FIORD WEST
2009 HYDROLOGIC ASSESSMENT

Submitted to

ConocoPhillips Alaska

ConocoPhillips Alaska, Inc.

Submitted by

Baker

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EXECUTIVE SUMMARY

This report presents observations and findings of the Fiord West 2009 Hydrologic Assessment conducted by Michael Baker Jr., Inc. (Baker) at the request of ConocoPhillips Alaska (CPAI). This assessment supports the Alpine Development Project and Alpine Satellite Development Plan, and represents the second consecutive year of study in the Fiord West region.

CPAI has proposed the development of a drilling pad and access road in the Fiord West region of the National Petroleum Reserve – Alaska (NPR-A) as part of the Alpine Satellite Development Plan (ASDP). Observations and measurements of water surface elevation (WSE) were recorded at four Fiord West locations associated with the proposed pad and access road, as well as two Nigliq Channel locations.

The 2009 Fiord West spring breakup was characterized by relatively low water surface elevation (WSE) throughout the monitoring area, with local flooding conditions primarily a result of local melt. The timing was similar to breakup timing observed in 2008. Timing of the Nigliq Channel breakup was earlier than the historical average by approximately five days.

Peak WSE occurred on June 3rd at all Fiord West monitoring sites. Peak WSE occurred on May 24 at both Nigliq Channel monitoring sites. The 2009 peak WSE at the two Nigliq gage locations was lower than the historical average by approximately 0.5 to 1.0 foot. No flow was observed at any of the Fiord West monitoring sites. Significant flow was observed at both Nigliq channel monitoring sites.

As a general note, 2009 spring breakup flooding on the Colville River did not exceed the 5-year recurrence interval for discharge. The Fiord West project area lies in a floodplain west of the Nigliq Channel. It is unlikely that the project area would be inundated with floodwater below a 25-year frequency discharge event. The Fiord West area could also be affected by ice-jamming, which could cause flooding at lower frequency discharge events.

Decisions regarding Fiord West road alignment and pad locations are pending. Hydrodynamic modeling analysis for the project area will be performed once the road alignment and pad location has been finalized.

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1.0 INTRODUCTION

This report presents the results of the 2009 spring breakup monitoring activities conducted near the northeastern border of National Petroleum Reserve – Alaska (NPR-A) in the vicinity of the proposed Fiord West pad and access road.

ConocoPhillips Alaska (CPAI) has proposed the development of a drilling pad and access road in the Fiord West region of NPR-A as part of the Alpine Satellite Development Plan (ASDP). Figure 1.1, shows the proposed pad at the location under evaluation at the time of this study. Additional locations are currently under review. The Fiord West Pad, designated FWP, will be accessible via a gravel road extending north approximately 1.7 miles from an intersection with the proposed CD5 access road.

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 CD1 processing facility (Alpine); CD2, CD3, and CD4 drilling pads; access roads; and associated pipelines.

Many areas on the North Slope of Alaska, including NPR-A and the Colville River Delta (CRD), share similar hydrologic and hydraulic characteristics common to the arctic climate and to the continuous presence of regional permafrost. Shallow groundwater is generally restricted to isolated zones beneath deep lakes and river channels. Groundwater influx is largely nonexistent. For much of the year, many ponds, lakes, small streams and drainages are completely frozen.

Spring breakup flooding is the largest annual flooding event in the North Slope region and monitoring of this event is integral to understanding regional hydrology and maintaining the continued safety of the environment, oilfield personnel, and facilities during the annual flooding event. Flow generally declines over the summer months, with occasional temporary minor flow increases resulting from rainfall events.

Spring breakup monitoring activities have been conducted specifically for the Alpine Development Project (ADP) since 1992. The 2009 hydrologic field program represents the 18th consecutive year of breakup investigations. This was the second consecutive year of study at Fiord West. Preliminary hydrologic and hydraulic assessments were conducted in 2008 in conjunction with the Alpine CRD spring breakup field program.

The Fiord West project area has been discontinuously studied under previous breakup programs. In previous years, the monitoring sites have been referred to as Paleo East and Paleo West due to the presence of an apparent paleochannel of the Niqliq Channel bisecting a portion of the study area. Historically, flooding in the paleochannels has been characterized as accumulated local melt only, typically with little or no velocity of flow.

During the 2008 breakup program, two options for the pad location and road alignment were investigated; observations and measurements were recorded for both. As plans for the Fiord West area have evolved, Options 1 and 2 have been combined. The current alternative includes the pad location from what was previously designated Option 2 and much of the proposed road route from former Option 1. The combined alternative for the Fiord West pad placement and road alignment as of April 2009, provided by PND Engineers, Inc., was used for this study.

The proposed Fiord West pad and part of the access road lie in the coastal zone within a portion of the Colville River Delta (CRD). The majority of the proposed access road lies west of the CRD. The Nigliq Channel, located east of the proposed road and pad is part of the CRD.

Observations and measurements for the 2009 Fiord West hydrologic assessment in NPR-A were recorded at four locations along the proposed access road and in the vicinity of the proposed Fiord West pad. No significantly sized drainages are crossed by the proposed alignment. However, the flooding events of proximal hydrologic features, in particular the Nigliq Channel, may also affect or be affected by the proposed Fiord West pad and alignment. As a result, two locations along the Nigliq Channel, in the adjacent CRD, were monitored.

Fieldwork began on May 16 and was completed on June 4. Fieldwork at the Nigliq Channel began on May 9 and was completed on May 28. Figure 1.2 shows the 2009 Fiord West Monitoring locations.

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

- **Section 1, Introduction**: discusses the objectives of the monitoring program and presents climatic information.
- **Section 2, 2009 Monitoring Locations**: outlines and discusses the 2009 monitoring sites.
- **Section 3, Methods**: describes the methods of both the fieldwork and the data analyses.
- **Section 4, 2009 Spring Breakup**: presents the observations and stage results for the Fiord West assessment.
- **Section 5, Two-Dimensional Hydrodynamic Model:** presents the results of the hydrodynamic modeling analysis for the proposed Fiord West facility and access road locations. (This section will be completed after receipt of a confirmed alignment.)
- **Section 6, References**: contains the references used in the development of this report. A list of Acronyms and a Glossary are also included to assist the reader.

We would like to thank Alaska Kuukpik/LCMF, Inc., and AirLogistics Helicopters for their assistance with the Fiord West water resources field work. Their support and diligence contributed to a safe and productive breakup monitoring season and is greatly appreciated. We would also like to express our gratitude to CPAI for their continued trust in Baker to perform this work.

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2009 FIORD WEST BREAKUP
EXISTING & PROPOSED FACILITIES
CRD & NPR-A
FIGURE 1.1
(SHEET 1 OF 1)

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2009 FIORD WEST BREAKUP GAGE LOCATIONS

FIGURE 1.2

(SHEET 1 OF 1)

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1.1 Monitoring Objectives

The primary objective of the 2009 Fiord West spring breakup program was to monitor and estimate the magnitude of breakup flooding. This was done by observation of breakup events, documentation of the distribution of floodwater, and measurement of water levels throughout the project area.

1.2 Climatic Review

Spring on the North Slope of Alaska is dominated by flooding. The open water season for the area, including CRD and NPR-A, is generally limited to a four-month period from June through September. Snow pack, sustained cold or warm temperatures, ice thickness, wind speed and direction, precipitation, and solar radiation contribute to the breakup cycle.

Review of daily high and low temperatures can be helpful when considering breakup timing. As nightly lows begin to approach and exceed freezing temperatures, breakup processes tend to accelerate.

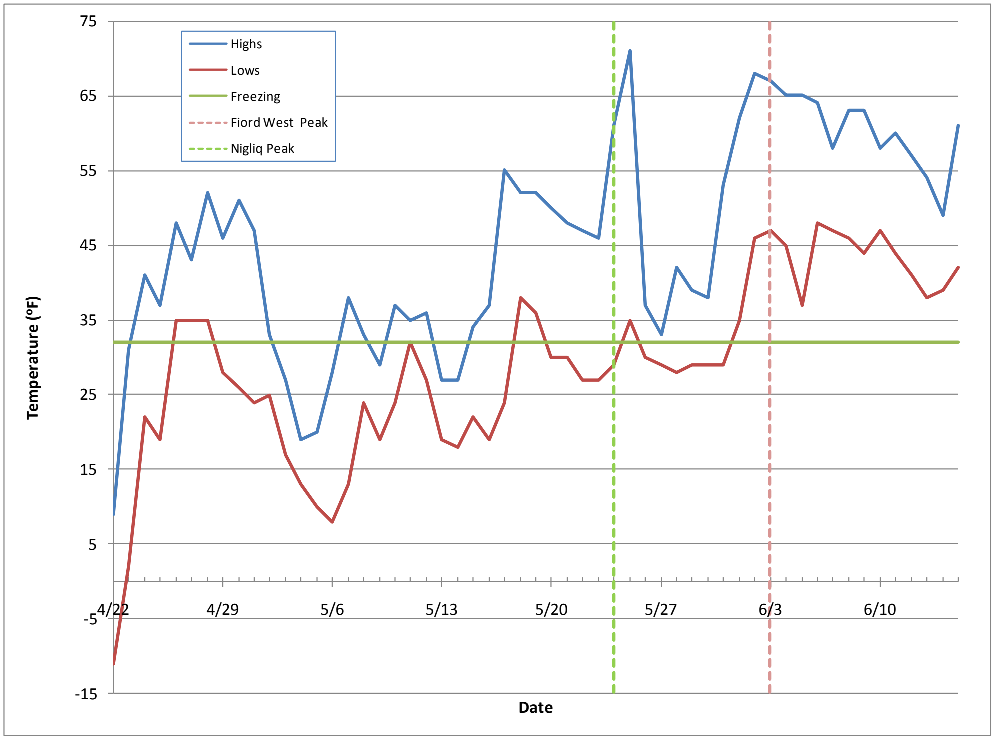
Unseasonably warm weather in late April, with temperatures close to freezing at night, appears to have affected the 2009 breakup cycle. This early warming trend may be considered as a contributing factor to the early arrival of flow to the Nigliq Channel. This is further discussed in Section 4.1.

Climatic records for 2009 are available from monitoring stations at Umiat and Nuiqsut. Umiat, located in the foothills of the Brooks Range, lies approximately 70 air miles south of the proposed Fiord West Pad location. Nuiqsut is located approximately 11 air miles southeast of the proposed Fiord West pad location. Graph 1.1 provides high and low temperatures for Umiat from April 22, 2009 to June 15, 2009. Graph 1.2 provides high and low temperatures for Nuiqsut from April 22, 2009 to June 15, 2009.

As Graph 1.1 shows, the Nigliq peak runoff on May 24 occurred approximately ten days before peak water surface elevation was observed in the Fiord West area. The timing of the Nigliq peak flow is more closely connected to warming trends in the foothills of the Brooks Range, where CRD runoff originates. Increasing temperatures in the foothills, and resulting spring runoff, initiates breakup processes in the Colville Delta.

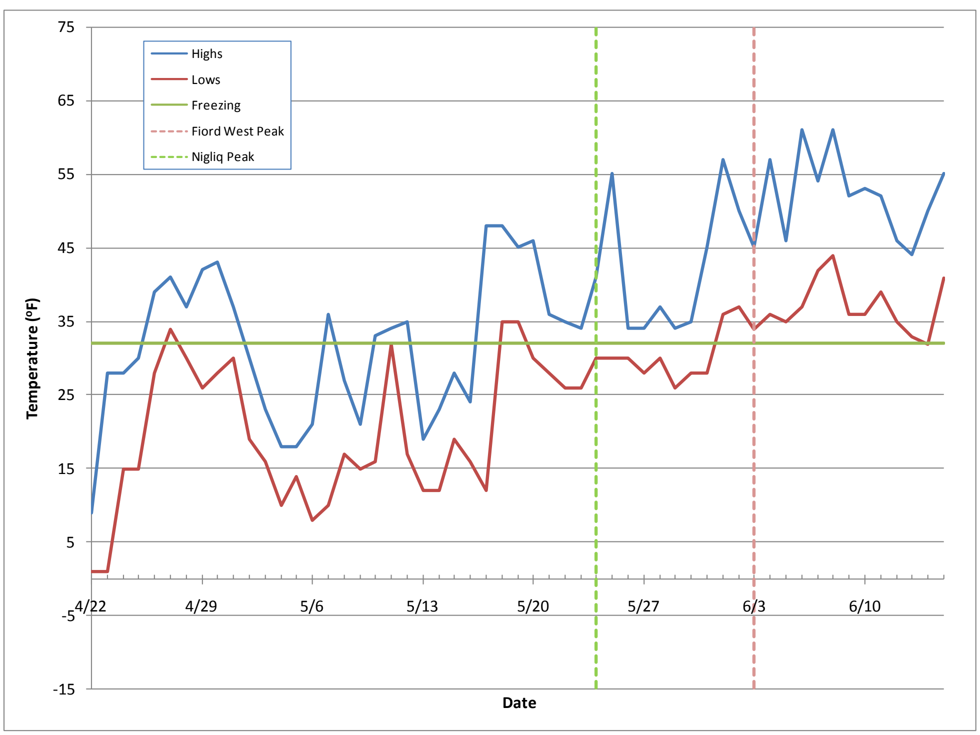
As Graph 1.2 illustrates, the peak water surface elevation in the Fiord West area in 2009 occurred after local nightly temperatures exceeded freezing. Warmer temperatures initiated and sustained local snowmelt resulting in observed surface water.

GRAPH 1.1: DAILY HIGH AND LOW TEMPERATURE AT UMIAT (APRIL 22 – JUNE 15, 2009)



Source: Weather Underground

GRAPH 1.2: DAILY HIGH AND LOW TEMPERATURE AT NUIQSUT (APRIL 22 – JUNE 15, 2009)



Source: Weather Underground

2.0 2009 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.

2.1 GAGE LOCATIONS AND SELECTION

The 2009 monitoring locations were selected to identify areas of surface flow or surface water concentration occurring along the proposed access road and at the proposed pad site. Locations were also selected to measure flooding conditions in the adjacent Nigliq Channel. Table 2.1 lists the 2009 monitoring locations.

TABLE 2.1: FIORD WEST MONITORING PROGRAM

Location Type	Location	Number of Gages
Proposed FW Access Road	FWR1	1
	FWR2	1
	FWR3	1
Proposed FW Pad	FWP	1
Nigliq Channel	MON22	4
	MON23	4
Total		**12**

Monitoring was conducted at three locations along the proposed Fiord West access road and one location adjacent to the proposed Fiord West pad. Three gage sites are located in the western portion of the CRD, including the Fiord West Pad (FWP), Fiord West Road 1 (FWR1) and Fiord West Road 2 (FWR2). The Fiord West Road 3 (FWR3) gage site lies west of the CRD.

Seasonal hydrologic water bodies (ponds, channels, and swales) crossed by the proposed alignment were identified using aerial imagery. Gage locations were selected using imagery and refined in the field to capture peak water surface elevations at defined crossings. Due to a lack of discernible flow noted in 2008 and modifications to the proposed pad and road locations, none of the 2008 Fiord West gaging sites were used for the 2009 monitoring program.

Gage sites at Monument 22 and Monument 23 (MON22 and MON23) are located in the CRD. These sites, located along the Nigliq Channel and previously used in the 2008 Fiord West assessment, were again utilized as monitoring sites. Figure 1.2 illustrates the 2009 gage locations.

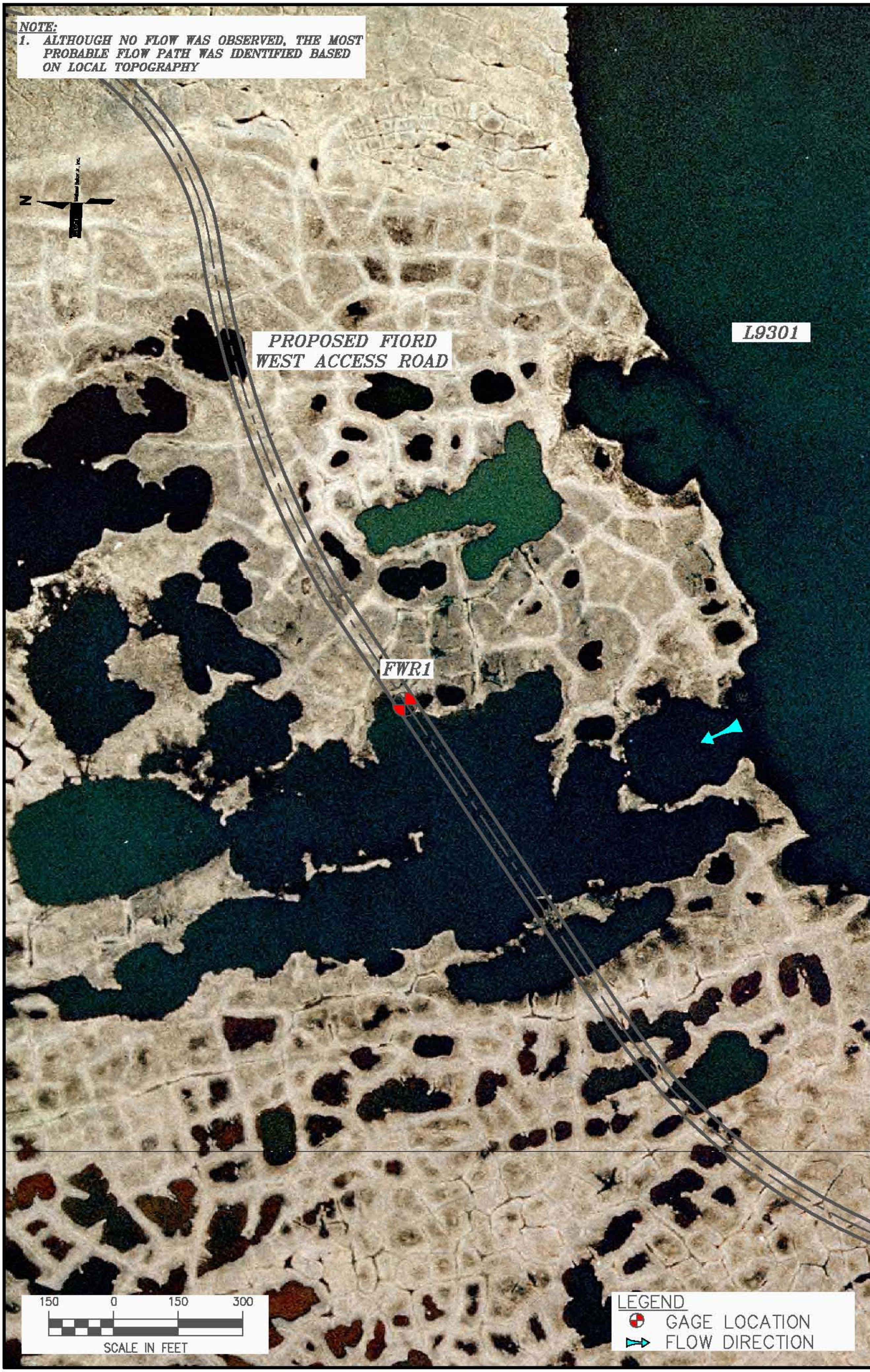
2.1.1 Fiord West Access Road

The proposed Fiord West access road is approximately 1.7 miles in length. The alignment extends north from the proposed CD5 access road at a location approximately 0.5 road miles east of the proposed CD5 pad. Topographic features along the proposed alignment include several shallow depressions which have the potential to accumulate water during spring breakup events and periods of heavy rainfall. Two lakes are also adjacent to the proposed road alignment, and could affect the road corridor. No defined drainage channels intersect the proposed Fiord West road alignment. Only one gage assembly was installed at each road site.

PHOTO 2.1: AERIAL VIEW OF FIORD WEST AREA, MAY 19, 2009

The FWR1 and FWR2 gages are located southwest of the proposed Fiord West pad, between Lake L9301 and Harrison Bay of the Beaufort Sea, in an area where small beaded lakes suggest a possible ephemeral or seasonal flow path between the lakes and/or the Nigliq Channel. Gages FWR1 and FWR2 were installed along the proposed access road corridor on May 17. FWR1 was surveyed on May 17. FWR2 was surveyed on May 19. Photo 2.1 shows the pre-breakup conditions at a typical location along the proposed Fiord West road alignment. Figure 2.1 and Figure 2.2 show the locations of the FWR1 and FWR2 gages, respectively.

FWR3 is located near the proposed CD5/Fiord West access road intersection, between Lake MB0301 to the west and Lake M0353 to the south. Gage FW3 was originally established in 2005. Though not directly on the proposed alignment, limited topographic relief and a historic record justified its use as a monitoring location in 2009. Gage FWR3 was surveyed on May 28. Figure 2.3 shows the location of the FWR3 gage.



2009 FIORD WEST BREAKUP

FWR1 GAGE LOCATION

FIGURE 2.1

(SHEET 1 OF 1)

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2009 FIORD WEST BREAKUP

FWR2 GAGE

LOCATION

FIGURE 2.2

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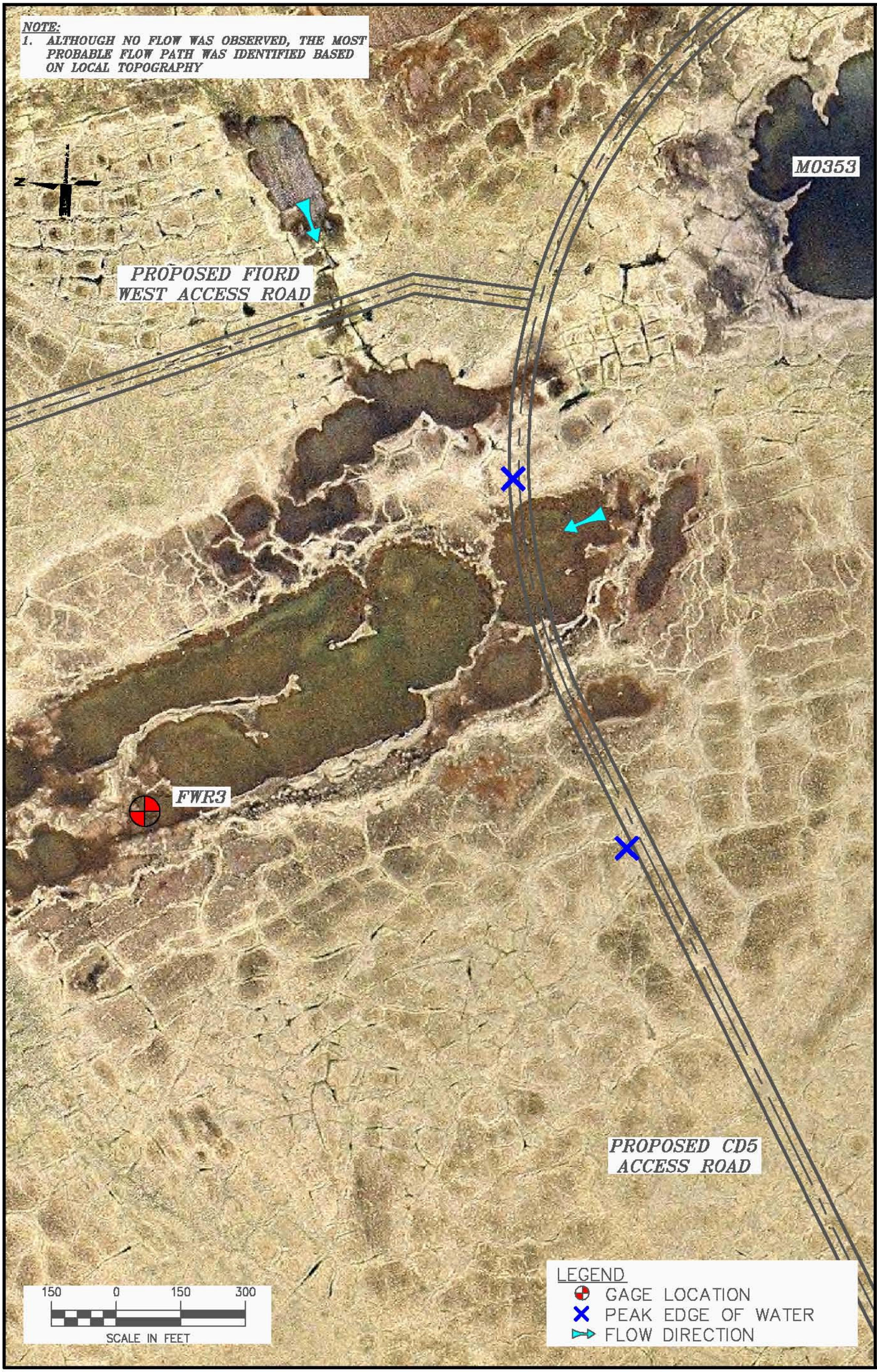

2009 FIORD WEST BREAKUP
FWR3 GAGE
LOCATION
FIGURE 2.3
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PHOTO 2.2: FIORD WEST PAD AREA, MAY 19, 2009

2.1.2 Fiord West Pad Site

The proposed Fiord West access road terminates at the proposed Fiord West Pad. This location marks the northern-most extent of the area of study. A gage designated FWP was installed at the eastern side of the proposed pad. This location was selected to monitor breakup-related overland flows in an area where low ground suggests possible seasonal or ephemeral flow parallel to and along the west bank of the Nigliq Channel and Lake L9301. One gage assembly and one angle iron were installed. The FWP gage was installed on May 17 and surveyed on May 19. Photo 2.2 shows pre-breakup conditions at the proposed Fiord West pad location. Figure 2.4 shows the FWP gage location.

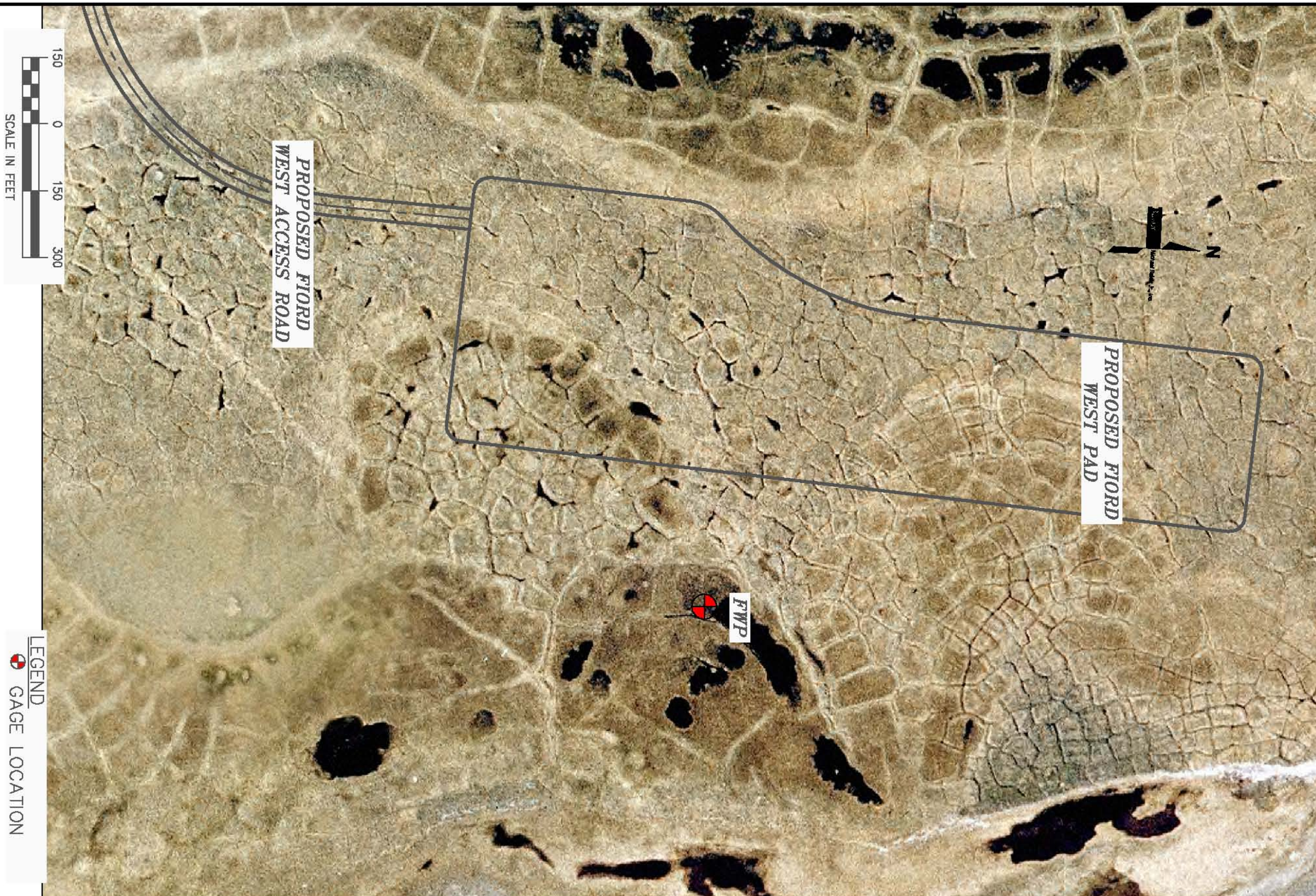
2.1.3 Nigliq Channel

The Nigliq Channel, located approximately 0.2 miles east of the proposed Fiord West Pad, is the only defined channel in the Fiord West vicinity. The channel forms the eastern boundary of the project area and constitutes a major potential flooding source in the region. The Nigliq is a major distributary of the Colville River. Due to the close proximity of the Nigliq Channel to other Alpine Facilities, and the potential to directly and indirectly affect those facilities, consistent monitoring has been conducted along the channel at various locations as part of annual breakup assessments for many years.

PHOTO 2.3: INITIAL WATER IN NIGLIQ CHANNEL AT MON 23, MAY 9, 2009

As part of the Fiord West monitoring, Nigliq Channel breakup events were observed using gages at MON22 and MON23, in addition to a pressure transducer (PT) at Monument 23 (MON23-PT). Gages MON22 and MON23 were previously installed as part of prior CRD spring breakup programs. MON22 was surveyed on May 16; MON23 and MON23-PT were surveyed on May 9. Photo 2.3 shows pre-breakup conditions in the Nigliq Channel near MON23 on May 9. Figure 2.5 shows the MON22 and MON23 gage locations.

Although not specifically included in this hydrologic assessment, the Fish Creek Basin drains into Harrison Bay on the west side of the Fiord West area. The proposed pad location is roughly one mile southeast of Harrison Bay. If conditions were right, breakup flow from the Fish Creek Basin area could result in flooding at proposed facilities. This potential for flooding should be considered as well. Given the proximity of the coast, timing of breakup in the Fish Creek Basin, and size of the contributing drainage area, the magnitude of flooding would not likely exceed that predicted for flood events in the CRD alone.



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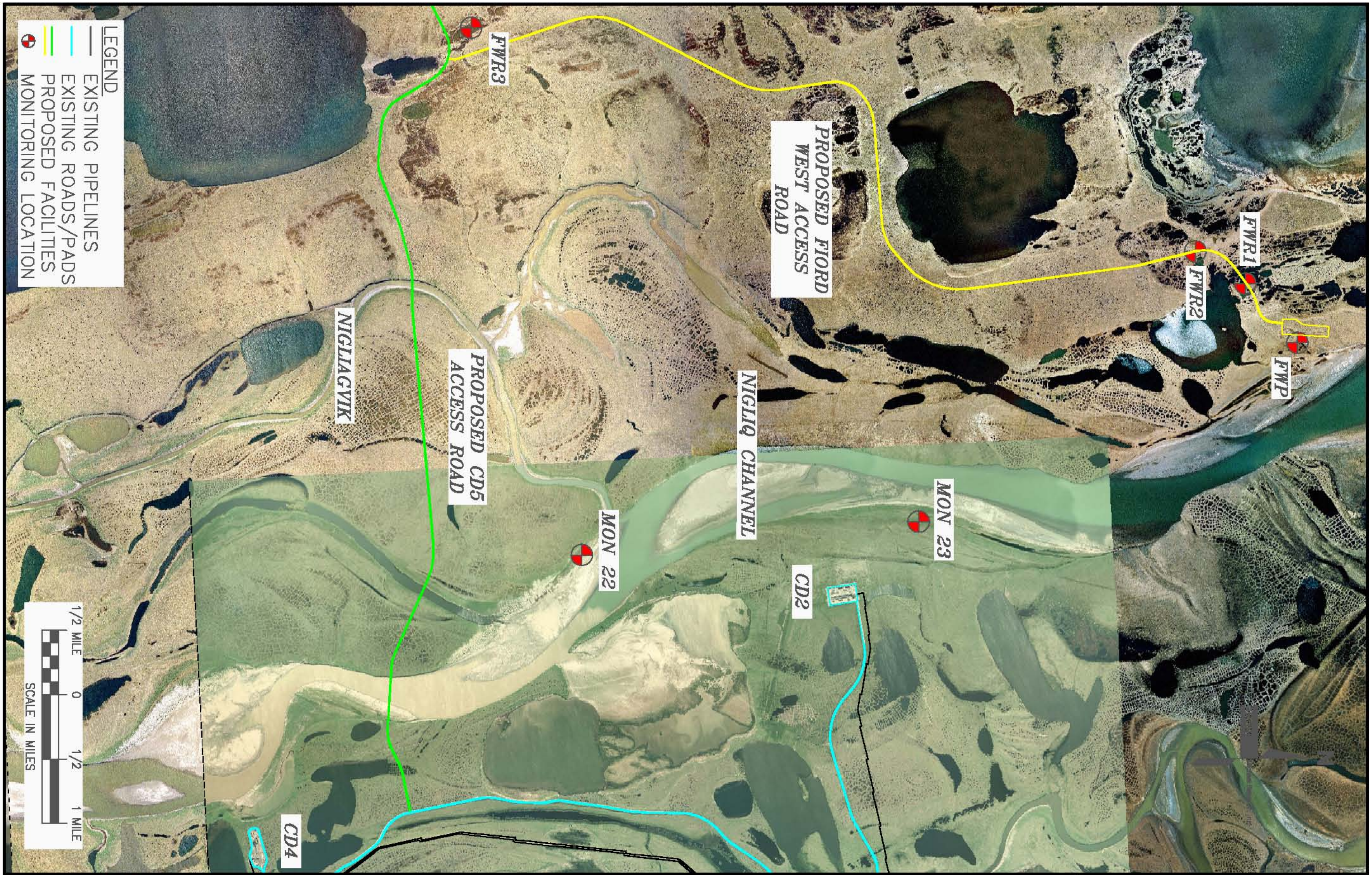
2009 SPRING BREAKUP
FWP GAGE
LOCATION

FIGURE 2.4
(SHEET 1 OF 1)



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DATE:	9/15/09	PROJECT:	117214
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2009 FIORD WEST BREAKUP
MON 22 & MON 23 GAGE
LOCATIONS

FIGURE 2.5
(SHEET 1 OF 1)

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3.0 METHODS

The primary methods used during the 2009 Fiord West spring breakup assessment were visual observations of melt water distribution and measurement of water surface elevation (WSE). The field methods are based on standard techniques proven to be safe, reliable, efficient and accurate for the conditions found in the CRD and NPR-A during spring breakup.

3.1 VISUAL OBSERVATIONS

Observations of breakup events in the project area were conducted from the ground and by helicopter. All observations were recorded daily in field notebooks. Digital photographs were taken to document the progression of spring breakup prior to, during, and after peak flooding events. The geographic position of the camera, date, and time were automatically imprinted onto each photo. Additional photographs were taken and manually geographically referenced to document the location of each image.

3.2 WATER SURFACE ELEVATION (WSE)

Temporary staff gages were installed at each site as instruments to measure WSE. At those times when water levels were not high enough to be recorded on the staff gages, standard level loop survey techniques were used to measure WSE using the gage as the basis of elevation. Gages installed at Fiord West study locations consisted of one to four assemblies per site. Each gage assembly consisted of a metal gage faceplate mounted on a 2 x 4 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 60CS GPSMAP in North American Datum of 1983 (NAD83). Photo 3.1 shows an example of a staff gage after installation.

PHOTO 3.1: STAFF GAGE INSTALLED AT SITE FWP, MAY 19, 2009

The elevation of each gage was surveyed from a local benchmark tied to British Petroleum Mean Sea Level (BPMSL) using standard level loop techniques. The basis of elevation for each gage and the horizontal position of respective benchmarks and gages are presented in Appendix A. The most recent basis of elevation of vertical control as of spring 2009 was used.

Gages were identified based on the site location. In those locations where terrain elevation varied by more than three feet or where loss of gages due to ice floes was likely, more than one gage was installed to effectively capture WSE data. This occurred along the Nigliq Channel at MON22 and MON23. These gages were further identified with alphabetical designations A, B, C or D, with A being closest to the water's edge.

3.3 Pressure Transducer (PT)

One pressure transducer (PT) was installed at the MON23 gage site to collect WSE data. The PT measures the pressure imparted by water at the sensor, allowing the depth of water above the sensor to be calculated. Variations in barometric pressure were taken into account using an independent barometric pressure logger. Resulting data yielded a more accurate and complete record of the fluctuations in WSE than could be captured by visual measurements.

In-Situ, Inc. Level TROLL® 500 sensors were used. The instrument is a non-vented pressure sensor designed to collect and store pressure and temperature data at discrete intervals. The factory-calibrated transducers were set to collect absolute pressure and water temperature at 15-minute intervals at MON23-PT. The measured pressure datum is the sum of the forces imparted by both the water column and atmospheric conditions. As a result, a correction of local barometric pressure was required and obtained from an In-Situ, Inc. BaroTROLL® sensor located at Monument 9 (MON9). This BaroTROLL® location is considered to be representative of the entire CRD. MON9 is located approximately 7 miles southeast of MON23-PT. See Appendix A for PT and BaroTROLL® basis of elevation and horizontal positions.

Prior to deployment, the PT was configured using Win-Situ LT 5.1.1.0®. Absolute pressure was set to zero. Transducers were housed in a segment of perforated galvanized steel pipe, clamped to angle iron placed in the active channel near the channel bottom surface. The transducer sensor was surveyed to establish a vertical datum using local control. Water depth was determined based on the recorded absolute pressure and barometric pressure data.

PT based WSE values were determined by summing the calculated water depth and the surveyed sensor elevation. A standard conversion using the density of water at 0°C was used to calculate all water depths from adjusted gage pressure. Fluctuations in water temperature during the sampling period were not significant enough to impact WSE calculations due to the limited range in temperature and observed water depths. Table 3.1 shows a comparison of sample temperatures and the resultant differences, demonstrating negligible differences attributed to temperature variation.

TABLE 3.1: COMPARISON OF TEMPERATURE FLUCTUATION ON WSE CALCULATION

Temp (°C)	Temp (°F)	Specific Volume (ft^3/lb)	Density (lb/ft^3)	PSI/1ft Depth	Calculated Depth (ft)*	Difference
-18	0	0.01743	57.3723	0.39842	0.9191	
-1	30	0.01747	57.2410	0.43349	1.0000	-0.0809
0.01	32.018	0.01602	62.4220	0.43349	1.0000	0.0000
2	35	0.01602	62.4220	0.43311	0.9991	0.0009
18	65	0.01604	62.3441	0.43133	0.9950	0.0041

*Calculated using the density at 0.01˚C (32.018°F)

3.4 Two Dimensional Hydrodynamic Model (Pending)

This section will be completed after receipt of final Fiord West road alignment and pad location placement.

3.4.1 Modification of Current Model (Pending)

Pending.

3.4.2 Assessment of Design Flood Events (Pending)

Pending.

3.4.3 Assessment of Hydrological Impacts of Existing Facilities (Pending)

Pending.

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4.0 2009 Spring Breakup

This section presents the images, data and observations for the Fiord West 2009 Hydrologic Assessment. Hydrologic data and observations were documented between May 9 and June 4, 2009, and are described in the following sections.

4.1 Hydrologic Observations Summary

The 2009 spring breakup event on the North Slope was affected by a period of unseasonably warm weather that occurred in late April and early May. Air temperatures over a 5- to 7-day period spiked into the 30s and even low 40s at Nuiqsut (see Graph 1.2 in Section 1.2). The timing of breakup in the study area was likely affected to some degree by the warm weather. An early warming trend can "set the stage" for breakup by pre-softening snow and ice such that when the main melt does occur, it occurs more rapidly and efficiently than if the early warming period had not occurred.

With the exception of the Nigliq gage locations where substantial flow was observed, no established stream flow channels were identified at any Fiord West monitoring site during the breakup period. Accumulated water was determined to be the result of local melt, ponding in areas to a depth of one foot or less. Comparing the 2009 Fiord West hydrological observations to historical observations from other locations within NPR-A suggests that 2009 breakup events were likely below average in terms of quantity of water.

An initial reconnaissance of pre-breakup conditions in the NPR-A was performed on May 16, including visits to all gaging stations along the proposed Fiord West access road and pad. Daily monitoring of all road and pad sites began on May 27 and continued until June 4. Initial observations of the Nigliq Channel conditions were documented on May 9, during the MON23 survey. Daily monitoring of both Nigliq sites began on May 22 and continued through May 28. Hydrologic conditions throughout breakup are described in the following sections.

4.1.1 FIORD WEST ACCESS ROAD

Localized melt and standing water was first observed on the FWR3 gage on June 1. High water was observed on FWR1 and FWR2 gages on June 3. Monitoring was discontinued at Fiord West road locations on June 4.

Throughout the monitoring period, no significant flow was observed at any Fiord West road location. Accumulation of water and increases in WSE was determined to be the result of local melt only due to a lack of observable flow, with observed water occurring only in isolated troughs and depressions in the terrain.

PHOTO 4.1: AERIAL VIEW OF TYPICAL FIORD WEST ROAD LOCATION, MAY 31, 2009

Photo 4.1 shows an aerial view of initial breakup conditions along the proposed Fiord West access road alignment on May 31. Photo 4.3 shows an aerial view of initial breakup conditions at FWR2 on May 31. Photo 4.2 shows an aerial view of initial breakup conditions at FWR1 on May 28.

PHOTO 4.3: AERIAL VIEW OF FWR2 AREA, MAY 31, 2009

PHOTO 4.2: AERIAL VIEW OF FWR1 AREA, MAY 28, 2009

4.1.2 Fiord West Pad Area

Localized melt and peak standing water was observed on the FWP gage on June 3. Monitoring was discontinued at the Fiord West pad on June 4.

Throughout the monitoring period, no defined drainage channels or significant flow was observed at the Fiord West pad location. Accumulation of water was determined to be the result of local melt only, with standing water occurring only in isolated troughs and depressions in the terrain. Photo 4.4 shows initial breakup conditions of the Nigliq Channel (in the background) at the FWP location on May 28.

PHOTO 4.4: AERIAL VIEW OF FWP, MAY 28, 2009

4.1.3 Nigliq Channel

Localized melt and standing water in the Nigliq Channel near the Fiord West location was first observed on May 9. Open channel flow was observed on May 22. Flow attributed to breakup flooding was significant and steady until meltwater abated. No ice jams were recorded in proximity of the monitoring area. No hydraulic connectivity in the form of overland flow was observed between the Nigliq Channel and the Fiord West pad vicinity. Monitoring of the Nigliq Channel was discontinued on May 28. Photo 4.5 shows initial breakup conditions of the Nigliq Channel at the MON22 location on May 22.

PHOTO 4.5: NIGLIQ CHANNEL LEFT BANK AT MON22, MAY 22, 2009

4.2 WATER SURFACE ELEVATION (WSE)

This section includes a summary of hydrologic data collected from monitoring locations along the proposed Fiord West access road and pad and at two locations on the Nigliq Channel.

4.2.1 FIORD WEST ACCESS ROAD

WSE monitoring along the Fiord West access road began on May 27. Measurable water was first observed at the FWR3 gage location on June 1. Measureable water was observed at FWR1 and FWR2 road gage locations on June 3. WSE at FWR3 on subsequent days varied, both increasing and decreasing over time. The recorded WSE at FWR1 and FWR2 decreased following the initial recorded WSE on June 3. Peak WSE, as noted by observation of high water marks on the gages, were observed at all Fiord West road sites on June 3.

PHOTO 4.6: FWR1, JUNE 1, 2009

Table 4.1 presents the observations and WSE recorded for FWR1. Table 4.2 presents the observations and WSE recorded for FWR2. Table 4.3 presents the observations and WSE recorded for FWR3.

The June 1 conditions at FWR1 are shown in Photo 4.6. The June 1 conditions at FWR2 are shown in Photo 4.7.

PHOTO 4.7: FWR2, JUNE 1, 2009

TABLE 4.1: WSE DATA FOR GAGE FWR1

	WSE (feet BPMSL)	
Date and Time	FWR1	Observations
6/3/09 12:00 AM	5.69	High Water Mark
6/3/09 4:06 PM	5.34	

Notes:

1. Elevations are based on Monument SHEWMAN at 7.085 feet BPMSL, established by Baker in 2009.
2. No discharge measurement was performed at this location.

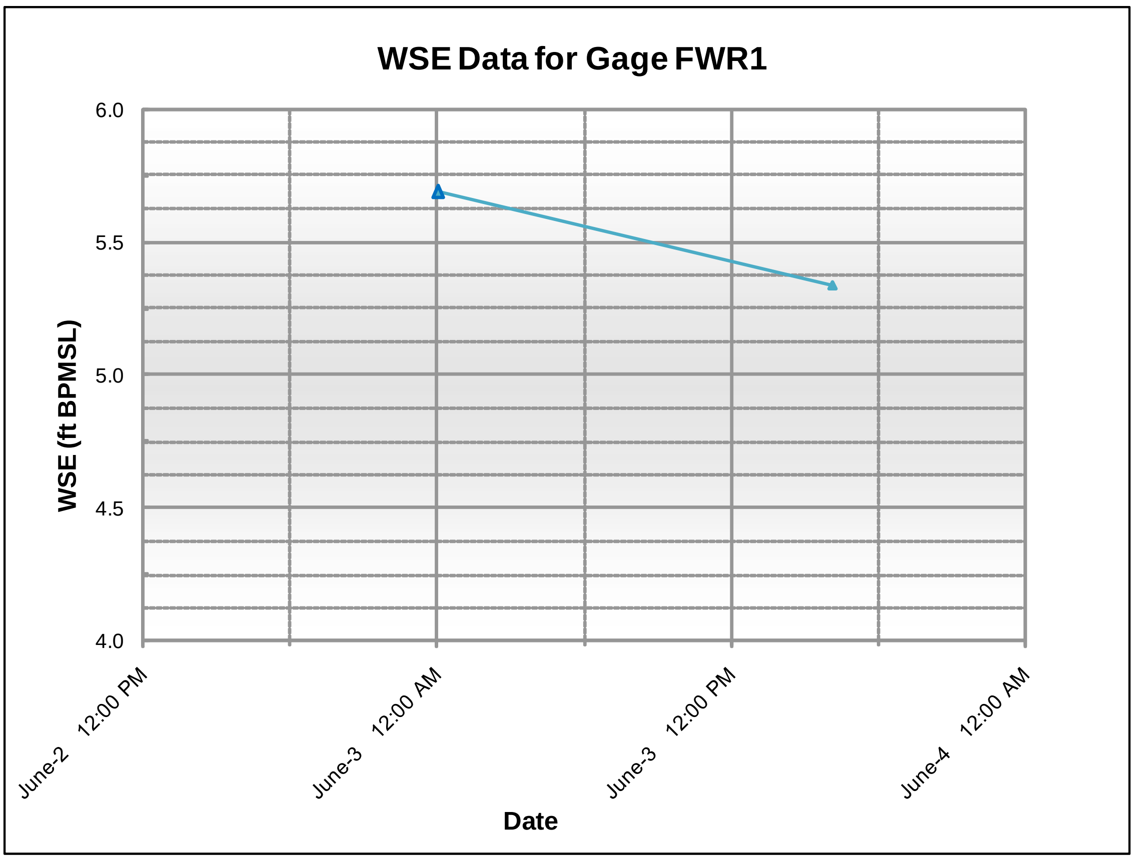


TABLE 4.2: WSE DATA FOR GAGE FWR2

	WSE (feet BPMSL)	
Date and Time	FWR2	Observations
6/3/09 12:00 AM	5.18	High Water Mark
6/3/09 4:06 PM	4.14	

Notes:

1. Elevations are based on Monument SHEWMAN at 7.085 feet BPMSL, established by Baker in 2009.
2. No discharge measurement w as performed at this location.

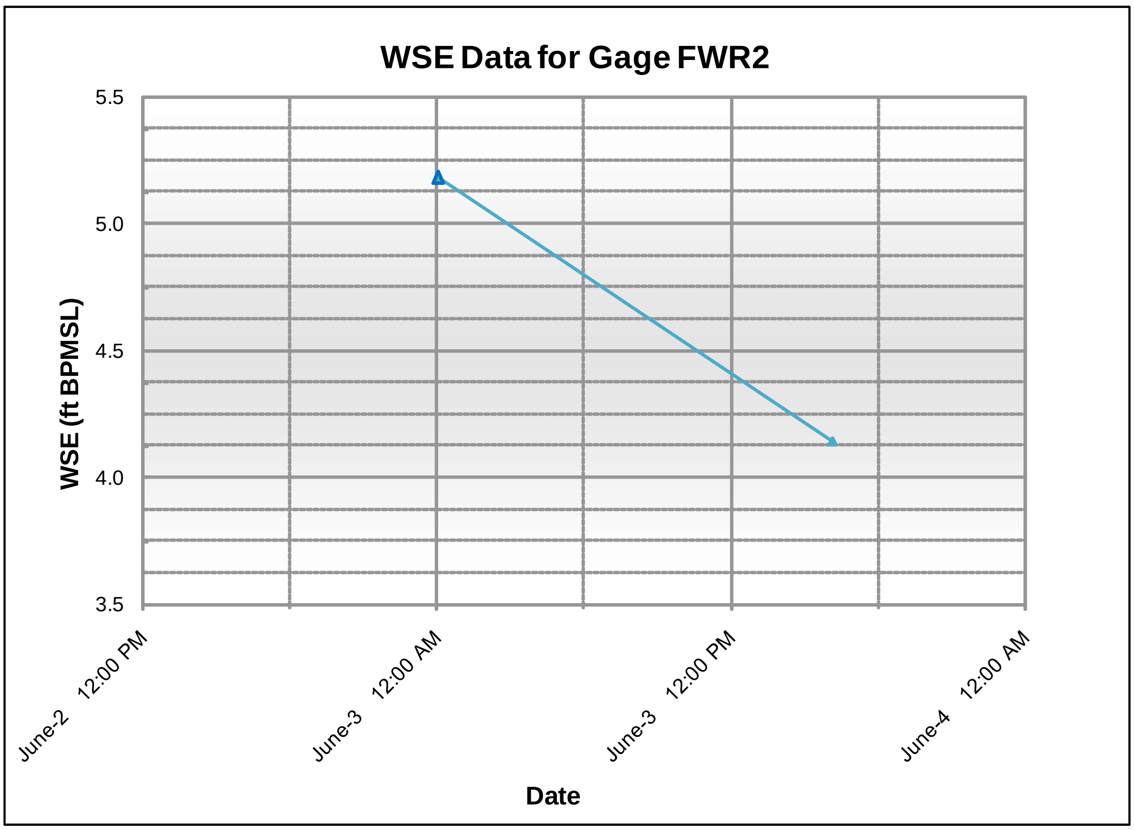
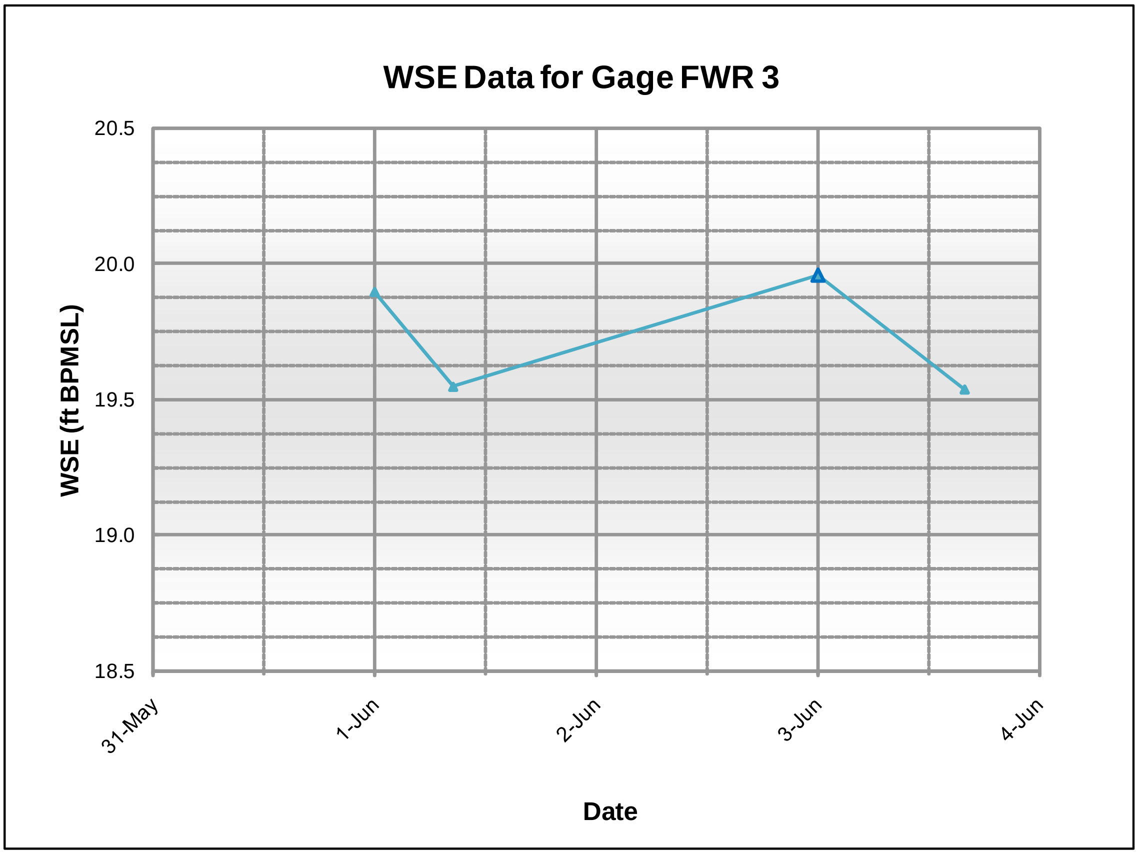


TABLE 4.3: WSE DATA FOR GAGE FWR3

Date and Time	WSE (feet BPMSL) FWR3	Observations
6/1/09 12:00 AM	19.90	
6/1/09 8:30 AM	19.55	
6/3/09 12:00 AM	19.96	High Water Mark
6/3/09 3:55 PM	19.54	

Notes:

1. Elevations are based on Monument SHEWMAN at 7.085 feet BPMSL, established by Baker in 2009.
2. No discharge measurement was performed at this location.



4.2.2 Fiord West Pad Area

WSE monitoring at the Fiord West pad began on May 27. Measurable water was first observed at the FWP gage location on June 3, after which water levels decreased. Peak WSE of 7.41 feet BPMSL at FWP occurred on June 3.

Table 4.4 presents the observations and WSE recorded for FWP. The June 1 conditions at FWP are shown in Photo 4.8.

PHOTO 4.8: FWP, JUNE 1, 2009

4.2.3 Nigliq Channel

WSE monitoring at the Nigliq Channel began on May 22 with observation of measureable water. Stage rose until peak on May 24 at both gage locations. Water surface then decreased steadily for the remainder of the observation period. Peak WSE was 7.76 feet BPMSL at MON22, and 7.01 feet BPMSL at MON23, based on observed high water marks on staff gages. Peak WSE based on the pressure transducer at MON23 occurred on May 23 and was 7.25 feet BPMSL.

Table 4.5 presents the observations and WSE recorded for MON22. Table 4.6 presents the observations and WSE recorded for MON23, including PT data. The May 22 conditions along the Nigliq at MON23 are shown in Photo 4.9.

PHOTO 4.9: NIGLIQ CHANNEL BANKRIGHT AT MON23, MAY 22, 2009

TABLE 4.4: WSE DATA FOR GAGE FWP

	WSE (feet BPMSL)	
Date and Time	**FWR3**	**Observations**
6/3/09 12:00 AM	7.41	High Water Mark
6/3/09 3:55 PM	7.31	

Notes:

1. Elevations are based on Monument SHEWMAN at 7.085 feet BPMSL, established by Baker in 2009.
2. No discharge measurement was performed at this location.

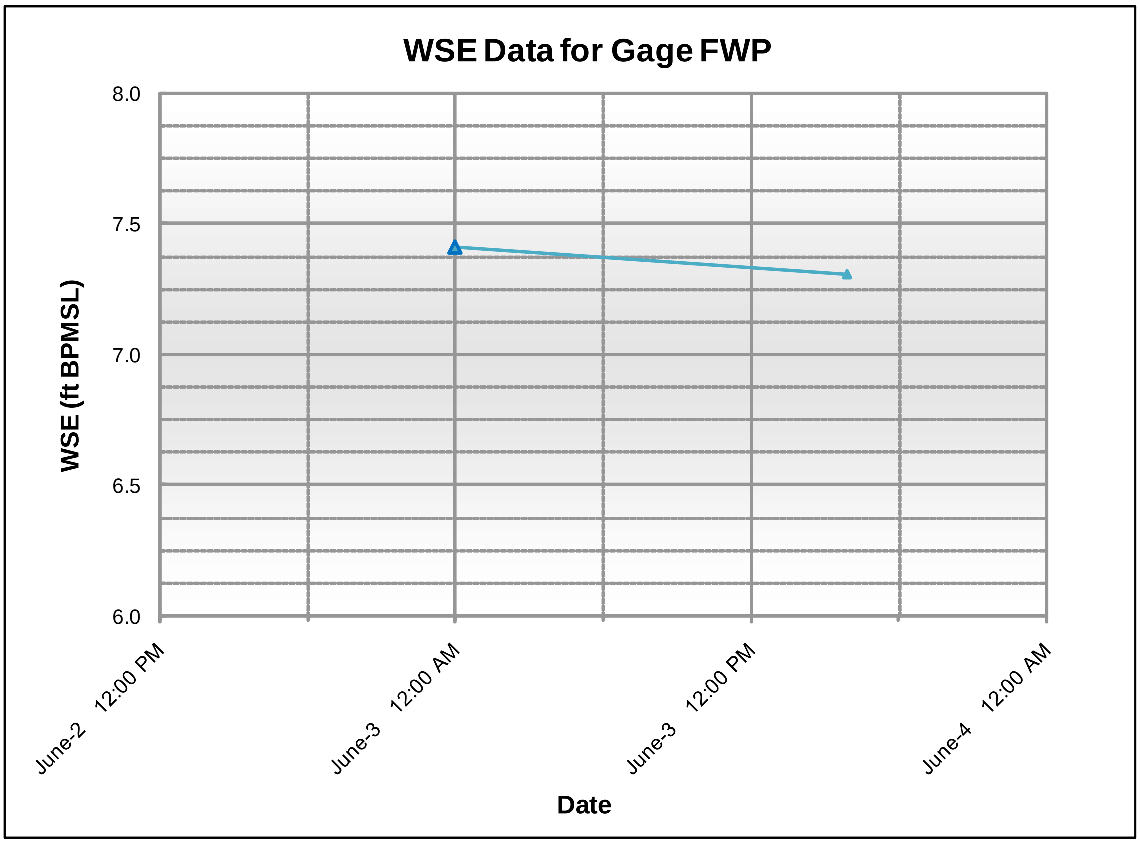


TABLE 4.5: WSE DATA FOR GAGE MON22

	WSE (feet BPMSL)	
Date and Time	MON22	Observations
5/22/09 4:43 PM	8.71	Waves; reading inaccurate
5/23/09 12:00 AM	7.74	
5/23/09 5:22 PM	7.64	Waves
5/24/09 12:00 AM	7.76	High Water Mark
5/24/09 5:02 PM	7.69	
5/25/09 12:00 AM	7.71	
5/25/09 10:35 AM	7.64	
5/27/09 12:00 AM	7.69	
5/27/09 10:00 AM	5.85	
5/28/09 4:02 PM	4.87	

Notes:

1. Elevations are based on Monument 22 at 10.10 feet BPMSL, updated by LCMF in 2003.
2. No discharge measurement w as performed at this location.

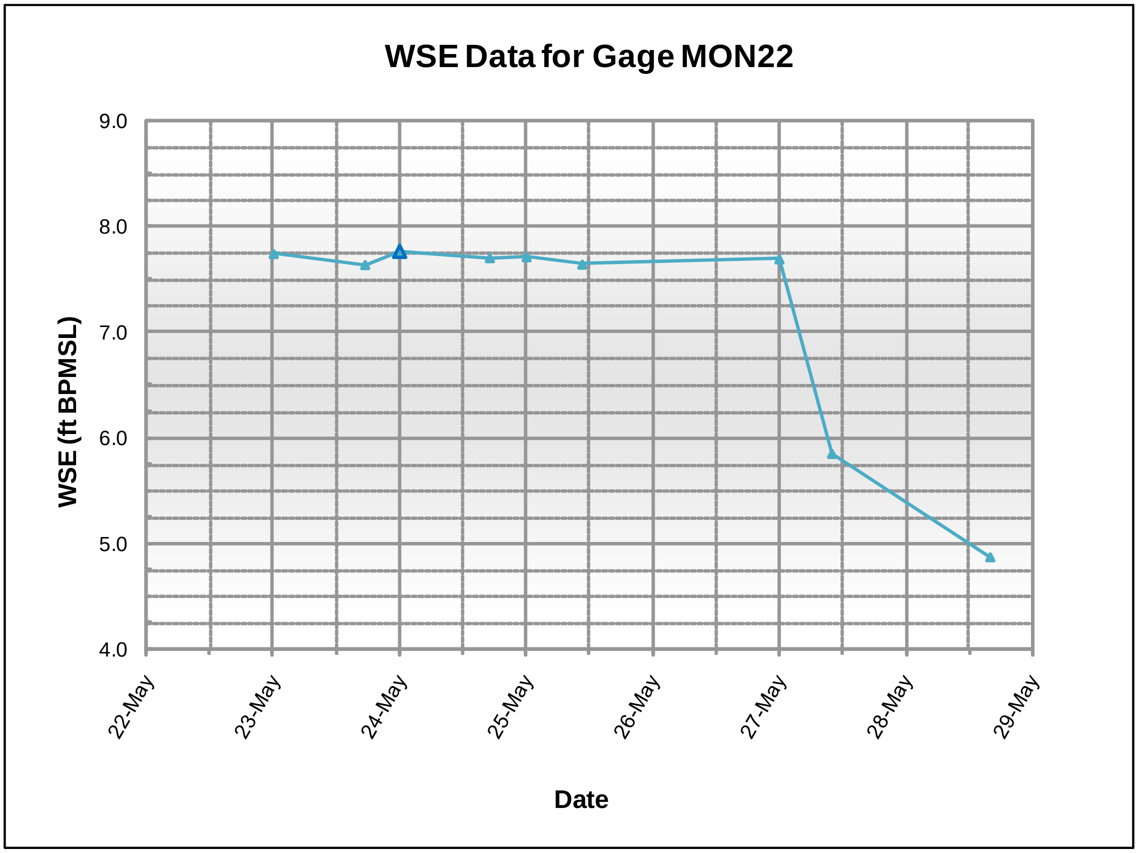
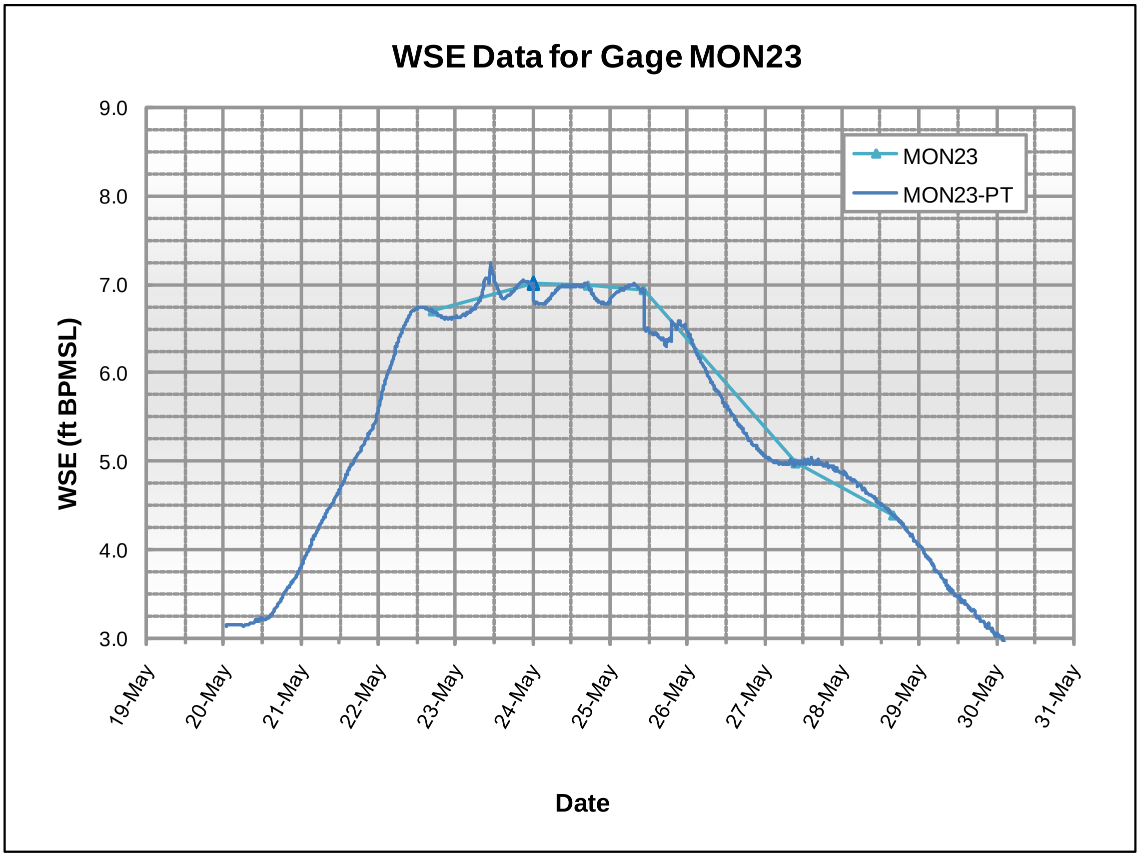


TABLE 4.6: WSE DATA FOR GAGE MON23

	WSE (feet BPMSL)	
Date and Time	MON23	Observations
5/22/09 4:53 PM	6.70	
5/24/09 12:00 AM	7.01	High Water Mark
5/24/09 5:11 PM	6.99	
5/25/09 10:30 AM	6.94	
5/27/09 9:47 AM	4.98	
5/28/09 4:12 PM	4.39	

Notes:

1. Elevations are based on Monument 23 at 9.523 feet BPMSL, updated by LCMF in 2005.
2. No discharge measurement w as performed at this location.



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5.0 Two Dimensional Hydrodynamic Model (Pending)

This section will be completed after receipt of final Fiord West road alignment and pad placement.

5.1 Modification to Current Model (Pending)

Pending.

5.2 Assessment of Design Flood Events (Pending)

Pending.

5.3 Assessment of Hydrological Impacts on Existing Facilities (Pending)

Pending.

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6.0 REFERENCES

6.1 REFERENCE LIST

Çengel, Ynus A. and Boles, Michael A. 2006. Fluid Mechanics: Fundamentals and Applications. 1st ed. McGraw-Hill, New York, New York. 2006.

-------- 2006. Thermodynamics: An Engineering Approach. 5st ed. McGraw-Hill, New York, New York. 2006.

Federal Emergency Management Agency (FEMA). 2003. Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix F: Guidance for Ice-Jam Analysis and Mapping. April 2003.

Michael Baker Jr., Inc. (Baker). 2005a. Alpine Facilities 2004 Spring Breakup and Hydrologic Assessment. Prepared for ConocoPhillips Alaska, Inc.

-------- 2005b. Colville River Delta and Fish Creek Basin 2005 Spring Breakup and Hydrological Assessment. Prepared for ConocoPhillips Alaska, Inc.

-------- 2007a. 2006 Colville River Delta and Fish Creek Basin Spring Breakup and Hydrological Assessment. January 2007. Prepared for ConocoPhillips Alaska, Inc.

-------- 2007b. 2007 Colville River Delta Spring Breakup and Hydrologic Assessment. November 2007. Prepared for ConocoPhillips Alaska, Inc.

-------- 2008a. Colville River Delta Lakes Recharge Monitoring and Analysis. Prepared for ConocoPhillips Alaska, Inc.

-------- 2008b. Fiord West 2008 CRD Breakup Assessment. Prepared for ConocoPhillips Alaska, Inc.

Office of Surface Water (OSW). 1999. Technical Memorandum No. 99.06. Website access 2009 http://water.usgs.gov/admin/memo/SW/sw99.06.html).

PND Inc. (PND). 2000. Alpine Development Swale Crossing Foundation Sections and Details. Drawing Number CE-CD00-306. Prepared for ARCO Alaska, Inc.

— — 2005. NPRA Small Stream Crossings 2004 Breakup Monitoring Report. Prepared for ConocoPhillips Alaska.

Rantz, S.E. and others. 1982. Measurement and Computation of Streamflow, Vols. 1 and 2. United States Geologic Survey Water Supply Paper 2175.

United States Army Corps of Engineers (USACE). 1982. Mixed Population Frequency Analysis TD-17, April 1982.

URS. 2001. 2001 Hydrologic and Hydraulic Assessment. Fish Creek, Judy Creek, and the Ublutuoch River, North Slope, Alaska. Prepared for ConocoPhillips Alaska, Inc.

-------- 2003. 2002 Hydrologic and Hydraulic Assessment. Fish Creek, Judy Creek, and the Ublutuoch River, North Slope, Alaska. Prepared for ConocoPhillips Alaska.

Weather Underground. Website access summer 2009. (http://www.wunderground.com)

Walker H.J. and P.F. Hudson. 2003. Hydrologic and Geomorphic Processes in the Colville River Delta, Alaska. Geomorphology, 56, 291-303.

6.2 ACRONYMS

ASDP	Alpine Satellite Development Plan
Baker	Michael Baker Jr. Inc.
BPMSL	British Petroleum Mean Sea Level
CPAI	ConocoPhillips Alaska, Inc.
CRD	Colville River Delta
FWP	Fiord West Pad
FWR	Fiord West Road
GPS	Global Positioning System
NAD83	North American Datum of 1983
NPR-A	National Petroleum Reserve, Alaska
PT	Pressure Transducer
WSE	Water Surface Elevations

6.3 Glossary

Alpine
CD1 pad

Alpine Facilities
CD1, CD2, CD3, and CD4 pads, including access roads and bridges

Breakup
Period of disintegration of ice cover in rivers and lakes

Drainage Basin
A region of land where water from rain or snowmelt drains downhill into a body of water (e.g. river or lake)

Gage
Fixed vertical graduated scale for determining water surface elevation at a specific location

Ice Jam
A stationary accumulation of fragmented ice or frazil, which restricts or blocks a stream channel

Monument
Benchmark of known elevation and horizontal position relative to a defined datum, used for horizontal and vertical control in surveying.

Paleochannel
An ancient streambed or channel

Pressure Transducer
A type of measurement device that converts pressure-induced mechanical changes into an electrical signal

Spring Breakup
See Breakup

Staff Gage
See Gage

Stage
The vertical distance from any selected and defined datum to the water surface

Water Surface Elevation (WSE)
See Stage

Appendix A SURVEY CONTROL AND GAGE SUMMARY

TABLE A.1: FIORD WEST GAGE LOCATIONS

Gage Site	Gage	Latitude (NAD 83)	Longitude (NAD83)	Basis of Elevation
FW Pad	FWP-A	N 70° 22' 27.8"	W 151° 06' 00.1"	SHEWMAN
	FWP-Z[1]	N 70° 22' 28.1"	W 151° 06' 01.7"	
FW Road 1	FWR1	N 70° 22' 13.7"	W 151° 06' 50.7"	SHEWMAN & CP03-06-64W
FW Road 2	FWR2	N 70° 22' 00.0"	W 151° 07' 19.0"	SHEWMAN
FW Road 3	FWR3	N 70° 18' 38.87"	W 151° 10' 43.9"	CP08-18-27A
Monument 22	MON22-A	N 70° 19' 07.1"	W 151° 03' 16.3"	MONUMENT 22
	MON22-B	N 70° 19' 06.5"	W 151° 03' 17.5"	
	MON22-C	N 70° 19' 06.5"	W 151° 03' 18.1"	
	MON22-D	N 70° 19' 05.9"	W 151° 03' 19.7"	
Monument 23	MON23-A	N 70° 20' 37.1"	W 151° 03' 58.9"	MONUMENT 23
	MON23-B	N 70° 20' 37.0"	W 151° 03' 56.1"	
	MON23-C	N 70° 20' 37.0"	W 151° 03' 55.0"	
	MON23-D	N 70° 20' 37.0"	W 151° 03' 54.1"	
	MON23-PT[2]	N 70° 20' 36.3"	W 151° 03' 59.1"	
Monument 9	MON9-BARO[3]	N 70° 14' 39.3"	W 150° 51' 37.6"	MONUMENT 9

[1] Angle iron without gage
[2] Pressure transducer
[3] BaroTROLL®

TABLE A.2: FIORD WEST CONTROL

Control	Elevation (BPMSL - Feet)	Latitude (NAD 83)	Longitude (NAD83)	Control Type	Reference
CP03-06-64W	7.990	N 70° 20' 37.8"	W 151° 04' 32.2"	Alcap	LCMF 2008
CP08-18-27A	20.605	N 70° 18' 31.6"	W 151° 10' 46.9"	Alcap	LCMF 2008
MONUMENT 9	25.060	N 70° 14' 40.6"	W 150° 51' 29.6"	Alcap	LCMF 2008
SHEWMAN	7.085	N 70° 22' 20.2"	W 151° 06' 53.4"	Alcap	Baker 2009