Global Water Futures

Annual Progress Report 2018-2019

UNIVERSITY OF SASKATCHEWAN | www.globalwaterfutures.ca

Operations Team Meeting, January 21-23, 2019
Photo Courtesy: Daniel Hallen, Specialist, Research Profile and Impact

GRAND CHALLENGE

How can we best prepare for and manage water futures in the face of dramatically increasing risks?

OUR MISSION

- **Improve disaster warning** – develop scientific knowledge, monitoring and modelling technologies, and national forecasting capacity to predict the risk and severity of extreme events
- **Predict water futures** – use Big Data to make informed decisions, better models to assess change in human/natural land and water systems
- **Inform adaptation to change and risk management** – propose governance mechanisms, management strategies, and policy tools to reduce the risk of water threats, design adaptive strategies, and enhance economic opportunities

DIRECTOR'S MESSAGE

Dear GWF investigators, researchers, students, partners, stakeholders and other friends:

Dr. John Pomeroy speaking at the Water Security for Canadians Workshop in Ottawa

As another year with exceptionally extreme impacts of climate change and developmental impacts on water occurs in Canada and around the world, it is a good time to take stock of recent accomplishments in Global Water Futures (GWF) and our plans for the future. The tremendous skill, excitement, determination and drive of GWF researchers is certainly needed as Canada and the world grapple with a global water crisis that is unprecedented in the existence of humanity. Addressing this crisis means that we need to solve water problems using novel approaches that draw upon both western science and traditional knowledge of water. To this end, GWF has approved six new Indigenous community water research projects, each of which was co-created and is co-led by an Indigenous community Co-Principal Investigator and a GWF university Co-Principal Investigator. The review process and criteria for these projects were co-created with Indigenous communities from across Canada. So now, GWF has 39 science projects and six core teams off and running. The scientific production is astonishing as you will see in the material that follows. There are also several new Affiliated Projects that have been approved which brings greater strength and diversity to the GWF effort and are warmly welcomed.

GWF has three formal seminar series as well as ad hoc seminars at the four partner universities – they are videoed and made available to the broader GWF community. The *Distinguished Lecture Series* is held from September to November. The *Women and Water Lecture Series* occurs from December to April. The new Women and Water Lecture Series is particularly excellent and highlights some of the best water research from GWF and abroad whilst providing a forum for exploring how to further advance the role of women as scientists and in science. Both of these series are recorded and broadcast live to all GWF researchers. The *Knowledge Mobilisation Webinar Series* runs between October and April and shares examples of successful initiatives in action, and discusses and troubleshoots common challenges that arise in KM across GWF.

GWF established and funds a the GWF Young Professionals group to stimulate the interaction, inclusion and participation of young professionals and early career researchers in activities that represent and pursue the interests of the YP community within the broader scientific landscape of GWF. There are four chapters, one at each of the four partner universities. The GWF YP

have enriched GWF considerably with their energy and new ideas and truly embody our water futures.

In November 2018, GWF and NRCan organized a substantial national meeting of 65 water scientists and managers in Ottawa. The meeting was hosted by NRCan and included senior science representation from Environment and Climate Change Canada, Statistics Canada and Agriculture and Agrifood Canada. The meeting evaluated how GWF and federal science departments can better coordinate their water research to promote more effective national water security research and development. A highlight of the meeting was the signing of an MOU between GWF and NRCan that forms a framework for cooperation in collaborative investigations and scientific exchanges to support water futures research.

The month of February 2019 saw great accomplishments from the GWF Core Forecasting and Modelling Team led by Dr. Alain Pietroniro. Global Water Futures was able to join with Environment and Climate Change Canada and NSERC's FloodNet in convening a history-making 1st National Workshop on Flow Forecasting. The Vancouver workshop included presentations by streamflow forecasters from every Canadian province and territory and many from industry as well as those from Environment and Climate Change Canada and the Core Forecasting and Modelling Team and the IMPC project of GWF. Workshop participants found advantages to pooling information products and resources for a Canada-wide community of practice to support forecasting and linking provinces, federal government and universities to help coordinate and develop this. GWF is committed to enhancing models for forecasting systems and is looking to strengthen partnerships to test and implement these systems for the provinces, industry and ECCC. With such a positive and cooperative approach we should all be able to work together to further improve flow forecasting in Canada, even as the stresses of extremes associated with climate change make this more challenging.

On March 22, 2019, GWF helped to organize World Water Day events in Saskatoon, Waterloo, Hamilton and Canmore to celebrate the start of the seasonal acceleration of the hydrological cycle and to review the activity at our partner institutions.

GWF partnered with the Forum for Leadership on Water, the Centre for Indigenous Environmental Resources, the POLIS Program on Ecological Governance and the UN University to convene a national discussion on water security at the Rideau Club in Ottawa on April 11th – Water Security for Canadians: Solutions for Canada's Water Crisis. This event brought together water and climate scientists, policy experts, legislators, and water decision rightsholders and stakeholders. Panelists discussed the scientific evidence of the worsening water sustainability and climate-related water crisis in Canada, and the science and policy solutions needed to adapt to the new climate and water realities across the country. The discussion explored how to create a better, safer and more secure water world for ourselves and for our children, while positioning Canada as an international leader in global water security.

International engagement and recognition for GWF continues to increase. GWF is now a Regional Hydroclimate Project of the Global Energy and Water Exchanges project (GEWEX) of the World Climate Research Programme in Washington, DC. We hosted the GEWEX Open Science Meeting in Canada for the first time in May 2018. International linkages to mountain research has been delivered by the GWF-managed International Network of Alpine Research Catchment Hydrology http://www.usask.ca/inarch/, a cross-cutting project of GEWEX with which a joint meeting was held in Santiago, Chile over 24-26 October 2018. A Memorandum of Understanding has been signed that will strengthen both Canada and China's commitment to managing freshwater resources globally in a time of rapid climate change. The partnership involves GWF and the Chinese Academy of Sciences' Third Pole Environment (TPE) program.

The GWF 2nd Annual Open Science Meeting in May in Saskatoon was a great success with over 600 attendees, making it the largest water science meeting in Canadian history. Part of that meeting was at the spectacular and historic Wanuskewin Heritage Park where we had talks on Indigenous water issues and engaged in cultural learning activities. Three keynotes from USA, UK and Germany on water and climate, ecosystems and water quality, and human dimensions, keynote talks from Chief Bobby Cameron of the Federation of Sovereign Indigenous Nations, President David Grimes of the World Meteorological Organisation, and Scott White, editor of *The Conversation* and a public talk by Professor Helen Baulch on Prairie water issues and challenges provided excellent, high level plenary sessions for the meeting. There were superbly run parallel sessions, poster sessions, lightening talks and opportunities for networking that showed the great advances being made in GWF, especially by our young professionals.

Coming up this year will be calls for new Pillars 1 and 2 projects and renewal of Pillar 3 projects as well as assessment and renewal of our core teams. An important initiative was the decision by the Strategic Management Committee to internationalize GWF's modelling capabilities with a GWF Planetary Freshwater Prediction program.

It is an honour to be involved with such talented and brilliant scientists and to have such superb administrative support that keeps GWF running. All the best to each of you and "keep going". We are on the right track and we can make our own water future for the world.

Yours Truly,

Professor John Pomeroy, FRSC
Canada Research Chair in Water Resources and Climate Change
Director, Global Water Futures Program

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EXECUTIVE SUMMARY

The University of Saskatchewan leads GWF in partnership with University of Waterloo, McMaster University and Wilfrid Laurier University. The GWF research program is funded in part by a $77.8-million grant (initial total program budget is $143.7 million) from the Canada First Research Excellence Fund (2016-2023). The overarching goal of the program is to deliver risk management solutions - informed by leading-edge water science and supported by innovative decision-making tools - to manage water futures in Canada and other cold regions where global warming is changing landscapes, ecosystems, and the water environment. GWF aims to position Canada as a global leader in water science for cold regions and addresses the strategic needs of the Canadian economy in adapting to change and managing risks of uncertain water futures and extreme events. End-user needs are critical inputs to drive strategy and shape GWF science.

End-user needs are our beacon, drive our strategy and shape our science as we focus on three main goals:

- Deliver new capability for providing disaster warning to governments, communities and the public, including Canada's first national flood forecasting and seasonal flow forecasting systems, new drought warning capability, and water quality models and monitoring that warn of hazards to health and drinking water supply;
- Diagnose and predict water futures to deliver improved scenario forecasting of changing climate, landscape and water for the future, with information outputs tailored to the needs of users. This will enable us, for example, to assess risks to human health from changing flood, drought and water quality; and
- Develop new models, tools and approaches to manage water-related risks to multiple sectors, integrating natural sciences, engineering, social and health sciences to deliver transformative decision-making tools for evidence-based responses to the world's changing cold regions. New models will define changing risk from floods and drought, and allow end-users to plan sustainable infrastructure investment to manage future risk.

The transdisciplinary structure of GWF ensures breaking down the traditional disciplinary and institutional barriers to ensure a holistic approach to what are inevitably comprehensive and complex water problems. The philosophy has been to establish a strong regional and topical research bases and then expand nationally and grow globally. Throughout the program, the principles of equity, diversity and inclusion has been primarily considered. As a network, in addition to achieving the mission to improve disaster warning, predict water futures, and inform adaptation to change and risk management, we are aiming to be known for engagement of Indigenous Communities in co-developing water research. Additional information is available at: https://www.globalwaterfutures.ca/

GWF through its international peer-review and competitive process has now funded a total of 39 pan-Canada projects, including 21 transformative science projects, 12 transdisciplinary projects

and 6 Indigenous community co-led water research projects. The transdisciplinary projects are contributing to a better understanding of storms, floods and droughts, how to better measure and manage the quality of source waters, how deep groundwater is affected by the surface, how to improve water governance and even how to encourage global water citizenship. The transformative projects include protecting prairie agricultural lands from drought and floods, mitigating algae blooms in lakes, developing new monitoring systems for Canadian watersheds using drones and satellites, using environmental DNA to assess ecosystem health, understanding the impact that changes to mountain snowpacks and glaciers will have on drinking water, and co-creating Indigenous water-quality tools with First Nations. Finally, the Indigenous community co-led projects are advancing understanding of traditional knowledge and western knowledge indicators and working together to research and aid in water governance, food security, sediment restoration, water security, climate change and human and ecosystem health in Indigenous communities.

Currently, the GWF network involves more than 356 stakeholders/users, 165 researchers from 15 Canadian universities and 563 research personnel, who are associated with 39 pan-Canada projects, and six core teams including modelling and forecasting, computer science, knowledge mobilization, data and technical teams. In addition, researchers are working with international organizations such as UNESCO, the World Climate Research Program, World Meteorological Organization, and Future Earth, to develop the tools and models to mitigate water disasters, protect the environment and take advantage of economic opportunities.

The reporting year has been very productive and GWF seen significant technical and scientific advancements coming out its funded projects and core team (see Section 10 of the report). Particularly, GWF in collaboration with the Environment and Climate Change Canada (ECCC) organized the first ever national workshop on flow forecasting on February 20-21, 2019, which was attended by forecasters from all 10 Provinces and 3 Territories, and major hydropower utilities including BC Hydro, Manitoba Hydro, and ON Power Generation. The purpose of the workshop was to coordinate GWF and ECCC prediction efforts with those of the provinces and territories and also have open discussions on issues and needs. In addition, GWF convened a national discussion on the future of water security in Canada on April 11, 2019 in Ottawa, ON. This event brought together more than 80 water and climate scientists, policy experts, legislators, and water decision rightsholders and stakeholders.

GWF has established a strong research base in Canada and is now planning to expand globally as we develop international projects in alignment with the GWF mission and availability of external funds.

One of the legacies of GWF will be its young professionals including graduate students and postdoctoral fellows. The first Global Water Futures - Young Professionals (GWF-YP) Executive Team formed shortly before the inaugural GWF Annual Science Meeting in May 2018. The team was made up of four chapter chairs - one from each GWF partner university - and a representative from CYHS. Holly Annand, Erin Nicholls, Cory Wallace, Samina Hayat, and Caroline Aubry-Wake

represented the University of Saskatchewan, McMaster University, Wilfrid Laurier University, University of Waterloo, and CYHS, respectively. GWF-YP hosted a professional development workshop and two social events at the 2018 Annual Science Meeting thanks to many volunteers from McMaster University. GWF-YP launched @gwf_yp twitter account in May 2018. The account now has over 300 tweets and followers. Twitter activity featured highlights from YP events, GWF workshop info, retweets of relevant news in Canadian hydrology, a twitter takeover during AGU, and the #YPSpotlight each week starting in November.

GWF by the Numbers

GWF has implemented a performance timeline to ensure that our program commitments are met and to track progress. This timeline focusses on three specific years, Year 0, Year 4 and Year 7. The 39 projects and 6 core teams have operated for less than a year in some cases and are just starting to produce scientific outcomes. Therefore, we expect a lag in program outcomes, which will result in not meeting target values for all performance indicators in 2018-2019. These are expected to be met later in 2019.

Currently, GWF has 563 highly qualified personnel (39 projects and core team personnel), including 95 undergraduate students, 139 master's students, 128 doctoral students, 73 postdoctoral fellows, 34 professional research associates, 18 research scientists, 46 technicians, and 5 visiting fellows/professors. These personnel are actively supervised by 157 researchers from 15 Canadian Universities.

This past year, Global Water Futures members published 314 peer-reviewed journal articles (cumulative 422), delivered 607 conferences presentations (cumulative 809), delivered 192 invited, plenary and keynote lectures (cumulative 309), published 6 books and book chapters (cumulative 09), and published 54 non-refereed articles and data that were related to their GWF research (cumulative 67). In addition, 44 graduate and undergraduate theses were completed during this period (cumulative 58). This is a remarkable dissemination of scientific information across Canada and the world and shows early leadership through invited and keynote presentations.

GWF needs substantial funding to grow and develop the program in order to meet our aspirations for international leadership. Funding from national and international governments, industries, communities and non-governmental organizations has assisted in attracting and attaining top international researchers and has allowed the growth of research facilities and programs. As of March 31, 2019, GWF *has leveraged $154.5 million in cash and formal in-kind contributions from the four partner universities and other public sector, NGO and industry partners to supplement its $77.84 million grant from CFREF. That is further enhanced by an additional $27 million in tri-agency, CFI and other research funding, providing total resources to support research in excess of $259 million.*

GWF has implemented a performance measurement plan to ensure that program commitments are met and to track the progression of the program. The performance indicators are broadly categorized under evidence of global research excellence, attracting and retaining the best and brightest talent, and ability to mobilize knowledge for the benefit of society and the economy.

Global Research Excellence	**2018 - 2019**	**Year 4 (2019-2020)**	**Year 7 (2022-2023)**	**Below/ Meeting/ Exceeding**
Number of international research programs and committee where GWF members are lead investigators and/or advisors. (see *Appendix D* for complete list)	56	4	10	Exceeding
Number of prestigious international, national and institutional awards, recognitions from professional societies, and national scholarships and fellowships. (cumulative number; see *Appendix E* for complete list for 2018-19)	208	100	200	Exceeding
Global leader in science impact - quality of research – rank in h-index (as per Web of Science on June 14, 2019 over last 5 years)	4	2	1	Meeting
Global leader in science dissemination – rank in number of peer reviewed journal articles and total citations (see *Appendix F* for complete list of publications; as per Web of Science on June 14, 2019 over last 5 years)	1	1	1	Exceeding
Number of presentations at international and national conferences (see *Appendix F* for complete list of publications)	607	500	1000	Exceeding
Number of international and national plenary, key note and invited speaking engagements (see *Appendix F* for complete list of publications)	192	130	200	Exceeding
Number of international visiting fellows (cumulative number; see *Appendix C* for complete list; the list for 2017-18 is available in previous report)	14	120	200	Below
Number of international joint faculty appointments (see *Appendix G* for complete list of publications)	26	50	100	Meeting
Level of cash and in-kind research funding brought by GWF Projects from national and international governments, industries, communities, and non-governmental organizations (see *Appendix H* for complete list of funding)	$259M	$250M	$450M	Exceeding
Attracting and Retaining the Best and Brightest Talent	**2018 - 2019**	**Year 4 (2019-2020)**	**Year 7 (2022-2023)**	**Below/ Meeting/ Exceeding**
Number of faculty recruited in the top 5% of peer group	11	16	30	Exceeding
% of GWF graduate students and PDFs holding major financial awards (see *Appendix E* for complete list)	21%	25%	35%	Meeting

Participation in skills-based short-courses and transdisciplinary boot camp (cumulative, see *Appendix I* for complete list)	186	250	500	Meeting
Cross-institutional and user training opportunities, leadership workshops, and special seminars (cumulative list; see *Appendix I* for complete list)	234	250	500	Exceeding
Number of short-courses for early career researchers (cumulative, see *Appendix I* for complete list)	37	12	20	Exceeding
Assignment of GWF mentors to early-career researchers (PDFs, research scientists and faculty <10y post PhD)	100%	100%	100%	Meeting
Ability to Mobilize Knowledge for the Benefit of Society and the Economy	**2018 - 2019**	**Year 4 (2019-2020)**	**Year 7 (2022-2023)**	**Below/ Meeting/ Exceeding**
Number of end users and partners linked to the program and engaged in the research process (see *Appendix J* for complete list)	356	300	500	Exceeding
Number of patent disclosures, licenses to industry, spin-off companies	0	300	500	Below
Number of policy briefs and meetings with governments (cumulative, see *Appendix K* for complete list)	83	20	50	Exceeding
Number of jobs created (see *Appendices A and B* for complete list)	563	450	850	Exceeding
Access of user tools (cumulative, see *Appendix K* for complete list)	19	20	50	Meeting
Hits to YouTube videos (see *Appendix K* for complete list)	69,670	10,000	100,000	Exceeding
Number of communities engaged in citizen science and public outreach (cumulative, see *Appendix K* for complete list)	116	100	500	Exceeding

GLOBAL WATER FUTURES: SOLUTIONS TO WATER THREATS IN AN ERA OF GLOBAL CHANGE

Annual Progress Report – April 1, 2018 to March 31, 2019

1. Global Water Futures

1.1 Introduction

The University of Saskatchewan leads GWF in partnership with University of Waterloo, McMaster University and Wilfrid Laurier University. The GWF research program is funded in part by a $77.8-million grant from the Canada First Research Excellence Fund (2016-2023). The overarching goal of the program is to deliver risk management solutions - informed by leading-edge water science and supported by innovative decision-making tools - to manage water futures in Canada and other cold regions where global warming is changing landscapes, ecosystems, and the water environment. GWF aims to position Canada as a global leader in water science for cold regions and addresses the strategic needs of the Canadian economy in adapting to change and managing risks of uncertain water futures and extreme events. End-user needs are critical inputs to drive strategy and shape GWF science.

Currently, the GWF network involves more than 335 stakeholders/ users, 162 researchers from 15 Canadian universities and 496 research personnel associate with 39 pan-Canada projects, and core teams including modelling and forecasting, computer science, knowledge mobilization, data and technical teams. Additional information is available at: https://www.globalwaterfutures.ca/

USask

Waterloo

McMaster

Wilfrid Laurier

GWF focuses on major river basins and key ecological, climatological, and physiographic regions across Canada (Figure 1), which are representative of the scientific and societal issues faced globally, and especially within "cold regions". Cold regions are dominated by cold water processes including snow, ice, and frozen soils, and it is here where Canada as a whole is an exemplar and can have global impact. Canadian landscapes, ecosystems and the water environment are at the forefront of climate change. River basins are challenged by increasing water demands, high nutrient loads, warming temperatures, altered patterns of rainfall, snowfall, snowmelt and freeze-thaw cycling, glacier loss and permafrost thaw, and changes in river flow regimes. These changes have increased the severity and frequency of extreme events,

leading Canada to experience catastrophic natural disasters in recent years; the 2013 Alberta floods, 2013 Toronto flood, 2016 Fort McMurray wildfire, and 2001-2004 Prairie droughts caused damages exceeding $20B. Northwestern Canada is one of the most rapidly warming regions on Earth. The scale and rapidity of recently observed warming-induced changes throughout this region indicate that it is particularly sensitive to climate warming and capable of rapid responses to perturbations. Systematic warming and crysopheric responses are leading to major landscape changes, including conversion of forests to wetlands, lakes to thaw lake basins, tundra to shrub vegetation, and changing the distribution and routing of water over the landscape, which confounds the prediction of eco-hydrological responses to combined warming and changes in precipitation regimes.

Figure 1. Map of the GWF geographic study domain across Canada and parts of the United States of America.

In addition to global warming-induced changes, human interventions have significantly affected Canada's river basins. Infrastructure developments such as dams, diversions, and irrigation networks, along with industrialization and urbanization, have altered the natural water-cycle.

Pollution from population growth, industrialization, and agriculture has degraded water quality in many regions. The implications of human-driven changes and their interactions with the natural environment, have not been adequately understood and characterized, however. Canada possesses a huge number of lakes, both large and small, that play a crucial role in water supply, food production, resource extraction, hydropower generation, transportation, recreation, biodiversity, and climate regulation. However, despite such water wealth, climate change, agricultural intensification, shoreline development and urbanization are exerting mounting pressures on the health and ecosystem services of lakes, and their associated social and economic benefits. In the North, resource exploration and production is expected to expand dramatically in the coming years, which will include construction of new highways, pipelines and other infrastructure.

The GWF geographic domain includes five major regions (Figure 1): 1) the Great Lakes and St. Lawrence in eastern Canada and the Maritimes (including the Saint John Basin), ii) the prairies in central and western Canada (western Nelson River Basin), iii) the Boreal Forest across much of northern Canada (northern St. Lawrence, eastern Nelson, Churchill, and southeastern Mackenzie Basins), iv) the western Cordillera from the U.S. Pacific northwest up to the Sub-Arctic Mountains of the Yukon and Alaska (Columbia, Fraser, and Yukon Basins, and the headwaters of the Nelson and Mackenzie Rivers), and v) the Sub-Arctic Taiga, Tundra, and southern Arctic in the North (northern Mackenzie Basin). This vast domain includes large lakes and an E-W as well as N-S transect from temperate-humid to semi-arid to mountain glaciated to boreal and then polar climates. Each of the individual regions feature unique aspects in terms of the environmental and societal challenges faced, while some issues span multiple regions (e.g. agriculture, urbanization, etc.), and others span all regions (e.g. water management, governance, policy, etc.). Further, the boundaries between regions are generally indistinct and in some cases shifting, with northward movement of the prairie–boreal forest transition due to natural and human disturbance, and expansion of shrub tundra in the North, for example.

1.2 Scientific Strategy

Climate warming and human actions are altering precipitation patterns, reducing snow levels, accelerating glacier melting, intensifying floods, and increasing risk of droughts, while pollution from population growth and industrialization is degrading water systems. With such unprecedented change, it is clear that the historical patterns of water availability are no longer a reliable guide for the future. Adaptation to these changes will require *new science* to understand the changing earth system (changing climate, land, water and ecosystems and their interactions); *new modeling tools* that precisely capture these interconnected forces and their societal implications; *new monitoring systems* with greater capacity to warn of critical environmental changes; and *more effective mechanisms to translate new scientific knowledge into societal*

action. This translates into the grand challenge for water science in Canada and globally: "How can we best prepare for and manage water futures in the face of dramatically increasing risks?"

Critical needs for addressing this grand challenge include: (A) *Improved disaster warning*. Currently, we lack the scientific knowledge, monitoring and modeling technologies, and national forecasting capacity to predict the risk and severity of potentially catastrophic events in Canada. These knowledge gaps and technology barriers have resulted in significant loss of life and property in recent years. (B) *Predicting water futures.* The world lacks water data on a scale to make informed decisions, and we cannot forecast future climate impacts without better models to assess changes in our human/natural land and water systems. These limitations create risks for water supplies, water quality and sustainability. (C) *Adapting to change and managing risk*. Nationally and globally, we lack the governance mechanisms, management strategies, and policy tools needed to reduce the risk of water threats, design adaptive strategies to cope with uncertainty, and take advantage of economic opportunities that arise as change unfolds.

GWF will achieve this through three interrelated pillars of activity (Figure 2).

- ***Pillar 1:*** Diagnosing and Predicting Change in Cold Regions will deliver transformative, transdisciplinary science on an unparalleled global scale across water, land and air and at the human-water interface. Informed by user needs, this comprehensive scientific approach will lead to a more complete understanding of our ecosystems and provide the necessary data that underpin cutting-edge technologies and forecasting models.
- ***Pillar 2:*** Decision Support Systems will create new water, snow and land sensing and modelling systems and deploy them across living laboratories in nature. These systems will feed in to our science, dramatically raise our observational power to unmatched levels and lead to the generation of the 'Big Data' required to uncover key insights and support user needs.
- ***Pillar 3:*** Designing User Solutions will work with our communities of users to translate decision support systems into user-friendly solutions providing stakeholders with warning systems for impeding climate disasters, predictable water futures for planning and evidence-based decision support for optimal economic and health choices for populations.

Figure 2: GWF Activity Pillars

2. Transformative and Transdisciplinary Science

2.1 Pillars 1-2 Transformative Science, Big Data and Decision Tools

A seven year $10-million science budget was created to support transformative research in advancing GWF capabilities. An open request for proposals was issued, which was followed by a careful review of the proposals by the Strategic Management Committee (SMC), in conjunction with comments and advice from international peer reviewers, 14 projects were approved, with a budget of $5.8 million. In addition to these projects, 7 smaller pilot and studentship projects were funded for a total of 21 projects with funding of $6.6 million.

These new 21 projects are delivering on two key areas: transformative science to help us understand, diagnose and predict change, and developing new decision support systems using new sensors, analytical procedures, and computer models. These projects are complementing the user-question led Pillar 3 projects (see Section 2.2), and contributing to a better understanding of snow and rain storms, floods and droughts, how to better measure and manage the quality of source waters, how deep groundwater is affected by the surface, how to improve water governance and even how to encourage global water citizenship. The list approved projects is as follows [Website]:

1. Southern Forests Water Futures, **Altaf Arain**, McMaster University
2. Proof of Concept for Agent Based Modeling as a Tool to Investigate Comprehensive Indigenous Health Impacts of Flooding, **Lalita Bharadwaj**, University of Saskatchewan
3. Linking Water Governance in Canada to Global Economic, Social and Political Drivers, **Rob de Loe**, University of Waterloo
4. Old Meets New: Subsurface Hydrogeological Connectivity and Groundwater Protection, **Grant Ferguson**, University of Saskatchewan
5. Omic' and Chemical Fingerprinting Methodologies using Ultrahigh-resolution Mass Spectrometry for Geochemistry and Healthy Waters, **Paul Jones**, University of Saskatchewan
6. Evaluation of Ice Models in Large Lakes using Three Dimensional Coupled Hydrodynamic-Ice Models, **Kevin Lamb**, University of Waterloo
7. Short-duration Extreme Precipitation in Future Climate, **Yanping Li**, University of Saskatchewan
8. Prairie Drainage Governance, **Philip Loring**, University of Saskatchewan
9. Linking Stream Network Process Models to Robust Data Management Systems for the Purpose of Land-use Decision Support, **Bruce MacVicar**, University of Waterloo
10. Winter Soil Processes in Transition, **Fereidoun Rezanezhad**, University of Waterloo
11. Global Water Citizenship - Integrating Networked Citizens, Scientists and Local Decision Makers, **Colin Robertson**, Wilfrid Laurier University

12. Sensors and Sensing Systems for Water Quality Monitoring, **Ravi Selvaganapathy**, McMaster University
13. Linking Multiple Stressors to Adverse Ecological Responses Across Watersheds, **Mark Servos**, University of Waterloo
14. Crowdsourcing Water Science**, Graham Strickert**, University of Saskatchewan
15. Storms and Precipitation Across the continental Divide Experiment (SPADE), **Julie Theriault**, University of Quebec at Montreal
16. SAMMS: Sub-Arctic Metal Mobility Study, **Brent Wolfe**, Wilfrid Laurier University
17. Adaptation Governance and Policy Changes in Relation to a Changing Moisture Regime Across the Southern Boreal Forest, **Colin Laroque**, University of Saskatchewan
18. Significance of Groundwater Dynamics within Hydrologic Models, **Walter Illman**, University of Waterloo
19. Diagnosing and Mitigating Hydrologic Model Uncertainty in High Latitude Canadian Watersheds, **Tricia Stadnyk**, University of Manitoba
20. Hydrological Processes in Frozen Soils**, Andrew Ireson**, University of Saskatchewan
21. Improved Estimates of Wetland Evaporation**, Warren Helgason**, University of Saskatchewan

In total, 94 researchers from 10 Canadian universities are involved in collaboration with 37 partners including international institutions, government agencies, industry partners, non-governmental organizations, and Indigenous communities. These projects have hired 100 highly-qualified personnel. The projects are leveraging the GWF investment of $6.6 million with an additional $423,000 in cash and $3.2 million of in-kind contributions from partners.

2.2 Pillar 3 User Questions-Led Projects

The SMC allocated $28 million over seven years and envisioned funding trans-disciplinary proposals driven by user needs that could have a regional, river basin or pan-Canadian focus. A request for letters of intent (LOI) was issued, which resulted in receipt 33 LOIs. Subsequently, the LOIs were carefully reviewed by the SMC in conjunction with independent advice and recommendations from the International Science Advisory Panel (ISAP). The SMC accepted the ISAP's recommendations and consequently 14 LOIs were invited to submit full proposals for this round of funding. Given the quality of the LOIs, the GWF program has funded 12 initial research projects across Canada totaling nearly $16.9 million over the next three years (2017-2020) to tackle some of Canada's most pressing water-related challenges.

The funded projects research include protecting prairie agricultural lands from drought and floods, mitigating algae blooms in lakes, developing new monitoring systems for Canadian watersheds using drones and satellites, using environmental DNA to assess ecosystem health, understanding the impact that changes to mountain snow packs and glaciers will have on drinking water, and co-creating Indigenous water-quality tools with First Nations.

Four projects are led by the University of Saskatchewan, three by the University of Waterloo, three by McMaster University, one by Wilfrid Laurier University, and one is jointly led by the University of Manitoba and University of Victoria. The list of funded projects is as follows [Website]:

1. Climate-Related Precipitation Extremes, **Ronald Stewart**, University of Manitoba; **Francis Zwiers**, University of Victoria
2. Northern Water Futures, **Jennifer Baltzer** and **William Quinton**, Wilfrid Laurier University
3. Next Generation Solutions to Ensure Healthy Water Resources for Future Generations, **John Giesy**, University of Saskatchewan
4. Forecasting Tools and Mitigation Options for Diverse Bloom-Affected Lakes, **Helen Baulch**, University of Saskatchewan
5. Agricultural Water Futures, **Merrin Macrae**, University of Waterloo
6. Boreal Water Futures, **Mike Waddington**, McMaster University
7. Prairie Water, **Colin Whitfield**, University of Saskatchewan and **Chris Spence**, Environment and Climate Change Canada
8. Integrated Modelling Program for Canada, **Saman Razavi**, University of Saskatchewan
9. Mountain Water Futures, **Sean Carey**, McMaster University
10. Lake Futures – Enhancing Adaptive Capacity and Resilience of Lakes and their Watersheds, **Nandita Basu**, University of Waterloo
11. Transformative Sensor Technologies and Smart Watersheds for Canadian Water Futures, **Claude Duguay**, University of Waterloo
12. Co-creation of Indigenous Water Quality Tools, **Dawn Martin-Hill**, McMaster University

In total, 117 researchers from 15 Canadian universities are involved in the 12 projects. They are collaborating with 135 partners including international institutions, government agencies, industry partners, non-governmental organizations, and Indigenous communities. About 278 highly qualified personnel will be hired for the projects over the next three years.

The $16.9 million investment in the projects has leveraged another $26.4 million in cash from universities and partners, as well as $116.5 million in in-kind contributions from partners.

3. Indigenous Community Water Research Strategy & Projects

3.1 The Need for a Strategy

Indigenous Communities across Canada, and especially those located in the more northern latitudes and remote locations, have experienced profound change in the ways they coexisted with the land, waterways, and plant and animal life. The change is due to both climate and anthropogenic influences. Examples of significant changes include: reduction in snow cover (of up to 2 months – Figure 3a); permafrost thaw; and reduction in river ice cover (winter minimum temperatures have increased by 6.5°C – Figure 3b) – all these changes have affected the gathering of food, land access and winter transportation. Many of the natural resource extraction operations in northern latitudes have legacy issues resulting in degradation of source water quality affecting the communities living downstream of these activities. Moreover, lack of infrastructure and proper warning systems have resulted in reduced water treatment capacity and increased drinking water boil water advisories. Construction of dams on rivers have resulted in change in flow regimes which have affected the availability of fish, flood events, ice cover and sediment transport with impacts on local flora and fauna; and increase in flood, drought and wildfire events.

Figure 3a: 1-2 Month Decline in Snow Cover Duration

Figure 3b: Cold Regions Losing Cold (+6.5 degrees)

Working together to address these challenges may also address reconciliation, empowering community partners to design culturally appropriate and scientifically credible educational opportunities for youth.

Many challenges arise due to the vastness of the Canadian landscape and lack of data. Water is an important aspect of life and for indigenous people it is a critical part of their culture and in many cases their livelihoods depend on it. The human dimension of water is of strategic relevance to GWF and dedicated significant effort in addressing indigenous water security and social justice issues in Western and Northern Canada. Our efforts lay the foundation for co-creation of knowledge by incorporating traditional knowledge with western science; effective knowledge dissemination by respecting indigenous ways through oral tradition and through cultural expressions such as arts, crafts, and ceremonies and the cultivation, collection, and preparation of traditional foods; and making significant effort in ensuring sustainability of collaborative research efforts.

3.2 Co-Development of a Strategy

Over the last couple of years, the GWF program has reached out to numerous researchers, Indigenous community partners and other partners for advice on what water research GWF and

Indigenous communities can conduct together to help address the water issues experienced by Indigenous communities in Canada. Consequently, a workshop was organized in Saskatoon, SK on April 17-18, 2018, and involved 62 attendees including 31 Indigenous community representatives to promote further discussion and action on these research ideas through development of Indigenous community – university partnership projects that both meet Indigenous community needs and are in alignment with the GWF vision/mission. This workshop provided an opportunity for Indigenous community members and GWF academic researchers to co-develop a strategy for Indigenous community water research.

While many GWF researchers had existing relationships and research projects in progress with their Indigenous partners, the workshop provided the first in-person opportunity for everyone to come together from across the country.

The workshop included introductory presentations and working sessions aimed at identifying the funding opportunity from GWF, and co-designing expressions of interest and the proposal evaluation criteria of importance to research with Indigenous communities. The workshop was highly interactive with the discussions and working sessions focused on building on existing relationships, identifying new potential partnerships, identifying common research themes and community needs, co-designing proposal elements and evaluation criteria, and identifying leveraging opportunities with funding partners.

While sharing ideas and potential projects that were emerging, the following research themes were identified as key importance to research with and in Indigenous communities by the group, and which could be focus areas for collaboration and knowledge mobilization across projects (not an exhaustive list):

- Citizen science (capacity building; monitoring; data acquisition)
- Decision support and visualization (web of knowledge; data sharing; computer apps)
- Impacts of floods, droughts, climate change, forestry and water management on water flow
- Environmental flows (quantity; quality; habitat; sediment)
- Western and traditional science (overlap; differences; standing)
- Cultural strengthening as an outcome of research
- Water and health (linking environmental and human health and livelihoods)
- GIS and remote sensing tools (permafrost mapping; drones; autonomous sensors)
- Governance and policy (legislation; knowledge; sharing; decision-making impact)

In essence, the workshop started and concluded on very positive notes with a commitment to co-develop and evolve GWF's Strategy for Indigenous Community Water Research. It was agreed that this was a great beginning to new relationships and a new way of engagement between academic research and Indigenous communities that could be the foundation for the much

needed partnerships, knowledge, and capacity to address the water and climate issues affecting Indigenous communities across Canada. The primary outcome of the workshop was the development of the request for proposals for the expressions of interest. Subsequently, in consultation with three Academic Indigenous Advisors, the SMC funded 6 projects co-led by Indigenous Community leaders.

3.3 Co-Led Projects

Below we summarize some of the innovative projects with indigenous communities, to meet their needs and cultural values. These projects are advancing understanding of traditional knowledge and western knowledge indicators and working together to research and aid in water governance, food security, sediment restoration, water security, climate change and human and ecosystem health in Indigenous communities. The list of funded projects is as follows: [Website]

- Is our Water Good to Drink? Water-related practices, perceptions, and TK indicators for human health; co-Led by Corinne Schuster-Wallace, University of Saskatchewan, Lalita Bharadwaj, University of Saskatchewan, and Diane Giroux, Akaitcho Territory Government
- Matawa Water Futures: Developing an Indigenous-informed framework for Watershed Monitoring and Stewardship; co-led by Terry Mitchell, Wilfrid Laurier University and Sarah Cockerton, Matawa First Nations Management
- FIShNET (Fish & IndigensouS NorthErn health): Healthy Water, Healthy Fish, Healthy People; co-led by Brian Laird, University of Waterloo and Virginia Sutherland, Mushkegowuk Council
- We need more than just water: Assessing sediment limitation in a large freshwater delta; co-led by Tim Jardine, University of Saskatchewan and Gary Carriere, Cumberland House Fishermen's Co-operative
- Ohneganos – Indigenous Ecological Knowledge, Training and co-creation of mixed method tools; co-led by Dawn Martin-Hill, McMaster University, Beverly Jacobs, University of Windsor, Lori Davis Hill, Six Nations Health Services, and Christine Wekerle, McMaster University
- Water knowledge camps: Building Capacity for Cross-Cultural Water Knowledge, Research, and Environmental Monitoring; co-led by Jennifer Baltzer, Wilfrid Laurier University and Leon Andrew, Sahtú Renewable Resources Board

A funding of $1.63 million has been approved for the above 6 projects, which includes 69 academic and indigenous community investigators, 14 Indigenous communities, 11 Canadian universities, and will train 36 highly qualified personnel over 3 years (2018-2021).

4. GWF Core Teams

GWF core teams provide the necessary underpinning for core program objectives and deliverables, specifically:

- National capability for the modelling needed to deliver key programme goals;
- Capability for observational science, in particular with respect to key observatories; and
- Support for delivering research that is driven by user-led needs and solutions.

A budget of $14.6 million has been allocated over 2017-2020 to support core team activities and about 80 highly qualified personnel who are ensuring that the GWF program stays on course to attain its objectives and mission.

4.1 Knowledge Mobilization Team

Purpose: The GWF KM Core Team is an advisory body that provides oversight, advice, and support for KM initiatives of GWF-funded projects. The KM specialists focus on assisting project investigators, researchers and staff to succeed in their stated KM goals while also, identifying and creating opportunities to facilitate and develop KM capacity across the GWF network. While the KM specialists' primary mandate is to support GWF Pillar 3 projects, their goal is to create resources that can be shared through the broader network, therefore supporting Pillar 1, 2 and supplementary initiatives as well. [Website]

Strategies and Best Practices: GWF's Pillar 3 projects espouse the philosophy of knowledge mobilization: co-production, collaboration and dissemination of knowledge with end users for solutions to real-world challenges. The field of KM has been evolving and many best practices have been developed. Below are the strategies and best practices that the GWF KM Core team encourages and provides support to implement at the project level.

Projects should make meaningful attempts to:

- Create a transdisciplinary project team that is made up of researchers and practitioners working together to co-produce knowledge through a positive and trusting relationship with all participants. To meet the needs of all potential users of the research, projects must be designed by the team and with the intended end user audience. It is critical to recognize that end users have practical experience, information and content to add to the research.
- Engage in KM throughout the entire project timeline. KM should be planned for at the outset of the project by building it into the research design. As part of this process, it is best practice to build agreement in advance among your team and it is critical that there is opportunity for end-users to be a part of setting expectations, timelines, and deliverables of the project.

- Determine how end user communities normally collect, evaluate and use knowledge and how they communicate with each other, and then create opportunities for active, inclusive and iterative communication between team members and end users, using their preferred communication channels.
- Strengthen mutual understanding within the project team through limiting the use of jargon, translating technical terms into plain-language or terms that are compatible for end user needs.
- Ensure dual accountability for KM within the team. Ideas and information must flow in all directions. Lines of accountability must be clear – between researchers and practitioners within the team. It is important that changes to the project's scope and/or timing are negotiated with all team members and end users are invited to participate in critical direction changes.

Team Leads: University of Saskatchewan – Lawrence Martz; Wilfrid Laurier University – Kelly Munkittrick; and University of Waterloo – Kevin Boehmer)

4.2 Computer Science Team

Purpose: To meet the demands of hydrological modelling and visualization of large data requires new science to support software improvement, human-computer interaction, and data management. As well, a consistent computing platform is required to support integration and to take advantage of common, scalable functionality**.** [Website]

Strategy: The following strategy outlines the new GWF cloud platform for supporting integrating hydrological, water quality and economic models, and developing user interfaces and scientific processing pipelines for these integrated models. The core computer science team works with other GWF projects and core technology teams to develop a software platform that meets their needs. The core computer science team is delivering core computing functionality and expertise, provide software, visualization and interaction innovation along with software development support to establish a new computing platform for use by GWF scientists.

The new GWF computing platform being developed will support the following objectives:

- **Improved evolution of hydrological modelling tools:** Existing hydrological modelling tools and environments are diverse and implemented with a broad range of technologies that make it challenging for them to evolve to address the broad range of new demands for understanding and adapting to water futures.
- **Improved scalability of hydrological modelling:** The Canadian Hydrological Model (CHM) is a multi-physics modelling software framework for the computer simulation of hydrological processes. It is a key component of the GWF core modelling effort. In order to run CHM in both research and operational modes for the domains of interest for the GWF, e.g., Yukon, Western Canada, all of Canada, CHM must evolve from shared-memory

parallelism to distributed-memory parallelism. This is expected to be a highly non-trivial undertaking because it must consider multi-objective load balancing based on multiple disparate processes, e.g., numerical, physical, and topographical. The inclusion of fully coupled processes, e.g., blowing snow and shallow water flow, further adds to the challenge.

- **Improved delivery of data and knowledge:** Delivery of data to and from diverse stakeholders for making sense of large datasets and complex model inputs and outputs requires specialized information query and visualization and interaction techniques.
- **Improved management of sensor data:** We lack an efficient approach to integrating spatially and temporally dense environmental data streams from terrestrial and remote sensing monitoring platforms in order to support science-based decision making for end-users from diverse geographic settings.

In order to accomplish these objectives, the following elements of the GWF computing platform are under development:

- **Software Reference Architecture and Platform**: A reference architecture and platform will be developed that provides a modern Big Data platform to support analytics, insight generation, and decision making.
- **Software Co-evolution Toolset and framework:** A framework and tools will be developed to support the re-engineering, co-development and migration of hydrological modelling tools, e.g., CRHM.
- **Hydrological Model Acceleration toolset and framework:** Algorithms and software will be developed and implemented to extend the capability or accelerate the performance of new or existing GWF hydrological modelling frameworks, e.g., CHM or VARS.
- **Interactive Visualization Toolset and framework:** A framework and tools will be developed that support connecting citizen science apps (developed as part of other GWF projects), and support interpreting, exploring and making sense of large data sets and complex model outputs.
- **Data Management toolset and framework:** A framework and tools will be developed to support an at-scale system that is responsible for storing, managing, processing and analyzing data that are collected throughout the life of the project.

Team Leads: University of Saskatchewan - Kevin Schneider; and University of Waterloo - Jimmy Lin

4.3 Data Management Team

Purpose: To promote and govern the management, retention, use, and dissemination of data collected as part of the GWF programme's research activities. [Website]

Data Strategy and Policy: The intention of the Data Policy is to be sufficiently flexible to accommodate the multi-disciplinary nature of GWF-funded research and the wide variety of data collected therein. GWF is committed to the establishment, long-term maintenance, validation, description, accessibility, and distribution of high-quality datasets, and fully adheres to the FAIR data principles (Findable, Accessible, Interoperable and Re-useable) that specific forms of research data collected with public funds should be publicly accessible, with a special obligation to openness and accountability.

GWF will develop and maintain a central data repository and archive to contain certain datasets, and will develop a central data indexing system and metadata catalogue to search and find datasets within the central archive and those stored elsewhere.

The objectives of this policy are to:

- Outline the roles and expectations of GWF researchers and the DM Team in the collection, management, dissemination, and preservation of (anonymised) quantitative research data.
- Respect the rights of the data originators and/or software developers who have invested considerable effort in obtaining and/or generating data and developing software by ensuring consumers of these products use them ethically and with proper attribution to the originators and/or developers.
- Benefit society and research communities by promoting the re-use of data collected and generated through GWF-funded projects.
- Improve the transparency, efficiency and reproducibility of research by ensuring data is managed appropriately and easily discoverable through a central metadata catalogue.
- Ensure that certain key hydrometeorological, hydrometric, groundwater, soil moisture, snowpack, and water quality data that is useful for model development, parameterisation and validation is available in a central data repository.
- Foster collaboration among GWF-funded researchers, and the general research community, through clear mechanisms and mandates for data sharing.
- Protect privacy and respect data ownership rights, especially data that falls under OCAP (Ownership, Control, Access, and Possession) principles or their equivalent.
- Encourage responsible data sharing by providing guidance to GWF researchers working with sensitive data.

Team Leads: University of Saskatchewan - John Pomeroy; McMaster University - Sean Carey; Wilfrid Laurier University - William Quinton; and University of Waterloo - Jimmy Lin

4.4 Technical Team

Purpose: To provide much needed strategic support to 60 research observatories and major research facilities within the GWF program across Canada. [Website]

Strategy: A team of 20 research technicians have been appointed to work on field sites often in remote locations and in harsh climate conditions, and to support analytical and instrument laboratories. These technicians have received specialized training to ensure their own safety, installation and maintenance of instruments, and securing data.

Here is a list of data technicians and respective research observatories and analytical loboratories they are responsible to service:

University of Saskatchewan

- Airborne Cold Regions Observatory
- Water Isotope Ecohydrology Laboratory
- Boreal Forest and Prairies
- Canadian Rockies Hydrological Observatory

University of Waterloo

- Remote Sensing
- Smart Sensors Network
- Water Quality and Aquatic Ecosystem
- Smart Watershed

McMaster University

- Yukon Research Sites
- Northern Boreal Plains
- Ontario Observatories

Wilfrid Laurier University

- Ecosystem Resilience
- Hydrometeorological
- Permafrost
- Water quality
- Biomonitoring

4.5 Modelling and Forecasting Team

Purpose: To deliver the "new modeling tools" and "new monitoring systems" for Canada and the cold regions of the world that were identified as key programme deliverables for GWF. The core modelling team will strategically link to and support GWF Projects with core functions. The projects will also substantially supplement core modelling resources. The GWF Modelling Team will be operated as a cohesive unit, the *Canadian Centre for Water Forecasting and Prediction* to

provide a critical mass of modelling capability and expertise to accomplish GWF's prediction goals. [Website]

Strategy: The core modelling and forecasting team is developiong tools to *Improve Disaster Warning, Prediction of Water Futures, and Adaptation to Change and Risk Management* for Canada. In order to accomplish these objectives, the following elements of the modelling systems need to be developed through the CORE and Pillar 3 outcomes:

- **Atmospheric models or forcing**: A series of coupled, uncoupled, historical or re-analyzed forcing data are required to drive the water, ecosystem, and energy modelling systems. These data can be derived from numerical weather prediction models (NWP), NWP reanalysis models, and climate models using various forms of interpolation, ensemble outputs, statistical downscaling and dynamical downscaling.
- **Hydrological and Water Quality Models:** These are focused around hydrological models and land-surface schemes that can resolve the coupled energy and water budget of the land surface at multiple scales, including features pertinent to cold regions such as lakes, wetlands, snow, frozen soils and glaciers. These models are coupled to or may include detailed models of groundwater storage and flow, permafrost, glacier dynamics, ecosystem landscape dynamics, fire, crop growth, non-point nutrient/contaminant fate and transport, and quantification of environmental flows within watersheds.
- **River Models:** These models will be coupled physical/chemical/biological schemes dealing with flow, velocity, depths, energy (temperature and ice formation), ice break-up, biological attributes such as trophic state, chemical attributes, such as hyporheic exchanges of nutrients and contaminants, and export fluxes to receiving water bodies.
- **Small Lake/Large Lake/Reservoir Models:** These models will couple physical and bio-chemical processes to simulate in-lake and outflow conditions, dynamics in lake/reservoir storage capacity, temporal and spatial variability of phytoplankton, dissolved oxygen, nutrients, and algal blooms, ice cover, ice thickness, and vertical temperature structure and mixing conditions on various time scales. The applied models will be of variable complexity, ranging from simple one-dimensional (1-D) models to more complex dynamic 3-D models. These models will incorporate the results from numerical weather predictions and climate modeling to assess and predict the impact of climate change and various land use practices in the watershed on lentic (still water) ecosystems.
- **Water Management Models:** These models simulate anthropogenic impacts on water resulting from small and large storages, drainage, irrigation and other abstractions, including groundwater extractions. At a basic level, these effects will be represented in land surface schemes and hydrological models. More generally, integrated water management modelling is needed to address long-term planning and short term operational management of water resource systems under varying hydroeconomic

conditions. Decision-making must integrate climate change, land management, water quality and hydrological considerations to meet human and ecosystem needs. Water management models can provide a new level of integrated modelling to support Canada's needs in these areas.

These various modelling systems require consideration of time-prediction elements within their design and implementation. Prediction systems for watershed management require different consideration for short-term forecasting, seasonal or longer term forecasting and "open loop" simulations. The latter are characterized as either analysis of either past events or future climate projections.

- **Now-casting and forecasting:** These use 0-14 day ensembles of simulations for assessing floods, high and low flows, snowcover and snowpacks, soil moisture, river ice breakup, wind-setup on large lakes, irrigation scheduling, reservoir operation, hydroelectricity production, in-stream flow needs, water quality, sediment transport, contaminant transport from spills, trophic state and environmental flows. Day-0 simulations (now-casting) are typically required for assessing ungauged or unmeasured basins. Projections can be extended from 10 days to multiple months.
- **Open Loop Simulations:** Long-term simulations are used for planning, design and/or climate projections. In a hind-cast (historical model), these types of simulations are used for management studies, carrying out "what if scenarios", assessing ungauged attributes, examining land and water management impacts, assessing future cryosphere, vegetation and water quality implications, calculating risk and probabilities and looking at trends. Special attention must also be given to long-lasting effects of pollution legacies and biological adaptation on water quality. Hind-cast simulations are further useful for calibration and validation of numerical models. In a future climate context, these type of simulations are used to understand and ascribe future impacts on water and river basins and look at management implications including potential mitigation. Ideally these would be extended to include coupled modelling of land-atmosphere feedbacks.

Modelling Platforms: The modelling strategy is based around a sequence of atmospheric driving models, linked to terrestrial, riverine and management models, with a hierarchy of time horizons and objectives that scale from short term/real time operations to medium term predictions at weekly to seasonal scales to long term predictions at seasonal to multi-decadal time scales as described in the diagram below. The core modelling team deals with most models and the core computer science team develops advanced visualisation methods and improved operations and software engineering of model architecture and operation to take advantage of high performance computing. The reader is referred to the year 1 and year 2 inception model summaries available on the GWF web page for reference and more details.

Figure 4: The GWF Integrated Modelling Strategy

Team Leads: University of Saskatchewan – Alain Pietroniro and John Pomeroy; University of Waterloo – Phillippe van Cappellen; McMaster University – Sean Carey

4.6 Communications Strategy

Purpose: To address strategies and tactics for building awareness with key audiences of the research program and its early findings to advance the strategic directions of GWF locally, nationally and internationally, as well as evaluating activities for measuring the success of the plan. [Website]

Communication Objectives: Support the goals of the GWF Program through the following:

- Support GWF efforts to position Canada as a global leader in water science for the world's cold regions (where snow, ice, and frozen soils control the storage and release of water), a global partner of choice for transdisciplinary water research, and a provider for Canada and the world of strategic tools to manage water futures
    - Develop strategies for increasing both national and international profile aimed at key government influencers
- Continue to build national and international profile for GWF and key partner universities by leveraging the communications, marketing, media relations and social media strengths of partners and stakeholders
- Enhance and protect the profile and reputation of GWF and its four institutional partners

- Support efforts to recruit more than 750 HQP by 2023 and attract international scientists as visiting fellows, research collaborators, and presenters
- Celebrate and demonstrate to current and potential funders the economic, environmental and societal impact of their investment
- Support development of research collaborations, donor relations, community initiatives, etc. in support of GWF objectives

Team Leads and Co-Leads:

- Chair: Kathryn Warden, Director, Research Profile and Impact, University of Saskatchewan
- Mark Ferguson, GIWS Communications Specialist, University of Saskatchewan
- Morgan Braaten, GIWS Outreach Coordinator, University of Saskatchewan
- Lori Dillon, Manager, Research Communications, McMaster University
- Allie Dusome, Communications Officer, University of Waterloo, the Water Institute
- Katharine Tuerke, Communications Officer, University of Waterloo
- Shawna Reibling, Knowledge Mobilization Officer, Wilfrid Laurier University
- Kimberly Elworthy, Research Communications Officer, Wilfrid Laurier

5. Affiliate Projects

GWF aims to be an inclusive program of water security researchers in Canada and globally that can contribute towards the vision and mission of the GWF. Many research opportunities may arise that will be pursued by eligible GWF members, but which were not included in their GWF funded projects, and by others who are not eligible for GWF funding. These opportunities may contribute strategically towards the GWF vision and mission and so it is possible for GWF to provide in-kind support to these projects and to benefit from such linkages to expand its research envelope. The purpose of the GWF Affiliated Projects is to find ways to align with and link to projects that are outside of the direct funding remit of GWF, to benefit both the Affiliated Projects and GWF. The benefits provided to Affiliate Projects include:

- Access to core modelling outputs and will facilitate links to existing GWF-funded projects and core teams, including knowledge mobilization, computer science, and certain observational data and sensor developments;
- Access to some administrative and outreach support from the GWF Secretariat, and the opportunity to showcase their project on the GWF website and via social media accounts;
- Participate in GWF topical workshops and Annual Science Meetings for research dissemination, planning, outreach, knowledge mobilization and professional development; and
- Participation in pursuing future funding opportunities with GWF members and projects.

Here is a list of Affiliate Projects approved by the GWF Strategic Management Committee for including in the network:

- Assessing the projection of soil moisture in the Canadian Prairie region under future climate change scenarios, David Sauchyn, Prairie Adaptation Research Collaborative, University of Regina, SK
- Building and sustaining infrastructure resilience through targeted climate adaptation training for professionals in Newfoundland and Labrador, Joseph Daraio, Civil Engineeringm Memorial University of Newfoundland, NL
- Combined Hydrological, Exposure and Risk Assessment Models in Support of Environmental Risk Assessment, Markus Brinkmann, University of Saskatchewan, SK
- Climate sensitivity of Alaskan rivers, fish and communities: Developing storylines of Arctic transformation, Keith Musselman, University of Colorado Boulder, USA

6. Research Observatories and Major Facilities

6.1 Research Observatories

GWF will deliver transformative new capabilities for observation, focussed on development of our world-leading multi-scale observatories. Through small catchments instrumented with hundreds of observation stations within our large river basin observatories (Figure 5), we will diagnose environmental change in key biomes and develop the large-scale science associated with global-scale modelling, land-atmosphere feedbacks and landscape change.

Figure 5: GWF's network of intensive surface observational sites across the country; see Table-1 for list of site names

These observatories also provide a key platform for science integration to address management/governance dimensions. We will enhance the Mackenzie River Basin Observatory, expand the Saskatchewan River Basin Observatory to include the Nelson-Lake Winnipeg Basin,

and develop the international Columbia-Lake Okanagan, Fraser and Yukon as new basins (Figure 2). In Central Canada, we will focus on the Great Lakes and their basins, expanding the Southern Ontario Watershed Consortium's pioneering 'intelligent watershed' monitoring systems to include the Grand River Basin. Working with our partners from the information and communication technology sector, we will spawn a new generation of watersheds that will provide real-time data and analytics to support operational management of flows and treatment utilities. In Eastern Canada, we will focus on the international and interprovincial Saint John River Basin to better understand aquatic ecosystem and transboundary water management issues and Quebec's BEREV experimental basin.

We will develop and deploy new sensors and observing systems, linking them with state-of-the-art data retrieval, management, and distribution systems. A new drone platform and novel satellite data assimilation will transform the observation of large remote cold region areas by detecting change on short time scales, deploying LiDAR (laser-based distance measurement), snow sonar, high-resolution monitoring of water elevations, and multi-spectral monitoring of land and water systems. We will use new acoustic sensors to measure snowpack properties remotely for the first time, and GPS and neutron scattering to measure frozen/unfrozen soil moisture. We will develop new in-stream water quality sensors and further develop chemical fingerprinting and environmental-DNA techniques, transforming capability for ecological monitoring and risk assessment. A high-performance, cloud-based geospatial data platform will be used to collect, manage, and analyze large quantities of multi-dimensional data for decision support. We will work with Indigenous and other communities to develop citizen science monitoring capability.

Table 1. List of GWF intensive surface observational sites. The list is preliminary and growing as sites are added and the surface network expands to include both new and existing sites across Canada. While most are well-established legacy sites from previous initiatives such as Changing Cold Regions Network, some are at an earlier stage of development and are being enhanced to bring them up to standard as part of our integrated network.

1. Wolf Creek Research Basin	21. Lake O'Hara	41. Haig Glacier
2. Athabasca Glacier	22. Nipika Mountain Resort	42. James Smith Cree Nation
3. Baker Creek	23. Conestogo Lake	43. Katepwa Lake
4. Brintnell-Bologna Icefield	24. Eastern Lake Erie	44. Kenaston/Brightwater Creek Mesonet Site
5. Dehcho First Nations	25. Forêt Montmorency	45. Lethbridge Irrigation Demonstration Farm
6. Fort McMurray	26. Ganatsekaigon Creek	46. Marmot Creek Research Basin
7. Havikpak Creek	27. Gatineau River and Saint-Maurice River watersheds, QC	47. Pasqua Lake

8. Helen Lake	28. Grand River Watershed	48. Quill Lakes, Saskatchewan
9. Inuvik to Tuktoyaktuk Highway	29. Morningside Creek	49. Redberry Lake Biosphere Reserve
10. Kakisa and Tathlina Lakes	30. Six Nations of the Grand River	50. Saskatchewan River Delta
11. Lubicon Lake Cree Nation	31. Turkey Point Sites	51. Sibbald Wetlands
12. Norman Wells/Tulita area	32. Western Basin Lake Ontario	52. St. Denis National Wildlife Area
13. Scotty Creek	33. Whitemann's Creek	53. Tobacco Creek
14. Slave Lake	34. Wilket Creek	54. Upper Qu'Appelle
15. Trail Valley Creek	35. Boreal Ecosystem Research and Monitoring Sites (BERMS), White Gull Creek, SK	55. Vermilion Basin
16. Tsa Tue Biosphere Reserve	36. Buffalo Pound Lake	56. Wapta Icefield/Peyto Glacier
17. Wabasca	37. Burstal Creek	57. Wascana and Upper Qu'Appelle
18. Cariboo Alpine Mesonet	38. Expiremental Lakes Area	58. West Nose Creek
19. Marian Lake Watershed	39. Fort Macleod	59. Yellow Quill First Nation
20. Columbia Icefield	40. Fortress Mountain	60. Attawapiskat

Research capabilities, cutting-edge instrumentation, and transformative science conducted at our research observatories within the Nelson-Churchill River Basin are outlined in the following videos. Similar videos will be developed for other observatories in near future.

Video File: St. Denis National Wildlife Area

Video File: Brightwater Creek

Video File: Canadian Rockies Hydrological Observatory

Video File: Forecasting Extreme Weather Events

Video File: E.B. Campbell Dam – Saskatchewan River Delta

Video File: Sediment and Nutrient Transport Modelling

Video File: Swift Current Research Site

Video File: Rosethern Research Site – Prarie Hydrology

Video File: Lake Diefenbaker

Video File: Buffalo Pound

Video File: Lake Diefenbaker – Toxicology & Water Quality

Video File: Swift Current Creek – Urban Municipal Drainage

Video File: Modelling Riverine Processes

Video File: Boreal Forest

Video File: Socio-Hydrology

Video File: Integrated Watershed Modelling

Video File: Mine Overlay Site Testing Facility

6.2 Major Facilities

- **Centre for Hydrology:** The USask Centre for Hydrology addresses Saskatchewan's water sustainability problems and provides national leadership in hydrological research and training. The centre includes unique facilities with equipment for stable isotope analysis, strong expertise in water and wastewater treatment, efficacy of constructed wetlands, mine reclamation and site remediation, water balance modelling, and

hydrogeochemistry. The centre has six labs: Cryospheric Environmental Lab (an experimental cold room for cryospheric simulation); Cool Sample Lab; Hydrological Modelling Lab (computer modelling with PC and Unix); Hydrological Instrumentation Lab; Hydrological Sampling Lab; and Ecohydrology Lab (natural water chemistry). [Website]

- **Centre for Cold Regions and Water Science:** The WLU Centre for Cold Regions and Water Science (CCRWS) is a collaborative research facility that houses four research centres/groups and a variety of state-of-the-art analytical equipment. The facility, which opened in 2013, is funded by Laurier, the Government of the Northwest Territories, the Canada Foundation for Innovation (CFI), the Ontario Ministry of Research and Innovation (MRI), and the Federal Economic Development Agency for Southern Ontario (FedDev Ontario) [Website].

Centre for Cold Regions and Water Science, Wilfrid Laurier University

- **Coldwater Laboratory:** In Alberta, the Centre for Hydrology maintains premises at the Coldwater Laboratory in Canmore, AB. The Coldwater Laboratory places over 20 researchers and students in the headwater region of 3 major river basins (Saskatchewan, Columbia and Mackenzie river basins) to study the impacts of climate change and extreme events on water resources in the region. This facility includes offices and a laboratory and provides easy access to over 35 high elevation stations within the southern Canadian Rockies. [Website]

USask Coldwater Lab, Canmore, AB

- **Mine Overlay Site Testing Facility (MOST):** The MOST facility is a research and testing facility that serves as a hub for the development of hillslope hydrological models in relation to mine cover systems and landscape engineering. The facility is funded by the Western Economic Diversification and includes a strong partnership with O'Kane Consulting, a world leader in mine cover design. The facility is the first of its kind to provide pilot scale cover trials with replications of key processes (placement, climate,

slope/aspect, vegetation) and the ability to evaluate and characterize the key mechanisms controlling the water dynamics in mine reclamation cover design. [Website]

- **Green Roof Environment and EngiNeering Facility (GREEN):** The GREEN facility is a research and testing place for industry to enhance and develop green technologies and all other aspects involved in the construction and efficient operation of green roof systems, specifically targeted to cold regions. Our multidisciplinary team of engineers, green roof consultants, water, soil and plant scientists created a new state-of-the-art facility at the USask to test cold region green roof designs. This facility serves as a research and green technology development platform that integrates fields of hydrology, soil physics, plant ecology, civil engineering, architecture and building science and provide a space to troubleshoot existing design challenges in this sector, enabling us to reduce the cost of new projects by providing proof of concept testing in cold regions prior to costly implementation.
- **Toxicology Research Centre:** The USask Toxicology Centre is the largest academic research and training centre in the area of aquatic and environmental toxicology in Canada. The centre provides broad-based expertise from the molecular to the ecosystem level, with partners from around the globe. It focuses on investigating the effects of water pollution on ecosystem and human health with an aim towards sustainability and stronger environmental stewardship. [Website]
- **Aquatic Toxicology Research Facility (ATRF):** The ATRF, the only facility of its type in Canada and one of only a few in the world, is a highly sophisticated laboratory for aquatic toxicology research. Located at the Toxicology Centre, the 7,100 sq-ft laboratory was specifically designed to provide areas with different water qualities and temperatures to perform both static and dynamic toxicological experiments with algae, crustaceans, insects, clams, amphibians or fish. In-house research facilities include five walk-in controlled-environment chambers and an analytical laboratory for water quality analysis. [Website]
- **Smart Water Systems Laboratory (SWSL):** The SWSL was recently created with support from Western Economic Diversification Canada to develop novel water and snow sensing technologies and bring them to pre-commercialization and commercialization stage. The SWSL will transform the observation of Canadian waters by detecting change in water quantity and quality at high resolutions. SWSL is developing novel sensors that measure snowpacks, ice, open water, flooding, streamflow, soil moisture, wetlands, vegetation and algal growth. Many of these sensors will be deployed on specialized all-weather drones (unmanned aerial systems) for rapid deployment across Canada with first applications in the Prairies and the mountain headwaters of the Saskatchewan River Basin. [Website]

- **Aqueous Geochemistry Laboratory (AGL):** The AGL is an analytical facility for water chemistry, which is providing high-quality and timely quantitative elemental analyses for both academic and non-academic clients. This laboratory supports comprehensive elemental analysis of aqueous samples ranging from fresh to brackish water. The laboratory houses several major pieces of analytical equipment to support a variety of methods including: i) inductively coupled plasma – mass spectrometry (ICP-MS); ii) inductively coupled plasma – optical emission spectroscopy (ICP-OES); iii) ion chromatograph (IC); iv) high performance liquid chromatography (HPLC); v) gas chromatography (GC); and vi) spectrophotometry. Ancillary equipment to support routine and unique sample processing requirements are also available in the laboratory. [Website]
- **Environmental Geochemistry and Isotope Lab:** Located at Unviersity of Waterloo, it is focused on watershed biogeochemistry and multidiscplinary problems. The lab extensively uses isotopic tools and tracers in addition to other geochemical techniques, which are listed at the following website [Website] The Environmental Isotope Lab at Waterloo develops and applies isotope technology to the Environment. The lab resources are used primarily in the fields of Earth Sciences and Biology. Many other environmental applications are also available. [Website]
- **Saskatchewan Water Chemistry and Ecology Lab:** The lab has expertise in aquatic ecosystem ecology and biogeochemistry, specifically, understanding the effects of changing climate and nutrient loads on aquatic ecology and biogeochemistry. [Website]

7. International Strategy and Engagement

The biggest challenge today among water researchers globally is the fragmented approach to science, which fails to leverage the collective intellectual power needed to address real-world problems. No single university can address these critical needs. GWF is integrating research and development efforts from multiple disciplines within the fields of natural science, health science, social science, engineering and computer science, drawing upon the entire spectrum of Canadian water expertise in universities, corporations, and government agencies, strong global networks and a broad range of stakeholders from industry, government, communities and the non-profit sector. The GWF is creating a transdisciplinary water research partnership on an unprecedented scale—*the world's first large-scale multi-site research consortium—to advance water security and cross-site learning and exploit opportunities to apply new big-data technologies to water problems.* We are focusing on regions dominated by 'cold' water processes, including snow, ice and frozen soils, where Canada as a whole is an exemplar and can have impact. 'Cold regions' are at the forefront of global warming, supply water for 50% of the world's population and face urgent societal needs, with rapidly changing landscapes, ecosystems, and water environments. We are developing the much-needed climate change-focused science, predictive models and market-oriented decision-support tools (software, models, apps, etc.) to enable communities, First Nations, agriculture, industries, and governments in Canada and beyond to prepare for and manage risk from floods, droughts, unsustainable water use and degrading water quality.

GWF has increasingly been recognized internationally. GWF was recently approved as a Regional Hydroclimate Project by the Global Energy and Water Exchanges project (GEWEX) of the World Climate Research Programme in Washington, DC. GWF hosted the GEWEX Open Science Meeting in Canmore, AB, Canada for the first time in May 2018. International linkages to research in 26 mountain research catchments around the world through the International Network of Alpine Research Catchment Hydrology, a cross-cutting project of GEWEX with which a joint meeting was held in Santiago, Chile over 24-26 October 2018. GWF is co-organising a meeting, "Towards a Sustainable Water Future" with the Sustainable Water Future Programme of Future Earth in Bangalore, India in September, 2019. Outcomes from the 39 research projects funded under GWF will contribute to the United Nations (UN) Water Action Decade and Sustainable Development Goals through supporting integrated water resources management and strengthening resilience and adaptive capacity to climate-related hazards. GWF is co-chairing a High Mountain Summit for the World Meteorological Organisation in Geneva, Switzerland in late October 2019. A Memorandum of Understanding has been signed that will strengthen both Canada and China's commitment to managing freshwater resources globally in a time of rapid climate change. The partnership involves GWF and the Chinese Academy of Sciences Third Pole Environment (TPE) program. The MOU is a direct outcome of discussions between GWF and TPE at the Open Science Conference of the World Climate Research Programme's Global Energy and

Water Exchanges Project in Canmore, Alberta in May where the need and opportunity for greater global collaboration was identified. Through initiatives such as collaborative research projects, personnel exchanges, and exchanges of scientific information and technical data, the goal is to advance water and climate research in critically important areas – especially the high mountains of Canada, the Arctic and the Tibetan Plateau, which is also known as the Third Pole – including climate change impacts on ecosystems, river basins, water bodies and natural resources development.

7.1 World Climate Research Programme – Regional Hydroclimate Programme

GWF is one of the three Regional Hydroclimate Projects of the Global Energy and Water Exchanges projects (GEWEX) of the UN World Climate Research Programme hat aim to improve the understanding and prediction of that region's weather, climate, and hydrology. This partnership will allow greater access to global modelling and satellite data, and in turn, provides a forum for GWF to communicate research results to the international community.

7.2 UNESCO & World Climate Research Programme – Global Hydroclimate Programme

The International Network for Alpine Research Catchment Hydrology (INARCH) project is led by John Pomeroy, Canada Research Chair in Water Resources and Climate Change. INARCH is a Global Hydroclimate Programme (GHP) cross-cut project of WCRP's GEWEX and a recognized contribution to the world water security initiative of UNESCO's International Hydrological Programme. The overall objective of INARCH is to better understand alpine cold region hydrological processes, improve their prediction and find consistent measurement strategies. To achieve this objective it is necessary to develop transferable and validated model schemes of different complexity that can support research in data-sparse mountain headwaters where climate change impacts on water resources are anticipated to be very severe. INARCH has 25 intensely instrumented high-mountain research catchments in North and South America, Europe and Asia that form a vast outdoor intercomparison laboratory. By combining the expertise of over 40 principal collaborators from 17 countries, INARCH addresses important issues such as snow, glacier and permafrost hydrology; representation of snow and ice in hydrological land surface models, model downscaling in complex terrain, and improving the prediction of climate change impacts in themountain headwaters that support water resources for half the world's population. [website]

7.3 Future Earth

Sustainable Water Future is one of the global programs under the Future Earth initiative aims to provide the knowledge and support to accelerate transformations to a 'more sustainable water world'. Through its partnerships with a large number of researchers and stakeholders, the program works together to harvest and synthesize authoritative sound and a scientific knowledge

base to achieve the Sustainable Development priorities associated with water. GWF is the Canadian node for the Sustainable Water Future program of Future Earth. As part of this engagement, GWF is sharing its expertise and outcomes with larger Sustainable Water Future community.

7.4 World Meteorological Organization

GWF is now a contributing organisation to WMO through the Executive Council Panel of Experts on Polar and High Mountain Observations, Research and Services (EC PHORS), which promote and coordinate relevant programmes that are carried out in the Antarctic, Arctic and high mountain regions by nations and by groups of nations.

8. Major Meetings and Collaborations

8.1 First Nations Water Security and Climate Change Symposium – Six Nations

On June 3, 2018, GWF researchers participated in a 1-day First Nations Water Security and Climate Change Symposium held on the Six Nations of the Grand River Territory. The symposium focus was on Indigenizing water security solution based research, health & climate change research. The symposium was designed based on the recent Naylor Review of Science & Innovation, the TRC Calls to Action and Federal government's commitment to proper inclusion of Indigenous Knowledge (IK) signal a critical need to link & engage the scientific community and develop relationships with existing researchers such as Global Water Futures, funding agencies NSERC, CIHR-IIPH and government including AFN research delegates. The purpose was to introduce FNs environmental researchers, leaders and agencies to environmental/water researchers in their traditional territories. Ultimately, the goal was to develop Indigenous communities research strategies for the GWF Program to foster knowledge-exchange identification of funding opportunities & synergies and sharing of FN research, potential partners within University-community based research. The symposium program included key notes by researcher leaders, Environmental Health Panel, Knowledge Guardians Panel, Co-creation GWF Panel, Governance Panel and Youth Panel.

Co-creation GWF Panel

For additional information, please contact Stephanie Morningstar at mornings@mcmaster.ca

8.2 Annual Science Meeting – Co-hosted by the Six Nations of the Grand River

The Inaugural GWF Annual Science Meeting June 3-6, 2018 was an incredible meeting of a transdisciplinary group of water researchers and stakeholders who discussed progress in meeting the GWF Grand Challenge. This meeting was remarkable for being exceptionally comprehensive in the subjects represented, for the early and rapid progress shown, and for being hosted and co-organized by a First Nation, on its own territory.

The Inaugural GWF Annual Science Meeting June 3-6, 2018

Over 400 people attended from across Canada, and from UN, WCRP and Future Earth. The meeting included 160 presententations by academics, students, researchers, Indigenous knowledge holders, policy makers, managers and communicators as well as a visit to Six Nations of the Grand River where researchers and community members engaged in land-based knowledge exchange activities. Additional information is avaialble at: [website]

GWF Young Professionals

GWF Poster Presentation

Special attention was paid to progress in: [Meeting Agenda and Abstracts]

- international linkages for GWF,
- regional and topical scientific advances in Canada,
- co-creation of knowledge with First Nations
- needs of Young Professionals
- integration of research needs and advances in understanding and technology on: modelling and observations, aquatic environment and ecosystems, human-water interactions, watershed management and disturbance, and climate and extreme weather.

GWF Annual Scinece Meeting at the Six Nations of the Grand River Territory on June 4, 2018

On June 4, GWF scientists were invited to Six Nations of the Grand River, Ohsweken to listen, learn, and share. Through food, music, cultural history and stories, and land-based knowledge exchange sessions, meaningful relationship-building occurred between researchers and the community. Within these relationships, research can more effectively recognize the importance of research co-creation and Indigenous, traditional, and local knowledge as key to successful research projects and the GWF program.

8.3 Operations Team Meeting, January 2019

This meeting was to bring together the GWF Operations Team—consisting of GWF project Principal Investigators/ representatives, project managers, core team leads, Strategic Management and Oversight Committees, Young Professional executives, secretariat, and core Knowledge Mobilization, outreach, data management, and communications staff—together to review collective progress towards our goals, discuss the science directions and operations of the GWF program, and to plan special initiatives [website].

GWF Operations Team

The broad goals of the meeting were to:

1. Review our progress towards addressing GWF's overarching goals and our contributions to international initiatives such as the UN International Water Action Decade: Water for Sustainable Development, 2018–2028;
2. Introduce new GWF projects under the Indigenous Communities Water Research funding stream, and review and establish best practices and approaches to working with Indigenous communities across the GWF program;
3. Review activities and progress in our core teams, and explore and discuss the linkages among these teams and among the GWF projects. Specific focus will be on integration of surface observations, remote sensing, and modelling; reviewing model products and their links to various projects; implementing a data management framework, improving data accessibility, and harmonizing protocols and standards across observatories; discussing computing infrastructure and services, the links to core modelling and data management, and possibilities for data visualization; and exploring the role of knowledge mobilization and communication in connecting this work and engaging internal and external audiences;

4. Explore possibilities to further internationalize GWF, including links to World Climate Research Programme and GEWEX, UNESCO and the UN at large, the World Meteorological Organization, and the Sustainable Water Futures Programme of Future Earth, as well as through new funding streams such as the Tri-Council's New Frontiers in Research Fund (NFRF)

8.3.1 Alignment with UN Sustainable Development Goals

All of the GWF projects and core teams were asked to develop posters indicating their significant achievements and also identify the alignment of their respective projects with the UN Sustainable Development Goals (SDG). Subsequently, it was determined that the GWF network is addressing the following SDG:

Posters showing alignment of GWF projects with the UN Sustainable Development Goals

- SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture
    - Target 2.1: By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round
    - Target 2.3: By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment
    - Target 2.4: By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

- SDG 3: Ensure healthy lives and promote well-being for all at all ages
    - Target 3.9: By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination
    - Target 3.D: Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks
- SDG 6: Ensure availability and sustainable management of water and sanitation for all
    - Target 6.1: By 2030, achieve universal and equitable access to safe and affordable drinking water for all
    - Target 6.2: By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
    - Target 6.3: By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
    - Target 6.4: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
    - Target 6.5: By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
    - Target 6.6: By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
    - Target 6.A: By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies
    - Target 6.B: Support and strengthen the participation of local communities in improving water and sanitation management
- SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
    - Target 9.1: Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all
    - Target 9.5: Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by

2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending

- SDG 10: Reduce inequality within and among countries
- SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable
    - Target 11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations
- SDG 12: Ensure sustainable consumption and production patterns
    - Target 12.2: By 2030, achieve the sustainable management and efficient use of natural resources
- SDG 13: Take urgent action to combat climate change and its impacts
    - Target 13.1: Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
    - Target 13.2: Integrate climate change measures into national policies, strategies and planning
    - Target 13.3: Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
- SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
    - Target 15.1: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements
    - Target 15.5: Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species
    - Target 15.9: By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts
- SDG 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
    - Target 16.7: Ensure responsive, inclusive, participatory and representative decision-making at all levels

- SDG 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development

As part of the Operations Team Meeting agenda, various discussion sessions were organized to identify gaps and also seek input on best practices that could be implemented to further strengthen the GWF research and networking activities. Meeting attendees were organized into 10 groups for Breakout Discussions focused on 4 topics: a) Forecasting and Modelling; b) Computer Science and Data Management; c) Knowledge Mobilization and Communications; and d) Core Teams Integration. In addition, a group discussion also ensued on the topic of Indigenous Communities Water Research. The following section summarizes the themes raised and also identifies potential next steps and actions. [Agenda]

8.3.2 Forecasting and Modelling Discussion

Some of the important elements of discussion are listed below:

- There is a need for the core forecasting and modelling to interact more with GWF projects, especially those dealing with sensor development and what data is required for sensor design and how ingested into models.
- There is a need to integrate new developments that the research models are producing to inform upgrades on the operational models to ensure better predictability or reduce uncertainty.
- Most people don't have the skills to run the models, but could make use of the outputs and datasets. Key is to make a way to access the results of the models, so people can make use of it. Integration with core team needed.
- Lots of discussion focused around users and their needs. The models can be useful in understanding environmental change and addressing relevant community concerns.
- In northern regions and Indigenous communities, technical limitations and accessibility to models and datasets can restrict the ability to make full use.
- Many projects do not require the large scale, but focus on process level. Then, how do you scale this up and is this integration necessary?
- There are two types of model output users: those that want the raw data and those that want a derived product. Need to consider the different needs (storage, tools) for each.
- Need to improve understanding of who is using what outputs, and for what purpose, and when. A data workflow (who doing what, and when) could create efficiencies among projects. This can reduce worktime and streamline efforts, and foster collaboration among projects and sharing of outputs.

8.3.3 Computer Science and Data Management Discussion

Some of the important elements of discussion are listed below:

Computer Science

- Idea – create tools to help researchers with visualizing data, etc. Need to make user friendly.
- Co-creation of user interfaces (e.g. app-based, web interface, scenario reports, maps) – taking from model output through to what users need, and adds value.
- Thought needs to be given on how GWF can play a role as a boundary organization (i.e. how can GWF connect modellers to users, and translate the questions and outcomes among these groups). Visualization plays a big role here.
- "Big data needs a big display". We can move forward with new tools and visualization approaches. This would help us to better get our results to the public.

Data Management

- In terms of archiving of data, a federated data management approach is likely best, with a central catalogue for searching data. Different repositories that are reliable and long term are needed (i.e. university libraries).
- Need better understanding of data needs of the models to add value to the data collected in the field.
- Clear ethics and principles about sharing and accessing the data, particularly when co-owned.
- DM activities were discussed. In cases of extremely large datasets, how do we decide what to keep? TBs of data are being collected in some studies. Difference between provisional and final data – we need a "clean room" for data.
- Ease of getting data. Why do people resist sharing data. It's not that they don't want to share, but that it is a lot of work, and we need to facilitate the process to make it easier. Simplify methods, common methods to ease the transfer
- Data archiving: Longevity and quality and clear documentation of what those data are; permission-based and agreement controlled.
- Standardizing the data schema for specific variables that are collected.
- Data not public (e.g. WISKI) – needs to be resolved.
- Social science data. Knowledge embedded in Indigenous communities. Could collect, archive, and make available, but lots of ethics to be considered. Soft data may span centuries, but how to collect and archive.
- Incentivize submission of data. Journal special issue ESSD. This is part of the knowledge translation credit.
- Early training of HQP on Data Management is required and provides value. Stress the importance early on in their training.

- Capacity challenges around the ability to manage data – there is need for training and best approaches.
- Non-numerical data needs consideration on ownership (i.e. research involving Indigenous communities – this needs to follow all the requirements of chapter 9).

8.3.4 Knowledge Mobilization and Communications Discussion

Re-occuring themes of successful KM included *trust, continuous flow of relevant information, ongoing commitment from researchers and partners, evolution of research questions and process over time, two-way engagement, understand decision-making processes of end user organizations*

Strengthening Knowledge Mobilization Strategies

- The KM Team can be thought of as functioning like a boundary organization/ knowledge brokers: connecting areas of expertise with end users; preparing research teams with messages that resonate prior to meetings and making presentations
- Need way to document the impact of research. Think about: success metrics, ways to seek end user input (e.g., survey), capturing stories; measuring behavior change, etc.
- Efficiencies can be achieved by identifying overlapping KM strategies and tactics can support groups of projects with similar thematic areas and common end users

Communicating and Sharing Lessons and Ideas

- Share KM materials and their outputs across GWF network
- Share the outcomes of the tactics and outputs in lessons learned: what worked; what didn't
- Need mechanisms that enable those with specific skills to mentor other researchers (e.g., relationship building, social media, Indigenous culture)

Building Relationship

- Build healthy relationship networks characterized by: reducing redundancy, reciprocity, respect
- Stakeholder management planning can help ensure the right level of engagement / communication messages / materials for different partners and reduce burden on projects and partners
- Meet partners and users where they are: go to non-academic conferences, workshops, etc.
- Ongoing feedback loops critical; not just at end of research process: listen to and respect expertise and ideas of end users and create opportunities for their input into research process and products

- Need to understand the constraints and opportunities in end user organizations to ensure uptake (e.g., decision-making processes and tipping points, what science/products makes their job easier)

8.3.5 Core Teams Integration Discussion

Here are some of the items arising from the discussion session:

- For communications, having scheduled meetings for different groups to touch base is important. Ideas for internal integration: sharing infographics, focus on young professionals, coordination opportunities, 'find-an-expert' space in the newsletter.
- Enhancing communications continually: within projects, between projects and across GWF.
- Website: have to dig deep into the websites to see what is going on. A lot comes up from a Google search and there is a need to reconcile all the different sites to show how the program is organized from top to bottom. Need a list of core team modellers and their profiles.
- Challenges with internal communication: there is a lack of information about what is happening across projects, different roles across institutions, geography is against us. We need better sources of information (e.g. an internal website, org charts, profiles of people).
- Internal communication: need more systematic mechanisms for communication between the core teams, between universities, and between upper management and the core team members. There is an opportunity for the DM and computer science teams to engage the KM and communications teams.
- Integrative discussions: we could think of groupings, specialization of KM personnel. Think of them in thematic areas that could help with coordination. We could organize short courses that are regional and thematically based. Synthesis papers defining what we know, what we don't, and what are the main research challenges and how we will address these?

8.3.6 Indigenous Communities Water Research Discussion

Re-occuring themes included *questions and ideas emerged around the following concepts: a need for a better understanding of what meaningful and ethical engagement looks like; reciprocity in research; establishment of lasting relationships; who, when, and how to do active reconciliation individually, per project, program-wide, and as institutions.*

Strengthening Best Practices in Ethical, Inclusive, and Co-creative Research

- GWF has an opportunity to set the bar on Co-Creative research with Indigenous communities through the evolution of their Indigenous Community Water Strategy.

- Indigenous partners operate on different timelines for various reasons (community engagement resulting in informed consent takes time.) There's a need to provide more space and time for GWF researchers to engage in learning and establishing best practices with Indigenous communities.
- Initiation of projects takes time; the most effective research questions for Indigenous communities comes from the communities themselves. How do non-academic community partners take the lead and initiate research projects when they're not tied to the academy?

Building Relationships and Trust

- There is hesitancy to engage with Indigenous communities due to lack of connections to those communities, distance, and lack of trust.
- There is a need to learn from one another to improve our understanding of each other's worldviews
- Relationship building with communities includes translation of worldviews and takes time and trust
- Desire for joint experiential learning and joint knowledge/science interfacing opportunities in the field
- Research shouldn't tax communities who are often overresearched with little going back to the community
- Active reconciliation needs to be determined by community partners and acted upon by academics

8.4 GWF and Natural Resources Canada Memorandum of Understanding

At a special ceremony on November 27, 2018, the University of Saskatchewan (USask) and Natural Resources Canada (NRCan) signed a five-year Memorandum of Understanding (MOU) that will strengthen the country's commitment to managing its freshwater resources in a time of rapid climate change. The partnership involves USask-led Global Water Futures (GWF)—the world's largest university-led freshwater research program—and NRCan. Through initiatives such as collaborative research projects, personnel exchanges, and exchanges of scientific information and technical data, the goal is to advance water research in critically important areas including climate change impacts on ecosystems, river basins, water bodies and natural resources development. The MOU is a direct outcome of discussions between GWF and NRCan at the GWF Inaugural Science Meeting in June 2018 where the need and opportunity for greater collaboration was identified.

From left: Katarina Pintar, director, Research Coordination and Integration Division (CFS) Daniel Lebel, director general, Geological Survey of Canada (LMS) Prashant Shukle, director general, Canada Centre for Mapping and Earth Observation (CCMEO) and John Pomeroy, director, Global Water Futures

It is anticipated that the collaboration will help inform policies on climate change adaptation and the assessment and monitoring of natural hazard risks including floods, droughts and wildfires. The research will examine water in its many forms—in Canada's mountains, glaciers, permafrost areas, forests, peatlands, wetlands, and groundwater—that make up the country's water environment. The research will involve next-generation research tools that include the use of artificial intelligence, drones, satellites, and big data platforms to support and predict future water issues.

Through the MOU, the parties affirm that a mutual priority is enhanced consultation and engagement with Indigenous peoples and the integration of Indigenous traditional knowledge with science to inform water issues.

9. GWF Professional Development and Career Advancement

GWF places significant emphasis on professional development and training of early career researchers who are considered as one of the legacy of the GWF program. GWF through its research and training programmes is creating national and international capacity to provide the expertise needed for Canada and the world to sustainably manage water futures.

9.1 The Future Professoriate

GWF strongly believes in professional development of graduate students and postdoctoral fellows, particularly international scholars. In order to achieve this objective, on behalf of GWF, Prof. Jeffrey McDonnell, Associate Director, Global Institute for Water Security, University of Saskatchewan offered a half-a-day workshop on "The Future Professoriate" organized by the GWF Young Professionals during the 1st Annual Science Meeting in June 2018 to shed light on and facilitate discussions regarding the workings of academia for graduate students and postdoctoral fellows interested in pursuing academic careers. In addition, student and postdoctoral fellows were advised in "creating a research brand" of their own ambitions and for a successful and satisfying research career[1, 2, 3, 4]. [Website]

Dr. Jeffrey McDonnell

GWF Young Professionals

9.2 Distinguished Lecture Series

GWF in collaboration with the Global Institute for Water Security, University of Saskatchewan hosts a yearly Distinguished Lecture Series entitled "Breakthroughs in Water Security Research,"[5] which brings 10 world-leading scientists to GWF for lectures, tutorials and workshops in the areas of soil physics, instrumentation, lab experiments, uncertainty estimation, hydro-ecological modeling, watershed observatory networks, instream flow modeling, engineering hydrology,

[1] McDonnell. 2015. Creating a research brand. Science 349(6249):758, doi: 10.1126/science.349.6249.758
[2] McDonnell. 2016. Orchestrating a powerful group. Science 352(6283), doi: 10.1126/science.352.6283.378
[3] McDonnell. 2016. The 1-hour workday. Science 353(6300):718, doi: 10.1126/science.353.6300.718
[4] McDonnell. 2017. Paper writing gone Hollywood. Science 355(6320):102, doi: 10.1126/science.355.6320.102
[5] http://www.usask.ca/water/lecture-series.php

aquatic ecosystem science, isotope hydrology and socio-hydrology. This lecture series provides GWF community including students, postdoctoral fellows, faculty, and staff with an opportunity to understand breakthroughs in various areas of water security from a global perspective and to network with international leaders. Each lecture is streamed live online and archived for subsequent access for the benefit of off-campus Canadian and international participants which further expands the reach of the lecture series. [Website]

2018 Distinguished Lecturers

9.3 Women in Water Lecture Series

The Women and Water Lecture Series, hosted by the Global Institute for Water Security, GWF - Young Professionals and GWF, will occur monthly from December to April. The series showcases research, support young professionals and provide a space for dialogue and networking. Additionally, the series explores water-related challenges, roles of women in water, gendered water-related impacts, women researchers in water, and challenges and opportunities facing female water researchers. [Website]

2019 Women in Water Lecture Series

9.4 Kananaskis Course on the Principles of Hydrology

The University of Saskatchewan Centre for Hydrology and the GWF with the assistance of the Canadian Society for Hydrological Sciences offered an intensive course on the physical principles of hydrology with particular relevance to Canadian conditions at the University of Calgary's Biogeoscience Institute's Barrier Lake Station in the Kananaskis Valley from January 10-21, 2019. The course was intended for hydrology and water resources graduate students and early to midlevel career water resource engineers, hydrologists, aquatic ecologists and technologists who are either working directly in hydrology and water resources or are looking to broaden their understanding of hydrological systems and processes. [Website-1; Website-2]

Students and Early Career Researchers and Water Resources Engineers

During this course, factors governing hydrological processes in Canadian landscapes were discussed including precipitation, interception, energy balance, snow accumulation, snowmelt, glaciers, evaporation, evapotranspiration, infiltration, groundwater movement and streamflow routing and hydraulics. These processes were framed within the context of distinctly Canadian landscape features such as high mountains, glaciers, peatlands, prairies, tundra, boreal forests, frozen rivers and seasonally frozen ground. Students were exposed to an overview of each subject, with recent scientific findings and new cutting edge theories, tools and techniques. They completed numerical and essay assignments to develop skills in problem solving and in synthesizing complex hydrological concepts. Field examinations in nearby environments and research basins enhanced the learning experience.

9.5 The 9th Annual Catchment Science Summer School

The Catchment Science Summer School is a 5-day short course that is intended for post-graduate students and post-docs interested in a hands-on catchment science curriculum, focusing on northern catchments, runoff processes and combined hydrometric, isotope/chemical tracer and modeling techniques in catchment hydrology. The learning objectives for this short course are to understand: [Website]

- Rainfall-runoff processes
- Rainfall-runoff model development, use, and testing
- Hydrochemical and isotopic measurement and analyses
- Linking field experiments with modeling approaches
- Evolution of empirical and theoretical understanding of runoff processes
- Landscape analysis, land-use and climate change impacts on streamflow

Photo Courtsey: Nino Amvrosiadi

Photo Courtsey: Sim Reaney & Bjorn Thomas

9.6 Isotope Tracers in Catchment Hydrology

Open to any graduate students in Canada (in-person or virtually via WebEx) registered for the full 3 credit course attended the week of lectures and participate in the class group project. This condense graduate course introduced graduate students and professionals to the principles of stable isotope chemistry applied to environmental research in the hydrosphere and biosphere. The course focused on the measurement, tracing, and linkage of light isotope abundances in and among hydrologic and biological components of earth system at the catchment scale. We specifically considered the application of stable isotope investigative tools to a variety of hydrological situations, ranging from water cycle dynamics, bio- and geochemical processes, nutrients and contamination, to isotope ecology. The course relied on several key textbooks, journal articles, as well as the research of the instructors. [Website]

9.7 Knowledge Mobilization Webinar Series

The GWF Knowledge Mobilization (KM) Core Team hosted a series of webinars to increase awareness about the value and principles of KM. Aimed at students, young professionals, researchers and Principal Investigators in the GWF network, the webinar series provided content that touched on various elements of KM, shared examples of successful initiatives in action, and discussed and troubleshooted common challenges that arised across the network. [Website]

Scheduled between November 2018 and April 2019, the webinar series facilitated:

- understanding of what KM is, what it isn't;
- how to engage specific groups of end-users; and
- help with your yearly reporting on KM outcomes.

9.8 World Water Day

All four partner institutions within the GWF network including USask (Saskatoon Campus and Canmore Cold Water Lab), Waterloo, McMaster and Wilfrid Laurier celebrated the World Water on March 22 in unison with the United Nations theme of “Leaving no one behind”. Our network believes in enabling water security by world-class research and training, science communication and science-informed policy with particular emphasis on equity, diversity and inclusion. This event was an excellent opportunity for our students and postdoctoral fellows to showcase their research, listen to our leaders on the significance of the World Water Day and the importantce of the UN Sustainable Development Goals, and also receive achievement awards. This year marked the inception of the Howard Wheater Lecture at the Global Institute for Water Security, USask. The innaugral speaker was Dr. Claudia Pohl-Wostl, Professor for resources management

and Deputy Director of the Institute for Environmental Systems Research at the University of Osnabrück, Germany. [USask, Waterloo, McMaster, Wilfrid Laurier, USask-Canmore]

Dr. Karen Chad, Vice-President Research, USask

Dr. Claudia Pahl-Wostl – Howard Wheater Lecturer

Student and Postdoctoral Fellows – Poster Competition

On World Water Day, Dr. Jay Famiglietti, Executive Director, Global Institute for Water Security and Canada 150 Research Chair in Hydrology and Remote Sensing was on expert panel organized by the Pew Charitable Trust and the US National Academy of Sciences, Engineering, and Medicine to discuss latest findings on the world's limited supply of fresh water-and what can be done. The Pew Charitable Trust is a US-based not-for-profit entity which uses evidence-based, nonpartisan analysis to solve today's challenges. The expert panel discussion is avaialble at: [Website]

Photo Courtsey: The Pew Charitable Trust

10. Significant Outcomes and Advances

10.1 National Flow Forecasting Workshop

GWF in collaboration with the Environment and Climate Change Canada (ECCC) organized the first ever national workshop on flow forecasting on February 20-21, 2019, which was attended by forecasters from all 10 Provinces and 3 Territories, and major hydropower utilities including BC Hydro, Manitoba Hydro, and ON Power Generation. The purpose of the workshop was to coordinate GWF and ECCC prediction efforts with those of the provinces and territories and also have open discussions on issues and needs.

Workshop led by Dr. Al Pietroniro (front-centre); Forecasters from 10 Provinces and 3 Territories

The following conclusions were derived from GWF's perspective:

- It would be useful to systematically share information on what practices are working, what information sources are becoming available and what improvements are needed. GWF could help to facilitate such regular discussions in the future and in-person meetings are quite valuable. We are happy to consider this the "user group" for the Core Modelling and Prediction Team.
- There seems to be common needs for specialized information on river ice dynamics and snowpack – for snowmelt driven and rainfall-on-snow driven flow events and water supply forecasts. GWF has new instruments – snow sonar, Airborne LiDAR, UAVs and is developing a satellite with GNSS that may help and can ask Karl-Erich Lindenschmidt to further focus efforts on river ice prediction.
- It would seem that a common and more efficient approach to data flow and characterizing river basins for model setup and parameterization could be useful and we would be interested in contributing to this.
- GWF will work toward enhancing models for forecasting systems and is looking for partnerships to test and implement these systems for the provinces, industry and ECCC. In some cases a cooperative river basin basis would be efficient and effective to

adopt for transboundary waters and we can work with all parties to help that happen. We also are keen on feedback as to what systems are needed and how things are working.

10.2 Water Security for Canadians

As the country faces increasingly extreme floods, droughts, fires and water pollution events that are hammering our infrastructure and economy and affecting the wellbeing of millions of Canadians each year, the GWF program and partners convened a national discussion on the future of water security in Canada on April 11, 2019 in Ottawa, ON. This event brought together more than 80 water and climate scientists, policy experts, legislators, and water decision rightsholders and stakeholders.

The meeting was opened by a Kenote from Honourable Minister Ralph Goodale, Minister of Public Safety and Emergency Preparedness who spoke about the ongoing effects of climate change on the Prairies' valuable water and soil resources threaten the ability of farmers and ranchers to continue to grow high-quality crops and raise world-class herds.

Panelists spoke to the scientific evidence of the worsening water sustainability and climate-related water crisis in Canada, and the science and policy solutions needed to adapt to the new climate and water realities across the country. All participants contributed to a timely discussion on how to create a better, safer and more secure water world for ourselves and for our children, while positioning Canada as an international leader in global water security expertise, science, prediction and advice.

Honourable Minister Ralph Goodale

GWF Science Panel

This event was co-hosted by: Global Water Futures, University of Saskatchewan, the Forum for Leadership on Water (FLOW), the Centre for Indigenous Environmental Resources (CIER), the POLIS Program on Ecological Governance (POLIS), and the United Nations University Institute for Water, Environment and Health (UN University).

For additional information and recording of the entire event, please visit [Website]

10.3 European Union Observation Program – Copernicus

An important international connection for GWF is with the European Union's Earth Observation Program Copernicus. GWF defines 'knowledge mobilization' as the process of moving knowledge from formal research into active use - this is precisely the mission of Copernicus, which acts as a central European data hub to support decision-making around the sustainable management of resources. With the support of partners such as the European Space Agency, Copernicus combines satellite and in-situ (on the ground) data in convenient indicators to help researchers, policy analysts and practitioners understand past and future trends. All information is provided free and open access to anyone who wishes to use it.

Specifically, Copernicus provides information support services focused on six themes – atmosphere, marine, land, security, emergency and climate change. The Copernicus Climate Change Service (C3S) is the most recent of these, coming online operationally in July 2018. C3S aims to support climate change adaptation and mitigation by providing reliable, open access information about climate change, and works with end-users to refine products to meet the needs of decision-makers and partners. A recent C3S product showcases regional projects to demonstrate best practices around user uptake of high-impact and relevant climate information from the C3S Climate Data Store. The Canadian showcase features GWF and work by Integrated Modelling Program for Canada (IMPC) researcher Dr. Tricia Stadnyk. Dr. Stadnyk's work uses the Hydrological Predictions for the Environment (HYPE) model to explore uncertainty in projected streamflow under future climates. Additional information is avaialble at: [Website]

10.4 Occasional paper – Global Fire Challenges in a Warming World

The International Union of Forest Research Organizations and the World Bank's Program on Forests jointly convened a Global Expert Workshop on Fire and Climate Change with the aim of improving the understanding of the complex interrelations between wildfire, climate, and land management, and of identifying urgently required response strategies and actions. Subsequently an Occasional Paper was developed, which was co-editted by Dr. Mike Flannigan, University of Alberta who is one of the GWF investigators associated with the Boreal Water Futures project.

10.5 Significant Technical & Scientific Advances

This section outlines the significant technical and scientific advances and knowledge mobilization initiatives by 39 funded GWF projects and Core Teams.

10.5.1 Core Teams

Core Team – Computer Science

The core computer science project will focus on creating a common platform for scientists from various disciplines and different universities/institutes to work together. The focus on the first 3 years will:

- A GWF computing platform to support hydrological modelling.
- A set of tools and approach to support migrating existing modelling tools to the new GWF computing platform. As a proof-of-concept, CRHM will be migrated.
- An approach for accelerating hydrological models.
- Tools that support interactive visualization.
- A data management environment.

Progress

Project 1: Software Reference Architecture and Platform for Hydrological Modelling and Project 2: Software Co-evolution (Lead: Kevin Schneider and Chanchal Roy) (Note that we integrated the reporting on these two projects since the same HQP are involved in both)

The project team developed a strategy for migrating CRHM based on a detailed analysis of thee modelling tool and using input from an initial reference architecture that was developed based on an analysis of existing scientific platforms and tools. Migration of CRHM to a modern computing platform was initiated and is 65% complete. CRHM is a state-of the-art legacy software tool in North America for generating hydrological cycles for cold regions which differ both naturally and operationally depending on geographical locations, environmental variabilities or parameters throughout the world. Canada's hydrology produces one of the most complex cycles known to us. CHRM is designed keeping this variability in mind. Migration became essential for the system as the Borland C++ compiler is outdated. We have been working on producing the next generation CRHM. We have adopted different migration strategies, including separating code between Core and GUI components, developing a console version of CRHM 2018 that runs in a standard C++ environment, and creating APIs to access CRHM core data structures, remove Borland dependencies and minimize MFC dependency. We have partially migrated CRHM Borland to Microsoft Visual Studio C++ 2017 version where different functionalities are working (such as opening, and viewing projects in T-Chart, saving and closing projects, constructing a new project and macro functionality for combining and changing existing projects). We are also working on developing an automated testing framework to make sure CRHM is working as expected which includes unit testing, system testing and user acceptance testing.

We have been working on restructuring CRHM to a new software architecture. This architecture is based on a cloud-based scientific workflow management system which allows adding a hydrological model or module as a plugin, reduce inter module dependencies and establish workflow provenance for error tracking and monitoring. When next-gen CRHM will be developed following the architecture, users will not need to install any software tool to run their simulations. We will also support high performance by integrating CRHM with distributed environments such

as Apace Beam and Spark. We expect that this integration will allow users to run a project with many HRUs (~29000) considerably faster than the current setup.

The time to train new CRHM developers was considerable, and to address this we built a reverse engineering tool for new developers that helps them better understand the usage of the system and its architectural components. Using the tool, we aim to transfer knowledge from our expert software engineering team to new CRHM developers. Our analysis and preliminary user study show that our approach can effectively answer developers' questions to understand CRHM at an architectural level. Next steps involve a more in-depth study of other hydrological modelling tools and environments in collaboration with the core modelling team.

Project 3: Hydrological Model Acceleration (Lead: Ray Spiteri)

Canada's water resources span an enormous range of geography, climate, and ecosystems. The need to make sound decisions and forecasts for water resource management drive the need for advanced models and supporting software. The Global Water Futures at the University of Saskatchewan has a scalable and common software framework for model simulation called the Canadian Hydrological Model (CHM) as part of the next-generation core modelling.

The CHM is presently being used for relatively small geographical extents, on the order of 100,000 km^2. To scale to the domains of interest for GWF, including Western Canada as well as pan-Canadian, the currently employed shared-memory parallelism using OpenMP is to be migrated to distributed-memory parallelism using MPI.

Various updates to the Canadian Hydrological Model (CHM) code involving: module organization, mesh restructuring/reordering, and mesh partitioning to distributed systems. In addition to that we did CHM tutorial/setup documentation, are obtaining baseline performance characteristics of CHM. Moreover, gained expertise in distributed linear algebra and abstracted memory models being extended (Tpetra/Kokkos).

Project 4: Interactive Visualization (Lead: Jyoti Mondal)

The interactive visualization team proposed to develop exploratory visualization frameworks to visualize the existing hydrological and environmental data, as well as the model predictions. The goal is to leverage browser-based visualization technologies to answer user queries in interaction time. Such a web-based platform will be able to connect the users in real time, help support better decision making and planning, as well as improve the understanding of the underlying hydrological models.

Researchers in GWF use the Weather Research and Forecasting (WRF) simulation data (about 1TB) stored in Compute Canada for their research. We have recently been able to successfully analyze and visualize the data in an interactive web platform. Previously, there was no visualization tool available to visualize these datasets. One reason is the huge size of the dataset

and the other is that the users had to download the dataset from the server for further exploration. To cope with this challenge, we have so far exploited two approaches: (a) Precomputing image tiles and storing them into appropriate data structures such that they can be retrieved and patched to construct the on-demand visualization. (b) Developing a machine learning model that can learn the climatic parameters, and then create an auxiliary dataset using dataset samples such that the missing datapoints can be predicted based on those machine learning models. This will significantly reduce the data-storage requirements.

The following are snapshots of our current development prototype using approach (a). The users can login and save individual comments, explore the surfaceplot of the individual variables, filter the dimensions, all in an interactive web-platform. We are currently working on making this as a full-fledged platform for the use of researchers as well as for general public.

During our exploration towards the web-platform and the user interface, we have achieved many technological advances. These findings have recently been published as refereed papers.

▲Fig 1: User Login, Contour Plots, Parallel Coordinates, and Control Panel

▲Fig 2: The change in the geospatial locations covered by different ranges of soil moisture (SMOIS)

The following are the snapshots of our current development prototype using approach (b). Preliminary investigation of this machine learning approach shows promise in predicting missing values and reconstructing original images.

a (Original- 2014) b (Predicted- 2014) c (Original- 2015) d (Predicted- 2015)

In addition to visualization, we are also contributing towards the scientific visual analytics. To help researchers find out the correlation between multiple parameters using aesthetic symbols, color blending, and textures.

Project 5: GWF Cuizinart (Lead: Jimmy Lin)

As the GWF Cuizinart moves into production and is made available to members of the GWF community, we will be ingesting more datasets into the backend – based on availability of source data that meets formatting requirements, the amount of interest in having access to the dataset, and other resource constraints.

- We will be exploring different backends for the GWF Cuizinart. In addition to the current SLURM-based backend, we are exploring PySpark.
- As the GWF Cuizinart gains broader usage across the community, we will be analyzing usage logs as a way to better understand researcher needs and to further refine the platform.
- To complement GWF Cuizinart, and in coordination with the core Data Management team at the University of Waterloo, we will be developing a visual metadata browser for collection-level metadata.
- We plan to further explore machine-learning techniques, in particular neural networks, to model various hydrological processes of interest, to complement existing modelling efforts.

Core Team – Communications

Engaging with Canadians through news

- Total GWF news story reach: 480.4 million* readers of 1,300 stories (2018-19)
- Top stories:
  - "Study finds rapid change in Earth's water supply" |*The Globe and Mail* | May 16, 2018
  - "How flood maps can protect your home" | *The Globe and Mail* | Apr. 23, 2019
  - "Root of change: Tree rings reveal 120 years of human influence on climate"| *The Globe and Mail* | May 1, 2019
  - "Six Nations water in focus at Mac conference" | *The Hamilton Spectator* | June 2, 2018
  - "Fortified Arctic infrastructure needed in face of climate change, study finds" | *Vancouver Sun* | Jan. 17, 2019
  - "Warming worse on Prairies: Federal scientists say urgent action needed to avoid 'effectively irreversible' changes" | *Winnipeg Free Press* | Apr. 2, 2019
  - "The new wildfire season"| *CBC Radio* Calgary (syndicated) | Apr. 8, 2019
  - Also: *CBC News*, *National Post*, *Maclean's*, *Ottawa Citizen, Saskatoon StarPhoenix*...

*Cision | Apr 5, 2018 – May 7, 2019

Fostering a national conversation on water security

- 25 USask and partner news releases (since Jan. 2018 alone)
  - Nearly all picked up through national and international news outlets
  - Promoted through Twitter, eNews, etc.
- Building national and international profile through paid and advertorial
  - Full-page advertorial in National Post, Ottawa Citizen, Hill Times, highlighted GWF achievements (Nov. 2018)
- Articles in *The Conversation* – national academic newswire, including

    - "As a Water Crisis looms in Capetown: Could it happen in Canada?", *Pomeroy,* – picked by Maclean's, **>53,000 "reads"**
    - Andrew Slaughter, several articles **> 65,000 "reads"**
    - Grant Ferguson article on groundwater supply in U.S. – **>6,400 "reads"** (PBS picked it up)
- GWF on Twitter
    - >1.4K followers
    - >1K tweets
    - >1K likes

Building stakeholder awareness

- GWF eNews
    - Bi-monthly distribution
    - 1,600 subscribers
        - 56% increase in readership in 2018
        - Approx. 50% open rate
- Promotional videos
    - General, thematic and institutional videos on GWF research and researchers
- GWF Lecture Series (all ongoing)
    - Women and Water Lecture Series
    - Distinguished Lecture Series
    - Knowledge Mobilization Series
- GWF Exhibits
    - American Geophysical Union (December, Washington, D.C.)
    - Canadian Water Research Assoc. (September, Saskatoon)
    - Water Week (November, Waterloo)
    - Water Security Conference (July, Toronto)
    - GWF Annual Science Meeting (July 2018, Hamilton and Six Nations, and May 2019 in Saskatoon)
    - World Water Day (March 22 across Canada)
- Information sessions for government
    - September visit (USask) of Minister Jonathan Wilkinson and Liberal water critic Francis Scarpaleggia
    - April forum on Water Security for Canadians (Ottawa) with Minister Ralph Goodale *(Global TV coverage, iPolitics)*
- Highlighting GWF engagement with Indigenous communities
    - Six Nations news releases stories, and
    - 6 new GWF Indigenous co-led project announcements
    - Connections with Wanuskewin Heritage Park during 2019 Annual Science Meeting

Core Team – Modelling and Forecasting

The modelling core project focuses on creating a common platform for scientists from various disciplines and different universities/institutes to work together. The focus in the first 3 years are to:

- Develop and apply new coupled modeling systems that integrate regional climate, land management, hydrology and water management over climate change sensitive regions.
- Improve models with the capability to explore and assess how changes in population, economic development, and land use will impact water resource management and water quality, in addition to climate change.
- Determine how state-of-the-art model scenarios and predictions can be best framed to inform decision making, policy and adaptive governance for the management of risks from hydrological change to water resources.

The research will further facilitate development and implementation of various plans and activities to diagnose and predict change in cold regions based on implementation and operation of high-resolution climate and weather models for both forecasting purposes and long-term prediction of climate change. This will support flood, drought and streamflow forecasting models and inform predictive models for the diagnosis of change in hydrological, water quality, snow, ice and water management systems. Over the 3-year period of this programme, the core team will process, analyze, manage, and visualize exceptionally large quantities of data to inform computer

Figure: Major Large Scale Basins For Hydrology Modelling

modelling and analytical tools for water-related disaster warning, prediction of future water flow and quality and to provide the quantitative support for adaptation to climate change and associated risk management.

The figure above highlights the Major basins for which we will carry-out the core modelling and that contain the hydrological observatories (not shown). Table 1 describes the general modelling approach being developed for all these major basins.

Table 1 - Major Deliverable Core Modelling Team

Activity	Year 1	Year 2	Year 3
Assessment/improvement of GEM,WRF, CRHM, MESH,VIC,HYPE and CHM models			
Model run validation and sensitivity test			
Optimization and Rigorous Uncertainty Assessment of GEM,WRF(NOAH-MP), CRHM, MESH, VIC, HYPE and CHM Model Parameters and Data			
Implementation of Flood, Drought and Seasonal Flow Forecasting Systems using GEM-MESH with data assimilation			
High-resolution WRF Climate Models for Canada, Scenarios of Change			
Assess and optimize chained biogeochemical watershed-lake modeling platform			
Assess and test statistical models for lake algal bloom prediction			

Atmospheric Modelling Outcomes: The purpose of the atmospheric modelling experiments were to provide the necessary and best possible forcing for current and potential climate futures. Expected outcomes from Atmospheric simulations were highlighted in the inception report as follows:

1. Core model forcing data (production runs)
    a. CAPA real-time analysis and archive
    b. Ensemble GEM forecasts (archived by McMaster)
    c. Ensemble Seasonal Forecast (GEM)
    d. WRF Pseudo-climate runs for Canada
    e. WATCH, ERA-Interim and other reanalysis data
2. Core modelling requirements for improved model forcing
    a. High RES implementation of GEM in the mountains for forecasting purpose
    b. HIGH RES WRF simulation in an analysis mode
    c. HIGH-RES WRF pseudo-global warming.
    d. Statistical downscaling of analysis and pseudo-analysis products for application

Key accomplishments are as follows:

- As of the end of Year 2 (March 31, 2019), CAPA real-time analysis is being provided and used as an ECCC operational product and is made available to investigators. GWF core in partnership with FLOODNET is archiving all ECCC GEM forecast and making these available to investigators through the CaSPAr platform developed under FLOODNET by University of Waterloo and McMaster University. Further development of CaSPAr through the University of Waterloo core modelling and computer science team has resulted in the "Data Cuizinart" that will allow investigators to retrieve all atmospheric re-analysis runs include already available ERA, WATCH and other re-analysis data. The core team at University of Waterloo ensures that NetCDF data distributed through the Cuizinart fulfill CF-1.6 standard and hence might require reformatting of the original data.
- The production runs for Western Canada using WRF and WRF PGW were completed by the U of S atmospheric modelling team. These atmospheric simulations consists of two climate scenarios: the current climate (CTL) from 2000-10 to 2015-09 and a pseudo-global warming (PGW) scenario representing the condition of 2085-2100 under RCP8.5 climate emissions scenario. These data are usable through the Data Cuizinart Platform. The U of S team also re-configured WRF-CONUS(2000-2013,CTL,PGW) to be compatible with the Data Cuizinart. This includes bias-correcting the WRF-CCRN (2000-2015) output using GEM-CaPA.
- Numerical experiments with GEM and GEM-Hydro using dynamically downscaled high-resolution information for analysis of the Calgary 2013 flood were also carried through the core efforts.

Further refinements of WRF and GEM will continue into year 3, including 1-KM GEM runs evaluated for Western Canada through ECCC. We also anticipate further work on bias-correcting WRF runs and WRF PGW for climate change analysis.

All deliverables are being met or exceeded. As such, we are proposing additional work as well as restructuring of deliverables for year 3 and beyond, subject to approval by the GWF SMC and management. Future plans are presented in Part 3 of this report.

Hydrology, Water Quality and Water Management Model Outcomes

Given the scope and focus of the program, hydrology models are the largest group of models and can be broken down by type in order to better explain the role of the systems, what they will be used for, how the various platforms will be consolidated and various hydrology non-point and water quality models will be enhanced. Hydrology models are broken into 3 distinct types, all being developed with the core framework. Brief updates on each of the proposed modelling systems are provided in the inception report but listed below.

Large Scale Hydrology-Land-Surface Schemes/Systems

MESH including GEM-HYDRO: Large-scale modelling was carried out on most of the major basins across Canada, with efforts focused on forecast experiments, production runs and model improvements. The largest focus for the last 2 years was on **Mackenzie and Saskatchewan-Nelson systems where both MESH and HYPE** models have been successfully implemented. ECCC has implemented GEM-HYDRO in a quasi-operational model on the Great-Lakes regions and the stand-alone MESH model is currently being evaluated in the Great lakes domain. An **Amazon-cloud prototype MESH forecast** system for the Yukon river basin was also established. Three-day ensemble forecast are issues daily using GEM ensemble precipitation forecast

Process improvements in the model suite were required in order to make them work adequately in these basins. There was a large focus on developing **permafrost algorithms in MESH** for the Mackenzie basins, including changes to the MESH code to extend the soil domain to 50 soil layers as well as changes in the permafrost parametrizations. In a similar way, the necessary model enhancements to improve modeling in the Saskatchewan system include **reservoir management and abstractions due to irrigation**. Historic production runs for both the Mackenzie and Saskatchewan-Nelson basins have been completed and analyzed. This includes optimization and sensitivity analysis. Similar historical analysis using MESH was completed as part of the Yukon forecasting prototype.

The development of MESH has also focused on improving the representation of mountain hydrological processes. MESH now represents slope and aspect in addition to land cover as a computational unit. The work requires distribution of grid forcing (incoming solar radiation, longwave radiation, temperature, pressure, and specific humidity) inputs for every grouped response units (GRUs) based on already developed formulas and equations using the average slope, aspect, elevation and difference in elevation between the forcing level and the elevation used to setup the model. These techniques are also being evaluated in the Red Deer and Simonette River basin. **The existing MESH** -Glacier components are being fully evaluated and tested on the Mackenzie and Sask-Nelson basins. Efforts are also focused on improving the existing PDMROF versions of MESH dealing with non-contributing area problems in the prairie pothole regions

Research has also focused on large-scale integrated modeling efforts**.** A **stream water temperature** model was coupled with MESH (the River Model Basin [RBM] model developed by the University of Washington in USA). This required building a Python interface to transform MESH input and output data into the input information required by RBM. Efforts have also been focused on developing a new **solute transport software for large-scale cold region basins for MESH**. Furthermore, progress was made on generating 10-day streamflow forecasts, using the Global Deterministic Prediction System (GDPS) as input to MESH to develop a **real-time ice-jam flood** forecasting system for the Athabasca River basin. A new physically-based **sediment transport model** was developed to estimate overland and in-stream sediment transport for large

scale cold region basins. The new model performs on the MESH computational grid and estimates the concentration and the erosion/deposition at every cell and at every time step.

GEM-Hydro, MESH-SVS and MESH-CLASS have been setup over the Lake Erie watershed to participate in the IMPC model intercomparison subproject.

VIC (Variable Infiltration capacity Model): Efforts were focused on developing a hydrologically-focused implementation of VIC. This included adding Grouped Response Unit approaches [**VIC-GRU**] (including utility codes) and coupling VIC with a vector-based routing scheme (Raven). The VIC efforts also focused on developing visualization tools and pre-processing tools.
VIC-GRU and the original version of VIC have been setup over the Lake Erie watershed to participate in the IMPC model intercomparison subproject.

NOAH-MP: A simple groundwater model has been implemented in the community Noah LSM with multi-parameterization options (the Noah-MP LSM) (Niu et al., 2011), by adding an unconfined aquifer at the bottom of soil layers, to reasonably capture the groundwater regime in the prairie pothole region under semi-arid and seasonally frozen soil climatic conditions. This coupled LSM-GW has the ability to address the two-way exchange between soil and groundwater as well as representing the freeze-thaw process. This deterministic distributed physical process-based LSM (Noah-MP LSM) coupled with the groundwater dynamics model, can be further coupled with the Convection-permitting high resolution Weather Research & Forecast model to study of the impact of climate change on local wetland distribution, ground water responses, etc.

Others: WRF-Hydro, i.e. the National Water Model used in the USA, has been setup over the Lake Erie watershed in collaboration with the NCAR and the University of Michigan. The Soil Water and Assessment Tool (SWAT) was setup over the Lake Erie watershed by the United States Environmental Protection Agency (EPA). The WATFLOOD model was setup by ECCC over the same watershed.

All three models participate in the IMPC model intercomparison subproject.

Deterministic Process-Based Hydrological Models

CRHM: CRHM modelling work has focused on developing and applying hydrological model to **headwater basins in the Canadian Rocky Mountains.** The primary focus of that is on evaluating physically based algorithms for small research basins including the **Marmot Creek Research Basin and the Fortress Mountain Snow Laboratory** in the front range of the Canadian Rocky Mountains. A secondary focus is to apply these algorithms to headwater basins such as **Upper Bow River** and **Elbow River** basins at Calgary.

Work has also focused on using CRHM to investigate the response of hydrological processes to climate changes in the **White Gull creek (WGC)**, a boreal forest basin in Canada. The WGC has an area of 602 km^2, and around 80% of the basin area is covered by boreal forest. The elevation

ranges from 470 to 690 m a.s.l.. The forest has significant effects on the snow processes such as snow interception, snow sublimation and snowmelt, which play an important role on shaping the timing and magnitude of the basin hydrograph.

A **Prairie Hydrology model (PHM)** has been developed an implemented in CHRM, and is being tested and evaluated on small prairie sub-catchments such as Smith Creek (southeastern Saskatchewan) and the Vermillion (east-central Alberta) and Camrose Creek (central Alberta).

CHM: CHM development continues to focus on snow predictions in the Canadian Rockies, inclusing significant work on the **Snowcast system** currently running over the upper Bow catchment **(http://www.snowcast.ca).** ECCC is currently running a version of GEM at 1-km over Western Canada. This model presents a large potential for mountain snow hydrology but its ability and limitations still need to be addressed. GEM-1km could be used as input to CHM over the Snowcast domain to determine if it leads to improved snow prediction compared to the versions of GEM available at lower resolution. In addition, so far, the Snowcast system is running without any assimilation of snow data. High-resolution satellite images from Sentinel 2 and Landsat present a strong potential to improve snow simulations. Therefore, a data assimilation framework should be developed in Snowcast.

Conceptual Hydrological Modelling systems

HYPE: Large-scale modelling with HYPE was carried out on most of the major basins, with efforts focused on forecast experiments, production runs and model improvements. The primary focus for the last 2 years was on the Mackenzie and Saskatchewan-Nelson systems where both MESH and HYPE models have been successfully implemented. HYPE for water quality modelling on the Beaver watershed - Lake Simcoe, Ontario was also carried out. This work focused on model setup, diagnosis and testing its efficiency (2003-2017). The water quality model (phosphorus) has been setup, and the sensitivity and parameter identifiability analyses have been carried out. Currently propagation of the hydrological uncertainty to the water quality model is being evaluated. HYPE has been setup over the Lake Erie watershed to participate in the IMPC model inter-comparison subproject.

Groundwater Models: Over the course of the last year, the Waterloo team worked on expanding a modeling framework that would simulate ice expansion induced mechanical damage on buried pipelines during freezing conditions. They developed a fully coupled thermal-hydraulic-mechanical model for moisture migration, heat transfer and pore ice formation in partially frozen variably saturated soil. The model structure was tested by building synthetic 2D transect model with typical scenarios tailored for freezing soil conditions in southern Ontario areas. The model will be applied in freeze-thaw scenarios within the discontinuous permafrost terrain with a specific focus on the role of partially saturated conditions, which are not classically considered in this type of application. The model framework can accommodate vapor flow and ice lens growth as well.

Others: The Large Basin Runoff Model (LBRM) has been setup by the US Army Corp of Engineers over the Lake Erie Watershed. GR4J has been setup in the Raven modeling framework for this watershed as well. Both models participate in the IMPC model inter-comparison subproject.

Water Quality Models

CRHM/MESH-WINTRA: Efforts on CRHM/MESH_WINTRA focused on three main challenges. The first activity consisted of an experimental-modeling effort to improve the modelling of snow chemistry and plant residue leaching processes (lab experiments and mathematical model/algorithm developments). The second activity was focused on developing water quality modules for CRHM. The third activity entailed the repurposing of a hydrodynamic and water quality river-aquifer model **(CRHM-FLUXOS)** to simulate snowmelt events and the associated nutrient transport in prairie environments. This work aims to support current research in prairie hydrology and biogeochemistry.

WASP: WASP model development has focused on collaboration with a pillar 3 project focused on the Grand River water quality assessment model. The core team has developed tested and evaluated a HEC-RAS hydraulic model (1-D) for the Grand River starting in the upper reaches of Waterloo to just past the six nations reserve. The hydraulic parameters derived form HEC-RAS were used as input into WASP, to drive the travel time and dispersion model. Work direct coupling the HEC-RAS and WASP in a continuos simulation models is being examined. Preliminar runs of WASP for the Grand River have been started.

ELCOM-CAEDYM (Lake Model): University of Waterloo staff have applied, calibrated and validated a 3-D coupled hydrodynamic-biogeochemical model for Lake St. Clair (ELCOM-CAEDYM: currently known as AEM3D). Researchers used the Lake St. Clair 3-D model to illustrate the spatial and temporal importance of nutrient loads for their within-lake transport, retention and their downstream export to Lake Erie for major watersheds (e.g. Thames, Sydenham and Clinton river watersheds). They also improved a 3-D coupled hydrodynamic-biogeochemical model of Lake Erie (ELCOM-CAEDYM: currently known as AEM3D) by refining the horizontal spatial resolution of the model domain (1x1 km) and increasing number of the tributaries (similar to those as in chained box and 1-D models).

Water Resource Modelling

The development of water resources modelling capabilities targets water resource management and decision making issues at a range of scales from local (e.g., systems with one or a few reservoirs) to large-scale, river basin systems (e.g., the Saskatchewan River Basin system). It provides tools to simulate the operation of the human-driven components of watersheds, including reservoirs, diversions, and irrigation, and unify these with the models of climate, hydrology, water quality, and hydro-economy. **MODSIM-DSS and WEAP** are the two main modelling platforms that were used. The basic principles of these two modelling platforms are essentially the same, while they have several differences in implementation and operation. They are both equipped with a scripting capability that provides flexibility to tailor the models to the

needs of Canadian watersheds. On the basis of these two platforms, GWF is developing its own water management code that are compatible with the general GWF modelling strategy.

Activities over the last two years focused on water management models for the Saskatchewan River Basin (SaskRB). This has involved setting up models for the different parts of the SaskRB, the Saskatchewan and Alberta portions, for which the models could be validated against existing **WRMM** setups, and the Trans Alta, Highwood Diversion and Southern Tributaries portions, for which little data were available and much of the operating policy and water use data had to be inferred from various sources and reports. These different portions of the SaskRB have now been completed and validated using multiple models. The last portion of the **SaskRB** that needs to be modelled and which we are currently working on is the North Saskatchewan. The resulting product will be an integrated model for the SaskRB. Other work includes extending the applicability of **VARS** model to water management issues. The objective of this research is to provide VARS with new features, including: (1) the ability to handle non-uniform distributed input variables and (2) the ability to deal with correlated variables. The new VARS model (called generalized VARS, or GVARS) has been coded in MATLAB language and tested with several test functions and models. Validating the GVARS package and planning to **apply the new GVARS package to the MODSIM Saskatchewan River water management model to evaluate the robust adaptation** of the Saskatchewan River Basin under climate change uncertainty and human interaction.

Core Team – Data Management

The past year has been transitional for the GWF Data Management (DM) core team. As the team membership has been solidified, work began on developing the foundation of the data management strategy of GWF.

Data Management Retreat: The Fall 2018 Data Management Retreat was held to allow the team to meet and get to know each other and to build a common understanding of the GWF Data Management strategy. The retreat was graciously hosted by the University of Waterloo on October 29-30 and November 1, 2018. The most prominent agenda item was the interpretation and implementation of GWF Data Policy (old policy adopted on March 1st, 2017), and how data management could be synergistically executed among the four universities. The following are outcomes of this retreat:

- **GWF Data Policy Review:** A section-by-section review of the GWF Data Policy was completed to assess how it meets the current and future needs of GWF researchers, as well as other issues related to the GWF DM Framework.
- **GWF Data Management Strategic Planning:** The GWF DM team discussed and identified short-term and long-term goals for the GWF Program. Short-term goals included: (1) data policy clarification, (2) identification of central system/central repository framework, (3) development of GWF DM Services List, (4) project level metadata development, and (5) Identification and Evaluation of Centralized Metadata Catalogue. These short-term goals support the long-term goals of: (1) development of metadata catalogue, (2) accessible data (by using trusted storage systems and repositories), (3) software repository

development, (4) journal publication catalogue development, and (5) providing DM documents for best practices.

Management of Data throughout the Research Lifecycle

a) **Planning**
   - The GWF Data Management Plan template, based on the default DMP Assistant template from Portage, is available in Appendix A of the data policy. The DM team has and will continue to work with research groups to develop data management plans consistent with the data policy.
   - Customization of the Portage DMP Tool is being explored so that questions can be tailored to enhance the usefulness of the Portage DMP Assistant for GWF researchers.

b) **Description/markup (metadata)**
   - Extensive work was done on developing a GWF metadata template. This template has been modified and used but a final template is forthcoming.
   - Basic metadata collection is underway. This information will be used to populate the GWF web portal.

c) **Storage / backup**
   - Various storage options have been identified/provided to researchers at the GWF partner institutions.
   - Research was conducted, and is ongoing, on the feasibility of using Compute Canada resources (available to all GWF researchers both with and without access to the Compute Canada GWF allocation) more broadly to store data in the active research lifecycle.

d) **Security and Access**
   - Data Managers have discussed appropriate storage resources, ethics requirements and access management with various projects. There is a great deal of diversity in the needs and capacity among the projects and institutions. Further work will be carried out to develop a framework that identifies types and points of risk, as well as mitigation measures and opportunities in 2019/2020.

e) **Training – Workshops:** The DM team hosted several workshops for researchers that included:
   - Data management workshops for the HQP of Prairie Water (23 October 2018; Title: GWF and Data) and IMPC (29 November 2018; Title: Capacities of the USask-GWF Data Management Team to Support Modellers).
   - Research Data Management workshop (28 May 2018) for the NWF (Northern water Futures) researchers and their HQP (Highly qualified personnel) to educate them about standards and best practices of research data management.
   - Research Data Management workshop with a focus on Metadata for the NWF HQP (24 October 2018)
   - Research Data Workshop for HQP of McMaster led projects (8 February 2019)

Data Governance

a) **Define Best Practices and Processes**
   - **Revised GWF Data Policy:** In Jan-Feb 2019, the team reviewed proposed revisions to the GWF Data Policy, and provided substantial recommendations and amendments

of the policy in a multi-university collaborative environment. The revised policy was approved by the SMC in March 2019. Within the revised policy, many of the requirements and skeleton data management processes have been identified. The next step will be to operationalize the policy through the development of easy to follow processes.

- **Metadata Templates:** The DM team spent a considerable amount of time discussing and drafting a metadata template based on existing schemas to be implemented across the entire GWF Program. The main challenge in this was reaching a consensus on the content such that a balance was reached between the "ideal" metadata and that which could be completed with reasonable effort by researchers. The standard has not yet been finalized. Consequently, during the 2018-2019 fiscal year, each university used their own template or a modified version of the proposed GWF template to collect their metadata from their respective institution.
- **Reporting Templates:** The team developed a reporting template to facilitate the measurement of progress of GWF projects towards their data management requirements. The reporting template will serve as a point of researcher/project engagement and will provide a consistent means of assessing the data management health across projects. This will also serve as a starting point from which we can offer assistance as we work to continuously improve the data and our service provision.

b) Formalize a Structure of Roles and Responsibilities

- **GWF DM Services List:** The DM team developed GWF DM Services List, which outlines various data management services of the GWF DM team, the benefits they bring to the GWF program, and the expectations of the DM Team and GWF researchers. Details of the list are available in current GWF Data Policy.
- **Responsible Data Manager:** Each GWF project has been matched with a data manager. That data manager will be responsible for communications with the project group and assisting them with data management.

c) Communications

- **GWF Data Portal Updates:** The DM team started to update the map on the data portal. Some additional pages have been added. These include a dataset publications catalogue, and a forecasts page which provides links to forecast data. In addition, we continue to operate and maintain a telemetry website to display the near real-time data.
- **WIKI:** Preliminary work has been done on a McMaster wiki space to house information on general data management and resources. The content will be migrated to a USASK wiki space (https://wiki.usask.ca/display/GWFDM), created by the DM team in May 2019. The USASK wiki space will serve as a resource for GWF researchers. The space is editable by all data managers and we will continue to develop and update its content.
- **Outreach:** The DM team conducted outreach regarding data management both within and outside of local institutions. These were:
    - Peterson, A. (2018). WISKI and the GIWS and Global Water Futures. Canadian WISKI User Group Workshop, Edmonton, Canada, January 19.

- Peterson, A. (2018). Overview of GWF Data Management Activities and Framework. Canadian Water Science Workshop (GWF-NRCan-ECCC-AAFC), Ottawa, Canada, November 27-28.
- Dukacz, K. (2018). Panellist for discussing research data management challenges and the impact of the pending Tri-Agency Research Data Management policy. McMaster Research Data Forum, Hamilton, Canada, December 12.
- Peterson, A. (2019). Data Management Team Advances. GWF Operations Meeting, Saskatoon, Canada, January 22-23.
- Mai, J. (2019). The Cuizinart – Example of cooperative tool development. GWF Operations Meeting, Saskatoon, Canada, January 22-23.
- Mai, J (2019). CaSPAr and Cuizinart - EPS tools for hydology. Workshop on Flow Forecasting, Vancouver, Canada, February 19-20.

Data Stewardship

a) Managing Data Assets

- A review and analysis of systems and resources for the management of data assets is being undertaken. To date the activities around this topic include:
  - **Compute Canada Users Survey:** A survey of the users of the GWF allocation on Compute Canada was conducted in December 2018. This survey provided necessary information for us to complete the annual progress report. Information from the users included their past and future usage of the storage and computing resources, and what they are using the resources for. The survey was fairly successful with a completion rate of 90%. This method would be recommended for gathering the information for next year's annual report.
  - **Central Storage – Timeseries Data:** WISKI is the software used to store, provide preliminary cleaning, and share the timeseries data. We continue to receive and host data from the legacy CCRN and USASK stations that now continue under the GWF program. The DM team will work to bring data from the new GWF stations into WISKI.
  - **Central Storage – Samples Data:** There are two software programs that are being considered as options for storing water quality data. Aquarius was evaluated in Spring 2018. Researchers reported concerns about control over access and the strict input format. Kisters gave a demo on how water quality can be stored in WISKI in April 2019. The DM team will consult with GWF researchers to choose one of those software for developing a GWF-wide central repository for samples data.

b) Preservation and Discovery

- **Dataset Publication:** We have been promoting dataset publication to make data accessible in the long-term. The DM Team is assisting researchers with publication through the Federated Research Data Repository (www.frdr.ca), but researchers may choose to publish their data in other recognized repositories. In total, we have assisted with 13 publications in the past year. We expect dataset publications to increase as the program progresses. The list of published GWF datasets is available here: http://giws.usask.ca/meta/ListPubs.php.

c) Data and Metadata Enrichment

- As per 2a: While there were efforts to create a GWF metadata template, the majority of the data collection so far has been university specific.
  - Metadata was collected in Feb-Mar 2019 from the HQP who are associated with WLU-GWF Program. Metadata collection was performed by collecting some information that included: the study site name(s) with latitude(s) and longitude(s) (decimal degrees), data collection period, type of data, subject domain, and research topic. These metadata will be exported to the GWF central metadata catalogue.
  - Metadata from HQPs at UW are being collected and deposited into the Polar Data Catalogue (PDC) metadata and data repository. All GWF metadata records within PDC follow the ISO 19115 and Federal Geographic Data Committee (FGDC) standard format and thus can provide metadata exchange with other data centres. A search for *gwf* on the PDC's search interface will provide all UW's GWF metadata records that are available for public viewing and exporting. At this time 46 metadata records are publicly available on the PDC portal.

Provision of Input and Assistance to Data Related Initiatives

a) Improvement of Delivery of Data and Knowledge

- The DM team is referring those with large scale modelling data to Juliane Mai so they can contribute to the GWF Cuizinart. This application makes data more readily available and useable to others. The Cuizinart is an online tool that will facilitate automatic subsetting and dissemination of gridded datasets across the GWF program and beyond. This tool is being developed by the UW Computing team (Juliane Mai, Jimmy Lin, Martin Gauch, Ethan Wang,) - a beta version of the web-frontend and a SLURM backend hosted on Graham is available. It contains currently data from four Weather Research Forecasting (WRF) Model products that were provided by Yanping Li's group (USask) as well as remote sensing temperature data that were made available by Homa Kheyrollah Pour (UW Core Modeller). Currently, four additional data products provided by Elvis Asong and Mohamed Elshamy (USask Core Modellers) are processed to be available in the Cuizinart soon.

b) Improvement of Management of Sensor Data

- To date, the DM team has not contributed to this effort.

c) Data Management Toolset and Framework

- **Data Management Software:** Radiam (Active Research Data Management Platform). The DM team began meeting with the Radiam Team in February 2019. The Radiam software is a tool for creating and managing metadata for unpublished research data during the active research phase. It has the potential to become the GWF metadata catalogue. The metadata can also be exported for inclusion in dataset publication at the end of research. The Radiam software is in the development phase. Beta testing of the software is scheduled to begin June 2019. The DM team have found a few GWF projects willing to participate in testing. Both the DM team and project groups will provide important feedback to the Radiam team during the beta testing which is expected to result in a product tailored to meet the needs of GWF.

d) GWF Cloud Components

- The DM team has facilitated discussions between Amazon Web Services and GWF, which is of importance to the core computer science and modelling teams. The primary use would be a computing resource for running forecasting models, and hosting and distributing large scale modelling data. Discussions are in the preliminary phase and feasibility is still being determined.

e) Input / Output / Format and Data Access Support

- The DM team completed the following work for the core modelling team:
  - Downloading and stitching together topography datasets (i.e. HDMA, MERIT DEM, MERIT Hydro) for seamless Pan-Canadian coverage.
  - Creation of a wiki (https://wiki.usask.ca/display/MDC) from metadata that the modelling core team had compiled, which increases the findability and accessibility of these datasets

10.5.2 GWF Projects

Agriculture Water Futures (AWF)

Project Goal: This project seeks to evaluate water availability, use, and quality in a pan-Canadian context with the goal of improving current and future agricultural water sustainability. This project will accomplish these goals through a combination of field-based research, data mining, and hydro-climatic and socio-economic modelling efforts. [Website; Social Media]

Current and future water-use in Canadian agriculture: The goal is to improve our ability to accurately calculate the water use and water productivity for crop and livestock production systems throughout Canada. This work is being done using a combination of field data collection (ON, SK) as well as modelling approaches. **Agyeman** has been working on using a high-resolution climate data to quantify future climate changes, trends and variability in agro-climatic indices and to estimate how patterns of growing season precipitation will change under future climate in western Canada. **Kurkute,** using high-resolution Weather Research and Forecasting (WRF) simulations, has projected increased amplitudes for precipitation and evapotranspiration and a decrease in runoff for both the Mackenzie and Saskatchewan River basins in a warmer climate. The higher resolution data has linked different responses to basin topography and orientation. **Fonstad** has instrumented cattle pens at the Clavet site in SK for hydrometric parameters and has obtained baseline data prior to cattle introduction. **DeHaan** has collected micrometeorological data from two field sites with differing crops for the determination of water use efficiency (WUE). **Kompanizare** has developed a C4 photosynthesis model for corn to quantify the WUE of the crop under different climate and water availability conditions. The model is presently at the leaf scale, and Kompanizare is working to extend it to the field scale. Further, we are currently in discussions with the Lake Water Futures (LWF) project, who are modelling crop dynamics in Ontario at the watershed scale. **Harder** has successfully conducted an intensive field campaign over the past year to collect observations over a variety of crop types in SK.

Ongoing analyses of these observations are revealing the significant heterogeneity of land-atmosphere between and within crop types that is critical to understand future crop-climate-hydrology interactions. There has been significant interaction with the Transformative Sensor Technologies and Smart Watersheds (TTSW) project, and Smart Water Systems Laboratory, utilizing UAV technologies to quantify the spatial variability of crop growth and water use. It is anticipated that there will be more significant interaction between the SK and ON teams in Yr 3, now that data sets have been generated, to compare aspects of crop-hydrology-climate interactions (**Harder, Kompanizare). Al-Bahouh** is assessing the water footprints of dairy farms in Ontario and in Kuwait by monitoring water consumption on farms in both Ontario and Kuwait and using the crop water-use model CropWat to assist with assessing the blue, grey and green water-use for dairy livestock feed production.

Current and future water quality in Canadian agriculture: The goal has been to improve our understanding of the impacts of climate, landscape drivers and land management on water quality. We have also been working with the core modelling team in the development of water quality modules and the inclusion of a subsurface tile drain component in CRHM, to allow simulations of water quality under future climates. This will support use of appropriate BMPs by climatic region and soil groups under future climates. Given that a significant amount of data was being compiled and synthesized to meet our objectives, most of the data synthesis papers thus far have had regional foci (Prairies, Great Lakes). For example, in ON, **Plach, Kompanizare** and **Pluer** demonstrated differences in the magnitudes, pathways and timing of runoff and chemistry across different seasons and soil textures. **J. Liu** found that soil phosphorus (P) drawdown was a promising strategy to reduce P concentrations in both snowmelt runoff and rainfall runoff without impacting crop yields in the Canadian prairies. **J. Liu** also led a review paper on the impacts of frost on P release from cover crops and plant residues. **Plach** and **Wilson** published papers examining differences in soil P and how these relate to P loads in runoff, and a comparison of MB and ON soils is now underway. **Kokulan** explored the impacts of tile drainage on runoff and P mobilization and has found that tile drainage will do little to change runoff pathways or P loads in the vertisolic clays of the Red River Valley, primarily due to the presence of frozen ground during snowmelt. An improved understanding of a range of BMPs in mitigating P losses in tile drainage under cold conditions in Ontario has been generated by **Marshall, Grant** and **Carlow.** They have shown that the incorporation of manure and the subsurface placement of P fertilizers have significant potential to mitigate P losses from fields; however, commercially-available filters will do very little. The impacts of cold season processes on P supply in soils (**Higgins)** and P retention or mobilization through riparian buffer strips (**Price)** have been explored. **Eider-Sodo** is addressing irrigation water quality and treatment issues, by exploring the use of hydrogen peroxide (H2O2) as an oxidizing agent for disinfection of re-circulated irrigation water in organic greenhouse production systems. With the exception of **Grant** (completed), the remaining MSc students are all in the mid- to late stages of thesis completion. Research assistant **Roste** has been

advancing research in and encouraging adaptive management using export coefficients for agricultural land use in the Canadian prairie to provide a preliminary screening for BMP implementation in the Prairies. **Baulch** published a detailed review of soil and water management practices across the northern Great plains. The goal of this work is to help inform decision making about nutrient management and BMP implementation, with timing roughly aligned to roll out of the new Canadian Agricultural Partnership.

With regards to the development of water quality models, **Kompanizare** and **Costa** have progressed on several initiatives. For example, working with the modeling core team in Saskatchewan (**Costa), Kompanizare** is developing a tile flow module to add to CRHM. **Kompanizare** is working on the verification of the CHRM model (with and without tile drainage) using field data from a farm in Ontario. In the Prairies, **Costa** has developed a complex of biogeochemical modules for nitrogen (N) and P simulation for CRHM. These new modules are currently being tested and validated, and also applied to the South Tobacco Creek Watershed, Manitoba. The Nutrient App (mobile application) has been developed for community-based measurement of nitrate and phosphate concentrations in water based on on-farm cheap instantaneous colorimetric water quality test kits (**Costa).** The estimation algorithms have been tested and validated against lab measurement, and **Costa** is now finalizing the mobile application interface and APIs for communication with a server managed by the Global Institute for Water Security. The FLUXOS model for hydrodynamic-nutrient transport simulations has been repurposed to simulate snowmelt events and the associated nutrient transport. Various modules have been developed for snow every balance-snowmelt and drop inlet spillway computations. It is currently being applied to the South Tobacco Creek, but some tests have also been conducted for the Smith Creek Watershed and two farms in Ontario by **Costa.** Finally, experimental analyses were conducted to (1) investigate and develop a process-based mathematical model for the temporal dynamics of snowmelt nutrient release from snow-plant residue mixtures, and to (2) investigate the effect of preferential meltwater flowpaths on the preferential elution of chemicals from melting snowpacks (**Costa** with **J. Liu). Roste** has looked at vegetation leaching as a source of P in runoff losses in the prairie and proposed an algorithm for use in modelling agricultural BMPs on the Prairies, working with colleagues at ECCC.

Strengthening capacity for adaptation in agricultural water decision-making: The goal of this component is to strengthen the foundation for adaptation in agricultural water decision-making in Canada, focusing on water quality. We are developing tools and approaches to further our understanding of the complex behaviour of human and natural systems that interact at relevant spatio-temporal and governance scales. The work is focused in Southern Ontario. Over the past year, **H. Liu** has conducted a meta-review of existing water quality treading programs in North-America, including an online survey to assess the performance of these existing schemes, as well as a literature review related to farmer motivation to apply BMPs and issues needing to be

addressed to expand BMP practices. **H. Liu** also designed an online survey including a choice experiment aiming to assess farmer attitudes toward conservation practices and identify key institutional-economic terms and conditions to incentivize farmer uptake of different types of BMPs. To evaluate the efficacy of BMPs in reducing total P loads to Lake Erie, **Pinto** updated a Soil and Water Assessment Tool (SWAT) model that was previously designed for the Grand River basin, to estimate the hydrological and water quality impacts of implementing different BMPs across the watershed. This work is ongoing. **Meinen** administered surveys to local farmers in southwestern Ontario and aggregated survey results for **Robinson** and **Deadman. Meinen** also set up an online survey via qualtrics for further surveys in future. **Zhang** is currently building on the Agent-based Model (ABM) built by **Guo.** He is currently exploring a series of different decision-making models in cognitive science and economy, digitalizing these conceptual decision-making models, and merging them into **Guo's** ABM to simulate different decision-making patterns of farmers. **Frank** has made progress on a range of efforts this year. First, she is developing the SWAT model for the Upper Thames watershed, and working on a manuscript related to the incorporation of social science data into physical models. A P load model for the 1970-2016 period has been developed, and **Frank** is currently working on a manuscript relating this to P reduction initiatives. **Frank** also launched a Delphi survey and will compile the results over the next few months. **Alvarado** conducted a literature review with **Lindamood** titled "Factors enabling or constraining on-farm water storage, and their relevance in Ontario".

Boreal Water Futures

Project Goal: To develop a more effective water futures risk assessment framework for the boreal region that provides both a next generation future climate and extreme weather product and future wildfire regimes prediction tool for provincial and federal government agencies, NGOs, and industry. [Website; Social Media]

Progress: Dr. S. Carey's team continues to operate a network of 8 eddy covariance towers above boreal landscapes and installed a network of sap flow sensors at a White Spruce forest in Wolf Creek with additional sap flow sensors to be installed in 2019. The team also flew a new LiDAR flight for Wolf Creek. MSc student Sean Leipe will be using this image and other remote sensing images and a historical LiDAR to detect ecosystem change. Along with Dr. R Petrone, they delivered a report to the Canadian Oil Sands Innovation Alliance (COSIA) that summarizes >70 years of boreal flux data. See publication above.

Dr. S. Jutras explored and analysed a lot of snow water equivalent data, directly linked to the doctoral objectives of M.Beaudoin-Galaise. Collaboration with Okan Aygun (C.Kinnard, J.Pomeroy) through CRHM.

Dr. R. Petrone and team continue to operate a network of 11 eddy covariance towers in boreal ecosystems, augmented by sap flow, chambers and porometry. Along with Dr. S Carey, they have

delivered a report to the Canadian Oil Sands Innovation Alliance (COSIA) that summarizes >70 years of boreal flux data (See publication above.) YP and technicians travelled to McMaster to learn how to build and operate sap flow systems from colleagues from the Southern Forests Waters Future project; and they established collaborations with the Dendrochronology lab of Dr. Mike Pisaric at Brock University and also with Dr.Patrick Fonti at the Swiss Federal Institute for Forest, Snow and Landscape Research WSL-Zurich. All of these collaborations and new KE opportunities increase the group's capacity to monitor vegetation response to the impact of human management and changing climate in cold regions using new methods and approaches, helping us to better diagnose and predict change in cold regions (pillar 1).

Dr. J.M. Waddington continued operation of a network of 3 eddy covariance towers and 10 micro-met towers to examine water futures for Boreal Wetlands. A new tower was installed this year in collaboration with Magnetawan First Nation to monitor for climate change and results of this program were presented at a recent Indigenous Knowledge and Species at Risk workshop in Parry Sound. Dr. Waddington presented a webinar with our Ducks Unlimited stakeholder on Boreal Wildfire risk and attended a workshop for Canadian Wildfire practitioners representing BWF. A video outlining Sophie Wilkinson's research was made in collaboration with our Canadian Forest Service, Alberta Wildfire and Firesmart stakeholders. Sophie Wilkinson also hosted a training workshop with Alberta Forest Rangers and demonstrated our Sphagnum propagation experiment at the Pelican Mountain Wildfire site. Postdoctoral fellow Manul Helbig represented Boreal Water Futures at a United States Geological Survey Powell Centre data and modelling workshop.

Dr. J. Price created a robust QA/QC'd MS Access/MS SQL database of 10+ years of field data, comprising of field notes, geochemistry, water, hydraulic conductivity, discharge, vegetation, peat properties, DGPS survey elevation data, land cover change, subsidence as a precursor to investigating the long-term changes to the peatlands surrounding the De Beers Victor mine pit. Further they are continuing to actively obtain new data collected at the De Beers Group of Companies Victor mine from their own research efforts as well as from government (MOECC) and industry monitoring.

They are organising two 2019 field visits to Victor mine for data collection for a suite of hydrogeochemical parameters as well as meteorological data, ground subsidence and water table elevation surveying. Water sampling for isotopic signature (a key aim of the Inception document) is occurring during this trip.

The half time post-doctoral candidate (Dr. Elmes) is developing a semi-distributed model of the Nayshkootayaow River watershed using RavenR (Hydrological Modelling Framework) as a means to incorporate its flexible process representation to quantify the impacts of winter roads on the hydrological connectivity and function of the peatlands in the JBL.

Communication is ongoing between Price and PhD student Nicole Balliston, with further expertise being discussed with Murray Richardson (GIS; Carleton University) and James Craig (hydrological modelling; University of Waterloo).

Dr. M. Flannigan The work of Canada Wildfire (CW) regarding extreme wildfire occurrence keeps moving forward with ongoing collaboration with the Canadian Forest Service focusing on changing landscape fire probabilities, extreme fire behavior modeling, and wildfire danger prediction capacities using machine learning. CW is striving at communicating the progress through a diversity of media, as illustrated in this report. François-Nicolas Robinne (post-doc) is making progress on the wildfire side of the socio-ecological systems group, with an accent put on publishing the scientific basis linking post-fire hydrology to the conservation of freshwater ecosystem services in Canada. At the moment, he is mostly gathering and crossing existing provincial and federal datasets to provide new insights on water security. He is planning on investing more time in the KM side of his work in the coming year. Related to the previous points, CW is extending its network of private and public collaborators, such as insurance companies, consultancies, and water providers (e.g. EPCOR).

Dr. J. Pomeroy's PDF, Dr. Zhihua, has made some very nice uncalibrated long term CRHM hydrological process and water balance simulations of Whitegull Creek using the BERMS data. The USask component of GWF partnering with GIWS will keep BERMS running, and thusly is considered a BWF site. Next steps will be running the CRHM Whitegull Creek model using the WRF PGW for current and future climate and then as a virtual basin driven by different WRF boreal forest gridcells to show the hydrological behaviour of such a basin to driving climate from across the boreal region. They will then repeat that with WRF PGW to show how it looks under RCP8.5 and then with forest disturbance. They would like to look at other basins to find a few other virtual basin structures to evaluate in this framework. The team is prioritizing physical basins (vs. virtual) and are actively considering strategic collaborations in BWF to achieve this.

Climate-Related Precipitation Extremes

Project Goal: This project will provide new insights into the future occurrence of precipitation-related extremes including drought, intense precipitation events and hazardous winter precipitation. Such extremes impact many sectors across Canada including agriculture (such as through effects on food production and crop damage), electrical utilities (such as through hydro power generation and transmission impacts), engineering design (such as through improved estimation of return levels for extreme precipitation), health (such as through impacts on water quality and water-borne diseases), and insurance (with a backdrop of recent record-breaking payouts such as the Calgary flooding and Fort McMurray wildfire). [Website]

Progress: The climate extreme precipitation project has made substantial scientific progress during its second year. A key highlight over the last year is the progress that has been made

towards the launch of new continental WRF simulations. We have been working, in collaboration the Hydrometeorology group at NCAR, on testing some modules in WRF model and fixing its warm bias before launching new extended domain North America runs. New WRF simulations are expected to be started, using CMIP5 multi-model ensemble data, in May 2019. The WRF model, Version 3.4.1, is being configured to cover the North American domain that extends up to 76°N (see map below).

WRF CONUS II domain

The model simulation time periods will cover a: i) historical period simulation: 20-year integration plus 1-year spinup, from 1995 to 2015 and a ii) future period simulation: 20-year integration plus 1-year spinup from 2080 to 2100. Both historical and future period simulation will be forced with 6-hr CCSM4 data. ERA-Interim reanalysis will be used for bias correction for the historical period while 19 CMIP5 model ensemble mean will be used for bias correction for the future period.

In the following, we are presenting scientific progress made in each sector.

Progress related to engineering design:

Projected changes in annual maximum hourly precipitation: Intensities of extreme precipitation events are projected to increase under future climate conditions. In order to reliably estimate temperature scaling relationships in non-stationary analyses of annual precipitation extremes, we have used a large ensemble of 35 North American regional climate simulations (CanRCM4) of hourly precipitation (1951-2100), (Li et al., 2019a). In this analysis, we considered both local and spatially pooled analyses using the index flood approach and the generalized extreme value distributions. We found that, using records that are the equivalent length of many multiples of historical observational records, the temperature scaling relationships are consistent with the Clausius-Clapeyron (C-C) rate (around 7% per 1°C warming) for the 100-year event, and can provide useful guidance about precipitation extremes in a warmer climate.

A follow-on study uses the CanRCM4 large ensemble to assess whether rarer precipitation extremes intensify more quickly with warming, which they do, and to determine the relative importance of thermodynamic and dynamic (circulation related) influences on extreme precipitation. (Li et al, 2019b).

Projected changes in probable maximum precipitation: Probable maximum precipitation (PMP) is a key parameter used to estimate Probable Maximum Flood (PMF), both of which are important for dam safety and civil engineering purposes. In a warming climate, two key challenges have contributed to modernizing PMP estimation methods. The first is the ability to quantify the uncertainties in PMP estimates, and the second is the use of climate model outputs to enable a more physics-based estimation of PMP in a changing climate. In this direction, two studies based on the PMP estimation technique described in Ben Alaya et al (2018) have been completed.

In the first study (Ben Alaya et al 2019a), PMP estimates from two Canadian RCMs, CanRCM4 and CRCM5, were compared with estimates derived from three reanalysis products: ERA-Interim, NARR and CFSR (Ben Alaya et al. 2018). Results indicated that PMP estimates based on the models are of sufficiently high quality that further study of the probabilistic PMP estimates is warranted, and that the two RCMs may provide a path towards projecting future changes in PMP that could serve as a basis for flood studies at the basin scale.

In the second study (Ben Alaya et al 2019b), a nonstationary extension of the previously proposed bivariate extreme value approach (Ben Alaya et al 2018) was developed in order to project changes in PMP. The approach is evaluated by comparing projected changes to 6-hourly PMP from CanRCM4 and CRCM5, over North America. Results suggest that, on the continent scale, PMP increases in these models at a rate of approximately 4% per 1°C warming, which is somewhat lower than the C-C rate. These findings make it possible for practitioners to take into consideration the evolution of PMP under a warming climate for the design of hydrological structures.

The unknown behavior of extreme precipitation for very long return levels: Extreme value theory applied to precipitation annual maxima is widely used to estimate extremes for a given return period. Such estimates are often required for many engineering tasks. Engineers in Canada are contemplating a transition from a 'uniform hazard' approach for infrastructure design to a 'uniform risk' approach. This development would lead to a requirement for the estimation of return levels corresponding to periods that are much longer than those currently used in infrastructure design. Testing the reliability of these estimates for very long return periods, such as the 1000-year level, is challenging given the short length of the available observational records. The CanRCM4 large ensemble provides an opportunity to perform such an evaluation in the context of the climate that is simulated by that model because the multiple simulations collectively provide samples of annual extremes that far exceed the length of any available observational sample. For example, the 35 simulations for which precipitation was archived for hourly and longer accumulations provide 1750 years of data that are representative of the 50-year period 1951-2000.

We analyzed this large sample of extremes using the Generalized Extreme Value distribution, which arises from statistical extreme value theory and is very widely used by practitioners. We found that, while relatively reliable estimates can be obtained for the 50- or 100-year return levels, there is significant bias when estimating the 1000-year return level that is not related to the reliability of parameter estimates of the GEV distribution (Ben Alaya et al 2019c). We showed that this bias comes about because the annual maxima of precipitation extremes are not "max-stable" at most locations in the climate simulated by CanRCM4, which suggests that analyses may have to be based on the extremes of blocks of data that are substantially longer than one year, which would pose a conundrum for practitioners who only have access to observational records.

Progress related to insurance sector: Our collaboration with CatIQ (Catastrophe Indices and Quantification) has allowed us to gather information on severe weather events (hail, heavy rain and winter storm events) that impacted the insurance industry. We therefore selected a number of extreme events that caused significant insurance losses records. Output from the NCAR WRF pseudo global warming (PGW) simulations and reanalysis data has been used to study these cases in order to better understand the meteorological and climatological nature of these events. Comparisons between the WRF and reanalysis characterizations of these events has allowed us to evaluate the performance of WRF in simulating these events. A study summarizing these analyses is in preparation.

Progress related to electrical utility sector: Extreme weather events are a major concern for electrical utility sector. Extreme winter storms can directly impact electricity distribution leading in some cases to serious consequences such as blackout. The work we are conducting with respect to this sector focuses on investigating major freezing precipitation events that have affected its operations including transmission, generation and distribution. One such major winter storm was the January Ice Storm of 2017 in the Maritime Provinces, mainly New Brunswick, which caused widespread power outages that lasted for a number of days.

Numerical simulations were conducted with the Global Environmental Multiscale (GEM) model (1 km). The storm was well simulated including the total accumulated precipitation as well as the precipitation type distribution at the surface. A detailed analysis of the weather event has been conducted. Examination of power outage locations and duration showed that areas associated with the highest ice accumulation are not associated with the longest power outage. The longest power outage seemed to occur when freezing rain is combined with strong wind episodes (McFadden, 2019).

In addition, we are focusing on examining the impact of hazardous winter precipitation (with surface air temperatures close to 0 °C) on electrical transmission lines operated by Manitoba Hydro, as well as their projected occurrence in a future warming climate. Ten such events have been analyzed to better understand the large, regional and local factors that affect the spatial

distribution of freezing precipitation. Particular emphasis is being placed on the modification by topography, such as Riding Mountain National Park, on near-surface temperatures to allow for or mitigate this hazardous precipitation within these past events and also within the PGW future climate (Tropea, and Stewart, 2018).

Progress related to health and agriculture sectors: Impacts of a warming and changing climate on these two sectors are continuously increasing including, among others, morbidity and mortality for health sector, and crop shortage for agriculture. Within the climate extremes project, we have been working on some critical indicators for these sectors with a main focus on droughts. For the 1999-2004 Prairie drought, we carried out a limited study of the ability of high-resolution models, WRF, to simulate seasonal and shorter time scale precipitation amounts at a few selected locations. Results showed that in general, WRF control runs simulated well the general pattern of reduced precipitation over the whole drought but was somewhat deficient in terms of shorter time scales. In particular, it tended to over-estimate large daily precipitation events and under-estimate small daily events. In comparison with CRCM5 over these same periods, WRF generally better simulated the precipitation.

An analysis of the spatial and temporal evolution of drought in the future is also being conducted in collaboration with Agriculture and Agri-Food Canada and ECCC. This study is examining key drought features including occurrence, onset, magnitude, strength and duration within past as well as within future events (Lui et al 2019). In addition, a study of changes in growing season temperature variability is underway. Preliminary results indicate that as the timing of the growing season advances due to warming, the risk of early growing season frost damage may increase because the season advances to an earlier time of year that has a more pronounced influence from Arctic outbreak events.

Evaluation of ice models in large lakes using three dimensional coupled hydrodynamic-ice models

Project Goal: The primary goal of this project is to compare and validate the ability of two existing ice models to simulate the evolution of ice cover on large lakes at large and small scales. [Website]

Progress: Hill (UG student, spring 2018) and two students Marks and Walberg (UG student, winter 2019) worked on development of python scripts for setting up and driving the MITgcm as well as analyzing the results including the development of a number of tools for visualization. They have also begun the development of tools that can be used to calculate nearshore-offshore and inter-basin exchange. These tools will also be used for the Lake Futures project. In the spring term of 2018 **Hill** worked on these tools and setup the ice model in the MITgcm and did some idealized simulations (e.g., simple rectangular lakes) of the formation of ice under the influence of wind. He made some preliminary comparisons of ice growth predicted by the MITgcm with

CLIMo, a one-dimensional lake ice model. Because the MITgcm ice model was developed for coarse resolution ocean applications some of the ice parameters in the MITgcm and in CLIMo are different hence the need to better understand the sensitivity of ice growth to their values and to determine the most appropriate values. Marks and Walberg continued the development of tools to aid running the MITgcm and analyzing the results. These include python scripts to generate bathymetry files at arbitrary resolution based on the NETcdf bathymetry file available from the Great Lakes Environmental Research Laboratory (GLERL) in the United States. This script partially automates the inclusion of river inflow/outflow by reading in error messages from the MITgcm and using them to correct the location of boundaries associated with rivers. Tuning the bathymetry near major inflows/outflows was found to be necessary and grids at 2km, 500 m and 200 m horizontal resolution have been created. The students also investigated and compared a number of interpolation schemes to convert sparse meteorological data to forcing files used to drive the model. Both Marks and Walberg will return for 8 month co-op works terms from September, 2019 – April 2020. They will again split their time between this project and the Lake Futures project.

Sarah Walsh (Masters Student) has continued work on comparing the ice growth predicted by the MITgcm and CLIMo. Andrew Grace (PhD student) has started conducting high-resolution process studies in idealized (rectangular) shallow lakes to better understand how various processes (longwave and, shortwave radiation, winds) affect ice growth.

Quantitative evaluation of high resolution ice model output will require high resolution observational data. Presently the main data source for ice concentration on the Great Lakes are coarse resolution ice charts. Andrea Scott and Homa Kheyrollah-Pour (GWF Core Modelling Team) have been working on downscaling ice concentration from these charts using SAR imagery. Scott has written a python code for this task and is incorporating a method to estimate uncertainty with the ice concentration. Preliminary results are encouraging. Forcing data has been provided by Serghei Bocaniov (Post-doctoral fellow in Lake Futures).

FIShNET (Fish & IndigenouS NorthErn healTh): Healthy Water, Healthy Fish, Healthy People

Project Goal: In partnership with Indigenous communities in other northern regions in Canada, the FIShNET team will evaluate: 1) health concerns and risk perceptions among community members; 2) environmental determinants of mercury and nutrients in wild-harvested fish; 3) balance between contaminant risks and nutrient benefits in traditional foods; 4) links between contaminant levels in the environment, human behavior patterns, and human exposure; and 5) access to traditional food and the impact on food security. [Website]

Progress: Since 2017, the FIShNET team has worked with the collaborators within the Northern Water Futures (NWF) project. Our progress under NWF has included important scientific and knowledge mobilization achievements. For example, we characterized levels and determinants

of several priority biomarkers (e.g., mercury, cadmium, and polycyclic aromatic hydrocarbons) in the Mackenzie Valley Biomonitoring Project. In addition, we have analyzed results from the Health Messages Survey (and complementary key-informant interviews) describing contaminant awareness and perceptions as well as preferences for communication strategies. By pairing the Health Messages Survey results with human biomarker data, we have shown that community-level responses (e.g., changing harvest locations) is associated with lower hair mercury levels of project participants. These results are being written within research manuscripts and incorporated into Arctic Monitoring and Assessment Programme 2020 reports.

Within FIShNET we will generate complementary information for Fort Albany First Nation and Mushkegowuk Council.

Forecasting Tools and Mitigation Options for Diverse Bloom-Affected Lakes (FORMBLOOM)

Project Goal: Solving the problem of algal blooms requires an understanding of how the physical environment links to geochemistry and bloom ecology, and this understanding must exist on the timescale upon which blooms develop and collapse – minutes to hours to weeks. And while solving blooms is a grand challenge, managing their impact is a key interim goal. [Website; Social Media]

Progress: ELA-IISD has been deeply involved in the sampling program at Lake 227, and analyses of new, and historic data (chiefly via engagement of scientist Dr. Scott Higgins, and hosting of FORMBLOOM HQP). In conjunction with IISD-ELA we have initiated planning of a new eutrophication experiment, aimed at testing mitigation strategies associated with redox control. IISD-ELA is eager to initiate the experiment this year, and we have obtained approvals from the management board and provincial authorities to start lake fertilization in May.

Our work on long-term data from Lake 227 (supported by current and historical monitoring of IISD-ELA) suggests a climatic influence on bloom duration. This key result is being written up by PDF Larsen but suggest, as related research in Buffalo Pound that warming temperatures are increasing bloom risk, even in the absence of changes in nutrient loading.

At Buffalo Pound, continuous monitoring was achieved in 2018 (now 5 years of buoy-based monitoring in the system from past and current projects -- phycocyanin relative fluorescence is plotted to the right). The five years of data show striking differences in bloom severity, and timing. Phycocyanin is an indicator of cyanobacterial biomass, and in this system, it is relatively well correlated to our microscopic analysis of biomass. Unfortunately, issues with the telemetry occurred

partly through the monitoring season, which we believe were associated with a change in the cellular network. This did not affect data collection, but prevented real-time data access by plant operators. We have upgraded our modem, and are doing initial testing. The lack of telemetry data was unfortunate, as these have been integrated into plant operations in the past. The monitoring buoy at BP does require replacement in the next 1-2 years, and we are engaged in conversations with the plant regarding whether to continue buoy-based monitoring, integrate sensors into the intakes, or both (with the current plan being to do both, because of the importance of the physical structure of the lake). Funding for new instrumentation will have to be sought in fall 2019 or spring 2020.

Forecasting work has progressed, and largely reflects insights of the operators -- that the raw sensor data are very useful in understanding bloom progression. Functionally, there is a very high degree of autocorrelation, associated the biomass-dependence of growth.

Toxin results have been noted for the Buffalo Pound water treatment plant, and to date, do not represent a major area of concern. The toxin and genomic partnership with ATRAPP has been a major area of success, and generated far more data than initially envisioned. ATRAPP is interested in recruiting our current PDF to work with them at the end of her term on FORMBLOOM, although we are also hoping to keep her engaged should we have continued funding, perhaps in a joint role.

We have continued engagement with the Saskatchewan Water Security Agency. As with the Water Treatment Plant, one major area of interest/concern is changing DOM in the lake, and impacts on water treatment. The Water Security Agency and plant have continued to support spatially extensive monitoring, and added chemical sampling to understand DOM character. This work is external to FORMBLOOM -- but central to user interests. Thus far it is supported on a shoestring through free analyses at UVM (in discussion re: whether this can be continued), and support of Baulch's Centennial Enhancement Chair. We do not have HQP dedicated to this program, so have provided only preliminary analyses/insights on our in lake DOM character analyses. We are considering options to help advance our understanding of changes in DOM in the lake -- in alignment with WSA and WTP priorities (funding opportunities to be assessed when NSERC partnership programs are revised). Via leadership of plant chemist Dan Conrad in designing and implementing a process experiment, we have published a recent collaborative article in Science of the Total Environment (Dan is the second author on the paper). As noted -- this reflects a high priority user need, external to FORMBLOOM, hence it is not formally listed as an 'output' -- but the citation is provided here for your reference[6].

[6] CJ Williams, D Conrad, DN Kothawala, HM Baulch. Selective removal of dissolved organic matter affects the production and speciation of disinfection byproducts. - Science of the Total Environment, 2019.

Saskatchewan Water Security Agency continues to link our work with watershed agencies concerned re: bloom risk. We have engaged (2017) the Lower Qu'Appelle Water stewards on BMP prioritization (more closely aligned with Agricultural Water Futures). In 2018, we engaged the Lower Souris Watershed Committee to work on Moosimin reservoir. This work -- in a report that has been shared with both agencies (but not yet finalized) shows fascinating dynamics -- with an extremely short residence time in the reservoir during spring melt, evidence of substantive internal loading, and major water quality issues -- which in many ways parallel those of Buffalo Pound (a similarly long, shallow, nutrient-rich reservoir). This work is helping to inform important scientific questions regarding the consequences of spring nutrient loading to 'flow through' systems -- and whether these nutrients are assimilated and recycled.

Close communications continue with the Grand River Conservation Authority (GRCA). Key areas of discussion are:

- *The impacts of extreme events and reservoir management on bloom dynamics.* We have drafted a manuscript (Larsen et al. submitted to Ecological Applications) that shows that an early extreme rainfall event leading to widespread flooding was associated with an early onset cyanobacterial blooms. This work was fortuitous in nature (capturing the flood event), but shows important potential implications of extreme events on water quality. The paper begins also to explore questions of reservoir management -- as there is the potential to alter management to improve water quality; however, this would impact the flood control and flow augmentation uses of the reservoir, so is not considered a likely path in the short-term. GRCA has commented on and supported these efforts, and our submission to LakeLine, but did not wish to be involved in final products.
- *Bloom toxicity.* Our toxin analyses show that a poorly characterized compound anabaenapeptolin is the most common toxin/metabolite present at many times -- creating challenges in terms of understanding and communicating risks. A potentially greater concern and challenge, is the finding of detectable anatoxin in Conestogo reservoir in 2018. These results have been communicated to GRCA. Levels were below key thresholds of concern; however, the presence of this toxin is unusual, and very much concerning. We will further discuss these new results with GRCA, and link them to Bhardwaj/Bradford for further discussion of communications strategies.

We were invited to give 3 talks at IFHAB 2019 -- 2 invitations we were able to accept, with Larsen and Venkiteswaran presenting. We have also been invited to participate in the ATRAPP annual meeting, strengthening connections among these large projects.

We designed and implemented a localized Early Warning System for Buffalo Pound Lake using remote sensing satellite data.

- Field data for different water quality parameters, including chlorophyll-a, Phycocyanin, toxin, and etc. were compiled from different sources: Buffalo Pound buoy (2014-2017),

cruise survey employing laboratory spectrophotometry measurements (2015-2017), cruise surveys employing laboratory HPLC method (1994-2017), and water treatment plants (1979-2017). Remote sensing satellite images (Sentinel-2, and Landsat-8) were downloaded for Buffalo Pound Lake for the time period of 2014-2017. ACOLITE, which is a specifically designed atmospheric correction algorithm for aquatic environments, was applied on remote sensing data.

- The concurrent remote sensing data and field measurements were used to produce chlorophyll-a concentration maps for Buffalo Pound Lake. Different empirical models were tested. However, we are planning to add the 2018 in situ data and satellite images to be able to develop the empirical algorithm based on a more comprehensive dataset.
- We are planning to collect UAV hyperspectral data over Buffalo Pound Lake and Conestogo Lake (pending permit from GRCA) in summer 2019. This dataset will be used to investigate the advantages that UAVs can supply for algal bloom detection, mapping, and designing the Early Warning Systems.

We continue to engage with Yellow Quill First Nation in Treaty 4, eastern Saskatchewan to discuss Indigenous perspectives of harmful algal blooms, and preferences for risk communications on reserve about HABSs. Fourteen interviews, and two sharing circles were conducted on reserve to discuss HABs. An additional 16 questionnaires about HABs experiences were received from other community members unable to attend in-person engagement events. Six sample risk communications posters and brochures were created with community input but have not been field tested yet with the community. We were also able to connect this community with the NSERC-funded LakePulse project for sampling in Nut Lake which occurred on July 16 2019.

In addition to engagement with YQFN, the risk communications team also interviewed 13 water managers from a variety of water security and health agencies on their policies, practices, and preferences for risk communications in the Prairies. Interviews are transcribed and coded and a paper is in prep from this specific work.

Two Master's of Public Health students also completed an environmental scan of agencies in each of the Canadian provinces and territories to discover current practices for risk communications on HABs both internally among agencies, and externally with the public. A paper is in preparation from this work.

An application to the Lake Winnipeg Basin Project to work with this community using the Nutrient App on nutrient management issues was also submitted in January 2019. We await the committee's decision on that application.

Global Water Citizenship – Integrating Networked Citizens, Scientists, and Local Decision-Makers

Project Goal: The project aims to build the discipline of transformative water science by developing and testing big data analytic tools that support citizens and scientists in two-way knowledge exchanges. [Website]

Data platform development: Since June 2018 we have been implementing a new data model and project data infrastructure, including development of the IBM Netezza Data warehouse and an associated virtual machine servers. We have worked with Laurier ICT to install a parallel version of R on the database server, create accounts and set up appropriate internal network access. We have created a new data model in the database using a version of the Icosahedral Snyder Equal Area Aperture 3 Hexagonal Grid parameterized for the Canadian domain. New tools for loading both vector and raster data are in development and being tested. Algorithms for neighbor finding, parent-child relationships, and basic spatial computations are being developed. Within this data structure, Q-Analysis is being implemented and evaluated for the analysis/decision-support value of sparse water quality monitoring data. This novel big data architecture will support integration of heterogeneous monitoring, satellite, and user/citizen data within a common framework.

CBM analysis tool development: Led by undergraduate student Mary Gray, we have created a CBM water quality analysis tool, developed in R/Shiny, this tool is designed to enable users in CBWM community to quickly analyze their own data. Identified in the recent Roundtable on Community Based Water Monitoring held in Fall of 2018 is the need for tools that enable citizens and communities to better understand the lakes and rivers they are engaged in monitoring. We have worked with the Gordon Foundation and several user groups to identify needs and incorporate them into the development of the online tool. A publication and first version for release is expected in summer 2019.

Tsá Tué Biosphere Reserve Project Initiation: Participating in a planning meeting for the Tsá Tué Biosphere Reserve in February 2019 led to initiation of a collaborative project linking GWC with this ongoing initiative. We are currently partners on a new funding application, and have done preliminary work identifying and obtaining satellite-based data products in support of the project. We are using this as a case study for the data platform, and expect to integrate fish health monitoring data into the platform in summer 2019. We expect a data inventory and access tool for this project to be in place by late Fall 2019.

Expansion of Cowichan Lake Project: An ongoing project with Joy Wade (Fundy Aqua Services / DFO contractor) in Cowichan Lake led to a collaborative short project around the SARA-listed Cowichan Lake Lamprey and water level change in the lake. Using data from local meteorological stations, lake water level measured at the weir, and recent aerial images from newly identified

spawning habitat areas (i.e., part of its critical habitat), we were able to link management regimes to lamprey habitat area at select sites. We could then retrospectively model habitat changes over time to put recent low-water seasons into historical context. These results have been communicated to stakeholders at DFO and the Cowichan Roundtable meeting in April 2019, which includes representatives from the Cowichan watershed board, Catalyst Paper (the mill), local conservation groups, Cowichan First Nation, BC Parks, and concerned citizens.

Spatially de-correlated extreme precipitation trend analysis: Trend analysis of extreme climate events over large regions like Canada is difficult in areas of low station density. Conversely where station density is high, spatial autocorrelation can invalidate inferences derived from classical statistical tools assuming independent observations. While gridded products are available for many variables, huge uncertainties exist and limit their use in northern Canada. We developed a method to evaluate the spatial correlation structure of observations as the basis for subsampling from a hexagonal lattice. These were then used within a generalized extreme value framework for trend detection. In areas of low station density, comparing the differences between station and gridded data trends provided a new measure of uncertainty. Preliminary results from this analysis were presented at SKI 2019 conference in February 2019, and a publication of these findings is in preparation, with anticipated submission in late spring/early summer 2019.

Permafrost probability mapping: This winter a WLU fourth year geomatics class project developed permafrost probability mapping for the Kakisa community. This work used GIS tools to generate solar radiation data sets combined with digital elevation models and historic and predicted climate variables. The input variables were used to create the raster probability surface based on multi-variable linear regression models reported in the literature and the model was tested against ground truth data from a reasonably similar site (Scotty Creek, NWT). This project also explored impacts of predicted changes to permafrost on Indigenous use of the land (through the use of simulated traditional use data). The end result is intended to contribute to an on-going project developing a local resource in the form of a Kakisa community atlas.

Spatial data assembly – Tlicho and Kakisa communities: A coop student (Misha Kuzma) was hired this winter to assemble spatial data from government and research sources for the communities of Behchokǫ̀, Whati, Wekweèti, and Kakisa. The data consolidated for the these communities will be used in conjunction with tutorials developed for community workshops. These workshops, the first of which will take place in Behchokǫ̀ in mid-May, will focus on building capacity in youth for digital mapping and community-based monitoring.

Safety of the land app – Kakisa: The spatial data described in points 6 and 7 above were developed in part to enhance an existing community food atlas in Kakisa. These data will also be used in a mobile phone app that is under development to improve safety while individuals are away from their community. This app will allow map data concerning predicted permafrost

change, shelters, trails, seismic lines, etc. to be used on disconnected mobile devices for both in-field reference in case of emergency and for community members to record observations of permafrost and snow pack change. This project is in coordination with GWF KM specialist Andrew Spring and liks to the NWF project.

Integrated Modelling Program for Canada (IMPC)

Project Goal: This project will seek to provide an integrated platform for forecasting, prediction and decision making under future water uncertainty. Advanced modelling tools will be developed and integrated to represent interactions across climatic, hydrological, ecological, economic, and management systems. These tools will enable prediction of extreme events such as floods and droughts and provide a new paradigm for model development, integrated water management and user engagement. Working closely in collaboration with stakeholders and user communities, this integrated modelling and management platform will identify tipping points and critical trade-offs for decision analysis and deliver optimal solutions using state-of-the-art tools for multi-criteria decision analysis under deep uncertainty. In addition, advanced visualization tools will enable researchers to improve communication and decision support with user groups. [Website; Social Media]

High Resolution Atmospheric Modelling: Continental scale simulations of historical and future climate from 4km WRF and multi-model RCMs that cover Nelson-Churchill, Mackenzie, and Great Lakes St. Lawrence, Yukon River, Columbia, Frazer, and Saint John Basins.

Improving Hydrological Process Representation: Glacier, perennial snow components added to MESH and tested for Peyto Glacier; Lowland pond components added to MESH and tested for Upper in Churchill and Mackenzie River Basins. Validation of capability to simulate frozen ground depth and temperature using HYPE in the Nelson River basin; Impacts of glaciers and depressional storage on runoff under climate change in Churchill-Nelson River and Mackenzie River. Improvements to HYPE frozen ground module and revised frozen ground simulations in the Nelson-Churchill River basins.

Integrating land-surface and in-stream water quality: Developed *t*he steady state SPARROW model (for which the South Saskatchewan, Red River and Assiniboine are already in place) to identify nutrient loads in Nelson-Churchill Basin; a new large, basin-scale water quality modelling toolkit linked to MESH and water resources model for the Nelson-Churchill basin; and open loop simulations of long-term climate change impact on water quality with MESH

River Ice Modelling: Implemented and evaluated a new river ice component based on RIVICE within the MESH and GEM-Hydro forecasting system

Model Inter-comparison: Developed a framework for inter-comparison of models (including at least MESH, VIC, HYPE, and GEM-Hydro) starting with Lake Erie. Completed Lake Erie comparison.

Expanded framework development, with possible modifications, to Great Lakes Basin and Sask-Nelson-Churchill River Basin; Complete Great Lakes scale comparison. Preliminary model runs for the Sask-Nelson-Churchill River Basin.

Floodplain Mapping: Development of the HEC-RAS model for flood sensitive areas on Saskatchewan and Qu'Appelle River Systems and some basins in Southern Ontario in Windsor, Hamilton, and London; Climate realizations and Generation of datasets. Analysis of flood-triggering mechanisms.

Characterization Model Uncertainty: Developed a software toolbox for efficient and robust sensitivity and uncertainty analysis in MATLAB (and possibility in Python). The toolbox will be applied to one or more hydrologic models of the Saskatchewan-Nelson basin (and possibly Great-Lakes) and controlling sources of uncertainty will be identified and communicated with other researchers; similar analysis was conducted on the water quality model of the Saskatchewan-Nelson River Basin.

Developing a water resources model: Detailed water management model developed, tested, and deployed in Nelson-Churchill Basin; Collectied data and identified key hydro-ecological endpoints and flow-ecology relationships for species of interest in Northern Rivers and deltas in Nelson-Churchill and Mackenzie River Basins; Developed rule curves for flow-ecology relationships and integration with water management model

Developing an integrated hydro-socio/economic model: Setting up an integrated information system for the Great Lakes Basin in Ontario; setting up an integrated information system for the Saskatchewan River Basin.

Future scenario generation: Scenario development background research. Environmental Scan to build a list of policy options (green infrastructure, hard infrastructure, water markets, co-operation-based approaches, insurance, environmental rights/flow management, etc.) and model representations; Validate policy options with key experts. Quantify policy variables. Intervene in modelling; Scenario planning workshop(s) with stakeholder groups in decision-theatre format. Observe decision-making based on control of policy option variables. Tradeoffs revealed in the consequences of decision-making. Will form basis of future scenarios around what is desirable to each stakeholder group.

Scenario discovery and multi-criteria evaluation and decision analysis: Formulations of decision making problems considering a range of scenarios and involving a range of stakeholders and users in Nelson-Churchill RB.

Outreach and user engagement: Conducting a user survey and developing an SNA for IMPC for Nelson Churchill and Mackenzie River Basins. A user-informed engagement strategy and action

plan to guide KM activities at the sub-project and whole project levels; Similar work will be conducted for Great-Lakes St. Lawrence, and Yukon RBs as appropriate;

Decision support/Visualization Systems: Developing a web application for visualization of spatio-temporal hydro-climatic variables, including observations and model results in the hindcast, nowcast and forecast, and prediction modes, that covers the entire country; Web applications for decision support systems for exploring solution spaces by changing model parameters, running simulations, and viewing visual representations of potential outcomes.

Lake Futures

Project Goal: The project focused on the causes, impacts and mitigation of great-lake issues by creating and applying models, determining indicators, and measuring vulnerability, resilience, and recovery of the lake ecosystem. [Website; Social Media]

Land-based pressures on lake ecosystems, including changing nutrient and dissolved organic matter (DOM) loadings caused by climate and land-use change: At the regional scale, we have synthesized water quality and streamflow information for 200 stations in US and Canada within the Great Lakes drainage basin. We have developed a biogeochemical classification scheme to identify (1) dominant controls on annual nutrient loads, (2) seasonal concentration regimes and dominant watershed controls. We have found evidence of changing phosphorus ratios with increasing winter flows. Conversations are underway with Prairie Waters to mimic the biogeochemical classification approach developed here at the pan Canadian scale. Synthesis of stream water quality was complemented by analysis of nutrient budgets. We have developed a 50-year Phosphorus (P) mass balance dataset across Ontario using agricultural census data and land use information to identify legacy P sources. We have quantified the flows of nitrogen (N) and phosphorus (P) through the urban, suburban, and rural system in the Greater Toronto Area (GTA). The budgets were used to identify ways in which nutrient movement within the GTA could be optimized to minimize environmental impacts. We have also made significant progress towards quantification of phosphorus accumulation in reservoirs (Connestoga and Belwood in Grand River Watershed (GRW)) to quantify how reservoirs modulate P loads. Data synthesis is complemented by modeling and multiple model elements were developed. A pan-Canadian lake-river routing network and an automated ArcGIS Tool box to generate lake-river routing structure was developed. A vegetation growth library Robin was developed in conjunction with Dr. Mai (core modeler). Robin was coupled with HYPE model, the coupled models have been set up in the Grand River watershed (GRW) in Ontario and calibrated with MODIS LAI product and county level yield data. We have also developed a hydrology and water quality model for the GRW. Finally, we have made significant progress in developing a novel model ELEMeNT that can predict how long it will take for water quality improvement, given agricultural legacies accumulated due to decades of fertilizer application. It was first applied across the GRW, and this year, by request

of ECCC, it was applied on the Thames River Watershed. We plan to apply the model to the entire Lake Erie basin, having started on the Maumee River watershed in US.

Physical and biogeochemical responses of lakes to the land-based pressures of WP1 plus direct climate forcing: Using historical data, we quantified net water exchanges between Lake Erie's three basins which were found to correlate to variations in climate conditions. Annual budgets for water, chloride and total phosphorus (TP) for the St. Clair–Lake Erie–Niagara River continuum were generated. Temporal trends of chloride are being related to climate variability and road salt usage. Estimates of the inter-basin exchanges and net sedimentation (burial) of TP are currently being refined. We have also applied a fully coupled hydrodynamics-biogeochemistry-ecology model to understand the initiation and propagation of algal blooms in Lake St. Clair and the export of phosphorus to Lake Erie. Remote sensing data was used with a newly developed machine learning technique to derive predictive relationships between chlorophyll-a concentrations and lake ice coverage, water column and land surface temperature, and TP loads and TP concentrations. We show that interannual trends in chlorophyll-a reveal climate-driven signals. This new statistical data treatment method is transferable to other cold regions' large lakes and we will apply the method to Great Bear Lake. We have recruited a PhD student (Sept 2019) to work on hydrodynamic modelling. Three undergraduate students have developed tools to generate bathymetries at arbitrary resolution and meteorological forcing fields from observed time series. Visualization tools have been developed for quantifying water exchanges between the basins and between nearshore and offshore regions.

Ecosystem health indicators and a biomonitoring framework linking water quality predictions to the integrity of the biotic system: Focused on understanding key drivers of eutrophication and where experts agree or disagree using fuzzy cognitive mapping (FCM), a method for quantifying expert knowledge. We used data from three previous workshops (2009-2014) to create an overall FCM of the state of understanding and based on this, held a new workshop to create an updated visualization. We plan to iteratively revisit the maps created at the workshop with the participants to refine and strengthen the data. Comparison between FCMs created in 2009 and current FCM will help evaluate how perception of these issues has evolved. A Valued Ecosystem Component (VEC) was developed over the past year in close collaboration with end-users at the OMNRF focused on walleye in the southern Grand River. Acoustic telemetry methods have been used to identify the movement patterns and upstream spawning habitat of riverine spawning walleye. Stable isotope analyses of nitrogen and carbon have been used to test for spatial and temporal changes in the trophic ecology of young-of-the-year walleye in the Grand. This research will aid in advancing monitoring and management practices that protect and enhance both the health of the Grand and the Lake Erie walleye fishery. PhD student Ho has spent the past year time shaping the research with end users and partners (e.g., GRCA, Six Nations of the Grand River). The goal is to understand how current monitoring activities in the

Grand River-Lake Erie Interface (GEI) can be strengthened as a more robust monitoring framework that considers cumulative effects, is co-created by diverse stakeholders and collaborators, is feasible for implementation post-research and which informs decisions. Research will be done using Community-based Participatory Action Research (CBPAR) using interviews, focus groups, workshops, participant observation, and questionnaires.

Socio-economic drivers and impacts on the GL ecosystem services, including agricultural land-use change, water intake, wastewater discharge, hydropower, tourism and recreation: Estimates of the economic costs of eutrophication in the Great Lakes Basin have been revised based on additional data collection and analysis. We also conducted a comprehensive review of water quality trading programs and compiled a database of current programs. Our interactions with water quality trading program managers have helped modify the research direction. The ECCC Water Quality Valuation Model was reviewed and this resulted in an almost 90 pages report with recommendations for the future development of the model. A meta-analysis is under way in which existing economic valuation studies of Canadian lakes and rivers are analyzed and synthesized. In addition, a public survey has been developed in collaboration with Brock University to assess public perception and valuation of water quality improvements in the Great Lakes basin. The survey is currently under Ethics review and is expected to be launched in June 2019 among a representative sample of residents in the Great Lakes basin in Ontario. An existing SWAT model for the GRW has been updated and calibrated over a time period of almost 30 years in order to be able to assess the impacts of best management practices in the watershed on water quality conditions draining into the lake. This work is conducted in direct collaboration with one of the post-docs employed in the Agri-Futures project and is an example of synergetic collaboration between the two projects. Finally, a macro-economic input-output model is under development for the Great Lakes basin to assess the impacts of nutrient flows (and policies) on the various water using sectors in the Great Lakes basin. Our Decision Making Under Uncertainty study focused on farmers' decision making under crop price and weather uncertainty, examining the optimal use of fertilizer by individual farmers seeking to maximize returns from farming. The impact of crop price uncertainty on farmers' optimal fertilizer application was evaluated using a model of optimal farm decisions with crop prices described by a stochastic differential equation.

Knowledge and tools in support of decision support tools and socially acceptable, user-driven solutions: We have made progress in creating an integrated watershed-lake modeling framework for Lake Erie and Ontario. We completed a case study for P and silicon cycling in Hamilton Harbour and the implications for algal productivity and nutrient export to western Lake Ontario. A prototype coupled watershed-lake biogeochemical model with detailed internal P loading processes was tested using a high-resolution data set for Lake Vansjø, Norway. Phosphorus load reductions, climate warming, and in-lake mitigation scenarios were tested. The model will be applied to the three basins of Lake Erie, considering the intra-basin exchanges and watershed

nutrient inputs. The latter project is conducted in close collaboration with ECCC colleagues. To aid in decision making, we have developed methodologies for economic valuation of ecosystem services in southern Ontario. This yielded a total potential value of $19 B/year for the Southern Ontario region. The value of the realized ecosystem services is $9.7B/year, ~50% of the value of the potential ecosystem services. The distribution map of realized ecosystem services can help inform and guide land use planning and environmental decision making. Finally, we have been developing a decision support tool that targets the management of harmful and nuisance algal growth. We are focusing on tools to manage two major nutrient inputs: agricultural inputs and Combined Sewer Overflows (CSOs). We have started assessing and modeling the delivery of P by urban storm water outflows to Lake Ontario in collaboration with the Toronto and Region Conservation Authority. To directly involve the relevant stakeholders and decision-makers, we have applied for membership to Conservation Halton, Lake Erie Working Group, Agriculture and Rural Affairs Advisory Committee, and the IJC. These collaborations are helping us obtain critical data that will inform the DPSIR-based decision-analysis framework.

Linking Multiple Stressors to Adverse Ecological Responses Across Watersheds

Project Goal: The project will support improved monitoring and risk assessment programmes through the development of models and tools that can be employed to predict the impacts of contaminants related to changing urban environments and climate on aquatic ecosystems. This work will focus on creating and applying knowledge necessary for predicting and interpreting the impacts of urbanization (e.g. wastewater, storm water, population growth) in the context of variability (natural and anthropogenic) at the watershed scale. This will form the foundation for building frameworks for consideration of multiple stressors that are a major challenge for watershed management, especially in the face of global environmental change. [Website]

Estimating contaminant exposure and effects: The modelling has been initially developed for estimating the exposure of estrogenic chemicals (i.e., estrone, 17βestradiol and 17α-ethinylestradiol) in the central Grand River. The preliminary work, published by Arlos et al (2018a,b) integrates five key components:

1. Estimation of the inputs into the wastewater system using prescription sales data and population statistics;
2. Estimates for removal during treatment;
3. A surface water (river) model based on WASP (EPA) and calibrated for the Grand River;
4. Dose-response relationships to predict effects;
5. Comparison to field data.

The model uses the predicted inputs into the river, hydrology (i.e., flow) and key fate/transformation processes (i.e., rates) to estimate exposure concentrations at key sites downstream of the wastewater outfalls. These exposure concentrations are linked to biological dose-response relationships to predict effects. The biological relationships developed in

controlled lab experiments for key biological endpoints (e.g., intersex, steroids, metabolism) are used in the model to make predictions of responses in wild fish. More than a decade of effluent and surface water chemistry as well as biological data collected at multiple sites in the Grand River are used to test and verify the model predictions (e.g., Marjan et al. 2018). This data set is unique as it has been collected during major infrastructure upgrades at two treatment plants that came fully on line in 2017/18. The conditions in the treatment plant have therefore changed over time such that the effluent chemical mixture composition and concentrations have changed dramatically. The model is being refined and applied to predict these different chemicals and scenarios.

A source model has been developed to predict contaminant loadings into wastewater treatment plants. This model takes into account current and projected populations in urban areas, as well as consumption and metabolism data on each constituent. We have been collecting influent data from the treatment plants to validate this component of the model. A basic wastewater treatment plant fate model is being developed to better simulate the removal of contaminants in treatment processes. This model will be calibrated to predict the removal rates of contaminants due to heterotrophic and autotrophic metabolisms. Observed removal rates of each contaminant under a variety of treatment strategies have been compiled from literature for comparison. Essentially we plan to use this model to better predict treatment effectiveness of chemicals with different properties under different treatment conditions.

The river model of the Grand River (based on WASP 8.0) has been extended south of Cambridge all the way to Ohsweken. The hydraulic components of the model have been calibrated using chloride data obtained from the Grand River Conservation Authority. Nasim Hosseini from the GWF core team assisted with the project by contributing to the calibration and verification of the model for physical flows and contaminant transport. The extended model was created using existing HEC-RAS model data provided by the GRCA. The GRCA also provided measured chloride concentration data at several stations in the river, which were used for verification. The model was calibrated for manning's n values. The resulting physical river model was imported into WASP for verification. The OSTRICH optimization toolkit along with the VARS (Variable Analysis of Response Surface) toolkit to perform sensitivity analysis for the model. Thanks to this work, the WASP river model is now capable of accurately portraying the transport of contaminants in the Grand River as far down as Ohsweken, with few outlying scenarios. The river model is being modified to include transformation rates and applied to several model chemicals.

Refining the inputs to the model: Studies have continued to better understand the linkages of estrogen exposure and responses, especially in terms of life cycle stage and duration of exposure. A lab experiment was conducted to determine the threshold and sensitive window of exposure for fish (histology, steroid production, physiology, somatic indices, behavior) based on dose and lifecycle exposure time. Intersex (severity and incidence), stimulated steroid production (11-

Ketotestosterone and testosterone), behavior follow a dose dependent pattern and cause effects at concentrations predicted in the river. The effects however, are dependent on the exposure period of gonadal development in the fish. These results will form the basis for refining the model to account for seasonal exposure.

Collections were made at 9 sites in 2018 and analysis (e.g. intersex, gene expression, sex steroids, somatic indices, age, stable isotopes) of wild fish has continued, primarily as part of the NSERC CRD, to determine the recovery of the responses after the implementation of upgrades (2017/18). Chemical analysis methods are being developed and applied to determine concentrations of specific estrogens, total estrogenicity (e.g. Yeast Estrogen Screen) and pharmaceuticals in effluent and river water over time in effluent and surface waters.

Metabolism in fish is being explored as a more sensitive and non-specific endpoint for assessment of effects. Effluent exposure and seasonal variation on metabolism and physiology of three closely related species of darters (rainbow, greenside, and fantail) have been investigated. Metabolism, osmoregulatory and metabolic activity, and gill histopathology were measured using closed-chamber respirometry, enzyme assays, and histological analysis, respectively. These studies aim to link changes in metabolism to whole effluent toxicity and provide a more robust endpoint that can be applied (similar to reproductive changes). We are now initiating studies to link these changes to habitat and water quality endpoints that can be incorporated into the models.

Linking Water Governance in Canada to Global Economic, Social and Political Drivers

Project Goal: The overarching goal of the proposed research is to identify and assess social, economic and political trends internal and external to the water sector that have, or may have, implications for water governance in Canada, and to assess ways of adapting water governance in Canada to better account for those drivers. A distinctive feature of our proposed project is knowledge co-production with key stakeholders and collaborators. [Website]

Progress: The major accomplishments by our team over the past year can be seen in the progress we made in three interrelated sets of activities.

Diagnostic Analysis Using the Social Ecological Systems Framework: The aim of this work is to synthesize relevant conceptual insights from the literature to develop a framework to help guide in the determination of whether or not, and how, a specific driver is “internal” or “external” to a water governance action situation. It elaborates on the usefulness of the Social-Ecological Systems Framework (SESF) as a tool to identify external drivers to a water governance and other similar environmental settings. The SESF is a descriptive framework to help examine, in a diagnostic fashion, how human communities and ecological systems interact. The focus is on identifying the main components that affect a particular situation of interest —termed the focal action situation—within a social-ecological system such as water quality governance in the

context of Lake Erie or the Great Lakes. This action situation can be examined through the lens of the components or subsystems that directly impact it: the *Governance Systems* in Canada and the United states and other relevant binational governance systems; the *Resource System* which refers to freshwater resource in the basin; *Actors,* referring to public and private stakeholders (including user groups) active in the action situation; and *Resource Units or Services* which refer to all the benefits to be gained from a healthy freshwater system.

With the help of the framework that we are developing in this working paper we have identified a number of external factors that could potentially be at work in influencing water governance in the Lake Erie basin. These 'external' factors are variously refereed in the literature as external perturbations, disturbances, stressors, pressures, shocks, challenges, externalities, exogenous variables, as well as external, global and exogenous drivers. For example, a number of social, economic, and political systems can act as external drivers. These include trends in economic growth, land use changes, demographic trends including urbanization and migration as well as market changes such as trends in investment and trade patterns. In addition, technological changes including new innovations and changes in socio-technical systems can act as external drivers to the water governance system as do shifts in the media landscape such as accuracy of information and credibility of the media and its interest in Lake Erie issues. Freshwater resource as a cross-cutting theme that is linked to health, food, the environment, energy, climate change and global trade provides an ideal context to test the usefulness of the diagnostic framework being developed in this working paper to analyze natural resource issues in Canada and socio-ecological systems more broadly.

Identifying External Drivers to Nutrient Management in Lake Erie Basin: This study, which is a component of a PhD research, directly applies and further develops the diagnostic framework noted above in (a). The objectives of this study include delineating the existing governance system for nutrient management in Lake Erie basin and the scales at which it is operating as well as identifying external drivers and the extent to which the governance system affects consideration of those external drivers. It also explores ways of modifying the governance system to better deal with the effect of external drivers. Progresses made to date include:

- PhD research proposal has been approved by thesis committee.
- Document analysis (n=100) is on-going. This will help to delineate the existing governance system for nutrient management in the Lake Erie basin and the scales at which it is operating.
- Policy Delphi surveys (n=40-60) are on-going. Policy Delphi is a method that uses iterative stages of data collection to reveal positions on an issue within a panel of people with relevant knowledge. It helps with the identification of external drivers of eutrophication in the Lake Erie basin; evaluating the extent to which they are accounted for in the existing

governance system as well as the extent to which the governance system affects consideration of external drivers. This policy Delphi survey is administered in two rounds:
    - Policy Delphi Survey #1: Round 1 is complete, Round 2 is in-progress.
    - Policy Delphi Survey #2: Round 1 is in-progress.
- Interviews that support the overall purpose of the study will not occur until later in 2019 as they are designed to build on the results of the policy Delphi survey.

Demographic Changes as External Driver in the Great Lakes basin: This study, being developed into a paper, is in its initial stages. It addresses the potential effects of changes in demographics in Ontario, especially as a result of immigration, on water governance processes in the Great Lakes basin. With recent declines in fertility rates in Canada, increases in population growth from immigration has become the primary source of population growth since 1999, accounting for up to two-thirds of such growth. In Ontario, the geographic focus of this study, more than 75% of the projected increase in population in the period 2017-2040 is expected to come from immigration. This immigration pattern has contributed to cultural diversity in the province as never seen before, as the majority of recent immigrants do not come from the same source countries as 50 years ago. Such changes in demographic characteristics, as well as the accompanying shifts in attitudes may affect the environmental values of the 'water user' groups as well as those involved in water-related decision-making processes. This brings a unique challenge to Canadian water governance structures and processes as they continuously deal with potentially shifting decision making contexts. At present we are conducting literature review to better understand this issue as well as designing methods for data collection and analyses. By collecting data from relevant sources this study will offer detailed and systematic exploration into the role of changing demographics and societal values on water governance processes in the Ontario portion of the Great Lakes basin as well as offer potential governance innovations in addressing those challenges.

Mountain Water Futures

Project Goal: The goal of this project is to understand future water for the mountains of Western Canada and to improve the ability to predict future hydrological regimes and plan appropriate adaptation. Changes to Canada's western mountains are having profound and rapid impact on the rate, magnitude and timing of streamflow regimes, which is challenging current water resource management practices in the region. [Website; Social Media]

Mountain Climate Extremes - MCE: WRF experiments were conducted in 2010 and 2015. In 2010, special consideration was made regarding days with the largest areas covered by transition regions; these were associated with atmospheric rivers with three of the top ones occurring in a January 11-15 multi-day event. Under an assumption of pseudo-global warming (PGW), the overall amount of precipitation within transition region increases over the whole 4-month period but not necessarily within individual events. On some days, such as January 11, warmer PGW

conditions lead to more transition regions being replaced by rain only than snow regions evolving into transition regions, leaving a net reduction. Additional transition region research was carried out using long-term surface observations to determine the occurrence of conditions near 0°C. Stations in the western Cordillera have some of the lowest but also some of the highest number of occurrences in the country although, in the latter case such as in the lee of the Rockies, these are often short-lived due to chinook and other mountain-induced circulations. The fraction of these occurrences with precipitation also varies across the region from as low as 5-10% upwards to 45%. We also continued the study during 2012-2013, which is associated with the major flooding event, and to extend it to the 13-year simulation period. The occurrence of precipitation events was investigated on both sides of the continental divide (Kananaskis, AB and Fernie, BC). We found that most long duration events (>24 h) are associated with mixed precipitation in Fernie but this is not the case in Kananaksis. Only rain or only snow events were more common. But those events are, however, associated with a trace of other types of precipitation, which indicates that all long duration events at both locations are associated with mainly mixed precipitation. This suggests a high variability of the snowline in those areas. Preliminary analysis showed that the height of the 0°C-isotherm can vary to up to an elevation of 1.5 km during one event.

VIC-GL has been coupled with a regional glaciation model to estimate the mass balance of glacier basins from 1985-2005. Projections of areas in glaciers show decreasing mass and contribution to runoff through the Fraser River Basin. These results have been actively disseminated to BC Hydro and insurance companies.

Collaboration with members of Pillar 1 project SPADE and Pillar 3 project Climate-Related Precipitation Extremes has been ongoing, and a special atmospheric observation period is being organized by SPADE in May-June 2019 and will be linked with MWF. This includes the deployment of a complete meteorological station in September 2018 at Nipika Mountain Resort, just outside the boundary of Kootenay National Park, British Columbia. Data collected since autumn up to the end of the SPADE field campaign in late June 2019 will become available for MWF researchers.

Cryosphere - CRY: Over the past year we have continued to make progress on updating estimates of glacier change for western Canada. Using space- and airborne data we produced a comprehensive estimate of glacier mass change for all glaciers in western North America that lie outside of Alaska and the Canada (BC, YK)-Alaska border. Using our airborne LiDAR (light detection and ranging) equipment we also surveyed glaciers and snow-covered terrain for several regions that we identified as 'observatory sites'. Some of these key datasets include LiDAR surveys of the Columbia and Bologna Icefields, Wolf Creek, Kananaskis, and Peyto Glacier. We are also updating estimates of glacier area change using spaceborne imagery and Google Earth Engine. That work is expected to be published later this year. Many of these datasets, and the

algorithms used to derived them, are shared with fellow scientists and government agencies including the Water Survey of Canada, BC Hydro and the Government of BC. These agencies require an assessment of present and future cryospheric change and how changes in snow and ice will affect Canada in the decades ahead.

Surface-Groundwater Interactions - SGW: During the reporting period, we published a synthesis of our field study on rock glacier aquifer system at Helen Creek watershed (Harrington et al., 2018), demonstrating the importance of rock glaciers in temporarily storing snowmelt water and releasing over a long time to sustain the year-around baseflow in mountain streams. This has important implications on the stability of freshwater ecosystem in fragile mountain environments and the year-around availability of water resources in downstream communities under future climates. We have also conducted detailed field studies of alpine aquifer systems at the Fortress study site. Preliminary results showed the importance of talus and moraine units in serving as a "gate keeper" of snowmelt water at the top of the headwater basins. We are currently developing numerical tools to represent the gate-keeper function of alpine aquifers in large-scale river basin models.

Field site set up for future experiments include drilling two shallow monitoring wells in Granger Basin, Wolf Creek. We conducted GPR surveys of Granger Basin, Wolf Creek. We also began developing sporadic permafrost groundwater models of Granger Basin. This has been done in collaboration with hydrogeology division of the Yukon Government. This has involved visiting Whitehorse and the Yukon's hydrogeologist, and an active exchange of data with the Yukon government.

Vegetation - VEG: We quantified subalpine forest water use for two growing seasons, gaining an understanding of the evapotranspiration (ET) and transpiration contributions to the seasonal water budget. A stable water isotope investigation provided insight to water sources of subalpine forests; results show soil moisture is the most important source, with younger trees placing more reliance on this source. Forest health could be compromised if successive years of summer drought occur, and growing seasons lengthen. Large scale eddy flux analysis has been completed with the WRF model, making advances on the sensitivity of mountain ET to variability and strength of mountains winds, influenced by complex topography and canopy variation. The hydrological role of tree island investigation has found higher rates of PET in open areas, compared to the closed islands. These islands also held the snowpack for longer, providing insulative properties prolonging melt. Modeling has been delayed on these projects as the student lead has gone on maternity leave. Experiments to partition transpiration from evaporation across an elevation gradient in Wolf Creek and assess the influence of ecosystem change on water storage and cycling have been set up. This work is ongoing and collaborative with BWF and other forest inter-comparison experiments. With the aid of Brian Menounos, a new LiDAR was obtained for Wolf Creek. This LiDAR will be analyzed to assess vegetation change

(notably shrubs) in Wolf Creek since 2007 (the last LiDAR acquisition). In addition, historical remote sensing imagery has been obtained to compare with current imagery for ecosystem classification. Water temperature work has largely been completed with a previous MSc student whose paper is now being prepared for publication.

Wetlands - WET: The subalpine wetland studied has been shown to have unique relationships with shading during the growing season. Shade in the wetland prolonged spring snowmelt into July, leaving less than two months for the remaining growing season. 27% of total season ET occurred in the two-week period after snowmelt. We studied fens in the alpine (2365 m) and foothills (1485 m). Water table dynamics differed between the two fens; the alpine fen has a high and stable water table even when snowmelt was advanced by three weeks, and did not freeze in winter. The foothills fen regularly experiences a large water table drop of up to 1 m after the ground thaws. The research reveals that the alpine fen has higher hydrological resilience to a warmer future than foothills fen owing mostly to suspected greater groundwater inputs. The research carried out explores partnering with beaver to provide flood mitigation. The research results challenge two long-standing hypotheses: 1) that beaver dams commonly breach during large floods, and 2) that beaver ponds have limited floodwater retention capacity. Analysis shows that the majority of them survived the massive 2013 flood. Further, detailed study of beaver ponds at Sibbald fen during the flood reveals that ponds detained floodwaters, even when breached. We conclude that beaver pond levels are much more dynamic than previously thought.

May 2018 marked the beginning of Dr Rooney's first field season in the Alberta Rocky Mountains. Our graduate students collected their first year of data examining the bird and vegetation communities in alpine peatlands across an elevation gradient. Our students worked with Dr. Rich Petrone's field team to gather groundwater flux data and collect water samples for stable isotope analysis at 9 sites in the mountains. Dr. Cherie Westbrook's student, Stephanie Streich, joined us for plant surveys and received training in vegetation survey methods. Dr. Derek Robinson and his technician joined us in July to collect high resolution drone imagery, mapping 8 study sites. Our field research was informed by the knowledge and expertise of local stakeholders who are, primarily, involved in various watershed stewardship groups in our study region. These partners included the Bow River Basin Council, the Ghost Watershed Stewardship Group and the Elbow Watershed Stewardship Group. In addition, we worked with Alberta Environment and Parks on site access and site selection. Notably, the Ghost Watershed Stewardship Group sent a representative to accompany us during the field work in their watershed. Partners remarked that they would like to see more of a rare plant survey conducted because our study approach could miss rare plant species in favor of capturing the dominant communities present across the heterogenous wetlands. In response, we are modifying our survey methods for this field season to better capture rare species.

Next generation solutions to ensure healthy water resources for future generations

Project Goal: Emerging and transformative technologies in biology and bioinformatics provide new capability to address urgent environmental needs. Environmental DNA (eDNA) and next generation sequencing (NGS) methods will be applied to monitor current status and predict future trends of the structures and functions of aquatic ecosystems exposed to stressors in Canada. Together these technologies have the potential to provide more rapid, comprehensive, and objective assessments of ecosystem status, including the presence of rare and endangered species, in real time, while reducing costs. [Website]

Progress: The project has continued to make good progress toward the main deliverable of establishing reliable protocols for applying eDNA and other emerging technologies to improve bioassessment and monitoring in Canadian watersheds. Close interactions have continued to be established and enhanced with a variety of end users across the country. This has included a survey of potential users (key monitoring agencies and users). Several integrated lab and field-based studies are being conduced. Progress on these outcomes has included: 1. Optimizing and expanding eDNA methods to detect aquatic invasive species (AIS). Detection of zebra mussel eDNA was achieved using real-time PCR with TaqMan chemistry. The protocol was applied in 2018 to monitor 73 Saskatchewan lakes, focusing on areas of likely invasion, and important recreational and sport fishing. Key locations included Boundary Dam Reservoir, Lake Diefenbaker, Fishing Lake and Tobin Lake. No invasive zebra or quagga mussels were detected in Saskatchewan lakes in the summer of 2018 using eDNA techniques. Targeted TaqMan™ multiplex eDNA detection methods are currently developed for Prussian carp and other invasive species of concern in Canada with a focus on the Canadian prairies region. Specifically, 73 Saskatchewan lakes were sampled in 2018. A study of wood frogs and their pathogen, ranavirus, was conducted in wetlands near Saskatoon; 2. A field study was conducted to determine effects of disturbance of sediment. Effects of climate change and pharmaceuticals on rates of eDNA shedding and degradation in brook, brown, and rainbow trout was completed in Bowman Creek (rare Charitable Reserve); 3. A barcode database of Canadian freshwater fishes was constructed for 252 Canadian, freshwater fishes; 4. Validation of the eDNA-based was conducted at the Saskatchewan River, the Saskatchewan River Delta, Meadow Lake, McClean Lake, Konner Lake and long-term monitoring lakes of Experimental Lakes Area (ELA). At the ELA, zooplankton metabarcoding was compared to results based on morphology-based identification. Aquatic insect specimens were collected in August in Lake 260 of ELA and are being sorted. Eighty sediment samples from McClean Lake, Konner Lake, and Lake 239 and 260 of the ELA were collected in 2018. The sequenced mitochondrial COI, 12S rRNA data and 16s rRNA are under processing, and will help to calibrate eDNA metabarcoding of macroinvertebrates with traditional survey and historical data. Furthermore, microbiomes and macrobiomes of samples from ORANO company, and Husky Oil Spill, FOReST, BOREAL and ERASe projects were also characterized; We completed development of techniques for isolating and characterizing microbiomes in guts of

fishes. Fish from the area of the Husky Oil Spill were analyzed for gut microbial communities. A trend of diminished diversity and richness in microbial communities in guts of fishes containing greater concentrations of PAHs. A of fish microbiomes in medaka exposed to perfluorobutane sulfonate (PFBS) was published.

Northern Water Futures

Project Goal: This project seeks to expand the capacity for research and monitoring in the NWT and improve the understanding of the long-term sustainability in water resources. [Website; Social Media]

Northern Resource Management and Security

- Progress in the development of a novel interface-based numerical model of permafrost evolution (CRAIG)
- Successful development of a 2D non-isothermal phase change finite element model of permafrost thaw to be used to investigate the controls on lateral thaw of permafrost in the wetland discontinuous permafrost systems of the southern NWT (CRAIG)
- Significant advances in the development of an upscaled solution for fill-and-spill outflows from bog cascades such as found in the discontinuous permafrost wetland landscapes in the southern NWT (CRAIG)
- Integrated sampling in a new site in the Mackenzie Mountains. This involved extensive geophysical measurements (GPR, ERT) to develop maps of surficial layers, characterization of sediment hydraulic properties, development of discharge rating curves, isotopic sampling to evaluate flowpaths and runoff source areas, and collection of high resolution imagery using UAV surveys to map topography and monitor snowmelt. (QUINTON)
- Three successful deployments of airborne InSAR capable Ku-band radar near Inuvik. (DERKSEN/MARSH)
- Radar flights with coincident ground measurements of snow and soil properties were completed in November 2018, January 2019 and March 2019. (DERKSEN/MARSH)
- In May 2018, an ice-jam flood event occurred mainly in the southern Athabasca sector of the delta. A novel application of an isotope-mass balance model, Remmer et al. [in review Hydrological Processes] developed a set of binary mixing models and estimated the proportion of input to flooded lakes attributable to river water and precipitation (snow, rain). This approach allowed identification of areas of river flooding (Figure 1, Appendix I) that were not captured by other methods, including direct observations from flyovers, and to demarcate flow pathways in the delta. (WOLFE/HALL)
- Establishment of a network of sap flux and dendrometer band stations coupled with eddy covariance towers across all major forested observatories in NWF. This will allow us to partition the contribution of trees to ecosystem level water fluxes

(SONNENTAG/BALTZER). Baltzer has organized a meeting of BWF, MWF, NWF, and SFWF projects to synthesize flux data across these projects.

- CANet-funded upgrade of the micrometeorological tower infrastructure for eddy covariance and supporting environmental measurements at the Scotty Creek, Smith Creek, Havikpak Creek and Trail Valley Creek observatories. A MSc student (El-Amine) and a postdoc (Meyer) are currently analyzing these data streams including their submission to the Ameriflux network. (SONNENTAG)
- Through shrub sap flux measurements, we have demonstrated that shrub expansion on the tundra has the potential to lead to a doubling of tundra ET (Black and Baltzer in review), possibly more given the substantial changes in vegetation composition and structure in shrub patches compared to open tundra (Wallace and Baltzer, in review) (BALTZER)
- A. Jitnikovitch completed his MSc thesis in October 2018, with a focus on using cosmic ray sensors to measure snow accumulation and melt. Anton installed and tested the SnowFox CRS in Southern Ontario, and at sites north of Inuvik, NWT. At the Inuvik sites, the installation included six sensors along an 80 m transect crossing a shrub patch induced snow drift. This study demonstrated that the SFs are able to accurately measure snow accumulation over an entire Arctic winter accumulation and melt period. (MARSH)

Integrated Ecosystem and Community Health

- Widespread sample collections of fish, water and sediments were taken to support ongoing biomonitoring and analyses of mercury content in fish in Tahlina and Kakisa Lakes. (LISTER/MACLATCHY)
- A water quality and monitoring meeting was established in the Sahtu (Great Bear Lake) and held in February 2019. The meeting brought together research from around the country to support the vision of community-led monitoring initiatives, refine research priorities and identify key elements of the aquatic monitoring program. (SPRING/BLAY-PALMER)
- Levels and determinants of several priority biomarkers measured in the Mackenzie Valley Biomonitoring Project were characterized. These included biomarkers for mercury (blood, hair), cadmium (blood, urine), and polycyclic aromatic hydrocarbons (urine). Contaminant exposure determinants for people were investigated. Traditional food consumption was not associated with cadmium biomarker levels, but smoking was a significant determinant. Several PAH biomarkers of pyrene, naphthalene, fluorene and phenanthrene were associated with smoking status and cooked meat consumption. (LAIRD)
- A Health Messages Survey designed to assess awareness and perceptions of contaminants, current food consumption patterns, and preferences for communication

strategies was implemented. In addition to the Health Messages Survey, interviews were completed in one of the NWT communities (n=12) to document perceptions and stories regarding contaminants and to provide context for the information gathered in the Health Messages Survey. Two terminology workshops were also held in the Sahtú region where key terms related to the biomonitoring project were identified and discussed and interpreted into Slavey language (Brandow et al., 2018; Brandow, 2018). (SKINNER)

Energy Security and Impacts of Industrial Development on Water Resources

- Data from 14 lakes was collected on water quality and invertebrates, nine of which experienced burns in their watersheds during 2014 and five which did not. Preliminary results suggest that water quality recovers fairly rapidly after fires, but the effects on invertebrate communities are longer lasting. (GRAY)
- Established the Field Observatory within the Husky Lease of the Sahtu Settlement Area (SSA). A combined data gathering approach was proposed and implemented during the field exercises at the site, which were conducted during the months of August and September 2018. The combined field activities involved the use of an integrated data gathering approach. This work is a joint effort of NWF and TTSW). (RUDOLPH)
- To enhance baseline understanding of this resource-rich environment we have begun the establishment of a fire chronosequence to evaluate rates of recovery following wildfire in this system. These are being set up identically to sites further south facilitating a NWT-wide understanding wildfire impacts on forest regeneration, carbon recovery and permafrost conditions (TURETSKY/BALTZER).

Impacts of Climate Warming on Infrastructure

- Installation of an eddy covariance (Campbell Scientific) tower and a series of EM50's in Snare Rapids and pressure transducers installed in a headwater and connected 2nd and 3rd order lakes with significant cooperation from both the NTPC and ENR. A second eddy covariance tower with several EM50s in the Snare Basin to increase our confidence in obtaining a meaningful ET estimate will be installed this summer. (ENGLISH)
- A detailed snow survey was designed and carried out in the Snare Basin with community member Mr. Roy Judas to determine the snowpack water equivalent variability in 9 terrain units (defined by differences in slope and aspect) across the landscape south of Wekweeti in an area equalling half an EASE-Grid pixel. We used this high site density survey to compare to the Globsnow SWE for that date. (ENGLISH)
- Predisposition of land to thermokarst (sudden permafrost collapse) was mapped for the Sahtu region of the NWT, and overlayed this spatial information with culturally significant areas indicated by the communities. (TURETSKY)
- Successful initial development of a regional flood forecasting model of the Liard using the Raven Hydrological model. This model is to be the basis of a predictive forecasting model

for Nahani Butte and other Liard communities. Initial progress has been made in incorporating ice jam forecasting into the modelling process. Model found to outperform other Liard models in the published literature. (CRAIG)

Old Meets New – Subsurface Hydrological Connectivity and Groundwater Protection

Project Goal: Recent concerns have risen for deeper groundwater systems due to issues related to unconventional oil and gas development and subsurface waste disposal – areas which both suffer from data scarcity. The first phase of this project will conduct a review of the available data for western Canada to improve our understanding of hydrogeological connectivity. [Website]

Database Development: Key databases have been assembled for the project

- ***Groundwater Chemistry:*** A database of 10,000 major ion analyses from deep hydrogeological units in Western Canada has been compiled from AccuMap, a commercial oil and gas database. This compilation required extensive culling to eliminate samples with excessive charge balance errors and contamination by drilling fluids or other sources. Data for the USA has been obtained from various USGS sources to create a database with a range of salinities covering most oil and gas producing regions.
- ***Hydrogeologic Properties:*** A database of over 500,000 core measurements of permeability and porosity have been compiled from AccuMap. This data adds to a database of several hundred permeability measurements made by Ferguson's research group based on drillstem test data in provincial databases. In addition, a database of several hundred hydraulic conductivity measurements from glacial tills has been compiled by David Ferris, an M.Sc. student working with Ferguson on a related project funded by the Fedoruk Institute.
- ***Oil and Gas Activity:*** A database containing the dates of installation and abandonment of over 700,000 oil, gas and injection wells has been compiled for Western Canada. Compilation of drilling, completion and abandonment regulations for Saskatchewan and Alberta is underway, with the intent of identifying important changes in the regulations that might affect groundwater protection.
    - Annual records of fluid production and injection have been compiled for the oil and gas producing region of Southeastern Saskatchewan.
    - An opportunity to add another student, Rima Bouslama, arose through a Mitacs program. This allowed us to look at surficial impacts of the oil and gas industry. Rima is currently working with a database of spills of oil and produced waters by the oil and gas industry in Saskatchewan made available by the provincial government.

Analyses to Date: Preliminary analysis of the position of the intermediation zone has been conducted for Western Canada and the United States. The analysis for the United States resulted

in a highlight article in *Environmental Research Letters* (Ferguson et al, 2018). Initial findings for Canada indicate variable separation of oil and gas activities from potable groundwater resources, ranging from over 1000 m in some areas to less than a few hundred m in others. A lack of access to shallow groundwater quality databases from provincial governments has impeded progress in this area.

A preliminary fluid budget has been produced for Southeastern Saskatchewan. There is an excess of water in the subsurface in this area, with the Mannville Group gaining significant amounts of water. While much of the injected water is water produced by the oil industry, substantial amounts of shallow groundwater and surface water are used for hydraulic fracturing and waterflooding. The exact sources of these waters are not clear.

Preliminary statistical analyses of permeability have been conducted. Conventional statistics have been calculated for nearly 100 different hydrostratigraphic units in Western Canada. These statistics will be used as model input later in this project.

'Omic' and chemical fingerprinting methodologies using ultrahigh-resolution mass spectrometry for geochemistry and healthy waters

Project Goal: This project supports the development of advanced mass spectrometry techniques for the analysis of chemicals of particular significance to aquatic systems. These methodologies are developed based on the two OrbiTrap mass spectrometry systems purchased by the GWF program. Projects range from advancing methodologies to improve regulatory methods for the analysis of persistent organic pollutants to the development of methods for the characterization of dissolved organic matter in aquatic systems. In addition, the instruments and associated HQP support a range of other analytical projects by various investigators including GWF investigators. [Website]

Characterization of Dissolved Organic Matter: Water samples have been collected over the last year from five locations in proximity to Saskatoon (Sth. Saskatchewan river (above and below Saskatoon), Pike Lake, and Buffalo Pound Lake (inflow and outflow locations)). Samples were collected on three consecutive weeks over all four seasons. In addition, short term temporal variations are being assessed using a 4 hourly temporal sampling scheme at one location. We have developed a direct infusion mass spectrometry technique to analyze the compounds present in these water samples. However, we have identified the potential for instrumental modifications that could enhance this technique and will be working with the manufacturer over the next few months to implement hardware modifications.

There are currently no commercially available software systems for the analysis of the type of data accumulated in this study so data analysis protocols have been developed using in house coding in the R Statistical package. These procedures are required to combine data from multiple samples, identify unique, non-overlapping features in each sample and then identify features

common to multiple samples. This approach has lead to the condensation of data files for multiple samples from several hundred thousand individual 'features' to a more manageable tens of thousands of common and/or unique features that have common characteristics. The next phase of the processing of the data is to determine chemical formulae for the identified features. In addition we are currently developing multivariate procedures to interpret differences between samples and what these might mean from an ecological perspective.

Development of Advanced 'Omic' Techniques: In conjunction with the GWF Project "Next generation solutions to ensure healthy water resources for future generations" and a DFO funded project methods for *proteomics* and *lipidomics* have been developed. Bottom up proteomics involves the enzymatic digestion of complex protein mixtures followed by chromatographic separation of the resulting peptides and identification of peptides and their amino acid sequences by mass spectrometry. The resulting data files can represent many thousands of individual peptides and bioinformatic software is used to identify and quantify the parent proteins. This proteomic approach provides data complimentary to genomic data determined by genomic DNA sequence analysis.

Lipidomics is a technique that determines the specific lipid components present in cells and tissues. Lipids are essential in many structural and functional aspect of cellular biochemistry. These lipidomic techniques are being developed in conjunction with a DFO funded project assessing the effects of perfluorinated compounds (PFCs) on salmonid fish – specifically arctic charr a species of great significance to Canada's northern first nation communities. PFCs are a group of compounds known to have significant impacts on lipid metabolism and the lipids which constitute cellular membranes.

Analysis of Persistent Organic Pollutants: Current regulatory methods for the analysis of dioxins and PCBs are based on the use of mass spectrometry technologies developed in the early 1990s. The need for strict QA/QC evaluation of part-per-trillion concentrations of these compounds have constrained the application of new mass spectrometry techniques to these analyses. We have been able to demonstrate the OrbiTrap mass spectrometry systems are able to exceed all current QA/QC requirements for these compounds and, indeed, make possible new, hitherto unimaginable, levels of QA/QC for these analyses. As an example, two currently acceptable methods for these analyses are high resolution accurate mass spectrometry and MS/MS technology which generates fragment or 'daughter' ions of the parent compound. While the battle between these relatively old technologies continues the instrumentation we currently use are able to perform the same two analyses *simultaneously* with greater mass accuracy than either previous system. Clearly, these new techniques offer opportunities to rewrite regulatory criteria for these analyses and to allow us to revisit what have been previously considered to be the 'gold standard' criteria for the identification of unknown compounds.

KM activities for this project are focused on informing the analytical and regulatory communities of the potential of these new mass spectrometry techniques to rewrite the way we do analytical and regulatory chemistry. This effort has to date focused on plenary presentation at specialized analytical/regulatory user meetings (e.g. Western Canadian Trace Organics Workshop) and one on one discussions and demonstrations with significant regulators such as the Ontario Ministry of the Environment. We are currently developing a special session at the upcoming Society for Environmental Toxicology and Chemistry meeting (Toronto, November 2019) to further focus attention the implications of new mass spectrometry techniques on environmental and regulatory chemistry.

We are currently working on a project with GWF researchers **Brinkman** and **Hecker** to demonstrate the advantages of the newly developed dioxin analysis methods on a project funded by the US-EPA.

Support for Other Analytical Projects: Instruments and HQP supported by the current project have also been essential in the support of other projects by both GWF researchers and other colleagues. The Q Exactive LC system has been supporting a research project funded by the Beef Cattle Research Council (**Jones** and **Giesy** coPIs)to evaluate the fate of synthetic hormones and antibiotics, and their metabolites, used in beef production on Canadian prairie feed lots. These compounds have significant potential to impact both ground and surface water resources in the Prairie Provinces. The Q Exactive LC and GC systems have been supporting Department of Fisheries and Oceans projects investigating the impacts of perfluorinated chemicals on northern fisheries (LC system, **Jones** and **Giesy** coPIs) and impacts of the Husky oil spill on the North Saskatchewan river (**Jardine**, **Jones** and **Giesy** coPIs). This later project has also attracted additional funding from the Saskatchewan Water Security Agency whose interest is in the quantification of previously unknown PAH biomarkers of the oil spill.

Prairie Drainage Governance

Project Goal: This project explores the role of policy and social institutions in the effective governance of agricultural drainage during times of rapid change. [Website]

Progress: Our research methodology is iterative, in that we are alternating among methods that investigate the broader context and those that dig into case-oriented specifics[7] (Vayda 1983). In Y1 we have successfully interviewed 29 stakeholders from multiple groups across Saskatchewan, 15 which speak to broad context and 29 that speak to specific case studies (note that some fit both characterizations, which is why they add up to more than the total N). With this work, we have identified specific case studies to pursue in more detail: drainage projects in Dry Lake, Black

[7] Note that Progressive Contextualization (Vayda 1983), a principle research methodology in Human Ecology that we are adopting here, does not begin with specifics regarding research questions or scales of analysis. These are identified progressively as the researchers learn more about the problem of interest.

Bird Creek, and Atwater-Kaposvar watersheds in Saskatchewan. We selected these cases through consultations with provincial experts in drainage governance as well as in response to community needs and interest.

We've transcribed 2/3 of the interviews and are in the process of thematic analysis using both a grounded approach and a deductive code book based on the Social-ecological Systems Framework (SESF, Ostrom 2009). So far, we have observed in our fieldwork multiple hallmark indicators of conflict escalation, which include diverging narratives of the "problem", skepticism about scientists' agendas, and the creation of straw-man or dehumanized caricatures of the "other sides". We are also seeing aspects of "environmentality", a feature in natural resource conflict where some people respond by embracing the language of the dominant natural resource management regime while others reject it.

Simplified model of conflict escalation over agricultural drainage

As part of our contextual research, we also performed a literature review on peer-review research on agricultural water management to explore which aspects of drainage as a social-ecological problem have and have not been explored. We structured our literature review using Ostrom's Social-ecological Systems framework (Ostrom 2009). What we found is that most existing research focuses on the specific biophysical aspects of drainage, while very little focus has been placed on the social aspect of these systems, especially governance. We produced a knowledge brief from this review that details more of the fine-scale findings of the review, which can be found here: https://gwf.usask.ca/drainage/documents/PDG_Knowledge%20Brief-Final.pdf.

Additionally, in our attempt to apply the SESF as a deductive framework for analyzing our expert and stakeholder interviews, we are finding that the framework is ill-suited to drainage. The SESF was developed for simple, extractive resource systems, such as fisheries. In the case of drainage, which meets many of the criteria of a "wicked" problem, we have different groups relying on different sets of ecosystem services, in different points in space and time. We are anticipating that we will need to either adapt the SES or develop a new framework, and believe that this may prove to be a significant, unexpected academic contribution of the project.

We've also begun the creation of a logic model for understanding the differing perceptions of the "drainage problem" as a way to explore possible cultural and social-psychological roots of the conflict. This work is based on the "life words" concept (Stone and Glover 2017). Here, we're tentatively proposing the notion of "water worlds": coherent cognitive ecologies within which stakeholder groups come to understand what the land is "for" and what people's roles are in it.

Logic model for drainage perspectives, which can serve as a precursor to agent-based modeling. Note that these are to some extent caricatures, and we expect that people can operate in hybrid spaces between them, though as conflict escalates people are likely to retreat to more idealized positions.

Prairie Water

Project Goal: Prairie Water is addressing sustainable water management and enhancing water resilience under a changing climate across three interrelated themes: hydrology, groundwater, wetlands, and governance. [Website; Social Media]

Progress: The surface Hydrology research theme made significant advancements over the last funding year. These include producing a classification of Prairie watersheds based on physiographic characteristics, of which this work is currently in review, and lays the framework for building our virtual basin of prairie watershed response. Two virtual basins were modelled

using the Cold-Region Hydrological Modelling platform, and a PDF produced hydrological output based on the needs of other PW research themes in order to ingest hydrological data into their workplans. This is a key step to link the various disciplines within the project. The methodological approach of the virtual basins and validation with field data is currently in preparation for publication.

During the reporting year, the Groundwater research by the U of Calgary team completed a recharge model for sites in Alberta. The model will be extrapolated to other provinces (SK and MB) over the next year in collaboration with the Hydrology team. PDF-H1 and PDF-G1 are currently working to compare CRHM and VSMB performance in simulating groundwater dynamics. Although the latter activity was not previously outlined in our Inception Report, it was identified as a necessary activity to complete during our Annual Partners Meeting. The exercise will ensure effective integration of surface and sub-surface hydrology endeavours within PW.

Also, projects have been focused on determining the amount of groundwater that is available for extraction in the Canadian Prairies and the connections between these deeper water supplies and the rest of the hydrologic cycle. Assessment of the East Regina aquifer is near completion. This lent insights into the vulnerability to contamination of source water aquifers. We are scaling up to larger regions within SK, and MSc-G1 has compiled a dataset of hydraulic conductivity measurement of glacial tills. This information, in conjunction with work being done under the "Old Meets New" Pillar 1/2, will assess deep aquifer recharge rates, the potential for contaminant transport through these tills, and thus, potential conflicts between the energy industry and water supply interests.

Our Wetlands theme made strong progress to meeting their objectives for the reporting year. A first manuscript on agricultural land management, which crosses interests of AWF and PW, was published in Environmental Reviews, and a second is in development focused on wetland biogeochemistry, links to catchment chemistry, and functionality to scope priorities for conservation of nutrient cycling ecosystem services. We completed a prairie-wide wetland pond survey in summer 2018, with a second planned for 2019, a combined effort of our biogeochemistry and pesticides sub-themes. A PDF modelled pesticide exposure distribution throughout the Prairies using pesticide use data (third-party) and the field campaign, and a manuscript is in preparation for this work. An ecological risk assessment to biodiversity is currently underway and is set for completion in 2019.

The biodiversity team developed mixed-effects models detailing the interactive impacts of climate and land use change on wetland macroinvertebrate and avian communities. The work, led by a PDF, is currently in review for publication. Findings will link to hydrological and chemical outputs from virtual basins to translate changes to biological ramifications. Another PDF assembled land assessment values, wetland inventory data, and land cover/use data for the

Vermilion River Basin (VRB). One of our PDF's and researchers are testing how drainage decisions based on land value and thus agricultural productivity impact hydrology. This informs the socio-economic dimension of prairie water management, and the socio-economic results are being used for scenario development in virtual basin modelling. A manuscript on valuing ecological services for agricultural wetlands was also prepared.

Due to the number of priorities under this theme, we have been pursuing external funding and collaborations. Loring (PDG project) and Baulch, with Spence, Whitfield, Bedard-Haughn, and partners from Ducks Unlimited proposed spin-off work from the virtual basin modelling, as a part of an NSERC Strategic Network Grant led by Elena Bennett (McGill). If successful, this will help further leverage GWF funds and progress key user-driven questions within a network of ecosystem services experts, helping strengthen capacity for ecosystem services research within GWF and Prairie Water specifically. Several additional proposals were advanced, to support a drainage manipulation experiment. While several were unsuccessful, we are awaiting the outcome of another.

The Governance theme made progress in co-designing research methods with partners and data collection. Many HQP activities over the reporting year focused on relationship building, including working with youth and women, and attending traditional ceremonies. Students received blessing from Chief and Council of Mistawasis Nêhiyawak, a key research partner, in August 2018, and data collection for our workplans occurred soon after. Significant community workshops include co-developing a water governance framework from the perspective of the community, and understanding how hydrological findings are valued and interpreted by stakeholders. Interviews conducted involved a number of stakeholders, with the intention of providing lessons for success when conducting source water protection plans.

Sensor and Sensing Systems for Water Quality Monitoring

Project Goal: The overarching goals of this project are 1) The development of low-cost sensing systems and its implementation for long term monitoring of water quality parameters and 2) The development of specific low cost sensors that are capable of detecting pathogens, heavy metals, oxidants and nutrients and integrate them with the sensing system. One of the key objectives of the GWF program is to integrate water quantity and water quality data in real-time and making it readily available to users wirelessly. Furthermore, the development of novel sensor technology and autonomous sensor networks has been identified as a high priority for user groups. This project meets these objectives. [Website]

However, a major challenge in the risk assessment of contaminated waters, whether from industrial, agricultural, or municipal operations, is the potentially intermittent and fluctuating nature of contaminant concentrations in those waters. Ecosystems, and human health, generally respond to peak stressor (such as heavy metals) concentrations that enter toxic ranges, rather

than average concentrations over time. Periodic sampling of water for contaminant analysis (e.g., weekly or monthly) can easily (and often does) miss these peak episodes of contaminant discharge as indicated by several of our collaborating GWF partners (Basu, Baltzer, MacRae, Duguay). Sensors and sensor networks will help monitor key contaminants at sites of interest in real-time, thus providing a much improved ability to perform accurate risk assessments of surface waters and effluent discharges, and allow industrial facility operators to implement corrective action much quicker should conditions change or accidental discharges of elevated contaminant concentrations occur.

Progress: Below are brief progress notes relating to each sensor or sensor network we are working on:

- Libelium sensor:
    - Deployment in South Saskatchewan River could not proceed, ion-sensors did not work
    - Focused on better delineating effluent exposure within lakes downstream of the mining operation (Orano project): data successfully collected and water samples also analyzed for routine parameters, new probes to be used for 2019 field testing
- Free chlorine sensor:
    - Free chlorine sensor: successfully tested in lab, to be tested at Six Nations (spring 2019)
- Optode system:
    - Installed in an agricultural field site and data successfully collected: oxygen, soil temperature and moisture content, and pore water chemistry data
- Wireless transmission system:
    - Tools for analysis and code generation for smart devices (user interface ready)
    - First results of water quality data form Six Nations being analyzed using machine learning
    - Wireless sensor network (WSN) – process of developing using IoT, visited Buffalo Pound Lake for water sample collection, and Smart Water System lab where drone based system will be used to test WSN
- Cyanobacteria sensor:
    - Sensor modeled & simulated, mask for microfluidic device has been designed and purchased, sensor to be fabricated
    - To enhance throughput, a thick micro-channel employed (time consuming process)
- Microwave sensor:
    - new design to increase the number of microwave sensors in one single microscope slide from originally one to now two (higher throughput for field testing)

    - Simulation and experimental studies have been performed
- Phosphate sensor:
    - New electrochemical approach allows detection as low as 10-7 M
- Microplasma:
    - Automated thread-based, colorimetric detection of metal ions
- Metal detection:
    - In vitro selection for Ni2+-dependent DNAzymes, demonstrated good selectivity, proceeding with charactization, reproducing lead detection assays
    - DNAzyme called 17E to be used for understanding effect of dissolved organic matter
    - Planned deployment Ptarmigan mine site outside of Yellowknife summer 2019
- Water quality testing, Fouling detection and removal:
    - 75 wells tested in Six Nations –measured several chemical parameters (conductivity, pH, TOC, TC, IC, turbidity, hardness), data to be released to community (winter)
    - pH sensors fouled with organic & biofoulants: analyzing signal changes

Short-duration extreme precipitation in future climate

Project Goal: The main objective of this project is to gain an in-depth understanding of physical mechanisms involved in short-duration extreme precipitation and how they may change in the warming world, thereby providing an important scientific foundation for interpreting projected future changes in extreme precipitation. We will aim to better understand the roles of thermodynamics and dynamics in storm system changes.

Precipitation and temperature relationships: Qiaohong Sun (PDF, PCIC): First, the binning scaling and trend scaling for precipitation extremes were analyzed. Due to limited data availability, especially for the sub-daily rainfall, the binning scaling, estimated empirically based on day-to-day variations in temperature through a binning technique or quantile regression, has been regarded as a substitute for trend scaling to project the long-term response of local extreme precipitation to temperature change. However, binning scaling reflects influence of seasonal cycle of storm systems. Based on a large ensemble of Canadian regional climate models (CanRCM4), we compared the binning scaling and trend scaling of precipitation extremes across different durations (3-hour, 12-hour, and 24-hour), temporal scales (annual, winter, and summer), and spatial scales (local and regional scales). Strong evidences have demonstrated that the binning scaling cannot project the long-term change in precipitation extreme, with the disagreement of spatial pattern and magnitude between the binning scaling and trend scaling regardless of the durations, seasons, and spatial scales. Second, trends of annual maximum daily precipitation over global land have been updated. We collected annual maximum 1-day precipitation (RX1day) and annual maximum 5-day precipitation amount (RX5day) from 43813

stations over global land during 1900-2018 period to update the change trends. The Mann-Kendall nonparametric trend test and nonstationary generalized extreme value analysis were adopted to evaluate the possible nonstationary behavior of these precipitation data. The statistically significant increasing trends were detected at the global scale, with about 8.34% and 9.51% of stations showing significant increases for RX1day and RX5day, respectively. By including the recent decadal data, more stations started to show statistically significant increasing trends, and less stations with decreasing trends. On the other hand, the nonstationary extreme value analysis showed a statistically significant positive association with global mean temperature, with 6.7%/°C and 5.54%/°C of the sensitivity of RX1day and RX5day to global warming respectively.

Changes in MCSs and characteristics of storms: Object-based algorithm provides additional spatiotemporal information of precipitation, besides traditional information like amount and intensity. Precipitation features derived from a convection-permitting climate model (CPCM) were compared with features from three independent precipitation datasets: the Canadian Precipitation analysis (CaPA) system, North American Regional Reanalysis (NARR), and Multi-Source Weighted-Ensemble Precipitation (MSWEP). It shows the CPCM is able to depict precipitation features including its size, track length, duration, and propagation speed. The statistical results derived from the WRF historical simulation (CTRL) and future climate (PGW) will be compared to identify the potential changes in MCSs and characteristics of storms that will be caused by climate change.

Physical processes underlying the changes in MCSs: Yunsung Hwang (PhD, USask): It is known that the precipitation would be less frequent but more extreme in a warmer climate as the warmer air can hold additional moisture. In this study, precipitation systems were divided into moderate and extreme to obtain their potential changes in the future. In order to present changes, two 7 years (2007 to 2013) WRF simulation results were utilized as retrospective simulation (CTRL) and future climate (PGW). Warm season precipitation (March to August) over the plains east of the Rookies were chosen to examine precipitation systems with less topographical impacts. Statistical analysis shows that moderate precipitation systems are the main contributor to the eastward propagation of precipitation systems. While the PGW simulations demonstrate additional occurrence of extreme precipitation in the central region (over 100mm/hr) for June, July and August.

To determine the convective potential, some thermodynamic indices underlying the Mesoscale Convective Systems (MCSs) were investigated, like Convective Available Potential Energy (CAPE) and Lifting Index (LI). Analyzing features of these indices especially under climate change, is helpful to predict future MCSs-related extreme precipitation effectively. This study uses 4 km resolved convective-permitting Weather Research Forecasting (WRF) model to conduct a control simulation (CTRL) for 13 years (2001-2013), and applies Pseudo Global Warming (PGW) method in the same simulation to represent future climate. Moderate and severe convections were

defined by using specified thresholds. Based on these, the study analyzed the frequencies of occurrences of convective indices CAPE and LI under different conditions, and compared their differences between two simulations during summertime (June to August), to show the response of deep convections to future warmer climate.

Physical realism of GCM and RCM simulated extreme precipitation: Mostofa Kamal (PhD, USask): We investigated the observed characteristics of extreme precipitation over western Canada using multiple statistical techniques and explores the impacts of climate change on future extreme precipitation by comparing the Pseudo Global Warming (PGW) projection against retrospective simulation (CTRL) generated using the Weather Research Forecasting (WRF) model at convection permitting scale (model's horizontal grid spacing < 4km). A comprehensive understanding of the projected changes in extreme precipitations events under changing climate conditions and the associated risks inherent to lives and property may result in better-informed decisions and drive society towards sustainability.

Significance of Groundwater Dynamics within Hydrologic Models

Project Goal: The main objective of this project is to examine the significance of shallow/deep groundwater flow including the unsaturated zone on surface water flow predictions through high-resolution numerical simulations with HydroGeoSphere (HGS), a fully-integrated hydrologic model. HGS simulations will be conducted with a representative seasonal cycle to investigate the spatial and temporal variations in surface water and groundwater fluxes including its distributions in a well-instrumented watershed. The calibrated model will then be used to examine the impacts of climate change, winter processes, and anthropogenic activity on surface water/groundwater interaction and to provide insights on contaminant transport and wetland management. Ms. Xin Tong, a new PhD student is conducting the research with support from Dr. Young-Jin Park.

Progress: In particular, four integrated hydrologic models using HGS are currently being developed to highlight the significance of groundwater fluxes on surface water flow within the ACW: (1) a model incorporating only overland flow data without considering the subsurface; (2) a model with a thin soil layer (1-meter deep); (3) a model with homogeneous subsurface and uniform hydraulic parameters; and (4) a model with detailed subsurface information on hydrostratigraphy and heterogeneous and anisotropic hydraulic parameters. These models all share the same high-resolution topography information, landcover representation, temporal precipitation records, evapotranspiration and wellfield operation data.

Incorporated data for the HGS hydrogeological models includes: 1) DEM data from Ontario Ministry of Natural Resources and Forestry, 2) land use data from the Grand River Conservation Authority (GRCA, 2009), 3) Soil Landscapes of Canada (SLC) developed by Agricultural and Agri-

Food Canada, 4) geological models through previously developed groundwater flow models (Matrix and SSPA, 2014a,b), 5) precipitation data from the Roseville Environment Canada weather station (OMNR, 2007) located just over 2 km outside the watershed, 6) daily stream discharge data from Environment and Natural Resources of Canada, and 7) wellfield operation data obtained from the Region of Waterloo's WRAS+ database (Regional Municipal of Waterloo, 2014).

We are also comparing several baseflow estimation techniques. In particular, a BSc student (Ms. Siyu Cheng) is calculating the value of baseflow using streamflow data from six gauging stations at the ACW (and in nearby streams) through the: 1) recession method; 2) Lyne and Hollick method; 3) Chapman method; and 4) Eckhardt method. The results are compared to determine the most suitable method for the study site, and the relationship between baseflow and streamflow are investigated. Ms. Cheng is planning to continue with your MSc under this project. Her research topic will be to conduct a more rigorous comparison of baseflow separation techniques using the calibrated HGS models developed by Ms. Tong.

Southern Forests Water Futures

Project Goal: The proposed work will develop and improve process-based land surface and ecosystem models (e.g. Canadian Land Surface Scheme-Canadian Terrestrial Ecosystem Model (CLASS-CTEM) and Boreal Ecosystems Productivity Simulator (BEPS) to more accurately account for cold region processes, through development and testing of new novel canopy conductance, evapotranspiration and ground water interflow algorithms. This modelling work will help to improve the predictive capabilities of the Canadian regional and global climate models. BEPS is incorporated in the Canadian regional (Global Environmental Multiscale Model, (GEM)) model and CLASS-CTEM is used in the Canadian Earth System Model (Can-ESM). Project data will be available to Canadian and international user communities and to the public through GWF Big-Data archives. [Website]

Micrometeorological and biometric measurements: Continuous micrometeorological measurements of energy, water and carbon fluxes were conducted in all four Turkey Point Observatory forest sites (79-, 44- and 16-year old conifer and 80-year old deciduous forest) using closed-path eddy covariance (EC) systems. All four stands are located in close proximity, near Lake Erie in southern Ontario. We also continuously measured weather variables, soil temperature and moisture at all four sites (at 2, 5, 10, 20, 50 and 100 cm depths) as well as the groundwater table at the 79- and 44-year old sites. Sapflow stations were established in the 79- and 44-year old conifer sites to estimate tree transpiration rates. Transpiration, soil water content and water table measurements were combined with eddy covariance fluxes will help to estimate plant and soil water budgets in these age-sequence conifer and deciduous forests. Annual biometric (e.g tree height, stem diameter, litterfall) measurements were conducted in

NFI plots at all four sites at the end of the growing season. Soil organic matter decomposition studies were also established in 2018 using soil chambers to quantify soil carbon and water flux. These soil measurements will be used to construct linear and non-linear models such as NARX neural networks. The results of these long-term measurements show significant impacts on growth and water use efficiency in response to changing climate and extreme weather events. In the 78-year old stand, early growing season climate impacts were identified in daily and monthly net ecosystem productivity (NEP) trends. Heat and drought extremes in 2005, 2007, 2012, and 2016 impaired stand-based NEP which was detectable by mid-June, and caused a significant decrease in total annual NEP as compared to wetter years 2006, 2008, 2011, 2013, and 2014. Drought during 2016 also forced a decline in total annual NEP and gross ecosystem productivity (GEP) in all three conifer stands (79-, 44- and 16-year). Annual NEP is also dependent upon age. Annual fluxes from the four-site chronosequence show that peak NEP occurs within the 43-year old conifer stand. Two manuscripts are being prepared presenting results of inter-annual micrometeorological fluxes and biometric measurements.

Ecological, tree-ring, elemental and stable isotopic and remote sensing studies: Trees were cored for dendrochronological samples to evaluate changes in ring growth and Water Use Efficiency (WUE) over the lifespan of our forests. Stable isotopic ratios (^{13}C to ^{12}C) of tree-rings were also measured as well. Isotopic signals from the tree ring growth records provided changes in intrinsic water use efficiency (iWUE) over the life cycle of all four forests. The ring-width and isotopic measurements were cross-examined with available climate records and eddy covariance data to identify the effect of climate variability and extreme events in these plantation stands. As of April, 2019, one manuscript was published in *Forest Ecology and Management* (McKenzie et al., 2018). Two additional manuscripts of results were submitted: one each to the *Canadian Journal of Forest Research* and *Forests*. Planned work includes increasing sample depth of tree ring isotope iWUE time series (Slater, Kim).

A vertical profile of atmospheric CO_2 properties (concentration and $^{13}C/^{12}C$ and $^{18}O/^{16}O$ ratios) will be constructed in the forest canopy. Easy-to-use analytical techniques for the stable isotopic analyses of atmospheric CO2 will be provided to the scientific community. Monitoring stable isotope compositions of atmospheric CO2 for geographic and seasonal variations in southern Ontario will provide background information for stable isotope dendroclimatology studies in these stands (Slater, Kim).

Dendrochronological records of elemental abundances are being examined as proxies for past changes in climate (i.e. droughts), soil nutrient levels and stand productivity using micro-XRF spectroscopy scans of wood samples. Micro- (N, P, K, Ca, Mg, S) and macro- (Cl, B, Cu, Fe, Ni, Zn, Mo, …) nutrient profiles from wood samples show seasonal variation which may be linked to cambium activity or physiological responses to climate. Elemental profiles will be constructed at 1-2 m intervals within the tree stem to determine inter-stem variability in elements due to

translocation effects. These profiles will also be compared between trees to determine inter-stand variability. Lastly, elemental profiles will be compared with regional climate records and forest thinning events to identify drought effects and nutritional availability on elemental concentrations respectively (Boyce).

Forest management studies: A sapflow experimental set-up was initiated in the Variable Retention Harvesting (VRH) plots that comprise 20 treatment plots (1 ha each) at our 88-year old red pine site. In this set-up, 80 sap flow sensors were installed in 10 plots, 2 replicates for each treatment. These VRH treatments include 5 different sets of harvesting densities and arrangements, each replicated 4 times (Fig. 1): A reference, non-treated control treatment plots (CN), partially harvested plots that have either 55% or 33% tree canopy retention with two different spatial patterns, either uniformly distributed (D) or aggregated (A - retention in 4 circular patches of different radius), resulting in the five treatments: CN, 33A, 55A, 33D and 55D. These measurements will help to determine how various VRH treatments will promote higher forest growth and improve stand water status. Sapflow sensors were built in collaboration with Northern Water Futures Project (Dr. Oliver Sonnentag).

A mobile open path eddy covariance (CPEC) system was assembled for the 2018 growing season. The CPEC was rotated between the VRH plots approximately every two to three weeks. The system was used to monitor the carbon and water fluxes of the understory vegetation and to determine their contribution to ecosystem level fluxes by comparing with the fluxes from eddy covariance system installed at the top of the flux tower. The data of carbon and water fluxes, water use regime, soil characteristics and forest growth was integrated to provide insight on forest management practice towards climate change adaptation. A manuscript showcasing the results is in preparation (Arain).

We are also in process to collect and analyze dendrochronological samples in all VRH treatment blocks by taking tree cores. Tree ring growth chronologies will be constructed for all five VRH treatments. Allometric equations will be used to quantify annual stem biomass growth and carbon sequestration. Carbon sequestered and radial growth change pre- and post-harvest will be analyzed and contribute to our understanding of how VRH may promote growth (Pisaric). This analysis will aid to identify if a specific spatial pattern of retention is responsible for an increase in sequestered carbon (Pisaric).

Individual tree rings samples will also be processed for stable carbon and oxygen isotope analysis (^{12}C, ^{13}C, ^{16}O, ^{18}O). Isotopic signals from the tree ring growth records from different VRH plots and radial growth ring dimensions will help to determine changes in intrinsic water use efficiency (iWUE) of all VRH treatment plots (Slater, Kim).

CLASS-CTEM and MESH Hydrologic Systems: We developed an integrated eco-hydrological modelling system (MESH-CTEM-N+) by incorporating the Nitrogen (N) coupled Canadian Land

Surface Scheme and Canadian Terrestrial Ecosystem model (CLASS-CTEM-N+) in the Modélisation Environmentale Communautaire (MEC) Surface and Hydrology system (MESH). This model is being used to investigate feedbacks between carbon, water, energy and nutrient cycles and to extrapolate site-level fluxes and information to watershed or catchment scales. The performance of the CLASS-CTEM-N+ model was evaluated for the Big Creek watershed in southern Ontario. The model shows promise in simulating hydrological processes with respect to observed streamflow and the coupling of CLASS-CTEM-N+ to MESH (NASH 0.41) for the period October 2004 – September 2017. We are collaborating with researchers from the Environment and Climate Change Canada (ECCC) (Drs. Pietroniro, Davison, Fortin). This work will help to improve the modelling of evapotranspiration, infiltration and the soil water balances at a watershed scale. A manuscript of results is in preparation for submission to *Ecological Modelling*.

Evaluation of climate change and management Impacts and up-scaling studies using BEPS model: The Boreal Ecosystem Productivity Simulator (BEPS) model has been improved by incorporating novel seasonal photosynthetic capacity (Vcmax) and two-leaf canopy conductance formulations. GPP and ET estimates were simulated using seasonal variations of leaf area index. Model was tested in eight different forest ecosystems across Canada. LAI was found to improve GPP simulations better than ET simulations in the eight forest sites. Additionally, the Medium Resolution Imaging Spectrometer (MERIS) terrestrial chlorophyll index (MTCI) was used to evaluate vegetation phenological controls on the seasonal variation in Vcmax. The MTCI only slightly improves GPP simulation for the forest sites. We will apply this high resolution modelling framework work to up-scale site-level information to other plant functional types at regional and national scales and evaluate the feasibility of similar management scenarios in different regions in Canada. BEPS is already coupled to the regional Global Environmental Multi-scale (GEM) model. Radiation parameterization scheme used in BEPS can be adopted in CLASS-CTEM+N. BEPS will also be used to evaluate forest management and VRH treatment impacts on the growth and water budgets in different forest sites in southeastern Canada.

Sub-Arctic Metal Mobility Study (SAMMS)

Project Goal: To address the pressing need to examine legacy metal pollution from mining with changes in DOM and hydrology due to climate change in the NWT, the Sub-Arctic Metal Mobility Study (SAMMS) will undertake six work plans. These have been designed to comprehensively trace the transport and behaviour of DOM and metals through terrestrial and aquatic ecosystems in headwater catchments along a 200 km airshed transect between Giant Mine and Whati, an area of concentrated mining activity. Work plan include: 1) terrestrial stores of historical metal deposition and transport to aquatic ecosystems, 2) DOM quantity and quality, metal binding, and toxicology, 3) modelling of DOM quantity and quality in cold regions, 4) metal depositional history, pathways, and processes in lake sediments, 5) paleo-ecotoxicology and ecosystem

structure, and 6) climate change effects including permafrost thaw. Findings will inform improved decision-making by multiple stakeholders in the NWT, including Indigenous peoples, about both legacy of mining activities and implications of new mining developments on water quality in a changing environment. [Website; Social Media]

Terrestrial Stores of Historical Metal Deposition and Transport to Aquatic Ecosystems:

- Work on settng up models to predict the export of water and organic matter from small watersheds to the small lakes sampled for lake sediment cores has recently started. [HQP: S Sharma; Supervisor: CJ Whitfield]
- Catchment areas that contribute water, organic matter, and thus metals to small lakes need to be identified in order to estimate the stores of metals in lakes and catchments. Work on generating digital elevation models and land cover classification for lakes along the 80 km transect (see WP4) is set to start in late-April. Ultimately, these results will be used to (a) estimate the load of metals from catchments to lakes and (b) serve as a ground-truthed model of water export from small catchments to feed into larger river flow models. [HQP: M Schultz, J Leathers; Supervisors: MJ English, JJ Venkiteswaran]
- Litterbag decomposition experiments have been installed throughout a lake's catchment accessible via Highway 3. This is part of a long-term carbon cycling experiment. [HQP: J Hickman; Supervisor: JJ Venkiteswaran]
- Piezometers and boards were installed and constructed throughout a wetland accessible via Highway 3. This wetland and its nearby lake will form the basis of continued fieldwork. [HQP: J. Leathers; Supervisor: JJ Venkiteswaran)
- Lakes along the Ingraham Trail were surveyed and sampled in winter to identify possible lakes for additional field work in the next summer field season. Lakes were sampled for water chemistry and aerial photo interpretation of the lakes' catchment was groundtruthed. [HQP: M Schultz; Supervisors: MJ English, JJ Venkiteswaran]

DOM Quantity and Quality, Metal Binding, and Toxicology:

- We are combining efforts on metal binding and dissolved organic matter quality with a research associate funded by Northern Water Futures. Results will inform how the metal-binding capacities of dissolved organic matter are modelled. [HQP: P Aukes; Supervisors: SL Schiff, JJ Venkiteswaran]

Metal Depositional History, Pathways, and Processes in Lake Sediments:

- We successfully collected sediment cores from 8 lakes at ~10-km increments along an 80 km transect northwest from Yellowknife, which aligns with the predominant wind direction. Radiometric dating and metal concentrations analyses are in progress. Preliminary results show that Giant Mine arsenic and associated metals are present in lake sediment at least as far as 40 km from Yellowknife, which further demonstrate

evidence of far-field atmospheric deposition of emissions. [HQP: I Jasiak; Supervisors: R Hall, B Wolfe]

- We successfully collected porewater from lake sediment cores along this 80 km transect. These are likely the first sediment porewater samples collected to assess the mobility of Giant Mine metals. Porewater concentration analyses are complete. Preliminary results from diagenetic modelling of porewater data show a variety post-deposition patterns and varying levels of metal mobility to the sediment surface. Reductive dissolution of mineral phase arsenic and subsequent reactions with sulphur and iron species likely control the fate of arsenic mobility in porewater. [HQP: É Leclerc; Supervisor R-M Couture]

Paleo-Ecotoxicology and Ecosystem Structure:

- A culture of a unique strain of Daphnia has been grown for use in sub-lethan toxicity tests. Samples for this strain were collected from the Yellowknife area, naturally elevated in geogenically derived arsenic. The unique origins of this Daphnia colony provide the SAMMS project with an environmentally relevant test species to use in heavy metal(loid) toxicity studies, compared to the standard Daphnia magna commonly used in aquatic toxicity testing. Methods of sedimentary exposure have been developed which provide both lethal and sub-lethal endpoint data for this important primary consumer. Preliminary results are promising, with mortality seen to increase in sediments enriched with anthropogenically derived metal(loids), and significant increases have been observed in the oxidative stress indicator, malondialdehyde for some sediment sections. Additional sublethal endpoints are being explored to provide more information regarding the mechanisms by which low trophic level organisms are being impacted by metal(loids) in aquatic ecosystems. [HQP C. Cheney; HQP: J Blais]

Storms and Precipitation Across the continental Divide Experiment (SPADE)

Project Goal: This project focuses on cold region processes related to storms and their precipitation at the top of the western Cordillera. The precipitation in this region provides the primary source of water for North American rivers going to the Pacific, Atlantic and Arctic Oceans, can trigger catastrophic flooding and it maintains the perilous existence of glaciers. Despite its essential role, very few observations that link surface features, precipitation and atmospheric conditions are available in this region. This project will start to address this gap by using a combination of sophisticated weather instruments, instrumented mountain basins and modelling tools to study storms and precipitation across the continental divide. [Website; Social Media]

Progress: Since April 2018, much progress has been made, mainly on the preparation of the field experiment and also on the numerical simulations setups, and is as follows.

To study storms and precipitation across the continental divide, we focus on two main locations (Nipika Mountain Resort in southeastern BC and Fortress Mountain in southwestern Alberta). First, a field visit to determine the locations for the meteorological equipment on both sides of the divide was organized in May 2018. We chose 3 sites (see figure below): on the western side, Nipika Mountain Resort for SPADE to deploy instrumentation on a plot of their land and on the eastern side (Fortress Mountain and Fortress Junction Service). All sites are now equipped with a basic meteorological station, including a precipitation gauge, as well as an optical disdrometer to characterize precipitation types and a Micro Rain Radar (MRR2) to measure precipitation aloft. The sites on the eastern side of the divide have a scanning lidar to measure wind field in the valley and at the top of Fortress Mountain. The instruments used are from Environment and Climate Change Canada, University of Northern British Columbia, University of Saskatchewan and Université du Québec à Montréal. The logistics have been possible with the help of the GWF Technical core team at the University of Saskatchewan. The installation week started on 22 April 2019. A first major spring storm on the eastern side of the continental divide has been documented, where 30 cm of snow was reported at Fortress Mountain. However, no manual observations were conducted at Nipika as the installation there begins on 30 April 2019.

Precipitation and surface temperature climatologies have been developed using observational stations from various sources including Parks Canada, Alberta Agriculture and Forestry, ECCC, and Changing Cold Regions Network (see figure below). We included non-active and active stations because surface observations within the SPADE region (114°W to 117°W and 50°N to 52°N) are sparse with few long-term records. Stations were chosen at a similar latitudinal transect that crossed the continental divide from 1982–2012, for which more of the stations were active during that period (A Brun-Berthet). A secondary shortterm analysis on precipitation and temperature was conducted for the most recent years from 2014-2018 by J Almonte. The climatology indicates wide variation in temperatures at each location over the two month period from ~-10°C to ~30°C, with the median temperature over 0°C. Precipitation accumulation varied over the continental divide with higher amounts towards the continental divide and less on either side of the divide.

Locations of SPADE field sites in red (Nipika Mountain Resort, Fortress Powerline and Fortress Junction Service). No special instruments will be installed at Haig Glacier but we will have access to basic meteorological information that will be made available by Dr. Shawn Marshall (U of Calgary).

To better anticipate precipitation events during the field project, verification of the ECCC forecast was conducted for Nipika Mountain Resort and Kananaskis (Nakiska Ridgetop) (C Carton). Overall, maximum observed temperatures were often higher than forecasted (2-5°C) and minimum temperatures were near forecasted temperatures. At Nakiska Ridgetop, both minimum and maximum temperatures were often below forecasted, with maximum temperatures 5-10°C below forecasted. At Kootenay NP West Gate, 5-day forecasts for minimum and maximum temperatures were more consistent with the observed temperatures than the 3- to 1-day lead time forecasts. In general, there was a tendency to overpredict chance of precipitation.

A comparison of estimated snowfall accumulations using GPM (Global Precipitation Measurement) satellite data and the Canadian Precipitation Analysis (CaPA) over the continental divide is underway (A Bertoncini). GPM and CaPA snowfall amounts were partitioned using GEM model output and were validated against observational stations in the Marmot Creek Research Basin. At lower elevations, GPM estimates were similar to observations. However, within alpine regions GPM underestimates snowfall with negative biases >2 mm/day from 2014-2017. This is in part due to GPM's inability to fully capture orographic enhancement, temperature gradients, and gauge uncertainties from snowfall undercatch. GPM correlation improved compared with CaPA relative to ground observations at all elevations, while biases diminished when compared to CaPA in the alpine.

SPADE also includes some numerical simulations. The GEM model started to be set up to run highresolution simulations over the SPADE domain (C Carton). This is in collaboration with the core modelling team member, V Vionnet, as well as K Winger, analyst at UQAM. In parallel, a summer student (C Moderie) began setting up the Computational Fluid Dynamics (CFD) simulations to obtain the wind field near the surface. It is continued by a MSc student (A Desroches-Laointe). This combined with a particle-tracking model will allow the study of precipitation trajectories near the surface (preferential deposition).

Transformative sensor Technologies and Smart Watersheds (TTSW)

Project Goal: To develop a new era of Big Data for water, using terrestrial sensor networks, new sub-orbital aircraft and drone instrument platforms, and near- and far-orbit satellites, linked to rapid information dissemination tools for users and the public. While new drone technology will provide unprecedented spatial data, the project will also deploy and commercialize systems for acoustic sounding of snow, develop and deploy ultrasonic sensors for multiple environmental measurements (snow depth, stream level, stream velocity, air temperature, humidity, blowing snow), and develop and deploy a portable waveguide spectrometer for the identification of water pollutants, to provide accurate and real-time data for Canada's water environment. [Website; Social Media]

Progress:

Develop, deploy and commercialize System for Acoustic Sounding of Snow 3 (SAS3): The latest version of this instrument is named 'Chione' and is being prepared for commercialization. Four co-op students were hired to assist with this process. Several copies of Chione were deployed in the winter of 2018/19 in various environments including windswept areas and deep snow with data evaluated against detailed snowpit measurements.

Develop and deploy ultrasonic sensor for multiple environmental measurements: The non-contact stream sensor (NCSS) has been developed and tested at field sites of over the past year in order to measure surface water velocity and water level. In addition, literature has suggested that this device can penetrate ice/snow on a stream to continue velocity measurements. This capability was tested over the past winter. The next step for this system is further field testing at sites in our network of observatories.

Develop and deploy a Portable Waveguide Spectrometer (PWS) for the identification of water pollutants: Honeywell's optical hand-held PWS testing has been put on hold due to resource shortages but will continue over the next year. To reconcile this setback, the microfluidics lab led by Carolyn Ren has been continuing to work on small microwave sensors including simulation, design, fabrication, and testing. This kind of sensor is designed to use the electromagnetic properties of water to indicate water contaminations such as trace metals, oil contamination and

microorganisms. This instrument is currently being tested in the lab with potential field testing planned to take place over the next year.

Identify and assess currently instrumented watersheds hosted by GWF researchers and partner institutions for inclusion as hydrologic observatories: Over the past year TTSW has engaged with GWF groups and partners at several field observatories. For example, core technician Aaron Vandenhoff is supporting field activities at the Sahtu site and facilitating connection between Northern Water Futures and the Govt. of NWT as well as First Nations collaborators. At Alder Creek, TTSW is working with MSc student Jacqueline Peters from the eDNA project (Servos) to combine biological and hydrological data. In total 60+ field observatories have been identified as part of the GWF network. Over the next year a basic list of the sensors and data collected at these sites will be compiled and sites will be considered for additional linking to the smart watershed technologies being developed in this project. Attempts to engage with the Eastern part of the country will also be made, initially through partners at Hydro Quebec.

Initiate the process of developing 'Smart' sensor networks for data logging and deploy and test 'transmitters' for communication from observatories to satellites and/or across Canada: PhD student Joey Ju is working with partner Solinst Canada on their "smart" data loggers to optimize battery life and capture extreme events from sensors. The loggers (iWT - Integrated Watershed Telemetry System) have been tested in the lab and will be deployed at the Alder Creek observatory this summer.

Co-I Rudolph met with partner Myriota/ exactEarth in September (2018) and April (2019) to begin moving forward with connecting current Myriota satellite transmitters with their existing satellite network, as well as the proposed satellite mission in this project to deliver data to researchers from field sites. Myriota has completed the development of their low-cost transmitters and released a developer toolkit which we will use to test data transmission in the lab, followed by deployment of transmitters at selected field sites. Myriota/exactEarth is working with Solinst and Ju to integrate data logging with these transmitters.

Assess and improve drone platforms and sensors for operation in cold weather in order to provide intermediary-scale measurements: The SenseFly eBee Plus (fixed-wing) UAV platform has been flown with RGB, multispectral, and thermal infrared sensors at the Sunfish Lake site (PhD student Mari Foroutan) at lower temperatures than previously tested, with satisfactory performance in temperatures as low as -10°C. Issues have been noted when flying in overcast or foggy conditions as this significantly lowers the quality of thermal imagery. Postdoctoral Fellow Phillip Harder and the Smart Water Systems Lab team have flown several UAV systems during Kananaskis Mountain campaigns in September 2018 and February 2019. The eBee plus and eBee X systems were found to operate at temperatures as low as -19°C. The M600 Pro UAV and Draganfly UAVs were both able to be flown at -12°C.

Co-I Pomeroy has received CFI funding for the airborne cold regions observatory (ACRO). They are currently looking to purchase a fixed wing platform which can carry a payload of up to 50 kgs.

Improve spatially-distributed measurements of snow water equivalent (SWE) and near-surface soil moisture/freeze-thaw state: Co-I Richard Kelly is waiting to receive funding for the CryoSAR instrument from CFI. Deployment will take place on a small airplane however, flight plans cannot be arranged until the agility of the system as well as its size and weight are known. To continue research during this setback, a field campaign took place in NWT in March 2019 coincident with active radar fights by partners Deutsches Zentrum für Luft-und Raumfahrt (DLR) and Environment and Climate Change Canada (ECCC). Our field team dug snow pits on, and drilled ice cores from Noell Lake and the Mackenzie River near Inuvik to compare with Ku band (ECCC flight) data as well as L, X, and C band data (DLR flight). This data will allow researchers to gain a better understanding of lake ice and snow-on-ice signals.

Co-I Aaron Berg has deployed a network of 20 ground-based radiometers to measure soil moisture at a berm site in southern Ontario. This network may be used to test Myriota communication devises over the next year.

In addition to these advancements, the SWSL is working on a self-calibrating heat pulse probe to measure soil water content. Tis instrument should be ready for field testing in the next year.

Multi-spectral instrument design and testing for water analysis: A hyperspectral imager for UAV deployment (Headwall Nano-hyperspec mounted to DJI M600 Pro) has been graciously provided as in-kind support by H2O Geomatics and tested over multiple targets including agriculture fields and water bodies over the past year. In September 2018 a field campaign with this instrument took place over Lake Erie in the Point Pelee region in conjunction with airborne hyperspectral flights by the National Oceanic and Atmospheric Administration (NOAA) and water samples and water surface spectra measured by Canada Centre for Inland Waters (CCIW). A co-op student has been hired at Waterloo through the FORMBLOOM project to assist in data processing.

A second campaign will take place in the summer of 2019 in conjunction with sampling from CCIW, NOAA hyperspectral flights and flights from the National Research Council (NRC) with the new hyperspectral WISE instrument (and CASI hyperspectral as back-up) comparable to that planned to be onboard the microsatellite mission proposed in this project.

Reflectometer design and testing for soil moisture and snow depth: Honeywell, together with partners at York University have built a GNSS-R instrument which is ready for field testing. A coordinated field campaign will take place with this system over an instrumented site in Mary Hill, ON in the coming summer. MSc student Yusof Ghiasi has begun working with a custom-built UAV-based GNSS instrument provided by Co-I Armaghan Salehian. This system will be moved to

a more stable UAV platform and tested in the coming field season, as well as during the Mary Hill field campaign.

Microsatellite Water Management Mission design: Communication with Honeywell has continued with main contact Ian D'Souza. The planned mission includes a hyperspectral imager, GNSS-Reflectometer, and communication capability with instrumented field sites. A survey was launched in November 2018 and shared with the water research and GWF communities in order to further gauge the needs of potential users as well as the viability of the mission (120+ respondents). A webinar was also held in November to provide an overview of the planned mission and answer questions about the mission from the science community (20+ attendees). We are currently awaiting a request for proposals from the Canadian Space Agency.

Winter Soil Processes in Transition

Project Goal: In an uncertain future climate, both the quantity and quality of water supplied by headwater wetland source areas in cold regions are expected to change significantly. However, our knowledge of how climate change will impact the biogeochemical functioning and hydrochemistry of these source areas remains limited. We propose to elucidate the role of winter soil processes on the export of carbon (C) and nutrients (N, P, S, Fe) to the river network under changing climate conditions. The project builds on the hypothesis that spring pulses of dissolved organic and inorganic C and nutrients by these headwaters reflect the cumulative effects of microbial and geochemical processing of redox sensitive elements during the non-growing season.

Progress: A series of controlled laboratory experiments were conducted by MSc students to understand in what processes the carbon and nutrient stocks, species, and fluxes in agricultural soils will be affected by a warming winter climate and what changes to the microbial community and their activities we can be expected in a warming winter. To understand these processes, MSc student #1 (Konrad Krogstad) measured the changes in soil carbon and nutrient pools in soil columns under winter climate scenarios to understand the effects of warming winters on how: 1) spring pulses of dissolved carbon and nutrients represent the cumulative processing of redox sensitive elements in winter soils, 2) these nutrient transformations have implications for crop nutrient availability and downstream water quality, 3) early soil thawing due to increased freeze-thaw frequency may diminish expected spring flushing and 4) microbial community activity and composition shifts are likely to be expressed in leachable carbon and nutrients (all addressing Objective 2 of the project). In addition, MSc student #2 (Grant Jensen) measured the microbial communities in soil columns to understand what changes to the microbial community and their activities we can be expected in a warming winter and what impact these changes will have in the consumption of fertilizer. These microbial community analyses are important in determining the impact of climate change for winter soils on how: 1) unexpectedly, microbes in frozen or

near-frozen soils are active, 2) renewed activity becomes even more prominent during thaw events with bursts of respiration and denitrification leading to the production of greenhouses gases, 3) increased microbial activity during freeze-thaw transitions may consume fall-amended fertilizer, reducing its efficacy come the growing season, and 4) shifts in microbial diversity in response to freeze-thaws may change the active metabolisms in soils, impacting crop growth (all addressing Objective 1 of the project). The results from the laboratory experiments conducted by MSc students are currently being integrated with bioenergetic analyses and reactive transport modeling in hydrology-biogeochemistry models to simulate and predict the biogeochemical transformations of carbon and nutrients in winter soils under changing climate conditions.

10.6 Significant Knowledge Mobilization Initiatives

The GWF Program promises state-of-the-art knowledge mobilization (KM) in conjunction with its scientific objectives of predicting change in cold regions, developing Big Data and support systems, and designing user solutions to focus on real world problems. Explicit in these objectives is robust engagement with a diverse end-user community.

Strong GWF-funded project-level KM initiatives will build robust overall outcomes for GWF and a variety of GWF program-level initiatives will foster stronger internal and external relationships and connections. A strong KM network will develop and share best practices and resources with all projects, researchers and staff, and build KM capacity across the entire GWF network. The KM Core Team envisions a GWF legacy that has fostered innovation in researcher-practitioner co-creation and has led to policy advancements and positive social change for water science and management in Canada.

10.6.1 Core Team

Increased appreciation for KM across GWF researchers

The KM Team has worked both as a collective and individually to create opportunities to build KM capacity throughout the network and directly with projects by providing tailored workshops, roundtables, one-one support and other activities. Examples:

- S. Merrill and A. Spring developed and delivered a KM workshop plenary for all attendees during the 2018 GWF ASM. The workshop included a KM lessons learned presentation by the Canadian Water Network, a Partners' Panel of GWF partners in NGOs, government and industry and First Nations, and a GWF year 1 highlights reel of successful KM activities. Interactive polling was used to gauge GWF researcher KM perceptions, awareness and support needs.
- The KM Webinar series was launched in fall 2018 as a Team collaboration. Five topics, chosen based on needs and interests of the network, were developed and delivered. Over 145 people registered for the five webinars, many of which were project managers and HQP but also professors. The most popular webinar was *Engaging with Indigenous*

Communities. Follow-up surveys gathered feedback on level of engagement, strengths and weaknesses and ideas for future topics and 95% percent ranked webinars very good or excellent.

- S. Merrill worked closely with Prairie Water, Integrated Modelling for Canada, and Extremes Precipitation teams to set an effective two-way engagement agenda and workshop format for the 2018/2019 annual project and partner meetings.
- A. Spring worked with Northern Water Futures to offer HQP training (open to all GWF HQP). This past year, nine events were coordinated with Laurier YP on topics of environmental education, northern governance, digital storytelling and plain language writing.
- S. Morningstar supported McMaster HQP and YP by offering digital storytelling workshops and worked one-on-one with HQP to facilitate video editing. She assisted the creation and delivery of a bi-weekly YP event focusing on lightning round talks (the L'eauDown); holds KM-focused GWF-McMaster team meetings; and delivers ad hoc consultation on Indigenous Research.
- N. Goucher and A. Dusome (GWF Comms) hosted training for Waterloo HQPs/professors on creating infographic posters for an end user audience (65 attendees). N. Goucher hosted follow up one-on-one sessions with over 20 students to provide feedback on poster drafts. Practitioners at the *Local Water Solutions* stakeholder workshop with noted appreciation for this style which facilitated deeper conversation and identify partnership opportunities.

Relationship building with partners, collaborators and knowledge users

KM specialists come to their job with broad and diverse network of contacts across non-profit organizations, government agency staff, Indigenous governments and communities, industry and other researchers. All specialists work to connect GWF researchers and projects with our contacts for increased collaborations and to help bring important and influential users to the table. Examples:

- S. Merrill identified and introduced key organizations playing a role in strategic national, regional and local community-based water data initiatives for Colin Robertson, PI of the Global Water Citizenship project to solicit feedback, beta testing and arrange presentations to community-based monitoring organizations.
- During her summer 2018 internship, Sarah Foley created a searchable database of GWF project and network-level stakeholders. It includes location and mapping capability and can promote cross-linkages across projects, support collaborations and provide important contextual information for communication with partners.
- S. Morningstar built relationships with the Native Women's Association of Canada (NWAC), Assembly of First Nations (AFN), and various FN community representatives at

the AFN Water & Climate Change Symposium Feb. 26-28, 2019., resulting in invitations to participate on the NWAC Environment and Biodiversity Unit council; present to Ogemawahj Tribal Council; and cultivated relationships with significant potential Maori (Aotearoa/New Zealand) stakeholders.

- S. Morningstar developed a relationship with a regional environmental group, Wellington Water Watchers, linking them with Co-Creation of Indigenous Water Quality Tools (CCIWQT). This linkage solidified in-kind and financial support for the CCIWQT November Water Week symposium, and is progressing to establish additional regional GWF project linkages.
- A. Spring built a network of communities, NGOs, and local, regional and territorial government partners from across the Northwest Territories and provides linkages to GWF projects, researchers and HQP to expand and create new engagement and outreach projects for youth, schools and government departments.
- N. Goucher invited over 50 of her contacts from provincial and federal government, industry associations and NGOs to the *Local Water Solutions* Network. The majority of these contacts were new to the projects at the workshop which helped to establish new project partners.

KM tools and resources

The team works collectively and individually to ensure broad application and tracking of KM activities by creating transferable templates, guides and toolkits. Many of these resources–including archived webinar video/audio content–are posted on the KM section of the GWF website (created by summer intern Sarah Foley, supervised by S. Merrill). Examples:

- N. Goucher made available various tools based on the *Local Water Solutions* workshop including: a guide to hosting stakeholder workshops (being used to plan a workshop in Saskatoon, June '19); a workshop summary report template; and workshop evaluation survey.
- S. Morningstar is transferring the content generated to workshop the creation of digital stories to other training opportunities, including the CCIWQT and Ohneganos projects.
- A. Spring co-developed communication and outreach tools such as presentations and student-focused communication plans, that have been shared across institutions, including the development of HQP training modules and presentations at Laurier and Waterloo.
- As part of the KM Webinar Series, the team created an evaluation template for webinars to obtain feedback from attendees and assist in continuous improvement.
- N. Goucher created a poster template for GWF projects, which has been used to develop posters for all of UW's GWF projects. It is available for use by other projects.

Documentation of GWF's KM impact

- Each team member hosted year-end check ins with projects to help with annual reporting and identify KM/communication successes and opportunities. As a result, each specialist is using the information in different ways to inform their work with projects, including a strategic KM analysis to identify prioritized tasks for 2019 work plans; stories for research impact communications; and a snapshot slide deck on the status of project.
- The team and project staff identified and fleshed out emerging stories of research impact with successful KM process and outcomes to date (examples in Outreach Publications section).
- S. Morningstar has developed and delivered methodology for training researchers and YP in documenting impact through digital storytelling. So far she has hosted a progressive series of 4 workshops (over 2 months), 15 HQPs have been trained, resulting in 5 videos to date.
- All KM team members actively work with projects to write articles and blogs that document progress, and engage with stakeholders. See Science and Publication Outreach list below.

10.6.2 GWF Projects

Some of the significant project-based KM activities that happened over last reporting year include:

Agriculture Water Future (AWF)

Communication within the AWF Project Team and with other GWF Projects: Since project inception, we have held routine meetings to share knowledge. Given the diversity of topics within the project, smaller, focused WP meetings within AWF have been preferred at present, with the plan to come together in a larger project meeting over the next year now that our HQP have some results to share and integration across WPs can begin in earnest. We continue to engage regularly with linked programs in GWF (LWF, PW, IMPC, TTSW, FORMBLOOM, WSP) through joint membership in these programs, and periodic meetings among key members of the groups. For example, the WP3 team has met with members of other GWF projects (**G. Strickert,** P. **Loring/H. Baulch)** to advance research related to human subjects and land use/management. PM **H. Bigas** and KM specialist **N. Goucher** attended a workshop held by the Prairie Water team in January 2019. **Macrae** and **Baulch** attended a series of meetings with **Loring** over the past year to discuss aspects of drainage in the Prairies. We are currently collaborating with **Rezanezhad** on several projects related to soil frost and biogeochemical cycles (AWF MSc **Higgins)** plus MSc student **H.Townsend**. We are also in discussions with **Spence** and **Basu** regarding land classifications and a comparison of modelled results. **Plach** presented at a TTSW meeting, and **Pinto** presented at an IMPC meeting and integrated with LWF. **Baulch** integrates with PW and FORMBLOOM. Some of these conversations were not possible in the previous year as the work within the WPs needed

to be completed first, before comparisons were possible. Now that these are underway, collaborations are developing.

Communication with Government and Land Stewards/Managers: Although large meetings are sometimes appropriate, feedback from many knowledge users is that such meetings can often be overwhelming or lack a scope that is focused enough for progress to occur. Consequently, our KM strategy has been to share information with our users and co-create the knowledge through ongoing dialogue, in a variety of settings. Members of the AWF team meet with government and land managers on an ongoing basis. This has been done via a range of forums including workshops, small group meetings and one-on-one conversations. In addition to the large number of small day-to-day meetings, notable meetings include meetings with OMAFRA and AAFC regarding the advancement of the development of the PLATO tool, which is a revised P Index (**Macrae, Plach, Pluer, Grant). de Loe** also met with OMAFRA regarding understanding the factors that facilitate and constrain the ability of grain farmers in Ontario to use a suite of measures that enhance soil and water management. Together, they co-developed the Delphi survey noted above. **Petrone** and his PDF Khomik (MWF/BWF) have continued to liaise with the USDA-ARS regarding the assessment of water use efficiency and drought stress in crops and the use of the eddy covariance technique. Sites will be instrumented this summer. **Brouwer (Pinto, Liu, Frank), Deadman (Guo, Frank)** and **Robinson** (**Meinen, Frank)** have all met with both the Grand River and Upper Thames region conservation authorities, and **Brouwer** has met with the Ontario Soil and Crop Improvement Association, several times throughout the year to develop work through AWF. In the Prairies, **Roste, Baulch** and **Elliott** worked closely with a watershed management group and the Saskatchewan Watershed Security Agency to develop their BMP screening. **Gordon, Macrae** and **Pluer** are working with VanderZaag (AAFC) and the Dairy Farmers of Canada on the determination of water footprints for dairy in Ontario. Three meetings have already occurred and field research is being initiated. **Pomeroy** has spoken at a significant number of meetings regarding aspects of AWF and GWF (listed below). Two larger meetings for knowledge users were held over the past year. One (June 2018) hosted by **Macrae** was related to the potential for controlled drainage in Ontario. **Basu** collaborated on this work. A second meeting was jointly held by AWF, LWF and WSP for users in the Great Lakes region. A second workshop for the Prairies (SK) (AWF, PWF, IMPC, Formbloom) is currently being planned for June 2019. The workshops were held in the two regions because most of the agricultural management within these regions occurs regionally, and, it is difficult for many of these users to travel across provinces. Under this workshop model, users interact with HQP in the early phases of the work, and consequently, co-create the knowledge together. This approach was preferred by users. Combining with other GWF projects avoids stakeholder fatigue, but also shows them that we are adding value to the work through collaboration and synergies.

Communication with Industry and the General Public (Outreach): AWF team members have also given numerous presentations to industry and the general public (producers). Numerous presentations have been given to members of the public (e.g. by **Macrae** (3), **Pluer** (2), **Plach** (2) in Ontario; **Roste, Baulch, Liu** in Saskatchewan, **Wilson** in Manitoba) over the past year. **Macrae's** Ontario work has been featured in two Ontario Farmer publications over the past year, as well as media releases for work on cover crops published in the Journal of Environmental Quality.

Climate-Related Precipitation Extremes

We have, over the past year, further strengthened our relationships with our users. We maintained active interactions with them to jointly establish and update our interests and priorities.

We have developed a strong relationship with the National Research Council, which is the body that oversees the evolution of the National Building Code of Canada. We also have considerable interaction with the engineering community in BC. PCIC is actively engaged with the BC Ministry of Transportation and Infrastructure (MOTI) via the offices of BC's Chief Engineer. PCIC has been assisting MOTI and Engineers and Geoscientists of BC in developing guidance to assist engineers to follow the mandate to consider future climate information in all design and construction projects for MOTI. Further, PCIC is working with MOTI to develop online climate information tools specifically to meet the needs of engineers in BC.

We have also developed an active interaction with CatIQ, which is a leader in delivering detailed analytical and meteorological information on Canadian natural and man-made catastrophes for the insurance industry. In addition, a member of this project (Hanesiak) was invited to give a talk and be a panel member on future changes in hail and severe weather environments at the recent 2019 CatIQ conference.

Strong communications have also been established with representatives of the electrical utility sector (Manitoba Hydro and NB Power), Health Canada as well as Agriculture and Agri-Food Canada to better quantify their needs and requirements regarding winter precipitation and drought. PCIC also interacts closely with BC Hydro, who seeks advice from them on both hydrological impacts and on their transmission and distribution system impacts of climate change. Our research activities have all been developed in consultation and collaboration with these representatives. We also organized an annual meeting with our users and researchers to share and communicate our research findings. During this meeting, we offered partners an opportunity to communicate feedbacks and needs for the third year. We also discussed the potential funding renewal of the second phase of the project. Presentations and outcomes of this meeting are available for the entire network on the project website. In addition, a status report on the scientific progress of the project has been developed and circulated to our users. A

number of research publications and presentations, as listed above, have been also released to support the transfer of the project findings.

All of these KM activities offer opportunities to co-create knowledge and to effectively apply it to the real-world designs.

Integrated Modelling Program for Canada (IMPC)

Meetings of the Knowledge Mobilization Oversight Committee (KMOC) and Strategic KM Analysis: Five meetings of the KMOC were held in Year 2 of the program (between March 31, 2018 and March 31, 2019). As in Year 1, the committee provided input around the user engagement survey design, research activities and the design of the IMPC Annual Meeting to facilitate more user engagement. In January 2019, The KMOC requested the User Engagement Specialist, with the assistance of the KM Specialist, complete a strategic KM analysis for the project that would guide KM activities in Year 3. This was 75% complete as of April 30, 2019. The remaining items include summarizing the findings and presenting them back to the KMOC.

Documenting Work Package KM Processes and Highlighting Success Stories: During Year 1 of the IMPC Project, participatory working groups and KM plans were developed for each of the Work Packages contributing to the project. Year 2 focused on documenting and showcasing, where appropriate, the plans and activities in collaboration with Co-Is and highlighting success stories. IMPC also began tracking work package KM progress according to CFREF requirements, which requests information on partner engagement along several stages of the research: (1) planning of the research, (2) design and data collection, (3) analysis of results, (4) exchange and dissemination of research, (5) user of research knowledge. Expectedly, considering the project phase, much of the knowledge mobilization activities over Year 1 and 2 of the program have taken place in terms of CFREF stages 1 to 4 (differentially across the work packages), but there are some example of stage 5 as well.

Lake Futures

Lake Futures (along with 4 other projects at UW and GWF core team members) hosted a stakeholder workshop (P2) in December 2018 to showcase our research and engage stakeholders on how best to increase the impact and uptake of our work. Prior to the workshop, the KM and Communication core members hosted an HQP training session on creating infographic posters to assist HQP in designing posters for an end-user audience. The training resulted in significant improvements to HQP being able to communicate the story of their research and developed engaging posters with targeted messages for stakeholders. The workshop facilitated successful interactions: conversations that took place inspired researchers to tweak methods, expand their network, and arrange follow-up meetings. LF students in different WPs have continued to work with stakeholder partners in various ways – see below for examples.

One of strongest measures of a successful partnership is the willingness to invest financially into a project. ECCC granted Basu $22K to expand the ELEMeNT model developed through GWF for the Grand River (WP1) to the Thames River watershed. This will help answer a question posed by the provincial and federal governments about timelines for meeting the 40% phosphorus reduction policy target in Lake Erie. The Record interviewed Basu about the potential environmental impact of Ontario's Bill 66 for a newspaper article (N5). The GRCA is also very interested in our work on reservoirs and has promised funding towards a Mitacs grant to continue some of the work started in LF.

The walleye-related research (WP3) (**HQP Quinn-Austin** with MacDougall at OMNRF) is a great example of co-creation, research partnership and a strong student-stakeholder pairing. **HQP Ho** has been actively consulting with stakeholders, including individuals from industry (e.g., Mining Watch Canada), government (e.g., ECCC, MECP, Parks Canada), Indigenous communities (e.g., Six Nations of the Grand River) and other organizations (e.g., conservation authorities, watershed councils, CWN, etc.) to help guide her research. Direction from the Wildlife Manager at Six Nations has guided Ho's Indigenous engagement approach. She has recently been named Resident Researcher at the Great Art for Great Lakes (GAGL) event series this summer, to facilitate connections between art and science. **HQP Ives** has organized Fuzzy Cognitive Mapping workshop (W4, P5) involving binational experts on Lake Erie eutrophication. Finally, HQP Jawed and Bocaniov are working on conceptual frameworks and project-level information materials (i.e. factsheets) as deemed useful for decision makers.

LF Co-PI Servos organized an HQP Summer School (2018, SC1) with the southern Grand River watershed. The HQP engaged in direct dialogues with biologists from the Long Point Conservation Authority at a watershed remediation site, managers from the Normandale Fish Culture Station responsible for fish stocking methods to raise threatened species, and the scientists and managers at the Lake Erie Assessment Unit (OMNRF). The Retreat had several outcomes including: (1) HQP got engaged in a direct dialogue with people responsible for water management and decisions in the watershed, (2) They got hands on experience touring the watershed that they model and study; (3) They broadened their perspective on the diversity of water issues and potential solutions.

Linking multiple stressors to adverse ecological responses across watersheds

We have made considerable progress towards the goals as laid out in the inception report. We have made considerable progress towards our KM goals as demonstrated by the willingness of our key partners to invest in our research. We were successful in securing additional leveraged funding through a partnership grant (NSERC CRD) with the Region of Waterloo. The Ontario Ministry of Environment Conservation and Parks had been directly engaged in our research and provided financial support to initiate collections in the Grand River so that we could archive samples for this project prior to the major wastewater upgrades in the Waterloo treatment plant

and completion of the final upgrades at the Kitchener plant. In addition, this funding has allowed us to complete a major laboratory study to validate some of the biological endpoints under controlled conditions. This has situated us in a very unique position having samples and data available for our model development and validation. We have been able to build on the work done by previous students to extend our model spatially as well as to include additional chemicals and biological endpoints. We have successfully recruited several students that are focused specifically on the model development.

As recommended we have reached out to the Six Nations (downstream of our main sites) and as a result, we are extending our modeling efforts down to the drinking water intake at Ohsweken. Our group has had a long-standing collaborative relationship with Six Nations of the Grand River (through the Wildlife Management Office). In addition, as suggested, we have also reached out to the Dr. Karen Kidd's group (newly established chair) at McMaster and have been facilitating sampling in the Grand River with several of her students and she is on the committee of one of our UW students. Karen has worked with Mark Servos on several wastewater and other related projects in the past.

We continue to hold formal meetings with several of our partners (e.g., Region of Waterloo, City of Guelph, GRCA, OMECP and ECCC) to discuss our research progress and plans. We hope to co-host a meeting with our partners this coming year (delayed at their request). We also interact with the Region of Waterloo and GRCA on a regular basis as they are providing data and advice (to the extent that they are co-authors on two papers resulting from our modelling in the Grand River) OMECP continues to support our project and we receive regular feedback from this group. The ECCC research groups in Burlington has been very engaged and collaborative in terms of supporting sampling and analysis. They sit on the graduate advisory committees of two of the students and have co-authors several manuscripts related to the outcome of this project. We met with ECCC senior policy makers in Ottawa to review the results of the studies.

The research group has a very strong relationship with the water, wastewater and watershed managers across the Grand River watershed. Servos and Parker have served on a variety of committees including the Grand River Watershed Water Plan Science Advisory Committee in the past. They are both asked for participation and advice on a variety of water and wastewater issues in the watershed. Mark Servos has been an active member of the Grand River Fisheries Management Plan Implementation Committee (GRFMPIC) that received the 2018 Grand River Watershed Award in recognition of continued partnerships and work towards managing the Grand River watershed. Wayne Parker has served on the stakeholders advisory group for the Region of Waterloo's update of the Wastewater Master Plan.

This year Servos co-chaired a session at a major international meeting (13th International Congress on the Biology of Fish) on Municipal Wastewater Effluent Impact. Our students have

been very active in making presentations at local as well as international conferences. Servos and Craig gave several invited talks. Servos gave a talk in the Distinguished Lecture series at the Swiss Federal Aquatic Science and Technology Institute in Zurich. Mark Servos spent 5 months between May 2018 and April 2019 in Zurich as the prestigious Eawag Proto-synthesis Fellow working on a related project in Switzerland; the research and policy around micropollutants in wastewater are being contrasted between the two countries.

Mark Servos has been a key member of the National Expert Panel on Wastewater that released their report officially in May 1, 2018 (Canada's Challenges and Opportunities to Address Contaminants in Wastewater). Wayne Parker was invited as a subject expert to speak to the Panel on the topic of emerging contaminant removal in wastewater treatment. This report is directly related to the GWF project and many aspects of the research were brought forward in the discussion of the committee. As a member of the Expert Panel, Mark Servos, also participated in meeting with top Directors and ADMs of Environment and Climate Change Canada. A Panel presentation was done at the Blue Cities Conference, in May 2018. The report is expected to influence the direction of ECCC programs on wastewater going forward including investment in infrastructure (expected to be >$8B).

Next generation solutions to ensure healthy water resources for future generations

Drs. Jardine and Hecker serve on the SK Aquatic Invasive Species (AIS) task force and will continue to report results back to relevant authorities, allowing a timely response in the event of a detection of invasive species in Saskatchewan water bodies. They have optimized targeted approaches for detecting AIS of interest, responding to the identified needs of SK Environment. Mark Servos serves on the Grand River Recreational Fisheries Committee (with broad end user representation at each level of government (municipal. provincial, federal), the Conservation Authority and NGOs (Trout Unlimited, Friends of the Grand River, Ontario Fish and Hunting Association, etc.) and has discussed the project progress at each of the meetings (every 2-3 months). We have planned a formal seminar with this group at upcoming meetings. We have met with representatives from the local Trout Unlimited Chapter about collaboration in the studies.

Mont'Alverne continues to assemble information from end-users on opportunities and challenges of using eDNA in aquatic assessment and monitoring. She has interviewed ~30 participants across various sectors (government, industry, academia, law, NGOs) and jurisdictions (SK, ON, AB, Canada) asking for their perceptions of strengths and weaknesses of the eDNA approach. This, combined with technical advances (as noted above) and her evaluation of legislation and policy documents, will enable a full understanding of potential barriers to adoption of eDNA methods and allow the research program to be further adapted to meet end-user needs.

To boost cooperation with industrial end user and knowledge mobilization, Dr. Hecker, Dr. Xie and Ms. DeBofsky visited Orano Canada Inc. (Former name: AREVA Resources Canada Inc.) on

June 20, 2018. Dr. Hecker gave a presentation on "Environmental DNA: A novel approach to characterize biodiversity" (Version June 2018) to the group. We discussed with Orano about the concentration and quality of eDNA, the quality of PCR products, and the solutions we developed to remove PCR inhibitors which is vital for successful eDNA amplification. Dr. Xie and Ms. DeBofsky discussed with Orano to increase the sample size (from three to five) of fish eDNA metabarcoding. Subsequently, Orano Canada Inc. contracted a consulting company to apply these eDNA field sampling methods for the collection of surface water samples as part of their routine monitoring activities under their mandate to comply with Canada's EEM program. The second field campaign was successfully completed, and water samples were received in good condition by our group, demonstrating successful translation of eDNA field collection methodology to one of our key industry partners.

Prof Giesy has met with Dr. F. Wrona of Environment and Parks Alberta to implement a joint sampling strategy to compare results of eDNA with routine monitoring of benthic invertebrate communities based on more traditional taxonomy based on visual morphology. Prof Giesy met with Ms. Janelle Villeneuve, a Water Quality Specialist in the Water Quality Section of Alberta Agriculture and Forestry. Janelle is in charge of monitoring water quality in the various water districts in Alberta. They have special interest in monitoring and developing predictive models for forecasting onset of hazardous algal blooms, monitoring of invasive species and chemical fingerprinting of waters used for irrigation. We are currently developing study plans to initiate pilot studies in the summer of 2019. It is hoped that the eDNA methods can be integrated into current monitoring programs and allow future programs to be more comprehensive and accomplished with fewer experts and less cost in a more timely manner.

Mark Servos serves on the Grand River Recreational Fisheries Committee (with broad end-user representation at each level of government (municipal. provincial, federal), the Conservation Authority and NGOs (Trout Unlimited, Friends of the Grand River, Ontario Fish and Hunting Association, etc.) and has discuss the project progress at each of the meetings (every 2-3 months). Students (Nathanael Harper and Heather Ikert) met with stakeholders at rare Research Reserve to present "Spatial and Seasonal Variation of Fish Communities in Bauman Creek: Conventional and Emerging Methods". This provided the group with an update on the data collected showing the spatial and seasonal changes in fish communities and progress on developing fish eDNA metabarcoding protocols for this stream. Mark Servos has discussed the potential application of eDNA in Mill Creek with a multi-sectoral working group (Friend of Mill Creek). Postdoctoral fellow Patricija Marjan joined efforts with the Grand River Conservation Authority (GRCA) field sampling crew led by Lori Richardson to obtain water samples to determine spatial distribution of brook trout using eDNA. The GRCA conducts annual surveys on presence/absence of brook trout at several sites in the Grand River tributaries that are affected by intense urbanization. This created a unique opportunity to work together, to maximize the

capacity of our teams and at the same time reduce the workload and avoid repeating certain procedures (e.g., stream measurements). We are planning to continue this collaboration in the coming year and potentially provide a reliable method for brook trout biomonitoring that GRCA can implement in the future. Trout Unlimited, GRCA and OMNRF have been involved in providing data and experience to the Grand River studies. An invited presentation was made to the local Trout Unlimited Chapter at their annual meeting (Marjan) and additional meeting are planned to discuss further data sharing.

Patricija Marjan traveled with Mark Servos to Chile where they met with scientists from the Melimoyu Ecosystem Research Foundation (MERI) who are interested in using eDNA to determine distribution of invasive brown trout fish species in remote areas in the Chilean Patagonia (Melimoyu Nature Reserve). A pilot study conducted at Melimoyu indicated that the methods we developed at UW can be successfully used for brown trout detection in two river system flowing through the nature reserve. There is a great potential for developing a long-term international collaboration with this research foundation under GWF. We have established strong links with this group and are planning additional collaborations.

Northern Water Futures

- Through our leveraged NSERC Promoscience Funding, we supported the Dehcho Youth Ecology Camp at Willow Lake, NWT. NWF HQP including Woodward, Wallace, Gibson and Brockington and SAMMS HQP Jasiak worked with the Dehcho First Nations to develop activities to support on-the-land science education in Dehcho highschool students. In 2019, NWF has plans to be involved in four on-the-land events across the NWT (ALL INVESTIGATORS)
- Biomarker results were returned for 202 participants of the Mackenzie Valley Biomonitoring Project and aggregate reports were provided to three participating communities (Sambaa K'e, K'asho Got'ine, Tulit'a). In person, meetings were held with regional and territorial organizations to discuss the results (Sahtú Renewable Resources Board, Sahtú Land and Water Board, NWT Department of Health and Social Services, Environment and Natural Resources, Environment Canada, local health centers. The exchanges with community leaders, government stakeholders (regional, territorial and national levels), co-located researchers and other researchers sharing similar interest helped to build our research strategy for the future. (LAIRD/SKINNER)
- NWF (co)led three major workshops in the NWT during 2018/19:
    - An ecological forecasting workshop in which 15 GNWT managers were trained in the use of the Spatial Discrete Event Simulator (SpaDES) modelling framework. This included substantial dialogue about module development beneficial to the GNWT, which is guiding our next steps.

- Wildfire results workshop. Baltzer organized a workshop in 2015 that led to substantial wildfire research activity in the NWT. BALTZER and TURETSKY led this follow up workshop in which results were presented, synthesis activities and plain language outputs determined, and next steps in research evaluated. This workshop included the GNWT, communities from across the NWT, and NASA ABoVE. Researchers from NWF and EXTREMES were involved in this meeting.
- Tsa Tué Biosphere Reserve Water Quality Monitoring Program planning meeting. SPRING was instrumental in organizing a water quality research and monitoring meeting that brought together researchers from around the country, including 3 GWF funded projects (NWF, LF and GWC) to support the vision of community-led monitoring initiatives. The Tsá TuéKe Kenahtsenehta Workshop facilitated a group of scientists and community residents to meet in Déljnę to develop a strategy for monitoring the ecosystem of Great Bear Lake.

- NWF supported a wide range of HQP training activities aimed at KM. These included workshops on plain language writing, media training, digital storytelling and environmental education. NWF HQP have produced a series of digital stories and plain language summaries that are helping to support KM in the project. We feel that this sort of professional development and training is a critical component of our program to ensure better KM practices in the next generation of scientists.

Old Meets New – Subsurface Hydrological Connectivity and Groundwater Protection

Knowledge mobilization in this project has been focused on working with researchers at other universities and government agencies. One of the goals of this project is to translate our experience in Western Canada, where we have a long history of oil and gas experience to other regions with either different experiences or no experience.

Preliminary results of this project were presented at a meeting in London, UK last July that was co-organized by the British Geological Survey. Shale gas development is still in the exploratory phase in England and learning from other regions, such as Saskatchewan and Alberta, was a key part of this meeting. Representatives from the Alberta Energy Regulator were also in attendance. There has been regular contact with their geologists over phone calls and side meetings at conferences during the past year.

Results of this work have also been presented at meetings held by the Illinois Geological Survey, the Northwest Territories Geological Survey. Ferguson and McIntosh have also been collaborating with Bridget Scanlon at the Texas Bureau of Economic Geology to compare groundwater protection in Canada, Texas and other oil and gas producing regions.

Results of this work have also been disseminated in other ways. Ferguson wrote a blog post for the American Geophysical Union and European Geoscience Union based on the results of the

meeting in London, UK with Sian Loveless, a hydrogeologist with the British Geological Survey. Ferguson and McIntosh wrote an article on groundwater resources, climate change and oil and gas development for The Conversation. Ferguson and McIntosh also gave interviews on this research to the CBC, PBS, NPR, Circle of Blue and The Revelator during the past year.

Further work on knowledge mobilization has commenced through conversations with Onion Lake First Nation that have been facilitated by Robert Patrick.

Prairie Drainage Governance

Our project has been extremely well-received by stakeholders on all sides of the issue, and we're working to be responsive to multiple requests and, as possible, incorporate user interests/needs into our work plan. Given Co-PI Loring's previous experience with conflict, we're also adjusting our KM strategy to emphasize products that can contribute to conflict de-escalation and management. The Atwater workshop noted above is one important example, in that we planned the event in direct response to requests from community members in the region. At this workshop, which was attended by approximately 15 people from the Atwater area that represented local government and the farming community. This workshop was focused on sharing preliminary findings and receiving feedback. We have already received positive feedback on this workshop and appreciation for involving the community before the publication of any results. We received interesting comments at the workshop which we are incorporating into our overall analysis. This included the addition of a politicians (elected representatives) circle, and lines showing connections or influences on other circles.

We also organized a listening session for project stakeholders in coordination with the Prairie Water annual meeting in Saskatoon in January 2019. This was attended by 27 individuals. We received positive feedback in person and by email. Participants used this opportunity to further conversations related to agricultural water management amongst themselves, which we continue to be part of.

In response to high-profile news reports on conflict over agriculture and water in Canada, we also authored an opinion piece for TheConversation.com focusing on the challenge posed by conflict and conflict escalation among environmental and agricultural sectors. This piece was extremely well-received by people from multiple sectors, and spawned several phone calls, in-person meetings, and helped us to identify possible new interviewees for the research.

We are also planning a short film on conflict over agricultural drainage as a KM opportunity. The goal will be to present the issue in a way that highlights the science and also re-humanizes the various stakeholders—this sort of strategy has been successful elsewhere as a way to de-escalate conflict so progress can be made on more effective management. In addition to its value for KM, we are considering using the film in later workshops as part of the collaborative process. We have recruited an undergraduate research assistant with exceptional professional experience in

videography to help with this project. Production funding will be leveraged from Loring's resources at University of Guelph.

Finally, based on our experiences thus far learning about drainage, Breen, Loring, and Baulch authored a peer-reviewed perspective piece (published in *Frontiers in Environmental Science)* on drainage as an exemplar of complex water-related challenges. According to Frontiers' metrics, the paper has been downloaded 1700 times in the 6 months since its publication, putting it in the top 39% of that journal's articles for readership.

Prairie Water

Currently, Prairie Water is in contact with over 30 partner organizations and communities (Fig. 1). The PM and PI's participated in webinars to present preliminary findings, and attended meetings hosted by partners to develop networks with stakeholders. Such events include the Assiniboine River Basin Initiative, Saskatchewan Conservation and Development Association, and Saskatchewan Association of Watersheds annual general meetings. The PW team also provided in-kind support to initiatives led by our partners, such as the Red River Basin Commission's "One Basin One Governance" and the Redberry Lake Biosphere Reserve, Prince Albert Model Forest, and Mistawasis Nêhiyawak joint project "Conserving Land and Water for Future Generations". Each project is projected to begin during the third GWF funding year.

Since its inception in November 2017, the Prairie Water User Community Advisory Committee has been meeting quarterly, including two in-person meetings, to discuss project progress and strategies for engaging stakeholder and rightsholders. The Prairie Water PM organized sub-committee meeting with the Committee to develop plans for increasing engagement from target groups, such as Indigenous, agricultural, and cross-provincial communities. The Advisory Committee also contributed greatly to the scoping of the Annual Partners Meeting, in particular in organizing our Water Ceremony. During our Annual Partners Meeting, we elected a new Chair, Wanda McFadyen from the Assiniboine River Basin Initiative, with Steve Strang, Red River Basin Commission, leaving his Chair role and remaining as a member on the committee. This change will continue our reach into communications with out-of-province organizations and considerations of trans-boundary issues with water management.

Prairie Water research themes connections to collaborations and user community

Some key KM activities this year include:

- Utilization of tools by governmental agencies, including groundwater recharge modeling and prediction tool by Alberta Agriculture and Forestry and Alberta Energy Regulator, and consultation and testing of catchment classification.
- Co-designing research objectives and outcomes with Mistawasis Nêhiyawak and achieving blessing from the community.
- Facilitating relationships with the Gordon Oakes Red Bear Centre at the University of Saskatchewan. The relationship fostered here has provided advice regarding tradition Indigenous protocols and grown to be utilized by GWF and the Global Institute for Water Security.
- Attending and presenting research at stakeholder meetings and workshops, which has led to expanding our network. For example, attending the Assiniboine River Basin Initiative conference led to PW being invited to the Saskatchewan Conservation and Development Association AGM. Attending this meeting led to new insights into water management in SK, and connections were developed with this important set of stakeholders, of which PW was not in contact prior to attending. Moreover, PW was asked to site on the developing committee for agriculture water management by the provincial Water Security Agency, whom are leading the initiative. This provides the opportunity for science collated and developed within PW to inform provincial government outreach initiatives and potentially policy development. PW meetings with the development committee are set for summer 2019.

Sensor and Sensing Systems for Water Quality Monitoring

A key goal of the project is on the development of sensing systems that could generate the data that is sought by a wide variety of stakeholders in academia, industry, government and non-governmental agencies. The knowledge about the sensor design, fabrication and testing methods will be disseminated mainly through the form of publications in journals and presentation in conferences. In this past year, we have published several papers in peer-reviewed journals as well as presented our work at several conferences.

Apart from the development of the sensors, the research proposed will also generate streams of data. Data from indigenous communities will be held by the communities themselves and we will work with the communities to identify appropriate methods of distributing the data. We are quantifying contaminants in drinking water and well water in First Nations' communities to inform sensor development. We have tested 75 wells on First Nations land at Six Nations in Ontario and quantified the concentration of coliforms, measured physical parameters of the water (conductivity, pH, turbidity) and chemical composition of the water (COD, TOC, IC, and TC and concentration of various minerals and heavy metals). These data are sensitive and are to be released to the members of the community this winter. This work is on-going and another 75

wells and taps are planned to be sampled in the next 4 months, with those results compiled and analyzed by the summer 2019. These data will be compared with the historical records to determine trends or changes in water quality on the Six Nations Reserve. On the other hand, the Libelium based network has been deployed in lakes downstream of mining operations in collaboration with Orano (previously Areva Resources, a uranium mine in northern Saskatchewan) and will generate data relating to food-chain transfer, risk assessment of selenium, effluent delineation, and cumulative risk assessment of multiple metals from aqueous exposure We will ensure that this stream of data is accessible to the stakeholders who are participating in the project and upon analysis to the wider GWF researchers.

Another key feature of knowledge dissemination plan will be the training of members of indigenous community members in the design, fabrication and testing of the sensors as well in building and maintaining the sensor systems. In summer 2019, we plan to hold a workshop for the community high school student, which will focus on the drinking water monitoring sensors (Chlorine and DO) as well as use of wireless data transmission system to collect data. The 2 month workshop will provide training related to sensor fabrication and instrumentation design. They will be provided tools to install sensing systems in their communities and data acquisition. Through this process, the community members will also have an input into the design of the sensing systems to fit their needs and preferences. For instance, they will have a significant input into the design of the user interface that will present the data in their native language rather than in English. The training and the interactions will help promote citizen science in these communities and enable the broadest possible uptake of these sensing technologies with the end users.

Significance of Groundwater Dynamics within Hydrologi Models

The project is actively engaging with personnel from the Knowledge Mobilization (KM) team. In particular, the KM team put together the project poster for the GWF Operations Meeting held at the University of Saskatchewan from Jan 21-23, 2019. Discussions with Nancy Goucher on how to mobilize the knowledge gained from this project to other users also took place on several occasions. In particular, with assistance from KM team, this project will approach the Region of Waterloo (RoW) to bring them on as a partner for the project with the goal to improve decision-making based on a more comprehensive understanding of surface and ground water interactions. Previous engagements with the RoW have resulted in very good interest from them and we were successful in obtaining wellfield operation data that could be used to calibrate the HGS model for the ACW.

The participation of the RoW and other agencies such as the Grand River Conservation Authority (GRCA), Environment and Natural Resources of Canada (ENRC), Agricultural and Agri-Food Canada (AAFC), and Ministry of Environment, Conservation and Parks (MOECP) will be critical in

expanding the model developed through this project to examine the importance of groundwater on surface water fluxes at the Grand River scale that we propose to examine during the renewal phase of this GWF project. The HGS model built during the renewal phase could be utilized to help track pathways of water and contaminants such as agricultural chemicals, road salt, and other contaminants in both surface water/groundwater. As HGS considers solute transport rigorously in both surface water and groundwater, we should be able to gain additional insights on contaminant transport with the calibrated HGS model.

Southern Forests Water Futures

- Southern Forests Water Futures researchers are working closely with the GWF Knowledge Mobilization Team for dissemination of project results to end users and policy makers. On April 1, 2019, Altaf Arain and Shawn McKenzie (PDF) met with Stephanie Morningstar, Knowledge Mobilization Specialist for GWF and discussed current and prospective strategies for KM and KD. Our ongoing KM and KD activities include community meetings and youth engagement through public lectures, high school visits. Further details are given below.
- We have developed as Southern Forests Water Futures website, where project information and activities are posted (http://www.southernforestswaterfuture.ca). This website will also helping with KM and KD activities.
- We also collaborate with members of McMaster Centre for Climate Change (MCCC, https://climate.mcmaster.ca/) for various activities such as Twitter feeds, sponsored public and academic lectures, conference sponsorship including the Mapping the Global Dimensions of Policy, and student engagement and communication activities.
- We are collaborating with the Ontario Climate Consortium (OCC) and United Nations University - Institute for Water Environment and Health (UNU-INWEH) for knowledge dissemination to the public and engagement with the global sustainable development and policy processes. We participated in the Water and Climate Dialogue – a lecture series organized by Dr. Nidhi Nagabhatla at the United Nations University – Institute for Water Environment and Health (UNU-INWEH) along with SGES in 2018. Lunchtime lectures held at the UNU-INWEH, McMaster Innovation Park, Hamilton, ON.
- Dr. Altaf Arain recorded a video on Southern Forests Water Future Project and Turkey Point Observatory for Global Water Futures (GWF) Program on 21st November 2018.
- Further details of public and academic seminars, high school outreach and social media activities are listed and discussed in detail in the Science and Public Outreach, Citizen Science section of this report.
- Our future strategies will include an increased social media presence, frequent updates on Southern Forests Water Futures on our website and increased marketing of the research activities being conducted by the Project group.

Storms and Precipitation Across the continental Divide Experiment (SPADE)

To prepare for the field project, we hosted a webinar for SPADE HQP and collaborators whereby scientific updates on SPADE related research by the students were shared amongst the group with 17 members in attendance. Moreover, an overview of the project was shared by project leads and further field protocols and safety on the field campaign logistics were addressed. The KM U Sask core team (S Merrill) participated to the webinar.

We have created KM opportunities to share our progress through a project website (gwfspade.weebly.com), which has seen 332 unique visits along with social media accounts such as Twitter (@gwf-spade) and Instagram (@gwf_spade). Those accounts have been created to disseminate current SPADE updates to the greater public. For example, our Twitter posts have been re-tweeted by UNBC and UQAM to reach a greater audience.

Transformative sensor Technologies and Smart Watersheds (TTSW)

The TTSW project has made great progress with a variety of KM activities including research partnerships and knowledge sharing. As a pillar 3 project TTSW is primarily working toward providing water research solutions to those who need them. Over the past year we have made connections with several GWF projects, governments, and industry partners in order to make transformative research solutions a reality. Activity at the Sahtu research site has facilitated a connection between Northern Water Futures, the Government of NWT, and First Nations collaborators; with a UAV campaign taking place at the site this coming summer. At Alder Creek, TTSW is working with partners from the eDNA project to combine biological and hydrological data and has begun testing event-based triggering data loggers. We have also recently partnered with York University and will be testing both airborne and UAV-based GNSS-R technology over agriculture fields in the coming year.

The technologies being tested as part of this project will allow researchers to collect data urgently needed to manage water in a changing climate. A great example of partnership success is our recent collaboration with FORMBLOOM, the Canadian Centre for Inland Waters (CCIW), and the National Oceanic and Atmospheric Administration (NOAA) to collect multi-scale hyperspectral data over Lake Erie. Airborne hyperspectral imaging by NOAA took place concurrently with our UAV-based hyperspectral data collection as well as water sampling and water surface spectra measurements by CCIW. This campaign allows for the comparison of multiple remote sensing techniques to measure water quality parameters, bringing the research community one step closer to detecting and managing harmful algal blooms.

In addition to research focused activities, we are also engaging with communities near our observatories. For example, we continue to build relationships with the cottagers at Sunfish Lake, ON, who have shown they value our work by investing in us. They have granted access to

properties for trail-camera installation, lent us a boat to conduct research, and have allowed us to deploy buoys in the lake as well as perform UAV flights with RGB, multispectral and thermal sensors year-round. With resources from GWF we are producing newsletters to share our research outcomes with this community and will present at their annual cottagers meeting this summer.

Winter Soil Processes in Transition

External Users: The results from this project will complement work undertaken by other GWF project teams, external end users will be recipients of this project's outcomes via the knowledge mobilization (KM) and communications programs. This strategy maximizes efficiency and reduces the potential for consultation fatigue, particularly for government collaborators and end users involved in the GWF projects, while ensuring awareness of this project and how it aligns with the overall GWF vision. In year 1 of the project, the team have been producing progress updates outlining the winter soil processes project activities through news items, conference presentations, websites and blogs (see below for conference presentations and Science and Public Outreach activities). Our Winter Soil Processes in Transition project was one of the five University of Waterloo projects that organized the workshop with external stakeholders and practitioners at University of Waterloo on December, 5, 2018. The workshop was designed to be an engagement opportunity to ensure the knowledge produced in this project will be used to inform decision-making and help transform the way communities and governments prepare for and manage increasing water and soil-related threats. During the workshop, Dr. Rezanezhad gave a presentation about the overall goal of this project followed presentations by the team in this project through two infographic posters (posters are attached to this report). In the afternoon, the team contributed to roundtable discussions with stakeholders where they led a conversation about how to ensure this research project can be incorporated into decision-making.

Stakeholder Partner: The soil and water samples for the laboratory experiments were collected from the rare Charitable Research Reserve, a 900+ acre land reserve located in the Region of Waterloo. Staff from rare have participated in site visits, soil sampling and facilitated open access to a large geospatial information database, and participated in conference calls and meetings to discuss the project work plan, to provide and receive feedback to/from the project team. The project team have supported the staff from rare with project-specific information they can include in their communications materials (e.g., a public level news item has been prepared and published on the rare Charitable Research Reserve blog highlighting the "Our Soils Get Colder – Will this Affect Plant Growth and Water Quality? https://raresites.wordpress.com). Through this channel, the project is helping increase public awareness about issues surrounding soil and aquatic resources, and highlight the excellence and global reach of the GWF project.

Scientific Community: The team will publish the results from this project as scientific publications in peer-reviewed journals and attendance at internationally recognized scientific conferences for

knowledge transfer to the broader scientific community. Given the current limited knowledge on the effects of changing winter conditions on soil biogeochemical processes and fluxes, the research team have been actively involved in the organization of conference sessions and/or workshops highlighting the importance of this topic (they organized 4 sessions on the topic of soil processes and have included the aspect of hydro(bio)geochemical dynamics of winter and snow-dominated terrestrial systems during the winter and shoulder seasons in all of their organized sessions; see below Workshops). The outcomes of this project and activities will form the core of future international research collaborations and therefore contribute to the international stature of GWF as a global leader in sustainable water futures.

11. Management – Breaking the Barriers – Disciplinary Silos and Institutional Divide

A significant care has been observed while devising and implementing a governance and management structure for GWF program. The GWF governance structure builds on lessons learned from previous experiences and established a lean matrix structure reflecting the trans-Canadian breadth of this partnership and the importance of inter- and trans-disciplinary collaboration and mobilization of solutions/information to end-users (see governance and management structure below). Research excellence has been the mantra, however, principles of equity, diversity and inclusion (Gender Summit 11 North America) have been the common thread while creating the governance structure. The structure primarily consists for three layers of decision making. The topmost decision making body is called the ***Oversight Committee***, which consists of the Vice-President Research from four partner institutions (Karen Chad, USask; Charmaine Dean, University of Waterloo; Robert Baker, McMaster University; Robert Gordon, Wilfrid Laurier University) and the GWF Program Director John Pomeroy. This committee ensures the vision, mission, and objectives are achieved, monitor progress, holds the program to the highest standards of research and training excellence, and promotes broad engagement across the university, partner universities, and other national and international partners and key stakeholders.

The second layer comprises of the ***Strategic Management Committee (SMC)***, chaired by the Program Director John Pomeroy which provides direction and ensures delivery of transformational science, and oversees the GWF-CFREF budget, allocating it among partner institutions and investigators by issuing strategic proposal calls. Distinguished scientists from academia and government serves on the committee. The current membership include Helen Baulch (Water and Environment), Corinne Schuster-Wallace (Water and Health), Lawrence Martz (Water Resources Management and Communities) and John Pomeroy (Program Director) from USask, David Rudolph (Big Data, Urban Communities and Groundwater) and Phillippe van Cappellen (University of Waterloo lead) from University of Waterloo, Sean Carey (McMaster University lead), Jennifer Baltzer (Wilfrid Laurier University lead), Ronald Stewart (Climate and Atmospheric Science), University of Manitoba, Deborah McGregor (Indigenous Community Water Research), York University, and Alain Pietroniro (Stakeholders/Users, government, Measurements, Modelling and Forecasting), Environment and Climate Change Canada.

The third layer of decision making is called the ***Operational Management Committee***, which comprises of the leads and program managers from 12 user questions-led projects [Website], 21 transformative science, decision tools and big data projects [Website], 6 Indigenous Communities co-led water research projects [Website], and 5 core support teams that implements the transformative and transdisciplinary science programs to achieve the overarching goals of the GWF Scientific Strategy.

The ***SMC*** is supported by the ***International Science Advisory Panel*** which offers guidance on strategic program direction to ensure delivery of transformational science that addresses the needs of Canada and the world. Composed of internationally recognized scientists and research leaders, this committee includes Dennis Lettenmaier (University of California at Los Angeles), Anthony Jakeman (Australian National University), Eric Kasischke (University of Maryland/NASA), Claudia Pahl-Wostl (University of Osnabrueck and Future Earth), Xin Li (CAREERI, Chinese Academy of Sciences), Roy Rasmussen (National Center for Atmospheric Research, USA), and Maria Donoso (UNESCO).

The ***SMC*** is in the process of forming a ***User Advisory Panel***, a high-level, strategic cross-sectoral committee which will ensure GWF delivers risk management solutions aligned with federal strategies and provincial, industrial and community needs of benefit to Canada. This panel will have representation from: provincial/territorial and federal (Environment and Climate Change Canada, Agriculture and Agri-Food Canada, Health Canada, Parks Canada, Natural Resources Canada) government agencies; industry (insurance, mining and minerals, oil and gas), urban and rural communities; and Indigenous communities.

Howard Wheater, Canada Excellence Research Chair Laureate and former Program Director for GWF-CFREF is the Strategic Advisor to the SMC.

The GWF Secretariat is jointly led by Phani Adapa, Director of Operations, Kelly McShane, Director of Finance, and Chris DeBeer, Science Manager. Together, they support the Program Director, SMC, Operations Management Committee, and assumes responsibility for day-to-day management of the GWF Secretariat, overseeing and coordinating operational support leads and teams including HR, Finance, Communications and Marketing, Stakeholder Outreach & Engagement, Commercialization & IP, Data Management & Training functions.

Please refer to Appendix A for list of personnel associated with the GWF Oversight Committee, Strategic Management Committee, International Science Advisory Panel and the Secretariat.

12. Performance Measurement Plan

The governance and management structure for GWF was created to achieve the mission and vision of GWF while targeted towards the CFREF criteria of global research excellence and leadership, and transdisciplinary research of economic benefit to Canada. GWF's mission is to position Canada as the global leader in water science for cold regions and to address the strategic needs of the Canadian economy in adapting to changing water and managing the risks of uncertain water futures and extreme events. GWF is achieving this mission by delivering risk management solutions—informed by leading-edge water science and supported by innovative decision-making tools—to manage water futures in Canada and other cold regions where global warming is changing landscapes, ecosystems, and the water environment.

GWF is formulated around three interrelated Pillars of activity:

Pillar 1 - Diagnosing and Predicting Change,

Pillar 2 - Developing Big Data and Decision Support Systems,

Pillar 3 - Designing User Solutions.

Its governance and management involves the Principal Investigator chairing the Oversight Committee of Vice-President Research from the four partner universities and the Director, a Director, chairing the Strategic Management Committee that takes advice from an International Advisory Panel and User Panels and a supporting Operations Committee composed of the projects and core teams. The governance and management structure for GWF was created to achieve the mission and vision of the GWF through these Pillars, whilst directed towards the CFREF criteria of global research excellence and leadership, and transdisciplinary research of economic benefit to Canada. In addition, the transdisciplinary structure ensures breaking down the traditional disciplinary and institutional barriers to ensure a holistic approach to what are inevitably comprehensive and complex water problems. The philosophy has been to establish a strong regional and topical research bases and then expand nationally and grow globally. Throughout the program, the principles of equity, diversity and inclusion has been of primary consideration. As a network, in addition to achieving the mission to improve disaster warning, predict water futures, and inform adaptation to change and risk management, we are aiming to be known for engagement of Indigenous communities in co-developing water research. Please see *Appendix A* for list of GWF Strategic Management Committee Members.

The first steps in defining GWF involved user engagement and the establishment of Core Teams. By engaging with the user community across Canada with a series of discussions, conducting a review of needs based on these discussions and finally developing a report on user needs and questions that we could address, GWF defined its Pillar 3 needs and set priorities for supportive

science in Pillars 1 and 2. During this process, it was realized that there was a need to hold additional consultations with Indigenous Communities across Canada to co-develop and co-lead Indigenous Communities water research projects. The Core Teams and their strategic activity plans were developed early on and now include modelling and forecasting, technical, data management, computer science, knowledge mobilization, and communications, which provide central capabilities and functions for Pillar 2 and support for the whole GWF program towards its mission and goals. (please see *Appendix B* for list of core team personnel)

Subsequent to the user needs survey and core team development, we initiated a formal request for proposals open to all members of the four partner universities and selected members of 14 other universities that were included with our original proposal. We instituted a rigorous international peer-review process to evaluate these with final recommendations by the Strategic Management Committee upon advice of the International Advisory Panel and overseen by the Oversight Committee. Subsequently, 12 stakeholder question-led transdisciplinary Pillar 3 projects were funded in July 2017; 21 transformative science, big data, and decision-support tools Pillars 1 & 2 projects were funded in December 2017; and 6 Indigenous Community co-led water research projects in December 2018. Please see *Appendix C* for list of GWF Researchers, Graduate Students, and Highly Qualified Personnel by Projects.

All funded 33 Pillar 1-2-3 projects, and core teams were requested to develop inception reports by April 30, 2018. The purpose of an Inception Report for each project was to establish a set of short-term plans and broader long-term plans, including contributions by specific co-investigators, collaborators, and teams within the project; timelines and deliverables; and anticipated difficulties or gaps that need further consideration. It is intended as a guidance document to help in the planning and execution of project activities, as a benchmark to gauge progress, and as a tool to help identify and resolve key problematic areas, such as lack of resources, commitments, or person-power. The Inception Report also clarifies important changes as the project has evolved and as users have been brought in since the funding announcement.

GWF has adopted a common management strategy, including monthly and quarterly reporting contributing to reviews of scientific and technical progress by the Operational Management Committee (OMC) (leads from 39 funded projects and core modelling and forecasting, computer science, knowledge mobilization, and technical teams), and an Annual Science Meeting to provide a broad perspective of scientific progress from the entire GWF program, to stimulate transdisciplinary discussions and interactions amongst researchers, students and partners, and to showcase and celebrate the scientific and technical advancements emerging from the GWF program. We have developed a common understanding of who needs what information, when they need it, how they want to receive it, and who is responsible to provide it. Each quarter, task leaders and theme leaders are reviewing project activities, measuring critical indicators, and

issuing yearly formal reports to the management team. We are using critical path analysis to help plan sequential tasks that must be completed in such a large program (e.g., develop a master schedule, resource planning, monitoring progress), taking remedial steps (restructuring, adding resources, etc.) when tasks fall behind.

An Operations Management Support (OMS) team has been constituted whose role is to communicate closely with the OMC to oversee development of inception reports, track and assist projects (budget spends, meeting objectives, etc.), report on core functions, identify any impending concerns, and assist with common management issues, and finally report back to the Strategic Management Committee (SMC) on a regular basis. The primary objectives of the OMS include:

- **Facilitate Interactions:** The 39 projects are grouped into 7 themes (e.g. Agriculture, Energy and Natural Resources, Indigenous communities, Water Environment, Urban and Rural Communities, Government and Governance, and other industry) to facilitate interactions among the PI and Co-Is to share best practices in conceptualizing, implementing and meeting project objectives, interacting with users, and sharing information on optimal operation of projects.
- **Identify Gaps:** During the interactions within the above themes, identify research gaps that needs further consideration.
- **Identify Opportunities:** Identify resources to provide additional support, develop efficiencies and incentives to address the above identified gaps.
- **Track Progress – 39 Projects and 6 Core Teams:** Track milestones and deliverables outlined in individual and core teams inception reports to update their status to the SMC and also compile annual progress reports to CFREF. Report on progress in operations, coordination and opportunities to the SMC.
- **Identify Financial Issues:** During thematic meetings and annual progress reports, identify financial issues that needs special attention.
- **Identify Communication Needs:** Develop and implement a communication strategy to identify communication needs and deliverables for GWF.

OMS Reporting and Project Tracking Schedule: The following notes are to support and justify the activities listed in the timeline chart on next page:

- **Operations Management Committee:** The OMC comprises the leads and co-leads for Pillars 1-2-3 projects, 6 Indigenous Community co-led water research projects, core modelling and forecasting, computer science, knowledge mobilization, and technical teams, and meets in-person twice in a year. This meeting will be in conjunction with the

GWF Annual Science Meeting to be scheduled in the month of May and the second in the month of November.

- **Operations Management Support – Thematic Panels:** The OMS (particularly the Director of Operations and the Science Manager) will meet with thematic groups four times a year. Two of these meeting will be in conjunction with the OMC meeting and two will be held via conference calls in the months of February and August. User Panels that correspond to the thematic groups may be invited to these meetings
- **Operations Management Support – Project Progress:** The progress of individual projects will be tracked three times a year: 1) twice during the OMC meetings, and 2) to secure information to complete the April GWF annual progress report.
- **Operations Management Support – Core Teams:** The OMS (particularly the Director of Operations and the Science Manager) will meet with the PIs of the core teams four times a year. Two of these meeting will be in conjunction with the OMC meeting and two will be held via conference calls in the months of February and August.
- **Project Progress Reports:** To fulfill GWF reporting requirements to CFREF against the performance indicators, individual PIs are required to provide written reports in April.
- **Project Financial Reports:** Reports will be required from the PIs twice per year (April and October) indicating whether they are in compliance with the budgets included in their inception reports. PIs will be required to provide justification, if there is more than 20% variance in individual line items and seek approval if the line items are expected to deviate by more than 20% over the entire project. In addition, any impending issues raised during OMC meetings will be conveyed to the Director of Finance for resolution.
- **Communications:** GWF project, core team and secretariat communications will be discussed on an ongoing basis and will adhere to the Communications Strategy approved by the SMC. An electronic monthly newsletter is sent to all GWF participants and stakeholders.

OMS Reporting and Tracking Schedule

13. Equity, Diversity and Inclusion

The GWF is committed to ensuring our highly qualified personnel and student population reflect the diversity of society and that barriers to recruitment, selection, promotion and retention are removed for members of systematically disadvantages groups – particularly women, Indigenous peoples, people with disabilities and visible minorities. GWF is committed to diversity recruitment/ retention, career development, and recognizing members of equity groups, including integrating the 10 key principles of the Athena Scientific Women's Academic Network (SWAN) Charter into our policies, practices, action plans, and culture. GWF is trying to role model equity through membership on our Oversight Committee (female PI & 2 out of 5 members are female), Strategic Management Committee (4 female out of 10 members), and panels, including workshops and Annual Science Meeting. We are also trying to implement principles outlined in the NSERC "Guide for Applicants: Considering equity, diversity and inclusion in your application". [Website]

The following table shows the equity, diversity and inclusion stats provide by the Federal CFREF Secretariat on GWF compared to total stats from 18 CFREF projects across Canada. GWF is fared above average in all of the categories except for the Indigenous people category. This could be due to fact that 178 personnel did not respond to the self identification survey and also that the Indigenous Communities co-led water research projects started in December 2018. Having said that, we will contuinune to adhere to the principle of equity, direvesity and inclusion and will strive to better ourselves over coming years.

	GWF	**CFREF - 18 Projects**
Number of participants contacted	618	5461
Number of surveys submitted	441	3404
Number not submitted (a)	177	2057
Number of incomplete surveys (b)	1	8
Number of non-respondents (a+b)	178	2065
Response rate	71%	62%
Women	179 (40.6%)	1134 (33.3%)
Indigenous peoples	*--	17 (0.5%)
Visible minorities	86 (19.5%)	643 (18.9%)
Persons with a disability	6 (1.4%)	62 (1.8%)

* In keeping with the Privacy Act, if the number of respondents who self-identified as belonging to one of the four groups is less than five, it is not provided to protect the privacy of the respondents.

14. Performance Indicators - GWF by Numbers

GWF is a seven year pan-Canadian research program focusing on solutions to water threats in the era of global change. As such, GWF has implemented a performance timeline to ensure that program commitments are met and to track the progression of the program. The performance timeline will align the project with targeted goals from the programs infancy to maturity. GWF will focus on two specific years (**mid-point at year-four and end-point at year-seven**) to assess the progression. It is important to note that GWF program has now funded 12 Transdisciplinary projects, 21 Transformative Science projects, 6 Indigenous Community co-led water research projects and 6 core teams that are producing scientific outcomes.

Global Research Excellence	2018 - 2019	Year 4 (2019-2020)	Year 7 (2022-2023)	Below/ Meeting/ Exceeding
Number of international research programs and committee where GWF members are lead investigators and/or advisors. (see *Appendix D* for complete list)	56	4	10	Exceeding
Number of prestigious international, national and institutional awards, recognitions from professional societies, and national scholarships and fellowships. (cumulative number; see *Appendix E* for complete list for 2018-19)	208	100	200	Exceeding
Global leader in science impact - quality of research – rank in h-index (as per Web of Science on June 14, 2019 over last 5 years)	4	2	1	Meeting
Global leader in science dissemination – rank in number of peer reviewed journal articles and total citations (see *Appendix F* for complete list of publications; as per Web of Science on June 14, 2019 over last 5 years)	1	1	1	Exceeding
Number of presentations at international and national conferences (see *Appendix F* for complete list of publications)	607	500	1000	Exceeding
Number of international and national plenary, key note and invited speaking engagements (see *Appendix F* for complete list of publications)	192	130	200	Exceeding
Number of international visiting fellows (cumulative number; see *Appendix C* for complete list; the list for 2017-18 is avaialble in previous report)	14	120	200	Below
Number of international joint faculty appointments (see *Appendix G* for complete list of publications)	26	50	100	Meeting
Level of cash and in-kind research funding brought by GWF Projects from national and international governments, industries, communities, and non-governmental organizations (see *Appendix H* for complete list of funding)	$259M	$250M	$450M	Exceeding

14.1 Evidence of Global Research Excellence

During last reporting year, GWF investigators led or were part of 56 international research programs and committee where GWF members are lead investigators and/or advisors. Some of the notable achievements include, inception of GWF as one of the three Regional Hydroclimate Project of the Global Energy and Water Exchanges (GEWEX) project of the World Climate Research Programme's (WCRP); GWF leading the International Network for Alpine Research Catchment Hydrology (INARCH) of the WCRP's GEWEX & UNESCO's International Hydrological Program; GWF is the Canadian node for the Sustainable Water Futures Program of Future Earth, and recently GWF has been approved as the contriobuting organization to the World Meteorological Organization.

Members of Global Water Futures have been recognized globally, nationally and locally for their research excellence this past year with a total of 136 awards. Of these, 30 were prestigious international and national awards, and recognitions from professional societies. John Pomeroy, Director GWF, and Howard Wheater, CERC Laureate, and founding Director of GWF were inducted as Fellows of the Royal Society of Canada (RSC) in 2018.

Dr. John Pomeroy

Dr. Howard Wheater

Dr. Patricia Gober, former GWF SMC member and core KM team lead has been named to the inaugural class of Fellows of the American Association of Geographers for 2018. Dr. Jeffrey McDonnell, Associate Director GIWS has been awarded the USask award for Research Excellence 2018.

Dr. Patricia Gober, Fellow AAG

Dr. Jeffrey McDonnell - USask Distinguished Researcher 2018

As part of the centenary celebrations, the Masaryk University, Czech Republic is recognizing Dr. John Giesy, CRC in Environmental Toxicology, Fellow RSC, and project lead for Next Generation Solutions for Healthy Water Resources with Doctor Honoris Causa to recognize outstanding contributions to the development of science, culture and the arts internationally.

Dr. Colin Laroque, GWF project lead for Adaptation Governance and Policy Changes in Relation to a Changing Moisture Regime Across the Southern Boreal Forest project earns U.S. award for undergraduate mentorship for his dedication to providing innovative and high-quality research experiences for undergraduate students.

Dr. John Giesy;
Photo Courtesy: USask On-Campus News

Dr. Colin Laroque;
Photo Courtesy: USask On-Campus News

Dr. Chanchal Roy, Core Computer Science Team Member received the Outstanding Young Computer Science Researcher Award 2018, CS-Can/Info-Can; Most Influential Paper Award 2018, Software Analysis, Evolution and Reengineering, Campobasso, Italy; and USask New Researcer Award 2019.

Dr. Francis Zwiers, GWF project co-lead for Climate-Related Precipitation Extremes received Fellowship of the American Geophysical Union, and Dr. Mark Servos, GWF project lead for Linking Multiple Stressors to Adverse Ecological Responses Across Watersheds received Fellowship of the Society of Environmental Toxicology and Chemistry.

Dr. Chanchal Roy
Photo Courtesy: USask

Dr. Francis Zwiers
Photo Courtesy: NCCARF

Dr. Mark Servos
Photo Courtesy: Canadian Rivers Institute

Dr. Julie Thériault GWF project lead for Storms and Precipitation Across the Continental Divide Experiment was awarded the Canada-Italy Innovation Award and Canada Research Chair Tier 2, and Dr. Masaki Hayashi GWF project co-lead for Mountain Water Futures was awarded the 2018 Darcy Lecture Series in Groundwater Science Award.

Dr. Julie Thériault
Photo Courtesy: Radio-Canada

Dr. Masaki Hayashi
Photo Courtesy: University of Calgary

Dr. Nandita Basu, GWF project lead for Lake Futures was awarded the Borland Hydrology Lecture, and Dr. Merritt Turetsky, GWF project member for Northern Water Futures was awarded the Leshner Fellowship of the American Association for the Advancement of Science, and was inducted to Royal Society of Canada's College of New Scholars, Artists, and Scientists. Also, Dr. Jennifer Baltzer, GWF project lead for Northern Water Futures and Dr. Alison Blay-Palmer GWF project member for Northern Water Futures were inducted to Royal Society of Canada's College of New Scholars, Artists, and Scientists.

Dr. Nandita Basu
Photo Courtesy: CBC

Dr. Merritt Turetsky
Photo Courtesy: Univ of Guelph

Dr. Jennifer Baltzer
Photo Courtesy: Wilfrid Laurier Univ

Dr. Alison Blay-Palmer
Photo Courtesy: Carlton Univ

Dr. Rebecca Rooney, GWF project team member for Lake Futures and Dr. Paul Craig, GWF project team member for Next generation Solutions to Ensure Healthy Water Resources for Future Generations received the Ontario Early Researcher Awards.

Dr. Karsten Liber, GWF project member for Sensors and Sensing Systems for Water Quality Monitoring received award for Outstanding Contribution to Canadian Ecotoxicology, and Dr.

Juewen Liu, GWF Technical Team lead from University of Waterloo received W.A.E. McBryde Medal from the Canadian Society for Chemistry.

Dr. Karsten Liber
Photo Courtesy: University of Saskatchewan

Dr. Juewen Liu
Photo Courtesy: University of Waterloo

Dr. Roy Brouwer, GWF project member for Integrated Modelling Project for Canada was Appointed University Research Chair in Water Resources Economics, University of Waterloo, and Dr. Brian Menounous, GWF project co-lead for Mountain Water Futures awarded the CUFA-BC Ehor Boyanowsky Academic of the Year Award, University of British Columbia.

Dr. Roy Brouwer
Photo Courtesy: University of Waterloo

Dr. Brian Menounous
Photo Courtesy: University of British Columbia

Caroline Aubry-Wake, PhD Candidate and GWF-YP chair won the Cryosphere Student Innovation Award from the American Geophysical Union at the Fall Meeting in Washington DC in 2018. The prize was for her proposal of an innovative method to determine debris cover thickness on glaciers.

Nathanial Harper, M.Sc. student at the University of Waterloo, working on the Next Generation Solutions for Healthy Water Resources project, was recognized for the Best Student Poster Award, Canadian Ecotoxicity Workshop for his poster titled "Validating Environmental DNA Metabarcoding Methods via Conventional Taxonomic Identification in Ontario's Grand River Watershed" With: N. Harper, P. Marjan, M. Lynch, A. Doxey, J.P. Giesy, M. Servos, P. Craig and

B. Katzenback. To: 45th Canadian Ecotoxicity Workshop, Vancouver, BC, September 30 – October 3, 2018.

This past year, Global Water Futures members published 314 peer-reviewed journal articles, delivered 607 conferences presentations, delivered 192 invited, plenary and keynote lectures, published 6 books and book chapters, and published 54 non-refereed articles and data that were related to their GWF research. In addition, 44 graduate and undergraduate theses were completed during this period.

A significant effort has been placed on leveraging opportunities to grow the GWF program. Consequently, significant amount of cash and in-kind support has been secured from national and international governments, industries, communities and non-governmental organizations. As of March 31, 2019, GWF *has leveraged $154.5 million in cash and formal in-kind contributions from the four partner universities and other public sector, NGO and industry partners to supplement its $77.84 million grant from CFREF. That is further enhanced by an additional $27 million in tri-agency, CFI and other research funding, providing total resources to support research in excess of $259 million*.

14.2 Attracting and Retaining the Best and Brightest Talent

So far GWF has recruited 11 new top and brightest faculty members who are at various stages of their career. They are:

1. James Famiglietti, Canada 150 Research Chair in Hydrology and Remote Sensing and Executive Director GIWS, USask
2. Kelly Munkittrick, Professor and Executive Director of Cold Regions and Water Science Initiatives, Wilfrid Laurier University
3. Martyn Clark, Professor, Cold Regions Hydrological Processes, USask
4. Karen Kidd, Stephen A. Jarislowsky Chair in Environment and Health, McMaster University
5. Corrine Schuster-Wallace, Associate Professor, Water and Health, USask
6. Patrick Lloyd Smith, Assistant Professor, Socio-economics, USask
7. Simon Papalexiou, Assistant Professor, Statistical Hydrology and Stochastic Processes, USask
8. Colin Whitfield, Assistant Professor, Water Quality Modelling, USask
9. Markus Brinkmann, Assistant Professor, Exposure and Risk Management Modelling, USask
10. Derek Gray, Assistant Professor, Freshwater Ecology, Wilfrid Laurier University
11. Homa Kheyrollah Pour, Canada Research Chair in Remote Sensing of Environmental Change and Assistant Professor, Wilfrid Laurier University

Global Water Futures currently has 563 highly qualified personnel (39 projects and core team personnel), including 95 undergraduate students, 139 master's students, 128 doctoral students, 73 postdoctoral fellows, 34 professional research associates, 18 research scientists, 46 technicians, and 5 visiting fellows/professors. These personnel are actively supervised by 157 researchers from 15 Canadian Universities.

Attracting and Retaining the Best and Brightest Talent	**2018 - 2019**	**Year 4 (2019-2020)**	**Year 7 (2022-2023)**	**Below/ Meeting/ Exceeding**
Number of faculty recruited in the top 5% of peer group	11	16	30	Exceeding
% of GWF graduate students and PDFs holding major financial awards (see *Appendix E* for complete list)	21%	25%	35%	Meeting
Participation in skills-based short-courses and transdisciplinary boot camp (cumulative, see *Appendix I* for complete list)	186	250	500	Meeting
Cross-institutional and user training opportunities, leadership workshops, and special seminars (cumulative list; see *Appendix I* for complete list)	234	250	500	Exceeding
Number of short-courses for early career researchers (cumulative, see *Appendix I* for complete list)	37	12	20	Exceeding
Assignment of GWF mentors to early-career researchers (PDFs, research scientists and faculty <10y post PhD)	100%	100%	100%	Meeting

The talent and training excellence achieved by the students and postdoctoral fellows at Global Waters Futures can be assessed by the number of honours and awards received. During 2018-2019, 340 members consisted of graduate students (masters and doctoral) and postdoctoral fellows, of which 21% held major financial awards.

Opportunities to extend knowledge and skills are available through skills-based-short courses and transdisciplinary boot camps.

14.3 Ability to Mobilize Knowledge for the Benefit of Society and the Economy

Ability to Mobilize Knowledge for the Benefit of Society and the Economy	**2018 - 2019**	**Year 4 (2019-2020)**	**Year 7 (2022-2023)**	**Below/ Meeting/ Exceeding**
Number of end users and partners linked to the program and engaged in the research process (see *Appendix J* for complete list)	356	300	500	Exceeding
Number of patent disclosures, licenses to industry, spin-off companies	0	300	500	Below
Number of policy briefs and meetings with governments (cumulative, see *Appendix K* for complete list)	83	20	50	Exceeding
Number of jobs created (see *Appendices A and B* for complete list)	563	450	850	Exceeding
Access of user tools (cumulative, see *Appendix K* for complete list)	19	20	50	Meeting
Hits to YouTube videos (see *Appendix K* for complete list)	69,670	10,000	100,000	Exceeding
Number of communities engaged in citizen science and public outreach (cumulative, see *Appendix K* for complete list)	116	100	500	Exceeding

In the first two years of GWF, over 356 end users and partners have been linked to the program and engaged in the research process. These end users and partners include, 82 Canadian and international academic institutions, 63 industry partners, 111 provincial and federal agencies, 45 Indigenous communities and 55 non-governmental organizations.

Since GWF is in early stages of its inception and operation, it has no patent disclosures, licenses to industry or spin off companies during 2018-2019 year. Similarly, it is expected that access to user tools will increase significantly as the network matures towards year 4.

A total of 575 jobs were created, which included hiring of 12 new faculty members and 563 (projects and core teams) highly qualified personnel.

A total of 42 promotional videos were developed from the program, which were viewed 69,670 times on YouTube. These promotional videos range from educational short documentaries to grad student experiences. Nineteen user tools have been developed.

As of March 30, 2019, 24 different communities across Canada were engaged in citizen science. These experiences allowed for communities to collaborate with the professionals of GWF.

15. GWF Grants and Scholarships

In addition to the project-based and core team funding, GWF has piloted Capacity Building Awards, Summer Student Internships, Sabbatical Research Grants, and PhD Excellence Scholarships at USask to further strengthen our research capacity and attract best-of-the-best graduate students globally. A brief description of these initiatives are as follows:

15.1 Capacity Building Awards (up to 5 awards of $25,000 for one year)

These are established A) To stimulate novel research, through workshops or similar activities, and/or B) to build and support research teams who are working to secure grants for new research in Water Security of high promise in terms of innovation and sustainability of longer term funding in alignment with GWF Mission of improving disaster warning, predict water futures and inform adaptation to change and risk management. It would normally be expected that these activities would engage researchers from various units and Colleges across the USask campus. Funding could also be provided in support of development of national or international collaboration or research with indigenous communities.

15.2 Summer Student Internships (up to 5 internships for $8,000 each per year)

These were established A) To provide additional technical support for various research projects of strategic relevant to the Global Water Futures (GWF) program mission of improving disaster warning, predict water futures and inform adaptation to change and risk management, and/or B) to train and provide professional development opportunity to undergraduate students. It would normally be expected that these activities would engage students from various units and Colleges across the USask campus.

15.3 Sabbatical Research Grant (partial financial support of up to $25,000 per sabbatical)

To host leading international researchers who could bring significant expertise to aid in achieving the Global Water Futures mission of improving disaster warning, predict water futures and inform adaptation to change and risk management. In addition, it is envisioned that these sabbatical visits will lead to enhanced relationships with their respective home institutions.

15.4 PhD Excellence Scholarships (up to $45,000 per year per student for three years)

To provide entrance scholarships for first-time PhD candidates who have outstanding academic records, show research promise, have exceptional communication, interpersonal and leadership abilities, and who are planning involvement in a research program in alignment with the Global Institute for Water Security (GIWS) and Global Water Futures (GWF) areas of research that include: 7 GIWS research themes, hydrometeorology and climate change, hydrology and

terrestrial ecosystems, water quality and aquatic ecosystems, human-water systems, and water and health and at the time of application have not yet been accepted or registered at the University of Saskatchewan.

16. GWF Young Professionals

16.1 Introduction

The 2018-2019 Global Water Futures - Young Professionals (GWF-YP) Executive formed in May 2018. Our first activities were at the GWF Annual Science Meeting at McMaster University in Hamilton, ON - where we held a professional development workshop, and two evening socials. Through the summer of 2018, our team drafted the GWF-YP mission statement and developed our membership structure. In the fall, our executive team sought partnerships with existing student groups at each partner university (McMaster, Wilfrid Laurier, Waterloo, and USask). Our goal was to leverage the capacity of existing groups and build larger communities of young water researchers at each university. These partnerships became instrumental to the success of our GWF-YP program. This report outlines the key initiatives of our GWF-YP team in 2018-2019; including event descriptions, number of attendees, academic/professional/social benefits, event costs, and lessons learned. Our team was also actively engaged on social media through our @gwf_yp twitter account and maintained the GWF-YP website; where we celebrated student success, advertised upcoming events, and administered travel bursary and membership applications. This was the first year of the GWF-YP program. We have lots to celebrate and lots to share with future executive teams. Additional information in GWF-YP and their activities is available at: [Website]

16.2 Executive Team

The first Global Water Futures - Young Professionals Executive Team formed shortly before the inaugural GWF Annual Science Meeting in May 2018. The team was made up of four chapter chairs - one from each GWF partner university - and a representative from CYHS. Holly Annand, Erin Nicholls, Cory Wallace, Samina Hayat, and Caroline Aubry-Wake represented the University of Saskatchewan, McMaster University, Wilfrid Laurier University, University of Waterloo, and CYHS, respectively. The executive team for the year 2018-19 is as follows:

Holly Annand, PhD, USask Chapter Chair & GWF-YP President

Samina Hayat, MSc, Waterloo Chapter Chair

Erin Nicholls, PhD, McMaster Chapter Chair

Cory Wallace, PhD, WLU Chapter Chair

Caroline Aubry-Wake, PhD, CYHS Chapter Chair (CYHS Presidents)

16.3 Social Media

In May 2018, we launched the Global Water Futures Young Professionals (@gwf_yp) twitter account. In 11 months, we've sent over 300 tweets and grown a following of 357 people, most of which are young professionals and early career professors in the Canadian water research community. We use this platform to advertise upcoming GWF-YP or GWF events and information. We also retweet announcements from our YP community, associated student groups, GWF projects, and relevant hydrological associations.

In November, we started a weekly #YPSpotlight. Each week we highlight the research of one GWF young professional to help them build an online presence and share their research contributions with a broad network of water scientists. #YPSpotlight tweeting responsibilities are shared between Chapter Chairs and rotate weekly between each partner university. This initiative has been successful at displaying the wide range of work being done by YPs across the network, helping us fulfill our mandate to "facilitate the exchange of scientific ideas and experiences." It also benefits the YPs being highlighted by increasing the reach and exposure of their research and social media presence.

During American Geophysical Union (AGU) annual meeting, we did a twitter takeover with Laura Lyon, MSc student at McGill University and part of Mountain Water Futures. Laura was a public affairs intern at AGU in the fall of 2018. She took over our @gwf_yp twitter account during AGU and tweeted about all kinds of great things happening behind the scenes at AGU. [Social Media]

16.4 Travel Bursaries

Travel Bursary applications opened in January 2019. We developed an online application form, which students can link to from our webpage. To be eligible for travel bursaries applicants must be GWF students or postdocs attending one of the GWF partner institutions. We decided to offer four awards each semester (fall, winter, summer) and reserve another four bursaries to be awarded at YP supported events like poster sessions or conferences. Applicants are only eligible to win ONE travel bursary per academic year. Only two students applied for WINTER 2019 travel bursaries. Both students were from USask and both were selected as winners. Mohammad Ghoreishi received support to attend EGU in Vienna, Austria and Probin

Rokaya received support for a River Ice Workshop in Ottawa, ON. Arrangements to pay these awards is underway. [Website]

16.5 Events

16.5.1 Annual Science Meeting 2018

McMaster University and Six Nations of the Grand River hosted the first Annual Science Meeting of Global Water Futures from June 3-6, 2018. GWF-YP organized four events in collaboration with the Canadian Young Hydrologic Society.

Professional Development Workshop

On June 3rd, Dr. Jeff McDonnell (USask) gave an informative talk entitled, "The Art of Scientific Investigation," providing advice on navigating grad school and career paths, attributes of successful scientists and tips on communicating research outcomes. The talk was attended by a total of 90 undergraduate, graduate, post-doctoral fellows and early career professionals.

Social, Networking, and Bonfire

Following the Professional Development Workshop, YPs gathered at The Phoenix Bar and Grill. Over 100 students of all levels, post-doctoral fellows and early career professionals gathered to network and socialize. Attendees represented over 17 universities across the country. GWF-YP Chapter Chairs introduced themselves and kicked off the GWF-YP program for the 2018-2019 year. Following the social networking event, attendees gathered at a bonfire on campus to continue the networking and discussion of ongoing GWF-YP research projects.

GWF-YP Oral Presentation and Poster Competition

Excellent research conducted by GWP-YPs were highlighted in a research competition. With over 80 participants, presentations showcased the incredible water-related research from across the country. The following awards were presented:

- Student Winners:
    - Meredith Marshall – University of Waterloo - "Incorporation and tillage practices to mitigate phosphorus loss through tile drains following fall application of dairy manure" (Poster Presentation)
    - Ana Laserna – McMaster University – "Chemiresistive sensors for monitoring the concentration of metal cations in water" (Poster Presentation)
- PDF Winners:
    - Kim Van Meter – University of Waterloo – "Landscape Legacies: Long-Term Nutrient Trajectories in Great Lakes watersheds and Beyond" (Oral Presentation)
    - Mahyar Shafii – University of Waterloo – "Spatio-temporal variations of landscape nitrate fluxes in agricultural catchments driven by flow pathways and nutrient transport mechanisms" (Oral Presentation)

Young Professionals Social

Dr. John Pomeroy highlighted the role of the Young Professionals Program within the larger GWF context and encouraged YPs to "Follow your instincts and follow your passions." Following Dr. Pomeroy's talk, YPs headed to Fairweather Brewing Company for an YP social.

16.5.2 McMaster University Events

McMaster Water Week – Research Showcase

GWF-YP co-hosted McMaster Water Week 2018. The week included a Young Professional Research Showcase, public keynote lecture, career night, community fair and documentary screening. The goal of McMaster Water Week is to celebrate and communicate water related research both within and beyond the McMaster community. The McMaster GWF-YP Chapter specifically hosted the Research Showcase, which was a Poster session and competition for undergraduate, graduate, post-doctoral researchers and technicians involved in water research at McMaster. Over 60 participants filled the atrium of the McMaster Student Centre. McMaster Centre for Climate Change, McMaster Water Network, and GWF-YP each sponsored student research prizes for best poster presentation. Dylan Hrach won the GWF-YP Best Research Poster Award of $500. Winners were announced at McMaster Innovation Park following Dr. Jay Famiglietti's Keynote Lecture.

The L'eau Down

The L'eau Down was a peer-to-peer research sharing opportunity for students that ran four times between January and March 2018. The biweekly events were open to students of all levels, post-doctoral researchers and GWF technicians. They served as a casual space for YPs to present their research findings, practice for upcoming conferences or presentations, or simply pose field or analysis related questions in a casual space. Each week, 1-2 students prepared presentations, with the length varying depending on the student's needs. Following the talks and question period, YPs used the time to discuss the future needs of the YP group. It was concluded that multiple short presentations from a large number of YPs was more preferred than longer, more formalized presentations from a select few students. In upcoming years, it is recommended to continue booking this biweekly meeting space for YPs, but to continue promoting the accepting, casual nature of peer to peer research sharing and collaboration.

World Water Day Networking Lunch and Social

McMaster GWF-YP celebrated World Water Day 2019 by hosting a Networking Lunch and Workshop in Partnership with McMaster Water Network and McMaster Water Network Student Chapter. The objective of the event was to connect water research across campus, and specifically provide an opportunity for students, young professionals, faculty and community members to address a number of water-related themes and challenges. Nine panelists (listed below) presented a brief, 3 minute overview of their work, which was followed by round-table discussions over lunch. Each table discussion was centered around key questions identified by GWF-YP and McMaster Water Network before the event.

Results from each table discussion were recorded, and will be synthesized into a McMaster Water Report put out by McMaster Water Network in Spring of 2019. This event provided an opportunity for GWF-YP to connect with water researchers of all levels outside their discipline, identify the water-related challenges facing local, national and global communities, and finally stressed the need for unifying interdisciplinary research and collaborations to address these issues.

Data Management Workshop

The McMaster GWF-YP Data Management workshop was run by Krysha Dukacz, the GWF Data Manager. This workshop arose from feedback from both YP and PIs indicating that while data management strategies are invaluable to successful research projects, data management plans are often thought of after data collection has already begun. Topics covered included the importance of data management, how to devise a data management strategy, and the role of YP in the larger GWF data management plan. The event was attended by 12 YP, who provided positive feedback on the event and indicated they would like to see more workshops of this nature in the future.

YP Dinner with Woo Water Lecturer

Each year, McMaster's School of Geography and Earth Sciences invites a speaker to give the Woo Water Lecture. In 2019, Dr. Melissa Lafreniere was the invited lecturer, speaking on her work entitled, "Permafrost Change, Hydrologic Connectivity and Biogeochemistry in the Canadian High Arctic." Following her lecture, Dr. Lafreniere shared dinner with 11 GWF-YP students to further discuss her research goals, challenges, and opportunities of graduate school and early career development. These opportunities are invaluable for YPs, as the setting allowed for a longer and more intimate question period and discussion than is typically allowed following a formal departmental lecture, with a focus specifically on long term research objectives and challenges frequently faced by early career researchers.

16.5.3 Wilfrid Laurier University Events

Cold Regions Research Centre Research Symposium Student Social

The CRRC Research Symposium student social was an event held at the end of a two day conference at Wilfrid Laurier University highlighting the research of the Cold Regions Research

Centre. Many of the conference attendees were also GWF-YPs and so GWF-YP Laurier partnered with the Cold Regions Research Centre-Early Career Researchers to organize a social at Morty's Pub. The event was attended by approximately 15 students, PDFs, and research associates and was a great opportunity for networking between lab groups within and outside of Laurier.

Bowling Extravaganza

Laurier YPs and Cold Regions Research Centre Early Career Researchers had a night of bowling and fun at Bingemans Kingpin Bowelounge in Kitchener. GWF-YP provided 1 hour free bowing, shoe rental, and pizza for 14 YPs and ECRs. All together a great night!

Women and Water Webinar Viewing Socials

The webinar viewing socials were a series of three events held in conjunction with the Women and Water Series at USask. The objective of these viewing socials was to encourage discussion amongst YPs and to support the Women and Water Series by increasing YP attendance. To achieve this, GWP-YP Laurier rented out the side room of Veritas café and provided appetizers so that people could view the webinar together. The first two events were attended by 12 Laurier students, PDFs, and researcher associates. At the end of the webinar attendees discussed the lectures and shared experiences relating to the topic at hand. There was often a nice mix of Laurier departments in attendance leading to some great inter-departmental networking.

Laurier World Water Day

Laurier Global Water Futures Young Professionals partnered with Northern Water Futures, the Laurier Institute for Water Science, and the Water Science Students Association to put on a 2 day World Water Day event at Laurier this year. The event included an evening lecture on March 21st and two panel discussions and a poster contest on March 22nd. Laurier Chair Cory Wallace acted as master of ceremonies for the morning panel discussion. The primary financial contribution of GWF-YP was appetizers for a social event held at the end of the

second day at Veritas café. The event was attended by approximately 25 undergraduate and graduate students, post-docs, research associates, professors, and other World Water Day attendees.

16.5.4 University of Waterloo Events

Holiday Social

The Holiday cookie exchange was hosted by Students of the Water Institute Graduate Section (SWIGS) in collaboration with GWF-YP. This social event was organized to promote networking among students working on wide variety of water related issues. Graduate researchers from various disciplines joined for coffee, snacks and GWF themed cookies.

World Wetlands Day

GWF-YP and Waterloo's Ecohydrology research group hosted World Wetlands Day 2019. This event catered to undergraduate and graduate wetland researchers. The objective of this event was to communicate importance of wetlands to general public, enable connections between researchers conducting diverse wetland research and to highlight climate change related challenges in the context of wetlands. This all-day event included talks from researchers from the University of Waterloo, McMaster University, Wilfrid Laurier University and University of Toronto. This was followed by a poster session and cocktail reception. The poster session highlighted the interdisciplinary work being conducted by YPs at various institutions and best poster prizes were given out to encourage YPs to communicate their research effectively. All students whose research was related to wetlands were strongly encouraged to participate. This event highlighted the breadth of wetland research happening at the University of Waterloo and other GWF partner institutes. Appetizers and drink were provided at the reception by both GWF-YP and the Ecohydrology group.

The Best Student Poster presentation award in the undergraduate category went to Meghan McLeod, a student in Applied Mathematics at the University of Waterloo. The award in the graduate category went to two students this year. Janey Hu and Suyuan Yang (both from the University of Waterloo's Faculty of Environment) tied for the Best Student Poster award in the graduate category.

At the end of the day, a public keynote presentation was organized and Dianna Kopansky, the coordinator of the Global Peatlands Initiative and UN-REDD Programme in the Freshwater, Land and Climate Branch at UN Environment. Lunch with the keynote speaker was organized the following day for YPs to discuss to facilitate networking and Dianna Kopansky discussed her career pathway, the importance of work-life balance and peatland research. Lunch was provided for all who attended.

World Water Day

World Water Day at the University of Waterloo was organized by the Water Institute. Undergraduate, graduate researchers as well as faculty members working on water related problems gathered to participate in this year's event. This included panel discussion on First Nations water issues, student poster session, and research talks. The GWF-YP chair was provided the opportunity to use this to reach out to GWF-YP community at the University of Waterloo. Water researchers affiliated with GWF were made aware of this program and the types of opportunities available to them. They were asked to sign up for YP emails if they were not already on the list. In addition, submissions for the YP chair position and ASM photo contest were encouraged. This led to several invitations and subsequent attendance of HPQ meetings (Lake Futures, etc) to speak directly to YPs about this program.

16.5.5 University of Saskatchewan Events

Distinguished Lecture Lunches

Every year the Global Institute for Water Security hosts a "Distinguished Lecture Series" for 9 weeks during the fall semester. Each week a different speaker comes to the U of S to present their research and engage with folks across campus. This year we added "lunch with the lecturer" to the "Distinguished Lecture Series" events. The goal of the lunch was to provide students with an opportunity to get to know each distinguished lecturer - ask questions about their careers, learn about their publication strategy, find out how they balance academic demands with family and/or personal life, and garner advice about securing an academic job.

The lunches were informal and semi-structured. The U of S Chapter Chair prepared questions for the lecturer each week and students were encouraged to bring questions of their own. As the semester progressed, student attendees brought more and more questions and led the discussion more freely. Attendance varied throughout the semester; starting with 8-10 students and ending with 16-20 students. Some students attended on multiple occasions, while others attended one or two lunches. The GWF-YP program covered the cost of lunch for the students and the distinguished lecturer on 7 occasions. Due to travel delays, two of the lecturers did not make it to Saskatoon to deliver their lectures in person. [Website]

Women and Water Lecture Series

The Women and Water Lecture Series was conceived after an initial Women in Water Lecture held at USask during Gender Equality Week in September 2018. USask chapter chair, Holly Annand, worked alongside Dr. Corinne Schuster-Wallace, a water and health researcher and Associate Professor in USask Geography and Planning, to make this lecture series become a reality. The goal of the series was to provide a space for women's voices in water research and water issues; demonstrate GWF leadership in recognizing the role of women in water; explore water from a transdisciplinary perspective; increase public engagement for GWF, GIWS, and USask; and, provide opportunities for female young professionals.

In conjunction with GWF and GIWS, we hosted a launch party in November and four lectures during the winter semester. Each lecture had a different theme: Climate Change and Society, Ecosystem Services, Knowledge Mobilization, and Snow and Ice. The lectures were live-streamed and are now available on the GIWS YouTube page. We gained momentum with each lecture and had nearly 60 people at NHRC for the final lecture of the series. The first three lectures featured three speakers and a panel discussion. The final lecture was a 'structured conversation' between our guests and it was a huge hit.

Our invited speakers were:

1) Climate Change and Society: Maureen Reed, David Natcher, and Maria Mora

2) Ecosystem Services: Heidi Swanson, Michelle Johnson-Jennings, and Patrick Lloyd-Smith
3) Knowledge Mobilization: Kathryn Warden, Stephanie Merrill, and Holly Annand
4) Snow and Ice: Gwenn Flowers and Caroline Aubry-Wake

This series has become a platform for conversations about women in science - with a specific focus on women and water. It has helped build community among female water researchers, highlighted the excellent work women are doing, and created space for women to share their experiences as female scientists. Each lecture featured at least one female young professional and one seasoned professional in her field. This enriched the experience for both lecturers and made for incredible dialogue during the Q&A sessions after each lecture. Next year we hope to feature more guests from outside USask and expand our viewership online and in-person. [Website]

Louis' and Hockey Game

GWF-YP partnered with GIWS-Students and Young Researchers to host a social event a Louis', the USask campus bar, followed by a Huskie hockey game at Merlish Belsher Place. GWF supplied appetizers for the social at Louis' and then the group walked over to the hockey game on a blistering cold evening in November. 12 people attended the event and we linked up with the students from USask Geography and Planning who were also holding a social event at Louis' that night - many of whom were also GWF-YP members. Tickets to the hockey game were free for students.

Table Mountain Ski Trip

GWF-YP again partnered with GIWS-SYR to take students on a bus trip to Table Mountain near North Battleford, SK. GIWS-SYR organized this trip and GWF-YP contributed funds towards bus transportation. 11 students participated in this trip. The event was planned fairly last-minute, so perhaps if more lead time is provided this event could grow in the future.

Saskatoon Regional Science Fair

Our Usask chapter chair attended the Saskatoon Regional Science Fair on behalf of GIWS and GWF on April 3rd, 2019. GIWS was the Platinum sponsor for the event and Holly presented an award to the top finalists who are now headed to Fredericton, SB for the Canada-Wide Science Fair. It was a great outreach activity. A few students were even doing water-related science projects.

17. Concluding Remarks

Eventhough GWF is a network of 18 Canadian institutions, it is functioning as a single team. This cohesion is exceptional in science and brings great strength to GWF. Excellence is the primary criteria across the program in addressing the GWF mission and vision. Equity, diversity and inclusion has been the common threads in initiation, development and implementation of our research program.

2018-2019 was a remarkable and productive year for GWF and members. A major focus was on establishment of 6 core research teams and 39 pan-Canada research projects. In addition, GWF has taken significant steps in engaging Indigenous Communities in Water Research, which to our knowledge has never been done by any of the large research networks.

As we move forward, we will continue to develop substantial research projects and activities in collaboration with our international partners. This will allow us to further strengthen our capabilities and also establish GWF as a global leader in water science for cold regions.

Our recent performance indicators (including equity, diversity and inclusion) are a testament to our excellence and effective governance and management.

In this brief overview of the recent work of GWF, it has not been possible to do full justice to the work of our members, and we encourage those interested to visit individual project web-sites (Transformative Science Projects; User Questions-led Projects; Indigenous Community Water Research Projects) or to contact our members/ secretariat directly. We welcome students and postdoctoral researchers to either join our team or spend time with us as visiting researchers. We especially welcome academic colleagues from across Canada and around the world for short or longer visits to our partner academic institutions. Our Director of Operations, 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 – GWF Management Committee Members

Name	Title	Organization
Oversight Committee		
Baker, Robert	Vice-President Research	McMaster University
Chad, Karen	Vice-President Research	University of Saskatchewan
Dean, Charmaine	Vice-President Research	University of Waterloo
Gordon, Robert	Vice-President Research	Wilfrid Laurier University
Pomeroy, John	GWF Director	University of Saskatchewan
Strategic Management Committee		
Baltzer, Jennifer	Canada Research Chair in Forests and Global Change	Wilfrid Laurier University
Baulch, Helen	Assistant Professor	University of Saskatchewan
Carey, Sean	Professor	McMaster University
Martz, Lawrence	Vice-Dean of Faculty Relations, Arts & Science	University of Saskatchewan
McGregor, Deborah	Canada Research Chair in Indigenous Environmental Justice	York University
Pietroniro, Alain	Executive Director	Environment Canada Water and Climate Services
Pomeroy, John	GWF Director	University of Saskatchewan
Rudolph, David	Professor and Head, Earth and Environmental Sciences	University of Waterloo
Schuster-Wallace, Corinne	Associate Professor, Geography & Planning	University of Saskatchewan
Stewart, Ronald	Professor	University of Manitoba
Van Cappellen, Philippe	Canada Excellence Research Chair – Laureate	University of Waterloo
Strategic Advisor – Strategic Management Committee		
Wheater, Howard	Canada Excellence Research Chair Laureate	University of Saskatchewan
Phare, Merrell-Ann	Indigenous Communities Engagement	The Phare Law Corporation
International Science Advisory Panel		
Donoso, Maria	Director, Division of Water Sciences	UNESCO
Jakeman, Anthony	Professor and Director, Integrated Catchment Assessment and Management Centre	Australian National University
Kasischke, Eric	Professor Emeritus	University of Maryland, USA
Lettenmaier, Dennis	Distinguished Professor	University of California at Los Angeles, USA
Li, Xin	Director of Laboratory of Remote Sensing and Geospatial Science at CAREERI	Chinese Academy of Sciences

Pahl-Wostl, Claudia	Professor	University of Osnabrück, Germany
Rasmussen, Roy	Senior Scientist	National Center for Atmospheric Research, USA
Secretariat		
Adapa, Phani	Director of Operations	University of Saskatchewan
Braaten, Morgan	Outreach Coordinator	University of Saskatchewan
DeBeer, Chris	Science Manager	University of Saskatchewan
Dumanski, Stacey	Outreach Coordinator – on mat. leave	University of Saskatchewan
Ferguson, Mark	Communications Specialist	University of Saskatchewan
Martel-Andre, Michelle	Human Resources and Facilities	University of Saskatchewan
McShane, Kelly	Director of Finance	University of Saskatchewan
Moradi, Laleh	Data Support	University of Saskatchewan
Olauson, Sherry	Clerical Assistant Finance	University of Saskatchewan
Peterson, Amber	Data Manager	University of Saskatchewan
Pomeroy, John	GWF Program Director	University of Saskatchewan

Appendix B – List of Core Team Personnel

Name	Title	Responsibility	Institution/ Supervisor
Modelling and Forecasting Team			
Asong, Elvis	Postdoctoral Fellow	Climate	USask - Wheater
Brown, Tom	Research Engineer	Next Generation Modelling	USask - Pomeroy
Costa, Diogo (now Research Scientist at ECCC)	Postdoctoral Fellow	Catchment, Lake & River Water Quality	USask - Wheater/Pomeroy
Do, Nhu	Postdoctoral Fellow	Water Resources	USask - Razavi
Elshamy, Mohamed	Research Scientist	Hydrological Modelling	USask - Wheater
Luca Fabris	Postdoctoral Fellow	Catchment, Lake & River Water Quality	McM - Carey
Fang, Xing (Logan)	Research Technician	Next Generation Modelling	USask - Pomeroy
Fayad, Abbas	Postdoctoral Fellow	Cold Region Processes	USask - Pomeroy
Gharari, Shervan	Postdoctoral Fellow	Hydrological Modelling	USask - Razavi
Harder, Phillip	Postdoctoral Fellow	Remote Sensing	USask - Pomeroy
He, Zhihua	Postdoctoral Fellow	Remote Sensing	USask - Pomeroy
Hosseini, Nasim	Postdoctoral Fellow	Hydrological Modelling	USask - Pietroniro
Kheyrollah Pour, Homa (now Faculty at WLU)	Research Scientist	Cold regions lake modeling: ice dynamics, circulation, nutrient cycles and algal blooms	Waterloo - PVC
Kinar, Nicholas	Research Scientist	Autonomous & Remote Sensing	USask - Pomeroy
Li, Hongxiu	Postdoctoral Fellow	Ecosystem services valuation, water accounting and hydroeconomic modeling	Waterloo - Brouwer
Li, Zhaoqin	Postdoctoral Fellow	Catchment, Lake & River Water Quality	USask - Lindenschmidt
Li, Zhenhua	Research Associate	Seasonal & Drought Forecasting	USask - Li

Liu, Jian	Postdoctoral Fellow	Water Quality	USask – Baulch/ Elliot
Loukili, Youssef	Research Scientist	Flood Forecasting	USask - Pomeroy
Mai, Julianne	Postdoctoral Fellow	Multiscale watershed hydrological flow and water quality modeling	Waterloo - Tolson
Marsh, Chris	Postdoctoral Fellow	Next Generation Modelling	USask - Pomeroy
McCarter, Colin	Postdoctoral Fellow/ Research Scientist	Biogeochemical reaction networks for carbon, nutrients and contaminants	Waterloo - PVC
Mekonnen, Balew	Postdoctoral Fellow	Next Generation Modelling	USask – Pomeroy/ Spence
Morales, Luis	Postdoctoral Fellow	Catchment, Lake & River Water Quality	USask - Lindenschmidt
Princz, Daniel	Postdoctoral Fellow	Hydrological Modelling	ECCC - Pietroniro
Rajulapati, Chandra	Postdoctoral Fellow	Hydrological Modelling - MESH	USask – Pomeroy/ Razavi
Rasouli, Kabir	Postdoctoral Fellow	Cold Regions Hydrology	USask - Pomeroy
Richard, Dominique	Postdoctoral Fellow	Cold Regions Hydrology	USask - Pomeroy
Rokaya, Prabin	Postdoctoral Fellow	River Ice Modelling	USask - Lindenschmidt
Seglenieks, Frank	Postdoctoral Fellow	Hydrological Modelling	ECCC - Pietroniro
Slaughter, Andrew	Postdoctoral Fellow	Water Resources	USask - Razavi
Shook, Kevin	Research Scientist	Next Generation Modelling	USask - Pomeroy
Tesemma, Zelalem	Postdoctoral Fellow	Data Assimilation	USask - Pomeroy
Tsurata, Kai	Postdoctoral Fellow	Hydrological Modelling – VIC	PCIC-UVic - Zwiers
Vionnet, Vincent	Research Scientist	Flood Forecasting	USask - Pomeroy
Woldegiorgis, Befekadu	Postdoctoral Fellow	Water Quality	USask – Baulch/ Lindenschmidt
Xu, Teng	Postdoctoral Fellow	Model-data assimilation systems for inland water quality forecasting and analysis	Waterloo – Duguay

Yassin, Fuad	PhD	Water Resources	USask - Razavi
Zhang, Zhe	PhD	Climate	USask - Li
Computer Science Team			
Alam, Mahabin	MSc	Software Architecture, and Platform for Hydrological Modelling	USask – Schneider/Roy
Bhattacharjee, Avijit	MSc	Software Reengineering and migration	USask – Broy/CRoy/Schneider
Gauch, Martin	MSc		Waterloo - Lin
Green, Kevin	Postdoctoral Fellow	Hydrological Model Evaluation	USask - Spiteri
Ll, Yukun	Undergraduate	Software Architecture, Co-Evolution and Platform for Hydrological Modelling	USask – Modal/Roy
Magnus, Alexander	Undergraduate	Interactive Visualization	USask - Mondal
McConkey, Ian	Undergraduate	Hydrological Model Evaluation	USask - Spiteri
Mondal, Manishankar	Postdoctoral Fellow	Software Architecture, Co-Evolution and Platform for Hydrological Modelling	USask - Schneider/Roy
Rahman, Shahriar	Undergraduate	Software Architecture, and Platform for Hydrological Modelling	USask - Schneider/Roy
Roy, Banani (now Assistant Professor at USask)	Research Associate	Interactive Software Engineering, Computer Supported Collaborative Work, Reverse Engineering	USask - Schneider
Rudnitskiy, Ilia	Research Technician	Interactive Visualization	USask - Mondal
Saha, Bishal	Undergraduate	Software Architecture, and Platform for Hydrological Modelling	USask - Schneider/Roy
Sengupta, Paromita	Undergraduate	Software Architecture, and Platform for Hydrological Modelling	USask - Schneider/Roy
Tasnim, Zarin	MSc	Machine Learning, Data Analytics	USask - Mondal/ Schneider
Wang, Binben	MSc	Hydrological Model Evaluation	USask - Spiteri
Wang, Ethan	MSc		Waterloo - Lin

Wang, Sean	Undergraduate	Hydrological Model Evaluation and Interactive Visualization	USask - Schneider-Mondal
Zahan, Hasnat	MSc	Information Visualization, Data Analytics	USask – Gutwin/ Mondal
Knowledge Mobilization Team			
Goucher, Nancy	KM Specialist	Pillar 3 Projects	Waterloo - Boehmer
Merrill, Stephanie	KM Specialist	Pillar 3 Projects	USask - Martz
Morningstar, Stephanie	KM Specialist - Indigenous	Pillar 3 Projects	McMaster - Carey
Spring, Andrew	KM Specialist	Pillar 3 Projects	WLU - Munkittrick
Data Management Team			
Dukacz, Krysha	Data Manager	GWF	McMaster - Waddington
Saha, Gopal	Data Manager	GWF	WLU - Steelworthy
Peterson, Amber	Data Manager	GWF	USask - Pomeroy
Persaud, Bhaleka	Data Manager	GWF	Waterloo - Lin
Technical Team			
Barrett, David	Research Technician	Yukon Research Sites	McMaster - Carey
Casey, Beel	Research Technician	Hydrometeorology	WLU - English
Courtin, Eric	Research Technician	Canadian Rockies Hydrological Observatory	USask - Pomeroy
de Jong, Tyler	Research Technician	Yukon Research Sites	McMaster - Carey
Dhiyebi, Hadi	Research Technician	Water Quality and Aquatic Ecosystem	Waterloo - Servos
Dixon, Heather	Research Technician	Biomonitoring	WLU - Andrea Lister (for Deb MacLatchy)
Galloway, Greg	Research Technician	Canadian Rockies Hydrological Observatory	USask - Pomeroy
Hickman, Jenny	Research Technician	Water Quality	WLU - Vekiteswaran
Huang, Po-Jun	Research Technician	Smart Sensors	Waterloo - Liu
Janzen, Kim	Research Technician	Water Isotope Ecohydrology Laboratory	USask - McDonnell
Johnson, Bruce	Research Technician	Prairies & Boreal Forest	USask - Helgason
Martin, Ian	Research Technician	Northern Boreal Plains	McMaster - Waddington

Niederkorn, Amanda	Research Technician	Smart Watershed	Waterloo - Rezanezhad
Nugent, Katy	Research Technician	Prairies	USask - Baulch
Smith, Keegan	Research Technician	Ontario Observatories	McMaster - Carey
Snidherhan, Ana	Research Technician	Ecosystem Resilience	WLU - Baltzer
Vandenhoff, Aaron	Research Technician	Smart Watershed	Waterloo - Rudolph
VanderGriendt, Marianne	Senior Research Technician	Smart Watershed	Waterloo - Rezanezhad
Wallace, Alistair	Manager, Smart Water Systems Laboratory	Airborne Cold Regions Observatory	USask - Pomeroy
Weiss, Niels	Research Technician	Permafrost	WLU - Phil Marsh
Zolfaghari, Kiana	Research Technician/ Scientist	Remote Sensing	Waterloo - Duguay
Pillar 3 Project Managers and Support Staff			
Almonte, Juris	Project Manager	SPADE	UQAM - Theriault
Attalla, Rana	Project Manager	Sensors and Sensing Systems for Water Quality Monitoring	McMaster-Selvaganapathy
Black, Katie	Project Manager	Boreal Water Futures	McMaster – Mike Waddington
Beaudin, Laura	Project Manager	Co-Creation of Indigenous Knowledge	McMaster – Martin-Hill
Bigas, Harriet	Project Manager	Agriculture Water Futures	Waterloo - Macrae
Brockington, Meghan	Project Manager	Northern Water Futures	WLU - Baltzer
Carlson, Hayley	Knowledge Mobilization	Integrated Modelling for Prediction and Management	USask - Razavi
Haghnegahdar, Amin	Project Manager	Integrated Modelling for Prediction and Management	USask - Razavi
Hoekstra, Marie	Project Manager	Sensor Technologies and Smart Watershed	Waterloo - Duguay
Irvine, Sarah	Project Manager	Mountain Water Futures	McMaster - Carey
Norris, Maggie	Project Manager	Lake Water Futures	Waterloo - Basu
Ouali, Dhouha	Project and KM Manager	Climate-Related Precipitation Extremes	UVic – Zwiers; Manitoba – Stewart

Wolfe, Jared	Project Manager	Prairie Water	USask - Spence/ Whitfield
Communications Team			
Braaten, Morgan	Outreach Coordinator	Global Water Futures	USask
Dillon, Lori	Manager – Research Communication	Office of Vice-President Research	McMaster
Ferguson, Mark	Communication Specialist	Global Water Futures	USask
Grant, Julie	Communication Officer	Water Institute	Waterloo
Kawawada, Karen	Research Communications Officer	Office of Research Services	WLU
Reibling, Shawna	Knowledge Mobilization Officer	Office of Research Services	WLU
Warden, Kathryn	Director of Research Profile & Impact	Office of Vice-President Research	USask

Appendix C – GWF Researchers, Graduate Students, and Highly Qualified Personnel by Projects

GWF Researchers by Projects (Principal Investigators)

Last, First	Professor/ Associate/ Assistant/ Adjunct	Academic Institution
'Omic' and chemical fingerprinting methodologies using ultrahigh-resolution mass spectrometry for geochemistry and healthy waters. (Jones)		
Giesy, John P.	Professsor	University of Saskatchewan
Hecker, Markus	Associate Professor	University of Saskatchewan
Jones, Paul D.	Associate Professor	University of Saskatchewan
Agent Based Modelling (Bharadwaj)		
Bharadwaj, Lalita	Professor	University of Saskatchewan
Bradford, Lori	Assistant Professor	University of Saskatchewan
Osgood, Nathaniel	Professsor	University of Saskatchewan
Strickert, Graham	Assistant Professor	University of Saskatchewan
Waldner, Cheryl	Professor	University of Saskatchewan
Agricultural Water Futures (AWF): Stressors and Solutions (Macrae)		
Baulch, Helen	Assistant Professor	University of Saskatchewan
Brouwer, Roy	Professor	University of Waterloo
de Loe, Rob	Professor	University of Waterloo
Deadman, Peter	Associate Professor	University of Waterloo
Elliott, Jane	Adjunct Professor	University of Saskatchewan
Fonstad, Terry	Associate Professor	University of Saskatchewan
Gordon, Robert	Professor	Wilfred Laurier University
Helgason, Warren	Associate Professor	University of Saskatchewan
Li, Yanping	Assistant Professor	University of Saskatchewan
Macrae, Merrin	Associate Professor	University of Waterloo
Petrone, Rich	Professor	University of Waterloo
Pomeroy, John	Professor	University of Saskatchewan
Robinson, Derek	Associate Professor	University of Waterloo
Wandel, Johanna	Associate Professor	University of Waterloo
Boreal Water Futures (Waddington)		
Barbour, Lee	Professor	University of Saskatchewan
Carey, Sean	Professor	McMaster University
Chow-Fraser, Pat	Professor	McMaster University
de Lannoy, Charles-François	Assistant Professor	McMaster University
Doubleday, Nancy	Professor	McMaster University
Flannigan, Mike	Professor	University of Alberta

Jutras, Sylvain	Assistant Professor	University of Laval
McKnight, Brent	Assistant Professor	McMaster
Petrone, Rich	Professor	University of Waterloo
Pomeroy, John	Distinguished Professor	University of Saskatchewan
Price, Jonathan	Professor	University of Waterloo
Waddington, Mike	Professor	McMaster
Climate-Related Precipitation Extremes (Stewart)		
Hanesiak, John	Professor	University of Manitoba
Kelly, Mary	Professor	Wilfrid Laurier University
Li, Yanping	Assistant Professor	University of Saskatchewan
Stewart, Ronald	Professor	University of Manitoba
Theriault, Julie	Associate Professor	University of Quebec at Montreal
Zwiers, Francis	Professor /Director of PCIC	Pacific Climate Impacts Consortium, University of Victoria (PCIC/UVIC)
Crowdsouring Water Science (Strickert)		
Deters, Ralph	Professor	University of Saskatchewan
Lambert, Simon	Associate Professor	University of Saskatchewan
Strickert, Graham	Assistant Professor	University of Saskatchewan
FIShNET (Fish & IndigenouS NorthErn healTh) (Skinner)		
Ferguson, Glenn	Adjunct Professor	University of Waterloo
Laird, Brian	Assistant Professor	University of Waterloo
Skinner, Kelly	Assistant Professor	University of Waterloo
Swanson, Heidi	Assistant Professor	University of Waterloo
Wallace, Jim	Assistant Professor	University of Waterloo
FormBloom (Baulch)		
Baulch, Helen	Assistant Professor	University of Saskatchewan
Bharadwaj, Lalita	Assistant Professor	University of Saskatchewan
Duguay, Claude	Professor	University of Waterloo
Higgins, Scott	Adjunct Professor	University of Saskatchewan/ University of Waterloo
Ingalls, Brian	Associate Professor	University of Waterloo
Schiff, Sherry	Professor	University of Waterloo
Venkiteswaran, Jason	Assistant Professor	Wilfrid Laurier University
Global Water Citizenship - Integrating Networked Citizens, Scientists and Local Decision Makers (Robertson)		
English, Michael	Associate Professer	Wilfrid Laurier University
Feick, Rob	Associate Professer	University of Waterloo
Robertson, Colin	Associate Professer	Wilfrid Laurier University
Governance Adaption (Laroque)		
Laroque, Colin	Professor	University of Saskatoon
Groundwater Dynamics (Illman)		
Illman, W	Professor	University of Waterloo

Hydrological Processes in Frozen Soils (Ireson)		
Ireson, Andrew	Associate Professor	University of Saskatchewan
Ice Modelling (Lamb)		
Lamb, Kevin	Professor	University of Waterloo
Scott, Andrea	Assistant Professor	University of Waterloo
Stastna, Marek	Professor	University of Waterloo
Improved Estimates of Wetland Evaporation		
Helgason, Warren	Associate Professor	University of Saskatchewan
Indigenous Water Tools (Martin-Hill)		
Chow-Fraser, Pat	Professor	McMaster University
Martin-Hill, Dawn	Associate Professor	McMaster University
Samaan, Constantine	Associate Professor	McMaster University
Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins (IMPC) (Razavi)		
Brouwer, Roy	Professor	Executive Director, Water Institute, University of Waterloo
Coulibaly, Paulin	Professor	McMaster University
Elshorbagy, Amin	Professor	University of Saskatchewan
Gober, Patricia	Professor Emeritus	University of Saskatchewan
Gutwin, Carl	Professor	University of Saskatchewan
Jardine, Tim	Assistant Professor	University of Saskatchewan
Li, Yanping	Assistant Professor	University of Saskatchewan
Lindenschmidt, Karl-Erich	Associate Professor	University of Saskatchewan
Pietroniro, Al	Adjunct Professor	University of Saskatchewan, Environment Canada Water and Climate Services
Pomeroy, John	Distinguished Professor	University of Saskatchewan
Razavi, Saman	Assistant Professor	University of Saskatchewan
Stadnyk, Tricia	Associate Professor	University of Manitoba
Strickert, Graham	Assistant Professor	University of Saskatchewan
Tolson, Bryan	Associate Professor	University of Waterloo
Wheater, Howard	Professor	University of Saskatchewan
Is our Water Good to Drink? (Schuster-Wallace)		
Bharadwaj, Lalita	Professor	University of Saskatchewan
Schuster-Wallace, Corinne	Assistant Professor	University of Saskatchewan
Lake Futures: Enhancing Adaptive Capacity and Resilience of Lakes and their Watersheds (Basu)		
Basu, Nandita	Associate Professor	University of Waterloo
Brouwer, Roy	Professor	University of Waterloo
Krantzberg, Gail	Professor	McMaster University

Lamb, Kevin	Professor	University of Waterloo
Roberts, Steven	Associate Professor	Wilfred Laurier University
Servos, Mark	Professor	University of Waterloo
Van Cappellen, Philippe	Professor	University of Waterloo
Linking multiple stressors to adverse ecological responses across watersheds (Servos)		
Craig, Paul	Professor	University of Waterloo
Parker, Wayne	Professor	University of Waterloo
Servos, Mark	Professor	University of Waterloo
Alencar, Paulo	Research/Adjunct Professor	University of Waterloo
Courtenay, Simon	Professor	University of Waterloo
Cowan, Don	Distinguished Professor Emeritus	University of Waterloo
MacVicar, Bruce	Associate Professor	University of Waterloo
Murphy, Stephen	Professor	University of Waterloo
Linking Water Governance in Canada to Global Economic, Social and Political Drivers (de Loe)		
de Loe, Rob	Professor	University of Waterloo
Garrick, Dustin	Project Leader	Oxford University
Matawa Water Futures (MWF) (Mitchell)		
Conly, Andrew	Associate Professor	Lakehead University
Diochon, Amanda	Assistant Professor	Lakehead University
Latta, Alex	Associate Professor	Lakehead University
Mitchell, Terry	Professor	University of Waterloo
Munkittrick, Kelly	Professor	Wilfred Laurier University
Pearson, David	Professor	Laurentian University
Rennie, Michael	Associate Professor	Lakehead University
Sioui, Miguel	Assistant Professor	Wilfred Laurier University
Smith, Peggy	Professor Emeritus	Lakehead University
Stewart, Robert	Associate Professor	Lakehead University
Thomas, Darren	Lecturer, PhD Student	Wilfred Laurier University
Mountain Water Futures (Carey)		
Carey, Sean	Professor	McMaster University
Déry, Stephen	Professor	University of Northern British Columbia
Hayashi, Masaki	Professor	University of Calgary
McKenzie, Jeffrey	Associate Professor	McGill University
Menounos, Brian	Associate Professor	University of Northern British Columbia
Petrone, Richard	Professor	University of Waterloo
Pomeroy, John	Professor	University of Saskatchewan
Rooney, Rebecca	Assistant Professor	University of Waterloo
Stewart, Ronald	Professor	University of Manitoba

Thériault, Julie	Assistant Professor	Université du Québec à Montréal
Westbrook, Cherie	Associate Professor	University of Saskatchewan
Zwiers, Francis	Professor	University of Victoria
Next Generation Solutions (Giesy)		
Craig, Paul	Assistant Professor	University of Waterloo
Doxey, Andrew	Assistant Professor	University of Waterloo
Giesy, John P.	Professor	University of Saskatchewan
Hecker, Markus	Professor	University of Saskatchewan
Jardine, Timothy	Assistant Professor	University of Saskatchewan
Jones, Paul D.	Associate Professor	University of Saskatchewan
Katzenback, Barb	Assistant Professor	University of Waterloo
Noble, Bram	Professor	University of Saskatchewan
Servos, Mark R.	Professor	University of Waterloo
Northern Water Futures (Baltzer)		
Baltzer, Jennifer	Associate Professor	Wilfrid Laurier University
Blay-Palmer, Alison	Associate Professor	Wilfrid Laurier University
English, Michael	Professor	Wilfrid Laurier University
Gray, Derek	Assistant Professor	Wilfrid Laurier University
MacLatchy, Deborah	Professor	Wilfrid Laurier University
Marsh, Phillip	Professor	Wilfrid Laurier University
Quinton, William	Associate Professor	Wilfrid Laurier University
Venkiteswaran, Jason	Assistant Professor	Wilfrid Laurier University
Wolfe, Brent	Professor	Wilfrid Laurier University
Ohneganos (Martin-Hill)		
Jacobs, Beverly	Assistant Professor	University of Windsor
Martin-Hill, Dawn	Professor	McMaster University
Wekerle, Christine	Assistant Professor	McMaster University
Old Meets New: Subsurface Connectivity and Groundwater Protection (Ferguson)		
Barbour, Lee	Professor	University of Saskatchewan
Ferguson, Grant	Associate Professor	University of Saskatchewan
Hendry, Jim	Professor	University of Saskatchewan
Lindsay, Matt	Assistant Professor	University of Saskatchewan
McDonnell, Jeff	Professor	University of Saskatchewan
Prairie Drainage Governance (Loring)		
Baulch, Helen	Associate Professor	University of Saskatchewan
Clark, Bob	Research Scientist (CWF) and Adjunct Professor	University of Saskatchewan
Gober, Patricia	Professor	Arizona State University
Loring, Philip	Associate Professor	University of Guelph
Macrae, Merrin	Associate Professor	University of Waterloo
Pahl-Wostl, Claudia	Professor	University of Osnabrück, Germany

Pomeroy, John	Professor	University of Saskatchewan
Strickert, Graham	Assistant Professor	University of Saskatchewan
Prairie Futures (Spence/Whitfield)		
Basu, Nandita	Associate Professor	University of Waterloo
Baulch, Helen	Assistant Professor	University of Saskatchewan
Bedard-Haughn, Angela	Associate Professor	University of Saskatchewan
Belcher, Ken	Associate Professor	University of Saskatchewan
Bharadwaj, Lalita	Associate Professor	University of Saskatchewan
Clark, Bob	Research Scientist	Environment and Climate Change Canada
Ferguson, Grant	Associate Professor	University of Saskatchewan
Hayashi, Masaki	Professor	University of Calgary
Liber, Karsten	Professor	University of Saskatchewan
Morrissey, Christy	Associate Professor	University of Saskatchewan
Pomeroy, John	Professor	University of Saskatchewan
Reed, Maureen	Professor	University of Saskatchewan
Shook, Kevin	Research Scientist	University of Saskatchewan
Spence, Chris	Adjunt Professor, Research Scientist	Environment and Climate Change Canada
Strickert, Graham	Assistant Professor	University of Saskatchewan
Whitfield, Colin	Assistant Professor	University of Saskatchewan
SAMMS (Sub-Arctic Metal Mobility Study) (Wolfe)		
Blais, Jules	Professor	University of Ottawa
Couture, Raoul-Marie	Associate Professor	Laval University
English, Michael	Professor	Wilfrid Laurier University
Hall, Roland	Professor	University of Waterloo
McGeer, James	Professor	Wilfrid Laurier University
Schiff, Sherry	Professor	University of Waterloo
Smith, Scott	Professor	Wilfrid Laurier University
Stevens, Kevin	Associate Professor	Wilfrid Laurier University
Venkiteswaran, Jason	Assistant Professor	Wilfrid Laurier University
Whitfield, Colin	Assistant Professor	University of Saskatchewan
Wolfe, Brent	Professor	Wilfrid Laurier University
Sensor and Sensing Systems for Water Quality Monitoring (Selvaganapathy)		
Deen, Jamal	Professor	McMaster University
DeLannoy, Charles	Assistant	McMaster University
Kruse, Peter	Associate	McMaster University
Liber, Karsten	Professor	University of Saskatchewan
Liu, Juewen	Professor	University of Waterloo
Martin-Hill, Dawn	Associate	McMaster University
McGreer, James	Professor	Wilfred Laurier University

Ren, Carolyn	Professor	University of Waterloo
Sekerinski, Emil	Associate	McMaster University
Selvaganapathy, Ravi	Professor	McMaster University
Smith, Scott	Professor	Wilfred Laurier University
Van Cappellen, Philippe	Professor	University of Waterloo
Wahid, Khan	Professor	University of Saskatchewan
Xu, Chang-qing	Professor	McMaster University
Short-duration extreme precipitation in future climate		
Li, Yanping	Assistant Professor	University of Saskatchewan
St Maurice, Jean-Pierre	Professor	University of Saskatchewan
Zwiers, Francis	Professor /Director of PCIC	University of Victoria
Southern Forests Water Futures (Arain)		
Arain, M. Altaf	Professor	McMaster University
Boyce, Joe	Professor	McMaster University
Chen, Jing	Professor	University of Toronto
Khomik, Myroslava	Research Associate	University of Waterloo
Kim, Sang-Tae	Professor	McMaster University
Pisaric, Michael	Professor	McMaster University
Slater, Greg	Professor	McMaster University
Storms and Precipitation Across the continental Divide Experiment (SPADE) (Theriault)		
Déry, Stephen	Professor	University of Northern British Columbia
Pomeroy, John	Professor	University of Saskatchewan
Stewart, Ronald	Professor	University of Manitoba
Thériault, Julie	Associate Professor	Université du Québec à Montréal
Transformative Sensor Technologies and Smart Watersheds (Duguay)		
Berg, Aaron	Professor	University of Guelph
Duguay, Claude	Professor	University of Waterloo
Kelly, Richard	Professor	University of Waterloo
Petrone, Richard	Professor	University of Waterloo
Pomeroy, John	Professor	University of Saskatchewan
Ren, Carolyn	Professor	University of Waterloo
Rezanezhad, Fereidoun	Assistant Professor	University of Waterloo
Rudolph, David	Professor	University of Waterloo
Salehian, Armaghan	Associate Professor	University of Waterloo
Schiff, Sherry	Professor	University of Waterloo
Selvaganapathy, Ravi	Professor	McMaster University
Servos, Mark	Professor	University of Waterloo
Sudicky, Ed	Professor Emeritus	University of Waterloo
Water Knowledge Camps (Baltzer)		
Baltzer, Jennifer	Associate Professor	Wilfred Laurier University

Gray, Derek	Assistant Professor	Assistant Professor
Laird, Brian	Assistant Professor	Assistant Professor
Rudolph, David	Professor	University of Waterloo
Skinner, Kelly	Assistant Professor	University of Waterloo
Spring, Andrew	Adjunct Professor	Wilfred Laurier University
Turetsky, Merrit	Associate Professor	University of Guelph
We need more than just water (Jardine)		
Brinkmann, Markus	Assistant Professor	University of Saskatchewan
Doig, Lorne	Research Associate	University of Saskatchewan
Gutwin, Carl	Professor	University of Saskatchewan
Jardine, Tim	Associate Professor	University of Saskatchewan
Lindenschmidt, Karl-Erich	Associate Professor	University of Saskatchewan
Patrick, Robert	Associate Professor	University of Saskatchewan
Strickert, Graham	Assistant Professor	University of Saskatchewan
Jardine, Tim	Professor	McMaster University
Winter Soil Processes in Transition (Rezanezhad)		
Baltzer, Jennifer	Associate Professor	Wilfrid Laurier University
Basu, Nandita	Associate Professor	University of Waterloo
Hug, Laura	Assistant Professor	University of Waterloo
Macrae, Merrin	Associate Professor	University of Waterloo
McCarter, Colin	Postdoctoral Fellow	University of Waterloo & University of Toronto
Parsons, Chris	Research Assistant Professor	University of Waterloo
Quinton, William	Associate Professor	Wilfrid Laurier University
Rezanezhad, Fereidoun	Assistant Professor	University of Waterloo
Rudolph, Dave	Professor	University of Waterloo
Smeaton, Christina	Research Scientist	University of Waterloo
Smith, Scott	Professor	Wilfrid Laurier University
Spence, Chris	Research Scientist	University of Saskatchewan
Stewart, Ronald	Professor	University of Manitoba
Van Cappellen, Philippe	Professor	University of Waterloo

Highly Qualified Personnel by Projects (Undergraduates, Postdoctoral Fellows, Professional Research Associates, Research Associates, Research Scientists, Technicians, Visiting Fellows, and Others)

Last, First	**Supervisor**	**Student**
Southern Forests Water Futures (Arain)		
Khorshidi, Arman	A. Arain (McMaster)	Undergraduate Student
Wu, Daniel	A. Arain (McMaster)	Undergraduate Student

McKenzie, Shawn	A. Arain (McMaster)	Postdoctoral Fellow
Xu, Bing	A. Arain (McMaster)	Postdoctoral Fellow
Brodeur, Jason	McMaster University	Others
Nesic, Zoran	University of British Columbia	Others
Yawar, Sadia	McMaster University	Others
You, Guangyong	A. Arain (McMaster)	Visiting Fellows/Professors
Martin, Ian	A. Arain (McMaster)	Technician
Smith, Keegan	A. Arain (McMaster)	Technician
Omic' and Chemical Fingerprinting Methodologies using Ultrahigh-Resolution Mass Spectrometry for Geochemistry and Healthy Waters (Jones)		
Gong, Yufeng	J. Giesy (Saskatchewan)	Postdoctoral Fellow
Challis, Jonathan	J. Giesy (Saskatchewan)	Postdoctoral Fellow
Shu, Su	J. Giesy (Saskatchewan)	Postdoctoral Fellow
Short-Duration Extreme Precipitation in Future Climate (Li)		
Sun, Qiaohong	F. Zwiers (Victoria)	Postdoctoral Fellow
Huang, Ya	Y. Li (Saskatchewan)	Visiting Fellows/Professors
Winter Soil Processes in Transition		
Duff, Dave	F. Rezanezhad (Waterloo)	Undergraduate Student
Riley Mills, Riley	F. Rezanezhad (Waterloo)	Undergraduate Student
Spizzirri, Gabriel	F. Rezanezhad (Waterloo)	Undergraduate Student
Vandergriendt, Marianne	F. Rezanezhad (Waterloo)	Technician
Vandenhof, Aaron	D. Rudolph (Waterloo)	Technician
Braun, Gena	Smith (Wilfrid Laurier)	Technician
Gharasoo, Mehdi	D. Rudolph (Waterloo)	Postdoctoral Fellow
Global Water Citizenship - Integrating Networked Citizens, Scientists and Local Decision Makers		
Gray, Mary	C. Robertson (Wilfred Laurier)	Undergraduate Student
Kuzma, Mykhaylo	Feick (Waterloo)	Undergraduate Student
Chaudhuri, Chiranjib	C. Robertson (Wilfred Laurier)	Postdoctoral Fellow
Sensors and Sensing Systems for Water Quality Monitoring (Selvaganapthy)		
Bantegui, Auristela	P. Van Cappellen/F. Rezanezhad (Waterloo)	Undergraduate Student
Mao, Alison	P. Van Cappellen/F. Rezanezhad (Waterloo)	Undergraduate Student
Frechette, Erik	C. DeLannoy (MacMaster)	Undergraduate Student
Heyblom, Kyle	C. DeLannoy (MacMaster)	Undergraduate Student
Tan, Ricardo	E. Sekerinski (McMaster)	Undergraduate Student
Yang, Wang	E. Sekerinski (McMaster)	Undergraduate Student
Elaghoury, Hassan	E. Sekerinski (McMaster)	Undergraduate Student

Lee, Hyerjin	C. Delannoy (McMaster)	Postdoctoral Fellow
Zhao, Pei	C. Ren (Waterloo)	Postdoctoral Fellow
Moon, Woohyun	J. Liu (Waterloo)	Research Scientist
Aryasomayajula, Aditya	R. Selvaganapathy (McMaster)	Others
Attalla, Rana	R. Selvaganapathy (McMaster)	Others
Linking Multiple Stressors to Adverse Ecological Responses Across Watersheds (Servos)		
Hodgson, Rhiannon	Craig (Waterloo)	Undergraduate Student
McLaren, Bill	Parker (Waterloo)	Undergraduate Student
Maier-Downing, Colby	Parker (Waterloo)	Undergraduate Student
Burton, Erika	M. Servos (Waterloo)	Undergraduate Student
Ju Kaiying, Sally	M. Servos (Waterloo)	Undergraduate Student
Bragg, Leslie	M. Servos (Waterloo)	Technician
Cunningham, Jessie	M. Servos (Waterloo)	Technician
London, Sydney	Craig (Waterloo)	Technician
Soles, Claire	Craig (Waterloo)	Technician
Hicks, Keegan	M. Servos (Waterloo)	Postdoctoral Fellow
Marjan, Patricija	Craig (Waterloo)	Postdoctoral Fellow
Storms and Precipitation Across the Continental Divide Experiment (SPADE) (Theriault)		
Brun-Berthet, Alix	J. Thériault (UQAM)	Undergraduate Student
Moderie, Charles	J. Thériault (UQAM)	Undergraduate Student
Hébert-Pinard, Charlie	J. Thériault (UQAM)	Undergraduate Student
Galloway, Greg	J. Pomeroy (Saskatchewan)	Technician
Heavens, Robin	J. Pomeroy (Saskatchewan)	Technician
Almonte, Juris	S. Déry (UNBC)	Research Associates
Morris, Jeremy	S. Déry (UNBC)	Research Associates
Thompson, Hadleigh	S. Déry (UNBC)	Research Associates
Smith, Hilary	S. Déry (UNBC)	Research Associates
SAMMS: Sub-Artic Metal Mobility Study (Wolfe)		
Mindforff, Leah	McGeer (WLU)	Undergraduate Student
Elgood, Richard	Schiff (UW)	Technician
Hickman, Jennifer	Venkiteswaran (WLU)	Professional Research Associates
Northern Water Futures (Baltzer)		
Napenas, Jean Roy	B. Laird (Waterloo)	Undergraduate Student
Whitehouse, Jason	H. Swanson (Waterloo)	Undergraduate Student
Trus, Julie	M. Turetsky (Guelph)	Undergraduate Student
Ogden, Emily	M. Turetsky (Guelph)	Undergraduate Student
Lam, Christina	B. Laird (Waterloo)	Undergraduate Student
Burchill, Colin	Hall (Waterloo), B. Wolfe (Wilfred Laurier)	Undergraduate Student

Rossi, Rebecca	Hall (Waterloo), B. Wolfe (Wilfred Laurier)	Undergraduate Student
Ghosh, Anita	Hall (Waterloo), B. Wolfe (Wilfred Laurier)	Undergraduate Student
Khan, Hufsa	Hall (Waterloo), B. Wolfe (Wilfred Laurier)	Undergraduate Student
Blake Haskell, Blake	Hall (Waterloo), B. Wolfe (Wilfred Laurier)	Undergraduate Student
Degre-Timmons, Genevieve	J. Baltzer (Wilfrid Laurier)	Technician
Friesen, Dirk	J. Craig (Waterloo)	Technician
Ngyuen, Amy	H. Swanson	Technician
Paul, Jason	J. Baltzer, S. Kokelj (Wilfid Laurier)	Technician
Vandenhoff, Aaron	D. Rudolph (Waterloo)	Technician
Aukes, Pieter	J. Venkiteswaran (Wilfrid Laurier)	Postdoctoral Fellow
Coles, Anna	J. Baltzer (Wilfrid Laurier)	Postdoctoral Fellow
Day, Nicola	J. Baltzer (Wilfrid Laurier)	Postdoctoral Fellow
Dearborn, Katherine	J. Baltzer (Wilfrid Laurier)	Postdoctoral Fellow
Dieleman, Catherine	M. Turetsky (Guelph)	Postdoctoral Fellow
Huang, Xiang	D. Rudolph (Waterloo)	Postdoctoral Fellow
Mai, Juliane	J. Craig (Waterloo)	Postdoctoral Fellow
Meyer, Gesa	O. Sonnentag, J. Baltzer (Wilfrid Laurier)	Postdoctoral Fellow
Pappas, Christoforos	O. Sonnentag, J. Baltzer (Wilfrid Laurier)	Postdoctoral Fellow
Ratelle, Mylene	B. Laird (Waterloo)	Postdoctoral Fellow
Voigt, Carolina	O. Sonnentag, (UdeM)	Postdoctoral Fellow
Dixon, Heather		Professional Research Associates
Hickman, Jennifer	M. English (Wilfrid Laurier)	Professional Research Associates
Hould Gosselin, Gabriel	P. Marsh (Wilfred Laurier)	Professional Research Associates
Sniderhan, Ana	J. Baltzer (Wilfrid Laurier)	Professional Research Associates
Connon, Ryan	D. MacLatchy (Wilfrid Laurier)	Research Scientist
Lister, Andrea	ENR, GNWT	Research Scientist
Ratelle, Mylene	B. Laird (Waterloo)	Research Scientist
Next Generation Solutions to Ensure Healthy Water Resources for Future Generations (Giesy)		
Burton, Erika	M. Servos (Waterloo)	Undergraduate Student

Jain, Niteesh	J. Giesy (Saskatchewan)	Undergraduate Student
Kennedy, Anna	J. Giesy (Saskatchewan)	Undergraduate Student
Jain, Niteesh	J. Giesy (Saskatchewan)	Undergraduate Student
Lin, Shiming	J. Giesy (Saskatchewan)	Undergraduate Student
Yang, Zilin	J. Giesy (Saskatchewan)	Undergraduate Student
Lemire, Danielle	T. Jardine (Saskatchewan)	Technician
Zee, Jenna	T. Jardine, M. Hecker (Saskathewan)	Technician
Bertucci, Juan	M. Hecker (Saskatchewan)	Postdoctoral Fellow
Marjan, Patricija	M. Servos, A Doxey (Waterloo)	Postdoctoral Fellow
Lynch, Michael	M. Servos, A Doxey (Waterloo)	Postdoctoral Fellow
Xie, Yuwei	J. Giesy (Saskatchewan)	Postdoctoral Fellow
FORMBLOOM (Baulch)		
Collopy, Paige	H. Baulch (Saskatchewan)	Undergraduate Student
Cantuaria Andrade, Ana Livia	H. Baulch (Saskatchewan)	Undergraduate Student
Soares-Paquin, Natthew	J. Venkiteswaran (Wilfried Laurier)	Undergraduate Student
Tran, Kimberly	S. Schiff (Waterloo)	Undergraduate Student
Jewett, Emma	S. Schiff (Waterloo)	Undergraduate Student
Wright, Philip	S. Schiff (Waterloo)	Undergraduate Student
Belcher, Kurt	L. Bradford (Saskatchewan)	Undergraduate Student
Cornell, Thomas	S. Schiff (Waterloo)	Undergraduate Student
Witham, Stephanie	H. Baulch (Saskatchewan)	Undergraduate Student
Elgood, Richard	S. Schiff (Waterloo)	Technician
Gruber, Bethany	S. Schiff (Waterloo)	Technician
Hoggarth, Cameron	H. Baulch (Saskatchewan)	Technician
McQuay, Eric	Elgood (Waterloo)	Technician
Nugent, Katy	H. Baulch (Saskatchewan)	Technician
Larsen, Megan	Venkiteswaran (Wilfred Laurier)	Postdoctoral Fellow
Zolfaghari, Kiana	C. Duguay (Waterloo)	Research Scientist
Kehoe, Michael	H. Baulch (Saskatchewan)	Professional Research Associates
Boreal Water Futures (Waddington)		
Evans, Sara	de Lannoy, McMaster	Undergraduate Student
Lalonde, Emily	Doubleday & McKnight	Undergraduate Student
Lalonde, Emily	Doubleday & McKnight	Undergraduate Student
McLaughlin, Liam	McKnight	Undergraduate Student
McLaughlin, Liam	McKnight	Undergraduate Student
Stephenson, Will	Doubleday & McKnight	Undergraduate Student

Tyler, Karisa	Petrone, Waterloo	Undergraduate Student
Verkaik, Gregory	Mike Waddington, McMaster	Undergraduate Student
Green, Adam	Petrone, Waterloo	Technician
Langs, Lindsey	Pomeroy,	Technician
Kessel, Eric	Petrone,	Technician
Treberg, Michael	Carey, McMaster	Technician
Drewitt, Gordon	Carey, McMaster	Technician
Smith, Keegan	Carey, McMaster	Technician
Martin, Ian	Waddington, McMaster	Technician
Clark, M. Graham	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Elmes, Matthew	Price (Waterloo)	Postdoctoral Fellow
Fabra, Jorge	Doubleday, McKnight (McMaster)	Postdoctoral Fellow
He, Zhihua	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Helbig, Manuel	Mike Waddington, McMaster	Postdoctoral Fellow
Khomik, Myroslava	Rich Petrone, UW	Postdoctoral Fellow
Newell, Sarah	Doubleday, McKnight (McMaster)	Postdoctoral Fellow
Robinne, François-Nicolas	Mike Flannigan, U of Alberta	Postdoctoral Fellow
N.Nagabhatla	UNU-INWEH	Research Scientist
Prairie Water (Spence)		
Anderson, Erik	Mantyka-Pringle/Clark (Saskatchewan)	Undergraduate Student
Cheecham-Uhrich, Debea	G. Strickert (Saskatchewan)	Undergraduate Student
Hill, Brandon	M. Hayashi (UCalgary)	Technician
Hoggarth, Cameron	H. Baulch (Saskatchewan)	Technician
Witham, Stephanie	H. Baulch, C. Whitfield (Saskatchewan)	Technician
Nugent, Katy	H. Baulch (Saskatchewan)	Technician
Gilmour, Kimberly	H. Baulch (Saskatchewan)	Technician
Dyck, Lauren	H. Baulch (Saskatchewan)	Technician
Roste, Jen	H. Baulch (Saskatchewan)	Technician
Sieben, Evan	M. Hayashi (UCalgary)	Technician
Betancur Vesga, Sandra	G. Strickert (Saskatchewan)	Technician
Baron, Anthony	C. Whitfield (Saskatchewan)	Technician
Asare, Eric	Belcher (Saskatchewan)	Postdoctoral Fellow
Malaj, Egina	Morrissey (Saskatchewan)	Postdoctoral Fellow
Mantyka-Pringle, Chrystal	Clark/Baulch (Saskatchewan)	Postdoctoral Fellow

Mekonnen, Balew	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Negm, Amro	Masaki (UCalgary)	Postdoctoral Fellow
Rasouli, Kabir	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Cavaliere, Emily	Basu (Waterloo), Baulch (Saskatchewan)	Postdoctoral Fellow
Mantyka-Pringle, Chrystal	Clark/Baulch (Saskatchewan)	Postdoctoral Fellow
Wolfe, Jared	Whitfield/Spence (Saskatchewan)	Professional Research Associates
Morrison, Alasdair	L. Bradford, G.Strickert (Saskatchewan)	Professional Research Associates
Integrated Modelling Program for Canada (Razavi)		
Brown, Tom	J. Pomeroy (Saskatchewan)	Technician
Fang, Xing	J. Pomeroy (Saskatchewan)	Technician
Awoye, Oyemonbade	S. Razavi (Saskatchewan)	Postdoctoral Fellow
Cuong, Nhu	S. Razavi (Saskatchewan)	Postdoctoral Fellow
Fayad*, Abbas	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Garcia Hernandezc, Jorge	Brouwer (Waterloo)	Postdoctoral Fellow
Gharari, Shervan	M. Clark, S. Razavi, J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
He, Zhihua	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Leroux, Nicolas	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Li, Zhaoqin	K. Lindenschmidt (Saskatchewan)	Postdoctoral Fellow
Mai, Juliane	Stadnyk, Asadzadeh (U Manitoba)	Postdoctoral Fellow
Morales, Luis	K. Lindenschmidt (Saskatchewan)	Postdoctoral Fellow
Pinto, Rute	Brouwer (Waterloo)	Postdoctoral Fellow
Rajulapati, Chandra	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Rasouli, Kabir	S. Razavi (Saskatchewan)	Postdoctoral Fellow
Richard, Dominique	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Rokaya, Prabin	K. Lindenschmidt (Saskatchewan)	Postdoctoral Fellow
Sadeghian, Amir	K. Lindenschmidt (Saskatchewan)	Postdoctoral Fellow
Tesemma, Zelalem	K. Lindenschmidt (Saskatchewan)	Postdoctoral Fellow
Bandi, Venkat	Gutwin (Saskatchewan)	Professional Research Associates
Budhathoki, Sujata	K. Lindenschmidt (Saskatchewan)	Professional Research Associates

Carlson, Hayley	P. Gober (Saskatchewan)	Professional Research Associates
Carr, Meghan	K. Lindenschmidt (Saskatchewan)	Professional Research Associates
Haghnegahdar, Amin	S. Razavi (Saskatchewan)	Professional Research Associates
Williams, Brandon	K. Lindenschmidt (Saskatchewan)	Professional Research Associates
Lento, Jennifer	Monk, Jardine, UNB/ECCC	Research Scientist
Costa, Diogo	J. Pomeroy (Saskatchewan)	Research Scientist
Loukili, Youssef	J. Pomeroy (Saskatchewan)	Research Scientist
Shook, Kevin	J. Pomeroy (Saskatchewan)	Research Scientist
Whitfield, Paul	J. Pomeroy (Saskatchewan)	Research Scientist
Bahremand, Abdolreza	S. Razavi (Saskatchewan)	Visiting Fellows/Professors
Huang, Ya	Y. Li (Saskatchewan)	Visiting Fellows/Professors
Slaughter, Andrew	Razavi (UofS)	Visiting Fellows/Professors
S. Khoshnod	S. Razavi, A. Haghnegahdar (Saskatchewan)	Visiting Fellows/Professors
Mountain Water Futures (Carey)		
Brun-Berthet, Alix	J. Thériault (UQAM)	Undergraduate Student
Nenson, Stefan	C. Westbrook (Saskatchewan)	Undergraduate Student
Barrett, David	S. Carey (McMaster)	Technician
de Jong, Tyler	S. Carey (McMaster)	Technician
Galloway, Greg	J. Pomeroy (Saskatchewan)	Technician
Heavens, Robin	J. Pomeroy (Saskatchewan)	Technician
Langs, Lindsey	J. Pomeroy (Saskatchewan)	Technician
Sieben, Evan	M. Hayashi (Calgary)	Technician
Treberg, Mike	S. Carey (McMaster)	Technician
Khomik, Myroslava	R. Petrone (Waterloo)	Postdoctoral Fellow
Mukherjee, Kriti	B. Menounos (UNBC)	Postdoctoral Fellow
Rasouli, Kabir	J. Pomeroy (Saskatchewan), M. Hayashi (Calgary)	Postdoctoral Fellow
Richard, Dominique	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Tesemma, Zelalem	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Wayand, Nicholas	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Fayad, Abbas	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Rajulapati, Chandra	J. Pomeroy, S. Razavi (Saskatchewan)	Postdoctoral Fellow
Leroux, Nicolas	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Liu, George	R. Stewart (Manitoba)	Research Scientists
Loukili, Youssef	J. Pomeroy (Saskatchewan)	Research Scientist
Shea, Joseph	J. Pomeroy (Saskatchewan)	Research Scientist

Brown, Tom	J. Pomeroy (Saskatchewan)	Professional Research Associates
Fang, Xing	J. Pomeroy (Saskatchewan)	Professional Research Associates
Ignacio Lopez Moreno, Juan	J. Pomeroy (Saskatchewan)	Professional Research Associates
Luo, Siqiong	J. Pomeroy (Saskatchewan)	Professional Research Associates
Ul Islam , Siraj	Stephen Déry (UNBC), Francis Zwiers (UVic), Brian Menounos (UNBC)	Professional Research Associates
Vionnet, Vincent	J. Pomeroy (Saskatchewan)	Professional Research Associates
Whitfield, Paul	J. Pomeroy (Saskatchewan)	Professional Research Associates
Picard, Antoine	M. Hayashi (Calgary)	Others
Waldner, Zachary	C. Westbrook (Saskatchewan)	Others
Lake Futures (Basu)		
Pereira Wilson, Matthew	H. Kheyrollah Pour (Waterloo)	Undergraduate Student
Jordan, Megan	Milojevic (Waterloo)	Undergraduate Student
Miller, Linea	N. Basu (Waterloo)	Undergraduate Student
McLeod, Meghan	N. Basu (Waterloo)	Undergraduate Student
Grootjen, Tori	N. Basu (Waterloo)	Undergraduate Student
Larmour, Zach	N. Basu (Waterloo)	Undergraduate Student
Charissa, Abishiktha	N. Basu (Waterloo)	Undergraduate Student
Thompson, Jesse	N. Basu (Waterloo)	Undergraduate Student
Starratt, Kathryn	N. Basu (Waterloo)	Undergraduate Student
Walberg, Senja	N. Basu (Waterloo)	Undergraduate Student
Marks, Gareth	N. Basu (Waterloo)	Undergraduate Student
Babaran, Dara	Courtenay (Waterloo)	Undergraduate Student
Hill, Timothy	N. Basu (Waterloo)	Undergraduate Student
Mei, Yufei	N. Basu (Waterloo)	Undergraduate Student
Goe, Ya	H. Kheyrollah Pour (Waterloo)	Undergraduate Student
Jawed, Zobia	B. Krantzberg (Waterloo)	Postdoctoral Fellow
Liu, Haiyan	R. Brouwer (Waterloo)	Postdoctoral Fellow
Pour, Homa Kheyrollah	P. Van Cappallen (Waterloo)	Research Scientist
Van Meter, Kim	N. Basu (Waterloo)	Research Scientist
Ives, Jessica	R. Rooney (Waterloo)	Others
Tenkouano, Guy	N. Basu (Waterloo)	Others

Watt, Caitlin	N. Basu (Waterloo)	Others
Transformative Sensor Technologies and Smart Watersheds for Canadian Futures (Duguay)		
Dressler, Reid	J. Pomeroy (Saskatchewan)	Undergraduate Student
Wan, Lixuan	J. Pomeroy (Saskatchewan)	Undergraduate Student
Sen, Pritam	J. Pomeroy (Saskatchewan)	Undergraduate Student
Phillips, Emmy	J. Pomeroy (Saskatchewan)	Undergraduate Student
Qin, Ke	D. Rudolph (Waterloo)	Undergraduate Student
Galloway, Greg	J. Pomeroy (Saskatchewan)	Technician
Vandenhoff, Aaron	D. Rudolph (Waterloo)	Technician
Coles, Anna	Northern Water Futures (Sask)	Postdoctoral Fellow
Harder, Phillip	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Leroux, Nicolas	J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Huang, Xiang	D. Rudolph (Waterloo)	Postdoctoral Fellow
Glass, Brittney	D. Rudolph (Waterloo)	Research Assistant
Tozatti, Patricia	J. Pomeroy (Saskatchewan)	Research Assistant
Conant, Brewster	D. Rudolph (Waterloo)	Research Assistant
Shea, Joseph	J. Pomeroy (Saskatchewan)	Research Scientist
Kinar, Nicholas	J. Pomeroy (Saskatchewan)	Research Scientist
Zhao, Dong	J. Pomeroy (Saskatchewan)	Research Scientist
Zolfaghari, Kiana	C. Duguay (Waterloo)	Research Scientist
Dusome, Allie	Waterloo	Others
Hoekstra, Marie	C. Duguay (Waterloo)	Others
Spring, Andrew	Laurier	Others
Goucher, Nancy	Waterloo	Others
Wallace, Alistair	J. Pomeroy (Saskatchewan)	Others
Persaud, Bhaleka	Waterloo	Others
AWF: Stressors and Solutions (Macrae)		
Aziz, Uswah	J. Pomeroy (Saskatchewan)	Undergraduate Student
Hunter, Anders	W. Helgason (Saskatchewan)	Undergraduate Student
Johnsom, Bruce	W. Helgason (Saskatchewan)	Technician
Plach, Janina	M. Macrae (Waterloo)	Technician
Nugent, Katy	H.Baulch (Saskatchewan)	Technician
Costa, Diogo	J. Pomeroy, H. Wheater (Saskatchewan)	Postdoctoral Fellow
Harder, Phillip	W. Helgason, J. Pomeroy (Saskatchewan)	Postdoctoral Fellow
Liu, Haiyan	R. Brouwer; University of Waterloo	Postdoctoral Fellow
Liu, Jian	H.Baulch (Saskatchewan)	Postdoctoral Fellow

Pinto, Rute	Roy Brouwer, University of Waterloo	Postdoctoral Fellow
Plach, Janina	M. Macrae; University of Waterloo	Postdoctoral Fellow
Costa, Diogo	J. Pomeroy (Saskatchewan)	Research Scientist
Frank, Anna	R. de Loë, R. Brouwer, and P. Deadman; University of Waterloo	Professional Research Associates
Kompanizare, Mazda	R. Petrone and M. Macrae; University of Waterloo	Professional Research Associates
Roste, Jen	H. Baulch and J. Elliott; University Elliott; University (Environment and Climate Change Canada), and Henry	Professional Research Associates
Prairie Drainage Governance (Loring)		
Minnes, Sarah	P. Loring (Geulph)	Postdoctoral Fellow
Gaspard, Valencia	P. Loring (Geulph)	Professional Research Associates
UW Team		
Mao, Allison	F. Rezeanazed (Waterloo)	Undergraduate Student
Dhiyebi, Hadi	M. Servos (Waterloo)	Technician
Huang, Po-Jun	University of Waterloo (Juewen Liu)	Technician
Niederkorn, Amanada	F. Rezeanazed (Waterloo)	Technician
Vandenhoff, Aaron	University of Waterloo (David Rudolph)	Technician
Vandergriendt, Marianne	F. Rezeanazed (Waterloo)	Technician
Zolfaghari, Kiana	University of Waterloo (Claude Duguay)	Research Scientist
FIShNET (Fish & IndigenouS NorthErn healTh) (Skinner)		
Drysdale, Mallory	B. Laird (Waterloo)	Others
Ratelle, Mylene	B. Laird (Waterloo)	Others
Evaluation of Ice Models in Large Lakes using Three-Dimensional Coupled Hydrodynamic-Ice Models (Lamb)		
Hill, Timothy	K. Lamb (Waterloo)	Undergraduate Student
Marks, Gareth	K. Lamb (Waterloo)	Undergraduate Student
Walberg, Senja	K. Lamb (Waterloo)	Undergraduate Student
Agent Based Modelling (Bharadwaj)		
Belcher, Kurt	L. Bradford (Saskatchewan)	Undergraduate Student
Mackie, Cayley	L. Bradford (Saskatchewan)	Undergraduate Student
Morrison, Alasdair	L. Bharadwaj	Research Scientist
Poochay, Erin	Yellow Quill First Nation	Others

Neapetung, Myron	Yellow Quill First Nation	Others
Marion, Bill	James Cree First Nation	Others
BlueSky Crowe, Jeff	Yellow Quill First Nation	Others
Crowe, Joe	Yellow Quill First Nation	Others
Co-Creation of Indigenous Water Quality Tools (Martin-Hill)		
Hildebrand, Julia	Samaan (Waterloo)	Undergraduate Student
Li, Casey	Samaan (Waterloo)	Undergraduate Student
Bider, Pascale	P. Chow-Fraser (McMaster)	Undergraduate Student
Nimri, Hisham	P. Chow-Fraser (McMaster)	Undergraduate Student
Looking Horse, Makasa	D. Martin-Hill (McMaster)	Undergraduate Student
Kreps, Piers	D. Martin-Hill (McMaster)	Undergraduate Student
McQueen, Denise	D. Martin-Hill (McMaster)	Undergraduate Student
Rafael, Josha	D. Martin-Hill (McMaster)	Undergraduate Student
Rabideau, Sarah	P. Chow-Fraser (McMaster)	Professional Research Associates
Linking Water Governance in Canada to Global Economic, Social and Political Drivers (de Loe)		
Isaac, Bereket N.	R. de Loë (Waterloo)	Professional Research Associates
Pharr, Kathryn	D. Garrick (Oxford)	Professional Research Associates
Lindamood, Danielle	R. de Loë (Waterloo)	Professional Research Associates
Groundwater Dynamics (Illman)		
Cheng, Siyu	W. Illman (Waterloo)	Undergraduate Student
Park, Young-Jin	W. Illman (Waterloo)	Professional Research Associates
Climate-Related Precipitation Extremes (Stewart)		
Loeb, Nicole	J. Hanesiak (Manitoba)	Undergraduate Student
Ali Ben Alaya, Mohamed	F. Zwiers (Uvic)	Postdoctoral Fellow
Huo, Fei	Y. Li (Saskatchewan)	Postdoctoral Fellow
Li, Lintao	Y. Li (Saskatchewan)	Postdoctoral Fellow
Park, Seoncheol	R. Stewart (Uvic)	Postdoctoral Fellow
St-Pierre, Mederic	J. Thériault (UQAM)	Professional Research Associates
Liu, George	R. Stewart, J. Hanesiak (Manitoba)	Research Scientist

Graduate Students by Projects (Masters and Doctoral)

Last, First	Supervisor	Student
Southern Forests Water Futures (Arain)		
Beamsderfer, Eric	A. Arain (McMaster)	Doctoral Student

Bodo, Alanna	A. Arain (McMaster)	Doctoral Student
Lau, Kei	J. Chen (Toronto)	Masters Student
Liu, Yihong	J. Chen (Toronto)	Masters Student
Ma, David	A. Arain (McMaster)	Masters Student
Zugic, Jessica	Michael Pisaric, Brock University	Masters Student
McKenzie, Shawn	A. Arain (McMaster)	Doctoral Student
Sauer, Stéfan	A. Arain (McMaster)	Masters Student
Linking Water Governance in Canada to Global Economic, Social and Political Drivers (de Loe)		
Murphy-Mills, Erin	R. de Loë (Waterloo)	Doctoral Student
Omic' and Chemical Fingerprinting Methodologies using Ultrahigh-Resolution Mass Spectrometry for Geochemistry and Healthy Waters (Jones)		
Tendler, Brett	P. Jones (Saskatchewan)	Masters Student
Vien, Alex	P. Jones (Saskatchewan)	Masters Student
Evaluation of Ice Models in Large Lakes using Three-Dimensional Coupled Hydrodynamic-Ice Models (Lamb)		
Walsh, Sarah	K. Lamb, A. Scott, M. Stastna (Waterloo)	Masters Student
Grace, Andrew	K. Lamb, A. Scott, M. Stastna (Waterloo)	Doctoral Student
Linking Stream Network Process Models to Robust Data Management Systems for the Purpose of Land-Use Decision Support (MacViar)		
Abedin, Sayed	B. MacVicar (Waterloo)	Doctoral Student
Gunsolus, Etta	B. MacVicar (Waterloo)	Doctoral Student
Tavares, Christina	P. Alencar	Doctoral Student
Hyung, Patricia	S. Murphy (Waterloo)	Doctoral Student
Turecek, Jessica	S. Murphy (Waterloo)	Doctoral Student
Winter Soil Processes in Transition (Rezanezhad)		
Krogstad, Konrad	F. Rezanezhad (Waterloo)	Masters Student
Jensen, Grant	L. Hug (Waterloo)	Masters Student
Global Water Citizenship - Integrating Networked Citizens, Scientists and Local Decision Makers		
Yee, Lauren	C. Robertson (Wilfred Laurier)	Masters Student
Wilson, Nick	C. Robertson (Wilfred Laurier)	Masters Student
Bondoruk, Ben	C. Robertson (Wilfred Laurier)	Masters Student
Hotati, Majid	C. Robertson (Wilfred Laurier)	Doctoral Student
Lawrence, Haydn	Feick (Waterloo)	Doctoral Student
Sensors and Sensing Systems for Water Quality Monitoring (Selvaganapthy)		
Kneller, Joshua	C. Xu (McMaster)	Masters Student
Zha, Rong	C. Xu (McMaster)	Doctoral Student
Flores, Beatriz Esther Cupe	K. Liber (Saskatchewan)	Masters Student
Park, Spencer	E. Sekerinski (McMaster)	Doctoral Student
Rabiul Hasan, Mohammed	K. Wahid (Saskatchewan)	Masters Student
Islam Chowdhury, Rakibul	K. Wahid (Saskatchewan)	Doctoral Student
Alam, Arif	J. Deen (McMaster)	Doctoral Student

Courtney, Matt	C. Ren (McMaster)	Doctoral Student
Damodara, Sreekant	R. Selvaganapathy (McMaster)	Doctoral Student
Fathalla, Mohamed	R. Selvaganapathy (McMaster)	Doctoral Student
Gill, Gaganprit	J. Liu, S. Smith, J. McGeer (Wilfred Laurier)	Doctoral Student
Mohammad Ali Ehsan ur Rahman, Gazi	K. Wahid (Saskatchewan)	Doctoral Student
Nguyen, Anna	C. Ren (McMaster)	Doctoral Student
Pan, Si	J. Deen (McMaster)	Doctoral Student
Patel, Vinay	R. Selvaganapathy (McMaster)	Doctoral Student
Peixoto Mendes, Maíra	K. Liber (Saskatchewan)	Doctoral Student
Saha, Dipankar	P. Kruse (McMaster)	Doctoral Student
Yao, Shucai	E. Sekerinski (McMaster)	Doctoral Student
Zhang, Nan	C. Delannoy (McMaster)	Doctoral Student
Zhang, Yushan	C. Xu (McMaster)	Doctoral Student
Linking Multiple Stressors to Adverse Ecological Responses Across Watersheds (Servos)		
Hayat, Samina	Servos, Waterloo	Masters Student
Hodgson, Rhiannon	Craig, Waterloo	Masters Student
Nikel, Kirsten	Servos, Waterloo	Masters Student
Srikanthan, Nivetha	Servos, Waterloo	Masters Student
Zeeb, Elijah	Parker, Waterloo	Masters Student
Arlos, Maricor	Servos-Parker (Waterloo)	Doctoral Student
Jamal, Soundus	Servos-Parker (Waterloo)	Doctoral Student
Narasimman, Barath (LM)	Servos-Parker (Waterloo)	Doctoral Student
Crowdsourcing Water Science (Strickert)		
Tyrone, Miranda	G. Strickert (Saskatchewan)	Masters Student
Lui, Mengxuan	R. Deters (Saskatchewan)	Doctoral Student
Jain, Tanvi	R. Deters (Saskatchewan)	Doctoral Student
Storms and Precipitation Across the Continental Divide Experiment (SPADE) (Theriault)		
Desroches Lapointe, Aurélie	J. Thériault, (Montreal)	Masters Student
Mitchell, Selina	S. Déry (Northern British Columbia)	Masters Student
Bertoncini, André	J. Pomeroy (Saskatchewan)	Doctoral Student
Muñoz, Oscar Rojas	J. Thériault, (Montreal)	Doctoral Student
SAMMS: Sub-Artic Metal Mobility Study (Wolfe)		
Jasiak, Izabela	Hall/Wolfe (Waterloo)	Masters Student
Leathers, Jeremy	Venkiteswaran (WLU)	Masters Student
Leclerc, Emilie	Couture (Laval)	Masters Student
Sharma, Shanta	Whitfield (USask)	Masters Student
Owca, Tanner	Wolfe/Hall (WLU)	Masters Student
Schultz, Mackenzie	Venkiteswaran/Wolfe (WLU)	Masters Student
Telford, James	Wolfe/Hall (WLU)	Masters Student
Gill, Gaganprit	Smith (WLU)	Doctoral Student

Aukes, Pieter	Schiff (Waterloo) / Venkiteswaran (WLU)	Doctoral Student
Cheney, Cynthia	Blais (Ottawa)	Doctoral Student
Adaptation Governance and Policy Changes in Relation to a Changing Moisture Regime Across the Southern Boreal Forest (Laroque)		
Andrews-Key, Sheri	C. Laroque (Saskatchewan)	Doctoral Student
Climate-Related Precipitation Extremes (Stewart)		
McFadden, Vanessa	J.Thériault (Montreal)	Masters Student
Tropea, Brock	R. Stewart (Manitoba)	Masters Student
Chartrand, Julien	J.Thériault (Montreal)	Masters Student
Bruneay, Jennifer	J. Hanesiak (Manitoba)	Masters Student
Scaff, Lucia	Y. Li (Saskatchewan)	Doctoral Student
Northern Water Futures (Baltzer)		
Bill, Kristen	M. Turetsky (Guelph)	Masters Student
Boag, Tara	H. Swanson (Wilfrid Laurier)	Masters Student
Brandow, Danielle	K. Skinner (Waterloo)	Masters Student
Brown, Genevieve		Masters Student
El-Amine, Mariam	O. Sonnentag (Montreal)	Masters Student
Faber, Jelle	B. Wolfe (Wilfrid Laurier)	Masters Student
Fung, Leicester	B. Laird (Waterloo)	Masters Student
Glass, Brittney	D. Rudolph (Waterloo)	Masters Student
Jayaratne, Neomi	A. Blay- Palmer (Wilfrid Laurier)	Masters Student
Jitnikovitch, Anton	P. Marsh (Wilfrid Laurier)	Masters Student
Judge, Connor	K. Skinner (Waterloo)	Masters Student
Klimpemt, Wynonan	B. Wolfe/ R. Hall (Wilfrid Laurier)	Masters Student
Kok, Kaitlin	A. Blay- Palmer (Wilfrid Laurier)	Masters Student
Malandra, Michelle	A. Blay- Palmer (Wilfrid Laurier)	Masters Student
Mills, Maggie	A. Blay- Palmer (Wilfrid Laurier)	Masters Student
Neary, Laura	B. Wolfe (Wilfrid Laurier)	Masters Student
Owca, Tanner	B. Wolfe (Wilfrid Laurier)	Masters Student
Packull-McCormick, Sara	D. Rudolph (Waterloo)	Masters Student
Jason, Paul	J. Baltzer (Wilfrid Laurier)	Masters Student
Pretty, Thomas	D. Gray, (Wilfrid Laurier)	Masters Student
Telford, James	B. Wolfe (Wilfred Laurier)	Masters Student
Warkentin, Meagan	J. Baltzer (Wilfred Laurier)	Masters Student
White, Alison	J. Baltzer (Wilfred Laurier)	Masters Student
Wicke, Andrew	D. Rudolph (Waterloo)	Masters Student
Wilson, Nick	M. English (Wilfrid Laurier)	Masters Student
Yamaguchi, Ari	D. MacLatchy (Wilfrid Laurier)	Masters Student
Akbarpour, Shaghayegh	J. Craig (Waterloo)	Doctoral Student
Amiri, Erfran	J. Craig (Waterloo)	Doctoral Student

Drysdale, Mallory	B. Laird (Waterloo)	Doctoral Student
Gibson, Carolyn	M. Turetsky (Guelph)	Doctoral Student
Kay, Mitch	B. Wolfe (Wilfred Laurier)	Doctoral Student
Kershaw, Geoff	W. Quinton (Wilfred Laurier)	Doctoral Student
Majumder, Barun	P. Marsh (Wilfrid Laurier)	Doctoral Student
Moslemi-Aqdam, Mehdi	H. Swanson (Wilfrid Laurier)	Doctoral Student
Packull-McCormick, Sara	B. Laird (Waterloo)	Doctoral Student
Perron, Nia	O. Sonnentag and J. Baltzer	Doctoral Student
Remmer, Casey	B. Wolfe (Wilfred Laurier)	Doctoral Student
Salman, Maxime	D. Rudolph (Waterloo)	Doctoral Student
Standen, Katherine	J. Baltzer (Wilfrid Laurier)	Doctoral Student
Taheri, Mahkameh	J. Craig (Waterloo)	Doctoral Student
Wallace, Cory	J. Baltzer (Wilfrid Laurier)	Doctoral Student
Woodworth, Stephanie	A. Sprimg, S. Wesche (Wilfrid Laurier), (Ottawa)	Doctoral Student
Next Generation Solutions to Ensure Healthy Water Resources for Future Generations (Giesy)		
Ankley, Phillip	T. Jardine (Saskatchewan)	Masters Student
Harper, Nathanael	T. Jardine, B. Noble (Saskatchewan)	Masters Student
Giovanini, Renata Mont'Alverne B.	T. Jardine, B. Noble (Saskatchewan)	Masters Student
Peters, Jacqueline	J. Giesy (Saskatchewan)	Masters Student
Weber, Alana	M. Servos, D. Rudolph (Waterloo)	Masters Student
DeBofsky, Abigail	J. Giesy (Saskatchewan)	Doctoral Student
Ikert, Heather	P. Craig, B. Katzenback (Waterloo)	Doctoral Student
FORMBLOOM (Baulch)		
Boyer, Lisa	H.Baulch (Saskatchewan)	Masters Student
McAleer, Esther	H.Baulch (Saskatchewan)	Masters Student
Shah, Puru	J. Venkiteswaran (Wilfred Laurier)	Masters Student
Henderson, Rachel	J. Venkiteswaran (Wilfried Laurier)	Masters Student
Gil, Arshdeep	L.Bradford, L. Bharadwaj (Saskatchewan)	Masters Student
Ramkissoon, Naveeta	L.Bradford, L. Bharadwaj (Saskatchewan)	Masters Student
Chegoonian, Amir Masoud	C. Duguay (Waterloo)	Doctoral Student
Boreal Water Futures (Waddington)		
Ruiz Caldas, Maria	C. de Lannoy (McMaster)	Masters Student
Deane, Patrick	M. Waddington (McMaster)	Masters Student
Leipe, Sean	S. Carey (McMaster)	Masters Student
Tyler, Karisa	R. Petrone (Waterloo)	Masters Student
Balliston, Nicole	J. Price (Waterloo)	Doctoral Student
Beaudoin-Galaise, Maxime	S. Jutras (Laval)	Doctoral Student
Lawford, Peter	J. Pomeroy (Saskatchewan)	Doctoral Student
Luymes, Nick	N. Doubleday, B. McKnight (McMaster)	Doctoral Student
Nicholls, Erin	S. Carey (McMaster)	Doctoral Student

Popovic, Natasa	R. Petrone (Waterloo)	Doctoral Student
Rupasinghe, Prabha	P. Chow-Fraser (McMaster)	Doctoral Student
Van Huizen, Brandon	R. Petrone (Waterloo)	Doctoral Student
Wilkinson, Sophie	M. Waddington (McMaster)	Doctoral Student
Wu, Yichen	C. de Lannoy (McMaster)	Doctoral Student
Prairie Water (Spence)		
Ferris, David	G. Ferguson (Saskatchewan)	Masters Student
Hewitt, Kelsey	G. Ferguson (Saskatchewan)	Masters Student
Bouslama, Rima	G. Ferguson (Saskatchewan)	Masters Student
Bryan, Tyler	G. Ferguson (Saskatchewan)	Masters Student
Wade, Andrea	C. Morrissey, K. Liber (Saskatchewan)	Masters Student
McFarlan, Laura	C. Whitfield, A. Bedard-Haughn (Saskatchewan)	Masters Student
Hergott, Amy	C. Whitfield, H. Baulch (Saskatchewan)	Masters Student
Duffy, Ashleigh	G. Strickert (Saskatchewan)	Masters Student
Thapa, Anuja	G. Strickert (Saskatchewan)	Masters Student
Mora Garces, Maria	L. Bharadwaj, G. Strickert (Saskatchewan)	Doctoral Student
Integrated Modelling Program for Canada (Razavi)		
Sotoodeh, Ehsan	Gutwin/Razavi (Saskatchewan)	Masters Student
Mairena, Aristedes	Gutwin (Saskatchewan)	Masters Student
Bhatti, Gurjot	Gutwin (Saskatchewan)	Masters Student
Mohammadiazar, Maryam	G. Strickert (Saskatchewan)	Masters Student
Lang, Zachary	K. Lindenschmidt (Saskatchewan)	Masters Student
Jin, Su	Asadzadeh, Stadnyk (U Manitoba)	Masters Student
Beiraghdar, Parya	Asadzadeh, Stadnyk (U Manitoba)	Masters Student
Mustakim, Syed	Razavi (Saskatchewan)	Masters Student
Keshavarz, Kasra	Razavi (Saskatchewan)	Masters Student
Robichaud, Hailey	W. Helgason (Saskatchewan)	Masters Student
Shen, Hongren	Tolson (Waterloo)	Doctoral Student
Sheikholeslami, Razi	Razavi (Saskatchewan)	Doctoral Student
Eamen, Leila	Razavi (Saskatchewan)	Doctoral Student
Ghoreishi, Seyedmohammad*	A. Elshorbagy, Razavi (Saskatchewan)	Doctoral Student
Scaff, Lucia	Y. Li (Saskatchewan)	Doctoral Student
Ma, Xiao	Razavi (Saskatchewan)	Doctoral Student
Bajracharya, Ajay	Razavi (Saskatchewan)	Doctoral Student
Zaghloul, Mohanad	A. Elshorbagy, S. Papalexiou (Saskatchewan)	Doctoral Student
Islam, Aminul	Gutwin (Saskatchewan)	Doctoral Student
Lawford, Peter	J. Pomeroy (Saskatchewan)	Doctoral Student
Lv, Zhibang	J. Pomeroy (Saskatchewan)	Doctoral Student
Marsh, Chris	J. Pomeroy, H. Wheater (Saskatchewan)	Doctoral Student

Pradhananga, Dhiraj	J. Pomeroy (Saskatchewan)	Doctoral Student
Krogh, Sebastian	J. Pomeroy (Saskatchewan)	Doctoral Student
Aubry-Wake, Caroline	J. Pomeroy (Saskatchewan)	Doctoral Student
Bertonicini, André	J. Pomeroy (Saskatchewan)	Doctoral Student
Mountain Water Futures (Carey)		
Beamish, Laura	Masaki Hayashi, UofC	Masters Student
He, Jesse	Masaki Hayashi, UofC	Masters Student
Hoenmans, Greg	J. Pomeroy (Saskatchewan)	Masters Student
Hrach, Dylan	R. Petrone (Waterloo)	Masters Student
Langs, Lindsey	R. Petrone (Waterloo)	Masters Student
Leipe, Sean	S. Carey (McMaster)	Masters Student
Lyon, Laura	Jeffrey McKenzie, McGill	Masters Student
Reynolds, Jordan	R. Rooney (Waterloo)	Masters Student
Robichaud, Hailey	J. Pomeroy (Saskatchewan)	Masters Student
Roesky, Ben	M. Hayashi (Calgary)	Masters Student
Ronnquist, Amanda	C. Westbrook (Saskatchewan)	Masters Student
Royall, Owen	R. Rooney (Waterloo)	Masters Student
Streich, Stephanie	C. Westbrook (Saskatchewan)	Masters Student
Williamson, Jessica	R. Petrone (Waterloo)	Masters Student
Aubry-Wake, Caroline	J. Pomeroy (Saskatchewan)	Doctoral Student
Bertonicini, André	J. Pomeroy (Saskatchewan)	Doctoral Student
Lawford, Peter	J. Pomeroy (Saskatchewan)	Doctoral Student
Lv, Zhibang	J. Pomeroy (Saskatchewan)	Doctoral Student
Marsh, Chris	J. Pomeroy (Saskatchewan)	Doctoral Student
Mercer, Jason	C. Westbrook (Saskatchewan)	Doctoral Student
Nicholls, Erin	S. Carey (McMaster)	Doctoral Student
Pradhanaga, Dhiraj	J. Pomeroy (Saskatchewan)	Doctoral Student
Rohanizadegan, Mina	R. Petrone (Waterloo)	Doctoral Student
Sanchez Garces, Mariá	C. Westbrook (Saskatchewan)	Doctoral Student
Sharma, Aseem	S. Déry (UNBC)	Doctoral Student
Shatilla, Nadine	S. Carey (McMaster)	Doctoral Student
Tang, Weigang	S. Carey (McMaster)	Doctoral Student
Tchuem, Obert	J. Thériault (UQAM)	Doctoral Student
Tennant, Christina	B. Menounos (UNBC)	Doctoral Student
Wang, Abby	R. Petrone (Waterloo)	Doctoral Student
Lake Futures (Basu)		
Chowdhury, Qualbe Shadman	N. Basu (Waterloo)	Masters Student
Dony, John	N. Basu (Waterloo)	Masters Student
Quinn-Austin, Hillary	M. Servos, R. Rooney (Waterloo)	Masters Student
Samson, Melani-Ivy	N. Basu (Waterloo)	Masters Student
Vien, Alex	P. Jones (Saskatchewan)	Masters Student

Han, Ming	Tolson (Waterloo)	Doctoral Student
Ho, Elaine	Courtenay, Trant (Waterloo)	Doctoral Student
Markelov, Igor	Van Cappellen (Waterloo)	Doctoral Student
Yang, Xinyuan (Wilson)	Insley (Waterloo)	Doctoral Student
Transformative Sensor Technologies and Smart Watersheds for Canadian Futures (Duguay)		
Ghiasi, Yusof	M. Servos (Waterloo)	Masters Student
Staines, Jacob	J. Pomeroy (Saskatchewan)	Masters Student
Peters, Jacqueline	D. Rudolph (Waterloo)	Masters Student
Glass, Brittney	D. Rudolph (Waterloo)	Masters Student
Wicke, Andrew	D. Rudolph (Waterloo)	Masters Student
Ju, Joey	D. Rudolph (Waterloo)	Doctoral Student
Lv, Zhibang	J. Pomeroy (Saskatchewan)	Doctoral Student
Pardo, Renato	Berg, Guelph	Doctoral Student
Salman, Max	Rudolph (Waterloo)	Doctoral Student
Foroutan, Mari	Duguay (Waterloo)	Doctoral Student
Murfitt, Justin	Duguay (Waterloo)	Doctoral Student
Thompson, Aaron	Kelly (Waterloo)	Doctoral Student
Hebert, Marie	Ren (Waterloo)	Doctoral Student
Courtney, Matthew	Ren (Waterloo)	Doctoral Student
Gao, Runze	Ren (Waterloo)	Doctoral Student
Co-Creation of Indigenous Water Quality Tools (Martin-Hill)		
Makhdoom, Sawson	P. Chow-Fraser (McMaster)	Masters Student
Sims, E. Danielle	R. Samaan (McMaster)	Masters Student
Jajki, Sonia	P. Chow-Fraser (McMaster)	Masters Student
Tedeschi, Alana	P. Chow-Fraser (McMaster)	Masters Student
Duignan, Sarah	Moffat (McMaster)	Doctoral Student
Sultana, Afroza	D. Martin-Hill (McMaster)	Doctoral Student
Fabra-Zamora, Jorge	Doubleday (McMaster)	Doctoral Student
Lymmes, Nick	P. Chow-Fraser (McMaster)	Doctoral Student
Marcaccio, James	P. Chow-Fraser (McMaster)	Doctoral Student
Deen, Tariq	A. Arain (McMaster)	Doctoral Student
Computer Science Team		
Alam, Mahjabin	C. Roy, K.Schneider, B.Roy (Saskatchewan)	Masters Student
Bhattacharjee, Avijit	C. Roy, K.Schneider, B.Roy (Saskatchewan)	Masters Student
Zahan, Hasnat	Gutwin, Mondal (Saskatchewan)	Masters Student
Tasnim, Zarin	Mondal, Schneider (Saskatchewan)	Masters Student
Zhmed, Zinayed	C.Roy, Mondal (Saskatchewan)	Masters Student
Wang, Binbem	R. Spiteri (Saskatchewan)	Masters Student
Gauch, Martin	Lin (Waterloo)	Masters Student
Persaud, Bhaleka	Lin (Waterloo)	Masters Student
Wang, Ethan	Lin (Waterloo)	Masters Student

Old Meets New (Ferguson)		
Jellicoe, Keegan	G. Ferguson, J. McIntosh (Saskatchewan)	Masters Student
Perra, Chris	G. Ferguson, J. McIntosh (Saskatchewan)	Masters Student
Bouslama, Rima	G. Ferguson, J. McIntosh (Saskatchewan)	Masters Student
van Hoy, Diane	G. Ferguson, J. McIntosh (Saskatchewan)	Doctoral Student
Steeves, Joel	G. Ferguson (Saskatchewan)	Doctoral Student
Mowat, Aidan	G. Ferguson, J.McIntosh, M. Lindsay (Saskatchewan)	Doctoral Student
Water Knowledge Camps (Baltzer)		
MacLeod-Fardy, Neala	A. Spring, A. Blay-Palmer (Wilfrid Laurier)	Masters Student
Woodworth, Stephanie	A. Spring (Wilfrid Laurier), S. Wesche (Ottawa)	Doctoral Student
FIShNET (Fish & IndigenouS NorthErn healTh) (Skinner)		
Philipps, Breanna	K. Skinner (Waterloo)	Masters Student
Agent Based Modelling (Bharadwaj)		
Thapa, Anuja	G. Strickert (Saskatchewan)	Masters Student
McDonald, Wade	N. Osgood (Saskatchewan)	Masters Student
Gibson, Randie	Waldner (Saskatchewan)	Doctoral Student
We need more than just water (Jardine)		
Ogbogboyibo, Mercy	G. Strickert, T. Jardine (Saskatchewan)	Masters Student
Sahrawat, Ankita	M. Brinkmann, G. Strickert (Saskatchewan)	Masters Student
Groundwater Dynamics (Illman)		
Tong, Xin	W. Illman (Waterloo)	Doctoral Student
Short-Duration Extreme Precipitation in Future Climate (Li)		
Flemke, Jason	Y. Li (Saskatchewan)	Masters Student
Kamal, Mostofa	Y. Li (Saskatchewan)	Doctoral Student
Hwang, Yunsung	Y. Li (Saskatchewan)	Doctoral Student

HQP who have moved on from the GWF program

Last, First	**Current Professional Title/ Programme of Study**	**Current Company/Institution Name**
Agent Based Modelling (Bharadwaj)		
Bradford, Lori	Assistant Professor	University of Saskatchewan
AWF: Stressors and Solutions (Macrae)		
Grant, Kirsten	MSc, Geography and Environmental Management, University of Waterloo	currently seeking full time employment
Guo, Zoe	MES, Geography and Environmental Management, University of Waterloo	unknown
Lindamood, Danielle	Knowledge Mobilization Manager	University of Waterloo
Boreal Water Futures (Waddington)		
Black, Katie	Biologist	Kilgour & Associates

Fabra, Jorge	Research Assistant, GWF IWQT (PhD Philosophy)	McMaster University
Green, Adam	Research Technician (MSc, Waterloo/Petrone)	University of Waterloo
Nwaishi, Felix	Assistant Professor (PDF, Waterloo/Petrone)	Mount Royal University
Threndyle, Ryan	Enterprise Customer Manager	PartnerStack Ventures
Van Beest, Christine	Technical Sales Representative (MSc, Waterloo/Petrone)	Gasmet Technologies
Climate-Related Precipitation Extremes (Stewart)		
Bruneau, Jennifer	Research Associate	University of Manitoba
Loeb, Nicole	Masters Student	University of North Dakota
McFadden, Vanessa	Forecaster	Environment and Climate Change Canada
Co-Creation of Indigenous Water Quality Tools (Martin-Hill)		
Bider, Pascale		
Carter, Jocelyn	Undergraduate student, Indigenous Studies Program	McMaster University
Jakji, Sonia	Master's student, Faculty of Social Sciences	McMaster University
Kreps, Piers	Master's student, International Social and Public Policy	London School of Economics
Lymmes, Nick	PhD candidate, Biology	McMaster University
Marcaccio, James	PhD candidate, Biology	McMaster University
Nimri, Hisham	BASc student, Mechatronics	McMaster University
Rafael, Josha	Undergraduate student, Arts & Science Program	McMaster University
Computer Science Team		
Alam, Mahjabin		Moved to Japan
Ferdous, Rayhan	BigData Platform Developer	LotLinx, Inc. Winnipeg, Manitoba, Canada
Guo, Wenxian	PhD Student	Department of Computer Science
Li, Yukun	IBM - IIDR Software developer	IBM, ON, Canada
McConkey, Ian	MSc Student	Department of Physics and Engineering Physics, University of Saskatchewan
Rahmna, Shahriar	Backend Software Developer	Diitalk Communications In.
Sengupta, Paromita	Controls and Instrumentation Developer (Intern)	Canada's National Synchrotron Light Source Facility

Crowdsourcing Water Science (Strickert)		
Miranda, Tyrone	Summer Student (Master of Water Security)	Water Security Agency
Evaluation of Ice Models in Large Lakes using Three-Dimensional Coupled Hydrodynamic-Ice Models (Lamb)		
Hill, Timothy	Starting a Masters in Glaciology in Fall 2019	University of Waterloo
FORMBLOOM (Baulch)		
Bradford, Lori	Assistant Professor	SENS, University of Saskatchewan
Collopy, Paige	Masters student	U of S
Salk, Kateri	Assistant Professor	Duke University
Global Water Citizenship - Integrating Networked Citizens, Scientists and Local Decision Makers (Robertson)		
Yee, Lauren	Senior Developer / MSc	Green Analytics
Integrated Modelling Program for Canada (Razavi)		
Carr, Meghan	Scientist	Minnow Consulting, Saskatoon
Desmarais, Mason	Student	University of Saskatchewan
Krogh, Sebastian	PDF	University of Nevada
Mairena, Aristedes	Research Associate	University of Saskatchewan
Sotoodeh, Ehsan	Software Developer	Independent
Lake Futures (Basu)		
Babaran, Dara	Graduate Student	Ryerson University
Djoumna, Georges	Postdoctoral Fellow	University of Waterloo
Goe, Ya	Undergrad Student	University of Waterloo
Grootjen, Tori	Undergrad Student	University of Waterloo
Hearne, Kara	Knowledge Mobilization Specialist	Consultancy
Hill, Timothy	Undergrad Student	University of Waterloo
Jordan, Megan	Undergrad Student	University of Waterloo
Li, Hongxiu	Postdoctoral Fellow	Consultancy
McCarter, Colin	Postdoctoral Fellow	University of Toronto (PDF)
Mei, Yufei	Undergrad Student	University of Waterloo
Miller, Linea	Undergrad Student	University of Waterloo
Pereira Wilson, Matthew	Undergrad Student	University of Waterloo
Shadman Chowdhury, Qualbe	Civil Engineering Technician	City of Markham
Starratt, Kathryn	Undergrad Student	University of Waterloo
Tenkouano, Guy	Intern	Stratos Inc.
Van Meter, Kim	Assistant Professor	University of Illinois at Chicago
Watt, Caitlin	Research Assistant	Agriculture and Agri-Food Canada

Linking Multiple Stressors to Adverse Ecological Responses Across Watersheds (Servos)		
Arlos, Maricor	Postdoctoral Fellow	EAWAG Swiss Federal Institute of Aquatic Science and Technology, ETH, Dübendorf, Switzerland
Hicks, Keegan	Fish Monitoring Biologist	Environmental Monitoring & Science Division, Alberta Environment and Parks
Danielle, Lindamood	Knowledge Mobilization Manager	forWater, University of Waterloo
Kathryn, Pharr	Coordinator	Oxford Water Network
Mountain Water Futures (Carey)		
Aksamit, Nikolas	Postdoctoral Fellow	University of Zürich
Almonte, Juris	Project Coordinator (SPADE)	University of Northern British Columbia
Braaten, Morgan	GWF Outreach Coordinator	University of Saskatchewan
Courtin, Eric	Technical Sales Consultant	Campbell Scientific
Shea, Joseph	Assistant Professor	University of Northern British Columbia
Wayand, Nic	Postdoctoral Fellow	University of Washington
Next Generation Solutions to Ensure Healthy Water Resources for Future Generations (Giesy)		
Ruso, Gabrielle		Job hunting
Zee, Jenna		X-Terra consulting
Northern Water Futures (Baltzer)		
Coles, Anna	Hydrologist	Government of the Northwest Territories
Connon, Ryan	Hydrogeologist	Government of the Northwest Territories
Paul, Jason	Research Technician	Wilfrid Laurier/GNWT
Reid, Kirsten	PhD Student	Memorial University of Newfoundland
Telford, James	Research Technician	University of Waterloo
White, Alison	Forest Research Intern	Ontario Ministry of Natural Resources and Forests
Omic' and Chemical Fingerprinting Methodologies using Ultrahigh-Resolution Mass Spectrometry for Geochemistry and Healthy Waters (Jones)		
Watts, Tena	Research Assistant	Ontario Ministry of the Environment
Prairie Drainage Governance (Loring)		
Breen, Sarah	Senior Policy Analyst	Rural Policy and Programs Branch Ministry of Forest,

		Lands, Natural Resource Operations and Rural Development
Norris, Maggie	Project Coordinator, Project: Lake Futures	University of Waterloo
Prairie Water (Spence)		
Abu, Razak	Postdoctoral Fellow	University of Saskatchewan
Anderson, Erik	University of Saskatchewan (Conservation Biology)	
Bradford, Lori	Assistant Professor	University of Saskatchewan
Cavaliere, Emily	Post-Doctoral Fellow	University of Saskatchewan
Gilmour, Kimberly	Junior Aquatics Technician	Golder Associates
Hill, Brandon	Hydrologist	Applied Aquatic Research Ltd.
Mantyka-Pringle, Chrystal	Conservation Planning Scientist	Wildlife Conservation Society
SAMMS: Sub-Artic Metal Mobility Study (Wolfe)		
Hickman, Jennifer	Research Associate	Government of the North West Territories
Sensors and Sensing Systems for Water Quality Monitoring (Selvaganapthy)		
Aryasomayajula, Aditya	Mechanical Engineer	iS5 Communications Inc., Mississauga ON
Transformative Sensor Technologies and Smart Watersheds for Canadian Futures (Duguay)		
Hearne, Kara	Environmental Planner	SLR Consulting
Shea, Joseph	Assistant Professor	University of Northern British Columbia
Winter Soil Processes in Transition (Rezanezhad)		
Duff, Dave	Undergraduate Student, Biochemistry	Wilfrid Laurier University
WLU Technical Team (Muttkittrick)		
Connon, Ryan	Hydrologist	Government of the Northwest Territories
Hickman, Jennifer	Adaptation Planning Specialist (start: April 2019)	Climate Change Unit, GNWT Department of Environmental and Natural Resources
Rudy, Ashley	Geotechnical Data Scientist	Northwest Territories Geological Survey

Appendix D – Leadership in International Research programs and Professional Societies

Number of international research programs and committee where GWF members are lead investigators and/or advisors are presented in *"Italics"*

Andrew, Leon

- Aboriginal Steering Committee Advisor to the NWT Water Stewardship Strategy, Mackenzie River Basin Board, the Canadian Mountain Network, and the Tracking Change: Local and Indigenous Knowledge in Watershed Governance
- SRRB representative on the NWT Conference of Management Authorities and the NWT Species At Risk Committee

Baltzer, Jennifer

- *Plot PI, Smithsonian Institute's ForestGEO Program.*
- Review Editor, Forest Ecophysiology, Frontiers in Forests and Global Change.
- Member, NASA ABoVe Wildfire Working Group
- Institutional Representative, Canadian Society for Ecology and Evolution.
- Associate Editor for Functional Ecology

Basu, Nandita

- *Chair of the Water Quality Technical Committee for the AGU Hydrology section* (2016-2018). Helped manage award nominations and organize conference sessions.
- Member of the Horton Medal Committee. The committee is charged with selecting the recipient of the Horton Medal, which is given annually to one honoree for outstanding contributions to hydrology.
- On editorial board of the journal Hydrology and Earth Sciences (2011 - present)
- On editorial board of the journal Hydrological Processes (2010 - present)
- Involved in international Multi-Lake Comparison Project (MLCP; Phase 1: Physics) to compare results and knowledge from numerical models of 32 lakes from around the world. The collaboration has resulted in a publication in Environmental Modeling & Software (for a publication details please see the section on referred publications). The followed work is focused on modeling water quality parameters (Phase 2: Biology and Water Quality).

Baulch, Helen

- Special issue associate editor, Journal of Environmental Quality

Bharadwaj, Lalita

- Member, FSIN Environmental Health Working Group.

Blay-Palmer, Alison

- *Director, Viessmann European Research Centre.*
- Scientific Advisor, United Nations, Food and Agriculture Organization.

Bocaniov, A S.

- Member of the organizing committee for the next joint IAGLR-ELLS Conference representing IAGLR (IAGLR: International Association for the Great Lakes; ELLS: European Large Lake Symposium); 2021; Northern Water Problems Institute, Petrozavodsk, Republic of Karelia, Russian Federation [S. Bocaniov was invited by the chair of the organizing committee on Feb. 18, 2019].
- External peer reviewer for the Maryland Sea Grant Graduate Research Support Grants (University of Maryland, College Park, Maryland, U.S.A.).
- Collaboration with the University of Michigan and Graham Sustainability Institute (Ann Arbor, MI, U.S.A.) to improve the current understanding of nutrient sources and loadings to Lake Erie from the Detroit River as well as the key mechanisms involved in nutrient loading dynamics and their inter-annual variations.
- Collaboration with the Great Lakes Center, SUNY Buffalo State, The State University of New York (http://greatlakescenter.buffalostate.edu/). The example of such collaboration is a joint publication (in press) in Journal of Great Lakes Research (for a publication details please see the section on referred publications).
- Bocaniov, S., Kheyrollah Pour, H., and Van Cappellen, P.: involved in Global Lake Ecological Observatory Network -Inter-Sectoral Impact Model Inter-comparison Project (GLEON-ISIMIP) working group (The aim of GLEON-ISIMIP is to better understand climate impacts across sectors using a multi-impact model framework. The second phase of this international effort (ISIMIP2b) is designed to provide robust information about the impacts of 1.5°C and 2°C global warming, as solicited by the IPCC's special report on this topic. ISIMIP provides consistently processed GCM forcing for various impact models, including lake models. The focus of the first round of lake sector simulations will be to evaluate the effects of projected climate change on lake thermal stratification at local to global scales.
- Participated in the team of scientists to discuss and develop future plans for an integrated research and monitoring strategy for Great Bear Lake (a recently declared UNESCO biosphere reserve which includes Great Bear Lake - The Tsá Tué International Biosphere Reserve; Northwest Territories, Canada).

Brouwer, Roy

- Member of the International Scientific Advisory Committee of the Chinese Research Academy for Environmental Sciences (CRAES). Beijing, China. October 2018. Appointed by the Chinese Minister for Ecology and Environment.

- Appointed in October 2018 by the Chinese Minister for Ecology and Environment as a member of the International Scientific Advisory Committee of the Chinese Research Academy for Environmental Sciences (CRAES) in Beijing.
- *Chief Editor Elsevier journal Water Resources and Economics*
- Member of the International Advisory Board of the Technical University of Vienna Doctorate Program on Water Resource Systems

Carey, Sean

- Associate Editor, Hydrological Processes.

Coulibaly, Paulin

- Associate Editor, ASE Journal of Hydrologic Engineering.

Courtenay, S.

- *Chair of the Fellows Board and Chair of the Science Directors Committee at the Canadian Rivers Institute (CRI). As Chair of the Science Directors Committee he is also on the Management Board of CRI to help oversee the development of the Institute research plan.*

Craig, James

- Vice-president, Canadian Society for Hydrologic Sciences.
- Board Member, Canadian Water Resources Association.
- Chair, External Advisory Board, Canadian Hydrology Features (ChyF) initiative (NRCan/USGS).
- Associate Editor, Groundwater.

Dery, Stephen

- Associate Editor, Journal of Hydrometeorology
- Associate Editor, Atmosphere-Ocean
- CMOS – Interior BC/Yukon Chapter, Vice-Chair and Treasurer
- UNBC representative to ARCUS

Dony, John

- In the winter of 2019, John volunteered for "Climate Change and You"; a community outreach program initiated by the Students of the Water Institute Graduate Section (SWIGS) at the University of Waterloo. John acted as a judge for the program, evaluating climate change awareness posters prepared by local elementary school students. With professional experience in greenhouse gas consulting, John thrived in witnessing the passion and enthusiasm that young students have for climate change action.

Duguay, Claude

- *Editorial Board – Editor, The Cryosphere – an interactive open-access journal of the European Geosciences Union.*
- Co-Guest Editor, Special issue on "Lake Remote Sensing" for journal Remote Sensing.
- Co-Guest Editor, Special issue on "Lake Remote Sensing" for journal Remote Sensing.
- Co-convenors, Session "Remote sensing of water quality and quantity", ASLO 2019, San Juan, Puerto Rico, 24 February-1 March 2019.

Elshorbagy, Amin

- Associate Editor, Water Resources Research

Ferguson, Grant

- *Chair, International Associations of Hydrogeologists – Groundwater and Energy Commission.*
- *Past President, International Associations of Hydrogeologists – Canadian National Chapter.*

Gharari, Shervan

- Co-conveners and chairs of session Diagnostic, Sensitivity, and Uncertainty Analysis of Earth and Environmental Models, 2018 Joint Meeting of the CGU-CSSS-CIG-CSAFM-ESSSA, June 10-14, 2018, Niagara Falls, Canada.

Giesy, John

- Fellow of Royal Society of Canada
- Fellow of the Society of Environmental Toxicology & Chemistry (SETAC)

Haghnegahdar, Amin

- Amin Haghnegahdar, Founding Chair, Large Scale Watershed Modelling and Analysis committee, Canadian Geophysical Union-Hydrology section, 2017-present
- Amin Haghnegahdar and Saman Razavi co-conveners and chair of session Recent Advances and Outstanding Challenges in Large-scale Watershed Modelling and Analysis, 2018 Joint Meeting of the CGU-CSSS-CIG-CSAFM-ESSSA, June 10-14, 2018, Niagara Falls, Canada.
- Amin Haghnegahdar and Saman Razavi, co-convener and chair, European Geosciences Union (EGU) General Assembly 2017 session on "Advances in Sensitivity and Uncertainty Analysis of Earth and Environmental Systems Models", April 23-28, 2017, Vienna, Austria

Hecker, Markus

- Chair, "Healthy Society and Environment" group of the College of the Royal Society of Canada.
- Board Member, Society of Environmental Toxicology & Chemistry North America.

- Editor, Environmental Science and Pollution Research; Editor of Environmental Sciences Europe.

Hanesiak, John

- *Invited editor of the HESS special issue - Understanding and predicting Earth system and hydrological change in cold regions.*

Hecker, Markus

- Member of the College of the Royal Society of Canada and board member of the RSC College Council
- Chair of the "Healthy Society and Environment" group of the College of the Royal Society of Canada
- Board Member of the Society of Environmental Toxicology & Chemistry North America

Helgason, Warren

- Conference co-chair of the 2018 International Conference and 69th IEC Meeting of the International Commission on Irrigation and Drainage, Aug 12-17 2018, Saskatoon, SK.

Ho, Elaine

- Fall term 2018: joined the Student Leadership Committee of Canadian Rivers Institute (CRI) as the University of Waterloo Representative

Ives, J.

- Board Secretary for the International Association for Great Lakes Research (2015-present). As Board Secretary, the role includes; developing agendas, taking minutes, and aid in logistics for three board meetings per year; as well as discussing and voting on strategic and administrative decisions for the association.
- *Director of Operations and Co-developer of the African Center for Aquatic Research and Education (ACARE) – a non-profit focused on facilitating inter-jurisdictional collaboration on the African Great Lakes (2017-present).* This role includes; aid in creation and refinement of ACARE, including vision, budget, board of directors, and legal presence; as well as assisting in the preparation of funding proposals and tracking specific project finances, donations, and working capital (https://www.agl-acare.org/)
- Technical Editor for the Journal of Great lakes Research (January 2019-present). This role includes; acting as a liaison between International Association for Great Lakes Research publications committee, JGLR editors, authors, and publisher (Elsevier); as well as, refining guiding documents, including the Guide to Authors, website content, and standard operating manual for the editorial office.

Jawed, Z.

- Appointed as a Board of Director (2019) by Hamilton City Council for Conservation Halton for the duration of 2019-2022 to make decisions around Watershed. This position will be directly involved with decisions around Lake Ontario, green/protected spaces and growing population needs
- Applied and waiting to hear about the appointment to Agriculture and Rural Affairs as an Advisory Board Member capacity.
- In the process of joining International Joint Commission and Lake Erie working group.

Kheyrollah Pour, Homa

- Participated in the team of scientists to discuss and develop future plans for an integrated research and monitoring strategy for Great Bear Lake (a recently declared UNESCO biosphere reserve which includes Great Bear Lake - The Tsá Tué International Biosphere Reserve; Northwest Territories, Canada).
- Collaboration with the Leibniz-Institute of Freshwater Ecology and Inland Fisheries and invitation of Dr. Georgiy Kirillin to visit University of Waterloo. The expense was covered by Seed Grant funding from Water Institute.

Krantzberg, Gail

- International Joint Commission's Great Lakes Early Warning System (GLEWS) working group. 2018 - present; GLEWS is a joint Science Advisory Board project. The objectives of the project are to: (1) synthesize current knowledge and approaches of environmental early warning systems and evaluate their applicability to the Great Lakes; (2) develop the conceptual framework for a Great Lakes early warning system (3) create a framework to help the IJC fulfil its mandate, in part, related to proactive identification of emerging issues concerning water quality of the Great Lakes and their connecting channels. Results of the project will be used to develop advice and recommendations to the governments on the process for identifying a list of emerging stressors and threats that warrant additional attention, as well as stressors and threats (individually or in combination) that are known but not receiving adequate science and management attention. The process used to identify current stressors and threats can be used and improved at regular intervals in the future to ensure their currency.

Laird, Brian

- Contributing text and tables for a chapter in the AMAP Mercury Assessment titled
- “Contributions and perspectives of Indigenous Peoples in mercury contamination research in the Arctic”

- Contributing data and text summarizing biomonitoring results for a chapter in the AMAP Health Assessment, titled: “NWT Mackenzie Valley Contaminant Biomonitoring study: provision of data for AMAP assessment ”
- Leading the write up of a chapter in the AMAP Health Assessment, titled: ”Dietary Transitions in Canada”
- Contributing text from the risk communication component of the biomonitoring project for a chapter in the AMAP Health Assessment, titled: “Risk Communication in the NWT Mackenzie Valley”

Li, Yanping

- Special issue editor of "Hydrology and Earth System Sciences" (HESS), European Geosciences Union journal, 2017
- The Canadian Space Agency (CSA)’s Earth System Science Advisory Committee (ESSAC), 2017-2022
- Canadian Space Agency (CSA)’s Earth System Science Advisory Committee (ESSAC), 2017-
- Committee of Canadian Meteorological and Oceanographic Society (CMOS), Saskatchewan section
- Representative of University of Saskatchewan for UCAR (University Corporation for Atmospheric Research)
- Special issue editor of "Hydrology and Earth System Sciences" (HESS), European Geosciences Union journal, 2017

Loring, Philip

- Arrell Food Institute (AFI): It is a research institute housed at the University of Guelph dedicated to transforming global food systems and elevating Canada’s place within the global food economy. The AFI is involved with an international network of research on agrifood and food security. Loring is an Arrell Research Chair and member of the leadership team. The work on the Prairie Drainage Governance project, and specifically the focus on governance and conflict, directly complements one of the institute’s three themes: food, policy, and society.
- The Canadian Rural Revitalization Foundation (CRRF)

MacVicar, Bruce

- Committee Member (2019-2021) Discovery Grant Review Panel, Natural Sciences and Engineering Research Council of Canada.
- Associate Editor (2013-2018) Journal of Geophysical Research - Earth Surface, American Geophysical Union.

Mai, Julie

- Co-conveners and chairs of session Diagnostics, Sensitivity, and Uncertainty Analysis of Earth and Environmental Models, AGU Fall Meeting 2018, Washington DC, 10-14 Dec 2018.

Marsh, Philip

- *Appointed by Polar Knowledge Canada as a Canadian Representative to the International Arctic Science Committee – Terrestrial Working Group.*
- *Editor, The Cryosphere*

McKenzie, Jeffrey

- *Working with Swedish Nuclear Fuel and Waste Management Company (SKB) on* groundwater-permafrost knowledge gaps program.
- Member, International research group studying numerical modeling of groundwater and permafrost (based out of France).

Pebbles, V.

- Co-chairs of a special session at ASLO. Advancing Knowledge and Management of HABs through Interdisciplinary Collaboration.

Petrone, Rich

- President, Canadian Geophysical Union.
- President, Canadian National Committee to the International Union of Geodesy and Geophysics.
- *Vice President, International Committee on Coupled Land-Atmosphere Systems, International Association of Hydrologic Sciences.*
- *Senior Canadian Representative, International Association of Hydrologic Sciences.*
- *Canadian Representative, UNESCO International Hydrology Program.*
- President, Canadian National Committee to the International Union of Geodesy and Geophysic.
- F-N Robinne and M. Flannigan were involved in a collaboration with the International Union of Forest Research Organizations (IUFRO) as part of an international panel on wildfire science organized on behalf of the World Bank.

Pietroniro, Alain

- *President, International Association of Hydrological Sciences – Commision of Remote Sensing.*
- *Canadian Delegate, WMO Commission of Hydrology.*

Pomeroy, John

- *Chair, International Network for Alpine Research Catchment Hydrology – A Global Hydroclimate Project of the World Climate Research Program and UNESCO's International Hydrological Program*
- *Pan-Third Pole Environment Program, Institute of Tibetan Plateau Research, China to implement MESH modelling strategy in the Tibetan Plateau*
- *Indian Institute of Sciences, Bangalore, India to implement MESH modelling strategy on the Ganges River Basin*
- *Government of Kazakhstan to develop a modelling strategy for major river basins in collaboration with the GWF Core Modelling and Forecasting team*
- *Applied for a research project in the Upper Nile River Basin in collaboration with University of Dar es Salaam – Tanzania, University of Nairobi – Kenya, Makerere University – Uganda, University of Addis Ababa – Ethiopia*
- *GWF as the Canadian Node for the Sustainable Water Future Program, Future Earth*
- Member, UNESCO International Hydrological Programme (IHP) National Committees.
- Representative of University of Saskatchewan for UCAR (University Corporation for Atmospheric Research).
- Associate Editor, Hydrological Research
- Associate Editor, Journal of Arid and Cold Regions Science
- Guest Editor, Earth System Science Data (2015-2018)
- Guest Editor, Hydrology and Earth System Science (2016-2018)
- Pomeroy, J. Future Earth Conference 'Towards a Sustainable Water Future', International Programme Committee Member, October 2018 to September 2019.
- University of Saskatchewan representative to University Cooperation for Atmospheric Research

Razavi, Saman

- Associate Editor, Journal of Hydrology, 2016-present.
- Co-Chair, Large Scale Watershed Modelling and Analysis committee, Canadian Geophysical Union-Hydrology section, 2017-present.
- *Chair, Hydrologic Uncertainty committee, American Geophysical Union, 2017-present.*
- Editorial Board Member, Environmental Modelling & Software, 2015-present.
- Member, Surface Water Hydrology Technical Committee, American Society of Civil Engineers, 2016-present.

Rooney, Rebecca

- Board of Directors Member and Membership Committee Chair, International Association for Great Lakes Research.

Rudolph, Dave

- Member of American Geophysical Union, Canadian Geophysical Union, National Ground Water Association, of Geological Society of America and the International Association of Hydrogeologists
- Board Member, National Association of Ground Water Scientists and Engineers (NGWA)
- Liaison for the Geological Society of America with the National Ground Water Association
- Associate Editor for the journal Ground Water
- Associate Editor for the journal Hydrogeology Journal

Salk, K.

- Cochairs of a special session at ASLO. Advancing Knowledge and Management of HABs through Interdisciplinary Collaboration.

Scneider, Kevin

- Elected Member, International Federation for Information Processing (IFIP) Working Group 2.7/13.4, User Interface Engineering, 2003–present.

Servos, Mark

- Fellow of the Society of Environmental Toxicology & Chemistry (SETAC)
- Visiting (Proto-Synthesis) Fellow, (2018-19) Swiss Federal Institute of Aquatic Science and Technology, ETH, Dübendorf, Switzerland (Eawag)
- *Science Director of the Canadian Rivers Institute*
- SETAC Fellow (Society of Environmental Toxicology and Chemistry)
- Canadian Rivers Institute (CRI) Fellow. Fellows share the goals of CRI and their primary focus is to expand and promote research on rivers and their estuaries.
- *Science Council, Water Research Centre for Agriculture and Mining (CRHIAM; Centro de recursos hidricos para la agricultura y la minera). Senior international panel to provide advice and direction to a major research network on mining issues in Chile. http://www.crhiam.cl/*
- Proto-Synthesis Visitor, Eawag - Swiss Federal Institute of Aquatic Science and Technology, ETH, Dübendorf, Switzerland. A visiting fellow at the institute working on a key knowledge synthesis activity; the relevance of wastewater-born microcontaminants in different ecological and socio-economic settings and the implications for water management. 2018-19.

Sonnentag, Oliver

- American Geophysical Union Fall Meeting Program Coordinator for the Biogeosciences section (3-year term).

- Subgroup co-lead of the Committee on Earth Observation Satellites Working Group on Calibration and Validation (2014-2017) and ICOS Ancillary Vegetation Measurement protocols.
- Member, Centre d'études Nordiques, U. Laval
- Working group member on USGS Powell Center Wetland FLUXNET Synthesis for Methane: https://www.sciencebase.gov/catalog/item/5b1703d0e4b092d9651fcc8c
- Working group member on NSF Arctic Data Center Reconciling historical and contemporary trends in terrestrial carbon exchange of the northern permafrost zone: https://arcticdata.io/reconciling-historical-and-contemporary-trends-in-terrestrial-carbon-exchange-of-the-northern-permafrost-zone/
- Member: PAGES Carbon in Peat on EArth through Time: http://pastglobalchanges.org/ini/wg/peat-carbon/intro
- Member: NASA Arctic-Boreal Vulnerability Experiment Hydrology & Permafrost/Carbon Dynamics Working Groups: https://above.nasa.gov/cgi-bin/above_wg.pl

Spiteri, Raymond

- Raymond Spiteri is Past-President of the Canadian Applied and Industrial Mathematics Society. He was also Chair of the Applied Mathematics stream on NSERC EG 1508.

Spring, Andrew

- Member, Food – Locally Embedded Globally Endangered (FLEdGE) Board of Directors
- Associate Director Laurier Centre for Sustainable Food Systems
- Advisor, UNESCO Tsá Tué Biosphere Reserve

Steffan, M.

- Co-chairs of a special session at ASLO. Advancing Knowledge and Management of HABs through Interdisciplinary Collaboration.

Thériault, Julie

- Member, International Commission on Clouds and Precipitation (ICCP)
- Member, University and Professional committee, CMOS
- Member, International Commission on Clouds and Precipitation
- Member, 2019 cohort Avant-Garde@CIRANO on climate change
- Member, Scientific Committee, CMOS
- Member, University and Professional Education Committee, CMOS
- International Commission on Clouds and Precipitation
- 2019 cohort Avant-Garde@CIRANO on climate change
- Scientific Committee, CMOS
- University and Professional Education Committee, CMOS

Turetsky, Merrit

- Member, Permafrost Action Team (SEARCH)
- Steering committee to create the Canadian Permafrost Association
- *Canadian liaison to the NASA ABoVE (Arctic Boreal Vulnerability Experiment) campaign*
- AAAS Leshner Institute Science Engagement Fellow
- Senior Investigator, Bonanza Creek Long Term Ecological Research (LTER) site
- Founding member, Permafrost Carbon Network.
- Associate Editor, Ecosystems.

Van Cappellen, Philippe

- Collaboration with the Leibniz-Institute of Freshwater Ecology and Inland Fisheries and invitation of Dr. Georgiy Kirillin to visit University of Waterloo. The expense was covered by Seed Grant funding from Water Institute.
- Member of the Steering Committee of the Ecohydrology Programme within UNESCO's International Hydrological Programme, IHP (2014-now). The Programme aims to advance the integration of social, ecological and hydrological research, and to generate outcomes that enable the development of effective policies and practices for integrated water resources management.
- *PI of the Canada-EU LEAP (Legacies of Agricultural Pollutants) project (2018-2020) funded under the ERA-NET Cofund WaterWorks 2015 Joint Call to support research on the sustainable management of water resources in agriculture, forestry and freshwater aquaculture sectors. The LEAP project brings together researchers from University of Waterloo, Stockholm University, University of Copenhagen and University of Coimbra.*
- Member of the External Advisory Committee of the Marie Curie Innovative Training Network C-Cascades (Carbon Cascades from Land to Ocean in the Anthropocene, 2015-2018) funded under the EU Horizon 2020 research and innovation programme.
- Member of the Advisory Board of the Berkeley National Laboratory Watershed Function Focus Area (SFA), funded by the US Department of Energy Office of Biological and Environmental Research. The SFA focuses on quantifying how perturbations to mountainous watersheds—floods, drought, fire and early snowmelt—impact the downstream delivery of water, nutrients, carbon, and metals.
- *Lead co-PI of the Cold Regions Ecohydrogeology (COREH) project supported by a University of Waterloo's International Research Partnership Grant. COREH was launched in February 2019 as an international research network on cold regions ecohydrogeology with partners from Canada (University of Waterloo), China (China University of Geosciences), Russia (Moscow State University), Sweden (Swedish University of Agricultural Sciences), and France (Earth Sciences and Astronomy Observatory Rennes and Subatech).*

- Distinguished Research Fellow at the Sino-Canada Plateau Lakes Research Centre of Yunnan University (2015-now), an Academic Committee Member for the National Base of International Science and Technology Collaboration at Southwest University (2018-now), a member of the International Advisory Committee of the Institute of Surface Earth System Science at Tianjin University (2018-now), and a Foreign Expert of the Ministry of Education 111 Project at China University of Geosciences (2018-now).
- Representative of the Ecohydrology Research Group at the University of Waterloo, signed a Memorandum of Understanding (MOU) with Dajian Environment Corporation (DEC), China, on June 2018, facilitate research activities that are expected to support sustainable watershed management strategies for two watersheds in China
- Academic Advisory Group members assisting the Ontario Climate Consortium with the preparation of its Best Practices Guidance report on Incorporating Climate Change Impacts into Drinking Water Source Protection Water Quality Risk Assessment (2018-2019).

Venkiteswaran, J.

- Co-chairs of a special session at ASLO. Advancing Knowledge and Management of HABs through Interdisciplinary Collaboration.

Wheater, Howard

- *UNESCO G-WADI Steering Committee*
- *Committee Member, The national Academies of Sciences, Engineering and Medicine Committee on Future Water Resources Needs for the Nation: Water Science at Research at the U.S. Geological Survey.*
- *Consultant, State of Nevada, USA concerning a proposed US Department of Environment licenses application for nuclear waste repository at Yucca Mountain, 2003 to present.*
- Council Member, Prince Sultan bin Abduaziz International Prize for Water, 2007 to present.
- *Expert consultant, Republic of Chile concerning a water conflict between Chile and Bolivia before the International Court of Justice.*

Wolfe, Brent

- Associate Editor of Arctic Science

Zolfaghari, Kiana

- Co-convenors, Session “Remote sensing of water quality and quantity”, ASLO 2019, San Juan, Puerto Rico, 24 February-1 March 2019.

Zwiers, Francis

- *Advisory Panel, DSC – Independent Science Panel, New Zealand Deep South National Science Challenge (large NZ Climate project the size and scope of a Canadian NCE).*
- *Advisory Panel, EUPHEME - The European Prototype demonstrator for the Harmonization and Evaluation of Methodologies for attribution of extreme weather Events.*
- *Advisory Panel, FACETS - Framework for Assessing Climate's Energy-water-land nexus using Targeted Simulations), DOE Funded.*
- Associate Editor, Journal of Climate.
- Associate Editor, JGR-Atmospheres.
- Co-Chief Editor, Advances in Statistical Climatology, Meteorology and Oceanography.

Appendix E – Major Awards and Recognitions

Name	Name of Award	Date
International Awards		
Aubry-Wake, Caroline	Cryosphere Student Innovation Award	Dec-18
Roy, Chanchal	10-year Most Influential Paper Award (MIP)	May-18
Zwiers, Francis	Fellow, American Geophysical Union (AGU)	Dec, 2018
Giesy, John	Erassmus Award from European Union	Jun-18
Giesy, John	Honorary Degree Doctor Honoris Causa in the field of Environmental Sciences, conferred by Masaryk University, Czech Republic	Mar-19
Thériault, Julie	Canada-Italy Innovation Award	Nov-18
Servos, Mark	Proto-Synthesis Visitor (2018-19) Swiss Federal Institute of Aquatic Science and Technology, ETH, Dübendorf, Switzerland (Eawag).	May 2018- May 2019
Servos, Mark	Fellow of the Society of Environmental Toxicology and Chemistry (SETAC)	2018
Hayashi, Masaki	Darcy Lecture Series in Groundwater Science	2018
Turetsky, Merritt	American Association for the Advancement of Science (AAAS) Leshner Fellow	2018/19
Basu, Nandita	Borland Hydrology Lecture	2019
Marsh, Philip	POLAR International Arctic Science Committee (IASC) Working Groups-Terrestrial	May-18
Rezanezhad, Fereidoun	Technical University of Munich (TUM) Visiting Professor award	Feb-19
Patel, Vinay	Third prize at First Future Engineers for Water and Environmental Safety (FEWES)	Nov-18
National Awards		
Blay-Palmer, Alison	Royal Society of Canada's College of New Scholars, Artists, and Scientists	2016-2023
Menounos, Brian	CUFA-BC Ehor Boyanowsky Academic of the Year Award	April, 2019
Roy, Chanchal	2018 CS-Can/Info-Can Outstanding Young Computer Science Researcher Prize	March 2019
Mantyka-Pringle, Chrystal	Mitacs Elevate Research Fellow	Jun-17
Craig, Paul	Ontario Early Researcher Award	Apr-19
Degré-Timmons, Genevieve	Les Offices jeunesses internationaux du Québec (LOJIQ) International mobility grant	

Baltzer, Jennifer	Royal Society of Canada's College of New Scholars, Artists, and Scientists	2017-2024
Pomeroy, John	Fellowship of the Royal Society of Canada	Jun-18
Pomeroy, John	Canada Research Chair Tier 1 (Renewal)	2018-2023
Liu, Juewen	W.A.E. McBryde Medal from the Canadian Society for Chemistry (CSC)	May-18
Thériault, Julie	Canada Research Chair Tier 2	2018-2023
Liber, Karsten	Outstanding Contribution to Canadian Ecotoxicology	3-Oct-18
Turetsky, Merritt	Royal Society of Canada's College of New Scholars, Artists, and Scientists	2016-2023
Perron, Nia	POLAR Knowledge Canada - Canada-Iceland Arctic Research Exchange Program	July, 2018
Rooney, Rebecca	Ontario Early Researcher Award	2017-2019
Brouwer, Roy	Appointed University Research Chair in Water Resources Economics	Sep-18
Institutional Award		
Basu, Nandita	Engineering Research Excellence Award	2017-18
Basu, Nandita	Excellence in Graduate Supervision	2018-19
Brouwer, Roy	Appointed University Research Chair in Water Resources Economics	Sep-18
Ferguson, Grant	GIWS Research Excellence Award	Mar-19
Jardine, Tim	New Researcher Award	May-18
Jawed, Zobia	Recipient of Mike Skinner Distinction Award	2018
Lawford, Peter	University of Saskatchewan Dean’s Scholarship	Jan-19
Marshall, Meredith	3MT Environment Faculty Champion	Mar-19
Menounos, Brian	UNBC NRESi Distinguished Scholar Award	March, 2018
Perron, Nia	Université de Montréal- Bourse alma mater pour l'excellence en géographie physique au doctorat	November, 2018
Roy, Chanchal	2019 New Researcher Award, University of Saskatchewan	Mar-19
Roy, Chanchal	New Scientist Research Award, College of Arts and Science, University of Saskatchewan, 2018	2018
Sniderhan, Anastasia	Award for Outstanding Graduate Work	Jun-18
Standen, Katherine	Dean of Graduate and Postdoctoral Studies Scholarship	Sep-18
Van Cappellen, Philippe	Outstanding Performance Award	2017-2018
Vivekananthan, Kokulan	2018-2019 PhD Scholar Grant	May-18

Student Award		
Annand, Holly	2018 TD Insurance Meloche Monnex Scholarship	Jun-18
Annand, Holly	CWRA 2018 Memorial Scholarship	Jun-18
Aubrey-Wake, Caroline	NSERC Vanier Scholarship	2018-2021
Balliston, Nicole	WCS (with support from the Weston Garfield Foundation) Canada Fellowship	Apr-19
Balliston, Nicole	NSERC Postgraduate Scholarship- Doctoral	Sept. 2018-2021
Balliston, Nicole	University of Waterloo President's Graduate Scholarship	Sept. 2018-2021
Beamesderfer, Eric	International Excellence award	May-18
Bertoncini, André	University of Saskatchwan Department of Geography and Planning Scholarship	2017-2020
Bevington, Alex	NSERC PGS-D	Sept. 2018
Brown, Genevieve	NSERC CGS-M scholarship	May-18
Cheechum-Uhrich, Denea	Queen Elizabeth Scholarship - Planetary Health Program	Mar-19
Cheechum-Uhrich, Denea	NextGen Study Bursary	Jan-19
Cheechum-Uhrich, Denea	NextGen Study Bursary	Sep-18
DesrochesLapointe, Aurélie	Master's program scholarship	2018-2019
Devoie, Élise	2018 Don Gray Scholarship in Canadian Hydrology	May-18
Devoie, Élise	NSERC PGS-D scholarship	May-18
Dony, John	UW Provost Graduate Scholarship	2018
Duff, Dave	NSERC Undergraduate Student Research Awards (USRA)	Spring 2018
Gibson, Carolyn	National Geographic Graduate Scholarship	2017
Gibson, Carolyn	Vanier Doctoral Fellowship	2019
Gibson, Carolyn	NSERC Doctoral Fellowship	
Gray, Mary	NSERC URSA	29-Mar-19
Hayat, Samina	RBC Water	Sep-18
Hébert-Pinard, Charlie	CRSNG undergraduate student research fellowship	Jan 2019- Apr 2019
Hergott &LauraMcFarlan, Amy	Outside the Box Award – University of Saskatchewan EcoHack	Nov-18
Ho, Elaine	Ontario Graduate Scholarship	2018
Ho, Elaine	UW President's Scholarship	2018
Jasiak, Izabela	NSERC CGS-M	1 Sep 19 – 31 Aug 19
Kershaw, Geoffrey	The Natural Sciences and Engineering Research Council of Canada (NSERC) - Postgraduate Scholarship-Doctoral (PGS D	1-May-19

Kershaw, Geoffrey	Garfield Weston Award (PhD)	2019-2020
Krogstad, Konrad	RBC Water Scholars Graduate Entrance Scholarship	Fall 2018
Lei, Calvin	University of Waterloo, Faculty of Science Award	2018-2019
McAleer, Esther	NSERC CGS	May-19
McAleer, Esther	Saskatchewan Opportunity Scholarship	May-19
McFadden, Vanessa	Master's program scholarship	2017-2018
McKenzie, Shawn	International Excellence award	May-18
Mills, Erin	Ontario Graduate Scholarship (OGS)	Sep-18
Mitchell, Selina	Graduate Entrance Research Award	Jan 2019- Dec 2019
Mora, Maria	Saskatchewan Innovation & Opportunity Scholarship	Sep-17
Mora, Maria	SENS PhD Standard Scholarship	Sep-17
n/a	Department of Computer Science Graduate Scholarship	Sep-18
Neary, Laura	RBC Water Scholarship	2018-2019
Neary, Laura	UW Graduate Entrance Scholarship	2018-2019
Neary, Laura	NSERC CGSM	1-Apr
Nicholls, Erin	NSERC Graham Bell award	May-19
Nicholls, Erin	NSERC Alexander Graham Bell	Sept. 2018
Nikel, Kristin	NSERC Scholarship	Sep-18
Nikel, Kristin	RBC Water	Sep-18
Packull-McCormick, Sara	NSERC Alexander Graham Bell Canada Graduate Scholarship	Sep-18
Packull-McCormick, Sara	President's Graduate Scholarship	Sep-18
Packull-McCormick, Sara	Northern Scientific Training Program Grant	Mar-19
Perron, Nia	Bourse de mobilité	Feb-18
Perron, Nia	The Natural Sciences and Engineering Research Council of Canada (NSERC) - Postgraduate Scholarship-Doctoral (PGS D)	1-May-19
Popovic, Natasa	Davis Memorial Scholarship in Ecology - University of Waterloo	Dec-18
Popovic, Natasa	Sharon and David Johnston Award - University of Waterloo	Nov-18
Sanchez Garces, Mariá	Dean's Scholarship	Sep-18
Schultz, Mackenzie	Office of Global Survey, UAlberta	1 Sep 18 – 31 Aug 19
Schultz, Mackenzie	NSERC CGS-M	1 Sep 19 – 31 Aug 19

Spizzirri, Gabriel	NSERC Undergraduate Student Research Awards (USRA)	Spring 2019
Standen, Katherine	NSERC PGS-D3	Sep-17
Tennant, Christina	NSERC Alexander Graham Bell	Sept. 2018
van Hoy, Diane	Dean's Scholarship	Sep-19
Vivekananthan, Kokulan	Canadian Soil Science Society Travel Grant	1-Jan-19
Wade, Andrea	Fish and Wildlife Development Fund Student Research Awards, Ministry of Environment, Government of Saskatchewan	15-Jan-19
Postdoctoral Award		
Challis, Jonathan	Banting Post-Doctoral Fellowship	Sep-19
Pappas, Chris	Swiss National Science Foundation Fellowship	
Rajulapati, Chandra	Pacific Institute for the Mathematical Sciences (PIMS) – GWF Fellowship	Nov-18
Shafii, Mahyar	Second Best Postdoctoral Oral Presentation Award	Jul-05
Van Meter, Kim	Best Postdoctoral Oral Presentation Award	Jul-05
Best Paper Award		
Basu, Nandita	Research Editors' Choice Award	
Bondaruk, Ben	SKI Best Student Paper Award	23-Feb-19
Cheng, Frederick	Water Resources	2017
Deane, Patrick	Top Student Poster, McMaster Water Week	Nov-18
Grant, Kirsten	D.M. Gray Award for Best Student Paper in Hydrology awarded by the Canadian Geophysical Union	Jun-18
Pelto, Ben	American Geophysical Union	Dec, 2018
Roszkowska	Best Paper Award (2018) was given by the editors of Environmental Science and Technology Letters	Apr-19
Best Presentation Awards		
Devoie, Élise	CCRN best student poster award	Mar-18
Harper, Nathanael	Arthur J. Niimi Outstanding Poster Presentation Award	3-Oct-18
Hrach, Dylan	GWF Young Professionals Best Student Post Award	November, 2018
Ikert, Heather	Laurentian Chapter of the Society of Environmental Toxicology and Chemistry. Awarded best PhD presentation	June 8, 2018.
Karran DJ, Loisel J, Von Ness K, Westbrook CJ, Kohlmeyer C, Bedard-Haughn A.	Biogeosciences Best Student Poster Award	Jun-18

Klemt, Wynona	Biology Graduate Seminar Award (MSc)	26-Apr-18
Marshall, Meredith	Best Student Poster	May-18
McFarlan, Laura	Certificate of Achievement: Best Session Presentation, SENS Symposium 2019	Mar-19
McLeod, Meghan	Best Undergraduate Poster award	2019
Packull-McCormick, Sara	Best Poster Award	Jun-18
Popovic, Natasa	Outstanding Student Presentation Award – Biogeoscience Section, American Geophysical Union Annual Meeting 2018.	Dec-18
Pretty, Thomas	2nd place best poster in terrestrial category at ArcticNet	Dec-18
Ratelle, Mylene	Best Poster Award	Jun-18
Thapa, Anuja	Poster competition, 3rd place, World Water Day 2019	Mar-19

Appendix F – Publications and Academic Presentations

Summary:

- Peer-reviewed journal publications: 314
- Conference Presentations – Invited, Plenary & Keynote: 192
- Conference Presentations: 596
- Books and Book Chapters: 06
- Non-refereed publications including model code: 44
- Graduate and undergraduate theses: 73
- Others: 06
- Datasets: 04
- Conference Posters: 11

Peered Reviewed Journal Publications

Abu, R., Reed, M.G., and Jardine, T.D. (Accepted). Demonstrating how to bridge science and indigenous knowledge to understand change in the Saskatchewan River Delta. International Journal of Water Resources Development. DOI: 10.1080/07900627.2018.1558050.

Alcon, F., Tapsuwan, S., Brouwer, R., Yunes, M., Mounzer, O. and de-Miguel, M.D. (2019). Modelling farmer choices for water security measures in the Litana river basin in Lebanon. Science of the Total Environment, 647: 37-46. DOI: https://doi.org/10.1016/j.scitotenv.2018.07.410.

Almonte J, Stewart RE. 2019. Precipitation transition regions over the southern Canadian Cordillera during January–April 2010 and under a pseudo-global warming assumption. Hydrol. Earth Syst. Sci. (Conditionally Accepted)

Amjath-Babua, T.S., Sharmab, B., Brouwer, R., Rasulb, G., Wahide, S.M., Neupaneb, N., Bhattaraif, U. and Sieber, S. (2019). Integrated modelling of the impacts of hydropower projects on the waterfood-energy nexus in a transboundary Himalayan river basin. Applied Energy, 239: 494-503.

Amjath-Babua, T.S., Sharmab, B., Brouwer, R., Rasulb, G., Wahide, S.M., Neupaneb, N., Bhattaraif, U. and Sieber, S. (2019). Integrated modelling of the impacts of hydropower projects on the waterfood-energy nexus in a transboundary Himalayan river basin. Applied Energy, 239: 494-503. i. The data used are listed in the references, figures, tables, and within the article.

Archibald, S., C.E.R. Lehmann, C.M. Belcher, W.J. Bond, R.A. Bradstock, A.L. Daniau, K.G. Dexter, E.J. Forrestel, M. Greve, T. He, S.I. Higgins, W.A. Hoffman, B.B. Lamont, D.J. Mcglinn, G.R. Moncreiff, C.P. Osborne, J.G. Pausas, O. Price, B.S. Ripley, B.M. Rogers, D.W. Schwilk, M.F. Simon, M.R. Turetsky, G.R. Van der Werf, A.E Zanne. (2018). Biological and geophysical feedbacks with fire in the Earth System. Environmental Research Letters. 13: 10.1088/1748-9326/aa9ead.

Asare E, Mantyka-Pringle C, Anderson, E, Belcher K, & Clark R. Quantifying Ecosystem Services for Agricultural Wetlands: A Global Review. Forthcoming

Asong, Z. E., Wheater, H. S., Bonsal, B., Razavi, S., & Kurkute, S., (2018), Historical drought patterns over Canada and their relation to teleconnections, Hydrology and Earth System Sciences, 22(6), 3105-3124.

Aziz T. and Van Cappellen, P. (2019). Comparative valuation of potential and realized ecosystem services in southern Ontario, Canada. Environmental Science and Policy. (Submitted and Under Review). i. Data will be published and a DOI assigned when the article is published.

Barber, Q. E., Parisien, M. A., Whitman, E., Stralberg, D., Johnson, C. J., St-Laurent, M. H., ... & Flannigan, M. D. (2018). Potential impacts of climate change on the habitat of boreal woodland caribou. Ecosphere, 9(10), e02472. doi 10.1002/ecs2.2472.

Baulch, H., J. Elliott, H. Wilson, M. Cordeiro, D. Lobb and D. Flaten. 2019 (in press). Soil and water management practices for agricultural nutrient mitigation in the Northern Great Plains. Environmental Reviews.

Baulch, H.M., Elliott, J.A., Cordeiro, D.N., Lobb, D.A., Wilson, H.F. In press. Soil and water management practices: opportunities to mitigate nutrient losses to surface waters in the Northern Great Plains. Environmental Reviews. https://doi.org/10.1139/er-2018-0101

Baulch, H.M., Elliott, J.A., Cordeiro, D.N., Lobb, D.A., Wilson, H.F., in press (2019). Soil and water management practices: opportunities to mitigate nutrient losses to surface waters in the Northern Great Plains. *Environmental Reviews*. DOI: https://doi.org/10.1139/er-2018-0101.

Ben Alaya, M. A., F. W. Zwiers and X. Zhang, 2019b: Evaluation and comparison of CanRCM4 and CRCM5 to estimate probable maximum precipitation over North America. Submitted, Journal of Hydrometeorology.

Ben Alaya, M. A., F. W. Zwiers, and X. Zhang, 2019a: Probable maximum precipitation in a warming climate over North America in CanRCM4 and CRCM5. Submitted, Climatic Change (in revision).

Ben Alaya, M.A., F.W. Zwiers and X. Zhang, 2019c: Should we expect extreme value theory to produce reliable estimates of long return period climate extremes. Submitted, Journal of Climate (In revision).

Berg A. 2018. Monitoring soil moisture in situ and using a variety of satellite sensors. Sino-American Technology and Engineering Workshop. Smart Water Management. Tinjin, China. Presentation and conference paper (11 pages).

Berg, A., Krafczek, M., Clewley, D., Whitcomb, J., Akbar, R., Moghaddam, M., & McNarin, H. (2018, July). Contributions of Geophysical and C-Band SAR Data for Estimation of Field Scale Soil Moisture. In *IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium* (pp. 6127-6130). IEEE.

Bergstedt, H., A. Bartsch, C. Duguay, B.M. Jones, and C.D. Arp. Influence of surface water on coarse resolution C-band backscatter: Implications for freeze/thaw retrieval from scatterometer data. *Remote Sensing of Environment*. In review.

Besnard S., Carvalhais, N., Arain, M.A., Black, A., Bruin, S.D. Buchmann, N., Cescatti, A., Chen, J., Clevers, J.G.P.W., Desai, A.R., Gough, C.M., Havrankova, K., Herold, M., Hörtnagl, L., Jung, M., Knohl, A., Kruijt, B., Krupkova, L., Law, B.E., Lindroth, A., Noormets, A., Roupsard, O., Steinbrecher, R., Varlagin, A., Vincke, C., & Reichstein, M. (2018). Quantifying the effect of forest age in annual net forest carbon balance. Environmental Research Letters, 13, 124018. doi: 10.1088/1748-9326/aaeaeb.
Besnard S., Carvalhais, N., Arain, M.A., Black, A., Bruin, S.D. Buchmann, N., Cescatti, A., Chen, J., Clevers, J.G.P.W., Desai, A.R., Gough, C.M., Havrankova, K., Herold, M., Hörtnagl, L., Jung, M., Knohl, A., Kruijt, B., Krupkova, L., Law, B.E., Lindroth, A., Noormets, A., Roupsard, O., Steinbrecher, R., Varlagin, A., Vincke, C., & Reichstein, M. (2018). Quantifying the effect of forest age in annual net forest carbon balance. Environmental Research Letters, 13, 124018. doi: 10.1088/1748-9326/aaeaeb.
Biagi, K. M., Oswald, C. J., Nicholls, E. M., & Carey, S. K. (2019). Increases in salinity following a shift in hydrologic regime in a constructed wetland watershed in a post-mining oil sands landscape. Science of The Total Environment, 653, 1445-1457.
Biagi, K. M., Oswald, C. J., Nicholls, E. M., & Carey, S. K. (2019). Increases in salinity following a shift in hydrologic regime in a constructed wetland watershed in a post-mining oil sands landscape. Science of The Total Environment, 653, 1445-1457. doi: 10.1016/j.scitotenv.2018.06.039
Black, KE and Baltzer, JL. Seasonal thaw and landscape position determine tall shrub function on the low arctic tundra. New Phytologist, in review.

Bocaniov, S., and Scavia, D. (2018). Nutrient loss rates in relation to transport time scales in a large shallow lake (Lake St. Clair, USA–Canada): Insights from a three-dimensional model. Water Resources Research 54: 3825-3840. i. The data used are listed in the references, figures, tables, supporting information, and can be available upon request by contacting the corresponding author (S. Bocaniov, sbocaniov@uwaterloo.ca).

Bocaniov, S., Van Cappellen, P., and Scavia, D. (2019). On the role of a large shallow lake (Lake St. Clair, USA-Canada) in modulating phosphorus loads to Lake Erie. Water Resources Research (in review; manuscript ID: 2019WR025019). i. Data will be provided in the supplementary material and published a recognized data repositiory once the paper is accepted.

Bradford, L.E.A., Vogel, T., Lindenschmidt, K-E, McPhedran, K., Strickert, G.E.H., Fonstad, T.A., and Bharadwaj, L.A. (2018) Co-design of water services and infrastructure for Indigenous Canada: A scoping review. FACETS. DOI: https://doi.org/10.1139/facets-2017-0124

Breen, S-P W., Loring, P.A., and Baulch, H.B. (2018) When a water problem is more than a water problem: Fragmentation, framing, and the case of agricultural wetland drainage. Frontiers in Environmental Science. 6:1¬8.

Breen, S-P., Loring, P.A., Baulch, H. (2018). When a Water Problem Is More Than a Water Problem: Fragmentation, Framing, and the Case of Agricultural Wetland Drainage. Front. Environ. Sci., 30 October 2018. https://doi.org/10.3389/fenvs.2018.00129

Brouwer, R. and Neverre, N. (2018). A global meta-analysis of groundwater quality valuation studies. European Review of Agricultural Economics. DOI: https://doi.org/10.1093/erae/jby043.

Brouwer, R., Miraldo Ordens, C., Pinto, R. and Condesso de Melo, M.T. (2018) Economic valuation of groundwater protection using a groundwater quality ladder based on chemical threshold levels. Ecological Indicators, 88: 292-304.

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Books and Book Chapters

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Debasish Chakroborti, Banani Roy, Amit Kumar Mondal, Golam Mostaeen, Ralph Deters, Chanchal K. Roy and Kevin A. Schneider. A Data Management Scheme for Micro-Level Modular Computation-intensive Programs in Big Data Platforms", In: Moshirpour M., Far B., Alhajj R. (eds) Highlighting the Importance of Big Data Management and Analysis for Various Applications, 20pp., vol x. Springer (to appear with minor revisions).

Derksen, C., D. Burgess, C. Duguay, S. Howell, L. Mudryk, S. Smith, C. Thackeray, and M. Kirchmeier Young, 2019. Changes in snow, ice, and permafrost across Canada; Chapter 5 in *Canada's Changing Climate Report*, (ed.) E. Bush and D.S. Lemmen; Government of Canada, Ottawa, Ontario, p. 194-260.

Levin-Koopman, J., Kuik, O., Tol, R.S.J., van der Vat, M.P., Hunink, J.C. and Brouwer, R. (2019). Distributing water between competing users in the Netherlands. In: Wittwer, G. (ed.).

Economy-Wide Modelling of Water at Regional and Global Scales. Advances in Applied General Equilibrium Modeling. Springer Singapore.

Pomeroy, J.W., Shook, K., Mekonnen, B., and Annand, H. (2018). Expanded Testing and Development of the Prairie Hydrological Model in Three Prairie Pothole Watersheds. Centre for Hydrology.

Rayhan Ferdous, Banani Roy, Chanchal K. Roy and Kevin A. Schneider, Workflow Provenance for Big Data: From Modelling to Reporting. In: Moshirpour M., Far B., Alhajj R. (eds) Highlighting the Importance of Big Data Management and Analysis for Various Applications, 17pp., vol x. Springer (to appear).

Non-Refereed Publications including Model Code

A numerical simulation was conducted to reproduce the characteristics of the storm of January 2017 over New Brunswick using the Global Environmental Multiscale (GEM) model (1 km). This output is stored at UQAM, and is available upon request.

Asadzadeh M. and Stadnyk T. et al. (2018), A python script to couple HEC-HMS (and HEC-DSSVue as well since HEC-HMS I/O is facilitated by HEC-DSSVue) and MODSIM.

Banani Roy, Manishankar Mandol, Hamid Khodabandehloo, Chanchal K. Roy and Kevin A. Schneider. Towards next-Gen CRHM. Poster presented at The Annual Science Meeting of Global Water Futures, 2019.

Banani Roy, Rayhan Ferdous, Paromita Sengupta and Kevin A. Schneider. An Approach for Transferring Software Architecture Knowledge. In *Proceedings of European Conference on Software Architecture (ECSA) 2019*. In progress.

Brouwer, R. and Pinto, R. (2018). Review and Evaluation of the Canadian Water Quality Valuation Model (WQVM 1.0). Report to Environment and Climate Change Canada. 88pages.

Carlson, H and Eamen L. (2019) "User Engagement strategies for data challenges in the Integrated Modelling Program for Canada." Global Water Futures feature article. https://gwf.usask.ca/articles/km/user-engagement-impc.php

Carlson, Hayley. (2019). Putting research into active use: HYPE an international example of success. Global Water Futures feature article. https://gwf.usask.ca/articles/2019/hype-int-impc.php

D2. Ridenour, C., Van Cappellen, P., Parsons, C., Marvin, C., and Fitzpatrick, M. (2019). Reactive Silicon Data in Hamilton Harbour, Lake Ontario. Data DOI: http://dx.doi.org/10.20383/101.0148

Data product for ECCC data catalogue. Water Quality and Quantity Monitoring at Edge-of-Field and In Streams; and Snow, Soil Surveys in Agricultural Catchments of the Lake Winnipeg Basin. PI: Jane Elliott

Developed and optimized protocols for eDNA sampling from water and sediment**

Do, N.C., and Razavi S., gSTAR-VARS code package

Ferguson, G. and McIntosh, J.C. 2019. The global race for groundwater speeds up to feed agriculture's growing needs. *The Conversation*. https://theconversation.com/the-global-race-for-groundwater-speeds-up-to-feed-agricultures-growing-needs-108458

Ferguson, G. and Loveless, S. 2018. Unconventional Oil and Gas Development and Groundwater – Comparing the English and Canadian Experiences. *Water Underground*. EGU Blogs/AGU Blogosphere. https https://blogs.agu.org/waterunderground/2018/11/06/unconventional-oil-and-gas-development-and-groundwater-comparing-the-english-and-canadian-experiences/

H. Dhiyebi, S. Courtenay and M. Servos (2018) Cumulative Effects in the Mill Creek Subwatershed. Technical report prepared for Friends of Mill Creek. 49 p.

Hickman, J., M. English, *N. Wilson, S. Kokelj, M. 2019. Snare Snow Report: Summary of 2018 Snow Survey and Results. Richardson. 12 pages presented to Northwest Territories Power Corporation, April 2019

Ilia Rudnitskiy and Debajyoti Mondal. Interactive Visualization of Geospatial Water Datasets (poster). The Annual Science Meeting of Global Water Futures, 2018.

Jarin Tasnim, Gazi MD Hasnat Zahan, Carl Gutwin, Kevin A. Schneider, and Debajyoti Mondal. Towards a Machine Learning Approach for the Prediction and Compression of WRF Datasets. The Annual Science Meeting of Global Water Futures, 2019.

Laird BD, *Ratelle M. 2018. Specialized Analysis of Chemical in Human Samples from Two First Nations Regions in the Northwest Territories, Canada: Results Report. Prepared for Population Biomonitoring Section, Health Canada.

Markelov, I., Van Cappellen, P., and Couture, R.M. (2019). Input and Output Variables for the biogeochemical modeling study of the Lakes Response to Climate Change, Internal Loads and Restoration Measures. Data DOI: http://dx.doi.org/10.20383/101.0149

Menounos B, Bevington A, Geertsema M. 2018. Glacier Environments, In Margottini, C. (Ed.). Encyclopedia of Engineering Geology, Dordrecht, the Netherlands: Springer.

Michael Beyene, Zonayed Ahmed, Chanchal K. Roy, Christopher Dutchyn, Kevin A. Schneider, and Debajyoti Mondal. ContourMove: Exploring Temporal Changes in Large Geo-spatial Data (poster). The Annual Science Meeting of Global Water Futures, 2019.

New Weather Research and Forecasting (WRF) model runs covering the North American domain (CONUS II) are expected to start in May 2019.

Pharr, Kathryn; Garrick, Dustin; Alvarado, Fabiola; Lindamood, Danielle; and de Loë, Robert. 2018. Diagnostic Analysis Using the Social Ecological Framework. Working paper. Waterloo, ON: Water Policy and Governance Group.

Ratelle M, Skinner K, *Brandow D, *Packull-McCormick S, Laird BD. (**2019**) Contaminant Biomonitoring in the Northwest Territories Mackenzie Valley: Investigating the Links between Contaminant Exposure, Nutritional Status, and Country Food Use. University of Waterloo. www.uwaterloo.ca/hetrg/research.

Rayhan Ferdous, Banani Roy, Chanchal K. Ry and Kevin A. Schneider. Workflow Provenance: From Modelling to Reporting. Poster presented at Global Institute of Food Security (GIFS) Emerging Conference (GIFSEC'18), University of Saskatchewan.

Rayhan Ferdous, Banani Roy, Chanchal Roy and Kevin Schneider. ProvMod: A Workflow Programming Model to Offer Automated Provenance and Log Analysis. In *Proceedings of International Conference on Web Services (ICWS), 2019*. In progress

Razavi S, Research Spotlight, American Geophysical Union (AGU). For Gupta and Razavi (2018) "Revisiting the Basis of Sensitivity Analysis for Dynamical Earth System Models" published in Water Resources Research (WRR), https://eos.org/research-spotlights/reframing-sensitivity-analysis-in-earth-system-models.

Razavi, S. (2017), Feature: When Uncertainty Matters, American Geophysical Union, Hydrology Section, December 2017 Newsletter (Invited Comment).

Roste, J. and Baulch, H. Moosomin Lake Watershed, SK Land Use and Water Quality for the Lower Souris Watershed Committee and Saskatchewan Water Security Agency.

Rudolph, D (2018). Regional hydrologic and ecologic characterization and baseline assessment of remote northern Canadian terrain in advance of shale oil and gas development, Annual progress report, NWT ESRB, April.

Rudolph, D (2019). Regional hydrologic and ecologic characterization and baseline assessment of remote northern Canadian terrain in advance of shale oil and gas development, Annual progress report, NWT ESRB, April.

Sadeghian, A., Carr, M., Lindenschmidt, K.E. (2018), Raw data and video outputs from a CE-QUAL-W2 hydrodynamic and nutrient model for different Lake Diefenbaker Reservoir withdrawal depth scenarios [Dataset]. Federated Research Data Repository. https://dx.doi.org/10.20383/101.0134 https://www.frdr.ca/repo/handle/doi:10.20383/101.0134

Shisong Wang, Chanchal K. Roy, Kevin A. Schneider, and Debajyoti Mondal. Towards Collaborative Exploration of GWF Datasets. The Annual Science Meeting of Global Water Futures, 2019.

Skinner K, *Ratelle M, *Brandow D, Laird B. 2018. Results Report: HEALTH MESSAGES SURVEY. Contaminant Biomonitoring in the Northwest Territories Mackenzie Valley: Investigating the Links between Contaminant Exposure, Nutritional Status, and Country Food Use. University of Waterloo.

Slaughter, A. and Razavi, S.: An ensemble of 500 time series of weekly flows from 16002001 for the four sub-basins of the Saskatchewan River Basin generated through disaggregating tree-ring reconstructed flow [Dataset]. Federated Research Data Repository. https://doi.org/10.20383/101.0139, 2019.

Stadnyk T. and Asadzadeh M et al. (2018), A python script to couple WATFLOOD and MODSIM.

Stadnyk TA. (2019) Assessing future water threats in Canada. Prepared for the Copernicus Climate Change Service #C3S_422_Lot1_SMHI.

Straker, J., Carey, S.K., Petrone, R.M., Baker, T.J. 2018. Using ecosystem water and carbon fluxes as integrated measures of reclamation success. Proceedings of the 2018 Northern Latitudes Mining Reclamation Workshop, Whitehorse, YT, September 10-13, 2018.

Straker, J., Carey, S.K., Petrone, R.M., Baker, T.J. 2018. Using ecosystem water and carbon fluxes as integrated measures of reclamation success. Proceedings of the 2018 British Columbia Technical and Research Committee on Reclamation, Williams Lake, BC, September 17-20, 2018.

Straker, J., Carey, S.K., Petrone, R.M., Baker, T.J., Strilesky SL. 2019. Developing a functional approach to assessment of land capability: utilizing ecosystem water and carbon nutrient fluxes as integrated measures of reclamation performance. Final Report delivered to Syncrude Canada Ltd and Suncor Energy Inc for COSIA Project Number LJ0127

The WRF-CCRN simulation: including two climate scenarios: the current climate (CTL) from 2000-10 to 2015-09 and a pseudo-global warming (PGW) scenario representing the condition of 2085-2100 under RCP8.5. The model domain covers western Canada with 4-km resolution from British Columbia to Manitoba (135-96W) in the west-east direction and from northern US to Arctic Ocean in the south-north direction (47-69N). The data is stored in Compute Canada server.

WRF-CONUS I: a high-resolution climate change simulation that permits convection and resolves mesoscale orography at 4 km grid spacing over about 2/3rds of North America using the WRF model. Two 13 years simulations were performed, consisting of a retrospective simulation (October 2000 to September 2013) with initial and boundary conditions from ERA-Interim and a future climate sensitivity simulation with initial and boundary conditions derived from reanalysis and modified by adding the CMIP5 ensemble mean of the high emission scenario climate change. Simulation period: 2000-10-01 to 2013-09-30. The data is stored in Compute Canada server.

Zhang, F., Do N. C., Razavi, S., Lindenschmidt K, 2019 'Variance-based sensitivity analyses of a river ice model', 20th Workshop on the Hydraulics of Ice Covered Rivers, CGU HS Committee on River Ice Processes and the Environment

Zwiers FW, Zhang X. 2018. Synthesis of key issues and challenges - Urban/Coastal/Riverine Flood and Climate Change. In International workshop on floods and climate change: Codes and standards perspective, Attar, A., Z. Lounis and M. Armstrong, Eds., National Research Council, Ottawa.

Graduate and Undergraduate Theses (under project investigator supervision)

Almonte J. 2018: Precipitation transition regions over the southern Canadian Cordillera under a warming climate. MSc, University of Manitoba.

Amir-Masoud Chegoonian, PhD comprehensive exam document, Fall 2018.

Arman Khorshidi (2019). An analysis of soil respiration in a young conifer forest (B.Sc. thesis). McMaster University, Hamilton, Canada.

Arman Khorshidi (2019). An analysis of soil respiration in a young conifer forest (B.Sc. thesis). McMaster University, Hamilton, Canada.

BES Honours Undergraduate thesis: Babaran, D. 2018. The adoption of VEC monitoring and multivariate analysis on the Blair Creek sub-watershed as a model for CEA. Bachelor of Environmental Studies Honours Thesis. School of Environment, Resources and Sustainability, University of Waterloo, Waterloo, ON.

Brandow, Danielle (2018). Country Food Consumption Notices: Assessing Awareness and Preferences of Health and Risk Communication Messages in the Sahtú Region of the

Northwest Territories. MSc Thesis. UWSpace. https://uwspace.uwaterloo.ca/handle/10012/14028.

Brett Tendler "Analysis of Metal Contaminants and Mercury Speciation in Fishes from the Slave and Athabasca Rivers" (submitted for Defense)

Burchill C. 2019. Paleolimnological reconstruction past hydrologic conditions at lakes of local interest in the Peace-Athabasca Delta. BA Honours Thesis (Geography and Environmental Studies WLU).

Burton, E. Undergraduate Thesis in Department of Biology under supervision of Prof Mark Servos and Patricija Marjan, entitled "Optimization of brook trout (*Salvelinus fontinalis*) environmental DNA collection methods".

Daniel Wu (2019). Evaluating impacts of thinning in a temperate pine forest using CLASS-CTEM Model (B.Sc. thesis). McMaster University, Hamilton, Canada.

Daniel Wu (2019). Evaluating impacts of thinning in a temperate pine forest using CLASS-CTEM Model (B.Sc. thesis). McMaster University, Hamilton, Canada.

Emily Ogden. Honours BSc thesis. Variation among land classification units in the NWT.

Faber J. in progress. Developing baseline knowledge of water and metals supplied by the Peace River to the Peace-Athabasca Delta, northern Alberta, using paleolimnology. MSc (Geography and Environmental Studies WLU).

Fung, Leicester (2019). Mercury Exposure Analysis Amongst Dene and Métis Community of the Northwest Territories. MSc Thesis. UWSpace. https://uwspace.uwaterloo.ca/handle/10012/14333.

Ghosh A. 2019. Examining the roles and impact of climate and geomorphic events on flood frequency in the Athabasca Delta. BSc Honours Thesis (Biology UW).

Glass, B. (2019). Examining Hydrogeological Processes in Freezing Soils using Remote Geophysical and Numerical Techniques. MSc. thesis. UWSpace. http://hdl.handle.net/10012/14466

Glass, B. (2019). Examining Hydrogeological Processes in Freezing Soils using Remote Geophysical and Numerical Techniques. University of Waterloo.

Gough, N. (2019). Design Considerations and Technology for Collaborative Web Applications, University of Saskatchewan.

Grant, K. (2018). Preferential flowpaths and fertilizer placement influence subsurface P transport across soil textures and seasonal conditions. University of Waterloo (Supervisor: Merrin Macrae).

Green, A. (2019). Microclimatic Effects of Forest to Peatland Transitions within the Boreal Plains. UWSpace.

Guo, L. (2018). Simulating Farmer Adoption of Agricultural Best Management Practices in the Upper Medway Creek Subwatershed. Masters Thesis. University of Waterloo. (Supervisor: Peter Deadman).

Harder, P. (2018) Stubble-Snow-Soil-Atmosphere interactions on the Canadian Prairies. PhD Thesis. University of Saskatchewan (Supervisors: John Pomeroy and Warren Helgason)

Harder, P. (2018). Snow-stubble-atmosphere interactions during snowmelt on the Canadian Prairies. University of Saskatchewan.

Haskell B. 2019. Tracking the influence of hydrological processes on concentrations of priority pollutants in periphyton biofilm across lakes in the Peace-Athabasca Delta. BSc Honours Thesis (Biology UW).

Honours Undergraduate thesis: Goe, Y. 2019. Identification of Algal Bloom Indicators Using Principal Component Analysis. Department of Earth and Environmental Science, University of Waterloo, Waterloo, ON.

Honours Undergraduate thesis: Grootjen, T. 2019. Reservoirs as hotspots for legacy phosphorus mobilization: A modelling approach. Bachelor of Applied Mathematics with Minor in Earth and Environmental Sciences, University of Waterloo, Waterloo, ON.

Jan 2018 McDonald, Wade. Agent Based Modelling of Flooding in Two Indigenous Communities in Saskatchewan, (Computer Science- Supervisor: Nate Osgood).

Jan 2018 Thapa, Anuja. A Participatory Approach to Enhance and Measure Social Learning for Flood Preparedness: An Exploratory Study in Mistawasis Nêhiyawak

Jasiak I. in progress. Defining a legacy pollution footprint: assessing spatio-temporal patterns of arsenic and other metals in sub-arctic lakes using paleolimnology. MSc (Biology UW).

Jennifer Bruneau (2019): Future Changes in Convective Precipitation and Severe Weather Environment in Western Canada and the Central U.S. Plains.

Jitnikovitch. 2018. Cosmic ray sensors for the continuous measurement of Arctic snow accumulation and melt. MSc Thesis, Wilfrid Laurier University.

Julie Trus. Honours BSc thesis. Biotic and abiotic controls on moss composition in the NWT.

Kay M. in progress. Paleolimnological reconstruction of past hydrological conditions and metal deposition in the Athabasca Delta, northern Alberta. PhD (Biology UW).

Khan H. 2019. Investigating past changes in water balance of two small central closed-drainage lakes in the Peace-Athabasca Delta using paleolimnological methods. BSc Honours Thesis (Biology UW).

Klemt W. 2018. Developing pre-industrial baselines from floodplain lake sediment cores to quantify the extent of metals pollution within the Alberta Oil Sands Region. MSc (Biology UW).

Klemt, Wynona. MSc Thesis, 2018. "Developing pre-industrial baselines from floodplain lake sediment cores to quantify the extent of metals pollution within the Alberta Oil Sands Region". https://uwspace.uwaterloo.ca/handle/10012/14181

Krogh Navarro, S. (2018). Past and Future Hydrology Near the Arctic Treeline. University of Saskatchewan.

Krogh Navarro, S. (2018). Past and Future Hydrology Near the Arctic Treeline. University of Saskatchewan

Laird, Matthew (2017). Dietary Exposure Assessment and Contaminants Biomonitoring in the Dehcho Region, Northwest Territories: Exploring the Relationship between Mercury Exposure, Omega-3 Fatty Acid Status, and Fish Consumption. MSc Thesis. https://uwspace.uwaterloo.ca/handle/10012/12673

Leroux, N. (2018). Mass and Heat Flow Through Snowpacks. University of Saskatchewan.

Leroux, N. (2018). Mass and Heat Flow Through Snowpacks. University of Saskatchewan

Leroux, N. (2018). Mass and Heat Flow through Snowpacks. University of Saskatchewan.

Liu E. Undergraduate Thesis in Toxicology Centre under supervision of Prof John Giesy and Yuwei Xie, entitled "Application of environmental DNA metabarcoding for determining community responses of sedimentary protozoa to Selenium in a freshwater mesocosm study".

Masters' thesis: Chowdhury, Q.S. 2018. Biogeochemical Signatures in Intensively Managed Great Lakes Watersheds, Department of Civil and Environmental Engineering, University of Waterloo, Waterloo, ON.

Masters' thesis: Samson, M. 2019. The Urban Metabolism of the Greater Toronto Area: A Study of Nitrogen and Phosphorus across an Urban, Suburban, and Rural Continuum Department of Civil and Environmental Engineering, University of Waterloo, Waterloo, ON.

McKenzie, Shawn (2019).- Integration of Eddy Covariance Fluxes, Tree Ring Records and Stable Isotope Compositions to Study Environmental Controls on Growth in Different-Age Pine Plantation Forests (Doctoral dissertation). McMaster University, Hamilton, Canada.

McKenzie, Shawn (2019).- Integration of Eddy Covariance Fluxes, Tree Ring Records and Stable Isotope Compositions to Study Environmental Controls on Growth in Different-Age Pine Plantation Forests (Doctoral dissertation). McMaster University, Hamilton, Canada.

Mercer J. 2018. Insights into mountain wetland resilience to climate change: an evaluation of the hydrologic processes contributing to the hydrodynamics of alpine wetlands in the Canadian Rocky Mountains, MSc thesis, University of Saskatchewan, 120 pp.

Mihalicz, J. (2018). Effects of a hydropeaking dam on river health and benthic macroinvertebrate secondary production in a northern Great Plains river. University of Saskatchewan.

Mollaee, S. (2018). Estimation of Phytoplankton Chlorophyll-a Concentration in the Western Basin of Lake Erie Using Sentinel-2 and Sentinel-3 Data. University of Waterloo.

Neary L. in progress. Characterizing carbon balance of lakes in the Peace-Athabasca Delta using isotopic methods. MSc (Biology UW).

Owca T. in progress. Determining sources, pathways and spatial distribution of metals in lakes of the Peace-Athabasca Delta from concentrations in surface sediment. MSc (Geography and Environmental Studies WLU).

Paul, J (2018) Near-surface permafrost ground ice characteristics and ecological and physical drivers of transient layer ice content in discontinuous permafrost. MSc Dissertation, Wilfrid Laurier University. https://scholars.wlu.ca/etd/2097/

Qin, K. (2019). Analysis of Groundwater Recharge Events in Winter and Early Spring to Establish Physical Triggers for a Reactive Monitoring System in the Mannheim Site. University of Waterloo.

Rayhan Ferdous. Workflow Provenance: from Modeling to Reporting. MSc Thesis in the Department of Computer Science, University of Saskatchewan. Co-supervisors: Banani

Remmer C. in progress. Use of water isotope tracers and periphyton for tracking hydrological and hydroecological conditions of lakes in the Peace-Athabasca Delta: A foundation for hydrological monitoring. PhD (Biology UW).

Riley Mills. Influence of Snow Cover on Soil Temperature and Freeze-Thaw Cycles. Undergraduate *Honours* Thesis. University of Waterloo, April 2019.

Rokaya P. (2018). Impacts of climate and regulation on ice-jam flooding of northern rivers and their inland deltas. University of Saskatchewan

Ronnquist. A. 2018. Persistence of beaver dams through the Alberta flood of 2013, BSc thesis, University of Saskatchewan, 26 pp.

Rossi R. 2019. Paleohydrological reconstruction of 'Spruce Island Lake', a drying basin in the Peace-Athabasca Delta, Alberta. BSc Honours Thesis (Biology UW).

Roy, Chanchal Roy and Kevin Schneider. Telford J. 2019. Using paleolimnology to establish baseline conditions for metal contaminants in advance of proposed mining to inform a northern community-led aquatic monitoring program, Tł chǫ Lands, Northwest Territories, ɻchǫ Government Canada. MSc (Geography WLU).

Savage C. in progress. Periphyton as a bio-monitoring agent of metal contaminants of concern in the Peace-Athabasca Delta. MSc (Biology UW).

Siyu Cheng, Comparison of baseflow estimation methods at the Alder Creek Watershed and nearby streams

Sotoodeh Mollashahi, E. (2019). Improving Revisitation in Long Documents with Two-Level Artificial-Landmark Scrollbars, University of Saskatchewan.

Telford J. 2019. Using paleolimnology to establish baseline conditions for metal contaminants in advance of proposed mining to inform a northern community-led aquatic monitoring program, Tłı̨ chǫ Lands, Northwest Territories, Canada. MSc (Geography and Environmental Studies WLU).

Ten Watts "Occurrence and In Vitro Toxicity of Unregulated Disinfection By Products in Two Saskatchewan Drinking Water Treatment Plants.

van Beest, C. (2019). Deeper Burning Increases Available Phosphorus, Promotes Moss Growth, and Carbon Dioxide Uptake in a Fen Peatland One-Year Post-Wildfire in Fort McMurray, AB. UWSpace. http://hdl.handle.net/10012/14429

Vanessa McFadden (2019): Étude de la tempête de verglas de janvier 2017 ayant causée des pannes de courants majeurs dans la province du Nouveau-brunswick.

Wang X. Automated Detection of Anomalies in High-Frequency Water Quality Sensor Data using Deep Learning [Master's Thesis]. [Hamilton, Ontario, Canada]: McMaster University, Department of Computing and Software; 2019, submitted.

White, A (2018). Drivers of post-fire vascular plant regeneration in the conifer-dominated boreal forest of southern Northwest Territories. MSc Dissertation, Wilfrid Laurier University. https://scholars.wlu.ca/etd/2026/

Whitehouse, J. 2019. Determining the Effectiveness of Biomanipulation on a Northern Pike (*Esox lucius*) Population on Lowering Total Mercury Concentrations in Fish Tissue. University of Waterloo Undergraduate Thesis. Supervisors: Heidi Swanson (University of Waterloo) and Heather Dixon (Wilfrid Laurier University)

Yamaguchi, A. 2018-2020. Trophic and biogeochemical dynamics of mercury in two fishery lakes in the Northwest Territories (MSc thesis, Laurier). Supervisors: D MacLatchy & H. Swanson (UWaterloo).

Yan Y. Anomaly Detection for Water Quality Data [Master's Thesis]. [Hamilton, Ontario, Canada]: McMaster University, Department of Computing and Software; 2019, submitted.

Conference Presentations (Invited, Plenary, Keynote)

Arain M.A. (2018, November 5). McMaster Global Water - International Threats. Oral presentation as the meeting of the Office of International Affairs and The McMaster Water Network, Hamilton, ON, Canada.

Arain M.A. (2018, November 5). *McMaster Global Water - International Threats*. Oral presentation as the meeting of the Office of International Affairs and The McMaster Water Network, Hamilton, ON, Canada.

Arain M.A. (2018, October 24-25). Carbon and Water Exchanges in Managed Forests in North American Cold Regions. Oral presentation at the meeting of the Ameriflux PIs, Bloomington, IN, USA.

Baltzer, J (2018) Experiences from the field: an ecologist's perspective on data management and open data. Plenary Talk, Tri-council Research Data Management Workshop, Waterloo, ON

Baltzer, J (2018) Understanding the impacts of the 2014 wildfires on NWT forests. Government of the Northwest Territories "Ledge Talk". Yellowknife, NT

Baltzer, J and Swanson, H (2018) Northern Canada – regional issues and Global Water Futures' scientific response. Plenary Talk, Global Water Futures Annual Scientific Meeting. Hamilton, ON

Baltzer, JL, Sonnentag, O (2018) Climate-change refugia in boreal North America: what, where, and for how long? Northern and permafrost issues. Invited talk, Boreal Climate Change Refugia Workshop, Canadian Forest Service, Edmonton, AB

Baltzer, JL. 2018. State changes following fire in boreal forests are driven by seedbed conditions and biogeographic context. Invited seminar. Umeå University, Sweden.

Basu, N. and Van Meter, K.J. (2019). Beyond the Mass Balance: A Process Based Approach to Modelling Legacy Phosphorus Dynamics. Association for the Sciences of Limnology and Oceanography Conference, San Juan, Puerto Rico, Feb 2019.

Basu, N. B., and Van Meter, K.J. (2018). Changing Waters: Role of Climate-Driven Changes in Discharge Regimes in Increasing Eutrophication Risk in the Great Lakes Basin. American Geophysical Union, December 10-14, 2018, Washington D.C.

Basu, N.B. (2018). Back to the Future: How Past Land Use Impacts Current Water Quality. Invited Speaker for SENR Seminar Series, Ohio State University, November 2018, Columbus, OH.

Basu, N.B. (2018). Biogeochemical Hotspots: Role of Small Water Bodies in Watershed Nutrient Processing, Webinar on Wetlands: From Science to Action organized by Canadian Freshwater Alliance, September 25, 2018 (https://www.freshwateralliance.ca/fresh_ideas_wetlands)

Basu, N.B. (2018). Great Lakes and Water Quality: A Regional Perspective. Plenary talk at the Global Water Futures Annual Science Meeting, Hamilton, ON

Basu, N.B. (2019). A Race against Time: Nutrient Legacies and Time Lags Provide New Insight into Improving Water Quality in Human-Impacted Landscapes. Invited Speaker at SESYNC Seminar, March 2019, Annapolis, MD.

Basu, N.B. (2019). Signatures of Human Impact: Legacies, Climate Change and the Future of our Waters. Keynote Speaker, Borland Hydrology Lecture, AGU Hydrology Days, March 2019, Fort Collins, CO.

Basu, N.B. (2019). Signatures of Human Impact: Legacies, Climate Change and the Future of Our Waters. Invited speaker for Stanford Woods Seminar, February 2019, Stanford, CA.

Basu, N.B. and Van Meter, K.J. (2018). Landscape Legacies: Long term Nitrogen Trajectories in Human Impacted Watersheds, Canadian Geophysical Union, June 2018

Basu, N.B. and Van Meter, K.J. (2018). Landscape Legacies: Long-Term Nitrogen Trajectories in the Mississippi River Basin and Beyond, Sixth Interagency Conference on Research in Watersheds (ICRW), July 23-26th, 2018, at the National Conservation Training Center (NCTC), Shepherdstown, West Virginia

Basu, N.B. and Van Meter, K.J. (2018). Modelling Nutrient Legacies and Dynamics in Human Dominated Landscapes, Invited Keynote Speaker, Integrated Hydrosystems Modeling, University of Tubingen, Tubingen, Germany.

Basu, N.B. and Van Meter, K.J. (2018). Nutrient Legacies in Anthropogenic Catchments: Implications for Water Quality. Invited Lecture at Canada Center for Inland Waters, Environment and Climate Change Canada, Burlington, ON, May 4, 2018.

Basu, N.B. and Van Meter, K.J. (2018). Nutrient Legacies in Anthropogenic Catchments: Implications for Water Quality. Invited Lecture at University of Illinois at Urbana Champaign, Urbana, IL April 20, 2018.

Basu, N.B., Van Meter, K.J. and Van Cappellen, P. Landscape Legacies: Long-Term Nitrogen Trajectories in Human-Impacted Watersheds. Canadian Geophysical Union Joint Meeting, Niagara Falls, Canada, June 2018

Basu, N.B., Van Meter, K.J., and Van Cappellen, P. (2018). Beyond the Mass Balance: Modeling Legacy Phosphorus Dynamics in a Great Lakes Watershed, American Geophysical Union 2018, Fall Meeting, Washington DC, USA

Baulch, H. and Whitfield, C. (2018) Canadian Prairies – regional issues and Global Water Futures' scientific response. Global Water Futures Inaugural Annual General Meeting. McMaster University, Hamilton, ON. June 6th. INVITED

Baulch, H. and Whitfield, C. (2018) Canadian Prairies – regional issues and Global Water Futures' scientific response. Global Water Futures Inaugural Annual General Meeting. McMaster University, Hamilton, ON. June 6th. Plenary.

Belcher, K. (2018) Drivers and Resistors - Unpacking Land Use Decision Making Part 1. Finding Common Ground Between the Agricultural Industry and Wetland Policy, Prairie Habitat Joint Venture Policy Workshop, Leduc, Alberta, April 18th. INVITED

Berg A, 2018. Soil moisture retrieval within an Arctic tundra regions: Challenges and progress. EUMETSAT Meteorological Satellite Conference. Tallinn, Estonia.

Berg A. 2018. Soil freeze thaw field experiments for validation of passive microwave freeze thaw products. Finland Meteorological Institute. Helsinki Finland.

Berg A. 2018. Global observations of frozen soils: what are we observing? Centre for Global Change Science, Distinguished Lecturer Series. University of Toronto.

Berg A. 2018. Monitoring soil moisture in situ and using a variety of satellite sensors. Sino-American Technology and Engineering Workshop. Smart Water Management. Tinjin, China. Presentation and conference paper (11 pages).

Berg A. 2018. Soil Freeze thaw field experiments in support of SMAP. NASA Jet Propulsion Laboratory. Pasadena, California.

Berg A. 2018. Soil freeze thaw information from satellites: what are we observing? Department of Geography, York University Colloquium Speaker.

Bradford - Invited Webinar to IISD Prairie Regional Adaptation Collaborative, November 22nd 2018

Brouwer R., (2018) Invited key note on the economics of sustainable groundwater resources management, Brazil National Groundwater Association (ABAS), Sao Paulo, Brazil, 6 November 2018.

Brouwer R., (2018) Invited key note, First International Water Security Conference, Toronto, Canada, June 20, 2018.

Brouwer R., (2018) Invited key note, UN High-Level Political Forum on Sustainable Development, United Nations, New York, July 13, 2018.

Brouwer, R. (2018). Economic, modelling and valuation of water security. 1st International Conference on Water Security, June 20, 2018, Toronto, ON.

Brouwer, R. Economics of sustainable groundwater resources management. Brazil National Groundwater Association (ABAS), Sao Paulo, Brazil, 6 November 2018. Invited keynote.

Brouwer, R. First International Water Security Conference, Toronto, Canada, 20 June 2018. Invited keynote.

Brouwer, R. Invited key note on the economics of sustainable groundwater resources management, Brazil National Groundwater Association (ABAS), Sao Paulo, Brazil, 6 November 2018.

Brouwer, R. Invited key note UN High-Level Political Forum on Sustainable Development, United Nations, New York, 13 July 2018.

Brouwer, R. UN High-Level Political Forum on Sustainable Development, United Nations, New York, 13 July 2018.

Carey SK. Water and Canada's extractive industries: challenges and opportunities. Public talk to United Nations University – INWEH Another Drop lecture. October 2018.

Carey SK. Water in the Changing North. Dr. John Rae talk given to the Hamilton Association for the Advancement of Literature, Science and Art. January 2018.

Chow-Fraser, Patricia. “Reflections of an ecologist in co-creation of Indigenous tools for ecosystem monitoring”, Environmental Studies seminar, University of Victoria. 10 October 2018.

Conference Pres Arain M.A. (2018, October 24-25). *Carbon and Water Exchanges in Managed Forests in North American Cold Regions*. Oral presentation at the meeting of the Ameriflux PIs, Bloomington, IN, USA.

Craig P.M. The cost of living in the Grand River: Energetics, stress, and epigenetics/ Invited Speaker, Laurentian SETAC Southern Ontario Pub night, Guelph, ON. May 1st, 2019

Craig P.M. Troubled waters ahead: The cost of living in the Grand River. Invited lecture, Trent University, March 2019.

Craig, P. The role of microRNA regulation on phenotypic responses to environmental stressors in fish. American Physiology Society Intersociety Meeting: Complexity and Integration, New Orleans in October 2018.

Day NJ, Cumming S, *Degré-Timmons G, Johnstone J, Gruel R, Mack M, McIntire E, Reid K, Schmiegelow F, Turetsky M, Walker X, *White A, & Baltzer J. (2018). Impacts of Wildfire Extent and Severity on Caribou Habitat: from woodland to barren ground. Northwest Territories Cumulative Impacts Monitoring Environmental Research and Monitoring Workshop 5-6 December, Yellowknife, Northwest Territories, Canada.

Debasish Chakraborti, Banani Roy, Mani Shankar Mondal, Ralph Deters, Chanchal K. Roy, Kevin A. Schneider. A Data Management Scheme for Micro-Level Modular Computationintensive Programs in Big Data Platforms. Presented at the third International Symposium on Big Data Management and Analytics (BIDMA’18). (presented, appeared as Springer book chapter).

Degré-Timmons, G. and J. Baltzer. (2018). How resilient are northern ecosystems to climate change? – A burning topic from Northwest Territories, Canada. Public presentation, Young emerging leaders program, Arctic Frontiers, Bodø, Norway.

Duguay, C., 2018. Advancing the retrieval of lake ice and sea ice parameters from satellite and ground-based measurements. EUMETSAT, Darmstadt, Germany, 6 December 2018.

Duguay, C., 2018. Satellite retrieval of lake ice cover extent and thickness: Advances and opportunities in the era of Sentinel-3. *2018 EUMETSAT Meteorological Satellite Conference*, Tallinn, Estonia, September 2018.

Duguay, C., 2019. Advancements in the retrieval of lake ice cover extent and thickness from satellite observations. ECMWF, Reading, United Kingdom, 15 February 2019.

Elliott, J. Nutrient sources and agricultural management practices. Lake Winnipeg Basin Symposium, February 20-21, 2019. Winnipeg, MB. Invited Presentation.

Elliott, J. Using soil science to understand agricultural impacts on surface water resources in cold regions. Department of Soil Science, University of Saskatchewan, January 16, 2019. Saskatoon, SK. Invited Presentation.

Elliott, J. Vegetation contributions to snowmelt runoff and runoff patterns in Manitoba. AAFC, Lake Winnipeg Meeting, July 17, 2018. Brandon, MB. Invited Presentation.

Elmes, MC, & Price, JS. 2018. Hydrogeological connectivity of a moderate-rich fen watershed in the Athabasca Oil Sands Area of the Western Boreal Plain, northern Alberta, World Wetlands Day, University of Waterloo, Waterloo, ON.

F. Rezanezhad, C. Smeaton, K. Pi, and P. Van Cappellen. The impact of warmer winter on soil health and water quality in Cold Regions? A seminar at the Cold Regions Ecohydrogeology (COREH) workshop in Harbin, China, April 30, 2019 (a new research collaboration funded by Waterloo International Research Partnership Grant and China University of Geosciences)

F. Rezanezhad. Soil Science Research Projects and Activities at University of Waterloo, Canada. Presented to Soil and Solid Waste Institute of Environment at Chinese Research Academy of Environmental Sciences. April 2, 2018, Beijing, China. (In this invited talk, Dr. Rezanezhad presented the GWF Winter Soil Processes in Transition Project)

Ferguson, G. (2018) Hydrogeological Lessons Learned from Deep Subsurface Development of the Williston Basin, Canada. Invited Lecture to International Association of Hydrogeologists - Australian National Chapter. April 8, 2017, Sydney, Australia. INVITED

Ferguson, G. 2018. Fluid production for geothermal energy. Northwest Territories Geothermal Energy Forum. Yellowknife, NWT. November 23, 2018.

Ferguson, G. 2018. The groundwater-energy nexus in sedimentary basins. University of Illinois, Champaign, Illinois, November 2, 2018.

Ferguson, G. 2018. The Race for Groundwater. World Water Day 2019. University of Saskatchewan, Saskatoon, SK. March 22.

Ferguson, G. 2019. Bottom up groundwater depletion. University of Texas. Austin, Texas. April 12, 2019.

Flannigan, 2018, Educated Luncheon: How will we manage wildfires in the future?. April 17, 2018 12:00 PM - 1:00 PM Maple Leaf Room Lister Conference Centre University of Alberta, Edmonton, Canada.

Flannigan, M. 2018. 1:00 PM https://zoom.us/webinar/register/WN_dgdLZps1QmK_rwDEUoMf7g, Canada.

Flannigan, M. 2018. Change for Climate Talks. Change for Climate Talks 2018 by City of Edmonton - Change for Climate https://www.eventbrite.ca/e/change-for-climate-talks-2018-tickets-49139734268, Edmonton,Canada.

Flannigan, M. 2018. Climate Change and Fire. Gave a webinar to the Dept. of Environment and Natural Resources, Northwest Territories., Edmonton, Canada.

Flannigan, M. 2018. Climate Change and Wildfire - How will we manage wildfires in the future?. 2018 SISCO Winter Workshop, Kamloops, Canada.

Flannigan, M. 2018. Climate Change and Wildfire - How will we manage fire in the future?. CIF-IFC 110th AGM & Conference, Grande Prairie, Canada.

Flannigan, M. 2018. Climate Change: Wildland Fire and Water. IBAA 2018 Convention, Banff, Canada.

Flannigan, M. 2018. Fire is coming our way. Wildfire & Climate Change Conference. June 26-June 28,2018, Nelson, Canada.

Flannigan, M. 2018. Future of Wildfires. Alumni Spring Reception - Lethbridge, Lethbridge, Canada.

Flannigan, M. 2018. How will we manage wildfires in the future? Visit with fellow alumni and learn how wildland fire research and artificial intelligence might protect communities from future wildfire devastation. 22nd Annual Arizona Brunch, Phoenix, United States.

Flannigan, M. 2018. How will we manage wildfires in the future?. Monday July 16th at Intact Insurance, Calgary, Canada.

Flannigan, M. 2018. How will we manage wildfires in the future?. Vancouver Alumni & Friends Brunch and Silent Auction Sunday, April 29, 2018 10:30 a.m. – 1:00 p.m., Vancouver, Canada.

Flannigan, M. 2018. How will we manage wildland fires in the future?. Monday July 20th Edmonton at Intact Insurance, Edmonton, Canada.

Flannigan, M. 2018. Long range wildfire forecast for Canada – Hot and smoky? Is this the new reality?. ICLR webinar.

Flannigan, M. 2018. Long range wildfire forecast for Canada-Hot and Smoky? Is this the new Reality?. 2018 AEMA Stakeholder Summit, Edmonton, Canada.

Flannigan, M. 2018. Overview of Global Forest Fire and Climate Change. Forest Fires Global Expert Workshop VIENNA, AUSTRIA, 2-4 JULY 2018, Vienna, Austria.

Flannigan, M. 2018. The Climate Change Altered Wildland Fire Regime for Canada in the 21st Century: Possible Implications. Preparing for the Future of Wildland Fire Conference. May 21-24,2018, Missoula, United States.

Flannigan, M. 2018. Weather, Climate Change and Fire - Is this the new reality?. BC AI Wildfire symposium 2018, Vancouver, Canada.

Golam Mostaeen, Banani Roy, Chanchal K. Roy and Kevin A. Schneider. Designing for Real-Time Groupware Systems to Support Complex Scientific Data Analysis. In Proc. Of the 11th ACM SIGCHI Symposium on Engineering Interactive Computing Systems, June, 2019 - Valencia, Spain (accepted and to be presented, article will be published in ACM on Human-Computer Interaction)

Haghnegahdar A., (2018), System Identification and Sensitivity/Uncertainty Analysis in Science and Engineering, School of Civil Engineering, Shiraz University, Shiraz, Iran, September 1st, 2018.

Hanesiak, J., Future Hail and Severe Weather Environment in southern Canada, CatIQ Connect Canada's Catastrophe Conference, Metro Toronto Convention Centre, February 4 - 6, 2019.

Hayashi: National Groundwater Association (NGWA) Henry Darcy Distinguished Lecture: “Alpine hydrogeology: the critical role of groundwater in sourcing the headwaters of the world” (see the appendix below for locations and dates). All of these were invited lectures, and some of them were key note lectures at scientific meetings.

Hecker. M “eDNA as an Early Detection Tool for the Potential Spread of Zebra Mussels (*Dreissena polymorpha*) to Saskatchewan Lakes.” Invited Keynote Presentation at the Annual Convention of the Saskatchewan Wildlife Federation. Prince Albert. March 9, 2018.

Hecker. M, “eDNA as an Early Detection Tool for the Potential Spread of Zebra Mussels (*Dreissena polymorpha*) to Saskatchewan Lakes.” Presentation to Saskatchewan Environment Aquatic Invasive Species Task Force. Saskatoon. January 19, 2018.

Hecker.M, “Environmental DNA: A novel approach to characterize biodiversity.” Presentation to Orano (former AREVA) Resources. February 27, 2018.

Jawed, Z. (2018). Panelist Sustainability Night at McMaster University. November 2018.

Jennifer Bruneau (2019): Future Changes in Convective Precipitation and Severe Weather Environment in Western Canada and the Central U.S. Plains.

Krantzberg, G. (2018). Governance challenges for a resilient Great Lakes basin ecosystem. Keynote ELLS-IAGLR Conference, Lake Geneva, France, September 2018

Krantzberg, G. (2018). If we really aren't sure can we take action? International Association for Great Lakes Research. June 18-22, 2018.

Leroux NR, Pomeroy JW, (2018). Improving the simulation of capillary pressure in snow with a non-equilibrium Richards equation model. International Symposium on Snow and Avalanche, Niseko, Japan, December 7, 2018

Leroux NR, Pomeroy JW, (2018). Improving the simulation of capillary pressure in snow with a non-equilibrium Richards equation model. International Symposium on Snow and Avalanche, Niseko, Japan, December 7, 2018.

Leroux NR, Pomeroy JW. 2018. Improving the simulation of capillary pressure in snow with a non-equilibrium Richards equation model. International Symposium on Snow and Avalanche, Niseko, Japan, December 7, 2018

Leroux, N.R., Pomeroy, J.W., 2018. Improving the simulation of capillary pressure in snow with a non-equilibrium Richards equation model. International Symposium on Snow and Avalanche, Niseko, Japan, December 7, 2018.

Leroux, N.R., Pomeroy, J.W., Helgason, W.D., 2018. Impact of Heat Convection Induced by Topography-Driven Air Ventilation on Snow Surface Temperature. Paper presented at 75th Eastern Snow Conference (pp.20-26).

Liu J. 2018. Agricultural phosphorus and water quality: Drivers and solutions. Shaanxi Province’s Young Scholars’ Science-Technology Forum, September, 2018. Yangling, China (Invited)

Liu J., Baulch H., and Elliott J. 2018. Agricultural water quality in Canadian prairies. Annual Convention – Pillars of Agrology: Water for All, Prince Albert, Canada (Invited)

Liu J., H.Baulch, and J. Elliott. Agricultural water quality in Canadian prairies. Saskatchewan Institute of Agrologists Annual Convention – Pillars of Agrology: Water for All, April 11, 2018. Prince Albert, SK. Invited Presentation.

Liu J., J. Elliott, H. Baulch and H.Wilson. Controls of nitrogen to phosphorus ratios in a Canadian prairie watershed. Global Water Futures 1st Annual General Meeting. Jun. 4-6, 2018. Hamilton, ON. Invited Presentation.

Looking Horse, Makasa. “Digital Water Storytelling and TEK”, World Water Day 2019, Water Institute Waterloo. 22 March 2019.

Loring. P.A., Baulch, H., Breen. S-P. (2018). Plenary Panel: Water Governance, a Prairie Perspective. 30th Annual Meeting of the Canadian Rural Revitalization Foundation. 12

October, 2018. Saskatoon, SK. Video here: https://www.youtube.com/watch?v=uPI_53EdFMQ

Macrae, M.L., Jarvie, H.P., Smith, D.R., King, K.W., and Kleinman, P.J.A. Role of P in Water Quality Impairment across Latitudes. (Invited). Soil Science Society of America International Soils Meeting. January 6-9, 2019, San Diego, USA. (Oral presentation).

Mantyka-Pringle C, Messmer D, Leston L, Asong E, Bayne E, Bortolotti L, Sekulic G, Wheater H, Howerter D & Clark R. (2018) Interaction Effects of Climate Variability and Change and Land-use on Avian and Aquatic Invertebrate Communities. Paper to be presented at the North American Congress for ConservatioBiology, July 21-26, Toronto, Ontario, Canada 2018

Mantyka-Pringle C. (2018) Ghosts of climate and land-use past or present – antagonistic, synergistic and direct effects of aquatic communities. Invited talk (fully supported) at the Annual British Ecological Society Aquatic Group meeting, Sept 9, Imperial College, London, UK. INVITED

Mantyka-Pringle C. (2018) Interactions between Climate Variability and Change and Land-use on Aquatic Ecosystems. Invited talk (fully supported) at the Annual British Ecological Society Aquatic Group meeting, Sept 9, Imperial College, London, UK. INVITED

Mantyka-Pringle C. (2018) Multiple stressors in freshwater and terrestrial ecosystems – State of the art. Invited plenary talk (fully supported) at the StressNet – Scientific workshop for the advancement of multiple stressor models and databases, Sept 13-15, University Koblenz-Landau, Landau, Germany, 2018. INVITED

Marjan, P. Environmental DNA (eDNA) of Brook Trout in Washington Creek. Trout Unlimited Middle Grand Chapter Annual General Membership Meeting, Five Oaks Centre, Brantford, Ont. January 26, 2019. *Invited Keynote speaker at a meeting of key partners.*

Martin-Hill, Dawn, Denise McQueen, Makasa Looking Horse. "Resilience building though Ecological Knowledge Digital Stories", McMaster Indigenous Health Movement Conference, McMaster University. 2 February 2019.

Martin-Hill, Dawn. "Haudenosaunee Women's Water Law", Indigenous Spirituality and Freedom of Religion for Ktunaxa, Faculty of Law, University of Windsor. 22 March 2019.

Martin-Hill, Dawn. "How to integrate IK in water research", Elevating Community-Based Water Monitoring in Canada: A National Discussion, Ottawa. 27-28 November 2018.

Martin-Hill, Dawn. "Indigenous science and ways of knowing", GWF Inaugural Annual Science Meeting, McMaster University. 5 June 2018.

Martin-Hill, Dawn. "Water: Our Spirit, Our Laws", Association of Iroquois and Allied Indian, Niagara Falls. 23-24 January 2019.

McIntosh, J.C. 2018. The Anthropocene in the Deep Subsurface. GIWS Distinguished Lecture Series, University of Saskatchewan. Saskatoon, SK. November 21, 2018.

Molot, L.A., S.L. Schiff, J.J. Venkiteswaran, H.M. Baulch, S.N. Higgins, A. Zastepa, M.J. Verschoor and D. Walters. 2018 Environment Canada, CCIW Burlington, "Guiding principles for preventing cyanobacteria blooms: Integrating nutrient limitation and sediment redox science into watershed management".

Molot, L.A., S.L. Schiff, J.J. Venkiteswaran, H.M. Baulch, S.N. Higgins, A. Zastepa, M.J. Verschoor and D. Walters. 2018 Ontario Ministry of Environment, Parks and Conservation, annual Science Forum; "Guiding principles for preventing cyanobacteria blooms: Integrating nutrient limitation and sediment redox science into watershed management".

Molot, L.A., S.L. Schiff, J.J. Venkiteswaran, H.M. Baulch, S.N. Higgins, A. Zastepa, M.J. Verschoor and D. Walters. 2018 Yigal Allon Kinneret Limnological Laboratory, Israel; "Guiding principles for preventing cyanobacteria blooms: Integrating nutrient limitation and sediment redox science into watershed management".

Mora, M., Bradford, L., Reed, M., Bharadwaj, L. (2019) Gender and Water Governance in the Global North: A Scoping Review. Women and Water Lecture Series. February 11th. INVITED

Nash, T. 2018. Future of wildfire management in Canada: An overview of the CIFFC horizon scanning and foresight report. CIFFC National Fire Management Conversation, Canada.

Pinto R. , (2018), Invited key note on Spatial Optimization of Land and Water Conservation Priorities at the 3rd Singapore-Nanjing Eco HiTech International Water Environment Management Summit, Nanjing, China, 22-23 October 2018

Pinto, R. Spatial Optimization of Land and Water Conservation Priorities. 3rd Singapore-Nanjing Eco HiTech International Water Environment Management Summit, Nanjing, China, 22-23 October 2018. Invited keynote.

Pomeroy J, (2018). Extreme Hydrology, Climate Change and Water Futures in Canada. Insurance Brokers Association of Alberta (IBAA), Banff, Canada, May 6, 2018

Pomeroy J, (2018). Extreme Hydrology, Climate Change and Water Futures in Canada. Insurance Brokers Association of Alberta (IBAA), Banff, Canada, May 6, 2018.

Pomeroy J, (2018). Global Water Futures (GWF) RHP. GEWEX Hydroclimatology Panel (GHP) Meeting, Santiago and Portillo, Chile, October 24, 2018

Pomeroy J, (2018). Global Water Futures for Alberta. Agri-Environmental Partnership of Alberta (AEPA) Advisory Committee Meeting, Edmonton, Canada, October 17, 2018

Pomeroy J, (2018). Global Water Futures for Alberta. Agri-Environmental Partnership of Alberta (AEPA) Advisory Committee Meeting, Edmonton, Canada, October 17, 2018.

Pomeroy J, (2018). Global Water Futures: Year One Progress. Integrated Modelling Program for Canada (IMPC) First Annual Meeting, Saskatoon, Canada, July 18, 2018

Pomeroy J, (2018). How interactions between climate and vegetation impact hydrological processes in mountain headwater basins. Fourth Annual International Network for Alpine Research Catchment Hydrology (INARCH) Workshop, Portillo, Chile, October 25, 2018

Pomeroy J, (2018). Impact of meteorological forcing data on snowpack and streamflow simulations in the Canadian Rockies. Fourth Annual International Network for Alpine Research Catchment Hydrology (INARCH) Workshop, Portillo, Chile, October 25, 2018

Pomeroy J, (2018). Improving hydrologic process representations. Integrated Modelling Program for Canada (IMPC) First Annual Meeting, Saskatoon, Canada, July 18, 2018

Pomeroy J, (2018). International Conference Plenary session: Agricultural Water Futures in an era of Changing Agriculture and Climate. International Conference and 69th International

Executive Council Meeting of the International Commission on Irrigation and Drainage, Saskatoon, Canada, August 12, 2018

Pomeroy J, (2018). International Conference Plenary session: Agricultural Water Futures in an era of Changing Agriculture and Climate. International Conference and 69th International Executive Council Meeting of the International Commission on Irrigation and Drainage, Saskatoon, Canada, August 12, 2018.

Pomeroy J, (2018). International Network for Alpine Research Catchment Hydrology (INARCH). GEWEX Hydroclimatology Panel (GHP) Meeting, Santiago, Chile, October 24, 2018

Pomeroy J, (2018). Opening Plenary: Global Water Futures Program and its Science Contributions to GEWEX. 8th Global Energy and Water Exchanges (GEWEX) Open Science Conference: Extremes and Water on the Edge, Canmore, Canada, May 6, 2018

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Pomeroy J, (2018). Rocky Mountain Water Supply Resilience and Vulnerability Evaluation. Alberta Innovates Water Innovation Program Forum, Edmonton, Canada, May 23, 2018

Pomeroy J, (2018). The Global Water Futures Program and its National Water Forecasting and Prediction System for Canada. 3rd Kazakhstan-Canada Business Council Meeting, Ottawa, Canada, June 11, 2018

Pomeroy J, (2018). The Global Water Futures Program and its National Water Forecasting and Prediction System for Canada. 3rd Kazakhstan-Canada Business Council Meeting, Ottawa, Canada, June 11, 2018.

Pomeroy J, (2018). The role of integrating observation and prediction systems in generating data and learning from models - a hydrological and weather extremes perspective. Joint Young Earth System Scientists (YESS) and Young Hydrologic Society (YHS) Early Career Researcher (ECR) Workshop at the 8th Global Energy and Water Exchanges (GEWEX) Conference, Canmore, Canada, May 3, 2018

Pomeroy J, (2018). The role of integrating observation and prediction systems in generating data and learning from models - a hydrological and weather extremes perspective. Joint Young Earth System Scientists (YESS) and Young Hydrologic Society (YHS) Early Career Researcher (ECR) Workshop at the 8th Global Energy and Water Exchanges (GEWEX) Conference, Canmore, Canada, May 3, 2018

Pomeroy J. 2018. Extreme Hydrology, Climate Change and Water Futures in Canada. Insurance Brokers Association of Alberta (IBAA), Banff, Canada, May 6, 2018

Pomeroy J. 2018. Global Water Futures (GWF) RHP. GEWEX Hydroclimatology Panel (GHP) Meeting, Santiago, Chile, October 24, 2018

Pomeroy J. 2018. Global Water Futures for Alberta. Agri-Environmental Partnership of Alberta (AEPA) Advisory Committee Meeting, Edmonton, Canada, October 17, 2018

Pomeroy J. 2018. How interactions between climate and vegetation impact hydrological processes in mountain headwater basins. Fourth Annual International Network for Alpine Research Catchment Hydrology (INARCH) Workshop, Portillo, Chile, October 25, 2018

Pomeroy J. 2018. Impact of meteorological forcing data on snowpack and streamflow simulations in the Canadian Rockies. Fourth Annual International Network for Alpine Research Catchment Hydrology (INARCH) Workshop, Portillo, Chile, October 25, 2018

Pomeroy J. 2018. International Network for Alpine Research Catchment Hydrology (INARCH). GEWEX Hydroclimatology Panel (GHP) Meeting, Santiago, Chile, October 24, 2018

Pomeroy J. 2018. Opening Plenary: Global Water Futures Program and its Science Contributions to GEWEX. 8th Global Energy and Water Exchanges (GEWEX) Open Science Conference: Extremes and Water on the Edge, Canmore, Canada, May 6, 2018

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Pomeroy J. 2018. The role of integrating observation and prediction systems in generating data and learning from models - a hydrological and weather extremes perspective. Joint Young Earth System Scientists (YESS) and Young Hydrologic Society (YHS) Early Career Researcher (ECR) Workshop at the 8th Global Energy and Water Exchanges (GEWEX) Conference, Canmore, Canada, May 3, 2018

Pomeroy, J. 2018. Opening Plenary: Global Water Futures Program and its Science Contributions to GEWEX. 8th Global Energy and Water Exchanges (GEWEX) Open Science Conference: Extremes and Water on the Edge, Canmore, Canada, May 6, 2018

Pomeroy, J. 2018. Rocky Mountain Water Supply Resilience and Vulnerability Evaluation. Alberta Innovates Water Innovation Program Forum, Edmonton, Canada, May 23, 2018.

Pomeroy, J., 2018. Extreme Hydrology, Climate Change and Water Futures in Canada. Insurance Brokers Association of Alberta (IBAA), Banff, Canada, May 6, 2018.

Pomeroy, J., 2018. Global Water Futures for Alberta. Agri-Environmental Partnership of Alberta (AEPA) Advisory Committee Meeting, Edmonton, Canada, October 17, 2018.

Pomeroy, J., Wheater, H. Baltzer, J., Baulch, H., Carey, S., Gober, P., Martz, L.W., Pietroniro, A., Rudolph, D.L., Stewart, R.E., Van Cappellen, P., and DeBeer, C. M. (2018). Global Water Futures - Translation of Transdisciplinary Observations, Science, and Predictions into Societal Action for Water and Climate Imperatives in Cold Regions. American Geophysical Union, December 10-14, 2018, Washington D.C.

Prof. Giesy made the following invited, plenary keynote presentation: “Environmental Forensics: What is it and What can it Do?” to the 1st Annual Science Meeting of the Global Water Futures Network, which was held in Hamilton, Ontario, Canada, June 6, 2018.

Ratelle M, *Fung L, Laird M, Laird BD. (2018) Cadmium and Mercury Exposure among Dene/Metis Communities of the Northwest Territories, Canada. International Society of Exposure Science-International Society of Environmental Epidemiology (ISES-ISEE) Joint Annual Meeting. Ottawa, Canada.

Rayhan Ferdous, Banani Roy, Chanchal K. Roy and Kevin A. Schneider. Workflow Provenance for Big Data: From Modelling to Reporting. Presented at the third International Symposium

on Big Data Management and Analytics (BIDMA'18). (Presented, appeared as Springer book chapter).

Razavi, S. (2018), how can hydro-economic models help policy making?, 2018 International Conference and 69th IEC Meeting of the International Commission on Irrigation and Drainage, side event organized by FAO on Hydroeconomic modelling for transboundary river basin management – Towards more integrated approaches. August 15, 2018, Saskatoon, Canada.

Razavi, S., (2018), Integrated Modelling and Management of Watershed Systems Under Uncertainty, Canadian Water Science Workshop, November 27-28, 2018 in Ottawa, Ontario. http://gin.gw-info.net/service/api_ngwds:gin2/en/workshop/rncan-gwf_nrcan-gwf/workshop.html.

Razavi, S., (2019), Integrated Modelling and Sensitivity Analysis, Environment and Climate Change Canada Workshop on Flow Forecasting, Simon Fraser University, Feb 20-21, 2019.

Robinne FN. Wildfires and soil hydrology. IUFRO - World Bank Global Fire Workshop. Vienne, Austria, July 2018.

Rudolph, D. L. (2018). A Renaissance in Regional Hydrogeology: From Data to Modelling, Canadian Water Science Workshop, Global Water Futures – NRCan – ECCC – AAFC, Ottawa, Nov.

Servos, M. Challenges and opportunities to address contaminants in wastewater. Swiss Federal Institute of Aquatic Science and Technology (Eawag), Zurich, Switzerland, May 25, 2018. Invited Seminar.

Servos, M., One fish, two fish, boy fish, girl fish? The recovery of adverse effects in fish in response to major wastewater infrastructure upgrades in Canada. Distinguished Lecturer Series, Swiss Federal Research Institute for Aquatic Science and Technology (Eawag), Zurich, Switzerland, Feb. 22, 2019.

Strickert, G.E.H. (2018) Relationships: Building a Strong Foundation. Saskatchewan Emergency Planners Association. Saskatoon, Saskatchewan, November 7th, 10:30 - 12:00pm. INVITED

Strickert, G.E.H. and Jardine, T. (2018) Cultural and Environmental Flows; user engagement. Integrated Modelling Program for Canada. IMPC 2nd annual meeting, National Hydrology Research Center, Saskatoon, Saskatchewan. July 17, 11:05 – 11:20.

Strickert, G.E.H., and Belcher, K., (2018). Understanding the social and economic drivers from a broad scale perspective. Prairie Habitat Joint Venture. The Kitchen Conversation: Finding Common Ground between Agricultural Industry and Wetland Policy. Session: Understanding Producer Decision Making. Le Duke, Alberta, April 19th, 8:45am.

Swanson, H.K. (2018). We Want to Drink the Water and Eat the Fish: Community-Partnered Contaminant Research in Canada's North. Water Institute Research Conference, University of Waterloo.

Swanson, H.K. (2018). We Want to Eat the Fish: investigating levels of mercury in northern fishes. Invited Lubinsky Memorial Public Lecture, University of Manitoba, Winnipeg, MB.

Swanson, H.K. (2018). Why do fish in northern lakes have such variable mercury concentrations: case study from the Dehcho region, NT. Invited speaker for: Freshwater Institute Seminar Series, Winnipeg, MB.

The Impact of OrbiTrap Technology on Environmental Chemistry, Paul Jones, Western Canadian Trace Organics Workshop, Vancouver BC, May 14-16, 2018.

Turetsky, M. (2018). A cross-scale framework of peatland resilience based on long-term research in interior Alaska and the Northwest Territories, Canada. American Geophysical Union Annual Meeting, New Orleans, USA

Turetsky, M. (2018). International collaborations between NASA and Global Water Futures/Northern Water Futures. All Scientist Meeting for NASA Arctic Boreal Vulnerability Experiment, Seattle, USATuretsky, M. (2018). Understanding and scaling change in lowland permafrost: Cross-scale feedbacks to hydrology and carbon. Arctic Systems Change Workshop. UCAR, Boulder Colorado, USA

Uses of Ultra-High Resolution Mass Spectrometry in Environmental Chemistry, Paul Jones, 28th University of Toronto Environmental Chemistry Colloquium, June 12-14, 2018.

Van Cappellen, P. (2018). Anthropogenic lakes: Global environmental impacts of dams and reservoirs. [Plenary Lecture]. 34th International Society of Limnology Congress, August 19-24, 2018, Nanjing, China.

Van Cappellen, P. (2018). From Integrated Water Management to Adaptive Water Management. [Plenary Lecture]. 3rd Singapore-Nanjing Eco Hi-Tech International Water Environment Management Summit, October 22-23, 2018, Nanjing, China.

Van Cappellen, P. (2019). Biogeochemical Processes and Cycling: From the Micro to Landscape Scale, [Symposium Keynote]. Observatoire des Sciences de l'Univers de Rennes (OSUR), January 30-31, Rennes, France.

Van Cappellen, P. (2019). What's in a Name: Ecohydrology – Waterloo Style, invited talk at Laboratoire the Physique Subatomique et des Technologies Associées (SUBATECH), January 28-29, 2019, Nantes, France.

Van Cappellen, P., Mellage A., Smeaton, C.M., and Rezanezhad, F. (2018). How Geophysics Informs Biogeochemistry: Challenges and (Missed) Opportunities. American Geophysical Union, December 10-14, 2018, Washington D.C.

Van Meter, K.J. and Basu, N.B. (2018). Landscape Legacies: Long-Term Nitrogen Trajectories in the Chesapeake Bay Watershed and Beyond, Chesapeake Research and Modelling Symposium, June 2018, Annapolis, MD.

Van Meter, K.J., Basu, N. B., & Zhang, Q. (2018). Chesapeake Legacies: Implications of Groundwater N Accumulation for Water Quality Improvements in the Chesapeake Bay. American Geophysical Union, December 10-14, 2018, Washington D.C.

Vanessa McFadden (2019): Étude de la tempête de verglas de janvier 2017 ayant causée des pannes de courants majeurs dans la province du Nouveau-brunswick.

Waddington, J.M. 2018 Ecohydrology, wetland, and forest management research in an era of transformative ecosystem change. Natural Resources Canada - Global Water Futures MOU Workshop, Ottawa ON.

Waddington, J.M. 2018. Survival of the thickest? Water storage and residence time in peatlands' USGS Powell Center Working Group, Fort Collins, CO (webinar).

Wallace, C.A. (2018). *Shrubification at the treeline-tundra transition zone.* Invited seminar presentation. Geography and Environmental Sciences Seminar Series. November 22nd, 2018

Wolfe, J.D., Baulch, H., Elliot, J., and Roste, J. (2018) Water Quality on the Prairies. Saskatchewan Association of Watersheds AGM, Swift Current SK. April 11th. Invited.

Yuwei Xie presented a talk titled "Environmental (DNA) metabarcoding for ecotoxicological assessment of anthropogenic activities". Toxicology 990 Seminar Series, University of Saskatchewan, Sept. 17, 2019.

Conference Presentations (non-invited)

A.M. Chegoonian, C.R. Duguay, Kiana Zolfaghari, and H.M. Baulch, 2018. Preliminary assessment of Landsat-8 and Sentinel-2 data for the estimation of chlorophyll-a concentration in Buffalo Pound Lake, Saskatchewan, Canada. Global Water Futures (GWF) Annual Science Meeting 2018, Hamilton, Canada, 4-6 June.

A.M. Chegoonian, Kiana Zolfaghari, K. Nugent, H.M. Baulch, P.R. Leavitt, C.R. Duguay. "Remote sensing of lakes to detect and map harmful algal blooms: First steps toward an early warning system for small inland waterbodies", Global Water Futures (GWF) Annual Science Meeting 2019, Saskatoon, Canada, 15-17 May.

Abdelhamed, M., Razavi, S., Elshamy, M., Wheater, H., (2018) Assessing baseflow simulation using MESH in Upper Liard Sub-Basin, GWF Annual Science Meeting 2018, 3-6 June 2018, Hamilton, ON, Canada

Abdrakhimova, P., Bentley, L.R., Hayashi, M. (2018) Hydrogeological factors affecting seasonal fluctuations of groundwater levels in a heterogeneous bedrock aquifer. Joint Annual Meeting of the Canadian Geotechnical Society and the International Association of Hydrogeologists - Canadian National Chapter. Edmonton, Alberta, September 23-26, 2018. (*Presentation*)

Adlard B, Laird BD, Lemire M, Ayotte P, Chan HM, Curren M, Khoury C. (2018). Levels of Contaminants in Human Populations in the Canadian Arctic. International Conference on Circumpolar Health. Copenhagen, Denmark. (Platform)

Adlard B, Laird BD, Lemire M, Ayotte P, Chan HM, Curren M, Khoury C. (2018). Levels of Contaminants in Human Populations in the Canadian Arctic. International Society of Exposure Science. Ottawa, Canada.

Al-Dabbag, O. and Krantzberg, G. (2018). The Effects of Nitrogen Dynamics on Toxic, Non-Diazotrophic Microcystis spp. in Eutrophic Lakes. International Association for Great Lakes Research Scarborough, ON. June 18-22, 2018.

Ali Shah, S., Do, N., Razavi, S., Slaughter, A. (2018) A., Application of Network Flow Models for Integrated Water Resources Management in Saskatchewan River Basin, GWF Annual Science Meeting 2018, 3-6 June 2018, Hamilton, ON, Canada

Ali Shah, S.M., Razavi, S., Slaughter, A., and Wheater, H., (2018) Investigating the vulnerability of irrigated agriculture across the Saskatchewan River Basin under different future scenarios, 69th International Conference of the International Commission on Irrigation and Drainage (ICID), August 2018, Saskatoon, SK, Canada.

Almonte J, Stewart RE. On the changing rain-snow transition region over the southern Canadian Cordillera: A perspective into the future. GEWEX Conf., Canmore, Alberta. 2018

Amiri, E., J.R. Craig, and *É. Devoie. (2018). Controlling factors on lateral permafrost thaw in the Northwest Territories: a numerical study, Canadian Geophysical Union Joint Meeting, Niagara Falls, ON.

Amiri, E.A., J.R. Craig, *Devoie, É., and Quinton, W. 2018. Numerical simulation of lateral permafrost thaw in the Northwest Territories, 5th European Conference on Permafrost, Chamonix Mont-Blanc, France.

Asadzadeh, M. 2018. Water resources modelling Manitoba (Nelson-Churchill). Integrated Modelling Program for Canada (IMPC). First Annual Meeting July 18-19, 2018. National Hydrology Research Centre, 11 Innovation Boulevard, Saskatoon, SK

Asare, E., and Belcher, K. (2019) Benefit/cost implications of wetland drainage on the most productive sections of agricultural lands, Vermilion River sub-basin 17, Alberta, Canada. Prairie Water 2nd Annual Partners Meeting. Holiday Express Inn & Suites, Saskatoon, SK. January 24-25, 2019. (*Poster*)

Asong ZE, Wheater HS, Pomeroy JW, Pietroniro A, Elshamy M, (2018). Regional scenarios of change over western Canada: future climate projections. American Geophysical Union (AGU) Annual Meeting, Washington, United States, December 14, 2018

Asong, E., Wheater, H., Razavi, S., Hawkins, E., Pomeroy, J., Pietroniro, A., Elshamy, M., (2018) Cascade of uncertainty in CMIP5 climate projections for scenario-led water resource impact assessments in major river basins of Canada , GWF Annual Science Meeting 2018, 3¬6 June 2018, Hamilton, ON, Canada.

Aubry-Wake C, Pomeroy JW, (2018). Impacts of snowpack accumulation and summer weather extremes on alpine glacier hydrology. 8th Global Energy and Water Exchanges (GEWEX) Open Science Conference: Extremes and Water on the Edge, Canmore, Canada, May 6, 2018.

Aubry-Wake C, Pomeroy JW, (2018). Influences of glacier retreat, summer weather and winter snowpack on the increased variability in runoff composition in a quickly changing glacierized catchment. American Geophysical Union (AGU) Annual Meeting, Washington, United States, December 13, 2018

Aubry-Wake C, Pomeroy JW. Impacts of snowpack accumulation and summer weather extremes on alpine glacier hydrology. 8th Global Energy and Water Exchanges (GEWEX) Open Science Conference: Extremes and Water on the Edge, Canmore, Canada, May 6, 2018

Aubry-Wake C, Pomeroy JW. Influences of glacier retreat, summer weather and winter snowpack on the increased variability in runoff composition in a quickly changing glacierized catchment. American Geophysical Union (AGU) Annual Meeting, Washington, United States, December 13, 2018

Ding, F. Rezanezhad, B. Gharedaghloo, P. Van Cappellen, E. Passeport. Bioretention cells under cold climate conditions. 2018 IAGLR Annual Meeting, June 18-22*, 2018,* Toronto, Canada.

Bahrami, A., Goïta, K., Magagi, R., Razavi, S., Elshamy, M., Haghnegahdar, A., Davison, B., (2018) Integration of GRACE data into a hydrology land-surface model in a snow dominated Canadian basin, Canadian Geophysical Union, 10-14 June 2018, Niagara Falls, ON, Canada.

Bajracharya, A.R., TA. Stadnyk, and M. Asadzadeh. 2018. Hydrological modelling of the Nelson Churchill River Basin using HYPE. First Annual Meeting July 18-19, 2018. National Hydrology Research Centre, 11 Innovation Boulevard, Saskatoon, SK

Balliston, N. & Price, J.S. 2019. Determining the role of confining layer thickness on peatland subsidence in a mine impacted area. Presented at the Canadian Geophysical Union Student Section Annual Meeting, April 2019 in Toronto, Ontario

Baltzer J, Marsh P, Swanson H, Turetsky M, Rudolph D, Spence C, Laird B, MacLatchy D, Hayashi M, English M, Venkiteswaran J, Hall R, Blay-Palmer A, Derksen C, Schiff S, McKenzie J, Quinton B, Sonnentag O, Skinner K, Craig J, Gray D, Wolfe B. (2018). Northern Water Futures. Global Water Futures Operations Meeting, Saskatoon, SK, January 21-23, 2019. (poster)

Baltzer, J, Day, N, Johnstone, J, Mack, M, Alexander, H, Arsenault, D, Barnes, J, Bourgeau-Chavez, L, Brown, C, Carrière, S, Greene, D, Gauthier, S, Parisien, M-A, Rogers, B, Thompson, D, Turetsky, M, Veraverbeke, S, Walker, X, Whitman, E, Yang, J (2018) State changes following fire in boreal forests are driven by seedbed conditions and biogeographic context. British Ecological Society Annual Meeting. Birmingham, UK

Baulch, H., Elliott, J., Wilson, H., Cordeliro, M., Flaten, D., and Lobb, D. (2018) Management options for nutrient control in the northern Great Plains. In Aquatic Environment and Ecosystems: Global Water Futures Inaugural Annual Science Meeting. McMaster University, Hamilton, ON. June 4-6, 2018. (*Poster*)

Beamesderfer, E.R., Arain, M.A., & Khomik, M. (2018, June 10-14). Exploring the effects of climatic variability versus phenology on the carbon cycle of a naturally regenerated Carolinian Forest. Oral presentation at the meeting of the CGU-CSSS-CIG-CSAFM-ESSSA, Niagara Falls, ON, Canada.

Beamesderfer, E.R., Arain, M.A., & Khomik, M. (2018, June 10-14). *Exploring the effects of climatic variability versus phenology on the carbon cycle of a naturally regenerated Carolinian Forest*. Oral presentation at the meeting of the CGU-CSSS-CIG-CSAFM-ESSSA, Niagara Falls, ON, Canada.

Beamesderfer, E.R., Arain, M.A., Khomik, M., & Burns, B. (2018, June 3-6). *Carbon, energy, and water exchange of a mature, temperate deciduous forest in Southern Ontario, Canada*. Poster presentation at the meeting of the Global Water Futures (GWF), Hamilton, ON, Canada.

Beamesderfer, E.R., Arain, M.A., Khomik, M., & Burns, B. (2018, June 3-6). *Carbon, energy, and water exchange of a mature, temperate deciduous forest in Southern Ontario, Canada*. Poster presentation at the meeting of the Global Water Futures (GWF), Hamilton, ON, Canada.

Beigzali, N., Boegman, L., Bocaniov, S., Ackerman, J.D., and Zhao, Y. (2018). Simulation of dynamic hypoxic zone movement in Lake Erie and associated impacts on walleye habitat. Conference of the International Association of the Great Lakes Research (IAGLR), June 18-22, 2018; University of Toronto, Toronto, Ontario, Canada.

Beiraghdar, P., M. Asadzadeh. 2018. Integrated Water Management Modeling: Research Plan for MH's System Operation. First Annual Meeting July 18-19, 2018. National Hydrology Research Centre, 11 Innovation Boulevard, Saskatoon, SK

Bergstedt, H., A. Bartsch, and C.R. Duguay, 2018. Influence of lake ice formation and break-up on ASCAT backscatter. *15th International Circumpolar Remote Sensing Symposium*, Potsdam, Germany, 10-14 September.

Bergstedt, H., A. Bartsch, and C.R. Duguay, 2018. Temporal and spatial dependencies of microwave scattering mechanisms in high latitudes across scales. *European Geosciences Union (EGU) General Assembly 2018,* Vienna, Austria, 8-13 April.

Bergstedt, H., A. Bartsch, C.R. Duguay, B.M. Jones, and C.D. Arp, 2018. Influence of lake ice formation and break-up on ASCAT backscatter. *AGU 2018 Fall Meeting*, Washington, DC, 10-14 December.

Bertoncini A L S, Pomeroy J W, Zilefac E A. GPM-IMERG Snowfall Estimates in Cold Mountainous Regions. Global Water Futures (GWF) Inaugural Annual Science Meeting, McMaster University (Hamilton, ON) and Six Nations of the Grand River (Ohsweken, ON), June 2018 (Oral Presentation), 8th Global Energy and Water Exchanges (GEWEX) Open Science Conference, Canmore, Alberta – Canada, May 2018 (Poster Presentation)

Biagi, K., Clark, M.G, Humphreys, E.H., Carey S.K. 2018. The role of winter processes in the hydrological development of a constructed wetland in the Athabasca Oil Sands Region, Alberta, Canada. Presented at the American Geophysical Union Meeting, Washington, DC, December 2018.

Biagi, K., Nicholls, E.M., Clark, G., Humphreys, H., Carey, S.K. 2018. The influence of winter processes on the hydrology of a constructed wetland in the Athabasca Oil Sands Region, Alberta: six years after construction. Presented at the Canadian Geophysical Union Annual General Meeting, June 2018, Niagara Falls, ON.

Bieniada, A., Hug, L., Parsons, C., Van Cappellen, P., and Strack, M. Methanogenic and methanotrophic communities in extracted and restored peatlands. Canadian Geophysical Union Annual Meeting 2018, Niagara Falls, Ontario, June 12, 2018

Bill, K, Turetsky, MR, Baltzer, JL, *Day, NJ, *Dieleman, CM, Walker, XJ, Mack, MC, Johnstone, JF. 2018. Post-fire ecosystem resilience and carbon dynamics in the Northwest Territories, Canada. AGU Fall Meeting, Washington, USA.

Bocaniov, S., Dagnew, A., Wang, Y.-C., Long, C., and Scavia, D. (2018). Lake St. Clair modeling update. System-wide Phosphorus Balance. SCDRS Advisory Group Meeting, Mar. 15; University of Windsor, Windsor, Ontario.

Bocaniov, S., Kheyrollah Pour, H., Markelov, I., Scavia, D., and Van Cappellen, P. (2019). Understanding the role of Lake St. Clair in total nutrient load. World Wetland Day 2019 Research Symposium; Feb. 4, 2019; University of Waterloo, Waterloo; Ontario. C6.

Bocaniov, S., Kheyrollah Pour, H., Scavia, D., and Van Cappellen, P. (2018). Physical and biological gradients and exchange processes in a large shallow lake (Lake St. Clair, USA – Canada. European Large Lakes- International Association for Great Lakes (ELLS-IAGLR), Evian, France, September 23-28, 2018.

Bocaniov, S., Kheyrollah Pour, H., Scavia, D., and Van Cappellen, P. (2018). Understanding the role of physical processes in algal bloom formation in Lake St Clair. International Association for Great Lakes Research. June 18-22, 2018.

Bocaniov, S., Markelov, I., Kheyrollah Pour, H., and Van Cappellen, P. (2018). Understanding the role of large-scale physical processes in algal bloom formation in a large shallow lake (Lake St. Clair, U.S.A. – Canada), Global Water Futures, Annual Science Meeting, Macmaster University, Canada, June 3-6, 2018.

Bodo, A., & Arain, A. (2018, June 3-6). Investigating the Effects of Variable Retention Harvesting Applications on Tree Transpiration in a Red Pine Plantation. Poster presentation at the meeting of the Global Water Futures (GWF), Hamilton, ON, Canada.

Bodo, A., & Arain, A. (2018, June 3-6). *Investigating the Effects of Variable Retention Harvesting Applications on Tree Transpiration in a Red Pine Plantation*. Poster presentation at the meeting of the Global Water Futures (GWF), Hamilton, ON, Canada.

Bodo, A., & Arain, A. (2018, March 18). Investigating the Effects of Variable Retention Harvesting Applications on Tree Transpiration in a Red Pine Plantation. Poster presentation at the meeting of the CGU Eastern Student Conference, London, ON, Canada.

Bodo, A., & Arain, A. (2018, March 18). *Investigating the Effects of Variable Retention Harvesting Applications on Tree Transpiration in a Red Pine Plantation*. Poster presentation at the meeting of the CGU Eastern Student Conference, London, ON, Canada.

Bondaruk, Ben, Steven Roberts, and Colin Robertson. "Discrete Global Grid Systems: Operational Capability of the Current State of the Art." In Proceedings of the Conference on Spatial Knowledge and Information - Canada, 7(6):1. Banff, AB, 2019.

Brandow D, Skinner K, Laird B. (2018). Country Food Contaminant Advisories: Assessing Awareness and Preferences of Health and Risk Communication Messages in the Sahtú Region, NWT. Global Water Futures Inaugural Annual Science Meeting, Hamilton and Ohsweken, June 4-6, 2018. (poster)

Brandow D, Skinner K, Laird BD. (2018). Country Food Contaminant Advisories: Assessing Awareness and Preferences of Health and Risk Communication Messages in the Sahtú Region, NWT. Indigenous Health Conference. Toronto, Canada. (Poster)

Brandow D, Skinner K, Simmons D, Andrew L, Bezha W, Laird B. (2018). Country Food Contaminant Advisories: Assessing Awareness and Preferences of Health and Risk Communication Messages in the Sahtú Region, NWT, Canada. 17th International Congress on Circumpolar Health, Copenhagen, Denmark,

Brouwer, R., and Liu, H. (2018). Estimating the Economic Costs of Eutrophication in the Great Lakes Basin, GWF Annual Science Meeting, McMaster University, June 3-6, 2018.

Brown, G., and J.R. Craig. (2018). Extending a general hydrologic modelling framework to TIN-discretized landscapes, Canadian Geophysical Union Joint Meeting, Niagara Falls, ON.

Bryan, T., and Morrissey, C. (2019) Influence of wetland pesticide pollution waterfowl distribution and abundance in the Prairie Pothole Region. Prairie Water 2nd Annual Partners Meeting. Holiday Express Inn & Suites, Saskatoon, SK. January 24-25, 2019. (*Poster*)

Budhathoki, S., Morales-Marin, L. and Lindenschmidt, K.-E. (2018) Sediment Yield and Transport Model for Cold Region Catchments. American Geophysical Union (AGU) 2018 Annual Meeting, Washington, D.C., 10 - 14 December 2018. Canadian Geophysical Union, 10-14 June 2018, Niagara Falls, ON, Canada

Byrnes, D., Van Meter, K. J., & Basu, N. B. (2018, December). Why Is This Still Green? Where and Why Have Changes from People with Power Not Made the Water Great Again. American Geophysical Union, December 10-14, 2018, Washington D.C.

Byrnes, D., Van Meter, K. J., and Basu, N. B. (2018, December). Back to the Future: Impact of Current Versus Historical Land Use on Water Quality Trends Across the Contiguous US. American Geophysical Union, December 10-14, 2018, Washington D.C.

Byrnes, D., Van Meter, K.J., and Basu, N.B. (2018). Biogeochemical Asynchrony: Anthropogenic and Landscape Drivers of Nutrient Seasonality Across the Great Lakes Basin and Beyond. Canadian Geophysical Union Joint Meeting, Niagara Falls, Canada, June 2018

Carey SK. Runoff Processes in Alpine Catchments: Challenges and Opportunities. Presented at the Fifth Annual International Network for Alpine Research Catchment Hydrology. October 2018, Portillo, Chile.

Carlow, R., Macrae, M.L., Plach, J., Kompanizare, M., Brunke, R., "How low can you go? The use of Geotextile as a Filter for Phosphorus in Overland Flow from Agricultural Croplands in Southern Ontario" CGU Annual Meeting, June 10-14, 2018, Niagara Falls, Ontario, Canada.

Carlow, R., Macrae, M.L., Plach, J., Kompanizare, M., Brunke, R., "How low can you go? The use of Geotextile as a Filter for Phosphorus in Overland Flow from Agricultural Croplands in Southern Ontario" IAGLR's 61st annual conference on Great Lake Research, June 18-22, 2018, Toronto, Ontario, Canada.

Carlson, H. 2018. "How Narratives Influence Water Policy in the Saskatchewan River Basin." Global Water Futures inaugural meeting, Hamilton, Canada, 4-6 June 2018.

Cavaliere, E. (2019) Prairie wetlands: Nutrient sinks or sources in spring-melt? Prairie Water 2nd Annual Partners Meeting. Holiday Express Inn & Suites, Saskatoon, SK. January 24-25, 2019. (*Poster*)

Chandrakumaran, T., Stone, M., Basu, N. B., and Emelko, M. (2018). Spatial and Temporal Trends in Phosphorus and Suspended Solids Yields along an Urban River Reach. International Association for Great Lakes Research Conference, Toronto, Canada, June 2018

Chasmer, L., E. Jones, D. Cobbaert, C. Hopkinson, C. Mahoney, J. Montgomery, M. Okhrimenko, R.M. Petrone, 2018. Mapping wetland changes associated with disturbance in the Oil Sands Region using remote sensing. Canadian Symposium on Remote Sensing, Saskatoon, June 19-21.

Chasmer, L., L. Flade, C. Hopkinson, Petrone, R.M., Devito, K. 2018. Spatial variability of peatland depth of peat burn following wildfire in relation to latent energy fluxes using lidar and

thermal IR imagery. International Association of Hydrological Sciences Conference – Remote Sensing and Hydrology Symposium, Cordoba Spain. May 8-10.

Chaudhuri, Chiranjib, and Colin Robertson. "A Novel Method to Analyze Trends of Extreme Precipitation Distribution- A Case Study over the Arctic Regions of Canada." In Proceedings of the Conference on Spatial Knowledge and Information - Canada, 7(2):1. Banff, AB, 2019.

Cheecham-Uhrich, D., Duffy, A., Thapa, A., Strickert, G., and Hassanzadeh, E. (2018) Incorporating the Social Component in Hydrological Modeling to Evaluate the Effectiveness of Agricultural BMPs in a Prairie River Basin. In Human-Water Interactions: Global Water Futures Inaugural Annual Science Meeting. McMaster University, Hamilton, ON. June 4-6, 2018. (*Poster*)

Chegoonian, A. Duguay, C., Zolfaghari, K., Baulch, H., 2018. Preliminary Assessment of Landsat-8 and Sentinel-2 Data for the Estimation of Chlorophyll-A Concentration in Buffalo Pound Lake, Saskachewan, Canada. Global Water Futures Annual Science Meeting. MacMaster University, Hamilton, Ontario.

Chegoonian, A.M., C.R. Duguay, K. Zolfaghari, and H.M. Baulch, 2018. Preliminary assessment of Landsat-8 and Sentinel-2 data for the estimation of chlorophyll-a concentration in Buffalo Pound Lake, Saskatchewan, Canada. Global Water Futures (GWF) Annual Science Meeting 2018, Hamilton, Canada, 4-6 June.

Cheney CL, MP Pothier, AJ Poulain, JR Thienpont, JB Korosi, LE Kimpe and JM Blais. 2019.

Cheney CL, MP Pothier, AJ Poulain, JR Thienpont, JB Korosi, LE Kimpe and JM Blais. 2018.

Cheney CL, MP Pothier, AJ Poulain, JR Thienpont, JB Korosi, LE Kimpe and JM Blais. 2018. Using paleoecotoxicology to assess the toxicity of lake sediments impacted by legacy gold mining in Yellowknife, NT, Canada. Society of Environmental Toxicology and Chemistry, Rome, Italy.

Cheng, F. Y., & Basu, N. B. (2018). The story of boy fish turning to girl fish (and the other way around): When bad stuff gets stuck in the ground under the moving water and stays there for a long time but comes back later, even when we don't want it. American Geophysical Union, December 10-14, 2018, Washington D.C.

Cheng, F. Y., Gall, H. E., Mashtare, M. L., Lee, L. S., & Basu, N. B. (2018). Nevertheless they persisted: Can hyporheic zones increase the persistence of estrogenic hormones in agricultural streams? American Geophysical Union, December 10-14, 2018, Washington D.C.

Cheng, F., and Basu, N.B. (2018). Biogeochemical hotspots: The importance of small water bodies in landscape nutrient processing. Canadian Geophysical Union Joint Meeting, Niagara Falls, Canada, June 2018

Chow-Fraser, Patricia. "Towards co-creation youth engagement in monitoring stream health in Indigenous communities" (oral presentation), GWF Inaugural Annual Science Meeting McMaster University. 4 June 2018.

Clark, M.G., Humphreys, E.H., Carey, S.K. 2018. The initial biometeorological development of a constructed watershed. Presented at the Canadian Geophysical Union Annual General Meeting, June 2018, Niagara Falls, ON.

Coles, AE, Kokelj, SV, Baltzer, JL (2018) Environmental change around northern communities: from boreal forest to arctic tundra. 46th Annual Geoscience Forum, Yellowknife, NT

Conant Jr., B., and Rudolph, D.L. (2019). Low Altitude Aerial Thermal Infrared Surveys to Detect Groundwater Discharges and Melting Permafrost. NovCare 2019: The 6th International Conference Novel Methods for Subsurface Characterization and Monitoring: From Theory to Practice. Waterloo, Ontario, Canada,

Copp J, Lai W, Pooni P, Sekerinski E. High Quality Low Cost Sensor Data Through Targeted Maintenance And Sampling Error Understanding. Poster presented at: MacWater Challenges in Water Monitoring, Poster Presentation; 2018 Jul 26; Hamilton, Ontario, Canada

Copp J, Sekerinski E, Wang X. Anomaly Detection of Water Quality Data with Machine Learning. Poster presented at: Advancing Water Technologies Showcase, Southern Ontario Water Consortium; 2018 Sep 20; Mississauga, Ontario, Canada.

Copp J, Sekerinski E, Wang X. Anomaly Detection of Water Quality Data with Machine Learning. Poster presented at: MacWater Challenges in Water Monitoring, Poster Presentation; 2018 Jul 26; Hamilton, Ontario, Canada.

Copp JB, Pooni P, Lai W, Wang X, Viveros R, Sekerinski E. When Grab Samples Just Won't do: High-Quality High-Frequency Water Quality Monitoring. In: 48th Annual WEAO Technical Symposium & OPCEA Exhibition [Internet]. Toronto, Canada: Water Environment Association of Ontario; 2019. p. 4. Available from: https://www.xcdsystem.com/weao/program/zE6W4pk/index.cfm?pgid=140#C

Copp, J., Sekerinski, E., and Wang, X. Automated detection of anomalies in high frequency water quality sensor data using machine learning. In: 48th Annual WEAO Technical Symposium & OPCEA Exhibition. Toronto, Canada: Water Environment Association of Ontario (April 2019) pg 3.

Costa D, Baulch H, Elliott J, Pomeroy J, Wheater H, (2018). An inverse modelling approach with equifinality control to investigate the dominant controls of snowmelt nutrient export in agricultural regions. Joint Meeting of the Canadian Geophysical Union (CGU), Canadian Soil Science Society, Computational Infrastructure in Geodynamics, Eastern Section of Seismological Society of America and Canadian Society for Agricultural and Forest Meteorology, Niagara Falls, Canada, June 10, 2018

Costa, D. "The Nutrient App". Lake Winnipeg Basin Symposium, Winnipeg (Oral Presentation). 20-21 March, 2019.

Costa, D. An inverse modelling approach with equifinality control to investigate the dominant controls of snowmelt nutrient export in agricultural regions (2018), Canadian Geophysical Union (CGU), Niagara Falls (Oral Presentation)

Costa, D. Pursuing reliable hourly nutrient predictions in cold regions through the coupling of CRHM to an extended version of WINTRA (2018), Global Water Futures Inaugural Annual Science Meeting, Ontario (Oral Presentation).

Craig, P., H. Ikert, R. Hodgson, I. Cadonic, N. Benoit, A. Doxey, M. Servos. The cost of living in the Grand River: energetics, stress, epigenetics. 13th International Congress on the Biology of Fish, Calgary, Alberta, July 15-19, 2018. abstract

Das, A. and Lindenschmidt, K.-E, (2018) Evaluation of the relative sensitivity of hydraulic model parameters and boundary conditions and Digital Elevation models on ice-jam flood delineation. 39th Canadian Symposium on Remote Sensing, Saskatoon, Saskatchewan, Canada, 19-21 June, 2018

Das, A., Rokaya, P. and Lindenschmidt, K.-E. (2018) Exploring the potential of integrating and assessing flood risk analysis in real-time ice-jam flood forecasting. American Geophysical Union (AGU) 2018 Annual Meeting, Washington, D.C., 10 - 14 December 2018.

Das, A., Rokaya, P. and Lindenschmidt, K.-E. (2018) Impacts of Climate Change on Ice-jam flooding along a northern river, Canada. Cryospheric Extremes Workshop, Helsinki, Finland, 26-28 April 2018.

Davison, B., Pietroniro, A., Wheater, H., Pomeroy, J., Princz, D., Soulis, R., Yassin, F., Elshaby, M., Razavi, S., Fortin, V., Lindenschmidt, K.-E., Morales, L., Haghnegahdar, A., Richard, D., Loukili, Y. and Tesemma, Z. (2018) The MESH Model: Past, Present and Future. Global Water Futures inaugural meeting, Hamilton, Canada, 4-6 June 2018.

Day NJ, *Dieleman CM, Thorn RG, Turetsky MR, & Baltzer JL. (2018). Mycology of Permafrost Soils. 11th International Mycological Congress. 16-21 July, San Juan, Puerto Rico, USA.

Day NJ, Cumming S, *Degré-Timmons G, Johnstone J, Gruel R, Mack M, McIntire E, Reid K, Schmiegelow F, Turetsky M, Walker X, White A, & Baltzer J. (2018). Impacts of Wildfire Extent and Severity on Caribou Habitat: from woodland to barren ground. Cold Regions Research Days, Wilfrid Laurier University, Canada

Day NJ, Cumming S, Dunfield K, Johnstone J, Mack M, Reid K, Turetsky M, Walker X, & Baltzer J. (2018). Some Like it Hot: Heat-resistant fungi in Canada's boreal forests. 34th Great Lakes Mycology Meeting, 28-29 April, Queen's University Biological Field Station, ON, Canada

Day NJ, Reid KA, Walker XJ, White AL, Cumming S, Dunfield K, Johnstone J, Mack M, Reid K, Turetsky M, & Baltzer J. (2018). Drivers of Land Cover Change After Large Fire Disturbance in Boreal Forests. Global Water Futures Annual Science Meeting. 3-6 June, Hamilton, ON, Canada.

De Haan, K., Petrone, R.M., Kompanizare, M., Macrae, M.L. "Expected Climate and Vegetation Controls on Water Use Efficiency in a Corn (Maize) field in Southern Ontario".

de Lannoy, Charles, Zeinab Housseini-Doust, Kurt Gibson, Erik Fréchette, Saif Syed, Nan Zhang. "Sensor Biofouling: Impact and Solutions" (oral presentation), GWF Inaugural Annual Science Meeting McMaster University. 6 June 2018.

DeBeer C, Wheater H, Pomeroy J, Stewart R, Carey S, (2018). Climatic, Cryospheric, Ecological, and Hydrological Change in the Interior of Western Canada: The Changing Cold Regions Network and its activities as a GEWEX RHP. 8th Global Energy and Water Exchanges

(GEWEX) Open Science Conference: Extremes and Water on the Edge, Canmore, Canada, May 6, 2018.

DeBeer C, Wheater H, Pomeroy J, Stewart R, Carey S. Climatic, Cryospheric, Ecological, and Hydrological Change in the Interior of Western Canada: The Changing Cold Regions Network and its activities as a GEWEX RHP. 8th Global Energy and Water Exchanges (GEWEX) Open Science Conference: Extremes and Water on the Edge, Canmore, Canada, May 6, 2018

DeBeer, C., Wheater, H., Pomeroy, J., Stewart, R., Carey, S.K. 2018. Climatic, Cryospheric, Ecological, and Hydrological Change in the Interior of Western Canada: The Changing Cold Regions Network and its activities as a GEWEX RHP. 8th Global Energy and Water Exchanges (GEWEX) Open Science Conference: Extremes and Water on the Edge, Canmore, Canada, May 6, 2018

DeBofsky, A., Xie, Y., Giesy, J. "Shifts of microbiota in fish guts following dietary exposure to benzo[a]pyrene". SETAC North America, Sacramento, California. November 8, 2018. Oral presentation.

Degré-Timmons, G., Greuel, R., S. Cumming, *N. Day, S. Hart, E. McIntire, P. McLoughlin, F. Schmiegelow, M. van Telgen, M. Turetsky, A. Truchon-Savard, J. Baltzer & J. Johnstone. (2019) Comparaison des estimés d'abondance de lichen après feu en Saskatchewan et aux Territoires du Nord-Ouest. Poster presentation, Centre for Northern Studies' Annual Symposium 2019, Quebec city, QC.

Derksen, C., J. King, C. Garnaud, S. Belair, M. Lapointe, Y. Crevier, R. Girard, G. Burbidge, J. Marquez, D. Bourne, and J. Lemmetyinen. (2018). A new dual-frequency Ku-band radar mission concept for cryosphere applications. POLAR 2018 SCAR/IASC Open Science Conference, Davos, Switzerland, June 2018.

Devoie, É., R.F. Connon, J.R. Craig, and W.L. Quinton. (2018). Modelling controls on local talik formation in discontinuous permafrost, Canadian Geophysical Union Joint Meeting, Niagara Falls, ON.

Dixon, H. et al. (2019). GWF 2nd Annual Open Science Meeting. May 15–17, 2019, Saskatoon. (poster)

Dixon, H. J., Brekke, L. and Swanson, H. K. (2019). Using Broad Scale Monitoring (BSM) methods to assess the fish community of a small sub-Arctic lake. Canadian Conference for Fisheries Research, London, ON.

Dixon, H. J., Harrison, G., Lister, A. and MacLatchy, D. (2019). Reproductive status of walleye (Sander vitreus) and lake whitefish (Coregonus clupeaformis) in two large, shallow subarctic lakes. Canadian Conference for Fisheries Research, London, ON, Canada, Jan 3-6, 2019. (presentation)

Do, N. C. and Razavi S. (2018), Variogram-based global sensitivity analysis of environmental models with dependent variables, AGU 2018 Fall Meeting, 10-14 December 2018, Washington D.C., United State of America.

Do, N.C., Razavi S. and Ali Shah S. M. (2018), Reliability and Vulnerability Assessment using Global Sensitivity Analysis: Case Study of Saskatchewan River Basin, Global Water Future Annual Science Meeting, 03-06 June 2018, Hamilton, Ontario, Canada.

Doubleday, McKnight and Newell. 2019. Small community response to forest fires and flooding in the Boreal. Saskatoon May 14-16, 2019.

Doubleday, Nancy and Jorge Fabra-Zamora. "Envisioning Polycentric Water Governance in a Canadian Context," GWF Inaugural Annual Science Meeting, McMaster University. 3-6 June 2018.

Drewry, D., Sonnentag, O., Miller, C.E., Schimel, D. et al. (2018), Airborne solar-induced chlorophyll fluorescence to characterize Arctic Boreal zone productivity. Abstract B31F-0484, Washington, D.C., USA.

Duffy, A., and Strickert, G. (2018) Dialogue That Flows: The role of narrative in supporting watershed governance. In Human-Water Interactions: Global Water Futures Inaugural Annual Science Meeting. McMaster University, Hamilton, ON. June 4-6, 2018. (*Poster*)

Duffy, A., and Strickert, G. (2019) Once upon a time... A story changed your drinking water. Prairie Water 2nd Annual Partners Meeting. Holiday Express Inn & Suites, Saskatoon, SK. January 24-25, 2019. (*Poster*)

Duguay, C.R., E.A. Zakharova, A.V. Kouraev, H. Kheyrollah Pour, and M. Hoekstra, 2018. Retrieval of ice thickness on large northern lakes from Jason-2 data. *POLAR2018*, Davos, Switzerland, 19-23 June.

Duignan, Sarah. "Investigating the Role of Water Security on Holistic Health with Six Nations of the Grand River" (oral presentation), McMaster Indigenous Graduate Student Research Symposium, McMaster University. 13 March 2019.

Duignan, Sarah. "Ohneganos Onegahde:Gyo (Water is Life): Preliminary Findings from Focus Groups on Water Quality and Access at Six Nations of the Grand River" (poster presentation), McMaster Water Week 2018 Research Showcase, McMaster University. 20 Nov 2018.

Dyck, L., and Whitfield, C.J. (2019) Carbon storage vs. methane emissions: What is happening in prairie wetlands? Prairie Water 2nd Annual Partners Meeting. Holiday Express Inn & Suites, Saskatoon, SK. January 24-25, 2019. (*Poster*)

E. Passeport, B. Ding, B. Gharedaghloo, F. Rezanezhad, L. Rhodes-Dicker, P. Van Cappellen. Bioretention cell performance in cold climate conditions. 9th International Conference *NOVATECH*, 1-5 July *2019,* Lyon, France. Extended Abstract.

E. Passeport, B. Ding, F. Rezanezhad, B. Gharedaghloo, P. Van Cappellen. Bioretention Cells Under Cold Climate Conditions. 2018 AGU Fall Meeting, 10-14 December 2018, Washington DC, USA.

E. Wilcox and P. Marsh. (2018). Assessing the hydrological variability of lakes between Inuvik and Tuiktoyaktuk. ArcticNet Annual Science Conference, Ottawa, Dec. 2018

Eamen, L., Razavi, S., Brouwer, R., (2018) An Evaluation of Current and Future Water Allocation Strategies in the Saskatchewan River Basin, GWF Annual Science Meeting 2018, 3-6 June 2018, Hamilton, ON, Canada.

Eamen, L., Razavi, S., Brouwer, R., Tollefson, L., (2018), An Evaluation of Current and Future Water Allocation Strategies in the Saskatchewan River Basin, Canada, International Conference of the International Commission on Irrigation and Drainage, 12–17 August 2018, Saskatoon, Saskatchewan, Canada.

Eitel, J., Maguire, A., Boelman, N. et al. incl. Sonnentag, O. (2018), Evaluating the potential of fall trends in photochemical reflectance index (PRI) time-series to improve understanding of climate change effects at northern treeline. Abstract B14C-04, 10-14 December 2018, Washington, D.C., USA.

Elaghoury H, Sekerinski E, Tan R. Implementation of a Long-range Low-cost Water Quality Sensor Network and its Visualization Tool [Internet]. Poster presented at: Advancing Water Technologies Showcase, Southern Ontario Water Consortium; 2018 Sep 20; MIssissauga, Ontario, Canada. Available from:https://gitlab.cas.mcmaster.ca/waterquality/reports/tree/master/ElaghouryTanSekerinski18/poster/MacWater%20July%2026

Elaghoury, H., Fadhel, M., Sekerinski, E., and Tan, R. Implementation of a long-range low-cost water quality sensor network and its visualization tool. MacWater Challenges in Water Monitoring, Poster Presentation, Hamilton, Ontario, Canada, July 2018.

Elmes, MC., & Price, JS. 2018. Hydrologic function of a moderate-rich fen watershed in the Athabasca Oil Sands Region of the Western Boreal Plain, northern Alberta. Canadian Geophysical Union 2018 Meeting, Niagara Falls, ON.

Elshamy M, Asong ZE, Wheater HS, Pietroniro A, Pomeroy JW, (2018). Regional scenarios of change over the Mackenzie River Basin: future hydrological projections and challenges with observational uncertainty. American Geophysical Union (AGU) Annual Meeting, Washington DC, United States, December 14, 2018

Elshamy M, Asong ZE, Wheater HS, Pietroniro A, Pomeroy JW. 2018. Regional scenarios of change over the Mackenzie River Basin: future hydrological projections and challenges with observational uncertainty. American Geophysical Union (AGU) Annual Meeting, Washington, United States, December 14, 2018

Elshamy, M., Asong, Z.E., Wheater, H.S., Pietroniro, A., Pomeroy, J.W., 2018. Regional scenarios of change over the Mackenzie River Basin: future hydrological projections and challenges with observational uncertainty. American Geophysical Union (AGU) Annual Meeting, Washington, United States, December 14, 2018

English, M. (2017). Identification of patterns in hydrological conditions governing flow in an unregulated river basin in the Northwest Territories, and implications for downstream hydroelectric power generation-Abstract submitted for the 5th European Conference on Permafrost in Chamonix, France, June 2017

English, M. (2017). Understanding how climate-driven hydrological conditions may influence patterns of surface discharge in an unregulated watershed in the NWT – Abstract submitted for an oral presentation at the 1st International Conference on Water Security in Toronto, June 2017

F. Rezanezhad, C. M. Smeaton, L. Hug, G. B. Jensen, K. J. Krogstad, M. L. Macrae, C. P.R. McCarter, T. Milojevic, R. Mills, C. T. Parsons, W. Quinton, D. Rudolph, S. Smith, H. Townsend, P. Van Cappellen. Winter Soil Processes in Transition. *Goldschmidt2019*, 18 - 23 August *2019.* Barcelona, Spain.

F. Rezanezhad, L.A. Hug, P. Van Cappellen, D. Rudolph, S. Smith, C. Smeaton, C. T. Parson and C. McCarter*. Winter Soil Processes in Transition. Global Water Futures Annual Science Meeting 2018, June 3-6, McMaster University, Hamilton.

F. Rezanezhad, T. Milojevic, D. Oh, C. Smeaton, C. T. Parsons, C. McCarter, and P. Van Cappellen. Soil hydrogeochemical processes under changing winter conditions. 2018 CGU Joint Meeting, 10-14 June 2018, Niagara Falls, Ontario, Canada.

F. Rezanezhad, T. Milojevic, D. Oh, H. Townsend, C. Smeaton, C. T. Parsons, C. McCarter and P. Van Cappellen. Soil biogeochemical processes controlling subsurface carbon and nutrient fluxes under variable winter conditions. 2018 AGU Fall Meeting, 10-14 December 2018, Washington DC, USA.

Faber J, *T Owca, *M Kay, J Wiklund, B Wolfe and RI Hall. (2018). Baseline hydrological conditions and sediment metal concentrations from paleolimnology. *Cold Regions Research Centre Day*, Wilfrid Laurier University, Waterloo.

Faber J, *T Owca, *M Kay, J Wiklund, B Wolfe and RI Hall. (2018). Understanding the effects of industry on the Peace-Athabasca Delta (Alberta): developing baseline hydrological conditions and sediment metal concentrations using paleolimnology. *ArcticNet Annual Scientific Meeting*, Ottawa.

Faber J, *T Owca, *M Kay, J Wiklund, B Wolfe and RI Hall. (2018). Assessing the impacts of industry on the Peace-Athabasca Delta (Alberta) by establishing baseline sediment metal concentrations and hydrologic conditions. *Ontario-Quebec Paleolimnology Group Graduate Student Conference*, Brock University, St. Catharines.

Faber J, *T Owca, *M Kay, J Wiklund, B Wolfe and RI Hall. (2018). Understanding the effects of industry on the Peace-Athabasca Delta (Canada): developing baseline hydrological conditions and sediment metal concentrations using paleolimnology. *International Paleolimnology Symposium*, Stockholm, Sweden.

Fabra-Zamora, Jorge. “Can Canadian Indigenous Communities Declare the Personality of their Water Bodies?: An International Law Argument” (poster presentation). McMaster Water Week 2018 Research Showcase, McMaster University, November 20, 2018.

Fabra-Zamora, Jorge. “The Human Right to Water and Its Relevance for Canadian Indigenous Communities” (oral presentation), McMaster Indigenous Graduate Student Research Symposium, McMaster University. 13 March 2019

Fadhel M, Sekerinski E, Tan R. A Comparison of Time Series Databases for Storing Water Quality Data. Poster presented at: GWF Annual Science Meeting; 2018 Jun 4; Hamilton, Ontario, Canada.

Fadhel M, Sekerinski E, Tan R. Implementation of a Long-range Low-cost Water Quality Sensor Network and its Visualization Tool [Internet]. Poster presented at: GWF Annual Science Meeting; 2018 Jun 4; Hamilton, Ontario, Canada. Available from:

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Fadhel, M., Sekerinski, E., and Yao, S. A comparison of time series databases for storing water quality data. In Proceedings of the International Conference on Interactive Mobile Communication, Technologies and Learning, IMCL 2018 (in press), Springer.

Ferguson, G., Hendry, J., Lindsay, M., Barbour, L., Grasby, S., McIntosh, J. (2018) Groundwater protection – Looking deeper. In Watershed Management and Disturbance: Global Water Futures Inaugural Annual Science Meeting. McMaster University, Hamilton, ON. June 5th, 2018. (*Oral Presentation*)

Ferguson, G., Lindsay, M.B.J., Eglington, B. Mowat, A., Tipton, K. and McIntosh, J.C. Lessons Learned from Development of the Williston Basin. Use of the deep subsurface in the UK: What are the implications for groundwater resources The Geological Society, Burlington House, London, UK> July 2018.

Ferguson, G.A. and McIntosh J.C. Large-scale changes in subsurface water budgets from oil and gas production. AGU Fall Meeting Abstracts, December 2018.

Ferris, D. and Ferguson, G. (2019) A GIS-based method for accommodating uncertainty in groundwater vulnerability assessment methods. Joint Annual Meeting of the Canadian Geotechnical Society and the International Association of Hydrogeologists - Canadian National Chapter. Edmonton, Alberta, September 23-26, 2018. (*Presentation*)

Ferris, D., and Ferguson, G. (2019) A statistical approach to incorporating uncertainty into regional groundwater vulnerability assessment – Aquifer Vulnerability Index (AVI) case study. Prairie Water 2nd Annual Partners Meeting. Holiday Express Inn & Suites, Saskatoon, SK. January 24-25, 2019. (*Poster*)

Fouché, J., Sonnentag, O., Helbig, M., Wischnewski, K., *Hould Gosselin, G., Quinton, W.L., Moore, T. (2018), Dissolved organic carbon export and its contribution to the carbon budget in a boreal peat landscape undergoing rapid permafrost thaw. 5th European Conference on Permafrost, Chamonix-Mont Blanc, France.

Frank, A., P. Deadman, R. Brouwer, R. de Loë, D. Robinson "Modeling of agricultural system impacts on phosphorus loads in the Thames River watershed: overview of research approach". Poster. GWF Annual Science Meeting – June 3-6, 2018

Fung L, Chaurasia A, *Ratelle M, Skinner K, Swanson H, Laird BD. (2018). Internal and external exposure analysis of mercury amongst Dene and Metis Communities of the Northwest Territories. Global Water Futures Annual Science Meeting. Hamilton, Canada. (Poster)

Fuzzen, M., G. Tetreault, K. Hicks, P. Marjan, L. Bragg, H. Dhiyebi, M. McMaster, M. Servos. Major wastewater treatment plant infrastructure upgrades reduce adverse biological responses in wild fish in the Grand River. 13th International Congress on the Biology of Fish, Calgary, Alberta, July 15-19, 2018. abstract

G. Jensen, K. Krogstad, F. Rezanezhad and L.A. Hug. Characterizing Soil Microbial Diversity through Freeze-Thaw Cycles and the Winter Transition. 2nd Global Water Futures (GWF) Annual Open Science Meeting. May 15 -17, 2019, Saskatoon, Saskatchewan, Canada.

G. Jensen, K. Krogstad, F. Rezenezhad, and L.A. Hug. Characterizing Soil Microbial Diversity through Freeze-Thaw Cycles and the Winter Transition. Canadian Society for Microbiologists Annual Meeting, June 10-14, 2019, Sherbrooke, Quebec, Canada

Garcia Hernandez, J., Pinto, R. and Brouwer, R. Assessing the economic impacts of water disruptions on the Great Lakes Basin using an input-output optimization model. Accepted for presentation at the annual conference of the European Association of Environmental and Resource Economists, Manchester, June 2019

Ge, Yichang, & Doubleday, N. 2019. The Use of Narrative Justice to Facilitate Moral Knowledge Acquisition of the Human Right to Clean Drinking Water. iSci Year-end Reporting Meeting. McMaster University, April 9, 2019.

George Liu, Ron Stewart, Barrie Bonsal , Allan Howard and Elaine Wheaton: Drought Evolution/ Model Evaluation During the 1999- 2004 Canadian Prairie Drought-Drought evolution – Regina 2019

Gharari, S., Razavi, S., (2018), An improved implementation of the VIC (Variable Infiltration Capacity) model for Canadian basins, European Geosciences Union (EGU) General Assembly, 8–13 April 2018, Vienna, Austria (Poster Presentation).

Gharari, S., Razavi, S., Wong, J., Pietroniro, A., Wheater, H., (2018) Regional modelling with a simple land surface model: the strengths, weaknesses and a novel implementation of the Variable Infiltration Capacity (VIC) model, GWF Annual Science Meeting 2018, 3-6 June 2018, Hamilton, ON, Canada

Gharari, S., Razavi, S., Wong, J., Pietroniro, A., Wheater, H., (2018) An improved representation of surface heterogeneity in the Variable Infiltration Capacity (VIC) model using Grouped Response Units (GRU),

Gharari, S., Razavi, S., Wong, J., Pietroniro, A., Wheater, H., (2018), Estimating near-surface soil moisture under climate change using an improved configuration of the Variable Infiltration Capacity (VIC) model based on Grouped Response Units (GRU), International Conference of the International Commission on Irrigation and Drainage, 12–17 August 2018, Saskatoon, Saskatchewan, Canada.

Ghoreishi, M., Razavi, S., Elshorbagy, A., (2018) Analyzing News Media Coverage in Extreme Environmental Events: The Key Role of Media in Human Adaptive behaviors, GWF Annual Science Meeting 2018, 3-6 June 2018, Hamilton, ON, Canada

Ghoreishi, M., Razavi, S., Elshorbagy, A., (2018), Improving Resilience of Water Resources Systems through Public Awareness: The Key Role of Media in Affecting Agricultural Water Use, International Conference of the International Commission on Irrigation and Drainage, 12–17 August 2018, Saskatoon, Saskatchewan, Canada.

Gibson, C, *Wallace, C, Brockington, M, Jasiak, I, *Woodworth, S, Tanche, K, Spring, A, Baltzer, J. 2018. Science Outreach and Youth Engagement in an innovative On-the-Land Camp in the NWT. ArcticNet. Ottawa.

Gill, A. 2018. A mixed method study to inform risk communications on Harmful Algal Blooms (HABs) in the Prairies. School of Public Health Poster Day. University of Saskatchewan, Saskatoon, SK. September 28, 2018

Glass, B. and Rudolph, D.L. (2019). Identifying Groundwater Discharge Zones in Northern Canada using Remotely Sensed Optical and Thermal Imagery. NovCare 2019: The 6th International Conference Novel Methods for Subsurface Characterization and Monitoring: From Theory to Practice. Waterloo, Ontario

Glass, B. and Rudolph, D.L. (2019). Identifying Groundwater Discharge Zones in Northern Canada using Remotely Sensed Optical and Thermal Imagery. 2nd Annual Open Science Meeting: Global Water Futures. Saskatoon, Saskatchewan, Canada, May 15-17, 2019.

Glass, B. K., Rudolph, D. L. and Duguay, C., 2018. Use of Remote Geophysical Imagery for the Analysis of Hydrogeological Processes in the Central Mackenzie Valley. Global Water Futures, Annual Science Meeting, MacMaster University, Hamilton, Ont., June.

Glass, B. K., Rudolph, D. L. and Duguay, C., 2018. Use of Remote Geophysical Imagery for the Analysis of Hydrogeological Processes in the Central Mackenzie Valley. Global Water Futures Annual Science Meeting. MacMaster University, Hamilton, Ontario.

Grant, K.N., Macrae, M.L., Ali, G.A. Subsurface flow paths and risk of P transport in no-till agricultural soils. Poster Presentation. Canadian Geophysical Union Joint Annual Meeting: June 10-14, 2018. Niagara Falls, Ontario, Canada.

Grant, K.N., Macrae, M.L., Ali, G.A. Subsurface flow paths and risk of P transport in no-till agricultural soils. Poster Presentation. Global Water Futures Annual Science Meeting: June 3¬6, 2018. Hamilton, Ontario, Canada.

Grant, K.N., Macrae, M.L., Rezanezhad, F., Lam, W.V. Mobilization of Phosphorus in frozen and unfrozen soil under no-till agricultural management with different fertilizer application strategies. Oral Presentation. Canadian Geophysical Union Joint Annual Meeting: June 10-14, 2018. Niagara Falls, Ontario, Canada.

Green, A.J., Bohrer, G., Petrone, R.M. 2018. The effects of forest sheltering on peatland surface level turbulent processes in the Boreal Plains, Alberta, Canada. Annual General Meeting of the Canadian Geophysical Union,June 10 - 14, 2018, Niagara Falls, Ontario, Canada.

Greuel, R., *G. Degré-Timmons, S. Cumming,* N. Day, S. Hart, E. McIntire, P. McLoughlin, F. Schmiegelow, M. van Telgen, M. Turetsky, A. Truchon-Savard, J. Baltzer & J. Johnstone. (2018). Comparing estimates of forage lichen recovery after fire in Saskatchewan and the Northwest Territories. Poster presentation, North American Caribou Workshop, Ottawa, ON.

H. Townsend, F. Rezanezhad, P. Van Cappellen and M. Macrae. Examining the influence of freeze-thaw cycles on carbon and nutrient dynamics in agroecosystems. 6th International Conference Novel Methods for Subsurface Characterization and Monitoring: From Theory to Practice, NovCare, May 28-31, 2019, Waterloo, Canada.

H. Townsend, F. Rezanezhad, P. Van Cappellen and M. Macrae. Understanding the influence of ice on the mobility of carbon, nitrogen and phosphorus in agricultural soils. 2nd Global Water Futures (GWF) Annual Open Science Meeting. May 15 -17, 2019, Saskatoon, Saskatchewan, Canada.

Haghnegahdar A., Razavi R, Pietroniro A., Pomeroy A., Wheater H., Gober P., The Integrated Modelling Program for Prediction and Management of Change in Canada's Major River

Basins (IMPC), EGU General Assembly, Vienna, Austria, 8-13 April 2018 (Oral presentation)

Haghnegahdar, A., Razavi, S., (2018) On Multi-criteria Global Sensitivity Analysis of

Haghnegahdar, A., Razavi, S., (2018), Towards Improved Subsurface Representation in Land Surface-Hydrology Models, American Geophysical Union (AGU) Fall Meeting, Washington DC. December 10-14, 2018.

Haghnegahdar, A., Razavi, S., Pietroniro, A., Pomeroy, J., Wheater, H., Gober, P., (2018) The Integrated Modelling Program for Canada (IMPC), , Canadian Water Resources Association, 28-31 May 2018, Victoria, BC, Canada

Haghnegahdar, A., Razavi, S., Wheater, H., (2018) Towards improved subsurface representation in Land Surface Models, GWF Annual Science Meeting 2018, 3-6 June 2018, Hamilton, ON, Canada

Haghnegahdar, A., Razavi, S., Wheater, H., (2018), Highlighting the importance of subsurface representation in Earth System Models, European Geosciences Union (EGU) General Assembly, 8–13 April 2018, Vienna, Austria (Poster Presentation).

Hallema, D.W., Sun, G., Caldwell P., Robinne, F.N., Bladon, K.D., Mordecai, R.S., Saia, S.M., McNulty, S.G. 2018. Machine learning in wildfire-linked water supply risk assessment: Data science toolkit. Presented at the American Geosciences Union Meeting, December 2018, Washington, DC, USA.

Han, M., Mai, J., Craig, J. R., Tolson, B. A., Gaborit, E., Lee, K., and Liu, H. (2019). Including Missing Lakes in Our Model: A Flexible Catchment-based Lake and River Routing Product for Hydrologic and Land Surface Models in Canada. World Waters Day at University of Waterloo, Waterloo, ON, March 22, 2019.

Han, M., Mai, J., Craig, J. R., Tolson, B. A., Gaborit, E., Lee, K., and Liu, H. (2018). Developing a Pan-Canadian Hydrologic Routing Network of Lakes and Rivers, 2018 Joint Meeting of CGU, CSSS, CIG, ES-SSA and CSAFM, June 10-14, Niagara Falls, ON.

Han, M., Mai, J., Tolson, B. A., Craig, J. R., and Basu, N.B. (2019). Developing a flexible vegetation growth library for hydrology models. GWF Annual Science Meeting, Saskatoon, SK.

Hanke, K., Macrae, M.L., Michaud, A. and Basu, N. Use of the SWAT model to determine the impacts of climate change on runoff and nutrient mobility in the Medway Creek watershed and examine the impacts of controlled drainage on runoff and nutrient losses at the field scale. Second Quebec-Ontario Controlled Drainage Workshop, June. 15, 2018

Harder PS, Pomeroy JW, Helgason WD, (2018). Modelling local scale sensible and latent heat advection contributions to snowmelt. Joint Meeting of the Canadian Geophysical Union (CGU), Canadian Soil Science Society, Computational Infrastructure in Geodynamics, Eastern Section of Seismological Society of America and Canadian Society for Agricultural and Forest Meteorology, Niagara Falls, Canada, June 10, 2018

Harper N, Marjan P, Lynch M, Doxey AC, Servos MR, Giesy JP, Craig PM and Katzenback BA. Validating environmental DNA metabarcoding methods via conventional taxonomic identification in Ontario's Grand River watershed. Poster Presentation, *Canadian*

Ecotoxicity Workshop. Vancouver, British Columbia, Canada. Sept 30 – Oct 3, 2018. *Awarded the Arthur J. Niimi Outstanding Student Poster Presentation Award.

Harper, N, Ikert H, Lynch M, Doxey AC, Servos MR, Giesy JP, Craig PM, and BA Katzenback. Validating eDNA metabarcoding surveys via electrofishing in an inhibitor-laden stream. 28th Comparative Physiology and Biochemistry Workshop. Keene, Ontario. January 27, 2019.

Harper, N, Ikert H, Lynch M, Doxey AC, Servos MR, Giesy JP, Craig PM, and BA Katzenback. Validating eDNA metabarcoding surveys via electrofishing in an inhibitor-laden stream. Oral Presentation. 28th Comparative Physiology and Biochemistry Workshop. Keene, Ontario. January 27, 2019.

Henderson RI, Salk KR, Schiff SL, and Venkiteswaran JJ. Diel trends in stable isotope values of dissolved inorganic carbon in a eutrophic boreal lake. CCFFR/SCL 2019 London ON. January 6-10, 2019.

Hergott, A., Cavaliere, E., Whitfield, C.J., and Baulch, H. (2019) The rate and controls of nitrogen biogeochemistry in the Prairie Potholes, Canada. Prairie Water 2nd Annual Partners Meeting. Holiday Express Inn & Suites, Saskatoon, SK. January 24-25, 2019. (*Poster*)

Hergott, A., Cavaliere, E., Whitfield, C.J., and Baulch, H. (2019) The rate and controls of nitrogen biogeochemistry in the Prairie Potholes, Canada. World Water Day Event, University of Saskatchewan, Saskatoon, SK March 22th, 2019 (*Poster*)

Hergott, A., Cavaliere, E., Whitfield, C.J., and Baulch, H. (2019) The rates and controls of nitrogen biogeochemistry in the Prairie Potholes, Canada. SENS Symposium, University of Saskatchewan, Saskatoon, SK March 28th, 2019 (*Presentation*)

Hickman, J., M. English, P. Marsh. (2018) Identification of patterns in hydrological conditions governing flow in an unregulated river basin in the Northwest Territories, and implications for downstream hydroelectric production. European Conference on Permafrost Chamonix, France, July.

Hickman, J., M.English, *N. Wilson, S.Kokelj, R. Judas. (2018). Using aerially weighted terrain units to improve accuracy in SWE estimates in the Snare River watershed, Northwest Territories, Canada. ArcticNet Annual Meeting. Ottawa. December

Ho, E., Courtenay, S., and Trant, A. 2018. Comparative review of freshwater monitoring approaches towards consideration of cumulative effects [poster]. McMaster University World Water Week conference, November 20, 2018, Hamilton, Ontario.

Hodgson R., Servos, M.R., Craig P.M. (2019). Wastewater Effluent Effects on Metabolism of Darter Species in the Grand River. Canadian Society of Zoologists. Canadian Society of Zoologists. Windsor, Ont., May 13-17, 2019

Hodgson, R, Servos, M.R, and Craig P.M. (2019). The Effects of Wastewater Effluent on Gill Physiology of Darter Species in the Grand River. 28th Comparative Physiology & Biochemistry Workshop. Poster presentation. Keene, Ontario, Jan. 25-27, 2019.

Hoekstra, M., Foroutan, M., Kang, K., Duguay, C., 2019. Preliminary Testing of the senseFly thermoMAP Infrared Camera for Surface Water Temperature Measurements of a Small

Lake - Wilmot, Ontario, Canada. GRSS Systems and Technologies for Remote Sensing Applications Through Unmanned Aerial Systems Conference. Rochester, NY.

Hoggarth, C. and Baulch, H. (2019) Which prairie wetlands do we need? Ecosystem services, biogeochemistry, and conservation priorities. Prairie Water 2nd Annual Partners Meeting. Holiday Express Inn & Suites, Saskatoon, SK. January 24-25, 2019. (*Poster*)

Hrach D, Petrone R. Quantifying seasonal evapotranspiration of a sub-alpine wetland, Kananaskis, Alberta. McMaster Water Week 2018, poster presentation. Award winner of the GWF Young Professionals Best Student Post Award. November 21, 2018

Hrach D, Petrone R. Quantifying seasonality and role of shading dynamics on a subalpine wetland, Kananaskis, Alberta. CGU Eastern Student Section Meeting 2018, poster presentation.

Huang, X., *Glass, B. and Rudolph, D.L. 2019. Impacts of variable soil freezing conditions in the shallow subsurface on stress fields over urban water mains. NovCare 2019: The 6th International Conference Novel Methods for Subsurface Characterization and Monitoring: From Theory to Practice. Waterloo, Ontario

Huang, X., and Rudolph, D.L. (2019). Modeling of water, vapor, heat and stress fields in variably saturated freezing the soil. 2019 GWF Annual Science Meeting. Saskatoon, Canada, May 15-17, 2019.

Hughes, A., Cey, E.E., and Hayashi, M. (2018) The role of irrigation in depression-focused groundwater recharge in the Canadian Prairies. Joint Annual Meeting of the Canadian Geotechnical Society and the International Association of Hydrogeologists - Canadian National Chapter. Edmonton, Alberta, September 23-26, 2018. (*Presentation*)

Hydrological Models, Canadian Water Resources Association, 28-31 May 2018, Victoria, BC, Canada.

Ikert H, Lynch M, Doxey AC, Servos MR, Giesy JP, Katzenabck BA, Craig PM. Identification of secreted microRNA from acutely stressed *Oncorhynchus mykiss.* Canadian Society of Zoologists. Windsor, Ont., May 13-17, 2019

Ikert H, Lynch M, Doxey AC, Sevos MR, Giesy JP, Katzenabck BA, Craig PM. (2019) Identification of Secreted microRNA from Acutely Stressed *Oncorhynchus mykiss)*. Canadian Society of Zoologists. Oral presentation.

Ikert HA, Lynch M, Marjan P, Doxey AC, Servos MR, Giesy JP, Katzenback BA and Craig PM. Alteration of secreted miRNA from stressed rainbow trout identified via high throughput sequencing. *Canadian Ecotoxicity Workshop*. Vancouver, British Columbia, Canada. Sept 30 – Oct 3, 2018.

Ikert HA, Lynch M, Marjan P, Doxey AC, Servos MR, Giesy JP, Katzenback BA and Craig PM. Functional implications of altered miRNA following a multiple stressor exposure in zebrafish (*Danio rerio*). *Society of Environmental Toxicology and Chemistry North America,* Sacramento, California, USA from November 4 – 8, 2018.

Ikert HA, Marjan P, Doxey AC, Servos MR, Giesy JP, Katzenback BA and Craig PM. Can microRNA secreted from trout be used to detect their response to stress? Oral Presentation, *Canadian Society of Zoologists*. St. Johns, Newfoundland. May 7 – 11, 2018.

Ikert HA, Marjan P, Doxey AC, Servos MR, Giesy JP, Katzenback BA and Craig PM. Can microRNA secreted from trout be used to detect their response to stress? *Global Water Futures Annual Science Meeting*. Hamilton, Ontario. June 3 – 6, 2018.

Ikert HA, Marjan P, Doxey AC, Servos MR, Giesy JP, Katzenback BA and Craig PM. Can microRNA secreted from trout be used to detect their response to stress? *Laurentian Chapter of the Society of Environmental Toxicology and Chemistry*. Kingston, Ontario. June 8, 2018. Awarded best PhD presentation

Ikert, Heather, P. Marjan, A.C. Doxey, M.R. Servos, J.P. Giesy, B.A. Katzenback, and P.M. Craig (2019). Can microrna secreted from trout be used to detect their response to stress? 28th Comparative Physiology & Biochemistry Workshop. Poster presentation. Keene, Ontario, Jan. 25-27, 2019.

Irvine, S., Rastelli, J., Biagi, K., Carey, S.K. 2018. Temporal and spatial variability in the DOC dynamics of a constructed wetland in the Athabasca Oil Sands Region. Presented at the Canadian Geophysical Union Annual General Meeting, June 2018, Niagara Falls, ON.

Ives, J., Rooney, R., Ivanova, S.V., Ciborowski, J., Barker, N., and Gannon, J. (2018). Assessing drivers of human-induced change in Lake Erie using fuzzy cognitive mapping. International Association for Great Lakes Research Conference, Toronto, Canada, June 2018.

Ives, J.T., Ciborowski, J.J.H., Rooney, R., Ivanova, S.V., Barker, N., Gannon, J., Bass, B., and Findlay, C.S. (2018). Assessing drivers of human-induced change in Lake Erie using fuzzy cognitive mapping. Poster presentation at the International Association for Great Lakes Research in Scarborough, ON, on June 18th-22nd 2018

J Hickman and R Connon. 2018. Arsenic mobility in terrestrial and aquatic ecosystems of the Lake 10 catchment, NWT. Canadian Association of Geographers – Ontario Division Annual Meeting, University of Toronto, Toronto.

J Hickman and R Connon. 2018. Characterizing arsenic deposition and mobility in terrestrial and aquatic ecosystems of the 'Lake 10' catchment, NWT. Geoscience Forum, Yellowknife.

Jasiak I, *M Kay, BB Wolfe and RI Hall. (2018). Clear as mud: Reconstructing the hydrology and contaminant deposition at a lake in the Peace-Athabasca Delta, Canada. *Ontario-Quebec Paleolimnology Group Graduate Student Conference*, Brock University, St. Catharines [*received best poster award*].

Jasiak I, J Telford, JA Wiklund, RI Hall and BB Wolfe. 2019. Defining a legacy pollution footprint: assessing spatiotemporal patterns of arsenic and other metals in sub-arctic lakes using paleolimnology. Canadian Geophysical Union – Hydrology Section Ontario Student Conference, Ryerson University, Toronto.

Jasiak I, M Schultz, J Telford, R Connon, J Hickman, BB Wolfe and JJ Venkiteswaran. SAMMS: Sub-Arctic Metal Mobility Study. Global Water Futures Annual Science Meeting, Hamilton.

Jasiak I, M Schultz, J Telford, RI Hall, BB Wolfe, L Mindorff and J McGeer. 2018. Assessing spatiotemporal patterns of arsenic and other metals in sub-arctic lakes. Cold Regions Research Centre Day, Wilfrid Laurier University, Waterloo.

Jasiak I, M Schultz, J Telford, RI Hall, BB Wolfe, L Mindorff and J McGeer. 2018. Tracking legacy pollution: assessing spatiotemporal patterns of arsenic and other metals in subarctic lakes

using paleolimnology. Canadian Association of Geographers – Ontario Division Annual Meeting, University of Toronto, Toronto received best poster award].

Jasiak I, M Schultz, J Telford, RI Hall, BB Wolfe, L Mindorff and J McGeer. 2018. Tracking legacy pollution: assessing spatiotemporal patterns of arsenic and other metals in subarctic lakes using paleolimnology. Geoscience Forum, Yellowknife.

Jasiak I. 2018. SAMMS: The Sub-Arctic Metal Mobility Study. Presentation to Government of the Northwest Territories – Environment and Natural Resources, Yellowknife (17 August 2018).

Jason Flemke, Yanping Li, Changhai Liu, (2018), Central U.S. WRF statistical verification of simulated composite radar. 8th GEWEX Science Conference, 6-11 May 2018 in Canmore, Alberta, Canada

Jason Flemke, Yanping Li, Changhai Liu, 2018: Central U.S. WRF statistical verification of simulated composite radar. 8th GEWEX Science Conference, 6-11 May 2018 in Canmore, Alberta, Canada

Jawed, Z. (August 2018). Use of Decision Support Tools to Address Emerging Issues in the Great Lakes, Global Water Future Annual Symposium, McMaster University. C27. Kheyrollah Pour, H., and Van Cappellen, P. (2019). Climate Change Signal in the Great Lake Water Quality. World Wetland Day, University of Waterloo, Feb 4, 2019.

Jawed, Z. and Krantzberg, G. (August 2018). The role of practitioners in Decision Support System formulation, Global Water Future Annual Symposium, McMaster University.

Jawed, Z. and Krantzberg, G. (June 2018). Use of Decision Support tools to Address emerging issues in the Great Lakes, GWF Annual Science Meeting, McMaster University.

JD Neufeld. 2018. Complex phototrophic ecology in a seasonally anoxic boreal shield lake. 17th International Symposium on Microbial Ecology (ISME17) August 12th-17th, 2018; Leipzig, Germany

K. Grant, M.L. Macrae, F. Rezanezhad, W.V. Lam. Phosphorus movement in frozen and unfrozen soil under no-till agricultural management with different fertilizer strategies. 9th World Water Day, University of Waterloo, March 22, 2018. **(Winner of Best Research Poster Award)**.

K. Grant, M.L. Macrae, F. Rezanezhad, W.V. Lam. Phosphorus transport in frozen and unfrozen soil under no-till agricultural management with different fertilizer application strategies. 2018 CGU Joint Meeting, 10-14 June 2018, Niagara Falls, Ontario, Canada. **(Winner of Don Gray Scholarship in Canadian Hydrology)**

K. Krogstad, G. Jensen, L.A. Hug and F. Rezanezhad. How are Fall Fertilizer Amendments Affected by Winter Soil Conditions? 2nd Global Water Futures (GWF) Annual Open Science Meeting. May 15 -17, 2019, Saskatoon, Saskatchewan, Canada.

K. Krogstad, G. Jensen, L.A. Hug and F. Rezanezhad. Investigating the Effects of Freeze-Thaw Conditions on Nutrient Cycling and Fall Fertilizer Efficacy. 6th International Conference Novel Methods for Subsurface Characterization and Monitoring: From Theory to Practice, NovCare, May 28-31, 2019, Waterloo, Canada.

K. Pi, J. Liu, F. Rezanezhad, P. Van Cappellen. Mercury sensing by DNA: Field-deployable routine detection of trace-level aqueous Hg^{2+}. 2nd Global Water Futures (GWF) Annual Open Science Meeting. May 15 -17, 2019, Saskatoon, Saskatchewan, Canada.

K.K. Kang, M. Hoekstra, M. Foroutan, A.M. Chegoonian, Kiana Zolfaghari, C.R. Duguay, "Operating Procedures and Calibration of a Hyperspectral Sensor onboard a Remotely Piloted Aircraft System for Water and Agriculture Monitoring", The International Geoscience and Remote Sensing Symposium (IGARSS), Yokohama, Japan (July-Aug 2019).

Karran DJ, Loisel J, Von Ness K, Westbrook CJ, Kohlmeyer C, Bedard-Haughn A. Enduring effects of topographic constraints on peat development in a beaver-inhabited montane fen. Joint meeting of the CGU-CSSS-GIC-ESSSA-CSAFM, Niagara Falls, Ontario, 10-14 June 2018.

Kay ML, *C Remmer, J Vucic, *L Neary, E MacDonald, K Wesenberg, K Thomson, K Brown, JA Wiklund, B Wolfe and RI Hall. (2018). Use of a binary mixture model to reconstruct 300 years of Athabasca River sediment metal concentration from floodplain lake cores. *International Paleolimnology Symposium*, Stockholm, Sweden.

Kay ML, *C Remmer, J Vucic, *L Neary, MacDonald, K Wesenberg, K Thomson, K Brown, JA Wiklund, B Wolfe and RI Hall. (2019). Use of mixture models to reconstruct long-term records of Athabasca River sediment metal concentrations from floodplain lake cores. *Canadian Geophysical Union – Hydrology Section Ontario Student Conference*, Ryerson University, Toronto.

Kay ML, *C Remmer, J Vucic, *L Neary, MacDonald, K Wesenberg, K Thomson, K Brown, JA Wiklund, B Wolfe and RI Hall. (2018). Use of mixture models to reconstruct 300 years of Athabasca River sediment metals concentrations from floodplain lake cores. *Ontario-Quebec Paleolimnology Group Graduate Student Conference*, Brock University, St. Catharines.

Kay ML, *C Remmer, J Vucic,* L Neary, E MacDonald, K Wesenberg, K Thomson, K Brown, JA Wiklund, B Wolfe and RI Hall. (2018). Discerning the effects of major energy projects, climate and change in distributary flowpaths on hydrology of lakes in the Athabasca Delta, Canada. *International Paleolimnology Symposium*, Stockholm, Sweden.

Kershaw, G., W. Quinton. (2018). Precipitation inputs in a Nival basin, Mackenzie Mountains, NWT. Annual meeting of the Cold Regions Research Centre: Cold Regions Research Centre Days, 29-30 Nov., 2018, Wilfrid Laurier University, Waterloo, Canada.

Kershaw, GL, WL Quinton, M English. (2018). Using stable isotopes to assess seasonal variations in runoff response from an alpine valley basin in the Mackenzie Mountains, NWT, Association of Canadian Universities for Northern Studies (ACUNS), Student Conference, November 1-3, 2018, Edmonton, Canada.

Keshavarz, K., Razavi, S. and Slaughter, A. (2018), An Evaluation of the Apportionment Agreements of the Transboundary Rivers of the Saskatchewan River Basin under Future Climate Change Scenarios, 69th International Conference of the International Commission on Irrigation and Drainage (ICID), August 2018, Saskatoon, SK, Canada.

Keshavarz, K., Razavi, S., Slaughter, A., (2018) Integrated Water Resources Management of the Saskatchewan River Basin using WEAP, GWF Annual Science Meeting 2018, 3-6 June 2018, Hamilton, ON, Canada.

Khan H, *ML Kay, I Jasiak, RI Hall and BB Wolfe. (2019). Investigating past changes in water balance of two small central closed-drainage lakes in the Peace-Athabasca Delta using paleolimnological methods. *Canadian Geophysical Union – Hydrology Section Ontario Student Conference*, Ryerson University, Toronto.

Kheyrollah Pour, H., Bocaniov, S., Markelov, I., and Van Cappellen, P. (2018). Effects of Winter Conditions on Chlorophyll-a in Lakes: Detection and Attribution of Climate Change Signal. European Large Lakes- International Association for Great Lakes (ELLS-IAGLR), Evian, France, September 23-28, 2018.

Kheyrollah Pour, H., Bocaniov, S., Markelov, I., and Van Cappellen, P. (2018). Seasonal Patterns of Chlorophyll and Temperature in Lakes: Detection and Attribution of Climate Change Signal. Global Water Futures, Annual Science Meeting, Macmaster University, Canada, June 3-6.

Kiana Zolfaghari, M. Hoekstra, C.R. Duguay, D. Rudolph, I. D'Souza, "Concept Design of a Canadian Water Microsatellite Mission", 6th International Conference Novel Methods for Subsurface Characterization and Monitoring: From Theory to Practice (NovCare), Waterloo, Ontario, Canada (May 2019).

Kiana Zolfaghari, M. Hoekstra, C.R. Duguay, D. Rudolph, I. D'Souza, "Canadian Water Microsatellite Mission – Concept Design", Global Water Futures (GWF) Annual Science Meeting 2019, Saskatoon, Canada, 15-17 May.

Kiana Zolfaghari, M. Hoekstra, C.R. Duguay, D. Rudolph, I. D'Souza, "Canadian Water Microsatellite Mission – Concept Design", Submitted to The International Geoscience and Remote Sensing Symposium (IGARSS), Yokohama, Japan (July-Aug 2019).

Kiana Zolfaghari, S. Bird, G. Wilkes, D. Ellis, K.D.M. Pintar, N. Gottschall, E. Topp, C.R. Duguay, H. McNairn, and D.R. Lapen, "A Comparison of Lab- and Field-based Water Quality Measurements for Agricultural Surface Waters", Global Water Futures (GWF) Annual Science Meeting 2018, Hamilton, Canada, 4-6 June.

Kiana Zolfaghari, S. Bird, G. Wilkes, D. Ellis, K.D.M. Pintar, N. Gottschall, E. Topp, C.R. Duguay, H. McNairn, and D.R. Lapen, "A Comparison of Lab- and Field-based Water Quality Measurements for Agricultural Surface Waters", International Association for Great Lakes Research (IAGLR), Toronto, Ontario, Canada (June 2018).

Kiana Zolfaghari, S. Bird, G. Wilkes, D. Ellis, K.D.M. Pintar, N. Gottschall, E. Topp, C.R. Duguay, H. McNairn, and D.R. Lapen, "Using WorldView Imagery to Study Chlorophyll-a Concentration in South Nation River, Eastern Ontario, Canada", OCEAN OPTICS XXIV, Dubrovnik, Croatia (Oct. 2018).

Kidd, K., M. Servos, M. Hecker, F. Gagné. Assessment of environmental risks related to emerging contaminants in municipal wastewaters – a toolbox approach. Water Research Foundation, Denver, Co., Sept. 20, 2018. Abstract

Kinar NJ, Pomeroy JW, (2018). Internet of Things (IoT) Systems and Measurement of Snowpacks. Joint Meeting of the Canadian Geophysical Union (CGU), Canadian Soil Science Society, Computational Infrastructure in Geodynamics, Eastern Section of Seismological Society of America and Canadian Society for Agricultural and Forest Meteorology, Niagara Falls, Canada, June 10, 2018

Klemt W, RI Hall and BB Wolfe. (2018). Defining the natural range of variation and extent of metal pollution of the Athabasca River in the Alberta oil sands region: an approach using floodplain lake sediments. *International Paleolimnology Symposium*, Stockholm, Sweden

Klemt W, RI Hall and BB Wolfe. (2018). Use of floodplain lake sediments to determine the natural range of variation and extent of vanadium pollution of the Athabasca River in the Alberta oil sands region. *Ontario-Quebec Paleolimnology Group Graduate Student Conference*, Brock University, St. Catharines.

Klemt W, RI Hall and BB Wolfe. (2019). Flood-influenced lakes as archives of natural and anthropogenic trace metal deposition in the oil sands region: an approach to define pre-industrial baseline conditions. *Canadian Conference for Fisheries Research / Society of Canadian Limnologists*, London.

Klemt, W., Wolfe, B., Hall, R. (2019). Flood-influenced lakes as archives of natural and anthropogenic trace metal deposition in the oil sands: an approach to define pre-industrial baseline conditions. Canadian Conference for Fisheries Research (CCFFR)/ Society of Canadian Limnologists (SCL). London, Ontario.

Klemt, W.; Wolfe, B.; Hall, R. 2018. Defining the natural range of variation and extent of metal pollution of the Athabasca River in the Alberta oil sands region: an approach using floodplain lake sediments. International Paleolimnology Association/ International Association of Limnogeology. Stockholm, Sweden.

Knox, S.H., Jackson, R.B., Poulter, B. et al. incl. Sonnentag, O. (2018), FLUXNET-CH4 Synthesis Activity: objectives, observations, and future directions. Abstract B43D-08, December 2018, Washington, D.C., USA.

Kompanizare*, M., Macrae, M.L., Plach, J., Carlow, R., Brunke, R., “Improving estimates of phosphorous loads from tile-drained landscapes using Kriging techniques” Global Water Future Annual Meeting, June 3-6, 2018, Hamilton, Ontario, Canada.

Kompanizare, M., Macrae, M., Petrone, R., “How will climate change affect P loss and water use efficiency?” Global Water Future, Local Water Solutions in a Changing Climate Workshop, Waterloo, ON, December, 2018.

Kompanizare, M., Macrae, M.L., Carlow, R., Brunke, R., “Hysteresis in tile flow rating curves: a case study from an Ontario farm” CGU Annual Meeting, June 10-14, 2018, Niagara Falls, Ontario, Canada.

Kompanizare, M., Petrone, R., Macrae, M.L., Green, A., Khomik, M., “Assessment of water use efficiency in selected vegetation coverage at a farm scale – model testing” CGU Annual Meeting, June 10-14, 2018, Niagara Falls, Ontario, Canada.

Krafczek, M. and A. Berg. 2018. Contributions of geophysical data and SAR data collected at C-band and L-band for estimation of field scale soil moisture. Joint meeting of the Canadian

Geophysical Union, Canadian Soil Science Society and the Canadian Society for Agricultural and Forest Meteorology. Niagara, Ontario.

L. Fairbairn, F. Rezanezhad, C.T. Parsons, M.L. Macrae and P. Van Cappellen. Soil carbon dioxide fluxes: Decoupling the effects of soil moisture and oxygen. 2nd Global Water Futures (GWF) Annual Open Science Meeting. May 15 -17, 2019, Saskatoon, Saskatchewan, Canada.

L.A., S.L. Schiff, J.J. Venkiteswaran, H.M. Baulch, S.N. Higgins, A. Zastepa, M.J. Verschoor and D. Walters. 2018 IFHAB workshop on harmful cyanobacteria blooms, Toronto, plenary speaker, "Guiding principles for preventing cyanobacteria blooms: Integrating nutrient limitation and sediment redox science into watershed management".

Laamrani A., A. Berg, P.R Voroney, M. March, A.S. McLaren, R.C. Martin. 2018. Agricultural Soil Organic Carbon Levels Estimation Using Ground-Based and UAV-Imagery Thermal Data. American Society of Agronomy, the Crop Science Society of America, and the Canadian Society of Agronomy meeting. Baltimore, MD

Laamrani, A., A. Berg, M. March, A. McLaren, R. Martin. 2018. Use of UAV acquired imagery as a precision agriculture method for measuring crop residue in southwestern Ontario, Canada. 14th Annual Precision Agriculture Conference. Montreal, Quebec.

Lalonde, E. 2019. A Vignette-Based Field Experiment to Assess Mining Site Managers' Perception of Threat. Isci 3A12 final program reporting.

Lam, W.V., Macrae, M.L., English, M.C., O'Halloran, I., and Ali, G.A. Using hysteresis loops to examine phosphorus mobilization in southern Ontario tile drains. Oral Presentation. 2018 Joint Meeting of the Canadian Geophysical Union, Canadian Soil Science Society, Computational Infrastructure in Geodynamics, Eastern Section of Seismological Society of America, and Canadian Society for Agricultural and Forest Meteorology. Niagara Falls, Ontario, June 10-14, 2018.

Lamb, K.G., Bryne-Mamahit, S., and Stastna, M. (2018). Idealized numerical simulations of Ontario's Grand River plume. EGU General Assembly 2018. Vienna, Austria. April 8-13, 2018.

Langs L, Petrone R. Investigating alpine forest water use during variable growing season and climate conditions in the Canadian Rocky Mountains, Kananskis, Alberta. Canadian Geophysical Union Annual Meeting Niagara Falls 2018, oral presentation.

Langs L, Petrone R. Methods investigating alpine forest water use under varying environmental conditions in the Canadian Rocky Mountains. Canadian Geophysical Union Annual Meeting Vancouver 2017, poster presentation.

Langs, L, Petrone R. A δ18O and δ2H stable water isotope analysis of subalpine forest water sources under seasonal and hydrological stress in the Canadian Rocky Mountains, Kananaskis, Alberta. Canadian Geophysical Union Annual Meeting Niagara Falls 2018, poster presentation.

Larsen M. 2018. Longer summers drive multiple cyanobacterial blooms on Lake 227 – Global Water Futures Annual Meeting, June 06-08.

Larsen M. 2018. Cyanobacterial bloom composition and duration in Conestogo Reservoir: An investigation in the drivers of bloom formation – Global Water Futures Annual Meeting, June 06-08.

Larsen M. 2018. When one becomes two! Longer summers lead to multiple cyanobacterial blooms – American Society of Limnology and Oceanography, June 10-15.

Larsen ML, Venkiteswaran JJ, Baulch HM, Schiff SL, Higgins SN. Constant nutrient loads yield a lake with changing cyanobacteria blooms. CCFFR/SCL Conference, London, Ontario, January 6-10, 2019.

Leathers J, J Venkiteswaran, M English, S Schiff, J Hickman and M Schultz. 2018. Determining effects of climate change on arsenic mobility in peatlands: an experimental approach. Canadian Association of Geographers – Ontario Division Annual Meeting, University of Toronto, Toronto.

Leathers JG, JJ Venkiteswaran, MC English, SL Schiff, J Hickman and M Schultz. 2018. Determining effects of climate change on arsenic mobility in peatlands: an experimental approach. Geoscience Forum, Yellowknife.

Leclerc E, J Telford, I Jasiak, M Schultz, M English, J Venkiteswaran, B Wolfe and R-Marie Couture. 2018. Mobility and temporal trends of arsenic in lake sediments influenced by Giant Mine emissions, Northwest Territories. Sentinel North Annual Meeting, Université Laval, Quebec City.

Lei and Rooney. Searching for plant biodiversity in Alberta's Rocky Mountain peatlands. Biology Graduate Student's Symposium, University of Waterloo. 25 April 2019

Leroux N, Pomeroy J, (2018). Simulation of capillary overshoot in snow with a non-equilibrium Richards equation model combined with a trapping model for the water phase. European Geosciences Union (EGU) General Assembly, Vienna, Austria, April 8, 2018.

Leroux N, Pomeroy J, Helgason W, (2018). Impact of heat advection induced by topography-driven air ventilation on snow surface temperature. 75th Annual Eastern Snow Conference (ESC): SNOW PAST PRESENT and FUTURE, College Park, Maryland, USA, June 5, 2018

Leroux N, Pomeroy J, Helgason W. Impact of heat advection induced by topography-driven air ventilation on snow surface temperature. 75th Annual Eastern Snow Conference (ESC): SNOW PAST PRESENT and FUTURE, College Park, Maryland, USA, June 5, 2018

Leroux N, Pomeroy J. Simulation of capillary overshoot in snow with a non-equilibrium Richards equation model combined with a trapping model for the water phase. European Geosciences Union (EGU) General Assembly, Vienna, Austria, April 8, 2018

Leroux, N., Pomeroy, J., 2018. Simulation of capillary overshoot in snow with a non-equilibrium Richards equation model combined with a trapping model for the water phase. European Geosciences Union (EGU) General Assembly, Vienna, Austria, April 8, 2018.

Leroux, N., Pomeroy, J., Helgason, W., 2018. Impact of heat advection induced by topography-driven air ventilation on snow surface temperature. 75th Annual Eastern Snow Conference (ESC): SNOW PAST PRESENT and FUTURE, College Park, Maryland, USA, June 5, 2018

Li, Z. and Lindenschmidt, K.-E. (2018) Compact and fully polarimetric Synthetic Aperture Radar (SAR) for retrieving surface soil moisture content in vegetated agricultural fields. 39th Canadian Symposium on Remote Sensing, Saskatoon, Saskatchewan, Canada, 19-21 June, 2018

Li, Z. and Lindenschmidt, K.-E. (2018) Monitoring river ice cover development using the Freeman-Durden decomposition of quad-pol Radarsat-2 images. Global Water Futures inaugural meeting, Hamilton, Canada, 4-6 June 2018.

Li, Z., Budhathoki, S., Morales, L., Williams, B. and Lindenschmidt, K.-E. (2018) Dynamic Soil Moisture and Contributing Drainage Area Monitoring and Modelling using Multi-temporal SAR image. American Geophysical Union (AGU) 2018 Annual Meeting, Washington, D.C., 10 - 14 December 2018.

Li, Z., Zhang, F. and Lindenschmidt, K.-E. (2018) Integrating Radarsat-2, air photos, and environmental data for estimating river ice volume as an essential input for near-real time ice-jam flood forecasting. 39th Canadian Symposium on Remote Sensing, Saskatoon, Saskatchewan, Canada, 19-21 June, 2018

Liu J. et al. (2018) Are we unintentionally managing the nitrogen to phosphorus ratio of runoff? (2018) Joint Meeting of the CGU—CSSS—CIG—ES-SSA—CSAFM. Jun. 10-14, 2018. Niagara Falls, Ontario, Canda.

Liu J. et al. (2018) Controls of nitrogen to phosphorus ratios in a Canadian prairie watershed. Global Water Futures 1st Annual General Meeting. Jun. 4-6, 2018. Hamilton, Ontario, Canada.

Liu J. et al. (2018) Temporal and spatial controls of nitrogen to phosphorus ratios in a Canadian prairie watershed. Joint Meeting of the CGU—CSSS—CIG—ES-SSA—CSAFM. Jun. 10-14, 2018. Niagara Falls, Ontario, Canada.

Liu J. et al. (2019) Impacts of cover crops and crop residues on phosphorus losses in cold climates: A review. Soils and Crops conference. Mar. 5-6, 2019. Saskatoon, Saskatchewan, Canada.

Liu, J., Van Meter, K.J., and Basu, N.B. (2018). “Past, Present, and Future: Quantification of Long-Term Phosphorus Legacies in the Grand River Watershed,” Global Water Futures 2018 Annual Science Meeting, Hamilton, ON (poster)

Liu, Y., Zarfl, C., Basu, N. B., & Cirpka, O. A. (2018, December). Modeling the Fate of Sediments and Attached PAHs in a Base-Flow-Dominated River. American Geophysical Union, December 10-14, 2018, Washington D.C.

Lowitt, K., Levkoe, C., Pictou, S., Spring, A., Turlo, C., Williams, P., Sayers, D. (2018). "Fish as food": Food systems as an organizing concept for local community sustainability and fisheries policy. Communities, Conservation & Livelihoods Conference, St. Mary’s University, Halifax, NS. May 28-30, 2018

Lucia Scaff, Yanping Li, A. Prein, K. Ikeda, R. Rasmussen, C. Liu, 2018: Convective precipitation initiation over the eastern foothill of the Canadian Rockies under historical and future climate conditions. 8th GEWEX Science Conference, 6-11 May 2018 in Canmore, Alberta, Canada

Lucia Scaff, Yanping Li, A. Prein, K. Ikeda, R. Rasmussen, C. Liu, (2018): Convective precipitation initiation over the eastern foothill of the Canadian Rockies under historical and future climate

Lyon L. How does sporadic permafrost influence catchment-scale groundwater processes? Geotop Student Meeting – Orford, QC. March 2019

Lyon LN, McKenzie J, Langston G, Carey SK. Effects of groundwater flow on permafrost distribution in a subarctic watershed. Presented at the Canadian Geophysical Union Annual General Meeting, June 2018, Niagara Falls, ON.

M. L. Macrae, F. Rezanezhad, K. Grant, J. Cober, V. Lam. Impacts of frost on P mobilization and transport in agricultural landscapes with temperate climates. 2018 AGU Fall Meeting, 10-14 December 2018, Washington DC, USA.

Macrae, M.L., Ali, G., King, K., Plach, J., Pluer, W., Morison, M., Tang, W. and Williams, M. Activation of surface and subsurface flow pathways in temperate, tile drained landscapes. Soil Science Society of America International Soils Meeting. January 6-9, 2019, San Diego, USA. (Oral presentation).

Macrae, M.L., Rezanehzad, F., Grant, K.N., Cober, J.R., Van Eerd, L.L., Lam, W.V, Plach, J.M. Impacts of Frost on Phosphorus Mobilization and Transport in Agricultural Landscapes with Temperate Climates. Oral Presentation. American Geophysical Union Fall Meeting, Washington, D.C. December 2018.

Mai J. and Li Z., (2018), Automatic subsetting of WRF derived climate change scenario forcings, IMPC Annual General Meeting, Saskatoon, SK, July 18-19, 2018.

Mai J. and Tolson B., et al. (2018), Status report on the Great Lakes Runoff Inter-comparison Project for Lake Erie (GRIP-E), GWF Annual Science Meeting Hamilton, ON, June 4-6, 2018.

Mai, J., B A. Tolson, H Shen, É Gaborit, N Gasset, V Fortin, M Dimitrijevic, M Abrahamowicz, D Durnford, YL Shin, T Stadnyk, LM. Fry, T Hunter, AD. Gronewold, J Smith, L Mason, L Read, K Fitzgerald, K Sampson, AF. Hamlet, F Seglenieks, S Gharari, S Razavi, A Haghnegahdar, D Princz, and A Pietroniro. 2018. The Great Lakes Runoff Inter-comparison Project for Lake Erie (GRIP-E). American Geophysical Union meeting, 10-14 December, Washington, DC.

Mai, J., Tolson, B., Shen, H., Gaborit, E., Fortin, V., Dimitrijevic, M. , Gasset, N., Durnford, D., Shin, Y., Stadnyk, T., Fry, L., Hunter, T., Gronewold, A., Smith, J., Mason, L., Read, L., FitzGerald. K., Sampson, K., Hamlet, A., Seglenieks, F., Gharari, S., Razavi, S., Haghnegahdar, A., Princz, D., Pietroniro., A., (2018), The Great Lakes Runoff Inter-comparison Project for Lake Erie (GRIP-E), American Geophysical Union (AGU) Fall Meeting, Washington DC. December 10-14, 2018.

Malaj, E., Liber, K., and Morrissey C.A., (2018) Pesticide distribution trends in the Canadian Prairie Pothole Region. SETAC North America 39th Annual Meeting, Sacramento, CA, USA. November 4-8, 2018 (*Poster*)

Malaj, E., Liber, K., and Morrissey, C. (2019) Pesticides contamination in wetlands of the Prairie Pothole Region. Prairie Water 2nd Annual Partners Meeting. Holiday Express Inn & Suites, Saskatoon, SK. January 24-25, 2019. (*Poster*)

Malaj, E., Liber, K., Badiou, P., Sheedy, C., Headley, J., Peru, K., and Morrissey C.A., (2018) Large-scale risk assessment of pesticides in Canadian Prairie wetlands. SETAC North America 39th Annual Meeting, Sacramento, CA, USA. November 4-8, 2018 (*Presentation*)

Malaj, E., Morrissey, C., and Liber, K. (2018) Occurrence and distribution of pesticides in the Prairie Pothole Region. In Aquatic Environment and Ecosystems: Global Water Futures Inaugural Annual Science Meeting. McMaster University, Hamilton, ON. June 4-6, 2018. (*Poster*)

Mantyka-Pringle C, Messmer D, Leston L, Asong E, Bayne E, Bortolotti L, Sekulic G, Wheater H, Howerter D & Clark R. (2018) Ghosts of climate and land-use past or present – antagonistic, synergistic and direct effects of aquatic communities. North American Congress for Conservation Biology, July 21-26, Toronto, Ontario, Canada. (*Presentation*)

March, M, A. Laamrani, A. Berg, R. Martin, P. Voroney. 2018. Assessing soil organic carbon levels at the sub-field scale in Southwestern Ontario using a UAV mounted multispectral sensor. 14th Annual Precision Agriculture Conference. Montreal Quebec, Canada.

March, M. M. Kopan, A. Berg, A. Laamrani, R. Pardo. 2018. Quantifying surficial crop residue using a supervised classification method and multispectral drone imagery. Joint meeting of the Canadian Geophysical Union, Canadian Soil Science Society and the Canadian Society for Agricultural and Forest Meteorology. Niagara Ontario.

Marinier, S and J M Thériault (2018), Precipitation characteristics during winter storms over eastern Canada using convection-permitting climate model simulations, 8TH GEWEX Open Science Conference: Extremes and water on the edge, Canmore, Canada

Marinos, R., & Basu, N. B. (2018). Geomorphic Versus Land Use Controls on the Source/Sink Behavior of the Riparian Zone. American Geophysical Union, December 10-14, 2018, Washington D.C.

Marjan P, Katzenback BA, Doxey AC, Craig PM, Giesy JP, Servos MR. From challenges to recommendations for brook trout (*Salvelinus fontinalis*) environmental DNA (eDNA) method development. Poster Presentation. *Canadian Ecotoxicity Workshop.* Vancouver, British Columbia, Canada. Sept 30 – Oct 3, 2018.

Marjan P, Katzenback BA, Doxey AC, Craig PM, Giesy JP, Servos MR. Temporal changes in brook trout (*Salvelinus fontinalis*) environmental DNA (eDNA) detection rates in the Grand River sub-watershed, Ontario – Washington Creek case study. *Canadian Ecotoxicity Workshop.* Vancouver, British Columbia, Canada. Sept 30 – Oct 3, 2018.

Markelov, I., Bocaniov, S., Kheyrollah Pour, H., and Van Cappellen, P. (2018). Dynamic modelling of geochemical (C, N, P, Fe, O, S) fluxes in lakes using a coupled water-column and sediment diagenesis model, Global Water Futures, Annual Science Meeting, Macmaster University, Canada, June 3-6.

Martin T, Kehoe L, Mantyka-Pringle C, Chades I, Wilson S, Bloom R, David S, Fisher R, Mehl K, Prieto D, Wayland M, Wellicome T, Zimmer K, & Smith P (2018) Prioritizing recovery funding to maximize conservation of endangered species. North American Congress for Conservation Biology, July 21-26, Toronto, Ontario, Canada. (*Presentation*)

Matte, D, J M Thériault, R Laprise (2018), Mixed precipitation occurrences over southern Québec, Canada, with warmer climate conditions using a Regional Climate Model. 8TH GEWEX Open Science Conference: Extremes and water on the edge, Canmore, Canada

McFadden, V and J M Thériault (2018). Simulations of the ice storm in the Maritime Provinces on 24-26 January 2017, Canadian Meteorological and Oceanographic Society (CMOS) Congress, Halifax, Canada [OP]

McFarlan, L., Whitfield, C.J., and Bedard-Haughn, A. (2019) Where's the P in Prairie Potholes? Understanding the role of wetlands in phosphorus retention and release. Prairie Water 2nd Annual Partners Meeting. Holiday Express Inn & Suites, Saskatoon, SK. January 24-25, 2019. (*Poster*)

McFarlan, L., Whitfield, C.J., and Bedard-Haughn, A. (2019) Where's the P in Prairie Potholes? Understanding the role of wetlands in phosphorus retention and release. SENS Symposium, University of Saskatchewan, Saskatoon, SK March 28th, 2019 (*Presentation*)

McIntosh, J.C. and Ferguson, G. (2019) Large-scale changes in subsurface water budgets from oil and gas production. AGU Fall Meeting. Washington, DC. Dec. 9-13, 2018. (*Presentation*)

McKenzie J. "Effects of groundwater flow on permafrost distribution in a subarctic watershed" CGU Joint Meeting – Niagara Falls, ON. June 2018

McKenzie J. Groundwater Flow and Permafrost Distribution in a Subarctic Watershed. GWF Annual Science Meeting – Hamilton, ON. May 2018

McKenzie, S.M., Arain, A., Pisaric, M., & Parker, W. (2018, June 10-14). Climate and Stand Density Effects on Growth in a Red Pine Plantation in Southern Ontario. Oral presentation at the meeting of the CGU-CSSS-CIG-CSAFM-ESSSA, Niagara Falls, ON, Canada.

McKenzie, S.M., Arain, A., Pisaric, M., & Parker, W. (2018, June 10-14). *Climate and Stand Density Effects on Growth in a Red Pine Plantation in Southern Ontario*. Oral presentation at the meeting of the CGU-CSSS-CIG-CSAFM-ESSSA, Niagara Falls, ON, Canada.

McKenzie, S.M., Arain, A., Pisaric, M., Slater, G., & Kim, S-T. (2018, June 3-6). Stable Isotope Methods to Evaluate Climatic Controls on Intrinsic Water Use Efficiency in Forest Ecosystems. Poster presentation at the meeting of the Global Water Futures (GWF), Hamilton, ON, Canada.

McKenzie, S.M., Arain, A., Pisaric, M., Slater, G., & Kim, S-T. (2018, June 3-6). *Stable Isotope Methods to Evaluate Climatic Controls on Intrinsic Water Use Efficiency in Forest Ecosystems*. Poster presentation at the meeting of the Global Water Futures (GWF), Hamilton, ON, Canada.

McKenzie, S.M., Arain, A., Pisaric, M., Slater, G., & Kim, S-T. 2018. Stable Isotope Methods to Evaluate Climatic Controls on Intrinsic Water Use Efficiency in Forest Ecosystems. Poster presentation at the McMaster Water Week Research Showcase, Hamilton, ON, Canada.

McKenzie, S.M., Arain, A., Pisaric, M., Slater, G., & Kim, S-T. 2018. *Stable Isotope Methods to Evaluate Climatic Controls on Intrinsic Water Use Efficiency in Forest Ecosystems*. Poster presentation at the McMaster Water Week Research Showcase, Hamilton, ON, Canada.

McLeod, M., Van Meter, K.J., and Basu, N.B. (2019). Beyond the Mass Balance: Modeling 100 years of Phosphorus Dynamics in a Great Lakes Watershed. World Wetland Day, University of Waterloo, Feb 4, 2019. (Won Best Undergraduate Poster Award)

Mekonnen, B.A., Pomeroy, J., Spence, C., Shook, K.R., Whitfield, C.J., and Wolfe, J.D. (2019) Virtual basin modelling approach to assess effects of climate change and wetland drainage on streamflows in the Prairie. Prairie Water 2nd Annual Partners Meeting. Holiday Express Inn & Suites, Saskatoon, SK. January 24-25, 2019. (*Poster*)

Mendoza, C., Lukenbach, M., Twerdy, P., Carey, S.K., Devito, K,, Landhausser, S. 2018. Ecohydrological development of a reclaimed upland-wetland system constructed on soft tailings at an oil-sand mine, NE Alberta, Canada. Presented at the European Geosciences Union Meeting, June 2018, April, Vienna, Austria.

Menounos B, Murherjee K, Shea J, Pomeroy, J. Airborne measurement of seasonal snow in western Canada. Global Water Futures Annual Meeting, Hamilton, Ontario, 3-6 June, 2018.

Mercer JJ, Westbrook CJ. Hydrological processes regulating alpine wetland water table dynamics. Society of Wetland Science Annual Meeting, Denver, Colorado, USA, May 29 – June 1, 2018.

Mirnasl, N., P. Deadman, A. Frank, D. Robinson, M. Macrae, "Assessing the impact of Beneficial Management Practices (BMPs) on P loading using ArcSWAT". Poster. McMaster Water Week 2018 – November 20-23, 2018

Molot L, Schiff SL, Venkiteswaran JJ, Verschoor M, Baulch H and S Higgins (2018). Hierarchy of Point Source Management Approaches to Mitigate Cyanobacteria Blooms. IAGLR, Toronto ON, 18-22 June.

Molot, L.A., S.L. Schiff, J.J. Venkiteswaran, H.M. Baulch, S.N. Higgins, A. Zastepa, M.J. Verschoor and D. Walters. 2019 Canadian Society of Limnologists annual conference, London, ON, "Guiding principles for preventing cyanobacteria blooms: Integrating nutrient limitation and sediment redox science into watershed management".

Molot, L.A., S.L. Schiff, J.J. Venkiteswaran, H.M. Baulch, S.N. Higgins, A. Zastepa, M.J. Verschoor and D. Walters. 2018 Restoration of eutrophic lakes, Lahti, Finland; "Guiding principles for preventing cyanobacteria blooms: Integrating nutrient limitation and sediment redox science into watershed management".

Molot, L.A., S.L. Schiff, J.J. Venkiteswaran, H.M. Baulch, S.N. Higgins, A. Zastepa, M.J. Verschoor and D. Walters. 2018 International Association for Great Lakes Research, annual conference, Toronto; "Guiding principles for preventing cyanobacteria blooms: Integrating nutrient limitation and sediment redox science into watershed management".

Mora, M.F. (2018) Water governance in Indigenous territories in Canada. In Human-Water Interactions: Global Water Futures Inaugural Annual Science Meeting. McMaster University, Hamilton, ON. June 4-6, 2018. (*Poster*)

Mora, M.F., Bradford, L., Reed, M., Bharadwaj, L. (2018) Gender and Water Governance in the Global North: A Scoping Review. 2018 IGU Regional Conference - CAG Annual Meeting - NCGE Annual Conference. Quebec, August 9th. (*Presentation*)

Mora, M.F., Watson, M., Johnston, A.B.D., and Bharadwaj, L. (2019) Collaborative water governance: A holistic perspective towards Mistawasis Nêhiyawak's well-being. Prairie Water 2nd Annual Partners Meeting. Holiday Express Inn & Suites, Saskatoon, SK. January 24-25, 2019. (*Poster*)

Morales-Marin L., Sanyal P., Kadowoki H., Li Z., Rokaya P., Lindenschmidt K. (2018). A hydrological and water temperature modelling framework to simulate the timing of river freeze-up and ice-cover breakup in large-scale catchments (C52B-05). American Geophysical Union (AGU) 2018 Annual Meeting, Washington, D.C., 10 - 14 December 2018.

Morgan, L.R., Hayashi, M., Negm, A., Cey, E.E. (2018) Land-use effects on depression-focussed groundwater recharge in the prairies: Water balance approach. Joint Annual Meeting of the Canadian Geotechnical Society and the International Association of Hydrogeologists - Canadian National Chapter. Edmonton, Alberta, September 23-26, 2018. (*Presentation*)

Muenich, R., Scavia, D., Read, J., Kerkez, B., Teshager, A., Bocaniov, S., Hu, Y., Kalcic, M., Wang, Y.-C., Long, C., and Vacarro, L. (2018). Watershed Assessment of Detroit River Nutrient Loads to Lake Erie. SCDRS Advisory Group Meeting, Mar. 15, 2018; University of Windsor, Windsor, Ontario.

Nan Zhang, Saif Syed, Zeinab Hosseini-Doust, Charles-Francois de Lannoy, "Electrically conductive membranes as sensors: stability, conductivity, and sensitivity", North American Membrane Society, NAMS 2019, Pittsburgh, PA, US (May 12-15, 2019) (talk)

Nan Zhang, Zeinab Hosseini-Doust, Charles-Francois de Lannoy, "Detection of Electrically conductive membrane fouling by impedance spectroscopy", North American Membrane Society, NAMS 2019, Pittsburgh, PA, US (May 12-15, 2019) (poster)

Neary L, *C Remmer, *M Kay, *W Klemt, B Wolfe and R Hall. (2018). Influences on carbon balance of shallow lakes, Peace-Athabasca Delta, Alberta. *Cold Regions Research Centre Day*, Wilfrid Laurier University, Waterloo.

Neary L, *C Remmer, *M Kay, *W Klemt, B Wolfe and R Hall. (2018). Effects of spring flooding and primary productivity on lake carbon balance in the Peace-Athabasca Delta, Alberta (Canada). *Canadian Association of Geographers – Ontario Division Annual Meeting*, University of Toronto, Toronto.

Neary, L., *Remmer, C., *Kay, M., Hall, R. and B. Wolfe. (2018) Widespread photosynthetically-induced CO2 invasion in numerous lakes across the Peace-Athabasca Delta (Alberta, Canada). Poster presented at Women in Science Undergraduate Symposium, University of Waterloo, Waterloo, Canada.

Neary, L., *Remmer, C., *Kay, M., Hall, R. and B. Wolfe. (2018) Widespread photosynthetically-induced CO2 invasion in numerous lakes across the Peace-Athabasca Delta (Alberta, Canada). Poster presented at World Water Day Symposium, University of Waterloo, Waterloo, Canada.

Neary, L., *Remmer, C., *Kay, M., Hall, R. and B. Wolfe. (2018) Widespread photosynthetically-induced CO2 invasion in numerous lakes across the Peace-Athabasca Delta (Alberta, Canada). Poster presented at Canadian Geophysical Union, Western University, London, Canada.

Neary, L., *Remmer, C., *Klemt, W., *Kay, M., Hall, R. and B. Wolfe. (2019). Effects of spring flooding and primary productivity on lake carbon balance in the Peace-Athabasca Delta, Alberta. Oral presentation at Association for the Sciences of Limnology and Oceanography Conference, San Juan, Puerto Rico.

Neary, L., *Remmer, C., *Klemt, W., *Kay, M., Hall, R. and B. Wolfe. (2019) Determining major influences on carbon balance of shallow northern floodplain lakes (Peace-Athabasca Delta, Alberta) Oral presentation at Canadian Conference for Fisheries Research and Society of Canadian Limnology Symposium, London, ON.

Neary, L., *Remmer, C., *Klemt, W., *Kay, M., Hall, R. and B. Wolfe. (2018) Effects of flooding and primary productivity on lake carbon balance in the Peace-Athabasca Delta (Alberta). Oral presentation at Canadian Association of Geographers of Ontario Conference, University of Toronto, Toronto, Canada.

Neary, L., *Remmer, C., *Klemt, W., *Kay, M., Hall, R. and B. Wolfe. (2018) Determining major influences on carbon balance of northern floodplain lakes (Peace-Athabasca Delta, Alberta). Oral presentation at Cold Regions Research Centre Symposium, Wilfrid Laurier University, Waterloo, Canada.

Negm, A., Hayashi, M., Itenfisu, D. (2018) Comparison of root water uptake and soil moisture dynamics under contrasting land uses in the Canadian Prairies. Joint Annual Meeting of the Canadian Geotechnical Society and the International Association of Hydrogeologists - Canadian National Chapter. Edmonton, Alberta, September 23-26, 2018. (*Presentation*)

Negm, A., Rasouli, K., Hayashi, M. (2018) The impacts of land cover changes on local-scale evapotranspiration and precipitation, and hydrological processes in the Canadian prairies. General Assembly of the European Geoscience Union, Vienna, Austria, April 8-13, 2018. (*Presentation*)

New Mass Spectrometry Techniques for the Measurement of Persistent Organic Pollutants. Jones, Paul D and Giesy, John P. SETAC Europe Annual Meeting, Rome, Italy, May 13-17 2018

Nwaishi, F.C., Plach, J.M., Morrison, M. Q., Macrae, M.L. & Petrone, R. M. 2018. Potential Implications of Exogenous Nutrient Inputs from Oil Sands Operations on the Nutrient Balance and Carbon Storage of Western Boreal Peatlands. Annual General Meeting of the Canadian Geophysical Union,June 10 - 14, 2018, Niagara Falls, Ontario, Canada.

Okamura, M., Ueyama, M., Ito, A. et al. incl. Sonnentag, O. 2018. Modeling greenhouse gas budget in northern ecosystems using a process-based ecosystem model, VISIT. B41H-0298, Washington, D.C., USA.

Owca T, *C Remmer, *M Kay, *J Faber, B Wolfe and RI Hall. (2018). Using paleolimnological baselines to assess sources and pathways of metals in surface sediment of floodplain lakes (Peace-Athabasca Delta, Alberta, Canada). *Ontario-Quebec Paleolimnology Group Graduate Student Conference*, Brock University, St. Catharines.

Owca T, *C Remmer, *M Kay, *J Faber, B Wolfe and RI Hall. (2018). Paleolimnological approaches for assessing sources and pathways of metals in surface sediment of floodplain lakes

(Peace-Athabasca Delta, Alberta, Canada). *International Paleolimnology Symposium*, Stockholm, Sweden.

Owca T,*J Faber, *C Remmer, B Wolfe and R Hall. (2019). Use of pre-industrial baselines to monitor for sources and pathways of metals in surface sediment of floodplain lakes in the Peace-Athabasca Delta (Alberta, Canada). *ASLO 2019 Aquatic Sciences Meeting*, San Juan, Puerto Rico.

Owca TJ, *ML Kay, *J Faber, *C Remmer, JA Wiklund, BB Wolfe and RI Hall. (2018). Using pre-industrial baselines to assess sources and pathways of metals in the PAD. *Cold Regions Research Centre Day*, Wilfrid Laurier University, Waterloo.

Owca TJ, *ML Kay, *J Faber, *C Remmer, JA Wiklund, BB Wolfe and RI Hall. (2018). Use of pre-industrial baselines to assess sources and pathways of metals in surface sediment of floodplain lakes in the Peace-Athabasca Delta (Alberta, Canada). *ArcticNet Annual Scientific Meeting*, Ottawa.

P. Marsh, C. Dersken, *G. Hould Gosselin, *A. Jitnikovitch, *B. Majumder, A. Pietroniro, P. Seccombe-Hett, J. Therialut, A. Tourc, M. Tsui, *B. Walker, and *E. Wilcox. (2018). Developing a novel snow observing system for improving the understanding and prediction of climate, hydrology, permafrost and ecology. ArcticNet Annual Science Conference, Ottawa, Dec. 2018.

Packull-McCormick S, Laird BD. (2018) Human biomonitoring to complement risk assessments of environmental contaminants in traditional food systems. Leveraging Systems Approaches to Improve Human & Planetary Health Workshop. Waterloo, Canada. (Poster)

Paleoecotoxicology: The application of novel tools to assess the toxicity of historically contaminated lake sediments. Laurentian Chapter of the Society of Environmental Toxicology and Chemistry Student Pub Night, Ottawa, Ontario. [received best student oral presentation award.]

Pardo, R., Berg, A. A., & Warland, J. S. (2018, December). Measuring freeze/thaw (F/T) state and frozen soil moisture fraction using 50 MHz coaxial impedance dielectric reflectometry probes in mid-latitudinal soils. In AGU Fall Meeting Abstracts.

Pardo-Lara, R., A. Berg and J. Warland. 2018. Identification of a dynamic temperature threshold for soil moisture freeze/thaw (F/T) state classification using the soil real dielectric constant. Joint meeting of the Canadian Geophysical Union, Canadian Soil Science Society and the Canadian Society for Agricultural and Forest Meteorology. Niagara, Ontario.

Pardo-Lara, R., A.A. Berg, J. Warland. 2018. Measuring freeze/thaw (F/T) state and frozen soil moisture fraction using 50 MHz coaxial impedance dielectric reflectometry probes in mid-latitudinal soils. American Geophysical Union Fall meeting. Washington D.C.

Park S, Sekerinski E. A Notebook Format for the Holistic Design of Embedded Systems (Tool Paper). Talk presented at: 4th Workshop on Formal Integrated Development Environment,; 2018 Jul 14; Oxford, U.K.

Park S, Sekerinski E. A Notebook Format for the Holistic Design of Embedded Systems (Tool Paper). In: 4th Proceedings Workshop on Formal Integrated Development Environment, Oxford, England, 14 July 2018 [Internet]. Open Publishing Association; 2018. p. 85–94.

(Electronic Proceedings in Theoretical Computer Science; vol. 284). Available from:http://eptcs.web.cse.unsw.edu.au/content.cgi?FIDE2018

Patrick, R., Strickert, G.E.H., and Jardine, T., (2018) Community-Engaged Scholarship and Indigenous Water Stewardship Planning. Planning Geography, Water Resources and Hydrology, Canada. American Association of Geographers Annual Meeting. Washington, DC, April 14th, 2018. (*Presentation*)

Pattison-Williams JK, Pomeroy JW, Badiou P, Gabor S, (2018). Wetlands, Flood Control and Ecosystem Services in the Smith Creek Drainage Basin: A Case Study in Saskatchewan, Canada. Alberta Land Institute's "Land, Water and Society" Conference, Edmonton, Canada, May 30, 2018.

Paul Craig. Cost of Living in the Grand River: energetics, stress and epigenetics. 13th International Congress on the Biology of Fish, Calgary, Alberta, Canada, July15th-19th, 2018.

Pavlovskii, I., Hayashi, M. (2018) Pitfalls in groundwater recharge evaluation using chloride mass balance in the Canadian Prairies. Joint Annual Meeting of the Canadian Geotechnical Society and the International Association of Hydrogeologists - Canadian National Chapter. Edmonton, Alberta, September 23-26, 2018. (*Presentation*)

Peddle, D.R. and 64 co-authors [including A Berg], 2018. "An Overview of Canadian Earth Observation Science and Excellence for Arctic and Northern Monitoring and Applications." Invited presentation by D.Peddle at EUMETSAT, Darmstadt, Germany, 9 April 2018.

Pelto B, Menounos B. Multi-year Seasonal Mass Balance Using Airborne Laser Altimetry, Columbia Basin, Canada. Annual Meeting of the American Geophysical Union, Washington, DC, 10-14 December, 2018.

Perron, N. S., *Pappas, C., Sonnentag, O., Hopkinson, C., Chasmer, L., and Baltzer J. (2018). Tree- and stand-level hydrodynamics of black spruce (Picea mariana) and their environmental controls in forested boreal peat landscapes. [B11B-0276] to be presented at 2018 Fall Meeting, AGU, Washington, D.C., 10 Dec, poster.

Perron, N.S., *Pappas, C, Sonnentag, O., Hopkinson, C., Chasmer, L., Baltzer, J.L. (2018), Tree-and stand-level hydrodynamics of black spruce (*Picea mañana*) and their environmental controls in forested boreal peat landscapes. Abstract B11B-0276, 10-14 December 2018, Washington, D.C., USA.

Pietroniro, A., Pomeroy, J., Razavi, S., Wheater, H., (2018), The Global Water Futures Core Modelling Strategy, American Geophysical Union (AGU) Fall Meeting, Washington DC. December 10-14, 2018.

Pietroniro, A., Pomeroy, J., Wheater, H., Fortin, V., Davison, B., Shook, K., Razavi, S., (2018), A Community Hydrological Modelling Framework for Global Water Futures, European Geosciences Union (EGU) General Assembly, 8–13 April 2018, Vienna, Austria (Oral Presentation).

Pilger, N, L. Mann, A. Berg, G. Taylor, P. Jossee. 2018. Semantic segmentation of roadside survey imagery for post-harvest tillage assessment. 14th Annual Precision Agriculture Conference. Montreal, Quebec, Canada.

Plach, J., Macrae, M.L., Kompanizare, M., Tang, V., “Phosphorus losses from agricultural fields in Ontario, Canada: Implications for land management efficacy in cold regions” CGU Annual Meeting, June 10-14, 2018, Niagara Falls, Ontario, Canada.

Plach, J.M., Macrae, M.L., Kompanizare, M., and Tang, V. Phosphorus losses from agricultural fields in Ontario, Canada: Implications for land management efficacy in cold regions. Poster Presentation. Canadian Geophysical Union (CGU): June 10-14, 2018, Niagara Falls, Ontario, Canada.

Plach, J.M., Macrae, M.L., Williams, M., Lee, B., and King, K. Dominant glacial landforms in the lower Great Lakes region exhibit differences in soil chemistry and potential risk of phosphorus loss. Oral Presentation. Global Water Futures: Annual General Meeting: June 3-6, 2018, Hamilton, Ontario, Canada.

Pluer, W. American Geophysical Union, Washington, D.C., Dec. 2018 – Poster presentation. Phosphorus losses from agricultural fields in Ontario Canada: Implications for land management efficacy in cold regions.

Pluer, W., Plach, J., Kompanizare, M., Carlow, R., Macrae, M., Brunke, R., McKague, K., “When and how does phosphorus runoff fields? Global Water Future, Local Water Solutions in a Changing Climate Workshop, Waterloo, ON, December, 2018.

Pomeroy J, Pietroniro A, Shook K, (2018). Using Science and Enlightened Modelling to Fight Hydromthology, Zombie Models and Hydrological Indifference in Prediction of Ungauged Basins. European Geosciences Union (EGU) General Assembly, Vienna, Austria, April 8, 2018.

Pomeroy J, Pietroniro A, Shook K, (2018). Using Science and Enlightened Modelling to Fight Hydromthology, Zombie Models and Hydrological Indifference in Prediction of Ungauged Basins. European Geosciences Union (EGU) General Assembly, Vienna, Austria, April 8, 2018

Pomeroy J, Pietroniro A, Shook K. Using Science and Enlightened Modelling to Fight Hydromthology, Zombie Models and Hydrological Indifference in Prediction of Ungauged Basins. European Geosciences Union (EGU) General Assembly, Vienna, Austria, April 8, 2018

Pomeroy JW, Wheater HS, Baltzer JL, Baulch HM, Carey SK, Boger P, Martz LW, Pietroniro A, Rudolph DL, Stewart RE, Van Cappellen P, DeBeer CM. Global Water Futures – Translation of Transdisciplinary Observations, Science, and Predictions into Societal Action for Water and Climate Imperatives in Cold Regions. Presented at the American Geophysical Union Meeting, Washington, DC, December 2018.

Pomeroy, J., Pietroniro, A., Shook, K., 2018. Using Science and Enlightened Modelling to Fight Hydromthology, Zombie Models and Hydrological Indifference in Prediction of Ungauged Basins. European Geosciences Union (EGU) General Assembly, Vienna, Austria, April 8, 2018.

Pomeroy, J., Pietroniro, A., and Shook, K. (2018) Using Science and Enlightened Modelling to Fight Hydromthology, Zombie Models and Hydrological Indifference in Prediction of Ungauged

Basins. European Geosciences Union (EGU) General Assembly, Vienna, Austria. April 8, 2018. (*Presentation*)

Popović, N., Green, A., Kessel, E., Petrone., R.M. 2018. Carbon and Water Fluxes During the Development of a Reclaimed Post-oilsands Landscape. Oral Presenter at the Canadian Geophysical Union (CGU) annual conference, Niagara Falls, June, 2018.

Potter, S., Rogers, BM, Walker, XJ, Veraverbeke, S, Hoy, EE, Baltzer, JL, Goetz, SJ, Jenkins, LK, Johnstone, JF, Kane, ES, Mack, MC, Turetsky, MR, Bourgeau-Chavez, LL, French, NHF. 2018. Above and belowground carbon emissions from historical fires across Alaska and Canada.

Pradhananga D, Pomeroy JW, (2018). Hydrological Response of Two Mountain Glaciers in the Canadian Rockies to Warming Climate and Change in Glacier Configurations. American Geophysical Union (AGU) Annual Meeting, Washington, United States, December 14, 2018

Pradhananga D, Pomeroy JW. Hydrological Response of Two Mountain Glaciers in the Canadian Rockies to Warming Climate and Change in Glacier Configurations. American Geophysical Union (AGU) Annual Meeting, Washington, United States, December 14, 2018

Pretty, T. and Gray. D.K. (2018). Impact of forest fire on aquatic invertebrates in subarctic lakes of the Taiga Plains. McMaster Water Week Research Showcase, Hamilton, Ontario

Pretty, T. and Gray. D.K. (2018). Impact of forest fire on aquatic invertebrates in subarctic lakes of the Taiga Plains. Arctic Net, Ottawa, Canada

Pretty, T. and Gray. D.K. (2019). Impact of forest fire on aquatic invertebrates in subarctic lakes of the Taiga Plains. Association for the Sciences and Limnology and Oceanography, San Juan , Puerto Rico

Radic V, Mekdes T, Menounos B, Fitzpatrick, N. Evaluation of Dynamically Downscaled Near-surface Mass and Energy Fluxes for Three Mountain Glaciers, British Columbia, Canada. Annual Meeting of the American Geophysical Union, Washington, DC, 10-14 December, 2018.

Ramkissoon, N. 2018. Perceptions of Managers for communicating about freshwater HABs in the Prairies. School of Public Health Poster Day. University of Saskatchewan, Saskatoon, SK. September 28, 2018

Ramkissoon, N. 2018. Perceptions of Managers for communicating about freshwater HABs in the Prairies. Saskatchewan Epidemiology Association, 18th Annual Fall Symposium & Workshop, University of Saskatchewan, Saskatoon, SK, October 3-4th 2018.

Rasouli K, Negm A, Pavlovskii I, Pomeroy JW, Hayashi M, (2018). Surficial geology-based mapping of the future changes in groundwater recharge in a semi-arid watershed in the Canadian Prairies with climate warming. American Geophysical Union (AGU) Annual Meeting, Washington, United States, December 14, 2018

Rasouli, K., Negm, A., Pavlovskii, I., Pomeroy, J.W., Hayashi, M. (2018) Surficial geology-based mapping of the future changes in groundwater recharge in a semi-arid watershed in the Canadian Prairies with climate warming. Fall Meeting of the American Geophysical Union, Washington D.C., December 10-14, 2018. (*Presentation*)

Ratelle M, Laird BD. (2018). Investigation of Cadmium Exposure in Regards to Smoking Status and Moose and Caribou Organs Consumption in Northern Canada. International Society of Exposure Science-International Society of Environmental Epidemiology (ISES-ISEE) Joint Annual Meeting. Ottawa, Canada.

Ratelle M, Skinner K, Swanson H, Laird BD (2018). Community Based Contaminant Biomonitoring in the Northwest Territories, Canada. Tribal Environmental Health Summit. Corvallis, USA (Poster).

Razavi, S., Gupta, H., (2018) Revisiting the Fundamental Basis of Global Sensitivity Analysis for Dynamical Environmental Models, 9th International Congress on Environmental Modelling and Software, June 24-28 2018, Fort Collins, CO, USA.

Razavi, S., Sheikholeslami, R., Gupta, H., Haghnegahdar, A., (2018) An Overview of VARS-TOOL and it New Features for Comprehensive, Efficient, and Robust Sensitivity and Uncertainty Analysis of Earth and Environmental Systems Models, GWF Annual Science Meeting 2018, 3-6 June 2018, Hamilton, ON, Canada

Razavi, S., Sheikholeslami, R., Gupta, H., Haghnegahdar, A., (2018), VARS-TOOL: A Novel Toolbox for Comprehensive and Efficient Global Sensitivity Analysis, American Geophysical Union (AGU) Fall Meeting, Washington DC. December 10-14, 2018.

Remmer C, *WH Klemt, BB Wolfe and RI Hall. (2018). Integrating modern and paleolimnological data to assess hydroecological conditions in a high-latitude floodplain landscape. *International Paleolimnology Symposium*, Stockholm, Sweden.

Remmer CR, *CAM Savage, *J Telford, BB Wolfe and RI Hall. (2018). Field testing cellulose-water $\delta^{18}O$ relations in periphytic algae for paleohydrological reconstructions. *International Paleolimnology Symposium*, Stockholm, Sweden.

Remmer CR, *L Neary, *T Owca, BB Wolfe and RI Hall. (2019). Isoscapes and limnoscapes of the Peace-Athabasca Delta: A foundation for hydrolimnological monitoring. *Canadian Conference for Fisheries Research / Society of Canadian Limnologists*, London.

Remmer CR, *T Owca, *L Neary, JA Wiklund, *M Kay, BB Wolfe and RI Hall. (2019). Delineating extent and magnitude of river flooding in a northern floodplain landscape using water isotope tracers. *ASLO 2019 Aquatic Sciences Meeting*, San Juan, Puerto Rico.

Remmer CR, *T Owca, *L Neary, JA Wiklund, *M Kay, BB Wolfe and RI Hall. (2018). Tracking the extent and magnitude of the 2018 spring flood in the Peace-Athabasca Delta (Canada) using water isotope tracers. *ArcticNet Annual Scientific Meeting*, Ottawa.

Remmer CR, *T Owca, *L Neary, JA Wiklund, *M Kay, BB Wolfe and RI Hall. (2018). Tracking the extent and magnitude of the 2018 spring flood in the Peace-Athabasca Delta (Canada) using water isotope tracers. *Cold Regions Research Centre Day*, Wilfrid Laurier University, Waterloo.

Reynolds and Rooney. Avian diversity in mountain peatlands. Biology Graduate Student's Symposium, University of Waterloo. 25 April 2019.

Rezanezhad, F., Milojevic, T., Oh, D., Smeaton, C., Parsons, C., McCarter, C., and Van Cappellen, P. (2018). Soil hydrogeochemical processes under changing winter conditions. Canadian Geophysical Union Annual Meeting 2018, Niagara Falls, Ontario, June 13, 2018

Robinne, F.N., Bladon, K.D., Silins, U., Emelko, M.B., Kienzle, S.W.,, Parisien M.A., Flannigan, M.D. 2018. A simple, reproducible model to assess regional-scale community water supply hazard from wildfire. Presented at the Joint Forest and Water Conference, November 2018, in Valdivia, Chile.

Robinne, F.N., Hallema, D.W., Bladon, K.D. 2018. Wildfire impacts on hydrologic systems: the state of knowledge in high-latitude forests of North-America. Presented at the Joint Forest and Water Conference, November 2018, in Valdivia, Chile.

Rohanizadegan M, Kosovic B, Pomeroy JW, Petrone RM, Helgason WD, (2018). Evaluating evaporative fluxes in complex mountain terrain. Joint Meeting of the Canadian Geophysical Union (CGU), Canadian Soil Science Society, Computational Infrastructure in Geodynamics, Eastern Section of Seismological Society of America and Canadian Society for Agricultural and Forest Meteorology, Niagara Falls, Canada, June 10, 2018

Rohanizadegan M, Kosovic B, Pomeroy JW, Petrone RM, Helgason WD. 2018. Evaluating evaporative fluxes in complex mountain terrain. Joint Meeting of the Canadian Geophysical Union (CGU), Canadian Soil Science Society, Computational Infrastructure in Geodynamics, Eastern Section of Seismological Society of America and Canadian Society for Agricultural and Forest Meteorology, Niagara Falls, Canada, June 10, 2018

Rohanizadegan, M., Kosovic, B., Pomeroy, J.W., Petrone, R.M., Helgason, W.D. 2018. Evaluating evaporative fluxes in complex mountain terrain. Joint Meeting of the Canadian Geophysical Union (CGU), Canadian Soil Science Society, Computational Infrastructure in Geodynamics, Eastern Section of Seismological Society of America and Canadian Society for Agricultural and Forest Meteorology, Niagara Falls, Canada, June 10, 2018.

Rokaya, P. and Lindenschmidt, K.-E. (2018) A novel stochastic modelling framework for ice-jam flood risk assessment and hazard mapping. American Geophysical Union (AGU) 2018 Annual Meeting, Washington, D.C., 10 - 14 December 2018.

Rokaya, P., Lindenschmidt, K.-E., Budhathoki, S. and Das, A. (2018) Ice-jam floods: Recent trends and patterns. Cryospheric Extremes Workshop, Helsinki, Finland, 26-28 April 2018.

Roy, A., P. Toose, A. Mavrovic, C. Pappas, A. Berg, T. Rowlandson, C. Derksen, A. Royer, M. El-Amine, W. Helgason, A. Barr, O. Sonnentag, 2018. Use of L-Band ground-based radiometers for freeze/thaw retrieval in a boreal forest. IEEE Geoscience and Remote Sensing Symposium. 9042-9044 Valencia, Spain.

Royall, Bolding, Cobbaert, Rooney. Evaluating the evaluation tool: can we rapidly estimate wetland function? Canadian Society for Ecology and Evolution Annual Conference. Guelph, Ontario. Poster. 19 July 2018.

Royall, Rooney. Evaluating the evaluation tool for wetland assessment in Alberta. Biology Graduate Student's Symposium, University of Waterloo. 25 April 2019

Ruecker, A. Berg, C. Champagne. 2018. Reducing Error Between Satellite and in situ Soil Moisture over Canadian Croplands. Joint meeting of the Canadian Geophysical Union, Canadian Soil Science Society and the Canadian Society for Agricultural and Forest Meteorology. Niagara, Ontario.

Ruiz Caldas, M. X., Evans, S., Wu, Y., de Lannoy, C.F., 2019. Gordon Conference: Environmental Nanotechnology, Newry, ME

Rupasinghe, P. A, Chow-Fraser, P. 2018. Standardized remote-sensing strategy to study post-fire health recovery of boreal forests in Alberta, Canada. Proceedings of the American Geophysical Union (AGU) Fall Meeting, The Resilience and Vulnerability of Arctic and Boreal Ecosystems to Climate Change, Walter E. Washington Convention Center, 801 Mt. Vernon Place, NW, Washington DC, USA. December 2018.

Rupasinghe, P. A, Chow-Fraser, P. 2018. Standardized remote-sensing strategy to study post-fire health recovery of boreal forests in Alberta, Canada. Proceedings of the Global Water Futures AGM, McMaster University, 1280, Main Street West, Hamilton, ON, Canada. June 2018.

Salk KR, Venkiteswaran JJ, Couture RM, Higgins SN, Paterson MJ, and SL Schiff. 2018. Pairing Ecosystem Modelling And Long-term Datasets For Harmful Algal Bloom Forecasting. ASLO Summer Meeting

Salman, M., Rudolph, D. L. and Steelman, C. (2019). Mapping Permafrost Continuity in the Central Mackenzie Valley Using Electrical Geophysical Methods. 2nd Annual Open Science Meeting: Global Water Futures. Saskatoon, Saskatchewan, Canada, May 15-17, 2019.

Samson, M.I., Van Meter, K.J., and Basu, N.B. (2018). "Urban Metabolism of the Greater Toronto Area: A Study of Nitrogen and Phosphorus Across an Urban, Suburban, Rural Continuum," June 13, 2018 Joint Meeting of the Canadian Geophysical Union and Canadian Soil Science Society, Niagara Falls, ON.

Samson, M.I., Van Meter, K.J., and Basu, N.B. (2018). "Urban Metabolism of the Greater Toronto Area: A Study of Nitrogen and Phosphorus Across an Urban, Suburban, Rural Continuum," Global Water Futures 2018 Annual Science Meeting, Hamilton, ON.

Sauer, S.J., Arain, A., Bartlett, P., Davison, B., & Melton, J.R. (2018, June 3-6). Integration of a Slope-Based Soil Water Algorithm into a Coupled Land Surface and Dynamic Vegetation Model. Oral presentation at the meeting of the Global Water Futures (GWF), Hamilton, ON, Canada.

Sauer, S.J., Arain, A., Bartlett, P., Davison, B., & Melton, J.R. (2018, June 10-14). Integration of a Slope-Based Soil Water Algorithm into a Coupled Land Surface and Dynamic Vegetation Model. Oral presentation at the meeting of the CGU-CSSS-CIG-CSAFM-ESSSA, Niagara Falls, ON, Canada.

Sauer, S.J., Arain, A., Bartlett, P., Davison, B., & Melton, J.R. (2018, June 3-6). *Integration of a Slope-Based Soil Water Algorithm into a Coupled Land Surface and Dynamic Vegetation Model*. Oral presentation at the meeting of the Global Water Futures (GWF), Hamilton, ON, Canada.

Sauer, S.J., Arain, A., Bartlett, P., Davison, B., & Melton, J.R. (2018, June 10-14). *Integration of a Slope-Based Soil Water Algorithm into a Coupled Land Surface and Dynamic Vegetation Model*. Oral presentation at the meeting of the CGU-CSSS-CIG-CSAFM-ESSSA, Niagara Falls, ON, Canada.

Sauer, S.J., Arain, A., Princz, D., Bartlett, P., Davison, B., & Melton, J.R. (2018, November 20). Development of the MESH-CTEM Hydrological-Biogeochemical Model. Poster presentation at the McMaster Water Week Research Showcase, Hamilton, ON, Canada.

Sauer, S.J., Arain, A., Princz, D., Bartlett, P., Davison, B., & Melton, J.R. (2018, November 20). *Development of the MESH-CTEM Hydrological-Biogeochemical Model*. Poster presentation at the McMaster Water Week Research Showcase, Hamilton, ON, Canada.

Schiferl, L.D., Biraud, S., Euskirchen, E.S. et al. incl. Sonnentag, O. (2018), Quantifying regional-scale carbon fluxes from arctic and boreal ecosystems: insights from recent campaigns and long term trends. Abstract A41C-06, 10-14 December 2018, Washington, D.C., USA.

Schultz M, J Leathers, I Jasiak, JJ Venkiteswaran, MC English, BB Wolfe, RI Hall, SL Schiff,

Schultz M, J Leathers, I Jasiak, JJ Venkiteswaran, MC English, BB Wolfe, RI Hall, SL Schiff,

Schultz M, J Leathers, I Jasiak, JJ Venkiteswaran, MC English, BB Wolfe, RI Hall, SL Schiff, J Hickman and R Connon. 2018. Arsenic mobility in terrestrial and aquatic ecosystems, NWT. Cold Regions Research Centre Day, Wilfrid Laurier University, Waterloo.

Servos, M. (2018). Modelling the response of fish to major infrastructure upgrades in wastewater treatment plants, GWF Annual Science Meeting, McMaster University, June 3-6, 2018.

Servos, M. and J. Giesy. Next generation solutions to ensure healthy water resources for future generations Global Water Inception Meeting, Waterloo, Ont., Jan. 21-23, 2018.

Servos, M. P. Craig, W. Parker. Can stressors associated with wastewater be managed to reduce environmental risk? Global Water Futures Operations Meeting, Saskatoon, Sask. Jan. 22-23, 2019.

Servos, M., L. Bragg, H. Dhiyebi, G. Tetreault M. Fuzzen, K. Hicks, P. Marjan, M. Arlos, W. Parker. Modeling the response of fish to major infrastructure upgrades in wastewater treatment plants. Inaugural Annual Science Meeting, Global Water Futures. Hamilton, Ontario, June 3-6, 2018. abstract

Servos, M., L. Bragg, H. Dhiyebi, G. Tetreault, M. Fuzzen, K. Hicks, P. Marjan, M. Arlos, W. Parker. Modelling the response of fish to major infrastructure upgrades in wastewater treatment plants, GWF Annual Science Meeting, McMaster University, June 3-6, 2018. Abstract

Servos, M.R., L. Bragg, H. Dhiyebi, G. Tetreault, M. McMaster, M. Fuzzen, K. Hicks, P. Marjan, K. McCann, N. Srikanthan, W. Parker, M. Arlos. Modeling the response of fish to major infrastructure upgrades in wastewater treatment plants. 45th Canadian Ecotoxicity Workshop, Vancouver, BC, Sept. 30 - Oct. 3, 2018. abstract

Servos, M.R., L. Bragg, H. Dhiyebi, G. Tetreault, M. McMaster, W. Parker, E. McCann, N. Srikanthan, M. Fuzzen, K. Hicks, P. Marjan, M. Arlos. Major wastewater treatment plant infrastructure upgrades reduce adverse biological responses in wild fish in the Grand River. 13th International Congress on the Biology of Fish, Calgary, Alberta, July 15-19, 2018. abstract

Shah P, Venkiteswaran J, Molot L. Phytoplankton Fractionation of Iron. CCFFR/SCL 2019 London ON. January 6-10, 2019.

Shah P. 2018. Phytoplankton Fractionation of Iron. IFHAB. 16 April.

Shatilla NJ, Carey SK, Tang W, Bonn H. High frequency data provides new insights into stream biogeochemistry at an alpine headwater catchment underlain by discontinuous permafrost in Yukon Presented at the Canadian Geophysical Union Annual General Meeting, June 2018, Niagara Falls, ON.

Shea J, Whitfield P, Pomeroy J, (2018). The role of basin geometry on snow sensitivity in mountain basins. Joint Meeting of the Canadian Geophysical Union (CGU), Canadian Soil Science Society, Computational Infrastructure in Geodynamics, Eastern Section of Seismological Society of America and Canadian Society for Agricultural and Forest Meteorology, Niagara Falls, Canada, June 10, 2018

Shea J, Whitfield P, Pomeroy J. The role of basin geometry on snow sensitivity in mountain basins. Joint Meeting of the Canadian Geophysical Union (CGU), Canadian Soil Science Society, Computational Infrastructure in Geodynamics, Eastern Section of Seismological Society of America and Canadian Society for Agricultural and Forest Meteorology, Niagara Falls, Canada, June 10, 2018

Sheikholeslami, R., Haghnegahdar, A., Razavi, S., (2018), Strategies for Handling Simulation Model Crashes in Global Sensitivity Analysis, American Geophysical Union (AGU) Fall Meeting, Washington DC. December 10-14, 2018.

Sheikholeslami, R., Razavi, S., (2018) An Automated Parameter Grouping Strategy for Efficient Sensitivity Analysis of Large-scale Hydrological Models, GWF Annual Science Meeting 2018, 3-6 June 2018, Hamilton, ON, Canada

Sheikholeslami, R., Razavi, S., Gupta, H., Becker, W., Haghnegahdar, A., (2018) Addressing Curse of Dimensionality in Global Sensitivity Analysis of Large Environmental Models: An Automated Grouping Strategy, 9th International Congress on Environmental Modelling and Software, June 24-28 2018, Fort Collins, CO, USA.

Shook K, Pomeroy J, (2018). The cold regions hydrological modelling paradox: why complex models can be run successfully with uncalibrated parameterisations. European Geosciences Union (EGU) General Assembly, Vienna, Austria, April 8, 2018.

Shook K, Pomeroy J. The cold regions hydrological modelling paradox: why complex models can be run successfully with uncalibrated parameterisations. European Geosciences Union (EGU) General Assembly, Vienna, Austria, April 8, 2018

Shook, K., and Pomeroy, J. (2018) Challenges in modelling Prairie hydrology under future climates. In Modelling and Observations: Global Water Futures Inaugural Annual Science Meeting. McMaster University, Hamilton, ON. June 5th, 2018. (*Oral Presentation*)

Shook, K., and Pomeroy, J. (2018) The cold regions hydrological modelling paradox: why complex models can be run successfully with uncalibrated parameterisations. European Geosciences Union (EGU) General Assembly, Vienna, Austria. April 8, 2018.

Skinner K, Laird B, Swanson H, Sutherland V, Cheechoo V, Ratelle M, Wallace J. *FIShNET (Fish and IndigenouS NorthErn HealTh): Healthy Water, Healthy Fish, Healthy People*. Global Water Futures Operations Meeting, Saskatoon, SK, January 23, 2019.

Slaughter, A., Haghnegahdar, A., Razavi, S., Carlson, H., Keshavarz, K., Ali Shah, S., (2018) Exploring water resources management models for achieving IWRM within Canada's

Major River Basins, 9th International Congress on Environmental Modelling and Software, June 24¬28 2018, Fort Collins, CO, USA

Slaughter, A., Razavi, S., Keshavarz, K., Ali Shah, S. M., (2018), Water resources management modelling for achieving equitable sharing of water within the Saskatchewan River Basin, International Conference of the International Commission on Irrigation and Drainage, 12–17 August 2018, Saskatoon, Saskatchewan, Canada.

Slaughter, A.R., Razavi, S., Ali Shah, S.M., Keshavarz, K., Haghnegahdar, A., Carlson, H. (2018) 9th International Congress on Environmental Modelling and Software, June 24-28 2018, Fort Collins, USA.

Slaughter, A.R., Razavi, S., Princz, D. (2018) Integration of a water resources management model with large-scale land surface modelling for integrated management of Canadian large river basins. American Geophysical Union (AGU) Fall Meeting, December 10-14 2018, Washington D.C.

Sniderhan A, *Day N, Cumming S, Johnstone J, Mack M, Turetsky M, Walker X, Baltzer J. (2018). Ecological Legacies and Their Effect on Boreal Wildfire Severity. ArcticNet Annual Scientific Meeting, Ottawa ON

Sniderhan A, Mamet S, Baltzer J. (2018). Forest Growth Dynamics in Northwestern North America. Global Water Futures Annual Scientific Meeting, Hamilton/Six Nations ON, June 2018.

Sonnentag O, *Pappas C, *Perron N, *Standen KM, Rakowsk S, Baltzer JL, Detto M. (2018). Functional and Hydraulic Traits Plasticity of Boreal Tree Species Along a Latitudinal Climate and Permafrost Gradient in Northwestern North America. American Geophysical Union, Washington, DC, USA, poster

Sonnentag, O., *Pappas, C., *Standen, K., *Perron, N. S., Rakowski, S., Baltzer, J. L., Detto, M. (2018); Functional and hydraulic traits plasticity of boreal tree species along a latitudinal climate and permafrost gradient in northwestern North America. [B13I-1587] 2018 Fall Meeting, AGU, Washington, D.C.

Spring A. Community-Based Health Research. (2018). Invited panelist. Hotıì ts'eeda Ełèts'ehdèe, Aurora Village, Yellowknife NT. May 22 – 24, 2018.

Spring, A and Simba, M. (2018). Climate change adaptation work in Kakisa, NT. NWT Association of Communities Climate Change conference and Charrette. Explorer Hotel, Yellowknife, NT, Oct 29-31, 2018.

Spring, A., *Johnston, C., and Scott, C. (2018). Yellowknife as a gateway to food security in the Northwest Territories. Workshop on Regional Centres and the Sustainability of Canada's Rural and Northern Landscapes. Lakehead University, Thunder Bay, ON. May 8-9, 2018.

Stadnyk, TA. 2018. HYPE Modelling in the Nelson River Basin A Multi-Model Assessment. Integrated Modelling Program for Canada (IMPC). First Annual Meeting July 18-19, 2018. National Hydrology Research Centre, 11 Innovation Boulevard, Saskatoon, SK

Standen KM, Baltzer JL. (2018). Plant community composition and function across a boreal productivity gradient. Chemistry-Biology Interface Symposium, Waterloo, ON, Oral Presentation

Standen KM, Baltzer JL. (2018). Plant function across a boreal productivity gradient. ArcticNet Scientific Meeting, Ottawa, ON, Poster Presentation

Standen KM, Baltzer JL. (2018). Plant function across a boreal productivity gradient. Cold Regions Research Centre Day, Waterloo, ON, Oral Presentation

Steeves, J. and Ferguson, G. 2018. Characterizing hydrogeological change from oil and gas development In the Western Canada Sedimentary Basin. GeoEdmonton2018, Edmonton, AB, October 2018.

Straker, J., Baker, T., Carey, S., Petrone, R.M. 2018. Using ecosystem water and carbon fluxes as integrated measures of reclamation success. British Columbia Technical and Research Committee on Reclamation, Williams Lake, BC, September 17-20, 2018.

Straker, J., Baker, T., Carey, S., Petrone, R.M. 2018. Using ecosystem water and carbon fluxes as integrated measures of reclamation success. Northern Latitudes Mining Reclamation Workshop, Whitehorse, YT, September 10-13, 2018.

Stralberg, D, Arsenault, D, Baltzer, JL, Barber, Q, Bayne, EM, Boulanger, Y, Brown, C, Cooke, H, DeVito, K, Edwards, J, Estevo, C, Flynn, N, Frelich, LE, Hogg, E, Johnston, M, Logan, T, Matsuoka, S, Moore, P, Morelli, TL, Morissette, JL, Nelson, E, Nenzén, H, Nielsen, SE, Parisien, M-A, Pedlar, J, Price, D, Schmiegelow, F, Slattery, S, Sonnentag, O, Thompson, D, Whitman, E (2018) Climate-change refugia in boreal North America: what, where, and for how long? Ecological Society of America Annual Meeting, New Orleans, USA.

Streich S, Westbrook C. The hydrological functions of a mountain valley-bottom wetland. Canadian Water Resources Association annual meeting, Victoria, BC, May 28 – June 1, 2018.

Strickert, G., Bradford, L., and Shantz, S. (2018) Connecting with Communities: Adventures in Community Engaged Scholarship. In Human-Water Interactions: Global Water Futures Inaugural Annual Science Meeting. McMaster University, Hamilton, ON. June 4-6, 2018. (*Poster*)

Strickert, G., Bradford, L., and Shantz, S. (2018) Connecting with Communities: Adventures in Community Engaged Scholarship. In Human-Water Interactions: Global Water Futures Inaugural Annual Science Meeting. McMaster University, Hamilton, ON. June 4-6, 2018. (*Poster*)

Strickert, G.E.H., and Shantz, S., (2018) Bluring Boundaries: Sustain Practices in Art and Science. Engagement Scholarship Consortium. Transforming Higher Education Through Engaged Scholarship A-5 Elk Lake. Minneapolis Minnesota, October 2nd, 10:00am – 11:00am, 2018.

Strickert. G.E.H., and L.E. Bradford and T. Jardine. (2018) H44B -07 Comparative Socio-hydrology: Regime Shifts, Systems Dynamics and Resilience: Connecting Human Dimensions and Hydrological Models. American Geophysical Union Fall Meeting, Washington DC, December 13th 17:30 – 17:45, 2018.

Strickert. G.E.H., Bradford, L.E., and T. Jardine. (2018) H44B -07 Comparative Socio-hydrology: Regime Shifts, Systems Dynamics and Resilience: Connecting Human Dimensions and

Hydrological Models. American Geophysical Union Fall Meeting, Washington DC, December 13th, 2018. 17:30 – 17:45, 2018.

Sultana, Afroza. "Impacts of contaminated water in Six Nations of the Grand River" (oral presentation) McMaster Indigenous Graduate Student Research Symposium, McMaster University. 13 March 2019.

Tang W, Carey SK. Detection of shifting flow regimes for watersheds in western North America using Deep Learning techniques. Presented at the American Geophysical Union Meeting, Washington, DC, December 2018.

Tang W, Carey SK. Detection of shifting flow regimes for watersheds in western North America using Deep Learning techniques. Presented at the Canadian Geophysical Union Annual General Meeting, June 2018, Niagara Falls, ON.

Telford J, BB Wolfe, RI Hall and J Hum. 2018. Using paleolimnology to establish baseline conditions for metal contaminants in advance of proposed mining, Marian Watershed, Northwest Territories, Canada. International Paleolimnology Symposium, Stockholm, Sweden.

Telford J, BB Wolfe, RI Hall and M Birlea. 2018. The use of lake sediment cores to establish baseline metal concentrations in advance of proposed mining, Marian Watershed, Northwest Territories, Canada. Geoscience Forum, Yellowknife. Telford J, BB Wolfe, RI Hall and M Birlea. 2018. Stories from Tlicho Lands: development of a successful northern partnership from an Early Career Researcher's perspective. ArcticNet Annual Scientific Meeting, Ottawa.

Telford J, BB Wolfe, RI Hall and M Birlea. 2018. Using paleolimnology to meet the needs of a northern community monitoring initiative. Cold Regions Research Centre Day, Wilfrid Laurier University, Waterloo.

Tetreault, G., K. Hicks, M. Fuzzen, K. McCann, L. Bragg, M. McMaster, M. Servos. Recovery of fish populations after infrastructure investments at municipal wastewater plants. International Association of Great Lakes Research, Toronto, June 18-22, 2018. abstract

Thapa, A. (2019). A participatory approach to enhance and measure social learning for flood preparedness: An exploratory study in Mistawasis Néhiyawak. SENS Symposium, University of Saskatchewan, Saskatoon, SK March 28th, 2019 (*Presentation*)

Thapa, A., & Strickert, G. (2019). Learning with Models: A case study for evaluating the role of scientific model in community flood management. World Water Day Event, University of Saskatchewan, Saskatoon, SK March 22th, 2019 (*Poster*)

Thapa, A., Strickert, G., and Shook, K. (2018) Building knowledge and capacity through watershed modeling in indigenous community. In Human-Water Interactions: Global Water Futures Inaugural Annual Science Meeting. McMaster University, Hamilton, ON. June 4-6, 2018. (*Poster*)

Tian, J., Lindo, Z., Petrone, R.M., McLaughlin, J., Branfireun, B.A. 2018. Greenhouse gas fluxes and carbon storage functions in two contrasting fen-peatland types: Implications for global warming. Annual General Meeting of the Canadian Geophysical Union,June 10 - 14, 2018, Niagara Falls, Ontario, Canada.

Tolson B. and Mai J. et al., (2018), Status report on the Great Lakes Runoff Inter-comparison Project for Lake Erie (GRIP-E), IMPC Annual General Meeting, Saskatoon, SK, July 18-19, 2018.

Tropea, B. and R. Stewart, 2018: Freezing rain and wet snow affecting Manitoba. Prairie Division Canadian Assoc. Geographers, Hecla, Manitoba.

Tsuji JM, Schiff SL, Thompson KT, Crowe SA, Liu K, Tran N, Venkiteswaran JJ, Elgood RJ, Molot LA and

Turetsky, MR, Baltzer, J, Douglas, T, *Gibson, C, Holloway, J, Kokelj, S, Lara, M, Lewkowicz, A, Olefeldt, D, Zwanenberg, N (2018) Interdisciplinary approaches to understanding the initiation and lateral expansion of thermokarst in peat-rich regions. European Union Conference on Permafrost 5, Chamonix, France

Ueyama, M., Okamura, M., Ito, A. et al. incl. Sonnentag, O. (2018), Constraining methane dynamics modules in ecosystem models using eddy flux measurements at northern ecosystems. Abstract B41H-0299, 10-14 December 2018, Washington, D.C., USA.

Using lake sediment cores as a tool to determine baseline toxicity data in an area where bio-monitoring did not occur historically. Advances in Earth Sciences Research Conference, University of Ottawa, Ottawa, Ontario. [received best student oral presentation award.]

Van Beest, C., Waddington, J.M., Nwaishi F.C., Khomik, M., Petrone, R.M.2018. Post Wildfire Burn Severity Effects on Peatland Carbon Exchange. Annual General Meeting of the Canadian Geophysical Union, June 10 - 14, 2018, Niagara Falls, Ontario, Canada.

Van Beest, C.E.S., Petrone,R.M., Nwaishi, F., Waddington, J.M. 2018. Nutrient Cycling in a Fen Peatland One-Year Post-Wildfire. Annual General Meeting of the Canadian Geophysical Union,June 10 - 14, 2018, Niagara Falls, Ontario, Canada.

Van Capellen, P. (2019). How geophysics informs biogeochemistry. World Wetland Day, University of Waterloo, Feb 4, 2019.

Van Huizen B, Petrone RM. 2018. Conceptualizing the Role of Seasonal Ground Ice in a Western Boreal Plains Peatland. Presented at the Canadian Geophysical Union Annual General Meeting, June 2018, Niagara Falls, ON.

Van Huizen B, Petrone RM. 2018. Spatial Patterns in Seasonal Ground Ice Melt in a Boreal Peatland. Presented at Cold Regions Research Centre Day, November 2018, Waterloo, ON.

Van Huizen B, Petrone RM. 2018. The ground heat flux components of a Western Boreal Plains Peatland. Presented at the Canadian Geophysical Union Eastern Student Conference, March 2018, London, ON.

Van Meter, K. J., Chowdhury, S., Byrnes, D., and Basu, N. B. (2018, December). Biogeochemical Asynchrony: Ecosystem Drivers of Seasonal Concentration Regimes across the Great Lakes Basin. American Geophysical Union, December 10-14, 2018, Washington D.C.

Van Meter, K. J., Van Cappellen, P., and Basu, N. B. (2018). Past, Present, and Future: Quantification of Long-Term Phosphorus Legacies in Canada's Grand River Watershed. Canadian Geophysical Union Joint Meeting, Niagara Falls, Canada, June 2018

Van Meter, K.J., Chowdhury, S., Byrnes, D., and Basu, N.B. (2018). Biogeochemical Asynchrony Ecosystem Drivers of Concentration-Discharge Dynamics Across Temporal Scales, GWF Annual Science Meeting, McMaster University, June 3-6, 2018.

Van Meter, K.J., Chowdry, S., Byrnes, D.K., and Basu, N.B. (2018). Biogeochemical Asynchrony: Ecosystem Drivers of Concentration-Discharge Dynamics Across Temporal Scales, Society for Freshwater Science 2018 Annual Meeting, Detroit, MI

Van Meter, K.J., Chowdry, S., Byrnes, D.K., and Basu, N.B. (2018). Biogeochemical Asynchrony: Ecosystem Drivers of Seasonal Concentration Dynamics, Global Water Futures 2018 Annual Science Meeting, Hamilton, ON (oral presentation, Winner of Best Postdoctoral Presentation Award)

Van Meter, K.J., Tenkouano, G., Parsons, C., Hall, R., and Basu, N. (2019). Reservoir Phosphorus Legacies: Reconstructing Long-Term Nutrient Dynamics Using Multi-proxy paleolimnological analyses. Association for the Sciences of Limnology and Oceanography Conference, San Juan, Puerto Rico, Feb 2019.

Van Staden, T., Van Meter, K.J., Basu, N.B., and Van Cappellen, P. (2019) Targeting phosphorus legacies in the Laurentian Great Lakes Watersheds. World Water Day, University of Waterloo, March 22, 2019.

Van Staden, T., Van Meter, K.J., Basu, N.B., and Van Cappellen, P. (2019) Phosphorus Legacies in Ontario Watersheds: Are Wetlands the Solution? World Wetland Day, University of Waterloo, Feb 4, 2019.

Van Staden, T., Van Meter, K.J., Basu, N.B., and Van Cappellen, P. (2018) Targeting phosphorus legacies in the Laurentian Great Lakes Watersheds. American Geophysical Union, December 10-14, 2018, Washington D.C.

Van Staden, T., Van Meter, K.J., Van Cappellen, P., and Basu, N.B. (2018). “Targeting Phosphorus Legacies in the Great Lakes Watersheds,” Global Water Futures 2018 Annual Science Meeting, Hamilton, ON.

Venkiteswaran JJ. 2018. SAMMS: The Sub-Arctic Metal Mobility Study. Presentation at the Wilfrid Laurier University – Government of the Northwest Territories Science Committee Annual General Meeting, Wilfrid Laurier University, Waterloo (2 May 2018).

Vionnet V, Gaborit E, Fortin V, Gasset N, Garnaud C, Gauthier N, Pomeroy JW. High-resolution hydrological forecasting of the June 2013 flood in the Canadian Rockies. 8th Global Energy and Water Exchanges (GEWEX) Open Science Conference: Extremes and Water on the Edge, Canmore, Canada, May 6, 2018

Vionnet V, Gaborit E, Fortin V, Gasset N, Garnaud C, Gauthier N, Pomeroy JW, (2018). High-resolution hydrological forecasting of the June 2013 flood in the Canadian Rockies. 8th Global Energy and Water Exchanges (GEWEX) Open Science Conference: Extremes and Water on the Edge, Canmore, Canada, May 6, 2018.

Vionnet V, Marsh C, Wayand N, Menounos B, Mukherjee K, Shea J, Gasset N, Pomeroy J. Multi-scale Snowdrift-resolving Modelling of Mountain Snowpack Evolution. Annual Meeting of the American Geophysical Union, Washington, DC, 10-14 December, 2018.

Volik, O., Petrone, R.M., Quanz, M., Macrae, M.L., Rooney, R., Price, J.S. 2018. Environmental controls on CO2 exchange along a salinity gradient in a saline boreal fen in the Athabasca Oil Sands Region. Annual General Meeting of the Canadian Geophysical Union,June 10 - 14, 2018, Niagara Falls, Ontario, Canada.

Walker, XJ, Baltzer, JL, Cumming, SG, Day, N, Goetz, SJ, Johnstone, JF, Potter, S, Rogers, BM, Schuur, E, Turetsky, MR, Mack, MC. 2018. Vulnerability of boreal forest legacy carbon to combustion increases with shortened fire return intervals. AGU Annual Meeting. Washington, USA.

Wallace, C.A. and Baltzer, J. (2018). Establishment and seed dispersal of a tall shrub at the boreal-arctic ecotone. Cold Regions Research Centre Annual Research Symposium. Waterloo, ON. November 28, 2018.

Wallace, C.A. and Baltzer, J. (2018). Seed dispersal as an explanation of spatial variability in shrub expansion at the taiga-tundra ecotone of the Northwest Territories. ArcticNet Annual Scientific Meeting, Ottawa, ON.

Wallace, C.A. and Baltzer, J. (2018). Tall shrubs mediate soil conditions and plant communities at the treeline-arctic tundra ecotone. Global Water Futures Annual Scientific Meeting.

Wang, J., Sulla-Menashe, D.J., Woodcock, C.E., Sonnentag, O., Friedl, M.A. (2018), Shifting plant functional types in the rapidly warming high northern latitudes. Abstract U13B-19, Washington, D.C., USA.

Watts, J., Natali, S.M., Minions, C. et al. incl. Sonnentag, O. (2018), Quantifying cold season soil CO2 emissions in Alaska and northwest Canada. Abstract B31F-0477, 10-14 December 2018, Washington, D.C., USA.

Werenka, A., Van Meter, K.J., Tolson, B., and Basu, N.B. (2018). Too Much Phosphorous: Is Investment in Biogas Plants a Viable Alternative for Water Quality Improvement? Canadian Geophysical Union Joint Meeting, Niagara Falls, Canada, June 2018.

Westbrook CJ, Ronnquist A, Bedard-Haughn A. Dynamic beaver pond levels in mountain peatlands provide transient floodwater storage. International Beaver Symposium, Denmark, September 17 – 20, 2018.

Westbrook CJ, Ronnquist A, Bedard-Haughn A. Dynamic beaver pond levels in mountain peatlands provide transient floodwater storage. Society of Wetland Science Annual Meeting, Denver, Colorado, USA, May 29 – June 1, 2018.

White, AL, *Day, NJ, Walker, XJ, Johnstone, JF, Cumming, SR, Mack, MC, Turetsky, MR., Baltzer, JL (2018) Environmental legacies drive post-fire vascular plant recovery in the sub-arctic boreal forest. CANQUA 2018. Ottawa, ON

White, J. R., Basu, N. B., Roy, E. D., Bargu, S., & Midway, S. R. (2018). Impact of a Temporally-Displaced Mississippi River Spring Flood on Nutrient and Aquatic Ecosystem Responses in Estuarine Waters: A Hydrologic Harbinger of a Shifting Climatic Future Affecting Coastal Food Webs. American Geophysical Union, December 10-14, 2018, Washington D.C.

Whitfield PH*, Shook KR*, Kraaijenbrink P, Pomeroy JW, (2018). Changing cold regions in western Canada: hydrology and hydrologic and landscape change east of the Cordillera. The 71st

Canadian Water Resources Association (CWRA) National Conference, Victoria, Canada, May 28, 2018

Whitfield PH, Shook KR, Kraaijenbrink P, Pomeroy JW, (2018). Changing cold regions in western Canada: hydrology and hydrologic and landscape change east of the Cordillera. The 71st Canadian Water Resources Association (CWRA) National Conference, Victoria, Canada, May 28, 2018.

Whitfield PH, Shook KR, Kraaijenbrink P, Pomeroy JW. 2018. Changing cold regions in western Canada: hydrology and hydrologic and landscape change east of the Cordillera. The 71st Canadian Water Resources Association (CWRA) National Conference, Victoria, Canada, May 28, 2018

Whitfield PH, Shook KR, Kraaijenbrink P, Pomeroy JW. Changing cold regions in western Canada: hydrology and hydrologic and landscape change east of the Cordillera. The 71st Canadian Water Resources Association (CWRA) National Conference, Victoria, Canada, May 28, 2018

Wicke, A. and Rudolph, D. L., 2018. Sahtu Hydrologic Observatory: Hydrogeologic Conceptual Model and Baseline Conditions, Global Water Futures, Annual Science Meeting. MacMaster University, Hamilton, Ont.

Wicke, A. and Rudolph, D. L., 2018. Sahtu Hydrologic Observatory: Hydrogeologic Conceptual Model and Baseline Conditions. Global Water Futures Annual Science Meeting. MacMaster University, Hamilton, Ontario.

Wicke, A., Rudolph, D. L. and Conant Jr. B. (2019). Characterization of Groundwater Flow Dynamics in Discontinuous Permafrost. 2nd Annual Open Science Meeting: Global Water Futures. Saskatoon, Saskatchewan, Canada, May 15-17, 2019.

Wilkinson SL,, Waddington JM, Kettridge N, Moore, P. 2018. Peatland drying and a orestation enhances peat burn severity and exposes remnant peat carbon stocks to increased post-re drying. Presented at the American Geophysical Union Meeting, Washington, DC, December 2018.

Williamson J, Petrone R. Assessing the role of tree growth patterns on the spatial variability of evapotranspiration on a subalpine hill slope in Kananaskis, Alberta. McMaster Water Week 2018, poster presentation. November 21, 2018

Williamson J, Petrone R. Assessing the role of tree growth patterns on the spatial variability of evapotranspiration on a subalpine hill slope in Kananaskis, Alberta. CGU Eastern Student Section Meeting 2018, poster presentation. November 21, 2018

Wolfe BB. 2018. Introduction to SAMMS (Sub-Arctic Metal Mobility Study). Presentation to Northern Water Futures Northern Student Training Series, Wilfrid Laurier University, Waterloo.

Wolfe, J., Shook, K., Whitfield, C., and Spence, C. (2018) A Watershed Classification for the Canadian Prairies. In Modelling and Observations: Global Water Futures Inaugural Annual Science Meeting. McMaster University, Hamilton, ON. June 4-6, 2018. (*Poster*)

Wolfe, J., Whitfield, C., and Spence, C. (2019) Prairie Water. Global Water Futures Operations Meeting. University of Saskatchewan, Saskatoon, SK. January 22-23, 2018. (*Poster*)

Wolfe, J.D., Shook, K.R., Spence, C. and Whitfield, C.J. (2019) Watershed classification for the Canadian Prairies. Prairie Water 2nd Annual Partners Meeting. Holiday Express Inn & Suites, Saskatoon, SK. January 24-25, 2019. (*Poster*)

Wong, J., Razavi, S., Gharari, S., Wheater, H., (2018) Quantifying the uncertainty of water budget components over large river basins in Canada, Canadian Geophysical Union, 10-14 June 2018, Niagara Falls, ON, Canada.

Wu, Y., de Lannoy, C. F., 2019. Hydrophobicity of peat soils under forest first conditions. Global Water Futures Second Annual Meeting, Saskatoon, SK

Xu, B., & Arain, A. (2018, June 10-14). The sensitivity of forest carbon fluxes to heat and drought stresses: a synthesis of seasonal pattern across forests in North America. Oral presentation at the meeting of the CGU-CSSS-CIG-CSAFM-ESSSA, Niagara Falls, ON, Canada.

Xu, B., & Arain, A. (2018, June 10-14). *The sensitivity of forest carbon fluxes to heat and drought stresses: a synthesis of seasonal pattern across forests in North America*. Oral presentation at the meeting of the CGU-CSSS-CIG-CSAFM-ESSSA, Niagara Falls, ON, Canada.

Yamaguchi, A. (2018). Thesis project summary. WLU-GNWT Annual General Meeting. (presentation)

Yamaguchi, A. (2019). GWF 2nd Annual Open Science Meeting. May 15–17, 2019, Saskatoon. (poster)

Yanping Li, Sopan Kurkute, Zhe Zhang, Zhenhua Li, Lucia Scaff, (2018): Projected changes over western Canada using convection-permitting regional climate model. 8th GEWEX Science Conference, 6-11 May 2018 in Canmore, Alberta, Canada

Yanping Li, Sopan Kurkute, Zhe Zhang, Zhenhua Li, Lucia Scaff, 2018: Projected changes over western Canada using convection-permitting regional climate model. 8th GEWEX Science Conference, 6-11 May 2018 in Canmore, Alberta, Canada

Yassin, F., Elshamy, M., Razavi, S., Wheater, H., (2018), Towards an Improved Parameterization of Reservoir Operation for Large-Scale Hydrological Modeling, American Geophysical Union (AGU) Fall Meeting, Washington DC. December 10-14, 2018.

You G., Arain A., He Y., Xu B., Wu D. Lin N., & Zou C. (2018, June 10-14). *The Relationship between Climate Variability and Vegetation Dynamic in Upper Stream of Heilongjiang (Amur) River, northeast Asia*. Oral presentation at the meeting of the CGU-CSSS-CIG-CSAFM-ESSSA, Niagara Falls, ON, Canada.

Zhang, F., Li, Zhaoqin, L. and Lindenschmidt, K.-E. (2018) Potential of RADARSAT-2 for improvement of an ice thickness model: a case study on the Slave River at Fort Smith, Alberta. 39th Canadian Symposium on Remote Sensing, Saskatoon, Saskatchewan, Canada, 19-21 June, 2018

Zhao, Pei, Ning Qin, Carolyn Ren and John Wen, 2018. Surface Modification of Polymer Filters by Etching and a PDA Coating for Oil-Water Separation. MRS Fall Meeting & Exhibit, November 25-30, Boston, MA, USA.

Zhe Zhang, Yanping Li, Fei Chen, Michael Barlage, (2018) Climate- Groundwater Interaction on Modeling Wetlands in Prairie Pothole Region. 8th GEWEX Science Conference, 6-11 May 2018 in Canmore, Alberta, Canada

Zhe Zhang, Yanping Li, Fei Chen, Michael Barlage, 2018: Climate- Groundwater Interaction on Modeling Wetlands in Prairie Pothole Region. 8th GEWEX Science Conference, 6-11 May 2018 in Canmore, Alberta, Canada

Zhenhua Li, Yanping Li, Barrie Bonsal, Alan Manson, (2018): MJO and Summer Precipitation/Drought in the Canadian Prairies. 8th GEWEX Science Conference, 6-11 May 2018 in Canmore, Alberta, Canada

Zhenhua Li, Yanping Li, Barrie Bonsal, Alan Manson, 2018: MJO and Summer Precipitation/Drought in the Canadian Prairies. 8th GEWEX Science Conference, 6-11 May 2018 in Canmore, Alberta, Canada

Zolfaghari, K., S. Bird, G. Wilkes, D. Ellis, K. Pintar, N. Gottschall, E. Topp, C.R. Duguay, H. McNairn, and D.R. Lapen, 2018. Using WorldView imagery to study chlorophyll-a concentration in South Nation River, Eastern Ontario, Canada. *Ocean Optics Conference XXIV*, Dubrovnik, Croatia, 7-12 October.

Zolfaghari, K., S. Bird, G. Wilkes, D. Ellis, K.D.M. Pintar, N. Gottschall, E. Topp, C.R. Duguay, H. McNairn, and D.R. Lapen, 2018. Comparison of lab- and field-based water quality measurements for agricultural surface waters. IAGLR 2018 - 61st Annual Conference on Great Lakes Research, Toronto, Canada, 18-22 June.

Others

By application: “Strategic thinking for making new space for Indigenous Water Governance” panel, World Indigenous Law Conference, University of Windsor, Ontario. 20 November 2018. The following presentations took place during this panel (by application)

Case Presentation to a 200 Level Undergraduate Psychology Class in August 2018, Social psychological phenomena and interconnections of the socio-ecological system related to flooding in Indigenous Communities.

Dawn Martin-Hill (Mohawk, Wolf Clan), “Indigenous governance & responses to climate change and water security.” Nidhi Nagabhatla, “Synopsis of direct and indirect drivers and role of Indigenous and local knowledge (ILK) systems.” Nancy Doubleday, “Bio-Centric Legal Spaces and Human Understanding” Jorge Fabra-Zamora, “The missing element in the ‘communicating framework.”

Kurt Gibson “Youth” panel, First Nations Water Security & Climate Change Symposium, Six Nations Territory

Nidhi Nagabhatla, Nancy Doubleday “Governance & Law” panel, First Nations Water Security & Climate Change Symposium, Six Nations Territory. 3 June 2018.

Patricia Chow-Fraser, Dawn Martin-Hill, Constantine Samaan “Co-Creation of Indigenous Water Quality Tools” panel, First Nations Water Security & Climate Change Symposium, Six Nations Territory. 3 June 2018.

Published Datasets

Sonnentag, O., Quinton, W.L. (2018), Ameriflux CA-SCC Scotty Creek Landscape. doi:10.3334/ORNLDAAC/1511.

Sonnentag, O., Quinton, W.L. (2019), Ameriflux CA-SCB Scotty Creek Bog. doi:10.17190/AMF/1498754.

Walker, X.J., B.M. Rogers, J.L. Baltzer, S.R. Cummings, *N.J. Day, S.J. Goetz, J.F. Johnstone, M.R. Turetsky, and M.C. Mack. 2018. ABoVE: Wildfire Carbon Emissions and Burned Plot Characteristics, NWT, CA, 2014-2016. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1561

Walker, X.J., J.L. Baltzer, S.G. Cumming, *N.J. Day, S.J. Goetz, J.F. Johnstone, S. Potter, B.M. Rogers, E.A.G. Schuur, M.R. Turetsky, and M.C. Mack. 2019. ABoVE: Characterization of Carbon Dynamics in Burned Forest Plots, NWT, Canada, 2014. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1664

Conference Posters

Balliston, N & Price, J. S. Characterizing Patterned Peatlands in the James Bay Lowlands and the Potential Feedbacks to Anthropocentric Stressors. Poster Presented at World Wetlands Day, March 2018, Waterloo, ON

Elmes, MC., Thompson, DK., & Price, JS. 2018. Changes to the hydrophysical properties of upland soils in the Athabasca Oil Sands Region following wildfire. Canadian Geophysical Union 2018 Meeting, Niagara Falls, ON

Popović, N., Green, A., Kessel, E., Kohmik, M., Petrone., R.M. 2018. What the Flux? Carbon and Water Dynamics During the Early Development of a Reclaimed, Post-. Oilsands Landscape in Northern Alberta, Canada. Poster Presenter at the American Geophysical Union Annual Meeting, D.C., Dec. 2018. (Outstanding Student Presentation Award – Biogeoscience Section, American Geophysical Union Annual Meeting 2018. The Outstanding Student Presentation Awards (OSPAs) promote, recognize and reward students for quality research in the Earth and space sciences. Awarded to the top 3-5% of presenters in each Section.)

Popović, N., Green, A., Kessel, E., Kohmik, M., Petrone., R.M. What the Flux? Carbon and Water Dynamics During the Early Development of a Reclaimed, Post-. Oilsands Landscape in Northern Alberta, Canada. Poster Presenter at World Wetlands Day Research Symposium, University of Waterloo, Feb. 2019.

Popović, N., Petrone, R.M., Price, J.S., Strack, M. 2018. Effect of Seasonal Variations in Water Availability on the Ecohydrological Function of a Constructed Peatland. Poster Presentation at McMaster Water Week Research Showcase, Hamilton, Nov. 2018.

Popović, N., Petrone, R.M., Price, J.S., Strack, M. 2018. The Role of Vascular Vegetation on Carbon and Water Dynamics in a Constructed Peatland. Poster Presentation at the Canadian Geophysical Union (CGU) annual conference, Niagara Falls, June, 2018

Robinne FNR, Hallema DW, Bladon KD, Sun G. 2018. Natural and social aspects of global wildfire threats to water supplies. Presented at the American Geosciences Union Meeting, December 2018, Washington, DC, USA.

Robinne FNR, Hallema DW, Sun G, Bladon KD. 2018. Global water security, wildfire risk, and society. Terrestrial Ecosystems and Agricultural and Forest Meteorology Symposium, Nanjing University of Information Science and Technology, Nanjing, Jiangsu Province, People's Republic of China, October 26-28, 2018.

Van Huizen B, Petrone RM. 2018. Comparing methods of determining seasonal ground ice position in a boreal peatland. Poster Presented at the Global Water Futures Annual Meeting, May 2018, Hamilton, ON.

Van Huizen B, Petrone RM. 2018. Melting Seasonal Ground Ice water inputs and spatial controls on melt in a Western Boreal Plains Peatland. Poster Presented at McMaster Water Week Research Showcase, November 2018, Hamilton, ON.

Van Huizen B, Petrone RM. 2018. Modelling Seasonal Ground Ice and Evapotranspiration in a Western Boreal Plains Peatland using the Cold Regions Hydrological Model (CRHM). Poster Presentation at the Canadian Geophysical Union Annual Meeting, June 2018, Niagara Falls, ON.

Appendix G – International Joint Faculty Appointment

Summary: International joint faculty appointments: 23

Arain, Altaf

- Adjunct Professor, United Nations University – Institute of Water Environment and Health (UNU-INWEH). Participation in research, HQP training and outreach activities in collaboration with UNU-INWEH team members. 2017 to Present.

Brouwer, Roy

- Visiting Professor, Swiss Federal Institute for Aquatic Science and Technology (Eawag)

Doubleday, Nancy

- Adjunct Professor, United Nations University – Institute of Water Environment and Health (UNU-INWEH). Water, Health, Environment student projects (re R. Narro; S. Newell); Water and Peace (A. Debray and N. Nagabhatla). January, 2016 to January, 2018.
- Adjunct Professor, United Nations University – Institute of Water Environment and Health (UNU-INWEH). Water, Health, Environment student projects (re R. Narro; S. Newell); Water and Peace (A. Debray and N. Nagabhatla). January, 2018 to January, 2020.

Gober, Patricia

- Project Advisor, Arizona State University, provides feedback and support for the project's foundational framework and ongoing field research methodology.

Giesy, John

- Distinguished Visiting Professor, University of Hong Kong. Grant proposals and joint projects, and manuscripts, advising students and teaching. November 2017 to December 2018.
- Concurrent Professor, Nanjing University. Grant proposals and joint projects, and manuscripts, advising students and teaching. 2003 to present.
- Guest Professor, Xiamen University. Grant proposals and joint projects, and manuscripts, advising students and teaching. 2008 to present.
- Member, Board of Directors. Program Review. City University Hong Kong, State Key Laboratory in Marine Pollution. 2006 to present.
- Distinguished Visiting Professor, Hong Kong Baptist University. Grant proposals and joint projects, and manuscripts, advising students. 2014 to present.
- Visiting Professor and Graduate Faculty, Baylor University. Grant proposals and joint projects, and manuscripts, advising students. 2016 to present.
- Einstein Professor, Chinese Academy of Science. Lectures and seminars. 2009 to present.

Hecker, Markus

- Guest Professor, Xiamen University. Joint projects and manuscripts, advising students and teaching.

Helgason, Warren

- Special Lecturer, Beijing Normal University. Deliver graduate course in Land-Atmosphere. 2010 to 2018.

Krantzberg, Gail

- Adjunct Professor, United Nations University – Institute of Water Environment and Health (UNU-INWEH). Research collaboration, curriculum development, joint policy briefs. March 15th, 2018 to TBD.

Liber, Karsten

- Distinguished Professor, Institute of Loess Plateau, Shanxi University, Shanxi, China

McDonnell, Jeffrey

- 6th Century Chair in Hydrology, University of Aberdeen
- University Distinguished Professor of Hydrology (Adjunct), Oregon State University
- Honorary Professor, Nanjing Hydraulic Research Institute
- Visiting Professor, Hohai University

Pahl-Wostl, Claudia

- Claudia provides feedback and support for the project's foundational framework and ongoing field research methodology.

Petrone, Rich

- Adjunct Professor, Univeristy of KwaZulu-Natal. PhD Committee Member. January 2018 to present.

Pomeroy, John

- Visiting Professor, Chinese Academy of Sciences, Lanzhou, China
- Honorary Professor, Dept. of Geography & Earth Sciences, Aberystwyth University, UK

Rezanezhad, Fereidoun

- Collaboration with Professors Kögel-Knabner and Carsten Muller at Technical University of Munich (TUM), Germany, on cold regions hydrogeochemistry research, to better understand the role of winter soil processes on the export of carbon and nutrients under non-growing season in cold region soil ecosystems.

Van Cappellen, Philippe

- Honorary Professor, Tianjun University. Students and PDF exchanges on joint project on nutrients in dam and reservoirs.

Appendix H – Leveraged cash and in-kind contributions by Pillars 1-2-3 projects (2016-2020) and additional major endeavours

Project Title	Cash	In-kind
Agent Based Modelling	$80,000	$0
Agricultural Water Futures (AWF): Stressors and Solutions	$1,113,000	$9,955,600
Boreal Water Futures	$8,341,663	$3,478,300
Climate-Related Precipitation Extremes	$165,000	$765,000
Co-creation of Indigenous Water Quality Tools	$35,000	$1,590,520
Crowdsouring Water Science	$0	$10,000
FIShNET (Fish & IndigenouS NorthErn healTh)	$110,400	$45,000
Forecasting Tools and Mitigation Options for Diverse Bloom-Affected Lakes	$1,398,720	$4,699,095
Global Water Citizenship	$0	$348,696
Groundwater Dynamics	$0	$5,000
Indigenous Water Tools	$0	$106,500
Integrated Modelling Program for Canada	$505,400	$11,845,480
Is our Water Good to Drink?	$35,000	$16,000
Lake Futures	$249,200	$4,737,441
Linking multiple stressors to adverse ecological responses across watersheds	$125,102	$24,296
Matawa Water Futures	$90,051	$53,885
Mountain Water Futures	$2,211,400	$621,000
Next Generation Solutions to Ensure Healthy Water Resources for Future Generations	$2,370,250	$1,641,750
Northern Water Futures	$5,800,380	$10,754,290
Ohneganos	$120,000	$52,000
Omic' and chemical fingerprinting methodologies	$160,000	$45,000
Prairie Drainage Governance	$4,000	
Prairie Water	$404,000	$36,204,900
SAMMS (Sub-Arctic Metal Mobility Study) (Wolfe)	$573,498	$4,020
Short-duration extreme precipitation in future climate	$0	$80,000
Storms and Precipitation Across the continental Divide Experiment (SPADE)	$0	$201,200
Transformative Sensor Technologies and Smart Watersheds for Canadian Water Futures	$281,279	$28,580,653
Water Knowledge Camps	$83,750	$57,000
Winter Soil Processes in Transition	$33,700	$0

Canada 150 Research Chair in Remote Sensing and Hydrology	$7,000,000	-
Smart Water Systems Laboratory – Western Economic Diversification	$1,374,576	-
Green Roof Technology – Western Economic Diversification	$643,702	-
Airborne Cold Regions Observatory – Canada Foundation for Innovation	$200,000	-
Computer Canada – Research Platforms and Portals	$900,000	-
University of Saskatchewan	$27,500,000	-
University of Waterloo	$15,000,000	-
McMaster University	$12,136,287	-
Wilfrid Laurier University	$10,580,000	-
Global Water Futures, Canada First Research Excellence Fund	$77,840,000	
Total	$176,615,617	$115,835,074

Appendix I – Professional and Career Development Opportunities

Short Courses Open to Professionals

Agent Based Modelling (Bharadwaj)

- Cheryl Waldner attended the Agent-Based and Hybrid Modeling Bootcamp for health researchers August 20-25, 2018.
- Nvivo Training Session attended by summer undergraduate student (Kurt Belcher)
- Nvivo training session completed by Alasdair Morrison

Agricultural Water Futures (AWF): Stressors and Solutions (Macrae)

- Mazda Kompanizare. BAYESIAN WATERLOO 2019, Environmental models and Bayesian methods, University of Waterloo, 25-27 March, 2019 (attended).
- John Pomeroy. Kananaskis Short Course on Principles of Hydrology (Jan 10-21, 2019) (provided). Intensive course on the physical principles of hydrology with particular relevance to Canadian conditions.

Boreal Water Futures (Waddington)

- John Pomeroy. Kananaskis Short Course on Principles of Hydrology (Jan 10-21, 2019) (provided). Intensive course on the physical principles of hydrology with particular relevance to Canadian conditions.

Climate Extremes (Zwiers)

- Short public course on winter precipitation organized by Coeur des sciences at UQAM. The course was on the description of the different types of ice crystals, on the formation of freezing rain and on precipitation measurements.
- 4 HQPs were involved, including Aurélie Desroches-Lapointe and Charlie Hébert-Pinard

Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins (IMPC) (Razavi)

- Short Course on Principles of Hydrology (Kananaskis, Jan 10-21, 2019)
- Spring school on "Environmental Models and Bayesian Inference" with Prof. Dmitri Kavetski at University of Waterloo, March 25-27, 2019, Organized and co-delivered by Juliane Mai, 15 participants (3 are GWF HQP)

Lake Futures: Enhancing Adaptive Capacity and Resilience of Lakes and their Watersheds (Basu)

- Servos, M., Rooney, R., Basu, N.B., Samson, M., Bocaniov, S., Quinn-Austin, H., Ho, E., Van Staden, T., Burton, E., & Jordan, M. (2018). June 7 & 8, 2018. Lake Futures HQP Summer Retreat, Long Point, ON. 7 HQP and 2 Professors attended the retreat. The retreat involved meetings with various stakeholders, including; Long Point Conservation Authority, Normandale Fish Culture Station, Long Point Bird Observatory, Ontario ministry of Natural Resources and Forestry, Dunnville Dam, etc.

Linking Stream Networks (MacVicar)

- Participant (2018) Southern Ontario Stream Monitoring and Research Team (SOSMART), Mississauga ON, Hosted by Credit Valley Conservation. Presentations by Kimisha Ghunowa and Elli Papangelakis on recent research from our group.
- Participant (2019) Southern Ontario Stream Monitoring and Research Team (SOSMART), Mississauga On, Hosted by Niagra Conservation
- Lead Organizer (2019) Student Symposium, Ontario and Quebec Hydraulic Research Association Project (OQHRAP), University of Waterloo, 35 HQP participants from 6 universities.
- Linking Water Governance in Canada to Global Economic, Social and Political Drivers (de Loe)

Mountain Water Futures (Carey)

- CSHS and University of Saskatchewan Centre for Hydrology Short Course on the Principles of Hydrology (Jan 2017). HQP in attendance: Lindsey Langs
- CREATE Professional Practice in Water Security Short Course (May 2018). HQP in attendance: Lindsey Langs, Jessica Williamson, Dylan Hrach
- Julie Thériault ran a short public course on winter precipitation organized by *Coeur des sciences* at UQAM. The course was on the description of the different types of ice crystals, on the formation of freezing rain and on precipitation measurements.
- 4 HQPs from UQAM were involved
- Kananaskis Short Course on Principles of Hydrology (Jan 10-21, 2019)

Next Generation Solutions (Giesy)

- Nathanael Harper, Heather Ikert and Patricija Marjan attended a field-based course titled "Introduction to Environmental Genomics for (Eco)Toxicology" at the Queens University Biological Station (QUBS), organized by Laurentian Chapter of the Society of Environmental Toxicology and Chemistry. Kingston, Ontario. June 7, 2018

Northern Water Futures (Baltzer)

- Structural Equation Modelling Course (PR Statistics, Nov 2018) • 2018/5 Multivariate analysis of spatial ecological data using R (MVSP03): Certificate of Completion, PR Statistics. – The course described recent methods (concepts and R tools) that can be used to analyze spatial patterns in community ecology. The umbrella concept of the course is beta diversity, which is the spatial variation of communities.
- Family-level aquatic invertebrate identification training (Ontario Benthos Biomonitoring Network)
- Stable isotope analysis workshop (UNB Fredericton, March 2018)

Storms and Precipitation Across the continental Divide Experiment (SPADE) (Theriault)

- Short public course on winter precipitation organized by Coeur des sciences at UQAM. The course was on the description of the different types of ice crystals, on the formation of freezing rain and on precipitation measurements.
- 4 HQPs were involved, including Aurélie Desroches-Lapointe and Charlie Hébert-Pinard

Transformative Sensor Technologies and Smart Watersheds (Duguay)

- Kananaskis Short Course on Principles of Hydrology (2019)
- Waterloo Wellington Flight Centre – 3-day UAV Pilot Training (Number of HQP attended: 2).

Waterloo Technical Core Team

- Dhiyebi: Completed the Small Vessel Operator training including Small Vessel Operator's Proficiency (SVOP), Small Domestic Vessel – Basic Safety (SDV-BS), Marine First Aid and Restricted Operator's Certificate (Maritime) (2018).
- Niederkorn: Ice Safety Awareness course (for winter sampling on lakes) – training given by Rescue Canada
- Vandenhoff: Attended a Regional-Scale Groundwater Geoscience workshop co-hosted by the Geological Survey of Canada, Ontario Geological Survey, and Conservation Ontario Geoscientists to stay up to date in the latest advances, applications and limitations in data collection and application at the regional scale applicable to global regional studies.

WLU Technical Team (Muttkitrnick)

- Structural Equation Modelling Course (attended by A. Sniderhan, PR Statistics, November 2018)
- Principles of Hydrological Modelling (attended by J. Hickman, Department of Civil and Environmental Engineering, University of Waterloo, June 2018)

Special Seminars

Agricultural Water Futures (AWF): Stressors and Solutions (Macrae)

- Agricultural Water Futures (AWF): Stressors and Solutions (Macrae) Jian Liu. A talk on "Agricultural water quality: challenges and solutions" in the SLSC 990 Graduate Student Seminar Series, University of Saskatchewan (about 40 HQPs). Jan. 7, 2019.
- Merrin Macrae, J. Plach, W. Pluer. "Recent Progress on Phosphorus and Water Quality in Ontario", half-day meeting with members of the Ontario PLATO team in Guelph, Ontario, March 19, 2019 to incorporate Macrae's research findings and data into the tool.

Boreal Water Futures (Waddington)

- Doubleday presented an invited paper on collaborative water governance and rural and remote communities, delivered at McMaster as WATER/Health Interactions in the Arctic.

McMaster Conference on Water: International Threats. West Room, University Club, November 5, 2018. Convened by Drs. Velma Grover & G. Kranzberg.

- Waddington JM, presented a webinar "Hot Hot Peat: Managing Boreal Wildfires in an Era of Climate Change" for Ducks Unlimited and the Canadian Institute of Forestry, February, 2019.

Global Water Citizenship (Robertson)

- Global Water Citizenship Annual Meeting. Six HQP involved in this meeting, all of whom presented their current research activities. Planning meeting among PIs (Robertson, Roberts, Feick, and English) occurred prior to the afternoon seminar session.

Knowledge Mobilization Core Team

- Merrill, S. (2019, March 29). Stories of Water Protection Impact in New Brunswick. Global Institute for Water Security, Women in Water Lecture Series. Saskatoon, SK

Lake Futures: Enhancing Adaptive Capacity and Resilience of Lakes and their Watersheds (Basu)

- **Krantzberg, G.** (2018). Career Presentation for the Institute of Public Administration of Canada, the South Western Ontario Regional Chapter: New Professionals Event. London, ON, June 2018.

Mountain Water Futures (Carey)

- Bow River Basin Council, June 2018 (Rooney HQP attended)
- Thériault, J M (2018) Precipitation and associated with atmospheric conditions east of the continental divide in the Canadian Rockies, University of Albany SUNY (approximately 30 people in audience)

Prairie Drainage Governance (Loring)

- We hosted a luncheon on January 25, 2019 to present on the intent of the project and mobilize preliminary findings.
    a. 2 HQP hosted this event

Prairie Water (Spence/Whitfield)

- PW/GWF student engagement and young professionals opportunities in KM
    - In collaboration with GWF KM Core, we are developing opportunities with students/HQP within Prairie Water to advance skills in knowledge mobilization and science communication. As we envision it, this will eventually contribute to workshop opportunities and seminars within Prairie Water and GWF that are co-produced with students/HQP. We are currently within the pilot testing stages of the above.
    - #HQP involved: 8
- Malaj, E. (2019) Ecological risk assessment of pesticides in the Prairie Pothole Region. *WildEcol Seminar Series*. University of Saskatchewan, Saskatoon, SK. February 1st, 2019.

Southern Forests Water Futures (Arain)

- Drs. Altaf Arain, Mike Pisaric, Fan-Rui Meng and Qiang Li offered a session entitled "CGU-H04 - Impacts of forest disturbances and climate change on watershed hydrology and biogeochemistry" at the Canadian Geophysical Union (CGU) annual meeting held in Niagara Falls from 10-14 June 2018.
- A special issue reporting papers presented at this conference and others is also in progress in peer-reviewed journal Forests.

Storms and Precipitation Across the continental Divide Experiment (SPADE) (Theriault)

- Thériault, J M (2018) Precipitation and associated atmospheric conditions east of the continental divide in the Canadian Rockies, University of Albany SUNY (approximately 30 people in attendance)
- Stewart, R E (March 2019) Occurrence of temperatures close to 0°C across Canada as well as associated precipitation such as freezing precipitation and wet snow, University of British Columbia, Vancouver, BC (approximately 50 people in attendance

Transformative Sensor Technologies and Smart Watersheds (Duguay)

- Microsatellite mission design webinar with Honeywell and water research community (2018). Recorded video at: https://youtu.be/Qp-P5QkPRcM

Winter Soil Processes in Transition (Rezanezhad)

- Dr. Rezanezhad (PI on this project) gave a seminar in the Department of Earth and Environmental Sciences at the University of Waterloo on March 18, 2019. The topic of the seminar was "The Critical Zone: Environmental research at the intersection of atmosphere, hydrosphere, geosphere and biosphere". Part of this seminar was focused on and presented this GWF Winter Soil Processes in Transition project.

Workshops

Agent Based Modelling (Bharadwaj)

- Presentation to Yellow Quill Council and Community Members (May 2018)
- Presentation to James Smith Cree Council Members (May 2018)
- Presentation of initial inundation modeling findings to Mistawasis Néhiyawak community (March 2019)
- Cognitive mapping and participatory mapping with Mistawasis Néhiyawak community (March 2019**)**

Agricultural Water Futures (AWF): Stressors and Solutions (Macrae)

- Mazda Kompanizare, Janina Plach, Anna Frank, Ryan Carlow, Kirsten Grant. Attended QUEBEC-ONTARIO COOPERATION FOR AGRI_FOOD RESEARCH, 2nd Workshop on Climate Change, Controlled Drainage and Water Quality, June 15, 2018

- Mazda Kompanizare, Janina Plach, Will Pluer, Anna Frank, Ryan Carlow, Kirsten Grant, Kevin de Haan, Stephanie Higgins, Meredith Marshall, Attended Global Water Futures, Local Water Solutions in a Changing Climate Workshop, Waterloo, ON, December 2018.
- Anna Frank. Attended Global Water Futures. Learn how to make infographics, November 14, 2018
- Phil Harder. Attended the " 2019 Saskatchewan Branch Workshop on Drainage and Drought in the Prairies" in Regina SK, February 1 2019
- Phil Harder. Attended the "CANADA-SASKATCHEWAN IRRIGATION CROP DIVERSIFICATION CENTRE (CSIDC) FIELD DAY" in Outlook SK on July 12, 2018.
- S. Higgins attended an R workshop offered by SWIGS (Students of the Water Institute Graduate Section); Approximately 20 Graduate students learned basic code used by R, how to download data, compile and process data using R; February 2, 2018.
- S. Higgins attended a GIS workshop offered by SWIGS (Students of the Water Institute Graduate Section); Approximately 20 Graduate students were taught how to export a site map, include and inset map, add necessary components and export as a pdf; March 2, 2019.

FIShNET (Fish & IndigenouS NorthErn healTh): Healthy Water, Healthy Fish, Healthy People (Skinner)

- CIHR/FLEdGE Workshop to Develop a CIHR Grant (Climate Change and Food Security in the NWT) on March 24-26, 2019. All of our (Swanson, Laird, Skinner) students were invited to participate in this workshop, to learn more about engaging with partners and stakeholders and communities and how to develop the ideas and plans for collaborative research. This workshop involved multiple universities (U Waterloo, Wilfrid Laurier University, U Guelph, and U Ottawa) and students (n=14) from all of those universities attended and had the opportunity to give a brief presentation on the research that they were doing. Mylene Ratelle, our project manager, also attended and 5 students that work directly under Swanson, Laird, and Skinner attended.

Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins (IMPC) (Razavi)

- Juliane Mai: OSTRICH crash course at University of Waterloo for students and post-docs, Nov 16, 2018, 9 participants (4 are GWF HQP)

Knowledge Mobilization Core Team

- Merrill, S. and Goucher, N. (2018, October 26). KM Webinar Series: Making research impact: The value of KM. Available at: https://www.youtube.com/watch?v=Uw5poq1GN6I
- Goucher, N. and Spring, A. (2018, November 16). KM Webinar Series: Maintaining KM momentum into year 2: Keeping partners engaged. Available at: https://www.youtube.com/watch?v=EWNQiatimzA

- Spring, A. and Reibling, Sh. (2019, February 15). KM Webinar Series: KM and Communications: What's the difference and how can they complement each other.
- Morningstar, S. and Spring, A. (2019, February 22). KM Webinar Series: Research with Indigenous Communities, part 1. Available at: https://www.youtube.com/watch?v=tej7EkJD7jk
- Goucher, N. and Merrill, S. (2019, March 15). KM Webinar Series: Documenting Research Impact. Available at https://www.youtube.com/watch?v=Jf_Ra5CN8nM&t=4s
- Merrill, S. (2019, January 15). Posters for the People: Communicating with partners and stakeholders through clear and relevant infographic-style posters. Delivered to HQP of Prairie Water project.
- Merrill, S. (2019, Feb 27). Posters for the People: Communicating with partners and stakeholders through clear and relevant infographic-style posters. Delivered to HQP of SPADE project.
- Merrill, S. (2019, March 26). Ensuring Research Impact: Precipitation Extremes project knowledge mobilization. Presented at Precipitation Extremes Annual Meeting and Workshop. Regina, SK.
- Merrill, S. and Spring, A. (2018, June 5). Knowledge Mobilization: GWF partners panel and year 1 highlights. Global Water Futures Annual Science Meeting. Hamilton, ON.
- Goucher, N. and Dusome, A. (2018, November 14). How to Create Infographics. Delivered to HQP of University of Waterloo Global Water Futures.
- Morningstar, S. (2018, October 20). Ohneganos Onegahde:gyo (Water is Life): Indigenous Relationship, Rights, and Responsibility to Water. Delivered to the McMaster Discovery Program course participants.
- Morningstar, S. (2018, November 14). Indigenous Research Engagement: A Brief Overview. Delivered to McMaster Research Dissemination in Earth Sciences course participants.
- Morningstar, S. (2018, July 23). Digital Storytelling: A Primer Before You Get Out in the Field. Delivered to HQP/YP and Indigenous Studies Program participants.
- Morningstar, S. (2018, August 20). Digital Storytelling: Storyboarding- Planning Your Digital Story.
- Morningstar, S. (2018, August 30). Digital Storytelling: External Sources, References, Citations, and Legal Considerations.
- Morningstar, S. (2018, August 31). Digital Storytelling: Editing, Polishing, and Sharing Your Final Piece.
- Goucher, N., Bigas, H., Norris, M., Milojevic, T. (2018, December 6). Local Water Solutions in a Changing Climate. Delivered to stakeholders for Lake Futures, Agricultural Water Futures, and Winter Soil Processes.
- Merrill, S. (2018, October 31). Introduction to knowledge mobilization and how to write a policy brief. Presentation to ENVS 807: Sustainability Theory, Masters course instructed by Dr. Maureen Reed, University of Saskatchewan.

- (Merrill) Canadian Freshwater Alliance Biannual National Meeting. September 2018. Moncton, NB
- (Merrill) Canadian Knowledge Mobilization Forum. June 2018. Winnipeg, MB
- (Spring) NWT Association of Communities Climate Change conference and Charrette. Explorer Hotel, Yellowknife, NT, Oct 29-31, 2018.
- (Spring) Hotıì ts'eeda Ełèts'ehdèe, Aurora Village, Yellowknife NT. May 22 – 24, 2018.
- (Spring) Forest Fire Research Workshop, Explorer Hotel, Yellowknife NT. March 5-7, 2019.
- (Goucher) H20 Global Leaders Summit, Kingston, ON. September 11-14, 2018.
- (Goucher, Morningstar, Spring) Water Institute Research Conference. Waterloo, ON. September 24, 2018.
- (Morningstar, Merrill, Spring, Goucher) First Nations Water & Climate Change Symposium. Six Nations of the Grand River, Ohsweken, ON. June 3, 2018.
- (Morningstar) Decolonizing Ohneka (Water) Research Through Community-led research, Digital Ohneka Stories, Art, and Resistance. November 23, 2018.
- (Morningstar) 2nd Annual Assembly of First Nations Water Symposium & Trade Show: First Nations and Water in the 21st Century. February 26-28, 2019.

Lake Futures: Enhancing Adaptive Capacity and Resilience of Lakes and their Watersheds (Basu)

- Blackwell, J., Tjebbes, A., McMillan, B., Wright, J, Ruthorford, H., and Ho, E. (2018). Facilitation of How to Change the World programming at Together 2018 Conference. November 4-6, 2018, University of Alberta, Edmonton, Alberta.
- Blomquist, J., (primary covener), Zhang, C., Stets, E. and Basu, N.B. (2018). coveners for the "Aquatic Ecosystem Responses to Human Disturbances and Management: A Comparative Discussion of Inland and Coastal Ecosystems and Their Contributing Watersheds" session at American Geophysical Union, December 10-14, 2018, Washington D.C.
- Chmiel, H., Filatov, N., Van Cappellen, P., and Kheyrollah Pour, H. (2018). co-chairing session of International Conference of "Big Lakes- Small World" (ELLS-IAGLR 2018): Challenging the Cold: Advances in Winter Limnology of Large Lakes under Climate Change. Evian, France, September 23-28, 2018.
- Ives, J. and Cibrowski, J. organized (2019) "Visualizing an Updated Understanding of Lake Erie Eutrophication – a Fuzzy Cognitive Mapping Workshop", March 12-13, 2019, University of Windsor, Windsor, ON. Attended by 18 experts, including two GWF HQP (J. Ives and S. Bocaniov). Participants learned about fuzzy cognitive mapping, and then worked in breakout groups to create visualizations of how various factors interact to result in eutrophication. The resultant visualizations will be combined to create an overarching map of eutrophication in Lake Erie, and areas of disagreement will be identified as potential areas for future work.
- Kheyrollah Pour, H., Milojevic, T., Van Cappellen (2018) organizing panel session at the 10th Canadian Science Policy Conference (CSPC 2018) meeting in Ottawa, Canada on November 7-9, 2018 (Managing Receiving Water: Can Canadian Water Policies and Regulations Address Current and Emerging Challenges?)

- Kheyrollah Pour, H., Bocaniov, S., and Van Cappellen, P. (2018). Co-chairing session organizing at the International Association of Great Lakes Research (IAGLR 2018) meeting in Toronto, Canada on June 18-22-2018 (Harmful Algal Blooms (HABs) and their Toxicity: Remote Sensing and Modeling Approaches).
- Lall, U. and Van Cappellen, P. Co-chairs of the 1st International Conference on Water Security, June 17-20, 2018, Toronto, ON.
- Macrae, M., Elliott, J., Wilson, H. and Basu, N.B. (2018). co-chairing session on "Agricultural Management and Water Quality in Current and Future Climates" at the Canadian Geophysical Union (CGU 2018) in Niagara Falls Canada (June 2018).
- Parsons, C., Dittrich, M., Van Meter, K.J., and Richards, A. (2018). Co-chairing session organizing at the International Association of Great Lakes Research (IAGLR 2018) meeting in Toronto, Canada on June 18-22-2018 Nutrient Sources, Transport & Retention in Great Lakes Watersheds: Field Measurements, Modeling and Management implications.
- Rezanezhad, F., McCarter, C., Weber, T., Macrae, M., Basu, N.B., and Van Cappellen, P. (2018). Co-chairing session on "Coupled Hydrological and Biogeochemical Functions, Part II: Terrestrial Ecosystems" at the Canadian Geophysical Union (CGU 2018) in Niagara Falls Canada (June 2018).
- Van Cappellen, P. (2018), Chaired the "Smart Water Environment Workshop", 3rd Singapore-Nanjing Eco Hi-Tech International Water Environment Management Summit, October 22-23, 2018, Nanjing, China.

Mountain Water Futures (Carey)

- CREATE for Water Security Fall Workshops (2017, 2018, 2019). Annual two-day workshop focused on collaboration, networking and skills building. HQP in attendance: Lindsey Langs, Mina Rohanizadegan, Dylan Hrach, Jessica Williamson, Myroslava Khomik
- CRHM Modelling Workshop (Feb 2018). Two-day workshop to learn about operation of the CRHM model. HQP in attendance: Lindsey Langs
- Thériault, J M (2019) Link between precipitation types, wind speed and gauge collection efficiency, Snow Workshop, Forêt Montmorency.
- Thériault, J M, S Déry, S Marshall, J W Pomeroy, R E Stewart and J. Almonte (2019). Storms and Precipitation Across the continental Divide Experiment. *Global Water Futures - Operation Meeting*, Saskatoon, Canada
- Thériault, J M, R Laprise, O Nikiema, M St-Pierre, K Winger and D Matte (2018), Preliminary analysis of convection-permitting climate model simulations using the Canadian Regional Climate Model over the Canadian Rockies, GEWEX Convection-Permitting Climate Modeling Workshop II, Boulder, United States [PP]

Prairie Drainage Governance (Loring)

- An upcoming Spring 2019 community workshop was held in the Atwater area with community members.
    - **a.** 2 HQP planned this event.

Southern Forests Water Futures (Arain)

- Shawn McKenzie (PhD candidate) led a dendrochronology workshop at the University of Waterloo in November, 2018. The workshop was attended by six graduate students who will be conducting field work in the Canadian Cordillera as part of their research. Co-PI Myroslava Khomik is supervising this research.
- Dr. Altaf Arain participated in a workshop entitled "Bridging Flood Science in Canada with Policy and Practice" organized by the United Nations University – Institute for Water Environment and Health (UNU-INWEH) and FloodNet at McMaster University form 20-22 February 2018. These activities and knowledge will help working being done under Southern Forests Water Futures project and enhance external collaborations on KM/KD and policy development activities.

Storms and Precipitation Across the continental Divide Experiment (SPADE) (Theriault)

- IEEE STRATUS conference, Rochester, NY (2018).
    a. Workshops preceding the conference on hyperspectral imaging and data chain processing (Number of HQP attended: 1).
- Local Water Solutions in a Changing Climate Workshop, Waterloo (2018).
    a. Stakeholder open house with presentations, poster session, and breakout sessions to meet with partners (Number of HQP attended: 2).

Waterloo Technical Core Team

- Dhiyebi: Attended the Pathway to Increase Standards and Competency of eDNA Surveys (PISCeS): A National Workshop on Environmental DNA. October 11-12, 2018. The workshop brought academic, industry and government stakeholders to discuss the complexities of eDNA with respect to scientific study and regulatory applications. The workshop included an eDNA tools and training session.
- Dhiyebi: During Summer 2018, Mark Servos organized an HQP retreat along the southern Grand River. The HQP met with Long Point Conservation Authority, Normandale Fish Culture Station, Long Point Bird Observatory, and Ontario Ministry of Natural Resources and Forestry. They were also able to tour Long Point Bay, Lake Erie, the Lower Grand River and Dunnville Dam; to experience the areas they have been researching. Hadi Dhiyebi helped with the preparation and implementation of this workshop.
- VanderGriendt: Feb 21, 2019, Agilent Seminar and Hands-On Workshop, (Chromatography, Spectroscopy, Genomics, Consumable, and Software iLab)

Winter Soil Processes in Transition (Rezanezhad)

- The team on this project have organized sessions in different conferences on the topic of soil processes and included the aspect of hydrobiogeochemical dynamics of winter and snow-dominated terrestrial systems during the winter and shoulder seasons, in all of their organized sessions:

- Conference session organizer and convener; 2019 Goldschmidt conference, 18-23 August, 2019, Barcelona, Spain. An adapting world: How terrestrial biogeochemistry responds to environmental change. Theme 12: Metals and nutrients in terrestrial and freshwater systems. Conveners: Fereidoun Rezanezhad, Adrian Mellage, Casey Bryce, E. Marie Muehe (University of Tubingen).
- Conference session organizer and convener, 2018 AGU Fall Meeting, 10-14 December 2018, Washington D.C., "Impacts of winter climate change on hydrobiogeochemical dynamics of terrestrial and aquatic systems during the winter and shoulder seasons"; Biogeoscience Session. Conveners: Fereidoun Rezanezhad, Alexandra R. Contosta (*University of New Hampshire),* Nora Casson (University of Winnipeg), Sarah Nelson (*University of Maine*) and Patrick Sorenson Lawrence Berkeley National Laboratory)
- Conference session organizer and convener, 2018 CGU Joint Meeting, 10-14 June 2018, Niagara Falls, Ontario, Canada, "Coupled Hydrological and Biogeochemical Functions, Part I: Wetland Ecosystems". Biogeoscience and Hydrology, Session CGU-H-08. Conveners: Colin McCarter, Fereidoun Rezanezhad, Maria Strack, Jonathan Price, Carl Mitchell
- Conference session organizer and convener, 2018 CGU Joint Meeting, 10-14 June 2018, Niagara Falls, Ontario, Canada, "Coupled Hydrological and Biogeochemical Functions, Part II: Terrestrial Ecosystems". Biogeoscience and Hydrology, Session CGU-H-09. Conveners: Fereidoun Rezanezhad, Colin McCarter, Tobias Weber, Merrin Macrae, Nandita Basu, Philippe Van Cappellen

WLU Technical Team

- Science Communication and Community Outreach (attended by A. Sniderhan, ArcticNet, Dec 2018)
- Community Collaborations and Engagement with Research (attended by A. Sniderhan, ArcticNet, Dec 2018)
- Permafrost Young Researchers Network Workshop (attended by J. Hickman, Chamonix, France, June 2018)
- Northwest Territories Association of Communities 2018 Climate Change Forum and Charrette (attended by J. Hickman, Yellowknife, NT, October 2018)

International Exchanges

Boreal Water Futures (Waddington)

- Drs. M. Khomik & R.M. Petrone joining Drs..Patrick Fonti & D. Castagneri at the Swiss Federal Institute for Forest, Snow and Landscape Research WSL-Zurich to work on reconstruction of water use efficiency as a response to climatic and anthropogenic disturbance
- Dr. N. Doubleday presented a Lecture and Workshop in cooperation with the National Institute for Research on Glaciers and Mountain Ecosystems (INAGEM) in Huaraz, Peru, on "Connecting Water, Climate, Justice: Introducing participatory action research as a

method for deepening risk research". INAIGEM & Water Without Borders Graduate Diploma Program, McMaster University-UNU-INWEH, February 18, 2019.

Climate Extremes (Zwiers)

- Thériault, Julie (2018) was invited to give a training course on rain-snow transitions for the Chinese Meteorological Administration in preparation of the Beijing Winter Olympics 2022. This course was organized by COMET© (Cooperative Program for Operational Meteorology, Education and Training), Boulder, Colorado. (approximately 20 students from China attended the class)
- Lijuan Du, visiting professor from China Institute of Water Resources and Hydropower Research, visited Yanping Li research team for the period of July 2018-December 2018.
- Ya Huang, PhD student from China Institute of Water Resources and Hydropower Research, visited visited Yanping Li research team for the period of August 2018-August 2019.

Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins (IMPC) (Razavi)

- Juliane Mai, Visit and Support at USACE (Detroit office) to setup calibration of LBRM for the project, Feb 14-15, 2019.
- Saman Razavi: Abdoreza Bahremand (University of Gorgan, Iran), Application of the MESH Land Surface-Hydrology Model to a Large River Basin in Iran, Sep 2017-Sep2018.
- Saman Razavi & Amin Haghnegahdar: Sajad Khoshnod, Application of the MESH Land Surface-Hydrology Model to a Hable Rud Basin in Iran, Jan 2019-Aug 2019
- Trish Stadnyk participated in the C3s project, on behalf of GWF by preparing a showcase for the European Union funded Copernicus Climate Change Service (C3S) initiative that "aims to facilitate climate adaptation worldwide and offers an interactive web application with refined data, guidance and practical showcases". It was recently featured at the C3S EU conference in Portgual, presented by Dr. David Gustafasson (SMHI). https://climate.copernicus.eu/
- Yanping Li: Dequan Wang, visiting professor from NingXia University, visited us for the period of March 2018-March 2019.

Lake Futures: Enhancing Adaptive Capacity and Resilience of Lakes and their Watersheds (Basu)

- I. Markelov: in the Departament de Geociències Institut de Diagnosi Ambiental i Estudis de l'Aigua (IDÆA-CSIC), c/ Jordi Girona 18 UPC Campus Norte 08034 Barcelona, España". He is working with professor Carlos Ayora in Barcelona since January 2018. Our collaboration combines hydrology and reactive transport modeling expertise of Dr. Ayora's research group with the biogeochemical expertise at the Ecohydrology Research Group in Waterloo. The main goal of the exchange is to focus on creating a reactive transport model of nutrient and metal cycling in the aquatic environment including contaminated sites.

- T. Van Staden**:** Currently on exchange to Sweden for one month. She is at Stockholm University working with Dr. Jerker Jarsjö and Dr. Benoît Dessirier on phosphorus legacy work, this time focusing on vulnerability of landscapes losing phosphorus to surface water. The exchange is part of the researcher mobility plan for LEAP, a close partner program of Lake Futures.

Linking Water Governance in Canada to Global Economic, Social and Political Drivers (de Loe)

- Xihua Wang: A PDF who is studying the pilot point approach for parameter estimation. We are considering the adoption of this approach for the parameter estimation necessary to calibrate the HGS models.

Mountain Water Futures (Carey)

- Drs. M. Khomik & R.M. Petrone joining Drs. Patrick Fonti & D. Castagneri at the Swiss Federal Institute for Forest, Snow and Landscape Research WSL-Zurich to work on reconstruction of water use efficiency as a response to climatic and anthropogenic disturbance
- Thériault, Julie (2018) Invited to give a training course on rain-snow transitions for the Chinese Meteorological Administration in preparation of the Beijing Winter Olympics 2022. This course was organized by COMET© (Cooperative Program for Operational Meteorology, Education and Training), Boulder, Colorado (Approximately 20 students from China attended the class)

Next Generation Solutions (Giesy)

- Prof. Giesy is a co-investigator on a large (more than 300,000,000 RMB) to establish a national centre for environmental monitoring that will be incorporating eDNA in monitoring of aquatic systems in China. This is in collaboration with Prof. Xiaowei Zhang, who is a collaborator on the GWF program.
- A formal exchange has been developed with the Research Centre for Environmental Chemistry and Ecotoxicology (RECETOX) at Masaryk University in Brno, Czech Republic. In 2019 Profs Giesy and Hecer both visited colleagues in Brno to work on various eDNA projects. In the summer of 2018, Prof Klara Hilscherova of RECETOX visited U of S for two weeks to learn eDNA techniques. During that visit she went to the Experimental Lakes District (ELA) to work in the field on three eDNA projects being conducted in collaboration with ELA.

Northern Water Futures (Baltzer)

- Canada-Iceland Arctic Research Exchange Program – An Arctic research exchange pilot program to encourage pan-northern research collaboration and foster Canadian-Icelandic Arctic research cooperation. This opportunity was funded through Polar Knowledge Canada (POLAR) and University of Iceland and one Canadian student was selected for it. It took place at the Canadian High Arctic Research Station (CHARS) campus in Cambridge Bay, Nunavut and the FORHOT research site, Iceland (1 HQP – Nia Perron)

- Arctic Frontiers Young Emerging Leaders Program. Geneviève Degre-Timmons was selected as a Canadian Ambassador to the Young Emerging Leaders program held in Bodø, Norway: https://www.arcticfrontiers.com/participant/genevieve-degre-timmons/

Prairie Drainage Governance (Loring)

- We continue to work with Dr. Patricia Gober, Arizona State University and Dr. Claudia Pahl-Wostl, University of Osnabrück, Germany**.**

Short Duration Extremes (Li)

- Dequan Wang, visiting professor from NingXia University, visited us for the period of March 2018-March 2019.

Southern Forests Water Futures (Arain)

- Dr. Guangyong You was a visiting scientist from China from October 2017 to December 2018. Dr. You studied the impacts of climate change on vegetation dynamics and hydrologic balance in Hulun Lake region in Inner Mongolia, China. A manuscript based on the work is in review with the Global Change Biology.

Storms and Precipitation Across the continental Divide Experiment (SPADE) (Theriault)

- Thériault, J M (2018) Invited to give a training course on rain-snow transitions for the Chinese Meteorological Administration in preparation of the Beijing Winter Olympics 2022. This course was organized by COMET© (Cooperative Program for Operational Meteorology, Education and Training), Boulder, Colorado. (approximately 20 students from China attended the class)
- Stewart, R E (January 2019) Invited to give seminar on the occurrence of temperatures close to 0°C across Canada as well as associated precipitation such as freezing precipitation and wet snow. This included illustrations of wide variations within the western Cordillera for the Institute for Chinese Meteorological Administration in Beijing, China. (approximately 50 people in audience).
- Stewart, R E (January 2019) Invited to give seminar on the occurrence of temperatures close to 0°C across Canada as well as associated precipitation such as freezing precipitation and wet snow. This included illustrations of wide variations within the western Cordillera for the Institute for Atmospheric Physics, Academy of Sciences in Beijing, China. (approximately 50 people in attendance).

Winter Soil Processes in Transition (Rezanezhad)

- Dr. Rezanezhad (PI on this project) received the Technical University of Munich (TUM) Visiting Professor award. As part of this award, Dr. Rezanezhad will visit the TUM in Spring 2019 to collaborate with Professors Kögel-Knabner and Carsten Muller on cold regions hydrogeochemistry research, to better understand the role of winter soil processes on the export of carbon and nutrients under non-growing season in cold region soil ecosystems.

Cross-institutional and use training opportunities

Agent Based Modelling (Bharadwaj)

- Community/Institutional reciprocal training opportunities in Indigenous Methodologies, Indigenous Knowledge, Community-Engaged Scholarship and qualitative research methodologies among academics and community partners.

Agricultural Water Futures (AWF): Stressors and Solutions (Macrae)

- Anna Frank. Attended Guest Seminar: Priorities and Strategies for Advancing Soil Health, November 26th, 2018, University of Guelph.
- Anna Frank. Changing Trends in Water Use: Managing Impacts on Water and Wastewater System Operations, November 21st, 2018, Canadian Water Network, attendees: Utility managers, knowledge and solution providers, government regulators
- Kokulan Vivekananthan. 3-day study tour organized by Canadian Agri-food Policy Institute targeting water management in the Canadian Prairies.
- Roste, J., and Baulch, H. (2019) Moosomin Lake watershed report on land use and water quality. Lower Souris Watershed Stewards Board meeting. March 18th, 2019.
- Crystal Rinas and Terry Fonstad. A tour of the environmental monitoring at the Livestock and Forage Centre of Excellence site was given to the Western Canada Feedlot Management School on February 8, 2019.

Boreal Water Futures (Waddington)

- Erin Nicholls participates in the NSERC CREATE in Water Security program.
- Natasa Popovic participates in the NSERC CREATE in Water Security program.
- Brandon Van Huizen participates in the NSERC CREATE in Water Security program.
- Erin Nicholls travelled to Quebec to work with researchers from other GWF programs on sapflow techniques.
- A one-day workshop was held by the Hydromet Lab (R.Petrone, Waterloo) on tree core analysis software led by Shawn McKenzie (PhD, GWF-SFWF Project at McMaster University). Members of our lab also travelled to Brock University (Dr. Michael Pisaric's lab) to learn methods of traditional tree-core analysis, as well as newer methods of quantitative wood anatomy.
- M. Elmes received introductory training on Raven modelling framework in December at Carleton University in Ottawa with Dr. Murray Richardson and his former HQP, Cameron Samson as part of the Water and Ice Research Laboratory (WIRL).

FORMBLOOM (Baulch)

- In spring 2018 Drs. Larsen and Salk taught a course on data analytics to 5 graduate students (4 MS, 1 PhD). In this course, we worked through contemporary data analyses while developing skills to design studies, manage data, and effectively report results. At the end of the semester, each student developed a report that combined data

management, data visualization, and statistical analysis on a real dataset related to their research.

- Four students from Universite de Sherbrooke were hosted by Bradford and community members on Yellow Quill First Nation's reserve for sampling of Nut Lake in July 16th 2018. They were informed of proper protocol and expectations of working with the community as well as shown the Yellow Quill First Nation water video (produced by Neapetung, Bradford and Bharadwaj). The PI from LakePulse provided a letter and official gift-offering for the community.

Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins (IMPC) (Razavi)

- Ajay Bajracharya is assisting water quality modellers establishing nutrient models for the Nelson River basin (other aspects of the IMPC project)

Lake Futures: Enhancing Adaptive Capacity and Resilience of Lakes and their Watersheds (Basu)

- **Courtenay, S.** was a Visiting Research Fellow in the Australian Rivers Institute, Griffith University – Nathan Campus in Brisbane Australia January 22 – April 13, 2018. Dr. Courtenay worked with ARI Director Dr. Stuart Bunn to better understand the origins and operation of the very successful Healthy Land and Water monitoring and management program for catchments of Southeast Queensland and potential applications to Canadian catchments.
- **Servos, M.** is a Visiting (Proto-Synthesis) Fellow (208-2019) at the Swiss Federal Institute of Aquatic Science and Technology (Eawag) in Switzerland.

Mountain Water Futures (Carey)

- Dendrochronology Processing Workshop hosted by Shawn McKenzie of McMaster University for University of Waterloo Hydrometeorology Group (December 2018). HQP in attendance: Lindsey Langs, Jessica Williamson, Dylan Hrach, Myroslava Khomik
- Members of our lab also travelled to Brock University (Dr. Michael Pisaric's lab) to learn methods of traditional tree-core analysis, as well as newer methods of quantitative wood anatomy.
- Stephanie Streich, lab exchange with University of Waterloo (June-July 2018)

Next Generation Solutions (Giesy)

- Mont'Alverne spent six weeks in Waterloo as part of the CREATE Water Security program. There, she spent time with Servos and other members of the UW team, learned more about their approaches, met with their end-user partners, and spent time in the field applying eDNA methods alongside conventional fish surveys

Prairie Drainage Governance (Loring)

- We are working with others in Global Water Futures projects on stakeholder engagement opportunities.

- We meet bi-weekly with Jared Wolfe, Project Coordinator of Prairie Water in order to coordinate efforts where applicable.

Southern Forests Water Futures (Arain)

- Alanna Bodo (PhD Candidate) taught sapflow sensor construction and installation to research groups affiliated with GWF. These students included Erin Nicholls from Mountain Water Futures (PI: Dr. Carey), Lindsey Langs and Adam Green (technicians) from Canada's Boreal Wildland-Society-Water Nexus (PIs: Dr. Waddington, Dr. Petrone).

Storms and Precipitation Across the continental Divide Experiment (SPADE) (Theriault)

- SPADE Webinar - an afternoon webinar meeting was hosted at UQAM, whereby SPADE HQP at UNBC, UofS and ECCC participated remotely. During this meeting scientific updates on SPADE related research by the students were shared amongst the group (17 members in attendance). Moreover, an overview of the project was shared by project leads, including discussion of the various field sites and further field protocols and field safety were presented.
- Webinar on Infographics presented by Stephanie Merrill (USask.) to HPQ at UNBC, UQAM and USask. There were 12 GWF HQP present.

WLU Technical Team

- Wilderness First Aid training (attended by H. Dixon, April 2018)
- Firearms training (attended by H. Dixon, April 2018)
- Field Health and Safety session (A. Sniderhan invited to present as part of panel discussion, NWF workshop series, February 2019)
- Standard First Aid training (attended by J. Hickman, March 2018)
- Wilderness First Responder Training Recertification. Wilderness Medical Associates, Wakefield Quebec (attended by A. Rudy, April 2018)

Other

Agricultural Water Futures (AWF): Stressors and Solutions (Macrae)

- Anna Frank. KM Webinar Series. Documenting Research Impact: Leverage funding, meet partner expectations and ensure you're making a difference, March 15, 2019.
- Anna Frank. KM Webinar Series. Maintaining KM Momentum: Keeping Partners Engaged, November 16, 2018
- Anna Frank. Canadian Water Resources Association webinar series. Forecasting for hydrology, October 23rd 2018.
- Phil Harder. Attend the “2018 International Conference and 69th IEC Meeting of the ICID: INNOVATIVE AND SUSTAINABLE AGRI-WATER MANAGEMENT: ADAPTING TO A VARIABLE AND CHANGING CLIMATE” in Saskatoon, Saskatchewan, Canada, 12-17 August 2018.
- Merrin Macrae. Nutrients Issue Table Panel. Monthly web meetings (N. Goucher also involved).Great Lakes St. Lawrence Collaborative.

Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins (IMPC) (Razavi)

- 4 hours of training from Social Sciences Research lab for Social Network Analysis (Hayley Carlson)

Mountain Water Futures (Carey)

- LI-Cor Biosciences Eddy Covariance 3-Day Training Course (June 2018). HQP in attendance: Lindsey Langs
- Westbrook: Taught a compressed course as part of the CREATE contribution to GWF: GEOG 829 – *Professional Practice in Water Security* – 19 students (May 2018)

Southern Forests Water Futures (Arain)

- Dr. Altaf Arain collaborated with the Ministry of Environment and Climate Change Canada (Dr. Doug Worthy group) to continuously measure trace gas (CO2, CO, CH4, N2O) measurements at the Turkey Point Deciduous (TPD) site. These fluxes are used for tracking cross-border transport of air pollution, trace gases, and estimate Canada's carbon emissions using atmospheric observations and models.
- Dr. Altaf Arain collaborated with Dr. Ingo Ensminger for the SpecNet - An Optical Sensor Network for Carbon Flux Analysis across Ecosystems. The goal of SpecNet is to compare optical and flux signals across terrestrial ecosystems having contrasting controls on carbon flux. NDVI and PRI measurements are being done at two of GWF-Turkey Point Observatory sites for long-term monitoring.

Transformative Sensor Technologies and Smart Watersheds (Duguay)

- EARTH 671 Field Methods in Hydrogeology (2018)
    - A course dealing with the theory and applications of field techniques in hydrology. Physical, chemical, and isotopic methods are included with applications to groundwater and surface water hydrology. The course consisted of lectures, field activities, projects and assignments. All were conducted over a 3-week time period at the end of the winter term (Number of HQP attended: 10)
- TTSW HQP Informal Meetings 2018, 2019
    - These informal meetings are held twice per semester for HQP in the TTSW project as a way for students to get to know one another, share ideas, and make research connections. Each attendee shares what their research progress and may make a presentation such as a practice talk for an upcoming conference, recent research results, or even photos from a field campaign. There is usually a guest from another GWF project or industry (Number of HQP attended: 14).

Winter Soil Processes in Transition (Rezanezhad)

- Dr. Rezanezhad (PI on this project) taught a special topic course on "Winter Soil *Processes" (*Earth691/692) in the Department of Earth and Environmental Sciences, University of Waterloo, (Fall 2018)

WLU Technical Team

- A, Rudy, Conference Chair: Arctic Change, Dec 12-16 2017, Northern Education and Outreach: Accomplishments, Opportunities and Challenges

Appendix J – Funding Agencies/ External Collaborators/ Partners/ Users and Stakeholders

Unit Name	Leveraged Contribution	
	Cash ($)	In-kind ($)
Academic Institutions		
Alberta Biodiversity Monitoring Institute		
Chinese Academy of Science		
Forêt Montmorency, Université Laval		200000
Global Institute for Water Security		
IISD-Experimental Lakes Area (ELA)	0	22000
Laurier		343696
Norwegian Institute for water Research (NIVA)		
Ohio State University		
Southern Ontario Water Consortium (analytical and ecotox nodes)	0	1000
Université de Montréal	10000	20000
Université du Québec à Montréal		66000
University of Calgary		15000
University of Manitoba		140000
University of Northern British Columbia	132000	33000
University of Osnabruck		
University of Saskatchewan		202000
University of Victoria		54000
University of Waterloo	181279	690000
Washington State University		1000
Western Partnership for Wildland Fire Science, University of Alberta		50000
Western University		10000
Wilfrid Laurier University		846000
York University, adjunct Wilfrid Laurier, adjunct University of Waterloo	8000	30000
International Institutions		
Bay-Delta Office, Department of Water Resources		
Bowling Green State University		

EAWAG (Swiss Federal Institute of Aquatic Science and Technology) EAWAG is both Academic and International so this entry is repeated below		
Gorgan University of Agricultural Sciences and Natural Resources		
Helmholtz Centre for Environmental Research		
Hydrometeorological Applications (HAP), NCAR, USA		
Indian Institute of Science		
Indian Institute of Technology (IIT) Delhi		
International Copper Association		
International Lead Association		
International Zinc Association		
Joint Research Center, European Commission		
Lawrence Berkeley National Laboratory		
Nanjing University, Nanjing, China	0	3000
NASA ABoVe		
NASA JPL		
National Center for Atmospheric Research		86000
NOAA-GLERL (Great Lakes Environmental Research Laboratory)		
Norwegian Institute for Water Research		60000
Red River Basin Commission		
Spanish National Research Council		
Swedish Meteorologic and Hydrologic Institute (SMHI)		5000
Swedish University of Agricultural Sciences		
Tai Lake riverine pollution prevention and management office, Chinese Ministry of Science and Technology, China	0	1000
Tai Lake riverine pollution prevention and management office, Chinese Ministry of Science Nanjing University, Nanjing, China		
United Nations University	0	
United Nations University - Institute for Water Environment and Health (UNU-INWEH)		
United States Department of Agriculture: Agricultural Research Service (USDA-ARS)		
University of New South Wales		
University of Arizona		

University of Michigan, Water Centre		12500
US Forest Service		1000
US NCAR		
USACE (U.S. Army Corps of Engineers)		
Yale University		
Provincial Governments		
Alberta Agriculture and Forestry		30000
Alberta Energy Regulator		
Alberta Environment and Parks	30000	33333
Alberta Geological Survey		
Alberta Innovates-Rocky Mountain Hydrological Resilience	550000	
Alberta Innovates-Water Innovation Program and Wildlife Branch		
Alberta Land Use		
BC Hydro		
BC Ministry of Forests, Lands, and Natural Resource Operations		
BC Parks		
City of Calgary	100000	200000
Climate Change Unit, ENR, GNWT		
Credit River Conservation		
Emergency Management & Fire Services		
Environment and Natural resources, Government of Northwest Territories		
Environmental Science Research Fund		
Friends of Mill Creek		
Geomatics Centre, GNWT		
GNWT	295000	2200000
GNWT Cumulative Impacts Monitoring Program	360000	
Grand River Conservation Authority		
Grand River Fisheries Management Plan Implementation Committee		
Hydro-Québec		60000
Long Point Region Conservation Authority (LPRCA)		
Manitoba Agriculture	0	0
Manitoba Hydro		45000
Manitoba Infrastructure		5000

Manitoba Sustainable Development		
Ministry of the Environment and Climate Change		9750
NB Power		15000
Northern Contaminants Program	58405	
Nova Scotia Department of Agriculture		
NWT Environmental Studies Research Fund	500000	
Ontario Climate Consortium (OCC) & Toronto Region Conservation Authority (TRCA)		
Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)		25500
Ontario Ministry of Environment and Climate Change (OMECC)		3000
Ontario Ministry of Natural Resources and Forestry - LEMU		4500
Ontario Ministry of Natural Resources and Forestry (OMNRF) – Alymer District		
Ontario Ministry of Natural Resources and Forestry (OMNRF) – Ontario Forest Research Institute (OFRI)		
Province of Saskatchewan-Forestry Branch	30000	
Saskatchewan Ministry of Agriculture		
Saskatchewan Ministry of the Environment: Fish		15000
Saskatchewan Research Council		10000
Saskatchewan Water Security Agency		2000
Toronto and Region Conservation Authority		180000
Water Standards Section, Ontario Ministry of Environment and Climate Change	63250	0
Yukon Environment		90000
Federal Government		
Agriculture and Agri-Food Canada (AAFC)	0	116000
Canada Centre for Remote Sensing (CCRS), Natural Resources Canada (NRCan)		
Canadian Forest Service		50000
Canadian Forest Service-Northern		
Canadian Ice Service		
Canadian Space Agency		100000
CFI - John R. Evans Leaders Fund		200000
CFI (CryoSAR)		1737102
Diversification Canada (WED)		

Environment and Climate Change Canada (ECCC)	17850	949200
Environment and Climate Change Canada- Atmospheric Science and Technology		150000
Environment and Climate Change Canada- Water Science and Technology Directorate		370000
Environment and Climate Change Canada, Centre for Inland Waters (CCIW)		
Environment and Climate Change Canada	18000	11250000
Geological Survey of Canada		
Government of Canada-Natural Resources Canada		
Health Canada		
Indigenous and Northern Affairs Canada		
International Joint Commission		
Natural Resources Canada (NRCan)		40000
Natural Resources Canada- Geological Survey of Canada		1200000
NISAR		
Northern Scientific Training Program	5400	
NSERC Create for Water Security		
NSERC Discovery Grants	1765000	
NSERC Promoscience		108000
Parks Canada		50000
Polar Continental Shelf Program (English)	38500	
Prairie Provinces Water Board		
Science and Technology Branch, Environment and Climate Change Canada	0	0
Social Science and Humanities Research Council of Canada (SSHRC) FLEDGE		30000
Statistics Canada Ottawa		
Water Survey of Canada		
Western Economic		1374576
Industry Partners		
Agriculture Producers Association of Saskatchewan		
Aquanty Inc.		13500
BC Hydro	335000	
BGC Consulting		
Buffalo Pound Water Treatment Plant (BPWTP)	0	
Campbell Scientific		1109600

Canadian Natural Resources Limited		
Canadian Oil Sands Innovation Alliance	1637600	
Canadian Rural Revitalization Foundation		25000
Canadian Sphagnum Peat Moss Association		14800
CatIQ		25000
CFI industry match		642000
De Beers Canada		1900000
DraganFly		20000
Ducks Unlimited Canada		960000
Ecology North		348000
EPCOR		
ESRI Canada		97500
exactEarth		1500000
FireSmart Canada		
Forsee Instruments		
Giant Mine Oversight Board		
Gordon Foundation		530000
Grain Farmers of Ontario	0	11700
Honeywell/COM DEV		625000
Hoskin Scientific		
Husky Oil Operations		
ICLR		45000
International Copper Association		
International Mineral Innovative Initiative		
International Plant Nutrition Institute (IPNI)		
International Zinc Association		
Livestock Research Innovation Corporation		
Manitoba Hydro		2000
Matrix Solutions	22500	250000
McKenna Geotechnical		
Mike Wiegele Helicopter Skiing		
Mistik Management		20000
Nestle Waters Canada		
Nickel Producers Environmental		
Nipika Mountain Resort		
O'Kane Consultants		

Orano Canada Inc. (Former name: AREVA Resources Canada Inc.)		33333
Partners FOR the Saskatchewan River Basin (PFSRB)		
Red River Basin Council		15000
Research Association		
Rural Policy Learning Commons	3000	12000
Saskatchewan Association of Watersheds		
Saskatchewan Irrigation Projects Association	0	3000
Solinst Canada		40000
Sorcerer Lodge		
Syncrude Canada Ltd.	924375	150000
The Saskatchewan River Delta Stewardship		12000
Thermo Fisher Scientific		
Wastewater, City of Guelph	0	0
Water Services, Region of Waterloo	0	0
Non-governmental Organizations		
Alberta NAWMP		
Assiniboine River Basin Initiative		
Avalanche Canada		
Bow River Basin Council		20000
Center for Excellence in Mining Innovation		
City of Calgary		
City of Saskatoon	0	3000
Columbia Basin Trust	140000	
Council of the Great Lakes Region		
Ducks Unlimited Canada (SK, AB, IWWR)		21000000
Elbow River Watershed Partnership		
Essex Region Conservation Authority		
Fraser Basin Council		
Friends of the Grand River	0	1000
Ghost Watershed Alliance Society		
Grand River Conservation Authority (GRCA)	0	20000
Hakai Institute	476000	
International Institute for Sustainable Development (IISD), Experimental Lakes Area		
Middle Grand Chapter of Trout Unlimited Canada	0	3000
Moose Jaw River Basin Stewards		11000

National Center for Atmospheric Research		
Nickel Producers Environmental Research Association		
North Saskatchewan River Basin Council		
Ontario Commercial Fisheries Association		
Ontario Federation of Anglers and Hunters	0	1000
Ontario Rivers Alliance	0	1000
Pacific Climate Impacts Consortium		306000
Prince Alberta Model Forest Association Inc.		
Red Deer River Watershed Association		200000
Redberry Lake Biosphere Reserve		
Region of Waterloo, Water Services		20620000
Saskatchewan Association of Watersheds		
Spray Lakes Sawmills	297000	
St. Williams Conservation Reserve Community Council (SWCRCC)		
Trout Unlimited National	0	3000
Upper Thames River Conservation Authority	0	12000
WUQWATR (Wascana Upper Qu'Appelle Watershed Association Taking Responsibility)		
Indigenous Communities		
6 Nations		
Beardy's and Okemasis First Nation		
Big Island Lake Cree Nation		
Canoe Lake Traditional Resource User Board		
Chiefs of Ontario		
Dehcho AAROM		20000
Dehcho First Nations		
Delta N90 Trappers	0	2000
DeneSuline Co-Management Board (Dillion)		
Divide Forest Advisory Corporation		
Haudenosaunee Resource Centre		
Indigenous Elders & Youth Council (IEYC)		
Inuvialuit FJMC		20000
James Smith Cree Nation		
Ka'a'gee Tu First Nation		80000
Knowledge Guardian		
Lubicon		

Metis Local 42		
Mistawasis Nêhiyawak		
North Slave Métis Alliance		
Northern Village of Buffalo Narrows		
Northern Village of Cumberland House		17000
Sahtu Renewable Resource Board		80000
Sakitawak Resource Management Inc.		
Six Nations of the Grand River Wildlife Management Office	0	1000
Six Nations Polytechnic		
The Cree Lubicon of Little Buffalo, AB		
Tłı̨chǫ Government		
Wek'èezhìi Land and Water Board		
Yellow Quill First Nation		
Yellowknives Dene First Nation		

Appendix K – Science and Public Outreach

Citizen Science

Agriculture Water Futures (Macrae)

- Costa, D. The Nutrient App has been developed for community-based on-site instantaneous measurement of nitrate and phosphate concentrations. The first year (2018-2019) was dedicated to the development of the algorithms necessary to estimate the concentrations in water, but users have also been engaged to test it in the field in the spring and summer of 2019. The users currently enrolled for testing and using the app are the (1) Prairie Water project of the GWF, (2) Water Science and Technology Branch of Environment and Climate Change Canada (ECCC), (3) University of Manitoba, (4) South Central Eco-Institute, and (5) International Institute for Sustainable Development (IISD).
- Macrae, M and Plach, J. Working together with Water Keepers to test "phosphorus strips" to estimate phosphorus concentrations in tile drainage. The strips can be distributed to farmers, and a sample can be sent to our lab to validate the field reading. We have recently received the strips and will distribute them at a farmer meeting over the next few months.

Boreal Water Futures (Waddington)

- Grade 1 - STEM day presentation at Lindbrook Boys School, Oakville, Ontario.
- Geography Day Open House Visit and interactive laboratory (Price and Petrone) workshop with Sir John A. MacDonald High School, November 15th, 2018 at Faculty of Environment, University of Waterloo, Waterloo, Ontario.
- iWetland Citizen Science. Wetland Water Level monitoring in the Georgian Bay Biosphere Reserve. McMaster University.

Indigenous Water Tools (Martin-Hill)

- Science and culture camp, Little Buffalo Alberta – July 2018
    - Youth engagement and science training with Lubicon Cree
- Pow-Wow at Six Nations – 27-29 July 2018
- Trip to Smithsonian – November 2018
    - Researching traditional water stories with Six Nations youth and community members, along with GWF team members
- Ohneganos Ohnegahdę:gyo – Water is Life Indigenous knowledge workshop – 22 November 2018
- Focused on Haudenosaunee youth engagement digital storytelling, geolinguistic mapping and food security.
- Kawenni:io/Gaweni:yo Private School Digital Water Stories celebration – 26 March 2019
    - Students from KGPS showed their digital stories to members of the Six Nations and McMaster communities and received certificates of completion from McMaster CCE

Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins (IMPC) (Razavi)

- Time Jardine et al.: In the ice-free season 2018, we once again deployed a buoy and associated sondes to measure a series of water quality variables at the head of the Saskatchewan River Delta. The sonde measures pH, conductivity, temperature, turbidity and dissolved oxygen, while additional sensors measure water level and CO2 concentration. This is done in partnership with Renee and Solomon Carriere from Cumberland House. With telemetry, this information has been made available in near-real time to Charlebois Community School on a monitor in the school lobby, allowing students to see how these variables change relative to flows in the river.
- Graham Strickert: An application tool developed in GWF project Crowd Sourcing Water Science will be tested in Cumberland House this summer.

Matawa Water Futures (Mitchell)

- Matawa Environmental Gathering- December 11-13, 2018
    - Hosted by Matawa Four Rivers Environmental Group in collaboration with Laurier and Laurentian Universities, Thunder Bay
- Community Based Monitoring (CBM) Workshop – January 29-30, 2019
    - Hosted by Four Rivers Group, Thunder Bay

Mountain Water Futures (Carey)

- Montessori School. Whitehorse Yukon. January 2019.
- Geography Day Open House Visit and interactive laboratory (Price and Petrone) workshop with Sir John A. MacDonald High School, November 15th, 2018 at Faculty of Environment, University of Waterloo, Waterloo, Ontario.
- iWetland Citizen Science. Wetland Water Level monitoring in the Georgian Bay Biosphere Reserve. McMaster University.

Northern Water Futures (Baltzer)

- Geoff Kershaw (PhD candidate) participates in Earth Watch each year. This involves him teaching groups of international students on site in the Mackenzie mountains. He also engages local Indigenous communities both in the NWT and in the Yukon (note that communities in both locations use the land adjacent to the Canol Trail where Geoff's study site is located).
- Through the Atlas project in Kakisa, community members are collecting and georeferencing photos of change occurring on their lands.

SAMMS (Venkitesewaran)

- Jasiak I, J Telford and E Leclerc. 2018. Lakes: our windows into the past. Presentation at Sir John Franklin High School, Yellowknife (4 June 2018).

Southern Forest Water Futures (Arain)

- We organized seven visits to four high schools in Hamilton, ON, to present climate change and water-related research. The presentations feature practical interactive learning

experience and delivered as a hands on approach led by graduate students who do experiments, analyses, and research on a daily basis. This is to foster interest in the environmental and water science field, post-secondary academic pursuits, awareness of climate and water issues, and how climate change and hydrologic processes research actually takes place.

- Dr. Altaf Arain organized a public lecture entitled "21stCentury Global Freshwater Security: Can it Exist and Can Scientists Communicate the Challenges?" on 20 November 2018. Speaker was Dr. Jay Famigliette, Canada 150 Research Chair, Hydrology & Remote Sensing, and Executive Director, Global Institute for Water Security. University of Saskatchewan. This lecture was a joint lecture with Global Water Futures (GWF) Program, McMaster Water Network, FloodNet, Sustainable Development Solutions Network (SDSN) Canada, Mohawk College Centre for Climate Change Management, City of Hamilton, City of Burlington, Ontario Climate Consortium (OCC) and United Nations University - Institute for Water, Environment and Health.
- The SFWF project holds a twitter account in collaboration with the McMaster Centre for Climate Change (MCCC) maintained by graduate students. Twitter feeds include policy briefs, new research, and the promotion of climate and water related activities and events.

Access to user tools

Agriculture Water Futures (Macrae)

- Costa, D. The Nutrient App has been developed for community-based on-site instantaneous measurement of nitrate and phosphate concentrations. The first year was dedicate to the development of the algorithms necessary to estimate the concentrations in water, but users have also been engaged to test it in the field in the spring and summer of 2019. The users currently enrolled for testing and using the app are the (1) Prairie Water project of the GWF, (2) Water Science and Technology Branch of Environment and Climate Change Canada (ECCC), (3) University of Manitoba, (4) South Central Eco-Institute, and (5) International Institute for Sustainable Development (IISD).

Global Water Citizen (Robertson)

- Survey and engagement sessions with user community for water quality data analysis tool we developed. This was to identify user community needs and gain feedback into second iteration of tool development. Approximately 15 users engaged/surveyed for input.

Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins (IMPC) (Razavi)

- IMPC/GWF DAta VISualization project (DAVIS): http://gwf-demo.usask.ca/v-12/ by Sotoodeh, Gharari, Gutwin, and Razavi
- VARS-TOOL: A toolbox for comprehensive, efficient, and robust sensitivity and uncertainty analysis: http://vars-tool.com by Razavi, S., Sheikholeslami, R., Gupta, H.V., and Haghnegahdar, A.

Northern Water Futures (Baltzer)

- Development of Ka'a'gee Tu Atlas that is being used to enhance on-the-land safety and community based monitoring and document traditional knowledge in a digital platform.
- Policy briefs and meeting with governments
- J. Hickman. Water Stewardship Strategy Workshop (GNWT) March 2018. Discussions held regarding various water issues of importance to the NWT including how droughts are impacting reservoir water levels, hydroelectric generation in this basin and significant cost of diesel fuel to generate electricity.
- J. Hickman, M. English, S. Kokolj, M. Richardson. Meeting with Northwest Territories Power Corporation in Yellowknife. Focus: An approach to realistically estimating snowpack water equivalent in the Snare River basin. Discussions held with NTPC in April 2019 to focus on approaches to measuring the annual snowpack in a more accurate way.
- B. Laird and K. Skinner. Through a series of phone and in-person meetings, Brian Laird and Kelly Skinner's team engaged with representatives from the Government of the Northwest Territories Department of Health and Social Services as well as Health Canada. Through these meetings, we described progress under the Mackenzie Valley Biomonitoring Project, the return of results for participants and communities, discussed implications for traditional food consumption notices, and designed communication materials to help health professionals interpret and discuss human biomonitoring results with their patients. More recently, Brian Laird has been appointed to Health Canada's Methylmercury Advisory Committee. o Further, our research team is contributing results from our NWF-funded project to a pair of reports (Human Health Assessment 2020; Mercury Assessment 2020) being created by Arctic Monitoring and Assessment Programme.
- B.Laird and K. Skinner: Summary of Meeting Dates: o Department of Health and Social Services (Government of the Northwest Territories): December 5th, 2018
- Population Biomonitoring Section (Health Canada): September 18th, 2018
- Rudolph, D. L. (2018). A Renaissance in Regional Hydrogeology: From Data to Modelling, Canadian Water Science Workshop, Global Water Futures – NRCan – ECCC – AAFC, Ottawa
- Baltzer, JL (2018) High latitude landcover changes. Canadian Water Science Workshop, Global Water Futures – NRCan – ECCC – AAFC, Ottawa
- Visit by GWNT ENR Deputy Minister Joe Dragon (Nov 2018) during which NWF faculty and HQP briefed DM Dragon on research advances.
- Laurier-GNWT Partnership AGM. This annual event serves as a platform for direct engagement of NWF scientists with GNWT managers and decision-makers. Through this partnership we also hold monthly calls during which research updates are provided.
- Baltzer, regular meetings with GNWT Forest and Fire divisions to report back on her fire research program. We have struck a communications group to ensure that the GNWT is briefed on all research prior to publication.

- DM Joe Dragon and several fire and forest managers participated in our two-day fire workshop in March 2019, during which presentations were given on the most recent research arising from these projects.

Policy Briefs and Meeting with Governments

Agriculture Water Futures (Macrae)

- Janina Plach, Merrin Macrae, Will Pluer. Meeting with Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), Agriculture and Agri-Food Canada (AFFC) and members of the PLATO team to improve predictive modeling of agricultural P runoff in Ontario landscapes. March 19, 2019. Guelph, Ontario.
- Anna Frank. Meeting with partners: Bradley MacMillan, Cindy (OMAFRA) – Funding Programs Data enquiry, October 29th, 2018.
- Anna Frank. Canadian Roundtable for Sustainable Crops, November 21st, 2018. Attended with partners from OMAFRA.
- Phil Harder. Participated in U of S water science briefing to Jonathan Wilkinson (Minister of Fisheries, Oceans and the Coast Guard) and Francis Scarpaleggia (Liberal Caucus Chair) on September 11, 2018.
- John Pomeroy. National Climate Change Science and Knowledge Workshop, Ottawa, ON, Feb 2019.
- John Pomeroy. National Flood Forecasting Workshop, Vancouver, BC, Feb 2019.
- John Pomeroy. Roundtable on Water Infrastructure, Regina, SK, Jan 2019.
- John Pomeroy. Climate Change Research in Saskatchewan Workshop, Regina, SK, Nov 2018
- John Pomeroy. Joint meeting of NRCan-GIWS/GWF-ECCC, Ottawa, ON, Nov 2018.
- John Pomeroy. Kazakhstan-Canada Business Council, Ottawa, ON, June 2018.
- Helen Baulch. Conversations with SK government are mainly facilitated by our two main contacts in the Saskatchewan Water Security Agency – John-Mark Davies, and Etienne Shupena-Soulodre. They have been kept apprised of critical developments through ongoing phone, email, and in-person conversations, and have passed on critical information (e.g. drawdown paper) to Saskatchewan Agriculture.
- Terry Fonstad and Crystal Rinas. Presentation “Livestock and Forage Centre of Excellence Environmental Monitoring Update” was given to Agricultural Operations, Saskatchewan Ministry of Environment on October 11, 2018.

Boreal Water Futures (Waddington)

- Pomeroy, National Climate Change Science and Knowledge Workshop, Ottawa, ON, Feb 2019
- Pomeroy, National Flood Forecasting Workshop, Vancouver, BC, Feb 2019
- Pomeroy, Roundtable on Water Infrastructure, Regina, SK, Jan 2019
- Pomeroy, Climate Change Research in Saskatchewan Workshop, Regina, SK, Nov 2018
- Pomeroy, Carey, and Waddington: Joint meeting of NRCan-GIWS/GWF-ECCC, Ottawa, ON, Nov 2018

- Pomeroy, Kazakhstan-Canada Business Council, Ottawa, ON, Jun 2018

FORMBLOOM (Baulch)

- Frequent 1:1 discussions with:
    - Yellow Quill First Nation. Weekly contact with Councilor Myron Neapteung. Six workshops in yellow Quill First Nation's reserve between June 6th and August 30th 2018. Edlers, youth, and community members were involved in interviewing and sharing circles.
    - Grand River Conservation Authority: Regular contact with Sandra Cooke. Frequency of meetings/communications ~3-4 times per year. Quality of interactions is very high. The GRCA provided data for Larsen's recently submitted manuscript, and has provided feedback on results and analyses to date.
    - Buffalo Pound Water Treatment Plant: Contact with Dan Conrad is somewhat lesser frequency this year (~4x per year phone meetings), as he plans for the plant upgrade, and retirement (decreasing his working days/week). His replacement should be named in the next few months, and allow us to revisit priorities, and outputs of our work to date. We have published a paper based on an experiment designed by Dan, addressing source water concerns associated with high DOM, hence GWF has acted as a catalyst, connecting users to researchers who can address key needs, even when direct funding was not provided. Dan also provided feedback on our article in LakeLine, and the water treatment plant continues to support sampling, analyses, and buoy deployment.
    - Saskatchewan Water Security Agency: There are two main points of contact -- Etienne Shupena-Soulodre, who acts as a conduit to watershed groups (e.g., connecting us with the Lower Souris Watershed Committee, and a recent contract completed by Roste). John-Mark Davies is the second point of contact -- and as a limnologist, he has provided valuable feedback on our work, helped support buoy deployment, and assisted in sampling and student mentorship. John-Mark co-authored our article in LakeLine and in that process, we engaged in valuable conversations regarding management options for eutrophic lakes, and impacts of nutrient loads on already eutrophied ecosystems. He has mentioned the wish to engage more deeply in student projects, creating outstanding mentorship opportunities for HQP.

Global Water Citizen (Robertson)

- Meetings with GNWT/ENR May 2018 on project objectives and scope.
- Meetings with Deline Government / GNWT / researchers around development of monitoring plan for Tsá Tué Biosphere Reserve

Indigenous Water Tools (Martin-Hill)

- Meeting with Elder Council at Band Council Lubicon Lake Band #453, Little Buffalo Alberta – 11 July 2018
- Haudenosaunee Confederacy Council Retreat, Gathering Place by the Grand, Ohsweken, ON - 30 March 2019

- Research team (including Dr Selvaganapathy from the "Sensors" project) presented current results to Six Nations Chiefs and Clanmothers
- Agenda attached (Appendix D)

Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins (IMPC) (Razavi)

- Crane, J., Coles, S., and Strickert, G., (2019) BRIEFING NOTES ON THE PROPOSED SASKATCHEWAN RIVER DELTA/MOSSY RIVER WATERSHED PROTECTED AREA. This briefing note was prepared at the request of Cumberland House Cree Nation Councilor Julius Crane and Chief Reny Chaboyer. Chief Chaboyer passed the briefing note to Prime Minister Trudeau in Saskatoon on September 12th, 2018.
- Carlson, H and A. Haghnedahgar. Plenary session **consultation with Saskatchewan Ministry of Environment on development on provincial climate change plan "Prairie Resilience," Regina, SK, July 2018**
- Carlson, H., Wolfe, J., Haghnegahdar, A., Halliday, R., and A., Slaughter. **Letter to Saskatchewan Ministry of Environment on recommended changes to resiliency framework for Prairie Resilience, August 7, 2018**
- Carlson, H. GWF Representative on NRCAN Federal Flood Risk Committee – 3 meetings since May 2018.
- Elshorbagy, A., Pomeroy, J., Shook, K., Lloyd-Smith, P., Razavi S., Carlson, H., and S. Merrill. (2018). Letter to Federal Flood Risk Committee providing feedback on two stream of work.
- Clark., M., Carlson, H., Razavi, S., and J., Pomeroy. (2019). Letter to the Climate Change Impacts and Adaptation Divison, Natural Resources Canada providing feedback on methods to estimate climate change-informed design water levels for floodplain mapping.
- Pomeroy, J. National Climate Change Science and Knowledge Workshop, Ottawa, ON, Feb 2019
- Pomeroy, J., National Flood Forecasting Workshop, Vancouver, BC, Feb 2019
- Pomeroy, J., Roundtable on Water Infrastructure, Regina, SK, Jan 2019
- Pomeroy, J., Climate Change Research in Saskatchewan Workshop, Regina, SK, Nov 2018
- Pomeroy, J., Joint meeting of NRCan-GIWS/GWF-ECCC, Ottawa, ON, Nov 2018
- Pomeroy, J., Kazakhstan-Canada Business Council, Ottawa, ON, Jun 2018

Lake Futures (Basu)

- Basu, N.B. (2018). Nutrient Legacies and Time Lags: Implications for Water Quality, Canada Center for Inland Waters, Environment and Climate Change Canada, Burlington, May 2018
- Ho, E. On July 8, 2018, contributed to SDG 6 policy briefs presented by the Women's Major Group (United Nations formal stakeholder group to represent women's interests worldwide) to the United Nations High-level Political Forum.
- Linking Water Governance in Canada (de Loe)

- Rob de Loë used took advantage of his position as Co-Chair, Great Lakes Water Quality Board, and member, 2020 Triennial Assessment of Progress Study Board, (a) to communicate knowledge and insights gained through the research to key actors in Canada-US nutrient management governance, (b) to build linkages with emerging IJC initiatives, and (c) to identify priorities of key actors in the basin that could be addressed through the project.
- In January 2018 Dr. Garrick briefed the World Bank on Water Security for Resilient Cities and Rural Livelihoods: Lessons from Rural-to-Urban Water Reallocation. This meeting was an opportunity to share ideas regarding external drivers that influence water governance at the global scale.

Linking multiple stressors to adverse ecological responses across watersheds (Servos)

- Participation on National Expert Panel
- The Expert panel created a national report on a strategy for wastewater management across Canada at the request of Environment and Climate Change Canada. The membership of the Panel included experts in wastewater including academia and practitioners. The committee met numerous times over 2017-2018 across the country (Vancouver, Calgary, Toronto, Montreal) to seek input from experts (workshops), review literature and prepare reports. The final report, Canada's Challenges and Opportunities to Address Contaminants in Wastewater is available on the Canadian Water Network webpage (http://www.cwn-rce.ca/focus-areas/blue-cities/national-project-on-contaminants-in-wastewater/).
- The report was presented at a special session of government and wastewater experts in Toronto, May 1-2 2018. Expert panel calls for holistic approach to wastewater management, Water Institute News, May 2018 (https://uwaterloo.ca/water-institute/news/expert-panel-calls-holistic-approach-wastewater-management).
- In addition, the Panel had two meetings with senior official and politicians and provided synthesis letters and reports (e.g. Jonathan Wilkinson, M.P. Parliamentary Secretary to the Minister of Environment and Climate Change, Mike Beale, ADM, Environmental Protection Branch, John Moffat – Associate ADM, Environmental Protection Branch, George Enei – ADM, Science and Technology Branch, Hilary Geller – ADM, Strategic Policy Branch) June 7, 2018 meeting and follow up letter June 15. There was also a meeting with senior ECCC ADMs in Hull, PQ, June 28, 2017.
- Special Session and Panel Discussion. National Expert Panel on Contaminants in Wastewater, Blue Cities, Canadian Water Network, Toronto, Ontario, May 1-2 2018. Susheel Arora, Halifax Water, Mike Darbyshire, Alberta Capital Region Wastewater Commission, Teresa McClenaghan, Canadian Environmental Law Association, Mark Servos, University of Waterloo. https://www.newswire.ca/news-releases/expert-panel-presents-a-blueprint-for-action-on-contaminants-in-wastewater-681357061.html
- Servos, M. Meeting on wastewater studies with Caroline Blais (Director), Forest Products and Fisheries Act, Environmental Protection Branch, Environment and Climate Change Canada, Ottawa, March 8, 2018. Briefing on research progress with Director of ECCC.

- Servos, M. Implication of wastewater infrastructure upgrades. Industrial Sectors, Chemicals, and Waste Directorate, Environment and Climate Change Canada, Ottawa, March 8, 2018. Invited Seminar.
- Servos M. and G. Tetreault. An overview of Grand River research projects. Middle Chapter of Trout Unlimited Annual Meeting, Five Oaks, Brantford, Jan. 26, 2019.

Mountain Water Futures (Carey)

- Pomeroy
  - National Climate Change Science and Knowledge Workshop, Ottawa, ON, Feb 2019
  - National Flood Forecasting Workshop, Vancouver, BC, Feb 2019
  - Roundtable on Water Infrastructure, Regina, SK, Jan 2019
  - Climate Change Research in Saskatchewan Workshop, Regina, SK, Nov 2018
  - Joint meeting of NRCan-GIWS/GWF-ECCC, Ottawa, ON, Nov 2018
  - Kazakhstan-Canada Business Council, Ottawa, ON, Jun 2018
- Westbrook
  - City of Calgary Watershed Health workshop where the group worked on developing a water-based health index for the city. March 19, 2019
- Carey
  - Met with Yukon and Federal Government officials regarding new work on the Dempster Highway. February 2019.

Next Generation Solutions (Giesy)

- We attended a meeting with the province of Saskatchewan's Rapid Response Team for Aquatic Invasive Species where we presented findings to date. Furthermore, Drs. Hecker and Jardine were invited to present their current work on eDNA AIS detection and monitoring approaches to the annual Saskatchewan Wildlife Federation convention in 2018 where they interacted with multiple community groups as well as provincial government groups. Based on discussions resulting from these interactions the Saskatchewan Wildlife Federation and the Province of Saskatchewan together with our group intend to establish a community education program on AIS and eDNA monitoring approaches.

Prairie Drainage Governance (Loring)

- Norris, M. Down the Drain: Agricultural surface drainage across Canada. Knowledge Brief: https://gwf.usask.ca/drainage/documents/PDG_Knowledge%20Brief-Final.pdf
- We are in frequent communications with government and community actors about our research, but are not yet ready to present results

Prairie Water (Spence)

- Wolfe, J.D. (2018) SK Ministry of Environment Prairie Resilience Framework for Climate Change Strategies: Second Installment and Changes – Plenary Discussions. July 10th, Regina, SK.

- Wolfe, J.D., Carlson, H. (2018) SK Ministry of Environment Prairie Resilience Framework for Climate Change Strategies: Global Water Futures site visit. Global Institute for Water Security, Saskatoon, SK. August 7th.
- Wolfe, J.D., Whitfield, C. (2018) Discussion on catchment classification studies and strategies for linking with water quality. Alberta Agriculture and Forestry. September 26th. (remote)
- Pomeroy, J. (2018) Climate Change Research in Saskatchewan Workshop, Regina, SK, Nov 2018
- Pomeroy, J. (2019) Roundtable on Water Infrastructure, Regina, SK, Jan 2019
- Pomeroy, J. (2019) National Climate Change Science and Knowledge Workshop, Ottawa, ON, Feb 2019

Southern Forest Water Futures (Arain)

- Research conducted by HQP in the SFWF Project contributed to meta analyses that make up to the IPCC reports, international policy documents. SFWF research also contributes to the growing body of literature that is published in top journals, which are often referenced by policymakers as they aim to develop policy for governmental action on climate and carbon neutrality.
- SFWF researchers and HQP participated in the Mapping the Global Dimensions of Policy conference that is held annually at McMaster. This conference attracts keynote speakers that speak on international policy.

Storms and Precipitation Across the continental Divide Experiment (SPADE) (Theriault)

- Pomeroy, John
    - National Climate Change Science and Knowledge Workshop, Ottawa, ON, Feb 2019
    - National Flood Forecasting Workshop, Vancouver, BC, Feb 2019
    - Roundtable on Water Infrastructure, Regina, SK, Jan 2019
    - Climate Change Research in Saskatchewan Workshop, Regina, SK, Nov 2018
    - Joint meeting of NRCan-GIWS/GWF-ECCC, Ottawa, ON, Nov 2018
    - Kazakhstan-Canada Business Council, Ottawa, ON, Jun 2018
- Pomeroy, John, R Stewart and J Thériault participated to the Water Security for Canadians: Solutions for Canada's Emerging Water Crisis, Strategic briefing and discussion, Ottawa, Ridean Club, April 2019

Transformative sensor Technologies and Smart Watersheds (TTSW) (Duguay)

- National Climate Change Science and Knowledge Workshop, Ottawa, ON, Feb 2019 (Pomeroy)
- National Flood Forecasting Workshop, Vancouver, BC, Feb 2019 (Pomeroy)
- Roundtable on Water Infrastructure, Regina, SK, Jan 2019 (Pomeroy)
- Climate Change Research in Saskatchewan Workshop, Regina, SK, Nov 2018 (Pomeroy)
- Joint meeting of NRCan-GIWS/GWF-ECCC, Ottawa, ON, Nov 2018 (Pomeroy)
- Kazakhstan-Canada Business Council, Ottawa, ON, Jun 2018 (Pomeroy)

WLU Technical Team (Munkittrick)

- Meeting with Northwest Territories Power Corporation (NTPC) in Yellowknife. Focus: An approach to realistically estimating snowpack water equivalent in the Snare River basin. (J. Hickman, M. English, S. Kokolj, M. Richardson). Discussions held with NTPC in April 2019 to focus on approaches to measuring the annual snowpack in a more accurate way
- NWT Permafrost Data Stakeholder Meeting and Thermokast Mapping Meeting, March 6-7, 2019. This meeting brought together permafrost and remote sensing experts to discuss the development of a mapping project determining the distribution of thermokast features and landforms across the entire NWT (C. Beel)
- Community Geohazard Mapping meeting - Monday, May 14, Yellowknife, NT. Meeting with the NWT Association of Communities and the NWT Geological Survey (A. Rudy)

News and Magazine Articles

Agriculture Water Futures (Macrae)

- Macrae, M.. Ontario Farmer. News Article on Recent Research Findings Related to Phosphorus Losses in Ontario. January, 2019.
- Pomeroy J., DeBeer C., Adapa P., Merrill S., (2019). How Canada can solve its emerging water crisis (Newspaper Article). In The Conversation and National Post.
- Pomeroy J, (2018). As a water crisis looms in Cape Town, could it happen in Canada? (Online Resource). In The Conversation and Maclean's.

Boreal Water Futures (Waddington)

- Hugh Biggar. Burn notice: A call to action for a fire-smart future. Article for Landscape News (online outlet of the Global Landscape Forum) based on the interview of M.Flannigan, FN Robinne, and Janice Burns. 2019 (To be published).
- Flannigan, 2019/03/17. Alberta researchers look to artificial intelligence programs to predict catastrophic wildfires, Bob Weber Edmonton The Canadian Press The Globe and Mall Technology https://www.theglobeandmail.com/business/technology/article-alberta-researchers-look-to-artificial-intelligence-programs-to/
- Flannigan, 2018/09/07 A summer of fire, heat and flood puts a focus on adapting to climate change, The Global and Mail --Shawn McCarthy Global Energy Reporter https://www.theglobeandmail.com/politics/article-a-summer-of-fire-heat-and-flood-puts-a-focus-on-adapting-to-climate/
- Flannigan, 2018/07/03 New book tells the story of the 2017 wildfires, https://www.ashcroftcachecreekjournal.com/community/new-book-tells-the-story-of-the-2017-wildfires/
- Flannigan, 2018/06/28 Creating a call to action on wildfire Wildfire and Climate Change Conference hosts 200 delegates in Nelson, https://www.piquenewsmagazine.com/whistler/creating-a-call-to-action-on-wildfire/Content?oid=9443749
- Flannigan, 2018/05/25 Climate and Wildland Fire, HazNet The Magazine of the Canadian Risks and Hazards Network http://haznet.ca/canadas-burning-question/

- Flannigan, 2018/05/10 Wildfire expert says situation can be dangerous even after rain, https://www.cbc.ca/news/canada/saskatoon/wildfire-expert-situation-dangerous-sask-1.4656773
- Flannigan, 2018/05/08 Wildfire season already in full swing in Alberta, http://www.660news.com/2018/05/08/wildfire-season-already-full-swing-alberta/
- Flannigan, 2018/05/08 Amid more than a dozen blaze bans, early wildfire conditions a concern, says province, http://vancouversun.com/news/local-news/amid-more-than-a-dozen-blaze-bans-early-wildfire-conditions-a-concern-says-province/wcm/6235c20a-da41-41a4-937a-5c8f9db18c2e
- Flannigan, 2018/05/05 Wet spring is no guard against forest fires, http://theprovince.com/opinion/columnists/flannigan-wet-spring-is-no-guard-against-forest-fires/wcm/13367943-acd4-4307-a25d-4fac6a93192f
- R.M. Petrone. Road construction impacts on Alberta peatland hydrology and nutrient cycling. The Water Institute Water Research, Issue 2, Winter 2018.
- R. Rooney, R.M. Petrone, D.T. Robinson.Greater hydrologic connectivity in Athabasca oil sands will result from climate change. The Water Institute Water Research, Issue 5, Winter 2019.
- Pomeroy J., DeBeer C., Adapa P., Merrill S., (2019). How Canada can solve its emerging water crisis (Newspaper Article). In The Conversation and National Post.
- Pomeroy J, (2018). As a water crisis looms in Cape Town, could it happen in Canada? (Online Resource). In The Conversation and Maclean's.
- Dr. Waddington's research was featured in National Geographic (release date: April 26, 2019). "Tree-planting programs can do more harm that good". Fort McMurray wildfire research featured in the article including an infographic.
- Waddington, 2018/08/06. National Post. Forest fires like Ontario's Parry Sound 33 can take a long-term toll on the environment, experts say https://nationalpost.com/news/experts-say-forest-fires-like-ones-in-ontario-can-take-long-term-toll-on-environment
- Waddington, 2018/08/02. Richmond News. Richmond bog fire could smoulder for years: Experts.https://www.richmond-news.com/news/richmond-bog-fire-could-smoulder-for-years-experts-1.23388149
- Waddington, 2018/08/06. Globe and Mail. As forest fires burn in Ontario, experts warn of long-term environmental impact https://www.theglobeandmail.com/canada/article-as-forest-fires-burn-in-ontario-experts-warn-of-long-term/
- Pomeroy, Jan 2019. Fortified Arctic infrastructure needed in face of climate change, says study, Text Interview. The Canadian Press / La Presse.
- Pomeroy, May 2018. The Drilldown: Indigenous bid for Trans Mountain project gets industry support, Text Interview. iPolitics, January 2019.
- Pomeroy, May 2018. Record floods show world has changed and N.B. must adapt, scientists say, Text Interview. The Canadian Press / La Presse, May 2018.
- Pomeroy, April 2018. Deliverance from Flood: Pitting city against country, Text Interview. Alberta Views, April 2018.

Climate-Related Precipitation Extremes (Stewart)

- Thériault, Julie (2018) Pluie, verglas, neige, Actualité UQAM

FORMBLOOM (Baulch)

- Baulch, H., Venkiteswaran, J., Davies, J-M. 2018. The water quality toolbox. Lakeline (North American Lake Management Society). Fall 2018 pages 16-19

Indigenous Water Tools (Martin-Hill)

- Six Nations hosts a landmark symposium on water safety" by Sonia Verma, Brighter World – 31 May 2018. https://brighterworld.mcmaster.ca/articles/six-nations-hosts-a-landmark-symposium-on-water-safety/
- "Six Nations water focus of Mac conference" by Nicole O'Reilly – 3 June 2018 https://www.thespec.com/news-story/8645830-six-nations-water-focus-of-mac-conference/
- "Making water testing more affordable" by Sara Laux, Brighter World – 4 June 2018 https://brighterworld.mcmaster.ca/articles/making-water-testing-more-affordable/
- "Engineering Fresh Faces: Charles de Lannoy" Brighter World – 25 September 2018 https://brighterworld.mcmaster.ca/articles/engineering-fresh-faces-charles-de-lannoy
- "While Nestlé extracts millions of litres from their land, residents have no drinking water" by Alexandra Shimo, The Guardian – 4 October 2018 https://www.theguardian.com/global/2018/oct/04/ontario-six-nations-nestle-running-water
- "'Third World conditions': Many of Canada's indigenous people can't drink the water at home" by Amanda Coletta, The Washington Post – 15 October 2018 https://www.washingtonpost.com/world/the_americas/third-world-conditions-many-of-canadas-indigenous-people-cant-drink-the-water-at-home/2018/10/14/c4f429b4-bc53-11e8-8243-f3ae9c99658a_story.html
- "Helping to solve the First Nations water crisis through collaboration" by Tim Alamenciak, TVO – 24 October 2018 https://www.tvo.org/article/helping-to-solve-the-first-nations-water-crisis-through-collaboration
- Six Nations newspaper "Two-row Times"
- Six Nations newspaper "Turtle Island News"

Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins (IMPC) (Razavi)

- Pomeroy J., DeBeer C., Adapa P., Merrill S., (2019). How Canada can solve its emerging water crisis (Newspaper Article). In The Conversation and National Post.

- Pomeroy JW, McPhee J, DeBeer C, (2018). Recent INARCH Activities and the 4th INARCH Workshop, Santiago and Portillo, Chile, 24-26 October 2018 (Newsletter Article). In Global Energy and Water Exchanges (GEWEX) News. 29 (Nov 2018), 17-19.
- Pomeroy J, (2018). As a water crisis looms in Cape Town, could it happen in Canada? (Online Resource). In The Conversation and Maclean's.
- Pomeroy J., Fortified Arctic infrastructure needed in face of climate change, says study, Text Interview. The Canadian Press / La Presse, January 2019.
- Pomeroy J., Epic 2013 flood harbinger of a changing climate's impact, Text Interview. Calgary Herald, June 2018.
- Pomeroy J., Record floods show world has changed and N.B. must adapt, scientists say, Text Interview. The Canadian Press / La Presse, May 2018.
- Pomeroy J., Forecasters on alert as river basins across Alberta have high snowpacks, Text Interview. Toronto Star Newspapers Ltd, April 2018.
- Pomeroy J., Could Calgary see 2013 flooding again?. Text Interview. Canadian Underwriter, April 2018.
- Pomeroy J., Deliverance from Flood: Pitting city against country, Text Interview. Alberta Views, April 2018.

Lake Futures (Basu)

- Canadian Science Policy Proceeding 2018: Van Cappellen, P., Pietroniro, A., Cobham, Crawhall, S.N., Krantzberg, G., Goucher, N., Milojevic, T., and Kheyrollah Pour, H. Water at the Science-policy interface: Challenges and opportunities for Canada, https://sciencepolicy.ca/panel-117-water-science-policy-interface-challenges-and-opportunities-canada
- Van Meter, K.J., Van Cappellen, P., and Basu N.B. (2018) Legacy nitrogen may prevent achievement of water quality goals in the Gulf of Mexico, Science
- KUT, NPR, "The Gulf of Mexico's 'Dead Zone' would take 30 years to reverse – If it can be reversed at all", April 2018, https://www.kut.org/post/gulf-mexicos-dead-zone-would-take-30-years-reverse-if-it-can-be-reversed-all
- Popular Science, Eschner, K. "Good job: Arctic sea ice is full of our junk plastic", April 2018, https://www.popsci.com/arctic-sea-ice-microplastic
- TVO, "Why Ontario is struggling to fight Lake Erie's toxic green goo", October 2018, https://www.tvo.org/article/why-ontario-is-struggling-to-fight-lake-eries-toxic-green-goo
- The Record, "Proposed bill could lead to policy patchwork in Ontario endangering environmental protections and public health", Dec 2018, https://www.therecord.com/news-story/9080434-proposed-bill-could-lead-to-policy-patchwork-in-ontario-endangering-environmental-protections-and-public-health/

Mountain Water Futures (Carey)

- Pomeroy

    - National Climate Change Science and Knowledge Workshop, Ottawa, ON, Feb 2019
    - National Flood Forecasting Workshop, Vancouver, BC, Feb 2019
    - Roundtable on Water Infrastructure, Regina, SK, Jan 2019
    - Climate Change Research in Saskatchewan Workshop, Regina, SK, Nov 2018
    - Joint meeting of NRCan-GIWS/GWF-ECCC, Ottawa, ON, Nov 2018
    - Kazakhstan-Canada Business Council, Ottawa, ON, Jun 2018
- Westbrook
    - City of Calgary Watershed Health workshop where the group worked on developing a water-based health index for the city. March 19, 2019
- Carey
    - Met with Yukon and Federal Government officials regarding new work on the Dempster Highway. February 2019.

Northern Water Futures (Baltzer)

- "GNWT more prepared for wildfires" by Brett McGarry, The Yellowknifer on March 13, 2019. https://nnsl.com/yellowknifer/after-2014-wildfires-gnwt-is-more-prepared/
- "A new 2014 for wildfires? We'll see it coming, say experts" by Ollie Williams, Cabin Radio. https://cabinradio.ca/13689/news/environment/wildfires/a-new-2014-for-wildfires-well-see-itcoming-say-experts/
- July 25, 2018: Collaborative fire research featured by NASA in an online article: https://www.nasa.gov/feature/goddard/2018/fires-floods-and-satellite-views-modeling-the-borealforest-s-future
- June 30, 2018: Wildfire research highlighted in The Discourse: https://www.thediscourse.ca/environment/good-news-wildfire-story-nwt
- "Global fire emissions declined over past 90 years, but not in Canada" by Ainslie Cruickshank, The Star Vancouver on April 17 2018: https://www.thestar.com/vancouver/2018/04/17/global-wildfireemissions-declined-over-past-90-years-but-not-in-canada.html
- "After the wildfires: what happens once the flames are doused?" by Doyle Rice, USA Today on July 30 2018: https://www.usatoday.com/story/news/nation/2018/07/30/carr-fire-what-happens-whenblazes-doused/865806002/
- On the land in Canada's North. Laurier Campus Magazine. Fall 2018. Available at: https://campusmagazine.wlu.ca/2018/fall-winter/research-file/on-the-land-in-canadas-north.html
- Laurier researchers search for solutions as warming climate changes the North. The Record. May 18, 2018. Available at: https://www.therecord.com/news-story/8618828-laurier-researchers-search-forsolutions-as-warming-climate-changes-the-north/
- Watching Trees Transpire. Northern Water Futures Newsletter 2018. https://researchcentres.wlu.ca/northern-water-futures/news/2018/watching-trees-transpire2.html

- For Peats Sake Let's Chill Out a Bit and Stop Global Warming. UdeM Nouvelles. March 2019. https://nouvelles.umontreal.ca/en/article/2019/03/19/for-peat-s-sake-let-s-chill-out-a-bit-andstop-global-warming/

Old Meets New (Ferguson)

- Ferguson, G. and McIntosh, J.C. 2019. The global race for groundwater speeds up to feed agriculture's growing needs. The Conversation. https://theconversation.com/the-global-race-for-groundwater- speeds-up-to-feed-agricultures-growing-needs-108458
- Ferguson, G. and Loveless, S. 2018. Unconventional Oil and Gas Development and Groundwater – Comparing the English and Canadian Experiences. Water Underground. EGU Blogs/AGU Blogosphere. https https://blogs.agu.org/waterunderground/2018/11/06/unconventional-oil-and-gas-development- and-groundwater-comparing-the-english-and-canadian-experiences/

Prairie Drainage Governance (Loring)

- Loring, P., Gaspard, V, & Minnes, S. (2019). *Stoking Conflict Between Farming and Conservation Hurts Everyone*. THE CONVERSATION: https://theconversation.com/stoking-conflict-between-farming-and-conservation-hurts-everyone-109778

Prairie Water (Spence)

- Giannelli, F. (2018) Uncovering the secret winter life of lakes (online article). September 22nd. https://news.usask.ca/articles/research/2018/research-uncovering-the-secret-winter-life-of-lakes.php
- Crossland, M. with Hayashi, M. (2018). Masaki Hayashi explains why we need to pay attention to or groundwater consumption this Sustainability Week. University Relations, University of Calgary. October 26th. https://www.ucalgary.ca/utoday/issue/2018-10-26/ucalgary-researcher-gives-glimpse-limited-resource-groundwater
- Pomeroy J, (2018). As a water crisis looms in Cape Town, could it happen in Canada? (Online Resource). In The Conversation and Maclean's.
- Pomeroy J., DeBeer C., Adapa P., Merrill S., (2019). How Canada can solve its emerging water crisis (Newspaper Article). In The Conversation and National Post.

Southern Forest Water Futures (Arain)

- Featured in the BRIGHT WORLD and Daily News article entitled "Telling the future of water in southern forests" on 12 February 2018. https://brighterworld.mcmaster.ca/articles/telling-the-future-of-water-in-southern-forests/
- Hydrometeorology and Climatology group featured in the BRIGHT WORLD and Daily News article entitled "Helping forests survive and thrive in the face of climate change" on 4 June 2018. https://brighterworld.mcmaster.ca/articles/helping-forests-survive-and-thrive-in-the-face-of-climate-change/
- Featured in the Daily News article entitled "Seventeen McMaster researchers included in 2018 Highly Cited Researchers list" on 28 November 2018.

https://dailynews.mcmaster.ca/articles/seventeen-mcmaster-researchers-included-in-2018-highly-cited-researchers-list/

Storms and Precipitation Across the continental Divide Experiment (SPADE) (Theriault)

- Thériault, J M (2018) Pluie, verglas, neige, Actualité UQAM
- Pomeroy J W, C DeBeer, P Adapa, S Merrill, (2019). How Canada can solve its emerging water crisis (Newspaper Article). In The Conversation and National Post.
- Pomeroy J W, (2018). As a water crisis looms in Cape Town, could it happen in Canada? (Online Resource). In The Conversation and Maclean's.

Transformative sensor Technologies and Smart Watersheds (TTSW) (Duguay)

- Pomeroy J., DeBeer C., Adapa P., Merrill S., (2019). How Canada can solve its emerging water crisis (Newspaper Article). In The Conversation and National Post.
- Pomeroy J, (2018). As a water crisis looms in Cape Town, could it happen in Canada? (Online Resource). In The Conversation and Maclean's.

Winter Soil Processes (F. Rezanezhad)

- Water Institute at University of Waterloo published a news item about the GWF Winter Soil Process project on "Global Water Futures project mobilizes interdisciplinary teams to investigate winter soil processes" by interviewing two MSc students in this project. https://uwaterloo.ca/water-institute/news/global-water-futures-project-mobilizes-interdisciplinary
- A public level news item has been prepared and published on the rare Charitable Research Reserve blog (Real people, real stories, real community) highlighting the "Our Soils Get Colder – Will this Affect Plant Growth and Water Quality? https://raresites.wordpress.com/2019/04/09/our-soils-get-colder-will-this-affect-plant-growth-and-water-quality/
- This news item has been also posted on UW Water Institute news page: https://uwaterloo.ca/water-institute/news/our-soils-get-colder-will-affect-plant-growth-and-water

Radio and TV Interviews

Agriculture Water Futures (Macrae)

- John Pomeroy. $1M to develop climate change strategy helps quench thirst for long-term Prairie water management plan, Broadcast Interview. CBC News Saskatoon, March 2019.
- John Pomeroy. Global Water Futures conference: Water problems seeking solutions, Broadcast Interview. Radio Canada International, June 2018.
- John Pomeroy. National flood forecasting strategy, Broadcast Interview. News Talk 770 CHQR, May 2018.
- John Pomeroy. Deliverance from Flood: Pitting city against country, Text Interview. Alberta Views, April 2018

Boreal Water Futures (Waddington)

- Sean Carey was interviewed on the CFMU radio show Earth Matters about change in the north.
- Sylvain Jutras was interviewed on Radio-Canada radio show "Les années lumières" about snow abundance in Quebec related to risks of flooding. March 24, 2019.
- Flannigan, 2019/03/19 - Long, cold winter won't affect fire season, says expert, the story in the folio on March 19,2019, https://www.folio.ca/long-cold-winter-wont-affect-fire-season-says-expert/
- Flannigan, 2019/03/17 - Training underway as Alberta's wildfire season starts Expert says conditions can change quickly, CBC News · Posted: Mar 17, 2019 5:56 PM MT | Last Updated: March 17, https://www.cbc.ca/news/canada/calgary/alberta-wildfire-season-starts-polar-vortex-1.5060446
- Flannigan, 2019/03/17 - Researchers look to artificial intelligence programs to predict wildfires, TV News Bob Weber, The Canadian Press Published Sunday, March 17, 2019 10:33AM EDT, https://www.ctvnews.ca/sci-tech/researchers-look-to-artificial-intelligence-programs-to-predict-wildfires-1.4339672#_gus&_gucid=&_gup=twitter&_gsc=aRkMCVm
- Flannigan, 2019/03/14 - CBC World at Six: March 14 2019, Mike Flannigan is interviewed in this segment about the health effects of wildfire. The segment starts at 22:43 and Flannigan is interviewed at 24:07., https://www.cbc.ca/listen/shows/cbc-news-the-world-at-six/segment/159141
- Flannigan, 2018/07/17 - Humans are making wildfires worse, but here's what we can do about it 'Every human-caused fire is preventable', The Verge By Rachel Becker and William Poor, https://www.theverge.com/2018/7/17/17578936/wild-fires-california-west-disaster-causes-prevention-climate-change
- Doubleday & Narro Perez, 2019-02-18; were interviewed by Spanish-language media in Huaraz, Peru.
- Pomeroy, June 2018. Of forests and floods: Devastatingly high water raises clear-cut questions, Broadcast Interview. CBC News.
- Pomeroy, June 2018. Global Water Futures conference: Water problems seeking solutions, Broadcast Interview. Radio Canada International,
- Pomeroy, May 2018. - National flood forecasting strategy, Broadcast Interview. News Talk 770 CHQR,

Climate-Related Precipitation Extremes (Stewart)

- Thériault, Julie (2018) Station météorologique UQAM, Capsule Météomedia

Indigenous Water Tools (Martin-Hill)

- "Why so few people on Six Nations reserve have clean running water, unlike their neighbours" – CBC Out in the Open – 21 April 2018 https://www.cbc.ca/radio/outintheopen/neighbours-1.4618733/why-so-few-people-on-six-nations-reserve-have-clean-running-water-unlike-their-neighbours-

1.4618968?fbclid=IwAR2nUxEBAAnvCC29QfUF9sb6f_tTK4tNFsc2XHhig-eXd92INA1NB6TuW0A

- "Trickling down knowledge about water quality concerns with Sarah Duignan" – CFMU Student Radio show The AlmaMAC: Episode 70 – 14 June 2018 http://cfmu.ca/episodes/9239-the-almamac-episode-70-june-1415-trickling-down-knowledge-about-water-quality-concerns-with-sarah-duignan

Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins (IMPC) (Razavi)

- Pomeroy J., As Calgarians eye melting rivers, experts say there are no big signs of flood, Broadcast Interview. CBC Calgary, March 2019.
- Pomeroy J., Calgary flood 5 years later - Nature's power and the long-lasting impacts on southern Alberta rivers, Broadcast Interview. Global News, June 2018.
- Pomeroy J., Global Water Futures conference: Water problems seeking solutions, Broadcast Interview. Radio Canada International, June 2018.
- Pomeroy J., National flood forecasting strategy, Broadcast Interview. News Talk 770 CHQR, May 2018.
- Pomeroy J., High snowpack across Alberta has river forecasters on alert this spring, Broadcast Interview. CBC Edmonton, April 2018.

Lake Futures (Basu)

- Krantzberg, G. 2018. Marking World Water Day: on TVO the Agenda with Steve Paikin. Toronto, https://www.tvo.org/video/world-water-woes.
- Ho, E. Interview with Elaine Ho about Youth Led Engagement, Water Quality, the UN SDGs and more! [Audio interview]. Eco Cast, Waterloo, Ontario, October 21, 2018. Online: https://www.theecomarket.org/podcast/elaineho. Length: 38:56.

Linking Stream Networks (MacVicar)

- CTV National News, April 24, 2019, Canadian Communities Struggling against Rising Floodwaters, Television Interview, https://www.ctvnews.ca/video?clipId=1667529, and in print https://www.ctvnews.ca/canada/ontario-cottage-country-town-declares-state-of-emergency-due-to-flooding-1.4392834.

Matawa Water Futures (Mitchell)

- Radio Interview: Matawa Radio Show, December 4, 2018
- Radio Interview: CBC – Up North, February 1, 2019
    - Segment Title: Traditional Knowledge and Western Science have a lot to offer one another when both are respected
    - https://www.cbc.ca/listen/live-radio/1-84-up-north/clip/15667892-traditional-knowledge-and-western-science-have-a-lot-to-offer-one-another-when-both-are-respected
- Radio Interview: CBC – Superior Morning, April 1, 2019
    - Segment Title: Matawa Watershed Protection

- https://www.cbc.ca/player/play/1469091395732

Mountain Water Futures (Carey)

- Pomeroy. Other Activity – As Calgarians eye melting rivers, experts say there are no big signs of flood, Broadcast Interview. CBC Calgary, March 2019.
- Pomeroy. Other Activity – Calgary flood 5 years later – Nature's power and the long-lasting impacts on southern Alberta rivers, Broadcast Interview. Global News, June 2018.
- Pomeroy. Other Activity – Global Water Futures conference: Water problems seeking solutions, Broadcast Interview. Radio Canada International, June 2018.
- Pomeroy. Other Activity – National flood forecasting strategy, Broadcast Interview. News Talk 770 CHQR, May 2018.
- Pomeroy. Other Activity – High snowpack across Alberta has river forecasters on alert this spring, Broadcast Interview. CBC Edmonton, April 2018.
- Dery S, Ul Islam S. UNBC study warns of future flooding in the Fraser River Basin. Broadcast Interview. CKPG Today. March 4, 2019.
- Thériault, Julie (2018) Station météorologique UQAM, Capsule Météomedia
- This is a short documentary on the weather station at UQAM. These are similar type of instruments used at Fortress Mountain and that will be used during SPADE.
- Pomeroy. Other Activity – Fortified Arctic infrastructure needed in face of climate change, says study, Text Interview. The Canadian Press / La Presse, January 2019.
- Pomeroy. Other Activity – The Drilldown: Indigenous bid for Trans Mountain project gets industry support, Text Interview. iPolitics, January 2019.
- Pomeroy. Other Activity – Epic 2013 flood harbinger of a changing climate's impact, Text Interview. Calgary Herald, June 2018.
- Pomeroy. Other Activity – Forecasters on alert as river basins across Alberta have high snowpacks, Text Interview. Toronto Star Newspapers Ltd, April 2018.
- Pomeroy. Other Activity – Could Calgary see 2013 flooding again? Text Interview. Canadian Underwriter, April 2018.
- Pomeroy. Other Activity – Deliverance from Flood: Pitting city against country, Text Interview. Alberta Views, April 2018.
- Zwiers. Government of Canada delivering Climate Expertise to Canadians in Collaboration with Pacific Climate Impacts Consortium. Government of Canada. February 2019
- Menounos. (Un)buried treasure: Melting glaciers in B.C.'s Golden Triangle are revealing rich mineral deposits. CBC News. August 2018.
- Menounos. Significant decline in North American Glaciers since 2000: UNBC study finds. Vancouver Sun. January 2019.
- Carey. It's shocking to see how fast these mountains are changing. Brighter World. June 2018.

Next Generation Solutions (Giesy)

- In Search of Cleaner Coal, Scientists Lace Lake With Toxic Element. Experimental Lakes Area toxicologists study how selenium, a coal-mining byproduct, moves around the food

web (https://www.cbc.ca/news/canada/manitoba/experimental-lakes-area-selenium-1.4771337)

Northern Water Futures (Baltzer)

- J. Baltzer Live radio interview with 570 News regarding Baltzer's research on wildfire impacts on caribou habitat in the north. August 28, 2018.
- J. Hickman and M. English. Interview with Cabin Radio in Yellowknife about our work in the Snare River basin and climate change May 2018.
- M Turetsky: 2018 highlights in climate science. Interview for Quirks and Quarks. December 2018
- M. Turetsky: CTV News: https://toronto.ctvnews.ca/video?clipId=1450827 • M Turetsky: CTV Toronto: https://www.ctvnews.ca/canada/forest-fires-will-become-morewidespread-and-destructive-expert-warns-1.4034546
- M Turetsky: Creator and Producer, Science Unscrambled for CTV's Your Morning program. Airs approximately monthly and covers recent science developments
- B. Laird. CBC News. Researchers see very reassuring early results in N.W.T. contaminants study. 2018. http://www.cbc.ca/news/canada/north/university-of-waterloo-contaminants-study-1.4530092
- B Wolfe and R. Hall. Climate change, not industry to blame for UNESCO site's decline: Scientists / Debate over Wood Buffalo UNESCO site politicized: Scientists (Radio interview with Elizabeth Priest, MIX 103.7 & 100.5 CRUZ FM, Fort McMurray AM radio, 16 August 2018).
- Climate change, not industry to blame for UNESCO site's decline: Scientists / Debate over Wood Buffalo UNESCO site politicized: Scientists (The Canadian Press, The National Post, The Toronto Star and several other outlets, 15 August 2018).

Old Meets New (Ferguson)

- "The Race for Groundwater speeds up to feed agriculture's growing needs," by Grant Ferguson and Jennifer McIntosh. Conversation Canada, published January 15, 2019. Covered by PBS News Hour, National Post and Winnipeg Free Press among others.
- "Warning: A 'Shrinking Window' of Usable Groundwater," by Tara Lohan, The Revelator, published January 11, 2019.
- "New Estimate Finds Less Fresh Groundwater in U.S. Than Previously Assumed" by Brett Walton, Circle of Blue, December 13, 2018.
- "Arizona 360", Arizona Public Media, "Study: US Groundwater Supply Falls Short of Estimations." Aired December 7, 2018.
- KJZZ (91.5) NPR "The Show". Aired December 6, 2018.
- "US Groundwater in Peril: Potable Supply Less than Thought," Mark Ferguson/Mari Jensen. November 28, 2018. Covered in USA Today, Tunis Daily News (Tunisia) News, Morning Ag Clips, Sugar, MultiBriefs, WaterWorld, The Rural Blog, Pinal Central, AZ Big Media, ScienceDaily, NSF News.
- "121 salt water leaks from Sask. oil industry since start of 2017" by Alicia Bridges, CBC News. July 25, 2018.

- "Husky pipe leaks water used in oil production into river near Turtleford, Sask." CBC News, July 19, 2018.

Prairie Water (Spence)

- Pomeroy, J. (2019) $1M to develop climate change strategy helps quench thirst for long-term Prairie water management plan, Broadcast Interview. CBC News Saskatoon, March 2019.

Southern Forest Water Futures (Arain)

- Global News TV Interview to highlight relationship between recent flooding climate change on 15 May 2018. Program aired from coast to coast across Canada on the Global TV Network, via 13 television stations, reaching 98.9% of English-speaking audience in Canada.

Storms and Precipitation Across the continental Divide Experiment (SPADE) (Theriault)

- Thériault, J M (2018) Station météorologique UQAM, Capsule Météomedia

Transformative sensor Technologies and Smart Watersheds (TTSW) (Duguay)

- Pomeroy, J. Global Water Futures conference: Water problems seeking solutions, Broadcast Interview. Radio Canada International, June 2018.
- Pomeroy, J. National flood forecasting strategy, Broadcast Interview. News Talk 770 CHQR, May 2018.

WLU Technical Team (Munkittrick)

- Cabin Radio, Yellowknife, NT – May 2018. Radio interview and written article published on Cabin Radio's website about the Snare River and SAMMS projects (**J. Hickman**). https://cabinradio.ca/6621/news/environment/scientists-unlock-snowmelt-key-to-yellowknifes-hydro-supply/
- CBC, Yellowknife, NT – March 2019. **J. Hickman** interview with CBC reporter about Laurier and Ecology North collaborative Twitter Bot climate change project. https://www.cbc.ca/news/canada/north/yellowknife-climate-watch-twitter-bot-1.5068769
- The Narwhal, Yellowknife, NT - March 2019. **J. Hickman** video interview with reporter from the Narwhal discussing climate change in northern Canada. https://www.facebook.com/thenarwhalca/videos/273146166933183/UzpfSTUwNjA3MDc0MzoxMDE1ODI4ODQ0MDM5MDc0NA/

Workshops and Presentations

Agriculture Water Futures (Macrae)

- Liu, H., R. Brouwer. How Much Does Eutrophication Cost Canada In The Great Lakes Basin? Local Water Solutions in a Changing Climate Workshop, December 5, 2018.
- Pluer, W., Plach, J., Kompanizare, M., Carlow, R., Macrae, M., Brunke, R., & McKague, K. When and how does phosphorus runoff fields? *Poster Presentation.* Local Water Solutions in a Changing Climate. University of Waterloo workshop, Waterloo, ON. 5 December 2018.

- Plach, J.M., Macrae, M.L., Williams, M., Lee, B., and King, K. Dominant glacial landforms in the lower Great Lakes region exhibit differences in soil chemistry and potential risk of phosphorus loss. *Oral Presentation*. Global Water Futures: Annual General Meeting: June 3-6, 2018, Hamilton, Ontario, Canada.
- Grant, K.N., Macrae, M.L., Rezanezhad, F., Ali, G.A., Lam, W.V. Optimizing fertilizer placement to protect water quality. Poster Presentation. Local Water Solutions in a Changing Climate Workshop. December 5, 2018. Waterloo, Ontario, Canada.
- Mirnasl, N., P. Deadman, A. Frank, D. Robinson. "What is the impact of the spatial distribution of Beneficial Management Practices (BMPs) on Phosphorus loading?". Infographic poster. GWF Local Water Solutions Workshop - Wednesday, December 5, 2018.
- Frank, R. Brouwer, M. Macrae. "How cost-effective are phosphorus reduction actions?". Infographic poster. GWF Local Water Solutions Workshop - Wednesday, December 5, 2018.
- Marshall, M. and Macrae, M.L.. *Does Tillage Affect P Concentrations in Tile Drains Following Fall Manure Application?* Local Water Solutions in a Changing Climate Workshop, December 5, 2018.
- Price, D. and Macrae, M.L. *What is the impact of bunker silo effluent on riparian zone and stream health?* Local Water Solutions in a Changing Climate Workshop, December 5, 2018.
- S.M. Higgins, M. L. Macrae. Will soil release more phosphorus with climate change in winter. Poster presented at: Local water solutions in a changing climate; December 5, 2018; Waterloo, ON.
- Ji, X., Pinto, R., Brouwer, R., 2018. Where are the most cost-effective areas for BMPs in the Grand River watershed to help reduce phosphorus loadings? Workshop Local Water Solutions in a Changing Climate, University of Waterloo, 5th December, 2018.
- Macrae, M.L. The effects of hydroclimatic conditions on biogeochemical processes in natural and disturbed landscapes. Invited Seminar, Dept. of Earth Sciences, University of Western Ontario. Sept. 21, 2018.
- Macrae, M.L. The Edge of Field Monitoring of Hydrologic and Nutrient Losses from Ontario Croplands. Second Quebec-Ontario Controlled Drainage Workshop, June. 15, 2018
- Macrae, M.L. Presentation to farmers at the Soil Health and Cover Crop Field Day. "Edge-of-Field Research in Ontario: Can Cover Crops Affect Phosphorus Losses?", Dresden, Ontario, Sept. 14, 2018.
- Macrae., M.L. Field Site Tour and presentation to industry specialists at the 4R Nutrient Stewardship meeting, Apr. 25, 2018. St. Marys, Ontario
- Pomeroy J, (2018). The Great Thaw: The Crisis of Canada's Changing Waters. Royal Society of Canada's Celebration of Excellence and Engagement (COEE), Halifax, Canada, November 15, 2018. (presentation)
- Pomeroy J, (2018). Global Water Scarcity and Climate Change Concerns. Action Canada Fellowship: Study Tour, Saskatoon, Canada, September 9, 2018. (presentation)
- Pomeroy J, (2018). Global Water Futures: Researching water in a changing climate. Freshwater Alliance Webinar, Toronto, Canada, June 28, 2018. (presentation)
- Pomeroy JW, (2018). Saskatchewan Water Futures. University of Saskatchewan Provincial Tour, Swift Current, SK, June 13, 2018. (presentation)

- Macrae, M.L. (2018) Factors influencing P losses from cold-climate tile drained agricultural land and ongoing cross regional research under the *Agricultural Water Futures* project. AAFC Workshop., July 17, 2018.
- Pluer, W., Macrae, M.L., Plach, J., Kompanizare, M. (2019) Reducing Phosphorus Losses from Ontario Fields. Presentation to the Grain Farmers of Ontario district meeting, January 18, 2019.
- Plach, J., Macrae, M.L., (2018) Phosphorus Biogeochemistry in Soils of the Great Lakes Region. Presentation to the Grain Farmers of Ontario Research Team, August, 2018.
- Brouwer, R. Guest lecture on the Economics of Sustainable Water Management. 5th GLOBAQUA Training Course, University of Athens, Greece.
- Brouwer, R. Guest lecture on the Economic Value of Water. Université de Laval, Quebec, Canada.
- Mirnasl S., P. Deadman, A. Frank, D. Robinson. 2018. What is the impact of the spatial distribution of Beneficial Management Practices (BMPs) on phosphorous loading? GWF – Local Water Solutions in a Changing Climate, Waterloo, Ontario, Dec 5, 2018

Boreal Water Futures (Waddington)

- Carey SK. Water and Canada's extractive industries: challenges and opportunities. Public talk to United Nations University – INWEH another Drop lecture. October 2018.
- Robinne FN. Wildfires and soil hydrology. IUFRO - World Bank Global Fire Workshop. Vienne, Austria, July 2018.
- McKnight, B, Newell, S. and Waddington, JM. Presented in a panel on Water Day at McMaster to an interdisciplinary group of students and faculty. March 22nd, 2019
- Doubleday presented an invited paper on collaborative water governance and rural and remote communities, delivered at McMaster as WATER/Health Interactions in the Arctic. McMaster Conference on Water: International Threats. West Room, University Club, November 5, 2018. Convened by Drs. Velma Grover & G. Kranzberg.
- Pomeroy J, (2018). The Great Thaw: The Crisis of Canada's Changing Waters. Royal Society of Canada's Celebration of Excellence and Engagement (COEE), Halifax, Canada, November 15, 2018
- Pomeroy J, (2018). Global Water Scarcity and Climate Change Concerns. Action Canada Fellowship: Study Tour, Saskatoon, Canada, September 9, 2018
- Pomeroy J, (2018). Global Water Futures: Researching water in a changing climate. Freshwater Alliance Webinar, Toronto, Canada, June 28, 2018
- Pomeroy JW, (2018). Saskatchewan Water Futures. University of Saskatchewan Provincial Tour, Swift Current, SK, June 13, 2018

Indigenous Water Tools (Martin-Hill)

- First Nations Water Security and Climate Change Symposium – 3 June 2018, Gathering Place, Six Nations Territory
    - Poster, agenda attached (Appendix D)
- Digital water stories workshop – August 2018
    - McMaster student training

- McMaster Ohneka (Water) Week – 23 November 2018
- Workshop: "Indigenous Knowledge and Sustainability Agenda", McMaster University – November 2018
    - Organized by Governance Team, with the UNU-INWEH and McMaster's Department of Peace Studies
- Workshop with University of Toronto & Kawenni:io Private School – 26 November 2018
- United Nations Day of Women and Girls in Science colloquium – 11 February 2019
    - Organized by Governance Team, with the UNU-INWEH and McMaster's Department of Peace Studies
    - Event poster attached (Appendix D)
- Digital water stories workshop – March 2019
    - Denise McQueen, Makasa Looking Horse led training with KGPS students (ages 12-17)

Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins (IMPC) (Razavi)

- Brouwer R. (2018), Guest lecture, Economics of Sustainable Water Management, 5th GLOBAQUA Training Course, University of Athens, Greece.
- Brouwer R. (2018), Guest lecture, Economic Value of Water, Summer school Université de Laval, Quebec, Canada.
- Haghnegahdar A., (2018) VARS-TOOL: A toolbox for Sensitivity and Uncertainty Analysis, School of Civil Engineering, Shiraz University, Shiraz, Iran, September 1st, 2018
- Jardine T.D., and Carriere S., (2018), Understanding, managing and preserving the Saskatchewan River Delta. Northumberland Learning Connection Speaker Series, April 19, Cobourg, ON.
- Jardine T.D., and Carriere S., (2018), Do rivers need floods? Northumberland Learning Connection Speaker Series, April 20, Port Hope, ON.
- Pomeroy J. (Chair), (2018), Fourth Annual International Network for Alpine Research Catchment Hydrology (INARCH) Workshop, October 2018
- Pomeroy J. (Co-convener), (2018), The Mountain Water Cycle Session, 8th Global Energy and Water Exchanges (GEWEX) Open Science Conference: Extremes and Water on the Edge, Canmore, Canada, May 2018
- Pomeroy J., (2018), The Great Thaw: The Crisis of Canada's Changing Waters. Royal Society of Canada's Celebration of Excellence and Engagement (COEE), Halifax, Canada, November 15, 2018
- Pomeroy J., (2018), Global Water Scarcity and Climate Change Concerns. Action Canada Fellowship: Study Tour, Saskatoon, Canada, September 9, 2018
- Pomeroy J., (2018), Global Water Futures: Researching water in a changing climate. Freshwater Alliance Webinar, Toronto, Canada, June 28, 2018
- Pomeroy J., (2018), Saskatchewan Water Futures. University of Saskatchewan Provincial Tour, Swift Current, SK, June 13, 2018

- Pomeroy J., (2018), Global Water Futures, Climate Change and Water Science for the Canadian Rockies and Beyond. Let's Talk Climate and Water Science, Canmore, Canada, May 5, 2018

Lake Futures (Basu)

- Babaran, D. (2018). The adoption of VEC monitoring and multivariate analyses on the Blair Creek Sub-watershed as a model for CEA. Grand River Conservation Authority – Lunch and Learn. 20 April 2018, GRCA Headquarters. Invited platform presentation.
- Basu, N.B (2018) was an invited participant in the Canadian Water Network (CWN) organized workshop on "Assessing the Adequacy of Urban Nutrient Load Mesaurements" attended by multiple user and stakeholder groups including ECCC, GRCA, TRCA, MECP, Conservation Halton, Toronto Water, City of Windsor, Region of Waterloo, and Regional Municipality of Durham.
- Basu, N.B. (2018) was an invited participant and a lead-off speaker in the Michigan Drinking Water Workshop organized by the Michigan Environmental Council. December 6, 2018, University of Michigan – Ann Arbor campus.
- Basu, N.B., Macrae, M., Van Meter, K.J., Rezanezhad, F., and Parsons, C. (2018). Local Water Solutions in a Changing Climate. Dec 5th, 2018. Stakeholder engagement workshop with panel discussion, infographic poster session and roundtables organized by University of Waterloo with multiple GWF projects and their stakeholders. There were 14 Lake Futures related infographic poster presentations.
- Basu, N.B., Norris, M., and Goucher, N. Lake Futures: Enhancing adaptive capacity and resilience of lakes and their watersheds. [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.
- Bocaniov, S. and Ives, J. (2019). Invited participants in a fuzzy cognitive mapping workshop: "Updating our collective understanding of Lake Erie eutrophication". This workshop was jointly sponsored by Global Water Futures (GWF)–Lake Futures (LF) through the University of Waterloo and the Lake Erie Millennium Network (LEMN; University of Windsor); March 12-13, 2019, University of Windsor, Windsor, Ontario.
- Bocaniov, S., Markelov, I., Kheyrollah Pour, H., Dove, A., Backus, S., and Van Cappellen, P. (2018). Basin-specific, phosphorus (P) mass balance approach for understanding re-eutrophication issues in Lake Erie: Preliminary results. [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.
- Brouwer, R. Guest lecture Economics of Sustainable Water Management, 5th GLOBAQUA Training Course, University of Athens, Greece.
- Brouwer, R. Guest lecture Economic Value of Water, Summer school Université de Laval, Quebec, Canada.
- Chowdhury, S. and Basu, N.B. (2018). How are intensive agriculture and rapid urbanization impacting nutrient loading across the Great Lakes Basin? [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.

- Dhiyebi, H. and Servos, M. (2018). Cumulative Effects in the Mill Creek Sub-watershed. Friends of Mill Creek (FOMC), April 18, 2018. FOMC includes representatives from industry, local government, OMNRF, GRCA and public.
- Han, M., Tolson, B., and Basu, N.B. (2018). Including Missing Lakes in Our Model: A flexible catchment-based lake and river routing product for hydrologic and land surface models in Canada. [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.
- Ho, E. (2018). The Sustainable Development Goals. Big IDEA presentation, IDEAS summer program for international youth, University of Waterloo, Waterloo, Ontario. July 15, 2018.
- Ho, E. (2018). Plastics in the Region of Waterloo: What is the problem and what can we do? Plastics in Waterloo Region and Albatross film screening, University of Waterloo, Waterloo, Ontario, July 25, 2018. Elaine organized this public/community event to raise awareness of microplastics in the aquatic environment
- Ho, E. (2018). Creating opportunities to affect change. Lecture to class of ERS 101 – Issue Analysis and Problem Solving for Environmental Studies 2, University of Waterloo, March 20, 2018. Guest lecture: Short lecture to first year environmental studies students regarding strategies to effect (environmental) change
- Ho, E. (2018). Case Study: Riverside Dam [Part 1] and Identifying and refining VECs and indicators [Part 2]. Lecture to class of ERS 215 – Environmental and Sustainability Assessment, University of Waterloo, May 28, 2018. Guest lecture:1-hour lecture to mixed class (required for engineering students and those pursuing Environmental Assessment Diploma) providing a local example of how different the implementation of environmental assessment can be from its theory, and then discussing how project impacts are measured/assessed.
- Ho, E. (2018). Natural Resource Management – A Water Spotlight. Lecture to class of ERS 202 – Natural Resource Ecology, University of Waterloo, October 30, 2018. Guest lecture: 1-hour lecture to second year environmental studies students providing an introduction to resource management in Ontario, focusing on water.
- Ho, E. (2018). Sustainable business: Backcasting and forward thinking. Lecture to class of ENBUS 407 – Corporate Sustainability Accounting and Reporting, University of Waterloo, November 15, 2018. Guest lecture: 1-hour lecture to fourth-year Environment and Business students on how businesses can evaluate corporate sustainability and what types of measures/indicators are meaningful.
- Ho, E. (2018) represented SDG 6 (Sustainable Development Goal 6 – 'clean water and sanitation for all') and University of Waterloo at the launch of the Sustainable Development Solutions Network Canada on May 7, 2018. She presented a short narrative on SDG 6 on stage at the event and discussed water with guests at the reception.
- Ho, E. (2018). Represented Women's Major Group during the opening plenary of the 2018 High-level Political Forum at United Nations Headquarters on July 9, 2018. Participated in Women's Major Group coordination of clothing colors to support SDG 6. Presented an intervention on accountability during a side event co-organized by civil society ('Major Groups and Other Stakeholders') and the United Nations Department of Economic and Social Affairs.

- Ho, E. (2018). Accountability and improving MGoS participation in SDG implementation. Intervention at Stakeholder Engagement in the High-Level Political Forum and its review in 2019, a Side Event of the 2018 High-level Political Forum organized by United Nations Department of Economic and Social Affairs and the Major Groups and Other Stakeholders, United Nations Headquarters, New York City, New York, July 9, 2018.1,2,3
- Ho, E., Courtenay, S., and Trant, A. (2018). Comparative review of freshwater monitoring approaches towards consideration of cumulative effects. [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.
- Ho, E., Trant, A., Servos, M., Basu, N.B. and Courtenay, S. (2018). Rethinking the framework: consideration of cumulative effects in (bio)monitoring in the lower Grand River and nearshore Lake Erie. Grand River Fisheries Management Plan Implementation Committee Meeting, Invited platform presentation, Grand River Conservation Authority Headquarters, Cambridge ON. May 2, 2018.
- Ives, J. and Rooney, R. (2018). Can we work together to identify knowledge gaps around eutrophication in Lake Erie? [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.
- Jawed, Z. (2018). Guest Speaker (Invited), Great Lakes-Save your Drinking Water, Guy B. Brown School, Hamilton, April 20, 2018.
- Jawed, Z. (2018). Guest Speaker (Invited), Nutrient Changes in the Great Lakes: Addressing Algae Blooms and Biodiversity in an Era of Climate Change, MacMaster, Hamilton, Oct 2018.
- Jawed, Z. (March 2018), Use of Decision Support Tools to address Emerging Issues in the Great Lakes, Talk presented to Graduate students taking SEP 709 Course
- Jawed, Z. (September 2018), Use of Decision Support Tools to address issues in the Great Lakes in an Era of Global and Climate Change, Talk presented to Graduate students taking SEP 709 Course
- Jawed, Z. (November 2018), Identifying Gaps and Opportunities from Treatment to Source Water: Policy, Design and Climate Change: Water, an Interdisciplinary Issue requires an interdisciplinary Approach. Talk presented to Interface members and open to all faculty across McMaster University
- Jawed, Z. (October 2018), Sustainability in Urban Development and Impacts on Water Resources, Talk presented to 4th year Biology students who are studying behaviour/restoration/global ecology
- Jawed, Z and Krantzberg, G. (2018). How can we make the results of Lake Futures accessible to decision-makers? [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.
- Krantzberg, G. (2018). Making decision in the face of uncertainty. Policy-science dilemmas. Invited presentation to Canada Centre for Inland Waters, Burlington, ON, November 2018.

- Liu, H., and Brouwer, R. (2018). How Much Does Eutrophication Cost Canada in the Great Lakes Basin? [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.
- Liu, J., and Basu, N.B. (2018). Can We Optimize Placement of Best Management Practices to Accelerate Water Quality Improvement under Nutrient Legacy? [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.
- Quinn-Austin, H., Servos, M. and Rooney, R. (2018). How does habitat degradation impact walleye in the southern Grand River? [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.
- Runnals, J. [Moderator], Biggs, M., Ho, E., Healy, B., and Weinlick, B. [Panelists]. (2018). Generation SDG Blueprint Launch. Panel at Together 2018: Collaboration, Innovation, and the Sustainable Development Goals. Edmonton, Alberta, November 5,
- 2018. Recording of the panel:
    - https://www.youtube.com/watch?v=M7OeGl6zxso&t=8960s (starts at 2:01:40)
    - Rutherford, H., Ho, E., and Pearce, K. [Panelists]. (2018). Catalyzing Collective Action: What the United Nations Sustainable Development Goals mean for the Region of Waterloo [panel discussion]. Speaker Showcase at The Eco Market Fall Showcase, Waterloo, Ontario, October 26, 2018.
    - Samson, M., Van Meter, K.J., and Basu, N.B. (2018). How Does the Urban Area Influence the Flow of Nitrogen and Phosphorus to the Lake? Case Study: The Greater Toronto Area. [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.
    - Thompson, J., Kheyrollah Pour, H., Bocaniov, S., Markelov, I., and Van Cappellen P. (2018). How might machine learning methods inform climate change impacts in our Great Lakes. [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.
    - Van Staden, T., Van Cappellen, and Basu, N.B. (2018). Where has legacy phosphorus accumulated? [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.
    - Van Meter, K.J. and Basu, N.B. (2018). Beyond the Mass Balance: Can we meet the 40% Phosphorus reduction goals in the Grand River Watershed? [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.
    - Yang, X., and Insley, M. (2018). How much fertilizer should farmer use under uncertainty? [infographic poster]. Global Water Futures stakeholder meeting, Local Water Solutions in a Changing Climate Workshop, December 5, 2018, Waterloo, Ontario.

Linking Stream Networks (MacVicar)

- Mulholland, D., (2019) Progress towards use of the Flowing Waters Information System (FWIS)Stream power modelling of urban impacts on stream systems, Southern Ontario Stream Monitoring and Research Team (SOSMART), Vineland, Ontario, Hosted by Credit Valley Conservation.
- Ghunowa, K., B.J. MacVicar (2018) Stream power modelling of urban impacts on stream systems, Southern Ontario Stream Monitoring and Research Team (SOSMART), Mississauga ON, Hosted by Credit Valley Conservation.
- Papangelakis, E., B.J. MacVicar (2018) Linking urban hydromodification to bedload sediment transport, Southern Ontario Stream Monitoring and Research Team (SOSMART), Mississauga ON, Hosted by Credit Valley Conservation.

Linking Water Governance in Canada to Global Economic, Social and Political Drivers (de Loe)

- Session Co-Chair (Matt Vijayan, University of Calgary), Municipal Wastewater Effluent Impact on Fish Physiology, 13th International Congress on the Biology of Fish, Calgary, Alberta, July 15-19, 2018.
- Servos, M. Workshop Chair, Wastewater Treatment Plant Upgrades in the Grand River. Region of Waterloo, Cambridge, Ontario, Feb. 14, 2018. Workshop with stakeholders to review the studies documenting the effects of wastewater upgrades.
- The Grand River Fisheries Management Plan Implementation Committee (GRFMPIC) meets regularly to discuss environmental issue impacting fish population (including wastewater upgrades and chemical contamination). Mark Servos has been an active member of the Committee (GRFMPIC) for many years. The GRFMPIC received the 2018 Grand River Watershed Award in recognition of continued partnerships and work towards managing the Grand River to realize the potential of the waters and fisheries in the communities throughout the Grand River watershed

Matawa Water Futures (Mitchell)

- Presentations & Workshop: Matawa Environment Gathering, December 11-13, 2018
- Workshop: Community Based Monitoring Workshop, January 29-30, 2019
- Presentation: Lakehead University Biology Seminar Series, March 8, 2019
    - Title: Bridging the gap: building environmental monitoring & research capacity within Matawa member First Nations

Mountain Water Futures (Carey)

- Pomeroy. Chair, Fourth Annual International Network for Alpine Research Catchment Hydrology (INARCH) Workshop, October 2018
- Pomeroy. Co-convener, The Mountain Water Cycle Session, 8th Global Energy and Water Exchanges (GEWEX) Open Science Conference: Extremes and Water on the Edge, Canmore, Canada, May 2018
- Presentation – Pomeroy J, (2018). The Great Thaw: The Crisis of Canada's Changing Waters. Royal Society of Canada's Celebration of Excellence and Engagement (COEE), Halifax, Canada, November 15, 2018

- Presentation – Pomeroy J, (2018). Global Water Scarcity and Climate Change Concerns. Action Canada Fellowship: Study Tour, Saskatoon, Canada, September 9, 2018
- Presentation – Pomeroy J, (2018). Global Water Futures: Researching water in a changing climate. Freshwater Alliance Webinar, Toronto, Canada, June 28, 2018
- Presentation – Pomeroy JW, (2018). Saskatchewan Water Futures. University of Saskatchewan Provincial Tour, Swift Current, SK, June 13, 2018
- Presentation – Pomeroy J, (2018). Global Water Futures, Climate Change and Water Science for the Canadian Rockies and Beyond. Let's Talk Climate and Water Science, Canmore, Canada, May 5, 2018
- Workshop – Petrone. Overview of MWF program. Bow River Basin Council. March 2019
- Presentation – Westbrook C, Streich S. Annual meeting of Canadian Water Resources Association, May 28, 2018.
- Discussion – Westbrook C. Roberta Bondar Conservation Foundation. March 2019.
- Presentation – Hayashi M. Alpine hydrogeology: the critical role of groundwater in sustaining the headwaters of the world. Canmore Museum. November 2018.

Northern Water Futures (Baltzer)

- J. Hickman, M. English. Talks given to Grade 9/10 students at John Franklin High School, Yellowknife about research in the Snare River basin Winter 2018
- Ratelle M*, Laird BD. (2018) Return of Results in Sambaa K'e: Community Results Forum. Sambaa K'e, Northwest Territories (Community Presentation).
- Ratelle M*, Laird BD. (2018) Return of Results in K'asho Got'ine: Community Results Forum. K'asho Got'ine, Northwest Territories (Community Presentation)
- Ratelle M*, Laird BD, Skinner K. (2018) Return of Results in Tulit'a: Community Results Forum. Tulit'a, Canada (Community Presentation)
- Hall RI and BB Wolfe. 2018. University-based research program in the PAD since 2000. Presentation to Wood Buffalo National Park staff, Fort Chipewyan.
- A Spring. NWT Association of Communities Climate Change conference and Charrette. Explorer Hotel, Yellowknife, NT, Oct 29-31, 2018.
- A Spring. Hotì ts'eeda Ełèts'ehdèe, Aurora Village, Yellowknife NT. May 22 – 24, 2018.
- A Spring. NWT Fire Research Workshop, Explorer Hotel, Yellowknife, NT. Feb 5-7, 2019

Prairie Drainage Governance (Loring)

- Loring, P., Gaspard, V, & Minnes, S. (2019). *Stoking Conflict Between Farming and Conservation Hurts Everyone*. THE CONVERSATION: https://theconversation.com/stoking-conflict-between-farming-and-conservation-hurts-everyone-109778

Prairie Water (Spence)

- Thapa, A., Mora, M.F., Duffy, A. (2018) Chief and Council Meeting, Mistawasis Nehiyawak (August 28, 2018)
- Thapa, A., Mora, M.F. (2019) Co-development of Mistawasis water governance framework with members of the community. Mistawasis Nehiyawak. (March 14, 2019)

- Thapa, A., Mora, M.F. (2019) Community Workshop: Creating Dialogue for Flood preparedness (research), Mistawasis Nehiyawak. (March 21, 2019)
- Prairie Water 2nd Annual Partners Meeting (2019) Holiday Express Inn & Suites, Saskatoon, SK (Jan. 24-25, 2019)
- Minnes, S, and Gaspard, G. Prairie Drainage Governance Stakeholder Introduction Meeting – joint meeting. Holiday Express Inn & Suites, Saskatoon, Saskatchewan. (Jan. 25, 2019)

Sensor and Sensing Systems for Water Quality Monitoring (Selvaganapathy)

- Real-time Water Quality Monitoring Workshop, Nov 7-8 2018, St. John's Newfoundland.

Southern Forest Water Futures (Arain)

- A special session was offered at the Canadian Geophysical Union Meeting (CGU) in Niagara Falls from 11-14 June, 2018.
    - Session Title: Impacts of Forest Disturbances and Climate Change on Watershed Hydrology and Biogeochemistry (CGU Session H-04).
    - Conveners: Qiang Li, M. Altaf Arain, Michael Pisaric and Fan-Rui Meng.
    - Session description: In forested watersheds, changes in forest cover due to natural and anthropogenic disturbances such as wildfire, insect infestation, thinning, harvesting, planting, and urbanization are considered as the most important drivers for biogeochemical and hydrological processes. Future climate change and extreme events such as droughts, flooding and heatwaves are also expected to exert major influences on forest ecosystems through altering rates of growth, evapotranspiration, runoff, catchment-scale water balance, soil-plant nutrient cycling and associated feedbacks. Understanding how these drivers influence forest growth and hydrological processes are pivotal for sustainable management of forest ecosystems and water resources. This session focuses on the effects of natural and anthropogenic disturbances and land cover change on biogeochemical and hydrological cycles in forested watersheds. We encourage submissions that employ field observation, statistical analysis, and hydrological and ecosystem modelling. We welcome contributions from researchers involved in large network projects such as Global Water Futures Program (GWF). All accepted abstracts will have the opportunity to submit a research paper in a special issue in Forests (http://www.mdpi.com/journal/forests/special_issues/Hydrology_Watershed).

Storms and Precipitation Across the continental Divide Experiment (SPADE) (Theriault)

- Presentation - Pomeroy J W, (2018). The Great Thaw: The Crisis of Canada's Changing Waters. Royal Society of Canada's Celebration of Excellence and Engagement (COEE), Halifax, Canada, November 15, 2018
- Presentation - Pomeroy J W, (2018). Global Water Scarcity and Climate Change Concerns. Action Canada Fellowship: Study Tour, Saskatoon, Canada, September 9, 2018
- Presentation - Pomeroy J W, (2018). Global Water Futures: Researching water in a changing climate. Freshwater Alliance Webinar, Toronto, Canada, June 28, 2018

- Presentation - Pomeroy J W, (2018). Saskatchewan Water Futures. University of Saskatchewan Provincial Tour, Swift Current, SK, June 13, 2018

Transformative sensor Technologies and Smart Watersheds (TTSW) (Duguay)

- Presentation - Pomeroy J, (2018). The Great Thaw: The Crisis of Canada's Changing Waters. Royal Society of Canada's Celebration of Excellence and Engagement (COEE), Halifax, Canada, November 15, 2018
- Presentation - Pomeroy J, (2018). Global Water Scarcity and Climate Change Concerns. Action Canada Fellowship: Study Tour, Saskatoon, Canada, September 9, 2018
- Presentation - Pomeroy J, (2018). Global Water Futures: Researching water in a changing climate. Freshwater Alliance Webinar, Toronto, Canada, June 28, 2018
- Presentation - Pomeroy JW, (2018). Saskatchewan Water Futures. University of Saskatchewan Provincial Tour, Swift Current, SK, June 13, 2018

Winter Soil Processes (F. Rezanezhad)

- On December 5, 2018, the Water Institute at the University of Waterloo hosted a workshop called *"Local Water Solutions in a Changing Climate"* to showcase research from five University of Waterloo projects including the GWF Winter Soil Processes in Transition project with external stakeholders and practitioners. The workshop was designed to be an engagement opportunity to ensure the knowledge produced at UW is actively used to inform decision-making and help transform the way communities and governments prepare for and manage increasing water-related threats. The day began with short presentations from either the PI or co-PI of each project, followed by a self-guided tour of the HQP research presented through infographics in poster format. The final session included discussion roundtables where practitioners were asked to lead a conversation about how their work relates to the research presented and how to ensure research is being incorporated into decision-making. Infographic posters were created for each of the 5 projects. These were designed by Creative Services. Two infographic posters presented in this stakeholder workshop to this project are attached to this report.

WLU Technical Team (Munkittrick)

- Marian Water Stewardship Program, Annual Results Workshop – March 11, 2019. J. Hickman Invited to present water quality and sediment results
- Design of Monitoring programs (4 hr) and Designing Adaptive monitoring programs (4 hr); K. Munkittrick, Canadian Rivers Institute and UNB, Fredericton, NB (Aug 17, 2018; 45 students), Vale Living with Lakes Centre, Laurentian University, Sudbury, ON (Sept 4, 2018; 40 students), as well as a shortened overview course to the Matawa First Nations, Thunder Bay, ON (May 10, 2018; 8 participants).
- 2018 Water Stewardship Strategy Meetings, held by GNWT, ENR – Dettah, NT, October 24-25. J. Hickman invited to participate on the 'Documenting and sharing water knowledge' panel and lead a discussion group highlighting WLU water research
- Canadian Permafrost Association Annual Business Meeting: A. Rudy presented as a member of the Board of Directors (Communication Director). More details can be found at Canadianpermafrostassociation.ca.

- Rudy organized and ran the official launch of Frozen Ground Cartoons at ArcticNet in December 2017. Frozen Ground Cartoons is an outreach project run by a collaboration of artists and permafrost scientists to make permafrost science accessible to the public. Frozengroundcartoon.com

- R. Connon helped organize and lead an Indigenous Community Workshop at Scotty Creek, June 4, 2018. Community members from Fort Simpson and Sambaa K'e flew into Scotty Creek for a tour of the research station and a two-way knowledge exchange on how permafrost thaw is changing the landscape

Promotional Videos

Global Water Futures

- E.B. Campbell Dam Research Site - Saskatchewan River Basin - https://youtu.be/wlcLB0nQw8g (views: 1443)
- Forecasting Extreme Weather Events - https://youtu.be/Z5vOuOS5Jro (views: 544)
- Mine Overlay Site Testing Facility - https://youtu.be/AlxweoN7erQ (views: 404)
- Modelling Water Sediment - https://youtu.be/Rdf8a-lgZfc (views: 109)
- Water Promotional - https://youtu.be/nFzThcezqyo (views: 415)
- Global Institute for Water Security - https://youtu.be/OVv9r6t03PQ (views: 5621)
- Global Water Futures - McMaster University https://www.youtube.com/watch?v=XhsJh-XBYtw (views: 116)
- Global Water Futures - University of Waterloo https://www.youtube.com/watch?v=Gv48cBojjIA (views: 95)
- Global Water Futures - Working together to prepare for the future of our water https://www.youtube.com/watch?v=xe0w7jkJ5bA (views: 393)
- Global Water Futures Inaugural Annual Science Meeting - https://www.youtube.com/watch?v=4LFxR2D--rA&list=PLinkRWs1GlTdChnl50ffSYFzVwSROjtES (views: 441)
- Brightwater Creek Watershed Site - Saskatchewan River Basin https://youtu.be/K8DWZGVnNwQ (views: 311)
- Boreal Forest Research Site - Saskatchewan River Basin https://youtu.be/0I9TX97GBsg (views: 1099)
- Integrated Modelling and Management of Watershed Systems - https://youtu.be/6dzOSQBXOOU (views: 1446)
- Lake Diefenbaker Research Site - Saskatchewan River Basin https://youtu.be/cZ1xfBG_Dbk (views: 887)
- Modelling Riverine Processes - Global Institute for Water Security https://youtu.be/b7o5MVE4wI4 (views: 310)
- Prairie Hydrology - Global Institute for Water Security https://youtu.be/Atm9JR1fYcg (views: 734)
- Socio-hydrology - Human Dimensions of Water Science in the Saskatchewan River Basin - https://youtu.be/e8DmQLuPqvA (views: 1089)

- St. Denis National Wildlife Area - Saskatchewan River Basin https://youtu.be/1sfTyNj4ZJM (views: 862)
- Swift Current Research Site - Saskatchewan River Basin https://youtu.be/i-GY5ImUpY0 (views: 1074)
- Toxicology: Urban Municipal Drainage - Global Institute for Water Security https://youtu.be/lWH_QEttTsg (views: 882)
- Toxicology: Water Quality - Global Institute for Water Security - https://youtu.be/tdBNdTQ9a6M (views: 670)

Agricultural Water Futures (AWF): Stressors and Solutions (Macrae)

- "Agricultural Water Futures in Canada: Stressors and Solutions". July-Aug 2018. Produced by the Water Institute, University of Waterloo. Video Link: https://www.youtube.com/watch?v=H14CSYno1xQ (Views: 130)

Boreal Water Futures (Waddington)

- Pelican Mountain Fuel Treatment Study. https://drive.google.com/open?id=1mjMO5pb4EwJ6ZabSNW9auCvRSTj1tjE0

Climate-Related Precipitation Extremes (Stewart)

- Thériault, Julie (2019) Les audacieuses, Le centre des sciences de Montréal. https://tv.uqam.ca/julie-theriault-portrait-dune-femme-inspirante (views: 276)

FORMBLOOM (Baulch)

- Buffalo Pound Lake Research Site - Saskatchewan River Basin https://youtu.be/v4o9zABsne0 (views: 1412)

Lake Futures (Basu)

- Basu, N.B. (2018). Biogeochemical Hotspots: Role of Small Water Bodies in Watershed Nutrient Processing, Webinar on Wetlands: From Science to Action organized by Canadian Freshwater Alliance, September 25, 2018 (https://www.freshwateralliance.ca/fresh_ideas_wetlands)
- Krantzberg, G. (2018). Canadian Science Policy Conference 2018, Interview with Gail Krantzberg, December 2018 (https://www.eng.mcmaster.ca/sept/news/canadian-science-policy conference).
- Lake Futures: Enhancing adaptive Capacity and resilience of lakes and their watersheds. Video about research project, produced by The Water Institute, 2018. (https://www.youtube.com/watch?v=-eb5mEnCvlE)
- Van Cappellen P. (2018). Canadian Science Policy Conference 2018, Interview with Philippe Van Cappellen, December 2018 (https://uwaterloo.ca/ecohydrology/news/ecohydrology-researchers-participate-10th-canadian-science)

Mountain Water Futures (Carey)

- Changing Cold Regions Network Documentary http://www.ccrnetwork.ca/outputs/informationproducts/index.php#documentary (views: 1375)
- Canadian Rockies Hydrological Observatory - Saskatchewan River Basin https://youtu.be/MVeVZxiiHJA (views: 549)
- Caroline Aubry-Wake. 2019. https://www.youtube.com/watch?v=TmE-2q75DXk

Northern Water Futures

- Rachel Henderson. Isn't it IRONic. Finalist in NSERC's Science, Action Video Contest https://www.youtube.com/watch?v=uzQmNvlRihU (views: 825)
- Laurier and Global Water Futures https://www.youtube.com/watch?v=dZvQEOTUWj8v (views: 108)
- Short promotional video on Laurier Northern Research: https://www.instagram.com/wilfridlaurieruni/p/Bv2LcSMgvUC/ (views: 2280)
- Baltzer Royal Society Induction video: https://www.youtube.com/watch?v=PT15kZntDgc (views: 34)
- Promotional video on Laurier Northern Researchers: https://www.youtube.com/watch?v=PcvxZpi_wQ (views: 34)

Omic' and chemical fingerprinting methodologies using ultrahigh-resolution mass spectrometry for geochemistry and healthy waters (Jones)

- Thermo Scientific, Applications Video on uses and advantages of the QE-GC system.

Prairie Water (Spence)

- http://artsandscience.usask.ca/news/articles/1340/_Becoming_Water_Art_and_Science_in_Conversation_available_fo

Southern Forest Water Futures (Arain)

- Hosted the iClimate Video Competition http://www.iclimatemac.ca/) which is designed to exhibit and highlight the environmental-related research at McMaster. Submissions were made individual graduate students or in groups. 2-3 minute videos were created by signing out and using our GoPro cameras. Final videos were judged by SFWF personnel for top prize of $250 or GoPro camera.

Storms and Precipitation Across the continental Divide Experiment (SPADE) (Theriault)

- Thériault, Julie (2019) Les audacieuses, Le centre des sciences de Montréal. https://tv.uqam.ca/julie-theriault-portrait-dune-femme-inspirante

Transformative sensor Technologies and Smart Watersheds (TTSW) (Duguay)

- Transformative Sensor Technologies and Smart Watersheds - Project video created by The Water Institute. https://www.youtube.com/watch?v=HZ9tY2EX3XE (views: 223)

Other

Agent Based Modelling (Bharadwaj)

- One page factsheets to communities were prepared and presented to explain the proposed project and introduce the research team.

FIShNET (Fish & IndigenouS NorthErn healTh): Healthy Water, Healthy Fish, Healthy People (Skinner)

- Water Institute News, University of Waterloo. (January 28, 2019). Waterloo Researchers Work with Indigenous Partners to Determine How Safe The Fish in Their Communities Are to Eat. https://uwaterloo.ca/water-institute/news

Lake Futures (Basu)

- Brouwer, R. and Pinto, R. (2018). Review and Evaluation of the Canadian Water Quality Valuation Model (WQVM 1.0). Report to Environment and Climate Change Canada. 88 pages.
- Dhiyebi, H. and M. Servos. 2018. Cumulative effects in the Mill Creek subwatershed. Report prepared for Friends of Mill Creek (FOMC). 49 p.
- Ives, J., Ciborowski, J., and Rooney, R. (2018) An Approach for Linking Watershed-based Drivers and Indicators of Eutrophication in Lake Erie: Fuzzy Cognitive Mapping [Fact sheet]. Retrieved from https://uwaterloo.ca/lake-futures/

Mountain Water Futures (Carey)

- MWF Newsletter. February 2019
- Ongoing maintenance of MWF Twitter (@MWFutures), Instagram (mwfutures), and website (www.mountainwaterfutures.ca)
- Community engagement – De Jong T, Barrett D. Whitehorse Montessori visit with hydrological activities. March 2019.

Transformative sensor Technologies and Smart Watersheds (TTSW) (Duguay)

- "University of Waterloo Research at Sunfish Lake" Flyer distributed to Sunfish Lake, ON Cottagers

GLOBAL WATER FUTURES

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Kananaskis Valley
Photo Courtesy: Alistair Wallace, Manager, Smart Water Systems Laboratory