



Colville River Delta 2015 Spring Breakup Field Report


ConocoPhillips

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7/14/2015

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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
Michael Baker	Michael Baker International
RM	River miles
USGS	United States 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 pads, access roads, and pipelines. The more recent CD5 development is connected to Alpine by an all season gravel road with four bridges. Both developments were monitored over the same period using similar methods.

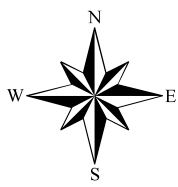
Spring breakup on the North Slope of Alaska is the largest annual flooding event in the region. Hydrology studies are conducted to document the magnitude and extent of the flooding. The information acquired through these efforts are integral to understanding the regional hydrology and maintaining the 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 2015 field program and a summary of the observations. A comprehensive hydrological assessment report will be submitted in November 2015.

1.1 STUDY OBJECTIVE

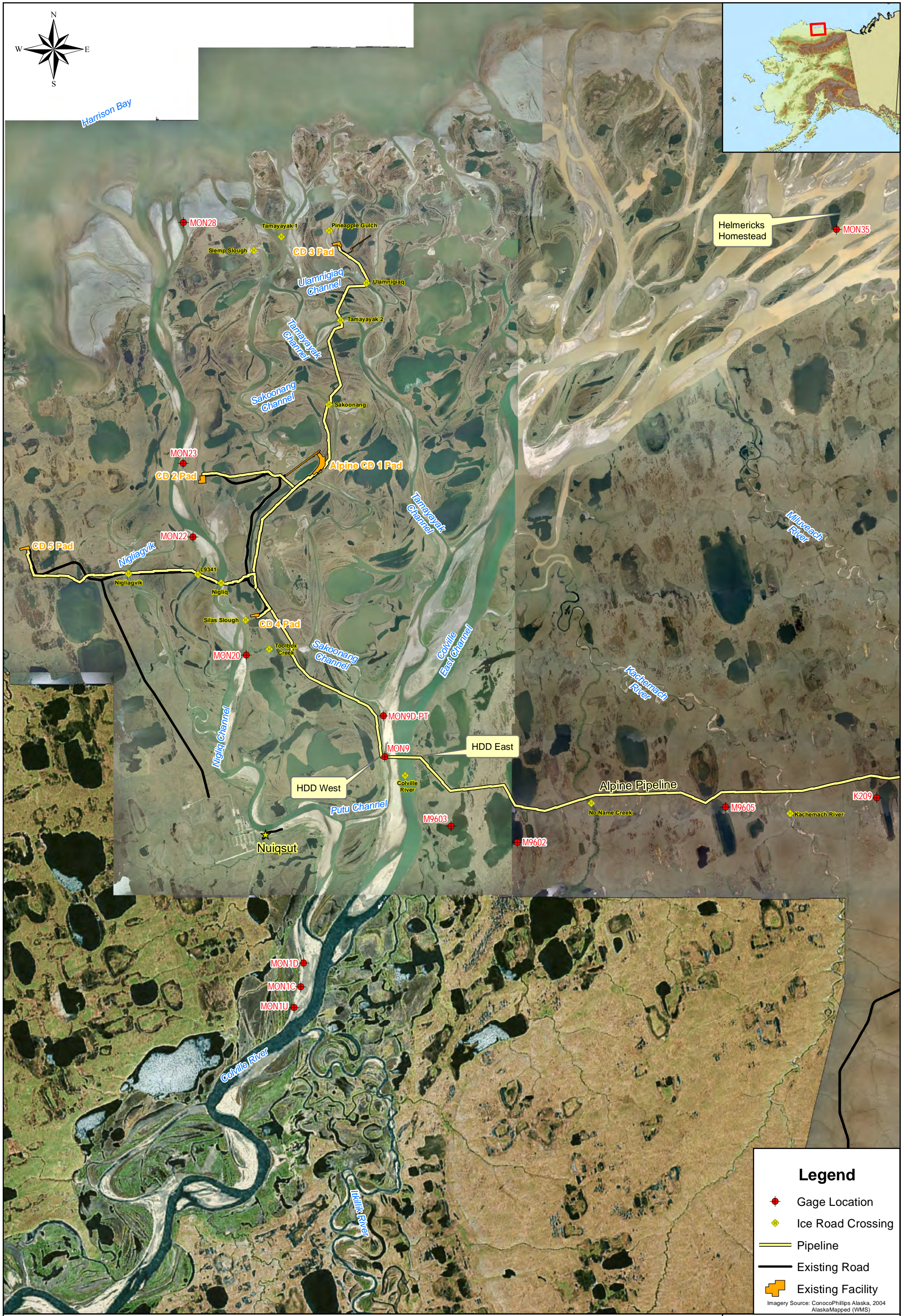
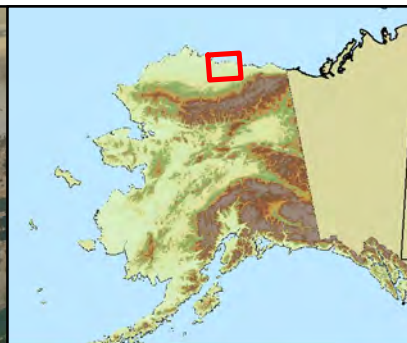
The objective of the CRD Spring Breakup Monitoring and Hydrologic Assessment Program is to estimate the magnitude of the 2015 breakup flooding by documenting the distribution of floodwater and measuring water surface elevations (WSE) and flow volume rate (discharge) at preselected locations. Monitoring 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 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 2015 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 daily and prior to beginning a new task. Hazard mitigation, protective equipment, and helicopter, truck, and boat safety were thoroughly evaluated.



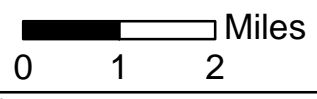
Harrison Bay



Legend

- + Gage Location
- ◆ Ice Road Crossing
- Pipeline
- Existing Road
- + Existing Facility

Imagery Source: ConocoPhillips Alaska, 2004
AlaskaMapped (WMS)



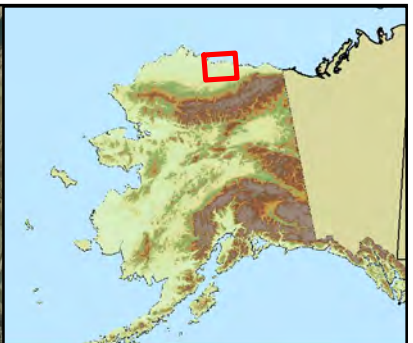
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2015 SPRING BREAKUP
COLVILLE RIVER DELTA

Monitoring Locations

Date:	05/14/2015	Project:	145876
Drawn:	MEA	File:	Figure 1
Checked:	SME	Scale:	1 in = 2 miles

FIGURE: 1
(SHEET 1 of 1)



Legend

- ◆ Gage Location
- ◆ Ice Road Crossing
- Pipeline
- Existing Road
- + Existing Facility

Imagery Source: ConocoPhillips Alaska, 2004
AlaskaMapped (MMS)

ConocoPhillips
Alaska

Miles
0 0.5 1

Date:	05/14/2015	Project:	145876
Drawn:	MEA	File:	Figure 2
Checked:	SME	Scale:	1 in = 1 miles



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2015 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 upstream of the delta with the U.S. Geological Survey (USGS) gage and webcam at Umiat. 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.

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 and on the Nigliq Channel upstream of the CD5 road crossing by boat using an acoustic doppler current profiler. Discharge was measured at the Long and Short Swale Bridges and at the Nigliagvik Channel 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.



Photo 2.1: Gage set MON9D showing staff gage elevation overlap from the “A” gage nearest the channel to the “E” gage at the top of the bank; April 29, 2015

2.4 FIELD WORK DATES

Field work started on April 26 and concluded on May 29. Tundra travel remained open and Hägglund tracked vehicles were used to access most sites before May 7. On May 8, setup was nearly complete and crew members worked on transitioning equipment to the upcoming monitoring efforts and tracked the progression of breakup.

On May 12, 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 17 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 29.

3.0 BREAKUP OBSERVATIONS

3.1 SUMMARY OF EVENTS

On May 12, the leading edge of floodwater was located in the Anaktuvuk River, approximately 100 river miles (RM) upstream from the MON1 gages on the Colville River. On May 15, the leading edge of floodwater was observed in the Colville River, on the Umiat webcam, approximately 80 RM upstream of MON1. Initial low velocity breakup flow moved through the Nigliq Channel and East Channel on May 18 (Photo 3.1).

On May 19, a large ice jam formed in the Colville River between Ocean Point and the Itkillik River confluence (approximately 5 RM upstream from MON1) and a smaller ice jam formed in the Nigliq Channel near Nuiqsut. Flow was observed in the Sagoonang Channel near CD1. Flow from the Nigliq Channel entered Nanuq Lake and moved toward the large swale bridge on the CD2 road via Lake M9524.

The ice jam upstream of MON1 was still in place on May 20 and causing inundation of low lying areas. Minimal ice floes were observed upstream of the jam and the channel was mostly free of intact ice. The ice jam in the Nigliq Channel near Nuiqsut remained in place. This ice jam was diverting flow outside the main channel near the village (Photo 3.2). WSEs continued to rise throughout the delta and flow was observed at both swale bridges along the CD2 road.

On May 21, the ice jam upstream of MON1 released and a new ice jam formed in the East Channel at the Tamayayak bifurcation (Photo 3.3). Backwater from the East Channel ice jam inundated low lying areas and was diverted into the Nigliq Channel.

During the day, water levels increased near Alpine facilities as water was diverted from the East Channel



Photo 3.1: Initial floodwater in the East Channel at HDD and the Colville ice bridge crossing, looking southeast; May 18, 2015

overland through the lake basins between the Nigliq and Sakoonang channels. Extensive flooding occurred around the CD2 and CD4 roads and pads (Photo 3.4). At 7:00 PM, a high water mark was observed at MON1, indicating water levels were receding at the head of the delta.

On May 22, discharge was measured in the Nigliq Channel just upstream of the CD5 road crossing. In addition, scour depth measurements were collected at the base of the Nigliq Bridge piers. Discharge through the CD2 road Long Swale Bridge was also measured on May 22. In the lower delta, Helmerick's Island was mostly inundated (Photo 3.5).



Photo 3.2: Ice jam in the Nigliq Channel near the village of Nuiqsut, looking west; May 20, 2015

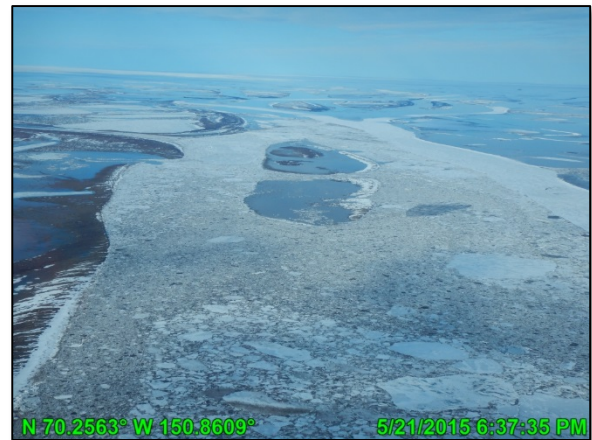


Photo 3.3: Ice jam in the East Channel extending from the Tamayayak bifurcation upstream to HDD, looking north; May 21, 2015



Photo 3.4: Extent of inundation near peak flooding around the CD2 road and pad, looking northwest; May 21, 2015



Photo 3.5: Lower delta showing Helmerick's Island mostly submerged, looking north; May 22, 2015

On May 23, most of the Alpine road drainage structures were still conveying relatively high flow. The majority of floating ice had cleared, reducing jam potential at drainage structures. Stranded ice was

observed on the overbanks throughout the delta indicating water levels were receding. Water levels began to equalize along the CD4 and CD2 roads. Floodwater had not subsided enough to be contained within the channels and lakes along the CD5 road.

Discharge measurements were performed at the Nigliagvik Bridge and the CD2 road Short Swale Bridge on May 23. Water levels continued to drop around facilities and throughout the delta. On May 24, the Short Swale Bridge and most culverts were no longer conveying flow. On May 25, discharge was measured in the Colville River at MON1 and at the Nigliq Bridge.

3.2 TIMING AND MAGNITUDE

Above average temperatures in the Brooks Range and the North Slope initiated spring breakup flooding in mid-May. The 2015 CRD spring breakup was a short duration, high magnitude event occurring earlier than average. The hydrograph recorded at the USGS gage at Umiat peaked at 59.9 feet on May 21; 59 feet is considered minimum flood stage at the Umiat gage (Figure 3.1). The confluences of the Chandler and Anaktuvuk rivers are downstream of Umiat and their contributions are not accounted for in the Umiat gage data.

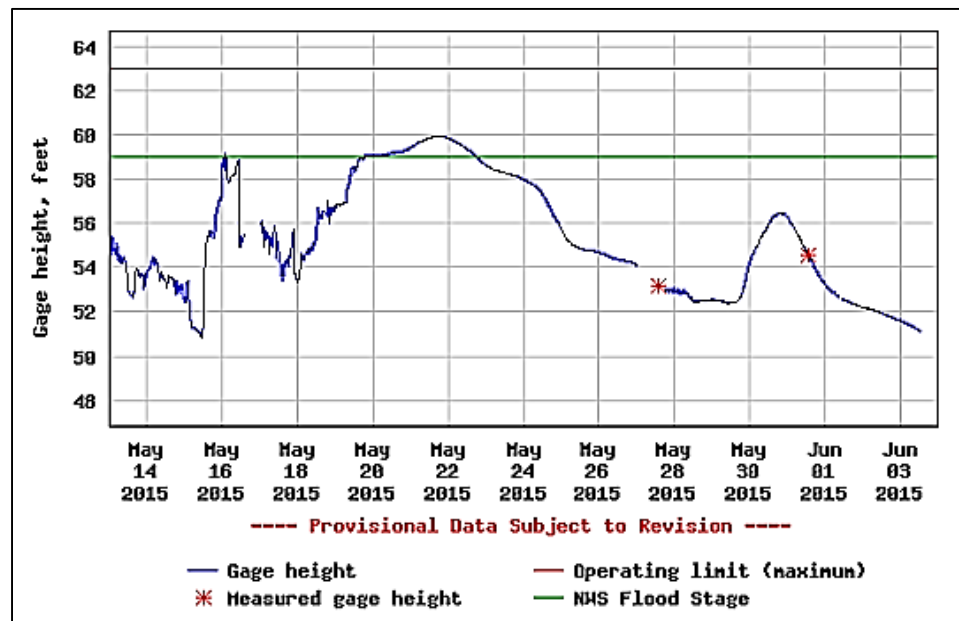


Figure 3.1: Colville River gage height at Umiat (USGS 2015)

Stage in the Colville River at the head of the delta, upstream of the Nigliq Channel bifurcation, increased rapidly on May 21 as a result of concurrent ice jams in the East Channel and Nigliq Channel. Based on preliminary staff gage observations, stage at MON1 peaked at 23.5 feet BPMSL on the evening of May 21 (Figure 3.2).

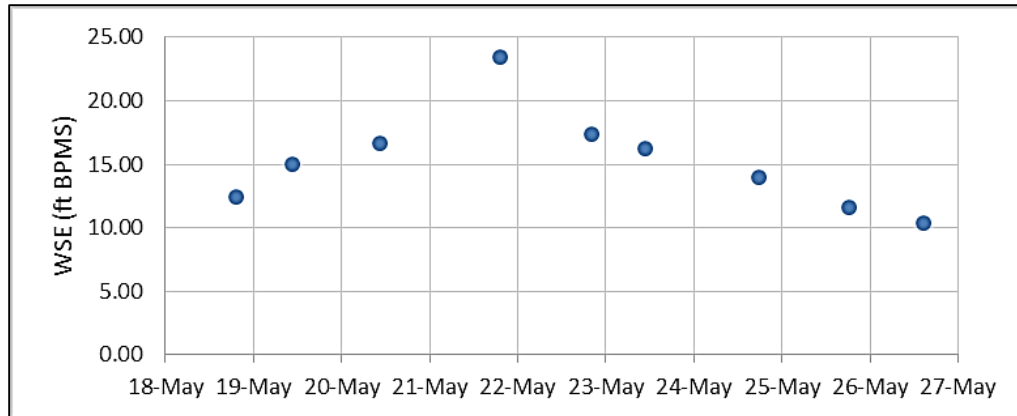


Figure 3.2: Preliminary WSEs at MON1 based on staff gage readings

4.0 ROADS AND FACILITIES OVERVIEW

High WSEs occurred around the CD2 and CD4 facilities as a result of concurrent ice jamming in the East Channel and the Nigliq Channel that forced floodwater overland and through the lake basins south of CD4 facilities. On the evening of May 21, floodwater overtopped the CD4 road at the south end of Lake L9323. Additionally, extensive overbank flooding was observed along the Alpine Pipeline from CD4 to the HDD crossing and at the HDD East pad. Overbank flooding was not as extensive at CD1 pad, CD3 pad, and the Sakoonang, Tamayayak, and Ulamnigiak pipeline crossings. The CD5 road bridges and culverts conveyed the large volume of flow that was forced into the Nigliq Channel. With exception of the CD4 road, no major erosion or scour was observed at the bridges, pads, or roads. Observed minor impacts around roads and facilities included:

- Ice ride-up on the west end side slope of the CD4 pad
- Redistribution of gravel fill at Nigliagvik Bridge East abutment. Gravel was removed from outside the southeast wing wall and deposited along sheet pile face under the bridge deck.
- Minor erosion on north side of CD2 road just east of the Long Swale Bridge resulting from the back eddy associated with sudden flow expansion at downstream side of bridge. Gravel was locally deposited as a minor outwash on north side of the CD2 Long Swale Bridge.
- Tension cracks and small cavities identified in CD2 Long Swale Bridge sheet pile backfill and along the cable tied concrete block mattress

5.0 REFERENCES

Michael Baker Jr., Inc. (Michael Baker). 2014. 2014 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment. Prepared for ConocoPhillips Alaska, Inc.

United States Geological Survey (USGS). 2015. Gage height data, May 13 through June 3, 2015. Accessed online at <http://waterdata.usgs.gov> on June 5, 2015