2013 Fish Creek Basin Spring Breakup Monitoring and Hydrologic Assessment

Submitted by:

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ACRONYMS AND ABBREVIATIONS

Baker	Michael Baker Jr., Inc.
BPMSL	British Petroleum Mean Sea Level
CD	Colville Delta
cfs	Cubic feet per second
CMS	Clover Material Source
CPAI	ConocoPhillips Inc., Alaska
CRD	Colville River Delta
FCB	Fish Creek Basin
GMT	Greater Moose's Tooth
HWM	High water mark
LCMF	UMIAQ, LLC
NAD83	North American Datum of 1983
PND	PND Engineers, Inc.
PT	Pressure transducer
RM	River miles
USGS	U.S. Geological Survey
WSE	Water Surface Elevation

1. INTRODUCTION

The 2013 Fish Creek Basin (FCB) Spring Breakup Monitoring and Hydrologic Assessment supports the Alpine Satellite Development Project. Michael Baker Jr., Inc. (Baker) conducted monitoring at 18 sites within the eastern portion of the FCB in the National Petroleum Reserve-Alaska for ConocoPhillips Inc., Alaska (CPAI). Results of the 2013 spring breakup monitoring activities and historical trends are presented in this report.

The Alpine facilities are owned by CPAI, in conjunction with Anadarko Petroleum Company, and are operated by CPAI. Alpine facilities refers to existing facilities, including the Colville Delta (CD) 1 processing facility (Alpine); CD2, CD3, and CD4 drilling pads; access roads; and associated pipelines.

Many areas on the North Slope of Alaska, including the Colville River Delta (CRD) and the FCB, share similar hydrologic and hydraulic characteristics common to the arctic climate and to the presence of continuous permafrost. Shallow groundwater is generally restricted to isolated zones beneath deep lakes and river channels. Groundwater influx is largely nonexistent.

Spring breakup is typically the largest annual flow or discharge event in this region of the North Slope. Monitoring of this event is integral to understanding the regional hydrology and maintaining the continued safety of the environment, oil field personnel, and facilities. Flow generally declines over the summer months, with occasional increases resulting from precipitation events. Flow is typically present year-round in the major streams in the FCB. For much of the year, little to no flow is present in many small streams and tributaries in the FCB, and most freeze to the bottom in winter.

Preliminary hydrologic and hydraulic assessments were conducted in the FCB between 2001 and 2003. Spring breakup monitoring in the FCB was conducted annually from 2003 to 2006, and then again in 2009. During the 2010, 2011, and 2013 spring breakup events, a smaller scale field program was conducted at key locations along the proposed road corridors.

This report is organized as outlined below.

- **Section 1 –** Introduction: Discusses the objectives of the monitoring program and outlines the 2013 monitoring locations.
- **Section 2 –** Methods: Describes the methods of the fieldwork and the data analyses.
- **Section 3 –** 2013 Spring Breakup Monitoring and Analysis: Presents the 2013 hydrologic observations and stage (or water surface elevation [WSE]) in the FCB and indirect discharge results for the assessment.
- **Section 4 –**2013 Results and Historical Data: Presents the results of the 2013 Spring Breakup Monitoring event with historical data.
- **Section 5 –** References: Contains the references used in the development of this report.

- **Appendix A –** 2013 Fish Creek Basin and Gage Locations: Includes survey control for monitoring gages and the geographic locations for gages and control.

UMIAQ, LLC (LCMF), the environmental coordinators, and Bristow Helicopters provided support during the 2013 FCB spring breakup field work and contributed to a safe and productive monitoring season.

1.1 MONITORING OBJECTIVES

The primary objectives of the 2013 FCB spring breakup program were monitoring and estimating the magnitude of breakup flooding at select locations in the FCB. The objective was accomplished by visually observing breakup events and floodwater distribution, and measuring water levels at specific drainages. Information obtained by this monitoring program will be instrumental in obtaining future permits and designing future facilities.

1.2 2013 MONITORING LOCATIONS

Selection of monitoring locations was based on aerial imagery and topography in relation to historic hydrologic and hydraulic observations in the region and proximity of proposed facilities to relevant terrain features. Monitoring locations in the FCB include sites in the Ublutuoch River, the Clover Material Source (CMS) area, the Greater Moose's Tooth (GMT) area, and small stream tributaries.

The 2013 FCB spring breakup monitoring program included the following 18 sites:

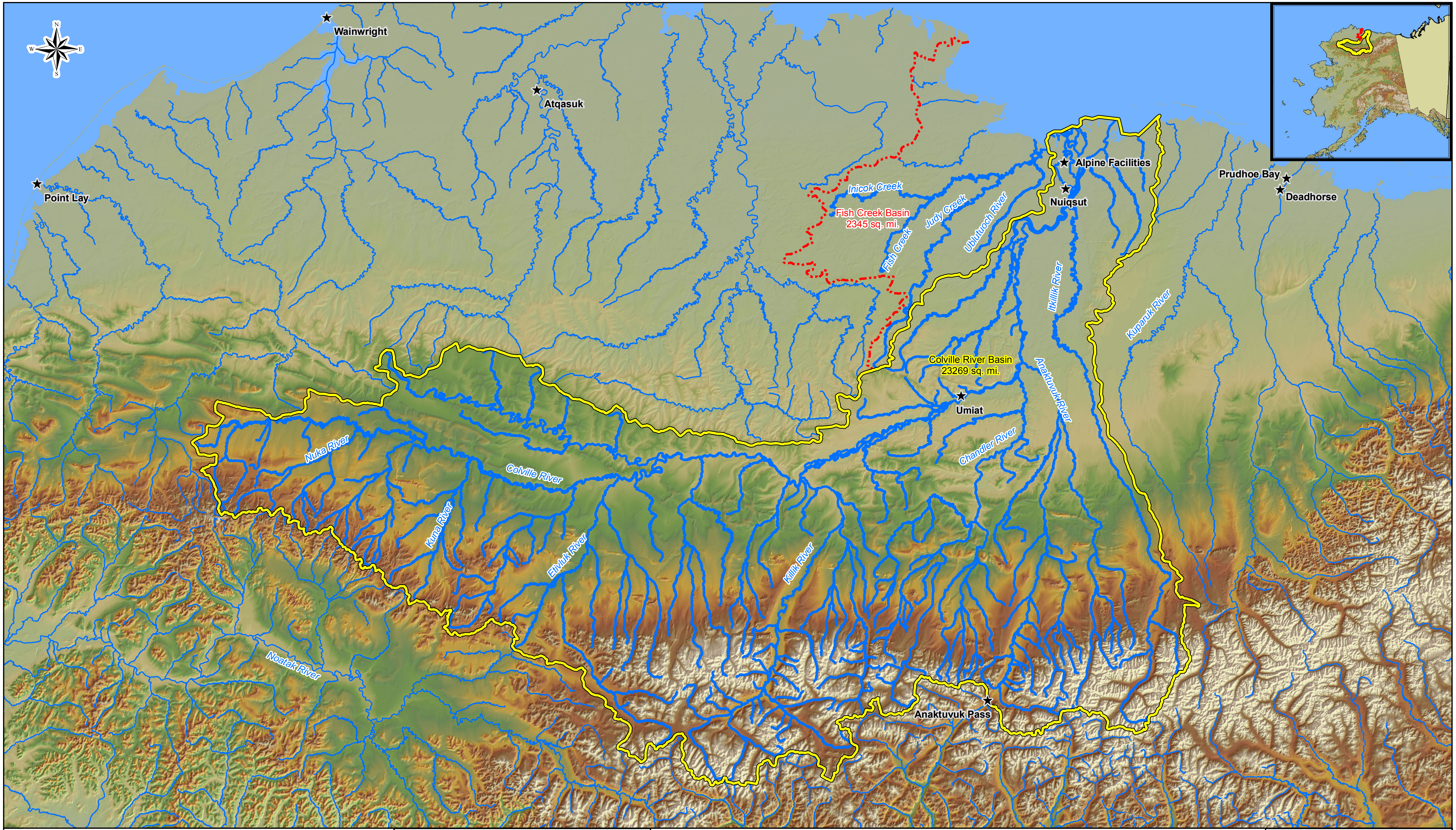
- Three sites at the Clover B CMS drainage (Clover B1, Clover B2, and Clover B3)
- Two sites at the Clover C CMS drainage (Clover C1 and Clover C2)
- Two Ublutuoch River locations near the CMS drainages' confluences at the proposed CMS area (UB11.45, and UB11.6)
- Three Ublutuoch River locations at the proposed GMT1 road crossing (UB6.7, UB6.8, and UB6.9)
- Seven small stream crossings along the GMT1 access road corridor (S1, S2, S3, S4, S5, S6, and S7)
- One small drainage in the proximity of proposed GMT2 pad (GMT2)

Observations and measurements were recorded at all locations except sites S1, S2, S3, S7, and GMT2 which were monitored by helicopter.

Gaging and monitoring sites are listed in Table 1.1. Figure 1.1 shows the CRD and Fish Creek basins drainage delineations. Figure 1.2 shows the location of the proposed GMT1 and GMT2 pads and access road corridor in relation to the CRD and other proposed and existing Alpine facilities. Figure 1.3 shows the 2013 FCB monitoring locations. Geographic references for all locations are provided in Appendix A.

Table 1.1: 2013 Fish Creek Basing Monitoring Locations

Monitoring Site		Gages
CMS Drainages and Ublutuoch River 11.45 and 11.6	Clover B1	Clover B1-A
	Clover B2	Clover B2-A
	Clover B3	Clover B3-A
	Clover C1	Clover C1-A
	Clover C2	Clover C2-A
	Ublutuoch 11.45	UB11.45-A
		UB11.45-B
		UB11.45-C
		UB11.45-D
		UB11.45-Z
	Ublutuoch 11.6	UB11.6-A
		UB11.6-B
		UB11.6-C
		UB11.6-D
		UB11.6-E
GMT1 Road Corridor	Ublutuoch 6.7	UB6.7-A
		UB6.7-B
		UB6.7-C
		UB6.7-D
	Ublutuoch 6.8	UB6.8-A
		UB6.8-B
		UB6.8-C
		UB6.8-D
	Ublutuoch 6.9	UB6.9-A
		UB6.9-B
		UB6.9-C
	S1	S1-A
	S2	S2-A
	S3	S3-A
	S4	S4-A (Downstream)
		S4-B (Centerline)
		S4-C (Upstream)
	S5	S5-A (Downstream)
		S5-B (Centerline)
		S5-C (Downstream)
	S6	S6-C
	S7	S7-A
GMT2 Road Corridor	GMT2	GMT2-A
Total Number of Gages		**38**



ConocoPhillips
Alaska

Date:	11/15/2013	Project:	135006
Drawn:	BTG	File:	Figure 1.1
Checked:	SME/DCL	Scale:	1 in = 25 miles

Legend

★ Place Name
Stream
Fish Creek Basin
Colville River Basin

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Fish Creek Basin &

Colville River Basin

Delineations

FIGURE: 1.1

(SHEET 1 of 1)

ConocoPhillips Alaska

0 1 2 4 Miles

Date:	11/15/2013	Project:	135006
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Legend

- Existing Road
- Proposed Road
- Alpine Sales Pipeline
- NPRA Boundary
- Mine Source
- Existing Facility
- Proposed Facility

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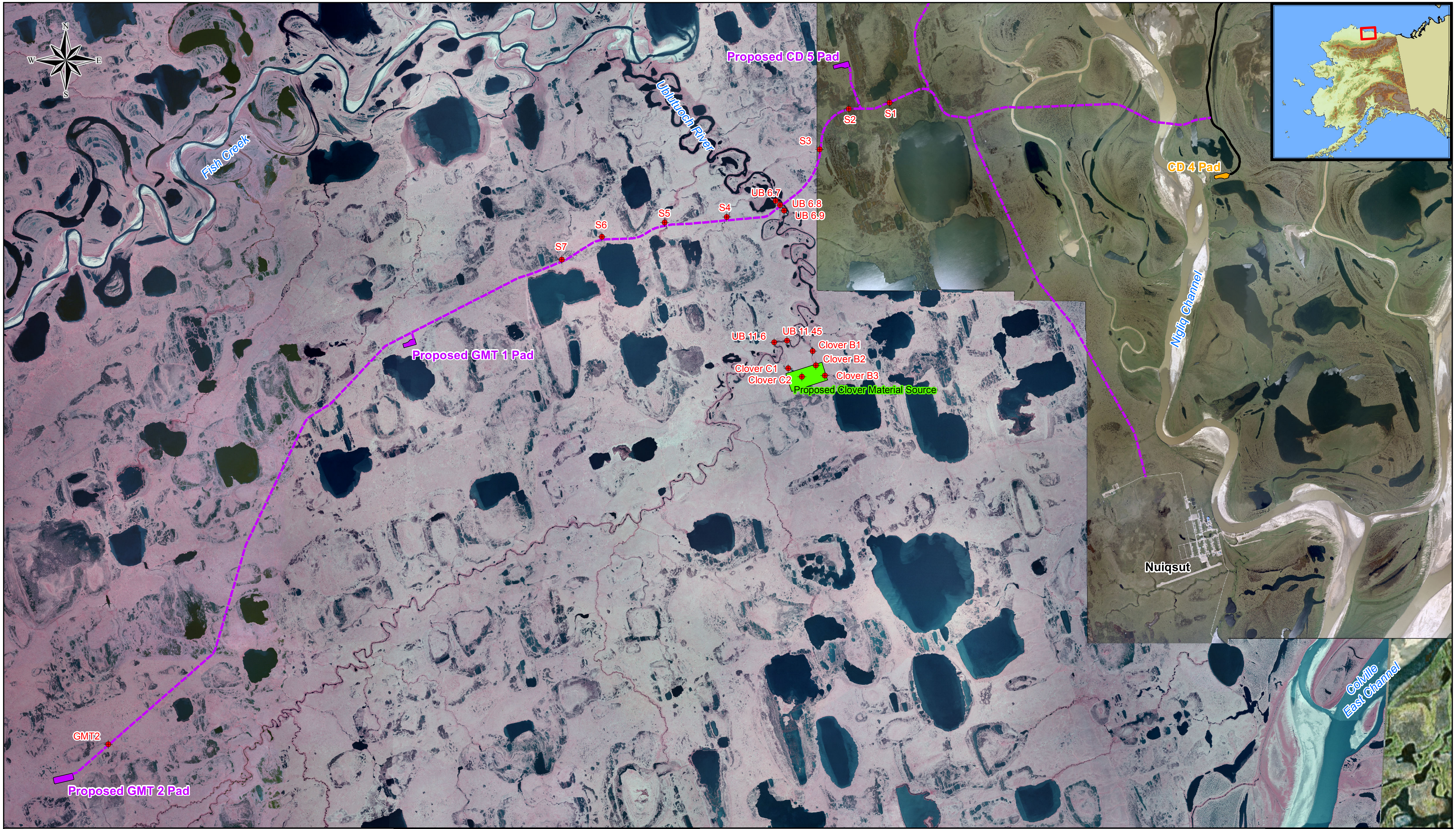
2013 Existing &

Proposed Facilities

CRD & FCB

FIGURE: 1.2

(SHEET 1 of 1)



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Checked: SME/DCL	Scale: 1 in = 1.25 miles		

Legend

- Gage Location
- Existing Road
- Proposed Road
- Material Source
- Existing Facility
- Proposed Facility

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2013 FCB Breakup

Monitoring Locations

FIGURE: 1.3

(SHEET 1 of 1)

2. METHODS

The field program consists of setup and monitoring activities. Prior to breakup, field crews rehabilitate existing gages, install new gages, and survey gages to tie into a control elevation. Monitoring activities include recording stage at gage sites and documenting observations of floodwater flow, distribution, and ice conditions. CPAI contracted Bristow Helicopters to provide helicopter support to access all sites.

The following field methodologies are proven to be safe, efficient, and accurate for the conditions encountered on the North Slope of Alaska during spring breakup. Data collection is affected by conditions related to safety, weather, and logistics.

2.1 USEVISUAL OBSERVATIONS

Field data collection and observations were recorded in field notebooks. Digital cameras with integrated global positioning systems were used for photographic documentation of spring breakup conditions. The geographic position of the camera in latitude and longitude, date, and time were automatically imprinted onto each photo. Photo location is based on the World Geodetic System of 1984 datum.

2.2 WATER SURFACE ELEVATION

Stage or WSE data was obtained from hydrologic gage readings and pressure transducer (PT) data. All monitoring sites had staff gages installed. Site visits were performed as conditions allowed. WSE data was taken at the following sites during spring breakup: Clover B1, Clover B2, Clover B3, Clover C1, Clover C2, UB6.7, UB6.8, UB6.9, UB11.45, UB11.6, and S4, S5, and S6. Photo 2.1 shows WSE data collection at UB11.45.

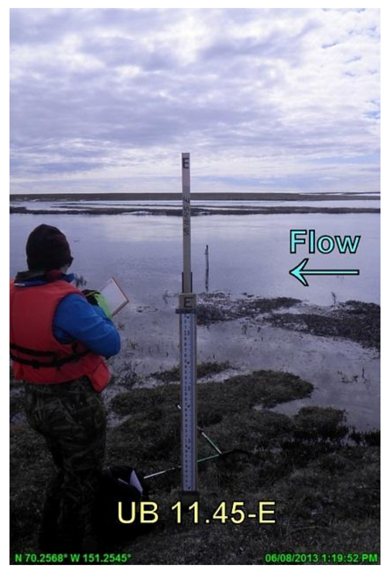


Photo 2.1: WSE reading at UB11.45, looking northeast; June 8, 2013

2.3 STAFF GAGES

Temporary staff gages consisted of one to five gage assemblies per site. Each gage assembly contained a metal gage faceplate mounted on a two-by-four timber attached with U-bolts to a 6-foot long 1.5-inch angle iron post driven approximately 2 feet into the ground. The horizontal position of each gage was recorded using a handheld Garmin Rino 530HCx in North American Datum of 1983 (NAD 83) with wide area augmentation system enabled allowing for 1 meter (3 feet) horizontal accuracy.

Where survey control is established, the elevation of each gage was surveyed from a local benchmark tied to British Petroleum Mean Sea Level (BPMSL) using standard level loop techniques. Where survey control is not established, local control elevations were assumed. The assumed elevations may be adjusted to other monitoring locations and to BPMSL in the future. The basis of elevation for each monitoring location and the horizontal position of respective benchmarks and gages are presented in Appendix A.

Photo 2.2: Gages at UB6.7, looking northeast; May 30, 2013

Gages were named based on the site location identification and their proximity to the channel. Locations are identified in river miles (RM) with RM 0 indicating the terminus of the river. The terminus is where smaller stream channels converge with larger channels or other water bodies. The terminus for the Ublutuoch River is at Fish Creek. From the terminus at Fish Creek, the RM increases upstream, in the southern direction.

At UB6.7, UB6.8, UB6.9, UB11.45, and UB11.6, where the stream bank elevation varied by more than three vertical feet or at locations where gages are typically damaged by ice, multiple gages were installed. At each site, gages are identified with alphabetical designations A, B, C, D, or E, with gage A being closest to the water's edge. Gages were installed with an overlap in coverage of vertical elevation. The overlapping vertical coverage provides for redundancy with WSE readings and acts as a backup if a gage is lost due to an ice floe or the stream becomes unsafe to wade. Photo 2.2 shows the array of gages at UB6.7 with gage A closest to the water's edge.

At Clover B1, Clover B2, Clover B3, Clover C1, and Clover C2 each site is represented by a single gage A.

At small stream monitoring sites S4 and S5, gages are labeled progressing upstream, with gage A downstream, gage B in the center, and gage C upstream.

2.4 PRESSURE TRANSDUCERS

PTs measure the absolute pressure of the atmosphere and water allowing the depth of water above the sensor to be calculated. The resulting data yields a comprehensive record of the fluctuations in stage. Each PT consists of an unvented pressure sensor designed to collect and store pressure and temperature data at discrete pre-set intervals. For 2013, the PTs were programmed to collect gage pressure and water temperature at 15-minute intervals from May 30 to July 15, 2013. Photo 2.3 and Photo 2.4 show a PT being installed at Clover C1-A.

Solinst® Levelogger Model 3001 PTs were installed at nine gage sites: Clover B1, Clover B2, Clover C1, Clover C2, UB6.7, UB6.8, UB6.9, UB11.45, and UB11.6. The reported pressure datum is the sum of the forces imparted by the water column and atmospheric conditions. Variations in barometric pressure were taken into account using an independent barometric pressure logger: a Solinst® Barologger. A correction of local barometric pressure was obtained from the Barologger. The Barologger was placed on the UB6.8-D gage, and the recorded barometric pressure was considered representative for the FCB project area. See Appendix A for PT and barometric pressure logger basis of elevation and horizontal positions.

Before mobilization to the field, the PTs were each put through a functional test by Baker. The PTs were configured using Solinst Levelogger v3.4.1, and absolute pressure for each PT was set to zero prior to placement in the field. Each PT was housed in a segment of perforated galvanized steel pipe, clamped to angle iron or the base of a gage assembly, and placed in the active channel as near to the channel bottom as possible. The PT sensor was surveyed to establish a vertical datum using local control.

PT-based stage values were determined by adding the calculated water depth to the surveyed sensor elevation. A standard conversion using the density of water at 0 degrees Celsius was used to calculate all water depths from adjusted gage pressure. Fluctuations in water temperature during the sampling period did not affect WSE calculations because of the limited range in temperature and observed water depths. PT readings have the potential to drift overtime affecting the accuracy of the recorded water level. Gage WSE readings were used to validate and adjust the data recorded by the PTs. PT data recorded after the final gage WSE cannot be validated; therefore PT data was only reported up to the date of the final gage WSE reading.

Photo 2.3: Installing a PT at Clover C1, looking northeast; June 1, 2013

Photo 2.4: Securing PT at Clover C1, looking northeast; June 1, 2013

2.5 DISCHARGE

Discharge was calculated indirectly based on field observations. Indirect discharge calculations assume open-channel conditions and stable channel geometry. Under open water conditions, the peak discharge occurs close to the timing of peak stage.

Generally, channels within the FCB broaden over the course of breakup from the melting of ice and snow, although snow dams and ice jams may form from the various floes and debris within the channel. Perpetual snow and ice induced changes to a channel's physical geometry can affect its ability to convey flow. As a result, an open channel analyses, free from snow and ice, may not accurately represent conditions during peak stage.

Indirect calculations of peak discharge were performed on the Ublutuoch River at UB6.8 and at S4, and S5 using the slope-area method for a uniform channel (Benson and Dalrymple 1967). WSE and slope data were obtained from observations made at gages during various stages of breakup. Cross-section geometry for UB6.8, S4, and S5 were based on channel profile measurements completed by Baker in 2010.

2.6 FLOOD AND STAGE FREQUENCY ANALYISIS

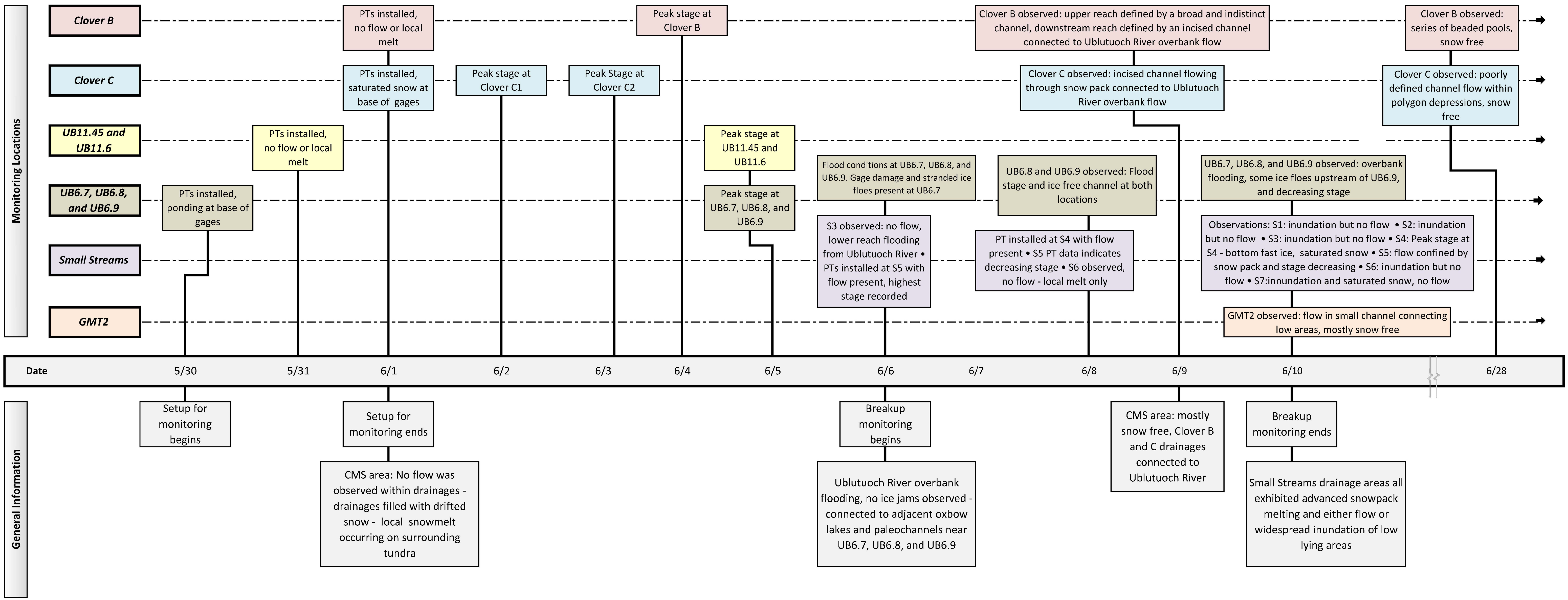
Flood and stage frequency analyses were last performed at UB6.8, S4, and S5 in 2009 (Baker 2009). Flood and stage frequency analyses are updated after every three seasons of data collection. Data for fewer than three years would likely not yield a significant change in the current recurrence interval values. FCB was not monitored in 2012; therefore 2013 is the third year of data since 2009. The 2013 discharge and stage data for UB6.8, S4, and S5, where included into the flood and stage frequency analysis.

3. 2013 SPRING BREAKUP MONITORING AND ANALYSIS

This section presents the images, data, observations, and analyses for the 2013 FCB spring breakup monitoring and hydrologic assessment. Hydrologic data and observations were documented between May 30 and June 10, 2013. On June 28 PTs were collected and post-breakup observations were documented.

Setup of the FCB was conducted between May 30 and June 1. Crews observed the degradation of snow and signs of local melt on May 31. Monitoring activities were limited in FCB because of simultaneous breakup monitoring in the CRD. Helicopter flights into the FCB were scheduled as time allowed. Observations of the FCB started on June 6 when field crews observed signs of breakup flow along the proposed GMT1 road corridor and in the vicinity of the CMS. A hydrologic timeline of spring breakup in the FCB is presented in Figure 3.1.

2013 Fish Creek Basin Spring Breakup Hydrologic Timeline



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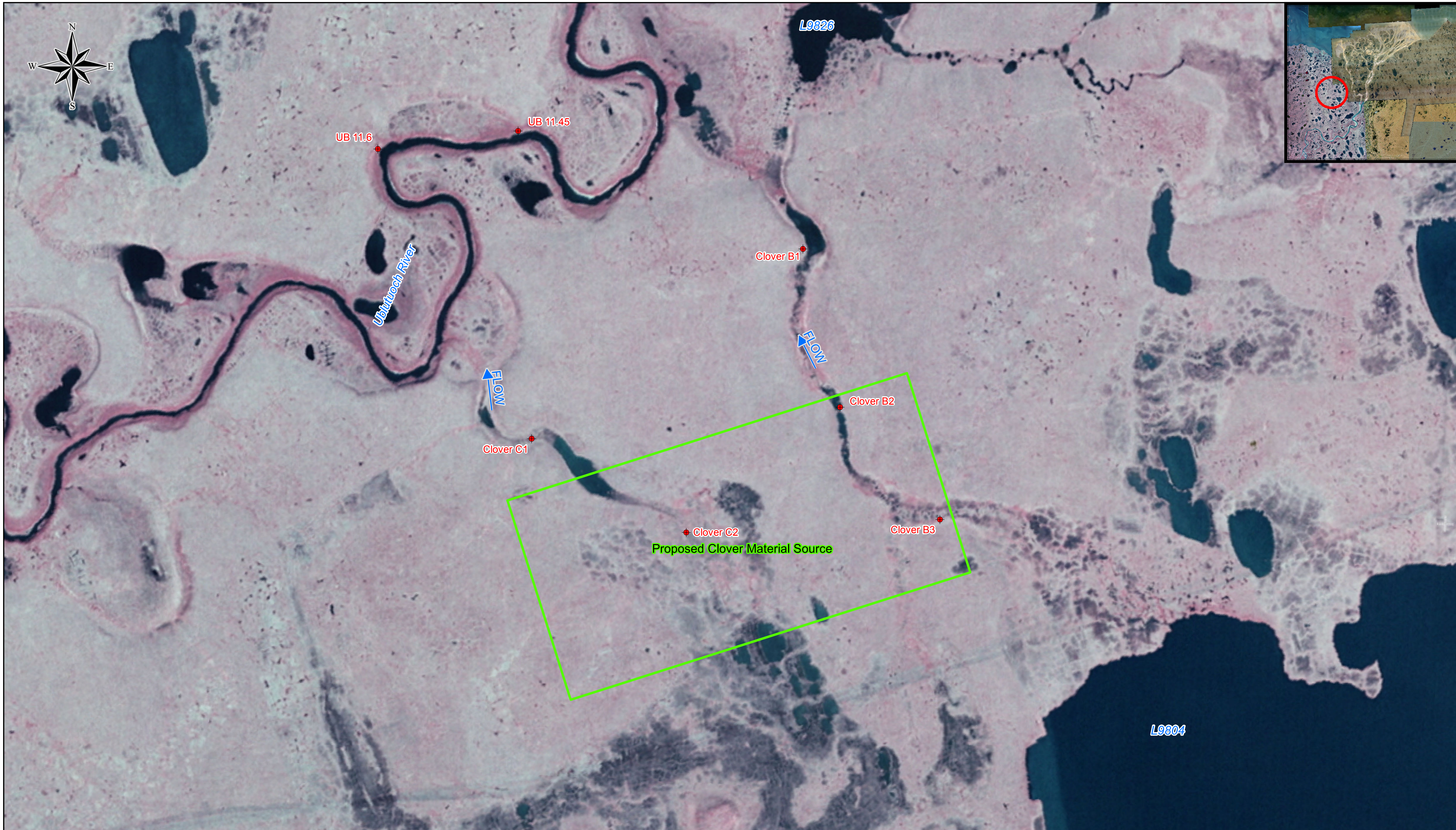
2013 FISH CREEK BASIN
SPRING BREAKUP
HYDROLOGIC TIMELINE
FIGURE: 3.1
(SHEET 1 of 1)

3.1 CLOVER MATERIAL SOURCE

Five CMS sites and two sites on the Ublutuoch River near the CMS were monitored in 2013. The five CMS sites were selected as representative of the two drainages, identified as Clover B and Clover C, running through the material source area. The two Ublutuoch River sites, UB11.45 and UB11.6, were selected because of their proximity to the CMS drainages and channel geometry. These two sites represent the limits of the most confined reach of the Ublutuoch River adjacent to the CMS drainages.

The proposed CMS area is located 2.3 miles south of the UB6.8 gage location. The area is roughly bounded on the north by the Ublutuoch River and on the west, east, and south by perennial and ephemeral drainage channels. All CMS gage locations were established based on topography, aerial imagery, and past breakup observations. Figure 3.2 shows a detail of the 2013 FCB breakup CMS monitoring locations and their proximity to the Ublutuoch River and the CMS boundary.



ConocoPhillips Alaska

Feet
0 300 600 1,200

Date:	11/15/2013	Project:	135006
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Checked:	SME/DCL	Scale:	1 in = 600 feet

Legend
Gage Location
Material Source

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2013 FCB Breakup

Clover Material Source Plan

FIGURE: 3.2

(SHEET 1 of 1)

3.1.1 CLOVER B GAGES

FCB monitoring sites Clover B1, B2, and B3 are located within the same unnamed beaded stream, identified for the purposes of this monitoring report as Clover B. Clover B flows north through the eastern portion of the proposed CMS. This drainage lies 0.25 miles upstream of Lake L9826, and 0.25 miles east-southeast from the nearest reach of the Ublutuoch River. The channel is well-defined during breakup. Generally this drainage empties into Lake L9826, although during periods of higher flow, overland flow to the Ublutuoch through a secondary drainage may occur. Tussocks and native grasses cover both overbanks, with dwarf willows and native grass in the channel. The confluence with the Ublutuoch River lies approximately 0.2 miles downstream from the Clover B1 gage location, at Ublutuoch RM 11.1.

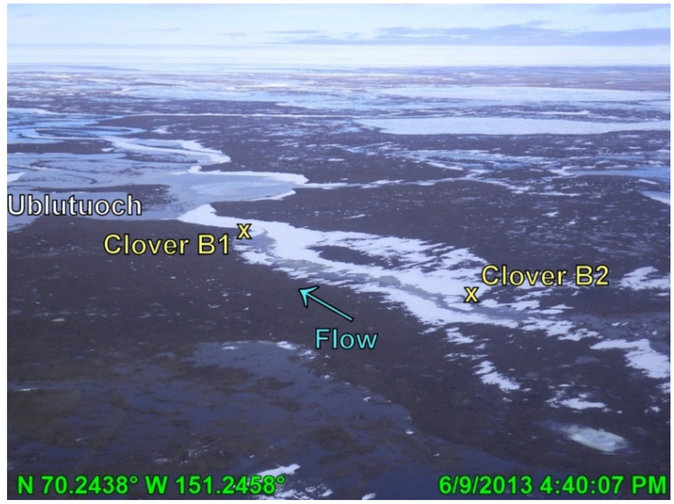


Photo 3.1: Flow over saturated snow within the Clover B drainage, looking northwest; June 9, 2013

Clover B1, B2, and B3 are placed within the main channel of the drainage. The Clover B2 gage is located approximately 1,000 feet upstream of the Clover B1 gages and 1,000 feet downstream of the Clover B3 gage. Clover B2 lies on the northern edge of the CMS boundary. The Clover B3 gage lies on the southeastern edge of the CMS boundary.

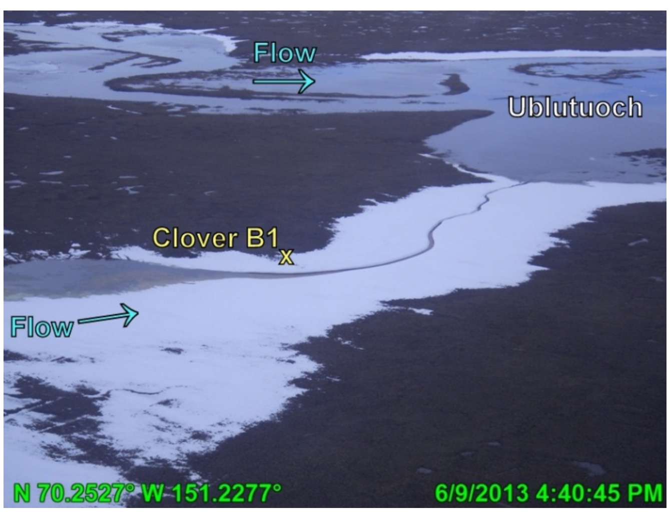


Photo 3.2: Deeply incised channel flowing through drifted snow from Clover B drainage into Ublutuoch River overbank flow , looking west; June 9,2013

1) SPRING BREAKUP OBSERVATIONS

PTs were installed at the Clover B1 and B2 gages on June 1. No flow was observed in the drainage at the time of PT installation. Drifted snow was present in the drainage, and the surrounding tundra was partially free of snow.

On the morning of June 4, PT data captured peak WSEs of 44.17 feet and 45.56 feet at Clover B1 and B2, respectively (referenced to assumed elevations at local control [Table 3.1 and Graph 3.1]).

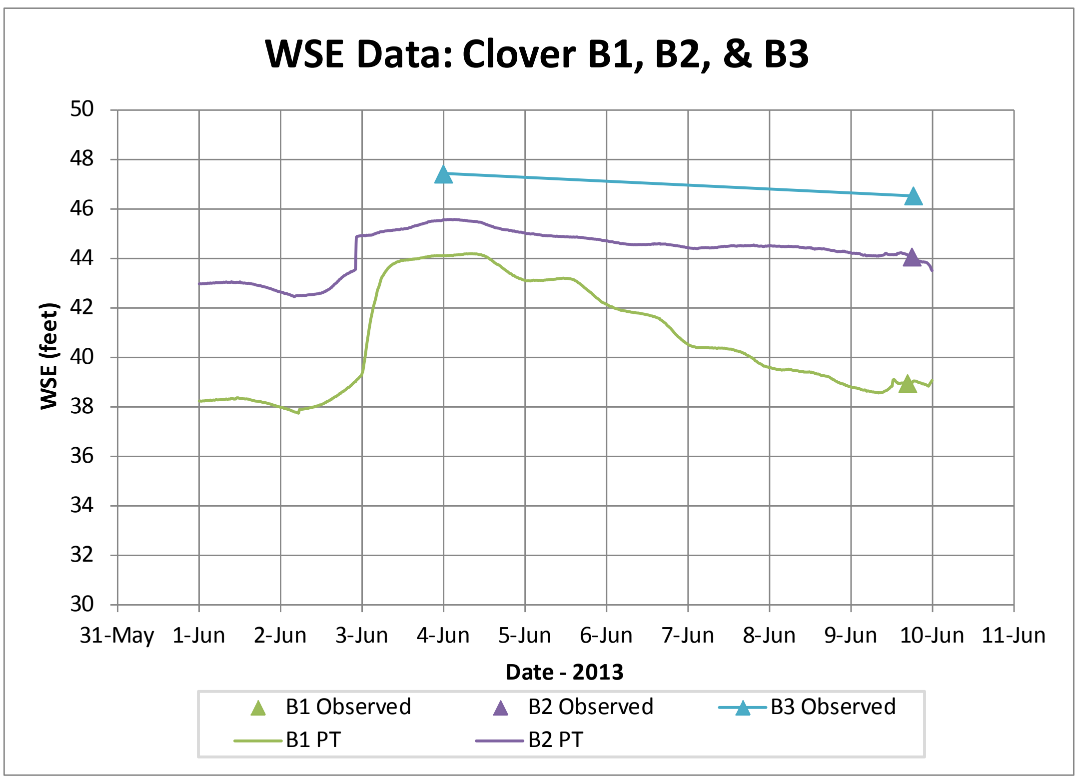
On June 9, local melt was present in surrounding tundra polygons and low lying areas. The surrounding tundra was mostly snow free. Drifted snow was still present within the drainage. The upstream reach of the drainage by Clover B2 and B3 was characterized by a broad and indistinct channel flowing over saturated snow pack connecting with overbank flow from the Ublutuoch River (Photo 3.2). A high water mark (HWM) of 47.42 feet was observed at Clover B3 and likely occurred on the morning of June 4 coinciding with the peak WSEs at Clover B1 and B2.

On June 28, no snow was present within the Clover B drainage. The drainage channel was characterized by a series of beaded pools hydraulically connected by low velocity flow over shallow grassy areas.

Table 3.1: 2013 Stage Data for B1, B2, & B3 (Clover B Gages)

Date and Time	WSE (feet)			Observations
	Clover B1	Clover B2	Clover B3	
6/4/13 1:45 AM	-	45.56	-	Peak stage at Clover B2 - based on PT data
6/4/13 8:00 AM	44.17	-	-	Peak stage at Clover B1 - based on PT data
6/4/13 12:00 AM	-	-	47.42	HWM - assumed date and time
6/9/13 4:45 PM	38.93	-	-	
6/9/13 5:45 PM	-	44.02	-	
6/9/13 6:23 PM	-	-	46.51	

Notes:
1. Elevations based on MEG at 46.984 feet, BAKER CP 3 at 48.000 feet, and CLARK at 47.293 feet, established by Baker in 2010 using a handheld Garmin Rino 520HCx GPS
2. Elevations not referenced to BPMSL



Graph 3.1: 2013 Stage Data for B1, B2, & B3 (Clover B Gages)

3.1.2 CLOVER C GAGES

Clover C1 and C2 are located within the same unnamed stream identified as Clover C for the purposes of this monitoring report. Clover C flows north through the western portion of the proposed CMS and lies 0.17 miles upstream of the Ublutuoch River. Tussocks and native grasses cover both overbanks, with native grass in the channel. The Ublutuoch River confluence lies 0.2 miles downstream from the Clover C1 gage location, at Ublutuoch RM 11.9.

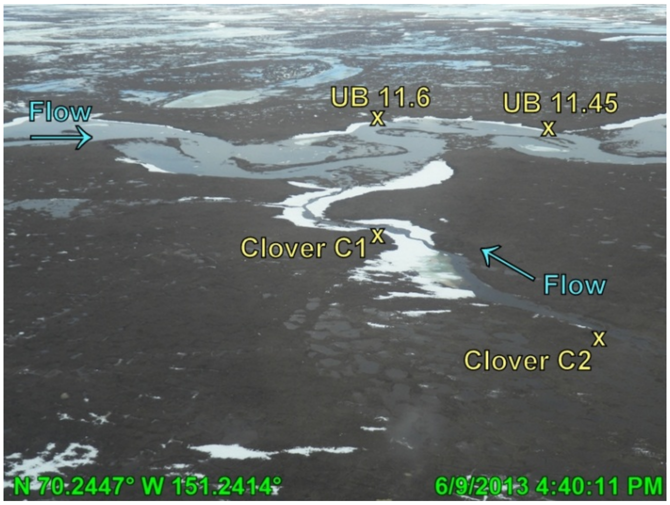


Photo 3.3: Moderately incised channel flowing through drifted snow from the Clover C drainage into the Ublutuoch River, looking northwest; June 9, 2013

The Clover C1 gage is located farthest downstream, approximately 350 feet northwest and outside of the proposed CMS boundary. The Clover C2 gage is located approximately 1,300 feet upstream of the Clover C1 gage. Clover C2 lies approximately 650 feet south of the northwestern limit of the CMS boundary.

1) Spring Breakup Observations

PTs were installed at the Clover C1 and C2 gages on June 1. The snow was saturated at the base of the gages; however, no flow was observed in the drainage at the time of PT installation. Drifted snow was present in the drainage, and the surrounding tundra was predominantly free of snow.

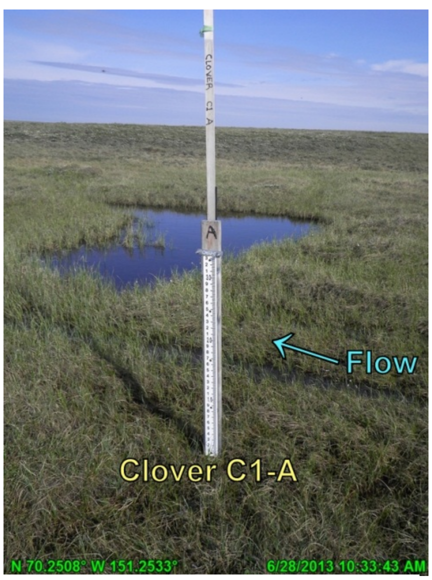


Photo 3.4: Clover C1 gage showing snow-free drainage and flow within polygon cracks, looking north; June 28, 2013

On the evening of June 2, PT data captured peak WSE of 32.65 feet at Clover C1 (referenced to assumed elevations at local control [Table 3.2 and Graph 3.2]). On the evening of June 3, PT data captured peak WSE of 35.87 feet at Clover C2 and was referenced to assumed elevations at local control.

On June 9, the Clover C area was mostly snow-free with local melt present in surrounding tundra polygons. Drifted snow was still present within the downstream reach of the drainage near Clover C1. A moderately incised channel was flowing through the drifted snow pack and connected to overbank flow from the main channel of the Ublutuoch River (Photo 3.3).

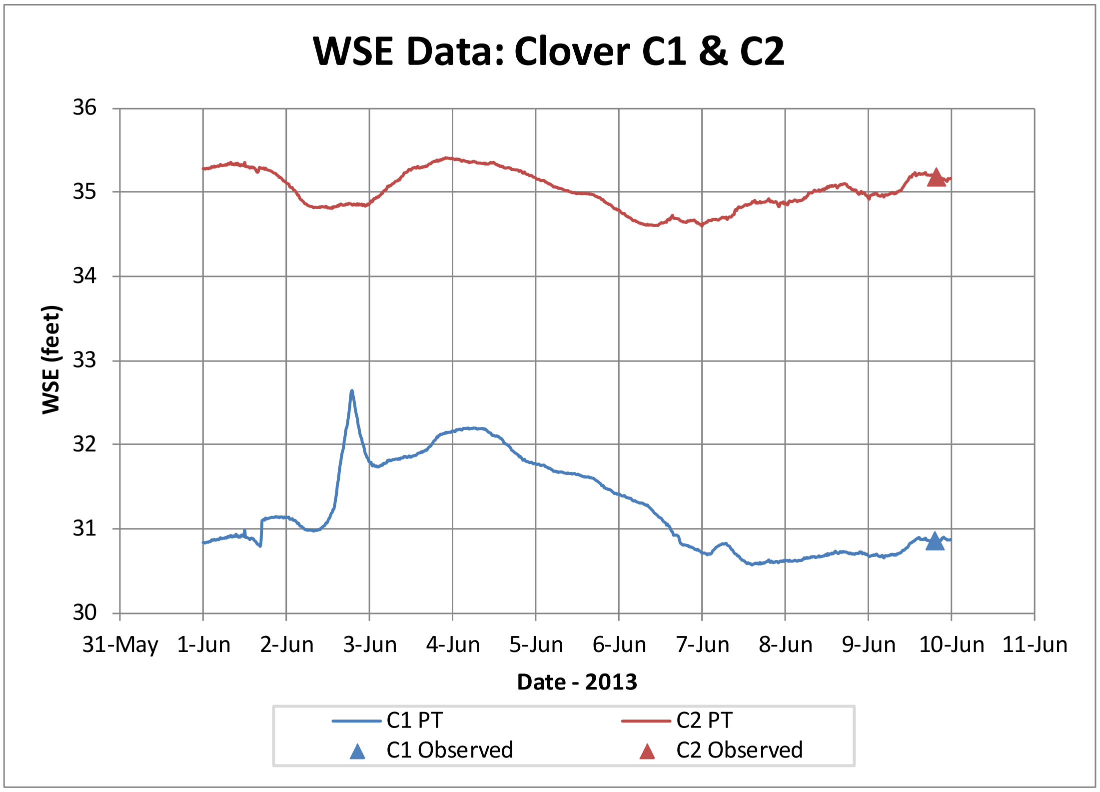
On June 28, no snow was present during observations within the Clover C drainage. The drainage channel was characterized by a poorly defined channel with low topographical relief. Flow was contained within polygon depressions (Photo 3.4).

Table 3.2: 2013 Stage Data for C1 and C2 (Clover C Gages)

Date and Time	WSE (feet)		Observations
	Clover C1	Clover C2	
6/2/13 7:00 PM	32.65	-	Peak stage at Clover C1 - based on PT data
6/3/13 10:00 PM	-	35.87	Peak stage at Clover C2 - based on PT data
6/9/13 7:21 PM	30.86	-	
6/9/13 7:31 PM	-	35.19	

Note:

1. Elevations based on EICKELMAN at 36.542 feet, BAKER CP 2 at 35.000 feet, and SHOCKER at 36.216 feet, established by Baker in 2010 using a handheld Garmin Rino 520HCx GPS
2. Elevations not referenced to BPMSL



Graph 3.2: 2013 Stage Data for C1 and C2 (Clover C Gages)

3.1.3 UBLUTUOCH RIVER 11.45 & 11.6

The Ublutuoch River monitoring sites, UB11.45 and UB11.6, are each comprised of five gages installed on the west bank of the river, as shown in Figure 3.2. UB11.45 and UB11.6 designations refer to the distance in RM from the confluence of the Ublutuoch River with Fish Creek. The gage locations were selected to monitor and document local breakup conditions near the drainages of the CMS site. The Clover C stream drains into the Ublutuoch River upstream of UB11.6 at RM 11.9 and the Clover B stream drains downstream of UB11.45 at RM 11.1.

Photo 3.5: Drifted snow in the main channel of the Ublutuoch River near UB11.45 and UB11.6, looking northeast; June 1, 2013

1) SPRING BREAKUP OBSERVATIONS

PTs were installed at the UB11.45 and UB11.6 gages on May 31. No flow or local melt was observed in the drainage at the time of installation. The drainage had deep drifted snow accumulation, and the surrounding tundra was mostly snow-free. Ponded water was observed on the fringe of nearby lakes.

Photo 3.6: Breakup conditions near UB11.6 showing overbank flooding, looking northeast; June 6, 2013

On June 1, local melt was present within polygon depressions on the surrounding tundra. The Ublutuoch River was still full of drifted snow, and no flow was observed in the main channel (Photo 3.5).

On the morning of June 5, PT data captured peak WSEs of 99.40 feet and 99.63 feet at UB11.45 and UB11.6 respectively and was referenced to assumed elevations at local control (Table 3.3 and Graph 3.3).

Photo 3.7: Stranded ice floes at UB11.45, looking south; June 6, 2013

On June 6, flooding conditions were observed at the UB11.45 and UB11.6 gage locations. The surrounding tundra was mostly snow-free. Open water and overbank flooding was observed on the Ublutuoch River main channel (Photo 3.6). Stranded ice floes were present on the banks of UB11.45 indicating water levels had peaked (Photo 3.7). No ice jams were observed in the vicinity of the UB11.45-UB11.6 reach during spring breakup 2013.

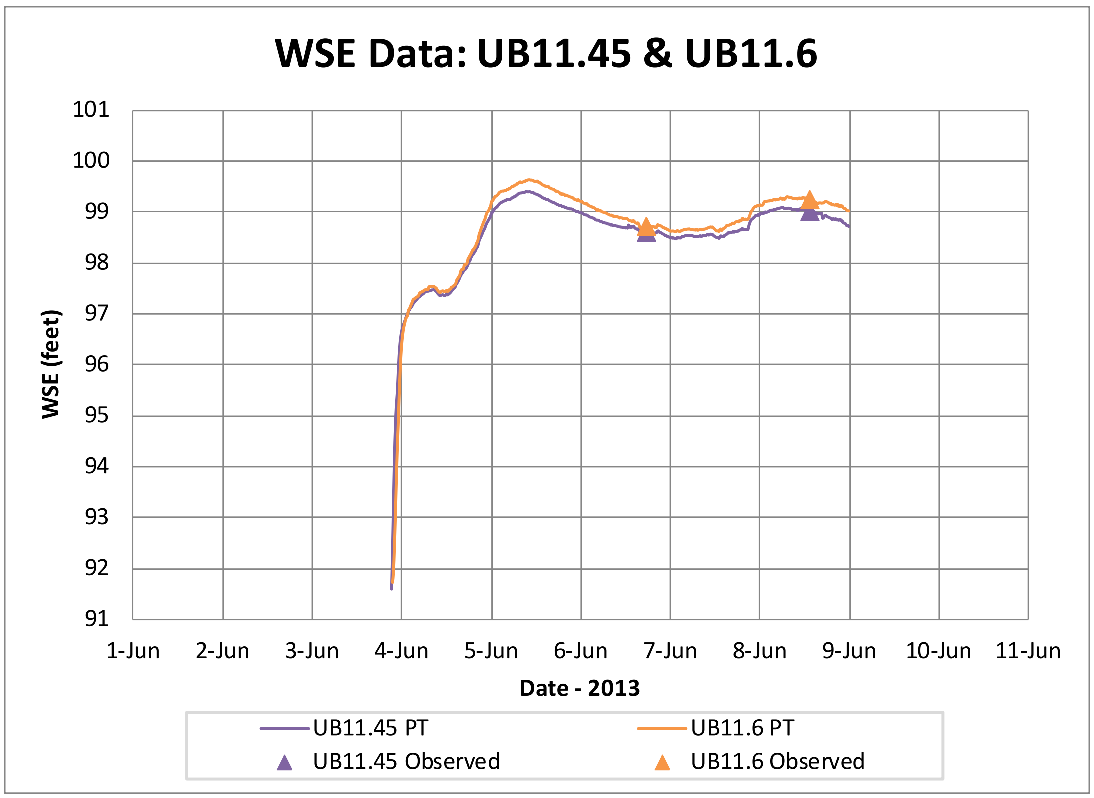
On June 28, the Ublutuoch River channel and banks were snow-free. Low velocity flow was observed in the channel, and water levels were below the channel banks.

Table 3.3: 2013 Stage Data for UB11.45 and UB11.6

Date and Time	WSE (feet)		Observations
	UB11.45	UB11.6	
6/5/13 9:30 AM	99.40	-	Peak stage at UB11.45 - based on PT data
6/5/13 10:00 AM	-	99.63	Peak stage at UB11.6 - based on PT data
6/6/13 5:45 PM	98.59	98.71	
6/8/13 1:30 PM	99.01	99.24	

Notes:

1. Elevations based on GUTZWILLER at 100.000 feet, established by Baker in 2011
2. Elevations not referenced to BPMSL



Graph 3.3: 2013 Stage Data for UB11.45 and UB11.6

3.2 GREATER MOOSES TOOTH 1 ROAD CORRIDOR

A gravel road is proposed to access the GMT1 and GMT2 drilling pads. The proposed road begins at the west end of the proposed CD5 access road and extends approximately 7.8 miles west to the GMT1 pad. It continues southwest 8.3 miles to the GMT2 pad. Between the CD5 access road and GMT1, the road alignment traverses the Ublutuoch River and several small drainages.

Ten locations along the proposed GMT1 road corridor were monitored in 2013 during spring breakup. Monitoring locations were at the Ublutuoch River (UB6.7 downstream, UB6.8 centerline, UB6.9 upstream) and small stream sites S1 through S7. The proposed GMT1 access road and small streams S4 and S5 alignments were provided by PND Engineers, Inc. (PND 2010). Figure 3.3 shows the 2013 FCB Ublutuoch River road crossing plan and profile.

3.2.1 UBLUTUOCH RIVER 6.7, 6.8, & 6.9

The Ublutuoch River monitoring sites were comprised of sets of three to four gages installed on the west bank of the river at RM 6.7, 6.8, and 6.9. The RM location designations, UB6.7, UB6.8, and UB6.9, refer to the distance in RM from the confluence of the Ublutuoch River and Fish Creek. The gage locations were selected to monitor and document local breakup conditions at the proposed bridge location and upstream and downstream of the proposed crossing. At the proposed bridge site, the Ublutuoch River has a drainage area of approximately 228 square miles.

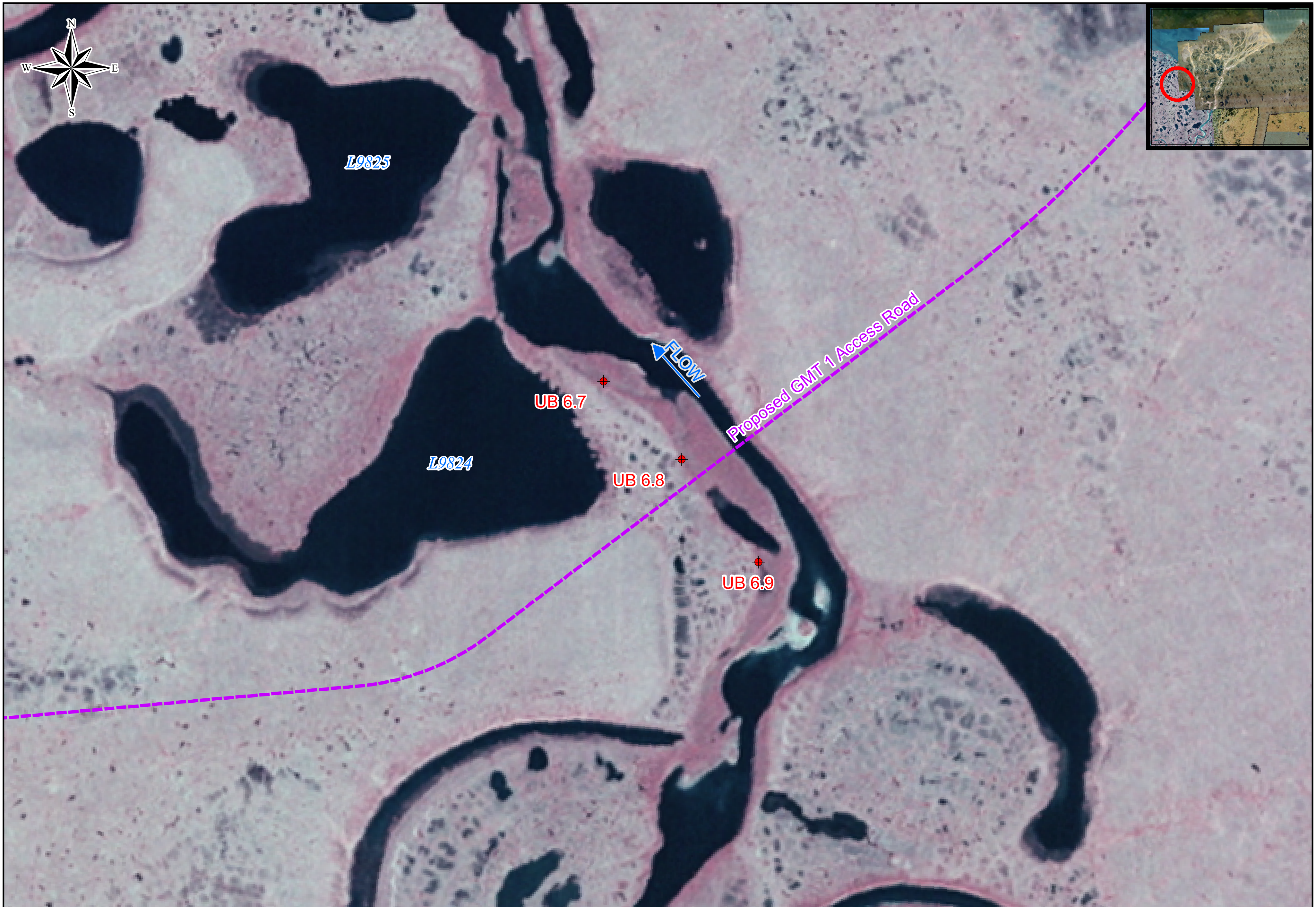
1) SPRING BREAKUP OBSERVATIONS

PTs were installed at UB6.7, UB 6.8, and UB6.9 gages on May 30. Ponded water was observed at the base of UB6.7 and UB6.9 gages. No flow was observed at the time of PT installation. The drainage had deep drifted snow accumulation, and snow covered the surrounding tundra.

On the afternoon of June 5, PT data captured peak WSEs of 9.65 feet, 9.83 feet, and 10.12 feet at UB6.7, UB6.8, and UB6.9, respectively (Table 3.4 and Graph 3.4).

On June 6, flood conditions were observed in the UB6.7, UB6.8, and UB6.9 reach of the Ublutuoch River. The main channel was characterized by discontinuous stretches of channel ice and saturated snow along the upper banks (Photo 3.8). Stranded ice floes were present on the banks at the UB6.7 gage location, and UB6.7-B and UB6.7-A gages showed evidence of ice floe damage (Photo 3.9). Paleochannels and adjacent lakes L9824 and L9825 were connected to the Ublutuoch River floodwater. Surrounding tundra polygon depressions were filled with local melt or persistent snow.

On June 8, ice-free overbank flooding was observed at UB6.8 and UB6.9 (Photo 3.10 and Photo 3.11). On June 10, overbank flooding and ice floes were present in the channel of the Ublutuoch River upstream of UB6.9 as stage decreased (Photo 3.12). No ice jams were observed at UB 6.7, UB6.8, or UB6.9 locations during breakup monitoring activities.



ConocoPhillips Alaska

Feet
0 250 500

Date:	11/15/2013	Project:	135006
Drawn:	BTG	File:	Figure 3.3
Checked:	SME/DCL	Scale:	1 in = 500 feet

Legend

Gage Location
Proposed Road

Baker

Michael Baker Jr., Inc.
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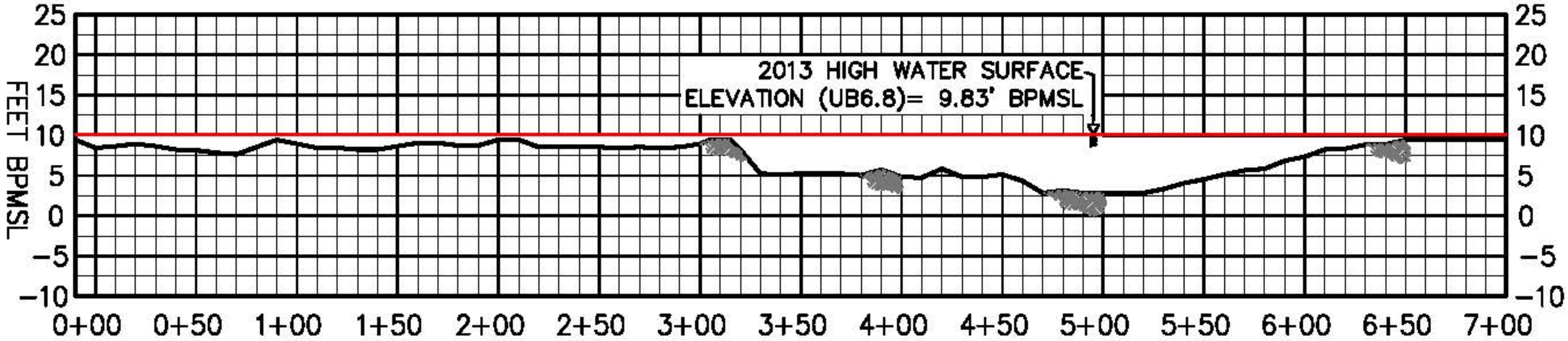
2013 FCB Breakup
Ublutuoch River
Road Crossing Plan

FIGURE: 3.3

(SHEET 1 of 2)

NOTES
1. BASIS OF ELEVATION, CP09-11-09B.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED JUNE 2010 BY JPM, HLR AND EJK



1 FISH CREEK BASIN – UBLUTUOCH RIVER CENTERLINE CROSS SECTION

50 0 50 100
HORIZONTAL SCALE IN FEET

12.5 0 12.5 25
VERTICAL SCALE IN FEET

ConocoPhillips Alaska, Inc.

DATE:	11/14/2013	PROJECT:	135006
DRAWN:	MNU	FILE:	FIGURE 3.3.DWG
CHECKED:	SME	SCALE:	AS SHOWN

Baker

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Fax: (907) 273-1699

2013 FCB BREAKUP
UBLUTUOCH RIVER
ROAD CROSSING PROFILE

FIGURE 3.3
(SHEET 2 OF 2)

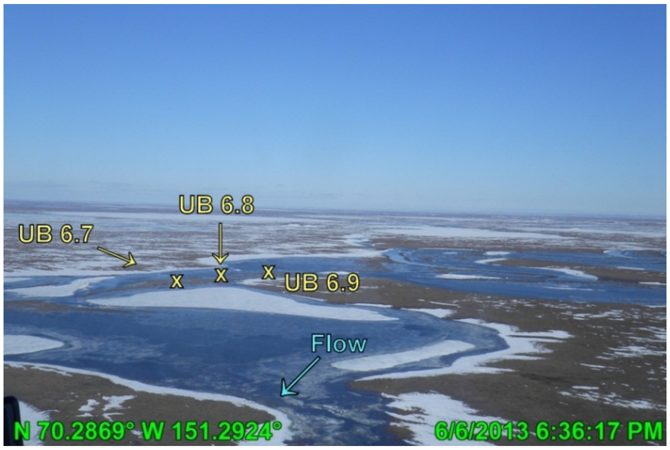


Photo 3.8: Breakup flow and channel ice in the Ublutuoch River, looking upstream (southeast); June 6, 2013

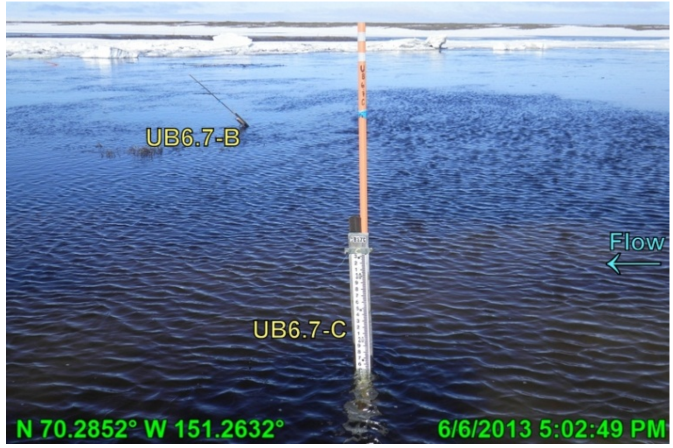


Photo 3.9: UB6.7 gage location showing stranded ice floes and ice floe gage damage, looking northeast; June 6, 2013

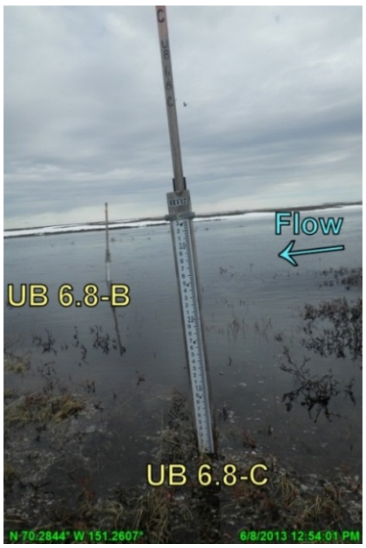


Photo 3.10: UB6.8 reach showing ice free channel and overbank flooding, looking northeast; June 8, 2013

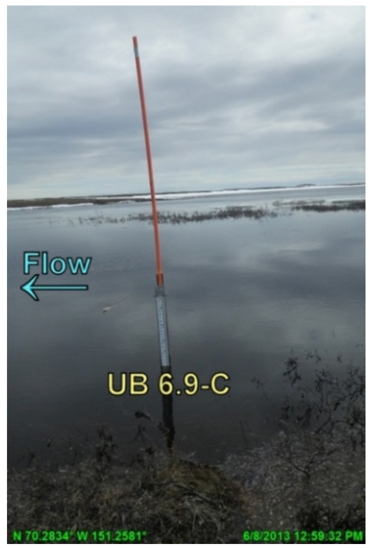


Photo 3.11: UB6.9 reach showing ice free channel and overbank flooding, looking southeast; June 8, 2013

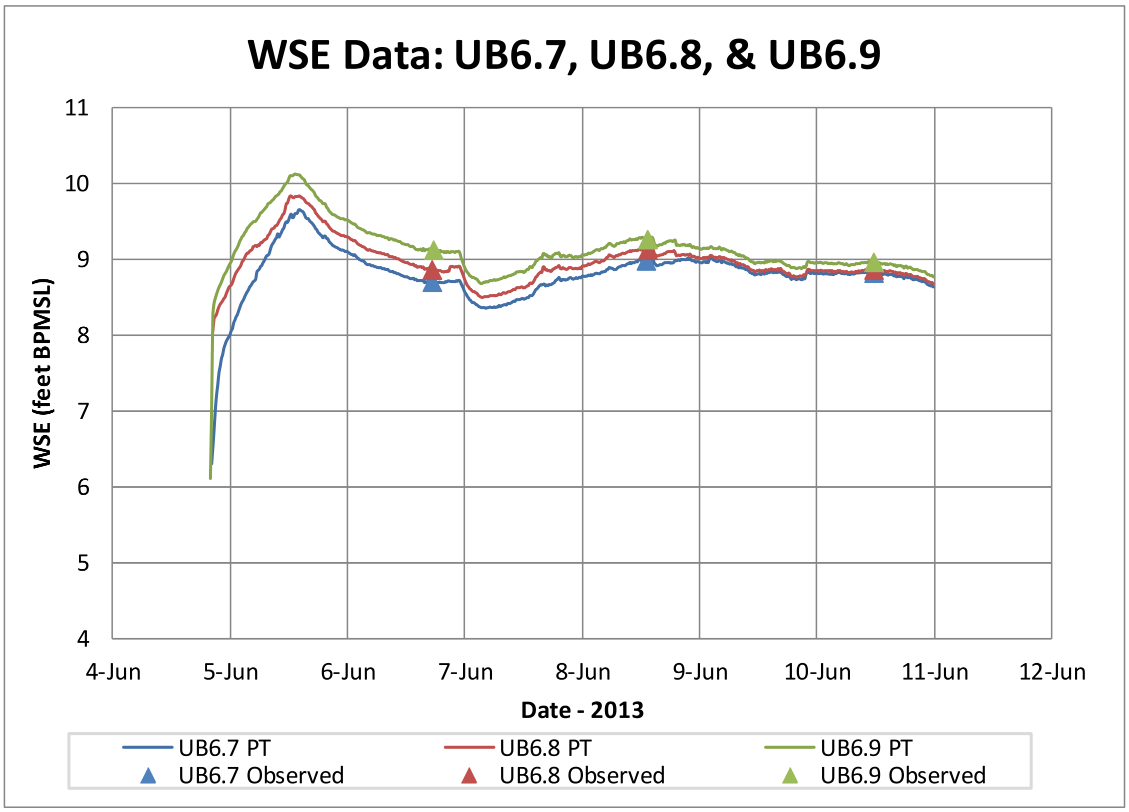
Photo 3.12: Overbank flooding and ice floes upstream of UB6.9, looking south; June 10, 2013

Table 3.4: 2013 Stage Data for UB6.7, UB6.8, and UB6.9

Date and Time	WSE (feet BPMSL)			Observations
	UB6.7	UB6.8	UB6.9	
6/5/13 12:30 PM	-	9.83	-	Peak stage at UB6.8 - based on PT data
6/5/13 1:15 PM	-	-	10.12	Peak stage at UB6.9 - based on PT data
6/5/13 2:15 PM	9.65	-	-	Peak stage at UB6.7 - based on PT data
6/6/13 5:00 PM	8.71	8.88	9.14	
6/8/13 12:45 PM	8.99	9.13	9.28	
6/10/13 11:15 AM	8.84	8.87	8.97	

Note:

1. Elevations based on CP09-11-09B at 9.638 feet BPMSL, surveyed by LCMF in 2009



Graph 3.4: 2013 Stage Data for UB6.7, UB6.8, and UB6.9

2) Indirect Discharge

Peak discharge at UB6.8 was estimated using a slope-area method. Indirect discharge was calculated using the energy grade-line slope as approximated by the water surface slope between UB6.7 and UB6.9, the corresponding WSE at UB6.8, and the 2010 cross-sectional data. Indirect discharge calculations were performed assuming an ice-free channel. Peak discharge in the Ublutuoch River was estimated to be 2,110 cubic feet per second (cfs) on the afternoon of June 5 with a corresponding WSE of 9.81 feet BPMSL at UB6.8. Saturated snow and ice were likely present in the drainage at the time of the indirect discharge calculations; therefore, the results are considered a high estimate. A summary of indirect discharge results and corresponding WSE elevation for the crossing location is presented in Table 3.5.

Table 3.5: Ublutuoch River Indirect Discharge and Corresponding WSE

Location	WSE at Peak Discharge (feet BPMSL)	Peak Discharge[1] (cfs)	Date & Time of Peak Discharge
UB6.8	9.81	2,110	6/5/13 1:00 PM

Note:
1. Peak discharge was calculated using the slope-area method and peak WSE.

3.2.2 Small Stream Crossings

In 2013, seven small streams, S1, S2, S3, S4, S5, S6, and S7 were monitored during spring breakup. Monitoring locations were chosen based on the location of proposed drainage structures provided by PND and observations made during 2009 and 2010 breakup monitoring. The small stream crossing gage locations monitored in 2013 are shown in Figure 3.4 through Figure 3.10 in numerical order. Profiles are shown for small stream crossings S4 and S5.

Date: 11/15/2013	Project: 135006		
Drawn: BTG	File: Figure 3.4		
Checked: SME/DCL	Scale: 1 in = 500 feet		

ConocoPhillips Alaska

Feet 0 250 500

Legend

Gage Location — Proposed Road

Baker

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Fax: (907) 273-1699

2013 FCB Breakup
S1 Plan

FIGURE: 3.4

(SHEET 1 of 1)

ConocoPhillips Alaska

Feet
0 250 500

Date:	11/15/2013	Project:	135006
Drawn:	BTG	File:	Figure 3.5
Checked:	SME/DCL	Scale:	1 in = 500 feet

Legend

Gage Location — Proposed Road

Baker

Michael Baker Jr., Inc.
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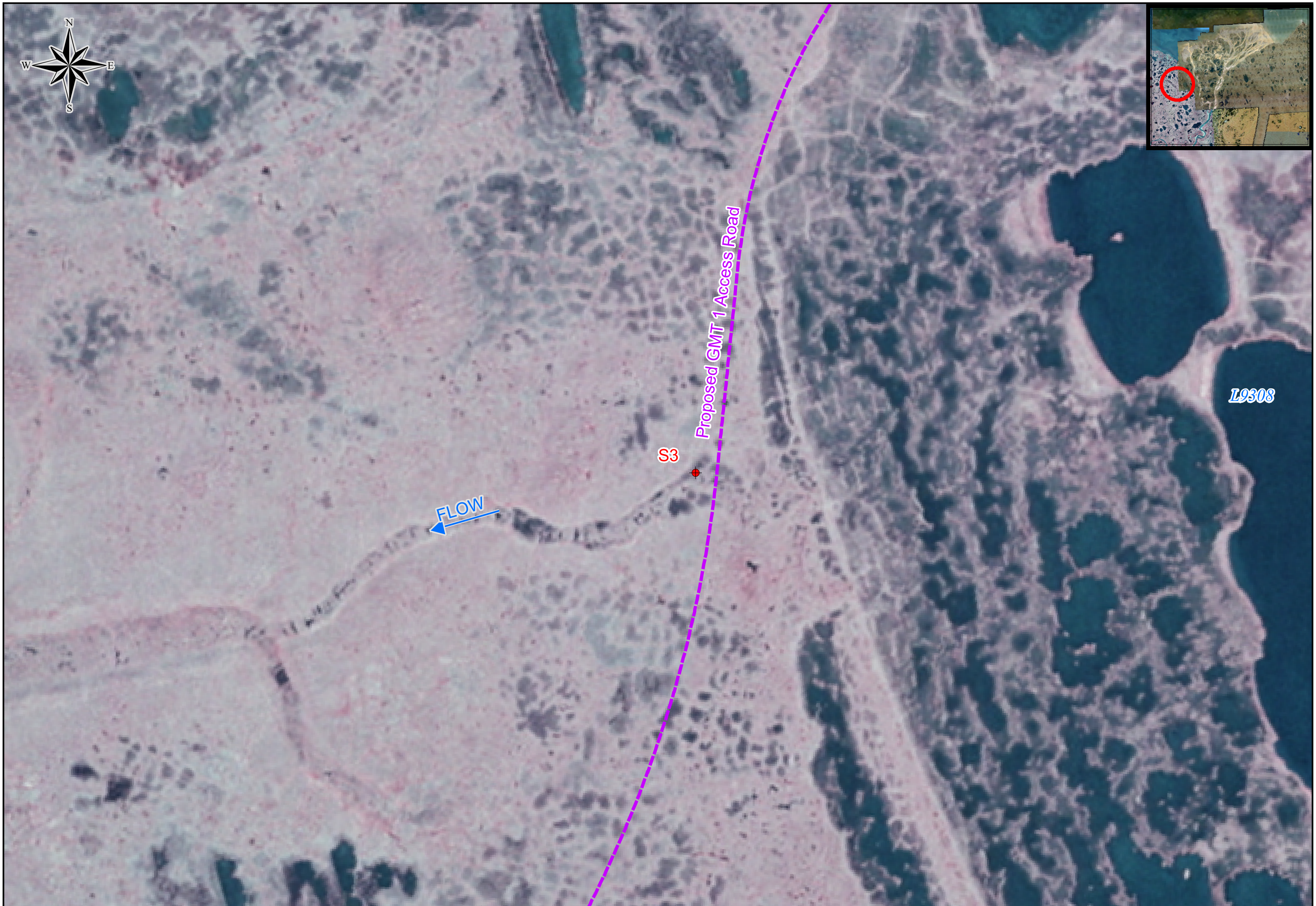
Anchorage, AK 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2013 FCB Breakup
S2 Plan

FIGURE: 3.5

(SHEET 1 of 1)



ConocoPhillips Alaska

Feet
0 250 500

Date:	11/15/2013	Project:	135006
Drawn:	BTG	File:	Figure 3.6
Checked:	SME/DCL	Scale:	1 in = 500 feet

Legend

Gage Location
Proposed Road

Baker

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2013 FCB Breakup
S3 Plan

FIGURE: 3.6

(SHEET 1 of 1)

ConocoPhillips Alaska

Feet
0 250 500

Date:	11/15/2013	Project:	135006
Drawn:	BTG	File:	Figure 3.7
Checked:	SME/DCL	Scale:	1 in = 500 feet

Legend

Gage Location
Proposed Road

Baker

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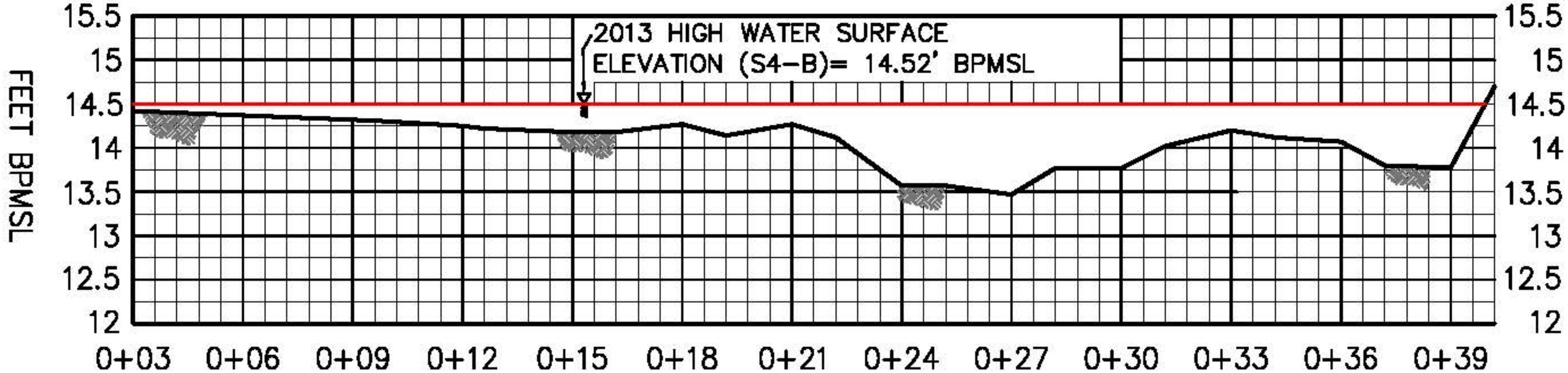
2013 FCB Breakup
S4 Plan

FIGURE: 3.7

(SHEET 1 of 2)

NOTES
1. BASIS OF ELEVATION, CP09-11-09B.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED JUNE 2010 BY JPM, HLR, AND EJK



1 FISH CREEK BASIN – S4 CENTERLINE CROSS SECTION

3 0 3 6
HORIZONTAL SCALE IN FEET

1.0 0 1.0 2.0
VERTICAL SCALE IN FEET

ConocoPhillips Alaska, Inc.

DATE:	11/14/2013	PROJECT:	135006
DRAWN:	MNU	FILE:	FIGURE 3.7.DWG
CHECKED:	SME	SCALE:	AS SHOWN

Baker

Michael Baker Jr., Inc.
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1400 West Benson Blvd., Suite 200
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Fax: (907) 273-1699

2013 FCB BREAKUP
S4 PROFILE

FIGURE 3.7
(SHEET 2 OF 2)

ConocoPhillips Alaska

Feet
0 250 500

Date:	11/15/2013	Project:	135006
Drawn:	BTG	File:	Figure 3.8
Checked:	SME/DCL	Scale:	1 in = 500 feet

Legend

Gage Location — Proposed Road

Baker

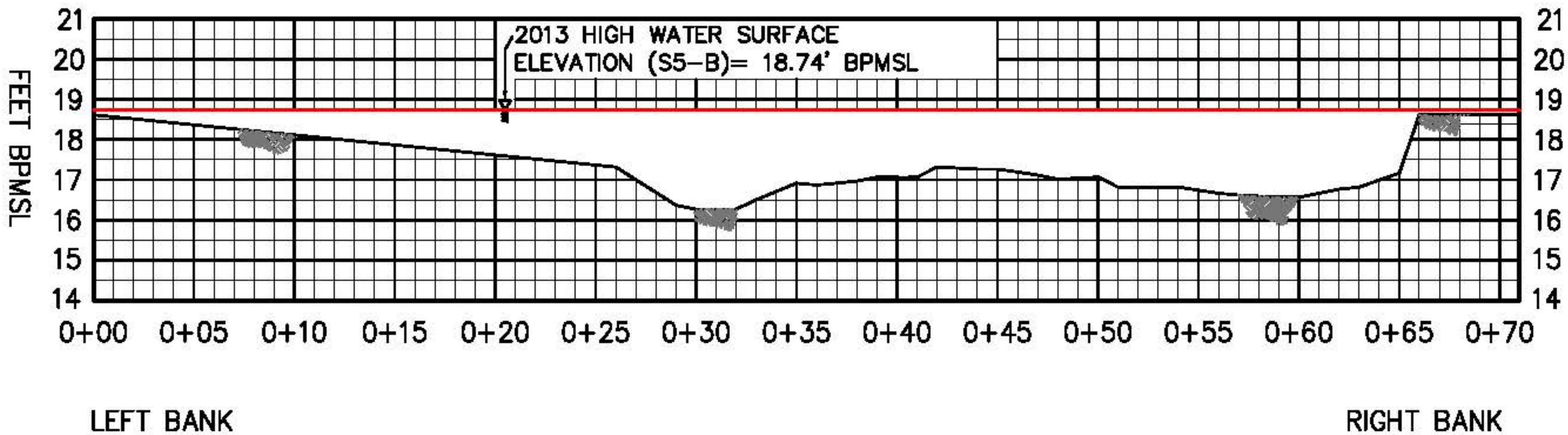
Michael Baker Jr., Inc.
1400 West Benson Blvd., Suite 200
Anchorage, AK 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2013 FCB Breakup
S5 Plan

FIGURE: 3.8

(SHEET 1 of 2)

NOTES
1. BASIS OF ELEVATION, CP09-11-09B.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED JUNE 2010 BY JPM, HLR, AND EJK



1 FISH CREEK BASIN – S5 CENTERLINE CROSS SECTION

5 0 5 10
HORIZONTAL SCALE IN FEET

2.25 0 2.25 4.5
VERTICAL SCALE IN FEET

ConocoPhillips Alaska, Inc.

DATE:	11/14/2013	PROJECT:	135006
DRAWN:	MNU	FILE:	FIGURE 3.8.DWG
CHECKED:	SME	SCALE:	AS SHOWN

Baker

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2013 FCB BREAKUP
S5 PROFILE

FIGURE 3.8
(SHEET 2 OF 2)

ConocoPhillips Alaska

Feet
0 250 500

Date: 11/15/2013	Project: 135006
Drawn: BTG	File: Figure 3.9
Checked: SME/DCL	Scale: 1 in = 500 feet

Legend

Gage Location Proposed Road

Baker

Michael Baker Jr., Inc.
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Anchorage, AK 99503
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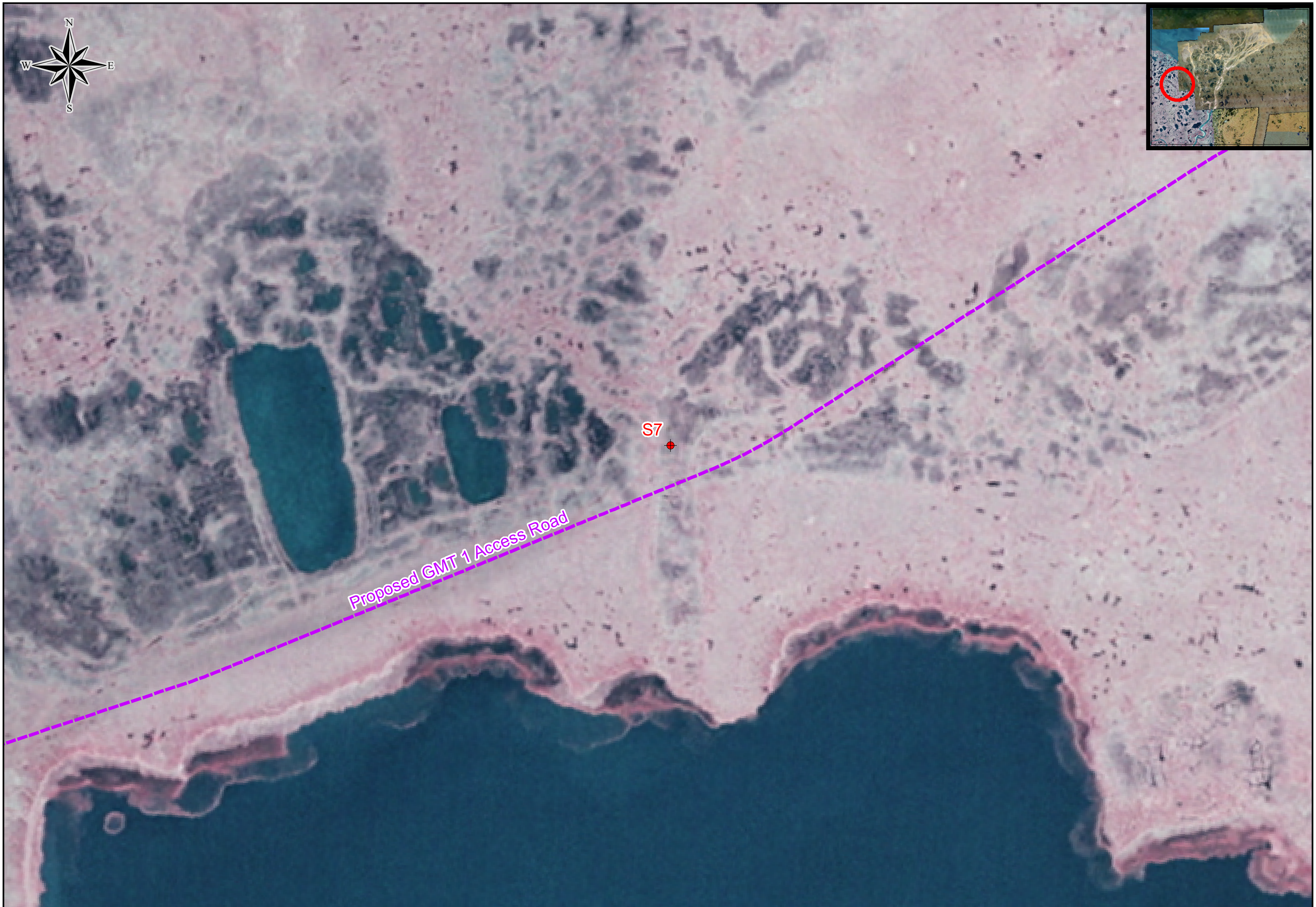
Fax: (907) 273-1699

2013 FCB Breakup
S6 Plan

FIGURE: 3.9

(SHEET 1 of 1)



ConocoPhillips Alaska

Feet
0 250 500

Date: 11/15/2013	Project: 135006
Drawn: BTG	File: Figure 3.10
Checked: SME/DCL	Scale: 1 in = 500 feet

Legend

Gage Location   Proposed Road

Baker

Michael Baker Jr., Inc.
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2013 FCB Breakup
S7 Plan

FIGURE: 3.10

(SHEET 1 of 1)

1) Spring Breakup Observations

Small Stream Crossing S1

On June 10, visual observations were conducted by helicopter overflight at the S1 gage location. Extensive ponded water and decayed snow cover was observed in the swale between Lake MB0301 Lake L9308 (Photo 3.13). Lake ice was still present in Lake MB0301. No visible flow was observed at S1 during breakup monitoring activities.

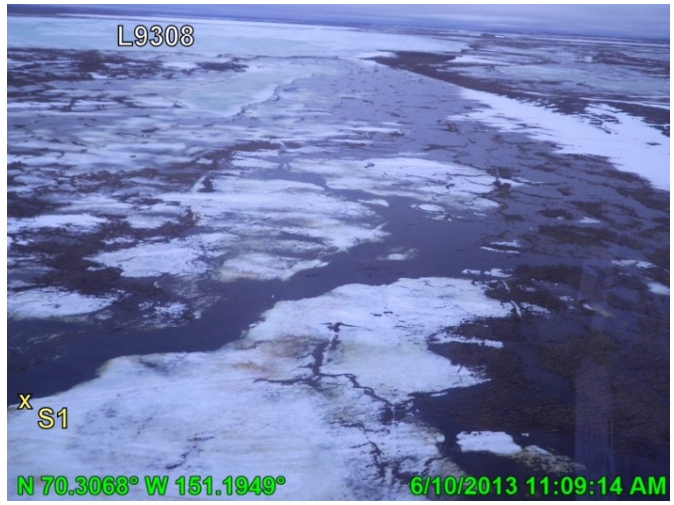


Photo 3.13: S1 gage location showing decayed snow cover and local melt, looking south; June 10, 2013

Small Stream Crossing S2

On June 10, visual observations were conducted by helicopter overflight at the S2 gage location. Extensive ponded water was present in all low lying areas and over patches of highly decayed snow cover (Photo 3.14). No visible flow was observed at S2 during breakup monitoring activities.

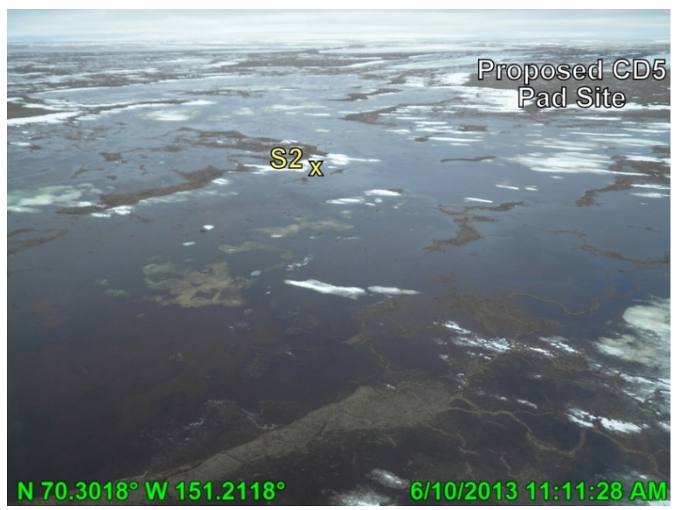


Photo 3.14: S2 gage location showing extensive local melt and decayed snow cover, looking north; June 10, 2013

Small Stream Crossing S3

On June 6, visual observations were conducted by helicopter overflight at the S3 gage location. Drifted snow was present in low lying areas with local melt accumulating in polygon depressions within the S3 drainage. Backwater from the Ublutuoch River was observed flooding into the lower reach of the S3 drainage (Photo 3.15).

On June 10, visual observations were conducted by helicopter overflight. Most of the drifted snow had melted, and ponded water remained in low lying areas of the drainage (Photo 3.16). No visible flow was observed at S3 during breakup monitoring activities.

Photo 3.15: The lower reach of S3 drainage showing drifted snow, local melt in polygons, and connection to the Ublutuoch River, looking west; June 6, 2013

Photo 3.16: S3 gage location showing local melt in low lying areas, looking south; June 10, 2013

Small Stream Crossing S4

Photo 3.17: S4-B gage location showing broad channel flowing through snow pack on banks, looking south; June 10, 2013

On June 8, a PT was installed at the S4-C gage, and initial WSEs were recorded at all S4 gages. The surrounding tundra was mostly snow-free with drifted snow present in the channel upstream of the S4-B gage location. A broad channel was observed flowing through saturated snow pack along the banks.

Stage at S4 continued to decline from the initial readings throughout the monitoring period, and it is possible peak WSE occurred before the first gage readings and PT installation. Initial WSE readings on June 8 were 13.58 feet, 14.50 feet and 14.93 feet at S4-A, S4-B, and S4-C gages, respectively (Table 3.6 and Graph 3.5).

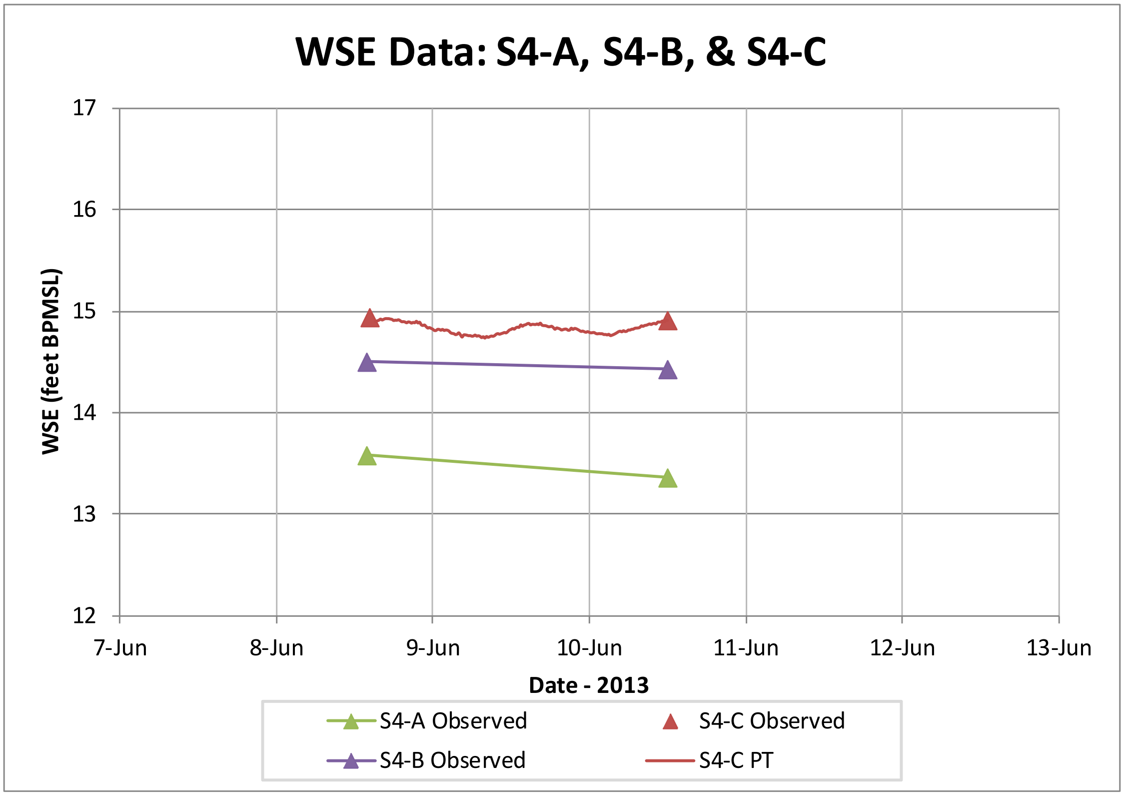
On June 10, open water was observed in the drainage though intermittent patches of saturated snow still remained along the banks. Bottom-fast ice was present in pooled areas along the stream (Photo 3.17).

Table 3.6: 2013 Stage Data for Small Stream Crossing S4

Date and Time	WSE (feet BPMSL)			Observations
	S4-A Downstream	S4-B Centerline	S4-C Upstream	
6/8/13 2:00 PM	13.58	14.50	14.93	Peak stage at S4-C - based on observations
6/10/13 12:00 PM	13.36	14.43	14.91	

Note:

1. Elevations based on COAL at 20.524 feet and CHAR at 24.248 feet, surveyed by LCMF in 2009



Graph 3.5: 2013 Stage Data for Small Stream Crossing S4

2) S4 Indirect Discharge

Peak discharge at S4 was estimated using a slope-area method. Indirect discharge was calculated using the energy grade-line slope as approximated by the water surface slope between S4-A and S4-C, the corresponding WSE at S4-B, and the 2010 cross-sectional data. Indirect discharge calculations were performed assuming an ice-free channel. Discharge in the S4 drainage was estimated to be 10 cfs on the afternoon of June 8. Saturated snow was present in the drainage at the time of the indirect discharge calculations; therefore the results are considered a high estimate. A summary of indirect discharge results and corresponding WSE data for the S4 crossing location is presented in Table 3.7.

Table 3.7: S4 Indirect Discharge and Corresponding WSE

Location	WSE at Peak Discharge[1] (feet BPMSL)	Peak Discharge[2] (cfs)	Date & Time
S4	14.5	10	6/8/13 2:00 PM
Notes: 1. At centerline gage S4-B 2. Peak discharge was calculated using the slope-area method and peak WSE.			

Small Stream Crossing S5

On June 6, PTs were installed at the S5-A and S5-C gages, and initial WSEs were recorded at all S5 gages. On June 6, flow was observed over and through extensive accumulations of drifted snow within the drainage. Hydraulic conditions were characterized as flow over saturated snow upstream of S5-B gage transitioning to an incised channel in the snow pack downstream of the S5-B gage and proposed S5 crossing location (Photo 3.18). Saturated snow along the drainage was present at the S5-A gage location downstream of the proposed S5 crossing (Photo 3.19 and Photo 3.20).

Stage at S5 continued to decline from the initial reading throughout the monitoring period, and it is possible peak WSE occurred before the first gage readings and pressure transducer installation. Initial WSE readings on June 6 were 17.72 feet, 18.74 and 20.39 feet at S5-A, S5-B and S5-C, respectively (Table 3.8 and Graph 3.6).

Photo 3.18: Flow over and through saturated snow at proposed S5 crossing location (S5-B), looking west; June 6, 2013

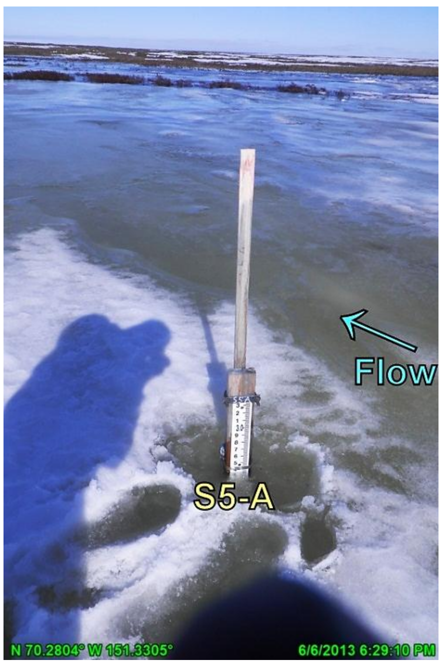


Photo 3.19: Flow through saturated snow at S5-A, downstream of the crossing centerline, looking downstream (northeast); June 6, 2013

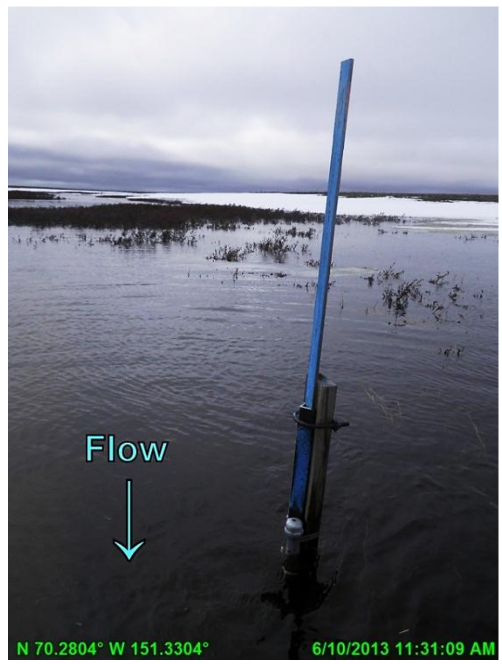


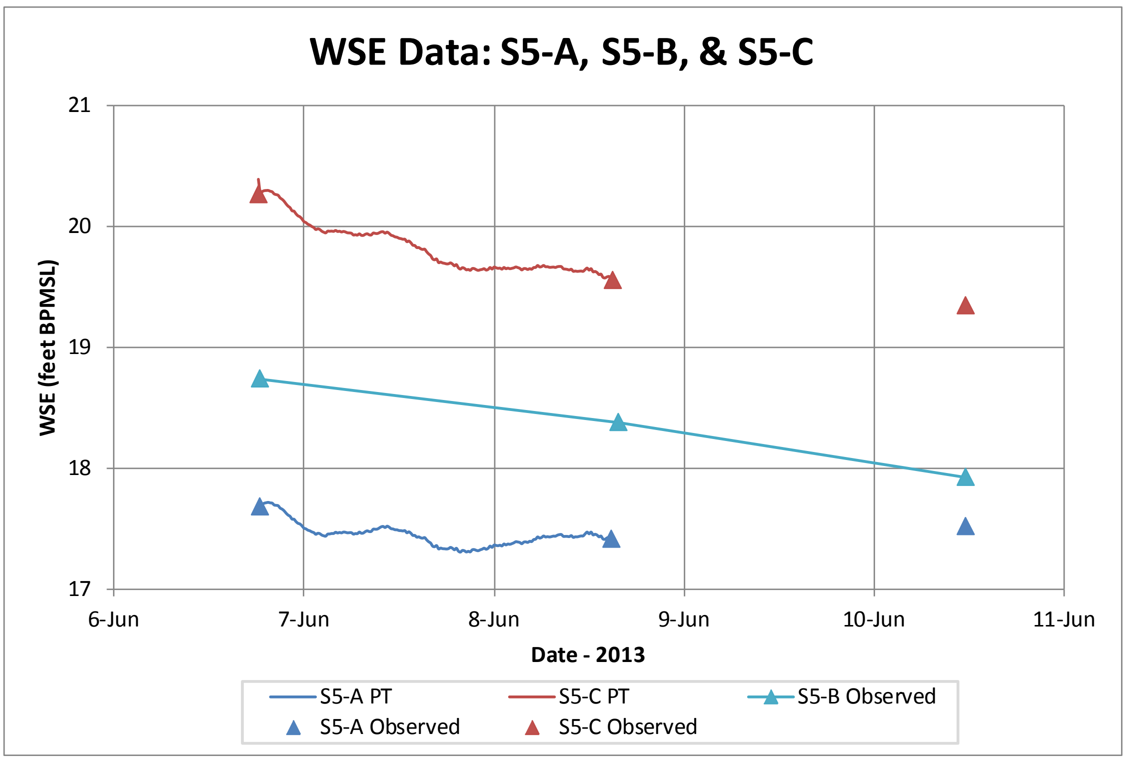
Photo 3.20: S5 gage location showing persistent snow (PT visible on gage S5-A), looking south toward S5-B; June 10, 2013

Table 3.8: 2013 Stage Data for Small Stream Crossing S5

Date and Time	WSE (feet BPMSL)			Observations
	S5-A Downstream	S5-B Centerline	S5-C Upstream	
6/6/13 6:15 PM	-	-	20.39	Peak stage at S5-C - based on PT data
6/6/13 7:30 PM	17.72	-	-	Peak stage at S5-A - based on PT data
6/6/13 6:25 PM	17.68	18.74	20.26	Peak stage at S5-B - based on observations
6/8/13 2:45 PM	17.42	-	19.56	
6/8/13 3:45 PM	-	18.38	-	
6/10/13 11:33 AM	17.52	17.93	19.35	

Note:

1. Elevations based on ALMA at 25.263 feet BPMSL, surveyed by LCMF in 2009, CLARA at 23.228 feet, and CP09-09-17 at 23.680 feet



Graph 3.6: 2013 Stage Data for Small Stream Crossing S5

3) S5 Indirect Discharge

Peak discharge at S5 was estimated using a slope-area method. Indirect discharge was calculated using the energy grade-line slope as approximated by the water surface slope between S5-A and S5-C, the peak WSE at S5-B, and the 2010 cross-sectional data. Indirect discharge calculations were performed assuming an ice-free channel. Discharge in the S5 drainage was estimated to be 137 cfs on June 6. Saturated snow was present in the drainage at the time of the indirect discharge calculations; therefore, the results are considered a high estimate. A summary of indirect discharge results and peak WSE elevation data for the S5 crossing location is contained in Table 3.9.

Table 3.9: S5 Indirect Discharge and Corresponding WSE

Location	WSE at Peak Discharge[1] (feet BPMSL)	Peak Discharge[2] (cfs)	Date & Time of Peak Discharge
S5	18.74	137	6/6/13 18:15:00 PM
Notes: 1. WSE measurement at centerline gage S5-B. 2. Peak discharge was calculated using the slope-area method and peak WSE.			

Small Stream Crossing S6

On June 8, the S6 drainage was characterized by local melt in saturated snow at the S6 gage location (Photo 3.21). Local melt was present in surrounding tundra polygons and low lying areas with some persistent snow remaining.

Stage at S6 continued to decline from the initial reading throughout the monitoring period, and it is possible peak WSE occurred before the first gage reading. On the afternoon of June 8, the WSE on gage S6 was 23.98 feet (Table 3.10 and Graph 3.7).

On June 10, the S6 drainage was characterized by ponded water, with little snow remaining (Photo 3.22). On the morning of June 10, the WSE on gage S6 was 23.72 feet. No visible flow was observed at S6 during breakup monitoring activities.

Photo 3.21: S6 gage location with local melt and saturated snow, looking west; June 8, 2013

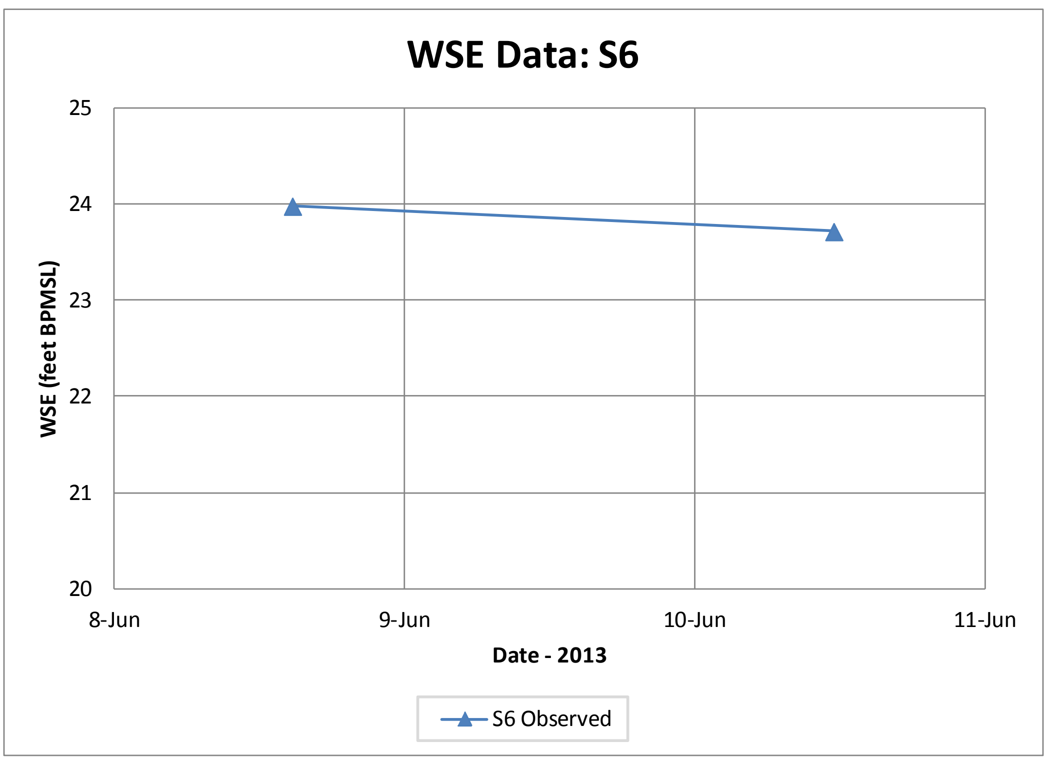
Photo 3.22: S6 drainage showing no flow, local melt, and little snow, looking northeast; June 10, 2013

Table 3.10: 2013 Stage Data for Small Stream Crossing S6

Date and Time	WSE (feet BPMSL)	Observations
	S6	
6/8/13 2:45 PM	23.98	Peak stage at S6 - based on observations; local melt, no flow
6/10/13 11:36 AM	23.72	

Note:

1. Elevations based on BRAD at 25.78 feet BPMSL, surveyed by LCMF in 2005



Graph 3.7: 2013 Stage Data for Small Stream Crossing S6

Small Stream Crossing S7

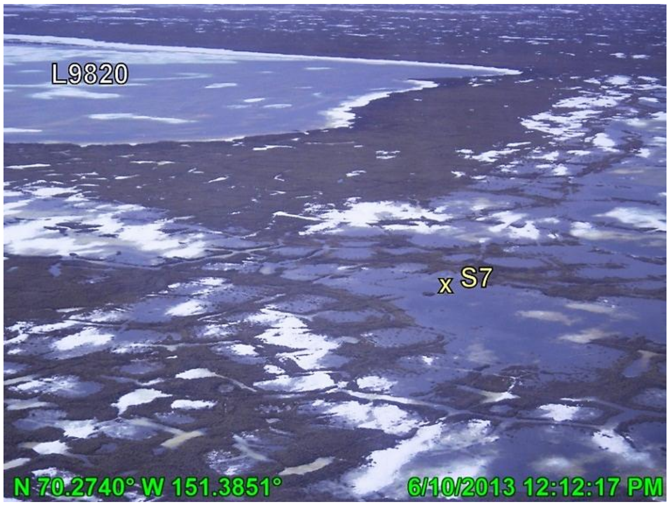


Photo 3.23: S7 drainage showing extensive local melt and areas of saturated snow, looking west; June 10, 2013

On June 10, visual observations were conducted by helicopter over flight at the S7 gage location. Extensive local melt was present in tundra polygons and low lying areas around the S7 drainage. The drainage was characterized by ponded water around tundra polygons with areas of saturated snow (Photo 3.22). No visible flow was observed at S7 during breakup monitoring activities.

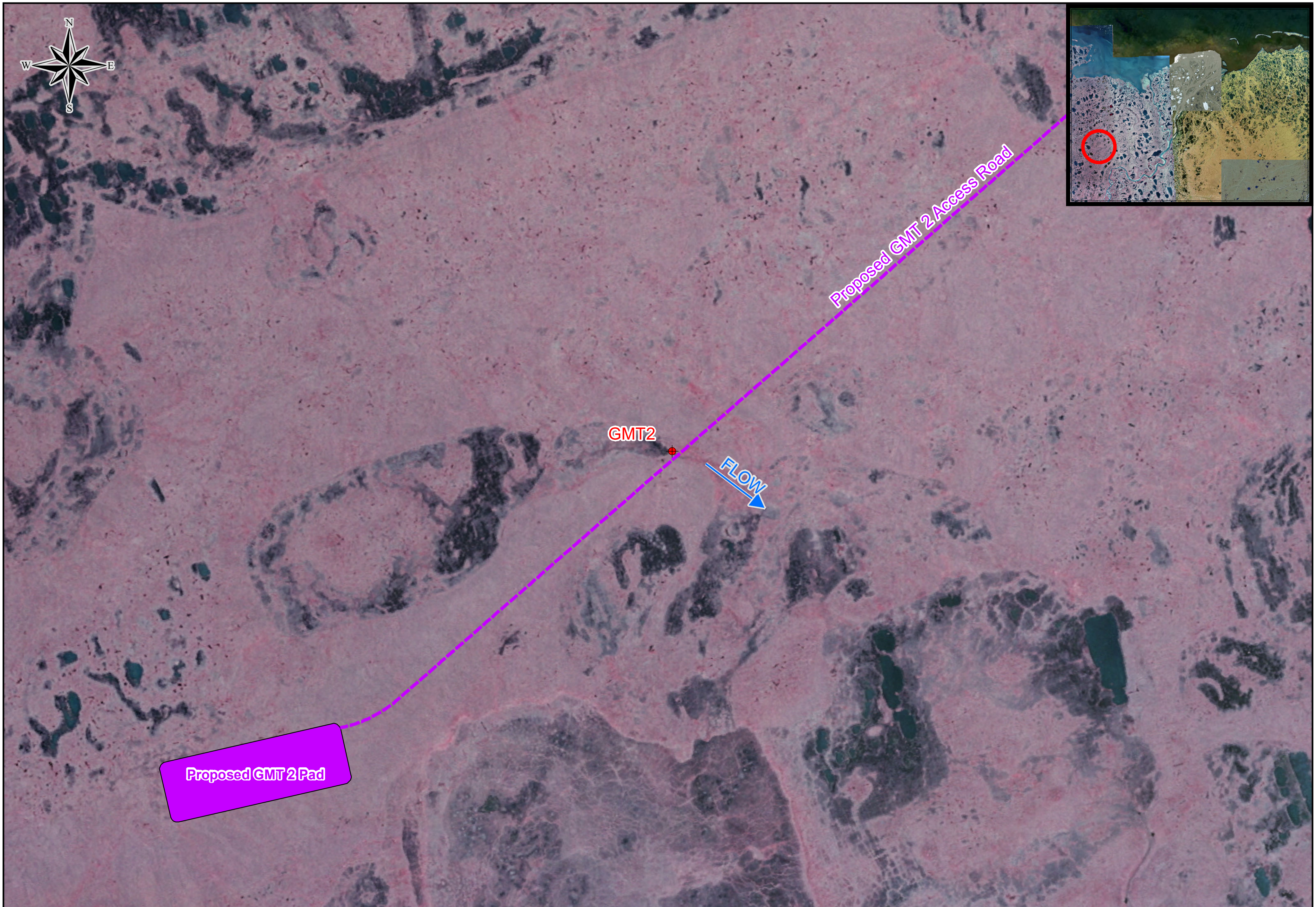
3.3 GREATER MOOSES TOOTH 2 ROAD CORRIDOR

The proposed GMT2 pad is located at the westernmost extent of the study area. A single drainage monitoring site is along the proposed GMT2 access road 0.7 miles northeast of the GMT2 pad. GMT2 was monitored aerially during 2013 spring breakup. Figure 3.11 shows the 2013 FCB GMT2 crossing plan.

1) Spring Breakup Observations

Photo 3.24: GMT2 area showing a small channel connecting low lying areas, looking northeast; June 10, 2013

On June 10, visual observations were conducted by helicopter overflight at the GMT2 gage location. Most of the snow cover in the GMT2 drainage area had melted. The drainage was characterized by flow in a small channel connecting several low lying areas (Photo 3.24).



ConocoPhillips
Alaska

Feet
0 500 1,000

Date:	11/15/2013	Project:	135006
Drawn:	BTG	File:	Figure 3.11
Checked:	SME/DCL	Scale:	1 in = 1000 feet

Legend
Gage Location
Proposed Facility
Proposed Road

Baker

Michael Baker Jr., Inc.
1400 West Benson Blvd., Suite 200
Anchorage, AK 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2013 FCB Breakup
GMT2 Drainage Plan

FIGURE: 3.11

(SHEET 1 of 1)

4. 2013 RESULTS AND HISTORICAL DATA

4.1 UBLUTUOCH HISTORICAL BREAKUP OVERVIEW

Since 2001, discontinuous breakup monitoring data for the FCB has been collected at various locations. The most consistent historical record of breakup peak stage and discharge observations is available for the Ublutuoch River. Table 4.1 presents the annual peak discharge, peak stage, and timing for the 10 years of available data.

Based on the 10-year data record, the average date of peak discharge and peak stage is June 4. Peak discharge and peak stage for 2013 were both estimated to have occurred on June 5.

Table 4.1: Timing of Ublutuoch River Historical Peak Discharge and WSE

Year	Location (RM)	Discharge		WSE		Reference
		Peak Discharge (cfs)	Date	Peak WSE (feet BPMSL)	Date	
2013	6.8	2,110	5-Jun	9.83	5-Jun	This Report
2011	6.8	2,350	2-Jun	9.39	2-Jun	Baker 2011
2010	6.8	5,360	8-Jun	10.38	8-Jun	Baker 2010
2009	6.8	1,990	30-May	8.45	29-May	Baker 2009
2006	6.8	1,290	6-Jun	6.19	7-Jun	Baker 2007
2005	6.8	1,680	9-Jun	10.01	7-Jun	Baker 2005b
2004	6.8 Up	2,800	5-Jun	10.50	6-Jun	Baker 2005a
2003	6.8 Up	1,300	9-Jun	10.14	6-Jun	Baker 2003
2002	13.7	1,900	22-May	18.22	22-May	URS 2003
2001	13.7	1,440	10-Jun	18.09	10-Jun	URS 2001

4.2 FLOOD AND STAGE FREQUENCY ANALYSIS

Flood and stage frequency analyses are typically performed or updated every three years or when sufficient annual data has been collected to either significantly affect results or support existing trends. Recurrence intervals for peak discharge were computed in 2013 for three locations in the GMT monitoring area: Ublutuoch River at UB6.8 and small stream sites S4 and S5.

Stage frequency for the Ublutuoch River was last analyzed in 2009. Since then, stage observations have been collected at the Ublutuoch River in 2010, 2011 and, 2013. This provides three additional years of historical annual peak WSE data to update the stage frequency analysis. Since the record of monitoring WSE at other GMT locations was limited, and these streams are affected by snow and ice, stage frequency analyses could not be performed at any other GMT monitoring sites.

4.2.1 UBLUTUOCH RIVER

The proposed GMT1 bridge crossing at the Ublutuoch River will be the largest drainage structure along the GMT1 and GMT2 access roads. The Ublutuoch River flood frequency and stage frequency analyses aid in the development of design criteria for the proposed bridge. For discussion on the 2009 analysis criteria, see the GMT1 Alpine Satellite Project 2009 Spring Breakup Hydrologic Assessment (Baker 2009) report.

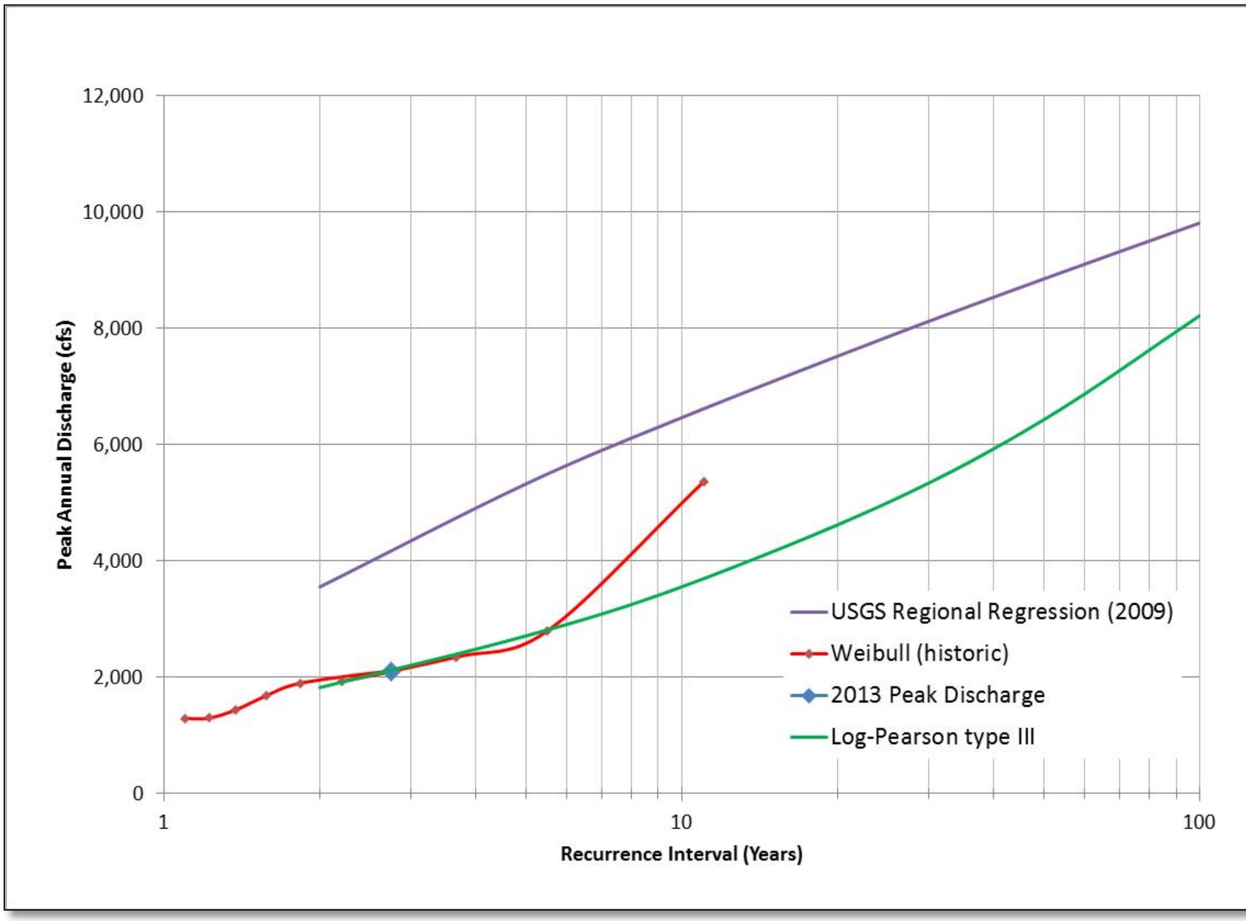
Flood Frequency

In 2009, an initial flood frequency analysis was performed for UB6.8. Results of this analysis are the basis for current design values and are presented in Table 4.2. This analysis uses the U.S Geological Survey (USGS) Region 7 regression equations, which use stream drainage areas and are based on empirical regional data. Results from this analysis tend to be conservative when compared to site-specific data. In 2013, Weibull analysis and the U.S. Water Resource Council recommended Log Pearson Type III distribution. These recommendations were performed using 10-years of historical peak discharge data and are compared to the Region 7 regression equation results and the 2013 peak discharge in Graph 4.1. The historical record comparison shows the regression equations over-predict the discharge quantities for a given recurrence interval, particularly for the lower recurrence flood years, when ice and snow would have more of an impact. The 2013 peak discharge in the Ublutuoch River at UB6.8 was 2,110 cfs, corresponding to a recurrence interval of 2.8- and 3.0-years based on the Weibull and Log Pearson Type III analysis, respectively. The 2013 peak discharge corresponds to less than a 2-year recurrence interval, based on the regression equations.

Table 4.2: Ublutuoch River UB6.7, UB6.8, and UB6.9 USGS Region 7 Regression Equations Estimates

Recurrence Interval (years)	Discharge (cfs) USGS Region 7 Regression Equations RM 6.8[1]
2	3,600
5	5,300
10	6,500
25	7,900
50	8,800
100	9,800

[1]Baker 2009



Graph 4.1: Ublutuoch River UB6.7, UB6.8, and UB6.9 Flood Frequency Estimates

Ublutuoch Stage Frequency

A Log-Pearson type III stage frequency analysis was performed in 2013 for the UB6.8 Bridge Crossing site based on 8 years of data. This analysis assumes open channel conditions and should be considered a conservative estimate, since breakup in the Ublutuoch River is typically impacted by snow and ice. It is generally considered inaccurate to extrapolate stage data for a river impacted by snow and ice beyond the observed record (USACE 2002 and FEMA 2003). In addition to the statistical analysis, a HEC-RAS model was developed in 2003 to estimate the 100-year flood stage. Peak stage for a 100-year event at UB6.8 is estimated to be 12.5 based on the 2013 stage frequency analysis and the 2003 HEC-RAS estimate.

Annually, recurrence intervals are assigned to each of the current and historical peak stage values using the Weibull plotting equation (USACE 1982). The 2013 peak stage in the Ublutuoch at UB6.8 of 9.83 feet BPMSL corresponds to a 1.8-year recurrence interval based on historical data. Historic stage recurrence data is included with the 2013 peak WSE in Table 4.3.

Table 4.3: Ublutuoch River UB6.7, UB6.8, and UB6.9 Weibull Analysis Historical Peak Recurrence Intervals

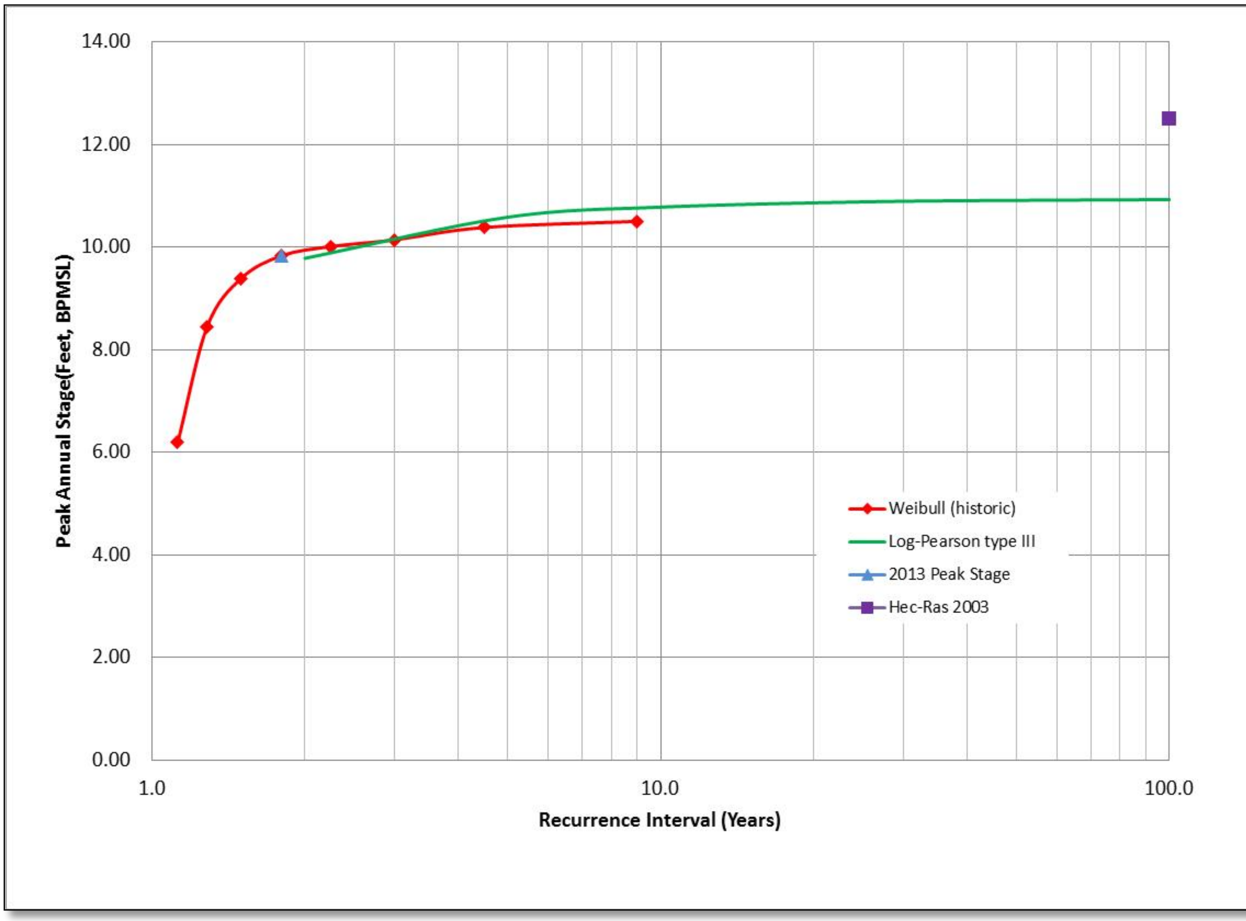
Year	Peak Annual Stage (feet BPMSL)	Probability	Recurrence Interval (years)	Reference
2013	9.83	0.56	1.8	This report
2011	9.39	0.67	1.5	Baker 2011
2010	10.38	0.22	4.5	Baker 2010
2009	8.45	0.78	1.3	Baker 2009
2006	6.19	0.89	1.1	Baker 2006
2005	10.01	0.44	2.3	Baker 2005b
2004	10.5	0.11	9.0	Baker 2005a
2003	10.14	0.33	3.0	Baker 2003

Based on the 2013 Log-Pearson type III stage frequency analysis, the 2013 peak WSE at UB6.8 corresponds to approximately a 2.2-year recurrence interval. The 2013 Log Person Type III design values are presented in Table 4.4. Both the historical Weibull and the 2013 Log-Pearson type III values are plotted for comparison with 2013 peak WSE and the HEC-RAS 100-year flood stage estimate in Table 4.4.

Table 4.4: Ublutuoch River UB6.8 Peak Annual Stage Estimates

Recurrence Interval (years)	Peak Annual Stage (feet BPMSL) Log-Pearson Type III[1]
2	9.8
5	10.6
10	10.8
25	10.9
50	10.9
100	10.9

[1]Baker 2013



Graph 4.2: Ublutuoch River UB6.7, 6.8 and 6.9 Stage Frequency Estimates

4.2.2 SMALL STREAM CROSSINGS

Small stream crossings S4 and S5 were selected for flood frequency analysis in 2013. Flood frequency analyses aid in the development of design criteria for proposed drainage structures. For discussion on the 2009 analysis criteria, see the report: GMT1 Alpine Satellite Project 2009 Spring Breakup Hydrologic Assessment (Baker 2009).

Flood Frequency

The recurrence interval for the 2013 peak discharge at small stream crossings S4 and S5 was computed based on the 2009 flood frequency analysis (Baker 2009). The 2009 analysis used the USGS Region 7 regression equations, applying stream drainage areas and based them on empirical regional data. The results from this analysis tend to be conservative when compared to site-specific data. Table 4.5 and Table 4.6 include the results of the 2009 flood frequency analyses for S4 and S5, respectively.

The 2013 peak discharge value at S4 of 10 cfs corresponds to less than a 2-year recurrence interval based on the regression equations. The 2013 peak discharge value at S5 of 137 cfs corresponds to a 4.6-year recurrence interval based on the regression equations.

Table 4.5: S4 Flood Frequency Analysis Results

Recurrence Interval (years)	Discharge (cfs) USGS Region 7 Regression Equations RM S4[1]
2	20
5	35
10	45
25	58
50	68
100	77
[1]Baker 2009	

Table 4.6: S5 Flood Frequency Analysis Results

Recurrence Interval (years)	Discharge (cfs) USGS Region 7 Regression Equations RM S5[1]
2	88
5	145
10	183
25	232
50	269
100	304
[1]Baker 2009	

5. REFERENCES

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APPENDIX A 2013 FISH CREEK BASIN AND GAGE LOCATIONS AND VERTICAL CONTROL

2013 Gage Locations				
Gage Site	Gage	Latitude (NAD 83)	Longitude (NAD 83)	Basis of Elevation
Clover B	Clover B1[1]	N 70° 15' 16.3"	W 151° 14' 19.1"	CLARK
	Clover B2[1]	N 70° 15' 05.7"	W 151° 14' 11.2"	MEG
	Clover B3	N 70° 14' 58.4"	W 151° 13' 51.0"	BAKER CP3
Clover C	Clover C1[1]	N 70° 15' 03.2"	W 151° 15' 11.9"	EICKELMAN SHOCKER BAKER CP2
	Clover C2[1]	N 70° 14' 57.1"	W 151° 14' 41.0"	
GMT2	GMT2-A	N 70° 10' 12.0"	W 151° 39' 41.0"	
S1	S1-A	N 70° 18' 21.0"	W 151° 11' 40.0"	
S2	S2-A	N 70° 18' 16.0"	W 151° 13' 09.0"	
S3	S3-A	N 70° 17' 46.0"	W 151° 14' 12.0"	CP-08-29C
S4	S4-A[1]	N 70° 16' 54.5"	W 151° 17' 33.6"	COAL CHAR
	S4-B	N 70° 16' 51.9"	W 151° 17' 37.6"	
	S4-C	N 70° 16' 49.3"	W 151° 17' 43.8"	
S5	S5-A[1]	N 70° 16' 49.4"	W 151° 19' 50.1"	ALMA CLARA
	S5-B	N 70° 16' 47.0"	W 151° 19' 48.2"	
	S5-C[1]	N 70° 16' 45.2"	W 151° 19' 48.7"	
S6	S6-C	N 70° 16' 34.2"	W 151° 22' 01.7"	BRAD
S7	S7-A	N 70° 16' 20.0"	W 151° 23' 34.0"	
Ublutuoch 6.7	UB6.7-A[1]	N 70° 17' 07.2"	W 151° 15' 46.8"	CP09-11-09B JACK
	UB6.7-B	N 70° 17' 07.0"	W 151° 15' 47.2"	
	UB6.7-C	N 70° 17' 06.8"	W 151° 15' 47.6"	
	UB6.7-D	N 70° 17' 06.5"	W 151° 15' 48.0"	
Ublutuoch 6.8	UB6.8-A[1]	N 70° 17' 04.2"	W 151° 15' 37.4"	
	UB6.8-B	N 70° 17' 04.1"	W 151° 15' 37.7"	
	UB6.8-C	N 70° 17' 04.0"	W 151° 15' 38.1"	
	UB6.8-D[2]	N 70° 17' 03.4"	W 151° 15' 40.9"	
Ublutuoch 6.9	UB6.9-A[1]	N 70° 17' 00.1"	W 151° 15' 28.1"	
	UB6.9-B	N 70° 17' 00.1"	W 151° 15' 28.5"	
	UB6.9-C	N 70° 17' 00.1"	W 151° 15' 28.8"	
Ublutuoch 11.45	UB11.45-A[1]	N 70° 15' 23.7"	W 151° 15' 15.8"	GUTZWILLER
	UB11.45-B	N 70° 15' 23.8"	W 151° 15' 15.9"	
	UB11.45-C	N 70° 15' 23.9"	W 151° 15' 15.9"	
	UB11.45-D	N 70° 15' 23.9"	W 151° 15' 16.1"	
	UB11.45-Z	N 70° 15' 25.0"	W 151° 15' 15.8"	
Ublutuoch 11.6	UB11.6-A[1]	N 70° 15' 22.3"	W 151° 15' 43.5"	
	UB11.6-B	N 70° 15' 22.4"	W 151° 15' 43.4"	
	UB11.6-C	N 70° 15' 22.4"	W 151° 15' 43.5"	
	UB11.6-D	N 70° 15' 22.4"	W 151° 15' 43.7"	
	UB11.6-E	N 70° 15' 22.4"	W 151° 15' 44.2"	

Notes:
1. PT installed
2. BaroTROLL or Barologger barometer

2013 Vertical Control					
Control	Elevation (BPMSL - feet)	Latitude (NAD 83)	Longitude (NAD 83)	Control Type	Surveyed By
ALMA	25.263	N 70° 16' 45.7''	W 151° 19' 53.2''	Alcap	LCMF 2009
BAKER CP2[1]	**35.000**	**N 70° 15' 01.8''**	**W 151° 15' 13.5''**	**Alcap**	**BAKER 2010**
BAKER CP3	**48.000**	**N 70° 15' 16.3''**	**W 151° 14' 22.6''**	**Alcap**	**BAKER 2010**
BRAD	25.780	N 70° 16' 37.4"	W 151° 22' 10.5"	Alcap	LCMF 2005
BRYNN	**89.272**	**N 70° 10' 11.1''**	**W 151° 39' 41.3''**	**Alcap**	**BAKER 2010**
CHAR	25.248	N 70° 16' 54.9''	W 151° 17' 41.8''	Alcap	LCMF 2009
CLARA	23.228	N 70° 16' 49.3''	W 151° 19' 59.0''	Alcap	LCMF 2009
CLARK	**47.293**	**N 70° 15' 16.5''**	**W 151° 14' 21.8''**	**Alcap**	**BAKER 2010**
COAL	20.524	N 70° 16' 52.4''	W 151° 17' 46.9''	Alcap	LCMF 2009
CP08-18-29C	19.560	N 70° 18' 18.2''	W 151° 13' 12.9''	Alcap	LCMF 2008
CP09-11-09B	9.638	N 70° 17' 02.9''	W 151° 15' 36.4''	Alcap	LCMF 2009
EICKELMAN	**36.542**	**N 70° 15' 02.0''**	**W 151° 15' 11.5''**	**Alcap**	**BAKER 2010**
GUTZWILLER	**100.000**	**N 70° 15' 24.5"**	**W 151° 15' 33.1"**	**Alcap**	**BAKER 2010**
JACK	23.450	N 70° 16' 55.4''	W 151° 15' 52.6''	Alcap	LCMF 2005
LOGAN	**90.000**	**N 70° 10' 11.1''**	**W 151° 39' 44.8''**	**Alcap**	**BAKER 2010**
MADISON	**90.137**	**N 70° 10' 10.3''**	**W 151° 39' 43.6''**	**Alcap**	**BAKER 2010**
MEG	**46.984**	**N 70° 15' 16.4''**	**W 151° 14' 21.1''**	**Alcap**	**BAKER 2010**
SHOCKER	**36.216**	**N 70° 15' 01.8''**	**W 151° 15' 9.3"**	**Alcap**	**BAKER 2010**

Note:
1. Elevations for control in bold were set by handheld Global Positioning System and are not referenced to BPMSL.

2013 Fish Creek Basin Spring Breakup Monitoring & Hydrologic Assessment