# Kotzebue to Cape Blossom Road 2012 Spring Breakup Study: Sadie Creek

Prepared for

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# REVISION HISTORY

| Revision | Date | Comments | MBJ Project Manager |
|---|---|---|---|
| Draft | 12/17/2012 | Draft for Review | D. Christianson |
| Final | 03/01/2013 | Final to Client | D. Christianson |
| | | | |

# EXECUTIVE SUMMARY

This report presents observations and findings of the Kotzebue to Cape Blossom Road 2012 Spring Breakup Study: Sadie Creek, conducted by Michael Baker Jr., Inc. for the State of Alaska Department of Transportation & Public Facilities. Spring breakup monitoring was conducted to determine the magnitude and extent of flooding during what is considered one of the higher-return annual flood events in the region.

Observations and measurements were recorded at four water crossings along the proposed routes (shown in Figure 1.1):

- One crossing at Sadie Creek (SC1) along Option 1
- Two crossings at Sadie Creek (SC2A and SC2B) along Option 2
- One crossing at an unnamed swale (JC)

Peak water surface elevation (WSE) and discharge for the study locations are summarized below:

| Location | Peak WSE (ft) | Date (2012) | Peak Discharge (cfs) | Date (2012) |
|---|---|---|---|---|
| **SC1** | 88.14 | May 21 | 331 | May 22 |
| **SC2A** | 93.44 | May 24 | 339 | May 24 |
| **SC2B** | 97.32 | May 22 | 62 | May 25 |
| **JC** | 97.70 | May 28 | 13 | May 28 |

Note: Elevations are based on a local benchmark of an assumed datum.

Bridges or adequately sized culverts are capable of conveying peak flow at the Sadie Creek crossings. However, because of the channel width during breakup and probable regulatory requirements, a bridge may be the more feasible crossing mode at SC1 and SC2A. A culvert is capable of conveying peak flow at SC2B and JC and will likely satisfy regulatory requirements. Breakup flow at the SC2B location was conveyed over and through the snowpack as it melted down to the natural channel. Collected WSE and discharge data was affected because of that process, the effects of which should be considered during drainage structure design.

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| Baker | Michael Baker Jr., Inc. |
| °C | degrees Celsius |
| cfs | cubic feet per second |
| DOT&PF | State of Alaska Department of Transportation & Public Facilities |
| D/S | downstream |
| floe | ice floe |
| ft | feet |
| fps | feet per second |
| FHWA | Federal Highway Administration |
| GPS | global positioning system |
| JC | Unnamed Swale |
| LEW | left edge of water |
| NAD83 | North American Datum of 1983 |
| NEPA | National Environmental Policy Act |
| PT | pressure transducer |
| REW | right edge of water |
| RM | river miles |
| SC | Sadie Creek |
| UC | uniform channel |
| U/S | upstream |
| USGS | United States Geological Survey |
| WSE | water surface elevation(s) |

# 1.0 INTRODUCTION

The State of Alaska Department of Transportation and Public Facilities (DOT&PF) has proposed the development of an all-season road from Kotzebue, Alaska, to Cape Blossom on the southern end of the Baldwin Peninsula. Proposed alternative road alignments cross Sadie Creek, located approximately 5 miles south-southeast of Kotzebue. Figure 1.1 shows the project area.

Michael Baker Jr., Inc. (Baker) conducted spring breakup monitoring to determine the extent and magnitude of flooding near proposed road infrastructure. This was the first spring breakup study conducted for this area. This report presents the methods and results of the 2012 spring breakup monitoring activities at Sadie Creek and at an unnamed swale (approximately 3 miles south-southeast of Kotzebue). The report is organized as described below.

- **Section 1 – Introduction**: Discusses the objectives of the monitoring program and presents climatic information.
- **Section 2 – 2012 Monitoring Locations**: Discusses the 2012 monitoring sites.
- **Section 3 – Methods**: Describes the methods of fieldwork and data analyses.
- **Section 4 – 2012 Spring Breakup Results**: Presents the hydrologic observations and water surface elevations (WSE) at the Sadie Creek and unnamed swale proposed road crossings.
- **Section 5 – Discharge:** Presents results of the direct-measured and indirect-calculated discharge.
- **Section 6 – Conclusions and Recommendations:** Summarizes breakup and provides suggestions for drainage structure types at the studied locations.
- **Section 7 – References:** Contains list of references used in the development of this report.
- **Appendices:** Appendix A includes elevations and geographic locations of hydrologic staff gages and survey control**.** Discharge measurement notes for all monitoring sites are included in Appendix B.


Kotzebue to Cape Blossom Road
Overview Map
Figure 1.1

## 1.1 MONITORING OBJECTIVES

The primary objective of the Kotzebue to Cape Blossom Road 2012 Spring Breakup Study was to monitor and estimate the magnitude of breakup flooding where the proposed all-season road crosses Sadie Creek.

The hydrological data from this study provides initial baseline information to begin establishing appropriate design criteria. The data can be compared to estimated discharge values provided in the *Kotzebue to Cape Blossom Road Reconnaissance Study* (DOT&PF 2011) and potential drainage structure sizes can be estimated.

Findings will support an Environmental Document. This document will fully meet the requirements of the National Environmental Policy Act (NEPA) (40 CFR Part 230), the regulatory requirements of the Council on Environmental Quality (42 U.S.C. 4321-4370a and 40 CFR 1500), procedures for implementing NEPA (33 CFR 230), and the NEPA regulatory requirements of the Federal Highway Administration (FHWA 23 CFR 771).

## 1.2 MONITORING TASKS

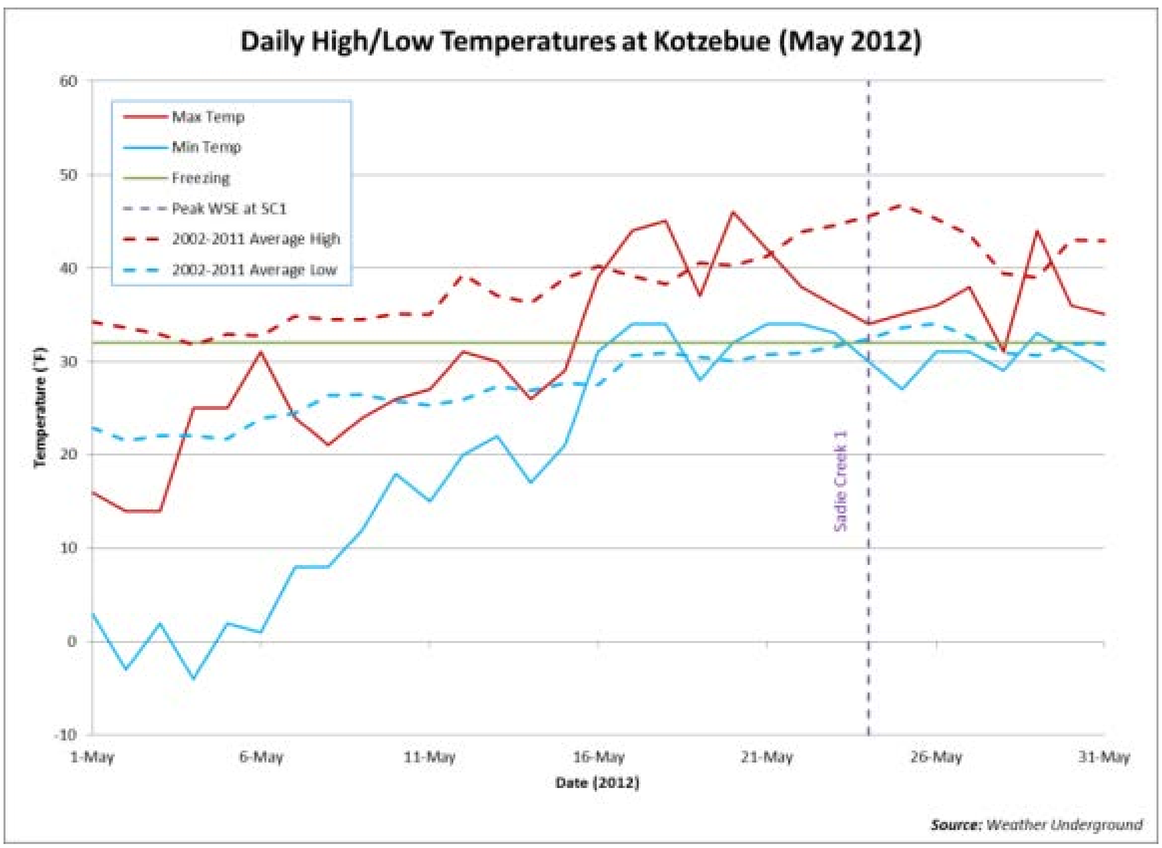
The hydrologic study was subdivided into four primary tasks:

- Task 1: Pre-field planning
    - Logistics, equipment, material, and personnel coordination and planning
    - Equipment maintenance, purchase and rental
    - Acquire Right Of Entry permits from Northwest Arctic Native Association and Kikiktagruk Inupiat Corporation
    - Selection of monitoring sites
- Task 2: Pre-breakup field setup
    - Site evaluation and refinement, temporary staff gage and local control installation and survey
    - Coordination of direct discharge measurement locations
- lTask 3: Breakup monitoring
    - Measurement of WSE using staff gages and pressure transducers (PT)
    - Photographic and written documentation of hydraulic and hydrologic conditions and floodwater distribution
    - Photographic and written documentation of ice jamming
    - Direct discharge measurements
- Task 4: Data analysis and reporting
    - Calculation of direct and indirect discharge
    - Review and tabulation of gaged and PT recorded WSE
    - Compilation of breakup observations, including photographic documentation
    - Report preparation presenting field observations and results of data analyses

## 1.3 CLIMATIC REVIEW

Spring above the Arctic Circle is often dominated by flooding. Little breakup meltwater is absorbed into the soil, as the active layer (underlain with continuous permafrost) remains frozen until later in the season. Meltwater often over-tops banks of streams and drainages filled with ice and wind-driven snow. Many streams and drainages freeze completely during the winter months. Snow pack, sustained cold or warm temperatures, ice thickness, wind speed and direction, precipitation, and solar radiation contribute to the timing and magnitude of the spring breakup event. The open water season for the area is generally limited to a four-month period from June through September.

Review of daily high and low temperatures can be helpful when considering breakup timing. Breakup processes initiate as daily temperatures rise toward freezing. As nightly lows begin to approach and exceed freezing temperatures, breakup processes tend to accelerate. Climatic records for 2012 are available from a monitoring station at Ralph Wien Memorial Airport in Kotzebue, approximately 4 air miles north of the monitored locations. Graph 1.1 provides high and low temperatures at Kotzebue for May 2012.




**GRAPH 1.1: DAILY HIGH AND LOW TEMPERATURES AT KOTZEBUE (MAY 2012)**

# 2.0 2012 MONITORING LOCATIONS

The Sadie Creek monitoring locations for the 2012 Spring Breakup Study were provided by DOT&PF based on proposed road alignments. An unnamed swale was identified by Baker as an active flow path that would likely require a hydraulic structure to maintain runoff conveyance.

WSE data is measured using a set of hydrologic staff gages at each site of interest. Gage locations were determined during pre-field planning; sites were selected at proposed road stream crossings, based on aerial imagery. Specific gage placement and the number of gages per set were refined during pre-breakup field setup based on field observations. Additional gages were installed during the early stages of monitoring to capture low stage conditions.

Monitoring was conducted at four channel crossings associated with the proposed alignment, presented in Figure 2.1. Two alternative alignments cross Sadie Creek; the western alignment (Option 1) crosses Sadie Creek (SC1) where all flow is confined to a single channel, while the eastern alignment (Option 2) crosses two smaller branches of Sadie Creek (SC2A and SC2B) approximately 1.5 river miles (RM) upstream of the western alignment. The confluence of the SC2A and SC2B channels lies approximately 0.75 RM upstream of the SC1 crossing. The fourth crossing is an unnamed swale (JC) which drains a ponded wetland area into June Creek.

Three gage sites (upstream [U/S], centerline, and downstream [D/S]) at each potential crossing on Sadie Creek and two gage sites (upstream and centerline) at the unnamed swale were monitored during the 2012 Spring Breakup Study. At each site, gages are installed in sets to capture the anticipated vertical change in WSE. The quantity of gages per set was dependent on local topography. Table 2.1 lists the hydrologic staff gages installed at each monitoring location and provides a summary of the naming convention. Hydrologic staff gages are discussed in more detail in Section 3.2.1.

**TABLE 2.1: KOTZEBUE TO CAPE BLOSSOM ROAD HYDROLOGIC STAFF GAGES**

**Gage Naming Convention**

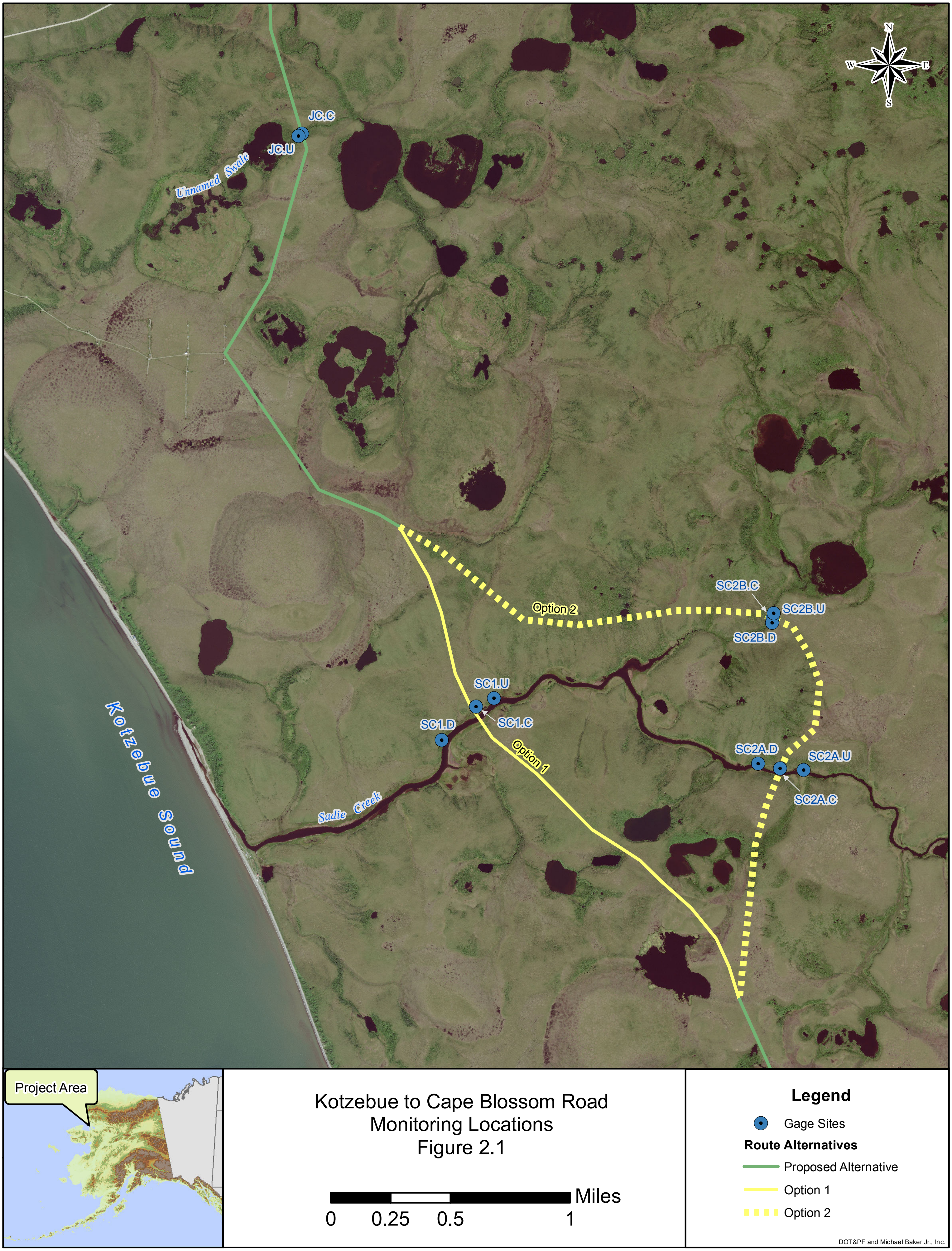
Example:

**SC1.U-C**

**[SC1]** Site (Sadie Creek 1)
**[.U]** Location (Upstream)
**[-C]** Gage ("C")

| Site | U/S | Centerline | D/S |
|---|---|---|---|
| **Sadie Creek 1 (SC1)** | SC1.U-A1<br>SC1.U-A<br>SC1.U-B<br>SC1.U-C | SC1.C-A<br>SC1.C-B<br>SC1.C-C<br>SC1.C-D | SC1.D-A1<br>SC1.D-A<br>SC1.D-B<br>SC1.D-C<br>SC1.D-D |
| **Sadie Creek 2A (SC2A)** | SC2A.U-A<br>SC2A.U-B | SC2A.C-A<br>SC2A.C-B<br>SC2A.C-C | SC2A.D-A1<br>SC2A.D-A<br>SC2A.D-B<br>SC2A.D-C |
| **Sadie Creek 2B (SC2B)** | SC2B.U-A<br>SC2B.U-B | SC2B.C-A<br>SC2B.C-B | SC2B.D-A<br>SC2B.D-B |
| **Unnamed Swale (JC)** | JC.U-A<br>JC.U-B | JC.C-A<br>JC.C-B | No gages installed |

*U/S – Upstream; D/S - Downstream*




Kotzebue to Cape Blossom Road
Monitoring Locations
Figure 2.1

## 2.1 SADIE CREEK SITE 1 (SC1)

SC1 is located roughly 5 miles south of Kotzebue along the Option 1 road alignment. Gages located at SC1 were installed along a well-defined, fairly straight reach on May 3 and surveyed for elevation on May 5, 2012. They were located at the proposed crossing centerline, 500 feet upstream, and 1,000 feet downstream. PTs were installed at SC1.U and SC1.D. Hydrologic staff gage locations at SC1 are presented in Figure 2.2 through Figure 2.4. Photo 2.1 shows pre-breakup conditions at SC1 on May 2.

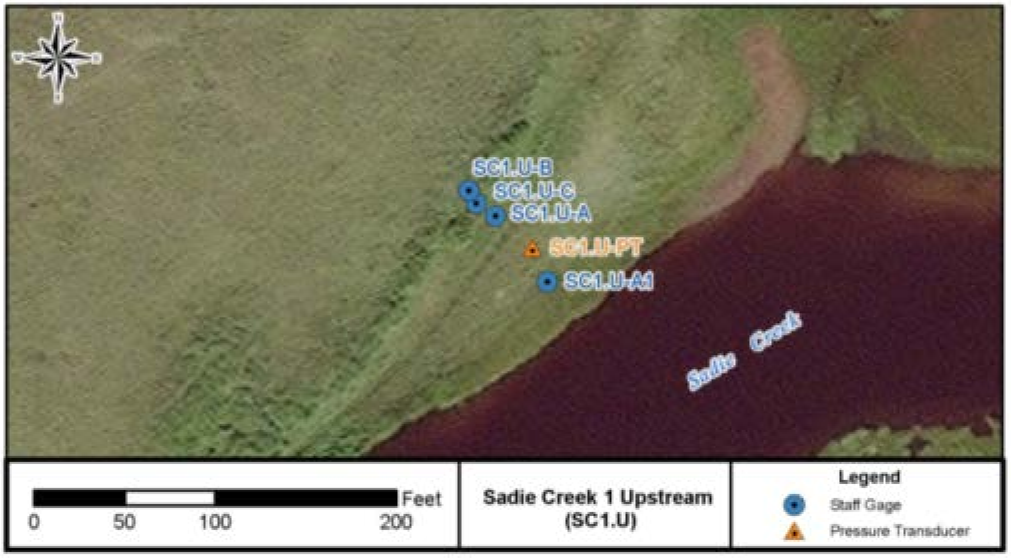



**FIGURE 2.2: HYDROLOGIC STAFF GAGES INSTALLED AT SC1.U**

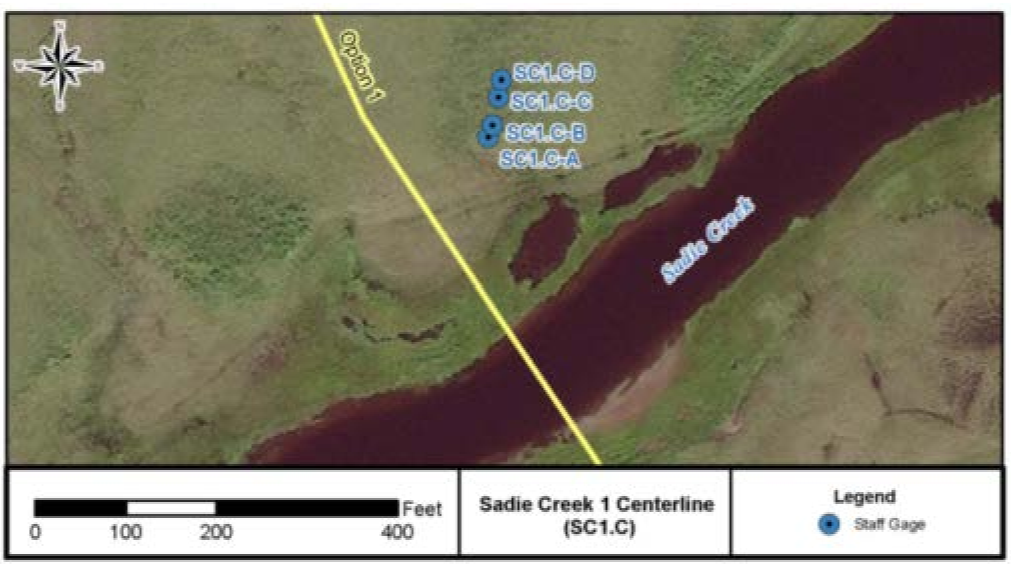



**FIGURE 2.3: HYDROLOGIC STAFF GAGES INSTALLED AT SC1.C**

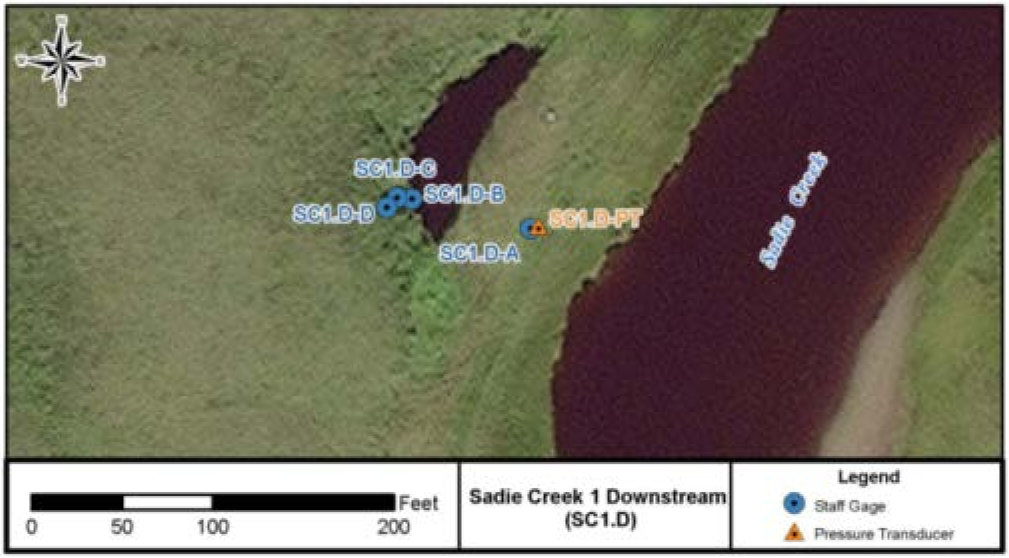



**FIGURE 2.4: HYDROLOGIC STAFF GAGES INSTALLED AT SC1.D**

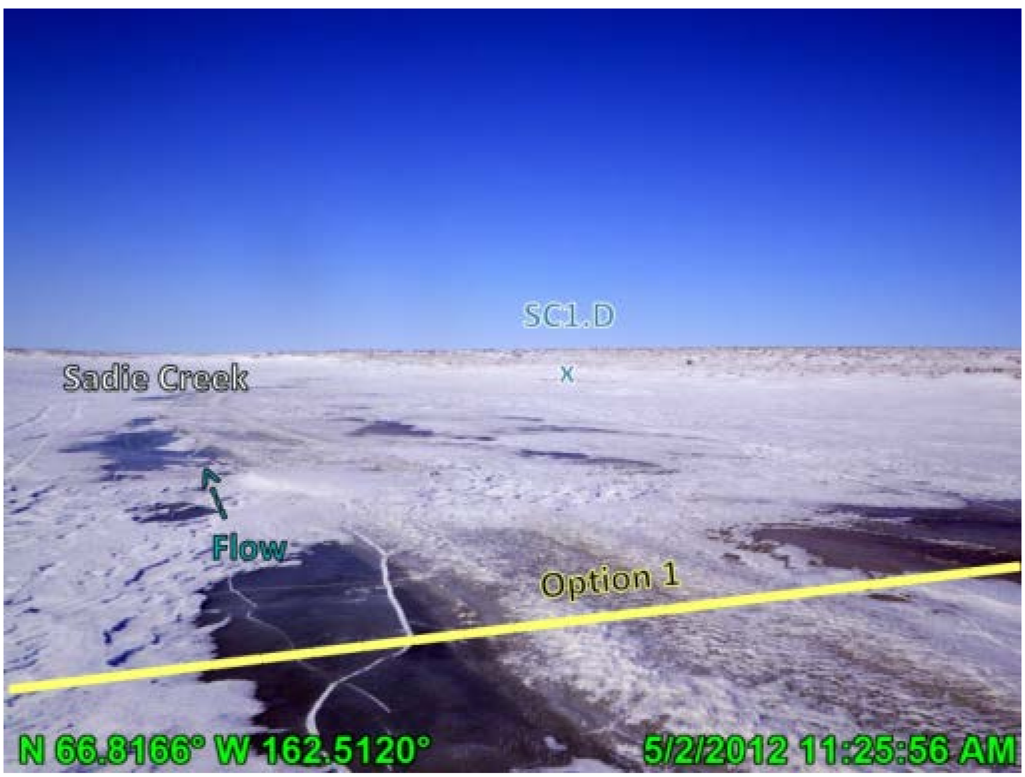



**PHOTO 2.1: PROPOSED SC1 CROSSING PRIOR TO BREAKUP, LOOKING WEST; MAY 2, 2012**

## 2.2 Sadie Creek Site 2A (SC2A)

SC2A gages are located along the Option 2 road alignment, which crosses the southern branch of Sadie Creek. Along this alignment are depressions and areas susceptible to ponding during flooding events. Upstream of SC2A, the channel splits into a network of ponds and connecting channels, some of which are likely ephemeral.

Gages located at SC2A were installed along a nearly straight reach and surveyed for elevation on May 4. Gages were established at the proposed road crossing centerline and approximately 500 feet upstream and downstream. PTs were installed at SC2A.U and SC2A.D. Hydrologic staff gage locations at SC2A are presented in Figure 2.5 through Figure 2.7. Photo 2.2 shows pre-breakup conditions at SC2A on May 2.

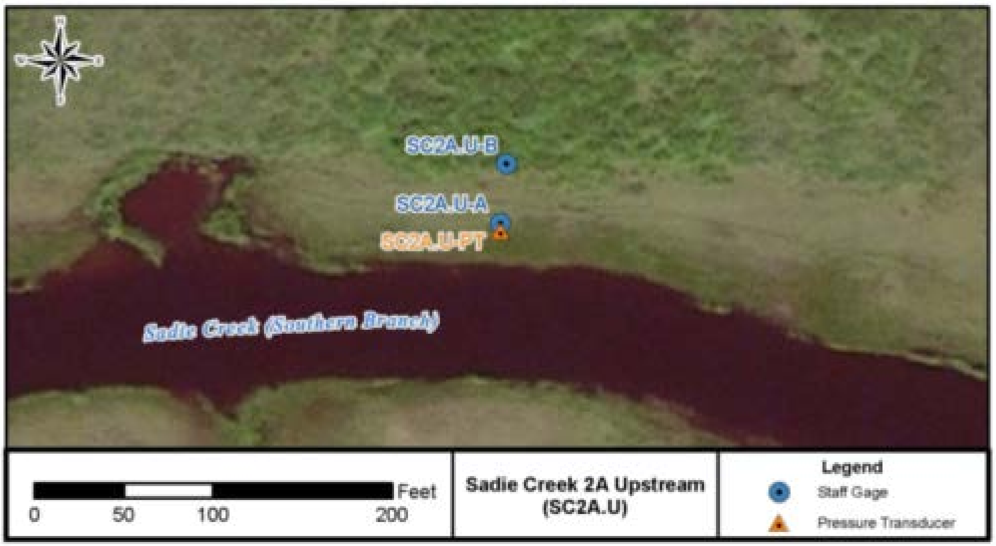



FIGURE 2.5: HYDROLOGIC STAFF GAGES INSTALLED AT SC2A.U

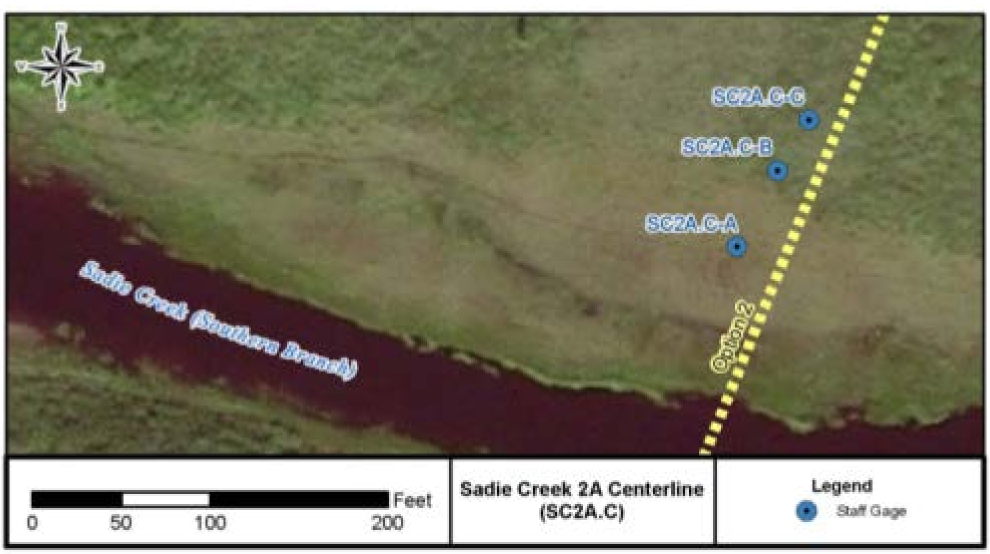



FIGURE 2.6: HYDROLOGIC STAFF GAGES INSTALLED AT SC2A.C

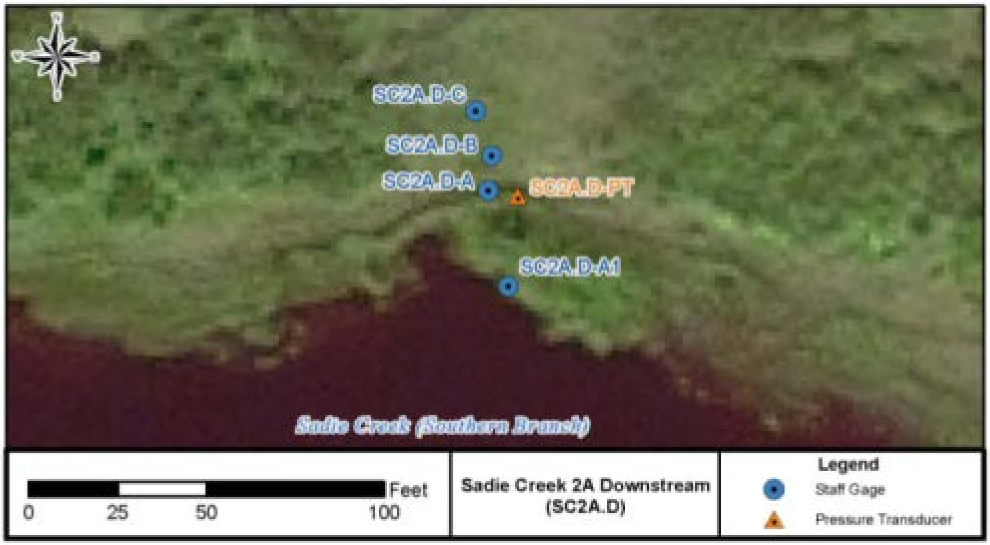



**FIGURE 2.7: HYDROLOGIC STAFF GAGES INSTALLED AT SC2A.D**

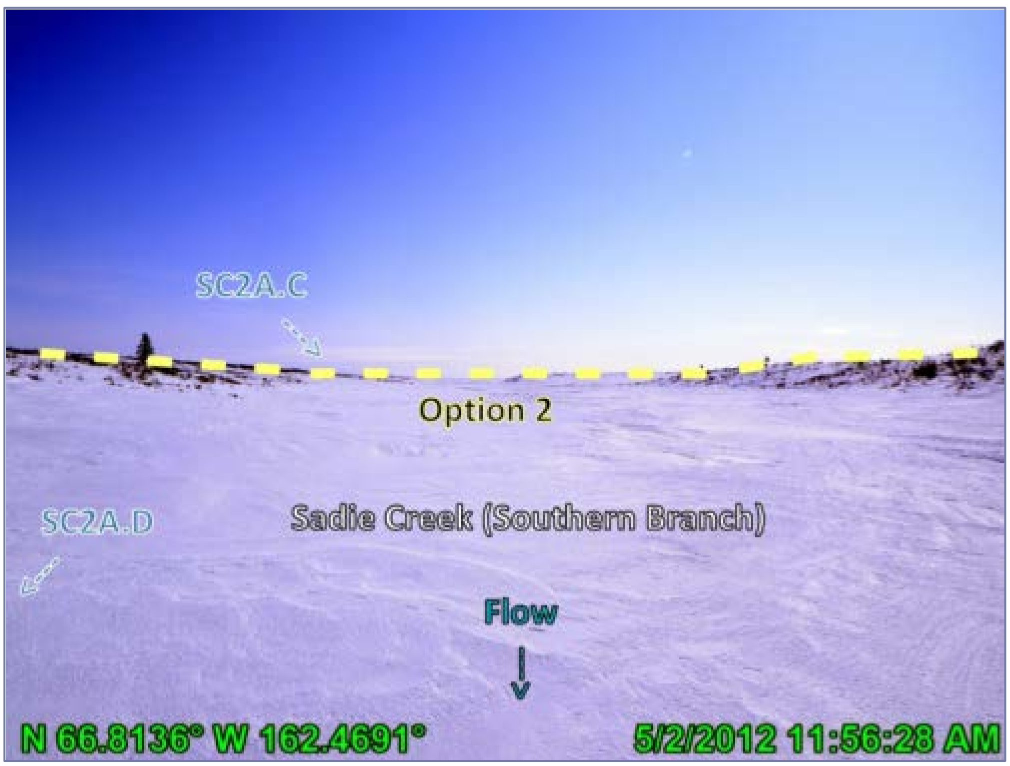



**PHOTO 2.2: PROPOSED SC2A CROSSING PRIOR TO BREAKUP, LOOKING EAST; MAY 2, 2012**

## 2.3 SADIE CREEK SITE 2B (SC2B)

SC2B gages are located along the Option 2 road alignment, which crosses the northern branch of Sadie Creek approximately 0.7 air miles north of SC2A. Directly upstream of the proposed SC2B crossing is a single pond fed by a network of ponds farther upstream. The stream branch is significantly smaller than SC2A. Originating from several ponds and wetlands, it is potentially ephemeral, flowing only as the result of breakup or heavy rain events.

Gages were established at the proposed road crossing centerline along a nearly straight reach, approximately 100 feet upstream and downstream, and surveyed for elevation on May 5. PTs were installed at SC2B.U and SC2B.D at the base of the "A" gages. Hydrologic staff gage locations at SC2B are presented in Figure 2.8. Photo 2.3 shows pre-breakup conditions at SC2B on May 2 ("←x→" indicates location and alignment of channel).

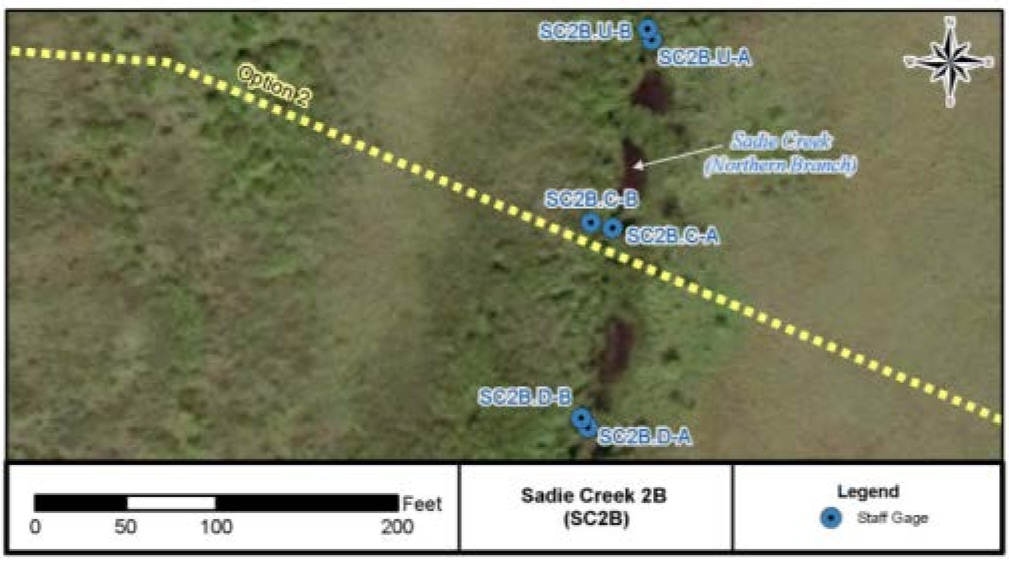



**FIGURE 2.8: HYDROLOGIC STAFF GAGES INSTALLED AT SC2B**


**PHOTO 2.3: SC2B PRIOR TO BREAKUP, LOOKING EAST; MAY 2, 2012**

## 2.4 UNNAMED SWALE (JC)

The proposed crossing of the unnamed swale is located 3 miles southeast of Kotzebue. Upstream of the site is a pond connected to a small network of wetlands or smaller ponds. This crossing was characterized by small brush and grasses with a fairly well defined drainage once the snowpack opened to floodwaters. On May 5, gages were installed and surveyed for elevation at the proposed road crossing centerline and 100 feet upstream. PTs were installed at JC.U and JC.C at the base of the "A" staff gages. Hydrologic staff gage locations at JC are presented in Figure 2.9. Photo 2.4 shows pre-breakup conditions at the proposed crossing on May 2.

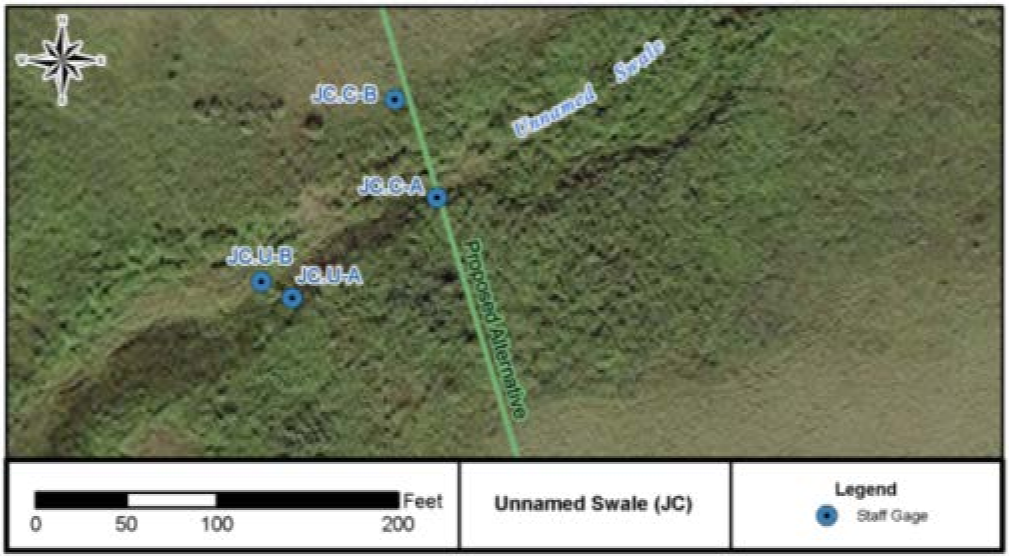



**FIGURE 2.9: HYDROLOGIC STAFF GAGES INSTALLED AT JC**


**PHOTO 2.4: PROPOSED CROSSING OF THE UNNAMED SWALE PRIOR TO BREAKUP, LOOKING EAST; MAY 5, 2012**

# 3.0 METHODS

Standard techniques appropriate for conditions found in arctic regions during spring breakup were used for data collection. These field methods included visual observations of melt water flow, ice behavior, documentation of WSE at gaging stations, and measurement of discharge. Challenges included logistics, weather, and safety.

## 3.1 VISUAL OBSERVATIONS

Evaluation of gaging locations was conducted from the ground via snowmachines during pre-breakup field setup from May 2 to May 5, 2012. Breakup monitoring observations were conducted via helicopter from May 18 to May 30, 2012. 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. The geographic position of the camera, date, and time were automatically imprinted onto each photo.

## 3.2 WATER SURFACE ELEVATION

### 3.2.1 HYDROLOGIC STAFF GAGES

Temporary staff gages were installed in sets at each site as indicated in Table 2.1. From staff gages, WSE was measured relative to an assumed elevation. 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.

Each gage assembly consisted of a 3.33-foot long metal gage faceplate mounted on a two-by-four timber attached 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 GPSMAP® 62st GPS device in North American Datum of 1983 (NAD83). Photo 3.1 shows an example of a staff gage after installation.


**PHOTO 3.1: GAGE ASSEMBLY AT SC2A.D, LOOKING SOUTH; MAY 23, 2012**

Temporary benchmarks, consisting of a 2-foot long piece of rebar and a 5-inch square cap, were placed on the upper banks at each monitoring site. Each benchmark was assigned an assumed elevation prior to breakup. They were not tied together or to a known datum. The elevation of each gage was established from its local benchmark using standard level loop techniques. Elevations at each gage location are relative only to that site.

The basis of elevation for each gage and the horizontal position of respective benchmarks and gages are presented in Appendix A.

In 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 provide redundancy in capturing WSE data. Where floodwaters were not high enough to reach gages, a gage was repositioned lower into the water. This occurred along the SC1 and SC2A channels.

### 3.2.2 Pressure Transducers (PT)

Pressure transducers (PT) were installed at each upstream and downstream (upstream and centerline at the unnamed swale) gage sites to record WSE data. PTs measure the absolute pressure imparted by the atmosphere and water at the sensor, allowing the depth of water above the sensor to be calculated with the aid of barometric pressure sensor data. Resulting data yields a more comprehensive record of the fluctuations in WSE than can be captured by visual staff gage measurements alone.

Solinst 3001 Levelogger® Gold 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. The measured pressure datum is the sum of the forces imparted by both the water column and atmospheric conditions. A correction of local barometric pressure was required and obtained from a Solinst 3001 Barologger® Gold located at SC1.C. This Barologger® location is considered to be representative of conditions at each monitoring site. See Appendix A for PT and Barologger® basis of elevation and horizontal positions.

Prior to deployment, PTs were configured using Solinst Levelogger Software 4.0.3® and underwent a functional test and calibration by Baker. The transducers were housed in a segment of perforated galvanized steel pipe, clamped to angle iron placed near the active channel at ground level (Photo 3.2). The transducer sensor was surveyed to establish a vertical datum using local control.


PHOTO 3.2: PT ASSEMBLY INSTALLED AT SC2A.U; MAY 4, 2012

Water depth was calculated as the density of water multiplied by gage pressure. Gage pressure was calculated as the difference in simultaneous absolute and barometric pressure data. A standard density of water at 0 degrees Celsius (°C) was used for all calculations. Fluctuations in water temperature during the sampling period were not significant enough to affect WSE calculations due to the limited range in temperature and observed water depths. PT-based WSE values were determined by adding the calculated water depth and the surveyed sensor elevation. Additionally, gage WSE readings were used to calibrate the data collected by the PTs.

## 3.3 Discharge Measurements

### 3.3.1 Direct Discharge

Discharge was measured using standard U.S. Geological Survey (USGS) midsection techniques (USGS 1982) at SC1, SC2A, and JC. Conditions did not allow for a safe or accurate direct discharge measurement at SC2B. Velocity and discharge measurements were taken daily as conditions permitted to collect data as close as possible to peak stage.

Depth and velocity measurements were taken from a jon boat at SC1 and SC2A with a sounding reel mounted on a wooden boom (Photo 3.3). A Price AA velocity meter was attached to the sounding reel and stabilized with a 30-pound Columbus-type lead sounding weight. A tag line was placed across the channel to define the cross section and to delineate measurement subsections within the channel. To ensure accurate performance of meters, procedures outlined in the Office of Surface Water Technical Memorandum No. 99.06 (OSW 1999) were followed.


**PHOTO 3.3: DIRECT-DISCHARGE MEASUREMENT AT SC1, LOOKING SOUTHEAST; MAY 27, 2012**

### 3.3.2 INDIRECT DISCHARGE

The slope-area method (Benson and Dalrymple 1967) for a uniform channel (UC) were used in the indirect discharge calculations  to develop the estimates of peak discharge. The method is based on channel cross-section geometry and stage differential between gage sites as an estimate for hydraulic gradient. The UC method uses a single cross-section typically at the centerline of each site. Accuracy of this method depends on conditions at the time of calculation, cross sectional flow geometry, hydraulic roughness imparted on flow, ice jam activity, and backwater effects. Cross-sectional geometry was collected during direct measurements. Stage and hydraulic gradient data were determined from observations made at nearby gages and PT data.

# 4.0 2012 Spring Breakup Results

Breakup monitoring began on May 22 when field personnel arrived in Kotzebue. Daily observations were documented between May 22 and May 30 and are reported in this section. Quicksilver Air provided helicopter support for the duration of breakup monitoring.

## 4.1 Breakup Timing

Unseasonably cool weather in late April and early May, with temperatures close to freezing at night, likely affected the 2012 breakup event. The cold temperatures preserved snowpack and ice, delaying breakup. The breakup event was affected by above average temperatures immediately preceding, and below average temperatures during, breakup. Between May 16 and May 23, air temperatures averaged above the freezing point and spiked into the mid-40's (see Graph 1.1). An early warming trend can often ripen the snow (local melt saturates the snow) for breakup by pre-softening snow such that when the main melt does occur, it occurs more rapidly and efficiently than without the early warming period.

Victor Jones, a local subcontractor with the Native Village of Kotzebue, provided photographic evidence of breakup processes at the monitoring areas beginning on May 18 (Photo 4.1), prior to Baker field crew mobilization to Kotzebue on May 22.


**PHOTO 4.1: BREAKUP INITIATION AT SC1.U, LOOKING SOUTH; MAY 18, 2012**

## 4.2 Hydrologic Observations and Stage Data

### 4.2.1 Sadie Creek 1 (SC1)

Stage was captured at the SC1 site via PT on May 21, estimated as the date of arrival of the leading edge of breakup meltwater at the crossing location. Stage quickly peaked at the upstream gaging location (SC1.U) on this day, as evidenced by PT data. No evidence was available to indicate peak stage or a stage crest on May 21 at either the centerline (SC1.C) or downstream (SC1.D) locations, though a peak or crest is not unlikely.

On May 22, stage was low with no discernible velocity. Ice was bottom-fast in the channel and no ice floes were present (Photo 4.2). Stage continued decreasing on May 23, reaching the lowest elevations during the breakup period before rising again.

All gage locations experienced a second stage crest on May 24, when peak stage was recorded at SC1.C and SC1.D. The width of flow was approximately 300 feet during the second crest, with floodwaters and snow present in both left and right overbank areas. The gradient at the crossing location is relatively shallow and flow velocities were low during the peak stage period. Flow was ineffective in the overbank areas, with the majority being conveyed through the thalweg. Stage recession for the second time during breakup continued on May 25 at which time bottom-fast ice was still present along the toe of the left (north) bank (Photo 4.3).

By May 26, ice had lifted off the channel bed both upstream and downstream of the SC1 reach (Photo 4.4) and stage at all locations rose slightly. The following day, ice floes were observed approximately 0.5 RM upstream of SC1 (Photo 4.5). No significant effects to flow were seen at the crossing location as a result of this ice. Floes remained in the channel upstream of SC1 on May 29 as stage continued to drop..

By the final day of monitoring on May 30, the channel reach at the crossing location was open though occasional ice floes were present downstream (Photo 4.6). Flow was becoming more contained within the defined channel banks as stage continued decreasing. Both overbanks were still inundated with floodwater in places and some snow was present.

Stage data for the SC1 gages during breakup monitoring are contained in Table 4.1 and Graph 4.1. The PT at the SC1.D location malfunctioned and data was not recoverable.


**PHOTO 4.2: BOTTOM-FAST ICE AT SC1.U, LOOKING SOUTHEAST; MAY 22, 2012**


**PHOTO 4.3: BOTTOM-FAST ICE ALONG TOE OF BANK AT SC1.C, LOOKING DOWNSTREAM; MAY 25, 2012**


**PHOTO 4.4: ICE LIFTING OFF THE CHANNEL BED 0.5 MILES UPSTREAM OF SC1 GAGES, LOOKING SOUTH; MAY 26, 2012**

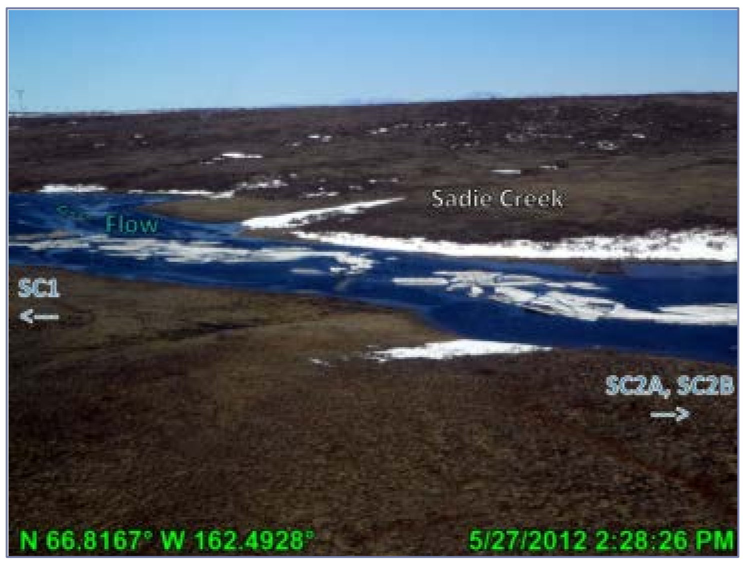



**PHOTO 4.5: ICE FLOES UPSTREAM OF SC1 GAGES, LOOKING NORTHWEST; MAY 27, 2012**

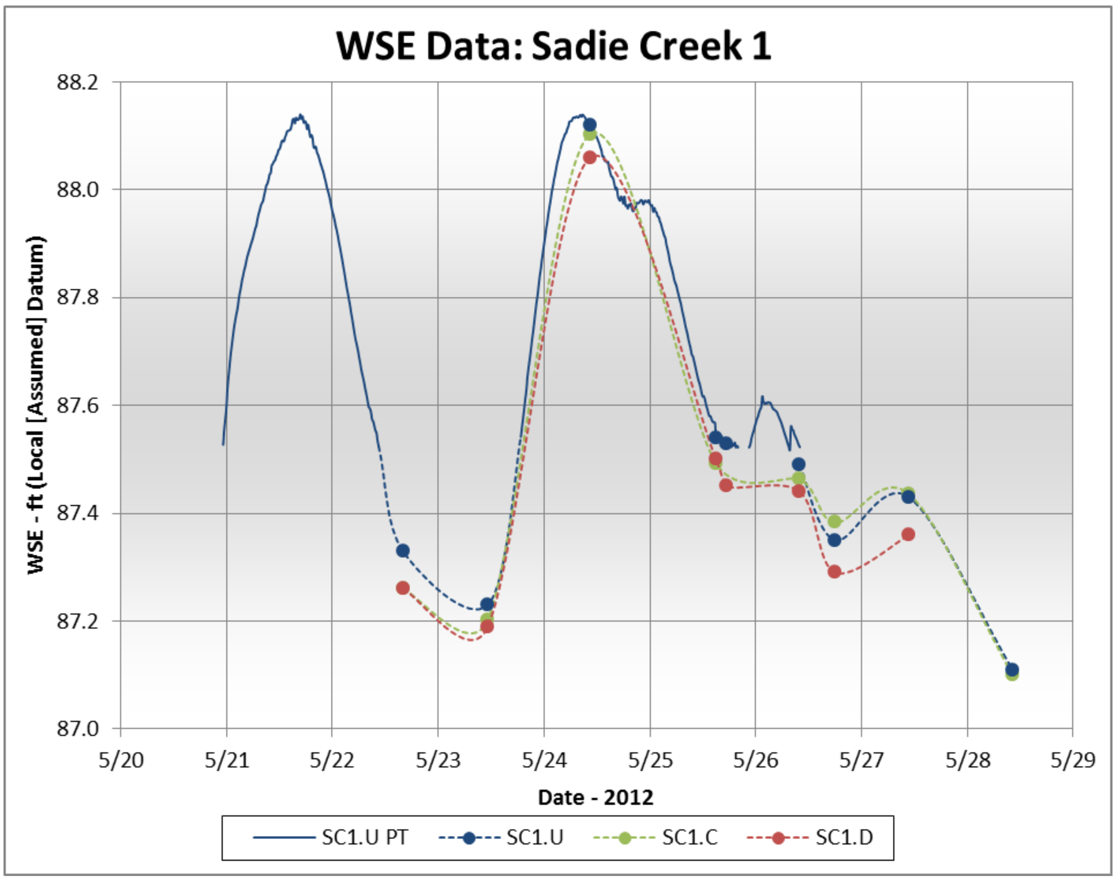

**PHOTO 4.6: OPEN CHANNEL CONDITIONS DOWNSTREAM OF SC1 GAGES, LOOKING UPSTREAM TO CROSSING LOCATION; MAY 30, 2012**

**TABLE 4.1: STAGE DATA, SC1 GAGES**

| Date and Time | WSE (feet) | | | Notes |
|---|---|---|---|---|
| | SC1.U | SC1.C | SC1.D | |
| 5/21/12 4:45 PM | 88.14 | - | - | **Peak stage;** based on PT data |
| 5/22/12 4:00 PM | 87.33 | 87.26 | 87.26 | |
| 5/23/12 11:15 AM | 87.23 | 87.20 | 87.19 | |
| 5/24/12 10:30 AM | 88.12 | 88.10 | 88.06 | **Peak stage;** based on gage data |
| 5/25/12 3:00 PM | 87.54 | 87.49 | 87.50 | |
| 5/25/12 5:30 PM | 87.53 | - | 87.45 | |
| 5/26/12 10:00 AM | 87.49 | 87.46 | 87.44 | |
| 5/26/12 6:00 PM | 87.35 | 87.38 | 87.29 | |
| 5/27/12 10:45 AM | 87.43 | 87.44 | 87.36 | |
| 5/28/12 10:15 AM | 87.11 | 87.10 | - | |

*Notes:*

1. Elevations are based on SC1 at 100.00 feet (local datum - assumed elevation) surveyed by Baker in 2012.
2. The PT at SC1.D malfunctioned and data was not recoverable.




**GRAPH 4.1: STAGE DATA, SC1 GAGES**

### 4.2.2 SADIE CREEK 2A (SC2A)

The leading edge of meltwater flow is estimated to have passed SC2A on May 21. An initial low stage crest was experienced at all gaging locations on this day, based on PT data. Stage had dropped below gage levels by May 22, reaching a breakup low on May 23. Bottom-fast ice was present along both banks and the channel was free of floes (Photo 4.7). Stage increased once again, reaching a peak at all locations on May 24. The width of flow at SC2A was approximately 160 feet during peak stage, with floodwaters and snow in both overbanks (Photo 4.8). No floes were in the vicinity. The gradient at the crossing location is relatively shallow and flow velocities were low during the peak period. Flow was ineffective in the overbank areas, with the majority being conveyed through the thalweg.

On May 25, the channel remained free of snow and ice floes as stage continued to drop. Conditions were similar until May 28 when bottom-fast ice lifted to the surface. Stage dropped below gages by May 29. Ice floes were grounding out approximately 0.5 RM downstream of SC2A and flow within the reach was confined almost entirely within the channel banks (Photo 4.9). No backwater effects were observed at the crossing location as a result of the rafted floes downstream. The majority of the snow in the area had melted and monitoring was discontinued.

Stage data for the SC2A gages during breakup monitoring are presented in Table 4.2 and Graph 4.2.


**PHOTO 4.7: BOTTOM-FAST ICE ALONG BANKS AT SC2A.D, LOOKING SOUTHWEST; MAY 22, 2012**


**PHOTO 4.8: CONDITIONS DURING PEAK STAGE AT SC2A.D, LOOKING SOUTHWEST; MAY 24, 2012**

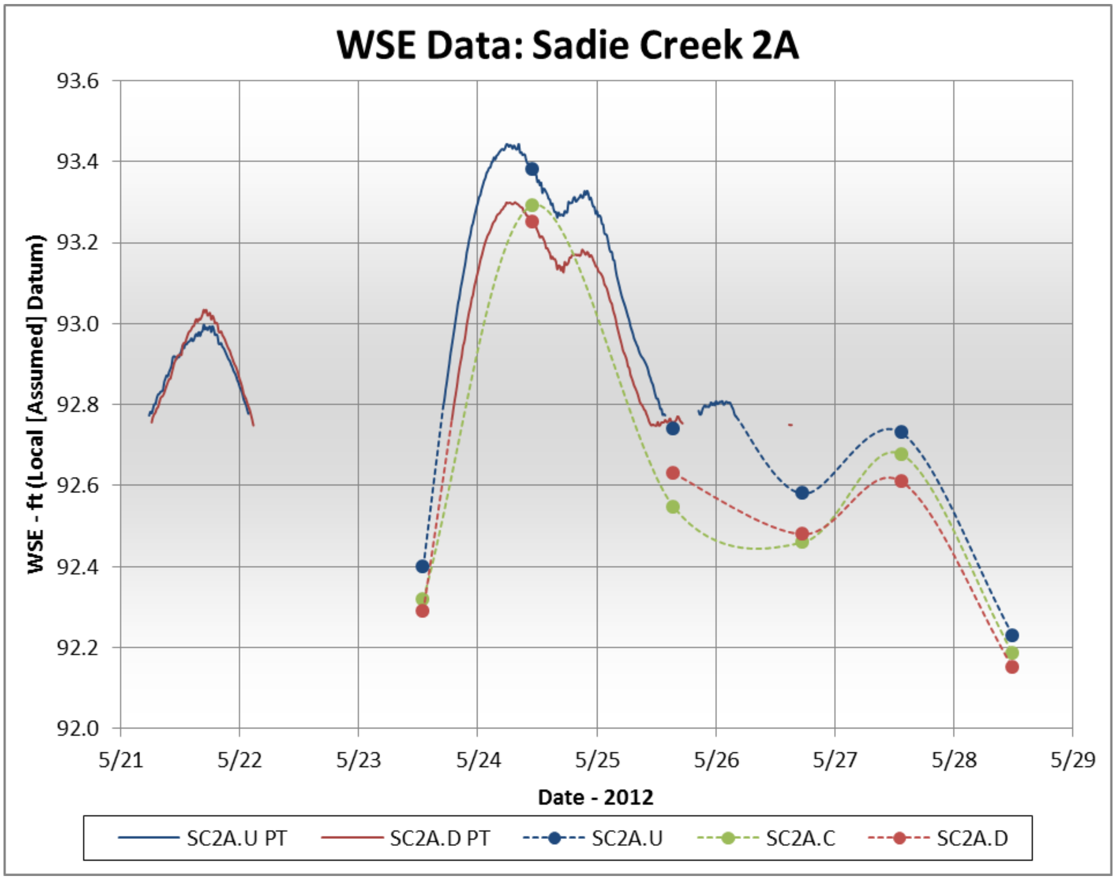

**PHOTO 4.9: ICE FLOES 0.5 RM DOWNSTREAM OF SC2A, LOOKING WEST; MAY 29, 2012**

**TABLE 4.2: STAGE DATA, SC2A GAGES**

| Date and Time | WSE (feet) | | | Notes |
|---|---|---|---|---|
| | SC2A.U | SC2A.C | SC2A.D | |
| 5/23/12 1:00 PM | 92.40 | 92.32 | 92.29 | |
| 5/24/12 8:00 AM | 93.44 | - | 93.30 | **Peak stage;** based on PT data |
| 5/24/12 11:00 AM | 93.38 | 93.29 | 93.25 | **Peak stage;** based on gage data |
| 5/25/12 3:30 PM | 92.74 | 92.55 | 92.63 | |
| 5/26/12 5:30 PM | 92.58 | 92.46 | 92.48 | |
| 5/27/12 1:25 PM | 92.73 | 92.68 | 92.61 | |
| 5/28/12 11:50 AM | 92.23 | 92.19 | 92.15 | |

*Notes:*

1. Elevations are based on SC2A at 100.00 feet (local datum - assumed elevation) surveyed by Baker in 2012.




**GRAPH 4.2: STAGE DATA, SC2A GAGES**

### 4.2.3 Sadie Creek 2B (SC2B)

This channel is a small tributary of Sadie Creek which drains a network of ponds. Conditions through this reach during spring breakup were very dynamic as flood flow was conveyed on top of and through the snowpack, adjacent to the natural channel, for the majority of the monitoring period. The gradient and geometry of the incised channel changed, becoming deeper and wider as breakup melt progressed. Eventually, flow cut through the snow near the end of the monitoring period, migrating to the natural channel on the ground. Stage was affected by this process and should not be considered representative of the natural channel.

The leading edge of meltwater flow is estimated to have passed SC2B on May 21. PT data indicates peak stage occurred at both the upstream (SC2A.U) and downstream (SC2A.D) locations on May 22. No evidence of peak stage occurring at the centerline location (SC2A.C) on this day is available, but it is likely that it occurred on May 22 as well.

Field crews first collected visual observations on May 23. The upstream gradient through this reach was steeper and flow was more confined within the channel cut through the snow. Downstream, the gradient became shallower, flow had lower velocity and was less confined, and ponding occurred on top of the snow (Photo 4.10 and Photo 4.11 on May 24). By May 25, the incised channel was more defined through the entire reach, though snow along both sides was saturated with ineffective flow (Photo 4.12). Water continued to pond just downstream, the shallow gradient and snow contributing to a backwater effect. Flow continued to deepen and widen the channel cut into the snowpack (Photo 4.13), reaching the natural channel by May 27 (Photo 4.14). The natural channel was partially under the left bank snowpack, which had been eroded over 10 feet deep and up to 20 feet wide in some locations through the crossing reach (Photo 4.15).

Stage data for the SC2B gages during breakup monitoring are presented in Table 4.3 and Graph 4.3.

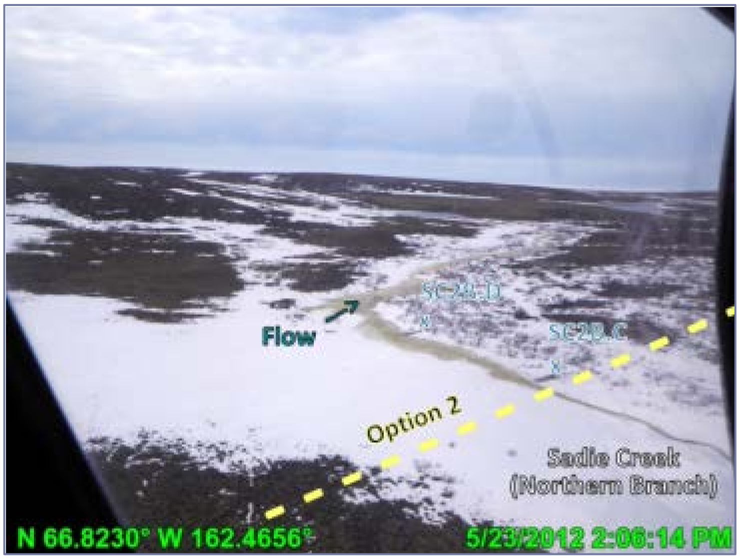



**PHOTO 4.10: STEEPER TO SHALLOWER GRADIENT FLOW OVER SNOW AT SC2B, LOOKING DOWNSTREAM; MAY 23, 2012**


**PHOTO 4.11: FLOW LESS CONFINED AS A RESULT OF SHALLOWER DOWNSTREAM GRADIENT AT SC2B, LOOKING DOWNSTREAM; MAY 24, 2012**

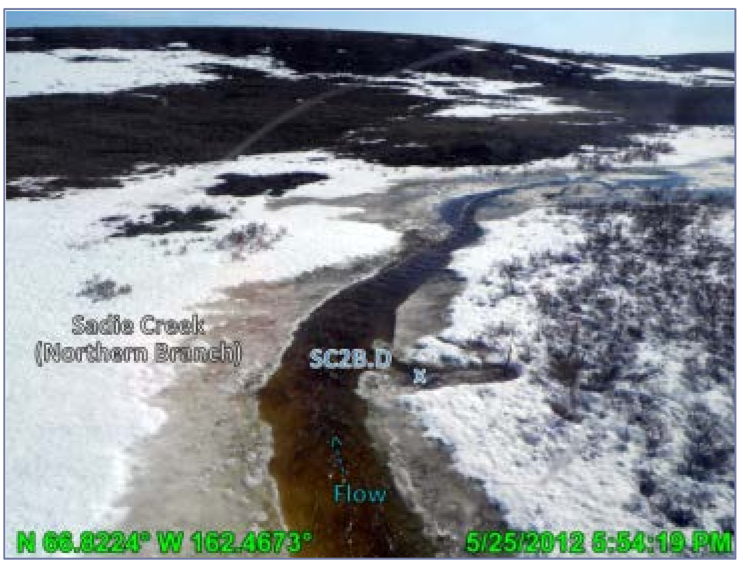



**PHOTO 4.12: BREAKUP PROGRESSION AT SC2B AND DOWNSTREAM PONDING, LOOKING DOWNSTREAM; MAY 25, 2012**

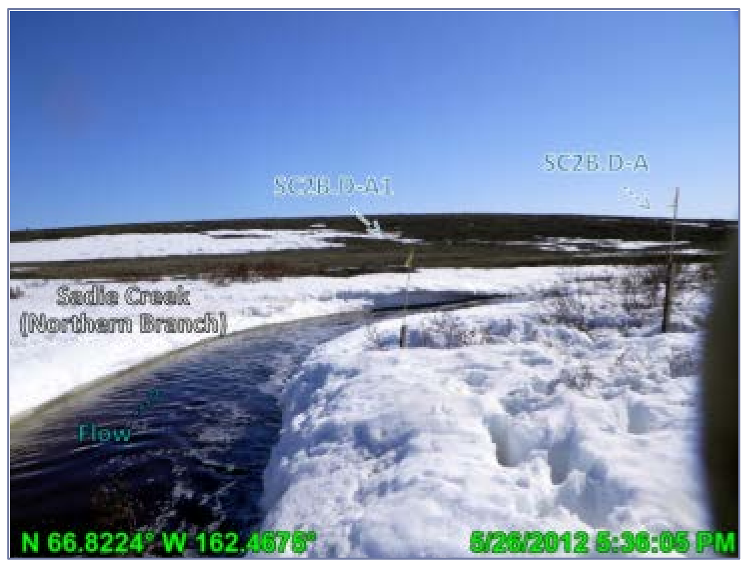



**PHOTO 4.13: SC2B CHANNEL CUTTING INTO THE SNOWPACK, LOOKING DOWNSTREAM; MAY 26, 2012**


**PHOTO 4.14: SC2B CHANNEL CUT TO THE BOTTOM OF THE SNOWPACK, LOOKING DOWNSTREAM; MAY 27, 2012**

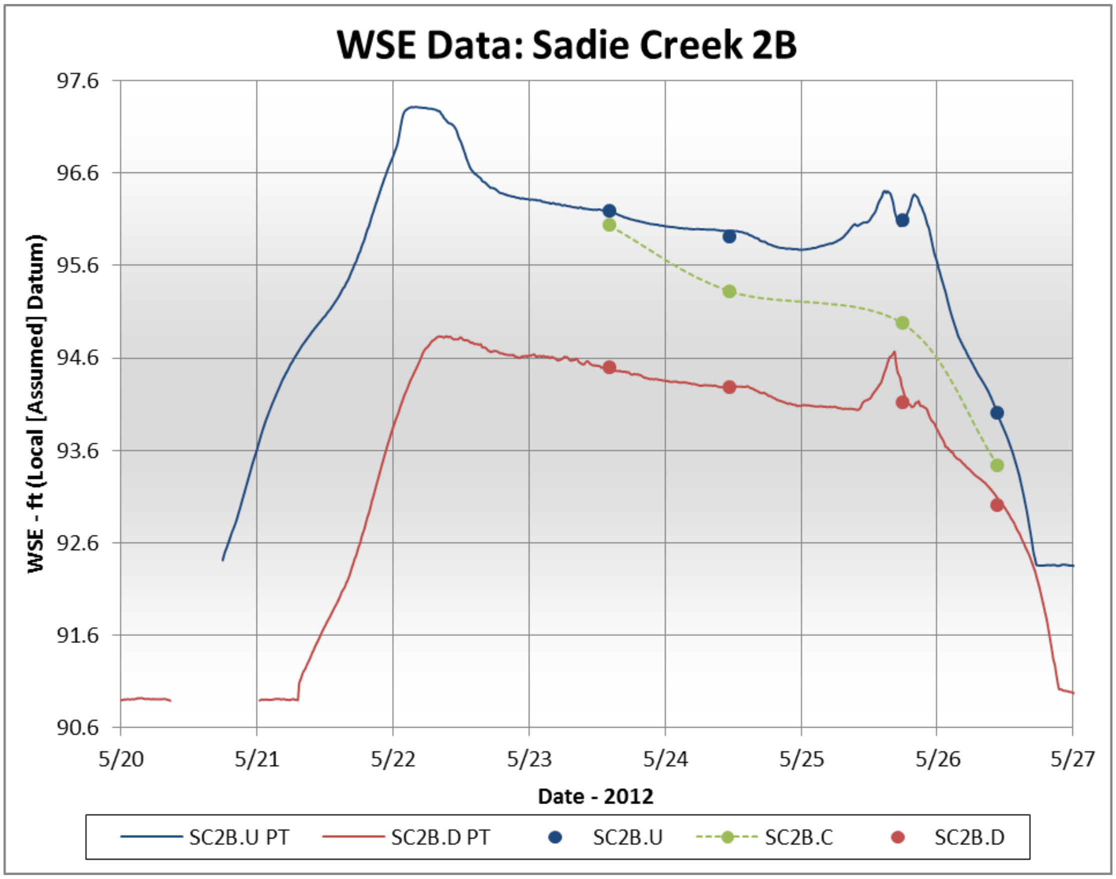

**PHOTO 4.15: CUT IN SNOWPACK LEFT BY SC2B AND MIGRATION OF FLOW TOWARD NATURAL CHANNEL, LOOKING DOWNSTREAM; MAY 29, 2012**

**TABLE 4.3: STAGE DATA, SC2B GAGES**

| Date and Time | WSE (feet) | | | Notes |
|---|---|---|---|---|
| | SC2B.U | SC2B.C | SC2B.D | |
| 5/22/12 4:00 AM | 97.32 | - | - | **Peak stage;** based on PT data |
| 5/22/12 9:30 AM | - | - | 94.84 | **Peak stage;** based on PT data |
| 5/23/12 2:15 PM | 96.19 | 96.03 | 94.49 | **Peak stage;** based on gage data |
| 5/24/12 11:30 AM | 95.91 | 95.32 | 94.28 | |
| 5/25/12 6:00 PM | 96.09 | 94.97 | 94.12 | |
| 5/26/12 10:45 AM | 94.00 | 93.43 | 93.00 | |

*Notes:*

1. Elevations are based on SC2B at 100.00 feet (local datum - assumed elevation) surveyed by Baker in 2012.
2. Flow through this reach was conveyed via a channel incised into the snowpack. Channel geometry and gradient changed with the progression of breakup melt. Stage data was affected by these processes and should not be considered representative of the natural channel.




**GRAPH 4.3: STAGE DATA, SC2B GAGES**

### 4.2.4 Unnamed Swale (JC)

The swale drains a network of small ponds and wetlands into June Creek. Local melt was observed at JC gages during the reconnaissance flight on May 22. By May 27, melt in the pond upstream had progressed sufficiently so water had reached the crossing location but stage was low (Photo 4.16). Snow was still present downstream of the gages and there was no flow. This swale was conveying flow at a maximum top-width of 30 feet by May 29 (Photo 4.17). The maximum depth was 1.3 feet and the surface of the water was discontinuous with ice, snow, and vegetation. Stage and flow had decreased by May 30, after which monitoring was discontinued.

Stage data for the JC gages during breakup monitoring are contained in Table 4.4 and Graph 4.4.

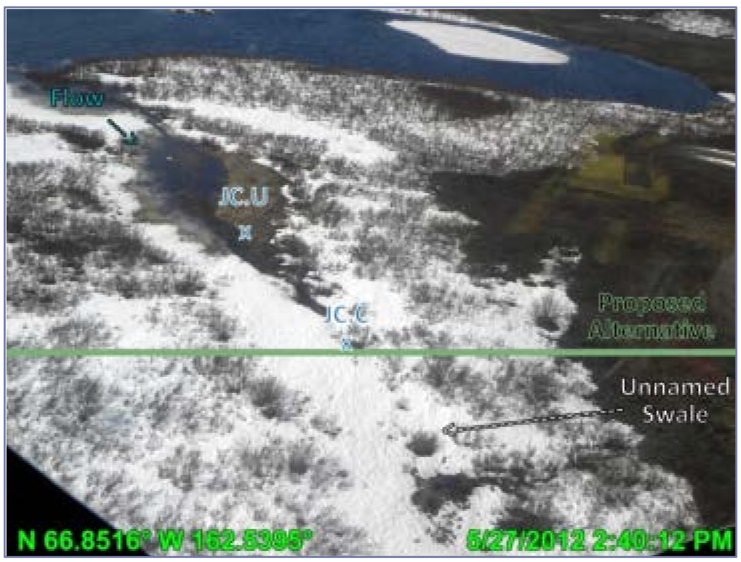



**PHOTO 4.16: PROPOSED UNNAMED SWALE CROSSING, LOOKING WEST; MAY 27, 2012**

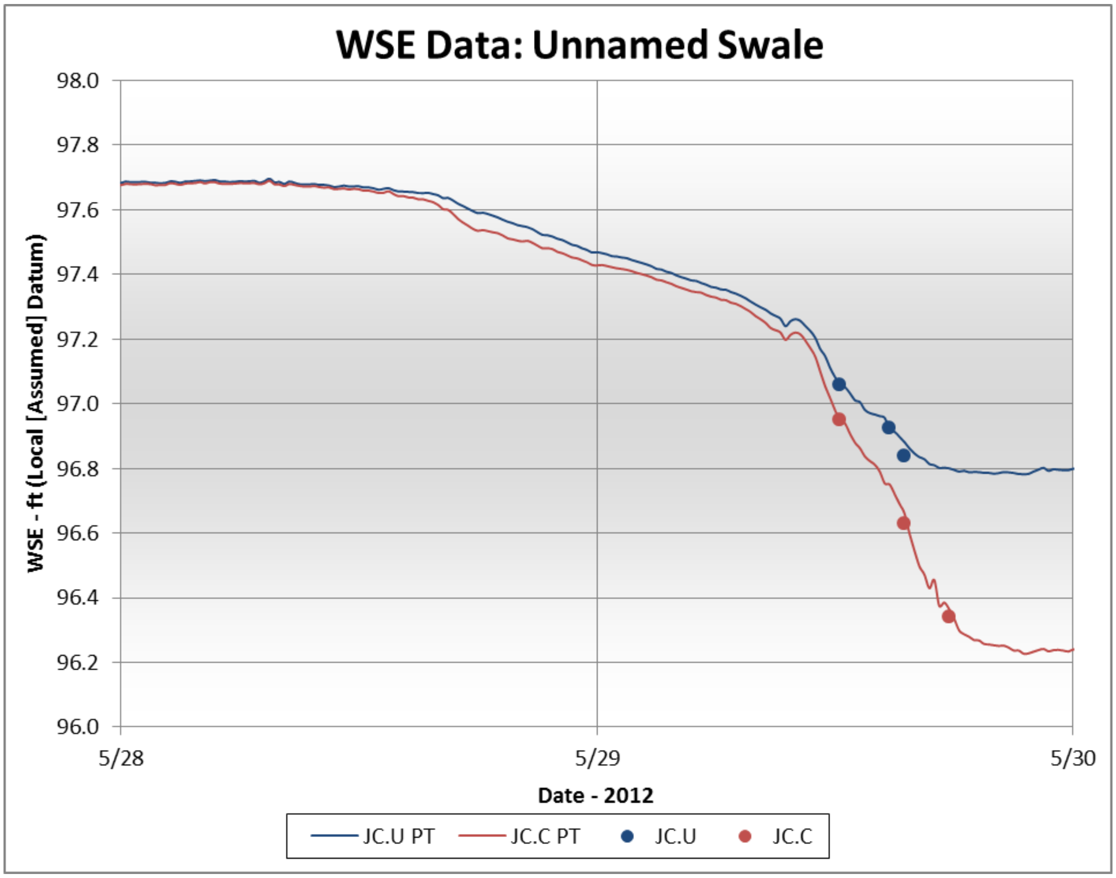

**PHOTO 4.17: PROPOSED UNNAMED SWALE CROSSING, LOOKING NORTHEAST; MAY 29, 2012**

**TABLE 4.4: STAGE DATA, JC GAGES**

| Date and Time | WSE (feet) | | Notes |
|---|---|---|---|
| | JC.U | JC.C | |
| 5/28/12 7:30 AM | 97.70 | 97.69 | **Peak stage;** based on PT data |
| 5/29/12 12:15 PM | 97.06 | 96.95 | |
| 5/29/12 2:45 PM | 96.92 | - | |
| 5/29/12 3:30 PM | 96.84 | 96.63 | |
| 5/29/12 5:45 PM | - | 96.34 | |

*Notes:*

1. Elevations are based on JC at 100.00 feet (local datum - assumed elevation) surveyed by Baker in 2012.
2. Local melt only through morning of May 28.
3. Only limited outflow was observed through the swale.




**GRAPH 4.4: STAGE DATA, JC GAGES**

# 5.0 DISCHARGE

Discharge was calculated at all monitoring locations using both direct and indirect methods. Measurements were performed at each site between May 24 and May 29 as close to peak stage as conditions allowed. Peak discharge through each crossing location was determined based on data collected during direct measurements and recorded stage values.

## 5.1 DIRECT DISCHARGE

Direct discharge measurements were performed as frequently as possible during peak stage conditions at each site. Data was collected using standard USGS techniques. Total discharge was determined by summing measurements in subsections along a cross-section, with the exception of SC2B. Flow at SC2B was conveyed over and through the snowpack instead of the natural channel, resulting in dynamic conditions impacting the accuracy of the discharge measurements. Total discharge for this location was determined using the continuity equation.

Measurements were collected by boat at SC1 and SC2A and by wading at SC2B and JC. Wind, ice, and snow in the channel and vegetation influenced the discharge measurements. Conditions at each location during direct discharge measurements are discussed in the following sections. Results are summarized in Table 5.1 and complete field data is included in 0.

### 5.1.1 SADIE CREEK 1 (SC1)

Direct discharge measurements were conducted at SC1 on May 24, 26, 27, and 28 near the centerline gaging location (SC1.C). The channel geometry at SC1.C was broad and shallow. Maximum measured top-width was 291 feet. Maximum measured depth was 4.4 feet. Large areas of ineffective flow covered both overbanks with the majority of flow being conveyed through the middle of the channel.

Conditions affecting discharge measurements were fairly consistent each day (Photo 5.1). A strong west wind persisted throughout the monitoring period and was strong enough to push the boat upstream of the tagline during each measurement. Direct discharge measurements were most likely impacted by the flow resistance induced by the wind, which varied in strength, and was weakest on May 26. The reach banks were free of snow prior to the first discharge measurement on May 24. Bottom-fast ice lined approximately half the channel cross section and remained in place during all discharge measurements. Bottom-fast ice began lifting upstream and downstream of the SC1.C on May 26. These floes gathered 0.5 RM upstream of SC1 and remained in place. No floes were in the vicinity of the crossing location during discharge measurements. No significant backwater effects were evident at SC1 as a result of downstream ice conditions.


**PHOTO 5.1: SC1 REACH UPSTREAM OF GAGES, LOOKING DOWNSTREAM; MAY 26, 2012**

### 5.1.2 Sadie Creek 2A (SC2A)

Direct discharge measurements were conducted at SC2A on May 25, 26, 27, and 28 near the centerline gaging location (SC2A.C). Maximum measured top-width was 162 feet. Maximum measured depth was 4.5 feet. Areas of ineffective flow covered both overbanks with the majority of flow being conveyed through the middle of the channel.

Conditions at SC2A were similar to SC1 and remained fairly consistent each day (Photo 5.2). Similar to SC1, wind resistance most likely had an impact on direct discharge measurements. The reach overbanks were free of snow for all direct discharge measurements. Bottom-fast ice was present along the profile, but was not continuous across the entire width. Ice was observed lifting off the channel bottom both upstream and downstream of SC2A on May 26, but bottom-fast ice was not observed lifting at SC2A.C. No floes were in the vicinity of the crossing location during measurements and no significant backwater effects were observed.


**PHOTO 5.2: SC2A REACH, LOOKING SOUTH; MAY 25, 2012**

### 5.1.3 SADIE CREEK 2B (SC2B)

Direct discharge measurements were conducted at SC2B on May 25 and 26 near the centerline gaging location (SC2B.C). As discussed, flow at this location moved on top of and through the snowpack (Photo 5.3 and Photo 5.4) for the duration of the monitoring period, gradually cutting a rectangular channel toward the natural bed. The geometry of the incised channel consistently changed, as did the gradient. Data was collected as conditions allowed and with regard to safety. Mean velocity was estimated from a single measurement from the center of the channel at 60% water depth from the surface. Cross-sectional area was determined using rough measurements of the width and depth of the channel, which was soft and saturated snow. Discharge was computed using the continuity equation (Equation 1) where Q is discharge, A is cross-sectional area, and V is velocity.

$$Q = A * V \qquad \text{(EQ 1)}$$

During the first measurement on May 25, the channel in the snowpack was approximately 5 feet wide and 2 feet deep. During the next morning's discharge measurement, the channel had incised approximately 3.5 feet into the snowpack, and was approximately 6.5 feet wide and 4 feet deep. Flow was non-laminar and the velocity across the entire cross section was high. An undetermined quantity of ineffective flow was contained within the surrounding snow. Flow eroded though the entire depth of the snowpack by May 27. On May 27, the majority of the flow was located under the snowpack as it connected with the natural channel, preventing discharge measurements.

The direct discharge measurements were compared to the SC1 and SC2A discharge measurements using a conservation of mass analysis (Equation 2) where:

$$Q_{SC1} = Q_{SC2A} * Q_{SC2B} \quad \text{(EQ 2)}$$

SC1 is downstream of the SC2A and SC2B bifurcation and because no other major tributaries are present between the monitoring locations, this provides a first order approximation for the reasonableness of the SC2B direct discharge measurements. Based on these results, the flow conditions, and the ability to access the incised channel, more confidence was placed on the May 25 direct discharge measurement than the May 26 measurement.


**PHOTO 5.3: SC2B CONDITIONS DURING DISCHARGE MEASUREMENT, LOOKING NORTHEAST; MAY 25, 2012**


**PHOTO 5.4: CONDITIONS UPSTREAM OF SC2B.U, LOOKING NORTH; MAY 26, 2012**

### 5.1.4 UNNAMED SWALE (JC)

Local melt was present under the snow at JC until flow was observed in the unnamed swale on May 29 (Photo 5.5). One discharge measurement was performed at the centerline gage location (JC.C).

Velocity was slow and the depth of water was low. Discharge was impacted by vegetation and snow in the channel.


**PHOTO 5.5: JC CONDITIONS BEFORE DISCHARGE MEASUREMENT, LOOKING DOWNSTREAM; MAY 29, 2012**

### 5.1.5 Direct Discharge Results

Table 5.1 summarizes the results of the direct discharge measurements performed during the 2012 breakup study.

**TABLE 5.1: DIRECT DISCHARGE MEASUREMENT RESULTS SUMMARY**

| Location | Date & Time | WSE[1,4] (ft) | Width (ft) | Area ($ft^2$) | Mean Velocity (ft/s) | Discharge (cfs) | Measurement Rating[2] | Meter Type | Number of Sections | Measurement Type |
|---|---|---|---|---|---|---|---|---|---|---|
| SC1 | 5/24/12 3:40 PM | 88.01[3] | 291 | 662 | 0.13 | 83 | Poor | Price AA | 29 | Boat |
| | 5/26/12 11:50 AM | 87.46 | 283 | 565 | 0.37 | 206 | Fair | Price AA | 30 | Boat |
| | 5/27/12 10:25 AM | 87.44 | 273 | 577 | 0.38 | **219** | Fair | Price AA | 30 | Boat |
| | 5/28/12 10:00 AM | 87.10 | 273 | 544 | 0.34 | 186 | Fair | Price AA | 30 | Boat |
| SC2A | 5/25/12 4:00 PM | 92.55 | 162 | 362 | 0.63 | **228** | Fair | Price AA | 18 | Boat |
| | 5/26/12 2:00 PM | 92.46 | 158 | 342 | 0.46 | 158 | Fair | Price AA | 17 | Boat |
| | 5/27/12 12:50 PM | 92.64 | 162 | 369 | 0.62 | 227 | Fair | Price AA | 34 | Boat |
| | 5/28/12 11:55 AM | 92.19 | 159 | 335 | 0.49 | 165 | Fair | Price AA | 22 | Boat |
| SC2B | 5/25/12 6:00 PM | 96.09 | 5 | 11 | 5.17 | 54 | Poor | Price AA | 1 | Wading |
| | 5/26/12 10:40 AM | 94.00 | 6.5 | 29 | 5.53 | **162** | Poor | Price AA | 1 | Wading |
| JC | 5/29/12 2:45 PM | 96.92 | 19 | 17 | 0.41 | **7** | Fair | Price AA | 20 | Wading |

1. Centerline WSE at start of measurement.
2. Measurement Rating:
   - E - Excellent: Point plots nearly on the rating curve; is within 2% of true value
   - G - Good: Within 5% of true value
   - F - Fair: Within 7-10% of true value
   - P - Poor: Velocity <0.70 ft/s; Shallow depth for measurement, less than 15% of true value
3. WSE measured at upstream gage.
4. Elevations are based on a local benchmark of an assumed datum.

## 5.2 Indirect Discharge

The slope-area method was used to calculate the indirect discharge at all locations. Equations used to estimate discharge through an open channel assume ideal conditions for a straight reach. Ideal conditions are represented by relative uniformity of physical characteristics through a reach, including cross sectional geometry, slope of the water surface, and channel roughness. Actual physical characteristics rarely represent ideal conditions..

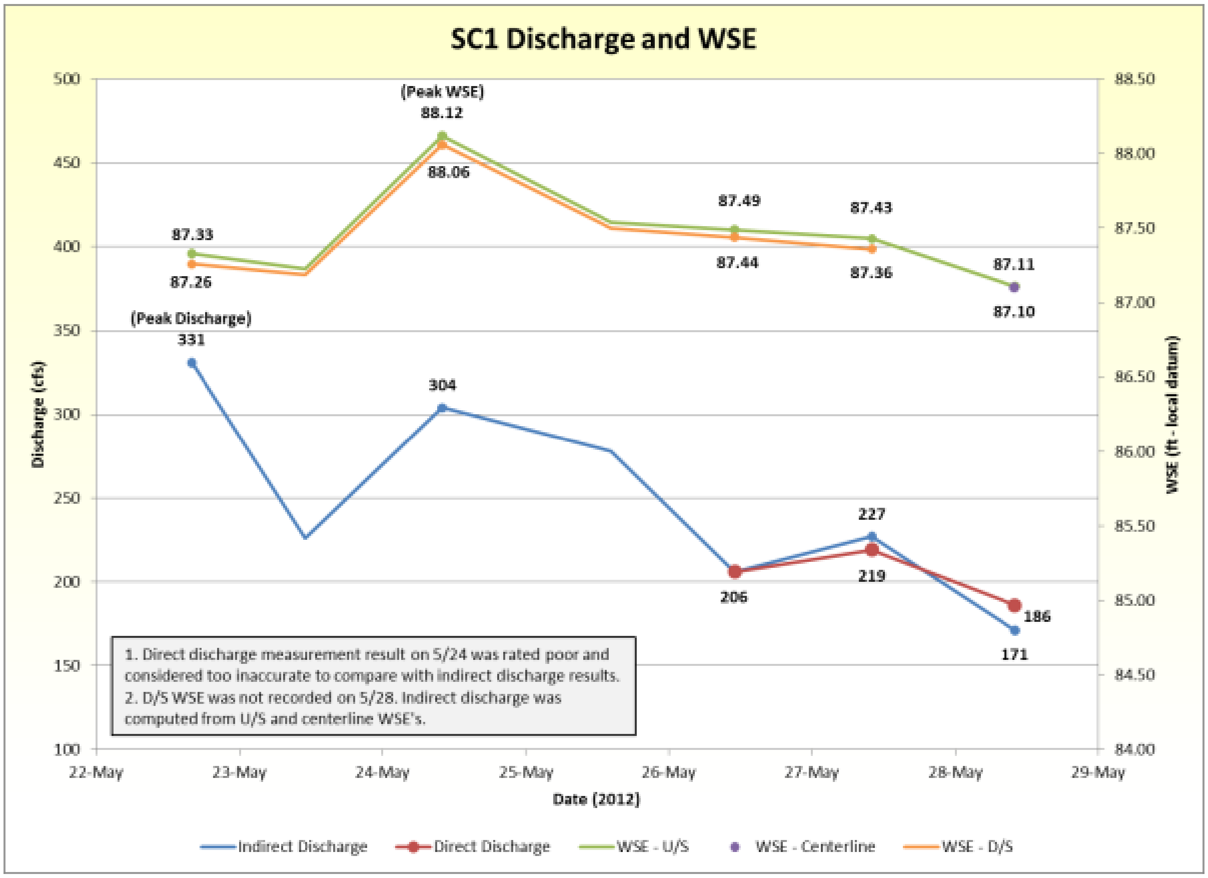
Calculations performed for peak flow at the stream crossings are based on data collected closest to the time of peak stage as possible to best represent peak discharge conditions. The presence and rapidly changing conditions of ice and snow in these streams during breakup flooding greatly affects actual discharge quantities. These effects were particularly apparent at the SC2B crossing location. In addition to energy losses due to the presence of snow and ice, additional losses in these streams are primarily attributable to factors such as strong winds, vegetation in the channel and overbanks, and irregularly shaped banks. The channel roughness was adjusted to calibrate the indirect discharge measurements and account for energy losses. The roughness was determined using cross section data and the slope of the water surface elevation at the time of direct discharge measurements. The slope of the water surface is assumed to represent the slope of the channel which is assumed to remain constant through the reach.

Physical data including WSE, cross sectional geometry, and factors contributing to energy losses were collected during direct discharge measurements and incorporated into the indirect discharge calculations. Indirect discharge calculations and results are discussed for the monitoring locations in the following sections.

### 5.2.1 Sadie Creek 1 (SC1)

Channel geometry and roughness from direct discharge measurements on May 26 were used to calibrate the indirect discharge calculations. The May 26 direct discharge measurement was considered the most accurate based on flow conditions, including wind impacts. Close agreement between the other direct discharge values and the indirect discharge values, with the exception of the May 24 direct discharge measurement, justifies using the May 26 calibration. The May 24 direct discharge measurement was heavily impacted by opposing winds and was considered too inaccurate to be included for comparison with indirect discharge results. Channel geometry, the presence of bottom-fast ice, and snow conditions along the banks remained relatively consistent through the monitoring period; therefore, the calibration was deemed applicable for all indirect discharge measurements. A comparison of direct and indirect discharge values and WSE at SC1 is shown in Graph 5.1.

Peak discharge at SC1 was calculated as 331 cfs, occurring on May 22.

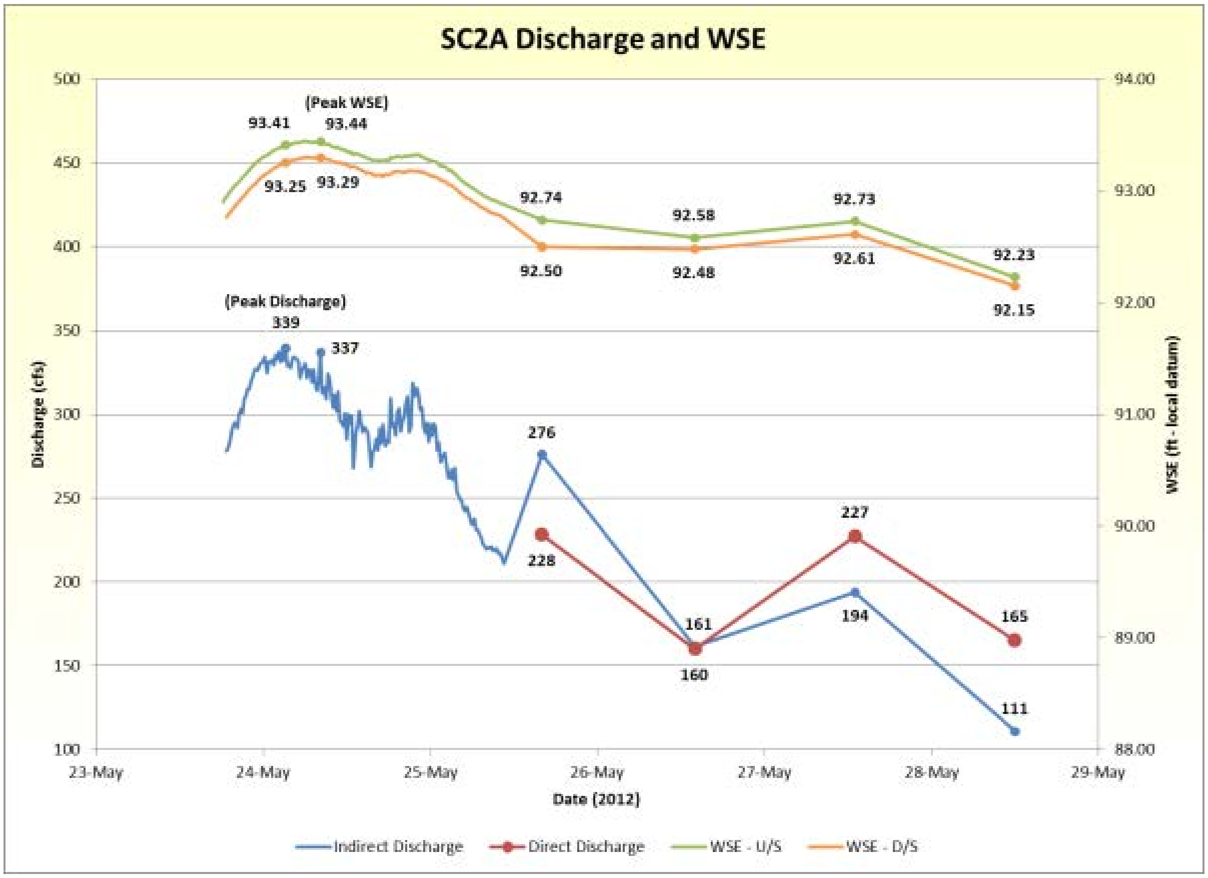



**GRAPH 5.1: SC1 DISCHARGE AND WSE**

### 5.2.2 Sadie Creek 2A (SC2A)

Channel geometry and roughness from direct discharge measurements on May 26 were used to calibrate the indirect discharge calculations. The May 26 direct discharge measurement was considered the most accurate based on flow conditions, including wind impacts. General agreement between the other direct discharge values and the indirect discharge values justifies using the May 26 calibration. Channel geometry, the presence of bottom-fast ice, and snow conditions along the banks remained relatively consistent through the monitoring period; therefore, the calibration was deemed applicable for all indirect discharge measurements. A comparison of direct and indirect discharge values and WSE at SC2A is shown in Graph 5.2.

Peak discharge at SC2A was calculated as 339 cfs, occurring on May 24.




**GRAPH 5.2: SC2A DISCHARGE AND WSE**

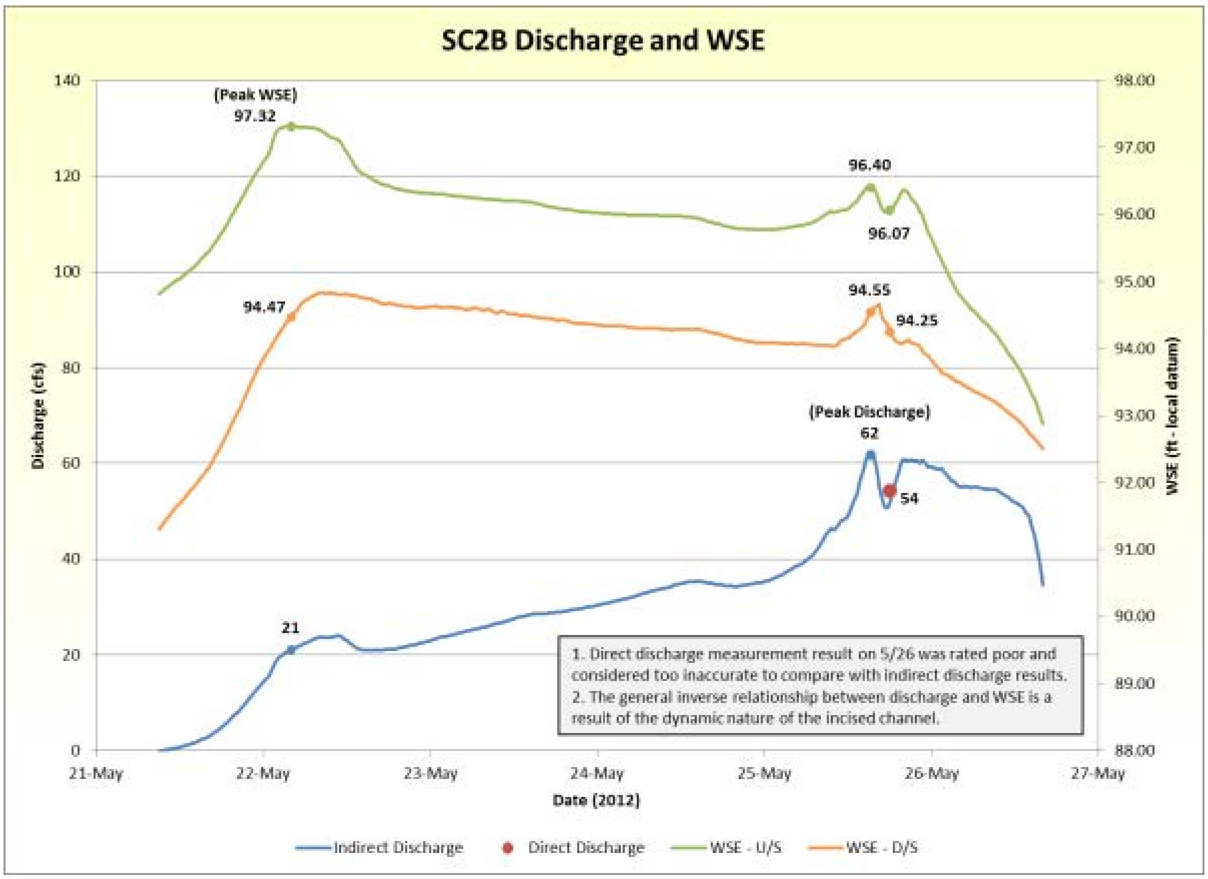
### 5.2.3 Sadie Creek 2B (SC2B)

SC2B consisted of an incised channel cut through the snow pack during most of the monitoring period. The channel deepened and widened as melt progressed, and as a result the measured cross section geometry only represented the incised channel at the time of measurement. The incised channel was bordered by a zone of saturated snow. For this analysis, percolating flow through the saturated snow was considered ineffective. Energy losses in the narrow deep channel were most likely dominated by the irregularities and the porosity of the snow banks rather than the bed roughness.

Indirect discharge computations prior to May 25 used the roughness determined from the May 25 direct discharge measurement and linearly extrapolated channel geometry. Indirect discharge computations between May 25 and May 26 used a linearly interpolated roughness and channel geometry by holding the May 26 measured channel geometry and using the difference between the SC1 and SC2A discharge on May 26 as an approximate discharge for SC2B.

A comparison of direct and indirect discharge values at SC2B is shown in Graph 5.3. The dynamic nature of the incised channel at SC2B resulted in an inverse relationship between the discharge and the WSE. As snow melt progressed and discharge increased, the widening and deepening of the channel caused the WSE to decrease. The May 26 direct discharge measurement was considered too inaccurate to be included for comparison with indirect discharge results. The single velocity measurement in the widening channel resulted in an overestimate of discharge.

Peak discharge at SC2B was determined to be 62 cfs, occurring on May 25. This value was the result of indirect discharge computations based on coarse direct discharge measurements. It is presented as a first order approximation and should be evaluated in terms of conditions at the time of measurement.

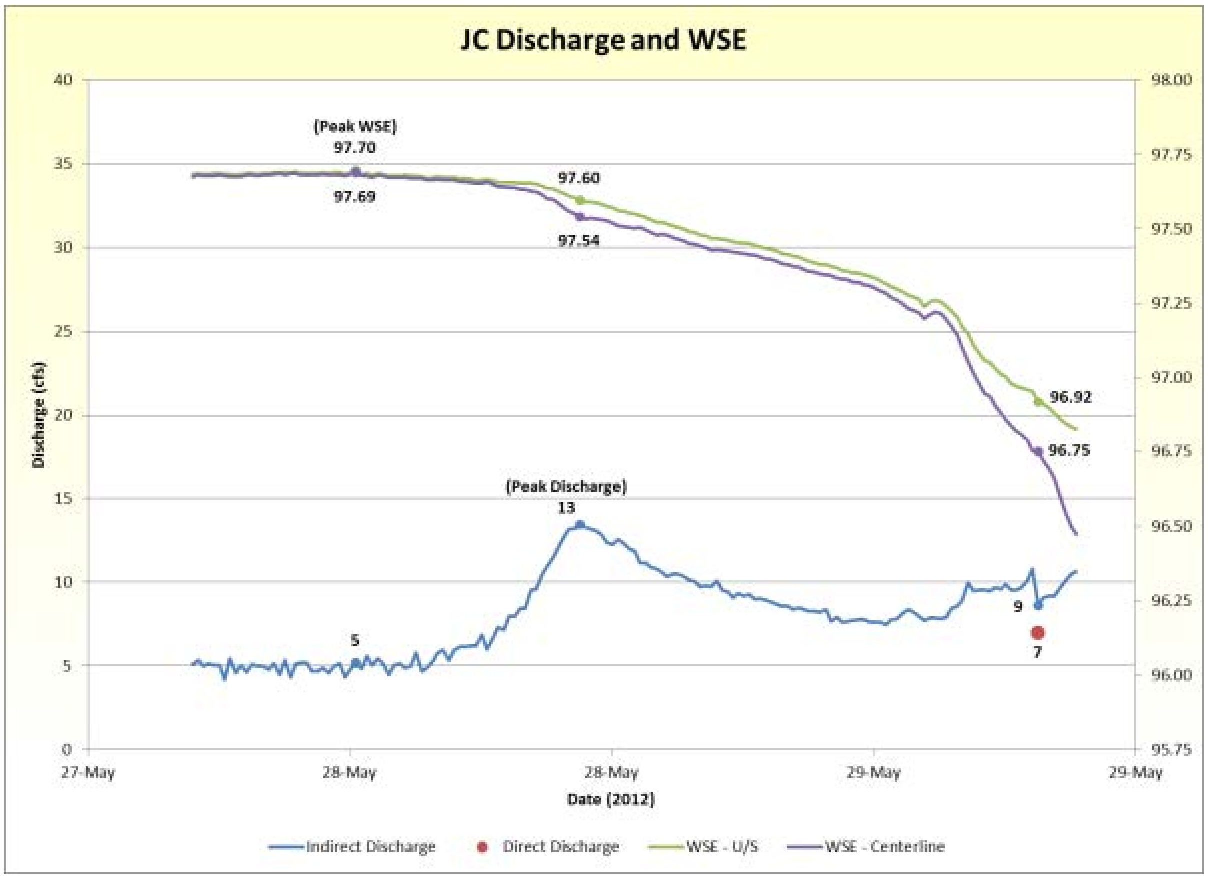



**GRAPH 5.3: SC2B DISCHARGE AND WSE**

### 5.2.4 UNNAMED SWALE (JC)

Flow at this location was the result of local melting and draining of ponded water in the gage vicinity. Measureable flow was only observed on May 29, and one direct discharge measurement was performed. Channel geometry and roughness from the measurement were used to calibrate the indirect discharge calculations. Discontinuous snow, ice, and vegetation were present in the channel during the direct discharge measurement. These conditions are considered representative of the swale for indirect discharge calculations.

A comparison of direct and indirect discharge values and WSE at JC is shown in Graph 5.4. Peak discharge at JC was calculated as 13 cfs, occurring on May 28.




**GRAPH 5.4: JC DISCHARGE AND WSE**

## 5.3 Peak Discharge Results

Table 5.2 summarizes the results of peak discharge through all crossing locations investigated for the 2012 spring breakup study. All peak discharge values are the result of indirect calculations.

**TABLE 5.2: PEAK DISCHARGE SUMMARY**

| Location | Date & Time | WSE[1] (ft) | | | Discharge[2] (cfs) | Cross-Sectional Area (ft$^2$) | Mean Velocity (ft/s) |
|---|---|---|---|---|---|---|---|
| | | U/S | Centerline[3] | D/S | | | |
| SC1 | 5/22/12 4:00 PM | 87.33 | 87.30 | 87.26 | 331 | 535 | 0.62 |
| SC2A | 5/24/12 3:15 AM | 93.41 | 93.33 | 93.25 | 339 | 490 | 0.69 |
| SC2B | 5/25/12 3:15 PM | 96.40 | 95.48 | 94.55 | 62 | 29 | 5.20 |
| JC | 5/28/12 5:45 PM | 97.60 | 97.54 | - | 13 | 30 | 0.44 |

[1] Elevations are based on a local benchmark of an assumed datum; WSE at the time of peak discharge.

[2] Discharge is based on slope of WSE between U/S and D/S gages; U/S and centerline gages at JC.

[3] WSE's at SC1, SC2A, and SC2B centerline gages are averages between U/S and D/S WSE's.

# 6.0 CONCLUSIONS AND RECOMMENDATIONS

Spring breakup at all crossing locations was characterized by relatively low flow. The overbanks were inundated with predominantly ineffective flow, with the majority of flow being conveyed through the thalweg of each channel. At all locations except SC2B, velocities were slow. Considering the floodwater volumes conveyed and associated top-widths of Sadie Creek, a bridge is recommended where the proposed road crosses it at both SC1 along Option 1 and SC2A along Option 2. A culvert, or set of culverts, could convey the observed flow at SC2B along Option 2, but ensuring the functionality of the intended design could be challenging for this crossing location, considering the migration of floodwaters down through the snowpack. A culvert, or set of culverts, is recommended where the proposed road crosses the unnamed swale.

The spring breakup discharge values are much lower than those estimated for Sadie Creek in the *Kotzebue to Cape Blossom Road Reconnaissance Study* (DOT&PF 2011). The study included estimated discharge values for return periods ranging from 2 years to 500 years. The 2-year flood event has an estimated discharge of 668 cfs, which is 1.97 times greater than the 2012 spring breakup peak discharge of 339 cfs. The comparison reinforces the conclusion that the 2012 spring breakup experienced low discharge.

# 7.0 REFERENCES

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# Appendix A 2012 Gage Locations and Vertical Control

| 2012 Gage Locations | | | | |
|---|---|---|---|---|
| **Gage Site** | **Gage** | **Latitude (NAD83)** | **Longitude (NAD83)** | **Basis of Elevation** |
| **Sadie Creek 1** | | | | |
| Upstream | SC1.U-A1 | N 66.81750° | W 162.50974° | SC1 |
| | SC1.U-A | N 66.81760° | W 162.50997° | |
| | SC1.U-B | N 66.81762° | W 162.51004° | |
| | SC1.U-C | N 66.81764° | W 162.51007° | |
| | SC1.U-PT[1] | N 66.81755° | W 162.50983° | |
| Centerline | SC1.C-A | N 66.81709° | W 162.51267° | SC1 |
| | SC1.C-B | N 66.81713° | W 162.51264° | |
| | SC1.C-C | N 66.81721° | W 162.51259° | |
| | SC1.C-D[2] | N 66.81726° | W 162.51257° | |
| Downstream | SC1.D-A | N 66.81503° | W 162.51791° | SC1 |
| | SC1.D-B | N 66.81508° | W 162.51836° | |
| | SC1.D-C | N 66.81508° | W 162.51842° | |
| | SC1.D-D | N 66.81506° | W 162.51845° | |
| | SC1.D-PT[1] | N 66.81504° | W 162.51788° | |
| **Sadie Creek 2A** | | | | |
| Upstream | SC2A.U-A | N 66.81342° | W 162.46252° | SC2A |
| | SC2A.U-B | N 66.81351° | W 162.46250° | |
| | SC2A.U-PT[1] | N 66.81340° | W 162.46253° | |
| Centerline | SC2A.C-A | N 66.81349° | W 162.46614° | SC2A |
| | SC2A.C-B | N 66.81361° | W 162.46599° | |
| | SC2A.C-C | N 66.81369° | W 162.46587° | |
| Downstream | SC2A.D-A1 | N 66.81369° | W 162.46941° | SC2A |
| | SC2A.D-A | N 66.81376° | W 162.46948° | |
| | SC2A.D-B | N 66.81379° | W 162.46947° | |
| | SC2A.D-C | N 66.81382° | W 162.46950° | |
| | SC2A.D-PT[1] | N 66.81376° | W 162.46942° | |
| **Sadie Creek 2B** | | | | |
| Upstream | SC2B.U-A[3] | N 66.82285° | W 162.46730° | SC2B |
| | SC2B.U-B | N 66.82286° | W 162.46731° | |
| Centerline | SC2B.C-A | N 66.82256° | W 162.46744° | SC2B |
| | SC2B.C-B | N 66.82257° | W 162.46750° | |
| Downstream | SC2B.D-A[3] | N 66.82226° | W 162.46753° | SC2B |
| | SC2B.D-B | N 66.82227° | W 162.46756° | |
| **Unnamed Swale** | | | | |
| Upstream | JC.U-A[3] | N 66.85139° | W 162.54061° | JC |
| | JC.U-B | N 66.85141° | W 162.54073° | |
| Centerline | JC.C-A[3] | N 66.85154° | W 162.54006° | JC |
| | JC.C-B[4] | N 66.85169° | W 162.54023° | |

[1] Pressure transducer on angle iron
[2] Barologger on top of gage
[3] Pressure transducer on bottom of gage
[4] Angle iron without gage

| 2012 Vertical Control | | | | | |
|---|---|---|---|---|---|
| **Control** | **Elevation[1]** | **Latitude (NAD83)** | **Longitude (NAD83)** | **Control Type** | **Reference** |
| JC | 100.00 | N 66.85173° | W 162.54024° | Rebar | Baker 2012 |
| SC1 | 100.00 | N 66.81744° | W 162.51260° | Rebar | Baker 2012 |
| SC2A | 100.00 | N 66.81385° | W 162.46576° | Rebar | Baker 2012 |
| SC2B | 100.00 | N 66.82269° | W 162.46822° | Rebar | Baker 2012 |

[1] Elevations are based on a local benchmark of an assumed datum.

# Appendix B DISCHARGE MEASUREMENT NOTES

Baker

# Discharge Measurement Notes

Date: May 24, 2012
Computed By: SMC
Checked By: WAB

Location Name: Sadie Creek 1

Party: SMC, WAB    Start: 3:40 PM    Finish: 4:50 PM

Temp: 35 °F    Weather: Foggy, 25-35mph west winds

**Channel Characteristics:**

Width: 291 ft    Area: 662 sq ft    Velocity: 0.13 fps    Discharge: 83 cfs

Method: 0.6 & 0.8/0.2    Number of Sections: 29    Count: various

Spin Test: - revolutions after - seconds    Meter: Price AA

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading    Cable    Ice    **Boat**

**Upstream** or Downstream side of bridge

| GAGE READINGS | | | |
|---|---|---|---|
| Gage | Start | Finish | Change |
| U/S A-1 | 0.78 | 0.74 | -0.04 |
| | | | |
| | | | |
| | | | |
| | | | |

**GPS Data:**

| | | | | |
|---|---|---|---|---|
| Left Edge of Water: | N | 66 ° | 48 ' | 58.6 " |
| | W | 162 ° | 30 ' | 37.6 " |
| Right Edge of Water: | N | 66 ° | 49 ' | 1.2 " |
| | W | 162 ° | 30 ' | 41.2 " |

LE Floodplain: ° ' "

RE Floodplain: ° ' "

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

**Descriptions:**

Cross Section: Good cross section, not a lot of abrupt changes in depth, snow/ice out to 40' (approx 25' past right edge of water)

Flow: Little to no flow in overbank areas both sides, waves moving u/s due to wind, capping. Meter is changing large angles due to movement of the boat and little to no flow in overbanks.

Remarks: Shallow gradient, low velocities; a 20 knot west (u/s) wind pushing boat u/s of tagline, likely affecting flow.

**SC1**
**May 24, 2012**

| Angle Coeff | Distance from initial point | Section Width | Water Depth | Observed Depth | Revolution Count | Time Increment | VELOCITY | | | Area | Discharge |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | At Point | Mean in Vertical | Adjusted for Angle Coeff | | |
| | (ft) | (ft) | (ft) | (%) | | (sec) | (fps) | (fps) | (fps) | (s.f.) | (cfs) |
| | | | REW @ 3:40 PM | | | | | | | | |
| -- | 14 | 3.0 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0 | 0 |
| -- | 20 | 8.0 | 1.4 | 0.6 | 0 | 40 | 0 | 0 | 0 | 11.2 | 0 |
| -- | 30 | 10.0 | 1.9 | 0.6 | 0 | 40 | 0 | 0 | 0 | 19.0 | 0 |
| -- | 40 | 10.0 | 2.7 | 0.6 | 0 | 40 | 0 | 0 | 0 | 27.0 | 0 |
| -- | 50 | 10.0 | 2.0 | 0.6 | 0 | 40 | 0 | 0 | 0 | 20.0 | 0 |
| -- | 60 | 10.0 | 2.1 | 0.6 | 0 | 40 | 0 | 0 | 0 | 21.0 | 0 |
| -- | 70 | 10.0 | 2.3 | 0.6 | 0 | 40 | 0 | 0 | 0 | 23.0 | 0 |
| -- | 80 | 10.0 | 2.5 | 0.6 | 0 | 40 | 0 | 0 | 0 | 25.0 | 0 |
| -- | 90 | 10.0 | 3.8 | 0.8<br>0.2 | 0<br>0 | 40<br>40 | 0<br>0 | 0 | 0 | 38.0 | 0 |
| -- | 100 | 10.0 | 3.6 | 0.8<br>0.2 | 0<br>0 | 40<br>40 | 0<br>0 | 0 | 0 | 36.0 | 0 |
| -- | 110 | 10.0 | 4.0 | 0.8<br>0.2 | 0<br>0 | 40<br>40 | 0<br>0 | 0 | 0 | 40.0 | 0 |
| -- | 120 | 10.0 | 4.1 | 0.8<br>0.2 | 0<br>0 | 40<br>40 | 0<br>0 | 0 | 0 | 41.0 | 0 |
| -- | 130 | 10.0 | 3.8 | 0.8<br>0.2 | 0<br>0 | 40<br>40 | 0<br>0 | 0 | 0 | 38.0 | 0 |
| 0.99 | 140 | 10.0 | 3.2 | 0.8<br>0.2 | 5<br>10 | 60<br>40 | 0.20<br>0.57 | 0.39 | 0.38 | 32.0 | 12.21 |
| 0.99 | 150 | 10.0 | 3.1 | 0.8<br>0.2 | 10<br>15 | 50<br>40 | 0.46<br>0.84 | 0.65 | 0.65 | 31.0 | 20.00 |
| 0.99 | 160 | 10.0 | 3.0 | 0.8<br>0.2 | 7<br>15 | 40<br>45 | 0.40<br>0.75 | 0.58 | 0.57 | 30.0 | 17.17 |
| 0.98 | 170 | 10.0 | 3.3 | 0.8<br>0.2 | 7<br>10 | 46<br>40 | 0.35<br>0.57 | 0.46 | 0.45 | 33.0 | 14.91 |
| 0.96 | 180 | 10.0 | 2.4 | 0.6 | 7 | 40 | 0.40 | 0.40 | 0.39 | 24.0 | 9.30 |
| 0.7 | 190 | 10.0 | 2.5 | 0.6 | 3 | 70 | 0.11 | 0.11 | 0.08 | 25.0 | 1.97 |
| 0.7 | 200 | 10.0 | 1.8 | 0.6 | 3 | 40 | 0.18 | 0.18 | 0.13 | 18.0 | 2.31 |
| 0.7 | 210 | 10.0 | 1.6 | 0.6 | 3 | 90 | 0.09 | 0.09 | 0.06 | 16.0 | 1.02 |
| 0.94 | 220 | 10.0 | 1.5 | 0.6 | 3 | 40 | 0.18 | 0.18 | 0.17 | 15.0 | 2.58 |
| 0.4 | 230 | 10.0 | 1.5 | 0.6 | 3 | 60 | 0.13 | 0.13 | 0.05 | 15.0 | 0.77 |
| 0.4 | 240 | 10.0 | 1.5 | 0.6 | 3 | 40 | 0.18 | 0.18 | 0.07 | 15.0 | 1.10 |
| -- | 250 | 10.0 | 1.5 | 0.6 | 0 | 40 | 0 | 0 | 0 | 15.0 | 0 |
| -- | 260 | 10.0 | 1.4 | 0.6 | 0 | 40 | 0 | 0 | 0 | 14.0 | 0 |
| -- | 270 | 10.0 | 1.4 | 0.6 | 0 | 40 | 0 | 0 | 0 | 14.0 | 0 |
| -- | 280 | 17.5 | 1.5 | 0.6 | 0 | 40 | 0 | 0 | 0 | 26.3 | 0 |
| -- | 305 | 12.5 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0 | 0 |
| | | | LEW @ 4:50 PM | | | | | | | | |

**Total Discharge:** **83.34** cfs

Baker

# Discharge Measurement Notes

Date: May 26, 2012
Computed By: SMC
Checked By: WAB

Location Name: Sadie Creek 1

Party: WAB, VJ    Start: 11:50 AM    Finish: 1:00 PM

Temp: 35-40 °F    Weather: Clear, Windy

**Channel Characteristics:**

Width: 283 ft    Area: 565 sq ft    Velocity: 0.37 fps    Discharge: 206 cfs

Method: 0.6 & 0.2/0.8    Number of Sections: 30    Count: various

Spin Test: - revolutions after - seconds    Meter: Price AA

| GAGE READINGS | | | |
|---|---|---|---|
| Gage | Start | Finish | Change |
| Centerline Survey | 87.46 | 87.38 | -0.08 |
| | | | |
| | | | |
| | | | |
| | | | |

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading    Cable    Ice    Boat

Upstream    or    Downstream    side of bridge

**GPS Data:**

| | | | | |
|---|---|---|---|---|
| Left Edge of | N | 66 ° | 48 ' | 58.6 " |
| Water: | W | 162 ° | 30 ' | 37.6 " |
| Right Edge of | N | 66 ° | 49 ' | 1.2 " |
| Water: | W | 162 ° | 30 ' | 41.2 " |

LE Floodplain: ° ' . "

RE Floodplain: ° ' . "

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

**Descriptions:**

Cross Section: Gradual changes in depth

Flow: Little to no flow in overbanks areas; stronger flow in the deeper, central part of the channel

Remarks: Strong wind blowing upstream; pushing boat upstream of tagline and potentially affecting flow (low velocities, shallow gradient). Grass in channel sometimes affecting flow measurements

**SC1**
**May 26, 2012**

| Angle Coeff | Distance from initial point (ft) | Section Width (ft) | Water Depth (ft) | Observed Depth (%) | Revolution Count | Time Increment (sec) | VELOCITY | | | Area (s.f.) | Discharge (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | At Point (fps) | Mean in Vertical (fps) | Adjusted for Angle Coeff (fps) | | |
| REW @ 11:50 AM | | | | | | | | | | | |
| -- | 1 | 4.5 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0 | 0 |
| 0.2 | 10 | 9.5 | 1.3 | 0.6 | 3 | 45 | 0.16 | 0.16 | 0.03 | 12.4 | 0.41 |
| 0.75 | 20 | 10.0 | 1.9 | 0.6 | 5 | 44 | 0.27 | 0.27 | 0.20 | 19.0 | 3.82 |
| 0.96 | 30 | 10.0 | 2.2 | 0.6 | 5 | 55 | 0.22 | 0.22 | 0.21 | 22.0 | 4.61 |
| 0.92 | 40 | 10.0 | 1.5 | 0.6 | 3 | 45 | 0.16 | 0.16 | 0.15 | 15.0 | 2.27 |
| 0.96 | 50 | 10.0 | 1.7 | 0.6 | 3 | 40 | 0.18 | 0.18 | 0.18 | 17.0 | 2.99 |
| 0.99 | 60 | 10.0 | 1.9 | 0.6 | 7 | 50 | 0.33 | 0.33 | 0.32 | 19.0 | 6.14 |
| 1 | 70 | 10.0 | 2.6 | 0.6 | 10 | 45 | 0.51 | 0.51 | 0.51 | 26.0 | 13.20 |
| 1 | 80 | 10.0 | 3.7 | 0.8<br>0.2 | 10<br>15 | 45<br>57 | 0.51<br>0.60 | 0.55 | 0.55 | 37.0 | 20.46 |
| 1 | 90 | 10.0 | 3.5 | 0.8<br>0.2 | 10<br>15 | 53<br>51 | 0.43<br>0.67 | 0.55 | 0.55 | 35.0 | 19.25 |
| 0.98 | 100 | 10.0 | 3.8 | 0.8<br>0.2 | 7<br>15 | 40<br>55 | 0.40<br>0.62 | 0.51 | 0.50 | 38.0 | 19.04 |
| 0.98 | 110 | 10.0 | 3.6 | 0.8<br>0.2 | 10<br>15 | 40<br>48 | 0.57<br>0.71 | 0.64 | 0.63 | 36.0 | 22.51 |
| 0.96 | 120 | 10.0 | 3.4 | 0.8<br>0.2 | 10<br>15 | 50<br>55 | 0.46<br>0.62 | 0.54 | 0.52 | 34.0 | 17.59 |
| 0.98 | 130 | 10.0 | 3.3 | 0.8<br>0.2 | 10<br>10 | 44<br>40 | 0.52<br>0.57 | 0.54 | 0.53 | 33.0 | 17.59 |
| 0.99 | 140 | 10.0 | 3.2 | 0.8<br>0.2 | 10<br>10 | 47<br>40 | 0.49<br>0.57 | 0.53 | 0.52 | 32.0 | 16.73 |
| 0.96 | 150 | 10.0 | 3.2 | 0.8<br>0.2 | 10<br>10 | 53<br>41 | 0.43<br>0.56 | 0.49 | 0.47 | 32.0 | 15.20 |
| 0.92 | 160 | 10.0 | 2.7 | 0.6 | 10 | 47 | 0.49 | 0.49 | 0.45 | 27.0 | 12.09 |
| 0.9 | 170 | 10.0 | 2.1 | 0.6 | 7 | 47 | 0.35 | 0.35 | 0.31 | 21.0 | 6.54 |
| 0.9 | 180 | 10.0 | 1.4 | 0.6 | 5 | 46 | 0.26 | 0.26 | 0.23 | 14.0 | 3.24 |
| 0.9 | 190 | 10.0 | 1.4 | 0.6 | 3 | 88 | 0.09 | 0.09 | 0.08 | 14.0 | 1.17 |
| 0.9 | 200 | 10.0 | 1.2 | 0.6 | 0 | 40 | 0 | 0 | 0 | 12.0 | 0 |
| -- | 210 | 10.0 | 1.0 | 0.6 | 0 | 40 | 0 | 0 | 0 | 10.0 | 0 |
| 1 | 220 | 10.0 | 1.0 | 0.6 | 3 | 90 | 0.09 | 0.09 | 0.09 | 10.0 | 0.91 |
| -- | 230 | 10.0 | 1.0 | 0.6 | 0 | 40 | 0 | 0 | 0 | 10.0 | 0 |
| 1 | 240 | 10.0 | 1.0 | 0.6 | 2 | 100 | 0.06 | 0.06 | 0.06 | 10.0 | 0.62 |
| -- | 250 | 10.0 | 1.0 | 0.6 | 0 | 40 | 0 | 0 | 0 | 10.0 | 0 |
| -- | 260 | 10.0 | 1.0 | 0.6 | 0 | 40 | 0 | 0 | 0 | 10.0 | 0 |
| -- | 270 | 10.0 | 1.0 | 0.6 | 0 | 40 | 0 | 0 | 0 | 10.0 | 0 |
| -- | 280 | 6.8 | 0.5 | 0.6 | 0 | 40 | 0 | 0 | 0 | 3.0 | 0 |
| -- | 283.5 | 1.8 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0.0 | 0 |
| LEW @ 1:00 PM | | | | | | | | | | | |

**Total Discharge:** **206.39** cfs

Baker

# Discharge Measurement Notes

Date: May 27, 2012
Computed By: SMC
Checked By: WAB

Location Name: Sadie Creek 1

Party: WAB, VJ    Start: 10:25 AM    Finish: 11:45 AM

Temp: 35-40 °F    Weather: 5-10 MPH west wind; Clear

**Channel Characteristics:**

Width: 273 ft    Area: 577 sq ft    Velocity: 0.38 fps    Discharge: 219 cfs

Method: 0.6 & 0.2/0.8    Number of Sections: 30    Count: various

Spin Test: - revolutions after - seconds    Meter: Price AA

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading  Cable  Ice  **Boat**

**Upstream** or Downstream side of bridge

| GAGE READINGS | | | |
|---|---|---|---|
| Gage | Start | Finish | Change |
| Centerline Survey | 87.436 | 87.413 | -0.02 |
| | | | |
| | | | |
| | | | |
| | | | |

**GPS Data:**

| | | | | |
|---|---|---|---|---|
| Left Edge of Water: | N | 66 ° | 48 ' | 58.6 " |
| | W | 162 ° | 30 ' | 37.6 " |
| Right Edge of Water: | N | 66 ° | 49 ' | 1.2 " |
| | W | 162 ° | 30 ' | 41.2 " |

LE Floodplain: ° ' . "

RE Floodplain: ° ' . "

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

**Descriptions:**

Cross Section: Gradual changes in depth, bottomfast ice 12'-150' along stationing

Flow: Ripples in main channel, no flow in overbanks

Remarks: Shallow gradient, low velocities; wind blows/maintains boat u/s of tagline

**SC1**
**May 27, 2012**

| Angle Coeff | Distance from initial point (ft) | Section Width (ft) | Water Depth (ft) | Observed Depth (%) | Revolution Count | Time Increment (sec) | VELOCITY At Point (fps) | VELOCITY Mean in Vertical (fps) | VELOCITY Adjusted for Angle Coeff (fps) | Area (s.f.) | Discharge (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | REW @ 10:25 AM | | | | | | | | |
| -- | 10 | 2.5 | 1.3 | 0.6 | 0 | 40 | 0 | 0 | 0 | 3.3 | 0 |
| 0.4 | 15 | 5.0 | 1.3 | 0.6 | 3 | 72 | 0.11 | 0.11 | 0.04 | 6.5 | 0.29 |
| 0.94 | 20 | 7.5 | 1.4 | 0.6 | 5 | 57 | 0.21 | 0.21 | 0.20 | 10.5 | 2.08 |
| 0.94 | 30 | 10.0 | 2.5 | 0.6 | 5 | 62 | 0.20 | 0.20 | 0.18 | 25.0 | 4.60 |
| 0.98 | 40 | 10.0 | 2.6 | 0.6 | 5 | 54 | 0.22 | 0.22 | 0.22 | 26.0 | 5.66 |
| 0.5 | 50 | 10.0 | 1.4 | 0.6 | 3 | 72 | 0.11 | 0.11 | 0.05 | 14.0 | 0.77 |
| 0.85 | 60 | 10.0 | 1.7 | 0.6 | 7 | 48 | 0.34 | 0.34 | 0.29 | 17.0 | 4.90 |
| 0.92 | 70 | 10.0 | 1.9 | 0.6 | 10 | 49 | 0.47 | 0.47 | 0.43 | 19.0 | 8.18 |
| 0.98 | 80 | 10.0 | 2.8 | 0.8<br>0.2 | 10 | 50 | 0.46 | 0.46 | 0.45 | 28.0 | 12.59 |
| 0.98 | 90 | 10.0 | 4.2 | 0.8<br>0.2 | 10<br>15 | 47<br>50 | 0.49<br>0.68 | 0.58 | 0.57 | 42.0 | 24.00 |
| 0.98 | 100 | 10.0 | 3.8 | 0.8<br>0.2 | 10<br>20 | 40<br>57 | 0.57<br>0.79 | 0.68 | 0.67 | 38.0 | 25.33 |
| 0.96 | 110 | 10.0 | 4.2 | 0.8<br>0.2 | 10<br>15 | 41<br>41 | 0.56<br>0.82 | 0.69 | 0.66 | 42.0 | 27.82 |
| 0.99 | 120 | 10.0 | 3.5 | 0.8<br>0.2 | 10<br>15 | 50<br>45 | 0.46<br>0.75 | 0.61 | 0.60 | 35.0 | 20.99 |
| 0.9 | 130 | 10.0 | 3.5 | 0.8<br>0.2 | 10<br>10 | 46<br>40 | 0.50<br>0.57 | 0.53 | 0.48 | 35.0 | 16.79 |
| 0.9 | 140 | 10.0 | 3.7 | 0.8<br>0.2 | 10<br>15 | 44<br>55 | 0.52<br>0.62 | 0.57 | 0.51 | 37.0 | 18.95 |
| 0.9 | 150 | 10.0 | 3.6 | 0.8<br>0.2 | 10<br>20 | 46<br>59 | 0.50<br>0.77 | 0.63 | 0.57 | 36.0 | 20.45 |
| 0.85 | 160 | 10.0 | 2.8 | 0.6 | 10 | 46 | 0.50 | 0.50 | 0.42 | 28.0 | 11.83 |
| 0.85 | 170 | 10.0 | 2.1 | 0.6 | 15 | 70 | 0.49 | 0.49 | 0.42 | 21.0 | 8.75 |
| 0.85 | 180 | 10.0 | 1.6 | 0.6 | 5 | 46 | 0.26 | 0.26 | 0.22 | 16.0 | 3.50 |
| 0.85 | 190 | 10.0 | 1.3 | 0.6 | 3 | 80 | 0.10 | 0.10 | 0.09 | 13.0 | 1.11 |
| 1 | 200 | 10.0 | 1.1 | 0.6 | 3 | 90 | 0 | 0 | 0 | 11.0 | 0 |
| -- | 210 | 10.0 | 1.0 | 0.6 | 0 | 40 | 0 | 0 | 0 | 10.0 | 0 |
| -- | 220 | 10.0 | 1.0 | 0.6 | 0 | 90 | 0 | 0 | 0 | 10.0 | 0 |
| 1 | 230 | 10.0 | 1.0 | 0.6 | 3 | 100 | 0.08 | 0.08 | 0.08 | 10.0 | 0.84 |
| -- | 240 | 10.0 | 1.1 | 0.6 | 0 | 100 | 0 | 0 | 0 | 11.0 | 0 |
| -- | 250 | 10.0 | 1.0 | 0.6 | 0 | 40 | 0 | 0 | 0 | 10.0 | 0 |
| -- | 260 | 10.0 | 1.0 | 0.6 | 0 | 40 | 0 | 0 | 0 | 9.5 | 0 |
| -- | 270 | 10.0 | 0.9 | 0.6 | 0 | 40 | 0 | 0 | 0 | 9.0 | 0 |
| -- | 280 | 6.5 | 0.6 | 0.6 | 0 | 40 | 0 | 0 | 0 | 3.8 | 0 |
| -- | 283 | 1.5 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0.0 | 0 |
| | | | LEW @ 11:45 PM | | | | | | | | |

**Total Discharge:** **219.42** cfs

Baker

# Discharge Measurement Notes

Date: May 28, 2012
Computed By: SMC
Checked By: WAB

Location Name: Sadie Creek 1

Party: WAB, SMC, VJ  Start: 10:00 AM  Finish: 11:00 AM

Temp: 30 °F  Weather: Overcast, patchy fog. 5-10 mph winds

**Channel Characteristics:**

Width: 273 ft  Area: 544 sq ft  Velocity: 0.34 fps  Discharge: 186 cfs

Method: 0.6 & 0.2/0.8  Number of Sections: 30  Count: various

Spin Test: - revolutions after - seconds  Meter: Price AA

| GAGE READINGS | | | |
|---|---|---|---|
| Gage | Start | Finish | Change |
| Centerline Survey | 87.103 | 87.099 | 0.00 |
| | | | |
| | | | |
| | | | |
| | | | |

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading Cable Ice **Boat**

**Upstream** or Downstream side of bridge

**GPS Data:**

Left Edge of Water: N 66 ° 48 ' 58.6 " W 162 ° 30 ' 37.6 "

Right Edge of Water: N 66 ° 49 ' 1.2 " W 162 ° 30 ' 41.2 "

LE Floodplain: ° ' "

RE Floodplain: ° ' "

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

**Descriptions:**

Cross Section: Gradual changes in depth, grassy toward banks, bottomfast ice in the channel

Flow: Small ripples in main channel, flow near banks is calm

Remarks: Boat is u/s of tag line due to low flow and winds.

**SC1**
**May 28, 2012**

| Angle Coeff | Distance from initial point (ft) | Section Width (ft) | Water Depth (ft) | Observed Depth (%) | Revolution Count | Time Increment (sec) | VELOCITY | | | Area (s.f.) | Discharge (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | At Point (fps) | Mean in Vertical (fps) | Adjusted for Angle Coeff (fps) | | |
| REW @ 10:00 AM | | | | | | | | | | | |
| -- | 12 | 1.5 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0.0 | 0 |
| -- | 15 | 4.0 | 1.3 | 0.6 | 0 | 40 | 0 | 0 | 0 | 5.2 | 0 |
| -- | 20 | 7.5 | 1.3 | 0.6 | 0 | 40 | 0 | 0 | 0 | 9.8 | 0 |
| 0.7 | 30 | 10.0 | 2.8 | 0.6 | 3 | 45 | 0.16 | 0.16 | 0.12 | 28.0 | 3.23 |
| 0.7 | 40 | 10.0 | 2.3 | 0.6 | 3 | 69 | 0.11 | 0.11 | 0.08 | 23.0 | 1.83 |
| -- | 50 | 10.0 | 1.3 | 0.6 | 0 | 40 | 0 | 0 | 0 | 13.0 | 0 |
| 0.85 | 60 | 10.0 | 1.3 | 0.6 | 3 | 60 | 0.13 | 0.13 | 0.11 | 13.0 | 1.41 |
| 0.85 | 70 | 10.0 | 1.5 | 0.6 | 5 | 45 | 0.26 | 0.26 | 0.22 | 15.0 | 3.35 |
| 0.94 | 80 | 10.0 | 2.5 | 0.8<br>0.2 | 10 | 50 | 0.46 | 0.46 | 0.43 | 25.0 | 10.78 |
| 0.94 | 90 | 10.0 | 4.2 | 0.8<br>0.2 | 10<br>15 | 52<br>54 | 0.44<br>0.63 | 0.54 | 0.50 | 42.0 | 21.16 |
| 0.94 | 100 | 10.0 | 3.7 | 0.8<br>0.2 | 10<br>10 | 45<br>40 | 0.51<br>0.57 | 0.54 | 0.51 | 37.0 | 18.72 |
| 0.98 | 110 | 10.0 | 4.2 | 0.8<br>0.2 | 10<br>15 | 50<br>48 | 0.46<br>0.71 | 0.58 | 0.57 | 42.0 | 23.99 |
| 0.98 | 120 | 10.0 | 4.4 | 0.8<br>0.2 | 10<br>15 | 43<br>53 | 0.53<br>0.64 | 0.59 | 0.57 | 44.0 | 25.28 |
| 0.99 | 130 | 10.0 | 3.5 | 0.8<br>0.2 | 7<br>15 | 45<br>58 | 0.36<br>0.59 | 0.47 | 0.47 | 35.0 | 16.44 |
| 0.92 | 140 | 10.0 | 3.4 | 0.8<br>0.2 | 7<br>15 | 43<br>59 | 0.38<br>0.58 | 0.48 | 0.44 | 34.0 | 14.94 |
| 0.92 | 150 | 10.0 | 3.3 | 0.8<br>0.2 | 10<br>10 | 48<br>40 | 0.48<br>0.57 | 0.52 | 0.48 | 33.0 | 15.88 |
| 0.94 | 160 | 10.0 | 3.3 | 0.6 | 10<br>10 | 49<br>40 | 0.47<br>0.57 | 0.52 | 0.49 | 33.0 | 16.08 |
| 0.9 | 170 | 10.0 | 2.4 | 0.6 | 10 | 56 | 0.41 | 0.41 | 0.37 | 24.0 | 8.89 |
| 0.9 | 180 | 10.0 | 1.3 | 0.6 | 5 | 50 | 0.24 | 0.24 | 0.21 | 13.0 | 2.79 |
| 0.9 | 190 | 10.0 | 1.2 | 0.6 | 3 | 60 | 0.13 | 0.13 | 0.12 | 12.0 | 1.38 |
| -- | 200 | 10.0 | 0.9 | 0.6 | 0 | 40 | 0 | 0 | 0 | 8.9 | 0 |
| -- | 210 | 10.0 | 0.8 | 0.6 | 0 | 40 | 0 | 0 | 0 | 7.7 | 0 |
| -- | 220 | 10.0 | 0.7 | 0.6 | 0 | 40 | 0 | 0 | 0 | 7.1 | 0 |
| -- | 230 | 10.0 | 0.7 | 0.6 | 0 | 40 | 0 | 0 | 0 | 6.8 | 0 |
| -- | 240 | 10.0 | 0.7 | 0.6 | 0 | 40 | 0 | 0 | 0 | 6.5 | 0 |
| -- | 250 | 10.0 | 0.8 | 0.6 | 0 | 40 | 0 | 0 | 0 | 7.6 | 0 |
| -- | 260 | 10.0 | 0.7 | 0.6 | 0 | 40 | 0 | 0 | 0 | 7.2 | 0 |
| -- | 270 | 10.0 | 0.7 | 0.6 | 0 | 40 | 0 | 0 | 0 | 6.9 | 0 |
| -- | 280 | 7.5 | 0.6 | 0.6 | 0 | 40 | 0 | 0 | 0 | 4.7 | 0 |
| -- | 285 | 2.5 | 0.0 | 0.6 | -- | -- | 0 | 0 | 0 | 0.0 | 0 |
| LEW @ 11:00 PM | | | | | | | | | | | |

**Total Discharge:** **186.15** cfs

Baker

# Discharge Measurement Notes

Date: May 25, 2012
Computed By: WAB
Checked By: SMC

Location Name: Sadie Creek 2A

Party: WAB, VJ    Start: 4:00 PM    Finish: 5:00 PM

Temp: 38 °F    Weather: Fog, clouds in the morning, clear in the afternoon, strong winds

**Channel Characteristics:**

Width: 162 ft    Area: 362 sq ft    Velocity: 0.63 fps    Discharge: 228 cfs

Method: 0.6 & 0.2/0.8    Number of Sections: 18    Count: various

Spin Test: - revolutions after - seconds    Meter: Price AA

| GAGE READINGS | | | |
|---|---|---|---|
| Gage | Start | Finish | Change |
| D/S A-1 | 0.38 | 0.38 | 0.00 |
| U/S A-1 | 0.585 | 0.57 | -0.02 |
| | | | |
| | | | |
| | | | |

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading    Cable    Ice    **Boat**

**Upstream** or Downstream side of bridge

**GPS Data:**

| | | | |
|---|---|---|---|
| Left Edge of Water: N | 66 ° | 48 ' | 46.5 " |
| W | 162 ° | 27 ' | 57.8 " |
| Right Edge of Water: N | 66 ° | 48 ' | 48.0 " |
| W | 162 ° | 27 ' | 57.9 " |

LE Floodplain: ° ' "

RE Floodplain: ° ' "

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

**Descriptions:**

Cross Section: Gradual changes in depth

Flow:

Remarks: Shallow gradient, low velocities, boat upstream of tagline due to strong winds. Long grass near banks made positioning the flow meter difficult.

**SC2A**
**May 25, 2012**

| Angle Coeff | Distance from initial point (ft) | Section Width (ft) | Water Depth (ft) | Observed Depth (%) | Revolution Count | Time Increment (sec) | VELOCITY At Point (fps) | VELOCITY Mean in Vertical (fps) | VELOCITY Adjusted for Angle Coeff (fps) | Area (s.f.) | Discharge (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| REW @ 4:00PM | | | | | | | | | | | |
| -- | 25 | 5.0 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0 | 0 |
| 0.97 | 35 | 10.0 | 1.6 | 0.6 | 5 | 47 | 0.25 | 0.25 | 0.24 | 16.0 | 3.92 |
| 1 | 45 | 10.0 | 1.8 | 0.6 | 5 | 44 | 0.27 | 0.27 | 0.27 | 18.0 | 4.83 |
| 1 | 55 | 10.0 | 1.7 | 0.6 | 5 | 43 | 0.27 | 0.27 | 0.27 | 17.0 | 4.66 |
| 1 | 65 | 10.0 | 1.9 | 0.6 | 5 | 48 | 0.25 | 0.25 | 0.25 | 19.0 | 4.70 |
| 0.99 | 75 | 10.0 | 2.0 | 0.6 | 7 | 42 | 0.39 | 0.39 | 0.38 | 20.0 | 7.63 |
| 1 | 85 | 10.0 | 2.2 | 0.6 | 10 | 56 | 0.41 | 0.41 | 0.41 | 22.0 | 9.05 |
| 1 | 95 | 10.0 | 2.9 | 0.6 | 20 | 54 | 0.83 | 0.83 | 0.83 | 29.0 | 24.20 |
| 1 | 105 | 10.0 | 3.7 | 0.8<br>0.2 | 20<br>20 | 44<br>40 | 1.02<br>1.12 | 1.07 | 1.07 | 37.0 | 39.59 |
| 1 | 115 | 10.0 | 3.8 | 0.8<br>0.2 | 20<br>25 | 45<br>51 | 1.00<br>1.10 | 1.05 | 1.05 | 38.0 | 39.83 |
| 0.99 | 125 | 10.0 | 3.6 | 0.8<br>0.2 | 20<br>20 | 48<br>41 | 0.94<br>1.09 | 1.01 | 1.00 | 36.0 | 36.17 |
| 0.98 | 135 | 10.0 | 2.9 | 0.8<br>0.2 | 15 | 40 | 0.84 | 0.84 | 0.83 | 29.0 | 24.00 |
| 0.97 | 145 | 10.0 | 2.6 | 0.8<br>0.2 | 15 | 53 | 0.64 | 0.64 | 0.62 | 26.0 | 16.19 |
| 0.85 | 155 | 10.0 | 2.0 | 0.8<br>0.2 | 10 | 40 | 0.57 | 0.57 | 0.48 | 20.0 | 9.67 |
| 0.4 | 165 | 10.0 | 1.6 | 0.8<br>0.2 | 7 | 42 | 0.39 | 0.39 | 0.15 | 16.0 | 2.47 |
| 0.3 | 175 | 10.0 | 1.6 | 0.8<br>0.2 | 3 | 40 | 0.18 | 0.18 | 0.05 | 16.0 | 0.88 |
| -- | 185 | 10.0 | 0.3 | 0.6 | 0 | 40 | 0 | 0 | 0 | 3.3 | 0 |
| -- | 187 | 6.0 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0 | 0 |
| LEW @ 5:00 PM | | | | | | | | | | | |

**Total Discharge:** **227.79** cfs

Baker

# Discharge Measurement Notes

Date: May 26, 2012
Computed By: SMC
Checked By: WAB

Location Name: Sadie Creek 2A

Party: WAB, VJ    Start: 2:00 PM    Finish: 3:00 PM

Temp: 38 °F    Weather: Clear and sunny, scattered clouds, windy

**Channel Characteristics:**

Width: 158 ft    Area: 342 sq ft    Velocity: 0.46 fps    Discharge: 158 cfs

Method: 0.6 & 0.2/0.8    Number of Sections: 17    Count: various

Spin Test: - revolutions after - seconds    Meter: Price AA

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading    Cable    Ice    Boat

Upstream or Downstream side of bridge

| GAGE READINGS | | | |
|---|---|---|---|
| Gage | Start | Finish | Change |
| D/S A-1 | 0.455 | 0.430 | -0.03 |
| U/S A-1 | 0.223 | 0.220 | 0.00 |
| | | | |
| | | | |
| | | | |

**GPS Data:**

| | | | | |
|---|---|---|---|---|
| Left Edge of Water: | N | 66 ° | 48 ' | 46.5 " |
| | W | 162 ° | 27 ' | 57.8 " |
| Right Edge of Water: | N | 66 ° | 48 ' | 48.0 " |
| | W | 162 ° | 27 ' | 57.9 " |

LE Floodplain: ° ' "

RE Floodplain: ° ' "

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

**Descriptions:**

Cross Section: Gradual changes in depth

Flow:

Remarks: Boat upstream of tagline due to strong winds, low velocities, shallow gradient.

**SC2A**
**May 26, 2012**

| Angle Coeff | Distance from initial point (ft) | Section Width (ft) | Water Depth (ft) | Observed Depth (%) | Revolution Count | Time Increment (sec) | VELOCITY At Point (fps) | VELOCITY Mean in Vertical (fps) | VELOCITY Adjusted for Angle Coeff (fps) | Area (s.f.) | Discharge (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| REW @ 2:00PM | | | | | | | | | | | |
| -- | 1.7 | 4.2 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0 | 0 |
| 0.3 | 10 | 9.2 | 1.2 | 0.6 | 3.0 | 40.0 | 0.18 | 0.18 | 0.05 | 11.0 | 0.60 |
| 0.7 | 20 | 10.0 | 1.5 | 0.6 | 3.0 | 53.0 | 0.14 | 0.14 | 0.10 | 15.0 | 1.50 |
| 0.9 | 30 | 10.0 | 1.7 | 0.6 | 5.0 | 80.0 | 0.16 | 0.16 | 0.14 | 17.0 | 2.38 |
| 0.9 | 40 | 10.0 | 1.8 | 0.6 | 3.0 | 60.0 | 0.13 | 0.13 | 0.12 | 18.0 | 2.07 |
| 1 | 50 | 10.0 | 1.8 | 0.6 | 3.0 | 41.0 | 0.18 | 0.18 | 0.18 | 18.0 | 3.22 |
| 0.99 | 60 | 10.0 | 2.1 | 0.6 | 7.0 | 46.0 | 0.35 | 0.35 | 0.35 | 21.0 | 7.35 |
| 1 | 70 | 10.0 | 2.9 | 0.6 | 15.0 | 52.0 | 0.65 | 0.65 | 0.65 | 29.0 | 18.96 |
| 1 | 80 | 10.0 | 3.7 | 0.8 | 15 | 57 | 0.60 | 0.81 | 0.81 | 37.0 | 29.93 |
| | | | | 0.2 | 20 | 44 | 1.02 | | | | |
| 1 | 90 | 10.0 | 3.8 | 0.8 | 15 | 52 | 0.65 | 0.78 | 0.78 | 38.0 | 29.52 |
| | | | | 0.2 | 20 | 50 | 0.90 | | | | |
| 1 | 100 | 10.0 | 3.5 | 0.8 | 20 | 70 | 0.65 | 0.76 | 0.76 | 35.0 | 26.49 |
| | | | | 0.2 | 20 | 52 | 0.87 | | | | |
| 1 | 110 | 10.0 | 2.8 | 0.6 | 15.0 | 43.0 | 0.79 | 0.79 | 0.79 | 28.0 | 22.03 |
| 1 | 120 | 10.0 | 2.3 | 0.6 | 10.0 | 47.0 | 0.49 | 0.49 | 0.49 | 23.0 | 11.20 |
| 0.99 | 130 | 10.0 | 1.9 | 0.6 | 5.0 | 90.0 | 0.14 | 0.14 | 0.14 | 19.0 | 2.64 |
| -- | 140 | 10.0 | 1.8 | 0.6 | 0.0 | 40.0 | 0 | 0 | 0 | 18.0 | 0 |
| -- | 150 | 10.0 | 1.5 | 0.6 | 0.0 | 40.0 | 0 | 0 | 0 | 15.0 | 0 |
| -- | 160 | 5.0 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0 | 0 |
| LEW @ 3:00 PM | | | | | | | | | | | |

**Total Discharge:** **157.89** cfs

Baker

# Discharge Measurement Notes

Date: May 27, 2012
Computed By: SMC
Checked By: WAB

Location Name: Sadie Creek 2A

Party: SMC, WAB, VJ    Start: 12:50 PM    Finish: 3:00 PM

Temp: °F    Weather: 10-15 MPH wind, clear

**Channel Characteristics:**

Width: 162 ft    Area: 369 sq ft    Velocity: 0.62 fps    Discharge: 227 cfs

Method: 0.6 & 0.2/0.8    Number of Sections: 34    Count: various

Spin Test: - revolutions after - seconds    Meter: Price AA

| GAGE READINGS | | | |
|---|---|---|---|
| Gage | Start | Finish | Change |
| Centerline Survey | 92.637 | 92.677 | 0.04 |
| | | | |
| | | | |
| | | | |
| | | | |

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading    Cable    Ice    Boat

Upstream    or    Downstream    side of bridge

**GPS Data:**

Left Edge of Water: N 66 ° 48 ' 46.5 " W 162 ° 27 ' 57.8 "

Right Edge of Water: N 66 ° 48 ' 48.0 " W 162 ° 27 ' 57.9 "

LE Floodplain: ° ' "

RE Floodplain: ° ' "

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

**Descriptions:**

Cross Section: Gradual changes in depth

Flow: Waves/ripples in main channel

Remarks: Wind 10-15 MPH pushed boat upstream side of tagline

| Angle Coeff | Distance from initial point (ft) | Section Width (ft) | Water Depth (ft) | Observed Depth (%) | Revolution Count | Time Increment (sec) | VELOCITY At Point (fps) | VELOCITY Mean in Vertical (fps) | VELOCITY Adjusted for Angle Coeff (fps) | Area (s.f.) | Discharge (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | REW @ 12:50PM | | | | | | | | |
| -- | 25 | 2.5 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0 | 0 |
| -- | 30 | 5.0 | 0.6 | 0.6 | 0 | 40 | 0 | 0 | 0 | 0 | 0 |
| 0.6 | 35 | 5.0 | 1.0 | 0.6 | 3 | 78 | 0.10 | 0.10 | 0.06 | 5.0 | 0.31 |
| -- | 40 | 5.0 | 1.6 | 0.6 | 0 | 40 | 0 | 0 | 0 | 8.0 | 0 |
| 0.85 | 45 | 5.0 | 1.6 | 0.6 | 5 | 75 | 0.16 | 0.16 | 0.14 | 8.0 | 1.12 |
| 0.85 | 50 | 5.0 | 1.4 | 0.6 | 3 | 135 | 0.07 | 0.07 | 0.06 | 7.0 | 0.40 |
| -- | 55 | 5.0 | 1.6 | 0.6 | 0 | 40 | 0 | 0 | 0 | 8.0 | 0 |
| -- | 60 | 5.0 | 1.5 | 0.6 | 0 | 40 | 0 | 0 | 0 | 7.5 | 0 |
| -- | 65 | 5.0 | 1.5 | 0.6 | 0 | 40 | 0 | 0 | 0 | 7.5 | 0 |
| -- | 70 | 5.0 | 1.6 | 0.6 | 0 | 40 | 0 | 0 | 0 | 8.0 | 0 |
| -- | 75 | 5.0 | 1.8 | 0.6 | 0 | 40 | 0 | 0 | 0 | 9.0 | 0 |
| 0.9 | 80 | 5.0 | 2.4 | 0.6 | 5 | 60 | 0.20 | 0.20 | 0.18 | 12.0 | 2.18 |
| 0.9 | 85 | 5.0 | 2.4 | 0.6 | 7 | 43 | 0.38 | 0.38 | 0.34 | 12.0 | 4.07 |
| 0.9 | 90 | 5.0 | 2.7 | 0.6 | 10 | 41 | 0.56 | 0.56 | 0.50 | 13.5 | 6.75 |
| 0.94 | 95 | 5.0 | 3.4 | 0.8<br>0.2 | 15<br>15 | 42<br>49 | 0.81<br>0.69 | 0.75 | 0.70 | 17.0 | 11.97 |
| 0.98 | 100 | 5.0 | 4.1 | 0.8<br>0.2 | 15<br>25 | 41<br>48 | 0.82<br>1.17 | 1.00 | 0.98 | 20.5 | 20.00 |
| 0.99 | 105 | 5.0 | 4.1 | 0.8<br>0.2 | 20<br>25 | 45<br>42 | 1.00<br>1.33 | 1.16 | 1.15 | 20.5 | 23.62 |
| 0.99 | 110 | 5.0 | 4.2 | 0.8<br>0.2 | 20<br>30 | 45<br>50 | 1.00<br>1.34 | 1.17 | 1.16 | 21.0 | 24.31 |
| 0.99 | 115 | 5.0 | 4.5 | 0.8<br>0.2 | 15<br>25 | 40<br>43 | 0.84<br>1.30 | 1.07 | 1.06 | 22.5 | 23.88 |
| 1 | 120 | 5.0 | 4.2 | 0.8<br>0.2 | 20<br>25 | 43<br>44 | 1.04<br>1.27 | 1.16 | 1.16 | 21.0 | 24.30 |
| 0.99 | 125 | 5.0 | 3.8 | 0.8<br>0.2 | 20<br>25 | 45<br>45 | 1.00<br>1.24 | 1.12 | 1.11 | 19.0 | 21.07 |
| 0.98 | 130 | 5.0 | 3.6 | 0.8<br>0.2 | 20<br>25 | 47<br>48 | 0.96<br>1.17 | 1.06 | 1.04 | 18.0 | 18.72 |
| 0.98 | 135 | 5.0 | 3.4 | 0.8<br>0.2 | 15<br>20 | 40<br>41 | 0.84<br>1.09 | 0.97 | 0.95 | 17.0 | 16.14 |
| 0.98 | 140 | 5.0 | 3.1 | 0.8<br>0.2 | 20<br>20 | 57<br>41 | 0.79<br>1.09 | 0.94 | 0.92 | 15.5 | 14.31 |
| 0.99 | 145 | 5.0 | 2.6 | 0.6 | 15 | 54 | 0.63 | 0.63 | 0.62 | 13.0 | 8.11 |
| 0.99 | 150 | 5.0 | 2.1 | 0.6 | 7 | 43 | 0.38 | 0.38 | 0.37 | 10.5 | 3.92 |
| 0.85 | 155 | 5.0 | 2.1 | 0.6 | 3 | 49 | 0.15 | 0.15 | 0.13 | 10.5 | 1.36 |
| 0.7 | 160 | 5.0 | 1.8 | 0.6 | 2 | 55 | 0.10 | 0.10 | 0.07 | 9.0 | 0.62 |
| -- | 165 | 5.0 | 1.6 | 0.6 | 0 | 40 | 0 | 0 | 0 | 8.0 | 0 |
| -- | 170 | 5.0 | 1.6 | 0.6 | 0 | 40 | 0 | 0 | 0 | 8.0 | 0 |
| -- | 175 | 5.0 | 1.3 | 0.6 | 0 | 40 | 0 | 0 | 0 | 6.5 | 0 |
| -- | 180 | 5.0 | 1.0 | 0.6 | 0 | 40 | 0 | 0 | 0 | 4.8 | 0 |
| -- | 185 | 3.5 | 0.4 | 0.6 | 0 | 40 | 0 | 0 | 0 | 1.4 | 0 |
| -- | 187 | 1.0 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0.0 | 0 |
| | | | LEW @ 3:00 PM | | | | | | | | |

**Total Discharge:** **227.15** cfs

Baker

# Discharge Measurement Notes

Date: May 28, 2012
Computed By: SMC
Checked By: WAB

Location Name: Sadie Creek 2A

Party: WAB, SMC, VJ    Start: 11:55 AM    Finish: 12:35 PM

Temp: 30 °F    Weather: Overcast and foggy to clear, 10-15 mph west winds

**Channel Characteristics:**

Width: 159 ft    Area: 335 sq ft    Velocity: 0.49 fps    Discharge: 165 cfs

Method: 0.6 & 0.2/0.8    Number of Sections: 22    Count: various

Spin Test: - revolutions after - seconds    Meter: Price AA

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading    Cable    Ice    **Boat**

**Upstream** or Downstream side of bridge

| GAGE READINGS | | | |
|---|---|---|---|
| Gage | Start | Finish | Change |
| Centerline Survey | 92.185 | 92.157 | 0.03 |
| | | | |
| | | | |
| | | | |
| | | | |

**GPS Data:**

| | | | |
|---|---|---|---|
| Left Edge of Water: | N | 66 ° | 48 ' | 46.5 " |
| | W | 162 ° | 27 ' | 57.8 " |
| Right Edge of Water: | N | 66 ° | 48 ' | 48.0 " |
| | W | 162 ° | 27 ' | 57.9 " |

LE Floodplain: ° ' "

RE Floodplain: ° ' "

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

**Descriptions:**

Cross Section: Uniform section, gradual changes in depths

Flow: Slow and calm, few ripples in the middle of the channel, flow near banks is calm.

Remarks: Shallow gradient, low velocities as wind maintains boat position upstream of tagline

**SC2A**
**May 28, 2012**

| Angle Coeff | Distance from initial point (ft) | Section Width (ft) | Water Depth (ft) | Observed Depth (%) | Revolution Count | Time Increment (sec) | VELOCITY At Point (fps) | VELOCITY Mean in Vertical (fps) | VELOCITY Adjusted for Angle Coeff (fps) | Area (s.f.) | Discharge (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| REW @ 11:55 AM | | | | | | | | | | | |
| -- | 31 | 4.5 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0 | 0 |
| -- | 40 | 9.5 | 1.2 | 0.6 | 0 | 40 | 0 | 0 | 0 | 11.4 | 0 |
| -- | 50 | 10.0 | 1.1 | 0.6 | 0 | 40 | 0 | 0 | 0 | 11.0 | 0 |
| -- | 60 | 10.0 | 1.1 | 0.6 | 0 | 40 | 0 | 0 | 0 | 11.0 | 0 |
| -- | 70 | 10.0 | 1.1 | 0.6 | 0 | 40 | 0 | 0 | 0 | 11.0 | 0 |
| -- | 80 | 12.5 | 2.0 | 0.6 | 0 | 40 | 0 | 0 | 0 | 25.0 | 0 |
| -- | 95 | 10.0 | 1.7 | 0.6 | 0 | 40 | 0 | 0 | 0 | 17.0 | 0 |
| 0.98 | 100 | 5.0 | 2.5 | 0.6 | 5 | 44 | 0.27 | 0.27 | 0.26 | 12.5 | 3.29 |
| 1 | 105 | 5.0 | 3.4 | 0.8<br>0.2 | 10<br>10 | 41<br>47 | 0.56<br>0.49 | 0.52 | 0.52 | 17.0 | 8.86 |
| 1 | 110 | 7.5 | 3.8 | 0.8<br>0.2 | 15<br>20 | 51<br>46 | 0.67<br>0.98 | 0.82 | 0.82 | 28.5 | 23.41 |
| 1 | 120 | 10.0 | 4.5 | 0.8<br>0.2 | 15<br>20 | 47<br>44 | 0.72<br>1.02 | 0.87 | 0.87 | 45.0 | 39.18 |
| 1 | 130 | 10.0 | 4.1 | 0.8<br>0.2 | 15<br>20 | 48<br>42 | 0.71<br>1.07 | 0.89 | 0.89 | 41.0 | 36.38 |
| 1 | 140 | 10.0 | 3.6 | 0.8<br>0.2 | 15<br>20 | 44<br>49 | 0.77<br>0.92 | 0.84 | 0.84 | 36.0 | 30.37 |
| 1 | 150 | 7.5 | 2.8 | 0.6 | 15 | 44 | 0.77 | 0.77 | 0.77 | 21.0 | 16.16 |
| 1 | 155 | 5.0 | 2.4 | 0.6 | 10 | 62 | 0.37 | 0.37 | 0.37 | 12.0 | 4.48 |
| 0.94 | 160 | 5.0 | 1.5 | 0.6 | 7 | 53 | 0.31 | 0.31 | 0.29 | 7.5 | 2.18 |
| 0.4 | 165 | 5.0 | 1.5 | 0.6 | 3 | 40 | 0.18 | 0.18 | 0.07 | 7.5 | 0.55 |
| -- | 170 | 5.0 | 1.3 | 0.6 | 0 | 40 | 0 | 0 | 0 | 6.5 | 0 |
| -- | 175 | 5.0 | 1.3 | 0.6 | 0 | 40 | 0 | 0 | 0 | 6.5 | 0 |
| -- | 180 | 5.0 | 1.0 | 0.6 | 0 | 40 | 0 | 0 | 0 | 5.0 | 0 |
| -- | 185 | 3.5 | 0.8 | 0.6 | 0 | 40 | 0 | 0 | 0 | 2.7 | 0 |
| -- | 187 | 1.0 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0.0 | 0 |
| LEW @ 12:35 PM | | | | | | | | | | | |

**Total Discharge:** **164.85** cfs

Baker

# Discharge Measurement Notes

Date: May 25, 2012
Computed By: SMC
Checked By: WAB

Location Name: Sadie Creek 2B

Party: WAB, VJ  Start: 6:00 PM  Finish: 6:05 PM

Temp: 38 °F  Weather: Clear and sunny, scattered clouds

**Channel Characteristics:**

Width: 5 ft  Area: 11 sq ft  Velocity: 5.17 fps  Discharge: 54 cfs

Method: Standard  Number of Sections: 1  Count: N/A

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

| GAGE READINGS | | | |
|---|---|---|---|
| Gage | Start | Finish | Change |
| D/S B | 1.05 | 1.05 | 0.00 |
| Centerline B | 1.36 | 1.36 | 0.00 |
| U/S B | 1.18 | 1.18 | 0.00 |
| | | | |
| | | | |

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading  Cable  Ice  Boat

Upstream or Downstream side of bridge

**GPS Data:**

Discharge Location N 66 ° 49 ' 21.9 "
W 162 ° 25 ' 2.1 "

LE Floodplain: ° ' "

RE Floodplain: ° ' "

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

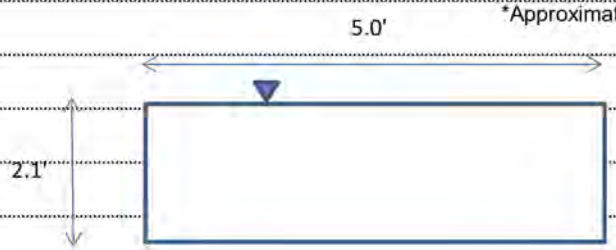
**Descriptions:**

Cross Section: Cross section cut in snowpack, changing quickly

Flow: Fast, strong flow through site;

Remarks: Velocity readings difficult due to condtions around site, mostly snowpack and water velocities. Cross section data is very rough and will affect the measurements.

*Approximate dimensions of channel




29 clicks X 5 revolutions/click = 145 revolutions

62 seconds

**SC2B**
**May 25, 2012**

| Angle Coeff | Distance from initial point (ft) | Section Width (ft) | Water Depth (ft) | Observed Depth (%) | Revolution Count | Time Increment (sec) | VELOCITY At Point (fps) | VELOCITY Mean in Vertical (fps) | VELOCITY Adjusted for Angle Coeff (fps) | Area (s.f.) | Discharge (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| REW @ 6:00PM | | | | | | | | | | | |
| 1 | 5 | 5.0 | 2.1 | 0.6 | 145.0 | 62.0 | 5.17 | 5.17 | 5.17 | 10.5 | 54.33 |
| LEW @ 6:05 PM | | | | | | | | | | | |

**Total Discharge:** **54.33** cfs

Baker

# Discharge Measurement Notes

Date: May 26, 2012
Computed By: SMC
Checked By: WAB

Location Name: Sadie Creek 2B

Party: WAB, VJ    Start: 10:40 AM    Finish: 10:45 AM

Temp: 38 °F    Weather: Clear and sunny, scattered clouds

**Channel Characteristics:**

Width: 6.5 ft    Area: 29 sq ft    Velocity: 5.53 fps    Discharge: 162 cfs

Method: Standard    Number of Sections: 1    Count: N/A

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

| GAGE READINGS | | | |
|---|---|---|---|
| Gage | Start | Finish | Change |
| D/S A | 2.22 | 2.22 | 0.00 |
| Centerline A | 2.60 | 2.60 | 0.00 |
| U/S A | 2.04 | 2.04 | 0.00 |
| | | | |
| | | | |

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading    Cable    Ice    Boat

Upstream    or    Downstream    side of bridge

**GPS Data:**

Discharge Location N 66 ° 49 ' 21.9 "
W 162 ° 25 ' 2.1 "

LE Floodplain: ° ' . "

RE Floodplain: ° ' . "

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

**Descriptions:**

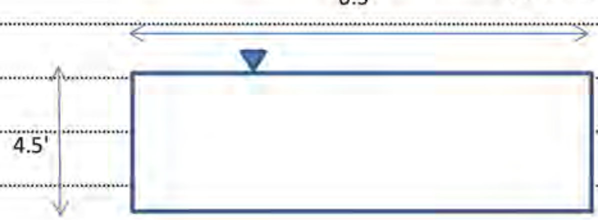
Cross Section: Cross section cut in snowpack, changing quickly

Flow: Fast, strong flow through site;

Remarks: Velocity readings difficult due to condtions around site, mostly snowpack and water velocities. Cross section data is very rough and affects the quality of the data collected.

*Approximate dimensions of channel

6.5'




25 clicks X 5 revolutions/click = 145 revolutions

50 seconds

**SC2B**
**May 26, 2012**

| Angle Coeff | Distance from initial point (ft) | Section Width (ft) | Water Depth (ft) | Observed Depth (%) | Revolution Count | Time Increment (sec) | VELOCITY At Point (fps) | VELOCITY Mean in Vertical (fps) | VELOCITY Adjusted for Angle Coeff (fps) | Area (s.f.) | Discharge (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| REW @ 2:00PM | | | | | | | | | | | |
| 1 | 6.5 | 6.5 | 4.5 | 0.6 | 125.0 | 50.0 | 5.53 | 5.53 | 5.53 | 29.3 | 161.75 |
| LEW @ 3:00 PM | | | | | | | | | | | |

**Total Discharge:** **161.75** cfs

Baker

# Discharge Measurement Notes

Date: May 29, 2012
Computed By: SMC
Checked By: WAB

Location Name: Unnamed Swale

Party: SMC, WAB Start: 2:45 PM Finish: 3:30 PM

Temp: 34 °F Weather: Clear, 15-20 MPH Northwest wind

**Channel Characteristics:**

Width: 19 ft Area: 17 sq ft Velocity: 0.41 fps Discharge: 7 cfs

Method: 0.6 Number of Sections: 20 Count: various

Spin Test: - revolutions after - seconds Meter: Price AA

Meter: ft above bottom of weight

Weight: lbs

Wading Cable Ice Boat

Upstream or Downstream side of bridge

| GAGE READINGS | | | |
|---|---|---|---|
| Gage | Start | Finish | Change |
| JC.U-A | 96.92 | 96.84 | -0.08 |
| | | | |
| | | | |
| | | | |
| | | | |

**GPS Data:** JCU

Left Edge of Water: N ° ' " W ° ' "

Right Edge of Water: N ° ' " E ° ' "

LE Floodplain: ° ' "

RE Floodplain: ° ' "

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

**Descriptions:**

Cross Section: Channel has heavy grass bed, small hill or thicker tuft of grass near center of cross section (Sta. 11) approximately one foot wide. Bottomfast ice is present, with degrading snowpack on the right bank.

Flow: Aside from vegetation, flow is unimpeded through cross section.

Remarks: Tall grass on left bank prevented the meter from capturing the flow, approximately 0.25 fps at Sta. 4 and 5.

| Angle Coeff | Distance from initial point (ft) | Section Width (ft) | Water Depth (ft) | Observed Depth (%) | Revolution Count | Time Increment (sec) | VELOCITY At Point (fps) | VELOCITY Mean in Vertical (fps) | VELOCITY Adjusted for Angle Coeff (fps) | Area (s.f.) | Discharge (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| REW @ 2:45 PM | | | | | | | | | | | |
| -- | 0 | 0.5 | 0.0 | -- | -- | -- | 0 | 0 | 0 | 0 | 0 |
| -- | 1 | 1.0 | 0.3 | -- | -- | -- | 0 | 0 | 0 | 0.3 | 0 |
| -- | 2 | 1.0 | 0.4 | -- | -- | -- | 0 | 0 | 0 | 0.4 | 0 |
| 1 | 3 | 1.0 | 0.7 | 0.6 | 0 | 40 | 0 | 0 | 0 | 0.7 | 0 |
| 1 | 4 | 1.0 | 0.9 | 0.6 | 0 | 40 | 0.25 est. | 0.25 | 0.25 | 0.9 | 0.23 |
| 1 | 5 | 1.0 | 1.0 | 0.6 | 0 | 40 | 0.25 est. | 0.25 | 0.25 | 1.0 | 0.25 |
| 1 | 6 | 1.0 | 1.0 | 0.6 | 5 | 48 | 0.25 | 0.25 | 0.25 | 1.0 | 0.25 |
| 1 | 7 | 1.0 | 1.1 | 0.6 | 3 | 43 | 0.17 | 0.17 | 0.17 | 1.1 | 0.19 |
| 1 | 8 | 1.0 | 1.1 | 0.6 | 7 | 50 | 0.33 | 0.33 | 0.33 | 1.1 | 0.36 |
| 1 | 9 | 1.0 | 1.2 | 0.6 | 5 | 70 | 0.18 | 0.18 | 0.18 | 1.2 | 0.21 |
| 0.98 | 10 | 1.0 | 1.2 | 0.6 | 7 | 43 | 0.38 | 0.38 | 0.37 | 1.2 | 0.44 |
| 1 | 11 | 1.0 | 0.0 | 0.6 | 0 | 40 | 0.00 | 0.00 | 0.00 | 0.0 | 0.00 |
| 1 | 12 | 1.0 | 1.2 | 0.6 | 5 | 41 | 0.29 | 0.29 | 0.29 | 1.2 | 0.34 |
| 1 | 13 | 1.0 | 1.1 | 0.6 | 20 | 42 | 1.07 | 1.07 | 1.07 | 1.1 | 1.17 |
| 1 | 14 | 1.0 | 1.2 | 0.6 | 15 | 57 | 0.60 | 0.60 | 0.60 | 1.2 | 0.72 |
| 1 | 15 | 1.0 | 1.3 | 0.6 | 7 | 52 | 0.31 | 0.31 | 0.31 | 1.3 | 0.41 |
| 1 | 16 | 1.0 | 1.1 | 0.6 | 15 | 54 | 0.63 | 0.63 | 0.63 | 1.1 | 0.69 |
| 1 | 17 | 1.0 | 1.1 | 0.6 | 15 | 50 | 0.68 | 0.68 | 0.68 | 1.1 | 0.75 |
| 1 | 18 | 1.0 | 1.0 | 0.6 | 20 | 47 | 0.96 | 0.96 | 0.96 | 1.0 | 0.96 |
| 0.94 | 19 | 0.5 | 1.0 | 0.6 | 7 | 40 | 0.40 | 0.40 | 0.38 | 0.5 | 0.19 |
| LEW @ 3:30 PM | | | | | | | | | | | |

**Total Discharge:** **7.15** cfs