Colville River Delta 2016 Spring Breakup Field Report

Prepared for ConocoPhillips Alaska, Inc.

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Acronyms and Abbreviations

BPMSL	British Petroleum Mean Sea Level
CPAI	ConocoPhillips Alaska, Inc.
CRD	Colville River Delta
GPS	Global positioning systems
HWM	High water mark(s)
Michael Baker	Michael Baker International
USGS	U.S. Geological Survey
WSE	Water surface elevation(s)

1.0 INTRODUCTION

Michael Baker International (Michael Baker) provided hydrology monitoring services to ConocoPhillips Alaska, Inc. (CPAI) for the Alpine Development Project in the Colville River Delta (CRD). Alpine facilities include the Colville Delta CD1 processing facility and the CD2, CD3, CD4, CD5 pads, access roads, and pipelines.

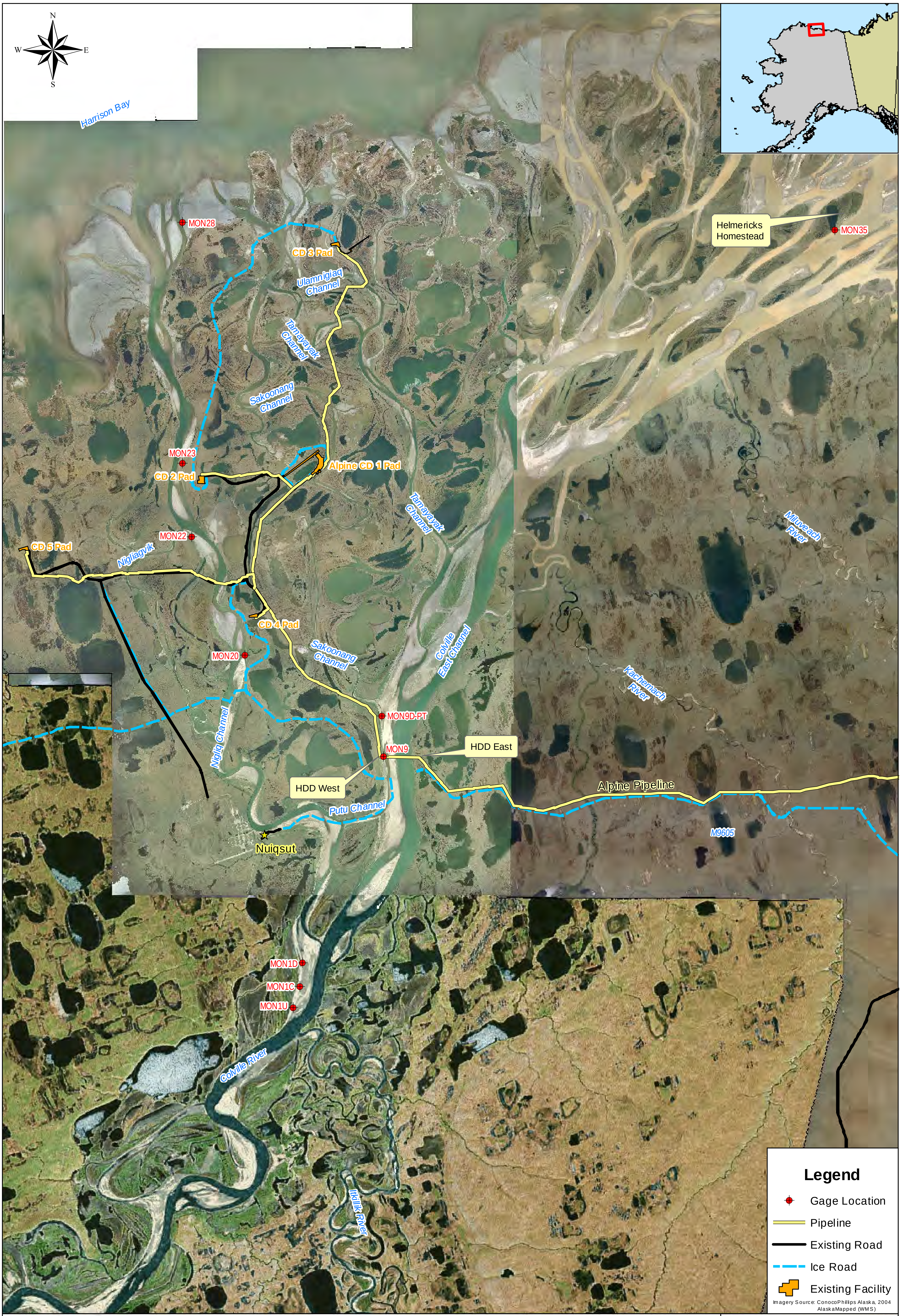
Spring breakup on the North Slope of Alaska is the largest annual flooding event in the region. Hydrology studies are conducted to document the magnitude and extent of flooding. The information acquired through these efforts are integral to understanding the regional hydrology and maintaining the continued safety of the environment, oilfield personnel, and facilities during annual flooding and is important to designing future facilities. This report provides an overview of the 2016 field program and a summary of the observations. A comprehensive hydrological assessment report will be submitted in December 2016.

1.1 STUDY OBJECTIVE

The objective of the CRD Spring Breakup Monitoring and Hydrologic Assessment Program is to estimate the magnitude of the 2016 breakup flooding by documenting the distribution of floodwater and measuring water surface elevations (WSE) and flow volume rate (discharge) at preselected locations. Monitoring locations cover the entire delta (Figure 1.1) with a focus around oilfield infrastructure, particularly cross-drainage structures (Figure 1.2).

WSE measurements were collected around facilities, access roads, pipelines, and at other key locations including water use lakes and the upstream and downstream extent of the delta. Discharge was measured at bridges, culverts, and on the Colville River at MON1. Breakup observations included photo documentation of floodwater progression, ice jam effects, ice bridge degradation, and flood impacts to roads and pads.

Safety was the first priority; all field tasks were performed in compliance with Michael Baker's North Slope Water Resources 2016 Health Safety and Environment Plan and project-specific Job Safety Analysis. Tailgate health and safety meetings were conducted by the field crew at the start of work each day and task specific hazard assessments were also completed prior to beginning non-routine tasks. Hazard mitigation, protective equipment, and helicopter, truck, and boat safety were thoroughly evaluated.



ConocoPhillips Alaska

Miles
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Drawn:	BTG	File:	Figure 1
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2016 SPRING BREAKUP
COLVILLE RIVER DELTA

Monitoring Locations

FIGURE: 1

(SHEET 1 of 1)

ConocoPhillips Alaska

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2016 SPRING BREAKUP
ALPINE AREA FACILITIES

Monitoring Locations

FIGURE: 2

(SHEET 1 of 1)

2.0 METHODS

2.1 VISUAL OBSERVATIONS

The progression of Colville River floodwaters was monitored in the foothills, upstream of the delta with the U.S. Geological Survey (USGS) gage and webcam at Umiat. The confluences of the Chandlar and Anaktuvuk Rivers are downstream of Umiat and contributions are not accounted for in the Umiat gage data. Prior to breakup reaching the CRD, upstream aerial reconnaissance to the Anaktuvuk River and Chandler River tributaries was performed to help forecast breakup timing and resource scheduling.

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. Observations of breakup progression, flow distribution, bank erosion, ice events, scour, lake recharge, and interactions between floodwaters and infrastructure were documented.

2.2 WATER SURFACE ELEVATION

Staff gages were used to measure changes in WSE. The gage elevations were surveyed to control points referenced to British Petroleum Mean Sea Level (BPMSL). Most monitoring locations had gage sets consisting of multiple gages. The number of gage assemblies per site depends on the slope of the channel bank and overbank. In locations where terrain elevation varied by more than three feet, multiple gages were installed linearly from the edge of the low water channel up to the overbank (Photo 2.1). When gages were destroyed by ice, temporary gages were installed or an elevation survey was completed to the water surface.

Photo 2.1: Gage set MON9 showing staff gage elevation overlap from the "A" gage nearest the channel to the "G" gage at the top of the bank; April 27, 2016

Pressure transducer data loggers were installed at most gage locations to provide continuous WSE measurements. The pressure of the water above the instrument is measured, allowing the depth of water to be calculated. The pressure transducers were programmed to collect data at 15-minute intervals and were attached to the gage at a known elevation.

2.3 DISCHARGE

Discharge was measured at MON1 on the Colville River by boat using an acoustic doppler current profiler. Discharge was measured at the Long and Short Swale Bridges, the Nigliq Bridge, and at the Nigliagvik Bridge using the USGS standard midsection technique. Analysis of discharge and WSE data is performed post-monitoring to calculate peak discharge at key locations and estimate recurrence intervals. Culvert performance was evaluated and discharge through culverts conveying flow was measured.

2.4 Field Work Dates

Field work started on April 25 and concluded on May 29. Tundra travel remained open and Hägglund tracked vehicles were used to access most sites before May 7. On May 6, setup was nearly complete and crew members worked on transitioning equipment to the upcoming monitoring efforts and began tracking the progression of breakup.

On May 10, crew members flew a reconnaissance flight towards the headwaters of the Colville River drainage and located the leading edge of floodwater. Helicopter transportation became available on May 13 and monitoring began when floodwater reached the CRD. Crew members departed as water receded and tasks were completed, with the final crew members departing on May 30.

3.0 Breakup Observations

3.1 Summary of Events

Alaska's 2015-2016 (December-February) winter was the second warmest on record, dating back to 1925 (NOAA 2016). In February 2016, snowpack east of the Colville River was 70-89% of the 1981-2010 median. In March and April 2016, snowpack over the entire north slope was also 70-89% of the 1981-2010 median (NRSC 2016). A warming trend in the foothills of the Colville River watershed began about May 10 (USGS 2016). A flight into the watershed on May 10 revealed no moving water as far as Umiat and 57 miles up the Anaktuvuk River from the confluence with the Colville River. Many open leads and local melt were observed.

On May 12, the leading edge of floodwater was observed in the Colville River, on the Umiat webcam, approximately 80 river miles upstream of MON1. Warm temperatures were recorded in Umiat with the daily low above freezing. On May 13, the leading edge was observed in the Colville River just downstream of the Anaktuvuk River confluence. Temperatures in the foothills dropped on May 14 and remained around freezing until May 18.

Photo 3.1: Arrival of the leading edge in the East Channel north of the Nigliq Channel bifurcation, looking south; May 15, 2016

On the morning of May 15, the leading edge passed MON1 and reached the Tamayayak Channel bifurcation in the East Channel (Photo 3.1). A 7.4 mile long ice jam was observed near Ocean Point with minimal backwater upstream of the ice jam.

On May 16, WSEs in the delta continued to rise. The ice jam near Ocean Point had not advanced further downstream, but was increasing in size. The ice jam was composed of mostly pancake ice with very few large floes. Moderate inundation of high-water channels and low laying areas was observed. The leading edge of floodwater had reached the ocean and backwater from the Nigliq Channel had reached the Nigliagvik Bridge. Flow over bottom-fast ice in the Kachemach River and local ponded water in the Miluveach River was observed.

By May 17, the ice jam near Ocean Point had grown to approximately 13.4 miles long. Inundation from the ice jam was still limited to moderate overbank flooding. Stage at MON1 crested and began receding in response to the cooler air temperatures. Channel ice was floating and remained intact in the Nigliq and East Channels. Floodwater reached the CD2 Swale Bridges via Nanuq Lake and Lake M9524 on the evening of May 17.

On May 19, the downstream extent of the ice jam near Ocean Point remained in place while the upstream extent had moved downstream approximately 1.4 miles (Photo 3.2). Stranded ice floes along the banks indicated water levels had dropped behind the ice jam, coinciding with dropping water levels throughout the delta and in most distributary channels.

Temperatures in Umiat began rising again and by May 21 daily low temperatures remained above freezing. On May 21, the ice jam near Ocean Point was approximately 5 miles long and stranded ice was observed along the banks. High water marks (HWM) 3-4 feet above the water surface were observed along the bluffs. The stage at the Umiat gage was rising due to an increase in melt water from the warmer ambient temperatures.

On May 22, the ice jam near Ocean Point was still in place and was approximately 4.1 miles long as the upstream extent of the ice jam continued to advance downstream. A second, approximately 2.4 mile long ice jam, had formed approximately 5 miles upstream of MON1. Rising water levels resulted in minor overbank flooding and flow through high water channels near the ice jams. Channel ice remained intact in the Nigliq and East Channels, while the rising water levels began breaking up ice in the smaller distributary channels.

On the morning of May 23, the ice jam located upstream of MON1 was still in place (Photo 3.3), but released shortly thereafter. Peak stage was observed at MON1 in the afternoon on May 23 as the ice jam and resulting backwater moved downstream. The East Channel was free of intact channel ice up to the Sakoonang Channel bifurcation. Ice jams formed at the Tamayayak Channel bifurcation (Photo 3.4) and in the Nigliq Channel upstream of Nuiqsut. The ice jam in the Nigliq Channel was diverting flow into the East Channel through the Putu Channel. The stage was relatively low and within the banks of the main channels. Overflow from the Sakoonang Channel filled low-lying paleo lakes and channels east and south of the CD4 Road. Nigliq Channel overflow was again conveyed through Nanuq Lake into Lake M9524 and through the CD2 Swale Bridges.

On May 24, the upstream extent of intact channel ice in the East Channel was located between the Kachemach and Miluveach river confluences. The ice jam at the Tamayayak Channel bifurcation had moved downstream and reformed upstream of the intact channel ice. The ice jam in the Nigliq Channel had advanced downstream of Nuiqsut and no significant overbank flooding was observed. Further downstream in the Nigliq Channel, the channel ice was still intact (Photo 3.5) but starting to deteriorate.

Stage around Alpine facilities peaked on May 25 and May 26 and fluctuated as water levels in tributary channels responded to ice jam movements in the East and Nigliq channels. On May 25, discharge was measured at MON1, the Swale Bridges along the CD2 Road, and at the Nigliq Bridge.

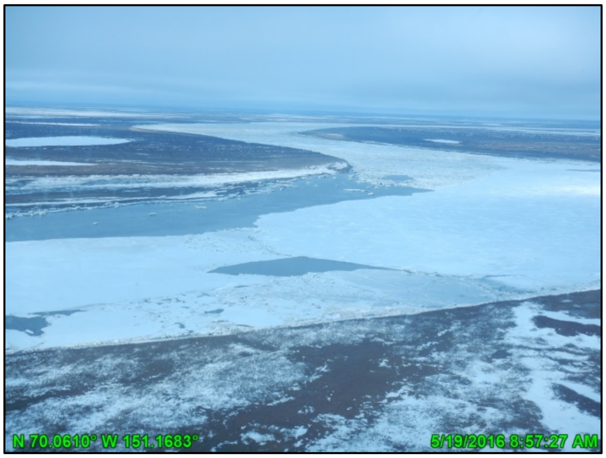


Photo 3.2: Downstream extent of ice jam near Ocean Point, looking southwest; May 19, 2016

Photo 3.3: Downstream extent of ice jam near Ocean Point, looking southwest; May 23, 2016

Photo 3.4: Ice jam forming in the East Channel at the Tamayayak bifurcation, looking south; May 23, 2016

Photo 3.5: Intact channel ice starting to deteriorate near the Nigliq Bridge, looking south; May 24, 2016

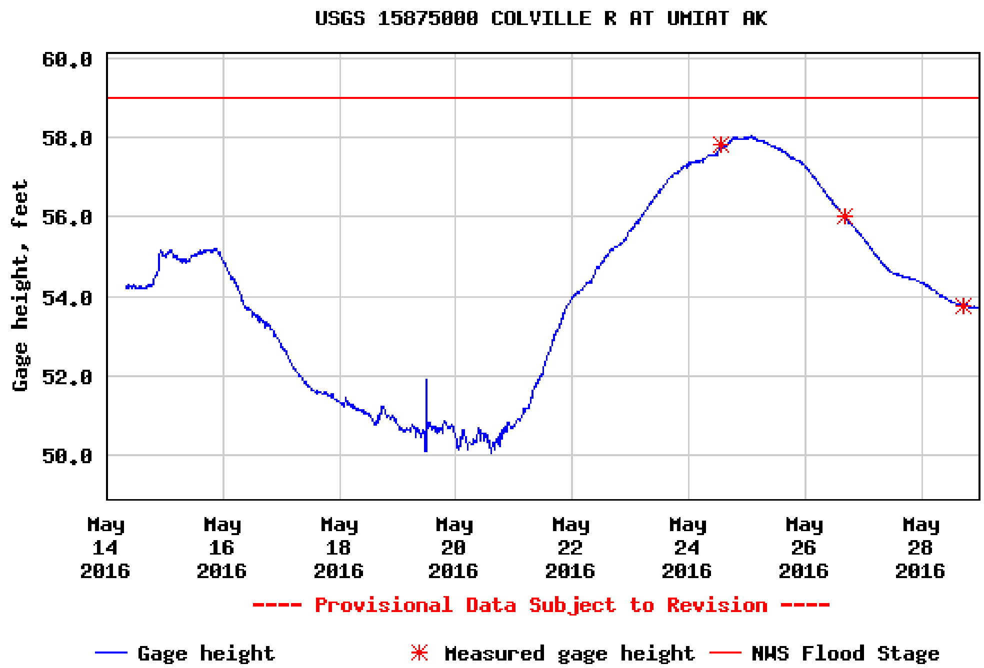
On May 26, water levels in the Nigliq and East Channels and around Alpine facilities were dropping. Channel ice remained intact at the mouth of the Nigliq Channel causing local flooding of the coastal mud flats. The ice jam in the East Channel remained in place near the Miluveach River confluence causing elevated water levels and some local overbank flooding in the eastern distributary channels.

On May 28, the ice jam in the East Channel had reduced in size and no backwater from the ice jam was observed. The Nigliq Channel was clear of ice. Stage continued to drop throughout the delta and around Alpine facilities.

3.2 Timing and Magnitude

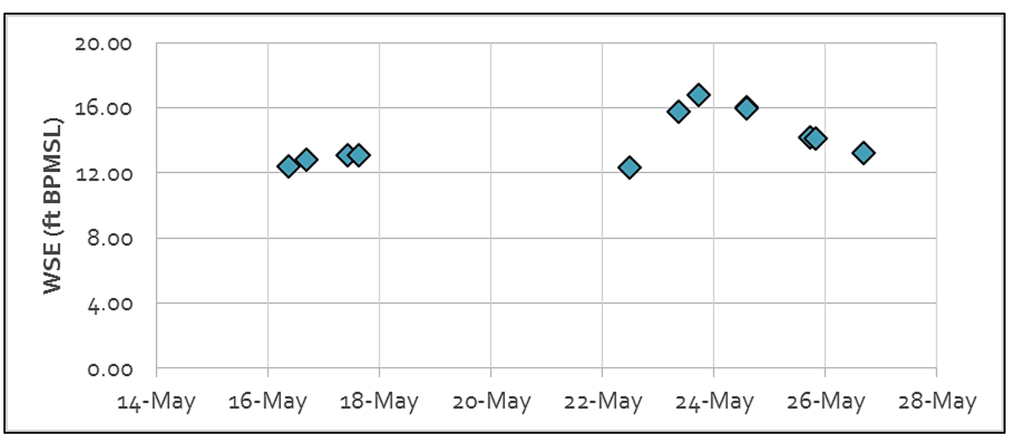
Above average temperatures in the Brooks Range, foothills, and the coastal plain initiated spring breakup flooding in early May. The 2016 CRD spring breakup occurred over a two week period of time. The hydrograph recorded at the USGS gage at Umiat showed two peaks, with the second peak being more distinct and with higher stage. The first high water event at Umiat reached a gage height of 55.2 feet on May 15 and the second peak occurred on May 25 at just over 58 feet. The minimum flood stage at the Umiat gage is considered 59 feet (Figure 3.1).

Figure 3.1: Colville River gage height at Umiat (USGS 2016)



Stage in the Colville River, at the head of the delta (MON1), peaked in the afternoon on May 23 as a result of an upstream ice jam release. Preliminary staff gage observations and HWMs, indicate peak stage at MON1 was 17.2 feet BPMSL (Figure 3.2). Based on historical data, the preliminary peak stage at MON1 was approximately a 2-yr event.

Figure 3.2: Preliminary WSEs at MON1 based on staff gage readings



4.0 Roads and Facilities Overview

Floodwater contact with roads and pads was limited to the CD2 Road near the Swale Bridges and the CD4 Road near the north and south culvert batteries. No overbank flooding was observed along the CD5 Road. All bridges and culverts that experienced flow performed as designed.

During breakup, Lake L9323 was not connected to the Nigliq Channel and as a result, flow was not conveyed through the Lake L9323 Bridge. Lake L9341 received backwater from the Nigliq Channel and downstream flow through the bridge was not observed. Ice remained intact at the Lake L9341 Bridge throughout the breakup period. The channel ice at the Nigliq Bridge broke up in the morning on May 25, and direct discharge was measured from the bridge that evening. The Nigliagvik Channel initially received backwater from the Nigliq Channel confluence. A large water surface differential developed between the upstream and downstream side of the Nigliagvik Bridge due to the presence of a large snow drift under the bridge. On May 23, the water surface equalized under the Nigliagvik Bridge as water broke through the snow drift. When direct discharge was measured at the Nigliagvik Bridge on May 26, a large portion of the snow drift remained near the east abutment.

Direct discharge was completed at the CD4 road culverts on May 24 as flow from the Sakoonang Channel was conveyed towards the CD4 culverts. Direct discharge measurements were conducted at CD2 road culverts on May 23 and May 24, and at the CD2 Swale Bridges on May 25. Based on preliminary staff gage observations and HWMs stage at gage G3 peaked at 7.5 feet BPMSL in the afternoon/evening of May 25.

No erosion or scour was observed at the bridge abutments, pads, or roads. Minimum scour was observed at the base of Pier 3 at the Nigliagvik Bridge.

Lake L9313 recharged by overland flow from the Sakoonang Channel near CD1, and no overland flow was observed entering Lake L9312.

5.0 References

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