Summary of Research Progress

May 2023

"Partnerships and tools for water resilient prairie communities"

A wetland near Shamrock, SK, summer 2019.
Anthony Baron, PW Wetland Survey Team

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1. Introduction

Prairie Water is a research project under Global Water Futures with the vision to gather and create "useable knowledge to build resilient communities by ensuring sustainable watershed management and governance on the Canadian Prairies". To achieve this vision, we have built partnerships with people and organizations invested in water management. These partners have also invested their time in guiding and collaborating on our research.

Vision

Usable knowledge to build **resilient** communities by ensuring **sustainable watershed management** and **governance** on the Canadian Prairies.

At the Annual Partners Meeting (APM) in 2022, our goal together was to provide a solid foundation for developing practical outlets for Prairie Water research. Since then, we have moved forward to meet the suggestions and requests of our partners. The theme for the recent 2023 APM was "Partnerships and Tools for Water Resilient Prairie Communities". We focused on presenting tools as vehicles for getting our research results into the hands of people that can use them. This was the first time we presented in detail the Prairie Hydrology Design and Analysis Product (PHyDAP) and Data Visualization Dashboard (DVD) tools in front of this audience.

Thank you to all who attended, registered, and showed interest in 2023 APM for Prairie Water! Meeting in-person was exciting and allowed us to reaffirm our relationships with our partners. The feedback from those who attended is highly valuable; however, we know that not all of our partners were able to attend. For the benefit of all partners, we wish to present the following written update of our progress. Following this update, we invite everyone to participate in an online survey to add to the feedback we received at the in-person Partners Meeting.

If you do not have access to any journal articles, please reach out to prairie.water@usask.ca to get a copy

2. Project status report

2.2 Overall progress of Prairie Water

We are now entering the final stage of the Prairie Water project. Many of our students, post-docs and technicians have completed their research with us and moved on to new opportunities. Our present activities focus heavily on research integration and knowledge mobilization, along with completing some core research activities. We are exploring opportunities with partners to understand how we can craft and share our research outputs in useful, and usable ways (feel free to share your ideas in this survey). Highlights of our overall progress to date include:

- Biophysical classification of small Prairie basins (Wolfe et al. 2019), serving as a foundation for a virtual basin modelling framework used by Team A and Team B (Figure 1).

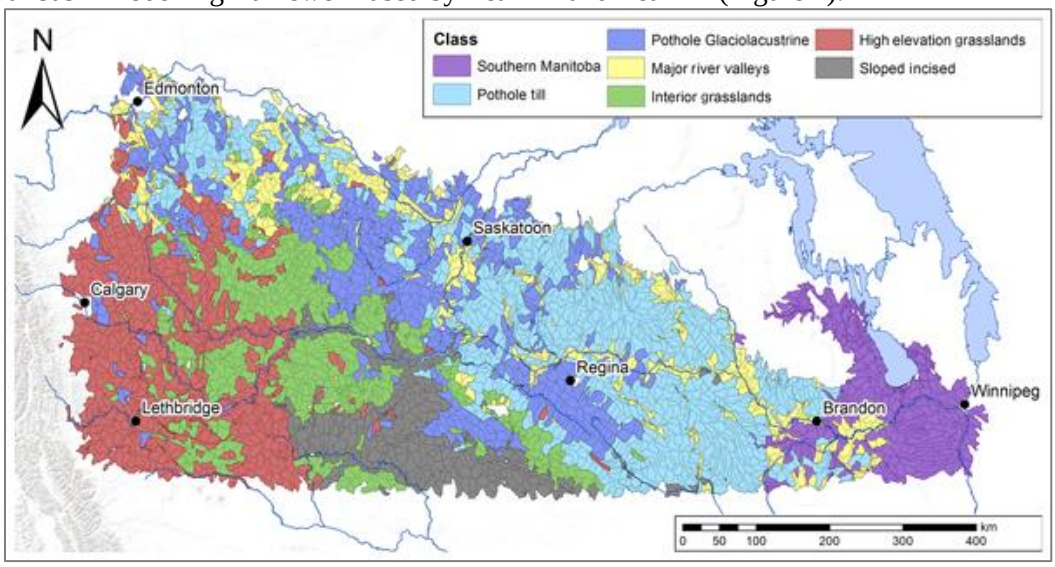

Figure 1: Prairie watershed classification, Wolfe et al., 2019 (Larger image).

- A virtual basin framework for modelling surface hydrology across the region, that provides a platform for integrated modelling of watershed response to climate and land management scenarios.
- Partner engagement to design and test pilot applications of our decision-support outputs (e.g. 2021 virtual workshop and 2023 Annual Partners Meeting tool workshops)
- Synthesis of the state of western science on expected impacts of wetland drainage in the Canadian Prairies (Baulch et al. 2021).
- Collaborations with multiple artists who have created work capturing Prairie Water research, including pieces installed at the National Hydrology Research Centre (link), shared through GWF's Virtual Water Gallery (link).
- Development of a tool for economic assessment of wetland conservation costs.
- Presentation of our research through a growing number of meetings, webinars and workshops organized by organizations in Saskatchewan and across the Prairies (e.g. New User Focused Tools to Support Water Management Decisions).
- Growing connections to network of Prairie stakeholders and rightsholders.

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2.1 Update on tools presented at the APM

PHyDAP – Prairie Hydrology Design and Analysis Product

Flows and flooding in Canadian Prairies are changing due to effects of changes in climate, land use, and drainage. When the Prairie Water project started, no tool existed to answer questions about how return-period flows or local-scale flooding might change in the future. The Prairie Water team developed PHyDAP to fill this information gap.

- PHyDAP hydrological data can be used as inputs for your chosen hydraulic model (e.g., PCSWMM, SWMM5) to design structures like culverts (Figure 2).
- PHyDAP datasets are now available online at the Federated Research Data Repository (Shook et al., 2023). For additional information on PHyDAP, read the 2021 Workshop Report or read our summary page.

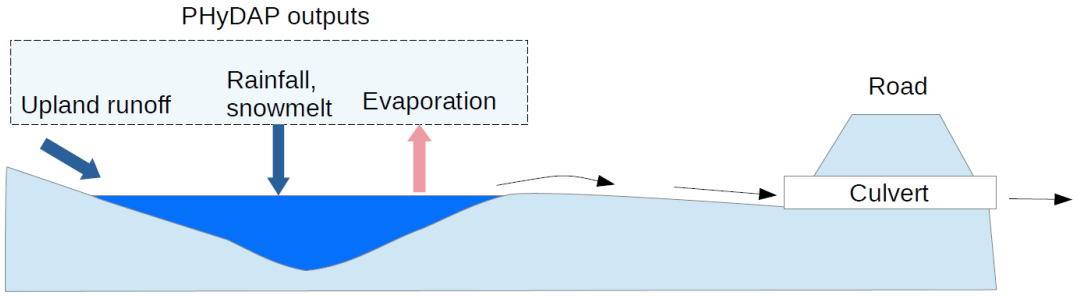

Figure 2: Conceptual figure showing how PHyDAP outputs (upland runoff, rainfall, snowmelt, and evaporation) are important for designed a downstream culvert.

Data Visualization Dashboard

The Dashboard was presented at the Annual Partners Meeting, February 2, 2023 in an interactive session guided by Colin Whitfield. People grouped up and explored the Dashboard on laptops. Right now, the Dashboard has these functions:

- View spatial data on interactive map, including prairie basins and their classes, pesticide exposure, and ground water recharge rates for Alberta
- View time series of basin flow and soil moisture for individual basins (Figure 3)
- Compare time series of basin flow and/or soil moisture for up to four scenarios of different precipitation and temperature levels
- Currently, the tool is being moved to a faster server and refined according to feedback from the APM.

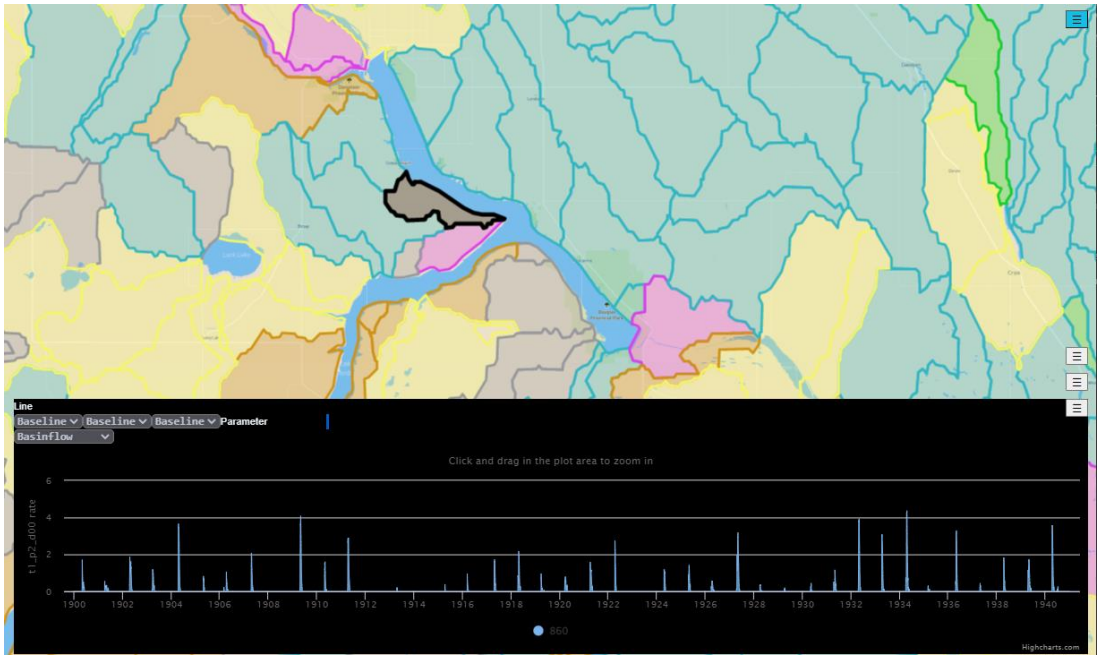

Figure 3: Screenshot of the Dashboard. A prairie basin near Diefenbaker lake is highlighted and time series of basin flow for this basin class is show on the bottom.

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2.3 Team A progress – Water Availability

The Water Availability Team continues to make progress in several areas. Groundwater hydrology studies in Alberta have shown the importance of topographic depressions for groundwater recharge. This is significant as we have also found that deep groundwater in the prairies is not well connected to surface hydrology. The basin classification and virtual modelling framework has allowed us to assess potential impacts of drainage and climate change on streamflow regimes (Spence et al. 2022a and Spence et al. 2022b) which improves on existing hydrological modelling techniques, and can support better hydraulic design. Studies of historic and existing oil wells are shedding light on their risk to groundwater. These studies highlight that current groundwater monitoring and investigations are not adequate to assess the risk of contamination. Our research outputs and activities include:

- Estimated the contribution of topographic depressions (potholes) to groundwater recharge over southern Alberta (Manitoba Cooperator) and the effect of climate change on recharge rates (Western Producer and Negm et al. 2021). We are currently working on extending the groundwater recharge model estimates to Saskatchewan.
- Found that shallow injection wells operated by the oil industry in south-east and west-central Saskatchewan may pose a risk to overlying groundwater supplies (Jellicoe et al. 2021).
- Completed a preliminary assessment of groundwater resources in the Prairies that suggests much of our groundwater is thousands of years old and not well connected to the surface and near-surface hydrologic cycle (Figure 2).
- Conducted a proximity analysis of spills from the oil industry and groundwater users in Saskatchewan; most spills occur within 1 km of a water well.
- Completed an analysis of abandoned oil wells revealing that older wells may pose a risk due to changes in abandonment standards over time (Perra et al. 2021).

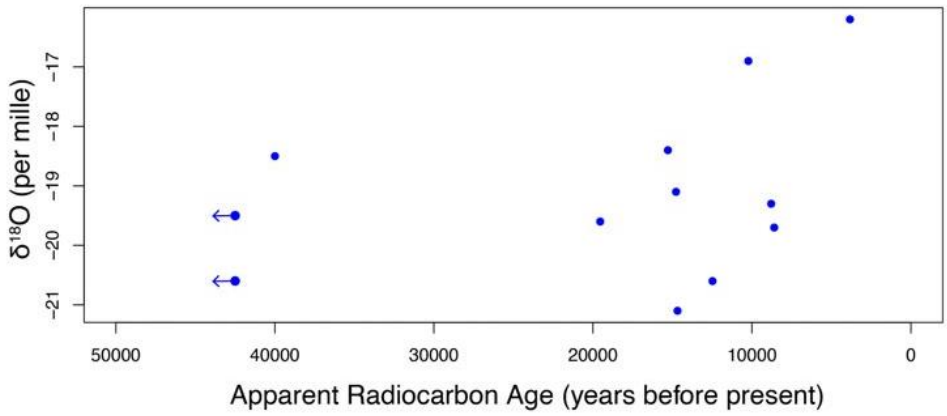

Figure 2: Investigation of radiocarbon dated groundwater ages in Saskatchewan Water Security Agency monitoring wells using delta oxygen-18 ($\delta^{18}O$) as a proxy for temperature. Lower $\delta^{18}O$ values indicate colder climates.

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- Applied the virtual basin modelling framework to assess the:
  - Effects of wetland drainage on surface runoff in different climate conditions for the Pothole-till watershed class (Spence et al. 2022b)
  - Impact of warming (temperature increase) on hydrology of grassland basins in the Prairie Pothole Region (Spence et al. 2022a).
  - Effects of wetland management on extreme streamflow for the different Prairie basins (Figure 3).
  - Combined impacts of wetland drainage and changes to climate on streamflow regimes in the Prairie Pothole Region (manuscript in preparation).

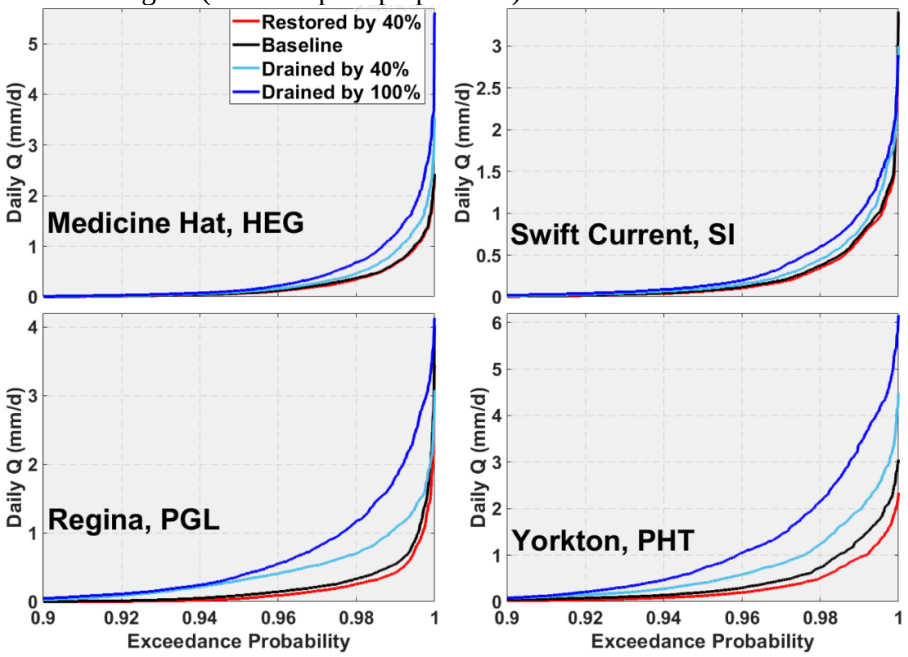

Figure 3: Effect of wetland drainage or restoration scenarios on daily flows (Q) in four different Prairie basins. Basin classes are: high elevation grasslands (HEG), sloped incised (SI), pothole glaciolacustrine (PGL), and pothole till (PHT). See map of Prairie basin classes (Figure 1).

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2.4 Team B progress – Aquatic Ecosystem Health

To date, our work on wetlands and aquatic ecosystem health has brought us a long way towards our initial goals. Many of these efforts are summarized below, and some new work (e.g. on pothole salinity) is underway. In the remaining stages of the project, we will work to connect the virtual modelling scenarios of surface hydrology with emerging information on aquatic ecosystems (biogeochemical and biodiversity data). This integration will allow us to explore how anticipated changes in hydrology associated with climate change can affect, for example, aquatic ecosystem services. Our integrated modelling is being expanded from the Pothole Till class to other watershed classes, and modelling outputs are being integrated in the data visualization tool presented at the APM.

- In Alberta, climate changes that yield progressively warmer, wetter conditions are benefiting some bird groups, while riparian vegetation can buffer negative impacts of climate and water quality gradients on macroinvertebrate biodiversity (Mantyka-Pringle et al. 2019).
- Investigation of total phosphorus concentrations in streams for small and moderate-sized basins in different watershed classes shows substantive regional variability (Figure 5).

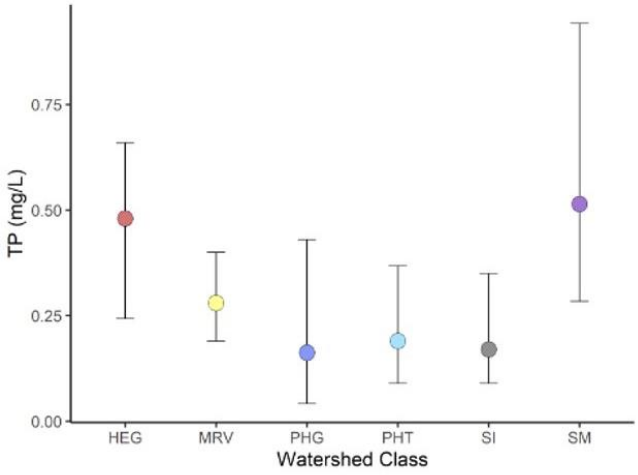


Figure 5: Total phosphorus concentrations in streams by watershed or basin class. Watershed classes are: high elevation grasslands (HEG), major river valleys (MRV), pothole glaciolacustrine (PHG), pothole till (PHT), sloped incised (SI), and Southern Manitoba (SM). See Figure 1 for map.

- Spatial analysis through wetland survey suggests potential links between land use and P levels in pothole ponds (McFarlan 2021, thesis).
- Nitrogen process rate measurements suggest pothole ponds have more limited capacity to remove nitrogen than previously thought, but are sites of extremely rapid nitrogen cycling (Hergott 2022, thesis).

- Analysis of changing agrochemical use in Canada over 35 years highlights increases in fertilizers (21%), fungicides (412%), herbicides (58%), and insecticides (52%) applied in the Prairie Region (Malaj et al. 2020a)
- Created an index for robust estimation of potential Prairie wetland pesticide exposure, highlighting areas vulnerable to contamination (Malaj et al. 2020b), and are now exploring how this index may be impacted by future change in climate (Figure 6).

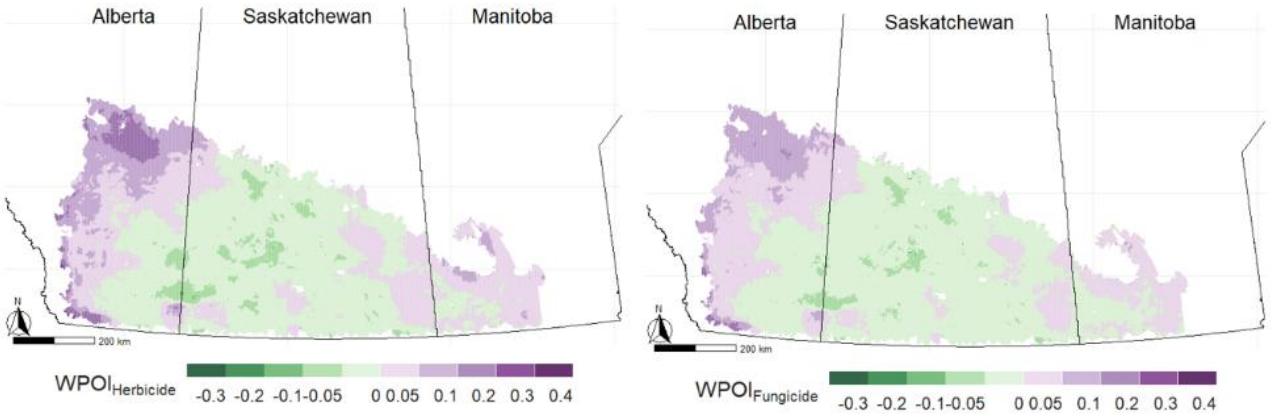


Figure 6: Projected changes in Wetland Pesticide Occurrence Index (WPOI) for herbicides and fungicide in a future climate scenario (2041–2060) compared to the baseline scenario (1981–2010).

- Found that simplified agricultural landscapes containing proportionately more cropland have increased in the last 20 years and are a strong predictor of rising pesticide use in the Prairies and Central regions of Canada (Malaj and Morrissey 2022).
- Integrated modelling work highlights complex effects of drainage on ecosystem services in the Pothole Till basin class, including potential for elevated nutrient export (Figure 7) and pronounced loss of riparian birds at low wetland drainage levels (Figure 8).

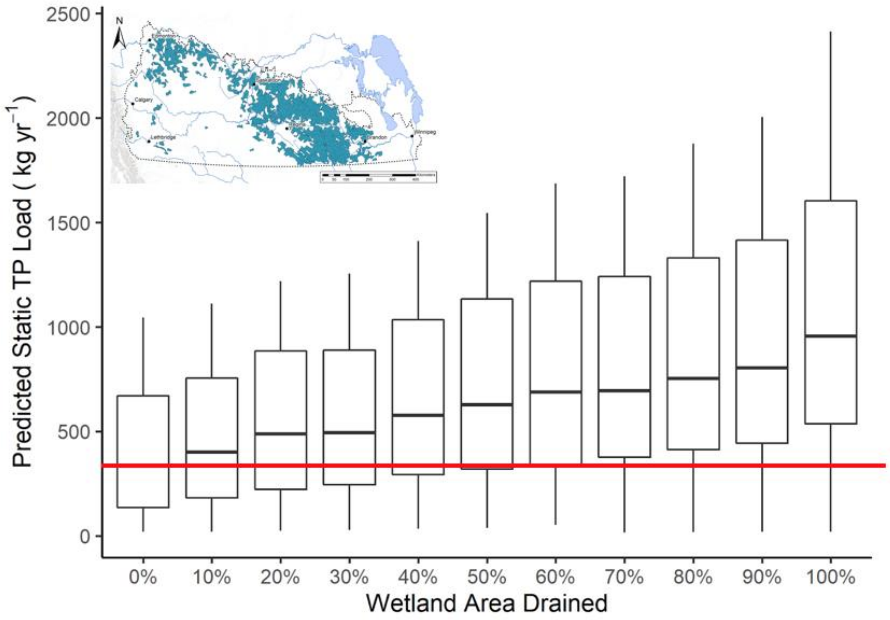


Figure 7: The modelled effect of wetland drainage on total phosphorus (TP) load or concentration in surface runoff for the Pothole Till basin class.

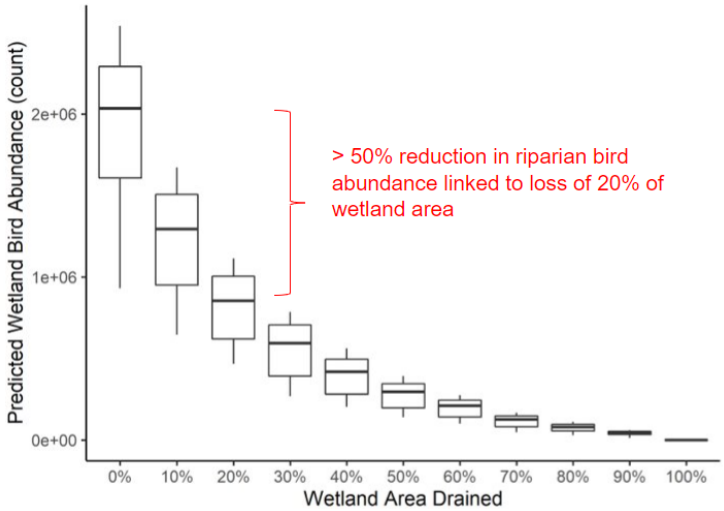
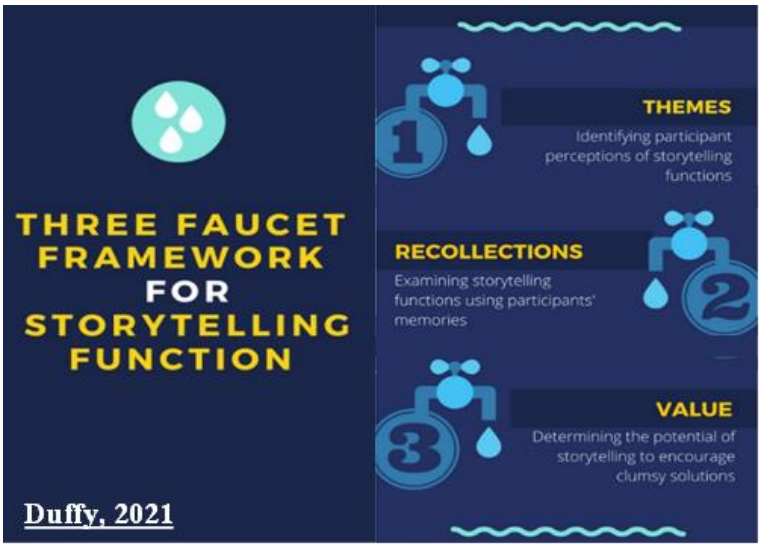


Figure 8: The modelled effect of wetland drainage on bird abundance for the Pothole Till basin class.

2.5 Team C Progress – Water Management Practices and Governance

The Water Management Practices and Governance team has been making steady progress toward the projects' goals. To better understand decisions involving water resources on the prairies, we have been developing participatory models, conducting economic analyses, implementing large-scale surveys, coordinating experimental decision labs, and conducting interviews. We are currently working on integrating our analyses with the other teams. Highlights of our work include:

- Developed wetland conservation cost curves for an Alberta watershed to understand the spatial differences in wetland conservation costs and how these costs are associated with wetland classes (Asare et al. 2021)
- Working version of a wetland conservation costs assessment webtool that allows users to input their own field or landscape level data (tool refinements in the works).
- Surveyed 450 producers across the three Prairie Provinces in 2021 to better understand land-use decisions involving wetlands and preferences for conservation policy options.
- Examined how participatory modelling and mapping can enhance social learning for disaster risk reduction in Indigenous communities (Thapa 2020, thesis)
- Developed Three Faucet Framework to demonstrate how stories, especially those told in informal settings, impact source water protection planning and implementation (Duffy 2021, thesis)

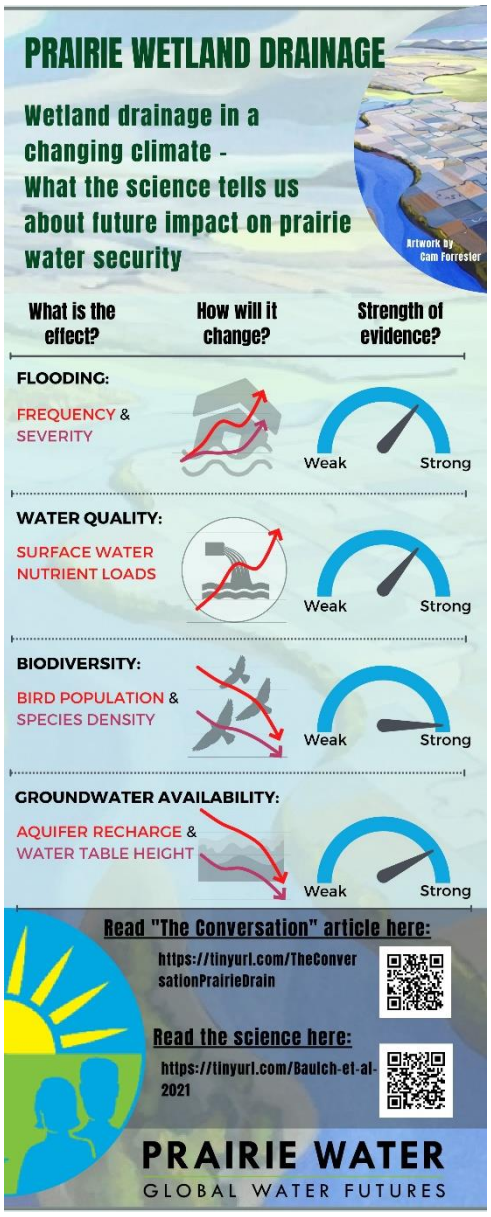


- Preliminary analysis shows that experimental decision labs highlight different preferences for information selection among individuals and groups, but they do not appear to have significantly influenced individual or group choices about adaptation options.
- Systematic review of relevant policy documents for water security on the Prairies is ongoing.
- Analysis of environmental crisis response highlighted that First Nations input on policy and reduction of bureaucratic hoops are needed to accelerate emergency processes (Kurt Belcher, thesis in progress).

2.6 Communication and Knowledge Mobilization

Up to now, Prairie Water's communication and knowledge mobilization has focused on connecting with partners at annual meetings and engaging with the Advisory Committee. During the last two years the Prairie Water team has presented at more webinars and meetings than during the start of the project, reflecting the stage of Prairie Water. Past knowledge mobilization activities and future plans are described below.

- Mapped out knowledge mobilization networks (APM 2022 report) specific to the prairies.
- Created three infographics to communicate key findings of Prairie Water:
  1) different watershed types across the prairies
  2) wetland drainage in a changing climate (see left)
  3) wetland bird diversity and abundance
- Presented a series of Prairie Habitat Joint Venture (PHJV) webinars about Prairie Water science, tools (PHyDAP, Data visualization dashboard), and contributions for decision making (link).
- Collaborated with the Water Security Agency (WSA) on AgH2Onward project and attended recent workshops hosted by WSA to develop Saskatchewan agriculture water management policy.



We plan to expand our methods of knowledge mobilization as much as possible and are currently developing a knowledge mobilization plan to see us through to the end of Prairie Water. Our planning is informed by guidance we received from the 2022 Annual Partners Meeting (report):

- Prioritize plain English reports, data catalogue, and social media presence.
- Utilize the existing network of partners for direct and indirect mobilization.
- Recognize challenges associated with knowledge mobilization (see Table 2, Annual Partners Meeting Report 2022).
- Work to fill gaps in the existing network. Gaps include: senior government decision-makers, municipal government associations, and Indigenous groups.

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3. Next steps and survey

Prairie Water is entering its final year. Looking forward, we are focusing on identifying specific groups with interest in targeted Prairie Water outcomes, to help effectively share our work. We are also considering how to carry forward this research and these partnerships *beyond* the Prairie Water project. Resilience to the real water challenges faced in the Prairies is not a one-time research goal, but something that requires continuous learning, adaptability, and cooperation.

As always, we welcome your input. To provide feedback on our 2023 APM, emerging research and knowledge mobilization activities please complete the survey, or reach out to us anytime at prairie.water@usask.ca.