Alberta Innovates Technology Futures

Characterizing the Organic Composition of Snow and Surface Water Across the Athabasca Region

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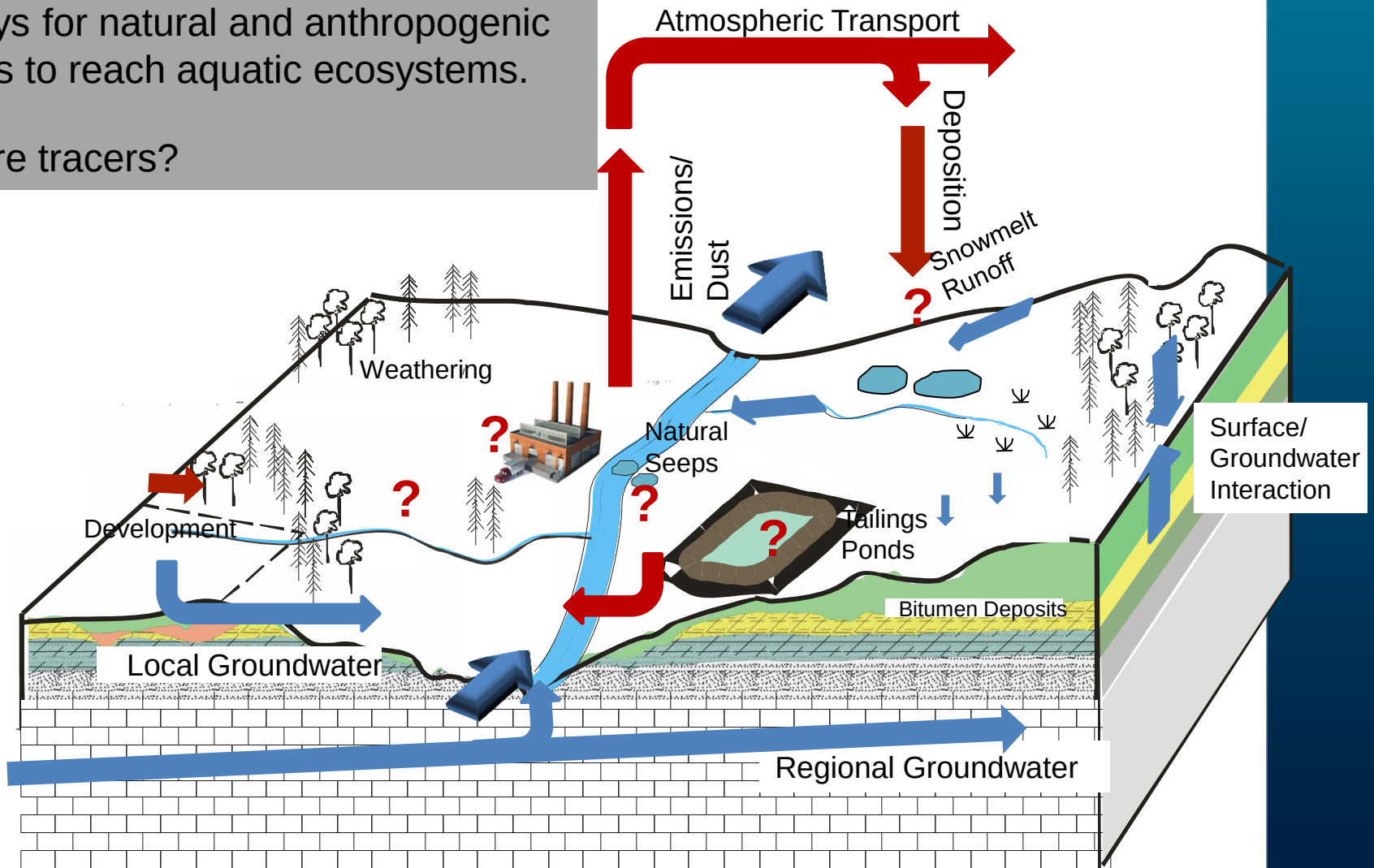
Alberta

SRIN Oil Sands Research and Information Network

Potential Sources of Organics

There are multiple potential sources and pathways for natural and anthropogenic organics to reach aquatic ecosystems.

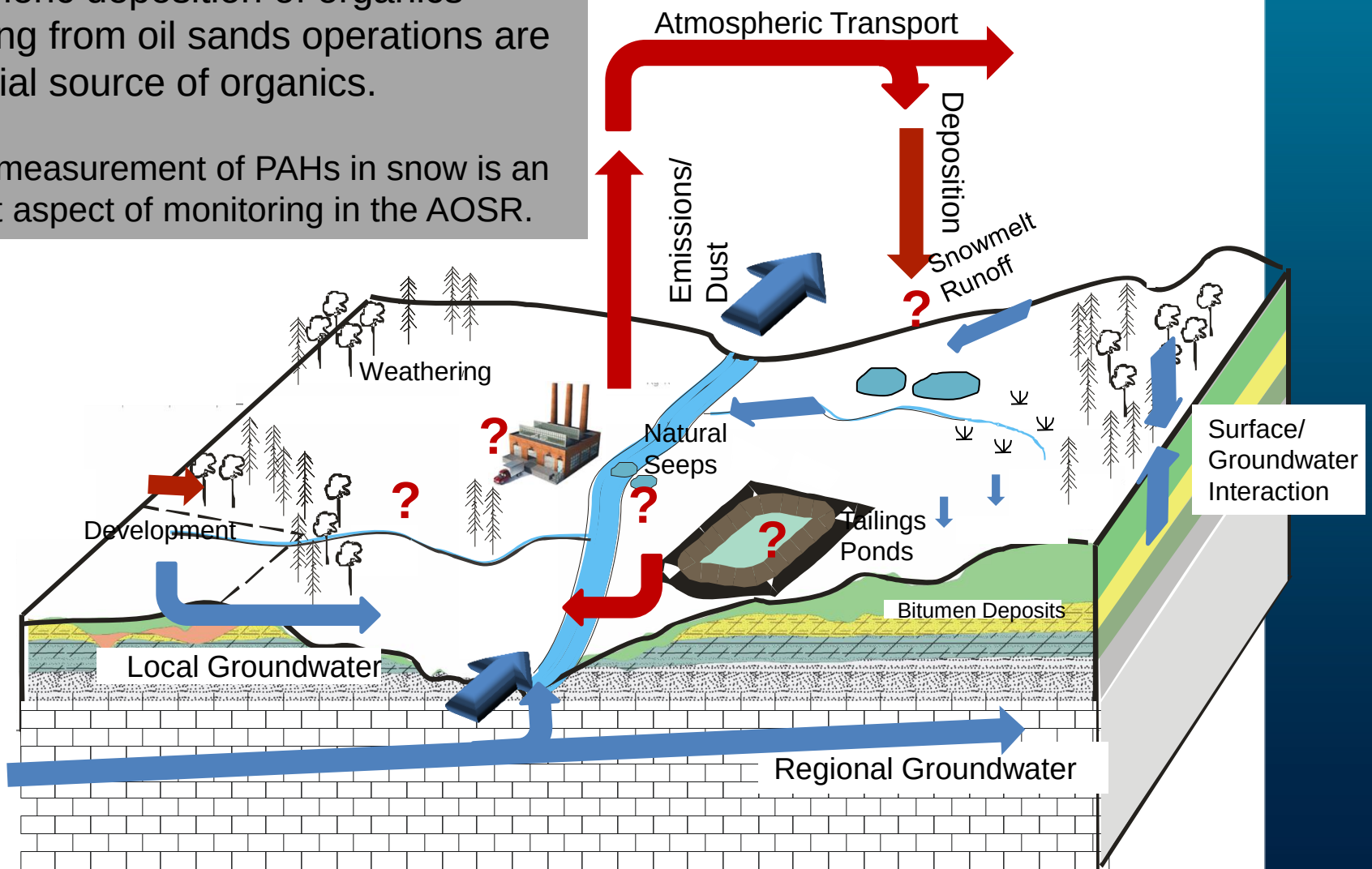
Are there tracers?



Potential Sources of Organics

Atmospheric deposition of organics originating from oil sands operations are a potential source of organics.

Detailed measurement of PAHs in snow is an important aspect of monitoring in the AOSR.



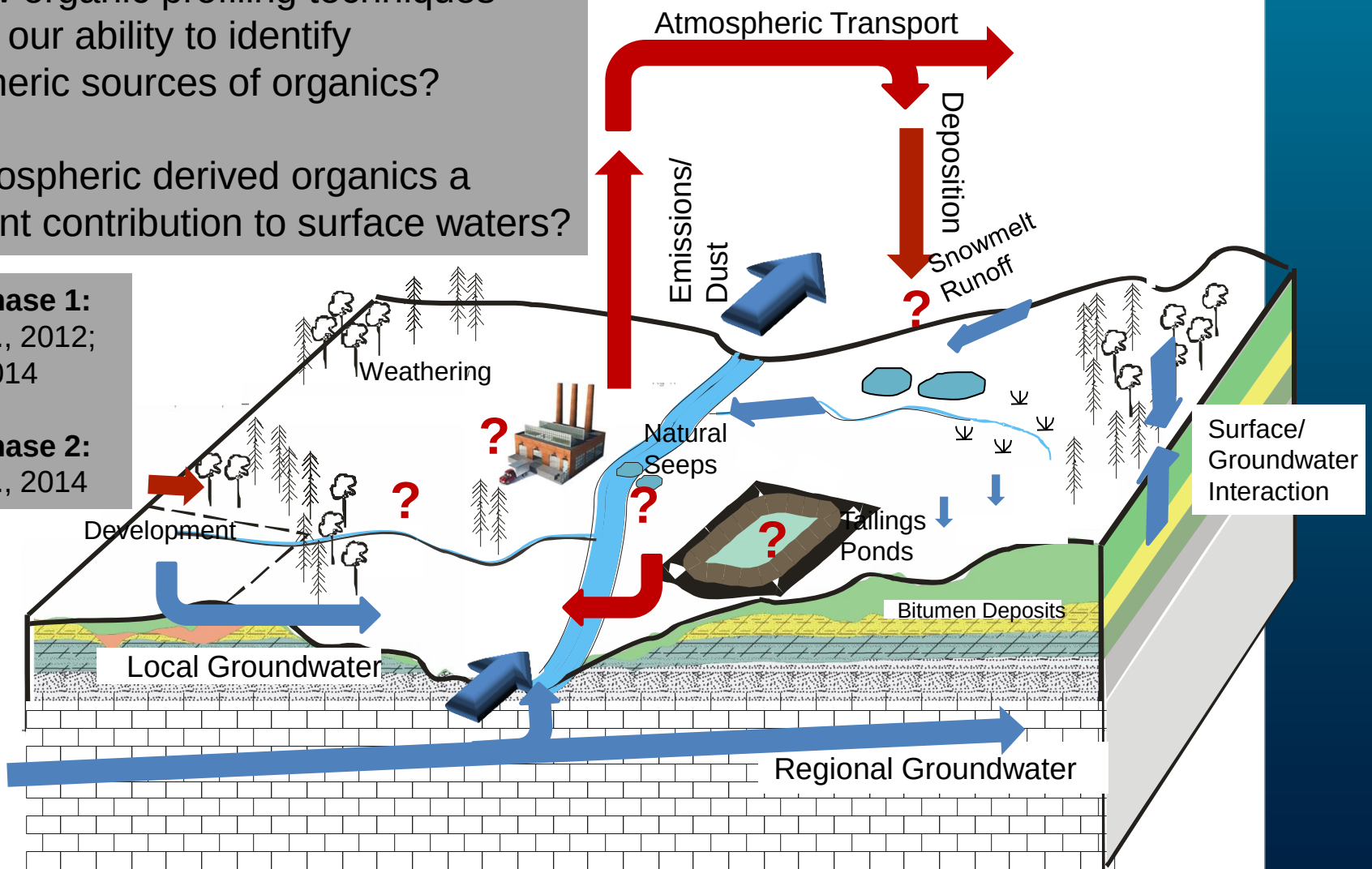
Objectives

Can new organic profiling techniques improve our ability to identify atmospheric sources of organics?

Are atmospheric derived organics a significant contribution to surface waters?

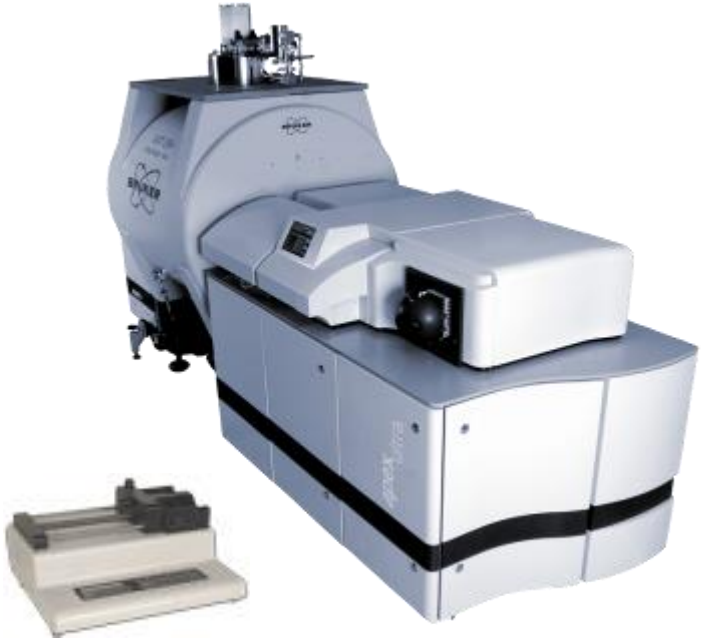
OSRIN Phase 1:
Birks et al., 2012;
Yi at el, 2014

OSRIN Phase 2:
Birks et al., 2014



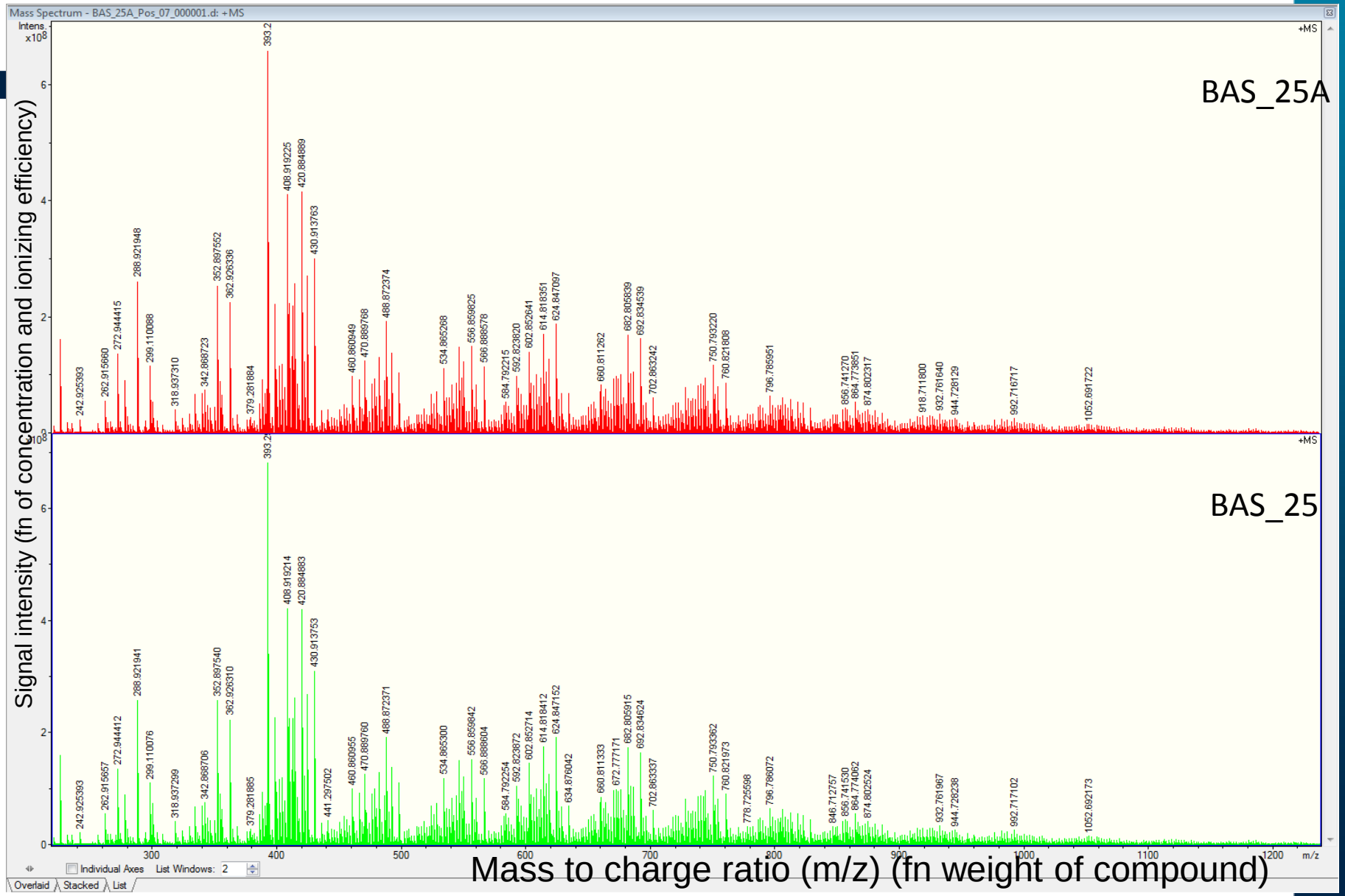
Methods: Organic Profiling

Electrospray ionization fourier transform ion cyclotron resonance mass spectrometry (ESI-FT-ICR MS)



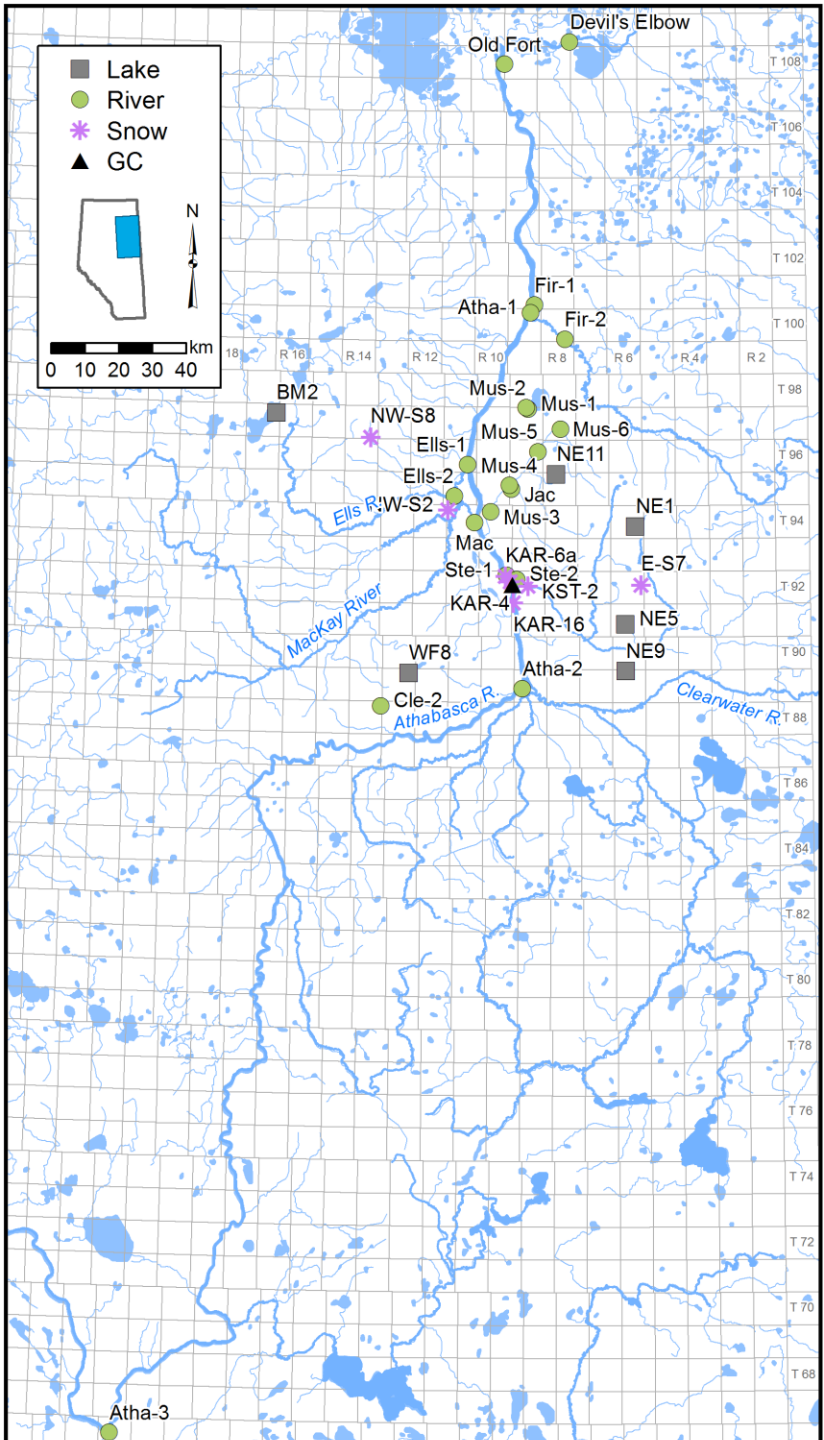
- > 500,000 FWHM with broadband detection
- Simultaneous detection of 10,000 compounds in a single acquisition
- Highest broadband mass resolution power and mass accuracy available, making it possible to identify individual compounds in a complex mixture of organics.

Methods: Organic Profiling



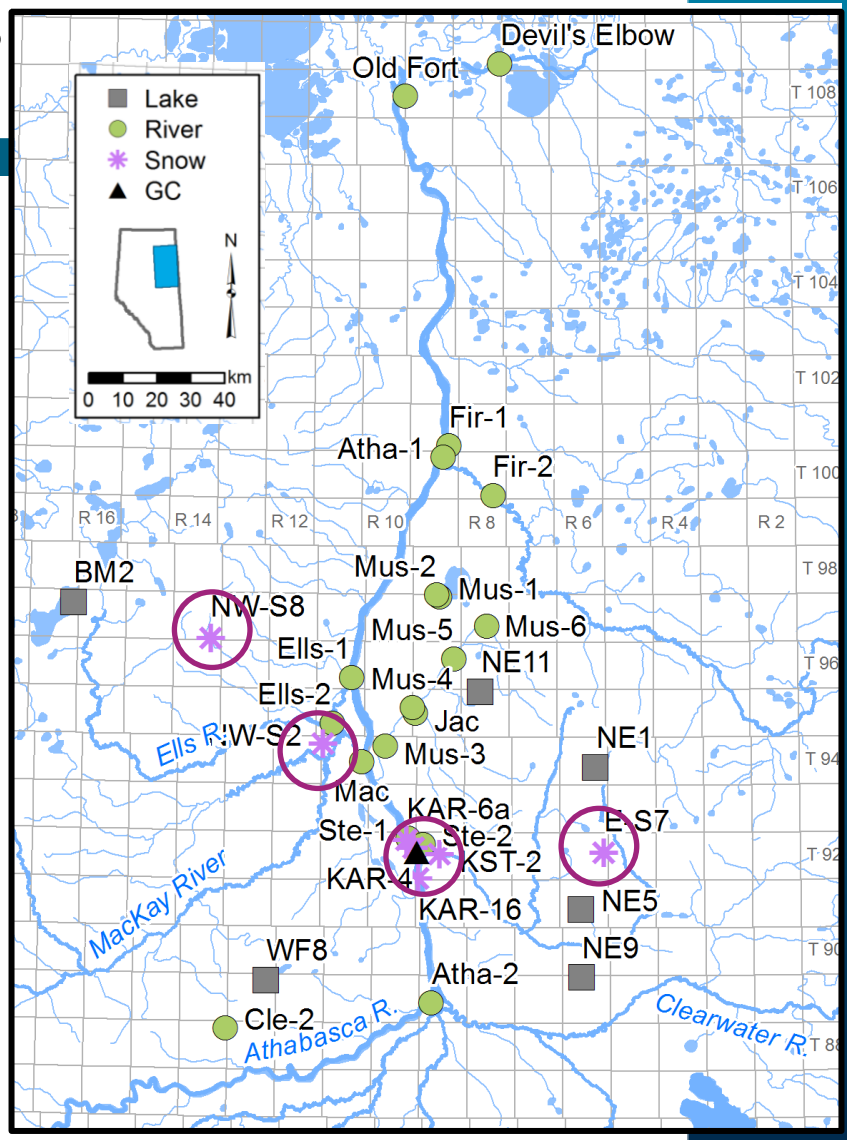
Snow & Surface Water Samples

- 79 surface water samples
  - 73 Athabasca River and tributary samples, and
  - 6 lake samples
- 7 snow samples.
- Samples were collected by ESRD during various snow and surface water monitoring programs

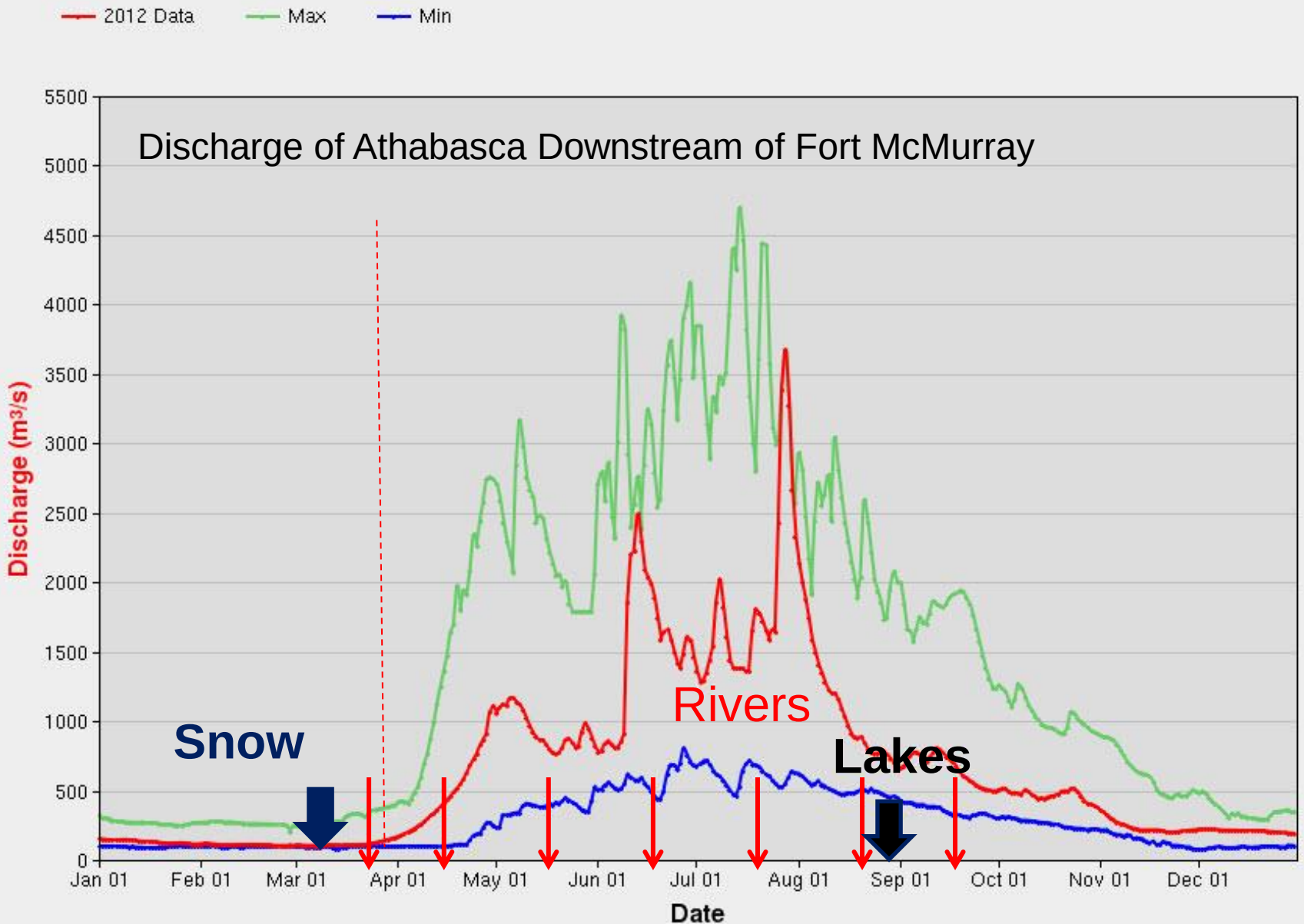


Snow & Surface Water Samples

- Snow
  - March 2012
- Rivers:
  - Monthly samples March 2012 to Sept 2012.
- Lakes
  - Aug. 2012



Snow & Surface Water Samples



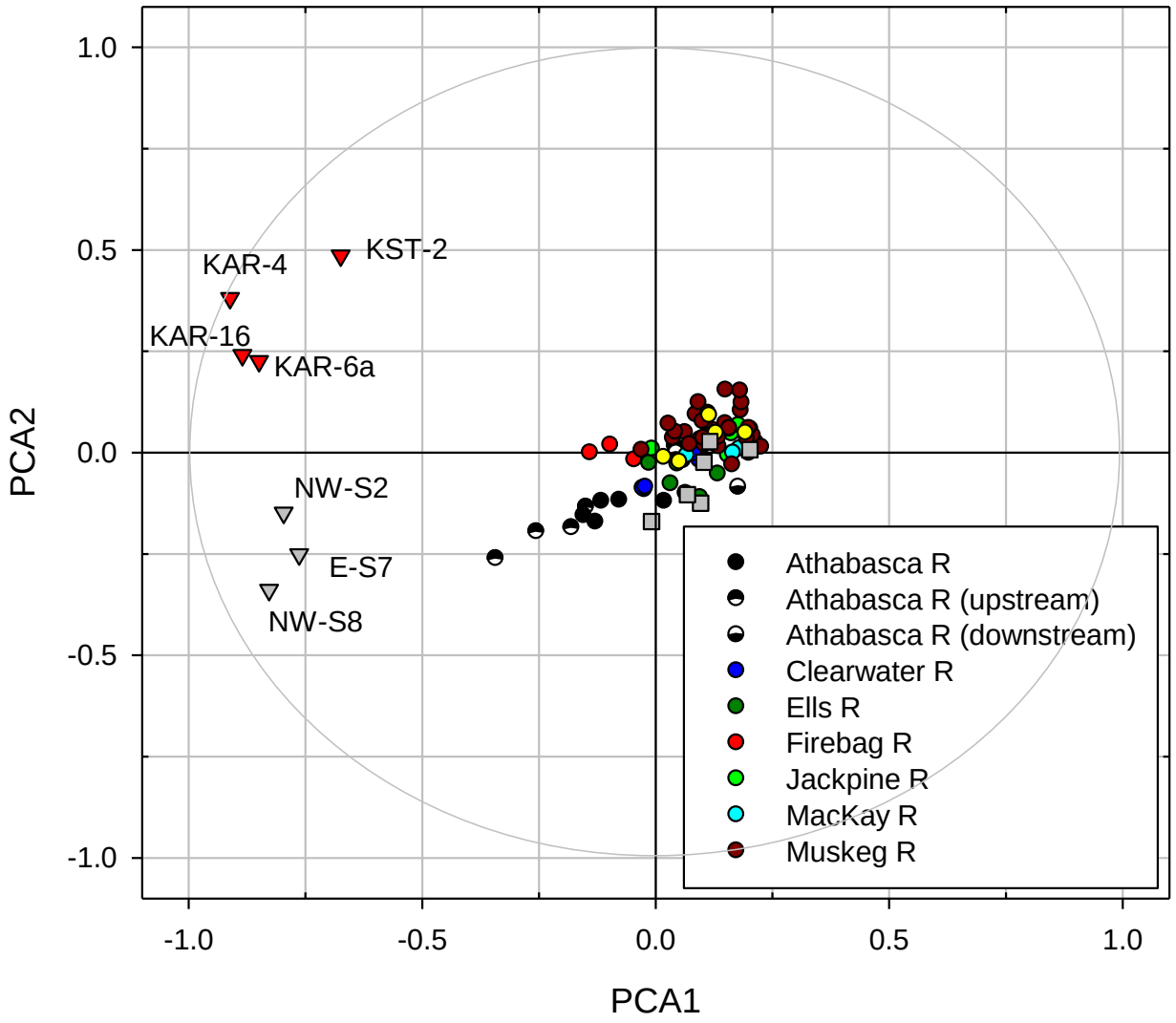
Results

- What dissolved organics were detected?

		# of Peaks
Snow	Far-Field	1738
	Near-Field	2120
Rivers	Athabasca	2816
	Tributaries	3183
Lakes	Lakes	3009

- The # of peaks detected in river samples increased from March (under-ice) to Sept.

Principal Component Analysis

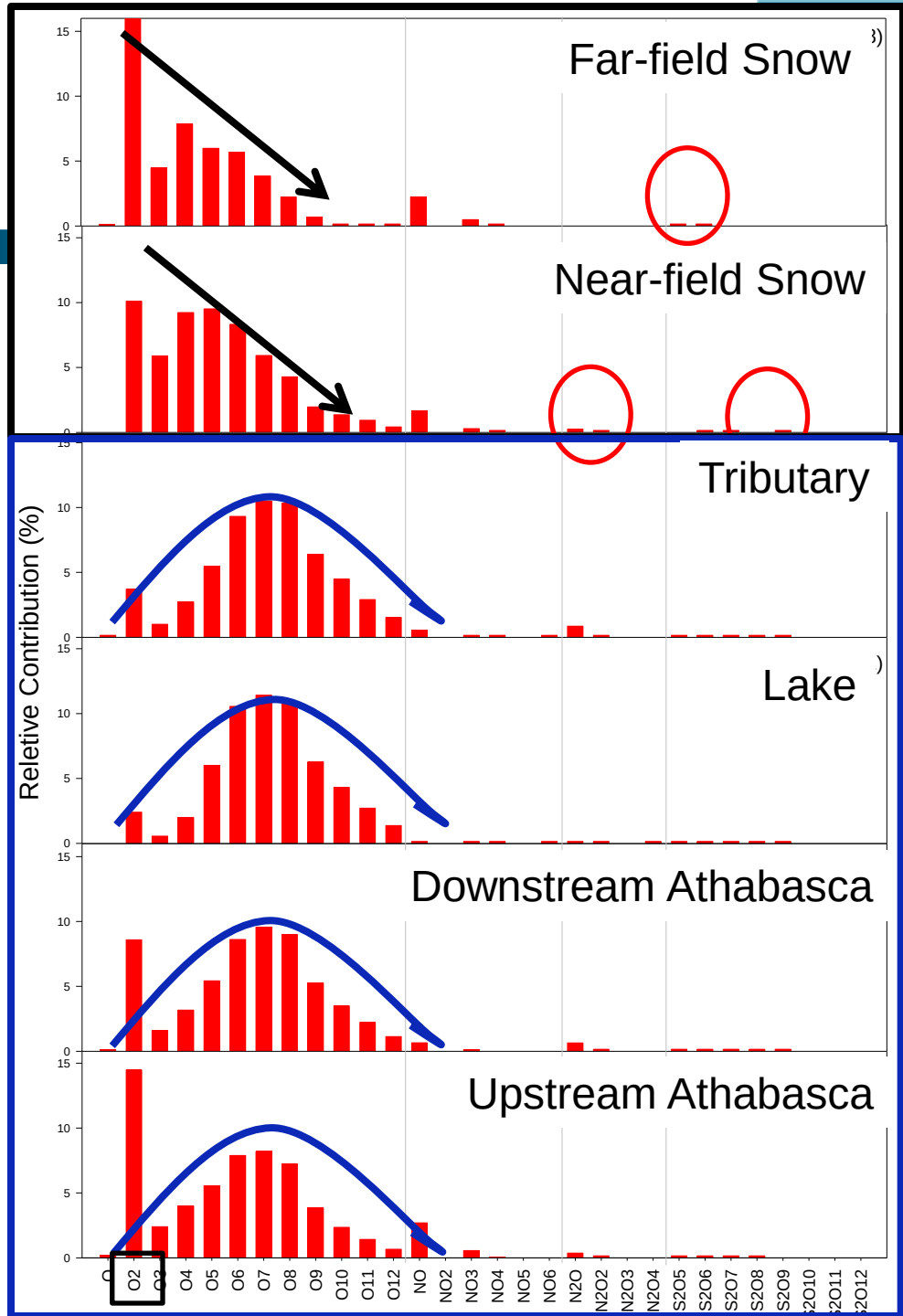


- Near field snow is different from background snow.
- Dissolved organics present in surface water are different from near field snow.

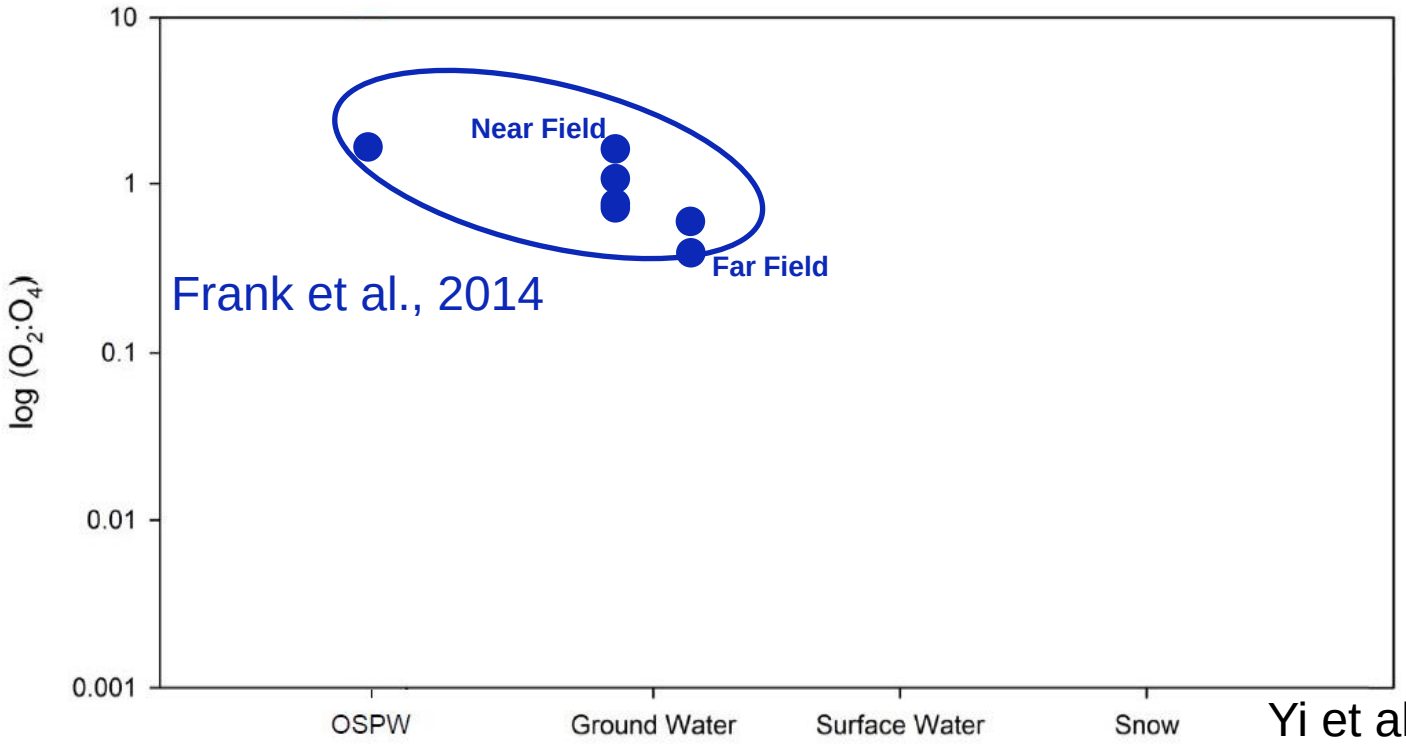
Results

- Different compound classes are present in:
  - Snow and surface water
  - Near and far field snow
- Near-field snow samples have N_2O_n and S_2O_n compound classes, which are absent in far-field snow

Naphthenic acids, $C_nH_{2n+z}O_2$



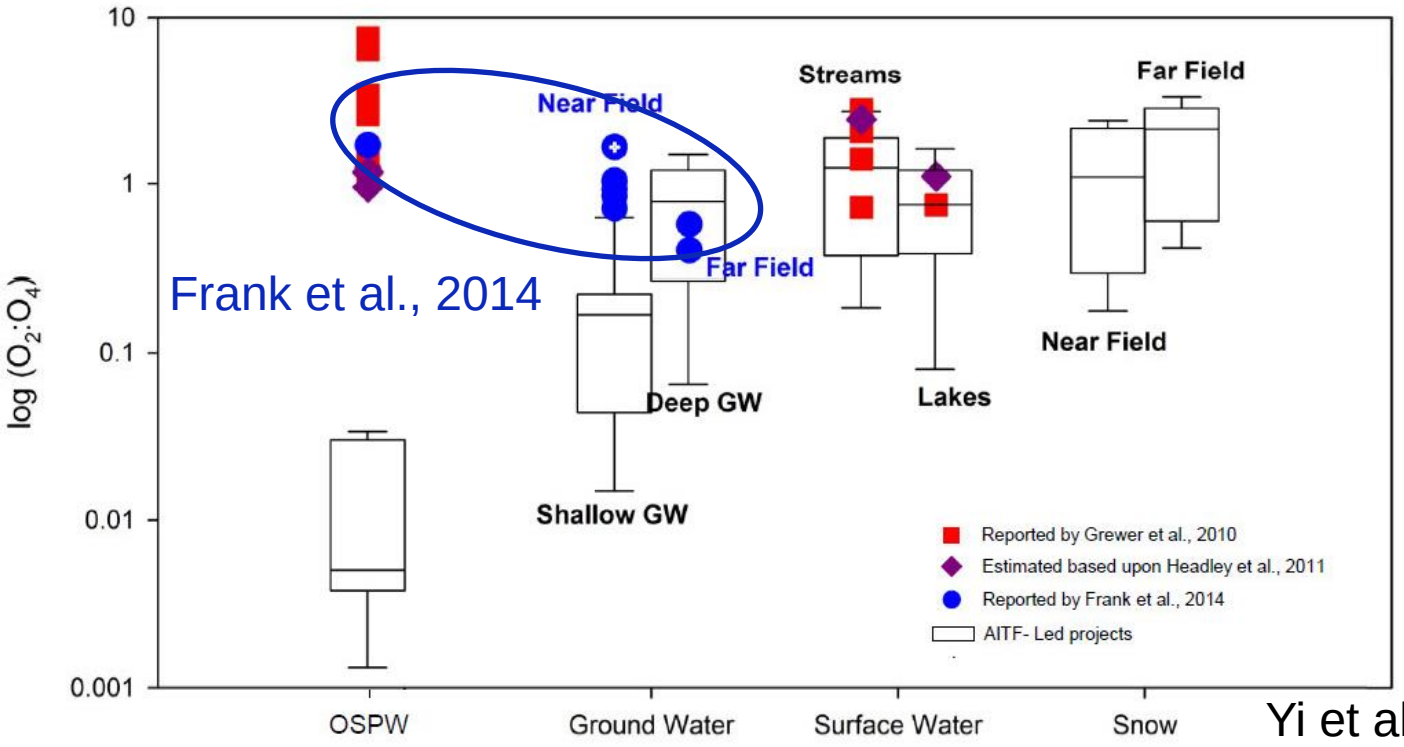
Results: New Tracers?



Yi et al., 2014

- Can we use these results to identify potential tracers of natural and anthropogenic sources of organics in the AOSR?
- Interest in using O_2:O_4 as a tracer of OSPW.

Results: New Tracers?



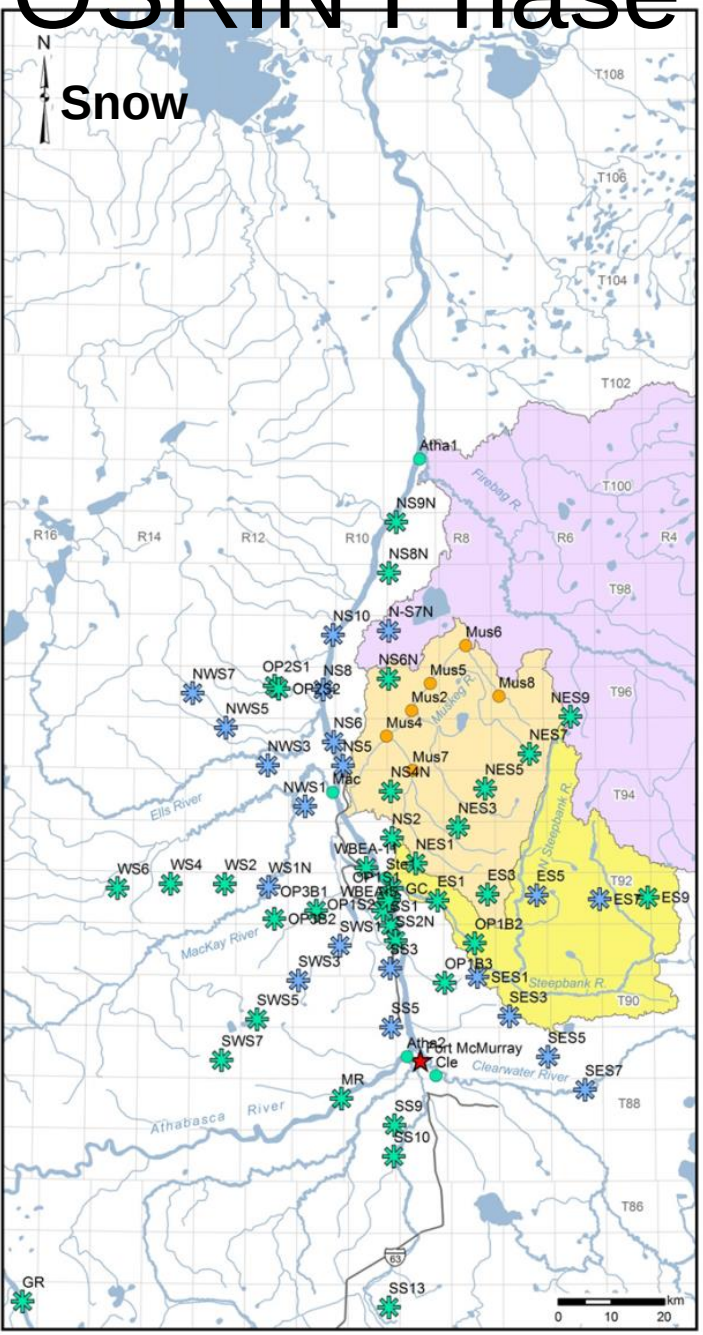
Yi et al., 2014

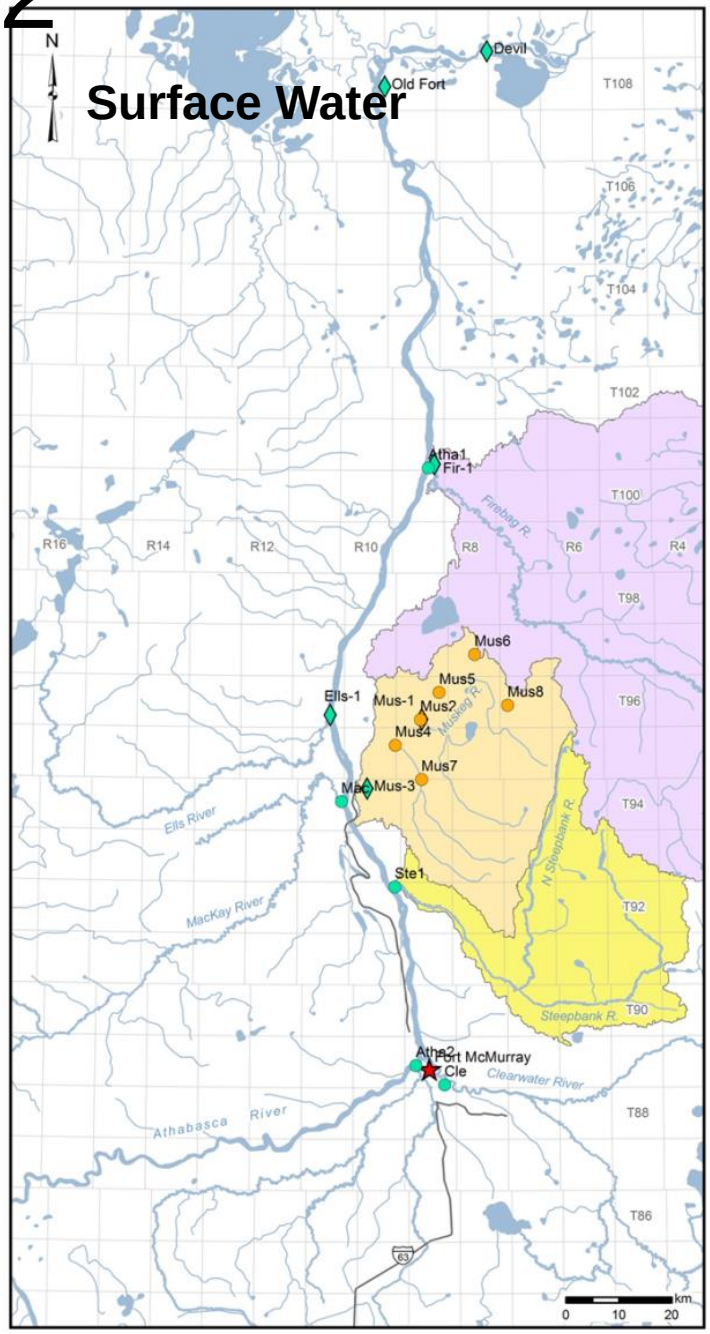
- Importance of characterizing all of the potential endmembers and multi-tracer approach.

Summary

- Near-field snow samples were compositionally different from far-field snow
- The dissolved organic composition of upstream Athabasca River is similar to far-field snow
- No evidence that Athabasca River become more similar to near-field snow
- Compound classes potentially indicating sources in AOSR have been identified
  - Near-field snow samples have N_2O_n and S_2O_n compound classes, which are absent in far-field snow.

OSRIN Phase 2





Legend

Snow Locations
- Snow FTICR and SWI
- Snow SWI Only

River Locations
- River FTICR and SWI
- River FTICR Only

Snow-River Co-Locations
- Co FTICR and SWI
- Co FTICR Only

City

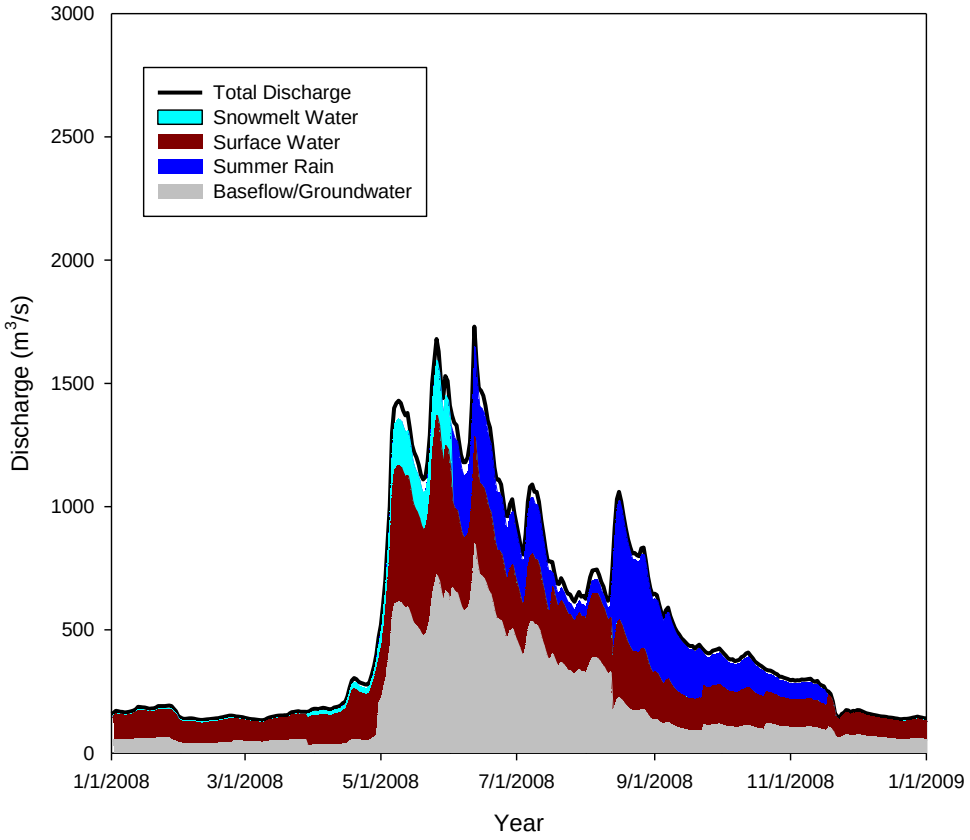
Road

Watercourse

Watershed
- Firebag River Watershed
- Muskeg River Watershed
- Steepbank River Watershed

Birks et al.,2014

Next Steps: Streamflow Partitioning



- Determining underlying causes of water cycle variability
- Source-apportionment
- Better understanding of water quality-water quantity relationships
- Role of snowmelt, groundwater or wetlands in determining water quality

Potential Applications of Results

- Ultrahigh resolution organic profiling may provide a way of identifying atmospherically derived organics.
- Identified compound classes present in near-field snow that are not present in far-field snow.
- Benefits of combining research with monitoring
  - Access to samples and expertise
  - Linking applied research with policy

Thanks !

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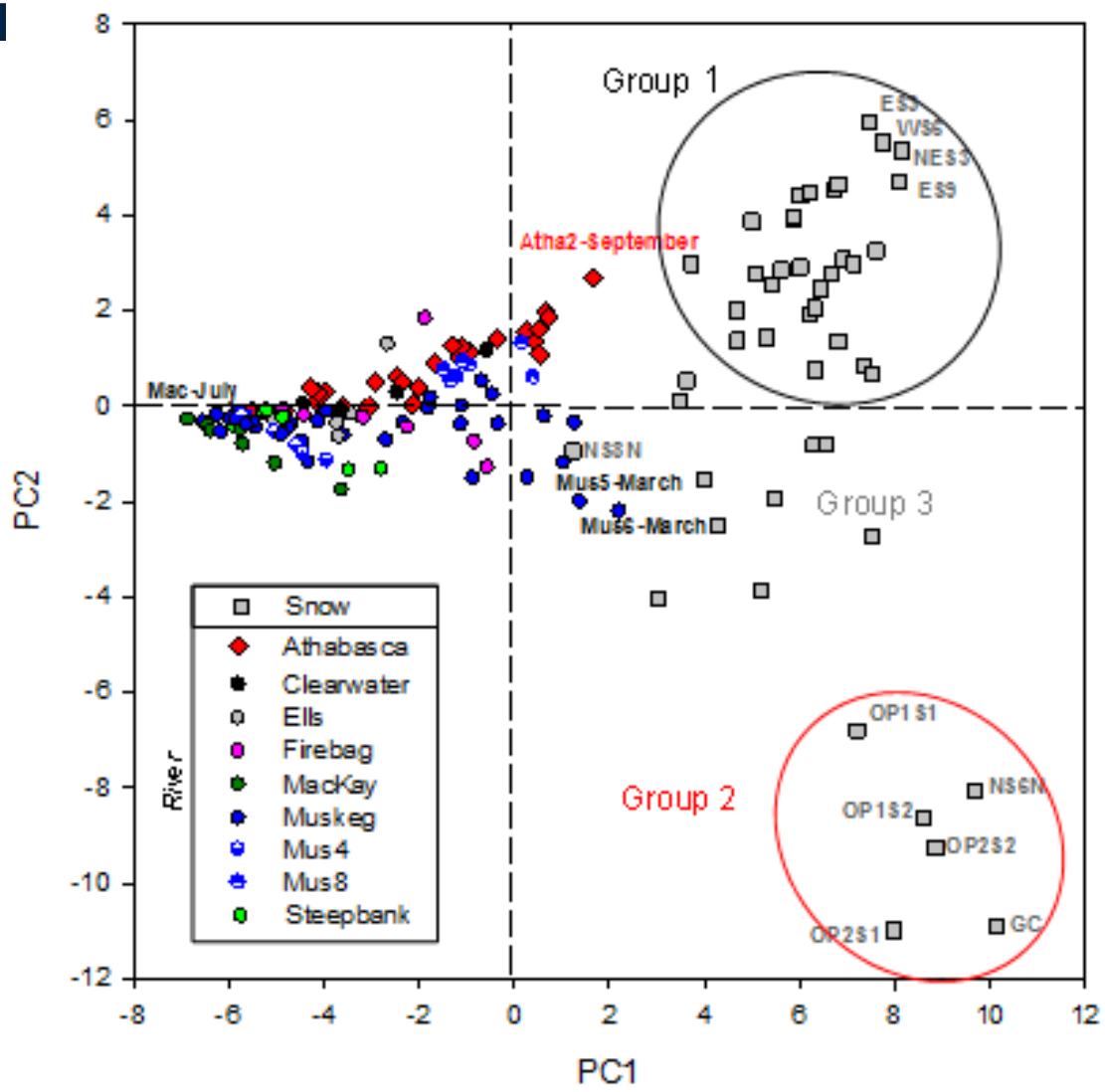
- Dr. Kusumakar Sharma (AESRD) and Emily Taylor (AITF).

OSRIN
Oil Sands Research and Information Network

Do the dissolved organics present in snow resemble those present in surface waters? : 2012



- Combining isotopic and organic profiling we have found that the dissolved organics present in rivers during the peak of snowmelt do not show evidence of a significant contribution of atmospheric organics.