2014 Colville River Delta Spring Breakup

Monitoring and Hydrological Assessment

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CONTENTS

FIGURES

TABLES

GRAPHS

PHOTOS

APPENDIX C PHOTOS

ACRONYMS AND ABBREVIATIONS

2D	Two-dimensional
ADF&G	Alaska Department of Fish and Game
ADCP	Acoustic Doppler Current Profiler
Baker	Michael Baker Jr., Inc.
BPMSL	British Petroleum Mean Sea Level
CPAI	ConocoPhillips Alaska, Inc.
CD	Colville Delta
cfs	cubic feet per second
CRD	Colville River Delta
E	Colville East Channel
fps	feet per second
ft	feet
ft/s	feet per second
ft^2	square feet
$(ft/s)^2$	square feet per second
DGPS	Differential global positioning system
GPS	Global positioning system
HDD	Horizontal directional drill
HWM	High water mark
LCMF	UMIAQ LLC (LCMF)
MON	Monument
N	Nigliq Channel
NAD83	North American Datum of 1983
OSW	U.S. Geological Survey, Office of Surface Water
PT	pressure transducer
RM	river mile
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WSE	Water surface elevation

1.0 INTRODUCTION

The Colville River Delta Spring Breakup Hydrologic Assessment supports the ConocoPhillips Alaska, Inc. (CPAI) Alpine Development Project. The Alpine facilities are operated by CPAI and owned by CPAI and Anadarko Petroleum Company. Alpine facilities include the Colville Delta (CD) 1 processing facility (Alpine) and the CD2, CD3, CD4, and CD5 pads, access roads, and pipelines.

Spring breakup monitoring activities have been conducted in the Colville River Delta (CRD) since 1992. The program was expanded to include additional Alpine facilities in 2004 and the CD5 development area in 2009. The 2014 hydrologic field program is the 23rd consecutive year of CRD spring breakup investigations.

The field program took place from May 1 to June 10, 2014. Field personnel set up and rehabilitated the monitoring gages between May 2 and May 14. Monitoring began on May 10 and concluded on June 9, 2014. Primary field tasks were documentation of the distribution of floodwater and the measurement of water levels and discharge quantities. Observations of lake recharge, ice jams, ice road crossing degradation, and post-breakup floodwater effects were collected. Hydrologic observations were documented at the Colville East Channel, Nigliq Channel, Alpine facilities and roads, CD3 pipeline crossings, and the CD2 and CD5 bridges.

Observations of the hydraulic effects of winter ice roads across the Colville East Channel near the Alpine pipeline horizontal directionally drilled (HDD) crossing, Nigliq Channel, Nigliagvik Channel, and the Kachemach River were documented. Additional ice road crossings also observed during breakup included No Name Creek, Pineapple Gulch, Silas Slough, Slemp Slough, Tamayayak Channel, and Toolbox Creek. Observations were also documented at the construction ice pads for the CD5 crossings at the Nigliq Channel, Nigliagvik Channel, and lakes L9323 and L9341.

UMIAQ, LLC (LCMF), CPAI Alpine Field Environmental Coordinators, North Slope Environmental Field Studies Coordinators, and Alpine Helicopter Coordinators, and Pathfinder Aviation provided support during the 2014 CRD spring breakup field work and contributed to a safe and productive monitoring season.

1.1 MONITORING OBJECTIVES

The primary objective of the CRD spring breakup monitoring and hydrologic assessment is to estimate the magnitude of flooding in the CRD and its effect on Alpine facilities.

Monitoring data is collected and used to evaluate the effect of breakup flooding events and associated ice on Alpine roads, pads, and pipelines. Flood stage, discharge data, and observations are also used to validate design parameters of existing infrastructure and for planning and design of proposed infrastructure. Flood data collection supports refinement of the CRD flood frequency analysis, 2-D surface water model, and stage frequency analyses.

CRD spring breakup monitoring is also conducted to satisfy permit requirements. Permit stipulations of the U.S. Army Corps of Engineers (USACE) Permit No. POA-2004-253-2 and the State of Alaska, Department of Natural Resources, Office of Habitat Management and Permitting, Fish Habitat Permit FH04-III-0238 require monitoring the Alpine facilities during spring breakup. Permit requirements include direct measurements and indirect calculations of discharge through drainage structures and documentation of pad and access road erosion caused by spring breakup flooding. USACE Permit No. POA-2005-1576 has similar requirements for breakup monitoring along the CD5 road and bridges. It also required submittal of a *Monitoring Plan with an Adaptive Management Strategy* (Baker and ABR 2013), and documenting annual hydrologic conditions including channel sedimentation and erosion, and performance of culverts and bridges for the CD5 development.

Culvert inlets and outlets are surveyed annually by LCMF to compare structure elevations on either side of the road to satisfy Alaska Department of Fish and Game (ADF&G) permit FH04-III-0238. Observations on functionality and flooding effects to the swale bridges are recorded to satisfy ADF&G permit FG97-III-0260.

ADF&G permits FG99-III-0051-Amendment #7 and FG97-III-0190-Amendment #5 require monitoring of recharge to Lakes L9312 and L9313. The Alpine facilities rely on water withdrawal from these lakes for daily operations; the volume of which is dictated in part by annual spring recharge.

1.2 2014 Monitoring Locations

A network of established staff gages (Photo 1.1 is an example) is used to monitor flood stage. Most monitoring locations are adjacent to major hydrologic features. A location is selected based on topography, importance to the historical record, and its proximity and hydraulic significance to existing or proposed facilities, temporary infrastructure (Photo 1.2).

Photo 1.1: Surveying and reinstalling gages at MON35, Helmericks Homestead, looking east; June 7, 2014

The 2014 monitoring locations are similar to those studied in 2013 (Baker 2013a). The CRD drainage basin delineation is shown in Figure 1.1. Figure 1.2 shows the CRD monitoring locations, and monitoring locations specific to the Alpine facilities are shown in Figure 1.3. The monitoring locations, including type of monitoring, are listed in Table 1.1. Vertical control and gage latitude/longitude locations are provided in Appendix A: A.1, 2014 Gage Locations and A.2, 2014 Vertical Control.

Locations are identified in river miles (RM) with RM 0 indicating the mouth of the Colville River at Harrison Bay. The termini of the Colville East and Nigliq Channels of the Colville River is at Harrison Bay. From Harrison Bay, the RM increase moving upstream. Measurements are identified along the Colville East Channel (E) and Nigliq Channel (N). RM locations in this report are based on the following assumptions: MON35 is located at RM E3.0 (East Channel River Mile 3.0) and MON28 is located at RM N0.8 (Nigliq Channel River Mile 0.8).

Photo 1.2: Setting up and chalking gages at the Sakoonang Channel adjacent to the pipeline bridge, looking southwest; May 5, 2014

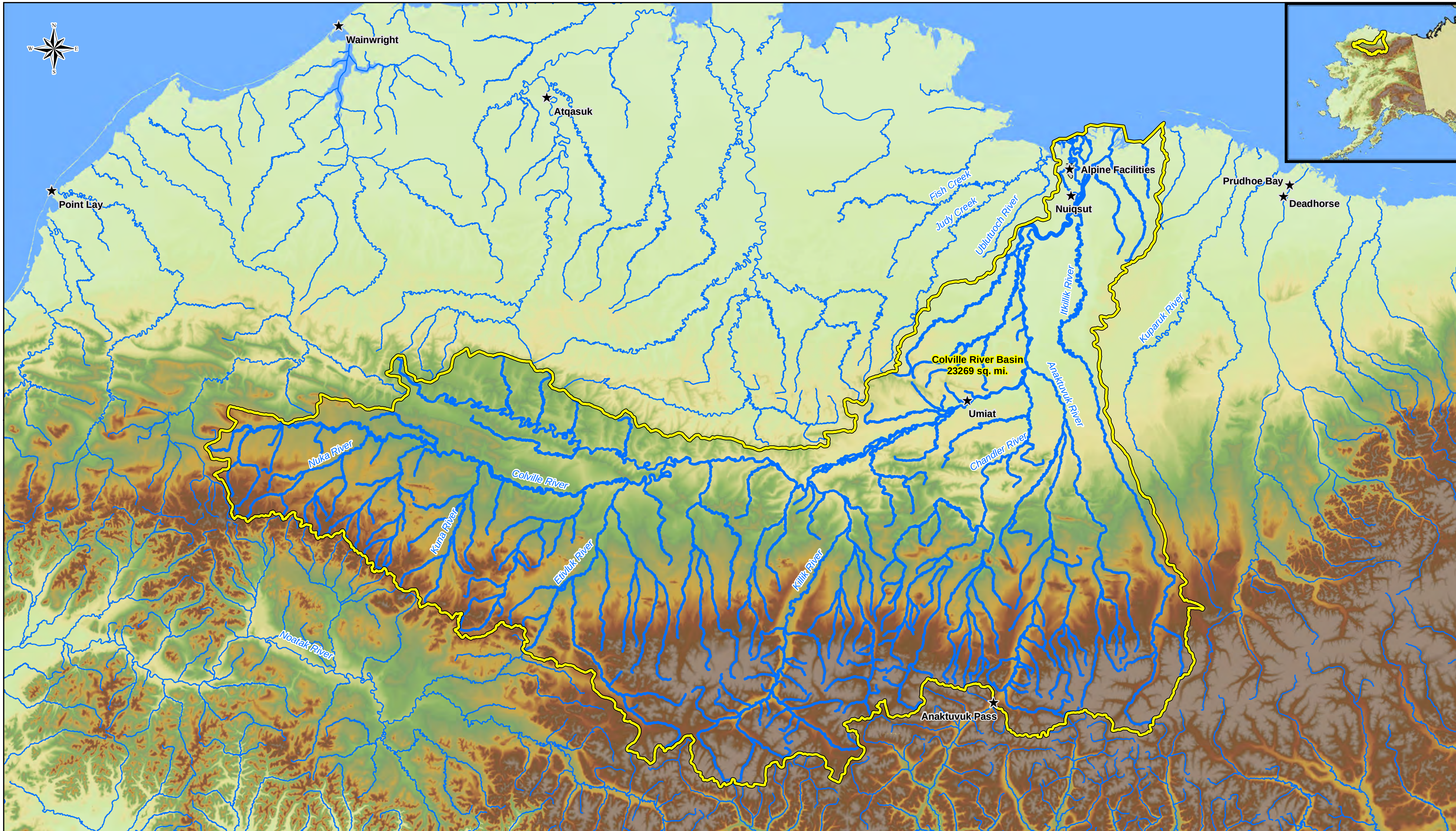
Water surface elevation (WSE) measurements were collected:

- Around Alpine pads and facilities
- Along access roads and pipelines
- At other locations, including drinking water lakes and ice road crossings

Discharge was measured:

- At Alpine facility culverts and bridges
- On the Colville River near Monument 1 (MON1)
- On the Nigliq Channel at the bridge
- At the Nigliagvik Channel Bridge

Culverts were monitored on the CD2, CD4, and CD5 roads throughout spring breakup.



ConocoPhillips Alaska

0 12.5 25 50 Miles

Date:	09/29/2014	Project:	141450
Drawn:	MEA	File:	Figure 1.1
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Legend

★ Place Name

Stream

Colville River Basin

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2014 SPRING BREAKUP
COLVILLE RIVER

Drainage Basin

FIGURE: 1.1

(SHEET 1 of 1)

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Miles
0 1 2

Date: 11/11/2014	Project: 141450
Drawn: MEA	File: Figure 1.2
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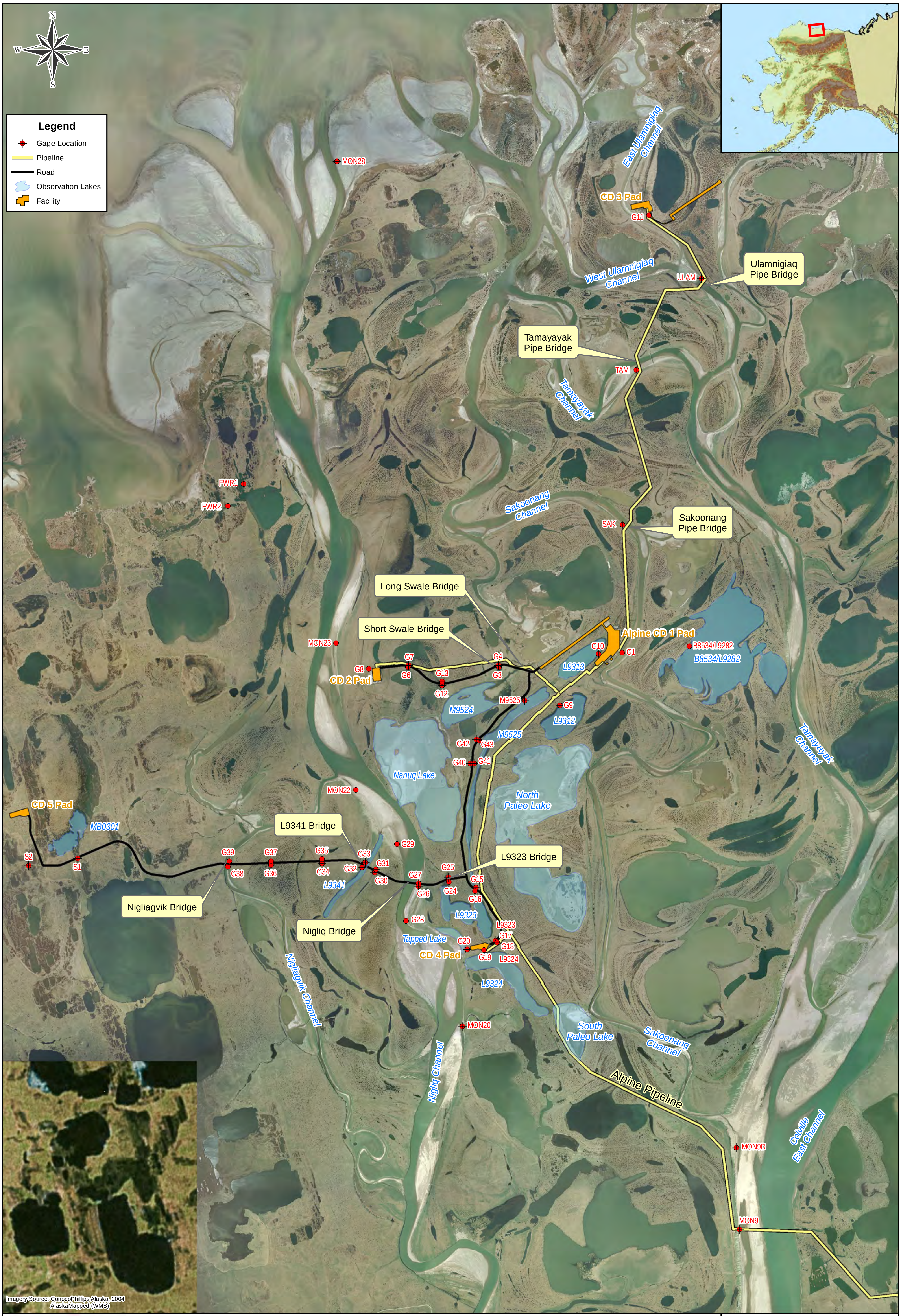
2014 SPRING BREAKUP
COLVILLE RIVER DELTA

Monitoring Locations

FIGURE: 1.2

(SHEET 1 of 1)



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Date: 11/11/2014	Project: 141450		
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2014 SPRING BREAKUP
ALPINE AREA FACILITIES

Monitoring Locations

FIGURE: 1.3

(SHEET 1 of 1)

Table 1.1: 2014 Monitoring Locations

Monitoring Locations		
Gage Name	**Type**	**Location**
Colville River Upstream of Bifurcation		
MON1U	Staff Gage/PT	Colville River flow confined to a single channel
MON1C	Staff Gage/PT Direct Discharge	Colville River flow confined to a single channel
MON1D	Staff Gage/PT	Colville River flow confined to a single channel
Colville River East Channel		
MON9	Staff Gage/PT	HDD crossing
MON9D	Staff Gage/PT	Downstream of the HDD crossing
MON35	Staff Gage	Helmericks Homestead
Nigliq Channel		
MON20	Staff Gage/PT	South of CD4
G28/G29	Staff Gage/PT	East bank south of crossing /west bank north of crossing, Nigliq Channel
G26/G27	Staff Gage/PT	East bank, Nigliq Channel adjacent to crossing - formerly known as G21 (2009-2011)
MON22	Staff Gage/PT	South of CD2
MON23	Staff Gage/PT	North of CD2
MON28	Staff Gage/PT	At Harrison Bay
Alpine Facilities and Roads		
CD1 Pad		
G1	Staff Gage/PT	CD1 betweeen pad and Sakoonang Channel
G9	Staff Gage	Lake L9312 northwest side
G10	Staff Gage	Lake L9313
CD2 Road and Pad		
G3/G4	Staff Gage/PT	CD2 access road, swale bridge vicinity
G12/G13	Staff Gage	CD2 access road
G6/G7	Staff Gage	CD2 access road
G8	Staff Gage	CD2 between pad and Nigliq Channel
CD3 Pad		
G11	Staff Gage	CD3 pad area
CD4 Road and Pad		
G42/G43	Staff Gage	CD4 access road
G40/G41	Staff Gage	CD4 access road
G15/G16	Staff Gage	CD4 access road
G17/G18	Staff Gage	CD4 access road
G19	Staff Gage	CD4 between southeast corner of pad and Lake L9324
G20	Staff Gage	CD4 between west end of pad and Nigliq Channel
CD5 Road		
G24/G25	Staff Gage/PT	Lake L9323
G30/G31	Staff Gage	CD5 access road
G32/G33	Staff Gage/PT	Lake L9341 - formerly known as G22 (2009-2011)
G34/G35	Staff Gage	CD5 access road
G36/G37	Staff Gage	CD5 access road
G38/G39	Staff Gage/PT	West bank, Nigliagvik - formerly known as G23 (2009-2011)
S1	Staff Gage	South of Lake MB0301 and CD5 Road
S2	Staff Gage	Southwest of CD5 access road and pad
CD3 Pipeline Stream Crossings		
SAK	Staff Gage/PT	Sakoonang (Pipe Bridge #2)
TAM	Staff Gage/PT	Tamayayak (Pipe Bridge #4)
ULAM	Staff Gage/PT	Ulamnigiaq (Pipe Bridge #5)
Downstream Nigliq Channel		
FWR1	Staff Gage/PT	Small drainage in the western Nigliq overbank area
FWR2	Staff Gage/PT	Small drainage in the western Nigliq overbank area
CD2 Road Bridges		
62-foot bridge	Direct Discharge	Along CD2 access road
452-foot bridge	Direct Discharge	Along CD2 access road
CD5 Road Bridges		
L9323 Bridge	Visual Survey	Along CD5 access road
Nigliq Channel Bridge	Direct Discharge	Along CD5 access road
L9341 Bridge	Visual Survey	Along CD5 access road
Nigliagvik Channel Bridge	Direct Discharge	Along CD5 access road
Road Culverts		
CD2 Road	Direct Discharge	26 culverts
CD4 Road	Direct Discharge	38 culverts
CD5 Road	Direct Discharge	43 culverts
Alpine Roads Erosion Survey		
CD2 Access Road	Visual	Access road from CD1 to CD2
CD4 Access Road		Access road from CD1 to CD4
CD5 Access Road		Access road from CD4 road to CD5
Ice Road Crossings		
Colville East Channel	Visual Survey	North of HDD
Kachemach River		South of pipeline crossing to 2L Pad - Kuparuk
Nigliagvik Channel		West of Nigliq Exploration Crossing
Nigliq Channel		West of B8531/L9326
No Name Creek		East of HDD between lakes M9602 and M9605
Pineapple Gulch		North of CD3 along bifurcation of Ulamnigiaq Channel
Silas Slough		West of CD4 on south end of Tapped Lake
Slemp Slough		West of CD3 and Tamayayak Bridge
Tamayayak		West of CD3 and Tamayayak Bridge
Toolbox Creek		Swale connecting Nigliq Channel and M9934, south of CD4

Note:
PT - Pressure Transducer

2.0 METHODS

2.1 VISUAL OBSERVATIONS

Breakup is monitored upstream of MON1 to track air temperatures and the progression of floodwaters before they reach the CRD. U.S. Geological Survey (USGS) gage readings and webcam photos on the Colville River at Umiat are observed daily prior to and during breakup monitoring. Helicopter overflights are also made upstream of MON1 to Ocean Point and the Anaktuvuk River to track the progression of the floodwaters.

Field data collection and observations of breakup progression, flow 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). The latitude and longitude, date, and time are imprinted onto each photo. The photo location is based on the World Geodetic System of 1984 datum.

Photo 2.1: Lake M9525 gage reading, looking northeast; May 18, 2014

2.2 WATER SURFACE ELEVATION

Stage or WSE data was collected using staff gages and pressure transducers (PT). Site visits were performed daily or as conditions allowed. The word stage and the acronym WSE can be used interchangeably.

2.2.1 STAFF GAGES

Staff gages are designed to measure floodwater levels. They are located as shown on Figure 1.2 and Figure 1.3. Extreme stage, erosion, and ice effects during breakup can require re-installation, rehabilitation, and re-survey of the gages and was performed as needed in the early spring before breakup and in the fall. At each site visit, chalk was applied to the angle iron gage supports. Subsequent high water marks (HWMs) were recorded when floodwaters removed the chalk. Peak WSE are sometimes captured as HWMs.

Two types of gages are used:

1) Some gages correlate to British Petroleum Mean Sea Level (BPMSL) elevation and were surveyed prior to breakup in May 2014 by LCMF. The pre-breakup survey is used to determine if correction factors must be applied to adjust elevation during flooding conditions. Adjustments are made annually by LCMF 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 or attached to pipeline vertical support members.

2) Some gages do not directly correspond to a BPMSL elevation. The gages are surveyed relative to a known benchmark elevation to determine a correction factor. The correction factor is based on survey tie-in to local control and applied to the gage reading to obtain the elevation in feet BPMSL.

Gage sets consist of one or more gage assemblies positioned along stream channels and lakes at locations throughout the CRD. Each gage in a set 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 100th of a foot between 0.00 to 3.33 feet.

The number of gage assemblies per set depends on site specific conditions, primarily slope of the channel bank and overbank. In locations where terrain elevation varied by more than three feet or where the loss of gages from ice impacts was considered to be likely, multiple gages were installed linearly from the edge of the low water channel up to the overbank (Photo 2.2). The elevations overlapped by approximately one foot. Individual gage assemblies were identified with alphabetical designations beginning with A representing the location nearest to the stream centerline.

Photo 2.2: MON9D gage setup; May 17, 2014

2.2.2 PRESSURE TRANSDUCERS

PTs are used at many gage locations. PTs provide a WSE measurement by sensing the absolute pressure of the atmosphere and water, allowing the depth of water above the sensor to be calculated. The PT is at a known elevation and by adding the depth of water, a WSE measurement is recorded.

PTs supplement gage measurements and are used to validate and adjust data. Each PT consists of an unvented pressure sensor designed to collect and store pressure and temperature data at discrete pre-set intervals. For 2014, the PTs were programmed to collect gage pressure and water temperature at 15-minute intervals from May 10 to July 15, 2014. Both In-Situ® Level TROLL® 500 PTs and Solinst® Levelogger® Model 3001 PTs were used during the 2014 monitoring program. Each PT was housed in a small perforated galvanized steel pipe and clamped to the angle iron or the base of the gage assembly nearest to the bed of the active channel (Photo 2.3).

Secondary PTs were installed at some monitoring locations to validate and backup the primary PT data. During post-processing, the secondary PT was used for QA/QC of the primary PT data. The redundancy assures data is available for sites where discharge measurements are calculated. Appendix A contains PT locations and elevations (A.1 and A.2) and details regarding setup and testing (A.3). Table 1.1 indicates monitoring locations with PT installations.

Photo 2.3: Pressure transducer setup; May 2, 2014

2.3 Peak Discharge

2.3.1 Direct Measurements

Direct discharge measurements were collected, as close to the observed peak stage as possible, at the following locations:

- Colville River MON1 (Photo 2.4)
- Culverts along the CD2 and CD4 roads
- Long and Short Swale Bridges along the CD2 Road
- Nigliq Channel Bridge
- Nigliagvik Channel Bridge (Photo 2.5)

Discharge was measured at MON1 and on the Nigliq Channel using an acoustic doppler current profiler (ADCP). Discharge was measured at the Long and Short Swale Bridges and at the Nigliagvik Channel Bridge using Standard USGS midsection techniques. Appendix B.1 summarizes the techniques.

Peak discharge was calculated and correlated to the discharge measurements or observed WSEs. Industry standard methods were used to calculate peak discharge for:

- Colville River (MON1)
- Colville East Channel(MON9)
- Nigliq Channel (G27 and MON23)
- Lake L9341 (G32)
- Nigliagvik Channel Bridge (G38)
- Alpine road culverts

Under open channel conditions, peak discharge typically occurs at the same time as peak stage. This is not always the case in the arctic where peak flow is typically affected by ice and snow. Ice-affected channels often produce backwater effects and can temporarily increase stage and reduce velocity yielding a lower discharge than an equivalent stage under open water conditions.

Direct discharge measurements of the Colville River and Nigliq Channel were collected using an ADCP with methods per the USGS *Quality-Assurance Plan for Discharge Measurements Using Acoustic Doppler Current Profilers* (USGS 2005) (Photo 2.6).

Photo 2.4: Readying boats, gear, and ADCP for discharge measurement at MON1, looking north; June 3, 2014

Photo 2.5: Nigliagvik Channel Bridge direct discharge measurement collection, looking east; June 8, 2014

Photo 2.6: Collecting discharge measurements on the Colville River near MON1; June 3, 2014

Direct discharge measurements have been collected at MON1 on the Colville River using an ADCP each year since 2005, with the exception of 2010 and 2012.

On the Nigliq Channel, direct discharge was measured downstream of the CD5 bridge crossing.

2.3.2 Indirect Calculation Method

Peak discharge was calculated for these locations:

- Colville River at MON1
- Colville East Channel at MON9
- Nigliq Channel at MON23
- CD2 and CD4 road culverts
- Long and Short Swale Bridges
- Nigliq Channel Bridge at gage G27
- Lake L9341
- Nigliagvik Channel Bridge

Industry-accepted engineering methods (FHWA 2012) and Bentley CulvertMaster® software were used to estimate discharge through the CD2 and CD4 road culverts. Time and magnitude of peak discharge through the culverts was determined based on recorded WSE and stage observations on both sides of the road prism. CD5 road culverts did not convey flow in 2014.

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 LCMF as-built surveys (LCMF 2002); as-built information is not available for the slip-lined culverts – field measurements and approximations were used for slip-lined culverts.
- Culvert upstream and downstream invert elevation (LCMF 2012, 2013, and 2014a)
- Culvert Manning's roughness coefficient (0.012 for smooth steel and 0.024 for corrugated metal pipe)

Results were evaluated in terms of culvert functionality based on visual inspection.

The peak discharge estimates for the Long and Short Swale Bridges and the Nigliagvik Channel Bridge were calculated using the velocity-area method by correlating the hydraulic depths and velocities measured during the discharge measurements with peak.

3.0 BREAKUP OBSERVATIONS

3.1 2014 SPRING BREAKUP CONDITIONS SUMMARY

Temperatures in early spring were above average. Rapid melting of snow and ice occurred the second week of May. Subsequent below freezing temperatures the third week of May slowed the progression of floodwaters. Air temperatures predominantly remained below freezing throughout the day from May 21 through 31. At the end of May and beginning of June, overnight temperatures again increased to above freezing.

The 2014 breakup occurred slowly over an extended period of time Figure 3.1 provides a visual timeline summarizing the major 2014 CRD breakup events.

The hydrograph recorded at the USGS gage at Umiat showed two distinct crests. The first high water event reached a gage height of 58.00 feet on May 18, and peak stage on June 1 reached a gage height of 58.15 feet; 59 feet is considered minimum flood stage at the Umiat gage. The Umiat station data are presented as preliminary and do not account for melt contribution from the Chandler or Anaktuvuk Rivers. These large drainages join the Colville River upstream of MON1 and downstream of Umiat. Figure 3.2 presents the stage data from the USGS gage at Umiat during the CRD breakup monitoring period.

Reconnaissance flights were flown upstream of MON1 to the confluence of the Anaktuvuk and Colville Rivers on May 10. Flow of melt water was observed from the Anaktuvuk and Chandler Rivers into the Colville River. On May 11, the leading edge of floodwater in the Colville River was identified approximately 36 RM upstream of MON1.

On May 12, the leading edge was near Ocean Point about 20 miles upstream of MON1. By May 13, the leading edge was observed approximately 9 miles downstream of Ocean Point, and the leading edge was identified at MON1 on May 14.

On May 15, the floodwater was in the Nigliq Channel and the Colville East Channel between the Sakoonang bifurcation and the Kachemach River confluence. Floodwater was observed in Sakoonang and Tamayayak Channels on May 16 with no floodwater observed in the immediate vicinity of the Alpine facilities. There was intact channel ice from Ocean Point to the coast, with open water conditions observed upstream of Ocean Point. A small ice jam downstream of Ocean Point had very little backwater behind it. There was also intact channel ice in the Nigliq Channel. The leading edge in the Nigliq Channel reached MON28 with overflow observed on coastal shorefast ice. The Nigliagvik Channel was connected to the Nigliq at both ends. Coastal floodwaters were reported on MON35 gages near the mouth of the East Channel.

Figure 3.1: 2014 Colville River Delta Spring Breakup Hydrologic Timeline

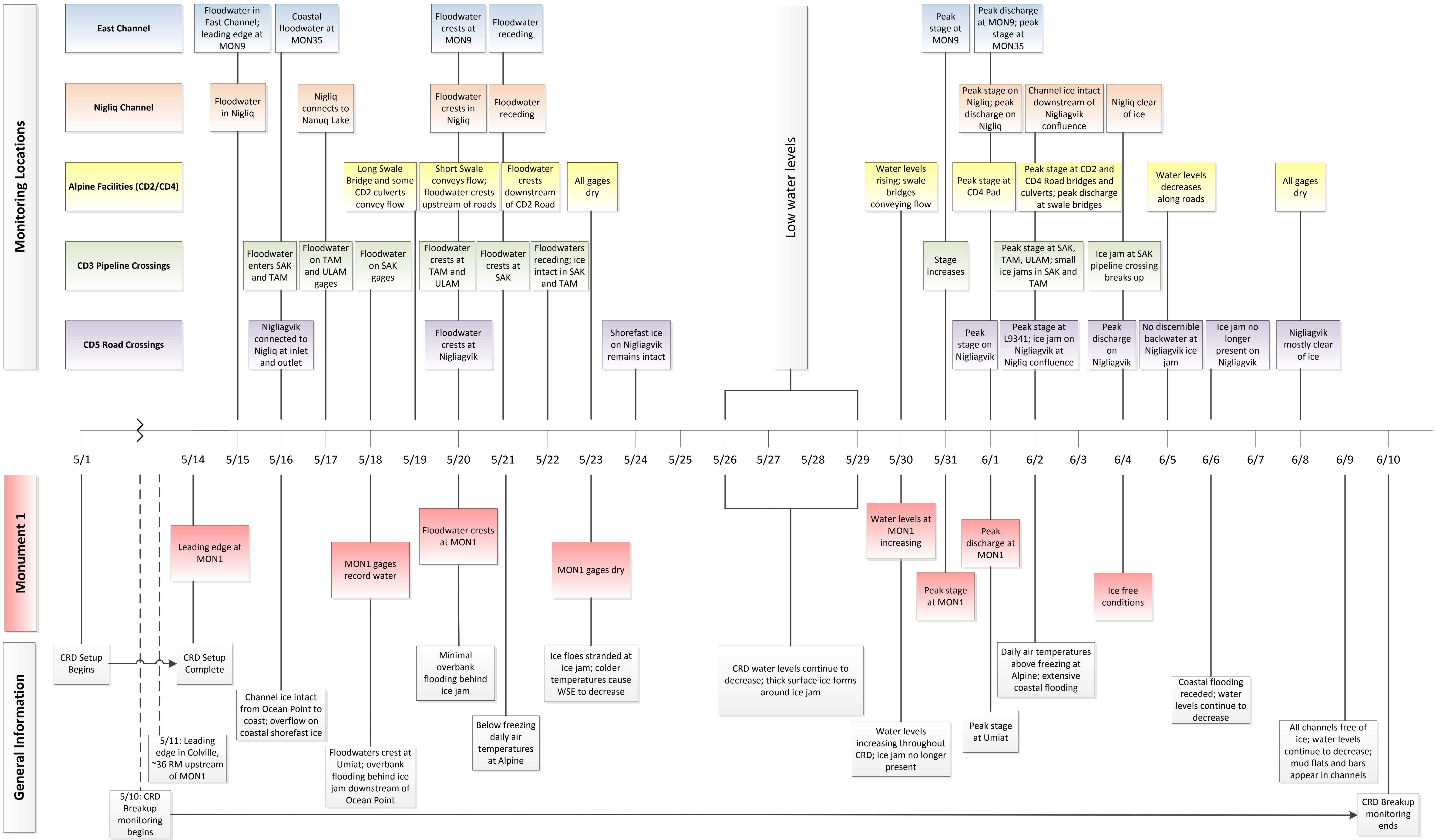
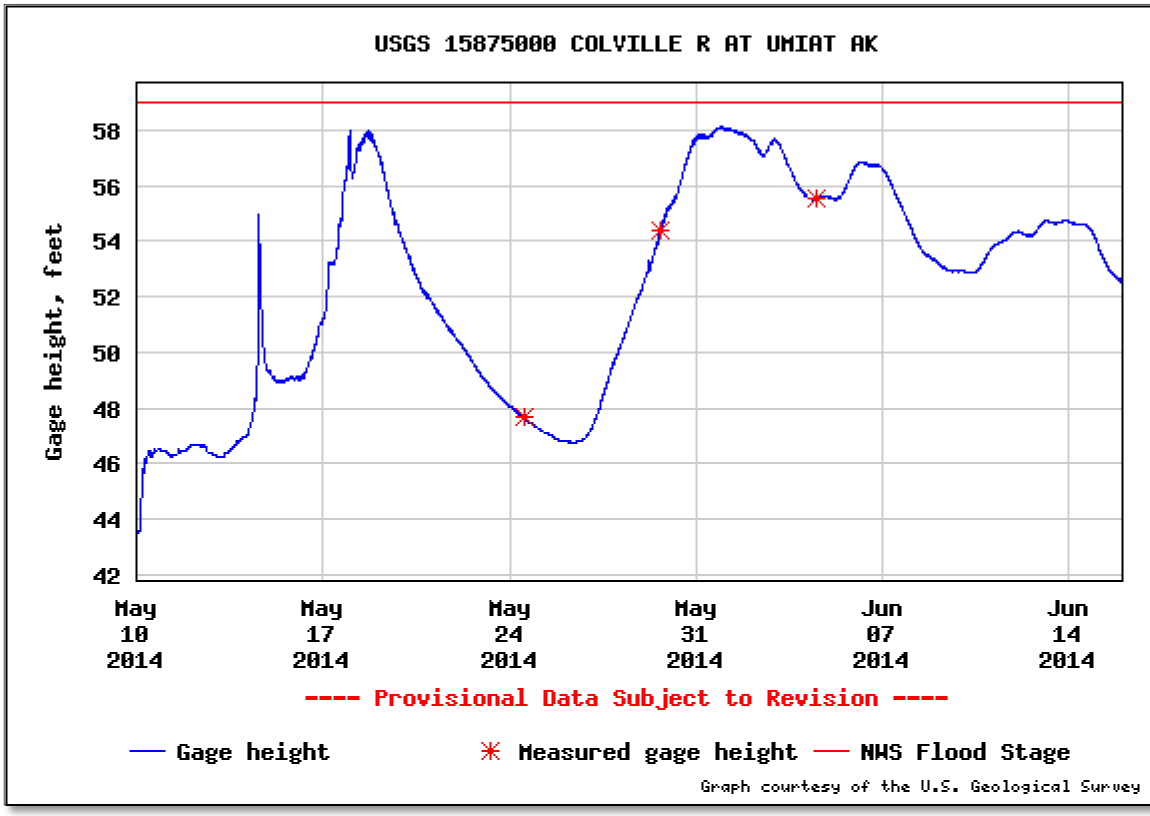


Figure 3.2: USGS Gage at Umiat Stage Data for the CRD Monitoring Period
May 10 through June 15, 2014



Reference: USGS 2014

On May 17, the Miluveach and Kachemach Rivers had substantial flow and were mostly clear of snow and ice. Water levels were slowly increasing in the Colville East Channel, and the Nigliq Channel was connected to the Nanuq Lake basin (Photo 3.1). However, no flow was observed through the CD2 road swale bridges. Overflow was observed on the coastal shorefast ice.

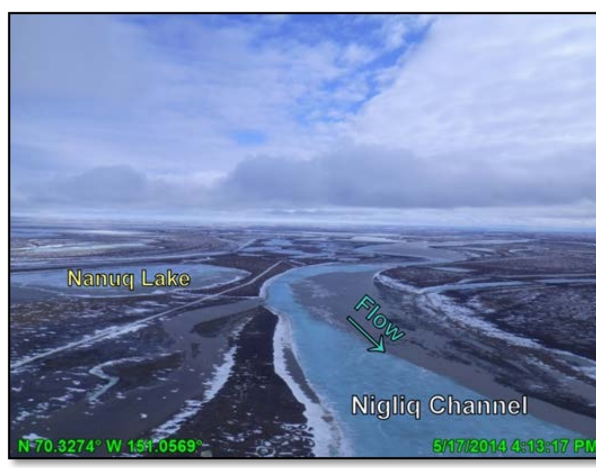


Photo 3.1: Nigliq Channel floodwaters connecting with Nanuq Lake, looking upstream (south); May 17, 2014

Water levels continued to rise at the head of the delta and in all channels on May 18, and floodwater was first recorded on the MON1 gages. Overbank flooding was observed behind the ice jam located downstream of Ocean Point.

From May 19 through 26, intact channel ice prevented the release of the ice jam located downstream of Ocean Point; floodwaters continued spreading in the overbank area. The decreasing air temperatures caused surface ice to form around the pans of stranded and jammed ice. On May 19, the Long Swale Bridge and a few culverts along the CD2 road were conveying flow.

On May 20, the swale bridges and a few culverts along the CD2 road were conveying water (Photo 3.2). Floodwaters crested at MON1 (14.34 feet BPMSL).

Photo 3.2: CD2 Road swale bridges conveying water, looking west; May 22, 2014

On May 21, water levels began to decrease in the CRD and around the Alpine facilities. The ice jam north of Ocean Point remained intact. Flow was present at the CD2 road swale bridges. Some culverts along the CD2 and CD4 road were conveying flow. Air temperatures decreased to below freezing throughout the day. Water levels at Umiat continued to decline.

On May 22, a direct discharge measurement was collected at the Long Swale Bridge on the CD2 road. Local melt water was ponded by the Short Swale Bridge. Discharge was also measured at culverts conveying flow along the CD2 road. No flow was observed at the CD4 and CD5 road culverts. The ice jam north of Ocean Point remained intact. Grounded ice and shoals within and upstream of the ice jam were visible, and there was low water and no overbank flooding behind the ice jam indicating the backwater was receding (Photo 3.3 and Photo 3.4).

Between May 24 and 26, floodwaters continued to recede with 70 to 80 percent of the snow pack melted at the headwaters of the Colville River. Water levels within the delta were decreasing.

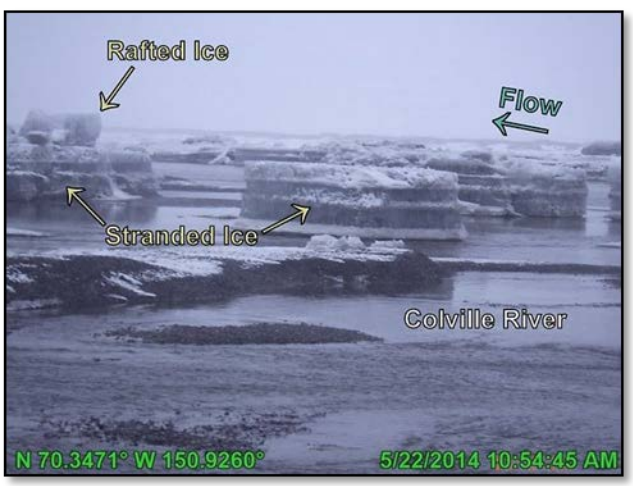


Photo 3.3: Stranded and rafted ice on shoals within ice jam upstream of MON1 (looking east); May 22, 2013

Photo 3.4: Rafted ice within ice jam upstream of MON1 (looking west); May 23, 2013

On May 23, water levels continued to decrease throughout the CRD, with intact channel ice in the Sakoonang, Tamayayak and Nigliq Channels. Floes in the ice jam north of Ocean Point were stranded as backwater continued to recede. No water was present on any of the MON1 gages; surface ice continued to develop.

Crews collected direct discharge data at the Nigliagvik Channel on May 24. Water levels continued to decrease and ice thickness increased throughout the CRD as air temperatures remained below freezing. On May 25, an erosion survey was performed on the CD2 and CD4 roads. Only local melt occurred around the CD5 road; floodwater was not observed near the road prism. On May 26, the ice jam remained in place trapped behind channel ice downstream of Ocean Point. Thick surface ice formed around the pans of stranded and jammed ice. Channel ice in the monitoring area remained intact and competent. Freezing rain and decreasing water levels caused monitoring to be temporarily suspended, and conditions at Umiat and Alpine were monitored remotely.

On May 28, floodwaters from the East Channel reached MON35, and water levels began to rise. By May 30, the ice jam had moved downstream of MON1, and flow was observed through the CD2 road swale bridges. Over the next two days, intact channel ice remained in the Nigliq Channel, and water levels continued to increase. Below freezing air temperatures at Alpine persisted. PT data from MON1 (15.18 feet BPMSL) indicated peak stage occurred on May 31-June 1. Ice was collecting along the banks of the Colville River near MON1 and MON9D.

On June 1, water levels continued to rise near Alpine facilities, and peak stage was reported at MON35 on the East Channel.

On June 2, decreasing stage and stranded ice floes along the river banks at MON1 indicated water levels had crested at the head of the CRD. The Nigliq Channel was predominantly free of channel ice upstream of the Nigliagvik Channel confluence; intact channel ice persisted downstream of the confluence. The CD2 road swale bridges and some culverts continued to convey flow, and peak stage was observed at the Alpine facility gages. Discharge measurements were collected at culverts and swale bridges along the CD2 road. Minimal flow was observed for a brief period through the CD4 road culverts, but no flow was noted during discharge measurements. No flow was observed through culverts on the CD5 road. Extensive coastal flooding occurred near the Nigliq Channel FWR and the MON28 gages. Air temperatures rose above freezing.

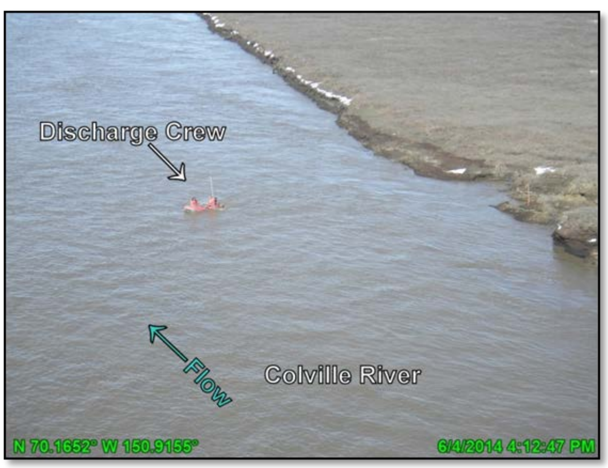


Photo 3.5: MON1 Discharge measurements on the Colville River; June 4, 2014

A small ice jam located at the mouth of the Nigliagvik Channel near the Nigliq confluence was growing, but no backwater was observed between June 2 and 5. On June 3, water levels began to decrease and above freezing air temperatures began melting channel ice and stranded ice floes. A discharge measurement was attempted at MON1.

On June 4, a discharge measurement was completed at MON1 (Photo 3.5). Some small ice floes were present along the west bank. The Nigliq Channel was mostly clear of channel ice with a few floes and some stranded ice along the banks. A small ice jam on the Sakoonang Channel upstream of the pipeline bridge crossing began moving downstream.

On June 5, water levels continued to decrease around the CRD. A discharge measurement was completed at the Nigliq Channel downstream of the bridge crossing; the channel was clear of ice and snow. The ice jam at the mouth of the Nigliagvik Channel remained in place, and water was conveying under the ice with no backwater behind the jam. Water levels decreased along the CD2 road.

Between June 6 and June 7, crews continued to monitor gages as water levels decreased, and coastal flooding receded. On June 8, a discharge measurement was completed at the Nigliagvik Channel Bridge, and the ice jam at the mouth was no longer evident. Visual surveys to document erosion resulting from breakup flooding were conducted on the CD2 and CD4 roads. Local melt with no flow was observed around the CD5 road.

By June 9, all river channels were ice free with some snow and a few stranded ice floes on the banks. Extensive mud flats and sand bars were appearing in the channels as water levels continued to decrease.

All road bridges and culverts passed spring breakup floodwater flows unimpeded.

3.2 Colville River Upstream of Bifurcation – MON1

The annual spring runoff begins in the Brooks Range, approximately 150 miles upstream (inland) of the MON1 monitoring site. MON1, located at the head of the delta, is on the farthest downstream confined reach of the Colville River, conveying approximately 22,500 square miles of runoff in a single channel.

MON1 is the only monitoring site upstream of the Colville River bifurcation into the Colville East and Nigliq channels. It has been monitored annually since 1992 and periodically since 1962. MON1 is considered the primary spring breakup monitoring site because of its location at the head of the delta and long historical record.

Three gaging stations are installed along the west bank upstream of the bifurcation. MON1U is located farthest upstream about 1.8 miles from the Nigliq bifurcation. MON1C, the center gage, is located 1.3 miles from the Nigliq bifurcation, and MON1D is the closest at 0.7 miles. The location plan view and channel cross section profiles are shown in Appendix B, B.2.1.

The leading edge of breakup floodwater reached the Colville River channel adjacent to MON1 on May 14. The MON1 gages remained dry. Floodwater was first observed at the MON1 gages on May 18, and channel ice was intact. The river channel was open by MON1 with ribbon ice on the east side. Floodwaters crested at MON1 on May 20.

An ice jam upstream of MON1 and below freezing temperatures caused floodwaters to recede, and the gages went dry on May 23. Intact channel ice was upstream of MON1 on May 26. After the ice jam moved downstream on May 30, the MON1 gages began recording water again on May 30 and 31. On May 31, the Colville River adjacent to MON1 was mostly clear of ice with stage rising.

Photo 3.6: MON1C Peak stage, looking east; May 31, 2014

Peak stage was observed on May 31 – June 1, and the high water period continued for about 24 hours (Photo 3.6). Peak stage was almost one foot higher than the first crest.

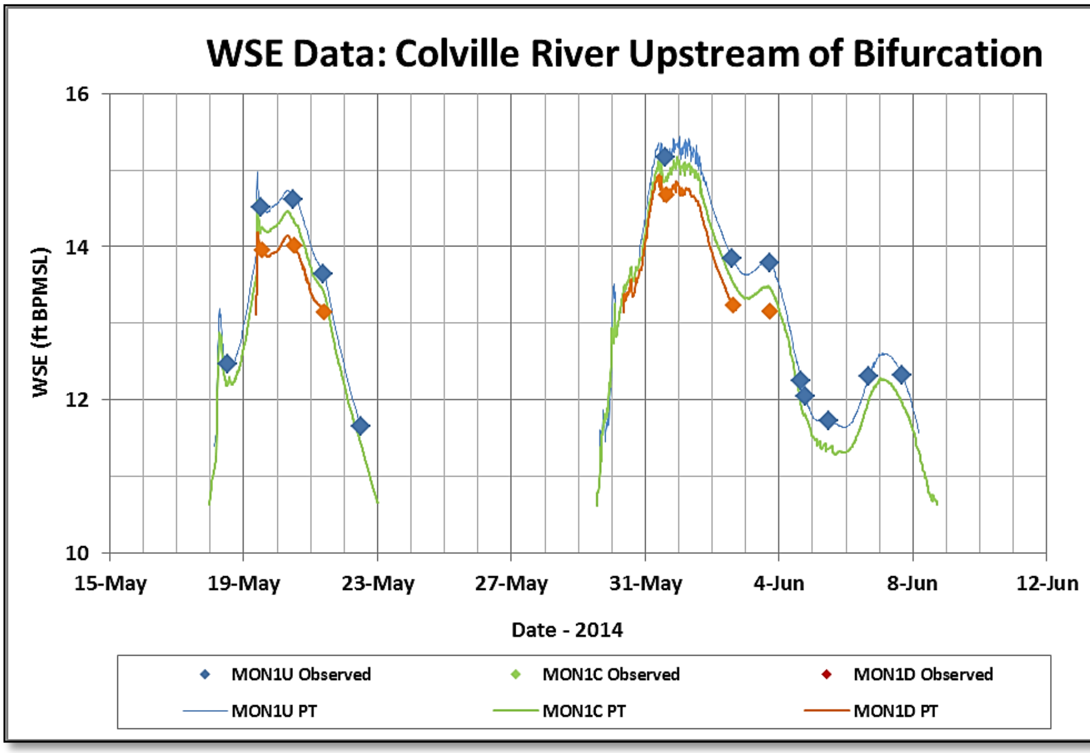
On June 2, water levels crested at the head of the delta. Ice floes were observed on the west side of the river adjacent to MON1 during direct discharge measurement collection on June 4.

Table 3.1 summarizes stage and ice observations during breakup, and Graph 3.1 shows the stage data collected at MON1.

Table 3.1: MON1 2014 Stage Data and Observations

Date	WSE (feet BPMSL)			Observations
	MON1U	MON1C	MON1D	
16-May	Dry	Dry	Dry	All MON1 gages are dry
18-May	12.47	12.22	Dry	First water received at gages
19-May	14.51	14.25	13.96	Stage increasing
20-May	14.62	14.34	14.02	Floodwater crested
21-May	13.65	13.40	13.15	Floodwater receding
22-May	11.65	11.40	11.16	The ice jam upstream of MON1 remains intact
24-May	Dry	Dry	Dry	Water receded, gage observations postponed
30-May	-	13.61	-	The ice jam is located downstream of MON1
31-May	*15.36*	*15.18*	*14.94*	Peak stage at MON1C and MON1D
1-Jun	*15.44*	*15.06*	*14.73*	Peak stage at MON1U
2-Jun	13.84	13.56	13.24	
3-Jun	13.79	13.47	13.16	
4-Jun	12.25	11.98	Dry	Ice free conditions, direct discharge measured
5-Jun	11.73	11.37	Dry	
6-Jun	12.31	12.02	Dry	
7-Jun	12.33	11.95	Dry	
8-Jun	10.75	10.43	Dry	Monitoring ended

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE
2. Dash (-) indicates no gage reading collected



Graph 3.1: MON1 2014 Stage Data

3.3 Colville River East Channel – MON9, MON9D, MON35

MON9, MON9D and MON35 monitoring sites are located on the East Channel.

MON9 is located on the west bank of the Colville East Channel at the HDD crossing of the Alpine Pipeline at about RM E16.8. MON9 has been monitored annually since 2005 and is downstream of the ice road crossing.

MON9D is located downstream of MON9, also on the west bank, upstream of the Sakoonang Channel distributary. Gages were added at MON9D in 2014 at the location previously monitored using a PT.

MON35 is located at the Helmericks Homestead at Colville Village on Anachlik Island at RM E3.0. Located on the west bank, it is the farthest downstream gage site on the Colville East Channel and is nearest to Harrison Bay. MON35 has been monitored intermittently since 1999. Stage data, observations, and photographs for this location are collected and provided by Jim Helmericks.

The leading edge was located near MON9 in the morning on May 15, and by evening was between the Sakoonang bifurcation and the Kachemach River confluence. On May 16 and 17, the MON9 gages began recording water as levels slowly increased. Channel ice was intact across the East Channel on May 18 and 19. Water levels crested at MON9 and MON9D on May 20. Between May 21 and 28, floodwater receded and daily temperatures dropped below freezing, and channel ice remained intact and competent. Stage continued to increase slowly between May 28 and 31, with peak stage occurring on May 31 at MON9 and MON9D. The East Channel was mostly clear of ice to about 7 miles downstream of MON9, with some ice collecting along the banks. On June 2, all river channels by MON9 were clear of ice. By June 3, the channel was clear of ice near MON9D.

Coastal floodwaters reached the MON35 gages on May 16. Overflow was observed on coastal shore fast ice on May 17. Water levels crested on May 20. Water receded at the gage locations and below freezing temperatures persisted between May 25 and May 30. On May 28, floodwaters from the Colville East Channel caused a rise in WSE, and peak stage occurred on June 1 at MON35 with Colville Village reporting most of the island underwater (Photo 3.7).

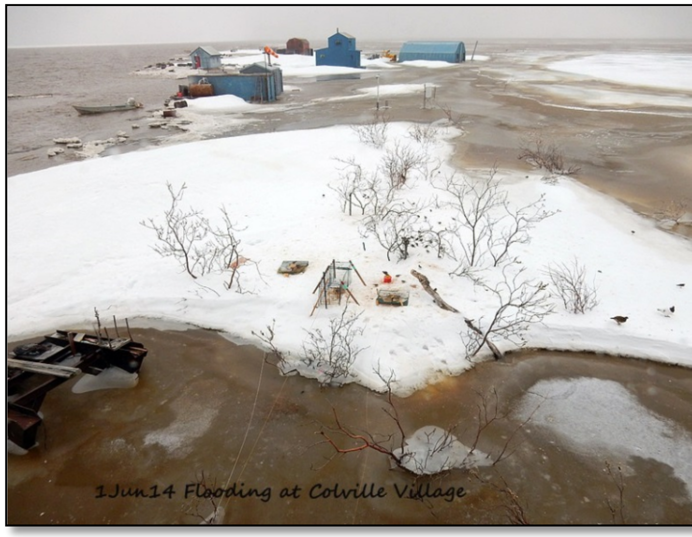


Photo 3.7: MON35 Peak stage, Helmericks Homestead, looking south; June 1, 2014

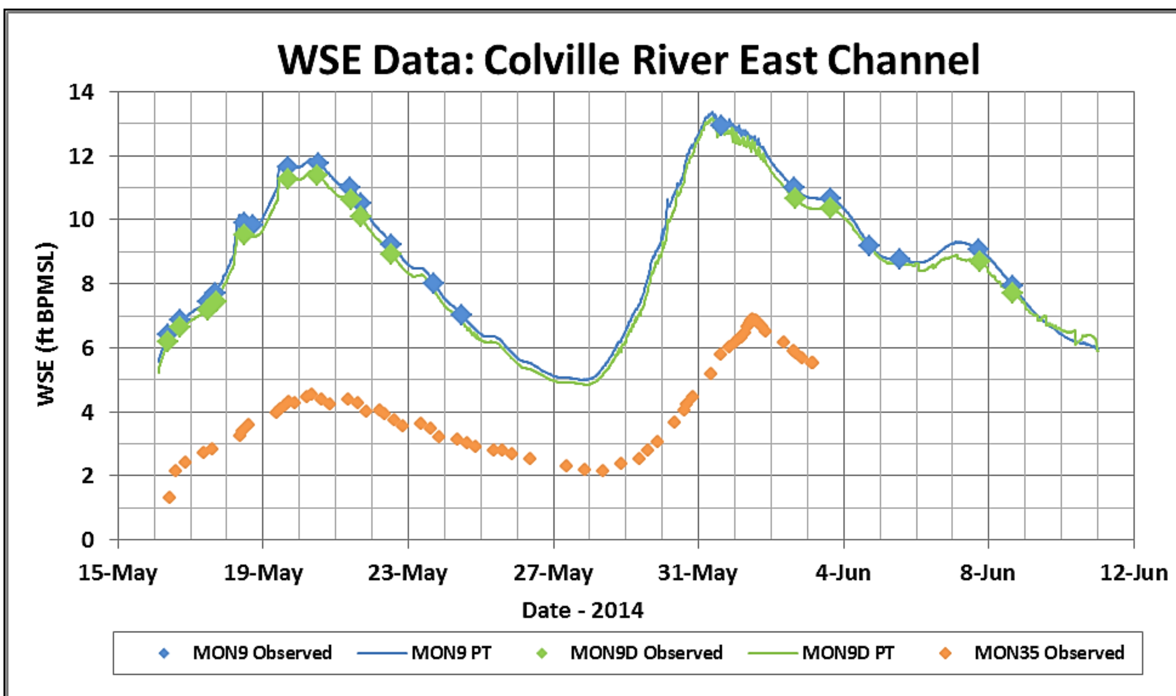
According to Jim Helmericks, it was the second highest flood level in recent history, similar to the breakup flood in 2000.

Table 3.2 summarizes stage and ice observations during breakup, and Graph 3.2 shows the stage data collected at the Colville East Channel gages.

Table 3.2: Colville River East Channel Gages 2014 Stage Data and Observations

Date	WSE (feet BPMSL)			Observations (MON 35)
	MON9	MON9D	MON35	
16-May	6.88	6.64	1.33	Coastal waters reach MON35; water on gages at MON9/MON9D
17-May	7.71	7.45	2.84	Overflow observed on coastal shore-fast ice
18-May	9.90	9.53	3.59	
19-May	11.66	11.27	4.31	
20-May	11.76	11.39	4.55	Floodwater crested
21-May	11.01	10.63	4.39	Floodwater receding
22-May	9.23	8.93	4.05	
23-May	8.01	-	3.65	
24-May	7.02	-	3.14	Coastal shore leads mostly frozen over
25-May	-	-	2.82	Below freezing air temperature
26-May	-	-	2.56	Coastal shore leads entirely frozen
30-May	-	-	4.49	
31-May	*13.35*	*13.18*	5.19	Peak stage at MON9 and MON9D
1-Jun	-	-	6.91	Peak stage observed at MON35
2-Jun	10.99	10.66	6.19	Floodwaters receding
3-Jun	10.67	10.35	Dry	
4-Jun	9.19	-	-	
6-Jun	8.75	-	-	
7-Jun	9.06	8.70	-	
8-Jun	7.93	7.71	-	Monitoring ended

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE
2. Dash (-) indicates no gage reading collected



Graph 3.2: East Channel Gages 2014 Stage Data

3.4 NIGLIQ CHANNEL

Gages G26 and G28 are located upstream and G27 and G29 are downstream of the Nigliq Channel bridge crossing. These gages were installed in 2013. Gages G26, G27, and G28 are on the east bank of the Nigliq Channel, and G29 is on the west bank.

MON20 is on the Nigliq Channel east bank at RM N12.2 and is the farthest gage upstream of the bridge crossing. MON22 is located on the west bank at RM N8.8 downstream of the bridge crossing. MON23 is on the east bank at RM N6.9 downstream of the bridge. MON28, the northernmost gage, is on the east bank at RM N0.8, downstream of the bridge, and is nearest to Harrison Bay. Gages at MON20, MON22, and MON23 have been monitored intermittently since 1998, and gages at MON28 since 1999.

In the evening of May 15, floodwater was observed in the Nigliq Channel near Nuiqsut. On May 16, Tapped Lake, Nanuq Lake, and Silas Slough were connected to the Nigliq Channel. Nigliq Channel gages began recording water between May 16 and 18 depending on the location. On May 17, Nanuq Lake began receiving flow from the Nigliq Channel. Backwater from the Nigliq Channel was observed in Toolbox Creek. Overflow was observed on coastal shorefast ice. Floodwaters crested on the Nigliq Channel gages on May 20.

On May 21, MON28 gages were inundated by seawater. A small ice jam formed behind intact channel ice at the confluence of Toolbox Creek and the Nigliq Channel. Lake M9524 and Nanuq Lake were connected creating flow through the Long and Short Swale Bridges.

Channel ice was intact on May 26 in the Nigliq Channel. All of the gages, except G28, were dry at some point between May 24 and May 28. Channel ice began breaking upstream of the Nigliq Channel bridge crossing, but remained intact at the crossing location on May 31. MON28 gages were inundated by seawater.

Peak stage was recorded on June 1 (MON20, MON22, G26/G27, and G28/G29) and June 2 (MON23 and MON28). Lake L9324 was connected to the Nigliq Channel via Tapped Lake and Silas Slough. Channel ice remained competent on June 1 downstream of the crossing location near MON23. On June 2, the channel was predominantly free of competent ice up to the Nigliagvik Channel confluence, with a small downstream jam beginning to break up in the evening. Lake L9341 and Nanuq Lake remained hydraulically connected to the Nigliq Channel, and extensive coastal flooding was observed near MON28. Open water conditions were observed at the crossing location on June 3, and MON28 continued to be inundated by coastal floodwaters.

On June 4, the Nigliq Channel was mostly free of ice with some stranded ice along the banks and a few grounded ice floes. Water levels continued to decrease (Photo 3.8). A discharge measurement was collected on June 5 at the Nigliq Channel crossing location, and a few ice floes were observed within the channel.

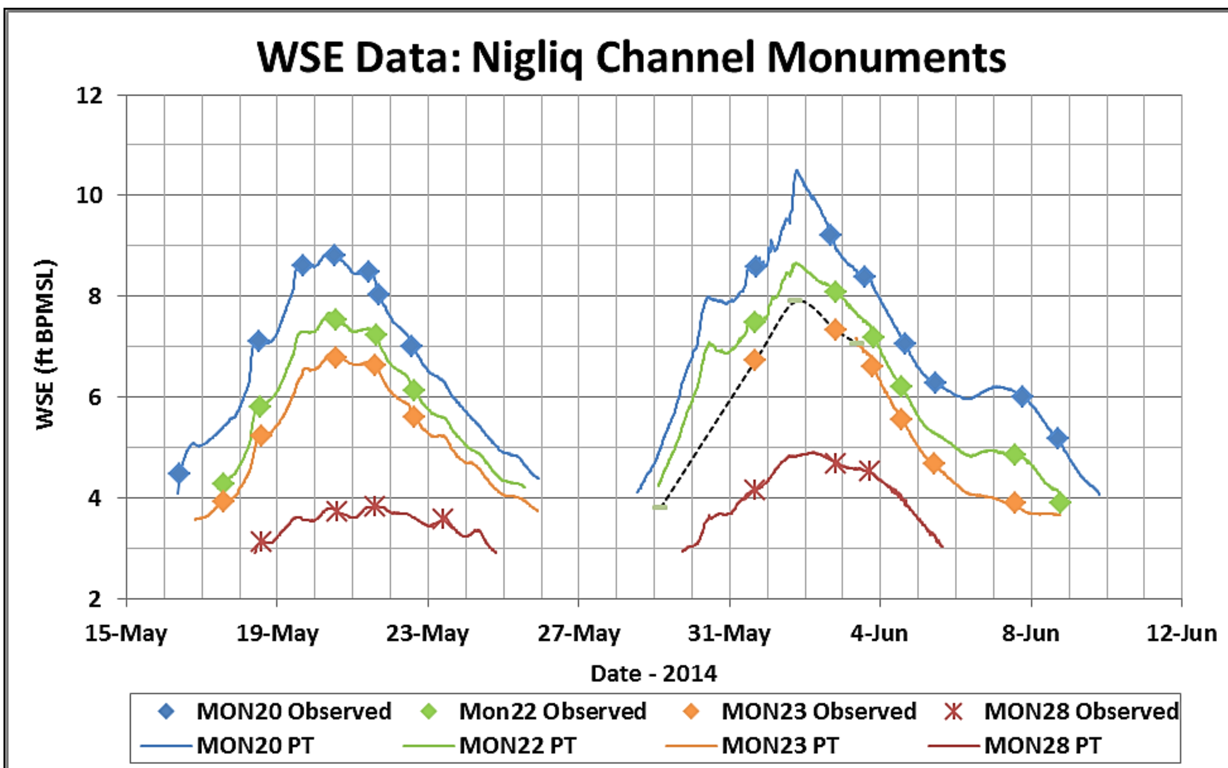
Photo 3.8: Nigliq Channel upstream of the bridge crossing, looking south; June 4, 2014

Table 3.3 and Table 3.4 summarize stage and ice observations during breakup at the Nigliq Channel monuments and gages, respectively. Graph 3.3 and Graph 3.4 shows the stage data collected at the monuments and gages, respectively.

Table 3.3: Nigliq Channel Monuments 2014 Stage Data and Observations

Date	WSE (feet BPMSL)				Observations
	MON20	MON22	MON23	MON28	
16-May	4.47	Dry	Dry	Dry	Southern-most gage, MON20, begins recording water
17-May	-	4.27	3.92	-	MON22 and MON23 begin recording water
18-May	7.11	5.81	5.23	3.13	Northern-most gage, MON28, begins recording water
19-May	8.62	-	-	-	
20-May	*8.81*	*7.67*	*6.86*	*3.79*	Floodwater crested
21-May	8.47	-	6.63	3.83	
22-May	7.01	6.12	5.60	-	
23-May	-	-	-	3.56	
31-May	8.58	7.47	6.72	4.19	
1-Jun	*10.49*	*8.67*	-	*4.87*	Peak stage at MON20 and MON22
2-Jun	*10.20*	*8.53*	7.90*	*4.90*	Peak stage at MON23 and MON28
3-Jun	8.38	7.19	6.61	4.52	
4-Jun	7.05	6.21	5.57	-	Channel predominantly clear of ice; direct discharge measured
5-Jun	6.27	4.84	4.70	-	
7-Jun	6.01	3.86	3.89	-	
8-Jun	5.17	3.95	3.17	-	

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE
2. Dash (-) indicates no gage reading collected
* WSE based on gage chalk high water mark

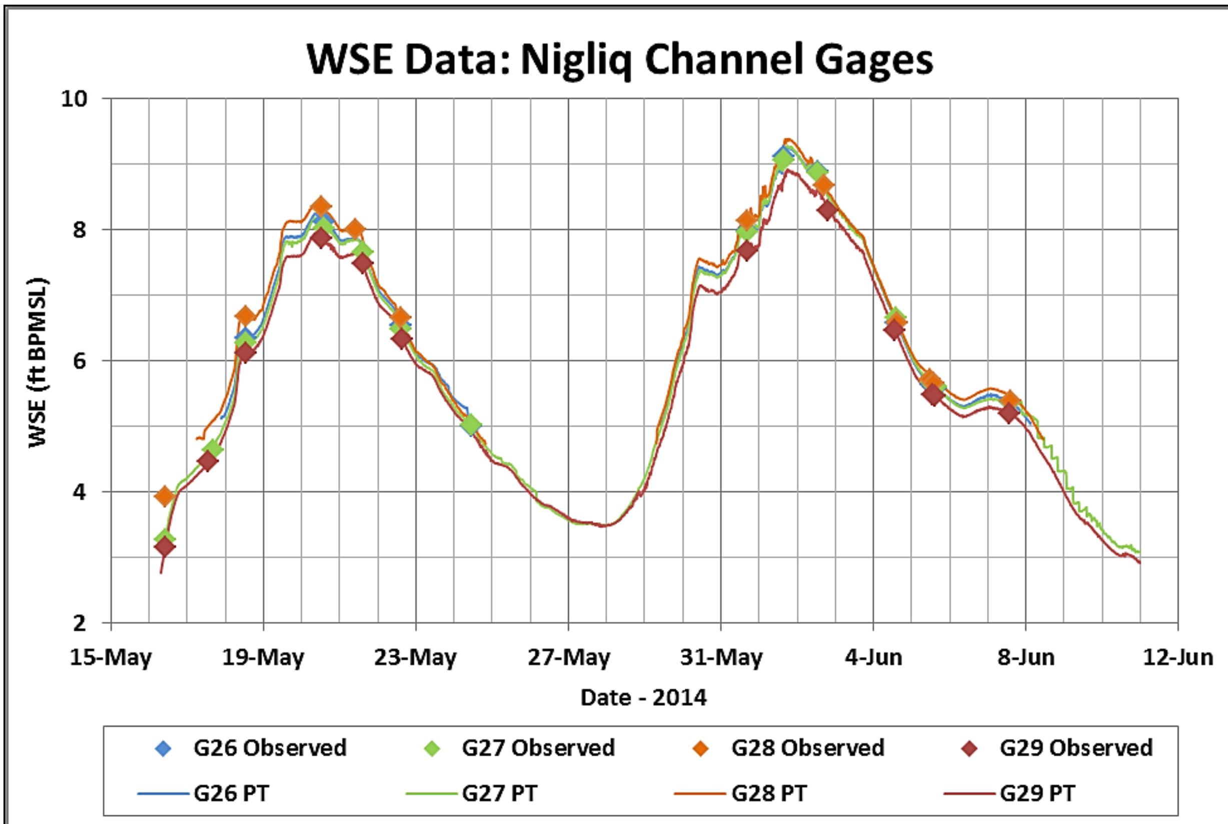


Graph 3.3: Nigliq Channel Monuments 2014 Stage Data

Table 3.4: Nigliq Channel Gages 2014 Stage Data and Observations

Date	WSE (feet BPMSL)				Observations
	G26	G27	G28	G29	
16-May	-	3.26	3.92	3.16	Mid-channel gages begin recording water
17-May	*5.12*	4.63	*5.08*	4.45	
18-May	6.35	6.29	6.67	6.11	Gage G26 begins recording water
20-May	8.11	8.02	8.35	7.86	Floodwater crested
21-May	-	7.65	8.00	7.48	Floodwater receding
22-May	6.54	6.48	6.64	6.33	
24-May	5.00	5.01	-	-	
31-May	7.98	7.96	8.12	7.66	
1-Jun	*9.25*	*9.28*	*9.38*	*8.92*	Peak stage observed at all gages
2-Jun	8.88	8.86	8.67	8.29	Open water conditions observed at the bridge crossing
4-Jun	6.58	6.64	6.57	6.46	Nigliq Channel predominantly clear of ice
5-Jun	5.63	5.67	5.70	5.48	
7-Jun	5.36	5.37	5.38	5.18	

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE
2. Dash (-) indicates no gage reading collected



Graph 3.4: Nigliq Channel Gages 2014 Stage Data

3.5 Downstream Nigliq Channel – FWR1, FWR2

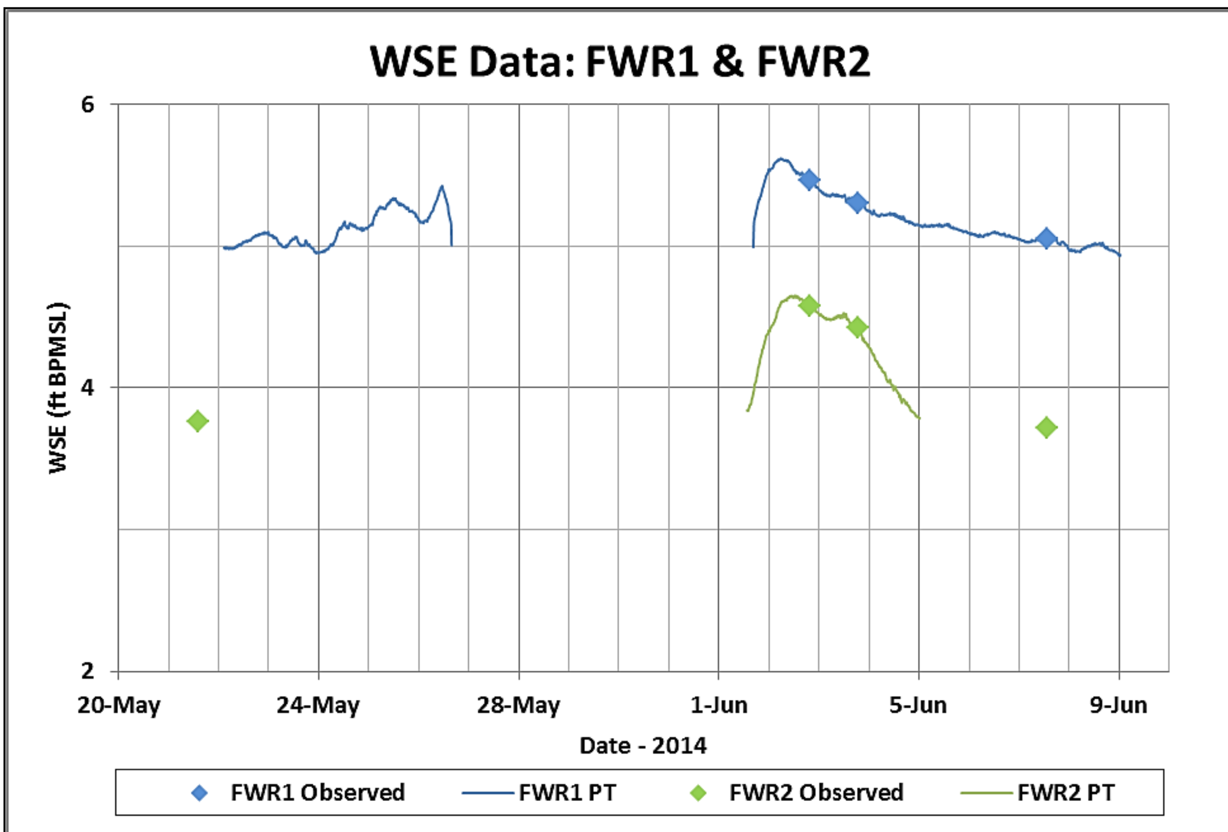
FWR1 and FWR2 are located in the downstream vicinity of the west Nigliq Channel overbank area and the northwest CRD. On May 21, local melt was present at FWR2, and the FWR1 gage was dry. By May 22, FWR1 was recording water. Both gages were dry on May 27, and the gages began recording water again on June 1. Peak stage was on June 2 at both locations. At FWR2, extensive coastal flooding from Harrison Bay was flowing into the area over the shorefast ice on June 2.

Table 3.5 summarizes stage and ice observations during breakup, and Graph 3.5 shows the stage data collected at the downstream Nigliq gages.

Table 3.5: Downstream Nigliq Gages 2014 Stage Data and Observation

Date	WSE (feet BPMSL)		Observations
	FWR1	FWR2	
21-May	-	3.76	
2-Jun	*5.62*	*4.65*	Peak stage
3-Jun	5.30	4.42	
7-Jun	5.05	3.72	

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE
2. Dash (-) indicates no gage reading collected



Graph 3.5: Downstream Nigliq Gages 2014 Stage Data

3.6 ALPINE FACILITIES AND ROADS

Staff gages are used to monitor water levels at the Alpine facilities and lakes. Gages are established at pads and roads adjacent to major water features to monitor the effect of breakup floodwaters on facility infrastructure. Adjacent to the access roads, the gages are paired to capture water levels on the upstream and downstream side of the drainage structures to determine stage differential.

CPAI maintains the drainage structures to keep them free of ice and snow accumulation and blockages during the winter months. Techniques include covering the culvert inlets and outlets during the winter and mechanically removing snow from the immediate upstream and downstream areas of all culverts and bridges in the spring prior to breakup flooding. Before breakup, culvert covers were removed and snow was removed from around the culverts and bridges so flood flows were not impeded.

Drainage structures are monitored for stage differential and functionality during spring breakup flooding. Spring breakup produces sufficient quantities of water and increased stage to result in some of these structures passing flow. Culverts and bridges were not blocked or undercut by flood flows and functioned properly during breakup. Most culverts were dry or did not experience flood flows. Local melt was not sufficient to create flow through the culverts.

Breakup progression at Alpine facilities is driven by conditions in the Sakoonang, Tamayayak, and Ulamnigiaq Channels to the east, and the Nigliq Channel to the west. Floodwaters typically overtop the active channel banks of the Nigliq and Sakoonang Channels and contribute to the annual recharge of many lakes and paleolake areas through overbank inundation or established drainages. Floodwater extents depend on WSE and ice and snow presence. Breakup at Alpine facilities generally begins with local melt, and floodwaters arriving one to two days after the leading edge reaches MON1.

3.6.1 CD1 AND LAKES L9312 AND L9313

Gage G1 is gage located on the Sakoonang Channel at the CD1 pad. Gages G9 and G10 are on lakes L9312 and L9313, respectively. Recharge at lakes L9312 and L9313 has been monitored annually since 1998. Historical observations indicate the Sakoonang Channel floodwater is the primary recharge mechanism for both lakes (Baker 2013a).

Floodwaters crested at gages G1 and G10 on May 21. Freezing temperatures caused WSE readings to drop until May 31. Peak stage at the CD1 pad recorded at gage G1 was on June 2.

Bankfull lake recharge is achieved when the stage hydrograph exhibits a rise and fall indicating either overland flow or local melt from within the drainage basin increased the lake WSE above bankfull conditions. Local melt contributions come from snow and ice within the lake drainage basins. Historical records indicate Lake L9313 bankfull elevation is approximately 6.5 feet BPMSL (Baker 2006a, 2007b) at gage G10. At Lake L9312, bankfull elevation is between 8.0 and 8.3 feet BPMSL at gage G9 (Baker 2013a).

Lake L9313 received overland flow from the Sakoonang Channel via Lake M9525. The peak WSE of 8.59 feet BPMSL was recorded on June 3 at gage G10 (Photo 3.9); the lake fully recharged. Lake L9312 was recharged via precipitation and snowmelt within the lake's basin. The peak WSE of 7.94 feet BPMSL was recorded on

June 6 at gage G9 (Photo 3.10). While the lake did recharge, based on aerial observations and WSE, bankfull recharge was not observed.

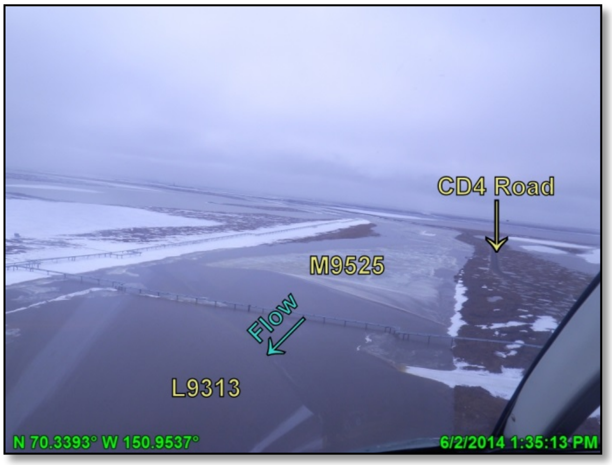


Photo 3.9: Lake L9313 receiving over land flow from Lake M9525; looking southwest; June 2, 2014

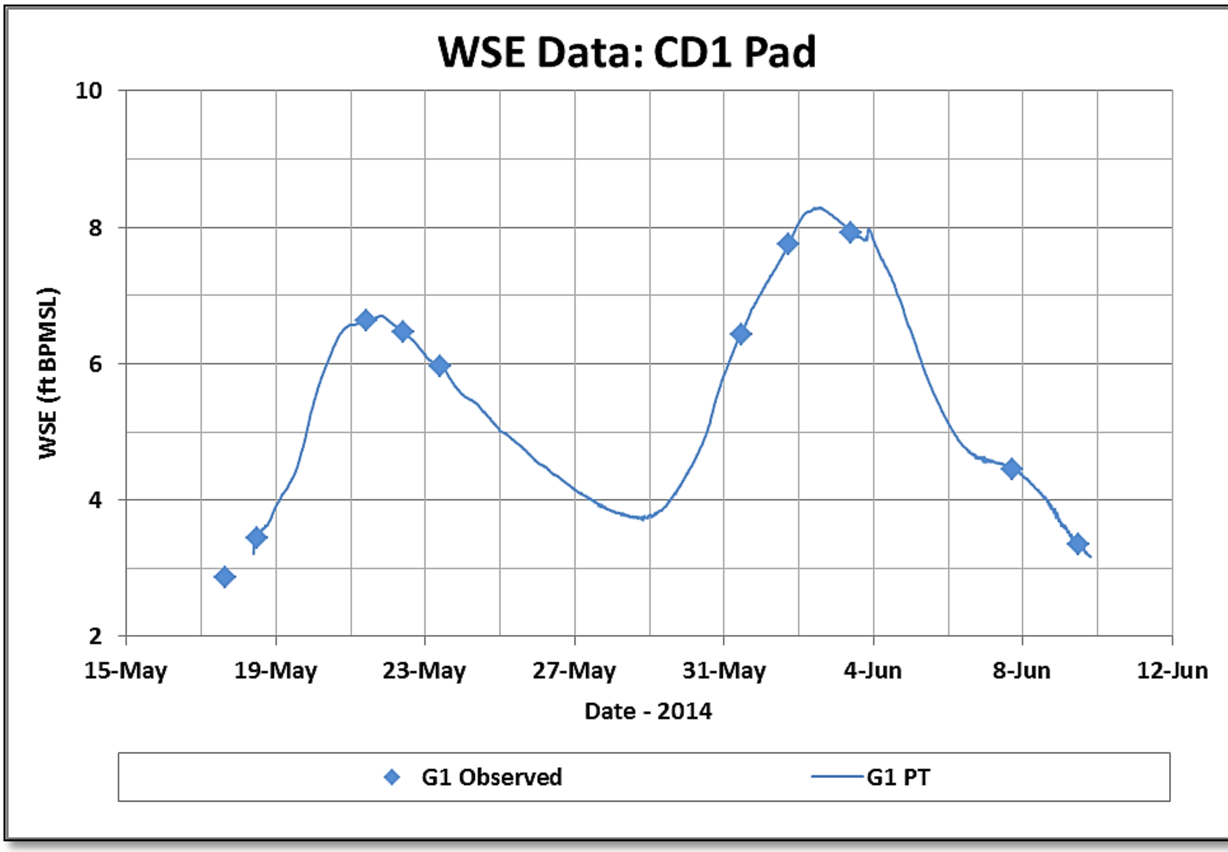
Photo 3.10: Lake L9312 at peak WSE, looking south, June 6, 2014.

Table 3.6 and Table 3.7 summarize stage and ice observations during breakup at CD1 and Lakes L9312 and L9313, respectively. Graph 3.6 and Graph 3.7 shows the stage data collected at CD1 and Lakes L9312 and L9313, respectively.

Table 3.6: Gage G1 2014 Stage Data and Observations

Date	WSE (feet BPMSL)	Observations
	G1	
17-May	2.87	
18-May	3.45	
21-May	6.63	Below freezing air temperatures; skim ice on water at gages; minor flow noted at G1; floodwater crested
22-May	6.47	
23-May	5.97	Thick ice on water surrounding gages
31-May	6.43	
1-Jun	7.76	
2-Jun	*8.29*	Peak stage at G1
3-Jun	7.91	
7-Jun	4.46	
9-Jun	3.36	

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE
2. Dash (-) indicates no gage reading collected

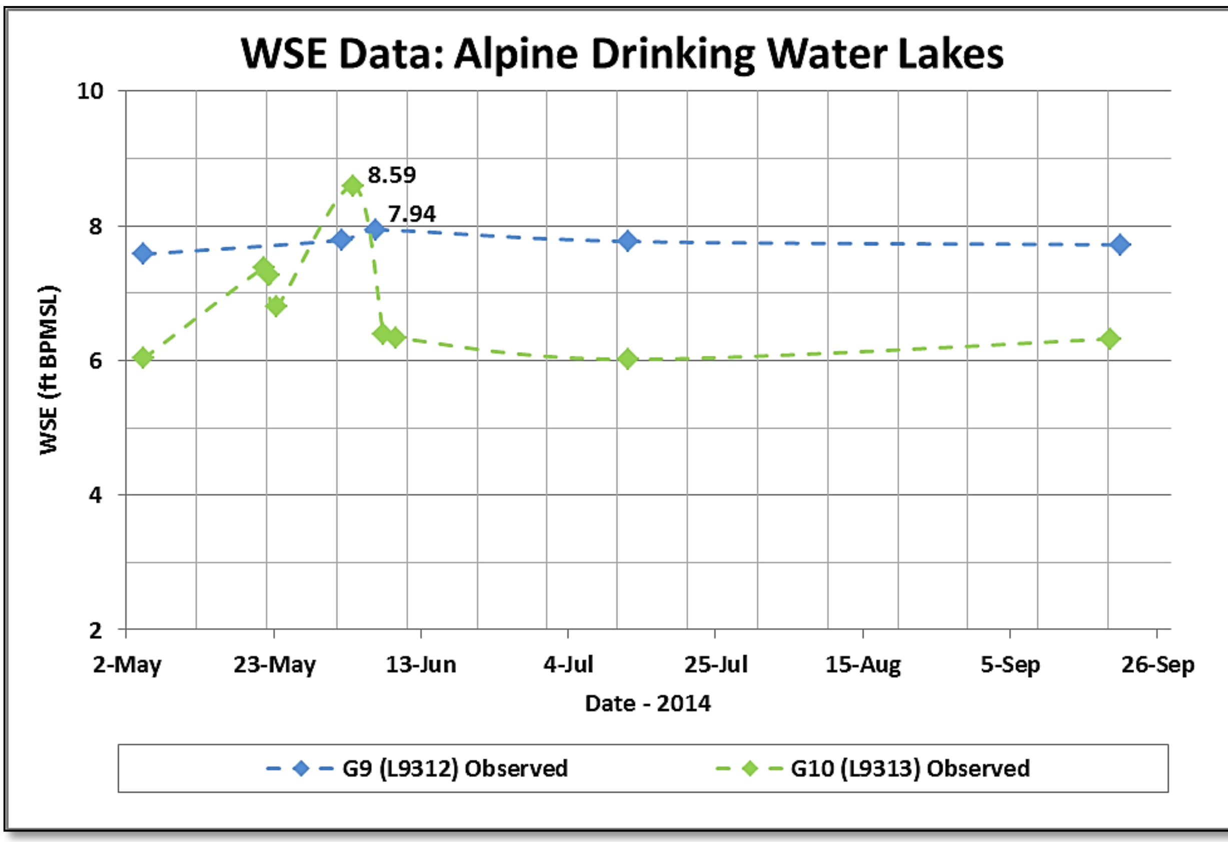


Graph 3.6: Gage G1 2014 Stage Data

Table 3.7: Lakes L9312 and L9313 2014 Stage Data and Observations

Date	WSE (feet BPMSL)		Observations
	G9 (L9312)	G10 (L9313)	
4-May	7.58	6.03	Lakes frozen, WSE surveyed during WQ sampling
18-May	-	-	Lakes frozen
21-May	-	7.38	Below freezing air temperatures; skim ice on water at gages; floodwater crested at G10.
22-May	-	7.27	
23-May	-	6.80	Thick ice on water surrounding gages
1-Jun	7.79	-	
3-Jun	-	8.59	Peak stage observed at G10; Lake L9313 connected to Lake M9525 and recharged to bankfull
6-Jun	7.94	-	Peak stage observed at G9
7-Jun	-	6.39	
9-Jun	-	6.34	
12-Jul	7.77	6.02	

Note:
Dash (-) indicates no gage reading collected



Graph 3.7: Lakes L9312 and L9313 2014 Stage Data

3.6.2 CD2 Road and Pad

Three sets of paired gages, G3/G4, G6/G7 and G12/G13, are located along the CD2 road adjacent to the drainage structures; one gage is on the upstream side and one on the downstream side. The drainage structures include a series of single culverts and multi-culvert batteries and two bridges: the Long (452 feet) and Short (62 feet) Swale Bridges.

Gage G8 is located on the northwest corner of the CD2 Pad and briefly experienced local melt on May 17. Otherwise, the gage remained dry throughout the monitoring period. Gage G8 is not represented on the hydrograph.

The Long Swale Bridge and a few culverts along the CD2 road were conveying floodwater on May 18; local melt was observed at the Short Swale Bridge. Flow was present at the Long and Short Swale Bridges on May 19, 20, and 21, and flow was observed passing through some of the culverts. Local melt water was evident at gages G6/G7 between May 17 and May 23. On May 20-21, stage slowly increased around facilities, and floodwaters crested at gages G3/G4.

On May 30, flow was once again observed at the swale bridges. As water levels continued to rise on June 1, floodwater was observed on gages G3/G4, G6/G7, and G12/G13 with peak stage observed on June 2. Floodwaters began to recede on June 3, and by June 6, all gages were dry. On June 3, there was ponding of local melt water by the culverts with some showing minimal flow. On June 4, the Long and Short Swale Bridges were still conveying water, and the top of the tundra vegetation was showing. On June 5, the Short Swale Bridge was no longer conveying floodwater.

Photo 3.11: Collecting a discharge measurement at CD2 Road culvert during peak stage, looking northwest; June 2, 2014

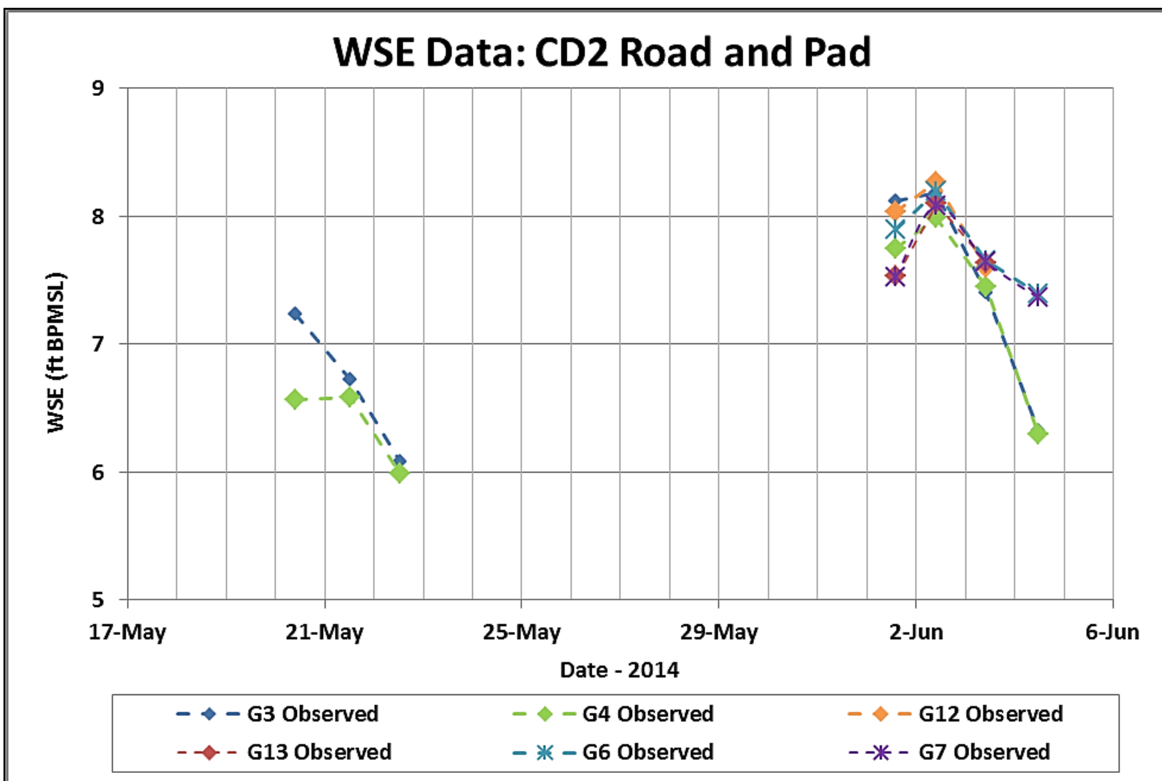
Direct discharge measurements were collected at the CD2 road culverts conveying floodwater and the Long Swale Bridge on May 22 within 24-hour of the first crest in floodwaters, and at both swale bridges on June 2 within 24-hours of peak stage (Photo 3.11). On May 22, ponded, local melt water was present at the Short Swale Bridge, so a direct discharge measurement was not collected. Erosion surveys along the CD2 road were conducted on May 25 and June 8.

Table 3.8 summarizes stage and ice observations during breakup, and Graph 3.8 shows the stage data collected at the CD2 gages.

Table 3.8: CD2 Gages 2014 Stage Data and Observations

Date	WSE (feet BPMSL)							Observations
	G3	G4	G12	G13	G6	G7	G8	
17-May	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Local melt
18-May	Dry	Dry	Dry	Dry	Dry	Dry	Dry	No flow through CD2 Road Swale Bridges or culverts; local melt at G6 and G7
20-May	7.23	6.57	Dry	Dry	Dry	Dry	Dry	Flow is present at the Long and Short Swale Bridges; some culverts along CD2 Road conveying flow; stage slowly increased around facilities throughout the day, floodwater crested at G3
21-May	6.72	6.59	Dry	Dry	Dry	Dry	Dry	Flow is present at the Long and Short Swale Bridges; some culverts along CD2 Road conveying flow; stage slowly increased around facilities throughout the day; floodwater crested at G4
22-May	6.08	5.99	Dry	Dry	Dry	Dry	Dry	Direct discharge measurement taken at the Long Swale Bridge; no flow at Short Swale Bridge; discharge measurements at culverts conveying flow
23-May	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Colder temperatures increase ice thickness; WSE throughout CRD decreases
1-Jun	8.12	7.75	8.04	7.53	7.90	7.53	Dry	Water levels rising around roads and pads
2-Jun	8.18	7.99	8.27	8.10	8.20	8.09	-	Peak stage observed; direct discharge measurements collected at CD2 culverts and bridges
3-Jun	7.40	7.45	7.60	7.64	7.66	7.65	Dry	Floodwater receding
4-Jun	6.32	6.30	Dry	Dry	7.40	7.37	-	
6-Jun	Dry	Dry	Dry	Dry	Dry	Dry	-	
8-Jun	Dry	Dry	Dry	Dry	Dry	Dry	Dry	

Note:
Dash (-) indicates no gage reading collected



Graph 3.8: CD2 Gages 2014 Stage Data

3.6.3 CD3 Pad

The CD3 Pad and airstrip remained above flood level for the duration of the 2014 breakup flood event. No floodwater or local melt was observed at gage G11, and the PT did not record water (Photo 3.12).

Photo 3.12: CD3 during peak stage, looking southeast; June 2, 2014

3.6.4 CD4 Road and Pad

Floodwaters crested on May 20 at gage G20 on the east side of the CD4 Pad. On May 21, floodwaters crested along the CD4 road at gages G15/G16. Air temperatures decreased, and water levels dropped between May 23 and May 31. On June 1, peak stage was observed at gage G20, and on June 2, peak stage was recorded at gages G15, G16, and G43.

Some culverts along the CD4 road were conveying minimal flood flows on May 21. CD4 road culverts, with the exception of the CD4-20 and CD4-23 batteries; remained dry throughout breakup. On May 22, discharge measurements were collected at the culverts, but flow was not measurable along the CD4 road. On June 1 and 2, minimal flow was observed through the culverts and floodwaters equalized rapidly. No flow was recorded during direct discharge measurements collected on June 2 at the culverts (Photo 3.13).

Gages G17, G18, G40, G41, and G42 did not receive floodwater during 2014 spring breakup and are not shown on table or graph. Gage G19 recorded local melt only (Photo 3.14) and was not connected to any lakes or channels and therefore is not shown on the graph; WSE are shown on the corresponding table.

Table 3.9 summarizes stage and ice observations during breakup for gages with measurable WSE, and Graph 3.9 shows the stage data collected at the CD4 gages.

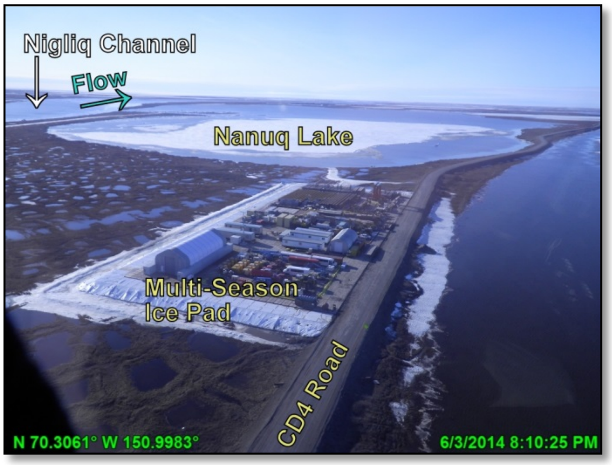


Photo 3.13: CD4 Road and multi-season ice pad, looking north; June 3, 2014

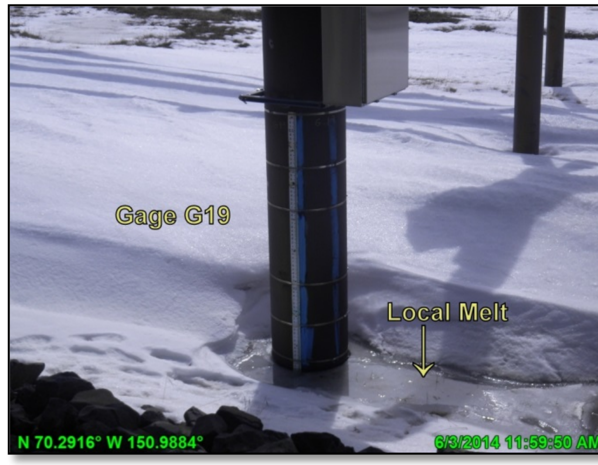


Photo 3.14: CD4 Pad gage G19 Local melt, looking south; June 3, 2014

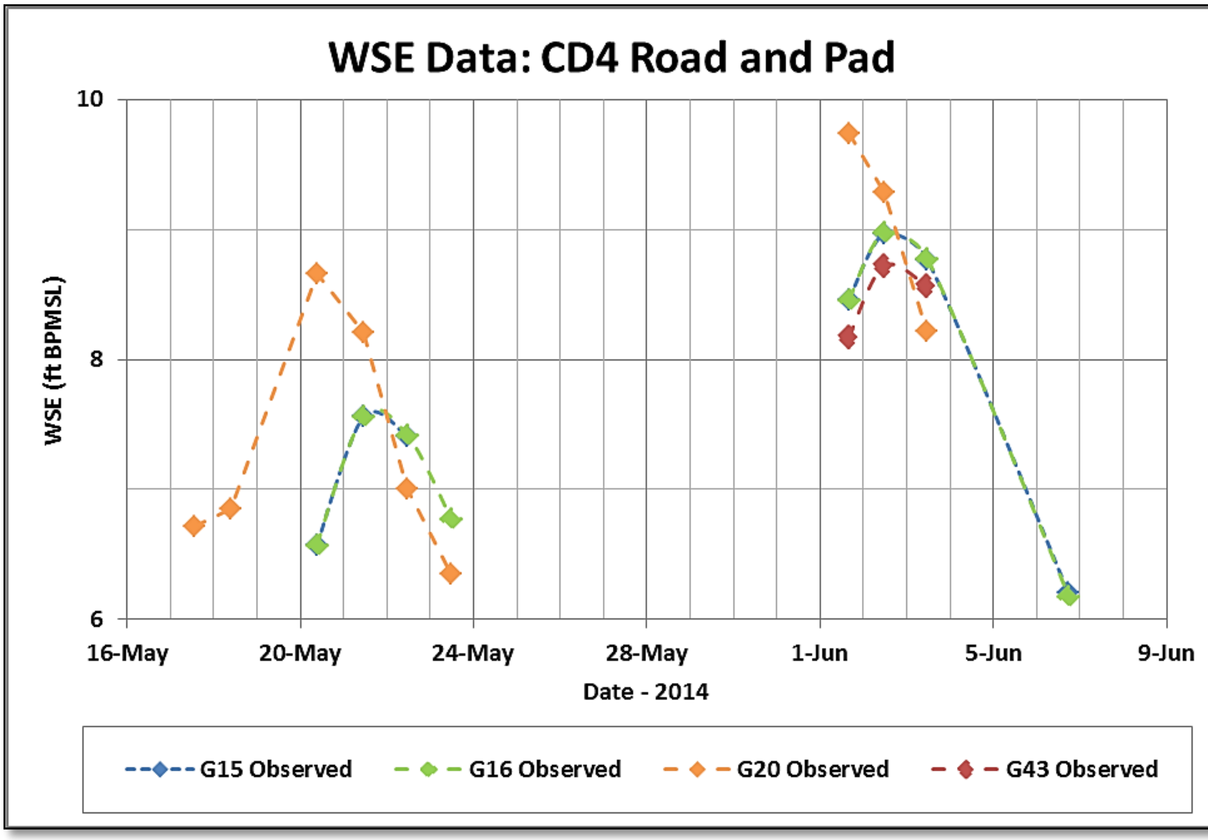
Table 3.9: CD4 Gages 2014 Stage Data and Observations

Date	WSE (feet BPMSL)					Observations
	G15	G16	G19	G20	G43	
17-May	Dry	Dry	Dry	6.72	Dry	
18-May	Dry	Dry	Dry	6.85	Dry	
20-May	6.57	6.57	Dry	8.66	Dry	Floodwater crested at G20
21-May	7.56	7.56	Dry	8.21	Dry	Some CD4 Road culverts conveying flow; floodwater crested
22-May	7.41	7.42	Dry	7.00	Dry	Floodwater receding
23-May	Dry	6.77	11.71	6.35	Dry	Local melt/ponded water at G19
1-Jun	8.46	8.46	Dry	9.74	8.17	Water levels rising around roads and pads; peak stage observed at G20
2-Jun	8.97	8.98	11.81	9.29	8.72	Peak stage observed at G15, G16 and G43; local melt water at G19; no flow observed through CD4 culverts during direct discharge measurements at
3-Jun	8.77	8.78	11.85	8.22	8.56	Local melt/ponded water at G19; floodwater receding
6-Jun	6.20	6.18	Dry	-	Dry	
8-Jun	Dry	Dry	Dry	Dry	Dry	

Note:

1. *Italicized* values are pressure transducer data indicating peak WSE

2. Dash (-) indicates no gage reading collected



Graph 3.9: CD4 Gages 2014 Stage Data

3.6.5 CD5 Road and Pad

Six sets of gages are located along the CD5 road on the north and south sides of the alignment between the CD4 road and the CD5 Pad. One gage set is located on the Nigliq Channel at the bridge crossing location. The observations for these gages (G26/G27) are discussed in the Nigliq Channel section. Gages G24/G25 are located at the north end of Lake L9323 at the bridge crossing. Gages G32/G33 are located on Lake L9341 at the bridge crossing, and gages G38/G39 are located adjacent to the Nigliagvik Channel bridge crossing. Gages G20/G31, G34/G35, and G36/G37 are located on either side of the road and are positioned to capture flow through the CD5 road culverts. Two single gages are located south of the CD5 road and pad; gages S1 and S2 are also positioned to capture flood flows from the culverts.

Local melt was evident on gages G24/G25 along the CD5 road crossing at Lake L9323 throughout the monitoring period. On June 1 and 2 during peak stage on the Nigliq Channel, Lake L9323 was not connected by floodwaters, and wet tundra polygons were evident (Photo 3.15).

At the Lake L9341 upstream gage, G32, WSE steadily increased beginning May 17 from backwater flowing south from the Nigliq Channel to the road crossing. At the downstream gage, G33, two crests were seen similar to other locations along the Nigliq Channel. Floodwaters crested on May 20, and peak stage was observed on June 2. Between June 2 and June 5, the Nigliq Channel was connected to Lake L9341, but the lake was still frozen (Photo 3.16). Direct discharge measurements were not collected at lakes L9323 or L9341 because there was no flowing water.

Photo 3.15: Lake L9323 Local melt , looking north, June 6, 2014

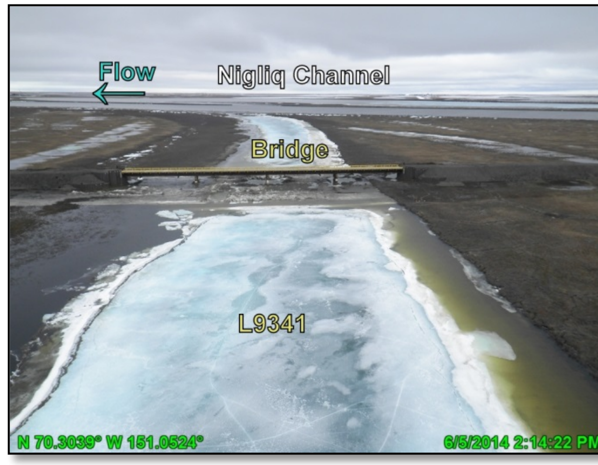


Photo 3.16: Lake L9341 Bridge, looking northeast towards the Nigliq Channel, June 5, 2014

On May 16, the Nigliagvik Channel was connected to the Nigliq Channel at both ends. Floodwaters crested at gages G38 (upstream) and G39 (downstream) adjacent to the bridge on May 20. The channel near the bridge was mostly free of ice except for shorefast ice along the banks on May 24, when the first direct discharge measurement was collected. Floodwaters began to recede on May 21 and continued until May 31, when WSE increased. Peak stage was observed on June 1. An ice jam was located at the mouth of the Nigliagvik Channel near the Nigliq confluence between June 2 and 5. There was no discernable backwater, and floodwaters were conveying around and under the ice jam. On June 6, the ice jam was no longer in place. On June 8, the Nigliagvik Channel was mostly free of ice, with traces of shorefast ice on the west bank at the bridge location (Photo 3.17). A second direct discharge measurement was collected.

Photo 3.17: Nigliagvik Channel Bridge, looking south, June 8, 2014

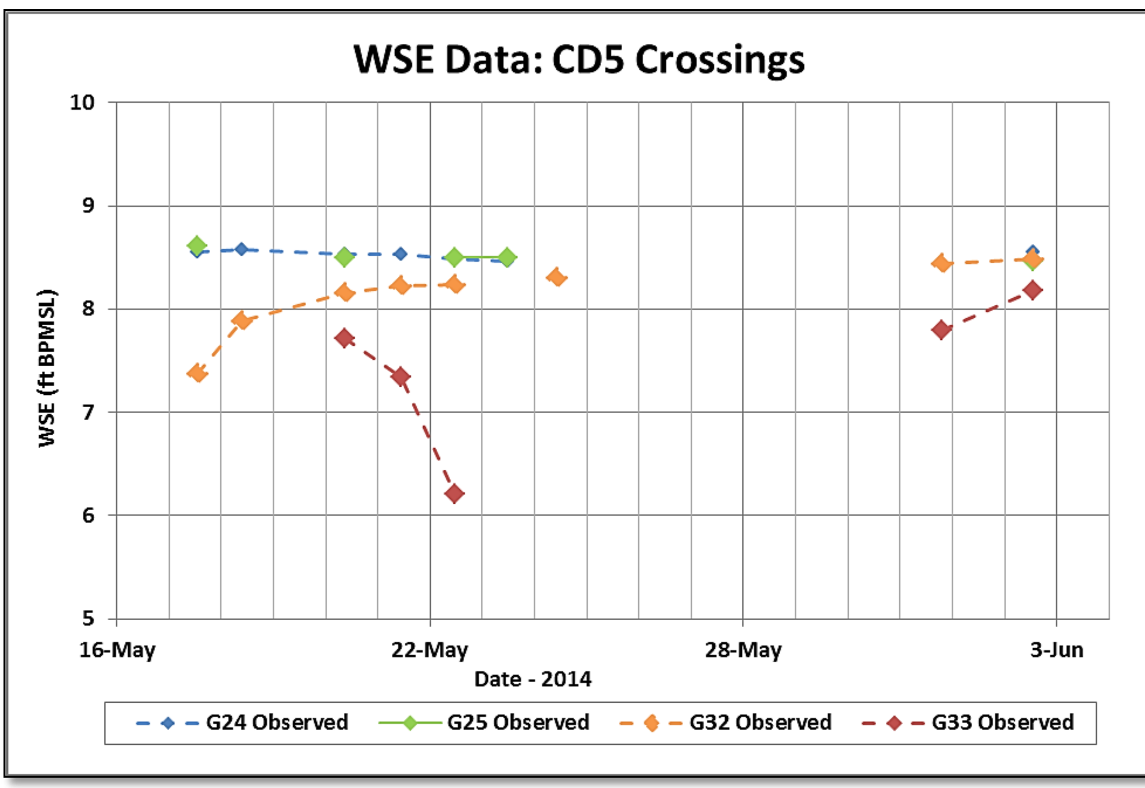
Gages G30/G31, G34/G35, and G36/37 are located along the CD5 road between the Nigliq Channel and CD5 Pad. Gage S1 is located south of Lake MB0301 and the CD5 road, and gage S2 is located south of the CD5 road and pad. WSE collected at these gages show ponding of local melt water with no flow observed through the CD5 road culverts and no floodwater around the road prism. No blockages were observed at any of the culverts. Because no flow was observed through the culverts or around the road, discharge measurements were not collected at the culverts, and an erosion survey was not performed. Photos of breakup conditions along the CD5 road are included in Appendix C.1.

Table 3.10, Table 3.11, and Table 3.12 summarize stage and ice observations during breakup for Lakes L9323 and L9341, the Nigliagvik Channel crossing, and the CD5 road small drainages, respectively. Graph 3.10, Graph 3.11, and Graph 3.12 shows the stage data collected at the CD5 gages. Gage readings at S1 and S2 are not included.

Table 3.10: Lakes L9323 and L9341 2014 Stage Data and Observations

Date	WSE (feet BPMSL)				Observations
	G24	G25	G32	G33	
17-May	8.55	8.61	7.37	Dry	Local melt at Lake L9323 (G24/G25), peak stage observed at G25
18-May	8.58	Dry	7.89	Dry	Local melt at Lake L9323 (G24/G25), peak stage observed at G24
20-May	8.53	8.50	8.16	7.72	Local melt at Lake L9323, floodwater crested at G33
21-May	8.53	Dry	8.23	7.34	Local melt at Lake L9323
22-May	8.48	8.50	8.24	6.21	Local melt at Lake L9323, floodwater crested at G32
23-May	8.46	8.50	-	-	Local melt at Lake L9323
24-May	-	-	8.30	Dry	
31-May	-	-	8.44	7.79	
2-Jun	8.55	8.46	8.48	8.18	Peak stage observed at Lake L9341 crossing (G32/G33)
7-Jun	-	-	Dry	Dry	
11-Jul	-	-	3.84	3.84	Gages dry, WSE surveyed

Note:
Dash (-) indicates no gage reading collected

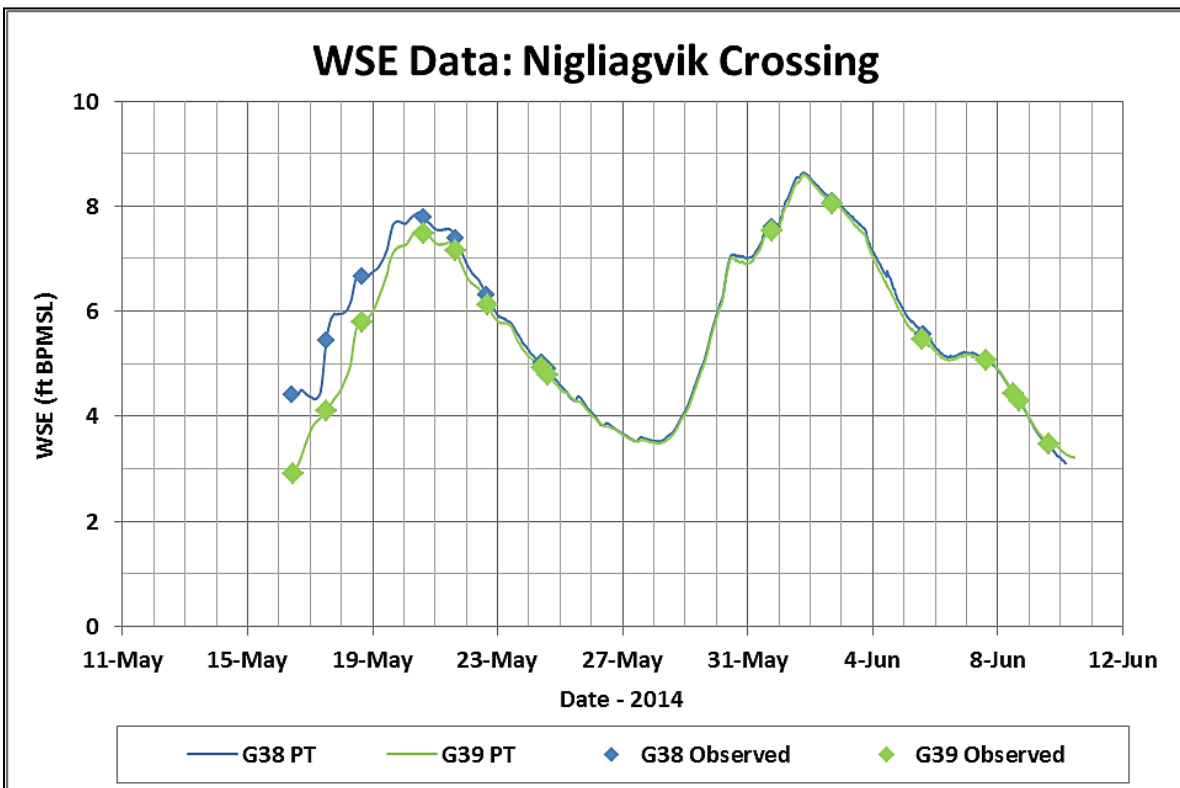


Graph 3.10: Lakes L9323 and L9341 2014 Stage Data

Table 3.11: Nigliagvik Channel Crossing 2014 Stage Data and Observations

Date	WSE (feet BPMSL)		Observations
	G38	G39	
16-May	4.41	2.90	Nigliagvik Channel connected to the Nigliq Channel on both ends; local melt at G38
17-May	5.44	4.10	Local melt at G38
18-May	6.65	5.79	
20-May	7.79	7.48	Floodwater crested
21-May	7.38	7.16	Below freezing air temperatures
22-May	6.30	6.12	
24-May	5.02	4.93	Nigliagvik Channel mostly free of ice, shorefast ice on banks, ice road remnant remains, snow piles on both sides of channel under bridge, direct discharge measurement taken
31-May	7.59	7.52	
1-Jun	*8.64*	*8.61*	Peak stage
2-Jun	8.10	8.05	Intact channel ice on the Nigliq downstream of the Nigliagvik Channel confluence, ice jam at mouth of Nigliagvik Channel with no discernable backwater
5-Jun	5.59	5.46	Ice jam at the mouth of the Nigliagvik Channel; no discernable backwater
7-Jun	5.08	5.06	Snow piles under bridge mostly melted, traces of shorefast ice on west bank, ice jam no longer evident
8-Jun	4.44	4.43	Nigliagvik Channel mostly free of ice; direct discharge measurement taken
9-Jun	3.47	3.46	

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE

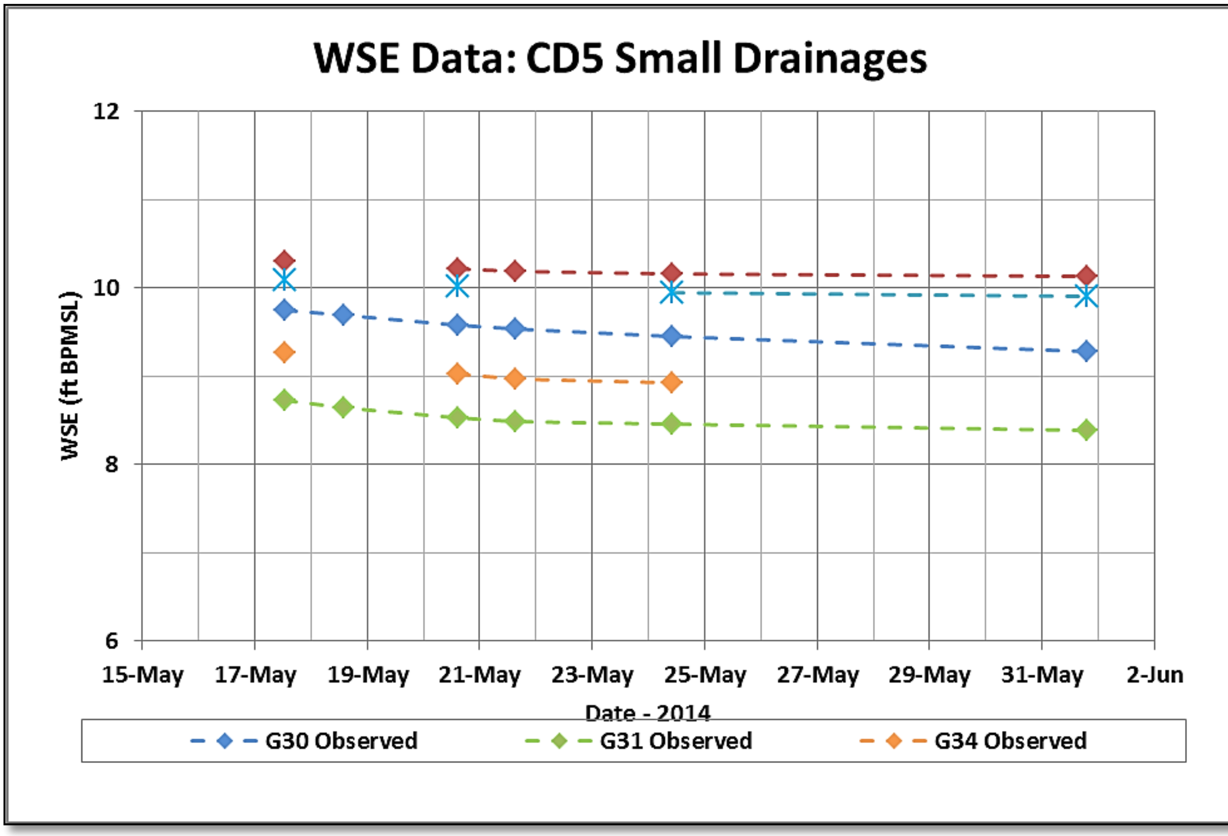


Graph 3.11: Nigliagvik Channel Crossing 2014 Stage Data

Table 3.12: CD5 Road Small Drainages 2014 Stage Data and Observations

Date	WSE (feet BPMSL)						Observations
	G30	G31	G34	G35	G36	G37	
17-May	9.74	8.73	9.26	Dry	10.30	10.09	Peak observed stage; ponded, local melt water
18-May	9.69	8.64	-	-	-	-	Local melt
20-May	9.57	8.53	9.02	Dry	10.21	10.02	Local melt
21-May	9.54	8.49	8.96	-	10.19	-	Local melt
24-May	9.45	8.45	8.93	-	10.16	9.95	Local melt
31-May	9.28	8.38	Dry	Dry	10.13	9.90	Ponded, local melt water

Note:
Dash (-) indicates no gage reading collected



Graph 3.12: CD5 Road Small Drainages 2014 Stage Data

3.6.6 CD3 Pipeline Stream Crossings – SAK, TAM, and ULAM

The CD3 pipeline crosses three channels between CD1 and CD3: Sakoonang, Tamayayak, and Ulamnigiaq. Sakoonang (SAK) gages are located on the southwest bank, Tamayayak (TAM) gages are on the south bank, and Ulamnigiaq (ULAM) gages are on the northeast bank. The gages are located downstream of the pipeline crossings. Observations of breakup processes, effects of flooding on infrastructure, and stage data has been collected at these locations intermittently since 2000.

On May 15, rafted ice was on intact channel ice in the Tamayayak, and on May 16, floodwaters were observed in the Sakoonang and Tamayayak Channels. Breakup floodwaters first reached the TAM and ULAM gages on May 17 and the SAK gages on May 18. There were two ice jams on the Sakoonang Channel on May 18; one was located upstream of the CD1 Pad, and the second was upstream of Lake L9324. Lake L9324 was connected to the Sakoonang Channel via the South Paleo Lake. The Sakoonang Channel was connected to the North and South Paleo Lakes on May 18. On May 19, Lake M9525 was connected to the North Paleo Lake via the Sakoonang Channel. Stage increased steadily until May 21, when below freezing daily air temperatures caused water levels to decrease. Between May 23 and May 26, intact channel ice was in the Sakoonang, Tamayayak, and Ulamnigiaq at the pipeline bridge crossing locations.

Peak stage occurred at the SAK, TAM and ULAM gages on June 2 (Photo 3.18, Photo 3.19, and Photo 3.20, respectively). Small ice jams were present in the Tamayayak and Sakoonang Channels on June 2. Intact channel ice remained at the TAM and SAK gage locations at the pipeline crossings. An ice jam was upstream of the pipeline crossing on the Tamayayak Channel, and the Sakoonang Channel ice was intact by the CD1 Pad. The Sakoonang Channel was connected to the North and South Paleo Lakes and Lake L9282/B8534. On June 3, some intact channel ice was near the pipeline crossing on the Sakoonang Channel, and ice flows were in the Tamayayak Channel. Minimal overbank flooding was noted on the Sakoonang Channel, and the ice jam upstream of the pipeline crossing broke up on June 4. On June 6, floodwaters from Lake L9282/B8534 were observed draining into the Sakoonang Channel.

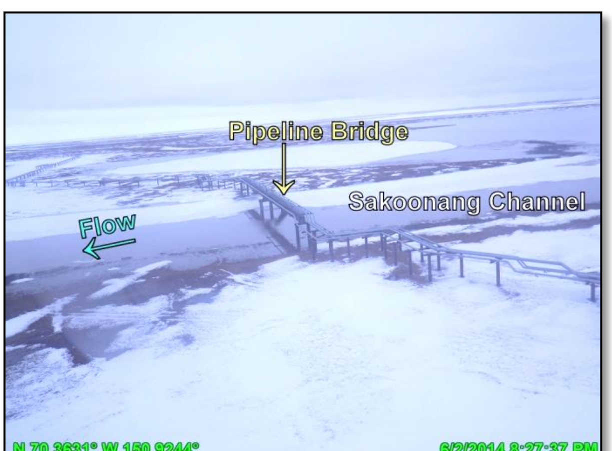


Photo 3.18: Sakoonang Channel pipeline crossing at peak stage, looking northeast; June 2, 2014

Photo 3.19: Tamayayak Channel pipeline crossing at peak stage, looking south; June 2, 2014

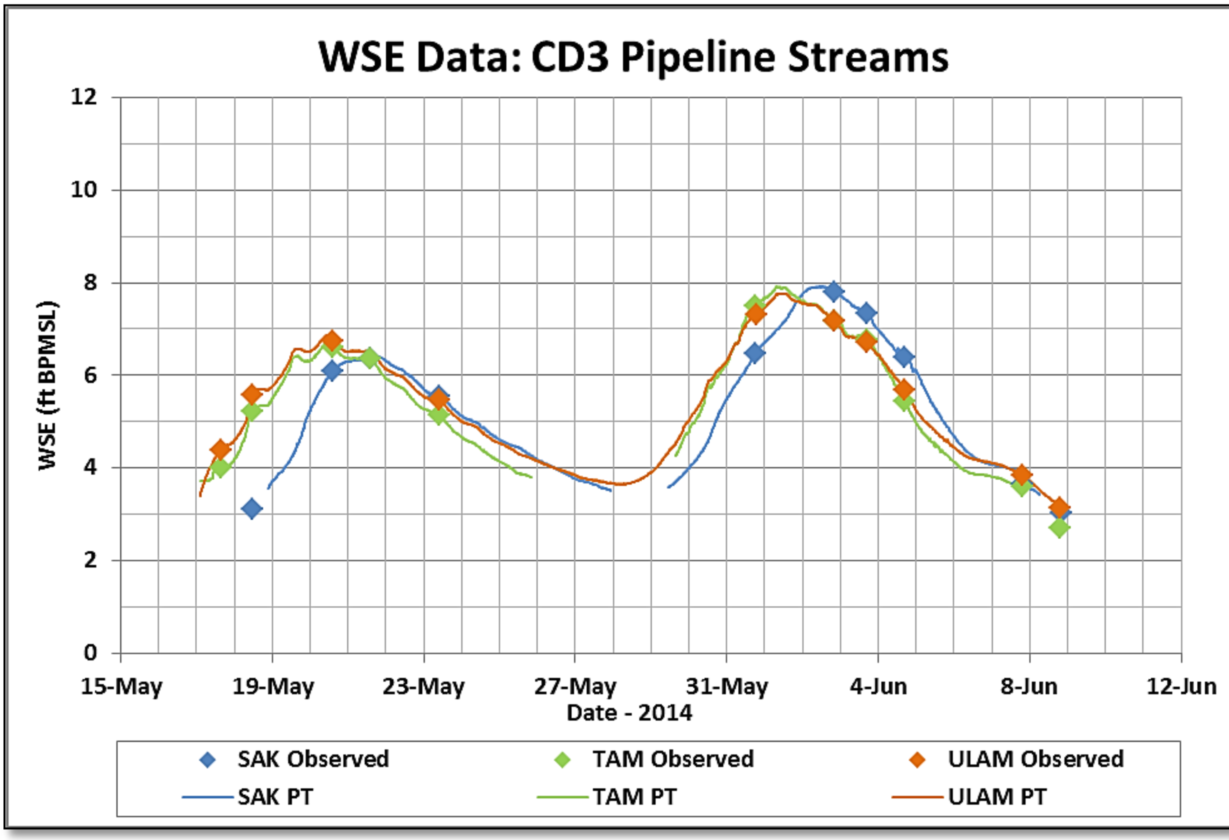
Photo 3.20: Ulamnigiaq Channel pipeline crossing at peak stage, looking north; June 2, 2014

Table 3.13 summarize observations at the Sakoonang, Tamayayak, and Ulamnigiaq Channel gages, and Graph 3.13 shows the stage data collected at the CD3 pipeline stream crossing gages.

Table 3.13: SAK, TAM, and ULAM Gages 2014 Stage Data and Observations

Date	WSE (feet BPMSL)			Observations
	SAK	TAM	ULAM	
17-May	-	4.00	4.40	Water on TAM and ULAM gages
18-May	3.12	5.24	5.55	Water on SAK gages
20-May	6.08	6.60	6.73	Floodwater crested at TAM and ULAM gages
21-May	6.37	6.37	6.50	Floodwater crested at SAK gages; daily air temperatures below freezing persisted through May 31
23-May	5.55	5.15	5.48	
31-May	6.47	7.50	7.31	
2-Jun	*7.92*	*7.92*	*7.77*	Peak stage; small ice jams present in the Tamayayak and Sakoonang channels
3-Jun	7.33	6.78	6.72	Intact channel ice remains at TAM and SAK gages
4-Jun	6.39	5.44	5.68	Ice jam upstream of the SAK gage breaks up
7-Jun	3.66	3.60	3.85	
8-Jun	3.04	2.71	3.14	

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE
2. Dash (-) indicates no gage reading collected



Graph 3.13: SAK, TAM, and ULAM Gages 2014 Stage Data

4.0 DIRECT AND PEAK DISCHARGE

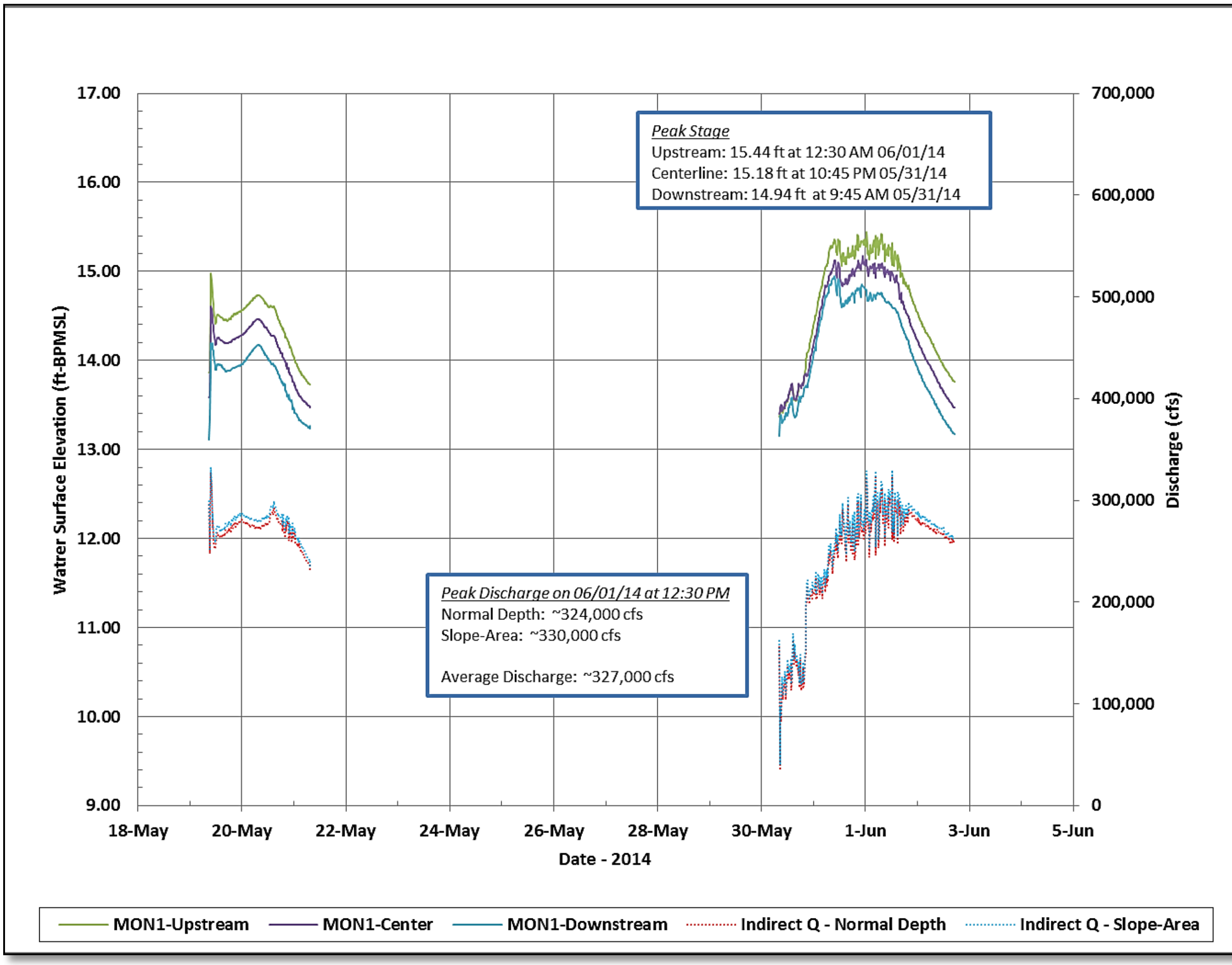
4.1 COLVILLE RIVER - MON1C

On June 4, discharge was measured on the Colville River adjacent to MON1C using an ACDP. Four transects and one loop test were completed during the direct discharge measurement. The corrected discharge, accounting for a moving bed condition, was approximately 180,000 cubic feet per second (cfs), having an average velocity of 4.6 feet per second (fps) with a maximum measured velocity of 8.7 fps, and an associated stage of 11.79 feet BPMSL. The location of the discharge measurement and the cross section geometry at the MON1 location is presented in Appendix B.2.1. A summary of discharge measurements and the WinRiverII output for each transect are presented in Appendix D, D.1.

Peak discharge was estimated using the Normal Depth and Slope-Area methods. The Normal Depth calculation was based on a topographic survey of the channel geometry at MON1C (LCMF 2004) The Slope-Area method used the cross section data at MON1U, MON1C, and MON1D. The MON1 cross-section profiles with peak water levels indicated are located in Appendix B, B.2.1.

The calculated peak discharge was 324,000 cfs and 330,000 cfs for the Normal Depth and Slope-Area methods, respectively. The difference for these two methods is less than 2%. Peak discharge at MON1C is estimated at 327,000 cfs with a corresponding WSE of 14.97 feet BPMSL during the afternoon on June 1.

Peak stage at MON1C occurred approximately 14 hours prior to calculated peak discharge. Graph 4.1 presents the discharge calculations and the WSEs versus time. At the time of calculated peak discharge, the channel was clear of ice except on the west bank where small ice floes were stranded on the shallow mud flats. The high discharge values computed on May 19 were affected by intact channel ice present at the time and are considered an over estimate.



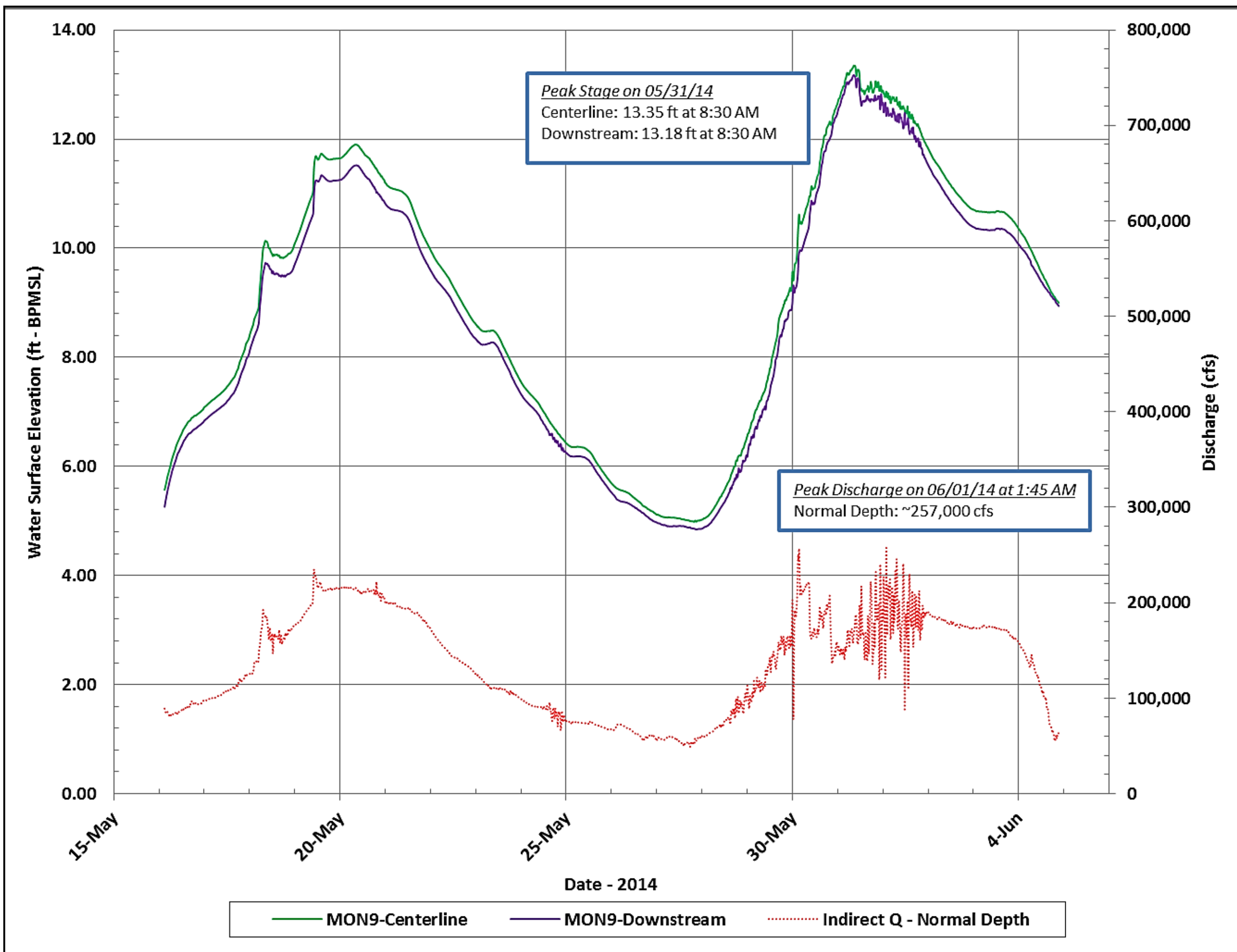
Graph 4.1: MON1 2014 WSE and Reported Discharge versus Time

4.2 Colville East Channel - MON9

Peak discharge was estimated at MON9 on the East Channel of the Colville River using the Normal Depth method. The energy grade-line slope as approximated by the water surface slope from MON9 to MON9D, the 2009 channel cross-section survey at MON9 (LCMF 2009), and WSEs at MON9 were used to calculate the peak discharge (Graph 4.2). The cross-section profile for MON9 with peak water level indicated is located in Appendix B.2.2.

In the afternoon on May 31, the channel at MON9 was almost completely clear of ice. Peak discharge at MON9 is estimated at 257,000 cfs with a corresponding WSE of 12.87 feet BPMSL during the morning on June 1. Peak stage occurred approximately 17 hours prior to peak discharge.

The large discharge values occurring on May 30 are considered an over estimate because of the presence of intact channel ice observed at the time.



Graph 4.2: MON9 2014 WSE and Calculated Discharge versus Time

4.3 CD5 Road Crossings – Lakes L9323, L9341

Lake L9323 remained isolated from floodwater, and as a result, gages G24 and G25 on the north and south side of the L9323 Bridge only recorded local melt. Because no flow was present, peak discharge was not computed.

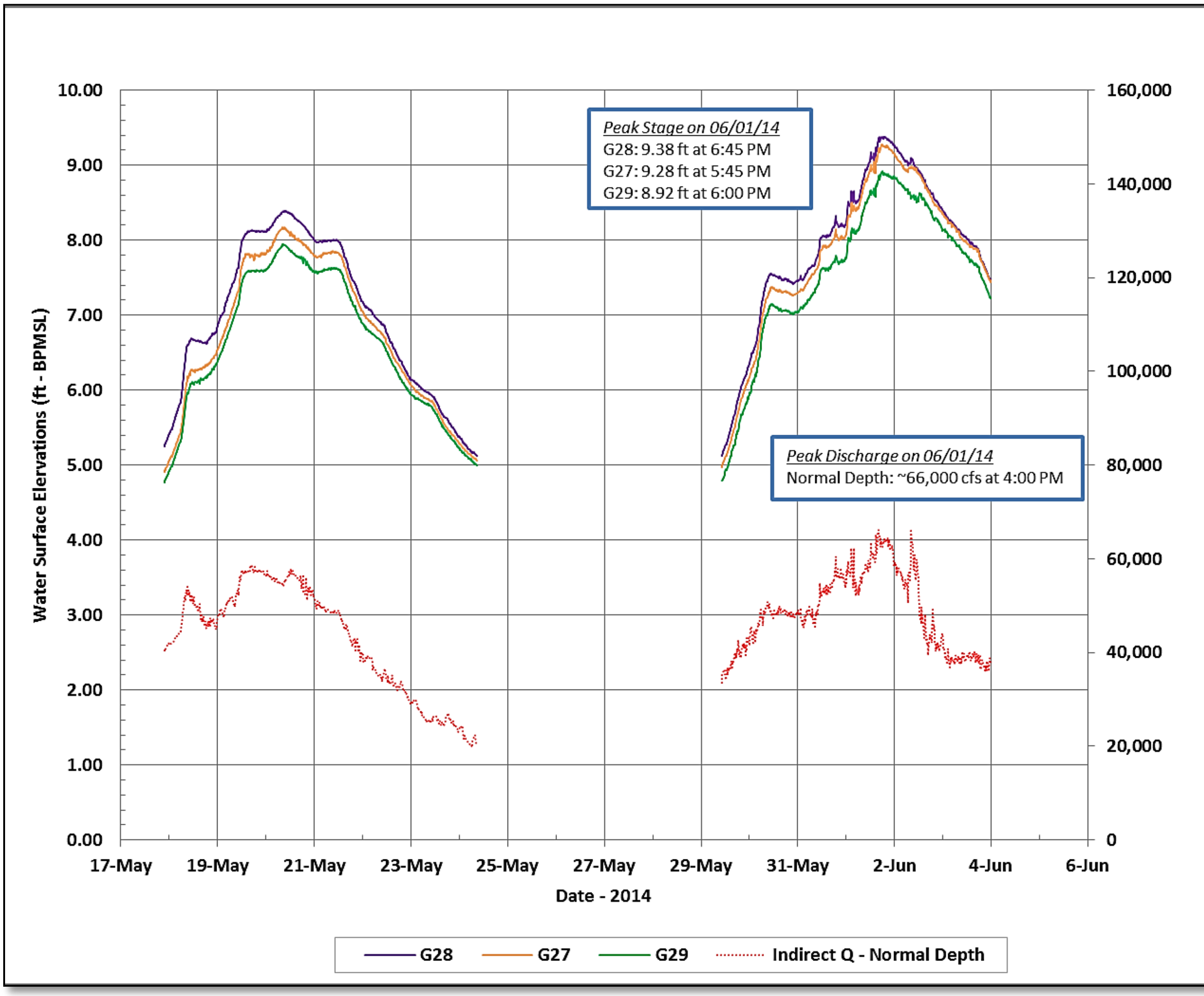
Lake L9341 received floodwater from the Nigliq Channel. The majority of the floodwater was Nigliq Channel backwater flowing south from the confluence downstream of the L9341 Bridge crossing. The remaining flow came from upstream on the Nigliq Channel. Snow and ice remained at the bridge crossing during peak flood conditions. The resulting WSE differential, influenced by snow and ice, yielded computed discharge values that were not representative and are not presented. The cross-section profile for Lake L9323 and Lake L9341 with peak water level indicated is located in Appendix B.3.1 and B.3.2, respectively.

4.4 Nigliq Channel Bridge - Gages G27/28/29

On June 5, discharge measurements were conducted on the Nigliq Channel downstream of the bridge. At the time of measurements, the channel was clear of ice. Four transects and one loop test were completed during the measurement. The discharge, accounting for the moving bed condition, was approximately 30,700 cfs, having an average velocity of 2.6 fps with a maximum measured velocity of 5.1 fps, and an associated stage of 5.61 feet BPMSL. The location of the discharge measurement and channel profile at the gage G27 location is presented in Appendix B.3.3. A summary of direct discharge measurements and the WinRiverII output for each transect are presented in Appendix D.2.

Peak discharge was estimated using the Normal Depth method. The energy grade-line slope as approximated by the water surface slope between gages G27, G28, and G29, WSEs at G27, and a cross-section survey from 2014 (LCMF 2014b) of the channel located just north of the bridge centerline (Graph 4.3) were used. The cross-section profile with peak water level indicated is located in Appendix B.3.3.

The calculated peak discharge was 66,000 cfs with a corresponding stage of 9.20 feet BPMSL during the afternoon on June 1. Intact channel ice covered the majority of the channel upstream from the bridge piers impacting flow. A correction factor was applied to the peak discharge calculation to account for the increase in resistance from the ice cover, reducing the calculated discharge (Chow 1959). This correction makes the assumption that the channel's cross-sectional area did not decrease because of the channel ice. In reality, the cross-sectional area is reduced by the channel ice, further decreasing the discharge.

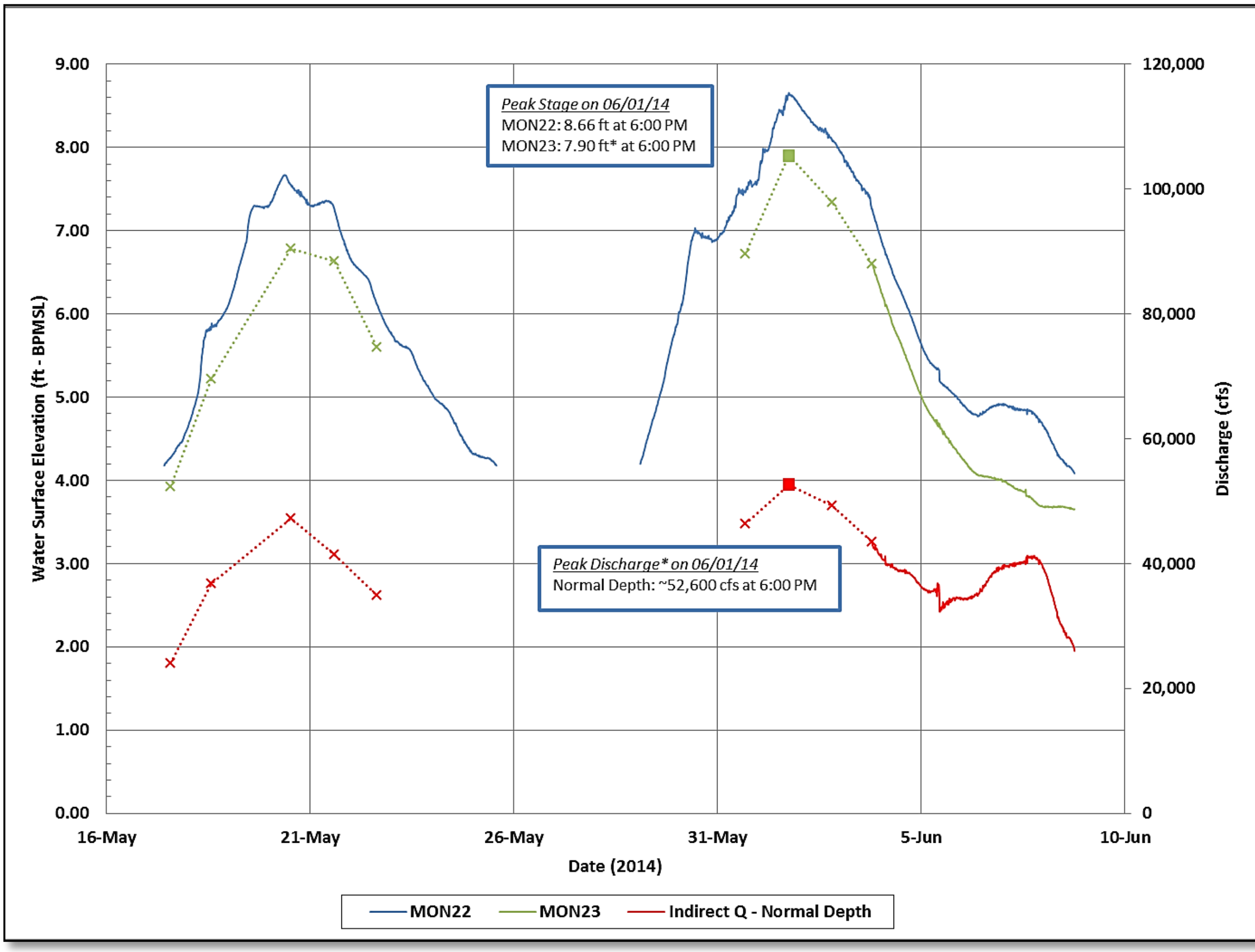


Graph 4.3: Nigliq Channel Bridge 2014 WSE and Calculated Discharge versus Time

4.5 Nigliq Channel – Downstream of Nigliq Channel Bridge – MON23

Peak discharge was estimated for the Nigliq Channel at MON23 using the Normal Depth method. The energy grade-line slope as approximated by the water surface slope from MON22 to MON23, WSEs at MON23, and the 2005 LCMF channel cross-section survey were used in the discharge calculations (LCMF 2005) (Graph 4.4). Observed WSEs were used to calculate discharge in the absence of PT data at MON23. HWMs were collected from the gages on June 2 and were used in the peak discharge calculation.

The calculated peak discharge was approximately 52,600 cfs and occurred during the evening on June 1. The cross-section profile with peak WSE indicated is located in Appendix B.4.



Graph 4.4: MON22 and MON23 2014 WSE and Calculated Discharge versus Time

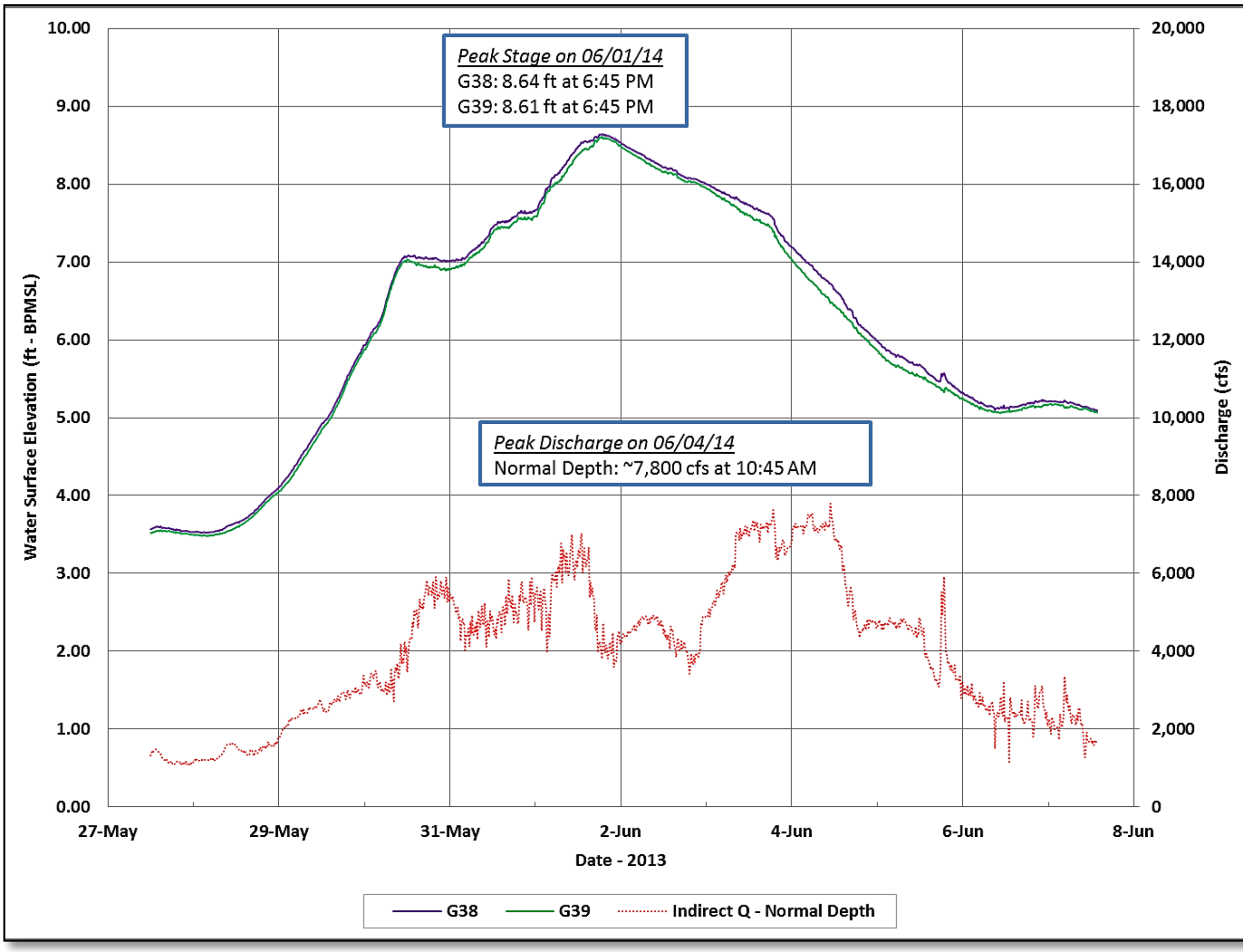
4.6 NIGLIAGVIK CHANNEL BRIDGE – GAGES G38/39

Discharge was measured at the Nigliagvik Channel Bridge crossing on May 24 and June 8. On May 24, measured discharge was 307 cfs with a corresponding stage of 4.9 feet BPMSL. The measurement was rated poor because of large amounts of snow and ice remaining in the channel. On June 8, measured discharge was 1,378 cfs with a corresponding stage of 4.36 feet BPMSL. The measurement was rated fair because of an ice shelf and snowpack extending over the west side of the channel. The snowpack was not observed impeding flow, but did prevent measurements at the west end of the cross section. The discharge measurement data is located in Appendix E.1.

Peak discharge was estimated using the Normal Depth method. The energy grade-line slope as approximated by the water surface slope from G38 to G39, WSEs at G38, and the 2014 LCMF channel cross-section survey were used along with the upstream topographic survey cross-section (LCMF 2014c). The cross-section profile with peak WSE indicated is located in Appendix B.3.4.

Peak discharge was approximately 7,800 cfs with corresponding stage of 6.72 feet BPMSL at 10:45 AM on June 4. Peak stage occurred on June 1 at 6:45 PM with a water level of 8.64 feet BPMSL (Graph 4.5).

The long duration between peak stage and peak discharge is likely in response to water levels in the Nigliq Channel. High water levels in the Nigliq Channel impede flow at the Nigliagvik Channel confluence resulting in elevated water levels and low water surface gradient. When the Nigliq Channel water levels drop, the Nigliagvik Channel will drain, and consequently, discharge will increase. Additionally, ice and snow was likely still present in the channel on June 1 when peak stage occurred.



Graph 4.5: Nigliagvik Channel Bridge 2014 WSE and Calculated Discharge versus Time

4.7 CD2 Road Swale Bridges

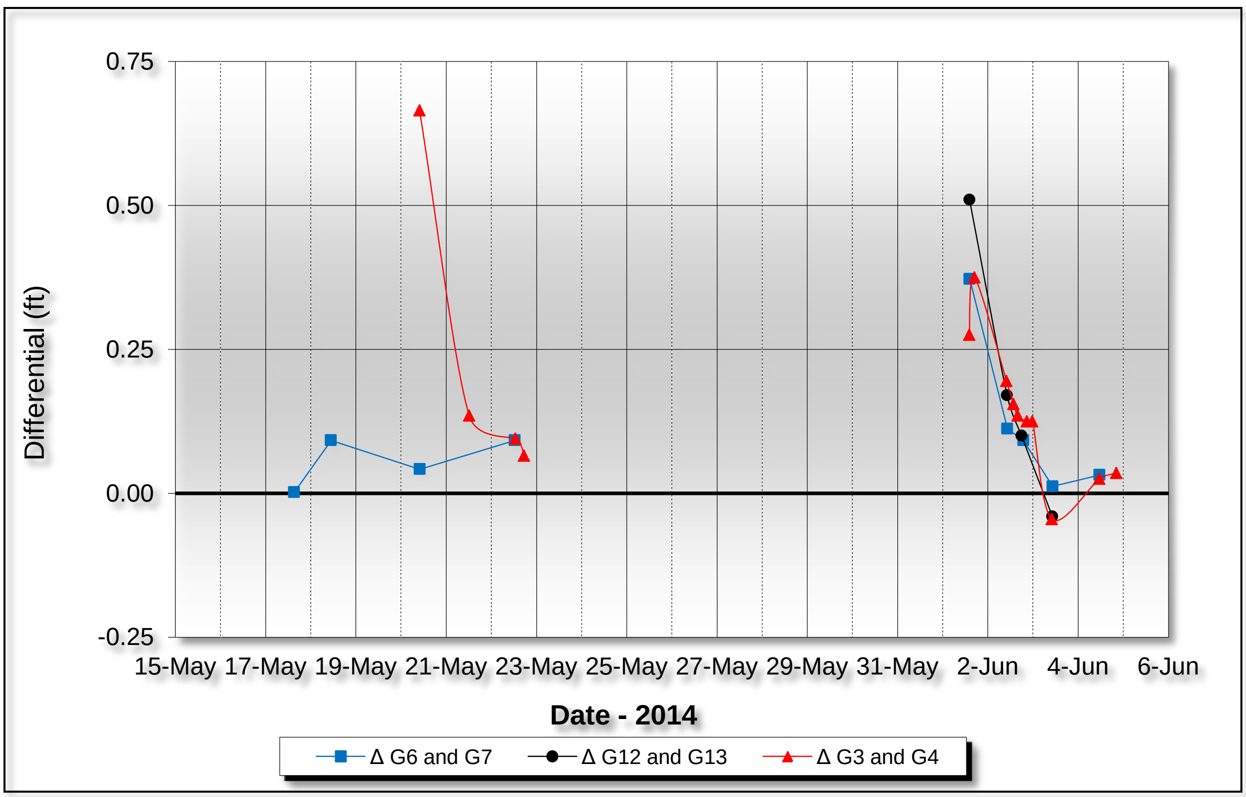
Discharge was measured at the Long Swale Bridge on May 22 and on June 2. On May 22, measured discharge was 700 cfs with a corresponding stage of 6.01 feet BPMSL and average velocity of 0.55 fps. On June 2, the measured discharge was 2,840 cfs with a corresponding stage of 7.95 feet BPMSL and average velocity of 1.30 fps. Discharge was measured at the Short Swale Bridge on June 2. The measured discharge was approximately 480 cfs with a corresponding stage of 7.86 feet BPMSL and an average velocity of 1.3 fps. Discharge was not measured at the Short Swale Bridge on May 22 because only local melt was present. The data collection forms for the discharge measurements are located in Appendix E.2.

Peak discharge was estimated at the swale bridges during peak stage. Peak stage occurred near the time of greatest WSE differential between gages G3 (headwater) and G4 (tailwater); therefore, peak discharge occurred around the time of peak stage. On the morning of June 2, the peak observed stage was 8.18 feet BPMSL on gage G3, and the corresponding peak discharge was calculated at 2,900 cfs for the Long Swale Bridge and 500 cfs for the Short Swale Bridge. The peak discharge estimates are approximately 5% greater than the measured discharge on the evening of June 2. Drainage structure locations are shown in Appendix B.5.

4.8 CD2 Road Culverts

Discharge measurements were collected at the CD2 road culverts on May 22 and June 2; only four culverts were conveying water on May 22. On June 2, the culverts were clear of snow and ice at the inlet and outlet. Measured discharge through the CD2 road culverts totaled 212 cfs. Velocities ranged from zero to 2.3 fps with an average velocity of 1.4 fps. The discharge summary for each culvert is presented in Appendix F.

Peak discharge was estimated at the CD2 road culverts using WSE data from the gages located in the vicinity of the culverts. Gages G6 and G7 were used to calculate discharge for culverts CD2-1 through CD2-8. Gages G12 and G13 were used to calculate discharge for culverts CD2-9 through CD2-18. Gages G3 and G4 were used to calculate discharge for culverts CD2-19 through CD2-26. Peak discharge calculations are dependent on the WSE differential between the headwater and tailwater elevation at the culvert. The WSE differential for the CD2 road gages is presented in Graph 4.6. Drainage structure locations are shown in Appendix B.5.



Graph 4.6: CD2 Road WSE Differential

Peak discharge for the CD2 road culverts was calculated at approximately 430 cfs on the afternoon of June 1. At the time of peak discharge, culverts CD2-1 to CD2-8 (near gages G6 and G7) were conveying 43% of the total discharge and also had the highest average velocity at 3.59 fps. Appendix F contains additional CD2 road culvert discharge data including a summary of calculated peak discharge and corresponding velocities, a comparison of stage with total discharge and average velocity, and the calculated discharge and velocity data.

Table 4.1 through Table 4.3 compares the velocity and discharge for each culvert between the direct discharge measurements and the indirect discharge calculations. The percent difference between the calculated peak discharge and the measured discharge is also presented.

Table 4.1: CD2 Road Culverts near G6/G7, Direct Measurement/Calculated Discharge Comparison

Culvert	Direct Measurement			Calculated			Percent Difference	
	Time of Measurement June 2	Measured Velocity (ft/s)	Direct Discharge (cfs)	Time of Indirect Calculation June 2	Velocity (ft/s)	Discharge (cfs)	Velocity (ft/s)	Discharge (cfs)
CD2-1	7:09 PM	-	-	6:56 PM	1.89	10.16	-	-
CD2-2	7:03 PM	1.97	10.04	6:56 PM	1.75	9.31	-11%	7%
CD2-3	7:00 PM	0.61	5.04	6:56 PM	0.80	0.09	31%	98%
CD2-4	6:54 PM	1.23	12.40	6:56 PM	1.75	17.41	43%	-40%
CD2-5	6:51 PM	1.35	12.96	6:56 PM	1.70	16.07	26%	-24%
CD2-6	6:48 PM	1.40	13.94	6:56 PM	1.65	16.80	18%	-20%
CD2-7	6:45 PM	1.21	9.53	6:56 PM	1.68	17.54	39%	-84%
CD2-8	6:41 PM	2.10	14.03	6:56 PM	1.75	11.58	-17%	17%
Average Measured Velocity (ft/s)			**1.41**	**Avg. Calculated Velocity (ft/s)**		**1.62**	**Avg. V Diff.**	**15%**
Total Measured Discharge (cfs)			**77.94**	**Total Calculated Discharge (cfs)**		**98.96**	**Tot. Q Diff.**	**27%**

Table 4.2: CD2 Road Culverts near G12/G13, Direct Measurement/Calculated Discharge Comparison

Culvert	Direct Measurement			Calculated			Percent Difference	
	Time of Measurement June 2	Measured Velocity (ft/s)	Direct Discharge (cfs)	Time of Indirect Calculation June 2	Velocity (ft/s)	Discharge (cfs)	Velocity (ft/s)	Discharge (cfs)
CD2-9	6:33 PM	0.80	2.57	5:56 PM	1.81	5.60	125%	118%
CD2-10	6:27 PM	0.56	2.77	5:56 PM	1.63	7.39	191%	166%
CD2-11	6:21 PM	1.25	6.79	5:56 PM	1.74	8.44	39%	24%
CD2-12	6:13 PM	0.35	3.16	5:56 PM	1.72	12.17	395%	285%
CD2-13	6:05 PM	1.63	11.98	5:56 PM	1.40	9.73	-14%	-19%
CD2-14	5:47 PM	1.28	9.67	5:56 PM	1.44	11.21	13%	16%
CD2-15	5:04 PM	1.53	6.57	5:56 PM	1.91	7.77	25%	18%
CD2-16	4:57 PM	-	-	5:56 PM	-	-	-	-
CD2-17	4:56 PM	-	-	5:56 PM	-	-	-	-
CD2-18	4:54 PM	-	-	5:56 PM	1.36	1.76	-	-
Average Measured Velocity (ft/s)			1.06	**Avg. Calculated Velocity (ft/s)**		1.63	**Avg. V Diff.**	54%
Total Measured Discharge (cfs)			43.52	**Total Calculated Discharge (cfs)**		64.07	**Tot. Q Diff.**	47%

Table 4.3: CD2 Road Culverts near G3/G4, Direct Measurement/Calculated Discharge Comparison

Culvert	Direct			Indirect			Percent Difference	
	Time of Measurement June 2	Measured Velocity (ft/s)	Direct Discharge (cfs)	Time of Indirect Calculation June 2	Velocity (ft/s)	Discharge (cfs)	Velocity (ft/s)	Discharge (cfs)
CD2-19	4:52 PM	-	-	3:56 PM	-	-	-	-
CD2-20	4:47 PM	2.31	12.69	3:56 PM	1.91	10.84	-17%	-15%
CD2-21	4:41 PM	1.93	16.66	3:56 PM	1.92	16.84	0%	1%
CD2-22	4:33 PM	2.00	18.42	3:56 PM	2.00	17.78	0%	-3%
CD2-23	4:25 PM	1.95	22.24	3:56 PM	2.03	22.67	4%	2%
CD2-24	4:18 PM	1.72	20.69	3:56 PM	1.99	23.63	16%	14%
CD2-25	9:13 PM	-	-	8:39 PM	-	-	-	-
CD2-26	9:16 PM	-	-	8:39 PM	-	-	-	-
Average Measured Velocity (ft/s)			1.98	**Avg. Calculated Velocity (ft/s)**		1.97	**Avg. V Diff.**	-1%
Total Measured Discharge (cfs)			90.70	**Total Calculated Discharge (cfs)**		91.76	**Tot. Q Diff.**	1%

4.9 CD4 Road Culverts

Discharge measurements were taken at the CD4 road culverts. The majority of the culverts remained dry because of low floodwater levels. The CD4-20 and CD4-23 culvert batteries received some floodwater from Lake M9525, but no differential in WSEs was observed on gages G15 and G16 and discharge was not computed.

On May 22 and June 2, there was no differential in WSE elevation between G15 and G16, and no flow was noted during discharge measurements at the CD4 road culverts. Drainage structure locations are shown in Appendix B.5.

4.10 CD5 Road Culverts

Only water from local melt reached gage sets G30/G31, G34/G35, and G36/G37 during spring breakup. Floodwater was not observed through the culverts or around the road prism; therefore, discharge measurements were not collected, and peak discharge calculations were not performed. Drainage structure locations are shown in Appendix B.5. Appendix C.1 contains photos documenting breakup conditions along the CD5 road.

5.0 ALPINE ROAD EROSION SURVEY

The Alpine gravel pads and access roads were inspected for erosion on June 8 following peak stage. The erosion survey identifies HWMs using debris stranded on the road prism side slopes or where silts and fine-grained sands have been washed away.

Other than minor high water scarp and runoff effects at delineators, no discernable erosion was observed during visual inspections of the CD2 and CD4 gravel road prisms. A prominent erosion line from the 2013 spring breakup was evident. Floodwaters did not reach the CD5 road prism or pad; therefore, an erosion survey was not conducted. Signs of erosion were not visible during aerial and ground reconnaissance. Photo 5.1 shows ponded water typical of breakup conditions along the CD5 road, and Photo 5.2 and Photo 5.3 show conditions during the road erosion survey along the CD2 and CD4 roads, respectively. Additional photo documentation of erosion surveys and breakup conditions along the CD5 road are shown in Appendix C.2.

Photo 5.1: CD5 Road culverts adjacent to Gage S1, ponded local melt water with no observed flow, looking north; June 5, 2014

Photo 5.2: CD2 Road Erosion Survey, looking north; June 8, 2014

Photo 5.3: CD4 Road Erosion Survey; June 8, 2014

6.0 BATHYMETRY AND SCOUR MONITORING

6.1 CHANNEL BATHYMETRY

Pre-construction topographic and bathymetric baseline surveys were performed in 2013 at the Nigliq Channel, Lake L9341, and Nigliagvik Channel Bridge locations. Transect layouts and bathymetric cross sections are provided in Appendix G. Four transects were surveyed at each bridge crossing (Table 6.1) in August 2014.

Table 6.1: 2014 Channel Bathymetry Transects

Bridge Crossing	Transect No.
Nigliq Channel	7-10
Lake L9341	36-39
Nigliagvik Channel	24-27

Spring breakup floodwater did not reach the bridge abutments or adjacent road embankments. Therefore, the observed change in channel bathymetry is not the result of flow contraction or expansion associated with the bridge opening.

The maximum observed channel scour and deposition for the Nigliq Channel, Lake L9341, and Nigliagvik Channel were:

- **Nigliq Channel:** The maximum observed channel scour of 12.6 feet was at station 7+70 along transect 10. The maximum observed deposition was 4.0 feet at station 8+79 along transect 8.
- **Lake L9341:** The maximum observed channel scour of 2.0 feet was at station 1+52 along transect 36. The maximum observed deposition was 1.8 feet at station 2+20 also along transect 36.
- **Nigliagvik Channel:** The maximum observed channel scour of 3.5 feet was at station 1+00 along transect 25. The maximum observed deposition was 3.6 feet at station 0+60 along transect 26.

The data suggests the lowering of the Nigliq Channel bed in response to a change in local flow dynamics near the bridge. The floating construction ice pad, situated in the channel and around the piers (Photo 6.1), caused vertical channel contraction, accelerating flow through the constriction below the ice. Flow vectors were likely directed toward the channel bed at the abrupt change in ice thickness associated with the upstream edge of the floating ice pad situated near transect 10. This is similar to the flow hydraulics at the upstream terminus of an ice or debris jam where the plunging flows can result in large depressions in the channel bed parallel to the constricting edge. In general, as the distance from the upstream terminus causing plunging flow increases, the flow vectors realign with the stream bed, reducing the erosive forces further downstream (Baker 2013b). The observed change in channel bathymetry is considered a response to short term impacts from the bridge construction pad and not attributed to the presence of CD5 infrastructure.

Photo 6.1: Nigliq Channel Bridge pilings at slotted construction ice pad, looking north; May 16, 2014

6.2 CD5 Pier Scour Elevations

Pier scour elevations were collected at the Nigliq and Nigliagvik Channels during direct discharge measurements to assess scour conditions during the spring breakup flood event in June 2014. Post-breakup surveys of the scour holes at the base of individual piers at the Nigliq Channel, Lake L9341, and Nigliagvik Channel were completed in August 2014 (LCMF 2014b,c). Scour holes were surveyed around the perimeter of each pier to define the depth and general shape of the depression.

6.2.1 Nigliq Channel

A minimum pier scour elevation of -28 feet BPMSL was observed at Pier 5. The scour elevation is 0.9 feet above the 50-year design scour elevation and 5.0 feet above the 200-year design scour elevation. A comparison of design and observed scour depths and elevations are presented in Table 6.2. Post-breakup contour plots around the piers are available in Appendix G. The pier scour associated with the relatively low recurrence interval discharge is likely attributed to the close proximity of piers to the upstream terminus of the construction ice pad. Piers 6, 7 and 8 were exposed to minimal floodwater during spring breakup and were not influenced by the construction ice pad, and were excluded from the surveys. Post-breakup contour plots around the piers are available in Appendix G.1.

Table 6.2: Nigliq Channel Bridge Comparison of Design and Observed Scour Depths and Elevations

Nigliq Channel Pier Scour		
During breakup 2014		**Elevation (ft BPMSL)[1]**
Pier 2		-19.1
Pier 3		-22.6
Pier 4		-21.8
Pier 5		-27.0
Post breakup 2014		**Elevation (ft BPMSL)[2]**
Pier 2		-18.5
Pier 3		-23.5
Pier 4		-22.0
Pier 5		-28.0
Design 2013[3]		**Elevation (ft BPMSL)[4]**
50-year	Piers 2-6	-28.9
	Piers 7-8	-7.1
200-year	Piers 2-6	-33.0
	Piers 7-8	-16.4

Notes:
1. Minimum channel bed elevations recorded by Baker in June 2014
2. Minimum channel bed elevations recorded by LCMF in August 2014
3. Design values presented in PND 2013
4. Elevations based on LCMF 2008 survey

6.2.2 Lake L9341

Ice remained at the bridge crossing during breakup and pier scour elevations were not measured.

The post-breakup minimum pier scour elevation of -1.2 feet BPMSL was observed at Pier 4. The scour elevation is 6.1 feet above the 50-year design scour elevation and 19.5 feet above the 200-year design scour elevation. A comparison of design and observed scour depths and elevations are presented in Table 6.3. Post-breakup contour plots around the piers are available in Appendix G.2.

Table 6.3: Lake L9341 Bridge Comparison of Design and Observed Scour Depths and Elevations

Lake L9341 Pier Scour	
Post breakup 2014	**Elevation (ft BPMSL)[1]**
Pier 2	2.0
Pier 3	3.5
Pier 4	-1.2
Design 2013[2]	**Elevation (ft BPMSL)[3]**
50-year	-7.3
200-year	-20.7

Notes:
1. Minimum channel bed elevations recorded by LCMF in August 2014
2, Design values presented in PND 2013
3. Elevations based on LCMF 2008 survey

6.2.3 NIGLIAGVIK CHANNEL

The minimum pier scour elevation of -4.0 feet BPMSL was observed at Pier 4. The scour elevation is 10.2 feet above the 50-year design scour elevation and 17.8 feet above the 200-year design scour elevation. A comparison of design and observed scour depths and elevations are presented in Table 6.4. Post-breakup contour plots around the piers are available in Appendix G.3.

Table 6.4: Nigliagvik Channel Bridge Comparison of Design and Observed Scour Depths and Elevations

Nigliagvik Pier Scour	
During breakup 2014	**Elevation (ft BPMSL)[1]**
Pier 3	-2.0
Pier 4	-3.3
Post breakup 2014	**Elevation (ft BPMSL)[2]**
Pier 3	-3.0
Pier 4	-4.0
Design 2013[3]	**Elevation (ft BPMSL)[4]**
50-year	-14.2
200-year	-21.8
Notes: 1. Minimum channel bed elevations recorded by Baker in June 2014 2. Minimum channel bed elevations recorded by LCMF in August 2014 3. Design values presented in PND 2013 4. Elevations based on LCMF 2008 survey	

7.0 ICE ROAD CROSSINGS DEGRADATION

Ice roads are constructed annually for supply delivery and transportation of equipment. Ice pads are used to facilitate construction. During the winter of 2013-2014, ice roads were constructed across several drainages and channels. Ice road crossings are mechanically slotted at the conclusion of the season to facilitate melt and the progression of breakup flooding.

Aerial surveys were conducted to observe and photo-document the progression of melt and degradation of the ice road crossings and construction ice pad (see Appendix C.3). Observations were conducted at the following ice road crossings and ice pads:

- Colville East Channel
- Kachemach River
- Nigliagvik Channel
- Nigliq Channel
- No Name Creek
- Pineapple Gulch
- Silas Slough
- Slemp Slough
- Tamayayak Channel
- Toolbox Creek
- Nigliq Channel Bridge Construction
- Nigliagvik Channel Bridge Construction
- Lake L9341 Bridge Construction
- Lake L9323 Bridge Construction

In general, ice road crossings melted at approximately the same rate as channel ice. During the first crest, floodwaters passed freely over the intact channel ice and ice road crossings. By the time peak WSE occurred, the ice road crossing, along with the channel ice, had cleared out. Photo 6.1 shows the slotted construction ice pad at the Nigliq Channel Bridge. Additional photos are shown in Appendix C.3.

8.0 BREAKUP TIMING AND MAGNITUDE

Colville River breakup monitoring has been ongoing since 1962. The timing and magnitude of breakup has been determined consistently since 1992 by measuring water surface elevations and discharge at established locations throughout the delta.

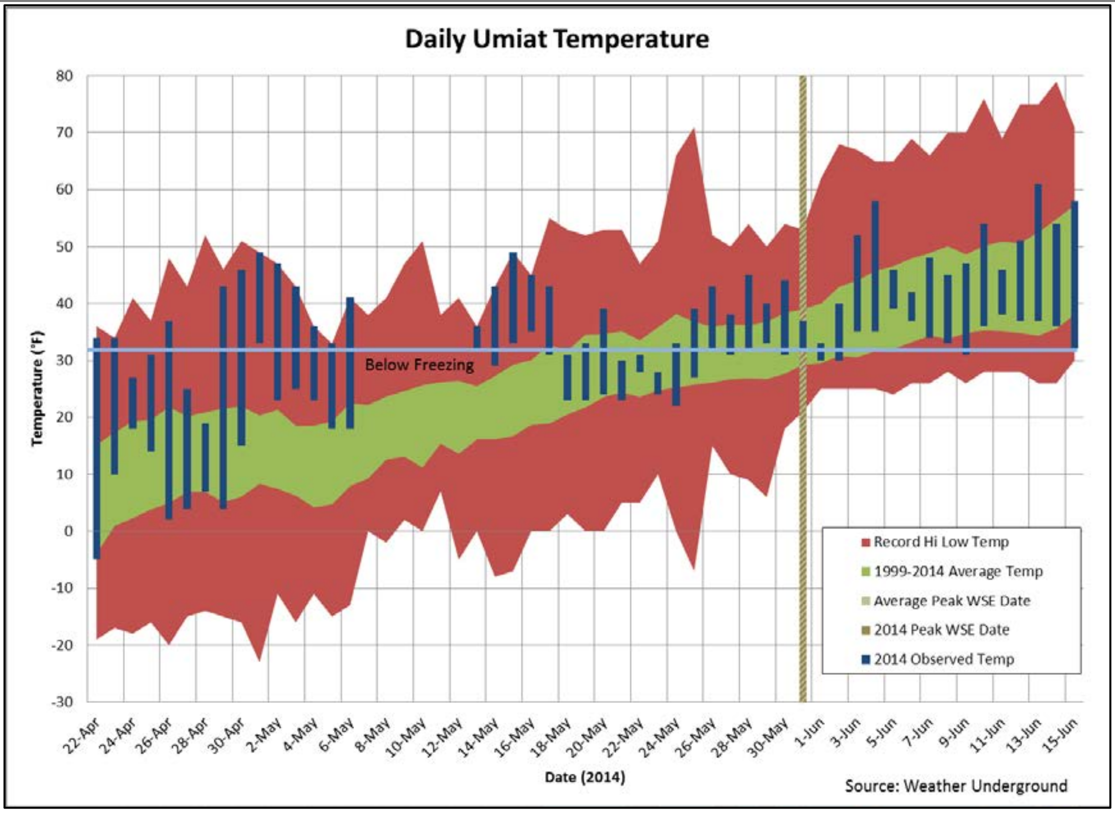
The daily high and low ambient air temperatures are used in the evaluation of breakup timing. The winter of 2013-2014 was the warmest on record for the past 13 years; the coldest was 2011-2012 (ICE 2014). Snow pack north of the Brooks Range was average, and south of the Brooks Range was below average. Spring temperatures in 2014 were above average, and warm weather during the first week of May caused snow and ice to rapidly melt in place. The warm weather was followed by below average temperatures and the recession of flood waters. A warming trend at the end of May and early June created a second crest in flood waters.

8.1 TEMPERATURES

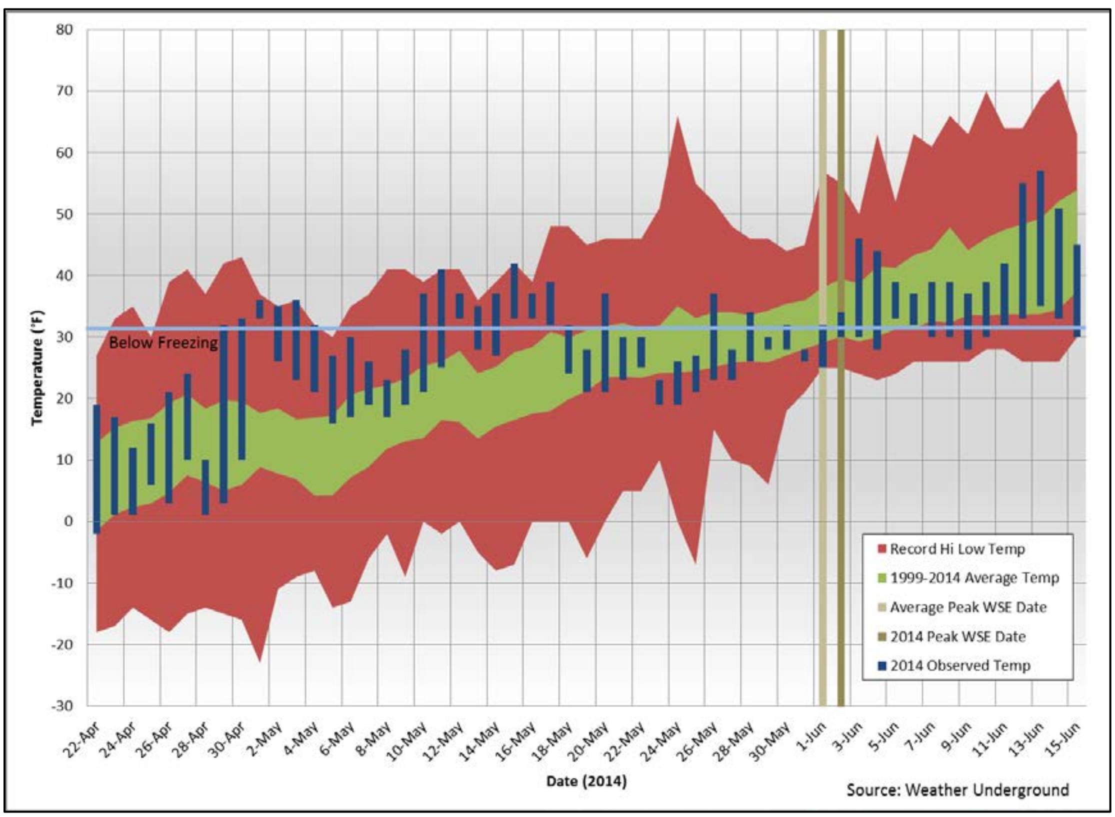
The Umiat USGS gaging station and web camera is located on the Colville River approximately 93 RM upstream of MON1. The stage and discharge data from this station represents conditions upstream of the CRD and is used for forecasting peak conditions.

The 2014 ambient air temperatures at Umiat were generally at or above historical averages; however, cooler temperatures in mid-May prolonged the initiation of breakup processes. Nighttime ambient air temperatures in Umiat did not stay above freezing until late May. Two near record temperature days on June 1 and June 2 accelerated melting of the snowpack. Graph 8.1 illustrates high and low ambient air temperatures recorded at Umiat from April 22 to June 15 during the breakup monitoring period (Weather Underground 2014). Average highs and lows for the same period for 1999 through 2014 are shown shaded in green. Dates of 2014 peak stage and average peak stage from 1999 to 2014 from the centerline gage at MON1 (MON1C) are included for comparison.

Temperatures for the Alpine area were obtained from the Nuiqsut weather station. Nuiqsut is located on the west bank of the Nigliq Channel, approximately 3.5 air miles northwest of MON1, and approximately 9 air miles south of the Alpine facilities, as shown in Figure 1.2. Nighttime ambient air temperatures in the CRD remained near or below freezing throughout the monitoring period. Graph 8.2 provides high and low ambient air temperatures recorded for Nuiqsut from April 22 to June 15 (Weather Underground 2014). Dates of the 2014 peak stage and average peak stage from 1999 to 2014 at Alpine facilities are included for comparison.



Graph 8.1: Umiat Daily High and Low Breakup Ambient Air Temperatures and MON1 Peak Stage



Graph 8.2: Nuiqsut Daily High and Low Breakup Ambient Air Temperatures and Alpine Facilities Peak Stage

8.2 Colville River Upstream of Bifurcation – MON1

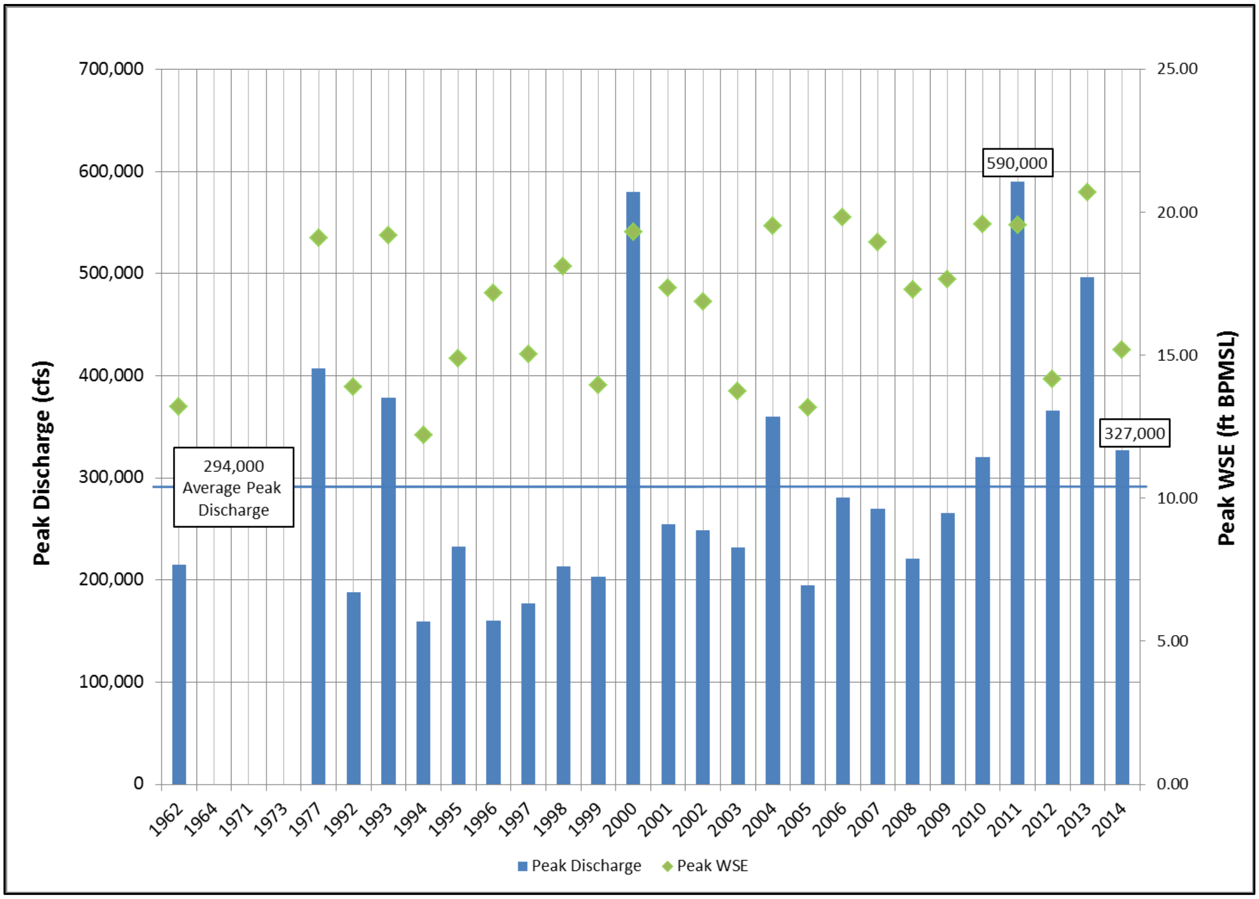
MON1, the primary monitoring site located at the head of the delta, provides the most consistent historical record of peak stage and discharge for the Colville River. Table 8.1 shows the annual peak stage and peak discharge at gage MON1C from 1962 to 2014.

Table 8.1: MON1C: Colville River Historical Peak Discharge and Stage

Year	Discharge		Stage (WSE)		Reference
	Peak Discharge (calculated cfs)	Date	Peak Stage (ft BPMSL)	Date	
2014	**327,000**	**1-Jun**	**15.18**	**31-May**	**This report**
2013	497,000	3-Jun	20.69	3-Jun	Baker 2013a
2012	366,000	1-Jun	14.18	27-May	Baker 2012b
2011	590,000	28-May	19.56	28-May	Baker 2012a
2010	320,000	31-May	19.59	1-Jun	Baker 2010
2009	266,000	23-May	17.65	23-May	Baker 2009b
2008	221,000	28-May	17.29	30-May	Baker 2008
2007	270,000	3-Jun	18.97	4-Jun	Baker 2007b
2006	281,000	30-May	19.83	30-May	Baker 2007a
2005	195,000	9-Jun	13.18	1-Jun	Baker 2005b
2004	360,000	26-May	19.54	27-May	Baker 2005a
2003	232,000	11-Jun	13.76	5-Jun	Baker 2006a
2002	249,000	27-May	16.87	24-May	Baker 2006a
2001	255,000	11-Jun	17.37	10-Jun	Baker 2006a
2000	580,000	11-Jun	19.33	11-Jun	Baker 2000
1999	203,000	30-May	13.97	30-May	Baker 1999
1998	213,000	3-Jun	18.11	29-May	Baker 1998b
1997	177,000	-	15.05	29-May	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	-	-	-	2-Jun	ABR 1996
1971	-	-	-	8-Jun	ABR 1996
1964	-	-	-	3-Jun	ABR 1996
1962	215,000	-	13.20	14-Jun	ABR 1996

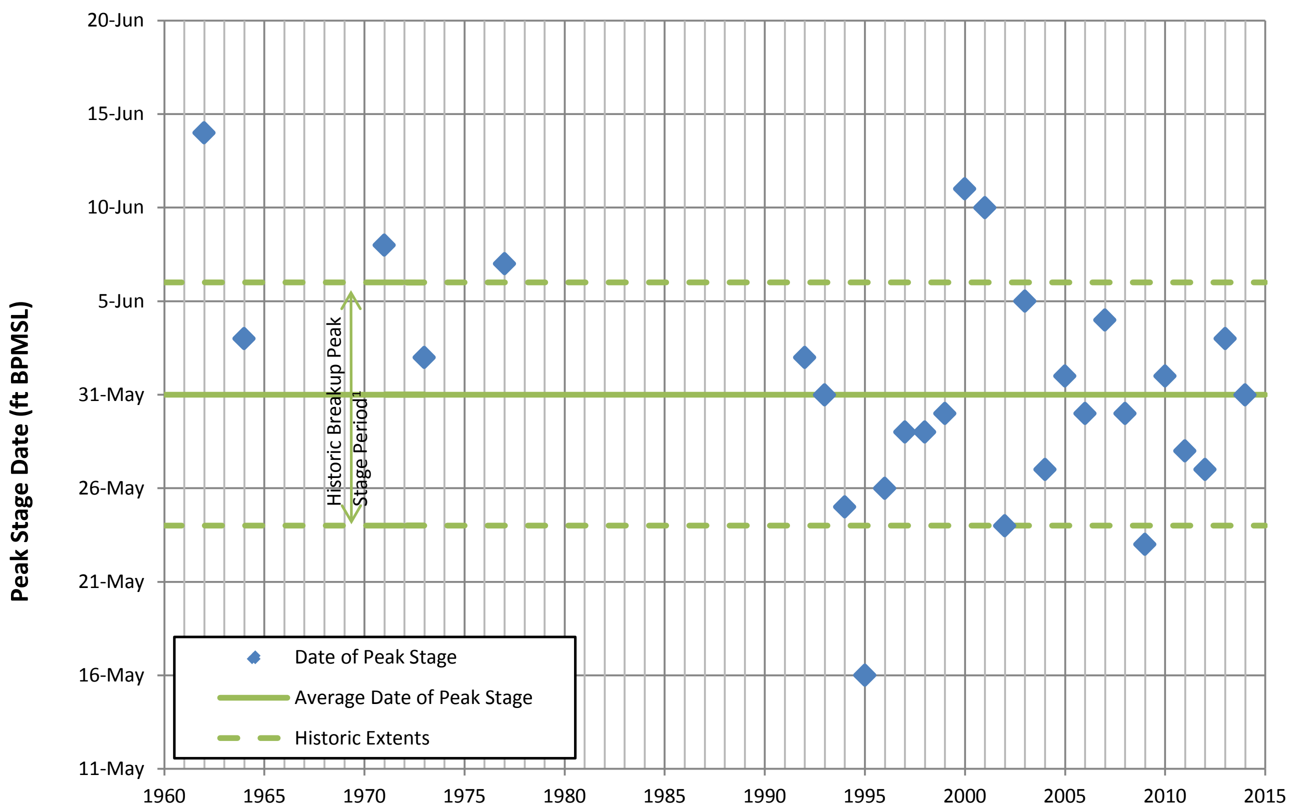
In 2014, peak discharge at MON1 occurred on June 1. Graph 8.3 shows the range of peak discharge and peak stage at MON1. The 2014 peak discharge at MON1C was 327,000 cfs, the maximum historical peak discharge was 590,000 cfs in 2011 (Baker 2012a), and the average historical peak is 294,000 cfs.

The 2014 peak WSE at MON1 was 15.18 feet BPMSL on May 31; about five feet below the maximum historical peak stage of 20.69 feet BPMSL in 2013 (Baker 2013a). The second highest historical peak stage was 19.83 feet BPMSL in 2006 (Baker 2007a), and the average historical peak is 16.79 feet BPMSL.



Graph 8.3: MON1 Annual Peak Discharge

Statistical analysis of historical peak stage dates show 68% of the peaks at MON1 occur during the 13-day period from May 24 to June 6. This represents one standard deviation of 6.3 days on either side of the average (mean) peak stage date of May 31, based on a normal distribution, as illustrated in Graph 8.4. The 2014 peak stage at MON1 on May 31 coincides with the historical average.



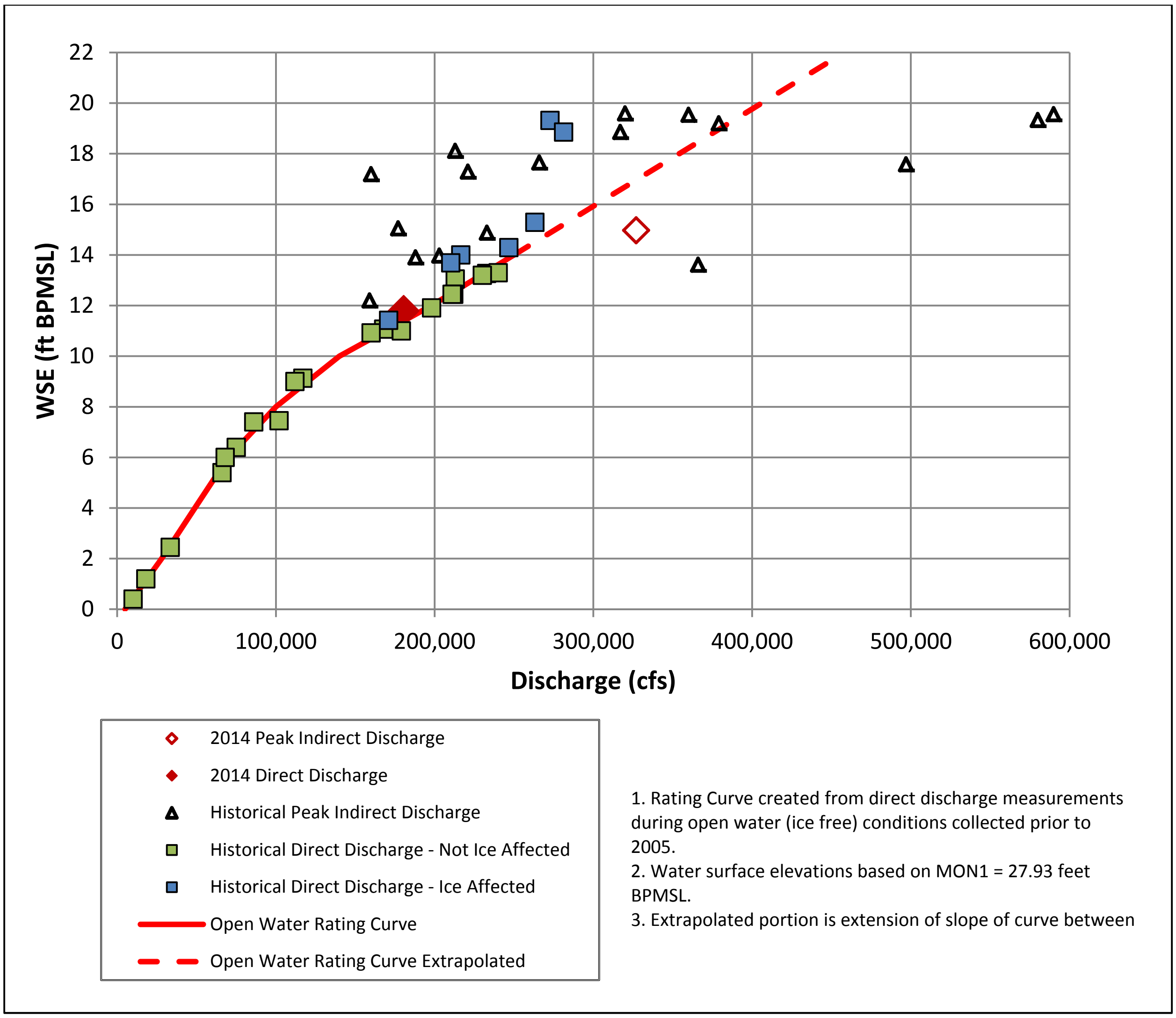
Note:
1. 68% of annual peak stage dates occured within one standard deviation on either side of the average (mean) date.

Graph 8.4: MON1 Annual Peak Stage and Dates

The MON1 stage-discharge rating curve, shown in Graph 8.5, represents a relationship between known stage and corresponding discharge measurements collected between 1992 and 2014. It compares both ice-affected and non-ice-affected discharge measurements to historical calculated discharge values. The rating curve more accurately represents the relationship between stage and discharge at lower stage values when ice-free discharge measurements are possible.

The limitations of this curve are the ice effects on stage and discharge common during peak-flow periods since open-water conditions rarely occur at or near recorded historical peak stage levels during breakup.

The 2014 peak discharge of 327,000 cfs at 14.97 feet BPMSL falls to the right of the rating curve and is typical of values resulting from an ice jam release. Conversely, values to the left of the rating curve tend to be the result of downstream ice jam backwater effects.



Graph 8.5: MON1 Stage-Discharge Rating Curve with Peak Discharge Values

8.3 CD2 Road and Pad – Swale Bridges

Discharge has been measured at the CD2 road swale bridges since 2000, and overall the measurements have been rated to be within 5-10% of the true discharge value. A summary of the 2014 discharge measurements at the Alpine swale bridges is presented with historical data in Table 8.2.

Table 8.2: Alpine CD2 Road Swale Bridges (2000-2014) Direct Discharge Historical Summary

Site	Date	WSE[1] (ft)	Width (ft)	Area (ft^2)	Mean Velocity (ft/s)[2]	Discharge (cfs)	Rating[3]	Number of Sections	Type	Reference
Short Swale Bridge (62 ft)	**6/2/2014**	**7.90**	**54**	**365**	**1.31**	**479**	**F**	**28**	**Cable**	**This Report**
	06/05/13	9.75	54	446	3.60	1608	G	36	Cable	Baker 2013a
	06/03/12	7.04	52	306	1.26	386	F	19	Cable	Baker 2012b
	05/28/11	8.15	52	336	2.51	840	F	27	Cable	Baker 2012a
	06/03/10	7.58	55	316	1.79	570	F	28	Cable	Baker 2010
	–[4]	–	–	–	–	–	–	–	–	Baker 2009b
	05/29/08	6.35	55	211	0.58	120	P	14	Cable	Baker 2008
	06/05/07	7.83	55	292	1.18	350	F	20	Cable	Baker 2007b
	05/31/06	8.49	55	615	1.59	980	F	20	Cable	Baker 2007a
	–[4]	–	–	–	–	–	–	–	–	Baker 2005b
	05/29/04	8.34	55	451	1.60	720	F	17	Cable	Baker 2005a
	–[4]	–	–	–	–	–	–	–	–	Baker 2003
	05/25/02	6.74	56.0	283	1.52	430	G	17	Cable	Baker 2002b
	06/11/01	7.64	56	336	1.79	600	G	15	Cable	Baker2001
	06/10/00	7.87	47	175	3.30	580	F	13	Cable	Baker2000
Long Swale Bridge (452 ft)	**6/2/2014**	**8.00**	**445**	**2183**	**1.30**	**2842**	**G**	**38**	**Cable**	**This Report**
	06/05/13	9.87	448	2947	2.47	7286	G	36	Cable	Baker 2013a
	06/03/12	7.10	445	1686	1.53	2582	-	26	Cable	Baker 2012b
	05/29/11	8.16	447	2027	2.22	4500	F	26	Cable	Baker 2012a
	06/01/10	7.97	441	1699	2.66	4500	G	25	Cable	Baker 2010
	05/26/09	5.89	445	1592	0.82	730	F	27	Wading	Baker 2009b
	05/29/08	6.35	445	949	2.03	1930	F	21	Wading	Baker 2008
	06/05/07	7.76	447	1670	0.74	1240	F	20	Cable	Baker 2007b
	05/31/06	8.42	409	1730	1.89	3260	F	29	Cable	Baker 2007a
	06/02/05	6.13	445	841	1.37	1100	G	20	Wading	Baker 2005b
	05/29/04	8.34	446	1700	1.40	2400	F	18	Cable	Baker 2005a
	06/08/03	5.48	444	478	0.88	420	G	16	Wading	Baker 2003
	05/25/02	6.74	445	930	3.47	3200	G	17	Cable	Baker 2002b
	06/11/01	7.64	460	1538	2.40	3700	G	16	Cable	Baker 2001
	06/09/00	7.34	437	1220	3.27	4000	F	15	Cable	Baker 2000

Notes:
1. Source of WSE is G3
2. Mean velocities adjusted with angle of flow coefficient
3. Measurement Rating -
    E - Excellent: Within 2% of true value
    G - Good: Within 5% of true value
    F - Fair: Within 7-10% of true value
    P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; less than 15% of true value
4. Bridge obstructed with snow or ice, no measurement made

The 2014 calculated peak discharge of 3,472 cfs through both bridges combined is less than the median peak historical discharge of 4,500 cfs. At the time of the 2014 peak discharge, about 85% of the flow was through the Long Swale Bridge. Table 8.3 summarizes the calculated peak annual discharge data at the Alpine swale bridges between 2000 and 2014.

Table 8.3: Alpine Swale Bridges (2000-2014) Calculated Peak Discharge Historical Summary:

Date[1]	Peak WSE (ft)[2]	Long Swale Bridge (452 ft)		Short Swale Bridge (62 ft)		References
		Discharge (cfs)[3]	Mean Velocity (ft/s)	Discharge (cfs)[3]	Mean Velocity (ft/s)	
06/02/14	**8.18**	**2971**	**1.30**	**501**	**1.31**	**This report**
06/04/13	10.27	7723	2.47	1706	3.60	Baker 2013a
06/03/12	7.6	2940	1.53	425	1.26	Baker 2012b
05/29/11	8.89	5200	2.22	940	2.51	Baker 2012a
06/02/10	8.64	5300	2.66	670	1.79	Baker 2010
05/25/09	7.63	1400	0.82	–[4]	–[4]	Baker 2009b
05/30/08	6.49	2100	0.49	100	0.58	Baker 2008
06/05/07	8.60	1500	1.35	400	1.18	Baker 2007b
05/31/06	9.72	4400	1.77	1100	1.59	Baker 2007a
05/31/05	6.48	1400	1.37	–[4]	–[4]	Baker 2005b
05/27/04	9.97	3400	1.38	900	1.59	Baker 2005a
06/07/03	6.31	700	0.88	–[4]	–[4]	Baker 2003
05/26/02	7.59	4000	3.47	500	1.52	Baker 2002b
06/11/01	7.95	3900	2.40	600	1.79	Baker 2001
06/12/00	9.48	7100	3.60	1000	4.30	Baker 2000

Notes:
1. Based on HWM, time is estimated
2. Source of WSE is Gage 3
3. Estimated peak discharge
4. Bridge obstructed with snow or ice, no velocity measurements

8.4 CD5 Road – Nigliq Channel, L9341, Nigliagvik Channel

Peak annual discharge has been calculated for the Nigliq Channel crossing since 2009 and Nigliagvik Channel crossing since 2012. Discharge calculations at Lake L9341 were not possible in most years because of ice blocking conveyance of Nigliq backwater to the upstream side of the bridge. A summary of the peak WSE and peak discharge during breakup flood events for the CD5 crossings is shown in Table 8.4.

Table 8.4: CD5 Road Historical Summary of Peak WSE and Discharge

Year	Nigliq Channel Crossing		Lake L9341 Crossing		Nigliagvik Channel Crossing	
	Peak Indirect Discharge (cfs)	Peak WSE (ft BPMSL)	Peak Indirect Discharge (cfs)	Peak WSE (ft BPMSL)	Peak Indirect Discharge (cfs)	Peak WSE (ft BPMSL)
2014	**66,000**	**9.38**	–[1]	**8.83**	**7,800**	**8.64**
2013	110,000 [2]	12.42 [3]	5,000 [2]	11.07	7,800 [2]	11.41
2012	94,000 [4]	8.82	6,000 [4]	8.58	11,000 [4]	8.51
2011	141,000 [4]	9.89	–[1]	9.5	–[1]	8.78
2010	134000 [4]	9.65	–[1]	5.85	–[1]	8.69
2009	57,000 [4]	7.91	–[1]	7.98	–[1]	7.71

Notes:
1. Data not available
2. Discharge computed with consideration of intact channel ice present at time of peak
3. Inferred from G25 at proposed Lake L9323 Crossing
4. Discharge computed as open water conditions, even though channel ice was present at time of peak

8.5 Alpine Drinking Water Lakes Recharge – Lakes L9312, L9313

Recharge of 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 monitoring indicate bankfull elevation of Lake L9313 is approximately 6.5 feet BPMSL.

Lake L9312 is surrounded by higher tundra than Lake L9313 and is less frequently recharged by floodwater from the Sakoonang Channel relying more on local melt of snow and ice and precipitation. Historical records indicate bankfull elevation of Lake L9312 is between 8 and 8.3 feet BPMSL.

Table 8.5 provides a historical summary of Alpine drinking water lakes WSE and magnitude of recharge from overland breakup flooding. Lake L9313 has recharged to bankfull 15 of the last 17 years, and Lake L9312 has recharged to bankfull 9 of the last 17 years. In some years when overland flow did not inundate L9312, such as 2003 and 2012, local melt did fully recharge the lake to bankfull.

Table 8.5: Alpine Drinking Water Lakes Historical Summary of Recharge

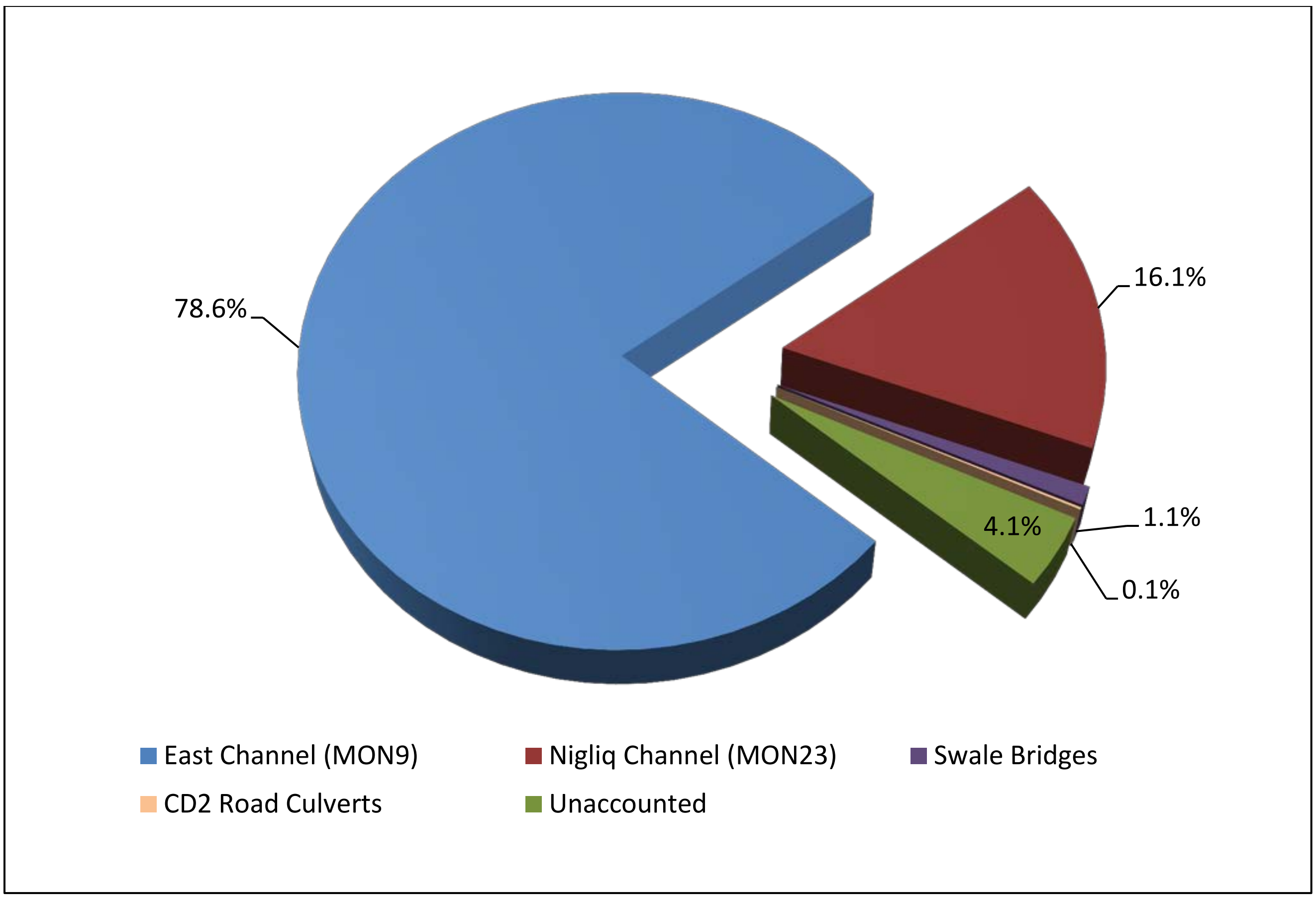
Year	Lake L9312		Lake L9313	
	Peak WSE (observed)	Bankfull Recharge (~8.0-8.3 ft BPMSL)	Peak WSE (observed)	Bankfull Recharge (6.5 ft BPMSL)
2014	**7.94**	**no**	**8.59**	**yes**
2013	8.79	yes	10.44	yes
2012	8.23	no	8.2	yes
2011	10.72	yes	10.67	yes
2010	7.63	no	7.52	yes
2009	7.65	no	7.12	yes
2008	7.45	no	6.95	yes
2007	9.35	yes	9.47	yes
2006	9.55	yes	9.95	yes
2005	8	no	6.12	no
2004	8.37	yes	9.4	yes
2003	8.01	no	7.12	yes
2002	8.05	yes	7.98	yes
2001	7.55	no	8.31	yes
2000	-	yes	-	yes
1999	7.93	no	6.14	no
1998	8.35	yes	7.35	yes

9.0 FLOW DISTRIBUTION

Figure 9.1 represents the distribution of discharge through the CRD. This figure compares peak discharge at MON1 with the peak discharges through MON9 in the Colville East Channel, MON23 in the Nigliq Channel, the Long and Short Swale Bridges, and the CD2 culverts. 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.

During the 2014 period of peak discharge, the Colville East Channel accounted for about 79% of the total discharge to the delta, and the Alpine swale bridges and CD2 culverts combined flow was less than 2% of the total. In 2014, the Nigliq Channel conveyed 16% of the total discharge and approximately 4% was unaccounted for.

Figure 9.1: 2014 Peak Flow Distribution



10.0 FLOOD FREQUENCY ANALYSIS

10.1 FLOOD FREQUENCY ANALYSIS RESULTS

A flood frequency analysis was performed in 2002 to estimate the recurrence interval and magnitude of peak flood discharge on the Colville River (Baker and Hydroconsult 2002). The analysis is updated at 3-year intervals: 2006 (Baker 2007a), 2009 (Baker 2009a), and 2012 (Baker 2012a). The results of the 2002 and 2012 analyses are presented in Table 10.1. The 2002 results are the basis for current design criteria.

Table 10.1: Colville River Flood Frequency Analysis Results

Return Period	2012 Results	2002 Results (Basis for Current Design Criteria)
	Flood Peak Discharge (cfs)	Flood Peak Discharge (cfs)
2-year	249,000	240,000
5-year	379,000	370,000
10-year	476,000	470,000
25-year	612,000	610,000
50-year	722,000	730,000
100-year	840,000	860,000
200-year	967,000	1,000,000

The 2014 peak discharge of 327,000 cfs has an estimated recurrence interval of 4 years, based on the flood frequency analysis results for current design criteria. The 2014 peak discharge was the result of an ice jam release sending a surge of ice floes and backwater through the MON1 reach and was not a sustained event. The 4-year estimated recurrence interval should be considered with respect to conditions at the time of peak discharge.

10.2 Two-Dimensional Surface Water Model

The CRD 2D surface water model was first developed in 1997 to estimate WSE and velocities at the proposed Alpine facility locations (Baker 1998a). The model has undergone numerous revisions since 1997. The proposed CD3 and CD4 developments were incorporated in 2002, including additional floodplain topographic survey data (Baker 2002a). In 2006, the model was modified to include as-built alignment conditions along the CD4 access road and pad and the 2004-2005 survey data of the Nigliq Channel near MON23 (Baker 2006b). The model was completely reconstructed in 2009 (Baker 2009a). In 2012, additional topographic survey data at the proposed CD5 crossings was incorporated into the model (Baker 2012b).

The 2D surface water model was developed to predict open water conditions during low-frequency, high-magnitude flood events having 50- and 200-year recurrence intervals. To estimate the relationship between discharge and stage during lower-magnitude flood events, 2- and 10-year flood events have been modeled. The model assumes open water, steady-state conditions, and does not account for snow, channel ice, or ice jams.

In general, the 2D model under-predicts stage for lower-return periods of approximately 10 years and less. This is to be expected, as the model does not account for ice and snow related events having a large effect on lower-magnitude floods and less of an effect on higher-magnitude floods. With an extended period of record, a stage frequency analysis can be a better estimate of low flood stage within the delta affected by recurrent ice jamming.

The 2012 2D surface water model predictions and the 2014 observations are presented in Table 10.2.

Variance in recurrence intervals is the result of timing and locations of ice jam formation and release; it is not considered to be representative of actual volumes and related stage of breakup flow. Stage and discharge resulting from ice jam formation and release are not typically sustained, as they would otherwise be if sufficient breakup melt was present to induce lower-frequency flood recurrence intervals. Flood stage recurrence throughout the CRD ranged from less than 2 years to greater than 200 years, based on the 2D model results. Outlying results are generally attributable to effects related to localized ice jam events as discussed below.

The formation of a major ice jam upstream of MON1, as occurred during the 2014 breakup season, is typical. When it released, it re-formed in the Nigliq and Colville East channels and sporadically advanced out of the CRD as lingering intact channel ice obstructed ice floes. The high stage recurrence interval at MON35 on the East Channel and MON28 on the Nigliq Channel at the edge of Harrison Bay is because of the effects of intact coastal ice, ice jams, and to a certain extent tidal and wind events. Additionally, MON35, MON28, and ULAM are near the downstream boundary of the 2D model and observed conditions are more susceptible to variance from modeled predictions.

Table 10.2: 2012 2D Model Predicted and 2014 Observed Peak WSE

Monitoring Sites	2D Model Predicted Water Surface Elevation [based on open water conditions] (feet BPMSL)				2014 Observed Peak WSE (feet BPMSL)	Approximate Recurrence Interval of Observed Peak WSE (years)
	2-year	10-year	50-year	200-year		
Colville East Channel						
Monument 1 (Centerline)	13.9	19.2	23.0	25.9	15.18	3
Monument 9 (HDD)	11.5	16.1	19.0	21.1	13.36	4
Monument 35 (Helmericks)	4.3	5.4	6.1	6.5	6.91	>200
Nigliq Channel						
Monument 20	7.8	11.4	14.6	16.8	10.49	7
Monument 22	6.3	9.3	12.1	14.2	8.67	7
Monument 23	5.1	7.4	10.2	12.0	7.35	9
Monument 28	3.1	3.4	3.9	4.3	4.90	>200
CD1 Pad						
Gage 1	7.3	9.7	12.5	14.6	8.29	4
Gage 9	8.3	10.8	13.4	15.7	7.94	<2
Gage 10	8.3	10.8	13.4	15.7	8.59	2
CD2 Pad						
Gage 8	\	8.7	10.6	12.3	Dry	-
CD2 Road						
Gage 3	6.4	9.4	12.0	14.0	8.18	5
Gage 4	6.2	8.5	10.1	11.7	7.99	7
Gage 6	\	9.5	12.2	14.2	8.20	<10
Gage 7	\	8.4	10.0	11.6	8.09	<10
Gage 12	\	9.5	12.1	14.2	8.27	<10
Gage 13	\	8.4	10.0	11.6	8.10	<10
CD3 Pad						
Gage 11	5.2	6.4	6.9	8.0	Dry	-
CD4 Pad						
Gage 19	\	11.9	14.6	16.6	11.81	<10
Gage 20	\	11.1	14.2	16.3	9.74	<10
CD4 Road						
Gage 15	8.4	10.8	13.5	15.8	8.97	3
Gage 16	8.4	11.1	14.2	16.1	8.98	3
Gage 17	\	11.1	14.2	16.2	Dry	-
Gage 18	\	11.9	14.7	16.7	Dry	-
CD3 Pipeline Crossings						
Sakoonang (Crossing #2) Gage	6.4	8.9	11.2	12.9	7.92	5
Tamayagiaq (Crossing #4) Gage	6.7	8.5	9.0	9.8	7.92	6
Ulamnigiaq (Crossing #5) Gage	5.5	7.1	7.8	8.7	7.77	48
CD5 Road Crossings						
Gage 24 (L9323)	\	11.1	14.0	15.8	8.58	<10
Gage 26 (Nigliq Channel)	6.7	9.8	12.5	14.6	8.61	5
Gage 30	\	\	12.8	14.8	9.74	<10
Gage 32 (L9341)	\	\	12.8	14.8	8.48	<10
Gage 34	\	\	12.7	14.8	9.26	<10
Gage 36	\	\	12.7	14.8	10.30	<10
Gage 38 (Nigliagvik)	6.9	10.0	12.7	14.9	8.10	4

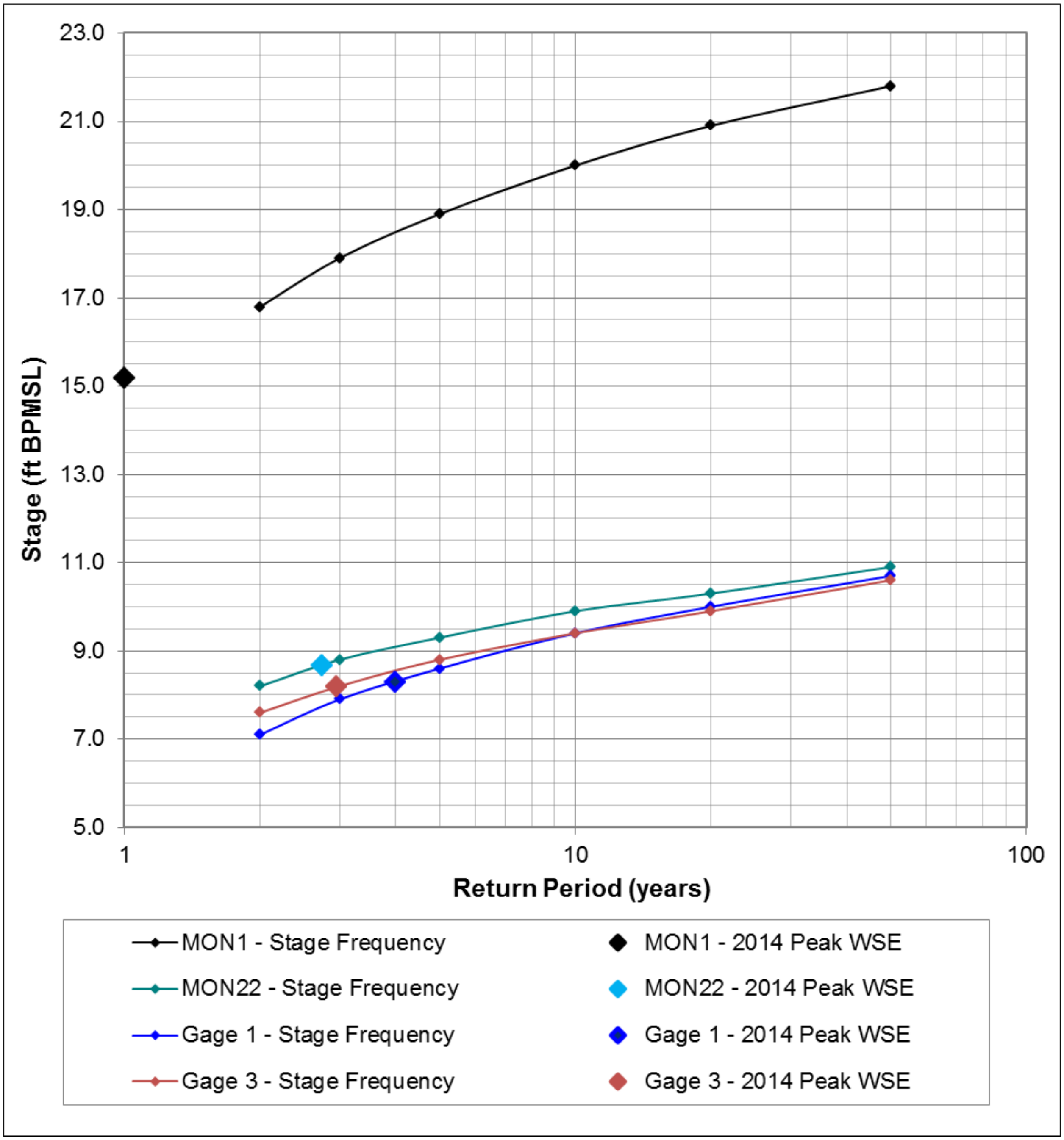
Note:
Sites having dry ground in 2D model are denoted with a backward slash "\".

10.3 Stage Frequency

A stage frequency analysis was performed for selected sites in 2006 (Baker 2007a), 2009 (Baker 2009a), and 2012 (Baker 2012b). The location and distribution of monitoring sites has varied based on the objectives of each year's field program. MON1, MON22, G1, and G3 were selected because each has a relatively long-term period of record. The data reflects ice-affected flooding conditions; thus, the stage analysis incorporates these conditions. Resulting values from the 2012 analysis are compared to the 2014 observed peak WSE in Table 10.3 and Graph 10.1.

Table 10.3: 2012 Stage Frequency Analysis Results and 2014 Observed Peak WSE

Monitoring Sites	Stage Frequency - Log-Pearson Type III (feet BPMSL)						2014 Observed Peak WSE (feet BPMSL)	Approximate Recurrence Interval of Observed Peak WSE (years)
	2-year	3-year	5-year	10-year	20-year	50-year		
Monument 1	16.8	17.9	18.9	20.0	20.9	21.8	15.2	<2
Monument 22	8.2	8.8	9.3	9.9	10.3	10.9	8.7	3
Gage 1	7.1	7.9	8.6	9.4	10.0	10.7	8.3	4
Gage 3	7.6	8.2	8.8	9.4	9.9	10.6	8.2	3
CD4 Pad (Gage 18)	9.9	10.8	11.7	12.8	13.7	14.8	Dry	<2



Graph 10.1: Stage Frequency Analysis Results and 2014 Observed Peak WSE

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Appendix A Pressure Transducer Methods, 2014 Vertical Control, and Gage Locations

A.1 2014 Gage Locations

2014 Gage Locations				
Gage Site	**Gage**	**Latitude (NAD 83)**	**Longitude (NAD83)**	**Basis of Elevation**
Colville River Upstream of Bifurcation				
Monument 1 U	MON1U-A[1]	N 70.1586°	W 150.9450°	MONUMENT 1
	MON1U-B[1]	N 70.1585°	W 150.9456°	
	MON1U-C	N 70.1585°	W 150.9462°	
	MON1U-D	N 70.1585°	W 150.9464°	
	MON1U-E	N 70.1585°	W 150.9464°	
	MON1U-F	N 70.1585°	W 150.9465°	
Monument 1 C	MON1C-A[1]	N 70.1658°	W 150.9384°	MONUMENT 1
	MON1C-B	N 70.1658°	W 150.9389°	
	MON1C-C[1]	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°	
Monument 1 D	MON1D-A[1]	N 70.1738°	W 150.9359°	MONUMENT 1
	MON1D-B[1]	N 70.1738°	W 150.9366°	
	MON1D-C	N 70.1738°	W 150.9372°	
	MON1D-D	N 70.1738°	W 150.9374°	
Colville River East Channel				
Monument 9	MON9-A[1]	N 70.2447°	W 150.8573°	MONUMENT 9
	MON9-B	N 70.2447°	W 150.8575°	
	MON9-C[1]	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-G	N 70.2446°	W 150.8581°	
	MON9-BARO[2]	N 70.2442°	W 150.8605°	
Monument 9D	MON9D-A[1]	N 70.2586°	W 150.8593°	MONUMENT 9
	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°	
	MON9D-E	N 70.2586°	W 150.8600°	

Notes:

1. Pressure Transducer
2. BaroTROLL or Barologger barometer
3. Staff gage surveyed and adjusted for elevation annually by LCMF

2014 Gage Locations				
Gage Site	Gage	Latitude (NAD 83)	Longitude (NAD83)	Basis of Elevation
Colville River East Channel				
Monument 35 (Helmericks)	MON35-A	N 70.4260°	W 150.4058°	MONUMENT 35
	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°	
Nigliq Channel				
Monument 20	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°	
Nigliq Channel Gages	G26-A[1]	N 70.3024°	W 151.0221°	MONUMENT 26
	G26-B	N 70.3022°	W 151.0192°	
	G26-C	N 70.3022°	W 151.0190°	
	G27-A[1]	N 70.3029°	W 151.0219°	
	G27-B	N 70.3029°	W 151.0217°	
	G27-C	N 70.3029°	W 151.0198°	
	G27-D	N 70.3029°	W 151.0188°	
	G28-A[1]	N 70.2964°	W 151.0281°	
	G28-B	N 70.2964°	W 151.0280°	
	G28-C	N 70.2964°	W 151.0279°	
	G28-D	N 70.2965°	W 151.0276°	
	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°	
Monument 22	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°	

Notes:
1. Pressure Transducer
2. BaroTROLL or Barologger barometer
3. Staff gage surveyed and adjusted for elevation annually by LCMF

2014 Gage Locations				
Gage Site	**Gage**	**Latitude (NAD 83)**	**Longitude (NAD83)**	**Basis of Elevation**
Nigliq Channel				
Monument 23	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°	
Monument 28	MON28-A[1]	N 70.4258°	W 151.0697°	MONUMENT 28
	MON28-B	N 70.4257°	W 151.0692°	
	MON28-C	N 70.4256°	W 151.0672°	
Alpine Facilities and Roads				
CD1 Gages	G1[1]	N 70.3428°	W 150.9208°	[3]
Lake L9312	G9	N 70.3336°	W 150.9519°	[3]
Lake L9313	G10	N 70.3425°	W 150.9328°	[3]
CD2 Gages	G3[1]	N 70.3400°	W 150.9831°	[3]
	G4[1]	N 70.3403°	W 150.9833°	[3]
	G6	N 70.3397°	W 151.0292°	[3]
	G7	N 70.3400°	W 151.0289°	[3]
	G8	N 70.3393°	W 151.0491°	PBM-F
	G12	N 70.3367°	W 151.0117°	CD2-14S
	G13	N 70.3373°	W 151.0118°	CD2-14S
CD3 Gage	G11	N 70.4175°	W 150.9105°	[3]
CD4 Gages	G15-A	N 70.3023°	W 150.9929°	CD4-20AW
	G15-B	N 70.3024°	W 150.9939°	
	G16-A	N 70.3017°	W 150.9933°	
	G16-B	N 70.3018°	W 150.9943°	
	G17-A	N 70.2933°	W 150.9827°	CD4-32E
	G18-A	N 70.2930°	W 150.9818°	
	G18-B	N 70.2925°	W 150.9828°	
	G19-A	N 70.2917°	W 150.9883°	[3]
	G19-Baro[2]	N 70.2917°	W 150.9883°	
	G20-A	N 70.2917°	W 150.9968°	PBM-P
	G20-B	N 70.2917°	W 150.9968°	
	G40-A	N 70.3234°	W 150.9968°	CD4-13W
	G41-A	N 70.3235°	W 150.9949°	CD4-13W
	G42-A	N 70.3276°	W 150.9939°	CD4-10E
	G43-A	N 70.3274°	W 150.9924°	CD4-10E

Notes:
1. Pressure Transducer
2. BaroTROLL or Barologger barometer
3. Staff gage surveyed and adjusted for elevation annually by LCMF

2014 Gage Locations				
Gage Site	**Gage**	**Latitude (NAD 83)**	**Longitude (NAD83)**	**Basis of Elevation**
CD5 Gages				
Lake L9323	G24-A[1]	N 70.3032°	W 151.0067°	MONUMENT 25
	G24-B	N 70.3034°	W 151.0041°	
	G25-A[1]	N 70.3040°	W 151.0069°	
	G25-B	N 70.3042°	W 151.0044°	
Lake L9341	G32-A[1]	N 70.3054°	W 151.0507°	MONUMENT 27
	G32-B	N 70.3055°	W 151.0513°	
	G33-A[1]	N 70.3063°	W 151.0491°	
	G33-B	N 70.3064°	W 151.0497°	
Small Drainages	G30	N 70.3046°	W 151.0443°	CD5-141S
	G31	N 70.3051°	W 151.0437°	CD5-141N
	G34	N 70.3060°	W 151.0710°	CD5-136S
	G35	N 70.3067°	W 151.0711°	CD5-136N
	G36	N 70.3055°	W 151.0968°	CD5-130S
	G37	N 70.3062°	W 151.0969°	CD5-130N
	S1-A	N 70.3058°	W 151.1944°	MONUMENT 31
	S2-A	N 70.3044°	W 151.2192°	MONUMENT 31
Nigliagvik Channel Gages	G38-A[1]	N 70.3051°	W 151.1186°	MONUMENT 28
	G38-B	N 70.3051°	W 151.1185°	
	G38-C	N 70.3051°	W 151.1182°	
	G38-D	N 70.3047°	W 151.1171°	
	G39-A[1]	N 70.3061°	W 151.1180°	
	G39-B	N 70.3061°	W 151.1179°	
	G39-C	N 70.3061°	W 151.1177°	
Pipeline River Crossings				
Sakoonang Pipe Bridge	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°	
Tamayayak Pipe Bridge	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°	
Ulamnigiaq Pipe Bridge	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°	

Notes:
1. Pressure Transducer
2. BaroTROLL or Barologger barometer
3. Staff gage surveyed and adjusted for elevation annually by LCMF

2014 Gage Locations				
Gage Site	**Gage**	**Latitude (NAD 83)**	**Longitude (NAD83)**	**Basis of Elevation**
Additional Monitoring Sites				
Downstream Nigliq Channel	FWR1-A[1]	N 70.3705°	W 151.1141°	SHEWMAN
	FWR2-A[1]	N 70.3667°	W 151.1219°	
Nuiqsut Road Crossing	NRC	N 70.27044°	W 151.10256°	
	NRD	N 70.27090°	W 151.10140°	
	NRU	N 70.26979°	W 151.10516°	

Notes:
1. Pressure Transducer
2. BaroTROLL or Barologger barometer
3. Staff gage surveyed and adjusted for elevation annually by LCMF

A.2 2014 Vertical Control

2014 Vertical Control					
Control	**Elevation (BPMSL - Feet)**	**Latitude (NAD 83)[1]**	**Longitude (NAD83)**	**Control Type**	**Reference**
CD2-14S	10.929	N 70.3369°	W 151.0112°	Culvert top	LCMF 2014a
CD4-10E	11.793	N 70.3274°	W 150.9930°	Culvert top	LCMF 2014a
CD4-13W	12.379	N 70.3234°	W 150.9961°	Culvert top	LCMF 2014a
CD4-20AW	6.762	N 70.3019°	W 150.9936°	Culvert top	LCMF 2014a
CD4-32E	12.566	N 70.2929°	W 150.9828°	Culvert top	LCMF 2014a
CD5-130N	13.836	N 70.3060°	W 151.0952°	Culvert top	LCMF 2014a
CD5-130S	14.001	N 70.3058°	W 151.0949°	Culvert top	LCMF 2014a
CD5-136N	13.685	N 70.3065°	W 151.0684°	Culvert top	LCMF 2014a
CD5-136S	14.248	N 70.3063°	W 151.0684°	Culvert top	LCMF 2014a
CD5-141N	12.431	N 70.3050°	W 151.0440°	Culvert top	LCMF 2014a
CD5-141S	13.169	N 70.3048°	W 151.0443°	Culvert top	LCMF 2014a
CP08-11-23	8.524	N 70.3916°	W 150.9079°	Alcap	LCMF 2008
CP08-11-35	9.146	N 70.4066°	W 150.8822°	Alcap	LCMF 2008
MONUMENT 1	27.930	N 70.1659°	W 150.9400°	Alcap	LCMF 2006
MONUMENT 9	25.060	N 70.2446°	W 150.8583°	Alcap	LCMF 2008
MONUMENT 22	10.030	N 70.3181°	W 151.0560°	Alcap	Baker 2010
MONUMENT 23	9.546	N 70.3444°	W 151.0613°	Alcap	Baker 2009c
MONUMENT 25	18.007	N 70.3024°	W 151.0130°	Capped drill stem	LCMF 2014
MONUMENT 26	11.580	N 70.3025°	W 151.0322°	Capped drill stem	LCMF 2014
MONUMENT 27	13.906	N 70.3060°	W 151.0533°	Capped drill stem	LCMF 2014
MONUMENT 28	3.650	N 70.4256°	W 151.0670°	Alcap	LCMF GPS 2002
MONUMENT 31	26.891	N 70.3051°	W 151.1992°	Capped drill stem	LCMF 2013
MONUMENT 35	5.570	N 70.4325°	W 150.3834°	Alcap	Lounsbury 1996
PBM-F	18.119	N 70.3393°	W 151.0468°	PBM in Casing	LCMF 2013
PBM-P	20.969	N 70.2914°	W 150.9889°	PBM in Casing	LCMF 2012
Pile 568	23.719	N 70.3639°	W 150.9206°	HSM - cap SW bolt	LCMF 2010
SHEWMAN	7.085	N 70.3723°	W 151.1148°	Alcap	Baker 2009b
1. North American Datum of 1989 (NAD 83)					

A.3 Pressure Transducer Setup and 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 datum is the sum of the forces imparted by the water column and atmospheric conditions. Variations in local barometric pressure are taken into account, using two independent barometric pressure loggers: In-Situ BaroTROLL® (primary) and Solinst Barologger® (secondary). A correction of barometric pressure was obtained from the BaroTROLL sensor installed at CD4 and the Barologger installed at MON9.

The PTs were tested before field mobilization. The PTs were configured using Win-Situ® LT 5.6.21.0 (for the Level TROLL 500s) or Solinst Levelogger® v4.0.3 (for the Solinst Leveloggers) 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. Gage WSE readings were used to validate and adjust the data collected by the PTs. PTs have the potential to drift and can be affected by ice floe impacts. 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 B Discharge Methods, Discharge Measurement Locations, and Cross-Sectional Geometry

B.1 Discharge Methods

B.1.1 Standard USGS Midsection Techniques

Standard USGS midsection techniques (USGS 1982) were used to measure velocities and determine discharge at the Long and Short Swale Bridges on the CD2 road and at the Nigliagvik Channel Bridge on the CD5 road.

Bridge depth and velocity measurements were taken from the upstream side of each bridge deck using a sounding reel mounted on a wooden boom. A Price AA velocity meter was attached to the sounding reel and stabilized with a 30-pound Columbus-type lead sounding 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 in March 2014 in accordance to USGS precise standards. A spin test of the meter was successfully completed before and after the measurements. Procedures outlined in OSW Technical Memorandum No. 99.06 (OSW 1999b) were followed to confirm accurate meter performance.

Velocity measurements at the outlets of the CD2 road culverts experiencing flow were conducted using a USGS wading rod and Marsh McBirney velocity meter at the downstream side of the culvert. Discharge was determined based on velocity, flow depth, and culvert geometry.

B.1.2 ADCP Methods

Direct discharge measurements were collected at MON1 and downstream of the Nigliq Channel Bridge using the ADCP.

Hardware and 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® v2.07 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.

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. Internal compass error was within the specified 5-degree limit.

ADCP Deployment and 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.

Cross sections were identified at established monitoring sites MON1C and downstream of gage G27. A minimum of four transects were completed, so the measured discharges varied by less than five percent of their mean. Cross section end points were dependent on a minimum water depth of approximately eight feet to provide acceptable data.

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.

ADCP Background and 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.

Colville River channels are composed of fine-grained sediment, and water velocities are sufficient to entrain the materials resulting from a moving river bed. When using bottom tracking, a moving bed will tend to 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) or 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. The mean correction procedure was applied to the Colville River and Nigliq Channel discharge calculations because of the simple geometry of the channel cross section. The results of the loop test, performed immediately following 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 daily direct discharge measurement was determined by averaging the corrected discharge measurements.

B.1.3 Indirect Calculation Methods

The Normal Depth method (Chow 1959) and Slope-Area method (Benson and Dalrymple 1967) were used to develop the estimates of peak discharge at MON1. Both methods use channel cross section geometry and stage differential between gage sites as an estimate for hydraulic gradient. The methods differ by the number of cross sections used in the calculations. At MON1, the Normal Depth method uses the cross section at MON1C where the Slope-Area Method uses the cross sections from MON1U, MON1C, and MON1D. Accuracy of each method depends on conditions at the time of calculation, particularly the presence of ribbon and bottom fast ice, ice jam activity, and backwater effects. The average of the Normal Depth and Slope-Area results were used to compute the peak indirect discharge at MON1.

Lacking additional cross sections, the Normal Depth method was used to estimate peak discharge at all other locations. Cross sectional geometry for MON9 is the result of data from the 2009 survey by LCMF for the Alpine Pipelines Monitoring report (Baker 2009c). Cross sectional geometry at MON23 is current as of 2005 (LCMF 2005) and at the Nigliagvik, Nigliq, and Lake L9341 locations as of 2014 (LCMF 2014). The Lake L9323 crossing was surveyed by LCMF in 2012. 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 soils or have bottom-fast ice. Stage and hydraulic gradient data were obtained from observations made at nearby gages and PT results.

B.2 Colville River Plan View and Cross-Sections

B.2.1 MON1

ConocoPhillips Alaska

Miles
0 0.25 0.5

Date:	10/01/2014	Project:	141450
Drawn:	MEA	File:	
Checked:	SME	Scale:	1 in = .5 miles

Legend

Gage Location

2004 Cross Section Alignment

Imagery Source: AlaskaMapped (WMS)

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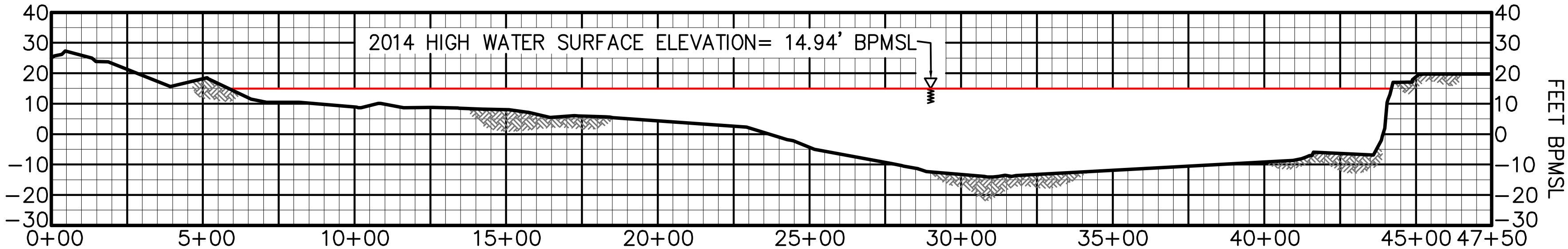
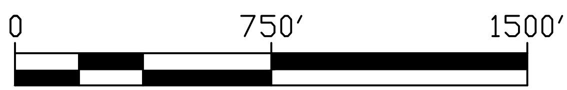
Anchorage, AK 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2014 SPRING BREAKUP
MONUMENT 1
PLAN

(SHEET 1 of 1)

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





1D COLVILLE RIVER CROSS SECTION AT MONUMENT 1 DOWNSTREAM

ConocoPhillips Alaska, Inc.

DATE: 09/30/2014	PROJECT: 141450
DRAWN: MNU	FILE: MON1.DWG
CHECKED: MJT	SCALE: AS SHOWN

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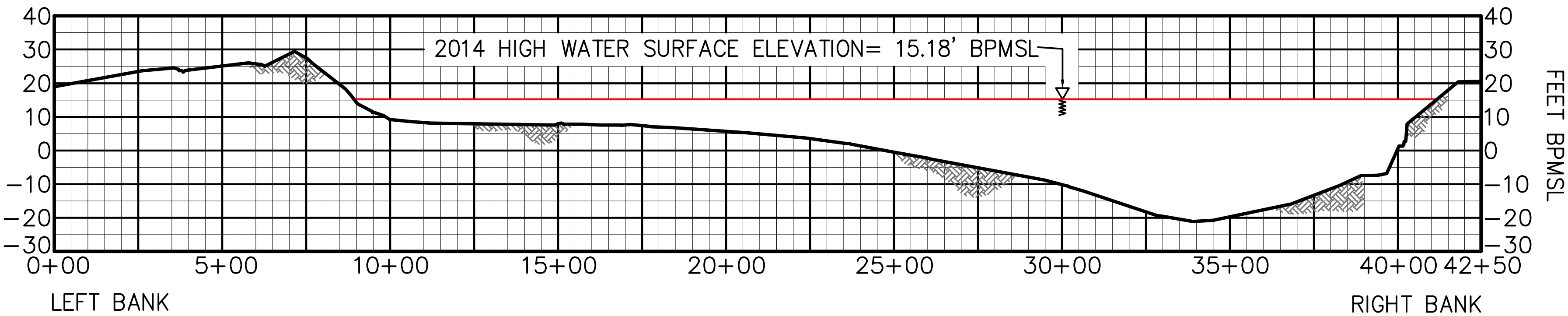
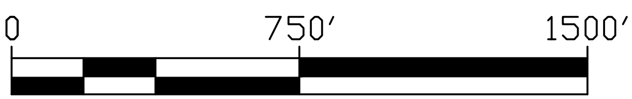
2014 SPRING BREAKUP
COLVILLE RIVER MONUMENT 1
DOWNSTREAM CROSS SECTION

(SHEET 2 OF 4)

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





1C COLVILLE RIVER CROSS SECTION AT MONUMENT 1 CENTERLINE

ConocoPhillips Alaska, Inc.

DATE:	09/30/2014	PROJECT:	141450
DRAWN:	MNU	FILE:	MON1.DWG
CHECKED:	MJT	SCALE:	AS SHOWN

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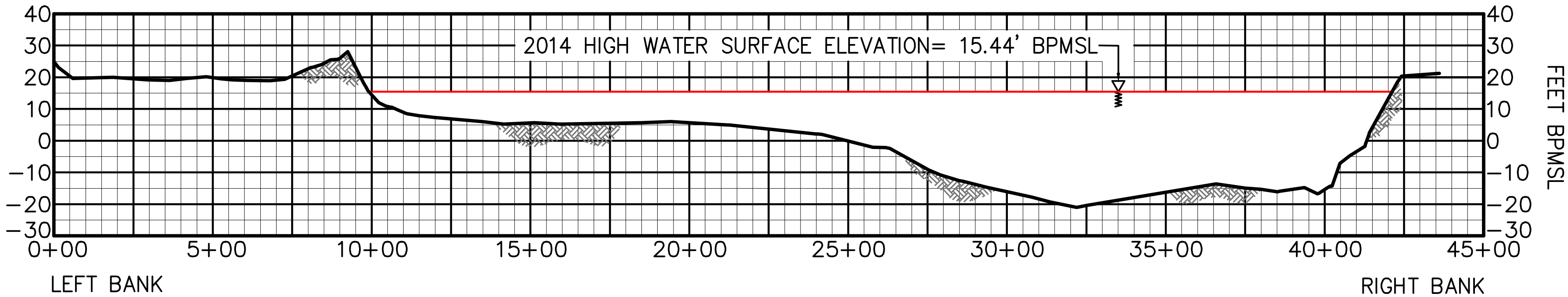
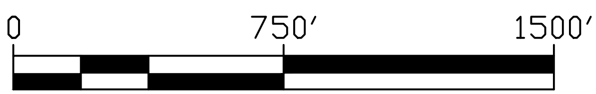
2014 SPRING BREAKUP
COLVILLE RIVER MONUMENT 1
CENTERLINE CROSS SECTION

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





1U COLVILLE RIVER CROSS SECTION AT MONUMENT 1 UPSTREAM

ConocoPhillips Alaska, Inc.

DATE:	09/30/2014	PROJECT:	141450
DRAWN:	MNU	FILE:	MON1.DWG
CHECKED:	MJT	SCALE:	AS SHOWN

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2014 SPRING BREAKUP
COLVILLE RIVER MONUMENT 1
UPSTREAM CROSS SECTION

(SHEET 4 OF 4)

B.2.2 MON9

ConocoPhillips Alaska

Feet
0 500 1,000

Date:	10/01/2014	Project:	141450
Drawn:	MEA	File:	
Checked:	SME	Scale:	1 in = 1000 feet

Legend

- Gage Location
- 2009 Cross Section Alignment
- Pipeline

Imagery Source: ConocoPhillips Alaska, 2004

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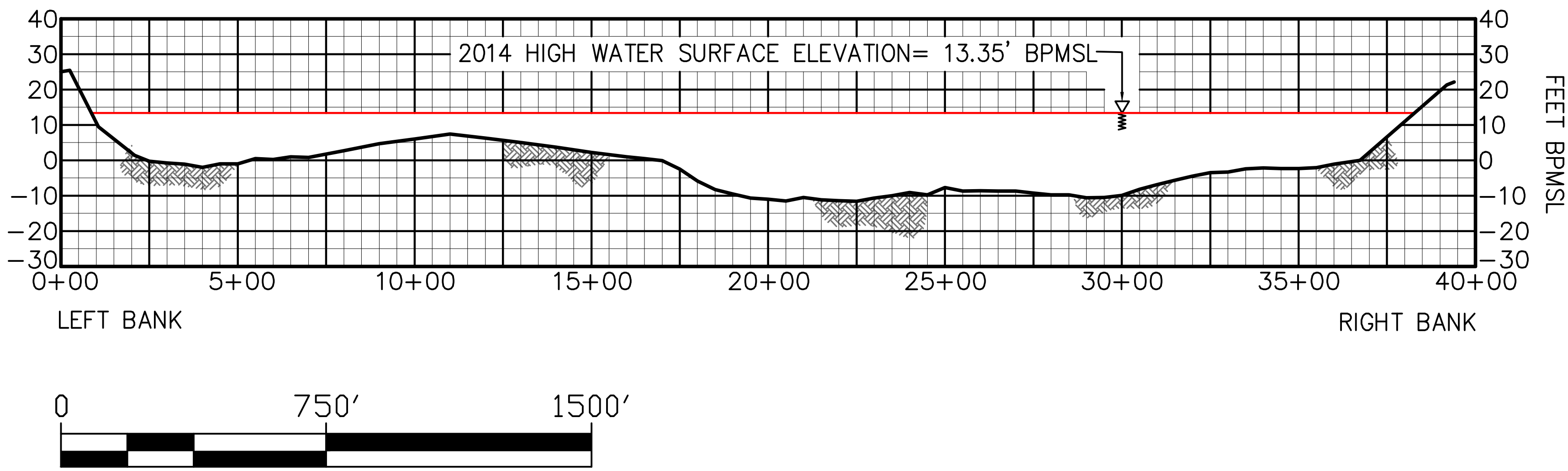
2014 SPRING BREAKUP
Monument 9 / HDD
PLAN

(SHEET 1 of 1)

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



1 COLVILLE EAST CHANNEL CROSS SECTION AT MONUMENT 9

ConocoPhillips Alaska, Inc.

DATE:	09/30/2014	PROJECT:	141450
DRAWN:	MNU	FILE:	MON9.DWG
CHECKED:	MJT	SCALE:	AS SHOWN

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2014 SPRING BREAKUP
COLVILLE EAST CHANNEL
MONUMENT 9 CROSS SECTION

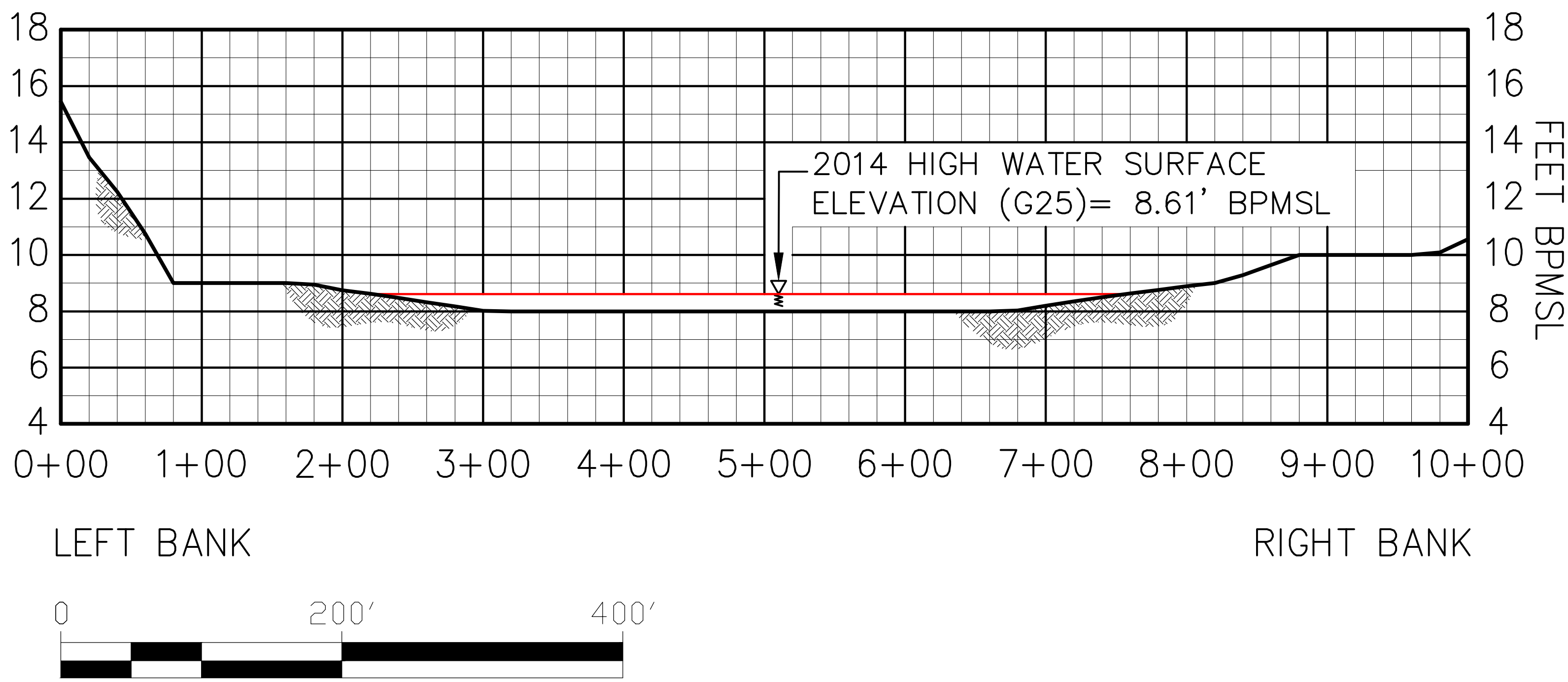
(SHEET 2 OF 2)

B.3 CD5 Road Crossings Cross-Sections

B.3.1 LAKE L9323

NOTES

1. BASIS OF ELEVATION, CP08-11-52A.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED SEPTEMBER 2012 BY UMIAQ (KUUKPIK/LCMF INC.)



1 CONSTRUCTED CD5 CROSSING – LAKE L9323 CENTERLINE CROSS SECTION

ConocoPhillips Alaska, Inc.

DATE:	09/30/2014	PROJECT:	141450
DRAWN:	MNU	FILE:	L9323.DWG
CHECKED:	MJT	SCALE:	AS SHOWN

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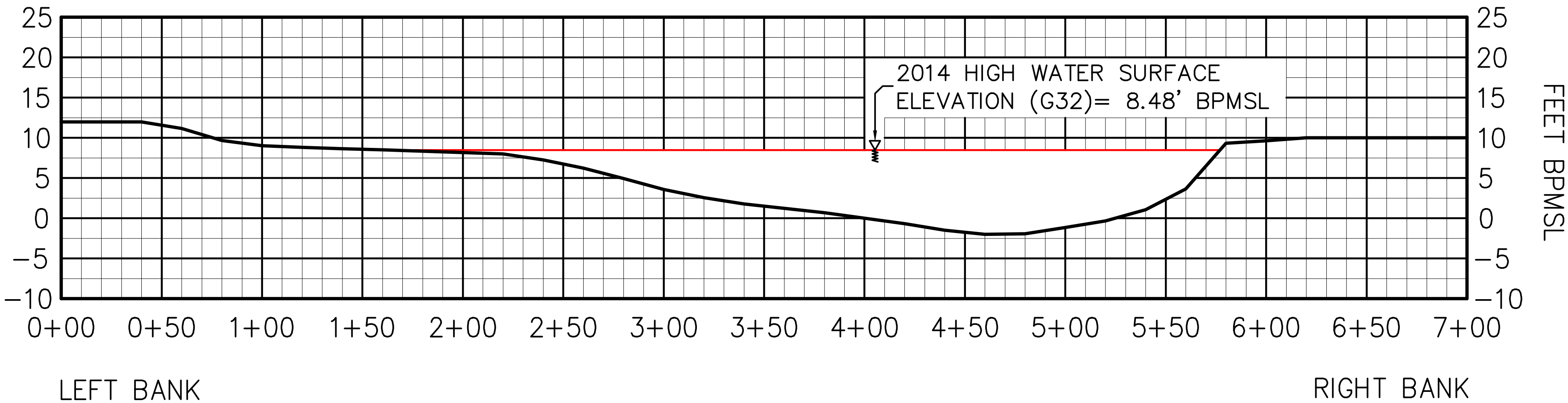
2014 SPRING BREAKUP
CD5 CROSSING
LAKE L9323 CENTERLINE

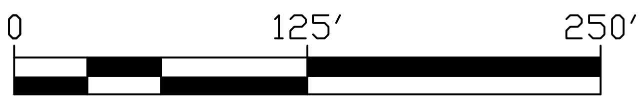
(SHEET 2 OF 2)

B.3.2 LAKE L9341

NOTES

1. BASIS OF ELEVATION, CP08–11–60C.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED OCTOBER 2008 BY UMIAQ (KUUKPIK/LCMF INC.)





(1) PROPOSED CD5 CROSSING – LAKE L9341 CENTERLINE CROSS SECTION

ConocoPhillips Alaska, Inc.

DATE:	09/30/2014	PROJECT:	141450
DRAWN:	MNU	FILE:	L9341.DWG
CHECKED:	MJT	SCALE:	AS SHOWN

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2014 SPRING BREAKUP

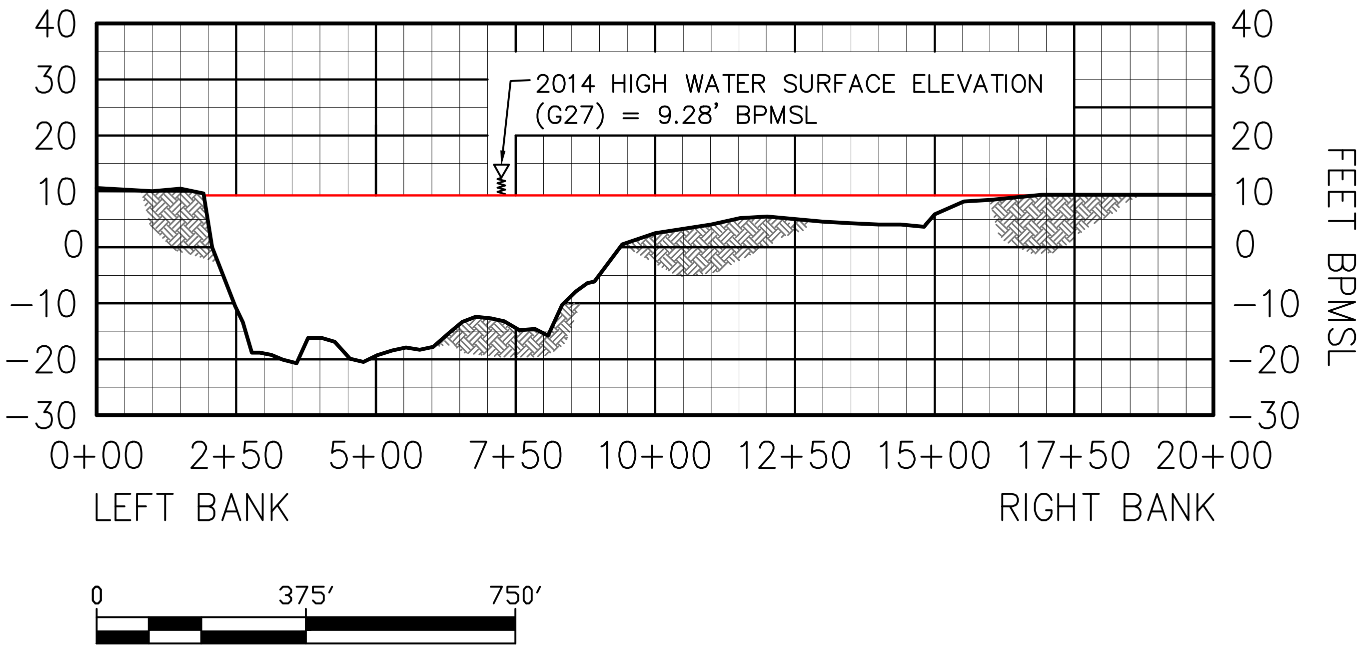
CD5 CROSSING

LAKE L9341 CENTERLINE

(SHEET 2 OF 2)

B.3.3 NIGLIQ CHANNEL

NOTES
1. BASIS OF ELEVATION, BAKER TBM 2010.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED AUGUST 2014 BY UMIAQ (KUUKPIK/LCMF INC.)



1 CONSTRUCTED CD5 CROSSING – NIGLIQ CHANNEL CENTERLINE CROSS SECTION

ConocoPhillips Alaska, Inc.

DATE:	09/30/2014	PROJECT:	141450
DRAWN:	MNU	FILE:	NIGLIQ.DWG
CHECKED:	MJT	SCALE:	AS SHOWN

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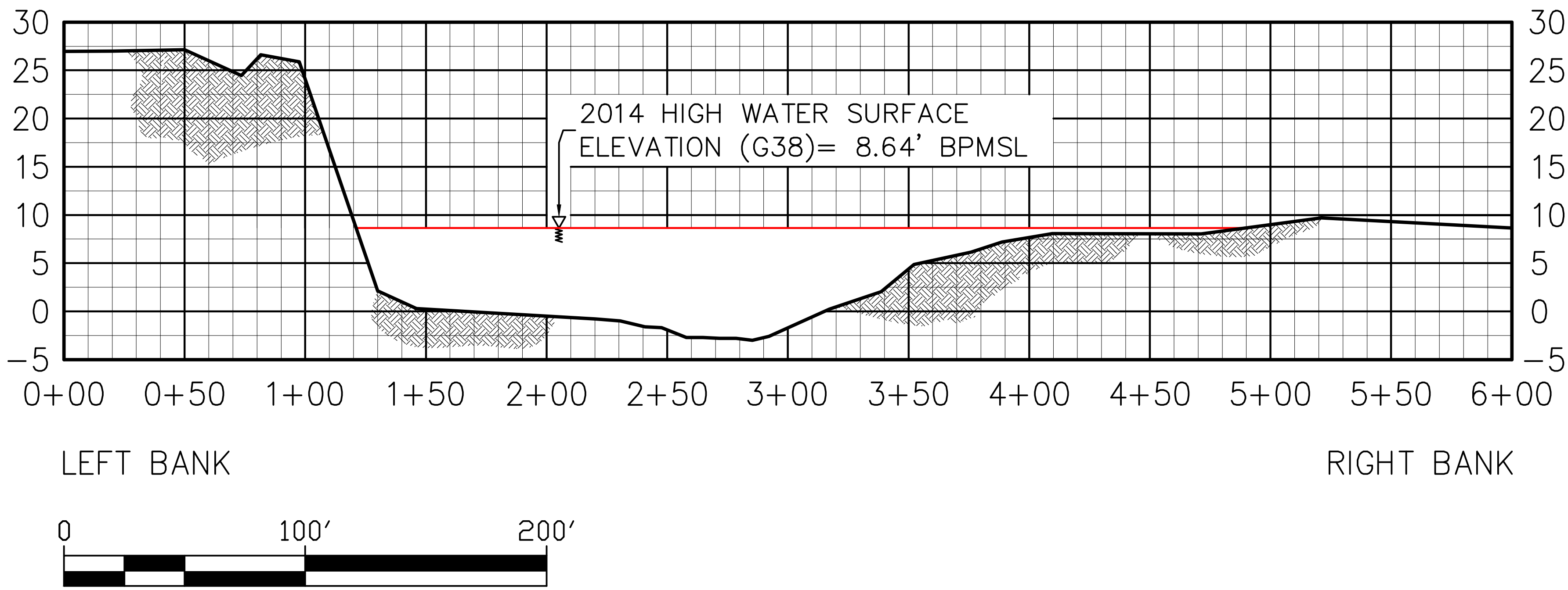
2014 SPRING BREAKUP
CD5 CROSSING
NIGLIQ CHANNEL CENTERLINE

(SHEET 2 OF 2)

B.3.4 NIGLIAGVIK CHANNEL

NOTES
1. BASIS OF ELEVATION, CP08-11-66C.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED AUGUST 2014 BY UMIAQ (KUUKPIK/LCMF INC.)



1 CONSTRUCTED CD5 CROSSING – NIGLIAGVIK CENTERLINE CROSS SECTION

ConocoPhillips Alaska, Inc.

DATE:	09/30/2014	PROJECT:	141450
DRAWN:	MNU	FILE:	NIGLIAGVIK.DWG
CHECKED:	MJT	SCALE:	AS SHOWN

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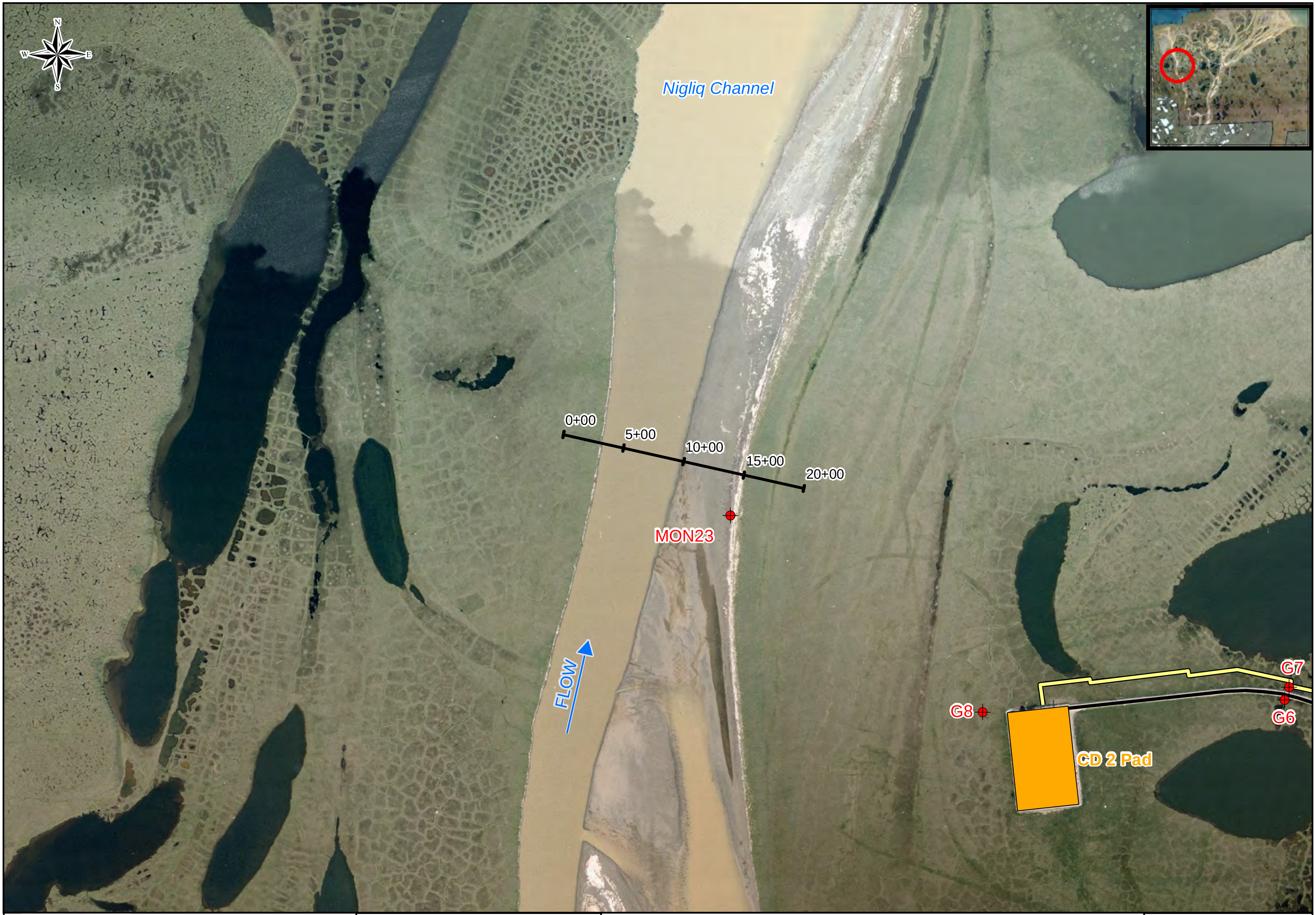
2014 SPRING BREAKUP
CD5 CROSSING
NIGLIAGVIK CENTERLINE

(SHEET 2 OF 2)

B.4 Nigliq Channel Cross-Section

B.4.1 MON23



ConocoPhillips Alaska

Feet
0 500 1,000

Date:	10/01/2014	Project:	141450
Drawn:	MEA	File:	
Checked:	SME	Scale:	1 in = 1000 feet

Legend
- Gage Location
- 2005 Cross Section Alignment
- Pipeline
- Existing Facility

Imagery Source: ConocoPhillips Alaska, 2004

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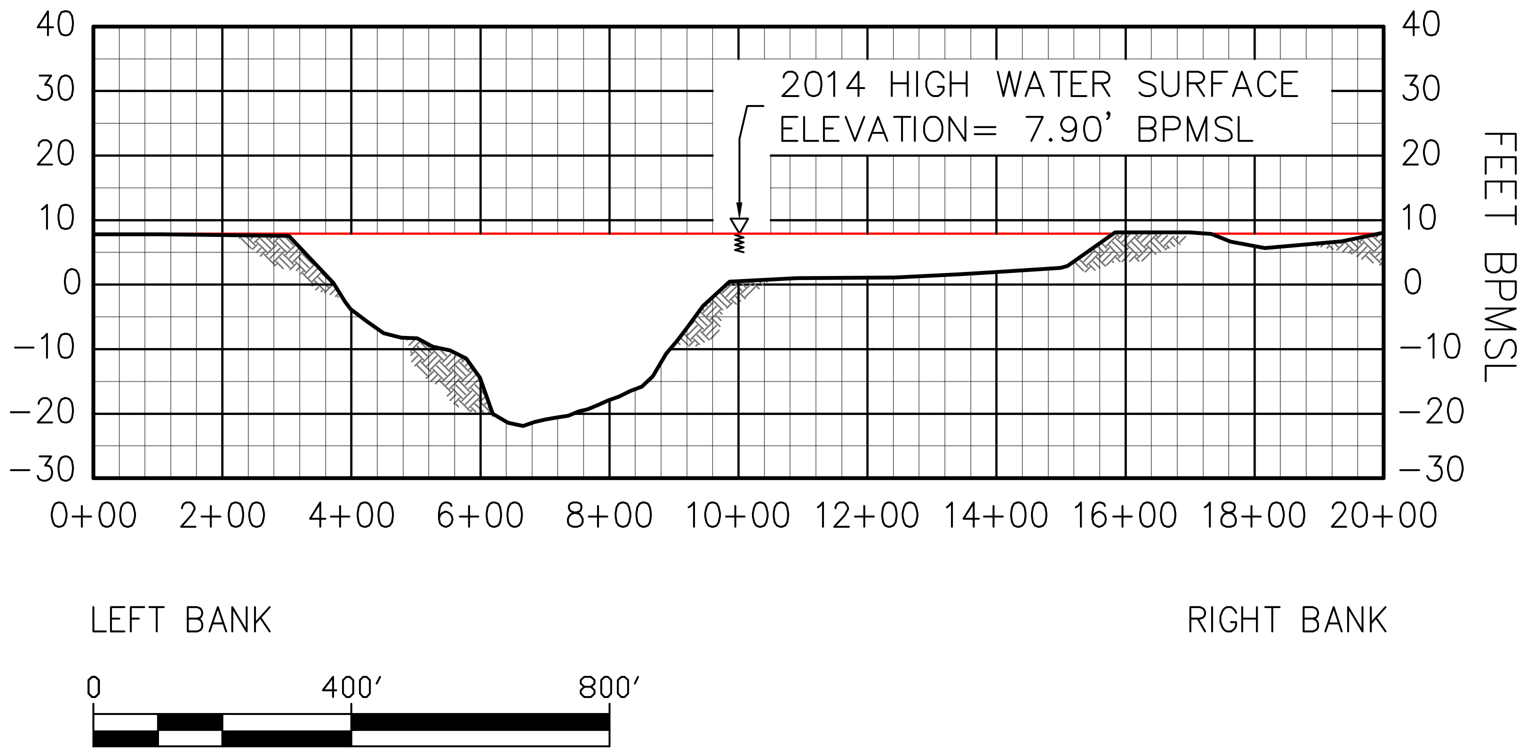
2014 SPRING BREAKUP
MONUMENT 23
PLAN

(SHEET 1 of 1)

NOTES
1. BASIS OF ELEVATION, MONUMENT 23.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED OCTOBER 2005 BY UMIAQ (KUUKPIK/LCMF INC.)



1 NIGLIQ CHANNEL CROSS SECTION AT MONUMENT 23

ConocoPhillips Alaska, Inc.

DATE: 09/30/2014	PROJECT: 141450
DRAWN: MNU	FILE: MON23.DWG
CHECKED: MJT	SCALE: AS SHOWN

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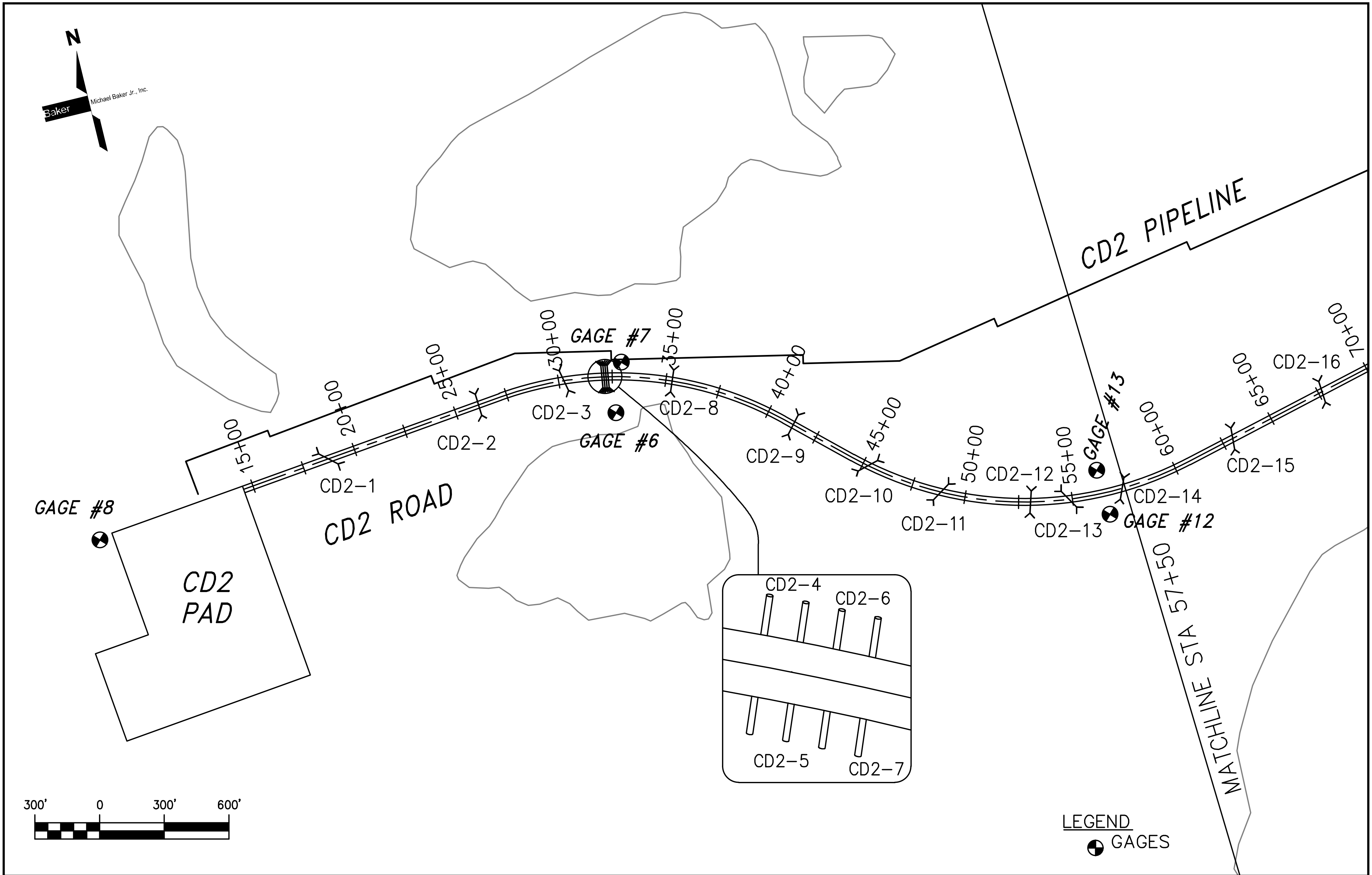
2014 SPRING BREAKUP
NIGLIQ CHANNEL
MONUMENT 23 CROSS SECTION

(SHEET 2 OF 2)

B.5 Alpine Facilities Drainage Structures Locations

B.5.1 CD2



ConocoPhillips Alaska, Inc.

DATE: 09/30/2014	PROJECT: 141450
DRAWN: SMC	FILE: ALPINE_FACILITES.DWG
CHECKED: SME	SCALE: AS SHOWN

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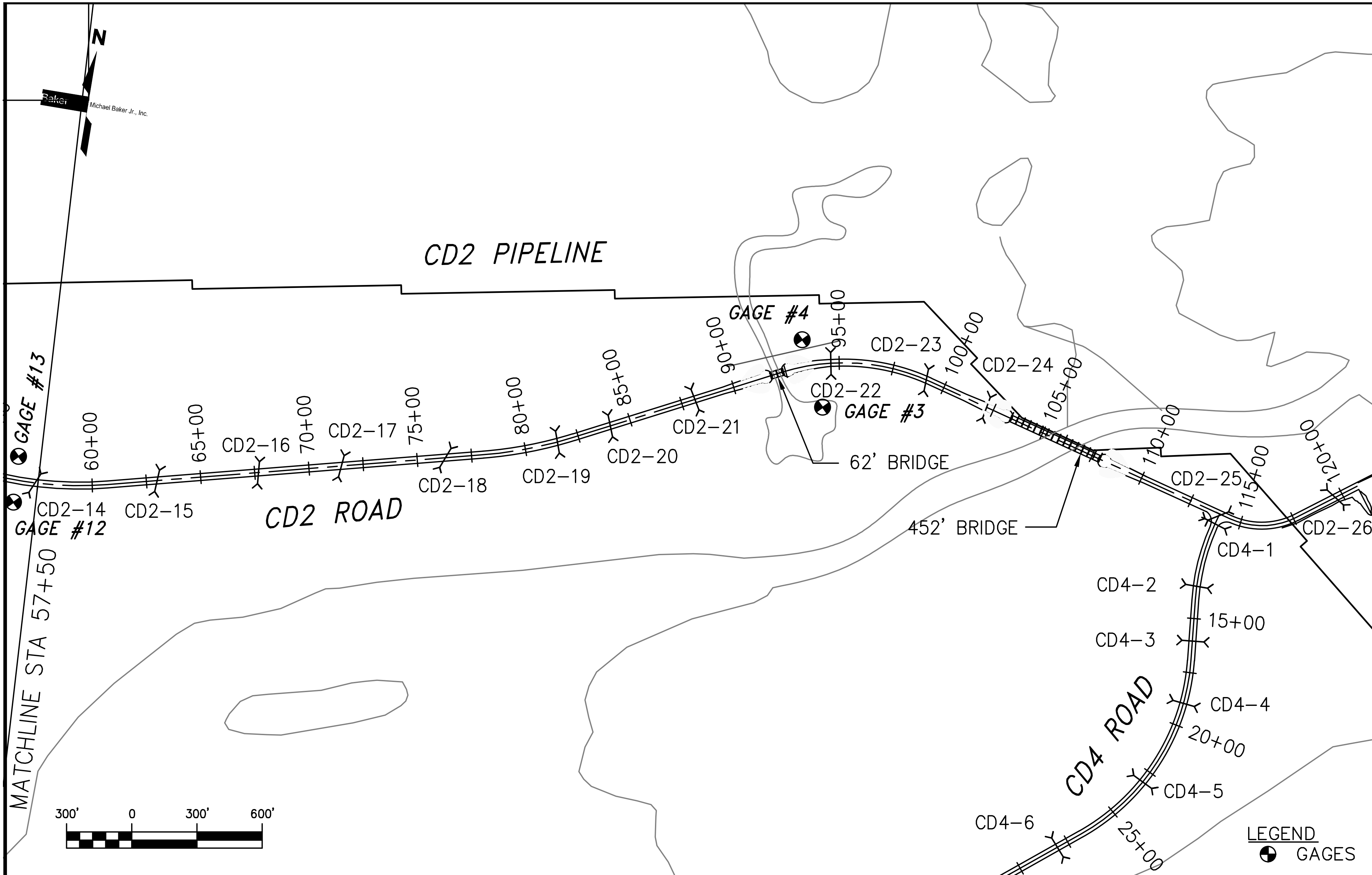
2014 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION



ConocoPhillips
Alaska, Inc.

DATE: 09/30/2014	PROJECT: 141450
DRAWN: SMC	FILE: ALPINE_FACILITES.DWG
CHECKED: SME	SCALE: AS SHOWN

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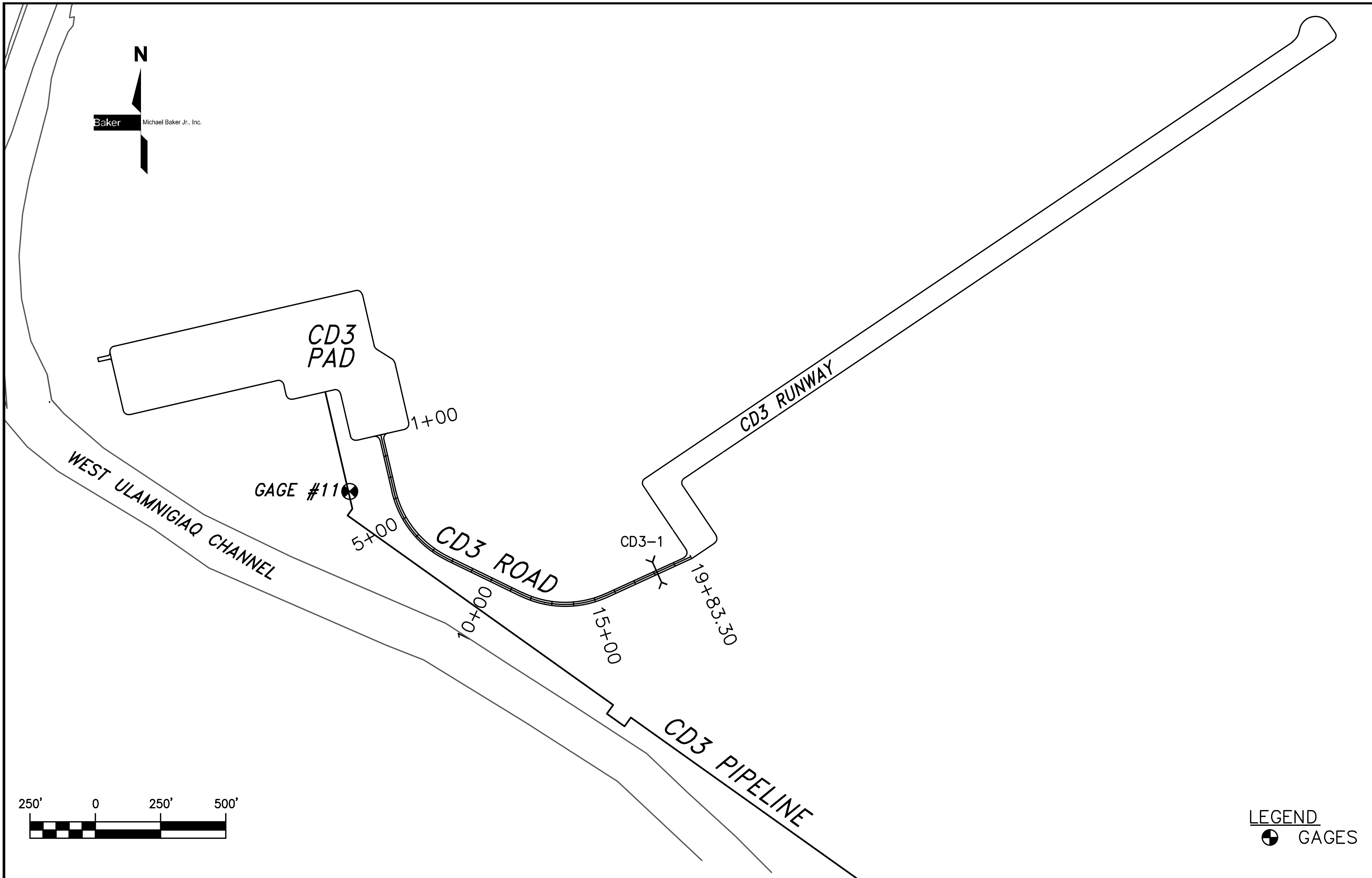
2014 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

B.5.2 CD3



ConocoPhillips Alaska, Inc.

DATE:	09/30/2014	PROJECT:	141450
DRAWN:	SMC	FILE:	ALPINE_FACILITES.DWG
CHECKED:	SME	SCALE:	AS SHOWN

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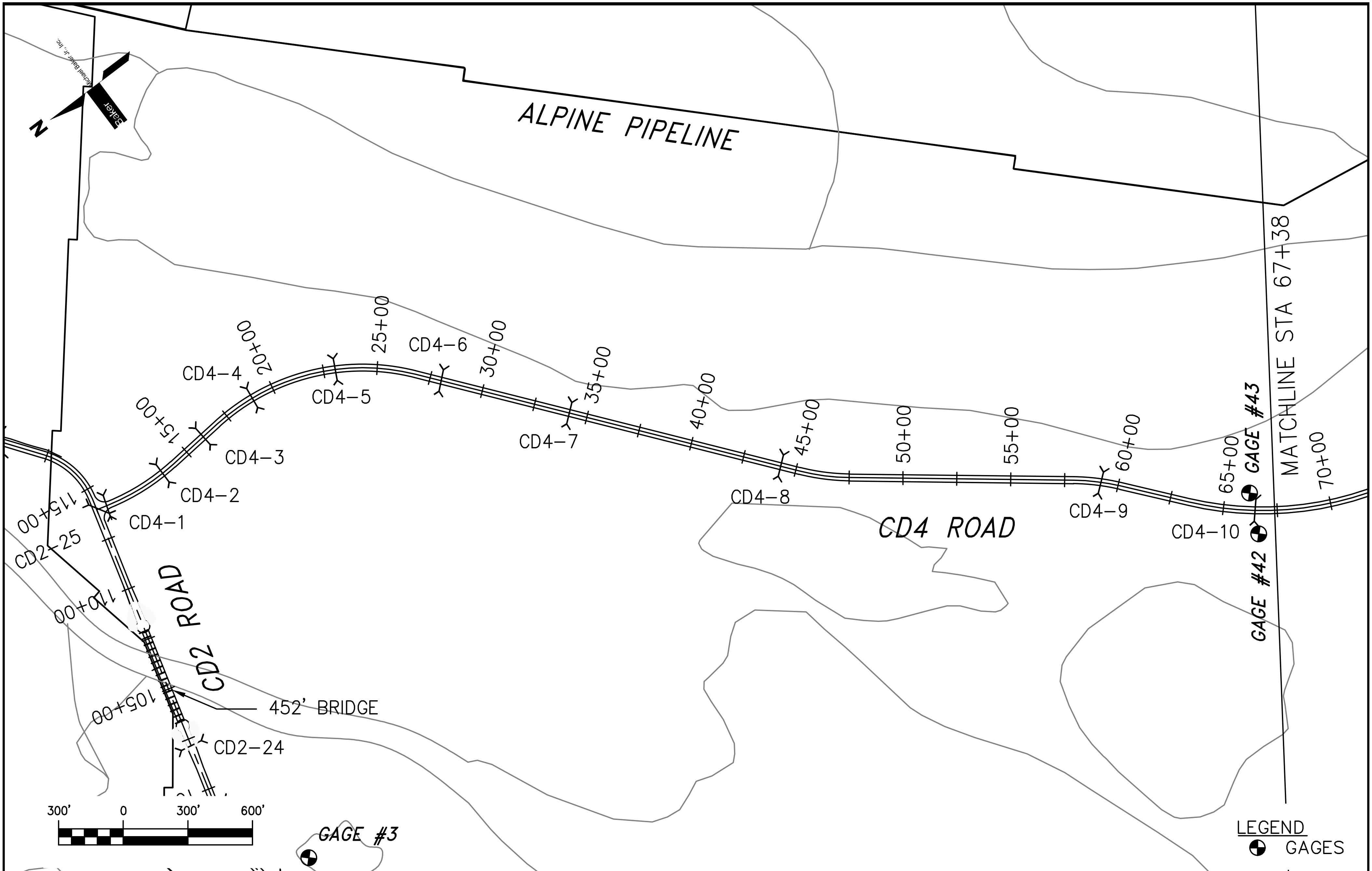
2014 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET13 OF 13)

B.5.3 CD4



ConocoPhillips Alaska, Inc.

DATE: 09/30/2014	PROJECT: 141450
DRAWN: SMC	FILE: ALPINE_FACILITES.DWG
CHECKED: SME	SCALE: AS SHOWN

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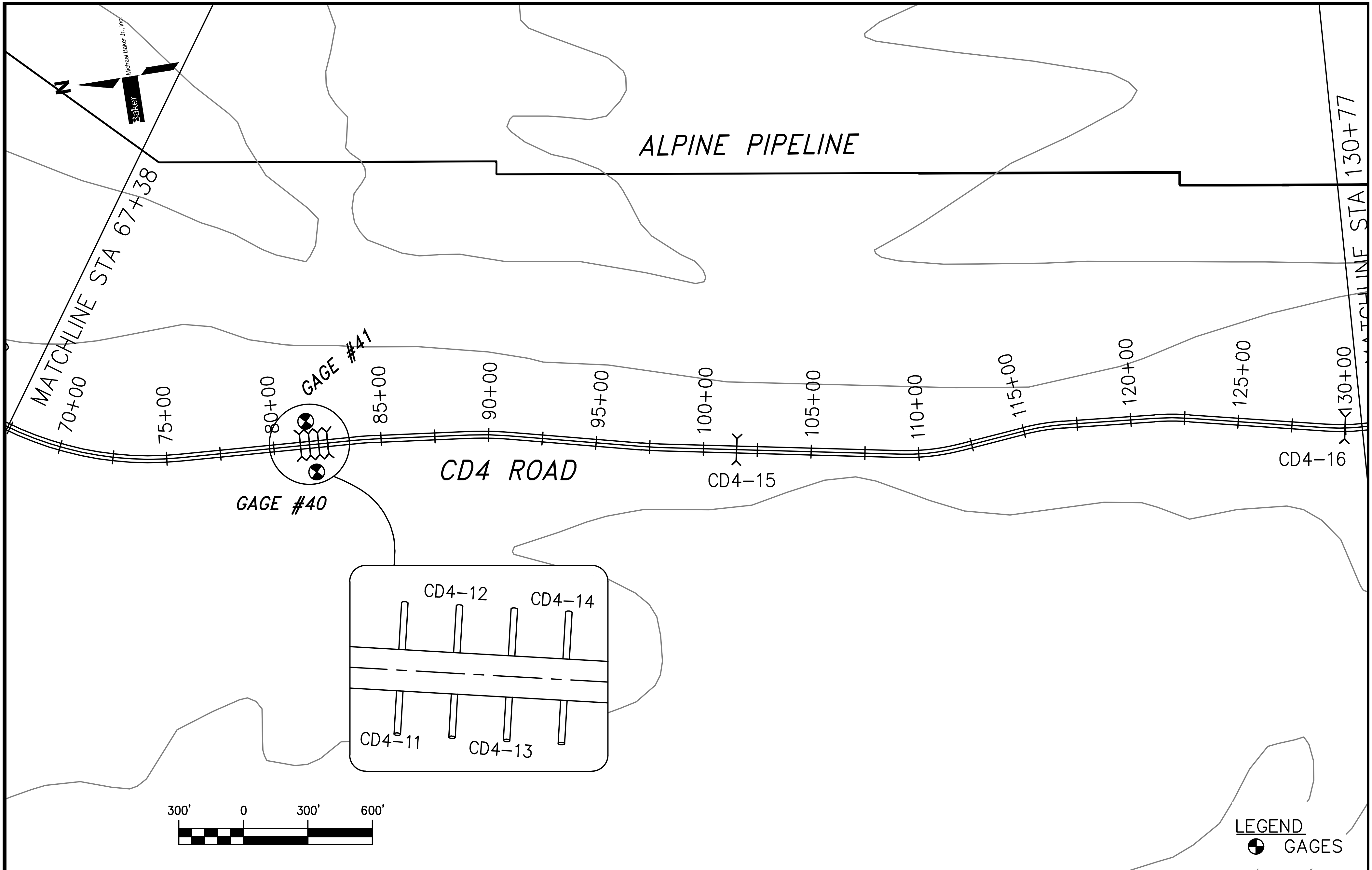
2014 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION



ConocoPhillips
Alaska, Inc.

DATE:	09/30/2014	PROJECT:	141450
DRAWN:	SMC	FILE:	ALPINE_FACILITES.DWG
CHECKED:	SME	SCALE:	AS SHOWN

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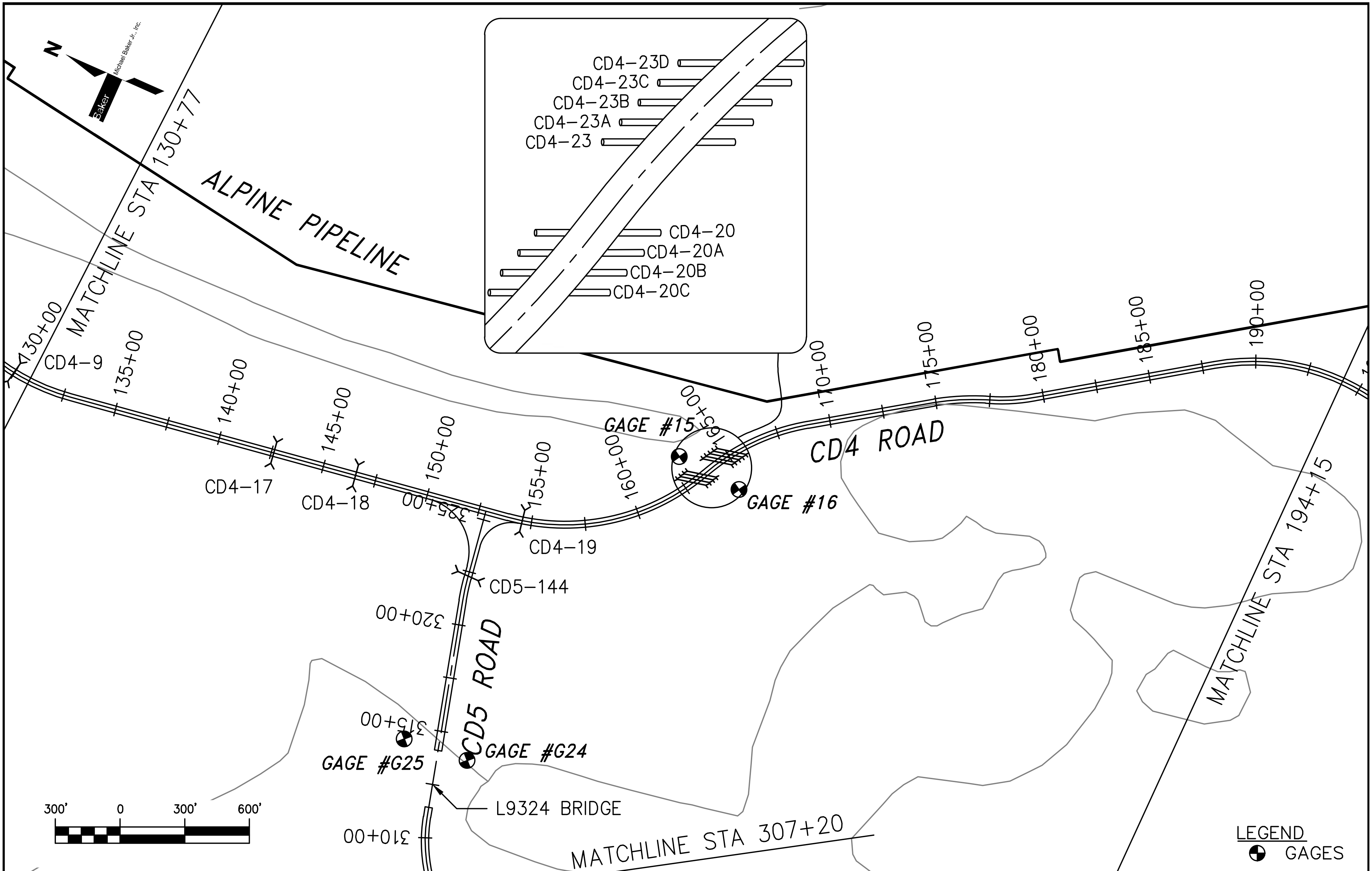
2014 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 4 OF 13)



ConocoPhillips
Alaska, Inc.

DATE: 09/30/2014	PROJECT: 141450
DRAWN: SMC	FILE: ALPINE_FACILITES.DWG
CHECKED: SME	SCALE: AS SHOWN

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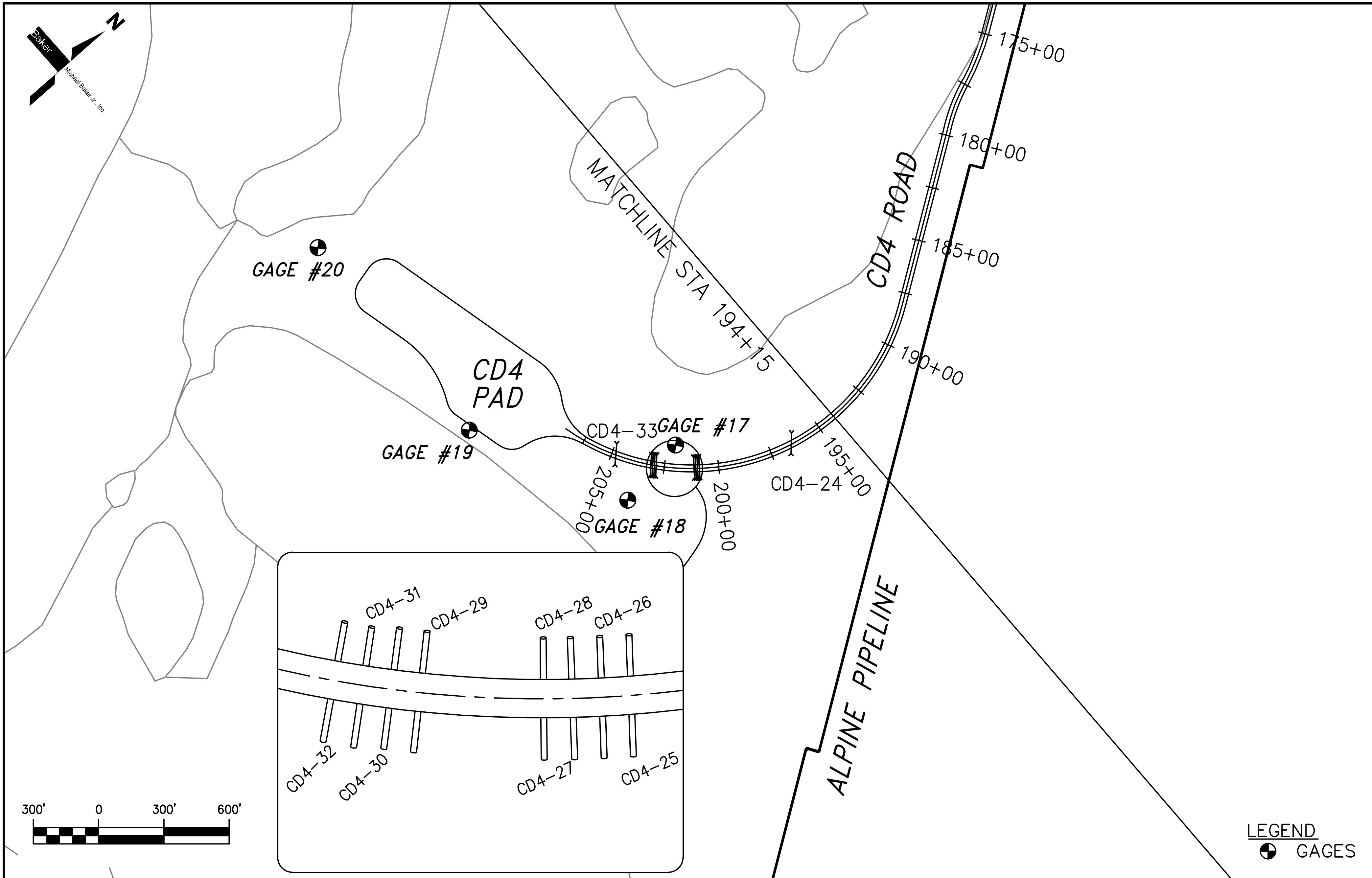
2014 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION



ConocoPhillips
Alaska, Inc.

DATE:	09/30/2014	PROJECT:	141450
DRAWN:	SMC	FILE:	ALPINE_FACILITES.DWG
CHECKED:	SME	SCALE:	AS SHOWN

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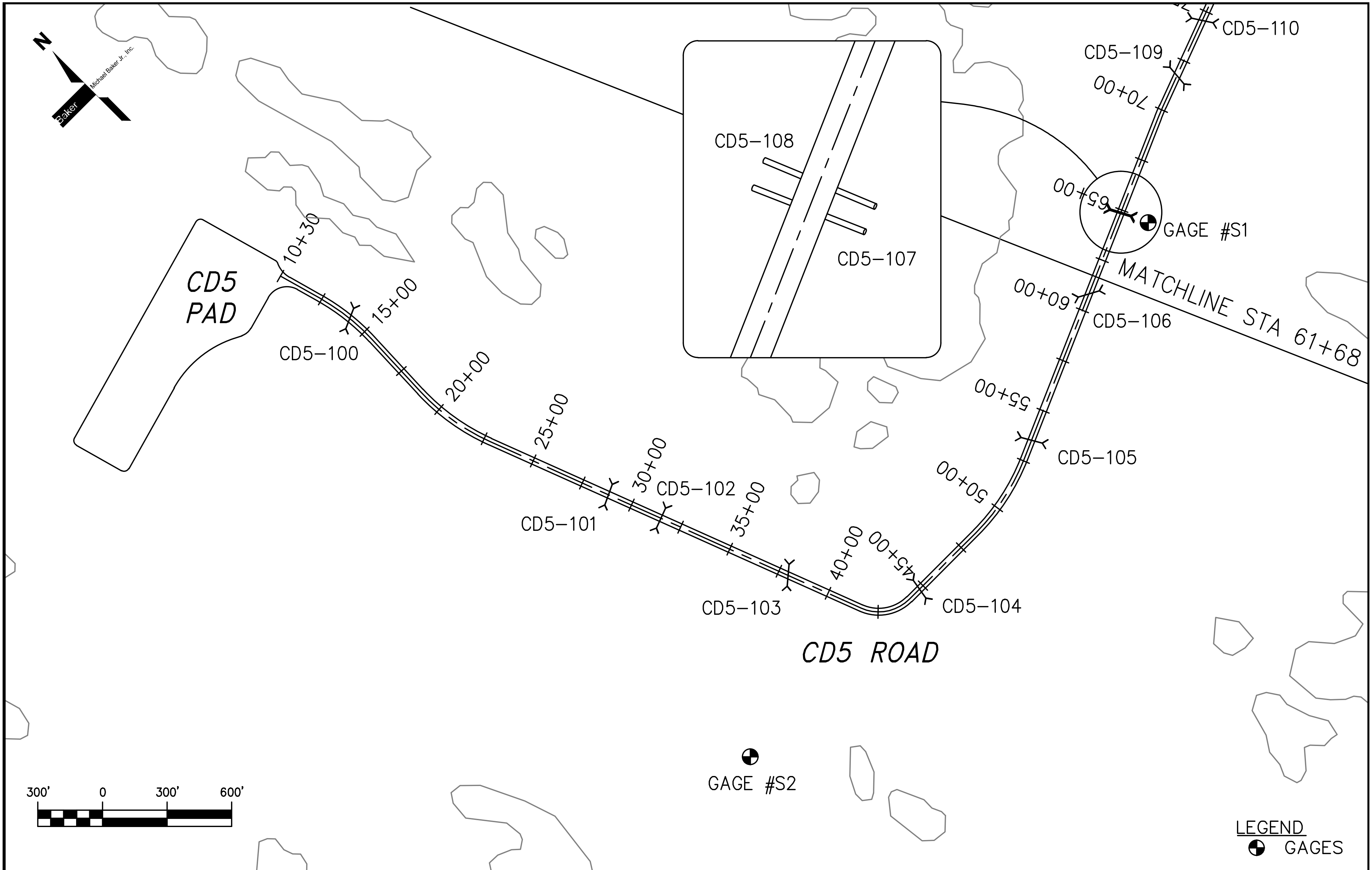
2014 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

B.5.4 CD5



ConocoPhillips Alaska, Inc.

DATE: 09/30/2014	PROJECT: 141450
DRAWN: SMC	FILE: ALPINE_FACILITES.DWG
CHECKED: SME	SCALE: AS SHOWN

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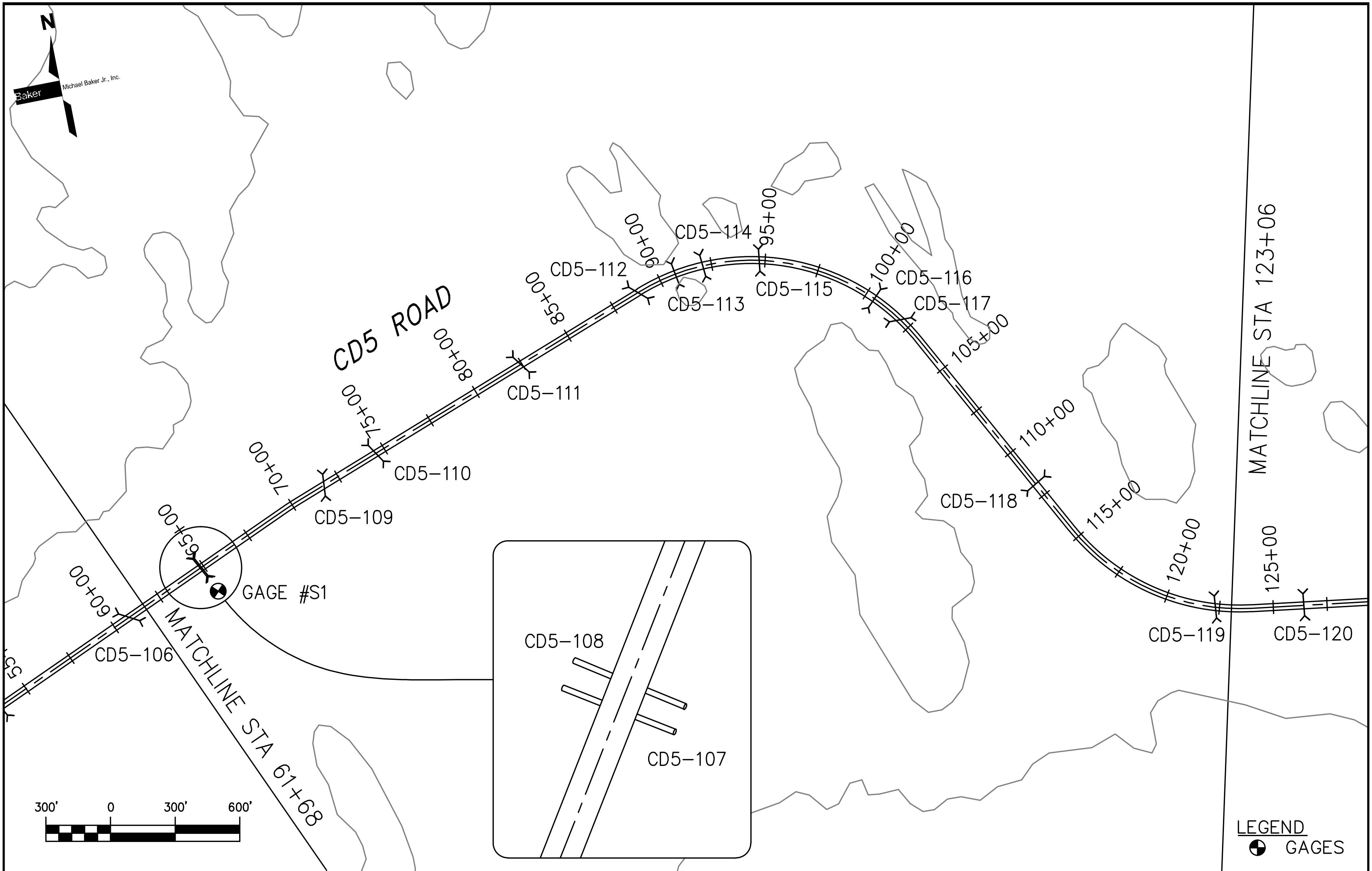
2014 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET 7 OF 13)



ConocoPhillips Alaska, Inc.

DATE: 09/30/2014	PROJECT: 141450
DRAWN: SMC	FILE: ALPINE_FACILITES.DWG
CHECKED: SME	SCALE: AS SHOWN

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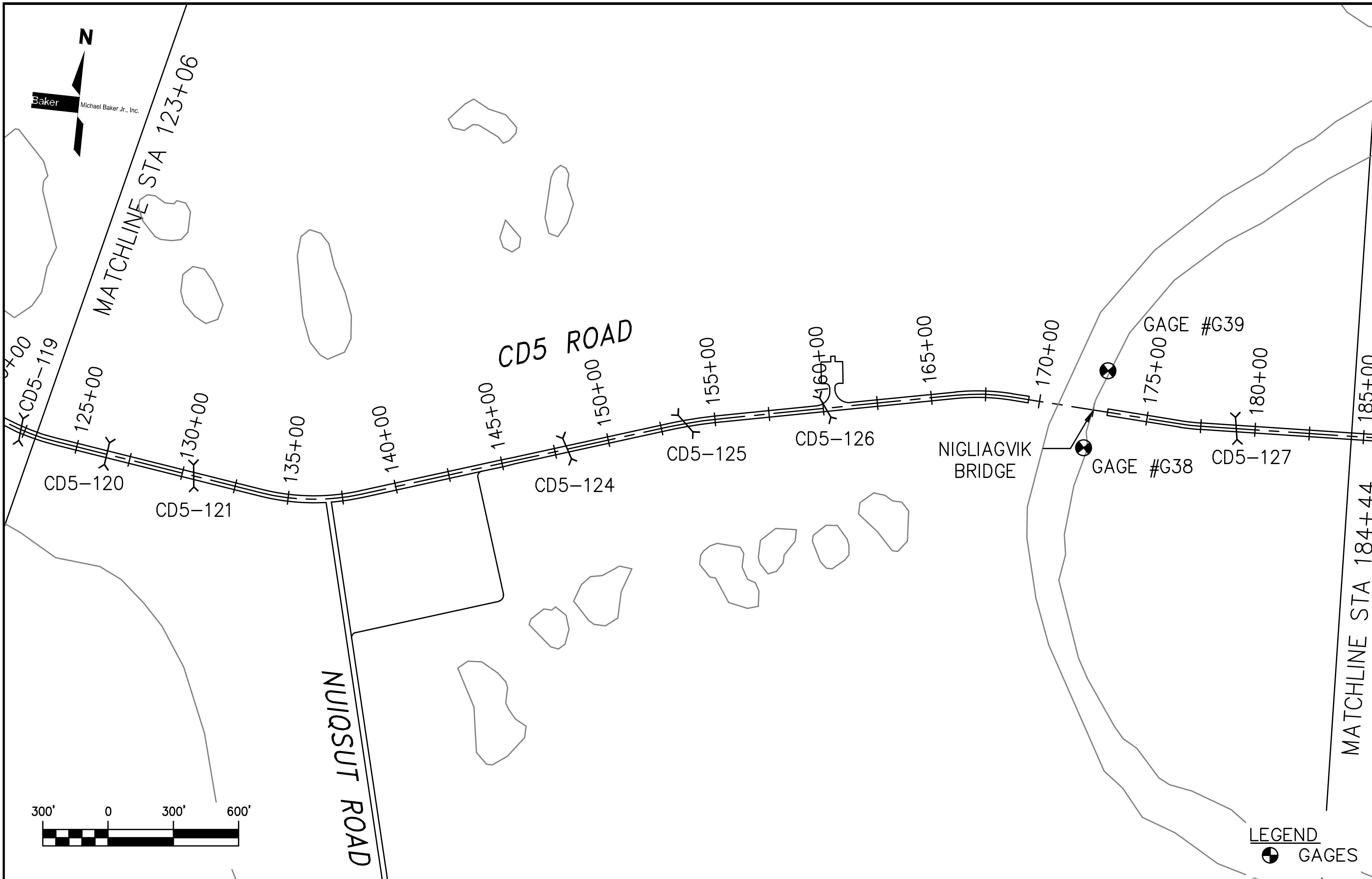
2014 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET 8 OF 13)



ConocoPhillips
Alaska, Inc.

DATE:	09/30/2014	PROJECT:	141450
DRAWN:	SMC	FILE:	ALPINE_FACILITES.DWG
CHECKED:	SME	SCALE:	AS SHOWN

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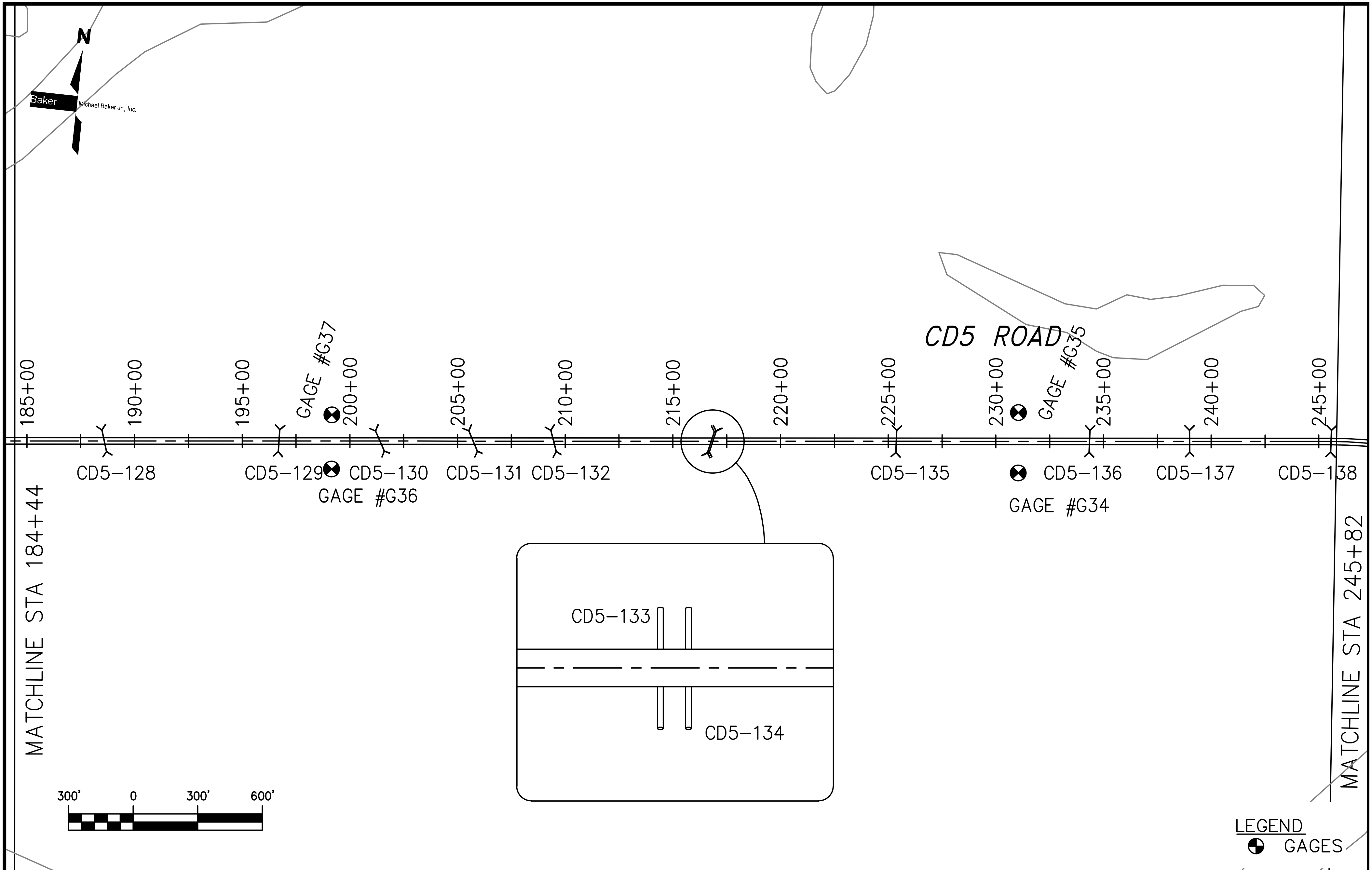
2014 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET 9 OF 13)



ConocoPhillips Alaska, Inc.

DATE: 09/30/2014	PROJECT: 141450
DRAWN: SMC	FILE: ALPINE_FACILITES.DWG
CHECKED: SME	SCALE: AS SHOWN

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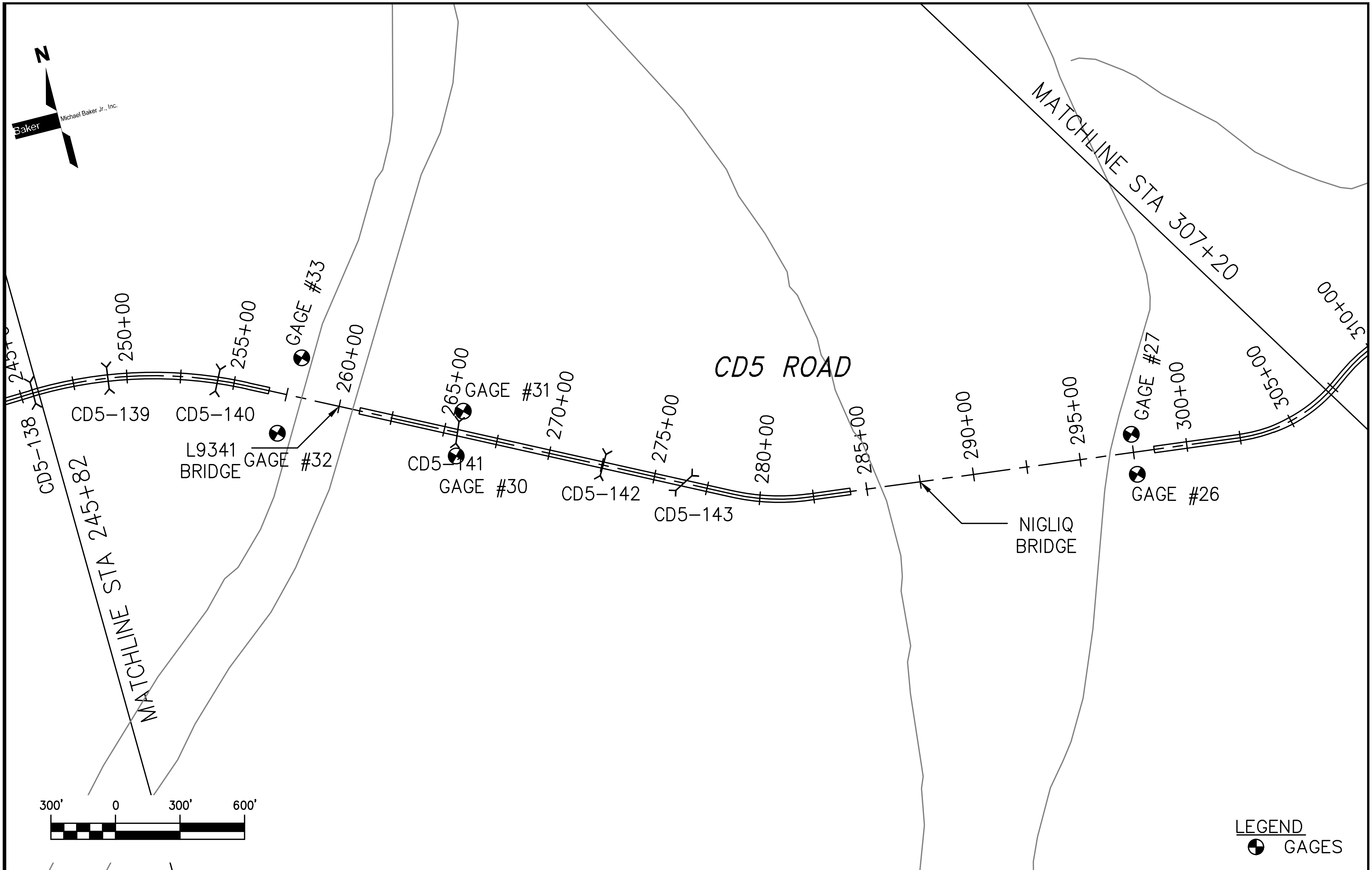
2014 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET10 OF 13)



ConocoPhillips Alaska, Inc.

DATE: 09/30/2014	PROJECT: 141450
DRAWN: SMC	FILE: ALPINE_FACILITES.DWG
CHECKED: SME	SCALE: AS SHOWN

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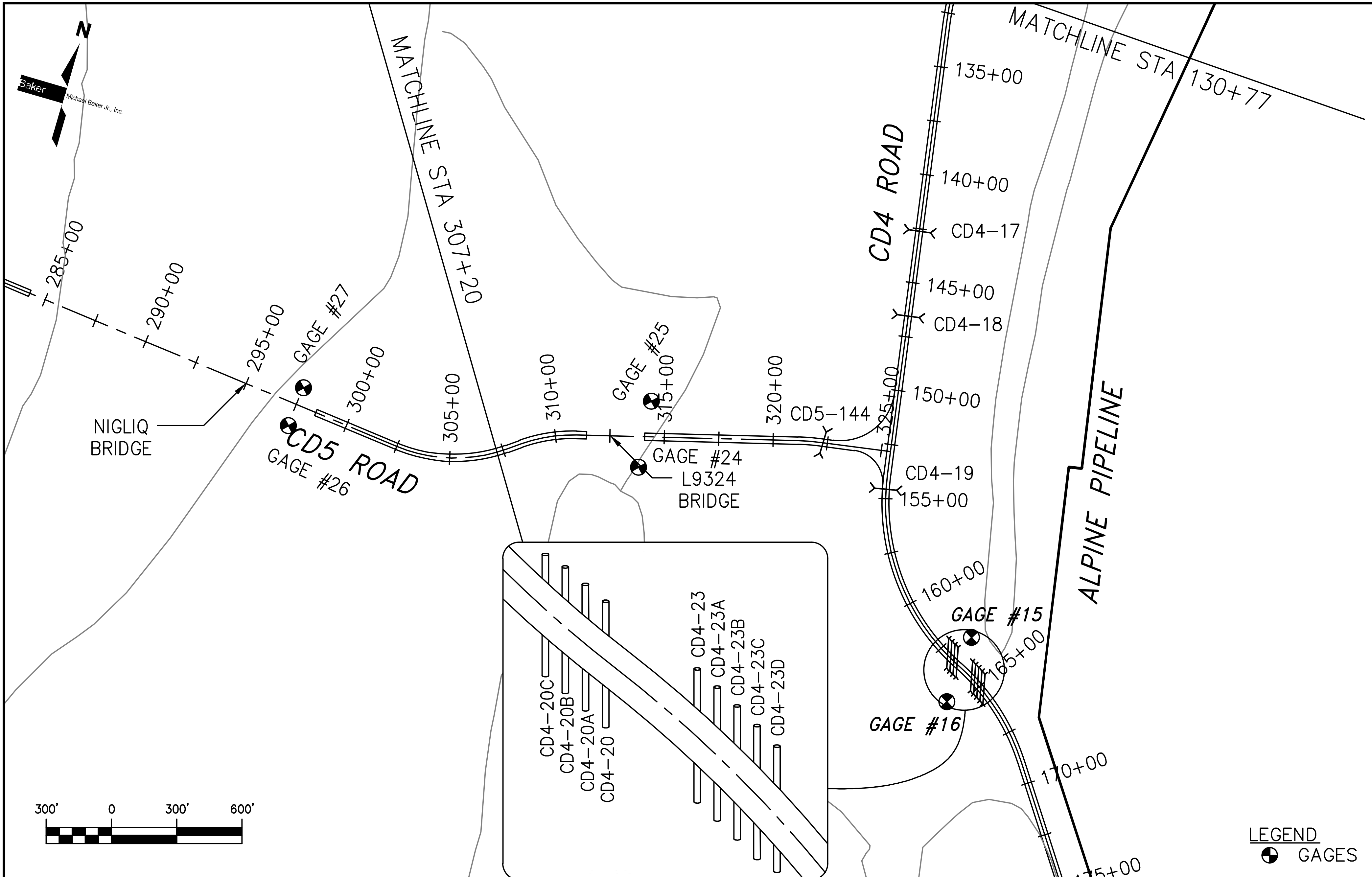
2014 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET11 OF 13)



ConocoPhillips Alaska, Inc.

DATE:	09/30/2014	PROJECT:	141450
DRAWN:	SMC	FILE:	ALPINE_FACILITES.DWG
CHECKED:	SME	SCALE:	AS SHOWN

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2014 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

Appendix C Additional Photographs

C.1 CD5 Road

Photo C.1: CD5 Road between Lake L9323 and CD4 Road, local melt water, looking southeast; June 7, 2014

Photo C.2: CD5 Road between Nigliq Channel and L9323, no overland flow along road, looking northeast; June 4, 2014

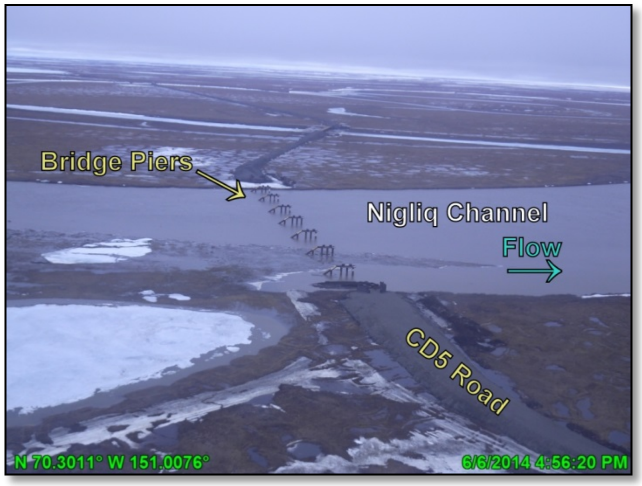


Photo C.3: CD5 Road between Nigliq Channel and CD5 pad, local melt water with no flow observed through culverts or around road prism, looking west; June 6, 2014

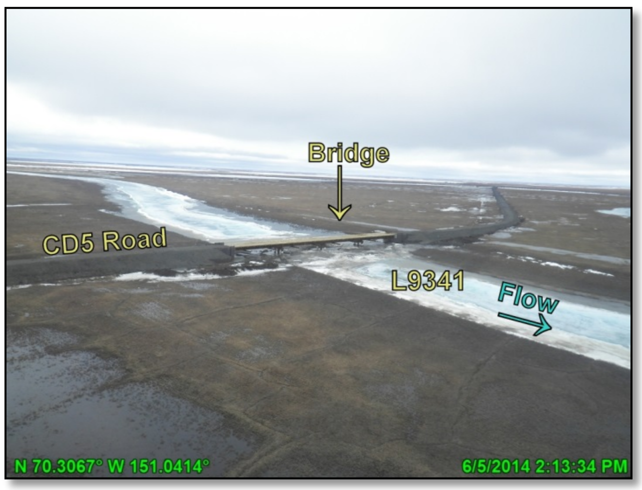


Photo C.4: CD5 Road between Lake L9341 and Nigliagvik Channel, local melt water with no flow through culverts or around road prism, looking west; June 5, 2014

Photo C.5: CD5 Road between Nigliagvik Channel and CD5 Pad, local melt water with no observed flow around road prism looking west; June 5, 2014

C.2 Erosion Survey

Photo C.6: CD2 Road Erosion Survey, looking north; June 8, 2014

Photo C.7: CD2 Road Erosion Survey, looking north; June 8, 2014

Photo C.8: CD2 Road Erosion Survey, looking north; June 8, 2014

Photo C.9: CD2 Road Erosion Survey, looking north; June 8, 2014

Photo C.10: CD4 Road Erosion Survey; June 8, 2014

Photo C.11: CD4 Road Erosion Survey; June 8, 2014

C.3 Ice Roads

Photo C.12: Colville East Channel ice road crossing slotted, looking east; May 15, 2014

Photo C.13: Colville East Channel ice road crossing ramps, looking southwest; May 16, 2014

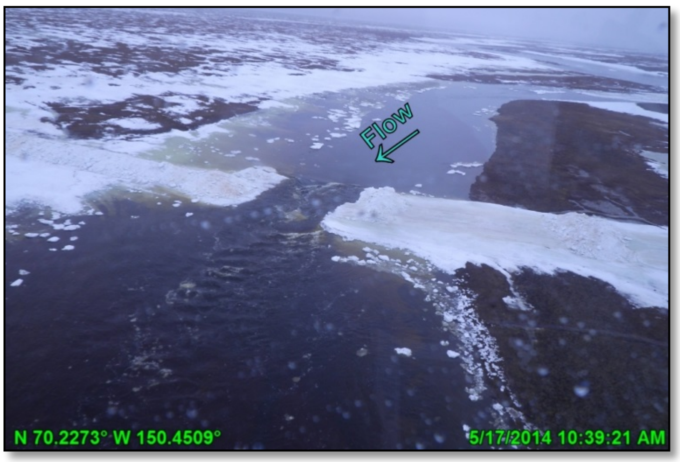


Photo C.14: Flow through the Kachemach ice road crossing, looking south; May 17, 2014

Photo C.15: Flow through slotted sections of the Nigliagvik exploration ice road crossing, looking southeast; May 17, 2014

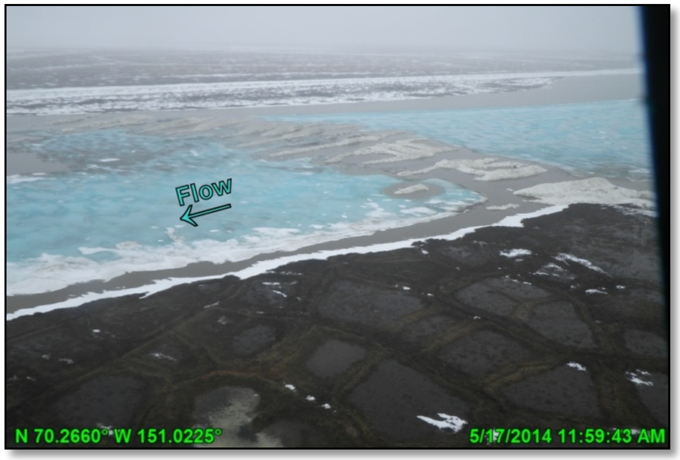


Photo C.16: Flow through the slotted Nigliq Channel exploration ice road crossing, looking east; May 17, 2014

Photo C.17: Flow over the No Name Creek ice road crossing, looking northeast; May 17, 2014

Photo C.18: Flow through slotted Pineapple Gulch ice road crossing, looking southwest; May 23, 2014

Photo C.19: Flow through slotted Silas Slough ice road crossing, looking northwest; May 17, 2014

Photo C.20: Slotted Slemp Slough ice road crossing, looking east; May 17, 2014

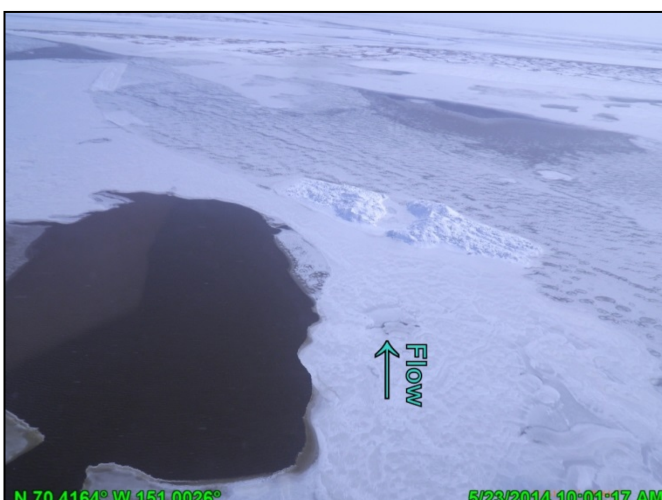


Photo C.21: Melt water at slotted Slemp Slough ice road crossing, looking northeast; May 23, 2014

Photo C.22: Flow through slotted Tamayayak ice road crossing, looking west; May 23, 2014

Photo C.23: Remnant of the Tamayayak ice road crossing, looking east; June 2, 2014

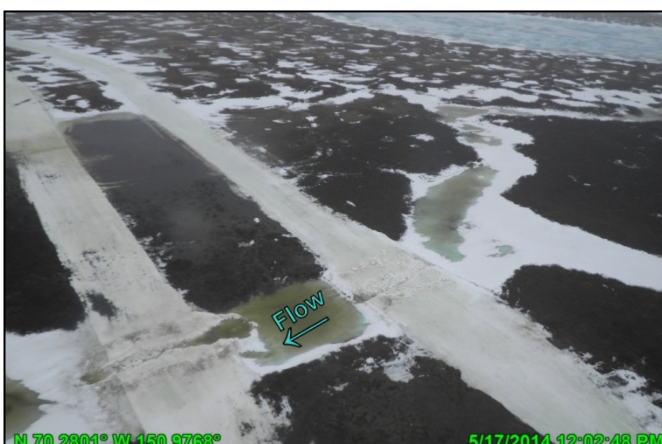


Photo C.24: Melt at slotted Toolbox Creek ice road crossing, looking north; May 17, 2014

Photo C.25: Degradation of construction ice pad at Nigliq Channel Bridge crossing, looking west;

May 22, 2014

Photo C.26: Open channel at Nigliq Channel Bridge crossing, looking north; June 3, 2014

Photo C.27: Degradation of Nigliagvik Channel Bridge construction ice pad, looking south; May 24, 2014

Photo C.28: Open channel at Nigliagvik Bridge crossing, looking north; June 8, 2014

Photo C.29: Lake L9341 Bridge and construction ice pad, looking northeast; May 18, 2014

Photo C.30: Lake L9341 Bridge and construction ice pad, looking west; June 7, 2014

Photo C.31: Lake L9323 Bridge and construction ice pad, looking west, May 22, 2014

Photo C.32: Lake L9323 Bridge crossing open water, looking southeast; June 7, 2014

Appendix D 2014 ADCP Direct Discharge Data

D.1 MON1

Station Number: Meas. No:
Station Name: MON1_RUNS_06042014 Date: 06/04/2014

Party:	Width: 929.7 m	Processed by:
Boat/Motor:	Area: 3817.0 m²	Mean Velocity: 1.33 m/s
Gage Height: 0.000 m	G.H.Change: 0.000 m	Discharge: 5,090 m³/s

Area Method: Mean Flow	ADCP Depth: 0.396 m	Index Vel.: 0.00 m/s	Rating No.: 1
Nav. Method: Bottom Track	Shore Ens.:10	Adj.Mean Vel: 0.00 m/s	Qm Rating: U
MagVar Method: None (19.4°)	Bottom Est: Power (0.1667)	Rated Area: 0.000 m²	Diff.: 0.000%
Depth: Composite	Top Est: Power (0.1667)	Control1: Unspecified	
Discharge Method: Distributed		Control2: Unspecified	
% Correction: 6.14		Control3: Unspecified	

Screening Thresholds:		ADCP:	
BT 3-Beam Solution: YES	Max. Vel.: 2.79 m/s	Type/Freq.: Workhorse / 1200 kHz	
WT 3-Beam Solution: NO	Max. Depth: 9.81 m	Serial #: 5283	Firmware: 51.40
BT Error Vel.: 0.10 m/s	Mean Depth: 4.11 m	Bin Size: 25 cm	Blank: 25 cm
WT Error Vel.: 1.07 m/s	% Meas.: 74.59	BT Mode: 5	BT Pings: 1
BT Up Vel.: 0.30 m/s	Water Temp.: None	WT Mode: 1	WT Pings: 1
WT Up Vel.: 3.05 m/s	ADCP Temp.: 4.7 °C	WV : 196	
Use Weighted Mean Depth: YES			

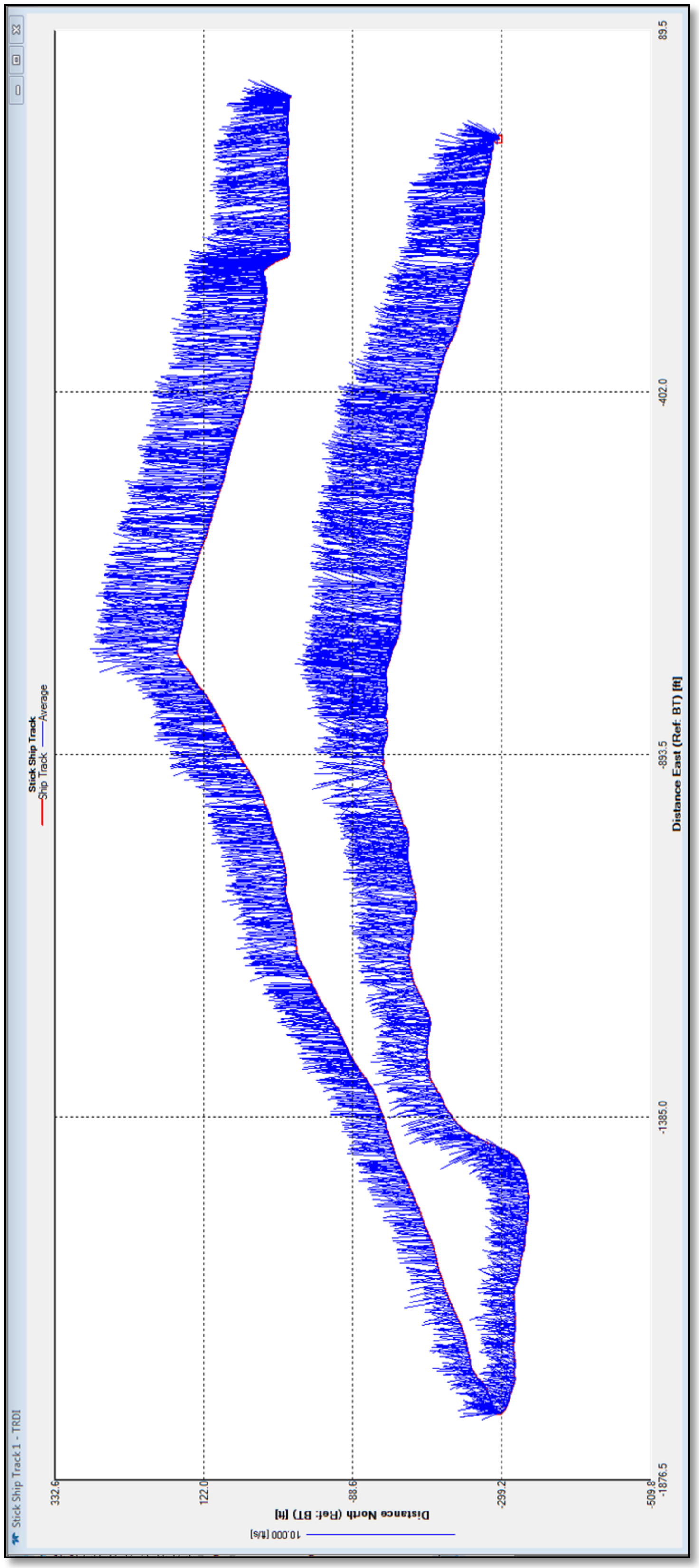
Performed Diag. Test: NO
Performed Moving Bed Test: YES
Performed Compass Calibration: NO Evaluation: NO
Meas. Location:

Project Name: mon1_runs_06042014_0_proce
Software: 2.14

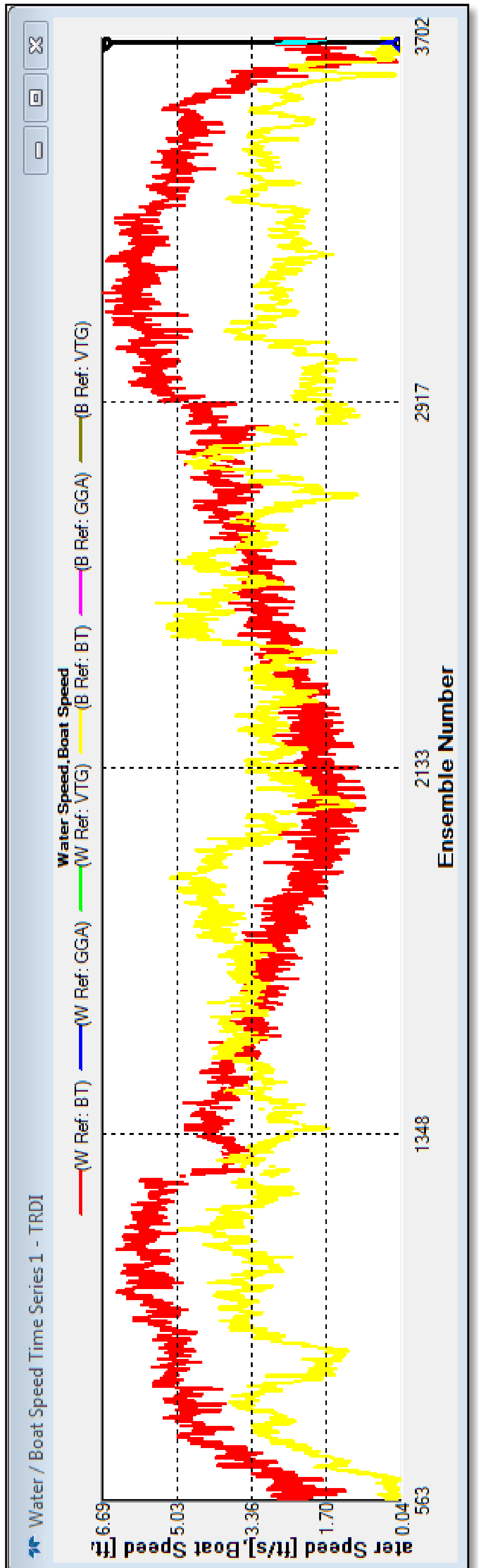
Tr.#		Edge Distance		#Ens.	MBT Corrected Discharge						Width	Area	Time		Mean Vel.		% Bad	
		L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins
002	L	370	7.37	2153	665	3795	509	136	5.99	5111	909.6	3786.5	16:30	16:45	0.70	1.35	4	0
003	R	370	7.37	1759	677	3814	510	112	5.70	5119	940.6	3853.7	16:49	17:01	0.82	1.33	3	0
004	L	370	7.37	2038	660	3772	494	104	6.18	5036	912.8	3768.4	17:06	17:20	0.70	1.34	3	0
006	R	370	7.37	2208	680	3807	511	92.0	5.99	5097	955.7	3859.2	17:37	17:52	0.69	1.32	3	0
Mean		370	7.37	2039	671	3797	506	111	5.96	5091	929.7	3817.0	**Total**	01:21	0.73	1.33	3	0
SDev		0.00	0.00	200	9.76	18.7	8.26	18.6	0.196	37.8	22.2	46.3			0.06	0.01		
SD/M		0.00	0.00	0.10	0.01	0.00	0.02	0.17	0.03	0.01	0.02	0.01			0.08	0.01		

Remarks:

MON1 ADCP Transect



MON1 ADCP Water and Boat Velocities



D.2 Nigliq Channel

Station Number:
Station Name: CD5 Bridge

Meas. No:
Date: 06/05/2014

Party:
Boat/Motor:
Gage Height: 0.000 m

Width: 419.4 m
Area: 1171.6 m²
G.H.Change: 0.000 m

Processed by:
Mean Velocity: 0.741 m/s
Discharge: 868 m³/s

Area Method: Mean Flow
Nav. Method: Bottom Track
MagVar Method: None (19.4°)
Depth: Composite
Discharge Method: Distributed
% Correction: 2.76

ADCP Depth: 0.366 m
Shore Ens.:10
Bottom Est: Power (0.1667)
Top Est: Power (0.1667)

Index Vel.: 0.00 m/s
Adj.Mean Vel: 0.00 m/s
Rated Area: 0.000 m²
Control1: Unspecified
Control2: Unspecified
Control3: Unspecified

Rating No.: 1
Qm Rating: U
Diff.: 0.000%

Screening Thresholds:
BT 3-Beam Solution: YES
WT 3-Beam Solution: NO
BT Error Vel.: 0.10 m/s
WT Error Vel.: 1.07 m/s
BT Up Vel.: 0.30 m/s
WT Up Vel.: 2.44 m/s
Use Weighted Mean Depth: YES

Max. Vel.: 1.56 m/s
Max. Depth: 5.69 m
Mean Depth: 2.79 m
% Meas.: 61.97
Water Temp.: None
ADCP Temp.: 5.6 °C

ADCP:
Type/Freq.: Workhorse / 1200 kHz
Serial #: 5283 Firmware: 51.40
Bin Size: 25 cm Blank: 25 cm
BT Mode: 5 BT Pings: 1
WT Mode: 1 WT Pings: 1
WV : 175

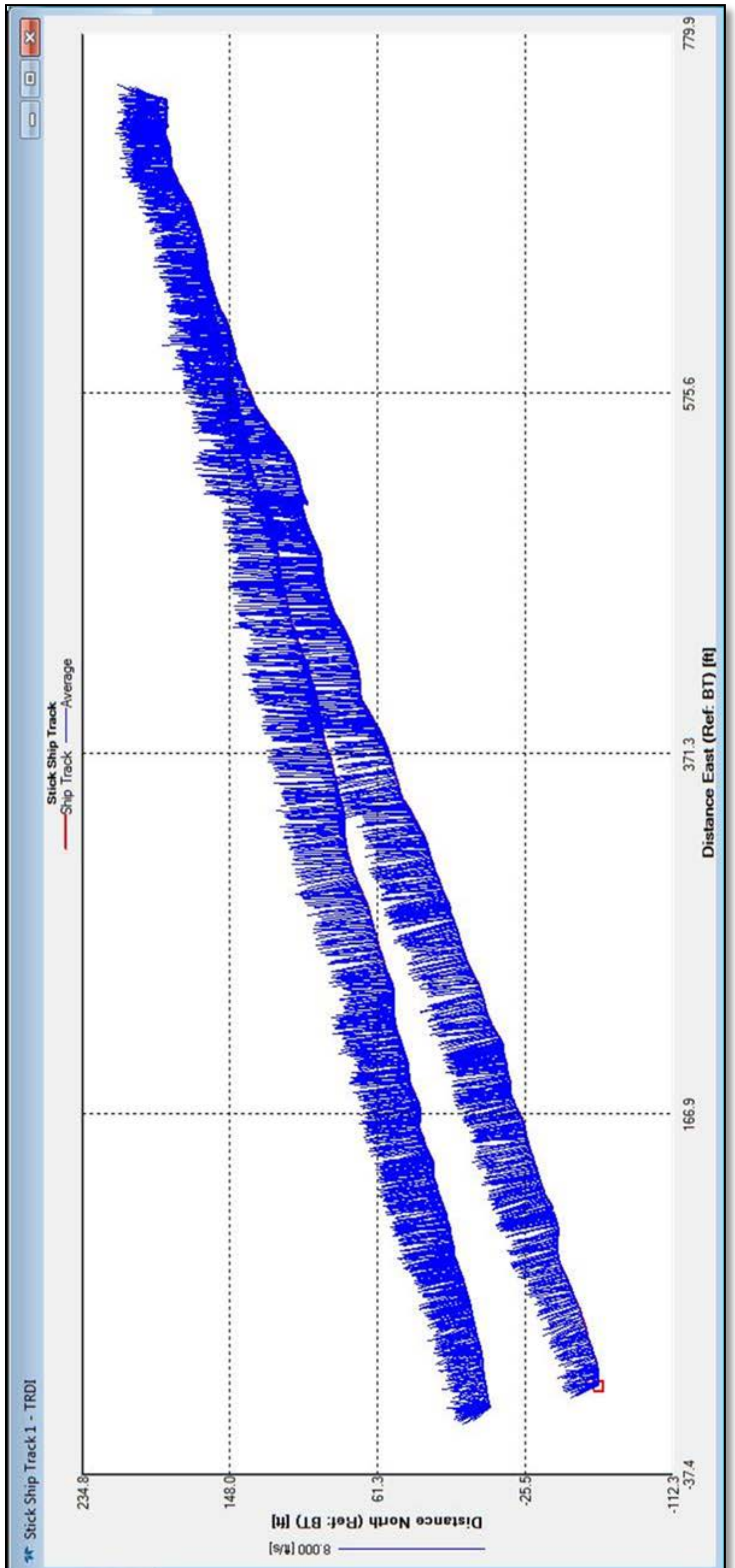
Performed Diag. Test: NO
Performed Moving Bed Test: YES
Performed Compass Calibration: NO Evaluation: NO
Meas. Location:

Project Name: cd5_nigliq_runs_processed.mm
Software: 2.14

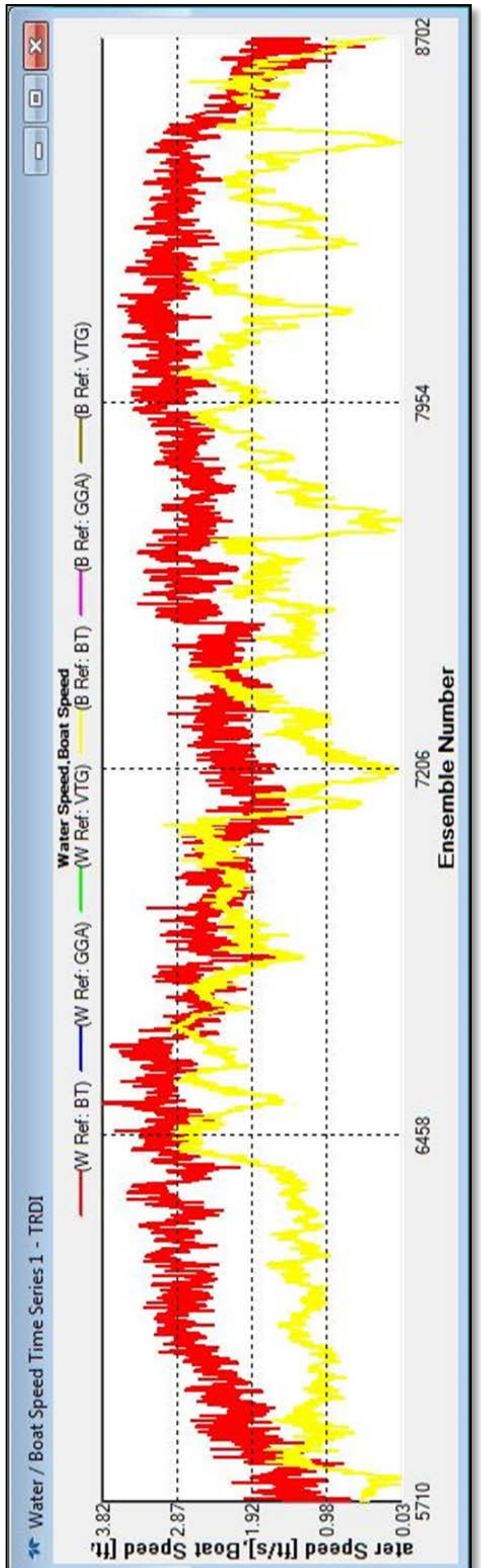
Tr.#		Edge Distance		#Ens.	MBT Corrected Discharge						Width	Area	Time		Mean Vel.		% Bad	
		L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins
003	L	6.43	177	1657	183	541	92.0	3.60	48.1	867	421.2	1160.5	13:37	13:45	0.47	0.75	0	0
005	L	6.43	177	1376	183	544	92.4	3.32	58.1	881	419.4	1173.9	13:59	14:07	0.57	0.75	0	0
007	L	6.43	177	1338	182	535	91.8	3.23	52.8	865	420.0	1163.3	14:28	14:35	0.58	0.74	0	0
008	R	6.43	177	1277	179	532	91.6	3.65	53.6	860	416.9	1188.6	14:44	14:51	0.61	0.72	1	0
Mean		6.43	177	1412	182	538	91.9	3.45	53.1	868	419.4	1171.6	**Total**	01:14	0.56	0.74	0	0
SDev		0.00	0.00	168	1.87	5.24	0.350	0.207	4.10	8.85	1.8	12.7			0.06	0.01		
SD/M		0.00	0.00	0.12	0.01	0.01	0.00	0.06	0.08	0.01	0.00	0.01			0.11	0.02		

Remarks:

Nigliq Channel ADCP Transect



Nigliq Channel ADCP Water and Boat Velocities



Appendix E Velocity Meter Discharge Measurement Notes

E.1 Nigliagvik Channel

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: May 24, 2014
Computed By: SMC
Checked By: MJT

Location Name: Nigliagvik Bridge

Party: KMB, DCL   Start: 9:30   Finish: 15:00

Temp: 22 °F   Weather: Partly cloudy, windy

Channel Characteristics:

Width: 78 ft   Area: 314 sq ft   Velocity: 0.98 fps   Discharge: 307 cfs

Method: USGS Midsection   Number of Sections: 40   Count: N/A

Spin Test: Passed after 180 seconds   Meter: MJBA01

GAGE READINGS			
Gage	Start	Finish	Change
G38	5.02	4.90	0.12
G39	4.93	4.79	0.14

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading **Cable** Ice Boat

Upstream or Downstream side of bridge

GPS Data: W Bridge Abutment

Left Edge of Water: N 70.30553333 ° W 151.1194167 °

Right Edge of Water: N 70.3055 ° W 151.1187667 °

E Bridge Abutment

LE Floodplain: ° ' . "

RE Floodplain: ° ' . "

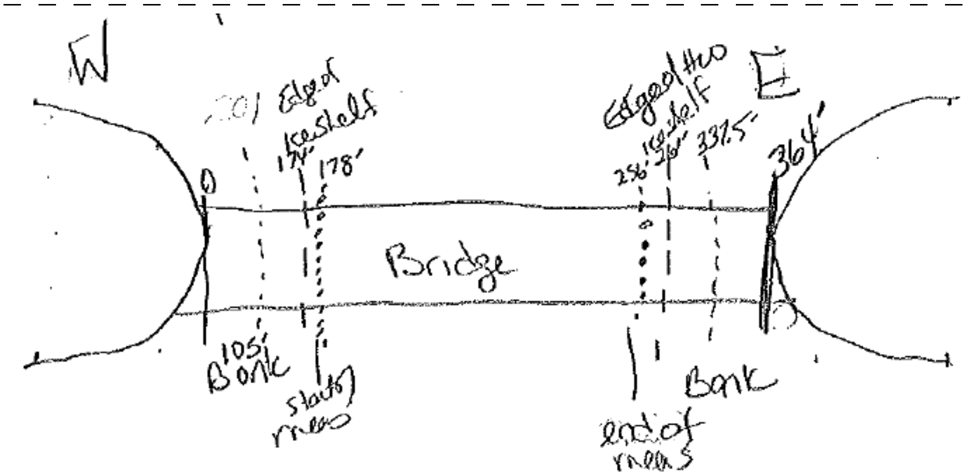
Measurement Rated: Excellent Good Fair **Poor** based on "Descriptions"

Descriptions:

Cross Section: Channel clear of snow and ice, possibly bottomfast ice near edges, ice shelf extending 70-75 feet into channel from each bank.

Flow: Ice in channel 300 to 500 feet both up and downstream of crossection

Remarks: Bank obscured by snow and ice.



Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: June 8, 2014
Computed By: SMC
Checked By: MJT

Location Name: Nigliagvik Bridge

Party: GCY, KMB   Start: 13:00   Finish: 16:27

Temp: 38 °F   Weather: Partly cloudy, windy (10-12 knots NE)

Channel Characteristics:

Width: 210 ft   Area: 1062 sq ft   Velocity: 1.30 fps   Discharge: 1378 cfs

Method: USGS Midsection   Number of Sections: 37   Count: N/A

Spin Test: Passed after 180 seconds   Meter: MJBA01

GAGE READINGS			
Gage	Start	Finish	Change
G38	4.43	4.30	0.13
G39	4.43	4.30	0.13

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading **Cable** Ice Boat

Upstream or Downstream side of bridge

GPS Data: W Bridge Abutment
Left Edge of Water: N 70.3056 ° W 151.1182 °
Right Edge of Water: N 70.3056 ° W 151.1199 °
E Bridge Abutment

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

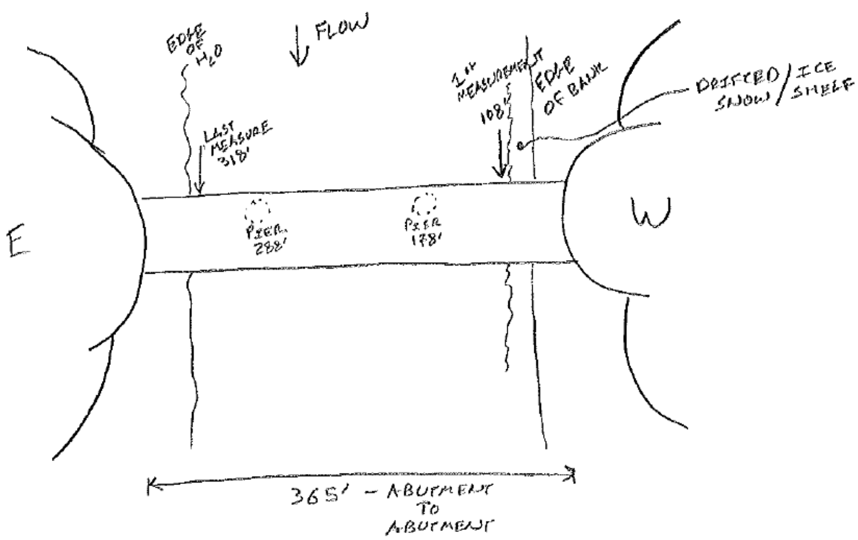
Measurement Rated: Excellent Good **Fair** Poor based on "Descriptions"

Descriptions:

Cross Section: Ice shelf and snowpack extending into the left side of the section impeding measurement.

Flow: Flow unobstructed through bridge, occasional small ice floes passing.

Remarks: Extra measurements made around piers to measure scour flow



E.2 Swale Bridges

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: May 22, 2014
Computed By: KMB
Checked By: SMC

Location Name: Long Swale Bridge

Party: DCL, KMB   Start: 10:04   Finish: 15:00

Temp: 29 °F   Weather: Cloudy, snowing

Channel Characteristics:

Width: 434 ft   Area: 1289 sq ft   Velocity: 0.55 fps   Discharge: 711 cfs

Method: USGS Midsection   Number of Sections: 37   Count: N/A

Spin Test: Passed after 180 seconds   Meter: MJBA01

GAGE READINGS			
Gage	Start	Finish	Change
G3	6.10	5.92	0.18
G4	6.06	5.88	0.18

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading **Cable** Ice Boat

Upstream or Downstream side of bridge

GPS Data: W Bridge Abutment

Left Edge of Water: N 70.3399 ° W 150.9758 °

Right Edge of Water: N 70.3396 ° W 150.9723 °

E Bridge Abutment

LE Floodplain: ° ' . "

RE Floodplain: ° ' . "

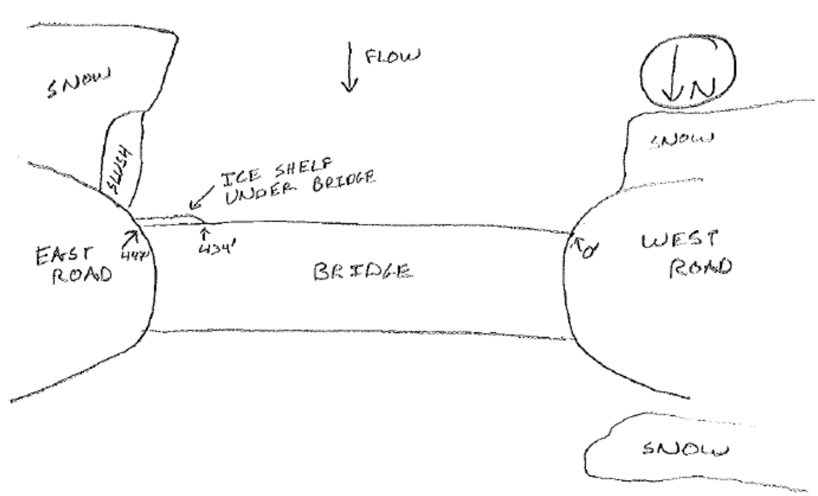
Measurement Rated: Excellent Good **Fair** Poor based on "Descriptions"

Descriptions:

Cross Section: Ice shelf extends 13 feet into the channel from the East abutment, slush present in channel about 10 feet past the ice shelf.

Flow: Occasional ice floes passing.

Remarks: Water level dropping throughout day.



Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: June 2, 2014
Computed By: DCL
Checked By: SMC

Location Name: Long Swale Bridge

Party: DCL, MJT Start: 16:00 Finish: 20:38

Temp: 32 °F Weather: Cloudy, light snow, calm

Channel Characteristics:

Width: 445 ft Area: 2183 sq ft Velocity: 1.30 fps Discharge: 2842 cfs

Method: USGS Midsection Number of Sections: 38 Count: N/A

Spin Test: Passed after 180 seconds Meter: MJBA01

GAGE READINGS			
Gage	Start	Finish	Change
G3	8.00	7.9	0.10
G4	7.87	7.78	0.09

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading **Cable** Ice Boat

Upstream or Downstream side of bridge

GPS Data: W Bridge Abutment
Left Edge of Water: N 70.3399 ° W 150.9758 °
Right Edge of Water: N 70.3396 ° W 150.9723 °
E Bridge Abutment

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

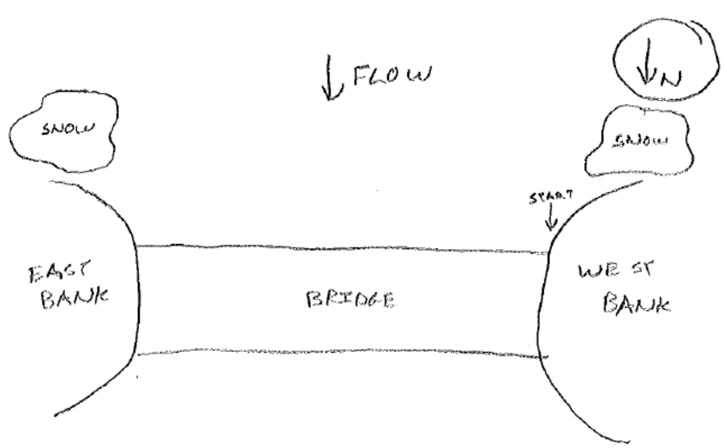
Measurement Rated: Excellent **Good** Fair Poor based on "Descriptions"

Descriptions:

Cross Section: Snow piles present upstream of each abutment, flow under bridge is unimpeded. Occasional ice floes present.

Flow: Slight eddy effects near vertical sheet pile abutments

Remarks:



Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: June 2, 2014
Computed By: DCL
Checked By: SMC

Location Name: Short Swale Bridge

Party: DCL, MJT   Start: 21:41   Finish: 23:42

Temp: 32 °F   Weather: Overcast; light snow, calm

Channel Characteristics:

Width: 54 ft   Area: 365 sq ft   Velocity: 1.31 fps   Discharge: 479 cfs

Method: USGS Midsection   Number of Sections: 28   Count: N/A

Spin Test: Passed after 180 seconds   Meter: MJBA01

GAGE READINGS			
Gage	Start	Finish	Change
G3	7.90	7.81	0.09
G4	7.78	7.69	0.09

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading **Cable** Ice Boat

Upstream or Downstream side of bridge

GPS Data: W Bridge Abutment
Left Edge of Water: N 70.3399 ° W 150.9847 °
Right Edge of Water: N 70.3400 ° W 150.9843 °
E Bridge Abutment

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

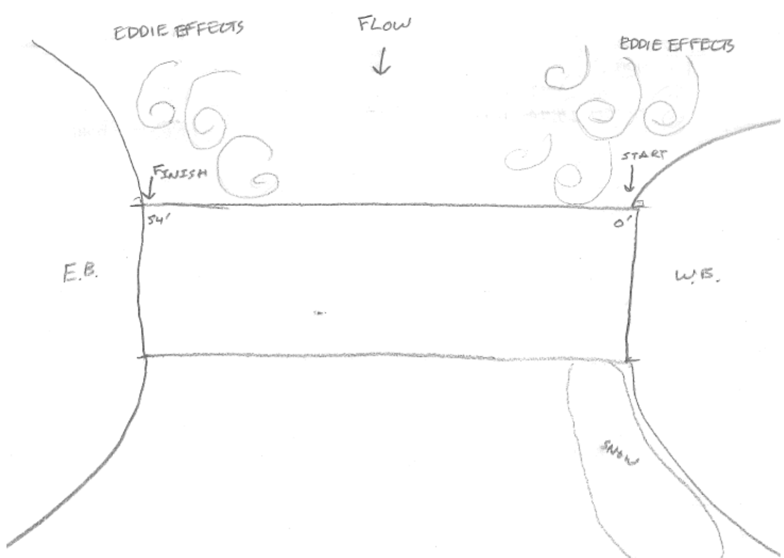
Measurement Rated: Excellent Good **Fair** Poor based on "Descriptions"

Descriptions:

Cross Section: Snow pile present on downstream side at left edge of flow.. Occasional ice floes present.

Flow: Large eddy effects near vertical sheet pile abutments

Remarks:



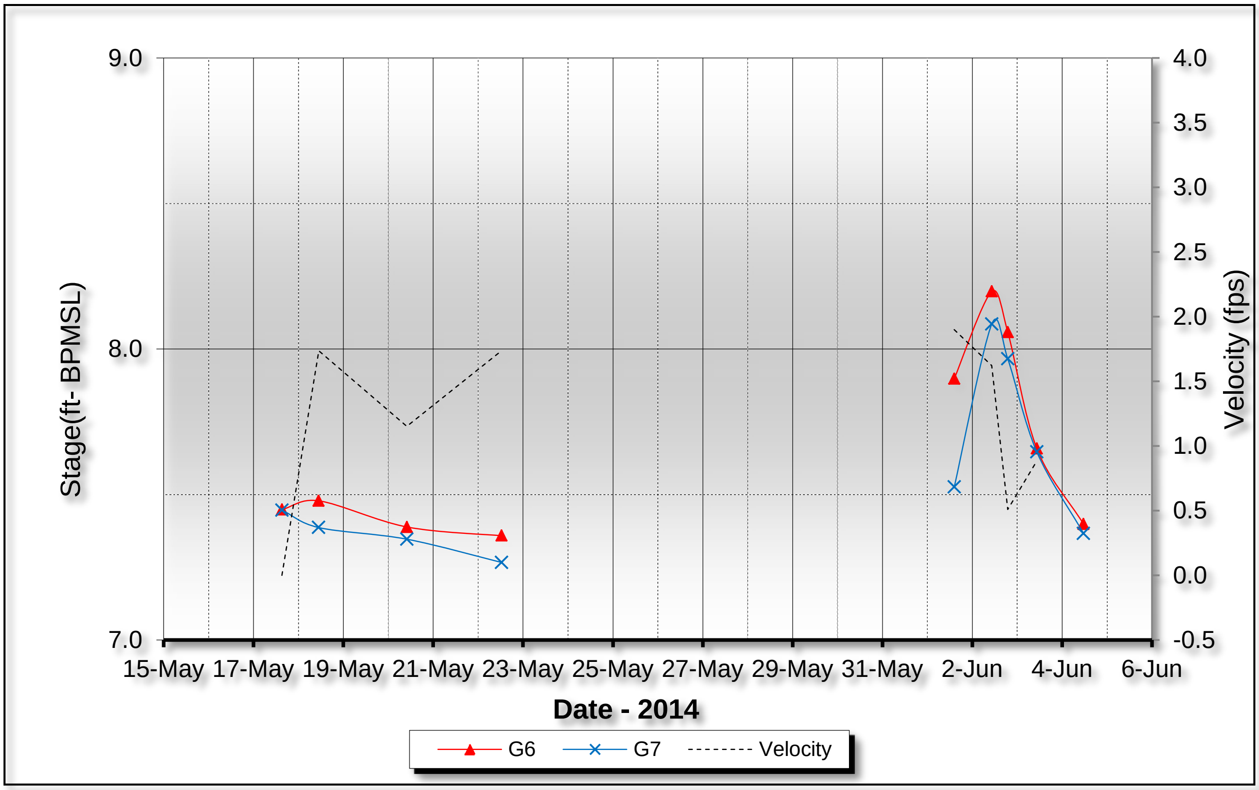
Appendix F Culvert Discharge Data

Table F.1: CD2 Road Culvert Direct Velocity and Discharge

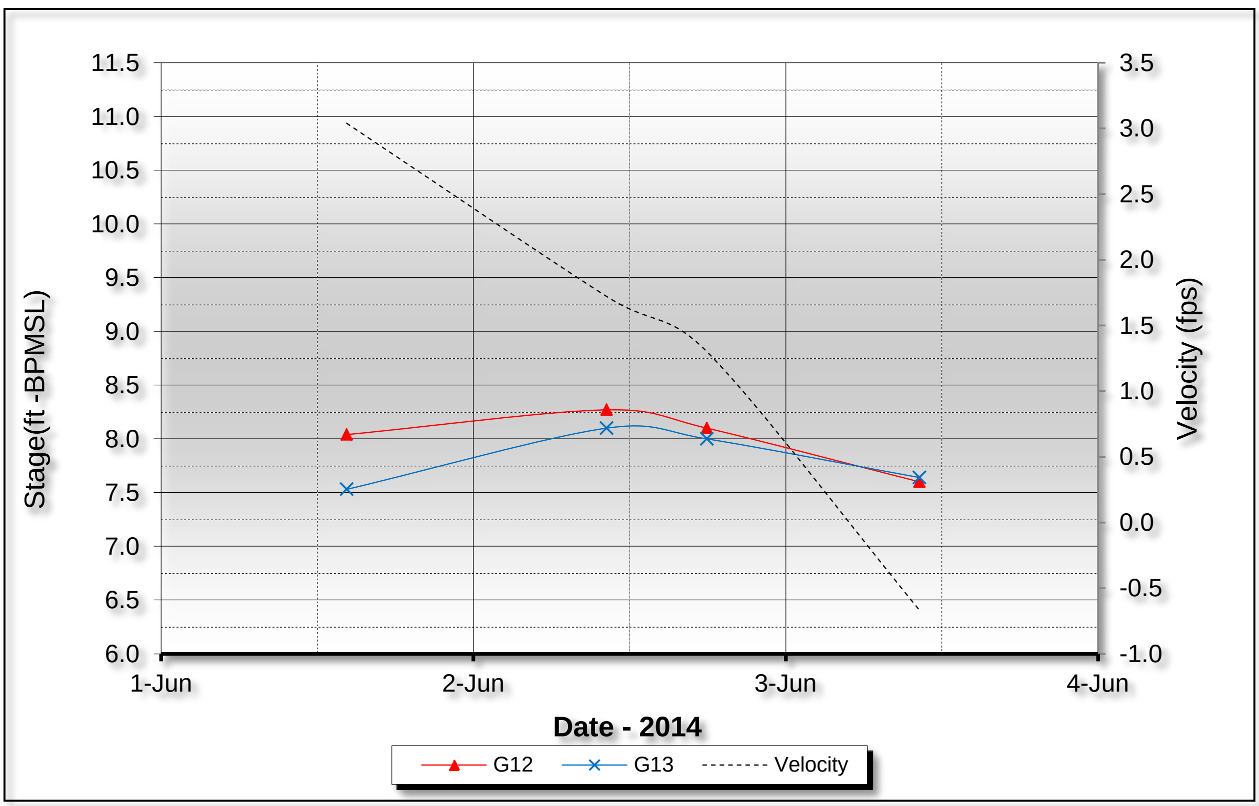
Culvert	Date & Time	Depth (ft)	Area (ft^2)	Measured Velocity (ft/s)	Direct Discharge (cfs)
CD2-1[1]	6/2/14 19:09	1.4	-	-	-
CD2-2	6/2/14 19:03	1.7	5.1	2.0	10.0
CD2-3	6/2/14 19:00	2.5	8.3	0.6	5.0
CD2-4	6/2/14 18:54	3.0	10.1	1.2	12.4
CD2-5	6/2/14 18:51	2.9	9.6	1.4	13.0
CD2-6	6/6/14 18:48	3.0	9.9	1.4	13.9
CD2-7	6/2/14 18:45	2.4	7.9	1.2	9.5
CD2-8	6/2/14 18:41	2.1	6.7	2.1	14.0
CD2-9	6/2/14 18:33	1.1	3.2	0.8	2.6
CD2-10	6/2/14 18:27	1.5	5.0	0.6	2.8
CD2-11	6/2/14 18:21	1.6	5.4	1.3	6.8
CD2-12	6/2/14 18:13	2.2	9.1	0.3	3.2
CD2-13[2]	5/22/14 12:47	1.0	2.8	0.2	0.5
	6/2/14 18:05	2.0	7.3	1.6	12.0
CD2-14	6/2/14 17:47	2.1	7.6	1.3	9.7
CD2-15	6/2/14 17:04	1.5	4.3	1.5	6.6
CD2-16[3]	6/2/14 16:57	0	0	0	0
CD2-17[3]	6/2/14 16:56	0	0	0	0
CD2-18[3]	6/2/14 16:54	0	0	0	0
CD2-19[3]	6/2/14 16:52	0	0	0	0
CD2-20	6/2/14 16:47	1.8	5.5	2.3	12.7
CD2-21	6/2/14 16:41	2.6	8.6	1.9	16.7
CD2-22[2]	5/22/14 13:03	0.8	1.8	0.9	1.7
	6/2/14 16:33	2.8	9.2	2.0	18.4
CD2-23[2]	5/22/14 13:07	1.5	4.3	1.6	7.0
	6/2/14 16:25	3.4	11.4	2.0	22.2
CD2-24[2]	5/22/14 13:14	1.7	5.1	1.4	7.3
	6/2/14 16:18	3.7	12.0	1.7	20.7
CD2-25[3]	6/2/14 21:13	0	0	0	0
CD2-26[3]	6/2/14 21:16	0	0	0	0
			Average Measured Velocity	1.4	
			Total Measured Discharge	212	

Notes:

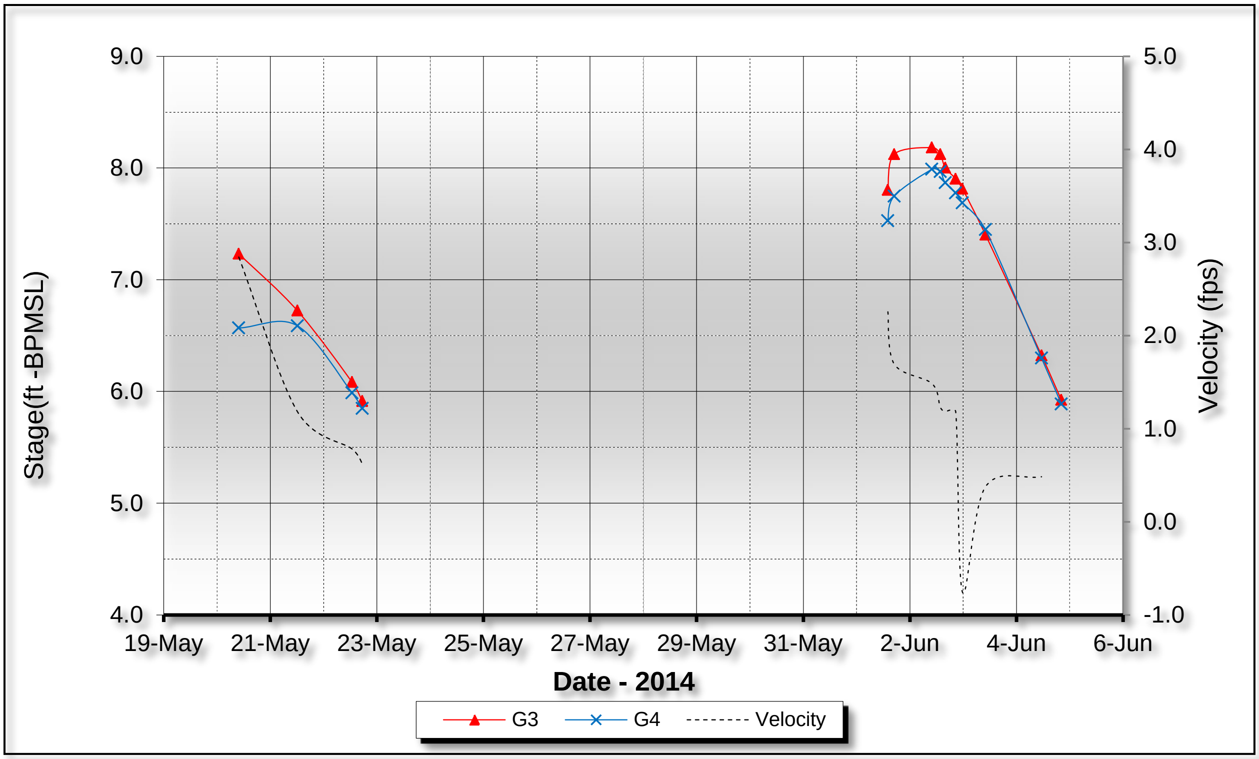
1. Invalid measurement due to snow
2. Measurements collected during twice during breakup, only 6/2 measurements included in total discharge
3. Water level below or water not present in area of culvert



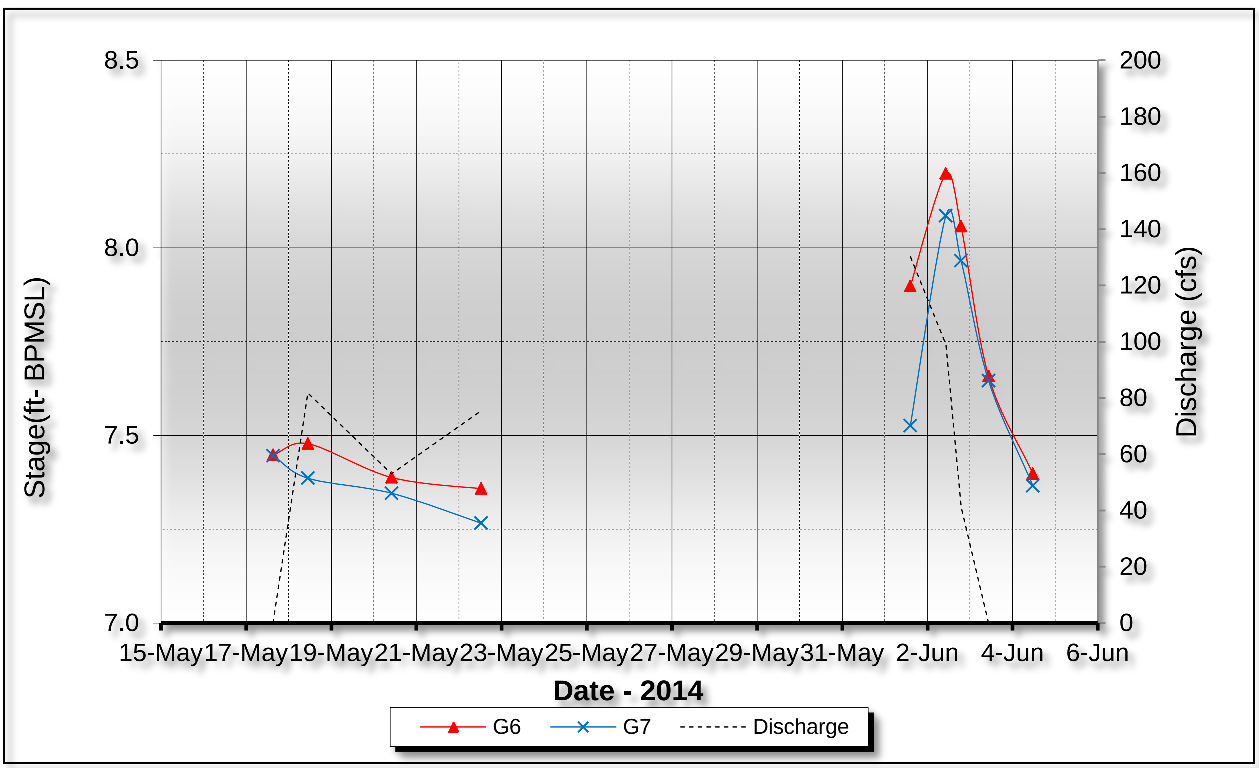
Graph F.1: Indirect Velocity vs. Observed Stage, CD2 Road Culverts CD2-1 through CD2-8 near G6/G7



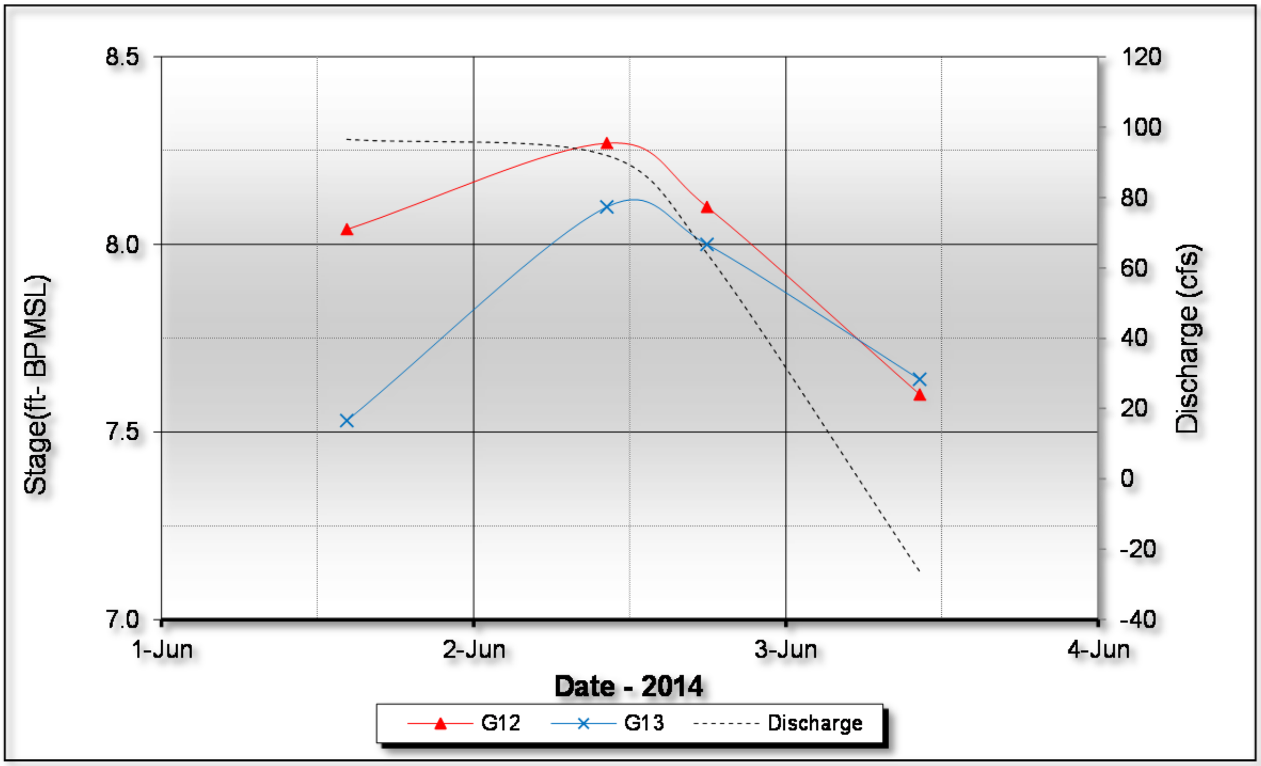
Graph F.2: Indirect Velocity vs. Observed Stage, CD2 Road Culverts CD2-9 through CD2-18 near G12/G13



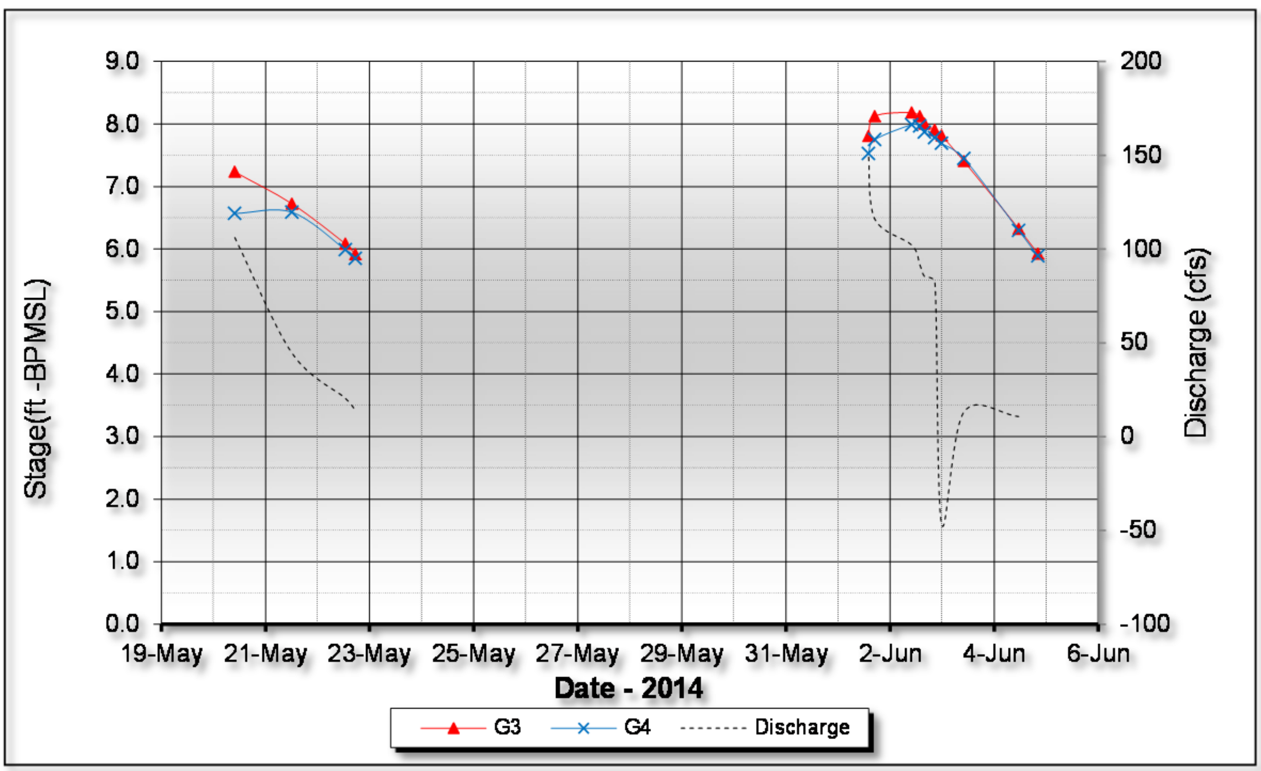
Graph F.3: Indirect Velocity vs. Observed Stage, CD2 Road Culverts CD2-19 through CD2-26 near G3/G4



Graph F.4: Indirect Discharge vs. Observed Stage, CD2 Road Culverts CD2-1 through CD2-8 near G6/G7



Graph F.5: Indirect Discharge vs. Observed Stage, CD2 Road Culverts CD2-9 through CD2-18 near G12/G13



Graph F.6: Indirect Discharge vs. Observed Stage, CD2 Road Culverts CD2-19 through CD2-26 near G3/G4

Table F.2: CD2 Road Culverts 2014 Indirect Velocity Summary

CD2 Culverts near G6/G7		CD2 Culverts near G12/G13		CD2 Culverts near G3/G4	
Culvert	Jun 01 2:22 PM	Culvert	Jun 01 2:15 PM	Culvert	Jun 01 4:55 PM
CD2-1	4.05	CD2-9	4.21	CD2-19	1.30
CD2-2	3.73	CD2-10	3.66	CD2-20	3.25
CD2-3	3.29	CD2-11	4.25	CD2-21	3.25
CD2-4	3.64	CD2-12	4.01	CD2-22	3.41
CD2-5	3.51	CD2-13	3.34	CD2-23	3.45
CD2-6	3.36	CD2-14	3.42	CD2-24	3.38
CD2-7	3.45	CD2-15	4.65	CD2-25	0.00
CD2-8	3.70	CD2-16	0.00	CD2-26	0.00
		CD2-17	0.00		
		CD2-18	2.86		
Average Velocity (ft/s)	**3.59**		**3.04**		**2.26**

Table F.3: CD2 Road Culverts 2014 Indirect Discharge Summary

CD2 Culverts near G6/G7		CD2 Culverts near G12/G13		CD2 Culverts near G3/G4	
Culvert	Jun 01 2:22 PM	Culvert	Jun 01 2:15 PM	Culvert	Jun 01 4:55 PM
CD2-1	14.80	CD2-9	7.41	CD2-19	0.07
CD2-2	13.50	CD2-10	9.36	CD2-20	16.92
CD2-3	20.65	CD2-11	13.01	CD2-21	26.99
CD2-4	30.38	CD2-12	19.49	CD2-22	28.70
CD2-5	27.33	CD2-13	15.81	CD2-23	37.27
CD2-6	28.83	CD2-14	18.84	CD2-24	39.06
CD2-7	30.63	CD2-15	10.95	CD2-25	0.00
CD2-8	17.96	CD2-16	0.00	CD2-26	0.00
		CD2-17	0.00		
		CD2-18	1.71		
Total Discharge (cfs)	**184.08**		**96.58**		**149.01**

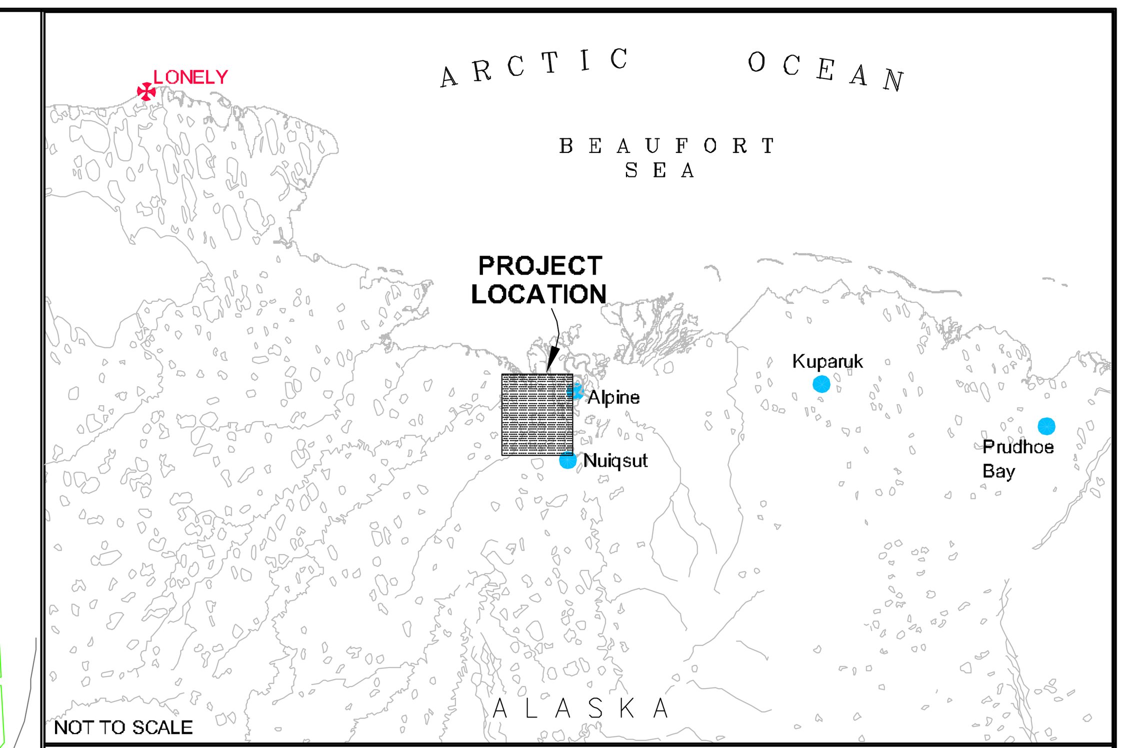
Appendix G Bathymetry and Scour

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

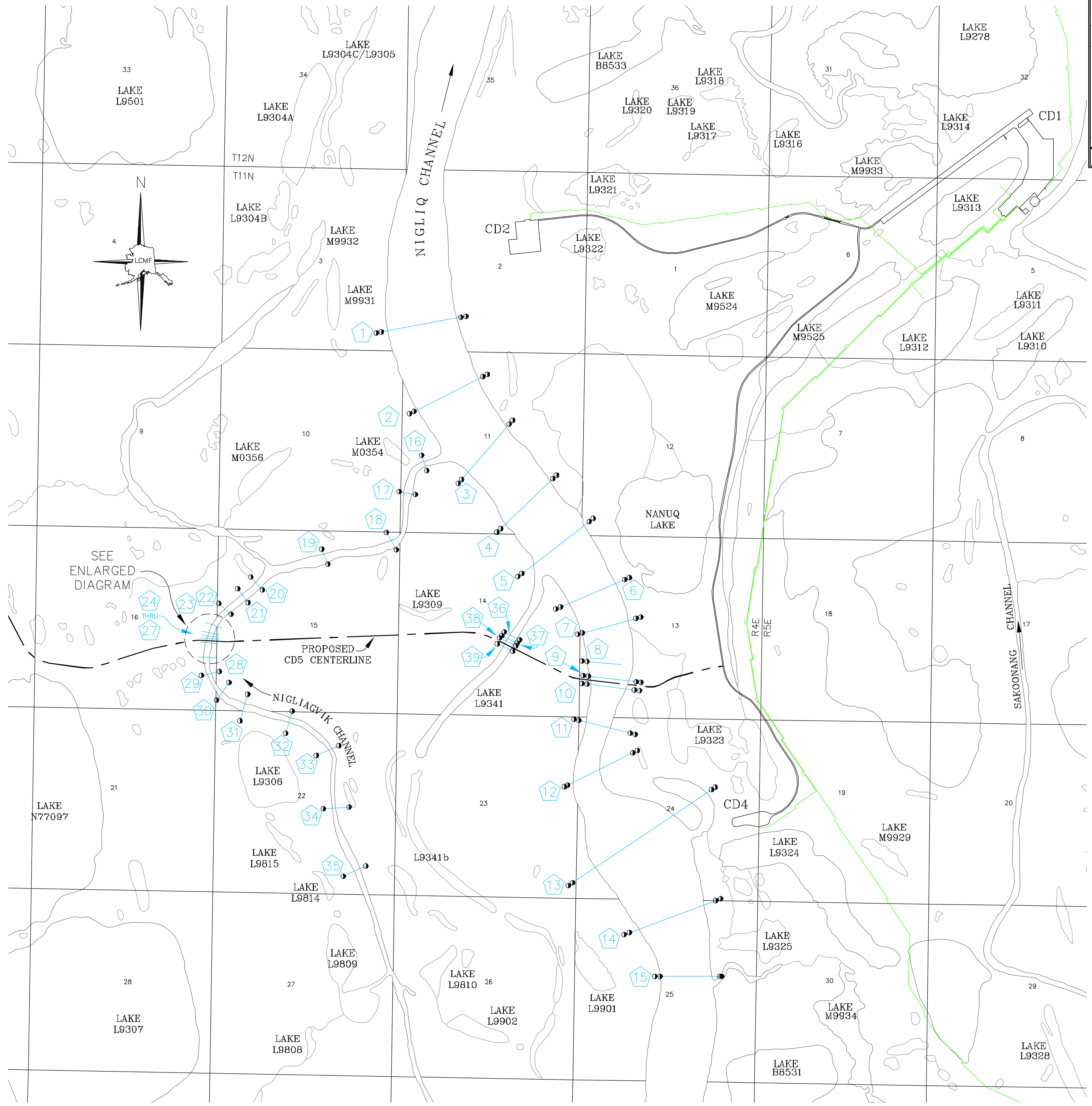
CD5 TRANSECT CONTROL

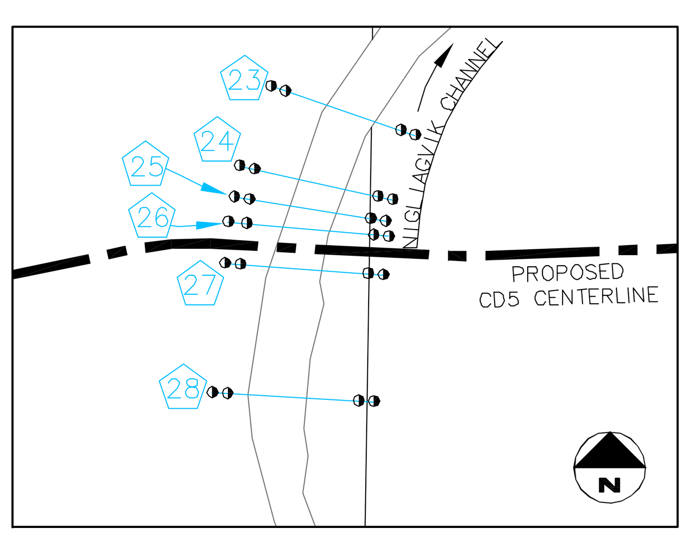
NORTHING	EASTING	ELEV	DESCRIPTION
5,971,410.172	1,507,156.498	8.419	01-LB200 Al Cap Flush
5,971,437.585	1,507,303.986	8.293	01-LB50 Al Cap Flush
5,971,895.681	1,509,763.370	9.145	01-RB200 Al Cap Flush
5,971,868.462	1,509,615.861	9.243	01-RB50 Al Cap Flush
5,969,060.230	1,508,119.673	8.815	02-LB200 Al Cap Flush
5,969,127.888	1,508,253.550	7.602	02-LB50 Al Cap Flush
5,970,206.027	1,510,386.345	9.199	02-RB200 Al Cap Flush
5,970,138.191	1,510,252.530	9.100	02-RB50 Al Cap Flush
5,967,032.208	1,509,538.684	9.609	03-LB200 Al Cap Flush
5,967,145.951	1,509,636.505	10.073	03-LB50 Al Cap Flush
5,968,868.861	1,511,117.903	9.529	03-RB200 Al Cap Flush
5,968,755.208	1,511,019.945	9.427	03-RB50 Al Cap Flush
5,965,610.334	1,510,661.026	12.474	04-LB200 Al Cap Flush
5,965,716.671	1,510,772.049	13.769	04-LB50 Al Cap 0.1' BGL
5,967,272.757	1,512,396.890	10.300	04-RB200 Al Cap 0.2' BGL
5,967,169.027	1,512,288.545	10.193	04-RB50 Al Cap Flush
5,964,321.916	1,511,269.778	12.004	05-LB200 Al Cap Flush
5,964,413.659	1,511,388.489	13.294	05-LB50 Al Cap Flush
5,966,013.949	1,513,463.365	8.712	05-RB200 Al Cap Flush
5,965,922.270	1,513,344.600	8.575	05-RB50 Al Cap Flush
5,963,381.275	1,512,373.997	11.414	06-LB200 Al Cap Flush
5,963,440.005	1,512,512.008	12.990	06-LB50 Al Cap Flush
5,964,292.039	1,514,511.947	9.753	06-RB250 Al Cap Flush
5,964,233.713	1,514,375.434	10.230	06-RB50 Al Cap Flush
5,962,644.637	1,513,005.297	10.674	07-LB200 Al Cap Flush
5,962,683.874	1,513,149.989	12.280	07-LB50 Al Cap Flush
5,963,144.212	1,514,845.101	10.802	07-RB200 Al Cap Flush
5,963,105.000	1,514,700.456	10.095	07-RB50 Al Cap Flush
5,961,864.570	1,513,132.749	10.466	08-LB200 Al Cap Flush
5,961,851.285	1,513,282.064	10.443	08-LB50 Al Cap Flush
5,961,442.215	1,513,168.246	10.517	09-LB200 Al Cap Flush
5,961,424.681	1,513,317.350	10.394	09-LB50 Al Cap Flush
5,961,244.616	1,514,849.163	9.279	09-RB200 Al Cap Flush
5,961,260.915	1,514,710.040	7.967	09-RB60 Al Cap Flush
5,961,214.588	1,513,133.884	10.300	10-LB200 Al Cap Flush
5,961,195.969	1,513,282.680	10.544	10-LB50 Al Cap Flush
5,961,004.246	1,514,808.609	7.234	10-RB200 Al Cap Flush
5,961,023.039	1,514,659.848	8.404	10-RB50 Al Cap Flush
5,960,173.818	1,512,898.221	10.959	11-LB200 Al Cap Flush
5,960,137.662	1,513,043.747	8.787	11-LB50 Al Cap Flush
5,959,767.171	1,514,537.179	9.008	11-RB50 Al Cap 0.2' BGL
5,958,209.502	1,512,625.605	11.011	12-LB200 Al Cap Flush
5,958,253.951	1,512,715.217	11.300	12-LB100 Al Cap Flush
5,959,260.248	1,514,746.096	10.244	12-RB200 Al Cap Flush
5,959,193.539	1,514,611.534	8.799	12-RB50 Al Cap 0.3' BGL
5,955,329.192	1,512,738.181	11.567	13-LB200 Al Cap Flush
5,955,412.726	1,512,862.669	12.000	13-LB50 Al Cap Flush
5,958,195.954	1,517,009.849	10.156	13-RB200 Al Cap Flush
5,958,123.512	1,516,901.775	11.679	13-RB70 Al Cap Flush
5,953,908.304	1,514,359.064	13.118	14-LB215 Al Cap Flush
5,953,965.615	1,514,513.824	15.550	14-LB50 Al Cap 0.1' BGL
5,954,950.395	1,517,166.201	9.597	14-RB200 Al Cap Flush
5,954,898.238	1,517,025.621	9.608	14-RB50 Al Cap Flush
5,952,688.522	1,515,254.050	13.908	15-LB200 Al Cap Flush
5,952,688.752	1,515,404.121	16.582	15-LB50 Al Cap Flush
5,952,691.471	1,517,145.169	12.616	15-RB50 Al Cap Flush
5,952,691.489	1,517,195.117	12.432	15-RB100 Al Cap Flush
5,967,852.367	1,508,476.551	10.009	16-LB100 Al Cap Flush
5,967,804.938	1,508,492.145	9.412	16-LB50 Al Cap Flush
5,967,407.545	1,508,622.063	9.108	16-RB100 Al Cap Flush
5,967,455.122	1,508,606.515	8.774	16-RB50 Al Cap Flush
5,966,795.100	1,507,822.749	8.513	17-LB100 Al Cap Flush
5,966,786.380	1,507,871.976	8.246	17-LB50 Al Cap Flush
5,966,712.363	1,508,294.902	8.485	17-RB100 Al Cap Flush
5,966,720.830	1,508,245.661	8.457	17-RB50 Al Cap Flush
5,965,609.725	1,507,451.169	8.512	18-LB100 Al Cap Flush
5,965,566.257	1,507,475.942	8.621	18-LB50 Al Cap Flush
5,965,103.267	1,507,739.379	7.676	18-RB100 Al Cap Flush
5,965,146.802	1,507,714.587	7.539	18-RB50 Al Cap Flush
5,965,119.470	1,505,573.359	8.506	19-LB100 Al Cap Flush
5,965,073.111	1,505,592.239	8.506	19-LB50 Al Cap Flush
5,964,684.565	1,505,750.603	8.083	19-RB100 Al Cap Flush
5,964,730.797	1,505,731.738	8.636	19-RB50 Al Cap Flush
5,964,307.477	1,503,508.726	13.755	20-LB100 Al Cap Flush
5,964,270.626	1,503,542.452	15.545	20-LB50 Al Cap Flush

NORTHING	EASTING	ELEV	DESCRIPTION
5,963,935.690	1,503,847.826	7.458	20-RB100 Al Cap Flush
5,963,972.576	1,503,814.200	7.417	20-RB50 Al Cap Flush
5,963,970.128	1,503,127.995	24.412	21-LB100 Al Cap Flush
5,963,930.056	1,503,157.752	20.803	21-LB50 Al Cap Flush
5,963,562.391	1,503,430.566	8.697	21-RB100 Al Cap Flush
5,963,602.565	1,503,400.675	9.087	21-RB50 Al Cap Flush
5,963,540.647	1,502,578.266	26.015	22-LB110 Al Cap Flush
5,963,500.955	1,502,623.070	23.980	22-LB50 Al Cap Flush
5,963,224.555	1,502,936.088	8.555	22-RB100 Al Cap Flush
5,963,257.687	1,502,898.557	9.083	22-RB50 Al Cap Flush
5,962,989.577	1,502,198.675	25.176	23-LB100 Al Cap Flush
5,962,973.595	1,502,246.059	25.141	23-LB50 Al Cap Flush
5,962,828.922	1,502,671.946	10.028	23-RB100 Al Cap Flush
5,962,845.024	1,502,624.671	8.043	23-RB50 Al Cap Flush
5,962,728.638	1,502,095.588	26.467	24-LB100 Al Cap Flush
5,962,717.892	1,502,144.420	27.045	24-LB50 Al Cap Flush
5,962,617.894	1,502,598.227	9.107	24-RB100 Al Cap Flush
5,962,628.649	1,502,549.420	8.314	24-RB50 Al Cap Flush
5,962,627.162	1,502,078.344	27.446	25-LB100 Al Cap Flush
5,962,619.301	1,502,127.772	26.188	25-LB50 Al Cap Flush
5,962,547.931	1,502,575.394	8.171	25-RB100 Al Cap Flush
5,962,555.825	1,502,525.976	8.195	25-RB50 Al Cap Flush
5,962,545.484	1,502,058.928	27.484	26-LB110 Al Cap Flush
5,962,539.978	1,502,118.584	27.711	26-LB50 Al Cap Flush
5,962,497.866	1,502,585.674	9.555	26-RB100 Al Cap Flush
5,962,502.417	1,502,535.991	8.293	26-RB50 Al Cap Flush
5,962,410.033	1,502,047.844	26.997	27-LB100 Al Cap Flush
5,962,406.342	1,502,097.705	27.070	27-LB50 Al Cap Flush
5,962,371.997	1,502,567.626	9.566	27-RB100 Al Cap Flush
5,962,375.740	1,502,517.809	8.014	27-RB50 Al Cap Flush
5,961,986.435	1,502,006.076	21.011	28-LB100 Al Cap Flush
5,961,983.639	1,502,055.975	21.172	28-LB50 Al Cap Flush
5,961,959.919	1,502,486.658	8.400	28-RB50 Al Cap Flush
5,961,957.165	1,502,536.545	9.177	28-RB100 Al Cap Flush
5,961,446.941	1,502,073.292	24.206	29-LB100 Al Cap Flush
5,961,457.435	1,502,122.177	23.598	29-LB50 Al Cap Flush
5,961,559.109	1,502,597.016	9.800	29-RB100 Al Cap Flush
5,961,548.659	1,502,548.070	8.629	29-RB50 Al Cap Flush
5,960,727.368	1,502,515.791	23.658	30-LB100 Al Cap Flush
5,960,768.276	1,502,544.696	23.216	30-LB50 Al Cap Flush
5,961,239.597	1,502,877.114	10.073	30-RB100 Al Cap Flush
5,961,198.806	1,502,848.280	9.549	30-RB50 Al Cap Flush
5,960,124.465	1,503,193.305	8.556	31-LB100 Al Cap Flush
5,960,172.316	1,503,207.309	9.605	31-LB50 Al Cap Flush
5,960,896.154	1,503,418.934	10.757	31-RB100 Al Cap Flush
5,960,848.113	1,503,404.835	11.123	31-RB50 Al Cap Flush
5,959,762.590	1,504,523.209	8.369	32-LB100 Al Cap Flush
5,959,810.483	1,504,537.155	7.694	32-LB50 Al Cap Flush
5,960,406.262	1,504,711.395	10.790	32-RB100 Al Cap Flush
5,960,358.154	1,504,697.383	11.437	32-RB50 Al Cap Flush
5,959,118.980	1,505,412.935	9.835	33-LB100 Al Cap Flush
5,959,138.925	1,505,458.824	8.589	33-LB50 Al Cap Flush
5,959,403.881	1,506,064.870	10.643	33-RB120 Al Cap Flush
5,959,375.875	1,506,000.696	10.409	33-RB50 Al Cap Flush
5,957,567.988	1,505,617.483	12.554	34-LB100 Al Cap Flush
5,957,571.230	1,505,667.205	12.478	34-LB50 Al Cap Flush
5,957,615.382	1,506,366.118	10.126	34-RB100 Al Cap Flush
5,957,612.244	1,506,316.188	10.539	34-RB50 Al Cap Flush
5,955,603.397	1,506,200.608	12.562	35-LB100 Al Cap Flush
5,955,624.246	1,506,246.168	13.026	35-LB50 Al Cap Flush
5,955,901.737	1,506,854.796	10.213	35-RB100 Al Cap Flush
5,955,880.894	1,506,809.410	9.424	35-RB50 Al Cap Flush
5,962,713.529	1,510,877.308	8.344	36-LB100 Al Cap Flush
5,962,690.391	1,510,921.654	8.055	36-LB50 Al Cap Flush
5,962,479.459	1,511,322.840	9.457	36-RB100 Al Cap Flush
5,962,502.704	1,511,278.621	8.645	36-RB50 Al Cap Flush
5,962,603.099	1,510,806.869	8.204	37-LB100 Al Cap Flush
5,962,581.024	1,510,851.779	8.345	37-LB50 Al Cap Flush
5,962,382.943	1,511,254.349	9.472	37-RB100 Al Cap Flush
5,962,405.053	1,511,209.407	8.823	37-RB50 Al Cap Flush
5,962,540.234	1,510,738.125	8.327	38-LB100 Al Cap Flush
5,962,518.597	1,510,783.313	8.173	38-LB50 Al Cap Flush
5,962,311.212	1,511,215.115	9.224	38-RB100 Al Cap Flush
5,962,332.715	1,511,169.978	9.063	38-RB50 Al Cap Flush
5,962,367.978	1,510,674.819	8.779	39-LB100 Al Cap Flush
5,962,346.171	1,510,719.677	7.761	39-LB50 Al Cap Flush
5,962,154.417	1,511,119.161	9.651	39-RB100 Al Cap Flush
5,962,176.142	1,511,074.113	9.465	39-RB50 Al Cap Flush



VICINITY MAP





ENLARGED DIAGRAM

LEGEND:

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

NOTES:

1. DATE OF SURVEY: AUGUST 29 TO SEPTEMBER 18, 2013; OCTOBER 21, 2013.
2. COORDINATES SHOWN ARE ALASKA STATE PLANE, ZONE 4 N.A.D. 83, IN FEET. BASED ON THE 2013 CD-5 CONTROL SURVEY
3. ELEVATIONS SHOWN ARE BRITISH PETROLEUM MEAN SEA LEVEL (B.P.M.S.L.) DATUM.
4. SEE DOCUMENT RPT-CE-CD-113 FOR TRANSECT BASELINE SURVEY DATA.
5. REFERENCE FIELD BOOK LCMF 2013-18, PGS. 57-59, 67, 70-72. LCMF 2013-20 PGS. 4-14; LCMF 2013-21, PG. 29.
6. PROPOSED GRAVEL ROAD ALIGNMENT, AS SHOWN, BASED ON INFORMATION PROVIDED BY PND ENGINEERING, RECEIVED 9/25/2013.

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

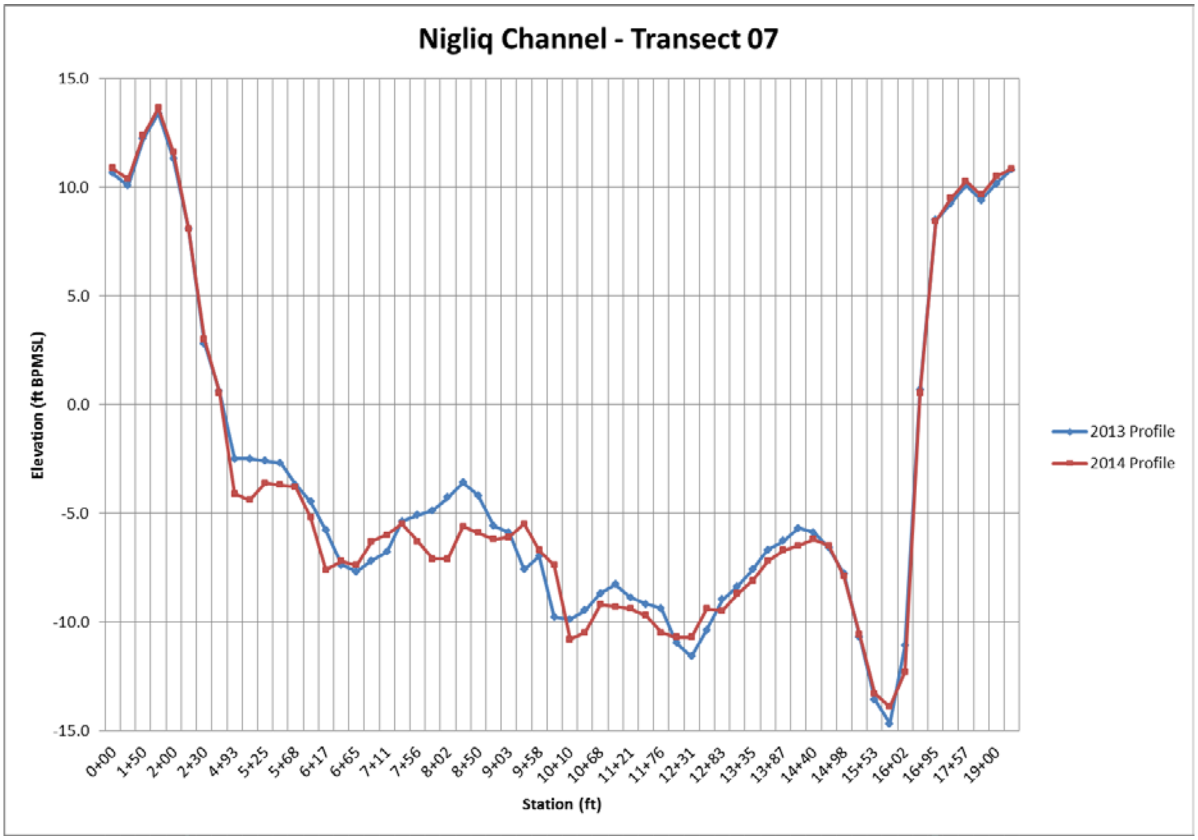
FORM: DSIZE

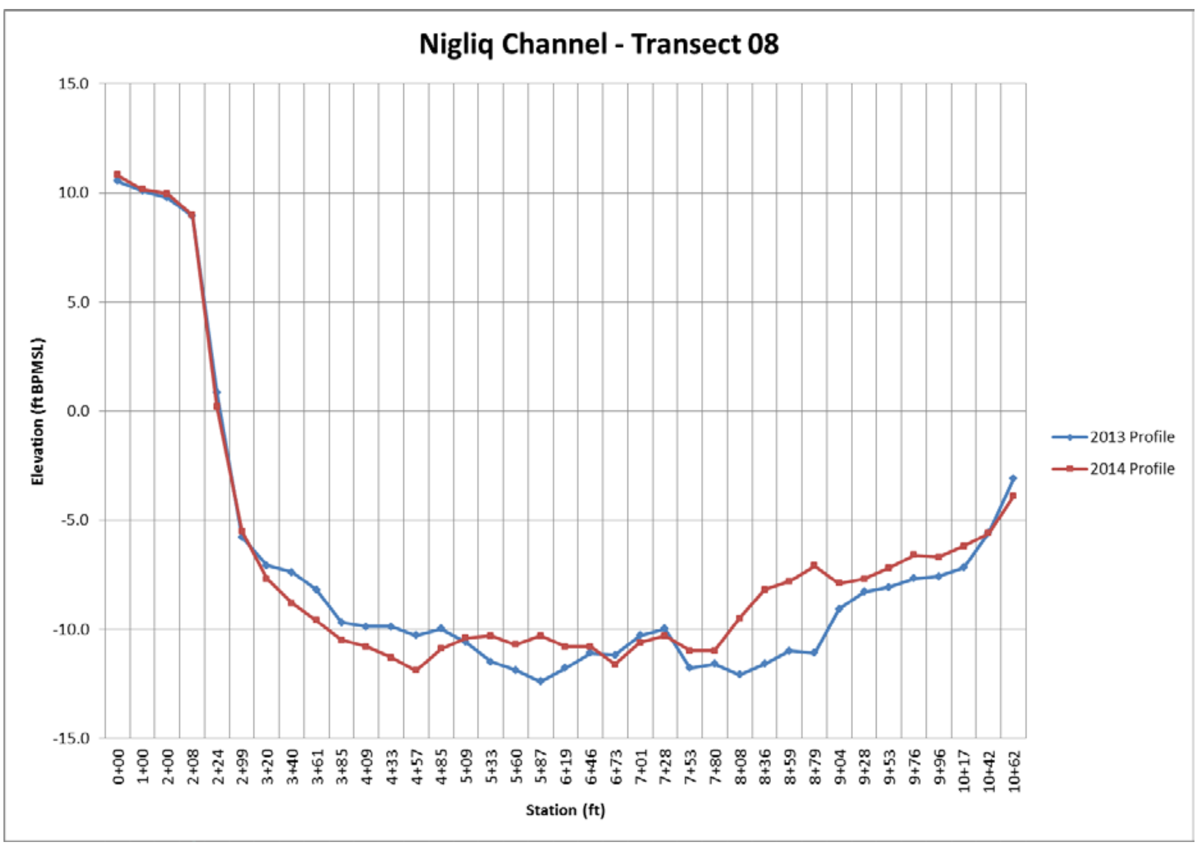
REFERENCE DWG NO/SHT NO:

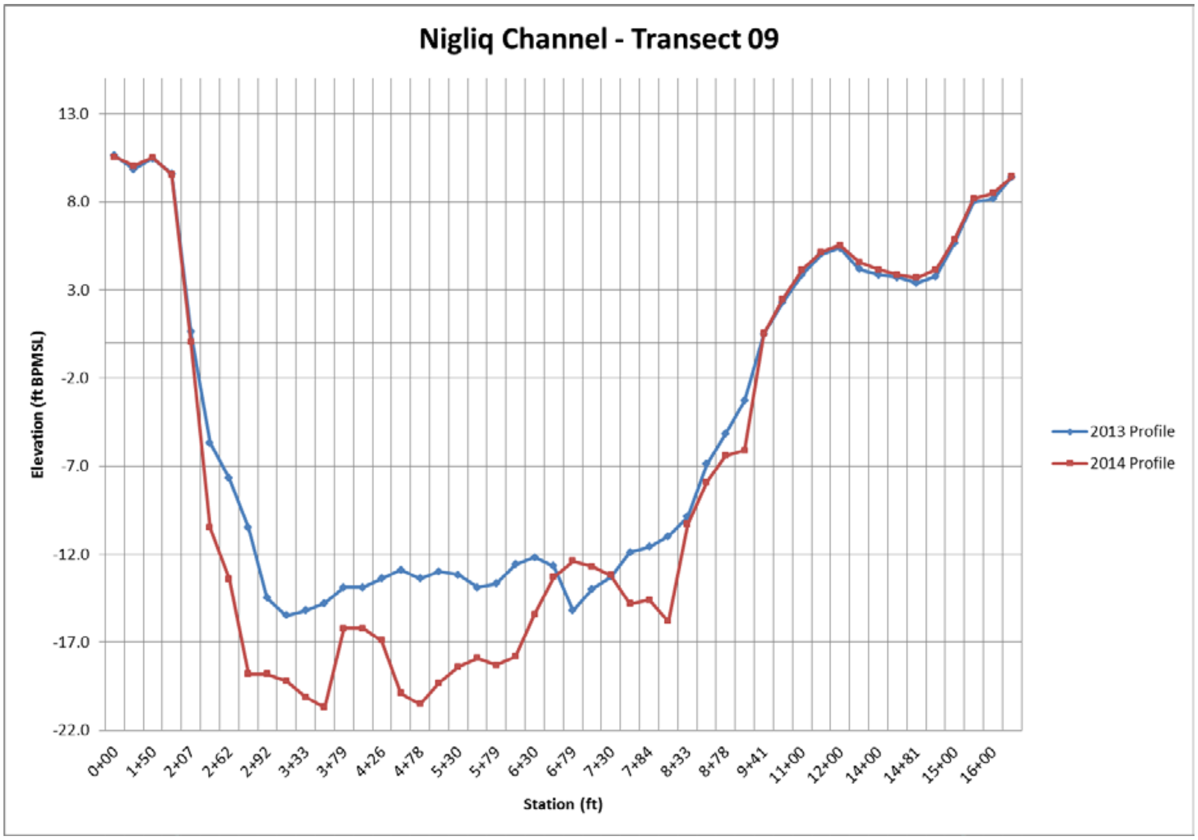
REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
1	10/22/13	ISSUED PER K130003ACS	AG	DB			

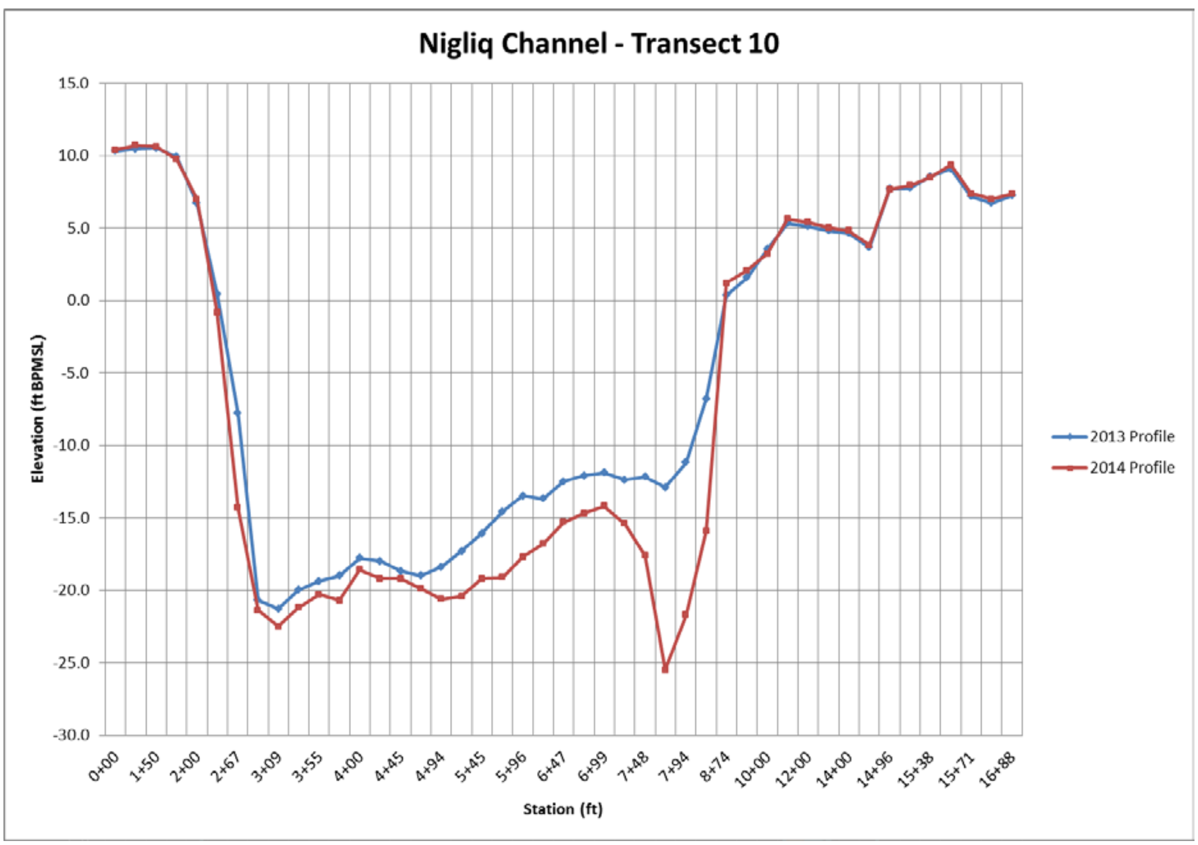
DATE: 8/26/13 | DRAWN: CZ | DESIGN: – | ECM NO: –
SCALE: 1" = 2000' | CHECKED: DB | CC NO: –
APPROVAL: – | CADD FILE NO.: 13-08-07-1 –
JOB NO: 02-204 | SUB JOB NO: – | DRAWING NO: CE-CD50-1004 | PART: 1 OF – | REV: 1

G.1 Nigliq Channel






Nigliq Channel - Transect 09
Elevation (ft BPMSL)
Station (ft)
2013 Profile
2014 Profile


Nigliq Channel - Transect 10
Elevation (ft BPMSL)
Station (ft)
2013 Profile
2014 Profile

CD-5 Michael Baker
Transect 7

Station	2013	2014	Description
0+00	10.6	10.9	Ground Shot
1+00	10.1	10.4	Ground Shot
1+50	12.2	12.4	Ground Shot
1+77	13.4	13.7	Grade Break
2+00	11.3	11.6	Ground Shot
2+23	8.1	8.1	Top of Bank
2+30	2.8	3.0	Toe of Bank
2+47	0.6	0.5	Edge of Water
4+93	-2.5	-4.1	River Bottom
5+06	-2.5	-4.4	River Bottom
5+25	-2.6	-3.6	River Bottom
5+45	-2.7	-3.7	River Bottom
5+68	-3.7	-3.8	River Bottom
5+91	-4.5	-5.2	River Bottom
6+17	-5.8	-7.6	River Bottom
6+42	-7.4	-7.2	River Bottom
6+65	-7.7	-7.4	River Bottom
6+88	-7.2	-6.3	River Bottom
7+11	-6.8	-6.0	River Bottom
7+37	-5.4	-5.5	River Bottom
7+56	-5.1	-6.3	River Bottom
7+82	-4.9	-7.1	River Bottom
8+02	-4.3	-7.1	River Bottom
8+25	-3.6	-5.6	River Bottom
8+50	-4.2	-5.9	River Bottom
8+74	-5.6	-6.2	River Bottom
9+03	-5.9	-6.1	River Bottom
9+32	-7.6	-5.5	River Bottom
9+58	-7.0	-6.7	River Bottom
9+84	-9.8	-7.4	River Bottom
10+10	-9.9	-10.8	River Bottom
10+39	-9.5	-10.5	River Bottom
10+68	-8.7	-9.2	River Bottom
10+91	-8.3	-9.3	River Bottom
11+21	-8.9	-9.4	River Bottom
11+50	-9.2	-9.7	River Bottom
11+76	-9.4	-10.5	River Bottom
12+02	-11.0	-10.7	River Bottom
12+31	-11.6	-10.7	River Bottom

CD-5 Michael Baker
Transect 7

Station	2013	2014	Description
12+57	-10.4	-9.4	River Bottom
12+83	-9.0	-9.5	River Bottom
13+09	-8.4	-8.7	River Bottom
13+35	-7.6	-8.1	River Bottom
13+64	-6.7	-7.2	River Bottom
13+87	-6.3	-6.7	River Bottom
14+17	-5.7	-6.5	River Bottom
14+40	-5.9	-6.2	River Bottom
14+69	-6.6	-6.5	River Bottom
14+98	-7.8	-7.9	River Bottom
15+24	-10.7	-10.6	River Bottom
15+53	-13.6	-13.3	River Bottom
15+79	-14.7	-13.9	River Bottom
16+02	-11.1	-12.3	River Bottom
16+84	0.7	0.5	Edge of Water
16+95	8.5	8.4	Top of Bank
17+00	9.2	9.5	Ground Shot
17+57	10.1	10.3	Ground Shot
18+00	9.4	9.6	Ground Shot
19+00	10.2	10.5	Ground Shot
19+07	10.8	10.9	Ground Shot

CD-5 Michael Baker
Transect 8

STA	2013	2014	Description
0+00	10.6	10.8	Ground Shot
1+00	10.1	10.2	Ground Shot
2+00	9.8	10.0	Ground Shot
2+08	8.9	9.0	Top of Bank
2+24	0.9	0.2	Edge of Water
2+99	-5.8	-5.5	River Bottom
3+20	-7.1	-7.7	River Bottom
3+40	-7.4	-8.8	River Bottom
3+61	-8.2	-9.6	River Bottom
3+85	-9.7	-10.5	River Bottom
4+09	-9.9	-10.8	River Bottom
4+33	-9.9	-11.3	River Bottom
4+57	-10.3	-11.9	River Bottom
4+85	-10.0	-10.9	River Bottom
5+09	-10.6	-10.4	River Bottom
5+33	-11.5	-10.3	River Bottom
5+60	-11.9	-10.7	River Bottom
5+87	-12.4	-10.3	River Bottom
6+19	-11.8	-10.8	River Bottom
6+46	-11.1	-10.8	River Bottom
6+73	-11.2	-11.6	River Bottom
7+01	-10.3	-10.6	River Bottom
7+28	-10.0	-10.3	River Bottom
7+53	-11.8	-11.0	River Bottom
7+80	-11.6	-11.0	River Bottom
8+08	-12.1	-9.5	River Bottom
8+36	-11.6	-8.2	River Bottom
8+59	-11.0	-7.8	River Bottom
8+79	-11.1	-7.1	River Bottom
9+04	-9.1	-7.9	River Bottom
9+28	-8.3	-7.7	River Bottom
9+53	-8.1	-7.2	River Bottom
9+76	-7.7	-6.6	River Bottom
9+96	-7.6	-6.7	River Bottom
10+17	-7.2	-6.2	River Bottom
10+42	-5.6	-5.6	River Bottom
10+62	-3.1	-3.9	River Bottom

CD-5 Michael Baker
Transect 9

STA	2013	2014	Description
0+00	10.6	10.6	Ground Shot
1+00	9.9	10.0	Ground Shot
1+50	10.5	10.5	Ground Shot
1+92	9.6	9.6	Top of Bank
2+07	0.6	0.0	Edge of Water
2+48	-5.7	-10.5	River Bottom
2+62	-7.7	-13.4	River Bottom
2+78	-10.5	-18.8	River Bottom
2+92	-14.5	-18.8	River Bottom
3+13	-15.5	-19.2	River Bottom
3+33	-15.2	-20.1	River Bottom
3+58	-14.8	-20.7	River Bottom
3+79	-13.9	-16.2	River Bottom
4+03	-13.9	-16.2	River Bottom
4+26	-13.4	-16.9	River Bottom
4+54	-12.9	-19.9	River Bottom
4+78	-13.4	-20.5	River Bottom
5+02	-13.0	-19.3	River Bottom
5+30	-13.2	-18.4	River Bottom
5+54	-13.9	-17.9	River Bottom
5+79	-13.7	-18.3	River Bottom
6+02	-12.6	-17.8	River Bottom
6+30	-12.2	-15.4	River Bottom
6+55	-12.7	-13.3	River Bottom
6+79	-15.2	-12.4	River Bottom
7+06	-14.0	-12.7	River Bottom
7+30	-13.3	-13.2	River Bottom
7+57	-11.9	-14.8	River Bottom
7+84	-11.6	-14.6	River Bottom
8+08	-11.0	-15.8	River Bottom
8+33	-9.9	-10.3	River Bottom
8+58	-6.9	-7.9	River Bottom
8+78	-5.2	-6.4	River Bottom
8+91	-3.3	-6.1	River Bottom
9+41	0.5	0.5	Edge of Water
10+00	2.3	2.5	Sand Bar
11+00	3.9	4.1	Sand Bar
11+52	5.0	5.2	Edge of Vegetation
12+00	5.4	5.5	Ground Shot

CD-5 Michael Baker
Transect 9

STA	2013	2014	Description
13+00	4.2	4.6	Ground Shot
14+00	3.9	4.1	Ground Shot
14+39	3.7	3.9	Edge of Water
14+81	3.4	3.7	Edge of Water
14+84	3.8	4.1	Toe of Bank
15+00	5.7	5.9	Top of Bank
15+52	8.0	8.2	Ground Shot
16+00	8.2	8.5	Ground Shot
16+92	9.4	9.4	Ground Shot

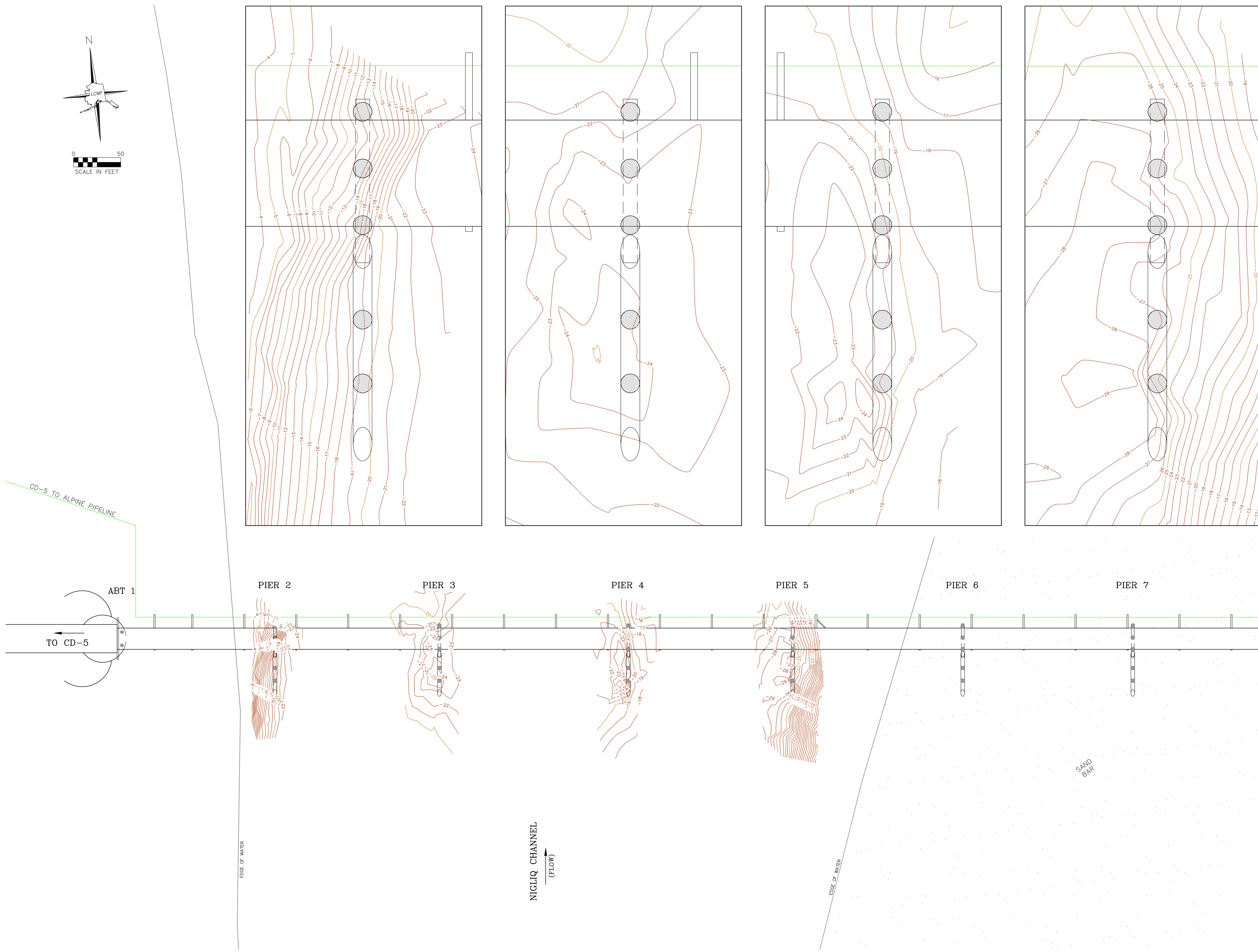
CD-5 Michael Baker
Transect 10

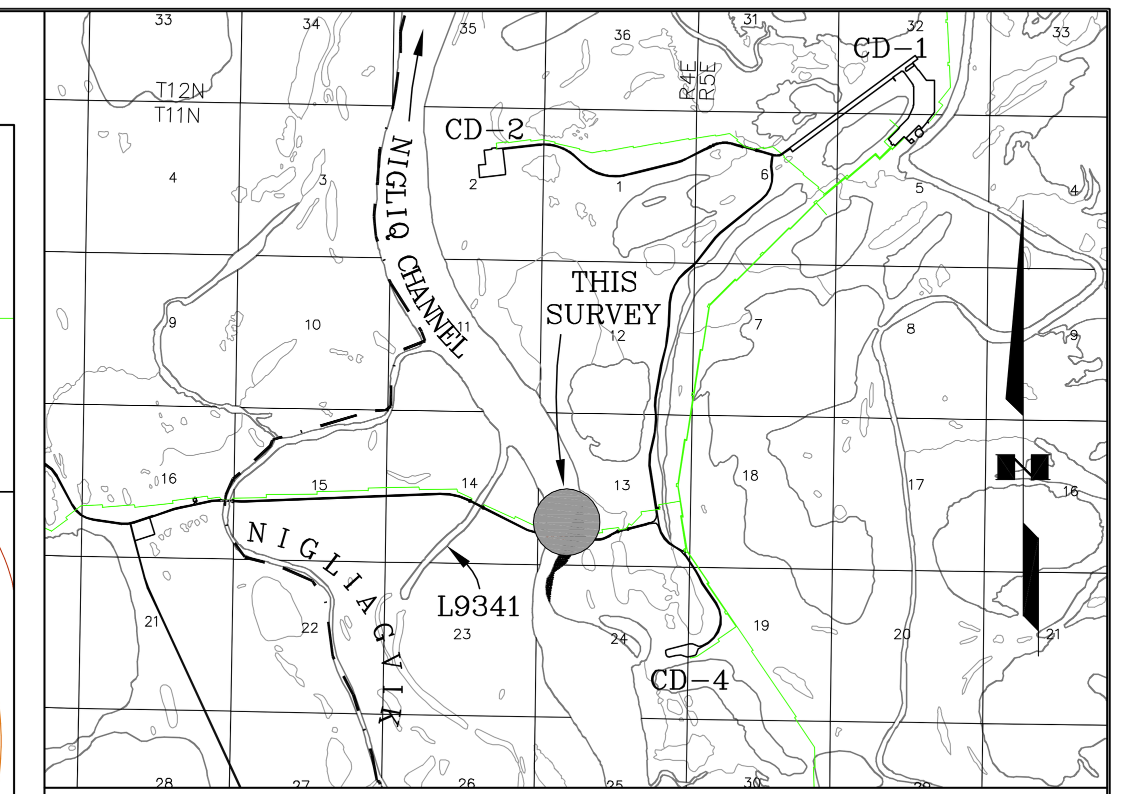
STA	2013	2014	Description
0+00	10.3	10.4	Ground Shot
1+00	10.4	10.7	Ground Shot
1+50	10.5	10.6	Ground Shot
1+90	9.9	9.7	Top of Bank
2+00	6.7	7.0	Ground Shot
2+12	0.5	-0.8	Edge of Water
2+67	-7.8	-14.3	River Bottom
2+87	-20.7	-21.4	River Bottom
3+09	-21.3	-22.5	River Bottom
3+30	-20.0	-21.2	River Bottom
3+55	-19.4	-20.3	River Bottom
3+76	-19.0	-20.7	River Bottom
4+00	-17.8	-18.6	River Bottom
4+21	-18.0	-19.2	River Bottom
4+45	-18.7	-19.2	River Bottom
4+70	-19.0	-19.9	River Bottom
4+94	-18.4	-20.6	River Bottom
5+21	-17.3	-20.4	River Bottom
5+45	-16.1	-19.2	River Bottom
5+69	-14.6	-19.1	River Bottom
5+96	-13.5	-17.7	River Bottom
6+20	-13.7	-16.8	River Bottom
6+47	-12.5	-15.3	River Bottom
6+71	-12.1	-14.7	River Bottom
6+99	-11.9	-14.2	River Bottom
7+23	-12.4	-15.4	River Bottom
7+48	-12.2	-17.6	River Bottom
7+70	-12.9	-25.5	River Bottom
7+94	-11.2	-21.7	River Bottom
8+15	-6.8	-15.9	River Bottom
8+74	0.4	1.2	Edge of Water
9+00	1.6	2.1	Sand Bar
10+00	3.6	3.2	Sand Bar
11+00	5.4	5.6	Edge of Vegetation
12+00	5.1	5.4	Ground Shot
13+00	4.8	5.0	Ground Shot
14+00	4.6	4.8	Ground Shot
14+84	3.7	3.8	Toe of Bank
14+96	7.7	7.7	Top of Bank

CD-5 Michael Baker
Transect 10

STA	2013	2014	Description
15+00	7.8	8.0	Ground Shot
15+38	8.6	8.5	Ground Shot
15+53	9.1	9.4	Grade Break
15+71	7.2	7.4	Grade Break
16+00	6.7	7.0	Ground Shot
16+88	7.2	7.4	Ground Shot

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





VICINITY MAP

NOTES

1. DATE OF SURVEY: AUGUST 16, 2014.
2. REFERENCE FIELD BOOKS: LCMF2014-21, PG. 30.
3. ELEVARIONS ARE BRITISH PETROLEUM MEAN SEAL LEVLE (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
NIGLIQ BRIDGE
SCOUR MONITORING

REDRAWN FROM:

CONSTRUCTION SHEET OF

DO NOT SCALE ABOVE SCALE FOR REFERENCE ONLY

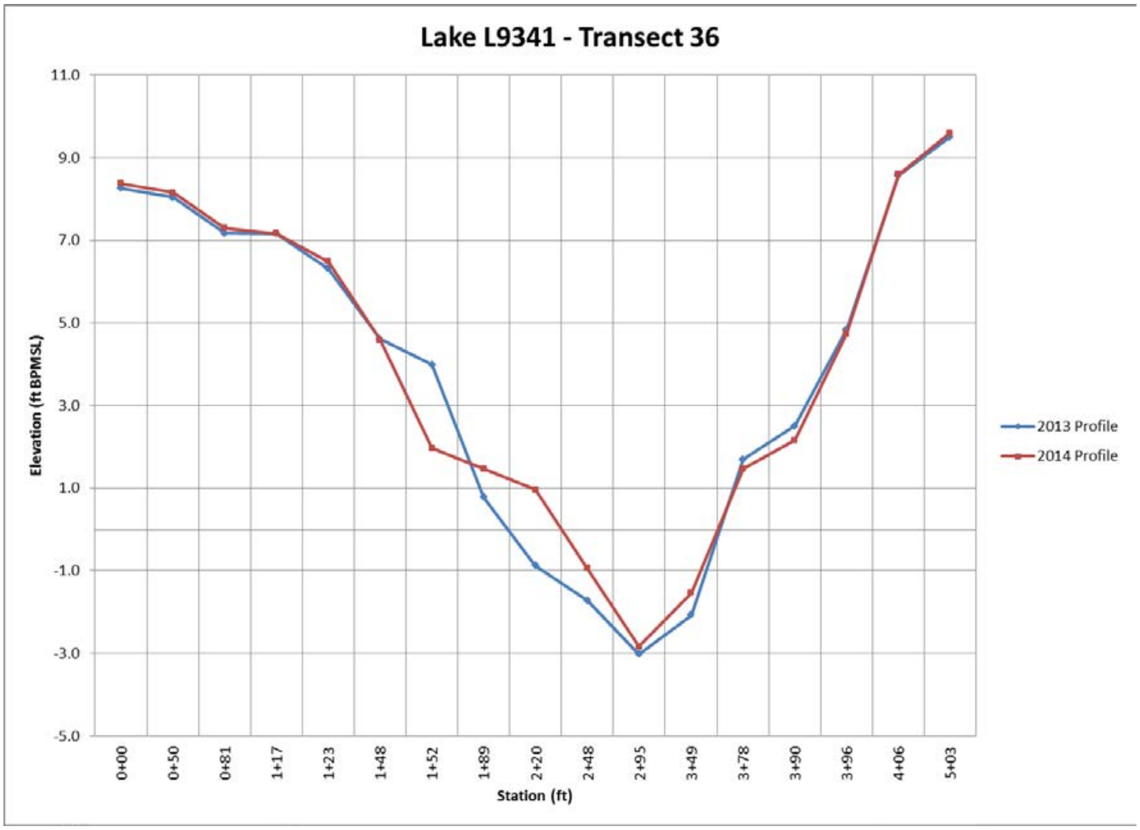
FORM: DSIZE

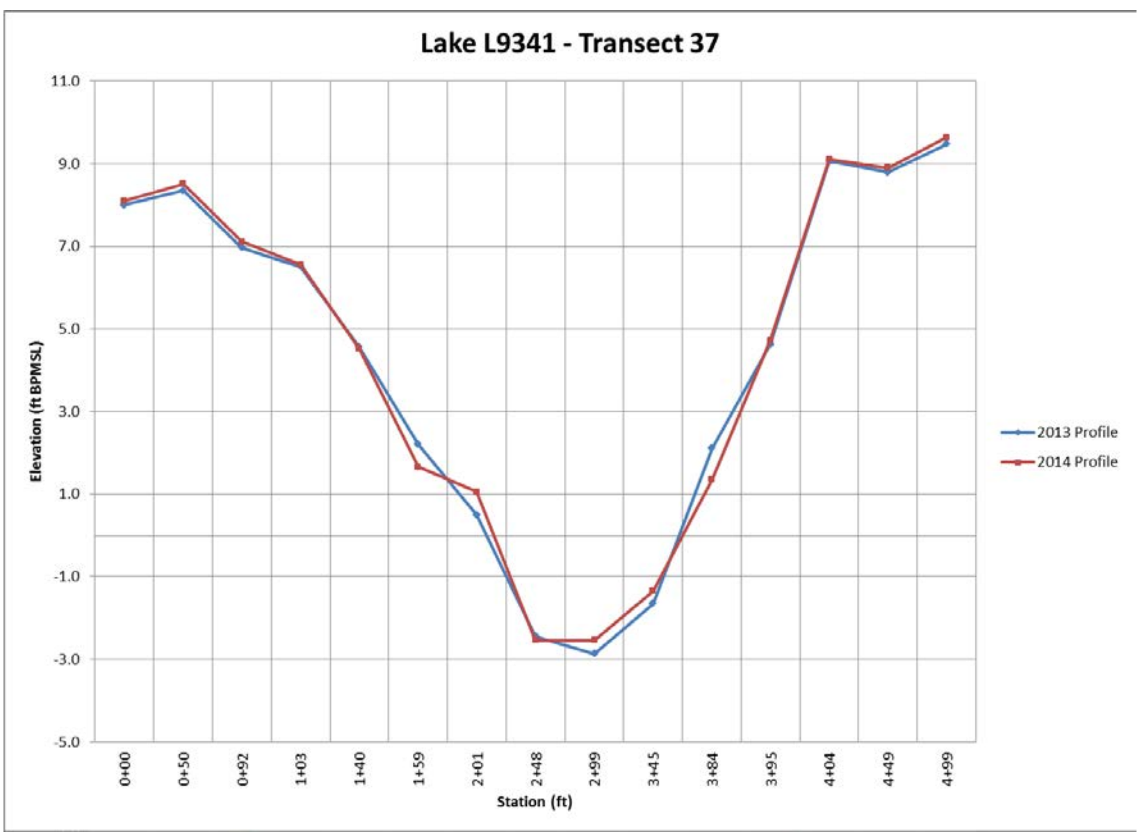
DATE: 08/23/14	DRAWN: CZ	DESIGN: GD	ECM NO: K140003ACS
	CHECKED: –		CC NO: –
SCALE: 1" = 50'	APPROVAL: –		CADD FILE NO. 14-08-12-1AW
JOB NO: – / SUB JOB NO: –	DRAWING NO: CE-CD50-1022		PART: 1 OF 1 / REV: 1

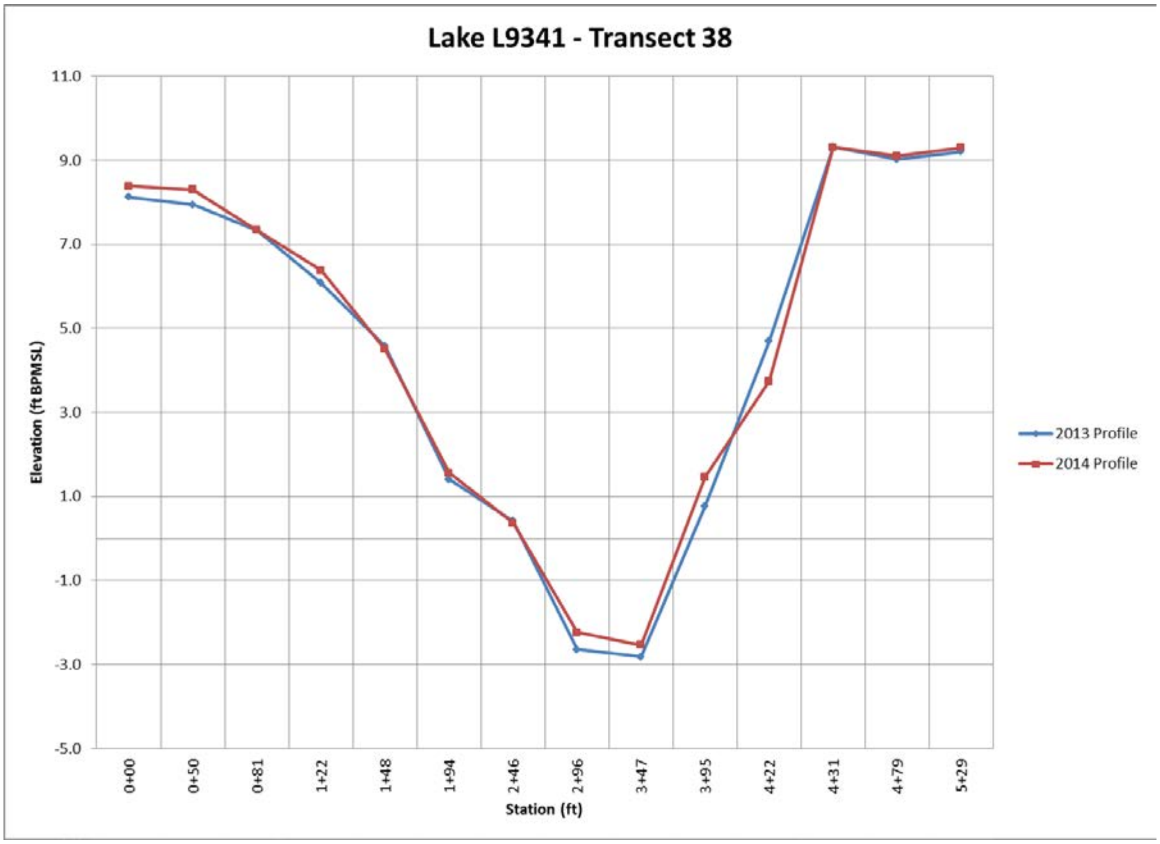
REFERENCE DWG NO/SHT NO:

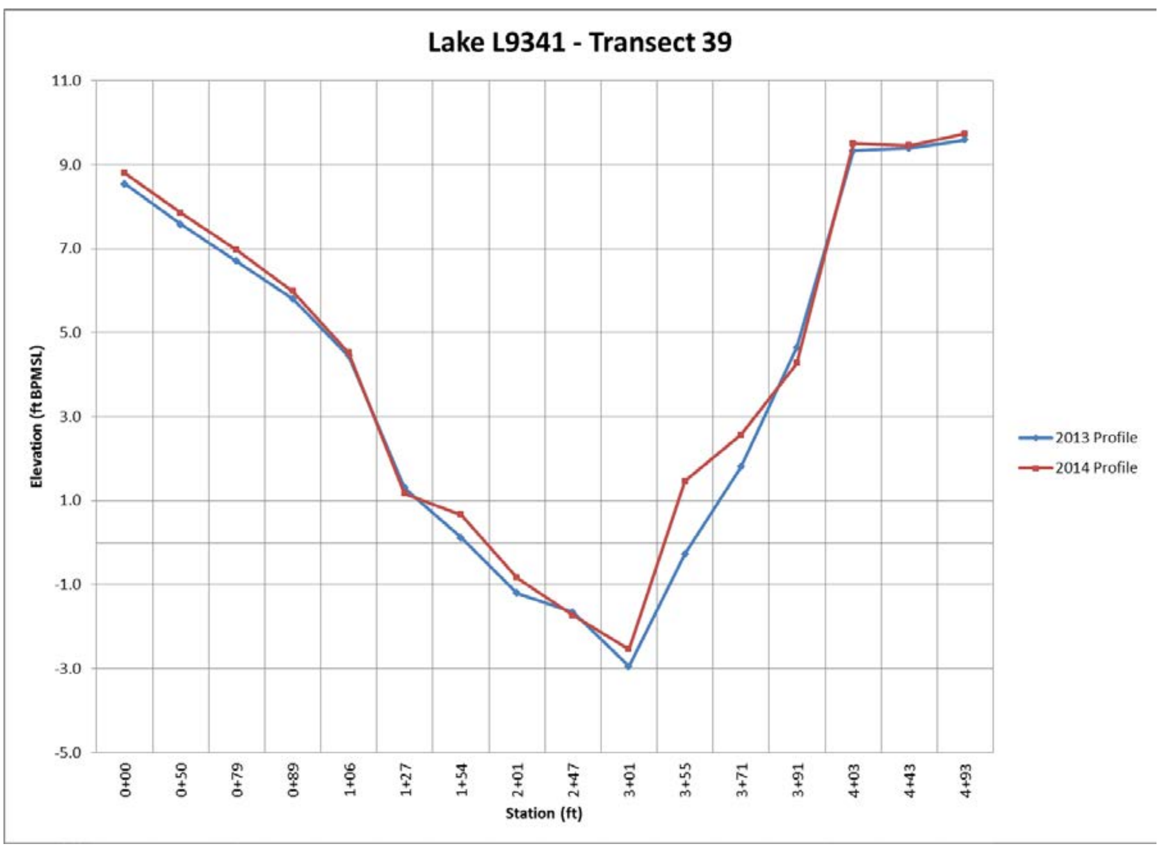
REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
1	08/25/14	ISSUED PER K140003ACS	CZ	GD			

G.2 Lake L9341






Lake L9341 - Transect 38
11.0
9.0
7.0
5.0
3.0
1.0
-1.0
-3.0
-5.0
Elevation (ft BPMSL)
0+00
0+50
0+81
1+22
1+48
1+94
2+46
2+96
3+47
3+95
4+22
4+31
4+79
5+29
Station (ft)
2013 Profile
2014 Profile


Lake L9341 - Transect 39
11.0
9.0
7.0
5.0
3.0
1.0
-1.0
-3.0
-5.0
Elevation (ft BPMSL)
0+00
0+50
0+79
0+89
1+06
1+27
1+54
2+01
2+47
3+01
3+55
3+71
3+91
4+03
4+43
4+93
Station (ft)
2013 Profile
2014 Profile

CD-5 Michael Baker
Transect 36

STA	2013	2014	Description
0+00	8.3	8.4	Ground Shot
0+50	8.0	8.2	Ground Shot
0+81	7.2	7.3	Ground Shot
1+17	7.2	7.2	Top of Bank
1+23	6.3	6.5	Edge of Vegetation
1+48	4.6	4.6	Edge of Water
1+52	4.0	2.0	River Bottom
1+89	0.8	1.5	River Bottom
2+20	-0.9	1.0	River Bottom
2+48	-1.7	-0.9	River Bottom
2+95	-3.0	-2.8	River Bottom
3+49	-2.1	-1.5	River Bottom
3+78	1.7	1.5	River Bottom
3+90	2.5	2.2	River Bottom
3+96	4.8	4.7	Edge of Water
4+06	8.6	8.6	Top of Bank
5+03	9.5	9.6	Ground Shot

CD-5 Michael Baker
Transect 37

STA	2013	2014	Description
0+00	8.0	8.1	Ground Shot
0+50	8.3	8.5	Ground Shot
0+92	7.0	7.1	Top of Bank
1+03	6.5	6.6	Edge of Vegetation
1+40	4.6	4.5	Edge of Water
1+59	2.2	1.7	River Bottom
2+01	0.5	1.1	River Bottom
2+48	-2.4	-2.5	River Bottom
2+99	-2.9	-2.5	River Bottom
3+45	-1.6	-1.3	River Bottom
3+84	2.1	1.4	River Bottom
3+95	4.6	4.7	Edge of Water
4+04	9.1	9.1	Top of Bank
4+49	8.8	8.9	Ground Shot
4+99	9.5	9.6	Ground Shot

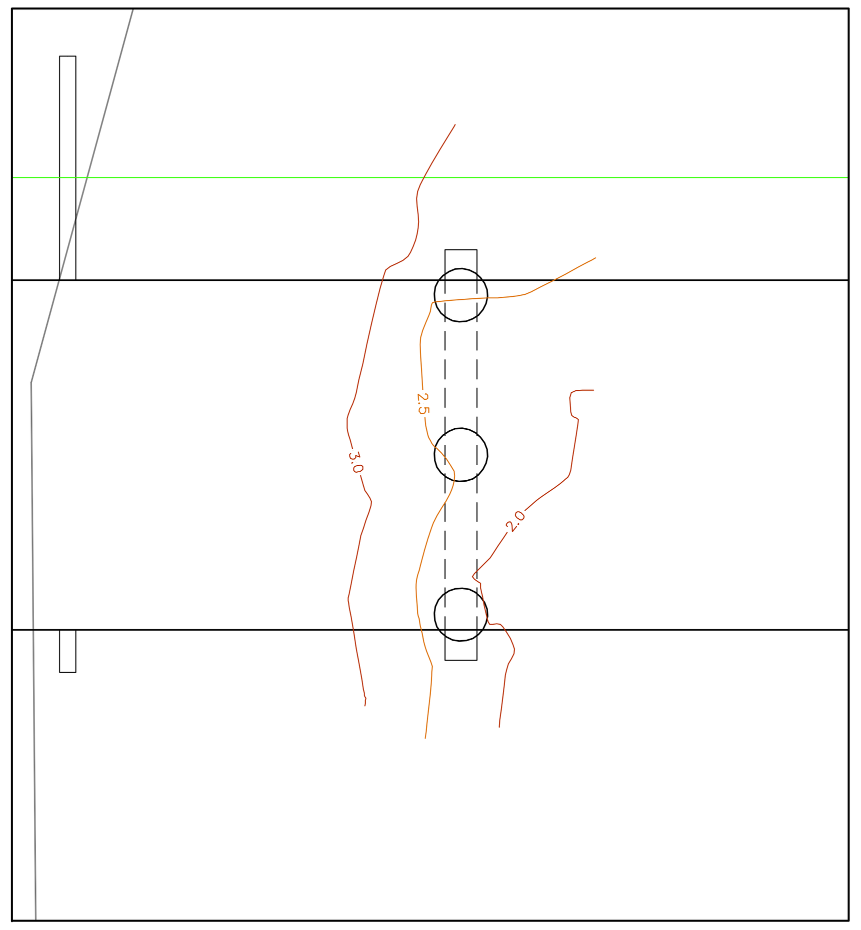
CD-5 Michael Baker
Transect 38

STA	2013	2014	Description
0+00	8.1	8.4	Ground Shot
0+50	7.9	8.3	Ground Shot
0+81	7.3	7.3	Top of Bank
1+22	6.1	6.4	Edge of Vegetation
1+48	4.6	4.5	Edge of Water
1+94	1.4	1.6	River Bottom
2+46	0.4	0.4	River Bottom
2+96	-2.6	-2.2	River Bottom
3+47	-2.8	-2.5	River Bottom
3+95	0.8	1.5	River Bottom
4+22	4.7	3.7	Edge of Water
4+31	9.3	9.3	Top of Bank
4+79	9.0	9.1	Ground Shot
5+29	9.2	9.3	Ground Shot

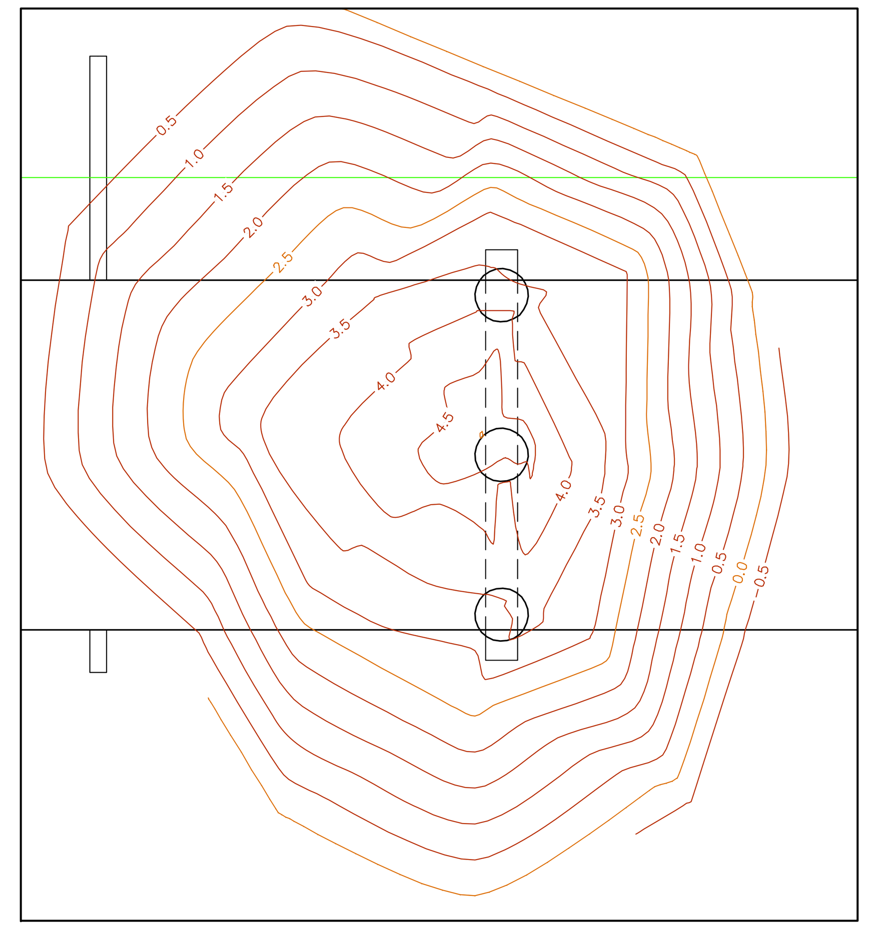
CD-5 Michael Baker
Transect 39

STA	2013	2014	Description
0+00	8.5	8.8	Ground Shot
0+50	7.6	7.8	Ground Shot
0+79	6.7	7.0	Top of Bank
0+89	5.8	6.0	Edge of Vegetation
1+06	4.4	4.5	Edge of Water
1+27	1.3	1.2	River Bottom
1+54	0.1	0.7	River Bottom
2+01	-1.2	-0.8	River Bottom
2+47	-1.7	-1.7	River Bottom
3+01	-3.0	-2.5	River Bottom
3+55	-0.3	1.5	River Bottom
3+71	1.8	2.6	River Bottom
3+91	4.6	4.3	Edge of Water
4+03	9.3	9.5	Top of Bank
4+43	9.4	9.5	Ground Shot
4+93	9.6	9.7	Ground Shot

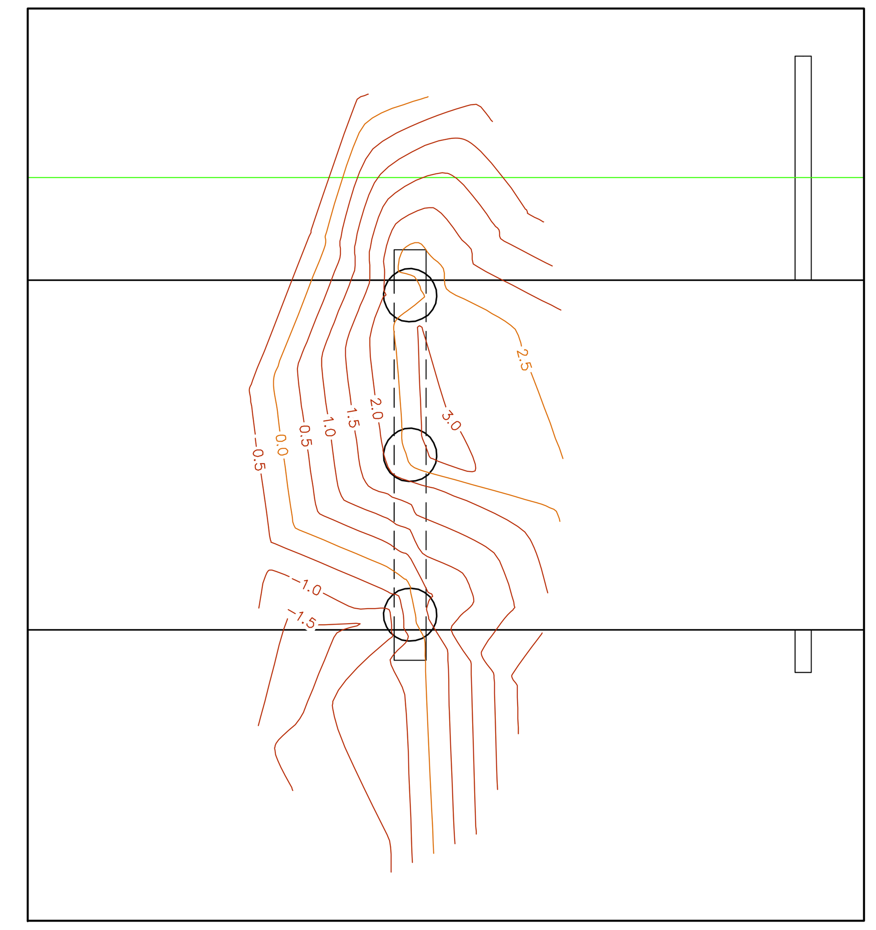
PIER 2
SCALE: 1" = 10'

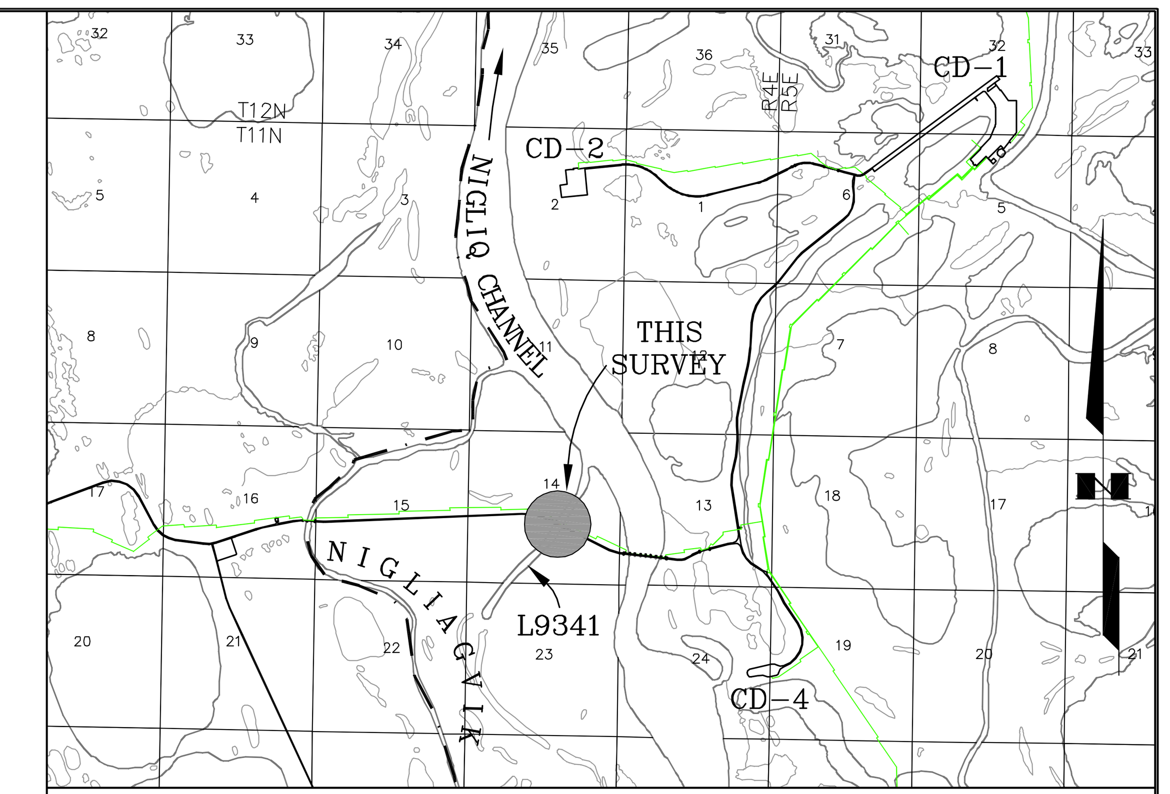


PIER 3
SCALE: 1" = 10'



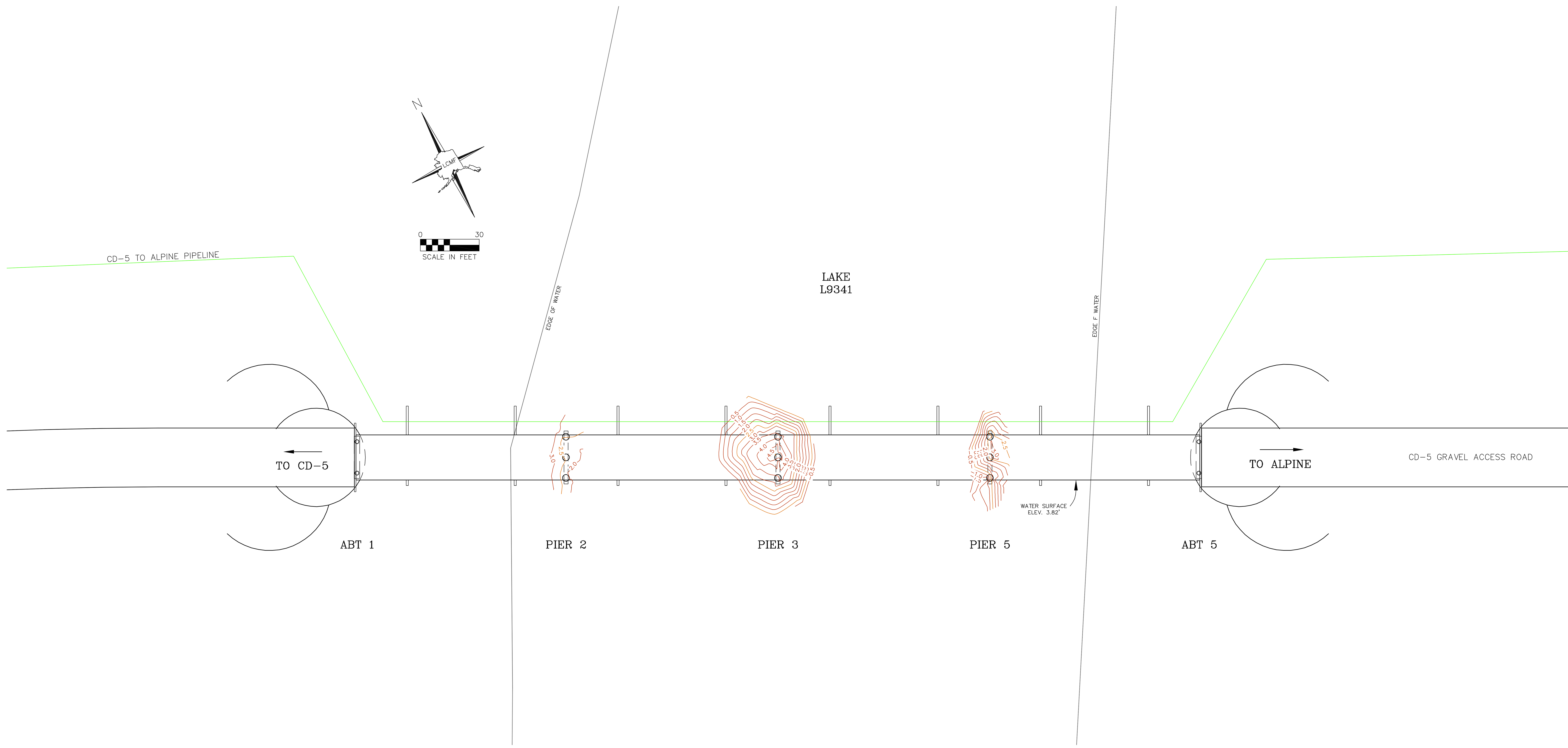
PIER 4
SCALE: 1" = 10'





VICINITY MAP

NOTES
1. DATE OF SURVEY: AUGUST 21, 2014.
2. REFERENCE FIELD BOOKS: LCMF2014-21, PG. 37.
3. ELEVARIONS ARE BRITISH PETROLEUM MEAN SEAL LEVLE (B.P.M.S.L.)
4. HORIZONTAL DATUM IS NAD 83 ALASKA STATE PLANE ZONE 4,.



FORM: DSIZE

KUUKPIK LCMF LLC
Alpine Survey Office

ConocoPhillips
Alaska, Inc.

ALPINE | MODULE: CD50 | UNIT: CD

CD-5 ACCESS ROAD
LAKE L9341 BRIDGE
SCOUR MONITORING

REDRAWN FROM: | CONSTRUCTION SHEET OF

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

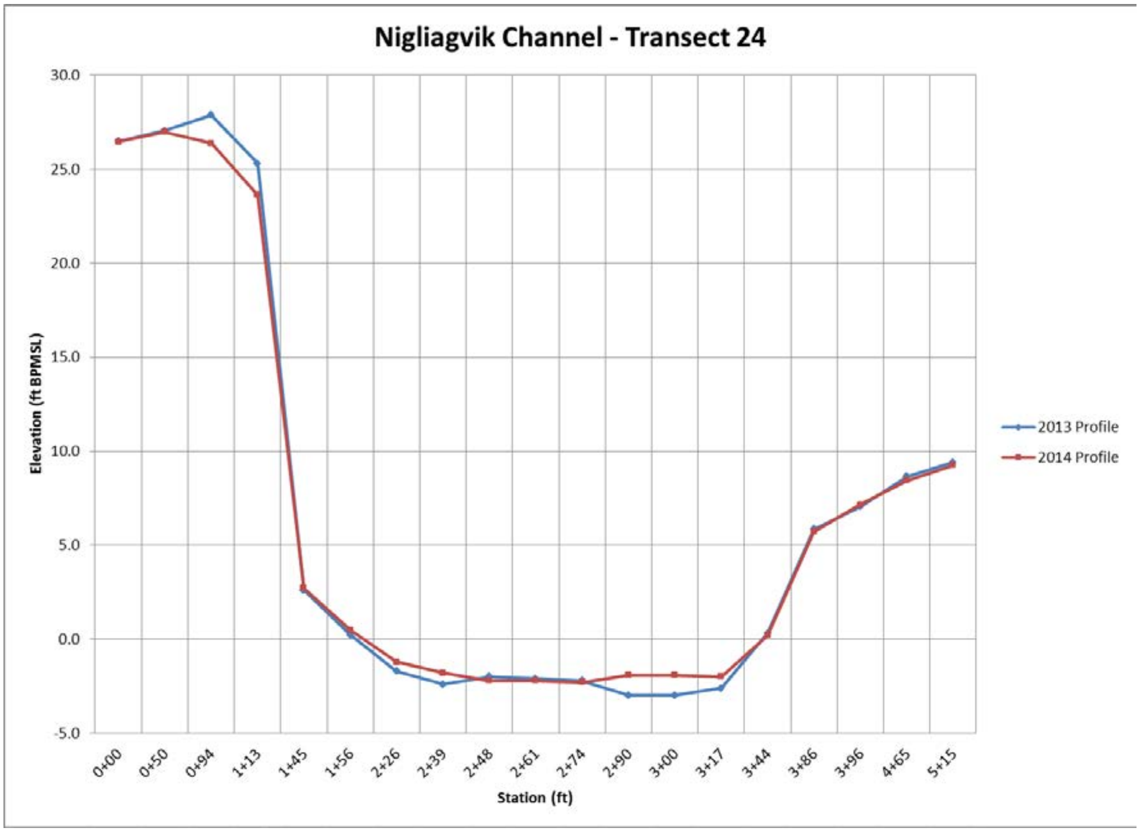
DATE: 8/24/14	DRAWN: CZ	DESIGN: –	ECM NO: K140003ACS
	CHECKED: GD		CC NO: –
SCALE: 1" = 30'	APPROVAL: –		CADD FILE NO. 14-08-12-1BW
JOB NO: –	SUB JOB NO: –	DRAWING NO: CE-CD50-1024	PART: 1 OF 1	REV: 1

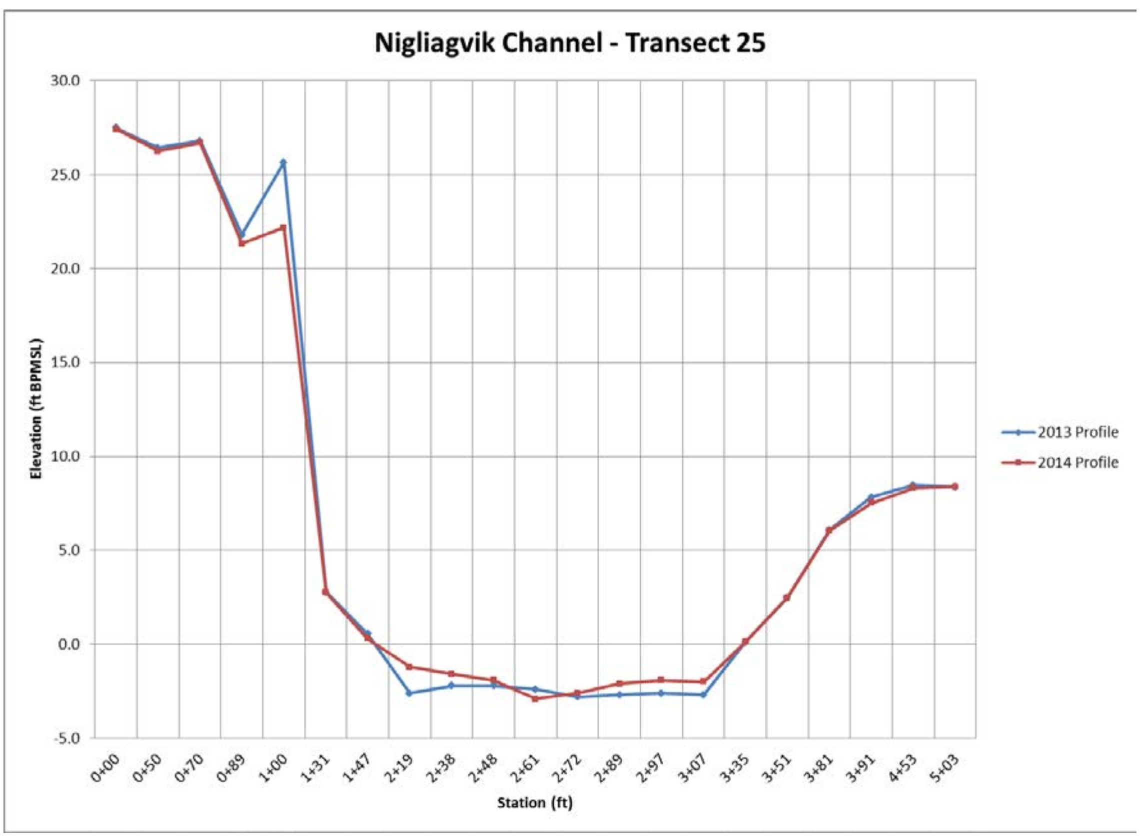
REFERENCE DWG NO/SHT NO:

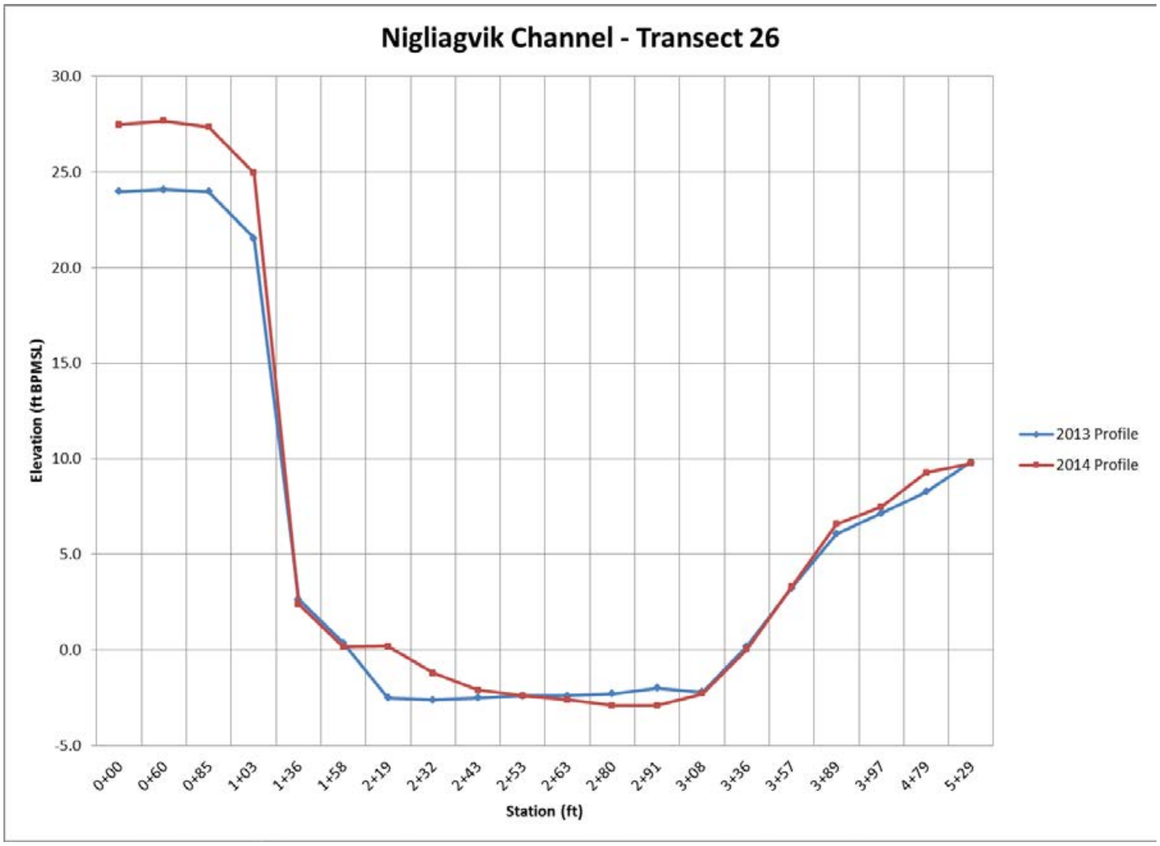
REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP

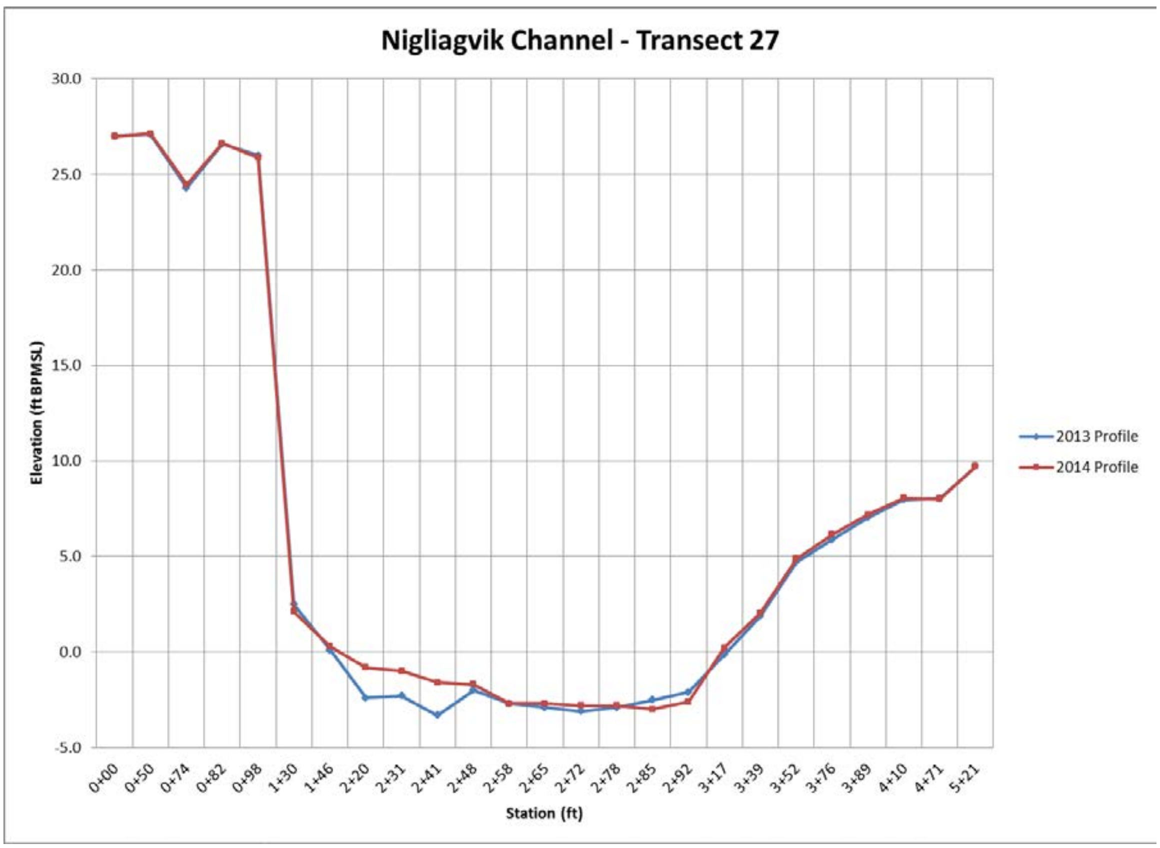
REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
1	08/25/14	ISSUED PER K140003ACS	CZ	GD			

G.3 Nigliagvik Channel






Nigliagvik Channel - Transect 26
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
Elevation (ft BPMSL)
0+00
0+60
0+85
1+03
1+36
1+58
2+19
2+32
2+43
2+53
2+63
2+80
2+91
3+08
3+36
3+57
3+89
3+97
4+79
5+29
Station (ft)
2013 Profile
2014 Profile


Nigliagvik Channel - Transect 27
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
Elevation (ft BPMSL)
0+00
0+50
0+74
0+82
0+98
1+30
1+46
2+20
2+31
2+41
2+48
2+58
2+65
2+72
2+78
2+85
2+92
3+17
3+39
3+52
3+76
3+89
4+10
4+71
5+21
Station (ft)
2013 Profile
2014 Profile

CD-5 Michael Baker
Transect 24

STA	2013	2014	Description
0+00	26.5	26.5	Ground Shot
0+50	27.0	27.0	Ground Shot
0+94	27.9	26.4	Ground Shot
1+13	25.3	23.6	Top of Bank
1+45	2.6	2.7	Toe of Bank
1+56	0.2	0.5	Edge of Water
2+26	-1.7	-1.2	River Bottom
2+39	-2.4	-1.8	River Bottom
2+48	-2.0	-2.2	River Bottom
2+61	-2.1	-2.2	River Bottom
2+74	-2.2	-2.3	River Bottom
2+90	-3.0	-1.9	River Bottom
3+00	-3.0	-1.9	River Bottom
3+17	-2.6	-2.0	River Bottom
3+44	0.3	0.2	Edge of Water
3+86	5.9	5.7	Edge of Vegetation
3+96	7.1	7.2	Top of Bank
4+65	8.7	8.5	Ground Shot
5+15	9.4	9.2	Ground Shot

CD-5 Michael Baker
Transect 25

STA	2013	214	Description
0+00	27.5	27.4	Ground Shot
0+50	26.4	26.2	Ground Shot
0+70	26.8	26.7	Ground Shot
0+89	21.8	21.3	Grade Break
1+00	25.7	22.2	Top of Bank
1+31	2.8	2.8	Toe of Bank
1+47	0.6	0.3	Edge of Water
2+19	-2.6	-1.2	River Bottom
2+38	-2.2	-1.6	River Bottom
2+48	-2.2	-1.9	River Bottom
2+61	-2.4	-2.9	River Bottom
2+72	-2.8	-2.6	River Bottom
2+89	-2.7	-2.1	River Bottom
2+97	-2.6	-1.9	River Bottom
3+07	-2.7	-2.0	River Bottom
3+35	0.1	0.1	Edge of Water
3+51	2.5	2.5	Ground Shot
3+81	6.1	6.1	Edge of Vegetation
3+91	7.8	7.5	Top of Bank
4+53	8.5	8.3	Ground Shot
5+03	8.4	8.4	Ground Shot

CD-5 Michael Baker
Transect 26

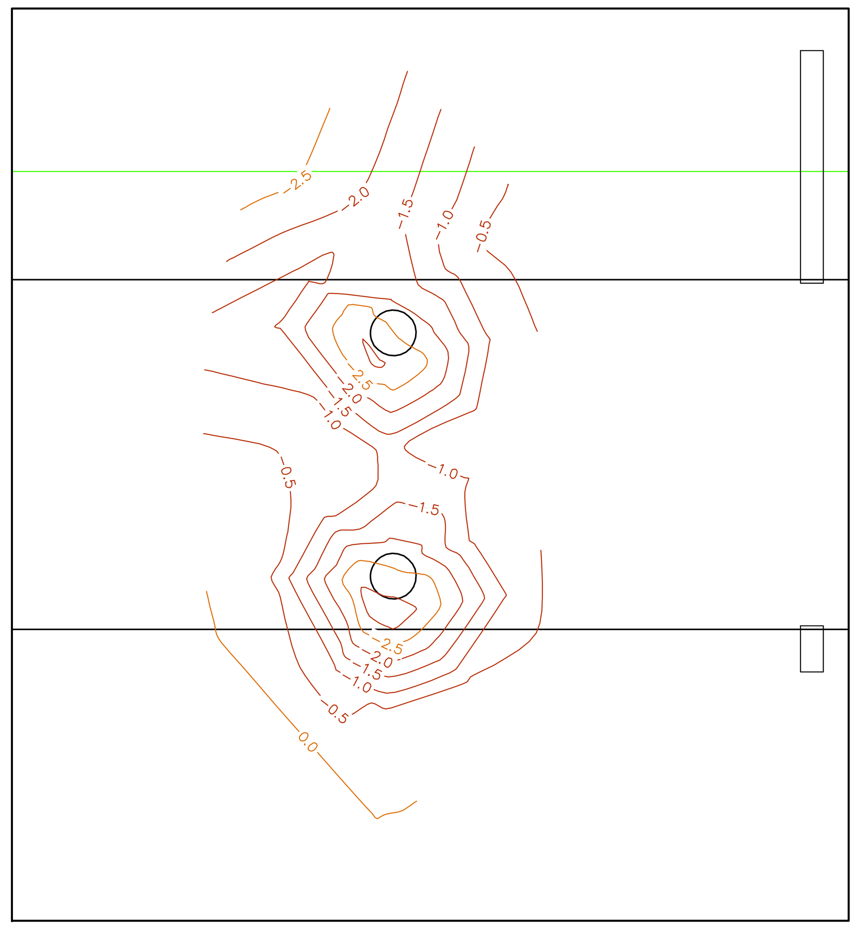
STA	2013	2014	Description
0+00	24.0	27.5	Ground Shot
0+60	24.1	27.7	Ground Shot
0+85	24.0	27.3	Ground Shot
1+03	21.5	24.9	Grade Break
1+36	2.7	2.4	Top of Bank
1+58	0.4	0.2	Toe of Bank
2+19	-2.5	0.2	Edge of Water
2+32	-2.6	-1.2	River Bottom
2+43	-2.5	-2.1	River Bottom
2+53	-2.4	-2.4	River Bottom
2+63	-2.4	-2.6	River Bottom
2+80	-2.3	-2.9	River Bottom
2+91	-2.0	-2.9	River Bottom
3+08	-2.2	-2.3	River Bottom
3+36	0.2	0.0	River Bottom
3+57	3.2	3.3	Edge of Water
3+89	6.1	6.6	Ground Shot
3+97	7.1	7.5	Edge of Vegetation
4+79	8.3	9.3	Top of Bank
5+29	9.8	9.8	Ground Shot
Station 4+79 falls in Slope of Gravel Road			

CD-5 Michael Baker
Transect 27

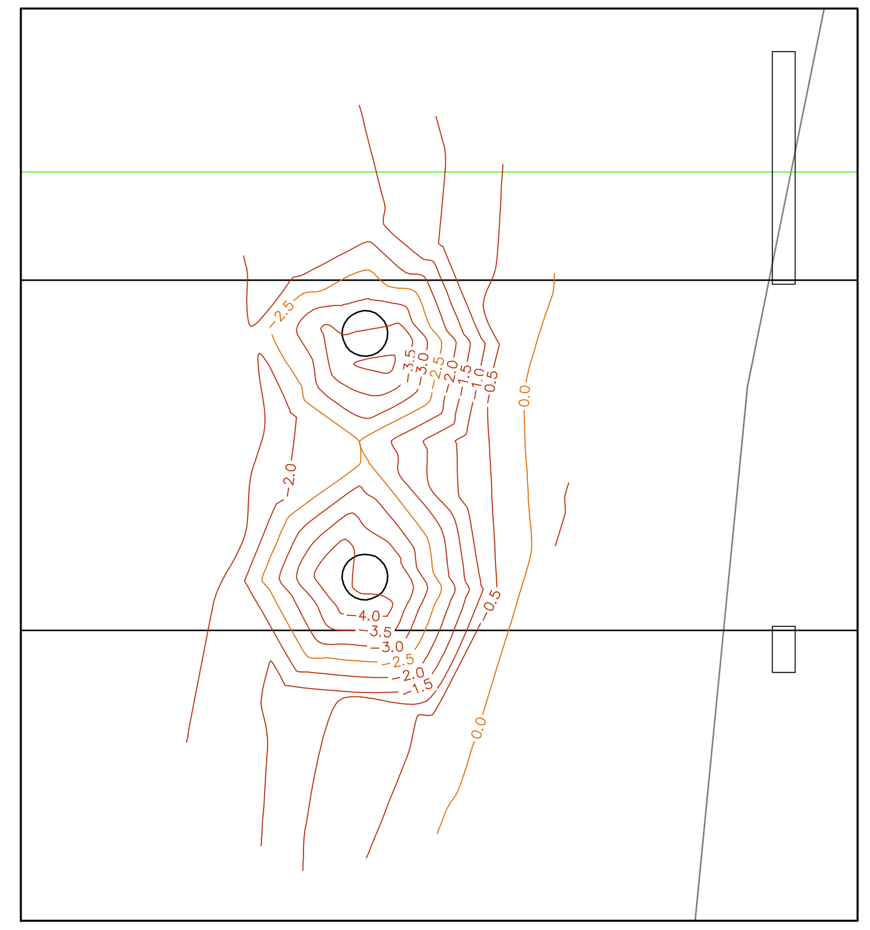
STA	2013	2014	Description
0+00	27.0	27.0	Ground Shot
0+50	27.1	27.1	Ground Shot
0+74	24.3	24.5	Grade Break
0+82	26.6	26.6	Grade Break
0+98	26.0	25.9	Top of Bank
1+30	2.5	2.1	Toe of Bank
1+46	0.1	0.3	Edge of Water
2+20	-2.4	-0.8	River Bottom
2+31	-2.3	-1.0	River Bottom
2+41	-3.3	-1.6	River Bottom
2+48	-2.0	-1.7	River Bottom
2+58	-2.7	-2.7	River Bottom
2+65	-2.9	-2.7	River Bottom
2+72	-3.1	-2.8	River Bottom
2+78	-2.9	-2.8	River Bottom
2+85	-2.5	-3.0	River Bottom
2+92	-2.1	-2.6	River Bottom
3+17	-0.1	0.2	Edge of Water
3+39	1.9	2.0	Ground Shot
3+52	4.7	4.9	Ground Shot
3+76	5.9	6.1	Edge of Vegetation
3+89	7.0	7.2	Top of Bank
4+10	8.0	8.1	Ground Shot
4+71	8.0	8.0	Ground Shot
5+21	9.7	9.7	Ground Shot

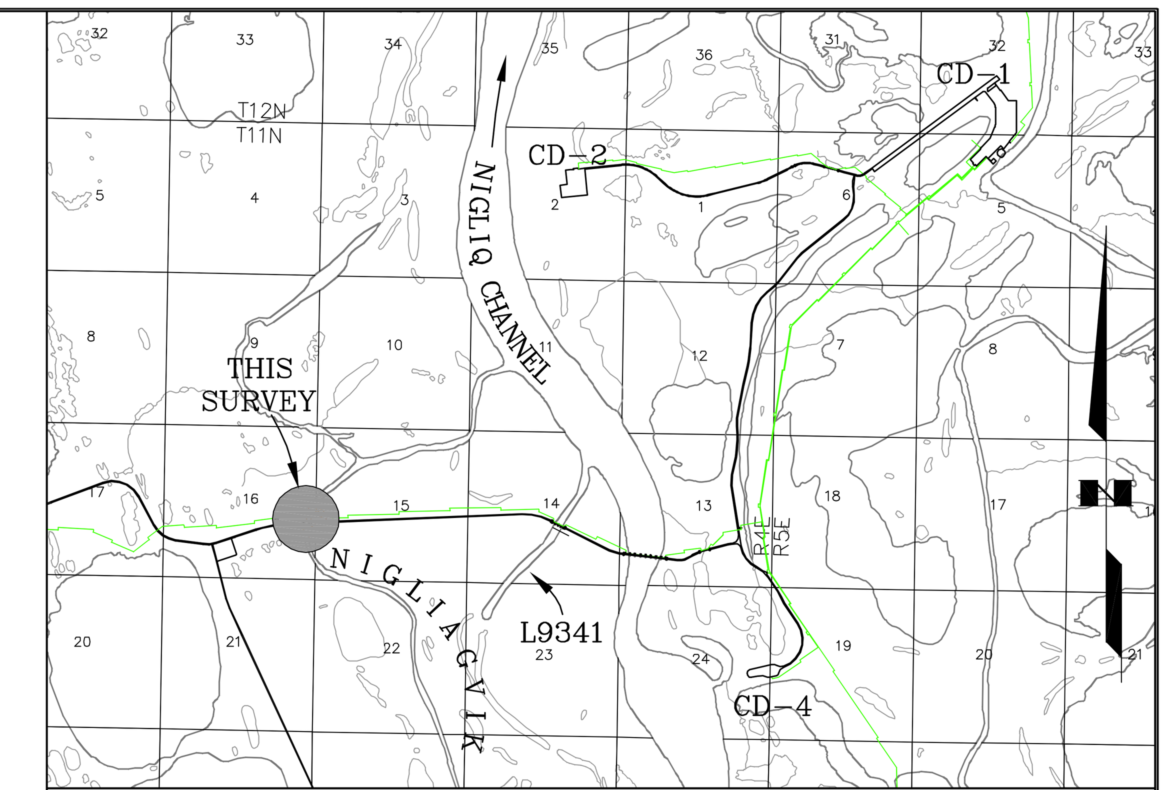
JOB NO:	SUB JOB NO:	DRAWING NO:
–	–	CE–CD50–1023

PIER 3
SCALE: 1" = 10'



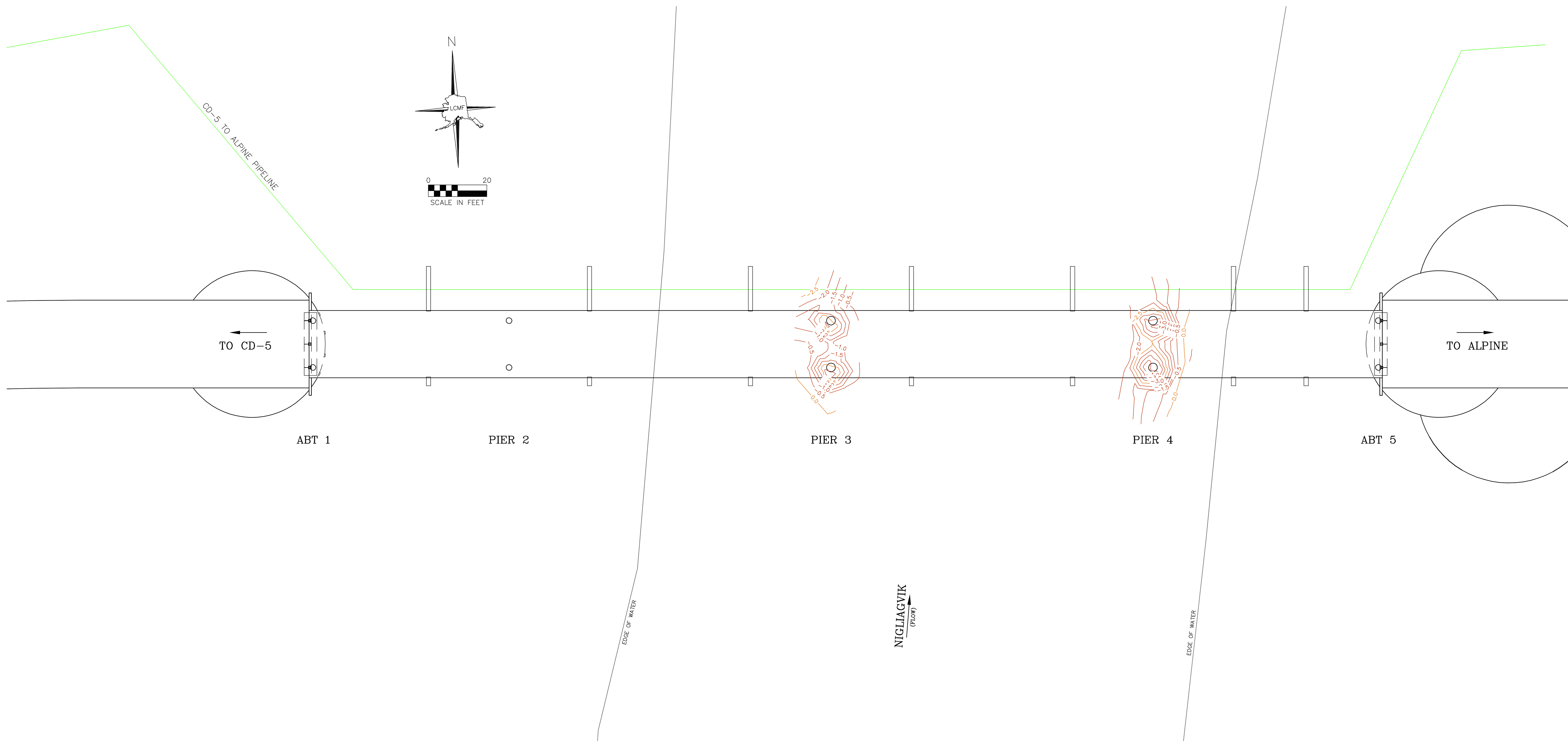
PIER 4
SCALE: 1" = 10'





VICINITY MAP

NOTES
1. DATE OF SURVEY: AUGUST 21, 2014.
2. REFERENCE FIELD BOOKS: LCMF2014–21, PG. 37.
3. ELEVARIONS ARE BRITISH PETROLEUM MEAN SEAL LEVLE (B.P.M.S.L.)
4. HORIZONTAL DATUM IS NAD 83 ALASKA STATE PLANE ZONE 4,.



FORM: DSIZE

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
1	08/25/14	ISSUED PER K140003ACS	CZ	GD			

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

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: 1

2014 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment