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**Global Institute for
Water Security**

U S A S K

FROM RESEARCH TO IMPACT:

Canada's National Freshwater
Science Agenda and Universities



**REPORT TO
ENVIRONMENT AND
CLIMATE CHANGE CANADA**

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This workshop took place on Treaty 6 Territory and the Homeland of the Metis. We pay our respects to the original inhabitants and stewards of this land. Let our respect for and relationship to this land and the water guide us on our journey towards reconciliation.

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Executive summary

In 2024, Environment and Climate Change Canada (ECCC) published the *Synthesis of Freshwater Science in Canada*, summarizing the current understanding, priorities, challenges, and issues facing aquatic ecosystems in Canada, focusing on 25 key freshwater priorities (ECCC, 2024). Importantly, this synthesis has laid the foundation to develop a **National Freshwater Science Agenda (NFSA)**, with the goal of creating a coordinated and collaborative plan to address the most urgent freshwater challenges across Canada over the next decade. The NFSA will outline priorities and opportunities for knowledge synthesis and serve as a guide for science providers to ensure decision-makers have the necessary understanding to address these challenges.

On November 26th and 27th, 2024, the Global Institute for Water Security at the University of Saskatchewan and ECCC facilitated a roundtable discussion to explore and refine priorities of the NFSA. Participants of this workshop included 20 representatives from academia and other research organizations, as well as five early career researchers. Throughout these two days, participants were presented with the results of a national survey on the current state of freshwater in Canada and asked to discuss: 1) the priority freshwater science themes; 2) the role of research organizations in implementing these priorities; and 3) the mechanisms necessary to ensure research impact. Discussions primarily focused on three emerging categories that encompassed the 25 priority research themes, including Freshwater & Climate, Freshwater & Land, and Freshwater & Ecosystems. **This report presents a synthesis of outcomes of this roundtable discussion, including priority research topics; key gaps, challenges, and opportunities for a National Freshwater Science Agenda; and recommendations for strengthening coordination and collaboration in freshwater science in Canada.**

An overarching recommendation was a reframing of the proposed NFSA to focus on the key freshwater challenges facing people living in Canada now and into the future. This reframing of freshwater priorities according to, for example, floods, droughts and wildfires, inter-basin transfers, drinking water security, and water security for food security, facilitates recognition of the interconnectedness of water quality, water quantity, ecohydrology, socio-economic dimensions of water and water use, and water management and governance.

Short-term research topics were identified, with participants engaging in a ‘dotmocracy’ exercise to prioritize these topics. According to this exercise, the top three **priority short-term research topics** were the loss of winter, water security for food security, and nature-based solutions, with 10 other short-term priority research topics short-listed. Many of these topics aligned with the three emerging themes (Freshwater & Climate, Freshwater & Land, and Freshwater & Ecosystems) and several of the key freshwater priorities identified in the *Synthesis of Freshwater Science in Canada* report (ECCC, 2024), such as: water balance, availability, and sustainability; water quality impacts in a changing climate; agricultural-sourced stressors; groundwater consumptive issues; emerging and legacy contaminants; and endocrine disrupting substances. Interestingly, several of the identified priority research topics did not directly align with ECCC’s 25 key freshwater priorities, including the loss of winter and nature-based solutions.



Despite not being included on the list of short-term research priorities, several of the ECCC-identified freshwater priorities were discussed throughout the meeting and deemed important. This discrepancy potentially reflects the problem-oriented focus of participants in this workshop—where discussions were focused on cross-cutting freshwater challenges that encompassed several of the key freshwater priorities, highlighting the interconnectedness of these challenges and freshwater priorities. Additionally, one key freshwater priority that was consistently discussed was the lack of Indigenous representation at this workshop. Although ECCC has planned additional roundtable discussions with Indigenous groups, participants felt that discussions on bridging research to impact would themselves be more impactful if they brought diverse groups together to learn, share, and collectively brainstorm opportunities to bridge knowledge to impact, particularly if held in culturally appropriate spaces and facilitated in culturally appropriate ways.

The discussions highlighted several key **research gaps and scientific challenges** in the realm of freshwater research. The gaps identified include the need to monitor **emerging contaminants** like microplastics and PFAS and threats from **expanding industries** (e.g., mining). Furthermore, a lack of **comprehensive monitoring** for ecosystems and biodiversity was identified, as well as **unclear indicators** for ecosystem services. Significant knowledge gaps were also identified in **cryosphere** studies, particularly regarding ice dynamics and permafrost. Importantly, **Indigenous and Traditional Ecological Knowledge** are often missing from water research and governance. Challenges in freshwater management include a **lack of long-term monitoring**, especially in remote areas, unclear **trade-offs in management and policy** implementation, understudied **economic impacts** of policies, and insufficient **interdisciplinary collaboration** to address interconnected environmental factors effectively. This lack of interdisciplinary collaboration contributes to **technical challenges** such as **inadequate or overly simplistic models**. Importantly, a lack of inter- and transdisciplinary collaboration and **outdated regulations** stymies progress towards understanding and protecting freshwater in Canada.

Beyond scientific challenges and gaps, there is a significant need for **improved coordination, collaboration, and communication** to integrate knowledge and coordinate action. Related to the lack of coordination is a **lack of continuity**—which was one of the key challenges consistently identified. For example, due to changing political priorities, funding for long-term monitoring is sometimes cut, leaving large gaps in monitoring data. Furthermore, the current funding paradigm and PI-driven research means that when a funding period ends or a PI retires, it is particularly challenging to continue research on that specific topic, with funding programs often requiring the PI to reinvent their program (e.g., using different acronyms). This lack of continuity, as well as a lack of collaboration and long-term partnerships between and amongst governments, academia, the private sector, and Indigenous groups, contributes to a **lack of coordinated efforts and fragmented research** across Canada. For **students**, key challenges included significant **barriers facing international students** (e.g., tuition fees, lack of recognition of international experience), lack of incentives and support to engage in **collaborative and transdisciplinary** research, lack of opportunities to develop **practical knowledge, experience, and professional skills**, and a lack of collaboration in the field of freshwater science impeding **learning opportunities**.



Across all discussions, **key opportunities** to drive innovation and address water-related challenges were to **increase collaboration and coordination, build capacity**, and to **address knowledge gaps and data management**. Strategies to increase collaboration and coordination between government, academia, the private sector, rights-holders (i.e., Indigenous Peoples, communities), as well as Indigenous governments and scholars include establishing **cooperative institutes, co-appointments, and co-located government-university facilities**. Opportunities to build capacity to collaboratively address freshwater science challenges include **improved education and training**, widespread adoption of the **Integrated Water Resource Management framework**, exploring **new funding models** to support long-term research and monitoring initiatives, and **committing to EDI, reconciliation, and decolonization**. Opportunities to fill knowledge and data gaps include **identifying priority areas for long-term monitoring**, investment in **new monitoring and surveillance technologies** such as AI, drones, and satellite-based monitoring, and establishing a **national data collection and management strategy** (or guidelines) that help to streamline data collection and integration and promotes **openly accessible data**. Furthermore, implementing **place-based research, nature-based solutions, and adaptive management** approaches that **incorporate Indigenous knowledge and governance models** will contribute to addressing environmental challenges and achieving biodiversity commitments. **For students**, important opportunities included internship or co-op opportunities, workshops and courses to build important skills (e.g., systems-thinking, practical environmental problem-solving, programming languages, inter- and transdisciplinary collaboration, science communication), and opportunities to collaborate with researchers and professionals across various water-related sectors in Canada.

Overall, key **recommendations** to build more coordination, collaboration, and capacity across freshwater science included **reframing research paradigms and the development of a Canada-wide water research network**. An overarching recommendation was a reframing of the proposed NFSA to focus on the key freshwater challenges facing people living in Canada now and into the future. This reframing of freshwater priorities according to problems or cross-cutting challenges such as floods, droughts and wildfires, inter-basin transfers, drinking water security, and water security for food security, facilitates the recognition of the interconnectedness of water quality, water quantity, ecohydrology, socio-economic dimensions of water and water use, and water management and governance. Furthermore, reframing towards problem-oriented research that focuses on these cross-cutting challenges can assist in coordinating inter- and transdisciplinary research to address problems in freshwater science. Developing a Canada-wide water research network that maps researchers, practitioners, projects, and data can enhance collaboration and streamline workflows between academia, government, and the private sector. Long term success was determined to require **holding regular meetings in neutral spaces and having a neutral secretariat (e.g., through a non-profit)** to facilitate collaboration and to ensure unbiased coordination.

In conclusion, participants of this workshop felt that the development and implementation of a National Freshwater Science Agenda was an important step towards enhancing freshwater science in Canada. Interestingly, participants agreed with the importance of the freshwater priorities and the research questions stemming from these priorities, but felt that these were



questions that we have the capacity to address. **Rather, the challenges that were most strongly emphasized were not necessarily scientific, but related to collaboration, coordination, and capacity in freshwater sciences in Canada.** Improving coordination, collaboration, and capacity in freshwater science in Canada can be achieved through several strategies listed here, but especially through reframing freshwater science priorities according to cross-cutting challenges facing people living in Canada now and into the future, as well as creating a Canada-wide water research network that connects researchers, practitioners, decision-makers, Indigenous groups, communities, and end-users to better understand and solve threats facing freshwater ecosystems in Canada. Underpinning these initiatives is the critical need to achieve continuity of effort and ensure that science agendas are not one-off efforts but sustained, team-driven investments in long-term solutions. **With sufficient and sustained coordination, collaboration, and capacity, Canada can more effectively solve threats facing freshwater ecosystems in Canada and strive to elevate our position as international leaders in freshwater science, policy, and action.**





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Background

In 2024, Environment and Climate Change Canada (ECCC) published the *Synthesis of Freshwater Science in Canada*, a report summarizing a multi-year effort of a team of over 100 subject matter experts from multiple federal departments to understand and characterize the current state of freshwater science in Canada (ECCC, 2024). This synthesis report summarizes the current understanding, priorities, challenges, and issues facing aquatic ecosystems in Canada, focusing on 25 key freshwater priorities. Importantly, this report has laid the foundation to develop a **National Freshwater Science Agenda (NFSA)**.

The goal of developing a NFSA is to create a coordinated and collaborative plan to address the most urgent freshwater challenges across Canada over the next decade. It will guide freshwater science to understand and tackle these challenges while informing management practices. National in scope but responsive to regional issues, the NFSA will cover natural, physical, social, economic, and health sciences to support the management of freshwater ecosystems. The NFSA will outline priorities and opportunities for knowledge synthesis and will serve as a guide for researchers to ensure decision-makers have the necessary understanding to address these challenges.

To date, the development of the NFSA has involved focused engagement, including discussions and listening sessions with Indigenous organizations, Self-Governing and Treaty Nations, federal, provincial, and territorial governments, academia, non-governmental organizations, and private sector entities, as well as a Canada-wide freshwater prioritization survey. Over 500 respondents completed three rounds of this survey, the results of which informed the identification of priority freshwater science themes. A second, ongoing stage of this process is the exploration and refinement of priorities through roundtable discussions focusing on regional and sectoral priorities as well as broader Indigenous engagement.

One of these roundtable discussions was facilitated by the Global Institute for Water Security (GIWS) at the University of Saskatchewan and ECCC on November 26th and 27th, 2024 in Saskatoon, Canada. Participants of this workshop included early career researchers and faculty from academia as well as leaders of research organizations from across Canada. Throughout these two days, participants were presented with the results of the national survey on the current state of freshwater in Canada and asked to discuss: 1) the priority freshwater science themes; 2) the role of research organizations in implementing these priorities; and 3) the mechanisms necessary to ensure research impact. Discussions primarily focused on the three emerging themes that encompassed the 25 key freshwater priorities—Freshwater & Climate, Freshwater & Land, and Freshwater & Ecosystems. For an outline of the meeting agenda, as well as examples of questions asked during facilitated discussion sessions, please see Appendix I.



This report presents a synthesis of outcomes of this roundtable discussion, including short-term priority research topics; key gaps, challenges, and opportunities for a National Freshwater Science Agenda; as well as recommendations for strengthening coordination and collaboration in freshwater science in Canada.

The next step for the NFSA includes producing a complete draft of the National Freshwater Science Agenda in March 2025, following input from the roundtable discussions, as well as meetings with representatives from Indigenous groups. Additionally, as a key outcome of this roundtable discussion, practical guidelines and recommendations for developing a Canada-wide water research network will be formalized and presented to ECCC.





Short-term research priorities

As part of the workshop, short-term research questions and topics were identified, and participants engaged in a ‘dotmocracy’ exercise to prioritize these questions and topics. In this dotmocracy exercise, participants were given three dots and tasked with placing them beside the question(s) or topic(s) they thought should be a priority. These topics aligned with several of the **key freshwater priorities** identified in the *Synthesis of Freshwater Science in Canada* report (ECCC, 2024). Interestingly, however, the top research priority identified in this workshop (loss of winter) was not directly identified in the 25 key freshwater priorities, although several of the key freshwater priorities relate to this topic (including water balance, availability, and sustainability, water quality impacts in a changing climate, etc.). Additional gaps included ecosystem collapse, nature-based solutions, as well as oil sands monitoring gaps and data analysis (though this may fall under emerging and legacy contaminants), assets and infrastructure, basin assessments, and transition of research assets (Table 1). Interestingly, many of the short-term research priorities were interconnected and encompassed several of the NFSA-identified key freshwater priorities, focusing on the problem itself (e.g., loss of winter, water security for food security, hydrologic change and ecosystem collapse), rather than the specific research topic (e.g., water quality impacts in a changing climate; agricultural-sourced stressors; groundwater consumptive issues). **Reframing the key freshwater science priorities towards key freshwater problems facing Canadians now and in the future is a key recommendation from this report, as will be discussed in Section 6 (Recommendations).**

Of the 25 key ECCC-identified freshwater priorities, 13 were not included in the discussion of priority short-term research topics, including: Indigenous co-development and the delivery of science programs and strategies; Aquatic invasive species; Hydropower stressors; Aquaculture-sourced stressors; Freshwater fish habitat; Metals and mining; Municipal wastewater effluents; Urban runoff; Chemical mixtures; Multiple stressors and cumulative effects; Stressor impacts on ecosystem services; and Management of environmental flows. Despite not being included on the list of priority research topics, **nearly all these freshwater priorities were discussed throughout the meeting and deemed important**, including Indigenous co-development and the delivery of science programs and strategies; multiple stressors and cumulative effects; management of environmental flows; and forest change.

This again may reflect the problem-oriented focus of the participants in this workshop—where discussions focused on cross-cutting freshwater problems that encompassed several of the key freshwater priorities without directly listing them as short-term research priorities. For example, one key freshwater priority that was consistently discussed was the lack of Indigenous representation at this workshop. Although ECCC has planned additional roundtable discussions with Indigenous groups, participants felt that discussions on bridging research to impact would themselves be more impactful if they brought diverse groups together to learn, share, and collectively brainstorm opportunities to bridge knowledge to impact, particularly if held in culturally appropriate spaces and facilitated in culturally appropriate ways. Discussions may be more fruitful, for example in terms of refining research priorities and understanding the relevance of each theme to various regions, how these freshwater challenges impact groups differently, and the potential barriers and opportunities to implementing the NFSA, if they



include Indigenous researchers, Knowledge-holders, and decision-makers, as well as representatives from academia and from federal and provincial governments.

Table 1: List of prioritized short-term research topics identified in workshop (listed in order of priority), the number of dots each topic received as part of the dotmocracy exercise, the relevant ECCC-identified key freshwater priorities, and the relevant emerging themes from the NFSA that these priorities fall under.

Workshop-identified priorities	# of dots	Relevant ECCC-identified priorities	NFSA Themes
Loss of winter (e.g., Lake ice, Snow, Freezing rain, Ice roads, Shoreline erosion)	9	Water balance, availability, and sustainability; Water quality impacts in a changing climate	Freshwater & Climate
Water security for food security	8	Agricultural-sourced stressors; Excess nutrients; Cyanobacterial and harmful algal blooms; Pesticides; Groundwater consumptive issues; Water quality impacts in a changing climate	Freshwater & Land Freshwater & Ecosystems Freshwater & Climate
Set of nature-based solutions for increased resilience	7	Maintaining aquatic biodiversity	Freshwater & Ecosystems
Hydrologic change and ecosystem collapse (identifying what leads to collapse, where collapse is a risk)	5	Water balance, availability, and sustainability; Groundwater consumptive issues	Freshwater & Land Freshwater & Ecosystems Freshwater & Climate
Transition of research assets, e.g., to government, to communities, to sustain and ensure impact (e.g., Scotty Creek Research Station)	4		Freshwater & Land Freshwater & Ecosystems Freshwater & Climate
Field-based process discovery to increase mechanistic knowledge (for models, for decision, for adaptation), e.g., Permafrost thaw; Shrubification; Ground water	3	Forest change; Water balance, availability, and sustainability	Freshwater & Climate



recharge; Forest interface; Infrastructure exposure/failure			
Variability within climate (e.g., changing shoulder seasons)	1	Water quality impacts in a changing climate; Water balance, availability, and sustainability; Hydro- climatic extremes (floods and droughts)	Freshwater & Climate
Oil sands monitoring gaps/ data analysis	1	Emerging and legacy contaminants	Freshwater & Land
Science communication	1		Freshwater & Land Freshwater & Ecosystems Freshwater & Climate
One Health lens	1		Freshwater & Land Freshwater & Ecosystems Freshwater & Climate
Emerging contaminants (e.g., microplastics, PFAS, pharmaceuticals)	0	Endocrine disrupting substances; Emerging and legacy contaminants; Plastics	Freshwater & Land
Assets & infrastructure (including impacts of permafrost loss; monitoring infrastructure; observation networks)	0		Freshwater & Ecosystems Freshwater & Climate
Basin assessments: - Where there is sufficient science and progress, - Where there is sufficient science but insufficient progress, - Where there is insufficient science	0		Freshwater & Land Freshwater & Ecosystems Freshwater & Climate



Challenges and gaps

Across the roundtable discussions, key challenges and gaps related to implementing the National Freshwater Science Agenda emerged. The challenges and gaps were, in some cases, specific to the three emerging themes (Freshwater & Climate, Freshwater & Land, and Freshwater & Ecosystems), and in other cases, related to freshwater science in Canada in general. Additionally, early career researchers were invited to share their perspectives on the important barriers they face as they transition from university to the workforce. These challenges are summarized in the following sections.

Scientific challenges and research gaps

The key research gaps and scientific challenges related to implementing the National Freshwater Science Agenda included numerous gaps in monitoring, data, and knowledge, as well as challenges related to a lack of interdisciplinary collaboration, which together, hinder model development. For example, key data and monitoring gaps include the need to monitor **emerging contaminants** like microplastics and PFAS and threats from expanding industries such as mining, as well as to fill significant knowledge gaps in **cryosphere** studies, particularly regarding ice dynamics and permafrost, as well as the broader effects of loss of ice and permafrost on hydrology and ecosystems. Additionally, **significant data gaps** included gaps in long-term data and a lack of infrastructure for real-time monitoring especially in remote areas, which hinders ecosystem assessment. Similarly, **ecosystem and biodiversity monitoring** remain inadequate, with unclear indicators for ecosystem responses to remediation and restoration. Related to the lack of data and understanding of underlying processes (and how they are connected), **existing models often fail to represent the complexity of landscape and ecosystem dynamics adequately**. This is often exacerbated by a lack of interdisciplinary integration and collaboration, as well as understanding of the importance of place and how threats and impacts differ from region to region and population to population. Because of these challenges, models have not yet evolved to effectively model complex systems and interactions. The need for **interoperable models combining expertise from various fields** and **better integration of place-based data** was an important challenge identified in this workshop.

Another key area where interdisciplinary collaboration is needed is between freshwater science and economics. This collaboration is needed to understand **economic drivers** that impact water, understand **economic tools to incentivize beneficial management practices**, and understand **economic trade-offs** of proposed policies and management strategies. For example, management strategies and policies in one sector (e.g., agriculture) can have costly implications for others (e.g., drinking water treatment). Thus, it is critical that inter- and transdisciplinary research is conducted to understand potential trade-offs of proposed management actions and policies.

Below is a list of specific gaps and challenges that were identified in this workshop relevant to **each emerging theme** (freshwater and climate, land-use, and ecosystems), as well as some **overarching gaps and challenges** related to freshwater science in Canada.



Freshwater & Climate

- **Cryosphere knowledge gaps:**
 - **Ice Dynamics:** Gaps in understanding hydrology, ice quality, ice jams, and their social implications.
 - **Permafrost:** Implications for hydrology, groundwater supply, and connections to wildfire and species extinction.
 - Cryosphere–carbon dynamics and climate change
 - Importance of **local-scale research**. Permafrost is incredibly variable/dynamic. Broad pictures result in inaccurate interpolations, which lead to inaccurate models.
 - **Loss of winter** and impacts on freshwater ecosystems and hydrology
- **Changing E-flows:** Lack of studies on how climate change affects the quantity, timing, and quality of water flows, and how these changes affect water.
 - Impacts of flow changes on **dams and reservoirs**, e.g., hydropower generation, drinking water availability and quality
 - Implications of reduced flows for municipal and industrial practices, e.g., the release of wastewater
 - Loss of groundwater storage
 - Risks of connectivity between (polluted) surface and ground water
- Lack of **preparedness** for scenarios like droughts and floods further complicate efforts to align research and management goals.

Freshwater & Land-use

- **Emerging Contaminants and Threats:**
 - Addressing the need to monitor **emerging contaminants** (e.g., microplastics, PFAS).
 - Understanding the impacts of **industrial legacies**, **emerging industries** (e.g., expanding mine operations), and **urbanization** on the environment.
 - Missing research on the effects of **pollutant mixtures** and **cumulative impacts**.
- **Mixtures and cumulative effects:** Missing science on the effects of mixtures of pollutants, e.g., agrochemicals, on ecosystems and cumulative effects.



- **Land-use changes:**
 - Lack of **nationwide land-use mapping** and understanding of **future land-use change** (e.g., in response to markets and climate change, including deforestation and forest fires) and impacts on water.
 - Need to understand **economic drivers** influencing land-use and industry decisions, how to **incentivize implementation of beneficial management practices**.
- **Soil and Ecosystem Interactions:** Soil characteristics and changes with land use and climate are often overlooked but are critical for understanding downstream impacts (e.g., frozen soils have different characteristics, changes in the time/depth of freezing influence ground and surface water).
- **Geo-engineering tools:** Limited application and testing of geo-engineering tools for lake remediation in Canada.
- **Baseline and Long-Term Monitoring:** Incomplete baseline data and long-term records hinder the ability to assess the impact of interventions and natural variability.
 - Lack of understanding of current state of freshwater ecosystems and flows Canada-wide.
 - Lack of monitoring in headwater systems challenges downstream assessments.
 - Limited parameters are measured in long-term monitoring so those gaps limit the questions we can ask.
 - Beginning to monitor sites after they are impacted challenges understanding of baseline and change.
- **Non-point source pollution:** Challenges identifying sources of non-point pollution and how to address non-point source pollution.
- **Inter-basin transfers/transboundary water issues:** Balancing fair and sustainable water allocations, managing transboundary water issues, including pollution.
- **Complexity of landscape:** Difficulty in long-term monitoring and assessing effectiveness of management actions such as beneficial land management practices, e.g., due to complex hydrology on Prairies.
 - **Models** not yet evolved to effectively model complex systems and interactions.
- **Water and food security:** Loss of water quantity and quality threatens food security (and vice versa).



Freshwater & Ecosystems

- **Ecosystem and Biodiversity Monitoring:**
 - Lack of **comprehensive monitoring** for ecosystems and biodiversity.
 - Lack of studies/emphasis on **range expansions** (both plants and animals), the **role (and future) of ecosystem engineers**, the **collapse and emergence of ecosystems** (e.g., in response to permafrost thaw, glaciers, tidal changes, forest fires).
 - Unclear indicators for ecosystem services and lack of coordinated evaluation efforts.
- **Remediation and Restoration:** Unclear **how ecosystems respond to remediation and restoration** and what **indicators** should be used.
- **Modeling:** Lack of models that integrate ecological and hydrological data.
 - Those that exist often lack complexity.
- **Taxonomists:** Lack of trained taxonomists.
- **Invasive species:** Lack of surveillance on bulk water transfer and (prevention of) spread of invasive species.





Beyond Scientific Challenges

A key takeaway from these roundtable discussions was that, while participants generally agreed with the key freshwater priorities and research questions highlighted in the ECCC Synthesis Report and national survey, they felt that the primary challenges facing freshwater science in Canada are not solely related to the science itself (though pressing challenges remain, as noted earlier). Indeed, one participant noted that “*many of the topics that are raised by this survey are not dissimilar to what we had before.*” **Instead, the participants felt that the largest barriers to connecting research to impact lie in the lack of capacity, coordination, and collaboration within freshwater science in Canada.** The current lack of capacity and coordination was viewed as contributing to our current **reactionary, rather than proactive, approach**, leading to freshwater science in Canada being stuck in the ‘problem space’ and preventing advancements in the ‘solution space’.

A lack of coordination, inefficient funding paradigms, and the siloed approach to water research result in inefficiencies, including fragmented research and knowledge mobilization strategies across universities and sectors. In the past (and currently in other regions in the world such as the U.S.), there has been **better coordination** amongst academic researchers, the private sector, and government researchers and decision makers to better understand problems and coordinate efforts towards solving these problems. Additionally, funding paradigms that create shorter-term research programs, as well as PI retirement, hinder long-term ecological monitoring and field testing, whereas a lack of integration of **multiple ways of knowing**—such as social sciences, economics, and Indigenous and Traditional Ecological Knowledge—and insufficient emphasis on equity, diversity, and inclusion (EDI), limit understanding of ecosystem values, culturally significant practices, and the broader implications of water policies, which can result in unintended economic, ecological, and cultural costs.

Overall, participants felt that to achieve the transition from research to impact, we need stable communication and an agreement between government and universities that does not change with political parties, but rather supports continued, long-term research programs and partnerships. Furthermore, we need to analyze the structure of the systems and policies that are in place and then create and reinforce structures that will support the implementation of the National Freshwater Science Agenda.

Below is a more detailed list of challenges and gaps that go beyond scientific challenges in Canada.

- **Lack of Coordination, Collaboration, and Communication:** Need for better coordination mechanisms and communication strategies to integrate knowledge and support and inform government agencies.
 - Difficulty in improving **inter-university partnerships** and overcoming **institutional barriers**, including a lack of **cooperative agreements between universities** to share courses and improve training.



- Difficulty in **building and maintaining long-term relationships** between government, academia, and the private sector.
- Few examples where **decision-makers and end-users are involved in research from the beginning**.
- Absence of **neutral entities (e.g., boundary organizations)** to bring together diverse stakeholders.
- **Funding:** Insufficient and short-term funding affects the sustainability of research programs, leading to reliance on community and organizational partners. Need to secure sustainable funding for long-term research and monitoring networks.
 - PI-driven research lacks long-term funding frameworks.
- **Continuity and Monitoring:** Ensuring **continuity in data collection and monitoring**, especially with personnel changes.
 - **Monitoring is largely viewed as government responsibility** (not university)
 - Need to ensure the **longevity of monitoring sites, field research stations, experimental research sites, and research programmes**, despite personnel changes (e.g., retirement of PIs), political changes, and current funding schemes (that fund new questions/problems rather than extend funding for current research).
 - Need for transparency and coordination in **monitoring priorities**.
 - Challenges in **integrating data** from various sources.
 - **Lack of infrastructure** for real-time monitoring in remote areas and ageing water delivery and wastewater networks challenge water security.
 - Ad hoc monitoring of systems (e.g., after impacts occur) challenges **understanding of baseline conditions**.
- **Training and Expertise:** University training models may not adequately prepare students for inter- and transdisciplinary challenges.
 - Funding and reward structures in academia challenge problem-focused, action-oriented research, development and maintenance of relationships and partnerships, etc.
 - Decline in field scientists and inadequate training in critical areas like taxonomy.



- **Indigenous Knowledge and Traditional Ecological Knowledge:** Missing or lack of emphasis on inclusion of Traditional and Indigenous knowledge and governance models in water research, management, and governance. Lack of understanding of what is valued in ecosystems by Indigenous groups. This was also raised as an issue with respect to the NFSA approach and limited Indigenous engagement in some of the meetings.
- **Science Communication:** Need for **improved science communication and collaboration** with the public and other sectors to elevate discussions on water issues.
- **Emphasis on equity, diversity, and inclusivity:**
 - Lack of understanding and emphasis on the **gender lens and intersectionality** with respect to water security.
 - **Inclusion of perspectives from underrepresented groups is lacking.**
- **Data Collection, Sharing, and Integration:** Lack of national guidelines on data collection that would streamline data integration (recognizing recent efforts to develop the National Freshwater Data Strategy through the Canada Water Agency). Need for better data collation and sharing to support collaborative research. Support needed to share data openly.
- **Regulations:** Lack of or outdated regulations and regulatory frameworks on, e.g., nutrient control, application of geochemical/geo-engineering to improve water quality in water bodies, and emerging contaminants like pharmaceuticals and microplastics.

Challenges for early career researchers

Insights into challenges that early career researchers perceive related to their future careers were collected as part of the roundtable discussions. These included significant challenges facing international students, lack of incentives and support to engage in collaborative and transdisciplinary research, lack of opportunities to develop practical knowledge, experience, and professional skills, and a lack of collaboration in the field of freshwater science impeding learning opportunities. For example, due to a lack of consideration of international knowledge and experience during recruitment, international students face challenges in securing employment. Additionally, high fees for international students in professional programs, without sufficient bursaries or scholarship support, are significant barriers to attracting international expertise in freshwater science.

Place-based, collaborative, and transdisciplinary research takes significant time to engage in, largely in part due to the time required to develop relationships, build trust, and co-design research goals. Importantly, academic reward structures tend to prioritize high-impact papers instead of community benefits (although there is evidence that this may be shifting in national funding frameworks), and case study research is not generally viewed as high-impact. In part due to the longer timelines required for user-engaged research, students and early career researchers often face funding constraints that limit their research scope and the translation of research into real-world applications.



Opportunities to gain hands-on experience and develop professional skills are limited in higher education. For example, curricula often lack skill-based training and professional development, such as building relationships, collaborating across disciplines, and engaging in transdisciplinary research. Thus, there is a need for training programs, internships, and co-ops for early career researchers to develop these skills, as well as to provide hands-on experience and industry exposure. Additionally, there is a lack of collaboration between universities and recruiting firms to organize interactive forums for students and firms, where opportunities to collaborate or intern may arise. Importantly, early career researchers also feel that they lack important knowledge about water laws, regulations, and policies, and thus are faced with barriers to working in government and consulting firms.

Overall, early career researchers agreed with other workshop participants that collaboration is a significant challenge for the NFSA and water security in Canada, requiring efforts to work across borders, scales, disciplines, and sectors. Some also felt that research is being deprioritized nationally, with open positions left unfilled and crucial institutions underfunded. Broader research themes that promote transdisciplinary teams could attract funding and public support, bringing together diverse stakeholders to address water challenges effectively.





Strategies for addressing challenges and filling gaps

During the discussions, three important themes emerged as opportunities to address the challenges in water research and management: **Coordination and Collaboration**, **Capacity Building**, and **Knowledge and Data Management**. One participant noted, “...it's great to identify the priorities, but unless the structures are in place to address the priorities effectively, it will fall short a little bit.” Thus, developing structures to enhance coordination, collaboration, and capacity will support the implementation of the NFSA. Key strategies include cross-university collaboration, sustainable funding, and the establishment of boundary organizations to promote continuity, integration, and resilience in freshwater research and management.

The strategies that were suggested were, in many cases, targeted at both government and academia. Universities and government can implement these strategies from different **roles and platforms**. For example, participants suggested that universities focus on the “why” behind issues—examining mechanisms and underlying causes—while governments address the “what” through regulations and tools. Universities are more open to taking risks compared to governments, which often follow strict templates that may not be conducive to scientific exploration. This complementary role allows universities to take on more innovative projects that drive deeper understanding. However, the outputs of this work should be connected to government in a way that is **actionable and useful**. Universities also have the role of educating future scientists and, if the multidisciplinary expertise present on university campuses across Canada is leveraged in university curricula, can offer important **interdisciplinary training** to equip emerging researchers with the knowledge and skills to address complex water challenges. For example, universities such as the University of Saskatchewan have the Global Institute for Food Security and the Global Institute for Water Security, both which have experts in various fields of water-related and associated science. Co-teaching and collaborative learning opportunities that connect water and food security can equip emerging researchers with the skills to work with people in both fields to understand problems and develop effective solutions.

The opportunities presented in the sections below pertain to both government and academia, and in most cases, are opportunities that can and should be implemented at a national level.

Coordination and Collaboration

A key theme throughout the entire workshop was **the need for more collaboration and partnerships** between and amongst government, academia, the private sector, rights-holders (e.g., communities, Indigenous peoples), as well as Indigenous governments and scholars. Each of these groups has skills, knowledge, and expertise that, combined, can contribute to addressing challenges facing freshwater ecosystems across Canada, and can contribute to the emergence of Canada as a global leader in freshwater research, policy, and action—**if stability in these partnerships is maintained in the long-term**. This sustained collaboration can be achieved through the creation of a **Canada-wide water research network** that holds **regular national meetings in neutral spaces** with leaders across all levels of government, academia (spanning natural sciences, social sciences, and economics), Indigenous groups, and the private sector (see



Section 6: Recommendations). **Facilitating regular meetings, creating physical spaces (e.g., collaboratoriums or co-located government-university facilities) where these groups can gather to work together, and creating co-appointments that ease movement between sectors** fosters the alignment of priorities and efforts, understanding of problems more holistically, and identification of possible solutions, including benefits, possible (unforeseen) trade-offs, consequences, costs, and mechanisms of implementation. As one participant stated, “*a new mechanism needs to be found and we need to bring stability to [government-academia collaboration]... there’s been recognition over three decades of the benefits of this collaboration. So why not stabilize [this]... the UK does this, the US does this, almost every major science country has these stable relationships*”.

Another opportunity for improved coordination is the **establishment and support of boundary organizations** (e.g., agricultural and water extension programs). These organizations can act as conduits or liaisons between regional groups, researchers, practitioners, and decision-makers, therefore contributing to more immediate identification of problems and impacts as they arise (helping to set or refine research agendas), more streamlined approaches to ensure that action is taken, and the adaptive management of strategies that are implemented to address these problems. **Importantly, promoting collaboration and partnerships, the establishment of boundary organizations, and challenging current funding paradigms** can increase the **longevity and impact** of research programs.

Specific opportunities and strategies for increasing collaboration include:

- **Collaborative Efforts:** Universities supporting all levels of government and engaging in collaborative research and innovation together with government, other universities, the private sector, and Indigenous scholars and government.
 - Develop **cooperative institutes** that bring people together across universities, government departments, and sectors, or **co-located government buildings on university campuses** to facilitate government and academia working next to each other.
 - Create new **co-appointments** where students, post-doctoral scholars, and research scientists can go back and forth between government and academic facilities.
 - Increase collaboration amongst Canadian universities
 - Advocate for **stable inter-university programs** that support graduate training and shared research infrastructure.
 - Build graduate training programs that **leverage expertise** across various universities and departments.
 - Work towards **credit transfer agreements** to enable seamless academic collaboration and training.



- Establish a **community of practice** to optimize efforts and coordinate priorities and practices across systems, for example through creation of a **Canada-wide water research network** for coordinating freshwater research and action in Canada.
 - Establishing a **national network map** that identifies researchers, practitioners, and decision-makers, catalogues policies developed in response to collaborative research efforts, monitors and reports on impact, and identifies and promotes enabling conditions for sustained efforts.
- **Leveraging partnerships and funding opportunities.** Strengthening public and private partnerships to support research and networks.
- **Co-develop governance models with Indigenous partners.**
- Put **equity, diversity, and inclusion** at the centre of collaborative efforts, including research, training, and education opportunities.
- Invest in **long-term partnerships with Indigenous groups, universities, government, and the private sector.**
 - Facilitating collaboration, rather than competition, amongst universities in Canada will strengthen research progress and training opportunities for students.
- **Boundary Organizations:** Establishing and supporting boundary organizations (e.g., water and agricultural extension) that bridge academia, government, and the private sector to enhance collaboration and knowledge synthesis. These organizations can play a crucial role in scaling up collaborative efforts, integrating data, and creating more cohesive workflows or pipelines. Recognising the important role of the Canada Water Agency as a boundary organisation.
- **Problem-oriented research:** Connecting sectors, expertise, and rights-holders by **focusing on the problem and how to solve it**, focusing on cross-cutting challenges, can enable better **inter- and transdisciplinary collaboration**, and ultimately lead to better understanding of the problem and outcomes of research (See Section 6: Recommendations).
 - Focusing on **specific problems or themes**, e.g., drought, can enhance **inter- and transdisciplinary** work.
 - **Collaboratively setting goals** based on synthesized, cross-cutting challenges.
 - Focusing on **desired outcomes/goals** for ecosystems and driving science with a positive outlook.



- **One Health framing:** Recognizing the interconnectedness between humans and the environment, focusing on the health and wellbeing of both to frame research.
 - Importance of transdisciplinary research to understand health impacts.
 - **The right to a healthy environment** as an approach to managing impacts on communities.
- **Science communication:** Enhancing science communication both internally and externally to demonstrate the value of research and engage the public and policymakers. Improved science communication can assist in raising awareness as well as building and repairing relationships and trust between science and the public.

Capacity Building

Building capacity was also viewed as critical to bridging research to an impact. As a starting point, participants felt that we need to ask the following three questions: **what are we good at, what do we have, and what do we need to get** (e.g., organization models, communication approaches, partnerships, and financial support)—essentially, perform a gap analysis, and then leverage data, tools, and expertise across Canada to build capacity to advance solutions. Several forms of capacity were viewed as important to bolster, including education and training, adaptive response and management, re-envisioning funding models, and committing to EDI, reconciliation, and decolonization.

Specific opportunities and strategies for building capacity include:

- **Improved Education and Training Models:** Support and promote the development of education and training models that integrate academic, policy, practical, and social (e.g., cultural, traditional) perspectives.
 - **Bridging academic and policy perspectives** into education and training to bring research results to government agencies.
 - Develop and promote **professional development curricula** in higher education.
 - Include **multiple ways of knowing** in research training and educational curricula.
 - Develop educational curricula that combine natural science with **interdisciplinary and transdisciplinary approaches**
 - Include **bioinformatics** as part of curricula
- **Integrated Water Resources Management (IWRM):** IWRM is critical for enabling adaptive management and place-based approaches to water management.
 - In IWRM, **science informs management decisions**, which are then **iterated** upon based on outcomes.



- Include **Indigenous knowledge** and emphasize **adaptive and place-based approaches**.
- **Emphasize adaptive management** to increase capacity to identify and respond to issues as they arise.
- **Innovative Funding Models:** Exploring new funding models to **support long-term research and monitoring** initiatives without requiring researchers to start new research programmes once funding concludes.
 - Implement **innovative and low-impact methods** for raising funds for water research, e.g., small added fees onto water utilities.
- **EDI:** Enhancing conditions for emerging scientists by promoting EDI and inclusion of multiple ways of knowing into research frameworks.
 - Framing **diversity as a strength** for understanding and addressing challenges facing freshwater ecosystems in Canada. Committing to and upholding **EDI+**.
 - Taking a **broader sociological perspective** to assess the scientific community and how we can improve the conditions for new researchers and help them to address these grand challenges.
 - Ensure the **voices of rights-holders are included** in research and collaborative efforts.
- **Decolonization and Reconciliation:** Including Indigenous ways of knowing into research frameworks. Commit to **reconciliation and decolonizing water** as critical pathways forward.
 - **Indigenous Knowledge is current knowledge.**
 - It is essential to include Indigenous representation, Indigenous Knowledge, and knowledge of rights-holders in all relevant meetings.
 - Learn from and with Indigenous governance systems

Knowledge and Data Gaps

Several opportunities to fill knowledge and data gaps were identified in the workshop. For example, **long-term monitoring** was recognized as being the **responsibility of governments**, rather than of universities, and is widely considered **critical for generating robust datasets** to understand change (outside of natural variability) and inform adaptive management strategies. Here, there are opportunities to be strategic in terms of **where and how we monitor**; for example, **priority areas** for long-term monitoring can be identified, and investments should be made in **new monitoring/surveillance technologies and techniques**,



such as AI, drones, and satellite-based monitoring, to ease data collection. Furthermore, establishing a **national data collection and management strategy** (or guidelines) can

streamline data collection and integration, and promoting efforts to **make data openly accessible** in a centralized repository can minimize duplication efforts (and identify which sites are well-studied and those which are not)—recognizing recent efforts to develop the National Freshwater Data Strategy through ECCC. Challenging current research approaches and **implementing place-based research, nature-based solutions, and adaptive management approaches that incorporate Indigenous knowledge and governance models** will contribute to addressing environmental challenges and achieving biodiversity commitments. Ultimately, tying these efforts to international initiatives will position Canada as a leader in freshwater sciences.

Specific strategies for filling knowledge and data gaps included:

- **National data management guideline:** Standardizing data collection to improve sharing, integration, and usability.
- **Promote and Support Place-Based Research:** Leveraging local data and resources for effective research and policymaking.
- **Long-term Monitoring:** Ensuring consistent and adequately funded monitoring by involving government. Using field stations for collaboration, innovation, and education.
- **International organizations and leadership:** Tie freshwater science efforts into international programs, e.g., UN organizations. Leading in the climate-freshwater nexus through initiatives like the International Year of the Glaciers, making Canada more attractive to researchers internationally.
- **Technological Advancements:** Use of technology (e.g., satellites, drones) for ecosystem monitoring and data collection.
 - Utilizing new technology and surveillance and monitoring techniques for real-time monitoring and data integration. Promoting open access to data and leveraging AI and other tools to assess threats to water quality. Universities can lead in verifying and ground-truthing these technologies.
 - Integrating these new tools and knowledge to support water management priorities
 - Prioritizing the development of affordable water treatment technologies.
- **Nature-Based Solutions and Governance:** Exploring nature-based solutions and new governance models, including partnerships with Indigenous governments and scholars.
- **Global Biodiversity Framework:** Leveraging existing frameworks to address ecosystem gaps and meet biodiversity commitments.



Opportunities for early career researchers

In response to challenges identified in transitioning from university to the workforce, early career researchers identified key opportunities to bolster their **training, practical experience, and ability to effectively collaborate** with diverse groups and ways of knowing. Practical experience and skills could be gained through **internships or summer jobs** with professors or the government. **Partnerships between universities** can promote exchanges, shared workshops, and shared courses, thus increasing the opportunities for students to develop knowledge and skills, as well as connections. Optional in-person or virtual **workshops to discuss and solve real problems**, organized within each university, could bolster students' ability to engage in systems-thinking and practical problem-solving, and to consider potential trade-offs, costs, and benefits of proposed strategies for solving environmental problems. Additional workshops or courses could include **programming languages** like RStudio and Python, with access to experts for guidance, as well as environmental law and policy in Canada. Skill-based training in communication, knowledge mobilization, and partnerships is critical for developing interdisciplinary and transdisciplinary competencies in emerging water scientists, building capacity to engage in the much-needed collaborative and coordinated research and work in Canada.

Additionally, the early career researchers felt that a Canada-wide water research network could facilitate **collaborative training** and **research opportunities** for students with researchers and representatives from various sectors in Canada. Creating opportunities for students and early career researchers to get involved and showcase their work in this network could increase student awareness of valuable job market skills, as well as opportunities for students to network with industry and government. Furthermore, the benefits would go beyond students and early career researchers, for example through sharing examples of freshwater research in Canada, as well as highlighting the public and academic interests related to hydrological research and priorities. Ultimately, promoting **interdisciplinary work and networking**, as well as **funding collaborative projects and learning opportunities** for graduate students and early career researchers would strengthen the community of water scientists.



Solution science: From research to impact

To engage in solution science and identify pathways that link research to impact, participants brainstormed strategies for implementing the National Freshwater Science Agenda in a coordinated, efficient, and effective manner. Important principles that participants identified for engaging in solution science included the **co-development of key priorities and goals** for science and action with end-users and rights-holders. Furthermore, the **enabling conditions and leverage points**, defined as points within complex systems that if changed, could transform the entire paradigm (Meadows, 1999), should be identified—this information can then be used to enable and sustain action on freshwater science. Important opportunities identified included producing a range of possible **scenarios of change** (e.g., in response to climate change, following construction of new mines/industry, implementation of restoration) and assessing the likelihood of those scenarios, then using this information to identify acceptable **trade-offs** and to **inform mitigation and adaptation strategies**. Additionally, despite being in use for several decades, the **Integrated Water Resource Management** framework was viewed as an important opportunity to **coordinate the sustainable and adaptive management** of water, land, and ecosystems. **Adaptive management** will be critical to ensuring the success and longevity of solution science. Furthermore, we need mechanisms in place to **ensure the longevity** of knowledge, relationships, action, and adaptive management in Canada.

Below is a list of strategies for using solution science to bridge research to impact.

Shared Vision and Goals:

- **Vision and Engagement:** Developing a long-term vision for freshwater science and ecosystems, and consistently elevating discussions on water issues to engage the public and decision-makers. Find champions to lead these initiatives.
- **Integrated Water Resource Management:** Prioritize Integrated Water Resource Management and adaptive strategies for coordinated science and governance.

Research and Collaboration:

- **University Role:** Define key research questions and create longer-term research positions for students and faculty.
- **Funding paradigm:** Overcome the current paradigm of PI-driven research that lacks continuity by challenging current funding paradigms and instead fostering sustainable funding for long-term research programs and creating cooperative institutions that bridge universities with government.
- **National Research Network:** Build a network of institutions to coordinate and unify water science efforts across Canada.



- **Goal-oriented science:** Synthesize and share the **status of challenges**, use this to **co-develop goals** that inform science, **build teams** and **map capacity** to address these challenges and chart the path forward. Universities and federal government can deliver on priorities through **targeted hotspots** and solution science.
- **Collaboration:** Promote partnerships among universities, government, and private sectors, learning from successful models in other countries.

Science Communication and Public Engagement:

- **Strengthen Communication:** Include dedicated science communicators in the freshwater sector to translate research into public and policy action.
- **Global Leadership:** Demonstrate Canada's leadership on the global stage by addressing challenges and leveraging opportunities in water management.
 - The Canada Water Agency can be a coordinated voice for water in Canada.
 - Lower tuition fees and other barriers to attract international students and expertise.

Policy and Resource Management:

- **Community-Driven Action:** Begin with local ecosystem initiatives while influencing the path to national and basin-scale approaches.
- **Investment:** Demonstrate the value of science as a long-term investment and advocate for creative, resource-efficient solutions without immediately seeking new funding.
- **Optimization:** Leverage existing systems and standardize practices to improve efficiency and maximize impact.
- **Longevity:** Build national structures that enable long-term funding, long-term monitoring, field stations, and experimental sites and are impervious to changing political priorities.

Key Considerations:

- **Holistic Approaches:** Integrate water research with climate, land use, and economic forecasts, incorporating Indigenous knowledge for comprehensive strategies.
- **Continuity of Effort:** Ensure that science agendas are **not one-off efforts but sustained**, team-driven investments in long-term solutions.
- **Community Building:** Strengthen a community of practice to coalesce resources, ideas, and efforts, emphasizing collaboration over competition.



Actionable Steps:

- Optimizing current freshwater science and take steps to optimize how we work as a community.
- Recruit graduate students through innovative approaches.
- Develop models demonstrating the societal and economic value of water science.
- Enhance capacity for science to influence government policy and international water management agendas, for example through better communication and collaboration.
- Build partnerships that make freshwater science and management resilient and impactful.





Recommendations

With respect to strategies for connecting research to impact, three key recommendations emerged as critical tools or leverage points for building more coordination, collaboration, and capacity in freshwater science in Canada: reframing the siloed research paradigm towards problem-oriented research that focuses on cross-cutting challenges facing people living in Canada, a comprehensive approach to ensure braiding of Indigenous and western sciences, and the development of a Canada-wide water research network.

Problem-oriented research

Although highly interconnected, focusing on the ECCC-identified freshwater priorities, rather than broader challenges facing freshwater ecosystems and people living in Canada, may contribute to a siloed approach that pervades understanding of the entire system (the problem and its impacts) as well as holistic solutions/strategies. Therefore, **reframing the NFSA, and freshwater science in general, towards problem-oriented research, framed around cross-cutting challenges** facing people living in Canada, was identified as a key opportunity to enhance coordination and inter- and transdisciplinary collaboration, contributing to more comprehensive understanding of problems, their impacts, and potential solutions to these challenges. Furthermore, focusing on specific problems may attract support for funding and public approval, as well as bring the appropriate knowledge- and rights-holders together (e.g., economists, social scientists, policy makers, natural scientists, water managers, community representatives, Indigenous groups, etc.).

To encourage adoption of problem-oriented research, funders could give special consideration or calls for proposals for projects that focus on multiple aspects of cross-cutting themes and articulate how their research will be inter- or transdisciplinary. In some ways, this is not a novel idea or funding paradigm—as one participant noted, “...[in the] 1970s and ‘80s, there was the water resources subvention grants and NSERC, where a university professor would apply on a topic that had been selected by a federal scientist in Environment Canada for extra NSERC funding to do it.” Therefore, as part of the workshop, participants developed a new framing that shifts the current proposed themes into cross-cutting elements of a thematic challenges approach (Figure 1). Arguably, these themes resonate more with people living in Canada, who see and experience these challenges and the ways they change over space and time. They also scale with respect to local to national research gaps and appropriate solutions.

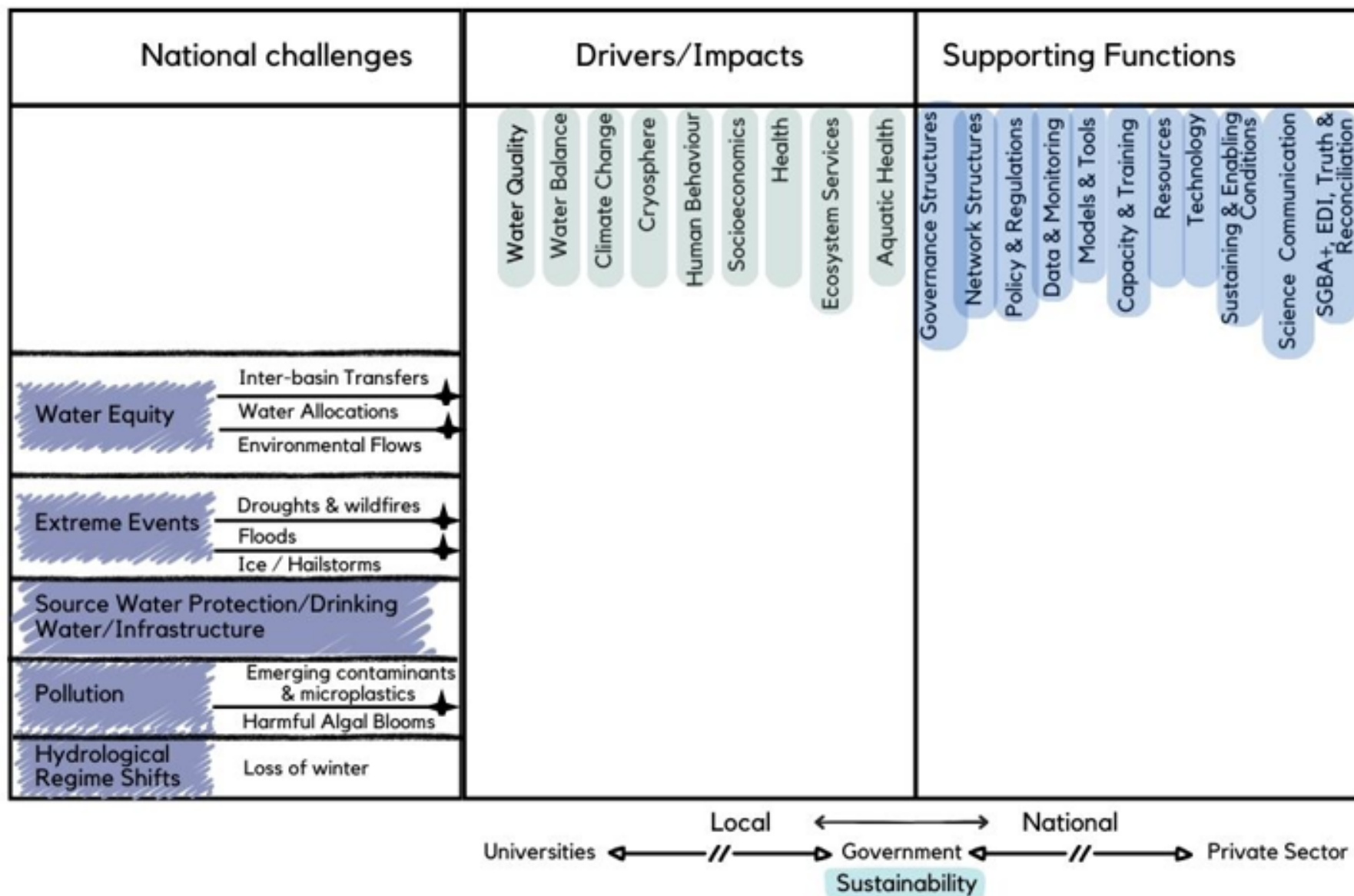


Figure 1: Reframing science priorities into cross-cutting elements of a thematic challenges approach, including national challenges faced by freshwater ecosystems and people living in Canada, drivers and impacts of those challenges, and the necessary supporting functions to understand and address these challenges. These cross-cutting challenges require consideration of multiple scales and actors.



Reframing towards a problem-oriented focus also enables reframing the current research paradigm to focus on desired outcomes. Engaging with people living in Canada to understand the desired water future for Canada’s ecosystems, economies, and communities could be an opportunity to set nationally recognized goals or targets for freshwater science. From these goals, scientists and government agencies, through, for example, modeling efforts, can work backwards to identify what is required to achieve these goals—a process referred to as ‘backcasting’ (Figure 2). Backcasting can be applied using the A-B-C-D method, where visioning is done through increasing **A**wareness and defining success. The next steps include **B**aseline mapping to understand current status and gaps and brainstorming **C**reative solutions to move from the problems identified in the baseline mapping (B) to the vision created (A). The final step is **D**eciding on priorities; essentially, deciding which actions are most feasible to achieve the vision (The Natural Step, n.d.).



Figure 2: The process of backcasting applied using the A-B-C-D method (in The Natural Step, n.d.).

The process of backcasting can occur at the initial stages of a problem-oriented research program, where the vision for that cross-cutting challenge is defined collectively. Baseline mapping for each individual challenge could then occur in interdisciplinary teams working on specific problems under that cross-cutting challenge, before coming together to share research outputs and collectively identify possible solutions and decide on priorities to achieve the shared vision.



Braiding Indigenous and Western Sciences

As noted throughout the workshop, lack of Indigenous representation at this workshop and in other water conversations must be addressed. This requires **different ways of engaging** in these conversations and in the research process that are held in **culturally appropriate spaces** and **facilitated in culturally appropriate ways**. Guidance and examples exist, such as the annual Nibi Gathering and the Global Water Futures Mistawasis Nêhiyawak Water Gathering Statement (2023).

Network: Water Research Canada

To coordinate and unify water science efforts across Canada, as well as to bring more stability to long-term partnerships and collaboration, a key recommendation was the creation of a **Canada-wide water research network**. In the final session, participants brainstormed a list of existing networks and models for increased (and sustained) collaboration (see Appendix II), and identified characteristics that would make this network more successful. For example, participants felt that members of this network should include government, academia, the private sector, non-governmental organizations, students and early career researchers/professionals, end-users, rights-holders (e.g., communities, Indigenous peoples), as well as Indigenous governments and scholars. Bringing together this diverse group of individuals with varied knowledge, skills, expertise, and capacity to take action can foster a deeper understanding of the challenges facing Canada's freshwater ecosystems and enable the development of more effective, inclusive solutions to these challenges. For example, the private sector is often where **innovation** occurs and represents an important group that is **applying environmental improvement** tools and techniques. Non-governmental organizations are ideally placed to be (and often are) **locally connected** and thus have better awareness of the problem and impacts on local communities. Similarly, rights-holders and end users are often the first to aware (and affected) **when specific problems or impacts arise**. Therefore, inclusion of these groups presents an important opportunity to develop partnerships and share information, form research teams surrounding specific problems, pilot and implement new and innovative solutions, and to engage in highly responsive, adaptive management.

In the initial stage of creating this network, **members from across the network can be mapped**, with profiles including their role and organization/institution, expertise, projects they are working on, and/or any projects they like to propose to the network. This network map would be updated at regular intervals to include new members. Including students and early career researchers in this network could facilitate **collaborative training** and **research opportunities** with researchers and representatives from various sectors in Canada. Creating opportunities for students and early career researchers to get involved and showcase their work in this network could provide valuable knowledge on job market skills and provide important opportunities to connect with industry and government.

Additional characteristics of this network that were viewed as critical to its success included **holding regular meetings in neutral spaces and having a neutral secretariat (e.g., through a non-profit)**. These meetings would include leaders across all levels of government,



academia (spanning natural sciences, social sciences, and economics), Indigenous groups, the private sector, and end-users. Together, these groups can report on challenges, successes, and gaps—contributing to **annual reporting** to the public (upholding science communication and demonstrating the value of science to the public), as well as **revision and re-prioritization of the National Freshwater Science Agenda**, thus contributing to improved **long-term optimization and coordination of efforts, priorities, and practices** in freshwater science across Canada. In addition to regular meetings with leaders and representatives across all groups in the network, groups in the network can be brought regularly together to **collaborate on proposals that address research needs** (e.g., at the local level). Having a **neutral secretariat** to assist in the development of proposals, to facilitate collaboration, and to ensure unbiased coordination was viewed as critical to the **long-term success** of the network.

Bringing together a robust network that has a **systems map** that showcases regional expertise, capacities, and research needs, that **meets regularly** to report on challenges and successes and to coordinate priorities, and that is **brought together over proposals and projects that address regional and local research needs**, will contribute to this network becoming a **community of practice**, defined as a group of individuals who share a common interest, passion, or profession that come together to share knowledge, learn from one another, and improve their expertise and impact in freshwater research. Building this community of practice will ultimately strengthen freshwater science in Canada. Furthermore, the establishment of this network can contribute to the emergence of Canada as a **global leader in freshwater research, policy, and action**—if stability in these partnerships is maintained in the long-term.

Indeed, maintaining this stability will require **stable funding**, and there are examples of such networks with stable funding (e.g., in the US) that Canada can look to for **guidance**. Examples of recommendations for creating a Canada Water Network are summarized below. The next stage of this work is to **identify characteristics of successful networks** and **propose a phased approach** for the development of this network.





Suggestions for creating a network

1. Foster University Collaboration

- Advocate for **stronger collaboration between universities** to address national water challenges through membership in the network.

2. Build an Agile, Centralized Network

- Design a **flexible and nimble network structure** capable of adapting to user needs and changes in research priorities.
- **Leverage existing models** (e.g., US National Water Research Institute, CUAHSI) for coordination between government, universities, and other stakeholders.
- Create a **neutral host/secretariat or backbone organization** to convene stakeholders, facilitate collaboration, and manage resources.

3. Ensure Inclusivity and Equity

- Engage **Indigenous communities** and integrate **decolonizing methodologies** into the network.
- **Engage a diverse range of rights-holders and disciplines**, including municipalities, industries, communities, social scientists and natural scientists, to achieve better outcomes.
- Develop governance models that **explicitly include diverse groups and Indigenous perspectives**.

4. Support Knowledge Retention and Capacity Building

- Establish mechanisms to **retain knowledge** within the country, focusing on training the next generation of researchers.
- Provide **ongoing funding stability** to prevent initiatives from dissolving after short-term grants. Avoid the constant need to reapply and restructure programs.
- Ensure **continuity of research networks** even after initial issues are resolved.

5. Facilitate Research Coordination

- Develop **Research Coordination Networks (RCNs)** to connect researchers and rights-holders.
- Utilize centralized platforms like a **SharePoint site** for sharing curated research, reports, and iterative feedback.
- Encourage regular convenings, such as **(bi)annual in-person events** and national forums, to gather input and strengthen ties.
- Engage in both **grassroots-level** and **high-level conversations** to address who is not currently involved (but should be) and influence broader strategies and policies.

6. Advocate for Integrated Funding and Support

- Lobby for **federal support** through dedicated acts or funding mechanisms, similar to the USGS model, to ensure sustained funding.



- **Create a funding model** similar to the US National Water Resources Research Institutes, with annual meetings for directors and diverse fund allocation methods (e.g., microgrants, leveraging larger grants).
- Encourage funding models where all participating institutes contribute, with municipalities and industries playing key roles in source water protection.
- **Seek funding from US sources** and **collaborate** with institutes like the Cooperative Institute for Great Lakes Research.

7. Prioritize Communication and Relationship Building

- Assign personnel skilled in convening and relationship-building (e.g., extension agents, facilitators) to serve as liaisons between researchers, universities, and government agencies.
- Develop a **national database or map of water researchers, practitioners, decision-makers, and end-users** to connect groups across expertise, capacities, and regions.
- Establish networks based on **end-user needs**, involving various stakeholders such as municipalities and not-for-profits.
- **Engage multiple rights-holders**, including municipalities, Indigenous groups, academics, government, and industry, **from the beginning** to enhance research effectiveness.

8. Embrace a National Identity and International Ties

- Position the network as the central hub for water research in Canada, unifying the efforts of multiple universities and research hubs under one banner.
- Support international collaborations and secretariats that align with national water goals while fostering Canadian leadership in global initiatives.





Conclusion

Overall, the development and implementation of a National Freshwater Science Agenda was viewed as an important step towards enhancing freshwater science in Canada. Interestingly, while participants agreed with the importance of the freshwater priorities and research questions put forth from these priorities, they strongly felt that national priorities should be reframed within the context of applying research to support solutions to urgent, cross-cutting societal water problems. The challenges that were viewed as the largest barriers to connecting research to impact were not necessarily scientific, but related to collaboration, coordination, and capacity in freshwater sciences in Canada. Improving coordination, collaboration, and capacity in freshwater science in Canada can be achieved through adopting a problem-oriented approach to research, focusing on the pressing, cross-cutting challenges facing freshwater ecosystems and people living in Canada, as well as the development of a Canada-wide water research network. This Canada-wide water research network would connect researchers, practitioners, decision-makers, Indigenous groups, communities, and end-users to better understand and solve threats facing freshwater ecosystems in Canada. Underpinning these initiatives is the critical need to achieve continuity of effort and ensure that science agendas are not one-off efforts but sustained, team-driven investments in long-term solutions. **With sufficient and sustained coordination, collaboration, and capacity, Canada can more effectively solve threats facing freshwater ecosystems in Canada and strive to elevate our position as international leaders in freshwater science, policy, and action.**

The next steps for the National Freshwater Science Agenda include producing a complete draft of the NFSA by March 2025, following inclusion of input and feedback from the roundtable discussions, as well as meetings with representatives from First Nations groups. Additionally, practical guidelines and recommendations for develop a Canada-wide water research network will be formalized in a follow up virtual workshop and presented to ECCC.



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Appendix I—Agenda and discussion questions

The structure of the meeting was as follows:

Tuesday, November 26, 2024

- Opening Remarks
- Presentation: National Freshwater Science Agenda Priorities
- Discussion—Fine-tuning of Priorities
- Discussion—Emerging Theme 1: Freshwater & Climate (i.e.: climate change – hydro-climate science, water stress and availability)
- Discussion—Emerging Theme 2: Freshwater and & Land (i.e.: land use and ecosystem changes, pollution, contaminants and Mixtures)
- Discussion—Emerging Theme 3: Freshwater & Ecosystems (i.e.: water quality, state of aquatic ecosystem health / species, cumulative effects)
- Discussion—Solution Science: Canadian universities and federal agencies delivering on priorities

Wednesday, November 27, 2024

- Discussion—Research to Impact: Implementation of the NFSA
- Discussion—Convening & coordinating national science capacity: A national water research network or other university opportunities within the National Freshwater Science Agenda
- Summary and next steps

Examples of questions that were asked to facilitate each discussion:

- Relevance of identified themes to different regions
- Missing themes/priorities
- Gaps in implementation resources (data, knowledge, models, training,)
- Current research strategies and opportunities
- Where universities stand to advance research themes
- The role of universities
- Any other insights



Appendix II—List of networks

- Canada Water Network
- Decolonizing Water Network
- IJC Scientific Committee (CAN-COVID, CAN-AVOT)
- International Institute for Sustainable Development
- Cooperative Institute for Research to Operations in Hydrology (CIROH)
- Consortium of Universities for the Advancement of Hydrologic Science (CUASI)
- US Co-operative institutes (e.g., Cooperative Institute for Great Lakes Research)
- Pay-Water Network and Water Research Foundation (direct funds to research priorities informed by end-user needs)
- US research coordination networks
- Federal-Provincial-Territorial Committee on Drinking Water
- National Water Res Research
- Association of Medical Faculty
- WISE Household Water and Security Experiences Network
- National Adaptation Plans Network
- Water Research Australia

