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34 YEARS EXPERIENCE IN THE FIELD

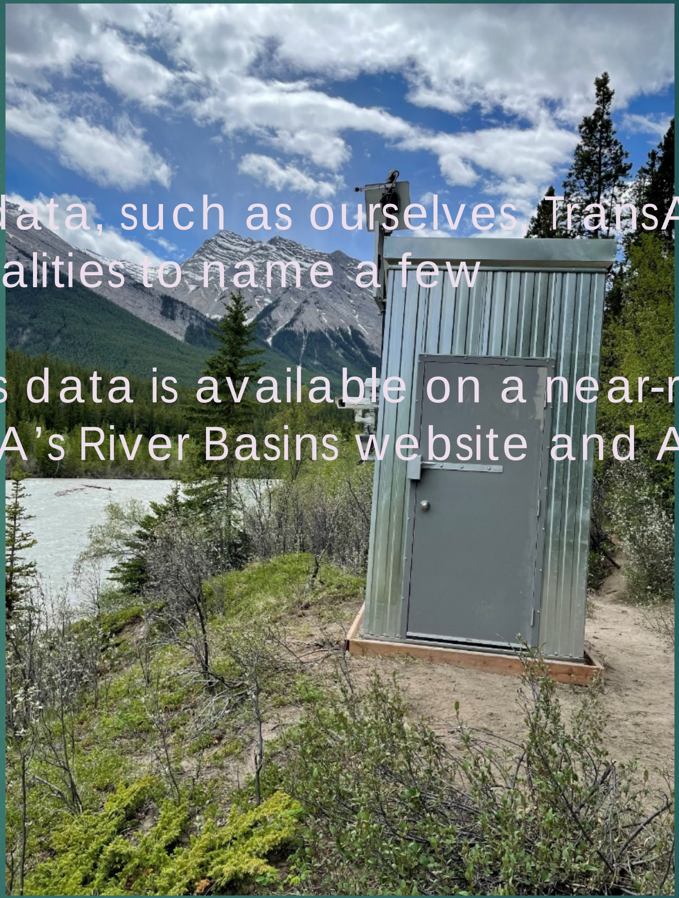
SPECIALIZING IN STREAMFLOW AND LAKE LEVEL MONITORING, METEOROLOGICAL MONITORING, SNOW SURVEYS, AND DABBLING IN WATER QUALITY AND GROUNDWATER

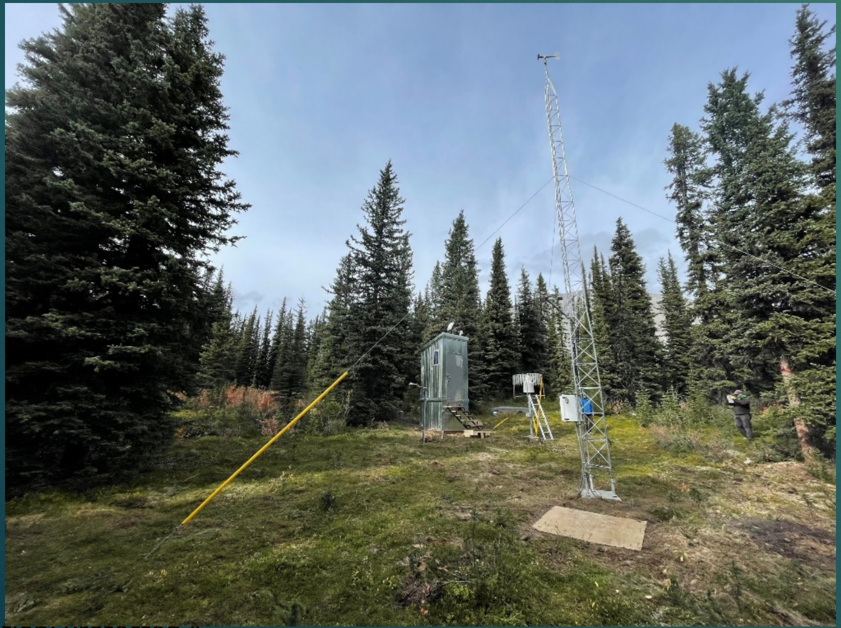
Under Ice Streamflow Monitoring

WHAT THE HECK'S GOING ON UNDER THERE?

Rick Pickering, Alberta Environment and Protected Areas February, 2023

- Network of over 400 hydrometric stations in Alberta
- WSC is the primary operator
- Other trusted partners supply data, such as ourselves, TransAlta Utilities, irrigation districts, and municipalities to name a few
  - The majority of this data is available on a near-real-time basis through AEPA's River Basins website and App





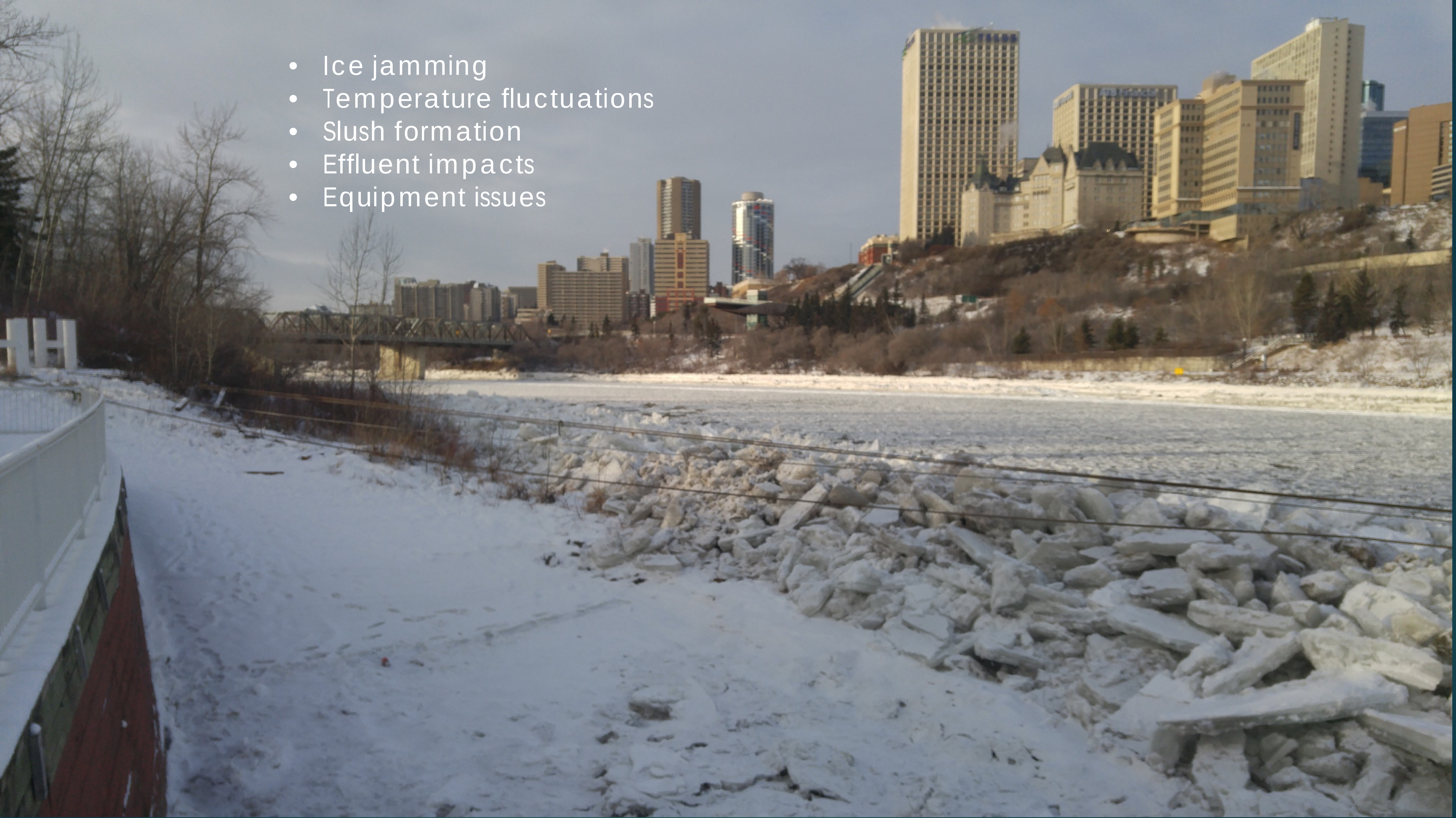
WaterSHED program

Key partnership formed with EpCor beginning in 2016, sampling and installation of stations began in 2018

Currently operating 9 new hydrometric stations, one new high-alpine weather station, and 16 remote cameras spanning nearly the entire length of the North Saskatchewan River drainage in Alberta

More and more users want to know what the flow is under ice conditions due to a variety of reasons; licensing and apportionment, forecasting, public safety, industrial impacts, water supply, and water quality concerns to name a few.

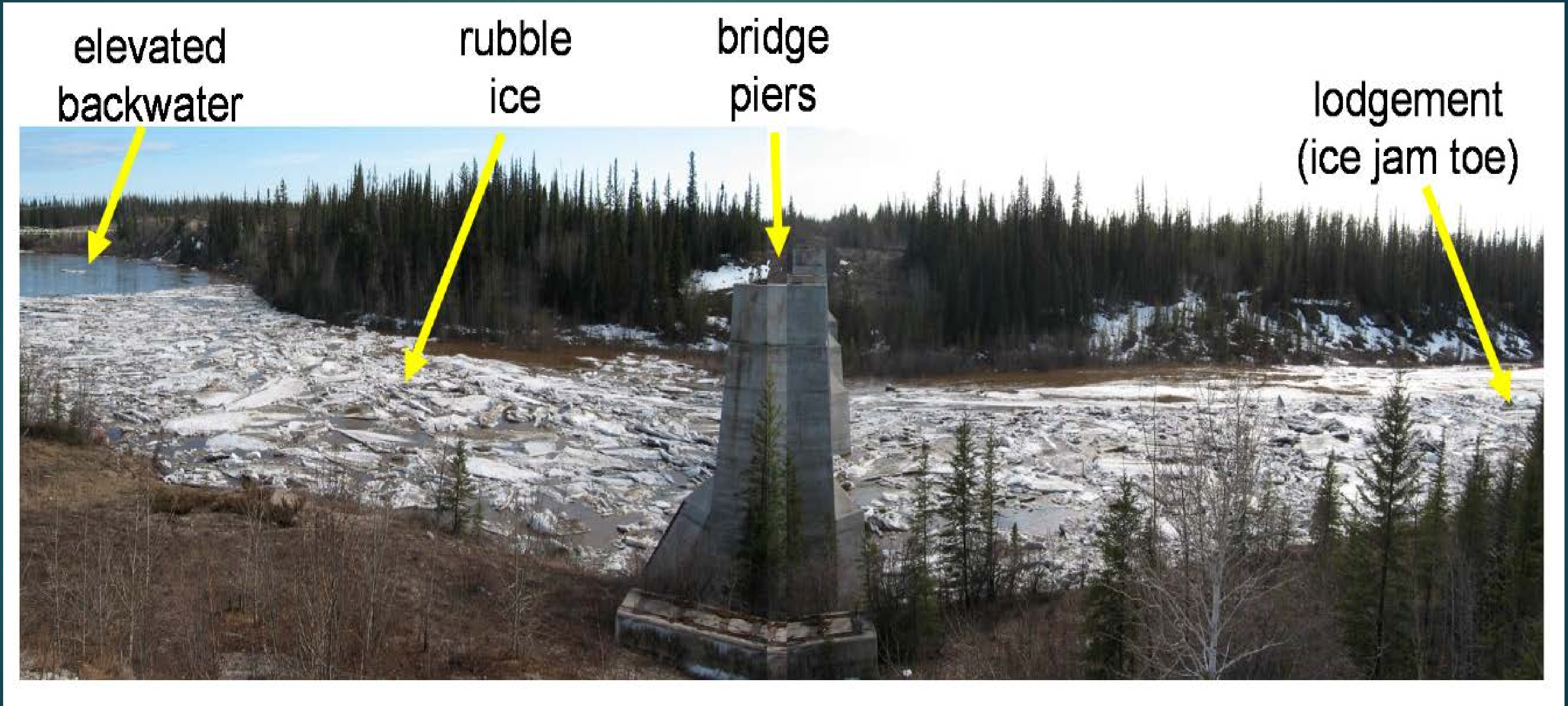
Unfortunately, this is very inexact science due to a myriad of factors.



- Ice jamming
- Temperature fluctuations
- Slush formation
- Effluent impacts
- Equipment issues

Whether a stream is large or small, the effects are the same, it is just a matter of scale.

Components of an ice jam



Siffleur River Feb. 14-20, 2022

Air temp ranged from -13 to +3, WL slowly dropped 10 cm in first 6 days, then rose 50 cm with reformation of ice on the 20th.

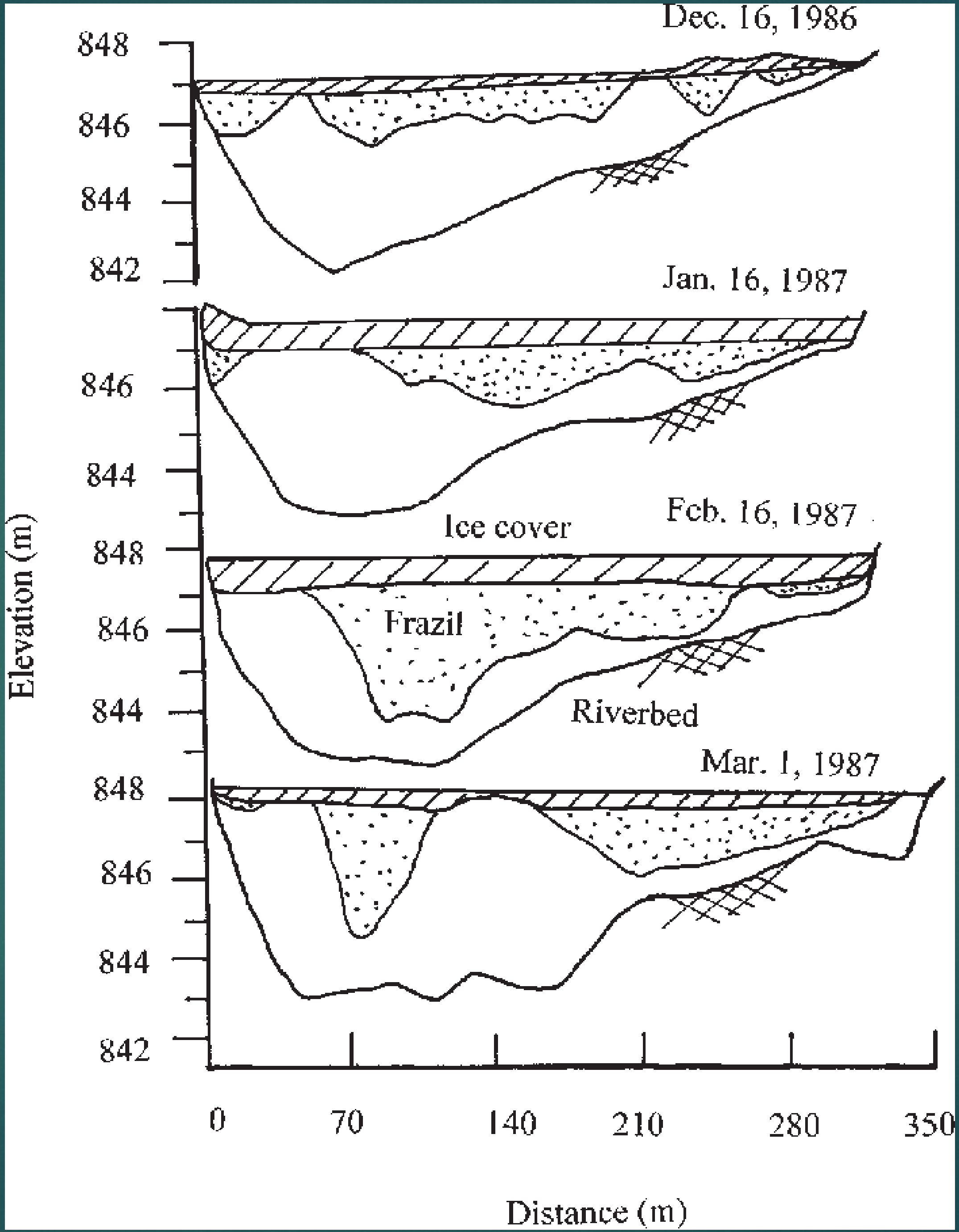




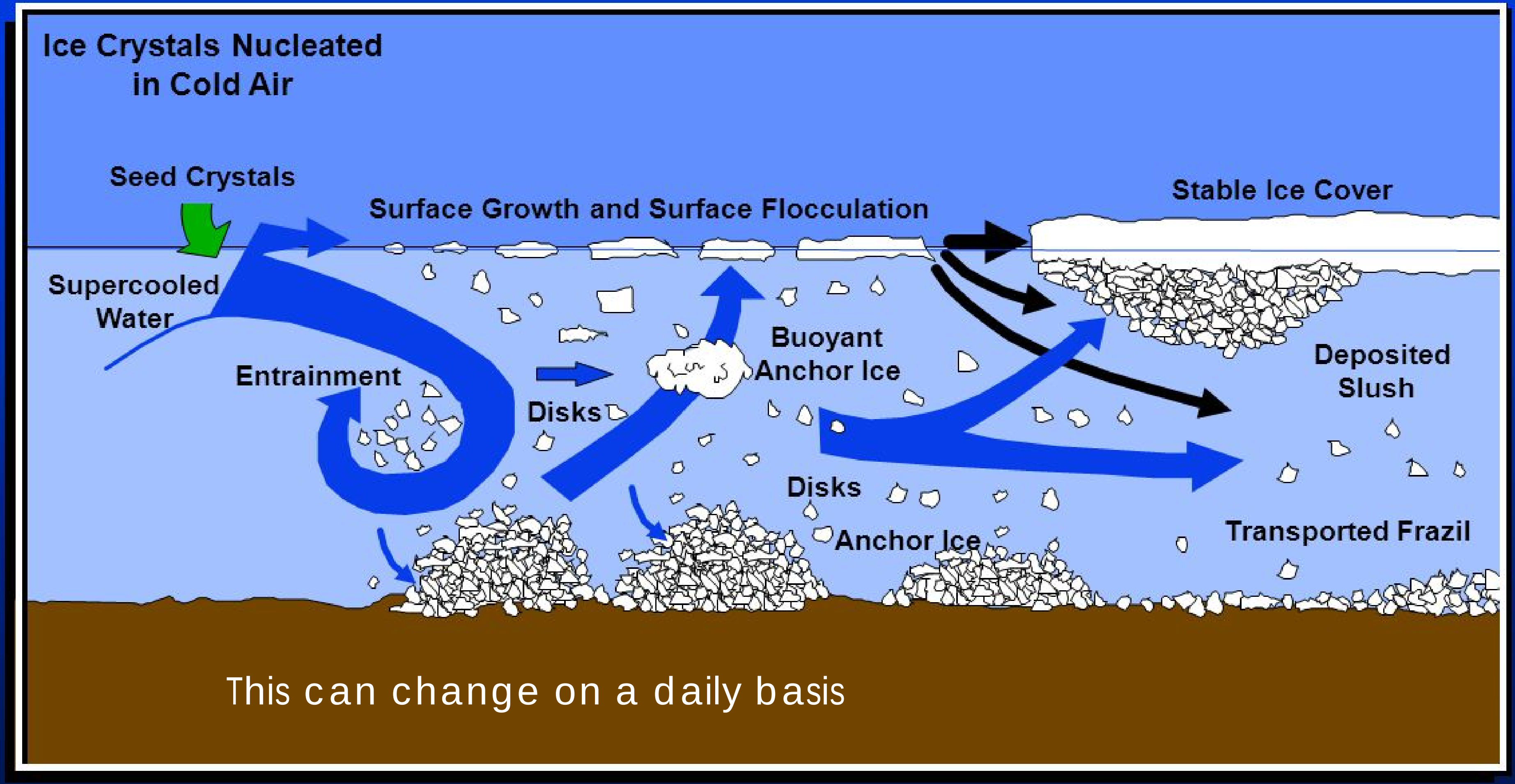


Variation in frazil ice build up month over month

(generated by a high-tech computer model of course!)



FRAZIL ICE IN RIVERS



March 18

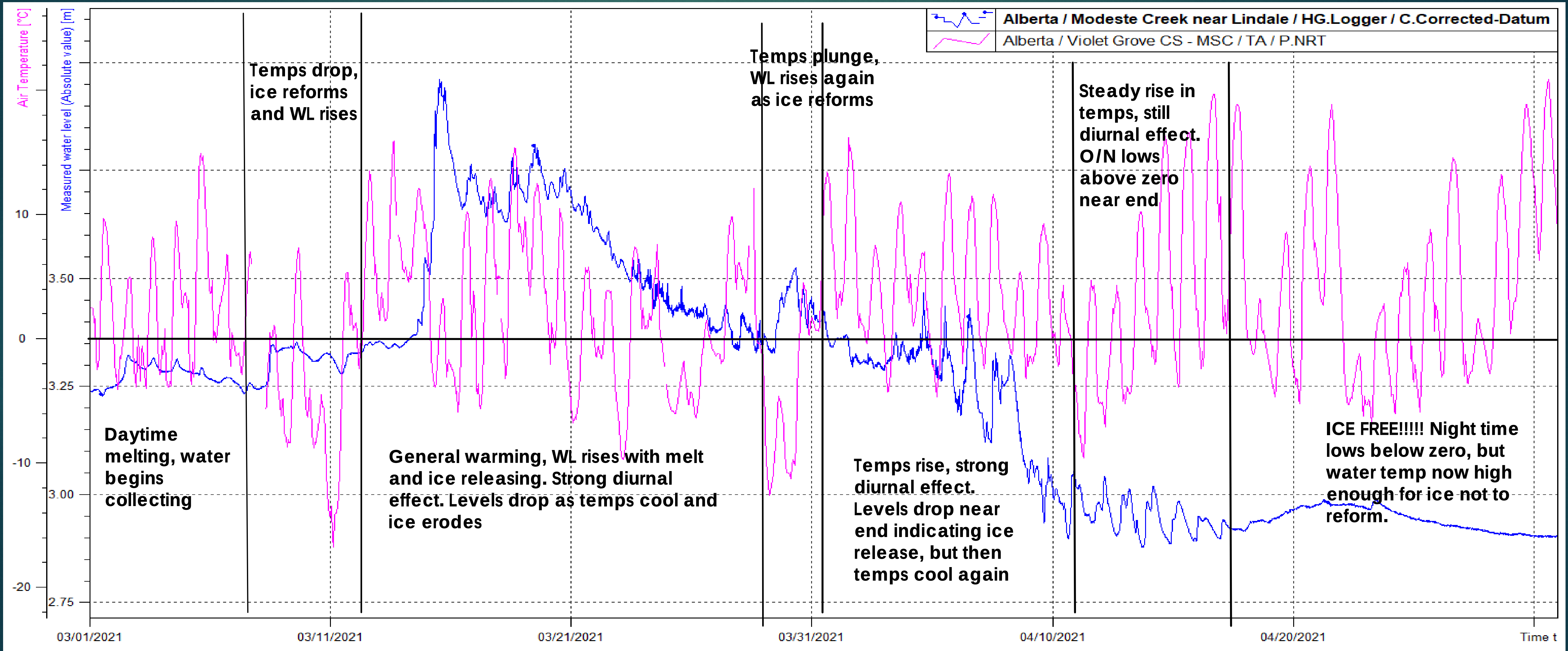
March 23

As the snowmelt begins in the spring water will often start to collect and pond at the gauge, resulting in a water level increase. This is due to the dam-like effects of the snow and ice in the channel. Water will <u>not</u> actually begin to flow over the surface until later when additional water arrives from upstream and the push of that water gains momentum. Some years this transition takes several days, other years it can happen overnight.

March 17 @ 17:00

March 18 @ 07:00

Often we will get periods of melting and runoff, followed by extreme cold and refreezing again. This really plays havoc with the record since flow had been established, but now there is an increased amount of water to form new ice.



Methods of measuring water level

For measuring water level, the most common method is with a bubbler and pressure sensor. The recorded values are logged every 15 minutes on an on-site data logger and transmitted out via satellite once an hour. Currently we use the FTS bubbler, though there was a manufacturing defect that caused a great deal of lost data and consternation, and is still slowly being addressed.

The bubbler contains a sensitive pressure transducer. Air bubbles are sent from the bubbler at a self-regulated rate of 60/minute. As the head pressure of water above the line on the streambed increases, the sensor monitors the force required to push the bubbles out the line and reflects this as water level change. It also self-adjusts to maintain that consistent bubble rate.

The line is anchored on the streambed by a 100-lb concrete block or other means. Despite the weight, these are often moved or taken away completely by ice and high water. In shallow streams the ice can form down and encase these blocks resulting in a small air pocket trapped in the ice. They can also become buried by silt and gravel which leads to spiky or erratic data.

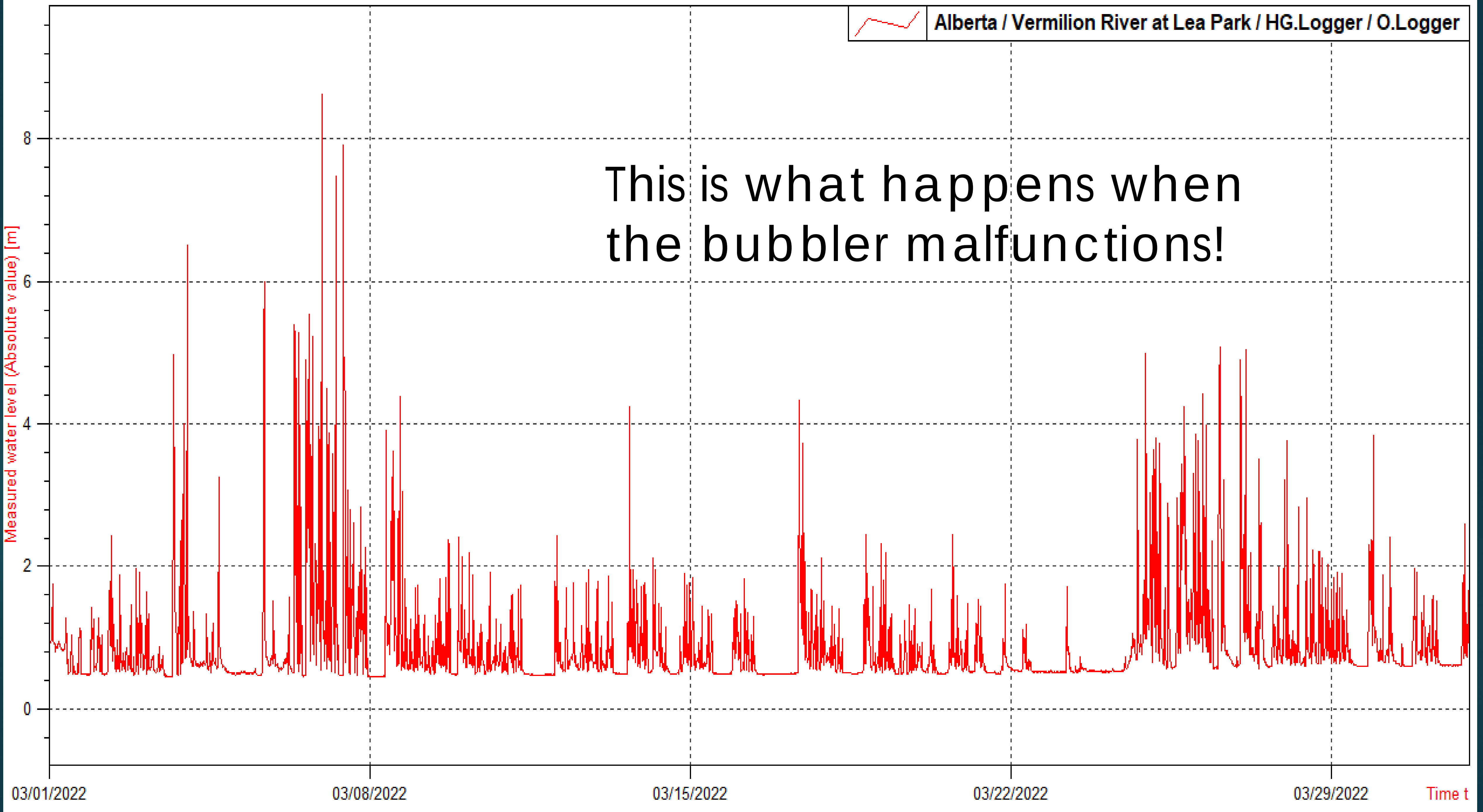
The bubblers have a purge mechanism which builds up to 90 psi pressure and then releases it out the line, blowing away silt and debris.

Many smaller creeks can freeze completely to bottom in the winter months. Certain types of pressure transducers can be damaged by freezing and would need to be removed prior to freeze-up.

If an orifice line freezes, it creates a back-pressure when the compressor runs resulting in the pressure-relief valve blowing off. Fortunately this mechanism prevents damage to the equipment, but it can often take until well into the spring for that line to thaw due to it being buried underground. The only remedy is to run a new temporary line but of course that cannot be done until water starts to accumulate in the channel. If you install the temporary line above the ice it will just be torn out when the ice begins to move or show abrupt shifts during the melt.

The data output at this time can be anything from a flat line to a wildly spiky or erratic record which is of little value. Occasionally water can infiltrate under the ice and fill the pocket or void near the line resulting in a level change with little visible evidence on the surface.

Most stations have been located where there is a deeper “gauging pool” to hopefully prevent this from happening. Given the very dry year last year it is very possible we will see frozen lines this winter or spring though.


Alberta / Vermilion River at Lea Park / HG.Logger / O.Logger
This is what happens when the bubbler malfunctions!
Measured water level (Absolute value) [m]
8
6
4
2
0
03/01/2022
03/08/2022
03/15/2022
03/22/2022
03/29/2022
Time t

Another option is a submersible pressure transducer. These perform the same function as the bubbler, without the need to supply air through a line. They are vented to atmospheric pressure, and return a stage value to the logger.
Why do we only use these is select situations?

If the ice and debris are going to inevitably take it away at some point, these cost over **$2000**, where a new block and line would cost less than **$200**!

Other options to measure stage:

Radar sensor:

- Excellent option where there is a clear line of sight to water and a structure to mount it on
- Does not require temperature compensation
- Will not work through ice
- High reflectivity of snow leads to erratic winter data

Acoustic sensor:

- Lower cost option
- Requires temperature compensation
- More prone to noise and scatter
- Needs frequent maintenance
- Needs line of sight with 22º/meter cone
- Will not work through ice

In the past, float-activated sensors and mercury manometers were the standard sensors deployed. For obvious safety reasons like confined space entry, floats freezing in, the need for a stilling well, and mercury contamination these have been phased out.

Measuring flow under ice

Accepted accuracy of final QA/QC'd open water flow data is + or – 5%.
Some sources claim under ice conditions this is more like + or – 50%.

And remember that is for FINAL QC'd data, not near-real-time data.

Basically what it boils down to is locating a section with good laminar flow, even depth, and uniform velocity and drilling holes through the ice to measure depth & velocity – easy, right!

Not when you can't see what's down there!

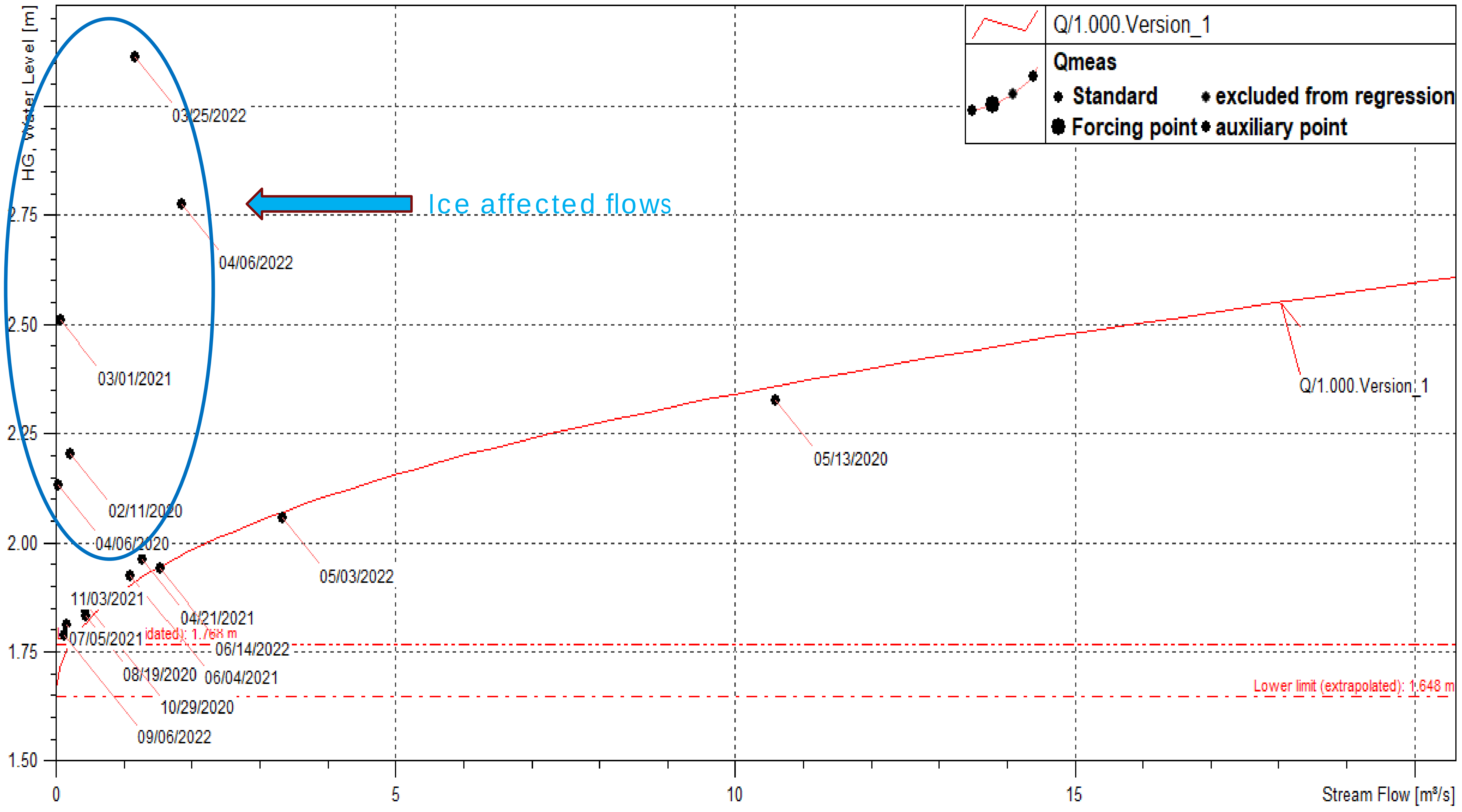
Methods of measuring flow under ice

We primarily use the Sontek Flowtracker2 with a specially adapted under-ice mount.

We also deploy the Sontek M9 ADCP under ice for larger, deeper rivers.

Occasionally we have to resort to old-school mechanical meters in slush conditions or in cases of equipment failure or power issues. Mechanical meters requires a beeper to count revolutions and a stopwatch to time them, both of which can be problematic in the cold. Results also have to be manually calculated.

The relationship between water level and flow (stage-discharge) is heavily impacted by the increased volume that ice occupies, and the increased effect of friction from the ice



Q/1.000.Version_1
Qmeas
Standard
excluded from regression
Forcing point
auxiliary point
Ice affected flows
HG, Water Level [m]
2.75
2.50
2.25
2.00
1.75
1.50
0
5
10
15
Stream Flow [m³/s]
03/25/2022
04/06/2022
03/01/2021
02/11/2020
04/06/2020
05/03/2022
05/13/2020
Q/1.000.Version_1
11/03/2021
04/21/2021
07/05/2021
06/14/2022
08/19/2020
06/04/2021
10/29/2020
09/06/2022
Lower limit (extrapolated): 1,648 m

Site	Station Name	
AB	Ram River near the Mouth	05DC006

Date YYYY-MM-DD	Time (MST)	Mean Gauge Height (m)	Flow (m³/s)	Shift (m)	% Diff of Shift Correction	Air Temp °C	Water Temp °C	Measurement Method
01/14/2015	10:55:00	0.671	5.050	-0.329	-81.9	-8.0	0.0	Ice
02/11/2015	16:00:00	0.628	3.880	-0.311	-82.8	-6.0	0.0	Ice
03/12/2015	14:50:00	0.690	4.830	-0.353	-83.9	12.0	0.0	Ice
12/16/2015	12:40:00	1.058	6.130	-0.694	-90.4	-11.0	0.0	Ice
01/18/2016	14:20:00	0.720	4.600	-0.389	-86.2	-7.0	0.0	Ice
02/19/2016	10:00:00	0.662	4.700	-0.328	-82.3	2.0	0.0	Ice
03/07/2016	16:40:00	0.670	4.940	-0.330	-82.2	6.0	0.0	Ice
12/15/2016	14:00:00	0.528	4.730	-0.193	-65.9	-17.0	0.0	Ice
01/20/2017	09:50:00	0.465	5.140	-0.122	-49.7	-8.0	0.0	Ice
02/14/2017	13:40:00	0.572	4.820	-0.235	-71.9	7.0	0.0	Ice
03/21/2017	14:10:00	0.377	3.950	-0.059	-40.4	3.0	0.0	Ice
12/13/2017	09:50:00	0.426	4.410	-0.101	-47.9	-7.0	0.0	Ice
01/12/2018	12:22:00	0.167	3.820	0.150	341.8	-29.0	0.0	Ice
01/30/2018	14:08:00	0.322	4.270	0.001	1.8	0.0	0.0	Ice
02/28/2018	11:18:00	0.398	3.190	-0.093	-56.8	-18.0	0.0	Ice
03/21/2018	09:25:00	0.432	2.870	-0.137	-67.1	-6.0	0.0	Ice
04/12/2018	08:50:00	0.420	3.690	-0.106	-55.1	-2.0	0.0	Ice
12/17/2019	16:00:00	1.000	5.360	-0.654	-91.0	3.0	0.0	Ice
01/21/2020	14:01:00	0.724	2.850	-0.430	-91.6	-5.0	0.0	Ice
02/13/2020	10:06:00	0.602	3.910	-0.284	-80.3	-11.0	0.0	Ice
04/07/2020	11:58:00	0.700	3.040	-0.398	-90.3	-2.0	0.0	Ice
01/27/2021	12:02:00	0.505	3.460	-0.196	-72.1	-16.0	0.0	Ice
03/03/2021	08:52:00	0.662	3.380	-0.354	-87.3	-4.0	0.0	Ice
03/29/2021	12:08:00	0.610	3.510	-0.300	-83.0	-7.0	0.0	Ice
12/17/2021	11:29:00	0.794	3.220	-0.488	-92.1	-29.0	0.0	Ice
02/01/2022	12:03:00	0.571	3.370	-0.264	-80.3	-22.0	0.0	Ice

Max WL	1.058 (Q = 63.8 m3/s in open water)
Min WL	0.167 (Q = 0.865 m3/s in open water)
Max Flow	6.130
Min Flow	2.850

In ice-affected conditions, the same flow can occur in the stream at several different water levels dependent on weather, ice conditions, flow volume, etc.

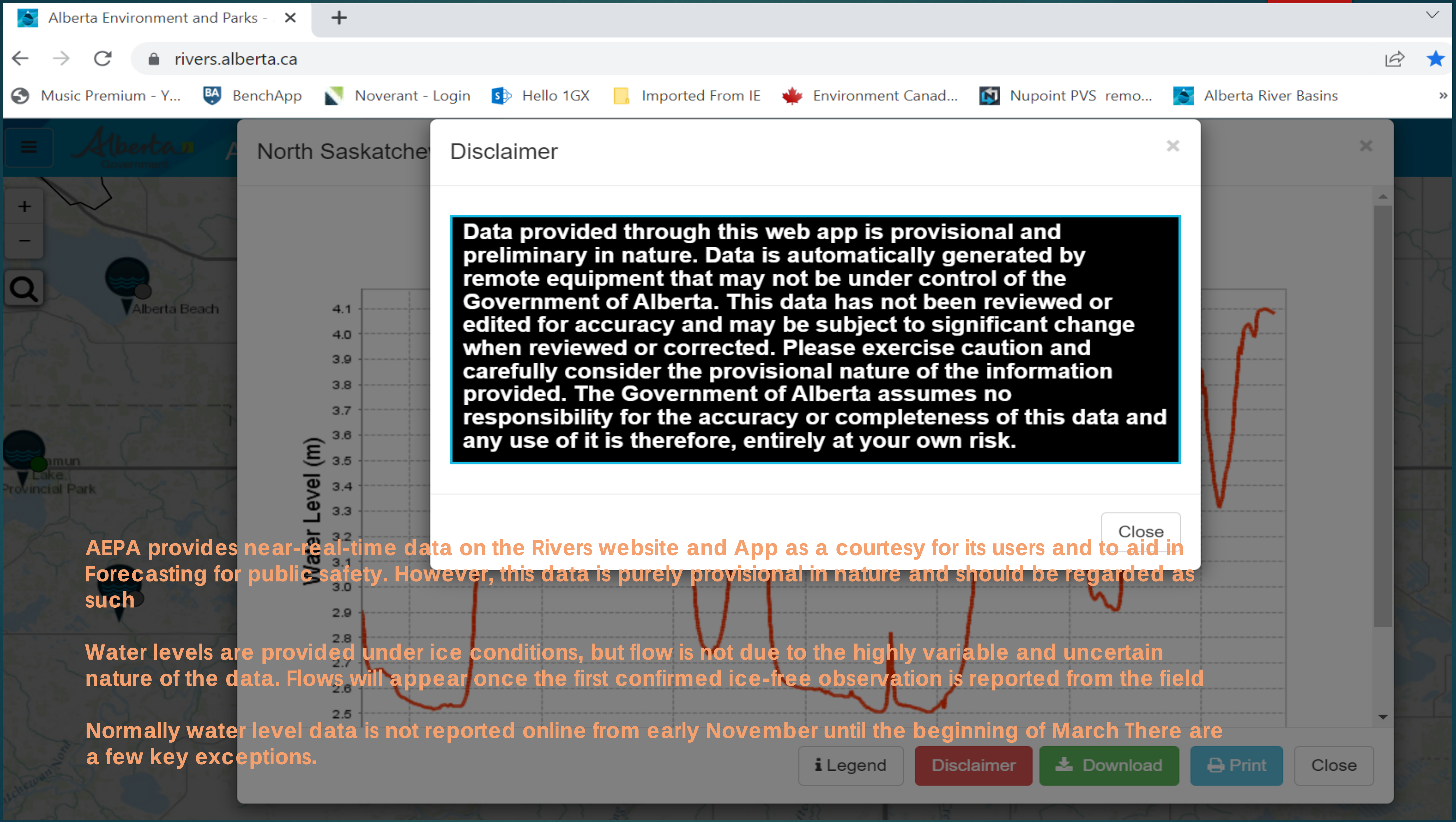
Sometimes the ice conditions present unique challenges

Just run out there and grab a flow measurement!

Cla

And sometimes it’s just damn cold!!!

Mike on his last field trip

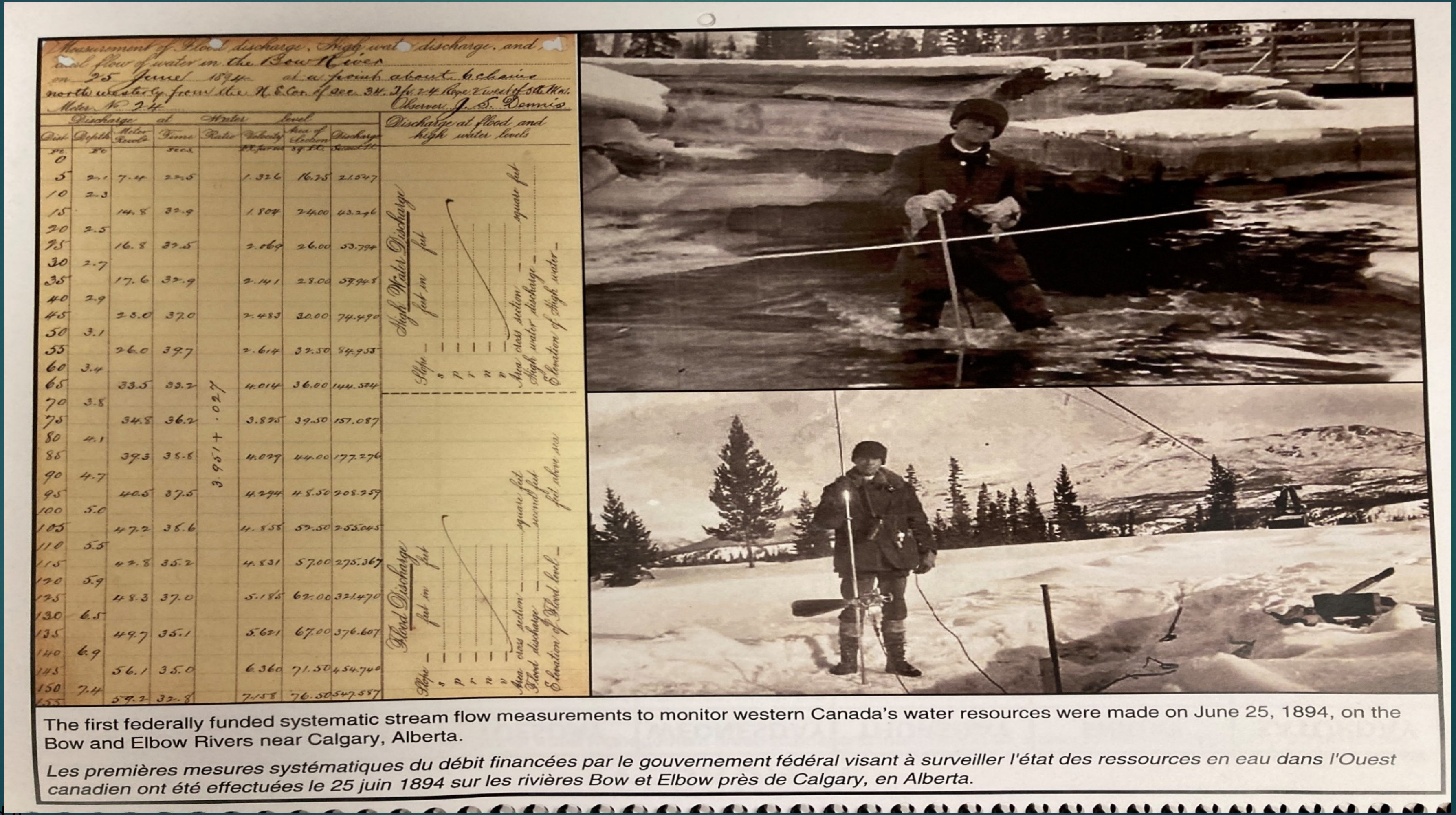


AEPA provides near-real-time data on the Rivers website and App as a courtesy for its users and to aid in Forecasting for public safety. However, this data is purely provisional in nature and should be regarded as such

Water levels are provided under ice conditions, but flow is not due to the highly variable and uncertain nature of the data. Flows will appear once the first confirmed ice-free observation is reported from the field

Normally water level data is not reported online from early November until the beginning of March There are a few key exceptions.

We are not the only ones doing this kind of work! Water Survey of Canada performs the same type of work at several stations across Alberta. Far fewer of the sites are operated year-round (annually). Most are seasonal, operating from March 1 – October 31, but there can frequently be ice conditions at the beginning and/or end of the seasonal operation period.



The first recorded flow observations in Alberta were made in June of 1894 on the Bow and Elbow Rivers.

QUESTIONS??

Alberta River Basins website: https://rivers.alberta.ca/

Environment Canada Water Office (real-time and historic flows and levels): https://wateroffice.ec.gc.ca/index_e.html