Global Institute for Water Security

Progress Report 2013-14

From left to right: Graham Strickert, Research Associate; Howard Wheater, Director, Global Institute for Water Security; Dawn Keim, Postdoctoral Fellow; Jay Sagin, Postdoctoral Fellow.

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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 Global Institute for Water Security (GIWS). The Institute was created in 2011 with support from the Canada Excellence Research Chair (CERC) in Water Security to foster research collaboration across the university and with key Federal and Provincial 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, and Groundwater and Hydrogeology. The Institute 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.

Saskatchewan is a prime location for water research. The province has one of the most extreme and variable climates in the world, contains globally-important biomes, and is home to major agriculture and natural resource industries. It is experiencing rapid economic and population growth, set against a context of climate and other environmental change. Hence 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 relevance.

At the University of Saskatchewan (U of S), excellence in water research runs deep. Our commitment to establishing and developing strong research and training programs in hydrology and toxicology, and recruiting top experts in these disciplines, stretches back over four decades. We have over 190 researchers specializing in water under the umbrella of GIWS. The U of S has among the world's highest concentration of water experts and has rapidly become a hub for international expertise.

A major focus of our institute is the Saskatchewan River Basin (SaskRB). This watershed is half the size of France and stretches from the Rocky Mountains in Alberta, north to the boreal forest, and through the Prairies into Manitoba. We have over 20 research projects going on throughout the river basin funded by the CERC program to understand how a changing climate and a changing environment affect our water resources, and what policies and practices need to be in

place to ensure that our towns and communities have the water they need now and into the future. We see the majority of water challenges worldwide here in the SaskRB, which makes what we are doing here globally applicable.

New interdisciplinary science and technological innovation is urgently required to inform water management and policy and to develop new solutions to critical problems facing global and domestic water security. It is now imperative to address these issues using the spectrum of relevant disciplines and to translate this integrated science into technologies and useful information for decision-making, working with stakeholders and state-of-the-art informatics tools. These global needs are addressed through our institute, which is already viewed as an internationally-leading institution for interdisciplinary water science.

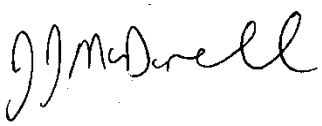
GIWS has come a long way since its foundation in 2011, and we are proud of our achievements thus far. However, none of this would have been possible without the far-sighted support of our major sponsors, the Canadian Government, through the Canada Excellence Research Chair program, the Province of Saskatchewan, and the U of S. 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 U of S 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. We're a hub for researchers—across Canada and internationally. We actively encourage your collaboration with our research staff and partners across campus. Beyond our Saskatchewan River Basin work, our program is growing internationally through formal research and graduate exchanges and partnerships with the Imperial College London (England), University of Aberdeen (Scotland), Lippmann Institute (Luxembourg), Nanjing Hydraulic Research Institute (China), Universidade Federal do Rio de Janeiro (Brazil), Universidad Austral de Chile (Chile), University of Georgia and Oregon State University (USA). Together with our research staff and our many international partners, we are tackling some of the world's biggest water security challenges. We host visiting scientists, sabbatical leaves and student internships. We invite you to come and be a part of our team!



Jeffrey J. McDonnell
Professor of Hydrology
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) integrates expertise of 192 members (69 Members, 18 Associate Members, 3 Affiliate Members, and 102 Student Members) from 14 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 a 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.

Our work focuses on 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.

GIWS research builds on world-class field and laboratory facilities to develop new hydro-ecological science and modelling tools and to address issues including climate change, water resources and water quality management. GIWS has developed the Saskatchewan River Basin (SaskRB; 340,000 km^2; roughly half the size of France in area) as a large-scale observatory for interdisciplinary water science, now recognized as a Regional Hydroclimate Project (RHP) by the World Climate Research Program (WCRP); one of ten RHPs in the world and the only one of its kind in North America. The SaskRB is located in one of the most extreme and variable climates of the world and experiences water security challenges of global significance. SaskRB is attracting significant international interest and engagement, for example including active research partnerships with the USA's National Aeronautics and Space Administration (NASA) and 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. It has also provided the geographic focus for our development of a new discipline of Socio-hydrology.

GIWS has also taken a leadership role at national level by leading a $5 million Changing Cold Regions Network (CCRN), funded by NSERC's Climate Change and Atmospheric Research initiative. CCRN expands the geographic scope of the GIWS focus to address environmental changes across the whole of western Canada's cold interior, and includes the strategically and scientifically important 1.8 million km^2 Mackenzie Basin. CCRN brings together 36 Canadian co-Investigators, 4 Federal government agencies and 15 leading international researchers. It is supported by and linked to WCRP's Global Energy and Water Exchanges (GEWEX) and Climate and Cryosphere (CliC) projects, to the Canadian High Arctic Research Station (CHARS) programme and integrated within NASA's Arctic Boreal Vulnerability Experiment (ABOVE) arctic programme.

Our institute is rapidly building international links and networks. GIWS members have leadership roles in various international initiatives, for international agencies such as the United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Meteorological Organization (WMO) and the International Atomic Energy Agency (IAEA), and also the Permanent Court of Arbitration, The Hague (Dr. Wheater was judge in a recent India-Pakistan arbitration) and hold visiting appointments in many international universities. Current collaborative research includes projects in Asia, Australia, Europe, North America and South America.

GIWS members are also developing new collaborations with industry in Canada and internationally. Industry involvement helps sustain research programs of economic benefit to Saskatchewan and to Canada, and facilitates training of highly qualified personnel (HQP) of relevance to industry partners. This will help our programs remain attractive to students and postdoctoral fellows and to industry who are seeking training opportunities for their employees and for the incoming workforce. Efforts are underway to initiate significant research collaboration with the agriculture, energy (hydro, oil sands, petroleum and nuclear) and mining (potash and uranium) industries.

GIWS by the numbers

During 2013-14, GIWS has financially supported 50 graduate students (19 PhD and 31 Masters), 28 postdoctoral fellows, 28 research assistants, 6 research associates and scientists, 26 undergraduate and graduate student assistants and 44 visiting scholars. In addition, its members have supported a further 159 graduate students (71 PhD and 88 Masters), 14 postdoctoral fellows, 12 research associates and scientists, 43 undergraduate and graduate research assistants, and 5 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 2013-14, the seven core faculty members have secured a total of about $2.6 million dollars (56% and 23% from Federal and International sources, respectively), while the membership as a whole has secured a total of $19.4 million (48% and 31% from Federal and Industry sources, respectively). The total external funding since inception in 2011 is now $47.2 million.

In 2013-14, GIWS members have published 209 journal articles, published and presented 158 papers in proceedings and at conferences, delivered 101 plenary, key note and invited lectures, and published 33 book chapters and books. From 2012-13 to 2013-14, we have seen an increase of 14% in journal publications.

One of the measurable parameters for research and training excellence is the number of awards and honours received by GIWS members and 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 American Geophysical Union (only 0.01% recognized as fellows), President-elect of the American Geophysical Union (7500-member Hydrology Section, the world's leading scientific hydrology organization), and representation on Canada's NSERC Joint Prize Committee. In addition, our

students have won many national and international awards, including three NSERC Alexander Graham Bell Scholarships, one recent Horton Research Grant from the AGU for best PhD proposal in hydrology (world-wide), the Stan Paterson Scholarship in Glaciology, and best MSc and PhD theses at U of S.

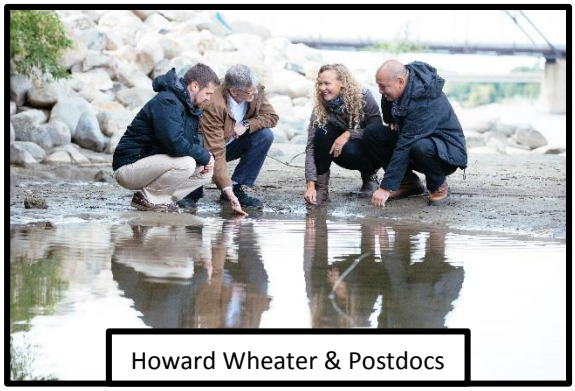
GIWS members include one Canada Excellence Research Chair (Howard Wheater), 5 Canada Research Chairs (John Giesy, John Pomeroy, Ajay Dalai, Ingrid Pickering, and Markus Hecker) and 3 Industrial Research Chairs (Lee Barbour, James Hendry, and Matt Lindsay).

Effective communication and engagement remain key components of GIWS collaboration and outreach as guided by four overarching communications goals to: 1) raise awareness of the local, national and international challenges of water security 2) communicate the work and achievements of the GIWS to address these, 3) cultivate and strengthen the sense of community and interdisciplinary working amongst U of S and affiliated agency water researchers, and 4) raise profile of the Institute nationally and internationally to strengthen member and potential-member participation and commitment to GIWS goals and mandate. This helps ensure that institute's research is useful, relevant and applicable to governments, organizations and individuals working in the broad world of water security. As an example of outreach and engagement, the Institute, in collaboration with the University's Department of Drama and School of Environment and Sustainability, developed a theatrical play called *Downstream*. This play represented an innovative way to communicate water research knowledge in an engaging and interactive way. As a testament to our efforts, Graham Strickert, Research Associate with the Global Institute for Water Security and the Changing Cold Regions Network, received the U of S award for distinction in outreach and engagement at the convocation ceremony in Fall 2014.

1. Introduction

Water Security is one of the major societal challenges for the 21st century. The Global Institute for Water Security (GIWS) at the University of Saskatchewan (U of S) was launched in March 2011 in recognition of the strategic importance of Water Security, and the breadth and depth of relevant expertise and facilities within the University and its co-located partners. 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.

The $30 million CERC grant to Dr. Wheater (2010-2017) has provided baseline funding for the Institute, supporting new research programmes and new Faculty appointments, and the administrative structure consistent with a world-class research institute. Three years on, we can report considerable success. GIWS now integrates expertise from 192 members from 14 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). We have developed new, internationally-recognised research facilities, have taken on 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.


Howard Wheater & Postdocs

Last year, we published our founding research progress report covering the period of 2011-13, which provided our members and stakeholders with details on GIWS vision, mission and governing structure. It also provided insight into our research themes, research objectives and research sites within Saskatchewan Research Basin (SaskRB). The present report provides an overview of progress and growth achieved by GIWS over the period of 2013-14.

2. Research Themes

Fresh water is essential for human life and well-being, for economic development and for entire global ecosystems. While water can be a major threat through floods and droughts, water resources are also under pressure world-wide, from population growth and movement, economic development, climate and land use changes, and pollution. Effective water management is thus a social imperative and water security is increasingly recognized as a strategic national and international priority. Further, effective water management is becoming

increasingly complex, requiring deep understanding of aquatic and terrestrial environments, their vulnerabilities to environmental change and water management and protection challenges.

Since its inception in March 2011, GIWS has developed 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. Themes 1 to 3 have been funded 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. The Themes are as follows:

2.1 Theme 1: Climate Change and Water Security

One of the greatest environmental and societal challenges associated with climate change is prediction and management of its impact on water security. There is an urgent need to improve the science upon which prediction of water resources for climate futures is based, particularly for high latitudes and cold regions. This need is particularly pressing for western Canada, where the cold region, semi-arid climate creates a hydrological system that is extremely vulnerable to climate change and can be profoundly affected by either changes in temperature or precipitation. The region is subject to both recurrent severe droughts and periods of intense flooding events, which are expected to increase in severity and frequency under climate change. There is a need for development of 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. In addition, given the high levels of uncertainty associated with climate futures, particularly for extreme events, there is a need for new adaptive approaches to governance, policy and management. For further information, please refer to GIWS website.

John Pomeroy – Fortress Mountain

2.2 Theme 2: Land-water Management and Environmental Change

Intensification of land and water management, due to agriculture, forestry, and urban and peri-urban 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 21st 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

Helen Baulch – Buffalo Pound

practices (BMPs) to mitigate adverse effects. For further information, please refer to GIWS website.

2.3 Theme 3: Sustainable Development of Natural Resources

Canada is at the forefront of natural resource development, including the energy sector (oil and gas, biofuels, hydropower, nuclear), mining (including potash, uranium, gold and base metals) and forestry. This area presents a unique opportunity for the development of 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. For further information, please refer to GIWS website.


Oil Sands - Fort McMurray

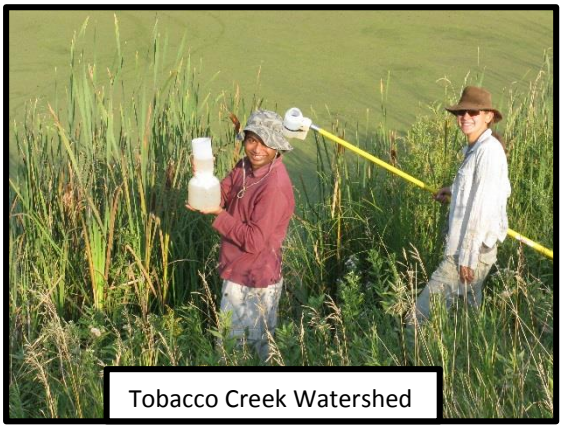
2.4 Theme 4: Socio-hydrology

Social scientists bring an interest in human values, markets, social organizations and political institutions to the traditional focus of water science on climate and hydrology, while hydrologists are increasingly aware of the need to understand the effects of human activities on land and water management. Socio-hydrology integrates these different communities and highlights the importance of the complex and dynamic interactions between humans and the environment. The socio-hydrology 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. For further information, please refer to GIWS website.


Downstream Play

2.5 Theme 5: Water and Health

Access to clean drinking water and sanitation is a basic requirement for human health. This remains a global priority, and is also an issue for rural and First Nations communities in Canada. However, water and health have multiple connections. GIWS is looking at issues that are critical to society, such as drinking water quality, water hygiene and sanitation, transmission of waterborne and water-related diseases in an ecosystem, aquatic pollution


Tobacco Creek Watershed

and effects on the food chain, wastewater re-use, extreme events such as flooding and drought, and health-based water quality standards. For further information, please refer to GIWS website.

2.6 Theme 6: Water and Wastewater Treatment Technologies

With increasing pressures on water quality due to human activities, there is a worldwide need to improve efficiency and effectiveness of water and wastewater treatment technologies, and to assess impacts of contaminants on environmental and human health. Treatment challenges 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. Five major areas of application of particular relevance to the U of S, the Province of Saskatchewan and Western Canada will be addressed by this theme, namely the needs of the oil and gas sector, the food and beverage industry, natural resources (particularly mining) industry, municipalities, and rural water supply and sanitation. For further information, please refer to GIWS website.

Water Treatment Facility – Buffalo Pound

2.7 Theme 7: Groundwater and Hydrogeology

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. While groundwater is often a cheap resource to develop, monitoring and investigation are expensive. 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. For further information, please refer to GIWS website.

Andrew Ireson - St. Denis

3. Saskatchewan River Basin

Through support from the CERC and Canada Foundation for Innovation, the 340,000 km^2 Saskatchewan River Basin (SaskRB) has been developed as a large scale observatory which has come to be seen as an internationally-leading initiative. This recognition was formalized when the SaskRB was named a Regional Hydroclimate Project (RHP) by the World Climate Research Programme (WCRP), one of 10 such projects in the world, and the only active RHP in North America. 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 size of France, spans Canada's three Prairie Provinces of Alberta, Saskatchewan and Manitoba and faces a climate characterized by extremes and rapid climate change. Further, the basin encompasses critical environments deemed significant both nationally and globally.

River flows for the SaskRB arise primarily (source of 80% of runoff) from the Rocky Mountains in Alberta, with the Saskatchewan River's two major tributaries flowing east from the continental divide. The South Saskatchewan River passes through the Canadian Prairies, a region characterized by climate variability and the source of 80% of the nation's agriculture. Much of the agriculture in the region relies on natural precipitation (in which snow plays a major role), but 75% of Canada's irrigated agriculture is conducted in Alberta and Saskatchewan. Consumptive water use in the SaskRB sees irrigated agriculture accounting for 82% of the basin's

diversions[1]. The North Saskatchewan River passes through Prairie landscapes and into the Boreal Forest, spanning 35% of Canada's total land area and a critically important global ecosystem[2]. Following the convergence of these tributaries, the river flows through the Saskatchewan Delta (one of the World's largest inland deltas and North America's largest freshwater wetland), and enters Lake Winnipeg, ultimately discharging its waters into Hudson Bay. Additional developments along the river include industrial and urban water supplies, flood relief and hydroelectricity. The basin is also home to Lake Diefenbaker, a 225 kilometer long, multipurpose reservoir with a storage capacity of 9.4 billion cubic meters of water.

A combination of extreme temperatures (ranging from -40 to +40^{o}C) and extreme events characterize the SaskRB and have defined the region's climate and culture. For example, a major drought extending from 1999 to 2004 brought about a $3.6 billion drop in agricultural production in the years 2000-2001, and a $5.8 billion decline in Gross Domestic Product (GDP)[3]. In recent years, extensive flooding has wreaked havoc across the Prairies with Manitoba facing damages in excess of $800 million (2011)[4] and Alberta responding to more than $5 billion in damages and four deaths (2013)[5].

The basin also faces an assortment of management concerns including provision of water resources to a population of approximately three million people, including those from rural and indigenous communities for whom quality drinking water is not guaranteed; response to competing needs associated with economic developments (i.e., agricultural expansion, industrial and natural resource development); considerations of water allocation between those who are upstream (Alberta) and downstream (Saskatchewan and Manitoba) within the SaskRB; management of extreme events (flood and drought); and mitigation of impacts on water quality from both urban and agricultural discharges. The region faces acute stressors with the river having been described by the World Wildlife Fund (2009) as Canada's most threatened river[6] and with full allocation of the South Saskatchewan River Basin in southern Alberta. It was noted earlier that regional flooding and drought have had significant economic costs and Saskatchewan's major reservoir, Lake Diefenbaker, is facing a decline in water quality (eutrophication) and concerns with respect to supply[7].

These pressures exist within the context of rapid environmental change. The warming climate in the west has led to glacial retreat in the Rocky Mountains, altering the rain/ snow balance and

[1] Martz et al. (2007). The South Saskatchewan River Basin: Physical Geography. In Climate Change and Water: SSRB Final Technical Report (eds. L. Martz, J. Brubneau, J.T. Rolfe), Saskatoon, SK, Canada
[2] Natural Resources Canada. (2009). The Atlas of Canada: Boreal Forest
[3] Wheaton et al. (2008). Dry times: hard lessons from the Canadian drought of 2001 and 2002. Canadian Geographic, 52: 241-262.
[4] CBC News. (April 14, 2011). 6 Sask. Communities declare flood emergencies
[5] CBC News. (June 25, 2013). Calgary floods to cost economy billions
[6] World Wildlife fund. (2009). Canada's Rivers at Risk: Environmental Flows and Canada's Freshwater Future
[7] Hecker et al. (2012). Seasonal Dynamics of Nutrient Loading and Chlorophyll A in a Northern Prairies Reservoir, Saskatchewan, Canada. Journal of Water Resources and Protection, 4: 180-202.

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[8]. Further, climate change is affecting agriculture, flood and drought risk, and water quality across the prairies[9]. 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.

Understanding and managing uncertain water futures overlays the various stressors noted above. Water management and planning are primarily conducted based on provincial jurisdictions, but this is fragmented by various responsibilities held by both the federal government and other agencies. This atmosphere is further complicated by the presence of varied legal frameworks for First Nations land and the accompanying water rights. What results is a lack of catchment-based integrated water resources planning and management alongside an overall strategic framework for inter-provincial allocation. In 1969 the Prairie Provinces Water Board established the apportionment agreement which continues to guide water transfers in the region[10] and requires that annually 50% of natural flow be permitted to flow across provincial borders. Concerns regarding these apportionment commitments have arisen in southern Alberta during multi-year droughts when flows have come close to this upper limit and where the principle of "first in time, first in right" applies. The apportionment agreement goes on to specify water quality standards at the provincial borders. It is noteworthy that at present there is no standard specified for Phosphorous at the Alberta-Saskatchewan border, despite relatively high nutrient loads.

4. Saskatchewan River Basin – Research Observatories

Many of the water security challenges experienced globally are also observed within the SaskRB which includes the regionally and globally relevant biomes of the Rocky Mountains, the Boreal Forest, the Prairies and the Saskatchewan River Delta. 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.

[8] Natural Resources Canada. (2012). Mountain Pine Beetle

[9] Shook and Pomeroy. (2012). Changes in the hydrological character of rainfall on the Canadian prairies. Hydrological Processes, 26: 1752-1766.

[10] Prairie Provinces Water Board. (1969). Master Agreement on Apportionment

In response, the SaskRB has been developed as a large-scale observatory and a GEWEX RHP to facilitate the integrated, multi-scale and multi-disciplinary research required. Funded by the CERC, the basin provides the place-based focus for a new programme of interdisciplinary research which seeks to provide the basis for a) improved understanding of key biomes and their integration at catchment-scale, including the associated hydrological, ecological and atmospheric interactions, and vulnerabilities to environmental and anthropogenic change, b) new decision support tools for strategic management of water futures that can be implemented across multiple scales and multiple jurisdictions, and c) new socio-hydrology research into societal controls and perspective on water management and water security.

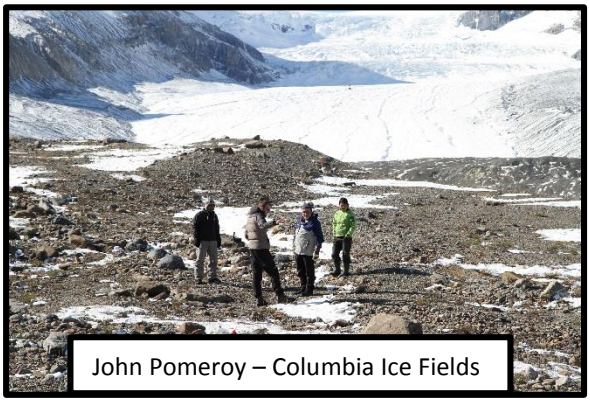
Several key science questions have been developed involving improved understanding and modelling of:

i. climate variability and change over the basin, including, in particular, the extremes of floods and droughts,
ii. effects of land use/management change on environments of regional and global importance, and
iii. societal controls on water management, including operational constraints, water management vulnerabilities and policy and governance opportunities.

To address these questions, a series of major research sites have been developed which will examine environmental and anthropogenic change across the above noted biomes. These include detailed observations, at local to small basin-scale, and build on legacy data to provide an historical context for the improved understanding and diagnosis of environmental change. These sites 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 for decision support.

Within the SaskRB, we have four sets of research sites: 1) Rocky Mountains, 2) Boreal Forest, 3) Prairies and 4) Saskatchewan River Delta.

4.1 Rocky Mountains: The major source for water in Western Canada is the Rocky Mountains and water availability 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 majority of Rocky Mountain research has centered on the Marmot Creek Observatory which has been a research focus for 50 years and was near the epicenter of Alberta flooding in June

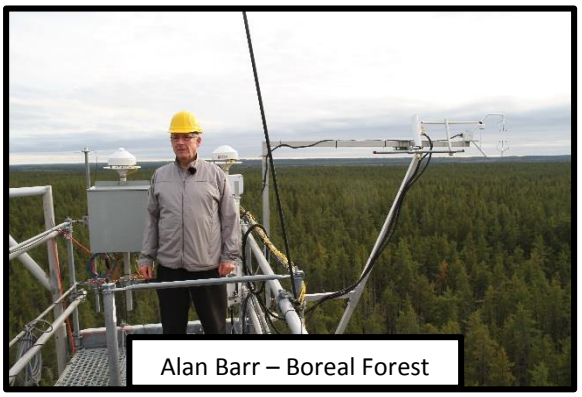


John Pomeroy – Columbia Ice Fields

2013[11]. Research at this site continues with enhanced instrumentation, but is also being expanded through the addition of high elevation sites including Peyto Glacier (a former International Hydrological Decade site). Aims include improvement of the understanding of the governing cold region hydrological factors for mountain water supply through intensive process studies in representative headwater research sites; development of an improved cold regions hydrology modelling system; and use of new scientific information and improved models to predict headwater resource sustainability in light of climate change and variability. Sibbald Wetlands is the focus of hydro-ecological research into Rocky Mountain wetlands and the effects of current and legacy beaver activity[12].


Sibbald Wetlands

4.2 Boreal Forest: Research in this region derives from a set of globally-important experimental sites developed under the international BOREAS (Boreal Ecosystem-Atmosphere Study) initiative to measure land-atmosphere exchanges of carbon, water and energy[13]. Through improved measurements (soil water, groundwater, surface water and ecological processes), and links with NASA's AirMOSS (Airborne Microwave Observatory of Subcanopy and Subsurface) and SMAP (Soil Moisture Active Passive) remote sensing soil moisture missions, short-term research objectives 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.


Alan Barr – Boreal Forest

Natural resource development is a national focus in Canada, particularly in the Athabasca Oil Sands of Alberta, which are found in the Boreal Forest. GIWS researchers are exploring effective management and environmental protection of watersheds in this region which could significantly

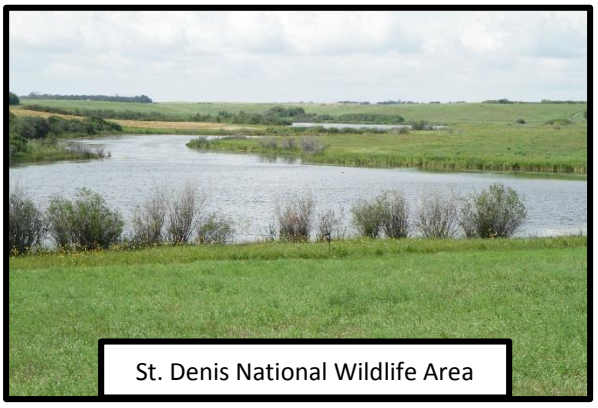
[11] Pomeroy et al. (2012). Sensitivity of snowmelt hydrology in marmot Creek, Alberta, to forest cover disturbance. Hydrological Processes, 26: 1891-1904; Reba et al. (2012). Estimating surface sublimation losses from snowpack in a mountain catchment using eddy covariance and turbulent transfer calculations. Hydrological Processes, 26: 2699-3711.

[12] Janzen and Westbrook. (2011). Hyporheic flows along a channeled peatland: influence of beaver dams. Canadian Water Resources Journal, 36(4): 331-347.

[13] Barr et al. (2012). Energy balance closure at the BERMS flux towers in relation to the water balance of the White Gull Creek watershed 1999-2009. Agricutural and Forest Meteorology, 153: 3-13.

alter water use and land and water reclamation practices by natural resources development operations both nationally and world-wide.

4.3 Prairies: One of the selected prairie research sites is St. Denis National Wildlife Area which consists of numerous prairie pothole lakes of varying salinity. With a research history stretching back 60 years, research at this site will focus on runoff processes and pothole lake connectivity, surface-subsurface interactions and salinity dynamics. A second prairie site at Brightwater Creek, near Kenaston, Saskatchewan, builds on a multi-scale soil moisture remote sensing experiment. In a relatively flat and typical agricultural area, multiple scale monitoring of spatial soil moisture, groundwater and land-atmosphere interactions is ongoing. In collaboration with EC, AAFC and the University of Guelph, this site is a test-bed for NASA's SMAP soil moisture remote sensing mission, to be launched in 2014. The site provides a focus for hydrological and land-surface modelling and studies the impacts of different agricultural land management practices on land-atmosphere feedbacks.


St. Denis National Wildlife Area

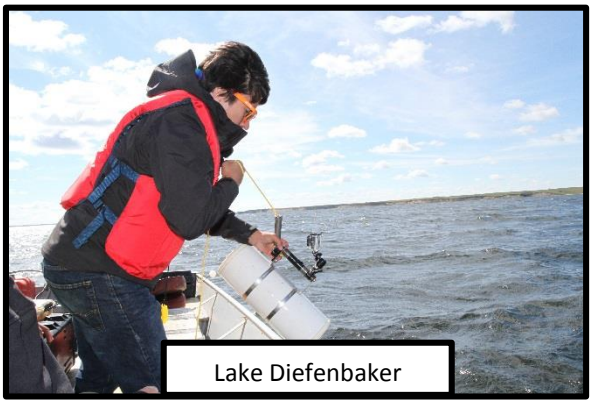
Three additional prairie sites address different aspects of prairie hydrology and agricultural management. Hydrological connectivity and the effects of agricultural drainage on flows and water quality is the research focus at Smith Creek, Saskatchewan. The site has demonstrated the dramatic effects of inter-annual climate variability on water quality, and a complex response of flood generation and transmission to agricultural drainage[14]. In collaboration with local community organizations, EC, AAFC and the University of Manitoba, 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. A principle goal of this research is to develop improved modelling capability for BMPs. Finally, Swift Current, 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.


Swift Current – AAFC Runoff Plots

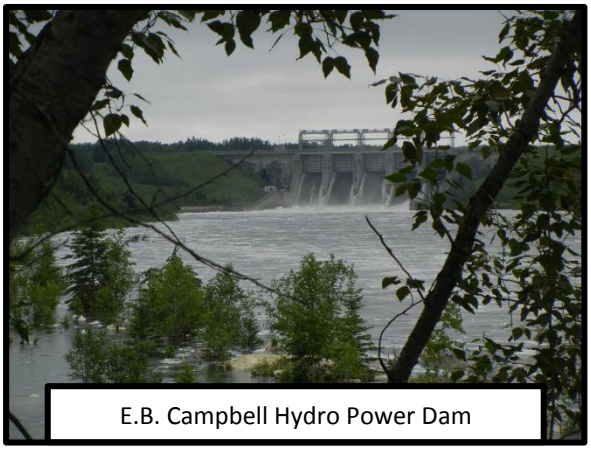
[14] Shook and Pomeroy. (2011). Memory effects of depressional storage in Northern Prairie hydrology. Hydrological Processes, 26: 1752-1766

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 Current Creek (SCC), is underway[15]. 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 Moosejaw, Saskatchewan.


Storm Water Saskatoon


Lake Diefenbaker

4.4 Saskatchewan River Delta: Located near the Saskatchewan/Manitoba border, the Saskatchewan River Delta, is a complex series of abandoned and active river channels, lakes and wetlands. Home to Cumberland Marshes which has been designated as an Important Bird Area, this region experiences the 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 and spring freshets have been dampened due to capture and storage in the


E.B. Campbell Hydro Power Dam

[15] North et al. (2014). Relationship between water quality parameters and bacterial indicators in a large prairie reservoir: lake Diefenbaker, SK, Canada. Canadian Journal of Microbiology, in press.

dams. 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.

High quality hydrological and water quality data are being used across these sites to provide new process insights and to develop improved models to support management and climate modelling. A focus for process modelling is the Cold Region Hydrological Modelling (CHRM) system[16] which represents key cold region hydrological processes (i.e., frozen soils, blowing snow) and has explored effects of agricultural changes in agricultural drainage and cropping practices. Research arising from the Tobacco Creek prairie site is being used to introduce agricultural water quality into this modelling system. 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. One outcome is an improved large-scale prairie model for EC's MESH modelling system[17]. 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.

5. Saskatchewan River Basin – climate, water resource and large-scale modelling

The SaskRB embodies many of the management pressures experienced worldwide, and an important objective of the SaskRB 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.

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, including Rocky Mountain precipitation and convective precipitation over the Prairies. 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[18], and detailed multi-model analyses have been made of the North American Regional Climate Change Assessment Program[19], providing new insights into the current skill levels of regional climate models, and the

[16] Pomeroy et al. (2007). The cold regions hydrological model: a platform for basing representation and model structure on physical evidence. Hydrological Processes, 21: 2650-2667

[17] Mekonnen et al. (2014). Towards an improved land surface scheme for prairie landscapes. Journal of Hydrology, 511: 105-116

[18] Chun et al. (2013). Precipitation downscaling in Canadian Prairie Provinces using the LARS-WG and GLM approaches. Canadian Weater Resources Journal, 38(4): 311-332

[19] Khaliq et al. (2014). Seasonal and extreme precipitation characteristics for the watersheds of the Canadian Prairie Provinces as simulated by the NARCCAP multi-RCM ensemble. Climate Dynamics, DOI 10.1007/s00382-014-2235-0

model uncertainty associated with future projections. Current work on extreme precipitation and drought is building on the IPCC AR5 (Intergovernmental Panel on Climate Change – Fifth Assessment Report) climate model results.

Given the challenges of Decision Making Under Uncertainty[20], 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. The results can then be used in scenario analysis within a water resource modelling framework. While we seek to reduce the associated uncertainties through the research outlined above, alternative and complementary approaches are also being explored. Through collaboration with Alberta Environment and Sustainable Resource Development in simulating the response of the complex South SaskRB water resource system in Southern Alberta (11,000 licence holders), a new approach has been developed to assess water resource vulnerability to climate change[21] [22]. 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[23]. 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 with the University of Regina is developing improved reconstructions of paleoclimate, based on multi-variate tree-ring analysis.


Jill Johnstone - Dendrochronology

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.

[20] Gober and Wheater. (2013). Socio-hydrology and the science-policy interface: A case study of the Saskatchewan River Basin. Hydrology and Earth System Sciences – Discussion, 10(5): 6669-6693.
[21] Nazemi et al. (2013). A stochastic reconstruction framework for analysis of water resource system vulnerability to climate-induced changes in river flow regime. Water Resources Research, 49(1): 291-305.
[22] Nazemi and Wheater. (2014). How can the uncertainty in the natural inflow regime propagate into the assessment of water resources system? Advances in Water Resources, 63: 131-142.
[23] Hassanzadeh et al. (2014). Managing water and food in complex systems: Developing a dynamic Agro-Hydro-Economy simulator for the Saskatchewan River Basin, Canada. Environmental Modelling and Software, 58: 12-26.

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 development and implementation of EC's MESH modelling system for the Basin. GEWEX has priority for 2013[24] and beyond and a current challenge is to include water management in the large-scale modelling, in particular irrigation water use and the impact of large dams.

It will be evident from much of the above discussion that water security is an issue that requires integration of the social sciences with the natural sciences and engineering. Social scientists bring an interest in human values, markets, social organizations and political institutions to the traditional focus of water science on climate and hydrology, while hydrologists are increasingly aware of the need to understand the effects of human activities on land and water management. The emerging field of socio-hydrology integrates these different communities and highlights the importance of the complex and dynamic interactions between humans and the environment. The SaskRB provides a focus for a socio-hydrology program that encompasses both the human drivers of hydrological change and the social processes through which hydrological science is translated and communicated to relevant decision makers. Engagement with a wide range of stakeholders is an important aspect at many of the sites noted above. Socio-hydrology research has included a series of stakeholder workshops across the basin to understand attitudes to, and concerns for, water security[25], and new methods of outreach include a current series of drama productions around the issue of water management in the Basin. And the focus of the water resource modelling development, as noted above, is to provide a new capability for stakeholder engagement in the exploration of water futures.

6. Saskatchewan River Basin – CERC Funded Research Projects

The SaskRB provides a place-based focus for disciplinary research and new interdisciplinary integration. Twenty-four research projects in the SaskRB are producing data, models and outcomes that interpret complex effects of climate change and land-use management on available water resources and biomes of local and global relevance, and investigate societal dimensions of land and water management, including extreme events (Appendix A). These studies range from the development of new statistical downscaling tools for climate change impact studies in western Canada to the assessment of links between water, animals and people in the Saskatchewan River Delta, working with First Nations communities. While outputs are too numerous to discuss, highlights include new assessment of climate futures for Western Canada, new approaches to downscaling climate models for impact assessment, a new approach to assess the vulnerability of complex water resource systems to climate change, applied to water-limited

[24] GEWEX. (2013). GEWEX Science Questions. http://www.gewex.org/pdfs/GEWEX_Science_Questions_final.pdf
[25] Gober et al. (2014). Divergent perspective on water security: Bridging the policy debate. Professional Geographer. DOI: 10.1080/00330124.2014.883960

Southern Alberta, development of new large-scale model capability for prairie hydrology, new insights into cold region lake biogeochemistry and response to nutrient loading, and development of the first strategic assessment model of nutrient loads in the Saskatchewan Basin headwaters. Major inter-disciplinary studies include work with First Nations in the Saskatchewan Delta to understand impacts of environmental change on their livelihoods and society. Work with industry includes an important study of the effects of eutrophication on drinking water supply to the South Saskatchewan region. Extensive engagement with stakeholders includes, e.g., surveys, a drought game tournament, and most recently, a theatrical production 'Downstream'. In addition, these projects are attracting significant international interest and engagement, for example including active research partnerships with the USA's National Aeronautics and Space Administration (NASA) and 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. It has also provided the geographic focus for our development of a new discipline of Socio-hydrology.

Some examples of relevant research are provided below:

Climate change

- GIWS has produced analyses of future rainfall and temperature trends over western Canada. High-resolution Regional Climate Model simulations have been used to establish future projections of monthly and extreme precipitation characteristics across the entire three Canadian Prairie Provinces.
- GIWS is measuring land-atmosphere exchanges of carbon, water and energy 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.
- GIWS studying the land-atmosphere feedbacks from different agricultural land management practices to develop hydrological and land-surface models based on multi-scale soil moisture remote sensing experiments at Brightwater Creek, near Kenaston, SK.

Flood risk management

- GIWS members have provided strategic advice to SWSA concerning the operational management of the Gardiner Dam, following the 2011 floods.
- GIWS members are leading a major scientific analysis of the 2013 Calgary floods.
- River ice modelling has been undertaken to assess the South Saskatchewan River's susceptibility to ice cover breakup and risk of ice jam flooding from hydro-peaking discharge from the Gardiner Dam.
- GIWS research is providing insights into the effects of agricultural drainage on flood risk, based on experimental and modelling research at Smith Creek.

Water resources

- A new interactive water resources model has been developed for Saskatchewan as the first part of an initiative to develop a basin-wide water resources model for the Saskatchewan River Basin. This allows economic analysis of water futures, including irrigation expansion in the Province.
- An analysis of vulnerability to climate change of the South Saskatchewan water resource system in Alberta has been published.
- Research is underway to develop scenarios and an operational plan to provide for sustainable hydro-power without endangering the Saskatchewan River Delta habitat in the long-term.
- New geospatial models have been developed for SWSA to identify fish habitat and guide monitoring programmes.

Water quality

- In collaboration with the Saskatchewan Water Security Agency a major study is underway to understand the long term fate of nutrients from Alberta on Lake Diefenbaker, to address concerns over increasing eutrophication and water supply.
    - One of the significant outcomes is that over the last 3 years, 90% of the Phosphorus coming from Alberta is settling in Lake Diefenbaker. Inter-provincial standards are currently under review. Currently, there is no limit on how much Phosphorus Alberta can release to Saskatchewan, however, there are guidelines at the Saskatchewan-Manitoba border that limit the Phosphorus that can be released to Manitoba.
- GIWS is developing the first integrated model of nutrient loading and fate in the South Saskatchewan River – a model for the Red Deer in AB has been completed.
- GIWS has undertaken pilot studies of pharmaceutical products and heavy metals in urban wastewater and storm water in Saskatoon and Swift Current.
- GIWS has provided information on the concentration levels of mercury in fish that has led to a reversal of the 2013 restrictions on the sale of Cumberland fish within the province.
- GIWS is researching New Sensor and Data Network Designs to Monitor and Forecast Surface Water Quality in Rivers, in collaboration with SK industry.
- GIWS is leading a collaborative project between U of S researchers and the community-based Slave River and Delta Partnership, Forts Resolution and Smith, NWT to develop a community-based environmental program to monitor ice and water quality and ecosystem health (aquatic invertebrates, fish and wildlife).

Water and agriculture

- Howard Wheater chaired the Council of Canadian Academies Expert Panel that saw the release of a 2013 report entitled *Water and Agriculture in Canada: Towards Sustainable*

Management of Water Resources. The report responds to the question "What additional science is needed to better guide sustainable management of water to meet the needs of agriculture?" by exploring effective water and land management strategies, governance and policy mechanisms and technological developments to assist in sustainable resource management.

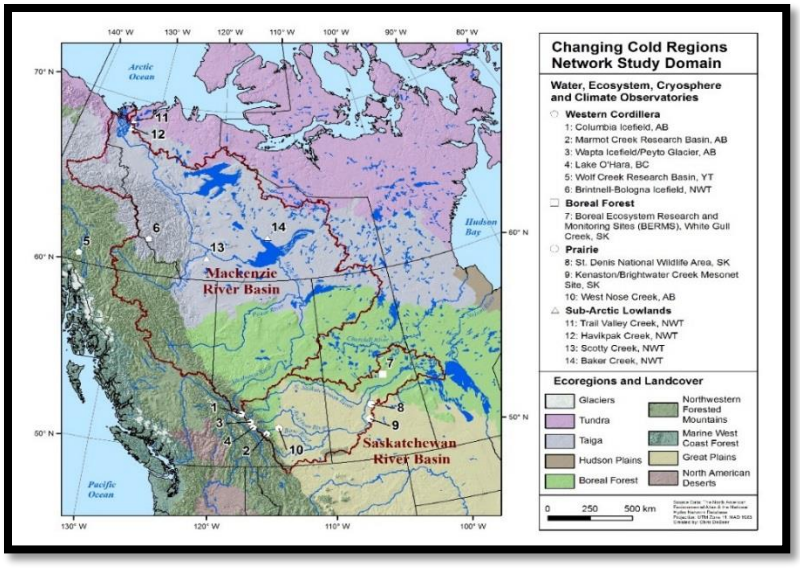
- GIWS is collaborating with farmers, Environment Canada and Agriculture and Agri-Food Canada to improve modelling capability for agricultural Beneficial Management Practices on flow and water quality (based on research at Tobacco Creek, Manitoba).
- GIWS has developed models to simulate the effects of agricultural drainage on stream flows, based on research at Smith Creek, SK.
- GIWS is studying the effects of agricultural land management practices on runoff water quality, chemical transport and soil erodability in particular trying to understand the fundamental drivers of threshold-like hydrological runoff responses to snowmelt and rainfall events in a semi-arid, prairie landscape.

Groundwater, Hydrogeology and Sustainability in Saskatchewan

- GIWS is leading an initiative with the Ministry of Economy, Ministry of Environment, Ministry of Agriculture and SWSA to coordinating the currently fragmented groundwater science base in SK, developing new research and assessment guidelines to ensure sustainable development practices, and creating training opportunities to meet the growing need for expertise in groundwater management.

7. Changing Cold Regions Network

GIWS has also taken a leadership role at national level by leading a $5 million Changing Cold Regions Network (CCRN), funded by NSERC's Climate Change and Atmospheric Research initiative. CCRN expands the geographic scope of the GIWS focus to address environmental changes across the whole of western Canada's cold interior, and includes the strategically and scientifically important 1.8 million km^2 Mackenzie Basin. CCRN brings together 36 Canadian co-Investigators, 4 Federal government agencies and 15 leading international researchers. It is supported by and linked to WCRP's Global Energy and Water Exchanges (GEWEX) and Climate and Cryosphere (CliC) projects, to



Canada's Canadian High Arctic Research Station (CHARS) programme and integrated within NASA's Arctic Boreal Vulnerability Experiment (ABOVE) arctic programme. The CCRN is addressing the following five themes:

1. Theme A: Observed Earth System Change in Cold Regions – Inventory and Statistical Evaluation
2. Theme B: Improved Understanding and Diagnosis of Local-Scale Change
3. Theme C: Upscaling for Improved Atmospheric Modelling and River Basin-Scale Prediction
4. Theme D: Analysis and Prediction of Regional and large-Scale Variability and Change
5. Theme E: User Community Outreach and Engagement

This past year, the Changing Cold Regions Network (CCRN) has entered into its second year of the five year programme. The network has made progress and marked achievements in a number of areas, including:

- Joint CCRN Theme C and EC Modelling Workshop held in Dorval, QC, January 22-23;
- Workshop on "Extreme Weather and Hydrology - Lessons Learned from the Western Canadian Floods of 2013 and Others" held in Canmore, AB, February 11-12;
- Publication of report on CCRN's 1st Annual Meeting in *Eos*, Transactions of the American Geophysical Union;
- Submission and acceptance of a paper on CCRN's observational, experimental, and modelling programme to *Science China, Earth Sciences* special issue on Watershed Science;
- Detailed planning for 2014-2015 Special Observation and Analysis Period (SOAP) at all CCRN field research sites;
- Coordination with other networks and projects such as Canadian Sea Ice and Snow Evolution (CanSISE) Network, NASA Arctic Boreal Vulnerability Experiment (ABoVE), and the Canadian High Arctic Research Station (CHARS); and
- A Boreal Ecosystem Research and Monitoring Sites (BERMS) workshop held in Saskatoon, SK, April 28-29;
- A workshop in Saskatoon to address key modelling challenges and developments in CCRN, September 15-16; and
- The next CCRN annual general meeting at Wilfrid Laurier University, Waterloo, ON, on October 19-22.

For additional information, please refer to www.ccrnetwork.ca or contact the network manager Dr. Chris DeBeer (chris.debeer@usask.ca).

8. 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.

8.1 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 192 members (69 Members, 18 Associate Members, 3 Affiliate Members, and 102 Student Members) from 14 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 B).

8.2 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 C).

8.3 Highly Qualified Personnel: During 2013-14, GIWS has financially supported 50 graduate students (19 PhD and 31 Masters), 28 postdoctoral fellows, 28 research assistants, 6 research associates and scientists, 26 undergraduate and graduate student assistants and 44 visiting scholars (Appendix C). In addition, its members have supported 159 graduate students (71 PhD and 88 Masters), 14 postdoctoral fellows, 12 research associates and scientists, 43 undergraduate and graduate research assistants, and 5 visiting scholars (Appendix D). Since inception in March 2011, GIWS supported a total of 352 personnel, including 7 GIWS faculty members, 9 administrative staff, 22 research technicians, 16 research associates/ scientists, 33 postdoctoral fellows, 26 doctoral students, 35 masters' students, 78 undergraduate and graduate student assistants and 93 visiting scholars. Over the same period, our 64 members have supported an additional 255 graduate students (112 Ph.D., 143 Masters'), 30 postdoctoral fellows, 11 research associates, 8 research scientists, 41 research technicians, 43 graduate and undergraduate research assistants, and 5 visiting students related to water security research. The institute successfully attracted top international students and postdoctoral fellows, with numbers showing more than five-fold increase from 2011-12 to 2013-14.

8.4 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 2013-14, the seven core faculty members have secured a total of about $2.6 million dollars (56% and 23% from Federal and International sources, respectively), while the members have secure a total of about $19.4 million (48% and 31% from Federal and Industry sources, respectively) (Appendix E). Since March 2011, the seven core faculty hired through the CERC program have secured a total of $13.3 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 $33.9 million over the last 4 years to support water security research, which results in a total GIWS funding of $47.2 million (average funding of $684K per researcher per year) on top of the original $30 million CERC investment.

8.5 Research Publications: In 2013-14, GIWS members have published 209 journal articles, published and presented 158 papers in proceedings and at conferences, delivered 101 plenary, key note and invited lectures, and published 33 book chapters and books. Since 2011, GIWS members have published a total of 506 journal articles and 33 books/book chapters, participated in 338 conference proceedings and presentations and delivered more than 201 invited, key-note and plenary lectures to share research outcomes and enlighten our stakeholders and scientific community. From 2012-13 to 2013-14, we have seen an increase of 14% in journal publications (Appendix F).

8.6 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 2013-14, 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 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 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, our students have won many national and international awards, including three NSERC Alexander Graham Bell Scholarships, one recent Horton Research Grant from the AGU for best PhD proposal in hydrology (world-wide), Stan Paterson Scholarship in Glaciology, best MSc and PhD theses at U of S.

8.7 Research Chairs: Of the total one CERC, 28 Canada Research Chairs (CRC) and 5 Industry Research Chairs (IRC) at U of S, GIWS has one CERC (Howard Wheater), 5 CRCs (John Giesy, John Pomeroy, Ajay Dalai, Ingrid Pickering, and Markus Hecker) and 3 IRCs (Lee Barbour, James Hendry, and Matt Lindsay) as its member.

9. International/ Global Outreach

The Institute has built many international links and networks. GIWS members have leadership roles in various international initiatives, for international agencies such as the United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Meteorological Organization (WMO) and the International Atomic Energy Agency (IAEA), and also the Permanent Court of Arbitration, The Hague (Dr. Wheater was judge in a recent India-Pakistan arbitration). GIWS members have provided advice to national and provincial/state governments, advise on major national research programmes in many countries, and hold visiting appointments in many international universities. Current collaborative research includes projects in Asia, Australia, Europe, North America and South America. International Water and Health research includes synchrotron-based research into arsenic pollution in Bangladesh, and research with Imperial College London addressing salinity in the Bangladesh delta and its impacts on the health of 20 million people.

Being a research intensive institute, our primary thrust is on developing and sustaining an excellent research platform for training of graduate students and postdoctoral fellows having multidisciplinary and interdisciplinary expertise in the areas of Hydrological Science, Hydrogeology, Water Resources Engineering, Aquatic Science, and Socio-Hydrology. This is achieved through development of world-class HQP training and mentoring program. Every year, the GIWS Distinguished Lecture Series, “Breakthroughs in Water Security Research” brings 11 international world-leading scientists to Saskatoon each Fall for lectures, tutorials and workshops. In 2013-14, the following leading scientists visited under this program:

1. Larry Band, Voit Gilmore Distinguished Professor of Geography and Director, Institute for the Environment, University of North Carolina
2. Keith Beven, Distinguished Professor, Lancaster Environment Centre, Lancaster University
3. Irena Creed, Canadian Research Chair in Watershed Sciences, Department of Biology, Western University
4. Efi Foufoula-Georgiou, McKnight Distinguished Professor, University of Minnesota
5. Carol Kendall, Research Hydrologist, U.S. Geological Survey
6. Dani Or, Professor and Director, Institute of Terrestrial Ecosystems, Swiss Federal Institute of Technology (ETH) Zurich
7. Leroy Poff, Professor and Director, Interdisciplinary Graduate Degree Program in Ecology, Colorado State University

8. John Selker, Professor and Director, Center for Transformative Environmental Monitoring, Oregon State University
9. Murugesu (Siva) Sivapalan, Professor, University of Illinois, Urbana-Champaign
10. Peter Troch, Professor of Surface Water Hydrology and Director, Biosphere 2, The University of Arizona
11. Harry Vereecken, Professor, Bonn University and Director, Agrosphere (IBG-3)

Some of the international news from our members is provided in Appendix G.

10. Industry Engagement

Western Canada is experiencing unprecedented natural resource development and economic expansion. With increasing economic expansion, irrigation and resource extraction, the western provinces have also seen an increase in population. Natural resource expansion, population growth and climate change all interact to create challenging scenarios for policy makers and governments to manage our water resources and ensure quality and quantity for the future. It is the importance of water and the complexity around its sustainable use and management that creates the need for well trained, motivated, professional water practitioners.

GIWS will continue to work with existing local stakeholders, including agriculture and the oil and gas and mining industries, and will develop new partnerships to pursue research projects of local significance but of international relevance.

GIWS members will also develop new collaborations with industry in Canada and internationally. Industry involvement helps sustain research programs of economic benefit to Saskatchewan and to Canada, and facilitates training of HQP of relevance to industry partners. This will help our programs remain attractive to students and postdoctoral fellows and to industry who are seeking training opportunities for their employees and for the incoming workforce.

In 2013-14, GIWS has seen a significant increase in industry collaborations and resulted in securing $6.2 million in research funds. Of the total 5 Industry Research Chairs (IRC) at U of S, GIWS has 3 IRCs (Lee Barbour, James Hendry, and Matt Lindsay) as its member. Jim Hendry holds the Cameco-NSERC IRC, providing research leadership into uranium tailings management and environmental risk assessment. Lee Barbour and Matt Lindsay holds the Syncrude-NSERC IRCs, with a focus on oil sands reclamation and the environmental management of tailings and leachates. Also, Andrew Ireson, Jeffrey McDonnell and Lee Barbour are leading a project in collaboration with Syncrude Canada Ltd to evaluate the controls on salt release from oil sands reclamation covers. In addition, GIWS has major expertise in the toxicological assessment of oil sands and other mining leachates, through John Giesy and Karsten Liber and their teams. With substantial industrial funding to GIWS members in this area, GIWS's direct support to-date has been limited to graduate student projects in the areas of oil sands landscape reclamation, the management of tailings and effluents in end-pit lakes, and toxicological research. Ongoing

discussions with mining and oil and gas industries are underway concerning hydrogeological research needs and the development of new research facilities for mine cover design and management.

With strong collaborations from the Saskatchewan Water Security Agency (SWSA) and the Buffalo Pound Water Treatment Plant, Helen Baulch is leading a Strategic Grant program funded by NSERC to study the lake metabolism and algal blooms and develop new tools for the management of potable water sources. Jeff Hudson is leading another major project on Lake Diefenbaker water quality in collaboration with SWSA to establish an understanding of Lake's sensitivity to changes in nutrient concentration and cyanobacteria blooms to better inform management of the reservoir.

Tim Jardine is leading a NSERC Collaborative Research and Development (CRD) Grant in partnership with SaskPower to identifying flood- and food-related limits to fish and wildlife production in the Saskatchewan River Delta as effected by the EB Campbell hydro-power dam. In addition, he was invited to participate in an external review of the environmental monitoring program developed by Sherritt International in response to the Obed Mountain Mine coal tailings spill in Apetowun Creek, Alberta on October 31st, 2013.

Lee Barbour and James Hendry are working with Teck Coal Ltd to study spatial Variability in Geochemistry and Water Flow Pathways - Water and Physical Characterization and geochemistry and Se Attenuation in Saturated Waste Rock at Teck's Fording River Operations with support from NSERC Industry Post Graduate scholarship program.

Won Jae Chang closely collaborating with Husky Oil to develop microbial assessment and bioremediation feasibility for petroleum hydrocarbon contaminated soils through a NSERC CRD. In addition, he is leading a major project on development of functionalized clay-based reactive media for removal of cationic salts from brine effluent in collaboration with the International Minerals Innovation Institute (Agrium, Mosaic, and PotashCorp). He has also initiated a new collaboration with Delco Water through a NSERC Engage grant on characterization of manganese-oxidizing bacterial populations in a biofiltration unit in a water treatment plant in Saskatchewan.

Amin Elshorbagy is collaborating with the City of Saskatoon in analyzing the variation in (IDF) curves under non-stationary climatic conditions.

Grant Ferguson is collaborating with the Slyvia Fedoruk Canadian Centre for Nuclear Innovation and Atomic Energy of Canada Limited (AECL) to study the probabilistic risk assessment of groundwater flow and contaminant transport at AECL Chalk River Facility.

In collaboration with Areva Canada Ltd and Western Economic Diversification, Karsten Liber, John Giesy and Markus Hecker have acquired an analytical toxicology base (ICP-MS-MS) in support of economic development in western Canada.

Through NSERC Engage grants, Karl-Eric Lindenschmidt initiated research collaborations with NorthPoint Energy Solutions on studying River ice modelling to assess the South Saskatchewan

River's susceptibility to ice cover breakup and risk of ice jam flooding from hydro-peaking discharge from the Gardiner Dam; and with Aquastructure Solutions Inc on studying New Sensor and Data Network Designs to Monitor and Forecast Surface Water Quality in Rivers. He also collaborated with the Manitoba Infrastructure and Transportation to model and forecast ice jamming along the Assiniboine and Red Rivers.

11. Significant Outcomes of Research

The research conducted at GIWS is of both basic and applied in nature and is of high significance to local, national and international research community, government organizations, not for profit organizations, and society. Some of the high impact research outcomes are listed in Appendix H.

12. Outreach and Engagement

One of the primary objectives of 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 CERC research programme, the GIWS, and challenges to be addressed by research conducted here. In February 2014, GIWS hosted its annual two-day workshop bringing together researchers, postdoctoral fellows, students and research staff from the U of S, EC, the SWSA and Agriculture and Agri-Food Canada (AAFC) working on water related projects. The workshop provided 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 visitation by international researchers to GIWS to explore potential collaborative research opportunities. Most notably, in autumn 2013 the GIWS Distinguished Lecture Series in Water Security was launched. Between September and November, eleven 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 available on the GIWS website spawning global interest in the outputs of this lecture series. Advertising efforts are under development for the 2014 Lecture Series.

As another example of outreach and engagement, the Institute, in collaboration with the University's Department of Drama and School of Environment and Sustainability, developed a theatrical play called *Downstream*. This play represented an innovative way to communicate water research knowledge in an engaging and interactive way. The production toured throughout Saskatchewan and Alberta in mid-February and took audience members through an exercise in decision-making when floods threaten. *Downstream* built on a series of workshops held in 2012 that used multiple social science methods to gather views on water security from those working with or having an interest in water stewardship.

As a testament to our efforts, Graham Strickert, Research Associate with the Global Institute for Water Security and the Changing Cold Regions Network, received the U of S award for distinction in outreach and engagement at the convocation ceremony in Fall 2014. Graham has played a key role in outreach and engagement by leading or participating in such innovative projects as *A Collaborative Approach to Defining Water Security in the Saskatchewan River Basin* workshop series, the play *Downstream* and the Invitational Drought Tournament. His latest project *Facilitated Empathy for Water Security in the Saskatchewan River Basin* aims to capture participants' cultural preferences, views about governance and social relations using various social science research tools.

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 communications remains a key component of GIWS collaboration and outreach as guided by four overarching communications goals to: 1) raise awareness of the local, national and international challenges of water security 2) communicate the work and achievements of the GIWS to address these, 3) cultivate and strengthen the sense of community and interdisciplinary working amongst U of S and affiliated agency water researchers, and 4) raise profile of the Institute nationally and internationally to strengthen member and potential-member participation and commitment to GIWS goals and mandate. Within this reporting period, media interactions and published stories of the CERC and other GIWS members numbered 102. A few highlights of communications activities include:

- Numerous presentations given by Howard Wheater locally (11), nationally (4) and internationally (4).
- Launch of Distinguished Lecture Series in Water Security in Fall 2013
- John Pomeroy participated in numerous (43) local, national and international media interviews for radio, TV, newspapers and public talks (6) relating to the Alberta Flood of 2013. In addition, John Pomeroy's work was showed on Discovery Channel "Daily Planet" Disaster Week, and CBC's "The Nature of Things" Snow.
- In March, the GIWS and the Canadian Water Resources Association celebrated World Water Day with an event showcasing student, postdoctoral and young professional water research at the UofS; events began with the Water Leaders of Tomorrow Lecture Series, showcasing the themes of the GIWS and the CERC in water security program, and finished with a student and postdoctoral fellow poster competition.
- Strong GIWS presence at AGU in San Francisco (December 2013), at CGU in Banff (May 2014), and at CMOS in Rimouski (June 2014).

- Lee Barbour's research on oil sands mine reclamation work has been showcased in Geotechnical News Magazine, The Professional Edge (SK Engineering), Globe and Mail Engineering in Canada, and UofS Research News.
- Tim Jardine was interviewed by the Terra Informa radio program following the public forum for the Obed mine tailings spill. In addition, he presented research outcomes to the Cumberland House Cree Nation Chief and Council and Cumberland House Mayor and Council, as well as helped organize and attended a community workshop and feast in Cumberland House, May 2014; attended by 11 U of S faculty/post-docs/students and 100 community members.
- Lalita Bharadwaj was interviewed by CBC Morning Edition: Live Interview, CBC Radio Yellowknife, and CBC Regina on Shale Gas Development in Canada. In addition, she delivered WEBEX presentation to the Government of Canada on Shale Gas Assessment Presentation Government of Canada with John Molson on May 29th, 2014.
- In February, 2014 Karl-Eric Lindenschmidt and Lorne Doig gave presentations to the grade 10-12 science class at Deninu School in Fort Resolution. Lindenschmidt focused on Slave River ice formation and dynamics. Doig discussed the importance of aquatic invertebrates (i.e., as fish food, sentinels of water quality) and their common use in environmental monitoring programs. The students then spent the better part of an afternoon learning how to identify various invertebrate species found in the Slave River and delta. They then analyzed invertebrate samples collected as part of the SWEEP monitoring activities in 2013. Some students then spoke with community elders and searched the internet for information as to which fish ate which type of invertebrate.
- Jeff Hudson was interviewed with Adrianna Christensen (CJME News Talk Regina) on the impact of the release of untreated effluent into Wascana Creek resulting from heavy rains on June 27, 2014.
- Helen Baulch was interviewed on CBC's The Afternoon Edition, Tuesday, August 12 for her work on real-time data monitoring to improve Regina and Moose jaw drinking water.
- Helen Baulch and Lalita Bharadwaj provided their expert opinion to Estevan Mercury news paper on the higher than normal levels of trihalomethane found in more than 100 municipalities in Saskatchewan.
- Jill Johnstone provided expert opinion to CBC Saskatchewan and the Globe and Mail on the effect of climate change fuelling forest fires.
- Patricia Gober was interviewed as part of a series on community building in Pheonix, Arizona. KJZZ Public Radio.

In addition, collaborations with the following provincial partners were established or sustained:

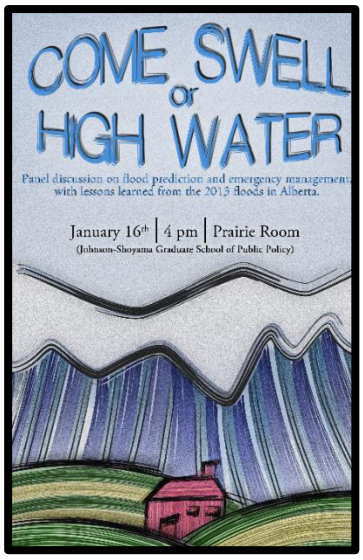
- Saskatchewan Water Security Agency;
- Saskatchewan Environment;
- Saskatchewan Agriculture;
- Saskatchewan Advanced Education & Employment;
- Saskatchewan Economy;
- Saskatchewan International Relations & Protocol;

- Saskatchewan Research Council;
- Alberta Environment and Sustainable Resource Development;
- Alberta Agriculture and Rural Development; and,
- PTRC – Petroleum Technology Research Centre

13. Student Corner

Over the course of the 2013/2014 school year, the Student Outreach Committee (SOC) at GIWS put on many exciting events. Some of the events focused on sharing and discussing the research of the Institute's members, others on raising awareness amongst the campus and wider community about water security issues, while others simply were about merry-making and camaraderie.

13.1 Student Outreach and Education



SOC kicked off academic year in September 2013 with drinks and burgers on Louis' sun-filled patio. Patricia Gober spoke about her research with the socio-hydrology team at GIWS and her previous involvement with the Decision Center for a Desert City at Arizona State University. Many new and returning students attended this event and everyone seemed eager to shake off the summer and hit the books! SOC enticed everyone to sign up to our list serv and to join our Facebook group to keep up with all our future events of the year.

In January 2014, SOC had a panel discussion chaired by John Pomeroy, from the Centre for Hydrology, which focused on extreme weather events, forecasting, and the June 2013 flooding in Calgary, Alberta. Distinguished panelists included Colin King, Government of Saskatchewan Emergency Preparedness Department; Toddi Steelman, Director of the School of Environment and Sustainability; and Kevin Shook, Centre for Hydrology. This event was extremely well received and had a large interactive audience with plenty of great questions. Everyone had a great experience.

Finally, in March 2014 we hosted a seminar called 'The Water Leaders of Tomorrow' and a student poster competition for the 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 many thought-provoking questions were asked of the students. The poster competition followed the seminars with great success. Anna Coles, a PhD student from the GIWS, took first place for her poster on snowmelt runoff generation on the prairies.

13.2 Building a Better Future

An on-going effort by the group throughout the year (in collaboration with the School of Environment and Sustainability Students Association, the USSU, and the Office of Sustainability) has been to raise awareness and to educate members of the campus community and the general public on the benefits of tap water over bottled water. Collectively, we called the campaign 'Better than Bottled'. This has included putting up information booths around campus, creating a website (betterthanbottled.ca), and launching a petition to reduce the sale of bottled water on campus.

November 2013 **March 2014**

We had information booths in November 2013 and March 2014. Passersby had a chance to win refillable water bottles, take a blind tap vs. bottled water taste test, and sign our petition. Booths were displayed during Sustainability Week, Earth Hour, Earth Day and World Water Week with student members from all contributing organizations volunteering for the cause.

Betterthanbottled.ca went live during March's World Water Week and hosts information on the campaign's objectives, academic research links and reviews of media attention the campaign has received. The booths and website have generated a buzz about the consumption of bottled water and SOC hope to see changes in the future as a result of their efforts. Currently, the GIWS student outreach committee is working on a plan to maintain the campaign in the future.

13.3 Promoting Water Security

Our group actively tries to engage the public as well as those on campus by collaborating with other environmentally-focused organizations throughout the city. In September 2013, we collaborated with the Saskatchewan Eco Network for World River's Day. This event was well attended by the general public and provided our group with a great chance to get the word out about what students at the GIWS are doing in the community with research and outreach.

Students of the GIWS also helped to organize an Earth Day celebration and concert at the Farmer's Market, in association with the Saskatchewan Environmental Society, Unitarian Congregation of Saskatoon, School of Environment and Sustainability Students Association, and the Environmental Studies Student Association. Students from the GIWS volunteered at the event running a fun and nature themed photo booth for both children and adults to enjoy. Later in the evening, students also helped run the bar, serving drinks to those enjoying the sounds of local bands during the evening concert.

13.4 The Social Scene

Every now and again students have to blow off steam. As general do-gooders SOC try to provide a venue for this type of activity. SOC organized three purely social gatherings this past year.

For Halloween, SOC collaborated with the Soil Science Graduate Students Association and designed a Halloween/Water/Soil themed scavenger hunt called 'The Haunted Mud Hunt'. The event had students making teams of three to five people and racing on foot around downtown Saskatoon to accomplish as many tasks as possible from the provided list. Once all teams had returned, judges scored the each team's efforts and 'The Beautiful Flowers' were crowned victorious. This event was great fun and SOC hope to continue it on an annual basis.

SOC's second social event was a skating and pub night combination in February at the Spadina Freehouse and Cameco Meewasin Skating Rink. Many students came out to this event, some of whom had never skated before!

The year-end event is always a fun night. This year SOC rented a room in Louis' pub and filled the night with fun water-themed board games (like Geysers and Waterfalls, originally known as Snakes and Ladders), and delicious burgers and drinks.

13.5 Paddles Up!

GIWS students, postdoctoral fellows and staff participated in the annual Dragon Boat Festival in Rotary Park. A spontaneous rallying effort a week earlier resulted in a team of 24 novice-to-experienced paddlers trying to find a shared rhythm and raise money for the Canadian Heart and Stroke foundation. 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.

14. Concluding Remarks

Overall, GIWS has experienced an exponential growth in its activities which are evident from "Performance Indicators", and local, national and international collaborative and outreach activities. A significant effort has been invested in enhancing communication of our research outcomes and impact stories to society and stakeholders. GIWS will continue to go 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 www.usask.ca/water 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 and we also welcome academic colleagues for short or longer visits. Our Assistant Director, Dr. Phani Adapa phani.adapa@usask.ca is always available for contact regarding the work of GIWS and welcomes enquiries from individuals, governments, industry and others concerning research collaboration.

APPENDIX A – List of GIWS Funded Research Projects

1. Effects of urbanization and agriculture on microbial communities in a creek from the semi-arid ecozone of the Canadian Prairies: Swift Current Creek, SK
2. Development of monitoring strategies and identification of hydrological and biogeochemical indicators in the Tobacco Creek
3. Prairie Hydrological Modelling: Understand implications of hysteresis in discharge storage relationships; use multifractal methods to downscale climate model products over Prairies; surface-groundwater modelling; nutrient and contaminant flux from snowmelt over frozen soils
4. Effects of climate change and climate-induced land-use change on hydrology, pedology, and ecology of a hummocky morainal agroecosystem
5. Evaluation of NARCCAP RCM precipitation simulations over the Canadian Prairies
6. Understanding of the interactions between climate, hydrology, and vegetation in the southern boreal forest
7. Sensitivity of Hydrology and Forest Resilience to Climate Variation in the Southern Boreal Forest of Western Canada
8. Boreal forest flux tower operations (BERMS – Boreal Ecosystem Research and Monitoring Sites)
9. Advance development and integration of information on how hydrological and cryospheric processes interact to form streamflow: Canadian Rockies
10. Develop and run hydrological models to produce water resource predictions for past and future climates: Canadian Rockies
11. Exploring water resource management in partnership with the community of water users of Lake Diefenbaker
12. Reconstructing the history of the phototrophic community within Lake Diefenbaker and analysis of biotoxins produced from a recent algal bloom
13. Reconstructing historical algal community composition and toxin production potential in inland waters: A rapid paleogenomic approach
14. An investigation into the past and present ecological status of Lake Diefenbaker using paleolimnological and whole sediment toxicity techniques
15. Water quality modelling of Lake Diefenbaker
16. The contribution of point and diffuse sources of nutrients to Lake Diefenbaker: A sensitivity analysis
17. Brightwater Creek multi-scale measurement and modelling programme
18. Peat properties and groundwater flows in relation to beaver paleoponds in mountain peatlands
19. Assessing links between water, animals and people in the Saskatchewan River delta
20. A collaborative approach to better understand the links between water, animals, and people in the Saskatchewan River Delta
21. Assessing links between water, animals and people in the Saskatchewan River delta (People dimension)
22. 'Exotic' chemical contaminants in the South Saskatchewan River Basin

23. Stakeholder definitions of water security in the South Saskatchewan River Basin
24. Investigating links between Lake Sturgeon (Acipenser fulvescens) habitat and geomorphology in the Saskatchewan River system using geomorphic response units (GRU)

APPENDIX B – 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

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

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

Khaliq, Naveed, Associate Professor, School of Environment and Sustainability
Stochastic modeling of hydrometeorological variables; Extreme value analysis; Impacts of climate and land use changes on water resource systems; Storm water modeling and river flow forecasting; Soil and water management; Applied software development

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

Patricia, Hania, Assistant Professor, College of Law
Legal water governance models in Canada; Teaches a course in Water Law

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

Putz, Gordon, Professor, Civil and Geological Engineering
Water quality modelling and management; Water and wastewater treatment

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

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.

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

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

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

Klaus, Julian, Centre de Recherche Public - Gabriel Lippmann, Luxembourg
Runoff generation processes; Catchment and Hillslope Hydrology; Stable Isotope Methods in Hydrology; Modeling of water and solute transport at hillslope and headwater scale

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

Mekonnen, Muluneh, Water Modelling Engineer, Alberta Environment and Sustainable Resource Development
Linked atmospheric-hydrologic-land surface model development and application

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

Nachshon, Uri, Postdoctoral Fellow, Global Institute for Water Security

Hydrology; Vadose zone; Salinization; Land-atmoshere interaction; Salt dynamics; Evaporation

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

Razavi, Saman, Postdoctoral Fellow, Civil and Geological Engineering
Environmental and Water Resources Systems Planning and Management; Hydrologic and Groundwater Modelling; Climate Change and Impacts on Hydrology and Water Resources; Reconstruction of Paleo-hydrology – Implications for Climate Change Analysis; Rainfall and runoff forecasting; Artificial Intelligence, and Machine Learning

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
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
Baijius, Warrick	Geography & Planning	R. Patrick	MA
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-Haughn	MSc
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. Lindenschmidt	MES
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. Lindenschmidt	MES
David, Cody	Soil Science	W. Helgason	MSc

Demuth, Brandon	Biology	D. Chivers	PhD
Dobrovolskaya, Yekaterina	SENS	B. Si	MES
Doering, Jonathon	Toxicology	M. Hecker	PhD
Dompierre, Kathryn	Civil & Geological Engineering	L. Barbour	PhD
Dudiak, Scott	Arts & Science	n/a	Undergraduate
Dumanski, Stacey	Geography & Planning	J. Pomeroy	MSc
Ferdous, Jannatul	Chemical & Biological Engineering	W. Helgason	PhD
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
Hamisi Karoyo, Abdalla	Chemistry	L. Wilson	PhD
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
Hoemsen, Brittney	Biology	D. Chivers	MSc
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
Jaramillo, Pablo	Engineering	n/a	Undergraduate
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
Lakken, Nils	SENS	D. Clark	MES
Leroux, Nicolas	Geography & Planning	J. Pomeroy	PhD
Liu, Ning	SENS	K-E. Lindenschmidt	PhD
Lokken, Torbjom	RRM	n/a	Undergraduate
Lucas, Brett	Toxicology	K. Liber	MSc
Madaeni, Fatemeh	Civil & Geological Engineering	A. Elshorbagy	PhD
Mahmood, Fazilatun	Geological Sciences	J. Hendry	PhD
Mamo, Moges	Civil & Geological Engineering	A. Ireson	MSc
Masse, Anita	Toxicology	D. Janz	Masters
Masud, Badrul	SENS	N. Khaliq	PhD

Mekonnen, Balew	Civil & Geological Engineering	K. Mazurek	PhD
Mercer, Jason	Geography & Planning	C. Westbrook	MSc
Mohamadmahdi, Kowsari	Chemical & Biological Engineering	J. Soltan	MSc
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
Roste, Jennifer	Geography & Planning	H. Wheater/J. Pomeroy	MSc
Sadeghi, Azam	Chemical & Biological Engineering	J. Soltan	MSc
Sadeghian, Amir	SENS	K-E. Lindenschmidt	PhD
Saunders, David	Toxicology	J. Giesy	MSc
Schabert, Marcie	Arts & Science	n/a	Undergraduate
Sizo, Anton	Geography & Planning	B. Noble	PhD
Steeves, Joel	Civil & Geological Engineering	L. Barbour	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, Faud	SENS	H. Wheater	PhD
Yee, Briana	Arts & Science	n/a	Undergraduate
Yip, Hayden	Biology	J. Hudson	MSc
Younes, Firas	SENS	R. Patrick	MSEM
Zee, Jenna	SENS	M. Hecker	MES
Zilefac, Elvis	SENS	H. Wheater	PhD

APPENDIX C – GIWS Employees and Students 2013-2014

The following table provides information on GIWS employees and students funded during the period of 2013-2014. A total of 157 personnel were funded during this period, including 7 GIWS faculty members, 7 administrative staff, 40 research assistant/technicians, 6 research associates/scientists, 28 postdoctoral fellows, 19 doctoral students, 31 masters' students and 19 undergraduate student assistants.

Name	Title/ Area	Supervisor/ Unit
CERC Faculty		
Baulch, Helen	Assistant Professor	SENS
Ireson, Andrew	Assistant Professor	SENS
Khaliq, Naveed	Associate Professor	SENS
Li, Yanping	Assistant Professor	SENS
Lindenschmidt, Karl-Eric	Associate 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	Communication Specialist – 0.5 FTE	H. Wheater
Olauson, Sherry	Clerical Assistant	H. Wheater
Porter, Lesley	Communication Specialist – 0.5 FTE	H. Wheater
Schlosser, Tiffany	Financial Officer	H. Wheater
Wilson, Katherine	Executive Assistant	H. Wheater
Zdravkovic, Branislav	IT Administrator – Data	H. Wheater
Technical Support		
Al-mahdawe, Mohammed	Research Assistant	B. Zdravkovic
Akomeah, Eric	Research Assistant	K. Lindenschmidt
Asante, Christian	Undergraduate Student Assistant	T. Jardine
Bauer, Jay	Research Technician	Baulch/Bedard-Haughn
Bayne, Dell	Research Technician	W. Helgason
Belosowsky, Tayler	Undergraduate Student Assistant	J. Hudson
Berry, Pamela	Research Assistant	K. Lindenschmidt
Bertollo, Steve	Research Technician	J. Pomeroy
Briens, Jennifer	Undergraduate Student Assistant	H. Baulch
Bush, James	Undergraduate Student Assistant	A. Bedard-Haughn
Campbell, Jordan	Undergraduate Student Assistant	J. McDonnell
Carriere, Michela	Undergraduate Student Assistant	T. Jardine
Charry, Bertrand	Research Assistant	J. Johnstone
Cowell, Mattea	Undergraduate Student Assistant	J. McDonnell
Crawford, Caley	Undergraduate Student Assistant	J. Hudson
DeBeer, Chris	Research Associate	H. Wheater
Dobrovolskaya, Katya	Research Assistant	H. Baulch
Doig, Lorne	Research Technician	K. Liber

Duncan, Angus	Research Technician	J. Pomeroy
Eisner, Bryanna	Undergraduate Student Assistant	M. Hecker
Elliott, Carlie	Undergraduate Student Assistant	C. Westbrook
Fang, Xing	Research Officer	J. Pomeroy
Flahr, Leanne	Research Assistant	T. Jardine
Gilmour, Kimberly	Research Assistant	H. Baulch
Guan, Juan	Research Officer	J. Pomeroy
Haines, Llewellyn	Research Assistant	J. Hudson
Hewlett, Curtis	Undergraduate Student Assistant	J. Hudson
Hill, Allison	Research Assistant	P. Jones
Hillis, Erin	Research Assistant	H. Baulch
Hoggarth, Cameron	Research Assistant	H. Baulch
Hopkins, Joe	Research Assistant	J. Hudson
Hosseini, Nasim	Research Assistant	K. Lindenschmidt
Hunter, Kristine	Lab Technician	J. Hudson
Isbister, Dallas	Research Assistant	K. Liber
Janzen, Kimberly	Research Associate	J. McDonnell
Johnson, Bruce	Research Technician	Helgason/ Wheater/ McDonnell
Johnson, Laurie	Research Technician	J. Hudson
Kaur, Navjot	Research Assistant	H. Baulch
Kiss, Jeremy	Research Assistant	Baulch/Bedard-Haughn
Kittisenee, Jetana	Research Technician	J. Hudson
Kusch, Jillian	Undergraduate Student Assistant	J. Hudson
Livingston, Andrew	Research Assistant	L. Bharadwaj
Mackinnon, Brett	Research Assistant	T. Jardine
Markwart, Blue	Undergraduate Student Assistant	K. Liber
Meissner, Anna	Research Assistant	J. Hudson
Mock, Tyler	Undergraduate Student Assistant	J. Hudson
Monteiro, Meagan	Undergraduate Student Assistant	W. Helgason
Mosaffa, Mahtab	Research Assistant	K. Lindenschmidt
Nazemi, Ali	Research Associate	Wheater/ Elshorbagy
Pomedli, Michelle	Undergraduate Student Assistant	J. Hudson
Ponomarenko, Yakiv	Undergraduate Student Assistant	J. Hudson
Pratt, Dyan	Research Assistant	L. Barbour
Prestie, Chance	Research Assistant	J. Hudson
Razouli, Kibar	Research Officer	J. Pomeroy
Sarauer, Bryan	Research Technician	M. Hecker
Settee, Pierrette	Research Assistant	M. Reed
Shook, Kevin	Research Scientist	J. Pomeroy
Sit, Victor	Lab manager	H. Baulch
Smith, Paul	Undergraduate Student Assistant	A. Wheater
Strickert, Graham	Research Associate	Wheater/ Clark
Timsic, Sandra	Research Associate	McDonnell

Weber, Darian	Undergraduate Student Assistant	K. Lindenschmidt
Williams, Tyler	Research Assistant	J. Pomeroy
Wilson, Heather	Research Technician	Bedard-Haughn/Spence
Yip, Hayden	Research Technician	J. Hudson
Postdoctoral Fellows		
Alebachew Ali, Melkamu	Postdoctoral Fellow	Ireson/Ferguson/McKay
Appels, Willemijn	Postdoctoral Fellow	J. McDonnell
Bradford, Lori	Postdoctoral Fellow	L. Bharadwaj
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
Kehoe, Michael	Postdoctoral Fellow	H. Baulch
Keim, Dawn	Postdoctoral Fellow	Ireson/Ferguson/McKay
Kinar, Nicholas	Postdoctoral Fellow	J. Pomeroy
Klaus, Julian	Postdoctoral Fellow	J. McDonnell
Mahmood, Taufique	Postdoctoral Fellow	Wheater/Pomeroy
Mamet, Steve	Postdoctoral Fellow	J. Johnstone
Morales Marin, Luis	Postdoctoral Fellow	Lindenschmidt/Wheater
Musselman, Keith	Postdoctoral Fellow	J. Pomeroy
Nachshon, Uri	Postdoctoral Fellow	Ireson/Wheater
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
Graduate Students		
Bam, Edward	Doctoral Student	A. Ireson
Beveridge, Danny	Doctoral Student	C. Westbrook
Cavaliere, Emily	Doctoral Student	H. Baulch
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
Liu, Ning	Doctoral Student	K. Lindenschmidt
Masud, Mohammed	Doctoral Student	N. Khaliq
Pradhananga, Dhiraj	Doctoral Student	J. Pomeroy

Sadeghian, Amir	Doctoral Student	K. Lindenschmidt
Safa, Hamideh	Doctoral Student	H. Wheater
Scaff, Lucia	Doctoral Student	Y. Li
Shahariar, Shayeb	Doctoral Student	A. Bedard-Haughn
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
Brannen, Rosa	Masters Student	A. Ireson
Bruce, Kristin	Masters Student	P. Gober
Carlson, Hayley	Masters Student	M. Fulton
Carr, Meghan	Masters Student	K. Lindenschmidt
Das, Apurba	Masters Student	K. Lindenschmidt
Dubourg, Paul	Masters Student	J. Hudson
Dumanski, Stacey	Masters Student	J. Pomeroy
Galuschik, Noel	Masters Student	H. Baulch
Gonda, Jordan	Masters Student	Wheater/Elshorbagy
Gooding, Raea	Masters Student	H. Baulch
Head, Kerry	Masters Student	J. Hudson
Hunter, Kristine	Masters Student	J. Hudson
Johansson, Jessica	Masters Student	J. Hudson
Lucas, Brett	Masters Student	Liber/Doig
Maher, Allen	Masters Student	C. Westbrook
Mamo, Moges	Masters Student	A. Ireson
Mercer, Jason	Masters Student	C. Westbrook
Morrison, Alasdair	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
Siemens, Evan	Masters Student	J. Pomeroy
Steeves, Kean	Masters Student	N. Hogan
Wang, Hanyang	Masters Student	B. Patrick
Wu, Hongye	Masters Student	C. Westbrook
Yip, Hayden	Masters Student	J. Hudson
Yuan, Hongda	Masters Student	P. Jones

APPENDIX D – 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 154 graduate students (PhD 71 and Masters 83) were funded by our members during the period 2013-14. In addition, our members supported and trained 92 highly qualified personnel, including 20 postdoctoral fellows and research associates, 18 research technicians, 6 research scientists, and 39 graduate and undergraduate 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
O. Abirhire	Hudson	MSc	Biology	Limnology
Abu, R.	Reed	PhD	SENS	Environmental governance
Amick, Kari	Clark	MES	SENS	Socio-ecology
Nikolas Aksamit	Pomeroy	PhD	Geography	Hydrology
Y. Al-Naggar	Giesy	PhD	Toxicology	Enviro. Tox.
H. Al-Harbi	Giesy	PhD	Toxicology	Enviro. Tox.
M. Amos	Barbour	MSc	Civil & Geolog. Engrg.	Geotech. Engrg. - Hydrology
Emily Anderson	Pomeroy	MSc	Geography	Hydrology
Christian Asante	Jardine	MES	SENS	Aquatic Toxicology
T. Baer	Barbour	MSc	Civil & Geo. Eng.	Geo. Enviro. Eng.
Tabata Bagatim	Hecker	MES	SENS	Aquatic Toxicology
Warrick Baijius	Patrick	MA	Arts & Sc.	Watershed Planning
M. Basdeo	Bharadwaj	MSc	SENS	Impact of Water Regulation
Bassett, E.	Reed	MSEM	SENS	Environmental farm plans
Shawn Beitel	Hecker	MSc	Toxicology	Aquatic Toxicology
R.L. Brown	Bedard-Haughn	MSc	Soil Sc.	Surface drainage and soil properties

Kristin Bruce	Gober	MPP	JSGS	Water Policy
Buchanan, A.	Reed	MES	SENS	Adaptive capacity
M.Buchynski	Barbour	MSc	Civil & Geo. Eng.	Geochemistry
L. Carse	Barbour	PhD	Q. U.Belfast (N.Ireland)	Geotechnics
Cavallaro, M.	Liber	PhD	Toxicology	Aquatic Toxicology
C. Chadwick	Elshorbagy	MSc (visiting)	Pontificia Universidad Católica de Chile	Climate Change
Liang Chen	Li, Yanping	PhD	GIWS	Coupled Modeling
J. Chilima	Bharadwaj	PhD	SENS	Community-based Approach
Sanjukta Choudhury	Pickering	PhD	Geological Sc.	Confocal X-ray fluorescence
A. Conway	Johnstone	PhD	Biology	Plant ecology
Crawford, S.	Liber	PhD	Toxicology	Aquatic Toxicology
Tengfei Cui	Martz	PhD	Geography and Planning	Climate change and grassland
D'Silva L.	Liber/ Doig	MSc	Toxicology	Ecotoxicology
Sandeepraja Dangeti	Chang	MSc	Civil & Geo. Eng.	
A. Debusschere	Barbour	MSc	Soil Science	Geology, statistics
S. Deen	Barbour	MSc	Civil & Geo. Eng.	Geochemistry
Merino Dianderas, C.	Liber	MSc	Universidad Peruana Cayetano Heredia, Lima, Peru	Aquatic Toxicology
J. Doering	Giesy/ Hecker	PhD	Toxicology	Enviro. Tox.
Dominic Demand	Pomeroy	MSc	Geography	Hydrology
K. Dompierre	Barbour/ Lindsay	PhD	Civil & Geolog. Engrg.	Environ. Engrg - Hydrogeol.
P. Dubourg	Hudson	MSc	Biology	Limnology
Stacey Dumanski	Pomeroy	MSc	Geography	Hydrology
Egunyu, F.	Reed	PhD	SENS	Collaborative forestry

L. Ford	Bharadwaj	MSc	SENS	Human Health Risk Assessment
M. Frey	Johnstone	MSc	Biology	Plant ecology
George, C.	Reed	PhD	SENS	Environmental justice
Gillio Meina, E.	Liber	PhD	Toxicology	Aquatic Toxicology
Kellie Grant	Patrick	MA	Arts & Sc.	Source Water Protection
G. Guenther	Bharadwaj	MSc	Toxicology	Endocrine Disrupters
Sara Hanson	Hecker	MSc	Toxicology	Aquatic Toxicology
Phillip Harder	Pomeroy	PhD	Geography	Hydrology
R. Harley	Barbour	PhD	Q. U.Belfast (N.Ireland)	Slope Stability
H. He	Giesy	PhD	Toxicology	Enviro. Tox.
K. Head	Hudson	MSc	Biology	Limnology
Henderson, A.	Reed	PhD	SENS	Species at risk
D. Henkel-Johnson	Johnstone	PhD	Biology	Plant ecology
M. Horachek	Johnstone	MSc	Biology	Plant ecology
K. Hunter	Hudson	MSc	Biology	Limnology
M. Huynh	Bharadwaj	PhD	Community Health and Epidemiology	Public Health Risks
Hyandye, Canute B.	Martz	PhD	Nelson Mandela African Institute of Science and Technology	Surface-Groundwater Balance
Ashley James	Pickering	PhD	Toxicology	Organomercury in zebrafish
A. Janfada	Barbour	PhD	Civil & Geo. Eng.	Geo. Enviro. Eng.
M. Jean	Johnstone	PhD	Biology	Plant ecology
J. Johansson	Hudson	MSc	Biology	Limnology
M. Johnson	Barbour	MSc	Soil Science	Soil Physics
Jihun Kim	Chang	PhD	Civil & Geo. Eng.	
Nicholas Kinar	Pomeroy	PhD	Geography	Hydrology
Wilhelm Kiwango	Martz	PhD	Nelson Mandela African Institute of Science and Technology	Decentralized environmental governance
S. Klemmer	Ferguson	MSc	Civil & Geo. Eng.	Rock Mechanics

B. Koehler	Barbour/ Ferguson	MSc	Civil & Geolog. Engrg.	Geo-Enviro. Engrg.
R. Koonkoon	Ferguson	PhD	Civil & Geo. Eng.	Geological
Sebastian Krogh	Pomeroy	PhD	Geography	Hydrology
S. Kuleza	Johnstone	MSc	Biology	Plant ecology
K. Kulpa	Barbour	MSc	Civil & Geo. Eng.	Hydro. Geol. Eng.
Sopan Kurkute	Li, Yanping	PhD	SENS	Boundary layer process
T. Kuzyk	Barbour	MSc	Civil & Geo. Eng.	Geochemistry
Lankshear, Jessica	Clark	MSEM	SENS	Bear-human conflict
J. Ledding	Barbour	MSc	Civil & Geolog. Engrg.	Geo-Enviro. Engrg.
Nicolas Leroux	Pomeroy	PhD	Geography	Hydrology
Shengnan (Jill) Li	Pickering	PhD	Biology	Selenium in fungus
Liu, D.	Liber	PhD	Ocean University of China, Qingdao, P.R. China	Aquatic Toxicology
M. Lu	Barbour	MEng	Civil & Geo. Eng.	Geo. Enviro. Eng.
Lucas, B.	Liber/ Doig	MSc	Toxicology	Ecotoxicology
Lucian, Salustian	Martz	MSc	Nelson Mandela African Institute of Science and Technology	Groundwater vulnerability model
Zhibang Lv	Pomeroy	PhD	Geography	Hydrology
K. Lynch	Barbour	PhD	Q. U.Belfast (N.Ireland)	Geotech. Engrg
Matt MacDonald	Pomeroy	PhD	Geography	Hydrology
Brett MacKinnon	Jardine	MES	SENS	Aquatic Toxicology
F. Madaeni	Barbour	PhD	Civil & Geo. Eng.	Geo. Enviro. Eng.
Chris Marsh	Pomeroy	PhD	Geography	Hydrology
Anita Massé	Janz	MSc	Toxicology	Aquatic Toxicology
K. McLaughlin	Bharadwaj	MSc	Geography and Planning	Trucking of Potable water

M. McLernon	Barbour	PhD	Q. U.Belfast (N.Ireland)	Geotech. Engrg. - numer. modeling
Landon McPhee	Janz	MSc	Toxicology	Aquatic Toxicology
Jordan Mihalicz	Jardine	MES	SENS	Aquatic Toxicology
G. Morandi	Giesy	MSc	Toxicology	Enviro. Tox.
Susan Nehzati	Pickering	MSc	Geological Sc.	Mercury custom chelators
J. Nesbitt	Lindsay	MSc	Geological Sc.	Geochemistry
Ohiozebau, Ehimai	Clark	PhD	SENS	Fish Health
Olagunju, Ayodele	Clark	PhD	SENS	Cumulative Effects Assessment
Sarah Patterson	Hecker	MSc	Toxicology	Aquatic Toxicology
Diana Payton	Gober/ Clark	MPP	JSGS	Water Policy
D. Penrod	Ferguson/ Lindsay	MSc	Geological Sc.	Hydrogeology
Dhiraj Pradhananga	Pomeroy	PhD	Geography	Hydrology
C. Prestie	Hudson	MSc	Biology	Limnology
Abdul Qader	Gober	MPP	JSGS	Water Policy
Ning Qiao	Martz	PhD	Geography and Planning	Prairie drainage modelling
K. Qin	Lindsay	MSc	Geological Sc.	Geochemistry
Kabir Rasouli	Pomeroy	PhD	Geography	Hydrology
Jamie Ross	Gober	MPP	JSGS	Water Policy
Jennifer Roste	Pomeroy	MSc	Geography	Hydrology
A. Sadeghi	Jones	MSc	Chem. Eng.	Chem. Eng.
H. Safa	Elshorbagy	PhD	Civil and Geo. Eng.	Water Resources
D. Saunders	Giesy	PhD	Toxicology	Enviro. Tox.
Lucia Scaff	Li, Yanping	PhD	SENS	Atmospheric Observations
M. Schabert	Barbour	MSc	Geological Sciences	Geochemistry
Will Schenn	Jardine/ Janz	PhD	SENS	Aquatic Toxicology
Schiffer, S.	Liber	MSc	Toxicology	Oil sands
E. Schmelling	Barbour	MSc	Geological Sciences	Hydrogeology

Dayna Schultz	Hecker	MSc	Toxicology	Aquatic Toxicology
K. Scott	Lindsay	MSc	Geological Sc.	Geochemistry
F. Shafiei	Hudson	PhD	Biology	Limnology
Shahadu, H.	Reed	PhD	SENS	Policy innovation and wildfire
S. Shahariar	Bedard-Haughn	PhD	Soil Sc.	Land-use management
Rosa Sharp	Pomeroy	PhD	Geography	Hydrology
A. Shenoy	Johnstone	PhD	Biology (Alaska)	Plant ecology
Darren Sherrell	Pickering	PhD	Geological Sciences	Metalloprotein diffract spectros
Shemsanga, Ceven	Martz	PhD	Nelson Mandela African Institute of Science and Technology	Groundwater Dynamics and Water Management
Evan Siemens	Pomeroy	MSc	Geography	Hydrology
L. Smith	Barbour	PhD	Geological Sciences	Geochemistry
Melani Sooriyaarachchi	Pickering	PhD	Chemistry, Calgary	Platinum-based anti-cancer drugs
C. Steele	Ferguson	MSc	Civil & Geo. Eng.	Hydrogeology
J. Steeves	Barbour/ Ferguson	MSc	Civil & Geolog. Engrg.	Hydrogeology
J. Stone	Barbour	MEng	Civil & Geo. Eng.	Geo. Tech. Eng.
Kelly Summers	Pickering	PhD	Chemistry	Copper in health and disease
J. Szmigielski	Barbour	MSc	Geological Sciences	Geochemistry
L. Tallon	Barbour	PhD	SENS	Soil Sci. - Geo-enviro. Engrg.
B. Tendler	Jones	MSc	Toxicology	Ecotoxicology
Jith Thomas	Janz	PhD	Toxicology	Aquatic Toxicology
J. Tipman	Barbour	MSc	Civil & Geo. Eng.	Geo. Enviro. Eng.
Tim Tse	Jones/Doig	PhD	Toxicology	Ecotoxicology
L. Ufondu	Ferguson	PhD	Civil & Geo. Eng.	Geological
D. Vardy	Giesy/ Hecker	PhD	Toxicology	Enviro. Tox.
X. Walker	Johnstone	PhD	Biology	Plant ecology
X. Wang	Bedard-Haughn	PhD	Soil Sc.	Mountain peatland

Welter, S.	Reed	MES	SENS	Adaptive capacity
White, K.	Liber	MSc	Toxicology	Oil sands process water
H. Yip	Hudson	MSc	Biology	Limnology
Kyle Young	Patrick	MSEM	SENS	Watershed Planning
Shaguftah Younis	Pickering	MSc	Chemistry	Arsenic sorption materials
Hongda Yuan	Jones	MSc	Toxicology	Ecotoxicology
Mohammadreza Zarcheshm	Martz	PhD	Geography and Planning	
Jenna Zee	Hecker	MES	SENS	Aquatic Toxicology
J. Zettl	Barbour	MSc	Civil & Geo. Eng.	Geo. Enviro. Eng.

Highly Qualified Personnel

Research Personnel	Supervisor	Position	Department	Subject Area
Adesokan, Adedoyinsola	Barbour	Research Assistant	Civil & Geo. Eng.	Geo-Enviro.
W. Apples	McDonnell/ Barbour	Postdoctoral Fellow	SENS	Overland flow
Baer, Thomas	Barbour	Graduate Student Research Assistant	Civil & Geo. Eng.	Geo-Enviro.
Blower, Anthony	Barbour	Undergraduate Research Assistant	Civil & Geo. Eng.	Oil-sands Research
Tom Brown	Pomeroy	Research Technician	Geography	
Lori Bradford	Bharadwaj	Postdoctoral Fellow	SPH	Water for Health
Buchynski, Matthew	Barbour	Undergraduate Research Assistant	Civil & Geo. Eng.	Oil-sands Research
Bullock, R.	Reed	Postdoctoral Fellow	SENS	Environmental Geography
Campbell, Anna	Barbour	Summer Student Assistant	Civil & Geo. Eng.	Geo-Enviro.

Carter, C.	Liber	Undergraduate Student Assistant	Toxicology	Culture Maintenance
Chostner, Virginia	Barbour	Research Assistant	Civil & Geo. Eng.	Geo-Enviro.
Alana Closs	Hudson	Research Technician	Biology	Limnology
G. Codling	Giesy	Research Associate	Toxicology	Enviro. Tox.
Jonathan Conway	Pomeroy	Postdoctoral Fellow	Geography	
Julien Cotelesage	Pickering	Research Associate	Geological Sciences	Structure analysis of biomolecules
Doig, L.	Liber	Research Scientist	Toxicology	Group Manager
Katrina Dorosh	Barbour	Undergraduate Field Research Assistant	Civil & Geo. Eng.	Geo-Enviro.
Angus Duncan	Pomeroy	Research Technician	Geography	
Bryanna Eisner	Hecker	Undergraduate Student Assistant	Toxicology	Aquatic Toxicology
Xing (Logan) Fang	Pomeroy	Research Technician	Geography	
Leanne Flahr	Jardine	Research Technician	Toxicology	Enviro. Tox.
Danielle Gagnon	Hecker	Undergraduate Student Assistant	Toxicology	Aquatic Toxicology
Xiu Juan (May) Guan	Pomeroy	Research Technician	Geography	
Mark Hackett	Pickering	Postdoctoral Fellow	Geological Sciences	Sulfur speciation in stroke
Llewellyn Haines	Hudson	Research Technician	Biology	Limnology
Timon Heide	Hecker	M.Sc. – Visiting Student	RWTH Aachen, Germany	Aquatic Toxicology
Horinek, Wanda	Barbour	Undergraduate Research Assistant	Civil & Geo. Eng.	Geo-Enviro.
Kristine Hunter	Hudson	Research Technician	Biology	Limnology

Isbister, D.	Liber	Undergraduate Student Assistant	Toxicology	Culture Manitenance
Daryl Janzen	Pomeroy	Postdoctoral Fellow	Geography	
Laurie Johnson	Hudson	Research Technician	Biology	Limnology
Nicholas Kinar	Pomeroy	Postdoctoral Fellow	Geography	
Jetana Kittisenee	Hudson	Research Associate	Biology	Limnology
Koehler, Bryan	Barbour	Graduate Student Research Assistant	Civil & Geo. Eng.	Geo-Enviro.
Nadine Lemoine	Bharadwaj	Research Associate	Slave River and Delta	SWEEP Project
Jillian Kusch	Hudson	Undergraduate Research Assistant	Biology	Limnology
Jialin Liu	Janz	Undergraduate Student Assistant	Toxicology	Aquatic Toxicology
	Barbour	Graduate Student Research Assistant	Civil & Geo. Eng.	Geo-Enviro.
Lu, Mengna				
Madaeni, Fatemehalsadat	Barbour	Research Assistant	Civil & Geo. Eng.	Geo-Enviro.
Taufique Mahmood	Pomeroy	Postdoctoral Fellow	Geography	
Steven Mamet	Johnstone	Postdoctoral Fellow	Biology	Ecology
Michelle Mandeville	Bharadwaj	Community Research Associate	Fort Resolution – Metis Council	SWEEP Project
R. Mankidy	Giesy	Research Scientist	Toxicology	Enviro. Tox.
Markwart, B.	Liber	Undergraduate Student Assistant	Toxicology	Paleolimnological Analyses
Matthews, A.	Liber	Undergraduate Student Assistant	Toxicology	Culture Manitenance

Eddy McKay	Bharadwaj	Community Research Associate	Fort Resolution – First Nation	SWEEP Project
Miller, Jesse	Barbour	Undergraduate Research Assistant	Civil & Geo. Eng.	Oil-sands Research
Tyler Mock	Hudson	Research Assistant	Biology	Limnology
Jordyn Morken	Johnstone	Undergraduate Research Assistant	Biology	Ecology (SURI)
Keith Musselman	Pomeroy	Postdoctoral Fellow	Geography	
Newman, Kevin	Barbour	Undergraduate Field Research Assistant	Civil & Geo. Eng.	Geo-Enviro.
Nguyen, H.	Liber	Undergraduate Student Assistant	Toxicology	Tissue Sampling
Nielsen, Andrea	Barbour	Undergraduate Research Assistant	Civil & Geo. Eng.	Geo-Enviro.
Rebecca North	Hudson	Postdoctoral Fellow	Biology	Limnology
Michelle Pomedli	Hudson	Research Technician	Biology	Limnology
Olena Pomonarenko	Pickering	Research Associate	Geological Sciences	Metals in biology
Yakiv Ponomarenko	Hudson	Undergraduate Research Assistant	Biology	Limnology
Pratijit, Praynay	Barbour	Undergrad Research Assistant	Civil & Geo. Eng.	Geo-Enviro.
Pratt, Dyan	Barbour	Research Engineer	Civil & Geo. Eng.	Geo-Enviro.
Hillary Prodahl	Hecker	Undergraduate Student Assistant	Toxicology	Aquatic Toxicology
Sarah Pryce	Hecker	Undergraduate Student Assistant	Toxicology	Aquatic Toxicology

Raes, K.	Liber	Undergraduate Student Assistant	Toxicology	Culture Maintenance
Raine, J.	Liber	Research Scientist	Toxicology	ATRF Manager
Jordie Richardson	Janz	Undergraduate Student Assistant	Toxicology	Aquatic Toxicology
Charlie Roy	Johnstone	Undergraduate Research Assistant	Biology	Ecology (NSERC USRA)
Sattler, Kelvin	Barbour	Undergraduate Research Assistant	Civil & Geo. Eng.	Geo-Enviro.
B. Sarauer	Giesy	Research Technician	Toxicology	Enviro. Tox.
Schreiber, Joey	Barbour	Undergraduate Research Assistant	Civil & Geo. Eng.	Oil-sands Research
Kevin Shook	Pomeroy	Scientist	Geography	
Satya Singh	Pickering	Research Associate	Geological Sciences	Mercury in amalgam
Smith, Laura	Barbour	Graduate Student Research Assistant	Civil & Geo. Eng.	Geo-Enviro.
Merran Smith	Bharadwaj	Research Assistant	Yukon Research Institute	Water Regulations
Kean Steeves	Janz	Undergraduate Student Assistant	Toxicology	Aquatic Toxicology
Song Tang	Hecker	Postdoctoral Fellow	Toxicology	Aquatic Toxicology
Brett Tendler	Hecker	Undergraduate Student Assistant	Toxicology	Aquatic Toxicology
Emily Tissier	Johnstone	Research Technician	Biology	Ecology
Townsend, M.	Liber	Research Technician	Toxicology	Tissue Sampling
Alexandre Truchon-Savard	Johnstone	Research Technician	Biology	Ecology

David Vandergucht	Hudson	Research Technician	Biology	Limnology
A. Vogt	Giesy	Postdoctoral Fellow	Toxicology	Enviro. Tox.
Wang, X.	Liber	Research Technician	Toxicology	ICP-MS specialist
Paul Whitfield	Pomeroy	Scientist	Geography	
Tyler Williams	Pomeroy	Research Technician	Geography	
S. Wiseman	Giesy	Research Scientist	Toxicology	Enviro. Tox.
Soo In Yang	Pickering	Postdoctoral Fellow	Geological Sciences	Selenium in the environment
Hayden Yip	Hudson	Research Technician	Biology	Limnology
Filip Zdrodowski	Hecker	M.Sc. – Visiting Student	RWTH Aachen, Germany	Aquatic Toxicology

APPENDIX E – GRANTS 2013-2014

Following table shows ongoing and new grants received by members of GIWS during the period of 2013-14. The seven core GIWS faculty and members have secured funding of $2,601,429 and $19,398,004, 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	
$56,330	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
$17,500	NSERC CGSM Scholarship for Raea Gooding, NSERC
$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
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) An evaluation of the controls on salt release from oil sands reclamation covers, Syncrude Canada Ltd., $85,731 (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)
$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 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 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)
$73,050	Convective Air Flow - Potential Impact on Covers and Waste Geochemistry - Coke Beach Instrumented Watershed", Syncrude Canada Ltd.
$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 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

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, K.-E., 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.)

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)
$25,000	Characterization of Manganese-Oxidizing Bacterial Populations in a Biofiltration Unit in a Water Treatment Plant in Saskatchewan: Delco Water – NSERC Engage Grant

Clark, Douglas

$74,862	The Human Dimensions of Water Security: Cultural Biases, Social Relations and Behavioral Strategies, SSHRC Insight Development Grant (PI: G. Strickert)
$45,843	Performing perspectives on water security in the Saskatchewan River Basin, SSHRC Connections Grant (PI: G. Strickert)
$100,457	TUNDRA: drivers of landscape change, contract from University of Tromsø for the Canadian component

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-Is: 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
$106,000	Analyzing the variation in (IDF) curves in the City of Saskatoon under non-stationary climatic conditions, City of Saskatoon

Ferguson, Grant

$8,000	Groundwater and Energy: Looking Broader and Deeper. Pardee Symposium Award, Geological Society of America (Co-I: Manning, A.)
$100,000	Exploring Data Needs for Geothermal Energy Development, NSERC Discovery Grant
$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: A. Ireson, M. Lindsay)

Giesy, John

$87,861	Study on marine environmental physiology and toxicology, Chinese Ministry of Education
$429,253	Great Lakes Restoration Initiative, Toxic Substances and Areas of Concern, Program: I-A-6 Great Lakes Sediment Core Surveillance Program, US EPA
$31,352	Uncovering the Molecular Links Between Hypoxia and Endocrine Disruption: A Functional Study of Zebrafish Leptin, Hong Kong Research Grants Council
$88,320	In Land and Life: Cadmium and Health Implications for Indigenous Communities in Central Alberta, National First Nations Environmental Contaminants Programme Health Canada (Co-I P.D. Jones)
$200,000	Novel Natural and Synthetic Brominated Compounds in the Environment, NSERC Discovery
$265,375	The Base Mine Lake Toxicity Identification and Evaluation Study; Advancing knowledge for water reclamation and return, Syncrude Canada Limited
$27,537	Sino-Canadian cooperation on microbial and phytoremediation technologies for clean-up of PAHs and heavy metals contaminated soils in Shanxi industrial regions, Shanxi Science and Technology Department
$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
$9,341	High Tier Foreign Expert Program, Minister of Education, China
	Saskatchewan River Basin: a large-scale observatory for new interdisciplinary water science, Canada Foundation for Innovation, $2,000,000 (PI: H. Wheater)
$75,545	Toxico-genomic Assessment of Emerging Environmental Pollutants Using Novel Functional Genomic and High Throughput Technologies, European Commission, Directorate for Innovation and Research, Directorate I Environment. (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. (Co-Is: M. Mora, X. Zhang)
$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 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. Leavitt, P. Jones, K. Liber, K-E. Lindenschmidt)
$272,382	CREATE Training Program in Human and Ecological Risk Assessment (HERA), NSERC (Co-I: S.D. Siciliano, L. Bharadwaj)

Gober, Patricia

$40,000	Water Knowledge Application Network (WatKAN), Canadian Water Network (Co-I: W. Quinton, J. Baltzer, H. Masaki, S. Kokelj, D. MacLatchy, P. Marsh, and H. Wheater)

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
$4,000	Visiting Lecturer, Olga Kalantzi, University of Saskatchewan, Special Visiting Lecturers' Fund
$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

Hudson, Jeff

$4,000	Summer Undergraduate Research Internship Award
$4,000	University Undergraduate Student Research Assistantships Grant
$13,328	CFI infrastructure operating fund
$51,564	Lake Diefenbaker Water Quality Assessment, Saskatchewan Watershed Authority
$894,418	Lake Diefenbaker water quality assessment, Saskatchewan water Security Agency

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)
$20,000	Role of Groundwater in Generating Streamflow and Nutrient Transport, Environment Canada, Government of Canada
$9,000	Contributing Area and Streamflow Duynamics in Saskatchewan Watersheds, Saskatchewan Water Security Agency

$12,000	Understanding and Modelling the Hydrology of the Southern Boreal Forest, Canadian Foundation for Climate and Atmospheric Sciences, Sub-contract from University of British Columbia
$17,500	NSERC PGSM Scholarship for Rosa Brannen, NSERC
$110,000	Groundwater-surface water interactions in the prairies, NSERC Discovery Grant
$100,000	Understanding and modeling the Hydrology of the Southern Boreal Forest, Canadian Foundation for Climate and Atmospheric Sciences (Co-I: T. Black, A. Barr, G. van der Kamp, W. Helgason, J. Johnstone)
$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)

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
$61,706	Variability of Hormonal Stress Markers and Stress Responses in a Large Cross-Sectional Sample of Elephant Seals, United States Department of Defence, Office of Naval Research (D.E. Crocker (PI), D.S. Houser, N. Kellar, J. Cockrem)
$13,800	Pathophysiology of Stress in Wild and Managed-Care Bottlenose Dolphins, United States Department of Defence, Office of Naval Research, (P.A. Fair (PI), G.D. Bossart, J. Reif, T. Romano, A. Dove, M. Peden-Adams)
$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)

Jardine, Tim

$20,000	A community-based approach to sustainable pond aquaculture in southern Ethiopia – A feasibility study assessing water and food security, One Health Research Development Grant. (Drew, M., Zatti, K., Zello, G., Hecker, M., Bell, S., and Sereda, J.)
$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, K.-E., Poelzer, G.M., Reed, M.G., and Strickert, G.E.H.)

Johnstone, Jill

$539,000	Population dynamics and critical habit of woodland caribou in the boreal shield of Saskatchewan, NSERC Collaborative Research and Development Grant (Co-I: McLoughlin, P.D.)
$150,000	Regional consequences of changing climate-disturbance interactions for the resilience of Alaska's boreal forest: Bonanza Creek LTER, U.S. National Science Foundation, Long-Term Ecological Research program (Co-I: Ruess, R., and 24 others)
$382,000	Identifying Indicators of State Change and Forecasting Future Vulnerability in Alaskan Boreal Ecosystems, U.S. Strategic Environmental Research and Development Program (SERDP) (Co-I: Schuur, E.A., M.C. Mack, A.D. McGuire, and T.S. Rupp)
$105,000	Resistance, resilience, and vulnerability of boreal forests to environmental change, NSERC Discovery Grant

Jones, Paul

$250,000	SWEEP – The Slave Watershed Environmental Effects Program, Canadian water Network, total $500,000 (Co-Is: Lindenschmidt, K., T. Jardine, Bharadwaj, L., and Doig, L.)
$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, K. Liber, K-E. Lindenschmidt)
$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., Lindenschmidt, K.-E., Poelzer, G.M., Reed, M.G., and Strickert, G.E.H.)
$961,000	Analytical Toxicology Base in Support of Economic Development, Western Economic Diversification (PI: K. Liber; Co-I: J.P. Giesy, M. Hecker)
$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., T. Jardine, Bharadwaj, L., and Doig, L)
$149,996	Aquatic Impact Assessment of Municipal Effluents (AIME), Canadian Water Network (Co-Is: M. Hecker, P. Jones, K. Liber, S. Wiseman)

Li, Yanping

$23,333	Short-Form Service Contract with Environment Canada Regarding Weather Research and Forecasting (WRF), Environment Canada
$15,000	Canada-Latin America and the Caribbean research exchange grants program (LACREG)
$10,000	Presidents NSERC Research fund, UofS internal fund

Liber, Karsten

$27,250	Sino-Canadian cooperation on microbial and phytoremediation technologies for clean-up of PAH and heavy metal contaminated soils in Shanxi industrial regions, Shanxi Science and Technology Department, Taiyuan, Shanxi, China
$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
$44,000	Network on environmental impact assessment of industry-contaminated areas in the Arctic, Nordic Council of Ministers' Arctic Co-operation Programme, Denmark
$961,000	Analytical Toxicology Base in Support of Economic Development, Western Economic Diversification (Co-I: J.P. Giesy, P.D. Jones, M. Hecker)
$10,000	Combined toxicity of metals and UV-B radiation in freshwater invertebrates: an intercontinental Comparison, Emerging Leaders in the Americas Program, Department of Foreign Affairs and International Trade Canada, Ottawa, ON
$35,000	Quantifying and modeling the bioavailability and toxicity of sediment-associated uranium to the freshwater midge Chironomus dilutus. AREVA Resources Canada Ltd.
$320,329	Distribution and impact of neonicotinoid insecticides on agricultural wetlands and water birds of Prairie Canada, NSERC Strategic Project Grant
$289,973	Vanadium toxicity to aquatic organisms representative of the Athabasca oil sands region, Syncude Canada Ltd.
$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)

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.)
$65,000	Management of economic risk of on-farm surface water retention systems, Manitoba Conservation Districts Association (MCDA)
$35,000	Developing a Geospatial Model of Qu'Appelle River System to Distinguish Fish & Macroinvertebrate Habitat, Saskatchewan Fish and Wildlife Development Fund

$25,000	Model Scenario to Estimate the Potential Impact of Hydrological Standards on Nurtient Retention in the Tobacco Creek Watershed, Government of Manitoba
$43,000	Defining Hydro-Geomorphological Regimes for IFN Studies Using Geomorphic Response Units (GRU), Government of Manitoba
$25,000	River ice modelling to assess the South Saskatchewan River's susceptibility to ice cover breakup and risk of ice jam flooding from hydro-peaking discharge from the Gardiner Dam, NSERC Engage grant with NorthPoint Energy Solutions Inc.
$25,000	New Sensor and Data Network Designs to Monitor and Forecast Surface Water Quality in Rivers, NSERC Engage grant with Aquastructure Solutions Inc.
$50,000	Modelling and forecasting ice jamming along the Assiniboine and Red Rivers, Manitoba Infrastructure and Transportation
$17,500	SSHRC CGSM Scholarship for Pamela Berry, SSHRC
$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.)

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)
$21,280	Synthesis of Geochemical Data on Fluid Fine Tailings for West In Pit, Syncrude Canada Limited
$30,000	New Faculty Student Support Grant, U of S
$10,000	Geochemical controls on molybdenum mobility, President's NSERC Fund, U of S
$30,000	New Faculty Startup Equipment Grant, U of S
$5,000	New Faculty Startup Operating Grant, U of S
$259,071	Characterization of controls on mass loading to an oil sands End Pit Lake, Syncrude Canada Ltd. (Co-I: L. Barbour)

$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)

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

Noble, Bram

$74,108 Flood risk in rural communities experiencing rapid environmental change: Toward a framework for stakeholder-based evaluation of alternative flood policy and mitigation strategies, SSHRC Insight Development Grant (Co-I: Ch. Westbrook)

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

Pomeroy, John

$57,850 Water Knowledge Application Network, Canadian Water Network

$24,675 Land and Infrastructure Resiliency Assessment (LIRA) Flood Assessment Tool Development, Agriculture and Agri-Food Canada

$134,100 Sensitivity of Dempster Highway Hydrological Response to Climate Warming, Yukon Government

$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)

Soltan, Jafar

$25,000	Treatment of membrane concentrate by advanced oxidation processes for blending with permeate water, NSERC Engage Grant
$10,000	Application of adsorption process for removal of emerging pollutants from drinking water, Shastri Research Grant (SRG), Shastri Indo-Canadian Institute

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, K.-E., Poelzer, G.M., Reed, M.G., and Strickert, G.E.H.)

Wheater, Howard

$528,772	Water Cycle Prediction in Western and Northern Canada, Environment Canada
$70,000	Development of Research Plans and Priorities for the Canada Excellence Research Chair in Water Security, Environment Canada, Government of Canada
$15,000	Conference Support for: Trending Now: Water – 7th International Scientific Conference on the Global Energy and Water Cycle and Associated Meetings: 3rd Pan-GEWEX Meeting, 1st Pan-CLIVAR Meeting and GEWEX Summer Sessions, Environment Canada, Government of Canada
$2,850	Water Knowledge Application Network (WatKAN), Canadian Water Network
$70,000	NSERC CGSD2 Scholarship for Chris Marsh, NSERC
$25,000	IIE Scholar Rescue Fund Fellowship for Reza Ghanbarpour, Institute of International Education
$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)
$4,409,191	CLIMATE KIC Addressing climate change mitigation and adaptation, European institute of Technology (PI: R. Anderson)

$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
$347,259	Monitoring and assessment of beneficial management practices: insight from the Tobacco Creek Watershed, Canadian water Networks (PI: H. Baulch)

APPENDIX F – Publications, Conference Proceedings and Presentations

Journal Publications - 2014

Allen, D.M., Bayer, P., **Ferguson, G.** and Blum, P. 2014. Hydrogeology of shallow thermal systems. *Hydrogeology Journal,* 22: 1-6. Springer/International Association of Hydrogeologists.

Amarakoon, I.D., Zvomuya, F., Degenhardt, D., **Cessna, A.J.**, Larney, F.J. and McAllister, T.A. 2014. Runoff losses of chlortetracycline, sulfamethazine and tylosin from surface-applied and soil-incorporated feedlot manure. *Journal of Environmental Quality*, 43: 549-557.

Arciszewski, T.J., Farwell, A.J., Servos, M.R., **Jardine, T.D.** and Munkittrick, K.R. 2014. Differential recovery of delta13C in multiple tissues of white sucker across age classes after the closure of a pulp mill. *Canadian Journal of Fisheries and Aquatic Sciences*, 71: 747-755.

Asadzadeh, M., **Razavi**, **S.,** Tolson, B.A., Fay, D. and Fan, Y. 2014. Pre-emption Strategies for Efficient Multi-objective Optimization: Application to the development of Lake Superior Regulation Plan. *Environmental Modelling and Software*.

Asong, Z.E., **Khaliq, M.N.**, **Wheater, H.S.** 2014. Regionalization of precipitation characteristics in the Canadian Prairie Provinces using large-scale atmospheric covariates and geophysical attributes. *Stochastic Environmental Research and Risk Assessment*, DOI 10.1007/s00477-014-0918-z.

Bañuelos, G. S., Arroyo, I., **Pickering, I. J**., Yang, S. I. and Freeman, J. L. Selenium biofortification of broccoli and carrots grown in soil amended with Se-enriched hyperaccumulator Stanleya pinnata. *Food Chemistry*, published online 23 June 2014. DOI: 10.1016/j.foodchem.2014.06.071.

Beitel, S.C., Doering, J.A., Patterson, S.E., **Hecker, M.** 2014. Assessment of the sensitivity of three North American fish species to disruptors of steroidogenesis using in vitro tissue explants. *Aquatic Toxicology*, 152: 273-283.

Bharadwaj, L. 2014. A framework for building research partnerships with first nations communities. *Environ Health Insights*. 2014 May 8: 8:15-25. doi: 10.4137/EHI.S10869. eCollection 2014.10 pages.

Carr, M., Lacho, C., Pollock, M., Watkinson, D. and **Lindenschmidt, K.-E.** 2014 A first tier desktop approach for identifying lake sturgeon (Acipenser fulvescens) habitat in the Saskatchewan River System. *River Systems*, (online first): 1-14. http://dx.doi.org/10.1127/1868-5749/2014/0086.

Chakraborty, P., Manek, A., Niyogi, S., **Hudson, J.** 2014. Determination of Dynamic Metal Complexes and their Diffusion Coefficients in the Presence of Different Humic Substances by Combining Two Analytical Techniques. *Analytical Letters,* 47: 1-18.

Chandler, R.E., Isham, V.S., Northrop, P.J., **Wheater, H.S.**, Onof, C.J., Leith, N.A. 2014. Uncertainty in Rainfall Inputs. *Applied Uncertainty Analysis for Flood Risk Management*, Edited by: Beven, K.; Hall, J.; Pages: 101-152. Book DOI: 10.1142/p588.

Chang, W., Ghoshal, S., 2014. Respiratory quotients as a useful indicator of the enhancement of petroleum hydrocarbon biodegradation in field-aged contaminated soils in cold climates. *Cold Regions Science and Technology*, 106-107 (2014) 110-119.

de Lafontaine, Y., Beauvais, C., **Cessna, A.J.**, Gagnon, P., Hudon, C. and Poissant, L. 2014. Sulfonylurea herbicides in an agricultural catchment and its adjacent wetland in the St. Lawrence River basin. *Journal of the Total Environment*, 479-480: 1-10.

Debeer, C.M. and **Wheater, H.S.** 2014. Observation, diagnosis, and prediction of environmental change in northwestern Canada: First annual general meeting of the changing cold regions network; Saskatoon, Saskatchewan, Canada, 21-23 October 2013. Eos, 95(11), 18 March: 98.

Dockrey, J.W., **Lindsay, M.B.J.**, Mayer, K.U., Beckie, R.D., Norlund, K.L.I., Warren, L.A. and Southam, G. 2014. Acidic microenvironments in waste rock characterized by neutral drainage: Bacteria-mineral interactions at sulfide surfaces. *Minerals* 4: 170-190. DOI:10.3390/min4010170.

Doering, J.A., Wiseman, S., Beitel, S.C., **Giesy, J.P.** and **Hecker, M.** 2014. Identification and Expression of Aryl Hydrocarbon Receptors (AhR1 and AhR2) Provide Insight in an Evolutionary Context Regarding Sensitivity of White Sturgeon (Acipenser transmontanus) to Dioxin-Like Compounds. *Aquatic Toxicology*, 150: 27–35.

Doig, L.E., Schiffer, S. and **Liber, K.** Reconstructing the ecological impacts of eight decades of mining, metallurgical and municipal activities on a small boreal lake in northern Canada. *Integrated Environmental Assessment and Management*, (Accepted June 2014).

Dupont, D., Waldner, C., **Bharadwaj, L.**, Plummer, R., Carter, B., Cave, K., and Zagozewski, R. 2014. Drinking Water Management: Health Risk Perceptions and Choices in First Nations and Non-First Nations Communities in Canada. *International Journal of Environmental Research and Public Health* 2014, 11: 5889-5903; doi:10.3390/ijerph110605889 *International Journal of Environmental Research and Public Health* ISSN 1660-4601 www.mdpi.com/journal/ijerph.

Elliott, J.A. and **Cessna, A.J.** 2014. Variability on the distribution and dissipation of the herbicide thifensulfuron-methyl in a prairie wetland. *Journal of Soil and Water Conservation* 69: 151-159.

Ferguson, G. 2014. Issue Paper: Deep Injection of Waste in the Western Canada Sedimentary Basin. *Groundwater*: Article first published online: 19 MAY 2014 | DOI: 10.1111/gwat.12198. Wiley/National Groundwater Association.

Ferguson, G. 2014. Screening for Heat Transport by Groundwater in Closed Geothermal Systems. *Groundwater*: Article first published online: 17 JAN 2014 | DOI: 10.1111/gwat.12162. Wiley/National Groundwater Association.

Ferguson, G. and Grasby, S.E. 2014. The geothermal potential of the basal clastics of Saskatchewan, *Canada. Hydrogeology Journal*, 22: 143:150. Springer/International Assocation of Hydrogeologists.

Garcia-Reyero, N., Kennedy, A.J., Escalon, B.L., Habib, T., Laird, J.G., Rawat, A., Wiseman, S., **Hecker, M.**, Denslow, N., Steevens, J.A., Perkins, E.J. 2014. Differential Effects and Potential Adverse Outcomes of Ionic Silver and Silver Nanoparticles in Vivo and in Vitro. *Environmental Science & Technology*, 214: 4546-4555.

Gaumont-Guay,D., **Black, T.A.**, **Barr, A.G.**, Griffis, T.J., Jassal, R.S., Krishnan, P., Grant, N. and Nesic, Z. 2014. Eight years of forest-floor CO2 exchange in a boreal black spruce forest: spatial integration and multi-temporal trends. *Agricultural and Forest Meteorology*, 184: 25-35.

Ge, L.-C, Chen, Z.-J., Liu, H.-Y., Zhang, G., Liu, H., Wei, W., Chen, X.-H., Wong, C.K.C., **Giesy, J.P.**, Du, J., Wang, H.-S. 2014. Involvement of Activating ERK1/2 Through G Protein Coupled Receptor 30 and Estrogen Receptor α/β in Low Doses of Bisphenol A Promoting Growth of Sertoli TM4 Cells. *Toxicology Letters*, 226:81-89.

Giesy, J.P., Solomon, K.R., Mackay, D., Giddings, J.M., Williams, W.M., Moore, D.R.J., Purdy, J. and **Cutler, G.C.** 2014. Ecological risk assessment for chlorpyrifos in terrestrial and aquatic systems in the United States – overview and conclusions. *Reviews of Environmental Contamination and Toxicology*, 231: 1-12.

Gober, P., **Strickert, G.E.**, **Clark, D.A.**, **Chun, K.P.**, **Payton, D.** and **Bruce, K.** 2014. Divergent perspectives on water security: Bridging the policy debate. *The Professional Geographer,* DOI: 10.1080/00330124.2014.883960.

Gober, P. and **Wheater, H.S.** 2014. Socio-hydrology and the science-policy interface: A case study of the Saskatchewan River Basin. *Hydrology and Earth System Sciences*, 18: 1423-1422.

Guo, R., Wilson, L., **Bharadwaj, L.** 2014. Uptake of chloroform from aqueous solution with synthetically engineered copolymer materials. *Topological and Supramolecular Polymer Science*, 1(1): 42-59.

Haghnegahdar, A., Tolson, B.A., **Davison**, **B.,** Seglenieks, F.R., Klyszejko, E., Soulis, E.D., Fortin, V. and Matott, L. S. 2014. Calibrating Environment Canada's MESH Modelling System over the Great Lakes Basin. *Atmosphere-Ocean,* 58(6): 1-13. DOI: 10.1080/07055900.2014.939131.

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Hassanzadeh, E., **Elshorbagy, A.**, **Wheater, H.** and **Gober, P.** 2014. Managing water in complex systems: An integrated water resources model for Saskatchewan, Canada. *Journal Environmental Modelling & Software*, 58: 12-26.

Henderson, A., **Reed, M.G.** and Davis, S. 2014. Voluntary Stewardship and the Canadian Species at Risk Act: Exploring Rancher Willingness to Support Species At Risk in the Canadian Prairies. *Human Dimensions of Wildlife*, 19:1: 17-32, DOI: 10.1080/10871209.2013.819595.

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Hu, W., She, D., Shao, M., **Chun, K.P.** and **Si, B.C.** 2014. Effects of initial soil water content and saturated hydraulic conductivity variability on small watershed runoff simulation using LISEM. *Hydrological Sciences Journal,* (doi: 10.1080/02626667.2014.903332).

Hudson, J. 2014. Relationship between water quality parameters and bacterial indicators in a large prairie reservoir: Lake Diefenbaker, SK, Canada. *Canadian Journal of Microbiology*, 60(4): 243–249.

Truong, H-Y.T., Chen, Y-W., Saleh, M., Nehzati, S., **George, G. N.**, **Pickering, I. J.** and Belzile, N. Proteomics of Desulfovibrio desulfuricans and X-ray absorption spectroscopy to investigate mercury methylation in the presence of selenium. *Metallomics,* 6(3): 465-475 (2014). DOI: 10.1039/C3MT00323J.

Janz, D., **Liber, K.**, **Pickering, I.**, Wiramanaden, C., Weech, S., Gallego-Gallegos, M., Driessnack, M., Franz, E., Goertzen, M., Phibbs, J., Tse, J., Himbeault, K., Robertson, E., Burnett-Seidel, C., England, K. and Gent, A. 2014. Integrative assessment of selenium speciation, biogeochemistry and distribution in a northern col dwater ecosystem. *Integrated Environmental Assessment and Management*, doi: 10.1002/ieam.1560.

Jardine, T.D., Hadwen, W.L., Hamilton, S.K., Hladyz, S., Mitrovic, S.M., Kidd, K.A., Tsoi, W.Y., Spears, M., Westhorpe, D.P., Fry, V.M., Sheldon, F. and Bunn, S.E. 2014. Understanding and overcoming baseline isotopic variability in running waters. *River Research and Applications,* 30: 155-165.

Jarošová, B., Bláha, L., **Giesy, J.P.** and Hilscherová, K. 2014. What Level of Estrogenic Activity Determined by In Vitro Assays in Municipal Waste Waters can be Considered as Safe? *Environmental International*, 64: 98–109.

Jeong, D.I., Sushama, L., **Khaliq, M.N.** 2014. The role of temperature in drought projections over North America. *Climatic Change* (conditionally accepted).

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Jin, X., Wang, Y., **Giesy, J.**, Richardson, K., Wang, Z. 2014. Development of aquatic life criteria in China: Viewpoint on the challenge. *Environmental Science and Pollution Research*, 21: 61-66.

Jones, K.L., Lindsay, M.B.J., Kipfer, R. and Mayer, K.U. 2014. Atmospheric noble gases as tracers of biogenic gas dynamics in a shallow unconfined aquifer. *Geochimica et Cosmochimica Acta*, 128: 144-157. DOI:10.1016/j.gca.2013.12.008.

Kevinsen, J., **Patrick, R.J.** and **Bharadwaj, L.A.** 2014. A framework for assessing effective urban water management: lessons from the Canadian Prairie. *Water International*, 39:1, 113-127, DOI:

10.1080/02508060.2014.865300 Published on Line December 13th, 2013. http://dx.doi.org/10.1080/02508060.2014.865300.

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Kidd, K.A., Paterson, M.J., Rennie, M.D., Podemski, C.L., Findlay, D.L., Blanchfield, P.J. and **Liber, K.** 2014. Responses of a freshwater food web to a potent synthetic estrogen. Special issue, Philosophical Transactions of the Royal Society B on Pharmaceuticals in the Environment (Accepted June 2014).

Klaus, J., **McDonnell, J.J.**, Jackson, C.R., Du, E. and Griffiths, N. 2014. Where does streamwater come from in low relief forested watersheds? A dual isotope approach. *Hydrology and Earth System Science*, 11: 2613-2638: DOI: 10.5194/hessd-11-2613-2014.

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Bam, E., **Ireson, A.M.**, and **van der Kamp, G.** 2014. Stable isotopic composition of precipitation, evaporated pond water, surficial and inter-till aquifer units in southeastern Saskatchewan, Canada. Canadian Geophysical Union Meeting in Banff, AB, May.

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Jardine, T., **Baulch, H.**, **Janz, D.**, Weber, L., Steeves, K., Keeping, D., Bast, M. and West, R. 2014. Biological response to flooding in the Saskatchewan River. Society of Canadian Limnologists, Yellowknife, NWT, January.

Jean, M., **Johnstone, J.F.**, Alexander, H. and Mack, M.C. 2014. How does variation in moss communities and functional traits influence successional trajectories among deciduous, coniferous, and mixed stands in Alaska? Genomes to Biomes: Canadian Society for Ecology and Evolution and Canadian Society of Zoologists Joint Conference, Montréal, QC, May 2014 (Oral presentation).

Johnstone, J.F., Brown, C.D. and Kuleza, S. 2014. At the burning edge: Potential tree recruitment after fire at high latitude treelines. Genomes to Biomes: Canadian Society for Ecology and Evolution and Canadian Society of Zoologists Joint Conference, Montréal, QC, May 2014 (Oral presentation).

Kim, J. and **Chang, W.** 2014. Cold Region Bioremediation: Part 2 – The substrate, temperature and unfrozen water dependency of microbial respiration during bioremediation in freezing contaminated soils. 37th Arctic and Marine Oilspill Program (AMOP) Technical Seminar on Environmental Contamination and Response, Canmore, AB, June 3-5 (Poster presentation).

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, GeoRegina 2014, Regina, SK, Sept. 28-Oct. 1 (Accepted).

Lankshear, J., Lokken, N., Hausner, V., Broderstad, E. and **D. Clark**. 2014. Challenged by corporations: local perspectives on land use and natural resource management in Churchill, Manitoba. International Congress of Arctic Social Sciences VIII, May 23, Prince George, BC.

Li, M., **Barbour, S.L.**, **Si, B.C.** 2014. Measuring the solid percentage of oil sands mature fine tailings using the heat pulse dual probe metho. , CGU-CSS 2014, Joint Canadian Geophysics Union & Canadian Society of Soil Science Annual Meeting, Poster Session C8, Banff, AB, May 6.

Li, Y. 2014: Precipitation and regional climate processes for BERMS area, BERMS Research Workshop, National Hydrology Research Center, Saskatoon, SK, April 28-29.

Li, Y., Elsaesser, G., Carbone, R.E. and Kummerow, C. 2014: Characteristics of the precipitation event life cycle in the tropical western Pacific, 94th American Meteorology Society Annual Meeting, Atlanta, GA, February 2-6.

Li, Y., Sezto, K., Stewart, R. and Theriault, J. 2014: WRF Model Simulation of June 2013 Alberta Flooding Event, Workshop on Extreme Weather and Hydrology - Lessons Learned from the Western Canadian Floods of 2013 and Others, Canmore, AB, February 11-12.

Liber, K., Carter, C., Townsend, M. and Wang, X. 2014. Analysis of river otter (Lontra canadensis) livers and kidneys from northern Saskatchewan for metals and trace elements via ICP-MS: 2013 samples. Report for Saskatchewan Environment, Regina, SK.

Masud, M.B., **Khaliq, M.N.**, **Wheater, H.S.** and **Asong, Z.E.** 2014. Probabilistic Characterization of Meteorological Droughts for the Saskatchewan River Basin. Canadian Meteorological and Oceanographic Society (CMOS) Conference, Rimouski, QC, June 1–5 (Presentation).

Matthies, R., **Lindsay, M.B.J.**, Blowes, D.W. and Ptacek, C.J. 2014. Zinc isotope partitioning in organic-substrate amended mine tailings. Proceedings of the 24th V.M. Goldschmidt Conference, Sacramento, CA, June 8–13, Goldschmidt Abstracts, 1624.

Mahmood, T. H., **Pomeroy, J. W.**, **Wheater, H. S.**, **Baulch, H. M.** and **Elliott, J.A.** 2014. Understanding the influence of cold region processes on nutrient exports from a prairie agricultural basin Canadian Geophysical Union, Banff, AB, May.

Mekonnen, M., **Wheater, H.S.**, **Ireson, A.M.**, **Spence, C.**, **Davison, B.**, and **Pietroniro, A.** 2014. A Variable Contributing Area Surface Runoff Generation Scheme for Prairie Landscapes. Canadian Geophysical Union Meeting in Banff, AB, May.

Mohammadzadeh, O. and **Giesy, J.P.** 2014. Preliminary Investigation into the Application of IPC Technology for Oil Recovery Using Chemical-Assisted Waterflooding Process. World Heavy Oil Congress, New Orleans. LA, March 5-7.

Nazemi, A. and **Elshorbagy, A.** 2014. A Stochastic Disaggregation Algorithm for Analysis of Change in the Sub-daily Extreme Rainfall. General Assembly of the European Geosciences Union, Vienna, Austria, April 27 - May 2 (Poster presentation EGU2014-7827).

Nazemi, A., Alam, Md. S. and **Elshorbagy, A.** 2014. Uncertainties in future projections of extreme rainfall: The role of climate model, emission scenario and randomness, In Proceedings of HIC 2014, 11th International Conference on Hydroinformatics, New York, NY, August 17-21, (CD-ROM).

North, R. L., **Baulch, H.**, **Vandergucht, D.**, **Sereda, J.**, **Lindenschmidt, K. E.**, Guildford, S., Davies, J. M., and **Hudson, J.** 2014. The interacting effects of light and nutrients on under-ice phytoplankton populations. Annual meeting of the Association for the Sciences of Limnology and Oceanography (ASLO). Portland, OR. May 18-23.

North, R.L., **Baulch, H.M.**, **Vandergucht**, **D.**, **Sereda, J.**, **Lindenschmidt, K.**, **Guildford, S.J.**, **Davies, J.M.**, **Hudson, J.J.** The interacting effects of light and nutrients on under-ice phytoplankton populations. Presented at the Joint Aquatic Sciences Meeting (JASM) 2014, Portland, OR.

North, R. L., **Baulch, H.**, **Vandergucht, D.**, Sereda, J., **Lindenschmidt, K.E.**, Guildford, S., Davies, J.M. and **Hudson, J.** 2014. The interacting effects of light and nutrients on under-ice phytoplankton populations. Joint Aquatic Sciences Meeting (SFS, *ASLO*, PSA, and SWS). Portland, OR, May.

Pan, X., **Helgason, W.**, and **Ireson, A.M.**, 2014. An efficient calibration technique for heat dissipation matric water potential sensors. Canadian Geophysical Union Meeting in Banff, AB, May.

Pan, X., **Peterson, A.**, Merriam, J., **Helgason, W.**, and **Ireson, A.M.**, 2014. Characterization of sub-field-scale hydrological processes in the non-drainage area of the Brightwater Creek sub-basin. Canadian Geophysical Union Meeting in Banff, AB, May.

Peterson, A., **Helgason, W.**, and **Ireson, A.M.**, 2014. An evaluation of a cosmic-ray neutron probe and point upscaling methods to provide accurate field average soil moisture estimations. Canadian Geophysical Union Meeting in Banff, AB, May.

Ponomarenko, Y., **Hunter, K.**, **Abirhire, O.**, **Prestie, C.** and **Hudson, J.** 2014. Photoammonification in Boreal and Plains Lakes. Genomes to Biomes Conference (joint meeting of the Society of Canadian Limnologists (SCL), the Canadian Society of Ecology & Evolution (CSEE) & the Canadian Society of Zoology (CSZ). Montreal, QC, May 25-29.

Prestie, C., **Hudson, J.** and **Sereda, J.** 2014. Carbon sources supporting native and naturalized fish populations in a large central Saskatchewan reservoir. Genomes to Biomes Conference (joint meeting of the Society of Canadian Limnologists (SCL), the Canadian Society of Ecology & Evolution (CSEE) & the Canadian Society of Zoology (CSZ). Montreal, QC, May 25-29.

Prestie, C., **Sereda, J.** and **Hudson, J.** 2014. Carbon sources supporting fish growth in Lake Diefenbaker, Saskatchewan. Annual Meeting of the Prairie University Biology Symposium (PUBS). Regina, SK, February 20-22.

Razavi, S., **Elshorbagy, A.**, **Wheater, H.**, and Saushyn, D. 2014. On the Reconstruction of Paleo-hydrology: A Foundation for More Reliable Water Resources Management. General Assembly of the European Geosciences Union, Vienna, Austria, April 27- May 2 (Poster presentation EGU2014-7971).

Reed, M.G. 2014. Linking gender, climate change, adaptive capacity, and Canadian forest-based communities. Gender Forum. Diefenbaker Canada Centre. University of Saskatchewan, Saskatoon, SK, May 27.

Reed, M.G. and Godmaire, H. 2014. Promoting transformational change by strengthening a national community of practice: Experiences of a partnership with Canadian biosphere reserves. Third International Science and Policy Conference on the Resilience of Social & Ecological Ecosystems, "Resilience and Development: Mobilizing for Transformation" Le Corum: Montpellier, France. May 4-8 (Presentation May 5).

Reed, M.G., Johnston, M. and Natcher, D. 2014. Gender and the challenge of preparing for climate change in Canadian forest-based communities. XXIV IUFRO (International Union of Forest Research Organizations) World Congress 2014. "Sustaining Forests, Sustaining People: The Role of Research" Salt Lake City, UT, October 5-11.

Rosamond, M.S., Venkiteswaran, J.J., **Baulch, H.M.**, Cummings, T.F., Schiff, S.L. 2014. Seasonal N2O:NO3- relationships and stream order in Southern Ontario: Implications for greenhouse gas measurement and management strategies. International Association for Great Lakes Research. Hamilton, ON, May.

Roste, J., **Pomeroy, J.W.**, **Wheater, H.S.**, **Baulch, H.**, **Elliott, J.**, **Mahmood, T.H**. 2014. Informing Canadian Prairie nutrient transfer model development with edge of field hydrochemistry observations Canadian Geophysical Union, Banff, AB, May.

Sagin, J., Sizo, A., **Wheater, H.**, **Jardine, T.** and **Lindenschmidt, K.-E.** 2014. Surface water coverage of an inland delta in a regulated river basin. Spatial Knowledge and Information Canada conference, Canadian GIS Association, February 7-9, Banff, AB.

Sampson, D.A., Quay, R., White, D.D. and **Gober, P.** 2014. WaterSim: A brief history. 16th Annual CAP LTER Poster Symposium and All Scientists Meeting 2014, January 17, SkySong, Scottsdale, AZ, (Poster presentation).

Sampson, D.A., R. Quay, D.D. White, and **P. Gober**. 2014. WaterSim: a brief history. Water Resources Research Center 2014 Annual Conference: Closing the Gap Between Water Supply and Demand, April 8, University of Arizona, Tucson, AZ (Poster presentation).

Saunders, D.M.V., Wiseman, S. and **Giesy, J.P.** 2014. Three Novel Brominated Flame Retardants Affect Fecundity and Transcript Profiles of the HPGL in Japanese Medaka. 14th Annual Workshop on Brominated & Other Flame Retardants (BFR). Indianapolis, IN, June 22-24.

Schiffer, S.R., **Doig, L.E.** and **Liber, K.** 2014. Standard vs. field-relevant species: Investigating the toxicity of vanadium to freshwater invertebrates and green algae. Society of Environmental Toxicology and Chemistry Prairie Northern Chapter 5th annual meeting, Saskatoon, SK, June 6.

Schiffer, S.R., **Doig, L.E.**, and **Liber, K.** 2014. Acute and chronic toxicity of aqueous vanadium to model and field collected planktonic and benthic invertebrates. Global Institute of Water Security and Canadian Water Resources Association World Water Day Conference, Saskatoon, SK, March 21 (2nd place, student poster competition).

Sizo, A., Bell, S., and **Noble, B.F.** 2014. Automated GIS routine for Strategic Environmental Assessment: a spatiotemporal analysis of urban and wetland change. Proceedings of Spatial Knowledge and Information Canada, vol. 2 (8pgs).

Small, G., **Baulch, H.**, Bechtold, H., Holzer, K., Newell, S. and Vaquer Sunyer, R. 2014. Headwaters to estuaries: Complex responses to cultural eutrophication at the watershed scale. Eco-DAS IX Symposium Proceedings. Ed. Paul Kemp. In press.

Steeves, J., **Barbour, S.L.** and **Ferguson, G.** 2014. Water Flow and Heat Transfer in a Frozen Soil. Cold Covers 2014. Whistler, BC, April.

Tse, T.J., **Doig, L.E.**, Quiñones-Rivera, Z.J., Leavitt, P.R., Codling, G., **Lucas, B.T.**, **Liber, K.**, **Giesy, J.P.**, **Wheater, H.S.** and**Jones, P.D.** 2014. Reconstructing spatial and temporal changes in phytoplankton productivity in a narrow river-valley reservoir. Society of Environmental Toxicology and Chemistry Prairie Northern Chapter 5th annual meeting, Saskatoon, SK, June 6.

Conference Proceedings and Presentations - 2013

Alharbi, H., Wiseman, S.B.A. and **Giesy, J.P.,** dos Santos Pereira, A. and Martin, J.W. 2013. Fractionation and Characterization of Polar Organic Compounds in OSPW Using Mixed-mode Solid Phase Extraction Coupled to Mass Spectrometry (Orbitrap). SETAC North America 36th Annual Meeting, November 17-23.

Azinfar, H., **Nazemi, A.**, **Hassanzadeh, E.**, **Elshorbagy, A.A.** and Hilderbrandt, A. 2013. The Vulnerability of Saskatoon's Storm Collection System to the Alteration in Future Rainfall Characteristics. Joint Congress of the CMOS, CGU, and CWRA, Saskatoon, SK, Canada, May 26-30, (Paper No. Abstract 6354).

Baer, T. and **Barbour, S.L.** 2013. Evaluating the use of stable isotopes of water to characterize oil sands mine waste, GeoMontreal 2013 - Canadian Geotechnical Society Conference, Montreal, PQ, September 29-October 3.

Brinkman, M., Hudjetz, S., Hennig, M., Kuckelkorn, J., Cofalla, C., Lorke, S., Kammann, U., **Hecker, M.**, Schuttrumpf, H., Schaffer, A., Hollert, H. and **Giesy, J.P.** 2013. Can flood events affect rainbow trout? The biomarker-cascade after exposure to PAHs in sediment suspension? SETAC Europe 23rd Annual Meeting, Glasgow, Scotland, May 12-16.

Chang, W., Bioremediation in northern climates: can hydrocarbon biodegradation occur in contaminated cold soils at seasonal freeze-thaw temperatures? Proceedings of the 2013 Northern Latitudes Mining Reclamation Workshop and 38th Annual Meeting of the Canadian Land Reclamation Association, pp. 21-31, Whitehorse, YT, September 9-12.

Crawford, S. and **Liber, K.** 2013. Formulated lab vs. field sediment: Bioavailability of spiked uranium to Chironomus dilutus. Society of Environmental Toxicology and Chemistry 34th Annual Meeting, Nashville, TN, November 17-21.

Crawford, S.E. and **Liber, K.** 2013. Quantifying the importance of physicochemical sediment characteristics in altering uranium bioavailability in reconstituted vs. natural freshwater sediment. 40th annual Aquatic Toxicology Workshop, Moncton, NB, October 6-9.

Codling, G., **Jones, P.D.**, Vogt, A., Wang, T., Li, A., Sturchio, N., Wang, P., Lu, Y., Rockne, K.J., Ji, K., Khim, J., Naile, J.E. and **Giesy, J.P.** 2013. Historical Trends of Inorganic and Organic Fluorine in the North American Great Lakes. SETAC North America 36th Annual Meeting, November 17-23.

Doering, J., Wiseman, S., Beitel, S., Vardy, D., Eisner, B., Reid, S., **Hecker, M.** and **Giesy, J.P.** 2013. Expression of Metallothionein in White Sturgeon (Acipenser transmontanus) Following in vitro and

Chronic Exposure to Cadmium or Copper. 40th Annual Aquatic Toxicity Workshop Annual Meeting, Moncton, NB, October 6-9.

Doering, J., Wiseman, S., Beitel, S., **Hecker, M.** and **Giesy, J.P.** 2013. The Aryl hydrocarbon Receptor Pathway of sturgeon: Evolutionary and ecotoxicological Implications to dioxin Sensitivity in fishes. 40th Annual Aquatic Toxicity Workshop. Annual Meeting, Moncton, NB, October 6-9.

Doering, J., Wiseman, S., Beitel, S., Patterson, S., **Hecker, M.** and **Giesy, J.P.** 2013. Effects of Exposure to a Model Dioxin-like Compound on the Transcriptome of White Sturgeon (Acipenser transmontanus). 40th Annual Aquatic Toxicity Workshop Annual Meeting, Moncton, NB, October 6-9.

dos Santos Pereira, A., Wiseman, S.B., Mankidy, R., He, Y., Alharbi, H., Martin, J.W. and **Giesy, J.P.** 2013. Characterization of the Toxic Constituents of Oil Sands Process Affected Water by Orbitrap-MS. SETAC Europe 23rd Annual Meeting, Glasgow, Scotland, May 12-16.

Elsaesser, G., **Li, Y.**, Kummerow, C. and Carbone, R.E. 2013: Multi-Sensor observations of the lifecycles of propagating tropical convective systems: Rainfall characteristics, diabatic heating/moistening and relationship to environment parameters. AGU Fall Meeting, San Francisco, CA, December 9-13.

Giesy, J.P. 2013. A Tiered Risk Assessment of Pentachlorophenol Based on Chinese Species. International Conference on Environmental Safety and Ecological Criteria, Nanjing, PR China, June 30-July 2.

Guo, J., Li, A., Corcoran, M., Rockne, K.J., Sturchio, N. and **Giesy, J.P.** 2013. Spatial Distribution and Time Trend of Selected Chlorinated and Brominated Compounds in the Sediments of Lake Michigan. SETAC North America 36th Annual Meeting, November 17-23.

Haakensen, M., Pittet, V., **Liber, K.**, **Doig, L.**, Castle, J. and Rodgers Jr, J. 2013. Assessing diversity of algae and cyanobacteria related to selenium uptake and consequent uptake by invertebrates. 2013 Annual North American Selenium Working Group Meeting, Nashville, TN, November 22.

Harley, R., Carse, L., Hughes, D., Lynch, K., **Barbour, S.L.** 2013. An evaluation of strain softening of glacial tills as a result of pore pressure *dynamics*. GeoMontreal 2013, 66th Canadian Geotechnical Conference Proceedings.

Hassanzadeh, E., **Elshorbagy, A.A.** and **Wheater, H.** 2013. Scenario-based Water Resources Management Using the Water Value Concept. General Assembly of the European Geosciences Union, Vienna, Austria, April 7-12 (Paper No. EGU2013-1847).

Hassanzadeh, E., **Elshorbagy, A.A.** and **Wheater, H.** 2013. Value-based Water Resources Management Model: Application to the Saskatchewan River Basin. 2013 Joint Congress of the CMOS, CGU, and CWRA, Saskatoon, SK, May 26-30 (Paper No. Abstract 6393).

Hassanzadeh, E., **Nazemi, A.** and **Elshorbagy, A.A.** 2013. A Novel Quantile-Quantile Downscaling Approach to Updating IDF Curves in the City of Saskatoon. 2013 Joint Congress of the CMOS, CGU, and CWRA, Saskatoon, SK, May 26-30 (Paper No. Abstract 6352).

He, Y., Wiseman, S.B., Mankidy, R., Alharbi, H. and **Giesy, J.P.** 2013. Assessing effects of dibenzothiophnes and related compounds on Aryl-hydrocarbon receptor antagonism and embryotoxicity to fathead minnow. SETAC North America 36th Annual Meeting, November 17-23.

Hecker, M., Beitel, S., Doering, J. and Eisner, B. 2013. Use of vitellogenin gene expression in the assessment of the sensitivity of four native Canadian fish species to 17-a Ethinylestradiol, in vitro. 40th Aquatic Toxicity Workshop in Moncton, NB, October 6 - 9.

Hecker, M., Beitel, S., Doering, J., Patterson, S. and Prodahl, H. 2013. Assessment of the disruption of steroidogenesis in three North American fish species by use of an in vitro gonadal explant assay. 40th Aquatic Toxicity Workshop, Moncton, NB, October 6-9.

Hecker, M., Doering, J., Wiseman, S., **Beitel, S.**, Vardy, D., Eisner, B., Reid, S., and Giesy, J. 2013. Expression of metallothionein in white sturgeon (Acipenser transmontanus) following in vitro and chronic exposure to cadmium or copper. 40th Aquatic Toxicity Workshop in Moncton, NB, October 6 - 9.

Hecker, M., **Zee, J.**, and Patterson, S. 2013. Molecular and Physiological Effects of Chronic Dietary Selenomethionine in Juvenile White Sturgeon (Acipenser transmontanus). 40th Aquatic Toxicity Workshop in Moncton, NB, October 6 - 9.

Hecker, M., Tompsett-Higley, A., Higley, E.B., Wiseman, S.B. and **Giesy, J.P.** 2013. Transcriptomic effects of Exposure to 17 alpha-ethynylestradiol During Sexual Differentiation on Genetic Male Xenopus laevis. SETAC Europe 23rd Annual Meeting, Glasgow, Scotland, May 12-16.

Henkelman, J. and **Johnstone, J.F.** 2013. An active soil warming system powered by alternative (renewable) energy for remote field sites. International Tundra Experiment ITEX, Bergün, Switzerland, September (Oral presentation).

Hewlett, C., **North, R.L.**, **Johansson, J.**, **Vandergucht, D.**, and **Hudson, J.** 2013. Nutrient inputs to Lake Diefenbaker reservoir through shoreline erosion and slumping. CGU/CWRA/CMOS Conference, Saskatoon, SK, May.

Hudson, J., **Sereda, J.**, **Vandergucht, D.**, **North, R.L.**, **Wheater, H.** and Davies, J. 2013. Introduction to the Lake Diefenbaker Study. CGU/CWRA/CMOS Conference, Saskatoon, SK, May.

Hudson, J., **Sereda, J.**, **Vandergucht, D.**, **North, R.L.**, **Wheater, H.**, and Davies, J. 2013. An introduction to the Lake Diefenbaker Study. American Society of Limnology & Oceanography (ASLO) Aquatic Sciences Conference, New Orleans, LA.

Hunter, K., **Johansson, J.**, **Sereda, J.**, **Vandergucht, D.**, **North, R.L.**, and **Hudson, J.** 2013. Spatial characterization of phosphorus and nitrogen limitation in Lake Diefenbaker: Influence of upstream processes and anthropogenic activities. CGU/CWRA/CMOS Conference 2013, Saskatoon, SK, May.

Jarošová, B., Filip, J., Hilscherová, K., Tuček J., Šimek, Z., Bláha, L., Zbořil, R. and **Giesy, J.P.** 2013. Sorption and chemical effects of zero-valent iron nanoparticles in removal of waterborne estrogens. Second European Symposium on Water Technology & Management, Leuven Belgium, November 20-21.

Johansson, J., **Hunter, K.**, **Vandergucht, D.**, **Sereda, J.**, **North, R.L.**, **Head, K.**, **Yip, H.**, and **Hudson, J.** Characterizing phosphorus and nitrogen dynamics under years with differing hydrologic regimes: A case study of a complex prairie reservoir. CGU/CWRA/CMOS Conference 2013, Saskatoon, SK, May.

Johnstone, J.F., Young, N., and **Mamet, S.** 2013. Reproducibility, precision, and time efficiency of three methods for vegetation monitoring in alpine tundra. International Tundra Experiment ITEX, Bergün, Switzerland, September (Oral presentation).

Jonas, A., Scholz, S., Novakova, K., Fetter, E., Sychrova, E., Kohoutek, J., Ortmann, J., Hilscherova, K. and **Giesy, J.P**. 2013. The Endocrine Disruptive Potential of Phytoplankton Exudates. SETAC Europe 23rd Annual Meeting, Glasgow, Scotland, May 12-16.

Jones, P., Tendler, B., Hill, A., Ohiozebau, ., Kelly, E. and and **Giesy, J.P.** 2013. Chemodynamic behavior of Thallium in the Slave River, Northwest Territories, Canada. 40th Annual Aquatic Toxicity Workshop Annual Meeting, Moncton, NB, October 6-9.

Lee, S., Hong, S., Noh, K., Liu, X., Khim, J., Yim, U., Shim, W., Choi, K. and **Giesy, J.P.** 2013. Evaluating Toxic Potential of Sediments in Taean Near Hebei Spirit Oil spill site and Contributions of PAHs and Alkylated PAHs. SETAC North America 36th Annual Meeting, November 17-23.

Li, A., Rockne, K.J., Sturchio, N., Wang, Y. and **Giesy, J.P.** 2013. Aquatic Sediment as Indicator and Chronological Recorder of Chemical Pollution – The Great Lakes Experience. 10th International Symposium on Persistent Toxic Substances (ISPTS). Edmonton, AB, August 13-17.

Li, Y. and Carbone, R.E. 2013: Lower Boundary Forcing related to the Occurrence of Rain in the Tropical Western Pacific. AGU Fall Meeting, San Francisco, CA, December 9 – 13.

Li, Y. and Carbone, R.E. 2013: Lower Boundary Forcing related to Occurrence of Rain in the Tropical Western Pacific. Water System Retreat, NCAR, Boulder, CO, December 18.

Lindenschmidt, K.-E. and Davies, J.-M. 2013. Winter flow testing of the Upper Qu'Appelle River. 17th CRIPE Workshop on the Hydraulics of Ice Covered Rivers, Edmonton, AB, July 21-24, pp. 312-328. http://cripe.civil.ualberta.ca/Downloads/17th_Workshop/Lindenschmidt-Davies-2013.pdf

Lindenschmidt, K.-E., Sydor, M., van der Sanden, J., Blais, E. and Carson, R.W. 2013. Monitoring and modeling ice cover formation on highly flooded and hydraulically altered lake-river systems. 17th CRIPE Workshop on the Hydraulics of Ice Covered Rivers, Edmonton, AB, July 21-24, pp. 180-201. http://cripe.civil.ualberta.ca/Downloads/17th_Workshop/Lindenschmidt-et-al-2013.pdf

Lindsay, M.B.J. 2014. Biogeochemistry of groundwater contamination, remediation and management in mining environments. Department of Geology – Colloquium Series, University of Kansas, Lawrence, KS, February 20.

Lucas, B., Tse, T., **Liber, K.**, **Jones, P.D.**, **Wheater, H.S.**, **Doig, L.E.** and **Giesy, J.P.** 2013. Reconstructing Environmental Trends in Potable Lakes and Reservoirs: The Paleoecotoxicology Toolbox. SETAC Europe 23rd Annual Meeting, Glasgow, Scotland, May 12-16.

Mahmood, T. H., **Pomeroy, J. W.**, **Wheater, H. S.** and **Baulch, H. M.** 2013. Effects of Land Management Practices on Cold Region Hydrological Processes in an Agricultural Prairie Basin. American Geophysical Union, Fall Conference, San Francisco, CA, December.

Mamet, S.D., **Johnstone, J.F.,** Metsaranta, J.M., Hogg, E.H., **Barr**, A., **van der Kamp**, G., and Black, A. 2013. Tree ring analysis of forest productivity across moisture gradient in the boreal forest of central Saskatchewan. 16th Conference of the International Boreal Forest Research Association, Edmonton, AB, October 2013 (Oral presentation).

Massé, A.J., Liu, J., Muscatello, J.R. and **Janz, D.M.** 2013. Effects of maternal dietary selenium exposure on early life stages of the amphibian Xenopus laevis. Society of Environmental Toxicology and Chemistry, Nashville, TN.

Massé, A.J., Liu, J., Muscatello, J.R. and **Janz, D.M.** 2013. Effects of maternal dietary selenium exposure on early life stages of the amphibian Xenopus laevis. Aquatic Toxicity Workshop, Moncton, NB.

McPhee, D.L. and **Janz, D.M.** 2013. Dietary selenomethionine exposure alters swim performance and metabolic capacity in juvenile fathead minnow and rainbow trout. Aquatic Toxicity Workshop, Moncton, NB.

McPhee, D.L. and **Janz, D.M.** 2013. Effects of dietary selenium exposure on swimming performance and energy homeostasis in two juvenile fish species. Society of Environmental Toxicology and Chemistry, Nashville, TN.

Mohammadzadeh, O. and **Giesy, J.P.** 2013. More Insights into Chemical Treatment of Fluid Fine Tailings (FFT) with IPC Technology. 63rd Canadian Chemical Engineering Conference' Symposium: Oil and Gas, Session on Heavy Oil Recovery and Upgrading. Fredericton, New Brunswick, October 20-23.

Nachshon, U., **Ireson, A.M.**, **van der Kamp, G.**, **Wheater, H.S.**, and Davies, S., 2013. Salt Dynamics in prairie wetlands under changing climate. IAH Geomontreal meeting, October.

Nazemi, A. and **Elshorbagy, A.A.** 2013. A Stochastic Rainfall Disaggregation Framework for Simulating the Sub-daily Extreme Rainfall Values in the City of Saskatoon, Joint Congress of the CMOS, CGU, and CWRA, Saskatoon, SK, May 26 - 30, Paper No. Abstract 6353.

Nazemi, A., **Wheater, H.** and **Elshorbagy, A.A.** 2013. Toward Emulating Complex Water Resource Systems: Linking Inflow Characteristics and System Response at the Annual Time Scale, Joint Congress of the CMOS, CGU, and CWRA, Saskatoon, SK, May 26 - 30, Paper No. Abstract 6648.

North, R., **Johansson, J.**, **Hunter, K.**, **Vandergucht**, D., Guildford, S., **Abirhire**, O., **Doig, L.**, **Liber, K.**, **Sadeghian**, **A.**, **Lindenschmidt, K.-E.** and **Hudson, J.** 2013. Evidence for internal phosphorus loading and its relationship to cyanobacterial biovolume and physiology in a large reservoir (Lake Diefenbaker, SK). Annual Meeting of the North American Lake Management Society. San Diego, CA, October 30 to November 1.

North, R., **Johansson, J.**, **Hunter, K.**, **Vandergucht**, D., Guildford, S., **Abirhire**, O., **Doig, L.**, **Liber, K.**, **Sadeghian**, **A.**, **Lindenschmidt, K.-E.** and **Hudson, J.** 2013. Evidence for internal phosphorus loading and its relationship to cyanobacterial biovolume and physiology in a large reservoir (Lake Diefenbaker, SK). North American Lake Management Society, 33rd International Symposium, San Diego, CA, October 30 - November 1.

North, R.L., Khan, N.H., Ahsan, M., **Prestie, C.**, Korber, D.R., **Lawrence, J.R.** and **Hudson, J.** 2013. Environmental factors controlling bacterial indicators in Lake Diefenbaker. CGU/CWRA/CMOS Conference, Saskatoon, SK.

North, R.L., Khan, N.H., Ahsan, M., **Prestie, C.**, Korber, D.R., **Lawrence, J.R.**, and **Hudson, J**. 2013. Bacterial abundances and water quality objectives in a large prairie reservoir: Lake Diefenbaker (SK, Canada). American Society of Limnology & Oceanography (ASLO) Aquatic Sciences Conference, New Orleans, LA.

North, R.L., Winter, J.G. and Dillon, P.J. 2013. Nutrient indicators of agricultural impacts in the tributaries of a large lake. CGU/CWRA/CMOS Conference, Saskatoon, SK.

Pickering, I.J., Ponomarenko, O., George, G.N., Gailer, J., Leslie, E.M., La Porte, P.F., Strait, K. and Spallholz, J. 2013. Synchrotron studies of selenium interactions with arsenic. Selenium in the Environment and Human Health - Proceedings of the 3rd International Conference on Selenium in the Environment and Human Health, 206-207, Hefei, Anhui, China, November 10-14.

Quay, R., Sampson, D., White, D., Kirkwood, C. and **Gober, P.** 2013. Using advanced scenario analysis as an anticipatory tool: Exploring the uncertainty of urban water demand and supply within Central Arizona. 15th Annual CAP LTER Poster Symposium and All Scientist Meeting 2013, SkySong, Scottsdale, AZ, January 11 (Poster presentation).

Reed, M.G. 2013. Can indigenous perspectives and knowledge be included in UNESCO biosphere reserves in Canada? Canadian Association of Geographers. Biocultural Conservation Session. St. John's, NL, August 13.

Reed, M.G. 2013. What is sustainability anyway? The university and sustainability. Land, Place and Environment: Advancing Learning and Practice Toward a Sustainable Future, Saskatoon: Sustainability Education Research Institute, University of Saskatchewan. October 4.

Sampson, D.A., Quay, R, White, DD., **Gober, P.** and Kirkwoodm C. 2013. Anticipatory water management in Phoenix using advanced scenario planning and analyses: WaterSim 5. American Geophysical Union Fall Meeting, December 9-13, San Francisco, CA, December 11 (Poster presentation).

Saunders, D.M., Wiseman, S., Mankidy, R. and **Giesy, J.P.** 2013. Three Novel Brominated Flame Retardants: Potential Effects on Fecundity, Reproductive Fitness, and Maternal Transfers in Japanese Medaka. SETAC North America 36th Annual Meeting, November 17-23.

Schiffer, S.R., **Doig, L.E.**, and **Liber, K.** 2013. Acute and chronic toxicity of aqueous vanadium to model and field collected freshwater invertebrates. 40th annual Aquatic Toxicity Workshop, Moncton, NB, October 6-9. (1st place, student poster competition).

Solomon, K.R., Mackay, D., Giddings, J.M., Williams, W.M., Moore, D.R., Purdy, J., Cutler, C. and **Giesy, J.P.** 2013. Ecological risk assessment for chlorpyrifos in terrestrial and aquatic systems in North America – overview and conclusions. Ecotoxicological Risk Assessment for Agricultural Use of Chlorpyrifos in the US. 246th ACS National Meeting & Exposition, Indianapolis, Indiana, September 8-12.

Sychrova, E., Novakova, K., Adamovsky, O., Prochazkova, T., Hilscherova, K. and **Giesy, J.P.** 2013. Bioactive Compounds from Cyanobacteria as Potential Endocrine Disruptors in Aquatic Environments. SETAC Europe 23rd Annual Meeting, Glasgow, Scotland, May 12-16.

Tallon, L.K., O'Kane, M., **Si, B.C.** and **Barbour, S.L.** 2013. Distributed Temperature Observations Reveal the Scale of Spatial Variability in Unsaturated Soil Covers. Proceedings of the 17th International Conference on Tailings and Mine Waste, Banff, AB, November 3-6, 10pp.

Tse, T.J., Quinones-Rivera, Z., Leavitt, P.R., **Doig, L.E.**, **Lucas, B.**, **Liber, K.**, **Wheater, H.**, **Jones, P.D.** and **Giesy, J.P.** 2013. Reconstructing the Historical Nutrient Status of Lake Diefenbaker, Saskatchewan, Canada, Using Sediment Algal Pigment Composition. SETAC North America 36th Annual Meeting, November 17-23.

Tse T.J., Quiñones-Rivera, Z., Leavitt, P.R., **Doig, L.E.**, **Lucas, B.**, **Liber, K.**, **Giesy, J.P.**, **Wheater, H.S.** and **Jones, P.D.** 2013. Reconstructing the nutrient status of Lake Diefenbaker, Saskatchewan, Canada, using sediment algal pigment composition. Society of Environmental Toxicology and Chemistry 34th Annual Meeting, Nashville, TN, November 17-21.

Vandergucht, D., **Johansson, J.**, **Hunter, K.**, **Yip, H.**, **Head, K.**, **Prestie, C.**, **Abirhire, O.**, **North, R.L.**, **Sereda, J.** and **Hudson, J.** 2013. Physical and chemical characterization of Lake Diefenbaker during the 2011 and 2012 ice free seasons. CGU/CWRA/CMOS Conference 2013, Saskatoon, SK, May.

Walker, X.J. and **Johnstone, J.F.** 2013. Regional variability of black spruce climate growth responses in interior Alaska. 16th Conference of the International Boreal Forest Research Association, Edmonton, AB, October (Oral presentation).

Wiseman, S.B., Mankidy, R., He, Y., Alharbi, H., dos Santos Pereira, A., Martin, J.W. and **Giesy, J.P.** 2013. Identification of Toxic Constituents of the Dissolved Organic Fraction of Oil Sands Process Affected Water Using Bioassay Directed Fractionation." SETAC Europe 23rd Annual Meeting, Glasgow, Scotland, May 12-16.

Books and Book Chapters - 2014

Basu, N. and **D.M. Janz.** 2014. Organometal(loid)s. Pp. 141-194 In: K.B. Tierney, A.P. Farrell and C.J. Brauner (Eds.) Fish Physiology Vol 33, Organic Chemical Toxicology of Fishes. Elsevier, San Diego.

Clark, D.A., Workman, L. and Slocomb, D.S. 2014. Science-based grizzly bear conservation in a co-management environment: The Kluane region case, Yukon. In: *Large Carnivore Conservation: Integrating Science and Policy in the North American West*. Eds. S.G. Clark and M.B. Rutherford, University of Chicago Press, Chicago, IL, pp. 108-139.

Clark, S.G., Cherney, D.N., and **Clark, D.A.** 2014. Large carnivore conservation: A perspective on constitutive decision-making and options. In: *Large Carnivore Conservation: Integrating Science and Policy in the North American West*. Eds. S.G. Clark and M.B. Rutherford, University of Chicago Press, Chicago, IL pp. 251-288.

Diduck, A., **Reed, M.G.** and George, C. 2014. Participatory approaches to resource and environmental management. In: *Resource and Environmental Management in Canada. 5th Edition.* Ed. B. Mitchell, Don Mills, Oxford University Press, In Press.

Gupta, H.V, Blöschl, G., **McDonnell**, J.J., Savenije, H.H.G., Sivapalan, M., Viglione, A. and Wagener, T. 2014. Synthesis of the Benchmark Report. In: *The PUB Benchmarking Report*. G. Blöschl et al. (eds), Cambridge University Press, in press.

Janz, D.M. 2014. Chlorobenzilate. In: *Encyclopedia of Toxicology, 3rd ed.*, Ed. P. Wexler, Elsevier, San Diego, CA, pp. 874-875.

Janz, D.M. 2014. Dinitrophenols. In: *Encyclopedia of Toxicology, 3rd ed.*, Ed. P. Wexler, Elsevier, San Diego, CA, pp. 177-178.

Janz, D.M. 2014. Dithiocarbamates. In: *Encyclopedia of Toxicology, 3rd ed.*, Ed. P. Wexler, Elsevier, San Diego, CA, pp. 212-214.

Janz, D.M. 2014. Hexachlorobutadiene. In: *Encyclopedia of Toxicology, 3rd ed.*, Ed. P. Wexler, Elsevier, San Diego, CA, pp. 872-873.

Gober, P., White, D.D., Quay, R., Sampson, D.A. and Kirkwood, C.W. 2014. Socio-hydrology modelling for an uncertain future, with examples from the USA and Canada. In: *Integrated Environmental Modelling to Solve Real World Problems: Methods, Vision and Challenges*. Eds. A.T. Riddick, H. Kessler and J.R.A. Giles, Geological Society, Special Publications, London, 408, doi.org/10.1144/SP408.2.

Gober, P. 2014. Decision making under uncertainty: A new paradigm for water resources planning and management. In: *Handbook of Water Engineering.* Eds. Lawrence K. Wang and Chi Ted Yang, Humana Press Inc. and Springer Science, New York, Vol. 15: 422-436.

Books and Book Chapters - 2013

Clark, D. 2013. Polar bear sport hunting in Canada: cross-scale effects on recreational hunting regimes (Box 18.6). In: *Arctic Biodiversity Assessment: Status and trends in Arctic biodiversity. Conservation of Arctic Flora and Fauna.* Ed. H. Meltofte, Akureyri, IS, pp. 504.

Clark, D.A. and Workman, L. 2013. Chapter 8: Transformation in subsistence systems in the southwest Yukon Territory, Canada. In: *Arctic Council. 2013. Arctic Resilience Interim Report*. Stockholm Environment Institute and Stockholm Resilience Centre, Stockholm, SU, pp. 103-106.

Davis, E.J. and **Reed, M.G.** 2013. Governing for transformation and resilience: The role of identity in renegotiating roles for forest-based communities of British Columbia's Interior. In: *The social transformation of rural Canada: New insights into community, culture, and citizenship.* Eds. J. Parkins and M.G. Reed, UBC Press, Vancouver, BC, pp. 249-268.

Horváth, I.T. and **Giesy, J.P.** 2013. Green Chemistry and Ecotoxicology. In: *Encyclopedia of Aquatic Ecotoxicology, Volume 1*. Eds. J.F. Férard and C. Blaise, Springer, Dordrecht, The Netherlands, pp. 569-573.

Izadifar, Z. and **Elshorbagy, A.A.** 2013. Chapter 9: Data Driven Techniques and Wavelet Analysis for the Modeling and Analysis of Actual Evapotranspiration. In: *Evapotranspiration - An Overview.* Ed. S. G. Alexandris, InTech, New York, pp. 167-206.

Janz, D.M. 2013. Biomarkers in fish ecotoxicology. In: *Encyclopedia of Aquatic Ecotoxicology*. Eds. J.-F. Férard and C. Blaise, Springer, Berlin, Germany, pp. 211-220.

Jones, P.D., **Hecker, M.**, Wiseman, S. and **Giesy, J.P.** 2013. Birds. Chap 10. In: *Endocrine Disruptors: Hazard Testing and Assessment Methods*. Ed. P. Matthiesson, J. Wiley and Sons, Hoboken, New Jersey.

Kofinas, G., **Clark, D.** and Hovelsrud-Broda, G. 2013. Chapter 5: Adaptive and transformative capacity. In: *Arctic Council. 2013. Arctic Resilience Interim Report*. Stockholm Environment Institute and Stockholm Resilience Centre, Stockholm, SU, pp. 71-91.

Massie, M. and **Reed, M.G.** 2013. Cumberland House in the Saskatchewan River Delta: Flood memory and the municipal response, 2005 and 2011. In: *Climate Change And Flood Risk Management: Adaptation and Extreme Events at the Local Level*. Ed. C. Keskitalo, Edward Elgar Publishers, Cheltenham, UK. pp. 150-189.

Kuby, M., Harner, J. and **Gober, P.** 2013. *Human Geography in Action (Sixth Edition).* New York: Wiley, 560 pp.

Parkins, J. and **Reed, M.G.** (eds.) 2013. *The Social Transformation of Rural Canada: New Insights into Community, Culture, and Citizenship.* UBC Press, Vancouver, BC, 21 chapters, 3 interleafs, 414 pp.

Parkins, J. and **Reed, M.G.** 2013. Introduction: Towards a transformative understanding of rural social change. In: *The social transformation of rural Canada: New insights into community, culture, and citizenship*. Eds. J. Parkins and M.G. Reed. UBC Press, Vancouver, BC, pp. 1-18.

Parkins, J. and **Reed, M.G.** 2013. Postscript: The future of rural studies in Canada. In: *The social transformation of rural Canada: New insights into community, culture, and citizenship*. Eds. J. Parkins and M.G. Reed. UBC Press, Vancouver, BC, pp. 387-389.

Patrick, R. 2013. Indigenous Planning and Source Water Protection. In: *Models of Indigenous Development*. Eds.I. Skelton and O. Ixtacuy Lopez.

Pomeroy, J.W. 2013. Preface. In: *Putting Prediction in Ungauged Basins into Practice*. Eds. J.W. Pomeroy, P.H. Whitfield, C. Spence. Canadian Water Resources Association and International Association of Hydrological Sciences, Cambridge, Ontario. pp. iii-v.

Pomeroy, J.W., **Spence, C.** and Whitfield, P.H. 2013. Putting prediction in ungauged basins into practice. In: *Putting Prediction in Ungauged Basins into Practice.* Eds. J.W. Pomeroy, P.H. Whitfield, C. Spence. Canadian Water Resources Association and International Association of Hydrological Sciences, Cambridge, Ontario. pp. 1-11.

Pomeroy, J.W., **Shook, K.R.**, Fang, X. and Brown, T. 2013. Predicting spatial patterns of inter-annual runoff variability in the Canadian Prairies. In: *Runoff Prediction in Ungauged Basins. Synthesis across Processes, Places and Scales*. Eds. G. Blöschl, M. Sivapalan, T. Wagener, A. Viglione and H. Savenije) Cambridge University Press, Cambridge, UK. pp. 283-289.

Pomeroy, J.W., Whitfield, P.H. and **Spence, C.** 2013. *Putting Prediction in Ungauged Basins into Practice*. Canadian Water Resources Association and International Association of Hydrological Sciences, Cambridge University Press, Cambridge, UK, 310 p.

Pomeroy, J.W., Fang, X., **Shook, K.** and Whitfield, P.H. 2013. Predicting in ungauged basins using physical principles obtained using the deductive, inductive and abductive reasoning approach. In: *Putting Prediction in Ungauged Basins into Practice.* Eds. J. W. Pomeroy, P.H. Whitfield, C. Spence. Canadian Water Resources Association and International Association of Hydrological Sciences, Cambridge, Ontario. 43-63.

Council of Canadian Academies. 2013. Water and Agriculture in Canada: Towards Sustainable Management of Water Resources. The Expert Panel on Sustainable Management of Water in the Agriclutural Landscapes of Canada, Council of Canadian Academies, Ottawa. 259 p. (**H. Wheater** chaired the expert panel and was lead author of substantial sections of the report).

Zhang, X., **Giesy, J.P.** and **Hecker, M.** 2013. Cell Lines in Aquatic Toxicology. In: Encyclopedia of Aquatic Ecotoxicology, Volume 1. Eds. J.F. Férard and C. Blaise. Springer, Dordrecht, The Netherlands, pp. 259-267.

Plenary, Key Note and Invited Lectures - 2014

Barbour, L. 2014. Two invited talks Brisbane and Syndey, Australia workshop. March 15-30, jointly sponsored by Geo-Slope and University of New South Wales. Invited workshop presenter.

Barbour, L. 2014.Research Methods, Guest Lecture for: CE 990 - 2013/14 Graduate Student Seminar Series, UofS, Saskatoon, SK, Feb. 27, Invited Presenter.

Barbour, L. Invited Presenter - NCGRT-ACSMP workshop: Aquitards, aquifers and mining, National Centre for Groundwater Research and Training, Australian Centre for Sustainable Mining Practices, University of New South Wales (UNSW), Australia, March 27: Geological weighing lysimeters - applications to mine hydrology, and March 28: Evaluation of soil-atmosphere-vegetation interactions for mine closure applications.

Barbour, L., O'Kane, M., McKenna, G. and Straker, J. 2014. Cover System and landform design in cold regions, Cold Covers Practice 2014 (Seminar), Whistler, B.C. April 7 - 9, Invited Workshop Presenter.

Bharadwaj, L. 2014. From the Lab to the Reserve: The Transformative Power of Engaged Scholarship. Engaged Scholar Day, University of Saskatchewan, Saskatoon, SK, May 14, Keynote Plenary.

Bharadwaj, L. 2014. Shale Gas Development in Canada: The Potential Health Risks Environmental Health Forum for Community Leaders. St John Room, Crowne Plaza, Fredericton, April 24.

Bharadwaj, L. 2014. Shale Gas Development in Canada: The Potential Health Risks. Environmental Health Public Lecture Hazen Hall, University of New Brunswick, Saint John, NB, April 24.

Bharadwaj, L. 2014. Shale Gas Development in Canada: What are the Potential Health Risks? Yukon Legislative Assembly Select Committee Regarding the Risks and Benefits of Hydraulic Fracturing, 33rd Yukon Legislative Assembly Public Proceedings, 2071 Second Avenue, Whitehorse, YK, May 27-28, Invited speaker.

Bharadwaj, L. 2014. Understanding and Managing Health Risks of Shale Gas Development. New Brunswick Energy Institute Environmental Health Sessions. Ask the Experts. Government Session, Irving Auditorium, Hugh John Fleming Forestry Complex (HJFFC) – 1350 Regent St, Fredericton, NB, April 23.

Bharadwaj, L. 2014. What is Healthy Water? Water and Innovation: an Interdisciplinary Exploration Workshop at UBC. Program on Water Governance, University of British Columbia, 439-2202 Main Mall, Vancouver, BC, January 30, Public Plenary.

Doig, L. and Jones, P.D. 2014. The Slave Watershed Environmental Effects Program. GIWS Workshop – Annual Progress and Plans. Park Town Hotel, Saskatoon, SK, February 25 - 26.

Ferguson, G. 2014. Deep Injection in the Western Canada Sedimentary Basin. National Groundwater Association Conference on Characterization of Deep Groundwater. Denver, CO, May 8.

Ferguson, G. 2014. Injection Wells and Energy Resources. ETH Zurich. Zurich, Switzerland. May 14.

Giesy, J.P. Wiseman, S.B., dos Santos Pereira, A., Remend, N., He, Y. and Mankidy, R. 2014. Acute toxicity of neutral-, acid-, and base- extractable fractions of oil sands process-affected water to fathead minnow (Pimephales promelas) embryos. 97th Canadian Chemistry Conference, Vancouver, BC, Canada, June 1-5, Invited.

Hecker, M. 2014. Characterization of complex environmental exposure scenarios by effects directed analysis. The First Xiamen Symposium on Marine Environmental Sciences; Xiamen, China, January 9 – 11, Plenary Keynote.

Hudson, J. 2014. A Glimpse at Three Years of Dynamic Behavior on Lake Diefenbaker. Global Institute of Water Security Annual Workshop. Park Town Hotel, Saskatoon, SK, Feb 25-26.

Hunter, K., **Vandergucht, D.**, **Abirhire, O.**, Dubourg, P., Hewlett, C., **Johansson, J.**, **North, R.**, **Prestie, C.**, **Sereda, J.**, **Yip, H.**, **DeBoer, D.** and **Hudson, J**. 2014. Characterizing the Limnology of Lake Diefenbaker. World Water Day Event. Global Institute of Water Security and The Canadian Water Resources Association. Saskatoon, SK, March 21.

Ireson, A.M. 2014. Quantifying groundwater recharge in diverse, complex settings. University of Queensland, Brisbane, Australia, March 17.

Johnstone, J.F. 2014. Disturbance as a catalyst and driver of forest change. Université Laval, Quebec City, QC, January, Invited seminar.

Jones, P.D. 2014. Reconstructing the nutrient status of Lake Diefenbaker, Saskatchewan, Canada, using sediment algal pigment composition. Tim Tse et al. Poster Presentation – Water Leaders of Tomorrow Lecture Series, Saskatoon, Saskatchewan, March 21.

Jones, P.D. 2014. SWEEP: The Slave Watershed Environmental Effects Program. JOSMP Fish Monitoring – Technical Workshop. Calgary, AB, April 29 - 30.

Jones, P.D., Markus H., **Cessna, A.**, **Putz, G.**, Codling, G., Tumber, V., Yuan, H., Beitel, S., Higley, E. and **Giesy, J.** 2014. Toxicity profiles of water samples from Swift Current Creek and Saskatoon Storm-Water runoff as determined by Analytical and Effect Directed Analysis, GIWS Workshop – Annual Progress and Plans. Park Town Hotel, Saskatoon, SK, February 25 - 26.

Kienzle, S, **Wheaton, E.**, Bonsal, B., **Wittrock, V.** and Barrow, E. 2014. The VACEA Project: Modelling Climate Impacts on Agro-Ecosystems. IRIACC (International Research Initiative on Adaptation to Climate Change) Panel, Congress of the Humanities and Social Sciences, Canadian Association of Geographers Congress, Brock University, St. Catharines, ON, May 24-30, Invited Presenter.

McDonnell, J.J. 2014 Japan Geophysical Union, Session on Insight into Change and Evolution in Hydrology, Yokohama, Japan, April 29-30.

McDonnell, J.J. 2014. 2014 Third International Tropical Hydrology Workshop, Malaysian Borneo, February 10-14.

McDonnell, J.J. 2014. Kyoto University, Department of Civil Engineering, Kyoto Japan, June 1.

McDonnell, J.J. 2014. NW Food and Agriculture University, Xian, China, June 16.

McDonnell, J.J. 2014. Tohoku University, Department of Civil Engineering, Sendai, Japan, May 28.

McDonnell, J.J. 2014. UC Irvine, Department of Civil and Environmental Engineering, Irvine, CA, January 10.

North, R.L. 2014. Timing matters: Nutrient loading from land to lake. Brandon University, Brandon, MB.

Patrick, R. 2014. Capacity building for source water protection: Yellowknife, NWT. Government of the Northwest Territories. February 20.

Patrick, R. 2014. Saskatchewan Association of Watersheds Annual Conference. Taking a Soft Path to Water Management. Saskatoon, SK, March 19-21.

Patrick, R. 2014. Source water protection planning in your community. Ontario First Nations Technical Services Corporation – Water Symposium. Niagara Falls, ON. March 3-5.

Patrick, R. 2014. Transportation Planning and Design. Presentation Title: Urban Transportation and Design: Getting to Where we Need to Go". Saskatoon Sustainability Networking Conference. Saskatoon, SK. January 24.

Pickering, I.J., 2014. Synchrotron studies of arsenic, selenium and the world's worst mass poisoning. Environmental Health Sciences Research Bureau Seminar, Health Canada, Ottawa, ON, June 16.

Reed, M.G. 2014. Learning with Canadian Biosphere Reserves: Connecting researchers and practitioners through a national community of practice. Knowledge Translation: Bridging Gaps Between Science and Society. First International Symposium of the ILEK (Integrated Local Ecological Knowledge) Programme. Research Institute for Humanity and Nature, Kyoto, Japan. September 13-14.

Reed, M.G. and Godmaire, H. 2014. Promoting Transformational Change by Strengthening a National Community of Practice: Working with Canadian Biosphere Reserves. AGM of the Canadian Biosphere Reserves Association and the Canadian Commission for UNESCO. Victoria, BC, June 5, Invited Presenter.

Roste, J., Mahmood, **T.**, **Galuschik, N.**, **Gooding, R.**, **Pomeroy, J.**, **Wheater, H.S.** and **Baulch, H.M**. 2014. Research Update: Hydrology and nutrient dynamics in Tobacco Creek. South Tobacco Creek Research consortium, University of Manitoba, Winnipeg, MB, May 26, Invited seminar.

Welter, S., **Reed, M.G.** and Gamble, A. 2014. Stretching community-based ecosystem management to protect Indigenous livelihoods: The Beardy's and Okemasis First Nation and the Prince Albert Model Forest. Ecosystem services under Pressure. Invited for the XXIV IUFRO (International Union of Forest Research Organizations) World Congress 2014. Sustaining Forests, Sustaining People: The Role of Research. Salt Lake City, UT, October 5-11, Invited sub-plenary session.

Wheater, H.S. 2014. An introduction to GIWS water quality research. Prairie Provinces Water Board, Committee on Water Quality, National Hydrology Research Centre, Saskatoon, SK, March 3.

Wheater, H.S. and **P.A. Gober**. 2014. Meeting the Science Challenges of Water Security in the Saskatchewan River Basin: a Regional Hydroclimate Project from Western Canada. Dooge Nash Symposium. Dublin, Ireland, April 24, Invited Speaker.

Wheater, H.S. Mackenzie River Basin Board – Saskatoon, Saskatchewan (2013);

Wheater, H.S. UNESCO Kovacs Colloquium – Paris, France (2013)

Wheaton, E. 2014 Agriculture and Patterns of Climate Extremes on the Canadian Prairies. 26th Conference of the Saskatchewan Soil Conservation Association, Saskatoon, SK, January 16, Invited Presenter.

Wheaton, E. 2014. Comments on the Guidebook: Pathways to Climate Change Resilience. International Forum Linking Gender, Adaptation, Climate Change and Forestry/ Resource Management in Canada, Saskatoon, SK, May, Invited Presenter.

Wheaton, E. and **V. Wittrock.** 2014. Dust Storms of the Canadian Prairies: A Dustier and Muddier Outlook. Invited Presentation to the Great Plains Drought Symposium, Lincoln, Nebraska, April 1-4.

Wittrock, V, Pittman, J. and **Wheaton, E.** 2014. Saskatchewan's Industry Adapting to our Changing Climate. Ministry of Environment, Regina, Saskatchewan, March, Invited Presenter.

Zwiers, F. and **Wheaton, E.** 2014. Changing Climates (IPCC AR5) and Implications for the Canadian Prairies. School of Environment and Sustainability, University of Saskatchewan, Saskatoon, SK, February 14, Invited Presentation.

Plenary, Key Note and Invited Lectures - 2013

Barbour, L. 2013. Can we Successfully Reclaim Oil Sands Mine Closure Landforms? - A review of Overburden Reclamation Research in the Oil Sands Industry. Saskatoon Geotechnical Group University of Saskatchewan, Saskatoon, SK, September 18, Invited Presenter.

Barbour, L. 2013. Hydrogeological Characterization of Oil Sands Mine Closure Landforms - Review of NSERC/SCL IRC. Barbour IRC Review Mtg (SCL & GIWS in attendance), University of Saskatchewan, Saskatoon, SK, May 7, Invited Presenter.

Barbour, L. 2013. Oil Sands Research. Meeting between reps from Global Institute for Water Security (GIWS) and Syncrude Canada Ltd. (SCL), National Hydrology Research Centre, Saskatoon, SK, May 7, Invited Presenter.

Barbour, L. 2013. Reconstruction of landforms for reclamation of oil sands mines. SK Department of Highways and Transportation. Saskatoon office, 4th Floor Boardroom), October 9, Invited Presenter.

Barbour, L. IRC (Barbour) Research: Syncrude Canada Ltd seminar/meetings/discussions: for Barbour and his students/research staff to give presentations/updates on their IRC work/projects, Edmonton, AB, Nov.26, Invited Presenter.

Bharadwaj, L. 2013. Traditional Knowledge Indicators for the SWEEP Program. Slave River Environment Effects Monitoring Program (SWEEP) Indicator Workshop. Slave River and Delta Partnership – University of Saskatchewan. Roaring Rapids Hall, Fort Smith, NT, July 11-12, Oral presentation.

Bharadwaj, L., 2013. A Rush for Metals: Voices from Ancash Peru. Global Health Conference, Saskatoon, SK, September 20 – 23, oral presentation.

Chilima, J. and **Bharadwaj, L.** 2013. Applying community-based participatory research approach in a multi-phases water resources management study: Lake Diefenbaker, Saskatchewan, Canada. A poster presented at Sharing Water Resources in a Growing Economy: Science to Policy, Prairie Northern Chapter of SETAC (SETAC PNC) 4th Annual Meeting, University of Lethbridge, Lethbridge, AB, June 7- 9, Oral presentation.

Ferguson, G. 2013. Competition for Pore Space in the Western Canada Sedimentary Basin. Queen`s-Royal Military College Centre for GeoEngineering. Kingston, ON. November 20.

Ferguson, G. Geothermal Opportunities in Saskatchewan. Canadian Society for Civil Engineering. Saskatoon Chapter, Saskatoon, SK, February 20.

Giesy, J.P. 2013. Ecotoxicological Evaluation of Perfluorooctanesulfonate (PFOS) in the Environment. International Conference on Environmental Safety and Ecological Criteria. Nanjing, PR China, June 30 - July 2, Invited, Plenary, Keynote.

Giesy, J.P. 2013. Predicting the Toxic Potency of Any Dioxin-like Compound to Any Avian Species. US Geological Survey, Midcontinent Research Laboratory, Columbia, MO, August 12, Invited.

Giesy, J.P., Lu, Y.L., Wang, L., Luo, T., Park, J. and Khim, J.S. 2013. Status and Trends of Contaminants in Bohai Bay and the Yellow Sea: An International Perspective. Toxicology, Centre, University of Saskatchewan, Saskatoon, SK, September, 23.

Gleeson, T., **Ferguson, G.**, Manning, A.H., Wada, Y., Bierkens, M.F.P. and van Beek, L.P.H. 2013. Beyond cross-sections: regional groundwater systems in the real, three-dimensional world including humans. International Symposium on Regional Groundwater Flow: Theory, Applications and Future Development, Xi'an, China, June 2013. Invited keynote speaker.

Gober, P. 2013. Scenario development and futures planning for the Saskatchewan River Basin. Below Your Watershed: Your Connection to the River and Groundwater, October 21-23, Medicine Hat, AB.

Guertin, M.A. and **Reed, M.G.** 2013. Implementing the periodic review in Canada La mise en oeuvre des examens periodiques au Canada. Strengthening the Biosphere Reserve Network Management Framework. EuroMAB. Brockville, ON, October 15-19.

Hudson, J. 2013. Potential Water Quality Issues in Lake Diefenbaker. Ken Cheveldayoff, Minister of the Environment, Saskatchewan. National Hydrology Research Centre, Saskatoon, SK. July 9

Hudson, J. 2013. Progress on Lake Diefenbaker. Saskatchewan Watershed Authority. Moose Jaw, SK. November 14.

Hudson, J. 2013. Water Quality Monitoring: Lake Diefenbaker as an Example. Annual meeting of the Provincial Association of Resort Communities of Saskatchewan (PARCS). Watrous, SK. October 5.

Ireson, A.M. 2013. Groundwater and salinization of prairie wetlands. Below your watershed conference, Medicine Hat, AB, organized by Partners FOR the Saskatchewan River Basin, October, Invited Talk.

Johnstone, J.F. 2013. Disturbance, resilience, and inertia of boreal forests under climate change. 16th Conference of the International Boreal Forest Research Association, Edmonton, AB, October, Invited keynote speaker.

Jones, P.D. 2013. Slave Watershed Environmental Effects Program (SWEEP). 2nd Northwest Territories Environmental Monitoring Annual Results Workshop. Yellowknife, NWT, December 10 - 12.

Jones, P.D. 2013. SWEEP: The Slave Watershed Environmental Effects Program. The 40th Annual Aquatic Toxicity Workshop, Moncton, NB, October 6-9.

Jones, P.D., Tendler, B., Hill, A.,Ohiozebau, E., **Giesy, J.**, Kelly, E., J. Fresque-Baxter. 2013. Chemodynamic behavior of Thallium in the Slave River, Northwest Territories The 40th Annual Aquatic Toxicity Workshop, Moncton, NB, October 6-9.

Lindenschmidt, K.-E. 2013. Development of a surface water quality modelling system for the South Saskatchewan River Basin. Sensors 4 Water - International conference on global challenges and opportunities, Assen, The Netherlands, September 9-10.

Lindenschmidt, K.-E. 2013. Water security issues in the Saskatchewan River Basin. Manitoba Conservations Districts Association 38th Annual Conference, Brandon, MB, December3.

McDonnell, J.J. 2013. AGU Chapman Conference on Soil Mediated Drivers of Coupled Hydrological and Biogeochemical Processes, Tucson, AZ, October 21-24.

McDonnell, J.J. 2013. Boundary conditions and re-thinking watershed hydrology from the bottom-up. Tsinghua University, Department of Hydraulics and Civil Engineering, Beijing, China, July 1.

McDonnell, J.J. 2013. Grand challenges in coupled soil, water and landscape processes. Hydropedology and Sustainable Natural Resource Management, Beijing Normal University, July 29.

McDonnell, J.J., 2013. Research frontiers in isotope hydrology. National Hydrology Research Center, Environment Canada, Saskatoon, SK, December 5

North, R.L. 2013. From zero to sixty: The hot and cold of algae, stench, and death. Presented at the Great Lakes Institute of Environmental Research-University of Windsor, Lum Clark Seminar Series.

North, R.L. 2013. The hot and cold of algae, stench, and death; my work in limnology. Presented at the University of Regina, Regina, SK, Biology Seminar Series.

North, R.P., **North, R.L.**, Livingstone, D.M., Köster, O. and Kipfer, R. 2013. Long-term changes in hypoxia in a large temperate lake: consequences of a climate regime shift. Presented in a workshop on internal phosphorus loading, NALMS Conference, San Diego, CA.

Patrick, R. 2013. How to develop a source water protection plan in a community near you!" Partners for the Saskatchewan River Basin. Annual Conference. Medicine Hat, AB, October 23.

Pickering, I. J. 2013. Applications of X-ray Absorption Spectroscopy in Life Sciences. 16th National School on Neutron and X-ray Scattering. Argonne National Laboratory, Argonne, IL, June 18.

Pickering, I. J. 2013. Applications of X-ray Absorption Spectroscopy in Environmental, Health and Chemical Sciences. 15th National School on Neutron and X-ray Scattering, Argonne National Laboratory, Argonne, IL, USA, August 10 - 24.

Pickering, I. J., Ponomarenko, O., George, G.N., Gailer, J., Leslie, E.M., La Porte, P.F., Strait, K. and Spallholz, J. 2013. Interactions of arsenic and selenium in vivo probed by synchrotron X-ray absorption spectroscopy and imaging. Seminar, Department of Chemistry, University of Calgary, Calgary, AB, October 4.

Reed, M.G., Godmaire, H., and 16 biosphere reserves. 2013. Canadian Commission for UNESCO 1 + 1 = 3: The Benefits of Partnership & Social Learning. EuroMAB Brockville, ON, Oct 15-19, Invited Keynote Presentation and Workshop.

Tim Tse et al. 2013. Reconstructing the nutrient status of Lake Diefenbaker, Saskatchewan, Canada, using sediment algal pigment composition. Society of Environmental Toxicology and Chemistry North America, 34th Annual Meeting, Nashville, Tennessee, November 17-21, Poster Presentation

Wheater, H.S. 2013. American Geophysical Union Fall Meeting, San Francisco, CA, December 9 – 13, 2 invited lectures.

Wheater, H.S. 2013. Canadian Society of Petroleum Technologists - Technical Luncheon, Calgary, AB, April 8, invited speaker

Wheater, H.S. 2013. Conference for Interdisciplinary Engineering in Agriculture and Biosystems, University of Saskatchewan, Saskatoon, SK, July 7 - 10, plenary speaker.

Wheater, H.S. 2013. Gordon Research Conference. New Hampshire, June 16 – 22, Invited.

Wheater, H.S. 2013. Joint Scientific Congress (CMOS, CGU, CWRA), Saskatoon, SK, May 26 – 31, Plenary Address.

Wheater, H.S. 2013. Peter Wolf Early Career Hydrologist's Symposium. London, UK, March 25.

Wheater, H.S. 2013. Water and Agriculture in Canada: Towards Sustainable Management of Water Resources. Saskatchewan Ministry of Agriculture, Walter Scott Building, Regina, SK, September 18, Invited.

Wheaton, E. 2013. Agriculture in New Climates. Citizens' Hearing on Climate Change, Saskatoon, SK, November 2, Invited Presenter.

Wheaton, E. 2013. How can Agriculture deal with the Risks and Benefits of a Changing Climate? Renewable Power Intelligent Choice (RPIC). Prince Albert, SK, October 29. Invited Presenter.

Wheaton, E. 2013. Risks and Benefits for Agriculture of a Changing Climate. Prince Albert Model Forest Board. Prince Albert, SK, October 29, Invited Presenter.

Wheaton, E., Bonsal, B. and **Wittrock, V.** 2013. Climate Extremes, Crops and Water: VACEA Progress. to the VACEA Canadian Team Meeting, Regina, SK. VACEA (Vulnerability and Adaptation to Climate Extremes in the Americas) is a project of the Prairie Adaptation Research Collaborative, Regina, SK. SRC #13224-5D13. Saskatchewan Research Council, Saskatoon, SK, November 12, Invited Presenter.

APPENDIX G – International News from Members

- In December 2013, an International Court of Arbitration, of which Howard Wheater was a member, issued its final award in a dispute between India and Pakistan concerning the Indus Waters Treaty.
- In July 2014, Howard Wheater was co-chair and a key-note speaker at the Global Energy and Water Exchanges (GEWEX) World Forum: 7th International Scientific Conference on the Global Energy and Water Cycle. The conference took place in The Hague, Netherlands and celebrates 25 years of GEWEX research and addressed a range of areas including research on water resources, extremes in water (i.e., droughts and floods), weather climate and hydrological model development and exploitation, research capacity development and training for the next generation of scientists.
- On July 29, Howard Wheater attended the 69th Soil and Water Conservation Society's International Annual Conference in Lombard, Illinois. The conference addressed soil conservation and water quality issues, with particular applicability to North America.Dr. Wheater was invited to participate on a plenary session panel on US/Canada border waters in response to the plenary address given by Jamshed Merchant, Consul General of Canada who addressed the importance of shared waters and the water quality protection issues facing the two countries.
- In April, Howard Wheater attended the Dooge-Nash International Symposium in Dublin, Ireland, held to commemorate the lifes of two pioneers of Hydrology. The Symposium's theme was grand challenges facing hydrology in the 21st century and was attended by national and international delegates from government, research and education whose interests span the broad range of disciplines within hydrological science.
- In 2013-14, Jeffrey McDonnell had extensive research collaborations with various institutes including Universidad del Tolima – Colombia, and Lippmann Institute Luxembourg in the area of hill slope hydrology; Waginingen University, The Netherlands on meltwater infiltration in frozen soil; the Helmholtz Institute Germany on rainfall interception modeling; Kazakhstan National Technical University on groundwater tracing with stable isotopes; Freiburg University, Germany on calculation of streamwater transit times at the Marmot Creek watershed; and University of Bayreuth, Germany on rainfall infiltration into Prairie soils. In addition, he has active collaborations with the Hydrohill research facility, Nanjing Hydraulic Research Institute; and Northwest Agriculture and Forestry Institute, China. He is a fellow of the Geological Society of America, the 6th Century Chair of Hydrology at the University of Aberdeen (UK), Honorary Professor of Hydrology at the Nanjing Hydraulic Research Institute (China), University Distinguished Professor of Hydrology (adjunct) at Oregon State University (USA), and also DeTao Master, Beijing DeTao Masters Academy. Jeff served as the 2013 Keohane Visiting Distinguished Professor at Duke University and University of North Carolina, Chapel Hill. He is currently leading major studies funded by the U.S. Department of Energy on studying the hydrological impacts of biofuel production in forested watersheds.

- John Pomeroy continued his collaborations on mountain hydrology observations, processes and modelling with University de Chile, Santiago; Ludwigs Maxmillian Universitat, Munich; Swiss Snow and Avalanche Research Institute, Davos; Institut National pour le Développement, Grenoble, France; Edinburgh University, Edinburgh; USDA Agricultural Research Service; National Centre for Atmospheric Research, NOAA; Univ of Idaho, Moscow; Univ of Washington, Seattle; Boise State Univ., Boise; Chinese Academy of Sciences, Lanzhou; and Pyrenean Institute of Ecology, Zaragoza, Spain.
- John Giesy is a Distinguished Professor Emeritus of Zoology at Michigan State University in East Lansing, Michigan, where he was a Professor for 26 years. He is also Chair Professor at Large of Biology & Chemistry, at City University of Hong Kong; 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 Visiting Professor of Biology at Hong Kong Baptist University. He is on the board of directors of the State Key Laboratory in marine Pollution in Hong Kong. He is Honorary Professor, at the State Key Laboratory of Environmental Criteria and Risk Assessment, Chinese Research Academy of Environmental sciences, Beijing, China. He is an Einstein Professor of the Chinese Academy of Sciences and the University of Saskatchewan Ambassador to China. He is leading many joint research projects in the United States of America, Europe and China (Appendix E).
- Karsten Liber holds a Concurrent Professorship with the Shanxi University, Taiyuan, Shanxi, China and also leading a program on Sino-Canadian cooperation on microbial and phytoremediation technologies for clean-up of PAH and heavy metal contaminated soils in Shanxi industrial regions, Shanxi Science and Technology Department. In addition, he is also part of the Network on environmental impact assessment of industry-contaminated areas in the Arctic, Nordic Council of Ministers' Arctic Co-operation Programme, Denmark. Recently, through the Emerging Leaders in the Americas Program he has sustained his collaborations with Universidad Peruana Cayetano Heredia in Peru on combined toxicity of metals and UV-B radiation in freshwater invertebrates.
- Doug Clark from SENS is leading a Canadian research component for a major study on drivers of landscape change in Tundra in collaboration with the University of Tromsø, Norway.
- David Janz from Western College of Veterinary Medicine is working in collaboration with the United States Department of Defence, Office of Naval Research on studying variability of hormonal stress markers and stress responses in a large cross-sectional sample of elephant seals and also studying the pathophysiology of stress in wild and managed-care bottlenose dolphins, United States Department of Defence, Office of Naval Research.
- Jill Johnstone is collaborating with research partners in the United States of America on studying the regional consequences of changing climate-disturbance interactions for the resilience of Alaska's boreal forest: Bonanza Creek LTER with support from the U.S. National Science Foundation, Long-Term Ecological Research program, and a study on Identifying Indicators of State Change and Forecasting Future Vulnerability in Alaskan

Boreal Ecosystems with support from the U.S. Strategic Environmental Research and Development Program.

- Lee Barbour and Bing Si are leading a multiscale soil water and temperature monitoring and stochastic simulation in semiarid farmlands program in collaboration with the Chinese National Natural Science Foundation.
- An ongoing collaboration between Lee Barbour (Civil and Geological Engineering) and Dr. David Hughes, The Queen's University, Belfast (QUB) has resulted in the graduation of two co-supervised PhD students at QUB during this past year with two new PhD students currently pursuing research at QUB. The general area of research is related to climate driven fluctuations in pore-pressures which may lead to instability and slope failures within large cuttings (excavations) associated with transportation infrastructure in Northern Ireland. Dr. Hughes and one of the PhD students (Ruth Harley) recently visited the UofS following the Canadian Geotechnical Conference held recently in Regina.
- Lee Barbour also presented two invited talks to a recent workshop on Groundwater and Mining held at the University of New South Wales in Sydney, Australia. This visit has led to the development of collaborative linkages with Dr. Wendy Timms and her students at UNSW including a recent visit by PhD student Katerina David to the UofS in late October to consult with Dr. Barbour and Dr. Hendry in regard to her PhD work on the impact of underground mining on groundwater disturbance.
- Jafar Soltan continued his collaborations with Brazil, Germany and India in the area of emerging contaminants such as pharmaceutical and personal care products, and their treatment using advanced oxidation technology.
- Tim Jardine was an invited attendee to the Fourth International Symposium on Riverine Landscapes, Yueyang, China, October 2013 comprising of a group of river scientists from Australia, USA and Europe that meets once every five years. In addition, Tim Jardine continued his collaboration with colleagues at National University of Singapore, on a grant to study biodiversity and biological interactions in Singaporean reservoirs. Recently, he has initiated a feasibility study on a community-based approach to sustainable pond aquaculture in southern Ethiopia leading to water and food security.
- Yanping Li has initiated a project in collaboration with University of Chile titled "Using Elqui Valley basin as an example to assess the water resources vulnerability of the Andes Western Slope under climate change background". For this international project, she has received funding support from the Canada-Latin America and the Caribbean Research Exchange Grants Program (LACREG), Association of Universities and Colleges of Canada (AUCC).
- GIWS large scale modeling group has established a strong collaboration with Hydro-meteorology group at National Center for Atmospheric Research (NCAR). For example, Yanping Li's hydrometeorology team at GIWS is heavily involved to the Continental scale Regional Climate modeling using 4-km WRF, which covers both Continental US and Southern Canada, using NCAR's supercomputers.
- Karl-Erich Lindenschmidt collaborated with Prof. Dirk Carstensen from the Technische Hochschule Nürnberg, Germany, on the design for winter flows of the Upland Canal for

Upper Qu'Appelle Water Supply Project in Saskatchewan[26]. A river ice model was implemented to assess the various design options. Additional flow depth for low flows under ice is sought to prevent the water column from freezing to the canal bottom and the ice cover grounding to the canal bed and liner.

- Patricia Gober served on two National Science Foundation (USA) review panels in 2014, one as a site visitor for the Stanford Engineering Research Center for water reuse (ReNEWIT) and the second as a member of Water Sustainability and Climate, an interdisciplinary competition. She was also a member of the review team for the Evelyn Pruitt Dissertation Fellowship committee for women graduate students of the Association of American Geographers and of the Nomination Committee for the Stockholm Water Prize representing the Swedish Academy of Sciences. She is co-chair of the Adaptation and Hazards Mitigation Technical Indicators team for the US National Climate Assessment.
- Amin Elshorbagy was invited in 2013 and 2014 to lecture in Sharjah, UAE about conflicts and conflict resolution in water resources and environmental issues. The full-day lecture is part of the International Diploma in Arbitration, organized by the International Academy of Legal Sciences, Sharjah international Commercial Arbitration Centre, and International Mediation and Arbitration Center.
- Matt Lindsay is collaborating with colleagues from the University of Huelva (Huelva, Spain) and the Institute of Environmental Assessment and Water Research (Barcelona, Spain) on a three-year project entitled "Stability of trace elements in acid mine drainage precipitates: applications and potential environmental implications". This project will focus on constraining geochemical and mineralogical controls on the transport of trace elements in groundwater and surface water. Models derived from this research will be used to inform development of new approaches for managing mine wastes and associated water quality in Spain and worldwide.
- In addition, our researchers Howard Wheater, Patricia Gober, Helen Baulch and Markus Hecker served as expert reviewers for various international research programs and grants review panels for agencies in Australia, Belgium, Germany, the Netherlands, Poland, Sweden, United Kingdom, and United States of America.

[26] Lindenschmidt, K.-E. and Carstensen, D. (in press) The upper Qu'Appelle water supply project in Saskatchewan, Canada – Upland Canal ice study. Österreichische Wasser- und Abfallwirtschaft.

APPENDIX H – Examples of Significant Outcomes of Research

- Following renewed concerns about mercury in fish from northern Saskatchewan lakes including Cumberland Lake, Saskatchewan Environment imposed new restrictions on the sale of fish within the province in the spring of 2013. Because this had a direct effect on the livelihoods of fishermen in the Saskatchewan River Delta, and was a potential threat to the health of community members where most fish is consumed, Tim Jardine and team immediately began testing concentrations in fish supplied by the community. They ultimately determined that concentrations were currently low and that they have been declining since the 1970s. This led to the conclusion that fish are not an immediate threat to the health of the community. This information has contributed to a reversal of the 2013 restrictions on the sale of Cumberland fish within the province.
- Future projections of monthly and extreme precipitation characteristics across the entire three Canadian Prairie Provinces (Alberta, Saskatchewan and Manitoba) at the scale of 47 watersheds, using 50 km grid resolution Regional Climate Model simulations are developed in the recently published article by Khaliq et al. (2014)[27]. The results of the study have strong region-wide implications for managing regional water resources and infrastructure facilities and therefore provide extremely useful information for decision-makers.
- John Pomeroy and team significantly contributed towards the advancement of knowledge and science in the area of cold regions hydrological processes and modeling, and beneficial agricultural management practices, which resulted in: 1) development of techniques and synthesis of recommendations for predictions in ungauged basins; 2) advancement and testing of acoustic snow water equivalent gauge; 3) determination of hydrological uncertainty due to errors in precipitation phase estimation; 4) detection of the influence of wetland drainage and climate change on prairie streamflow; 5) measurement of a major flood in the Canadian Rocky Mountains and determination of causal processes; 6) improved understanding and modeling of tundra vegetation-snow interaction impact on hydrology; 7) determination of Yukon headwater basin hydrology sensitivity to climate change; 8) hydrological process modelling in Tibetan Plateau to understand impacts of snowmelt and frozen soil; 9) forest hydrological process modelling in Canadian Rockies to determine impacts of forest cover change; 10) development of wetland modelling framework for Canadian Prairies; and 11) development of method to use reanalysis data to model mountain hydrology in Patagonia.
- Lake Diefenbaker is considered as the Prairie Jewel, which supplies drinking water to about 65% of Saskatchewan residents. In the recent past, nutrient loading of Lake Diefenbaker has been a concern primarily due to various land-use management practices and urbanization resulting in reduced water quality. With support from the CERC and the Saskatchewan Water Security Agency, Jeff Hudson's team has produced data on nutrient loadings and their impacts on aquatic ecology. Three years of nutrient input and export

[27] Khaliq et al. (2014). Seasonal and extreme precipitation characteristics for the watersheds of the Canadian Prairie Provinces as simulated by the NARCCAP multi-RCM ensemble. Climate Dynamics, DOI 10.1007/s00382-014-2235-0

calculations (mass balance) indicate that the reservoir is acting as a major sink for phosphorus; a potential water quality issue if this nutrient diffuses from the sediments under low oxygen conditions and fertilizes the overlying water column. In a recent publication[28], Hudson and crew have also shown that a slight warming of the reservoir (i.e., from climate warming) may lead to an increase in microbial pathogens and this increase will likely result in frequent exceedances of provincial guidelines. Hudson and crew are currently coordinating a special journal issue on Lake Diefenbaker (of 12 to 15 papers) characteristerizing the poorly understood limnology of the reservoir. The special issue will be published in early 2015. Lorne Doig and team generated phosphorus release rates for Lake Diefenbaker sediments under well-oxygenated and anoxic conditions. These data are essential for understanding current and future phosphorus dynamics in this economically important reservoir, and have allowed Karl Lindernschmidt to develop the first dynamic water quality model of the reservoir. A special issue of Great Lakes Research is in press.

- In a recently published article in Nature Climate Change[29], Grant Ferguson showed that the coastal aquifers are more vulnerable to groundwater extraction than to predicted sea-level rise under a wide range of hydrogeologic conditions and population densities. Only aquifers with very low hydraulic gradients are more vulnerable to sea-level rise and these regions will be impacted by saltwater inundation before saltwater intrusion. Human water use is a key driver in the hydrology of coastal aquifers, and efforts to adapt to sea-level rise at the expense of better water management are misguided.
- Jeffrey McDonnell in his recently published article[30] reported that in some forested watershed systems, streams and trees appear to return different pools of water to the hydrosphere. Thus far, evidence for this has come exclusively from wet Mediterranean climates. New work is needed to test the hypothesis across different climates and vegetation regimes, especially places that contrast with the Mediterranean climates and forest types where two water worlds have been found. These include, but are not restricted to humid areas where plant water use and precipitation input are in phase, wetter zones where seasonality of precipitation is low, and drier zones where water stress is higher.
- Jill Johnstone and team published a study titled “The heat is on for black spruce in the northern boreal forest”[31]. In this study, they explored relationships between climate and tree-ring growth of black spruce, a tree that dominates cool and moist habitats in the boreal forests of North America. Approximately half of the trees measured in Alaska and Yukon Territory showed reduced growth in response to warm temperatures, even in when they grew in cooler north-facing slope or in moist valley bottoms. Widespread

[28] North et al. (2014). Relationship between water quality parameters and bacterial indicators in a large prairie reservoir: Lake Diefenbaker, Saskatchewan, Canada. Can. J. Microbiol. 60: 243-249.

[29] Ferguson and Gleeson. (2012). Vulnerability of coastal aquifers to groundwater use and climate change. Nature Climate Change, 2: 342-345. DOI: 10.1038/ncclimate1413.

[30] McDonnell. (2014). The two water worlds hypothesis: ecohydrological separation of water between streams and trees? WIREs Water 2014. doi: 10.1002/wat2.1027

[31] Walker and Johnstone. (2014). Widespread negative correlations between black spruce growth and temperature across topographic moisture gradients in the boreal forest. Environmental Research Letters, 9: 064016.

growth reduction of black spruce across a wide range of habitat types suggests that there is no "safe haven" for boreal forests to escape drought stress caused by climate warming.

- Razavi and Wheater conducted a study to understand the non-stationarity in climate and hydrology through tree-ring proxy records[32]. They investigated the time series of tree-ring chronologies that demonstrated significant correlations with streamflows, with the objective of identifying the spatiotemporal patterns and extents of non-stationarities in climate and hydrology, which are essentially representations of past "climate changes". Results confirm that stationarity has never existed in the hydrology of the region, as the statistical properties of annual paleo-hydrologic proxy records across the basin, i.e., the mean and autocorrelation structure, have consistently undergone significant changes (non-stationarities) at different points in the history of the region. The results demonstrate that the 89-year period of observational record in this region is a poor representation of the long-term properties of the hydrologic regime, and reinforce conclusions of earlier work that 21st century droughts were less severe than those in the palaeo-record. .
- In another study, Razavi and Wheater explored: (1) the effect of temporal scaling on the strength of the relationship between the hydrologic variables and tree growth rates, and (2) the reconstruction uncertainty due to the dissimilarity or inconsistency between different tree-ring chronologies in a basin[33]. Based on the insight gained, a methodology was developed to generate an ensemble of paleo-hydrology reconstructions on a multi-year time scale. It was shown that such ensemble reconstructions preserve the long-term variability (Hurst behaviour) of hydrologic variables. They more credibly pinpoint the timing and extent of past dry and wet periods and provide a dynamic range of uncertainty in reconstruction.
- In a recently pair of published papers, Howard Wheater and Alireza Nazemi argued that during the current "Anthropocene", the human interventions manifested through water resource management are significant and should be included in large-scale models for simulating regional and global water availability and climate[34, 35]. The authors critically review current state-of-the-art models, highlight gaps and opportunities towards improved modeling and propose a framework to move this agenda forward through a global initiative.
- Amin Elshorbagy and team published the first simulation-based integrated water resources model for the Saskatchewan portion of the Saskatchewan River Basin[36]. This

[32] Razavi and Wheater. (2014). Towards understanding non-stationarity in climate and hydrology through tree-ring proxy records. Water Resources Research (in review).

[33] Razavi and Wheater. (2014). Time scale effect and uncertainty in reconstruction of paleo-hydrology. Journal of Hydrology (in review).

[34] Nazemi and Wheater. (2014). On inclusion of water resource management in Earth System models – Part 1: Problem definition and representation of water demand, Hydrol. Earth Syst. Sci. Discuss., 11: 8239-8298. Doi:10.5194/hessd-11-8239-2014.

[35] Nazemi and Wheater. (2014). Assessing the Vulnerability of Water Supply to Changing Streamflow Conditions. Eos Trans. AGU, 95(32): 288. DOI: 10.1002/2014EO320007.

[36] Hassanzadeh, E., Elshorbagy, A., Wheater, H., and Gober, P. 2014. Managing water in complex systems: An integrated water resources model for Saskatchewan, Canada. Journal Environmental Modelling & Software, 58: 12 - 26. DOI: 10.1016/j.envsoft.2014.03.015.

hydro-economic model, named SWAMP, allows for investigating the long term tradeoffs of various water resources management options in Saskatchewan, and thus, developing adaptive management to cope with continuously changing environment.

- Karl-Erich Lindenschmidt published a study, in collaboration with Jeff Sereda from the Saskatchewan Water Security Agency, on the impacts of prolific macrophytic growth on the ice-cover formation along the Qu'Appelle River[37]. The river is an important conduit for water supply in southern Saskatchewan and recommendations were laid on for the operations of the river's discharge regulation during winter were made. Karl-Erich Lindenschmidt also explored the processes leading to the formation of air pockets along the Slave River which can have grave implications for winter travel on the ice cover to local trap lines and fishing areas[38]. The phenomenon has never be published before and it is hoped that the dangers posed by air pockets to local community members receives more attention nationally and internationally.
- Bob Patrick in the Department of Geography and Planning in cooperation with Technical Services Alberta Group developed source water protection guidance document and template for the First Nations sponsored by the Aboriginal Affairs and Northern Development Canada (AANDC). This template was piloted in Siksika First Nation in 2013. Since then 2 other plans have been developed as community-based projects: one with Frog Lake First Nation the second with Muskowekwan First Nation with Geography and Planning grad student Kellie Grant. The plan now is to continue watershed planning and source water protection work in the Saskatchewan River Basin in the next year in cooperation with the community and GIWS. In addition, in the area of source water protection, Bob Patrick and his graduate student Hanyang Wang identified a series of factors that serve to both facilitate and constrain source water protection plan implementation in the South Sask River Watershed. These factors are likely present across all watershed plans in Saskatchewan and thus demand the attention of policy makers.
- GIWS's modeling group has established a strong collaboration with Hydro-meteorology group at National Center for Atmospheric Research (NCAR). For example, Yanping Li's team at GIWS is heavily involved to the Continental scale Regional Climate modeling using 4-km WRF, which covers both Continental US and Southern Canada, using NCAR's supercomputers.
- Collaborating with other Canadian atmospheric scientists in EC Toronto EC King City, EC Edmonton, Professors from Univ of Manitoba, UQAM, etc, Yanping Li's team at GIWS have been intensely evolved in the analysis of the June 2013 Alberta flooding event, and have finished the paper (to be submitted) entitled "The June 2013 Alberta Catastrophic Flooding: Water vapor transport analysis by WRF simulation". Yanping Li's team has also been working intensively on land surface-atmosphere interfaces and interactions using coupled regional climate and land-surface models. One of the ongoing projects is the calibration of the land-surface model Noah-MP for the Canadian Prairies using

[37] Lindenschmidt, K.-E. and Sereda, J. (2014) The impact of macrophytes on winter flows along the Upper Qu'Appelle River. Canadian Water Resources Journal 39(3): 342-355.

[38] Das, A., Kells, J., Slave River Delta Partnership and Lindenschmidt, K.-E. (in review) The formation of pockets and layers of compressed air under the ice cover of the Slave River. Canadian Journal of Civil Engineering.

observations from Boreal Ecosystem Research and Monitoring Sites (BERMS) and Prairie Hydro-Ecological Research Sites (Brightwater Creek and St. Denis National Wildlife Area).

- As part of the NSERC Collaborative Research and Development grant with Syncrude, John Giesy's group has established a predictive model that is accurate within a factor of 2 to predict acute lethality of oil-sands affected process water. The method relies upon use of new ultrahigh resolution linear trap mass spectrometer (orbitrap) that allows to identify essentially all of the 250,000 organic compounds in the mixture and obtain their accurate mass. From this the group has derived the mole fractions of individual compounds for which they have derived bioconcentration factors and then by using a target lipid model are able to predict toxicity. This information was necessary for the government to be able to monitor for releases of effluents from the oil sand development and be able to set standards to protect the aquatic environment.
- Patricia Gober's current research deals with these comparative and synthetic issues of how to make water decisions in exceptionally complex and uncertain decision environments. A recently published chapter in the Geological Society of London[39] uses examples from Alberta and Arizona to demonstrate the challenges of uncertainty for water planning and policy. Her research group at ASU has extended its deep knowledge about Phoenix to assess vulnerability to heat stress in Chicago[40] and water shortage in Portland[41].
- A 'catalogue' of the stable isotopes of water for all mine site waters (including sand and fine tailings, shale overburden, recycle water, fresh process water) has been established for Syncrude's Mildred Lake oil sands mine site along with the first Local Meteoric Water Line (LMWL) for the oil sands region through the work of M.Sc. student, Thomas Baer. Thomas was supervised by Lee Barbour.
- A numerical model of water balance from a reclamation soil cover placed over shale overburden at Syncrude's Mildred Lake mine site has been calibrated to nearly 10 years of monitoring data by Lee Barbour's team, in collaboration with Sean Carey at McMaster. This model has then been used to characterize the impact of increasing cover thickness on soil water storage, transpiration rates, and water release to adjacent wetlands for reclaimed oil sands covers over 60 years of climate data. The results have highlighted that increasing cover thickness has a limited impact on increasing

[39] Patricia Gober, Dave D. White, Ray Quay, David A. Sampson, and Craig W. Kirkwood (2014) Socio-hydrology modelling for an uncertain future, with examples from the USA and Canada. In *Integrated Environmental Modelling to Solve Real World Problems: Methods, Vision and Challenges*, Geological Society, London, Special Publications, 408, eds. A.T. Riddick, H. Kessler and J.R.A. Giles. London: Geological Society, doi.org/10.1144/SP408.2. (PUBLISHED)

[40] Chuang, Wen-Ching, Patricia Gober, Winston T. L. Chow, and Jay Golden (2013) Sensitivity to heat: A comparative study of Phoenix, Arizona and Chicago, Illinois (2003-2006). Urban Climate, 5: 1-18.

[41] Kelli Larson*, Colin Polsky, Patricia Gober, Heejun Chang, and Vivek Shandas. 2013. Vulnerability of water systems to the effects of climate change and urbanization: A comparison of Phoenix, Arizona and Portland, Oregon (USA). Environmental Management 52(1): 179-195.

transpiration rates once an optimal cover thickness is reached but can drastically decrease the frequency and magnitude of water release to adjacent wetlands[42].

[42] Huang, Barbour and Carey. (2014). The impact of reclamation cover depth on the performance of reclaimed shale overburden at an oil sands mine in Northern Alberta, Canada. Hydrological Process, Special Issue Canadian Geophysical Union 2014, March (in review).

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