

#### **OUR VISION**

To undertake world-class research that enables and enhances water security. We define water security as the sustainable use and protection of water resources, the safeguarding of access to water functions and services for humans and the environment, and protection against water-related hazards (flood and drought).

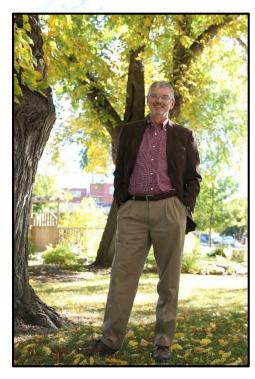
#### **OUR MISSION**

- Create a focus and platform for interdisciplinary collaboration that recognizes the societal dimensions of water security, human impacts on the environment, and the linkages and feedbacks between atmosphere, land and water systems. This requires new integration of the relevant spectrum of natural, health and social sciences, public policy and engineering;
- Develop the knowledge, science and technologies needed to support integrated water quantity and quality management in the face of uncertain climate and water resource futures, and address local, regional and global water security agendas;
- Develop partnerships with key stakeholders to translate science into policy and management support to meet water security challenges, including interactions among water, food, energy and ecosystem services (i.e., benefits to human welfare), climate change adaptation and mitigation challenges, and the human health agenda;
- Provide tools, technologies, and computer models for application to key globally significant water security issues, with international application; and,
- Create a unique opportunity for governments, industry and universities to invest in and collaborate on one of our most pressing global issues.

#### **DIRECTOR'S MESSAGE**

Welcome to the University of Saskatchewan's (UofS) Global Institute for Water Security (GIWS). GIWS builds on a 53-year history of nationally-leading water research in Saskatoon, including the co-location of the federal National Hydrology Research Center in 1986. The University of Saskatchewan established *Water Security: Stewardship of the World's Freshwater Resources* as a signature area of research focus and excellence in 2010. The Global Institute for Water Security was founded in 2011 with Canada Excellence Research Chair support in the amount of \$30 million, probably the world's largest single university investment in water.

The Institute fosters research collaboration across the university and with key Federal, Provincial and industrial partners. Together, we are addressing regional and global challenges of Water Security, including the sustainable use and protection of water resources and protection against



water-related hazards such as flooding and drought. Key research themes include Climate Change and Water Security, Land- Water Management and Environmental Change, Sustainable Development of Natural Resources, Socio-hydrology, Water and Health, Water and Wastewater Treatment Technologies, Groundwater and Hydrogeology. The Institute works to ensure that society globally has the understanding and the tools to sustainably manage and protect the world's water resources, and that Canada has the research and expertise needed to understand and manage our water systems in an era of rapid societal and environmental change.

The global economy and infrastructure depend on water, as do the health and livelihoods of the world's population. But the global water environment currently faces unprecedented challenges. Climate change is altering the historical patterns of water availability that have provided the foundation for the growth of human society and industry as we know it. Climate change and human actions are compromising water quality and intensifying the competition for water. Canada and other countries in northern latitudes face the world's highest rates of warming. We see changing landscapes and altering patterns of precipitation, runoff, and evaporation, as well as the amount of water stored in snow, glaciers, and permafrost. Climate change is changing the nature and severity of floods and droughts; recent extreme events have caused \$23 billion in losses in western Canada alone. Sustainable development of water resources is essential, as well as the management of risk to people and assets from extreme events. We need to be able to better understand, predict and plan for an uncertain future, managing the risks of flood and drought, supporting sustainable economic development and protecting our environment, all in a warming world. These are global problems, but with strong local importance.

At GIWS we have recognized that while disciplinary water science is essential, new interdisciplinary research is required, given the complexities of our human-natural water systems, to provide the knowledge and tools that will be needed for effective decision making in the future. We have therefore, developed a range of interdisciplinary research programs to address the science and management challenges of Water Security. We are working at multiple scales, including large river basins and whole groundwater systems, to address the interactions and feedbacks associated with the large footprint of human activities. We lead major initiatives for the World Climate Research Programme (WCRP) and UNESCO, and are working with industry and communities to address their needs for safe management of water and sustainable management of wastes. This is a transformative research agenda, which depends on the skills and expertise of our Highly Qualified Personnel. I am therefore particularly pleased this year to recognize two major innovations in graduate training. In September 2015, we began a new multiuniversity graduate research program in Water Security and in 2016 we commence a new 12month professional Masters in Water Security. These programs will provide the next generation of researchers and practitioners needed to tackle the large issues that the world now faces with respect to water security.

GIWS has come a long way since its foundation in 2011, and we are proud of our achievements thus far. However, none of this would have been possible without the far-sighted support of our major sponsors, the Canadian Government, through the Canada Excellence Research Chair program, the Province of Saskatchewan, and the UofS. I would like to record my personal thanks to these sponsors for their recognition of the strategic importance of water security and their vision and confidence in the UofS and myself to deliver on this important and unique opportunity.

Finally, we hope you will enjoy reading about our research achievements and plans, and our outstanding team of students and researchers. And as my close colleague and Associate Director, Jeff McDonnell notes, we very much welcome interest in our work and have many opportunities for collaboration.

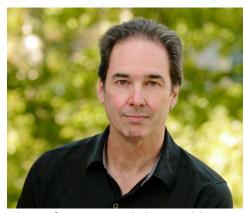
Professor Howard Wheater, FREng

Canada Excellence Research Chair in Water Security

Director, Global Institute for Water Security

#### ASSOCIATE DIRECTOR'S MESSAGE

It is a pleasure to welcome you to the University of Saskatchewan's Global Institute for Water Security. This past year has seen several exciting new developments, including (as noted by our Director, Howard Wheater) two new GIWS-sponsored graduate training programs in water security: the research-based CREATE Program in Water Security that ramps up this year; and the new course-based masters program in Water Security that takes flight in the 2016-17 academic year. These are exciting developments for the campus and our partners. It



will also help to further internationalize our program, as students from around the world come to Saskatoon for graduate training and research.

Our new MOST Facility was constructed this Fall and is a new 3600 square foot high bay building across the street from the Global Institute. This state-of-the-art facility will be a hub for development and testing of hillslope hydrological models in relation to mine cover systems and landscape engineering. The facility is funded by Western Economic Diversification and includes a new strong partnership with O'Kane Consulting, a world leader in mine cover design.

We continue to be a hub for researchers internationally, this year hosting sabbatical and research visitors over a dozen countries, including for lectures and short research visits. We continue to build our global footprint through international faculty and student exchange, joint teaching and research programs as part of our core mission. Our GIWS faculty members have worked in the field across Europe, Asia, South America and Africa this year. Locally, we continue to run workshops for our graduate students and post docs including the "Launching an Academic Career" day and the Fall series of GIWS Post Doc Mentoring Lunches. Our philosophy is to give Canadian students international experiences and to give international students Canadian experiences. Our program continues to build partnerships, with our significant ones this year including Imperial College London (England), University of Aberdeen (Scotland), Luxembourg Institute for Science and Technology (Luxembourg), Northwest Agriculture and Forestry University (China), Universidade Federal do Rio de Janeiro (Brazil), Universidad Austral de Chile (Chile), University of Georgia and Oregon State University (USA) to name a few. Together with our research staff and our many international partners, we are tackling some of the world's biggest water security challenges. We invite you to come and be a part of our team as a visiting scientist, sabbatical visitor or student intern!

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Professor Jeffrey J. McDonnell, FRSC Associate Director, Global Institute for Water Security

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#### **EXECUTIVE SUMMARY**

Established in March 2011, the Global institute for Water Security (GIWS), University of Saskatchewan (U of S) works to ensure that society has the understanding and the tools to sustainably manage and protect the world's water resources and ensure that Canada, and the world, has the research and expertise needed to understand our water systems in an era of rapid societal and environmental change. It integrates expertise of 211 members (71 Members, 22 Associate Members, 3 Affiliate Members, and 115 Student Members) from 15 academic units across the U of S, and has formed strong and mutually supportive working partnerships with Federal and Provincial agencies, in particular Environment Canada (EC) and the Saskatchewan Water Security Agency (SWSA). GIWS was created to provide: a) a vehicle for the new disciplinary and trans-disciplinary science needed to address the local, regional and global challenges of water security (and specifically the Canada Excellence Research Chair (CERC) programme), and b) a platform and focus for the U of S signature area of water. This initiative is funded by the CERC in Water Security - a federal-provincial-university partnership with base funding of \$30 million over seven years. The institute combines expertise in natural, health and social sciences, public policy and engineering, recognizing that people and their activities are of critical importance for water science and management.

GIWS aims to be a global leader in Cold Region (CR) water science and focuses its efforts through seven research themes: Climate Change and Water Security; Land-Water Management and Environmental Change; Sustainable Development of Natural Resources; Socio-hydrology, Water and health, Water and Wastewater Treatment Technologies, and Groundwater and Hydrogeology.

We have developed new, internationally recognized research facilities, have taken on important national and international science leadership roles, attracted substantial additional research funding, and are beginning to deliver the exciting science that was foreseen at the programme outset. Recent highlights include three ground-breaking papers in the journal Nature, election of GIWS Associate Director McDonnell to the Fellowship of the Royal Society of Canada, establishment of the MOST (Mine Overlay Site Testing) facility, and leadership of two World Climate Research Programme (WCRP) initiatives (the Changing Cold Regions Network Regional Hydroclimate Project, including the Saskatchewan River Basin (SaskRB; 406,000 km²) and Mackenzie River Basin (MRB; 1.8 million km²), and the International Network for Alpine Research Catchment Hydrology - INARCH). INARCH also forms part of UNESCO's International Hydrological Programme. These programmes address critical societal needs and support the development of the new trans-disciplinary science. These are designed to address WCRP priorities related to large-scale science, as well as the needs and concerns of local and regional stakeholders.

GIWS strongly believes in internationalization of higher education, and has been working to facilitate faculty and student exchange, joint teaching and research programs, as well as international curriculum development and delivery. For example, in 2014-15, our members have delivered 8 international short courses and since 2011, GIWS has hosted 137 international visiting scholars and scientists. In addition, UofS has developed two important new strategic educational initiatives in graduate education and training: 1) The NSERC *Collaborative Research and Training* 

Experience (CREATE) Program in Water Security, which commenced in September 2015, stimulates research Masters and PhD students to integrate science, engineering, and policy as they address current and future challenges in complex water systems. 2) Beginning in 2016, we will offer an innovative one-year professional Master of Water Security graduate program that provides intensive cross-training to build disciplinary and interdisciplinary expertise for research and practice.

#### GIWS by the numbers

During 2014-15, GIWS has financially supported 51 graduate students (24 PhD and 27 Masters), 32 postdoctoral fellows, 38 research assistants, 10 research associates and scientists, 10 undergraduate and graduate student assistants and 26 visiting scholars. In addition, its members have supported a further 169 graduate students (65 PhD and 104 Masters), 26 postdoctoral fellows, 18 research associates and scientists, 38 Research Assistants, Research Engineers and Summer Students, and 18 visiting scholars.

While GIWS has the benefit of base funding of \$30 million for seven years, we have been working to develop added value for this investment from external funding. In 2014-15, the seven core faculty members have secured a total of about \$2.7 million dollars (mostly from Federal sources), while the membership as a whole has secured a total of \$19.4 million (71% and 15% from Federal and Industry sources, respectively). The total external funding since inception in 2011 is now \$68.3 million.

In 2014-15, GIWS members published 209 journal articles, published and presented 216 papers in proceedings and at conferences, delivered 60 plenary, key note and invited lectures, and published 10 book chapters and books. Since 2011, GIWS members have published a total of 715 journal articles and 43 books/book chapters, participated in 554 conference proceedings and presentations and delivered more than 261 invited, key-note and plenary lectures to share research outcomes and enlighten our stakeholders and scientific community.

One of the measurable parameters for research and training excellence is the number of awards and honours received by GIWS members and students. In last 5 years, our students have won many national and international awards, including 3 Vanier scholarships, 23 Canada Graduate Scholarships and 19 Tri-agency Postgraduate Scholarships.

Our membership includes one Canada Excellence Research Chair, nine Canada Research Chairs (CRC), four Industrial Research Chairs (IRC), and six endowed Chairs. Over last 5 years, the water area at UofS has seen an increase of 23% in new faculty appointments, 300% in IRC appointments, 29% in CRC appointments, plus the addition of the CERC in water security.

We are pleased to report that in last 5 years, 48 of our trainees have become faculty members and research scientists in 18 different countries, 38 trainees are working with provincial and federal organizations, 90 are with consulting and private firms, 36 are working in research administration and providing technical support at national and international universities, and 71 are pursuing higher studies.

# 1. Global Institute for Water Security

#### 1.1 Global Challenges of Water Security

Water security embodies a complex and interdependent set of issues that include interactions between human society and the natural environment, require holistic assessment and pose significant challenges to science, policy and governance. Water security issues can be categorized into two major areas of focus: a) resource allocation and competing needs, and b) effects of extreme events (flood and drought) - with a need to understand and manage these two areas within the context of environmental change and uncertain water futures (Wheater, 2015)<sup>1</sup>.

Water quality and quantity are key dimensions of water security. With increasing pressures on water resources, there is increasing competition for the uses of water at local, regional and

international scales, both between sectors of the economy and between upstream and downstream jurisdictions, including the basic societal needs for drinking water supply, irrigation, hydropower and industrial uses. Rivers are used to receive, transport and dilute wastes, and intensification of human activities is putting increasing





pressure on the quality of both surface waters and groundwater, with consequences for water resource availability for various uses. Water-related ecosystem functions, with their dependence on water quantity (and its temporal variability) and water quality, represent a further critical dimension of water security.

Human activities are changing land use and land management, and changing the quantity and quality of surface water and groundwater resources. These reflect physical changes to the environment, but are strongly influenced by societal needs and priorities.

Flooding remains globally, one of the most dangerous and damaging natural hazards and is often seen simply as the response of a natural system to an extreme weather event. However, the reality is that human activity changes the environment in multiple ways. Thus flood risk results from complex interactions between extreme events, human changes to the natural environment,

<sup>&</sup>lt;sup>1</sup> Wheater. 2015. Water Security – Science and Management Challenges. Proceedings of the 11th Kovacs Colloquium, Paris, France, June 2014. DOI: 10.5194/piahs-366-23-2015

human perceptions and responses to risk, and the capacity of human institutions to reduce and manage risk. Similarly, drought has multiple physical and societal dimensions. Clearly a lack of precipitation will lead to pressures on water resources and agriculture, and effects can be severe, depending on the resilience of the local society and population (Wheater, 2015).

The anthropogenic effects of land and water management on water security noted above need to be understood and managed in the context of climate variability and change. Climate is itself a multi-faceted driver of hydrological change. Changing patterns of precipitation and temperature will change river flows and groundwater recharge. However, important feedbacks exist from land to climate – some known, some as yet unknown. More generally, water futures will also depend on anthropogenic responses to climate change in the form of changes to land and water management.

The interface between the research, practitioner and stakeholder communities is increasingly seen as important to the perception and management of water security, including organizational and institutional flexibility for handling uncertainty and change, social capital and adaptive governance, and the need for engagement with stakeholders in knowledge exchange (Gober and Wheater, 2013<sup>2</sup>; Wheater and Gober, 2014<sup>3</sup>).

## 1.2 Global Institute for Water Security – Origin and Research Agenda

With increasing pressures on the water environment, there is an increasing need for advances in disciplinary science to underpin our capability to understand and model the natural environment. However, the continuation of disciplinary research, while absolutely needed, can perhaps be described as 'business as usual' for the research community. Therefore, given the nature and the magnitude of challenges outlined above, the Canada Excellence Research Chair (CERC) in Water



<sup>&</sup>lt;sup>2</sup> Gober and Wheater. 2013. Socio-hydrology and the science-policy interface: A case study of the Saskatchewan River Basin. Hydrology and Earth System Sciences 18, 1413–1422, doi: 10.5194/hess-18-1413-2014.

<sup>&</sup>lt;sup>3</sup> Wheater and Gober. 2014. Meeting the science challenges of Water Security in the Saskatchewan River Basin: a regional hydroclimate project from Western Canada. In: J.J. O'Sullivan and M. Bruen, eds. Dooge Nash International Symposium. 23–26th April, 2014, Dublin Castle, Dublin, Ireland, University College Dublin, 431–446.

Security was created with a three-way investment of \$30 million from the Canadian Federal Government, the Government of Saskatchewan, and the University of Saskatchewan. Subsequently, the Global Institute for Water Security (GIWS) was established in March 2011 to provide: a) a vehicle for the new disciplinary and trans-disciplinary science needed to address the local, regional and global challenges of water security (and specifically the Canada Excellence Research Chair (CERC) programme), b) a platform and focus for the U of S signature area of water, and c) to address four critical dimensions that require a new paradigm for research:

- a) The effects of the Anthropocene on the water environment are pervasive and poorly understood study of the hydrological effects of the Anthropocene is in its infancy and is a strategic priority.
- b) Effects of human activities on the water environment and the management challenges of Water Security are multi-faceted and subject to complex interdependencies new transdisciplinary science is needed.
- c) The challenges of Water Security management in the Anthropocene require new understanding of process interactions and feedbacks across multiple scales.
- d) Stakeholder engagement is a necessity, not an option.

Since its inception in 2011, GIWS members have attracted \$68.3 million in additional research funding. During 2014-2015, they supported 220 graduate students and 130 postdoctoral researchers, research associates and research engineers. The present report 2014-15 is unable to do full justice to the outputs from our team, but we aim to illustrate some of the interdisciplinary research conducted at the GIWS and provide examples of progress made toward putting our research agenda in action. For more detailed insights into our members and their work, please visit our web site <a href="www.usask.ca/water">www.usask.ca/water</a>. Futher information on our governance structure and our research themes, objectives and sites can also be found in our <a href="founding">founding</a> progress report 2011-13 and progress report 2013-14.

# 2. Global Leadership

GIWS works to ensure that society has the understanding and the tools to sustainably manage and protect the world's water resources and ensure that Canada, and the world, has the research and expertise needed to understand our water systems in an era of rapid societal and environmental change. Particularly, it claims to be a global leader in Cold Region (CR) water science. We note that the world's cold regions provide water resources for 50% of the world's population, are sites of globally-important agricultural and natural resource production, feeding and fueling the world, and are a critically-important component of the Earth System. Canada's cold regions, as elsewhere, are also home to many First Nations communities who rely heavily on traditional livelihoods, and have made innovative partnerships with modern resource development.

Our research program is supported by UofS \$160 M investment over last 5 years in state-of-theart water science laboratory and field research facilities, many of which are unique across the globe. These facilities position UofS and Canada as a leader and partner of choice in cold regions water science.

#### 2.1 Laboratory Research Facilities

Our major laboratory research facilities include the unique Mine Overlay Site Testing (MOST) cold region hillslope hydrology facility (\$5.5 M) at UofS which helps industry manage risk and economically expedite mine reclamation work. A new UofS \$25 M livestock research facility also provides a field observatory for studying shallow hydrogeology of prairie systems. In addition, Canada's premier Toxicology Centre for water pollution research, as well as the associated \$13 M Aquatic Toxicology Research Facility, and the unique-in-Canada \$1 M R.J.F. Smith Centre for Aquatic Ecology, one of a few in the world, are equipped for leading-edge analysis of water quality and its impacts on aquatic ecosystems. UofS and Environment Canada operate the Saskatchewan Isotope Laboratory (\$3.7 M), which analyses stable and radiogenic isotopes for environmental studies. The Saskatchewan Structural Sciences Centre (\$4.6 M in recent upgrades) provides molecular structural characterization and analytical services for both life and physical sciences. Finally, the \$20.6 M BioXAS beamline at the national synchrotron facility, the Canadian Light Source, adds to the powerful CLS capacity for advanced geochemical research by supporting research into water and health. Our Socio-hydrology research is supported by the \$3.5 M Social Science Research Lab, including the Survey and Group Analysis Lab, the Experimental Decision Lab, and the Qualitative Research Lab.

Data collection and management needs of our research programs are supported by cutting-edge computational facilities such as the Human-Computer Interaction Lab, and \$11 M Centre for High-Performance Computing, and Compute Canada infrastructure (3,150TB storage, Silo; 3,100 TB tape storage and back-up), the High Performance Computing Research Facility Data Centre and Moneta (256 RAM) and Meton (2048 GD Ram) large memory systems.

The capabilities of our facilities are illustrated with 2 examples:

#### 2.1.1 Mine Overlay Site Testing Facility

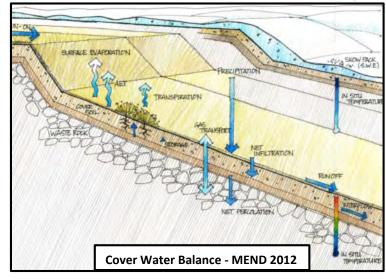
The Mine Overlay Site Testing Facility (MOST) bridges the critical gap between small scale lab experiments and complex, costly and time consuming large scale constructed hillslope research in mine reclamation cover design. The primary focus of this facility is cover systems testing for cold regions. The facility is funded through Western Economic Diversification Canada, the UofS, GIWS and industry partners.

Cover system design is complex, expensive and failure can jeopardize the environment. To minimize cost and risk and to develop fundamental hydrological principles, the facility's goals are to collaborate between industry, research and consultants to:

Evaluate effective hydrological properties on cover materials;

- Assess how these properties evolve over time;
- Measure how water is partitioned between runoff, infiltration, etc;
- Evaluate potential contaminant release;
- Use key findings to develop and inform site modeling;
- Provide insight to regulators and industry based on key findings; and
- Train highly qualified personnel with expertise in mine cover systems.

The MOST facility is the first of its kind to provide pilot scale cover trials with replications of key processes



(placement, climate, slope/aspect, vegetation) and the ability to evaluate and characterize the key mechanisms controlling the water dynamics in mine reclamation cover design.<sup>4</sup>

The MOST research facility will bring long-term benefits to industry in terms of reductions in time and resources through implementation of effective and efficient mine overlay designs and innovations in operational processes. Typically, evolution of field-based cover systems under natural conditions occurs over 3-5 years, exposing it to multiple freeze/thaws and precipitation events. It is expected that the MOST facility can accelerate what happens in the field over years to a period of mere months, using a partially climate controlled environment.

<sup>&</sup>lt;sup>4</sup> MEND (Mine Environment Neutral Drainage) 2012. Cold regions cover system design technical guidance document. Canadian Mine Environment Neutral Drainage Program, Project 1.61.5c, March.

## 2.1.2 Aquatic Toxicology Research Facility

Housed within the University of Saskatchewan Toxicology Centre, the Aquatic Toxicology Research Facility (ATRF) is the only laboratory of its type in Canada where researchers can study the adverse effects of chemical and physical agents on aquatic organisms under controlled environmental conditions.

The ATRF is a 7,100 sq. ft., self-sufficient, multi-user facility available to all research partners of the Toxicology Centre. It was designed to simultaneously provide different water quality parameters and



temperatures, ranging from less than 6 to 45°C, in order to perform both static and continuous flow toxicology experiments with a broad range of freshwater organisms including algae, crustaceans, insects, clams, amphibians and small and large species of fish. The facility includes walk-in, controlled-environment chambers and self-contained proportional diluter systems for toxicant delivery. This equipment provides the ideal conditions for conducting both acute and chronic aquatic toxicity tests freshwater invertebrates, algae, small fish and amphibians.

The ATRF consists of separate rooms for animal holding/ culture and experimentation/ chemical exposure, and for the pre- and post-treatment of water.

The ATRF is clearly a unique aquatic facility that is an ideal locale for aquatic research projects, and is specialized for experiments in aquatic toxicology.

#### 2.2 Field-based Research Facilities

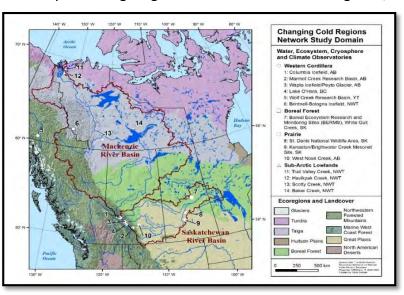
To engender trans-disciplinary working requires inter-disciplinary focus on common problems and common places. To address the management challenges of Water Security, we must work at multiple scales, including the scales of large river basins and whole groundwater systems. Research at these large scales is needed to address the interactions and feedbacks associated with the large footprint of the Anthropocene (Wheater, 2015). Consequently, through support from the CERC and Canada Foundation for Innovation, GIWS has established the Saskatchewan River Basin (SaskRB; 406,000 km²) as a large scale observatory, which has come to be seen as an internationally-leading initiative. The multiple dimensions of water security and the accompanying science and management challenges, ranging from issues of water quality and quantity, anthropogenic activites, competing societal uses, industrialization, agricultural intensification, extreme weather events (flooding and drought), etc. are all represented in the

SaskRB. The basin, with an area approximately half the of size France, spans Canada's three Prairie **Provinces** of Alberta. Saskatchewan and Manitoba and faces climate characterized by extremes and rapid climate change. Further, the basin encompasses critical environments deemed significant both nationally and globally.



GIWS focus on interdicipinary research on SaskRB has been complemented by the <u>Changing Cold Regions Network</u> (CCRN) project, with its focus on changing climate, cryosphere, hydrology and ecosystems and expansion to the Mackenzie River Basin (MRB; 1.8 million km<sup>2</sup>). The CCRN is led by Howard Wheater, CERC in Water Security and brings together 42 Canadian co-Investigators, 4

Federal government agencies and 15 leading international researchers. CCRN is integrating existing and new experimental data with modelling and remote sensing products to understand, diagnose and predict changing land, water and climate, and their interactions and feedbacks, for this important region and also its effects on large-scale Earth system change and the region's major rivers - the Saskatchewan, Mackenzie and Peace-Athabasca.



The above field facilities build on the long history of observations and expertise available with the <u>Centre for Hydrology</u>, which focuses on the advancement of the theory and practice of hydrology as a physical environmental science, leading to improved prediction and management of water resources in Canada and around the world. The Centre has a long track record of innovation in observing systems. Recent developments include new sonar-based snow sensors and innovative application of Unmanned Aerial Vehicles (drones) for remote sensing of hydrological and cryospheric systems.

#### 2.3 Regional and Global Hydroclimate Projects – World Climate Research Program

GIWS is leading two large and high-profile basin-scale science programmes that are addressing critical societal needs and support the development of the new trans-disciplinary science. These programmes are associated with the World Climate Research Programme's (WCRP) Global Energy and Water Exchanges (GEWEX) project, which includes a global network of Regional Hydroclimate Projects (RHPs). These are designed to address GEWEX priorities related to large-scale science, but draw on local and regional funding sources and commonly address linkages to stakeholder needs and concerns. The programmes are: 1) The Changing Cold Regions Network (CCRN) – A Regional Hydroclimate Project, and 2) The International Network for Alpine Research Catchment Hydrology (INARCH) – A Global Hydroclimate Project.

CCRN is also supported by and linked to Climate and Cryosphere (CliC) projects, to the Canadian High Arctic Research Station (CHARS) programme and integrated within NASA's Soil Moisture Active Passive (SMAP), Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS), and Arctic Boreal Vulnerability Experiment (ABOVE) arctic programmes. CCRN has an active research partnership with the US National Centers for Atmospheric Research (NCAR);

currently discussions are underway concerning use of the basin as a focus for international model development and inter-comparison studies. In addition, SaskRB basin-scale water quality modelling is also under development. The SaskRB is a tributary of Lake Winnipeg, and the SaskRB project supports the work of the Canada-US International Joint Commission by developing a nutrient model for the Saskatchewan River, based on the U.S. Geological Survey SPARROW (SPAtially Referenced Regressions ON Watershed attributes) modelling platform, to provide the first basin-wide modelling capability with which nutrient management issues can be explored. In addition, as noted above, large-scale hydrological modelling is being addressed by the development and implementation of Environment Canada's MESH modelling system for the Basin.

The INARCH project is a GHP cross-cut project of the GEWEX project, and is led by John Pomeroy, Canada Research Chair in Water Resources and Climate Change. INARCH is also a recognized contribution to water security elements of the International Hydrological Programme of UNESCO. The overall objective of INARCH is to better understand alpine cold region hydrological processes, improve their prediction and find consistent measurement strategies. To achieve this objective, it is necessary to develop transferable and validated model schemes of different

complexity that can support research into data on sparse mountain areas where climate change impacts on water resources are anticipated to be very severe. By combining the expertise of 15 countries, the INARCH will address important issues that affect the headwaters of most major catchments worldwide by improving our understanding and prediction of mountain hydrology that supports water resources for half the world's population.



#### 3. Research & Innovation

The area of water security research is broad. To guide our efforts, and based on our current research strengths, we have identified a set of seven inter-disciplinary research themes, recognizing the need for deep disciplinary knowledge and the broader disciplinary dimensions of water security, and addressing challenges of local, regional and global significance.

These themes are supported by fully instrumented research observatories within SaskRB, providing data of both regional and global significance. Due to the importance of, and diversity

in, its cold region hydro-climate and ecological zones, the rapid rate of environmental change and the need for improved understanding, diagnosis and modelling of change, the basin also raises numerous globally-relevant science challenges.

#### 3.1 Research Themes

Themes 1 to 3 were initiated with funding through the CERC grant to Dr. Wheater. As GIWS has matured, Themes 4 to 7 have been developed to address broader inter-disciplinary issues that focus additional U of S expertise and address other local and global priorities.

- **3.1.1** Theme 1: Climate Change and Water Security: Developing sophisticated understanding and modelling of current and future effects of climate change on hydrology, ecology and water resource systems, and the associated land-atmosphere feedbacks.
- **3.1.2** Theme 2: Land-water Management and Environmental Change: Exploring the effects of agricultural and urban land and water management on water quality and water movement through a watershed, as well as the potential for agricultural beneficial management practices (BMPs) to mitigate adverse effects.
- **3.1.3** Theme 3: Sustainable Development of Natural Resources: Developing new science and management practices that could significantly change the way water is used, how land and water are reclaimed, and how environmental risks are assessed and managed in natural resources development.
- **3.1.4** Theme 4: Socio-hydrology: This program encompasses both the human drivers of hydrological change and the social processes through which hydrological science is translated and communicated to relevant decision-makers.
- **3.1.5** Theme 5: Water and Health: We are looking at issues that are critical to society, such as drinking water quality, water hygiene and sanitation, transmission of waterborne

**Rocky Mountains, Alberta** Rain on Snow Event 2013 Stakeholder Workshop, Saskatoon **SK River Delta** 

and water-related diseases in an ecosystem, aquatic pollution and effects on the food chain, wastewater re-use, extreme events such as flooding and drought, and health-based water quality standards.

**3.1.6** Theme 6: Water and Wastewater Treatment Technologies: We are assessing impacts of contaminants on environmental and human health by addressing challenges that include

appropriate technology for rural communities, development of advanced water treatment technologies to tackle emerging contaminants in our water systems, improved technologies for the treatment of industrial wastes, including those generated by natural resource extraction, and improved technologies for remediation of pollution.



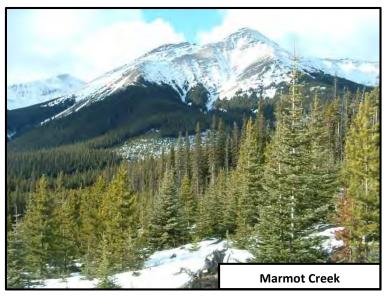
**3.1.7** Theme 7: Groundwater and Hydrogeology: This theme

is exploring major challenges to quantify the extent of groundwater resources and their quality, the natural recharge, the long-term impacts of abstractions and waste disposals, the impact of resource development, and hence to provide the information needed for sustainable development.

#### 3.2 Canadian Research Observatories

The international context for our field observatories was set out in Section 2.2, above, "Field-based Research Facilities". The research sites within SaskRB and MRB provide the basis for the development of improved process understanding and fine-scale models, and the application of those models in the analysis and prediction of environmental change at local scales. They also provide an important resource for the development and testing of improved large-scale models, which are needed for weather and climate models and for large basin-scale hydrological, water resource and water quality modelling, used in decision support.

Western Cordillera: In Western Canada, the availability of water is dependent upon cold water processes involving snow, glaciers, wetlands and frozen soils that control the storage and delivery of water to river systems. The Western Cordillera includes the southern cordillera headwaters exemplified by the Canada Foundation for Innovation (CFI) -funded Canadian Rockies Hydrological Observatory (including Marmot Creek) in the sub-alpine and mountain forested



Saskatchewan River headwaters, Lake O'Hara alpine sites and the Natural Resources Canada (NRCan) -funded Columbia Icefield Glacier-Climate Observing System in the glaciated Athabasca headwaters, Alberta. This provides a cluster of >25 high elevation snow/ice and hydro-

meteorological stations in nested gauged catchments. In addition, the NRCan-funded Brintnell-Bologna Icefield, North West Territories and the Yukon Environment-supported Wolf Creek Research Basin, Yukon, exemplify glaciated and nonglaciated sub-arctic northern cordillera headwaters of the Mackenzie River. Unique observations of alpine and sub-alpine sub-surface storage and release are available from Lake O'Hara and Marmot Creek. Alpine treelines in this

area are advancing in elevation where geomorphology and microclimate permit. Provincial, territorial and federal observation stations for flood forecasting, climate and fire prediction are clustered at both high and low elevations in the region. The archive for Marmot Creek covers most of 50 years and for Wolf Creek, covers 20 years. Sibbald Wetlands is the focus of hydroecological research into Rocky



Mountain wetlands and the effects of current and legacy beaver activity<sup>5</sup>.

**3.2.2** <u>Sub-arctic Lowlands</u>: Key study sites are located at the northern (Trail Valley and Havikpak Creeks) and southern (Scotty Creek) margins of the Taiga Plains ecoregion along the Mackenzie Valley. In addition, between these end-member sites we have a network of 204 representative permanent sample plots (PSPs), each with historical and contemporary data on vegetation (ground and canopy), soil properties and active layer thickness. These existing observatories,

along with Wolf Creek (Western Cordillera), are ideally suited for the study of permafrost thawinduced changes to ecosystems and the resulting impacts on surface-atmosphere interactions and hydrology, as they cover a wide latitudinal and altitudinal range and therefore, a wide range of permafrost ecosystem characteristics, from discontinuous permafrost characterised by a forest wetland mosaic to continuous permafrost overlain by forest,



<sup>&</sup>lt;sup>5</sup> Janzen and Westbrook. 2011. Hyporheic flows along a channeled peatland: influence of beaver dams. Canadian Water Resources Journal, 36(4): 331-347.

grading into tundra. In addition, these sites are located in areas where permafrost is very sensitive to change.

**3.2.3** Boreal Forest: Key short-term objectives of research conducted at Boreal Forest sites are to assess the vulnerability of ecosystem response to climate variability and change, and the performance of land surface schemes for simulating hydrological processes in the Boreal Forest. Longer-term objectives are to synthesize, integrate and upscale hydro-ecological understanding of stand-scale processes to watershed scales. The western boreal forest study area traverses the latitudinal and altitudinal extents of boreal forests in Canada, and the range of permafrost conditions across which these forests exist (nonpermafrost through to deep, continuous permafrost). Western permafrost-free boreal sites include the Boreal Ecosystem Research and Monitoring Sites (BERMS) in Saskatchewan that derive from the mid-1990s NASA-Canada Boreal Ecosystem-Atmosphere Study (BOREAS) and were subsequently expanded to the Environment Canada (EC) BERMS Programme. These sites in the Boreal Plains ecozone are characterized by heterogeneous forest types interspersed with wetlands and frequent wildfire disturbance, and include Black Spruce, Aspen, Jack Pine and Fen. Additional data sources in this region include Northern Alberta flux tower sites, developed in collaboration with the Oil Sands industry, as well as provincial and federal observation stations for climate and fire prediction.

**3.2.4** <u>Prairies</u>: The prairie hydrology is complex and presents a unique set of challenges including the effects of changing climate on agriculture, flood and drought risk, and water quality. In addition, land management practices, such as drainage and wetland removal, are changing the landscape and the ecological services that it provides.

The <u>St. Denis National Wildlife Area</u> site comprises internally drained wetlands, cultivated fields and pasture, and consists of numerous prairie pothole lakes of varying salinity. The focus is on runoff processes and pothole lake connectivity, surface-subsurface interactions and salinity



dynamics. The <u>Brightwater Creek</u>, near Kenaston, Saskatchewan, represents mesonet site of lowland level pasture and cultivated grasslands. A multi-scale monitoring of spatial soil moisture, groundwater and land-atmosphere interactions is ongoing. Specialised soil moisture measurement arrays, cosmic ray soil moisture probes, a geological weighing lysimeter coupled to a network of groundwater observation wells, atmospheric measurements using large aperture scintillometer and Sonic Detection and Ranging (SODAR) and weather radar provide a unique



concentration of measurements in a Canadian prairie environment. Hydrological connectivity and the effects of agricultural drainage on flows and water quality is the research focus at <u>Smith Creek</u>, Saskatchewan. The site has demonstrated the dramatic effects of inter-annual climate

variability on water quality, and a complex of flood generation response transmission to agricultural drainage<sup>6</sup>. The effects of agricultural Beneficial Management Practices (BMPs) on flows and water quality, particularly those associated with changing tillage practices and on-farm reservoirs, are explored at Tobacco Creek, Manitoba. The Swift Current research site in Saskatchewan is home to AAFC agricultural research runoff plots. Thorough analysis of high frequency, long-term data,



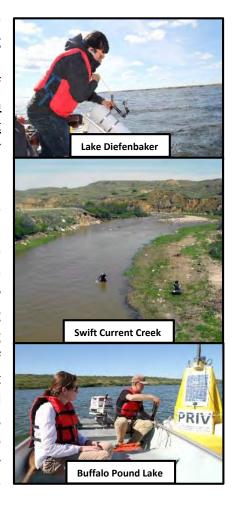
experimental monitoring of the surface hydrology and hydrological model building and testing are conducted at this site to improve understanding of the fundamental drivers of threshold-like hydrological runoff responses to snowmelt and rainfall events in a semi-arid, prairie landscape. Similarly, at semi-arid West Nose Creek site in Alberta, the studies are focused on groundwater recharge, groundwater hydraulics, surface- groundwater interaction, snow hydrology, and



<sup>&</sup>lt;sup>6</sup> Shook and Pomeroy. 2011. Memory effects of depressional storage in Northern Prairie hydrology. Hydrological Processes, 26: 1752-1766

sustainable watershed management. At the <u>Rosthern</u> research site in Saskatchewan, the effect of agricultural practices such as stubble height on prairie snow dynamics, melting, and management is studied.

Research to explore water quality issues in the basin spans the study of the winter biogeochemistry of lakes to the monitoring of pharmaceutical products and heavy metals in urban wastewater and storm water. The first major study of pollutant loads and their ecological impacts for the South Saskatchewan River, Lake Diefenbaker and its tributary, Swift <u>Current Creek</u>, is underway. This project brings together researchers from the U of S (Biology, Toxicology, Geography, Civil and Geological Engineering, the Schools of Environmental and Sustainability and Public Health), EC and the SWSA. Lake Diefenbaker is more than 200 kilometers long and plays a major role in economic and social development of a large proportion of the province. However, the capability of the reservoir to continue to provide water of reasonable quality under rapid economic development and under a changing climate is unknown given nutrient loads and increasing evidence of eutrophication. A comprehensive evaluation of the sensitivity of the reservoir to current and future nutrient inputs includes limnology, paleo-limnology, toxicology and hydrodynamic water quality modelling. A similar study has been initiated for Buffalo Pound Lake, including real-time water quality monitoring to support treatment of this major source of drinking water for the cities of Regina and Moose Jaw, Saskatchewan



**3.2.5** River Deltas: The Saskatchewan River, Peace-Athabasca, and Slave River deltas are a biologically diverse and complex systems of rivers, lakes, and wetlands and are part of the Delta Dialogue Network (DDN). These deltas support a range of fish, wildlife, bird, and plant species. The ecological changes in these deltas are often an indicator of issues arising in our river systems; if there are problems, people in the delta are often the first to notice. These deltas continue to play an important role in supporting traditional, subsistence, and cultural activities of the Aboriginal peoples who have occupied these regions since time immemorial. Historically, inland deltas were also a central part of the fur trade industry<sup>7</sup>.

<sup>&</sup>lt;sup>7</sup> http://www.usask.ca/research-groups/ddn/index.php

Located near the Saskatchewan/ Manitoba border, the Saskatchewan River Delta, is a complex series of abandoned and active river channels, lakes wetlands. Home Cumberland Marshes which has been designated as an Important Bird Area, this region experiences accumulated effects of upstream water use, including abstractions and power generation. Since the beginning of the last century, annual discharge has been reduced by approximately 30%. In addition, winter base-flow is now higher have and spring freshets



dampened due to capture and storage and the Experts in climate, hydrology, ecology and social science are addressing the cumulative repercussions of these changes in flow for the production of fish, water-birds and mammals, and for the activities and livelihoods of local communities. The aim of this research is to develop scenarios and an operational plan to provide for sustainable power output without endangering the Delta habitat in the long-term.

Working with local communities and the Slave River and Delta Partnership (SRDP), the <u>Slave Watershed Environmental Effects Program</u> (SWEEP) is establishing a community-based monitoring program. This program will empower communities to assess impacts to water quanitity and quality in the Slave River Delta, monitor future changes, and collect information that can inform management decisions. A system of environmental indicators that incorporate both western science and Traditional Knowledge will address key community priorities, including water quality, hydrology and sediment load, air and climate, vegetation, and health of wildlife, fish, and insect populations.

One of the primary concerns in the Peace-Athabasca and Slave River deltas is understanding what factors are contributing to the changes in the delta, that people are seeing. A decreasing number of annual floods and lower water levels are especially important, given their ecological and social role in the region. In response to this concern, we are working to understand how water flow is changing in the Peace-Athabasca-Slave catchment area. By modelling both natural and regulated river flow scenarios, this project will provide insight into what the influence of climate change and the Bennett Dam have been on water flow in the area. In addition, another component of this project will examine whether or not there will be severe enough ice jams to flood the Slave River Delta and maintain delta ecology. It will also look at what changes in vegetation have occurred in the delta.

#### 3.3 International Research Observatories

In addition to Canadian research sites, our researchers are extensively involved at various international research observatories of strategic importance, providing scientific insight into water security issues as effected by the socio-economics, geography, hydrology, and climate. A few select international research observatories are mentioned below.

**3.3.1 Cold Regions Science:** The <u>INARCH project</u> under the leadership of John Pomeroy, Canada Research Chair in Water Resources and Climate Change is currently coordinating research efforts at <u>23 international research sites and basins</u>, including:



- Open Air Laboratory (OpAL), Austria, Rofental
- Marmot Creek Research Basin, Alberta, Canada
- Peyto Glacier, Alberta, Canada
- Quesnel River Research Basin, British Columbia, Canada
- Wolf Creek Research Basin, Yukon, Canada
- Upper Diguillín, Chile
- Upper Maipo, Chile
- Nam Co Monitoring and Research Station for Multisphere Interactions, China
- Qomolangma Atmospheric and Environmental Observation and Research Station, China
- Southeast Tibet Observation and Research Station for the Alpine Environment, China
- Upper Heihe River Basin, China
- Arve Catchement, Chamonix Bonneville Annemasse Généve, France
- Col de Porte Experimental Site, France
- Col du Lac Blanc Experimental Site, France
- Schneefernerhaus and Research Catchment, Zugspitze, Germany
- Langtang Catchment, Nepal
- Izas Research Basin, Spain
- Tarfala Research Catchment, Sweden
- Dischma Research Catchment, Switzerland
- Weissfluhjoch Snow Study Site, Davos, Switzerland
- Grand Mesa Study Site, Colorado, USA
- Senator Beck Basin Study Area, Colorado, USA
- Reynolds Creek Experimental Watershed, Idaho, USA

**3.3.2 Climate and Atmospheric Science:** Yanping Li, Assistant Professor, School of Environment and Sustainability is part of the PECAN (Plains Elevated Convection At Night), which is an

international field experiment funded through the National Science Foundation held in Oklahoma/Kansas States involving scientists from NCAR (National Center for Atmospheric Research), many American universities, University of Manitoba Canada. Universities Institutes from Europe. This project focuses on the understanding of the physical mechanisms that contribute to the initiation of the warm-season



nocturnal precipitation over US Great Plains. In addition, she collaborated with the hydrometeorology group at the NCAR Research Application Lab (RAL) on a Continental Scale Regional Climate modeling using 4-km WRF. This 10-year climate simulation covers both the continental US and south Canada. This project focuses on examining the extent to which global warming will affect the severity and occurrence frequency of extreme rainfall events over the Canadian Prairies as well as to diagnose the physical processes that could cause such changes.

In addition, Yanping Li, in collaboration with Profesors Roberto Rondanelli and José Rutllant from the University of Chile, is leading a project through the Canada-Latin America and the Caribbean Research Exchange Grants Program, using the Elqui Valley basin as an example to assess the water resources vulnerability of the Andes Western Slopes under climate change. The Field work monitors the Andes Barrier Jet under dry conditions using a SODAR. This is the first time in this basin that the wind has been monitored with a SODAR wind profiler. They are also monitoring the Andes Barrier Jet evolution.

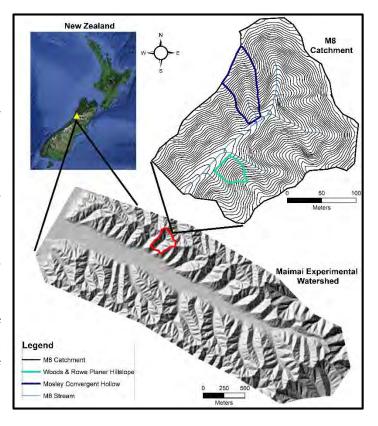


**3.3.3** Watershed Hydrology: Water-related problems continue to be at the forefront of environmental issues worldwide. Key to solving many of these problems is understanding watersheds research and developing new predictive approaches that work for the right reasons. Jeffrey McDonnell, Associate Director, GIWS has focused his work on basic questions regarding watershed hydrology of water delivery to streams through the examination of three basic questions:

- 1. Where does water go when it rains (or when snow melts)?
- 2. What flow path does it take to the stream?
- 3. How long does it reside in the catchment?

His personal exploration of these issues experimental watersheds included research sites and funded projects in Canada, U.S. (GA, OR, WA, CA, SC, NY, VT, ID, AZ, NC, AL, AK), New Zealand, China, Japan, Luxembourg, Scotland, England, Sweden, Ethiopia, Chile, and Brazil, and his expertise in this area is sought by leading research groups world-wide. Recent high profile work on artificial experimental hillslopes includes experiments at Biosphere2, Arizona, where he has been drying down the tropical biome to assess new theories of water cycling by plants. He is cosupervising students and HQP at most of these above noted locations.

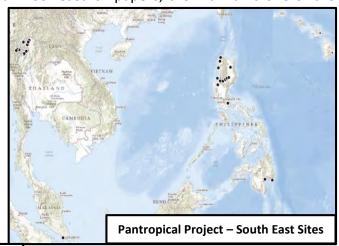




For example, Jeffrey McDonnell's team is working at the Maimai Experimental Watershed on the West Coast of the South Island of New Zealand. The site has been the focus of catchment hydrology research since the 1970s. It stands as a quintessential steep, humid and temperate headwater system which has produced pivotal research offering insight to catchment hydrologists on the mechanisms and processes which transform rainfall into streamflow. Research at the Maimai has focused on understanding how a catchment stores, then subsequently releases water from different landscape positions, as well as how the flowpaths taken by water as it makes its way to the stream channel shape the timing, magnitude and chemical composition of the stream hydrograph. The extremely responsive nature of the hydrologic system at the Maimai has allowed researches to better identify the individual mechanisms controlling stream response in forested catchments. With more than 40 years of continuous investigation producing more than 100 research papers, the Maimai is one of the

world's foremost research catchments.

Understanding fresh water fluxes (plant transpiration, streamflow and groundwater recharge) are of fundamental importance for predicting the effects of global change on water security and ecosystem services. Therefore, Jeff's group has been tirelessly conducting field campaigns to collect vegetation (i.e. stem), soil, groundwater, and stream water samples for stable





isotope analyses from a wide range of site physiography as part of his Pantropical project. Isotope information will be used to leverage on existing site information that will be useful in understanding likely (meso to macroscale) controls on ecohydrological separation<sup>8</sup>. Consequently, Jeff has 42 sites in Hawaii, Thailand, Singapore, and the Philippines sampled for the Pantropical two water worlds hypothesis project. In addition,

other confirmed sites for the Pantropical project include Jamaica, Mexico, and Malaysian Borneo. Physiographic characteristics span a wide range: -83 to 1389 masl in elevation; 1000-3000 mm y-1 rainfall; 1 to 20 degrees N of the equator; and from natural to plantation forest ecosystems.

<sup>&</sup>lt;sup>8</sup> Evaristo et al. 2014. Global separation of plant transpiration from groundwater recharge and streamflow. *Nature*, DOI: 10.1038/nature14983

**3.3.4 Environmental Toxicology:** John Giesy, Canada Research Chair in Environmental Toxicology and his research group at the Toxicology Center are conducting research of international significance in the area of eco-toxicology. In general the impact of their research is on social policy for the protection of the quality of water globally. They work on socially relevant issues to reduce uncertainty for policy makers. Consequently, their work has led to the banning globally of perfluorinated chemicals, which are now listed on the Stockholm convention and are working on projects that will lead to phasing out of perfluorinated chemicals in China<sup>9</sup>. In addition, particularly in China, eutrophication is a huge issue, primarily due to the usage of fertilizers<sup>10</sup>. Their work is making an impact on how to reduce the use of excess fertilizer in China. In addition, work in underway on writing the water quality criteria for China<sup>11</sup>.



John Giesy (center) with Jingchun Tang (to his left) and his research group at the Nankai University, China

Currently, John Giesy and his group have active research sites in South Africa, Egypt, Germany, Czech Republic, Korea, China, Nepal, Tibet, Hong Kong, and US Great Lakes. Additional information about his group and activities are available on his <u>research website</u>.

**3.3.5 Mine Reclamation:** Lee Barbour, Syncrude-NSERC Industry Research Chair has active collaborations with Prof. Kevin Briggs, University of Bath, on measuring evaporation and cracking in moisture-limited soils, which is also linked to his work at the Queens University Belfast on hydrogeological responses within glacial till drumlins. This research was conducted at UK sites, which helped Lee Barbour to improve understanding of soil-atmosphere-vegetation-transfer (SVAT) processes in fractured soils related to clay-rich soils in the UK and mine waste in Canada. In addition, Lee Barbour in coordination with Jim Hendry, Cameco-NSERC Industry Research Chair maintains active collaboration with Dr. Wendy Timms from University of New South Wales, Sydney, Australia in the area of stable isotope profiling and geo-lysimeters. This research has

<sup>&</sup>lt;sup>9</sup> Meng et al. 2015. Are Levels of Perfluoroalkyl Substances in Soil Related to Urbanization in Rapidly Developing Coastal Areas in North China? *Environ. Pollut.* 199:102-109. DOI.org/10.1016/j.envpol.2015.01.022

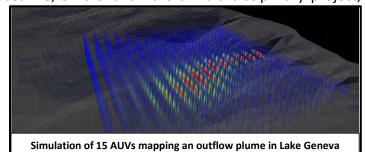
<sup>&</sup>lt;sup>10</sup> Liu et al. 2014. Assessment of Ecological Safety of Farmland Fertilization in China. J. Advanced Mat. Res. 962-965:2170-2174. DOI: 10.4028/www.scientific.net/AMR.962-965.2170

<sup>&</sup>lt;sup>11</sup> Liu et al. 2014. Setting Water Quality Criteria in China: Approaches for Developing Species Sensitivity Distributions for Metals and Metalloids. *Rev. Environ. Contamn. Toxicol.* 230:35-58. DOI: 10.1007/979-3-319-04411-8\_2.

particular application on the impact of underground mining on groundwater disturbance in Australia and Canada.

**3.3.6 Lake Biology:** Michael Kehoe, Postdoctoral Fellow, GIWS is part of a successful project titled "A Flexible Underwater Distributed Robotic System for High-Resolution Sensing of Aquatic Ecosystems" funded through the SINERGIA programme, National Swiss Science foundation. The project is led by Alcherio Martinoli (Principal Applicant), Alfred Wüest, and Bastiaan Ibelings from the École Polytechnique Fédérale de Lausanne, Switzerland. It is a multi-disciplinary project,

which will use autonomous underwater vehicles in conjunction with innovative instrumentation to measure the physical, chemical and biological parameters of freshwater lakes (Lake Greffen, Lake Geneva, Lake Hallwil) at



Onboard computing, navigation and communication

Tool mm

Battery pack
Stabilisation thrusters

Sensor payload

Autonomous Underwater Vehicle

extremely high resolution. This will allow greater understanding of how fine spatial structure in lake water columns contribute to phytoplankton population dynamics and diversity. A particular focus is on how phytoplankton blooms occur.

Michael Kehoe is a collaborator on a subproject which will test how fine scale variation of turbulence in the water column promotes diversity of phytoplankton communities. Particularly, he will measure the sinking rate of individual phytoplankton cells using a methodology developed during his PhD programme.

A timely aspect of this project is that climate change is already changing the turbulent characteristics of oceans and lakes around the world. Information from this project will deliver novel technologies for lake (and ocean) sampling, improved hydrodynamic models and information on how turbulence affects phytoplankton communities. All of this will help to predict how climate change could impact the phytoplankton community composition and productivity in a changing climate.

#### 3.4 Modelling Under Current and Future Climate

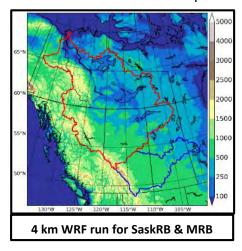
The warming climate in the west has led to glacial retreat in the Rocky Mountains, altering the rain/ snow balance and the snow accumulation and melt processes, both of which subsequently influence the timing and magnitude of river flows. Another manifestation of climate change is the infestation of mountain pine beetle, which has destroyed forests in British Columbia and is travelling eastward into the basin. Further, climate change is affecting agriculture, flood and

drought risk, and water quality across the prairies. Changes in farming practices (i.e., drainage, wetland removal) are in turn, altering the prairie landscape and the associated ecological services it provides. Declining river flows, mainly due to upstream withdrawals and river regulation (i.e., hydropower dams) represent a significant threat to the Saskatchewan Delta, one of Canada's richest regions for its abundant and diverse wildlife. First Nations communities who live in and off of this land, have profound concern with this ecosystem change and the accompanying impact it will have on traditional pursuits, such as hunting, fishing and trapping, and on the associated tourism stemming from those activities.

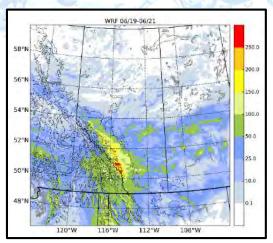
At GIWS, we are interested in understanding and modelling the individual processes of the hydrological cycle, their interactions, and their combined effects from a systems perspective. This give us the capability to predict what is going to happen to our water resources in the short and long-term, and also to predict natural hazards such as floods and droughts. We consider this as a system with many different working elements/processes, belonging to three main families of processes: atmosphere modelling, land-surface hydrology modelling, and water infrastructure modelling.

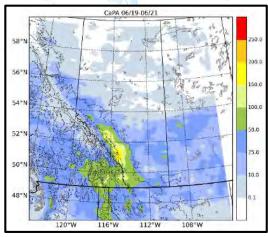
A critical need is to understand better climate variability and change, and to provide improved tools to evaluate scenarios of future climate. Research is therefore underway into climate processes and modelling<sup>12</sup>, including Rocky Mountain precipitation and convective precipitation over the Prairies. We are working on a historic climate run (2000-15) and a 15-year future run to 2100 and beyond with Pseudo Global Warming (PGW) simulation for the whole of western Canada, including the SaskRB and MRB, using a continental scale 4 km Weather Research and Forecast (WRF) model in collaboration with scientists from the National Climate and Atmospheric

Research (NCAR) Centre, USA. The 4 km resolution allows direct use of microphysics and resolves the convection explicitly, thus providing very convincing spatial detail. The translation of precipitation to surface hydrology and flooding information will help to clarify the possible effects of climate change on western Canada water resources. An example of this work is a numerical study of the June 2013 flood-producing extreme rainstorm over southern Alberta, which accurately shows simulated (left - WRF) and accumulated (right - CaPA) precipitation for period from June 19, 2014, 00 UTC to June 21, 2014, 00 UTC (see below). The black contours highlight the location of the Rockies.



<sup>&</sup>lt;sup>12</sup> Scaff et al. 2015. Inconsistency in precipitation measurements across Alaska and Yukon border, The Cryosphere Discuss., 9, 3709-3739, doi:10.5194/tcd-9-3709-2015





Concerning future climate, improved statistical downscaling methods have been developed for the Prairie Provinces, providing improved capability to generate time-series of precipitation and evaporation for future climate scenarios<sup>13</sup>. Detailed multi-model analyses have been made of the North American Regional Climate Change Assessment Program<sup>14</sup>, providing new insights into the current skill levels of regional climate models, and the model uncertainty associated with future projections. Current work on extreme precipitation<sup>15</sup> and drought<sup>16</sup> is building on the IPCC AR5 (Intergovernmental Panel on Climate Change – Fifth Assessment Report) climate model results.

It will be evident that the high quality hydrological and water quality data from our research sites and their small-scale basins can be used to provide new process insights and to develop improved models to support management and climate modelling. For example, a focus for process modelling is the Cold Region Hydrological Modelling (CHRM) system<sup>17</sup>, which represents key cold region hydrological processes (e.g., frozen soils, blowing snow) and has explored effects of agricultural changes in agricultural drainage and cropping practices. Recent developments include improved algorithms for i) soil freezing-thawing, ii) frost table impacts on soil moisture storage and hydraulic conductivity, iii) flow through organic materials, iv) snow dynamics on glaciers, v) snow redistribution by avalanche, and vi) wetland fill and spill. New multiscale algorithms have been developed for fine scale modelling of radiative transfer to snow under forests and in forest gaps. Research arising from the Tobacco Creek prairie site is being used to introduce agricultural water quality into this modelling system. Other platforms are being used to explore the movement of water in frozen soil and coupled runoff-dissolved organic carbon

<sup>&</sup>lt;sup>13</sup> Chun et al. 2013. Precipitation downscaling in Canadian Prairie Provinces using the LARS-WG and GLM approaches, Can. Water Resour. J., 38(4): 311-332, doi:10.1080/07011784.2013.830368.

<sup>&</sup>lt;sup>14</sup> Khaliq et al. 2015. Seasonal and extreme precipitation characteristics for the watersheds of the Canadian Prairie Provinces as simulated by the NARCCAP multi-RCM ensemble. Clim. Dynam., 44: 255-277, doi 10.1007/s00382-014-2235-0.

<sup>&</sup>lt;sup>15</sup> Asong et al. 2015. Regionalization of precipitation characteristics in the Canadian Prairie Provinces using large-scale atmospheric covariates and geophysical attributes. Stochastic Environmental Research and Risk Assessment, 29: 875-892, doi: 10.1007/s00477-014-0918-z.

<sup>&</sup>lt;sup>16</sup> Masud et al. 2015. Analysis of meteorological droughts for the Saskatchewan River Basin using univariate and bivariate approaches. Journal of Hydrology, 522: 452-466, doi:10.1016/j.jhydrol.2014.12.058.

<sup>&</sup>lt;sup>17</sup> Pomeroy et al. 2007. The cold regions hydrological model: a platform for basing representation and model structure on physical evidence. Hydrol. Process., 21: 2650-2667, doi:10.1002/hyp.6787.

algorithms to improve our understanding of coupling between the carbon and water balance. The sites also provide data to support the testing, inter-comparison and refinement of land-surface schemes for weather, climate and large-scale hydrological models. GIWS works in close collaboration with Environment Canada to improve Canadian modelling systems, including the Canadian Land Surface Scheme (CLASS) and its hydrological extension (MESH). Comparative analysis of models includes NCAR's WRF system, including CLM and NOAH-MP, and the UK's JULES modelling system. Work is also underway on coupled hydro-ecological models, in particular using the Canadian CTEM model (linked to CLASS). Outcomes thus far include an improved large-scale prairie model for EC's MESH modelling system<sup>18</sup>, improved modelling of permafrost processes, and the assimilation of remotely sensed data to improve model performance and identifiability. Modelling research is also providing new insights into the connectivity of prairie lakes and wetlands, in particular showing complex cycles of hysteresis as wetlands fill, spill and empty under cycles of wet and dry years<sup>19</sup>.

The SaskRB and MRB embody many of the management pressures experienced worldwide, and an important objective of research on these river basins is to provide improved modelling tools and methodologies to address water management at the river basin scale, as well as the need to support improved weather prediction and global and regional climate modelling.

Large scale hydrological model capability is needed for a range of applications, including flood forecasting, flood risk management, water resource operational management and planning, and the analysis of land atmosphere feedbacks under changing land management and climate. Preliminary analysis (using MESH) has identified key issues to be addressed. These include, for example, uncertainty in inputs (particularly precipitation), the representation of key biomes (in particular upscaling of mountain hydrological processes, and representation of variable contributing areas in the prairies), the representation of water management (e.g., reservoirs, irrigation<sup>20,21</sup>), the utility of remote sensing products such as GMP, SMAP and GRACE, and regionalisation of model parameters.

Given the challenges of Decision Making Under Uncertainty<sup>22</sup>, development of new water resources modelling and decision support tools is required. Traditional approaches to assessment of effects of future climate involve a cascade of uncertainty; uncertain future emissions and socioeconomic scenarios are used to generate uncertain outputs from global or regional climate models, which are downscaled and input to hydrological models, introducing further uncertainty. Through collaboration with Alberta Environment and Sustainable Resource Development in simulating the response of the complex South SaskRB water resource system in Southern Alberta

<sup>&</sup>lt;sup>18</sup> Mekonnen et al. 2014. Towards an improved land surface scheme for prairie landscapes. J. Hydrol, 511, 105-116, doi:10.1016/j.jhydrol.2014.01.020.

<sup>&</sup>lt;sup>19</sup> Shook et al. 2013. Storage dynamics simulations in prairie wetland hydrology models: evaluation and parameterization. *Hydrological Processes*, 27(13): 1875-1889. doi: 10.1002/hyp.9867.

<sup>&</sup>lt;sup>20</sup> Nazemi and Wheater. 2014. How can the uncertainty in the natural inflow regime propagate into the assessment of water resources system? *Adv. Water Resour.*, 63, 131-142, doi:10.1016/j.advwatres.2013.11.009.

<sup>&</sup>lt;sup>21</sup> Nazemi et al. 2013. A stochastic reconstruction framework for analysis of water resource system vulnerability to climate-induced changes in river flow regime. *Water Resour. Res.*, 49(1), 291-305, doi:10.1029/2012WR012755.

<sup>&</sup>lt;sup>22</sup> Gober and Wheater. 2014. Socio-hydrology and the science-policy interface: A case study of the Saskatchewan River Basin. *Hydrology and Earth System Sciences* 18, 1423-1422.

(11,000 licence holders), a new approach has been developed to assess water resource vulnerability to climate change<sup>11,12</sup>. A major focus has also been on the development of user-focused decision support modelling tools, with which stakeholders can be engaged in a dialogue. A new systems dynamic modelling capability has been developed for the province of Saskatchewan that is capable of interactive exploration of scenarios of changing inflows from Alberta and changing agricultural, domestic and industrial water use in the Province. This includes capability for dynamic (climate-dependent) irrigation demand, and economic valuation<sup>23</sup>. The project is working towards a basin-wide (multi-province) simulation capability that can be used for risk-based assessment of future water scenarios. To support this, paleoclimate evidence provides important insights into historical drought, on a time scale of many centuries. Hence research is developing improved reconstructions of paleoclimate, based on multi-variate tree-ring analysis<sup>24</sup>.

Intensification of land and water management, due to agriculture, forestry, and urban and periurban development, is a global phenomenon, raising concerns for changes to hydrology, including flood and drought risk, and water quality, across the world's developed and developing economies. In particular, nutrient pollution has been defined as one of the 'Grand Challenges' of the 21<sup>st</sup> century by the US Academy of Engineering. Scientists at GIWS are exploring the effects of agricultural and urban land and water management on water quality and water movement through a watershed, as well as the potential for agricultural beneficial management practices (BMPs) to mitigate adverse effects. Basin-scale water quality modelling is also under development. The SaskRB is a tributary of Lake Winnipeg, and the SaskRB project is assisting the work of the Canada-US International Joint Commission by developing a nutrient model for the Saskatchewan River, based on the U.S. Geological Survey SPARROW (SPAtially Referenced Regressions ON Watershed attributes) modelling platform, to provide the first basin-wide modelling capability with which nutrient management issues can be explored.

Groundwater is important to water security in a number of ways: it is a critical component of the hydrological cycle; it is an important water resource; and it plays a major role in the transmission of contaminants. There are thus major challenges to quantify the extent of groundwater resources and their quality, the natural recharge, the long—term impacts of abstractions and waste disposals, the impact of resource development, and hence, to provide the information needed for sustainable development. Research is underway (including major modelling work) to understand near-surface groundwater and groundwater surface-water interactions and evaluate the hydrogeology associated with the Bakken shale oil play in the south of the prairies, including the sustainable yield from the Quaternary and (lower quality) Tertiary and Upper Cretaceous aquifers, the role of aquitards and buried valleys, and cumulative impacts of deep waste disposals.

<sup>&</sup>lt;sup>23</sup> Hassanzadeh et al. 2014. Managing water and food in complex systems: Developing a dynamic Agro-Hydro-Economy simulator for the Saskatchewan River Basin, Canada, *Env. Modell. Softw.*, 58, 12-26.

<sup>&</sup>lt;sup>24</sup> Razavi and Wheater. 2014. Towards understanding non-stationarity in climate and hydrology through tree-ring proxy records. Water Resources Research, 51(3): 1813-1830. doi:10.1002/2014WR015696

#### 3.5 Significant Research Outcomes

GIWS members are involved in a broad set of water security research projects ranging from basic research to applied research of local and global significance. Our research projects have produced many outcomes to advance scientific understanding and its socioeconomic significance. Selected examples are provided below.

# 3.5.1 Existence of Two Water Worlds – Challenging the Existing Land Surface Model Parameterizations<sup>25</sup>

Understanding fresh water fluxes (plant transpiration, streamflow and groundwater recharge) is of fundamental importance for predicting the effects of global change on water security and ecosystem services. Existing land surface model parameterizations assume that plants and streams draw from a singular, well-mixed subsurface water reservoir – the soil. Recent watershed-based case studies have shown evidence of ecohydrological separation<sup>26</sup> (i.e. water for plant transpiration is different than water that recharge groundwater and replenishes streamflow), however these studies have not been widely tested. Part of the present study data from 47 globally-distributed sites were analyzed, which proved the existence of two water worlds.

#### 3.5.2 What is the Ideal Reclamation Cover Thickness for Oil Sands?<sup>27</sup>

Sustainable development of oil sands mines is important for the environment and the Canadian economy. The saline-sodic shale overburden on oil sands needs to be removed and reclaimed using locally sourced peat and glacial mineral soil cover to support vegetation growth, which is correlated to long-term evapotranspiration rates of the cover. This study delved into the process of determining the optimal soil cover depth that can not only sustain vegetation growth, but also keep saline-sodic shale contained. The depth has been determined as 100 cm over 60 year climate cycle.

# **3.5.3** Genes Clean Contamination - Bio-remediation of Petroleum Hydrocarbon Contaminated Soils<sup>28</sup>

Contamination of the environment with petroleum hydrocarbons (Alkanes, aromatic hydrocarbons, and polycyclic aromatic hydrocarbons) is a serious problem worldwide. They cause hardening and limit wetting of soils, and can result in toxicity to plants and/ or soil invertebrates, as well as pose risks such as mutagenicity and carcinogenicity to humans and wildlife through direct contact with these soils or soil organisms. Minimally invasive techniques such as

<sup>&</sup>lt;sup>25</sup> Evaristo et al. 2014. Global separation of plant transpiration from groundwater recharge and streamflow. *Nature*, DOI: 10.1038/nature14983

<sup>&</sup>lt;sup>26</sup> Brooks et al. 2010. Ecohydrologic separation of water between trees and streams in a Mediterranean climate. Nature Geoscience 3: 100-104.

<sup>&</sup>lt;sup>27</sup> Huang et al. 2015. The impact of reclamation cover depth on the performance of reclaimed shale overburden at an oil sands mine in Northern Alberta, Canada. Hydrological Processes, 29: 2840-2854, 10.1002/hyp.10229

<sup>&</sup>lt;sup>28</sup> Liu et al. 2015. Distribution of petroleum degrading genes and factor analysis of petroleum contaminated soil from the Dagang Oilfield, China. Nature, 5, doi: 10.1038/srep11068

application of microorganisms to enzymatically degrade contaminants have been favoured for remediation of soils, however, effective techniques for characterization of microbes bioremediation capacities are required. Consequently, this study has successfully established a process for genes that encode for enzymes that can degrade petroleum hydrocarbons.

### 3.5.4 Can Naphthenic Acid Affect or Cease Reproduction?<sup>29</sup>

Naphthenic acids are the group of organic acids that represent a substantive component of wastewater associated with oil sands mining and upgrading. To the best of our knowledge, this is the first research to examine the reproductive endocrine potency of naphthenic acids purified from an oil sands source of wastewater. The study used a number of well-established bioassays such as the yeast androgen and estrogen screen, and the H4IIE bioassay in combination with chemical characterization to examine for components of the oil sands mixture that may be responsible for impacts in wild fishes observed in the field. The study found anti-androgenic and anti-estrogenic activity, as well as the ability to activate the Ah receptor.

Environmental impacts associated with non-conventional sources of oil, such as from the oil sands, are an important and controversial global issue. Our work provides important conclusions as to mechanisms of toxicity of oil sands wastewaters. With billions of cubic meters of oils sands wastewaters stockpiled, these are important considerations for disposal or inclusion of material into a reclaimed landscape.

## 3.5.5 Aquatic Insect Population as an Indicator of Water Quality<sup>30</sup>

In agricultural intensive areas, use of insecticides (such as neonicotinoides) to protect seedlings from early-season root and leaf-feeding pests are common. Neonicotinoides exhibit chemical properties that enhance environmental persistence and susceptibility to transport into aquatic ecosystems through runoff and drainage of agricultural areas. Exposure of aquatic macroinvertebrates to contaminated toxic water may result in a decline in their population and can be used as a sensitive biological indicator of water quality and environmental conditions. This study has concluded that based on comprehensive species sensitivity distribution analysis of 214 toxicity tests of 48 species that any long-term neonicotinoid concentrations in water exceeding 0.035  $\mu$ g/L or short term peak exposures exceeding 0.2  $\mu$ g/L can affect sensitive aquatic invertebrate populations.

## 3.5.6 Bioavailability and Toxicity of Selenium in Coldwater Aquatic Ecosystem<sup>31</sup>

Selenium is a trace element that has potential to be toxic once it becomes bioavailable and gets into the food web. Numerous studies have shown their detrimental effect on fish population and aquatic birds. An increased understanding is needed of how specific hydrological, geochemical, physiological, and ecological processes govern the bioavailability and toxicity of Selenium in

<sup>&</sup>lt;sup>29</sup> Leclair, et al. 2015. In vitro assessment of endocrine disrupting potential of naphthenic acid fractions derived from oil sands-influenced water. Environmental Science and Technology, 49(9): 5743-5752.

<sup>&</sup>lt;sup>30</sup> Morrissey et al. 2015. Neonicotinoid contamination of surface waters and relative risks to aquatic invertebrates: a review. Environment International 74: 291-303, http://dx.doi.org/10.1016/j.envint.2014.10.024

<sup>&</sup>lt;sup>31</sup> Janz et al. 2014. Integrative assessment of selenium speciation, biogeochemistry and distribution in a northern coldwater ecosystem. Integr. Environ. Assess. Manag. 10: 543-554, doi: 10.1002/ieam.1560

coldwater aquatic ecosystems. This is particularly important for Canada due to its expanding natural resource extraction activities that can increase Selenium loading. This multidisciplinary research study represents the most comprehensive assessment of linkages between Selenium speciation, biogeochemistry and bioaccumulation in a coldwater aquatic ecosystem. It also emphasized the fact that under long term-loading of an aquatic system with Selenium, decreases in loading over time were not reflected in concentrations in sediments and aquatic vertebrates such as fish. The system will likely require longer recovery intervals due to the continual biogeochemical cycling of Selenium once incorporated into aquatic food webs.

#### 3.5.7 Dynamics of Beaver Population on Wetlands and Greenhouse Gas Emission<sup>32,33</sup>

Wetlands represent a dominant source of biogenic greenhouse gas release, particularly methane. The spatial extent of wetlands are correlated to release of methane. Beavers are one of the major factors that can influence creation of open-water ponds and associated wetland complexes. Wetlands inhabitated by beavers have an order of magnitude greater area of open water and 12 times the number of individual open water features than those without. These studies have established that anthropogenic influence in reintroducing beavers to the natural system has led to an increase of methane emission by 200 times. It is anticipated that continued range expansion and population growth in South America and Europe could further increase methane emissions.

#### 3.5.8 Boreal Plains Ecozone of Western Canada<sup>34</sup>

A review paper that summarizes our understanding of climate change impacts on hydrology in the Boreal Plains Ecozone has been published, with 12 coauthors from multiple disciplines, all affiliated with the GIWS. The paper summarizes the gaps in our knowledge about how climate change will impact the forest, and describes a future research agenda that will address limited understandings of process interactions through better, integrated monitoring networks, and better model-data integration. This paper supports the objectives of the Changing Cold Regions Network project, and motivates the interdisciplinary modelling work our research team and others are developing.

# 3.5.9 Influence of Groundwater on Hydrology and Mapping of Wetland Soils in the Canadian Prairie Pothole Region<sup>35</sup>

The Prairie Pothole Region (PPR) of North America contains thousands of glacially formed wetlands embedded in a landscape matrix of natural grassland and agriculture, and is renowned for its aquatic and avian diversity (waterfowl and ducks). It also provides valuable ecosystem services, including maintaining regional and national biodiversity, attenuating floodwater, cycling

<sup>&</sup>lt;sup>32</sup> Morrison et al. 2015. Distribution of Canadian Rocky Mountain wetlands impacted by beaver. Wetlands, 35: 95-104, doi: 10.1007/s13157-014-0595-1

<sup>&</sup>lt;sup>33</sup> Whitfield et al. 2015. Beaver-mediated methane emission: The effects of population growth in Eurasia and the Americas. AMBIO, 44: 7-15, doi: 10.1007/s13280-014-0575-y

<sup>&</sup>lt;sup>34</sup> Ireson et al. 2015. The changing water cycle: the Boreal Plains ecozone of Western Canada. WIREs, doi: 10.1002/wat2.1098

<sup>&</sup>lt;sup>35</sup> Pennock et al. 2014. Application of hydropedology to predictive mapping of wetland soils in the Canadian Prairie Pothole Region. Geoderma, 235-236: 199-211, http://dx.doi.org/10.1016/j.geoderma.2014.07.008

nutrients, sequestering atmospheric carbon, recharging groundwater, and providing recreational opportunities. Therefore, digital mapping of these wetlands is critical, but has been met with limited success in part because terrain attributes based on hillslope hydrology are inappropriate for predicting the pedological consequences of wetland hydrology. As part of this study, recent development in the hydrology and hydrochemistry of wetlands has been applied for predictive mapping of wetlands in PPR. This was achieved by understanding the spatial distribution of wetland-recharge and wetland-discharge soils in freshwater ponds. In addition, the role of groundwater in sustaining streamflow and wetland connectivity was determined. Field observations at St Denis National Area demonstrated how subsurface connectivity is spatially and temporally variable, and a transmissivity feedback mechanism applies, such that the contributions from groundwater to filling wetlands increase non-linearly with rising water tables<sup>36</sup>. An interesting and unexpected groundwater dynamic at the Brightwater Creek field site was observed, where two years of monitoring provided excellent insights into the hydrological controls on runoff generation<sup>37</sup>.

The first integrated groundwater-surface water model for the Canadian prairies, using PARFLOW-CLM was developed<sup>38</sup>. This shows how ponds can be modelled effectively as surface expressions of groundwater, but it remains a significant challenge to simulate surface exchanges of water in such a model framework, due to problems of numerical stability. The model also simulates the freeze-thaw processes, and does a reasonable job of capturing the depth and timing of freezing, though work is needed to better capture the response of the profile during thawing.

## 3.5.10 Change in Prairie Hydrology – More Rain than Snow<sup>39</sup>

A substantial change to observed character of precipitation, runoff generation mechanisms and depressional storage has been observed in the Canadian Prairies resulting in the dramatic shift in surface hydrology. Streamflow generation (1975-1994) in the Canadian Prairies is primarily by snowmelt, which ends in May due to lack of runoff of groundwater contributions. However, climate change has prompted an increase in multiple-day rainfall events by half, which have resulted in more rainfall-runoff streamflow. Research at Smith Creek has shown that annual streamflow volume and runoff ratio have increased 14-fold and 12-fold, respectively, since 1975, with dramatically increasing contributions from rainfall and mixed runoff regimes. Snowmelt runoff has declined from 86% in the 1970s to 47% recently while rainfall runoff has increased from 7% to 34% of discharge.

<sup>&</sup>lt;sup>36</sup> Brannen et al. 2015. Influence of shallow groundwater-surface water interactions on the hydrological connectivity and water budget of a wetland complex. Hydrological Processes. doi:10.1002/hyp.10563

<sup>&</sup>lt;sup>37</sup> Pan et al., in preparation – Faculty Advisor is Andrew Ireson

<sup>&</sup>lt;sup>38</sup> Ali et al., in preparation – Faculty Advisor is Andrew Ireson

<sup>&</sup>lt;sup>39</sup> Dumanski et al. 2015. Hydrological regime changes in a Canadian Prairie basin. Hydrological Processes, doi: 10.1002/hyp.10567

## 3.5.11 Macrophytes Infestation – A Barrier to Water Supply<sup>40</sup>

With an increase in demand for water in southern Saskatchewan (for domestic, industrial, agricultural and recreational use) an increase in water supply from Lake Diefenbaker to the Buffalo Pound Lake (major source of water) via the Upper Qu'Appelle River is required. A numerical modelling study was carried out to simulate the degree of ice cover thickening and backwater staging during freeze-up at various discharge scenarios for the Upper Qu'Appelle River. Macrophyte infestation over a stretch of 4 km was considered as the major hinderance to an increase in flow demands, which could be mitigated through dredging and removal of nutrient-rich sediment.

## 3.5.12 The Influence of Wind over Precipitation Data in the North<sup>41</sup>

Powerful statistical analysis tools were used to account for inconsistency in gauge precipitation observations across the Alaska and Yukon border by using the bias-corrected data to account for wind effect on the gauge catch, wetting loss and trace events. The analysis showed that monthly corrections increase solid precipitation by up to 105% in January and 4% in July. This discontinuity was greater for snowfall than for rainfall, as gauge snowfall observations have large errors in the windy and cold conditions.

## 3.5.13 Vulnerability of Water Resources and Framework for Sensitivity Analysis 42,43,44

Natural streamflows are major water supplies globally and are sensitive to climate change. This has serious implications for water resource management: while changes in climate perturb water availability, human activities are developed around certain streamflow characteristics, such as flow seasonality and volume. Therefore, any shifts in streamflow regime can greatly affect human livelihoods. For example, water resources systems have been shown to be sensitive to human influence such as irrigated farming.

Sensitivity analysis is an essential paradigm in Earth and Environmental Systems modeling. However, the term "sensitivity" has a clear definition, based in partial derivatives, only when specified locally around a particular point (e.g., optimal solution) in the problem space. This study revisits the theoretical basis for sensitivity analysis, summarizes and critically evaluates existing approaches in the literature, and demonstrates their flaws and shortcomings through conceptual examples. It also demonstrates the difficulty involved in interpreting "global" interaction effects, which may undermine the value of existing interpretive approaches. With this background, a

<sup>&</sup>lt;sup>40</sup> Lindenschmidt and Sereda. 2014. The impact of macrophytes on winter flows along the Upper Qu'Appelle River. Canadian Water Resources Journal, 39(3): 342-355, http://dx.doi.org/10.1080/07011784.2014.942165

<sup>&</sup>lt;sup>41</sup> Scaff et al. 2015. Inconsistency in precipitation measurements across Alaska and Yukon border. The Cryosphere Discuss., 9: 3709-3739, doi:10.5194/tcd-9-3709-2015.

<sup>&</sup>lt;sup>42</sup> Nazemi and Wheater. 2014. Assessing the Vulnerability of Water Supply to Changing Streamflow Conditions. Eos

<sup>-</sup> Transactions of the American Geophysical Union, 95(32): 288, doi: 10.1002/2014EO320007

<sup>&</sup>lt;sup>43</sup> Hassanzadeh, et al. 2014. Managing water in complex systems: An integrated water resources model for Saskatchewan, Canada. Environmental Modelling & Software, 58: 12-26, doi: 10.1016/j.envsoft.2014.03.015

<sup>&</sup>lt;sup>44</sup> Razavi and Gupta. 2015. What do we mean by sensitivity analysis? The need for comprehensive characterization of "global" sensitivity in Earth and Environmental systems models, Water Resources Research, 51, doi:10.1002/2014WR016527

comprehensive, robust, and efficient set of tools were developed to analyze and understand the internal functioning of a system (e.g., a watershed system) and identify the influential component and the way they interact.

### 3.5.14 Environment Friendly and Cost Effective Advanced Oxidation Technology<sup>45</sup>

Membrane technology is one of the most effective water treatment technologies, and its utilization is rapidly expanding. Production of concentrates (organic materials, chemicals, microbial products, biological materials) and their proper disposal is a concern. This study evaluates the effectiveness of advanced oxidation treatments (UV and Ozone) on degradation of managanese and organics in reverse osmosis concentrate stream and identifies options for optimal treatment processes under different concentrations.

# 3.5.15 Repositioning Canada as a Leader in Sustainability and Climate Governance – Honouring Indigenous Treaty Rights<sup>46</sup>

This article argues that honouring the treaties with many Canadian First Nations would expedite environmental and social benefits to all Canadians, globally repositioning Canada as a leader in sustainability and climate governance. This was demonstrated by using the oil sands in Treaty Eight as an example. In addition, it also indicates that sustainability includes the traditional practices and knowledge of indigenous people, and requires rethinking alternatives to the dominant capitalist paradigm based on non-renewable resource dependency as a source of infinite growth. Finally, this study also suggests that in accordance with the United Nations Declaration on the Rights of Indigenous Peoples' principle of free, prior and informed consent, policymakers must respect the right of indigenous peoples to saying no to development on their traditional territories.

# 3.5.16 Water Governance in the Saskatchewan River Basin – Strenghts, Weaknesses & Opportunities<sup>47</sup>

Watershed governance involves a range of political, organizational and administrative processes for development and management of water resources and delivery of water services for sustainable watershed ecosystem. The multi-jurisdictional governance structure of Saskatchewan River Basin (SaskRB) was examined which suggests the advantages of the current fragmented, multiagency regime of water governance in the SaskRB are outnumbered by the disadvantages. Some of the important recommendations for improving water governance included creating an inter-jursidictional body with basin-wide planning, ensuring more communication and cooperation between organizations, improving public engagement,

<sup>&</sup>lt;sup>45</sup> Jeirani et al. 2015. Effectiveness of advanced oxidation processes for the removal of manganese and organic compounds in membrane concentrate. Separation and Purification Technology, 149: 110-115, http://dx.doi.org/10.1016/j.seppur.2015.05.009

<sup>&</sup>lt;sup>46</sup> Mantyka-Pringle et al. 2015. Honouring indigenous treaty rights for climate justice. Nature Climate Change, doi:10.1038/nclimate2714

<sup>&</sup>lt;sup>47</sup> Morgan et al. 2014. Water Governance in the Saskatchewan River Basin: A Preliminary Study. Journal of Rural and Community Development, 9(4): 34-48.

education, and awareness, and either giving the Prairie Province Water Board greater responsibility based on their existing jurisdiction or reviewing their mandate.

## 3.5.17 Drought Adaptation under Uncertain Climate Futures<sup>48</sup>

A main goal of drought research and monitoring and associated policy development is to ensure sufficient water resources for people, the economy, and the environment. Droughts can bring a host of other problems in addition to water scarcity. These include increased risks of fire, increased soil erosion, water quality degradation, and habitat deterioration, as well as pests and diseases. Most sectors are sensitive to drought, including agriculture, energy production, tourism, manufacturing, transportation, and health. This study gives an overview of the current realities of drought and implications for program and policy formulation. The most significant goal is to address how individuals and society can best adapt to drought and water scarcity.

### 3.5.18 Climate, Cryospheric and Hydrological Changes over the Interior of Western Canada<sup>49</sup>

The western and northern regions of Canada are at the forefront of global warming, which is reflected in the current integrated review of the observed changes in climate, cryospheric, and hydrological Earth system components and a concise and up-to-date regional picture of some of the temporal trends since the mid or late-20th century. The focus has been on air temperature, precipitation, seasonal snow cover, mountain glaciers, permafrost, freshwater ice cover, and river discharge. It is concluded that systematic warming and significant changes to precipitation, snow and ice regimes are unambiguous. However, integrated effects on streamflow are complex. It is argued that further diagnosis is required before predictions of future change can be made with confidence.

### 3.5.19 Snow Dynamics and Properties<sup>50</sup>

The Canadian Rockies Hydrological Observatory stations are now complete with the installation of the Athabasca Forefield Station near the Columbia Icefield. Data from hundreds of sensors on these stations are being archived and used to drive and evaluate models of mountain climate and hydrology in the headwaters of the Saskatchewan River Basin.

The group at the Centre for Hydrology contributed significantly towards advancement of snow science through various successful projects and field-based experiments as follows:

• Establishment of the accuracy of sonar for snowpack physical measurement in the context of a review of all physical measurement techniques for the seasonal snowpack.

<sup>&</sup>lt;sup>48</sup> Wheaton, E. 2015. Droughts Challenge Water Resource Management and Policy. Policy paper prepared for the Institute on Science for Global Policy, "Living with Less Water Conference," 20-21 Feb, Tucson, AZ, USA. University of Saskatchewan, Saskatoon, SK. 4 pp.

<sup>&</sup>lt;sup>49</sup> DeBeer et al. 2015. Recent climatic, cryospheric, and hydrological changes over the interior of western Canada: a synthesis and review. Hydrology and Earth System Sciences Discussions, 12: 8615-8674, doi:10.5194/hessd-12-8615-2015

<sup>&</sup>lt;sup>50</sup> http://www.usask.ca/hydrology/

Field experiments on i) saltation of snow using particle tracking velocimetry on a mountain to determine individual particle trajectories in saltating snow for the first time, ii) heterogeneous flow through snow using dye tracing, infrared photography of grain size and acoustic measurement of snow wetness and density, iii) uncertainty in measurement of snowfall and snow accumulation in mountains through measurement comparison of various devices and manual measurements, iv) turbulent transfer over glaciers and the effect of icefield winds in modulating turbulent transfer using eddy correlation, SODAR, kite-sonding and energy balance stations, v) "snow-drone" UAV measurements of snowcovered area and snow depth changes during spring ablation in prairie and alpine environments, vi) measurement of advection of sensible and latent heat energy to snow patches during ablation in prairie and alpine environments, vii) evolution of a mountain snow drought and consequences for snowpack, soil moisture, and streamflow generation, viii) variation in evapotranspiration over mountain ridges, ix) glacier meteorology and mass balance in the Canadian Rockies and NWT, and x) surface processes and permafrost dynamics along the Dempster Highway corridor, Yukon.

## 4. Internationalization of Curriculum and Training

Water Security is one of the greatest challenges for humankind, with global implications. There is a need a) to develop local and regional studies that are of global significance, and to share that information, b) to address key water challenges around the world, and c) to provide students and researchers with new insights and tools to address these problems. International collaboration and cooperation therefore play a critical role in advancing water science to deliver sustainable solutions.

GIWS strongly believes that internationalization of higher education embraces the mobility of faculty and students, educational aids and international cooperation, and curriculum internationalization. In other words, internationalization of higher education includes faculty and student exchange, joint teaching and research programs, as well as international curriculum development and delivery.

GIWS's philosophy has been to give Canadian students international experience and to give international students Canadian experiences. Our students and postdoctoral fellows represents ethnic and gender diversity representing a mixing of cultures —scientifically and sociologically—which are the key to breakthroughs.

#### 4.1 International Short Courses and Workshops

GIWS researchers not only believe in scientific training of highly qualified personnel (HQP), but also focus on mentoring and launching the research careers of young researchers. Beyond our own labs at the U of S, our members have active HQP training programs through various international shortcourses. For example, Jeffrey McDonnell, Associate Director GIWS delivers the "Catchment Science Summer School" at the University of Aberdeen, training 120 PhD students

from universities across Europe, a new "Watershed Hydrology Masterclass" at the University of Arizona, a "Forest Hydrology Shortcourse" at the Universidad Austral de Chile, Valdivia Chile, and an "Advanced Isotope Hydrology for Uranium Mining Applications", Federal University of Rio de Janeiro and Instituto de Radioproteção e Dosimetria, Rio de Janeiro, Brazil. Similarly, he teaches an Isotope Hydrology course for the UN's International Atomic Energy Agency, and has trained



93 graduate students through courses in Brazil, Chile, China and Philippines. Jeffrey McDonnell is also the 6<sup>th</sup> Century Chair of Hydrology at the University of Aberdeen (UK), Honorary Professor of Hydrology at the Nanjing Hydraulic Research Institute (China), and University Distinguished Professor of Hydrology (adjunct) at Oregon State University (USA).

John Giesy, Canada Research Chair in Environmental Toxicology also holds joint appointments as the Chair Professor at Large of Biology & Chemistry, at City University of Hong Kong (retired in 2015), Concurrent Professor of Environmental Science at Nanjing University, China, Visiting Professor at Xiamen University, Xiamen, China, Honorary Professor of Biological Science at the University of Hong Kong, Hong Kong, China and Distinguished Honorary Professor of Zoology at King Saud University, Riyadh, Saudi Arabia. As part of his affiliations he travels to respective institutions every year to deliver special courses in the area of environmental toxicology and also co-supervises numerous local graduate students and technical personnel. John Giesy delivered a shortcourse on Chemodynamics to 25 graduate students at the City University of Hong Kong, a

shortcourse on Human Ecological Risk Assessments in a Changing Environment at the School of the Environment, Peking University, and shortcourse on Risk Assessment for China in the 21st Centurty at the School of the Environment, Nanjing University, Nanjing, China. Currently, he is supervising students and postdoctoral fellows at the City



University, Egypt

University of Hong Kong, The University of Hong Kong, Hong Kong Baptist University, Nanjing University, Xiamen University, The Chinese Research Academy of Environmental Sciences (CRAES), Peking, The Research Center for Eco-Environmental Sciences (RCEES) of the Chinese Academy of Sciences, Beijing and Research Center for Toxic Compounds in the Environment (RECETOX) at Masaryk University, Brno, Czech Republic.

Similarly, John Pomeroy, Canada Research Chair in Water Resources and Climate Change is an Honorary Professor of the Centre for Glaciology, Aberystwyth University, Wales, and a Visiting Professor of the Chinese Academy of Sciences. In addition, he has joint research and training collaborations with University de Chile, Santiago; Freiburg University (Germany); and Edinburgh University (Scotland). As part of his appointments and interactions, every year he delivers special courses and workshops to train graduate students and technical staff. For example, he has delivered a short-course on Surface-Atmosphere Exchange over Mountainous Terrain at part of Innsbruck Summer School of Alpine Research, Austria to 21 students.

Yangping Li, Assistant Professor, School of Environment and Sustainability (SENS) in collaboration with Professor Roberto Rondanelli and Professor José A. Rutllant from University of Chile organized the two-week field campaign to train local students held in Elqui Valley basin in Chile in July 2015. The project was titled "Using Elqui Valley basin as an example to assess the water resources vulnerability of the Andes Western Slope under climate change background" as part of her Canada-Latin America and the Caribbean Research Exchange Program. In adition, she oparticipated in PECAN (Plains Elevated Convection At Night), an international field experiment funded through the National Science Foundation, which was held in Oklahoma/Kansas from May 29 to June 23, 2015. This provided an opportunity for her own students to interact with participating international students and scientists to exchange information. The field campaign was focused on the understanding of the physical mechanisms that contribute to the initiation of the warm-season nocturnal precipitation over US Great Plains.

Similiary, Markus Hecker, Canada Research Chair in Predictive Aquatic Ecotoxicology delivered a graduate lecture during the 6<sup>th</sup> Environment and Health Summer School on "Oceans and Human Health" at Hong Kong, Shenchen and Zhuhai, China. In addition, Andrew Ireson, Assistant Professor, SENS will be teaching a course in groundwater in January 2016 at the Africa Institute of Sanitation and Waste Management, part of the KNUST University in Ghana, as part of their MSc program in Environmental Engineering.

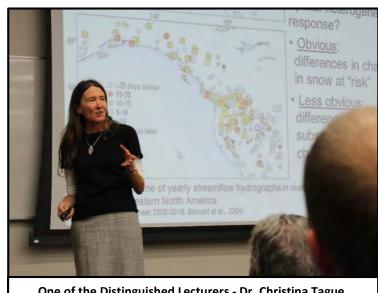
#### **4.2 Promoting Academic Success of International Scholars**

GIWS strongly believes in professional development of graduate students and postdoctoral fellows, particularly international scholars. In order to achieve this objective, GIWS offers a short course on "The Future Professoriate," to shed light on and facilitate discussions regarding the workings of academia for graduate students and postdoctoral fellows interested in pursuing

academic careers. In addition, we advise our student and postdoctoral fellows in "creating a research brand" of their own ambitions and for a successful and satisfying research career<sup>51</sup>.

In addition, GIWS hosts a yearly Distinguished Lecture Series entitled "Breakthroughs in Water

Security Research," which brings 10 world-leading scientists to GIWS for lectures, tutorials and workshops in areas of soil physics, instrumentation, lab experiments, uncertainty estimation, hydroecological modeling, watershed observatory networks, instream flow modeling, engineering hydrology, aquatic ecosystem science, isotope hydrology and socio-hydrology. This lecture series provides students, postdoctoral fellows, faculty, staff and the broader community with an opportunity to understand breakthroughs in various areas of



One of the Distinguished Lecturers - Dr. Christina Tague, University of California, Santa Barbara

water security from a global perspective and to network with international leaders. Each lecture is streamed live online and archived for subsequent access for the benefit of off-campus Canadian and international participants, which further expands the reach of the lecture series. For information and to view archived lectures from our Distinguished Lecture Series, please see <a href="http://www.usask.ca/water/News/dls/index.php">http://www.usask.ca/water/News/dls/index.php</a>.

#### 4.3 Graduate Program in Water Security

Starting September 2016, GIWS is offering an innovative Master of Water Security (MWS) graduate program that builds both disciplinary expertise and awareness of and capability for interdisciplinary work. MWS is a cross-disciplinary, course-based, professional-style program that can be completed within one year of full-time study that will provide an unprecedented depth and breadth of training for industry, government and research. Students enrolled in this program will not only take courses for credit, but also have to attend a mandatory Field Camp in the weeks before the start of the fall term. This program is intended to provide prospective or current environmental practitioners a post-graduate learning opportunity in water security. Applications from outstanding students are welcomed.

<sup>&</sup>lt;sup>51</sup> McDonnell. 2015. Creating a research brand. Science 349(6249):758, doi: 10.1126/science.349.6249.758

#### 4.4 NSERC CREATE Program for Water Security

In order to address pressing global water security challenges such as flooding, drought and reduced water quality, the Collaborative Research and Training Experience (CREATE) program in water security was funded by the Natural Science and Engineering Research Council (NSERC) of Canada in 2015, to support graduate education and training. The NSERC CREATE for Water Security program is based on a science-practitioner model to stimulate graduate students to learn and understand the integration of science, engineering and policy analysis to address current and future challenges in managing complex and uncertain water systems. Our research and training model expands interactions across disciplines without diluting disciplinary credentials, blurs the line between research and practice, and builds necessary personal and professional skills. Applications from well-qualified Canadian and international students are welcomed.

#### The program:

- Trains researchers capable of investigating the nature and causes of rapid social and environmental change in complex and uncertain water systems.
- Trains practitioners capable of translating this new science into actionable knowledge for water resources management and land-use planning decisions and policies.
- Provides classroom and field experiences that bring together researchers and practitioners for problem-solving and decision-making.
- Enhances Canadian research momentum in the field of water security.

For additional information, please refer to GIWS NSERC-CREATE Website.

#### 5. Performance Indicators

GIWS was created with the vision to attain research excellence at U of S and become one of the world- leading research-intensive institutions in the area of water security. The path to attain such a feat in a relatively short time is complex and involves multiple dimensions. Persistent and intensive efforts have been invested to recruit members, recruit and retain HQP, develop internationally-recognized research facilities with cutting-edge instrumentation, find a niche in research, take on national and international science leadership roles, attract substantial additional research funding, develop leading training programs, gain recognition of research outcomes through peer reviewed publications, secure national and international awards and honours, and establish collaboration with industry, government and non-government organizations. Since inception, GIWS has made remarkable progress in each of these areas, and is now delivering the exciting science that was foreseen at the programme outset. We are pleased to report that in last 5 years, 48 of our trainees have become faculty members and research scientists in 18 different countries, 38 trainees are working with provincial and federal organizations, 90 are with consulting and private firms, 36 are working in research administration

and providing technical support at national and international universities, and 71 are pursuing higher studies.

- **5.1 Membership:** A key aim of GIWS is to develop the new science and new trans-disciplinary science integration that is needed to address the major challenges to water security faced locally, regionally and globally. GIWS now integrates expertise from 211 members (71 Members, 22 Associate Members, 3 Affiliate Members, and 115 Student Members) from 15 academic units across the U of S, and has formed strong and mutually supportive working partnerships with Federal and Provincial agencies, in particular Environment Canada (EC) and the Saskatchewan Water Security Agency (SWSA) (Appendix A).
- **5.2 Support Staff:** GIWS has grown under a policy of developing a lean and efficient administration, and only making new staff appointments when absolutely necessary. However the number of researchers and the level of research funding and facilities to be managed are large, and financial accounting requirements are quite onerous. Therefore, GIWS currently has a Director, an Associate Director, an Assistant Director, an Executive Assistant, a Financial Officer, a Communication Specialist (0.5FTE), a Clerical Assistant, and a Data Manager (Appendix B).
- **5.3 Highly Qualified Personnel:** During 2014-15, GIWS has financially supported 51 graduate students (24 PhD and 27 Masters), 32 postdoctoral fellows, 38 research assistants, 10 research associates and scientists, 10 undergraduate and graduate student assistants and 26 visiting scholars (Appendix B). In addition, its members have supported 169 graduate students (65 PhD and 104 Masters), 26 postdoctoral fellows, 12 research associates, 6 scientists, 38 Research Assistants, Research Engineers and Summer Students, and 18 visiting scholars (Appendix C).
- **5.4 Research Funding:** To support our research and training endeavours, financial resources are critical. Healthy financial resources help attract and retain the 'best-of-the-best' from around the world, and help develop cutting edge research facilities. Therefore, another of the institute's main objectives has been the pursuit of research funding to leverage the base CERC funding of \$30 million over seven years. In 2014-15, the seven core faculty members have secured a total of about \$2.7 million dollars, primarily from Federal resources, while the members have secured a total of about \$19.4 million (71% and 15% from Federal and Industry sources, respectively) (Appendix D). Since March 2011, the seven core faculty hired through the CERC program have secured a total of \$15 million in additional research funds from organizations such as EC, CFI, the Canadian Water Network, the SWSA, and NSERC's Climate Change and Atmospheric Research program. In addition, our broader GIWS membership has also secured further funding of \$53.3 million over the last 4 years to support water security research, which results in a total GIWS funding of \$68.3 million on top of the original \$30 million CERC investment.
- **5.5 Research Publications:** In 2014-15, GIWS members have published 209 journal articles, published and presented 216 papers in proceedings and at conferences, delivered 60 plenary, key note and invited lectures, and published 10 book chapters and books. Since 2011, GIWS members have published a total of 715 journal articles and 43 books/book chapters, participated

in 554 conference proceedings and presentations and delivered more than 261 invited, key-note and plenary lectures to share research outcomes and enlighten our stakeholders and scientific community (Appendix E).

5.6 Awards and Honours: One of the measurable parameters for research and training excellence is the number of awards and honours received by GIWS members and students. Again in 2014-15, we have achieved significant success in this area and are targeting to promote and support our members and students in pursuing strategic awards and honours in the near future. Some of the recent awards and honours include life-time achievement awards, fellowships in prestigious societies, capacity building and internationalization awards, leadership roles, editorship in journals, provincial- and national-level graduate scholarships, and many top paper and conference presentation awards received by graduate students. It is noteworthy that the GIWS members sit on the advisory panels for the world's two leading water prizes (Stockholm Water Prize and Prince Sultan Bin Abdulaziz International Prize for Water), has three fellows of the Royal Society of Canada, three fellows of the American Geophysical Union (only 0.01% recognized as fellows), fellow of Chinese Academy of Sciences, fellow of Beijing DeTao Masters Academy, president-elect of the American Geophysical Union (7500-member Hydrology Section, the world's leading scientific hydrology organization), Secretary-elect of the Canadian Geophysical Union Hydrology Section; president of International Association of Hydrogeologists - Canadian National Chapter, and representation on the NSERC Joint Prize Committees. In addition, in last 5 years, our students have won many national and international awards, including 3 Vanier scholarships, 23 Canada Graduate Scholarships and 19 Tri-agency Postgraduate Scholarships.

John Giesy was awarded the inaugural GIWS Research Excellence Award in recognition of his outstanding excellence in water security research, as acknowledged by his peers based on his international stature, impact research, training of highly qualified personnel, and research productivity. In addition, he was appointed as the UofS Science Ambassador to China. He also received the the Famous Overseas Lecturer Award from Peking University, Distinguished Visiting Scholar



Award, from the University of Hong Kong and the International Collaboration Award from the Chinese Academy of Sciences. He was elected (one of 20 worldwide in the inaugural class) a Fellow of the Society of Environmental Toxicology and Chemistry.

Some notable achievements include:

- Lee Barbour, Syncrude-NSERC Industry Research Chair was awarded the R.M. Hardy Keynote Address & Award by the Canadian Geotechnical Society and was appointed as the Honorary Professor at Queen's University Belfast N.Ireland.
- Al Naggar (John Giesy's student) and group received the best student paper award during the 73rd Annual Meeting of the Acadian Entomological Society, Truro, NS, Canada, and the best poster presentation award during the 4th, SETAC Prairie Northern Chapter Annual Meeting, Saskatoon, SK, Canada. Similarly, Guo (John Giesy's student) and team received the ACS Reward from American Chemical Society and was featured in SpectroscopyNow.com. Also, Saunders (John Giesy's student) and group received the Platform Presentation Award during the 4th, SETAC Prairie Northern Chapter Annual Meeting, Saskatoon, SK, Canada. One of John Giesy's scholars (Yi Wan) received the "973 young scientists" supported by the Minstry of Science and Technology of China and three scholars (Yi Wan, Xiaowei Zhang, Hong Chang) received Excellent Young Scientist awards, supported by National Natural Science Foundation of China.
- Markus Hecker, Canada Research Chair in Predictive Aquatic Ecotoxicology was appointed the Visiting Professor by the Chinese Academy of Medical Science and Peking Union Medical College, and was the Guest Professor at the Xiamen University, China. In addition, his students Shawn Beitel received 3<sup>rd</sup> Place Platform Award at the 4<sup>th</sup> Society of Toxicology and Chemistry Prairie Northern Chapter, and Bryanna Eisner received 1<sup>st</sup> Place in the Fisher Scientific Toxicology Undergraduate Research Award.
- Wonjae Chang, Civil and Geological Engineering received the 2014 Outstanding Reviewer Award from the Journal of Environmental Engineering, American Society of Civil Engineers (ASCE).
- Lucia Scaff (Yanpign Li's student) received the oral presentation award during the CCRN Early Career Researcher Network (ECRN) meeting, Waterloo, Canada.
- Emily Anderson (John Pomeroy's student) received the W. Garfield Weston Award for Northern Research.
- Breda Muldoon (Natacha Hogan's student) received the 1st Place Poster Award in 2014 and 2nd Place Award in 2015 under the Master's student category during the North American Society of Environmental Toxicology and Chemistry (SETAC) conference, Vancouver, BC and Calgary, AB, respectively.
- **5.7 Research Chairs and Faculty:** During the past 4 years, UofS has appointed 23 new faculty members in water science. Today GIWS integrates the efforts of 151 faculty members at UofS. Our faculty includes one Canada Excellence Research Chair, nine Canada Research Chairs (CRC), four Industrial Research Chairs (IRC), and six endowed Chairs. Over last 5 years, the water area at UofS has seen an increase of 23% in new faculty appointments, 300% in IRC appointments, 29% in CRC appointments, plus the addition of the CERC in water security.

#### 6. Collaborations and Outreach

One of the primary objectives of the GIWS is to stimulate, reinforce and enhance collaborative, interdisciplinary research opportunities across the campus community and with external stakeholders. These include research partnerships with internal and external stakeholders, provision of expert advice to stakeholders, and engagement with the community at local, national and international levels regarding the GIWS research programme. In February 2015, GIWS hosted its annual two-day workshop bringing together researchers, postdoctoral fellows, students and research staff from the UofS, Environment Canada (EC), the Saskatchewan Water Security Agency (SWSA) and Agriculture and Agri-Food Canada (AAFC) working on water-related projects. The workshop provides the opportunity for research teams to present their findings and to discuss opportunities for interdisciplinary collaborative research.

Over the course of the reporting period, collaboration with external partners was also enhanced through visits by international researchers to GIWS to explore potential collaborative research opportunities. Most notably, in autumn 2014, the second GIWS Distinguished Lecture Series in Water Security was held. Between September and November, ten distinguished lecturers from a broad range of disciplines visited the UofS to give a lecture, participate in a graduate course in water security and meet with potential collaborative research partners. Each lecture was streamed live and has subsequently been made available on the GIWS website spawning global interest in the outputs of this lecture series.

One of the most important research partnerships for the GIWS is that with EC. Collaborative research continues to be pursued and is facilitated by our joint location in the National Hydrology Research Centre. Another key strategic partnership has developed with the SWSA (formerly the Saskatchewan Watershed Authority), based on regular, ongoing meetings and research collaboration. Both collaborative relationships have resulted in leveraged research funding for activities begun under the auspices of the CERC programme.

Effective communication remains a key component of GIWS collaboration and outreach as guided by three overarching communications goals to: 1) raise local, national and international profile by communicating the work and achievements of the GIWS, 2) cultivate and strengthen the sense of community amongst UofS and affiliated agency water researchers, and 3) raise profile for the institute internally on the UofS campus to strengthen member and potential-member participation and commitment to GIWS goals and mandate. Within this reporting period, media interactions and published stories of GIWS members numbered 106 (this number includes on campus publications). A few highlights of communications activities include:

- Continued circulation of a weekly online newsletter, GIWS This Week, to keep the GIWS membership base well informed of water-related activities/opportunities. We continue to receive positive feedback about this communications tool;
- Publication of two issues of Water News newsletter;

- The October 2014 issue of the U of S alumni magazine the Green & White was entirely focused on U of S water research and the work of GIWS members. This included an opinion piece by Howard Wheater, faculty profiles and four feature articles showcasing Socio-hydrology, flooding, cold-region/Rocky Mountains and Lake Diefenbaker research;
- Continuation of the Distinguished Lecture Series in Water Security in Fall 2014 which saw ten international experts in water security research visit GIWS, give seminars and meet with faculty and students;
- In March, GIWS and the Canadian Water Resources Association celebrated World Water Day with an event showcasing water research at the U of S. Events began with the Water Leaders Lecture Series and presentation of the inaugural GIWS excellence award winners. The day finished with a student and postdoctoral fellow poster competition;
- Media highlights:
  - GIWS research and activities were highlighted in five news releases and two media advisories.
  - Howard Wheater gave seven media interviews during the reporting period.
  - In March, Howard Wheater was featured in an 800-word spotlight piece for the Canada Excellence Research Chairs website, written by Meagan Hinther;
- o Internally, GIWS and/or its researchers were featured in seven *On Campus News* stories;
- Website reorganization to the brand new U of S responsive templates has begun and will continue throughout the summer and fall;
- GIWS members convened 54 sessions and poster presentations at the AGU Fall Meeting in December 2014, more than 50 sessions and posters at the joint CGU/AGU meeting in Montreal in May 2014 and had a strong showing at CMOS in Whistler, May 2015.

A new communications and teaching method undertaken during this reporting period has been the development of a video suite featuring some of the work of the Institute, focused mainly on the experimental sites in the Saskatchewan River Basin. The Saskatchewan River Basin: A Large Scale Observatory takes a tour through eight of our research sites in the basin – from the Canadian Rockies through to the Saskatchewan River Delta, and features an overview video of GIWS as well as a video on our Socio-Hydrology programme. The series is being used to train students about the water challenges faced across the river basin and to expose them to GIWS research. The success of this initial venture prompted a funding application to the Gwenna Moss Centre for Teaching Effectiveness which has been successful and will see the preparation of ten additional videos.

Additional outreach activities by our members have been listed in Appendix F.

## 7. Student Corner

Over the course of the 2014/2015 school year, the Student Outreach Committee (SOC) from the GIWS put on some exciting events. The events were designed to share and discuss the research of GIWS's members as well as to bring together student members of the GIWS, allowing them to get to know each other, and have some fun.





**7.1 Dragon Boat Festival:** In July 2014, the GIWS students, postdoctoral fellows and staff participated in the annual Dragon Boat Festival in Rotary Park to raise money for the Canadian Heart and Stroke foundation. A

spontaneous rallying effort resulted in a team of 24 novice-to-experienced paddlers trying to find a shared rhythm and have fun. Though the weather interfered with practices, the team quickly made progress and managed to improve their times with every heat. Much fun was had by all. Plans are already forming for next year's team entry.

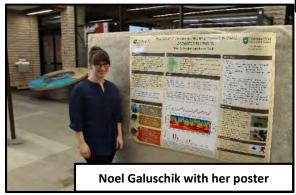


**7.2 SENS Farewell/Welcome BBQ:** In August 2014, SOC-GIWS teamed up with the School of Environment and Sustainability Student (SENS) Association for a farewell/welcome barbeque for departing and new students of SENS and GIWS. It was a beautiful evening on the banks of the



South Saskatchewan River, where the students participated in recreational games, and had a chance to share experiences and relax. This was also an opportunity for us to entice new students to join our student body and be affiliated with our Facebook group to secure information on current and future events.

7.3 World Water Day: In March 2015, SOC helped host a seminar series called 'The Water Leaders of Tomorrow' and a student poster competition for World Water Day. The seminar featured a series of student research projects from each of the Institute's research themes. The event was well attended and the audience participated in positive discussions and provided constructive feedback. During





Abdalla Karoyo Receiving the Best PhD Thesis Award

this event, the inaugural award for the Best Doctoral Thesis Award was conferred to Abdalla Karoyo, in recognition of his excellence in water security research and innovation. The award was made based on candidate's research innovation, impact or research in the field of wastewater treatment, research publications track record, scholarships received, and potential for career growth.

The poster competition followed the seminar. Noël Galuschik, a MES student from GIWS and SENS, took first place for her poster on phosphorus retention in an agricultural watershed.

**7.4 Better Than Bottled:** An on-going effort throughout the year (in collaboration with the School of Environment and Sustainability Students Association, the University of Saskatchewan Student Union, and the Office of Sustainability) has been to continue last year's 'Better than Bottled' campaign. This campaign raises awareness and attempts to educate members of the campus

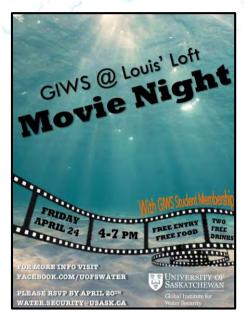
community and the general public on the benefits of tap water over bottled water. A website (betterthanbottled.ca) was created to promote this effort and has continued to gather signatures for a petition



to reduce the sale of bottled water on campus.

**7.5 Social Events:** The SOC-GIWS also organized two movie nights. At Louis' Loft, student members have watched *Flow:* For the Love of Water as well as a short documentary about a canoe expedition across Alaska by Jason Mercer (one of our student members). We also gathered together at the Broadway Theatre to watch *Monsoon* and for a question and answer session with the director.

The SCO-GIWS maintains a Facebook group for students of the GIWS (<a href="https://www.facebook.com/UofSWater">https://www.facebook.com/UofSWater</a>), where they advertise events and post interesting news and studies related to water security. As of June 2015, the page has 327 'likes'.



## 8. Concluding Remarks

2014-2015 was another remarkable and productive year for GIWS and members. We have experienced exponential growth in terms of activities, members, and outcomes as evidenced by our "Performance Indicators", which we anticipate to continue in foreseen future. GIWS productivity and training programs are testaments of our commitment and excellence to advance the area of Water Security having local, national and global significance.

A significant effort has been invested in enhancing communication of our research outcomes and impact stories to society and stakeholders. GIWS will continue to move forward with its momentum and will establish new and sustain existing collaborations of mutual benefit to local and international partners and communities.

In this brief overview of the recent work of GIWS, it has not been possible to do full justice to the work of our members, and we encourage those interested to visit our web-site <a href="www.usask.ca/water">www.usask.ca/water</a> or to contact our members directly. We welcome students and postdoctoral researchers to either join our team full time or spend time with us as visiting researchers. We also welcome academic colleagues for short or longer visits. Our Assistant Director, Dr. Phani Adapa <a href="mailto:phani.adapa@usask.ca">phani.adapa@usask.ca</a> is always available for contact regarding the work of GIWS and welcomes enquiries from individuals, governments, industry and others concerning research collaboration.

## **APPENDIX A – Current Membership**

**Members:** Individuals working at a level of responsibility which includes initiating and leading water research activities. This may include, but is not limited to Faculty members at UofS; Research Scientists, Staff Scientists, or Science Associates in recognized co-located (e.g. Saskatoon-based) research institutions (i.e. Environment Canada, Saskatchewan Research Council, Canadian Light Source, Agriculture and Agri-food Canada); and UofS Research Scientists.

Barbour, Lee, Professor, Civil and Geological Engineering

Geotechnical/Geo-environmental: Saturated/Unsaturated Groundwater Flow and Contaminant Transport, Mine Waste Reclamation

**Baulch, Helen**, Assistant Professor, School of Environment and Sustainability Water quality; Aquatic ecology; Global change; Biogeochemical cycles; Greenhouse gas emissions; Eutrophication

Bedard-Haughn, Angela, Associate Professor, Soil Science

Study fundamental understanding of pedologic properties of Canadian ecosystems and how land use and climate changes affect, and are affected by, these properties

**Belcher, Ken**, Professor, Bioresource Policy, Business and Economics Ecological economics; Resource and environmental economics; Environmental policy; Climate change; Wetland and wildlife conservation policy

Bharadwaj, Lalita, Associate Professor, School of Public Health

Barriers and Key Issues to the Access of Safe and Sustainable Drinking Water Sources in First Nations Communities; Community Based Participatory Research with Indigenous Communities; Human and Environmental Health Risk Assessment; Community-Based Education

**Cessna, Allan**, Research Scientist, Agriculture and Agri-Food Canada Agricultural pesticides and veterinary pharmaceuticals

**Chambers, Patricia**, Research Scientist and Section Head, Environment Canada Human Impacts on Aquatic Ecosystems Processes

Chang, Won Jae, Assistant Professor, Civil and Geological Engineering

Contaminated site assessment and remediation; Bioremediation of oil sands pollutants, mine wastes, frozen contaminated sites; Characterization of microbial communities/populations; Molecular biology techniques for contaminated environmental matrices

**Clark, Bob**, Research Scientist and Adjunct Professor, Environment Canada Avian Ecology, Reproction and breeding habitate selection, Landscape ecology

**Clark, Doug**, Centennial Chair and Assistant Professor, School of Environment and Sustainability Polar bear-human conflicts; Decision-making under conditions of rapid social-ecological change; Wildlife and protected area management; Environmental governance and policy processes

**Dalai, Ajay**, Canada Research Chair in Bioenergy and Environmental Friendly Chemical Processes, Chemical and Biological Engineering Renewable Energy; Heavy Oil and Gas Processing; Catalytic Reaction Engineering

**Davison, Bruce**, Research Scientist, Environment Canada

Hydrometeorological modelling, including incorporating physical or statistical processes into models; Operationalization of modelling tools; Incorporating software engineering tools into model development; Models for decision making

**de Boer, Dirk**, Research Scientist, Environment Canada Drainage basin; Suspended sediment; Fluvial geomorphology; Soil Erosion

Doig, Lorne, Research Scientist, Toxicology Centre

Bioavailability and toxicity of metals, including nanomaterials, in surface waters and sediments; Deriving environmental quality criteria (water, sediment, and tissue-based); Aquatic ecotoxicology; Aquatic paleoecotoxicology

Elliott, Jane, Research Scientist, Environment Canada

Soil processes; Soil-water interactions and agrochemical leaching; Impacts of management practices on water transport of nutrients and contaminants

Elshorbagy, Amin, Professor, Civil and Geological Engineering

Water Resources Engineering: Hydrinformatics - mechanistic & data-driven watershed modeling, soft-computing techniques; Multicriterion decision analysis, system dynamics

**Ferguson, Grant**, Associate Professor, Civil and Geological Engineering Hydrogeology; Geothermal Energy; Climate Change

**Fulton, Murray**, Professor and Graduate Chair, Johnson-Shoyama School of Public Policy Economics of biotechnology; Policy analysis of corruption; Performance of co-operatives

**Giesy, John**, Professor and Canada Research Chair in Environmental Toxicology Ecology; Ecotoxicology; Aquatic toxicology; Environmental analytical chemistry of organic compounds; Environmental chemistry (Fates of trace substances in aquatic ecosystems)

**Gober, Patricia**, Professor, Johnson-Shoyama School of Public Policy

Water policy; Sustainability science; Decision making under uncertainty; Urban systems; Human migration and population geography; Science-policy interface and stakeholder engagement; Applied climatology

**Hania, Patricia**, Assistant Professor, College of Law Legal water governance models in Canada

**Gray, Richard**, Professor, Bioresource Policy, Business and Economics Agricultural trade; Agricultural marketing; Environmental economics

**Hecker, Markus**, Associate Professor and Canada Research Chair in Predictive Aquatic Ecotoxicology

Investigation of biological effects of environmental stressors; Environmental risk assessment; Development and application of bioanalytical techniques to assess environmental pollution; Aquatic ecology/fish biology

Helgason, Warren, Assistant Professor, Chemical and Biological Engineering

Atmospheric boundary layer processes; Energy and mass transport in the soil-plant-atmosphere continuum; Irrigation

Hendry, Jim, Professor and NSERC-Cameco Industrial Research Chair

Aqueous and environmental geochemistry of contaminants in uranium tailings; Characterization of biogeochemical reaction rates in vadose zones; Fate and transport of solutes in aquitards; Sorption controls on the transport of bacteria in saturated porous media; Reactive barrier technologies

**Hill, Harvey**, Research Scientist, Agriculture and Agri-Food Canada Economics; Climate decision support and adaptation

Hobson, Keith, Research Scientist, Environment Canada

Conservation and management of boreal forest birds and other wildlife; Conservation and management of waterbirds with particular emphasis on the interactions between fish-eating birds and commercial and sport fisheries; Use of stable isotopes to track the source and fate of environmental contaminants in terrestrial and marine systems

Hogan, Natacha, Assistant Professor, Animal and Poultry Science

Aquatic toxicology; Sources and fate of aquatic contaminants; Aquatic animal health; Agricultural intensity and water quality

Howard, Allan, Manager, Agriculture and Agri-Food Canada

Adaptation techniques for drought and conditions of extreme wetness; Best practices for monitoring soil moisture; Models for assessing drought and for forecasting regional scale crop yield; Develop systems for accessing local and regional scale information on climate impacts

**Hudson, Jeff**, Associate Professor, Biology

Biogeochemical cycles in aquatic ecosystems; Effects of food web structure, ultraviolet radiation, climate change and biodiversity on elemental cycling and energy flow

**Ireson, Andrew**, Assistant Professor, School of Environment and Sustainability Climate change and water security; Land-water management and environmental change; Sustainable development of natural resources

Janz, David, Professor, Veterinary Biomedical Sciences

Climate change and water security; Land-water management and environmental change

Jardine, Tim, Assistant Professor, School of Environment and Sustainability Freshwater food webs; Applications of stable isotope analysis in ecology; Tropical floodplain hydrology and ecology; Contaminant biomagnification in aquatic ecosystems; Sources and fate of trace metals; Fish migration; Land-water and river-ocean connectivity

**Johnstone, Jill**, Associate Professor, Biology Climate change and water security

**Jones, Paul**, Associate Professor, School of Environment and Sustainability Land-water management and environmental change; Naphthenic Acid

**Laroque, Colin**, Professor, College of Agriculture and Biorsource Climate change; Boreal ecosystems; Dendrochronology; Dendrochemistry; Dendrohydrology

**Kells, Jim,** Professor and Head, Civil and Geological Engineering
Hydraulic Structures; Use of Rock in Hydraulic Engineering; Scour Processes in Cohesionless
Materials; Water Quality of Stormwater Runoff; Ecologically Engineered Systems

**Li, Yanping**, Assistant Professor, School of Environment and Sustainability Regional climate modelling; Mesoscale dynamics; Boundary layer meteorology; Air-sea interaction

**Liber, Karsten**, Professor and Director, Toxicology Centre Bioavailability and toxicity of metals, including nanomaterials, in surface waters and sediments; Deriving environmental quality criteria (water, sediment, and tissue-based); Aquatic ecotoxicology; Aquatic paleoecotoxicology

**Lindenschmidt, Karl-Eric**, Associate Professor, School of Environment and Sustainability Surface water quality modelling; River ice processes; Climate change and river morphology; Flood and flood risk management

**Lindsay, Matt**, Assistant Professor, Geological Sciences Groundwater; Biogeochemistry; Mining management and reclamation

**Marsh, Phil**, Research Scientist, Geography and Planning Hydrologic processes and modelling of snowmelt and rainfall runoff in cold environments; Impact of climate change on water resources of the Canadian Arctic

Martz, Lawrence, Professor, Geography and Planning Soil erosion and sediment transport; Impacts of climate change on water use in the South Saskatchewan River Basin

**McDonnell, Jeffrey**, Professor and Associate Director, Global Institute for Water Security Watershed hydrology; Runoff processes; Modelling, Isotope hydrology

**McKenzie, Marcia**, Associate Professor and Director, Sustainability Education Research Institute Place, environment and sustainability

**Meda, Venkatesh**, Associate Professor, Chemical and Biological Engineering Water treatment system design and development

Morrissey, Christy, Assistant Professor, Biology

Ecotoxicology; Water pollution; River and wetland ecology; Freshwater biology; avian and aquatic ecotoxicology

Noble, Bram, Professor, Geography and Planning

Environmental impact assessment; Cumulative effects assessment; Strategic environmental assessment; Environmental planning and management; Environmental decision making

Patrick, Bob, Associate Professor, Geography and Planning

Water Policy and Governance; Watershed Planning and Management; Source Water Protection; Integrated Water Resource Management; First Nations access to safe Drinking Water; Regional Planning; Urban Water Issues

Pennock, Dan, Professor, Soil Science

Landscape-scale soil processes and the spatial pattern of soil properties

**Pickering, Ingrid**, Professor and Canada Research Chair in Molecular Environmental Science Development of new synchrotron radiation techniques; Metals and metalloids transformation in the environment; Identification of toxicologically significant compounds in vivo

**Pomeroy, John**, Professor and Canada Research Chair in Water Resources and Climate Change Hydrological processes and modelling in mountain, prairie and arctic environments; Climate change, hydrology and water resources; Snow chemistry and ecology; Droughts in the Canadian Prairies; Cold regions hydrometeorological modelling and surface-atmosphere feedbacks

Razavi, Saman, Assistant Professor, School of Environment and Sustainability Environmental and Water Resources Systems Planning and Management; Hydrologic and Groundwater Models Development and Calibration; Single- and Multi-objective Optimization and Uncertainty Analysis; Climate Change and Impacts on Hydrology and Water Resources; Reconstruction of Paleo-hydrology – Implications for Climate Change Analysis; Short-term and Long-term Rainfall and runoff forecasting; Surrogate Modeling, Artificial Intelligence, and Machine Learning

Reed, Maureen, Professor, School of Environment and Sustainability

Environmental Governance; Sustainability of Rural Communities; Feminist and Gender-based Analysis; Social Resilience; Political Ecology; Forestry; Model Forests; Biosphere Reserves; National Parks

Shook, Kevin, Research Scientist and SGI Canada Research Fellow, Geography and Planning

Snowmelt modelling; Fractal analysis of hydrological phenomena; Flood modelling and extreme events analysis

#### Si, Bing, Professor, Soil Science

Understand the mechanisms of soil water dynamics and thermal regimes in non-level landscapes—at the pedon, hillslope (catchment) and landscape scale

### Singh, Satya, Research Scientist, Geological Sciences

Environmental geochemistry particularly in trace metal biogeochemistry; geochemical cycling; Remediation of contaminated soils, sediment, surface and groundwater; Quantification of geochemical processes in wetlands and mining wastes

**Soltan, Jafar**, Associate Professor, Chemical and Biological Engineering Emerging pollutants in water; ozone in water treatment; catalytic ozonation in water treatment; advanced oxidation; industrial wastewater treatment; environmental catalysis

### Spence, Christopher, Research Scientist, Environment Canada

Hydrology and hydrometeorology of Canada's cold regions, especially the subarctic Canadian Shield; Hydrological processes in the Prairie Pothole region of Saskatchewan

**St-Maurice, Jean-Pierre**, Canada Research Chair in Environmental Sciences, Arts and Science Atmospheric electricity; Space weather; Geophysical fluid dynamics; Atmospheric evolution; Climate change

**Steelman, Toddi**, Professor and Executive Director, School of Environment and Sustainability Socio-hydrology: communication, knowledge co-production, knowledge mobilization, community involvement, science-policy interface, decision making

#### van der Kamp, Garth, Research Scientist, Environment Canada

Impacts of climate changes and land-use changes on prairie wetlands and lakes; Evaluation of groundwater availability and sustainability; Impacts of groundwater withdrawals on aquatic ecosystems; Groundwater flow and solute transport in low -permeability formations; Study of the hydrology of peatlands

#### van Rees, Ken, Professor, Soil Science

Agroforestry and biomass energy systems and their impacts on soils

## Waiser, Marley, Research Scientist, Environment Canada

Effects of Human and Veterinary Pharmaceuticals and Herbicides on Indices of Aquatic Ecosystem Health

#### Westbrook, Cherie, Associate Professor, Geography and Planning

Wetland Ecohydrology; Effect of beavers and humans on pathways between surface and ground waters; Transport of water and nutrients from wetlands and riparian areas

**Wheater, Howard**, Professor, Canada Excellence Research Chair in Water Security, and Director, Global Institute for Water Security

Hydrological processes and modelling, with applications to the management of flood risk, water resources, water quality, wastes and climate change adaptation

**Wheaton, Elaine**, Senior Research Scientist, Saskatchewan Research Council Climatology; Climate impacts and adaptation; Climate change; Hazards climatology

**Wittrock, Virginia**, Research Scientist, Saskatchewan Research Council Climatology; Climate impacts and adaptation; Climate change; Hazards climatology

Wilson, Lee, Associate Professor, Chemistry

Water, Solution Chemistry, Hydration Phenomena, Polymers, Biomaterials, Membranes, Porous Materials, Colloids & Surfactants, Materials & Environmental Science, and Chemical Separations

Yang, Daqing, Research Scientist, Environment Canada

Global water resources and availability; Climate change; Extreme hydrological events; Human impact on water systems; Arid and cold region hydrology

Associate Members: Individuals who are making a significant contribution to water research or who are providing support for water research activities in areas relevant to GIWS. This may include, but is not limited to UofS research staff (e.g. Research Associates, Research Assistants, Research officers or Postdoctoral fellows); Research staff from recognized national or international research institutions who are affiliated with a member of the Institute; and Professional affiliates – professional individuals who may not hold a PhD, but who can serve on graduate student advisory committees and/or teach graduate courses.

**Abbasi, Soroush,** Postdoctoral Fellow, Environment Canada Water resources management; water quality; hydrology; hydrogeology

**Apples, Willemijn**, Postdoctoral Fellow, Global Institute for Water Security Vadose zone; groundwater; infiltration; recharge; solute transport

**Chu, Yin**, Visiting Scholar, Civil and Geological Engineering Watershed Modeling; Water Quality; Hydrology; Forest Watershed; Water Pollution Control

**Chun, Kwok Pan**, Postdoctoral Fellow, Global Institute for Water Security Hydrology; Statistics; Climate change

**Ghanbarpour, Reza**, Water Allocation Modeller, Alberta Energy and utilities Board Flood-risk modelling, Watershed hydrology, Decision analysis, Optimization

**Haghnegahdar, Reza**, Postdoctoral Fellow, School of Environment and Sustainability Land surface-Hydrological Modeling, Model Sensitivity and Uncertainty Assessment, Model Calibration/Validation **Kehoe, Michael**, Postdoctoral Fellow, School of Environment and Sustainability Water quality; Ecological modeling; Toxic cyanobacteria blooms; Monitoring; Data mining

**Keim, Dawn**, Postdoctoral Fellow, Global Institute for Water Security
Recharge processes; hydrogeology; unsaturated flow processes; contaminant transport

**Mahmood, Taufique**, Postdoctoral Fellow, Global Institute for Water Security Hydrology; water quality; remote sensing

**Mamet, Steven**, Postdoctoral Fellow, Biology, University of Saskatchewan Effect of climate and environmental change on tree line dynamic

**Mantyka-Pringle, Chrystal**, Postdoctoral Fellow, School of Environment and Sustainability Conservation planning; biodiversity; Land-use change; Climate change; Environmental decision-making; Prioritization; Water management

**Musselman, Keith**, Postdoctoral Fellow, Centre for Hydrology, University of Saskatchewan Hydrology; Water Resources; Snow; Hydrometeorology

**Nazemi, Ali**, Research Associate, Global Institute for Water Security Water resources modelling and management under climate change conditions

**North, Rebecca**, Postdoctoral Fellow, Global Institute for Water Security Utrophication issues; Phytoplankton physiology and ecology; Land use practices and nutrient bioavailability; Nutrient limitation of algae; Aquatic biogeochemistry

**Pan, Xicai**, Postdoctoral Fellow, Global Institute for Water Security Hydrology; Cryosphere; Climate; Soil physics; Hydrogeophysics

**Pernica, Patricia**, Postdoctoral Fellow, Global Institute for Water Security Lake-atmosphere interaction; physical limnology; modelling; mixing dynamics

**Ryan, Chris,** Director of Business Development, Level Science Inc. Environmental forensics; Athabasca oils sands; Synchrotron radiation; Absorption spectroscopy; Naphthenic acids; Petroleum Coke; Mine drainage; Industrial effluent

Sagin, Jay, Postdoctoral Fellow, Global Institute for Water Security Remote Sensing and GIS applications; Hydrology; Hydrogeology; Modelling; Trans-boundary basins

**Strickert, Graham**, Research Associate, Global Institute for Water Security Complex human-environmental systems; Socio-hydrology; Mixed-methods; Fuzzy cognitive maps **Affiliates:** Distinguished individuals who have a demonstrable commitment to the goals and objectives of GIWS's SaskRB program. Affiliates are generally positioned outside traditional research environments.

Halliday, Bob, Senior Vice President, Chief Financial Officer, Applied Materials, Inc.

Lamb, Susan, Chief Executive Officer, Meewasin Valley Authority and Chair of VIDO/Intervac liaison Committee

**Sanford, Bob**, EPCOR Chair of the Canadian Partnership Initiative in support of United Nations "Water for Life" Decade, Director of the Western Watersheds Research Collaborative

**Student Members:** Students registered at a postsecondary institution who are engaged in water-related research activities, and who are under the supervision or co-supervision of a GIWS member, or any graduate or undergraduate student registered at the University of Saskatchewan.

Glossary: MSc – Master of Science; PhD – Doctor of Philosophy; MSEM – Master in Sustainable Environmental Management; MPP – Master of Public Policy; MES – Master of Environment and Sustainability; MPH – Master of Public health; MPA – Master of Public Administration; SENS – School of Environment and Sustainability; JSGS – Johnson Shoyama Graduate School of Public Policy; SPH – School of Public Health

Name	College/ School	Supervisor	Degree
Abirhire, Oghenemise	Biology	J. Hudson	Masters
Adesokan, Adedoyonsola	SENS	n/a	MSEM
Aghbolaghy, Mostafa	Chemical & Biological Engineering	J. Soltan	PhD
Ahmed, Hafiz	Chemical & Biological Engineering	W. Helgason	MSc
Aksamit, Nikolas	Centre for Hydrology	J. Pomeroy	PhD
Alam, Md. Shahbul	Civil & Geological Engineering	A. Elshorbagy	MSc
Amin, Mahmud Rashedul	Civil & Geological Engineering	K. mazurek	MSc
Amos, Mike	Civil & Geological Engineering	L. Barbour	
Anderson, Emily	Geography	J. Pomeroy	MSc
Armstrong, James	Biology	N. Chilton	MSc
Armstrong, Maria	Geography	H. Baulch	MSc
Awume, Bennet	SENS	n/a	MSEM
Baer, Thomas	Civil & Geological Engineering	L. Barbour	MSc
Bagatim, Tabata	SENS	M. Hecker	MSc
Baijius, Warrick	Geography & Planning	R. Patrick	MA

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Bam, Edward	SENS	A. Ireson	PhD
Beitel, Shawn	Toxicology	P. Jones	MSc
Bihum, Samantha	Arts & Science	n/a	Undergraduate
Brannen, Rosa	SENS	A. Ireson	MES
Brown, Robin	Soil Sc.	A. Bedard-	MSc
		Haughn	
Brown, Robyn	Arts & Science	n/a	Undergraduate
Bruce, Kristin	JSGS	P. Gober	MPP
Buchanan, Astri	SENS	M. Reed	MES
Burke, Amanda	SENS	H. Wheater	MES
Burlock, David	Arts & Science	n/a	Undergraduate
Carr, Meghan	SENS	K-E.	MES
		Lindenschmidt	
Cavaliere, Emily	SENS	H. Baulch	PhD
Chowdhury, Rocky	Civil & Geological Engineering	K. Mazurek	MSc
Coles, Anna	SENS	J. McDonnell	PhD
Das, Apurba	SENS	K-E.	MES
		Lindenschmidt	
David, Cody	Soil Science	W. Helgason	MSc
Demuth, Brandon	Biology	D. Chivers	PhD
Dobrovolskaya,	SENS	B. Si	MES
Yekaterina			
Doering, Jonathon	Toxicology	M. Hecker	PhD
Dompierre, Kathryn	Civil & Geological Engineering	L. Barbour	PhD
D'Silva, Lawrence	Toxicology Centre	K. Liber	MSc
Dudiak, Scott	Arts & Science	n/a	Undergraduate
Dumanski, Stacey	Geography & Planning	J. Pomeroy	MSc
Ferdous, Jannatul	Chemical & Biological	W. Helgason	PhD
	Engineering		
Ford, Lorelei	SENS	L. Bharadwaj	MES
From, Richard	Geological Sciences	K. Larson	MSc
Gabrielli, Chris	SENS	J. McDonnell	PhD
Galuschik, Noel	SENS	H. Baulch	MES
Garvey, Phillip	Soil Science	S. Siciliano	PhD
Gibb, Josh	SENS	K. Mazurek	PhD
Gilmour, Kim	Arts & Sc.	n/a	Undergraduate
Gonda, Jordan	Civil & Geological Engineering	A. Elshorbagy	MSc
Gooding, Raea	SENS	H. Baulch	MES
Green, Derek	Toxicology Centre	D. Janz	MSc
Harder, Phillip	Geography & Planning	J. Pomeroy	MSc
Hassanzadeh, Elmira	Civil & Geological Engineering	A. Elshorbagy	PhD
Hatzel, Kayla	Arts & Science	n/a	Undergraduate
Head, Kerry	Biology	J. Hudson	MSc
Hermann, Kristian	Geological Sciences	J. Hendry	MSc
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Hoemsen, Brittney	Biology	D. Chivers	MSc
Hossain, Md. Kamrul	Civil & Geological Engineering	A. Elshorbagy	PhD
Howitt, Nicholas	SENS	n/a	MSEM
Hueser, James	Arts & Science	n/a	Undergraduate
Hunter, Kristine	Biology	J. Hudson	M.Sc.
Jafri, Syed	SPH	A. Backman	MPH
Jeirani, Zahra	Chemical & Biological	J. Soltan	PhD
	Engineering		
Johansson, Jess	Biology	J. Hudson	MSc
Kardas, Jeffrey	Geography & Planning	n/a	Undergraduate
Karran, Daniel	Geography	n/a	Undergraduate
Kelly, Meghan	SENS	n/a	MSEM
Kowsari, Mohamadmahdi	Chemical & Biological	J. Soltan	MSc
	Engineering		
Leroux, Nicolas	Geography & Planning	J. Pomeroy	PhD
Lokken, Nils	SENS	D. Clark	MES
Lokken, Torbjom	RRM	n/a	Undergraduate
Liu, Ning	SENS	K-E.	PhD
		Lindenschmidt	
Lucas, Brett	Toxicology	K. Liber	MSc
Mahmood, Fazilatun	Geological Sciences	J. Hendry	PhD
Mamo, Moges	Civil & Geological Engineering	A. Ireson	MSc
Marsh, Chris	Geography	Pomero/	
Masse, Anita	Toxicology	D. Janz	Masters
Masud, Badrul	SENS	N. Khaliq	PhD
Meissner, Anna	SENS	K-E.	MES
		Lindenschmidt	
Mekonnen, Balew	Civil & Geological Engineering	K. Mazurek	PhD
Mercer, Jason	Geography & Planning	C. Westbrook	MSc
Mohamadmahdi, Kowsari	Chemical & Biological	J. Soltan	MSc
	Engineering		
Morrison, Alasdair	Geography & Planning	C. Westbrook	MSc
Mulhall, Liam	SENS	H. Baulch	MSEM
Parratt, Toomas	Civil & Geological Engineering	G. Putz	PhD
Payton, Diana	JSGS	P. Gober	MPP
Perry, Tom	Arts & Science	n/a	Undergraduate
Peterson, Amber	Civil & Geological Engineering	A. Ireson	MSc
Phillips, Iain	Biology	D. Chivers	PhD
Prestie, Chance	Biology	J. Hudson	MSc
Rahimova, Nargiz	SENS	H. Hesseln	MES
Rasouli, Kabir	Geography & Planning	J. Pomeroy	PhD
Rokaya, Prabin	SENS	S. Razavi	PhD
Roste, Jennifer	Geography & Planning	H. Wheater/J.	MSc
	_	Pomeroy	

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Rozon, Jordan Hilare	Geography & Planning	J. Pomeroy	MSc
Sadeghi, Azam	Chemical & Biological	J. Soltan	MSc
	Engineering		
Sadeghian, Amir	SENS	K-E.	PhD
		Lindenschmidt	
Saunders, David	Toxicology	J. Giesy	MSc
Schabert, Marcie	Arts & Science	n/a	Undergraduate
Shafiei, Farshad	Biology	J. Hudson	PhD
Shahariar, Md Shayeb	Soil Science	A. Bedard-	PhD
		Haughn	
Sizo, Anton	Geography & Planning	B. Noble	PhD
Steeves, Joel	Civil & Geological Engineering	L. Barbour	MSc
Tendler, Brett	Toxicology Centre	J. Geisy	MSc
Tootoosis, Mylan	Native Studies	R. Innes	PhD
Tritschler, Felix	SENS	J. McDonnell	MSc
Tse, Timothy	Toxicology	P. Jones	MSc
Ufondu, Lotanna	Civil & Geological Engineering	G. Ferguson	PhD
Virdi, Satpal	JSGS	D. Beland	MPA
Weber, Darian	Arts & Science	n/a	Undergraduate
Yassin, Fuad	SENS	H. Wheater	PhD
Yee, Briana	Arts & Science	n/a	Undergraduate
Yip, Hayden	Biology	J. Hudson	MSc
Younes, Firas	SENS	R. Patrick	MSEM
Tuan, Hongda	Toxicology Centre	M. Hecker	MSc
Zee, Jenna	SENS	M. Hecker	MES
Zilefac, Elvis	SENS	H. Wheater	PhD

## **APPENDIX B – GIWS Employees and Students 2014-2015**

The following table provides information on GIWS employees and students funded during the period of 2014-15. A total of 155 personnel were funded during this period, including 7 GIWS faculty members, 7 administrative staff, 38 research assistant/technicians, 10 research associates/scientists/specialists, 32 postdoctoral fellows, 24 doctoral students, 27 masters' students and 10 undergraduate student assistants.

Name	Title/Area	Supervisor/Unit
CERC Faculty		
Baulch, Helen	Assistant Professor	SENS
Ireson, Andrew	Assistant Professor	SENS
Li, Yanping	Assistant Professor	SENS
Lindenschmidt, Karl-Erich	Associate Professor	SENS
Razavi, Saman	Assistant Professor	SENS
McDonnell, Jeffrey	Professor and Associate Director	SENS
Wheater, Howard	Professor and Director	SENS
Administrative Staff		
Adapa, Phani	Assistant Director	H. Wheater
Hinther, Meagan	Communications Specialist - 0.5 FTE	H. Wheater
McDonnell, Veva	Business Development Officer - 0.6 FTE	H. Wheater
Olauson, Sherry	Clerical Assistant	H. Wheater
Wilson, Katherine	Executive Assistant	H. Wheater
Zagozewski, Tim	Financial Officer	H. Wheater
Zdravkovic, Branislav	IT Administrator – Data	H. Wheater
Technical Support		
Abbasi, Soroush	Research Associate	K. Lindenschmidt
Al-mahdawe, Mohammed	Research Assistant	B. Zdravkovic
Annand, Holly	Research Assistant	J. Pomeroy
Barr, Alan	Research Technician	H. Wheater
Bauer, Jay	Research Technician	Baulch/Bedard-Haughn
Bayne, Dell	Research Technician	W. Helgason
Berry, Pamela	Research Assistant	K. Lindenschmidt
Brenna, Britni	Research Assistant	H. Baulch
Carlos, Dylan	Undergraduate Student Assistant	J. Hudson
Carriere, Michela	Undergraduate Student Assistant	T. Jardine
DeBeer, Chris	Research Associate	H. Wheater
Dobrovolskaya, Katya	Research Assistant	H. Baulch
Doig, Lorne	Research Technician	K. Liber
Dumanski, Stacey	Research Assistant	J. Pomeroy
Duncan, Angus	Research Technician	J. Pomeroy
Elliott, Carlie	Undergraduate Student Assistant	C. Westbrook
Esfahbod, Bahareh	Data Visualization Specialist	S. Razavi
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Fang, Xing Research Officer J. Pomeroy Flahr, Leanne Research Assistant T. Jardine Galagher, Lindsey Research Assistant M. Reed Gilmour, Kimberly Research Assistant H. Baulch Gooding, Raea Research Assistant H. Baulch Research Officer Guan, Juan J. Pomeroy Hosseini, Nasim Research Assistant K. Lindenschmidt Hunter, Kristine J. Hudson Lab Technician Research Associate J. McDonnell Janzen, Kimberly

Johnson, Bruce Research Technician Helgason/ Wheater/ McDonnell Kambietz. Alvse Research Assistant H. Baulch

Kambietz, AlyseResearch AssistantH. BaulchKaur, NavjotResearch AssistantH. BaulchKiss, JeremyResearch AssistantBaulch/Bedard-Haughn

Knuston, Brooke Research Assistant J. McDonnell

Kusch, JillianUndergraduate Student AssistantJ. HudsonMillar, CodyResearch AssistantJ. McDonnellMeissner, AnnaResearch AssistantJ. Hudson

Mock, Tyler Undergraduate Student Assistant J. Hudson

Mosaffa, Mahtab Research Assistant K. Lindenschmidt
Moradi, Laleh Research Assistant B. Zdravkovic
Mowat, Aiden Research Assistant C. Whitfield
Nazemi, Ali Research Associate Wheater/ Elshorbagy

North, Rebecca Research Associate H. Baulch

Penrod, Danielle Research Assistant K. Lindenschmidt
Pomedli, Michelle Undergraduate Student Assistant J. Hudson

L. Barbour Pratt, Dyan Research Assistant Prestie, Chance J. Hudson Research Assistant H. Wheater Research Assistant Princz, Dan J. McDonnell Rodriguez-Prado, Arcadio Research Associate Settee, Pierrette Research Assistant M. Reed Shook, Kevin Research Scientist J. Pomeroy

Smith, Lukas Undergraduate Student Assistant A. Bedard-Haughn Smith, Paul Undergraduate Student Assistant A. Wheater

Strickert, Graham Research Associate Wheater/ Clark

Theoret, Curtis Undergraduate Student Assistant A. Ireson

Tomchuk, Patricia Research Assistant J. Hudson

Weber, Darian Undergraduate Student Assistant K. Lindenschmidt Whitfield, Colin Research Scientist H. Wheater

Williams, Tyler Research Assistant J. Pomeroy
Wilson, Heather Research Technician Bedard-Haughn/Spence

Yassin, Fuad Research Assistant K. Lindenschmidt

Yip, Hayden Research Technician J. Hudson

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Postuocioi ai Fellows		
Alebachew Ali, Melkamu	Postdoctoral Fellow	Ireson/Ferguson/McKay
Ameli, Ali	Postdoctoral Fellow	J. McDonnell
Appels, Willemijn	Postdoctoral Fellow	J. McDonnell
Bradford, Lori	Postdoctoral Fellow	L. Bharadwaj
Chen, Liang	Postdoctoral Fellow	Y. Li
Chu, Thuan	Postdoctoral Fellow	K. Lindenschmidt
Chun, Kwok Pan	Postdoctoral Fellow	H. Wheater
Codling, Garry	Postdoctoral Fellow	J. Giesy
Conway, Jonathan	Postdoctoral Fellow	Pomeroy/Helgason
Guerrero, Jose-Luis	Postdoctoral Fellow	H. Wheater
Janzen, Daryl	Postdoctoral Fellow	Ireson/Wheater
Karoyo, Abdalla	Postdoctoral Fellow	L. Wilson
Kehoe, Michael	Postdoctoral Fellow	H. Baulch
Keim, Dawn	Postdoctoral Fellow	Ireson/Ferguson/McKay
Kinar, Nicholas	Postdoctoral Fellow	J. Pomeroy
Mahmood, Taufique	Postdoctoral Fellow	Wheater/Pomeroy
Mantyka-Pringle, Chrystal	Postdoctoral Fellow	Jardine/Bedard-Haughn/Baulch
Morales Marin, Luis	Postdoctoral Fellow	Lindenschmidt/Wheater
Musselman, Keith	Postdoctoral Fellow	J. Pomeroy
North, Rebecca	Postdoctoral Fellow	Wheater/Hudson
Orlowski, Natalie	Postdoctoral Fellow	J. McDonnell
Pan, Xicai	Postdoctoral Fellow	Ireson/ Helgason
Pedinotti, Vanessa	Postdoctoral Fellow	H. Wheater
Peng, Hui	Postdoctoral Fellow	Giesy/Jones
Pernica, Patricia	Postdoctoral Fellow	Wheater/McKay
Paule, Armelle	Postdoctoral Fellow	J. Lawrence
Razavi, Saman	Postdoctoral Fellow	Wheater/Elshorbagy
Sagin, Jay	Postdoctoral Fellow	Lindenschmidt/Wheater
Sapriza Azuri, Gonzalo	Postdoctoral Fellow	H. Wheater
Vogt, Anja	Postdoctoral Fellow	Giesy/Jones
Wong, Jeff	Postdoctoral Fellow	H. Wheater
Yetemen, Omer	Postdoctoral Fellow	Ireson/Johnstone
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## **Graduate Students**

Bam, Edward	Doctoral Student	A. Ireson
Cavaliere, Emily	Doctoral Student	H. Baulch
Chilima, Jania	Doctoral Student	L. Bharadwaj
Coles, Anna	Doctoral Student	J. McDonnell
Evaristo, Jaivime	Doctoral Student	J. McDonnell
Faizen Ahmed, Hafiz	Doctoral Student	W. Helgason
Gabrielli, Chris	Doctoral Student	J. McDonnell
Hossain, Kamrul	Doctoral Student	Wheater/Elshorbagy
Kurkute, Sopan	Doctoral Student	Y. Li

Liu, Ning	Doctoral Student	K. Lindenschmidt
Masud, Mohammed	Doctoral Student	N. Khaliq
Prabin, Rokaya	Doctoral Student	K. Lindenschmidt
Pradhananga, Dhiraj	Doctoral Student	J. Pomeroy
Sadeghian, Amir	Doctoral Student	K. Lindenschmidt
Safa, Hamideh	Doctoral Student	H. Wheater
Santosh, Apoorva	Doctoral Student	K. Lindenschmidt
Scaff, Lucia	Doctoral Student	Y. Li
Shafiei, Farshad	Doctoral Student	J. Hudson
Sheikholeslami, Seyed	Doctoral Student	S. Razavi
Terry, Julie	Doctoral Student	Lindenschmidt/Baulch
Tse, Timothy	Doctoral Student	P. Jones
Wang, Xiaoyue	Doctoral Student	A. Bedard-Haughn
Yassin, Fuad	Doctoral Student	H. Wheater
Zilefac, Asong	Doctoral Student	Wheater/Khaliq
Abirhire, Oghenemise	Masters Student	J. Hudson
Armstrong, Marie	Masters Student	C. Westbrook
Berry, Pamela	Masters Student	K. Lindenschmidt
Brannen, Rosa	Masters Student	A. Ireson
Carlson, Hayley	Masters Student	M. Fulton
Carr, Meghan	Masters Student	K. Lindenschmidt
Das, Apurba	Masters Student	K. Lindenschmidt
Dumanski, Stacey	Masters Student	J. Pomeroy
Galuschik, Noel	Masters Student	H. Baulch
Gonda, Jordan	Masters Student	Wheater/Elshorbagy
Gooding, Raea	Masters Student	H. Baulch
Hewitt, Kelsey	Masters Student	G. Ferguson
Hunter, Kristine	Masters Student	J. Hudson
Mamo, Moges	Masters Student	A. Ireson
Meissner, Anna	Masters Student	K. Lindenschmidt
Mercer, Jason	Masters Student	C. Westbrook
Peterson, Amber	Masters Student	Ireson/Helgason
Prestie, Chance	Masters Student	J. Hudson
Ross, Jamie	Masters Student	M. Fulton
Roste, Jennifer	Masters Student	Wheater/Baulch
Hosseini Safa, Hamideh	Masters Student	Wheater/Elshorbagy
Schiffer, Stephanie	Masters Student	K. Liber
Steeves, Kean	Masters Student	N. Hogan
Willness, Ross	Masters Student	K. Belcher
Wu, Hongye	Masters Student	C. Westbrook
Yip, Hayden	Masters Student	J. Hudson
Yuan, Hongda	Masters Student	P. Jones

# APPENDIX C - Students and Highly Qualified Personnel Not Funded by CERC

The following table provide information on students and highly qualified personnel not funded by the CERC program. It was determined that a total of 169 graduate students (PhD 65 and Masters 104) were funded by our members during the period 2014-15. In addition, our members supported and trained 115 highly qualified personnel, including 38 postdoctoral fellows and research associates, 15 research technicians, 6 research scientists, 28 Visiting Scholars (including 10 Distinguished Lecturers) and 38 Research Assistants, Research Engineers and Summer Students.

Glossary: MSc – Master of Science; PhD – Doctor of Philosophy; MSEM – Master in Sustainable Environmental Management; MPP – Master of Public Policy; MES – Master of Environment and Sustainability; MPH – Master of Public health; MPA – Master of Public Administration; SENS – School of Environment and Sustainability; JSGS – Johnson Shoyama Graduate School of Public Policy; SPH – School of Public Health

#### Students

Student	Supervisor/ Co- Supervisor	Degree	Department	Subject Area
Abirhire, O.	Hudson	MSc	Biology	Limnology
Agbovi, H.	Wilson	PhD	Chemistry	07
Ahmed, H.	Helgason	PhD	Biological	Snow-forest
,	5 6 7 7 7		Engineering	Interactions
Aksamit, N.	Pomeroy	PhD	Geography	Hydrology
Alam, S.	Barbour	PhD	Civil & Geo	Geoenviron.
Al-Naggar, Y.	Giesy	PhD	Toxicology	Enviro. Tox.
Al-Harbi, H.	Giesy	PhD	Toxicology	Enviro. Tox.
Al-Ibrahim, A.	Patrick	MA	Geography	Urban Water
Amadi, C.	Van Rees	PhD	Soil Sc.	Greenhouse Gas
Amos, M.	Barbour	MSc	Civil & Geolog.	Geotech. Engrg
•			Engrg.	Hydrology
Anderson, E.	Pomeroy	MSc	Geography	Hydrology
Andrews, E.	Steelman	MES	SENS	Sustainability
Armstrong, M.	Baulch/	MSc	Geography	Nutrient
C,	Westbrook		<b>.</b>	Chemistry
Bagatim, T.	Hecker	MES	SENS	Aquatic
,				Toxicology
Baijius, W.	Patrick	MA	Arts & Sc.	Watershed
				Planning
Bains, S.	Bharadwaj/	MSc	SENS	Water Policy
	Steelman			•
Baldwin, C	Bharadwaj	MES	SENS	Social Impacts
Bangsund, A.	Barbour/	MSc	Geological Sc	Hydrogeology
	Hendry		-	
Basdeo, M.	Bharadwaj	MSc	SENS	Impact of Water
				Regulation

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Bendzak, M.	Van Rees	PhD	Soil Sc.	Nutrient Cycling
Bhalkaran, S.	Wilson	MSc	Chemistry	
Bianchini, K.	Morrissey	PhD 🖊	Toxicology	Avian
				Ecotoxicology
Bissonnette, J.	Hendry	MSc	Geological Sc.	
Brown, R.L.	Bedard-Haughn	MSc	Soil Sc.	Surface drainage
				and soil properties
Buchynski, M.	Barbour	MSc	Civil & Geo. Eng.	Geochemistry
Bulla, B.	Steelman	PhD	North Carolina	Forestry and Env.
			State Univ.	
Carlson, A.	Patrick	MNGD	ICNGD	Water Palnning
Cavallaro, M.	Liber/ Morrissey	PhD	Toxicology	Aquatic
				Toxicology
J. Chilima	Bharadwaj	PhD	SENS	Community-based
				Approach
Choudhury, S.	Pickering	PhD	Geological Sc.	Confocal X-ray
				fluorescence
Conway, A.	Johnstone	PhD	Biology	Plant ecology
Cowan, B.	Patrick	MNGD	ICNGD	Northern
				Recycling
Cruz-	Lindsay	PhD	Univ. de Huelva,	Geochemistry
Hérnandez, P.			Spain	
Sandeepraja	Chang	MSc	Civil & Geo. Eng.	
Dangeti				
Danquah, M.	Wilson	MSc	Chemistry	
David, C.	Helgason	MSc	Soil Sc	Greenhouse Gas
				Emissions
Dean, S.	Barbour/	MSc	Civil & Geo. Eng.	Geochemistry
	Hendry			
Debusschere, A.	Barbour	MSc	Soil Science	Geology, statistics
Dehabadi, L.	Wilson	PhD	Chemistry	
Dhillon, G.	Van Rees	PhD	Soil Sc.	Soil Carbon
Doering, J.	Giesy/ Hecker	PhD	Toxicology	Enviro. Tox.
Dolatkhah, A.	Wilson	MSc	Chemistry	
Dompierre, K.	Barbour/	PhD	Civil & Geolog.	Environ. Engrg -
	Lindsay		Engrg.	Hydrogeol.
Dumanski, S.	Pomeroy/	MSc	Geography	Hydrology
	Westbrook			
Ekechukwu, B.	Soltan	MEng	Chemical Eng	Water Treatment
Ferdous, J.	Helgason	MSc	Biological Eng	Greenshouse Gas
		50	ביסוסטוכמו בווט	Emissions

				- 0
L. Ford	Bharadwaj	MSc	SENS	Human Health Risk Assessment
Fowlie, C.	Hendry	MSc 📗	Geological Sc.	NISK ASSESSITION
Frey, R.	Hendry	MSc	Geological Sc.	
Galik, B.	Steelman	PhD	North Carolina	Forestry and Env.
Gairk, D.	Steeman	THE	State Univ.	rorestry and Env.
Garez, H.	Morrissey	MSEM	SENS	Sustainability Sc
Gibb, N.	Chang	MSc	Civil & Geo	Bioremediation
Goulet, F.	Patrick	MNGD	ICNGD	Diamond Mining
Grant, K.	Patrick	MA	Geography	Source Water
C. G. 1. 5, 1. 1.				Protection
Green, D.	Janz	MSc	Toxicology	Ecoepidemiology
Greuel. R.	Johnstone	MSc	Biology	Plant Ecology
Guenther, G.	Bharadwaj	MSc	Toxicology	Endocrine
				Disrupters
Hanson, S.	Hecker	MSc	Toxicology	Aquatic
				Toxicology
Harder, P.	Pomeroy	PhD	Geography	Hydrology
Harley, R.	Barbour	PhD	Q. U.Belfast	Slope Stability
			(N.Ireland)	
Harris, N.	Chang/ McBeth	MSc	Civil & Geo	Bioremediation
Head, K.	Hudson	MSc	Biology	Limnology
Henkel-Johnson,	Johnstone	PhD	Biology	Plant ecology
D.				
Hermann, K.	Hendry	MSc	Geological Sc.	
Hewitt, K.	Ferguson	MSc	Civil & Geo	Hydrogeology
Horachek, M.	Johnstone/ Laroque	MSc	Biology	Plant ecology
Hossain, A.	Hendry	MSc	Geological Sc.	
Hossain, Md K.	Elshorbagy	PhD	Civil & Geo	Flood Modeling
Hunter, K.	Hudson	MSc	Biology	Limnology
Huynh, M.	Bharadwaj	PhD	Community	Public Health
			Health and	Risks
			Epidemiology	
James, A.	Pickering	PhD	Toxicology	Organomercury in
				zebrafish
Jean, M.	Johnstone	PhD	Biology	Plant ecology
Jeirani, Z.	Soltan	PhD	Chemical Eng	Catalytic
				Ozonation
Johansson, J.	Hudson	MSc	Biology	Limnology
Johnson, M.	Barbour	MSc	Soil Science	Soil Physics
Karran, D.	Westbrook	PhD	Geography	
Klemmer, S.	Ferguson	MSc	Civil & Geo	Rock Mechanics

Koehler, B. Barbour/ Ferguson Engrg.  Kolawole, I. Elshorbagy PGD Civil & Geo Modeling Kong, D. Wilson MSc Chemistry Konkoon, R. Ferguson PhD Civil & Geo Geological Kowsari, M. Soltan MSc Chemical Eng Emerging Pollutants Krogh, S. Pomeroy PhD Geography Hydrology Kuleza, S. Johnstone MSc Biology Plant ecology Kuzyk, T. Barbour/ MSc Civil & Geo. Eng. Leroux, N. Pomeroy PhD Geography Hydrology Leroux, N. Pomeroy PhD Geography Hydrology Li, S. Pickering PhD Biology Selenium in fungus Lieu, A. Hendry PhD Geological Sc. Liu, G. Noble MA Geography Hydrology Ly, Z. Pomeroy PhD Geography Hydrology Lynch, K. Barbour PhD Q. U.Belfast Geotech. Engrg MacDonald, M. Pomeroy PhD Geography Hydrology Madaeni, F. Barbour PhD Civil & Geo. Eng. Mafar, M. Bharadwaj PhD SENS Inter-culturality Mahaminia, M. Wilson MSc Chemistry Mahaminia, M. Wilson MSc Chemistry Main, A. Morrissey MSc SENS Dendrochronology Marleau, N. Laroque MSc SENS Dendrochronology Marsh, C. Pomeroy/ PhD Geography Hydrology Massé, A. Janz MSc Geography Hydrology Maulel, V. Steelman MES SENS Sustainability Msc Geography Hydrology Msc Geography Hydrology Msc Geography Hydrology Msc SENS Sustainability Msc Geography Hydrology Msc Geography Hydrology Msc Geography Hydrology Msc SENS Sustainability Msc Geography Hydrology Msc		_ 7		C CONTRACTOR	are a land
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Kong, D.Wilson Konkoon, R.MScChemistry Civil & Geo GeologicalKowsari, M.SoltanMScChemical Eng Emerging PollutantsKrogh, S.Pomeroy Kuleza, S.Johnstone Johnstone HendryMScGeography GeochemistryHydrology Hydrology Plant ecology Plant ecology Planting Planting Planting Planting Planting Potable waterK. McLaughlin Mercer, J.Westbrook PlantingMScGeography Planting Potable water		Ferguson		Engrg.	
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Kuleza, S. Kuzyk, T. Barbour/ Hendry  Labarrere, C. Morrissey  PhD  Toxicology  Avian Ecotoxicology  Leroux, N. Pomeroy Li, S. Pickering  PhD  Biology  Phydrology  Selenium in fungus  Lieu, A. Hendry  Liu, G. Noble MA  Geography Hydrology  Liu, G. Noble MA  Geography Hydrology  Liu, Q. Lindsay MSc Geological Sc.  Geochemistry  Hydrology  Liu, Q. Lindsay MSc Geological Sc. Geochemistry  Hydrology  Lynch, K. Barbour PhD  Geography Hydrology  Lynch, K. Barbour PhD  Geography Madaeni, F. Barbour PhD  Geography Mahaninia, M. Wilson MSc MSc Chemistry  Mahanood, N. Barbour/ PhD  Geological Sc. Geochemistry  Hydrology  Hydrology  Civil & Geo. Eng. Geo. Enviro. Eng. Inter-culturality  Mahaninia, M. Wilson MSc Chemistry  Mahanood, N. Barbour/ PhD  Geological Sc Geochemistry  Mahaninia, M. Wilson MSc Chemistry  Mahanood, N. Barbour/ Hendry  Main, A. Morrissey MSEM SENS  Ecotoxicology  Mallet, J. Laroque MSc SENS  Dendrochronology  Mallet, J. Laroque MSc SENS  Dendrochronology  Malleau, N. Laroque MSc SENS  Dendrochronology  Marsh, C. Pomeroy/ Wheater  Massé, A. Janz  MSc Toxicology  Aquatic Toxicology  Mauel, V. Steelman MES SENS  Sustainability Trucking of Planning Potable water  Mercer, J. Westbrook MSc Geography  MSc Geography  MSc Geography  MSc Geography  Potable water					Pollutants
Kuzyk, T.  Barbour/ Hendry  Labarrere, C.  Morrissey  PhD  Toxicology  Avian Ecotoxicology  Leroux, N.  Pomeroy  PhD  Geography  Hydrology  Liy, S.  Pickering  PhD  Geological Sc.  Liu, G.  Liu, G.  Liu, Q.  Lindsay  Liu, Z.  Pomeroy  PhD  Geography  Hydroelectric  Liu, Q.  Lindsay  MSc  Geological Sc.  Geochemistry  Hydrology  Lynch, K.  Barbour  PhD  Geography  Hydrology  Lynch, K.  Barbour  PhD  Geography  Hydrology  Lynch, K.  Barbour  PhD  Geography  Madaeni, F.  Barbour  PhD  Geography  Mafar, M.  Bharadwaj  PhD  SENS  Inter-culturality  Mahaninia, M.  Wilson  MSc  Chemistry  Mahmood, N.  Barbour/  PhD  Geological Sc  Geochemistry  Hendry  Mahmood, N.  Barbour/  Mahmood, N.  Barbour/  Mahmood, N.  Barbour/  Mahmood, N.  Barbour/  PhD  Geological Sc  Geochemistry  Geo. Enviro. Eng.  Inter-culturality  Mahaninia, M.  Wilson  MSc  Chemistry  Mahmood, N.  Barbour/  PhD  Geological Sc  Geochemistry  Mahmood, N.  Barbour/  PhD  Geological Sc  Geochemistry  Mahmood, N.  Barbour/  PhD  Geological Sc  Geochemistry  Mahmood, N.  Barbour/  PhD  Geological Sc  Dendrochronology  Mallet, J.  Laroque  MSc  SENS  Dendrochronology  Malleau, N.  Laroque  MSc  SENS  Dendrochronology  Marleau, N.  Laroque  MSc  SENS  Dendrochronology  Marleau, N.  Laroque  MSc  SENS  Dendrochronology  Marleau, N.  Marleau, N.  Laroque  MSc  SENS  Dendrochronology  Marsh, C.  Pomeroy/  PhD  Geography  Hydrology  Wheater  Massé, A.  Janz  MSc  Toxicology  Aquatic  Toxicology  Mauel, V.  Steelman  MES  SENS  Sustainability  Trucking of  Planning  Potable water  Mercer, J.	_	Pomeroy	PhD	Geography	Hydrology
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Leroux, N. Pomeroy PhD Geography Hydrology Li, S. Pickering PhD Biology Selenium in fungus Lieu, A. Hendry PhD Geological Sc. Liu, G. Noble MA Geography Hydroelectric Liu, Q. Lindsay MSc Geological Sc. Geochemistry Lv, Z. Pomeroy PhD Geography Hydrology  Lynch, K. Barbour PhD Geography Hydrology  Lynch, K. Barbour PhD Geography Hydrology  MacDonald, M. Pomeroy PhD Geography Hydrology  Madaeni, F. Barbour PhD Civil & Geo. Eng. Mafar, M. Bharadwaj PhD SENS Inter-culturality  Mahaninia, M. Wilson MSc Chemistry  Mahmood, N. Barbour/ PhD Geological Sc Geochemistry  Main, A. Morrissey MSEM SENS Ecotoxicology  Maillet, J. Laroque MSc SENS Dendrochronology  Malleau, N. Laroque MSc SENS Dendrochronology  Marleau, N. Laroque MSc SENS Dendrochronology  Marleau, N. Laroque MSc SENS Dendrochronology  Marsh, C. Pomeroy/ PhD Geography Hydrology  Marsh, C. Pomeroy/ PhD Geography Hydrology  Mauel, V. Steelman MES SENS Sustainability  K. McLaughlin Bharadwaj MSc Geography  MSC Geography  Mercer, J. Westbrook MSc Geography  Mercer, J. Westbrook MSc Geography		Hendry			
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Li, S. Pickering PhD Biology Selenium in fungus  Lieu, A. Hendry PhD Geological Sc.  Liu, G. Noble MA Geography Hydroelectric  Liu, Q. Lindsay MSc Geological Sc.  Lv, Z. Pomeroy PhD Geography Hydrology  Lynch, K. Barbour PhD Q. U.Belfast Geotech. Engrg (N.Ireland)  MacDonald, M. Pomeroy PhD Geography Hydrology  Madaeni, F. Barbour PhD Civil & Geo. Eng. Geo. Enviro. Eng.  Mafar, M. Bharadwaj PhD SENS Inter-culturality  Mahaninia, M. Wilson MSc Chemistry  Mahanmood, N. Barbour/ PhD Geological Sc Geochemistry  Hendry  Main, A. Morrissey MSEM SENS Ecotoxicology  Maillet, J. Laroque MSc SENS Dendrochronology  Maloney, E. Morrissey MSC Toxicology Aquatic  Ecotoxicology  Marleau, N. Laroque MSc SENS Dendrochronology  Marsh, C. Pomeroy/ PhD Geography Hydrology  Massé, A. Janz MSc Toxicology Aquatic  Ecotoxicology  Mauel, V. Steelman MES SENS Sustainability  K. McLaughlin Bharadwaj MSc Geography and Trucking of Potable water  Mercer, J. Westbrook MSc Geography  Mercer, J. Westbrook MSc Geography					<b>-</b> .
Lieu, A. Hendry PhD Geological Sc. Liu, G. Noble MA Geography Hydroelectric Liu, Q. Lindsay MSc Geological Sc. Ly, Z. Pomeroy PhD Geography Hydrology  Lynch, K. Barbour PhD Geography Hydrology  Lynch, K. Barbour PhD Geography Hydrology  MacDonald, M. Pomeroy PhD Geography Hydrology  Madaeni, F. Barbour PhD Civil & Geo. Eng. Mafar, M. Bharadwaj PhD SENS Inter-culturality  Mahaninia, M. Wilson MSc Chemistry  Mahmood, N. Barbour/ PhD Geological Sc Geochemistry  Main, A. Morrissey MSEM SENS Ecotoxicology  Maillet, J. Laroque MSc SENS Dendrochronology  Maloney, E. Morrissey MSC Toxicology Aquatic Ecotoxicology  Marleau, N. Laroque MSc SENS Dendrochronology  Marsh, C. Pomeroy/ PhD Geography Hydrology  Massé, A. Janz MSc SENS Dendrochronology  Mauel, V. Steelman MES SENS Sustainability  K. McLaughlin Bharadwaj MSc Geography		•		•	
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Liu, Q. Li, Z. Pomeroy PhD Geography Hydrology  Lynch, K. Barbour PhD Q. U.Belfast (N.Ireland) MacDonald, M. Pomeroy PhD Geography Hydrology  Madaeni, F. Barbour PhD Geography Mafar, M. Bharadwaj PhD SENS Inter-culturality Mahaninia, M. Wilson MSc Chemistry Mahmood, N. Barbour/ PhD Geological Sc Geochemistry  Maillet, J. Laroque MSc MSc MSc SENS SENS Dendrochronology Marleau, N. Laroque MSc Marleau, N. Laroque MSc Marleau, N. Laroque MSc Marsh, C. Pomeroy/ Wheater  Massé, A. Janz MSC MSC Geography MSC Toxicology Aquatic Toxicology Aquatic Toxicology Mauel, V. K. McLaughlin Bharadwaj MSc Geography MSc Geography MSc Geography Trucking of Potable water  Mercer, J. Westbrook MSc Geography  MSC MSC Geography	•	•		_	
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Lynch, K.  Barbour  PhD  Q. U.Belfast (N.Ireland)  MacDonald, M. Pomeroy PhD Geography Madaeni, F. Barbour PhD Civil & Geo. Eng. Geo. Enviro. Eng. Inter-culturality  Mahaninia, M. Wilson MSc Chemistry Mahmood, N. Barbour/ Hendry Main, A. Morrissey MSEM SENS Geochemistry  Maillet, J. Laroque MSc MSc SENS Dendrochronology Maloney, E. Morrissey MSC Marleau, N. Laroque MSc SENS Dendrochronology Marsh, C. Pomeroy/ Wheater  Massé, A. Janz MSc Toxicology Macl, V. K. McLaughlin Bharadwaj MSc Geography MSc Geography MSc Geography PhD Geography Aquatic Toxicology Aquatic Toxicology Aquatic Toxicology Aquatic Toxicology Aquatic Toxicology Aquatic Toxicology Marleau, N. Baradwaj MSC Geography Aquatic Toxicology Aquatic Toxicology Marleau, V. K. McLaughlin Bharadwaj MSc Geography and Planning Potable water  Mercer, J. Westbrook MSc Geography		•		_	•
MacDonald, M. Pomeroy PhD Geography Hydrology Madaeni, F. Barbour PhD Civil & Geo. Eng. Geo. Enviro. Eng. Mafar, M. Bharadwaj PhD SENS Inter-culturality Mahaninia, M. Wilson MSc Chemistry Mahmood, N. Barbour/ PhD Geological Sc Geochemistry Hendry Main, A. Morrissey MSEM SENS Ecotoxicology Maillet, J. Laroque MSc SENS Dendrochronology Maloney, E. Morrissey MSc Toxicology Aquatic Ecotoxicology Marleau, N. Laroque MSc SENS Dendrochronology Marsh, C. Pomeroy/ PhD Geography Hydrology Wheater  Massé, A. Janz MSc Toxicology Aquatic Toxicology Mauel, V. Steelman MES SENS Sustainability K. McLaughlin Bharadwaj MSc Geography	Lv, Z.	Pomeroy	PhD	Geography	Hydrology
MacDonald, M.PomeroyPhDGeographyHydrologyMadaeni, F.BarbourPhDCivil & Geo. Eng.Geo. Enviro. Eng.Mafar, M.BharadwajPhDSENSInter-culturalityMahaninia, M.WilsonMSCChemistryMahmood, N.Barbour/ PhDGeological ScGeochemistryMain, A.MorrisseyMSEMSENSEcotoxicologyMaillet, J.LaroqueMScSENSDendrochronologyMaloney, E.MorrisseyMScToxicologyAquatic EcotoxicologyMarleau, N.LaroqueMScSENSDendrochronologyMarsh, C.Pomeroy/ WheaterPhDGeographyHydrologyMassé, A.JanzMScToxicologyAquatic ToxicologyMauel, V.SteelmanMESSENSSustainabilityK. McLaughlinBharadwajMScGeography and PlanningTrucking of Potable waterMercer, J.WestbrookMScGeography	Lynch, K.	Barbour	PhD	Q. U.Belfast	Geotech. Engrg
Madaeni, F.BarbourPhDCivil & Geo. Eng.Geo. Enviro. Eng.Mafar, M.BharadwajPhDSENSInter-culturalityMahaninia, M.WilsonMScChemistryMahmood, N.Barbour/ HendryPhDGeological ScGeochemistryMain, A.MorrisseyMSEMSENSEcotoxicologyMaillet, J.LaroqueMScSENSDendrochronologyMaloney, E.MorrisseyMScToxicologyAquatic EcotoxicologyMarleau, N.LaroqueMScSENSDendrochronologyMarsh, C.Pomeroy/ WheaterPhDGeographyHydrologyMassé, A.JanzMScToxicologyAquatic ToxicologyMauel, V.SteelmanMESSENSSustainabilityK. McLaughlinBharadwajMScGeography and PlanningTrucking of Potable waterMercer, J.WestbrookMScGeography				(N.Ireland)	
Mafar, M.BharadwajPhDSENSInter-culturalityMahaninia, M.WilsonMScChemistryMahmood, N.Barbour/ HendryPhDGeological ScGeochemistryMain, A.MorrisseyMSEMSENSEcotoxicologyMaillet, J.LaroqueMScSENSDendrochronologyMaloney, E.MorrisseyMScToxicologyAquatic EcotoxicologyMarleau, N.LaroqueMScSENSDendrochronologyMarsh, C.Pomeroy/ WheaterPhDGeographyHydrologyMassé, A.JanzMScToxicologyAquatic ToxicologyMauel, V.SteelmanMESSENSSustainabilityK. McLaughlinBharadwajMScGeography and PlanningTrucking of Potable waterMercer, J.WestbrookMScGeography	MacDonald, M.	Pomeroy	PhD	Geography	Hydrology
Mahaninia, M.WilsonMScChemistryMahmood, N.Barbour/ HendryPhDGeological ScGeochemistryMain, A.MorrisseyMSEMSENSEcotoxicologyMaillet, J.LaroqueMScSENSDendrochronologyMaloney, E.MorrisseyMScToxicologyAquatic EcotoxicologyMarleau, N.LaroqueMScSENSDendrochronologyMarsh, C.Pomeroy/ WheaterPhDGeographyHydrologyMassé, A.JanzMScToxicologyAquatic ToxicologyMauel, V.SteelmanMESSENSSustainabilityK. McLaughlinBharadwajMScGeography and PlanningTrucking of Potable waterMercer, J.WestbrookMScGeography	Madaeni, F.	Barbour	PhD	Civil & Geo. Eng.	Geo. Enviro. Eng.
Mahmood, N.Barbour/ HendryPhDGeological ScGeochemistryMain, A.MorrisseyMSEMSENSEcotoxicologyMaillet, J.LaroqueMScSENSDendrochronologyMaloney, E.MorrisseyMScToxicologyAquatic EcotoxicologyMarleau, N.LaroqueMScSENSDendrochronologyMarsh, C.Pomeroy/ WheaterPhDGeographyHydrologyMassé, A.JanzMScToxicologyAquatic ToxicologyMauel, V.SteelmanMESSENSSustainabilityK. McLaughlinBharadwajMScGeography and PlanningTrucking of Potable waterMercer, J.WestbrookMScGeography	Mafar, M.	Bharadwaj	PhD	SENS	Inter-culturality
Main, A.MorrisseyMSEMSENSEcotoxicologyMaillet, J.LaroqueMScSENSDendrochronologyMaloney, E.MorrisseyMScToxicologyAquatic EcotoxicologyMarleau, N.LaroqueMScSENSDendrochronologyMarsh, C.Pomeroy/ WheaterPhDGeographyHydrologyMassé, A.JanzMScToxicologyAquatic ToxicologyMauel, V.SteelmanMESSENSSustainabilityK. McLaughlinBharadwajMScGeography and PlanningTrucking of Potable waterMercer, J.WestbrookMScGeography	Mahaninia, M.	Wilson	MSc	Chemistry	
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Maillet, J.  Maloney, E.  Morrissey  MSc  Toxicology  Aquatic Ecotoxicology  Marleau, N.  Laroque  MSc  SENS  Dendrochronology  Aquatic Ecotoxicology  Dendrochronology  Marsh, C.  Pomeroy/ Wheater  MSc  Toxicology  Aquatic Toxicology  Aquatic Toxicology  Mauel, V.  Steelman  MES  SENS  Sustainability  K. McLaughlin  Bharadwaj  MSc  Geography  MSc  Geography  Planning  Potable water  Mercer, J.  Westbrook  MSc  Geography		Hendry			
Maloney, E. Morrissey MSc Toxicology Aquatic Ecotoxicology  Marleau, N. Laroque MSc SENS Dendrochronology  Marsh, C. Pomeroy/ PhD Geography Hydrology  Wheater  Massé, A. Janz MSc Toxicology Aquatic Toxicology  Mauel, V. Steelman MES SENS Sustainability  K. McLaughlin Bharadwaj MSc Geography and Planning Potable water  Mercer, J. Westbrook MSc Geography	Main, A.	Morrissey	MSEM	SENS	Ecotoxicology
Marleau, N. Laroque MSc SENS Dendrochronology Marsh, C. Pomeroy/ PhD Geography Hydrology Wheater  Massé, A. Janz MSc Toxicology Aquatic Toxicology Mauel, V. Steelman MES SENS Sustainability K. McLaughlin Bharadwaj MSc Geography and Planning Potable water  Mercer, J. Westbrook MSc Geography	Maillet, J.	Laroque	MSc	SENS	Dendrochronology
Marleau, N. Laroque MSc SENS Dendrochronology Marsh, C. Pomeroy/ PhD Geography Hydrology Wheater  Massé, A. Janz MSc Toxicology Aquatic Toxicology Mauel, V. Steelman MES SENS Sustainability K. McLaughlin Bharadwaj MSc Geography and Planning Potable water  Mercer, J. Westbrook MSc Geography	Maloney, E.	Morrissey	MSc	Toxicology	Aquatic
Marsh, C.  Pomeroy/ Wheater  Massé, A.  Janz MSc Toxicology Aquatic Toxicology  Mauel, V.  K. McLaughlin Bharadwaj MSc Geography and Planning Potable water  Mercer, J.  Westbrook MSc Geography Geography Hydrology  Aquatic Toxicology  Toxicology  Aquatic Toxicology  Toxicology  Planning Fotable water  Geography					~ .
Wheater  Massé, A.  Janz MSc Toxicology Aquatic Toxicology  Mauel, V.  K. McLaughlin Bharadwaj MSc Geography and Planning Potable water  Mercer, J.  Westbrook MSc Geography	Marleau, N.	Laroque	MSc	SENS	Dendrochronology
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Mauel, V. Steelman MES SENS Sustainability K. McLaughlin Bharadwaj MSc Geography and Trucking of Planning Potable water  Mercer, J. Westbrook MSc Geography		Wheater			
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K. McLaughlin Bharadwaj MSc Geography and Trucking of Planning Potable water  Mercer, J. Westbrook MSc Geography					Toxicology
Planning Potable water  Mercer, J. Westbrook MSc Geography	Mauel, V.	Steelman	MES	SENS	•
Mercer, J. Westbrook MSc Geography	K. McLaughlin	Bharadwaj	MSc		-
,				-	Potable water
Michelson C Morrissey MSc Riology Fcotoxicology					
ivincherson, c. iviornssey ivisc biology Ecoloxicology	Michelson, C.	Morrissey	MSc	Biology	Ecotoxicology

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Mihalicz, J.	Jardine/ Baulch	MES	SENS	Aquatic
				Toxicology
Moate, A.	Hecker	MSc	Toxicology	Emerging
				Contaminants
Morandi, G.	Giesy	MSc	Toxicology	Enviro. Tox.
Morrison, A.	Noble/	PhD	Geography	Flood Risk
	Westbrrok			
Muldoon, B.	Hogan	MSc	Toxicology	Aquatic
				Toxicology
Myers, D.	Laroque	MSc	Geography	Dendrochronology
Nehzati, S.	Pickering	MSc	Geological Sc.	Mercury custom
				chelators
Nelson, F.	Hendry	MSc	Geological Sc.	
Norbury, V.	Morrissey	MSc	Biology	Ecotoxicology
Novak, K.	Van Rees	MSc	Soil Sc.	Soil Physics
Patterson, S.	Hecker	MSc	Toxicology	Aquatic
				Toxicology
Penrod, D.	Ferguson/	MSc	Geological Sc.	Hydrogeology
	Lindsay			
Peterson, A.	Helgason	MSc	Civil & Geo Eng	Soil Moisture
Pettem, C.	Janz	MSc	Toxicology	Zebrafish
Ponomarenko,	Pickering	MSc	Geological Sc	Gallium and
Υ.				Arsenic
Pradhananga, D.	Pomeroy	PhD	Geography	Hydrology
Prestie, C.	Hudson	MSc	Biology	Limnology
Rapoliti, M	Morrissey	MSEM	SENS	Sustainability Sc
Rasouli, R.	Pomeroy	PhD	Geography	Hydrology
Richardson, K.	Patrick	MSEM	SENS	<b>Urban Biodiversity</b>
Robertson, J.	Hendry	MSc	Geological Sc.	
Roste, J.	Pomeroy	MSc	Geography	Hydrology
Sadeghi, A.	Soltan	MSc	Chemical Eng	Water Treatment
Sangha, A.	Bharadwaj	MES	SENS	Land use
Saunders, D.	Giesy	PhD	Toxicology	Enviro. Tox.
Schabert, M.	Barbour/	MSc	Geological	Geochemistry
	Hendry		Sciences	
Schenn, W.	Jardine/ Janz	PhD	SENS	Aquatic
	•			Toxicology
Schmelling, E.	Barbour/	MSc	Geological	Hydrogeology
	Hendry		Sciences	
Schultz, D.	Hecker/ Janz	MSc	Toxicology	Aquatic
•	•		<i>5,</i>	Toxicology
Shacklock, K.	Hendry	MSc	Geological Sc.	3,
Shafiei, F.	, Hudson	PhD	Biology	Limnology
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Shahadu, H.	Reed/ Steelman	PhD	SENS	Policy innovation
				and wildfire
Shahariar, S.	Bedard-Haughn	PhD 🖊	Soil Sc.	Land-use
				management
Shekh, K.	Hecker	PhD	Toxicology	Aquatic
				Toxicology
Shenoy, A.	Johnstone	PhD	Biology (Alaska)	Plant ecology
Siemens, A.	Chang	MSc	Civil & Geo	Bioremediation
Siemens, E.	Pomeroy	MSc	Geography	Hydrology
Sizo, A.	Noble	PhD	Geography	Urban wetland
Smith, L.	Barbour/	PhD	Geological	Geochemistry
	hendry		Sciences	
Sooriyaarachchi,	Pickering	PhD	Chemistry,	Platinum-based
M.			Calgary	anti-cancer drugs
Stanton, R.	Morrissey	MSc	Biology	Ecotoxicology
Steele, C.	Ferguson	MSc	Civil & Geo	Hydrogeology
Steeves, J.	Barbour/	MSc	Civil & Geo	Hydrogeology
	Ferguson		Engrg.	
Stone, J.	Barbour	MEng	Civil & Geo. Eng.	Geo. Tech. Eng.
Sumaila, S.	Hendry	MSc	Geological Sc.	
Summers, K.	Pickering	PhD	Chemistry	Copper in health
				and disease
Szmigielski, J.	Barbour/	MSc	Geological	Geochemistry
	Hendry		Sciences	
Tallon, L.	Barbour	PhD	SENS	Soil Sci Geo-
				enviro. Engrg.
Tipman, J.	Barbour	MSc	Civil & Geo. Eng.	Geo. Enviro. Eng.
Turcjemek, J.	Hendry	MSc	Geological Sc.	
Udoetok, I.A.	Wilson	PhD	Chemistry	
Ufondu, L.	Ferguson	PhD	Civil & Geo	Geological
Vardy, D.	Giesy/ Hecker	PhD	Toxicology	Enviro. Tox.
Walker, X.	Johnstone	PhD	Biology	Plant ecology
Wallace, B.M.	Bedard-Haughn	PhD	Soil Sc.	Winter Nitrogen
				Losses
Wang, X.	Bedard-Haughn	PhD	Soil Sc.	Mountain
				peatland
Wu, H.	Westbrook	MSc	Geography	
Xue, C.	Wilson	PhD	Chemistry	
Yip, H.	Hudson	MSc	Biology	Limnology
Young, K.	Patrick	MSEM	SENS	Water Planning
Younis, S.	Pickering	PhD	Chemistry	Arsenic sorption
7	Haakan	NATC	CENC	materials
Zee, J.	Hecker	MES	SENS	Aquatic
				Toxicology

## **Highly Qualified Personnel**

Glossary: Postdoctoral Fellow – PDF; Visiting Scholar – VS; Research Engineer – RE; Research Assistant – RA; Research Associate – RAsso; Research Technician – RT; Summer Student – SS; Research Scientist – RS

Research	Supervisor	Position	Department	Subject Area
Personnel				
Agnew, R.	Barbour	RA	Civil & Geo	Geo-Enviro
Ahlert, H.	Hecker	PhD – VS	RWTH Aachen	Aquatic
			Univ Germany	Toxicology
Alimezeli, A.	Bharadwaj/	PDF	SPH	First Nations
	Waldner			
Amos, M.	Barbour	RE	Civil & Geo	Geo-Enviro
Ang, E.N.	Hecker	MESPOM	Central	Endocrine
			European Univ	Disruptors
Annand, H.	Pomeroy	RA	Geography	
Apples, W.	McDonnell/	PDF	SENS	Overland flow
	Barbour/			
	Hendry			
Baer, T.	Hendry	RA	Geological Sc	
Bader, A.	Johnstone	RA	Biology	Ecology
Beria, H.	Li	UG – VS	GIWS	Hydroclimatology
Bews, B.	Barbour/	RE	Civil & Geo	Geo-Enviro
	Hendry			
Biswas, A.	Hendry	PDF	Geological Sc	
Bourke, S.	Hendry	PDF	Geological Sc	
Brown, T.	Pomeroy	RT	Geography	
Bradford, L.	Bharadwaj	PDF	SPH	Water for Health
Braun, H.	Pomeroy	VS	Geography	
Buchynski, M.	Hendry	RA	Geological Sc	
Cai, M.	Giesy	VS	Toxicology	Enviro. Tox.
Carlos, D.	Hudson	RT	Biology	Limnology
Carroll, A.	Westbrook	RA	Geography	
Chen, C.	Giesy	VS – Nanchang	Toxicology	Enviro. Tox.
		Univ		
Chen, G.	Hendry	PDF	Geological Sc	
Chen, J.	Hendry	RA	Geological Sc	
Chostner, V.	Barbour/	RA	Civil & Geo. Eng.	Geo-Enviro.
	Hendry			
Chowdhury, S.	Barbour	PDF	Civil & Geo	Num. Modeling
Chuhaniuk, S.	Barbour	RE	Civil & Geo	Geo-Enviro
Cilia, C.	Lindsay	USRA	Geological Sc.	Geochemistry
Clark, M.	Morrissey	SS	Biology	Ecotoxicology
Closs, A.	Hudson	RT	Biology	Limnology
Codling, G.	Giesy	RAsso	Toxicology	Enviro. Tox.

Congram, M. Morrissey SS Biology Conway, J. Pomeroy PDF Geography Cowell, M. Lindsay USRA Geological Sc. Geochemistry Cotelesage, J. Pickering PDF Geological Sc. Biomolecule Structure  Das, S. Hendry RAsso Geological Sc. Demuth, M. Pomeroy VS NRCan Coblesage, J. Pickering RASSO Geological Sc. Demuth, M. Pomeroy VS NRCan Civil & Geo Geo-Enviro  K. Dolgova, N. Pickering RASSO Geological Sc. Selenium in Zebrafish  Duncan, A. Pomeroy RT Geography Eisner, B. Hecker SS Toxicology Aquatic Toxicology  Elliott, C. Westbrook RA Geography Esselfie-Dughan, J. Essery, R. Pomeroy VS Univ. Edinburgh Fan, J. Hendry RASSO Geological Sc Fang, X. Pomeroy RT Geography Faucher, I. Hendry RA Geological Sc Fahr, J. Morrissey RA Biology Ecotoxicology Flahr, L. Morrissey RA Biology Ecotoxicology Gomez, M. Hendry RASSO Geological Sc Gonzales, A. Razavi VS Univ. Tlaxcala Gonzales, A. Razavi VS Univ. Tlaxcala Guan, X.J. Pomeroy RT Geography Guenther, D. Pomeroy VS Geological Sc Firmthy Achen, Aquatic Geography Helnder, D. Hendry PDF Geological Sc Geological Sc Geological Sc Geological Sc Geological Sc Geological Sc Firmthy Achen, Aquatic Geography Helnder, D. Hendry PDF Geological Sc Geological Sc Univ. Huang, M. Hendry RASSO Geological Sc Hunter, K. Hudson RT Biology Limnology Helmer, K. Hudson RT Biology Limnology Janzen, D. Pomeroy PDF Geography  Firmthy Mater and Health Health		- A There		C COLOR	276-0
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Helmle, R. Westbrook RA Geography Hilscherova, K. Giesy VS – Masaryk Toxicology Enviro. Tox. Univ. Hong, S. Giesy VS – Korean Toxicology Enviro. Tox. Univ. Huang, M. Hendry RAsso Geological Sc Hunter, K. Hudson RT Biology Limnology Idowu, B. Bharadwaj RA SPH Water and Health	Halder, D.	Hendry	PDF	Geological Sc	
Helmle, R. Westbrook RA Geography Hilscherova, K. Giesy VS – Masaryk Toxicology Enviro. Tox. Univ. Hong, S. Giesy VS – Korean Toxicology Enviro. Tox. Univ. Huang, M. Hendry RAsso Geological Sc Hunter, K. Hudson RT Biology Limnology Idowu, B. Bharadwaj RA SPH Water and Health	Heide, T.	Hecker	VS	RWTH Aachen,	•
Hilscherova, K. Giesy  VS – Masaryk Univ.  Hong, S. Giesy  VS – Korean Univ.  Huang, M. Hendry RAsso Hunter, K. Hudson Idowu, B. Bharadwaj  RA  VS – Masaryk Toxicology Enviro. Tox.  Geological Sc Biology Limnology Water and Health				Germany	Toxicology
Hong, S.  Giesy  VS – Korean Univ.  Huang, M. Hendry RAsso Geological Sc Hunter, K. Hudson RT Biology Limnology Idowu, B. Bharadwaj RA SPH Water and Health	Helmle, R.	Westbrook	RA	Geography	
Hong, S.  Giesy  VS – Korean  Univ.  Huang, M.  Hendry  RAsso  Geological Sc  Hunter, K.  Hudson  RT  Biology  Limnology  Idowu, B.  Bharadwaj  RA  SPH  Water and  Health	Hilscherova, K.	Giesy	VS – Masaryk	Toxicology	Enviro. Tox.
Univ.  Huang, M. Hendry RAsso Geological Sc  Hunter, K. Hudson RT Biology Limnology Idowu, B. Bharadwaj RA SPH Water and Health			Univ.		
Huang, M. Hendry RAsso Geological Sc Hunter, K. Hudson RT Biology Limnology Idowu, B. Bharadwaj RA SPH Water and Health	Hong, S.	Giesy	VS – Korean	Toxicology	Enviro. Tox.
Hunter, K. Hudson RT Biology Limnology Idowu, B. Bharadwaj RA SPH Water and Health			Univ.		
Idowu, B. Bharadwaj RA SPH Water and Health	Huang, M.	Hendry	RAsso	Geological Sc	
Health	Hunter, K.	Hudson	RT	Biology	Limnology
	Idowu, B.	Bharadwaj	RA	SPH	Water and
Janzen, D. Pomeroy PDF Geography					Health
	Janzen, D.	Pomeroy	PDF	Geography	

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Javaid, H.	Lindenschmidt	VS	GIWS	Hydrological
				Modelling
Karoyo, A.H.	Wilson	PDF 🖖	Chemistry	
Kinar, N.	Pomeroy	PDF	Geography	
Kusch, J.	Hudson	RT	Biology	Limnology
Kulpa, K.	Barbour/	RA	Civil & Geo	Geo-Enviro
	Hendry			
Lefrancois, B.	Chang	RE	Civil & Geo	Bioremediation
Levesque, K.	Johnstone	RA	Biology	Ecology
Lin, J.	Hendry	RAsso	Geological Sc	
Liu, H.	Giesy	VS – Nanjing	Toxicology	Enviro. Tox.
		Univ.		
Lu, M.	Barbour/		Civil & Geo. Eng.	Geo-Enviro.
	Hendry	RA		
Mahmood, T.	Pomeroy	PDF	Geography	
Mamet, S.	Johnstone	PDF	Biology	Ecology
Mankidy, R.	Giesy	RS	Toxicology	Enviro. Tox.
Marks, D.	Pomeroy	VS	USDA	Ag. Research
McPhee, L.	Hogan	PDF	Toxicology	Aquatic
				Toxicology
McKay, E.	Bharadwaj	RAsso	Fort Resolution	SWEEP Project
			<ul><li>First Nation</li></ul>	
Michel, N.	Morrissey	PDF	Toxicology	<b>Avian Population</b>
	•			Ecology
Mingbin, H.	Barbour	RS	Civil & Geo	Geo-Enviro
Mock, T.	Hudson	RA	Biology	Limnology
Mohamed, M.H.	Wilson	RAsso	Chemistry	
Musselman, K.	Pomeroy	PDF	Geography	
Nelson, F.	Hendry	RA	Geological Sc	
Nuesser	Hecker	RA	RWTH Aachen	Toxicogenomic
			Univ Germany	J
Okpalauwaekwe,		RA	MPH	First Nations
U.				
Olver, D.	Johnstone	RA	Biology	Ecology
Paul, B.	Chang	PDF	Civil & Geo	Bioremediation
Peng, H.	Giesy	PDF	Toxicology	Enviro. Tox.
Plante, A.	Morrissey	RA	Biology	Ecotoxicology
Polkraka, K.	Morrissey	USRA	Biology	Ecotoxicology
Pomedli, M.	Hudson	RT	Biology	Limnology
Pomonarenko,	Pickering	RAsso	Geological	Metals in Biology
O. ,	G		Sciences	0,
Pratt, D.	Barbour/	RE	Civil & Geo. Eng.	Geo-Enviro.
•	Hendry		. 3	
Samuel, J.	Pomeroy	VS	Geography	
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Sarauer, B.	Giesy	RT	Toxicology	Enviro. Tox.
Schmeling, E.	Hendry	RA	Geological Sc	
Schmidt, K.	Morrissey	SS	Biology	Ecotoxicology
Shook, K.	Pomeroy	RS	Geography	
Singh, K.	Johnstone	PDF	Biology	Ecology
Singh, S.	Hendry/ Pickering	RAsso	Geological Sc	
	r renermb			
St. Yves, A.	Geisy	RT	Toxicology	Enviro. Tox.
Sun, J.	Giesy	PDF	Toxicology	Enviro. Tox.
Tang, S.	Hecker	PDF	Toxicology	Aquatic
				Toxicology
Tissier, E.	Johnstone	RT	Biology	Ecology
Tomchuk, P.	Hudson	RT	Biology	Limnology
Truchon-Savard,	Johnstone	RT	Biology	Ecology
A.				
Vessey, C.	Lindsay	USRA	Geological Sc.	Geochemistry
Villeneuve, S.	Barbour	RS	Civil & Geo	Geo-Enviro
Vogt, A.	Giesy	PDF	Toxicology	Enviro. Tox.
Whitfield, P.	Pomeroy	RS	Geography	
Wiseman, S.	Giesy	RS	Toxicology	Enviro. Tox.
Yang, S.I.	Pickering	PDF	Geological	Selenium in the
			Sciences	environment
Yip, H.	Hudson	RT	Biology	Limnology
Zdrodowski, F.	Hecker	VS	RWTH Aachen,	Aquatic
			Germany	Toxicology
Zhang, K.	Giesy	VS – Univ of	Toxicology	Enviro. Tox.
		Alberta		

### APPENDIX D - GRANTS 2014-2015

Following table shows ongoing and new grants received by members of GIWS during the period of 2014-15. The seven core GIWS faculty and members have secured funding of \$2,655,221 and \$19,408,877, respectively, which is in addition to the base operating funding of \$30 million from CERC program. To avoid double counting of total grant value, we have listed amounts in *Italics* that were either previously reported or are co-led by investigators.

Baulch, Helen	
<i>\$56,330</i>	Regional Application of the MAGIC Model & Uncertainty Framework for
	the Final Implementation of the Acid Deposition Management
	Framework, Cumulative Environmental Management Association
\$9,286	Dynamic Modelling of Lake and Soil Response to Acidic Depositions in
	Saskatchewan, Ministry of Environment, Government of Saskatchewan
\$30,245	Critical Loads of Nitrogen and Sulphur for Soils of Northern Saskatchewan,
	Ministry of Environment, Government of Saskatchewan
\$347,259	Monitoring and assessment of beneficial management practices: insight
	from the Tobacco Creek Watershed, Canadian Water Network (Co-I: H.
	Wheater and J. Pomeroy)
\$880,000	Undertaking lake metabolism and algal blooms: New tools for the
	management of potable water sources, Natural Sciences and Engineering
	Research Council (NSERC) Strategic Project Grant (Co-I: J.P. Giesy, R.
	Leavitt, P. Jones, K. Liber, K-E. Lindenschmidt)
\$130,000	Biogeochemistry of lakes in winter and the implications of declining ice
	cover, NSERC Discovery Grant
\$411,158	Identifying flood- and food-related limits to fish and wildlife production in
	the Saskatchewan River Delta, NSERC Collaborative Research and
	Development Grant – SaskPower (PI: T. Jardine)

Bedard-Haughn	, Angela
\$80,755	Nutrient Dynamics in Drained Agricultural Soils and Drainage Ditches, Saskatchewan Ministry of Agriculture – Agriculture Development Fund
\$190,000	Hydric Soils of the Prairie Pothole Region, NSERC Discovery grant
\$125,077	Lake Winnipeg Basin Stewardship Fund (LWBSF), Environment Canada
Barbour, Lee	
\$4,000	Oil Sands & Teck Research - Laboratory Testing, UofS, USRA Grant for summer salary support of Anna Campbell (Co-PI: J. Hendry)
\$259,071	Characterization of controls on mass loading to an oil sands End Pit Lake, Syncrude Canada Ltd., (Co-I: M. Lindsay)
\$85,731	An evaluation of the controls on salt release from oil sands reclamation covers, Syncrude Canada Ltd., (Co-Is: J. McDonnell, A. Ireson)
\$21,000	IPS Scholarship for Terryn Kuzyk: Spatial Variability in Geochemistry and Water Flow Pathways - Water and Physical Characterization", NSERC

	Industrial Post-Graduate Scholarship, Total = \$21,000: \$15,000/NSERC, \$6,000/TECK Coal Ltd.) (Co-I: J. Hendry)
404 000	
\$21,000	IPS Scholarship for Marcie Schabert: Geochemistry and Se Attenuation in
	Saturated Waste Rock at Teck's Fording River Operations", NSERC
	Industrial Post-Graduate Scholarship, (Total = \$21,000: \$15,000/NSERC,
	\$6,000/TECK Coal Ltd.) (Co-I: J. Hendry)
\$1,735,695	UofS Research Proposal for Teck Coal's Applied Research and
71,733,033	·
	Development Program on Selenium and Watersheds - Y2-4", TECK Coal Ltd. (Co-I: J. Hendry)
\$21,000	IPS Scholarship for Jakub Szmigielski: Field Scale Characterization of
7-7-7	Saturated Zone Geochemistry at a Teck's West Line Creek (Natural Site)",
	•
	NSERC Industrial Post-Graduate Scholarship, (Total = \$21,000:
	\$15,000/NSERC, \$6,000/TECK Coal Ltd.) (Co-I: J. Hendry)
<i>\$73,050</i>	Convective Air Flow - Potential Impact on Covers and Waste Geochemistry
	<ul> <li>Coke Beach Instrumented Watershed", Syncrude Canada Ltd.</li> </ul>
\$130,000	Multiscale soil water and temperature monitoring and stochastic
	simulation in semiarid farmlands", Chinese National Natural Science
	Foundation, \$130,000 (PI: Bing Si)
\$1,298,392	Evaluation and Modeling of Soil Water Dynamics to Determine Land
71,230,332	Capability of Coarse Textured Hydrocarbon Affected Reclamation Soils -
	·
	Aurora Capping Study", CONRAD (sponsors: Shell Canada Energy, CNRL,
	IORL, Suncor, Syncrude, TEPCA), Industry Contract (PI: Bing Si)
\$1,305,800	Hydrogeological Characterization of Oil Sands Mine Closure Landforms",
	NSERC Industrial Research Chair - Syncrude Canada Ltd portion
\$1,305,800	Hydrogeological Characterization of Oil Sands Mine Closure Landforms",
	NSERC Industrial Research Chair - NSERC portion
\$135,000	Large scale mine cover monitoring and mine cover design for cold
. ,	regions", NSERC, Discovery Grant
\$122,305	An evaluation of the controls on salt release from oil sands reclamation
7-1-7000	covers, Syncrude – NSERC Collaborative Research and Development Grant
	(Co-ls: A. Ireson, J. McDonnell)
Ć1 045 000	,
\$1,845,000	Mine Overlay Site Testing (MOST) Facility, Western Economic
	Diversification (Co-PI: J. McDonnell, J. Hendry, A. Ireson)
\$1,650,000	Water Security – Collaborative Research and Training Experience
	(CREATE) Program, NSERC CREATE Grant (PI: C. Westbrook; Co-I: H.
	Baulch, H. Wheater, J. Pomeroy, J. McDonnell, P. Gober, B. Noble, K.
	Belcher, A. Bedard-Haughn)
\$449,408	Characterization of controls on mass loading to an oil sands End Pit Lake,
. ,	Syncrude – NSERC Collaborative Research and Development Grant (Co-I:
	M. Lindsay)
\$151,819	Development of a Local Meteoric Water Line (LMWL) and a Stable Isotope
\$101,012	·
64.C E.C.	of Water Catalogue for the Aurora North Mine Site", Syncrude Canada Ltd.
\$16,562	Demo Pond Sample Analyses (Lab testing)", SCL/BGC Engineering Inc.
\$5,000	Seasonally Frozen Capillary Barrier, O'Kane Consultants Inc.

Bharadwaj, Lalita	
\$48,948	Beyond Physical, Impacts of Water Resource management in Saskatchewan First Nations Communities, SSHRC, WEPGN Partnership grant
	SWEEP – The Slave Watershed Environmental Effects Program, Canadian water Network, total \$500,000 (Co-Is: Lindenschmidt, K., P.D. Jones, T. Jardine, and Doig, L.)
\$199,882	Delta Dialogue Network, SSHRC Partnership Development Grant (PI: Steelman, T.; Co-Is: Fresque-Baxter, J.A., McLachlan, S.M., Jardine, T., Bradford, L.E.A., Jones, P.D., Lindenschmidt, KE., Poelzer, G.M., Reed, M.G., and Strickert, G.E.H.)
\$117,715	Geospatial models and isotope tracers to identify key fish and animal habitats along the Slave River, NWT Cumulative Impact Monitoring Program (Co-Is: Doing, L., Lindenschmidt, K., Jones, P., and Doig, L.)
\$300,000	Water Security for Rural Saskatchewan, Saskatchewan Health Research Foundation (Co-PI: C. Waldner)
Chang, Won Jae	
\$115,000	Remediation in Challenging Environments: A New Approach for Accelerating Bioremediation in Cold Climates, NSERC Discovery Grant
\$99,245	Microbial Assessment and Bioremediation Feasibility for Petroleum Hydrocarbon Contaminated Soils, Husky Oil Operations - NSERC-CRD Grant
\$365,000	Development of Functionalized Clay-Based Reactive Media for Removal of Cationic Salts from Brine Effluent, International Minerals Innovation Institute (Agrium, Mosaic, and PotashCorp), IMII-Mitacs Accelerate Cluster Grant
\$25,000	Characterization of Manganese-Oxidizing Bacterial Populations in a Biofiltration Unit in a Water Treatment Plant in Saskatchewan: Delco Water – NSERC Engage Grant
\$25,000	Lime-Based Stabilization of Residual Petroleum Hydrocarbons in Contaminated Soils after Biodegradation, Graymont – NSERC Engage Grant
\$208,897	Geoenvironmental Engineering Laboratory for Contaminated Site Remediation Research, Canada Foundation for Innovation
Doig, Lorne	
\$117,715	Geospatial models and isotope tracers to identify key fish and animal habitats along the Slave River, NWT Cumulative Impact Monitoring Program (Co-Is: Doing, L., Lindenschmidt, K., Jones, P., and Bharadwaj, L.)
\$500,000	SWEEP – The Slave Watershed Environmental Effects Program, Canadian water Network (Co-ls: Lindenschmidt, K., P.D. Jones, T. Jardine, and Bharadwaj, L.)

Elshorbagy, Amin	
\$280,000	Co-Leader Theme 4 - Canadian FloodNet, NSERC Strategic Network Grant
\$105,000	Sustainability-oriented Water Resources Allocation, Management, and
	Planning, NSERC Discovery Grant
Ferguson, Grant	
\$100,000	Exploring Data Needs for Geothermal Energy Development, NSERC
	Discovery Grant
<i>\$865,735</i>	Probabilistic Risk Assessment of Groundwater Flow and Contaminant
	Transport, Slyvia Fedoruk Canadian Centre for Nuclear Innovation and
	Atomic Energy of Canada Limited (Co-I: A. Ireson, M. Lindsay)
\$525,000	Hydrogeological Research for Saskatchewan's Potash Industry,
	International Minerals Innovation Institute (Co-I: M. Lindsay, B. Eglington,
	C. Hawkes, J. Hendry)
Giesy, John	
\$87,861	Study on marine environmental physiology and toxicology, Chinese
	Ministry of Education
<i>\$429,253</i>	Great Lakes Restoration Initiative, Toxic Substances and Areas of Concern,
	Program: I-A-6 Great Lakes Sediment Core Surveillance Program, US EPA
\$200,000	Novel Natural and Synthetic Brominated Compounds in the Environment,
	NSERC Discovery
\$2,000,000	Saskatchewan River Basin: a large-scale observatory for new
	interdisciplinary water science, Canada Foundation for Innovation (PI: H.
	Wheater, Co-I: J. Pomeroy)
\$202,496	Aquatic Impact Assessment of Municipal Effluents (AIME), Canadian
	Water Network (Co-Is: M. Hecker, P. Jones, K. Liber, S. Wiseman)
\$961,000	Analytical Toxicology Base in Support of Economic Development, Western
4	Economic Diversification (PI: K. Liber; Co-I: P.D. Jones, M. Hecker)
\$880,000	Undertaking lake metabolism and algal blooms: New tools for the
	management of potable water sources, Natural Sciences and Engineering
	Research Council (NSERC) Strategic Project Grant (PI: H. Baulch; Co-I: R.
6272 202	Leavitt, P. Jones, K. Liber, K-E. Lindenschmidt)
\$272,382	CREATE Training Program in Human and Ecological Risk Assessment
¢265.275	(HERA), NSERC (Co-I: S.D. Siciliano, L. Bharadwaj)
\$265,375	The Base Mine Lake Toxicity Identification and Evaluation Study;
	Advancing knowledge for water reclamation and return, Syncrude Canada
	Limited and NSERC Collaborative Research and Development grant, total
Ć142.480	funding of \$1,061,500
\$142,180	Marine Biogeochemistry and Ecotoxicology Program of Introducing
	Talents of Discipline to Universities, Ministry of Education and the State
	Administration of Foreign Experts, China to State Key Lab of Marine
	Environmental Science, Xiamen University, total funding \$710,900

\$75,545	Toxico-genomic Assessment of Emerging Environmental Pollutants Using
\$73,545	Novel Functional Genomic and High Throughput Technologies, European
	Commission, Directorate for Innovation and Research, Directorate I
	Environment, total funding \$453,270 (Co-PI: X. Zhang)
\$16,439	A comparative Assessment of the Potential Impacts of Harmful Algal
	Blooms on Aquatic Birds from Lake Taihu, China, and Brazos River Lakes in
	Central Texas, USA, Texas A&M University-NSFC joint research program
	and National Science Foundation of China, total funding \$32,878 (Co-Is:
	M. Mora, X. Zhang)
\$1,999,566	Facility for Applied Avian Research, Canada Foundation for Innovation (PI:
	C. Morressey, Co-I: K. Machin)
\$491,180	Emission, Diffusion and Environmental Effects of Emerging Pollutants
	from Rapid Urbanization, National Science Foundation of China (Co-I: X.
	Zhang)
\$444,998	Assessing the Adverse Effects of Emerging Chemical Contaminants on
T	Fishes of Commercial, Aboriginal and Recreational value to Canadians (Co-
	I: M. Hecker, P. Jones, S. Wiseman)
	i. ivi. ricekci, i . Jones, J. vviscinarij

Hecker, Markus	
\$575,000	Predictive Aquatic Ecotoxicology, Canada Research Chair Program
\$402,261	Predictive Aquatic Eco-Toxicology Facility, CFI Infrastructure Grant for Canada Research Chairs
\$200,000	Predictive Aquatic Ecotoxicology, Provincial Support for Canada Research Chair Program
\$75,000	Predictive Aquatic Eco-Toxicology Facility, Institutional Support for Canada Research Chair Program
\$36,203	Predictive Aquatic Eco-Toxicology Facility, CFI Institutional Operation Fund
\$444,998	Assessing the Adverse Effects of Emerging Chemical Contaminants on Fishes of Commercial, Aboriginal and Recreational Value to Canadians (AECCO), Fisheries and Oceans Canada
\$299,140	Safe Water for Health Research Team (SWHRT), Saskatchewan Health Research Foundation (PI: L. Bharadwaj and others)
\$202,496	Aquatic impact assessment of municipal effluents, Canadian Water Networks
\$200,000	Functional Transcriptomics of Native Canadian Fish Species; NSERC Discovery
\$961,000	Analytical Toxicology Base in Support of Economic Development, Western Economic Diversification (PI: K. Liber; Co-I: J.P. Giesy, P.D. Jones)
\$402,261	Predictive Aquatic Ecotoxicology Facility; CFI and matching CRC portion
\$444,998	Assessing the Adverse Effects of Emerging Chemical Contaminants on Fishes of Commercial, Aboriginal and Recreational value to Canadians (Co-I: M. hecker, P. Jones, S. Wiseman)

Helgason, Warren	
\$988,149	Improved water and nutrient use efficiency to maximize the net
di	greenhouse gas balance in irrigated production systems, Agriculture and Agri-Food Canada (Co-I: R. Farrell)
\$51,500	Feasibility study of an 'off-grid' sprinkler irrigation system, Saskatchewan Ministry of Agriculture - Agriculture Development Fund
Decade Per	
Hendry, Jim	
\$525,000	Hydrogeological Research for Saskatchewan's Potash Industry, International Minerals Innovation Institute (Co-I: G. Ferguson, M. Lindsay, B. Eglington, C. Hawkes)
\$1,735,695	UofS Research Proposal for Teck Coal's Applied Research and Development Program on Selenium and Watersheds - Y2-4", TECK Coal Ltd. (Co-I: J. Hendry)
\$150,000	Towards Environmentally Responsible Resource Extraction (TERRE), NSERC CREATE Program, \$1,650,000 (PI: D.W. Blowes; Co-I: 9 Co-Applicants, 20 Collaborators)
\$1,113,725	Cameco Industry Research Chair in Environmental and Aqueous Geochemistry, \$222,745 per year for 5 years
\$1,189,500	NSERC Industry Research Chair in Environmental and Aqueous Geochemistry, \$237,900 per year for 5 years
\$90,000	Saskatchewan Potash Producers Grant
\$26,000	Canadian Water Network, National Centre of Excellence Grant
Hogan, Natacha	
\$202,496	Aquatic impact assessment of municipal effluents, Canadian Water Networks (PI: M. Hecker; Co-I: J. Giesy, S. Wiseman, C. Somers, A. Hontella)
\$903,925	Fate and toxicity of lubricating oils across Canadian ecoprovinces, TransCanada Corp – NSERC Collaborative Research and Development Grant (PI: S. Siciliano; Co-I: E. Farrell)
Hudson, Jeff	
\$894,418	Lake Diefenbaker water quality assessment, Saskatchewan water Security Agency
\$4,000	University Undergraduate Student Research Assistantships Grant
\$4,500	Summer Undergraduate Research Internship Award
\$13,328	CFI infrastructure operating fund
Ireson, Andrew	
\$85,731	An evaluation of the controls on salt release from oil sands reclamation covers, Syncrude Canada Ltd. (Co-Is: J. McDonnell, L. Barbour)
\$17,500	NSERC PGSM Scholarship for Rosa Brannen, NSERC

\$110,000	Groundwater-surface water interactions in the prairies, NSERC Discovery Grant
\$393,795	Causes and health impacts of saline intrusion into drinking water ponds in Bangladesh, Leverhulme Trust, England
\$865,735	Probabilistic Risk Assessment of Groundwater Flow and Contaminant Transport, Slyvia Fedoruk Canadian Centre for Nuclear Innovation and Atomic Energy of Canada Limited (Co-I: G. Ferguson, M. Lindsay)
\$122,305	An evaluation of the controls on salt release from oil sands reclamation covers, Syncrude – NSERC Collaborative Research and Development Grant (Co-Is: J. McDonnell, L. Barbour)
Janz, David	
\$60,000	Development of Selenium Thresholds in Amphibians Exposed to Selenomethionine, Stantec Consulting Ltd.
\$210,000	Cellular Mechanisms and Ecophysiological Consequences of Selenium Toxicity in Fish, NSERC, Discovery Grant
\$411,158	Identifying flood- and food-related limits to fish and wildlife production in the Saskatchewan River delta, NSERC Collabroative Research and Development Grant – SaskPower (PI: T. Jardine; Co-I: H. Baulch, and K. Hobson)
\$35,000	Bioaccumulation and biological effects of PBDEs and priority emerging flame retardants in two marine mammal species from the St. Lawrence Estuary, Fishries and Oceans Canada, total grant \$292,100 (Co-Is: Houde, M., Lesage, V., Michaud, R., Zbinden, D.)
Jardine, Tim	
\$411,158	Identifying flood- and food-related limits to fish and wildlife production in the Saskatchewan River delta, NSERC Collabroative Research and Development Grant – SaskPower (Co-I: H. Baulch, K. Hobson, D. Janz )
\$135,000	Ecological benefits and toxicological consequences of flooding in river ecosystems, NSERC Discovery Grant
\$500,000	SWEEP – The Slave Watershed Environmental Effects Program, Canadian water Network (Co-Is: Lindenschmidt, K., P.D. Jones, Bharadwaj, L., and Doig, L.)
\$117,715	Geospatial models and isotope tracers to identify key fish and animal habitats along the Slave River, NWT Cumulative Impact Monitoring Program (Co-Is: Lindenschmidt, K., Jones, P.D., Bharadwaj, L., and Doig, L.)
\$199,882	Delta Dialogue Network, SSHRC Partnership Development Grant (PI: Steelman, T.; Co-Is: Fresque-Baxter, J.A., McLachlan, S.M., Bharadwaj, L.A., Bradford, L.E.A., Jones, P.D., Lindenschmidt, KE., Poelzer, G.M., Reed,

M.G., and Strickert, G.E.H.)

Li, Yanping	
\$15,000	Using Elqui Valley basin as an example to assess the water resources vulnerability of the Andes Western Slope under climate change background, Canada-Latin America and the Caribbean research exchange grants program (LACREG)
\$24,500	Pseudo-global warming (PGW) technique to examine projected changes of extreme rainstorms over Western Canada in a warmed climate, Environment Canada
\$3,891	Study of the convective storms on U.S. Great Plains through PECAN (Plains Elevated Convection at Night) field campaign, National Center for Atmospheric Research (NCAR), United States of America
Liber, Karsten	
\$38,400	Analysis of river otter (Lontra canadensis) livers and kidneys from Northern Saskatchewan for metals and trace elements via ICP-MS. Saskatchewan Ministry of Environment
\$961,000	Analytical Toxicology Base in Support of Economic Development, Western Economic Diversification (Co-I: J.P. Giesy, P.D. Jones, M. Hecker)
\$35,000	Quantifying and modeling the bioavailability and toxicity of sediment- associated uranium to the freshwater midge Chironomus dilutus. AREVA Resources Canada Ltd.
\$232,000	Neonicotinoid insecticide toxicity to aquatic organisms: Addressing key knowledge gaps on toxicity thresholds, mixtures and mitigation strategies using buffer zones. Dept of Fisheries and Oceans, National Contaminants Advisory Group (Co-I: K. Liber)
\$880,000	Undertaking lake metabolism and algal blooms: New tools for the management of potable water sources, Natural Sciences and Engineering Research Council (NSERC) Strategic Project Grant (PI: H. Baulch; Co-I: P. Giesy, R. Leavitt, P. Jones, K-E. Lindenschmidt)
\$160,000	Assessment of metal contamination of rivers Shanxi Province, P.R. China, associated risk to environmental and human health, and recommendation of options for environmental restoration. 100 Talents Program, Shanxi Province, P.R. China
Lindenschmidt,	Karl-Eric
\$117,715	Geospatial models and isotope tracers to identify key fish and animal habitats along the Slave River, NWT Cumulative Impact Monitoring Program. (Co-Is: Jardine, T., Jones, P., Bharadwaj, L., and Doig, L.)
\$35,000	Developing a Geospatial Model of Qu'Appelle River System to Distinguish Fish & Macroinvertebrate Habitat, Saskatchewan Fish and Wildlife

Development Fund

\$880,000	Undertaking lake metabolism and algal blooms: New tools for the
	management of potable water sources, NSERC Strategic Project Grant (PI:
	H. Baulch)
\$500,000	SWEEP – The Slave Watershed Environmental Effects Program, Canadian
	water Network (Co-Is: P.D. Jones, T. Jardine, Bharadwaj, L., and Doig, L.)
\$199,882	Delta Dialogue Network, SSHRC Partnership Development Grant (PI:
	Steelman, T.; Co-Is: Fresque-Baxter, J.A., McLachlan, S.M., Bharadwaj, L.A.,
	Bradford, L.E.A., Jardine, T., P.D. Jones, Poelzer, G.M., Reed, M.G., and
	Strickert, G.E.H.)
\$90,000	Water Ecosystems Monitoring using Earth Observation, C-Core, Funded by
	Canadian Space Agency WEMEO
\$25,000	Incorporating dynamic ice jam modelling into flood risk assessment and
	mapping, NSERC Engage grant with Stantec, Calgary and Edmonton Offices.

Lindsay, Matt	
\$140,000	Biogeochemical and Mineralogical Processes in Redox Dynamic Groundwater Systems, NSERC Discovery Grant
\$694,136	Mine Closure Geochemistry, Associate Industrial Research Chair, NSERC Industrial Research Chairs Program
\$694,136	Mine Closure Geochemistry, Associate Industrial Research Chair, Syncrude Canada Ltd., Industry Contribution
\$37,043	Portable Gas Chromatography to Support Biogeochemical Investigations of Closure Technologies for Oil Sands Mines, CFI - John R. Evans Leaders Fund
\$33,000	Towards Environmentally Responsible Resource Extraction (TERRE), NSERC CREATE Program, \$1,650,000 (2% available to M. Lindsay) (PI: D.W. Blowes; Co-I: 9 Co-Applicants, 20 Collaborators)
\$865,735	Probabilistic Risk Assessment of Groundwater Flow and Contaminant Transport, Slyvia Fedoruk Canadian Centre for Nuclear Innovation and Atomic Energy of Canada Limited (Co-I: G. Ferguson, A. Ireson)
\$525,000	Hydrogeological Research for Saskatchewan's Potash Industry, International Minerals Innovation Institute (Co-I: G. Ferguson, B. Eglington, C. Hawkes, J. Hendry)
\$259,071	Characterization of controls on mass loading to an oil sands End Pit Lake, Syncrude Canada Ltd., (Co-I: M. Lindsay)
\$8,335	Portable Gas Chromatography to Support Biogeochemical Investigations of Closure Technologies for Oil Sands Mines, CFI - John R. Evans Leaders Operating Fund

McDonnell, Jeffrey	
\$150,000	Impacts of biofuel production in forested watersheds, US Dept. of Energy
\$425,000	How do watersheds store and release water? NSERC Discover Grant
\$120,000	How do watersheds store and release water? NSERC Accelerator Award
\$108,300	Hydrological impacts of biofuel production. US Dept of Energy

\$208,512	Eucalyptus plantation impacts on catchment water balance, US Dept. of
	Energy
\$143,855	Sustainable Water Use and Bioenergy: Application of Isotopic Tracers
	techniques to Improve Methods for Estimating Water Use in Intensively
	Managed Woody Crop Systems, Su-contract, University of Georgia, USA
\$50,000	Canada-Brazil Awards – Examining the Impacts of Land-use Change on
	Water Quantity and Quality in Headwater Cathments, Department of
	Foreign Affairs, Trade and Development Canada
\$85,731	An evaluation of the controls on salt release from oil sands reclamation
	covers, Syncrude Canada Ltd (Co-Is: A. Ireson, L. Barbour)
\$1,290,000	Water sustainability in the Willamette basin, Oregon, National Science
	Foundation Hydrological Science Grant
\$1,846,000	The Mine Overlay Site Testing (MOST) Facility, Western Economic
	Diversification
	Co-Investigatore on Vegetation effects on water flow in high-latitute
	ecosystem, European Research Council, Euro 1.4 Million

Morrissey, Christy		
\$1,999,566	Facility for Applied Avian Research, Canada Foundation for Innovation (Co-	
	I: J.P. Giesy, K. Machin)	
\$232,000	Neonicotinoid insecticide toxicity to aquatic organisms: Addressing key	
	knowledge gaps on toxicity thresholds, mixtures and mitigation strategies	
	using buffer zones. Dept of Fisheries and Oceans, National Contaminants	
	Advisory Group (Co-I: K. Liber)	
\$320,000	Distribution and Impact of Neonicotinoid Insecticides on Prairie Wetlands	
	and Waterbirds, NSERC Strategic Project Grant (Co-I: K. Liber)	
\$140,000	Effect of endocrine disrupting chemicals on avian life cycles, NSERC	
	Discovery Grant	
\$20,000	Pesticide impacts on bird migration, Molson Foundation	
\$20,000	Threats to shorebird migration, Environment Canada Grant	
\$10,000	Impacts of Run-of-River Hydropower on American Dippers and the River	
	Food Webs of Southern British Columbia, Environment Canada contract	
\$12,000	Environment Canada Science Horizons internship	

Pickering, Ingrid	
\$188,752	The molecular basis of mercury toxicity, Canadian Institutes of Health Research (CIHR) and Saskatchewan Health Research Foundation (SHRF) - Regional Partnership Program (RPP) Operating Grant (Co-I: G. N. George, M. Korbas)
\$425,000	Canada Research Chair Operational Support, University of Saskatchewan (OVPR, College, Department)
\$250,000	Support for Canada Research Chair, Province of Saskatchewan Spectroscopic Speciation of Selenium in the Environment, NSERC Discovery Grant, \$250,000

\$112,000	Selenium Fortified Table Salt to Treat Arsenic Poisoning in Bangladesh, Grand Challenges Canada – Stars of Global Health, Round 7, Stage 1 (Co-
	I: G. George)
\$488,832	Laboratory Equipment to Complement Synchrotron-based Studies of Heavier Elements in Biological and Environmental Samples, Canada Foundation for Innovation (CFI), Leaders Opportunity Fund (Canada Research Chairs)
\$3,000	Seeing the Light, Saskatchewan Health Research Foundation (SHRF) Research Connections Grant
\$250,000	Spectroscopic Speciation of Selenium in the Environment, Natural Sciences and Engineering Research Council (NSERC) Discovery Grant
Pomeroy, John	
\$100,000	Marmot Creek Watershed Study, Government of Alberta
\$350,000	Snow Hydrology, Discovery Grant, NSERC
\$142,484	Snowmelt Observation System, Research Tools and Instruments Grant, NSERC
\$65,033	South Tobacco Creek, Canadian Water Network Grant
\$1,400,000	Canada Research Chair in Water Resources and Climate Change
\$11,935	Canada Research Chair Operating Grant
\$350,000	Highly Qualified Personnel, Canada Research Chair
\$140,065	Canada Research Chair Research Grant
\$2,000,000	Saskatchewan River Basin: a large-scale observatory for new interdisciplinary water science, CFI (Co-I: J. Giesy, J. Pomeroy)
\$60,000	Alberta Environment and Sustainable Resource Development
\$100,527	Canada Foundation for Innovation – Infrastructure Operating Fund
Soltan, Jafar	
\$25,000	Treatment of membrane concentrate by advanced oxidation processes for blending with permeate water, NSERC Engage Grant
\$254,207	Analytical Infrastructure for the Catalytic Ozonation Laboratory, John R. Evans Leaders Fund, Canada Foundation for Innovation CFI
\$2,000	Treatment of reject water, USRA Program
Steelman, Toddi	
\$199,882	Delta Dialogue Network, SSHRC Partnership Development Grant (Co-Is: Fresque-Baxter, J.A., McLachlan, S.M., Bharadwaj, L.A., Bradford, L.E.A., Jardine, T., Jones, P.D., Lindenschmidt, KE., Poelzer, G.M., Reed, M.G., and Strickert, G.E.H.)
\$350,716	A Pre/Post Disaster Investigation of the Effect of Network Capacities on Disaster Response, National Science Foundation Award, United States of America. (Co-I: B. Nowell)

\$364,344	Relational Risk Assessment and Management: Investigating Local Capacity in Wildfire Response Networks, Joint Fire Science Award/US Department of
	the Interior. (Co-I: B. Nowell)
\$73,428	Northern Governance Innovation and Development for Socially Resilient Boreal Communities, SSHRC Insight Development Grant (PI: R. Bullock; Co-I: K. Coates, G. Broad)
\$6,984	The Next Generation of Delta Stewards, President's SSHRC Fund, University of Saskatchewan.
Strickert, Graha	m
\$199,882	Delta Dialogue Network, SSHRC Partnership Development Grant (PI: Steelman, T.; Co-Is: Fresque-Baxter, J.A., McLachlan, S.M., Bharadwaj, L.A., Bradford, L.E.A., Jardine, T., Jones, P.D., Lindenschmidt, KE., Poelzer, G.M., and Reed, M.G.)
\$239,525	The Human Dimensions of Permafrost Thaw. College and Community Social Innovation Fund, Partnership Development Grant, Social Science and Humanities Research Council of Canada (Co-Is: Bell, S., Clark, D., Calmels, F., Collins, C., Jinnear, L.)
Van Rees, Ken	
\$1,555,610	Shelterbelts as an Agroforestry Management Practice for the Mitigation of GHGs, AAFC Agriculture Greenhouse Gas Program, 5 years (Co-I: S. Kulshreshtha, J. Piwowar, C. Laroque)
\$165,000	Root dynamics and plasticity of boreal species on reclaimed saline-sodic overburdens and naturally saline sites, NSERC Discovery Grant, 5 years
\$1,375,000	FORWARD III: Modeling to contribute to cumulative effects management in the Canadian Boreal forest, NSERC CRD
Westbrook, Cher	io
\$1,650,000	Water Security – Collaborative Research and Training Experience (CREATE) Program, NSERC CREATE Grant (Co-I: H. Baulch, L. Barbour, H. Wheater, J. Pomeroy, J. McDonnell, P. Gober, B. Noble, K. Belcher, A. Bedard-Haughn)
Wheater, Howa	rd
\$528,772	Water Cycle Prediction in Western and Northern Canada, Environment Canada
\$2,850	Water Knowledge Application Network (WatKAN), Canadian Water Network
\$30,000,000	Canada Excellence Research Chair in Water Security: Sustainable freshwater resources and environmental change, Government of Canada, Government of Saskatchewan and University of Saskatchewan

\$5,000,000	Chaging Cold Regions network, Climate Change and Atmospheric Research, NSERC (36 Canadian Scientists and 15 International
	Collaborators),
\$2,000,000	Saskatchewan River Basin: a large-scale observatory for new interdisciplinary water science, CFI (Co-I: J. Giesy, J. Pomeroy)
\$1,059,806	Hydrological extremes and feedback in the changing water cycle, Natural Environment research Council, UK
\$475,000	Water Sciences research in Western Canada, Environment Canada
\$30,000	Saskatchewan River Basin: A Large-scale Observatory Videos, Curriculum Innovation Fund, Gwenna Moss Centre for Teaching Effectiveness, University of Saskatchewan
\$34,000	Water Security – Environmental Impact and Modelling, Curriculum Innovation Fund, Gwenna Moss Centre for Teaching Effectiveness, University of Saskatchewan
\$240,000	Saskatchewan River Basin: a large-scale observatory for new interdisciplinary water science, CFI Infrastructure Operating Fund (Co-I: J. Giesy, J. Pomeroy)
Wilson, Lee	
\$112,000	Modular Biomaterial Technology for Water Security & Health in Developing Nations, Grand Challenges Canada (GCC) Stars in Global Health Round 7 Phase I (Co-I: M.H. Mohamed)
\$200,000	Value added carbohydrate-based materials for the separation of biofuel mixtures, Saskatchewan Government - Agriculture Development Fund (Co-I: C.H. Niu)
\$109,000	Development of biomass flocculants for water and wastewater treatment, Saskatchewan Government - Agriculture Development Fund
\$12,000	Polysaccharide Materials for the Removal of Fertilizer Effluent in Surface
	Water Environments, Environment Canada Horizon Internship Program (Co-I: J.V. Headley)
\$12,000	

## **APPENDIX E – Publications, Conference Proceedings and Presentations**

#### **Journal Publications - 2015**

- Abirhire, O., North, R., Hunter, K., Vandergucht, D., Sereda, J., and Hudson, J. 2015. Environmental factors influencing phytoplankton communities in Lake Diefenbaker, Saskatchewan, Canada. Journal of Great Lakes Research, http://dx.doi.org/10.1016/j.iglr.2015.07.002.
- Ahmed, H., and Helgason, W. 2015. Reliability model for designing solar powered center pivot irrigation systems. Transactions of the ASABE, 58(4): 947-958, DOI:10.13031/trans.58.10930.
- Akomeah, E., Chun, K.P., and Lindenschmidt, K-E. 2015. Dynamic water quality modelling and uncertainty analysis of phytoplankton and nutrient cycles for the upper South Saskatchewan River. Environmental Science and Pollution Research (accepted).
- Al Naggar, Y., Codling, G., Vogt, A., Naiem, E., Mona, M., Seif, A., and Giesy, J.P. 2015. Organophosphorous Insecticides in Honey, Pollen and Bees (Apis mellifera L.) and Their Potential Hazard to Bee Colonies in Egypt. Ecotox. Environ. Safety, 114: 1-8. DOI.org/10.1016/j.ecoenv.2014.12.039
- Al Naggar, Y., Vogt, A., Codling, G., Naiem, E., Mona, M., Seif, A., Robertson, A., and Giesy, J.P. 2015. Exposure of Honey Bees (Apis mellifera L.) in Saskatchewan, Canada to to Organophosphorous Insecticide. Apidologie, DOI: 10.1007/s13592-015-0357-y
- Amichev, B.Y., Bentham, M.J., Cerkowniak, D., Kort, J., Kulshreshtha, S., Laroque, C.P., Piwowar, J.M., and Van Rees, K.C.J. 2015. Mapping and quantification of planted tree and shrub shelterbelts in Saskatchewan, Canada. Agroforstry Systems, 89: 49-65.
- Arens, C.J., Hogan, N.S., Kavanagh, R.J., Mercer, A.G., van der Kraak, G.J., and van den Heuvel, M.R. 2015. Sublethal effects of aged oil sands-affected water on white sucker (Catostomus commersonii). Environmental Toxicology and Chemistry, 34: 589-599.
- Armstrong, R.N, Pomeroy, J.W. and Martz, L.W. 2015. Variability in evaporation across the Canadian Prairie region during drought and non-drought periods. Journal of Hydrology, 521: 182-195.
- Bai, Y.-C., Wu, F.-C., Xing, B.-S., Meng, G.-L.W., Shi, G.-L., Ma, Y., and Giesy, J.P. 2015. Isolation and Characterization of Chinese Standard Fulvic Acid Sub-fractions Separated from Forest Soil by Stepwise Elution with: Pyrophosphate Buffer. Sci. Rep. 5: 8723. DOI: 10.1038/srep08723
- Beitel, S.C., Doering, J.A., Eisner, B.K., and Hecker, M. 2015. Comparison of the sensitivity of four native Canadian fish species to  $17-\alpha$  Ethinylestradiol, using an in vitro liver explant assay. Environ. Sci. Pollut. Res. Accepted for Publication.
- Beníšek, M., Kukučka, P., Mariani, G., Suurkuusk, G., Gawlick, B.M., Locoro, G., Giesy, J.P., and Bláha, L. 2015. Dioxins and Dioxin-like Compounds in Composts and Digestates from European Countries as Determined by the in vitro Bioassay and Chemical Analysis. Chemosphere, 122: 168-175, DOI: 10.1016/j.chemosphere.2014.11.039
- Brannen, R, Spence, C. and Ireson, A.M. 2015. Influence of shallow groundwater-surface water interactions on the hydrological connectivity and water budget of a wetland complex. Hydrological Processes. doi:10.1002/hyp.10563

- Brown, C.D., Liu, J., Yan, G., and Johnstone, J.F. 2015. Disentangling legacy effects from environmental filters of post-fire assembly of boreal tree assemblages. Ecology, in press.
- Carbone, R.E., and Li, Y. 2015. Tropical Oceanic Rainfall and Sea Surface Temperature Structure: Parsing Causation from Correlation in the MJO. Journal of Atmospheric Science, 72(7): 2703–2718.
- Casey, L.S., and Wilson, L.D. 2015. Investigation of Chitosan-PVA Composite Films and their Adsorption Properties. Journal of Geoscience and Environment Protection, 3(2): 78-84.
- Changnon, M., Kreutzweiser, D., Mitchell, E.A.D., Morrissey, C.A., Noome, D.A. and Van der Sluijs, J. 2015. Risks of large scale use of systemic insecticides to ecosystem functioning and services. Environ Sci and Poll Res (special issue), 22: 119–134, DOI 10.1007/s11356-014-3277-x.
- Chen, C., Wu, F.-C., Mu, Y.-S., Zhang, R.-Q., and Giesy, J.P. 2015. Derivation of Marine Water Quality Criteria for Metals Based on a Novel QICAR-SSD Model. Environ. Sci. Pollut. Res. 22: 4297-4304, DOI: 10.1007/s11356-014-3655-4.
- Choudhury, S., Thomas, J.K., Sylvain, N.J., Ponomarenko, O., Gordon, R.A., Heald, S.M., Janz, D.M., Krone, P.H., Coulthard, I., George, G.N., and Pickering, I.J. 2015. Selenium preferentially accumulates in the eye lens following embryonic exposure: a confocal X-ray fluorescence imaging study. Environmental Science & Technology, 49(4): 2255–2261, DOI: 10.1021/es503848s
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- Das, A., Sagin, J., van der Sanden, J., Evans, E., MacKay, H. and Lindenschmidt, K.-E. 2015. Monitoring the freeze-up and ice cover progression of the Slave River. Canadian Journal of Civil Engineering, (in press), http://dx.doi.org/10.1139/cjce-2014-0286.
- Delavau, C., Chun, K.P., Stadnyk, T., Birks, S. J., and Welker, J. 2015. North American precipitation isotope ( $\delta$ 18O) zones revealed in time series modelling of precipitation across Canada and the northern United States. Water Resources Research.
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- Dhillon, G.S., Amichev, B.Y., de Freitas, R., and Van Rees, Ken. 2015. Accurate and Precise Measurement of Organic Carbon Content in Carbonate-Rich Soils. Communications in Soil Science and Plant Analysis (Accepted Dec 3, 2014)
- Doering, J.A., Farmahin, R., Wiseman, S., Beitel, S.C., Kennedy, S.W., Giesy, J.P., and Hecker, M. 2015. Differences in Activation of Aryl Hydrocarbon Receptors of White 2 Sturgeon Relative to Lake Sturgeon Are Predicted by Identities of 3 Key Amino Acids in the Ligand Binding Domain. Environ. Sci. Technol. 49: 4681-4689, DOI: 10.1021/acs.est.5b00085
- Doering, J.A., Beitel, S.C., Eisner, B.K., Heide, T., Hollert, H., Giesy, J.P., Hecker, M., and Wiseman, S. B. 2015. Identification and Response to Metallothionein in two Ancient Fishes:

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- Ferguson, G. 2015. Issue Paper: Deep Injection of Waste in the Western Canada Sedimentary Basin. Groundwater, 53 (2): 187-194, Wiley/National Groundwater Association.
- Ferguson, G. and Jasechko, S. 2015. The Isotopic Composition of the Laurentide Ice Sheet and Fossil Groundwater. Geophysical Research Letters, 42, doi:10.1002/2015GL064106, American Geophysical Union/Wiley.
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# **Conference Proceedings and Presentations - 2015**

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- Amos, M., Barbour, S.L., Pratt, D., and Si, B. 2014. Development of a Time Domain Reflectometry Sensor for Cone Penetration Testing. GeoRegina 2014, 67th Canadian Geotechnical Conference Proceedings, Sept.28-Oct.1.
- Appels, W.M., Ireson, A.M.I., McDonnell, J., and Barbour, S.L. 2015. Soil and vegetation development affect the evolution of hydrological pathways in engineered hillslopes. Oral presentation H13A-01 Abstract 35736 in: http://www.gac.ca/wp/wp-content/uploads/2011/09/2015\_Joint\_Assembly\_Abstract\_Proceedings.pdf, Joint
- Appels, W.M., Ireson, A.M.I., and Barbour, S.L. 2015. Preferential unsaturated flow and transport in heterogeneous mine waste rock dumps. Poster H44B-0186, Joint Assembly (AGU-GAC-
- Appels, W.M., Ireson, A.M.I., McDonnell, J., and Barbour, S.L. 2015. Evolution of hydrological pathways in engineered hillslopes due to soil and vegetation development. HS 2.3.1, Abstract EGU2015-9528 (http://meetingorganizer.copernicus.org/EGU2015/EGU2015-9528.pdf), Poster in: 'Understanding catchment and hillslope responses: from changing states and non-linearities to emergent behaviours', EGU General Assembly 2015, Vienna, Austria, April 12-17.

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- Appels, W.M., Ireson, A., Barbour, S.L. and McDonnell, J.J. 2014. Stable Isotope Applications to Understand Soil Reclamation Cover Hydrology. 2014 GSA Annual Meeting, Vancouver, British Columbia, Oral Presentation, Abstract only published (No. 248308) in GSA Abstracts with Programs Vol. 46, No. 6, Session 161-8: " Oral presentation T161 (Hendry, Barbour): Application of Isotopes of Water to Characterize Hydrogeological Processes in Mine Environments", Oct. 20.
- Barbour, S.L., and Hendry, M.J. 2015. Development of in-situ vapour sampling for stable isotopes of water within unsaturated mine waste. Poster 098p, Internat. Symp. On Isotope Hydrology (IAEA), Vienna Austria, May 13.
- Barbour, S.L., Hendry, M.J. and Carey, S.K. 2014. Characterizing Net Percolation through Coal Mine Waste Rock Dumps using High-Resolution Profiles of Stable Isotopes of Water. 2014 GSA Annual Meeting, Vancouver, British Columbia, Oral Presentation, Abstract only published (No. 249337) in GSA Abstracts with Programs Vol. 46, No. 6, Session 161-4: "T161 (Hendry, Barbour): Application of Isotopes of Water to Characterize Hydrogeological Processes in Mine Environments", Oct. 20. Barbour Presenting.
- Berry, P., Belcher, K., and Lindenschmidt, K.-E. 2015. Adapting to climate change on the Canadian Prairies: Can on-farm surface water retention systems provide an economically viable water management solution? Canadian Water Resources Association annual conference, 2-4 June, Winnipeg, Manitoba.
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- Dompierre, K., and Barbour, S.L. 2015. Evaluation of thermal properties of oil sand fluid fine tailings. In: 'Mining Waste Management and Environmental Geotechnology: Mine Waste Disposal', GeoQuebec 2015, 68th Canadian Geotechnical Conference, Quebec City, Sept. 20-23.
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- Dompierre, K, Barbour, S.L. and Wheater, H. 2014. Characterization of the thermal regime through oil sands fluid fine tailings in an End Pit Lake. GeoRegina 2014, 67th Canadian Geotechnical Conference Proceedings, Sept.28-Oct.1.
- Elshorbagy, A., and Alam, S. 2015. Downscaling of Extreme Precipitation: Proposing a New Statistical Approach and Investigating a Taken-for-Granted Assumption. General Assembly of the European Geosciences Union, Vienna, Austria, April 12-17 (Abstract and oral presentation EGU2015-7872).
- Elshorbagy, A., Hassanzadeh, E., Wheater, H. and Gober, P. 2015. A Risk-Based Framework to Assess Long-term Effects of Policy and Water Supply Change on Water Resource Systems. General Assembly of the European Geosciences Union, Vienna, Austria, April 12-17 (Abstract and oral presentation EGU2015-7656).
- Ford, L. and Bharadwaj, L. 2015. Groundwater Consumption in Rural Communities: Impact of Risk Perception on Human Health Risk. Connecting Water Resources 2015: From Knowledge to Action, Canadian Water Network, Ottawa, March 10-12.

- Giesy, J.P. 2015. Aquatic Impact Assessment of Municipal Effluents (AIME): A Toolbox Approach, With: M. Hecker, T. Bagatim, G. Codling, S. Hanson, N. Hogan, A. Hontela, P. Jones, H. Peng, B. Sarauer, K. Steeves, S. Wiseman. To: 25th Annual meeting, May 4-8, Barcelona, Spain.
- Giesy, J.P. 2015. Identification and Toxicity Assessment of Classes of Compounds Contributing to the Acute Toxicity of Oil Sands Process Affected Water, With: G. Morandi, S. Wiseman, K. Zhang, A. dos Santos Pereira, and J.W. Martin. To: 25th Annual meeting, May 4-8, Barcelona, Spain.
- Giesy, J.P. 2015. Emerging Contaminants of Urban Origin: Sources, Sampling, Analytical Issues and Remediation Techniques, with: G. Codling, H.-D. Yuan, P.D. Jones and M. Hecker. To: 25th Annual meeting, May 4-8, Barcelona, Spain.
- Giesy, J.P. 2015. Altered Reproductive Capacity of Japanese Medaka Exposed to Maternally Transferred TBCO, with: S. Wiseman, D. Saunders, J. Sun, H. Peng, S. Tang, J. Kuzma, M. Hecker. To: 25th Annual meeting, May 4-8, Barcelona, Spain.
- Giesy, J.P. 2015. Detection, Identification and Quantification of Hydroxylated Isomers of Bis(2ethyl-hexyl)-tetraromophthalate, with: D. Saunders, H. Peng, J. Sun, S. Wiseman, P.D. Jones. To: 25th Annual meeting, May 4-8, Barcelona, Spain.
- Gonda, J., Elshorbagy, A., and Wheater, H. 2015. Environmental Flow and Economy in the Bow River Basin: Reaching a Compromise Through a Hydro-Economic Model. Proc. 22nd Canad. Hydrotech. Conf., Montreal, QC, Canada, Apr 29 May 2, 8 pp.
- Harley, R., Bergamo, P., Hughes, D., Donohue, S., Carse, L., and Barbour S.L. 2015. Estimation of the small strain stiffness of glacial till using geophysical methods and barometric loading response. In: 'Soil and Terrain Characterization: In situ Testing', GeoQuebec 2015, 68th Canadian Geotechnical Conference, Quebec City, Sept. 20-23.
- Harley, R., Sivakumar, V., Hughes, D., Lynch, K., and Barbour, S.L. 2014. Progressive deformation of glacial till due to viscoplastic straining and pore pressure variation. GeoRegina 2014, 67th Canadian Geotechnical Conference Proceedings, Sept.28-Oct.1.
- Hassanzadeh, E., Elshorbagy, A., Nazemi, A., Wheater, H., and Gober, P. 2015. Integrated Water Resource Management Under Water Supply and Irrigation Development Uncertainty. Proc. 22nd Canad. Hydrotech. Conf., Montreal, QC, Canada, Apr 29 May 2, 4 pp.
- Hodges, G., Falciani, F., Ankley, G., Butler, E., Hecker, M., Tollefsen, K.E., Garcia-Reyero, N., Kille, P., Becker, D., Brockmeier, E., Chipman, K., Colbourne, J., Collette, T., Cossins, A., Cronin, M., Graystock, P., Gutsell, S., Knapen, D., Katsiadaki, I., Lange, A., Marshall, S., Owen, S., Perkins, E.J., Plaistow, S., Schroeder, A., Taylor, D., Vian, M. and Hutchinson, T.H. 2015. Potential Roles of Omics Data in the use of Adverse Outcome Pathways for Environmental Risk Assessment. SETAC Europe 25th Annual Meeting, May 3-7, Barcelona, Spain.
- Horachek, M.E., Johnstone, J.F., and Laroque, C. 2015. Radial growth patterns of jack pine in relation to climate, moisture availability, and dwarf mistletoe infection in the Boreal Plains Ecozone of Saskatchewan, Canada. Canadian Society for Ecology and Evolution annual meeting, Saskatoon, SK, May 2015.

- Hosseini Safa, H., Elshorbagy, A., and Wheater, H. 2015. Balancing Economic and Environmental Protection Goals in Water Resources Management in the Oldman River Basin.Proc. 22nd Canad. Hydrotech. Conf., Montreal, QC, Canada, Apr 29 May 2, Poster.
- Hudson J., Vandergucht, D., Hunter, K., North, R., Sereda, J., Wheater, H., and Davies, J. 2015. An Overview of The Lake Diefenbaker Study. Annual Meeting of the Society of Canadian Limnologists, January 8-11, Ottawa, Canada.
- Hunter, K., Johansson, J., North, R., Vandergucht, D., Abirhire, O., Sereda, J. and Hudson, J. 2015. Light and Nutrient Effects on Phytoplankton Populations in Lake Diefenbaker, a Large Prairie Reservoir. Annual Meeting of the Society of Canadian Limnologists, January 8-11, Ottawa, Canada.
- Huyhn, M., and Bharadawaj, L. 2015. Cyanotoxin at Saskatchewan Lakes in 2013— Canadian Water Network From Knowledge to Action; Connecting water resources conferences, March 10-12, Ottawa, ON.
- Jean, M.J., Melvin, A.M., Mack, M.C., and Johnstone, J.F. 2015. Room to breathe: impacts of environment and leaf litter on moss growth and N-fixation. Canadian Society for Ecology and Evolution annual meeting, Saskatoon, SK, May 2015.
- Karoyo, A. H., and Wilson, L.D. 2015. Structural Studies of Supramolecular Host-Guest Systems, U of S GIWS Symposium, Saskatoon, SK. (March 2015).
- Kim, J., and Chang, W. 2015. Evaluation of generalized microbial respiration equations for petroleum hydrocarbon-contaminated, cold-climate soils during bioremediation. 38th Arctic and Marine Oilspill Program (AMOP) Technical Seminar on Environmental Contamination and Response Conference Proceedings, Vancouver, BC, June 2-4, 2015.
- Koehler, B., Barbour S.L., and Ferguson, G. 2014. Evaluation of Density Dependant Convective Airflow Causing Accelerated Drying of Reclamation Soil Covers. 10th International Conference on Acid Rock Drainage (ICARD-IMWA2015), April 21-24, 2015, Santiago, Chile, Accepted December.
- Koehler, B. J., Barbour, S.L., and Ferguson, G. 2014. An Evaluation of Density Dependant Convective Airflow Causing Accelerated Drying of Reclamation Soil Covers. GeoRegina 2014, 67th Canadian Geotechnical Conference Proceedings, Sept.28-Oct.1.
- Kong, D., and Wilson, L.D. 2015. Modified biopolymers for recognition of oxoanion guests in water, 2015 U of S Graduate Students Symposium, Saskatoon. SK. (May 2015).
- Kulshreshtha, S. and Wheaton, E. 2015. Water Demand and Climate Extremes in Saskatchewan: Exploring Future Risks. Presentation at the Canadian Water Resources 2015 Conference, Winnipeg, MB.
- Kusch, J., Hunter, K., Vandergucht, D., and Hudson, J. 2015. Spatial and Temporal Trends in Phosphorus and Nitrogen in Lake Diefenbaker, Saskatchewan. Annual Meeting of the Society of Canadian Limnologists, January 8-11, Ottawa, Canada.
- Kusch, J., Hunter, K., Vandergucht, D., and Hudson, J. 2015. The Effect of Temperature, Turbidity, and Depth on Spatial and Temporal Trends in Nitrogen and Phosphorous in Lake Diefenbaker, Saskatchewan. Prairie University Biological Symposium, February 19-21, Winnipeg, Canada.

- Kuzyk, T., Barbour, S.L., and Hendry. J. 2015. A Conceptual Model for Pore Water Release from Coal Waste Rock Piles in the Elk Valley, British Columbia, Canada. IAH CNC 2015 Waterloo Conference, Waterloo, ON, 27-30 October, 2015.
- Kuzyk, T., Barbour, S.L. and Hendry, M.J. 2014. A Conceptual Model for the Flushing of Coal Waste Rock Piles in the Elk Valley, British Columbia, Canada. 2014 GSA Annual Meeting in Vancouver, British Columbia, Poster Presentation, Abstract only published (No. 249669) in GSA Abstracts with Programs Vol. 46, No. 6, Session 296-6: "T103. Mining and the Environment: Addressing Common Challenges Faced across the Mining Industry (Posters)", Oct. 22.
- Laroque, C.P, Davis, E., Mood, B.J. 2015. Forecasting radial growth in shelterbelt trees across southern Saskatchewan. Annual Meeting of the Canadian Association of Geographers. Vancouver, BC. June 1-6.
- Lemke, R., Bedard-Haughn, A., Gan, Y, and Baron, V. 2015. Canola cropping and carbon and nitrogen cycling on the Canadian prairies. Presentation to the International Workshop on Greenhouse Gas Emission from Oilseed Rape Cropping and Mitigation Options. Braunschweig, Germany.
- Lindenschmidt, K.-E., Kells, J., and Liu, N. 2015. Mapping Breakup Risk of River Ice Covers Impacted by Hydro-peaking Operations. Canadian Water Resources Association annual conference, 2-4 June, Winnipeg, Manitoba.
- Lindenschmidt, K.-E., and Das, A. 2015. Characterising river ice processes using geospatial modelling. Canadian Water Resources Association annual conference, 2-4 June, Winnipeg, Manitoba.
- Maavara, T., Hood, J., North, R., Doig, L., Parsons, C., Johansson, J., Liber, K., Hudson, J., Lucas, B., Vandergucht, D., and Van Cappellen, P. 2015. A long-term sink for nutrient silicon in Canada's most threatened river system. Joint Assembly of the Annual meeting of the American and Canadian Geophysical Unions. Montreal, Quebec. May 3-7.
- MacKinnon, B., Baulch, H., Sagin, J., Lindenschmidt, K., and Jardine, T. 2015. Influence of hydrological connectivity on winter limnology in floodplain lakes of the Saskatchewan River Delta, SK. Canadian Conferences for Fisheries Research, January.
- Mahaninia, M., and Wilson, L.D. 2015. Cross-Linked Chitosan Beads for Phosphate Anion Removal, 2015 Green Chemistry Applied in Industry A Symposium by GCI at UofT, Toronto, ON. (May 2015).
- Mahaninia, M., and Wilson, L.D. 2015. Cross-Linked Chitosan Beads for Phosphate Anion Removal, 2015 U of S Graduate Students Symposium, Saskatoon. SK. (May 2015)
- Mahmood, F.N., Hendry, M.J., Barbour, S.L. and Klein, R. 2014. Origin and fate of nitrate derived from blasting in coal waste-rock spoils in British Columbia and Alberta, Canada. 2014 GSA Annual Meeting in Vancouver, British Columbia, Oral Presentation, Abstract only published (No. 248788) in GSA Abstracts with Programs Vol. 46, No. 6, Session 279-5: "T103. Mining and the Environment: Addressing Common Challenges Faced across the Mining Industry", Oct. 22.

- Maillet, J., Laroque, C.P. 2015. From Annual to Intra-annual: exploring the radial growth-climate relationship with high resolution data. Annual Meeting of the Canadian Association of Geographers. Vancouver, BC. June 1-6.
- Maillet, J., Laroque, C.P. 2015. Watching Trees Grow: The use of intra-annual measures of radial-growth in dendroclimatological studies. Annual Meeting of the Canadian Society for Ecology and Evolution. Saskatoon, SK. May 21-25.
- Mamet, S.D., Singh, K.K., Chun, K.P., Brown, C.D., Bernard, J., and Johnstone, J.F. 2015. A sensitive slope at treeline: Do substrate and environmental characteristics determine tree sensitivity to climate? Canadian Society for Ecology and Evolution annual meeting, Saskatoon, SK, May 2015.
- Mamet, S.D., Singh, K.K., Brown, C.D., and Johnstone, J.F. 2015. Pattern and process in a multi-species treeline environment: cross-scale analysis of treeline dynamics within the Wolf Creek Research Basin, southwestern Yukon, Canada. American Association of Geographers annual meeting, Chicago, IL, April 2015.
- Masse, A., and Muscatello, J. 2015. Early life stage developmental effects of elevated maternal dietary selenium exposure in amphibians. Society of Environmental Toxicology and Chemistry (SETAC) Europe, Barcelona, Spain
- McLaughlin, K., and Bharadwaj, L. 2015. The risks to potable water trucked to cisterns in Beardy's Okemasis First Nation Saskatchewan Canadian Association of Geographers (CAG); Vancouver, BC June.
- Meissner, A.G.N., Carr, M.K., Phillips, I.D., and Lindenschmidt, K.-E. 2015. Developing a geospatial model to distinguish riverine macroinvertebrate habitat. Canadian Water Resources Association annual conference, 2-4 June, Winnipeg, Manitoba.
- Michel, N.L., Clark, R.G., Hobson, K.A., and Morrissey, C.A. 2015. Where have all the grassland birds gone? Effects of land use, pesticides and climate on grassland birds in Canada's Prairie Potholes Region. Canadian Section of The Wildlife Society Annual General Meeting, Saskatoon, SK. 14 March.
- Michelson, C.I., Morrissey, C.A. and Clark, R.G. 2015. Effects of agricultural intensification on reproductive performance and nestling quality of tree swallows (Tachycineta bicolor) breeding in central Saskatchewan. Canadian Section of The Wildlife Society, Saskatoon, SK. 14 March.
- Michelson, C.I., Morrissey, C.A. and Clark, R.G. 2015. Dietary responses of tree swallows (Tachycineta bicolor) to agricultural intensification and implications on body condition. Canadian Society of Ecology and Evolution, Saskatoon, SK. 23 May.
- Morken, J.A., Conway, A.C., and Johnstone, J.F. 2015. The effects of fire severity and herbivory on the growth and succession of the boreal forest in interior Alaska. Canadian Society for Ecology and Evolution annual meeting, Saskatoon, SK, May 2015.
- Muldoon, B., and Hogan, N.S. 2015. Developing the brook stickleback (Culaea inconstans) as a bioindicator of exposure to endocrine disrupting compounds in aquatic environments. Prairie Northern Chapter of the Society of Environmental Toxicology and Chemistry Annual Meeting. June 4-5, Calgary, AB.

- Nesbitt, J.A., and Lindsay, M.B.J. 2015. Vanadium geochemistry of petroleum coke at an oil sands mine in northern Alberta, Canada. Canadian Light Source Annual Users' Meeting, May 4–6, Saskatoon, Canada.
- Norbury, V.M., Bishop, C.A., Jardine, T.D., Elliott, J., and Morrissey, C.A. 2015. Impacts of run-of-river dams on American dippers and the river food webs of coastal British Columbia. Canadian Section of the Wildlife Society Annual Conference, Saskatoon, SK. 14-15 March.
- Norbury, V.M., Bishop, C.A., Jardine, T.D., Elliott, J., and Morrissey, C.A. 2015. Impacts of run-of-river dams on American dippers and the river food webs of coastal British Columbia. Columbia Mountains Institute of Applied Science, Regulated Rivers Conference, Castlegar, BC. 6-7 May.
- North, R., Hunter, K., Johansson, J., Vandergucht, D., Dubourg, P., Abirhire, O., Ponomarenko, Y., Silsbe, G., Guildford, S., and Hudson, J. 2015. Nitrogen Transformations in a Large Dynamic Reservoir (Lake Diefenbaker, Saskatchewan). Annual Meeting of the Society of Canadian Limnologists, January 8-11, Ottawa, Canada.
- O'Kane, M., Birkham, T., Goodbrand, A., Barbour, S.L., Carey, S.K., Straker, J., Baker, T., and Klein, R. 2015. Near-surface water balances of coal waste rock dumps. 10th International Conference on Acid Rock Drainage (ICARD-IMWA2015), paper 277, Chapter 3, April 21-24, 2015, Santiago, Chile.
- O'Kane, M., Barbour, S.L., Meiers, G., and McDonnell, J. 2014. Practical Considerations when Designing for Geosynthetics in a Cover System. Geosynthetics Mining Solutions 2014 conference, Sept.8-11, Vancouver.
- Oldach, M., Helps, D., Prestie, C., and Hudson, J. 2015. Effect of Metals on the Allometry of Planktonic Food Webs in Lakes Exposed to Mining Operations in Northern Saskatchewan. Annual Meeting of the Society of Canadian Limnologists, January 8-11, Ottawa, Canada.
- Pomedli, M., Belosowsky, T., Hunter, K., and Hudson, J.J. 2015. Comparison Between Water Column and Sediment Trap Nutrient Stoichiometry in Lake Diefenbaker, SK. Annual Meeting of the Society of Canadian Limnologists, January 8-11, Ottawa, Canada.
- Pomeroy, J., Fang, X., Shook, K., and Westbrook, C. 2015. Modelling the impact of depressional storage drainage on the hydrology of a Canadian Prairie basin. AGU-CGU Joint Congress, May, Montreal, Canada.
- Ponomarenko, Y., Hunter, K., Abirhire, O., and Hudson, J. 2015. Photoammonification in Plains and Boreal Shield Lakes with an Expanded Dataset. Annual Meeting of the Society of Canadian Limnologists, January 8-11, Ottawa, Canada.
- Prestie, C., Sereda, J., and Hudson, J. 2015. Assimilation of Aquaculture Waste by Lake Whitefish in Lake Diefenbaker, Saskatchewan. Annual Meeting of the Society of Canadian Limnologists, January 8-11, Ottawa, Canada.
- Prepas, E., McEachern, P., Germida, J., Van Rees, K. C. J., Putz, G., Lanoo, M., Chen, H., and Pyle, G. 2015. FORWARD III: Watershed research and modelling to contribute to cumulative effects management in the Canadian Boreal Forest COSIA Meeting Calgary.

- Razavi, S., and Gupta, H.V. 2015. A Critical Look at Sensitivity Analysis of Hydrologic Systems Models, American Geophysical Union-Canadian Geophysical Union (CGU-CGU) Joint Assembly, May 3-7, Montreal, QC.
- Razavi, S., Elshorbagy, A., Wheater, H., and Sauchyn, D. 2015. Evaluation of Paleo-Hydrologic Extremes and Their Uncertainties, American Geophysical Union-Canadian Geophysical Union (CGU-CGU) Joint Assembly, May 3-7, Montreal, QC.
- Razavi, S., and Gupta, H.V. 2015. A New Framework for Effective and Efficient Global Sensitivity Analysis of Earth and Environmental Systems Models, European Geosciences Union (EGU) General Assembly, April 12-17, Vienna, Austria.
- Ross, J., and Strickert, G.E. 2015. Perspectives on Equitable Water Resources Allocation from a Decision Experiment. 21st International Symposium on Society and Resource Management, Charleston, SC, USA, June 17.
- Sagin, J., and Lindenschmidt, K.-E. 2015. Digital Terrain Model (DTM) of the Slave River and Delta, NWT, Canada. CGU-AGU Joint Assembly, 3-7 May, Montreal, Canada. https://agu.confex.com/agu/ja2015/meetingapp.cgi#Paper/36111
- Schabert, M., Hendry, J., and Barbour, S.L. 2015. Application of Push-Pull Tests to Define Biogeochemical Controls on Selenium and Nitrate Attenuation in Saturated Coal Waste Rock. In Session: 'Innovation in the remediation of contaminated sites', IAH CNC 2015 Waterloo Conference, Waterloo, ON, 27-30 October, 2015.
- Schmeling, E., Hendry, M.J. and Barbour, S.L. 2014. Application of 1-D Vertical Profiles of δ2H and CL to evaluate Vertical Leakage through a Fractured Cretaceous Aquitard at a Proposed Mine Dewatering Site, Fort à la Corne, Saskatchewan, Canada. 2014 GSA Annual Meeting, Vancouver, British Columbia, Oral Presentation, Abstract only published (No. 249354) in GSA Abstracts with Programs Vol. 46, No. 6, Session 161-12: "T161 (Hendry, Barbour): Application of Isotopes of Water to Characterize Hydrogeological Processes in Mine Environments", Oct. 20.
- Shafiei, F., Hunter, K., Johansson, J., Vandergucht, D., and Hudson, J. 2015. Nitrogen and Phosphorus Loads and Nutrient Limitation in Lake Diefenbaker. Annual Meeting of the Society of Canadian Limnologists, January 8-11, Ottawa, Canada.
- Singh, K.K., Henkelman, J., and Johnstone, J.F. 2015. Implications of high-resolution remote sensing data and landscape characteristics for large area boreal forest vegetation assessment. Canadian Society for Ecology and Evolution annual meeting, Saskatoon, SK, May 2015.
- Smith, L.A., Barbour, S.L., and Hendry, J. 2015. Determining in situ properties of claystone aquitards using pore pressure responses from grouted-in pressure transducers. Geoconvention 2015, Geoscience New Horizons, in: 'Physical Properties of Rock' Session, May 4-8, 2015, Calgary.
- Smith, L., Hendry, M.J., Barbour, S.L. and Van der Kamp, G. 2014. Determining In Situ Properties of Caprock Formations using Pore Pressure Responses from Grouted-In Pressure Transducers. 2014 GSA Annual Meeting in Vancouver, British Columbia, Oral Presentation, Abstract only published (No. 246940) in GSA Abstracts with Programs Vol. 46, No. 6, Session

- 339-5: "T160. (Osborn, Ryan): Enviro. Effects of Oil and Gas Development on Water Quality: Toward Sustainability and Stewardship", Oct. 22.
- Stanton, R., Clark, R.G., and Morrissey, C.A. 2015. Agricultural landscapes influence tree swallow (Tachycineta bicolor) foraging strategy and return rates, but not adult body condition. Canadian Society of Ecology and Evolution (CSEE). Saskatoon, SK. 22 May.
- Stanton, R., Clark, R.G., and Morrissey, C.A. 2015. Agricultural landscapes influence tree swallow (Tachycineta bicolor) foraging strategy, adult body condition, and return rates. Canadian Section of the Wildlife Society (TWS). Saskatoon, SK. 14 March.
- Straker J., Baker, T., O'Kane M., Shurniak, R., Barbour, S.L., and Carey S. 2015. Ecosystem reconstruction a global assessment of methods for estimating soil water regimes for mine reclamation and closure. Mine Closure 2015 10th International Conf. on Mine Closure, June 1-3, 2015, Vancouver, BC, Proceedings: Chapter 11: Ecosystem Reconstruction, pp.1035-1046.
- Straker J., Baker, T., Barbour, S.L., O'Kane M., Carey S., and Charest D. 2015. Mine reclamation and surface water balances: an ecohydrologic classification system for mine-affected watersheds. Mine Closure 2015 10th International Conf. on Mine Closure, June 1-3, 2015, Vancouver, BC, Proceedings: Chapter 11: Ecosystem Reconstruction, pp.1023-1034.
- Straker J., O'Kane M., Carey S., Charest D., and Barbour, S.L. 2015. Mine water management for closure mine reclamation and surface water balances. 10th International Conference on Acid Rock Drainage (ICARD-IMWA2015), paper 115, Chapter 14, April 21-24, 2015, Santiago, Chile.
- Strickert, G.E., Ross, J., Bradford, L.E., and Gober, P. 2015. The Effects of Policy on Water Allocation: Results from a Decision Experiment. 68th National Canada Water Resources Association Conference Policy, Planning and Management, June 2.
- Szmigielski, J., Hendry, M.J and Barbour, S.L. 2014. Hydrogeological Characterization of a Groundwater System Downgradient of a Coal Waste Rock Spoil. 2014 GSA Annual Meeting in Vancouver, British Columbia, Poster Presentation, Abstract only published (No. 249013) in GSA Abstracts with Programs Vol. 46, No. 6, Session 296-8: "T103. Mining and the Environment: Addressing Common Challenges Faced across the Mining Industry (Posters) ", Oct. 22.
- Thomas, J., Masse, A., and Muscatello, J. 2015. Selenium ecotoxicology in fish and frogs. Canadian Society of Zoologists, Calgary, Canada
- Tipman, J., Barbour, S.L., and van der Kamp, G. 2015. Calibration of Geolysimeters to Track Shortterm Soil Vegetation Atmosphere Transfers. GeoQuebec 2015, Canadian Geotechnical Conference, Quebec City, Sept. 20-23.
- Udoetok, I.A., Wilson, L.D., and Headley, J.V. 2015. Structure and adsorption Properties of Cross-linked Cellulose-Epichlorohydrin Polymers in Aqueous Solution, GIWS Symposium, Saskatoon, SK. (March 2015).
- Udoetok, I.A., Wilson, L.D., and Headley, J.V. 2015. Structure and adsorption Properties of Cross-linked Cellulose-Epichlorohydrin Polymers in Aqueous Solution, 98th CSC Conference, Ottawa, ON. (June 2015)

- Udoetok, I.A., Wilson, L.D., and Headley, J.V. 2015. Fractionation of Carboxylate Anions from Aqueous Solution Using Chitosan Cross-Linked Sorbent Materials, 98th CSC Conference, Ottawa, ON. (June 2015)
- Walker, X.W. and Johnstone, J.F. 2015. Drought stress in northern boreal forests signals decreased resilience to fire. Canadian Society for Ecology and Evolution annual meeting, Saskatoon, SK, May 2015.
- Wang, X., Westbrook, C., Helgason, B., and Bedard-Haughn, A. 2015. Assessing pedogenic controls vs. relative depth on carbon mineralization, organic matter composition and microbial community in a mountain peatland. Canadian Soil Science Society Meeting.
- Westbrook, C.J., and Bedard-Haughn, A. 2015. Alberta's 2013 flood: Response of a mountain peatland. AGU-CGU Joint Congress May, Montreal, Canada. This paper resulted in a press release in Science News
- Yassin, F.A., Wheater, H.S., Razavi, S., Azuri, G.S., Davison, B., and Pietroniro, A. 2015. Comprehensive, Process-based Identification of Hydrologic Models using Satellite and In-situ Water Storage Data: A Multi-objective Calibration Approach. European Geosciences Union (EGU) General Assembly, April 12-17, Vienna, Austria.
- Yip, H., and Hudson, J. 2015. Lake Diefenbaker from Above, Long Term Patterns in Water Quality as Determined By Satellite Imagery. Annual Meeting of the Society of Canadian Limnologists, January 8-11, Ottawa, Canada.

# **Conference Proceedings and Presentations - 2014**

- Amadi, C., Farrell, R. and Van Rees, K. 2014. Comparative measurements of soil organic carbon content and greenhouse gas fluxes in nine shelterbelt and crop field soils. Soil Science Society of America Annual Meeting, Long Beach CA, USA. November.
- Amadi, C., Farrell, R. and Van Rees, K. 2014. Mature Caragana shelterbelts on Prairie soils: are they environmental assets? Poster presentation, Soil Science Society of America Annual Meeting, Long Beach CA, USA. November.
- Beitel, S., Doering, J., Patterson, S., Eisner, B., and Hecker, M. 2014. In vitro Assessment of the Disruption of Steroidogenesis in Three North American Fish Species. 41st Aquatic Toxicity Workshop in Ottawa, ON, Canada. Sep 28 Oct 1.
- Bharadwaj, L. 2014. Community-Based Participatory Research: An approach to Sustainable Water Supplies in First Nations Communities. October 27-29, 2014 Partners FOR Saskatchewan River Basin and Canadian Water Resources Association's. "Long Term Threats to the Saskatchewan River Basin." Delta Bessborough Hotel, Saskatoon, Sk.
- Bharadwaj, L., Johnston, P., Zagosewski, R., and Waldner, C. 2014. First Nations Safe Drinking Water Program: Ensuring the Health of First Nations Children, Youth and Families (2008-2015 Progress). Federation of Saskatchewan Indian Nations Environmental Working Group September 10, 2014 Best Western, Saskatoon, SK.

- Bianchini, K. and Morrissey, C.A. 2014. The initiation and regulation of avian migratory fat deposition and how contamination affects pre-migratory fuelling in shorebirds. SETAC North America 35th Annual Meeting, Vancouver, BC. 12 November, 2014.
- Cavallaro, M., Peru, K., Headley, J., Morrissey, C., and Liber, K. 2014. Biodiversity and Pesticides: Effects of Chronic Neonicotinoid Insecticide Exposure on Aquatic Insect Emergence in Prairie Wetlands. The Society of Environmental Toxicology and Chemistry. Vancouver, BC. November.
- Cavallaro, M., Phillips, I., Headley, J., Peru, K., Morrissey, C., and Liber, K. 2014. Investigating the Impacts of Neonicotinoid Insecticides on Macroinvertebrate Communities in Limnocorrals in a Prairie Pond. Joint Entomological Meeting of the Canadian Entomological Society. Saskatoon, SK. October.
- Cavallaro, M.C., Morrissey, C., Headley, J., Peru, K., and Liber, K. 2014. Effects of Chronic Neonicotinoid Insecticide Exposure on Aquatic Insect Emergence in Prairie Wetlands. The Society of Environmental Toxicology and Chemistry: Prairie Northern Chapter. Saskatoon, SK. June.
- Cruz-Hernández, P., Lindsay, M.B.J., Parviainen, A., Pérez-López, R., and Nieto, J.M. 2014. Arsenic mobilization in iron precipitates from Acid Mine Drainages at different time-scales. Proceedings of the XXXIV Reunión Científica de la Sociedad Española de Mineralogía, July 2–7, Granada, Spain.
- Das, S., Hendry, J. and Lindsay, M.B.J. 2014. Laboratory evaluation of selenium treatment using zero-valent iron (ZVI) under oxic conditions. GSA Annual Meeting, October 19–22, Vancouver, Canada.
- David, C., Farrell, R., and Helgason, W. 2014. The influence of irrigated crop management on soil greenhouse gas fluxes: A Saskatchewan example. Proceedings of Soils and Crops 2014 Workshop, March 11-12, Saskatoon, SK.
- David, C., Lemke, R., Wahab, J., Helgason, W., and Farrell, R. 2014. The effect of fall nitrogen and cropping sequence on GHG emissions under irrigation. Canadian Geophysical Union Annual meeting, Banff, Alberta, May 4-7.
- David, C., Helgason, W., and Farrell, R. 2014. Irrigation induced changes in seasonal soil conditions and resulting greenhouse gas dynamics. Canadian Geophysical Union Annual meeting, Banff, Alberta, May 4-7.
- Dhillon, G. S., and Van Rees, K. C. J. 2014. Carbon sequestration potential of the shelterbelt agroforestry systems. Soil Science Society of America Annual Meeting, Long Beach CA, USA. November.
- Dhillon, G. S., Peak, D., and Van Rees, K. C. J. 2014. Prediction of soil organic carbon (SOC) concentration using ATR-FTIR for shelterbelts and agricultural fields in Saskatchewan. Soil Science Society of America Annual Meeting, Long Beach CA, USA. November.
- Ferdous, J., Helgason, W., and David, C. 2014. The effect of irrigation upon surface energy flux, soil environment, and greenhouse gas emissions. Canadian Geophysical Union Annual meeting, Banff, Alberta, May 4-7.

- Ford, L. and Bharadwaj, L. 2014. Groundwater Consumption in Rural Communities Impact of Risk Perception on Human Health. 7thInternational Symposium: Safety & Health in Agricultural & Rural Populations, in Saskatoon, October 19-22.
- Giesy, J.P. 2014. Health Status of Fishes from the Athabasca and Slave River System, Northern Canada, With P. Jones, A. Hill, B.J. Tendler, E. Ohiozebau, E. Kelly, J. Fresque-Baxter. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13,.
- Giesy, J.P. 2014. Pursuing the Chemical Culprits: What Organic Compounds are Responsible for Toxicity of Oil Sands Process- Affected Water? With: S.B. Wiseman, A. dos Santos Pereira, G. Morandi, R. Mankidy, Z. Kun, N. Zetouni, E.K. Asiedu, J.W. Martin. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. The Presence of Polycyclic Aromatic Hydrocarbons in edible fish tissue from the Athabasca/Slave river system, Canada, With: E. Ohiozebau, B. Tendler, A. Hill, G. Codling, E. Kelly, P. Jones. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Functionality of aryl hydrocarbon receptors (AhR1 and AhR2) of white sturgeon and implications for the risk assessment of dioxin-like compounds, With: J. Doering, R. Farmahin, S.B. Wiseman, S.W. Kennedy, M. Hecker. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Mixtures of Two Novel Brominated Flame Retardants Affect Fecundity and Transcript Profiles of the HPGL-Axis in Japanese Medaka, With: D.M. Saunders, M. Podaima, G. Codling, S. Wiseman. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Assessment of PAHs and PCBs in sediment in aquatic systems in Durban, South Africa, using chemical and biological analysis, With: N.L. Vogt, R. Pieters, B. Newman. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Assessing biological effects of municipal wastewater effluent using the fathead minnow reproductive bioassay, With: K. Steeves, S. Hanson, T. Bagatim, S.B. Wiseman, P.D. Jones, M. Hecker, A. Hontela, N. Hogan. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Assessing potential endocrine disrupting effects of municipal effluents on fathead minnow (Pimephales promelas) populations in Southern Saskatchewan, With S. Hanson, T. Bagatim, K. Steeves, S.B. Wiseman, N. Hogan, A. Hontela, P.D. Jones, M. Hecker. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Bioassay-directed characterization of endocrine-disrupting potencies of municipal effluents in Canada, With: T. Bagatim, S. Hanson, K. Steeves, S.B. Wiseman, N. Hogan, P.D. Jones, M.Hecker. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.

- Giesy, J.P. 2014. Reconstructing long-term limnological trends in phytoplankton and toxin production using paleogenomics and next generation sequencing. With T. Tse, A. Hill, S. Wiseman, M. Hecker, L.E. Doig, H. Wheater, P.D. Jones. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Teratogenic Retinoic Acids in Aqueous Environment, With: J. Hu, X. Wu, J. Jinag, Y. Wan. To Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Chemical Profile of Swift Current Wastewater Treatment Plant Discharge and Its Potential Effects." With: H. Yuan, G. Codling, H. Wheater, M. Hecker, P.D. Jones. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Species-specific bioaccumulation of perfluoroalkyl acids (PFAAs) in intertidal organisms of the west coast of South Korea, with J. Khim, S. Hong, T. Wang, J.E. Naile, J. Park, B. Kwon, S. Song, J. Ryu, G. Codling, P.D. Jones, Y. Lu. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Assessing the mechanistic toxicity of oil sands process affected waters (OSPW) using a genome wide live cell array reporter system, with: G. Morandi, H. Al Harbi, R. Mankidy, A. dos Santos Pereira, J. Martin, S. Wiseman. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Is oxidative stress a mechanism of toxicity of oil sands process affected water? With: S.B. Wiseman, Y. He, G. Morandi, R. Mankidy, H. Al Harbi, A. dos Santos Pereira, J.W. Martin. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13, 2014.
- Giesy, J.P. 2014. Inhibition of multi-xenobiotic resistance (MXR/MDR) efflux activity as a potential mechanism of toxicity of oil sands process affected water, with: H. Al Harbi, D.M. Saunders, J.W. Martin, A. dos Santos Pereira, S.B. Wiseman. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Reporter gene screening for endocrine disruptive compounds in the aquatic environment of a South African game reserve downstream of a DDT sprayed area, With: R. Pieters, M. Delport, M. Hannam, S. Prinsloo, V. Wepener, N.J. Smit, Y. Ikenaka, M. Ishizuka. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Organophosphorous pesticides in honey, pollen and bees (Apis mellifera L.) and their potential hazard to bee colonies in Egypt, with: Y. Al. Naggar, A. Vogt, G. Codling, E. Naem, M. Mona, A. Saif. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Effect-directed analysis and mixture effects of AhR-active compounds in crude oil and oil-contaminated sediments, with: S. Hong, J. Khim, S. Lee, K. Choi, G. Kim, S. Ha, U. Kim, W. Shim, J. Jung. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.

- Giesy, J.P. 2014. Mixed Halogenated Carbazole Identification and Spatial Distribution and Temporal Trend in the Sediments of Upper Great Lakes, with: J. Guo, D. Chen, A. Li, Z. Li, P.A. Padiara, K. Rockne, N. Sturchio, D. Potter, R. Yang. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Chemodynamic behavior of Thallium in the Slave River, Northwest Territories, Canada, with: B.J. Tendler, A. Hill, E. Ohiozebau, E. Kelly, J. Fresque-Baxter, P.D. Jones. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Two Highly Brominated Flame Retardants Are Photolytically Degraded to Biologically Active By-Products: Cytotoxic Effect and mRNA Expression in CEH, with: G. Su, R.J. Letcher, D. Crump, R. Farmahin, S.W. Kennedy. To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Giesy, J.P. 2014. Legacy and Emerging Halogenated Organic Compounds in the Surface Sediments of Lake Huron, with: Z. Li, P. Ranasinghe, J. Guo, A. Li, K.J. Rockne, J.P. Giesy, and N. C. Sturchio. To: To: Society of Environmental Toxicology and Chemistry, 35th Annual meeting, Vancouver, BC, Canada, November 9-13.
- Gonda, J., Elshorbagy, A., Wheater, H. and Razavi, S. 2014. Scale vs. Complexity: A Multi Scale Water Resources Model. The 2014 AGU Fall Meeting, San Francisco, USA, December 15-19 (Poster presentation).
- Helgason, W. 2014. Factors influencing snow surface heat exchange and surface temperature dynamics. Canadian Geophysical Union Annual meeting, Banff, Alberta, May 4-7.
- Kehoe, M., and Baulch, H. 2014 Seasonal and decadal dynamics in long term algal and limnological data set. Global Lakes Ecological Observatory Network Meeting. Quebec.
- Kim, J., and Chang, W. 2014. Site remediation in northern climates: microbial respiration models for petroleum hydrocarbon-contaminated soils at low temperatures. 67th Canadian Geotechnical Conference Proceedings (CD-ROM), GeoRegina 2014, Regina, SK. Sept. 28-Oct. 1, 2014.
- Koehler, B., Barbour, S.L., and Ferguson, G. 2014. An Evaluation of Density Dependant Convective Airflow Causing Accelerated Drying of Reclamation Soil Covers. 67th Canadian Geotechnical Conference.
- Liu, Q., Mohamed, M.H., and Wilson, L.D. 2014. Kinetic Uptake Studies of Powdered Materials in Solution", U of S Chemistry Research and Awards Day, Saskatoon, SK. (September 2014).
- Helgason, B.L., VandenBygaart, A.J., Konschuh, H.J., Bedard-Haughn, A., Gillespie, A.W. and Gregorich, E.G. 2014. Erosion and burial of C in croplands: Is it biologically available? Sixth International Workshop on Soil and Sedimentary Organic Matter Stabilization and Destabilization (SOM6), Kiawah Island, SC.
- Mack, M.C., Alexander, H.D., Melvin, A.M., Jean, M., and Johnstone, J.F. 2014. Plant functional traits reinforce alternate successional trajectories in Alaskan boreal forest. Ecological Society of America annual meeting, Sacramento, CA, August 2014.

- Main, A.R., Michel, N.L., Headley, J.V., Peru, K.M., Cessna, A.J. and Morrissey, C.A. 2014. Drivers of neonicotinoid fate and persistence in Prairie wetlands. SETAC, North America, Vancouver, BC, November 9-13.
- Melvin, A.C., Mack, M.C., Johnstone, J.F., Schuur, E.A.G., Genet, H., and McGuire, A. D. 2014. Tree species linked to large differences in ecosystem carbon distribution in Alaskan boreal forest. American Geophysical Union annual fall meeting, San Francisco, CA, December 2014.
- Millette, V., Marleau, N., Ansdell, K., and Laroque, C.P. 2014. Basalt Composition at an old mine site in Saskatchewan: Is there a link with Soil Composition and Tree Growth? Annual Saskatchewan Geological Survey Open House, December 2014, Saskatoon SK.
- Masse, A., and Muscatello, J. 2014. Establishing dose-dependent developmental effects of maternal dietary selenium in the model amphibian species Xenopus laevis. Society of Environmental Toxicology and Chemistry, Vancouver, Canada
- Mclaughlin, K., and Bharadwaj, L. 2014. Community-based participatory research to address cistern drinking water quality: experiences from Beardy's Okemasis First Nation, Saskatchewan. Indigenous Health Conference; Toronto, ON November 2014 Challenging Health Inequities Indigenous Health Conference November 20-21, 2014 | University of Toronto Conference Centre
- Mclaughlin, K., and Bharadwaj, L. 2014. Trucked to Cistern Water Supply: What are the Risks? 7th International Symposium: Safety & Health in Agricultural & Rural Populations: Global Perspectives (SHARP); Saskatoon, SK October 2014
- Mclaughlin, K., and Bharadwaj, L. 2014. Risks to the Trucked to Cistern Water Supply in a Saskatchewan First Nation Community Prairie Association of Geographers Conference (PCAG); Riding Mountain National Park, MB September 2014.
- Michel, N.L., Clark, R.G., Hobson, K.A., and Morrissey, C.A. 2014. Population dynamics of aerial insectivorous birds: overview and climatic drivers. Joint meeting of American Ornithologists' Union, Cooper Ornithological Society, and Society of Canadian Ornithologists, Estes Park, CO. 24 September.
- Michel, N.L., Clark, R.G., Hobson, K.A., and Morrissey, C.A. 2014. Aerial insectivorous bird declines: When? Where? Why? WildEcol seminar series, University of Saskatchewan and Environment Canada, Saskatoon, SK. 22 October.
- Michelson, C.I., Clark, R.G. and Morrissey, C.A. 2014. Agricultural intensification does not disrupt the picky eating habits of tree swallows (Tachycineta bicolor). Joint meeting of the American Ornithologists' Union, Copper Ornithological Society, and Society of Canadian Ornithologists, Estes Park, CO. 24 Sept.
- Michelson, C.I., Morrissey, C.A., Stanton, R.L., and Clark, R.G. 2014. Effects of agricultural intensification on tree swallow (Tachycineta bicolor) reproduction and nestling body condition. Joint meeting of the American Ornithologists' Union, Copper Ornithological Society, and Society of Canadian Ornithologists, Estes Park, CO. 26 Sept.
- Muldoon, B., and Hogan, N.S. 2014. A novel method for the assessment of androgenic and estrogenic compounds using the brook stickleback (Culaea inconstans). North American

- Society of Environmental Toxicology and Chemistry Annual Meeting. November 9-13, Vancouver, BC.
- Nazemi, A., Alam, S., and Elshorbagy, A. 2014. Uncertainties in Future Projections of Extreme Rainfall at Fine Scales: The Role of Various Sources. The 11th International Conference on Hydroinformatics, New York City, USA, August 17-21, 4 pp.
- North, R., Baulch, H., and Lindenschmidt, K.-E. 2014. Winter Limnology Studies of Prairie Reservoirs. Lake assessments sessions presented at: NALMS 34th International Symposium, November 11-14, Tampa, Florida.
- Nuesser L., Brack W., Patterson S., Wiseman S., Seiler T.B., M. Hecker, Hollert H. 2014. Assessment of the toxicogenomic potential of complex industrial wastewater effluents in zebrafish using RNA sequence-bysynthesis technology and qPCR. SETAC North America 35th Annual Meeting, Nov 9-13, Vancouver, Canada.
- Patrick, R. 2014. Prairie Division Canadian Association of Geographers, September, Elkhorn Lodge, MB.
- Patterson, S., Zee, J., Wiseman, S., and Hecker, M. 2014. Effects of Chronic Dietary Selenomethionine Exposure on the Physiological Stress Response in Juvenile White Sturgeon (Acipenser transmontanus). SETAC North America 35th Annual Meeting, Nov 9-13, Vancouver, Canada.
- Pernica, P., North, R., and Baulch, H. 2014. A method to estimate mixing depth under ice in midlatitude lakes. Global Lakes Ecological Observatory Network Meeting. Quebec.
- Pomeroy, J., Dumanski, S., Shook, K., and Westbrook, C. 2014. Changes to prairie flooding and implications for the Saskatchewan River Basin. Saskatchewan River Threat conference, October 28, Regina, SK.
- Razavi, S., Elshorbagy, A., Wheater, H. and Sauchyn, D. 2014. Reconstruction of Paleo-hydrologic Data for Vulnerability Assessment of Water Resources Systems. The 11th International Conference on Hydroinformatics, New York City, USA, August 17-21, 4 pp. (paper 1378 & Oral presentation).
- Pratt, D.L., Hendry, M.J., Barbour, S.L. and Schmeling, E. 2014. Optimization and Configuration of a Hydrocarbon Gas Removal System for the Determination of δ2H and δ18O on Picarro CRDS. 2014 GSA Annual Meeting, Vancouver, British Columbia, Oral Presentation, Abstract only published (No. 246284) in GSA Abstracts with Programs Vol. 46, No. 6, Session 161-2: "T161 (Hendry, Barbour): Application of Isotopes of Water to Characterize Hydrogeological Processes in Mine Environments", Oct. 20.
- Qin, G., Tang, S., Beitel, S., Doering, J., Liu, H., Wang, M., Du, H. and Hecker, M. 2014. Impact of predator cues on responses to silver nanoparticles in Daphnia carinata. SETAC North America 35th Annual Meeting, Nov 9-13, Vancouver, Canada.
- Razavi, S., and Gupta, H.V. 2014. What Do We Mean By Sensitivity Analysis? The Need For A Comprehensive Characterization Of Sensitivity In Earth System Models, American Geophysical Union (AGU) Meeting, December 15-19, San Francisco, CA.

- Ryan, A., Santore, R., Vardy, D., and Hecker, M. 2014. Evaluating the likelihood that early life stages of white sturgeon were affected by metals in sediment exposures. SETAC North America 35th Annual Meeting, Nov 9-13, Vancouver, Canada.
- Sadeghian, A., Hudson, J., Wheater, H., and Lindenschmidt, K.-E. 2014. Lake Diefenbaker Hydrodynamic Model. Lake assessments sessions presented at: NALMS 34th International Symposium, November 11-14, Tampa, Florida.
- Sadeghian, A., Hudson, J., Wheater, H., and Lindenschmidt, K.-E. 2014. Lake Diefenbaker Hydrodynamic Model. Poster sessions presented at: NALMS 34th International Symposium, November 11-14, Tampa, Florida.
- Sagin, J., Dussion, R., Zagozewski, R., and Bharadwaj, L. 2014. Landfill a Risk Hazard in Cumberland House Reserve and Village of Cumberland House. 11th Annual Canadian Risk and Hazards Network Symposium, Eaton Chelsea, Toronto October 22-24.
- Smith, L.A., Hendry, M.J., and van der Kamp, G. 2014. A new technique for determining in situ parameters of argillaceous deposits using pore pressure responses. GeoConvention 2014: FOCUS. Calgary, Alberta, Canada, May 12-14.
- Stanton, R., Clark, R.G., and Morrissey, C.A. 2014. Indirect effects of agricultural intensification and pesticides on tree swallow (Tachycineta bicolor) foraging, body condition and stress physiology. 2014. Society of Environmental Toxicology and Chemistry (SETAC). Vancouver, BC.
- Stanton, R., Clark, R.G., and Morrissey, C.A. 2014. Indirect effects of agricultural intensification on components of tree swallow (Tachycineta bicolor) stress physiology. 2014. AOU/COS/SCO Joint Meeting. Estes Park, CO. 27 September.
- Stanton, R., Clark, R.G., and Morrissey, C.A. 2014. Indirect effects of agricultural intensification on tree swallow (Tachycineta bicolor) foraging and dispersal behaviours. AOU/COS/SCO Joint Meeting, Estes Park, CO. 25 September.
- Steeves, J., Barbour, S.L., Ferguson, G., and Carey, S. 2014. The role of forced convection in thawing a sloped frozen layer. 67th Canadian Geotechnical Conference.
- Steeves, J., Barbour, S.L., and Ferguson, G. 2014. The role of forced convection in thawing a sloped frozen layer. GeoRegina 2014, 67th Canadian Geotechnical Conference Proceedings, Sept.28-Oct.1.
- Terry, J. A., Baulch, H. M., Bauer, J., Sagin, J., and Lindenschmidt, K.-E. 2014. Whole lake modelling to understand complex processes. Global Lakes Ecological Observatory Network Meeting. Quebec.
- Thomas, J. (2014). Mechanisms of developmental toxicity in zebrafish exposed to selenium. International Congress on the Biology of Fish, Edinburgh, United Kingdom
- Walker, X.J., Mack, M.C., and Johnstone, J.F. 2014. Radial growth and  $\delta$  13 C responses of black spruce to climate. Ecological Society of America annual meeting, Sacramento, CA, August 2014.
- Westbrook, C.J., Morrison, A., Wang, X., and Bedard-Haughn, A. 2014. Subsurface complexity of Rocky Mountain peatlands regulates carbon and nitrogen dynamics. American Geophysical Union Annual Meeting, San Francisco, CA.

- Villeneuve, D., Crump, D., Garcia-Reyero, N., Hecker, M., Hutchinson, T., Lalone, C., Landesmann, B., Lettieri, T., Munn, S., Nepelska, M., Ottinger, M., Vergauvwen, L., and Whelan, M. 2014. Adverse Outcome Pathway (AOP) Development: Guiding Principles and Best Practices. SETAC North America 35th Annual Meeting, Nov 9-13, Vancouver, Canada.
- Zee, J., Patterson, S., Wiseman, S., Gagnon, D., and Hecker, M. 2014. Is Oxidative Stress the Main Driver of Selenium Toxicity in Juvenile White Sturgeon (Acipenser transmontanus). SETAC North America 35th Annual Meeting, Nov 9-13, Vancouver, Canada.
- Zheng X., Tang S., Liu H., Hecker, M., and Wiseman, S. 2014. Effects of 6-OH-BDE-47, 6-MeO-BDE-47 and BDE-47 on receptor-associated mRNA expression in zebrafish embryos/larvae. SETAC North America 35th Annual Meeting, Nov 9-13, Vancouver, Canada.
- Zuniga-Benitez, H., Soltan, J., and Penuela, G. 2014. Effect of sonication operating parameters on Benzophenone-3 degradation, The 20th International Conference on Advanced Oxidation Technologies for Treatment of Water, Air and Soil (AOTs -20), San Diego, California, November 17-20.

# **Books and Book Chapters - 2015**

- Giesy, J.P. and Jones, P.D. 2015. Perfluorinated Substances in the Environment: History of an Environmental Issue. Pp. 74-78 In: Newman, M.C. Fundamental of Ecotoxicology: The Science of Pollution, 4th Ed. CRC Press, Boca Raton, FL. 654 p.
- Gober, P., and Quay, R. 2014. Harnessing urban water demand: The challenges ahead. In Handbook on Urbanization and Global Environmental Change, eds., K.C. Seto and W. Solecki. Taylor & Francis, forthcoming.

### **Books and Book Chapters - 2014**

- Janz D. 2014. Dithiocarbamates. Wexler P. Encyclopedia of Toxicology. 3rd edition: 212-214.
- Janz D. 2014. Chlorobenzilate. Wexler P. Encyclopedia of Toxicology. 3rd edition: 874-875.
- Janz D. 2014. Hexachlorobutadiene. Wexler P. Encyclopedia of Toxicology. 3rd edition: 872-873.
- Janz D. 2014. Dinitrophenols. Wexler P. Encyclopedia of Toxicology. 3rd edition: 177-178.
- Pomeroy, J.W. 2014. October 13: John Pomeroy. Global Chorus: 365 Voices on the Future of the Planet, Rocky Mountain Books: 318-318.
- Sauchyn, D., Bonsal, B., Kienzle, S., St Jacques, J., Vanstone, J., and Wheaton, E. 2014. Adaptation according to Mode of Climate Variability: A Case Study from Canada's Western Interior. Pp. 1-24 Chapter in Leal Filho, W(ed) Handbook of Climate Change Adaptation. Springer-Verlag, Berlin, Heidelberg, DOI: 10.1007/978-3-642-40455-9\_93-1.

  Available at http://link.springer.com/referenceworkentry/10.1007/978-3-642-40455-9\_93-1
- Wheater, H.S., and Gober, P. 2014. Meeting the Science Challenges of Water Security in the Saskatchewan River Basin: a Regional Hydroclimate Project from Western Canada. In Proceedings of the Dooge-Nash International Symposium, Dublin, April 23-24.

# Plenary, Key Note and Invited Lectures - 2015

- Barbour, S.L. 2015. Evaluation of Soil Atmosphere Vegetation Transfers (SVAT) for mine closure applications. **P**resentation at Technical Meeting for N.Ireland Geotechnical Group (NIGG), Institution of Civil Engineers (ICE), QUB, N.Ireland, May 8, 2015.
- Barbour, S.L. 2015. On joint research, with D. Hughes and grad students at QUB, N.Ireland, **May** 7, 2015.
- Barbour, S.L. 2015. Invited talks for UK: Geotechnical modeling using SLOPE/W, SEEP/W, SIGMA/W. GeoSlope International Geotechnical Modeling Workshop (May 5-6, 2015, London).
- Barbour, S.L. 2015. EPSRC (UK) funded multi-university research study (ISMART, http://www.ismartproject.org/project/community.html). This group (Hughes, Briggs, etc) is attempting to link SW/GW models to geotechnical infrastructure, QUB, N.Ireland, May 4, 2015.
- Bedard-Haughn, A., Pennock, D., and Helgason, B. 2015. What lies beneath: Carbon in wetland and buried soils. Grassland Carbon Workshop, University of Alberta, Edmonton, AB.
- Bedard-Haughn, A. 2015. Soils in the Landscape: Micro- and macro-scale variability. Soils and Crops 2015, International Year of Soils Special Session. Saskatoon, SK.
- Ferguson, G. 2015. Using co-produced water and disposal wells to assess the geothermal potential of sedimentary basins. 2015 American Geophysical Union Joint Assembly. Montreal, QC. May 3-7.
- Ferguson, G. 2014. Heat Transport in Low-Temperature Geothermal Developments. Geological Society of America Annual Meeting. Vancouver, BC. October 19-22.
- Ferguson, G. 2014. Data, Knowledge and Research Needs. Saskatchewan Groundwater Workshop. Saskatoon, SK. Oct. 1.
- Giesy. J.P. 2015. Perfluorinated Chemicals in the Environment: Anatomy of an Environmental Issue. Canadian Society of Zoologists, Annual Meeting, May 25-29, Calgary, AB.
- Patrick, R. 2015. Prince Albert Model Forest. Board of Directors Meeting. "Source water protection planning for safe drinking water with First Nations". Prince Albert, SK, February 10.
- Patrick, R. 2015. Capilano University (Sechelt, BC campus). "Watershed Planning for Source Water Protection". Sechelt, BC. March 11.
- Pickering, I.J. 2015. Applications of X-ray Absorption Spectroscopy in Life Sciences. 17th National School on Neutron and X-ray Scattering, Argonne National Laboratory, Argonne, IL, USA, June 17.
- Pickering, I.J., and George, G.N. 2015. Metals and Molecules: Illuminating Problems in Human Health with Synchrotron Light. Seminar, Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, CA, USA, March 27.
- Razavi, S. 2015. Sensitivity Analysis for Hydrological Inferences, Discussion Meeting on Quantification and Reduction of Uncertainties in Hydrological Inferences, invited and sponsored by the Indian Academy of Sciences, February 26-28, Bangalore (Coorg), India.

- Spence, C., Brannen, R., Hedstrom, N., Kokelj, S.V., Kokelj, S., McCluskie, M., and Westbrook, C. 2015. The strengths and weaknesses of using hydrological connectivity to interpret stream biogeochemistry. AGU-CGU Joint Congress, May, Montreal, Canada.
- Steelman, T.A., and Nowell, B. 2015. "Managing Wildfire Networks: Brokering Relationships and Mission Conflict." Webinar for U.S. Forest Service, Public Affairs. May 21.
- Steelman, T.A. 2015. "Wildfire Policy as a Socio-Ecological Problem." Invited Plenary. 13th International Wildland Fire Safety Summit and 4th Human Dimensions of Wildland Fire Conference. Boise, ID. April.
- Strickert, G.E. 2015. Livable Cities Forum: Building Flood Resilient Communities A National Dialogue, in Calgary, AB Tools and Concepts for Designing Resilient Cities: Concept Maps, Uncomfortable Knowledge and Clumsy Solutions. September 28th 30th, 2015.
- Strickert, G.E. 2015. Reconsidering Outreach. University of Saskatchewan Engaged Scholars Day, Saskatoon, Saskatchewan, April.
- Van Rees, K. 2015. Site and Forest Productivity. Mistik Management Ltd. Public Advisory Group Workshop. March 19, 2015. Meadow Lake SK.
- Westbrook, C.J. 2015. Beaver in Tierra del Fuegian wetlands. 2015. World Wetlands Day, University of Waterloo, February 2.
- Wheaton, E. 2015. Drought and Water Policy. Invited presentation to "Living with Less Water" conference, Institute on Science for Global Policy, 20-21 Feb, Tucson, AZ, USA.
- Wheaton, E. 2015. Droughts Challenge Water Resource Management and Policy. Policy paper prepared for the Institute on Science for Global Policy, "Living with Less Water Conference," 20-21 Feb, Tucson, AZ, USA.
- Wheaton, E. 2015. Anticipating Climate Risks for the Canadian Prairies. Invited presentation to Saskatchewan Institute of Agrologists' 2015 Convention, 15 April, Regina, SK.
- Wilson, L.D. 2015. NMR Structural Studies of Cyclodextrin-Perfluorocarbon Guest Systems. 2nd Crystal Engineering and Emerging Materials Workshop of Ontario and Quebec, Guelph, ON. (Professor D. Soldatov) [June 2015]
- Wilson, L.D. 2015. Green Chemistry Strategies for the Remediation of Waterborne Contaminants. 2015 Conference on Environmental Pollution and Public Health, Dalian, China (April, 2015)
- Wilson, L.D. 2015. Biopolymer Adsorbent Materials for Environmental Remediation. Beijing, China (Professor Xiao Feng) [April 2015]

### Plenary, Key Note and Invited Lectures - 2014

Barbour, S.L. 2014. Tracking Water Movement in Closure Landforms in Oil Sands Mines - Extending Temporal and Spatial Monitoring Scales". 2014 GSA Annual Meeting in Vancouver, British Columbia, Oral Presentation, Abstract only published (No. 246104) in GSA Abstracts with Programs Vol. 46, No. 6, Session 145-2: Pardee Keynote Session P3 (Ferguson, Manning), "Energy Resource Development and Groundwater: Looking Broader and Deeper II", Oct. 20.

- Bangsund, A.L., Hendry, M.J., Barbour, S.L. and Huang, M. 2014. Origin, transport and fate of dissolved gases in a two-tiered aquitard system, central Saskatchewan, Canada. Geological Survey Open House, Saskatoon, SK, Dec. 1-3, 2014.
- Barbour, S.L. 2014. IRC Research: Syncrude Cda Ltd seminar/mtgs/discussions: for Barbour & his students/research staff to give presentations/updates on their IRC work/projects, Edmonton AB, Nov. 25, 2014.
- Barbour, S.L. 2014. SCL Research: Syncrude Cda Ltd Base Mine Lake R&D Team meetings, Edmonton AB, Nov. 6-7, 2014.
- Barbour, S.L. (Keynote Address). 2014. SCL's 50th Anniv. R&D Seminar entitled: The Changing Colour of Environmental Research and Closure... the journey from Green to Blue, Edmonton, AB, Two presentations: Nov.5 and Nov.26, 2014, Barbour presented.
- Barbour, S.L. 2014. Geotechnical modeling using SLOPE/W, SEEP/W, SIGMA/W. GeoSlope International Geotechnical Modeling Workshop, Nov.3-4, 2014, Calgary, AB.
- Barbour, S.L. 2014. Evaluation of Soil Atmosphere Vegetation Transfers (SVAT) for Mine Closure Applications. SMA Environmental Forum, Saskatoon, October 2014.
- Barbour, S.L. (Short Course Presenter). 2014. Cover Systems for Managing Solid Waste Design, Construction, and Performance Monitoring. Presented at: GeoRegina 2014, Regina, SK, Canada, with Mike O'Kane Justin Straker, Gord McKenna, Sept. 28, 2014.
- Barbour, S.L. 2014. SCL Hydrogeology Research: Syncrude Cda Ltd mtgs/discussions: for Barbour/Lindsay/Fleming/Ireson to give presentations/updates on their IRC work/SCL projects to D. Heisler (SCL), Saskatoon SK, Sep. 24-25, 2014.
- Bharadwaj, L. and Goldstein, B. 2014. Shale Gas Development in Canada: What are the Potential Health Impacts? Canadian Medical Association Journal October 6th, 2014. Invited Commentary.
- Dumanski, S., Pomeroy, J., and Westbrook, C. 2014. Impact of increasing rainfall and rain-on-snow on flood generation in a Canadian Prairie catchment. AGU, San Francisco, USA, Dec 15-19.
- Giesy, J.P. 2014. Effects of sub-lethal doses of organophosphorus insecticides on honey bee survival and learning. With: Y. Al Naggar, E. Naiem, M. Mona, A. Seif, C. Cutler, J.P. Giesy. To: Joint Annual meeting with Entomological Society of Saskatchewan. Saskatoon, Sk, Canada. September 28- October 1.
- Hecker, M. 2014. Characterization of adverse outcome pathways of ethynylestradiol in Xenopus laevis With: Tompsett A., Higley E., Pryce S., Wiseman S., Giesy J. 41st Aquatic Toxicity Workshop in Ottawa, ON, Canada. Sep 28 Oct 1.
- Hecker, M. 2014. Effect Director Analysis: A novel approach for the assessment of complex mixtures of contaminants With: Wiseman S., Higley E., Giesy J., Jones P., Yuan H. 41st Aquatic Toxicity Workshop in Ottawa, ON, Canada. Sep 28 Oct 1.
- Lindsay, M.B.J. 2014. Groundwater contamination, remediation, and management in mining environments. Synchrotron Environmental Science VI, September 11–12, Argonne National Laboratory, IL, USA.

- Matthies, R., Blowes, D.W., Sinclair, S.A., Lindsay, M.B.J., and Ptacek, C.J. 2014. Application of zinc isotope ratio measurements to two mine-waste systems. GSA Annual Meeting, October 19–22, Vancouver, Canada.
- Morrissey, C.A, Mineau, P., Devries, J., Sanchez-Bayo, F., Liess, M., Cavallaro, M., and Liber, K. 2014. Society for Environmental Toxicology and Chemistry. Evaluation of worldwide contamination of surface waters and relative risks to aquatic invertebrates from neonicotinoid insecticides Vancouver, B.C. November 2014.
- O'Kane, M.A., and S.L. Barbour. 2014. Challenges with measuring cover system performance. 21st Annual BC-MEND ML/ARD Workshop: "Challenges and Best Practices in Metal Leaching and Acid Rock Drainage", UBC, Vancouver, B.C., Dec.3-4.
- Patrick, R. 2014. Technical Services Alberta Group (Alberta). Annual Conference. Edmonton, AB. Building Community Resilience with Source Water Protection. October 17.
- Patrick, R. 2014. Saskatchewan Aboriginal Land Technicians. Annual Conference. Planning for source water protection using the AANDC template. Saskatoon, SK. August 2.
- Patrick, R. 2014. Partners for the Saskatchewan River Basin. Annual Conference. Source water protection planning at Muskowekwan First Nation. Saskatoon, SK. October 27.
- Patrick, R. University of Northern British Columbia (Terrace Campus). "Getting from Good to Great: Place-Making for Sustainability in Terrace, BC". Terrace, BC. January 14, 2014.
- Pickering, I.J. 2014. Mercury, fish and risks to human health: how synchrotron X-rays can help our understanding. Departmental Seminar, Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL, November 25.
- Smith, L., Barbour, S.L., Hendry, J., and van der Kamp, G. 2014. Geological Weighing Lysimeters Applications to Mine Hydrology. SMA Environmental Forum, Saskatoon, October.
- Strickert, G.E. and Bradford, L.E. 2014. Performing Perspectives on Water Security A play about the making of a play. The Partners for the Saskatchewan River Basin Annual Conference. Saskatoon, Saskatchewan, June 20.
- Strickert, G.E. 2014. Water Security and Systems Thinking: A introduction to fuzzy cognitive maps. Geography and Planning, GEPL385: Analysis of Environmental Management and Policy Making, School of Environment and Sustainability, University of Saskatchewan, October 7.
- Van Rees, K. 2014. Creativity and Innovation: an example with soil and art. Celebration of Teaching, University of Saskatchewan Sept 12.
- Wheaton, E. 2014. Past Climate Trends and Future Projections: Impacts on Agriculture in the Canadian Prairies. Invited presentation to the Canadian Entomology Society, 29 Sep, Saskatoon, SK.
- Wheaton, E. 2014. Food Security and Climate Change: Canadian Prairie Agriculture. Invited presentation to the Canada World Youth, 8 Oct, Saskatoon, SK.
- Wilson, L.D. 2014. Investigation of Polysaccharide Adsorbent Materials. Hangzhou, China, Institute of Polymer Science, Zhejiang University (Professor Xiao-jun Huang), November.
- Wilson, L.D. 2014. Investigation of Polysaccharide Adsorbent Materials. Tianjin, China, Environmental Science and Engineering, Nankai University (Professor Jingchun Tang), November.

Wilson, L.D. 2014. Thermodynamic Properties of Surfaces and Interfaces. Shanghai, China, Department of Chemistry, East China University of Science and Technology (Professor Yi-tao Long), November.

#### **Patent**

- Hecker, M. 2015. United States Patent Application No. 61/242,822: Steroidogenesis Modified H295R Cells and Methods for Screening for Endocrine Disrupting Chemicals. Granted.
- Laroque, C. Patent Projects (pending) ROI 14-019 re Pro6 Band Dendrometer prototype development.
- Razavi, S. and Gupta, H. 2015. Methods and systems for determining global sensitivity of a process, US (Non-provisional) Patent App. No. 14/752,268, Filed June 26, 2015.

### APPENDIX F - Collaborations and Outreach

#### Barbour, Lee

- Profiled on the <u>NSERC Dashboard</u> ('Restoring Contaminated Sites'); <a href="http://www.nserc-crsng.gc.ca/db-tb/index-eng.asp?province=12&category=0">http://www.nserc-crsng.gc.ca/db-tb/index-eng.asp?province=12&category=0</a>
- 'Cornerstone' 50 yr Anniv. of SCL Magazine Article; 'Reclamation Rockstar Sycrude funding helps a Univeristy of Saskatchewan researcher better understand watersheds', pg. 84-85, by Ashleigh Mattern/ photos by John Gaucher; <a href="http://www.syncrude.ca/assets/pdf/Fifty-Anniversary/Cornerstone Syncrude 2014 LR.pdf">http://www.syncrude.ca/assets/pdf/Fifty-Anniversary/Cornerstone Syncrude 2014 LR.pdf</a>
- Summary of Journal of Environmental Quality article (Li/Barbour/Si): "Measuring solid percentage of oil sands mature fine tailings using the dual probe heat pulse method," Invited to be published Feb.3/15 in: CSA News Magazine 2015 60:15-15 (distribution to all ASA, CSSA, and SSSA members), New summary title: 'Consolidation of Oil Sands Mature Fine Tailings using the Heat Pulse Probe', doi:10.2134/csa2015-60-2-6.

#### Baulch, Helen

- Whitfield et al paper on beaver received extensive media coverage, including the National Post, Star Phoenix, Nature World News, Science World report, Irish Times, CBC radio. News articles were in the 98th percentile of 3 million articles tracked by Altmetric. As of Jan 2015, article has received the most media attention of any article previously published by Ambio.
- Media communications regarding research program on Buffalo Pound Lake, led to coverage on CBC radio, the Green and White and the Sheaf. (Summer/autumn 2014)

# Bedard-Haughn, Angela

- Wetland soils in the agricultural landscape. Presentation at Agriculture Research Review,
   Ministry of Agriculture Regional Services Branch, Saskatoon, SK, November 19, 2014
- Online interview with Lindsey Smith for <u>RealAgriculture.com</u> re: "How long it takes to make soil (Hint: too long)". November 5, 2014

### Bharadwaj, Lalita

• Hydro-Fracking is it Safe? What is the Evidence? Policy Brief. Evidence for Democracy September 24th, 2014.

### Change, Wonjae

• UofS NEWS Media Release http://words.usask.ca/news/2015/07/29/cfi-funds-four-research-projects-at-the-u-of-s/

#### Johnstone, Jill

- Globe and Mail story, "What wildfires in the Northwest Territories say about climate change" by Ivan Semeniuk, 14 July 2014.
- CJWW Radio (Saskatoon), Interview on the afternoon news, 17 July 2014.
- CBC Radio Saskatchewan, Interview on the morning news, with website news story, 18
  July 2014.

NewsTalk650 Radio (Saskatoon), Interview on the Brett Loucks Show, 18 July 2014.

# Morrissey, Christy

- "The New DDT"- Earth Focus feature. Consultant, interviews and pesticide research featured http://youtu.be/EWLPORypiB8
- "The Messenger", Consultant, interviews and research featured as expert on impacts of pesticides on migratory songbirds, Feature film premiere, Hot Docs Film Festival, April 2015
- "Songbird SOS", The Nature of Things, Consultant, interviews and research featured as expert on impacts of pesticides on migratory songbirds, Aired March 2015; <a href="http://www.cbc.ca/natureofthings/episodes/songbirdsos">http://www.cbc.ca/natureofthings/episodes/songbirdsos</a>
- CBC online news article <a href="http://www.cbc.ca/news/technology/bees-birds-may-suffer-long-term-consequences-from-common-pesticides-1.2786859">http://www.cbc.ca/news/technology/bees-birds-may-suffer-long-term-consequences-from-common-pesticides-1.2786859</a>
- CBC Quirks and Quarks radio <a href="http://www.cbc.ca/quirks/2014/10/04/2014-10-04-1/">http://www.cbc.ca/quirks/2014/10/04/2014-10-04-1/</a>
- Environmental Health News feature article http://www.environmentalhealthnews.org/ehs/news/2014/aug/a-new-generation-of-scientists
- Star Phoenix article www.thestarphoenix.com/news/saskatoon/Student+tracks+pesticides+wetlands/10287260/story.html
- Star Phoenix article http://www.thestarphoenix.com/technology/plans+follow+Ontario+lead+pesticides/10418229/story.htm
- The Sheaf's article <a href="http://thesheaf.com/2015/03/18/u-of-s-research-takes-flight-in-songbirdsos-documentary/">http://thesheaf.com/2015/03/18/u-of-s-research-takes-flight-in-songbirdsos-documentary/</a>
- CBC Saskatoon news article online <a href="http://www.cbc.ca/news/canada/saskatoon/are-the-prairies-getting-quieter-songbirds-are-declining-in-number-1.3002029">http://www.cbc.ca/news/canada/saskatoon/are-the-prairies-getting-quieter-songbirds-are-declining-in-number-1.3002029</a>
- CBC Saskatoon and Regina radio <a href="http://www.cbc.ca/player/Radio/Local+Shows/Saskatchewan/Saskatoon+Morning/ID/2660154701/">http://www.cbc.ca/player/Radio/Local+Shows/Saskatchewan/Saskatoon+Morning/ID/2660154701/</a>
  <a href="http://www.cbc.ca/player/Radio/Local+Shows/Saskatchewan/Saskatoon+Morning/ID/2660154701/">http://www.cbc.ca/player/Radio/Local+Shows/Saskatchewan/Saskatoon+Morning/ID/2660154701/</a>
- CBC The Current radio <a href="http://www.cbc.ca/radio/thecurrent/the-current-for-may-1-2015-1.3056951/the-messenger-death-of-songbirds-is-environmental-warning-1.3057085">http://www.cbc.ca/radio/thecurrent/the-current-for-may-1-2015-1.3056951/the-messenger-death-of-songbirds-is-environmental-warning-1.3057085</a>
- Chemical & Engineering News article <a href="http://cen.acs.org/articles/93/web/2015/05/Persistent-">http://cen.acs.org/articles/93/web/2015/05/Persistent-</a> Industrial-Pollutants-Stymie-Songbird.html

#### Pickering, Ingrid

- Canadian Light Source: 10 Years of Discovery with Ingrid Pickering and Graham George.
   One of a series of video vignettes to celebrate 10 years, released March 10, 2015. https://youtu.be/ti-Mial-A14
- Saskatchewanderer Promotional Video: http://saskatchewanderer.ca/?p=1890 or https://youtu.be/T uOYvOfl9M, released online October 29, 2014

### Pomeroy, John

- Cochrane Times (24 Jun 2015): Elbow River Partnership talks flood mitigation
- CTV News Calgary ( 22 June 2015: Farmers fear dry conditions could spell drought this summer
- CTV News (20 June 2015): Developing Drought Risk in Western Canada
- CBC News (16 June 2015): California's drought offers Canada lessons in crisis prevention

- iPolitics / The Sprout (15 June 2015): Western Canada may be in for long-term drought
- Globe and Mail (14th June 2015): Signs of drought appear to be in Western Canada for the long term
- News Talk 980 (5 June 2015): North American droughts and floods linked, Sask. expert
- CBC Radio One Calgary Eyeopener (11 May 2015): Interview covers challenges of managing for flood and drought risks
- CBC News (11 May 2015): Flood mitigation must consider droughts as well, says water expert
- Nature (7 May 2015): Water resources: Research network to track alpine water
- Calgary Herald (9 April 2015): Low snowpack could lead to summer water shortages
- The Star Phoenix (24 Apr 2015): National climate strategy needed, expert says
- Globe and Mail (13 March 2015): Warmer weather in Alberta and B.C.'s mountains creating shorter ski season
- Rocky Mountain Outlook (19 Mar 2015): Rockies-initiated water research network receives global recognition
- NPR (5 Mar 2015): Snow Is Delicious. But Is It Dangerous To Eat?
- Calgary Herald (6 Jan 2015): Ski resorts start to address threat of climate change
- Calgary Herald (30 Dec 2014): Calgary's 2013 flood could have been 'much, much worse,' expert says
- The Nature of Things (13 Nov 2014): Chasing Snowflakes
- Rocky Mountain Outlook (14 Aug 2014): Fortress snow study site Canada's most sophisticated
- Moosomin World Spectator (11 Aug 2014): Hydrology expert says future flooding may be alleviated
- Western Producer (18 Jul 2014): Pay farmers to stop drainage: research chair
- Western Producer (17 Jul 2014): Lake Winnipeg to get worst of flood
- Yorkton This Week (16 Jul 2014): Floods show something is changing
- Winnipeg Free Press (12 Jul 2014): Analysis Manitoba at ground zero
- CBC TV The National (11 Jul 2014): Why did the prairies flood again so soon?
- Yale Environment 360 (10 Jul 2014): Loss of Snowpack and Glaciers In Rockies Poses Water Threat
- ClimateWire (10 Jul 2014): A spectrum of anxiety mounts as unusual weather floods North America's farm belt
- CBC News Manitoba (10 Jul 2014): Draining wetlands contributes to Prairie summer floods, says expert
- NewsTalk 650 (10 Jul 2014):
- Globe and Mail (9 Jul 2014): Loss of ponds, wetlands exacerbated Manitoba flooding: report
- Saskatoon Star Phoenix (9 Jul 2014): Sound advice on water woes
- RCI Radio Canada International (9 Jul 2014): Weird floods "consistent with changes in climate"
- Politics and its Discontents (Blog) (9 Jul 2014): Has Harper Betrayed The West?

- Saskatoon Star Phoenix (8 Jul 2014): More prolonged storms a reality, researcher says
- Saskatoon Star Phoenix (8 Jul 2014): Drainage contributing to flooding, expert says
- Regina Leader Post (8 Jul 2014): Mandryk: Floods tells us our climate is changing
- CBC The Current (8 Jul 2014): State of Emergency: What's the long-term solution to prairie flooding?
- CBC News Manitoba (8 Jul 2014): Manitoba flooding: Next 48 hours critical, province says
- Ruminations (Blog) (8 Jul 2014): Calamitous Climate
- PostMedia / Canada.com (7 Jul 2014): Changing climate at root of 'utterly unprecedented' summer flood
- CBC The Morning Edition Saskatoon (2 Jul 2014): Expert says southeast Saskatchewan should expect more flooding
- CBC Saskatoon Morning (2nd July 2014)

### Steelman, Toddi

- Global Saskatoon Morning Show. June 30, 2015. "Wildfire Situation in Northern Saskatchewan." Interview with Toddi Steelman.
- CTV Saskatoon Evening News. June 29, 2015. "Wildfires Continue to Threaten." Available at: http://saskatoon.ctvnews.ca/video?clipId=646885 Includes comments from Toddi Steelman.
- CTV Saskatoon Morning Show. May 29, 2015. "High Wildfire Risk in Saskatchewan."
   Interview with Toddi Steelman. CJWW Radio. May 27, 2015. "Hot and Dry Conditions Keep Fire Risk High." Interview with Toddi Steelman. CKOM Radio. May 27, 2015. "Wildfire Risk in Saskatoon." Interview with Toddi Steelman. Warren, Jeremy. May 20, 2015. "MVA Warns of Budget Crisis: Inflation Has Eroded Funding." The Star-Phoenix (Saskatoon). Available at:
  - http://www.thestarphoenix.com/news/saskatoon/warns+budget+crisis/11067838/story.html Interview with Toddi Steelman.
- Roach, John, and NBC News. April 24, 2015. "Billions of Dollars of Real Estate at Risk to Wildfire, Experts Say." Available at: http://www.nbcnews.com/science/environment/billions-dollars-real-estate-risk-wildfire-experts-say-n343586. Includes interview with T. Steelman.
- Steelman, Toddi. October 11, 2014. "Opinion: CCS Project A Bold Move." The Star-Phoenix (Saskatoon). Page A10.
- Steelman, Toddi A., and Branda Nowell. 2015. "Managing Wildfire Networks: Brokering Relationships and Mission Conflict." Webinar for U.S. Forest Service, Public Affairs. May 21.
- Steelman, Toddi and Branda Nowell. 2015. "Managing Wildfire Networks: Brokering Relationships and Mission Conflict." Area Commanders/Incident Commanders National Workshop. Phoenix, AZ. March.
- Steelman, Toddi. 2015. "An Update on the Delta Dialogue Network: Where We Have Been, Where We Are Going." Peace-Athabasca Delta Ecological Monitoring Program Meetings. Fort Chipewyan, AB. February 10-11, 2015.

# Strickert, Graham

- Strickert, G.E. and Clark, D.A. (2015) Yukon Grant Writing Workshop. Developing a SSHRC College and Community Social Innovation Fund Application Partnership Development Grant. Whitehorse, Yukon (January, 20<sup>th</sup> 24<sup>th</sup>, 2015)
- Strickert, G.E. and Jardine, L. (2015) Saskatchewan Association of Watersheds Annual General Meeting. Melfort, Saskatchewan (April 14<sup>th</sup>, 15<sup>th</sup>)
- Strickert, G.E. (2015) Workshop I with Red Deer River Watershed Alliance: Project Blue Thumb: Improving Water Security in the Red Deer River Watershed. Funded by Alberta Eco-Trust. Facilitated by Reos and Partners. (April 28<sup>th</sup> 29<sup>th</sup>, 2015).
- Strickert, G.E., Jardine, T., and Patrick, B., (2015) Meeting with Keepers of the Saskatchewan River Delta. Review of Terms of Reference for Water stewardship Plan for the Saskatchewan River Delta. (Feb 11<sup>th</sup> 13<sup>th</sup>, 2015).
- Strickert, G.E., Jardine, T., and Patrick, B., (2015) Meeting with Keepers of the Saskatchewan River Delta. Review of Terms of Reference for Water stewardship Plan for the Saskatchewan River Delta. (May 26<sup>th</sup> 27<sup>th</sup>, 2015).
- Strickert, G.E. (2015) Workshop II with Red Deer River Watershed Alliance: Project Blue Thumb: Improving Water Security in the Red Deer River Watershed. Funded by Alberta Eco-Trust. Facilitated by Reos and Partners. (June 16-17<sup>th</sup>, 2015).
- Strickert, G.E. & Jardine T. (2015) Meeting with Northern Village of Cumberland House and Sask Power Regarding the Re-Licensing of E.B. Campbell Dam.

