NAVD88 was recorded on May 29, prior to stage falling for the season.

The peak discharge of 135,000 cfs occurred prior to peak stage, on May 24. Peak annual discharges at this location, with the exception of the lowest year of the 2002 to 2018 reporting period (2017), occur during spring breakup and are affected by snow and ice. These values range from 82,000 cfs in August 2017 to 268,000 cfs in May 2015. USGS stage and discharge data presented in Graph 4.1 and Graph 4.2, respectively, is provisional and subject to revision.



Graph 4.1: Colville River at Umiat Stage (USGS 2019)



Graph 4.2: Colville River at Umiat Discharge (USGS 2019)

HEAD OF THE DELTA

MON1 is located at the head of the Colville River Delta, where all flow is confined to a single channel. Stage and discharge have been monitored at MON1 annually since 1992 and periodically since 1962. This location has the longest historical record of all CRD monitoring locations.

Channel ice remained intact through the MON1 reach (Photo 4.1) until peak discharge and peak stage occurred on May 24. Peak conditions at MON1 occurred when an ice jam (Photo 4.2) and associated backwater released from upstream and progressed through the MON1 reach (Photo 4.3 and Photo 4.4). During peak conditions, floodwater was contained within the banks. The estimated peak discharge was assigned a fair quality rating (Table 2.1) because of the ice influences.

Discharge was not measured at MON1 in 2019 because of helicopter mechanical issues and subsistence hunting activity in the area during peak conditions. Stage and discharge results at MON1 are presented in Graph 4.3. Site specific discharge data and plan and profile drawings are provided in Appendix C.

Photo 4.1: Intact channel ice through MON1 reach just prior to release, looking southwest (upstream); May 24, 2019

Photo 4.2: Ice jam upstream of horseshoe bends upstream of MON1, looking southwest (upstream); May 22, 2019

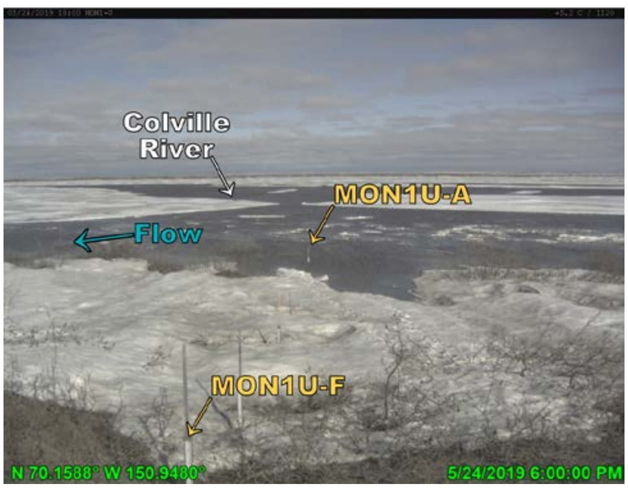


Photo 4.3: Ice jam release through the MON1 reach the day of peak stage, at MON1U looking east; May 24, 2019

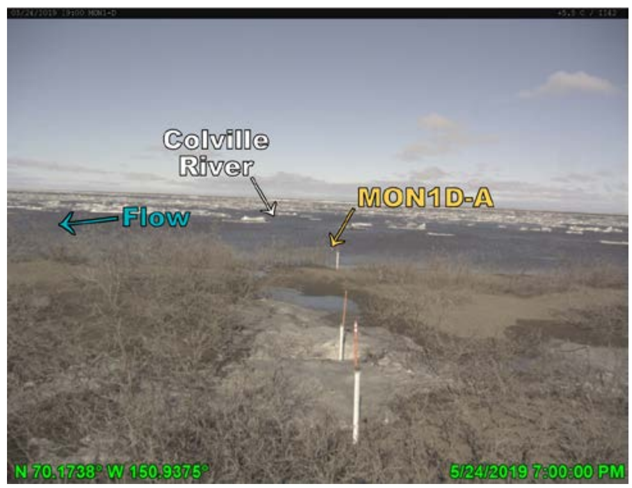
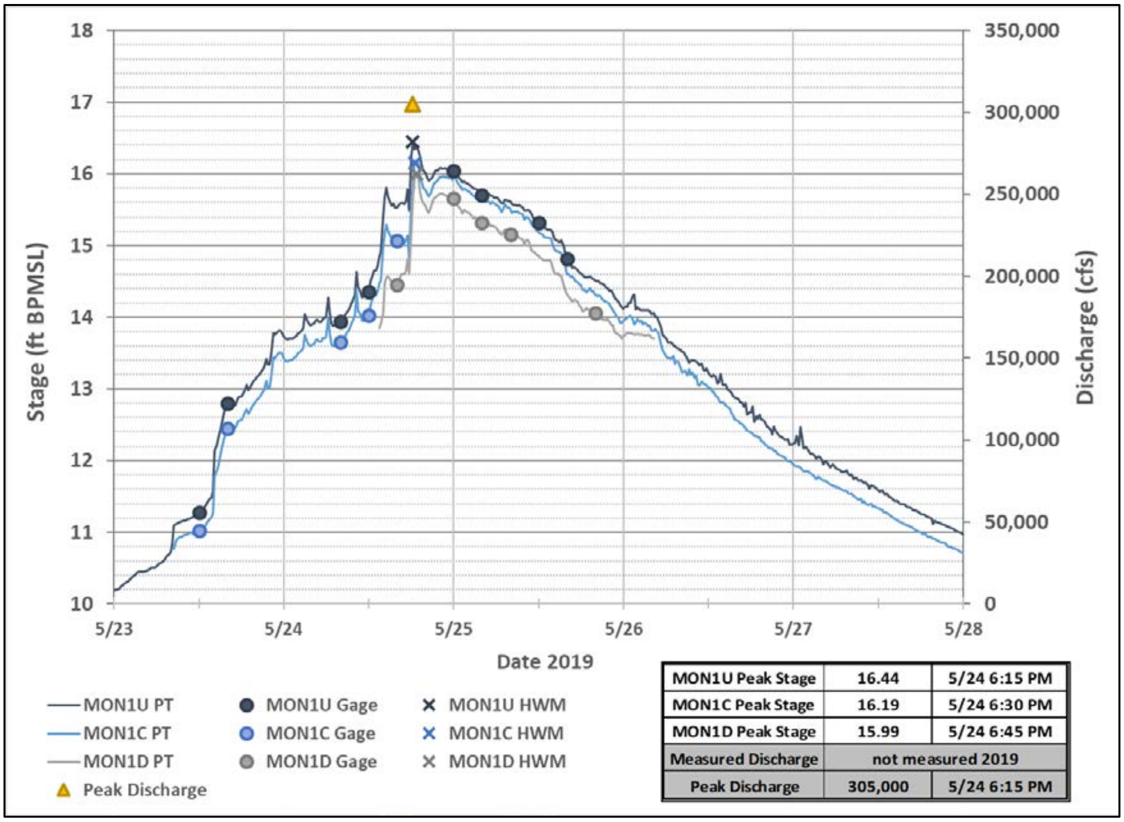


Photo 4.4: Ice jam release through the MON1 reach the day of peak stage, at MON1D looking east; May 24, 2019



Graph 4.3: Colville River at the Head of the Delta Stage & Discharge

4.2 Colville River East Channel

MON9 is located at the Colville HDD pipeline crossing. It has been monitored annually since 2005. Data is collected to estimate the distribution of discharge between the East Channel and Nigliq Channel and to monitor stage and ice affects at the HDD pipeline crossing. MON35 is located at the Helmericks Homestead. It has been monitored since 1999 for stage at the outer extents of the CRD.

Channel ice remained intact in the East Channel until May 25 (Photo 4.5). Peak discharge and peak stage at MON9 and MON9D were the result of an upstream ice jam and associated backwater releasing on May 25 and progressing through the MON9 reach. During peak discharge, large ice floes were observed flowing through the reach via remote field camera images (Photo 4.6). The estimated discharge was assigned a fair quality rating (Table 2.1) due to these influences. Site specific discharge data and plan and profile drawings are provided in Appendix C. Large rafted floes were stranded on the bank at MON9D after the ice jam release through the reach (Photo 4.7).

All stage observations at MON35 were manually recorded by Jim Helmericks. The leading edge of flow in the East Channel passed Helmericks and reached Harrison Bay on May 21. Peak stage at MON35 occurred on May 26 at which time channel ice was still intact. The channel ice began to break up by May 27 (Photo 4.8) and the majority of the ice cleared the MON35 reach on May 28, after which the entire East Channel was open water.

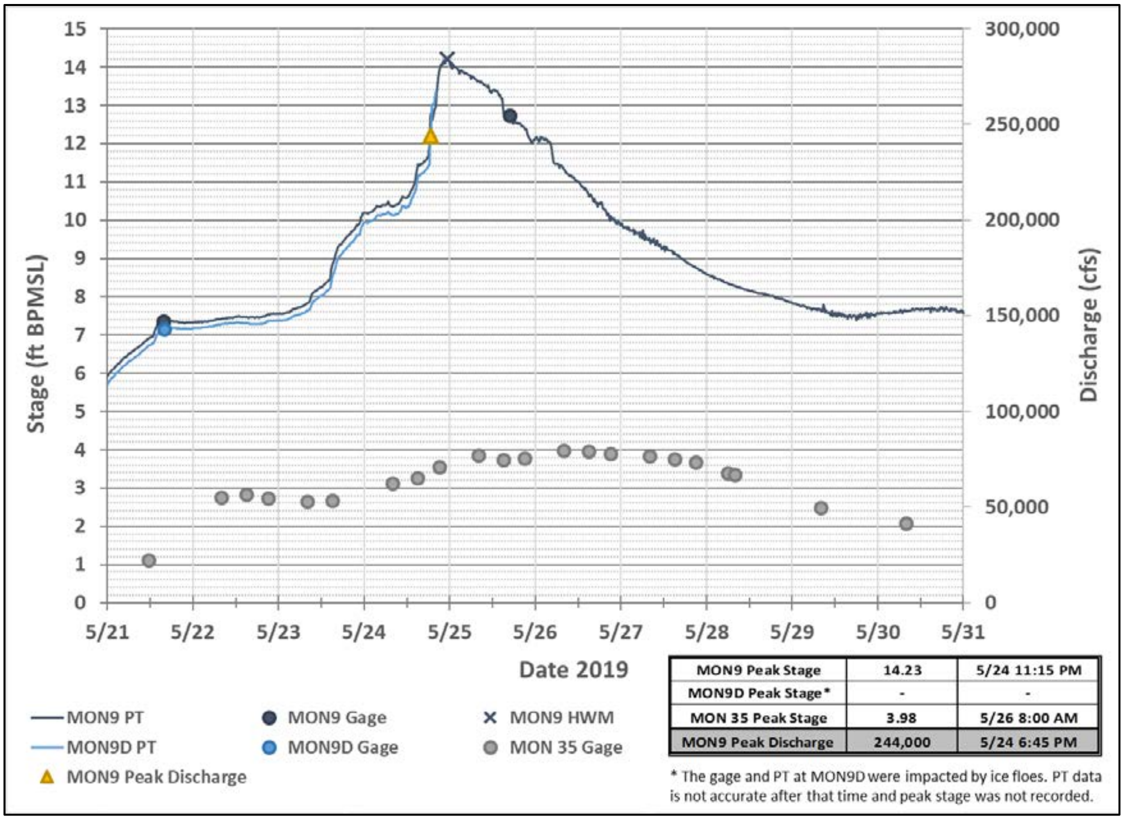
Stage and discharge at MON9 and MON9D and stage at MON35 are presented in Graph 4.4.

Photo 4.5: Intact channel ice in the East Channel just prior to upstream ice jam release, looking northwest (downstream); May 24, 2019

Photo 4.6: Ice jam release moving through MON9 reach and influencing peak discharge, looking east; May 24 2018

Photo 4.7: Rafted ice floes post ice jam release stranded on the bank at MON9D; May 25, 2019

Photo 4.8: Break up of channel ice at MON35/Helmericks Homestead; May 27, 2019



Graph 4.4: Colville River East Channel Stage & Discharge

4.3 Nigliq Channel

MON20, MON22, and MON23 have been monitored intermittently since 1998 and MON28 has been monitored since 1999. Four additional gage stations, G29, G28, G27, and G26, provide site specific data upstream and downstream of the Nigliq Bridge and are discussed in Section 4.4, Nigliq Bridge. Discharge in the Nigliq Channel is measured and calculated at the bridge.

The leading edge of upstream meltwater had progressed past all Nigliq Channel monitoring locations (Photo 4.9) to the coast by May 21. At that time, flow had entered Nanuq Lake but had not yet approached the CD2 road swale bridges. Nigliq Channel ice remained intact as stage rose on May 22 (Photo 4.10). Stage peaked progressively downstream at Nigliq Channel monitoring sites on May 25 and 26. This was influenced by ice jams progressing downstream, forming and flushing out channel ice previously intact at the downstream end of ice jams upon release. By May 26, much of the Nigliq Channel was ice-free open water (Photo 4.11 at MON20). Some floes remained in the vicinity of MON22 (Photo 4.12) and MON23 (Photo 4.13) and channel ice was intact downstream of MON23 to the coast at MON28 (Photo 4.14). Peak conditions at MON28 coincided with the presence of intact channel ice.

Stage at MON20, MON22, MON23, and MON28 is presented in Graph 4.5.

Photo 4.9: Leading edge past MON20 with channel ice, looking southwest (upstream); May 21, 2019

Photo 4.10: Channel ice in the Nigliq Channel at MON22 and hydraulic connection with Nanuq Lake, looking northwest (downstream); May 22, 2019

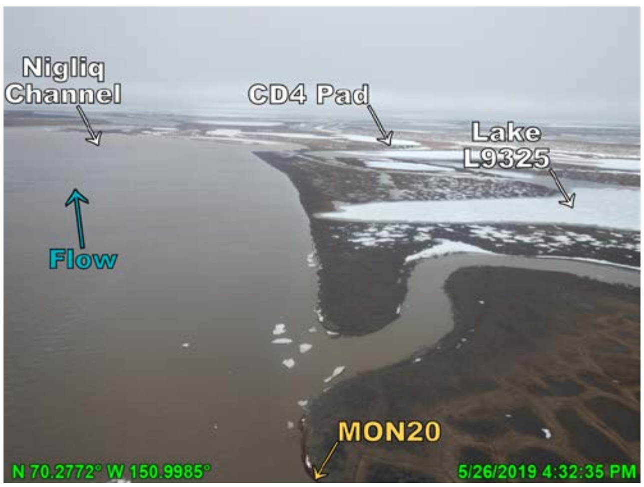
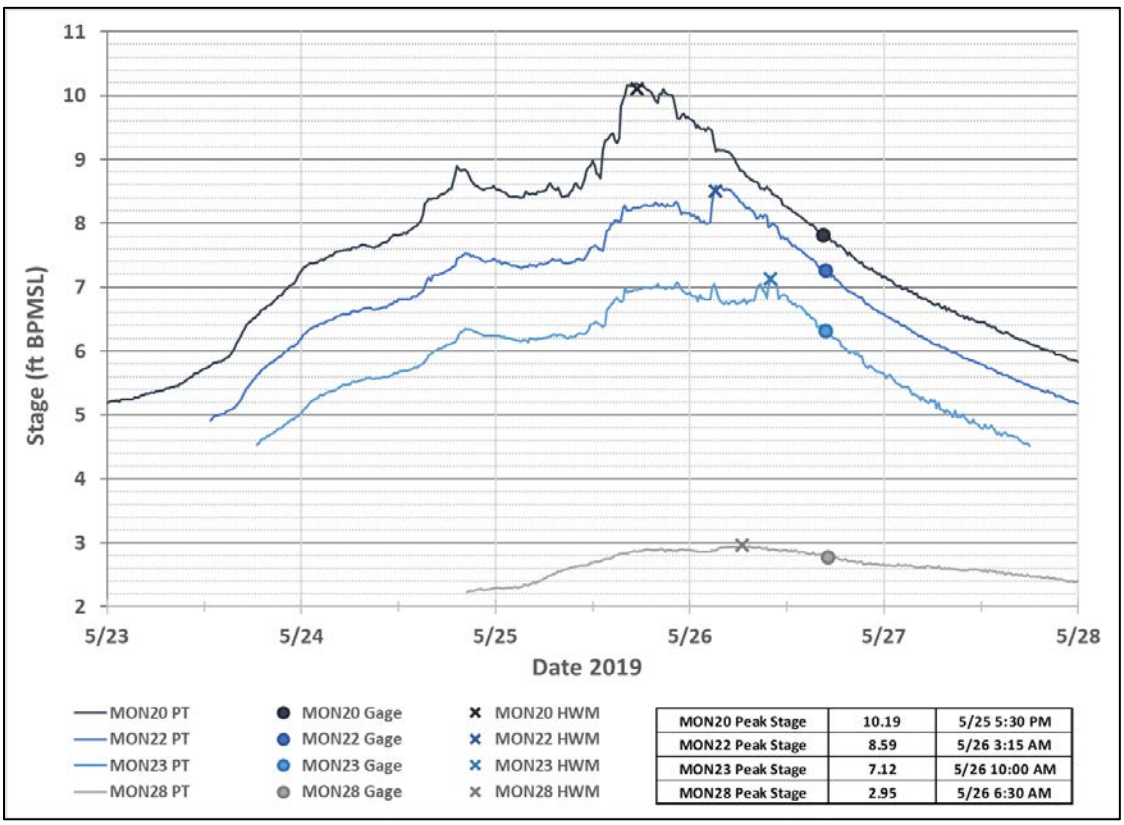


Photo 4.11: Open channel at MON20 the day after peak stage, looking north (downstream); May 26, 2019

Photo 4.12: Post-peak remnant floes at MON22 soon after peak, looking northwest (downstream); May 26, 2019

Photo 4.13: Post-peak remnant floes at MON23 soon after peak, looking northwest (downstream); May 26, 2019

Photo 4.14: Channel ice presence in the Nigliq at MON28, looking northwest (downstream); May 26, 2019



Graph 4.5: Nigliq Channel Stage

4.4 Alpine Facilities

Conditions in active channels surrounding Alpine facilities, including the Sakoonang, Tamayayak, and Ulamnigiaq channels to the east/northeast and the Nigliq Channel to the west, dictate the progression of the floodwater around facilities. Floodwaters in the Nigliq and Sakoonang channels typically overtop the banks and facilitate the annual recharge of many lakes and paleochannels through overbank inundation. The extent of inundation is dependent on topography, vegetation, WSEs, and local ice and ice jam influences. Lakes L9312 and L9313 (G9 and G10 monitoring stations) were recharged above bankfull levels, and recorded spring peak stage of 8.09 ft and 8.72 ft-BPMSL, respectively. Further information on drinking water lake recharge at Alpine facilities is found in Section 8.4.

Drainage structures are kept free of ice, snow accumulation, and blockages through regular maintenance by CPAI. Plywood covers are installed at the culvert inlets and outlets during the winter and removed prior to breakup. Snow is also mechanically removed from the immediate upstream and downstream areas of all culverts and the CD2 swale bridges prior to breakup flooding. Snow was cleared from the entrances and exits of CD2 swale bridges prior to the arrival of floodwater, though drifted snow remained immediately beneath the swale bridges at the onset of breakup flow (Photo 4.15 and Photo 4.16).

Culverts were monitored to assess flow conditions and culvert performance. All culvert covers were removed prior to the arrival of floodwater. Snow and ice were cleared at all culvert inlets prior to breakup. Limited flow restrictions were observed related to piles of removed snow and ice in and around culvert ends. Culvert locations and proximity to gages are shown in Appendix A. Detailed culvert discharge measurements, calculations, and performance summary field notes are provided in Appendix C.

Photo 4.15: Drifted snow upstream of the CD2 road short swale bridge, looking west; May 25, 2019

Photo 4.16: Drifted snow downstream of the CD2 short swale bridge, looking west; May 25, 2019

CD1 PAD & LAKES L9312 & L9313

Gage station G1 is situated along the east end of the CD1 pad to monitor stage in the adjacent Sakoonang Channel. Spring breakup stage data and observations have been collected at gage G1 since 2000. Peak stage at G1 occurred under the influence of ice in the channel (Photo 4.17), which remained within its banks in the vicinity of the CD1 pad. Stage at gage G1 is presented in Graph 4.6.

Recharge at drinking water source Lake L9312 (gage G9) and Lake L9313 (gage G10) has been monitored annually since 1998. Overbank flooding from the Sakoonang Channel is the primary recharge mechanism for both lakes. Snowmelt from within each drainage basin, however, also contributes to recharge. Lake L9313 recharged from overbank flow this spring (Photo 4.18). Overbank flow did not recharge Lake L9312 this year (Photo 4.19), however PT data indicates that this lake did recharge above the bankfull elevation from snowmelt. Stage at gage G9 (L9313) and gage G10 (L9313) is presented in Graph 4.7.

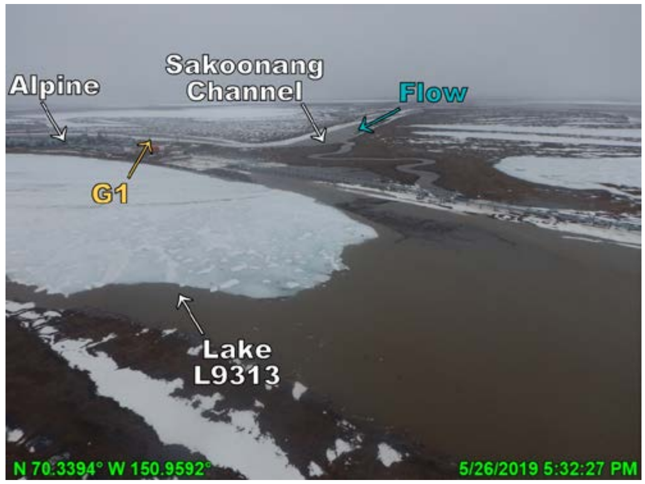
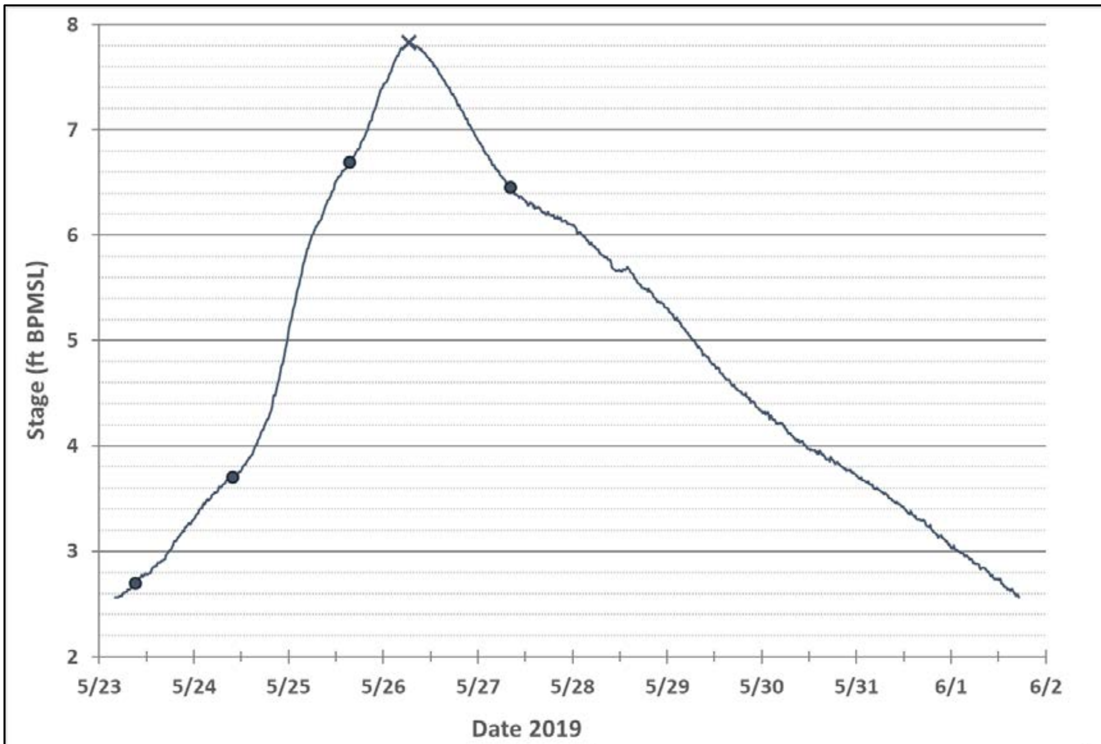


Photo 4.17: Peak stage at G1 under the influence of channel ice in the Sakoonang, looking east; May 26, 2019

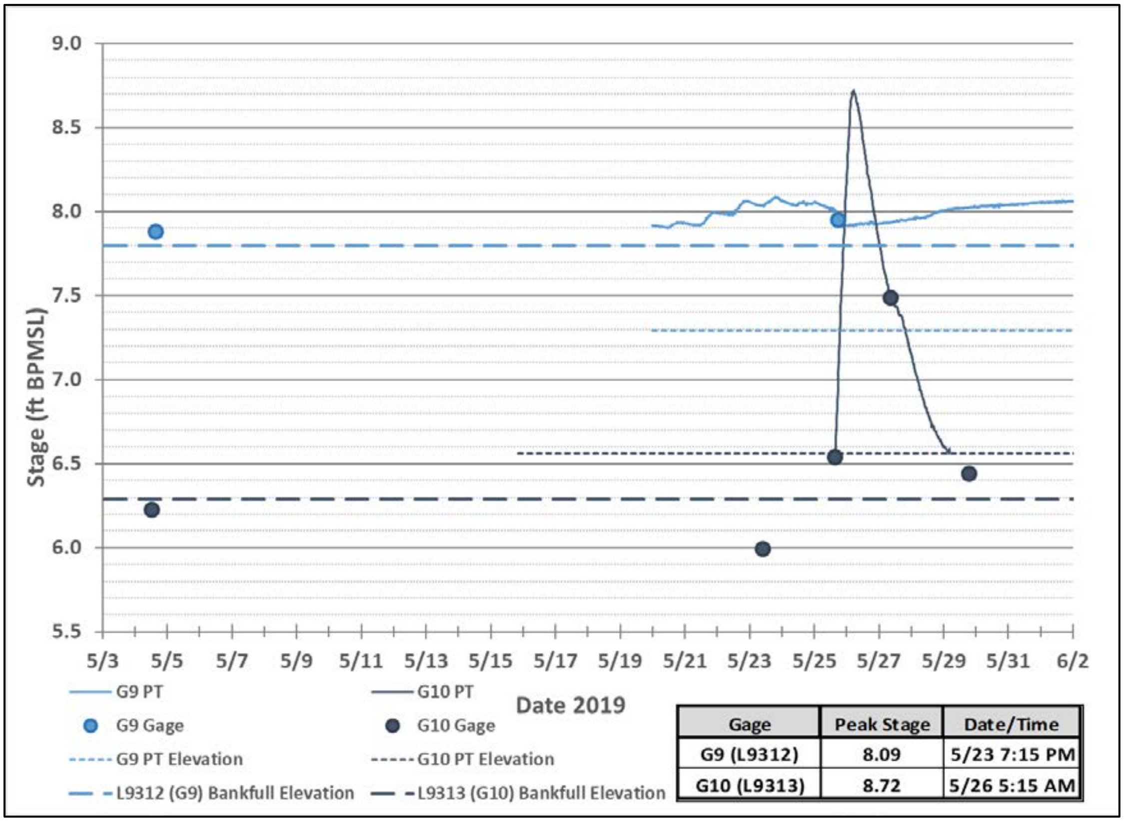


G1 Peak Stage	7.83	5/26 6:30 AM

Graph 4.6: CD1 Pad (Gage G1) Stage

Photo 4.18: Lake L9313 being recharged from overland flow, looking east; May 26 2019

Photo 4.19: Lake L9312 (in background) hydraulically isolated from major water bodies; May 26, 2019



Gage	Peak Stage	Date/Time
G9 (L9312)	8.09	5/23 7:15 PM
G10 (L9313)	8.72	5/26 5:15 AM

Graph 4.7: Lakes L9312 (Gage G9) and L9313 (Gage G10) Stage

CD2 ROAD & PAD

Stage data and observations of breakup processes have been collected along the CD2 road and pad intermittently since 1998.

Floodwater along the CD2 road was only present around gages G3/G4. Monitoring locations G6/G7, G12/G13, and G8 were either dry or only had local melt. The long swale bridge, the short swale bridge, and four adjacent culverts conveyed flow from the Nigliq Channel (via Nanuq Lake then Lake M9524) across the CD2 road north toward lakes L9316 and M9933 (Photo 4.20). Peak stage occurred at G3 and G4 on May 25 and May 26. Discharge was measured at the long swale bridge and area culverts on May 25, within a few hours of peak; discharge was measured at the short swale bridge on May 26.

The measured average velocity at the long swale bridge on May 25 was 1.4 ft per second (fps) and the highest depth-averaged velocity within a single section was 2.8 fps. An excavator removed ice floes that had accumulated on the upstream side of the bridge prior to the discharge measurement (Photo 4.21). Additional floes accumulated during the measurement, producing small eddies that affected velocities at the bridge. Some drifted snow was present at the downstream side of the east abutment as well as at the upstream side of the west abutment. These factors influenced the rating of the quality of the measurement as "fair."

Photo 4.20: Flood extents along the CD2 road during peak stage conditions, looking north (downstream); May 26, 2019

The measured average velocity through the short swale bridge on May 26 was 0.70 fps and the highest depth-averaged velocity within a single section was 0.99 fps. Flow had cleared the snow through the majority of the bridge opening at the time of the measurement, though some remained at the downstream side of the west abutment (Photo 4.22). This factor influenced the rating of the quality of the measurement as "good."

Photo 4.21: Excavator removing accumulated ice floes from the long swale bridge prior to discharge measurement, looking east; May 25, 2019

Photo 4.22: Limited snow on the downstream side of the short swale bridge affecting flow during discharge measurement, looking southwest (upstream); May 26, 2019

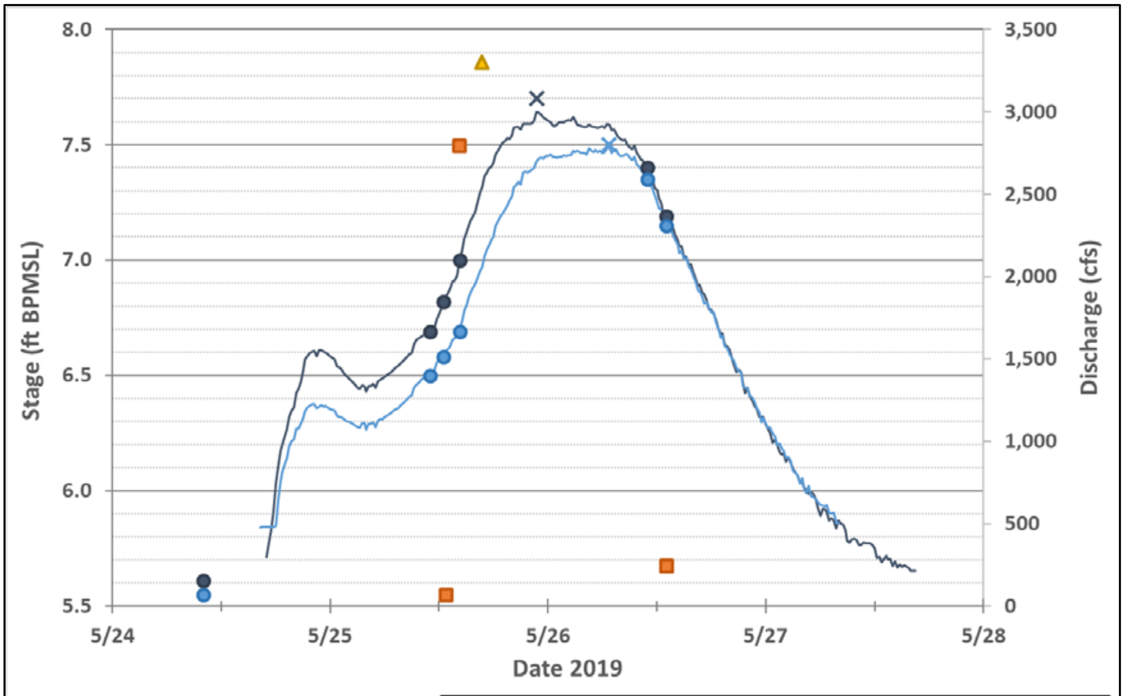
All culverts along the CD2 road in the presence of floodwater performed as designed (Photo 4.23 and Photo 4.24). Peak discharge through area drainage structures occurred on May 25 during peak stage differential across the CD2 road as measured at gages G3 and G4. This is consistent with the conditions under which peak discharge typically occurs. Peak discharge at the CD2 road bridges and culverts was calculated using the measured velocity and adjusting the hydraulic depth for peak conditions.

Photo 4.23: Culvert CD2-24 passing flow as designed, south (upstream) end, looking east; May 25, 2019

Photo 4.24: Culvert CD2-24 passing flow as designed, north (downstream) end, looking north; May 25, 2019

Stage and total discharge at CD2 bridges and culverts are provided in Graph 4.8. Measured discharge and peak discharge at culverts conveying flow is summarized in Table 4.2 and

Table 4.3, respectively. Historical measured and peak discharge at the long and short swale bridges are summarized in Section 8.0. A summary of the CD2 road swale bridge discharge measurement is presented in Appendix C.



G3 Peak Stage	7.64	5/25 10:45 PM
G4 Peak Stage	7.49	5/26 6:45 AM
G3/G4 Bridges + Culverts Measured Discharge	3,108	5/25 and 5/26 (various times)
G3/G4 Bridges + Culverts Peak Discharge	3,300	5/25 4:45 PM

Graph 4.8: CD2 Road Bridges and Culverts (Gages G3 & G4) Stage & Discharge

Table 4.2: CD2 Road Culverts (Gages G3 & G4) Measured Discharge

Culvert	Measurement Date & Time	Total Depth of Flow (ft)	Measurement Depth [1] (ft)	Flow Depth[2]	Measured Velocity (ft/s)	Calculated Discharge[3] (cfs)	Total Discharge (cfs)
CD2-21	5/25 12:33 PM	1.4	0.6	Less than Half Full	2.2	8.8	69
CD2-22	5/25 12:41 PM	1.7	0.7	Less than Half Full	3.0	15.1	
CD2-23	5/25 12:52 PM	2.0	0.8	More than Half Full	3.6	22.3	
CD2-24	5/25 12:59 PM	2.2	0.9	More than Half Full	3.3	23.1	

Notes:
1. Measurement taken at 0.6 of total depth of flow.
2. Culverts are 48 inches in diameter.
3. Negative values indicate flow moving north to south through culvert.

Table 4.3: CD2 Road Culverts (Gages G3 & G4) Peak Discharge

Culvert	Calculated Date & Time	WSE Differential (ft)[1]	Total Depth of Flow (ft)	Flow Depth[2]	Calculated Velocity (ft/s)	Calculated Discharge (cfs)	Total Discharge (cfs)
CD2-21	5/25 4:45 PM	0.35	1.8	Less than Half Full	3.0	16	91
CD2-22	5/25 4:45 PM		1.8	Less than Half Full	3.3	18	
CD2-23	5/25 4:45 PM		2.5	More than Half Full	3.4	27	
CD2-24	5/25 4:45 PM		2.7	More than Half Full	3.3	30	

Notes:
1. Calculated during peak stage differential between G3 (upstream) and G4 (downstream).
2. Culverts are 48 inches in diameter.

CD3 PAD & PIPELINE

Stage data and observations of breakup processes have been collected at the CD3 pad and along the pipeline intermittently since 2000.

Gage G11 at the CD3 pad remained dry throughout breakup. Peak stage in the Sakoonang Channel (CD3 Pipe Bridge #1) occurred under the influence of intact channel ice (Photo 4.25). Peak stage in the Tamayayak Channel (CD3 Pipe Bridge #2) occurred during the presence of channel ice broken into floes (Photo 4.26). Peak stage in the Ulamnigiaq Channel (CD3 Pipe Bridge #3) occurred during open channel conditions in the vicinity (Photo 4.27). Open channel conditions at all CD3 pipeline crossing locations were observed by June 4. Stage at the Sakoonang, Tamayayak, and Ulamnigiaq gages is presented in Graph 4.9.

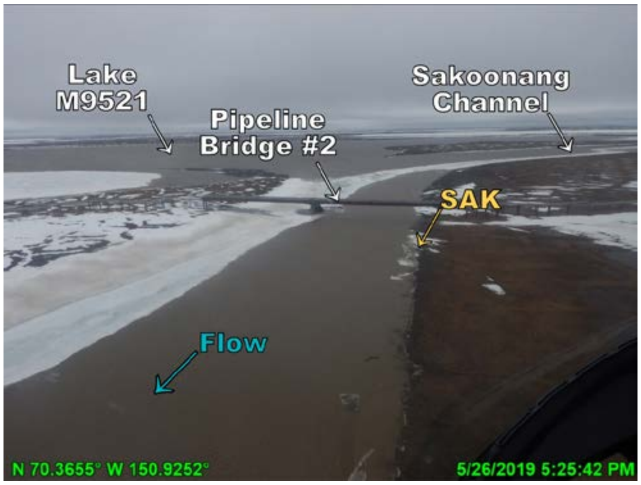


Photo 4.25: Sakoonang Channel the day of peak stage at SAK, looking east (upstream); May 26, 2019

Photo 4.26: Tamayayak Channel the day prior to peak stage at TAM, looking west (downstream); May 26, 2019

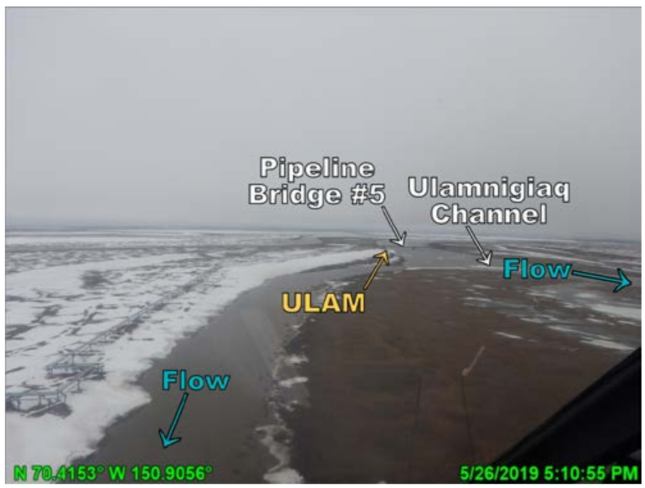
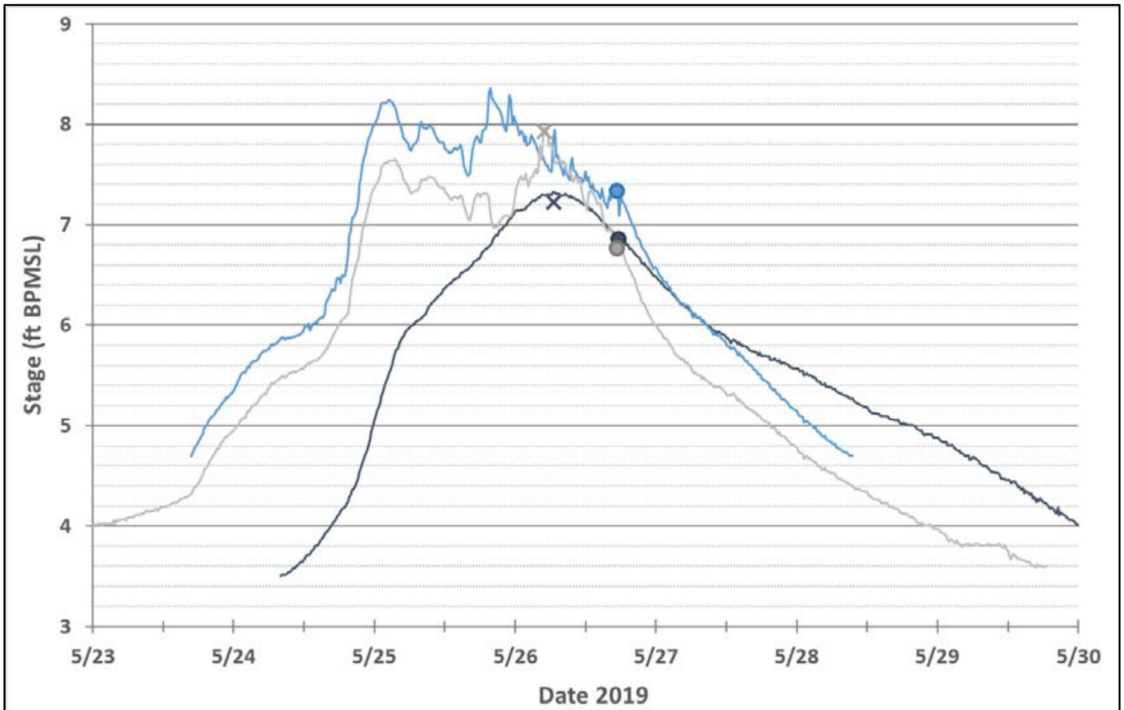


Photo 4.27: Ulamnigiaq Channel the day of peak stage at ULAM, looking east (upstream); May 26, 2019



TAM Peak Stage	8.36	5/25 7:45 PM
ULAM Peak Stage	7.97	5/26 5:00 AM
SAK Peak Stage	7.33	5/26 6:30 AM

Graph 4.9: CD3 Pipelines Stage

CD4 ROAD & PAD

Stage data and observations of breakup processes have been collected at the CD4 road and pad intermittently since 2005.

Initial melt was observed at road gages G15/G16 on March 26 (Photo 4.28 and Photo 4.29). The PT stage indicates that connectivity through the road culverts at the G15/G16 gages. These drainage structures, however, were not accessible because of ice and snow blockages. Discharge was not measured, and peak discharge was not calculated for culverts at this location.

Initial melt was observed at road gages G17 and G18 on May 25. Stage increased sufficiently to cause a brief hydraulic connection through the culverts on this day which was, based on the lack of evidence of overland flooding in the area (Photo 4.30), attributed to local melt. Discharge was measured at culverts CD4-25, 26, 27, and 28 on May 25 (Photo 4.31), which performed as designed to equalize flow across the CD4 road. Peak discharge was calculated for these culverts. The timing of peak discharge, however, nearly coincides with the measured discharge, suggesting that the peak value is too high. This is likely influenced by ice and snow inside the culverts and variation in the culvert invert elevations since the date of last survey (UMIAQ 2017).

Road gages G40, G41, G42, and G43 remained dry throughout monitoring.

At the CD4 pad, gage G19 remained dry. No PT was installed on the G20 gage and no HWM was observed. Peak stage timing at G20, however is estimated to have coincided between the MON20 and G28 peaks, based on proximity of those sites in the Nigliq Channel.

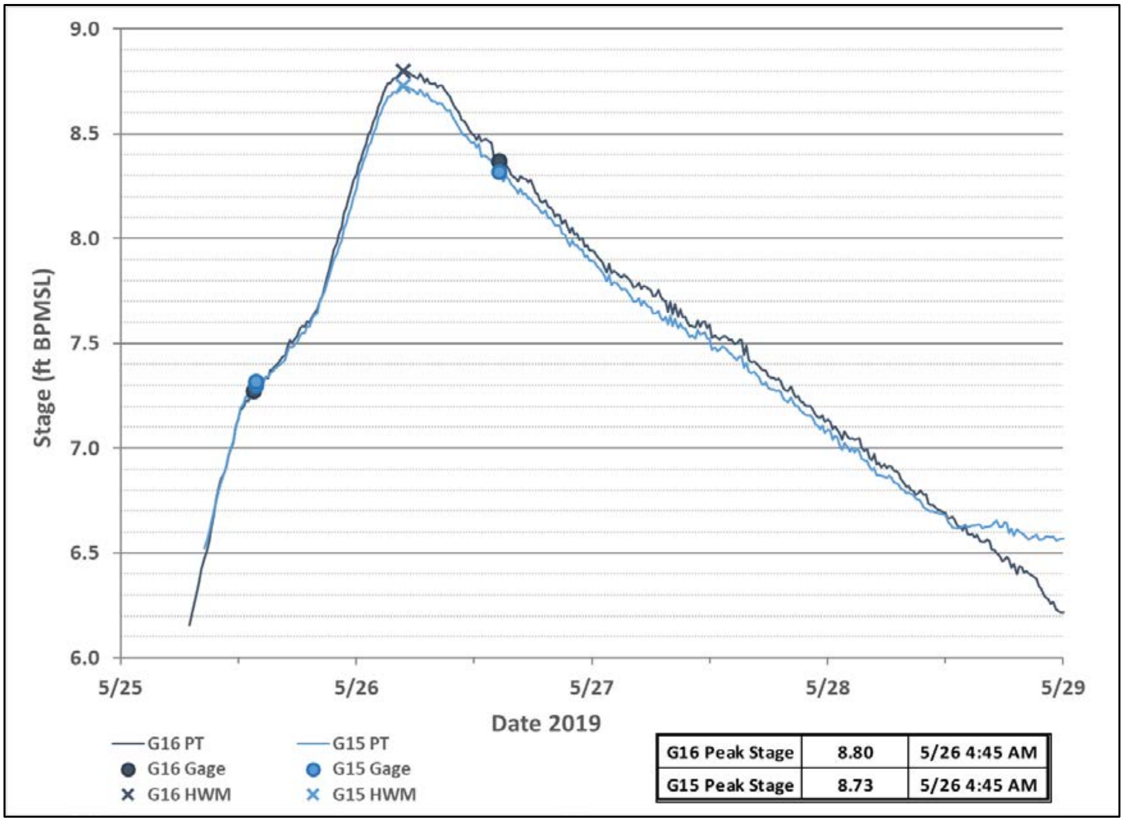
Stage and discharge, as applicable, at CD4 road gages G15/G16, G17/G18, and CD4 pad gages G19/G20 are provided in Graph 4.10, Graph 4.11, and Graph 4.12. Measured and peak discharge at G17/G18 culverts conveying flow is summarized in Table 4.4 and Table 4.5. Additional culvert discharge data is provided in Appendix C.

Photo 4.28: Peak stage at gage G16, looking north; May 26, 2019

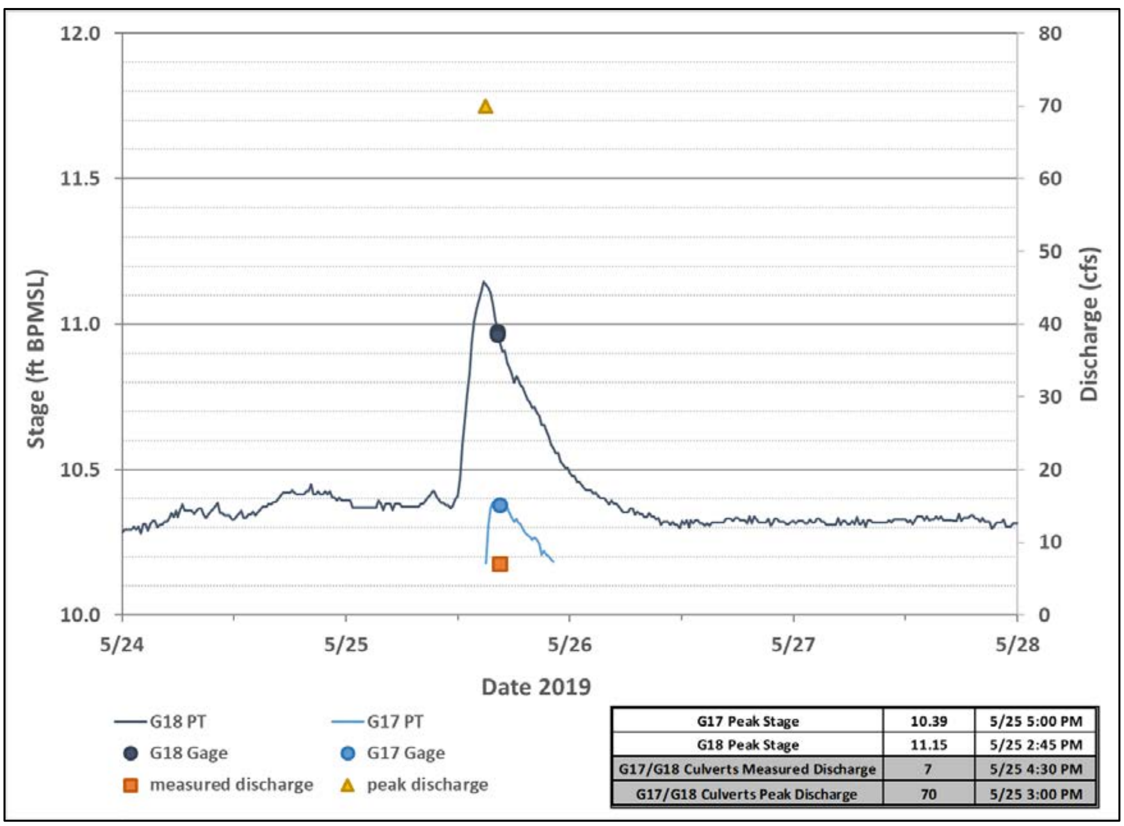
Photo 4.29: Peak stage at gage G15, looking north; May 26, 2019

Photo 4.30: Lack of evidence of overland flooding at CD4 road near gages G17/G18, looking north; May 26, 2019

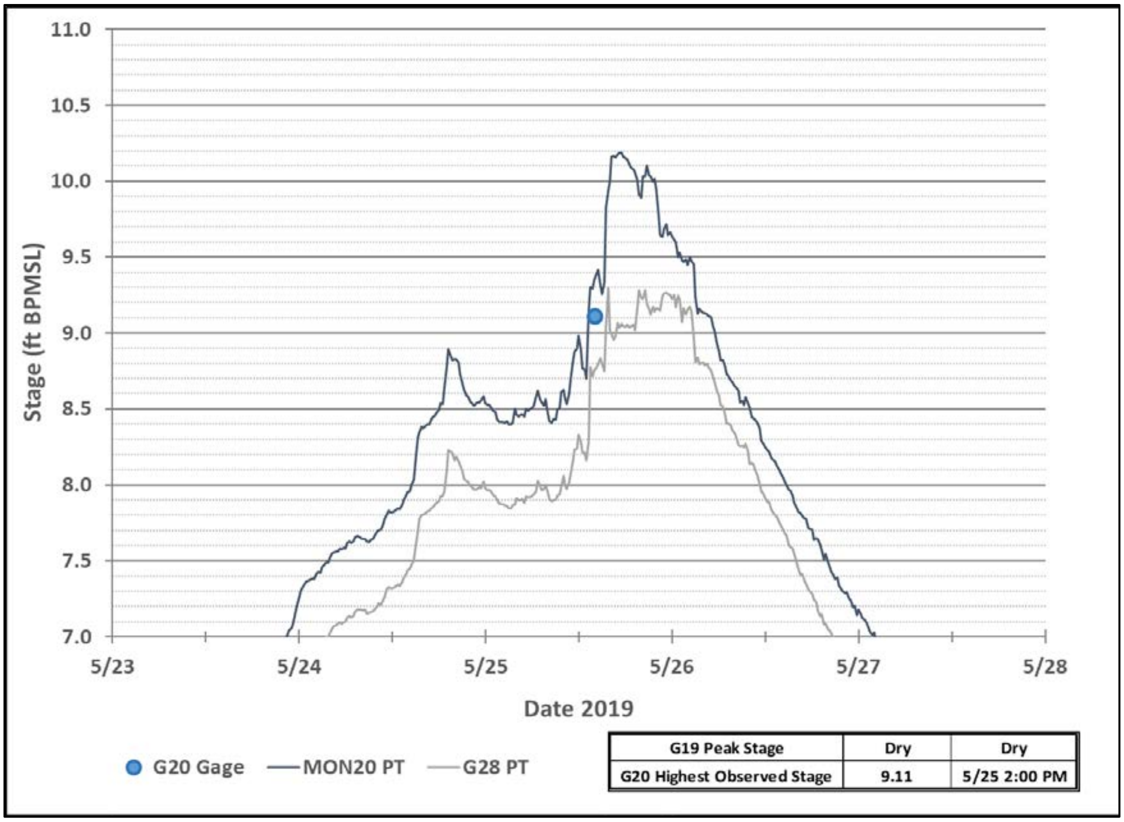
Photo 4.31: Local melt at CD4 road culverts near gages G17/G18; May 25, 2019



Graph 4.10: CD4 Road Culverts (Gages G15 & G16) Stage



Graph 4.11: CD4 Road Culverts (Gages G17 & G18) Stage & Discharge



Graph 4.12: CD4 Pad (Gages G19 & G20) Stage

Table 4.4: CD4 Road Culverts (Gages G17 & G18) Measured Discharge

Culvert	Measurement Date & Time	Total Depth of Flow (ft)	Measurement Depth[1] (ft)	Flow Depth[2]	Measured Velocity (ft/s)	Calculated Discharge[3] (cfs)	Total Discharge (cfs)
CD4-26	5/25 4:31 PM	0.5	0.2	Less than Half Full	1.6	1.4	6.9
CD4-27	5/25 4:28 PM	0.9	0.4	Less than Half Full	1.6	3.5	
CD4-28	5/25 4:21 PM	0.6	0.2	Less than Half Full	1.7	2.0	

Notes:
1. Measurement taken at 0.6 of total depth of flow.
2. Culverts are 48 inches in diameter.
3. Negative values indicate flow moving north to south through culvert.

Table 4.5: CD4 Road Culverts (Gages G17 & G18) Peak Discharge

Culvert	Calculated Date & Time	WSE Differential (ft)[1]	Total Depth of Flow (ft)	Flow Depth[2]	Calculated Velocity (ft/s)	Calculated Discharge (cfs)	Total Discharge (cfs)
CD4-26	5/25 3:00 PM	0.96	1.4	Less than Half Full	5.7	22	69
CD4-27	5/25 3:00 PM		1.5	Less than Half Full	5.9	24	
CD4-28	5/25 3:00 PM		1.4	Less than Half Full	5.7	22	

Notes:
1. Calculated during peak stage differential between G18 (upstream) and G17 (downstream).
2. Culverts are 48 inches in diameter.

CD5 ROAD

Stage data and observations of breakup processes have been collected along the CD5 road since 2009. The CRD floodwater remained within channels and no overbank flooding was observed along the CD5 road.

C. Lake L9323 Bridge

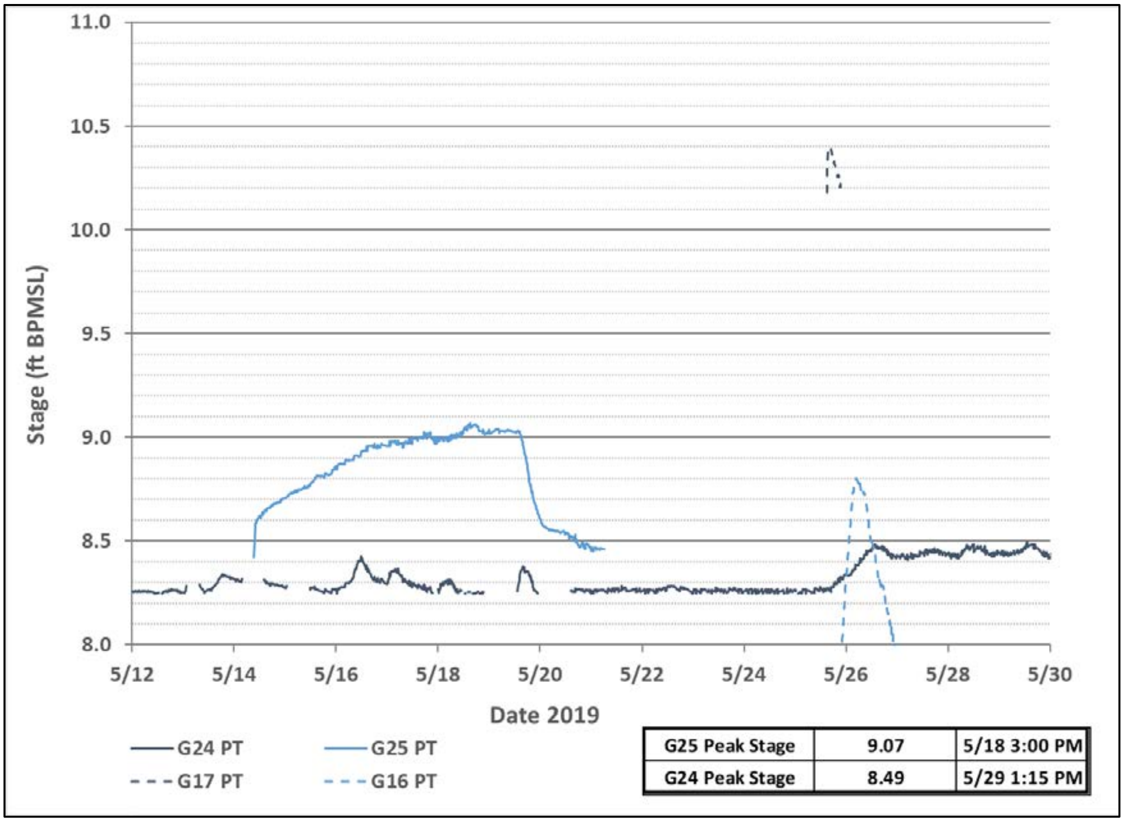
The CD5 Road Bridge #1 crosses a swale at the north/downstream end of the western lobe of Lake L9323. Lake L9323 can become hydraulically connected to the Nigliq Channel (via Tapped Lake and north of the Lake L9323 Bridge) and/or the Sakoonang Channel (via a low-lying area crossed by the Alpine Sales Pipeline and the CD4 road) during periods of high water. Lake L9323 also becomes hydraulically connected to adjacent water bodies through the CD4 road culverts at the northern/downstream and southern/upstream ends of the eastern lobe. Gage G24 is south/upstream and gage G25 is north/downstream of the bridge.

The Nigliq Channel did not hydraulically connect to Lake L9323 (Photo 4.32), therefore no flow was conveyed through the Lake L9323 Bridge. Aside from brief and limited connections of the eastern lobe of the lake to Lake M9525 through the CD4 road culverts, Lake L9323 recharge was limited to meltwater within the lake basin.

Stage at G25 peaked prior to G24. A hydraulic connection through the bridge was not observed or recorded in the PT data. Stage data suggests meltwater was locally isolated upstream and downstream of the bridge as well as between the western and eastern lobes of Lake L9323 throughout the spring breakup monitoring period.

Lake L9323 bridge stage data is provided in Graph 4.13. Stage data at G17 and G16, near the northern and southern ends, respectively, of the eastern lobe of the lake, are provided for reference. The graph shows stage above the PTs only; gaps in data indicate stage dropped below the PTs.

Photo 4.32: No hydraulic connection through Lake L9323 bridge during peak conditions at Alpine facilities, looking northeast (upstream); May 26, 2019



Graph 4.13: Lake L9323 Bridge (Gages G24 & G25) Stage

D. Nigliq Bridge

The leading edge of floodwater in the Nigliq Channel passed under the bridge on May 21. Channel ice remained intact through the reach (Photo 4.33) until cleared by the progression of ice jamming and release through the bridge on May 25 (Photo 4.34 and Photo 4.35). Stage through the reach peaked after the channel ice moved downstream (Photo 4.36), potentially the result of backwater created by jams further downstream. Some floes remained caught or grounded on the upstream side of the bridge on May 26 (Photo 4.37).

Discharge was measured on May 26 downstream of the Nigliq Bridge. At the time of the measurement, large pans were still situated upstream of the bridge but the channel, where the measurement was performed, was mostly clear of snow and ice and conditions were considered steady and uniform (Photo 4.38). The average velocity was 2.57 fps. The quality of the measurement was classified as good. Indirect discharge calculated at the time of direct measurement was 0.67 percent higher than the measured discharge.

Peak discharge occurred on the evening of May 25, after channel ice had cleared the bridge opening. Some floes remained and stage was likely influenced by backwater resulting from ice jamming downstream. Peak discharge was assigned a fair quality rating (Table 2.1) because of these influences.

Nigliq Bridge stage and discharge data is provided in Graph 4.13. A summary of the discharge measurement, peak discharge calculation methods, and plan and profile drawings are presented in Appendix C.

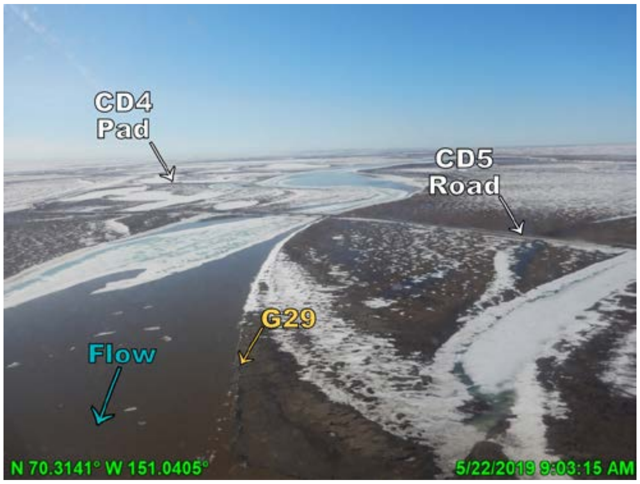


Photo 4.33: Channel ice at Nigliq Bridge, looking south (upstream); May 22, 2019

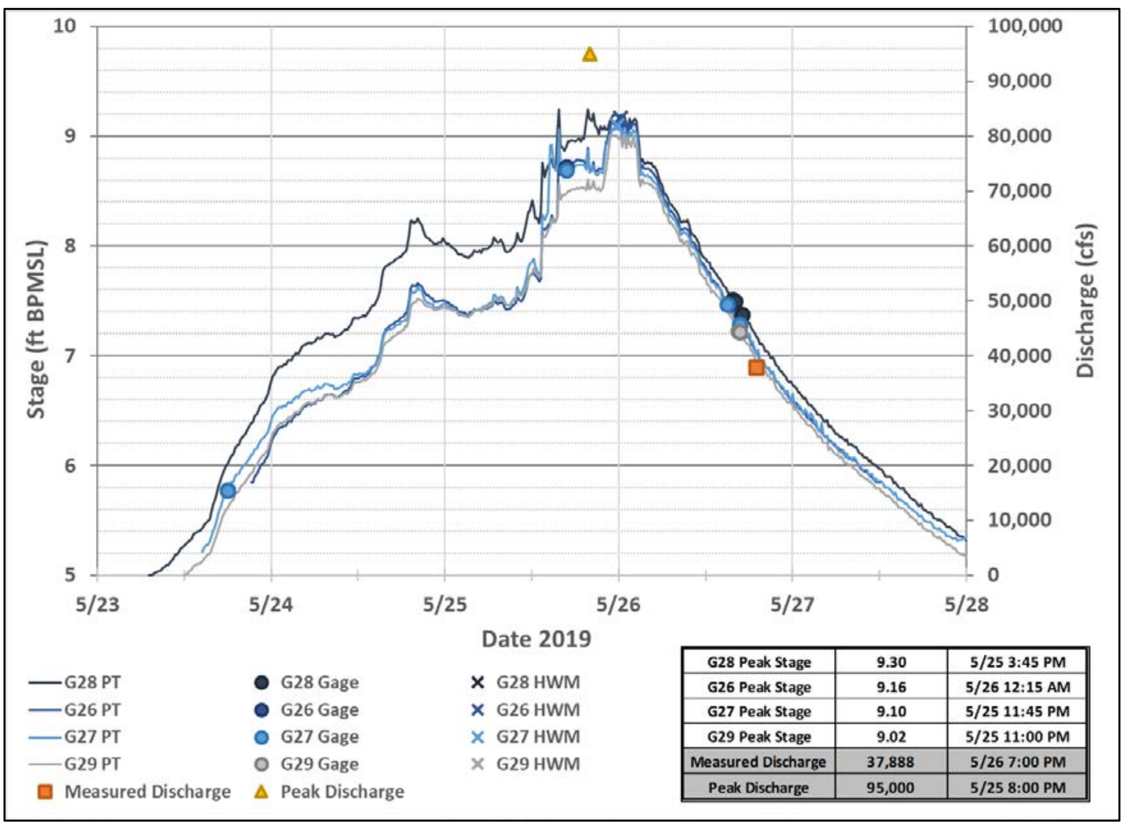
Photo 4.34: Channel ice intact at Nigliq Bridge at 7:30pm, looking east; May 25, 2019

Photo 4.35: Channel ice being broken and pushed downstream at 7:45pm by upstream ice jam release, looking east; May 25, 2019

Photo 4.36: Peak conditions at the Nigliq Bridge, looking east; May 26, 2019

Photo 4.37: Floes caught or grounded upstream of the Nigliq Bridge, looking north (downstream); May 26, 2019

Photo 4.38: Measuring discharge downstream from the Nigliq Bridge, looking south; May 26, 2019



Graph 4.14: Nigliq Bridge (Gages G26, G27, G28, and G29) Stage & Discharge

E. Lake L9341 Bridge

The CD5 Road Bridge #3 crosses Lake L9341, which is the downstream-most water body in a series of lakes formed through a paleochannel of the Nigliq Channel. This paleochannel can become an active channel during periods of high water. During lower stage breakup events, Lake L9341 only experiences backwater from the Nigliq Channel at its northern end. Gage G32 is south (upstream) and gage G33 is north (downstream) of the bridge.

Competent ice was present and visible throughout the paleochannel including at the Lake L9341 surface throughout breakup (Photo 4.39) including during peak conditions. Peak breakup stage at the Lake L9341 bridge was the result of backwater from the Nigliq Channel (Photo 4.40). Nigliq Channel water levels were not sufficient to enter the upstream end of the paleochannel; therefore, no flow was observed through the Lake L9341 bridge.

Lake L9341 Bridge stage data is provided in Graph 4.15.

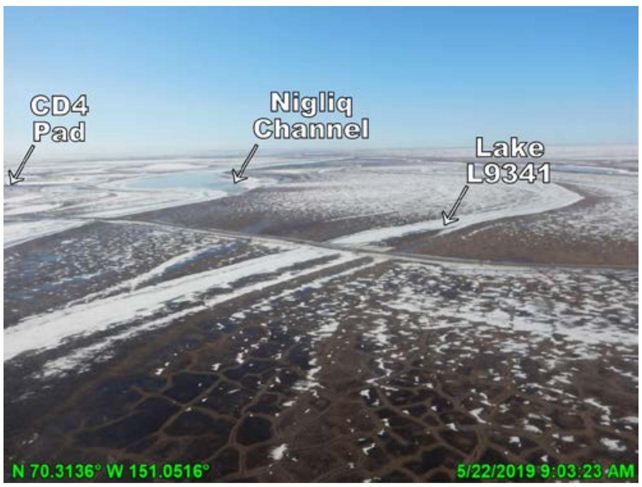
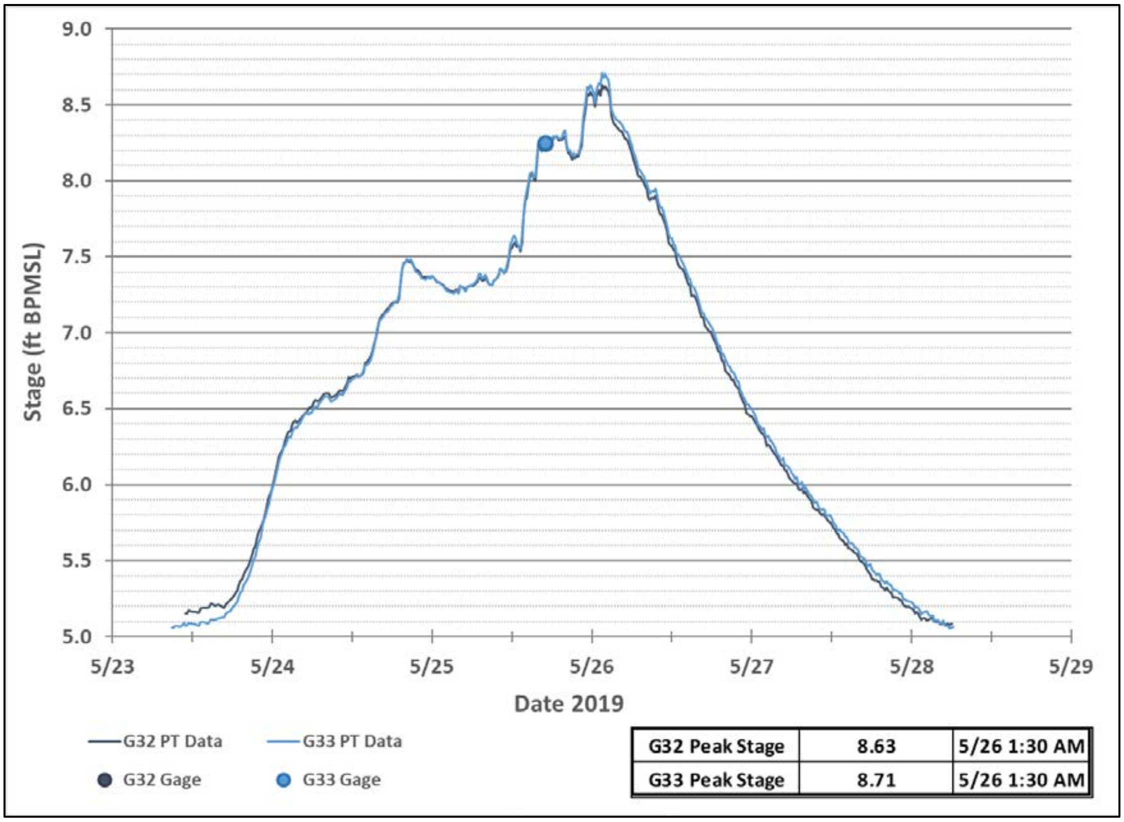


Photo 4.39: Competent ice in Lake L9341 as breakup initiates, looking south; May 22, 2019

Photo 4.40: Nigliq Channel backwater influence at the north end of Lake L9341 the day of peak stage, looking southeast (downstream); May 26, 2019



Graph 4.15: Lake L9341 Bridge (Gages G32 and G33) Stage

F. Nigliagvik Bridge

The CD5 Road Bridge #4 crosses the Nigliagvik Channel, which is an anabranch of the Nigliq Channel. The Nigliagvik Channel diverges from the Nigliq Channel approximately 4 RM upstream of the Nigliq bridge and 5.5 RM upstream of the Nigliagvik bridge; it converges with the Nigliq Channel approximately 2 RM downstream of each bridge. The Nigliagvik Channel is typically hydraulically connected throughout its length with the Nigliq Channel during the open water season. During spring breakup, backwater from the Nigliq Channel typically reaches the Nigliagvik Bridge prior to downstream flow from the south. The backwater flow typically meets downstream flow at some location along the channel. During the lowest spring flood events however, downstream flow has been observed not progressing far enough to integrate with backwater flow. Channel ice is typically present at the peak of lower spring flood events because flow is not enough to move floes downstream. Gage G38 is south (upstream) and gage G39 is north (downstream) of the bridge.

The PT at gage G39 malfunctioned and data recovered was inaccurate. Gage readings show that the water surface gradient under the bridge was negative, indicating backwater flow, in the period leading up to peak conditions. On May 26, the peak water surface elevations recorded at the G38 and G39 gage sites indicated a slight downstream gradient was established through the bridge though still largely influenced by backwater flow from the Nigliq Channel. By May 28, the gradient had increased, indicating upstream to downstream flow was well established.

Channel ice was present upstream of the bridge throughout breakup (Photo 4.41) including during peak conditions (Photo 4.42) and floes remained in the vicinity of the bridge after peak. This ice prevented measuring discharge during peak conditions. Peak discharge could not be calculated due to a lack of data from the equipment malfunction.

Nigliagvik Bridge stage data is provided in Graph 4.16. Plan and profile drawings at the Nigliagvik Bridge are presented in Appendix C.

Photo 4.41: Conditions in the Nigliagvik Channel, looking southwest (upstream); May 22, 2019

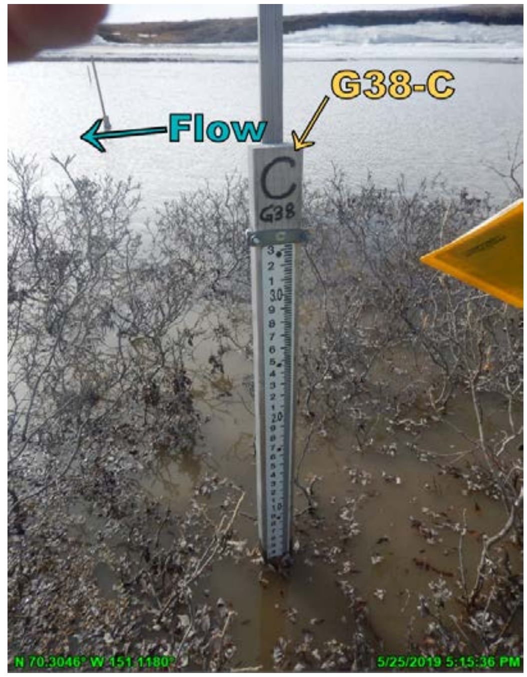
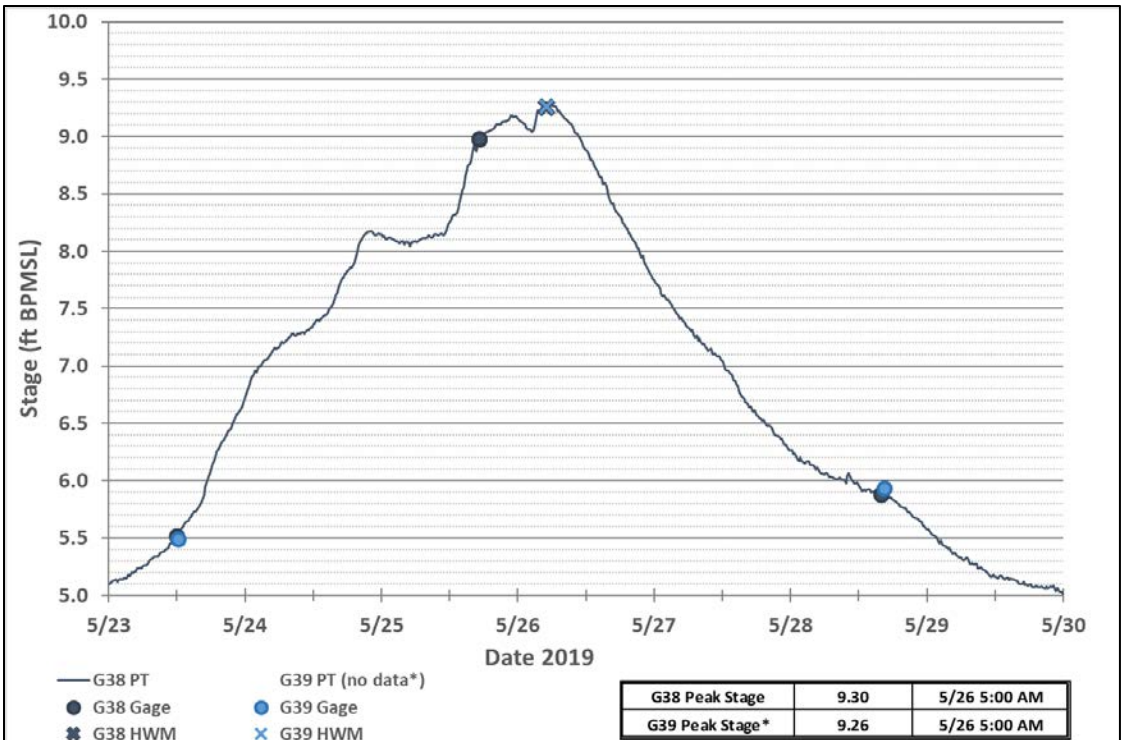


Photo 4.42: Nigliagvik Channel one day prior to peak stage, looking west; May 25, 2019



G38 Peak Stage	9.30	5/26 5:00 AM
G39 Peak Stage*	9.26	5/26 5:00 AM

* The G39 PT malfunctioned during the 2019 monitoring period. That data is not presented due to inaccuracies. Peak stage presented is a HWM. Timing is estimated to coincide with peak stage at G38.

Graph 4.16: Nigliagvik Bridge (Gages G38 & G39) Stage

G. Culverts

The CD5 culverts east of the Nigliagvik Channel convey overbank floodwater from the Nigliq and Nigliagvik Channels during large flood events or just equalize local meltwater across the CD5 road during low flood events. The CD5 culverts west of the Nigliagvik Channel are topographically isolated from CRD flooding. Lacking major channels in the vicinity, culverts in this region allow hydraulic equalization of meltwater between lakes, swales, and/or paleochannels.

Flow through CD5 road culverts east of the Nigliagvik was limited to the equalization of local melt water. Water levels at gages G30/G31, gages G34/G35, and gages G36/G37 were below PT elevation throughout breakup; these gages only saw ponding of local meltwater.

Stage remained below the PT elevation at gages S1/S1D throughout breakup. Flow was observed (Photo 4.43) and measured at two culverts along the CD5 road west of the Nigliagvik Channel twice during breakup monitoring. Peak discharge was not calculated for either location; there are no gages at the CD5-04 vicinity and stage at S1/S1D was too low for PT recordings at the CD5-07 vicinity. Gages S1/S1D stage and discharge data is provided in Graph 4.17. Measured discharge at CD5 road culverts conveying flow is summarized in Table 4.4. Additional culvert discharge data is provided in Appendix C.

Photo 4.43: South to north (downstream) flow through culverts at S1/S1D gages, looking south; May 25, 2019

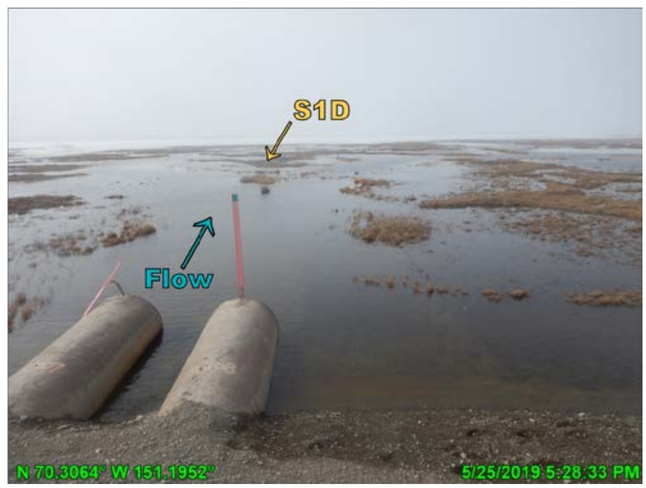
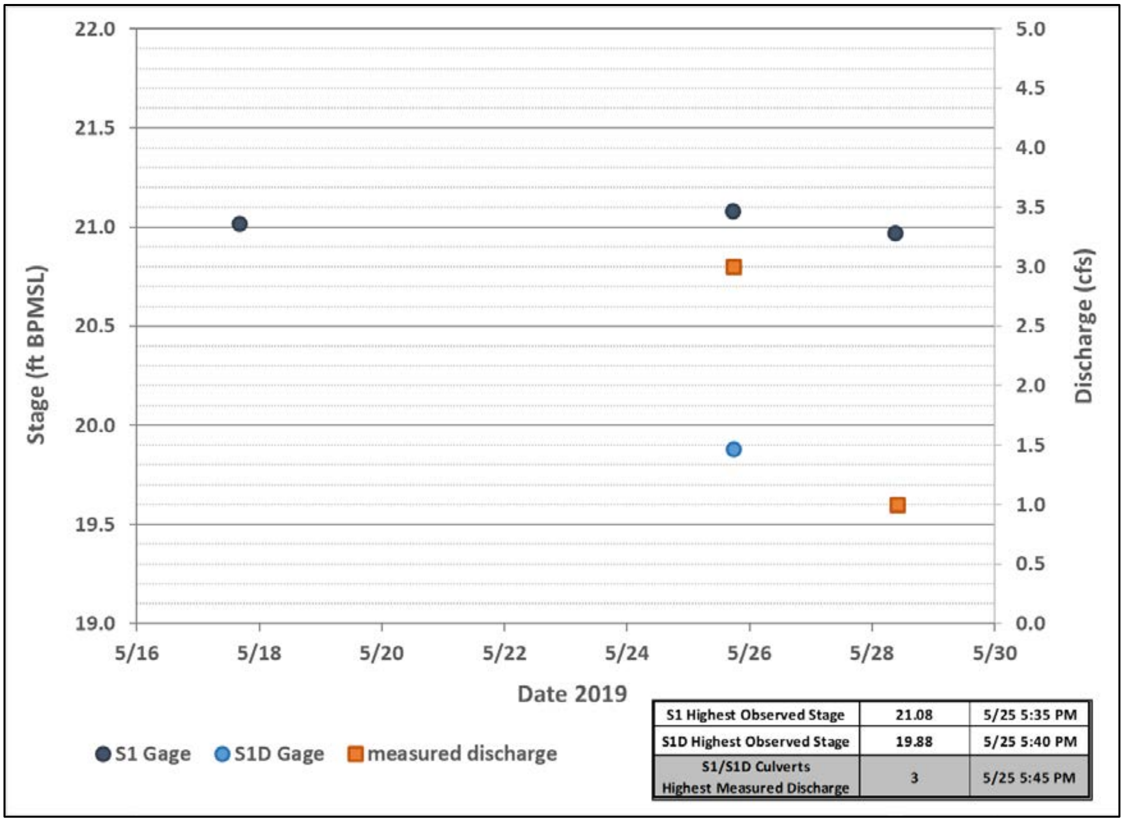


Photo 4.44: South to north (downstream) flow through culverts at S1/S1D gages, looking north; May 25, 2019



Graph 4.17: CD5 Road Culverts (Gages S1 and S1D) Stage and Discharge

Table 4.6: CD5 Road Culverts (Gages S1 and S1D) Measured Discharge

Culvert	Measurement Date & Time	Total Depth of Flow (ft)	Measurement Depth[1] (ft)	Flow Depth[2]	Measured Velocity (ft/s)	Calculated Discharge[3] (cfs)	Total Discharge (cfs)
CD5-04	5/25 5:53 PM	1.3	0.5	Less than Half Full	3.4	12	12
CD5-07	5/25 5:46 PM	1.0	0.4	Less than Half Full	1.7	3	3
CD5-04	5/28 9:59 AM	1.3	0.5	Less than Half Full	2.7	10	10
CD5-07	5/28 9:50 AM	0.8	0.3	Less than Half Full	0.8	1	1

Note:
1. Measurement taken at 0.6 of total depth of flow.
2. Culvert CD5-04 is 48 inches in diameter; culvert CD5-07 is 24 inches in diameter.
3. Negative values indicate flow moving north to south through culvert.

4.5 Peak Discharge Distribution

The distribution of peak discharge between the East Channel and Nigliq Channel bifurcations is presented in Figure 4.1. Each section of the pie graph is represented by the location's peak discharge; however, peak discharge did not occur at the same time and date for each location. Combined peak discharges in the East Channel and the Nigliq Channel were 11% greater than the peak discharge calculated for the Colville River at the head of the CRD/MON1 (Figure 4.2). Flow through minor channels downstream of MON1 not accounted for at MON9 or the Nigliq Bridge is negligible.

The discharge quantity downstream of a location is typically larger than the discharge upstream because the distance between provides for a larger drainage area to contribute runoff, assuming no losses occur via distributary channels, etc. However, because losses between MON1 and the Nigliq Bridge/MON9 were negligible, it is not likely that the actual combined peak discharge in the Colville East Channel and the Nigliq Channel would be as large as 11% greater that the peak discharge at the head of the CRD. Timing, storage and attenuation contribute to the overestimate, as do the errors associated with indirect methods of calculating peak discharge at each location, which are influenced by channel ice and ice jam events.

Figure 4.1: Peak Discharge Distribution in Colville East Channel and Nigliq Channel

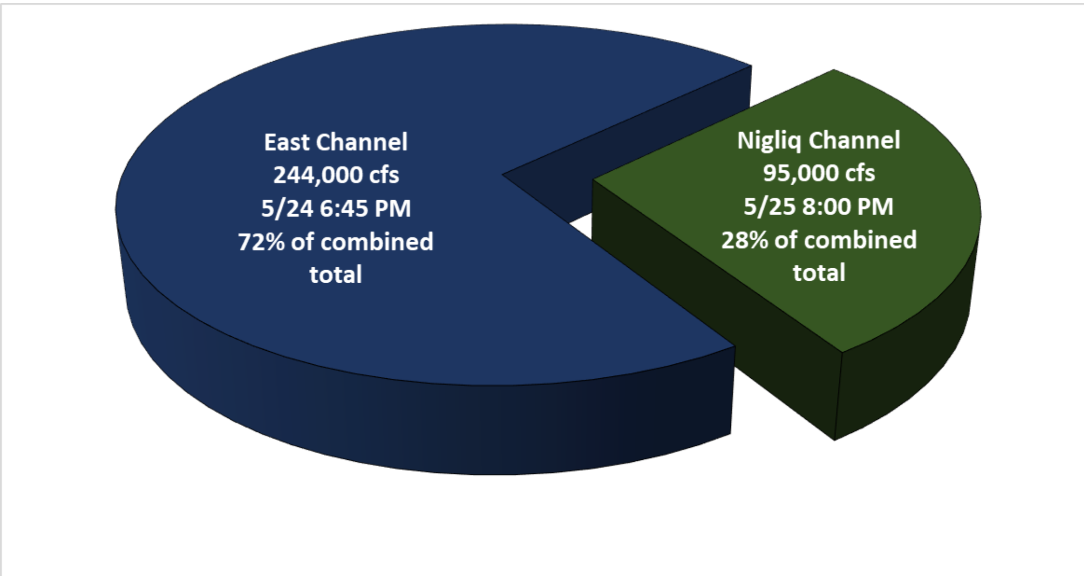
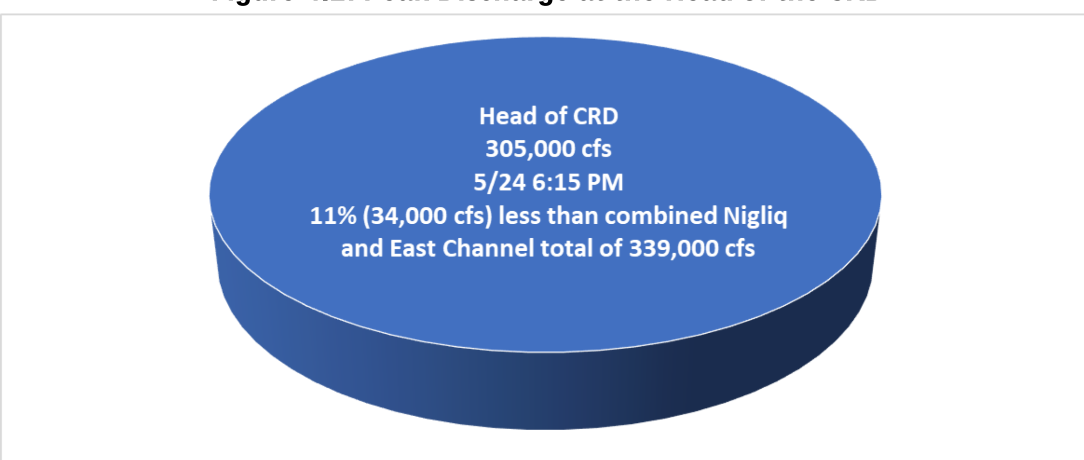


Figure 4.2: Peak Discharge at the Head of the CRD



5. POST-BREAKUP CONDITIONS ASSESSMENT

Alpine road and pads were inspected for erosion between June 3 and June 4. Photo 5.1 through Photo 5.4 show major drainage structures that passed breakup flow as stage is subsiding. No discernable erosion attributable to 2019 breakup flooding was observed during aerial and ground reconnaissance of the CD2, CD4, and CD5 roads. Floodwaters did not reach CD5 bridge abutments or the CD5 road within the CRD. Washlines from 2015 spring breakup, which was the largest historical flood event to impact Alpine facilities, remain evident along portions of the CD2, CD4, and CD5 roads. There were no signs of sloughing or undermining at drainage structures. Additional photo documentation of erosion surveys and breakup conditions along the Alpine facilities roads and pads are shown in Appendix D.

Photo 5.1: CD2 road long swale bridge as breakup ebbs, looking north; May 28, 2019

Photo 5.2: CD2 road short swale bridge as breakup ebbs, looking north; May 28, 2019

Photo 5.3: CD5 road Nigliq Bridge #2 as breakup ebbs, looking south (upstream); May 29, 2019

Photo 5.4: CD5 road Nigliagvik Bridge #4 as breakup ebbs, looking south (upstream); May 29, 2019

6. CD5 PIER SCOUR, BANK EROSION, & BATHYMETRY

6.1 Pier Scour

Post-breakup pier scour elevations that encompass all piles in each pier group were measured by UMIAQ in August 2019. Post-breakup contour plots around the piers and within the main channel of the Nigliq Bridge and Nigliagvik Bridge are provided in Appendix E (UMIAQ 2019a).

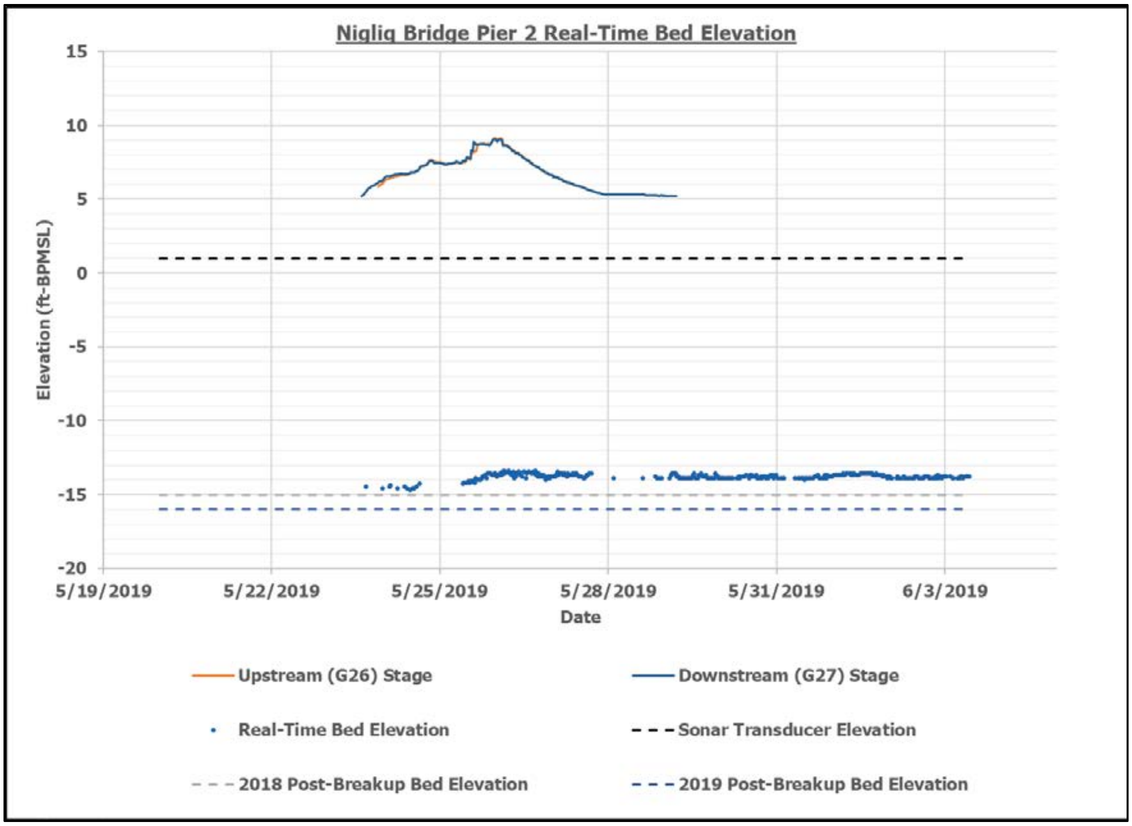
NIGLIQ BRIDGE

The minimum post-breakup scour elevation (-30.2 ft BPMSL at pier 4, pile D) is 1.3 ft below the 50-year design scour elevation and 2.8 ft above the 200-year scour elevation. A comparison of design and observed scour elevations are presented in Table 6.1. Real-time pier scour at piers 2 through 5 and corresponding WSEs during spring breakup monitoring are presented in Graph 6.1 through Graph 6.4. Real-time pier scour measurements indicated little to no active scour during peak conditions. The scatter in sonar measurements during real-time monitoring at some locations are likely attributed to a high concentration of near-bed sediments suspended in turbulence associated with eddies converging on the downstream side of the pier. In these cases, the lower readings are interpreted as the true bed elevations.

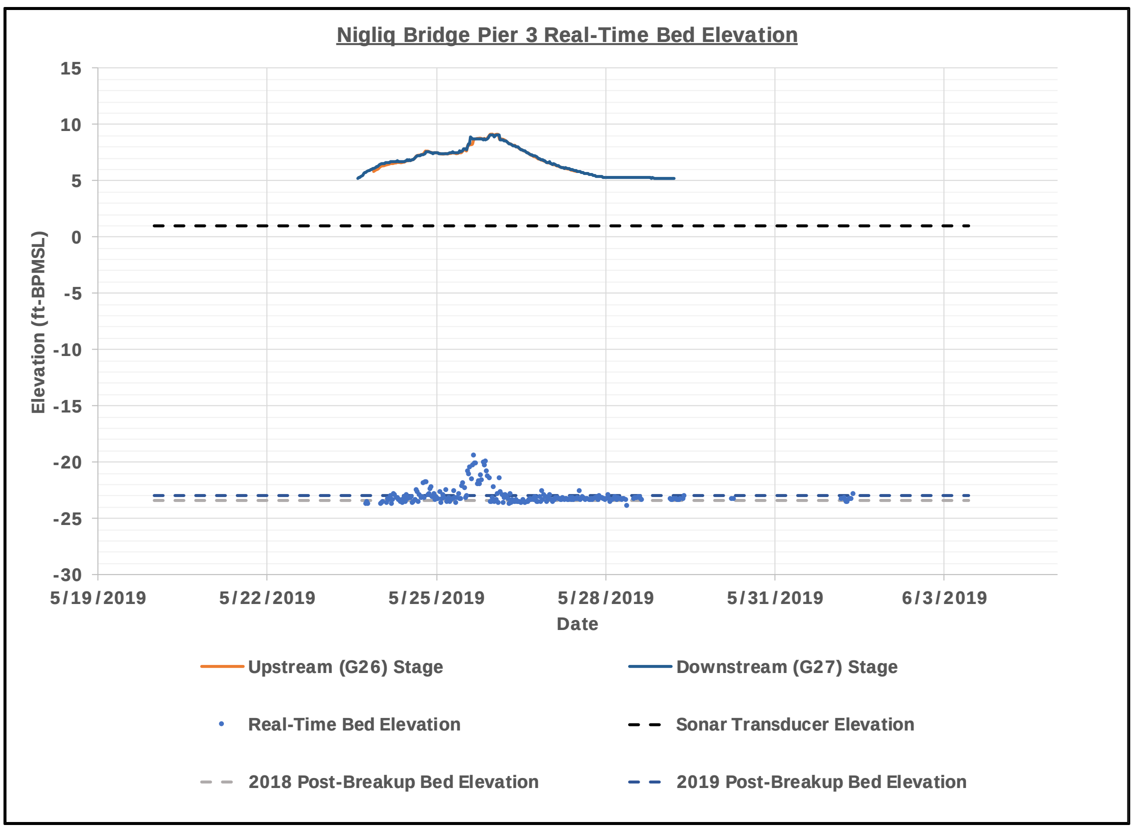
Table 6.1: Nigliq Bridge Comparison of Design and Observed Pier Scour Elevations

Nigliq Bridge Pier Scour		
During Breakup 2019		**Elevation (ft-BPMSL)[1,2]**
Pier 2	Pile E	-14.7
Pier 3	Pile E	-23.9
Pier 4	Pile E	-30.6
Pier 5	Pile E	-20.9
Post-Breakup 2019		**Elevation (ft-BPMSL)[3]**
Pier 2	Pile A on northeast side	-21.5
Pier 3	Pile C on northwest side	-25.0
Pier 4	Pile D on south side	-30.2
Pier 5	Pile E on north side	-18.3
Design 2013		**Elevation (ft-BPMSL)[4,5]**
50-year	Pier 2-6	-28.9
	Pier 7-8	-7.1
200-year	Pier 2-6	-33.0
	Pier 7-8	-16.4

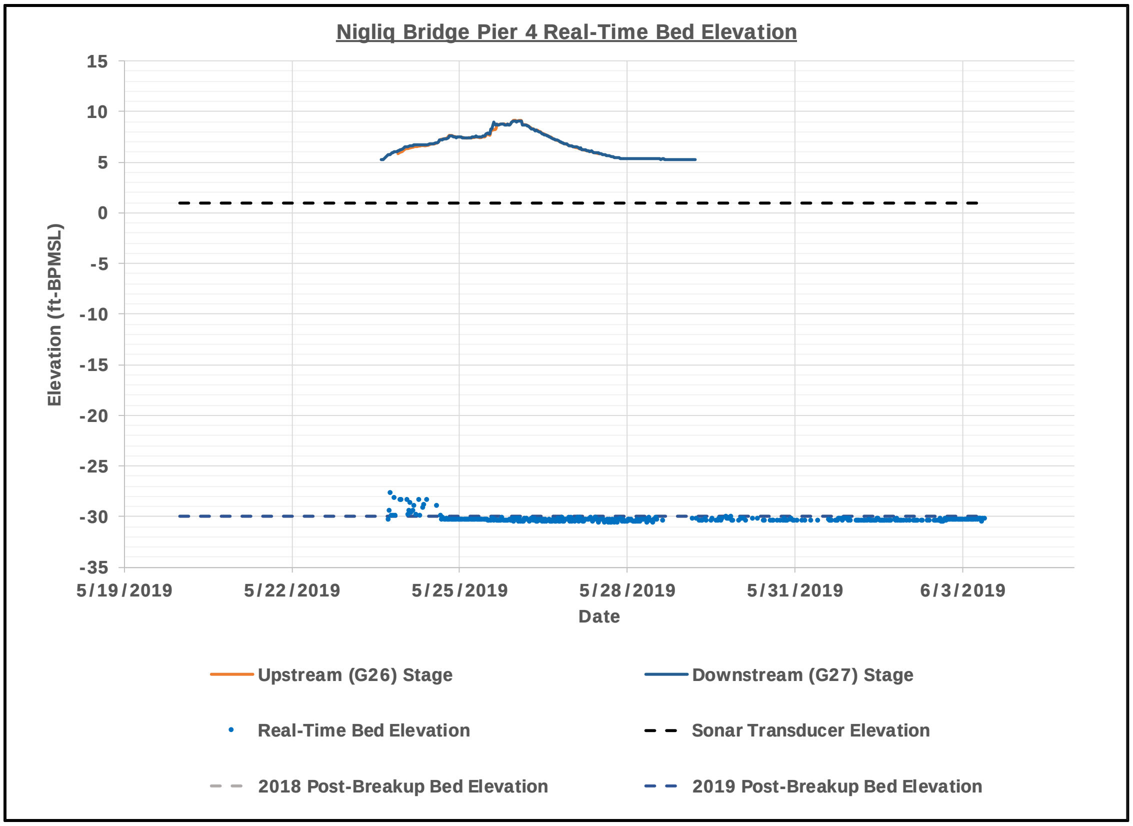
Notes:
[1]Minimum channel bed elevations recorded by real-time scour system in May and June 2019.
[2]Real-time scour measurements at downstream side of downstream pile.
[3]Minimum channel bed elevations recorded by LCMF in August 2019.
[4]Design values presented in PND 2013.
[5]Elevations based on LCMF 2008 survey.



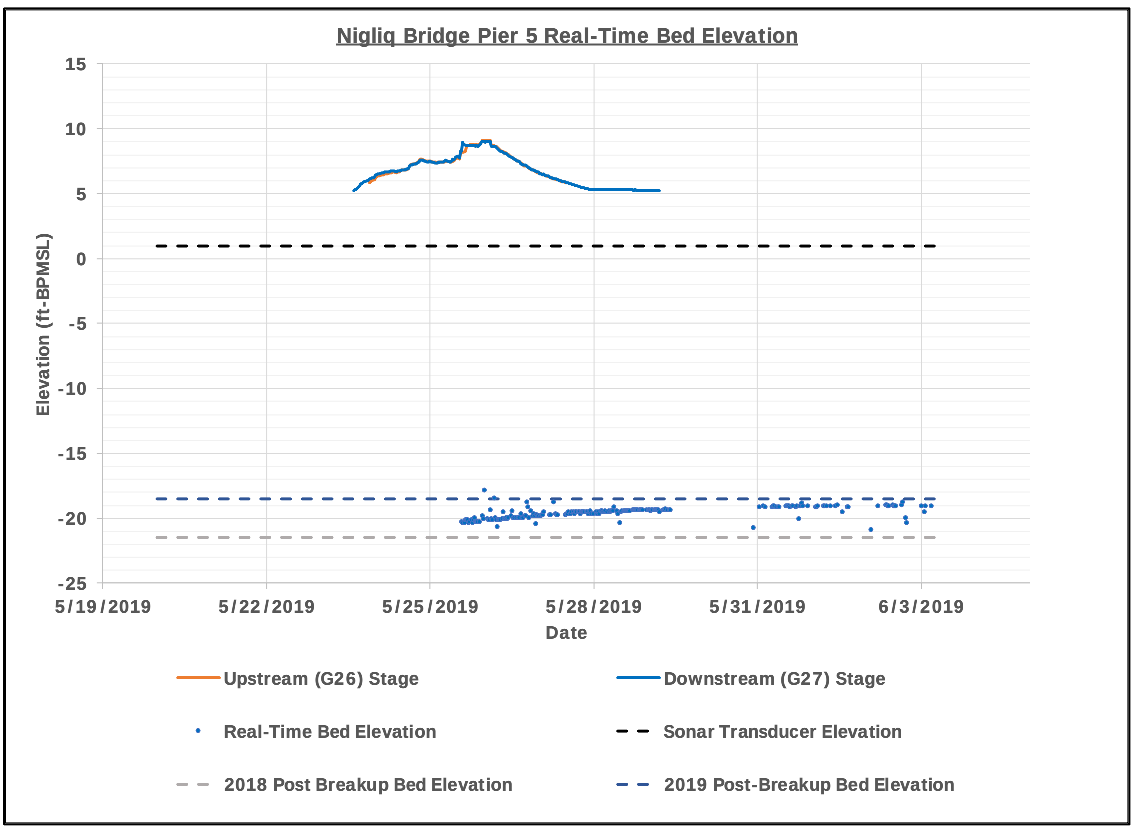
Graph 6.1: Nigliq Bridge Pier 2 (Pile E) Real-Time Scour Elevations



Graph 6.2: Nigliq Bridge Pier 3 (Pile E) Real-Time Scour Elevations



Graph 6.3: Nigliq Bridge Pier 4 (Pile E) Real-Time Scour Elevations



Graph 6.4: Nigliq Bridge Pier 5 (Pile E) Real-Time Scour Elevations

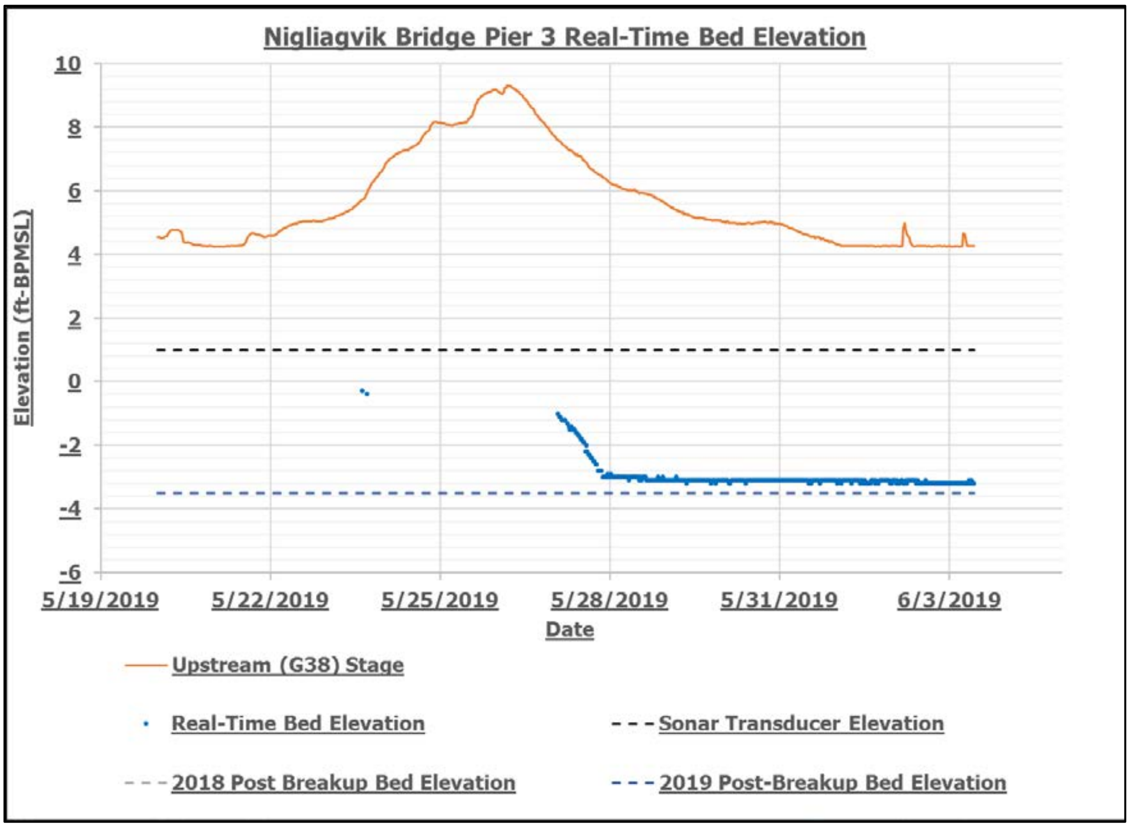
NIGLIAGVIK BRIDGE

The minimum post-breakup scour elevation (-5.7 ft BPMSL at pier 4, pile B) is 8.5 ft above the 50-year design scour elevation and 16.1 ft above the 200-year scour elevation. A comparison of design and observed scour elevations are presented in Table 6.2. Real-time pier scour at pier 3 and corresponding WSEs during spring breakup monitoring is presented in Graph 6.1. Real-time pier scour measurements indicated little to no active scour during peak conditions.

Table 6.2: Nigliagvik Bridge Comparison of Design and Observed Pier Scour Elevations

Nigliagvik Bridge Pier Scour		
During Breakup 2019		**Elevation (ft-BPMSL)[1]**
Pier 3	Pile B on north side	-3.2
Post-Breakup 2019		**Elevation (ft-BPMSL)[1]**
Pier 3	Pile A on north side	-5.0
Pier 4	Pile B on North side	-5.7
Design 2013		**Elevation (ft-BPMSL)[2,3]**
50-year	Pier 3-4	-14.2
200-year	Pier 3-4	-21.8

Notes:
[1]Minimum channel bed elevations recorded by LCMF in August 2019
[2]Design values presented in PND 2013
[3]Elevations based on LCMF 2008 survey



Graph 6.5: Nigliagvik Bridge Pier 3 (Pile B) Real-Time Scour Elevations

6.2 Bank Erosion

Site conditions during the bank erosion survey at the Nigliq Bridge and Nigliagvik Bridge are presented in Photo 6.1 through Photo 6.4. Maximum incremental and cumulative erosion at the Nigliq Bridge and Nigliagvik Bridge and maximum incremental, maximum cumulative, and average erosion along the top of bank, upstream and downstream of the bridges, is presented in Table 6.3. Bank erosion tabulated data is presented in Appendix E (UMIAQ 2019b).

Photo 6.1: West bank of the Nigliq Channel near the Nigliq Bridge, looking south (upstream); August 13, 2019

Photo 6.2: East bank of the Nigliq Channel near the Nigliq Bridge, looking northwest; August 13, 2019

Photo 6.3: West bank of the Nigliagvik Channel near the Nigliagvik Bridge, looking north (downstream); August 13, 2019

Photo 6.4: East bank of the Nigliagvik Channel, looking north (downstream); August 13, 2019

Table 6.3: Nigliq Channel and Nigliagvik Channel Bank Erosion

		Nigliq Channel						Nigliagvik Channel					
		West Bank			East Bank			West Bank			East Bank		
		Station[1] (STA)	Distance (ft)	Rate (ft/yr)	Station[1] (STA)	Distance (ft)	Rate (ft/yr)	Station[1] (STA)	Distance (ft)	Rate (ft/yr)	Station[1] (STA)	Distance (ft)	Rate (ft/yr)
Bridge Stations[2]	Maximum Incremental Erosion (2018-2019)	12+00	2.7	--	None	None	--	4+70	2.4	--	5+23	0.2	--
	Maximum Cumulative Erosion (2013-2019)	12+00	12.0	0.1	14+00	4.2	0.7	5+00	20.9	3.5	5+23	1.5	0.3
All Stations	Maximum Incremental Erosion[3] (2018-2019)	1+00	9.0	--	None	None	--	7+00	5.6	--	7+00	0.2	--
	Maximum Cumulative Erosion[3] (2013-2019)	0+00	35.6	5.9	12+00	7.5	1.3	0+00	8.9	1.5	4+00	7.2	1.2
	Average Cumulative Erosion (2013-2019)	All	--	0.7	All	--	0.1	All	--	1.2	All	--	0.1

Notes:
1. Stationing begins upstream of bridge
2. Nigliq Bridge Stations 10+00 through 13+00 on West Bank and 13+00 through 15+00 on East Bank. Nigliagvik Bridge Stations 4+00 through 6+00 on both banks
3. Excludes bridge transects

6.3 Bathymetry

BATHYMETRY AT BRIDGES

The 2019 survey results at each CD5 bridge location were compared with the survey results from 2013-2018 to obtain maximum incremental scour and deposition between 2019 and 2018, and maximum cumulative scour and deposition between 2019 and 2013 (Table 6.4). Transect profiles, bathymetric cross-sections, and tabulated data are provided in Appendix E (UMIAQ 2019c).

Table 6.4: Nigliq Bridge, Lake L9341 Bridge, and Nigliagvik Bridge Scour and Deposition

	Nigliq Bridge			Lake L9341 Bridge			Nigliagvik Bridge		
	Depth (ft)	Station (STA)	Transect	Depth (ft)	Station (STA)	Transect	Depth (ft)	Station (STA)	Transect
Maximum Incremental Scour (2018-2019)	2.9	6+79	9	1.3	1+89	36	2.1	2+19	26
Maximum Cumulative Scour (2013-2019)	11.9	2+67	10	1.3	3+90	36	3.4	1+00	25
Maximum Incremental Deposition (2018-2019)	4.9	8+33	9	2.5	2+20	36	1.6	1+29	25
Maximum Cumulative Deposition (2013-2019)	6.8	8+58	9	0.9	2+95	36	3.4	0+85	26

CHANNEL BATHYMETRY

The 2019 survey results at Nigliq Channel and Nigliagvik Channel were compared with the 2013, 2016, 2017 and 2018 survey results to obtain maximum incremental scour and deposition between 2019 and 2018, and maximum cumulative scour and deposition between 2019 and 2013 (Table 6.5). Transect profiles, bathymetric cross-sections, and tabulated data are provided in Appendix E (UMIAQ 2019c).

Table 6.5: Nigliq Channel & Nigliagvik Channel Scour & Deposition

	Nigliq Channel			Nigliagvik Channel		
	Depth (ft)	Station (STA)	Transect	Depth (ft)	Station (STA)	Transect
Maximum Incremental Scour (2018-2019)	12.5	20+10	6	3.9	4+79	32
Maximum Cumulative Scour (2013-2019)	21.0	39+38	13	4.3	4+59	33
Maximum Incremental Deposition (2018-2019)	4.9	8+33	9	8.1	1+91	16
Maximum Cumulative Deposition (2013-2019)	10.7	4+94	11	7.4	1+91	16

7. ICE ROAD CROSSINGS BREAKUP

Ice roads are constructed annually for ground transportation of supplies and equipment to Alpine facilities. Aerial surveys were conducted during spring breakup to observe and document the progression of melting of the ice road crossings. To facilitate melt and the progression of breakup flooding, ice road crossings are mechanically slotted at the conclusion of the winter season.

In general, ice road crossings melted at a similar rate as channel ice. Aerial surveys showed that slotting was completed, and floodwaters were passing freely through the ice road crossings. The majority of the crossings were submerged during the peak of flooding. When flooding receded, the ice road crossings and channel ice had cleared at most locations. Photos of all monitored ice road crossings are presented in Appendix D.

8. HISTORICAL BREAKUP TIMING & MAGNITUDE

Colville River breakup monitoring has been ongoing, intermittently, since 1962. The timing and magnitude of breakup flooding has been determined consistently since 1992 by measuring WSEs and discharge at established locations throughout the delta.

8.1 Colville River – Head of the Delta

The historical record of peak stage and peak discharge for the CRD is at MON1C, at the head of the delta. Annual peak stage and peak discharge at MON1C has been recorded intermittently from 1962 to 1992 and annually from 1992 to 2019 (Table 8.1 and Graph 8.1).

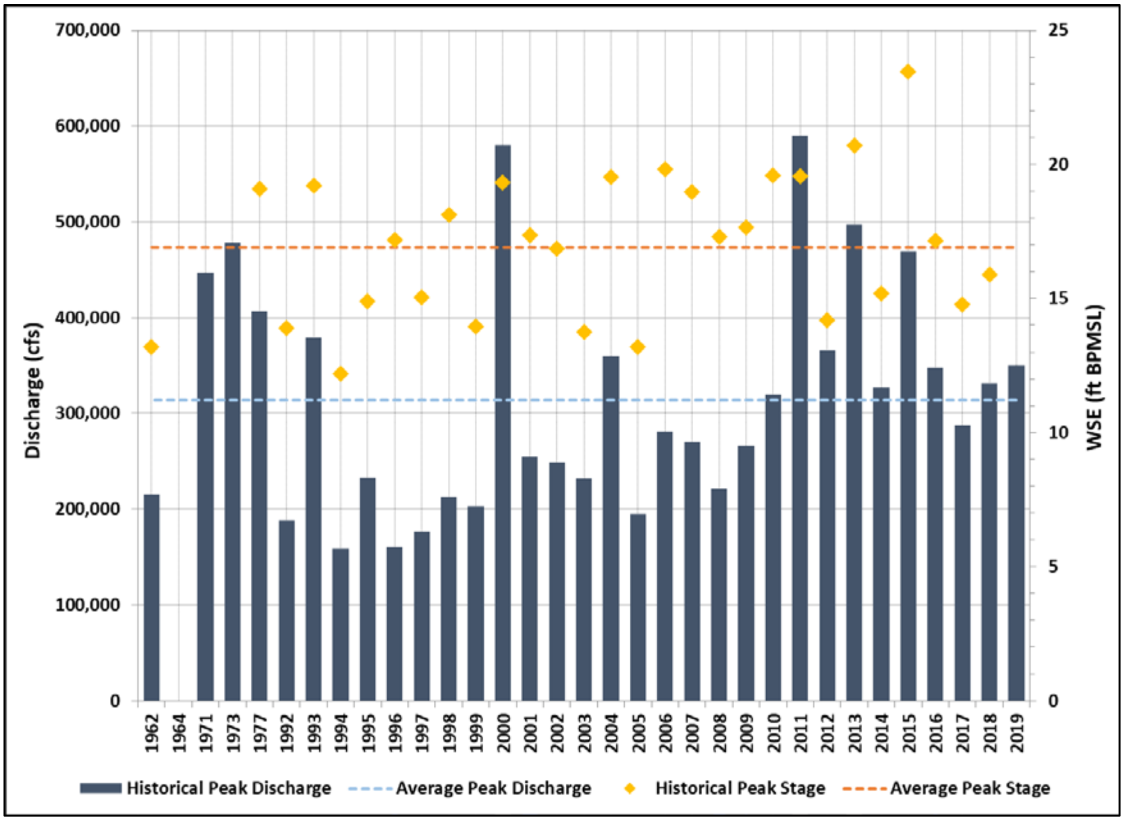
Peak stage at MON1C was 16.19-ft BPMSL and occurred on May 24. The average historical peak stage is 16.91 ft BPMSL and the average date is May 30. The maximum historical peak stage is 23.47 ft BPMSL occurring in 2015.

Peak discharge at MON1C was 305,000 cfs and occurred on May 24. The average historical peak discharge is 314,000 cfs and the average date is May 31. The maximum historical peak discharge is 590,000 cfs occurring in 2011.

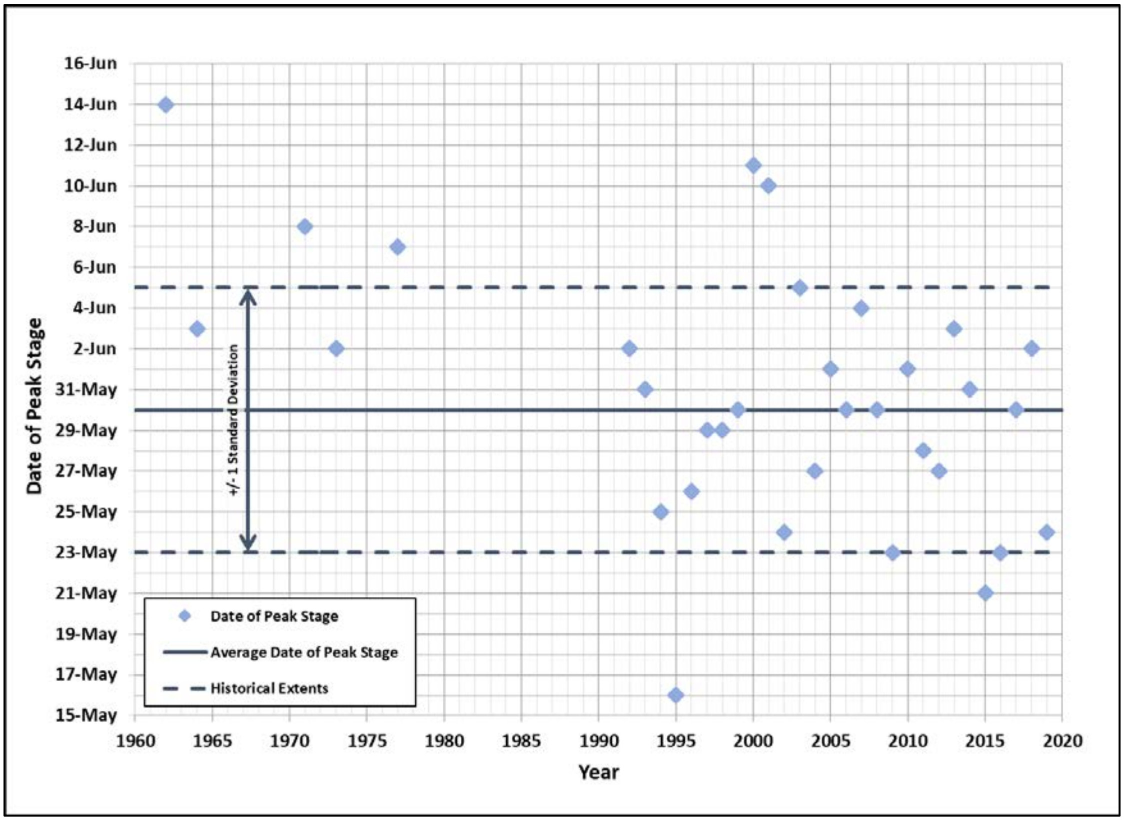
Statistical analysis of historical peak stage dates shows 78 percent of the peaks at MON1C occur during a 13-day period from May 23 to June 5. This represents one standard deviation of 6.3 days on either side of the average (mean) peak stage date of May 30, based on a normal distribution, as illustrated in Graph 8.2. Peak stage at MON1C this year was six days prior to the historical average.

Table 8.1: Colville River at the Head of the Delta Peak Discharge and Peak Stage Historical Summary

Year	Discharge		Stage (WSE)		Reference
	Peak Discharge (cfs)	Date	Peak Stage (ft BPMSL)	Date	
2019	**305,000**	**24-May**	**16.19**	**24-May**	**Michael Baker 2019**
2018	331,000	1-Jun	15.90	2-Jun	Michael Baker 2018
2017	288,000	30-May	14.79	30-May	Michael Baker 2017
2016	348,000	23-May	17.16	23-May	Michael Baker 2016
2015	469,000	22-May	23.47	21-May	Michael Baker 2015
2014	327,000	1-Jun	15.18	31-May	Michael Baker 2014
2013	497,000	3-Jun	20.69	3-Jun	Michael Baker 2013
2012	366,000	1-Jun	14.18	27-May	Michael Baker 2012b
2011	590,000	28-May	19.56	28-May	Michael Baker 2012a
2010	320,000	31-May	19.59	1-Jun	Michael Baker 2010
2009	266,000	23-May	17.65	23-May	Michael Baker 2009b
2008	221,000	28-May	17.29	30-May	Michael Baker 2008
2007	270,000	3-Jun	18.97	4-Jun	Michael Baker 2007b
2006	281,000	30-May	19.83	30-May	Michael Baker 2007a
2005	195,000	9-Jun	13.18	1-Jun	Michael Baker 2005b
2004	360,000	26-May	19.54	27-May	Michael Baker 2005a
2003	232,000	11-Jun	13.76	5-Jun	Michael Baker 2006a
2002	249,000	27-May	16.87	24-May	Michael Baker 2006a
2001	255,000	11-Jun	17.37	10-Jun	Michael Baker 2006a
2000	580,000	11-Jun	19.33	11-Jun	Michael Baker 2000
1999	203,000	30-May	13.97	30-May	Michael Baker 1999
1998	213,000	3-Jun	18.11	29-May	Michael Baker 1998b
1997	177,000	-	15.05	29-May	Michael Baker 2002b
1996	160,000	26-May	17.19	26-May	Shannon & Wilson 1996
1995	233,000	-	14.88	16-May	ABR 1996
1994	159,000	25-May	12.20	25-May	ABR 1996
1993	379,000	31-May	19.20	31-May	ABR 1996
1992	188,000	-	13.90	2-Jun	ABR 1996
1977	407,000	-	19.10	7-Jun	ABR 1996
1973	478,000	-	-	2-Jun	ABR 1996
1971	447,000	8-Jun	-	8-Jun	ABR 1996
1964	-	-	-	3-Jun	ABR 1996
1962	215,000	-	13.20	14-Jun	ABR 1996

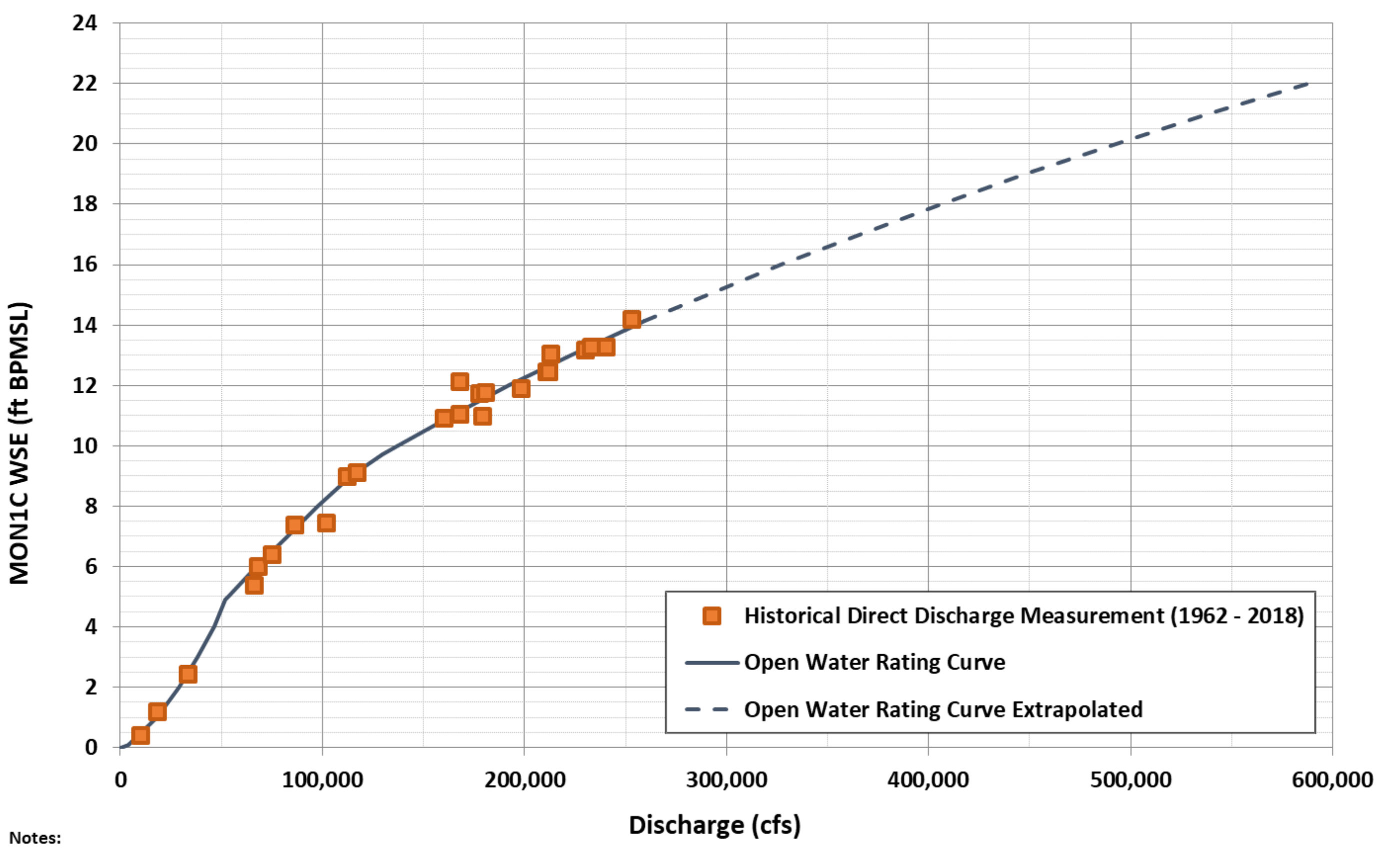


Graph 8.1: Colville River at the Head of the Delta Historical Peak Stage and Peak Discharge



Graph 8.2: Colville River at the Head of the Delta Historical Timing of Peak Stage

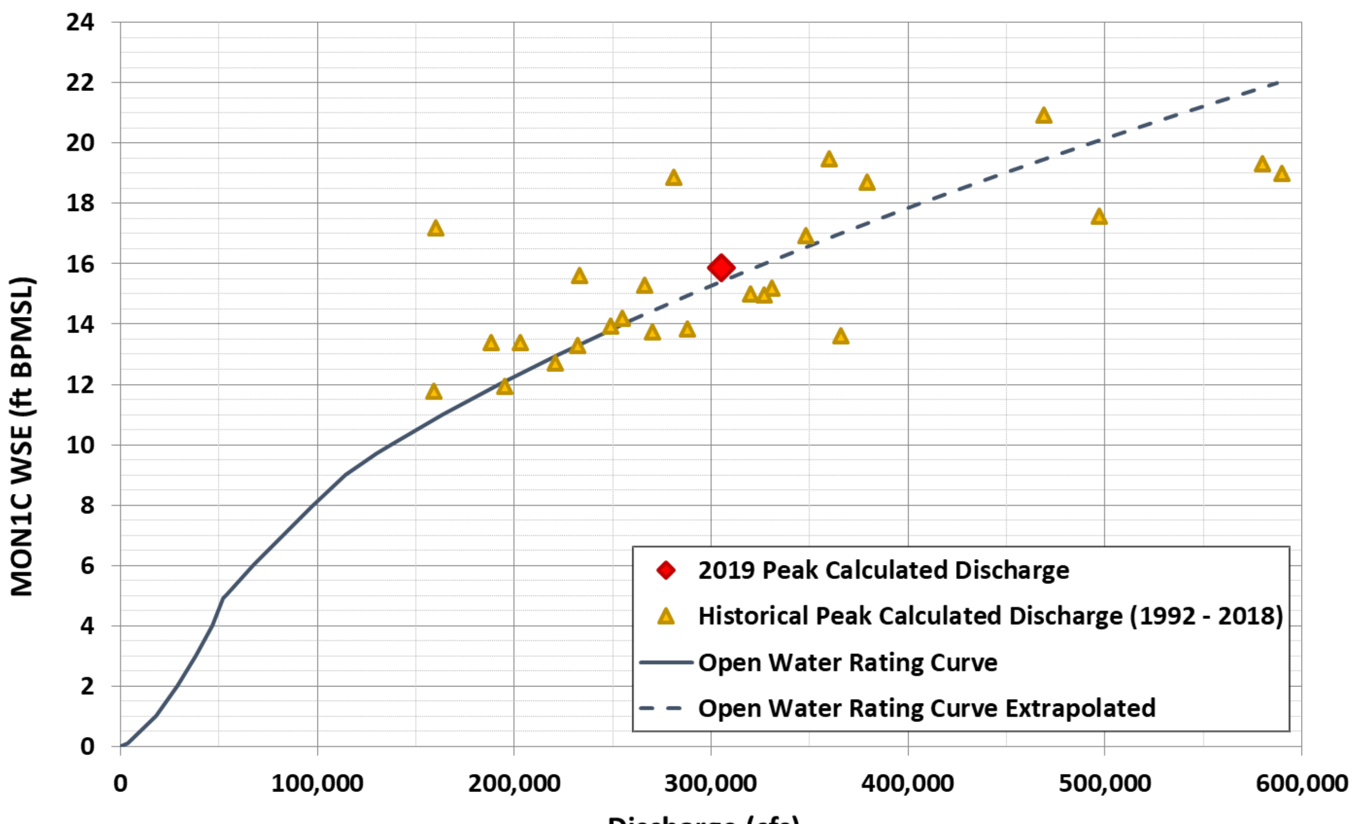
The MON1C stage-discharge rating curve, shown in Graph 8.3, represents a relationship between stage and discharge. The rating curve was calculated from direct discharge measurements taken during ice-free conditions between 1992 and 2005. Colville River discharge can be greatly influenced by channel ice; the rating curve more accurately represents the relationship between stage and discharge at lower stage values when ice-free discharge measurements are possible. A direct measurement was not collected in 2019 because of lack of accessibility to the site during peak conditions.



Notes:
1. Rating curve calculated from direct discharge measurements made during open water (ice free) conditions between 1962 and 2005.
2. Extrapolated portion is extension of slope of curve between highest known stage/discharge value; physical geometery of the banks and floodplain would cause the curve to asymptote at an unknown stage - to be used for reference only.
3. Stage corresponds to direct measurement/indirect calculation
4. Historical direct discharge measurements are those collected during open water conditions; direct measurements from 2006, 2007, 2008, and 2009 were ice-affected and are not included.

Graph 8.3: Colville River at the Head of the Delta Stage-Discharge Rating Curve with Measured Discharge

Peak discharge between 1992 and 2019 are plotted against the open water rating curve in Graph 8.4. Open water conditions rarely occur (ice is generally present) at or near peak stage during breakup. Differences between peak discharge and the open water rating curve are attributed to ice effects on stage and discharge. Values that fall to the right and below the rating curve tend to be the result of an upstream ice jam release. Conversely, values that fall to the left and above the rating curve tend to be the result of downstream ice jam backwater effects. Peak discharge in 2019 falls to the left of the rating curve by 5 percent.



Notes:
1. Rating curve calculated from direct discharge measurements made during open water (ice free) conditions between 1962 and 2005
2. Extrapolated portion is extension of slope of curve between highest known stage/discharge values; physical geometery of the banks and floodplain would cause the curve to asymptote at an unknown stage - to be used for reference only
3. Stage corresponds to direct measurement/indirect calculation
4. Calculated peak discharge in 1997 was 177,000 cfs; corresponding stage data is not available

Graph 8.4: Colville River at the Head of the Delta Stage-Discharge Rating Curve with Peak Discharge

8.2 CD2 Road Bridges

Discharge has been measured at the CD2 road bridges since 2000, and overall the measurements are estimated to be within 5-10% of the true discharge value based on the quality rating assigned to measurements. Measured flow through both the Long Swale Bridge and Short Swale Bridge was 82.1% of the average annual measured flow through both bridges (3,700 cfs). A summary of historical discharge measurements at the CD2 road bridges is presented in Table 8.2.

Table 8.2: CD2 Road Bridges Measured Discharge Historical Summary

Date	Stage[1] (ft)	Stage Differential[2] (ft)	Width (ft)	Area (ft^2)	Mean Velocity[3] (ft/s)	Discharge (cfs)	Measurement Rating[4]	Number of Sections	Measurement Type	Reference
Short Swale Bridge (62 ft)										
05/26/19	**7.27**	**0.02**	**53**	**349**	**0.7**	**244**	**G**	**11**	**Cable**	**This report**
06/03/18	6.63	0.08	36	32	0.22	5.40	P	22	Cable	Michael Baker 2018
2017[5]	–	–	–	–	–	–	–	–	–	Michael Baker 2017
05/25/16	7.39	0.32	53	322	2.11	700	G	27	Cable	Michael Baker 2016
05/23/15	7.85	0.05	54	373	0.81	302	F	19	Cable	Michael Baker 2015
06/02/14	7.90	0.12	54	365	1.31	479	F	28	Cable	Michael Baker 2014
06/05/13	9.75	0.46	54	446	3.60	1,608	G	36	Cable	Michael Baker 2013
06/03/12	7.04	0.17	52	306	1.26	386	F	19	Cable	Michael Baker 2012b
05/28/11	8.15	0.43	52	336	2.51	840	F	27	Cable	Michael Baker 2012a
06/03/10	7.58	0.16	55	316	1.79	570	F	28	Cable	Michael Baker 2010
2009[5]	–	–	–	–	–	–	–	–	–	Michael Baker 2009b
05/29/08	6.35	0.18	55	211	0.58	120	P	14	Cable	Michael Baker 2008
06/05/07	7.83	0.09	55	292	1.18	350	F	20	Cable	Michael Baker 2007b
05/31/06	8.49	0.26	55	615	1.59	980	F	20	Cable	Michael Baker 2007a
2005[5]	–	–	–	–	–	–	–	–	–	Michael Baker 2005b
05/29/04	8.34	0.14	55	451	1.60	720	F	17	Cable	Michael Baker 2005a
2003[5]	–	–	–	–	–	–	–	–	–	Michael Baker 2003
05/25/02	6.74	0.22	56	283	1.52	430	G	17	Cable	Michael Baker 2002b
06/11/01	7.64	0.56	56	336	1.79	600	G	15	Cable	Michael Baker 2001
06/10/00	7.87	0.61	47	175	3.30	580	F	13	Cable	Michael Baker 2000
Long Swale Bridge (452 ft)										
05/25/19	**6.84**	**0.29**	**440**	**2,046**	**1.37**	**2,795**	**F**	**21**	**Cable**	**This report**
06/03/18	7.05	0.16	431	2,090	1.50	3,140	P	-	Cable	Michael Baker 2018
06/01/17	5.92	0.04	445	1,505	0.86	1,290	F	27	Cable	Michael Baker 2017
05/25/16	7.48	0.40	445	2,025	2.25	4,800	G/F	28	Cable	Michael Baker 2016
05/22/15	9.93	0.55	447	3,024	3.12	9,440	G	24	Cable	Michael Baker 2015
06/02/14	8.00	0.13	445	2,183	1.30	2,842	G	38	Cable	Michael Baker 2014
06/05/13	9.87	0.42	448	2,947	2.47	7,286	G	36	Cable	Michael Baker 2013
06/03/12	7.10	0.17	445	1,686	1.53	2,582	-	26	Cable	Michael Baker 2012b
05/29/11	8.16	0.38	447	2,027	2.22	4,500	F	26	Cable	Michael Baker 2012a
06/01/10	7.97	0.47	441	1,699	2.66	4,500	G	25	Cable	Michael Baker 2010
05/26/09	5.89	0.09	445	1,592	0.82	730	F	27	Wading	Michael Baker 2009b
05/29/08	6.35	0.18	445	949	2.03	1,930	F	21	Wading	Michael Baker 2008
06/05/07	7.76	0.08	447	1,670	0.74	1,240	F	20	Cable	Michael Baker 2007b
05/31/06	8.42	0.18	409	1,730	1.89	3,260	F	29	Cable	Michael Baker 2007a
06/02/05	6.13	0.08	445	841	1.37	1,100	G	20	Wading	Michael Baker 2005b
05/29/04	8.34	0.14	446	1,700	1.40	2,400	F	18	Cable	Michael Baker 2005a
06/08/03	5.48	-0.05	444	478	0.88	420	G	16	Wading	Michael Baker 2003
05/25/02	6.74	0.22	445	930	3.47	3,200	G	17	Cable	Michael Baker 2002b
06/11/01	7.64	0.56	460	1,538	2.40	3,700	G	16	Cable	Michael Baker 2001
06/09/00	7.34	0.78	437	1,220	3.27	4,000	F	15	Cable	Michael Baker 2000

Notes:

1. Source of stage is G3
2. Stage differential between G3/G4 at time of discharge measurement
3. Mean velocities adjusted with angle of flow coefficient
4. Measurement Rating -
   - E - Excellent: Within 2% of true value
   - G - Good: Within 5% of true value
   - F - Fair: Within 8% of true value
   - P - Poor: Velocity < 0.70 ft/s; shallow depth for measurement; greater than 8% error
5. Bridge obstructed with snow or ice and/or lack of flow, no measurement made

Calculated peak flow through both bridges was 73 percent of the average annual peak flow through both bridges (4,450 cfs). Table 8.3 summarizes peak stage and peak calculated discharge at the CD2 Long and Short Swale Bridges between 2000 and 2019.

Table 8.3: CD2 Road Bridges Peak Stage and Discharge Historical Summary

Date[1]	Peak Stage[2] (ft BPMSL)	Stage Differential[3] (ft)	Long Swale Bridge (452 ft)		Short Swale Bridge (62 ft)		References
			Peak Discharge (cfs)	Mean Velocity (ft/s)	Peak Discharge (cfs)	Mean Velocity (ft/s)	
05/25/19	**7.32**	**0.35**	**3,000**	**1.37**	**250**	**0.71**	**This report**
06/02/18	7.12	0.25	3,240	1.50	12	0.22	Michael Baker 2018
05/31/17	6.04	0.04	1,350	0.86	–[4]	–[4]	Michael Baker 2017
05/25/16	7.50	0.44	4,800	2.35	680	2.06	Michael Baker 2016
05/22/15	11.93	1.54	12,350	3.12	484	0.81	Michael Baker 2015
06/02/14	8.18	0.19	2,971	1.30	501	1.31	Michael Baker 2014
06/04/13	10.27	1.17	7,723	2.47	1,706	3.60	Michael Baker 2013
06/03/12	7.60	0.41	2,940	1.53	425	1.26	Michael Baker 2012b
05/29/11	8.89	0.30	5,200	2.22	940	2.51	Michael Baker 2012a
06/02/10	8.64	0.59	5,300	2.66	670	1.79	Michael Baker 2010
05/25/09	7.63	0.45	1,400	0.82	–[4]	–[4]	Michael Baker 2009b
05/30/08	6.49	0.26	2,100	0.49	130	0.58	Michael Baker 2008
06/05/07	8.60	0.43	1,500	1.35	400	1.18	Michael Baker 2007b
05/31/06	9.72	0.87	4,400	1.77	1,100	1.59	Michael Baker 2007a
05/31/05	6.48	0.20	1,400	1.37	–[4]	–[4]	Michael Baker 2005b
05/27/04	9.97	0.50	3,400	1.38	900	1.59	Michael Baker 2005a
06/07/03	6.31	0.12	700	0.88	–[4]	–[4]	Michael Baker 2003
05/26/02	7.59	0.69	4,000	3.47	500	1.52	Michael Baker 2002b
06/11/01	7.95	0.73	3,900	2.40	600	1.79	Michael Baker 2001
06/12/00	9.48	0.73	7,100	3.60	1,000	4.30	Michael Baker 2000

Notes:
[1]Based on gage HWM readings.
[2]Source of stage is Gage 3.
[3]Stage differential between G3/G4 at time of peak discharge.
[4]Bridge obstructed with snow or ice, no velocity measurements.

8.3 CD5 Road Bridges

Peak annual discharge has been calculated at the Nigliq Bridge since 2009 and at the Nigliagvik, Lake L9341, and Lake L9323 Bridges since 2012. A summary of peak stage and peak discharge during breakup flood events for the CD5 road bridges is shown in Table 8.4.

Table 8.4: CD5 Road Bridges Peak Discharge and Peak Stage Historical Summary

Year	Lake L9323 Bridge		Nigliq Bridge		Lake L9341 Bridge		Nigliagvik Bridge	
	Peak Discharge (cfs)	Peak Stage [G24] (ft BPMSL)	Peak Discharge (cfs)	Peak Stage [G26] (ft BPMSL)	Peak Discharge (cfs)	Peak Stage [G32] (ft BPMSL)	Peak Discharge (cfs)	Peak Stage [G38] (ft BPMSL)
Post-Bridge Construction								
2019	**- [1]**	**8.49**	**95,000**	**9.16**	**- [1]**	**8.63**	**- [3]**	**9.30**
2018	- [1]	9.67	42,200	8.43	- [1]	8.77	10,400	7.43
2017	- [1]	9.54	47,400	8.60	- [1]	7.10	2,550	6.86
2016	- [1]	8.85	65,000	9.05	- [1]	8.65	2,800	8.35
2015[2]	9,100	15.39	112,000	14.50	22,500	14.51	17,300	13.57
2014	- [1]	8.58	66,000	9.38	- [3]	8.48	7,800	8.64
Pre-Bridge Construction								
2013	- [1]	12.40	110,000 [4]	12.42 [5]	5,000 [4]	11.07	7,800 [4]	11.41
2012	- [1]	8.55	94,000 [6]	8.82	6,000 [6]	8.58	11,000 [6]	8.51
2011	- [3]	- [3]	141,000 [6]	9.89 [7]	- [3]	9.5 [8]	- [3]	8.78 [9]
2010	- [3]	- [3]	134,000 [6]	9.65 [7]	- [3]	5.85 [8]	- [3]	8.69 [9]
2009	- [3]	- [3]	57,000 [6]	7.91 [7]	- [3]	7.98 [8]	- [3]	7.71 [9]

Notes:
[1]No discharge reported because of a lack of hydraulic connection through bridge, backwater flow, and/or ice conditions return unreasonable calculation results.
[2]Discharge influenced by flow contraction through bridges.
[3]Data not available.
[4]Indirect discharge computed with consideration of intact channel ice present at time of peak discharge.
[5]Inferred from G25 at Lake L9323 Crossing.
[6]Indirect discharge computed as open water conditions, even though channel ice was present at time of peak discharge.
[7]Stage data from decommissioned gage G21 at proposed bridge centerline.
[8]Stage data from decommissioned gage G22 at proposed bridge centerline.
[9]Stage data from decommissioned gage G23 at proposed bridge centerline.

8.4 Alpine Drinking Water Lakes Recharge

Recharge of Alpine drinking water lakes L9312 and L9313 has been documented annually since 1998. Primary recharge mechanisms for these lakes are overland flood flow and local melt. Lakes are determined to be fully recharged if bankfull conditions are met—either overland floodwater was observed flowing into the lake, or there was evidence of a stage rise and fall on the breakup hydrograph.

In most years, Lake L9313 is recharged by overland flow from the Sakoonang Channel via the North Paleo Lake and Lake M9525. The historical record of observed flooding and stage indicates bankfull elevation of Lake L9313 is approximately 6.5-ft BPMSL at gage G10 (Michael Baker 2006a, 2007b). Observations on July 10 and July 18, 2018 indicated a hydraulic connection was established between Lakes L9313 and M9525, implying WSE at Lake L9313 was at or above bankfull elevation. The measured WSE on July 10 was 6.29-ft BPMSL, suggesting actual bankfull elevation at L9313 is lower than 6.5-ft BPMSL. Based on the 2018 observations, the bankfull recharge elevation at Lake L9313 has been revised to 6.29-ft BPMSL.

Lake L9312 is surrounded by higher tundra than Lake L9313 and is less frequently recharged by floodwater from the Sakoonang Channel. Recharge at this lake relies more on local melt of snow and ice and precipitation. Bankfull elevation of Lake L9312 is 7.8 ft BPMSL at gage G9 per the Fish Habitat Permit FG99-III-0051-Amendment #8.

Table 8.5 provides a historical summary of Alpine drinking water lakes stage and bankfull recharge record. Lake L9312 has recharged to bankfull 16 of the last 22 years, and Lake L9313 has recharged to bankfull 19 of the last 22 years.

Table 8.5: Alpine Drinking Water Lakes Historical Recharge Summary

Year	Lake L9312		Lake L9313	
	Peak Stage (ft BPMSL)	Bankfull Recharge to 7.8 ft BPMSL[1]	Peak Stage (ft BPMSL)	Bankfull Recharge to 6.29 ft BPMSL[2]
2019	**8.09**	**Yes[3]**	**8.72**	**Yes**
2018	8.10	Yes[3]	6.29	Yes[3]
2017	-	No[3]	7.40	Yes
2016	7.47	No[3]	8.15	Yes
2015	13.32	Yes	12.71	Yes
2014	7.94	Yes	8.59	Yes
2013	8.79	Yes	10.44	Yes
2012	8.23	Yes	8.20	Yes
2011	10.72	Yes	10.67	Yes
2010	7.63	No[3]	7.52	Yes
2009	7.65	No[3]	7.12	Yes
2008	7.45	No[3]	6.95	Yes
2007	9.35	Yes	9.47	Yes
2006	9.55	Yes	9.95	Yes
2005	8.00	Yes	6.12	No[3]
2004	8.37	Yes	9.40	Yes
2003	8.01	Yes	7.12	Yes
2002	8.05	Yes	7.98	Yes
2001	7.55	No[3]	8.31	Yes
2000	-	Yes	-	Yes
1999	7.93	Yes	6.14	No[3]
1998	8.35	Yes	7.35	Yes

Notes:
[1]Bankfull recharge is based on peak stage exceeding 7.8 ft BPMSL per Fish Habitat Permit FG99-III-0051, Amendment #8.
[2]Bankfull recharge elevation is based on visual observations of hydraulic connectivity of lake to breakup floodwater.
[3]Lake recharged from snow meltwater.

9. FLOOD & STAGE FREQUENCY ANALYSES

9.1 Flood Frequency

A flood frequency analysis is performed every three years for the head of the CRD at MON1 to estimate and update flood magnitudes for standard recurrence intervals. The current basis of design flood magnitudes are compared with the flood frequency analysis results to ensure the basis of design values are relevant as the body of data grows. The most recent flood frequency analysis was performed in 2018. These values are presented in Table 9.1 along with the current basis of design.

Table 9.1: Colville River Flood Frequency Analysis Comparison

Return Period	Basis for Current Design Criteria[1]	2018 Analysis Values[2]
	Discharge (cfs)	Discharge (cfs)
2-year	240,000	266,000
5-year	370,000	396,000
10-year	470,000	487,000
25-year	610,000	608,000
50-year	730,000	702,000
100-year	860,000	800,000
200-year	1,000,000	901,000

Notes:
[1]Michael Baker and Hydroconsult 2002
[2]Michael Baker 2018

This year's peak discharge of 305,000 cfs has a recurrence interval of 3.5 years. The flood recurrence interval should be considered with respect to conditions at the time of peak discharge. The ranking of the 2019 peak discharge relative to the historical record (evaluated using current basis of design flood magnitudes) is shown in Table 9.2.

Table 9.2: Colville River Flood Frequency Analysis Comparison

Year	Peak Discharge (cfs)	Recurrence Interval (years)
2011	590,000	22.9
2000	580,000	21.8
2013	497,000	12.9
2015	469,000	10
1993	379,000	5.5
2018	331,000	4.1
2012	366,000	4.9
2004	360,000	4.8
2016	348,000	4.5
2014	327,000	4
2010	320,000	3.8
2019	305,000	3.5
2017	288,000	3.1
2006	281,000	2.9
2007	270,000	2.7
2009	266,000	2.6
2001	255,000	2.3
2002	249,000	2.2
1995	233,000	<2
2003	232,000	<2
2008	221,000	<2
1998	213,000	<2
1999	203,000	<2
2005	195,000	<2
1997	177,000	<2
1994	165,000	<2
1992	164,000	<2
1996	160,000	<2

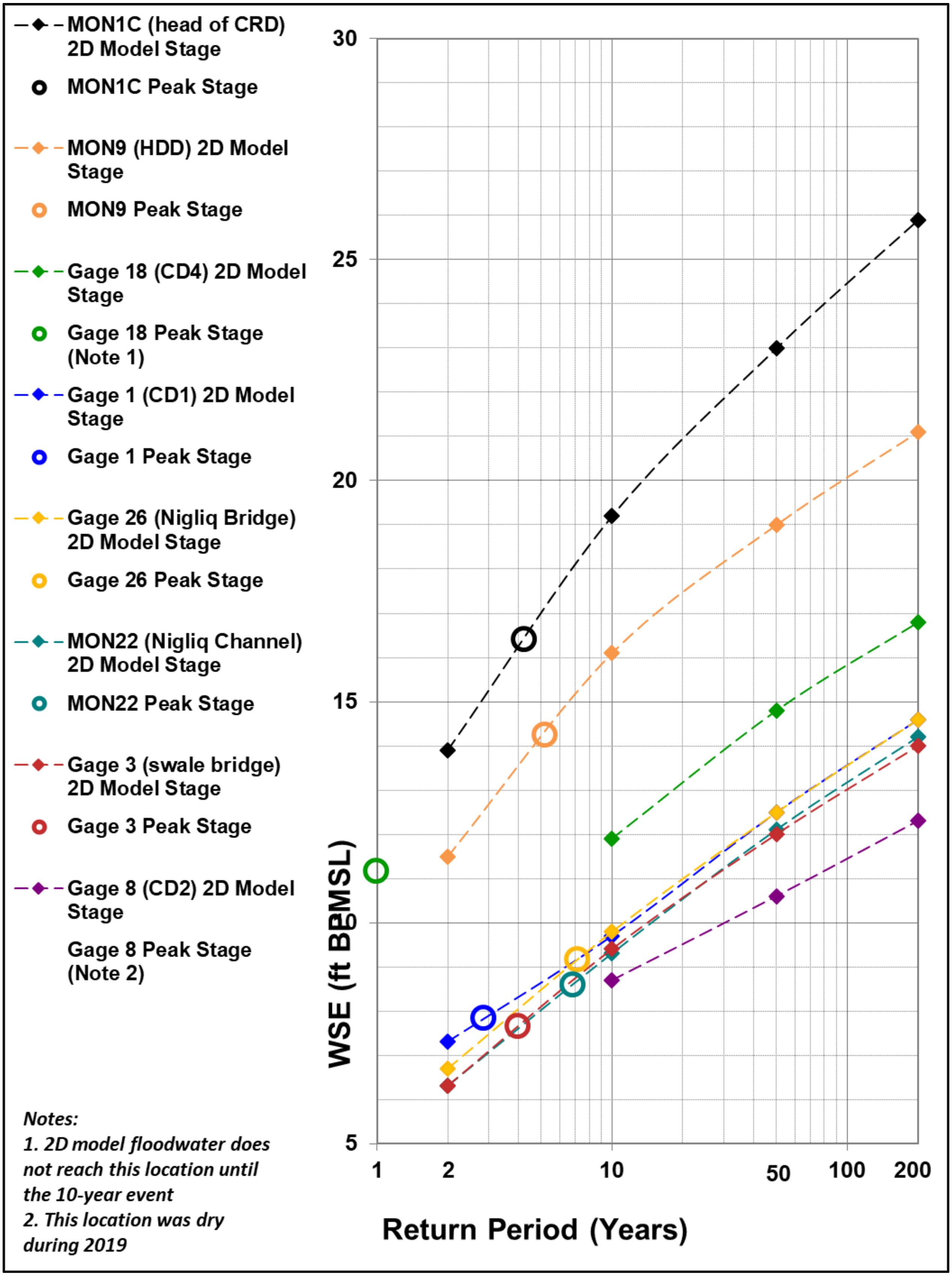
9.2 Stage Frequency

HIGH MAGNITUDE, LOW FREQUENCY

The CRD 2D surface water model was first developed in 1997 to estimate stage and velocities at the proposed Alpine facility locations (Michael Baker 1998a). The model has undergone numerous revisions to include improved topographic and bathymetric data and the addition of CD3, CD4, and CD5 facilities (Michael Baker 2002a, 2006b, 2009a, and 2012b).

The 2D model was developed to predict open water flood conditions during low-frequency, high-magnitude events, i.e. design events having 50- and 200-year recurrence intervals. To estimate the relationship between discharge and stage during more frequent, lower magnitude floods, 2- and 10-year recurrence intervals have also been modeled. The 2019 peak stage at select gage stations were assigned a recurrence interval relative to the 2D model predictions (Graph 9.1 and Table 9.3). The 2D model assumes open water steady-state conditions and does not account for snow, channel ice, or ice jams. Elevated stage resulting from snow and ice effects is typically localized and more pronounced during lower magnitude flood events. As a result, the 2D model generally under-predicts stage for lower recurrence intervals of approximately 10 years and less.

Based on the 2D model predictions, flood stage recurrence intervals throughout the CRD ranged from below model results of area inundation (i.e. site-specific areas can be dry during lower magnitude flood-recurrence events) to a maximum of 8.2 years. Peak spring breakup flood stage is highly variable throughout the CRD. Local ice and snow processes influence specific sites, and the effect is more pronounced during lower-magnitude, higher-frequency spring breakup flood events.



Graph 9.1: 2D Model Stage and Peak Stage Recurrence Intervals

Table 9.3: Peak Stage Frequency Relative to 2D Model Stage Frequency Analysis

Gage Station	2D Model Stage Recurrence Intervals[1,2] (ft BPMSL)				Peak Stage (ft BPMSL)	Peak Stage Recurrence Interval (years)
	2-year	10-year	50-year	200-year		
Colville River						
MON1C (head of CRD)	13.9	19.2	23	25.9	16.19	4.0
Colville River East Channel						
MON9 (HDD)	11.5	16.1	19	21.1	14.23	5.2
MON35 (Helmericks)	4.3	5.4	6.1	6.5	3.98	<2
Nigliq Channel						
MON20	7.8	11.4	14.6	16.8	10.19	5.8
MON22	6.3	9.3	12.1	14.2	8.59	6.8
MON23	5.1	7.4	10.2	12	7.12	8.2
MON28	3.1	3.4	3.9	4.3	2.95	<2
CD1 Pad & Drinking Water Lakes						
Gage G1	7.3	9.7	12.5	14.6	7.83	2.9
Gage G9 (Lake L9312)	8.3	10.8	13.4	15.7	8.09	<2
Gage G10 (Lake L9313)	8.3	10.8	13.4	15.7	8.72	2.6
CD2 Pad & Road						
Gage G8 (CD2 pad)	\	8.7	10.6	12.3	dry	-
Gage G3 (swale bridges)	6.3	9.4	12	14	7.64	4.0
Gage G4 (swale bridges)	6.2	8.5	10.1	11.6	7.49	4.9
Gage G6	\	9.5	12.2	14.2	7.96	<10
Gage G7	\	8.4	10	11.6	7.91	<10
Gage G12	\	9.5	12.1	14.1	7.9[3]	-
Gage G13	\	8.4	10	11.6	7.8[3]	-
CD3 Pad & Pipeline						
Gage G11	5.2	6.4	6.9	8	dry	-
SAK Gage (Pipeline Crossing #2)	6.4	8.9	11.2	12.9	5.78	<2
TAM Gage (Pipeline Crossing #4)	6.7	8.5	9	9.8	7.84	5.5
ULAM Gage (Pipeline Crossing #5)	5.5	7.1	7.8	8.7	6.88	8.0
CD4 Pad & Road						
Gage G15	8.4	10.8	13.5	15.9	8.7[3]	-
Gage G16	8.4	11.1	14.2	16.3	8.8[3]	-
Gage G17	\	11.1	14.2	16.3	10.39	<10
Gage G18	\	11.9	14.8	16.8	11.15	<10
Gage G19 (CD4 pad)	\	\	14.7	16.8	dry	-
Gage G20 (CD4 pad)	\	11.1	14.3	16.4	-	-
CD5 Road						
Gage G24 (Lake L9323/CD5 Bridge #1)	\	11.1	14.1	16	8.5[3]	-
Gage G26 (Nigliq/CD5 Bridge #2)	6.7	9.8	12.5	14.6	9.16	7.2
Gage G27 (Nigliq/CD5 Bridge #2)	6.7	9.8	12.5	14.5	9.1	7.0
Gage G30	\	\	13.3	15.5	dry	-
Gage G32 (Lake L9341/CD5 Bridge #3)	\	\	13.3	15.1	8.63	<50
Gage G34	\	\	13.3	15.7	dry	-
Gage G36	\	\	13.3	15.7	dry	-
Gage G38 (Nigliagvik/CD5 Bridge #4)	6.9	10	12.8	14.9	9.3	7.0

Notes:
[1]Sites having dry ground in 2D model during lower recurrence intervals are denoted with a backward slash "\."
[2]2D WSEs based on post-CD5 model results.
[3]Stage attributed to ponded local melt.

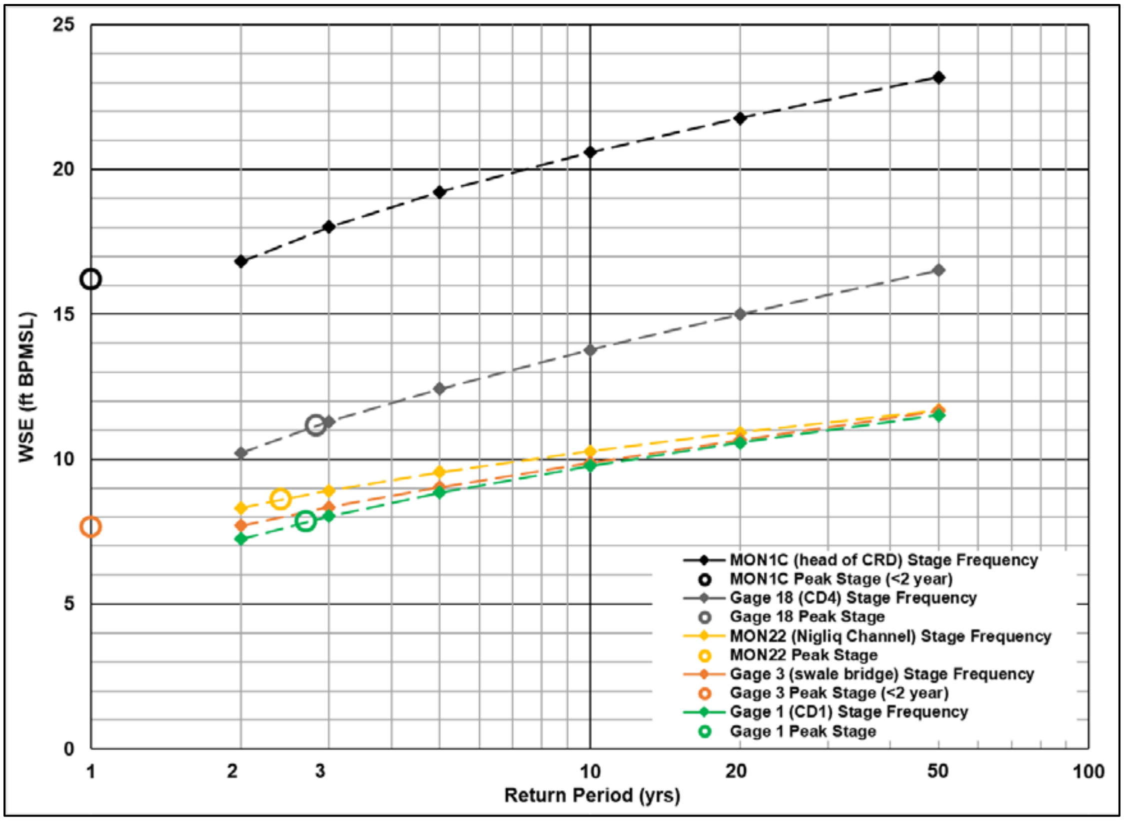
LOW MAGNITUDE, HIGH FREQUENCY

A site-specific stage frequency analysis using the historical record can provide a better estimate of low magnitude recurrence intervals. MON1C, MON22, gage G1, gage G3, and gage G18 have the longest periods of continuous record and are distributed throughout the project area. The maximum period of continuous record is 24 years at MON1C. Analyses have been performed every three years as the body of data grows (Michael Baker 2007a, 2009a, and 2012b), the most recent being in 2018 (Michael Baker 2018).

It is considered risky to extrapolate stage data for a river impacted by ice and ice jamming beyond the continuous record (USACE 2002; FEMA 2003). This is because of the inherent unpredictability of ice jams, the greater impact ice effects have on lower magnitude events, and the upper limit of stage considering available floodplain storage for overbank flow (for example, water height can only increase so much once it has crested the banks and spilled into the floodplain). Stage frequency was extrapolated to the 50-year recurrence interval, almost twice the continuous record at MON1C, for comparison to the 2D model because this is where the 2D model results and stage frequency analysis results tend to converge. Unlike the 2D model, the observed data upon which the stage frequency analyses are based reflect ice-affected flooding conditions. Therefore, the stage frequency analysis results can be used to supplement design criteria for low-magnitude, ice impacted flood events. Results from the most recent stage frequency analysis are compared to this year's observed peak stages in Table 9.4 and Graph 9.2. Based on the stage frequency analysis, all gage stations analyzed fell below the 3-year recurrence interval.

Table 9.4: Peak Stage Frequency Relative to Stage Frequency Analysis

Monitoring Location	Stage Frequency Recurrence Intervals (ft BPMSL)						Peak Stage	Peak Stage Recurrence Interval
	2-year	3-year	5-year	10-year	20-year	50-year	(ft BPMSL)	(years)
MON1C (head of CRD)	16.82	18.02	19.23	20.59	21.78	23.18	16.19	<2
MON22 (Nigliq Channel)	8.31	8.92	9.55	10.27	10.92	11.70	8.59	2.4
Gage G1 (CD1 Pad)	7.24	8.03	8.84	9.77	10.57	11.52	7.83	2.7
Gage G3 (CD2 Road)	7.70	8.35	9.04	9.88	10.67	11.67	7.64	<2
Gage G18 (CD4 Road)	10.22	11.30	12.43	13.77	15.00	16.52	11.15	2.8



Graph 9.2: Stage Frequency and Peak Stage Recurrence Intervals

10. REFERENCES

Alaska Biological Research (ABR). 1996. Geomorphology and Hydrology of the Colville River Delta, Alaska, 1995. Prepared for ARCO Alaska, Inc.

Chow, V.T., 1959, Open-Channel Hydraulics, New York, McGraw-Hill, p. 138.

Federal Emergency Management Agency (FEMA). 2003. Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix F: Guidance for Ice-Jam Analysis and Mapping. April 2003.

ICE Consult and Design (ICE). 2019 NPR-A North Tundra Monitoring Station. Cumulative Freezing Degree Days. Winters 2002-2019 Coldest to Warmest Year. October 2019.

Michael Baker International (Michael Baker). 1998a. Colville River Delta Two-Dimensional Surface Water Model Project Update. September 1998. Prepared for ARCO Alaska, Inc.

——— 1998b. 1998 Spring Breakup and Hydrologic Assessment, Colville River Delta, North Slope, Alaska. October 1998. Prepared for ARCO Alaska, Inc.

——— 1999. 1999 Spring Breakup and Hydrologic Assessment, Colville River Delta, North Slope, Alaska. November 1999. Prepared for ARCO Alaska, Inc.

——— 2000. Alpine Facilities Spring 2000 Breakup Monitoring Alpine Development Project. November 2000. Prepared for Phillips Alaska, Inc.

——— 2001. Alpine Facilities 2001 Spring Breakup and Hydrologic Assessment. August 2001. Prepared for Phillips Alaska, Inc.

——— 2002a. Colville River Delta Two-Dimensional Surface Water Model, CD-Satellite Project Update. May 2002. Prepared for ConocoPhillips Alaska, Inc.

——— 2002b. Alpine Facilities 2002 Spring Breakup and Hydrologic Assessment. October 2002. Prepared for ConocoPhillips Alaska, Inc.

——— 2003. Alpine Facilities 2003 Spring Breakup and Hydrologic Assessment. September 2003. Prepared for ConocoPhillips Alaska, Inc.

——— 2005a. Alpine Facilities 2004 Spring Breakup and Hydrologic Assessment. March 2005. Prepared for ConocoPhillips Alaska, Inc.

——— 2005b. 2005 Colville River Delta and Fish Creek Basin Spring Breakup and Hydrologic Assessment. December 2005. Prepared for ConocoPhillips Alaska, Inc.

——— 2006a. 1992-2005 Annual Peak Discharge Colville River Monument 1 Estimate, Calculation, and Method Review. Prepared for ConocoPhillips Alaska, Inc.

——— 2006b. Colville River Delta Two-Dimensional Surface Water Model CD5 Update. February 2006. Prepared for ConocoPhillips Alaska, Inc.

——— 2007a. 2006 Colville River Delta and Fish Creek Basin Spring Breakup and Hydrological Assessment. January 2007. Prepared for ConocoPhillips Alaska, Inc.

——— 2007b. 2007 Colville River Delta Spring Breakup and Hydrologic Assessment. November 2007. Prepared for ConocoPhillips Alaska, Inc.

——— 2008. 2008 Colville River Delta Spring Breakup and Hydrologic Assessment. December 2008. Prepared for ConocoPhillips Alaska, Inc.

——— 2009a. Colville River Delta, Two-Dimensional Surface Water Model Update. CD5 Alpine Satellite Development Project. September 2009. Prepared for ConocoPhillips Alaska, Inc.

——— 2009b. Colville River Delta Spring Breakup 2009 Hydrologic Assessment. December 2009. Prepared for ConocoPhillips Alaska, Inc.

——— 2009c. Alpine Pipeline River Crossings 2009 Monitoring Report. September 2009. Prepared for ConocoPhillips Alaska, Inc.

——— 2010. 2010 Colville River Delta Spring Breakup 2010 Hydrologic Assessment. November 2010. Prepared for ConocoPhillips Alaska, Inc.

——— 2012a. Colville River Delta Spring Breakup 2011 Hydrologic Assessment. January 2012. Prepared for ConocoPhillips Alaska, Inc.

——— 2012b. 2012 Colville River Delta Spring Breakup Monitoring and Hydrologic Assessment. December 2012. Prepared for ConocoPhillips Alaska, Inc.

——— 2013a. 2013 Colville River Delta Spring Breakup Monitoring and Hydrologic Assessment. November 2013. Prepared for ConocoPhillips Alaska, Inc.

——— 2014. 2014 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment. November 2014. Prepared for ConocoPhillips Alaska, Inc.

——— 2015. 2015 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment. November 2015. Prepared for ConocoPhillips Alaska, Inc.

——— 2016. 2016 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment. December 2016. Prepared for ConocoPhillips Alaska, Inc.

——— 2017. 2017 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment. November 2017. Prepared for ConocoPhillips Alaska, Inc.

——— 2018. 2018 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment. November 2018. Prepared for ConocoPhillips Alaska, Inc.

Michael Baker International (Michael Baker) and Alaska Biological Research (ABR), 2013 Monitoring Plan with an Adaptive Management Strategy CD5 Development Project for ConocoPhillips, Alaska. March 2013.

Michael Baker International (Michael Baker) and Hydroconsult EN3 Services, Ltd. 2002. Colville River Flood Frequency Analysis, Update. September 2002. Prepared for ConocoPhillips Alaska, Inc.

National Oceanic and Atmospheric Administration (NOAA). Website access 2019. (https://www.noaa.gov/weather).

Natural Resource Conservation Service (NRCS). 2018. Alaska Snow Survey Report. July 2018. United States Department of Agriculture (USDA).

Office of Surface Water (OSW). 1999a. Development of New Standard Rating Tables for the Price Type AA and Pygmy Current Meters. Technical Memorandum No. 99.05. Website access 2009. (http://water.usgs.gov/admin/memo/SW/sw99.05.html). U.S. Geological Survey (USGS).

——— 1999b. Care and Maintenance of Vertical-Axis Current Meters. Technical Memorandum No. 99.06. Website access 2009. (http://water.usgs.gov/admin/memo/SW/sw99.06.html). USGS.

PND Engineers (PND). 2013. Proposed CD5 Access Road Bridges Scour Estimates Summary. May 2013.

Shannon & Wilson, Inc. 1996. 1996 Colville River Delta Spring Breakup and Hydrologic Assessment, North Slope, Alaska. November 1996. Prepared for Michael Baker Jr., Inc.

UMIAQ/LCMF LLC, Inc. (UMIAQ) 2002. As-built survey. CD2 and CD4 culverts. Prepared for ConocoPhillips Alaska, Inc. (Submitted as Kuukpik/UMIAQ LLC, Inc. [UMIAQ]).

——— 2004. Cross-section survey, Colville River at Monument 01. Prepared for Michael Baker Jr., Inc. (Submitted as Kuukpik/UMIAQ LLC, Inc. [UMIAQ]).

——— 2014. DOT HDD Waterway Crossing Inspection. Prepared for ConocoPhillips Alaska, Inc. 2014.

——— 2016a. Cross-section survey of the Nigliq & Nigliagvik Channel crossings. Prepared for ConocoPhillips Alaska, Inc. July 2016.

——— 2017. As-built survey, CD2, CD4, and CD5 access road culverts. Prepared for ConocoPhillips Alaska, Inc. July 2017.

——— 2019a. CD5 access road Nigliq & Nigliagvik Bridge scour monitoring. Prepared for ConocoPhillips Alaska, Inc. August 2018.

——— 2019b. Top of bank survey of the Nigliq Channel & Nigliagvik Channel. Prepared for ConocoPhillips Alaska, Inc. August 2018.

——— 2019c. Cross-section survey of the Nigliq Channel, Nigliagvik Channel, and Lake L9341. Prepared for ConocoPhillips Alaska, Inc. August 2018.

——— 2018d. As-built survey, CD2, CD4, and CD5 access road culverts. Prepared for ConocoPhillips Alaska, Inc. July 2018.

U.S. Army Corps of Engineers (USACE). 1991. U.S. Army Corps of Engineers Ice-Influenced Flood Stage Frequency Analysis TL 110-2-325. Washington D.C. July 2002.

——— 2002. U.S. Army Corps of Engineers Ice Engineering Manual EM 1110-2-1612. Washington D.C. 30 October 2002.

——— 2010. User's Manual for HEC-SSP Statistical Software Program Version 2.0, Annual Flood-Frequency Analysis Using Bulletin 17B Guidelines. Brunner, G.W. and Fleming, M.J.

U.S. Geological Survey (USGS). 1968. Bodhaine, G.L. Measurement of Peak Discharge at Culverts by Indirect Methods. Techniques of Water Resources Investigations of the U.S. Geological Survey. USGS-TWRI Book 3, Chapter A3. United States Government Printing Office, Washington, DC. 1968.

——— 1982. Measurement and Computation of Streamflow, Vols. 1 and 2. S.E. Rantz and others. Water Supply Paper 2175.

——— 2006. Mueller, D.S., and Wagner, C.R. Measuring discharge with acoustic Doppler current profilers from a moving boat. U.S. Geological Survey Techniques and Methods 3A-22,72p. (available online at http://pubs.water.usgs.gov/tm3a22).

——— 2019a. Gage height and discharge data, May 11 through June 15. Website access September 1, 2019. https://waterdata.usgs.gov/nwis/uv?site_no=15875000.

——— 2018b. Guidelines for determining flood flow frequency—Bulletin 17C: U.S. Geological Survey Techniques and Methods, book 4, chap. B5, https://doi.org/10.3133/tm4B5.

APPENDIX A VERTICAL CONTROL, GAGE LOCATIONS, & CULVERT LOCATIONS

A.1 VERTICAL CONTROL

Control	Elevation (ft BPMSL)	Latitude (NAD83) [1]	Longitude (NAD83)	Control Type	Reference
CD2-4N	8.96	N 70.3399°	W 151.0292°	Culvert top	UMIAQ 2017
CD2-14N	10.83	N 70.3371°	W 151.0110°	Culvert top	UMIAQ 2017
CD2-14S	10.89	N 70.3369°	W 151.0111°	Culvert top	UMIAQ 2017
CD2-22N	9.14	N 70.3404°	W 150.9829°	Culvert top	UMIAQ 2017
CD2-22S	9.09	N 70.3402°	W 150.9827°	Culvert top	UMIAQ 2017
CD2-6N	8.89	N 70.3399°	W 151.0290°	Culvert top	UMIAQ 2017
CD2-6S	7.78	N 70.3397°	W 151.0291°	Culvert top	UMIAQ 2017
CD4-10E	11.72	N 70.3274°	W 150.9929°	Culvert top	UMIAQ 2017
CD4-10W	12.17	N 70.3275°	W 150.9934°	Culvert top	UMIAQ 2017
CD4-12E	11.42	N 70.3235°	W 150.9954°	Culvert top	UMIAQ 2017
CD4-12W	12.412	N 70.3401°	W 150.9962°	Culvert top	UMIAQ 2017
CD4-22E	6.73	N 70.3021°	W 150.9932°	Culvert top	UMIAQ 2017
CD4-22W	7.45	N 70.3018°	W 150.9930°	Culvert top	UMIAQ 2017
CD4-6E	14.37	N 70.3348°	W 150.9707°	Culvert top	UMIAQ 2017
CD5-29N	12.28	N 70.3060°	W 151.0951°	Culvert top	UMIAQ 2016
CD5-29S	12.38	N 70.3058°	W 151.0948°	Culvert top	UMIAQ 2016
CD5-35N	13.09	N 70.3065°	W 151.0683°	Culvert top	UMIAQ 2016
CD5-35S	13.26	N 70.3063°	W 151.0683°	Culvert top	UMIAQ 2016
CD5-40N	10.65	N 70.3050°	W 151.0439°	Culvert top	UMIAQ 2016
CD5-40S	10.93	N 70.3048°	W 151.0442°	Culvert top	UMIAQ 2016
CP01-13-09A	12.94	N 70.3401°	W 150.9843°	Top rail support	UMIAQ 2016
CP08-11-12	7.36	N 70.3639°	W 150.9204°	Alcap	BAKER 2012
CP08-11-23	8.52	N 70.3916°	W 150.9078°	Alcap	LCMF 2008
CP08-11-35	8.88	N 70.4066°	W 150.8822°	Alcap	BAKER 2015 (UMIAQ 2010)
CP08-12-61	11.95	N 70.2777°	W 150.9935°	Alcap	LCMF 2017
MONUMENT 1	27.93	N 70.1659°	W 150.9400°	Alcap	LCMF 2005
MONUMENT 9	25.06	N 70.2446°	W 150.8583°	Alcap	UMIAQ 2016
MONUMENT 20	18.97	N 70.2800°	W 151.0115°	Alcap	BAKER 2017
MONUMENT 21	13.30	N 70.3424°	W 150.9236°	Top of bolt	UMIAQ 2016
MONUMENT 22 (BAKER)	10.03	N 70.3181°	W 151.0560°	Alcap	BAKER 2010
MONUMENT 22	11.21	N 70.3422°	W 150.9321°	Alpine drill stem	LCMF 2015
MONUMENT 23	9.55	N 70.3444°	W 151.0613°	Alcap	BAKER 2009
MONUMENT 25	17.89	N 70.3024°	W 151.0130°	Capped drill stem	UMIAQ 2016
MONUMENT 27	13.86	N 70.3060°	W 151.0533°	Capped drill stem	UMIAQ 2016
MONUMENT 28 (Colville @ Coast)	3.65	N 70.4256°	W 151.0670°	Alcap	UMIAQ GPS 2002
MOUNMENT 29	28.63	N 70.3052°	W 151.1228°	Capped drill stem	UMIAQ 2016
NANUQ 4	12.64	N 70.2954°	W 150.9813°	Alcap	UMIAQ 2016

Control	Elevation (ft BPMSL)	Latitude (NAD83) [1]	Longitude (NAD83)	Control Type	Reference
NANUQ-5	17.42	N 70.2917°	W 150.9805°	Alcap	UMIAQ 2016
PMB-F	17.83	N 70.3393°	W 151.0467°	Top of rod	UMIAQ 2016
PMB-P	20.89	N 70.2915°	W 150.9889°	South side of CD4 pad	UMIAQ 2017
Pile 08	16.74	N 70.4175°	W 150.9105	SW Bolt	UMIAQ 2010
Pile 568	23.72	N 70.3639°	W 150.9206°	HSM cap SW bolt	LCMF 2010
TBM A	5.89	N 70.4264°	W 150.4053°	Corner of entryway	BAKER 2017
TBM B	8.46	N 70.4264°	W 150.4056°	East corner of structure	BAKER 2017
TBM C	8.15	N 70.3338°	W 150.4057°	West corner of structure	BAKER 2017
TBM 02-01-39 O	11.59	N 70.3338°	W 150.9522°	Top SW corner 2nd HSM	LCMF 2015
TBM 02-01-39 P	11.83	N 70.3337°	W 150.9521°	Top SW corner 1st HSM	LCMF 2015
TBM 05-05-06 B	21.01	N 70.3427°	W 150.9250°	NW corner F1 Product	UMIAQ 2016
TBM 99-32-60	15.86	N 70.3420°	W 150.9321°	Top lifting lug	LCMF 2015
TBM L99-32-59	14.60	N 70.3338°	W 150.9522°	Pile Cap SE VSM	UMIAQ 2015
TBM M9603-X	-	N 70.2213°	W 150.7896°	Angle iron	BAKER 2011
TBM M9605-X	-	N 70.2290°	W 150.5127°	Angle iron	BAKER 2011

1. North American Datum of 1983 (NAD83)

A.2 CRD GAGE LOCATIONS

Gage Station	Gage Type	Gage Assembly	Latitude (NAD83)	Longitude (NAD83)	Control
MON1U	Indirect-Read	MON1U-A[1]	N 70.1585°	W 150.9450°	MONUMENT 1
		MON1U-A1[2]	N 70.1585°	W 150.9451°	
		MON1U-B	N 70.1585°	W 150.9455°	
		MON1U-C	N 70.1585°	W 150.9461°	
		MON1U-D	N 70.1585°	W 150.9462°	
		MON1U-E	N 70.1585°	W 150.9464°	
		MON1U-F	N 70.1585°	W 150.9465°	
MON1C		MON1C-A[1]	N 70.1657°	W 150.9383°	
		MON1C-A1[2]	N 70.1656°	W 150.9385°	
		MON1C-B	N 70.1658°	W 150.9386°	
		MON1C-C	N 70.1658°	W 150.9392°	
		MON1C-D	N 70.1658°	W 150.9393°	
		MON1C-E	N 70.1658°	W 150.9395°	
		MON1C-F	N 70.1659°	W 150.9397°	
MON1D		MON1D-A[1]	N 70.1738°	W 150.9359°	
		MON1D-B[2]	N 70.1738°	W 150.9371°	
		MON1D-C	N 70.1738°	W 150.9372°	
		MON1D-D	N 70.1738°	W 150.9373°	
		MON1D-Z	N 70.1737°	W150.9376°	
MON9	Indirect-Read	MON9-A[1]	N 70.2447°	W 150.8573°	MONUMENT 9
		MON9-B[1]	N 70.2447°	W 150.8575°	
		MON9-B1	N 70.2446°	W 150.8576°	
		MON9-C	N 70.2447°	W 150.8578°	
		MON9-D	N 70.2446°	W 150.8580°	
		MON9-E	N 70.2446°	W 150.8580°	
		MON9-F	N 70.2446°	W 150.8580°	
		MON9-F1	N 70.2446°	W 150.8580°	
		MON9-F2	N 70.2446°	W 150.8580°	
		MON9-G	N 70.2446°	W 150.8581°	
		MON9-BARO[3]	N 70.2442°	W 150.8605°	
MON9D		MON9D-A[1]	N 70.2586°	W 150.8593°	
		MON9D-B[1]	N 70.2586°	W 150.8597°	
		MON9D-C	N 70.2586°	W 150.8598°	
		MON9D-D	N 70.2586°	W 150.8600°	
		MON9-D1	N 70.2586°	W 150.8600°	
		MON9D-E	N 70.2586°	W 150.8600°	
MON35		MON35-A	N 70.4260°	W 150.4058°	TBM B
		MON35-B	N 70.4260°	W 150.4058°	
		MON35-C	N 70.4261°	W 150.4058°	
		MON35-D	N 70.4261°	W 150.4058°	
		MON35-E	N 70.4261°	W 150.4058°	
MON20	Indirect-Read	MON20-A[1]	N 70.2786°	W 150.9986°	PBM-P
		MON20-B	N 70.2786°	W 150.9985°	
		MON20-C	N 70.2786°	W 150.9983°	
		MON20-D	N 70.2785°	W150.9982°	
		MON20-E	N 70.2785°	W 150.9982°	
MON22		MON22-A[1]	N 70.3186°	W 151.0546°	MONUMENT 22
		MON22-B	N 70.3185°	W 151.0549°	
		MON22-C	N 70.3185°	W 151.0550°	
		MON22-D	N 70.3183°	W 151.0555°	
MON23		MON23-A[1]	N 70.3436°	W 151.0659°	MONUMENT 23
		MON23-B	N 70.3436°	W 151.0657°	
		MON23-C	N 70.3436°	W 151.0652°	
		MON23-D	N 70.3436°	W 151.0649°	
		MON23-E	N 70.3436°	W 151.0648°	
MON28		MON28-A[1]	N 70.4258°	W 151.0697°	MONUMENT 28 (Colville @ Coast)
		MON28-B	N 70.4257°	W 151.0692°	
		MON28-C	N 70.4256°	W 151.0672°	

Notes:
1. PT, 2. RTFM PT, 3. Baro PT

A.3 ALPINE FACILITIES GAGE LOCATIONS

Gage Station	Gage Type	Gage Assembly	Latitude (NAD83)	Longitude (NAD83)	Control
G1	Direct-Read	G1[1]	N 70.3428°	W 150.9208°	TBM 05-05-06 B
G9		G9[1]	N 70.3336°	W 150.9519°	TBM 02-01-39 O
G10		G10[1]	N 70.3425°	W 150.9328°	MONUMENT 22
G3	Direct-Read	G3[1,2]	N 70.3400°	W 150.9831°	CD2-22S
G4		G4[1]	N 70.3403°	W 150.9833°	
G6	Direct-Read	G6[1]	N 70.3396°	W 151.0293°	CD2-6N
G7		G7[1]	N 70.3400°	W 151.0289°	
G12	Indirect-Read	G12[1]	N 70.3367°	W 151.0117°	CD2-14S
G13		G13[1]	N 70.3373°	W 151.0118°	CD2-14N
G8	Indirect-Read	G8	N 70.3393°	W 151.0491°	PBM-F
SAK	Indirect-Read	SAK-A[1]	N 70.3646°	W 150.9217°	Pile 568 cap SW bolt
		SAK-B	N 70.3645°	W 150.9220°	
		SAK-C	N 70.3645°	W 150.9220°	
TAM		TAM-A[1]	N 70.3917°	W 150.9115°	CP08-11-23
		TAM-B	N 70.3915°	W 150.9113°	
		TAM-C	N 70.3914°	W 150.9113°	
		TAM-Z	N 70.3912°	W 150.9109°	
ULAM		ULAM-A[1]	N 70.4068°	W 150.8835°	CP08-11-35
		ULAM-B	N 70.4069°	W 150.8833°	
		ULAM-C	N 70.4070°	W 150.8831°	
		ULAM-Z	N 70.4070°	W 150.8831°	
G11	Direct-Read	G11	N 70.4175°	W 150.9105°	Pile 08
G15	Indirect-Read	G15-A[1]	N 70.3023°	W 150.9929°	CD4-22W
		G15-B	N 70.3023°	W 150.9929°	
G16		G16-A[1]	N 70.3017°	W 150.9933°	CD4-22E
		G16-B	N 70.3017°	W 150.9933°	
G17		G17-A[1]	N 70.2933°	W 150.9827°	NANUQ-5
G18		G18-A	N 70.2930°	W 150.9818°	
	Direct-Read	G18-B[1,2,3,4]	N 70.2925°	W 150.9828°	
G19	Direct-Read	G19	N 70.2915°	W 150.9882°	PBM-P
G20	Indirect-Read	G20-A	N 70.2917°	W 150.9968°	
		G20-B	N 70.2917°	W 150.9968°	
G40		G40	N 70.3234°	W 150.9968°	CD4-12E
G41		G41	N 70.3235°	W 150.9949°	
G42		G42	N 70.3276°	W 150.9939°	CD4-10E
G43		G43	N 70.3274°	W 150.9924°	
G24	Indirect-Read	G24-A[1]	N 70.3030°	W 151.0065°	MONUMENT 25
		G24-B	N 70.3034°	W 151.0041°	
G25		G25-A[1]	N 70.3044°	W 151.0066°	
		G25-B	N 70.3046°	W 151.0049°	
G26		G26-A[1]	N 70.3023°	W 151.0217°	MONUMENT 25
		G26-B[1]	N 70.3022°	W 151.0206°	
		G26-C	N 70.3022°	W 151.0190°	
		G26-D	N 70.3022°	W 151.0190°	
		G26-E	N 70.3023°	W 151.0185°	

Notes:
1. PT, 2. RTFM PT, 3. Baro PT

Gage Station	Gage Type	Gage Assembly	Latitude (NAD83)	Longitude (NAD83)	Control
G27	Indirect-Read	G27-A[1]	N 70.3033°	W 151.0216°	PBM-24
		G27-B[1]	N 70.3033°	W 151.0207°	
		G27-C	N 70.3033°	W 151.0194°	
		G27-D	N 70.3032°	W 151.0185°	
		G27-E	N 70.3032°	W 151.0179°	
G28		G28-A[1]	N 70.2959°	W 151.0329°	
		G28-B	N 70.2959°	W 151.0331°	
		G28-C	N 70.2959°	W 151.0331°	
		G28-D	N 70.2959°	W 151.0332°	
		G28-E	N 70.2959°	W 151.0335°	
G29		G29-A[1]	N 70.3095°	W 151.0332°	
		G29-B	N 70.3095°	W 151.0334°	
		G29-C	N 70.3095°	W 151.0337°	
		G29-D	N 70.3094°	W 151.0343°	
		G29-E	N 70.3093°	W 151.0350°	
G32		G32-A[1]	N 70.3054°	W 151.0507°	MONUMENT 27
		G32-B	N 70.3055°	W 151.0513°	
G33		G33-A[1]	N 70.3065°	W 151.0484°	
		G33-B	N 70.3065°	W 151.0487°	
		G33-C	N 70.3068°	W 151.0500°	
G38		G38-A[1]	N 70.3046°	W 151.1187°	MONUMENT 29
		G38-B[1]	N 70.3046°	W 151.1185°	
		G38-C	N 70.3046°	W 151.1183°	
		G38-D	N 70.3047°	W 151.1172°	
G39		G39-A[1]	N 70.3064°	W 151.1177°	
		G39-B[1]	N 70.3063°	W 151.1175°	
		G39-C	N 70.3063°	W 151.1172°	
		G39-D	N 70.3063°	W 151.1170°	
G30		G30[1]	N 70.3046°	W 151.0443°	CD5-40S
G31		G31[1]	N 70.3051°	W 151.0437°	CD5-40N
G34		G34[1]	N 70.3060°	W 151.0710°	CD5-35S
G35		G35[1]	N 70.3067°	W 151.0711°	CD5-35N
G36		G36[1]	N 70.3056°	W 151.0968°	CD5-29S
G37		G37[1]	N 70.3063°	W 151.0971°	CD5-29N
S1		S1-A[1]	N 70.3060°	W 151.1947°	CD5-09S
		S1-D[1]	N 70.3066°	W 151.1957°	CD5-09N

Notes:
1. PT, 2. RTFM PT, 3. Baro PT

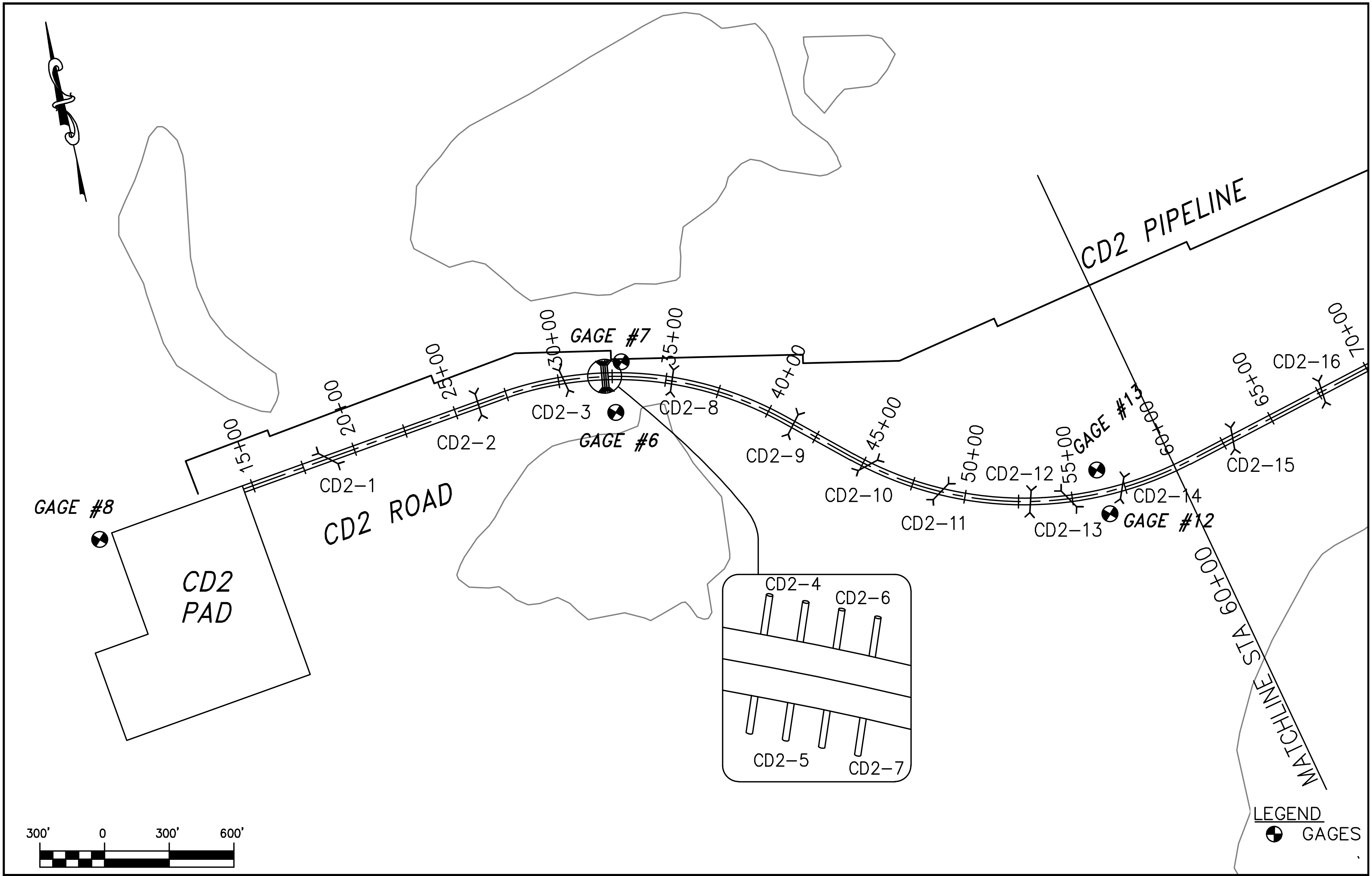
A.4 CULVERT LOCATIONS

Culvert	Station	Latitude (NAD83)	Longitude (NAD83)
CD2-01N	18+71	N 70.3396°	W 151.0403°
CD2-01S		N 70.3395°	W 151.0396°
CD2-02N	26+12	N 70.3399°	W 151.0340°
CD2-02S		N 70.3397°	W 151.0340°
CD2-03N	30+24	N 70.3399°	W 151.0308°
CD2-03S		N 70.3397°	W 151.0306°
CD2-04N	32+01	N 70.3399°	W 151.0292°
CD2-04S		N 70.3397°	W 151.0292°
CD2-05N	32+10	N 70.3399°	W 151.0291°
CD2-05S		N 70.3397°	W 151.0292°
CD2-06N	32+21	N 70.3399°	W 151.0290°
CD2-06S		N 70.3397°	W 151.0291°
CD2-07N	32+30	N 70.3399°	W 151.0290°
CD2-07S		N 70.3397°	W 151.0291°
CD2-08N	35+29	N 70.3397°	W 151.0265°
CD2-08S		N 70.3394°	W 151.0268°
CD2-09N	41+30	N 70.3388°	W 151.0224°
CD2-09S		N 70.3386°	W 151.0227°
CD2-10N	45+25	N 70.3381°	W 151.0198°
CD2-10S		N 70.3379°	W 151.0206°
CD2-11N	48+85	N 70.3375°	W 151.0174°
CD2-11S		N 70.3374°	W 151.0180°
CD2-12N	53+08	N 70.3372°	W 151.0144°
CD2-12S		N 70.3370°	W 151.0145°
CD2-13N	54+84	N 70.3371°	W 151.0133°
CD2-13S		N 70.3369°	W 151.0129°
CD2-14N	57+38	N 70.3371°	W 151.0110°
CD2-14S		N 70.3369°	W 151.0111°
CD2-15N	63+01	N 70.3373°	W 151.0065°
CD2-15S		N 70.3372°	W 151.0066°
CD2-16N	67+69	N 70.3377°	W 151.0029°
CD2-16S		N 70.3375°	W 151.0029°
CD2-17N	71+51	N 70.3380°	W 150.9999°
CD2-17S		N 70.3378°	W 150.9999°
CD2-18N	76+29	N 70.3383°	W 150.9960°
CD2-18S		N 70.3381°	W 150.9963°
CD2-19N	81+56	N 70.3387°	W 150.9922°
CD2-19S		N 70.3386°	W 150.9921°
CD2-20N	84+06	N 70.3391°	W 150.9905°
CD2-20S		N 70.3389°	W 150.9901°
CD2-21N	88+50	N 70.3396°	W 150.9873°
CD2-21S		N 70.3394°	W 150.9869°
CD2-22N	94+42	N 70.3403°	W 150.9829°
CD2-22S		N 70.3401°	W 150.9827°
CD2-23N	98+66	N 70.3403°	W 150.9793°
CD2-23S		N 70.3402°	W 150.9795°
CD2-24N	101+43	N 70.3402°	W 150.9771°
CD2-24S		N 70.3400°	W 150.9772°
CD2-25N	113+94	N 70.3393°	W 150.9670°
CD2-25S		N 70.3391°	W 150.9679°
CD2-26N	119+33	N 70.3397°	W 150.9638°
CD2-26S		N 70.3396°	W 150.9632°
CD4-01E	10+50	N 70.3391°	W 150.9670°
CD4-01W		N 70.3391°	W 150.9678°
CD4-02E	13+51	N 70.3383°	W 150.9674°
CD4-02W		N 70.3383°	W 150.9679°
CD4-26E	201+05	N 70.2932°	W 150.9813°
CD4-26W		N 70.2934°	W 150.9818°
CD4-27E	201+05	N 70.2932°	W 150.9815°
CD4-27W		N 70.2934°	W 150.9820°
CD4-28E	201+21	N 70.2932°	W 150.9816°

Culvert	Station	Latitude (NAD83)	Longitude (NAD83)
CD4-03E	16+02	N 70.3376°	W 150.9672°
CD4-03W		N 70.3376°	W 150.9676°
CD4-04E	18+95	N 70.3368°	W 150.9669°
CD4-04W		N 70.3369°	W 150.9674°
CD4-05E	23+08	N 70.3358°	W 150.9680°
CD4-05W		N 70.3359°	W 150.9685°
CD4-06E	28+03	N 70.3347°	W 150.9707°
CD4-06W		N 70.3349°	W 150.9711°
CD4-07E	34+16	N 70.3336°	W 150.9747°
CD4-07W		N 70.3338°	W 150.9750°
CD4-08E	44+28	N 70.3318°	W 150.9811°
CD4-08W		N 70.3320°	W 150.9815°
CD4-09E	59+20	N 70.3287°	W 150.9886°
CD4-09W		N 70.3288°	W 150.9890°
CD4-10E	66+48	N 70.3273°	W 150.9929°
CD4-10W		N 70.3274°	W 150.9934°
CD4-11E	81+24	N 70.3235°	W 150.9954°
CD4-11W		N 70.3235°	W 150.9961°
CD4-12E	81+66	N 70.3234°	W 150.9954°
CD4-12W		N 70.3234°	W 150.9961°
CD4-13E	82+09	N 70.3233°	W 150.9955°
CD4-13W		N 70.3233°	W 150.9961°
CD4-14E	82+51	N 70.3232°	W 150.9955°
CD4-14W		N 70.3232°	W 150.9960°
CD4-15E	102+00	N 70.3179°	W 150.9980°
CD4-15W		N 70.3179°	W 150.9985°
CD4-16E	129+97	N 70.3104°	W 151.0003°
CD4-16W		N 70.3104°	W 151.0009°
CD4-17E	143+00	N 70.3070°	W 150.9990°
CD4-17W		N 70.3068°	W 150.9994°
CD4-18E	146+55	N 70.3059°	W 150.9985°
CD4-18W		N 70.3059°	W 150.9989°
CD4-19E	154+57	N 70.3038°	W 150.9973°
CD4-19W		N 70.3037°	W 150.9978°
CD4-20AE	162+95	N 70.3022°	W 150.9937°
CD4-20AW		N 70.3019°	W 150.9936°
CD4-20BE	163+15	N 70.3021°	W 150.9934°
CD4-20BW		N 70.3018°	W 150.9933°
CD4-21E	163+35	N 70.3021°	W 150.9933°
CD4-21W		N 70.3018°	W 150.9932°
CD4-22E	163+55	N 70.3021°	W 150.9932°
CD4-22W		N 70.3018°	W 150.9930°
CD4-23E	164+40	N 70.3019°	W 150.9926°
CD4-23W		N 70.3017°	W 150.9925°
CD4-23AE	164+60	N 70.3019°	W 150.9924°
CD4-23AW		N 70.3016°	W 150.9923°
CD4-23BE	164+80	N 70.3019°	W 150.9923°
CD4-23BW		N 70.3016°	W 150.9922°
CD4-23CE	165+00	N 70.3018°	W 150.9921°
CD4-23CW		N 70.3016°	W 150.9920°
CD4-23DE	165+20	N 70.3018°	W 150.9920°
CD4-23DW		N 70.3016°	W 150.9919°
CD4-24E	197+02	N 70.2942°	W 150.9798°
CD4-24W		N 70.2944°	W 150.9803°
CD4-25E	200+89	N 70.2933°	W 150.9812°
CD4-25W		N 70.2934°	W 150.9818°
CD5-21S	126+42	N 70.3033°	W 151.1546°
CD5-22N	130+54	N 70.3034°	W 151.1513°
CD5-22S		N 70.3032°	W 151.1512°
CD5-23N	148+07	N 70.3043°	W 151.1377°
CD5-23S		N 70.3041°	W 151.1374°

Culvert	Station	Latitude (NAD83)	Longitude (NAD83)
CD4-28W		N 70.2933°	W 150.9821°
CD4-29E	201+21	N 70.2929°	W 150.9825°
CD4-29W		N 70.2931°	W 150.9828°
CD4-30E	201+37	N 70.2929°	W 150.9826°
CD4-30W		N 70.2930°	W 150.9829°
CD4-31E	201+37	N 70.2928°	W 150.9827°
CD4-31W		N 70.2930°	W 150.9830°
CD4-32E	202+88	N 70.2928°	W 150.9828°
CD4-32W		N 70.2930°	W 150.9832°
CD4-33E	202+88	N 70.2926°	W 150.9838°
CD4-33W		N 70.2928°	W 150.9841°
CD5-01E	14+08	N 70.3122°	W 151.2186°
CD5-01W		N 70.3121°	W 151.2190°
CD5-02E	28+83	N 70.3083°	W 151.2161°
CD5-02W		N 70.3082°	W 151.2166°
CD5-03E	31+50	N 70.3076°	W 151.2153°
CD5-03W		N 70.3075°	W 151.2158°
CD5-04N	37+97	N 70.3060°	W 151.2134°
CD5-04S		N 70.3059°	W 151.2138°
CD5-05N	44+77	N 70.3047°	W 151.2103°
CD5-05S		N 70.3045°	W 151.2104°
CD5-06N	53+53	N 70.3051°	W 151.2036°
CD5-06S		N 70.3049°	W 151.2033°
CD5-07N	60+82	N 70.3059°	W 151.1984°
CD5-07S		N 70.3058°	W 151.1978°
CD5-08N	64+82	N 70.3064°	W 151.1953°
CD5-08S		N 70.3062°	W 151.1950°
CD5-09N	64+89	N 70.3064°	W 151.1952°
CD5-09S		N 70.3062°	W 151.1950°
CD5-10N	71+74	N 70.3072°	W 151.1900°
CD5-10S		N 70.3070°	W 151.1901°
CD5-11N	74+56	N 70.3074°	W 151.1881°
CD5-11S		N 70.3073°	W 151.1878°
CD5-12N	82+45	N 70.3082°	W 151.1821°
CD5-12S		N 70.3081°	W 151.1818°
CD5-13N	88+82	N 70.3089°	W 151.1774°
CD5-13S		N 70.3087°	W 151.1769°
CD5-14N	90+76	N 70.3090°	W 151.1757°
CD5-14S		N 70.3088°	W 151.1756°
CD5-15N	92+09	N 70.3091°	W 151.1746°
CD5-15S		N 70.3089°	W 151.1746°
CD5-16N	94+73	N 70.3090°	W 151.1724°
CD5-16S		N 70.3088°	W 151.1725°
CD5-17N	100+44	N 70.3083°	W 151.1683°
CD5-17S		N 70.3081°	W 151.1686°
CD5-18N	101+99	N 70.3079°	W 151.1673°
CD5-18S		N 70.3079°	W 151.1679°
CD5-19N	111+86	N 70.3056°	W 151.1634°
CD5-19S		N 70.3055°	W 151.1639°
CD5-20N	122+31	N 70.3037°	W 151.1578°
CD5-20S		N 70.3035°	W 151.1578°
CD5-21N	126+42	N 70.3035°	W 151.1545°

Culvert	Station	Latitude (NAD83)	Longitude (NAD83)
CD5-24N	153+63	N 70.3048°	W 151.1336°
CD5-24S		N 70.3046°	W 151.1331°
CD5-25N	160+11	N 70.3052°	W 151.1284°
CD5-25S		N 70.3050°	W 151.1280°
CD5-26N	179+13	N 70.3056°	W 151.1130°
CD5-26S		N 70.3054°	W 151.1129°
CD5-27N	188+59	N 70.3058°	W 151.1054°
CD5-27S		N 70.3056°	W 151.1052°
CD5-28N	196+71	N 70.3059°	W 151.0987°
CD5-28S		N 70.3057°	W 151.0987°
CD5-29N	201+40	N 70.3060°	W 151.0951°
CD5-29S		N 70.3058°	W 151.0948°
CD5-30N	205+72	N 70.3060°	W 151.0916°
CD5-30S		N 70.3058°	W 151.0913°
CD5-31N	209+46	N 70.3061°	W 151.0885°
CD5-31S		N 70.3059°	W 151.0883°
CD5-32N	216+78	N 70.3062°	W 151.0824°
CD5-32S		N 70.3060°	W 151.0826°
CD5-33N	216+86	N 70.3062°	W 151.0823°
CD5-33S		N 70.3060°	W 151.0825°
CD5-34N	225+38	N 70.3063°	W 151.0755°
CD5-34S		N 70.3061°	W 151.0755°
CD5-35N	234+35	N 70.3065°	W 151.0683°
CD5-35S		N 70.3063°	W 151.0683°
CD5-36N	239+00	N 70.3065°	W 151.0645°
CD5-36S		N 70.3064°	W 151.0645°
CD5-37N	245+56	N 70.3066°	W 151.0592°
CD5-37S		N 70.3065°	W 151.0592°
CD5-38N	249+12	N 70.3066°	W 151.0563°
CD5-38S		N 70.3064°	W 151.0564°
CD5-39N	254+23	N 70.3063°	W 151.0522°
CD5-39S		N 70.3060°	W 151.0525°
CD5-40N	265+63	N 70.3049°	W 151.0439°
CD5-40S		N 70.3047°	W 151.0441°
CD5-41N	272+56	N 70.3041°	W 151.0388°
CD5-41S		N 70.3039°	W 151.0391°
CD5-42N	276+40	N 70.3036°	W 151.0359°
CD5-42S		N 70.3035°	W 151.0365°
CD5-43N	322+30	N 70.3042°	W 151.0003°
CD5-43S		N 70.3040°	W 151.0003°



ConocoPhillips Alaska, Inc.

DATE:	11/14/2019	PROJECT:	171385
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

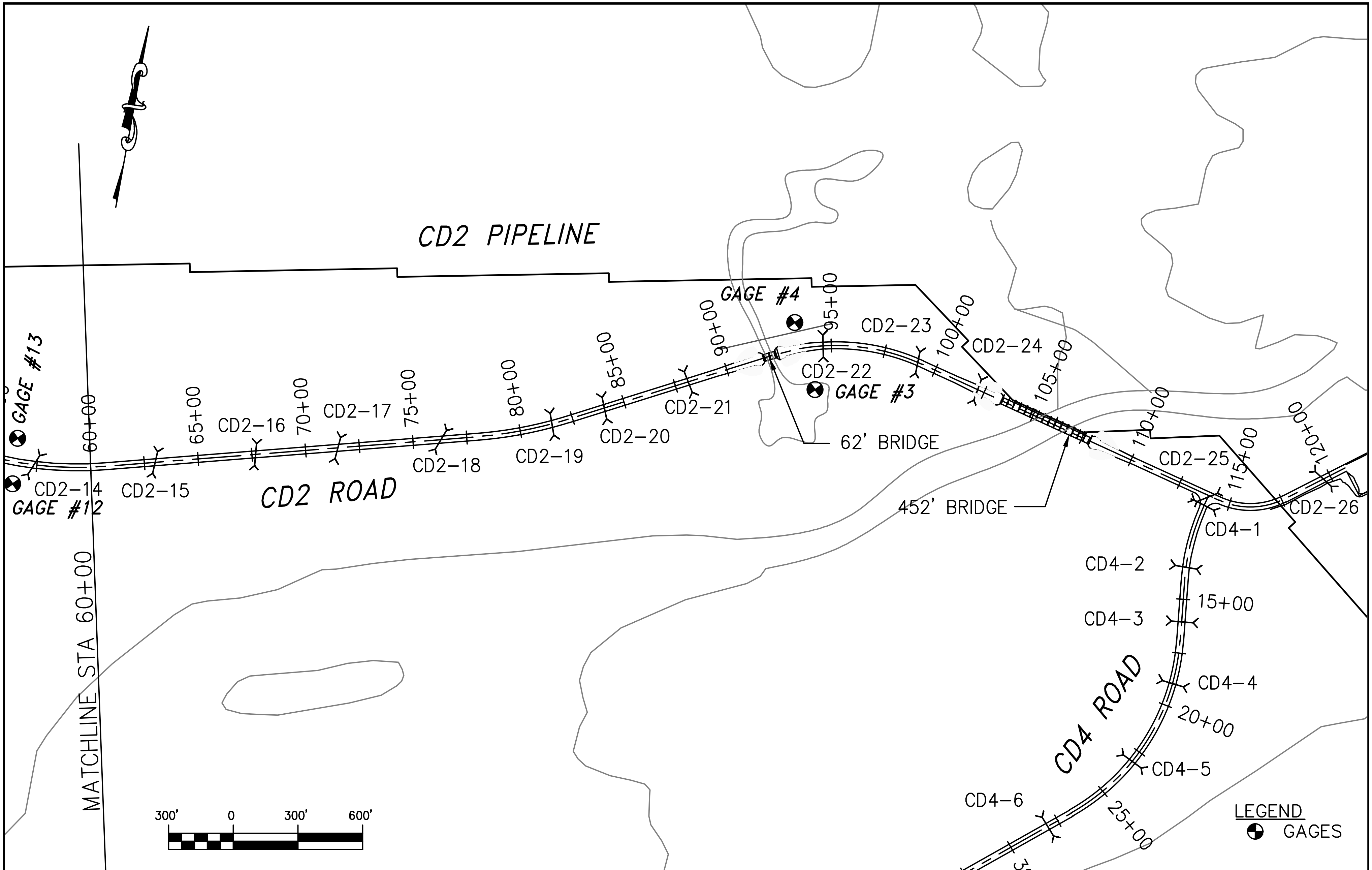
Michael Baker INTERNATIONAL
Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273–1600
Fax: (907) 273–1699

2019 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET 1 OF 13)



ConocoPhillips
Alaska, Inc.

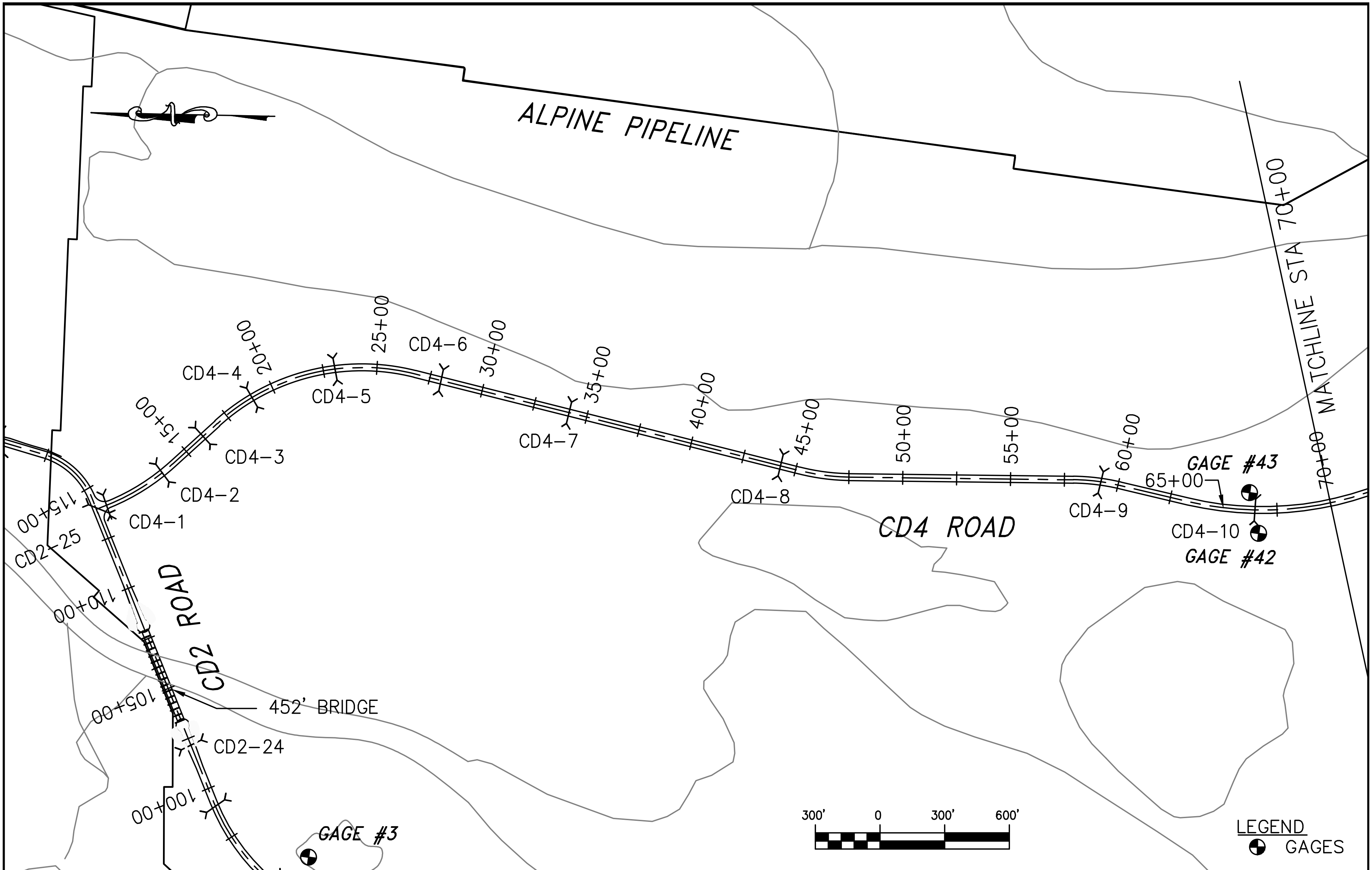
DATE: 11/14/2019	PROJECT: 171385
DRAWN: DTR	FILE: ALPINE_FACILITES.DWG
CHECKED: GCY	SCALE: AS SHOWN

Michael Baker INTERNATIONAL

Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273–1600
Fax: (907) 273–1699

2019 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 2 OF 13)



ConocoPhillips Alaska, Inc.

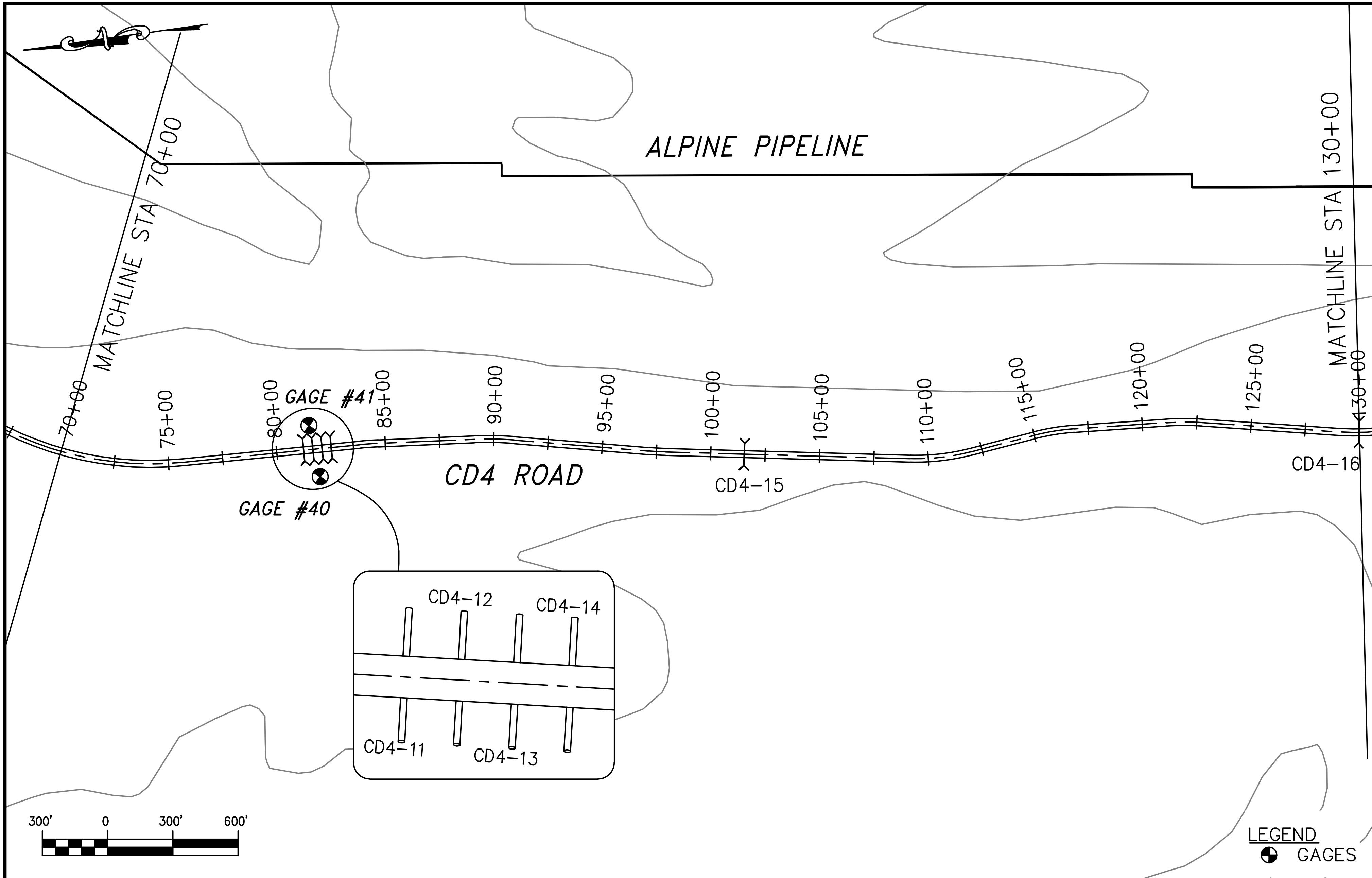
DATE:	11/14/2019	PROJECT:	171385
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker INTERNATIONAL

Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 3 OF 13)



ConocoPhillips Alaska, Inc.

DATE:	11/14/2019	PROJECT:	171385
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

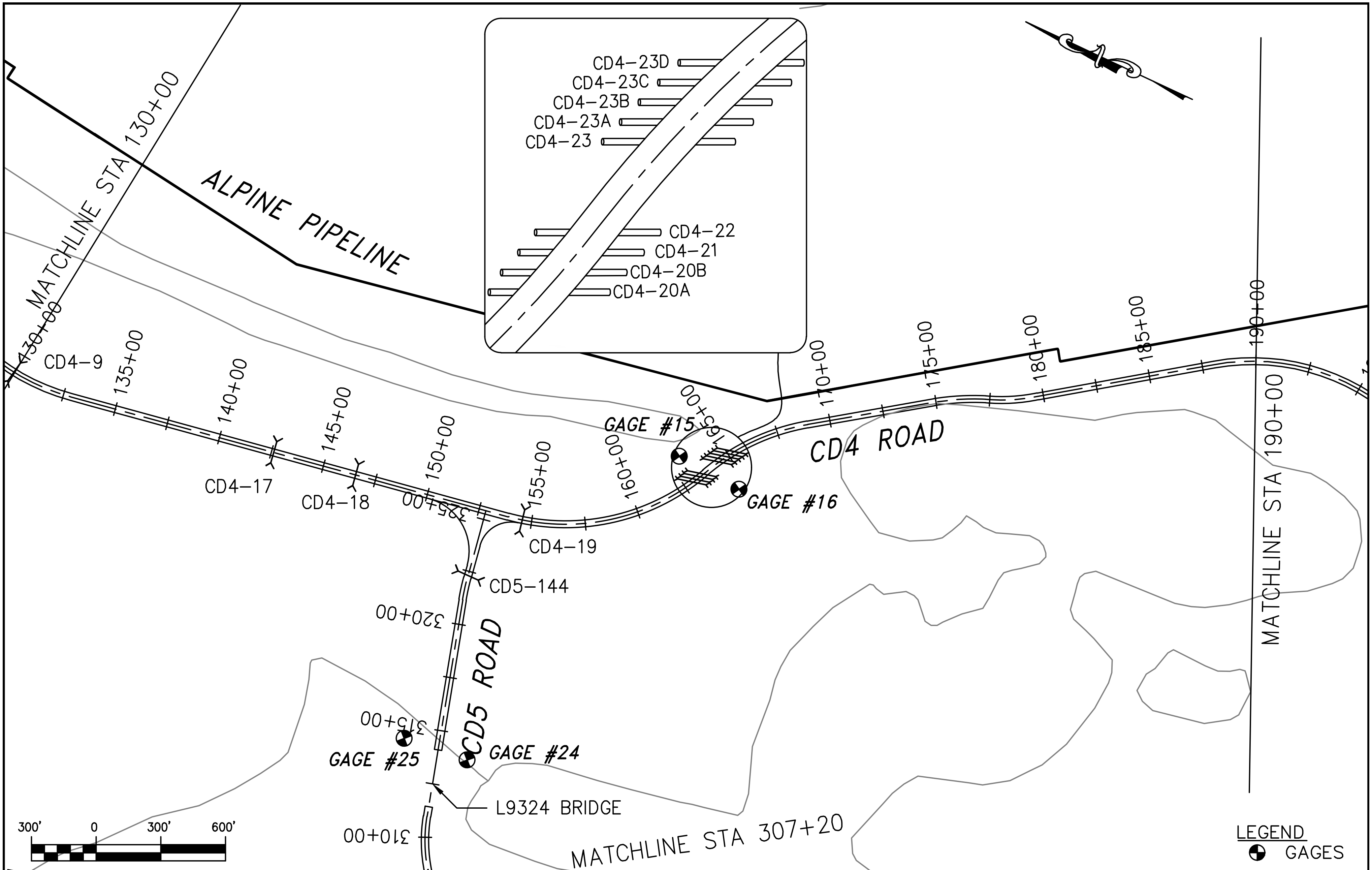
Michael Baker INTERNATIONAL
Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273–1600
Fax: (907) 273–1699

2019 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET 4 OF 13)



ConocoPhillips
Alaska, Inc.

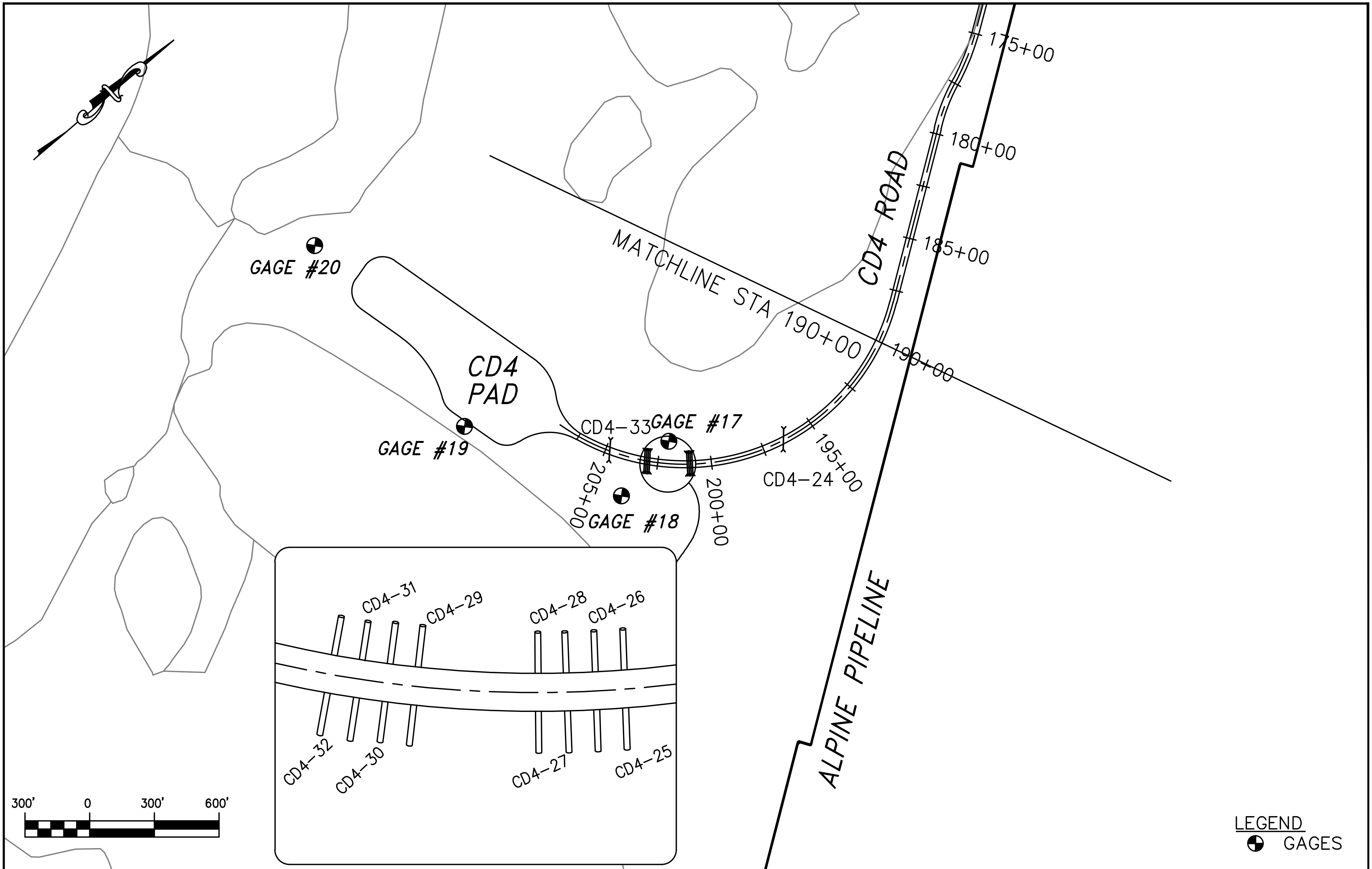
DATE:	11/14/2019	PROJECT:	171385
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker INTERNATIONAL

Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 5 OF 13)



ConocoPhillips
Alaska, Inc.

DATE:	11/14/2019	PROJECT:	171385
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

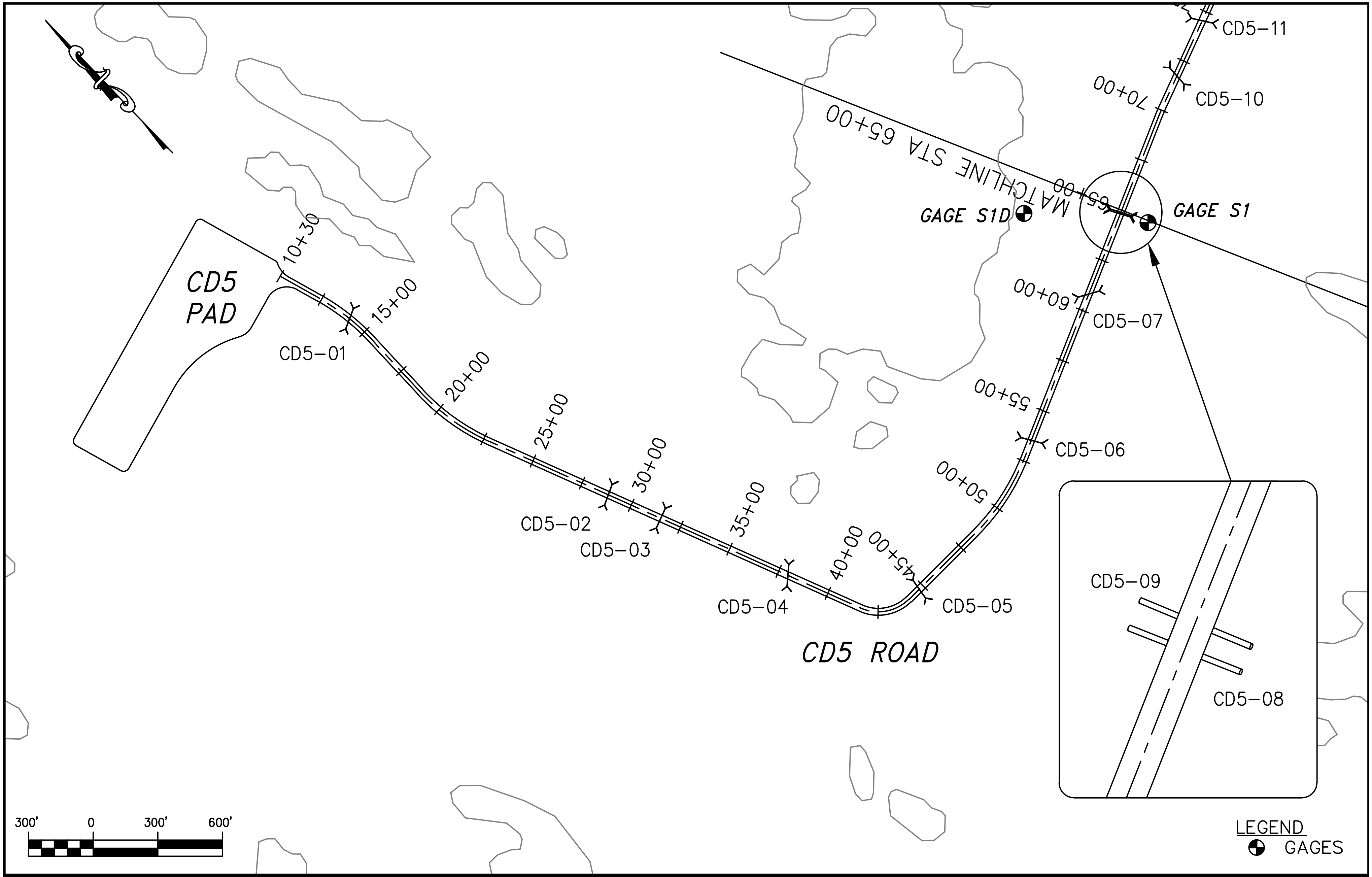
Michael Baker INTERNATIONAL
Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273–1600
Fax: (907) 273–1699

2019 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET 6 OF 13)



ConocoPhillips Alaska, Inc.

DATE:	11/14/2019	PROJECT:	171385
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

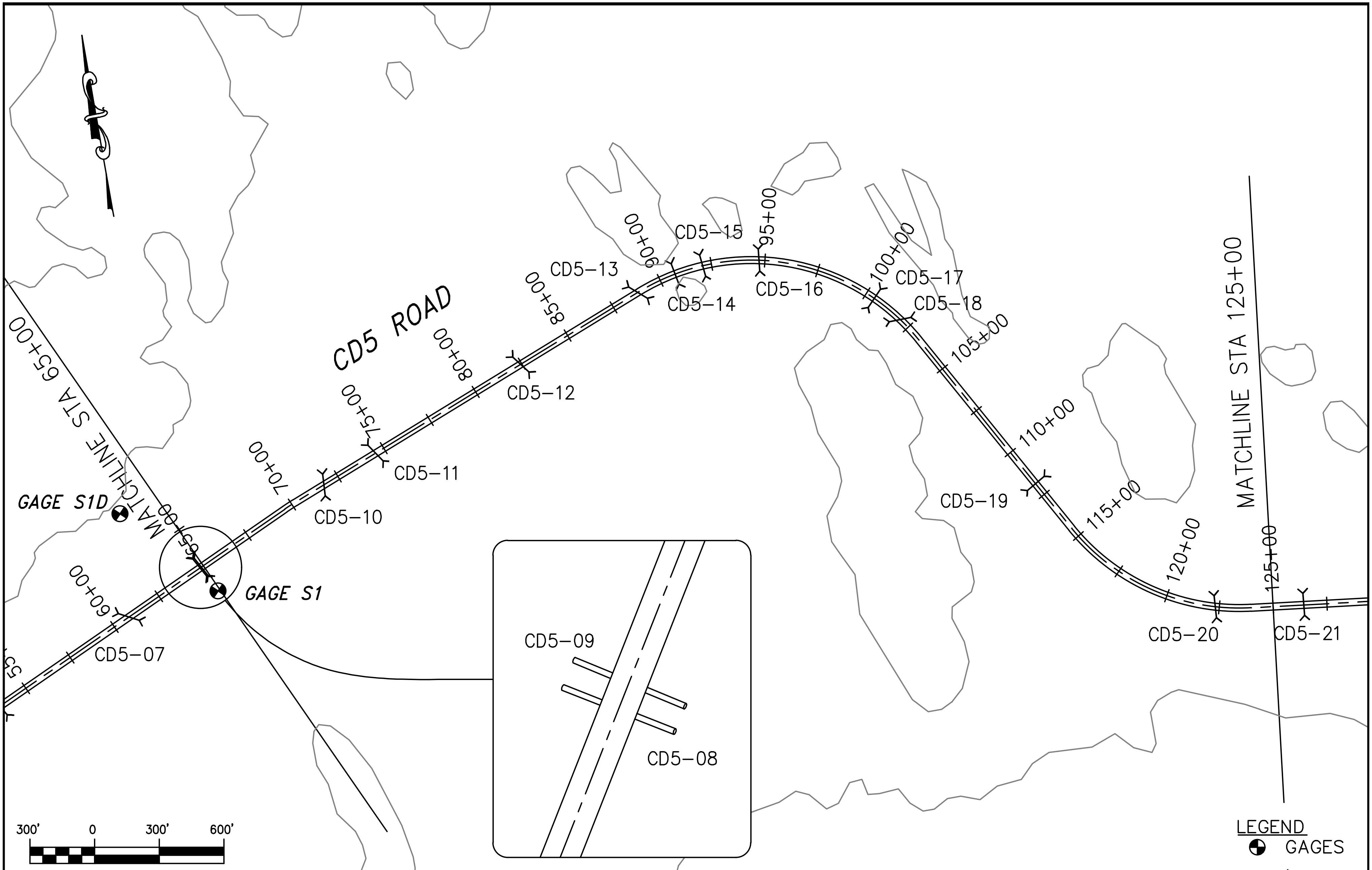
Michael Baker INTERNATIONAL

Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273–1600
Fax: (907) 273–1699

2019 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION



ConocoPhillips
Alaska, Inc.

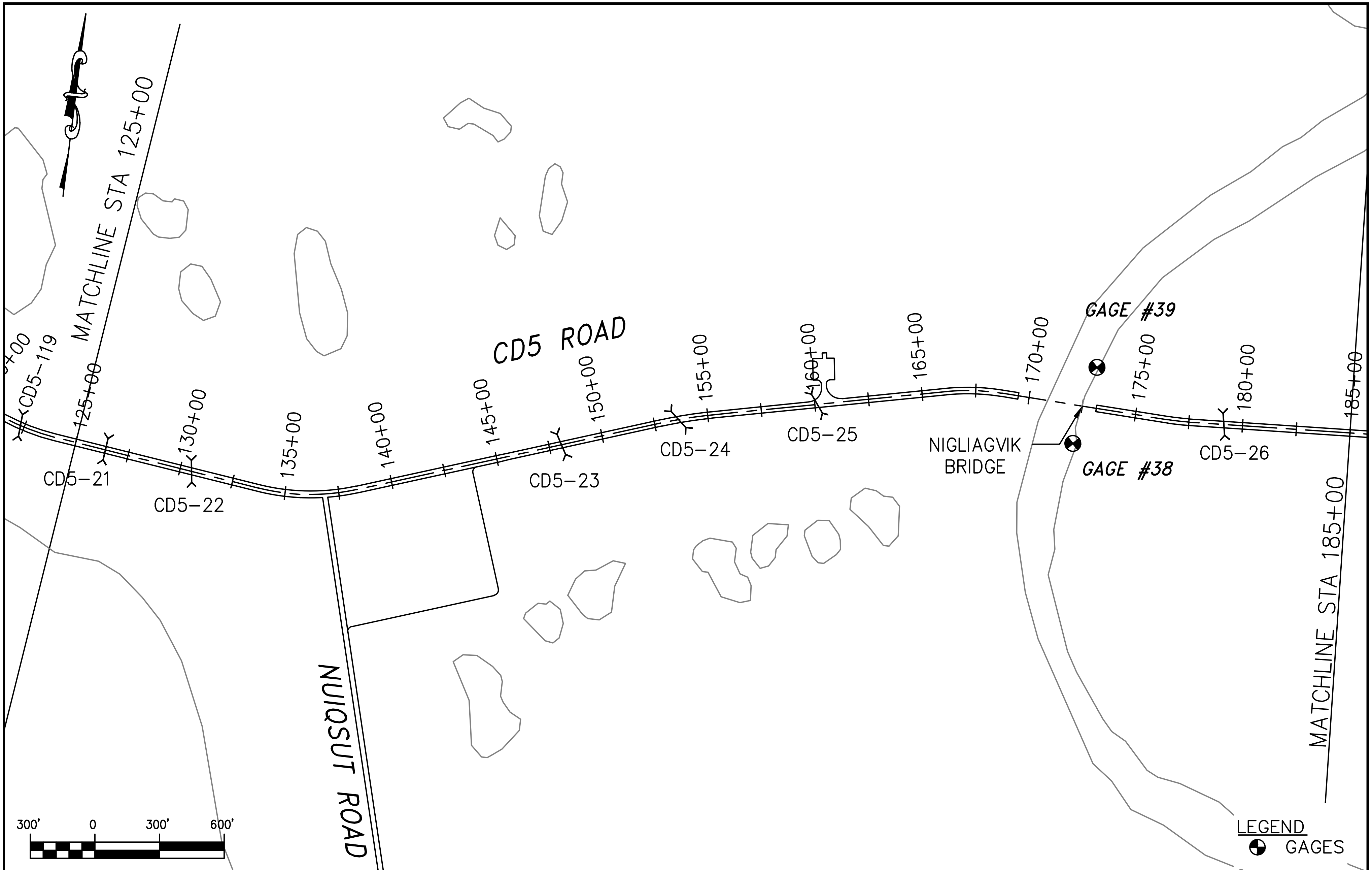
DATE:	11/14/2019	PROJECT:	171385
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker INTERNATIONAL

Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273–1600
Fax: (907) 273–1699

2019 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 8 OF 13)



ConocoPhillips Alaska, Inc.

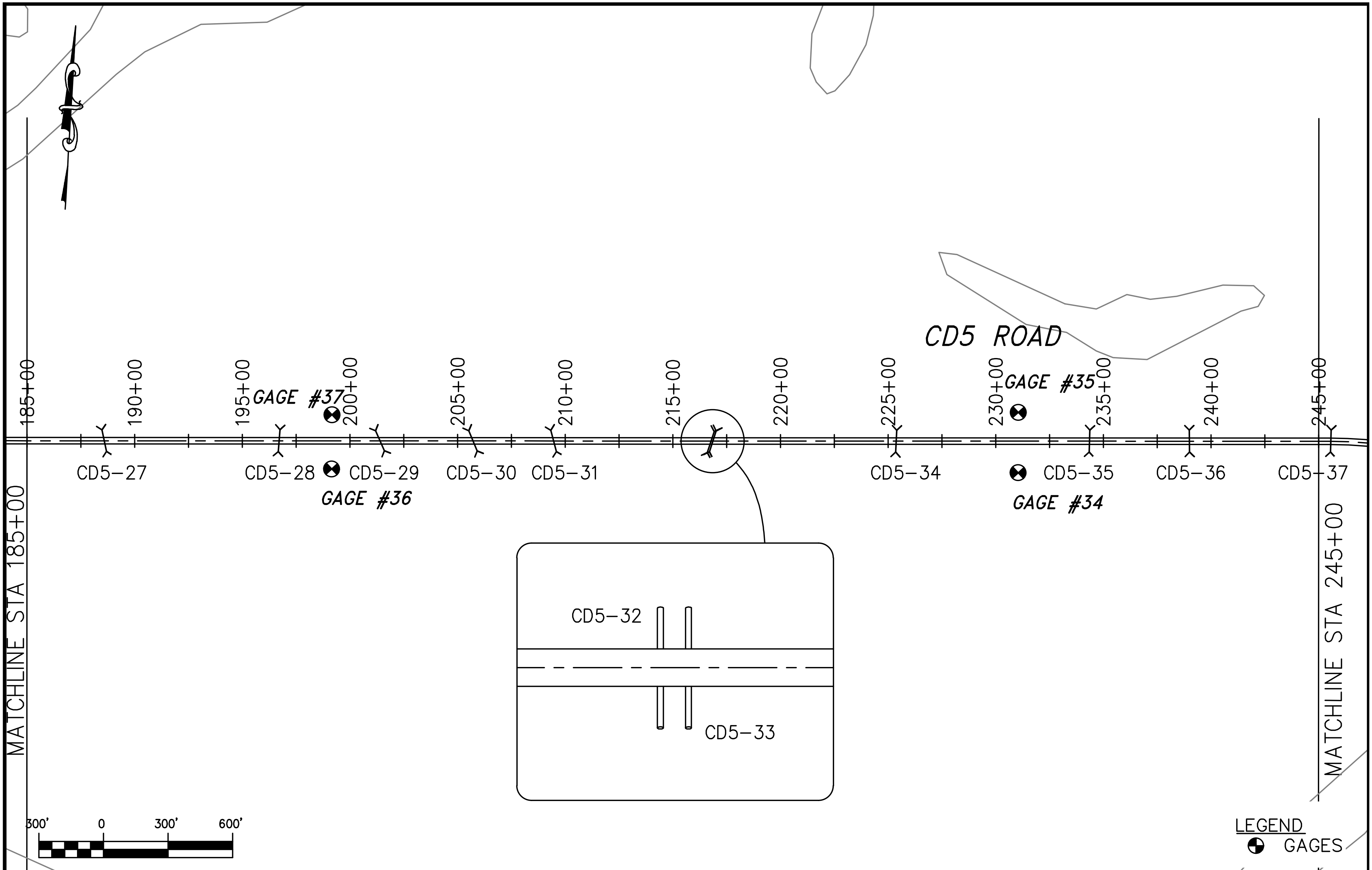
DATE:	11/14/2019	PROJECT:	171385
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker INTERNATIONAL
Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION



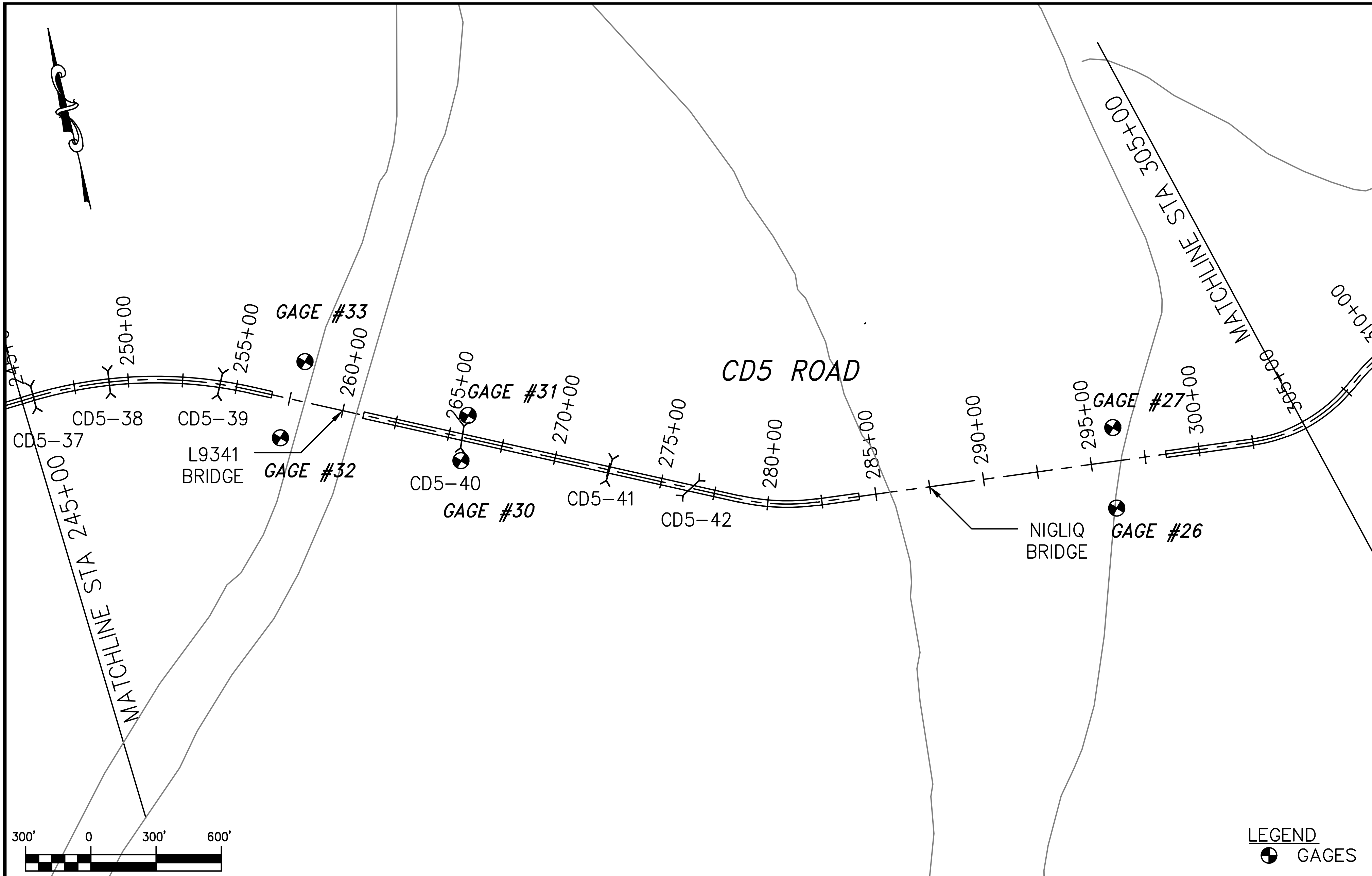
ConocoPhillips Alaska, Inc.

DATE: 11/14/2019	PROJECT: 171385
DRAWN: DTR	FILE: ALPINE_FACILITES.DWG
CHECKED: GCY	SCALE: AS SHOWN

Michael Baker INTERNATIONAL
Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273–1600
Fax: (907) 273–1699

2019 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET10 OF 13)



ConocoPhillips
Alaska, Inc.

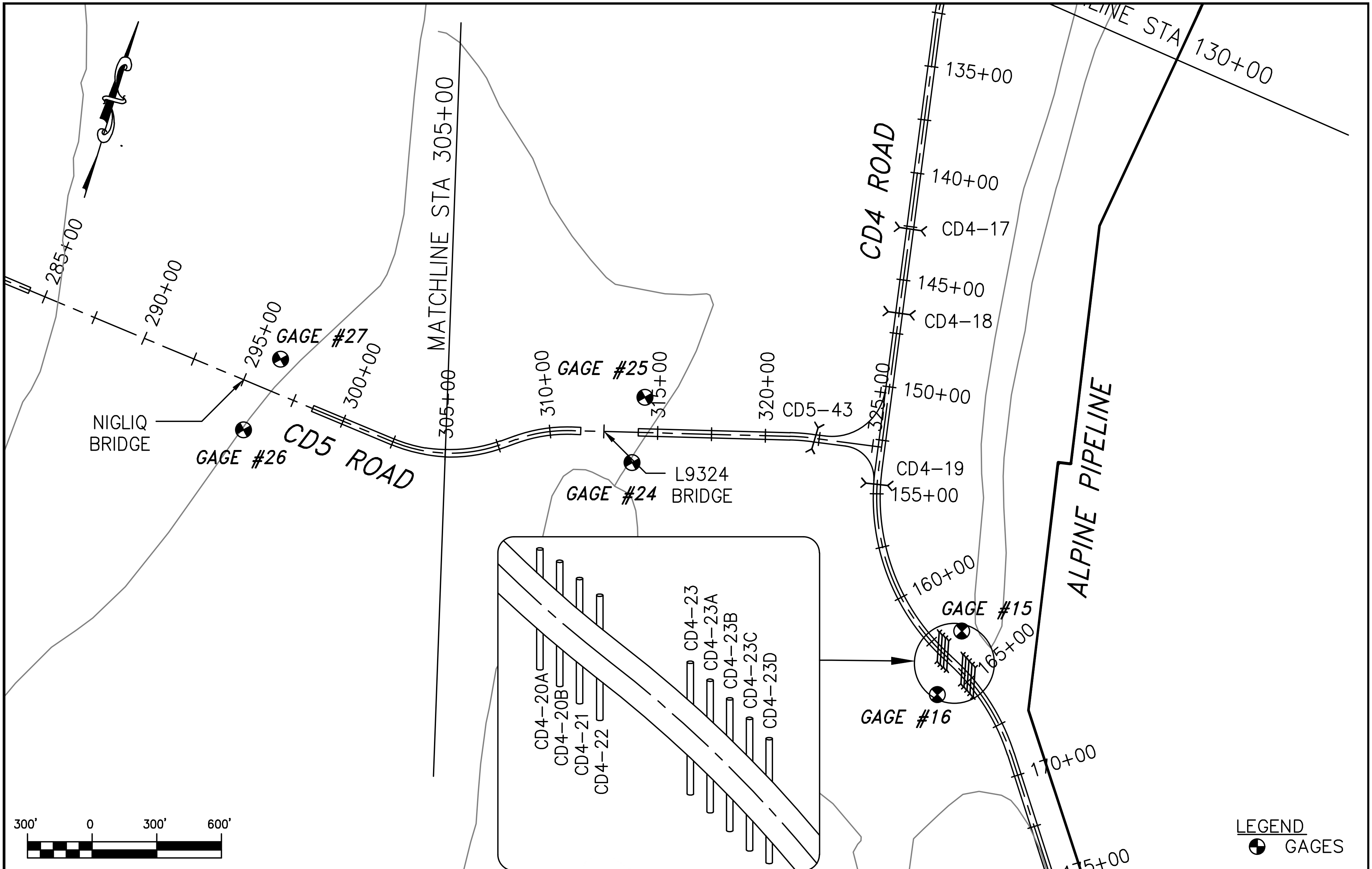
DATE:	11/14/2019	PROJECT:	171385
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker
INTERNATIONAL

Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET11 OF 13)



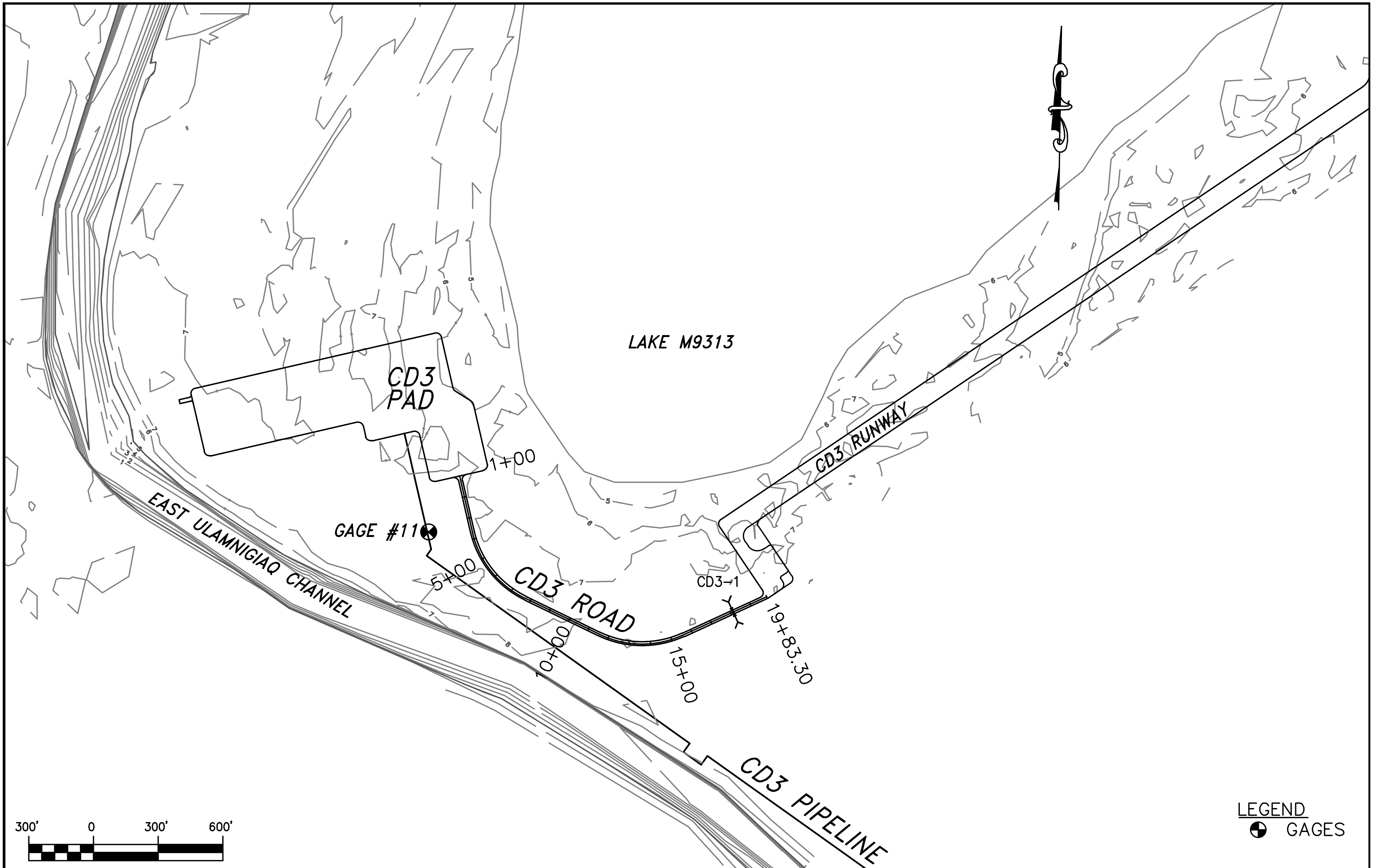
ConocoPhillips Alaska, Inc.

DATE: 11/14/2019	PROJECT: 171385
DRAWN: DTR	FILE: ALPINE_FACILITES.DWG
CHECKED: GCY	SCALE: AS SHOWN

Michael Baker INTERNATIONAL
Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET12 OF 13)



ConocoPhillips Alaska, Inc.

DATE:	11/14/2019	PROJECT:	171385
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker INTERNATIONAL

Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET13 OF 13)

APPENDIX B PT SETUP & TESTING METHODS

PTs measure the absolute pressure of the atmosphere and water, allowing the depth of water above the sensor to be calculated. Resulting data yield a comprehensive record of the fluctuations in stage. The reported pressure is the sum of the forces imparted by the water column and atmospheric conditions. Variations in local barometric pressure were taken into account using a Solinst Barologger® barometric pressure logger. A correction of barometric pressure was obtained from the Solinst Levelogger installed at the Tinmiaqsiugvik Bridge.

The PTs were tested before field mobilization. The PTs were configured using Solinst Levelogger® v4.0.3 (for both the Solinst Leveloggers and Barologgers) software prior to placement in the field. Absolute pressure was set to zero. The PT sensor was surveyed during setup to establish a vertical datum using local control.

PT-based stage values were determined by adding the calculated water depth and the surveyed sensor elevation. PTs have the potential to drift and can be affected by ice and sediment. Gage WSE readings were used to validate and adjust the data collected by the PTs. A standard conversion using the density of water at 0°C was used to calculate all water depths from adjusted gage pressures. Fluctuations in water temperature during the sampling period did not affect WSE calculations because of the limited range in temperature and observed water depths

APPENDIX C DISCHARGE METHODS, SITE SPECIFIC INFORMATION, & PLAN & PROFILE DRAWINGS

C.1 METHODS

C.1.1 MEASURED DISCHARGE

1) USGS Midsection Technique

Bridge flow depth and velocity measurements were taken from the upstream side of bridge decks using a sounding reel mounted on a USGS Type A crane with 4-wheel truck. A Price AA velocity meter was attached to the sounding reel and stabilized with a counter weight. A tag line was placed along the bridge rail to define the cross section and to delineate measurement subsections within the channel. The standard rating table No.2 for Price AA velocity meters, developed by the USGS Office of Surface Water (OSW) Hydraulic Laboratory as announced in the OSW Technical Memorandum No. 99.05 (OSW 1999a), was used to convert revolutions to stream velocity. The Price AA velocity meter was serviced prior to spring breakup monitoring in accordance with USGS precise standards. A spin test of the meter was completed prior to and after each measurement. Procedures outlined in OSW Technical Memorandum No. 99.06 (OSW 1999b) were followed to confirm accurate meter performance. Discharge was calculated based on velocity and flow depth.

2) USGS Velocity/Area Technique

Standard USGS velocity/area techniques (USGS 1968) were used to measure depth of flow and velocity to determine discharge at each culvert experiencing flow. Depth of flow and velocity were measured on the downstream end of the culvert using a HACH FH950 electromagnetic velocity meter attached to a wading rod. The accuracy of the HACH meter is ± 2% of the reading, ± 0.05 ft/s between 0 ft/s and 10 ft/s, and ± 4% of the reading from between 10 ft/s and 16 ft/s. Discharge was calculated based on velocity, flow depth, and culvert geometry.

3) ADCP METHODS

A direct discharge measurement was performed at the Nigliq Bridge on May 26 using an Acoustic Doppler Current Profiler (ADCP). Discharge was not measured in the Colville River at MON1 because of lack of access during peak conditions.

A. HARDWARE & SOFTWARE

A Teledyne RD Instruments 600-kilohertz Workhorse Sentinel broadband ADCP was used. The unit has a phased array, Janus four-beam transducer with a 20-degree beam angle. The ADCP unit and supporting laptop (Panasonic Toughbook CF-19) were self-powered via internal batteries.

BBTalk v3.06, a DOS-based communication program, was used to perform pre-deployment tests. WinRiverII v2.18 was used to configure, initiate, and communicate with the ADCP while on the river. WinRiverII was also used to review and evaluate collected discharge data after returning from the field.

B. PRE-DEPLOYMENT TESTING

Prior to deployment of the ADCP unit, a full suite of tests were run in accordance with the manufacturer's instructions using BBTalk. The tests confirmed the signal path and all major signal processing subsystems were functioning properly. Tests also confirmed accurate tilt and pitch readings. A beam continuity test was performed to verify the transducer beams were connected and operational. Additional diagnostic tests were performed using WinRiverII. Pre-deployment tasks also included compass calibration and verification and a moving bed test. The internal compass was calibrated to an error of 1.9°, which is within the specified 5° limit. A loop test was performed to detect and estimate compensation for a moving bed, which was identified at a velcoity of 0.073 ft/s.

C. ADCP DEPLOYMENT & DATA COLLECTION

The Workhorse Sentinel ADCP was mounted to an Achilles SGX-132 inflatable raft powered by a Tohatsu 9.8 horsepower outboard motor. A fabricated aluminum tube framework spanning the boat's gunwales provided a rigid and secure placement of the ADCP unit, and allowed necessary navigation adjustments as river conditions required.

The discharge measurement was performed approximately 1,100-ft downstream of the Nigliq Bridge, between gages G27 and G29. Cross section end points were marked with handheld GPS units having wide area augmentation system enabled accuracy. The position of the boat was determined by tracking the bottom of the channel with the ADCP. Distances to the right and left edge of water from respective end points were estimated from GPS coordinates.

The four most agreeing of a total of six transects were used. The measured discharges varied by 0.00%, which is less than the standard 5% of their mean. Cross section end points were dependent on a depth associated with a minimum of two good bins to provide acceptable data.

D. ADCP BACKGROUND & DATA PROCESSING

An ADCP measures the velocity of particles in the water. Particles, on average, move at the same horizontal velocity of the water relative to the ADCP unit. The velocity of flow is then calculated relative to the earth, based on the simultaneous velocity and position of the boat. The velocity and position of the boat were recorded by tracking the bottom of the channel with the ADCP unit.

The Nigliq Channel bed is composed of fine-grained sediment, and water velocities are sufficient to entrain the materials resulting in a moving river bed condition. When using bottom tracking, a moving bed can affect the accuracy of the results by biasing the velocity and discharge lower than actual values. This phenomenon can be eliminated with the use of either a differential global positioning system (DGPS), the loop method (USGS 2006). To account for the bias introduced by a moving bed, the loop method was employed.

The loop method is a technique to determine whether a moving bed is present and, if present, to provide an approximate correction to the final discharge value. The USGS established guidance for the loop method by outlining procedures for mean correction and distributed correction (USGS 2006). Both procedures yield results within 2 percent of the actual discharge, as measured using DGPS. Since a moving bed was identified, the mean correction procedure was applied to the because of the simple geometry of the channel cross section. The results of the loop test, performed during discharge measurements, was used to estimate the mean velocity of the moving bed. The mean velocity was multiplied by the cross-sectional area perpendicular to the mean observed flow to yield a discharge correction. The resulting correction was applied to each transect, and the resulting direct discharge measurement was determined by averaging the corrected discharge measurements.

C.1.2 PEAK DISCHARGE

1) Culverts

Bentley CulvertMaster® software was used to calculate peak discharge through the CRD road culverts associated with gage stations that experienced flow. Timing and magnitude of peak discharge through the culverts was determined based on recorded stage on both sides of the road prism. Peak discharge results were evaluated against visual assessment of performance. Average velocity and discharge through the culverts assumes ice-free open-water conditions and were estimated based on several variables, including:

- Headwater and tailwater elevations at each culvert (hydraulic gradient)
- Culvert diameter and length from UMIAQ as-built surveys (UMIAQ 2002, 2017)
- Culvert upstream and downstream invert elevations (UMIAQ 2017, 2019d)
- Culvert Manning's roughness coefficients (0.013 for smooth steel and 0.024 for corrugated metal pipe)

2) Streams

Peak discharge in streams was calculated indirectly using either the Slope Area (Benson and Dalrymple 1967) or the Normal Depth (Chow 1959) method. Both methods use channel roughness, cross sectional geometry, and stage differential between gage sites as an estimate for the energy grade line. The methods differ by the number of cross sections used in the calculations. The Slope Area method is considered the standard for indirect discharge calculations and is generally used if sufficient stage data is available for multiple cross-sections through a reach. The accuracy of each method, however, depends on conditions at the time of calculation, particularly the presence of ribbon and bottom-fast ice, ice jam activity, and backwater effects. Direct discharge measurements at or near the time of peak can support calibration and accuracy of indirect calculations.

The Slope Area method was used to estimate peak discharge at MON1, using the cross sections surveyed at MON1U, MON1C, and MON1D.

The Normal Depth method was used to estimate peak discharge at MON9 and the Nigliq Bridge crossing because they each only have a single surveyed cross-section.

Cross sectional geometry for MON1 is current as of 2004 (UMIAQ 2004), MON9 is current as of 2014 (UMIAQ 2014), Nigliq Bridge (CD5 Bridge #2) is current as of 2016 (UMIAQ 2016a). Cross-sectional geometry data was collected in the summer at all locations and does not account for bank-fast or bottom-fast ice or snow. Additionally, because of channel bed morphology, cross sectional geometry becomes less accurate with time, particularly for those CRD channels that are predominantly comprised of fine grained. Stage and energy gradient data were obtained from observations, gage data, and PT data.

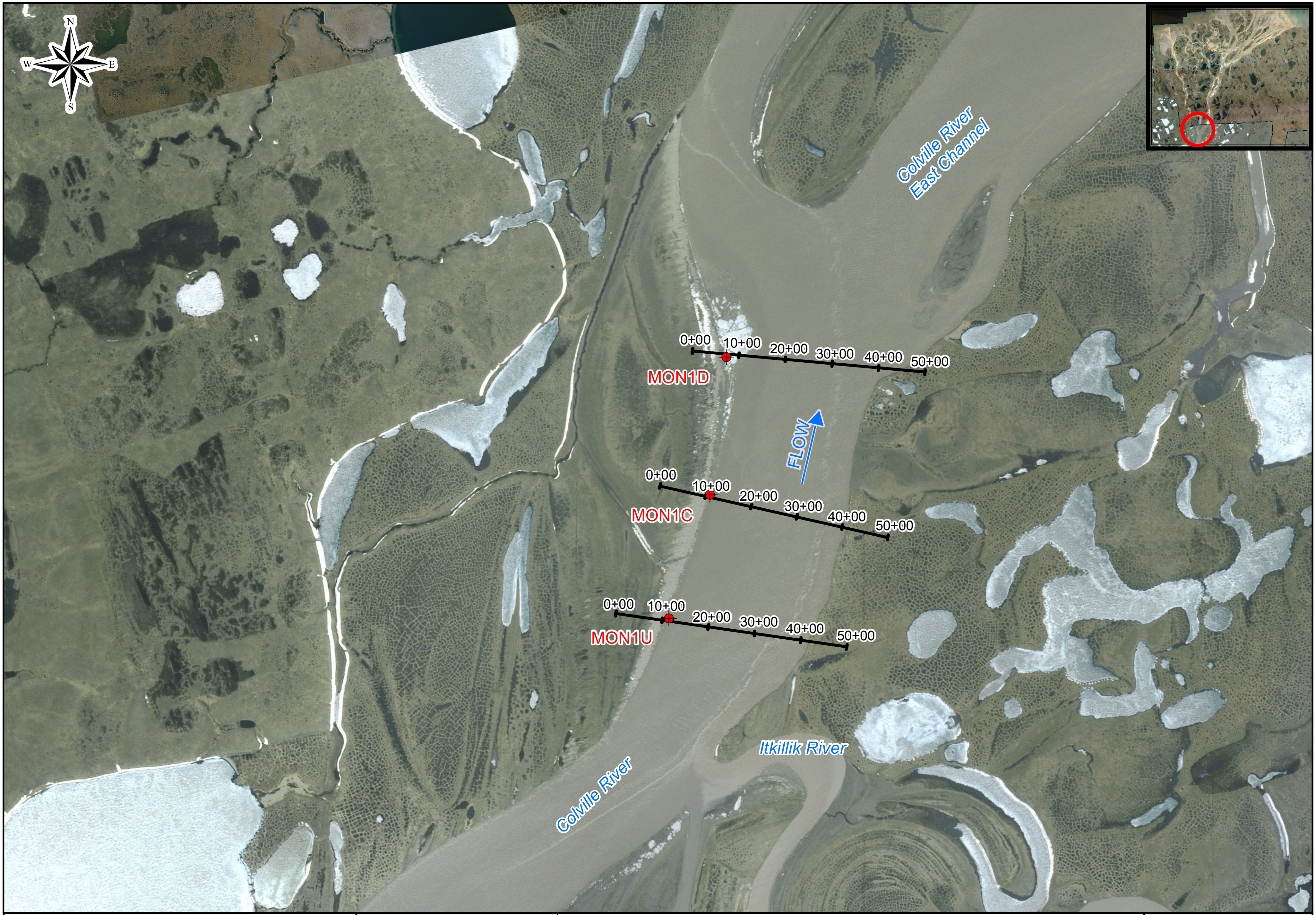
Peak discharge was not calculated at the Lake L9323 bridge (CD5 Bridge #1), Lake L9341 bridge (CD5 bridge #2), or the Nigliagvik bridge (CD5 Bridge #4). There was no flow to pass though the Lake L9323 bridge; there was only limited backwater flow passing through the Lake L9341 bridge which was additionally under the significant influence of competent lake ice; and the PT failed at the Nigliagvik bridge which did not allow for calculation during peak conditions.

C.2 Site Specific Data & Plan & Profile Drawings

C.2.1 MON1

1) PEAK DISCHARGE DATA

Peak discharge at MON1 was calculated indirectly using the Slope Area method. The Slope Area method is considered to be a more refined approach than the Normal Depth method and can be used when sufficient stage data is available to characterize discharge at more than one cross-section. The energy grade-line was approximated by the average water surface slope between MON1U, MON1C, and MON1D. Manning's n roughness values used were 0.0256 for the main channel and 0.06 for the overbanks, based on historical calibration of measured discharge and corresponding stage.



ConocoPhillips
Alaska

Miles
0 0.25 0.5

Date: 11/14/2019	Project: 171385
Drawn: BTG	File: 2019_CRD_8x11L_Mon1.mxd
Checked: GCY	Scale: 1 in = .5 miles

Legend

Gage Location

2004 Cross Section Alignment

Imagery Source: GeoNorth WMS

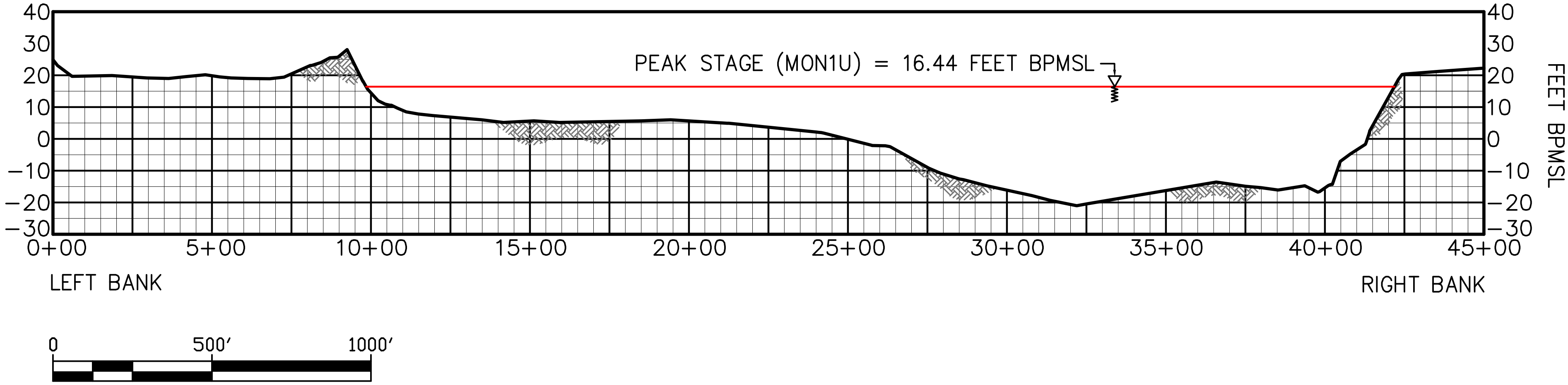
Michael Baker
INTERNATIONAL

Michael Baker International
3900 C Street, Suite 900
Anchorage, AK 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 SPRING BREAKUP
MONUMENT 1
PLAN

(SHEET 1 of 4)

NOTES
1. BASIS OF ELEVATION, MONUMENT 1.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED AUGUST 2004 BY UMIAQ (KUUKPIK/LCMF INC.)



1U COLVILLE RIVER AT MON1 UPSTREAM CROSS-SECTION

ConocoPhillips Alaska, Inc.

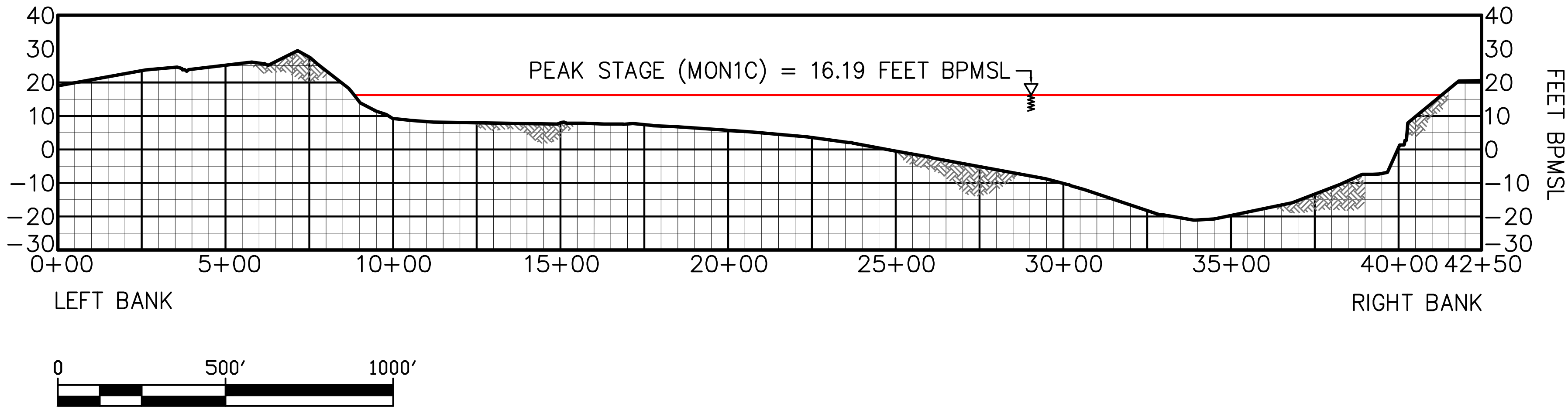
DATE:	11/14/2019	PROJECT:	171385
DRAWN:	HLR	FILE:	MON1 X-SECTIONS.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker INTERNATIONAL
Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 SPRING BREAKUP
MONUMENT 1 UPSTREAM
PROFILE

NUMBER
(SHEET 4 OF 4)

NOTES
1. BASIS OF ELEVATION, MONUMENT 1.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED AUGUST 2004 BY UMIAQ (KUUKPIK/LCMF INC.)



1C COLVILLE RIVER AT MON1 CENTERLINE CROSS−SECTION

ConocoPhillips
Alaska, Inc.

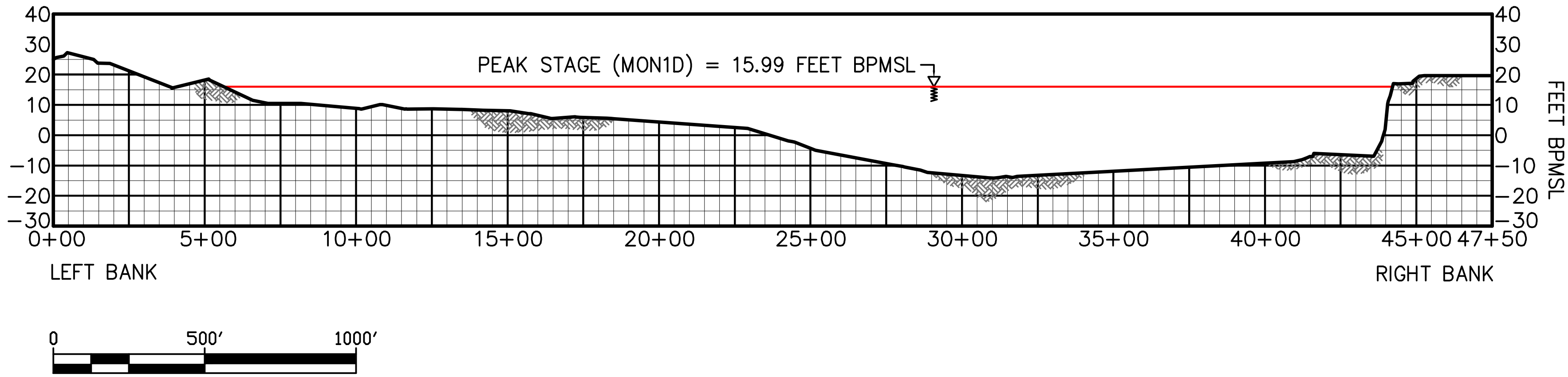
DATE:	11/14/2019	PROJECT:	171385
DRAWN:	HLR	FILE:	MON1 X-SECTIONS.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker INTERNATIONAL
Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273−1600
Fax: (907) 273−1699

2019 SPRING BREAKUP
MONUMENT 1 CENTERLINE
PROFILE

(SHEET 3 OF 4)

NOTES
1. BASIS OF ELEVATION, MONUMENT 1.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED AUGUST 2004 BY UMIAQ (KUUKPIK/LCMF INC.)



1D COLVILLE RIVER AT MON1 DOWNSTREAM CROSS–SECTION

ConocoPhillips Alaska, Inc.

DATE:	11/14/2019	PROJECT:	171385
DRAWN:	HLR	FILE:	MON1 X-SECTIONS.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker INTERNATIONAL
Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273–1600
Fax: (907) 273–1699

2019 SPRING BREAKUP
MONUMENT 1 DOWNSTREAM
PROFILE

C.2.2 MON9

1) PEAK DISCHARGE DATA

Peak discharge at MON9 was calculated using the Normal Depth method. The energy grade-line was approximated by the water surface slope between MON9 and MON9D. Manning's n roughness values used were 0.021 for the low flow channel and 0.023 for the main channel.

2) PLAN & PROFILE

ConocoPhillips Alaska

Feet
0 500 1,000

Date: 11/14/2019	Project: 171385
Drawn: BTG	File: 2019_CRD_8x11L_Mon9.mxd
Checked: GCY	Scale: 1 in = 1000 feet

Legend

- Gage Location
- 2009 Cross Section Alignment
- Pipeline

Imagery Source: ConocoPhillips Alaska, 2015

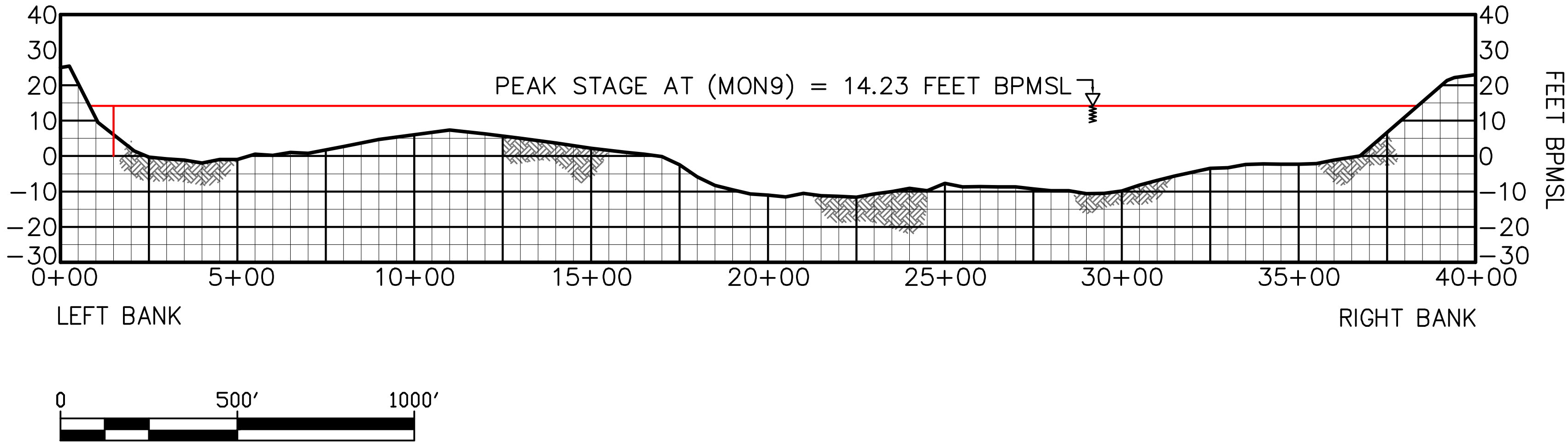
Michael Baker INTERNATIONAL

Michael Baker International
3900 C Street, Suite 900
Anchorage, AK 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 SPRING BREAKUP
Monument 9 / HDD
PLAN

(SHEET 1 of 2)

NOTES
1. BASIS OF ELEVATION, MONUMENT 9.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED NOVEMBER 2009 BY UMIAQ (KUUKPIK/LCMF INC.)



1 COLVILLE EAST CHANNEL AT MON9 CROSS–SECTION

ConocoPhillips
Alaska, Inc.

DATE:	11/14/2019	PROJECT:	171385
DRAWN:	HLR	FILE:	MON9 X-SECTION.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker INTERNATIONAL
Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273–1600
Fax: (907) 273–1699

2019 SPRING BREAKUP
MONUMENT 9 / HDD
PROFILE

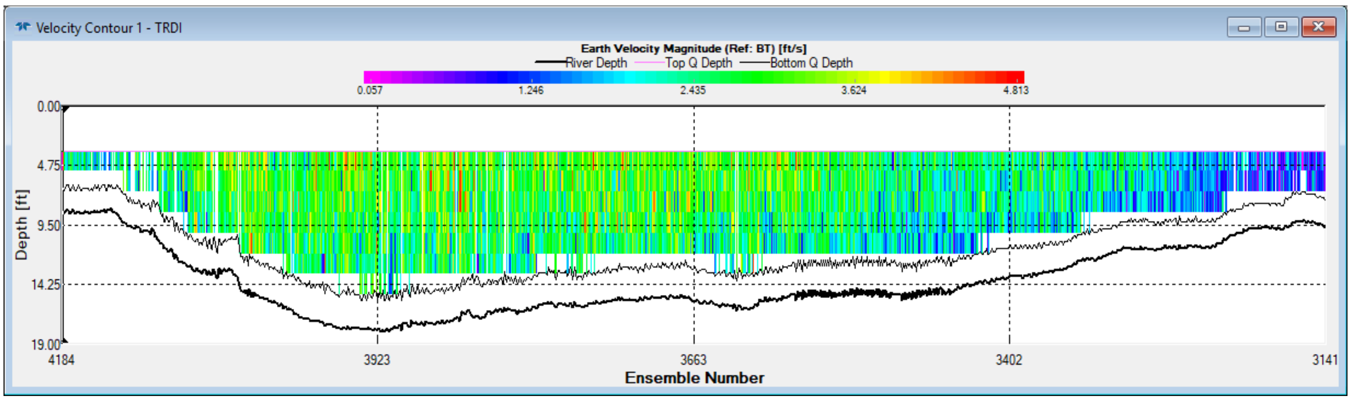
(SHEET 2 OF 2)

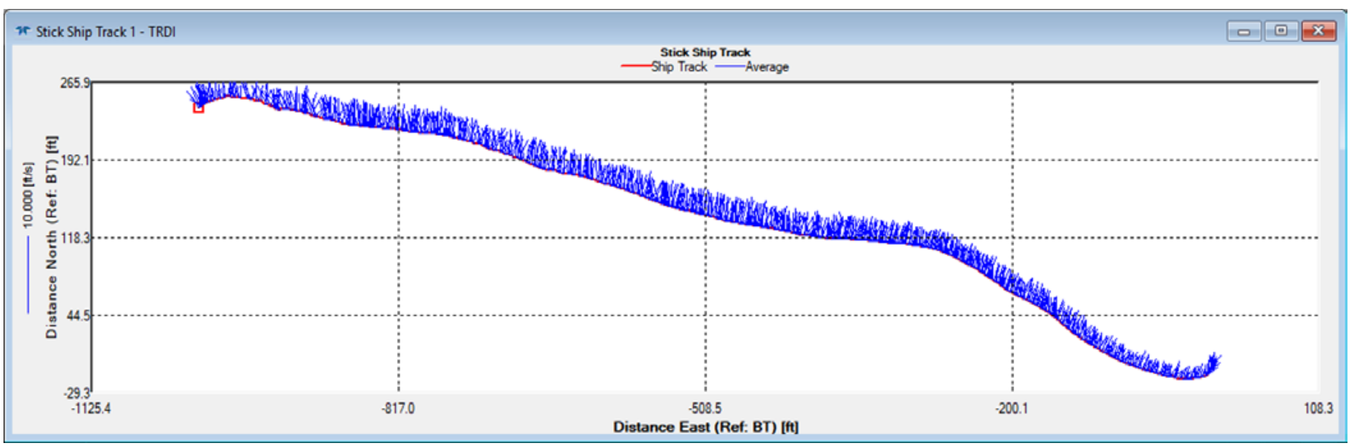
C.2.3 NIGLIQ BRIDGE

1) MAY 26 SPRING BREAKUP MEASURED DISCHARGE SUMMARY

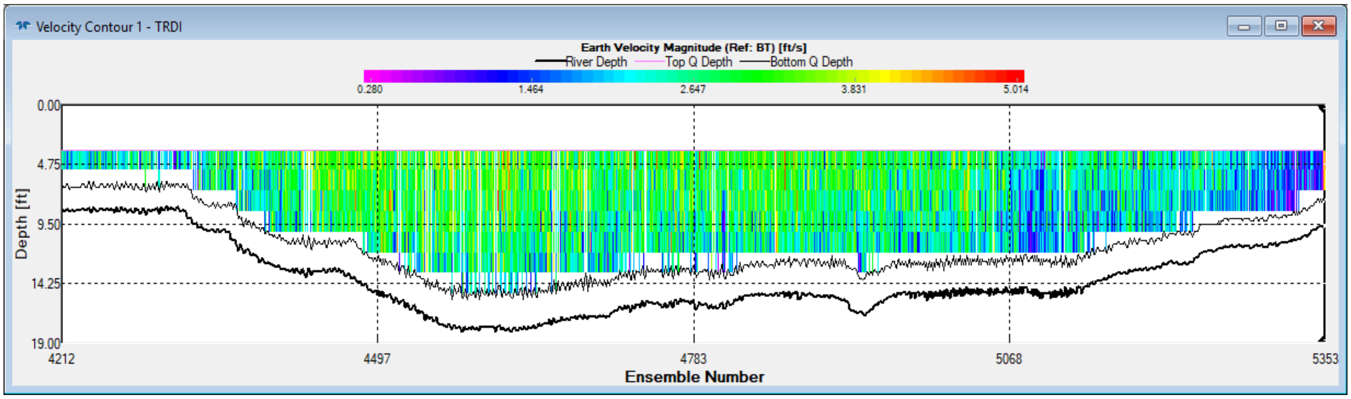
Transect	Area (ft^2)	Unadjusted Measured Discharge (cfs)	Discharge Correction Attributed to Moving Bed (cfs)	Adjusted Measured Discharge (cfs)	Error	Average Velocity (ft/s)
Downstream001 at 18:56	14,990	36,967	1,094	38,061	0.46%	2.54
Downstream002 at 19:03	14,648	37,186	1,069	38,255	0.97%	2.61
Downstream004 at 19:13	14,788	36,338	1,080	37,417	-1.24%	2.53
Downstream005 at 19:20	14,644	36,748	1,069	37,817	-0.19%	2.58
Average	**14,768**	**36,810**	**1,078**	**37,888**	**--**	**2.57**

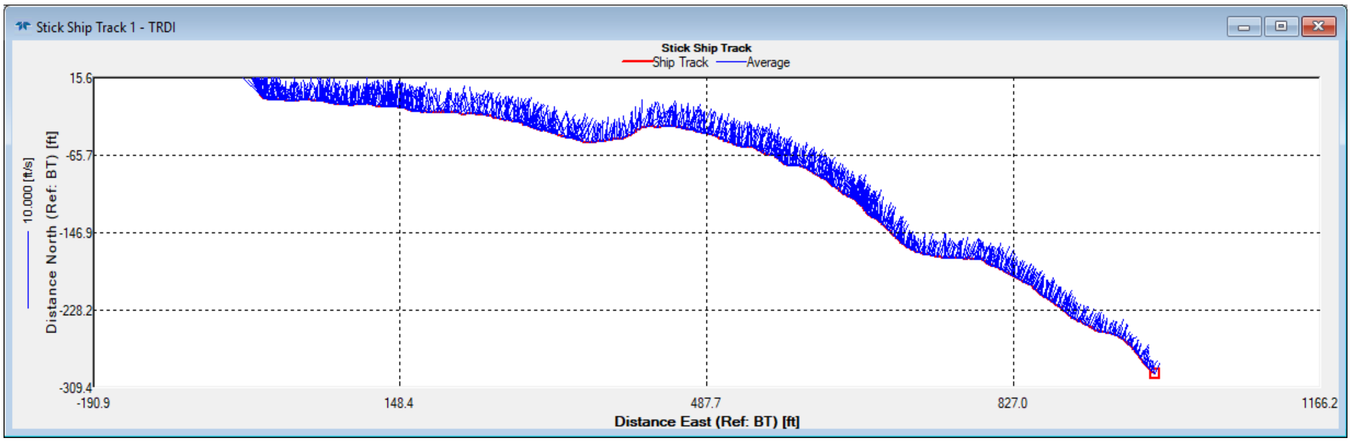
E. TRANSECT DOWNSTREAM001 RAW DATA OUTPUT



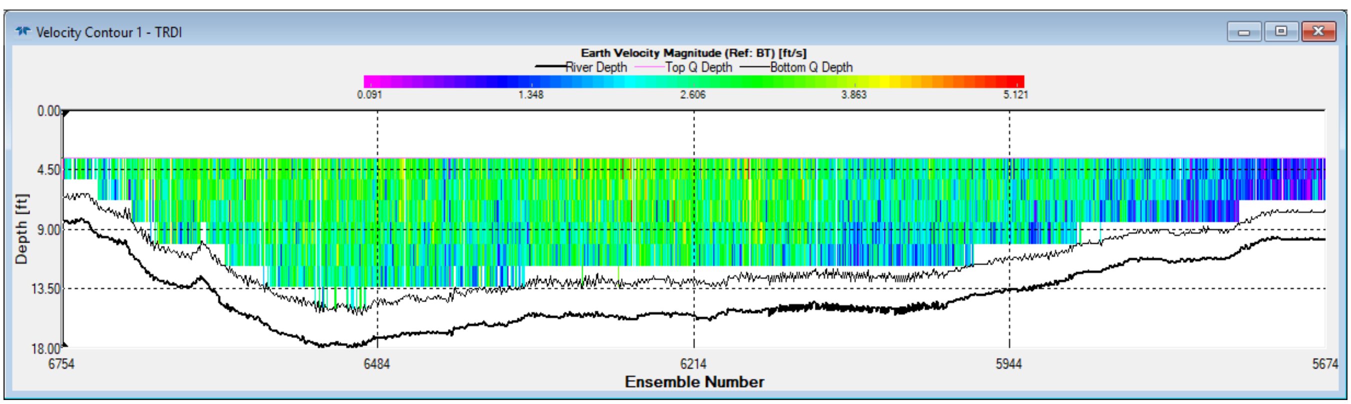


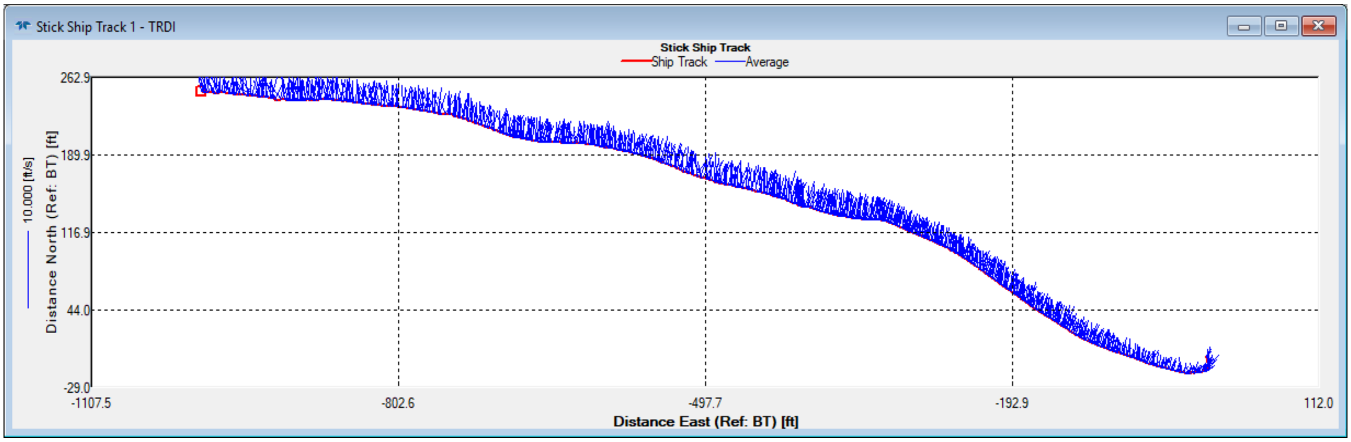
F. TRANSECT DOWNSTREAM002 RAW DATA OUTPUT



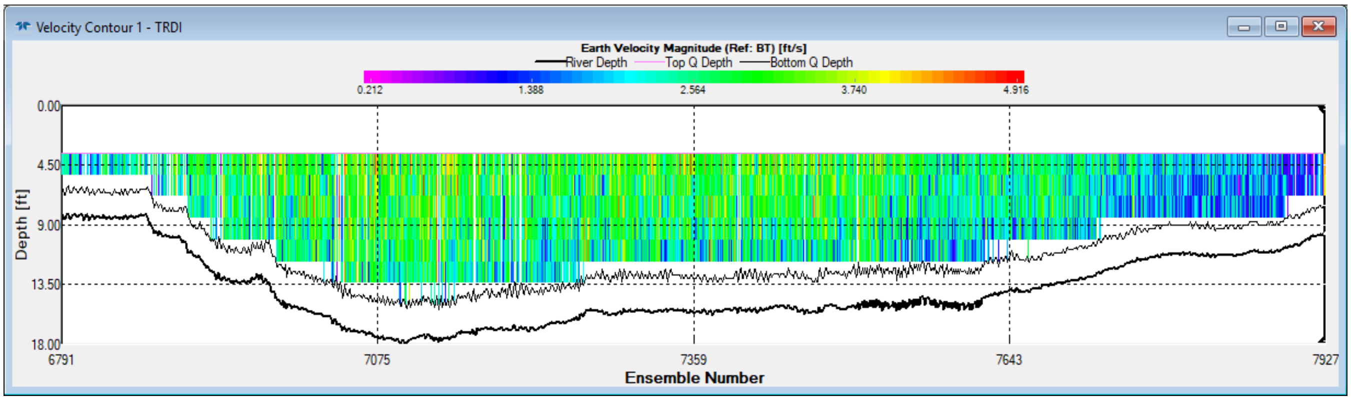


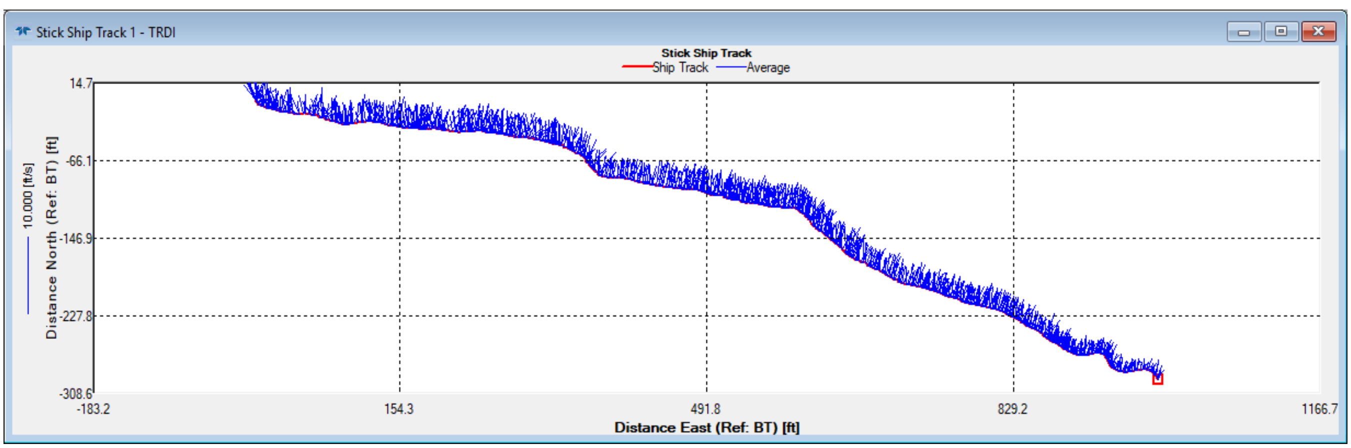
G. TRANSECT DOWNSTREAM004 RAW DATA OUTPUT





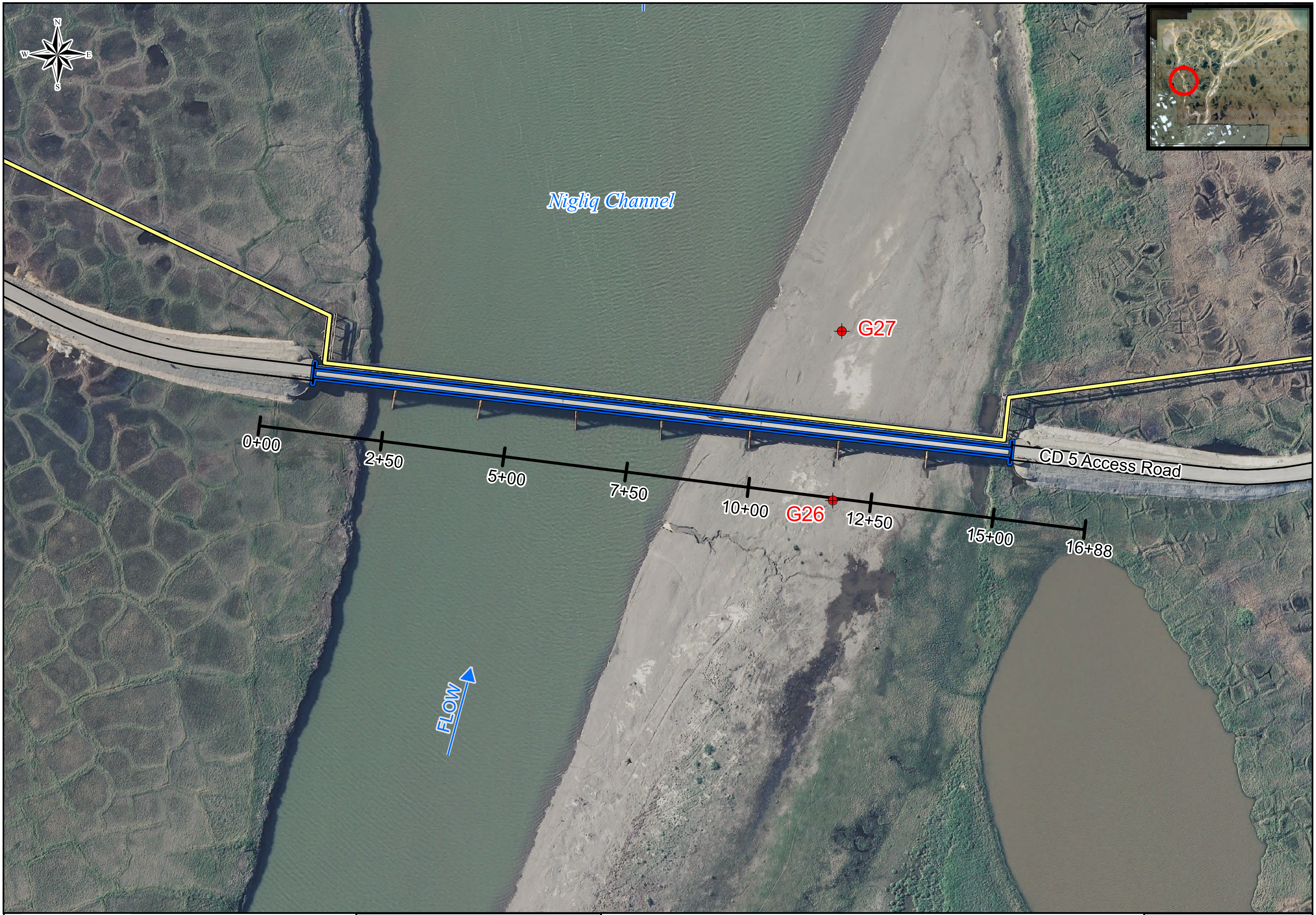
H. TRANSECT DOWNSTREAM005 RAW DATA OUTPUT





2) PEAK DISCHARGE DATA

Peak discharge was calculated using the Normal Depth method. The channel geometry applied in the Normal Depth calculation was from Transect 10 surveyed for the *Monitoring Plan with an Adaptive Management Strategy* in July 2016. The friction slope used in the Normal Depth calculation was based on WSEs at gages G26 and G28. The channel roughness values used were calibrated from the measured discharge. Manning's n values used were 0.095 for the left overbank, 0.06 for the right overbank, and 0.036 for the main channel. Main channel roughness is relatively high to account for minor obstructions from the bridge piers and scour holes.



ConocoPhillips Alaska

Feet
0 125 250

Date:	11/14/2019	Project:	171385
Drawn:	BTG	File:	2019_CRD_8x11L_Nigliq.mxd
Checked:	GCY	Scale:	1 in = 250 feet

Legend
- Gage Location
- 2016 Cross Section Alignment
- Road
- Bridge
- Pipeline

Imagery Source: ConocoPhillips Alaska, 2015

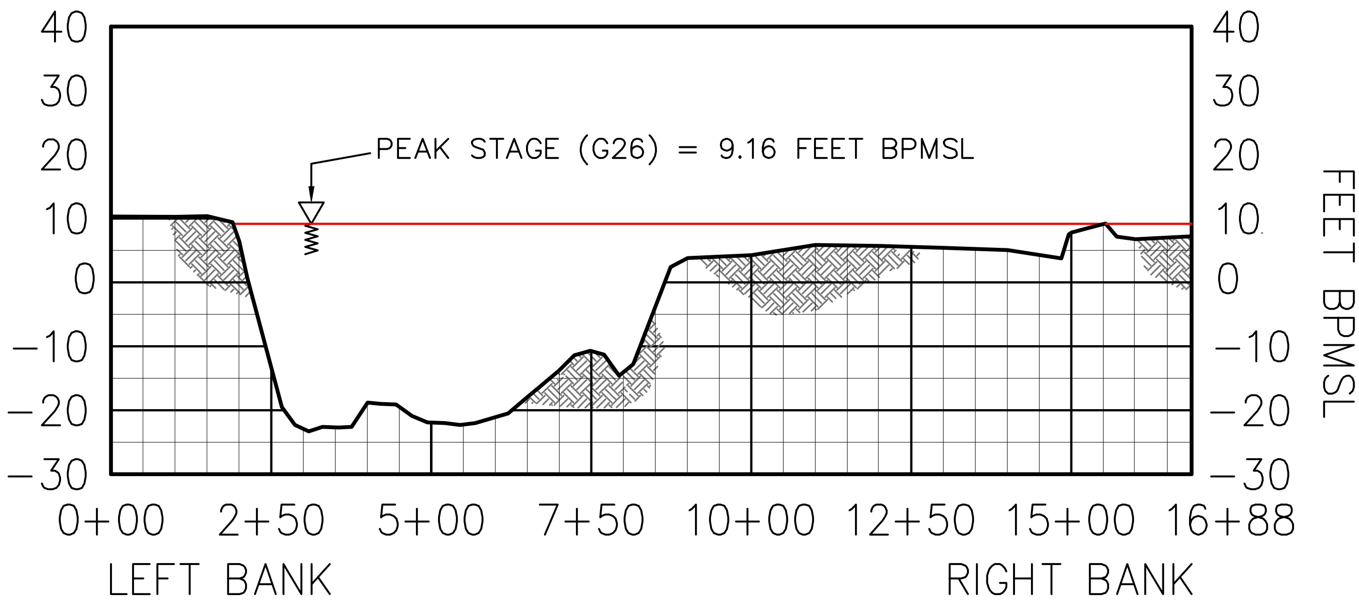
Michael Baker INTERNATIONAL

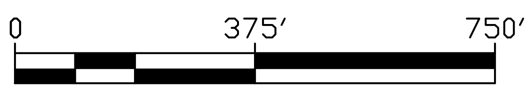
Michael Baker International
3900 C Street, Suite 900
Anchorage, AK 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 SPRING BREAKUP
NIGLIQ CHANNEL
TRANSECT 10 PLAN

(SHEET 1 of 2)

NOTES
1. BASIS OF ELEVATION, MONUMENT 26.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED JULY 2016 BY UMIAQ (KUUKPIK/LCMF INC.)





1 CD5 CROSSING – NIGLIQ CHANNEL CENTERLINE CROSS-SECTION
TRANSECT 10 (DOC LCMF–156 CD5 BRIDGE TRANSECTS REV4)

ConocoPhillips Alaska, Inc.

DATE:	11/14/2019	PROJECT:	171385
DRAWN:	HLR	FILE:	NIGLIQ X-SECTION.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker INTERNATIONAL
Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273–1600
Fax: (907) 273–1699

2019 SPRING BREAKUP
NIGLIQ CHANNEL
TRANSECT 10 PROFILE

(SHEET 2 OF 2)

C.2.4 NIGLIAGVIK BRIDGE

1) MEASURED DISCHARGE

Discharge was not measured at the Nigliagvik Bridge because of the presence of ice in the channel just upstream of the bridge during peak conditions.

2) PEAK DISCHARGE DATA

Peak discharge was not calculated at the Nigliagvik Bridge because of an equipment malfunction at G39.

ConocoPhillips Alaska

Feet
0 125 250

Date:	11/14/2019	Project:	171385
Drawn:	BTG	File:	2019_CRD_8x11L_Nigliagvik.mxd
Checked:	GCY	Scale:	1 in = 250 feet

Legend

- Gage Location
- 2016 Cross Section Alignment
- Road
- Bridge
- Pipeline

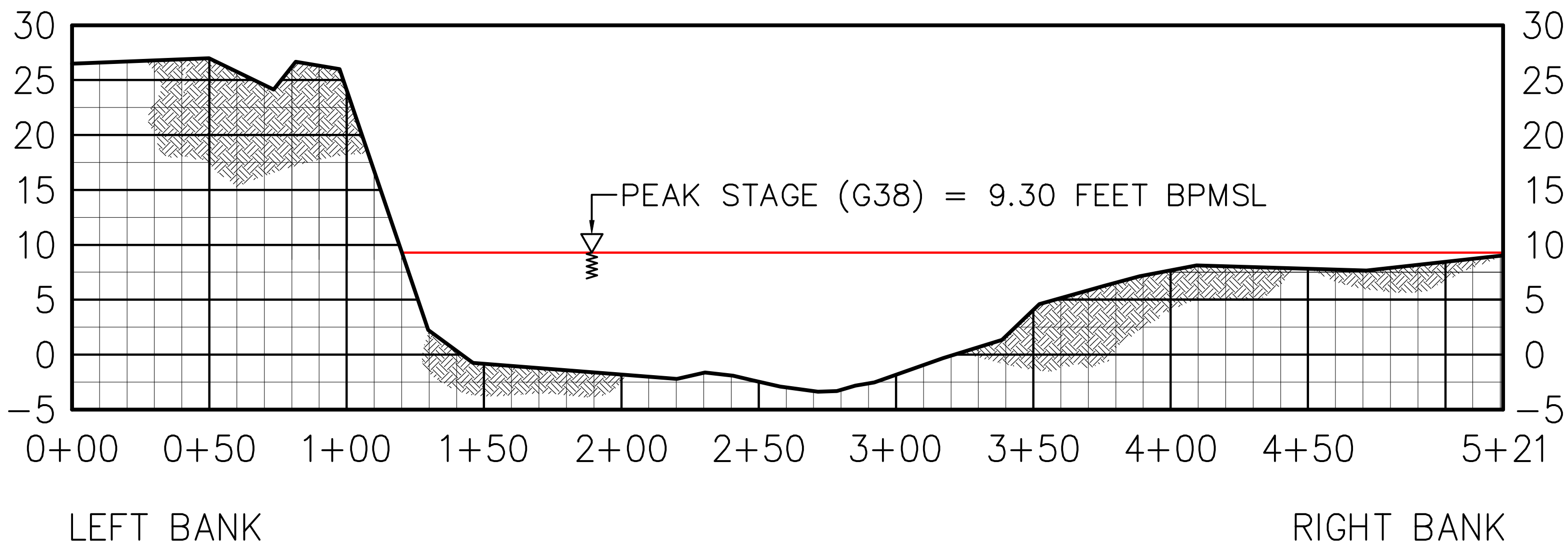
Imagery Source: ConocoPhillips Alaska, 2015

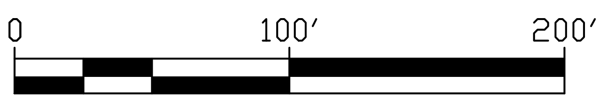
Michael Baker International
3900 C Street, Suite 900
Anchorage, AK 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 SPRING BREAKUP
NIGLIAGVIK CHANNEL
TRANSECT 27 PLAN

(SHEET 1 of 2)

NOTES
1. BASIS OF ELEVATION, MONUMENT 29.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED JULY 2016 BY UMIAQ (KUUKPIK/LCMF INC.)





1 CD5 CROSSING – NIGLIAGVIK CENTERLINE CROSS-SECTION

TRANSECT 27 (DOC LCMF-156 CD5 BRIDGE TRANSECTS REV4)

ConocoPhillips Alaska, Inc.

DATE: 11/14/2019	PROJECT: 171385
DRAWN: HLR	FILE: NIGLIAGVIK X-SECTION.DWG
CHECKED: GCY	SCALE: AS SHOWN

Michael Baker INTERNATIONAL
Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 SPRING BREAKUP
NIGLIAGVIK CHANNEL
TRANSECT 27 PROFILE

(SHEET 2 OF 2)

C.2.5 LONG SWALE BRIDGE

1) MEASURED DISCHARGE

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: May 25, 2019
Computed By: KDB
Checked By: HLR

Location Name: Long Swale Bridge

Party: DTR, MDB, ACG, CMB   Start: 5/25/2019 10:55   Finish: 5/25/2019 14:12

Temp: 34 °F   Weather: Foggy

Channel Characteristics:

Width: 439.5 ft   Area: 2046 sq ft   Velocity: 1.37 fps   Discharge: 2795 cfs

Method: Mid-section technique   Number of Sections: Count:

Spin Test: OK minutes after OK seconds   Meter: Price AA

GAGE READINGS			
Gage	Start	Finish	Change
G3	6.69	7.00	0.31
G4	6.50	6.69	0.19

Meter: 0.94 ft above bottom of weight

Weight: 30 lbs

Wading **Cable** Ice Boat

Upstream or Downstream side of bridge

GPS Data:
Left Edge of Water:
Right Edge of Water:

LE Floodplain: ° ' . "
RE Floodplain: ° ' . "

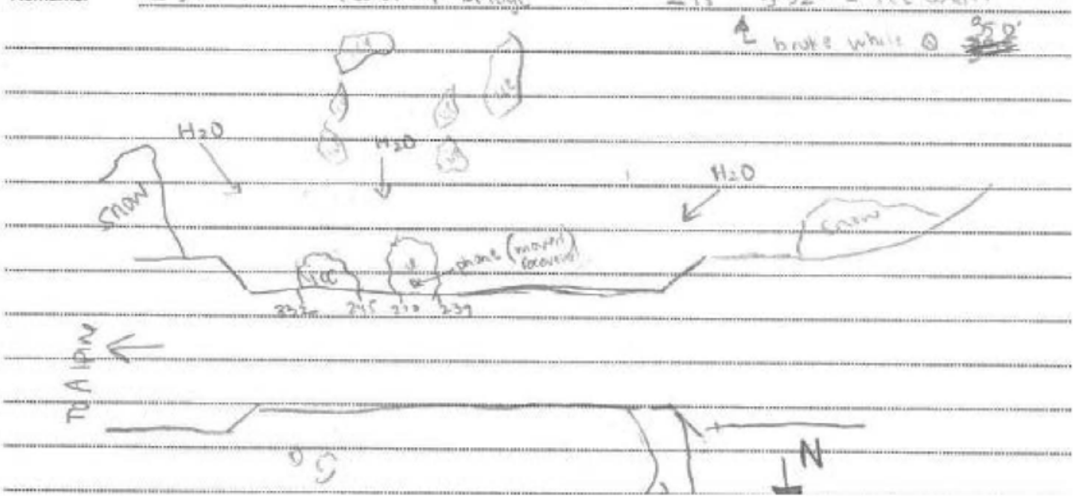
Measurement Rated: Excellent Good **Fair** Poor based on "Descriptions"

Descriptions:

Cross Section:

Flow:

Remarks: 239' - 270' = ice under bridge   295' - 332' - ice under / broke while @ 350'



Long Swale Bridge
May 25, 2019

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
1	0	-	-	-	-	-					
0.9	10	15.0	3.1	1.9	50	40	2.77	2.77	2.50	46.5	116.08
0.95	20	10.0	3.1	1.9	60	47	2.83	2.83	2.69	31.0	83.42
0.95	30	10.0	3.9	2.3	40	40	2.22	2.22	2.11	39.0	82.35
0.99	40	15.0	3.4	2.1	30	43	1.56	1.56	1.54	51.0	78.56
0.99	60	20.0	4.1	2.5	20	44	1.02	1.02	1.01	82.0	82.80
0.99	80	20.0	3.2	1.9	25	43	1.30	1.30	1.29	64.0	82.35
0.98	100	20.0	3.6	2.2	30	42	1.59	1.59	1.56	72.0	112.38
0.98	120	20.0	4.4	2.7	25	42	1.33	1.33	1.30	88.0	114.71
0.98	140	20.0	4.0	2.4	25	40	1.40	1.40	1.37	80.0	109.43
0.99	160	20.0	4.4	2.7	20	40	1.12	1.12	1.11	88.0	97.59
1	180	20.0	5.1	4.1 1.0	15 7	40 40	0.84 0.40	0.62	0.62	102.0	63.66
1	200	20.0	4.5	3.6 0.9	15 15	48 47	0.71 0.72	0.71	0.71	90.0	64.27
0.97	220	37.5	5.7	4.6 1.1	30 20	46 48	1.46 0.94	1.20	1.16	213.8	247.99
0.92	275	32.5	7.5	6.0 1.5	30 50	43 43	1.56 2.58	2.07	1.90	243.8	463.92
0.98	285	7.5	6.7	5.4 1.3	30 50	43 48	1.56 2.31	1.94	1.90	50.3	95.30
0.99	290	25.0	6.5	5.2 1.3	25 40	45 45	1.24 1.98	1.61	1.59	162.5	259.03
0.85	335	30.0	4.6	3.6 1	50 50	47 45	2.36 2.47	2.42	2.05	138.0	283.33
0.98	350	22.5	4.3	2.6	25	53	1.06	1.06	1.04	96.8	100.30
0.94	380	30.0	4.6	3.6 0.9	15 10	56 42	0.61 0.54	0.58	0.54	138.0	74.66
0.99	410	28.5	4.2	2.6	20	44	1.02	1.02	1.01	119.7	120.87
0.98	437	16.0	3.1	1.9	25	44	1.27	1.27	1.25	49.6	61.76
1	442	-	-	-	-	-					

Total Discharge: 2794.78 cfs

C.2.6 SHORT SWALE BRIDGE

1) MEASURED DISCHARGE

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: May 26, 2019
Computed By: KDB
Checked By: HLR

Location Name: Short Swale Bridge

Party: ACG, KDB, TC (ABR) Start: 5/26/2019 12:00 Finish: 5/26/2019 13:00

Temp: 30 °F Weather: Overcast 20 MPH

Channel Characteristics:

Width: 52.5 ft Area: 349 sq ft Velocity: 0.70 fps Discharge: 244 cfs

Method: Mid-section technique Number of Sections: Count:

Spin Test: OK minutes after OK seconds Meter: Price AA

GAGE READINGS			
Gage	Start	Finish	Change
G3	7.35	7.19	-0.16
G4	7.40	7.15	-0.25

Meter: 0.94 ft above bottom of weight

Weight: 30 lbs

Wading **Cable** Ice Boat

Upstream or Downstream side of bridge

GPS Data:
Left Edge of Water:
Right Edge of Water:

LE Floodplain: ° ' . "
RE Floodplain: ° ' . "

Measurement Rated: Excellent **Good** Fair Poor based on "Descriptions"

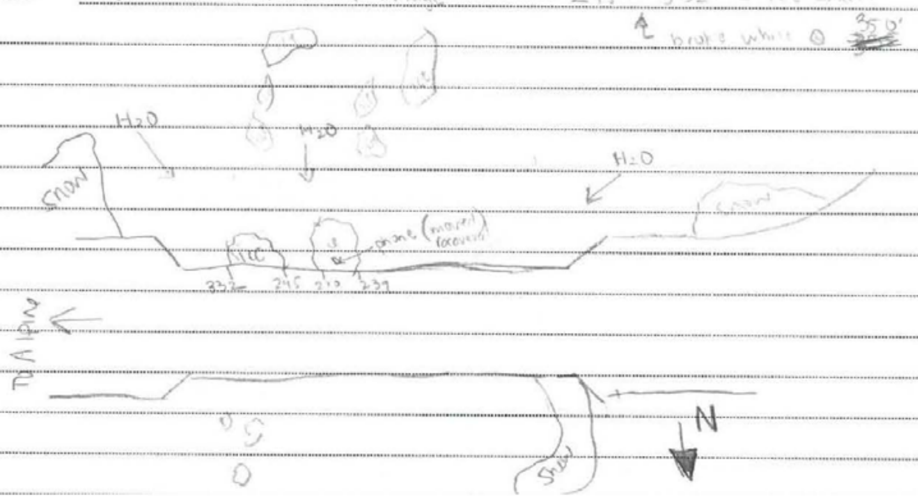
Descriptions:

Cross Section: Constricted flow between abutments

Flow: Minor snow constriction near West abutment on DS side

Remarks: 239' - 270' - ice under bridge 295' - 332' - ice under

broke while @ 350'



Long Swale Bridge
May 25, 2019

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
1	0	-	-	-	-	-					
0.94	5	7.5	5.3	1.1 4.2	7 10	42 46	0.39 0.50	0.44	0.41	39.8	16.48
0.9	10	5.0	5.1	1 4.2	15 15	44 52	0.77 0.65	0.71	0.64	25.5	16.33
1	15	5.0	5.9	1.2 4.7	15 15	49 46	0.69 0.74	0.71	0.71	29.5	21.09
1	20	5.0	6.1	1.2 4.9	20 20	44 47	1.02 0.96	0.99	0.99	30.5	30.13
0.99	25	5.0	6.4	1.3 5.1	20 15	50 51	0.90 0.67	0.78	0.78	32.0	24.81
0.99	30	5.0	7.4	1.5 5.9	15 15	40 42	0.84 0.81	0.82	0.82	37.0	30.22
0.99	35	5.0	7.7	1.5 6.2	15 20	48 47	0.71 0.96	0.83	0.82	38.5	31.69
0.98	40	5.0	8.4	1.7 6.7	15 20	54 45	0.63 1.00	0.81	0.80	42.0	33.50
0.98	45	5.0	7.4	1.5 5.9	15 10	53 45	0.64 0.51	0.57	0.56	37.0	20.84
0.97	50	5.0	7.5	1.5 6	15 10	64 43	0.53 0.53	0.53	0.52	37.5	19.37
1	55	-	-	-	-	-					

Total Discharge: 244.46 cfs

C.2.7 CULVERTS

1) MEASURED DISCHARGE

Date	Time	Culvert ID	Flow Conditions	Flow Direction	Total Depth (ft)	Measured Depth (ft)	v1 (ft/s)	v2 (ft/s)	v3 (ft/s)	Upstream Gage	Upstream WSE (ft BPMSL)	Downstream Gage	Downstream WSE (ft BPMSL)	Notes
5/25/2019	12:33	CD2-21	Flowing	South to North	1.4	0.56	2.24	2.23	2.23	G3	6.82	G4	6.58	
5/25/2019	12:41	CD2-22	Flowing	South to North	1.7	0.68	3.06	2.95	2.91	G3	6.82	G4	6.58	
5/25/2019	12:52	CD2-23	Flowing	South to North	2.0	0.80	3.60	3.52	3.54	G3	6.82	G4	6.58	
5/25/2019	12:59	CD2-24	Flowing	South to North	2.2	0.88	3.24	3.28	3.26	G3	6.82	G4	6.58	
5/25/2019	16:21	CD4-28	Flowing	South to North	0.6	0.24	1.66	1.72	1.66	G18-A	0.90	G17-A	0.37	Ice on bottom, diameter = 2.7
5/25/2019	16:28	CD4-27	Flowing	South to North	0.9	0.36	1.72	1.65	1.54	G18-A	0.90	G17-A	0.37	Ice on bottom, diameter = 2.9
5/25/2019	16:31	CD4-26	Flowing	South to North	0.5	0.20	1.52	1.62	1.63	G18-A	0.90	G17-A	0.37	Ice on bottom, diameter = 2.7
5/25/2019	17:46	CD5-07	Flowing	South to North	1.0	0.40	1.66	1.65	1.66	S1	0.32	S1D	0.10	
5/25/2019	17:53	CD5-04	Flowing	East to West	1.3	0.52	3.45	3.46	3.41	n/a	n/a	n/a	n/a	
5/28/2019	9:50	CD5-07	Flowing	South to North	0.8	0.32	0.84	0.82	0.84	S1	0.21	S1D	dry	
5/28/2019	9:59	CD5-04	Flowing	East to West	1.3	0.52	2.74	2.70	2.77	n/a	n/a	n/a	n/a	

Note: Any culvert not listed was observed to either be stagnant or dry at the time of the discharge measurements

2) PEAK DISCHARGE

I. CULVERT CD2-21

Culvert Calculator Report
CD2-21 @ peak stage differential

Comments: 5/25/19 4:45 pm

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	7.32 ft	Headwater Depth/Height	0.50
Computed Headwater Elevation	7.32 ft	Discharge	16.31 cfs
Inlet Control HW Elev.	6.98 ft	Tailwater Elevation	6.97 ft
Outlet Control HW Elev.	7.32 ft	Control Type	Outlet Control

Grades

Upstream Invert	5.31 ft	Downstream Invert	5.20 ft
Length	76.70 ft	Constructed Slope	0.001330 ft/ft

Hydraulic Profile

Profile	M1	Depth, Downstream	1.77 ft
Slope Type	Mild	Normal Depth	1.53 ft
Flow Regime	Subcritical	Critical Depth	1.18 ft
Velocity Downstream	3.04 ft/s	Critical Slope	0.003537 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Steel	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	7.32 ft	Upstream Velocity Head	0.15 ft
Ke	0.90	Entrance Loss	0.14 ft

Inlet Control Properties

Inlet Control HW Elev.	6.98 ft	Flow Control	N/A
Inlet Type	Projecting	Area Full	12.6 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Title: 2019 CPAI CRD Breakup
c:\..\culvert master files\2019 cd2.cvm
11/06/19 05:51:05 PM© Bentley Systems, Inc. Haestad Methods Solution Center Watertown, CT 06795 USA +1-203-755-1666

Anchorage Office

Project Engineer: Haley.Runa
CulvertMaster v3.3 [03.03.00.04]
Page 1

J. CULVERT CD2-22

Culvert Calculator Report
CD2-22 @ peak stage differential

Comments: 5/25/19 4:45 pm

Solve For: Discharge

Culvert Summary			
Allowable HW Elevation	7.32 ft	Headwater Depth/Height	0.55
Computed Headwater Elevation	7.32 ft	Discharge	17.71 cfs
Inlet Control HW Elev.	6.97 ft	Tailwater Elevation	6.97 ft
Outlet Control HW Elev.	7.32 ft	Control Type	Outlet Control

Grades			
Upstream Invert	5.14 ft	Downstream Invert	5.19 ft
Length	72.80 ft	Constructed Slope	-0.000797 ft/ft

Hydraulic Profile			
Profile	A2	Depth, Downstream	1.78 ft
Slope Type	Adverse	Normal Depth	0.00 ft
Flow Regime	Subcritical	Critical Depth	1.24 ft
Velocity Downstream	3.28 ft/s	Critical Slope	0.003538 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Steel	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	7.32 ft	Upstream Velocity Head	0.14 ft
Ke	0.90	Entrance Loss	0.12 ft

Inlet Control Properties			
Inlet Control HW Elev.	6.97 ft	Flow Control	N/A
Inlet Type	Projecting	Area Full	12.6 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Title: 2019 CPAI CRD Breakup
c:\..\culvert master files\2019 cd2.cvm
11/06/19 05:51:05 PM© Bentley Systems, Inc. Haestad Methods Solution Center Watertown, CT 06795 USA +1-203-755-1666

Anchorage Office

Project Engineer: Haley.Runa
CulvertMaster v3.3 [03.03.00.04]
Page 2

K. CULVERT CD2-23

Culvert Calculator Report
CD2-23 @ peak stage differential

Comments: 5/25/19 4:45 pm

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	7.32 ft	Headwater Depth/Height	0.75
Computed Headwater Elevation	7.32 ft	Discharge	27.36 cfs
Inlet Control HW Elev.	6.97 ft	Tailwater Elevation	6.97 ft
Outlet Control HW Elev.	7.32 ft	Control Type	Outlet Control

Grades

Upstream Invert	4.31 ft	Downstream Invert	4.51 ft
Length	72.80 ft	Constructed Slope	-0.002843 ft/ft

Hydraulic Profile

Profile	A2	Depth, Downstream	2.46 ft
Slope Type	Adverse	Normal Depth	0.00 ft
Flow Regime	Subcritical	Critical Depth	1.55 ft
Velocity Downstream	3.38 ft/s	Critical Slope	0.003604 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Steel	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	7.32 ft	Upstream Velocity Head	0.14 ft
Ke	0.90	Entrance Loss	0.12 ft

Inlet Control Properties

Inlet Control HW Elev.	6.97 ft	Flow Control	N/A
Inlet Type	Projecting	Area Full	12.6 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Title: 2019 CPAI CRD Breakup
c:\..\culvert master files\2019 cd2.cvm
11/06/19 05:51:05 PM© Bentley Systems, Inc. Haestad Methods Solution Center Watertown, CT 06795 USA +1-203-755-1666

Anchorage Office

Project Engineer: Haley.Runa
CulvertMaster v3.3 [03.03.00.04]
Page 3

L. CULVERT CD2-24

Culvert Calculator Report
CD2-24 @ peak stage differential

Comments: 5/25/19 4:45 pm

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	7.32 ft	Headwater Depth/Height	0.79
Computed Headwater Elevation	7.32 ft	Discharge	29.90 cfs
Inlet Control HW Elev.	6.97 ft	Tailwater Elevation	6.97 ft
Outlet Control HW Elev.	7.32 ft	Control Type	Outlet Control

Grades

Upstream Invert	4.14 ft	Downstream Invert	4.26 ft
Length	76.00 ft	Constructed Slope	-0.001566 ft/ft

Hydraulic Profile

Profile	A2	Depth, Downstream	2.71 ft
Slope Type	Adverse	Normal Depth	0.00 ft
Flow Regime	Subcritical	Critical Depth	1.62 ft
Velocity Downstream	3.30 ft/s	Critical Slope	0.003633 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Steel	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	7.32 ft	Upstream Velocity Head	0.15 ft
Ke	0.90	Entrance Loss	0.13 ft

Inlet Control Properties

Inlet Control HW Elev.	6.97 ft	Flow Control	N/A
Inlet Type	Projecting	Area Full	12.6 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

M. CULVERT CD4-26

Culvert Calculator Report
CD4-26 @ peak stage differential

Comments: 5/25/19 3:00 pm

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	11.14 ft	Headwater Depth/Height	0.57
Computed Headwater Elevation	11.14 ft	Discharge	22.31 cfs
Inlet Control HW Elev.	10.98 ft	Tailwater Elevation	10.18 ft
Outlet Control HW Elev.	11.14 ft	Control Type	Outlet Control

Grades

Upstream Invert	8.85 ft	Downstream Invert	8.96 ft
Length	78.30 ft	Constructed Slope	0.000000 ft/ft

Hydraulic Profile

Profile	H2	Depth, Downstream	1.39 ft
Slope Type	Horizontal	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	1.39 ft
Velocity Downstream	5.73 ft/s	Critical Slope	0.003559 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Steel	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	11.14 ft	Upstream Velocity Head	0.26 ft
Ke	0.90	Entrance Loss	0.23 ft

Inlet Control Properties

Inlet Control HW Elev.	10.98 ft	Flow Control	N/A
Inlet Type	Projecting	Area Full	12.6 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Project Engineer: Haley.Runa
c:\...\culvert master files\2019 cd4.cvm   **Anchorage Office**   CulvertMaster v3.3 [03.03.00.04]
11/06/19 05:52:22 PM© Bentley Systems, Inc.   Haestad Methods Solution Center   Watertown, CT 06795 USA   +1-203-755-1666   Page 1

N. CULVERT CD4-27

Culvert Calculator Report
CD4-27 @ peak stage differential

Comments: 5/25/19 3:00 pm

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	11.14 ft	Headwater Depth/Height	0.64
Computed Headwater Elevation	11.14 ft	Discharge	24.33 cfs
Inlet Control HW Elev.	10.99 ft	Tailwater Elevation	10.18 ft
Outlet Control HW Elev.	11.14 ft	Control Type	Outlet Control

Grades

Upstream Invert	8.56 ft	Downstream Invert	8.86 ft
Length	77.70 ft	Constructed Slope	-0.003861 ft/ft

Hydraulic Profile

Profile	A2	Depth, Downstream	1.46 ft
Slope Type	Adverse	Normal Depth	0.00 ft
Flow Regime	Subcritical	Critical Depth	1.46 ft
Velocity Downstream	5.88 ft/s	Critical Slope	0.003574 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Steel	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	11.14 ft	Upstream Velocity Head	0.17 ft
Ke	0.90	Entrance Loss	0.16 ft

Inlet Control Properties

Inlet Control HW Elev.	10.99 ft	Flow Control	N/A
Inlet Type	Projecting	Area Full	12.6 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

O. CULVERT CD4-28

Culvert Calculator Report
CD4-28 @ peak stage differential

Comments: 5/25/19 3:00 pm

Solve For: Discharge

Culvert Summary			
Allowable HW Elevation	11.14 ft	Headwater Depth/Height	0.60
Computed Headwater Elevation	11.14 ft	Discharge	22.37 cfs
Inlet Control HW Elev.	10.93 ft	Tailwater Elevation	10.18 ft
Outlet Control HW Elev.	11.14 ft	Control Type	Outlet Control

Grades			
Upstream Invert	8.75 ft	Downstream Invert	8.90 ft
Length	78.70 ft	Constructed Slope	-0.001919 ft/ft

Hydraulic Profile			
Profile	A2	Depth, Downstream	1.39 ft
Slope Type	Adverse	Normal Depth	0.00 ft
Flow Regime	Subcritical	Critical Depth	1.39 ft
Velocity Downstream	5.74 ft/s	Critical Slope	0.003559 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Steel	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	11.14 ft	Upstream Velocity Head	0.19 ft
Ke	0.90	Entrance Loss	0.17 ft

Inlet Control Properties			
Inlet Control HW Elev.	10.93 ft	Flow Control	N/A
Inlet Type	Projecting	Area Full	12.6 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Project Engineer: Haley.Runa
c:\...\culvert master files\2019 cd4.cvm Anchorage Office CulvertMaster v3.3 [03.03.00.04]
11/06/19 05:52:22 PM© Bentley Systems, Inc. Haestad Methods Solution Center Watertown, CT 06795 USA +1-203-755-1666 Page 3

APPENDIX D ADDITIONAL PHOTOGRAPHS

D.1 EROSION SURVEY

D.1.1 CD2 ROAD

Photo D.1: CD2 road long swale bridge SW abutment, looking east; June 3, 2019

Photo D.2: CD2 road long swale bridge NW abutment, looking east; June 3, 2019

Photo D.3: CD2 road short swale bridge SW abutment, looking west; June 3, 2019

Photo D.4: CD2 road short swale bridge NW abutment, looking east; June 3, 2019

Photo D.5: Road in vicinity of culvert CD2-21N post-breakup, looking west; June 3, 2019

Photo D.6: Road in vicinity of culvert CD2-21S post-breakup, looking east; June 3, 2019

Photo D.7: Road in vicinity of culvert CD2-22N post-breakup, looking west; June 3, 2019

Photo D.8: Road in vicinity of culvert CD2-22S post-breakup, looking west; June 3, 2019

Photo D.9: Road in vicinity of culvert CD2-23N post-breakup, looking west; June 3, 2019

Photo D.10: Road in vicinity of culvert CD2-23S post-breakup, looking east; June 3, 2019

Photo D.11: Road in vicinity of culvert CD2-24N post-breakup, looking west; June 3, 2019

Photo D.12: Road in vicinity of culvert CD2-24S post-breakup, looking east; June 3, 2019

D.1.2 CD4 ROAD

Photo D.13: CD4 road post-breakup, looking northeast; June 3, 2019

Photo D.14: CD4 road in vicinity of G15 culverts post-breakup, looking northwest; June 3, 2019

Photo D.15: CD4 road in vicinity of G15 culverts post-breakup, looking northwest; June 3, 2019

Photo D.16: CD4 road in vicinity of G16 culverts post-breakup, looking southwest; June 3, 2019

Photo D.17: CD4 road in vicinity of G17 culverts post-breakup, looking west; June 4, 2019

Photo D.18: CD4 road in vicinity of G17 culverts post-breakup, looking east; June 4, 2019

Photo D.19: CD4 road in vicinity of G18 culverts post-breakup, looking west; June 4, 2019

Photo D.20: CD4 road in vicinity of G18 culverts post-breakup, looking east; June 4, 2019

D.1.3 CD5 ROAD

Photo D.21: CD5 road Lake L9341 Bridge #3 as breakup subsides, looking south (upstream); May 28, 2019

Photo D.22: CD5 road Nigliagvik Bridge #4 as breakup subsides, looking west; May 28, 2019

Photo D.23: CD5 road Nigliq Bridge #2 bank sloughing at west abutment, looking south (upstream); May 28, 2019

Photo D.24: CD5 road Nigliq Bridge #2 bank sloughing at west abutment, looking north (downstream); May 28, 2019

Photo D.25: Road in vicinity of culvert CD5-04N post-breakup, looking south; June 3, 2019

Photo D.26: Road in vicinity of culvert CD5-04S post-breakup, looking south; June 3, 2019

Photo D.27: Road in vicinity of culvert CD5-05N post-breakup, looking west; June 3, 2019

Photo D.28: Road in vicinity of culvert CD5-04S post-breakup, looking west; June 3, 2019

Photo D.29: Road in vicinity of culvert CD5-06N post-breakup, looking east; June 3, 2019

Photo D.30: Road in vicinity of culvert CD5-06S post-breakup, looking east; June 3, 2019

D.2 ICE ROAD CROSSINGS BREAKUP

Photo D.31: Initial flow through slotted Colville River Ice Bridge, looking east; May 20, 2019

Photo D.32: Breakup progression at Colville River Ice Bridge, looking southeast (upstream); May 22, 2019

Photo D.33: Peak conditions at Colville River Ice Bridge, looking south (upstream); May 24, 2019

Photo D.34: Open channel at Colville River Ice Bridge, looking south (upstream); May 26, 2019

Photo D.35: Peak conditions at Toolbox Creek ice road crossing, looking south; May 26, 2019

Photo D.36: Post-breakup at Toolbox Creek ice road crossing, looking southwest; May 30, 2019

Photo D.37: Peak conditions at Slias Slough ice road crossing, looking northeast; May 26, 2019

Photo D.38: Peak conditions at Slias Slough ice road crossing, looking northeast; May 26, 2019

Photo D.39: Peak conditions at No Name Creek ice road crossing; May 30, 2019

Photo D.40: Slotting at Slemp Slough ice road crossing; May 20, 2019

Photo D.41: Peak conditions at Kachemach ice road crossing, looking north; May 30, 2019

Photo D.42: Peak conditions at Kachemach ice road crossing, looking northwest; May 30, 2019

Photo D.43: Slotting at Pineapple Creek ice road crossing, looking north; May 20, 2019

Photo D.44: Peak conditions at Pineapple Creek ice road crossing, looking north; May 26, 2019

Photo D.45: Slotting at Tamayayak ice road crossing #1, looking south; May 20, 2019

Photo D.46: Peak conditions at Tamayayak ice road crossing #1, looking south; May 26, 2019

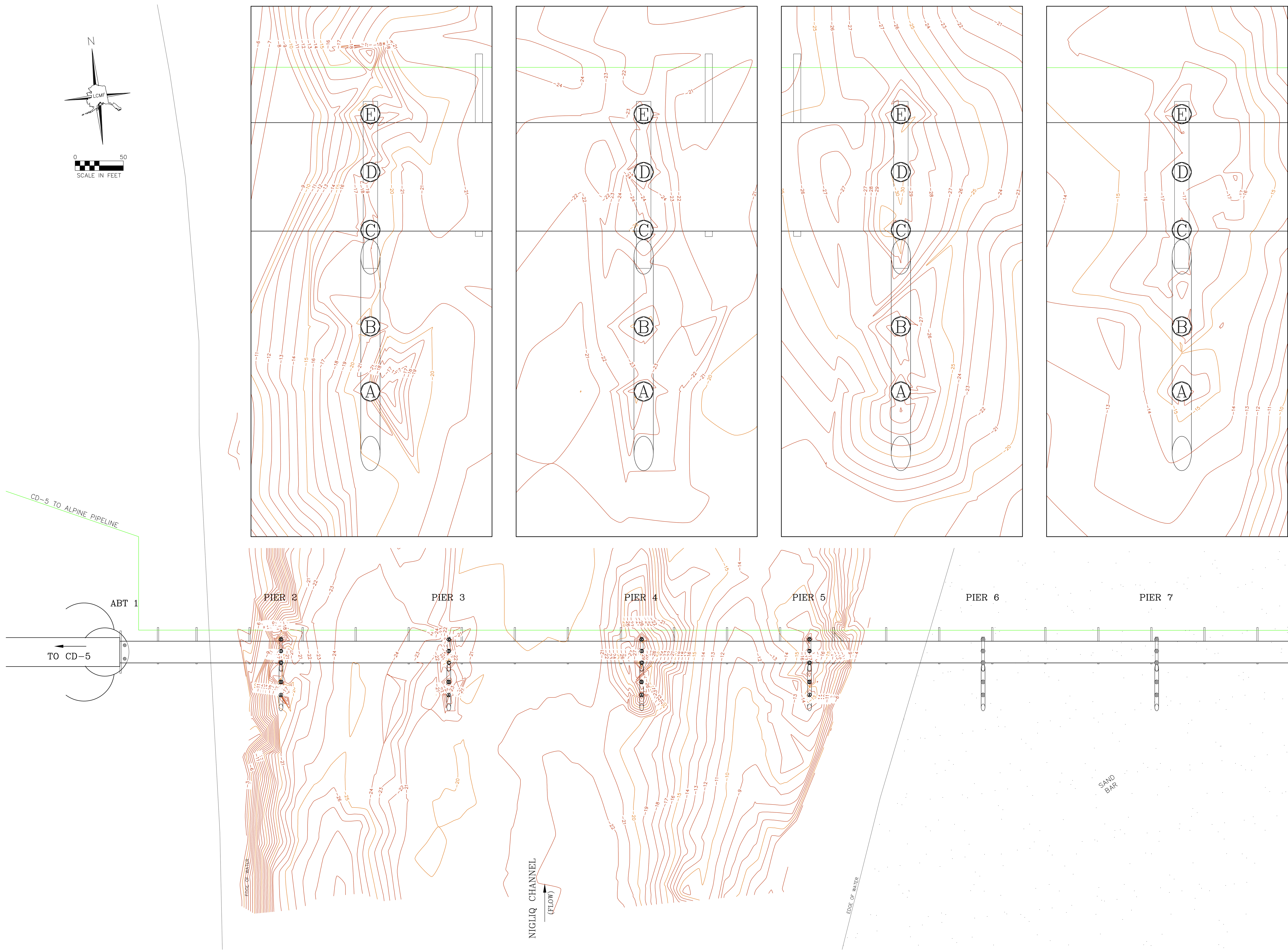
Photo D.47: Peak conditions at Tamayayak ice road crossing #1, looking north; May 26, 2019

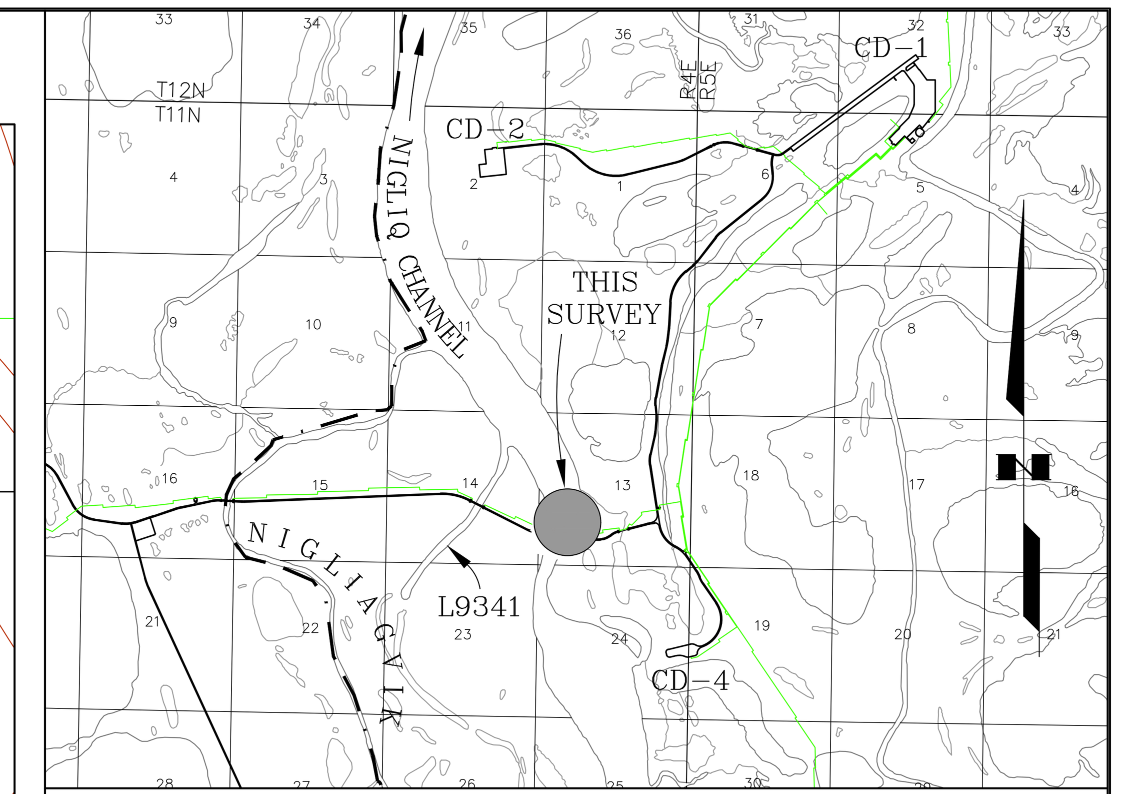
APPENDIX E CD5 PIER SCOUR, BANK EROSION, & BATHYMETRY

E.1 PIER SCOUR

E.1.1 NIGLIQ BRIDGE

DRAWING NO:	SUB JOB NO:	JOB NO:
CE-CD50-1022	–	–





VICINITY MAP 1" = 1 MILE

NOTES:

1. DATES OF SURVEY: AUGUST 30, 2019 THROUGH SEPTEMBER 1, 2019.
2. REFERENCE FIELD BOOK: 2019–32, PGS. 51–74.
3. ELEVATIONS ARE BRITISH PETROLEUM MEAN SEAL LEVEL (B.P.M.S.L.)
4. AVERAGE WATER SURFACE ELEVATION DURING SURVEY IS 1.7'.
5. HORIZONTAL DATUM IS NAD 83 ALASKA STATE PLANE ZONE 4.

LEGEND:
–18– 1' CONTOUR
–20– 5' CONTOUR

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE : 907-670-4739

ConocoPhillips Alaska, Inc.

ALPINE MODULE: CD50 UNIT: CD

CD–5 ACCESS ROAD
NIGLIQ BRIDGE
SCOUR MONITORING

REDRAWN FROM:
CONSTRUCTION SHEET OF

1 2 3 4 5 6
DO NOT SCALE ABOVE SCALE FOR REFERENCE ONLY

FORM: DSIZE

REFERENCE DWG NO/SHT NO:

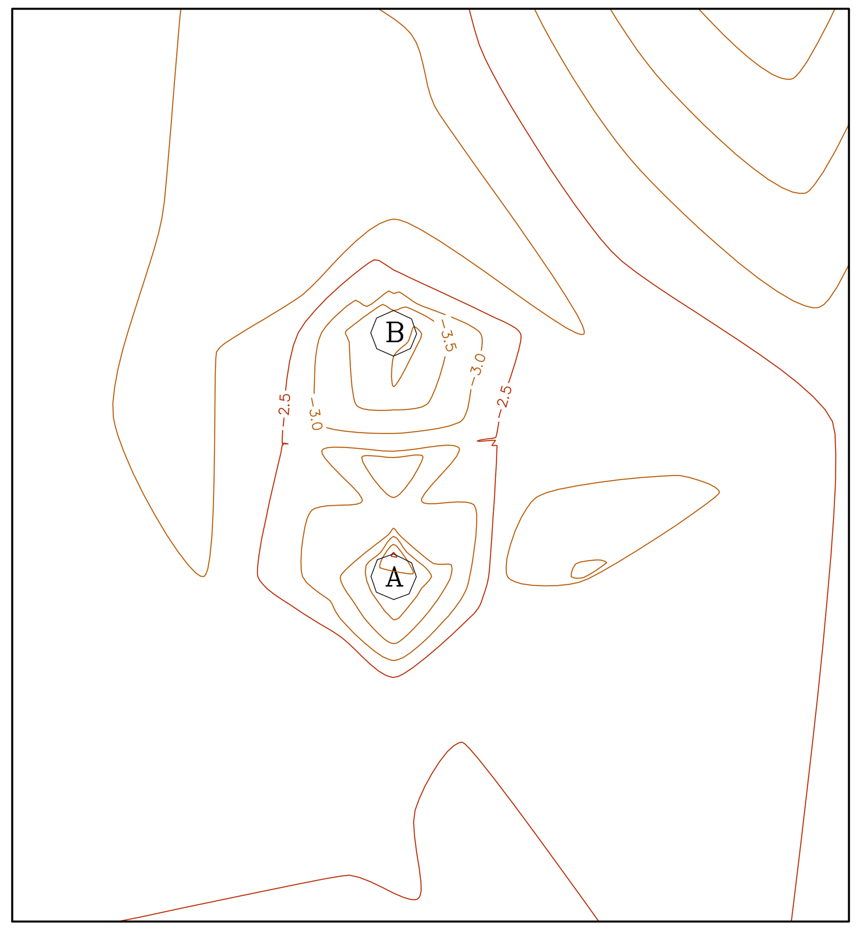
REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
6	08/31/19	UPDATED PER K190003ACS	SZ	CZ			
5	8/21/18	UPDATED PER K180003ACS	SZ	DB			
4	8/4/17	UPDATED PER K170003ACS	CZ	GD			
3	8/10/16	UPDATED PER K160003ACS	TRB	DB			
2	8/30/15	UPDATED PER 20968257ACS	TB	DB			
1	08/25/14	ISSUED PER K140003ACS	CZ	GD			

DATE: 08/23/14	DRAWN: CZ	DESIGN: GD	ECM NO: K140003ACS
	CHECKED: –		CC NO: –
SCALE: 1" = 50'	APPROVAL: –		CADD FILE NO. 14–08–12–1AW
JOB NO: – / SUB JOB NO: –	DRAWING NO: CE–CD50–1022		PART: 1 OF 1 / REV: 6

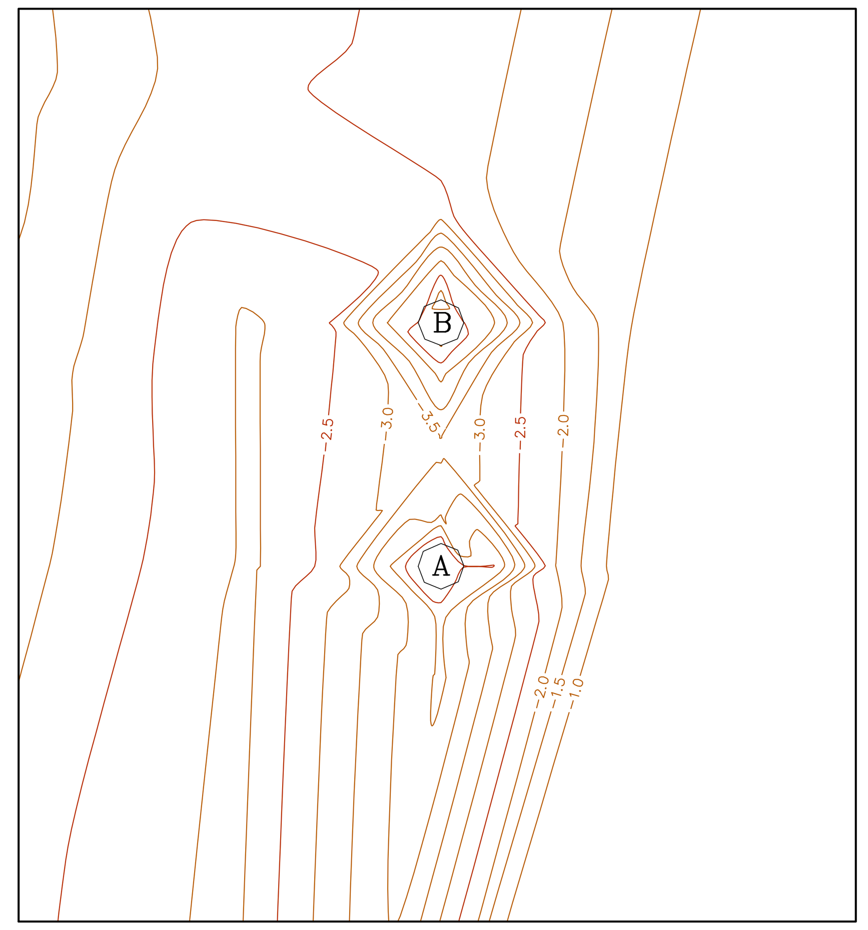
E.1.2 NIGLIAGVIK BRIDGE

JOB NO:	SUB JOB NO:	DRAWING NO:
–	–	CE-CD50-1023

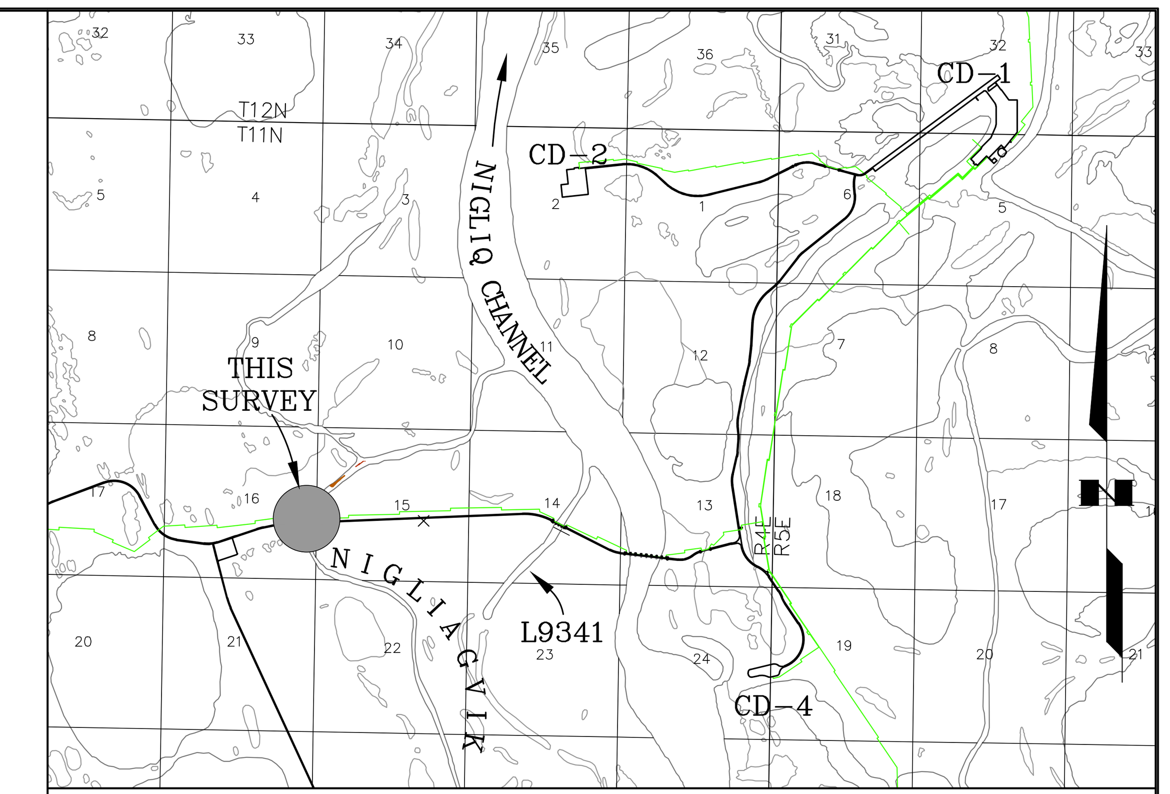
PIER 3
SCALE: 1" = 10'



PIER 4
SCALE: 1" = 10'



LEGEND:
0.5' CONTOUR
2.5' CONTOUR



VICINITY MAP

NOTES

1. DATE OF SURVEY: SEPTEMBER 1 – 2, 2019.
2. REFERENCE FIELD BOOKS: 2019-35 PGS:2-10
3. ELEVATIONS ARE BRITISH PETROLEUM MEAN SEAL LEVEL (B.P.M.S.L.)
4. HORIZONTAL DATUM IS NAD 83 ALASKA STATE PLANE ZONE 4,.

KUUKPIK LCMF LLC
Alpine Survey Office

ConocoPhillips
Alaska, Inc.

ALPINE | MODULE: CD50 | UNIT: CD

CD-5 ACCESS ROAD
NIGLIAGVIK BRIDGE
SCOUR MONITORING

REDRAWN FROM:
CONSTRUCTION SHEET OF

DO NOT SCALE — ABOVE SCALE FOR REFERENCE ONLY

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
6	09/03/19	UPDATED PER K190003ACS	SZ	CZ			
5	08/12/18	UPDATED PER K180003ACS	RR	CZ			
4	9/21/17	UPDATER PER K170003ACS	RR	DB			
3	7/31/16	UPDATED PER K160003ACS	CZ	DB			
2	9/8/15	UPDATED PER 20968257ACS	CZ	DB			
1	08/25/14	ISSUED PER K140003ACS	CZ	GD			

REFERENCE DWG NO/SHT NO:

DATE: 8/25/14	DRAWN: CZ	DESIGN: –	ECM NO: K140003ACS
SCALE: 1" = 20'	CHECKED: GD		CC NO: –
	APPROVAL: –		CADD FILE NO. 14-08-12-1CW
JOB NO: – / SUB JOB NO: –	DRAWING NO: CE-CD50-1023		PART: 1 OF 1 / REV: 6

FORM: DSIZE

E.2 BANK EROSION

E.2.1 NIGLIQ CHANNEL WEST & EAST BANK TABULATED DATA

Calc'd By: SZ
Date: 11/05/2019
RPT-CE-CD-112 REV8

Alpine AP00
West Bank Nigliq
Streambank Monitor

KUUKPIK UMIAQ

Doc.LCMF-155 REV8

	West Bank Monitor - Top of Bank Locations							
Baseline	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location							
Station	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/24/2018	8/13/2019	Description
0+00	180.2			153.6	147.0	147.0	144.6	Baseline Offset (In Feet)
				-26.6	-6.6	0.0	-2.4	Incremental Change
				-26.6	-33.2	-33.2	-35.6	Cumulative Change
1+00	191.0			168.5	168.5	164.8	155.8	Baseline Offset (In Feet)
				-22.5	0.0	-3.7	-9.0	Incremental Change
				-22.5	-22.5	-26.2	-35.2	Cumulative Change
2+00	193.1			184.4	181.6	177.7	173.1	Baseline Offset (In Feet)
				-8.7	-2.8	-3.9	-4.6	Incremental Change
				-8.7	-11.5	-15.4	-20.0	Cumulative Change
3+00	189.2			186.1	186.1	183.4	178.6	Baseline Offset (In Feet)
				-3.1	0.0	-2.7	-4.8	Incremental Change
				-3.1	-3.1	-5.8	-10.6	Cumulative Change
4+00	192.2			187.7	187.7	185.7	182.4	Baseline Offset (In Feet)
				-4.5	0.0	-2.0	-3.3	Incremental Change
				-4.5	-4.5	-6.5	-9.8	Cumulative Change
5+00	202.9			197.1	194.8	191.3	188.0	Baseline Offset (In Feet)
				-5.8	-2.3	-3.5	-3.3	Incremental Change
				-5.8	-8.1	-11.6	-14.9	Cumulative Change
6+00	224.0			207.8	203.8	203.8	200.8	Baseline Offset (In Feet)
				-16.2	-4.0	0.0	-3.0	Incremental Change
				-16.2	-20.2	-20.2	-23.2	Cumulative Change
7+00	228.9			209.3	206.0	202.7	202.7	Baseline Offset (In Feet)
				-19.6	-3.3	-3.3	0.0	Incremental Change
				-19.6	-22.9	-26.2	-26.2	Cumulative Change
8+00	232.9			219.1	215.1	212.3	212.3	Baseline Offset (In Feet)
				-13.8	-4.0	-2.8	0.0	Incremental Change
				-13.8	-17.8	-20.6	-20.6	Cumulative Change
9+00	220.0			217.9	217.9	217.9	219.4	Baseline Offset (In Feet)
				-2.1	0.0	0.0	1.5	Incremental Change
				-2.1	-2.1	-2.1	-0.6	Cumulative Change

Doc LCMF-155 Nigliq Streambank Monitor Rev9.xlsx 1 of 4 West Bank Monitor

Calc'd By: SZ
Date: 11/05/2019
RPT-CE-CD-112 REV8

Alpine AP00
West Bank Nigliq
Streambank Monitor

KUUKPIK UMIAQ
Doc.LCMF-155 REV8

	West Bank Monitor - Top of Bank Locations							
Baseline	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location							
Station	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/24/2018	8/13/2019	Description
10+00	216.8	216.8	213.5	213.5	213.5	210.9	209.5	Baseline Offset (In Feet)
		0.0	-3.3	0.0	0.0	-2.6	-1.4	Incremental Change
		0.0	-3.3	-3.3	-3.3	-5.9	-7.3	Cumulative Change
11+00	209.1	209.1	204.9	204.8	204.8	204.8	204.8	Baseline Offset (In Feet)
		0.0	-4.2	-0.1	0.0	0.0	0.0	Incremental Change
		0.0	-4.2	-4.3	-4.3	-4.3	-4.3	Cumulative Change
12+00	199.0	199.0	199.0	199.8	189.8	189.7	187.0	Baseline Offset (In Feet)
		0.0	0.0	0.8	-10.0	-0.1	-2.7	Incremental Change
		0.0	0.0	0.8	-9.2	-9.3	-12.0	Cumulative Change
13+00	192.1	192.1	192.1	192.1	188.3	188.3	188.6	Baseline Offset (In Feet)
		0.0	0.0	0.0	-3.8	0.0	0.3	Incremental Change
		0.0	0.0	0.0	-3.8	-3.8	-3.5	Cumulative Change
14+00	200.9			198.8	193.7	193.7	194.4	Baseline Offset (In Feet)
				-2.1	-5.1	0.0	0.7	Incremental Change
				-2.1	-7.2	-7.2	-6.5	Cumulative Change
15+00	190.0			190.0	186.2	186.2	184.8	Baseline Offset (In Feet)
				0.0	-3.8	0.0	-1.4	Incremental Change
				0.0	-3.8	-3.8	-5.2	Cumulative Change
16+00	211.0			209.5	203.3	203.3	202.3	Baseline Offset (In Feet)
				-1.5	-6.2	0.0	-1.0	Incremental Change
				-1.5	-7.7	-7.7	-8.7	Cumulative Change
17+00	204.0			204.0	202.9	200.6	200.8	Baseline Offset (In Feet)
				0.0	-1.1	-2.3	0.2	Incremental Change
				0.0	-1.1	-3.4	-3.2	Cumulative Change
18+00	212.0			208.3	208.3	208.3	208.6	Baseline Offset (In Feet)
				-3.7	0.0	0.0	0.3	Incremental Change
				-3.7	-3.7	-3.7	-3.4	Cumulative Change
19+00	221.9			221.9	221.9	221.9	222.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.1	Incremental Change
				0.0	0.0	0.0	0.1	Cumulative Change
20+00	232.9			232.9	232.9	232.9	230.1	Baseline Offset (In Feet)

Doc LCMF-155 Nigliq Streambank Monitor Rev9.xlsx 2 of 4 West Bank Monitor

Calc/d By: SZ
Date: 11/05/2019
RPT-CE-CD-112 REV8

Alpine AP00
West Bank Nigliq
Streambank Monitor

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

Doc.LCMF-155 REV8

	West Bank Monitor - Top of Bank Locations							
Baseline	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location							
Station	**8/21/2013**	**8/24/2014**	**8/27/2015**	**7/6/2016**	**8/24/2017**	**8/24/2018**	**8/13/2019**	**Description**
				0.0	0.0	0.0	-2.8	Incremental Change
				0.0	0.0	0.0	-2.8	Cumulative Change
21+00	233.9			227.5	227.5	227.5	227.7	Baseline Offset (In Feet)
				-6.4	0.0	0.0	0.2	Incremental Change
				-6.4	-6.4	-6.4	-6.2	Cumulative Change

Doc LCMF-155 Nigliq Streambank Monitor Rev9.xlsx 3 of 4 West Bank Monitor

Calc/d By: SZ
Date: 11/05/2019
RPT-CE-CD-112 REV8

Alpine AP00

West Bank Nigliq

Streambank Monitor

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

Doc.LCMF-155 REV8

	West Bank Monitor - Top of Bank Locations							
Baseline	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location							
Station	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/24/2018	8/13/2019	Description
22+00	237.8			233.3	233.3	233.3	233.4	Baseline Offset (In Feet)
				-4.5	0.0	0.0	0.1	Incremental Change
				-4.5	-4.5	-4.5	-4.4	Cumulative Change
23+00	237.9			233.0	233.0	233.0	233.4	Baseline Offset (In Feet)
				-4.9	0.0	0.0	0.4	Incremental Change
				-4.9	-4.9	-4.9	-4.5	Cumulative Change
24+00	229.9			229.9	229.9	229.9	230.5	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.6	Incremental Change
				0.0	0.0	0.0	0.6	Cumulative Change
25+00	214.1			214.1	214.1	214.1	214.4	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.3	Incremental Change
				0.0	0.0	0.0	0.3	Cumulative Change
25+11	213.9			213.9	213.9	213.9	214.1	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.2	Incremental Change
				0.0	0.0	0.0	0.2	Cumulative Change

***Note: Survey completed on 8/22/13 was used for baseline data to compute Incremental /Cumulative Change. Negative numbers indicate erosion.

Calc'd By: SZ
Date: 11/05/2019
RPT-CE-CD-112 REV8

Alpine AP00
East Bank Nigliq
Streambank Monitor

KUUKPIK UMIAQ ALPINE SURVEY OFFICE

Doc.LCMF-155 REV8

	East Bank Monitor - Top of Bank Locations							
Baseline	See Drawing CE-AP00-1126 Rev 7 for Survey Baseline Location							
Station	**8/22/2013**	**8/24/2014**	**8/27/2015**	**7/6/2016**	**8/24/2017**	**8/25/2018**	**8/13/2019**	**Description**
0+00	169.9			169.9	169.9	169.9	169.8	Baseline Offset (In Feet)
				0.0	0.0	0.0	-0.1	Incremental Change
				0.0	0.0	0.0	-0.1	Cumulative Change
1+00	174.0			174.0	174.0	174.0	173.9	Baseline Offset (In Feet)
				0.0	0.0	0.0	-0.1	Incremental Change
				0.0	0.0	0.0	-0.1	Cumulative Change
2+00	178.9			178.9	178.9	178.9	179.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.1	Incremental Change
				0.0	0.0	0.0	0.1	Cumulative Change
3+00	191.0			191.0	191.0	191.0	191.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	0.0	Cumulative Change
4+00	188.0			188.0	188.0	188.0	188.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	0.0	Cumulative Change
5+00	196.1			196.1	196.1	196.1	196.3	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.2	Incremental Change
				0.0	0.0	0.0	0.2	Cumulative Change
6+00	201.1			201.1	201.1	201.1	201.1	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	0.0	Cumulative Change
7+00	208.1			208.1	208.2	208.2	208.3	Baseline Offset (In Feet)
				0.0	0.1	0.0	0.1	Incremental Change
				0.0	0.1	0.1	0.2	Cumulative Change
8+00	199.8			199.8	199.9	199.9	199.8	Baseline Offset (In Feet)
				0.0	0.1	0.0	-0.1	Incremental Change
				0.0	0.1	0.1	0.0	Cumulative Change
9+00	406.2			406.2	406.0	406.0	406.0	Baseline Offset (In Feet)
				0.0	-0.2	0.0	0.0	Incremental Change
				0.0	-0.2	-0.2	-0.2	Cumulative Change

Doc LCMF-155 Nigliq Streambank Monitor Rev9.xlsx 1 of 2 East Bank Monitor

Calc'd By: SZ
Date: 11/05/2019
RPT-CE-CD-112 REV8

Alpine AP00

East Bank Nigliq

Streambank Monitor

KUUKPIK UMIAQ

Doc.LCMF-155 REV8

	East Bank Monitor - Top of Bank Locations							
Baseline	See Drawing CE-AP00-1126 Rev 7 for Survey Baseline Location							
Station	**8/22/2013**	**8/24/2014**	**8/27/2015**	**7/6/2016**	**8/24/2017**	**8/25/2018**	**8/13/2019**	**Description**
10+00	280.9			280.7	280.6	280.6	280.6	Baseline Offset (In Feet)
				-0.2	-0.1	0.0	0.0	Incremental Change
				-0.2	-0.3	-0.3	-0.3	Cumulative Change
11+00	192.2			192.0	192.0	192.0	192.1	Baseline Offset (In Feet)
				-0.2	0.0	0.0	0.1	Incremental Change
				-0.2	-0.2	-0.2	-0.1	Cumulative Change
12+00	100.1			107.9	107.6	107.6	107.6	Baseline Offset (In Feet)
				7.8	-0.3	0.0	0.0	Incremental Change
				7.8	7.5	7.5	7.5	Cumulative Change
13+00	192.0	192.0	192.0	192.0	191.8	191.8	191.8	Baseline Offset (In Feet)
		0.0	0.0	0.0	-0.2	0.0	0.0	Incremental Change
		0.0	0.0	0.0	-0.2	-0.2	-0.2	Cumulative Change
14+00	210.0	210.0	210.0	*Unable to	205.8	205.8	205.8	Baseline Offset (In Feet)
		0.0	0.0		-4.2	0.0	0.0	Incremental Change
		0.0	0.0		-4.2	-4.2	-4.2	Cumulative Change
15+00	192.0	192.0	192.0	192.0	192.0	192.0	192.0	Baseline Offset (In Feet)
		0.0	0.0	0.0	0.0	0.0	0.0	Incremental Change
		0.0	0.0	0.0	0.0	0.0	0.0	Cumulative Change

***Note: Survey completed on 8/22/13 was used for baseline data to compute Incremental/Cumulative Change.
Negative numbers indicate erosion.
Positive numbers indicate erosion Sta 9+00 to 12+00.

Doc LCMF-155 Nigliq Streambank Monitor Rev9.xlsx 2 of 2

East Bank Monitor

E.2.2 NIGLIAGVIK CHANNEL WEST & EAST BANK TABULATED DATA

Calc'd By: MB
Date: 08/13/2019
RPT-CE-CD-111 REV7

Alpine AP00
West Bank Nigliagvik
Streambank Monitor

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

Doc.LCMF-154 REV7

Baseline	West Bank Monitor - Top of Bank Locations							Description
Station	See Drawing CE-AP00-1126 Rev 7 for Survey Baseline Location							
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	8/24/2017	8/25/2018	8/13/2019	Date
0+00	110.0			100.7	100.7	100.7	101.1	Baseline Offset (In Feet)
				-9.3	0.0	0.0	0.4	Incremental Change
				-9.3	-9.3	-9.3	-8.9	Cumulative Change
1+00	103.0			97.9	97.9	97.9	98.2	Baseline Offset (In Feet)
				-5.1	0.0	0.0	0.3	Incremental Change
				-5.1	-5.1	-5.1	-4.8	Cumulative Change
2+00	99.6			99.6	97.5	97.5	97.5	Baseline Offset (In Feet)
				0.0	-2.1	0.0	0.0	Incremental Change
				0.0	-2.1	-2.1	-2.1	Cumulative Change
3+00	98.8			91.3	91.3	91.3	91.4	Baseline Offset (In Feet)
				-7.5	0.0	0.0	0.1	Incremental Change
				-7.5	-7.5	-7.5	-7.4	Cumulative Change
4+00	106.0	106.0	106.0	102.4	102.4	102.4	99.7	Baseline Offset (In Feet)
		0.0	0.0	-3.6	0.0	0.0	-2.7	Incremental Change
		0.0	0.0	-3.6	-3.6	-3.6	-6.3	Cumulative Change
5+00	102.0	93.5	93.5	81.1	81.1	81.1	81.1	Baseline Offset (In Feet)
		-8.4	0.0	-12.4	0.0	0.0	0.0	Incremental Change
		-8.4	-8.4	-20.9	-20.9	-20.9	-20.9	Cumulative Change
6+00	92.0	90.4	90.4	87.9	87.9	87.9		Baseline Offset (In Feet)
		-1.6	0.0	-2.5	0.0	0.0	-87.9	Incremental Change
		-1.6	-1.6	-4.1	-4.1	-4.1	-92.0	Cumulative Change

Doc LCMF-154 Nigliagvik Streambank Monitor Rev7.xlsx 1 of 2 West Bank Monitor

Calc'd By: MB
Date: 08/13/2019
RPT-CE-CD-111 REV7

Alpine AP00
West Bank Nigliagvik
Streambank Monitor

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

Doc.LCMF-154 REV7

Baseline	West Bank Monitor - Top of Bank Locations							Description
Station	See Drawing CE-AP00-1126 Rev 7 for Survey Baseline Location							
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	8/24/2017	8/25/2018	8/13/2019	Date
7+00	107.1			107.1	107.1	107.1	101.5	Baseline Offset (In Feet)
				0.0	0.0	0.0	-5.6	Incremental Change
				0.0	0.0	0.0	-5.6	Cumulative Change
8+00	115.0			112.8	112.8	112.8	112.9	Baseline Offset (In Feet)
				-2.2	0.0	0.0	0.1	Incremental Change
				-2.2	-2.2	-2.2	-2.1	Cumulative Change
9+00	96.1			91.8	91.8	91.8	92.0	Baseline Offset (In Feet)
				-4.3	0.0	0.0	0.2	Incremental Change
				-4.3	-4.3	-4.3	-4.1	Cumulative Change
10+00	106.1			106.1	106.1	105.2	106.4	Baseline Offset (In Feet)
				0.0	0.0	-0.9	1.2	Incremental Change
				0.0	0.0	-0.9	0.3	Cumulative Change
completed on 8/21/13 was used for baseline data to compute Incremental/Cumulative Change. Negative numbers								

Calc'd By: MB
Date: 08/13/2019
RPT-CE-CD-111 REV7

Alpine AP00
East Bank Nigliagvik
Streambank Monitor

KUUKPIK UMIAQ ALPINE SURVEY OFFICE

Doc.LCMF-154 REV7

Baseline Station	East Bank Monitor - Top of Bank Locations							Description
	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location							
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	8/24/2017	8/24/2018	8/13/2019	Date
0+00	165.1			165.1	165.3	165.3	165.4	Baseline Offset (In Feet)
				0.0	0.2	0.0	0.1	Incremental Change
				0.0	0.2	0.2	0.3	Cumulative Change
1+00	185.0			185.0	185.0	185.0	185.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	0.0	Cumulative Change
2+00	165.0			165.0	165.1	165.1	165.0	Baseline Offset (In Feet)
				0.0	0.1	0.0	-0.1	Incremental Change
				0.0	0.1	0.1	0.0	Cumulative Change
3+00	162.3			162.3	162.2	162.2	102.4	Baseline Offset (In Feet)
				0.0	-0.1	0.0	-59.8	Incremental Change
				0.0	-0.1	-0.1	-59.9	Cumulative Change
4+00	154.9	154.9	154.9	147.6	147.6	147.6	147.7	Baseline Offset (In Feet)
		0.0	0.0	-7.3	0.0	0.0	0.1	Incremental Change
		0.0	0.0	-7.3	-7.3	-7.3	-7.2	Cumulative Change
5+00	141.0	141.0	138.4	Under	143.7	143.7	143.7	Baseline Offset (In Feet)
		0.0	-2.7	Bridge	5.3	0.0	0.0	Incremental Change
		0.0	-2.7		2.7	2.7	2.7	Cumulative Change
6+00	120.9	120.9	120.9	120.9	121.1	121.1	121.0	Baseline Offset (In Feet)
		0.0	0.0	0.0	0.2	0.0	-0.1	Incremental Change
		0.0	0.0	0.0	0.2	0.2	0.1	Cumulative Change

Doc LCMF-154 Nigliagvik Streambank Monitor Rev7.xlsx 1 of 2 East Bank Monitor

Calc'd By: MB
Date: 08/13/2019
RPT-CE-CD-111 REV7

Alpine AP00
East Bank Nigliagvik
Streambank Monitor

KUUKPIK UMIAQ ALPINE SURVEY OFFICE

Doc.LCMF-154 REV7

Baseline	East Bank Monitor - Top of Bank Locations							Description
Station	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location							
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	8/24/2017	8/24/2018	8/13/2019	Date
7+00	119.0			119.0	119.5	119.5	119.3	Baseline Offset (In Feet)
				0.0	0.5	0.0	-0.2	Incremental Change
				0.0	0.5	0.5	0.3	Cumulative Change
8+00	120.9			120.9	121.3	121.3	121.2	Baseline Offset (In Feet)
				0.0	0.4	0.0	-0.1	Incremental Change
				0.0	0.4	0.4	0.3	Cumulative Change

***Note: Survey completed on 8/21/13 was used for baseline data to compute Incremental/Cumulative Change. Ne

***Note: Based on field evaluations and review of aerial imagery, the 2013 top of bank point at station 3+00 along the east bank is considered a misrepresentation of the bank at the time of survey. There is no visible erosion at this location and the 2013 top of bank was repositioned to align with the 2016 top of bank.

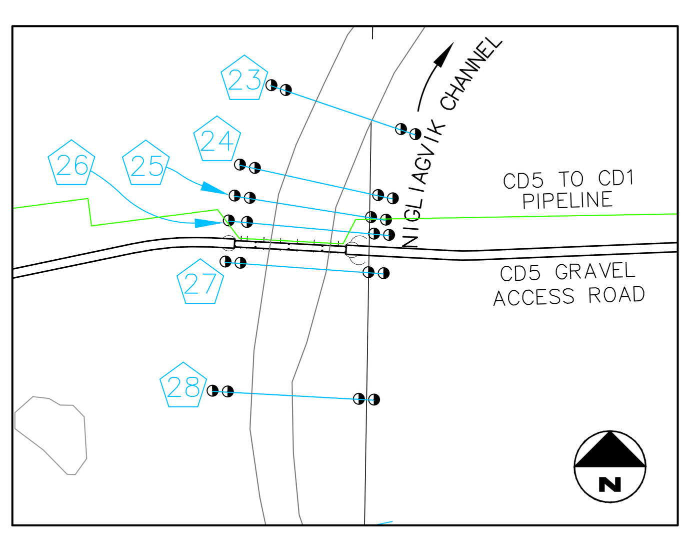
E.3 BATHYMETRY

E.3.1 TRANSECT PROFILES

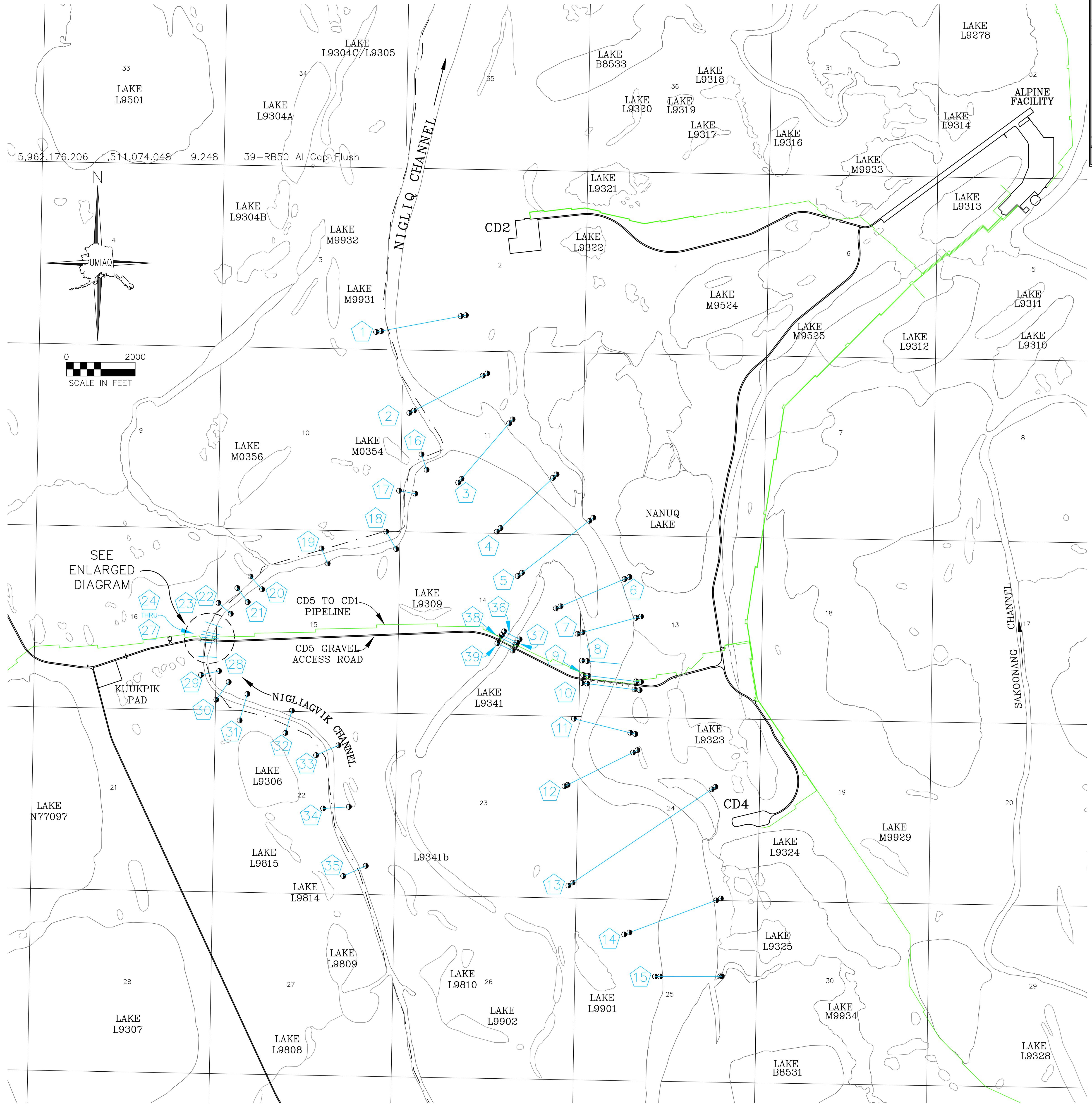
JOB NO: 02-204 | SUB JOB NO: – | DRAWING NO: CE-CD50-1004

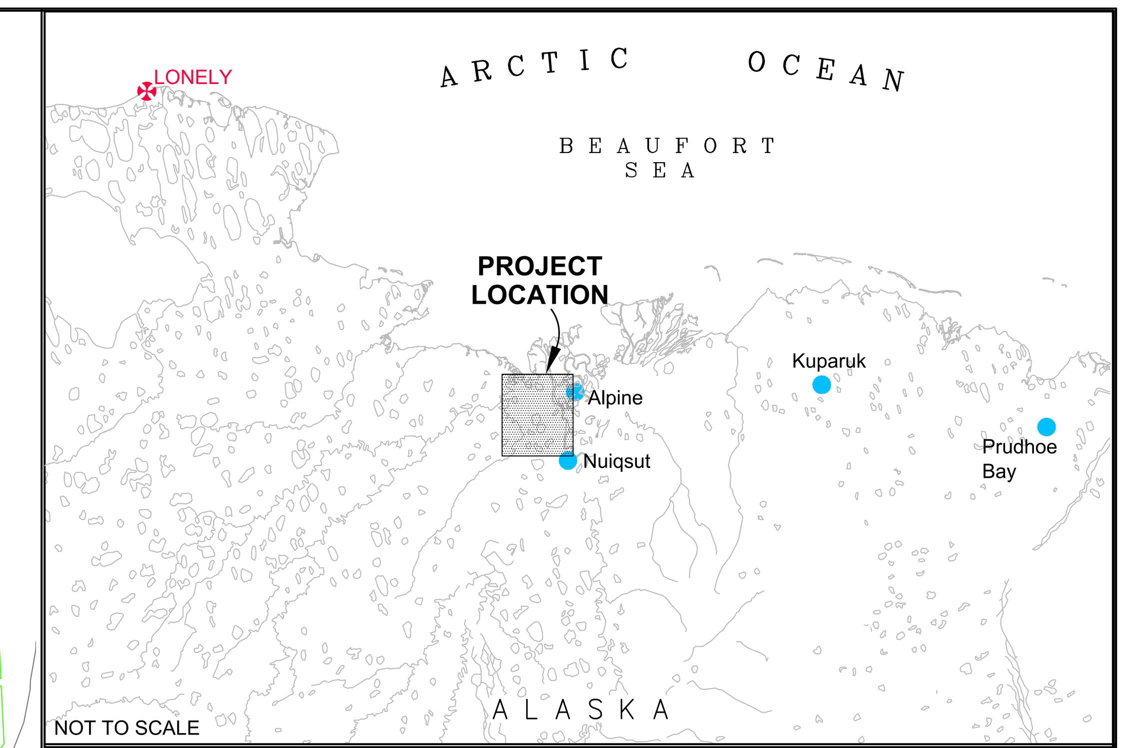
CD5 2017 TRANSECT CONTROL

NORTHING	EASTING	ELEV	DESCRIPTION	NORTHING	EASTING	ELEV	DESCRIPTION
5,971,410.079	1,507,156.531	8.39	01–LB200 Al Cap Flush	5,963,972.572	1,503,814.158	7.59	20–RB50 Al Cap Flush
5,971,437.609	1,507,304.061	8.37	01–LB50 Al Cap Flush	5,963,970.131	1,503,127.991	24.55	21–LB100 Al Cap Flush
5,971,895.666	1,509,763.389	9.13	01–RB200 Al Cap Flush	5,963,929.997	1,503,157.807	20.75	21–LB50 Al Cap Flush
5,971,868.384	1,509,615.796	9.28	01–RB50 Al Cap Flush	5,963,562.385	1,503,430.606	8.83	21–RB100 Al Cap Flush
5,969,060.212	1,508,119.663	8.87	02–LB200 Al Cap Flush	5,963,602.552	1,503,400.707	9.12	21–RB50 Al Cap Flush
5,969,127.986	1,508,253.629	7.65	02–LB50 Al Cap Flush	5,963,540.635	1,502,578.236	26.09	22–LB110 Al Cap Flush
5,970,206.007	1,510,386.350	9.26	02–RB200 Al Cap Flush	5,963,500.929	1,502,623.041	24.05	22–LB50 Al Cap Flush
5,970,138.188	1,510,252.432	8.96	02–RB50 Al Cap Flush	5,963,224.550	1,502,936.061	8.70	22–RB100 Al Cap Flush
5,967,032.227	1,509,538.697	9.67	03–LB200 Al Cap Flush	5,963,257.784	1,502,898.581	9.16	22–RB50 Al Cap Flush
5,967,145.969	1,509,636.499	10.13	03–LB50 Al Cap Flush	5,962,989.540	1,502,198.702	25.27	23–LB100 Al Cap Flsh
5,968,868.865	1,511,117.892	9.41	03–RB200 Al Cap Flush	5,962,973.551	1,502,246.078	25.13	23–LB50 Al Cap Flush
5,968,755.138	1,511,019.833	9.05	03–RB50 Al Cap Flush	5,962,828.919	1,502,671.911	10.17	23–RB100 Al Cap Flush
5,965,610.351	1,510,661.003	12.54	04–LB200 Al Cap Flush	5,962,844.993	1,502,624.671	7.92	23–RB50 Al Cap Flush
5,965,716.677	1,510,772.064	13.71	04–LB50 Al Cap Flush	5,962,728.640	1,502,095.594	26.44	24–LB100 Al Cap Flush
5,967,272.750	1,512,396.862	10.36	04–RB200 Al Cap Flush	5,962,717.858	1,502,144.429	26.95	24–LB50 Al Cap Flush
5,967,169.020	1,512,288.517	10.23	04–RB50 Al Cap Flush	5,962,617.871	1,502,598.118	9.07	24–RB100 Al Cap Flush
5,964,321.998	1,511,269.867	11.98	05–LB200 Al Cap Flush	5,962,628.701	1,502,549.442	8.42	24–RB50 Al Cap Flush
5,964,413.665	1,511,388.462	13.14	05–LB50 Al Cap Flush	5,962,627.134	1,502,078.374	27.30	25–LB100 Al Cap Flush
5,966,013.940	1,513,463.318	8.66	05–RB200 Al Cap Flush	5,962,619.297	1,502,127.805	26.17	25–LB50 Al Cap Flush
5,965,922.233	1,513,344.473	8.66	05–RB50 Al Cap Flush	5,962,548.009	1,502,575.213	8.35	25–RB100 Al Cap Flush
5,963,381.239	1,512,373.965	11.39	06–LB200 Al Cap Flush	5,962,555.885	1,502,525.978	8.2	25–RB50 Al Cap Flush
5,963,439.930	1,512,511.976	13.14	06–LB50 Al Cap Flush	5,962,545.552	1,502,059.146	27.26	26–LB110 Al Cap Flush
5,964,291.972	1,514,511.882	9.79	06–RB250 Al Cap Flush	5,962,540.029	1,502,118.494	27.46	26–LB50 Al Cap Flush
5,964,233.822	1,514,375.381	10.19	06–RB50 Al Cap Flush	5,962,498.526	1,502,585.637	9.40	26–RB100 Al Cap Flush
5,962,644.628	1,513,005.197	10.58	07–LB200 Al Cap Flush	5,962,502.417	1,502,535.991	8.29	26–RB50 Al Cap Flush
5,962,683.997	1,513,149.917	12.40	07–LB50 Al Cap Flush	5,962,409.840	1,502,047.832	26.75	27–LB100 Al Cap Flush
5,963,144.351	1,514,844.945	10.50	07–RB200 Al Cap Flush	5,962,406.393	1,502,097.689	27.08	27–LB50 Al Cap Flush
5,963,105.246	1,514,700.397	9.82	07–RB50 Al Cap Flush	5,962,371.836	1,502,567.565	9.06	27–RB100 Al Cap Flush
5,961,864.665	1,513,132.738	10.2	08–LB200 Al Cap Flush	5,962,375.576	1,502,517.753	7.45	27–RB50 Al Cap Flush
5,961,851.284	1,513,282.157	10.33	08–LB50 Al Cap Flush	5,961,986.379	1,502,006.081	20.98	28–LB100 Al Cap Flush
5,961,442.295	1,513,168.264	10.42	09–LB200 Al Cap Flush	5,961,983.603	1,502,055.994	21.16	28–LB50 Al Cap Flush
5,961,424.719	1,513,317.431	10.13	09–LB50 Al Cap Flush	5,961,957.194	1,502,536.500	9.11	28–RB100 Al Cap Flush
5,961,244.647	1,514,849.158	9.12	09–RB200 Al Cap Flush	5,961,959.887	1,502,486.585	8.59	28–RB50 Al Cap Flush
5,961,260.962	1,514,709.975	8.00	09–RB60 Al Cap Flush	5,961,446.898	1,502,073.299	24.32	29–LB100 Al Cap Flush
5,961,214.591	1,513,133.902	10.18	10–LB200 Al Cap Flush	5,961,457.481	1,502,122.198	23.74	29–LB50 Al Cap Flush
5,961,195.839	1,513,282.747	10.25	10–LB50 Al Cap Flush	5,961,559.094	1,502,596.981	9.95	29–RB100 Al Cap Flush
5,961,004.269	1,514,808.574	7.14	10–RB200 Al Cap Flush	5,961,548.539	1,502,547.942	8.74	29–RB50 Al Cap Flush
5,961,023.112	1,514,659.873	8.32	10–RB50 Al Cap Flush	5,960,727.323	1,502,515.764	23.70	30–LB100 Al Cap Flush
5,960,173.813	1,512,898.140	10.87	11–LB200 Al Cap Flush	5,960,768.246	1,502,544.713	23.31	30–LB50 Al Cap Flush
	DESTROYED		11–LB50 Al Cap Flush	5,961,239.638	1,502,877.149	10.09	30–RB100 Al Cap Flush
5,959,731.052	1,514,682.745	9.82	11–RB200 Al Cap Flush	5,961,198.817	1,502,848.288	9.62	30–RB50 Al Cap Flush
5,959,767.242	1,514,537.080	9.00	11–RB50 Al Cap Flush	5,960,124.411	1,503,193.299	8.62	31–LB100 Al Cap Flush
5,958,209.440	1,512,625.576	11.02	12–LB200 Al Cap Flush	5,960,172.274	1,503,207.266	9.61	31–LB50 Al Cap Flush
5,958,254.040	1,512,715.127	10.92	12–LB100 Al Cap Flush	5,960,896.074	1,503,418.951	10.76	31–RB100 Al Cap Flush
5,959,260.219	1,514,746.099	9.87	12–RB200 Al Cap Flush	5,960,848.125	1,503,404.834	11.27	31–RB50 Al Cap Flush
5,959,193.533	1,514,611.494	8.71	12–RB50 Al Cap Flush	5,959,762.546	1,504,523.242	8.41	32–LB100 Al Cap Flush
5,955,329.125	1,512,738.208	11.43	13–LB200 Al Cap Flush	5,959,810.524	1,504,537.152	7.89	32–LB50 Al Cap Flush
5,955,412.750	1,512,862.609	12.06	13–LB50 Al Cap Flush	5,960,406.267	1,504,711.424	10.85	32–RB100 Al Cap Flush
5,958,195.963	1,517,009.777	10.14	13–RB200 Al Cap Flush	5,960,358.129	1,504,697.371	11.51	32–RB50 Al Cap Flush
5,958,123.467	1,516,901.811	11.55	13–RB70 Al Cap Flush	5,959,118.940	1,505,412.996	10.03	33–LB100 Al Cap Flush
5,953,908.305	1,514,359.013	13.31	14–LB215 Al Cap Flush	5,959,138.921	1,505,458.863	8.59	33–LB50 Al Cap Flush
5,953,965.587	1,514,513.819	15.69	14–LB50 Al Cap Flush	5,959,403.885	1,506,064.808	10.64	33–RB120 Al Cap Flush
5,954,950.427	1,517,166.196	9.37	14–RB200 Al Cap Flush	5,959,375.851	1,506,000.615	10.61	33–RB50 Al Cap Flush
5,954,898.227	1,517,025.567	9.62	14–RB50 Al Cap Flush	5,957,567.999	1,505,617.468	12.62	34–LB100 Al Cap Flush
5,952,688.560	1,515,253.984	13.81	15–LB200 Al Cap Flush	5,957,571.228	1,505,667.234	12.76	34–LB50 Al Cap Flush
5,952,688.785	1,515,404.124	16.65	15–LB50 Al Cap Flush	5,957,615.360	1,506,366.139	10.14	34–RB100 Al Cap Flush
5,952,691.528	1,517,195.155	12.55	15–RB100 Al Cap Flush	5,957,612.187	1,506,316.238	10.73	34–RB50 Al Cap Flush
5,952,691.504	1,517,145.172	12.62	15–RB50 Al Cap Flush	5,955,603.337	1,506,200.646	12.56	35–LB100 Al Cap Flush
5,967,852.411	1,508,476.570	9.97	16–LB100 Al Cap Flush	5,955,624.160	1,506,246.181	13.00	35–LB50 Al Cap Flush
5,967,804.830	1,508,492.228	9.22	16–LB50 Al Cap Flush	5,955,901.753	1,506,854.754	10.25	35–RB100 Al Cap Flush
5,967,407.583	1,508,622.098	9.35	16–RB100 Al Cap Flush	5,955,880.833	1,506,809.440	9.42	35–RB50 Al Cap Flush
5,967,455.156	1,508,606.495	8.81	16–RB50 Al Cap Flush	5,962,713.562	1,510,877.357	8.07	36–LB100 Al Cap Flush
5,966,795.092	1,507,822.806	8.49	17–LB100 Al Cap Flush	5,962,690.396	1,510,921.695	8.07	36–LB50 Al Cap Flush
5,966,786.414	1,507,872.068	8.36	17–LB50 Al Cap Flush	5,962,479.473	1,511,322.888	9.50	36–RB100 Al Cap Flush
5,966,712.462	1,508,294.932	8.55	17–RB100 Al Cap Flush	5,962,502.709	1,511,278.659	8.95	36–RB50 Al Cap Flush
5,966,720.904	1,508,245.574	8.57	17–RB50 Al Cap Flush	5,962,603.138	1,510,806.681	8.54	37–LB100 Al Cap Flush
5,965,609.736	1,507,451.191	8.67	18–LB100 Al Cap Flush	5,962,580.899	1,510,851.601	8.30	37–LB50 Al Cap Flush
5,965,566.246	1,507,475.943	8.64	18–LB50 Al Cap Flush	5,962,382.914	1,511,254.351	9.43	37–RB100 Al Cap Flush
5,965,103.321	1,507,739.424	7.92	18–RB100 Al Cap Flush	5,962,405.072	1,511,209.390	8.82	37–RB50 Al Cap Flush
5,965,146.872	1,507,714.623	7.65	18–RB50 Al Cap Flush	5,962,540.247	1,510,738.266	7.55	38–LB100 Al Cap Flush
5,965,119.506	1,505,573.364	8.71	19–LB100 Al Cap Flush	5,962,518.495	1,510,783.408	7.94	38–LB50 Al Cap Flush
5,965,073.146	1,505,592.274	8.72	19–LB50 Al Cap Flush	5,962,311.243	1,511,215.086	8.87	38–RB100 Al Cap Flush
5,964,684.662	1,505,750.583	8.18	19–RB100 Al Cap Flush	5,962,332.728	1,511,169.935	8.96	38–RB50 Al Cap Flush
5,964,730.844	1,505,731.763	8.59	19–RB50 Al Cap Flush	5,962,367.922	1,510,674.689	8.40	39–LB100 Al Cap Flush
5,964,307.555	1,503,508.766	13.76	20–LB100 Al Cap Flush	5,962,346.127	1,510,719.731	7.44	39–LB50 Al Cap Flush
5,964,270.636	1,503,542.458	15.57	20–LB50 Al Cap Flush	5,962,154.431	1,511,119.189	9.32	39–RB100 Al Cap Flush
5,963,935.619	1,503,847.844	7.68	20–RB100 Al Cap Flush	5,962,176.176	1,511,074.056	9.20	39–RB50 Al Cap Flush



ENLARGED DIAGRAM





VICINITY MAP

NOTES:

1. DATE OF SURVEY: AUGUST 29 TO SEPTEMBER 18, 2013; OCTOBER 21, 2013; JUNE 29 TO JULY 26, 2016; JULY 26, 2017 TO AUGUST 24, 2017; AUGUST 12 TO AUGUST 19, 2018; AUGUST 19 TO AUGUST 31, 2019.
2. COORDINATES SHOWN ARE ALASKA STATE PLANE, ZONE 4 N.A.D. 83, IN FEET.
3. ELEVATIONS SHOWN ARE BRITISH PETROLEUM MEAN SEA LEVEL (B.P.M.S.L.) DATUM.
4. REFERENCE FIELD BOOK 2013–18, PGS. 57–59, 67, 70–72. 2013–20 PGS. 4–14; 2013–21, PG. 29; 2016–11, PG. 76, 2016–12, PGS. 17–20, 26–28, 36–37 & 59; 2017–13, PGS. 70–73, 2017–14, PGS. 15–17; 2017–15, PGS. 3–27; 2018–18, PG. 2–4; 2018–13, PG. 35–38; 2018–17, PG. 19–20; 2019–28, PGS. 56–67; 2019–29, PG. 43–44; 2019–34, PG.4

LEGEND:

◑ 2" ALUMINUM CAP ON 5/8" x 30" REBAR (TYPICAL 4 REBAR ON EACH TRANSECT)

KUUKPIK LCMF LLC Alpine Survey Office

ConocoPhillips Alaska, Inc.

ALPINE | MODULE: CD50 | UNIT: CD

CD–5 ROAD
MONITORING PLAN BASELINES
ALPINE, ALASKA

REDRAWN FROM: | CONSTRUCTION SHEET OF

DO NOT SCALE | ABOVE SCALE FOR REFERENCE ONLY

REFERENCE DWG NO/SHT NO:

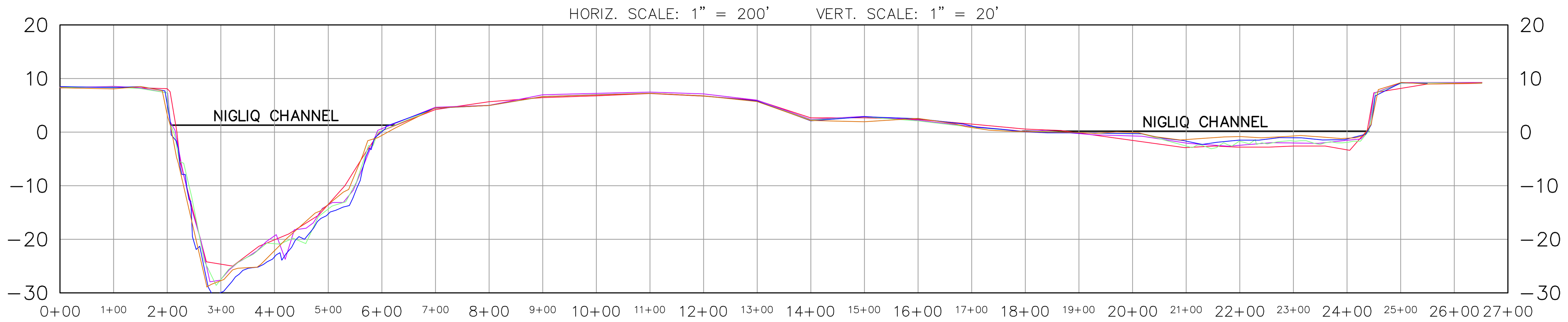
REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
5	09/02/19	UPDATED PER K190003ACS	SZ	CZ			
4	08/20/18	UPDATED PER K180003ACS	SZ	CZ			
3	10/9/17	UPDATED PER K170003ACS	KD	CZ			
2	7/29/16	UPDATED PER K160003ACS	CZ	DB			
1	10/22/13	ISSUED PER K130003ACS	AG	DB			

DATE: 8/26/13	DRAWN: CZ	DESIGN: –	ECM NO: –
	CHECKED: DB		CC NO: –
SCALE: 1" = 2000'	APPROVAL: –		CADD FILE NO. 13–08–07–1 –
JOB NO: 02–204	SUB JOB NO: –	DRAWING NO: CE–CD50–1004	PART: 1 OF 6 / REV: 4

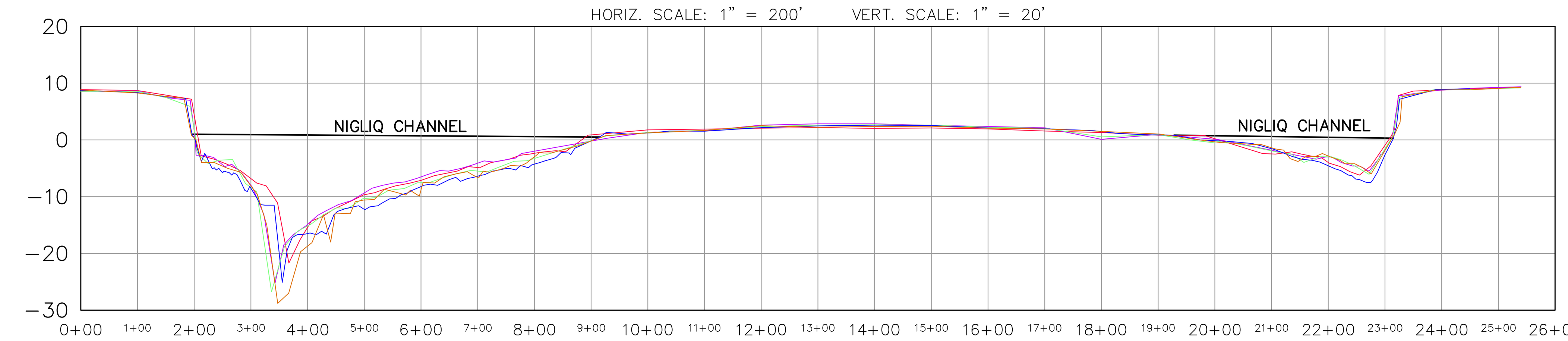
FORM: DSIZE

JOB NO:	SUB JOB NO:	DRAWING NO:
–	–	CE-CD50-1004

Profile View of Transect-1



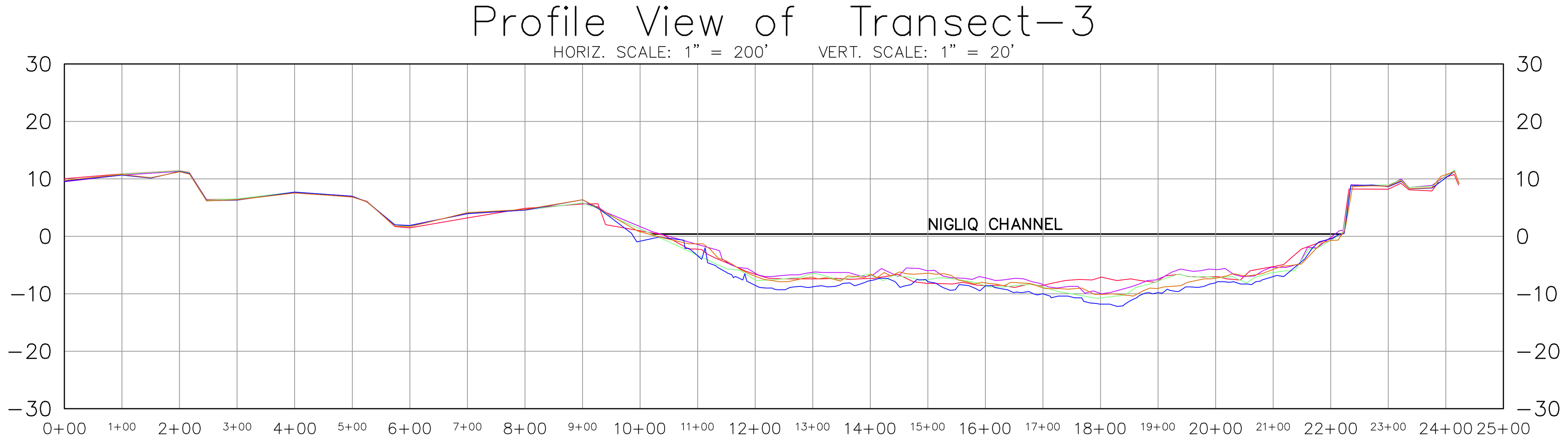
Profile View of Transect-2



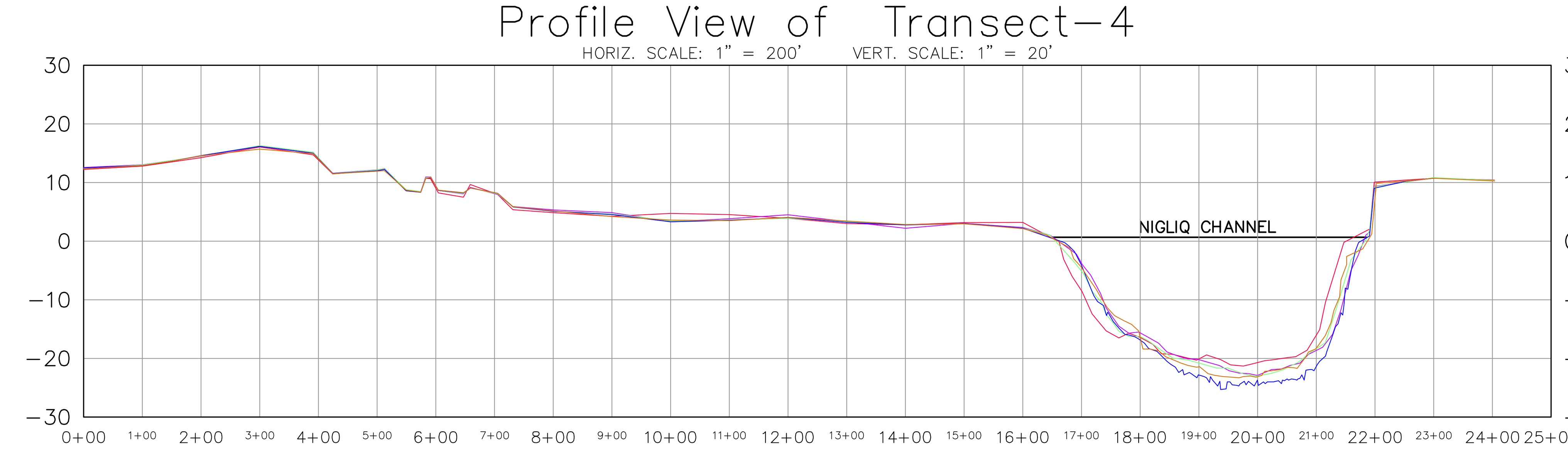
LEGEND:
VIEW LOOKING DOWNSTREAM

- 2013 TRANSECT PROFILE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE
- 2017 TRANSECT PROFILE
- 2018 TRANSECT PROFILE
- 2019 TRANSECT PROFILE

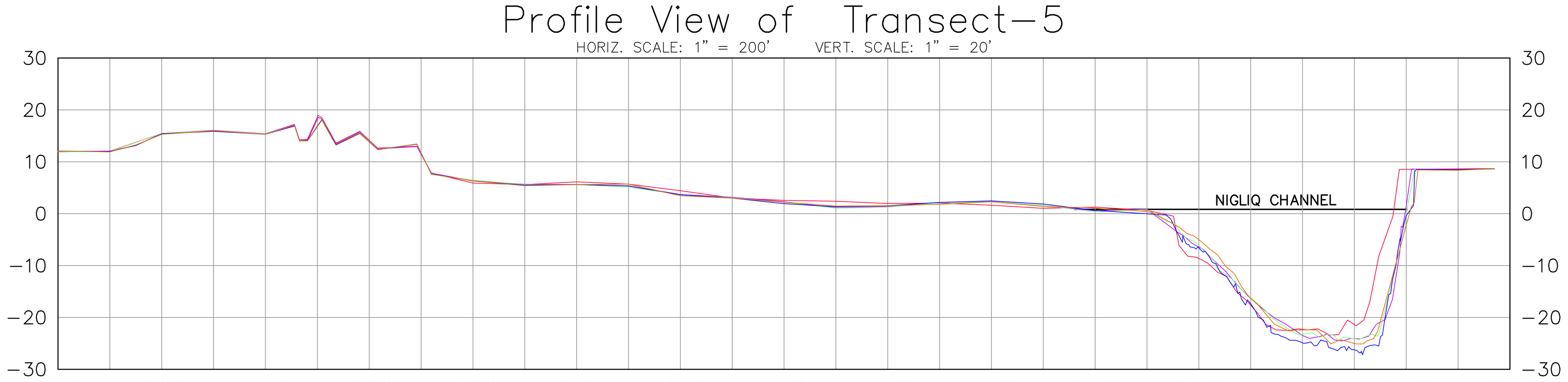
Profile View of Transect-3



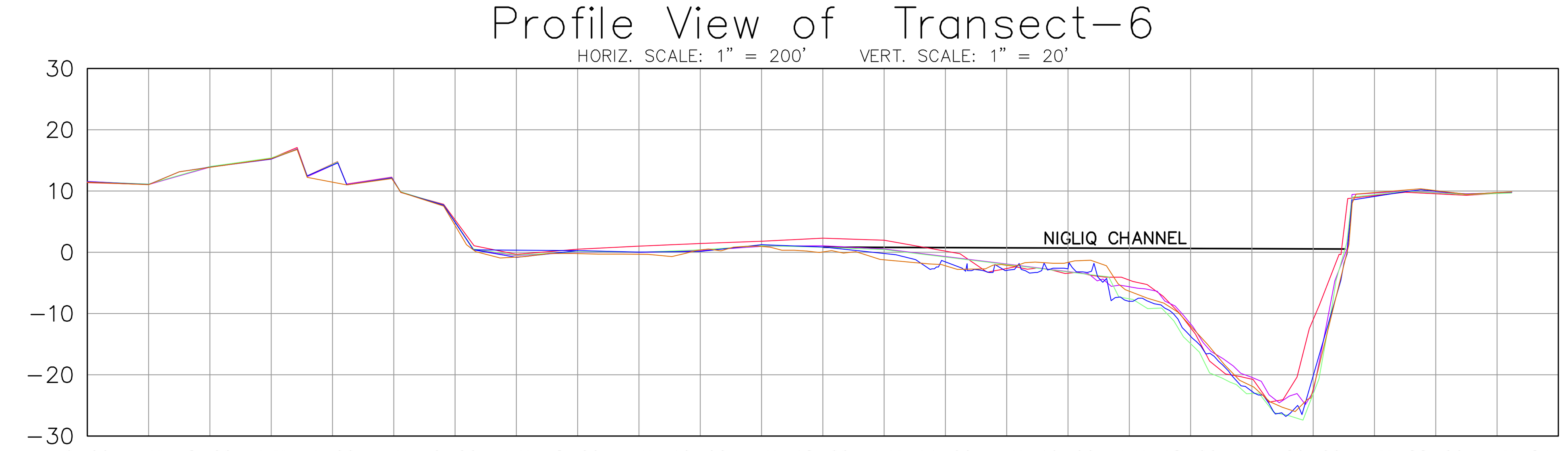
Profile View of Transect-4



Profile View of Transect-5



Profile View of Transect-6



KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE: 907-670-4739

FORM: DSIZEPID

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
4	09/02/2019	UPDATED PER K190003ACS	SZ	CZ			
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

ECM NO: K160003ACS
CC NO: –
CADD FILE NO. 13-08-07-1 –
SCALE: 1" = 200' DATE: 7/01/2016

ConocoPhillips
Alaska, Inc.

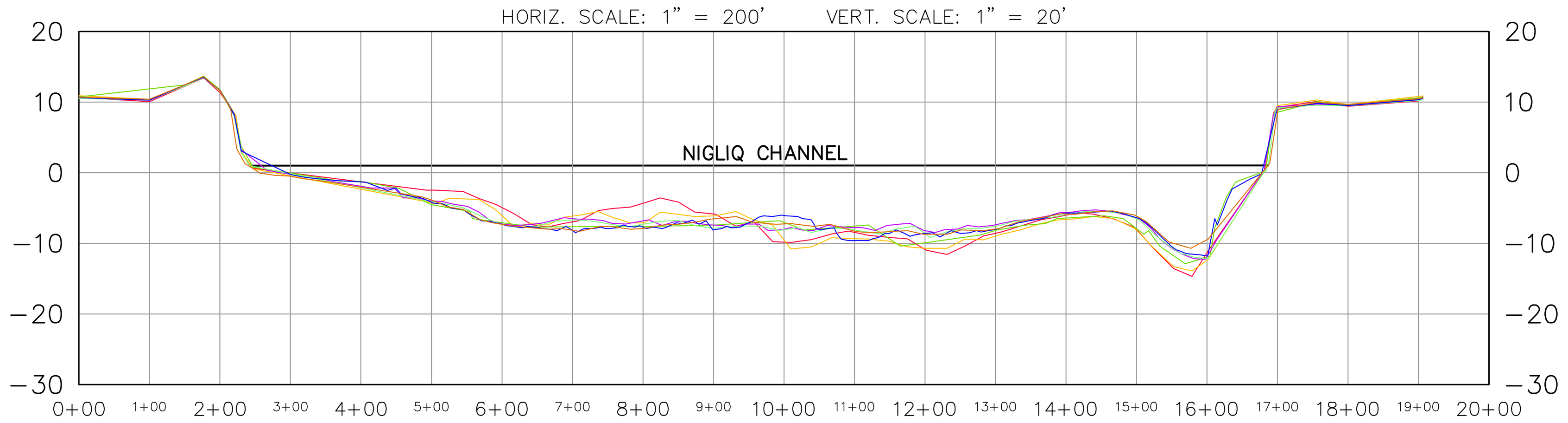
DRAWN: CZ DESIGN: – CHECKED: DB
REDRAWN FROM: – APPROVAL: –

ALPINE MODULE: CD50 UNIT: CD
CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

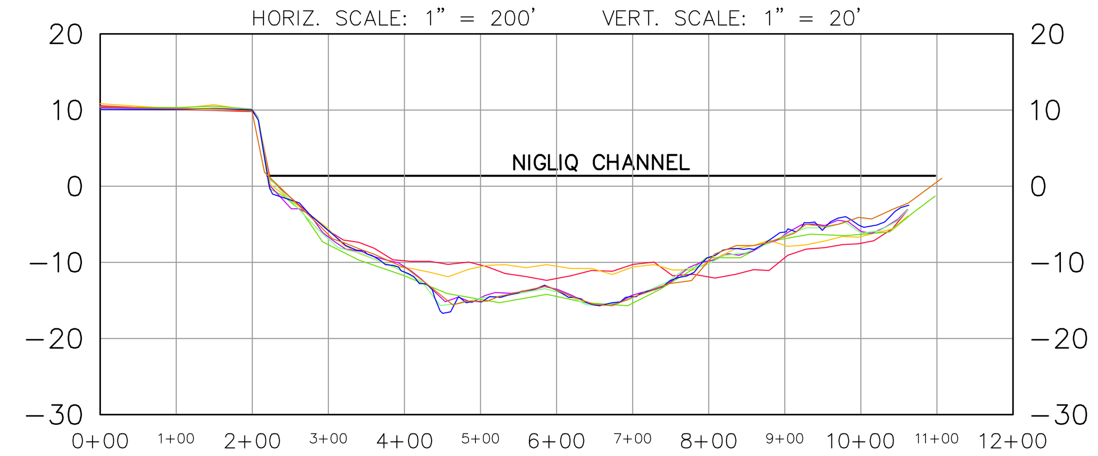
JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE-CD50-1004	2 of 6	4

DRAWING NO:	SUB JOB NO:	JOB NO:
CE-CD50-1004	–	–

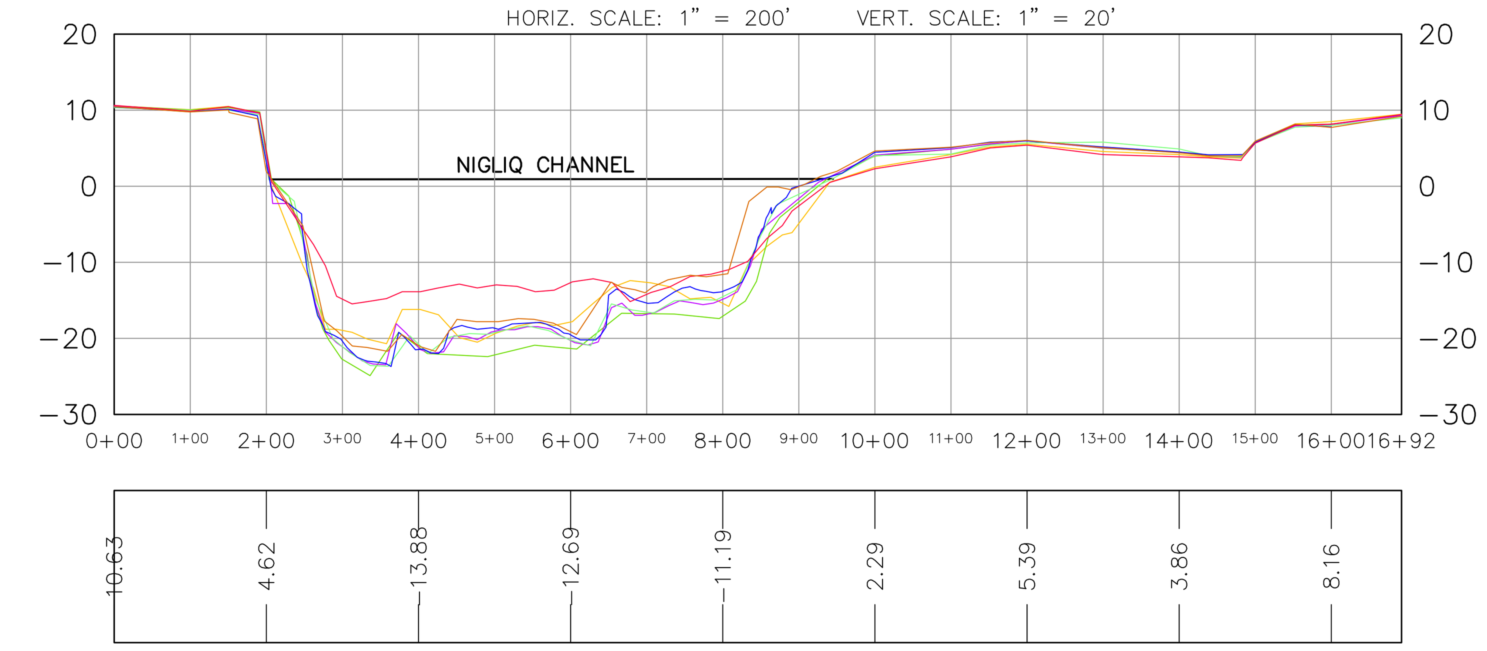
Profile View of Transect-7
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



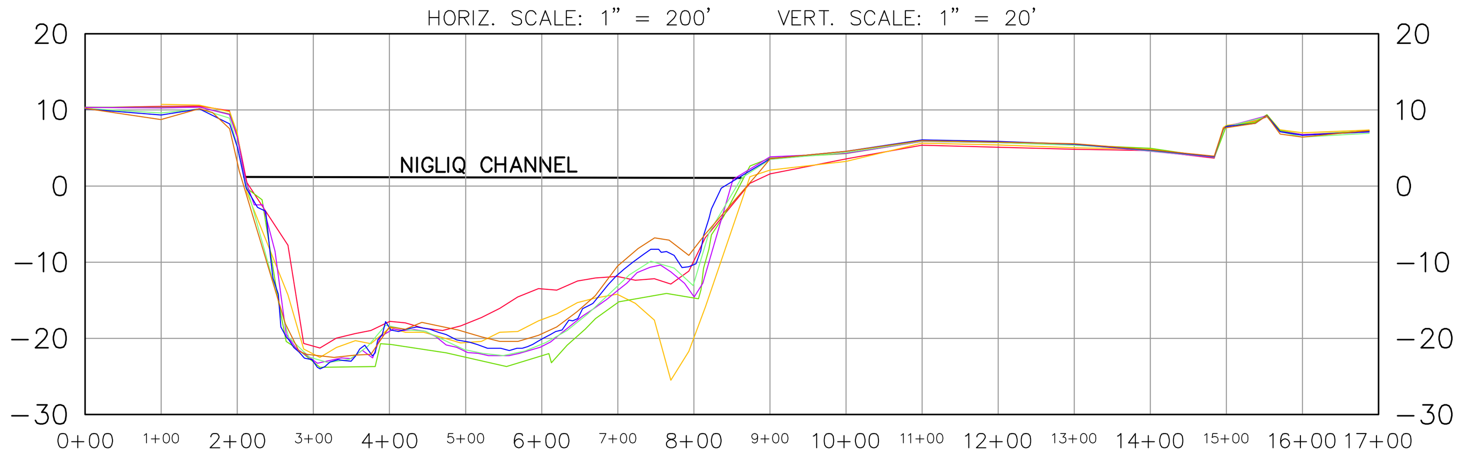
Profile View of Transect-8
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



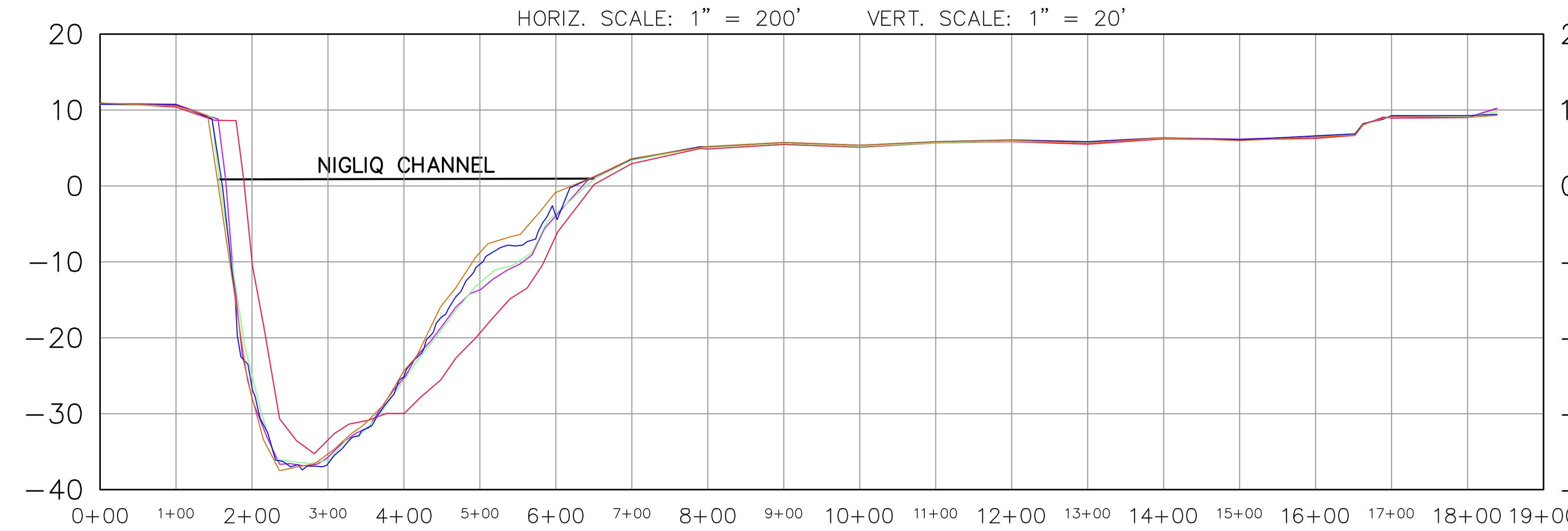
Profile View of Transect-9
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



Profile View of Transect-10
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'

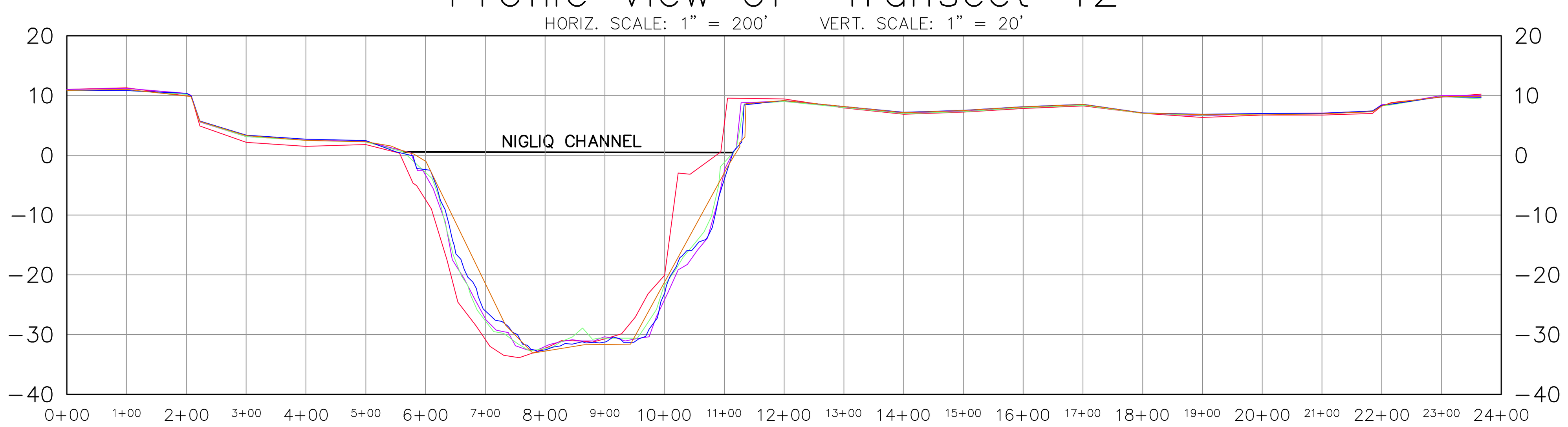


Profile View of Transect-11
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



LEGEND:
VIEW LOOKING DOWNSTREAM
- 2013 TRANSECT PROFILE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE
- 2017 TRANSECT PROFILE
- 2018 TRANSECT PROFILE
- 2019 TRANSECT PROFILE

Profile View of Transect-12
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE : 907-670-4739

FORM: DSIZEPID

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
4	09/02/19	UPDATED PER K190003ACS	SZ	CZ			
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

ECM NO: K160003ACS
CC NO: –
CADD FILE NO. 13-08-07-1 –
SCALE: 1" = 200' DATE: 7/01/2016

ConocoPhillips
Alaska, Inc.

DRAWN: CZ DESIGN: – CHECKED: DB
REDRAWN FROM: – APPROVAL: –

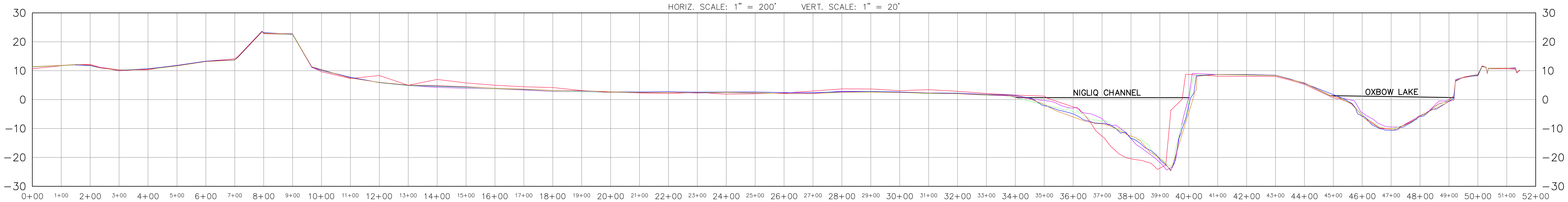
ALPINE MODULE: CD50 UNIT: CD
CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE-CD50-1004	3 of 6	4

DRAWING NO: CE-CD50-1004 | SUB JOB NO: – | JOB NO: –

Profile View of Transect-13

HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'

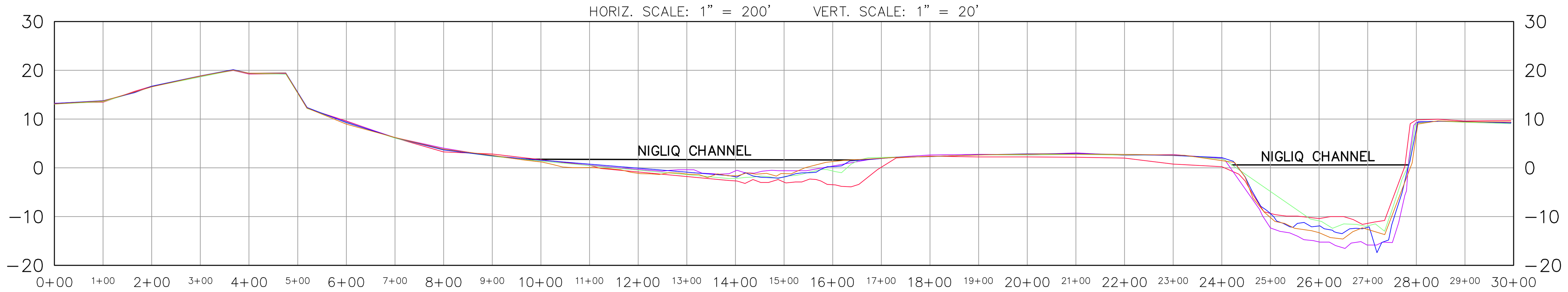


LEGEND:
VIEW LOOKING DOWNSTREAM

- 2013 TRANSECT PROFILE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE
- 2017 TRANSECT PROFILE
- 2018 TRANSECT PROFILE
- 2019 TRANSECT PROFILE

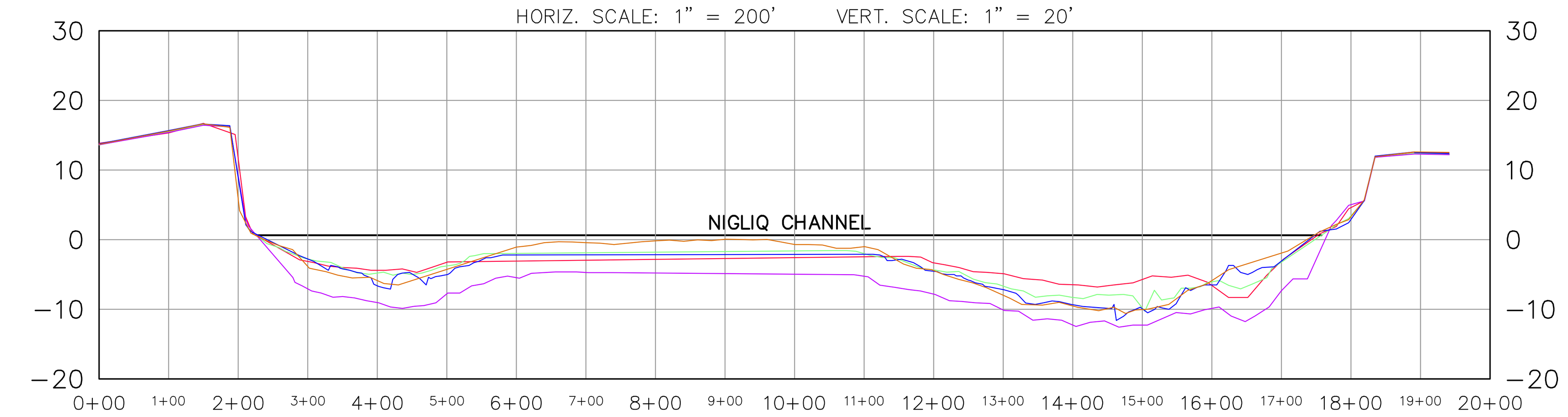
Profile View of Transect-14

HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



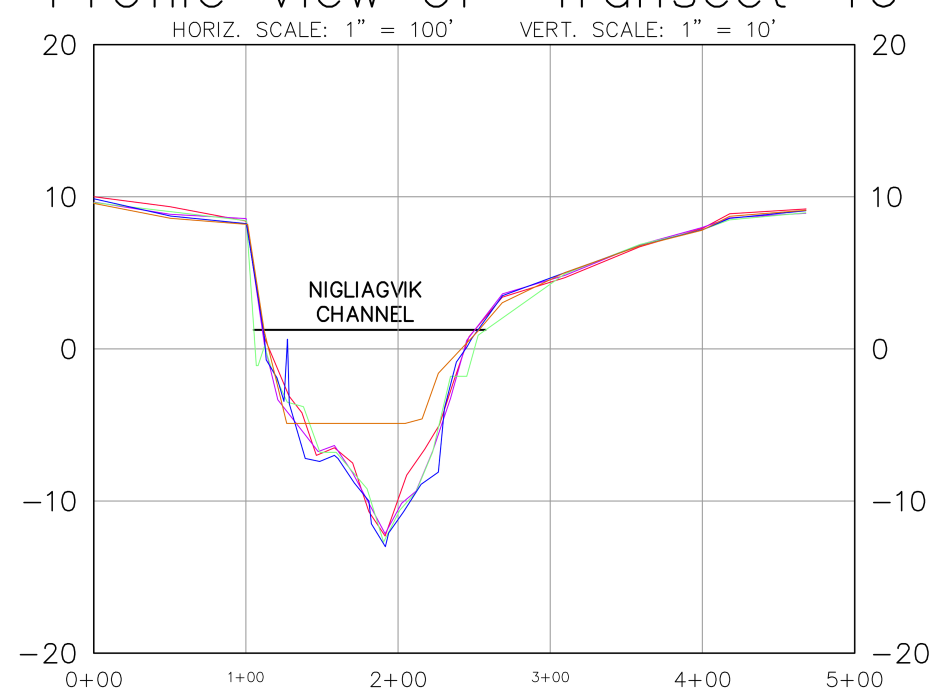
Profile View of Transect-15

HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



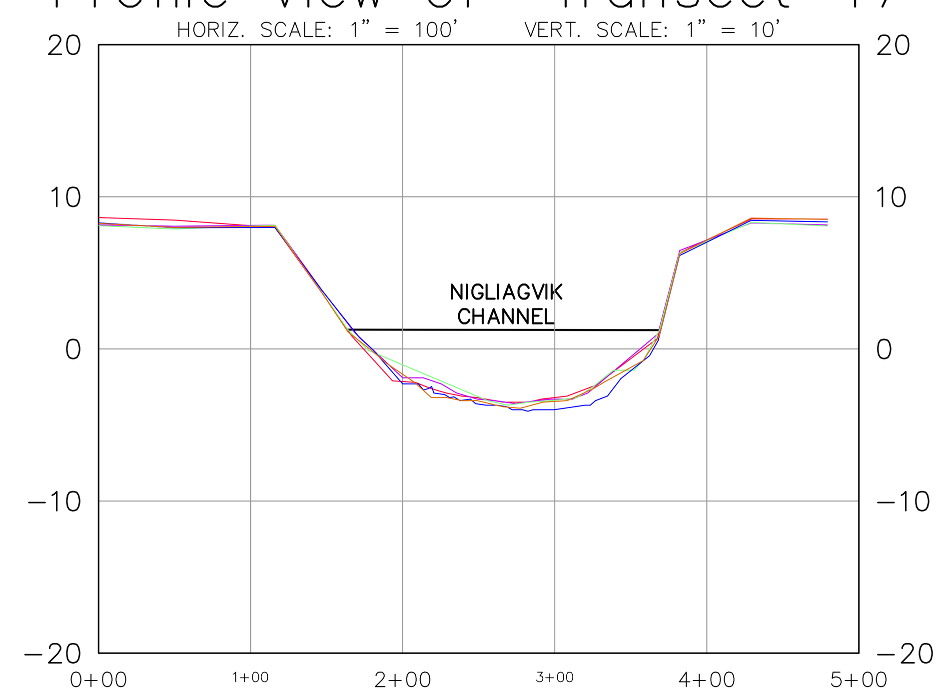
Profile View of Transect-16

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



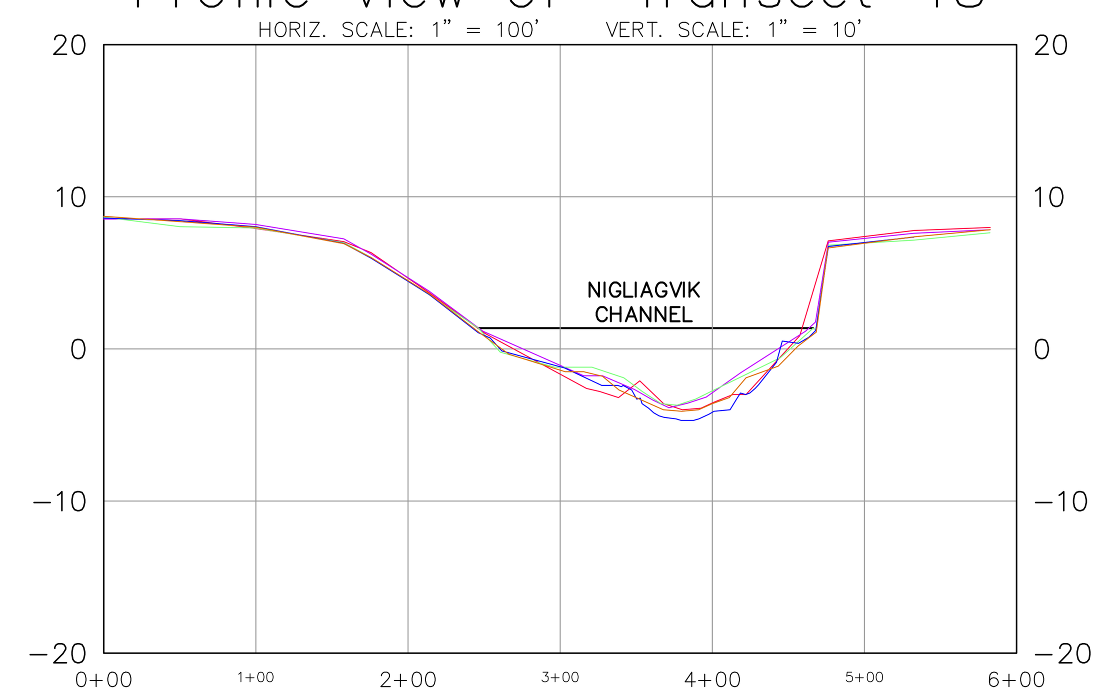
Profile View of Transect-17

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



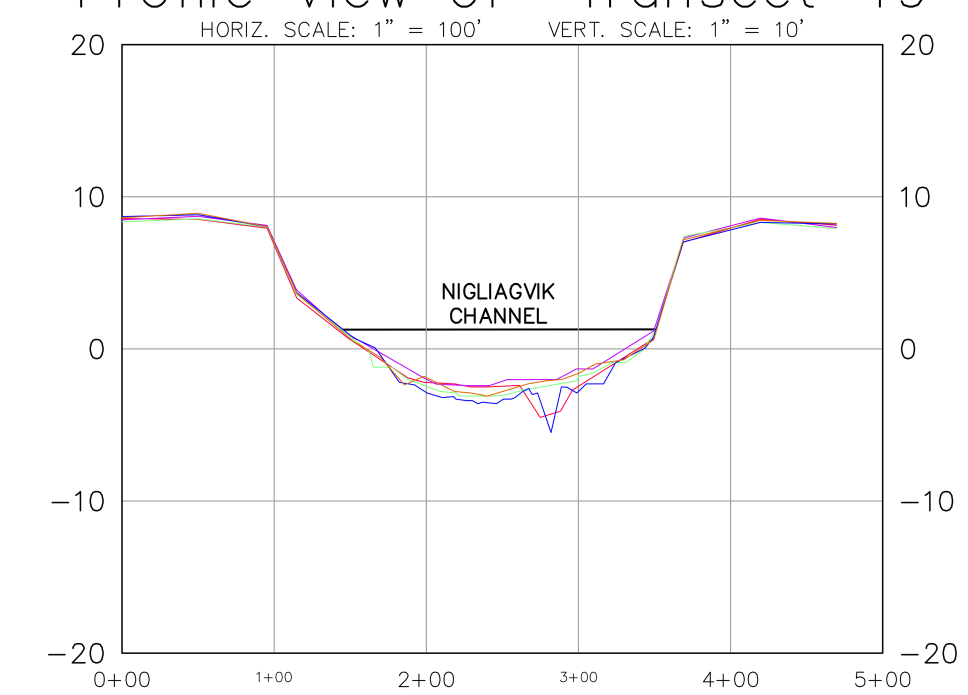
Profile View of Transect-18

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



Profile View of Transect-19

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE : 907-670-4739

FORM: DSIZEPID

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
4	09/02/19	UPDATED PER K190003ACS	SZ	CZ			
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

ECM NO: K160003ACS
CC NO: –
CADD FILE NO. 13-08-07-1 –
SCALE: VARIES DATE: 7/01/2016

ConocoPhillips
Alaska, Inc.

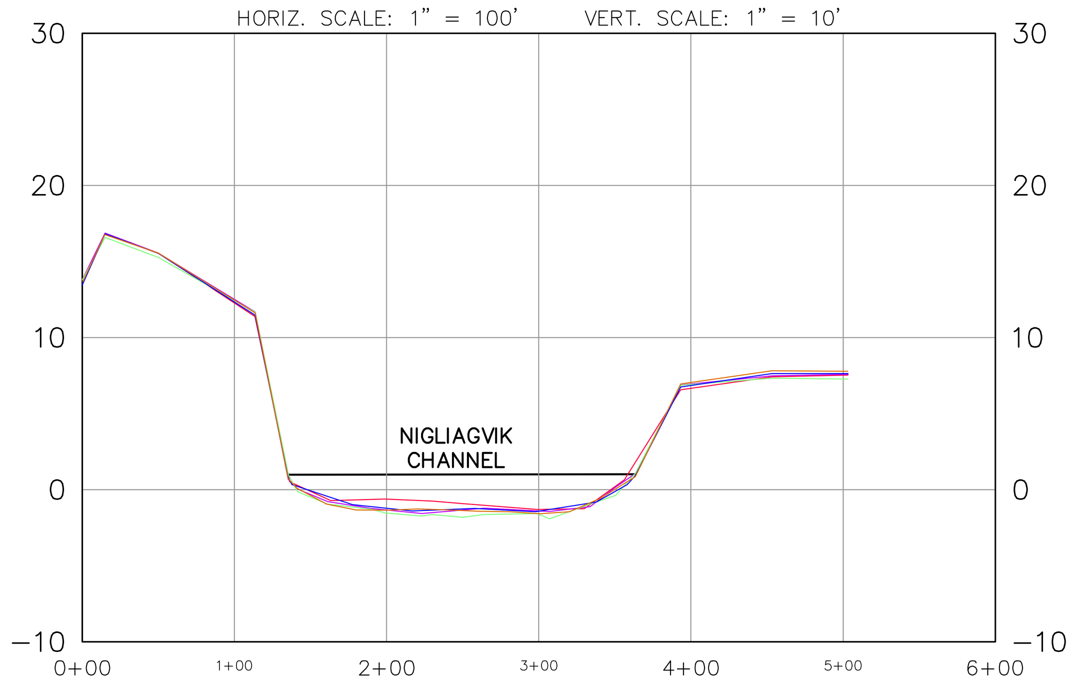
DRAWN: CZ DESIGN: – CHECKED: DB
REDRAWN FROM: – APPROVAL: –

ALPINE MODULE: CD50 UNIT: CD
CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

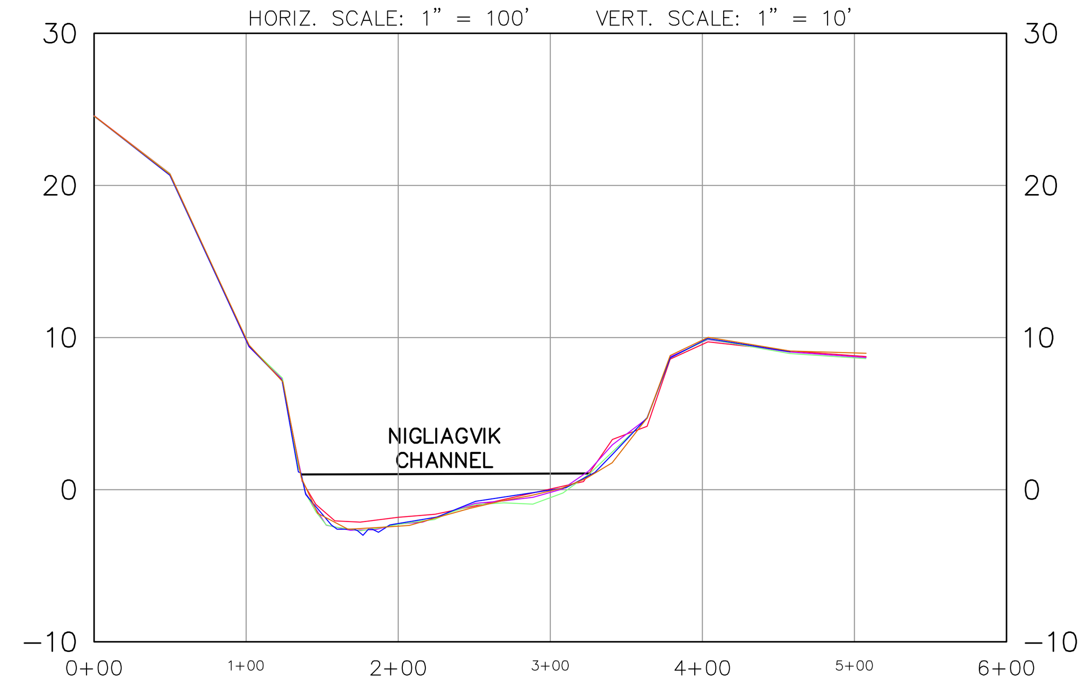
JOB NO: – SUB JOB NO: – DRAWING NO: CE-CD50-1004 PART: 4 of 6 REV: 4

DRAWING NO:	SUB JOB NO:	JOB NO:
CE-CD50-1004	–	–

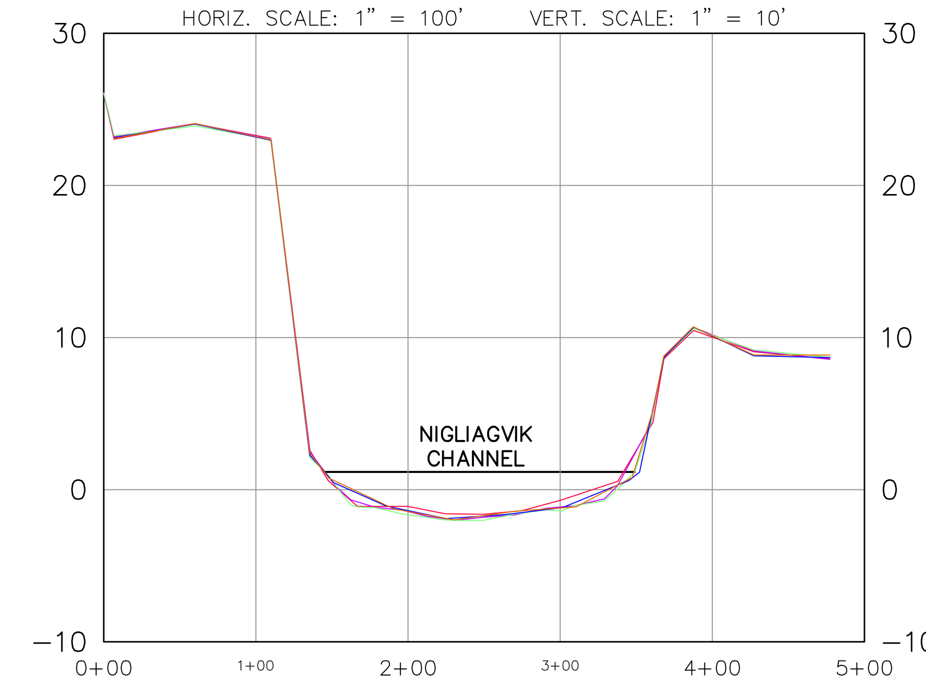
Profile View of Transect-20
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



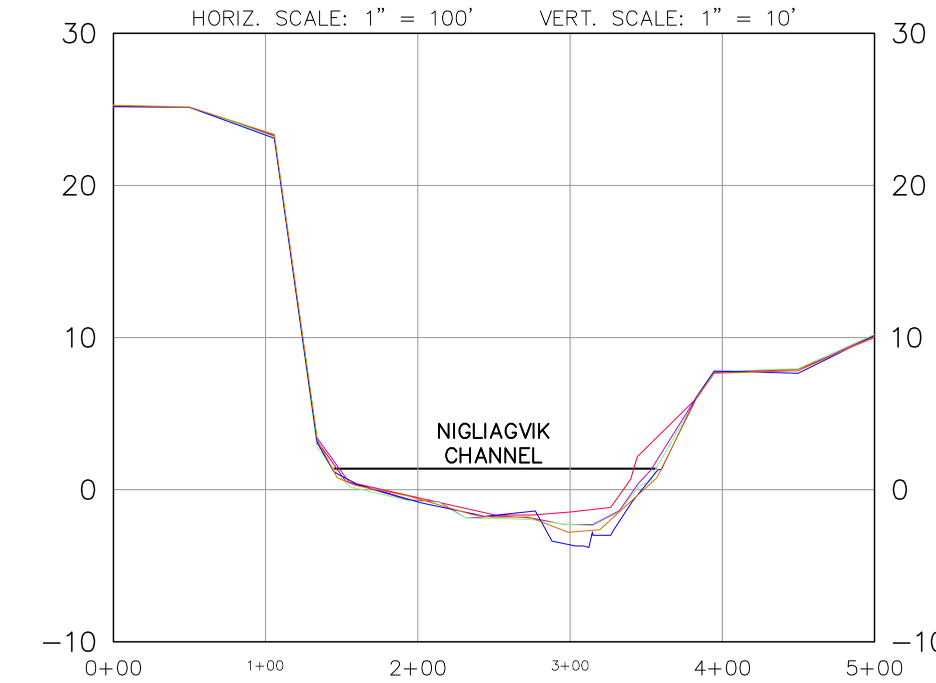
Profile View of Transect-21
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



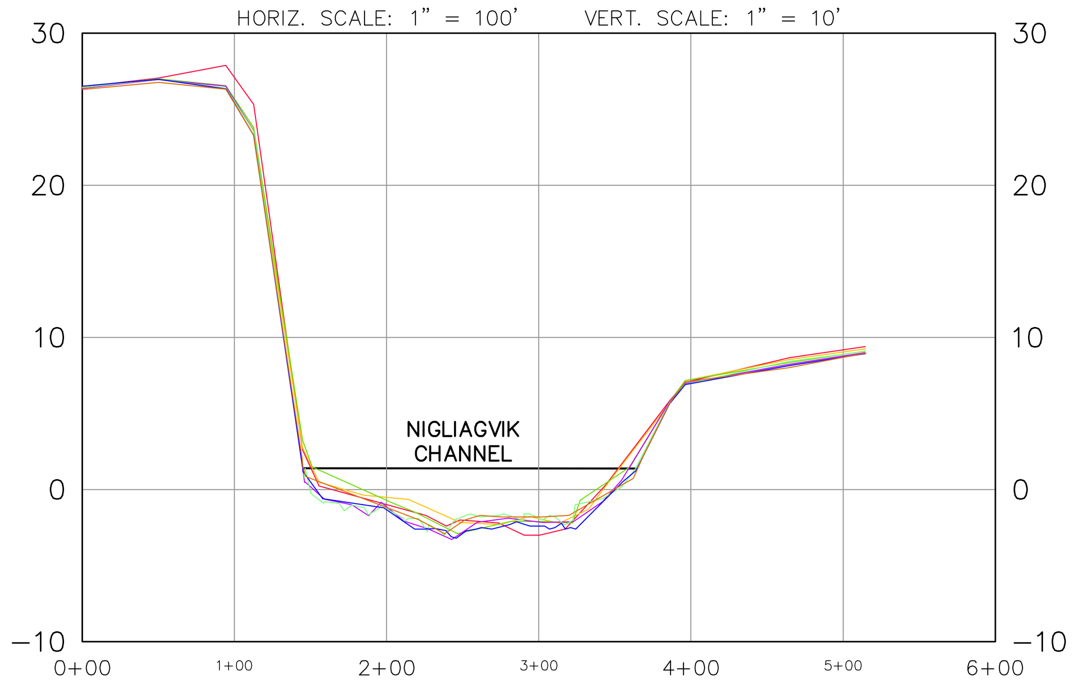
Profile View of Transect-22
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



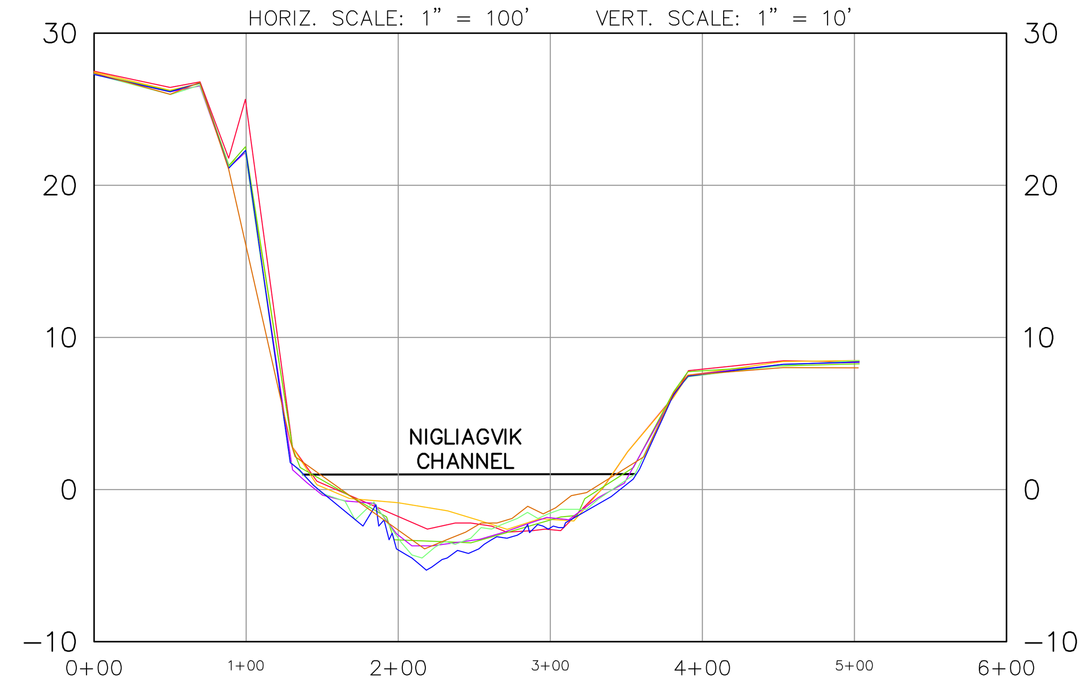
Profile View of Transect-23
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



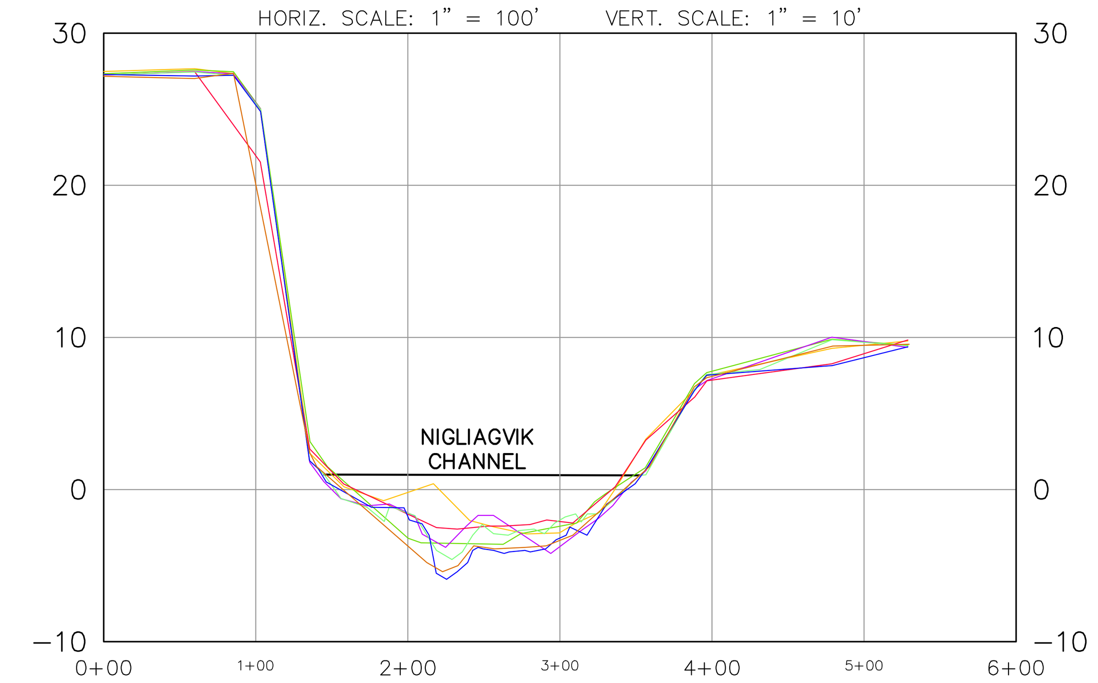
Profile View of Transect-24
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



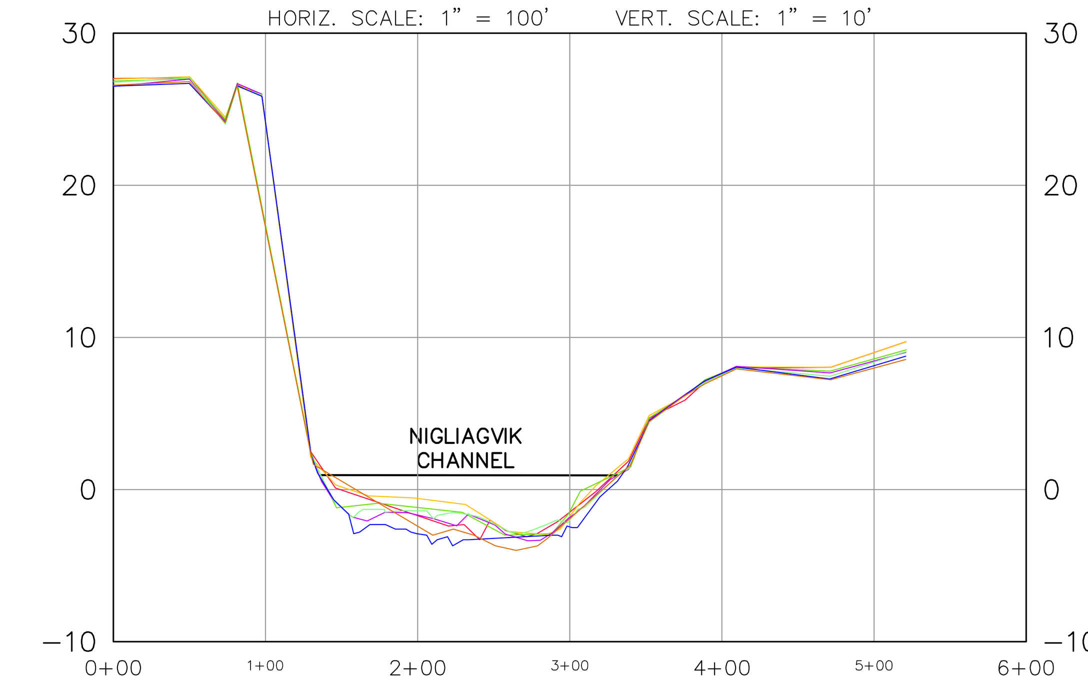
Profile View of Transect-25
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



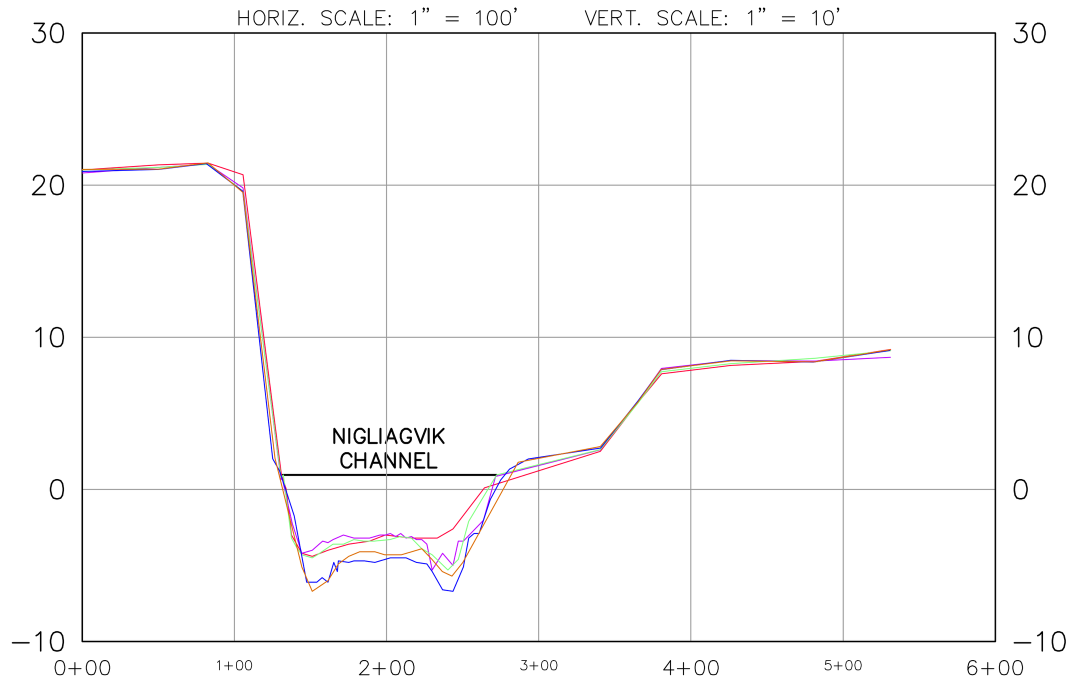
Profile View of Transect-26
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



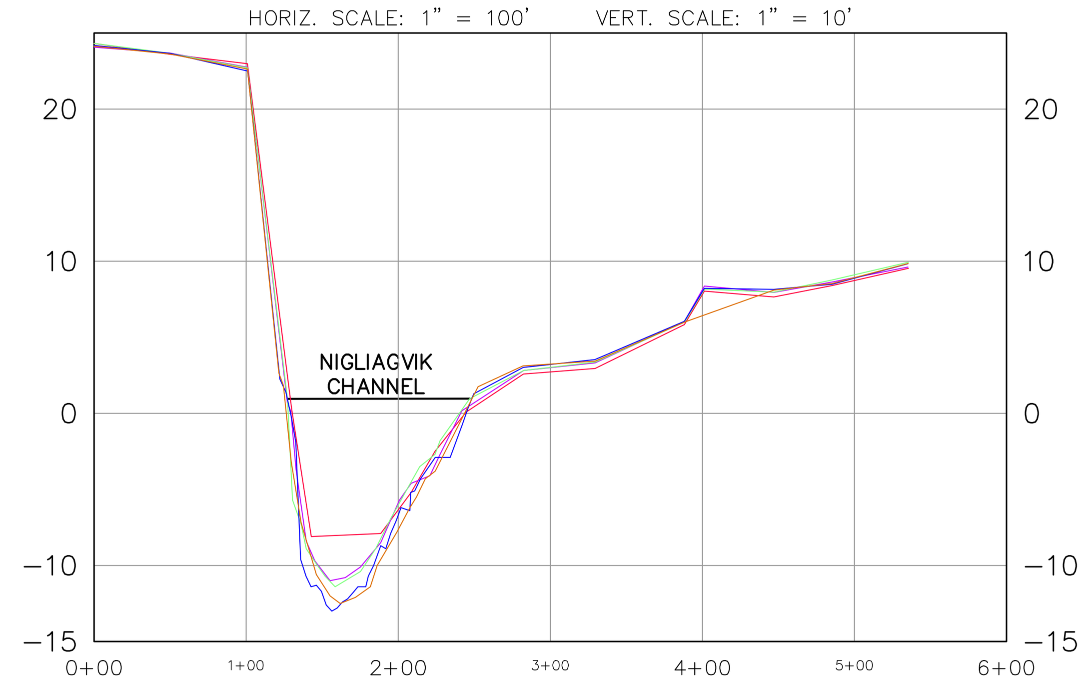
Profile View of Transect-27
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



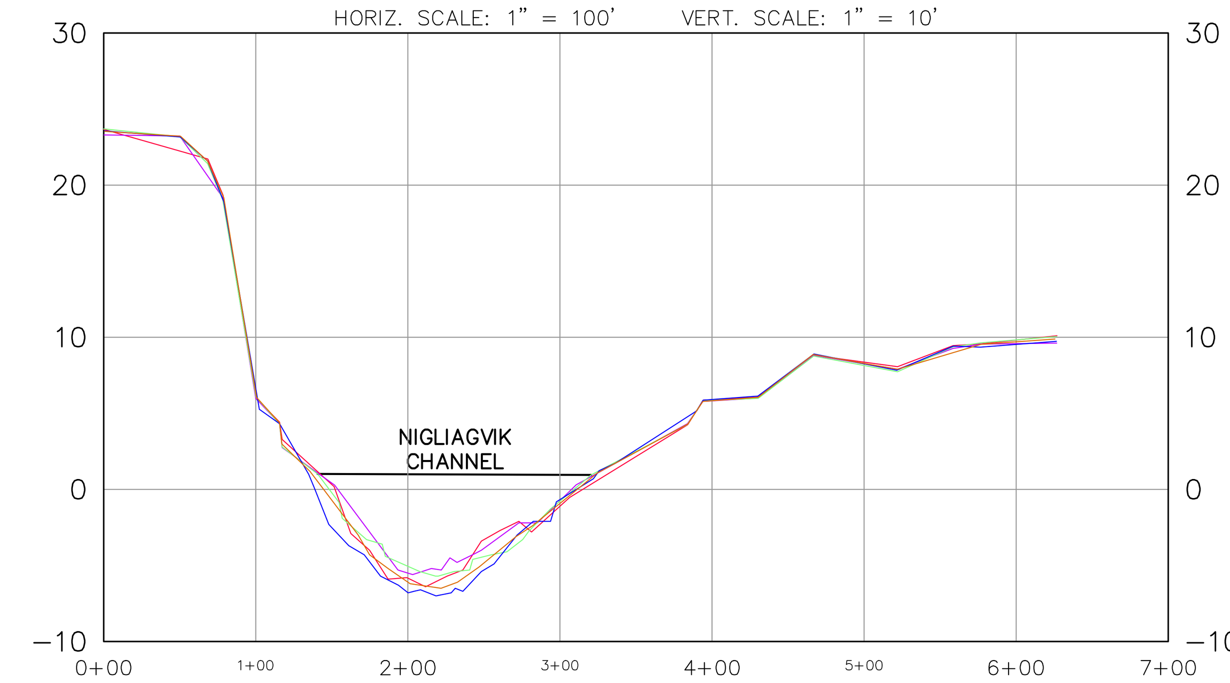
Profile View of Transect-28
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



Profile View of Transect-29
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



Profile View of Transect-30
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



LEGEND:
VIEW LOOKING DOWNSTREAM
- 2013 TRANSECT PROFILE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE
- 2017 TRANSECT PROFILE
- 2018 TRANSECT PROFILE
- 2019 TRANSECT PROFILE

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE: 907-670-4739

FORM: DSIZEPID

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
4	09/02/19	UPDATED PER K190003ACS	SZ	CZ			
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

ECM NO: K160003ACS
CC NO: –
CADD FILE NO: 13-08-07-1 –
SCALE: 1" = 200'
DATE: 7/01/2016

ConocoPhillips
Alaska, Inc.

DRAWN: CZ
DESIGN: –
CHECKED: DB
REDRAWN FROM: –
APPROVAL: –

ALPINE
MODULE: CD50
UNIT: CD

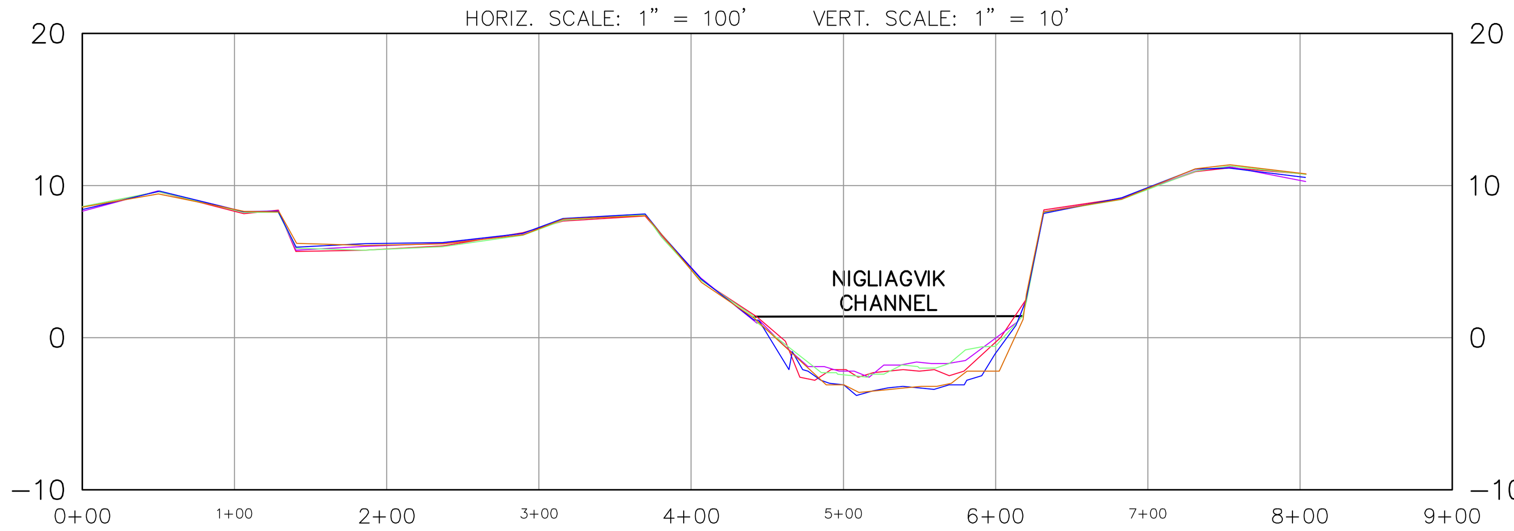
CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE-CD50-1004	5 of 6	4

JOB NO:	SUB JOB NO:	DRAWING NO:
–	–	CE-CD50-1004

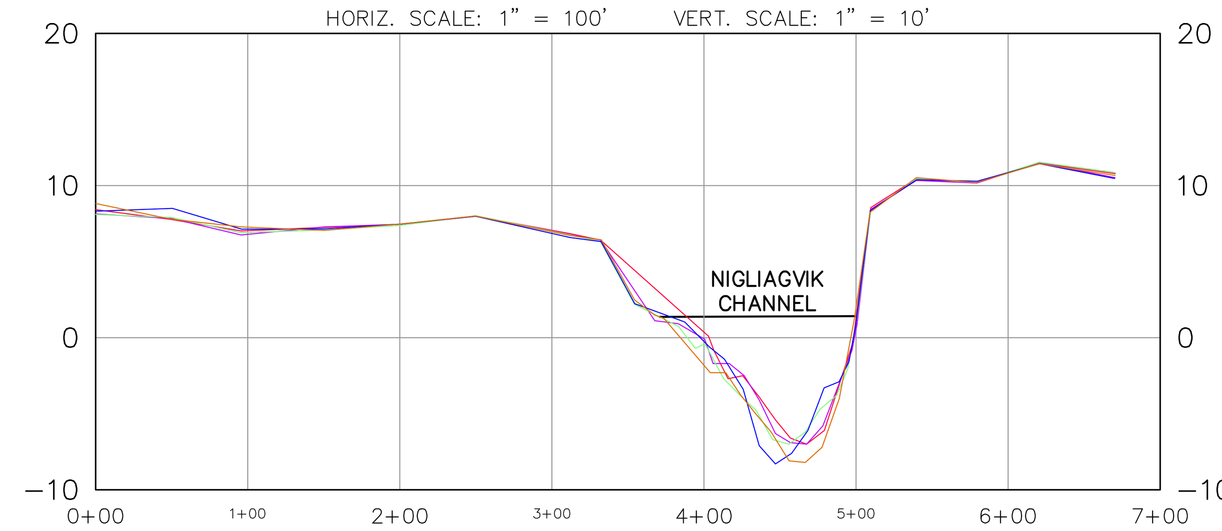
Profile View of Transect-31

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



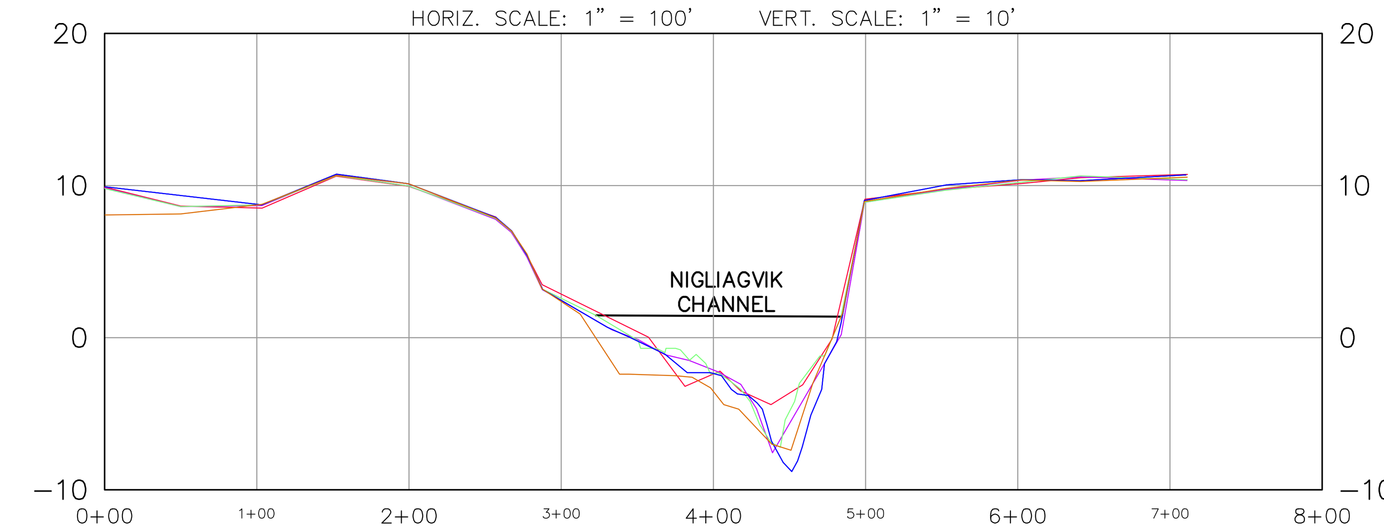
Profile View of Transect-32

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



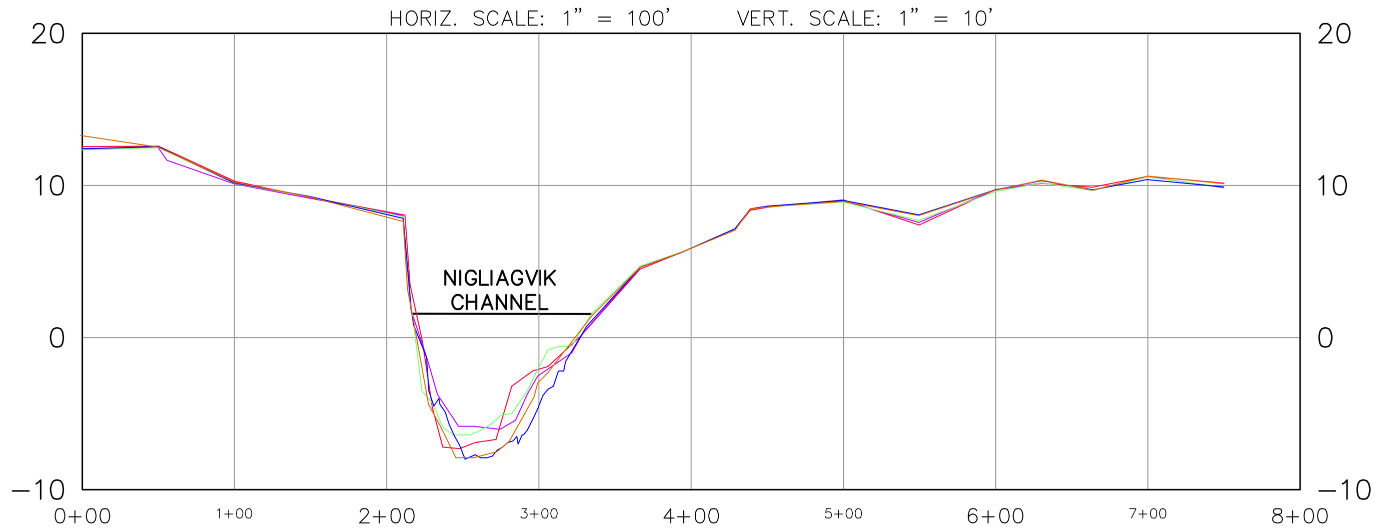
Profile View of Transect-33

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



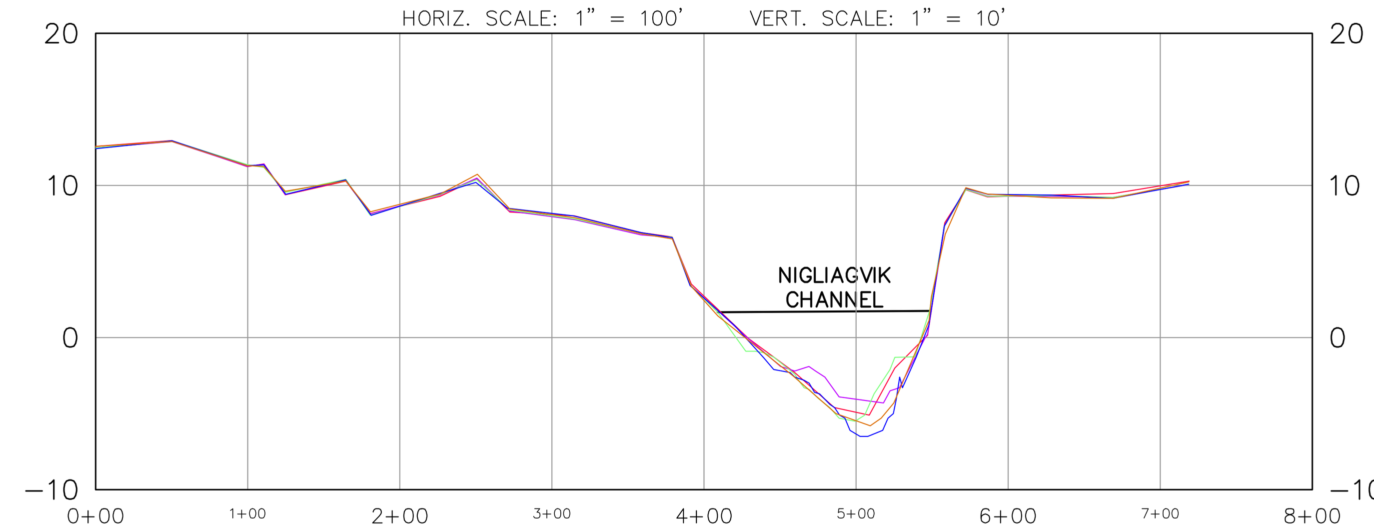
Profile View of Transect-34

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



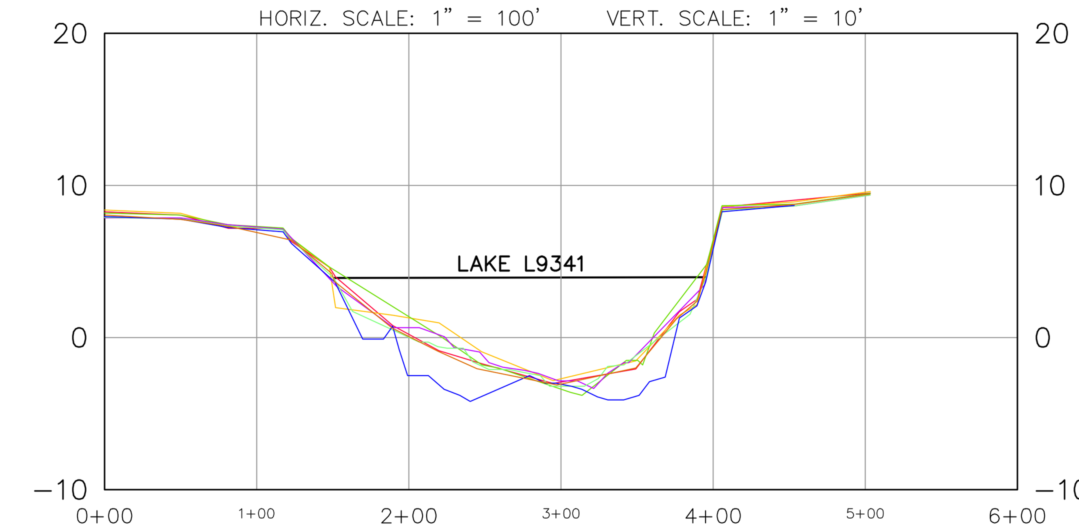
Profile View of Transect-35

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



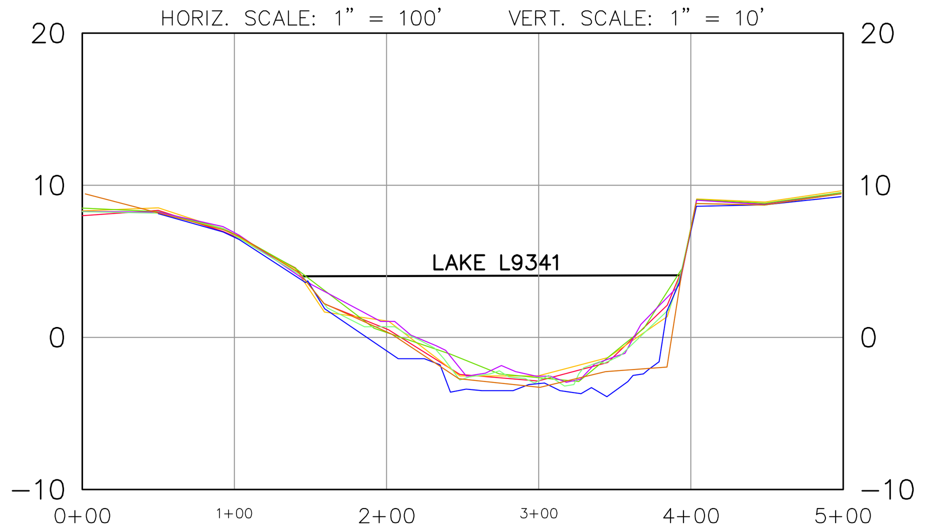
Profile View of Transect-36

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



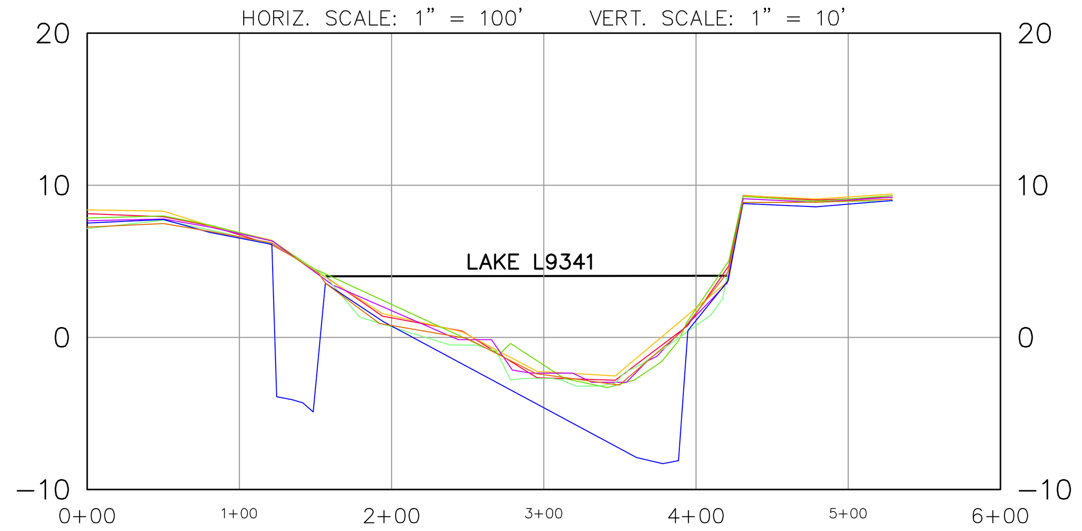
Profile View of Transect-37

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



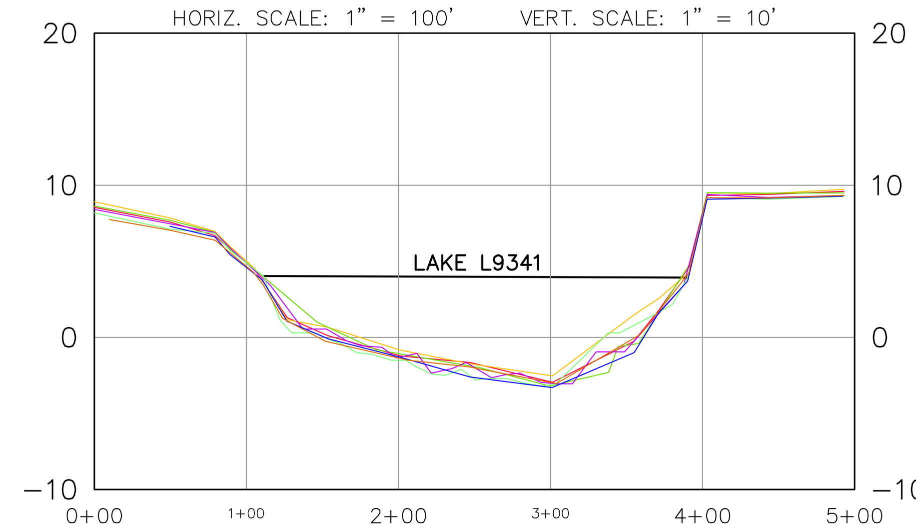
Profile View of Transect-38

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



Profile View of Transect-39

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



LEGEND:
VIEW LOOKING DOWNSTREAM

- 2013 TRANSECT PROFILE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE
- 2017 TRANSECT PROFILE
- 2018 TRANSECT PROFILE
- 2019 TRANSECT PROFILE

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE : 907-670-4739

FORM: DSIZEPID

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
4	09/02/19	UPDATED PER K190003ACS	SZ	CZ			
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

ECM NO: K160003ACS
CC NO: –
CADD FILE NO. 13-08-07-1 –
SCALE: 1" = 200' DATE: 7/01/2016

ConocoPhillips
Alaska, Inc.

DRAWN: CZ DESIGN: – CHECKED: DB
REDRAWN FROM: – APPROVAL: –

ALPINE MODULE: CD50 UNIT: CD
CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE-CD50-1004	6 of 6	4

E.3.2 NIGLIQ CHANNEL & BRIDGE TABULATED DATA (TRANSECTS 1 – 15)

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 1

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	8.4	8.2	8.3	8.5	8.3	Ground Shot
1+00	8.4	8.5	8.4	8.3	8.1	Ground Shot
1+50	8.1		8.1	8.5	8.4	Ground Shot
1+91					7.7	Top of Bank
2+00		7.3	7.3	-	-	Top of Bank (2017)
2+05	7.5	-	-	-	-	Top of Bank (2013)
1+98					2.9	Toe of Bank
2+06		1.9	1.6	1.5	-	Toe of Bank (2018)
Varies	0.0	0.3	-0.8	1.5	1.1	Edge of Water
2+24	-5.5	-6.4	-5.5	-3.1	-6.7	River Bottom
2+73	-24.2	-24.2	-24.9	-25.7	-28.9	River Bottom
3+22	-25.0	-23.2	-24.7	-27.9	-25.7	River Bottom
3+71	-21.3	-22.1	-21.9	-25.2	-25.0	River Bottom
4+27	-19.0	-21.7	-20.1	-22.0	-19.1	River Bottom
4+82	-15.5	-14.2	-15.8	-16.5	-14.9	River Bottom
5+31	-10.0	-13.1	-13.1	-13.9	-11.0	River Bottom
5+70	-3.7	-6.8	-4.1	-4.6	-3.0	River Bottom
Varies	0.1	0.3	-0.1	1.3	0.7	Edge of Water
7+00	4.2	4.6	4.4	4.5	4.5	Sand Bar
8+00	5.6	5.0	5.0	5.0	4.9	Sand Bar
9+00	6.4	7.0	6.6	6.6	6.6	Sand Bar
10+00	6.8	7.2	6.9	6.9	6.9	Sand Bar
11+00	7.2	7.5	7.3	7.2	7.2	Sand Bar
12+00	6.7	7.1	6.7	6.8	6.7	Sand Bar
13+00	5.9	5.9	5.7	5.8	5.7	Sand Bar
14+00	2.7	2.3	2.2	2.1	2.2	Sand Bar
15+00	2.7	2.9	2.8	2.9	1.9	Sand Bar
16+00	2.4	2.2	2.1	2.5	2.5	Sand Bar
17+00					0.8	River Bottom
17+00	1.5	1.0	0.9	0.9	-	Sand Bar (2018)
					0.1	River Bottom
18+00	0.6	0.1	0.1	0.1	-	Sand Bar (2018)
Varies	0.3	0.3	0.1	1.5	1.0	Edge of Water
20+98	-2.9	-2.1	-2.5	-2.3	-1.2	River Bottom
21+53	-2.6	-2.6	-3.0	-1.9	-1.0	River Bottom
21+96	-2.8	-2.3	-1.9	-1.5	-0.9	River Bottom
22+55	-2.8	-2.0	-2.1	-1.1	-1.0	River Bottom
23+00	-2.6	-2.0	-1.7	-1.1	-0.8	River Bottom
23+59	-2.6	-2.1	-2.0	-1.5	-0.9	River Bottom
24+05	-3.4	-1.3	-1.9	-1.3	-1.1	River Bottom
Varies	0.3	0.3	0.1	1.4	1.4	Edge of Water
24+58					7.9	Top of Bank
24+50	7.3	7.3	7.2	6.7	-	Top of Bank (2018)
25+02			9.1	9.2	9.1	Ground Shot
25+50	8.9	9.2	9.2	9.0	9.0	Ground Shot
26+51	9.1	9.3	9.1	9.2	9.1	Ground Shot

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 1 of 47 Transect_01

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 2

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	8.9	8.5	8.5	8.7	8.6	Ground Shot
1+00	8.7	8.6	8.6	8.3	8.3	Ground Shot
1+50			7.5	7.5	7.5	Ground Shot
1+82					7.3	Top of Bank
1+93		6.9	5.9	-	-	Top of Bank (2017)
1+95	7.2	-	-	-	-	Top of Bank (2013)
Varies	0.7	0.1	0.7	1.5	0.8	Edge of Water
2+12	-2.8	-2.7	-3.0	-1.8	-1.8	River Bottom
2+35	-3.4	-3.1	-3.9	-4.9	-4.9	River Bottom
2+58	-4.3	-4.7	-3.5	-5.7	-5.7	River Bottom
2+81	-5.4	-6.1	-5.6	-7.2	-7.2	River Bottom
3+10	-7.6	-8.4	-9.2	-10.2	-10.2	River Bottom
3+27	-8.1	-13.2	-18.0	-11.5	-11.5	River Bottom
3+47	-11.1	-25.2	-22.8	-11.5	-11.5	River Bottom
3+67	-21.7	-18.5	-18.1	-19.4	-19.4	River Bottom
3+87	-17.6	-16.7	-16.0	-16.7	-16.7	River Bottom
4+07	-14.3	-15.1	-14.9	-16.4	-16.4	River Bottom
4+27	-13.5	-13.3	-13.2	-16.1	-16.1	River Bottom
4+46	-12.2	-11.4	-12.4	-13.2	-13.2	River Bottom
4+78	-10.7	-10.7	-12.0	-11.8	-11.8	River Bottom
4+98	-9.7	-9.7	-10.4	-12.3	-12.3	River Bottom
5+18	-9.3	-8.5	-10.2	-11.8	-11.8	River Bottom
5+35	-8.7	-8.0	-9.3	-11.0	-11.0	River Bottom
5+55	-8.1	-7.6	-8.8	-10.3	-10.3	River Bottom
5+81	-7.6	-7.4	-8.1	-8.9	-8.9	River Bottom
6+01	-7.1	-6.8	-7.5	-8.0	-8.0	River Bottom
6+24	-6.3	-6.1	-7.2	-8.0	-8.0	River Bottom
6+44	-5.9	-5.5	-6.5	-7.0	-7.0	River Bottom
6+64	-5.5	-5.0	-5.9	-6.6	-6.6	River Bottom
6+83	-4.7	-4.4	-5.5	-6.8	-6.8	River Bottom
7+03	-4.9	-3.7	-5.5	-6.3	-6.3	River Bottom
7+23	-4.0	-3.9	-5.4	-5.5	-5.5	River Bottom
7+55	-3.4	-3.5	-4.3	-5.0	-5.0	River Bottom
7+75	-2.7	-2.4	-3.7	-4.5	-4.5	River Bottom
7+92	-2.5	-2.1	-3.7	-4.4	-4.4	River Bottom
8+09	-2.2	-1.8	-3.3	-4.0	-4.0	River Bottom
8+38	-1.9	-1.3	-2.6	-3.1	-3.1	River Bottom
8+55	-2.1	-1.0	-2.2	-2.0	-2.0	River Bottom
Varies	0.8	0.2	0.7	1.5	0.8	Edge of Water
10+00	1.8	1.3	1.3	1.3	1.2	Sand Bar
11+00	1.9	1.6	1.7	1.5	1.7	Sand Bar
12+00	2.0	2.6	2.3	2.2	2.5	Sand Bar
13+00	2.2	2.8	2.6	1.2	2.2	Sand Bar
14+00	2.0	2.8	2.7	2.5	2.4	Sand Bar
15+00	2.1	2.6	2.6	2.6	2.4	Sand Bar
16+00	1.9	2.3	2.2	2.5	2.1	Sand Bar
17+00	1.6	2.1	2.0	2.1	1.9	Sand Bar
18+00	1.3	0.1	0.5	1.0	1.5	Sand Bar
19+00	0.8	0.9	0.9	0.8	-	Sand Bar
Varies	0.8	0.0	-0.3	1.6	1.0	Edge of Water
20+84	-2.4	-1.6	-1.6	-0.7	0.8	River Bottom
21+07	-2.5	-2.0	-2.0	-1.7	1.6	River Bottom

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 2 of 47 Transect_02

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 2

KUUKPIK UMIAQ ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
21+36	-2.1	-2.6	-2.5	-2.9	3.3	River Bottom
21+53	-2.5	-2.9	-3.6	-3.4	3.4	River Bottom
21+72	-2.9	-3.4	-3.5	-3.6	2.9	River Bottom
21+85	-2.9	-3.3	-3.0	-3.9	2.7	River Bottom
22+01	-4.1	-3.0	-3.0	-5.1	3.0	River Bottom
22+21	-4.7	-4.0	-3.4	-5.4	3.6	River Bottom
22+38	-5.6	-4.6	-4.2	-6.2	4.2	River Bottom
22+55	-6.2	-4.6	-5.0	-7.0	4.9	River Bottom
22+75	-4.6	-5.5	-5.6	-7.5	6.0	River Bottom
Varies	0.7	0.0	0.2	1.6	1.1	Edge of Water
23+13		0.8	0.5		-	Toe of Bank
23+16	1.8	-	-	-	-	Toe of Bank (2103)
23+24	7.8	7.8	-	-	-	Top of Bank (2016)
23+26			7.5	7.1	3.1	Top of Bank
23+90	8.6	8.7	8.9		8.9	Ground Shot
24+50	9.0	9.1	8.9	8.9	8.8	Ground Shot
25+40	9.3	9.4	9.2	9.0	9.2	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 3

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	10.0	9.5	9.6	9.6	9.6	Ground Shot
1+00	10.8	10.7	10.8	10.7	10.8	Ground Shot
2+00	11.4	11.3	11.4	11.3	11.2	Ground Shot
2+17	11.1	11.0	11.0	-	10.8	Top of Bank
2+47	6.4	6.3	6.3	6.2	6.2	Toe of Bank
3+00	6.4	6.5	6.5	6.3	6.3	Ground Shot
4+00	7.6	7.7	7.7	7.7	7.5	Ground Shot
5+00	6.8	7.0	6.9	7.0	6.8	Ground Shot
5+25	6.1	6.0	6.0	6.0	6.0	Top of Bank
5+74	1.7	2.0	2.0	2.0	1.8	Toe of Bank
6+00	1.5	1.9	1.7	1.9	1.7	Sand Bar
7+00	3.2	3.9	4.0	3.9	4.1	Sand Bar
8+00	4.8	4.6	4.6	4.6	4.7	Sand Bar
9+00	5.6	5.8	5.8	6.4	6.3	Sand Bar
9+27	5.7	5.1	4.9	4.9	5.0	Top of Bank
9+40	2.0	4.2	3.9	4.0	4.2	Toe of Bank
Varies	0.2	0.8	0.4	0.5	0.9	Edge of Water
10+85	-2.2	-1.0	-2.2	-0.8	-1.3	River Bottom
10+95	-2.2	-1.3	-2.6	-2.9	-1.3	River Bottom
11+07	-2.3	-1.6	-3.1	-4.0	-1.3	River Bottom
11+17	-3.1	-1.9	-3.5	-4.6	-1.8	River Bottom
11+31	-3.8	-2.3	-4.1	-5.1	-3.0	River Bottom
11+44	-4.3	-3.9	-4.6	-5.9	-4.0	River Bottom
11+60	-5.0	-4.9	-5.8	-6.7	-5.0	River Bottom
11+85	-6.1	-5.6	-6.5	-7.8	-6.2	River Bottom
12+07	-6.8	-6.7	-7.7	-8.9	-7.2	River Bottom
12+23	-7.3	-7.0	-7.6	-9.0	-7.6	River Bottom
12+48	-7.4	-6.8	-7.4	-9.3	-7.9	River Bottom
12+72	-7.4	-6.7	-7.0	-8.8	-7.6	River Bottom
12+89	-7.4	-6.4	-6.7	-9.9	-7.2	River Bottom
13+15	-7.4	-6.3	-6.8	-8.6	-7.3	River Bottom
13+40	-7.3	-6.3	-7.6	-8.7	-7.5	River Bottom
13+64	-7.5	-6.3	-7.3	-8.1	-6.9	River Bottom
13+81	-7.4	-6.8	-6.9	-8.4	-7.1	River Bottom
14+07	-7.3	-6.7	-6.9	-7.6	-6.9	River Bottom
14+32	-6.9	-6.3	-7.2	-7.4	-6.6	River Bottom
14+48	-6.6	-7.0	-7.0	-8.9	-6.2	River Bottom
14+75	-7.9	-5.6	-7.3	-8.1	-6.6	River Bottom
14+99	-8.2	-6.0	-7.6	-7.5	-6.4	River Bottom
15+16	-8.2	-5.9	-7.2	-8.2	-6.6	River Bottom
15+42	-8.3	-7.2	-7.3	-9.3	-6.8	River Bottom
15+61	-8.0	-7.3	-7.6	-8.5	-7.8	River Bottom
15+86	-8.5	-7.0	-8.1	-9.3	-8.2	River Bottom
16+02	-8.6	-7.3	-8.7	-8.6	-8.2	River Bottom
16+27	-8.5	-7.6	-8.8	-9.1	-8.5	River Bottom
16+51	-8.9	-7.3	-8.6	-9.7	-8.1	River Bottom
16+75	-8.3	-7.9	-8.4	-9.6	-8.2	River Bottom
16+98	-8.6	-8.2	-8.8	-10.1	-8.9	River Bottom
17+14	-8.2	-8.8	-9.2	-10.7	-9.1	River Bottom
17+39	-7.7	-8.7	-9.8	-10.4	-9.2	River Bottom
17+63	-7.5	-8.7	-10.2	-10.7	-9.1	River Bottom
17+85	-7.6	-9.5	-10.5	-11.6	-9.9	River Bottom

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 4 of 47 Transect_03

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 3

KUUKPIK UMIAQ ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
18+02	-7.1	-10.0	-10.7	-11.8	-10.1	River Bottom
18+28	-7.7	-9.8	-10.4	-12.2	-10.1	River Bottom
18+53	-7.4	-8.8	-9.6	-11.2	-10.5	River Bottom
18+69	-7.7	-8.3	-8.6	-10.3	-9.9	River Bottom
18+96	-8.0	-7.6	-8.0	-9.9	-9.1	River Bottom
19+12	-6.9	-7.0	-7.4	-9.6	-8.8	River Bottom
19+37	-6.6	-5.7	-6.6	-9.6	-8.7	River Bottom
19+53	-7.0	-6.1	-6.8	-8.8	-8.0	River Bottom
19+80	-7.1	-6.0	-7.0	-8.7	-7.4	River Bottom
20+04	-7.0	-5.8	-7.2	-7.9	-7.2	River Bottom
20+19	-7.4	-5.6	-7.1	-7.9	-6.9	River Bottom
20+43	-7.6	-7.0	-7.5	-8.3	-6.7	River Bottom
20+60	-6.0	-6.9	-7.9	-8.4	-6.9	River Bottom
20+82	-5.6	-6.0	-6.8	-7.6	-6.5	River Bottom
21+04	-5.2	-5.4	-6.2	-6.8	-5.6	River Bottom
21+19	-4.9	-5.4	-6.0	-7.0	-5.1	River Bottom
21+31	-3.8	-4.8	-6.0	-6.0	-5.1	River Bottom
21+50	-2.2	-1.9	-4.1	-4.0	-5.1	River Bottom
Varies	-0.4	0.9	0.2	0.4	1.1	Edge of Water
22+22	-	1.0	0.8	0.5	-	Toe of Bank
22+35	-	9.0	8.8	8.8	8.6	Top of Bank
23+00	8.2	8.7	8.9	8.6	8.7	Ground Shot
23+22	9.2	10.0	9.8	9.5	9.7	Top of Bank
23+36	8.1	8.5	8.5	8.2	8.3	Toe of Bank
23+76	7.9	8.9	8.7	8.4	8.5	Toe of Bank
24+15	10.7	11.5	11.5	11.3	11.3	Top of Bank
24+22	8.9	9.4	9.3	9.4	9.5	Toe of Bank

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 4

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	12.2	12.6	12.4	12.5	12.5	Ground Shot
1+00	12.8	13.0	13.0	12.9	12.9	Ground Shot
2+00	14.2	14.4	14.5	14.6	14.6	Ground Shot
3+00	16.1	16.2	16.3	16.2	15.7	Ground Shot
3+91	14.7	15.2	15.2	15.0	14.9	Top of Bank
4+24	11.5	11.6	11.6	11.5	11.5	Toe of Bank
5+00	12.1	12.1	12.1	12.0	11.9	Ground Shot
5+12	12.4	12.4	12.3	12.2	12.0	Top of Bank
5+49	8.6	8.7	8.8	8.6	8.7	Toe of Bank
5+74	8.3	8.4	8.5	8.3	8.4	Toe of Bank
5+83	10.7	10.9	10.8	10.7	10.7	Top of Bank
5+91	10.7	11.0	10.9	10.8	10.9	Top of Bank
6+04	8.2	8.6	8.6	8.7	8.7	Toe of Bank
6+47	7.5	8.0	8.1	8.2	8.3	Toe of Bank
6+59	9.7	9.2	9.1	9.1	9.1	Top of Bank
7+05	8.0	7.9	8.1	8.2	8.1	Top of Bank
7+31	5.3	5.9	5.8	5.8	5.9	Toe of Bank
8+00	4.9	5.3	5.1	5.1	5.1	Sand Bar
9+00	4.2	4.9	4.7	4.5	4.2	Sand Bar
10+00	4.7	3.3	3.4	3.3	3.6	Sand Bar
11+00	4.5	3.8	3.6	3.6	3.5	Sand Bar
12+00	3.9	4.5	3.9	4.0	4.0	Sand Bar
13+00	3.0	3.3	3.3	3.2	3.4	Sand Bar
14+00	2.8	2.2	2.8	2.7	2.8	Sand Bar
15+00	3.1	3.0	2.9	3.0	3.0	Sand Bar
16+00	3.2	2.3	2.2	2.2	2.1	Sand Bar
Varies	-0.1	1.0	1.0	-0.3	1.0	Edge of Water
16+70	-3.1	-0.7	-1.6	-1.4	-0.6	River Bottom
16+84	-6.0	-1.7	-3.4	-4.0	-2.1	River Bottom
17+01	-8.6	-4.0	-8.6	-4.1	-4.3	River Bottom
17+18	-12.4	-5.8	-12.4	-8.6	-7.2	River Bottom
17+42	-15.3	-11.4	-12.4	-12.7	-11.4	River Bottom
17+63	-16.5	-14.5	-15.3	-14.5	-13.1	River Bottom
17+80	-15.7	-15.7	-16.2	-16.0	-13.9	River Bottom
18+00	-16.4	-15.5	-16.2	-17.4	-16.0	River Bottom
18+21	-17.6	-16.3	-17.3	-18.5	-18.5	River Bottom
18+36	-19.2	-17.4	-18.4	-19.5	-19.0	River Bottom
18+55	-19.3	-18.9	-19.9	-21.0	-21.0	River Bottom
18+79	-19.9	-19.7	-20.2	-23.3	-21.2	River Bottom
18+96	-20.3	-20.1	-20.7	-23.3	-21.5	River Bottom
19+13	-19.4	-20.8	-21.0	-23.3	-22.6	River Bottom
19+37	-20.2	-21.2	-21.6	-25.3	-23.0	River Bottom
19+54	-21.1	-22.1	-21.8	-24.0	-23.2	River Bottom
19+75	-21.3	-22.6	-22.6	-23.9	23.1	River Bottom
19+92	-20.9	-22.9	-22.9	-24.7	-23.1	River Bottom
20+12	-20.4	-22.4	-22.8	-24.3	-22.2	River Bottom
20+29	-20.2	-21.9	-22.3	-24.0	-22.1	River Bottom
20+48	-19.9	-21.8	-21.8	-23.8	-21.6	River Bottom
20+65	-19.7	-20.8	-20.8	-23.6	-21.7	River Bottom
20+84	-18.6	-19.3	-19.8	-21.9	-19.4	River Bottom
21+06	-15.1	-18.1	-18.0	-20.5	-17.8	River Bottom
21+15	-10.4	-15.9	-17.3	-18.8	-16.1	River Bottom

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 6 of 47 Transect_04

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 4

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
Varies	-0.2	1.1	0.2	-0.3	1.2	Edge of Water
21+91	2.1	1.5	2.0	0.9	-	Toe of Bank
21+98	10.1	9.3	9.3	9.3	-	Top of Bank (2018)
22+02					9.8	Top of Bank
22+53			10.2	10.2	10.2	Ground Shot
23+00	10.7	10.8	10.8	10.7	10.7	Ground Shot
24+03	10.4	10.3	10.4	10.4	10.4	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 5

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	11.9	11.9	11.9	12.1	12.1	Ground Shot
1+00	12.0	12.1	12.0	11.9	11.9	Ground Shot
2+00	15.5	15.5	15.5	15.4	15.3	Ground Shot
3+00	16.1	16.0	16.0	15.8	16.0	Ground Shot
4+00	15.4	15.4	15.4	15.3	15.3	Ground Shot
4+56	17.2	17.1	17.0	16.9	17.0	Top of Bank
4+65	14.2	14.2	14.1	14.0	14.0	Toe of Bank
4+81	14.3	14.1	14.1	14.1	14.0	Toe of Bank
5+08	18.5	18.2	18.2	18.1	18.0	Top of Bank
5+36	13.6	13.4	13.3	13.3	13.2	Toe of Bank
5+82	15.9	15.7	15.6	15.5	15.4	Top of Bank
6+16	12.6	12.5	12.4	12.3	12.4	Toe of Bank
6+92	13.0	12.9	13.4	13.4	13.4	Top of Bank
7+20	7.8	7.8	7.5	7.7	7.6	Toe of Bank
8+00	5.9	6.3	6.5	6.3	6.3	Sand Bar
9+00	5.6	5.7	5.6	5.5	5.4	Sand Bar
10+00	6.1	5.6	5.6	5.6	5.6	Sand Bar
11+00	5.7	5.3	5.1	5.3	5.7	Sand Bar
12+00	4.4	3.7	3.7	3.7	3.4	Sand Bar
13+00	3.0	3.1	3.1	3.0	3.0	Sand Bar
14+00	2.5	2.3	2.2	1.9	2.2	Sand Bar
15+00	2.4	1.1	1.1	1.3	1.5	Sand Bar
16+00	1.9	1.4	1.3	1.5	1.5	Sand Bar
17+00	2.0	2.1	2.1	2.2	1.8	Sand Bar
18+00	1.6	2.3	2.3	2.5	2.3	Sand Bar
19+00	1.0	1.6	1.6	1.9	-	Sand Bar
19+00					1.7	River Bottom
20+00	1.2	0.5	0.3	0.6	-	Sand Bar (2018)
20+00					-1.0	River Bottom
21+00	0.6	0.8	0.8	-0.3	-0.4	Sand Bar (2018)
Varies	-0.5	0.8	0.8	-0.3	1.2	Edge of Water
21+62	-6.1	-3.5	-3.5	-3.6	-2.6	River Bottom
21+79	-8.2	-4.4	-4.8	-5.8	-3.8	River Bottom
21+96	-8.4	-6.8	-5.8	6.8	-4.6	River Bottom
22+17	-9.5	-8.3	-8.0	-7.5	-6.2	River Bottom
22+36	-11.3	-9.7	-10.7	-10.4	-8.0	River Bottom
22+53	-12.1	-11.0	-11.7	-12.1	-10.1	River Bottom
22+73	-15.1	-14.3	-13.4	-15.0	12.0	River Bottom
22+93	-16.8	-16.0	-15.6	-16.6	-15.5	River Bottom
23+13	-19.1	-17.5	-17.3	-19.5	-17.6	River Bottom
23+30	-21.4	-18.9	-18.8	-21.8	-19.2	River Bottom
23+49	-22.4	-20.2	-20.5	-23.2	-21.3	River Bottom
23+73	-22.5	-21.1	-22.2	-24.3	-22.6	River Bottom
23+93	-22.2	-23.4	-23.3	-24.7	-22.4	River Bottom
24+10	-22.4	-24.0	-23.1	-24.9	-22.4	River Bottom
24+29	-22.2	-23.7	-23.5	-25.4	-22.4	River Bottom
24+53	-23.4	-23.2	-23.2	-28.8	-25.1	River Bottom
24+70	-23.3	-24.3	-23.3	-25.8	-24.3	River Bottom
24+87	-20.5	-24.5	-23.9	-26.4	-24.7	River Bottom
25+04	-21.6	-24.0	-24.2	-26.4	-25.1	River Bottom
25+18	-20.5	-24.1	-23.8	-27.0	-25.1	River Bottom
25+30	-16.9	-23.6	-23.4	-25.4	-24.4	River Bottom

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 8 of 47 Transect_05

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 5

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
25+47	-8.2	-21.3	-23.6	-25.5	-22.7	River Bottom
Varies	-0.5	0.8	-0.5	-0.3	1.4	Edge of Water
25+87	8.5	-	-	-	-	Top of Bank (2013)
26+11		8.6	-	-	-	Top of Bank (2016)
26+17			8.5	8.1	-	Top of Bank (2018)
26+23					8.4	
27+00	8.6	8.5	8.5	8.5	8.4	Ground Shot
27+70	8.7	8.7	8.6	8.6	8.6	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 6

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	11.4	11.6	11.5	11.5	11.5	Ground Shot
1+00	11.0	11.1	11.1	11.1	11.0	Ground Shot
2+00	14.0	13.9	14.0	13.9	13.8	Ground Shot
3+00	15.3	15.2	15.4	15.2	15.3	Ground Shot
3+42	17.1	16.9	16.8	16.8	16.8	Top of Bank
3+59	12.5	12.3	12.4	12.5	12.2	Toe of Bank
4+08	14.8	14.6	14.7	14.6	-	Top of Bank (2018)
4+23					11.0	Top of Bank
4+23	11.1	11.1	11.0	11.0	11.0	Toe of Bank (2018)
4+96	12.3	12.2	12.2	12.1	12.0	Top of Bank
5+11	9.8	9.8	9.8	9.8	9.8	Toe of Bank
5+81	7.8	7.7	7.7	7.7	7.5	Top of Bank
6+31	1.1	0.4	0.5	0.4	1.2	Edge of Water/Toe of Bank
7+00	-0.3	-0.5	-0.5	-0.8	-0.8	River Bottom
8+00	0.5	0.0	0.1	0.3	-	Edge of Water
9+00	1.0	0.0	0.0	0.0	-	Sand Bar
9+00					-0.3	River Bottom
10+00	1.4	0.3	0.4	0.1	-	Sand Bar
10+00					-0.4	River Bottom
11+00	1.8	1.0	1.1	1.2	-	Sand Bar
11+00					-0.9	River Bottom
12+00	2.3	1.1	0.8	0.9	-	Sand Bar
12+00					-0.8	River Bottom
13+00	2.0	0.5	0.4	-0.3	-1.5	Sand Bar
Varies	-0.2	0.5	0.4	-0.4	-	Edge of Water
14+68	-3.3	-1.5	-2.1	-3.2	-2.7	River Bottom
14+78	-3.1	-1.7	-2.2	-2.0	-2.1	River Bottom
14+94	-2.8	-1.9	-2.3	-2.3	-2.0	River Bottom
15+14	-2.4	-2.1	-2.5	-2.8	-2.3	River Bottom
15+34	-2.8	-2.3	-2.7	-3.0	-1.7	River Bottom
15+49	-2.6	-2.5	-2.9	-3.3	-1.6	River Bottom
15+72	-2.9	-2.8	-3.1	-2.7	-1.8	River Bottom
15+95	-3.5	-3.1	-3.3	-2.6	-1.8	River Bottom
16+15	-3.3	-3.5	-3.5	-3.2	-1.4	River Bottom
16+38	-3.8	-3.5	-3.7	-3.1	-1.3	River Bottom
16+61	-4.1	-4.4	-3.9	-4.3	-2.2	River Bottom
16+87	-4.1	-5.4	-7.3	7.3	-5.6	River Bottom
17+06	-4.8	-5.6	-7.7	-8.0	-6.7	River Bottom
17+29	-5.3	-5.6	-9.2	-7.9	-7.5	River Bottom
17+55	-7.2	-8.0	-9.1	-9.0	-8.3	River Bottom
17+82	-10.0	-10.2	-12.5	-12.0	-9.8	River Bottom
18+08	-13.4	-12.2	-15.7	-14.6	-12.9	River Bottom
18+31	-17.8	-16.2	-19.7	-16.5	-15.0	River Bottom
18+57	-19.9	-17.4	-20.8	-19.2	-18.4	River Bottom
18+80	-20.3	-19.8	-22.0	-21.5	-20.9	River Bottom
19+02	-20.8	-20.4	-23.1	-23.0	-22.0	River Bottom
19+28	-24.5	-23.3	-24.7	-24.7	-24.0	River Bottom
19+51	-24.1	-23.5	-26.4	-26.6	-25.3	River Bottom
19+74	-20.4	-23.1	-26.8	-25.0	-26.0	River Bottom
19+93	-12.5	-16.2	-24.0	-26.5	-23.8	River Bottom
20+10	-8.6	-4.1	-20.7	-6.6	-19.1	River Bottom
Varies	-0.3	0.6	1.6	-0.3	1.3	Edge of Water

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx   10 of 47   Transect_06

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 6

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
20+63	-	9.4	9.0	8.5	-	Top of Bank (2018)
					9.5	Top of Bank
21+50	9.8	10.0	9.9	9.9	10.0	Ground Shot
22+50	9.3	9.5	9.4	9.5	9.5	Ground Shot
23+24	9.8	9.8	9.7	9.8	9.9	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 7

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2014	2015	2016	2017	2018	2019	Description
0+00	10.6	10.9	10.7	10.7	10.5	10.6	10.7	Ground Shot
1+00	10.1	10.4	10.4	10.3	10.3	10.3	10.4	Ground Shot
1+50	12.2	12.4	12.4	12.3	12.3	12.4	12.4	Ground Shot
1+77	13.4	13.7	13.7	13.5	13.5	13.5	13.6	Grade Break
2+00	11.3	11.6	11.7	11.6	11.6	11.6	11.6	Ground Shot
2+15							9.0	Top of Bank
2+20			8.4	8.3	8.0	8.1	-	Top of Bank (2018)
2+23	8.1	8.1	-	-	-	-	-	Top of Bank (2014)
2+24							3.4	Toe of Bank
2+30	2.8	3.0	3.7	3.3	2.9	3.1	-	Toe of Bank (2018)
Varies	0.6	0.5	0.8	0.3	1.0	-0.3	1.3	Edge of Water
4+93	-2.5	-4.1	-4.2	-4.0	-4.0	-3.9	-3.7	River Bottom
5+06	-2.5	-4.4	-4.6	-4.0	-4.5	-4.4	-4.1	River Bottom
5+25	-2.6	-3.6	-5.0	-4.3	-5.0	-5.0	-4.9	River Bottom
5+45	-2.7	-3.7	-5.3	-4.7	-5.0	-5.2	-5.2	River Bottom
5+68	-3.7	-3.8	-6.6	-5.6	-6.2	-6.8	-6.5	River Bottom
5+91	-4.5	-5.2	-7.0	-7.0	-7.0	-7.1	-7.1	River Bottom
6+17	-5.8	-7.6	-7.3	-7.5	-7.6	-7.6	-7.5	River Bottom
6+42	-7.4	-7.2	-7.7	-7.3	-7.7	-7.7	-7.8	River Bottom
6+65	-7.7	-7.4	-7.7	-7.2	-7.2	-8.0	-8.0	River Bottom
6+88	-7.2	-6.3	-7.7	-6.4	-6.7	-7.6	-8.2	River Bottom
7+11	-6.8	-6.0	-7.6	-6.6	-6.7	-8.2	-8.3	River Bottom
7+37	-5.4	-5.5	-7.6	-6.8	-6.9	-7.8	-7.7	River Bottom
7+56	-5.1	-6.3	-7.6	-7.2	-7.3	-7.9	-7.5	River Bottom
7+82	-4.9	-7.1	-7.6	-7.3	-7.7	-7.7	-8.0	River Bottom
8+02	-4.3	-7.1	-7.6	-6.7	-7.3	-7.8	-7.8	River Bottom
8+25	-3.6	-5.6	-7.6	-7.5	-6.9	-7.9	-7.5	River Bottom
8+50	-4.2	-5.9	-7.5	-7.0	-6.8	-7.1	-7.3	River Bottom
8+74	-5.6	-6.2	-7.5	-7.2	-7.5	-7.0	-7.0	River Bottom
9+03	-5.9	-6.1	-7.4	-7.5	-7.9	-8.0	-0.6	River Bottom
9+32	-7.6	-5.5	-7.2	-7.8	-7.6	-7.8	-6.2	River Bottom
9+58	-7.0	-6.7	-7.0	-7.3	-7.6	-6.6	-7.0	River Bottom
9+84	-9.8	-7.4	-6.9	-8.2	-7.9	-6.2	-7.1	River Bottom
10+10	-9.9	-10.8	-7.4	-7.8	-8.0	-6.2	-7.2	River Bottom
10+39	-9.5	-10.5	-8.0	-8.2	-8.5	-6.7	-7.6	River Bottom
10+68	-8.7	-9.2	-7.8	-7.5	-7.9	-7.9	-7.3	River Bottom
10+91	-8.3	-9.3	-7.6	-7.8	-7.9	-9.6	-8.2	River Bottom
11+21	-8.9	-9.4	-7.4	-7.8	-8.4	-9.3	-8.5	River Bottom
11+50	-9.2	-9.7	-9.4	-7.5	-8.4	-8.6	-8.3	River Bottom
11+76	-9.4	-10.5	-10.3	-7.2	-7.7	-9.0	-8.2	River Bottom
12+02	-11.0	-10.7	-9.9	-8.4	-8.6	-8.6	-8.7	River Bottom
12+31	-11.6	-10.7	-9.5	-8.1	-8.4	-8.6	-8.7	River Bottom
12+57	-10.4	-9.4	-9.1	-7.5	-8.0	-8.6	-8.2	River Bottom
12+83	-9.0	-9.5	-8.8	-7.7	-7.9	-8.4	-8.2	River Bottom
13+09	-8.4	-8.7	-8.0	-7.2	-7.4	-7.9	-7.8	River Bottom
13+35	-7.6	-8.1	-7.6	-6.8	-6.8	-7.0	-6.9	River Bottom
13+64	-6.7	-7.2	-7.2	-6.4	-6.5	-6.5	-6.4	River Bottom
13+87	-6.3	-6.7	-6.5	-6.1	-6.3	-6.4	-6.0	River Bottom
14+17	-5.7	-6.5	-6.3	-5.6	-5.7	-5.7	-5.8	River Bottom
14+40	-5.9	-6.2	-6.2	-5.4	-5.5	-5.6	-5.5	River Bottom
14+69	-6.6	-6.5	-6.3	-5.7	-5.7	-5.4	-5.4	River Bottom
14+98	-7.8	-7.9	-7.8	-6.5	-6.4	-6.1	-6.0	River Bottom

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 7

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2014	2015	2016	2017	2018	2019	Description
15+24	-10.7	-10.6	-9.2	-7.8	-8.6	-7.9	-7.6	River Bottom
15+53	-13.6	-13.3	-11.8	-10.9	-10.9	-10.5	-10.0	River Bottom
15+79	-14.7	-13.9	-12.6	-12.2	-11.9	-11.5	-10.7	River Bottom
16+02	-11.1	-12.3	-12.3	-12.3	-12.2	-11.8	-9.4	River Bottom
Varies	0.7	0.5	0.2	0.3	1.0	-0.2	1.3	Edge of Water
16+95	8.5	8.4	8.4	8.3	-	-	-	Top of Bank (2016)
16+97					8.7	7.9	-	Top of Bank (2018)
17+00							8.9	Top of Bank
17+00	9.2	9.5	9.4	9.3	9.2	8.9	8.9	Ground Shot
17+57	10.1	10.3	10.0	9.7	9.6	9.8	9.9	Ground Shot
18+00	9.4	9.6	9.6	9.5	9.4	9.5	9.7	Ground Shot
19+00	10.2	10.5	10.6	10.4	10.2	10.3	10.4	Ground Shot
19+07	10.8	10.9	10.7	10.5	10.3	10.5	10.6	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 8

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2014	2015	2016	2017	2018	2019	Description
0+00	10.6	10.8	10.3	10.3	10.1	10.1	10.1	Ground Shot
1+00	10.1	10.2	10.3	10.2	10.1	10.1	10.2	Ground Shot
2+00	9.8	10.0	10.1	10.0	9.9	10.0	9.8	Ground Shot
2+00							9.8	Top of Bank
2+08	8.9	9.0	9.0	9.0	8.9	8.7	-	Top of Bank (2018)
Varies	0.9	0.2	-0.4	0.2	1.3	-0.2	1.8	Edge of Water
2+99	-5.8	-5.5	-7.3	-6.6	-6.6	-3.7	-6.6	River Bottom
3+20	-7.1	-7.7	-8.7	-8.3	-8.3	-7.8	-7.4	River Bottom
3+40	-7.4	-8.8	-9.7	-8.6	-8.8	-8.4	-8.1	River Bottom
3+61	-8.2	-9.6	-10.4	-9.2	-9.8	-9.1	-8.9	River Bottom
3+85	-9.7	-10.5	-11.2	-9.9	-10.6	-10.4	-10.0	River Bottom
4+09	-9.9	-10.8	-12.1	-11.2	-11.6	-11.5	-11.3	River Bottom
4+33	-9.9	-11.3	-13.1	-13.6	-13.5	-12.9	-12.9	River Bottom
4+57	-10.3	-11.9	-14.1	-15.2	-15.6	-16.5	-15.8	River Bottom
4+85	-10.0	-10.9	-14.3	-15.3	-15.2	-15.3	-15.2	River Bottom
5+09	-10.6	-10.4	-15.0	-14.4	-14.6	-14.9	-15.1	River Bottom
5+33	-11.5	-10.3	-15.2	-14.0	-14.4	-14.5	-14.4	River Bottom
5+60	-11.9	-10.7	-14.7	-13.8	-14.0	-13.6	-13.7	River Bottom
5+87	-12.4	-10.3	-14.2	-13.2	-13.5	-13.2	-13.1	River Bottom
6+19	-11.8	-10.8	-14.9	-14.3	-14.6	-14.6	-14.5	River Bottom
6+46	-11.1	-10.8	-15.4	-15.6	-15.6	-15.4	-15.3	River Bottom
6+73	-11.2	-11.6	-15.6	-15.5	-15.6	-15.3	-15.7	River Bottom
7+01	-10.3	-10.6	-15.3	-14.4	-14.7	-14.5	-14.5	River Bottom
7+28	-10.0	-10.3	-13.9	-13.5	-13.5	-13.6	-13.3	River Bottom
7+53	-11.8	-11.0	-12.5	-12.4	-12.2	-12.4	-12.8	River Bottom
7+80	-11.6	-11.0	-11.1	-10.5	-10.7	-11.3	-12.0	River Bottom
8+08	-12.1	-9.5	-9.4	-9.7	-9.8	-9.1	-8.9	River Bottom
8+36	-11.6	-8.2	-9.4	-9.1	-9.0	-8.2	-8.0	River Bottom
8+59	-11.0	-7.8	-8.5	-8.6	-8.4	-8.3	-7.8	River Bottom
8+79	-11.1	-7.1	-7.2	-7.5	-7.6	-7.2	-7.4	River Bottom
9+04	-9.1	-7.9	-6.8	-7.1	-6.5	-5.6	-6.4	River Bottom
9+28	-8.3	-7.7	-6.3	-5.0	-5.5	-4.8	-5.0	River Bottom
9+53	-8.1	-7.2	-6.4	-5.2	-5.5	-5.4	-5.3	River Bottom
9+76	-7.7	-6.6	-6.5	-4.6	-4.9	-4.1	-4.5	River Bottom
9+96	-7.6	-6.7	-6.4	-5.6	-5.0	-5.1	-4.1	River Bottom
10+17	-7.2	-6.2	-6.2	-6.2	-5.8	-5.2	-4.3	River Bottom
10+42	-5.6	-5.6	-6.0	-4.8	-4.3	-3.3	-3.5	River Bottom
10+62	-3.1	-3.9	-3.4	-3.1	-3.1	-2.5	-2.2	River Bottom

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 14 of 47 Transect_08

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 9

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE: 907-670-4739

DOC LCMF-156 REV7

STA	2013	2014	2015	2016	2017	2018	2019	Description
0+00	10.6	10.6	10.6	10.6	10.3	10.4	10.5	Ground Shot
1+00	9.9	10.0	10.0	9.9	10.0	9.8	9.8	Ground Shot
1+50	10.5	10.5	10.3	10.1	10.0	10.1	10.0	Ground Shot
1+89							8.9	Top of Bank
1+92	9.6	9.6	9.7	9.6	9.4	9.2	-	Top of Bank (2018)
Varies	0.6	0.0	0.9	0.7	0.8	-0.2	2.0	Edge of Water
2+48	-5.7	-10.5	-7.1	-5.7	-7.0	-5.5	-5.2	River Bottom
2+62	-7.7	-13.4	-13.8	-15.3	-14.6	-14.3	-14.0	River Bottom
2+78	-10.5	-18.8	-18.7	-19.2	-17.4	-19.1	-17.7	River Bottom
2+92	-14.5	-18.8	-21.6	-20.6	-20.2	-20.1	-19.5	River Bottom
3+13	-15.5	-19.2	-23.5	-21.8	-21.9	-22.0	-21.0	River Bottom
3+33	-15.2	-20.1	-24.9	-23.0	-23.2	-23.0	-21.2	River Bottom
3+58	-14.8	-20.7	-21.4	-23.5	-23.5	-23.3	-21.7	River Bottom
3+79	-13.9	-16.2	-19.2	-19.4	-21.7	-19.8	-19.5	River Bottom
4+03	-13.9	-16.2	-21.4	-21.5	-20.8	-21.4	-21.1	River Bottom
4+26	-13.4	-16.9	-22.1	-22.0	-20.0	-22.0	-21.0	River Bottom
4+54	-12.9	-19.9	-22.2	-19.8	-19.5	-18.4	-17.5	River Bottom
4+78	-13.4	-20.5	-22.3	-20.2	-19.4	-18.8	-17.8	River Bottom
5+02	-13.0	-19.3	-22.4	-19.0	-19.0	-18.8	-17.9	River Bottom
5+30	-13.2	-18.4	-21.5	-19.0	-18.6	18.1	-17.5	River Bottom
5+54	-13.9	-17.9	-20.9	-18.5	-18.5	-17.9	-17.5	River Bottom
5+79	-13.7	-18.3	-21.3	-18.8	-19.4	-18.6	-18.0	River Bottom
6+02	-12.6	-17.8	-19.7	-20.6	-20.3	-19.7	-19.0	River Bottom
6+30	-12.2	-15.4	-17.7	-20.7	-21.0	-20.2	-18.8	River Bottom
6+55	-12.7	-13.3	-16.7	-16.0	-15.5	-14.0	-12.6	River Bottom
6+79	-15.2	-12.4	-16.8	-16.5	-16.3	-14.5	-16.5	River Bottom
7+06	-14.0	-12.7	-17.0	-16.7	-16.6	-15.3	-13.6	River Bottom
7+30	-13.3	-13.2	-16.8	-15.7	-15.6	-14.6	-12.3	River Bottom
7+57	-11.9	-14.8	-17.0	-15.3	-14.8	-13.2	-11.7	River Bottom
7+84	-11.6	-14.6	-17.3	-15.4	-14.9	-14.0	-12.1	River Bottom
8+08	-11.0	-15.8	-16.6	-14.5	-13.9	-13.5	-10.8	River Bottom
8+33	-9.9	-10.3	-15.1	-10.5	-15.9	-11.0	-6.1	River Bottom
8+58	-6.9	-7.9	-6.2	-5.1	-5.1	-4.2	-0.1	River Bottom
8+78	-5.2	-6.4	-4.1	-3.5	-2.3	-2.6	-0.3	River Bottom
8+91	-3.3	-6.1	-2.8	-2.4	-2.0	-1.5	-0.5	River Bottom
Varies	0.5	0.5	1.2	0.5	0.9	-0.3	2.0	Edge of Water
10+00	2.3	2.5	4.0	4.1	4.0	4.4	4.6	Sand Bar
11+00	3.9	4.1	4.9	4.9	4.2	5.1	5.1	Sand Bar
11+52	5.0	5.2	5.5	5.6	5.4	5.8	5.7	Edge of Vegetation
12+00	5.4	5.5	6.0	6.0	5.7	5.9	6.0	Ground Shot
13+00	4.2	4.6	5.0	5.0	5.8	5.2	5.1	Ground Shot
14+00	3.9	4.1	4.5	4.5	4.9	4.5	4.4	Ground Shot
14+39	3.7	3.9	4.0	4.0	4.0	4.1	4.0	Edge of Water
14+82	3.4	3.7	3.9	3.8	3.8	4.2	4.0	Edge of Water
14+84	3.8	4.1	4.2	4.0	4.0	4.2	4.1	Toe of Bank
15+00	5.7	5.9	5.7	5.7	5.7	5.8	5.9	Top of Bank
15+52	8.0	8.2	8.0	7.9	7.8	8.0	8.2	Ground Shot
16+00	8.2	8.5	8.1	8.1	8.0	7.9	7.7	Ground Shot
16+92	9.4	9.4	9.3	9.3	9.0	7.8	9.2	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 10

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2014	2015	2016	2017	2018	2019	Description
0+00	10.3	10.4	10.3	10.3	10.2	10.1	10.2	Ground Shot
1+00	10.4	10.7	10.3	10.3	9.6	9.3	8.7	Ground Shot
1+50	10.5	10.6	10.4	10.3	10.1	10.1	10.1	Ground Shot
1+67							9.7	Top of Bank
1+90	9.9	9.7	9.5	9.4	8.9	8.2	-	Top of Bank (2018)
2+00	6.7	7.0	6.5	6.4	5.3	5.1	4.0	Ground Shot
Varies	0.5	-0.8	-0.3	0.7	1.2	-0.2	2.0	Edge of Water
2+67	-7.8	-14.3	-20.4	-19.5	-19.9	-20.2	-19.7	River Bottom
2+87	-20.7	-21.4	-21.3	-22.3	-21.6	-22.6	-21.7	River Bottom
3+09	-21.3	-22.5	-23.8	-23.3	-23.2	-24.0	-22.3	River Bottom
3+30	-20.0	-21.2	-23.8	-22.6	-23.1	-22.8	-23.1	River Bottom
3+55	-19.4	-20.3	-23.7	-22.7	-22.4	-22.3	-22.2	River Bottom
3+76	-19.0	-20.7	-23.7	-22.6	-21.1	-22.3	-22.1	River Bottom
4+00	-17.8	-18.6	-20.8	-18.8	-18.3	-18.9	-18.5	River Bottom
4+21	-18.0	-19.2	-21.1	-19.0	-18.9	-18.8	-18.8	River Bottom
4+45	-18.7	-19.2	-21.5	-19.1	-19.1	-18.6	-18.0	River Bottom
4+70	-19.0	-19.9	-21.9	-20.9	-20.3	-19.3	-18.2	River Bottom
4+94	-18.4	-20.6	-22.3	-21.9	-21.2	-20.3	-20.4	River Bottom
5+21	-17.3	-20.4	-23.0	-22.0	-22.0	-21.3	-19.8	River Bottom
5+45	-16.1	-19.2	-23.7	-22.3	-22.2	-21.3	-20.4	River Bottom
5+69	-14.6	-19.1	-23.2	-22.0	-21.5	-21.3	-20.4	River Bottom
5+96	-13.5	-17.7	-22.4	-21.2	-20.1	-20.4	-19.6	River Bottom
6+20	-13.7	-16.8	-21.5	-20.5	-19.8	-19.1	-18.5	River Bottom
6+47	-12.5	-15.3	-19.7	-18.2	-17.9	-17.4	-16.5	River Bottom
6+71	-12.1	-14.7	-17.4	-16.2	-16.2	-15.4	-14.0	River Bottom
6+99	-11.9	-14.2	-15.2	-13.8	-13.2	-11.8	-11.0	River Bottom
7+23	-12.4	-15.4	-14.8	-11.4	-10.8	-9.5	-8.8	River Bottom
7+48	-12.2	-17.6	-14.4	-10.7	-9.7	-8.3	-7.1	River Bottom
7+70	-12.9	-25.5	-14.1	-11.3	-10.5	-9.1	-7.1	River Bottom
7+94	-11.2	-21.7	-14.8	-14.6	-12.7	-10.6	-9.1	River Bottom
8+15	-6.8	-15.9	-10.8	-12.8	-7.9	-6.5	-6.3	River Bottom
Varies	0.4	1.2	2.6	0.8	1.1	-0.3	1.9	Edge of Water
9+00	1.6	2.1	3.7	3.8	3.5	3.6	3.6	Sand Bar
10+00	3.6	3.2	4.3	4.3	4.4	4.6	4.6	Sand Bar
11+00	5.4	5.6	5.8	5.9	5.9	6.1	6.0	Edge of Vegetation
12+00	5.1	5.4	5.7	5.7	5.7	5.9	5.8	Ground Shot
13+00	4.8	5.0	5.4	5.4	5.3	5.5	5.6	Ground Shot
14+00	4.6	4.8	5.0	5.1	5.0	4.7	4.8	Ground Shot
14+84	3.7	3.8	3.7	3.7	3.8	3.9	4.0	Toe of Bank
14+96	7.7	7.7	6.8	7.5	7.4	7.5	7.5	Top of Bank
15+00	7.8	8.0	7.9	7.8	7.7	7.8	7.7	Ground Shot
15+38	8.6	8.5	8.4	8.8	8.4	8.2	8.2	Ground Shot
15+53	9.1	9.4	9.4	9.2	9.1	9.2	9.2	Grade Break
15+71	7.2	7.4	7.3	7.2	7.2	7.1	6.8	Grade Break
16+00	6.7	7.0	6.8	6.7	6.4	6.6	6.4	Ground Shot
16+88	7.2	7.4	7.2	7.2	6.9	7.1	7.3	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 11

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	10.9	10.9	10.7	10.7	10.8	Ground Shot
1+00	10.4	10.7	10.5	10.7	10.6	Ground Shot
1+42					9.3	Top of Bank
1+47			9.1	8.8	-	Top of Bank (2018)
1+50	8.7	-	-	-	-	Ground Shot
1+55		8.8	-	-	-	Top of Bank (2016)
1+79	8.6	-	-	-	-	Top of Bank (2013)
Varies	0.6	0.8	0.9	-0.2	2.2	Edge of Water
2+01	-10.6	-28.3	-25.0	-26.9	27.0	River Bottom
2+16	-19.0	-33.1	-31.0	-32.5	-33.4	River Bottom
2+36	-30.7	-36.7	-36.1	-36.2	-37.5	River Bottom
2+59	-33.6	-36.6	-36.4	-36.7	-37.0	River Bottom
2+82	-35.3	-36.7	-36.4	-36.9	-36.6	River Bottom
3+08	-32.7	-35.9	-35.5	-35.5	-34.7	River Bottom
3+28	-31.4	-34.0	-33.3	-33.6	-32.6	River Bottom
3+54	-30.9	-31.8	-31.8	-31.4	-31.0	River Bottom
3+77	-30.0	-29.7	-29.2	-28.2	-28.8	River Bottom
4+00	-30.0	-25.0	-25.8	-25.1	-24.3	River Bottom
4+23	-27.8	-22.5	-22.5	-22.1	-21.0	River Bottom
4+48	-25.6	-18.3	-19.2	-17.3	-17.0	River Bottom
4+68	-22.7	-16.0	-16.4	-14.6	-13.4	River Bottom
4+94	-20.1	-13.7	-13.3	-10.7	-9.4	River Bottom
5+16	-17.5	-12.3	-11.5	-8.6	-7.6	River Bottom
5+40	-14.9	-11.1	-10.8	-7.9	-6.7	River Bottom
5+62	-13.5	-9.1	-9.1	-7.3	-6.0	River Bottom
5+82	-10.5	-5.6	-6.1	-4.9	-3.2	River Bottom
6+02	-6.1	-3.6	-3.8	-4.5	-0.9	River Bottom
Varies	0.2	0.8	0.9	-0.3	1.5	Edge of Water
7+00	2.9	3.4	3.4	3.5	3.6	Sand Bar
7+90	4.9	5.1	5.0	5.1	5.1	Edge of Vegetation
8+00	4.9	5.1	5.0	5.2	5.2	Ground Shot
9+00	5.5	5.6	5.6	5.7	5.7	Ground Shot
10+00	5.1	5.2	5.2	5.3	5.4	Ground Shot
11+00	5.6	5.7	5.7	5.8	5.8	Ground Shot
12+00	5.8	5.9	5.9	6.1	6.0	Ground Shot
13+00	5.5	5.8	5.7	5.8	5.6	Ground Shot
14+00	6.2	6.3	6.3	6.4	6.3	Ground Shot
15+00	6.1	6.2	6.1	6.1	6.0	Ground Shot
16+00	6.3	6.5	6.5	6.6	6.4	Edge of Vegetation
16+52	6.7	6.8	6.8	6.9	6.7	Grade Break
16+62	8.0	8.2	8.1	8.2	8.1	Grade Break
16+89	9.1	8.9	8.8	8.8	8.9	Ground Shot
17+00	8.9	9.1	9.1	9.3	9.1	Ground Shot
18+00	9.0	9.0	9.2	9.3	9.0	Ground Shot
18+39	10.2	10.2	9.8	9.4	9.5	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 12

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	11.0	11.0	10.8	10.9	11.0	Ground Shot
1+00	11.3	11.2	10.8	10.8	11.0	Ground Shot
2+00	9.9	10.4	10.2	10.4	10.2	Ground Shot
2+08	10.0	10.0	9.9	9.9	9.8	Top of Bank
2+22	4.9	5.6	5.6	5.7	5.7	Toe of Bank
3+00	2.2	3.1	3.1	3.3	3.3	Sand Bar
4+00	1.5	2.5	2.5	2.6	2.5	Sand Bar
5+00	1.8	2.3	2.2	2.5	2.3	Sand Bar
Varies	0.4	0.4	0.6	0.6	1.6	Edge of Water
5+79	-4.7	0.4	-1.7	-0.1	-0.2	River Bottom
5+85	-5.1	-2.6	-2.1	-2.2	-0.6	River Bottom
6+10	-9.0	-5.6	-3.9	-2.5	-3.0	River Bottom
6+36	-17.5	-11.1	-11.3	-10.0	11.7	River Bottom
6+54	-24.6	-20.7	-18.4	-16.5	-17.1	River Bottom
6+85	-28.6	-24.0	-25.9	-22.3	-23.3	River Bottom
7+08	-32.0	-29.3	-28.6	-26.5	-26.0	River Bottom
7+31	-33.5	-29.7	-29.8	-27.8	-28.4	River Bottom
7+57	-33.9	-31.9	-31.6	-30.0	-31.0	River Bottom
7+83	-33.0	-32.6	-32.6	-32.7	-33.1	River Bottom
8+06	-32.1	-31.7	-32.2	32.4	-32.3	River Bottom
8+29	-31.0	-31.2	-31.1	-31.9	-31.7	River Bottom
8+56	-31.1	-31.1	-29.6	-31.6	-31.6	River Bottom
8+79	-31.3	-31.1	-30.8	-31.3	-31.6	River Bottom
9+02	-30.7	-30.4	-30.6	-31.2	-30.9	River Bottom
9+28	-29.9	-30.7	-30.6	-31.0	-31.4	River Bottom
9+51	-27.1	-30.7	-30.6	-31.3	-31.2	River Bottom
9+72	-23.2	-30.4	-28.1	-30.0	-28.9	River Bottom
10+00	-20.1	-22.9	-21.9	-23.0	-21.0	River Bottom
10+23	-3.0	-19.2	-19.1	-17.7	-17.5	River Bottom
10+43	-3.2	-18.3	-15.9	-15.9	-15.0	River Bottom
Varies	0.6	0.5	0.5	0.6	1.5	Edge of Water
11+05	9.5	-	-	-	-	Top of Bank (2013)
11+20		1.3	1.2	2.2	-	Toe of Bank (2018)
11+28		8.8	8.6	8.4	-	Top of Bank (2018)
11+35					3.1	Toe of Bank
11+36					8.6	Top of Bank
12+00	9.4	9.1	9.0	9.1	9.2	Ground Shot
13+00	7.9	8.0	8.0	8.1	8.2	Edge of Vegetation
14+01	6.9	7.0	7.0	7.2	7.1	Ground Shot
15+01	7.2	7.3	7.3	7.5	7.5	Ground Shot
16+00	7.8	8.0	8.0	8.1	8.1	Ground Shot
17+01	8.3	8.4	8.4	8.5	8.5	Ground Shot
18+00	7.0	7.1	7.0	7.1	7.0	Ground Shot
19+00	6.3	6.6	6.7	6.9	6.8	Ground Shot
20+00	6.7	7.0	7.0	7.0	6.7	Ground Shot
21+00	6.7	7.1	7.0	7.0	6.9	Ground Shot
21+85	7.0	7.4	7.3	7.4	7.3	Toe of Bank
22+00	8.2	8.5	8.3	8.3	8.2	Top of Bank
22+16	8.8	8.6	8.4	8.6	8.7	Ground Shot
23+00	9.7	10.0	9.9	9.8	9.8	Ground Shot
23+67	10.2	10.0	9.4	9.7	9.9	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 13

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	10.6	11.4	11.2	11.4	11.4	Ground Shot
1+00	11.7	11.7	11.7	11.8	11.8	Ground Shot
1+50	12.1	11.9	12.0	12.1	12.1	Ground Shot
2+00	12.2	11.8	11.7	11.8	12.0	Ground Shot
2+34	11.2	11.1	10.9	11.0	11.0	Edge of Vegetation
3+00	10.3	9.9	10.2	10.1	10.0	Ground Shot
4+00	10.3	10.6	10.6	10.6	10.5	Ground Shot
4+36	10.9	10.9	10.8	11.1	10.9	Edge of Vegetation
5+00	11.7	11.6	11.6	11.8	11.7	Ground Shot
6+00	13.2	13.2	13.1	13.3	13.1	Ground Shot
7+00	14.1	13.7	13.6	13.7	13.6	Ground Shot
7+11	14.9	14.6	14.6	14.7	14.6	Grade Break
7+95	23.7	23.4	23.4	23.6	23.4	Grade Break
8+00	22.8	23.0	22.9	23.1	23.0	Ground Shot
9+00	22.4	22.4	22.4	22.6	22.8	Top of Bank
9+67	11.2	11.1	11.3	11.3	11.3	Toe of Bank
10+00	9.6	10.0	10.0	10.2	10.4	Sand Bar
11+00	7.3	7.6	7.7	7.7	7.4	Sand Bar
12+00	8.3	5.9	5.8	5.9	5.9	Sand Bar
13+00	5.0	4.8	4.8	5.0	5.0	Sand Bar
14+00	6.9	4.2	4.4	4.7	4.8	Sand Bar
15+00	5.8	3.9	4.1	4.4	4.5	Sand Bar
16+00	4.9	3.7	3.7	3.9	3.9	Sand Bar
17+00	4.4	3.3	3.4	3.6	3.6	Sand Bar
18+01	4.2	2.8	2.9	3.2	3.1	Sand Bar
19+00	3.1	2.6	2.6	2.9	3.1	Sand Bar
20+00	2.5	2.4	2.5	2.7	2.7	Sand Bar
21+00	2.3	2.4	2.4	2.6	2.5	Sand Bar
22+00	2.1	2.5	2.4	2.7	2.5	Sand Bar
23+00	2.5	2.2	2.3	2.5	2.4	Sand Bar
24+00	1.8	2.3	2.4	2.6	2.5	Sand Bar
25+00	2.0	2.2	2.2	2.6	2.4	Sand Bar
26+00	2.3	2.1	2.1	2.4	2.1	Sand Bar
27+00	3.0	2.2	2.1	2.4	2.1	Sand Bar
28+00	3.7	2.9	2.7	2.7	2.5	Sand Bar
29+00	3.6	2.8	2.7	2.8	2.5	Sand Bar
30+00	3.1	2.7	2.5	2.6	2.4	Sand Bar
31+00	3.4	2.1	2.0	2.3	2.2	Sand Bar
32+00	2.9	2.0	2.1	2.2	2.0	Sand Bar
33+00	2.1	1.5	1.5	1.8	1.7	Sand Bar
34+00	1.6	0.9	1.6	1.4	1.2	Sand Bar
35+00	1.2	-	1.2	2.0	-	Sand Bar
Varies	0.5	1.4	1.6	0.4	1.1	Edge of Water
36+19	-3.2	-2.8	-4.6	-5.9	-6.7	River Bottom
36+39	-5.3	-4.4	-5.4	-7.0	-7.3	River Bottom
36+59	-7.8	-5.0	-7.0	-7.5	-7.8	River Bottom
36+79	-10.9	-5.8	-7.0	-8.0	-8.3	River Bottom
37+07	-13.3	-8.7	-7.3	-8.2	-8.5	River Bottom
37+30	-16.2	-9.0	-8.4	-8.7	-9.3	River Bottom
37+59	-18.8	-10.0	-10.1	-10.0	-10.6	River Bottom
37+84	-20.2	-11.5	-11.8	-11.2	-11.8	River Bottom
38+16	-20.8	-15.6	-14.1	-14.0	-13.0	River Bottom

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 19 of 47 Transect_13

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 13

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
38+38	-21.1	-16.7	-13.5	-15.2	-14.5	River Bottom
38+70	-22.1	-19.2	-17.5	-17.7	-18.3	River Bottom
38+92	-24.2	-22.1	-19.8	-19.0	-19.6	River Bottom
39+21	-22.6	-24.4	-21.8	-22.6	-22.6	River Bottom
39+38	-3.7	-23.5	-22.9	-24.4	-24.7	River Bottom
Varies	0.1	1.1	0.3	0.4	1.2	Edge of Water
40+00	8.7	-	-	-	-	Ground Shot (2013)
40+12		9.1	-	-	-	Top of Bank (2016)
40+17			8.4			Top of Bank (2017)
40+26			-	8.2		Top of Bank (2018)
40+29					8.1	Top of Bank
41+00	8.1	8.6	8.6	8.7	8.7	Ground Shot
42+00	8.1	8.5	8.5	8.7	8.6	Ground Shot
43+00	8.0	8.4	8.3	8.4	8.4	Ground Shot
43+53	6.7	7.0	6.9	7.1	6.9	Edge of Vegetation
44+00	5.2	5.6	5.5	5.6	5.7	Top of Bank
Varies	0.2	1.4	1.4	0.5	1.3	Edge of Water
45+19	0.4	0.8	0.7	-0.5	-0.6	River Bottom
45+64	-1.5	-0.4	-1.4	-1.3	-1.6	River Bottom
46+13	-6.5	-5.7	-5.6	-6.6	-5.6	River Bottom
46+62	-10.0	-8.8	-9.4	-10.1	-9.7	River Bottom
47+14	-10.3	-9.5	-9.8	-10.4	-10.3	River Bottom
47+65	-7.8	-7.5	-7.9	-8.2	-8.1	River Bottom
48+13	-5.2	-4.8	-5.2	-5.6	-5.1	River Bottom
48+65	-1.5	-0.5	-2.2	-2.3	-2.2	River Bottom
Varies	-0.2	1.1	0.7	0.5	1.5	Edge of Water
49+22	6.8	6.9	6.6	6.4	6.2	Top of Bank
49+53	7.6	7.8	7.9	7.8	7.9	Grade Break
50+00	8.3	8.2	8.2	8.5	8.7	Ground Shot
50+14	11.7	11.5	11.4	11.4	11.6	Ground Shot
50+28	11.2	11.3	11.0	11.2	11.2	Grade Break
50+33	9.0	8.9	9.0	9.1	9.2	Grade Break
50+36	10.6	10.6	10.7	10.8	10.8	Grade Break
51+00	10.7	10.9	10.9	10.9	10.8	Ground Shot
51+30	10.5	10.7	11.0	11.0	10.9	Grade Break
51+34	9.2	9.3	9.4	9.4	9.2	Grade Break
51+44	10.1	10.0	10.1	10.1	10.1	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 14

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	13.2	13.2	13.1	13.1	13.3	Ground Shot
1+00	13.5	13.7	13.6	13.8	13.7	Ground Shot
1+65	15.7	15.6	15.5	15.5	15.6	Ground Shot
2+00	16.7	16.7	16.6	16.8	16.6	Ground Shot
3+00	18.8	18.8	18.8	18.9	18.8	Ground Shot
3+67	20.0	20.0	20.0	20.1	20.0	Grade Break
4+00	19.2	19.3	19.4	19.4	19.4	Ground Shot
4+76	19.3	19.3	19.2	19.5	19.4	Top of Bank
5+19	12.2	12.2	12.2	12.4	12.3	Toe of Bank
6+00	9.6	9.5	9.4	9.3	9.0	Edge of Vegetation
7+00	6.1	6.2	6.1	6.2	6.2	Edge of Vegetation
8+00	3.3	4.0	3.7	3.7	3.8	Sand Bar
9+00	2.8	2.4	2.4	2.5	2.6	Sand Bar
10+00	1.7	-	1.8	1.9	1.7	Sand Bar
11+00	0.5	-	0.5	-	1.2	Sand Bar
Varies	-0.1	1.7	1.8	1.5	1.2	Edge of Water
13+87	-2.6	-1.2	-2.2	-1.6	-1.6	River Bottom
14+03	-2.7	-0.5	-2.2	-1.9	-1.6	River Bottom
14+20	-3.2	-1.0	-2.0	-1.0	-1.0	River Bottom
14+36	-2.4	-1.1	-1.9	-1.7	-1.2	River Bottom
14+52	-3.0	-0.7	-1.7	-1.9	-1.2	River Bottom
14+68	-3.0	-0.5	-1.8	-2.0	-1.1	River Bottom
14+88	-2.4	-0.6	-2.2	-2.1	-1.7	River Bottom
15+04	-3.1	-0.6	-1.7	-1.5	-1.2	River Bottom
15+24	-2.9	-0.6	-1.6	-1.2	-0.9	River Bottom
15+36	-2.9	-0.6	-1.3	-1.0	-0.3	River Bottom
15+53	-2.3	-0.5	-0.9	-1.0	-0.5	River Bottom
15+66	-2.4	-0.3	-0.6	-0.9	-0.7	River Bottom
15+76	-2.7	-0.1	-0.3	-0.3	-0.9	River Bottom
15+89	-3.4	0.2	-0.4	0.2	-1.1	River Bottom
16+05	-3.5	0.5	-0.8	0.3	-	River Bottom
16+18	-3.8	0.7	-1.0	0.4	-	River Bottom
16+18					1.5	Sand Bar
16+38	-3.9	1.0	0.7	0.4	-	River Bottom
16+54	-3.4	1.7	1.6	0.9	-	River Bottom
Varies	-0.4	1.7	2.1	1.4	1.1	Edge of Water
17+31	2.0	2.2	2.2	2.2	2.1	Sand Bar
18+00	2.4	2.6	2.3	2.3	2.4	Sand Bar
19+00	2.2	2.8	2.7	2.7	2.7	Sand Bar
20+00	2.2	2.7	2.7	2.9	2.8	Sand Bar
21+01	2.2	3.1	2.8	2.9	2.8	Sand Bar
22+00	2.0	2.5	2.6	2.7	2.7	Sand Bar
23+00	0.8	2.8	2.6	2.5	2.6	Sand Bar
24+00	0.2	1.9	1.8	2.1	1.8	Sand Bar
Varies	-1.3	1.6	1.6	1.4	1.1	Edge of Water
24+48	-2.7	-4.3	-0.5	-1.9	-3.6	River Bottom
24+64	-5.5	-6.5	-1.3	-4.6	-6.2	River Bottom
24+87	-9.0	-9.8	-2.5	-8.5	-9.1	River Bottom
25+10	-9.6	-12.3	-3.6	-10.1	-11.0	River Bottom
25+33	-9.9	-13.0	-4.8	-12.1	-11.4	River Bottom
25+56	-9.9	-14.0	-5.9	-11.4	-12.6	River Bottom
25+82	-10.2	-14.7	-10.5	-12.1	-12.8	River Bottom

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 21 of 47 Transect_14

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 14

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
26+01	-10.4	-15.2	-10.8	-11.9	-13.3	River Bottom
26+24	-10.0	-15.2	-12.2	-12.8	-14.3	River Bottom
26+50	-10.0	-16.5	-11.5	-13.5	-14.6	River Bottom
26+70	-10.6	-15.4	-11.6	-12.5	-13.1	River Bottom
26+89	-11.6	-15.1	-11.8	-12.5	-12.3	River Bottom
27+15	-11.1	-15.8	-11.5	-17.4	20.0	River Bottom
27+35	-10.8	-15.2	-13.0	-14.5	-13.7	River Bottom
Varies	0.3	1.6	0.6	1.3	1.0	Edge of Water
27+87	9.0	-	-	-	-	Top of Bank (2013)
27+95		8.7	-	-	-	Top of Bank (2016)
27+98			8.8	-	-	Top of Bank (2017)
28+00	9.8	9.3	9.1		9.0	Ground Shot
28+03	-	-	-	9.4	9.0	Top of Bank (2018)
28+44	10.0	9.6	9.6	9.5	9.6	Ground Shot
29+00	9.6	9.5	9.3	9.5	9.4	Ground Shot
29+94	9.7	9.4	9.1	9.4	9.4	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 15

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	13.8	13.6	13.6	13.7	14.0	Ground Shot
1+00	15.3	15.4	15.5	15.6	15.6	Ground Shot
1+50	16.7	16.4	16.6	15.6	16.6	Ground Shot
1+88		16.2	16.3	16.4	16.1	Top of Bank
1+95	15.1	-	-	-	-	Top of Bank (2013)
2+02					4.2	
2+11	3.3	3.0	2.4	2.1	-	Toe of Bank
Varies	0.9	1.9	1.5	1.2	0.9	Edge of Water
2+88	-2.9	-5.4	-2.4	-2.3	-3.2	River Bottom
3+09	-3.3	-7.3	-3.0	-3.1	-4.1	River Bottom
3+30	-3.8	-7.6	-3.2	-4.4	-4.6	River Bottom
3+50	-4.0	-8.1	-4.0	-4.2	-5.1	River Bottom
3+71	-4.1	-8.3	-4.8	-4.7	-5.5	River Bottom
3+91	-4.4	-8.7	-4.5	-5.5	-5.9	River Bottom
4+12	-4.4	-9.0	-4.8	-6.9	-6.4	River Bottom
4+36	-4.2	-9.8	-4.8	-4.8	-6.5	River Bottom
4+57	-4.7	-9.5	-4.9	-5.4	-6.0	River Bottom
4+81	-3.9	-9.0	-4.3	-5.3	-5.5	River Bottom
5+01	-3.2	-7.6	-3.8	-5.0	-5.0	River Bottom
11+47	-2.4	-6.8	-2.7	-2.8	-1.1	River Bottom
11+64	-2.4	-7.1	-3.4	-3.0	-3.2	River Bottom
11+81	-2.5	-7.3	-4.0	-3.9	-3.8	River Bottom
11+98	-3.3	-7.8	-4.3	-4.6	-4.2	River Bottom
12+16	-3.6	-8.7	-4.6	-4.9	-5.2	River Bottom
12+36	-4.0	-8.8	-4.5	-5.2	-5.6	River Bottom
12+57	-4.6	-9.0	-5.7	-6.0	-6.0	River Bottom
12+77	-4.7	-9.1	-6.2	-6.8	-6.9	River Bottom
13+01	-4.9	-10.1	-6.7	-7.2	-8.0	River Bottom
13+29	-5.6	-10.2	-7.4	-8.5	-9.3	River Bottom
13+56	-5.8	-11.3	-8.1	-9.1	-9.4	River Bottom
13+80	-6.4	-11.5	-8.0	-8.9	-9.1	River Bottom
14+08	-6.5	-12.4	-8.3	-9.5	-9.7	River Bottom
14+35	-6.8	-11.8	-7.9	-9.8	-1.0	River Bottom
14+59	-6.5	-11.6	-7.9	-9.3	-10.0	River Bottom
14+87	-6.2	-12.2	-8.1	-10.0	-10.1	River Bottom
15+14	-5.2	-11.3	-8.0	-10.0	-9.7	River Bottom
15+42	-5.4	-10.4	-8.4	-9.5	-8.4	River Bottom
15+66	-5.1	-10.6	-7.0	-7.1	-7.3	River Bottom
15+93	-6.1	-10.0	-6.2	-6.5	-6.4	River Bottom
16+24	-8.3	-10.9	-6.6	-3.7	-4.3	River Bottom
16+52	-8.3	-11.7	-6.7	-5.0	-3.5	River Bottom
16+79	-5.1	-9.6	-5.5	-4.0	-2.5	River Bottom
17+03	-2.8	-7.3	-3.0	-3.0	-1.6	River Bottom
Varies	0.8	2.0	1.6	1.2	1.1	Edge of Water
17+79	1.9	2.8	2.1	1.5	2.2	Sand Bar
17+97	4.4	4.9	3.0	2.5	2.9	Sand Bar
18+19	5.6	5.6	5.6	5.6	5.7	Toe of Bank
18+35	11.9	11.8	11.8	12.0	11.9	Top of Bank
18+91	12.6	12.3	12.4	12.5	12.6	Ground Shot
19+41	12.5	12.2	12.3	12.4	12.5	Ground Shot

E.3.3 NIGLIAGVIK CHANNEL & BRIDGE TABULATED DATA (TRANSECTS 16 – 35)

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 16

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	10.0	9.7	9.6	9.8	10.0	Ground Shot
0+50	9.4	8.9	9.0	8.7	8.6	Ground Shot
1+00	8.4	8.6	8.4	8.2	8.2	Top of Bank
Varies	0.8	0.3	0.2	0.8	1.2	Edge of Water
1+28	-3.1	-3.4	-3.5	-3.5	-4.9	River Bottom
1+37	-4.2	-5.7	-3.8	-7.2	-4.9	River Bottom
1+46	-7.0	-6.8	-6.1	-7.4	-4.9	River Bottom
1+58	-6.5	-6.4	-6.8	-7.0	-4.9	River Bottom
1+70	-7.5	-8.2	-8.1	-8.8	-4.9	River Bottom
1+81	-10.7	-10.2	-9.6	-10.0	-4.9	River Bottom
1+91	-12.3	-12.2	-12.6	-13.0	-4.9	River Bottom
2+06	-8.3	-9.8	-10.1	-10.7	-4.9	River Bottom
2+17	-6.6	-8.1	-8.1	-8.9	-3.2	River Bottom
2+27	-5.0	-6.8	-4.9	-4.0	-1.6	River Bottom
2+37	-2.1	-3.3	-1.8	-0.9	-1.6	River Bottom
Varies	0.8	0.6	0.9	0.7	1.2	Edge of Water
2+68	3.4	3.6	2.0	3.5	3.0	Sand Bar
3+10	4.7	4.8	4.9	5.0	5.0	Edge of Vegetation
3+59	6.7	6.9	6.9	6.8	6.8	Edge of Vegetation
4+00	7.9	8.0	7.8	7.8	7.8	Ground Shot
4+18	8.9	8.6	8.5	8.6	8.7	Ground Shot
4+68	9.2	8.9	9.0	9.1	9.2	Ground Shot

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 24 of 47 Transect_16

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 17

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE: 907-670-4739

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	8.6	8.2	8.1	8.3	8.5	Ground Shot
0+50	8.5	8.1	7.9	7.9	8.0	Ground Shot
1+16	8.0	8.1	8.1	8.0	8.1	Top of Bank
1+47	3.7	3.9	3.7	3.8	3.7	Edge of Vegetation
Varies	0.9	1.0	1.3	0.8	1.1	Edge of Water
1+93	-2.1	-1.9	-0.8	-2.0	-1.8	River Bottom
2+08	-2.2	-1.9	-1.4	-2.3	-2.2	River Bottom
2+19	-2.6	-2.3	-1.9	-2.4	-3.0	River Bottom
2+29	-2.9	-2.9	-2.3	-2.5	-3.2	River Bottom
2+39	-3.1	-3.3	-2.7	-3.0	-3.4	River Bottom
2+49	-3.2	-3.4	-3.1	-3.6	-3.4	River Bottom
2+66	-3.5	-3.6	-3.6	-3.8	-3.8	River Bottom
2+83	-3.5	-3.4	-3.5	-4.0	-3.7	River Bottom
2+91	-3.3	-3.3	-3.5	-4.0	-3.5	River Bottom
3+08	-3.1	-3.3	-3.3	-3.9	-3.4	River Bottom
3+27	-2.4	-2.9	-2.4	-3.1	-2.6	River Bottom
Varies	0.7	1.0	1.2	0.6	0.8	Edge of Water
3+82	6.3	6.5	6.3	6.1	6.3	Top of Bank
4+29	8.6	8.3	8.3	8.4	8.6	Ground Shot
4+79	8.5	8.2	8.1	8.4	8.5	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 18

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	8.6	8.5	8.7	8.6	8.7	Ground Shot
0+50	8.6	8.6	8.0	8.4	8.4	Ground Shot
1+00	7.9	8.2	8.0	8.0	8.0	Ground Shot
1+58	7.1	7.2	7.0	6.9	6.9	Top of Bank
1+76	6.3	6.2	6.0	6.0	6.0	Edge of Vegetation
2+14	3.7	3.8	3.6	3.6	3.6	Edge of Vegetation
Varies	1.0	1.2	1.4	1.1	1.1	Edge of Water
3+17	-2.6	-1.8	-1.2	-1.8	-1.5	River Bottom
3+26	-2.8	-1.8	-1.4	-2.4	-1.8	River Bottom
3+38	-3.2	-2.7	-1.8	-2.5	-2.7	River Bottom
3+52	-2.1	-3.4	-2.7	-3.2	-3.4	River Bottom
3+68	-3.6	-3.9	-3.6	-4.5	-4.0	River Bottom
3+80	-4.0	-3.6	-3.6	-4.7	-4.1	River Bottom
3+93	-3.9	-3.2	-3.1	-4.6	-3.7	River Bottom
4+01	-3.5	-2.8	-2.7	-4.1	-3.4	River Bottom
4+14	-3.0	-1.9	-2.1	-3.6	-3.0	River Bottom
4+22	-3.0	-1.6	-1.7	-3.0	-1.9	River Bottom
Varies	0.9	1.2	1.4	0.8	1.1	Edge of Water
4+68		1.8	1.3	1.2	-	Toe of Bank
4+76	7.1	7.0	6.8	6.7	6.6	Top of Bank
5+33	7.8	7.6	7.1	7.3	7.4	Ground Shot
5+83	8.0	7.8	7.6	7.7	7.8	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 19

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE: 907-670-4739

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	8.6	8.5	8.36	8.7	8.8	Ground Shot
0+50	8.5	8.7	8.6	8.8	8.9	Ground Shot
0+95	7.9	8.1	8.0	8.3	8.0	Top of Bank
1+15	3.3	3.9	3.6	3.7	3.6	Edge of Vegetation
Varies	0.7	1.2	1.3	0.7	0.5	Edge of Water
1+88	-1.9	-1.3	-2.0	-2.3	-2.4	River Bottom
1+99	-2.2	-1.9	-2.4	-2.8	-2.0	River Bottom
2+19	-2.3	-2.4	-2.9	-3.3	-2.6	River Bottom
2+29	-2.5	-2.4	-3.1	-3.4	-3.0	River Bottom
2+40	-2.5	-2.4	-3.1	-3.5	-2.9	River Bottom
2+61	-2.4	-2.0	-2.8	-2.8	-2.5	River Bottom
2+75	-4.5	-2.0	-2.5	-5.5	-2.2	River Bottom
2+88	-4.1	-2.0	-2.3	-2.5	-2.0	River Bottom
2+96	-2.7	-1.3	-2.1	-2.5	-1.8	River Bottom
Varies	0.7	1.2	1.3	0.8	0.6	Edge of Water
3+69	7.0	7.3	7.4	7.0	7.2	Top of Bank
4+20	8.5	8.6	8.3	8.3	8.5	Ground Shot
4+70	8.1	8.0	7.9	8.2	8.3	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 20

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	13.8	13.8	13.8	13.7	13.7	Ground Shot
0+15	16.8	16.9	16.6	16.8	16.8	Grade Break
0+50	15.5	15.5	15.3	15.5	15.6	Ground Shot
1+13	11.4	11.7	11.7	11.5	11.6	Top of Bank
1+35	-	0.7	-	-	-	Toe of Bank
Varies	0.5	0.0	1.0	0.9	0.7	Edge of Water
1+63	-0.7	-0.8	-1.0	-	-1.0	River Bottom
1+99	-0.6	-1.3	-1.5	-1.0	-1.4	River Bottom
2+30	-0.8	-1.5	-1.6	-1.4	-1.3	River Bottom
2+50	-0.9	-1.3	-1.8	-1.2	-1.4	River Bottom
2+99	-1.3	-1.4	-1.6	-1.5	-1.6	River Bottom
3+30	-1.3	-1.1	-1.1	-0.8	-1.0	River Bottom
Varies	0.6	0.1	1.0	0.9	0.9	Edge of Water
3+64	-	1.1	1.08	0.9	-	Toe of Bank
3+93	6.6	6.9	6.9	6.7	7.0	Top of Bank
4+53	7.4	7.5	7.3	7.6	7.8	Ground Shot
5+03	7.5	7.6	7.3	7.6	7.8	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 21

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	*2013*	2016	2017	2018	2019	Description
0+00	24.6	24.5	24.54	24.6	24.6	Ground Shot
0+50	20.8	20.7	20.8	20.7	20.7	Ground Shot
1+02	9.5	9.4	9.4	9.4	9.5	Ground Shot
1+24	7.2	7.3	7.3	7.2	7.1	Top of Bank
1+34	-	1.8	1.5	1.2	-	Toe of Bank
Varies	0.5	1.2	1.0	1.1	0.8	Edge of Water
1+46	-1.0	-1.3	-1.5	-1.3	-1.6	River Bottom
1+58	-2.1	-2.4	-2.4	-2.3	-2.1	River Bottom
1+75	-2.1	-2.7	-2.7	-2.7	-2.5	River Bottom
2+00	-1.8	-2.3	-2.3	-2.3	-2.4	River Bottom
2+24	-1.6	-2.0	-2.0	-1.8	-1.8	River Bottom
2+50	-1.1	-1.1	-1.0	-0.8	-1.2	River Bottom
Varies	0.5	1.2	1.1	1.1	0.7	Edge of Water
3+41	3.3	2.9	2.5	2.3	1.8	Grade Break
3+64	4.2	4.7	4.7	4.7	4.7	Toe of Bank
3+79	8.6	8.7	8.7	8.7	8.8	Top of Bank
4+04	9.7	9.9	9.9	9.9	10.0	Grade Break
4+58	9.1	9.0	8.9	9.1	9.1	Ground Shot
5+08	8.7	8.7	8.6	8.8	9.0	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 22

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	26.0	26.0	26.07	26.1	26.1	Ground Shot
0+07	23.0	23.2	23.3	23.1	23.1	Ground Shot
0+60	24.0	24.1	23.9	24.0	24.1	Ground Shot
1+10	23.1	23.1	23.0	23.0	23.0	Top of Bank
1+36	2.6	2.5	2.1	2.2	2.4	Toe of Bank
Varies	0.6	0.3	1.2	1.1	0.8	Edge of Water
1+67	-1.1	-0.8	-1.1	-0.3	-0.6	River Bottom
2+00	-1.1	-1.5	-1.7	-1.9	-1.3	River Bottom
2+24	-1.6	-1.9	-2.0	-1.9	-2.0	River Bottom
2+50	-1.6	-1.8	-2.0	-1.2	-1.7	River Bottom
2+75	-1.4	-1.6	-1.5	-1.4	-1.4	River Bottom
3+01	-0.7	-1.2	-1.4	-1.2	-1.2	River Bottom
Varies	0.6	0.2	1.2	1.1	0.8	Edge of Water
3+61	4.4	4.3	4.3	5.3	5.2	Toe of Bank
3+68	8.6	8.7	8.7	8.7	8.8	Top of Bank
3+88	10.5	10.7	10.6	10.7	10.7	Ground Shot
4+27	9.1	9.1	9.2	8.8	8.8	Ground Shot
4+77	8.6	8.6	8.7	8.7	8.9	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 23

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	25.2	25.2	25.3	25.2	25.2	Ground Shot
0+50	25.1	25.1	25.2	25.1	25.1	Ground Shot
1+06	23.2	23.3	23.2	23.1	23.3	Top of Bank
1+34	3.2	3.4	2.8	3.1	3.2	Toe of Bank
Varies	0.5	0.5	1.4	1.2	0.8	Edge of Water
2+25	-1.1	-1.5	-1.5	-1.7	-1.7	River Bottom
2+51	-1.7	-1.7	-1.7	-1.4	-1.8	River Bottom
2+75	-1.7	-1.9	-1.7	-2.1	-2.1	River Bottom
3+00	-1.5	-2.3	-1.5	-1.8	-2.8	River Bottom
3+27	-1.2	-1.7	-1.7	-2.2	-2.6	River Bottom
Varies	0.7	0.4	1.4	1.3	0.8	Edge of Water
3+44	2.2	-	-	-	-	Grade Break (2013)
3+53	-	1.3	0.6	1.3	-	Toe of Bank
3+84	6.1	6.2	6.1	6.2	6.1	Edge of Vegetation
3+95	7.7	7.7	7.8	7.8	7.6	Top of Bank
4+50	7.9	7.8	7.9	7.8	7.8	Ground Shot
5+00	10.0	10.2	10.2	10.1	10.2	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 24

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2014	2015	2016	2017	2018	2019	Description
0+00	26.5	26.5	26.4	26.4	26.4	26.5	26.3	Ground Shot
0+50	27.0	27.0	27.0	26.9	27.0	27.0	26.8	Ground Shot
0+94	27.9	26.4	26.5	26.5	26.4	26.3	26.3	Ground Shot
1+13	25.3	23.6	23.8	23.6	23.5	23.3	23.3	Top of Bank
1+45	2.6	2.7	3.2	0.5	0.8	1.4	1.5	Toe of Bank
Varies	0.2	0.5	1.5	0.5	1.4	1.2	0.8	Edge of Water
2+26	-1.7	-1.2	-1.9	-2.6	-2.7	-2.6	-2.5	River Bottom
2+39	-2.4	-1.8	-2.6	-3.3	-2.8	-2.7	-2.9	River Bottom
2+48	-2.0	-2.2	-2.9	-2.9	-1.9	-3.2	-2.2	River Bottom
2+61	-2.1	-2.2	-2.6	-2.2	-1.8	-2.5	-1.7	River Bottom
2+74	-2.2	-2.3	-2.3	-2.1	-1.7	-2.5	-1.8	River Bottom
2+90	-3.0	-1.9	-2.1	-2.0	-2.0	-2.8	-1.8	River Bottom
3+00	-3.0	-1.9	-2.1	-2.2	-1.9	-2.4	-1.8	River Bottom
3+17	-2.6	-2.0	-2.2	-2.1	-2.3	-2.2	-1.7	River Bottom
Varies	0.3	0.2	1.5	0.6	1.4	1.3	0.7	Edge of Water
3+86	5.9	5.7	5.8	5.8	5.7	5.6	5.7	Edge of Vegetation
3+96	7.1	7.2	7.2	7.0	6.9	6.9	6.9	Top of Bank
4+65	8.7	8.5	8.3	8.2	8.4	8.2	8.0	Ground Shot
5+15	9.4	9.2	9.1	9.0	9.1	8.9	9.0	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 25

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE: 907-670-4739

DOC LCMF-156 REV7

STA	2013	2014	2015	2016	2017	2018	2019	Description
0+00	27.5	27.4	27.3	27.3	27.3	27.3	27.2	Ground Shot
0+50	26.4	26.2	26.2	26.1	26.0	26.1	26.0	Ground Shot
0+70	26.8	26.7	26.7	26.5	26.6	26.7	26.8	Grade Break
0+89	21.8	21.3	21.3	21.2	21.2	21.1	21.1	Grade Break
1+00	25.7	22.2	22.5	22.1	22.2	22.3	22.3	Top of Bank
1+29					1.8	1.7	3.3	Toe of Bank
1+31	2.8	2.8	2.7	1.3	-	-	-	Toe of Bank (2016)
Varies	0.6	0.3	1.4	0.4	1.0	1.3	2.2	Edge of Water
2+19	-2.6	-1.2	-3.4	-3.7	-3.0	-5.2	-3.9	River Bottom
2+38	-2.2	-1.6	-3.5	-3.5	-3.6	-4.0	-3.2	River Bottom
2+48	-2.2	-1.9	-3.5	-3.4	-3.2	-4.2	-2.8	River Bottom
2+61	-2.4	-2.9	-3.2	-3.1	-2.6	-3.3	-2.2	River Bottom
2+72	-2.8	-2.6	-2.8	-2.8	-2.1	-3.2	-2.0	River Bottom
2+89	-2.7	-2.1	-2.3	-2.1	-1.7	-2.8	-1.2	River Bottom
2+97	-2.6	-1.9	-2.1	-1.8	-1.7	-2.6	-1.6	River Bottom
3+07	-2.7	-2.0	-1.8	-1.9	-1.3	-2.2	-1.2	River Bottom
Varies	0.1	0.1	1.5	0.4	1.0	1.3	2.1	Edge of Water
3+51	2.5	2.5	-	-	-	-	-	Ground Shot (2014)
3+81	6.1	6.1	6.4	6.2	6.3	6.2	6.3	Edge of Vegetation
3+91	7.8	7.5	7.7	7.5	7.4	7.4	7.5	Top of Bank
4+53	8.5	8.3	8.1	8.2	8.2	8.3	8.0	Ground Shot
5+03	8.4	8.4	8.3	8.4	8.5	8.4	8.5	Ground Shot

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 33 of 47 Transect_25

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 26

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2014	2015	2016	2017	2018	2019	Description
0+00	24.0	27.5	27.3	27.3	27.3	27.3	27.2	Ground Shot
0+60	24.1	27.7	27.6	27.5	27.4	27.2	27.2	Ground Shot
0+85	24.0	27.3	27.5	27.3	27.2	27.2	27.4	Ground Shot
1+03	21.5	24.9	25.0	25.0	25.0	24.9	24.9	Top of Bank
1+36	2.7	2.4	3.1	1.8	1.9	1.9	2.4	Toe of Bank
Varies	0.4	0.2	1.5	0.5	1.0	1.4	1.5	Edge of Water
2+19	-2.5	0.2	-3.5	-3.5	-4.0	-3.0	-5.1	River Bottom
2+32	-2.6	-1.2	-3.5	-3.0	-4.4	-5.4	-5.0	River Bottom
2+43	-2.5	-2.1	-3.6	-1.7	-3.0	-4.0	-3.7	River Bottom
2+53	-2.4	-2.4	-3.6	-1.7	-2.6	-3.9	-3.8	River Bottom
2+63	-2.4	-2.6	-3.6	-2.1	-3.0	-4.2	-3.9	River Bottom
2+80	-2.3	-2.9	-2.8	-3.3	-2.6	-4.1	-3.8	River Bottom
2+91	-2.0	-2.9	-2.6	-4.0	-2.8	-3.9	-3.7	River Bottom
3+08	-2.2	-2.3	-2.2	-3.2	-1.7	-2.5	-3.0	River Bottom
Varies	0.2	0.0	1.4	0.5	0.9	1.4	1.5	Edge of Water
3+57	3.2	3.3		1.2	1.0	-	-	Ground Shot
3+89	6.1	6.6	7.0	6.6	6.6	6.5	6.7	Edge of Vegetation
3+97	7.1	7.5	7.7	7.2	7.6	7.5	7.3	Top of Bank
4+79	8.3	9.3	9.9	10.0	9.9	8.1	9.4	Ground Shot
5+29	9.8	9.8	9.5	9.4	9.4	9.4	9.5	Ground Shot
Station 4+79 falls in Slope of Gravel Road								

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 34 of 47 Transect_26

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 27

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2014	2015	2016	2017	2018	2019	Description
0+00	27.0	27.0	26.8	26.5	26.8	26.6	26.5	Ground Shot
0+50	27.1	27.1	27.0	27.0	27.1	26.7	26.8	Ground Shot
0+74	24.3	24.5	24.3	24.1	24.0	24.1	24.1	Grade Break
0+82	26.6	26.6	26.7	26.7	26.5	26.5	26.6	Grade Break
0+98	26.0	25.9	25.9	26.0	26.0	25.9	25.9	Top of Bank
1+30	2.5	2.1	2.5	2.2	2.3	2.3	2.3	Toe of Bank
Varies	0.1	0.3	1.5	0.5	1.0	1.3	1.7	Edge of Water
2+20	-2.4	-0.8	-1.4	-2.2	-1.6	-3.1	-2.8	River Bottom
2+31	-2.3	-1.0	-1.5	-1.6	-1.6	-3.3	-2.8	River Bottom
2+41	-3.3	-1.6	-2.1	-1.9	-1.8	-3.3	-3.0	River Bottom
2+48	-2.0	-1.7	-2.5	-2.3	-2.2	-3.3	-3.7	River Bottom
2+58	-2.7	-2.7	-3.0	-2.9	-2.7	-3.3	-3.8	River Bottom
2+65	-2.9	-2.7	-3.0	-3.2	-2.9	-3.0	-4.0	River Bottom
2+72	-3.1	-2.8	-3.0	-3.4	-2.8	-3.0	-4.0	River Bottom
2+78	-2.9	-2.8	-2.9	-3.3	-2.6	-3.0	-3.7	River Bottom
2+85	-2.5	-3.0	-2.9	-2.8	-2.3	-3.0	-3.2	River Bottom
2+92	-2.1	-2.6	-2.4	-2.5	-2.0	-3.0	-	River Bottom
Varies	-0.1	0.2	1.5	0.6	0.9	1.5	1.6	Edge of Water
3+39	1.9	2.0		1.3	1.4	-	-	Ground Shot
3+52	4.7	4.9	4.7	4.6	4.4	4.5	4.5	Ground Shot
3+76	5.9	6.1	6.2	6.3	6.2	6.2	6.2	Edge of Vegetation
3+89	7.0	7.2	7.2	7.1	7.0	7.2	6.9	Top of Bank
4+10	8.0	8.1	8.0	8.1	8.0	8.0	7.9	Ground Shot
4+71	8.0	8.0	7.8	7.7	7.4	7.3	7.2	Ground Shot
5+21	9.7	9.7	9.2	9.0	9.1	8.8	8.5	Ground Shot

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 35 of 47 Transect_27

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 28

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	21.0	20.8	21.0	20.9	20.9	Ground Shot
0+50	21.3	21.2	21.2	21.0	21.0	Ground Shot
0+83	21.5	21.4	21.4	21.4	21.5	Ground Shot
1+06	20.7	19.8	19.6	19.6	19.5	Top of Bank
1+31	1.0	0.6	0.8	2.0	2.0	Toe of Bank
Varies	0.0	0.8	0.9	1.2	1.6	Edge of Water
1+37	-3.0	-2.2	-3.1	-1.0	-	River Bottom
1+44	-4.2	-4.2	-4.3	-6.1	-5.1	River Bottom
1+51	-4.4	-4.0	-4.5	-6.1	-6.7	River Bottom
1+61	-4.0	-3.5	-3.9	-6.1	-6.0	River Bottom
1+75	-3.6	-3.1	-3.5	-4.8	-4.4	River Bottom
1+89	-3.4	-3.2	-3.4	-4.7	-4.1	River Bottom
1+99	-3.0	-3.0	-3.3	-4.5	-4.3	River Bottom
2+16	-3.2	-3.1	-3.2	-4.6	-4.1	River Bottom
2+33	-3.2	-4.8	-4.6	-6.4	-4.6	River Bottom
2+44	-2.6	-5.0	-4.9	-6.7	-5.7	River Bottom
Varies	0.1	0.9	1.0	1.3	1.8	Edge of Water
3+40	2.5	2.6	2.6	2.7	2.8	Ground Shot
3+65	5.7	5.8	5.7	5.8	5.7	Edge of Vegetation
3+81	7.6	8.0	7.7	7.9	7.9	Top of Bank
4+26	8.2	8.5	8.3	8.4	8.5	Ground Shot
4+81	8.4	8.4	8.6	8.4	8.4	Ground Shot
5+31	9.2	8.7	9.1	9.1	8.9	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 29

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	24.3	24.1	24.3	24.2	24.1	Ground Shot
0+50	23.6	23.7	23.7	23.7	23.6	Ground Shot
1+01	23.0	22.7	22.7	22.5	22.6	Top of Bank
1+27		0.7	0.9	2.2	2.6	Toe of Bank
Varies	0.2	0.1	0.9	1.4	1.8	Edge of Water
1+43	-8.1	-9.7	-9.4	-11.4	-10.5	River Bottom
1+89	-7.9	-8.5	-8.1	-8.7	-10.0	River Bottom
2+09	-5.2	-4.6	-4.4	-5.2	-6.2	River Bottom
2+24	-2.5	-2.7	-2.7	-2.9	-3.8	River Bottom
Varies	0.1	0.2	1.0	1.3	1.8	Edge of Water
2+82	2.6	2.8	2.8	3.0	3.1	Ground Shot
3+30	2.9	3.3	3.4	3.5	3.4	Ground Shot
3+88	5.8	6.0	6.0	6.0	6.0	Edge of Vegetation
4+01	8.0	8.4	8.2	8.2	8.2	Top of Bank
4+47	7.7	7.9	8.0	8.2	8.0	Ground Shot
4+85	8.4	8.6	8.8	8.5	8.5	Ground Shot
5+36	9.5	9.6	9.9	9.8	9.9	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 30

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	23.7	23.3	23.69	23.6	23.5	Ground Shot
0+50		23.2	23.2	23.2	23.2	Ground Shot
0+69	21.7	21.5	21.4	21.6	19.2	Top of Bank
0+79	19.3	19.1	19.0	13.4	-	Grade Break
1+00	6.0	6.0	6.1	5.3	6.1	Toe of Bank
1+16	4.4	4.3	4.3	4.3	4.4	Top of Bank
1+17	3.3	2.7	2.8	4.3	3.0	Toe of Bank
Varies	0.2	0.3	1.0	1.0	1.2	Edge of Water
1+63	-2.9	-1.2	-2.5	-4.3	-3.0	River Bottom
1+75	-4.0	-2.8	-3.4	-4.3	-4.3	River Bottom
1+87	-5.9	-4.3	-4.6	-5.7	-5.2	River Bottom
1+99	-5.8	-5.5	-5.0	-6.8	-6.2	River Bottom
2+12	-6.4	-5.2	-5.5	-7.0	-	River Bottom
2+26	-5.7	-4.5	-5.5	-6.8	-6.5	River Bottom
2+36	-5.3	-4.6	-5.4	-6.7	-6.1	River Bottom
2+48	-3.4	-4.0	-4.5	-5.4	-5.1	River Bottom
2+61	-2.7	-3.1	-4.2	-4.5	-4.5	River Bottom
2+73	-2.1	-2.2	-3.5	-3.0	-3.1	River Bottom
2+81	-2.8	-2.2	-2.5	-2.1	-2.4	River Bottom
Varies	-0.5	0.3	1.0	1.2	1.1	Edge of Water
3+84	4.3	4.3	4.3	5.1	4.3	Sand Bar
3+94	5.9	5.8	5.8	5.9	5.8	Grade Break
4+30	6.1	6.0	6.0	6.1	6.0	Edge of Vegetation
4+67	8.8	8.8	8.8	8.9	8.9	Grade Break
5+22	8.1	7.9	7.7	7.8	7.9	Grade Break
5+58	9.4	9.3	9.4	9.4	9.4	Grade Break/Edge of Veg
5+77	9.6	9.5	9.6	9.3	9.6	Ground Shot
6+27	10.1	9.6	10.1	9.7	9.9	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 31

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	8.6	8.3	8.6	8.4	8.6	Ground Shot
0+50	9.6	9.6	9.6	9.6	9.5	Ground Shot
1+06	8.1	8.3	8.2	8.3	8.3	Edge of Vegetation
1+29	8.4	8.3	8.2	8.3	8.3	Top of Bank
1+40	5.7	5.7	5.9	5.9	6.2	Toe of Bank
1+85	5.7	6.0	5.7	6.2	6.1	Ground Shot
2+37	6.0	6.2	6.0	6.2	6.2	Ground Shot
2+89	6.9	6.8	6.7	6.8	6.8	Ground Shot
3+16	7.7	7.8	7.7	7.8	7.8	Ground Shot
3+70	8.0	8.1	8.1	8.1	8.0	Top of Bank
3+80	6.7	6.8	6.6	6.8	6.8	Grade Break/Edge of Veg
4+06	3.8	3.9	3.8	3.9	3.7	Sand Bar
4+43	1.4	0.9	1.0	1.2	-	Grade Break
Vaies	-0.2	1.1	1.4	1.1	1.3	Edge of Water
4+71	-2.6	-1.3	-1.1	-0.9		River Bottom
4+81	-2.8	-1.9	-1.9	-2.8		River Bottom
4+92	-2.1	-2.0	-2.3	-3.0	-3.1	River Bottom
5+02	-2.1	-2.2	-2.5	-3.1	-3.1	River Bottom
5+10	-2.6	-2.3	-2.5	-3.8	-3.6	River Bottom
5+20	-2.3	-2.4	-2.4	-3.5	-3.5	River Bottom
5+29	-2.2	-1.8	-2.3	-3.3	-3.4	River Bottom
5+39	-2.1	-1.8	-1.8	-3.2	-3.3	River Bottom
5+50	-2.2	-1.6	-2.0	-3.3	-3.2	River Bottom
5+60	-2.1	-1.7	-2.0	-3.4	-3.2	River Bottom
5+70	-2.5	-1.7	-1.7	-3.1	-2.2	River Bottom
5+79	-2.2	-1.5	-0.9	-3.1	-	River Bottom
Vaies	0.0	1.1	1.4	0.9	1.2	Edge of Water
6+20	2.6	2.6	2.4	2.4	2.8	Toe of Bank
6+32	8.4	8.3	8.2	8.2	8.2	Top of Bank
6+83	9.2	9.1	9.1	9.2	9.1	Grade Break
7+31	10.9	11.0	10.9	11.1	11.1	Edge of Vegetation
7+54	11.2	11.2	11.3	11.2	11.4	Ground Shot
8+04	10.7	10.3	10.7	10.5	10.4	Ground Shot

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 39 of 47 Transect_31

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 32

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	8.4	8.1	8.1	8.3	8.2	Ground Shot
0+50	7.8	7.8	7.9	7.6	8.1	Ground Shot
0+96	7.0	6.7	6.9	7.1	7.3	Ground Shot
1+50	7.2	7.3	7.1	7.1	7.1	Ground Shot
2+00	7.4	7.4	7.4	7.5	7.5	Ground Shot
2+50	8.0	8.0	8.0	8.0	8.0	Ground Shot
3+12	6.8	6.8	6.7	6.6	6.7	Edge of Vegetation
3+32	6.4	6.4	6.3	6.3	6.4	Top of Bank
3+54		3.1	2.2	2.2	2.5	Ground Shot
3+68		1.1	-	-	1.5	Ground Shot
Varies	0.1	0.9	1.4	1.0	1.3	Edge of Water
4+07	-0.8	-1.7	-1.6	-0.6	-2.3	River Bottom
4+16	-2.7	-1.7	-3.0	-1.4	-2.3	River Bottom
4+26	-2.5	-2.5	-2.9	-3.4	-2.3	River Bottom
4+36	-3.9	-4.1	-5.1	-7.1	-5.1	River Bottom
4+47	-5.4	-6.3	-6.7	-8.3	-6.2	River Bottom
4+57	-6.6	-6.9	-6.9	-7.6	-6.9	River Bottom
4+68	-7.0	-7.0	-6.0	-6.1	-8.2	River Bottom
4+79	-6.1	-5.8	-4.5	-3.3	-7.2	River Bottom
Varies	-0.4	0.9	1.4	0.9	1.3	Edge of Water
5+10	8.5	8.4	8.3	8.3	8.2	Top of Bank
5+40	10.4	10.3	10.4	10.4	10.5	Ground Shot
5+79	10.2	10.2	10.2	10.3	10.2	Ground Shot
6+21	11.5	11.5	11.5	11.4	11.4	Ground Shot
6+71	10.8	10.5	10.8	10.5	10.6	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 33

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE: 907-670-4739

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	9.9	9.8	9.8	9.9	9.6	Ground Shot
0+50	8.6	8.6	8.6	8.5	8.6	Ground Shot
1+03	8.5	8.7	8.7	8.7	8.8	Edge of Vegetation
1+52	10.6	10.7	10.6	10.7	10.7	Grade Break
2+00	9.9	10.0	10.0	10.1	10.1	Ground Shot
2+57	7.9	7.8	7.8	7.9	7.9	Top of Bank
2+67	6.9	6.9	7.0	7.0	7.0	Edge of Vegetation
2+78	5.4	5.3	5.4	5.4	5.5	Sand Bar
2+87	3.5	3.2	3.2	3.2	3.2	Grade Break
Varies	0.0	0.5	1.5	0.7	1.5	Edge of Water
3+81	-3.2	-1.5	-1.1	-2.3	-2.5	River Bottom
4+04	-2.2	-2.3	-2.4	-2.5	-3.3	River Bottom
4+18	-3.5	-3.1	-3.4	-3.7	-4.7	River Bottom
4+38	-4.4	-7.5	-6.9	-6.8	-7.0	River Bottom
4+59	-3.1	-4.2	-2.7	-7.2	-7.4	River Bottom
Varies	-0.1	0.2	1.4	0.8	1.6	Edge of Water
4+99	9.1	8.9	8.9	9.0	8.9	Top of Bank
5+53	9.7	9.8	9.7	10.0	9.8	Edge of Vegetation
6+02	10.1	10.3	10.2	10.4	10.4	Ground Shot
6+41	10.5	10.6	10.6	10.3	10.6	Ground Shot
7+11	10.7	10.3	10.4	10.7	10.5	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 34

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	12.6	12.4	12.3	12.4	12.5	Ground Shot
0+50	12.6	12.5	12.5	12.6	12.5	Ground Shot
1+00	10.3	10.1	10.1	10.2	10.2	Ground Shot
1+50	9.2	9.2	9.2	9.3	9.2	Ground Shot
2+12	8.1	8.0	7.9	7.8	7.6	Top of Bank
2+15	3.5	1.9	2.0	1.8	3.1	Toe of Bank
Varies	-0.3	0.6	1.6	0.8	1.4	Edge of Water
2+30	-4.6	-3.7	-4.3	-4.5	-4.4	River Bottom
2+37	-7.2	-4.3	-5.9	-4.9	-5.8	River Bottom
2+48	-7.3	-5.8	-6.4	-7.1	-7.9	River Bottom
2+58	-6.9	-5.8	-6.3	-7.7	-7.9	River Bottom
2+72	-6.7	-6.0	-5.4	-7.4	-7.5	River Bottom
2+82	-3.2	-5.4	-5.0	-6.8	-6.8	River Bottom
2+96	-2.2	-3.1	-2.3	-5.4	-3.9	River Bottom
3+06	-1.9	-2.1	-0.8	-3.4	-2.3	River Bottom
Varies	0.1	0.3	1.6	0.7	1.4	Edge of Water
3+66	4.5	4.6	4.7	4.6	4.6	Grade Break
3+94	5.6	5.6	5.6	5.6	5.6	Sand Bar
4+29	7.1	7.1	7.1	7.2	7.1	Edge of Vegetation
4+39	8.4	8.5	8.4	8.4	8.5	Top of Bank
4+50	8.6	8.6	8.6	8.6	8.6	Ground Shot
5+00	9.0	9.0	8.9	9.0	8.9	Ground Shot
5+50	7.4	7.6	7.7	8.1	8.0	Ground Shot
6+00	9.7	9.7	9.6	9.7	9.7	Ground Shot
6+30	10.1	10.2	10.2	10.3	10.3	Edge of Vegetation
6+64	9.9	9.7	9.7	9.7	9.7	Ground Shot
7+00	10.6	10.6	10.5	10.4	10.9	Ground Shot
7+50	10.1	9.9	9.9	9.9	10.1	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 35

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2016	2017	2018	2019	Description
0+00	12.6	12.5	12.5	12.4	12.4	Ground Shot
0+50	13.0	12.9	12.9	12.9	12.9	Ground Shot
1+00	11.2	11.3	11.4	11.3	11.3	Ground Shot
1+11	11.4	11.4	11.2	11.3	11.3	Grade Break
1+25	9.4	9.4	9.6	9.4	9.6	Grade Break
1+65	10.3	10.4	10.4	10.4	10.3	Grade Break
1+81	8.1	8.1	8.0	8.0	8.3	Grade Break
2+27	9.3	9.4	9.4	9.5	9.4	Grade Break
2+51	10.4	10.5	10.4	10.2	10.7	Grade Break
2+72	8.2	8.3	8.4	8.5	8.5	Grade Break
3+15	8.0	7.7	7.8	8.0	7.9	Grade Break
3+59	6.9	6.8	6.8	6.9	6.8	Edge of Vegetation
3+79	6.6	6.6	6.6	6.6	6.5	Top of Bank
3+92	3.5	3.4	3.4	3.4	3.4	Sand Bar
Varies	-0.1	0.1	1.7	0.8	1.4	Edge of Water
4+60	-2.3	-2.2	-2.4	-2.6	-2.5	River Bottom
4+86	-4.6	-3.9	-5.0	-4.6	-5.0	River Bottom
5+09	-5.1	-4.2	-4.2	-6.5	-5.8	River Bottom
5+26	-2.0	-3.3	-1.3	-4.1	-4.3	River Bottom
Varies	-0.2	0.0	1.7	0.8	1.1	Edge of Water
5+47	0.2	0.2	-	1.2	2.7	Toe of Bank
5+58	7.6	7.4	7.4	7.3	6.8	Top of Bank
5+72	9.7	9.7	9.7	9.8	9.8	Grade Break
5+86	9.2	9.3	9.3	9.4	9.4	Edge of Vegetation
6+28	9.4	9.3	9.3	9.4	9.2	Ground Shot
6+69	9.5	9.2	9.2	9.2	9.6	Ground Shot
7+19	10.3	10.1	10.1	10.1	10.1	Ground Shot

E.3.4 LAKE L9341 BRIDGE TABULATED DATA (TRANSECTS 36 – 39)

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 36

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2014	2015	2016	2017	2018	2019	Description
0+00	8.3	8.4	8.2	7.9	7.9	7.9	8.0	Ground Shot
0+50	8.0	8.2	8.0	7.9	7.8	7.8	7.8	Ground Shot
0+81	7.2	7.3	7.4	7.4	7.3	7.2	7.3	Ground Shot
1+17	7.2	7.2	7.2	7.1	7.1	6.9	6.4	Top of Bank
1+23	6.3	6.5	6.5	6.6	6.4	6.2	-	Edge of Vegetation
Varies	4.6	4.6	4.6	3.4	3.9	3.6	4.1	Edge of Water
1+52	4.0	2.0	4.4	3.4	3.7	3.5	-3.7	River Bottom
1+89	0.8	1.5	2.1	0.7	-0.5	0.8	-0.5	River Bottom
2+20	-0.9	1.0	0.0	0.1	-0.6	-3.4	-0.9	River Bottom
2+48	-1.7	-0.9	-1.8	-1.0	-1.9	-4.2	-2.1	River Bottom
2+95	-3.0	-2.8	-3.2	-2.9	-3.2	-3.0	-2.1	River Bottom
3+49	-2.1	-1.5	-1.5	-1.2	-1.2	-4.0	-3.1	River Bottom
3+78	1.7	1.5	2.5	1.7	1.0	1.3	-2.0	River Bottom
3+90	2.5	2.2	4.1	3.0	2.7	2.1	1.2	River Bottom
Varies	4.8	4.7	4.8	3.5	4.0	3.7	4.3	Edge of Water
4+06	8.6	8.6	8.7	8.5	8.4	8.3	8.4	Top of Bank
5+03	9.5	9.6	9.5	9.4	9.4	9.3	9.3	Ground Shot

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 44 of 47 Transect_36

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 37

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2014	2015	2016	2017	2018	2019	Description
0+00	8.0	8.1	8.5	8.3	8.3	8.3	8.4	Ground Shot
0+50	8.3	8.5	8.3	8.2	8.2	8.1	8.2	Ground Shot
0+92	7.0	7.1	7.2	7.3	7.1	6.9	7.1	Top of Bank
1+03	6.5	6.6	6.6	6.7	6.5	6.4	6.6	Edge of Vegetation
Varies	4.6	4.5	4.6	3.5	4.0	3.6	4.3	Edge of Water
1+59	2.2	1.7	3.1	3.0	2.2	1.9	2.2	River Bottom
2+01	0.5	1.1	0.0	1.1	0.7	-1.4	0.2	River Bottom
2+48	-2.4	-2.5	-1.4	-2.0	-2.8	-3.6	-2.7	River Bottom
2+99	-2.9	-2.5	-2.6	-2.6	-2.9	-3.0	-3.3	River Bottom
3+45	-1.6	-1.3	-1.3	-1.3	-1.7	-3.9	-2.2	River Bottom
3+84	2.1	1.4	3.0	2.5	1.6	1.7	1.9	River Bottom
Varies	4.6	4.7	4.8	3.5	4.1	3.6	4.2	Edge of Water
4+04	9.1	9.1	9.1	9.0	8.8	8.6	8.8	Top of Bank
4+49	8.8	8.9	8.8	8.7	8.7	8.7	8.7	Ground Shot
4+99	9.5	9.6	9.5	9.4	9.5	9.2	9.3	Ground Shot

Doc LCMF-156 CD5 Bridge Transects Rev7.xlsx 45 of 47 Transect_37

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 38

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2014	2015	2016	2017	2018	2019	Description
0+00	8.1	8.4	7.8	7.7	7.1	7.5	7.3	Ground Shot
0+50	7.9	8.3	8.0	7.8	7.7	7.8	7.5	Ground Shot
0+81	7.3	7.3	7.4	7.2	7.1	6.9	7.0	Ground Shot
1+22	6.1	6.4	6.3	6.3	6.1	6.1	6.2	Edge of Vegetation
Varies	4.6	4.5	4.6	3.5	4.0	3.6	4.2	Edge of Water
1+94	1.4	1.6	2.4	2.1	0.9	1.0	0.9	River Bottom
2+46	0.4	0.4	0.0	-0.2	-0.5	-0.5	-0.1	River Bottom
2+96	-2.6	-2.2	-1.6	-2.4	-2.7	-2.5	-2.4	River Bottom
3+47	-2.8	-2.5	-3.2	-3.0	-3.0	-3.0	-3.1	River Bottom
3+95	0.8	1.5	1.0	0.8	0.4	0.4	0.4	River Bottom
Varies	4.7	3.7	5.0	3.6	4.0	3.7	4.3	Edge of Water
4+31	9.3	9.3	9.3	9.1	8.9	8.8	8.9	Top of Bank
4+79	9.0	9.1	9.0	8.9	8.9	8.6	8.9	Ground Shot
5+29	9.2	9.3	9.3	9.2	9.0	9.0	9.1	Ground Shot

Calc'd By: MB
Date: 8/20/19
RPT-CE-CD-114 REV7

CD-5 Michael Baker
Bridge Transects
Transect 39

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV7

STA	2013	2014	2015	2016	2017	2018	2019	Description
0+00	8.5	8.8	8.6	8.4	8.2	8.2	8.0	Ground Shot
0+50	7.6	7.8	7.7	7.5	7.1	7.3	7.0	Ground Shot
0+79	6.7	7.0	6.9	6.9	6.9	6.7	6.4	Top of Bank
0+89	5.8	6.0	5.8	5.9	5.7	5.5	-	Edge of Vegetation
Varies	4.4	4.5	4.5	3.4	4.0	3.8	4.3	Edge of Water
1+27	1.3	1.2	2.6	1.9	0.6	1.1	1.2	River Bottom
1+54	0.1	0.7	0.6	0.6	-0.1	-0.1	-0.3	River Bottom
2+01	-1.2	-0.8	-1.1	-1.4	-1.5	-1.3	-1.5	River Bottom
2+47	-1.7	-1.7	-2.0	-1.7	-2.4	-2.6	-1.9	River Bottom
3+01	-3.0	-2.5	-3.2	-3.1	-3.1	-3.3	-3.1	River Bottom
3+55	-0.3	1.5	-0.4	-0.3	-0.8	-1.0	0.2	River Bottom
3+71	1.8	2.6	1.7	1.5	1.6	1.6	-	River Bottom
Varies	4.6	4.3	4.8	3.4	3.9	3.7	4.2	Edge of Water
4+03	9.3	9.5	9.5	9.4	9.2	9.1	9.2	Top of Bank
4+43	9.4	9.5	9.5	9.2	9.1	9.1	9.2	Ground Shot
4+93	9.6	9.7	9.5	9.3	9.3	9.3	9.2	Ground Shot

2019 Colville River Delta Spring Breakup Monitoring & Hydrological Assessment