Environment and Climate Change Canada
Environnement et Changement climatique Canada

2019

LAKE WINNIPEG BASIN PROGRAM SYMPOSIUM

Summary Report

Canada

PREAMBLE

Environment and Climate Change Canada (ECCC) held a Lake Winnipeg Basin Program Symposium on March 20th and 21st, 2019 in Winnipeg, Manitoba in conjunction with a number of other Lake Winnipeg-related events during Canada Water Week, including the Lake Winnipeg Research Consortium's annual Science Workshop and the launch of "Lake Winnipeg DataStream" by the Gordon Foundation. Together, the week provided the space to share new knowledge derived from scientific studies conducted on the lake and in the basin, showcase on-the-ground actions on nutrient reduction, and highlight the important collaborative partnerships that are required to address the complex issues related to water quality and quantity, including climate change. Approximately 100 stakeholders attended each day of the Symposium representing government and non-governmental organizations (NGOs), scientists, Indigenous governments, organizations and communities and regional conservation districts.

Nadine Stiller, Associate Regional Director General, West and North, ECCC, launched the Symposium by acknowledging the event was being held on Treaty 1 Territory and the traditional homeland of the Métis Nation. First Nation Elder John Letandre provided an opening prayer and his daughter Freedom sang the Bear song, signifying courage and the need to do the right thing. Métis Elder Linda St. Cyr-Saric also shared an opening prayer. The Honourable Catherine McKenna, Minister of Environment and Climate Change Canada and Terry Duguid, Member of Parliament (Winnipeg South), welcomed participants via video and acknowledged the importance of the health of Lake Winnipeg.

Five sessions comprised the Symposium agenda (Appendix A). Day 1 focused largely on what we have learned from the ongoing lake and watershed science, followed by a poster session that allowed a deeper dialogue between participants and the science community. Day 2 focused on transboundary collaboration, community-based monitoring, collaboration in the basin, and action-oriented projects on nutrient reduction that are underway in the basin. There were opportunities to ask questions after each presentation and network between sessions.

This event was a celebration of sorts—a celebration in recognition of progress made toward reducing nutrient inputs to Lake Winnipeg, and of the need and willingness to work together in collaborative partnerships, including transboundary, and through reconciliation, to more effectively address issues of water quality throughout the Lake Winnipeg Basin.

To close the Symposium, First Nation Elder John Letandre sang a song of gratitude—gratitude to the Creator; to the Bear, a symbol of courage; and to the Eagle, a symbol of love. Métis Elder Linda St. Cyr-Saric closed the Symposium with a prayer.

TABLE OF CONTENTS

LIST OF ACRONYMS

AAFC	Agriculture and Agri-Food Canada
AMC	Assembly of Manitoba Chiefs
ARBI	Assiniboine River Basin Initiative
Bay SSM	Bayesian State-Space Models
BMP	Beneficial management practice
BWT	Boundary Waters Treaty
CanSWAT	Canadian Soil and Water Assessment Tool
CanWIN	Canadian Watershed Information Network
CBM	Community-Based Monitoring
CD	Conservation District
CESI	Canadian Environmental Sustainability Indicators
CIER	Centre for Indigenous Environmental Resources Inc
CLI	Collaborative Leadership Initiative
CPR	Conservation, Protection and Restoration
DEM	Digital Elevation Model
DFO	Department of Fisheries and Oceans
DRP	Dissolved Reactive Phosphorus
ECA	Ecological Causal Assessment
ECCC	Environment and Climate Change Canada
GWF	Global Water Futures
ha	Hectares
IISD	International Institute for Sustainable Development
IJC	International Joint Commission
IMA	International Multi-Agency Arrangement
IRLWWB	International Rainy-Lake of the Woods Watershed Board
IRRB	International Red River Board
ISRB	International Souris River Board
LiDAR	Light Detection and Ranging
LOWWSF	Lake Of the Woods Water Sustainability Foundation
LWBP	Lake Winnipeg Basin Program
LWF	Lake Winnipeg Foundation
LWIC	Lake Winnipeg Indigenous Collective
LWRC	Lake Winnipeg Research Consortium
MAA	Master Agreement on Apportionment
MCDA	Manitoba Conservation Districts Association
MMF	Manitoba Metis Federation
MOU	Memorandum of Understanding
MV	Motor Vessel
NGO	Non-governmental organization
NRCan	Natural Resources Canada
OECD	Organization for Economic Cooperation and Development
PFSRB	Partners FOR the Saskatchewan River Basin
PPWB	Prairie Provinces Water Board
RRB	Red River Basin
RRBC	Red River Basin Commission
SCO	Southern Chiefs' Organization
SPARROW	SPAtially-Referenced Regression On Watershed
SRB	Saskatchewan River Basin
SRRCD	Seine Rat River Conservation District
SWAT	Soil and Water Assessment Tool
SWE	Snow Water Equivalent
TK	Traditional Knowledge
TN	Total Nitrogen
TP	Total Phosphorus
UM	University of Manitoba
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
U.S.	United States of America
USGS	United States Geological Survey
WASP	Water Quality Analysis Simulation Program
WMR	Winnipeg Metropolitan Region

INTRODUCTION

Lake Winnipeg is Canada's sixth largest lake and the eleventh largest freshwater lake in the world. Water from almost a million square kilometres of land drains into Lake Winnipeg from four provinces (Alberta, Saskatchewan, Manitoba, Ontario) and four states, (Montana, North Dakota, South Dakota and Minnesota) (Figure 1).

An important geologic divide between the Interior Plains (Prairie) and Canadian Shield runs north-south through the centre of the lake. The climate, soils and vegetation characterizing these ecozones have shaped the land use activities and population densities; the Prairies, for example, are largely agricultural with more urban centres, while the Shield is forested and less densely populated.

Figure 1. *Lake Winnipeg and its basin of nearly one million square kilometres. Source:* ECCC, *State of the Lake Winnipeg : 1999-2007 - Highlights*

Lake Winnipeg's drainage basin is nearly 40 times larger than its surface area—the largest drainage area to lake-surface in the world. The large drainage to lake-surface area makes the lake's water quality susceptible to decline due largely to human activities within its vast basin, especially the Prairie region. Of particular concern is eutrophication caused by human activities that contribute excess nutrients to rivers, most notably the Red River, that flow into Lake Winnipeg. Eutrophication is typically characterized by large and frequent

"blooms" of algae. However, it can also have less visible symptoms such as the production of toxins by certain groups of algae or by changes in the types of organisms in the lake and how they interact with one another (the food web). Often, these unseen changes are only revealed through science and monitoring.

Municipal and industrial wastewater released directly into rivers, as well as agricultural runoff are sources of nutrients to Lake Winnipeg. Landscape alterations that impact the natural hydrology, such as drainage ditches and wetland loss, are also important factors influencing the transport of nutrients off the land. In addition, climate variability can impact the amount of water available, and in turn the amount of runoff and frequency and intensity of flooding (or droughts), especially in the spring.

Protecting and improving the water quality in Lake Winnipeg is a complex challenge, especially given the size of its basin and the interprovincial and international boundaries it crosses. Thus, transboundary collaboration, through formal governance mechanisms, is essential, and continued action within the basin to reduce nutrient loading to the lake is imperative. Moreover, scientific research and monitoring programs for both the lake and watershed are necessary to evaluate the response of the lake to nutrient reduction actions in the basin, and ultimately the effectiveness of those actions.

The Governments of Canada and Manitoba have collaborated on Lake Winnipeg-related science since 2004, when an ECCC-led federal science program was co-developed with the Manitoba government to begin addressing the issue of eutrophication in Lake Winnipeg. The intended outcomes of this program were: to reduce the magnitude and extent of harmful algal blooms by reducing nutrient loading; reduce beach closures and improve water quality for recreation; restore the ecological integrity of Lake Winnipeg; and a sustainable fishery.

The Lake Winnipeg Basin Initiative (2007–2017) was launched in 2007 and renewed in 2012. In 2017, the Lake Winnipeg Basin Program (LWBP) was launched under the Freshwaters Initiative for another five years. The LWBP continues to provide science support to determine the ecological integrity of Lake Winnipeg under current and future stressors, including zebra mussels and climate variability, and support collaboration and actions that target priority areas of high nutrient loss within the basin.

This report provides a summary of the progress made to date on many of the projects and activities supported by the LWBP and presented at the ECCC LWBP Symposium, 2019.

SYMPOSIUM OBJECTIVES

The Symposium objectives were to:

- share information and findings on scientific work in the Lake Winnipeg Basin;
- showcase projects being funded by ECCC that support nutrient reduction efforts in the basin;
- highlight transboundary partnerships that support collaborative efforts in the basin; and
- provide an opportunity for networking and identifying potential collaborative opportunities among individuals and agencies engaged in work addressing nutrients in Lake Winnipeg.

DAY 1 SYMPOSIUM PRESENTATIONS

The symposium was kicked off with overview presentations on the Lake Winnipeg Basin Program and its science plan followed by a presentation on reporting progress regarding the health of Lake Winnipeg. A session on the in-lake science and another on the watershed science, followed these presentations. The day wrapped up with a poster session that allowed Symposium participants to engage on a one-on-one level with the scientific community.

Lake Winnipeg Basin Program Overview – Ute Holweger, ECCC

Ute Holweger (Manager, LWBP) launched the information sessions with an overview of the LWBP. ECCC is involved in many efforts related to Lake Winnipeg, all of which are carried out in partnership with other groups and governments, and many were highlighted during the Symposium and summarized in this report. This includes the Manitoba–Canada Memorandum of Understanding (MOU), initiated in 2010 and expiring in 2020. A science subsidiary arrangement was signed in 2012 in order for ECCC and Manitoba to work together on more effective reporting, such as Lake Indicator factsheets and State of the Lake reporting. Further, an adaptive management sub-committee was struck in 2018 who is in the early stages of exploring an adaptive management framework related to nutrients.

The LWBP is an important federal commitment of $25.7 M between 2017 and 2022 in support of freshwater action in the Lake Winnipeg Basin. Of the $25.7M, there is $9.2 M in Grants and Contributions funding for stakeholder-driven projects that support the program's three pillars: nutrient reduction; collaborative governance; and Indigenous engagement.

Pillar 1 - Nutrient Reducing Actions supports projects aimed at reducing nutrient loading to Lake Winnipeg and increasing public knowledge and engagement. ECCC is taking a more targeted approach to prioritize beneficial management practice (BMP) projects in geographically strategic areas with high nutrient loading. Evaluating the effectiveness of BMPs is also emphasized. Eleven projects are currently funded under this pillar.

Pillar 2 - Collaborative Governance supports efforts to enhance the coordination of federal actions related to Lake Winnipeg, including the development of nutrient objectives developed by transboundary management bodies. In addition, this pillar supports capacity building within, and collaboration among, watershed organizations at the regional, sub-basin level to address water quality concerns through improved information sharing and coordination of actions. Five projects are currently funded under this priority area.

Pillar 3 - Indigenous Engagement supports increased Indigenous participation in decision-making processes and strengthened Indigenous engagement regarding nutrient reduction aimed at restoring and protecting Lake Winnipeg. This pillar is also a tool to broaden reconciliation processes. Seven projects are currently funded under this priority area.

Of the $9.2 M in Grants and Contributions, $950,000 over five years is allocated to help fund the operation of the Motor Vessel Namao, a research platform that is owned and operated by the Lake Winnipeg Research Consortium (LWRC) and from which lake science is conducted. As well, the Canadian Watershed Information

Network (CanWIN) receives $250,000 in funding to support ongoing Lake Winnipeg Basin science and monitoring data management. The remaining $8 M will support application-based projects under the three pillars. In the 2018/2019 Call for Proposals, 23 projects were approved for a total of $3.82 M in funding. A complete list of funded projects can be found in Appendix C.

Since its inception, the LWBP recognizes the importance of supporting science—research, predictive modeling and monitoring—that advises the development, implementation and evaluation of nutrient management strategies. The LWBP includes a commitment of $8.5 M to implement the ECCC Science Plan, as well as $265,000 in support of projects with federal counterparts, notably the Department of Fisheries and Oceans Canada (DFO) to develop new bathymetric maps of Lake Winnipeg, and Natural Resources Canada (NRCan) to update the National Hydrometric Network.

Question: In response to a question posed by an audience member on Indigenous Engagement, it was clarified that financial support is provided through an application-based process to Indigenous organizations, such as the Assembly of Manitoba Chiefs and the Lake Winnipeg Indigenous Collective, to carry out Indigenous-led activities. Day 2 of the Symposium would provide an opportunity to learn more about those projects being funded.

ECCC Science Plan Overview – Ram Yerubandi, ECCC

Ram Yerubandi (Research Manager, Watershed Hydrology and Ecology Research Division) described ECCC's Lake Winnipeg Science Plan as an important catalyst that has successfully brought many groups together in a collective effort to understand the contribution of nutrient loading to the lake from across a diverse landscape, and study the response of both the lake and basin to remedial actions undertaken within the basin.

The LWBP science plan continues to build on previous work and adds a focus on improving knowledge of nutrient export to streams and understanding the impacts of climate variability and zebra mussels on the nutrient balance in the lake. The science can be divided into five general areas—monitoring, watershed research, in-lake research, integrated lake-watershed modeling and reporting. A brief overview of each area is provided below, with more details provided in the presentations and posters that follow.

1) Lake and Watershed Monitoring – to establish an improved water quality monitoring network in order to acquire data to augment research and modelling activities, assess the status and trends of nutrient loading and changes in water quality over time, and report to key stakeholders. Federal water quality monitoring includes transboundary sites (federal and provincial borders), key Lake Winnipeg tributaries, and the nearshore environment, including Netley-Libau Marsh. A key deliverable of this area is the ability to calculate nutrient loading to Lake Winnipeg, and to evaluate the lake's response.

2) Watershed Research – to more precisely determine where and how nutrients are exported to tributaries, to more effectively target remedial actions in the basin, and to assess effectiveness of current BMPs at reducing nutrients in runoff. This research area also includes groundwater and how it influences nutrient loading to streams.

3) In-Lake Research – to understand the key processes affecting Lake Winnipeg's nutrient balances and ultimately to support adaptive management decision-making. This research area includes: the ongoing acquisition of physical data (temperature, currents, sediments) for lake model refinement; improving estimates of the amount of phosphorus released from the sediment (internal loading) and its role in contributing to the development of algal blooms; using remote sensing technology to improve estimates of algal bloom frequency, extent and duration; identifying factors that contribute to changes in the diversity of the phytoplankton community and the occurrence of harmful algal blooms; and determining the impact of zebra mussels, an invasive species, on the structure of the lower food web and nutrient cycling.

4) Integrated Lake-Watershed Modelling – is based on a modelling framework for the United States of America (U.S.) and Canadian portions of the Lake Winnipeg Basin that is integrated with the Estuary, Lake, and Coastal Ocean Model – Computational Aquatic Ecosystem DYnamics Model (ELCOM-CAEDYM). The transboundary area includes the Red and Assiniboine rivers. Enhancing the predictive capacity to determine the lake's response to different BMPs, climate and hydrological variability, and zebra mussels will ultimately assist in the development of meaningful ecological objectives for the lake.

5) Reporting – to communicate on how the lake and its basin are responding to nutrient management decisions and other factors such as climate variability and invasive species. Additional information on reporting was provided in the next presentation.

Reporting on the health of Lake Winnipeg and its basin – Sharon Reedyk, ECCC

Sharon Reedyk (Integration Planning Officer) outlined some of the challenges around reporting on the health of Lake Winnipeg and its basin. Less scientific information is available on Lake Winnipeg as most research has been conducted over the past 15 years, unlike the Laurentian Great Lakes where research has been ongoing for a much longer period. As such, it is not possible to fully understand the complex changes that are occurring in the lake. The size of its basin poses additional challenges. The basin, extending from the mountains in the west and through the prairies has a diverse landscape and climate. Furthermore, the basin crosses provincial and international boundaries. Under Canada's *Water Act,* the management of water is vested in the Provinces and reporting is consequently done at the sub-basin level within provincial boundaries. With differences in scale, methodologies and indicators among provinces, collating a comprehensive State of the Basin report remains challenging. This is a recognized gap that should be addressed in the future.

Despite these challenges, there are a number of federal reporting tools that apply to Lake Winnipeg's basin. For example, two of the Canadian Environmental Sustainability Indicators (CESI) are for River Water Quality and River Water Quantity. These indicators provide a measure of health for several sites in the basin. Additionally, the Risk of Soil Erosion and Risk of Phosphorous Loss to Water are two examples of Agri-

Environmental Indicators, developed by Agriculture and Agri-Food Canada (AAFC) that provide insight on risks related to agriculture within the basin. These indicators are developed in collaboration with scientists from federal, provincial and academic organizations.

Reporting on Lake Winnipeg is key to understanding its ecosystem, how it is changing due to multiple stressors, and its response to remedial actions in the basin. To that end, a series of indicators specific to Lake Winnipeg are under development, and a series of fact sheets describing these indicators is planned. To date, two factsheets are available on the CanWIN site—an introduction to the indicator series and fish populations. There are also CESI indicators for nutrient (nitrogen and phosphorus) concentrations in Lake Winnipeg as wells as in the Red, Winnipeg and Saskatchewan rivers. In addition, Manitoba Sustainable Development has published an update on the nutrient concentrations and nutrient loading to the lake over the 1994 to 2016 time period. Lastly, a State of the Lake report was completed for the 1999 to 2007 period in 2011 and the next update up to 2016 will be released in 2019.

Questions: One question related to how Anishinaabe knowledge is being incorporated into our understanding of the lake. The answer included a recognition that this is a knowledge gap and efforts are being made to rectify this. Community-based monitoring carried out by Indigenous communities includes the capturing of traditional knowledge which will be valuable in bridging this knowledge gap. The other questions pertained to regulation of the lake: the impact of hydro development on phosphorous loading to the lake and how the science informs water levels regulated by Manitoba Hydro. The answer indicated that ECCC's science program does not inform Manitoba Hydro about regulation of lake levels; however, Manitoba Hydro has programs of its own that do. The answer also included an explanation of how lake nutrient budgets are calculated and how lake level plays a role. To calculate the load to the lake, one needs to understand how much water is flowing into the lake, as well as the concentration of nutrients in that water, as well as knowing how much phosphorus is released internally in the lake from the sediments. The storage of water in the lake influences the lake residence time, which can affect the flushing rate and how much phosphorus moves through the system.

WHAT HAVE WE LEARNED FROM IN-LAKE SCIENCE?

Nutrients and algal blooms – Dr. Caren Binding, ECCC

Nutrients are a source of food for phytoplankton, also known as algae. Algae form the base of the aquatic food web, supporting the overall productivity of the lake ecosystem up to the fish community. The algal community, therefore, is an important component of the ecosystem: in essence, no algae means no fish. However, in excess, nutrients can cause profound changes in waterbodies, including the development of large surface algal blooms, which can cover vast areas. Another change can occur in the predominant types of algae present in the water, typically becoming dominated by a group known as cyanobacteria. (As the name suggests, bacteria comprise this group based on their cell type —prokaryote—but they carry out photosynthesis and are thus included with the algae.) Another change is the possible production of toxins by some, but not all, types of cyanobacteria. This scenario leads to what is known as a harmful algal bloom.

As part of the research program on Lake Winnipeg, Dr. Caren Binding (Research Scientist) is using remote sensing to document historical and current algal bloom conditions to identify the main drivers for their

development, both spatially and over time. An understanding of what drives the spatial and temporal variability of bloom formation will help assess the effectiveness of nutrient management actions being undertaken in the basin.

The lake-wide surveys of Lake Winnipeg carried out on the research vessel *Namao* include the characterization of the algal community in terms of the species present, their abundance and toxicity. This information coupled with satellite imagery is being used to establish seasonal variability in bloom formation. In general, spring algal blooms in the south basin and narrow portion of the lake are dominated by diatoms, a group of algae that thrive under more turbid conditions and in cool water, sometimes even forming under ice during the winter. In the summer and fall, widespread algal blooms can form in both basins but more predominantly in the north basin, usually on the surface of the lake. These blooms are typically dominated by cyanobacteria; however, the species present differ between basins. The north basin supports nitrogen-fixing taxa while the south basin tends to have more non nitrogen-fixing cyanobacteria. This difference is due to the ratio of nitrogen to phosphorus in the lake. With a low nitrogen to phosphorus ratio, the nitrogen-fixers dominate as they are able to convert atmospheric nitrogen into a form that supports growth.

Why are algal blooms more severe in some years than others? There appears to be three important drivers of bloom variability working on different time scales. On a daily basis, wind can impact the development of surface blooms. Seasonally, prolonged periods of no wind and reduced mixing is coincident with peak severity. Lastly, on an annual basis, the severity of bloom formation can be predicted based on total phosphorus loading and summer temperature.

To extract quantitative information from satellite remote sensing imagery of algal blooms required the development of algorithms to detect the unique spectral signature of algae measured from their optical properties. From this information, Algal Bloom Indices can be developed and reported as mapped products. Currently, an experimental web tool is under development that allows a lake-specific, user-defined, near-real time view of bloom extent, intensity and severity. In addition, annual bloom reports will be available from 2003 onwards that show the seasonal summaries of bloom indices.

ECCC's nearshore monitoring program – Elise Watchorn, ECCC

Although research and monitoring on Lake Winnipeg has increased in the last 15 years; the focus has largely been on offshore areas of the lake where the LWRC's research vessel *Namao* is used to carry out this work. The nearshore area has been largely under-studied until recently. However, nearshore research is very valuable to users of the lake, whether recreationally or commercially, and as important habitat for aquatic life. The nearshore is also subject to considerable change, due to human alteration of the shoreline, erosion, and the influence of inflowing rivers. As well, invasive species like the zebra mussel can colonize the nearshore areas in great densities and is known to impact water quality and profoundly disrupt food web structure and function in lakes.

Recognizing the nearshore as a monitoring gap, the LWRC introduced two north basin nearshore sites to their station network in 2012 and added an additional 10 sites in 2014. ECCC augmented the work by developing a more comprehensive program through the ECCC Science Plan to monitor nearshore water quality and aquatic life.

Elise Watchorn (Environmental Scientist) described the monitoring that is being carried out in the nearshore as well as the important partnerships associated with the program. ECCC's program consists of nine road accessible sites that are visited three times a year—spring, summer and fall. It aligns with the LWRC's offshore program schedule to observe differences in these areas of the lake. Netley-Libau Marsh, an important coastal wetland where the Red River enters Lake Winnipeg, is also monitored. At each sampling site, samples are collected where the water depth is one meter and where the water depth is three meters and analyzed for physical parameters, nutrients, metals, ions and chlorophyll. Phytoplankton is collected by surface grab samples and the community is characterized by identifying species and their numbers. Similarly, zooplankton—small animals that typically consume phytoplankton, although some eat other zooplankton—are sampled using horizontal and vertical tows and quantified. The organisms that live in the sediment of the lake, known as zoobenthos, are sampled using an Ekman dredge[1] (at 3 m) and a triangular kick net (at 1 m).

DFO has been an important collaborator of the nearshore sampling program, and ECCC has partnered with them to characterize the nearshore fish community. Another study with DFO aims to establish food web structure and how it is changing using stable isotopes. Organisms for this study include zooplankton, invertebrates, zebra mussels and small fishes.

Bathymetric survey of Lake Winnipeg – Doug Watkinson, DFO

Up-to-date bathymetry and substrate maps were identified as important research gaps in the LWRC's State of the Science II Report in 2015. A bathymetric map is essentially the same as a topographic map except it is of the bottom of a water body. Lake Winnipeg's bathymetry was originally surveyed between 1901 and 1904 and again in 1974. Moreover, there is no comprehensive substrate data available that characterizes the nature of the bottom sediments.

This knowledge gap is being addressed through the LWBP, in partnership with DFO. Doug Watkinson (Fisheries Biologist) reported on progress made to date on this initiative and how the data is being used to establish linkages between fish movement and habitat availability. The information is also contributing to knowledge of zebra mussel distribution patterns and will be used for nutrient modelling efforts by ECCC.

Bathymetry was determined using a Biosonics MX Visual Habitat Echosounder with a 200 kHz single conical beam. The transducer was mounted to the underside of a tow body and deployed over the side of a boat. ArcMap, Geographic Information System software, was used to generate bathymetric maps for the south basin and part of the narrows.

[1] Ekman dredge - A relatively lightweight bottom sampler primarily designed for sampling soft sediments consisting of two opposing scoops that close using a trigger mechanism (cable and messenger system) and trap sediment inside.

For the substrate mapping, a ponar grab sampler[2] was used to collect sediment at each survey station. Samples were bagged and analyzed for particle size corresponding to gravel, sand, silt, clay and colloids. Various particle size cluster analyses were performed on the sediment samples and Visual Habitat software was used to establish three distinct types of substrates: high silt/low clay; high clay/low silt; and sand/gravel. The high clay/low silt class is typically in the offshore of the lake.

The fish telemetry study involved tagging nearly 800 large-bodied fishes with acoustic transmitters, including sturgeon, walleye, burbot, common carp, freshwater drum, channel catfish and bigmouth buffalo. A grid of receivers covering 10,000 km^2 (and 800 km in rivers) was set up along a 7 km grid (14 km in the north basin) at the 3 and 6 m contours of the lake to capture signals from the tagged fish. There are many aspects to this project—with regard specifically to substrate and fish movement, linkages between species movement and substrate are being observed. Sturgeon, for example, are staying near harder substrates and within the Winnipeg River. Also, there is more movement than expected in and out of rivers.

Future efforts will be directed toward Improving the nearshore resolution of substrate type, completing the bathymetric survey of the narrows and north basin, and linking new data with the ongoing fish movement study.

Questions: One participant asked what kind of recommendations are being made from this study. The study is primarily for data acquisition to update the bathymetry and substrate maps. In the future, this type of information could inform fisheries management decisions. Another question pertained to where the receivers are located, specifically whether they are in the north basin. It was noted that there is a receiver in the Saskatchewan River and nearby in the lake. However, the extent of the actual grid stops near Berens Island.

WHAT HAVE WE LEARNED ABOUT NUTRIENTS FROM WATERSHED-BASED RESEARCH?

Water quality monitoring in the Lake Winnipeg Basin – Elise Watchorn, ECCC

The management of water within Lake Winnipeg's basin is vested in the four Provinces, while the federal government, notably ECCC, has the responsibility to monitor water at interprovincial and international boundaries. Monitoring at these boundaries is important in terms of establishing the contribution of nutrients from the respective jurisdictions and informing management decisions.

Elise Watchorn (Environmental Scientist) described the federal water quality monitoring program as it relates to Lake Winnipeg and its basin. A number of inter-jurisdictional boards, such as the Prairie Provinces Water Board (PPWB), International Red River Board (IRRB), and the International Souris River Board (ISRB) guide ECCC's water quality monitoring program. In turn, the data acquired from such programs support the boards in various ways including resolving disputes over boundary waters.

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[2] Ponar Grab Sampler - A heavy bottom sampler widely used for taking samples of hard bottoms such as sand, gravel or clay consisting of two opposing semi-circular jaws that snap shut when the lowering cable slackens and trap sediment inside.

In support of the PPWB, ECCC monitors all of the major rivers that cross the Alberta-Saskatchewan border (South and North Saskatchewan, Red Deer and Battle rivers) and the Saskatchewan-Manitoba border (Qu'Appelle, Assiniboine, Red Deer, Carrot and Saskatchewan rivers). Each river has site-specific guidelines to ensure that water quality is acceptable for the most sensitive water uses. Monitoring includes monthly sampling for nutrients, metals, major ions, physical characteristics, pesticides and chlorophyll.

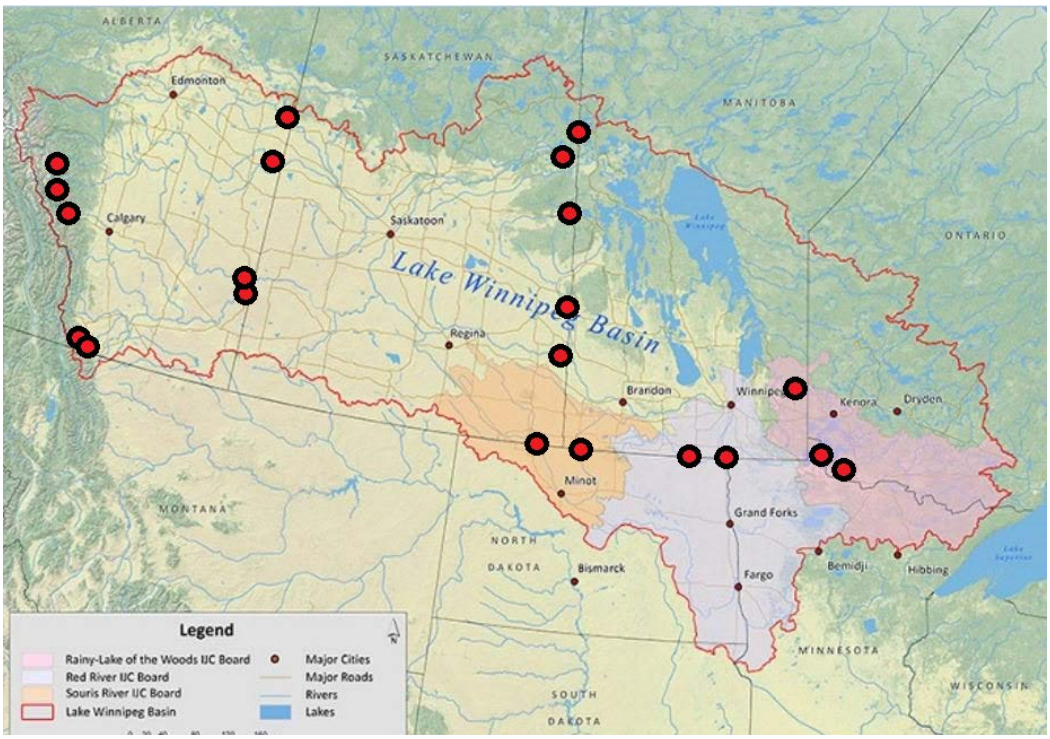


Figure 2. *Federal water quality monitoring sites at interprovincial and international boundaries within the Lake Winnipeg Basin. Source: Elise Watchorn, ECCC; Water Quality Monitoring in the Lake Winnipeg Basin Presentation*

ECCC is responsible for monitoring the Red River at Emerson on the international border to support ongoing efforts of the IRRB. Sampling occurs weekly during the open water season and monthly during the ice cover season for a number of parameters including nutrients, metals, major ions, physical parameters, pesticides and bacteria. There is also an automated sampler in the middle of the river at this site that takes real-time measurements for turbidity, dissolved oxygen, conductivity, temperature and pH. The data is available immediately to ECCC science staff.

A similar water quality monitoring program exists under the ISRB at Sherwood and Westhope where the Souris River crosses into the U.S. and re-enters Canada, respectively. A total of 47 water quality parameters are measured eight times a year in collaboration with the United States Geological Survey (USGS). There are guidelines in place to ensure that exceedances are investigated by the Aquatic Ecosystem Health Committee. Some of the issues that ECCC has addressed by monitoring the Souris River water quality include low dissolved oxygen resulting in fish kills, detection of pesticides, and guideline exceedances for metals.

In addition to the transboundary boards, ECCC works with Manitoba through the Canada-Manitoba MOU. Under this agreement, ECCC monitors the major rivers at the provincial border including the Winnipeg River (Pointe du Bois) and Pembina River (Windygates). Monthly monitoring for nutrients, physical parameters, metals, ions, pesticides and bacteria takes place at these locations. ECCC and Manitoba duplicate

monitoring efforts on the Red River at Selkirk and other locations, sending samples to different labs for analyses, for quality assurance/quality control purposes.

ECCC has a number of other monitoring programs that are not transboundary in nature. One is the Mountain Parks Agreement (Alberta) whereby ECCC carries out water quality monitoring of streams and rivers in Banff, Jasper and Waterton National Parks. Although far from Lake Winnipeg, this area contains the headwaters of the major prairie rivers flowing into the lake and, therefore, serve as important reference sites. Another program is the Lake of the Woods initiative, which has been in place since 2008. This program includes both Lake of the Woods and Rainy River and focuses on nutrient loading from tributaries and the atmosphere, as well as understanding the drivers and impacts of harmful algal blooms. Bi-annual sampling at 30 stations includes water quality, sediment and benthic invertebrates. Lastly, ECCC monitors the eastern tributaries flowing into Lake Winnipeg. This program includes sampling the Manigotagan, Bloodvein, Berens and Pigeon rivers in order to better understand their contributions of nutrients to Lake Winnipeg.

Human influences in the basin – Dr. Patricia Chambers, ECCC

Monitoring rivers within the Lake Winnipeg Basin helps to identify general areas of high nutrient loading. Once identified, these areas can be further characterized in terms of land-use activities and their relative contributions of nutrients in runoff.

The aim of the study presented by Patricia Chambers (Research Scientist), was to compare the contributions of rural nutrient sources derived from livestock, cropland and small sewage systems, and characterize factors impacting nutrient loss, such as seasonal variability. Understanding the extent to which these human activities affect nutrient export to rivers will help direct management actions more strategically toward specific land-use activities.

This study involved 11 watersheds within the Red River Basin, three of which were used to illustrate the nature of the project. The first watershed was mostly cropland with no sewage discharge; the second had a high density of livestock (cattle, pigs and poultry); and the third watershed had the greatest sewage discharge (open lagoons) from a small town of 8,000 people.

Three important hydrological events were observed throughout the study, in order of importance—snowmelt, summer rain and discharge of wastewater lagoons, which occasionally augmented streamflow. Findings to date from this study show that the highest phosphorus loading to streams occurs during the high-flow snowmelt period. Thus, retaining phosphorus on the land during this time of year is critical. During the summer period; however, managing human activities more effectively to reduce the occurrence of runoff of phosphorus during summer rain and sewage discharge events is important.

Given that phosphorus loading is related to environmental factors, such as snowmelt and rainfall, another important consideration is climate variability and its impact on the hydrology and consequently nutrient export to prairie streams.

To date, a number of effective actions are being taken in the Red River Basin to mitigate nutrient loss. They include fertilizer application using the injection method (four inches below the surface), microdams and mini marshes to reduce the flow rate by retaining water, and sewage holding cells to remove nutrients from lagoons.

Nutrient pathways and landscape-based modelling – Dr. Luis Leon, ECCC

The main objective of Lake Winnipeg modelling is to develop models to assist in predicting the lake's response, in terms of nutrient dynamics and loadings, to various scenarios involving nutrient reductions (BMPs), climate variability, a combination of BMPs and climate scenarios, and the influence of zebra mussels. Lake Winnipeg modelling involves model development for both the lake and watershed (or sub-basins) and joining them within an integrated modelling framework. Luis Leon (Research Scientist) provided an update on ECCC's modelling progress to date.

ECCC's Lake Winnipeg Basin Initiative (2012–2017) used two modelling systems—Water Quality Analysis Simulation Program (WASP) and the Canadian Soil and Water Assessment Tool (CanSWAT). WASP is a lake model used to simulate in-lake concentrations of nitrogen and phosphorus and the phytoplankton response to various nutrient loading scenarios. CanSWAT is a watershed model used for predicting the effects of various BMPs on the lake based on simulations of water quality (sediment and nutrients) and quantity (hydrology) in the watershed.

ECCC's current science plan builds on previous modelling efforts and focuses on watershed modelling for both the Red River Basin and Assiniboine River Basin. The Red River Basin model required the harmonization of Canadian and U.S. data for consistency, which has been completed by the International Joint Commission (IJC) in year 1. Year 2 (2019) includes CanSWAT model setup, calibration and validation, which is in progress. Year 3 will aim to analyze agricultural BMPs and climate change scenarios in terms of loading to the lake. The Assiniboine River Basin model involves SWAT model setup to include the fill-and-spill process of prairie potholes. Calibration and validation for nutrient transport simulation is ongoing. As for the Red River Basin model, it will be applied to evaluate BMPs and climate change scenarios.

Lake modelling aims to simulate water movements and water quality and predict the lake's response to various watershed scenarios aimed at reducing nutrients to the lake. This will be achieved once the watershed and lake models are connected. The potential impacts of zebra mussels on nutrient cycling are also being integrated into the lake model. Additional data requirements for this component include zebra mussel densities, size, nutrient content and biomass, which are being acquired during the research surveys of the LWRC. Outputs from the hydrodynamic models will continue to be assessed and validated against field data, and the development of an ice model is underway.

Question: An audience member asked whether ECCC was modeling outside of the Red River Basin. The answer was no because the Red River is the greatest contributor of nutrients to Lake Winnipeg.

Nutrient sources and agricultural management practices – Dr. Jane Elliott, ECCC

One of the challenging aspects about nutrient management in the Prairies is that it is a cold region and its unique geological and climatic characteristics prevent the use of information from other areas that do not

experience such harsh winters. Jane Elliott (Research Scientist) explained some of these characteristics and her research findings on cold region BMPs in the LaSalle Basin from a collaborative project between ECCC and AAFC.

In cold regions, studies indicate that most nutrients are transported in the dissolved form during the spring snowmelt period, with limited infiltration due to frozen soils. Jane Elliott's work expands upon this and has three components. The first is to acquire additional data on edge-of-field nutrient loss in the LaSalle River Basin, a particularly challenging area due to its flat topography and artificial drainage, which can often result in reversed flow back onto the land. Of interest is whether the water quality drivers in this landscape differ from areas with a more natural hydrology within the Lake Winnipeg Basin. The second is to explore the contribution of dormant vegetation to nutrient loading during the snowmelt period, an often overlooked source of nutrients. This is important in terms of BMPs since some areas use vegetation to trap particulate material. Lastly, the third component is an evaluation of BMPs involving field and laboratory data combined with other studies, and in collaboration with AAFC.

Findings to date show annual cropland soils are an important source of phosphorus. Similarly, vegetation can also be an important source of nutrients due to freezing and the resulting release of nutrients. With regard to fertilizer and manure applications, surface application in the fall is not recommended, nor is applying fertilizer to snow, which is no longer permitted in Manitoba, but is still practiced in Saskatchewan. A collaborative, comprehensive review paper on BMPs and water quality drivers in relation to these practices was recently published as well.

Questions: An audience member was interested in additional information regarding Global Water Futures (GWF) Program (University of Saskatchewan) as a funding source. It was explained that the Agricultural Water Futures Program is part of the GWF and includes an inter-provincial data analysis project from long-term datasets to determine drivers and improve on modelling efforts related to climate change. Another question from the audience related to drainage off fields, how fast water moves and the influence of culverts. Although the presenter could not comment on the rate of flow off fields, it was noted that culverts can slow the flow of water, which could be favorable in some cases.

POSTER SESSION

The Poster Session was an opportunity for Symposium participants to engage one-on-one with scientists at greater length than during presentations. Within this report, the posters presented have been divided into three general categories—lake, basin and modeling. A Lake Winnipeg infographic was also on display to provide a general overview of the lake and basin characteristics.

Infographic on Lake Winnipeg – Environment and Climate Change Canada

Lake Winnipeg is the 11th largest freshwater lake in the world with a shoreline spanning 1,750 km. The lake supports an annual one hundred-million dollar tourism industry. The outlet at the north end of the lake flows into the Nelson River, which flows into Hudson Bay. Lake Winnipeg receives water from an area that is just under one million square kilometres, covering nearly 10% of Canada's surface. This enormous basin includes portions of four provinces and four U.S. states and is home to approximately seven million people living mostly in five of Canada's 20 largest cities.

THE LAKE ECOSYSTEM

The Lake Winnipeg Research Consortium Inc.

Karen Scott (Lake Winnipeg Research Consortium)

The Lake Winnipeg Research Consortium Inc. (LWRC) is a registered charity, founded in 1998 to facilitate scientific research on Lake Winnipeg. The LWRC has two programs—Science and Education. The Science Program coordinates whole lake scientific research and monitoring to gain a better understanding of ecological processes and how they are changing over time, as well as support lake and watershed management decision-making. The Science Program offers science support and infrastructure in the form of: an annual science workshop to convene the active science team; two research vessels, Motor Vessels (MV) *Namao* and *Fylgja*; three whole-lake surveys during the open water season (spring, summer, fall); a network of 65 monitoring stations including offshore, nearshore, river mouths and outflows; lake access for special projects; and a scholarship offered to honours and graduate students.

The Education Program provides a unique opportunity for hands-on learning through the Lake Ecology Field Program aboard the MV *Namao*. Also offered are classroom visits for all grades and an annual Water Award at the Manitoba Schools Science Symposium.

Phosphorus loading contributions from deposited and re-suspended sediments of Lake Winnipeg

Dr. David Depew and Kim Rattan (ECCC)

Much of the focus on Lake Winnipeg is targeted toward understanding nutrient loading to the lake from the basin. However, there is another source of phosphorus that is derived from within the lake, notably from the sediments at the bottom of the lake. This contribution of phosphorus is known as the internal load. The objectives of this study were to determine if sediments that become re-suspended into the water column are a source or sink of phosphorus and to examine the potential release of dissolved phosphorus from the sediment due to conditions of low dissolved oxygen.

To date, the findings show that there is no evidence of widespread low oxygen conditions. Among the five fractions of phosphorus measured in the surface sediments, two dominate during the summer—redox sensitive and organic phosphorus. Equilibrium phosphorus concentration differs considerably among sites but is sufficiently high to conclude that re-suspension events potentially contribute to internal loading. Future effort will be directed toward assessing potential drivers of phosphorus release from the sediment other than low oxygen conditions, which do not persist in the lake.

Assessing Lake Winnipeg Basin walleye fish movement patterns

Inesh Munaweera*, Saman Muthukumarana*, Darren Gillis*, Douglas Watkinson, Colin Charles, Eva Enders (DFO, *University of Manitoba)

This poster described a large-scale, long-term fish tagging project in Lake Winnipeg, led by DFO with collaborators from the University of Manitoba (UM). The objectives were to study where walleye go and how seasonal factors influence their behaviour, and to reconstruct the movement paths of individual fish to determine unusual behaviour. This study drew from an existing dataset of fish positions representing detections from 358 tagged walleye that were recorded within a grid of 148 acoustic receivers installed on the bottom of Lake Winnipeg.

Bayesian State-Space Models (Bay SSMs) were used to reconstruct individual fish movement paths. This is a class of models that can be used to model systems that have unobservable components. In this case, the true fish positions were unobserved since their recorded locations were based on where the receivers were located, rather than where the fish were. The Bay SSM allows the true fish movement to be estimated when run in conjunction with an observation model, which describes the probability of detecting fish. Some of the ways in which this data can be used include: the number of detections for fish released at various locations; within day variation of detections by season; number of detections during the fall, winter and spring; movement paths; and average distance traveled.

Future work will involve developing more sophisticated movement models considering both the temporal and spatial variations that were observed in this study. In addition, the reconstructed paths will be combined with biological data and environmental factors to improve the interpretation of fish movement.

THE LAKE WINNIPEG BASIN

An ecological causal assessment of Red River Valley, Manitoba tributaries: linking ecological effects to human activity

K. Painter*, B. Brua, P. Chambers, J. Culp, K. Rattan, A. Yates* (ECCC, *University of Western Ontario)

Tributaries in the Red River Basin (RRB) represent important links between urban and agricultural activities and Lake Winnipeg. Understanding the ecological status of these tributaries is important for remedial actions to be assessed and deemed effective. At present, this knowledge is lacking.

Ecological changes associated with agricultural and urban activities are likely occurring in the RRB; however, it is difficult to identify the many different causes of these changes from one another. An Ecological Causal Assessment (ECA) framework is a valuable tool to link the ecological status of a system with potential causes

that are supported by scientific evidence. Outcomes of these assessments help identify knowledge gaps and determine the best course of remedial actions.

The first objective of this study was to determine the current state of tributaries in the seven main sub-basins in the RRB and evaluate their ecological condition using an ECA framework. The second objective was to use the above analysis of past and present spatial/temporal trends (in climate, hydrology, land use, water chemistry and ecology) to produce an assessment at the regional scale. This will prove useful in exploring the causes of change, or lack thereof, over time.

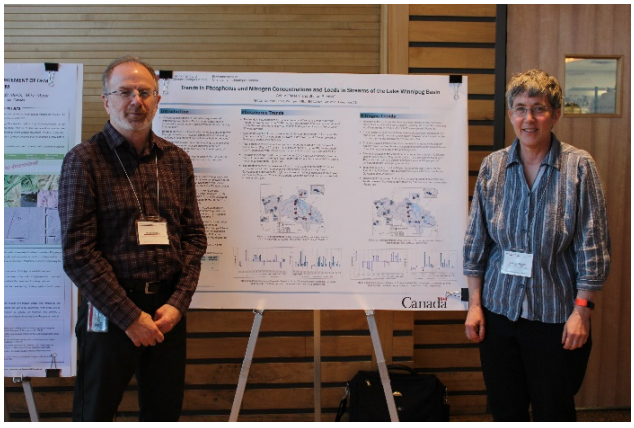
Interestingly, study results found a stronger cause-effect linkage between wastewater and ecological effects than agriculture. However, the weaker link with agricultural causes is likely due to a lack of studies that connect specific agricultural drivers to ecological effects. Similarly, climate change, hydrology and agricultural drainage were not apparent in the ECA either, again likely due to a lack of research connecting drivers to ecological effects.

It was recommended that management actions be targeted at known stressors that can be addressed in the short-term, including biomonitoring using region specific and stressor specific indicators. More knowledge is required regarding the linkages of hydrology, climate and BMP implementation to the ecology of the RRB. Lastly, using an adaptive management plan will allow evidence-based decision-making on an iterative basis.

Trends in phosphorus and nitrogen concentrations and loads in streams of the Lake Winnipeg Basin

Arthur Friesen and Sharon Reedyk (ECCC)

Concerted efforts are being made to reduce nutrient loading to Lake Winnipeg from external sources in the basin. Analyzing the directional trends (increasing or decreasing) in stream nutrient concentrations and loads over time is a means to track progress and identify areas in need of a more targeted approach to nutrient reduction. The main objective of this work is to use trend analyses to help inform policy and program decisions for the LWBP.



This study involved trend analyses for flow-normalized total nitrogen (TN) and total phosphorus (TP) concentrations and load with Weighted Regressions on Time, Discharge and Season (WRTDS) models using data from 18 sites within the Lake Winnipeg Basin. The TP trends were evaluated for up to four trend periods: 40-yr (1976–2016), 30-yr (1986–2016), 20-yr (1996–2016), and 10-yr (2006–2016). The TN trends were assessed for the 20-yr (1996-2016) and 10-yr (2006-2016) periods.

Of the 52 TP model runs, 25 showed significant trends in concentration, 20 of which were upward trends. For load, 29 had significant trends, 27 of which were upwards. Most of the significant trends occurred in the 20 and 40-year time periods, while in the more recent 10-year period, only two concentration trends (one up, one down) and six load trends (four up, two down) were significant. A primary driver for many of the upward

trends in load (and some in concentration) was an increase in discharge. Rivers draining the eastern Prairies showed the greatest percent increases in load expressed as total change over a given trend period. In the 20 and/or 30-year time periods, the Assiniboine, Qu'Appelle and Red Deer River sites had total increases in load of over 200%. The Red and Souris river sites showed increases of around 100%.

Of the 36 TN model runs, 19 showed significant trends in concentration (nine increasing) while 20 were significant for load (12 increasing). The 10-year period showed more significant decreasing trends in concentration but the same number of upward and downward trends in load. The stream sites in the eastern Prairies showed more upward trends, while streams in the Saskatchewan and Winnipeg River basins showed more downward trends. The increasing trends in load seem to be driven by discharge while downward load trends seem to be driven by reductions in concentration.

MODELLING

A comparison of the Red-Assiniboine Basin SPARROW with a Bayesian approach

E. A. Blukacz-Richards, Alex Neumann*, G. Benoy**, Dale Robertson***, Félix Ouellet*, David Saad***, George Arhonditsis* (ECCC, *University of Toronto, **IJC, ***USGS)

SPAtially-Referenced Regression On Watershed attributes (SPARROW) models use a mass balance approach to estimate the amount of a given contaminant (in this case nutrients) transported from watersheds to water bodies by linking existing monitoring data with land surface characteristics and nutrient sources (e.g. wastewater treatment plants, fertilizers) within a defined network of streams. Outputs from modeling can help determine appropriate management actions in terms of reducing loads, predicting changes in water quality resulting from remedial actions, identifying gaps and prioritizing monitoring.

This research builds on previous work by the USGS that involved the first binational application of SPARROW models in the Red-Assiniboine River Basin. The final USGS SPARROW model served as a guide for running the Bayesian SPARROW in this study. A comparison between calibrated models was also made.

Results of the model comparison showed USGS SPARROW estimated that 1% of agricultural fertilizer and manure inputs are exported to streams, compared to approximately 3% using the Bayesian model. The remaining contributions were nearly the same. Both models showed that precipitation enhanced the total phosphorus load but they differed in the order of magnitude. The Bayesian SPARROW model was also able to identify TP losses in on-stream reservoirs in a range of typical values for eutrophic systems.

Ongoing model comparison between the USGS and Bayesian SPARROW models will include incremental yields and nutrient sources within the Red-Assiniboine River Basin. SPARROW models will also be used to study nutrient sources over multiple spatial (determine hot spots) and temporal (wet vs dry years, spring freshet vs summer base flow) scales.

Modeling the hydrology of the Assiniboine Watershed for improved understanding and prediction of nutrient loading under BMPs and climate change scenarios

Y. Dibike, R. Shrestha, L. de Rham, A. Muhammad*, G. Evenson**, J. Rowley, C. Spence, B. Bonsal, A. Richards, T. Stadnyki (ECCC, *University of Manitoba, **Ohio State University)

The Red and Assiniboine river basins are the largest contributors of nitrogen and phosphorus to Lake Winnipeg. Two important factors in the transport and delivery of nutrients to the lake are hydro-climatic variability and land management practices.

The Soil and Water Assessment Tool (SWAT) is a model used to simulate water quality and quantity and predict the potential impacts of land use and climate change over a range of scales, from a small watershed to a river-basin scale. The main components of SWAT are hydrology, weather, erosion, soil temperature, crop growth, nutrients, pesticides and agricultural management.

This project developed a modified version of SWAT for the Assiniboine River Basin to examine the individual and combined impacts of BMPs and future climate change scenarios on the watershed's hydrology and nutrient contribution. This modification accounts for the fill-and-spill processes associated with prairie potholes and wetlands common in the Assiniboine River Basin. The variable contributing area dynamics will be implemented to account for this. The project is part of ECCC's efforts to enhance its predictive capacity related to nutrient management in the Lake Winnipeg Basin.

Ongoing and future work includes implementing the dynamic contributing area in the SWAT model; calibrating and validating for nutrient transport simulation using available nutrient data; applying the model using different BMP scenarios and predicting possible outcomes of climate variability on hydrology and nutrient loading in the Assiniboine River Basin.

Historical variability and future projections of temperature, precipitation and snow in the Assiniboine-Red River Basin

Rajesh Shrestha, Barrie Bonsal, Ashish Kayastha, Yonas Dibike, Chris Spence (ECCC)

Hydrology is an important driver in the transport of nutrients to Lake Winnipeg. Changes in the hydrological regime due to climate variability could profoundly impact water availability and consequently nutrient loading to Lake Winnipeg. This project examined the historical variability and projected future changes in two hydroclimatic drivers, temperature and precipitation, using Global Climate Model outputs. A process-based model for snow accumulation and melt was also used to project changes in snow regime.

Results showed that historically, there is a significant increase in the annual minimum temperature and precipitation, but no trend was observed in the annual maximum temperature or annual maximum snow water equivalent (SWE) magnitude and timing. Future projections for temperature and precipitation in the Assiniboine River Basin show seasonal warming by up to 10ºC and increased precipitation by 40% by the end of the century. Projected monthly and maximum SWE show a decline for both the Assiniboine River Basin and Red River Basin, and the timing of maximum SWE is projected to be earlier, mainly due to higher temperatures. Despite increases in precipitation, snowpack volume will decline because of less snow in the winter and a shorter season.

Future efforts will focus on the implications of temperature, precipitation and snow storage changes on flood and drought conditions and on the relationships between various conditions, such as wet-dry, warm-cold and nutrient loading.

LiDAR Applications (Light Detection and Ranging)

Manitoba Infrastructure and Manitoba Sustainable Development

Light Detection and Ranging (LiDAR) uses remote sensing technology whereby lasers collect continuous elevation data over large areas. This technology is commonly used to make high-resolution 3-D maps. Historically, Manitoba has acquired LiDAR data on an intermittent, site-specific basis. Over the past five years, Manitoba has invested over $2 M to develop a LiDAR inventory that is able to more strategically support land and water management on a watershed basis. The inventory currently consists of 70,000 km^3 of LiDAR data.

Three applications of LiDAR data include flood risk mapping, watershed delineation and surface water management, and hydrologic modeling and distributed retention planning.

LiDAR data was captured between 2014 and 2018 in the Lower Assiniboine River Basin, the south basin of Lake Manitoba and the Souris River Basin. This data will be used to produce flood risk maps, improve flood forecasting and support future surface water management studies and planning.

LiDAR has also proven valuable in delineating watersheds and flow paths, as well as determining the amount and depth of water that can be retained at a given site. This technology has assisted Conservation Districts (CDs) in the design and implementation of water retention projects, saving both time and money as compared to traditional ground-truthing surveys.

LiDAR is also very valuable for hydrologic modeling. LiDAR data has been used to evaluate the impact of proposed or illegally constructed drainage works, and combined with drone photography, it can be used to quickly determine how dikes and diversions will impact adjacent landscapes. Drainage mitigation is another area that benefits from this technology.

Automatic extraction of high-resolution geospatial data

Natural Resources Canada

There is increasing demand for data and high-resolution geospatial products. To meet these needs, Natural Resources Canada is updating hydrography and infrastructure data using LiDAR and imagery. NRCan is also creating new products to meet the needs of its partners and Canadians and is also improving data accessibility through open licenses and appropriate management and dissemination systems.

NRCan is responsible for providing and maintaining the National Hydrographic Network, a geospatial data product that describes Canada's inland waters. Having a hydrologically-enforced digital elevation model (DEM) is the first step to deriving a hydrological network. Automation is necessary to provide complete, current and accurate information.

Hydrography extraction requires automated methodologies to extract water-related data from LiDAR data and produce hydrologically-conditioned DEMs. Deep learning methods allows for the efficient automatic extraction of geospatial data from multiple sources. The integration of data cube products allow the analysis of spatial data and facilitates the generation of dynamic products.

Intended and potential uses of geospatial data include climate change monitoring, natural resource management, solar energy potential, forecast and flood risk mitigation, infrastructure and coastal erosion management, and intervention planning. Click here for more information on Canada's geospatial information.

Automatic breach detection and hydro enforcement of digital elevation models from high-resolution LiDAR digital elevation models

Marc-André Daviault, Jean-François Bourgon, Marie-Claude Morin, Mike Major (NRCan)

Methods exist to automatically develop DEMs. For this study, two methods were combined to detect culverts and infrastructure and then account for natural obstructions—the Poppenga and Lindsay methods. This project aims to create an open source tool that automatically derives a hydrologically-conditioned DEM from high-resolution LiDAR based DEM.

Five areas totaling 600 km^2 were selected across Canada for their diversity of challenges, including St-Malo Manitoba. Preliminary results show that both methods detect breaches well. The Poppenga method was effective at detecting culverts, large pits and man-made obstacles, whereas the Lindsay method was better at detecting small pits, artifacts and natural obstructions. Next steps will be to validate the methods and develop a methodology to automatically discriminate commission breaches from Poppenga method.

DataStream—Advancing data sharing for collaborative water stewardship

L. Day, C. DuBois (The Gordon Foundation)

Community-based monitoring initiatives are becoming increasingly valuable as a means to generate data that can be used to evaluate change in aquatic systems. Data sharing, however, remains an issue that hinders the potential to leverage the data generated to full potential. DataStream was designed to address this issue. It is an on-line, open-data platform for sharing and accessing water quality data. Its structure allows different groups to organize, visualize and share data, and its searchable database allows both contributors and users to access monitoring data in a common format.

DataStream is led by the Gordon Foundation and is delivered in collaboration with regional groups, such as the Lake Winnipeg Foundation for the Lake Winnipeg Basin. It was piloted in 2016 in the Mackenzie River Basin and has since grown to include other regions such as Atlantic Canada. Over the long term, the vision is to expand across Canada through networked regional hubs.

DataStream is open, accessible and free to use.

DAY 2 SYMPOSIUM PRESENTATIONS

TRANSBOUNDARY COLLABORATION IN THE BASIN

The International Red River Board and Prairie Provinces Water Board – Mike Renouf, ECCC

This session began with Mike Renouf (Manager, Transboundary Waters Unit) who provided an overview of the history and work of the International Joint Commission's (IJC) International Red River Board (IRRB) and the Prairie Provinces Water Board (PPWB). His discussion focused on water quality and nutrients, as well as the role these boards play and the gaps they have not yet filled.

When discussing transboundary water management boards, it is helpful to return to the original arrangements or agreements that created those boards to understand why they were formed. The IJC is governed by the Boundary Waters Treaty (BWT) of 1909 and the PPWB is governed by the Master Agreement on Apportionment (MAA) in 1969.

Figure 3. *Transboundary basins along the Canada–U.S. border. Source: Mike Renouf, ECCC; Transboundary Collaboration IRRB & PPWB*

International Red River Board

The BWT was negotiated during a time of industrial and urban growth within the Great Lakes Region (and other transboundary areas). The emerging disputes over water led to a dialogue between Canada and the U.S. and to a mechanism to address them, notably the BWT. Its purpose is to provide principles and mechanisms to address current and future issues related to water along the boundary of the two countries. It is considered to be one of the world's first references to addressing water pollution.

The BWT creates the IJC with powers to authorize the construction of structures that could change water flow across boundaries, conduct studies to inform governments, and use "references" in order to study and propose recommendations to specific disputes. Many of the transboundary basins have boards, the IRRB being one of them. The IJC also watches over the transboundary basins that do not have boards.

The IJC has a long history working in the Red River Basin, dating back to 1929. The current iteration of the IRRB was created in 2001 with the amalgamation of two boards. It has a mandate to report on flood preparedness, water quantity issues, water quality objectives within the basin, and has the authority to make recommendations to governments to address these issues.

There are currently only five Red River water quality objectives at the international boundary—dissolved oxygen, total dissolved solids, chloride, sulphate and *E. coli*. The IRRB has an active Water Quality Committee

that is reviewing these objectives, including a trend analysis at various locations within the basin to establish which parameters should be added to this list.

A binational water quality model (SPARROW) was also developed in collaboration with a number of agencies, including ECCC, for the Red and Assiniboine river basins and is being expanded to include the Saskatchewan River Basin and Rainy-Lake of the Woods Basin as well. This model will provide a general view of where nutrients originate and their sources.

Another activity of the IRRB is to develop a scientifically defensible nutrient management strategy for the Red River and its basin aimed at protecting and/or restoring aquatic ecosystem integrity and uses in the Red River and Lake Winnipeg. Among its components, it is recommending targets for nutrients, identifying nutrient hot spots and actions for targeted nutrient reduction, and developing indicators for measuring progress. The Water Quality Committee of the IRRB has recommended a two-fold approach for nitrogen and phosphorus targets at the border, including concentration objectives and nutrient load allocation targets. IRRB approval of this recommendation is pending.

IRRB is only responsible for the main stem portion of the Red River. Thus, the Assiniboine River Basin contribution is not included in their mandate. The Souris River Basin, which drains to the Assiniboine River, has its own Board, the International Souris River Board.

Prairie Provinces Water Board

Agreements to share water within the Prairie Provinces began in the 1930s when the federal government transferred responsibility for resource management to the provincial governments through the *Resource Transfer Act*. This created problems for basins that crossed provincial boundaries, but also led to the creation of the MAA between Canada, Alberta, Saskatchewan and Manitoba in 1969. This agreement outlines the provincial "obligations" regarding surface water and groundwater quality and quantity, and in turn, their respective "entitlements". The MAA also established the PPWB, which has the responsibility to create a forum for continuous, cooperative dialogue on water management. This forum allows the respective jurisdictions to agree on apportionment methods, water quality objectives, monitoring needs, and other issues of concern, including those that pertain to groundwater. The PPWB also has the authority to make recommendations to government.

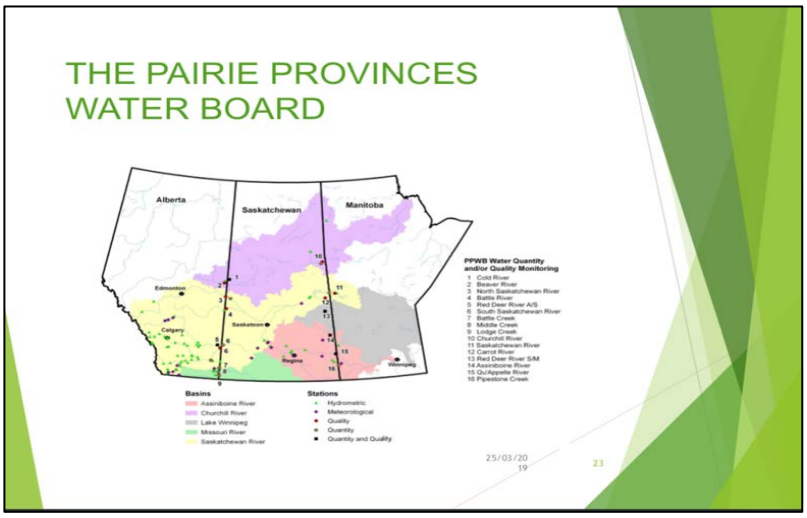


Figure 4. *Water quality and/or quantity monitoring locations of the Prairie Provinces Water Board. Source: Mike Renouf, ECCC; Transboundary Collaboration IRRB & PPWB Presentation*

Water quality is covered in Schedule E of the MAA. The first water quality objectives were established in 1992 and most recently updated in 2015. The water quality objectives are defined for twelve specific rivers and reaches: six on the Alberta-Saskatchewan boundary and six on the Saskatchewan-Manitoba boundary. Thus, there are 71 parameters for each river, with objectives intended to protect all uses on all rivers. The nutrient objectives include ammonia, total phosphorus, total dissolved phosphorus, total nitrogen and dissolved nitrogen. The next update is due in 2020.

In conclusion, transboundary water boards are one component of a much larger collaborative effort. Although they cannot remedy all challenges, they do provide opportunities for dialogue between governments, and bring together government science that can integrate research that leads to recommendations to government and other agencies, such as non-governmental organizations, that are working toward common goals.

Question: What is the PPWB doing about reconciliation and Indigenous water rights—not just having Indigenous representation on a board, but actual water rights to Indigenous peoples and how those rights have been ignored. It was noted that the authority over water rights remains with governments. For the PPWB to take on this question, governments would either need to request the board to do so or update the mandate of the board. That said, there are conversations at the PPWB table regarding how the board should be engaging with Indigenous peoples.

Panel discussion with Basin Organizations

With the support of the LWBP, four organizations—the Red River Basin Commission, Assiniboine River Basin Initiative, Lake of the Woods Water Sustainability Foundation and Partners FOR the Saskatchewan River Basin—formally met twice in 2018 to begin discussing how to better collaborate on water governance. Each representative provided a brief overview of their respective agency's mandate and three key challenges they are facing, which was followed by a panel discussion centred around the question "What are the desired or potential benefits, if any, from engaging with other basin organizations?".

Red River Basin Commission - Ted Priester

The Red River Basin Commission (RRBC) was formed in 1979 in response to flooding along the U.S. portion of the Red River Basin. The most important challenge was deemed to be relationships—establishing and nurturing relationships from federal government to individual landowners. A second challenge is water quantity—too much or not enough. Related to this is the third challenge—water quality and ensuring it is protected.

Assiniboine River Basin Initiative - Wanda McFayden

The Assiniboine River Basin Initiative (ARBI) was formed in 2014 as a result of problems associated with excess moisture and flooding, especially in 2011. ARBI's framework for water stewardship was developed by stakeholders in the Assiniboine River Basin, which includes the sub-basins of the Qu'Appelle, Souris and Assiniboine rivers. ARBI is currently engaged with the IJC in the Souris River Plan of Study.

Challenges of importance include transboundary communications—sharing information and knowledge across the basin is both relevant and important. In addition, elevating water management to a higher level and providing opportunities to meet at a basin scale to overcome the challenges imposed by borders. The use of science, research and technology was also deemed important especially in order to improve the science base for decision-making and optimize land and water management at a landscape level. Making science available in a format that is meaningful to the public is also essential. Working toward a uniform and fair approach to more unified water management is important in terms of sustainable development and building resiliency in communities. Increasing knowledge and awareness of the value of water is important, including an awareness of how land and water interact. Lastly, aquifers are often forgotten despite 80% of rural residents relying on aquifers for water.

Lake of the Woods Water Sustainability Foundation - Todd Sellers

The Lake of the Woods Water Sustainability Foundation (LOWWSF) represents the eastern transboundary area of the basin and includes the Winnipeg River Basin. The Winnipeg River supplies about 45% of the water to Lake Winnipeg and contributes about 13% (800 tonnes) and 26% (17,000 tonnes) of the phosphorus and nitrogen load, respectively.

Figure 5. *Framework describing the International Watershed Coordination Program. Source: Todd Sellers. Lake of the Woods Water Sustainability Foundation Presentation*

Three key issues were deemed of particular importance to the Foundation. The first is multiple stressors, such as cyanobacterial harmful algal blooms, toxin production, aquatic invasive species, and climate change, which can exacerbate the other stressors. Second are the challenges related to its location—the Winnipeg River Basin is comparatively remote and removed from many of the decision-makers, especially in Ontario. Also, both the basin and Lake of the Woods are multi-jurisdictional, which creates challenges, especially when trying to bring people together—building trust and providing a venue for dialogue is key. Moreover, there is no water agreement between Ontario and Manitoba, nor is there an agreement between Canada and the U.S. for Lake of the Woods—important shortcomings that need to be addressed. The third, and possibly most important issue, is coordination within a multi-jurisdictional setting—who leads? As an NGO, the LOWWSF has brought people together toward common objectives including reaching consensus on the initial science needs, contributing to a State of the Basin report, and developing a preliminary nutrient budget. Government engagement has now increased, including through the IJC with the establishment of the International Rainy-Lake of the Woods Watershed board (IRLWWB) that has both water quality and quantity mandates for the basin. Of the 20-member board, six are members of the general public (both U.S. and Canada) and there are designated seats for Treaty 3 peoples. Thus, this board is providing an opportunity for conversations regarding rights and entitlements to be integrated into future management of this system.

One of the key roles the IRLWWB plays is as coordinator through the International Watershed Coordination Program, which interfaces with the IJC and multiple governments including First Nations, Métis and Tribes. The coordinator also supports the International Multi-Agency Arrangement (IMA), a collective that allows government scientists to work together to develop common objectives, as well as local grassroots groups, such as other NGOs and conservation districts. The Program is intended to keep the dialogue open and moving forward toward agreement on action for Lake of the Woods and ultimately, Lake Winnipeg.

Partners for the Saskatchewan River Basin - Johanne Kristjanson

Partners FOR the Saskatchewan River Basin (PFSRB) is an environmental non-profit organization that was founded in 1993 to address issues of coordination within a geographically, hydrologically, and politically complex basin. Its mission is to promote awareness, linkages, stewardship and respect for the Saskatchewan River Basin (SRB) ecosystem. Eight issues were identified in the Saskatchewan River State of the Basin report; however, just three were elaborated on—natural hazards risk, water use data, and nutrients and other pollutants.

Natural hazards risk includes flood and drought events that are driven by extreme weather and linked with mountain runoff, where the water originates, and the Plains runoff, where it is consumed. In general, drought contingency planning needs to be improved, urban flood risk mapping is out of date, and overland rural flooding is poorly understood as it is a more recent phenomenon. Regarding the issue of water use data, the three Prairie Provinces have water allocation systems that grant licenses for water use within the SRB; however, water consumption data is lacking, especially on the South Saskatchewan River, where irrigation and evaporative losses are significant. Pollutants, including nutrients, is an important issue as water travels over the prairie landscape and is influenced by agricultural practices, urban centres and natural processes.

Some key activities of the PFSRB include developing and implementing projects with partner agencies (e.g. Global Waters Future Prairie water allocation and use project), policy and information gathering projects (e.g. State of the Basin report in 2009), holding an annual water conference that rotates among the three Prairie Provinces, and offering an education program to school-aged children (i.e. Caring for our Watersheds and Yellow Fish Road).

Panel Discussion

Following the brief overviews of the respective NGOs, the panel discussion began with the question: “What are the desired or potential benefits, if any, from engaging with other basin organizations?”

ARBI representative, Wanda McFadyen, reflected on the two formal meetings that brought together the four organizations. Despite their distinct priorities and unique geography, the organizations share similar concerns and common values and play an important role in collaborative water governance. Each brings stakeholders together and builds relationships over a common cause, advocates for water in the basin, sometimes advises on research, brings regional and transboundary issues to the forefront, and serves as a bridge for political bodies.

The groups turned to the Organization for Economic Cooperation and Development (OECD) Principles for Water Governance (2015) to provide a framework for ongoing dialogue on their potential roles in water governance in the Lake Winnipeg Basin. Of the 12 overarching OECD principles, Trust and Engagement is perhaps the key principle that these organizations bring to the table, due to their structure, networks and reach, as well as the level of trust that has developed over time with grassroots organizations and stakeholders. Another principle that these groups are well-suited to serve is citizen engagement, due to their structures and flexibility that allows them to work and communicate at the grassroots, local and landscape levels. The third principle that these groups are well-suited for is supporting science. Local citizens want to be engaged; they support science and have an interest in participating in science through citizen science programming.

The groups also feel that they can contribute in a number of areas pertaining to science. The first is monitoring and evaluation. The State of the Lake report needs to include the contributing basins in order to make clear to all citizens the linkages of local waterways to the lake. The second area is engaging in collaboration and communication at the grassroots level. As governments increasingly move away from this area, NGOs can play an important role at the local level by liaising between interested citizens and water managers. Lastly, education and outreach at the local level is an important role that each of these NGOs plays.

These NGOs, however, have limited capacity in the form of staffing and financial resources, often relying on volunteers and board members. A level of core funding is required in order for these groups to play a larger role in water governance and capacity building. Assistance with staffing, multi-year funding, and support with mapping and data analysis would also be of benefit. Financial audits are also costly and can consume a good portion of the budget.

Question: An audience member from the Swan Lake First Nation (Pembina River sub-basin) posed a question about how issues that are ongoing, such as the construction of a dam on Rock Lake or pipeline development despite opposition, fit into the picture. There are a lot of pipelines going through the basin but this was not mentioned by any of the panelists. How can communities protect water when there is such heavy pressure from industry? Are there any agreements or MOUs between the NGOs and Enbridge or TransCanada in the event a pipeline bursts for example? In response, the RRBC has facilitated some of discussions between the IJC and provincial and state departments pertaining to the Pembina River and has established a team to look at flooding issues on the Pembina River. Otherwise, the RRBC is not involved with pipeline development as it involves a group of agencies that focus on energy and not water matters.

COMMUNITY-BASED MONITORING

Lake Winnipeg Community Based Monitoring Network – Chelsea Lobson, Lake Winnipeg Foundation

The Community-Based Monitoring (CBM) session opened with Chelsea Lobson, Lake Winnipeg Foundation (LWF), who provided an overview of the LWF's CBM program for phosphorus. Recognizing the importance of community-level engagement as a solution to issues of water quality, the LWF developed the CBM program. The Program was derived from the LWF's Health Plan, a set of eight evidence-based actions to address the causes of eutrophication in Lake Winnipeg. Specifically, CBM falls under the actions of Monitoring our Waterways (Action 4) and Setting the Standard for Wastewater Treatment (Action 3).

The pilot CBM program was launched in 2016 and within three years has grown from working with two conservation districts to eight, and from 200 samples taken (nine sites) to 1,000 samples (over 100 sites). Highlights of this program include frequent sampling during the spring melt period and after large rain events to capture pulses of nutrient runoff. It also identifies hot spots for phosphorus and, when feasible, sampling is carried out at flow stations in order to calculate phosphorus loading in addition to concentration. Generating credible data renders it more useful for decision-making. In that regard, measures have been taken to ensure that the sampling protocol is consistent, field audits and inter-agency comparisons are performed, and the analyses are conducted in a federal laboratory.

One of the key findings to date confirms that high runoff events are high phosphorus events and water retention in high export areas would be of benefit. There is also considerable spatial variation among the sub-basins and identifying areas of low vs high export will help target remedial efforts. To date, the data has been used by conservation districts to help define projects and in funding applications, and by others to validate trend analysis and modeling. Data is available on CanWIN and DataStream. The future looks bright for the program as new partners continue to show interest including the Manitoba Metis Federation, new conservation districts and academia. The program will also expand to the Winnipeg River system and Dauphin Lake and will be used to monitor some BMPs involving water retention.

Question: Was mostly related to the geographic extent of the program and opportunities for partnerships beyond Manitoba. The program is expanding to Ontario and there is interest in Saskatchewan; up and downstream of Swan Lake, Manitoba is also being sampled. Individuals are welcome to become volunteer samplers.

Manitoba Métis Lake Winnipeg Basin community-based monitoring program – Fisheries Minister, John Parenteau, Manitoba Metis Federation

One of the LWF's partners in the CBM program is the Manitoba Metis Federation (MMF), which leads into the second speaker in this session, Fisheries Minister John Parenteau. The MMF is the official representative of the Manitoba Métis community; the Métis are one of Canada's three rights holding Aboriginal peoples.

The Métis have a strong connection to land and water and in order to protect their rights, the MMF needs to address environmental issues concerning natural resources. The MMF also has much to contribute, including Traditional Knowledge (TK), to solving environmental issues. Combining TK with western science leads to more

holistic solutions. There is also a large rural Métis community with strong connections to water, representing a knowledgeable and interested resource to engage in water stewardship.

The MMF has a long history in water conservation, fisheries projects, and CBM, including the Métis Community-based Climate Monitoring Program, which will function in conjunction with the Métis Guardians Program to help protect the Boreal forest. The Manitoba Métis Lake Winnipeg Basin CBM program is delivered in partnership with the LWF and is being funded by the LWBP. It includes both a sampling program and a TK study that includes interviews and community meetings.

COLLABORATION IN THE BASIN

First Nations Conservation, Protection and Restoration (CPR) of the Lake Winnipeg Basin – Cheyenne Thomas, Assembly of Manitoba Chiefs

Cheyenne Thomas, Assembly of Manitoba Chiefs (AMC), provided a brief overview of the CPR project, which has numerous facets. First, the AMC plans to start a Water Council with Indigenous communities in the Lake Winnipeg Basin. There are plans to create an Indigenous story of *Zaaga'igan Winibe* (Lake Winnipeg) based on legends and stories of the lake from Elders and community members. A two-day regional gathering is being planned to bring together representatives from communities to discuss how First Nations can start using their own techniques to save Lake Winnipeg. Another aspect of this project is to produce an Indigenous narrative from land-based cultural camps held during a canoe trip along Lake Winnipeg. An Indigenous mapping project is also being planned to map the territories of different communities from the Indigenous perspective using different media such as photography, song, dance, writing and video. Ojibwe, Dene and Cree will play an important part in storytelling. The data collected during this project will represent Indigenous perspectives that can be used adjacent to western science in helping conserve, protect and restore Lake Winnipeg.

Collaborative Leadership Initiative – Merrell-Ann Phare, Centre for Indigenous Environmental Resources

The presenter, Merrell-Ann Phare, Centre for Indigenous Environmental Resources (CIER) was accompanied by two partners in the Initiative—Colleen Sklar, Winnipeg Metropolitan Region (WMR) and Frances Smee, Reeve of the Rural Municipality of Rosser.

The Collaborative Leadership Initiative (CLI) is funded under the Collaborative Governance Pillar of the LWBP. Governance is decision-making by those with authority to make decisions on behalf of those they represent. This project focuses on how various governments can work together, despite their differences, to achieve positive outcomes for water. An important driver for this project is the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) as well as reconciliation. Indigenous people are often not included in decision-making about water, despite Indigenous water rights. This project works toward reconciliation and

implementing UNDRIP by having all governments, including Indigenous governments, participate in cooperative decision-making around water. In other words, collaborative consent.

Collaborative consent is "an ongoing process of committed engagement between Indigenous and non-Indigenous governments to secure mutual consent on proposed pathways forward". It is about changing the way that decisions are made.

The CLI started with a partnership between three organizations—CIER, the Southern Chiefs' Organization (SCO) and the WMR—and involves all locally elected official within a 200 km radius from Winnipeg for a total of 26 Chiefs, Mayors and Reeves participating to date. The big question driving the process is "how do we work together?" The premise is that if elected leaders within this circle could make just one positive, consistent decision about water regionally, it could have positive impacts on Lake Winnipeg.

The process began without knowing where it would end; however, it did follow a structure that was guided by three Elders. Leaders came together for four themed meetings—Observing Our Worlds, Building a Common Understanding, Envisioning the Future, and Forging the Partnership—and at the final meeting would decide if they wanted to work together. On March 1st, 2019 all 26 leaders committed to a four-year inter-governmental MOU to work together on issues of common concern with water being the primary issue, as well as waste management and economic development. The MOU was signed on Treaty 1 Territory at Lower Fort Garry, which is the location of the original Treaty signing in 1871.

The next phase is to create a regional decision-making framework for both water and waste to improve Lake Winnipeg outcomes, as well as an action plan to identify specific activities and timelines. A digital and social media strategy is in development to help forge new partnerships.

Questions: An audience member asked if any priority areas have been identified. The answer was yes; within each community, a number of issues such as drainage, proper training for wastewater management and others have been identified. There is also an effort to find a framework that can be used to prioritize items to ensure that expenditures are optimized in terms of impact on water. Another question related to governments outside of the project boundary and if they are left out. A number of signatories are from outside of the project area; however, the project started where 70% of the population of Manitoba resides. Over time, this area will hopefully expand and, best-case scenario, will encompass the entire basin under an effective mechanism that allows collective decision-making.

Spirit of Water Event and One Basin, One Governance – Ted Priester, Red River Basin Commission

The scheduled speaker Grand Chief Jerry Daniels from the Southern Chiefs' Organization was not able to attend the Symposium, and Ted Priester (RRBC) provided some details about two collaborative projects between the RRBC and the SCO including the Spirit of Water Event and One Basin, One Governance.

At the RRBC's annual conference in 2018, the Spirit of Water event facilitated a gathering of 30 Chiefs from the SCO, Ministers from several ministries, the Mayor of Winnipeg, and numerous elected officials from multiple levels of government from both Canada and the U.S. The 30 Chiefs had an opportunity to talk about water and how Indigenous people fit into the conversation about water. Many of the Chiefs expressed the

sentiment that this was the first time that they felt heard at this level. The meeting represented the first step of an initiative called One Basin, One Governance, which essentially would include Chiefs representing Indigenous communities within the Lake Winnipeg Basin, including Indigenous leaders from all four of the U.S. states. The gathering would again provide the opportunity to be heard and talk about water from the traditional perspective. This event is planned in Winnipeg for September 2019.

Lake Winnipeg Indigenous Collective: for all future generations – Daniel Kanu, Lake Winnipeg Indigenous Collective

The last speaker in the Collaboration in the Basin session was Daniel Kanu, Director of the Lake Winnipeg Indigenous Collective (LWIC), who spoke about and the work that has done by the LWIC over the last five years since its inception.

Daniel reminded the audience that, although the dialogue is focused on problems, Lake Winnipeg is still a beautiful lake that sustains life and communities and is worth protecting. The sixteen First Nations around the lake have been doing that, even before the LWIC was formed, through Guardian programs, shoreline remediation, Indigenous protected areas, walks for water, and teaching youth through song and ceremonies. It was these initiatives that ultimately brought people together to form the LWIC.

The Vision for the Collective is to protect Lake Winnipeg and raise the voice of Indigenous peoples and perspectives on the lake. This perspective is long-term from both the past and into the future, to ensure that the lake continues to live for generations to come.

At present, efforts are focusing on building the Collective to become an independent organization. To that end, LWIC is looking to other Indigenous environmental NGOs across the country to gain insight into how they govern themselves. It is also strengthening collaborations with First Nations around the lake, as well as organizations working on Lake Winnipeg and with Indigenous governance. Youth play a key role in the LWIC – youth camps are one means to teach about the importance of Lake Winnipeg and to prepare them as future leaders. LWIC holds two annual steering committee meetings and is holding a Treaty and water-law workshop. LWIC is especially interested in not only collecting TK through surveys (three completed to date), but also in how it can be used in the broader governance of the lake alongside western science. Each type of knowledge has weaknesses as well as its own means to validate itself. Acceptance of this needs to happen in order to use them together. LWIC is also involved with the water quality monitoring through the LWF CBM program and the Métis Guardians program.

ACTION IN THE BASIN

Dana Hay (Senior Program Officer, LWBP) chaired the Action in the Basin session, which profiled projects funded through the LWBP beginning in the 2018-2019 fiscal year. The presentations were in a “lightning round” format to provide a brief overview; highlight early successes, challenges and gaps that may have been identified during the first year; and to share what is being planned in the future.

Seine-Rat River nutrient reduction through mapped and managed water retention - Jodi Goerzen, Seine-Rat River Conservation District

The Seine-Rat and Roseau watersheds are high nutrient contributors to the Red River and Lake Winnipeg and are considered "nutrient hot spots". The Seine-Rat River Conservation District (SRRCD) is now targeting these hot spots by strategically implementing nutrient reduction strategies, like water retention projects to reduce overland flooding, and demonstrating their effectiveness to sixteen partner municipalities, landowners and NGOs. A few of these natural infrastructure projects are highlighted below.

The Kismet Creek Animal Sanctuary water retention project used LiDAR to delineate the flow path and appropriate water storage areas to capture runoff before it enters the creek. This urban-based project involved the installation of reducers on culverts to slow down runoff from an expanded parking area. The project included the development of a water retention structure that reduced the flow from the parking lot into the Manning Canal by 80%. This equates to approximately five acre/feet of water. The Herschfeld project is more representative of the types of projects that the SRRCD does with landowners and farmers. The project involved the construction of berms to hold back water in a swamp network that the CD owns. LiDAR proved valuable in revealing the pre-project multi-directional flow of water caused by ridges and drains dug in the past. This project stores approximately 25 acre/feet of water.

Mapping plays a key role in all of these projects. The SRRCD acquired LiDAR in the spring 2018 and used it immediately, including the incorporation of the data in the Wetland Digital Elevation Model (DEM) Pond Modeler to develop flood risk maps. The CD used LiDAR for sustainable water management projects including 37 sites that were analyzed, 12 sites that were ground-truthed, 7 projects that were completed, and 70 acre/feet of water stored—this could not have been achieved in one year without this technology and funding from the LWBP. Future plans include cattail harvesting in partnership with the International Institute for Sustainable Development (IISD), partnering with the LWF in their CBM program, and continuing to demonstrate successes of well-managed surface water.

Use of soil amendments to reduce phosphorus release to floodwater from waterlogged, anoxic soils in Manitoba - Darshani Kumaragamage, University of Winnipeg

In the Prairies, the spring snowmelt period is often accompanied by prolonged flooding. Water saturated soils can become anaerobic, which in turn may increase the release of phosphorus from the soils to the overlying floodwater. The objective of this study was to determine how effective various soil amendments are at reducing phosphorus release from soils during flooding. Both laboratory and field studies were carried out to simulate flooding conditions.

Intact soil columns were collected from eight fields in intensive agricultural areas in the Red River Basin. These columns were amended with either alum or gypsum and incubated for eight weeks at 4^0C, replicating snowmelt conditions. The floodwater above the columns and pore water within the soil were sampled weekly for dissolved reactive phosphorus (DRP) concentration.

Results showed that, under the control conditions, DRP is released from soils even at low temperatures. Also, both alum and gypsum were effective in reducing the pore- and flood- water DRP in most of the soils, but the

variation among soils was considerable. Future plans for this work are to take it from the lab to the field, under real snowmelt conditions, and to use magnesium sulphate as a soil amendment. Also, a study aimed at identifying the mechanism will be pursued.

Questions: Is ferric chloride of interest as a soil amendment? The answer was no because it would change to ferrous chloride under the experimental conditions. In response to whether the soil amendment is a one-time application, it is currently not known. Does the alum move with the water? That will depend on the soil pH; with the typically high pH soils that are common in the area, it is not likely. There could be an agronomic benefit with magnesium but likely not alum.

Manitoba Conservation Districts Association Water Retention Program - Sean Goertzen, Manitoba Conservation Districts Association

The Manitoba Conservation Districts Association (MCDA) represents the 18 Conservation Districts in Manitoba. The objective of this LWBP funded project is for these 18 CDs to create a network of water retention sites over three years, whereby up to 5,000 kg of phosphorus per year will be held back as a result. Over 17 km of streambanks will also be stabilized, preventing erosion and nutrient runoff. These projects will also help communities adapt to climate change by retaining over one million cubic metres of water on the landscape and mitigating spring flooding. An additional 200 hectares (ha) of wetland habitat will also be restored or created. This project demonstrates how collaborative, targeted actions can be effective in reducing nutrient loading to Lake Winnipeg.

Site selection is based on a number of methods including the use of LiDAR. CDs work closely with landowners to select sites and agreements are signed—these agreements are for a minimum of 10 years, and often in perpetuity through caveats placed on the land title. Following this is surveying, designing, licencing and then construction. Sites are monitored and evaluated over time to determine their effectiveness for the intended purpose, as well as to verify the integrity of infrastructure. Ongoing communication with the landowners is also important in the long term.

After one year, 17 of the 40 sites are completed and three are partially completed. This equates to 283,000 m^3 of water retained on the land, over 120 ha of wetlands, 6.4 km of protected streambanks, and 790 km of the drainage area impacted. Another less tangible but equally important outcome of this project is that it also has been success at breaking down silos. On this project alone, 18 CDs are working with over six government programs and dozens of landowners and municipalities. In addition, the MCDA is serving as a hub between two levels of government and the 18 CDs, which allows more efficient communication and allocation of funding on an as-needed basis.

Questions: An audience member suggested that it would be worthwhile on some of these retention projects to start monitoring at least one if not two years before the project to determine the extent of change in concentration. Even better would be to calculate the loads in and out, but that is much harder to

accomplish. Another audience member asked what the appetite is to include cattail harvesting in these projects to increase nutrient removal. In response—anything that will result in more nutrient capture the better and the MCDA will consider this suggestion.

The Nutrient App: Promoting beneficial management practices acceptance through on-farm instantaneous community-based nutrient sampling - Diogo Costa, Global Institute for Water Security, University of Saskatchewan

This project involved the development and testing of a new app that measures local nitrate and phosphate with the potential for measuring other parameters in the future. The ultimate goal is to support BMP adoption through on-farm community-based nutrient sampling using the Nutrient App.

The procedure involves using Hach nitrate test strips or API phosphate test kits on a water sample, launching the app, and taking a photograph of the test result. The concentration is then calculated based on colour and the data is uploaded to a map or database. The measurement range for nitrate is 0–50 mg/l and for phosphate 0–10 mg/l. By enhancing the accuracy of affordable, readily available instantaneous colorimetric test kits, the cost per sample is only $1. An April 2019 launch date is anticipated for the app. Future work will finalize the app's interface, field test a variety of water samples (well, wetland, river, lake), and further refinement of the prediction algorithms. Partners include the Prairie Water Project, South Central Eco-Institute and Clavet Research.

Enhancing Indigenous Engagement Training Workshop - Wanda McFadyen, Assiniboine River Basin Initiative

ARBI has been actively engaged with First Nation communities since its inception. There is a designated representative from each jurisdiction on the ARBI board ensuring participation at the table. ARBI is also a partner in the Southern Chiefs' Organization and Red River Basin commission's Memorandum of Understanding signed at the "Spirit of Water" event in 2018 (described above) recognizing the importance of water and the need and desire to collaborate.

To further strengthen the relationship with First Nation and Tribal communities, ARBI hosted a workshop in December 2018. The primary topics of discussion were Treaties, the *Indian Act* and engagement, allowing participants to gain a better understanding not only of history but challenges faced by Indigenous communities today. It also provided knowledge on how to engage with First Nation communities on water projects. ARBI will continue to actively dialogue with communities in order to learn, build trust, and develop deeper relationships that forge lasting partnerships for the stewardship of water.

Manitoba Non-Point Source Nutrient Reduction - Stephen Carlyle, Manitoba Habitat Heritage Corporation

This two-year project is in partnership with Ducks Unlimited and involves the restoration and retention of 40 ha and 432 ha of wetland, respectively. The retention will be achieved through conservation easements (agreements) that protect the habitat in perpetuity. Similarly, the restorations are often done under easements but also under 10-year contracts. The LWBP funding supports the restoration component of the project.

This year alone, 354 ha of wetland retention was achieved. Wetland restoration objectives of the project have been surpassed with 53 ha of wetlands restored. This will result in 4.02 kg/ha/year of sequestered phosphorus and 15.17 kg/ha/yr of sequestered nitrogen. Ultimately, it is estimated that this project will result in the retention of approximately 18,000 kg of phosphorus.

Engaging grain and oilseed producers can be a challenge due to the private cost associated with restoring wetlands instead of draining them to produce crops. One of the challenges to restoring wetlands is that landowners that are further from the lake may not see the direct impacts of draining wetlands, and as such, greater effort is required to convince landowners of the benefits to retain and/or restore wetlands. However, these projects also provide opportunities to engage with beef producers about conservation farming approaches. New Provincial wetland policies draft regulations include an expedited process for licencing wetland restoration projects, which will be of benefit to projects like this.

Question: What are the pros and cons of producers preferring to store water where it is convenient? It depends on the project—to enhance waterfowl habitat, numerous smaller wetlands are better. However, for water retention capacity, one large wetland works well.

Lake Winnipeg Basin Integrated Capacity Inventory for use in an adaptive management framework - Karen Scott, Lake Winnipeg Research Consortium Inc.

Adaptive nutrient management within the Lake Winnipeg Basin poses challenges. It is a large area with multiple levels of government and a complex range of stakeholders. No single government department or NGO has the mandate or capacity to tackle it alone, especially when funding is cyclical and limited. Strategic partnerships are imperative in order to leverage experience and expertise, allocate limited resources, and learn and adapt together to create and maintain sustainable processes to manage water more effectively.

This project is a collaborative effort between the LWRC, IISD and LWF. The overarching goal is to enable more effective long-term coordination of existing efforts to improve water quality, in particular nutrient reduction, that are currently underway in the Lake Winnipeg Basin. In simply terms, this translates into who is doing what, where, when, why and how?

The objectives of the project are two-fold. First is to compile an inventory of organizational roles and outputs (institutional capacity) based on the arbitrary categories of Government, Research and Monitoring, Indigenous and Grassroots. Second is to use this inventory to identify elements that could be relevant within a general adaptive management framework for managing nutrients. This exercise will reveal gaps, redundancies, weaknesses, effective transferable practices, etc. from a more holistic perspective that reflects the needs of adaptive nutrient management—that is, a transparent and structured decision-making process whereby actions are pursuant to desired outcomes.

Redeploying water retention: Green infrastructure and phosphorus capture in the Lake Winnipeg Basin – Joey Simoes, International Institute for Sustainable Development

Joey Simoes (IISD) noted that the main purpose for water retention projects in Manitoba is to reduce spring runoff and improve wetland habitat. When water retention projects are poorly managed or abandoned,

they may become overgrown and less effective at flood mitigation and nutrient retention. They may even become sources of nutrients as plants die and decompose. This four-year project will redeploy abandoned water retention sites through green infrastructure[3].

This study focuses on the De Salaberry water retention site located in the Seine-Rat River Watershed, a known source of high phosphorus loading. The De Salaberry site is the largest in the SRRCD with a capacity of 376 acre/feet. The objectives are to monitor water in and out of the retention site and develop a hydrologic and nutrient transport model. This will be followed by creating green infrastructure and determining/evaluating BMPs for phosphorus reduction. In addition, the results of this study will be extrapolated to other potential sites, identified through an inventory, to evaluate the potential basin-wide benefits. These benefits may include flood storage performance, phosphorus capture and area of restored wetland among others.

NEXT STEPS

Canada-Manitoba Lake Winnipeg MOU, Adaptive Management Framework – Ute Holweger, ECCC

The day wrapped up by Ute Holweger who provided a brief summary of the Symposium sessions followed by a brief overview of the next steps that ECCC is taking. Immediate priorities include a Symposium summary report, continued development of Indicator Fact Sheets and the State of the Lake Report. She also acknowledged that more work needs to be done related to Indigenous engagement and the use of TK, including in the State of the Lake report. Moving forward, incorporating and using TK, as well as broader reconciliation efforts, is a priority for the federal government.

Regarding adaptive management, an Adaptive Management Subcommittee of the Canada-Manitoba MOU Steering Committee was formed this past year and is currently working with a consultant to explore case studies from other jurisdictions. This information will be used in conjunction with other pieces to decide on the direction to take, be it adaptive management, an ecosystem integrity framework or another approach.

At present, ECCC has a formal arrangement with the Manitoba government through the Canada-Manitoba MOU, which expires in 2020. To ensure ongoing collaboration, work has begun on exploring options for its renewal or replacement with another formal arrangement.

To close the Symposium, First Nation Elder John Letandre sang a song of gratitude—gratitude to the Creator; gratitude to the Bear who represents courage so we can each do what we can to preserve water; and gratitude to the Eagle, a symbol of love. Métis Elder Linda St. Cyr-Saric closed the Symposium with a prayer.

[3] Green infrastructure - An approach to water management that protects, restores, or mimics the natural water cycle.

APPENDICES

Appendix A. ECCC Symposium Agenda

Environment and Climate Change Canada | Environnement et Changement climatique Canada

Canada

Lake Winnipeg Basin Program Symposium
March 20, 2019
Qualico Centre Winnipeg, MB

AGENDA

1:00 pm	Opening Prayer Greetings	Elder John Letandre Elder Linda St. Cyr-Saric
	Welcome and Opening Remarks Greetings	Nadine Stiller, ARDG *ECCC* Honourable Catherine McKenna, *Minister of Environment and Climate Change* Terry Duguid, *MP Winnipeg South*
1:30 pm	Symposium Objectives and Lake Winnipeg Basin Program Overview	Ute Holweger, *ECCC*
1:45 pm	ECCC Science Plan Overview	Ram Yerubandi, *ECCC*
2:00 pm	Reporting on the Health of Lake Winnipeg and its Basin	Sharon Reedyk, *ECCC*
2:15 pm	What have we learned from In-Lake Science? • Nutrients and algal blooms • Nearshore Monitoring • Bathymetric Survey	Caren Binding, *ECCC* Elise Watchorn, *ECCC* Doug Watkinson, *DFO*
3:00 pm	Break	
3:30 pm	What have we learned about nutrient sources through watershed-based research? • Water Quality Monitoring • Human Influences in the Basin • Nutrient pathways and Landscape-based modelling • Nutrient Sources and Beneficial Management Practices	Elise Watchorn, *ECCC* Patricia Chambers, *ECCC* Luis Leon, *ECCC* Jane Elliot, *ECCC*
4:45 pm	Wrap-up and Overview Day 2	Ute Holweger, *ECCC*
5:00 pm	Poster Presentation Session	

Environment and Climate Change Canada | Environnement et Changement climatique Canada

Canada

Lake Winnipeg Basin Program Symposium
March 21, 2019
Canad Inns Destination Centre Polo Park Winnipeg, MB

AGENDA

8:30 am	Welcome	Nadine Stiller, ARDG *ECCC*
8:35 am	Recap of Day One and Overview of Actions in the Basin	Ute Holweger, *ECCC*
8:45 am	Transboundary Collaboration in the Basin • Prairie Provinces Water Board and International Joint Commission • Panel Discussion with Lake Winnipeg Basin Organizations	Mike Renouf, *ECCC* Ted Preister, *Red River Basin Commission* Wanda McFadyen, *Assiniboine River Basin Initiative* Todd Sellers, *Lake of the Woods Water Sustainability Foundation* Dr. Johanne Kristjanson, *Partners FOR the Saskatchewan River Basin*
10:00 am	Break	
10:30 am	Community-Based Monitoring • Lake Winnipeg Community-Based Monitoring Network: Data for decision-making and public engagement • Manitoba Metis Lake Winnipeg Basin Community Based Monitoring Program	Chelsea Lobson, *Lake Winnipeg Foundation* Representative from *Manitoba Metis Federation*
11:15 am	Collaboration in the Basin • Collaborative Leadership Initiative • Spirit of Water/One Basin, One Governance • Lake Winnipeg Indigenous Collective • First Nations Conservation, Protection and Restoration (CPR) of the Lake Winnipeg Water Basin	Merrell-Ann Phare, *Centre of Indigenous Environmental Resources* Grand Chief Jerry Daniels, *Southern Chiefs' Organization* Daniel Kanu, *Lake Winnipeg Indigenous Collective* Cheyenne Thomas, *Assembly of Manitoba Chiefs*
12:15	Lunch	

1:15 pm	Action in the Basin: Project Presentations	
	Seine-Rat River Nutrient Reduction through Mapped and Managed Water Retention	Jodi Goerzen, *Seine Rat River Conservation District*
	Use of soil amendments to reduce phosphorus release to flood water from waterlogged, anoxic soils in Manitoba	Darshani Kumaragamage, *University of Winnipeg*
	Manitoba Conservation Districts Association Water Retention Program	Sean Goertzen, *Manitoba Conservation Districts Association*
	The Nutrient App : Promoting beneficial management practices acceptance through on-farm instantaneous community-based nutrient sampling	Diogo Costa, *University of Saskatchewan*
	Enhancing Indigenous Engagement Training Workshop	Wanda McFadyen, *Assiniboine River Basin Initiative*
2:20 pm	Break	
2:50 pm	Action in the Basin: Project Presentations *(cont.)*	
	Manitoba Non-Point Source Nutrient Reduction	Stephen Carlyle, *Manitoba Habitat and Heritage Corporation*
	Lake Winnipeg Basin Integrated Capacity Inventory	Karen Scott, *Lake Winnipeg Research Consortium*
	Redeploying Water Retention: Green Infrastructure and Phosphorous Capture in the Lake Winnipeg Basin	Joey Simoes, *International Institute for Sustainable Development*
3:15 pm	Symposium Summary and Next Steps	Ute Holweger, *ECCC*
3:45 pm	Closing Prayer	Elder Linda St. Cyr-Saric Elder John Letandre

Appendix B. ECCC 2017-2022 Lake Winnipeg Basin Program Science Plan

Environment and Climate Change Canada
2017-2022 Lake Winnipeg Basin Program Science Plan

BACKGROUND

Lake Winnipeg is Canada's sixth largest lake; its basin spans four provinces and four states. The health of the lake is important to Canada's economy as the lake generates revenue in the hydroelectric, recreation and commercial fishery industries. The lake's current poor health, characterized in part by frequent harmful algae blooms, is due to excess nutrient loading, notably phosphorus and nitrogen, from multiple local and transboundary sources.

SCIENCE PRIORITIES

Building on previous efforts, science activities will focus on in-lake and watershed research to address knowledge gaps, improved monitoring networks to better inform decision making, and establishment of indicators to track progress towards achieving a healthy, sustainable lake ecosystem. Improving knowledge of nutrient export to streams and understanding the impacts of climate variability and zebra mussels on the nutrient balance in the lake are key focus areas.

BUDGET 2017

Canada's Freshwater Action Plan has allocated $25.7 million over five years to protect freshwater resources in the Lake Winnipeg Basin. One-third of this funding ($8.46 million) will directly support the science priorities. The remaining funds support targeted nutrient reduction by building increased capacity to protect freshwater through collaboration and enhancing indigenous engagement, and through on-the-ground action to implement nutrient reduction activities.

KEY MESSAGES

- Building on science delivered under previous Initiatives
- Focusing effort on key knowledge gaps and targeted areas of the basin
- Consider the impacts of climate variability and invasive species on the lake nutrient balance
- Completing timely reporting to assist with adaptive management

PHASE 1: LAKE CHARACTERIZATION TO SUPPORT NUTRIENT OBJECTIVES DEVELOPMENT

PHASE 2: WATERSHED BASED RESEARCH AND MODELING TO SUPPORT NUTRIENT MANAGEMENT

PHASE 3: TARGETED NUTRIENT RESEARCH AND MODELING TO SUPPORT NUTRIENT REDUCTIONS TO THE LAKE

PROJECTS	KEY DELIVERABLES
OBJECTIVE 1: MONITORING TO ASSESS STATUS AND TRACK CHANGE	
Monitor water quality in the Lake Winnipeg basin Coordinate with Province of Manitoba to monitor water quality of Lake Winnipeg Assess the state of the nearshore waters in Lake Winnipeg	**Implementation of monitoring activities in Lake Winnipeg and its key tributaries** • Water quality data of selected tributaries in the basin • Water quality data of the nearshore areas of Lake Winnipeg **Analysis, interpretation and reporting of aquatic status, changes and trends** • Calculation of nutrient loadings to Lake Winnipeg • Water quality status and trend assessments **OUTCOME:** An improved monitoring network, data to augment research and modelling activities , and analysis to report on status and trends to key stakeholders.
OBJECTIVE 2: RESEARCH ON NUTRIENT SOURCES AND TRANSPORT PATHWAYS TO STREAMS	
Develop watershed models to assess nutrient reduction scenarios Study sources and transport pathways of nutrients Evaluate effectiveness of BMPs Understand groundwater contribution to nutrient loading of streams Understand in-stream nutrient cycling through biological indicator assessment	**Assessment of impacts of climate variability on nutrient export to Lake Winnipeg** • Improved watershed models for BMP scenario testing under varied climatic conditions • Development of predictive relationships for N and P export under different BMP, climatic , and hydrologic scenarios • Recommendations for targeted BMPs (e.g. wetland drainage limits, restoration locations) **Quantification of nutrient sources and transport processes to Lake Winnipeg tributaries** • Field-verified estimates of nutrient loss to surface runoff from varied land management practices • New information for improved sewage effluent management • Significance of groundwater fluxes of nutrients to tributaries **Development of in-stream biological indicators to track nutrient loading to streams** • New information on nutrient up-take by in-stream biological organisms • Evaluation of ecological indicators for diagnosing cumulative impacts **OUTCOME:** Improved estimates of where and how nutrients are exported to key tributaries in the Lake Winnipeg basin to support targeted nutrient reduction activities.
OBJECTIVE 3: RESEARCH ON LAKE ECOSYSTEM COMPONENTS TO ACHIEVE A SUSTAINABLE NUTRIENT BALANCE	
Evaluate impacts of zebra mussels on Lake Winnipeg Use remote sensing to track algal blooms Understand influence of internal nutrient loading on algal blooms	**Quantification of in-lake processes affecting lake ecology** • Evaluation of impacts of zebra mussels on lake water quality and ecology • Refinement of the Lake Winnipeg water quality model to include impacts of multiple stressors • Near real-time reporting of algal blooms and annual reporting on bloom intensity, extent and duration • Improved estimates of sediment nutrient release • New data on sediment composition and optical properties of algae species **OUTCOME:** New knowledge on key processes affecting the lake nutrient balance to support adaptive management of the lake.
OBJECTIVE 4: REPORTING ON PROGRESS TOWARDS RESTORING A HEALTHY LAKE WINNIPEG	
Synthesize and report on the State of Lake Winnipeg science	**Development and reporting on the State of the Lake** • Identification of key ecological , social and economic indicators of lake health • Publication of indicator fact sheets • Development of State of Lake Winnipeg Update Report • Ensuring open access to monitoring data **OUTCOME:** Increased awareness and understanding of the health status of Lake Winnipeg by its key stakeholders.

Appendix C. Projects supported under the LWBP 2018/19 Grants and Contributions.

Recipient	Project Title
Nutrient Reduction Projects	
Assiniboine River Basin Initiative Inc.	Assiniboine River Basin Initiative to Strategically Target Wetland Restoration Opportunities within Annually Cropped Farmland
Deerwood Soil and Management Association	Nutrient and Flow Reduction in Tobacco Creek Model Watershed
International Institute for Sustainable Development	Redeploying Water Retention: Green Infrastructure and Phosphorous Capture in the Lake Winnipeg Basin
Manitoba Habitat and Heritage Corp.	Manitoba Non-point Source Nutrient Retention
Manitoba Conservation Districts Association	Exploring Livestock Grazing as a Riparian Phosphorus Management Tool
Manitoba Conservation Districts Association	Manitoba Conservation Districts Association Water Retention Program
Red River Basin Commission	Netley-Libau Marsh Renewal
Seine-Rat River Conservation District	Seine-Rat River Nutrient Reduction through Mapped and Managed Water Retention
University of Saskatchewan (Pomeroy)	The Nutrient App: Promoting BMPs Acceptance through On-Farm Instantaneous Community based Nutrient Sampling
University of Winnipeg (Kumaragamage)	Use of soil amendments to reduce phosphorus release to flood water from water logged anoxic soils in Manitoba
Upper Assiniboine River Conservation District	Addressing nutrient pollution at its origins
Collaborative Governance Projects	
Assiniboine River Basin Initiative Inc.	Transboundary Events in the ARB
Center for Indigenous Environmental Resources	Collaborative governance as a reconciliation process in the Winnipeg Metropolitan Region and the south of Lake Winnipeg
Lake of the Woods Water Sustainability Foundation	Enhancing Capacity for Collective Governance in the Lake of the Woods Basin

Lake Winnipeg Foundation Inc.	Lake Winnipeg Community Based Monitoring Network: Data for Decision Making and Public Engagement
Lake Winnipeg Research Consortium	Lake Winnipeg Basin Integrated Capacity Inventory
Indigenous Engagement Projects	
Assiniboine River Basin Initiative Inc.	Enhancing Indigenous Engagement Training Workshop
Assembly of Manitoba Chiefs	First Nations CPR of Lake Winnipeg Water Basin
Grand Council Treaty #3	Treaty #3 Watershed Management Plan
Lake Winnipeg Foundation Inc.	Lake Winnipeg Indigenous Collective: Building Capacity, relationships and representation
Manitoba Metis Federation	Manitoba Métis Lake Winnipeg Basin Community-Based Monitoring Program
Manitoba Conservation Districts Association	Building watershed resilience through partnership, collaboration, sharing and capacity building with Manitoba's First Nations and
Red River Basin Commission	One Basin, One Governance

UPDATE: Since the Symposium, 2019/2020 Lake Winnipeg Basin Program projects have been approved. A list and description of the projects are posted on the Lake Winnipeg Basin Program website.

Appendix D. What We Heard – Evaluation Summary

Topics or aspects of the Symposium you found most interesting or useful?

- Overview of Grant and Contribution Projects
- Appreciated having the Indigenous voice represented and hearing about the community engagement that has taken place to date
- Networking and information sharing
- Science work overview
- Project presentations on nutrient reduction & mitigation

What could be improved for another time?

- More Indigenous participation as there was a lot of discussion on Indigenous collaboration but few Indigenous representatives attended
- More youth involvement and engagement
- Wider variety of projects and presentations

Comments and suggestions (including topics or initiatives you would be interested in hearing about next time)

- Include a component to collaborate on LWB programs, gaps, opportunities, etc
- Several participants mentioned that they would like to see a presentation on Traditional Knowledge interfaced with Western Science. A way to learn about the health of the lake from a traditional knowledge perspective, as well as find some sort of way to bring the western science perspective and the Indigenous teachings/ traditional knowledge together.
- Update from the Manitoba government and other federal programs
- Include information on other impacts to the lake and how they relate to LWBP (climate change, fisheries, invasive species, etc)
- Have an opportunity for participants to express where they want stronger connections/ engagement so the event is more than information sharing
- A suggestion was made to use the Lake Winnipeg Symposium as a forum to identify opportunities for students both within government and with other organizations that focus efforts on Lake Winnipeg.
- More information on topics such as: Netley-Libau Marsh Research, collaborating on the Adaptive Management Framework & ecosystems, uses of LiDAR, Discussion history of Indigenous water rights, Continuous monitoring with low cost tools and devices, phosphorus recycling on the landscape; what Alberta & Saskatchewan are doing with basin health