SAMMS

# SAMMS (Sub-Arctic Metal Mobility Study) Newsletter – Winter 2018

Welcome to **SAMMS, the 'Sub-Arctic Metal Mobility Study'**. SAMMS is one of several projects supported by the 'Global Water Futures: Solutions to Water Threats in an Era of Global Change' program.

In this inaugural newsletter, we summarize findings that led to conceiving of the SAMMS research program, we provide an overview of our research plan, we introduce members of the research team, and we highlight recent and upcoming SAMMS research activities. It is our intention to use newsletters as one of several means to keep partners informed of our research progress and plans. We hope you find this helpful.

On behalf of the research team, we would like to extend a thank you to our research partners for providing letters of support for our proposal and we look forward to continued interactions as the SAMMS research program evolves. If you have any questions, suggestions or concerns, please do not hesitate to contact Brent or Jason.

We look forward to hearing from you,

Sincerely,

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## Origin of SAMMS

The origin for the 'idea' of the SAMMS research program began in 2011. In the fall of that year, SAMMS researchers Brent Wolfe (Wilfrid Laurier University), Roland Hall (University of Waterloo), and their graduate students (Matthew Elmes, Lauren MacDonald) launched a study in the Slave River Delta. The study (which was an invited contribution to the Slave River and Delta Partnership) was designed to use information preserved in lake sediment records in the delta to examine if contaminants, such as concentrations of metals and polycyclic aromatic compounds, had increased since the start of mining in the Alberta oil sands region. The study aimed to address concerns of the community of Fort Resolution about pollution from the oil sands industry possibly reaching the Slave River Delta.

Upon examination of a sediment record from lake 'SD2', the researchers did not find any evidence of pollution related to oil sands development. However, to their surprise, they did observe enrichment in arsenic concentrations beyond background levels in sediments deposited during the 1950s (Figure 1). In fact, maximum arsenic concentrations (19.1 mg kg-1) exceed Canadian Council of Ministers of the Environment (CCME) Probable Effects Level (17.0 mg kg-1). At this time, the lake did not receive floodwaters from the Slave River and so the mostly likely origin of the arsenic was by atmospheric deposition. Examination of possible sources led the researchers to conclude that the arsenic most likely came from emissions during the early years of gold extraction at Giant Mine in Yellowknife. Support for this interpretation were other elements enriched above background levels during this interval in the lake sediment core including antimony, calcium and strontium, which are major volatile elements within the mineralogy of the Giant Mine ore deposit. These results implied that peak emissions from Giant Mine during the 1950s may have travelled 140 km to the southeast, much farther than previously recognized. This study was published in 2016 in the journal Science of the Total Environment. [Please contact Brent Wolfe (bwolfe@wlu.ca) to receive a copy of the paper.]

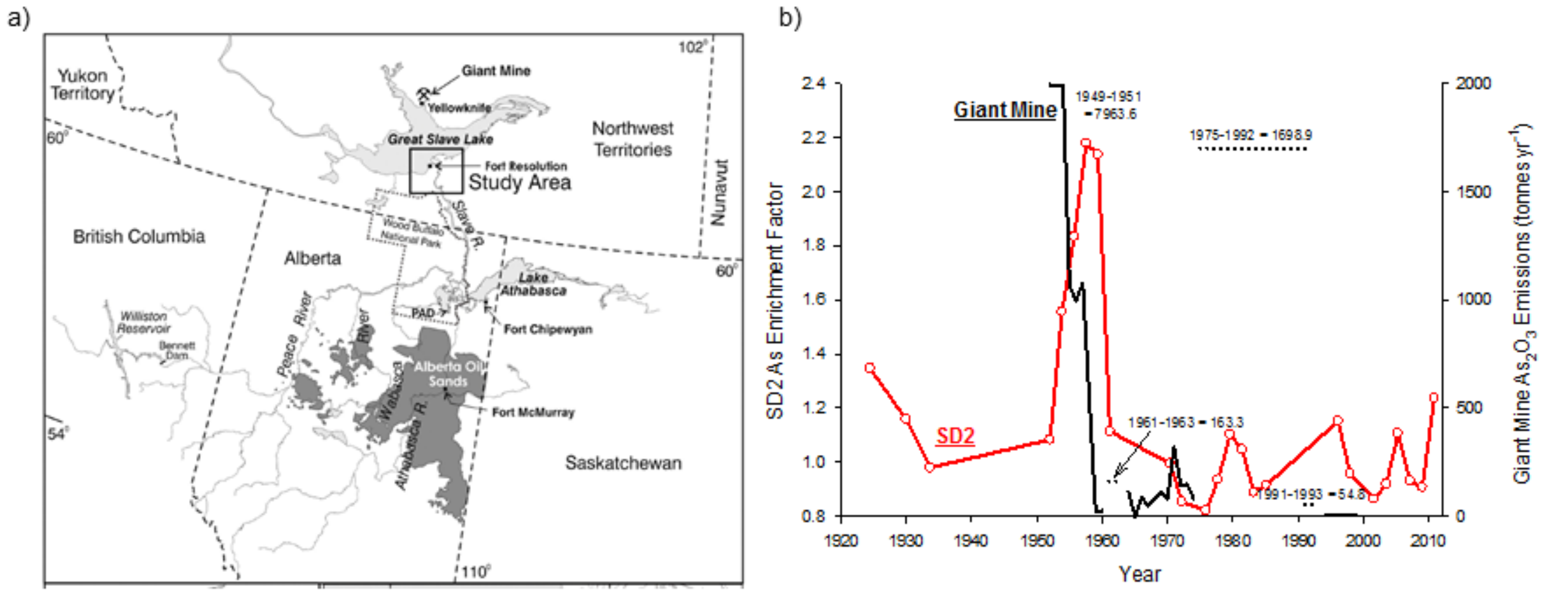


Figure 1. a) 'Study Area' includes location of lake 'SD2' in the Slave River Delta. b) As2O3 aerial emission history from Giant Mine (Galloway et al. 2015) and the arsenic (As) enrichment record preserved in the sediment core from lake SD2 (modified from MacDonald et al. 2016). Note that peak arsenic enrichment in the SD2 record closely corresponds with maximum emissions from Giant Mine.

More recently (since 2015), Brent Wolfe, Roland Hall and their [MSc student, James Telford], have been working with the Tłı̨chǫ Government in the Marian Watershed. They were invited to contribute to the Marian Watershed Stewardship Program (MWSP). The MWSP aims to establish baseline data that can serve as reference points for detecting effects of ongoing climate change and potential mining, such as Fortune Minerals proposed NICO mine, on aquatic ecosystems. They have collected sediment cores from several lakes in the Marian Watershed and have analyzed them for metal concentrations. Results from 'Nico Lake' show that levels of arsenic are enriched in the latter half of the 20th century, exceeding background concentrations of the late 19th and early 20th centuries (Figure 2). This has led to further speculation of far-field atmospheric emission trajectories of Giant Mine, results that have been shared with our northern community partners and government agencies.

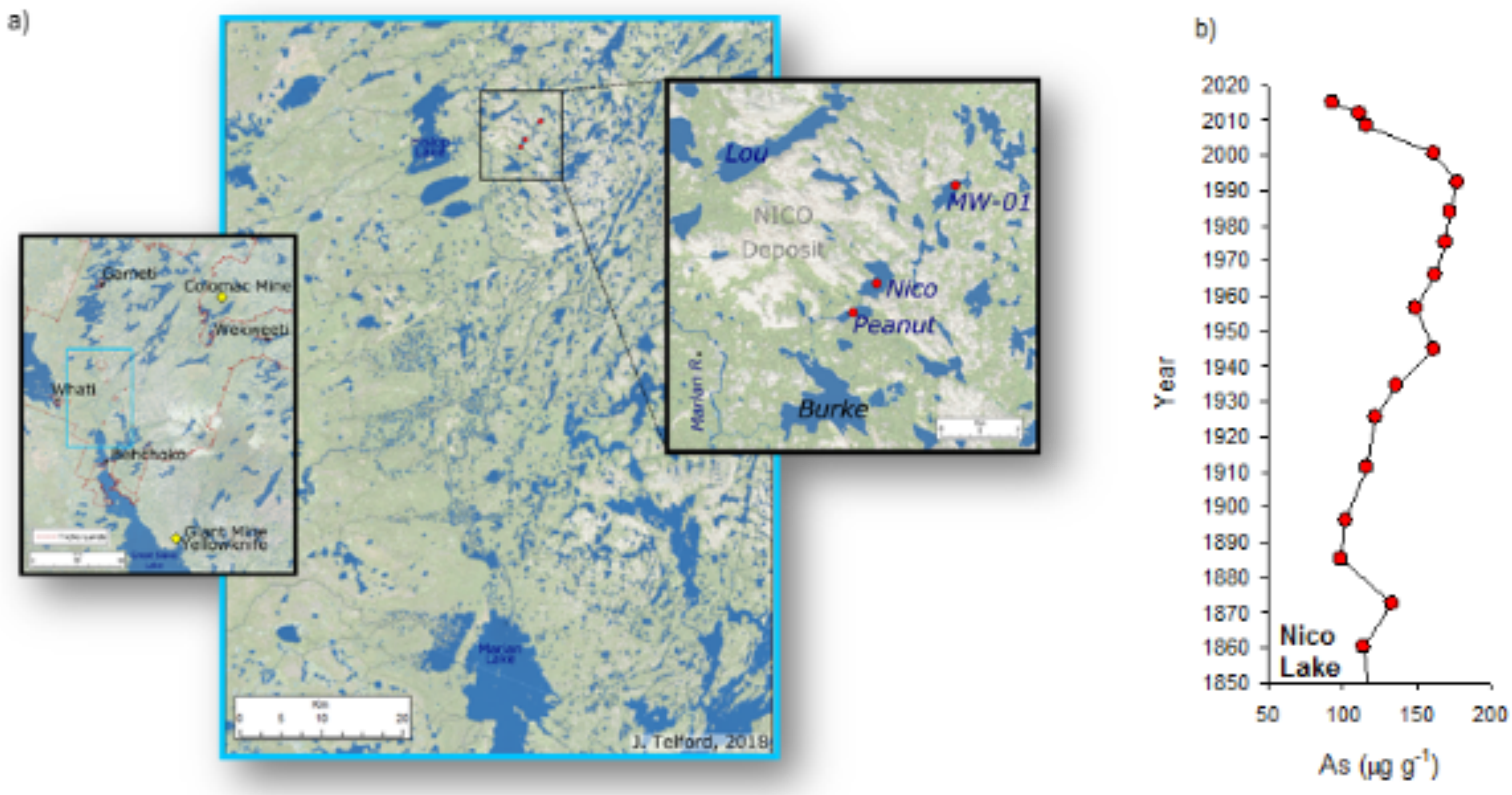

Figure 2. a) Location of lake sediment coring sites in Marian Watershed. b) Arsenic (As) concentration profile 1850-present from Nico Lake, displaying increased concentrations during the late 20th century (James Telford, MSc in progress).

The results shown in Figure 1 and Figure 2 served as the foundation to develop the SAMMS proposal. But in the past few months, more interesting and somewhat puzzling results have emerged from our lake sediment core studies in the Marian Watershed. Analysis of metal concentrations deeper in the Nico Lake sediment record reveal even higher arsenic concentrations during the early part of the past millennium (Figure 3a). A similar arsenic profile was generated from nearby 'Peanut Lake'. Although concentrations of arsenic at these locations vastly exceed CCME Probable Effects Level, they also indicate that processes and conditions in the past have mobilized natural sources of arsenic leading to enriched concentrations preserved in lake sediment records in this area. Indeed, these two lakes are located on the NICO deposit, which contains arsenic-bearing arsenopyrite. But the possibility of far-field emissions from Giant Mine remain, given the results obtained from a sediment core retrieved from lake 'MW-01', which show an increase in arsenic concentrations beginning in the 1950s (Figure 3b). Notably, lake MW-01 is not located on the NICO ore deposit and, therefore, has much lower sediment arsenic concentrations.

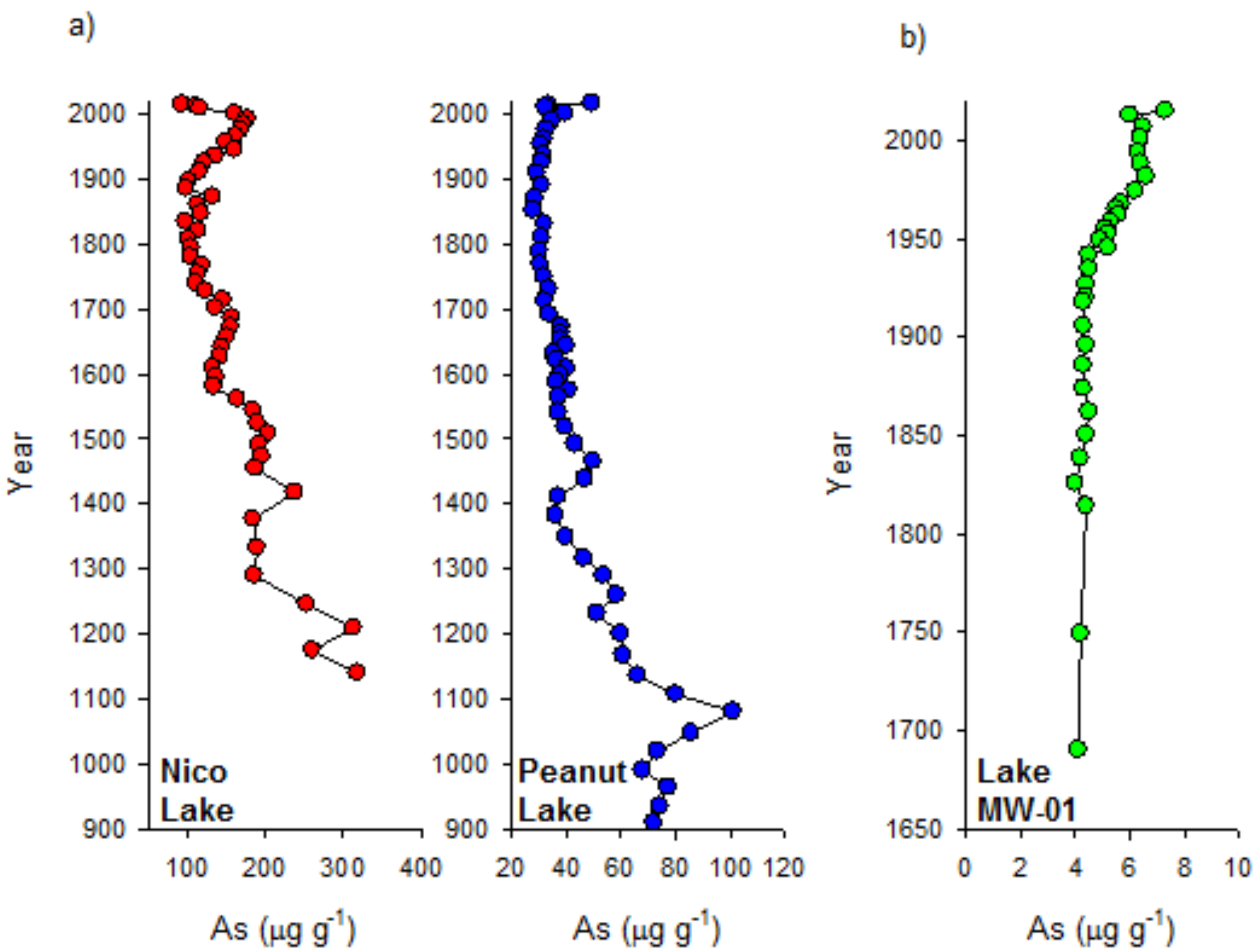


Figure 3. a) 900-yr and 1100-yr arsenic (As) concentration profiles from Nico Lake and Peanut Lake showing evidence of naturally elevated concentrations at the base of the records. b) 300-yr arsenic concentration (As) profile from lake MW-01 displaying evidence of higher concentrations during the late 20th century (James Telford, MSc in progress).

These results have raised further questions. Under what type/s of conditions does arsenic become mobilized, possibly moving from terrestrial to aquatic portions of catchments? The early part of the past millennium was a time interval known as the Medieval Warm Period (MWP). Might we be returning to climatic conditions similar to the MWP, and what are the implications for mobility of arsenic (and other metals) in sub-arctic watersheds where, potentially, both natural and mine-legacy metals are present? What is the origin of recent increases in arsenic concentrations in lake sediment records analyzed in the Marian Watershed? Are these related to far-field emissions from Giant Mine (~175 km) or do they reflect natural processes and increased arsenic mobility related to the effects of recent climate change?

Thus, SAMMS is designed to identify, quantify, and predict mobility of natural source and legacy mine-source metals in soil, wetlands, and lake sediments that extend from former, present, and planned mine sites currently and as climate change alters the quantity and quality of dissolved organic matter (DOM) produced and exported from vast organic stores in subarctic NWT watersheds. Much of our attention will focus on the behaviour of DOM because metals tend to bind to organic material. It is our hope that findings will inform improved decision-making by multiple stakeholders in the NWT, including Indigenous peoples, about the legacy of mining activities and implications of new mining developments on water quality in a changing environment.

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# The SAMMS Research Program

SAMMS will undertake an array of field, laboratory and modelling studies, four of which will be completed during the first three-year phase. This research is grouped under six ‘work plans (WPs)’ (Figure 4). These have been designed to comprehensively trace the transport and behaviour of DOM and metals through terrestrial and aquatic ecosystems in headwater catchments along a 200 km airshed transect between Giant Mine and Whatì, an area of concentrated mining activity.

Work plans include:
WP1: Terrestrial stores of historical metal deposition and transport to aquatic ecosystems (Yrs 1-3)
WP2: DOM quantity and quality, metal binding, and toxicology (Yrs 1-3)
WP3: Modelling of DOM quantity and quality in cold regions (Yrs 4-7)
WP4: Metal depositional history, pathways, and processes in lake sediments (Yrs 1-3)
WP5: Paleo-ecotoxicology and ecosystem structure (Yrs 1-3)
WP6: Climate change effects including permafrost thaw (Yrs 4-7)

Fieldwork plans for 2018 are currently in development. We anticipate launching WP4 (*Metal depositional history, pathways, and processes in lake sediments*) in May 2018 and WP1 (*Terrestrial stores of historical metal deposition and transport to aquatic ecosystems*) in August 2018. Once plans are finalized, we will pass along these details.

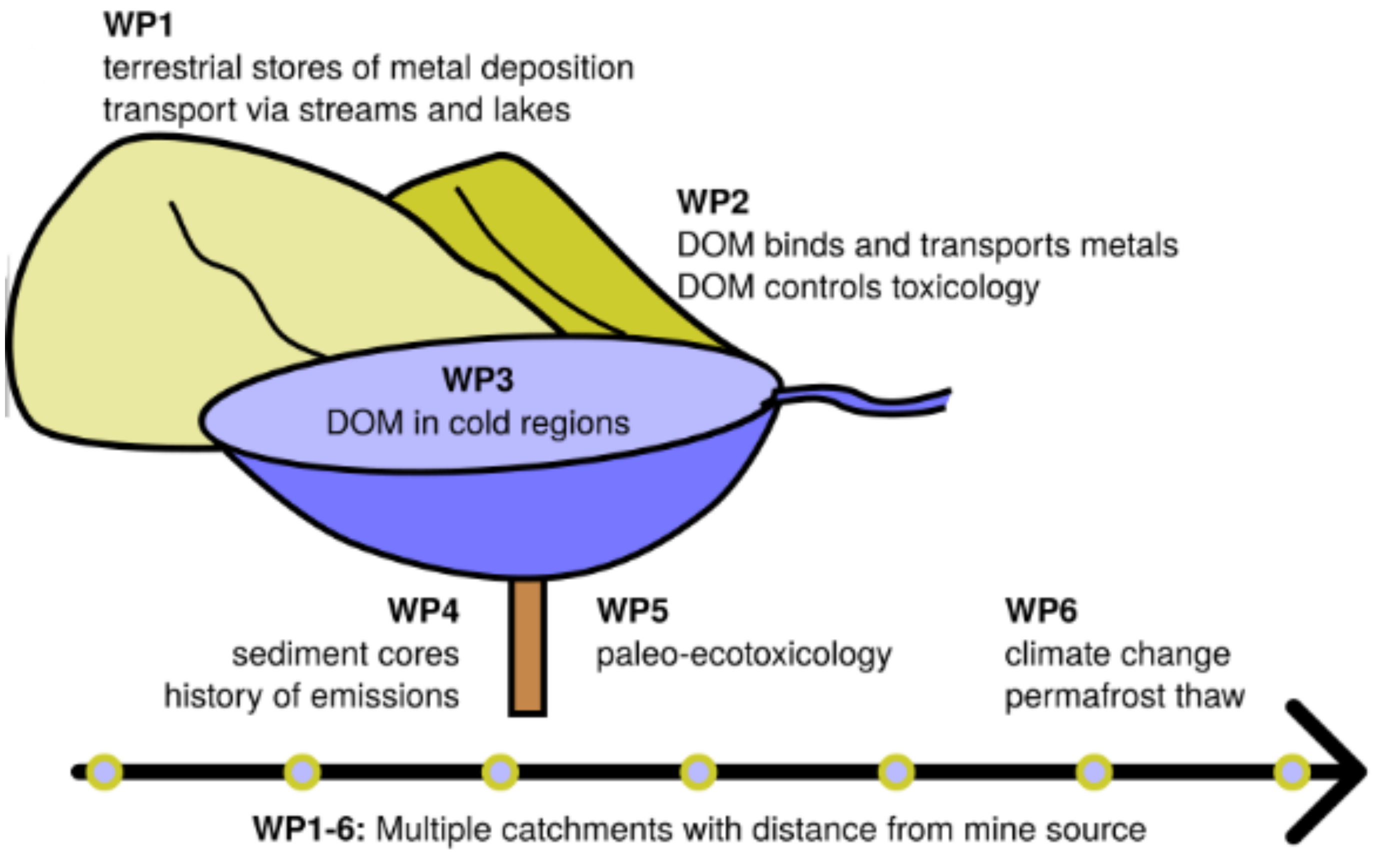


Figure 4. *Conceptual arrangement of WPs 1-6 that comprise SAMMS.*

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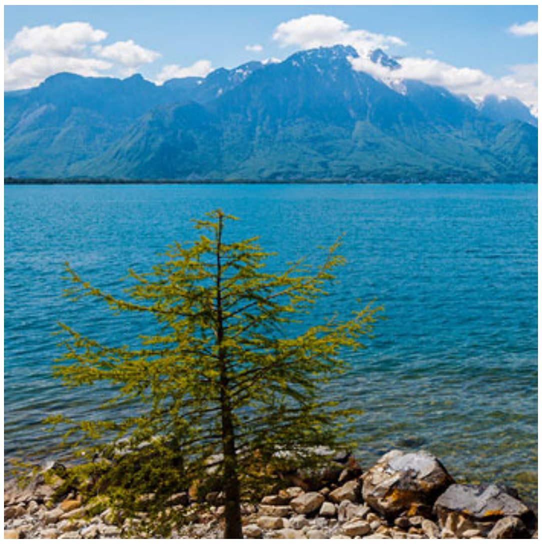
## SAMMS in the News!

Global Water Futures to fund Laurier water research addressing climate change in Canada's North



"Laurier has an extraordinary strength and capacity in impactful water research," said Robert Gordon, vice-president: research at Laurier. "This investment, through Global Water Futures, further demonstrates the leadership by Laurier researchers in cold regions research and the collaborative approach to solving critical issues facing our northern communities."

Learn More

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## Meet the Researchers

Contributing researchers bring a broad range of experience and expertise to the SAMMS program and are introduced below:

***Principal Investigators*:**

Brent B. Wolfe, Professor
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*SAMMS expertise*: Reconstruction of past conditions in lakes [WP4,5]

Jason J. Venkiteswaran, Assistant Professor
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*SAMMS expertise*: Cycling of nutrients and related elements [WP1,2,6]

***Co-Principal Investigators*:**

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*SAMMS expertise*: Hydrology of sub-arctic catchments [WP1,6]

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*SAMMS expertise*: Reconstruction of past conditions in lakes [WP4,5]

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*SAMMS expertise*: Toxicology of metals [WP2,3]

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*SAMMS expertise*: Cycling of nutrients and related elements [WP1,2]

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*SAMMS expertise*: Metal speciation and toxicity in the environment [WP3,6]

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*SAMMS expertise*: Water quality effects on wetland vegetation and mycorrhizal fungi [WP1,6]

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*SAMMS expertise*: Biogeochemical modelling of catchments [WP2,6]

***Co-Investigators*:**

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*SAMMS expertise*: Reconstruction of past toxicology in lakes [WP5]

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*SAMMS expertise*: Sediment-water interactions of metals [WP1,2,4]

# Join our Team!

MSc and PhD Opportunities Available

SAMMS (Sub-Arctic Metal Mobility Study) seeks multiple graduate students (MSc and/or PhD) to research the presence and fate of mining related metals in the Northwest Territories, Canada, and to develop predictions of the fate and toxicity of these metals under climate change regimes.

Successful applicants will work in a co-supervised environment. SAMMS is led by Prof. Brent Wolfe and Prof. Jason Venkiteswaran (Wilfrid Laurier University, Waterloo, Canada). Opportunities to work at multiple universities are available and encouraged. Start dates: January 1, 2018, May 1, 2018, and September 1, 2018.

Learn More

SAMMS is a project funded through Global Water Futures: Solutions to Water Threats in an Era of Global Change, a University of Saskatchewan-led research program funded in part by a $77.8-million grant from the Canada First Research Excellence Fund.

Global Water Futures (GWF) is led by the Global Institute for Water Security at the University of Saskatchewan in partnership with University of Waterloo, McMaster University and Laurier and is the largest university-led water research program ever funded worldwide and one of the largest water science collaborations in the world. It aims to position Canada as a global leader in water science for cold regions and will address the strategic needs of the Canadian economy in adapting to change and managing risks of uncertain water futures and extreme events. End-user needs will be our beacon and will drive strategy and shape our science.