CULVERT MONITORING REPORT

2019 GREATER MOOSE'S TOOTH 2 (GMT2/MT7)

SPRING BREAKUP

ConocoPhillips
Alaska

PREPARED BY:

Michael Baker
INTERNATIONAL

MICHAEL BAKER INTERNATIONAL
3900 C STREET, SUITE 900
ANCHORAGE, AK 99503

TABLE OF CONTENTS

FIGURES

TABLES

PHOTOS

APPENDIX F PHOTOS

ACRONYMS & ABBREVIATIONS

Baro	Barometric
BPMSL	British Petroleum Mean Sea Level
CFDD	cumulative freezing degree days
cfs	cubic feet per second
CPAI	ConocoPhillips Alaska, Inc.
CRD	Colville River Delta
DS	Downstream
ft	Feet
fps	Feet per second
GMT2/MT7	Greater Moose's Tooth 2
GPS	Global positioning systems
HWM	High water mark(s)
Michael Baker	Michael Baker International
NAD83	North American Datum of 1983
NPR-A	National Petroleum Reserve Alaska
PT	Pressure transducer
UMIAQ	UMIAQ, LLC (formerly LCMF)
US	Upstream
USACE	U. S. Army Corps of Engineers
USGS	U.S. Geological Survey
WGS84	World Geodetic System of 1984
WSE	Water surface elevation(s)

1 INTRODUCTION

The ConocoPhillips Alaska Inc. (CPAI) Greater Moose's Tooth 2 (GMT2/MT7) facility is located within the Greater Moose's Tooth Unit and part of the Alpine Satellite Development program. GMT2/MT7 Spring Breakup Culvert Monitoring supports the ConocoPhillips Alaska, Inc. Environmental group in meeting State of Alaska, federal, and local permit stipulations. GMT2 facilities include the GMT2 access road and pad. The GMT2 access pad, road and 80 culverts were installed during the winter of 2018-2019.

The GMT2/MT7 access road spring breakup culvert monitoring field program took place during the 2019 spring breakup monitoring and hydrologic assessment field program. Spring breakup monitoring began on April 19 and concluded on June 5. An additional site visit was performed on July 2 to retrieve field equipment and document summer conditions. Figure 1 shows the GMT2/MT7 access road culvert monitoring locations. Culvert locations and properties are provided in Appendix A and indirect-read hydrologic staff gage (gage) and associated vertical control locations are provided in Appendix B.

UMIAQ, LLC (UMIAQ) and CPAI Alpine Field Environmental Coordinators provided support during the field program and contributed to a safe and productive monitoring season. The field methodologies used to collect hydrologic data on the North Slope of Alaska during spring breakup are proven safe, efficient, and accurate for the conditions encountered.

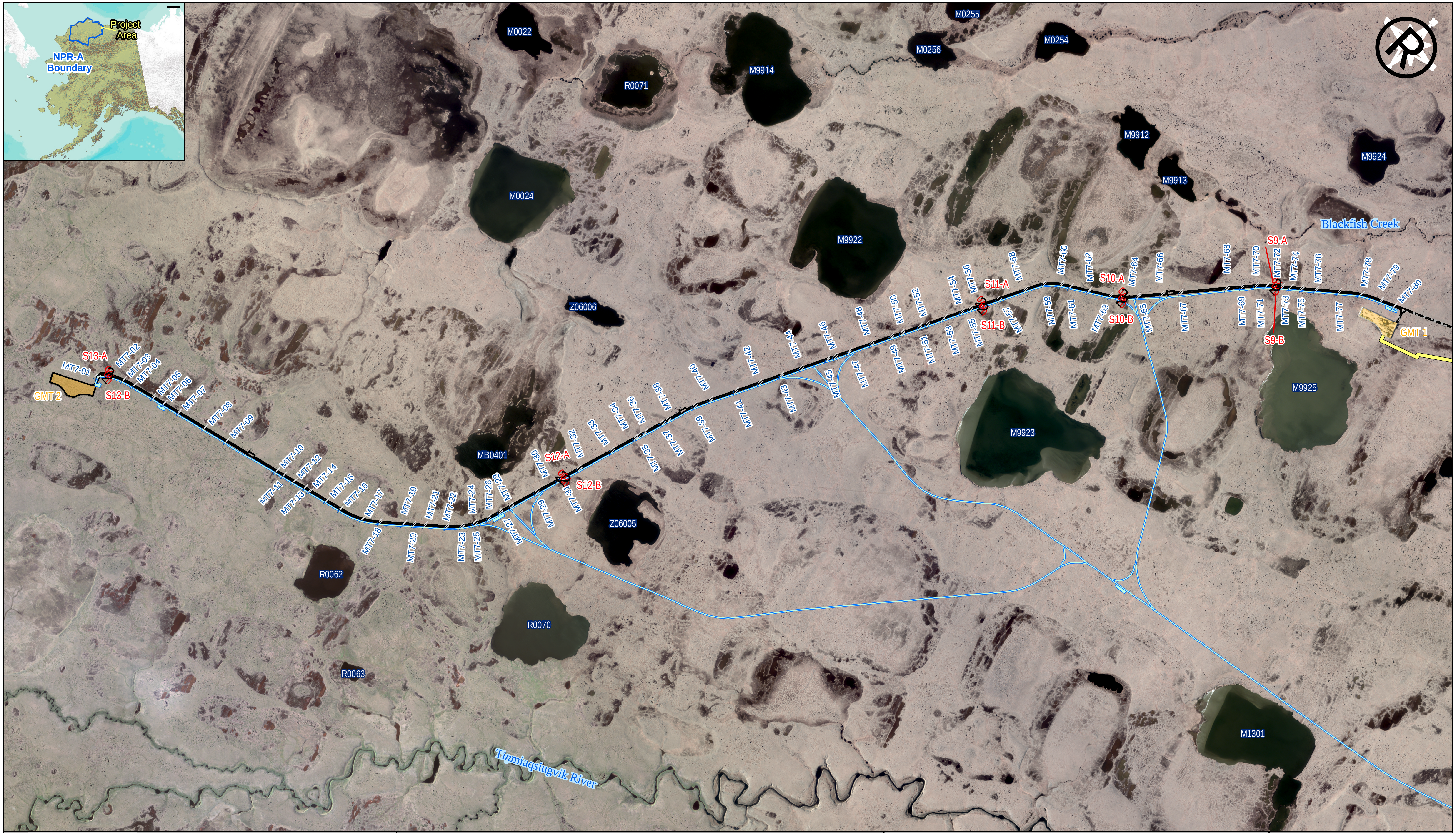
1.1 Study Objective

This report addresses culvert performance and evaluation of areas where additional culverts or modifications to existing culverts are necessary to maintain natural drainage. This meets hydrology monitoring requirements set forth in the U.S. Army Corps of Engineers (USACE) permit POA-2015-00486, Special Condition 5.b. This permit requires annual GMT2/MT7 access road culvert monitoring reports to be submitted for three years post-construction. This is the first year of reporting.

The following tasks were performed to meet the permit requirements:

- Aerial and ground photo documentation of the GMT2/MT7 access road and pad to demonstrate hydraulic connections during spring breakup and post breakup (summer) conditions
- Identification of areas of differential ponding (ponding on one side of the road), drying, erosion, or stream channel changes adjacent to fill areas
- Demonstration of culvert conveyance of surface water flow based on the maintenance of natural drainage patterns and lack of evidence to the contrary (ponding, drying, erosion, stream channel changes)
- Evaluation of all areas where additional culverts are necessary to maintain natural drainage patterns
- Evaluation of all areas where culvert maintenance, repair, upgrade, setting adjustments, or replacement are necessary to maintain natural drainage patterns

Culvert locations and properties referenced in this report are taken from the IFC drawings of applicable facilities produced by UMIAQ in August of 2018 and provided in Figure 1.



ConocoPhillips Alaska	0 0.25 0.5 1 miles
Date: 7/8/2019	Project: 171763
Drawn: JEG	File: Figure 1
Checked: GCY	Scale: 1 in = 0.5 miles

gage(s) + PT
Culvert
GMT2 Road
GMT1 Road
Ice Road
Ice Pad
Pipeline
Facility

Imagery Source : Conoco Phillips Alaska 2018 Aerial

Michael Baker INTERNATIONAL

Michael Baker International, Inc.
3900 C. Street Suite 900
Anchorage, AK 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2019 GMT2 Gage Stations

FIGURE: 1

(SHEET 1 of 1)

1.2 Data Collection

Data was collected at the following locations, as provided in Table 1.

Table 1: GMT2 / MT7 Access Road Culvert Data Collection

Culverts	Associated Gages	Location Description
GMT2-01 through GMT2-19	S13-A/S13-B	Gage located in small, poorly defined network of polygon troughs near the proposed GMT2 pad location.
GMT2-20 through GMT2-39	S12-A/S12-B	Gages and culverts located in a swale depression between Lakes Z06005 and MB0401.
GMT2-40 through GMT2-59	S11-A/S11-B	Gages and culverts located on the southwest corner of a paleolake between Lakes M9923 and M9922.
GMT2-60 through GMT2-69	S10-A/S10-C	Gages and culverts located on the east end of a paleolake between Lakes M9923 and M9913.
GMT2-70 through GMT2-80	S9-A/S9-B	Gages and culverts located on the northwest corner of lake M9925 in a shallow depression.

2 METHODS

2.1 Observations

Gage locations were selected based on topography and hydraulic significance. Field data collection and observations of interactions between floodwaters and infrastructure were recorded in field notebooks and on culvert monitoring field sheets. Photographic documentation of spring breakup conditions were collected using digital cameras with integrated global positioning systems (GPS). The latitude, longitude, data, and time are imprinted on each photo. The photo locations are referenced to the World Geodetic System of 1984 (WGS84) horizontal datum.

CPAI Alpine Field Environmental Coordinators provided a pickup truck for culvert access during spring breakup setup and monitoring. Soloy Helicopters provided helicopter support for performing overflights during spring breakup monitoring.

2.2 Water Surface Elevations

Water surface elevation (WSE) data was collected on both sides of the road prism to document WSE differential for assessing culvert performance. This was completed using a network of gages with pressure transducers (PTs) attached to each gage. For the purposes of this report, stage and WSE are used interchangeably.

2.2.1 Hydrologic Staff Gages

Gage assemblies (gage and PT) were installed or rehabilitated prior to breakup. Gage assemblies do not directly correspond to an established vertical datum. The gage stations consist of one or more gage assemblies positioned on the upstream and downstream sides of the road prism. Each gage assembly includes a standard U.S. Geological Survey (USGS) metal faceplate mounted on a wooden two-by-four. The two-by-four is attached with U-bolts to a 1.5-inch-wide angle iron gage support post driven into the ground. The faceplate is graduated and indicates water levels every 100th of a foot between 0.00 to 3.33 feet. Gage assemblies were identified with alphabetical designations, with the letter ‘A’ representing the gage assembly located on the north (downstream [DS]) side of the GMT2/MT7 access road and the letter ‘B’ representing gage assemblies located on the south (upstream [US]) side of the GMT2/MT7 access road.

High water marks (HWMs) on the gages were recorded by applying chalk on the angle iron posts and measuring the wash line. HWMs were recorded to document peak stage.

2.2.2 Pressure Transducers

PTs were attached to all gages to supplement gage readings and provide a continuous record of WSE when the water column is above the PT sensor. PTs were programmed to collect data at 15 minute intervals beginning on May 15th. Each PT was housed in a small perforated galvanized steel pipe and secured to the base of the gage assembly. By sensing the absolute pressure of the atmosphere and water column above the PT, the depth of water above the sensor was calculated. During data processing, the PT measurements were adjusted to WSE readings at the gages. PT setup, testing, and processing methods are detailed in Appendix C.

2.3 Discharge Measurements

Site visits and direct measurements were performed as near to peak flow conditions as possible. Measurements were collected in all culverts observed conveying flow. Culvert velocity and flow depth were measured directly using a HACH FH950 electromagnetic velocity meter and a wading rod. Discharge was calculated using measured velocity, flow depth, and the inside culvert diameter. Inside culvert diameter was determined based on the outside culvert diameter and wall thickness data provided by UMIAQ (UMIAQ 2018). Discharge methods are detailed in Appendix D.

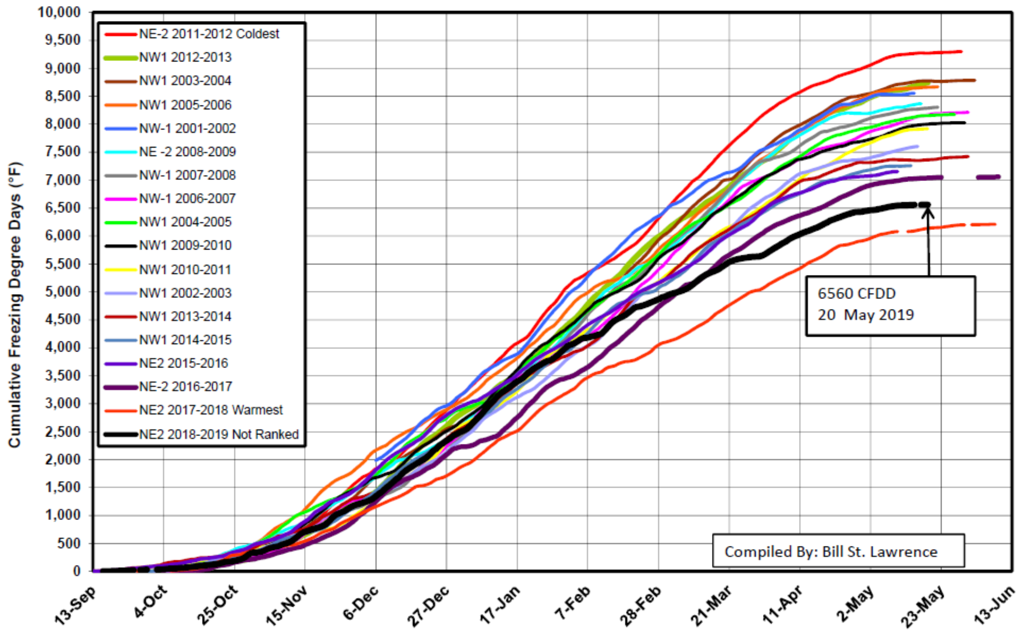
2.4 Culvert Performance Evaluation

Culvert performance was evaluated based on observations, WSE, and discharge measurements with a focus on maintenance, repair, upgrade, setting adjustments, and/or replacement. In addition, the condition of the road fill around the culverts was evaluated to identify areas of erosion.

3 RESULTS

3.1 General Climatic Summary

According to cumulative freezing degree-days (CFDD) measured at the National Petroleum Reserve Alaska (NPR-A) tundra monitoring station, the 2018-2019 (September – May) winter was the 2nd warmest on record for the past 18 years (Graph 3.1)



Graph 3.1: NPRA N. Tundra Monitoring Station CFDD, Winters 2002-2019 (ICE 2019)

There is no NRCS North Slope snowpack data currently available for the 2018-2019 winter season, but general observations indicate snowpack was at or above normal levels in the Colville River drainage basin.

A warming trend in the Upper Colville River watershed (the Brooks Range foothills, as recorded at Umiat) started April 23 (USGS 2019). Daily maximum temperatures began to exceed freezing on May 12 and daily minimum temperatures began to exceed freezing on May 21. In the CRD, daily maximum temperatures exceeded freezing from April 29 to May 4, followed by a cooler period with sub-freezing temperatures (Weather Underground 2019). Daily high temperatures consistently exceeded freezing on May 16 and continued through the breakup monitoring period. Daily minimum temperatures remained below freezing through the breakup monitoring period.

3.2 General Observations Summary

Culverts were cleared in April by mechanically removing snow and ice from the inlets and outlets prior to spring breakup flooding. Visual inspections performed at the end of April confirmed that snow had been cleared from all culvert inlets and outlets, however, drifted snow had accumulated between ice roads and the south edge of the GMT2/MT7 access road, partially burying most culverts.

On May 27, local melt was observed throughout the GMT2/MT7 access road area on both sides of the road. Snow cover on the surrounding tundra was approximately 50%.

On May 28, local melt was observed at many monitoring stations. In many locations, the ice road was blocking drainage. Snow cover was approximately 30%. By June 2, snow cover was around 10% and local ponding was present at most monitoring locations.

On June 3, snow cover on the surrounding tundra was approximately 5%. In general, conveyance channels had cut through the remaining ice roads and drifted snow. On June 4, many culverts in defined drainages along the road were observed conveying flow. Cross flow culverts, situated on higher ground, remained dry during spring breakup monitoring. Discharge measurements were performed at all culverts conveying flow on May 29 and June 4.

3.3 Site Specific Observations & Water Surface Elevations

Summarized observations of flow conditions are tabulated in Appendix E. Additional site-specific monitoring photos are provided in Appendix F.

3.3.1 S9 Culverts (GMT2-70 through GMT2-80)

The S9 monitoring location is situated in a swale depression near the outlet of lake M9925. The primary source of water in this area is local melt from Lake M9925. Culverts GMT2-70 through GMT2-72 are located in this depression while culverts GMT2-73 to GMT2-80 are situated further east. An ice road adjacent to the south embankment of the GMT2 road affected drainage in the area.

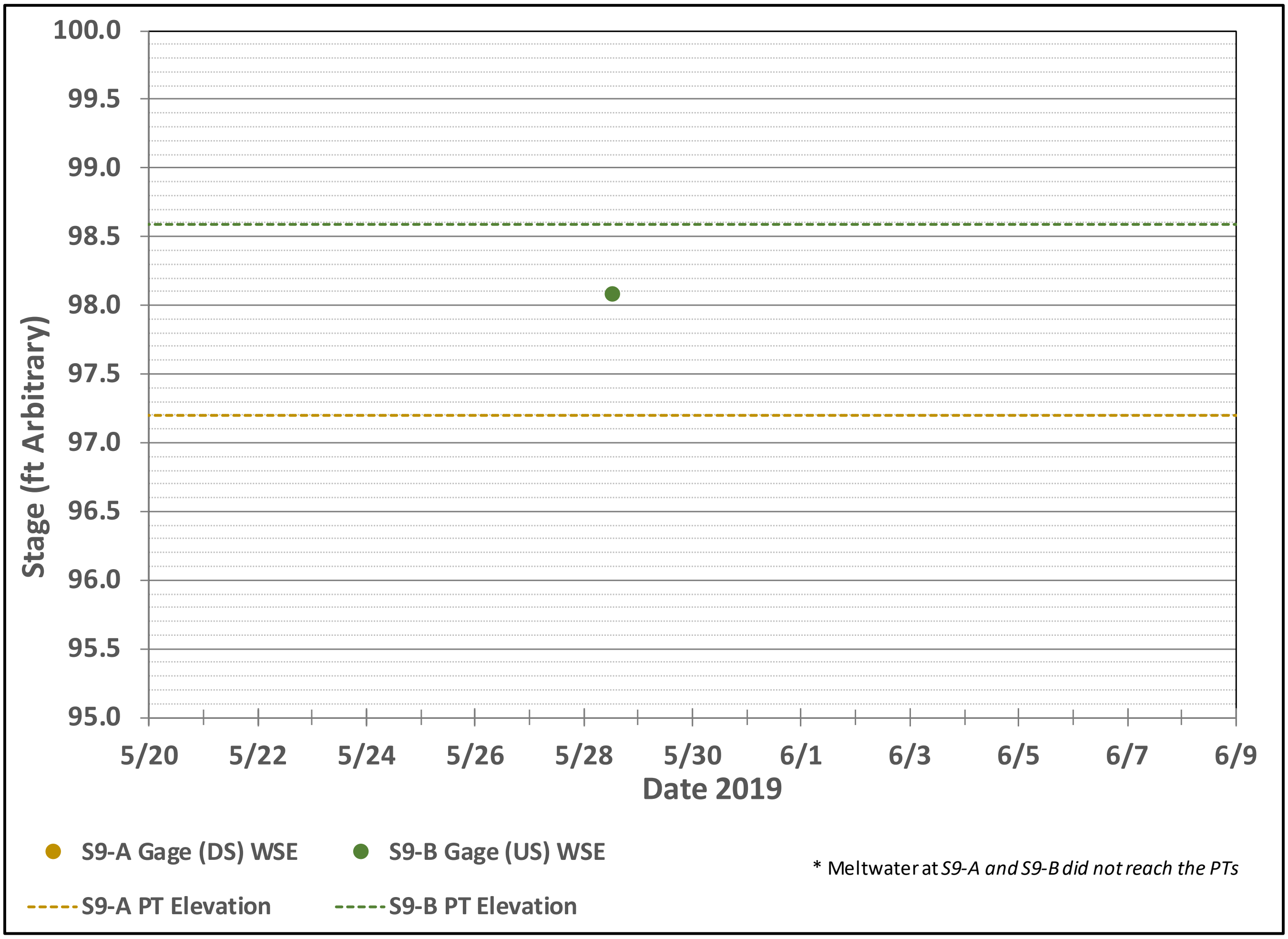
Local melt was first observed on May 27 as ponded water started accumulating on both sides of the road. Visual observations on May 28 showed minimal meltwater at gage station S9 (Photo F.1). Any meltwater from Lake M9925 traveled through a low-lying area to the west of S9 and passed through culvert GMT2-70 and 71. On May 28, flow was measured at various culverts to the east, but meltwater through these culverts was disconnected from Lake M9925.

On June 3, aerial observations revealed differential ponding around the S9 gage area. Meltwater had reached the embankment on the south (upstream) side of the alignment and ponding was observed extending from culvert GMT2-72 to GMT2-75 (Photo F.2). The ice road had deteriorated and was submerged under ponded water and likely impacted the drainage in this area. By June 4, water was observed flowing through the S9 culverts, although a small area of differential ponding was still observed around GMT2-72 and GMT2-73.

On July 2, field crews returned to S9 to further inspect the area of ponding around culvert GMT2-72 and GMT2-73. The appearance of differential ponding was still observed (Photo F.3). Historical aerial imagery reveals that the road alignment bisects a poorly defined natural drainage and, absent the road, the northernmost extent of meltwater ponding may not extend beyond the northernmost extent of the road footprint. Therefore, it is uncertain whether moving existing culverts or installing an additional culvert would improve drainage or decrease the appearance of differential ponding in the area.

Meltwater at the S9 gage stations did not reach the PTs. Visual observations and aerial photography suggest peak stage occurred around June 2. The ice road, being in close proximity to the GMT2 road, caused drifted snow to accumulate between the two roads, which temporarily impacted culvert performance. With the exception of temporary blockage from drifted snow accumulation, all culverts were observed to be functioning as designed and natural drainage patterns in the area were maintained.

S9 spring breakup stage data is provided in Graph 3.2. Measured discharge data is presented in section 3.4. Photos are provided in Appendix F.1.



Graph 3.2: S9 Water Surface Elevations

3.3.2 S10 Culverts (GMT2-60 through GMT2-69)

The S10 monitoring location is situated on the east end of a paleolake between Lakes M9923 and M9913. Culverts GMT2-60 through GMT2-64 are located in the paleolake while culverts GMT2-65 through GMT2-69 are located on higher ground to the east. An ice road adjacent to the south embankment of the GMT2 road affected drainage in the area.

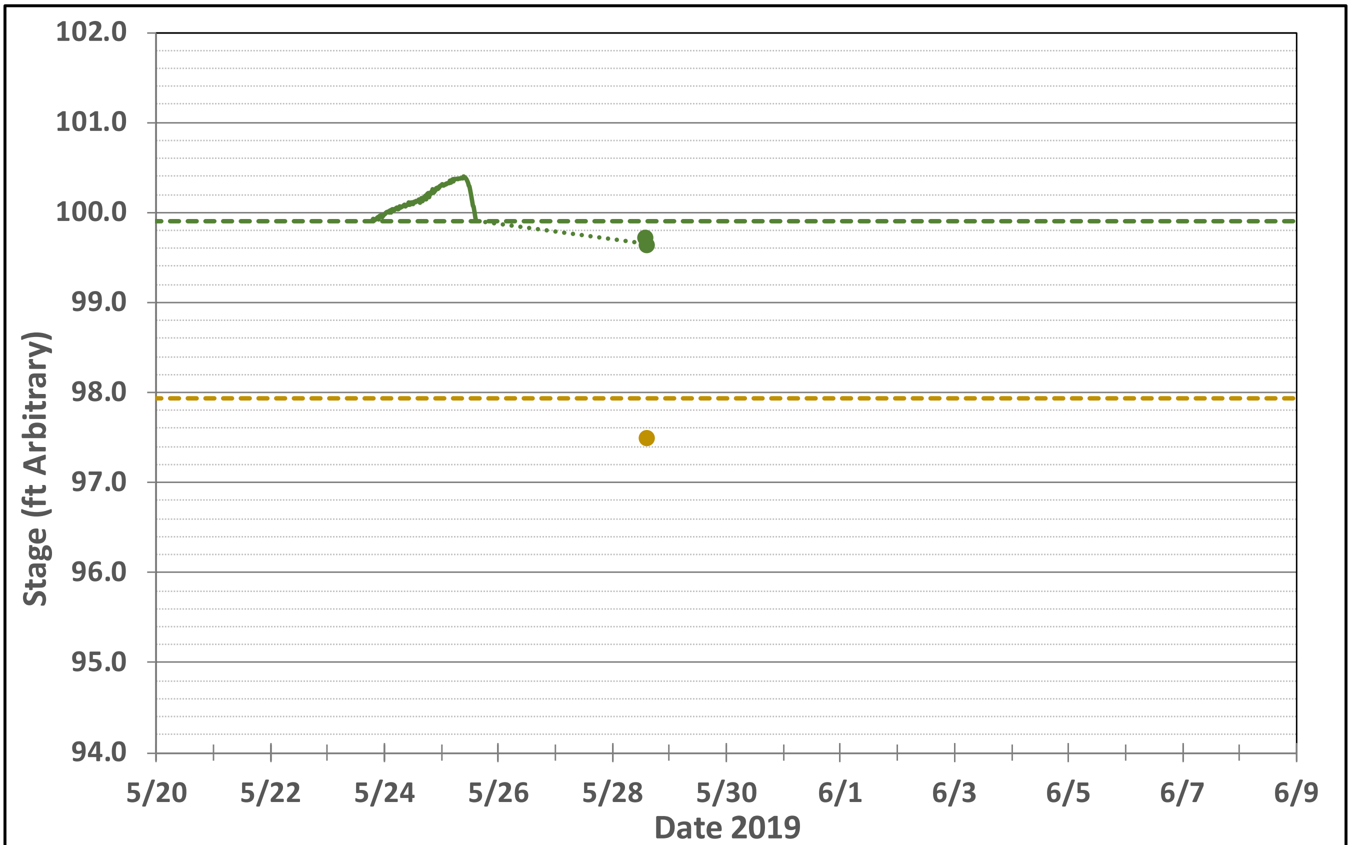
Local melt was first observed in the S10 monitoring location on May 27 as meltwater pooled in low areas of the associated paleolake on both sides of the road. Differential ponding was observed at culvert GMT2-64, with larger quantities of meltwater on the south (upstream) side of the alignment (Photo F.4). On May 28, field crews walked the alignment and discovered the culvert installation cap was still in place on the inlet of culvert GMT2-64. Once this cap was removed, rapid flow through the culvert was observed as the area hydraulically equalized. By May 29, meltwater had cut flow paths through the ice road at most culvert locations. Flow was confirmed through culvert GMT2-61, GMT2-65 and GMT2-67. At GMT2-61, ponded water and differential pooling was observed on the south side of the road, but flow through GMT2-61 suggests the ponding was due to a partially blocked culvert (Photo F.5).

On June 3, aerial observations revealed hydraulically equalized conditions at most locations. Areas of minor ponding were still observed at GMT2-61 (Photo F.6). On June 4, discharge was measured through culverts that were conveying flow, although stage had receded relative to the May 29 measurement. Aerial observations from

July 2 show equalized hydraulic conditions in the area and any ponded water at GMT2-61 had dissipated (Photo F.7).

PT data indicates peak stage occurred at S10-B on May 25. Meltwater at the S10-A gage did not reach the PT. The ice road, being in close proximity to the GMT2/MT7 road, caused drifting snow to accumulate between the two roads, which temporarily impacted drainage. With the exception of temporary blockage from drifted snow accumulation, all culverts were observed to be functioning as designed and natural drainage patterns in the area were maintained.

S10 spring breakup stage data is provided in Graph 3.3. Measured discharge data is presented in section 3.4. Photos are provided in Appendix F.2.



Spring		
S10-B (US) Peak Stage	100.40	5/25/19 9:15 AM
* Meltwater at S10-A (DS) did not reach the PT **Dotted line on S10-B PT represents interpolated data		

Graph 3.3: S10 Water Surface Elevations

3.3.3 S11 Culverts (GMT2-40 through GMT2-59)

The S11 monitoring location is situated on the southwest corner of a paleolake between Lakes M9923 and M9922. Culverts GMT2-56 through GMT2-57 are located in this paleolake, while the other culverts are located outside the paleolake depression. An ice road adjacent to the south embankment of the GMT2/MT7 road affected drainage in the area.

Local melt was first observed in the S11 area on May 27 as meltwater, impeded by the ice road, collected in the associated paleolake on the south side of the GMT2/MT7 road. Differential ponding was observed near culvert

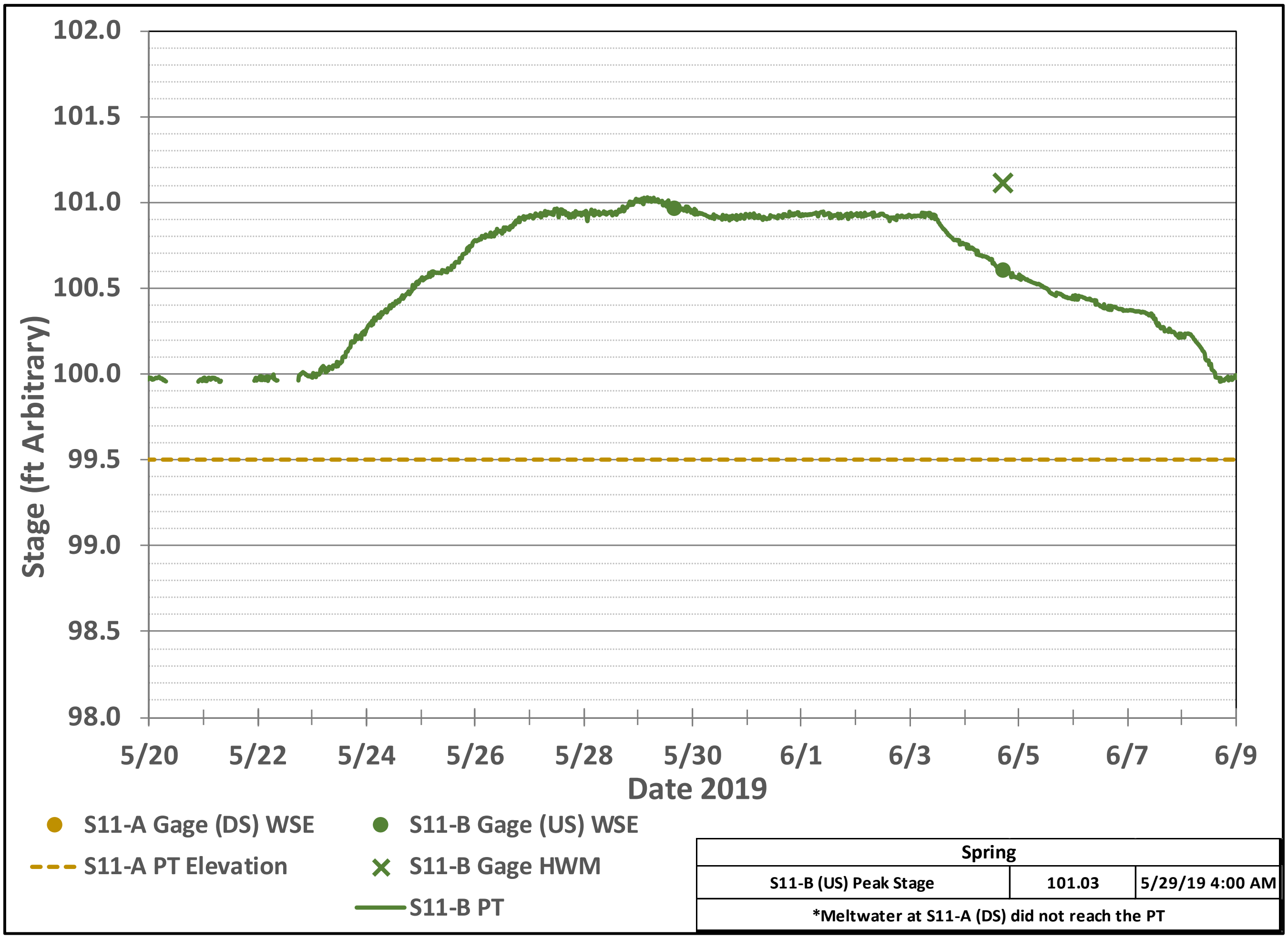
GMT2-41 on May 28 (Photo F.8). Differential ponding was also observed around S11 at culvert GMT2-56 (Photo F.9). On May 29, field crews landed at GMT2-56 to inspect conditions at the site. The south (inlet) end was mostly submerged and appeared to be blocked (Photo F.10), and the north (outlet) end of GMT2-56 was dry (Photo F.11). In addition, the ice road was blocking drainage, leading to large quantities of meltwater accumulating in the associated paleolake to the south.

Aerial observations from June 3 revealed little change. Differential ponding was still observed near S11 at culvert GMT2-56 (Photo F.12) and further west at culvert GMT2-41 (Photo F.13). The ice road and ice blockage in culverts were likely the main cause for poor drainage in the area. On June 4, increased meltwater conveyance through the culverts suggested culvert relief from blockage. Culvert GMT2-56 was observed to be conveying flow, and aerial observations revealed the partial restoration of natural drainage patterns as compared with the previous day (Photo F.14). Ponding on the south side of the alignment around GMT2-41 was still present, although flow through the culvert was observed and measured. The deteriorating ice road had allowed pooled meltwater to reach the toe of the embankment at the GMT2-41 inlet (Photo F.15).

On July 2, field crews returned to S11 to further inspect the area of ponding around culverts GMT2-56 and GMT2-41. The area around GMT2-41 appeared hydraulically equalized and mostly dry (Photo F.16). The appearance of differential ponding around culvert GMT2-56 was still observed based on aerial photography (Photo F.17). Similar to S9, historical aerial imagery reveals that the road alignment bisects a poorly defined natural drainage and, absent the road, the northernmost extent of meltwater ponding may not extend beyond the northernmost extent of the road footprint. Therefore, it is uncertain whether moving existing culverts or installing an additional culvert would improve drainage or decrease the appearance of differential ponding in the area.

PT data indicates peak stage occurred at S11-B on May 25. Meltwater at the S11-A gage did not reach the PT. The ice road, being in close proximity to the GMT2/MT7 road, caused drifting snow to accumulate between the two roads which affected drainage. With the exception of temporary blockage from drifted snow accumulation, all culverts were observed to be functioning as designed and natural drainage patterns in the area were maintained.

S11 spring breakup stage data is provided in Graph 3.4. Measured discharge data is presented in section 3.4. Photos are provided in Appendix F.3.



Graph 3.4: S11 Water Surface Elevations

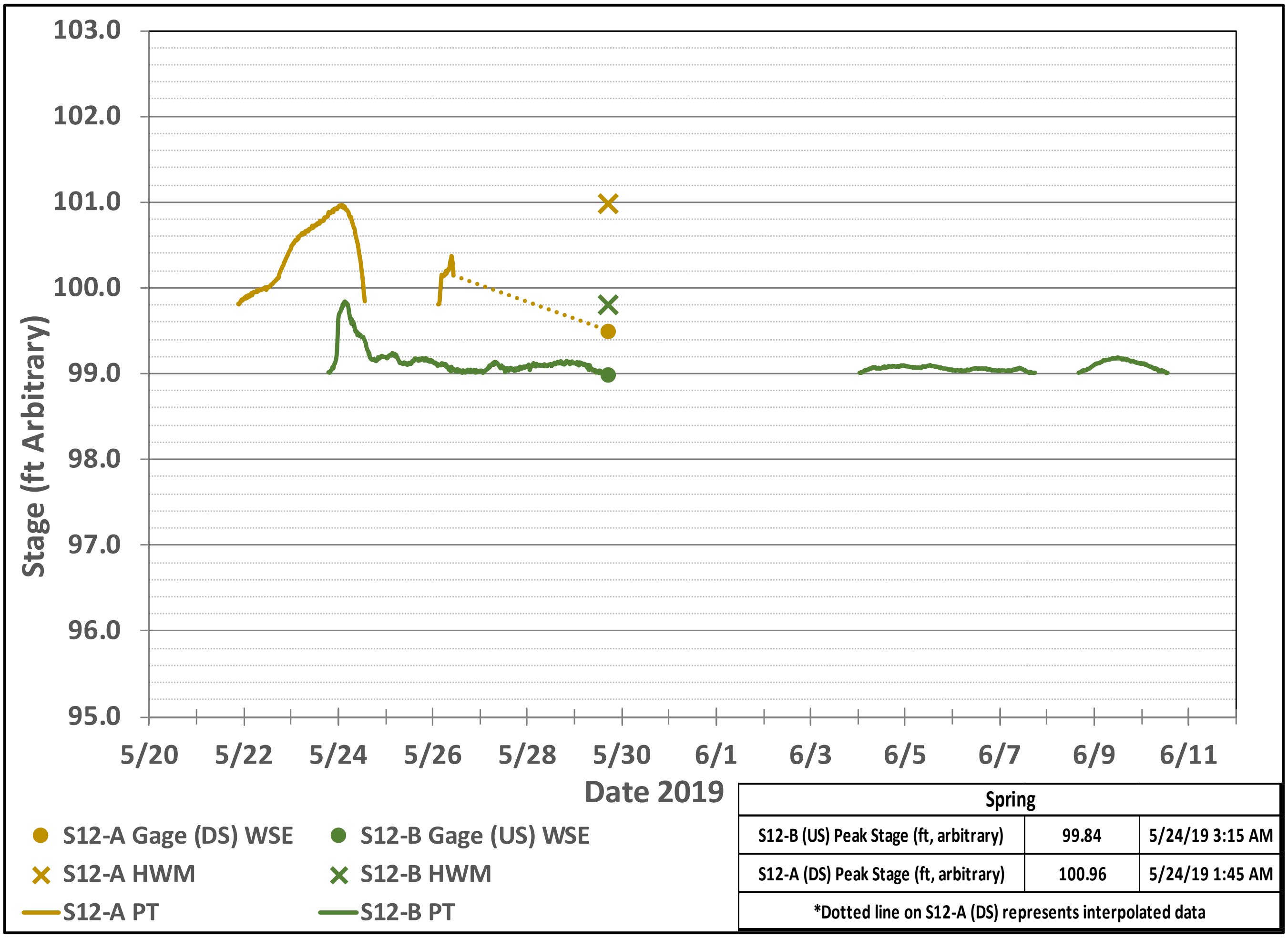
3.3.4 S12 Culverts (GMT2-20 through GMT2-39)

The S12 monitoring location is situated in a small swale depression between Lake Z06005 and MB0401. Culverts GMT2-29 through GMT2-32 are near the S12 gage station while the other culverts are situated outside of the small swale. An ice road adjacent to the south embankment of the GMT2/MT7 road affected drainage in the area.

Local meltwater was first observed at S12 on May 27. In general, the ice road was impeding meltwater from reaching the south (inlet) end of the culverts, however, photographic documentation suggests some meltwater draining from Lake Z06005 had cut a path through the ice road and was flowing through culvert GMT2-31 (Photo F.18). Aerial observations also indicate natural drainage patterns were maintained through an ice road intersection constructed around culvert GMT2-28 (Photo F.19). By May 28, flow paths through the ice road were observed at most culverts. An overflight performed on June 3 confirmed hydraulically equalized conditions across the area, however, at S12, meltwater from a small lake on the south (upstream) side of the alignment was reaching and sloughing the embankment around GMT2-31 (Photo F.20). Aerial observations from July 2 show equalized hydraulic conditions in the area (Photo F.21).

PT data indicates peak stage occurred at S12-B and S12-A on May 24. The ice road, being near the GMT2/MT7 road, caused drifting snow to accumulate between the two roads which affected drainage. With the exception of temporary blockage from drifted snow accumulation, all culverts were observed to be functioning as designed and natural drainage patterns in the area were maintained.

S12 spring breakup stage data is provided in Graph 3.5. Detailed measured discharge data is presented in section 3.4. Photos are provided in Appendix F.4.



Spring		
S12-B (US) Peak Stage (ft, arbitrary)	99.84	5/24/19 3:15 AM
S12-A (DS) Peak Stage (ft, arbitrary)	100.96	5/24/19 1:45 AM
*Dotted line on S12-A (DS) represents interpolated data		

Graph 3.5: S12 Water Surface Elevations

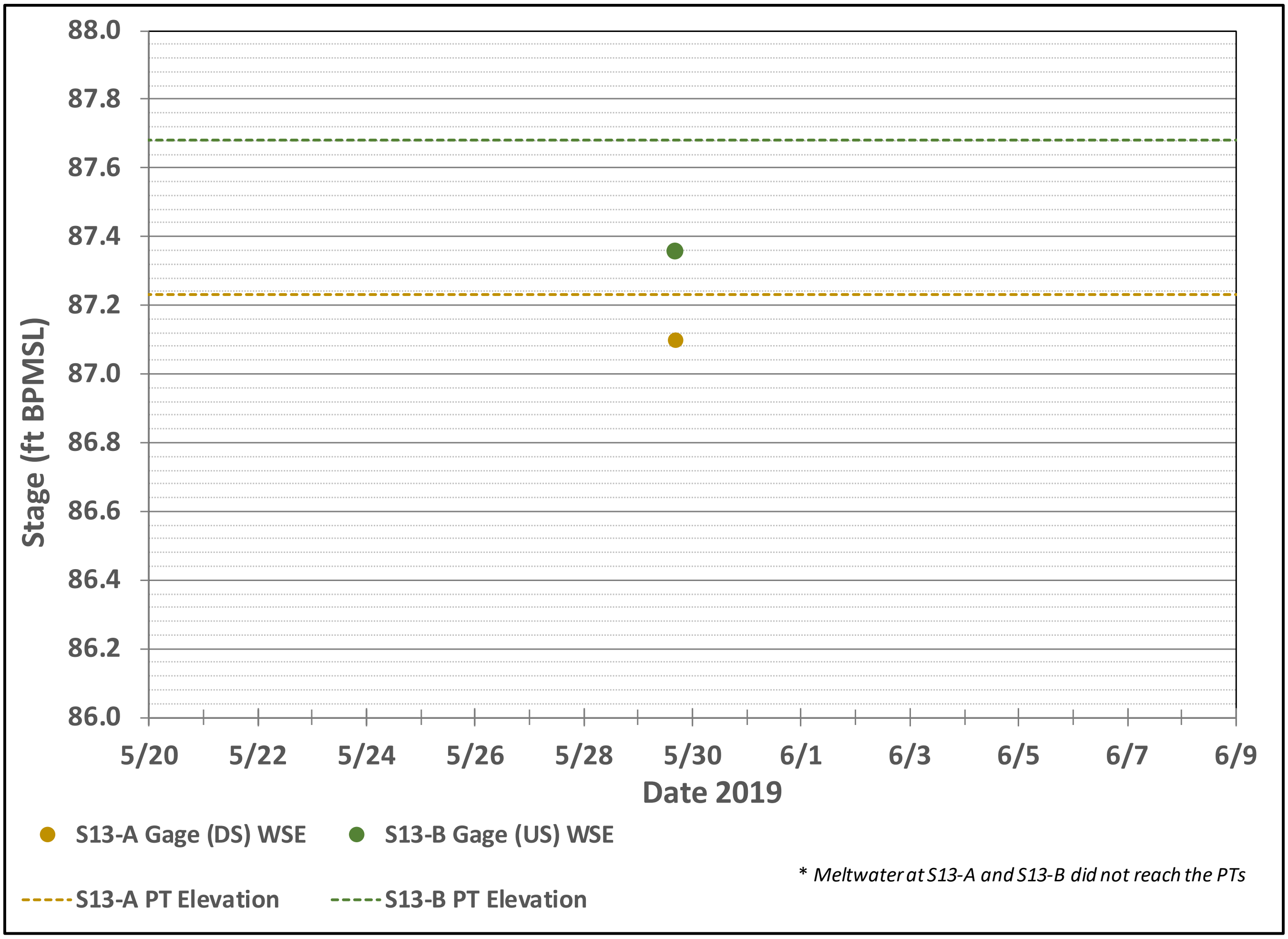
3.3.5 S13 Culverts (GMT2-01 through GMT2-19)

The S13 monitoring location is situated in small, poorly defined network of polygon troughs near the GMT2/MT7 pad location. Culverts GMT2-01 through GMT2-04 are located in this series of polygons while culverts GMT2-05 through GMT2-20 are located on higher ground to the west. An ice road adjacent to the south embankment of the GMT2/MT7 road affected hydraulic performance in the area. In July 2019, a 4-foot extension was added to culvert GMT2-001 because the road was wider than originally designed at this location (Photo F.22).

Local melt was first observed around S13 on May 27. On this day, ponded meltwater was observed on both sides of the GMT2/MT7 road, with more water ponding on the north (downstream) side in a low-lying area. Meltwater was encroaching but had not reached the toe of the embankment on the north side (Photo F.23). On May 29, areas of ponded water reached the embankment on the south side of the alignment, particularly around the road and pad intersection between GMT2-01 and GMT2-02, and near culvert GMT2-04 and GMT2-08 (Photo F.24). Flow was observed and measured through culvert GMT2-12. By June 2, the area was mostly hydraulically equalized, and stage had receded considerably (Photo F.25). Snow cover on the surrounding tundra was less than 5%. Discharge was measured again through GMT2-12 on June 4, although stage had receded relative to the May 29 measurement.

Meltwater at the S13-B gage stations did not reach the PTs. Visual observations and aerial photography suggest peak stage occurred around May 30. With the exception of temporary blockage from drifted snow accumulation, all culverts were observed to be functioning as designed and natural drainage patterns in the area were maintained.

S13 spring breakup stage data is provided in Graph 3.6. Detailed measured discharge data is presented in section 3.4. Photos are provided in Appendix F.5.



Graph 3.6: S13 Water Surface Elevations

3.4 Discharge Measurements

Discharge was measured on May 28, May 29, and June 4 at culverts observed conveying flow. A summary of the discharge measurements is presented in Table 2.

Table 2: GMT2/MT7 Access Road Culvert Discharge

Culvert	Measurement Date & Time	Culvert Inside Diameter (ft)	Flow Area (ft^2)	Measured Depth of Flow (ft)	Measured Velocity (fps)	Discharge (cfs)
GMT2-64	5/28/2019 14:00	2.00	1.17	0.32	8.40	9.86
GMT2-65	5/28/2019 13:24	2.00	0.16	0.08	4.44	0.73
GMT2-67	5/28/2019 13:14	2.00	0.16	0.08	2.03	0.33
GMT2-71	5/28/2019 12:41	2.00	0.16	0.08	4.25	0.69
GMT2-74	5/28/2019 12:28	2.00	0.45	0.16	0.81	0.36
GMT2-77	5/28/2019 12:12	2.00	1.17	0.32	0.37	0.43
GMT2-79	5/28/2019 11:59	2.00	0.45	0.16	0.12	0.06
GMT2-12	5/29/2019 16:19	2.00	0.98	0.28	1.82	1.78
GMT2-21	5/29/2019 16:30	2.00	1.17	0.32	1.85	2.17
GMT2-26	5/29/2019 16:38	2.00	0.61	0.20	3.13	1.92
GMT2-31	5/29/2019 16:52	2.00	1.77	0.44	0.76	1.34
GMT2-34	5/29/2019 15:55	2.00	0.61	0.20	2.67	1.64
GMT2-51	5/29/2019 15:37	3.00	1.78	0.36	1.00	1.79
GMT2-52	5/29/2019 15:32	3.00	2.94	0.52	1.06	3.10
GMT2-53	5/29/2019 15:25	2.00	2.16	0.52	2.55	5.51
GMT2-61	5/29/2019 14:54	2.00	0.61	0.20	4.44	2.73
GMT2-12	6/4/2019 15:08	2.00	0.53	0.18	0.38	0.20
GMT2-26	6/4/2019 15:32	2.00	0.23	0.10	1.35	0.31
GMT2-30	6/4/2019 15:43	2.00	1.27	0.34	0.26	0.33
GMT2-41	6/4/2019 16:05	2.00	1.08	0.30	8.05	8.66
GMT2-53	6/4/2019 16:30	2.00	1.57	0.40	0.83	1.31
GMT2-56	6/4/2019 16:41	2.00	0.98	0.28	5.14	5.04
GMT2-64	6/4/2019 16:59	2.00	0.45	0.16	2.95	1.32
GMT2-70	6/4/2019 14:25	2.00	0.11	0.06	0.86	0.09
GMT2-71	6/4/2019 14:19	2.00	0.11	0.06	2.27	0.24
GMT2-72	6/4/2019 13:48	2.00	0.16	0.08	3.12	0.51
GMT2-73	6/4/2019 13:52	2.00	0.98	0.28	6.01	5.89
GMT2-74	6/4/2019 13:57	2.00	0.79	0.24	4.04	3.20
GMT2-75	6/4/2019 14:02	2.00	0.16	0.08	4.69	0.77

3.5 Culvert Performance Evaluation

No performance issues were identified at any culverts along the GMT2/MT7 access road. Temporary ponded water was present in drainages at several locations along the access road but was attributed to the ice road, snow or culvert caps frozen in place impeding flow and not culvert placement (Photo 3.1 and Photo 3.2).

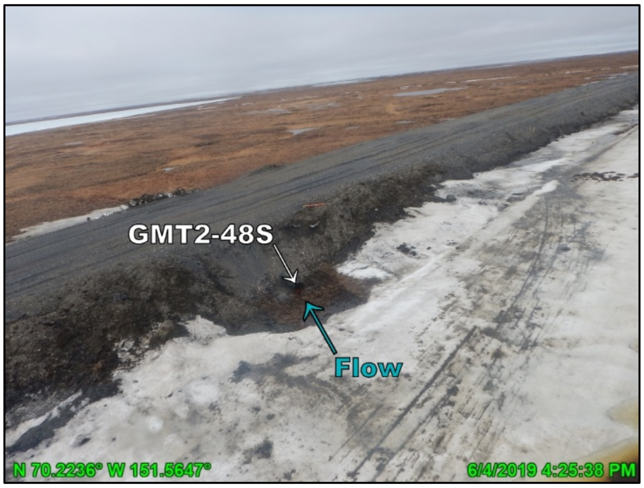


Photo 3.1: Culvert GMT2-48 and adjacent ice road, looking north; June 4, 2019

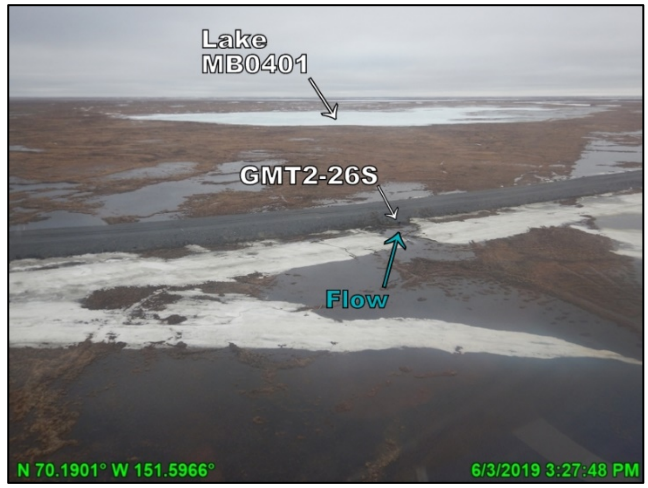


Photo 3.2: Local ponding at culvert GMT2-26 looking north; June 3, 2019

Some culvert caps left in place were blocking flow (Photo 3.3). In addition, drifted snow and the adjacent ice road also impeded drainage in some locations (Photo 3.4 and Photo 3.5). Once conveyance paths were established by either removing culvert caps or meltwater naturally cutting through snow/ice, the culverts all performed as designed and natural drainage patterns were maintained (Photo 3.6 and Photo 3.7). With exception of the minimal sloughing observed at culvert GMT2-31, no displacement of uncompacted gravel fill attributed with spring breakup flooding was observed along the road embankment or around culvert inlets and outlets. There were no signs of undermining at drainage structures. Several culverts were perched on either the north or south sides of the road which may lead to the development of scour holes (Photo 3.8). Besides these perched culverts, no culvert maintenance, repair, upgrade, setting adjustments, and/or replacements are recommended at this time.

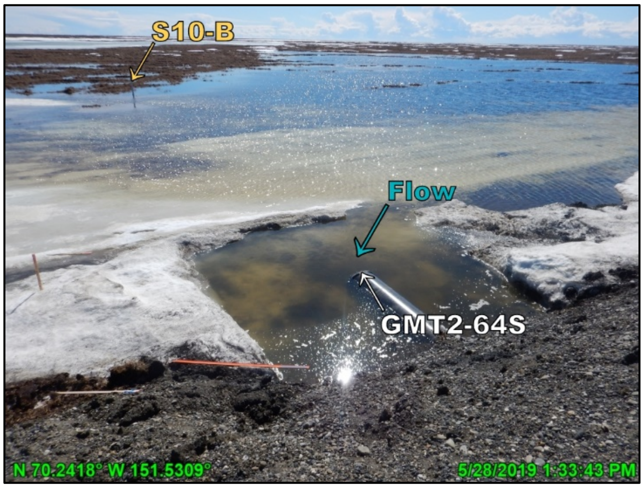


Photo 3.3: Culvert GMT2-64S blocked by a culvert cap, looking south; May 28, 2019

Photo 3.4: Culvert GMT2-60 and adjacent ice road, looking south; May 29, 2019

Photo 3.5: Ponded water on the north side of GMT2/MT7 access road near culvert GMT2-28, looking west; June 3, 2019

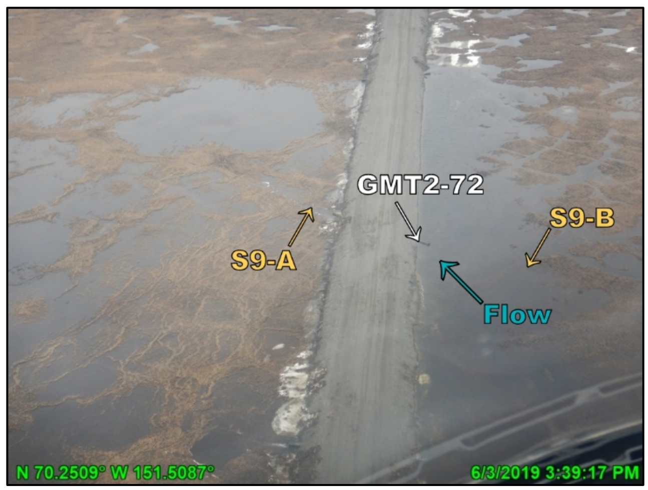


Photo 3.6: Meltwater on both sides of the GMT2/MT7 access road near S9 monitoring location, looking northeast; June 3, 2019

Photo 3.7: Meltwater on both sides of the GMT2/MT7 access road near culvert GMT2-22, looking north; June 3, 2019

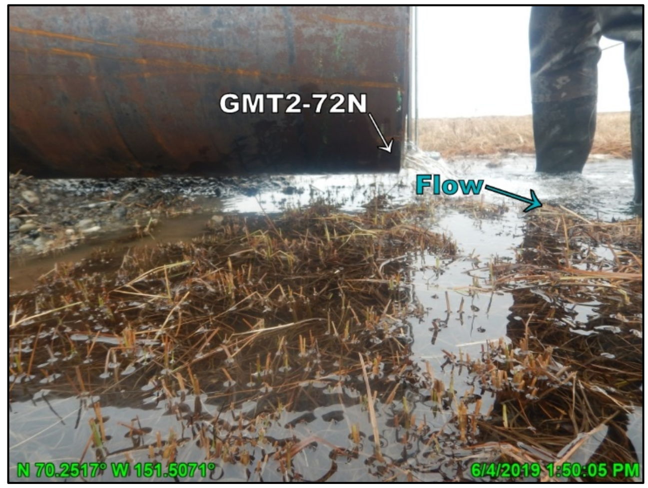


Photo 3.8: Culvert GMT2-72 perched on the north (DS) side of the GMT2/MT7 access road, looking southwest; June 4, 2019

4 REFERENCES

Bodhaine G. L. 1968. Measurement of Peak Discharge at Culverts by Indirect Methods. Techniques of Water Resources Investigation of the United States Geological Survey, U.S. Geological Survey, Washington.

Chow, V.T. 1959. Open-Channel Hydraulics, New York, McGraw-Hill, p. 138.

ICE Consult and Design (ICE). 2019 NPR-A North Tundra Monitoring Station. Cumulative Freezing Degree-Days. Winters 2002-2019 Coldest to Warmest Year. June 8, 2019.

UMIAQ, LLC (UMIAQ). 2017. GMT2/MT7 Design Culvert Data. March 2017. Prepared for ConocoPhillips Alaska, Inc.

UMIAQ, LLC (UMIAQ). 2018. Alpine GMT2 Roads and Pads Civil IFC. August 2018. Prepared for ConocoPhillips Alaska, Inc.

Wunderground. 2019. Temperature data at Alpine Airstrip, AK, April 1 through June 25, 2019. Accessed online at https://www.wunderground.com on June 5, 2019.

Appendix A Culvert Locations & Properties

Culvert	Station	Latitude (NAD83)	Longitude (NAD83)	Outside Diameter (in)	Outside Diameter (ft)	Wall Thickness1 (ft)	Inside Diameter1 (ft)
GMT2-01N	03+06	70.1750°	-151.6902°	24	2	0.052	1.90
GMT2-01S		70.1750°	-151.6909°				
GMT2-02N	06+91	70.1759°	-151.6893°	24	2	0.052	1.90
GMT2-02S		70.1757°	-151.6889°				
GMT2-03N	11+97	70.1765°	-151.6855°	24	2	0.052	1.90
GMT2-03S		70.1763°	-151.6854°				
GMT2-04N	15+58	70.1768°	-151.6827°	24	2	0.052	1.90
GMT2-04S		70.1766°	-151.6827°				
GMT2-05N	22+49	70.1773°	-151.6776°	24	2	0.052	1.90
GMT2-05S		70.1772°	-151.6771°				
GMT2-06N	26+34	70.1776°	-151.6744°	24	2	0.052	1.90
GMT2-06S		70.1774°	-151.6743°				
GMT2-07N	31+64	70.1780°	-151.6704°	24	2	0.052	1.90
GMT2-07S		70.1778°	-151.6702°				
GMT2-08N	40+82	70.1787°	-151.6632°	24	2	0.052	1.90
GMT2-08S		70.1785°	-151.6631°				
GMT2-09N	48+59	70.1793°	-151.6572°	24	2	0.052	1.90
GMT2-09S		70.1791°	-151.6570°				
GMT2-10N	66+45	70.1806°	-151.6433°	24	2	0.052	1.90
GMT2-10S		70.1804°	-151.6432°				
GMT2-11N	69+00	70.1808°	-151.6414°	24	2	0.052	1.90
GMT2-11S		70.1806°	-151.6412°				
GMT2-12N	72+69	70.1811°	-151.6384°	24	2	0.052	1.90
GMT2-12S		70.1809°	-151.6385°				
GMT2-13N	76+50	70.1813°	-151.6355°	24	2	0.052	1.90
GMT2-13S		70.1812°	-151.6354°				
GMT2-14N	78+37	70.1815°	-151.6339°	24	2	0.052	1.90
GMT2-14S		70.1813°	-151.6342°				
GMT2-15N	84+25	70.1819°	-151.6295°	24	2	0.052	1.90
GMT2-15S		70.1817°	-151.6294°				
GMT2-16N	89+18	70.1823°	-151.6257°	24	2	0.052	1.90
GMT2-16S		70.1821°	-151.6256°				
GMT2-17N	96+57	70.1830°	-151.6201°	24	2	0.052	1.90
GMT2-17S		70.1828°	-151.6202°				
GMT2-18N	101+98	70.1839°	-151.6169°	24	2	0.052	1.90
GMT2-18S		70.1837°	-151.6164°				
GMT2-19N	109+35	70.1853°	-151.6124°	24	2	0.052	1.90
GMT2-19S		70.1851°	-151.6122°				
GMT2-20N	112+35	70.1858°	-151.6107°	24	2	0.052	1.90
GMT2-20S		70.1857°	-151.6103°				
GMT2-21N	115+83	70.1864°	-151.6086°	24	2	0.052	1.90
GMT2-21S		70.1863°	-151.6083°				
GMT2-22N	122+38	70.1877°	-151.6048°	24	2	0.052	1.90
GMT2-22S		70.1875°	-151.6044°				
GMT2-23N	127+12	70.1886°	-151.6022°	24	2	0.052	1.90
GMT2-23S		70.1885°	-151.6018°				
GMT2-24N	131+04	70.1895°	-151.6006°	36	3	0.083	2.83
GMT2-24S		70.1894°	-151.6000°				
GMT2-25N	131+10	70.1895°	-151.6006°	36	3	0.083	2.83
GMT2-25S		70.1894°	-151.6000°				
GMT2-26N	135+74	70.1907°	-151.5991°	24	2	0.052	1.90

Culvert	Station	Latitude (NAD83)	Longitude (NAD83)	Outside Diameter (in)	Outside Diameter (ft)	Wall Thickness1 (ft)	Inside Diameter1 (ft)
GMT2-26S		70.1906°	-151.5987°				
GMT2-27N	139+70	70.1917°	-151.5984°	24	2	0.052	1.90
GMT2-27S		70.1917°	-151.5978°				
GMT2-28N	143+52	70.1927°	-151.5976°	24	2	0.052	1.90
GMT2-28S		70.1927°	-151.5970°				
GMT2-29N	152+40	70.1951°	-151.5957°	24	2	0.052	1.90
GMT2-29S		70.1950°	-151.5952°				
GMT2-30N	159+87	70.1971°	-151.5942°	24	2	0.052	1.90
GMT2-30S		70.1970°	-151.5937°				
GMT2-31N	161+36	70.1974°	-151.5939°	24	2	0.052	1.90
GMT2-31S		70.1974°	-151.5933°				
GMT2-32N	167+24	70.1990°	-151.5927°	24	2	0.052	1.90
GMT2-32S		70.1990°	-151.5922°				
GMT2-33N	178+69	70.2021°	-151.5903°	24	2	0.052	1.90
GMT2-33S		70.2020°	-151.5898°				
GMT2-34N	186+75	70.2042°	-151.5887°	24	2	0.052	1.90
GMT2-34S		70.2041°	-151.5882°				
GMT2-35N	187+88	70.2045°	-151.5884°	24	2	0.052	1.90
GMT2-35S		70.2044°	-151.5879°				
GMT2-36N	190+10	70.2052°	-151.5879°	24	2	0.052	1.90
GMT2-36S		70.2049°	-151.5876°				
GMT2-37N	196+24	70.2066°	-151.5868°	24	2	0.052	1.90
GMT2-37S		70.2067°	-151.5861°				
GMT2-38N	198+17	70.2072°	-151.5864°	24	2	0.052	1.90
GMT2-38S		70.2072°	-151.5858°				
GMT2-39N	207+45	70.2096°	-151.5843°	24	2	0.052	1.90
GMT2-39S		70.2096°	-151.5838°				
GMT2-40N	212+53	70.2109°	-151.5827°	24	2	0.052	1.90
GMT2-40S		70.2108°	-151.5822°				
GMT2-41N	220+80	70.2130°	-151.5799°	24	2	0.052	1.90
GMT2-41S		70.2128°	-151.5795°				
GMT2-42N	228+59	70.2149°	-151.5774°	24	2	0.052	1.90
GMT2-42S		70.2148°	-151.5769°				
GMT2-43N	235+52	70.2167°	-151.5750°	24	2	0.052	1.90
GMT2-43S		70.2166°	-151.5746°				
GMT2-44N	241+96	70.2182°	-151.5730°	24	2	0.052	1.90
GMT2-44S		70.2182°	-151.5724°				
GMT2-45N	250+51	70.2204°	-151.5700°	24	2	0.052	1.90
GMT2-45S		70.2203°	-151.5697°				
GMT2-46N	252+97	70.2210°	-151.5693°	24	2	0.052	1.90
GMT2-46S		70.2209°	-151.5688°				
GMT2-47N	257+56	70.2222°	-151.5677°	24	2	0.052	1.90
GMT2-47S		70.2220°	-151.5674°				
GMT2-48N	264+81	70.2240°	-151.5654°	24	2	0.052	1.90
GMT2-48S		70.2238°	-151.5649°				
GMT2-49N	271+24	70.2256°	-151.5632°	24	2	0.052	1.90
GMT2-49S		70.2254°	-151.5628°				
GMT2-50N	274+61	70.2264°	-151.5621°	36	3	0.083	2.83
GMT2-50S		70.2263°	-151.5616°				
GMT2-51N	280+35	70.2278°	-151.5602°	36	3	0.083	2.83
GMT2-51S		70.2277°	-151.5598°				
GMT2-52N	282+85	70.2284°	-151.5594°	36	3	0.083	2.83
GMT2-52S		70.2284°	-151.5589°				

Culvert	Station	Latitude (NAD83)	Longitude (NAD83)	Outside Diameter (in)	Outside Diameter (ft)	Wall Thickness1 (ft)	Inside Diameter1 (ft)
GMT2-53N	288+14	70.2299°	-151.5575°	24	2	0.052	1.90
GMT2-53S		70.2296°	-151.5574°				
GMT2-54N	294+05	70.2313°	-151.5557°	24	2	0.052	1.90
GMT2-54S		70.2311°	-151.5553°				
GMT2-55N	296+83	70.2319°	-151.5548°	24	2	0.052	1.90
GMT2-55S		70.2318°	-151.5543°				
GMT2-56N	300+38	70.2328°	-151.5536°	24	2	0.052	1.90
GMT2-56S		70.2327°	-151.5531°				
GMT2-57N	305+96	70.2342°	-151.5519°	24	2	0.052	1.90
GMT2-57S		70.2342°	-151.5512°				
GMT2-58N	314+66	70.2364°	-151.5488°	24	2	0.052	1.90
GMT2-58S		70.2363°	-151.5484°				
GMT2-59N	320+54	70.2378°	-151.5467°	24	2	0.052	1.90
GMT2-59S		70.2377°	-151.5463°				
GMT2-60N	325+88	70.2389°	-151.5437°	24	2	0.052	1.90
GMT2-60S		70.2387°	-151.5433°				
GMT2-61N	328+82	70.2393°	-151.5416°	24	2	0.052	1.90
GMT2-61S		70.2391°	-151.5414°				
GMT2-62N	334+52	70.2402°	-151.5378°	24	2	0.052	1.90
GMT2-62S		70.2400°	-151.5375°				
GMT2-63N	341+20	70.2412°	-151.5334°	24	2	0.052	1.90
GMT2-63S		70.2410°	-151.5329°				
GMT2-64N	344+85	70.2418°	-151.5311°	24	2	0.052	1.90
GMT2-64S		70.2417°	-151.5307°				
GMT2-65N	349+75	70.2428°	-151.5285°	24	2	0.052	1.90
GMT2-65S		70.2427°	-151.5281°				
GMT2-66N	357+06	70.2444°	-151.5249°	24	2	0.052	1.90
GMT2-66S		70.2443°	-151.5244°				
GMT2-67N	362+88	70.2456°	-151.5219°	24	2	0.052	1.90
GMT2-67S		70.2455°	-151.5215°				
GMT2-68N	377+03	70.2486°	-151.5148°	24	2	0.052	1.90
GMT2-68S		70.2485°	-151.5144°				
GMT2-69N	381+62	70.2496°	-151.5125°	24	2	0.052	1.90
GMT2-69S		70.2495°	-151.5121°				
GMT2-70N	386+01	70.2506°	-151.5103°	24	2	0.052	1.90
GMT2-70S		70.2504°	-151.5099°				
GMT2-71N	389+31	70.2513°	-151.5084°	24	2	0.052	1.90
GMT2-71S		70.2511°	-151.5082°				
GMT2-72N	391+87	70.2517°	-151.5069°	24	2	0.052	1.90
GMT2-72S		70.2516°	-151.5066°				
GMT2-73N	393+93	70.2521°	-151.5056°	24	2	0.052	1.90
GMT2-73S		70.2519°	-151.5053°				
GMT2-74N	396+47	70.2526°	-151.5040°	24	2	0.052	1.90
GMT2-74S		70.2523°	-151.5039°				
GMT2-75N	399+96	70.2531°	-151.5021°	24	2	0.052	1.90
GMT2-75S		70.2530°	-151.5016°				
GMT2-76N	404+42	70.2540°	-151.4993°	24	2	0.052	1.90
GMT2-76S		70.2538°	-151.4990°				
GMT2-77N	411+47	70.2552°	-151.4951°	24	2	0.052	1.90
GMT2-77S		70.2551°	-151.4947°				
GMT2-78N	418+30	70.2565°	-151.4906°	36	3	0.083	2.83
GMT2-78S		70.2562°	-151.4907°				
GMT2-79N	424+62	70.2573°	-151.4864°	24	2	0.052	1.90

<table>
<tr><th>Culvert</th><th>Station</th><th>Latitude (NAD83)</th><th>Longitude (NAD83)</th><th>Outside Diameter (in)</th><th>Outside Diameter (ft)</th><th>Wall Thickness1 (ft)</th><th>Inside Diameter1 (ft)</th></tr>
<tr><td>GMT2-79S</td><td></td><td>70.2571°</td><td>-151.4860°</td><td></td><td></td><td></td><td></td></tr>
<tr><td>GMT2-80N</td><td rowspan="2">429+09</td><td>70.2578°</td><td>-151.4830°</td><td rowspan="2">24</td><td rowspan="2">2</td><td rowspan="2">0.052</td><td rowspan="2">1.90</td></tr>
<tr><td>GMT2-80S</td><td>70.2576°</td><td>-151.4828°</td></tr>
</table>

Appendix B Gage & Associated Vertical Control Locations

Monitoring Location	Gage ID	Gage Position Relative to Road	Gage Location		Associated Vertical Control	Vertical Control Location	
			Latitude (NAD83)	Longitude (NAD83)		Latitude (NAD83)	Longitude (NAD83)
S9	S9-A	downstream	70.2518°	-151.5070°	GMT2/MT7-72N	70.2517°	-151.5069°
	S9-B	upstream	70.2514°	-151.5062°		70.2516°	-151.5066°
S10	S10-A	downstream	70.2419°	-151.5313°	GMT2/MT7-64N	70.2418°	-151.5310°
	S10-B	upstream	70.2415°	-151.5301°		70.2416°	-151.5306°
S11	S11-A	downstream	70.2328°	-151.5538°	GMT2/MT7-56N	70.2328°	-151.5536°
	S11-B	upstream	70.2326°	-151.5524°		70.2326°	-151.5530°
S12	S12-A	downstream	70.1974°	-151.5940°	GMT2/MT7-31N	70.1974°	-151.5938°
	S12-B	upstream	70.1974°	-151.5928°		70.1974°	-151.5933°
S13	S13-A	downstream	70.1759°	-151.6893°	PBM-16	70.1751°	-151.6883°
	S13-B	upstream	70.1756°	-151.6886°			

Appendix C PT Setup, Testing & Processing Methods

PTs measure the absolute pressure of the atmosphere and water, allowing the depth of water above the sensor to be calculated. Resulting data yield a comprehensive record of the fluctuations in water levels. The reported pressure is the sum of the forces imparted by the water column and atmospheric conditions. Variations in local barometric pressure are taken into account, using two independent barometric pressure loggers: In-Situ BaroTROLL® and Solinst Barologger®. A correction of barometric pressure was obtained from the Barologger installed at the Colville River East Channel horizontal directionally drilled pipeline crossing. The PT sensors were surveyed during spring breakup setup to establish a vertical datum using local control.

All PTs were tested before field mobilization and configured using Win-Situ® LT 5.6.21.0 (for the Level TROLL 500s) or Solinst Levelogger® v4.0.3 (for the Solinst Leveloggers) software prior to placement in the field. Absolute pressure was set to zero.

PT-based water level values were determined by adding the calculated water depth and the surveyed sensor elevation. PTs have the potential to drift and can be affected by ice and sediment. Gage WSE readings were used to validate and adjust the data collected by the PTs. A standard conversion using the density of water at 0°C was used to calculate all water depths from adjusted gage pressures. Fluctuations in water temperature during the sampling period did not affect WSE calculations because of the limited range in temperature and observed water depths.

Appendix D Discharge Methods

Standard USGS velocity/area techniques (Bodhaine 1968) were used to measure depth of flow and velocity to determine discharge at each culvert experiencing flow. Depth of flow and velocity were measured on the downstream end of the culvert using a HACH FH950 electromagnetic velocity meter attached to a wading rod. The accuracy of the HACH meter is ± 2% of the reading, ± 0.05 ft/s between 0 ft/s and 10 ft/s, and ± 4% of the reading from between 10 ft/s and 16 ft/s.

Appendix E GMT2 Road Culvert Visual Observation Summary

Observation Date	Time	Culvert ID	Flow Conditions	Flow Direction	Notes
5/28/2019	12:00	GMT2-80	Flowing	-	Minimal flow
5/28/2019	12:00	GMT2-79	Flowing	South to North	-
5/28/2019	12:00	GMT2-78	Stagnant	-	Possible ice road impact
5/28/2019	12:15	GMT2-77	Flowing	South to North	-
5/28/2019	12:15	GMT2-76	Stagnant	-	Possible blockage. ½ submerged inlet, dry outlet
5/28/2019	12:30	GMT2-75	Flowing	South to North	Minimal flow
5/28/2019	12:30	GMT2-74	Flowing	South to North	-
5/28/2019	12:30	GMT2-73	Stagnant	-	Equalized
5/28/2019	12:30	GMT2-72	Flowing	South to North	Minimal flow
5/28/2019	12:45	GMT2-71	Flowing	South to North	-
5/28/2019	13:00	GMT2-70	Flowing	-	Minimal flow
5/28/2019	13:00	GMT2-69	Stagnant	-	Possible ice road impact
5/28/2019	13:00	GMT2-68	Flowing	South to North	Minimal flow
5/28/2019	13:15	GMT2-67	Flowing	South to North	-
5/28/2019	13:30	GMT2-65	Flowing	South to North	-
5/28/2019	13:30	GMT2-64	Flowing	South to North	Blocked. Cap present
5/28/2019	14:00	GMT2-64	Flowing	South to North	After removing cap
5/29/2019	15:00	GMT2-61	Flowing	South to North	-
5/29/2019	15:00	GMT2-60	Stagnant	-	Possible ice road impact
5/29/2019	15:00	GMT2-59	Dry	-	Minimal meltwater
5/29/2019	15:00	GMT2-58	Stagnant	-	Possible ice road impact
5/29/2019	15:15	GMT2-57	Stagnant	-	Possible ice road impact
5/29/2019	15:15	GMT2-56	Dry	-	Meltwater present. Drainage impeded by ice road
5/29/2019	15:15	GMT2-55	Stagnant	-	Possible ice road impact/blockage. ½ submerged inlet, dry outlet
5/29/2019	15:15	GMT2-54	Stagnant	-	Possible ice road impact
5/29/2019	15:30	GMT2-53	Flowing	South to North	-
5/29/2019	15:30	GMT2-52	Flowing	South to North	-
5/29/2019	15:30	GMT2-51	Flowing	South to North	-
5/29/2019	15:45	GMT2-50	Stagnant	-	Possible ice road impact
5/29/2019	15:45	GMT2-49	Stagnant	-	Possible ice road impact
5/29/2019	15:45	GMT2-48	Dry	-	Meltwater present. Drainage impeded by ice road
5/29/2019	15:45	GMT2-47	Dry	-	Meltwater present. Drainage impeded by ice road
5/29/2019	15:45	GMT2-46	Dry	-	Meltwater present. Drainage impeded by ice road
5/29/2019	15:45	GMT2-45	Dry	-	Meltwater present. Drainage impeded by ice road
5/29/2019	15:45	GMT2-44	Dry	-	Meltwater present. Drainage impeded by ice road
5/29/2019	15:45	GMT2-43	Dry	-	Meltwater present. Drainage impeded by ice road
5/29/2019	15:45	GMT2-42	Dry	-	Minimal meltwater
5/29/2019	15:45	GMT2-41	Dry	-	Meltwater present. Drainage impeded by ice road
5/29/2019	15:45	GMT2-40	Dry	-	Blocked. Cap present
5/29/2019	15:45	GMT2-39	Stagnant	-	Possible ice road impact
5/29/2019	15:45	GMT2-38	Stagnant	-	Possible ice road impact
5/29/2019	15:45	GMT2-37	Stagnant	-	Possible ice road impact
5/29/2019	16:00	GMT2-36	Stagnant	-	Possible ice road impact
5/29/2019	16:00	GMT2-35	Stagnant	-	Possible ice road impact
5/29/2019	16:00	GMT2-34	Flowing	North to South	-
5/29/2019	16:00	GMT2-02	Stagnant	-	Equalized
5/29/2019	16:15	GMT2-01	Stagnant	-	Possible ice road impact
5/29/2019	16:15	GMT2-03	Stagnant	-	Equalized
5/29/2019	16:15	GMT2-04	Stagnant	-	Equalized
5/29/2019	16:15	GMT2-05	Stagnant	-	Equalized
5/29/2019	16:15	GMT2-06	Stagnant	-	Equalized

Observation Date	Time	Culvert ID	Flow Conditions	Flow Direction	Notes
5/29/2019	16:15	GMT2-07	Stagnant	-	Equalized
5/29/2019	16:15	GMT2-08	Dry	-	Minimal meltwater
5/29/2019	16:15	GMT2-09	Stagnant	-	Equalized
5/29/2019	16:15	GMT2-10	Stagnant	-	Possible ice road impact
5/29/2019	16:15	GMT2-11	Stagnant	-	Possible ice road impact
5/29/2019	16:15	GMT2-12	Flowing	North to South	-
5/29/2019	16:30	GMT2-13	Stagnant	-	Equalized
5/29/2019	16:30	GMT2-14	Dry	-	Minimal meltwater
5/29/2019	16:30	GMT2-15	Stagnant	-	Equalized
5/29/2019	16:30	GMT2-16	Stagnant	-	Equalized
5/29/2019	16:30	GMT2-17	Stagnant	-	Equalized
5/29/2019	16:30	GMT2-18	Stagnant	-	Equalized
5/29/2019	16:30	GMT2-19	Stagnant	-	Possible ice road impact
5/29/2019	16:30	GMT2-20	Stagnant	-	Possible ice road impact
5/29/2019	16:30	GMT2-21	Flowing	North to South	-
5/29/2019	16:30	GMT2-22	Stagnant	-	Possible ice road impact
5/29/2019	16:30	GMT2-23	Stagnant	-	Possible ice road impact
5/29/2019	16:30	GMT2-24	Stagnant	-	Possible ice road impact
5/29/2019	16:30	GMT2-25	Stagnant	-	Possible ice road impact
5/29/2019	16:45	GMT2-26	Flowing	North to South	-
5/29/2019	16:45	GMT2-27	Stagnant	-	Possible ice road impact
5/29/2019	16:45	GMT2-28	Stagnant	-	Possible ice road impact
5/29/2019	16:45	GMT2-29	Stagnant	-	Possible ice road impact/blockage. ½ submerged inlet, dry outlet
5/29/2019	16:45	GMT2-30	Stagnant	-	Possible ice road impact
5/29/2019	16:45	GMT2-31	Flowing	North to South	-
5/29/2019	17:00	GMT2-32	Stagnant	-	Possible ice road impact
5/29/2019	17:00	GMT2-33	Stagnant	-	Possible ice road impact
6/4/2019	13:45	GMT2-72	Flowing	South to North	-
6/4/2019	13:45	GMT2-73	Flowing	South to North	-
6/4/2019	14:00	GMT2-74	Flowing	South to North	-
6/4/2019	14:00	GMT2-75	Flowing	South to North	-
6/4/2019	14:15	GMT2-76	Dry	-	Minimal meltwater
6/4/2019	14:15	GMT2-71	Flowing	South to North	-
6/4/2019	14:30	GMT2-70	Flowing	South to North	Minimal flow
6/4/2019	14:45	GMT2-05	Dry	-	Perched. Minimal meltwater
6/4/2019	14:45	GMT2-06	Stagnant	-	Equalized. Cap present but not blocking flow path
6/4/2019	14:45	GMT2-07	Dry	-	Minimal meltwater. Cap present but not blocking flow path
6/4/2019	15:00	GMT2-10	Stagnant	-	Possible blockage. ½ submerged inlet, dry outlet
6/4/2019	15:00	GMT2-11	Stagnant	-	Possible blockage. ½ submerged inlet, dry outlet
6/4/2019	15:15	GMT2-12	Flowing	North to South	-
6/4/2019	15:30	GMT2-14	Dry	-	Perched. Minimal meltwater
6/4/2019	15:30	GMT2-15	Dry	-	Minimal meltwater
6/4/2019	15:30	GMT2-17	Stagnant	-	Equalized
6/4/2019	15:30	GMT2-18	Stagnant	-	Equalized
6/4/2019	15:30	GMT2-19	Stagnant	-	Equalized
6/4/2019	15:30	GMT2-20	Stagnant	-	Equalized
6/4/2019	15:30	GMT2-21	Stagnant	-	Equalized
6/4/2019	15:30	GMT2-22	Stagnant	-	Possible ice road impact
6/4/2019	15:30	GMT2-23	Stagnant	-	Equalized
6/4/2019	15:30	GMT2-24	Stagnant	-	Possible ice road impact
6/4/2019	15:30	GMT2-25	Stagnant	-	Possible ice road impact
6/4/2049	15:30	GMT2-26	Flowing	North to South	-
6/4/2019	15:45	GMT2-27	Stagnant	-	Possible ice road impact
6/4/2019	15:45	GMT2-28	Stagnant	-	Possible ice road impact

Observation Date	Time	Culvert ID	Flow Conditions	Flow Direction	Notes
6/4/2019	15:45	GMT2-29	Stagnant	-	Possible ice road impact
6/4/2019	15:45	GMT2-30	Stagnant	-	Possible ice road impact
6/4/2019	15:45	GMT2-31	Flowing	North to South	-
6/4/2019	16:00	GMT2-32	Stagnant	-	Possible ice road impact/blockage. ½ submerged inlet, dry outlet
6/4/2019	16:00	GMT2-33	Stagnant	-	Possible ice road impact
6/4/2019	16:00	GMT2-34	Stagnant	-	Equalized
6/4/2019	16:00	GMT2-35	Stagnant	-	Equalized
6/4/2019	16:00	GMT2-36	Stagnant	-	Possible ice road impact/blockage. Submerged inlet, dry outlet
6/4/2019	16:00	GMT2-37	Stagnant	-	Possible ice road impact
6/4/2019	16:00	GMT2-38	Stagnant	-	Equalized
6/4/2019	16:00	GMT2-39	Stagnant	-	Possible ice road impact
6/4/2019	16:00	GMT2-40	Dry	-	Minimal meltwater
6/4/2019	16:00	GMT2-41	Flowing	South to North	-
6/4/2019	16:15	GMT2-42	Stagnant	-	Possible ice road impact
6/4/2019	16:15	GMT2-43	Stagnant	-	Equalized
6/4/2019	16:15	GMT2-44	Stagnant	-	Possible ice road impact. Minimal flow observed
6/4/2019	16:30	GMT2-45	Stagnant	-	Possible ice road impact
6/4/2019	16:30	GMT2-46	Stagnant	-	Equalized
6/4/2019	16:30	GMT2-47	Stagnant	-	Possible ice road impact
6/4/2019	16:30	GMT2-48	Dry	-	Meltwater present. Drainage impeded by ice road
6/4/2019	16:30	GMT2-49	Stagnant	-	Possible ice road impact
6/4/2019	16:30	GMT2-50	Stagnant	-	Possible ice road impact
6/4/2019	16:30	GMT2-51	Stagnant	-	Equalized
6/4/2019	16:30	GMT2-52	Stagnant	-	Equalized
6/4/2019	16:30	GMT2-53	Flowing	South to North	-
6/4/2019	16:45	GMT2-54	Stagnant	-	Possible ice road impact
6/4/2019	16:45	GMT2-55	Stagnant	-	Possible ice road impact
6/4/2019	16:45	GMT2-56	Flowing	-	-
6/4/2019	17:00	GMT2-57	Stagnant	-	Possible ice road impact
6/4/2019	17:00	GMT2-58	Stagnant	-	Possible ice road impact
6/4/2019	17:00	GMT2-59	Dry	-	Minimal meltwater
6/4/2019	17:00	GMT2-60	Dry	-	Minimal meltwater
6/4/2019	17:00	GMT2-61	Flowing	South to North	-
6/4/2019	17:00	GMT2-62	Dry	-	Minimal meltwater
6/4/2019	17:00	GMT2-63	Dry	-	Minimal meltwater
6/4/2019	17:00	GMT2-64	Flowing	South to North	-
6/4/2019	17:00	GMT2-65	Flowing	-	Minimal flow. Perched
6/4/2019	17:15	GMT2-66	Flowing	-	Minimal flow
6/4/2019	17:15	GMT2-67	Flowing	-	Minimal flow
6/4/2019	17:15	GMT2-68	Flowing	-	Minimal flow
6/4/2019	17:15	GMT2-69	Stagnant	-	Equalized

Appendix F Monitoring Location Photos

F.1 S9 Monitoring Location

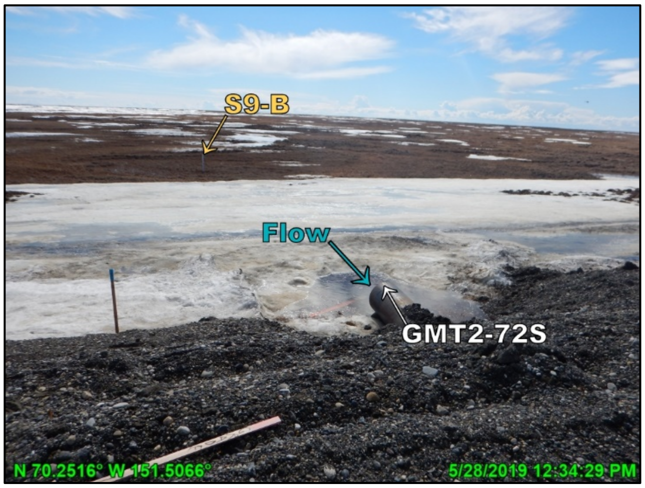


Photo F.1: Minimal meltwater at S9, looking south; May 28, 2019

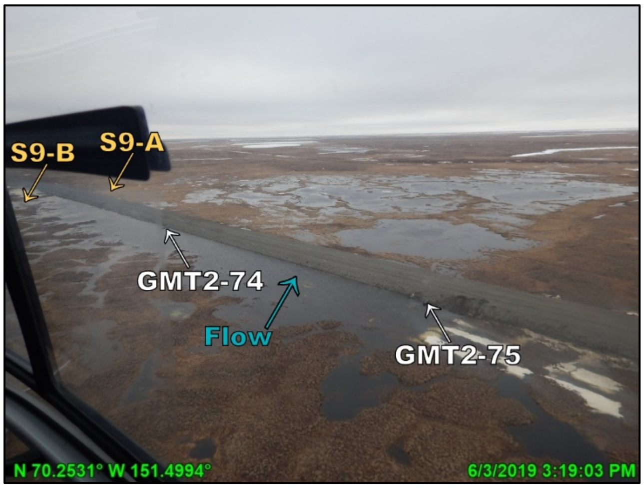


Photo F.2: Differential ponding near GMT2-75, looking west; June 3, 2019

Photo F.3: Summer conditions near S9, looking southwest; July 2, 2019

F.2 S10 Monitoring Location

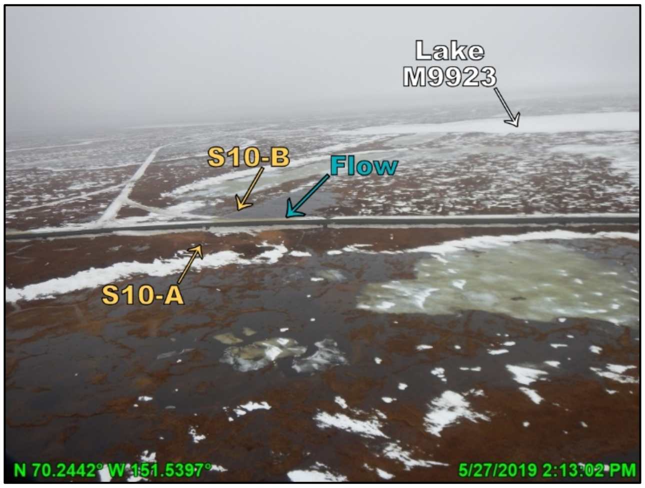


Photo F.4: Meltwater accumulation near S10, looking south; May 27, 2019

Photo F.5: Differential ponding near GMT2-61, looking northeast; May 29, 2019

Photo F.6: Areas of ponding near GMT1-61, looking northeast; June 3, 2019

Photo F.7: Summer conditions near S10, looking south, July 2, 2019

F.3 S11 Monitoring Location

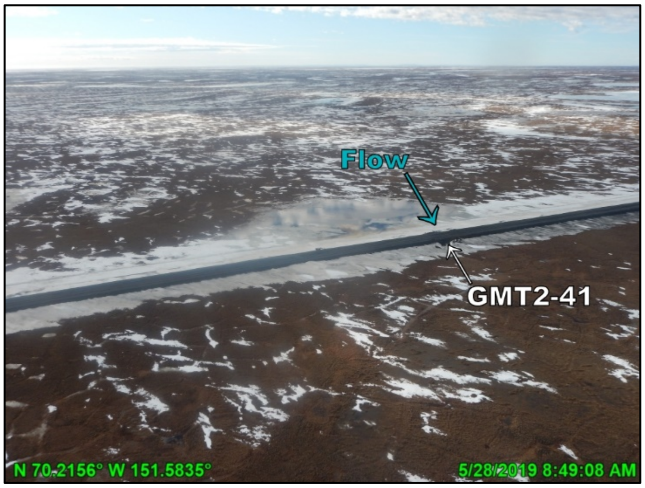


Photo F.8: Differential ponding near GMT2-41, looking south; May 28, 2019

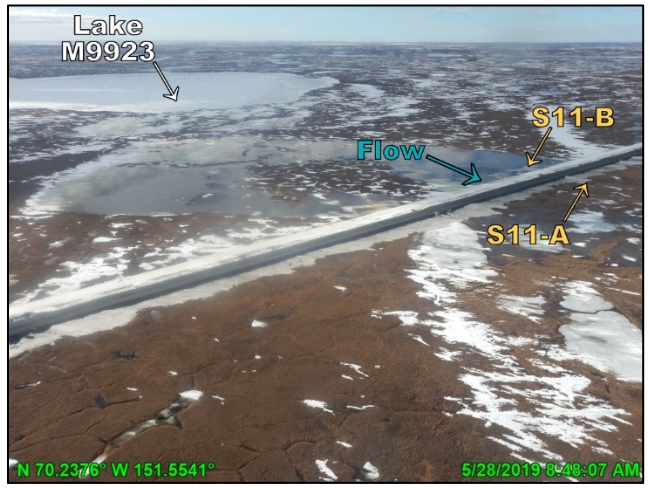


Photo F.9: Differential ponding near S11, looking south; May 28, 2019

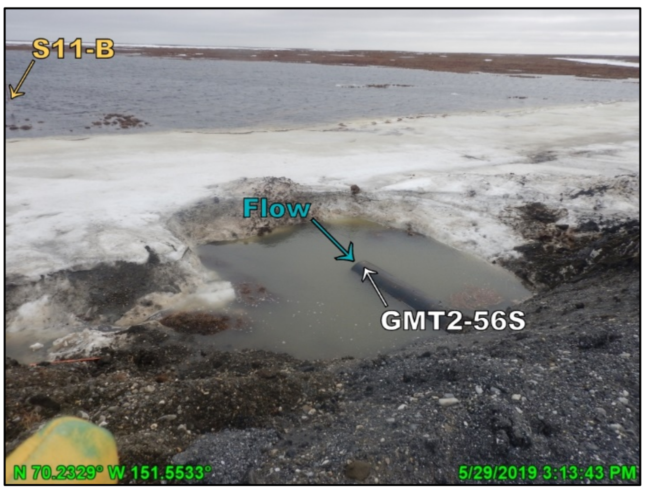


Photo F.10: Blocked culvert GMT2-56 inlet with meltwater ponding, looking south; May 29. 2019

Photo F.11: Dry conditions at GMT2-56 outlet, looking north; May 29, 2019

Photo F.12: Differential ponding near S11, looking north; June 3, 2019

Photo F.13: Differential ponding near culvert GMT2-41, looking west; June 3, 2019

Photo F.14: Restoration of natural drainage pattern near S11, looking south; June 4, 2019

Photo F.15: Continued differential ponding near GMT2-41, looking south; June 4, 2019

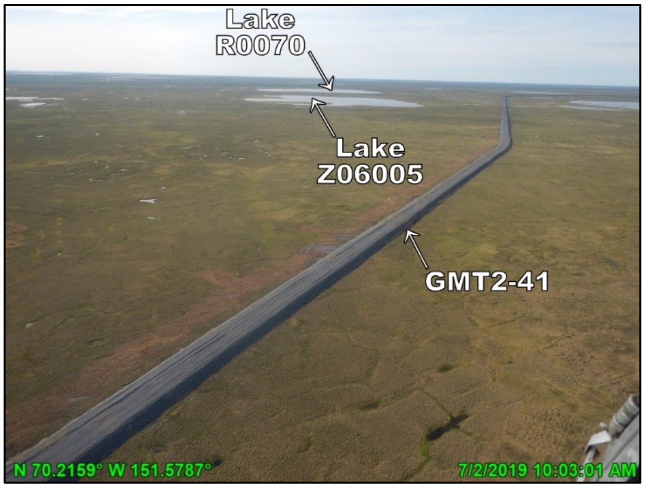


Photo F.16: Equalized summer conditions near GMT2-41, looking south; July 2, 2019

Photo F.17: Summer conditions near S11, looking south; July 2, 2019

F.4 S12 Monitoring Location

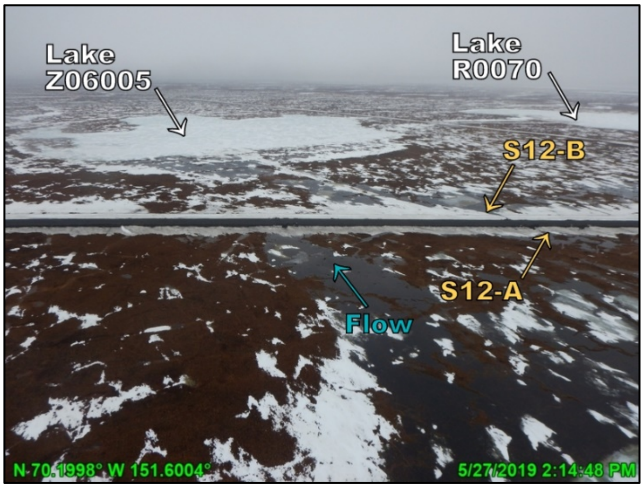


Photo F.18: Hydraulic conditions around S12, looking south; May 27, 2019

Photo F.19: Ice road intersection around S12, looking southeast; May 27, 2019

Photo F.20: Minor sloughing near culvert GMT2-31, looking west; May 29, 2019

Photo F.21: Summer conditions near S12; July 2, 2019

F.5 S13 Monitoring Location

Photo F.22: **Extension on culvert GMT2-01, looking west; July 2019**

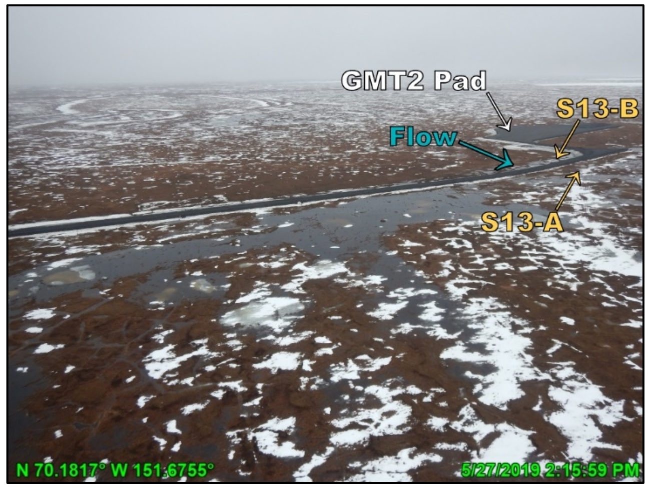


Photo F.23: **Meltwater around S13, looking south; May 27, 2019**

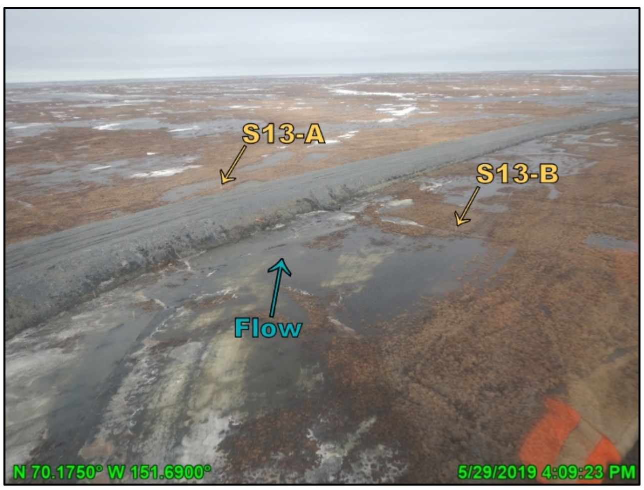


Photo F.24: Ponding near S13, looking north; May 29, 2019

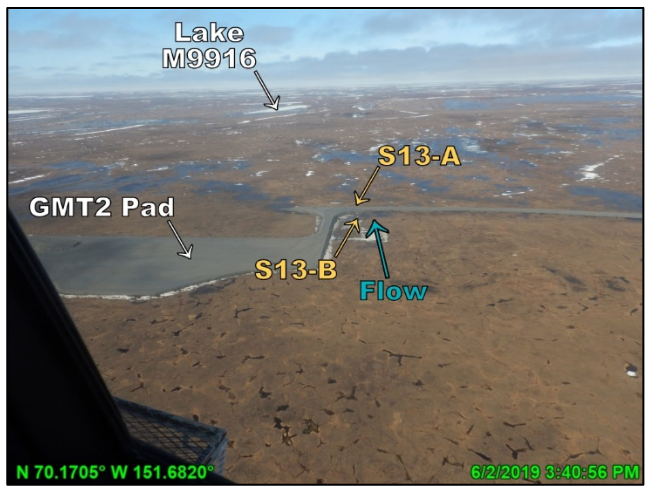


Photo F.25: **Hydraulically equalized conditions near S13, looking north; June 2, 2019**