Fish Creek Basin

Spring Breakup

2011

Hydrologic Assessment

Prepared for

ConocoPhillips Alaska

Prepared by

Baker

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124033-MBJ-RPT-001

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November 23, 2011

Revision History

Revision	Date	Description
Rev. A DRAFT	10/18/2011	Initial Draft Submission
Rev. 0	11/23/2011	Deliverable Submittal

Executive Summary

This report presents observations and findings of the Fish Creek Basin (FCB) Spring Breakup 2011 Hydrologic Assessment conducted by Michael Baker Jr., Inc. for ConocoPhillips Inc., Alaska. The assessment supports the Alpine Satellite Development Project.

Observations and measurements were recorded at sixteen locations associated with the proposed Greater Moose's Tooth (GMT) 1 and GMT2 access road corridor, and the proposed Clover Material Source (CMS) area. All the monitored locations lie within the FCB of the National Petroleum Reserve, Alaska, although no measurements were taken on Fish Creek itself. The sixteen monitoring locations included:

- Seven sites at the two CMS drainages (Clover B , Clover C)
- Two Ublutuoch River (UB) locations near the CMS drainages' confluences (UB11.45, UB11.6)
- Three small stream (S) crossings along the GMT1 access road corridor (S3, S4, S5)
- Three Ublutuoch River locations at the proposed GMT1 road crossing (UB6.7, UB6.8, UB6.9)
- One drainage in the proximity of proposed the GMT2 pad (GMT2)

The 2011 FCB breakup was characterized by relatively low water surface elevations (WSE) on the streams throughout the monitoring area. The 2011 Ublutuoch River peak WSE (peak stage) and estimated peak discharge was comparable to previously recorded observations.

The 2011 peak WSE at the proposed Ublutuoch River road crossing (UB6.8) occurred at midday on June 2 and was 9.39 feet British Petroleum Mean Sea Level (BPMSL). This was approximately 1 foot lower than the maximum peak observed at that location over the historical record. The peak WSE recurrence interval is approximately 2 years, based on the current stage frequency analysis, last updated in 2009. The timing of the 2011 peak of the Ublutuoch River, based on the nine-year period of record, was earlier than the historical average by about 2 days.

The 2011 UB6.8 peak discharge occurred during peak stage on June 2. The peak discharge estimate is 2,350 cubic feet per second which corresponds to a recurrence interval of less than 2 years, based on the current flood frequency analysis, last updated in 2009.

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Acronyms and Abbreviations

ADP	Alpine Development Project
ASDP	Alpine Satellite Development Plan
BPMSL	British Petroleum Mean Sea Level
Baker	Michael Baker Jr., Inc.
CD	Colville Delta
cfs	cubic feet per second
CMS	Clover Material Source
CPAI	ConocoPhillips, Alaska, Inc.
CRD	Colville River Delta
EOW	Edge of Water
FCB	Fish Creek Basin
FEMA	Federal Emergency Management Agency
fps	feet per second
GMT1	Greater Moose's Tooth 1
GMT2	Greater Moose's Tooth 2
GPS	Global Positioning System
HWM	High Water Mark
NAD83	North American Datum of 1983
NPR-A	National Petroleum Reserve, Alaska
OSW	Office of Surface Water
PT	Pressure Transducer
PND	PND Engineers, Inc.
RM	River Mile
TBM	Temporary Benchmark
UB	Ublutuoch River
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WAAS	Wide Area Augmentation System
WSE	Water Surface Elevations

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Section 1 Introduction

The Fish Creek Basin (FCB) Spring Breakup 2011 Hydrologic Assessment supports the Alpine Satellite Development Project (ASDP). Michael Baker Jr., Inc. (Baker) conducted monitoring at sixteen locations within the eastern portion of the FCB in the National Petroleum Reserve-Alaska (NPR-A) for ConocoPhillips Inc., Alaska (CPAI). Monitoring was conducted at locations along the proposed Greater Moose's Tooth (GMT) 1 and GMT2 access road corridors and in the Clover Material Source (CMS) area. Results of the 2011 spring breakup monitoring activities and historical trends are presented in this report.

Figure 1.1 shows the Colville River and Fish Creek basins, and the Ublutuoch River sub-basin, drainage delineations. Figure 1.2 shows the location of the proposed GMT1 and GMT2 pads and access road corridor in relation to the Colville River Delta (CRD) and other proposed and existing Alpine facilities.

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

The proposed GMT1 and GMT2 drilling pads would be accessed via gravel roads. The proposed GMT1 access road begins at the west end of the proposed CD5 access road and extends approximately 8 miles west to the pad location. The proposed GMT2 access road begins approximately 1 mile northeast of the GMT1 pad and extends an additional 8 miles southwest, terminating at the GMT2 pad. The GMT1 and GMT2 proposed road alignments cross the Ublutuoch River and several small drainages. The CMS lies approximately 4 miles south of the proposed CD5 pad and 6 miles east of the proposed GMT1 pad.

Many areas on the North Slope of Alaska, including the 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, oilfield 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 and 2011 spring breakup, a limited smaller scale field program was conducted at key locations along the proposed road corridors.

Observations and measurements for the 2011 FCB spring breakup hydrologic assessment were recorded at sixteen locations:

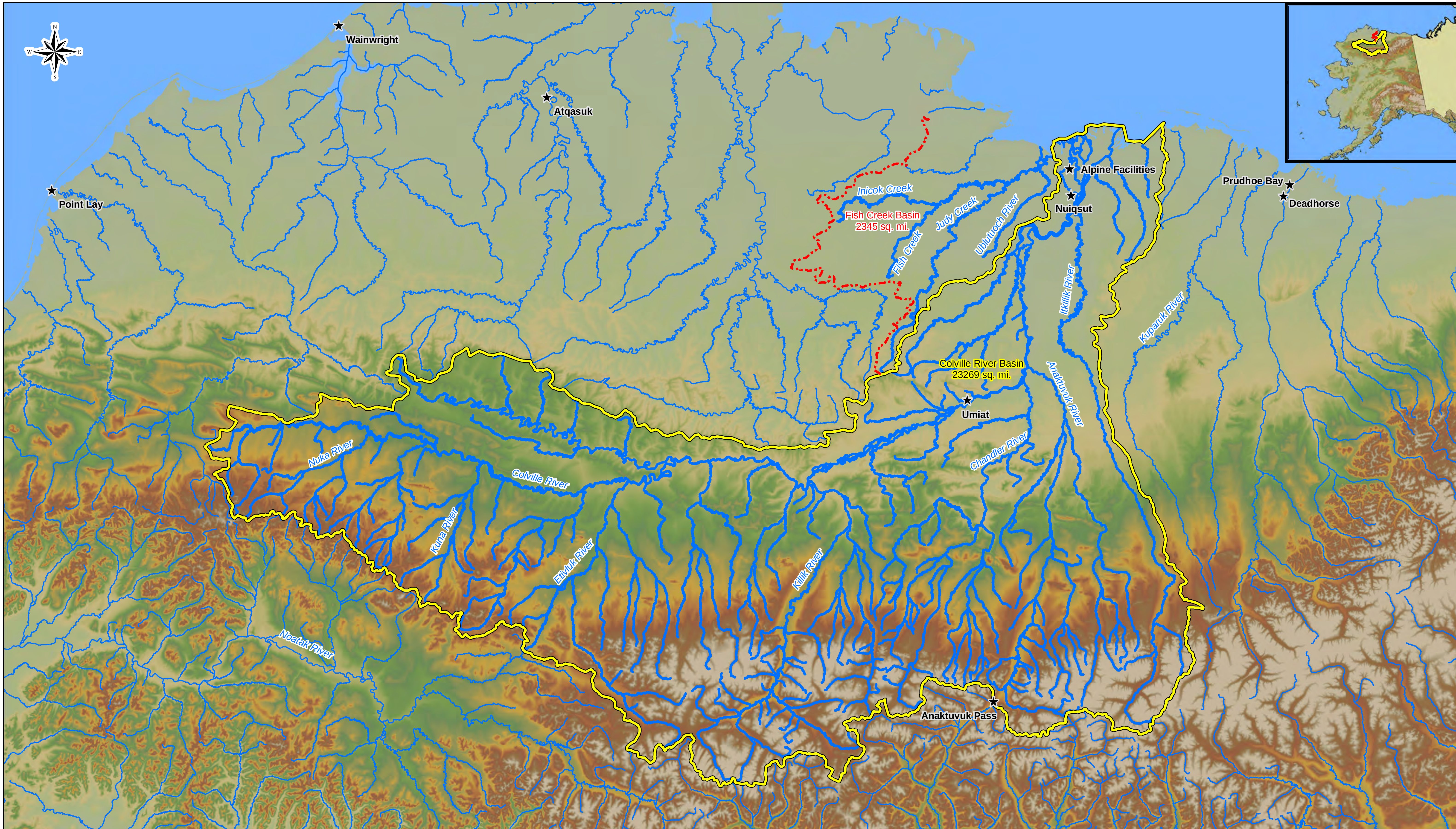
- Seven sites at the two CMS drainages (Clover B , Clover C)
- Two Ublutuoch River locations near the CMS drainages' confluences (UB11.45, UB11.6)
- Three small stream crossings along the GMT1 access road corridor (S3, S4, S5)
- Three Ublutuoch River locations at the proposed GMT1 road crossing (UB6.7,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

Fieldwork began with setup on May 4. Monitoring was completed by June 8 at all locations except the CMS drainages which continued post-breakup every two weeks until July 19. This monitoring was conditional on the presence of flow in the drainages, and totaled three biweekly post-breakup events. Figure 1.3 illustrates the 2011 monitoring locations.

This report presents the results of the 2011 FCB spring breakup monitoring program.

- Section 1, Introduction: discusses the objectives of the monitoring program and historical overview of the Ublutuoch River breakup
- Section 2, 2011 Monitoring Locations: outlines and discusses the 2011 monitoring sites
- Section 3, Methods: describes the methods used to collect and analyze the data
- Section 4, 2011 FCB Spring Breakup Hydrologic Observations: presents summaries of observations, stage, and discharge results for the assessment
- Section 5, Flood and Stage Frequency Analysis: presents the results of the flood frequency analysis for the Ublutuoch, S4 and S5 locations and the stage frequency analysis for the Ublutuoch River
- Section 6, References: contains the references used in the development of this report

UMIAQ (LCMF), Inc., and Bristow Helicopters provided assistance with the water resources fieldwork and contributed to a safe and productive breakup monitoring season.



ConocoPhillips Alaska

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Legend

- ★ Place Names
- Streams
- Fish Creek Basin
- Colville River Basin

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Fish Creek Basin & Colville River Basin Delineations

FIGURE: 1.1

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Legend

- Existing Roads
- Proposed Roads
- Alpine Sales Pipeline
- Mine Source
- Existing Facilities
- Proposed Facilities
- NPRA Boundary

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2011 Existing & Proposed Facilities

CRD & FCB

FIGURE: 1.2

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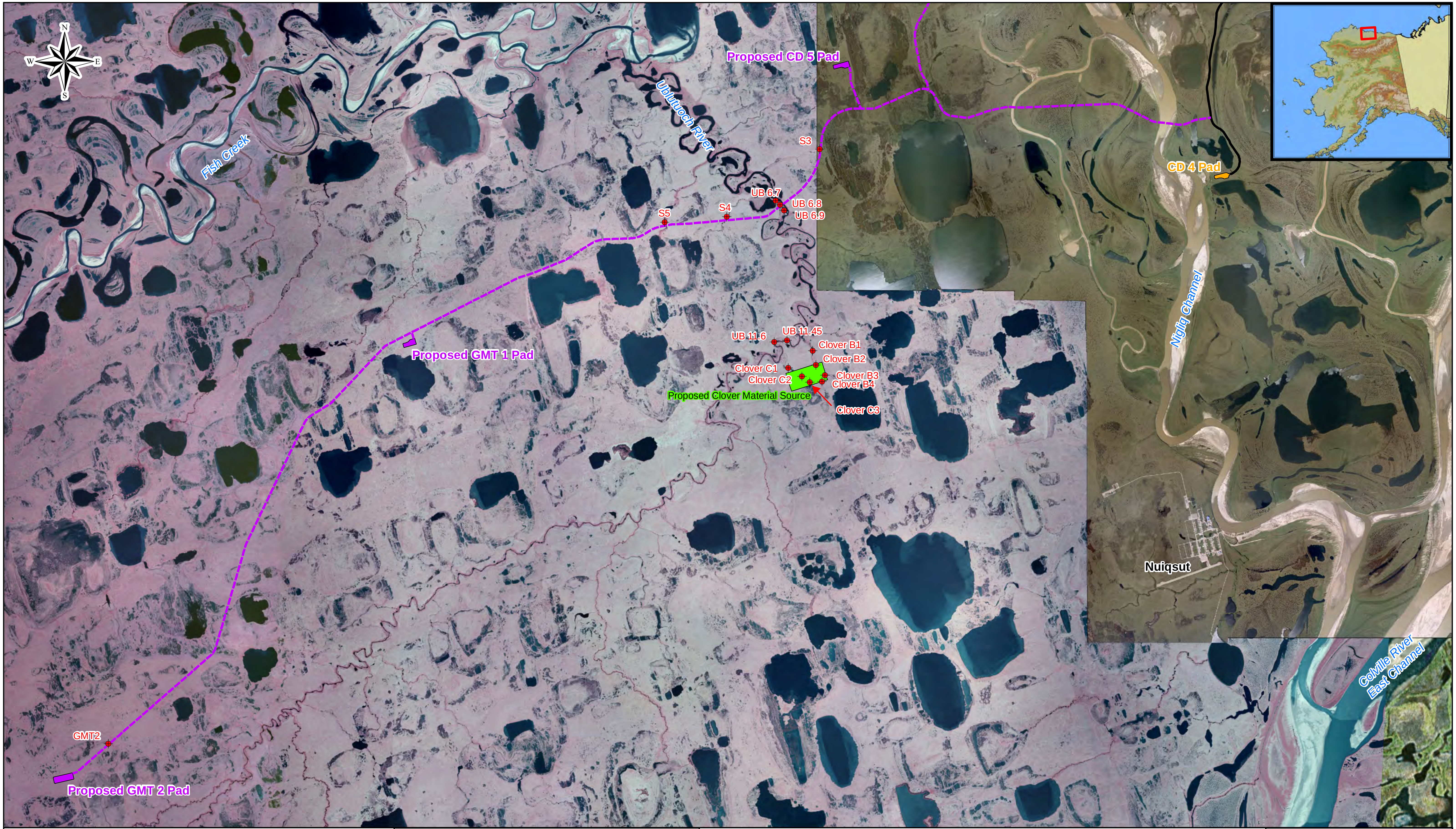

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Legend

- Gage Location
- Existing Roads
- Proposed Roads
- Material Source
- Existing Facilities
- Proposed Facilities

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2011 FCB Breakup

Monitoring Locations

FIGURE: 1.3

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1.1 2011 Monitoring Objectives

The primary objective of the 2011 FCB spring breakup program was to monitor and estimate the magnitude of breakup flooding at select locations in the FCB. The objective was accomplished by visually observing breakup events and floodwater distribution, measuring water levels at specific drainages, and collecting discharge measurements.

1.2 Ublutuoch Historical Breakup Overview

The Ublutuoch River lies in the southeast portion of the FCB. The river is sinuous with a low gradient, generally flowing north into Fish Creek at a location approximately 10 river miles upstream of Harrison Bay. The channel is characterized by numerous meander bends, often with undercut banks and associated bank sloughing along the outer edges.

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 1.1 presents the annual peak discharge, peak stage, and timing for the nine years of available data.

Based on the nine-year data record, the average date of peak discharge is June 4, and the average date of peak stage is June 3. Peak discharge and peak stage for 2011 were both estimated to have occurred on June 2.

Table 1.1: Timing of Ublutuoch River Historical Peak Discharge and Water Surface Elevation

Year	Location (RM)	Discharge		WSE		Reference
		Peak Discharge (cfs)	Date	Peak WSE (feet BPMSL)	Date	
2011	6.8	2,350	2-Jun	9.39	2-Jun	This report
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

Notes:
RM - River miles
cfs - cubic feet per second
WSE - water surface elevation
BPMSL - British Petroleum Mean Sea Level

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Section 2 2011 Monitoring Locations

Monitoring locations were selected 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.

In 2009, general visual observations were made during breakup in the CMS. Discharge and WSE data was collected at four drainages within and near the CMS in 2010. CMS boundary changes necessitated an adjustment to the number and location of monitoring sites, which were renamed for clarity in 2011. Five monitoring sites within the newly defined CMS were added in 2011 to better measure local hydrology. Two new sites, at river mile (RM) 11.45 and 11.6 on the Ublutuoch River (UB11.45 and UB11.6) were also monitored. These locations represent the limits of the most confined reach of the Ublutuoch River adjacent to the CMS drainages. Ublutuoch River monitoring sites are identified based on their upstream proximity in river miles to the Fish Creek confluence.

Small streams S3, S4, and S5 were included in the 2011 monitoring program, all of which are located along the proposed GMT1 road. In addition, the proposed bridge crossing at the Ublutuoch River (UB6.8), locations upstream (UB6.9) and downstream (UB6.9), and a small drainage near the GMT2 pad (GMT2) were monitored in 2011.

Table 2.1 shows the 2011 monitoring locations as compared to 2010, including the updated site names. Coordinates for each monitoring site are located in Appendix A. Table 2.2 shows the 2011 monitoring locations and the number of gages located at each site.

Table 2.1: 2010 and 2011 Fish Creek Basin Monitoring Locations

Location Type	2010 Name	2011 Name
CMS	CMS2-B	Clover B1
	-	Clover B2
	-	Clover B3
	-	Clover B4
	CMS2-C	Clover C1
	-	Clover C2
	-	Clover C3
	CMS2-A	-
	CMS1-A (Bill's Creek)	-
GMT2 Drainage	GMT2	GMT2
Ublutuoch River	UB 6.7	UB 6.7
	UB 6.8	UB 6.8
	UB 6.9	UB 6.9
	-	UB 11.45
	-	UB 11.6
Small Streams	-	S3
	-	S4
	S5	S5

Table 2.2: 2011 Fish Creek Basin Monitoring Sites

Location Type	Site	Number of Gages
CMS	Clover B1	2
	Clover B2	1
	Clover B3	1
	Clover B4	1
	Clover C1	1
	Clover C2	1
	Clover C3	1
GMT2 Drainage	GMT2	1
Ublutuoch River	UB 6.7	4
	UB 6.8	4
	UB 6.9	3
	UB 11.45	4
	UB 11.6	4
Small Streams	S3	1
	S4	3
	S5	3
Total	**16**	**35**

2.1 Clover Material Source Drainages and Ublutuoch River 11.45 and 11.6

Seven CMS locations were selected for monitoring in 2011. The seven sites were selected as representative of the two drainages, identified as Clover B and Clover C, running through the material source area. The seven CMS gage locations were established based on topography, aerial imagery, and 2010 breakup observations. Figure 1.3 shows the CMS breakup gage locations within the FCB monitoring area. Figure 2.1 shows a detail of the 2011 CMS monitoring locations and their proximity to the Ublutuoch River and the CMS boundary.

For 2011, two new locations on the Ublutuoch River near the CMS were identified for monitoring, UB11.45 and UB11.6. The locations were selected because of their proximity to the CMS drainages and channel geometry.

2.1.1 Clover B1, B2, B3, and B4

Photo 2.1: Typical vegetation found in Clover B drainage, photo taken in vicinity of B1; July 19, 2011

FCB monitoring sites Clover B1, B2, B3, and B4 are located within the same unnamed beaded stream, which is 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 (Photo 2.1). The confluence with the Ublutuoch River lies approximately 0.2 miles downstream from the Clover B1 gage location, at Ublutuoch RM 11.1.

Clover B1, B2, and B3 were placed within the main channel of the drainage and Clover B4 was placed in a tributary. A minimum of one gage was established at each site, and more gages were added if conditions warranted as discussed in Section 3.2.1.

The Clover B1 gages are the farthest downstream, located approximately 900 feet north-northwest and outside of the proposed CMS boundary. This is the closest Clover B monitoring location to the Ublutuoch River.

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 is located approximately 1,000 feet upstream of Clover B2 and lies on the southeastern edge of the CMS boundary. Clover B3 is the farthest upstream gage in the main channel of this drainage.

The Clover B4 gage is located in a tributary approximately 1,400 feet upstream from Clover B2. Clover B4 is on the southern edge of the CMS boundary.

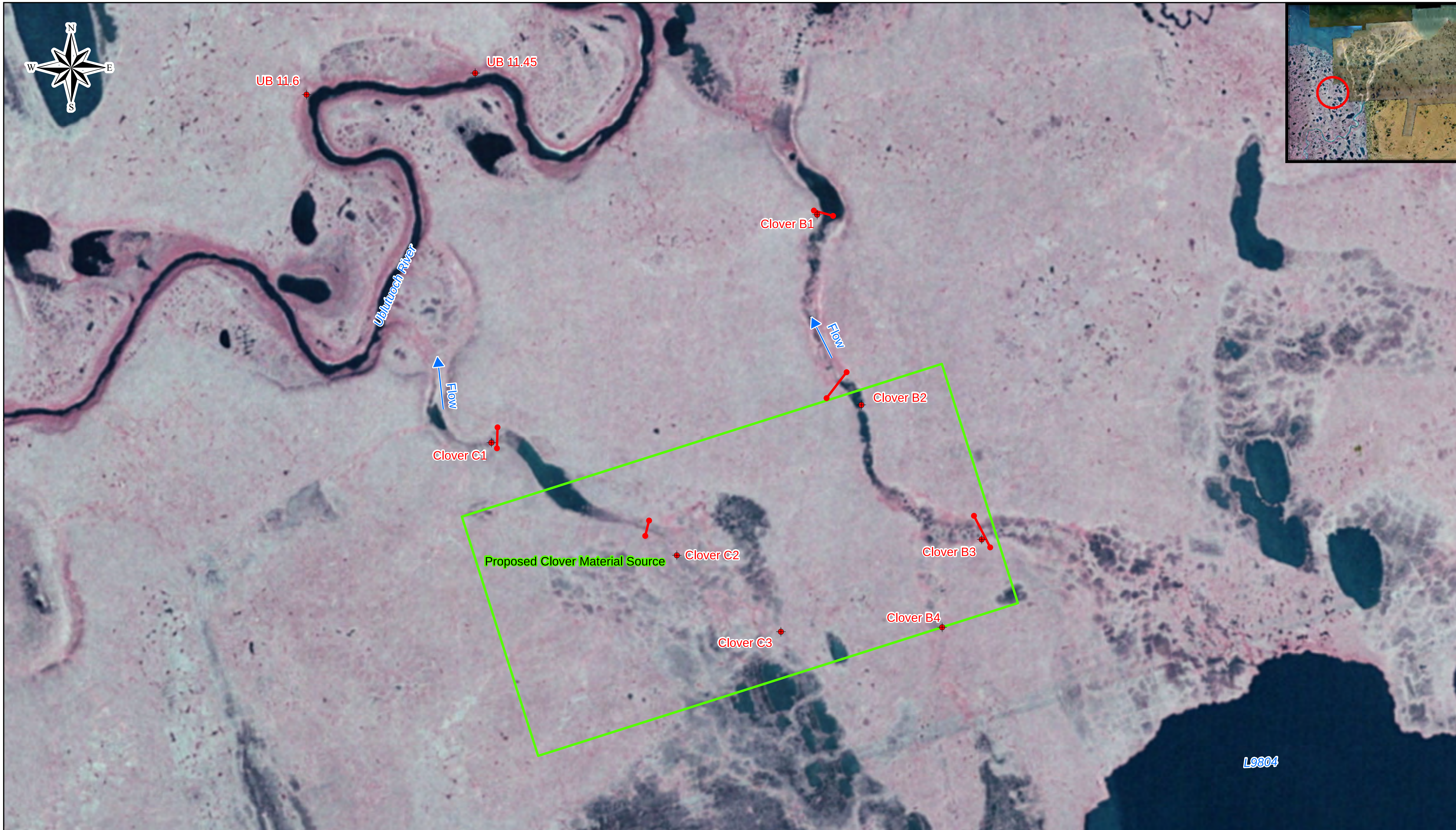
2.1.2 CLOVER C1, C2, AND C3

Clover C1, C2, and C3 are all located within the same unnamed stream which is identified for the purposes of this monitoring report as Clover C. Clover C flows north though the western portion of the proposed CMS and lies 0.17 miles upstream of the Ublutuoch River. The drainage was well-defined during breakup, and later in the season definition diminished as flow ceased. Some ponds in the vicinity of the C1 gage, like the one in Photo 2.2, had a water depth of 0.30 feet when monitoring ended on July 19. Tussocks and native grasses cover both overbanks, with native grass in the channel. The confluence with the Ublutuoch River lies 0.2 miles downstream from the Clover C1 gage location, at Ublutuoch RM 11.9.

Photo 2.2: Pond in the tundra in the vicinity of Clover C1 after flow has ceased; June 21, 2011

One gage was established at each site, and additional gages were not required for monitoring. The Clover C1 gage is located farthest downstream, approximately 350 feet northwest and outside of the proposed CMS boundary. The C1 gage site is about 800 feet from the Ublutuoch River confluence.

The Clover C2 gage is located approximately 1,300 feet upstream of the Clover C1 gage and 750 feet downstream of the Clover C3 gage. Clover C2 lies within the CMS boundary approximately 650 feet south of the northwestern limit.



ConocoPhillips Alaska

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Legend

- Gage Location
- Discharge Measurement
- Material Source

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2011 FCB Breakup

Clover Material Source

Monitoring Locations

FIGURE: 2.1

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The Clover C3 gage is located within the CMS boundary approximately 800 feet from the southeastern boundary and 750 feet upstream of Clover C2. The Clover C3 gage is located the farthest upstream in this drainage.

2.1.3 Ublutuoch River 11.45 and 11.6

The Ublutuoch River monitoring sites, UB11.45 and UB11.6, are new for 2011 and were comprised of four gages installed on the west bank of the river at each location, as shown in Figure 2.1. 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.

2.2 Greater Moose's 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, and an additional 8.3 miles southwest to the GMT2 pad. Between the CD5 access road and GMT1, the road alignment traverses the Ublutuoch River as well as several small drainages.

The 2011 GMT1 road corridor gage sites focused on six locations:

- Three gage sites at the proposed Ublutuoch River bridge site (UB6.7, UB6.8, UB6.9)
- Three gage sites at the additional proposed drainage structure locations identified as small streams (S3, S4, and S5)

The proposed GMT1 access road alignment was provided by PND Engineers, Inc. (PND).

2.2.1 Ublutuoch River 6.7, 6.8, and 6.9

Photo 2.3: Gages at UB6.9, Gage A is closest to the channel (background), looking east; May 7, 2011

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, as shown in Figure 2.1 and presented in Photo 2.3. The RM location designations, UB6.7, UB6.8, and UB6.9, refer to the distance in river miles 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 conditions of the proposed crossing. The proposed Ublutuoch bridge location at UB6.8 remains the same as it was in 2005, 2006, and 2010. At the proposed bridge site, the Ublutuoch River has a drainage area of approximately 228 square miles. The Ublutuoch River drainage basin is included in Figure 1.2.

2.2.2 Small Stream Crossings

In 2011, three small streams, S3, S4, and S5, 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 stream gage locations monitored in 2011 are shown in Figure 2.3 through Figure 2.5.

2.2.2.1 Site S3

The S3 stream consists of a series of polygons interlaced with shallow channels that drain a 0.9 square mile area into the Ublutuoch River over a distance of 0.27 miles (Photo 2.4). S3 is located west of Lake L9308 and flows west toward Ublutuoch River. Tussocks are abundant in the area.

Photo 2.4: Stream S3 defined by flow through series of polygons – channel slope is from right to left in photo, looking north; June 9, 2011

Channelized flow was not present at S3 during spring breakup monitoring in 2009 and 2011. This location was not monitored in 2010. Culverts are proposed as drainage structures for this GMT1 road crossing location. A single gage was placed at S3. See Figure 1.3 for the S3 monitoring site in reference to the FCB and Figure 2.3 for details.

2.2.2.2 Site S4

Photo 2.5: Flow in S4 during breakup monitoring, looking southeast; June 6, 2011

Site S4 bisects a channel of beaded streams that drain a small sub-basin composed of 0.7 square miles of ponds and marshes. Grassy swales of fairly uniform topography define the channel of connected pools draining northeast into the Ublutuoch River. Native grass dominates the area with the presence of tussocks limited to regions bordering the channel reach.

Channelized flow was present at S4 during spring breakup monitoring in 2005, 2006, 2009, and 2011 (Photo 2.5). This location was not monitored in 2010. Culverts are proposed as drainage structures for this GMT1 road crossing location. Three gages were placed at this site, one at the proposed road crossing centerline (S4-B), one approximately 330 feet upstream (S4-C), and one approximately 300 downstream of the crossing (S4-A). The purpose of the configuration of the gages at S4 was to facilitate the calculation of indirect discharge. See Figure 1.3 for the S4 monitoring locations in reference to the FCB, and Figure 2.4 for details.

2.2.2.3 SITE S5

The 3.6 square mile drainage basin of S5 flows northeast into the Ublutuoch River via connected pools, small ponds, and lakes. The drainage at S5 connects two smaller lakes and is uniform in cross-section, having a firm channel bed with underlying sedge and banks dominated by willows.

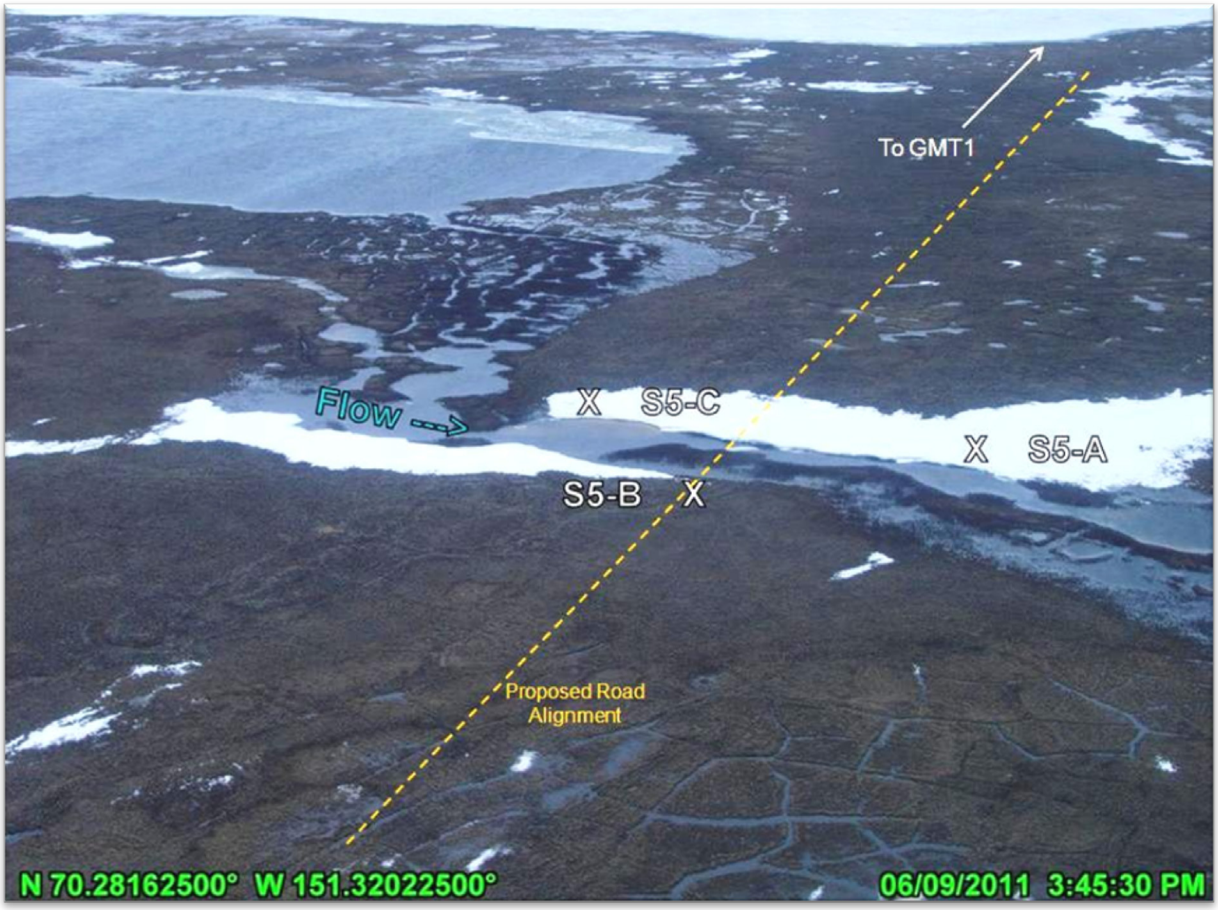
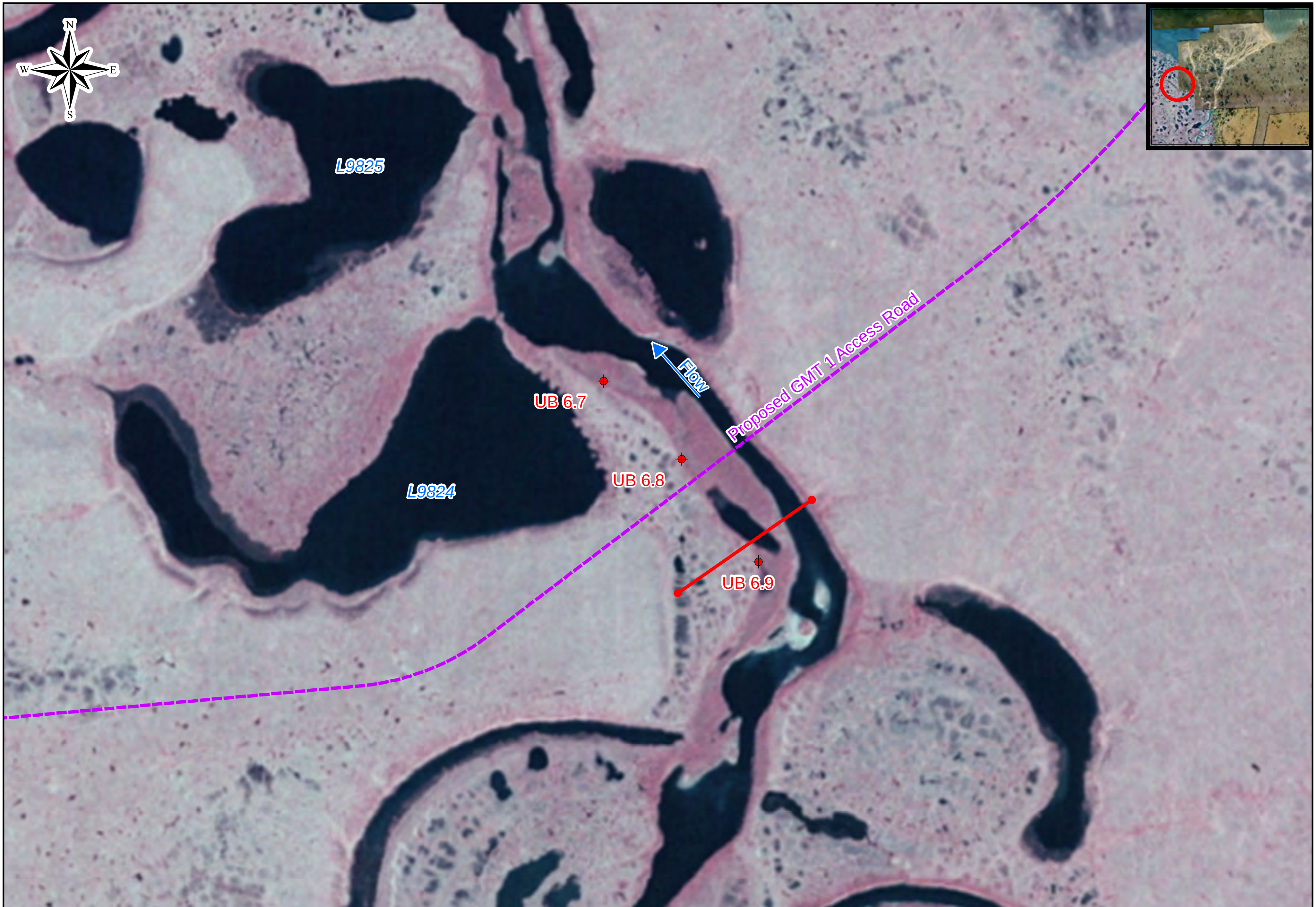


Photo 2.6: GMT 1 road crossing at S5, looking west; June 9, 2011

Channelized flow was present at this location during spring breakup monitoring in 2005, 2006, 2009, 2010, and 2011. A bridge is proposed as the drainage structure for this road crossing location. Three gages were placed at this site, one at the proposed bridge crossing centerline (S5-B), one gage approximately 200 feet upstream (S5-C), and one approximately 250 feet downstream of the crossing (S5-A). The configuration of the gages at S5 facilitates the calculation of indirect discharge. See Figure 1.3 for the S5 monitoring location in reference to the FCB, and Figure 2.5 for details.



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Legend

- Gage Locations
- Discharge Measurement
- Existing Roads
- Proposed Roads

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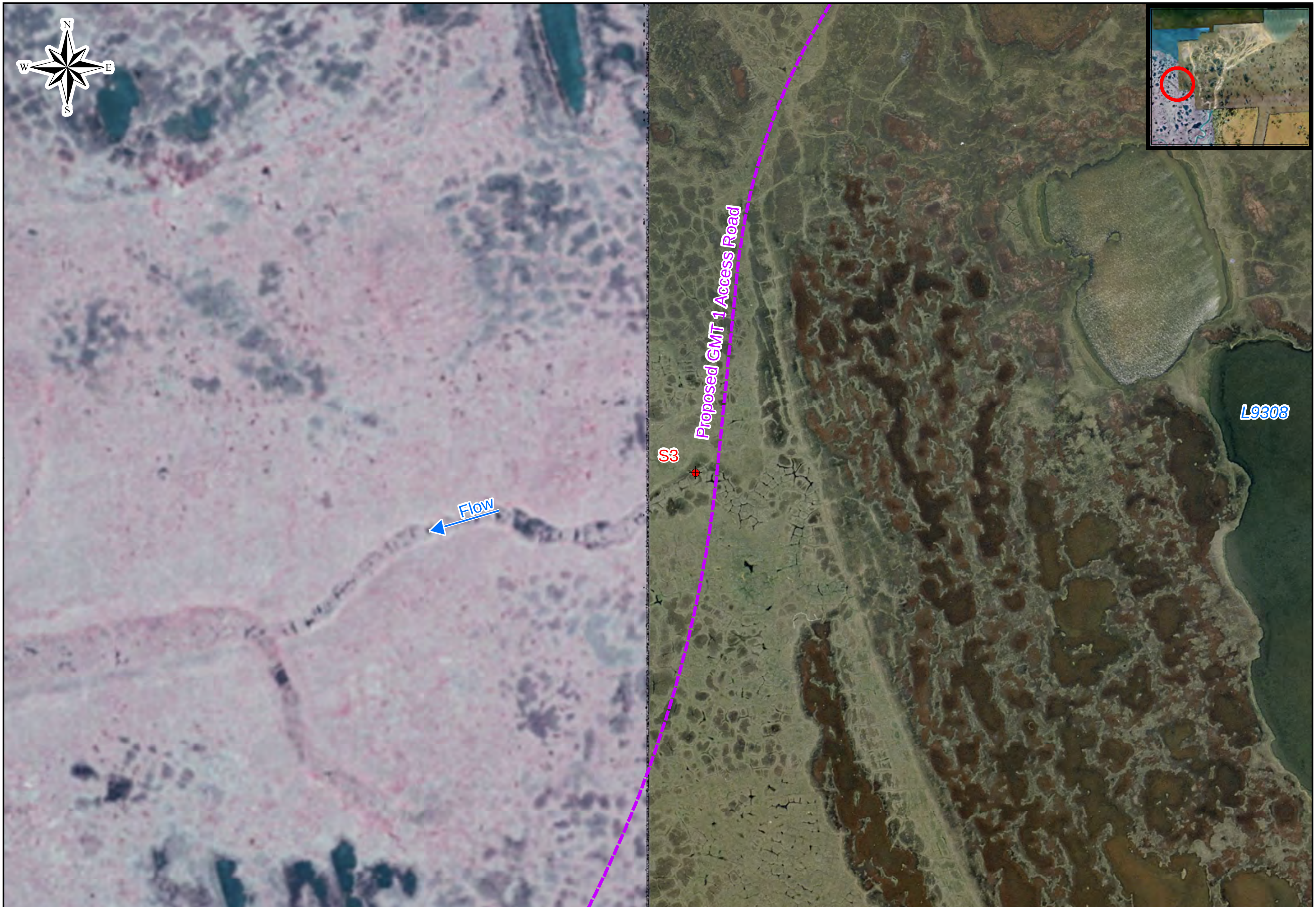
2011 FCB Breakup
Ublutuoch River
Road Crossing
Monitoring Locations

FIGURE: 2.2

(SHEET 1 of 1)



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Legend

Gage Locations
Existing Roads
Proposed Roads

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2011 FCB Breakup
S3
Monitoring Location

FIGURE: 2.3

(SHEET 1 of 1)

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Date:	10/14/2011	Project:	124033
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Legend

- Gage Locations
- Discharge Measurement
- Existing Roads
- Proposed Roads

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2011 FCB Breakup
S4
Monitoring Locations

FIGURE: 2.4

(SHEET 1 of 1)

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Feet
0 250 500

Date:	10/14/2011	Project:	124033
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Legend

- Gage Locations
- Discharge Measurement
- Existing Roads
- Proposed Roads

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2011 FCB Breakup
S5
Monitoring Locations

FIGURE: 2.5

(SHEET 1 of 1)

2.3 GREATER MOOSE'S TOOTH 2 ROAD CORRIDOR

The 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. During the 2010 spring breakup monitoring, channelized flow through the drainage was observed at the gage site and WSE were monitored. This shallow drainage is poorly defined.

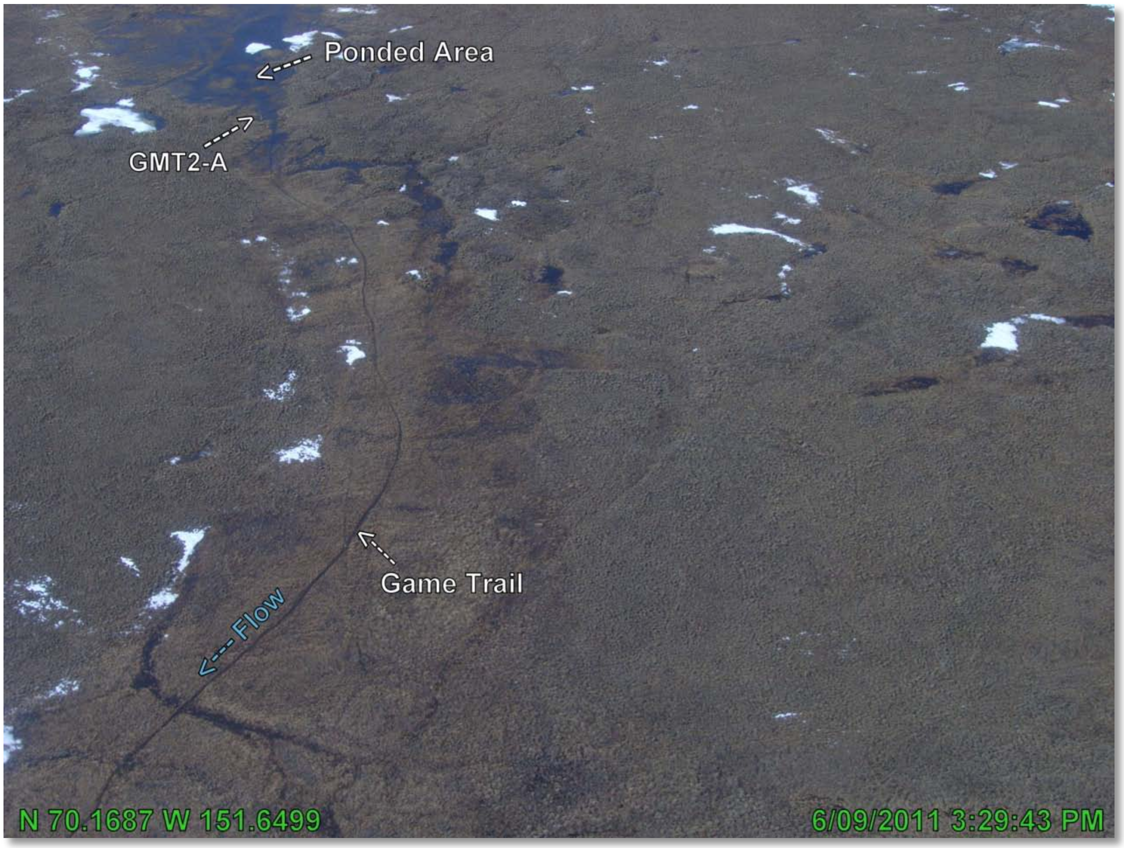
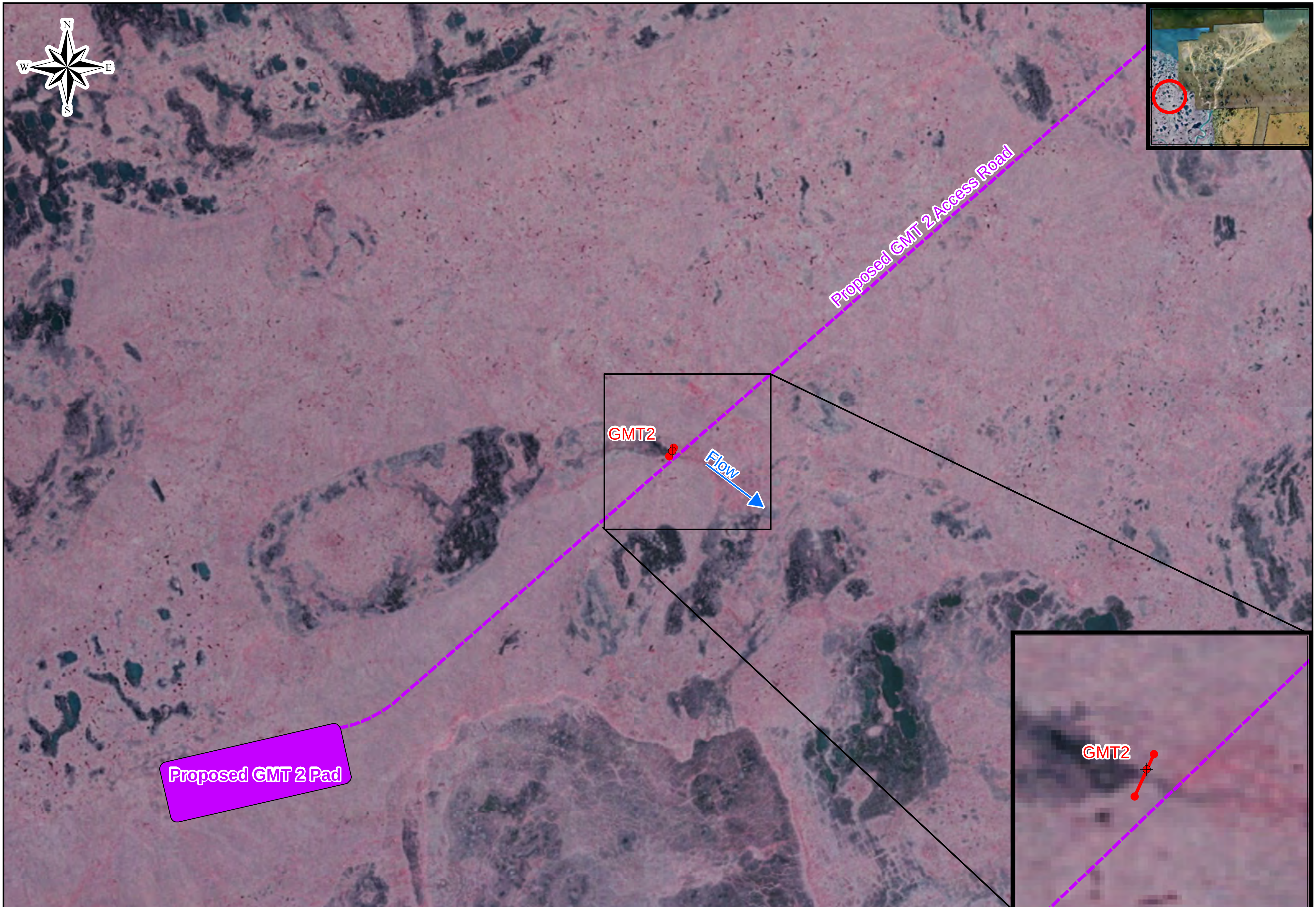


Photo 2.7: GMT2 Gage – Game trail downstream of gage and ponded area upstream of gage, looking north; June 9, 2011

Monitoring at the GMT2 location continued in 2011. The drainage at this location was well defined during breakup when channelized flow was present; later in the season flow ceased. Upstream of the GMT2 gage, the channel appeared to be confined to a game trail. Downstream of the gage, the channel widens into a large ponded area. When monitoring ended on July 19, 0.2 feet of water remained in the marshy ponded area by the gage. Tussocks and native grasses cover both overbanks and the channel. Figure 2.6 shows the location of the GMT2 gage.



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Legend
- Gage Locations
- Existing Roads
- Proposed Roads
- Discharge Measurement
- Existing Facilities
- Proposed Facilities

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2011 FCB Breakup
GMT2 Drainage
Gage Location

FIGURE: 2.6

(SHEET 1 of 1)

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Section 3 Methods

The primary methods used to assess the extent and magnitude of the 2011 FCB spring breakup flood flow were visual observations of the distribution of flow, the recording of WSE, and the measurement of stream discharge. Field methods were based on standard techniques proven safe, reliable, efficient, and accurate for the conditions found in the FCB during spring breakup.

3.1 Visual Observations

Field observations were recorded daily in field notebooks. Progression of breakup prior to, during, and after peak flooding events was documented using digital cameras with global positioning capability. The geographic position of the camera in latitude and longitude (lat/long), date, and time were automatically imprinted onto each photo. As in past years, the photo datum is WGS 84. At times when the camera had difficulty locking on to a geographic position, the locations were manually geographically referenced, confirmed, and then imprinted onto each photograph.

3.2 Water Surface Elevation

WSE was obtained from staff gage readings and correlated with pressure transducer (PT) records. All monitoring sites had staff gages installed. PTs were installed at UB6.7, UB6.9, UB11.45, UB11.6, Clover B2, and Clover C2.

3.2.1 Staff Gages

Temporary staff gages consisted of one to four 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 (NAD83) with wide area augmentation system (WAAS) enabled allowing for 1 meter (3 feet) horizontal accuracy. Photo 3.1 shows a setup of four staff gage assemblies at site UB11.45 on the Ublutuoch River.

Photo 3.1: Staff gage setup at a site along the Ublutuoch River, looking south; May 21, 2011

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 has not been established (Clover sites, GMT2 pad, Ublutuoch River RM 11 locations), local control was assumed. These assumed elevations can 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. For each site, the most recent basis of elevation of vertical control was used. Level loop surveys were conducted between gages and control during pre-breakup setup between May 3 and May 7, 2011. Photo 3.2 shows the gage at Clover C3 being surveyed for elevation prior to breakup.

Photo 3.2: Surveying a gage in the CMS monitoring area for elevation prior to breakup, May 6, 2011

Photo 3.3: Chalking a gage to record high water mark, May 6, 2011

Gages were named based on the site location identification and their proximity to the channel. At locations where the stream bank elevation varied by more than three vertical feet or at locations that typically lost gages due to ice impacts, multiple gages were installed. At each site, gages are identified with alphabetical designations A, B, C, or D, with A being closest to the water's edge (e.g., UB6.8-A, UB6.8-B, UB6.8-C, and UB6.8-D). 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. At sites S4 and S5, gages were installed upstream (-C), centerline (-B) and downstream (-A) of the proposed road crossing. Gages were marked with environmental chalk to capture high water marks (HWM), as seen in Photo 3.3.

3.2.2 Pressure Transducers

PTs measure the absolute pressure imparted by the atmosphere and water at the sensor, allowing the depth of water above the sensor to be calculated. Each PT consists of a non-vented pressure sensor designed to collect and store pressure and temperature data at discrete pre-set intervals. Resulting data yield a more complete record of the fluctuations in WSE than can be captured by visual measurements alone. Additionally, the PTs record the time and elevation of peak stage. For locations with multiple PTs installed, the PTs provide a comprehensive record of the WSE gradient that is used to identify the time and approximate magnitude of the peak indirect discharge.

Photo 3.4: Barometric PT installed on UB6.8 Gage D, pre-breakup; May 23, 2011

Solinst® Levelogger Model 3001 PTs were installed at six gage locations: UB6.7, UB6.9, UB11.45, UB11.6, Clover B2, and Clover C2. The PT recorded pressure datum is the sum of the forces imparted by both 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 barometric pressure logger location was considered representative of the FCB. 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 though a functional test and calibration 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 during setup to establish a vertical datum using local control. For 2011, the PTs were programmed to collect absolute pressure and water temperature at 15-minute intervals from May 20 to August 8. They were retrieved from all locations by July 20, 2011.

3.3 DISCHARGE MEASUREMENTS

Discharge was measured directly and calculated indirectly based on field observations. Standard United States Geological Survey (USGS) midsection methods were used to measure discharge. When possible, velocity and discharge measurements were taken as close to the observed peak stage as possible to determine the peak direct discharge. Indirect discharges were calculated based on observed data.

Photo 3.5: Baker crew performing a direct discharge measurement at S5; June 4, 2011

3.3.1 USGS MIDSECTION TECHNIQUES – DIRECT DISCHARGE MEASUREMENT

Standard USGS midsection techniques (Rantz 1982) were used to measure direct discharge at the proposed GMT1 road Ublutuoch River bridge crossing location (UB6.8). A Price AA velocity meter was used to measure velocities at UB6.8. Measurements were taken using a sounding reel connected to a boat-mounted boom with a 30-pound Columbus-type lead sounding weight. A tag line was used to define the cross section and to delineate measurement subsections within the channel. The Price AA meter was rated by the USGS at the Office of Surface Water (OSW) Hydraulic Laboratory in 2011 prior to breakup. A spin test of the meter was successfully completed prior to the discharge measurement at the Ublutuoch River. To ensure accurate performance of meters, procedures outlined in OSW Technical Memorandum No. 99.06 (1999) were followed. Photo 4.60 shows this method being used at UB 6.8, the proposed bridge crossing site at the Ublutuoch River.

A Marsh-McBirney Flo-Mate 2000 portable velocity meter and USGS wading rod were used to measure direct discharge at Clover B1, B2, B3, C1, C2, GMT2, S4 and S5. A tag line was used to define the cross section and delineate measurement subsections within each channel. Photo 3.5 shows the discharge measurement at S5, the small stream site where a bridge crossing is proposed.

3.3.2 INDIRECT DISCHARGE CALCULATIONS

Indirect discharge calculations assume, open-channel conditions, stable channel geometry, and; when hydraulic gradient data isn't available for the slope area method, the calculation is based on the assumption that the measured average adjusted velocity taken during a direct discharge measurement is representative of the average velocity during peak stage. 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, measured velocities during these effected conditions may not be representative of velocities under open channel conditions.

For 2011, the indirect discharge calculations used each channel's physical characteristics as input variables. Indirect discharge calculations were performed for the nine locations where flow was observed.

Indirect calculations of peak discharge for the Ublutuoch River at UB6.8, S4 and S5 were performed 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 S4, S5 and the Ublutuoch River is based on cross sections surveyed by Kuukpik/LCMF in 2005.

Indirect calculations of peak discharge at Clover B1, B2, B3, C1, C2 and GMT2 were performed by correlating hydraulic depths observed during the direct discharge measurement and peak discharge conditions, and using velocities collected during the direct measurement. This velocity-area method assumes the average measured velocity varies little between the time of direct measurements and actual peak discharge. The assumption is valid if the observed increase in stage, and change in stage differential between upstream and downstream, is relatively low. For this reason, direct discharge measurements are collected as near to peak discharge as possible.

3.4 Flood and Stage Frequency Analysis Method

Flood and stage frequency analyses were performed at S4, S5, and UB6.8 in 2009 (Baker 2009a). The 2011 discharge data for S4, S5, and UB6.8, and stage data at UB6.8, was compared to the respective 2009 flood and stage frequency analysis results for these locations. A flood and stage frequency analyses was not performed in 2011 since an additional 2 years of data would likely not yield a significant change in the current recurrence interval values.

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Section 4 2011 FCB Spring Breakup Hydrologic Observations

This section presents the images, data, observations, and analyses results for the 2011 FCB spring breakup hydrologic assessment. Hydrologic data and observations were documented for GMT2, Ublutuoch River, and small streams between May 21 and June 9, and at CMS drainages until July 19, 2011.

An initial reconnaissance flight of the FCB was conducted on May 21 in conjunction with the installation of PTs for pre-breakup setup. Crews observed the degradation of snow and signs of local melt. Helicopter reconnaissance flights into the FCB were scheduled approximately every other day. During the May 30 reconnaissance flight, breakup flow was not observed at any monitoring location, but some local melt was present in the Ublutuoch River. Snow cover was estimated between 70 to 80 percent and becoming saturated. Daily breakup observations of the FCB started on June 1 when field crews observed the first signs of breakup flow along the proposed GMT1 road corridor and in the vicinity of CMS. Spring breakup monitoring of the FCB ended on June 21. Summer monitoring of CMS continued until July 19. A hydrologic timeline of spring breakup in the FCB is presented in Figure 4.1.

4.1 Clover Material Source Drainages and Ublutuoch River UB11.45 and UB11.6

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. The two drainages, Clover B and C, within CMS were monitored during spring breakup 2011.

Water surface data were obtained daily at all Clover B and Clover C gage locations between June 1 and June 6 while spring breakup flow was present. Additional site visits were conducted on June 9, June 21, July 5, and July 19. On July 19, low flow through pooled areas was present at Clover B1 and B2. Flow was determined to have ceased at Clover C2 by June 21 and by July 19 for Clover B3 and Clover C1. PT data were also collected for the Clover B and Clover C drainages. Direct discharge measurements were performed at Clover B and Clover C gage locations where flow was present on June 4, 2011.

Water surface data were obtained near CMS at the Ublutuoch River, UB11.45 and UB11.6, daily from June 1 through June 6 while spring breakup flow was present. PT data were also collected at each location. No discharge measurements were performed for this reach of the Ublutuoch River.

After the initial melt associated with warmer spring temperatures, breakup proceeded rapidly throughout the FCB until temperatures decreased on June 3. Snow cover was still intact over the majority of the area, and melting progressed more slowly until the end of the spring breakup monitoring period.

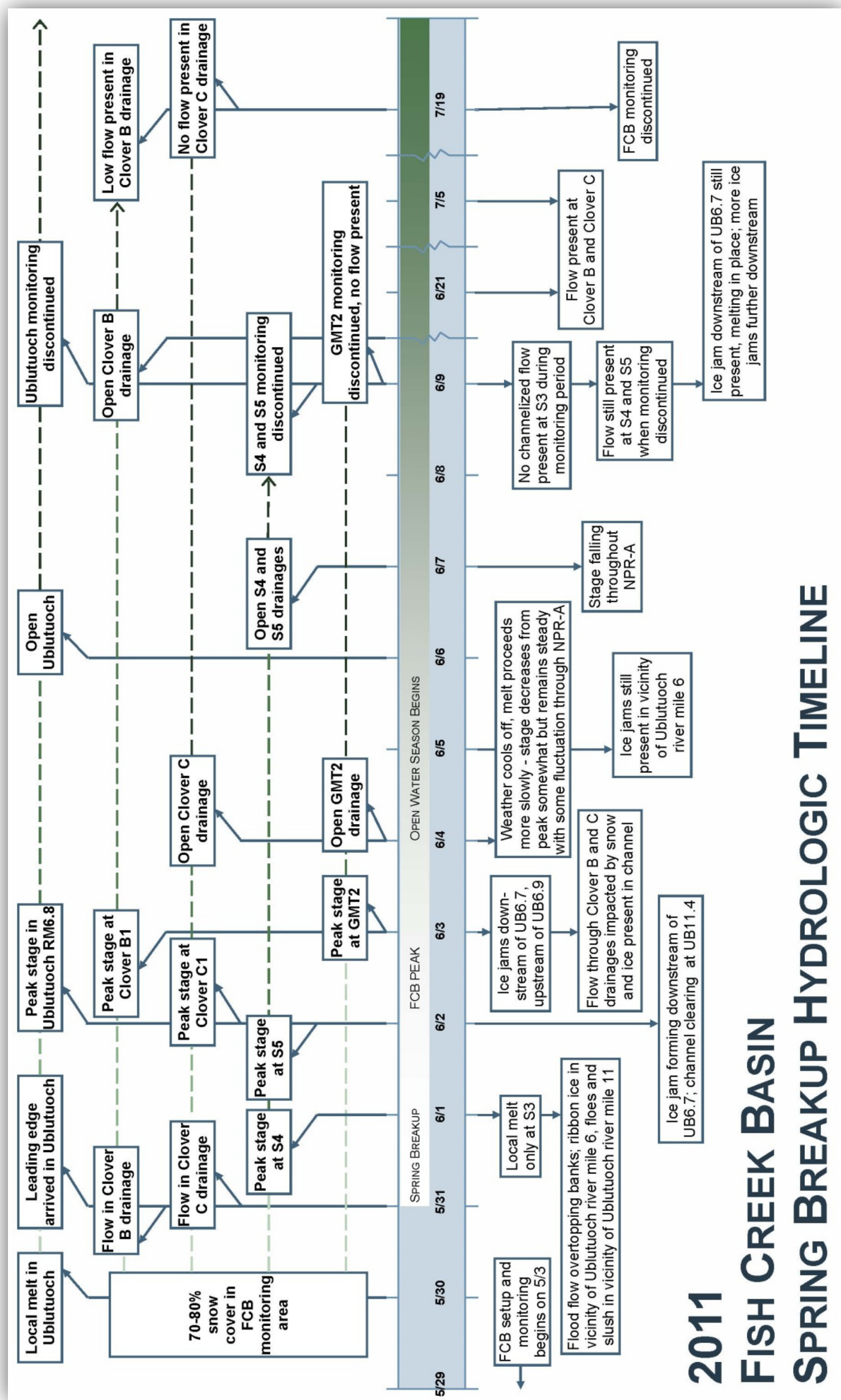


Figure 4.1: 2011 Fish Creek Basin Spring Breakup Hydrologic Timeline

4.1.1 Clover B Hydrologic Observations and Water Surface Elevation

Daily gage WSE data collection at Clover B sites began June 1. After breakup, monitoring continued at Clover B every two weeks until July 19. Flow was still present in this channel on July 19 when observations ceased. The Clover B2 PT recorded data between May 20 and July 20. Data were not recovered because of malfunctions likely related to freeze/thaw of water on the exposed PT sensor. Photo 4.1 shows the Clover B drainage on June 1. In the bottom left corner, Clover B is seen draining into the Ublutuoch River.

Photo 4.1: Clover B drainage at the beginning of spring breakup, looking upstream (southeast) from the Ublutuoch River; June 1, 2011

Significant snow was present in this drainage at the beginning of breakup, with the majority of accumulation at the downstream location, Clover B1 (Photo 4.2). Ice was observed on the channel bed and remained until June 6. Flow downstream of B1 appeared to pass through a confined artificial channel bound by snow. This snow lined channel was open on June 9 (Photo 4.3), but had melted significantly by June 21 (Photo 4.4). By June 21, there was some snow remaining on the right bank, but the stage had dropped and it did not appear to affect flow.

The descriptive terms right bank and left bank are relative to an observer looking downstream, in which the right bank is to the observer's right, and vice versa.

Photo 4.2: Clover B1 - Drainage flowing north into the Ublutuoch River during peak stage, looking northwest; June 3, 2011

Photo 4.3: Clover B1 – As breakup flood flow recedes, looking upstream (south) toward Clover B2; June 9, 2011

Photo 4.4: Clover B1 – After breakup; beaded pools with flow present, looking upstream (south) toward Clover B2; June 21, 2011

Photo 4.5: Clover B1 – After breakup; pool with flow, No Snow Present, looking east; July 5, 2011

By July 5, all snow in the vicinity of Clover B drainage had melted (Photo 4.5 and Photo 4.6). During final monitoring on July 19, the channel consisted of beaded pools, and low flow through grassy areas between the pools was still present (Photo 4.7).

At Clover B2, near the north edge of the CMS boundary, the channel was less confined by snow during breakup, but flow was still affected by shallow snowpack accumulation (Photo 4.8). Slush floes and bottom ice were observed in the channel until June 4, after which stage decreased and the channel opened. Photo 4.9 and Photo 4.10 show Clover B2 as breakup flood water receded. By June 21, no snow was present on either bank at Clover B2 (Photo 4.11).

Photo 4.6: Clover B1 – Low flow between pools still present draining towards the Ublutuoch River; July 5, 2011

Photo 4.7: Clover B1 – Pool with low flow at the end of monitoring, looking northwest; July 19, 2011

Photo 4.8: Clover B2 vicinity – After peak stage, looking downstream (north) toward Clover B1; June 3, 2011

Photo 4.9: Clover B2 – As breakup flood flow receded, looking east; June 6, 2011

By July 5, no snow was present in the area (Photo 4.12). During final monitoring on July 19, Clover B2 consisted of beaded pools with low flow present (Photo 4.13).

Photo 4.10: Clover B2 – As breakup flood flow recedes, looking upstream (southeast) toward Clover B3; June 9, 2011

Photo 4.11: Clover B2 – After breakup; beaded pools with flow present, looking upstream (southwest); June 21, 2011

Photo 4.12: Clover B2 – After breakup; beaded pools with flow present, looking upstream (southeast) toward Clover B3; July 19, 2011

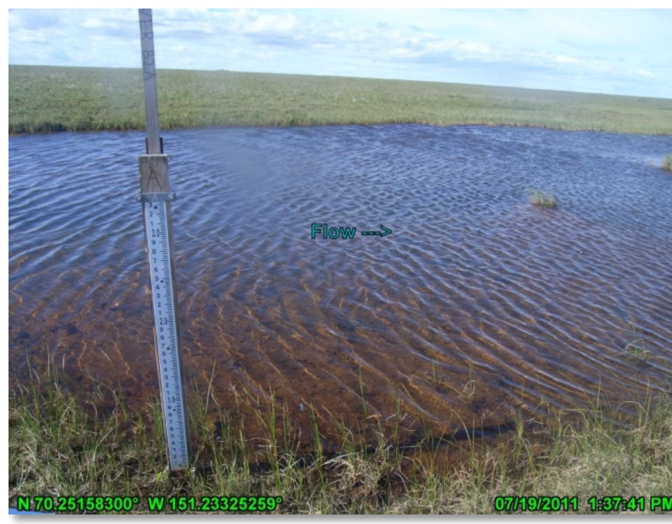


Photo 4.13: Clover B2 – Pool with low flow at the end of monitoring, looking west; July 19, 2011

Clover B3 during spring breakup was poorly defined because of the low topographic relief (Photo 4.14). At the beginning of monitoring on June 1, flow was divided into two distinct channels. By June 4 as stage decreased, flow had divided into multiple polygon cracks. No snow was present in the channel by June 4, and the majority of snow in the area had melted by June 6 (Photo 4.15). Photo 4.16 and Photo 4.17 show Clover B3 as breakup flow receded.

Photo 4.14: Clover B3 – After peak stage, looking east; June 3, 2011

Photo 4.15: Clover B3 – Flow in polygon cracks as stage drops, looking upstream (southeast) with Clover B4 site to the south; June 6, 2011

Photo 4.16: Clover B3 – Polygon crack as breakup flood flow recedes, looking upstream (east); June 9, 2011

Photo 4.17: Clover B3 – After breakup; polygon crack with small pools, flow present, looking downstream (west); June 21, 2011

On July 5, low flow was observed through a single polygon crack (Photo 4.18). During the final monitoring visit on July 19, the channel consisted of small ponds, marshy areas, and polygons. No visible flow was seen (Photo 4.19).

During the spring breakup monitoring period, no distinguishable channelized flood flow was observed at Clover B4 (Photo 4.20, Photo 4.21 and Photo 4.22). Collected WSE data at B4 was the result of local melt and overland sheet flow.

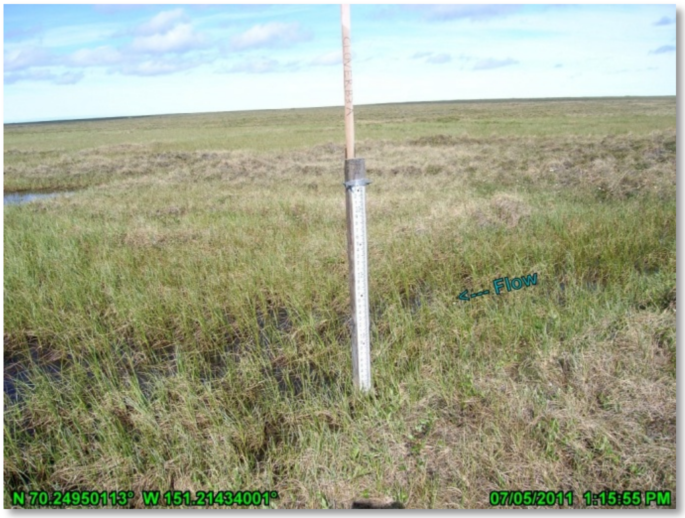


Photo 4.18: Clover B3 – After breakup; polygon crack with low flow, looking east; July 5, 2011

Photo 4.19: Clover B3 – Small ponds and marshy areas, no visible flow, looking downstream (north); July 19, 2011

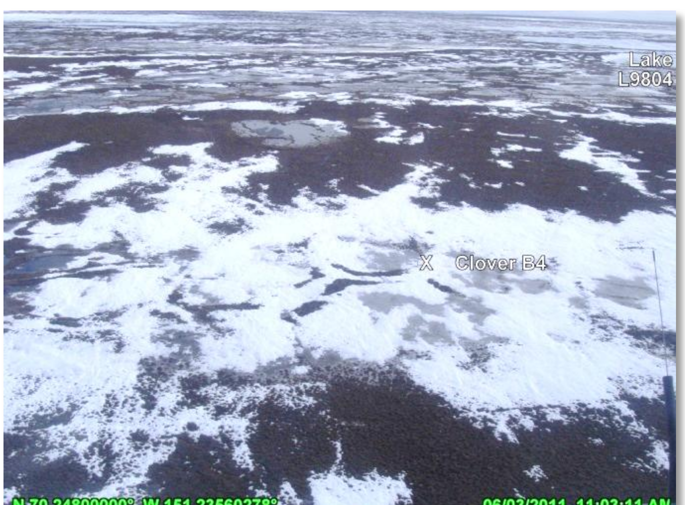


Photo 4.20: Clover B4 – Snow beginning to melt during breakup, no channelized flow, looking east; June 3, 2011

Photo 4.21: Clover B4 – Local melt, no channelized flow, looking upstream (southeast); June 6, 2011

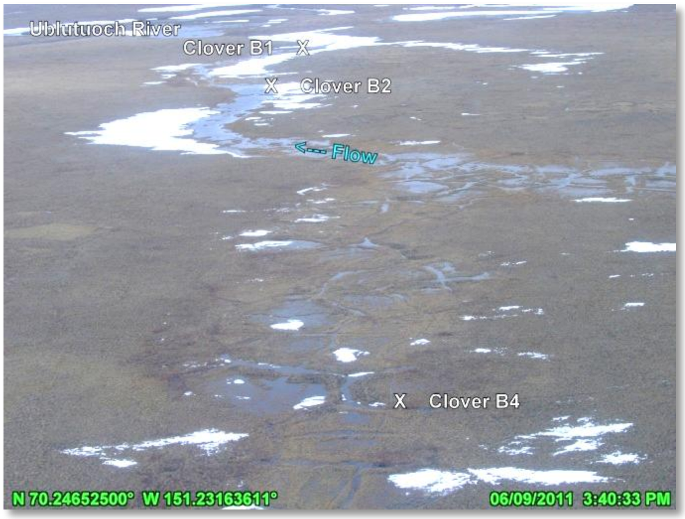


Photo 4.22: Clover B4 – Local melt, no channelized flow, looking downstream (north); June 9, 2011

Photo 4.23: Clover B4 – Small ponds and marshy areas, no flow, looking upstream (south); July 19, 2011

The majority of snow had melted by June 21. Small ponds of water were present at this location throughout the monitoring period including the final visit on July 19 (Photo 4.23).

Peak WSE based on assumed elevations from 2010 were measured at Clover B1 (June 3, 39.08 feet), Clover B2 (June 1, 43.63 feet) and Clover B3 (June 1, 46.67 feet). Throughout the monitoring period, stage at Clover B2 and B3 continued to decline after the initial readings. The observed peak WSE obtained at these locations maybe lower than the actual peak WSE. The hydrograph for Clover B monitoring sites is provided in Table 4.1. Clover B4 is not represented in Table 4.1 since measurable flow was not observed in this area.

Table 4.1: Clover B Water Surface Elevation

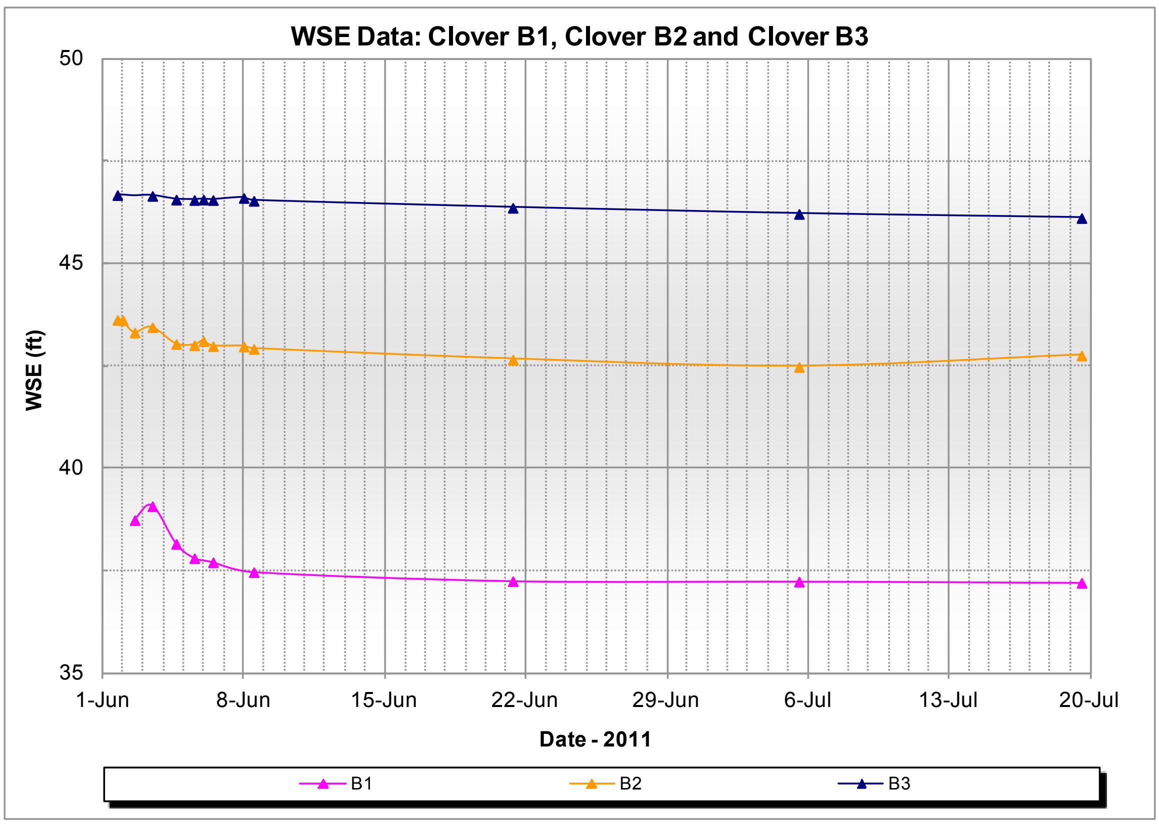
Date and Time	WSE (ft - assumed)			Observations
	B1	B2	B3	
6/1/11 5:30 PM	-	**43.63**	**46.67**	**Peak Stage Clover B2 and Clover B3**
6/2/11 12:00 AM	-	43.62	-	HWM - *time estimated*
6/2/11 2:05 PM	38.74	43.32	46.64	B1: narrow channel due to snow, bottom ice; B2: ice/snow; B3: divided channel
6/3/11 11:10 AM	**39.08**	43.45	46.65	**Peak Stage Clover B1**; weather cooling, breakup melt progressing less rapidly
6/4/11 3:30 PM	38.16	43.04	46.56	B1: sig. snow, bottom ice; B2: snow, ice-free bottom; B3: flow in polygon cracks
6/5/11 1:05 PM	37.81	43.01	46.55	B1: sig. snow; B2: snow, channel losing definition
6/6/11 12:00 AM	-	43.11	46.56	HWM - *time estimated*
6/6/11 11:20 AM	37.71	42.99	46.55	B1: significant snow, bottom ice-free; B2: some snow present; B3: less snow
6/8/11 12:00 AM	-	42.98	46.60	HWM - *time estimated*
6/8/11 11:55 AM	37.47	42.92	46.53	B1: significant snow both banks, flow; B2: less snow, flow; B3: less snow, flow
6/21/11 8:20 AM	37.25	42.66	46.36	B1: some snow in area, ponding, flow; B2: no snow, flow; B3: pond, low flow
7/5/11 1:05 PM	37.24	42.48	46.21	B1: no snow in area, pond, flow; B2: pond, light flow; B3: pond, low flow
7/19/11 1:30 PM	37.21	42.76	46.11	B1: pond, low flow; B2: pond, low flow; B3: sm pond, no flow

Notes:

1. Clover B1 is downstream, Clover B2 is midline at the CMS boundary and Clover B3 is upstream.

2. WSE are based on Baker CP3 and MEG at 48.000 and 46.984, respectively, established by Baker in 2010 using a handheld Garmin Rino 520HCx GPS. These elevations are not tied to any other monitoring locations, known survey control or feet BPMSL.

3. In 2011, there was no defined channel and no channelized flow present at Clover B4. WSE data collected at this location is the result of local melt or overland sheet flow and is not included in this table.



4.1.2 Clover B Discharge

4.1.2.1 Direct Discharge

Direct discharge measurements were performed at Clover B1, B2 and B3 on June 4 after peak stage. Discharge measurements are conducted as close to peak stage as possible. No measurable flow was observed at Clover B4 during the spring breakup monitoring season, and no discharge measurement or calculation was performed.

Direct discharge measurements at all Clover B locations were rated poor based on channel conditions. The channel cross sections at all sites were irregular and transformative because of ice and snow. During initial period of breakup flow, the channel at Clover B1 was confined by snow, and as breakup progressed, the channel broadened. Photo 4.24 shows channel conditions during the discharge measurement at Clover B1, and Photo 4.25 shows conditions of the main channel during the discharge measurement at Clover B3.

The direct discharge measurements were taken one day after estimated peak stage at Clover B1 and three days after estimated peak stage at Clover B2 and B3.

Photo 4.24: Channel conditions during discharge measurement at Clover B1, looking east; June 4, 2011

Photo 4.25: Main channel conditions during discharge measurement at Clover B3, looking downstream (northwest); June 4, 2011

A summary of the 2011 direct discharge measurements of the Clover B drainage is presented in Table 4.2 and complete discharge notes are included in Appendix B.

Table 4.2: Clover B Direct Discharge Summary

Location	Date & Time	WSE[1] (ft BPMSL)	Width (ft)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	Measurement Rated[2]	Meter Type	Number of Sections	Measurement Type
Clover B1	6/4/11 2:35 PM	38.18	33	24	0.32	**8**	P	Marsh McBirney	24	Wading
Clover B2	6/4/11 3:35 PM	43.04	39.5	18	0.40	**7**	P	Marsh McBirney	27	Wading
Clover B3	6/4/11 4:20 PM	46.56	68	29	0.15	**4**	P	Marsh McBirney	40	Wading

[1] WSE values at the start of the measurement; based on GPS data; elevations are not relative or tied to local control.
[2] Measurement Rating
E - Excellent: Point plots nearly on the rating curve; within 2% of true value
G - Good: Within 5% of true value
F - Fair: Within 7-10% of true value
P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; less than 15% of true value

4.1.2.2 Indirect Discharge

Indirect discharge for the Clover B drainage was calculated using a velocity-area method as discussed in Section 3.3.2. Over the course of breakup monitoring the Clover B channel morphology was observed to be continuously changing and open water conditions were not observed until July 5.

A summary of indirect discharge and peak WSE elevation data for the Clover B drainage is shown in Table 4.3.

Table 4.3: Clover B Indirect Discharge and Peak Water Surface Elevation

Location	Peak WSE[1] (ft BPMSL)	Peak Discharge[2] (cfs)	Date & Time[3]
Clover B1	39.08	**17**	6/3/11 11:10 AM
Clover B2	43.63	**17**	6/1/11 5:30 PM
Clover B3	46.67	**5**	6/1/11 5:30 PM

[1] WSE values at the start of the measurement; based on GPS data; elevations are not relative or tied to local control.
[2] Peak discharge was calcuated using the velocity-area method and peak WSE.
[3] Peak WSE value is a high water mark; time is estimated

4.1.2.3 COMPARISON OF 2010 AND 2011

Table 4.4 shows a summary and comparison of the 2010 and 2011 discharge data for the Clover B1 site. The channel conditions for Clover B1 in 2010 and 2011, with respect to presence of snow and ice were similar. Channel conditions at Clover B1 during the discharge measurements in 2010 and 2011 are shown in Photo 4.26 and Photo 4.27, respectively.

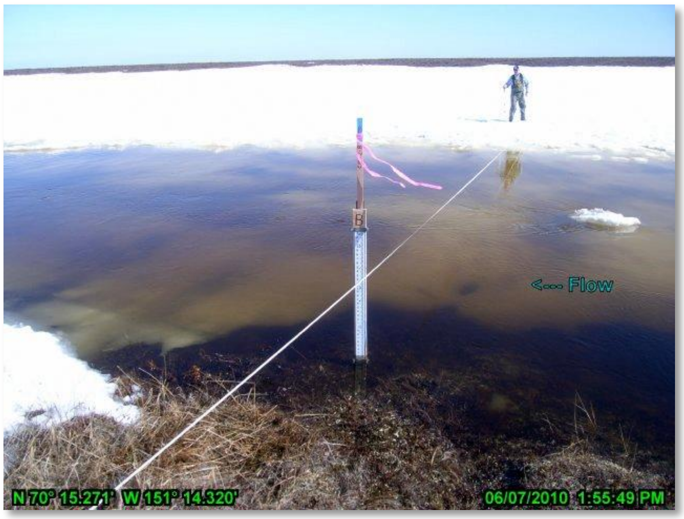


Photo 4.26: Channel conditions during the 2010 Clover B1 discharge measurement, from left bank; June 7, 2010

Photo 4.27: Channel conditions during the 2011 Clover B1 discharge measurement, from left bank; June 4, 2011

The direct discharge measured in 2011 was estimated to be approximately 27 hours after peak stage which was about 15 hours later than in 2010. Velocities in 2011 were measured to be 1.29 feet per second (fps) slower than those in 2010. Additionally, there is a 2.52 feet difference between the 2010 and 2011 WSE recorded during the direct discharge measurement. Also between 2010 and 2011, there was a 2.74 feet difference in the recorded peak WSE which resulted in a smaller channel cross-sectional area that was used to calculate the peak indirect discharge for Clover B1.

As discussed in Section 3.3.2, indirect discharge calculations using the velocity-area method assume open-channel conditions, stable channel geometry, and are based on the assumption that the measured average adjusted velocity taken during a direct discharge measurement is representative of the average velocity during peak stage.

Table 4.4: Clover B 2010 to 2011 Discharge Results Comparison

Location ID	Year	Direct Discharge					Indirect Discharge			
		Timing of Measurement Related to Peak[1] (hrs)	WSE[2] (ft BPMSL)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	WSE[3] (ft BPMSL)	Area (ft^2)	Velocity[4] (ft/s)	Discharge[5] (cfs)
Clover B1/ CMS2-B	2011	27 after	38.18	24	0.32	**8**	39.08	54	0.32	**17**
	2010	12 after	40.70	37	1.61	**59**	41.82	77	1.61	**124**

[1] Timing of peak based on HWM is estimated
[2] WSE values at the start of the measurement; based on GPS data; elevations are not relative or tied to local control
[3] Peak WSE based on HWM
[4] Peak velocity is assumed to be the same as the velocity measured during the direct measurement, performed as close to peak as possible
[5] Indirect discharge at this location was determined using a velocity-area method

4.1.3 Clover C Hydrologic Observations and Water Surface Elevation

Daily gage WSE data collection at all Clover C sites began June 1. After breakup, monitoring continued at Clover C every two weeks through July. Flow was still present in this channel on July 19, after which observations were discontinued. The PT installed at Clover C2 recorded data from May 20 through July 20. This data was recovered and is presented in Table 4.5. Photo 4.28 shows the Clover C drainage on June 1. At the bottom of the photo, Clover C is seen draining into the Ublutuoch River.

Photo 4.28: The Clover C drainage at the beginning of spring breakup, looking upstream (southeast) from the Ublutuoch River, June 1, 2011

Significant snow was present in the Clover C drainage at the beginning of breakup, with the majority of accumulation at the downstream location of C1. Breakup flow passed through a moderately defined channel that was confined and cut through snow upstream and downstream of the gage location (Photo 4.29). Ice remained on the bottom of the channel at Clover C1 until June 3. By June 6, stage had dropped. The channel was open, but some snow was observed on the overbanks upstream and downstream (Photo 4.30 and Photo 4.31) on June 9. By June 21 (Photo 4.32), the snow had melted.

Photo 4.29: Clover C1 - After peak stage, looking northeast; June 3, 2011

Photo 4.30: Clover C1 - Drainage flowing north into the Ublutuoch River as breakup flows recede, looking northwest; June 6, 2011

Photo 4.31: Clover C1 – As breakup flood flow recedes, looking northeast; June 9, 2011

Photo 4.32: Clover C1 - After breakup; snow melted in area, looking upstream (southeast) toward Clover C2; June 21, 2011

On July 5, a small channel through grass was observed with low flow present (Photo 4.33). During the final monitoring visit on July 19, the area was marshy with some small ponds and no visible flow was seen (Photo 4.34).

At the north edge of the CMS boundary, the channel at Clover C2 was poorly defined because of low topographic relief. Flow was divided into a few polygon cracks as stage decreased. No snow was present in the channel by June 3 (Photo 4.35), and the majority of snow in the area had melted by June 6 (Photo 4.36). The channel was losing definition by June 9 (Photo 4.37) and by June 21, no flow was observed, and the area was marshy (Photo 4.38).

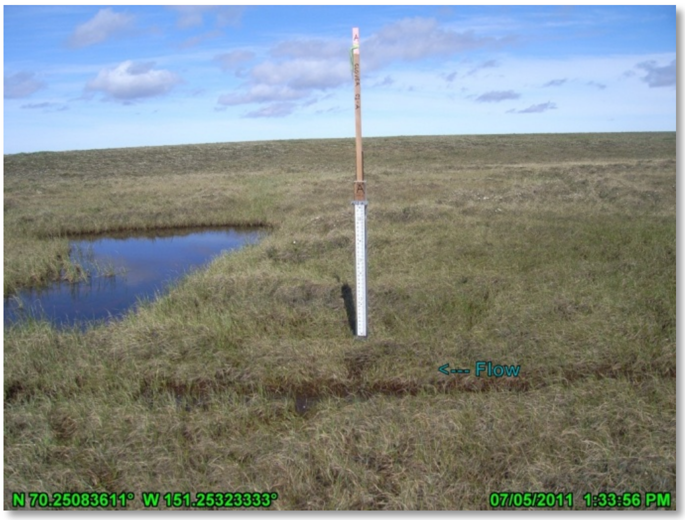


Photo 4.33: Clover C1 – After breakup; small grassy channel with low flow, looking east; July 5, 2011

Photo 4.34: Clover C1 – Small ponds and marshy areas, no visible flow, looking east; July 19, 2011

Photo 4.35: Clover C2 – Flow in polygon cracks as stage drops, looking upstream (south); June 3, 2011

Photo 4.36: Clover C2 – The majority of snow in the area melted; looking east, June 6, 2011

Photo 4.37: Clover C2 – Channel losing definition as stage drops further, looking north;, June 9, 2011

Photo 4.38: Clover C2 – No flow through marshy area, no defined channel, looking east; June 21, 2011

Photo 4.39: Clover C2 – No flow through marshy area, looking east; July 5, 2011

Photo 4.40: Clover C2 – No flow through marshy area, looking southeast; July 19, 2011

No change in site conditions at C2 was observed on July 5 (Photo 4.39) and during final monitoring on July 19; the area was still marshy though slightly less wet (Photo 4.40).

No channelized flood flow was observed at Clover C3 during the spring breakup monitoring period (Photo 4.41 and Photo 4.42). WSE data collected during breakup was the result of local melt and overland sheet flow. Ponded water was present at this location through June 9, and the area was drier by June 21 (Photo 4.43). No water was observed at Clover C3 during the monitoring visit on July 19 (Photo 4.44).

Photo 4.41: Clover C3 – Snow beginning to melt during breakup, no channelized flow, looking downstream (northwest) toward Clover B2; June 3, 2011

Photo 4.42: Clover C3 – Local melt, no channelized flow, looking east; June 6, 2011

Photo 4.43: Clover C3 – Area dry, looking east; June 21, 2011

Photo 4.44: Clover C3 – Area dry, looking east; July 19, 2011

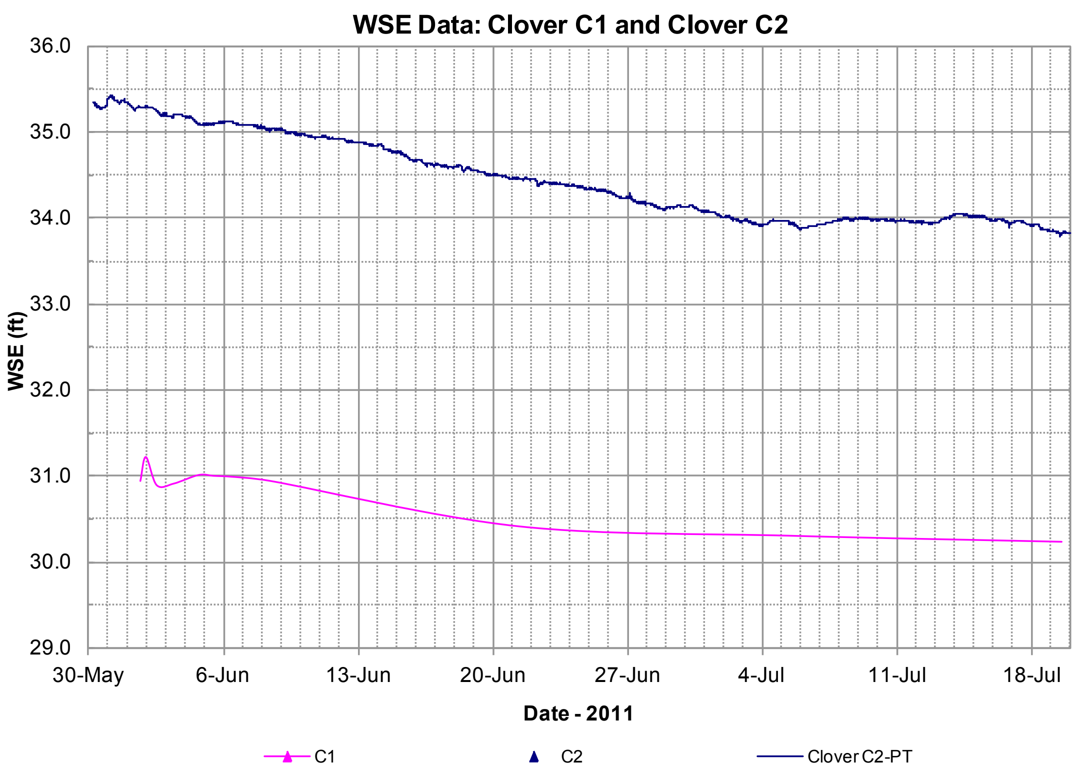
Peak WSE based on assumed elevations from 2010 and HWM were recorded at Clover C1 (June 2, 31.22 feet) and Clover C2 (May 31, 35.37 feet). The timing of WSE based on HWM at C2 was estimated, and PT data were used to confirm the timing. The hydrographs for the Clover C monitoring sites is provided in Table 4.5. Clover C3 is not represented in Table 4.5, since measurable flow was not observed in this area.

Table 4.5: Clover C Water Surface Elevation

Date and Time	WSE (ft - assumed)		Observations
	C1	C2	
5/31/11 8:15 PM	-	**35.37**	**Peak Stage Clover C2,** HWM - *time estimated*
5/31/11 10:00 PM	-	35.35	HWM - *time estimated*
6/1/11 5:05 PM	30.94	35.29	C1: flow, channel confined by snow, slush, icy bottom; C2: some flow, snow
6/2/11 12:00 AM	**31.22**	-	**Peak Stage Clover C1,** HWM - *time estimated*
6/2/11 1:35 PM	30.89	35.23	
6/3/11 10:55 AM	30.91	35.19	Weather cooling, breakup melting progressing less rapidly; C1: ice/snow free channel, still confined by snow up&downstream; C2: channel losing definition
6/4/11 5:45 PM	31.01	35.09	C1: flow in two channels, snow in area; C2: some snow in area
6/5/11 12:50 PM	31.00	35.09	
6/6/11 10:25 AM	30.99	35.15	C1: significantly less flow, single channel, snow; C2: channel is a polygon
6/7/11 4:45 AM	-	35.11	HWM - *time estimated*
6/8/11 11:35 AM	30.94	35.04	C1: channel losing definition; C2: no water on gage
6/21/11 9:20 AM	30.41	-	C1: low flow present, poorly defined channel; C2: no flow, some wet areas
7/5/11 1:30 PM	30.30	33.94	C1: low flow present
7/19/11 2:05 PM	30.23	33.83	C1: no flow

Notes:

1. Clover C1 is downstream and Clover C2 is upstream at the CMS boundary.
2. WSE are based on Baker CP2 and EICKELMAN at 35.000 and 36.542 assumed elevation, respectively, established by Baker in 2010 using a handheld Garmin Rino 520HCx GPS. These elevations are not tied to any other monitoring locations, known survey control or feet BPMSL.
3. In 2011, there was no defined channel and no channelized flow present at Clover C3. WSE data collected at this location is the result of local melt or overland sheet flow and is not included in this table.



4.1.4 Clover C Discharge

4.1.4.1 Direct Discharge

Direct discharge measurements were performed at Clover C1 and C2 on June 4. Discharge measurements were conducted as close to peak flow as possible. No measurable flood flow was present at Clover C3 during the monitoring period, and consequently no discharge measurement was performed at that location.

Photo 4.45: Discharge measurement at Clover C1; June 4, 2011

Direct discharge measurements at all Clover C locations were rated poor based on channel conditions; cross sections at all sites were irregular and transformative due to ice and snow upstream and downstream of Clover C1. Photo 4.45 shows the discharge measurement being performed at Clover C1.

The direct discharge measurements were taken two days after estimated peak stage at Clover C1 and four days after peak stage at Clover C2.

A summary of the 2011 direct discharge measurements in the Clover C drainage is presented in Table 4.6, and notes are in Appendix B.

Table 4.6: Clover C Direct Discharge Summary

Location	Date & Time	WSE[1] (ft BPMSL)	Width (ft)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	Measurement Rated[2]	Meter Type	Number of Sections	Measurement Type
Clover C1	6/4/11 6:06 PM	31.01	34	8	0.20	**2**	P	Marsh McBirney	46	Wading
Clover C2	6/4/11 5:23 PM	35.09	27	9	0.26	**2**	P	Marsh McBirney	29	Wading

[1] WSE values at the start of the measurement; based on GPS data; elevations are not relative or tied to local control.
[2] Measurement Rating
E - Excellent: Point plots nearly on the rating curve; within 2% of true value
G - Good: Within 5% of true value
F - Fair: Within 7-10% of true value
P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; less than 15% of true value

4.1.4.2 Indirect Discharge

Peak discharge in the Clover C drainage was calculated using a velocity-area method as discussed in Section 3.3.2. Over the course of breakup monitoring, the Clover C channel morphology was observed to be continuously changing and open water conditions were not observed until June 21.

A summary of indirect discharge results and peak WSE elevation data for the Clover C drainage is contained in Table 4.7.

Table 4.7: Clover C Indirect Discharge and Peak Water Surface Elevation

Location	Peak WSE[1] (ft BPMSL)	Peak Discharge[2] (cfs)	Date & Time[3]
Clover C1	31.22	**3**	6/2/11 12:00 AM
Clover C2	35.37	**4**	5/31/11 8:15 PM

[1] WSE values at the start of the measurement; based on GPS data; elevations are not relative or tied to local control.
[2] Peak discharge was calcuated using the velocity-area method and peak WSE.
[3] Peak WSE value is a high water mark; time is estimated

4.1.4.3 Comparison of 2010 and 2011

Table 4.8 shows a summary and comparison of the 2010 and 2011 discharge data for the Clover C1 site. The channel conditions for Clover C1 in 2010 and 2011, with respect to presence of snow and ice were distinctly different. Channel conditions at Clover C1 during the discharge measurements in 2010 and 2011 are shown in Photo 4.46 and Photo 4.47, respectively.

Photo 4.46: Channel conditions during the 2010 Clover C1 discharge measurement; June 7, 2010

Photo 4.47: Channel conditions during the 2011 Clover C1 discharge measurement; June 4, 2011

The direct discharge measured in 2011 was estimated to be approximately 66 hours after peak stage. Velocities in 2011 were measured to be 1.51 fps slower than those in 2010. There was a 0.26 foot difference between the 2010 and 2011 WSE recorded during the direct discharge measurement and no significant difference in peak WSE. Differences in calculated peak cross-sectional area between 2010 and 2011 were about 1 square foot.

As discussed in Section 3.3.2, indirect calculations using the velocity-are method assume open-channel conditions, stable channel geometry, and are based on the assumption that the measured average adjusted velocity taken during a direct discharge measurement is representative of the average velocity during peak stage.

Table 4.8: Clover C 2010 to 2011 Discharge Results Comparison

Location ID	Year	Direct Discharge					Indirect Discharge			
		Timing of Measurement Related to Peak[1] (hrs)	WSE[2] (ft BPMSL)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	WSE[3] (ft BPMSL)	Area (ft^2)	Velocity[4] (ft/s)	Discharge[5] (cfs)
Clover C1/ CMS2-C	2011	66 after	31.01	8	0.20	**2**	31.22	15	0.20	**3**
	2010	0	31.27	15	1.71	**25**	31.27	16	1.71	**27**

[1] Timing of peak based on HWM is estimated
[2] WSE values at the start of the measurement; based on GPS data; elevations are not relative or tied to local control
[3] Peak WSE based on HWM
[4] Peak velocity is assumed to be the same as the velocity measured during the direct measurement, performed as close to peak as possible
[5] Indirect discharge at this location was determined using a velocity-area method

4.1.5 Ublutuoch River 11.45 & 11.6 Hydrologic Observations and Water Surface Elevation

Daily gage WSE data collection at UB11.45 and UB11.6 began June 1. PTs were installed at both gage locations and recorded data from May 20 through July 20. This data was recovered and is presented in Table 4.5.

Photo 4.48: Breakup flow through the UB11.45-UB11.6 reach of the Ublutuoch River, looking upstream (southwest); June 1, 2011

Photo 4.49: – Gages at UB11.6 surrounded by snow, UB11.45 downstream in the background, looking east; June 3, 2011

By June 1, significant flow containing ice rafts, snow and slush were present in this reach of the Ublutuoch River (Photo 4.48). Flow was overbank and the gages at UB11.45 were overtopped. An additional gage was installed at this location higher up the bank. Significant snow surrounded the gages at UB11.6 (Photo 4.49) throughout the breakup season. Snow quickly melted at UB11.45, which is on a point bar in the river. Conditions were similar through June 3, with fewer floes and slush in the channel. Temperatures cooled at this time, and breakup melting progressed less rapidly throughout the FCB. By June 6, WSE had dropped considerably. Flow velocities were high, generally confined within the stream banks and carried occasional small floes (Photo 4.50). Snow was still present when daily monitoring ceased on June 9 (Photo 4.51). No significant ice jams were observed in the vicinity of the UB11.45-UB11.6 reach during spring breakup 2011.

Photo 4.50: Flow confined to channel banks as stage drops at UB11.45-UB11.6, looking south; June 6, 2011

Photo 4.51: Snow still present as breakup flow recedes at UB11.6, looking downstream (east); June 9, 2011

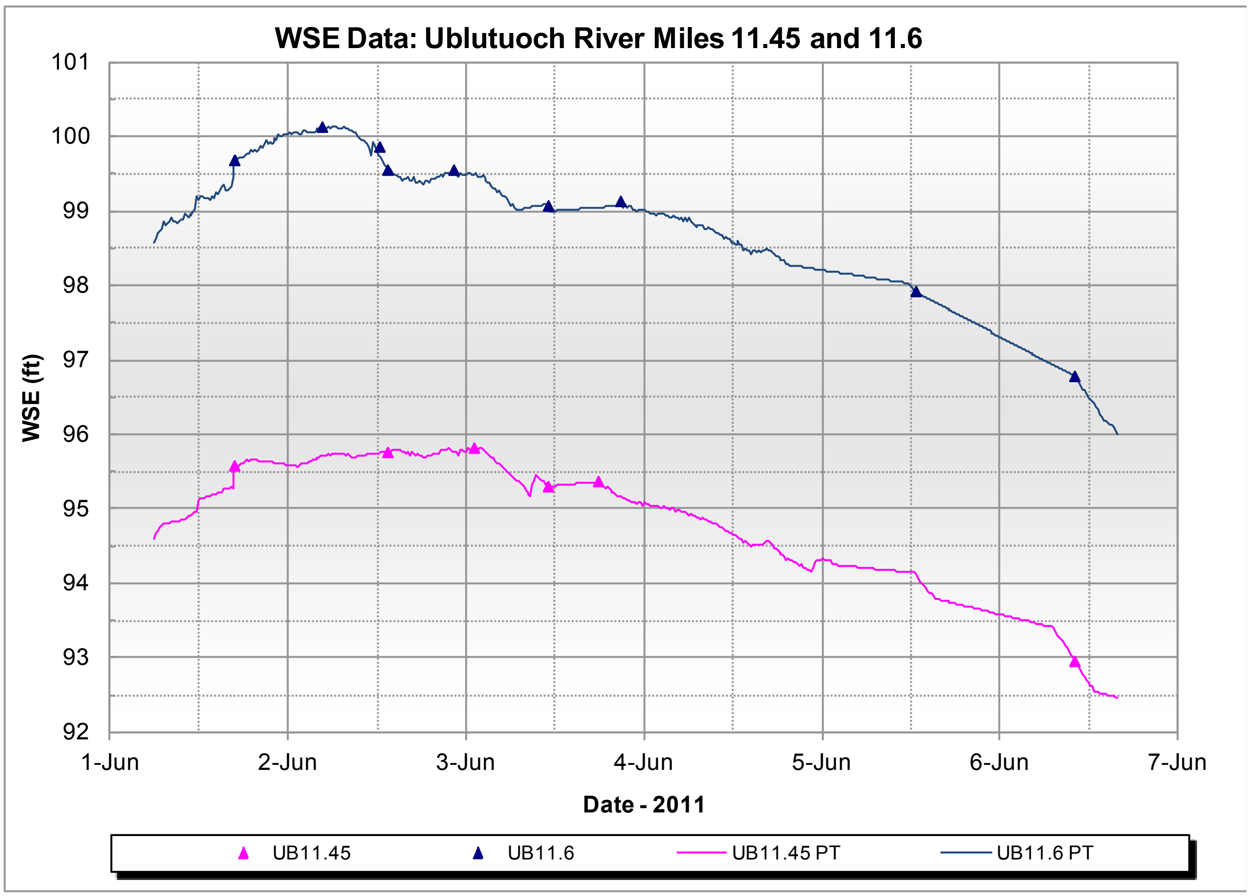
Peak WSEs based on HWM were recorded at UB11.45 (June 3, 95.83 feet) and UB11.6 (June 2, 100.14 feet). HWMs are time-estimated and correlated with recorded PT data. A hydrograph for Ublutuoch River UB11.45 and UB11.6 is provided in Table 4.9

Table 4.9: Ublutuoch 11.45 & 11.6 Water Surface Elevation

Date and Time	WSE (ft - assumed)		Observations
	UB11.45	UB11.6	
6/1/11 4:40 PM	95.59	99.69	Floes and slush in channel; WSE at UB11.45 estimated, gages overtopped
6/2/11 4:30 AM	-	**100.14**	**Peak Stage UB11.6 -** based on pressure transducer data only
6/2/11 12:15 PM	-	99.87	HWM - *time estimated*
6/2/11 1:20 PM	95.77	99.56	Snow present on left banks; channel generally ice/snow free
6/2/11 10:15 PM	-	99.56	HWM - *time estimated*
6/3/11 1:00 AM	**95.83**	-	**Peak Stage UB11.45 -** based on pressure transducer data only
6/3/11 11:00 AM	95.31	99.08	Weather cooling, breakup melting progressing less rapidly; some floes
6/3/11 5:45 PM	95.38	-	HWM - *time estimated*
6/3/11 8:45 PM	-	99.14	HWM - *time estimated*
6/5/11 12:35 PM	94.14	97.93	
6/6/11 10:00 AM	92.96	96.79	Occasional floes in channel

Notes:

1. Elevations are based on GUTZWILLER at 100.00 feet assumed elevation, established by Baker in 2011. These elevations are not tied to any other monitoring locations, know n survey control or feet BPMSL.



4.2 Greater Moose's Tooth 1 Road Corridor

A gravel road is proposed to access the GMT1 and GMT2 drilling pads. Four locations along the proposed GMT1 road corridor were monitored in 2011 during spring breakup. These were at the Ublutuoch River (UB6.7 downstream, UB6.8 centerline, UB6.9 upstream) and small stream sites S3, S4 and S5.

4.2.1 Ublutuoch River 6.7, 6.8 and 6.9 Hydrologic Observations and WSE

A bridge crossing is proposed at the centerline gage location, UB6.8. Daily gage WSE data collection at UB6.7, UB6.8 and UB6.9 began June 1. PTs installed at UB6.7 and UB6.9 recorded data from May 20 through July 20. This data was recovered and is presented in Table 4.10.

Photo 4.52: Breakup flow and channel ice in the Ublutuoch River, looking downstream (north) from UB6.8; June 1, 2011

By June 1, significant flow was present in this reach of the Ublutuoch River, inundating the overbank areas. There was some snow along the right bank and discrete sections of ribbon ice throughout the channel (Photo 4.52). No ice jams had formed in the vicinity. There was some channel ice approximately 0.3 RM upstream of UB6.9 on June 2. Also on June 2, the stage was high on the overbanks (Photo 4.53 and Photo 4.54), and occasional ice floes were beginning to jam on intact channel ice downstream of UB6.7, near Lake L9824.

Photo 4.53: Peak stage in the Ublutuoch River at the proposed bridge crossing (UB6.8), downstream of UB6.7 looking upstream (south); June 2, 2011

Photo 4.54: Peak stage in the Ublutuoch River at the proposed bridge crossing (UB6.8), upstream of UB6.9 looking downstream (northeast); June 2, 2011

Photo 4.55: Ice jam forming downstream of UB6.7, looking downstream (northeast); June 3, 2011

Photo 4.56: Ice jam upstream of UB6.9, looking downstream (northeast); June 3, 2011

Temperatures cooled on June 3, and breakup melting progressed less rapidly throughout the FCB. The ice jam downstream of UB6.7 was still in place on June 3 (Photo 4.55), and more floes had jammed on the channel ice upstream of UB6.9 (Photo 4.56).

By June 6, stage had dropped considerably, and flow was generally confined within the stream banks (Photo 4.57). The channel was ice and snow free except where there were jams. The ice jams downstream of UB6.7 and upstream of UB6.9 were still present on June 6 and were melting in place by June 9 (Photo 4.58).

Photo 4.57: Proposed bridge crossing location UB6.8 as stage dropped and flow was mostly confined to the banks, looking east; June 3, 2011

Photo 4.58: Ice jam downstream of UB6.7 melting in place, looking downstream (northwest); June 9, 2011

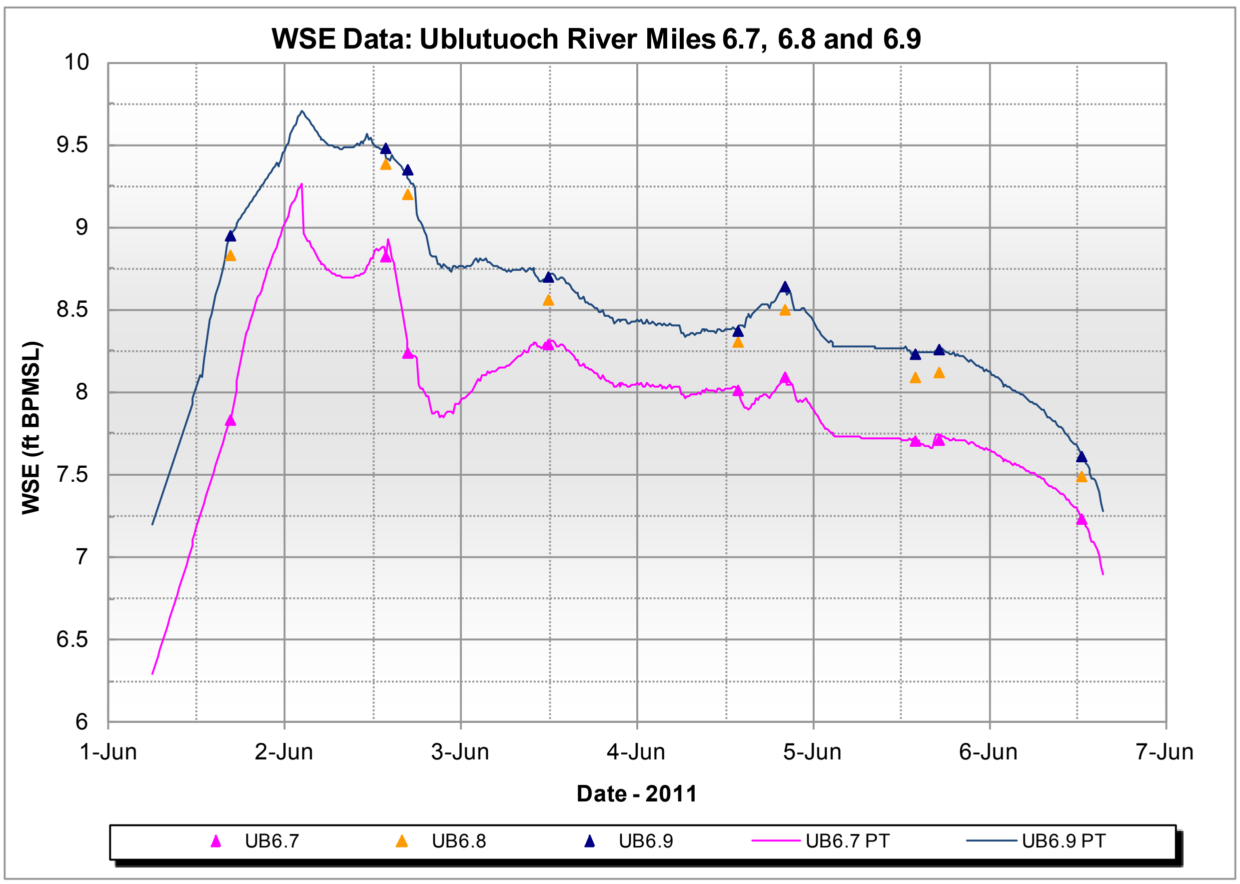
Peak WSE was 9.39 feet BPMSL at UB6.8 on June 2. Peak WSEs based on HWMs were recorded at UB6.7 (June 2, 9.26 feet BPMSL) and UB6.9 (June 2, 9.71 feet BPMSL). HWMs are time-estimated and are correlated with recorded PT data. A hydrograph for Ublutuoch River UB6.7, UB6.8 and UB6.9 is provided in Table 4.10.

Table 4.10: Ublutuoch 6.7, 6.8 & 6.9 Water Surface Elevation

Date and Time	WSE (feet BPMSL)			Observations
	UB6.7	UB6.8	UB6.9	
6/1/11 4:25 PM	7.84	8.84	8.95	Ribbon ice in channel, snow along banks, no ice jams seen, flow overbank
6/2/11 2:15 AM	**9.26**	-	**9.71**	**Peak Stage UB6.7 and UB6.9 -** based on pressure transducer data only
6/2/11 1:35 PM	8.83	**9.39**	9.48	**Peak Stage UB6.8**
6/2/11 4:35 PM	8.24	9.21	9.35	Ice jam forming downstream of UB6.7; flow in overbanks
6/3/11 11:45 AM	8.30	8.57	8.70	Weather cooling, breakup melting progressing less rapidly
6/4/11 1:35 PM	8.02	8.31	8.38	Ice jam still in place downstream of UB6.7
6/4/11 8:00 PM	8.10	8.51	8.65	HWM - *time estimated*
6/5/11 1:45 PM	7.71	8.10	8.24	
6/5/11 5:00 PM	7.72	8.13	8.26	HWM - *time estimated*; ice jam ~0.5 river miles upstream of UB6.9; still present downstream of UB6.7
6/6/11 12:25 PM	7.24	7.50	7.62	Ice jam clear upstream of UB6.9; jam downstream of UB6.7 melting in place

Notes:

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



4.2.2 Ublutuoch River 6.7, 6.8 and 6.9 Discharge

4.2.2.1 Direct Discharge

Photo 4.59: Channel conditions during the discharge measurement at the proposed Ublutuoch bridge location (UB6.8), upstream of UB6.9 looking downstream (northeast); June 2, 2011

A direct discharge measurement in the Ublutuoch River was conducted at UB6.8 on June 2 beginning at 1:55 PM, approximately at the time of peak flow. Discharge was measured to be 2,200 cubic feet per second (cfs). The measurement was rated fair to poor based on channel conditions. The channel is not uniform; the left bank side is much shallower than the right bank side. Occasional ice floes were present in the channel during the discharge measurement, and jams were beginning to form on channel ice approximately 1,700 feet upstream and 1,000 feet downstream of the tagline, near the UB6.7 gages. The upstream jam was causing flow to divert into the low-lying areas and oxbow lakes on both left and right overbanks, and the downstream jam was causing more flow to divert into Lake L9824 to the west and the unnamed lake to the east. Photo 4.59 and Photo 4.60 show channel conditions at UB6.8 during the direct discharge measurement.

A summary of the 2011 direct discharge measurement at UB6.8 is presented in Table 4.11, and notes are in Appendix A.

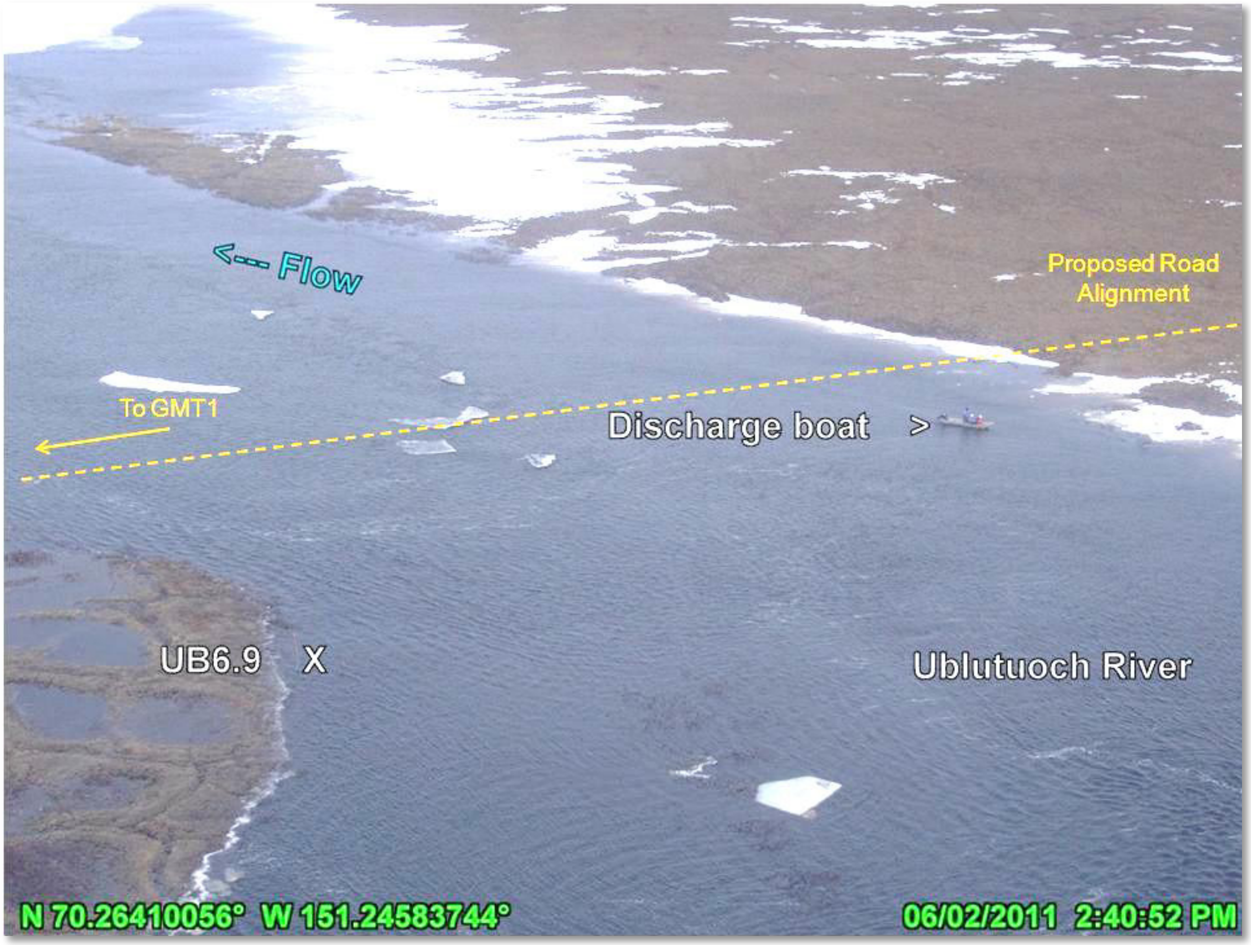


Photo 4.60: Baker crew performing discharge measurement at the proposed Ublutuoch bridge location (UB6.8), looking downstream (northeast); June 2, 2011

Table 4.11: Ublutuoch Direct Discharge

Location	Date & Time	WSE[1] (ft BPMSL)	Width (ft)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	Measurement Rated[2]	Meter Type	Number of Sections	Measurement Type
UB 6.8	6/2/11 1:55 PM	9.39	650	1600	1.4	**2200**	F-P	Price AA	68	Boat

[1] WSE at gage UB6.8 at the start of the measurement
[2] Measurement Rating:
E - Exceller Point plots nearly on the rating curve; within 2% of true value
G - Good: Within 5% of true value
F - Fair: Within 7-10% of true value
P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; less than 15% of true value

4.2.2.2 Indirect Discharge

Peak discharge at UB6.8 was estimated using a slope-area method as discussed in Section 3.3.2. Indirect discharge was calculated using the energy grade-line slope as approximated by the water surface slope between UB6.7 and UB6.9, the peak WSE at UB6.8, and the 2010 cross-sectional data collected during the direct discharge measurement at UB6.8. Indirect discharge calculations were performed assuming an ice-free channel and are considered a conservative estimate. Since in 2011 peak discharge occurred at the same time as the direct measurement, the calculated value is more representative of actual conditions at the time of peak.

The 2011 peak discharge in the Ublutuoch at UB6.8 likely occurred at the time of peak stage, which was recorded at the time of the direct measurement at midday on June 2. Peak discharge in the Ublutuoch River was estimated to have been 2,350 cfs at UB6.8. A summary of indirect discharge results and peak WSE elevation data for the Ublutuoch bridge crossing location is contained in Table 4.12. A historical record of peak discharge in the Ublutuoch River is presented in Table 1.1.

Table 4.12: Ublutuoch Indirect Discharge and Peak Water Surface Elevation

Location	Peak WSE (ft BPMSL)	Peak Discharge[1] (cfs)	Date & Time
UB 6.8	9.39	**2,350**	6/2/11 1:35 PM

[1] Peak discharge was calcuated using the slope-area method and peak WSE.

4.2.3 Small Stream Crossing S3 Hydrologic Observations and Water Surface Elevation

S3 is a shallow drainage between a ponded area west of Lake L9308 and the Ublutuoch River. Daily gage WSE data collection at S3 began June 1.

Spring breakup at this location was characterized by quick melting until June 3 when temperatures decreased and breakup progressed less rapidly (Photo 4.61). There was no channelized hydraulic connection observed between the ponded area west of Lake L9308 and the Ublutuoch River, and measurable flow was not present in the vicinity of the gage location during spring breakup monitoring (Photo 4.62). WSE and peak stage data are considered the result of local melt and overland sheet flow.

Photo 4.61: Breakup conditions at S3, looking east; June 3, 2011

Photo 4.62: S3 - Local melt and no channelized flow, looking north; June 9, 2011

No measureable flow was observed at S3 during spring breakup. No direct discharge measurement was performed and indirect discharge was not calculated.

4.2.4 Small Stream Crossing S4 Hydrologic Observations and Water Surface Elevation

S4 is a beaded stream draining a low lying area into the Ublutuoch River. Daily gage WSE data collection at S4 began June 1.

By June 1, significant flow was present in this drainage and conditions were overbank, though ice and snow were present in the channel limiting flow into overbank areas, particularly along the left bank. Topography of the right bank is steeper than the left bank. The channel is shallower upstream of the gages, and flow was less confined by snow in the overbank areas. The channel was narrower downstream and more confined by topography and snow. During monitoring, stage was high enough to channelize the beaded pools into a smoother reach. Temperatures cooled on June 3, and breakup melting progressed less rapidly throughout the FCB. Conditions at this time were similar to June 1 (Photo 4.63 and Photo 4.64), and ice was still present in some portions of the channel bottom. By June 4, there was no longer bottom ice and stage had dropped though still over bank. The channel had divided into braids that were mostly free of ice and snow, though some snow remained on the left bank of the crossing location, S4-B (Photo 4.65). Beaded pools were more evident by June 9, as stage receded and snow melted along the stream banks (Photo 4.66).

Photo 4.63: S4 - Stream draining northeast into Lake L9824; June 3, 2011

Photo 4.64: Breakup conditions at S4 reach after peak stage; June 3, 2011

The timing of peak WSE were based on HWMs recorded at downstream location S4-A (June 2, 14.16 feet BPMSL), centerline location S4-B (June 2, 15.35 feet BPMSL) and upstream location S4-C (June 2, 15.54 feet BPMSL). The hydrograph for S4 is provided in Table 4.13.

Photo 4.65: Channel conditions at S4 as stage drops, upstream of S4-A looking upstream (southwest); June 4, 2011

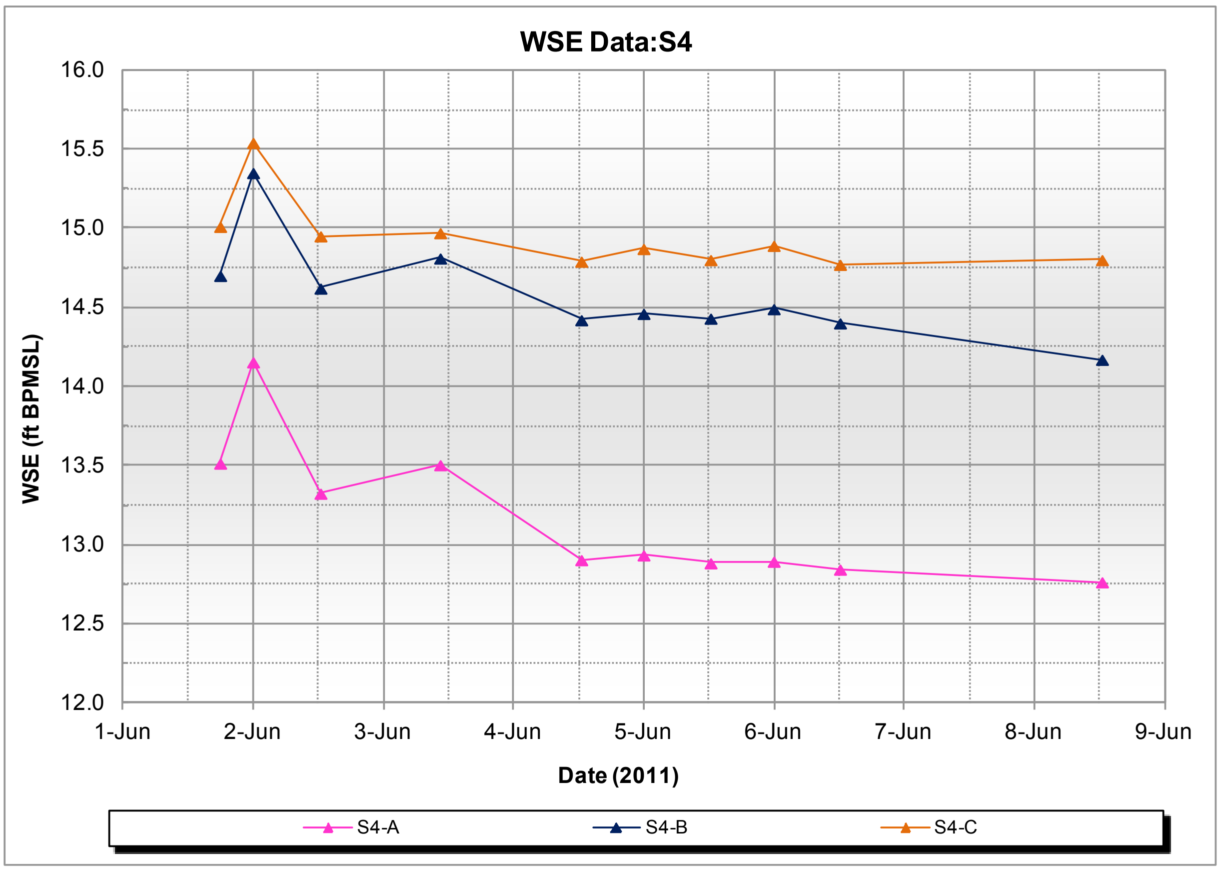
Photo 4.66: Beaded pools become more evident as breakup flows recede in S4 stream, looking east; June 9, 2011

Table 4.13: S4 Water Surface Elevation

Date and Time	WSE (feet BPMSL)			Observations
	S4-A	S4-B	S4-C	
6/1/11 5:56 PM	13.52	14.70	15.01	Ice and snow in channel
6/2/11 12:00 AM	**14.16**	**15.35**	**15.54**	**PEAK STAGE**, HWM - *time estimated*
6/2/11 12:26 PM	13.33	14.62	14.95	
6/3/11 10:30 AM	13.51	14.81	14.97	Weather cooling, breakup melting progressing less rapidly; snow in area, ice/snow in channel and on bottom
6/4/11 12:31 PM	12.91	14.42	14.79	Significant snow present on left bank, no ice/snow in channel or bottom
6/5/11 12:00 AM	12.94	14.46	14.87	HWM - *time estimated*
6/5/11 12:21 PM	12.89	14.43	14.80	
6/6/11 12:00 AM	12.90	14.49	14.89	HWM - *time estimated*
6/6/11 12:13 PM	12.85	14.40	14.77	Channel becoming more beaded than linear - less flow
6/8/11 12:32 PM	12.77	14.17	14.80	

Notes:

1. S4-A is downstream, S4-B is centerline and S4-C is upstream
2. Elevations are based on COAL at 20.524 feet BPMSL and CHAR at 25.248 feet BPMSL, both updated by LCMF in 2009.



4.2.5 Small Stream Crossing S4 Discharge

4.2.5.1 Direct Discharge

A direct discharge measurement was performed at S4 (centerline S4-B) on June 4, beginning at 12:45 PM, approximately 60 hours after peak. Discharge was measured to be 4.4 cfs. The measurement was rated poor based on channel conditions. The channel was braided and contained willows and grass. Areas of pooled water were upstream and downstream of the measurement location and some water was flowing under snow along the left bank. Photo 4.67 shows S4 channel conditions during the discharge measurement.

Photo 4.67: Channel conditions during the discharge measurement at the proposed S4 crossing location, looking west; June 4, 2011

A summary of the 2011 direct discharge measurements at S4 is presented in Table 4.14, and notes are in Appendix B.

Table 4.14: S4 Direct Discharge

Location	Date & Time	WSE[1] (ft BPMSL)	Width (ft)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	Measurement Rated[2]	Meter Type	Number of Sections	Measurement Type
S4	6/4/11 12:45 PM	12.91	30	11	0.39	**4.4**	P	Marsh McBirney	21	Wading

[1] WSE at gage S4-B at the start of the measurement
[2] Measurement Rating:
E - Excellent: Point plots nearly on the rating curve; within 2% of true value
G - Good: Within 5% of true value
F - Fair: Within 7-10% of true value
P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; less than 15% of true value

4.2.5.2 Indirect Discharge

Peak discharge at the S4 drainage was estimated using a slope-area method as discussed in Section 3.3.2. Discharge was calculated using the energy grade-line slope as approximated by the water surface slope between upstream and downstream gages at S4, WSE, and the 2011 cross-sectional data collected during the direct discharge measurement. Indirect discharge calculations were performed assuming an ice-free channel and are considered a conservative estimate.

Peak stage is estimated to have occurred between the evening of June 1 and the morning of June 2. Peak discharge at S4 was calculated as 16 cfs. A summary of indirect discharge results and peak WSE elevation data for the S4 crossing location is contained in Table 4.15.

Table 4.15: S4 Indirect Discharge and Peak Water Surface Elevation

Location	Peak WSE[1] (ft BPMSL)	Peak Discharge[2] (cfs)	Date & Time[3]
S4	15.35	**16**	6/2/11 12:00 AM

[1] At midline gage S4-B
[2] Peak discharge was calcuated using the slope-area method and peak WSE.
[3] Peak WSE value is a high water mark; time is estimated

4.2.6 Small Stream Crossing S5 Hydrologic Observations and Water Surface Elevation

S5 centerline is a beaded stream draining a ponded area into the Ublutuoch River. Daily gage WSE data collection at S5 began June 1.

By June 1, significant flow was present in this drainage and conditions were over bank, and ice and snow were present in the channel limiting flow into both left and right overbank areas. The channel morphology is shallower upstream and flow was less confined by snow in the overbank areas. The channel was narrow and confined downstream though with less snow. Stage was high enough on June 1 to channelize the beaded pools.

Temperatures cooled on June 3, and breakup melting progressed less rapidly throughout the FCB. Conditions at this time were similar to June 1, with slush floes and ice still present in portions of the channel bottom (Photo 4.68 and Photo 4.69). By June 4, stage had dropped though still over bank. Some portions of the channel bottom were icy. On June 4, snow was observed on both banks which confined flow (Photo 4.70), although some flow was present underneath the snow.

Beaded pools in the channel were more evident by June 6. By June 9, stage and the amount of snow continued to decline along the banks of S5 (Photo 4.71).

Photo 4.68: Channel conditions at proposed S5 crossing location (S5-B) after peak stage, looking downstream (north) toward S5-A; June 3, 2011

Photo 4.69: Channel conditions at proposed S5 crossing location (S5-B) after peak stage, looking upstream (southwest) toward S5-C; June 3, 2011

Photo 4.70: Breakup conditions at S5 reach, snow on overbanks looking east; June 4, 2011

Photo 4.71: Beaded pools become more evident as breakup flows recede in S5 stream, looking west; June 9, 2011

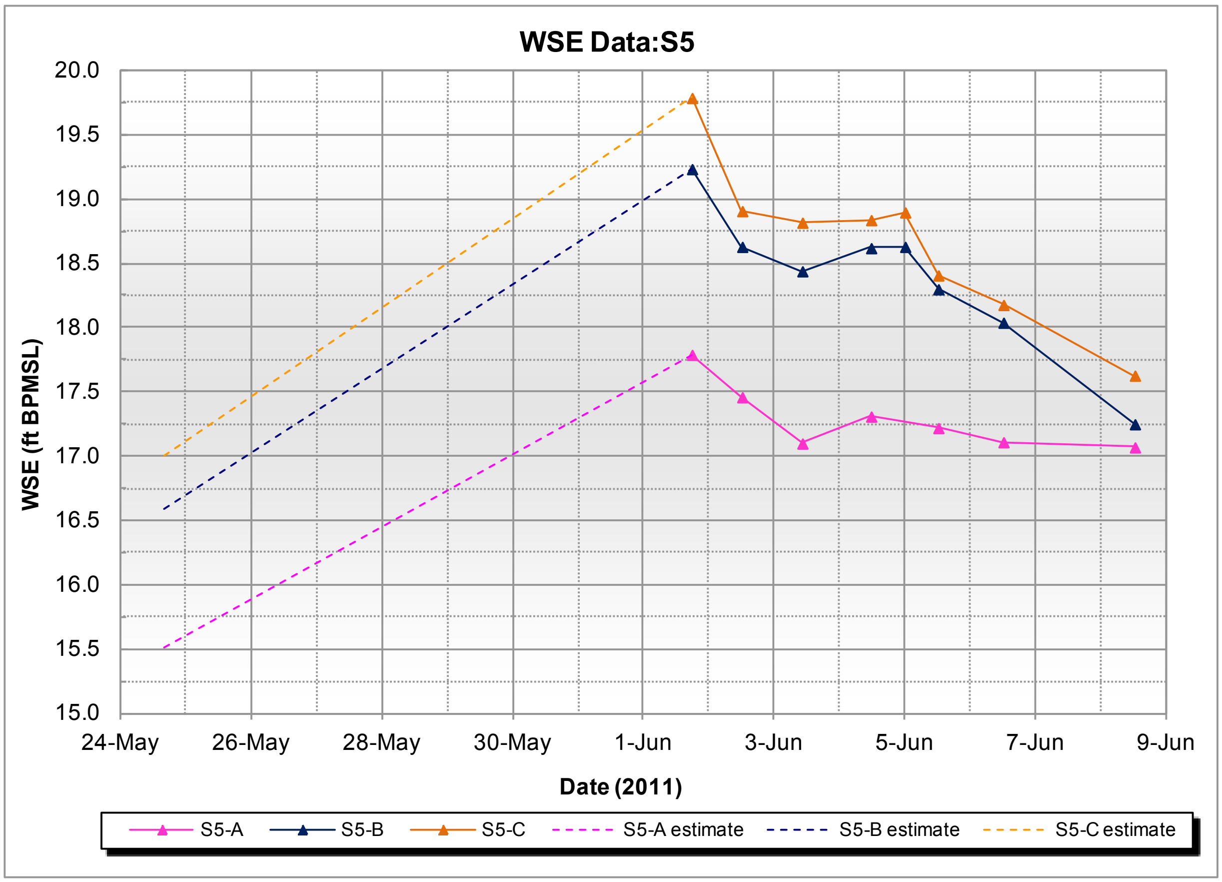
Peak WSEs for S5 gages were directly measured at downstream location S5-A (June 1, 17.79 feet BPMSL), centerline location S5-B (June 1, 19.24 feet BPMSL) and upstream location S5-C (June 1, 19.79 feet BPMSL). Stage at S5 continued to decline from the initial readings throughout the monitoring period, and it is possible that peak WSE occurred before the first gage reading. An estimate of pre-breakup WSE was made based on conditions during setup. The hydrograph for S5 locations is provided in Table 4.16.

Table 4.16: S5 Water Surface Elevation

Date and Time	WSE (feet BPMSL)			Observations
	S5-A	S5-B	S5-C	
5/24/11 4:20 PM	*15.51*	*16.59*	*17.00*	**Estimate** - maximum pre-breakup WSE based on conditions during set-up and observations of conditions prior to NPR-A breakup
6/1/11 5:45 PM	**17.79**	**19.24**	**19.79**	**PEAK STAGE**
6/2/11 12:10 PM	17.46	18.63	18.91	
6/3/11 10:15 AM	17.10	18.44	18.82	Weather cooling, breakup melting progressing less rapidly; snow in area, ice/snow in channel and on bottom
6/4/11 11:30 AM	17.31	18.62	18.84	Significant snow present on left bank, no ice/snow in channel or bottom
6/5/11 12:00 AM	-	18.63	18.90	HWM - *time estimated*
6/5/11 12:10 PM	17.22	18.30	18.41	
6/6/11 12:05 PM	17.11	18.04	18.18	Some snow still in area and on banks
6/8/11 12:20 PM	17.07	17.25	17.63	Channel becoming more beaded than linear - less flow

Notes:

1. S5-A is downstream, S5-B is centerline and S3-C is upstream
2. Elevations are based on ALMA at 25.263 feet BPMSL and CLARA at 23.228 feet BPMSL, both updated by LCMF in 2009.



4.2.7 SMALL STREAM CROSSING S5 DISCHARGE

Photo 4.72: Channel conditions during the discharge measurement at the proposed S5 bridge location, looking downstream (northeast); June 4, 2011

4.2.7.1 DIRECT DISCHARGE

A direct discharge measurement was performed at S5 (centerline S5-B) on June 4, beginning at 11:25 AM, approximately 66 hours after peak. Discharge was measured to be 61 cfs. The measurement was rated poor based on channel conditions. The channel bottom was icy and contained willows throughout the majority of the cross-section. The channel was somewhat confined by snow on both banks, though some flow was passing under the snow. Photo 4.72 shows channel conditions at S5 during the discharge measurement.

A summary of the 2011 direct discharge measurement at S5 is presented in Table 4.17, and complete notes are in Appendix B.

Table 4.17: S5 Direct Discharge

Location	Date & Time	WSE[1] (ft BPMSL)	Width (ft)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	Measurement Rated[2]	Meter Type	Number of Sections	Measurement Type
S5	6/4/11 11:25 AM	17.31	39	69	0.88	**61**	P	Marsh McBirney	28	Wading

[1] WSE at gage S5-A at the start of the measurement
[2] Measurement Rating:
E - Excellent: Point plots nearly on the rating curve; within 2% of true value
G - Good: Within 5% of true value
F - Fair: Within 7-10% of true value
P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; less than 15% of true value

4.2.7.2 Indirect Discharge

Peak discharge for S5 drainage was estimated using a slope-area method as discussed in Section 3.3.2. Indirect discharge was calculated using the energy grade-line slope (as approximated by the water surface slope between upstream and downstream gages at S5), WSE, and the 2011 cross-sectional data collected during the direct discharge measurement. Indirect discharge calculations were performed assuming an ice-free channel and are considered a conservative estimate.

Peak stage occurred the evening of June 1. Peak discharge at S5 was calculated as 84 cfs. A summary of indirect discharge results and peak WSE elevation data for the S5 crossing location is contained in Table 4.18.

Table 4.18: S5 Indirect Discharge and Peak Water Surface Elevation

Location	Peak WSE[1] (ft BPMSL)	Peak Discharge[2] (cfs)	Date & Time
S5	19.24	**84**	6/1/11 5:45 PM

[1] At midline gage S5-B
[2] Peak discharge was calcuated using the velocity-area method and peak WSE.

4.2.8 Greater Moose's Tooth 2 Road Corridor Hydrologic Observations and Water Surface Elevation

GMT2 drainage is a poorly defined, shallow beaded stream that drains a ponded area into Lake M9925. Daily gage WSE data collection at GMT2 began June 2.

By June 2, flow was present in this drainage and conditions were over bank (Photo 4.73). At the crossing location, the channel is well defined with higher flow velocity bound upstream and downstream by beads or pools of lower flow velocity. Some snow was present along the banks and throughout the area. Temperatures cooled on June 3, and breakup melting progressed less rapidly throughout the FCB. Conditions on June 3 were similar to June 1, and the channel was generally ice and snow free (Photo 4.74).

By June 4, stage had dropped. Snow was observed in the general vicinity and in the upstream bead or pool. The channel had lost definition by June 6 and was essentially flowing within a polygon crack (Photo 4.75). Flow had ceased by June 9 and the size of the upstream ponded area had decreased along with the amount of snow in the area (Photo 4.76). Channelized flow was not observed from within beaded stream north of GMT2 into Lake M9925 during monitoring.

Photo 4.73: GMT2 channel conditions, after peak stage, looking east; June 2, 2011

Photo 4.74: Ice and snow free channel at GMT2; June 3, 2011

Photo 4.75: Pooled area upstream and polygon crack downstream of GMT2, no defined channel, looking west; June 6, 2011

Photo 4.76: GMT2 becoming even less defined as breakup flood flow ceases, looking east; June 9, 2011

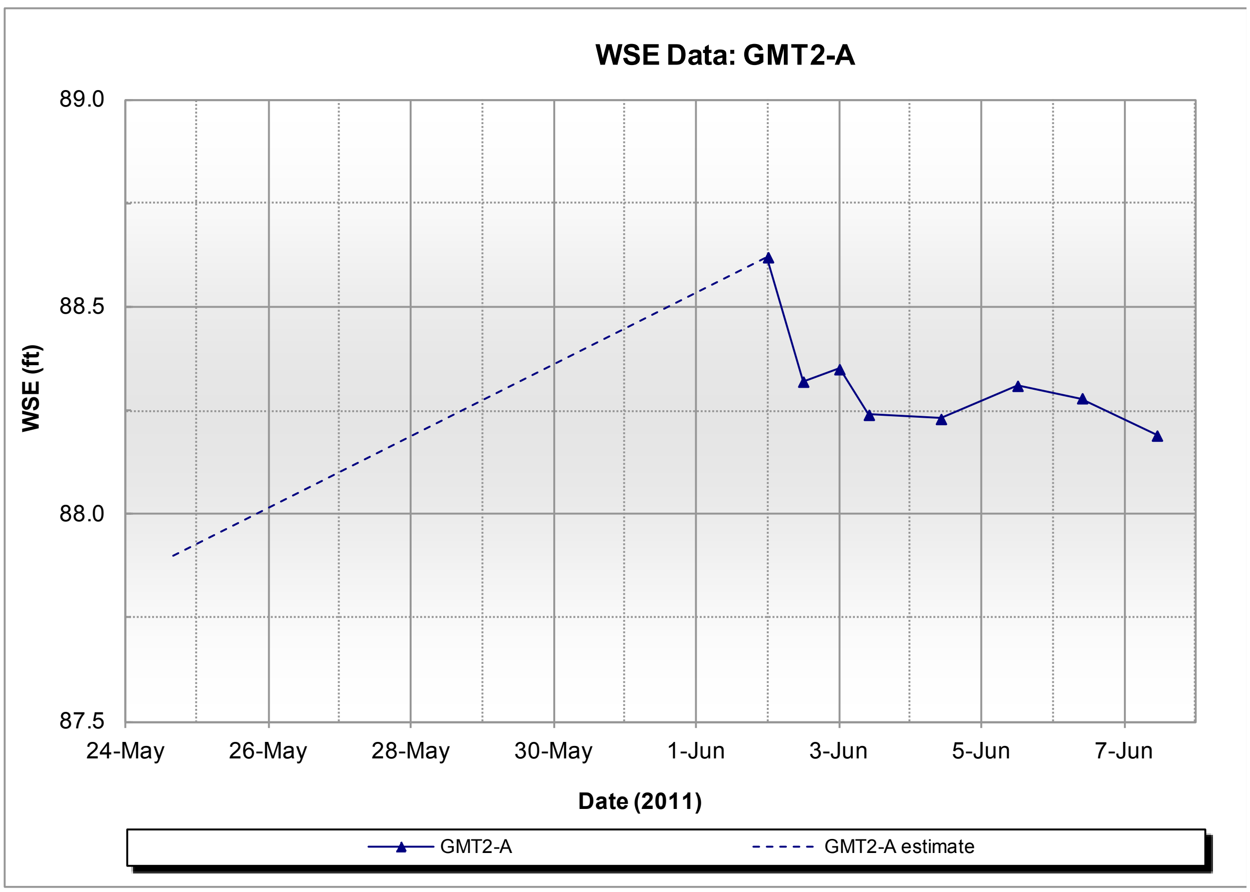
Peak WSE based on assumed elevations from 2010, and HWM were recorded at GMT2 (June 2, 88.62 feet). HWMs at GMT2 are time-estimated. Stage at GMT2 continued to decline from the initial readings throughout the monitoring period, and it is possible that peak WSE occurred before the first gage reading. An estimate of pre-breakup WSE was made based on conditions during setup. The hydrograph for the GMT2 crossing location is provided in Table 4.19.

Table 4.19: GMT2 Water Surface Elevation

Date and Time	WSE (ft - assumed) GMT2-A	Observations
5/24/11 4:20 PM	*87.90*	**Estimate** - maximum pre-breakup WSE based on conditions during set-up and observations of conditions prior to NPR-A breakup
6/2/11 12:00 AM	**88.62**	**PEAK STAGE**, HWM - *time estimated*
6/2/11 11:50 AM	88.32	
6/3/11 12:00 AM	88.35	HWM - *time estimated*
6/3/11 9:55 AM	88.24	Weather cooling, breakup melting progressing less rapidly; snow in area, channel relatively ice/snow free, poorly defined except at gage location
6/4/11 10:10 AM	88.23	Ponded areas upstream and downstream of gage location
6/5/11 11:56 AM	88.31	
6/6/11 9:40 AM	88.28	Some flow still present
6/7/11 10:50 AM	88.19	
6/8/2011		No flow present at this location

Notes:

1. Elevations are based on MADISON, BRYNN and LOGAN at 90.137, 89.272 and 90.000 feet assumed elevation, respecitvely, established by Baker in 2010 using a handheld Garmin Rino 520HCx GPS. These elevations are not tied to any other monitoring locations,



4.2.9 Greater Moose's Tooth 2 Discharge

4.2.9.1 Direct Discharge

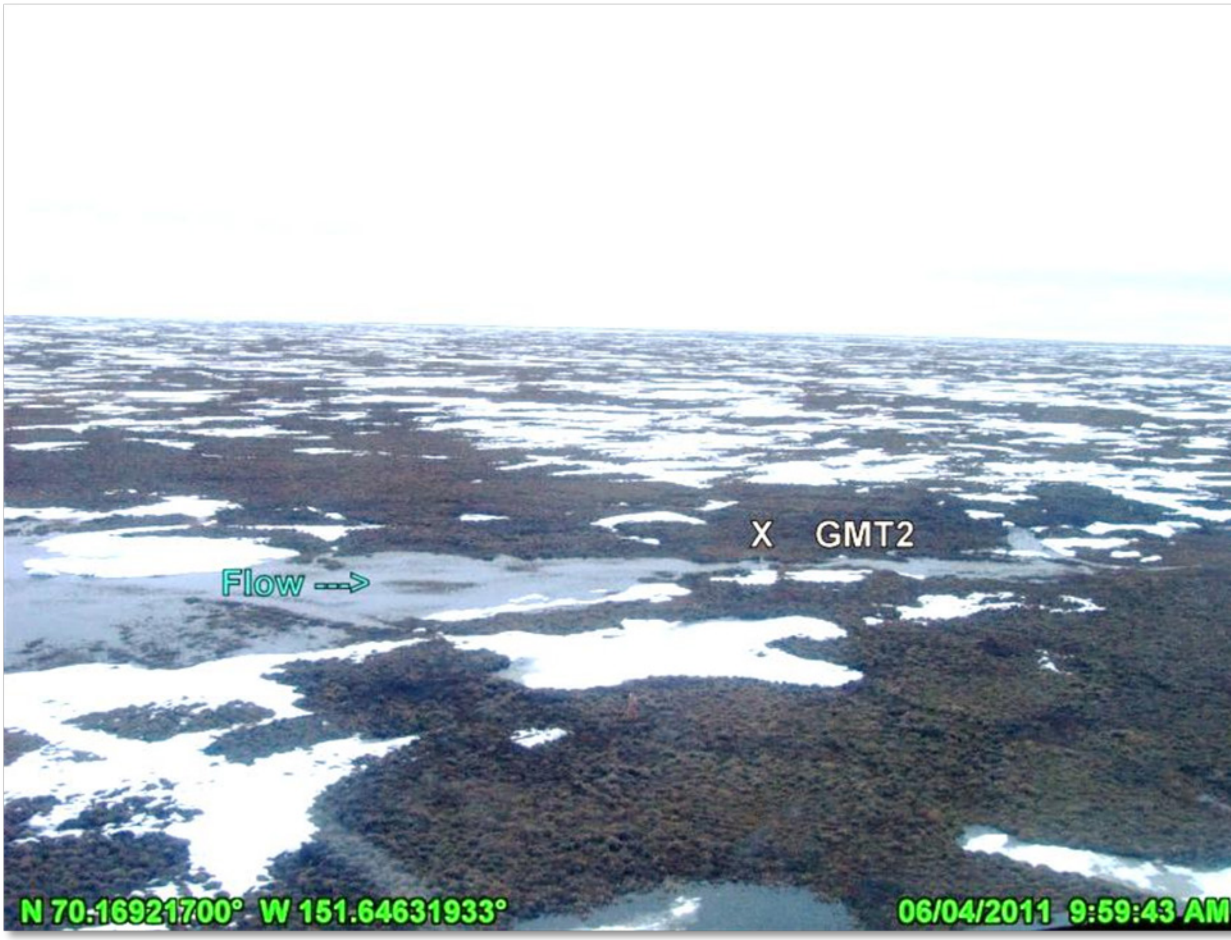


Photo 4.77: Channel conditions during the discharge measurement at the proposed S5 bridge location, looking downstream (East), June 4, 2011

A direct discharge measurement was performed at GMT2 on June 4, beginning at 10:15 AM, approximately 58 hours after peak stage. Discharge was measured to be 1.6 cfs. The measurement was rated fair based on channel conditions. The channel was relatively uniform and ice free. The majority of the cross-section was grassy, and there were small pools upstream and downstream of the discharge measurement. Photo 4.77 shows conditions at GMT2 at the time of the discharge measurement.

A summary of the 2011 direct discharge measurement at GMT2 is presented in Table 4.20, and notes are in Appendix B.

Table 4.20: GMT2 Direct Discharge

Location	Date & Time	WSE[1] (ft BPMSL)	Width (ft)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	Measurement Rated[2]	Meter Type	Number of Sections	Measurement Type
GMT2	6/4/11 10:15 AM	88.23	12.5	3.7	0.43	**1.6**	F	Marsh McBirney	26	Wading

[1] WSE values at the start of the measurement; based on GPS data; elevations are not relative or tied to local control.
[2] Measurement Rating:
E - Excellent: Point plots nearly on the rating curve; within 2% of true value
G - Good: Within 5% of true value
F - Fair: Within 7-10% of true value
P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; less than 15% of true value

4.2.9.2 Indirect Discharge

Indirect discharge at GMT2 was calculated using a velocity-area analysis as discussed in Section 3.3.2. Peak stage was estimated to have occurred between the evening of June 1 and the morning of June 2. Peak discharge at GMT2 was calculated to be 4 cfs. A summary of indirect discharge results and peak WSE elevation data for the GMT2 crossing location is contained in Table 4.21.

Table 4.21: GMT2 Indirect Discharge and Peak Water Surface Elevation

Location	Peak WSE[1] (ft BPMSL)	Peak Discharge[2] (cfs)	Date & Time[3]
GMT2	88.62	**4**	6/2/11 12:00 AM

[1] WSE values are based on GPS data; elevations are not relative or tied to local control.
[2] Peak discharge was calcuated indirectly using the velocity-area method and peak WSE.
[3] Peak WSE value is a high water mark; time is estimated

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Section 5 Flood and Stage Frequency Analysis

Flood analyses were performed in 2009 (Baker 2009) for nine locations in the GMT monitoring area to determine recurrence intervals for peak discharge. Additionally, sufficient historical annual peak WSE data had been collected at the Ublutuoch River for a stage frequency analysis to be performed in 2009. Since the record of monitoring WSE at other GMT locations was more limited, and these streams are affected by snow and ice, stage frequency analyses could not performed at any other GMT monitoring site with any confidence in accuracy. 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.

For 2011, three locations from 2009 were monitored: the Ublutuoch River at UB6.8 and small stream sites S4 and S5. Presented in this section are the 2011 peak discharge values from the three locations compared to the recurrence intervals from the 2009 flood frequency analysis, and 2011 peak stage at UB6.8 compared to the recurrence intervals from the 2009 stage frequency analysis.

5.1 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 Greater Moose's Tooth 1 (GMT1) Alpine Satellite Project 2009 Spring Breakup Hydrologic Assessment (Baker 2009a) report.

5.1.1 Ublutuoch Flood Frequency

In 2009, a flood frequency analysis was performed for UB6.8. Results of this analysis are the basis for current design values, presented in Table 5.1. This analysis uses the 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. A Weibull analysis performed using historical peak discharge data is included with the Region 7 regression equation results in Graph 5.1. 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.

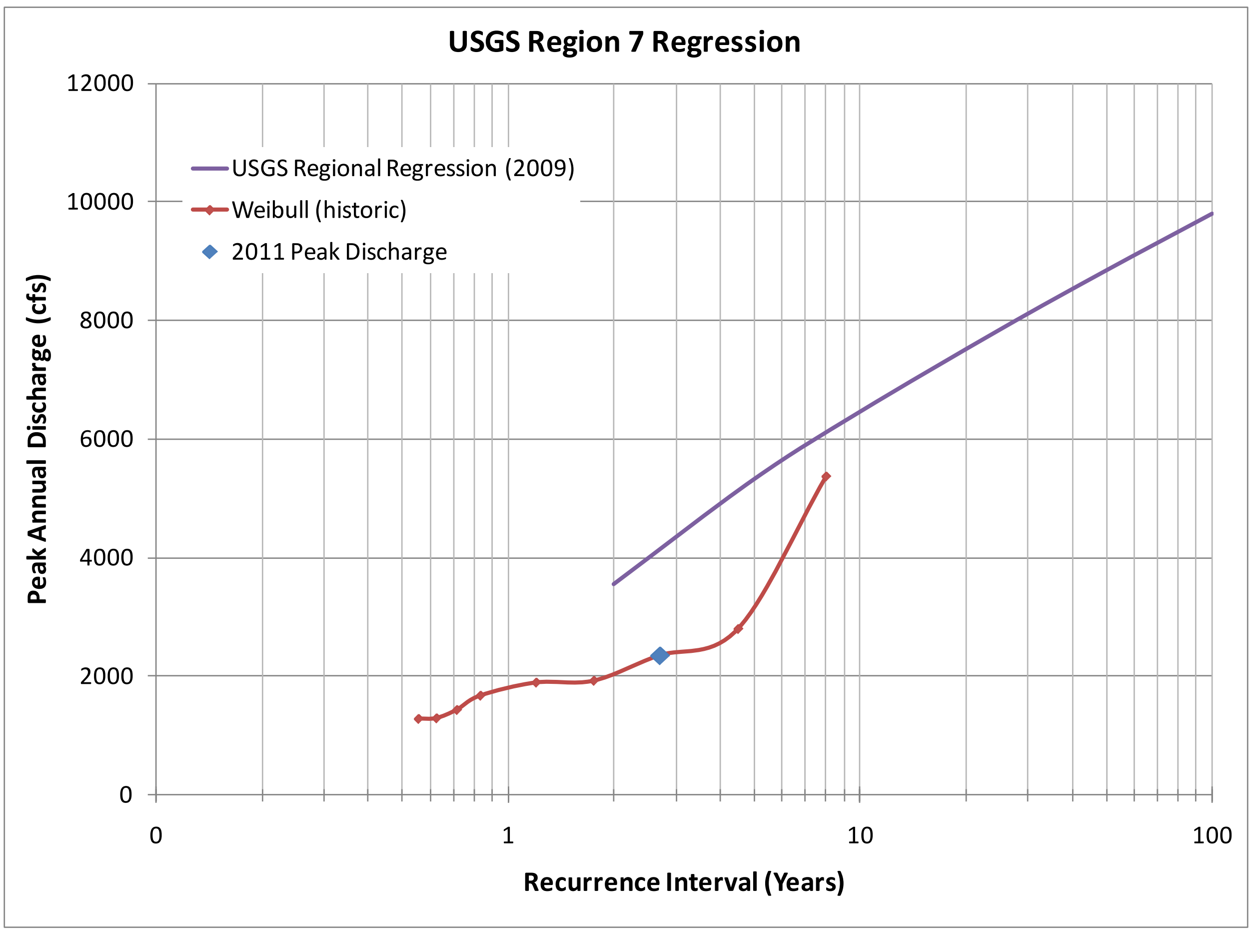
The 2011 peak discharge in the Ublutuoch River at UB6.8 was 2,350 cfs, which corresponds to a recurrence interval lower than accountable using the USGS Region 7 regression equations. The 2011 peak discharge at UB6.8 corresponds to less than a 2-year recurrence interval, based on the regression equations; and based on historical record, 2011 peak discharge corresponds to a 2.7-year recurrence interval.

Table 5.1: Ublutuoch River UB6.8 Flood Frequency Analysis Results

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 5.1: Ublutuoch River UB6.8 Flood Frequency Estimates



5.1.2 Ublutuoch Stage Frequency

A HYFRAN stage frequency analysis was performed in 2009 for the UB6.8 bridge crossing site based on 5 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). At UB6.8 the observed record is seven years and spring breakup flood events are typically impacted by snow and ice. In addition to the statistical analysis, a HEC-RAS model was developed in 2003 to estimate the 100-year flood stage. Given the current stage frequency analysis and the 2003 HEC-RAS estimate, peak stage for a 100-year event is estimated to be 12.5 feet at UB6.8.

Annually, recurrence intervals are assigned to each of the current and historical peak stage values using the Weibull plotting equation (USACE 1982). The 2011 peak stage in the Ublutuoch at UB6.8 of 9.39 feet BPMSL corresponds to a 1.6-year recurrence interval based on historical data. Historic stage recurrence data is included with the 2011 peak WSE in Table 5.2.

Table 5.2: Ublutuoch River UB6.8 Weibull Based Stage Recurrence Intervals

Year	Peak Annual Stage (Feet, BPMSL)	Probability	Recurrence Interval (Years)	Reference
2011	9.39	0.63	1.6	This report
2010	10.38	0.25	4.0	Baker 2010
2009	8.45	0.75	1.3	Baker 2009
2006	6.19	0.88	1.1	Baker 2006
2005	10.01	0.50	2.0	Baker 2005c
2004	10.50	0.13	8.0	Baker 2005a
2003	10.14	0.38	2.7	Baker 2003a

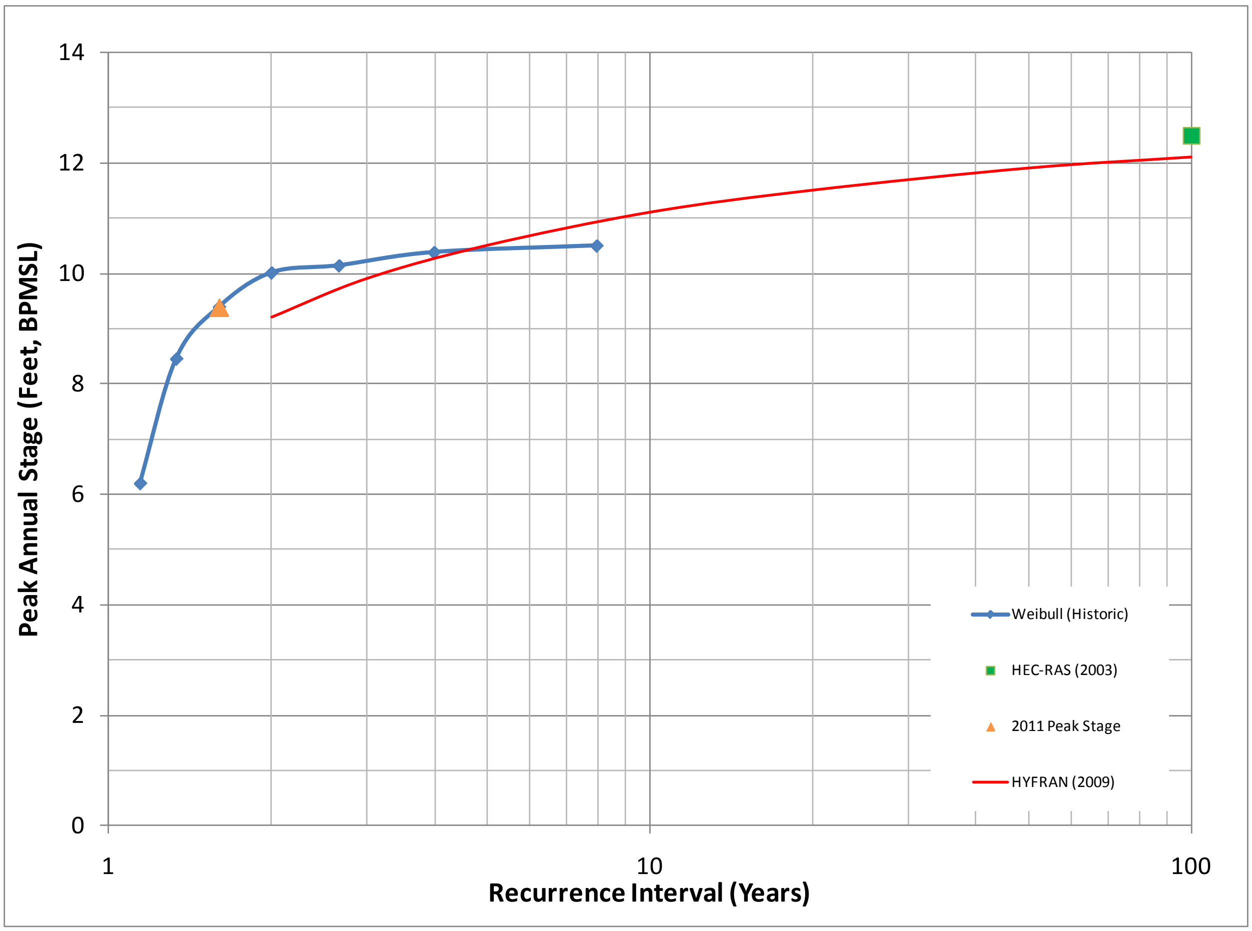
Based on the 2009 HYFRAN stage frequency analysis, the 2011 peak WSE at UB6.8 corresponds to approximately a 2.1-year recurrence interval. The 2009 Log Person Type III design values are presented in Table 5.3. Both the historical Weibull and the 2009 HYFRAN values are plotted for comparison with 2011 peak WSE and the HEC-RAS 100-year flood stage estimate in Graph 5.2.

Table 5.3: Ublutuoch River UB6.8 Peak Annual Stage Estimates

Recurrence Interval (Years)	Peak Annual Stage (Feet, BPMSL)
	log Pearson type III[1]
2	9.2
5	10.5
10	11.1
50	11.9
100	12.1

[1] Baker 2009

Graph 5.2: Ublutuoch River UB6.8 Stage Frequency Estimates



5.2 Small Stream Crossings S4 and S5

Small stream crossings S4 and S5 were selected for monitoring in 2011. Flood frequency and stage frequency analyses aid in the development of design criteria for proposed drainage structures. Due to lack of historical data, a stage frequency analysis could not be performed with an acceptable level of confidence. For discussion on the 2009 analysis criteria, see the report: Greater Moose's Tooth 1 (GMT1) Alpine Satellite Project 2009 Spring Breakup Hydrologic Assessment (Baker 2009).

5.2.1 S4 and S5 Flood Frequency

In 2009, a flood frequency analysis was performed at small stream crossings S4 and S5. This analysis uses the 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.

The 2011 peak discharge values at S4 and S5 were 16 cfs and 84 cfs, respectively. These results are both considered low estimates, as discussed in 4.2.5.2 and 4.2.7.2. Both of these quantities correspond to a recurrence interval lower than the USGS Region 7 regression equation results. Regression equations over-predict the discharge quantities for a given recurrence interval, especially for the lower recurrence flood years when ice and snow tend to have more impact. The recurrence intervals for peak stage at both S4 and S5 were less than 2 years. Table 5.4 and Table 5.5 include the results of the 2009 flood frequency analyses for S4 and S5, respectively.

Table 5.4: S4 Flood Frequency Analysis Results

Recurrence Interval (Years)	Discharge (cfs) USGS Region 7 Regression Equation S4[1]
2	21
5	35
10	45
25	58
50	68
100	78

1. Baker 2009

Table 5.5: S5 Flood Frequency Analysis Results

Recurrence Interval (Years)	Discharge (cfs) USGS Region 7 Regression Equation S5[1]
2	87
5	144
10	182
25	231
50	267
100	303

1. Baker 2009

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Appendix A 2011 Fish Creek Basin Survey Control and Gage Locations

Table A.1: 2011 Survey Control

Control	Elevation (BPMSL - feet)	Latitude (NAD 83)	Longitude (NAD83)	Control Type	Reference
ALMA	25.263	N 70° 16' 45.7"	W 151° 19' 53.2"	Alcap	LCMF 2009
BAKER CP2	**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**
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: Elevations for control in **bold** were set by handheld GPS and are not verified by survey to local control, not in BPMSL.

Table A.2: 2011 Gage Locations

Gage Site	Gage	Latitude (NAD 83)	Longitude (NAD83)	Basis of Elevation
Clover B	Clover B1	N 70° 15' 16.3"	W 151° 14' 19.1"	CLARK MEG BAKER CP3
	Clover B2[1]	N 70° 15' 05.7"	W 151° 14' 11.2"	
	Clover B3	N 70° 14' 58.4"	W 151° 13' 51.0"	
	Clover B4	N 70° 14' 53.4"	W 151° 13' 57.2"	
Clover C	Clover C1	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"	
	Clover C3	N 70° 14' 53.0"	W 151° 14' 23.7"	
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-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"	
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	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"	
S3	S3-A	N 70° 17' 46.1"	W 151° 14' 12.7"	CP08-18-29C
S4	S4-A	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	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	N 70° 16' 45.2"	W 151° 19' 48.7"	
GMT2	GMT2-A	N 70° 10' 12.2"	W 151° 39' 41.3"	MADISON BRYNN LOGAN

Notes:
1. A pressure transducer was installed on this gage to determine water surface elevation.
2. A BaroTroll was installed on this gage to determine barometric pressure.

Appendix B 2011 Fish Creek Basin Direct Discharge Measurement Notes

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Discharge Measurement Notes

Baker

Date: June 4, 2011
Computed By: EJK
Checked By: HLR

Location Name: Clover B1

Party: JMS, SME   Start: 1435   Finish: 1503

Temp: 25 °F   Weather: Overcast, light wind

Channel Characteristics:

Width: 33 ft   Area: 24 sq ft   Velocity: 0.32 fps   Discharge: 7.9 cfs

Method: Standard   Number of Sections: 24   Count: N/A

Spin Test: N/A revolutions after N/A seconds   Meter: Marsh McBirney

Meter: - ft above bottom of weight

Weight: - lbs

Wading Cable Ice Boat

Upstream or Downstream side of bridge

GAGE READINGS			
Gage	Start	Finish	Change
Clover B1-B	-0.02	-0.03	-0.01

GPS Data: Clover B1-Q LEW, REW

Left Edge of	N	70 °	15 '	16.3 "	LE Floodplain:	N	70° 15'	16.5 "
Water:	W	151 °	14 '	18.5 "		W	151° 14'	19.7 "
Right Edge of	N	70 °	15 '	16.2 "	RE Floodplain:	N	70° 15'	16.2 "
Water:	W	151 °	14 '	17.6 "		W	151° 14'	16.5 "

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

Descriptions:

Cross Section: Ice on bottom across entire channel - very slippery.

Flow:

Remarks: Confined channel, snow on both sides.

Clover B1
June 4, 2011

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
REW	20.0	0.5	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	21.0	1.3	0.35	0.6	0.11	0.11	N/A	0.4	0.05
	22.5	1.5	0.55	0.6	0.24	0.24	N/A	0.8	0.20
	24.0	1.5	0.75	0.6	0.26	0.26	N/A	1.1	0.29
	25.5	1.5	0.70	0.6	0.25	0.25	N/A	1.1	0.26
	27.0	1.5	0.50	0.6	0.24	0.24	N/A	0.8	0.18
	28.5	1.5	0.50	0.6	0.36	0.36	N/A	0.8	0.27
	30.0	1.5	0.45	0.6	0.36	0.36	N/A	0.7	0.24
	31.5	1.5	0.50	0.6	0.40	0.40	N/A	0.8	0.30
	33.0	1.5	0.70	0.6	0.43	0.43	N/A	1.1	0.45
	34.5	1.5	0.80	0.6	0.36	0.36	N/A	1.2	0.43
	36.0	1.5	0.60	0.6	0.37	0.37	N/A	0.9	0.33
	37.5	1.5	0.70	0.6	0.28	0.28	N/A	1.1	0.29
	39.0	1.5	0.70	0.6	0.37	0.37	N/A	1.1	0.39
	40.5	1.5	1.00	0.6	0.34	0.34	N/A	1.5	0.51
	42.0	1.5	1.00	0.6	0.39	0.39	N/A	1.5	0.59
	43.5	1.5	1.00	0.6	0.36	0.36	N/A	1.5	0.54
	45.0	1.5	1.20	0.6	0.36	0.36	N/A	1.8	0.65
	46.5	1.5	1.20	0.6	0.32	0.32	N/A	1.8	0.58
	48.0	1.5	1.10	0.6	0.26	0.26	N/A	1.7	0.43
	49.5	1.5	1.00	0.6	0.29	0.29	N/A	1.5	0.44
	51.0	1.5	0.80	0.6	0.32	0.32	N/A	1.2	0.38
	52.5	1.0	0.40	0.6	0.24	0.24	N/A	0.4	0.10
LEW	53.0	0.3	0.00	0.0	0.00	0.00	N/A	0.0	0.00
									0.00
									0.00
									0.00
									0.00
									0.00
									0.00
									0.00
									0.00

Total Measured Discharge: 7.9

Baker

Discharge Measurement Notes

Date: June 4, 2011
Computed By: EJK
Checked By: HLR

Location Name: Clover B2

Party: SME, HLR, EJK, JMS Start: 1535 Finish: 1558

Temp: 25 °F Weather: Overcast, light wind

Channel Characteristics:

Width: 39.5 ft Area: 18 sq ft Velocity: 0.40 fps Discharge: 7.1 cfs

Method: Standard Number of Sections: 27 Count: N/A

Spin Test: N/A revolutions after N/A seconds Meter: Marsh McBirney

Meter: - ft above bottom of weight

Weight: - lbs

Wading Cable Ice Boat

Upstream or Downstream side of bridge

GAGE READINGS			
Gage	Start	Finish	Change
Clover B2-A	0.48	0.48	0.00

GPS Data: CloverB2-Q LEW, REW

Left Edge of	N	70 º	15 '	6.7 "	LE Floodplain:	N	70º 15'	6.1 "
Water:	W	151 º	14 '	15.7 "		W	151º 14'	16.9 "
Right Edge of	N	70 º	15 '	7.1 "	RE Floodplain:	N	70º 15'	7.5 "
Water:	W	151 º	14 '	15.2 "		W	151º 14'	13.7 "

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

Descriptions:

Cross Section: Grassy islands on both sides of channel, wider channel upstream. Downstream flow diverges into multiple smaller channels

Flow:

Remarks: Grass throughout water column, snow on right bank of floodplain.

Clover B2
June 4, 2011

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
LEW	19.5	0.5	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	20.5	1.3	0.00	0.0	0.00	0.00	N/A	0.0	0.00
grass	22.0	1.5	0.10	0.6	0.00	0.00	N/A	0.2	0.00
grass	23.5	1.5	0.10	0.6	0.00	0.00	N/A	0.2	0.00
grass	25.0	1.5	0.25	0.6	0.00	0.00	N/A	0.4	0.00
grass	26.5	1.5	0.20	0.6	0.00	0.00	N/A	0.3	0.00
grass	28.0	1.5	0.00	0.6	0.00	0.00	N/A	0.0	0.00
grass	29.5	1.5	0.00	0.6	0.00	0.00	N/A	0.0	0.00
grass	31.0	1.5	0.25	0.6	0.00	0.00	N/A	0.4	0.00
grass	32.5	1.5	0.25	0.6	0.00	0.00	N/A	0.4	0.00
grass	34.0	1.5	0.50	0.6	0.18	0.18	N/A	0.8	0.14
grass	35.5	1.5	0.45	0.6	0.06	0.06	N/A	0.7	0.04
grass	37.0	1.5	0.40	0.6	0.07	0.07	N/A	0.6	0.04
grass	38.5	1.5	0.25	0.6	0.03	0.03	N/A	0.4	0.01
grass	40.0	1.5	0.40	0.6	0.13	0.13	N/A	0.6	0.08
grass	41.5	1.5	0.40	0.6	0.07	0.07	N/A	0.6	0.04
grass	43.0	1.5	0.30	0.6	0.37	0.37	N/A	0.5	0.17
grass	44.5	1.5	0.40	0.6	0.44	0.44	N/A	0.6	0.26
grass	46.0	1.5	0.60	0.6	0.55	0.55	N/A	0.9	0.50
grass	47.5	1.5	0.80	0.6	0.49	0.49	N/A	1.2	0.59
grass	49.0	1.5	1.00	0.6	0.67	0.67	N/A	1.5	1.01
grass	50.5	1.5	1.00	0.6	0.67	0.67	N/A	1.5	1.01
grass	52.0	1.5	1.00	0.6	0.52	0.52	N/A	1.5	0.78
grass	53.5	1.5	0.95	0.6	0.64	0.64	N/A	1.4	0.91
grass	55.0	1.5	0.95	0.6	0.46	0.46	N/A	1.4	0.66
grass	56.5	1.5	0.80	0.6	0.65	0.65	N/A	1.2	0.78
grass	58.0	1.3	0.50	0.6	0.22	0.22	N/A	0.6	0.14
REW	59.0	0.5	0.00	0.0	0.00	0.00	N/A	0.0	0.00
									0.00
									0.00
									0.00
									0.00

Total Measured Discharge: 7.1

Baker

Discharge Measurement Notes

Date: June 4, 2011
Computed By: EJK
Checked By: HLR

Location Name: Clover B3

Party: SME, HLR, EJK, JMS   Start: 1620   Finish: 1656

Temp: 25 °F   Weather: Overcast - beginning to break, light wind

Channel Characteristics:

Width: 68 ft   Area: 29 sq ft   Velocity: 0.15 fps   Discharge: 4.2 cfs

Method: Standard   Number of Sections: 40   Count: N/A

Spin Test: N/A revolutions after N/A seconds   Meter: Marsh McBirney

Meter: - ft above bottom of weight

Weight: - lbs

Wading Cable Ice Boat

Upstream or Downstream side of bridge

GAGE READINGS			
Gage	Start	Finish	Change
Clover B3-A	0.15	0.15	0.00

GPS Data: Clover B3-Q LEW, REW **"Main Channel"**

Left Edge of Water:	N	70 °	14 '	58.8 "	LE Floodplain:	N	70° 14'	58.0 "
	W	151 °	13 '	50.8 "		W	151° 13'	49.5 "
Right Edge of Water:	N	70 °	14 '	59.3 "	RE Floodplain:	N	70° 14'	59.7 "
	W	151 °	13 '	51.7 "		W	151° 13'	52.3 "

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

Descriptions:

Cross Section: Braided channel; left-most channel - grass thoughout water column and bound by tussocks/hummocks. Right-most channel c
braid contains grass throughout water column.

Flow:

Remarks: Gage not at main channel

Clover B3
June 4, 2011

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
LEW	6.0	0.3	0.20	0.6	0.03	0.03	N/A	0.1	0.00
Secondary Channel	6.5	0.5	0.30	0.6	0.03	0.03	N/A	0.2	0.00
	7.0	0.5	0.60	0.6	0.33	0.33	N/A	0.3	0.10
	7.5	0.5	0.60	0.6	0.21	0.21	N/A	0.3	0.06
	8.0	0.5	0.60	0.6	0.25	0.25	N/A	0.3	0.08
	8.5	0.5	0.70	0.6	0.32	0.32	N/A	0.4	0.11
	9.0	0.5	0.80	0.6	0.30	0.30	N/A	0.4	0.12
	9.5	0.5	0.80	0.6	0.49	0.49	N/A	0.4	0.20
	10.0	0.5	0.80	0.6	0.11	0.11	N/A	0.4	0.04
	10.5	0.5	0.80	0.6	0.28	0.28	N/A	0.4	0.11
	11.0	0.5	0.80	0.6	0.21	0.21	N/A	0.4	0.08
	11.5	0.5	0.80	0.6	0.26	0.26	N/A	0.4	0.10
	12.0	0.5	0.60	0.6	0.27	0.27	N/A	0.3	0.08
	12.5	0.5	0.40	0.6	0.24	0.24	N/A	0.2	0.05
	13.0	0.5	0.30	0.6	0.03	0.03	N/A	0.2	0.00
	13.5	0.5	0.10	0.6	0.00	0.00	N/A	0.1	0.00
REW	14.0	0.3	0.00	0.6	0.00	0.00	N/A	0.0	0.00
LEW	43.0	1.5	0.01	0.0	0.00	0.00	N/A	0.0	0.00
Main Channel	46.0	3.0	0.10	0.0	0.00	0.00	N/A	0.3	0.00
	49.0	3.0	0.30	0.6	0.06	0.06	N/A	0.9	0.05
	52.0	3.0	0.50	0.6	0.25	0.25	N/A	1.5	0.38
	55.0	3.0	0.60	0.6	0.20	0.20	N/A	1.8	0.36
	58.0	3.0	0.50	0.6	0.38	0.38	N/A	1.5	0.57
	61.0	3.0	0.50	0.6	0.35	0.35	N/A	1.5	0.53
	64.0	3.0	0.35	0.6	0.11	0.11	N/A	1.1	0.12
	67.0	3.0	0.60	0.6	0.10	0.10	N/A	1.8	0.18
	70.0	3.0	0.60	0.6	0.08	0.08	N/A	1.8	0.14
	73.0	3.0	0.50	0.6	0.13	0.13	N/A	1.5	0.20
	76.0	3.0	0.50	0.6	0.12	0.12	N/A	1.5	0.18
	79.0	3.0	0.50	0.6	0.04	0.04	N/A	1.5	0.06
	82.0	3.0	0.50	0.6	0.05	0.05	N/A	1.5	0.08
	85.0	3.0	0.45	0.6	0.01	0.01	N/A	1.4	0.01

Clover B3
June 4, 2011

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
Main Channel	88.0	3.0	0.30	0.0	0.06	0.06	N/A	0.9	0.05
	91.0	3.0	0.30	0.0	0.05	0.05	N/A	0.9	0.05
	94.0	3.0	0.30	0.6	0.00	0.00	N/A	0.9	0.00
	97.0	3.0	0.10	0.0	0.00	0.00	N/A	0.3	0.00
	100.0	2.0	0.35	0.6	0.11	0.11	N/A	0.7	0.08
	101.0	1.0	0.40	0.6	0.14	0.14	N/A	0.4	0.06
	102.0	1.0	0.40	0.6	0.05	0.05	N/A	0.4	0.02
REW	103.0	0.5	0.10	0.6	0.00	0.00	N/A	0.1	0.00

Total Measured Discharge: 4.2

Baker

Discharge Measurement Notes

Date: June 4, 2011
Computed By: EJK
Checked By:

Location Name: Clover C1

Party: JMS, SME, HLR, EJK   Start: 1806   Finish: 1835

Temp: 30 °F   Weather: Partly cloudy, light wind

Channel Characteristics:

Width: 34 ft   Area: 8.3 sq ft   Velocity: 0.20 fps   Discharge: 1.7 cfs

Method: Standard   Number of Sections: 46   Count: N/A

Spin Test: N/A revolutions after N/A seconds   Meter: Marsh McBirney

GAGE READINGS			
Gage	Start	Finish	Change
survey to WSE	31.01	31.01	0.00

Meter: - ft above bottom of weight

Weight: - lbs

Wading Cable Ice Boat

Upstream or Downstream side of bridge

GPS Data: Clover C1-Q LEW, REW **"Main Channel"**

Left Edge of	N	70 °	15 '	3.1 "
Water:	W	151 °	15 '	10.9 "
Right Edge of	N	70 °	15 '	3.4 "
Water:	W	151 °	15 '	11 "

LE Floodplain: ° ' . "

RE Floodplain: ° ' . "

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

Descriptions:

Cross Section: Two channels - bigger channel located on left floodplain, smaller on right side, grass throughout, big island in middle

Flow:

Remarks: No snow on channel, more snow upstream/downstream. Waypoints taken.

Clover C1
June 4, 2011

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
LEW	2.0	0.5	0.10	0.0	0.00	0.00	N/A	0.1	0.00
	3.0	1.0	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	4.0	1.0	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	5.0	1.0	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	6.0	1.0	0.20	0.0	0.00	0.00	N/A	0.2	0.00
	7.0	1.0	0.20	0.6	0.14	0.14	N/A	0.2	0.03
	8.0	1.0	0.15	0.6	0.13	0.13	N/A	0.2	0.02
	9.0	0.8	0.20	0.6	0.29	0.29	N/A	0.2	0.04
	9.5	0.5	0.50	0.6	0.43	0.43	N/A	0.3	0.11
	10.0	0.5	0.20	0.6	0.02	0.02	N/A	0.1	0.00
	10.5	0.5	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	11.0	0.8	0.10	0.0	0.00	0.00	N/A	0.1	0.00
	12.0	1.0	0.40	0.6	1.57	1.57	N/A	0.4	0.63
	13.0	1.0	0.25	0.6	0.19	0.19	N/A	0.3	0.05
	14.0	1.0	0.10	0.0	0.00	0.00	N/A	0.1	0.00
	15.0	1.0	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	16.0	1.0	0.35	0.6	0.11	0.11	N/A	0.4	0.04
	17.0	1.0	0.40	0.6	0.14	0.14	N/A	0.4	0.06
	18.0	1.0	0.50	0.6	0.12	0.12	N/A	0.5	0.06
	19.0	1.0	0.40	0.6	0.09	0.09	N/A	0.4	0.04
	20.0	1.0	0.40	0.6	0.09	0.09	N/A	0.4	0.04
	21.0	1.0	0.40	0.6	0.02	0.02	N/A	0.4	0.01
	22.0	1.0	0.40	0.6	0.07	0.07	N/A	0.4	0.03
	23.0	1.0	0.40	0.6	0.07	0.07	N/A	0.4	0.03
	24.0	1.0	0.50	0.6	0.07	0.07	N/A	0.5	0.04
	25.0	1.0	0.40	0.6	0.18	0.18	N/A	0.4	0.07
	26.0	1.0	0.30	0.6	0.42	0.42	N/A	0.3	0.13
	27.0	1.0	0.30	0.6	0.43	0.43	N/A	0.3	0.13
	28.0	1.0	0.2	0.6	0.29	0.29	N/A	0.2	0.06
REW	29.0	0.5	0.1	0.0	0.00	0.00	N/A	0.1	0.00
Isaland									
LEW	34.5	0.3	0.3	0.0	0.00	0.00	N/A	0.1	0.00
	35.0	0.5	0.3	0.6	0.08	0.08	N/A	0.2	0.01

Clover C1
June 4, 2011

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
REW	35.5	0.3	0.15	0.0	0.00	0.00	N/A	0.0	0.00
Island									
LEW	57.0	0.3	0.10	0.0	0.00	0.00	N/A	0.0	0.00
	57.5	0.5	0.20	0.6	0.03	0.03	N/A	0.1	0.00
	58.0	0.5	0.20	0.6	0.07	0.07	N/A	0.1	0.01
	58.5	0.5	0.20	0.6	0.11	0.11	N/A	0.1	0.01
	59.0	0.5	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	59.5	0.5	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	60.0	0.5	0.10	0.0	0.00	0.00	N/A	0.1	0.00
	60.5	0.5	0.20	0.0	0.00	0.00	N/A	0.1	0.00
	61.0	0.5	0.40	0.6	0.17	0.17	N/A	0.2	0.03
	61.5	0.5	0.50	0.6	0.01	0.01	N/A	0.3	0.00
	62.0	0.5	0.25	0.6	0.02	0.02	N/A	0.1	0.00
	62.5	0.5	0.10	0.0	0.00	0.00	N/A	0.1	0.00
REW	63.0	0.3	0.00	0.0	0.00	0.00	N/A	0.0	0.00

Total Measured Discharge: 1.7

Discharge Measurement Notes

Baker

Date: June 4, 2011
Computed By: EJK
Checked By: HLR

Location Name: Clover C2

Party: JMS, SME, HLR, EJK   Start: 1723   Finish: 1741

Temp: 30 °F   Weather: Partly cloudy, light wind

Channel Characteristics:

Width: 27 ft   Area: 8.8 sq ft   Velocity: 0.26 fps   Discharge: 2.3 cfs

Method: Standard   Number of Sections: 29   Count: N/A

Spin Test: N/A revolutions after N/A seconds   Meter: Marsh McBirney

GAGE READINGS			
Gage	Start	Finish	Change
pressure transducer	35.09	35.09	0.00

Meter: - ft above bottom of weight

Weight: - lbs

Wading Cable Ice Boat

Upstream or Downstream side of bridge

GPS Data: For main channel

Left Edge of	N	70 °	14 '	58.4 "
Water:	E	151 °	14 '	46.1 "
Right Edge of	N	70 °	14 '	58.7 "
Water:	E	151 °	14 '	45.9 "

LE Floodplain:	N	70°	14'	58.2 "
	W	151°	14'	46.3 "
RE Floodplain:	N	70°	14'	59.1 "
	W	151°	14'	45.7 "

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

Descriptions:

Cross Section: Grass throughout water column, braided upstream, more confined and ponding downstrean

Flow:

Remarks: Some snow still present in area

Clover C2
June 4, 2011

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
LEW	0.5	0.3	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	1.0	0.8	0.10	0.0	0.00	0.00	N/A	0.1	0.00
	2.0	1.0	0.34	0.6	0.37	0.37	N/A	0.3	0.13
	3.0	1.0	0.50	0.6	0.39	0.39	N/A	0.5	0.20
	4.0	1.0	0.60	0.6	1.75	1.75	N/A	0.6	1.05
	5.0	1.0	0.55	0.6	0.54	0.54	N/A	0.6	0.30
	6.0	1.0	0.40	0.6	0.41	0.41	N/A	0.4	0.16
	7.0	1.0	0.30	0.6	0.24	0.24	N/A	0.3	0.07
	8.0	1.0	0.30	0.6	0.41	0.41	N/A	0.3	0.12
	9.0	1.0	0.30	0.6	0.20	0.20	N/A	0.3	0.06
	10.0	1.0	0.40	0.6	0.31	0.31	N/A	0.4	0.12
	11.0	1.0	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	12.0	1.0	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	13.0	1.0	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	14.0	1.0	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	15.0	1.0	0.10	0.0	0.00	0.00	N/A	0.1	0.00
	16.0	1.0	0.40	0.6	0.04	0.04	N/A	0.4	0.02
	17.0	1.0	0.30	0.0	0.00	0.00	N/A	0.3	0.00
	18.0	1.0	0.20	0.0	0.00	0.00	N/A	0.2	0.00
	19.0	1.0	0.10	0.0	0.00	0.00	N/A	0.1	0.00
	20.0	1.0	0.10	0.0	0.00	0.00	N/A	0.1	0.00
	21.0	1.0	0.30	0.0	0.00	0.00	N/A	0.3	0.00
	22.0	1.0	0.60	0.6	0.02	0.02	N/A	0.6	0.01
	23.0	1.0	0.90	0.6	0.05	0.05	N/A	0.9	0.05
	24.0	1.0	0.70	0.6	0.05	0.05	N/A	0.7	0.04
	25.0	1.0	0.70	0.6	-0.08	-0.08	N/A	0.7	-0.06
	26.0	1.0	0.60	0.6	-0.01	-0.01	N/A	0.6	-0.01
REW	27.0	0.8	0.10	0.0	0.00	0.00	N/A	0.1	0.00
	27.5	0.3	0.0	0.0	0.00	0.00	N/A	0.0	0.00

Total Measured Discharge: 2.3

Baker

Discharge Measurement Notes

Date: June 4, 2011
Computed By: EJK
Checked By: HLR

Location Name: GMT2-A

Party: HLR, SME, EJK, JMS   Start: 10:15   Finish: 10:37

Temp: ~25 °F   Weather: Light wind, overcast

Channel Characteristics:

Width: 12.5 ft   Area: 3.7 sq ft   Velocity: 0.43 fps   Discharge: 1.6 cfs

Method: Standard   Number of Sections: 26   Count: N/A

Spin Test: N/A revolutions after N/A seconds   Meter: Marsh McBirney

Meter: - ft above bottom of weight

Weight: - lbs

Wading Cable Ice Boat

Upstream or Downstream side of bridge

GAGE READINGS			
Gage	Start	Finish	Change
GMT2-A	0.83	0.83	0.00

GPS Data:

Left Edge of Water: N ° ' " / E ° ' "

Right Edge of Water: N ° ' " / E ° ' "

LE Floodplain: N 70° 10' 11.7 " / W 151° 39' 41.9 "

RE Floodplain: N 70° 10' 12.4 " / W 151° 39' 40.9 "

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

Descriptions:

Cross Section: Fairly uniform, grass, small pond upstream and downstream of discharge location. Small channel, grass in channel except fo 1 foot at the thalweg.

Flow:

Remarks: REW to LEW width is ~ 12 feet, effective flow width is ~ 5 feet

GMT2-A
June 4, 2011

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
REW	34.0	0.3	0.00	0.0	0.00	0.00	N/A	0.0	0.00
	34.5	0.5	0.05	0.0	0.00	0.00	N/A	0.0	0.00
	35.0	0.5	0.08	0.0	0.00	0.00	N/A	0.0	0.00
	35.5	0.5	0.20	0.0	0.00	0.00	N/A	0.1	0.00
	36.0	0.5	0.04	0.0	0.00	0.00	N/A	0.0	0.00
	36.5	0.5	0.05	0.0	0.00	0.00	N/A	0.0	0.00
	37.0	0.5	0.03	0.0	0.00	0.00	N/A	0.0	0.00
	37.5	0.5	0.12	0.0	0.00	0.00	N/A	0.1	0.00
	38.0	0.5	0.08	0.0	0.00	0.00	N/A	0.0	0.00
	38.5	0.5	0.22	0.0	0.00	0.00	N/A	0.1	0.00
	39.0	0.5	0.17	0.0	0.00	0.00	N/A	0.1	0.00
	39.5	0.5	0.03	0.0	0.00	0.00	N/A	0.0	0.00
	40.0	0.5	0.05	0.0	0.00	0.00	N/A	0.0	0.00
	40.5	0.5	0.23	0.6	0.13	0.13	N/A	0.1	0.01
Right edge of flow	41.0	0.5	0.40	0.6	0.14	0.14	N/A	0.2	0.03
	41.5	0.5	0.50	0.6	0.14	0.14	N/A	0.3	0.04
	42.0	0.5	0.55	0.6	0.33	0.33	N/A	0.3	0.09
	42.5	0.5	0.75	0.6	0.63	0.63	N/A	0.4	0.24
	43.0	0.5	0.80	0.6	1.86	1.86	N/A	0.4	0.74
	43.5	0.5	0.55	0.6	0.80	0.80	N/A	0.3	0.22
	44.0	0.5	0.50	0.6	0.30	0.30	N/A	0.3	0.08
	44.5	0.5	0.50	0.6	0.17	0.17	N/A	0.3	0.04
	45.0	0.5	0.45	0.6	0.10	0.10	N/A	0.2	0.02
	45.5	0.5	0.45	0.6	0.15	0.15	N/A	0.2	0.03
	46.0	0.5	0.50	0.6	0.09	0.09	N/A	0.3	0.02
LEW/edge of flow	46.5	0.3	0.00	0.0	0.00	0.00	N/A	0.0	0.00
									0.00
									0.00
									0.00
									0.00
									0.00
									0.00

Total Measured Discharge: 1.57

Baker

Discharge Measurement Notes

Date: June 2, 2011
Computed By: EJK
Checked By: HLR

Location Name: Ublutuoch 6.9

Party: SME, HLR, EJK Start: 13:55 Finish: 17:00

Temp: 35 °F Weather: Partly cloudy, windy

Channel Characteristics:

Width: 650 ft Area: 1600 sq ft Velocity: 1.4 fps Discharge: 2200 cfs

Method: Standard Number of Sections: 68 Count: 1

Spin Test: N/A* revolutions after N/A seconds Meter: Price AA; #S01016

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading Cable Ice **Boat**

Upstream or Downstream side of bridge

GAGE READINGS			
Gage	Start	Finish	Change
UB6.7-B	2.24	2.20	-0.04
UB6.9-C	1.37	1.24	-0.13

GPS Data: UB Q LEW, REW

Left Edge of Water: N 70 ° 16 ' 58.8 "; W 151 ° 15 ' 37.5 "

Right Edge of Water: N 70 ° 17 ' 2.7 "; W 151 ° 15 ' 21.9 "

LE Floodplain: ° ' . "

RE Floodplain: ° ' . "

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

Descriptions:

Cross Section: Left overbank section shallow, wide - no effective flow present.

Flow: Ice jam forming downstream of Ublutuoch 6.7. Cold, windy and snow on left and right bank. Flow effected by ice.

Remarks: Stage falling

Marked GPS points 'UB_Q_LEMC', 'UB_Q_LES', 'UB_Q_LEW', 'UB_Q_REW', 'UB_Q_RES'

* Meter was refurbished by USGS prior to use for this measurement.

Ublutuoch 6.9
June 2, 2011

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	VELOCITY At Point (fps)	Mean in Vertical (fps)	Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
REW/ edge of channel	51.0	4.5	0.0	0.0	-	-	0.0	0.0	N/A	0.0	0.00
	60.0	9.5	0.6	0.0	-	-	0.0	0.0	N/A	5.7	0.00
	70.0	10.0	0.6	0.0	-	-	0.0	0.0	N/A	6.0	0.00
Edge of snow	80.0	10.0	1.1	0.0	-	-	0.0	0.0	N/A	11.0	0.00
Edge of willows	90.0	10.0	1.2	0.0	-	-	0.0	0.0	N/A	12.0	0.00
0.96	100.0	10.0	2.1	Surface	20	64	0.71	0.71	0.68	21.0	14.8
0.99	110.0	10.0	2.6	Surface	20	55	0.82	0.82	0.81	26.0	21.4
0.99	120.0	10.0	3.6	0.8	30	47	1.44	1.85	1.83	36.0	66.4
				0.2	40	40	2.25				
1.00	130.0	10.0	3.8	0.8	40	48	1.88	2.09	2.09	38.0	79.3
				0.2	50	49	2.30				
1.00	140.0	10.0	4.3	0.8	40	52	1.73	2.12	2.12	43.0	91.1
				0.2	50	45	2.50				
1.00	150.0	10.0	4.9	0.8	40	54	1.67	2.11	2.11	49.0	103.6
				0.2	50	44	2.56				
1.00	160.0	10.0	5.4	0.8	40	41	2.20	2.38	2.38	54.0	128.4
				0.2	50	44	2.56				
1.00	170.0	10.0	6.1	0.8	40	46	1.96	2.23	2.23	61.0	136.0
				0.2	50	45	2.50				
1.00	180.0	10.0	6.6	0.8	40	49	1.84	2.14	2.14	66.0	141.5
				0.2	50	46	2.45				
1.00	190.0	10.0	6.6	0.8	50	51	2.21	2.35	2.35	66.0	155.4
				0.2	50	45	2.50				
1.00	200.0	10.0	6.6	0.8	50	50	2.25	2.30	2.30	66.0	151.7
				0.2	50	48	2.35				
1.00	210.0	10.0	6.6	0.8	40	44	2.05	2.02	2.02	66.0	133.6
				0.2	40	45	2.00				
1.00	220.0	10.0	6.3	0.8	40	45	2.00	2.37	2.37	63.0	149.5
				0.2	50	41	2.75				
1.00	230.0	10.0	6.6	0.8	30	49	1.38	1.84	1.84	66.0	121.4
				0.2	50	49	2.30				
1.00	240.0	10.0	5.1	0.8	-	*Grass*	0	1.41	1.41	51.0	71.9
				0.2	30	48	1.41				

Ublutuoch 6.9
June 2, 2011

Angle Coeff	Distance from initial point	Section Width	Water Depth	Observed Depth	Revolution Count	Time Increment	VELOCITY			Area	Discharge
							At Point	Mean in Vertical	Adjusted for Angle Coeff		
	(ft)	(ft)	(ft)	(ft)		(sec)	(fps)	(fps)	(fps)	(s.f.)	(cfs)
0.99	250.0	10.0	4.3	0.8	-	*Grass*	0	1.47	1.46	43.0	63.2
				0.2	30	46	1.47				
0.97	260.0	10.0	4.6	0.8	-	*Grass*	0	1.19	1.15	46.0	54.6
				0.2	30	57	1.19				
0.94	270.0	10.0	4.5	0.8	-	*Grass*	0	1.33	1.25	45.0	59.7
				0.2	30	51	1.33				
0.94	280.0	10.0	3.6	0.8	-	*Grass*	0	1.11	1.04	36.0	40.0
				0.2	30	61	1.11				
0.92	290.0	10.0	4.7	0.8	-	*Grass*	0	1.06	0.97	47.0	49.7
				0.2	30	64	1.06				
0.90	300.0	10.0	4.6	0.8	20	44	1.03	1.13	1.02	46.0	51.9
				0.2	30	55	1.23				
0.90	310.0	10.0	3.7	0.8	20	40	1.13	1.09	0.98	37.0	40.3
				0.2	20	43	1.05				
0.92	320.0	10.0	4.4	0.8	20	46	0.98	0.96	0.88	44.0	42.3
				0.2	20	48	0.94				
0.97	330.0	10.0	4.2	0.8	20	56	0.81	0.84	0.81	42.0	35.2
				0.2	20	52	0.87				
0.99	340.0	10.0	4.3	0.8	20	48	0.94	0.98	0.97	43.0	42.3
				0.2	30	66	1.03				
0.99	350.0	10.0	4.3	0.8	30	60	1.13	1.21	1.20	43.0	52.2
				0.2	30	52	1.30				
1.00	360.0	10.0	4.3	0.8	30	61	1.11	1.31	1.31	43.0	56.2
				0.2	30	45	1.50				
0.99	370.0	10.0	4.2	0.8	-	*Grass*	0.00	0.96	0.95	42.0	40.4
				0.2	20	47	0.96				
Left edge of channel	380.0	7.5	1.2	0.0	0	0	0.00	0.00	N/A	9.0	0.0
	385.0	5.0	0.0	0.0	0	0	0.00	0.00	N/A	0.0	0.0
	390.0	5.0	0.0	0.0	0	0	0.00	0.00	N/A	0.0	0.0
	395.0	5.0	0.0	0.0	0	0	0.00	0.00	N/A	0.0	0.0
	400.0	7.5	0.5	0.0	0	0	0.00	0.00	N/A	3.8	0.0
	410.0	10.0	0.90	0.0	0	0	0.00	0.00	N/A	9.0	0.0
	420.0	10.0	1.00	0.0	0	0	0.00	0.00	N/A	10.0	0.0

Ublutuoch 6.9
June 2, 2011

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
	430.0	10.0	0.90	0.0	0	0	0.00	0.00	N/A	9.0	0.00
	440.0	10.0	1.00	0.0	0	0	0.00	0.00	N/A	10.0	0.00
	450.0	10.0	0.90	0.0	0	0	0.00	0.00	N/A	9.0	0.00
	460.0	10.0	0.90	0.0	0	0	0.00	0.00	N/A	9.0	0.00
	470.0	10.0	0.80	0.0	0	0	0.00	0.00	N/A	8.0	0.00
	480.0	10.0	0.90	0.0	0	0	0.00	0.00	N/A	9.0	0.00
	490.0	10.0	0.00	0.0	0	0	0.00	0.00	N/A	0.0	0.00
	500.0	10.0	0.00	0.0	0	0	0.00	0.00	N/A	0.0	0.00
	510.0	10.0	0.70	0.0	0	0	0.00	0.00	N/A	7.0	0.00
	520.0	10.0	0.70	0.0	0	0	0.00	0.00	N/A	7.0	0.00
	530.0	10.0	0.40	0.0	0	0	0.00	0.00	N/A	4.0	0.00
	540.0	10.0	0.50	0.0	0	0	0.00	0.00	N/A	5.0	0.00
	550.0	10.0	0.80	0.0	0	0	0.00	0.00	N/A	8.0	0.00
	560.0	10.0	1.20	0.0	0	0	0.00	0.00	N/A	12.0	0.00
	570.0	10.0	0.80	0.0	0	0	0.00	0.00	N/A	8.0	0.00
	580.0	10.0	1.00	0.0	0	0	0.00	0.00	N/A	10.0	0.00
	590.0	10.0	1.00	0.0	0	0	0.00	0.00	N/A	10.0	0.00
	600.0	10.0	0.50	0.0	0	0	0.00	0.00	N/A	5.0	0.00
	610.0	10.0	0.00	0.0	0	0	0.00	0.00	N/A	0.0	0.00
	620.0	10.0	0.90	0.0	0	0	0.00	0.00	N/A	9.0	0.00
Icy bottom	630.0	10.0	1.80	0.0	0	0	0.00	0.00	N/A	18.0	0.00
Icy bottom	640.0	10.0	1.60	0.0	0	0	0.00	0.00	N/A	16.0	0.00
Icy bottom	650.0	10.0	1.30	0.0	0	0	0.00	0.00	N/A	13.0	0.00
Icy bottom	660.0	10.0	1.20	0.0	0	0	0.00	0.00	N/A	12.0	0.00
	670.0	10.0	0.80	0.0	0	0	0.00	0.00	N/A	8.0	0.00
	680.0	10.0	0.50	0.0	0	0	0.00	0.00	N/A	5.0	0.00
	690.0	10.0	0.8	0.0	0	0	0.00	0.00	N/A	8.0	0.00
LEW/ edge of snow	700.0	5.0	1.0	0.0	0	0	0.00	0.00	N/A	5.0	0.00

Total Measured Discharge: 2194.1

Baker

Discharge Measurement Notes

Date: June 4, 2011
Computed By: EJK
Checked By: HLR

Location Name: S4

Party: HLR, SME, EJK, JMS   Start: 12:45   Finish: 13:15

Temp: ~36 °F   Weather: Cloudy and breezy

Channel Characteristics:

Width: 30 ft   Area: 11 sq ft   Velocity: 0.39 fps   Discharge: 4.4 cfs

Method: Standard   Number of Sections: 21   Count: N/A

Spin Test: N/A revolutions after N/A seconds   Meter: Marsh McBirney

Meter: - ft above bottom of weight

Weight: - lbs

Wading Cable Ice Boat

Upstream or Downstream side of bridge

GAGE READINGS			
Gage	Start	Finish	Change
S4A	0.46	0.47	0.01
S4B	0.82	0.83	0.01
S4C	0.64	0.64	0.00

GPS Data: S4-Q LEW, REW

Left Edge of	N	70 °	16 '	53.4 "	LE Floodplain:	N	70°	16'	53.5 "
Water:	W	151 °	17 '	35.4 "		W	151°	19'	35.9 "
Right Edge of	N	70 °	16 '	53.2 "	RE Floodplain:	N	70°	16'	53.4 "
Water:	W	151 °	17 '	34.5 "		W	151°	19'	34.2 "

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

Descriptions:

Cross Section: Braided small stream with willows, grass, and small pools upstream and downstream of the discharge measurement location
Snow is on the left bank.

Flow:

Remarks:

S4
June 4, 2011

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
REW	10.0	0.8	0.11	0.6	0.00	0.00	N/A	0.1	0.00
grass	11.5	1.5	0.17	0.6	0.00	0.00	N/A	0.3	0.00
grass	13.0	1.5	0.15	0.6	0.04	0.04	N/A	0.2	0.01
grass	14.5	1.5	0.20	0.6	0.12	0.12	N/A	0.3	0.04
grass	16.0	1.5	0.24	0.6	0.15	0.15	N/A	0.4	0.05
grass	17.5	1.5	0.24	0.6	0.30	0.30	N/A	0.4	0.11
grass	19.0	1.5	0.15	0.6	0.00	0.00	N/A	0.2	0.00
grass	20.5	1.5	0.28	0.6	0.26	0.26	N/A	0.4	0.11
grass	22.0	1.5	0.15	0.6	0.16	0.16	N/A	0.2	0.04
grass	23.5	1.5	0.30	0.6	0.13	0.13	N/A	0.5	0.06
grass	25.0	1.5	0.85	0.6	0.90	0.90	N/A	1.3	1.15
grass	26.5	1.5	0.85	0.6	0.56	0.56	N/A	1.3	0.71
grass	28.0	1.5	0.95	0.6	0.53	0.53	N/A	1.4	0.76
grass	29.5	1.5	0.65	0.6	0.21	0.21	N/A	1.0	0.20
grass	31.0	1.5	0.65	0.6	0.22	0.22	N/A	1.0	0.21
grass	32.5	1.5	0.40	0.6	0.83	0.83	N/A	0.6	0.50
grass	34.0	1.5	0.22	0.6	0.49	0.49	N/A	0.3	0.16
willows	35.5	1.5	0.30	0.6	0.10	0.10	N/A	0.5	0.05
willows	37.0	1.5	0.35	0.6	0.32	0.32	N/A	0.5	0.17
willows	38.5	1.5	0.20	0.6	0.12	0.12	N/A	0.3	0.04
LEW	40.0	0.8	0.00	0.6	0.00	0.00	N/A	0.0	0.00
									0.00
									0.00
									0.00
									0.00
									0.00
									0.00
									0.00
									0.00
									0.00
									0.00
									0.00

Total Measured Discharge: 4.36

Baker

Discharge Measurement Notes

Date: June 4, 2011
Computed By: EJK
Checked By: HLR

Location Name: S5

Party: HLR, SME, EJK   Start: 1125   Finish: 1153

Temp: 25 °F   Weather:

Channel Characteristics:

Width: 39 ft   Area: 69 sq ft   Velocity: 0.88 fps   Discharge: 61 cfs

Method: Standard   Number of Sections: 28   Count: N/A

Spin Test: N/A revolutions after N/A seconds   Meter: Marsh McBirney

Meter: - ft above bottom of weight

Weight: - lbs

Wading Cable Ice Boat

Upstream or Downstream side of bridge

GAGE READINGS			
Gage	Start	Finish	Change
S5A	1.80	1.80	0.00
S5C	1.84	1.82	-0.02

GPS Data: S5-Q LEW, REW

Left Edge of	N	70 °	16 '	47.3 "	LE Floodplain:	N	70°	16'	47.1 "
Water:	W	151 °	19 '	48.1 "		W	151°	19'	49.1 "
Right Edge of	N	70 °	16 '	46.9 "	RE Floodplain:	N	70°	16'	47.0 "
Water:	W	151 °	19 '	46.2 "		W	151°	19'	45.0 "

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

Descriptions:

Cross Section: LEW approximately 3' overhang with flow underneath that can not be effectively measured. REW has a smaller overhang tha approximately 1 foot with flow underneath.

Flow: Bottom of channel is icy.

Remarks: Channel cross section width is composed of ~80% willows to include upstream and downstream of the discharge measureme locations. Stage falling during discharge measurement.

S5
June 4, 2011

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
Estimate - under snow	26.0	1.3	1.30	0.6	0.38	0.38	N/A	1.6	0.62
LEW	29.0								0.00
slush/snow	28.5	2.0	2.25	0.6	0.83	0.83	N/A	4.5	3.74
ice	30.0	1.5	2.35	0.6	2.07	2.07	N/A	3.5	7.30
willows	31.5	1.5	2.35	0.6	1.26	1.26	N/A	3.5	4.44
	33.0	1.5	2.10	0.6	0.53	0.53	N/A	3.2	1.67
willows	34.5	1.5	1.70	0.6	0.69	0.69	N/A	2.6	1.76
willows	36.0	1.5	1.75	0.6	0.56	0.56	N/A	2.6	1.47
willows	37.5	1.5	1.65	0.6	0.46	0.46	N/A	2.5	1.14
willows	39.0	1.5	1.55	0.6	0.51	0.51	N/A	2.3	1.19
willows	40.5	1.5	1.55	0.6	0.57	0.57	N/A	2.3	1.33
willows	42.0	1.5	1.30	0.6	0.56	0.56	N/A	2.0	1.09
willows	43.5	1.5	1.35	0.6	0.72	0.72	N/A	2.0	1.46
willows	45.0	1.5	1.35	0.6	0.53	0.53	N/A	2.0	1.07
willows	46.5	1.5	1.50	0.6	0.73	0.73	N/A	2.3	1.64
willows	48.0	1.5	1.60	0.6	0.93	0.93	N/A	2.4	2.23
willows	49.5	1.5	1.55	0.6	0.61	0.61	N/A	2.3	1.42
willows	51.0	1.5	1.80	0.6	0.76	0.76	N/A	2.7	2.05
willows	52.5	1.5	1.80	0.6	0.87	0.87	N/A	2.7	2.35
willows	54.0	1.5	1.80	0.6	0.73	0.73	N/A	2.7	1.97
willows	55.5	1.5	1.95	0.6	0.84	0.84	N/A	2.9	2.46
willows	57.0	1.5	2.00	0.6	0.70	0.70	N/A	3.0	2.10
willows	58.5	1.5	2.05	0.6	0.92	0.92	N/A	3.1	2.83
willows	60.0	1.5	2.05	0.6	0.84	0.84	N/A	3.1	2.58
willows	61.5	1.5	1.85	0.6	1.34	1.34	N/A	2.8	3.72
willows	63.0	1.5	1.80	0.6	1.62	1.62	N/A	2.7	4.37
slush/snow	64.5	1.0	1.45	0.6	1.92	1.92	N/A	1.5	2.78
REW	65.0	0.3	1.00	0.6	0.99	0.99	N/A	0.3	0.25
									0.00
									0.00
									0.00
									0.00

Total Measured Discharge: 61