ECS Lunch and Learn

Supporting internal knowledge transfer within TRCA

November 25, 2021

Toronto and Region Conservation Authority

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& Hayley Carlson

Chapter 4: Water Resources

Government of Canada / Gouvernement du Canada

Canada

- What and how we are doing on climate change adaptation in the water resources sector in Canada.
- Reviewed material from hundreds of pieces of peer-reviewed and grey literature. Some original research based on interviews with water professionals and a document analysis focused on the prairie provinces.
- Content structured around key messages.
- Digital delivery format at changingclimate.ca

Key Message 1

Global climate change has already altered patterns of rainfall, snow, ice and permafrost melt, exacerbating existing water availability and quality issues, as well as changing the nature and timing of water related natural hazards such as high flows/floods and low flows/droughts.

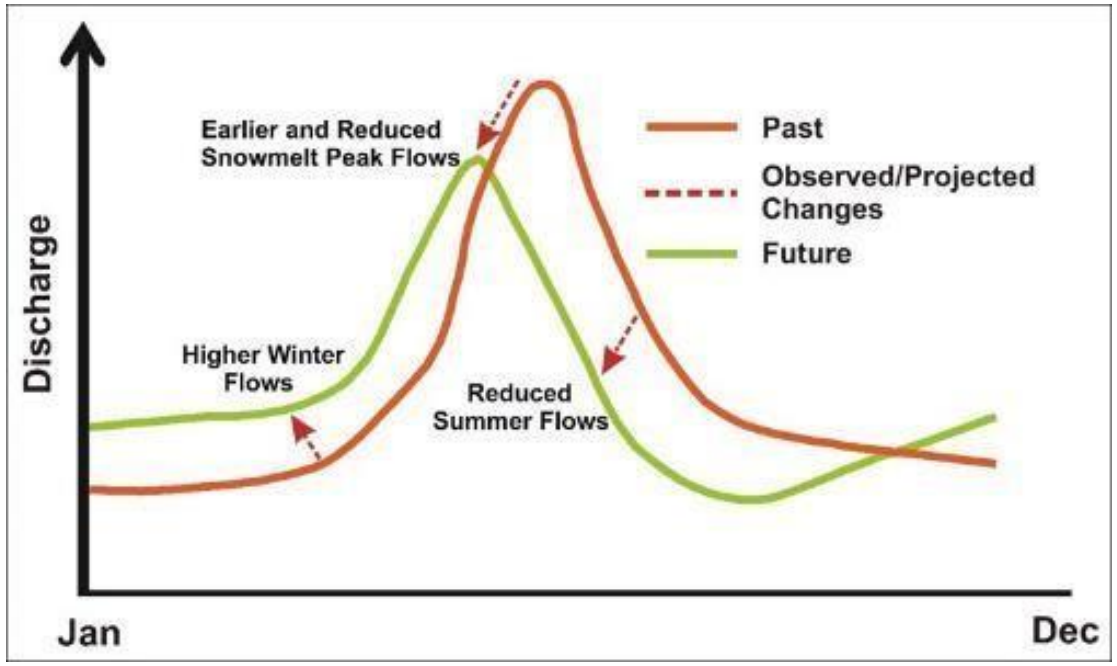
Surface Runoff: Streamflow

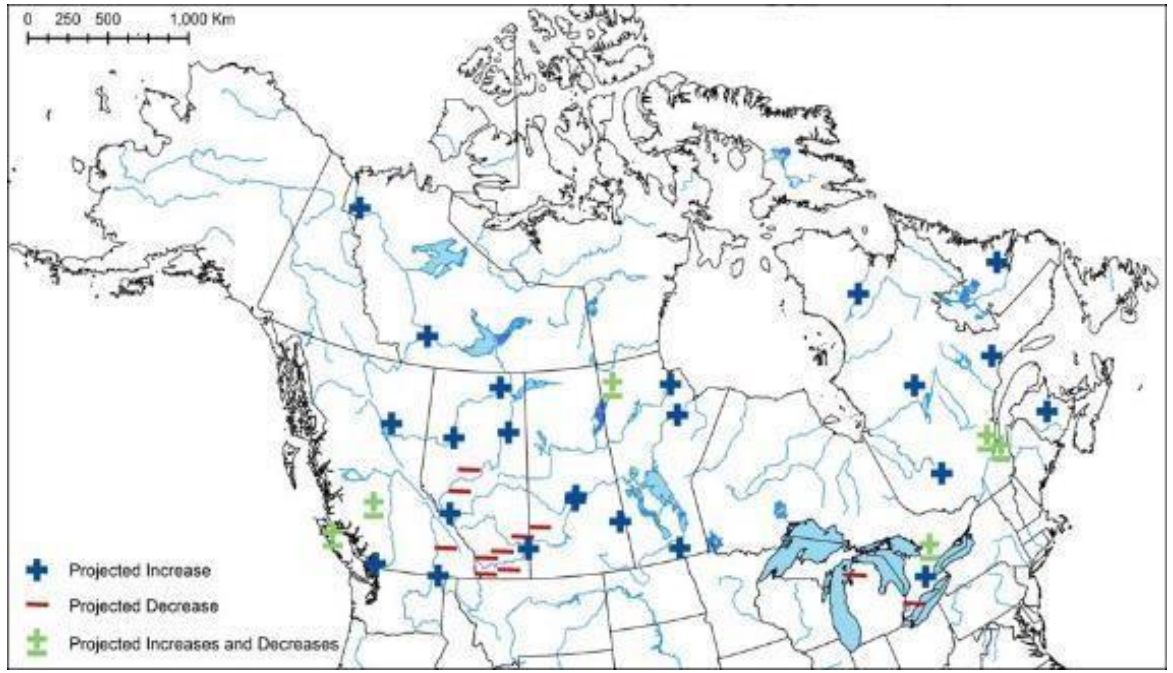
- The seasonal timing of peak streamflow has shifted, driven by **warming temperatures,** occurring earlier, with higher winter and early spring flows (***high confidence***).

- In some areas, reduced summer flows have been observed (***medium confidence***).

- Seasonal changes projected to continue, with shifts from more snowmelt-dominated regimes toward rainfall-dominated regimes (***high confidence***).

- There have been no consistent trends in annual streamflow amounts across Canada as a whole. In the future, annual flows are projected to increase in most northern basins but decrease in southern interior continental regions (***medium confidence***).





Streamflow Related Flooding

- Streamflow-related floods result from many factors, and in Canada these mainly include excess precipitation, rapid snowmelt, ice jams, rain-on-snow, or a combination of these factors. There have been no spatially consistent trends in these flood-causing factors or in flooding events across the country.

- Projected increases in **extreme precipitation** are expected to increase the potential for future urban flooding (***high confidence***).

- Projected **higher temperatures** will result in a shift toward earlier floods associated with spring snowmelt, ice jams, and rain-on-snow events (***medium confidence***).

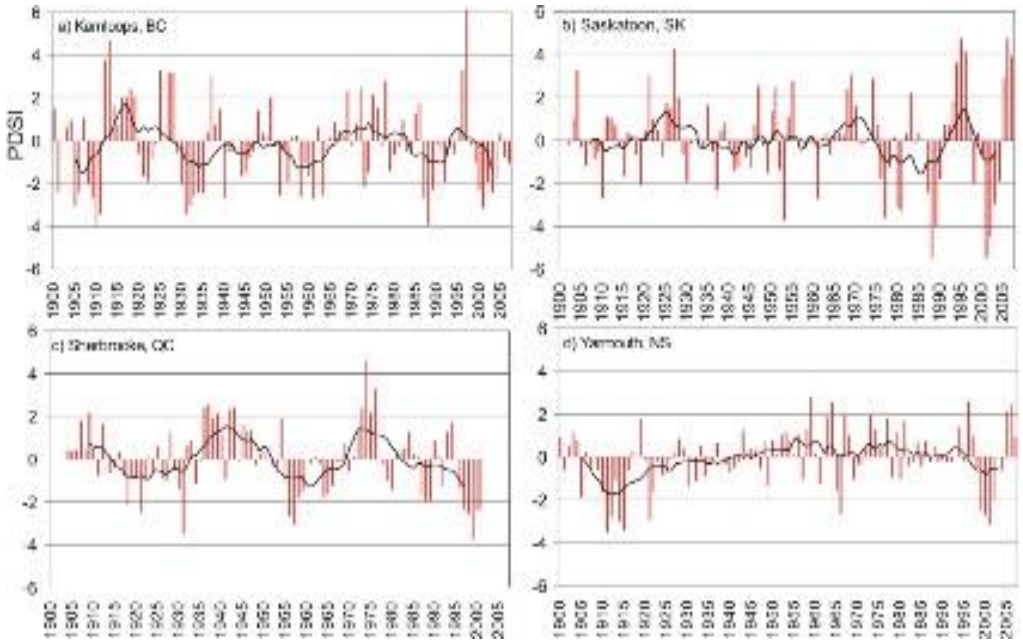
- It is ***uncertain*** how projected higher temperatures and reductions in snow cover will combine to affect the frequency and magnitude of future snowmelt-related flooding.

Soil Moisture and Drought

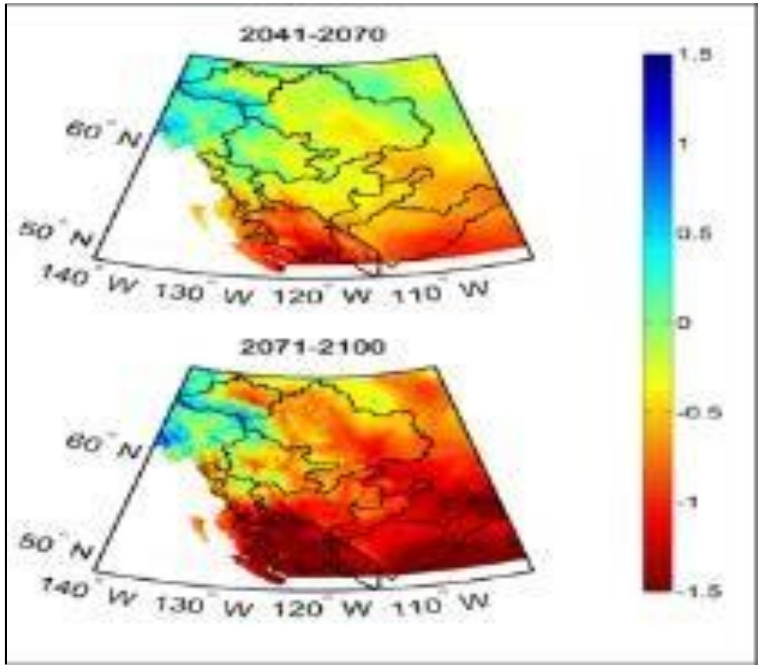
- Periodic droughts have occurred across much of Canada, but no long-term changes are evident.

- Future droughts and soil moisture deficits are projected to be **more frequent and intense** across the southern Canadian Prairies and interior British Columbia during summer, and to be more prominent at the end of the century under a high emission scenario (***medium confidence***).

Past Changes in Drought



Projected Changes in Summer Drought across Western Canada



Drier in south from 2041-2070; For 2071–2100, drier almost everywhere and very dry for the south

No long-term trend; Multi-year cycles

Thawing permafrost is causing washouts and collapse along the Dempster Highway

Disappearance of the Sims River due to glacier retreat

Changing precipitation regimes and low recharge of freshwater sources contributed to water emergencies in Iqaluit in 2018 and 2019

Type of event

- Ice melt, permafrost thaw and shorter duration of snow cover
- Water quality issues and ecosystem impacts
- Soil moisture deficits and drought
- Extreme precipitation and flooding

Inuvik

Yukon

Kluane National Park and Reserve

Iqaluit

Northwest Territories

Nunavut

The 2016 Fort McMurray wildfire caused millions of dollars in increased water treatment costs

Changing river flows are contributing to the decline of 15 of 17 environmental health measures in Wood Buffalo National Park

Over $50 million has already been dedicated to improving water quality in Lake Winnipeg

Wood Buffalo National Park

Fort McMurray

British Columbia

Alberta

Saskatchewan

Manitoba

Lake Winnipeg

Ontario

Quebec

Newfoundland and Labrador

PEI

Nova Scotia

New Brunswick

Fredericton

Eel Ground First Nation

Rocky Mountain floods in 2013 cost $6 billion and caused 100,000 people to be evacuated

71 long-term water advisories in place for First Nation communities

Three of the four worst floods in New Brunswick's history occurred after 2008 (with the 2018 and 2019 floods costing over $80 million)

Warming water and nutrients causing algal blooms on Lake Eerie could cost Canada $5.3 billion in the next 30 years

Toronto

Lake Erie

Record floods and fires in British Columbia in 2017 and 2018 cost over $1.25 billion

Drought in the Prairies (2001–2002) cost $5.8 billion

Summer floods the Prairies in 2014 cost $1.8 billion

Toronto floods in 2013 cost $1 billion

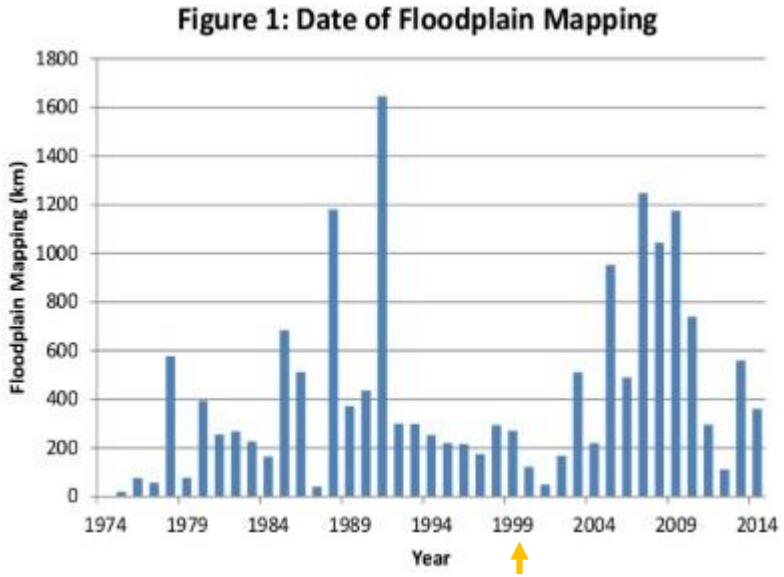
Ontario and Quebec floods in 2017 caused more than $223 million in insured damage

Key Message 2

Canadian organizations and institutions are unevenly prepared to manage the new water-related risks of climate change. Partnerships and networks allow organizations at a variety of scales to access additional resources, share knowledge and risk, and enhance adaptive capacity. Transboundary organizations offer useful insights into effective coordination of water systems with diverse stakeholders and high uncertainty.

Flood Management and Fragmentation in Canada

- 75% of annual weather event expenditures under the Federal DFAA are flood related.
- Since the discontinuation of *Flood Damage Reduction Program* in 1999, flood management highlight fragmented and reflects uneven adaptive capacity.
- Recently Federal Government has released Flood Mapping Guidelines Series.
- Still no institutional guidance on how to account for climate change impacts in floodplain mapping.



The National Floodplain Mapping Assessment (2014) found half of existing flood mapping was completed post-FDRP, 59% in Ontario, 21% in Quebec, 10% in B.C., and the remaining 10% distributed across the rest of the country.

Henstra et al. (2019)'s more recent study found that while many Canadian municipalities have some sort of flood map, most of these maps are of poor quality and are ill-suited for communicating flood risk to the public.

Calgary's River Flood Story

Map Gallery

Introduction | Flood Map | Land Use Regulations | Our Flood History | Reducing Flood Risk | How to Prepare | Our changing climate

Calgary's Flood Map

The colours on this map show areas at risk of river flooding. Check your home, place of work, local playfield or commuting route to see if there's a flood risk. You can:

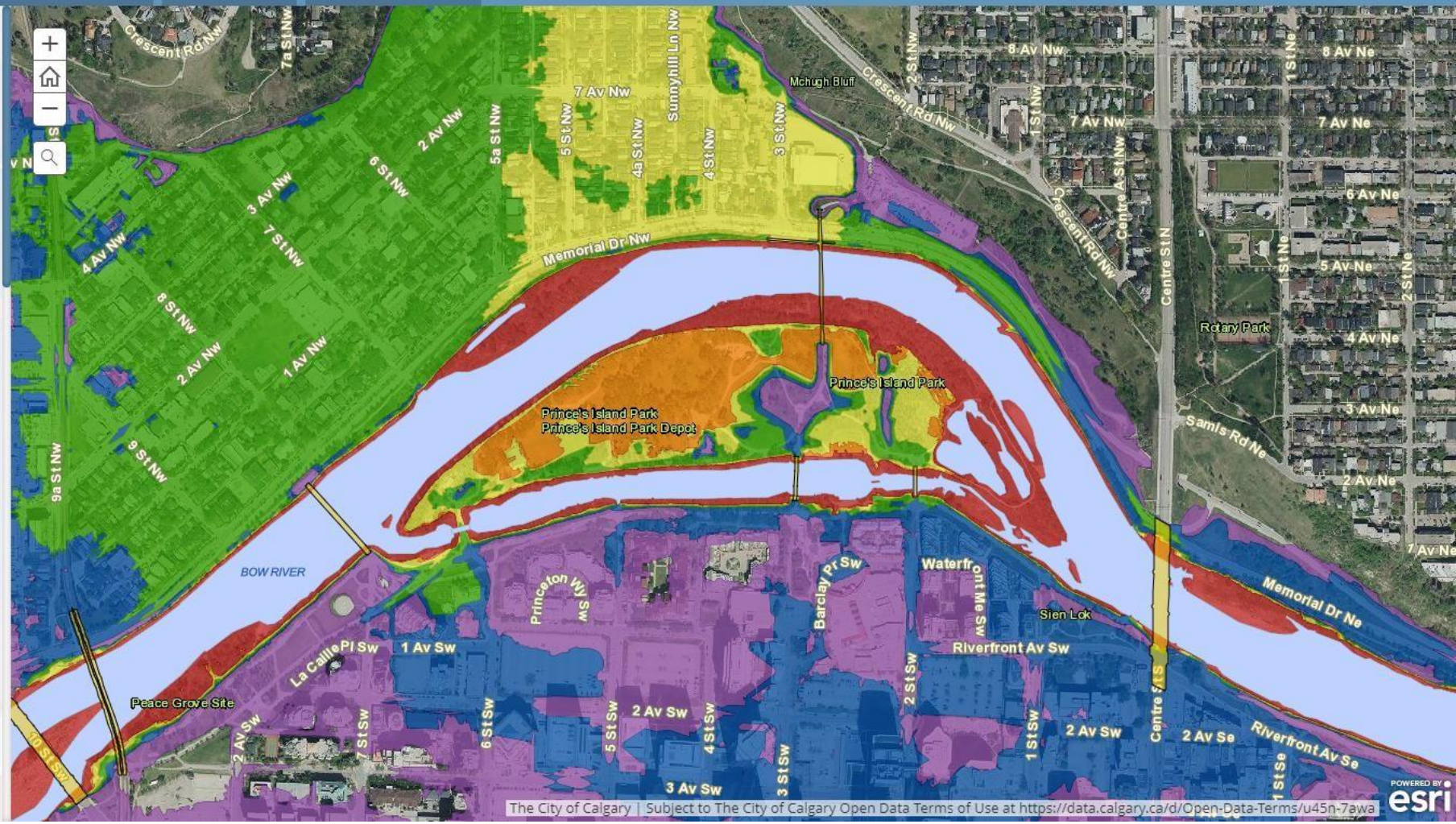
- search by address (click on the magnifying glass)
- move the map
- zoom in and out

For example - check out the Beltline

As the river swells and river flow increases, more areas are flooded. Each colour on the map indicates a different likelihood of flooding. Small floods (red), are more likely to occur than very large floods (purple).

LEGEND	Flowrate that could flood this area – Bow River upstream of the Elbow River	Flowrate that could flood this area – Bow River downstream of the Elbow River	Flowrate that would flood this area – Elbow River downstream of Glenmore Dam	Natural chance of a property within this area flooding in any given year without mitigation – given as "% chance" of this flood occurring in any year, and as "1:X" probability flood	Natural chance of a property within this area flooding in 25 years without mitigation – given as "% chance" of this flood occurring at least once over 25 years (e.g., a typical mortgage life)
	up to 839 m^3/s	up to 1040 m^3/s	up to 201 m^3/s	12.5% (1:8)	97%
	840-927 m^3/s	1041-1160 m^3/s	202-234 m^3/s	10% to 12.5% (1:8 to 1:10)	93% to 97%
	928-1230 m^3/s	1161-1500 m^3/s	235-275 m^3/s	5% to 10% (1:10 to 1:20)	72% to 93%
	1231-1660 m^3/s	1501-2150 m^3/s	276-494 m^3/s	2% to 5% (1:20 to 1:50)	40% to 72%
	1661-2020 m^3/s	2151-2820 m^3/s	495-803 m^3/s	1% to 5% (1:50 to 1:100)	22% to 40%
	2021-3340 m^3/s	2821-5610 m^3/s	804-2270 m^3/s	0.1% to 1% (1:100 to 1:1000)	2.5% to 22%

The likelihood or chance of a flood occurring is the probability that natural conditions (like rainfall and snowmelt) will produce this much flow in our rivers. This probability is shown as a per cent chance of flooding in a time period ("1% chance in any given year"), or a "one-in-X" chance of flooding ("1 in 100 chance in any given year"). This size flood is sometimes called a "one-in-one-hundred flood", or "1:100 flood"

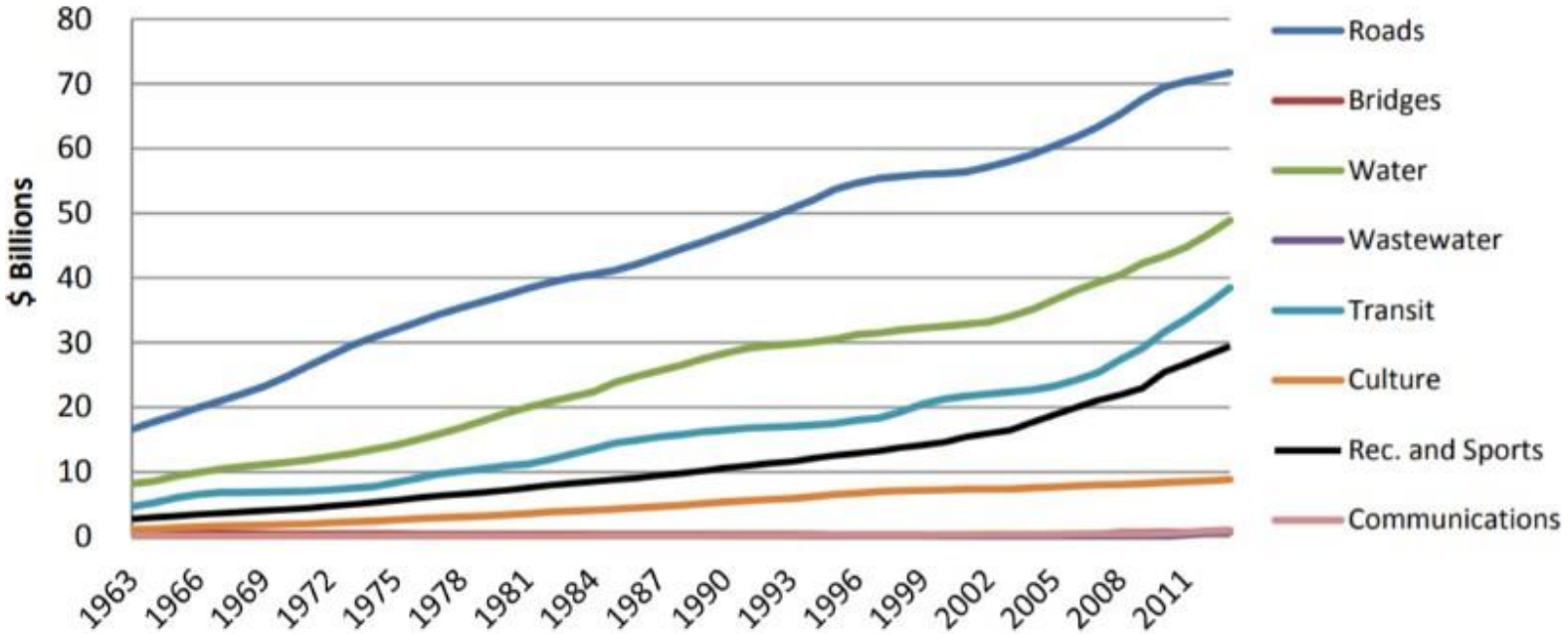


Uneven Adaptive Capacity

- Perceptions of declining technical skills and resources, employee turnover and burnout, and a lack of stable funding.
- Capacity challenges concentrated in rural, northern and Indigenous communities and non-governmental organizations and municipalities.

IPCC defines adaptive capacity as “the ability of a system to adjust to climate change to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.”

Figure 4: Municipally Owned Core Public Infrastructure Net Stock (Billions, constant $)



Notes: Net stock using a hyperbolic function for depreciation from general government. Core public infrastructure includes roads, bridges, transit, water, wastewater, culture, and sports and recreation. Communication Infrastructure includes connectivity, broadband, and telecommunications infrastructure. Data for 2013 based on forecast.
Source: Statistics Canada, National Economic Accounts Division.

Municipalities are responsible for 60% of public infrastructure across Canada, but <20% have formally introduced adaptation strategies.

According to the 2016 Canadian Infrastructure Report Card:

- About 50% of municipalities have undertaken a risk assessment of their water-related assets;
- < 20% have formally introduced adaptation strategies

Potable Water, Wastewater and Stormwater

- Of our linear assets (e.g., watermains, sewers), 30% are in fair or worse condition.
- Climate change puts an additional strain on these infrastructure systems.

Asset Category	Subcategory	# And % in Poor/Very Poor Condition	# And % in Fair Condition
Potable Water	Linear Infrastructure	17,788 km (9.6%)	32,641 km (17.7%)
	Non-linear Infrastructure	573 Facilities (6.4%)	1,333 Facilities (15%)
Wastewater	Linear Infrastructure	16,350 km (10.8%)	26,211 km (17.3%)
	Non-linear Infrastructure	1,386 Facilities (10%)	2,896 Facilities (20.6%)
Stormwater	Linear Infrastructure	50,251 km (11.3%)	84,614 km (19%)
	Non-linear Infrastructure	700 Facilities (4.4%)	1,866 Facilities (11.8%)

Adaptive Strategies

- Partnerships.
- Risk-sharing tools.
- Larger institutions and governments providing support for local adaptation efforts.
- Incorporation of diverse sources of knowledge

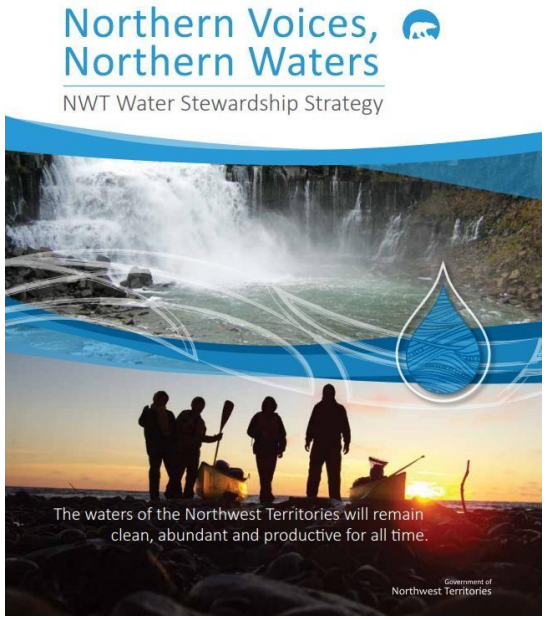
Hazard-based (historical event used to estimate probability) v. Risk-based (incorporates exposure and vulnerability)

Thistlethwaite and Henstra (2017) find cities do not always take advantage of all risk-sharing tools available.

e.g. Edmonton, Mississauga, Kitchener and Waterloo charge user fees for storm water management roughly based on the property's contribution to runoff, but Calgary and Toronto do not.

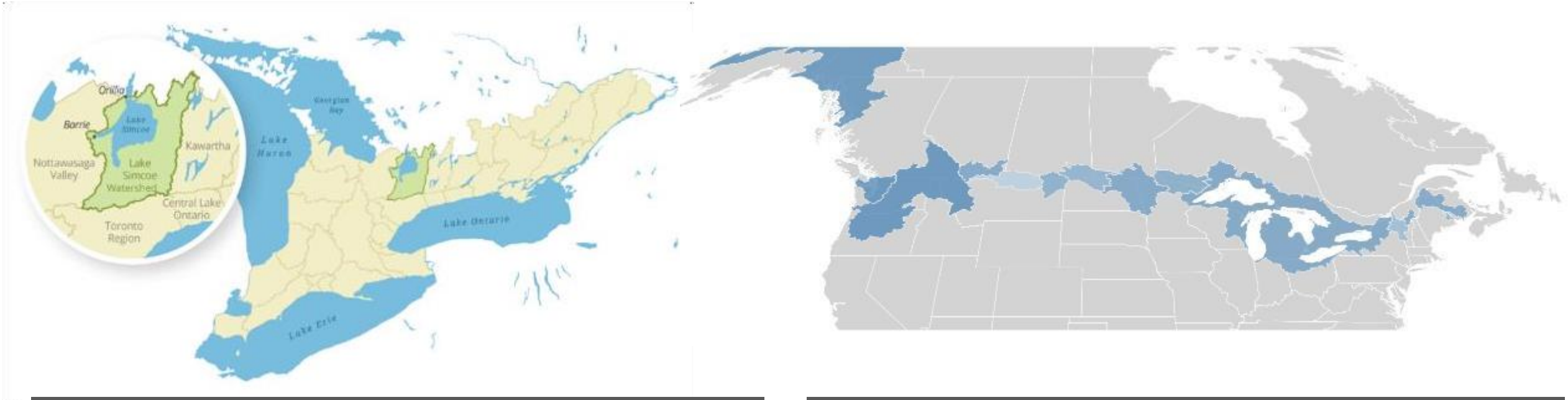
ICLEI Local Governments for Sustainability

Traditional knowledge is "…knowledge and values, which have been acquired through experience, observation, from the land or from spiritual teachings, and handed down from one generation to another" (Government of Northwest Territories Traditional Knowledge Policy: Implementation Framework, p. 1).



Thistlethwaite, J., and Henstra, D. (2017): Municipal flood risk sharing in Canada: A policy instrument analysis; Canadian Water Resources Journal, v. 42, p. 349–363.

Transboundary and Watershed Organizations



Case 2 explores Lake Simcoe Conservation Authority's role in the climate change adaptation strategy for Lake Simcoe:

- Partners identified vulnerabilities such as the drying of wetlands and spread of aquatic invasive species, using future scenarios of climate and non-climate stressors.
- Now building resilience by promoting natural infrastructure and a new Phosphorous Offsetting Policy.

Case 3 explores notable accomplishment of the International Joint Commission in the Great Lakes:

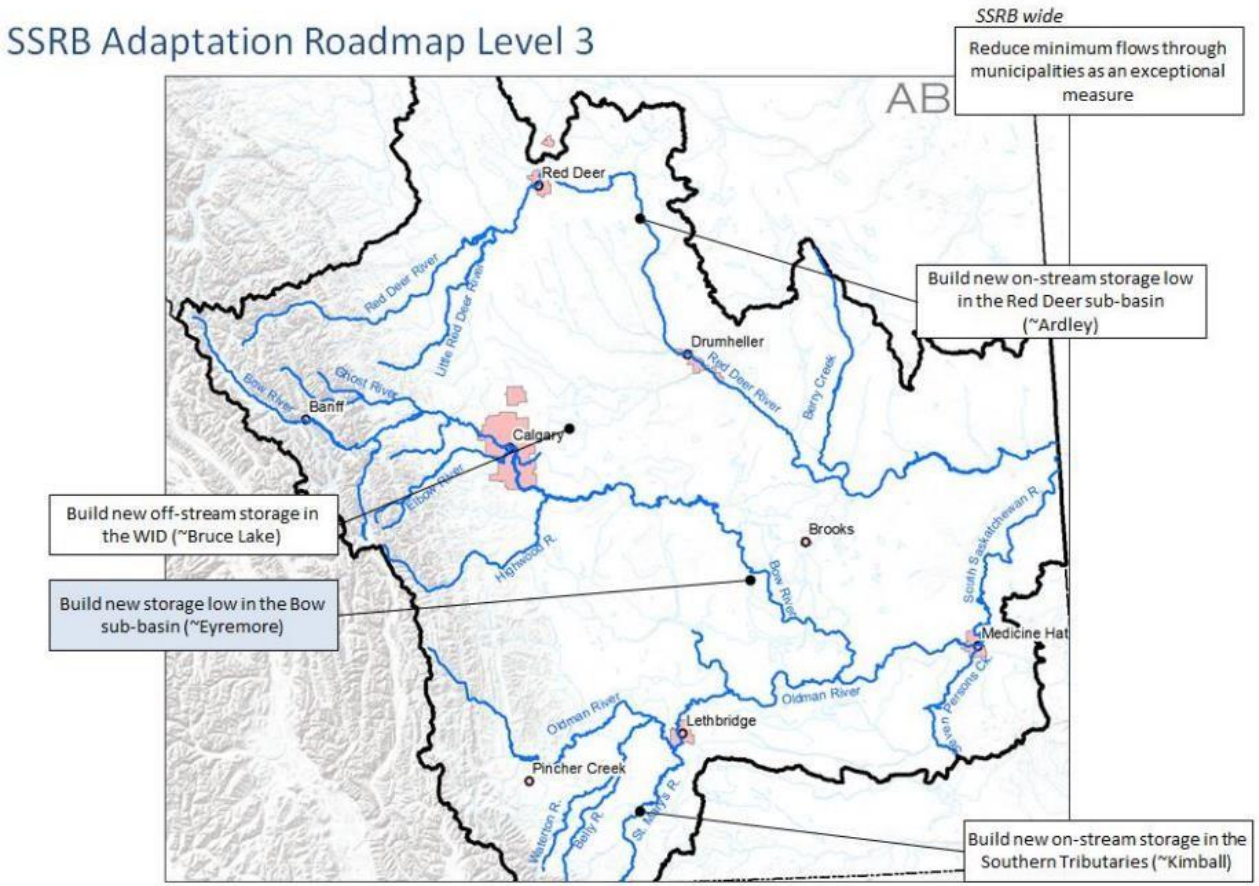
- Large transboundary integrated assessments such as the Lake Ontario–St. Lawrence River Study (1990–2005) and the International Upper Great Lakes Study (2007–2012).
- The Great Lakes Water Quality Agreement & the Great Lakes Water Quality Protocol of 2012
- A Climate Change Framework (2018).

Key Message 3

Promising examples of coordination and innovation occur in the water sectors across Canada. New approaches use scenarios to explore how decision-making strategies perform across a range of plausible futures; implement iterative processes for monitoring and adjusting actions; and engage stakeholders in social learning, laying the groundwork for innovation and adaptation.

Scenarios to explore plausible futures and develop robust or “low regret” solutions.

Climate Vulnerability and Sustainable Water Management in the South Saskatchewan River Basin Project (2016)



Shows the adaptation options considered most resilient in the SSRB, with the most promising in blue.

International Upper Great Lakes Study (2007–2012)

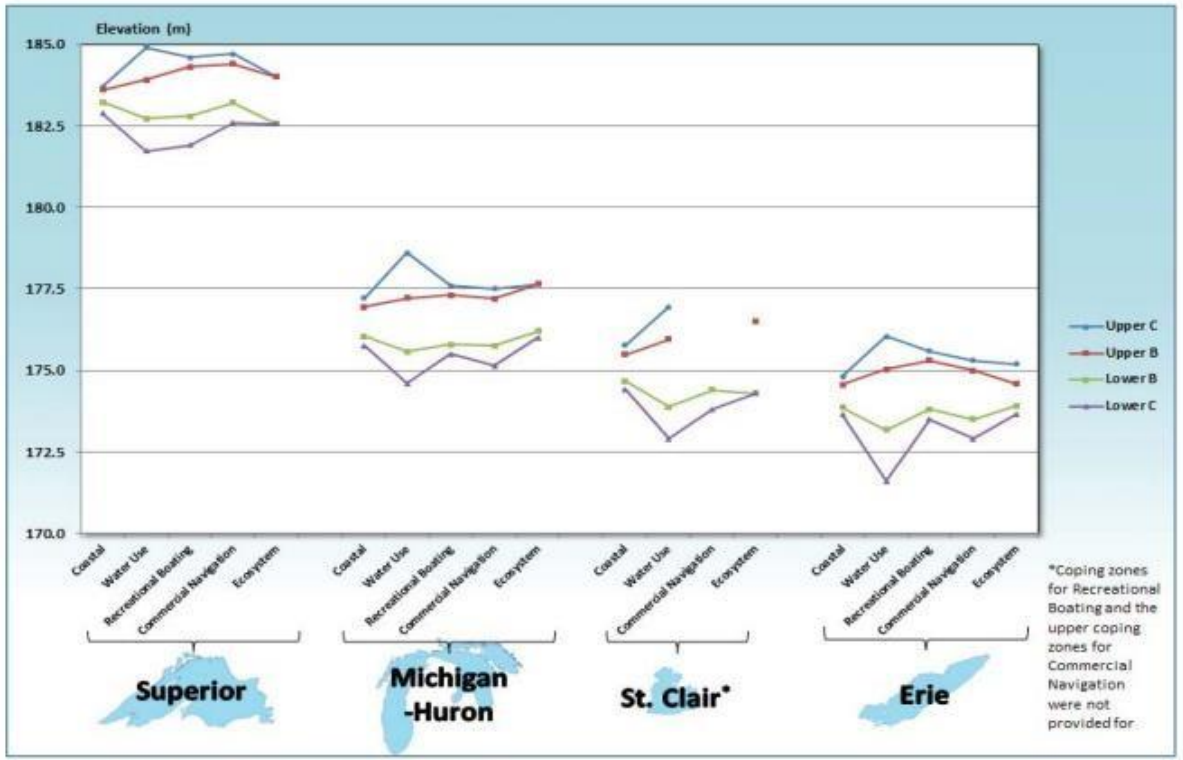


Figure 9-4 **Lake Coping Zone Definitions by Sector**

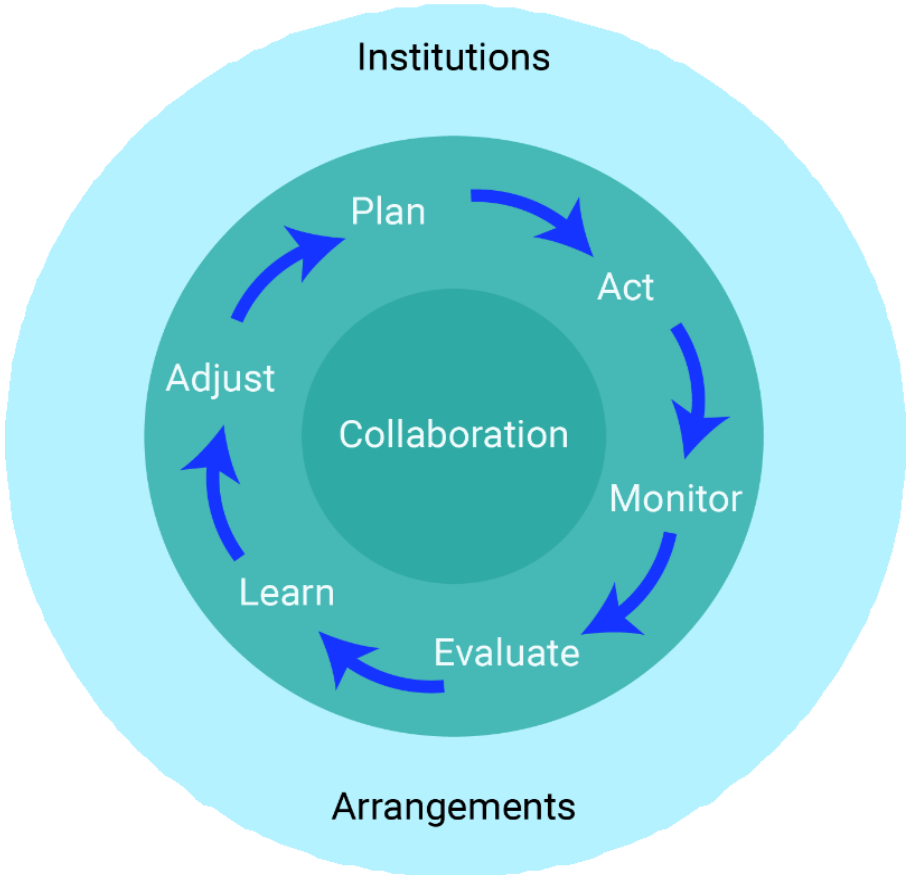
Coping zone by interest and by lake, for lakes Superior, Michigan-Huron, St. Clair and Erie.

Note: Ecosystem zones are only surpassed if combined with a consecutive sequence (e.g., above or below a mean level during the growing season for five or more consecutive years) (DePinto, et al., 2011).

Shows “coping zones” for different water use sectors in the Great Lakes region (Coastal, Water use, Commercial navigation, Recreational boating and Ecosystems)

Adaptive Management

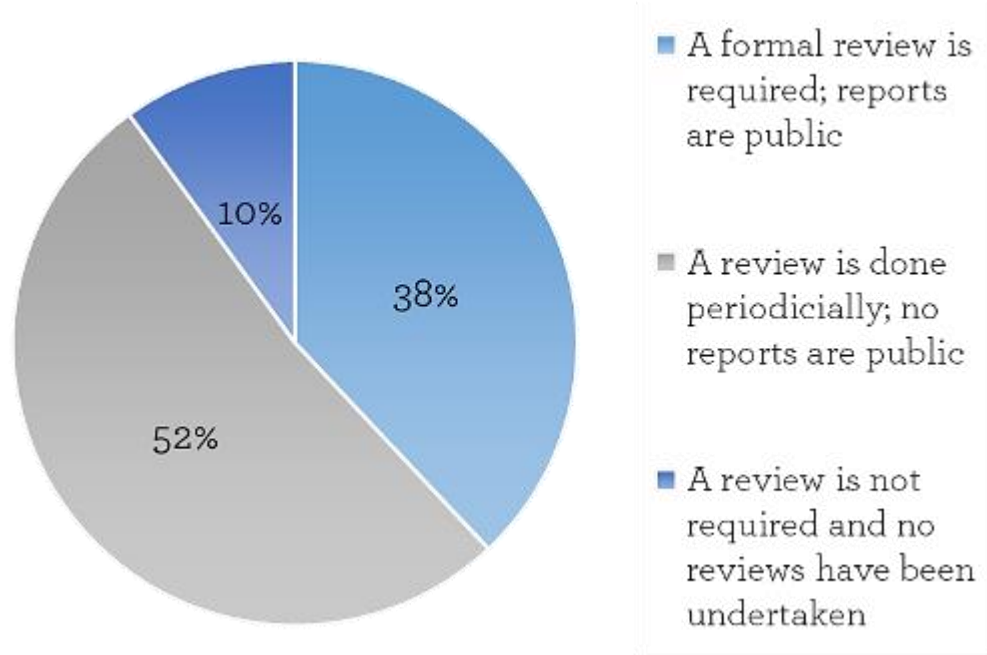
- Adaptive management provides a structured, iterative process of robust decision making in the face of uncertainty, with an aim to reduce uncertainty over time via system monitoring (Williams and Brown, 2014).



How are we doing? Variable.

- IJC a leader (e.g. The 2012 Great Lakes Water Quality Agreement, Great Lakes – St. Lawrence River Adaptive Management (GLAM) Committee.)

Bizikova et al. (2013) find water-related policies in BC, SK, MB, NS don't always include explicit monitoring and review processes, and don't always feed back into policy reviews or adjustments.



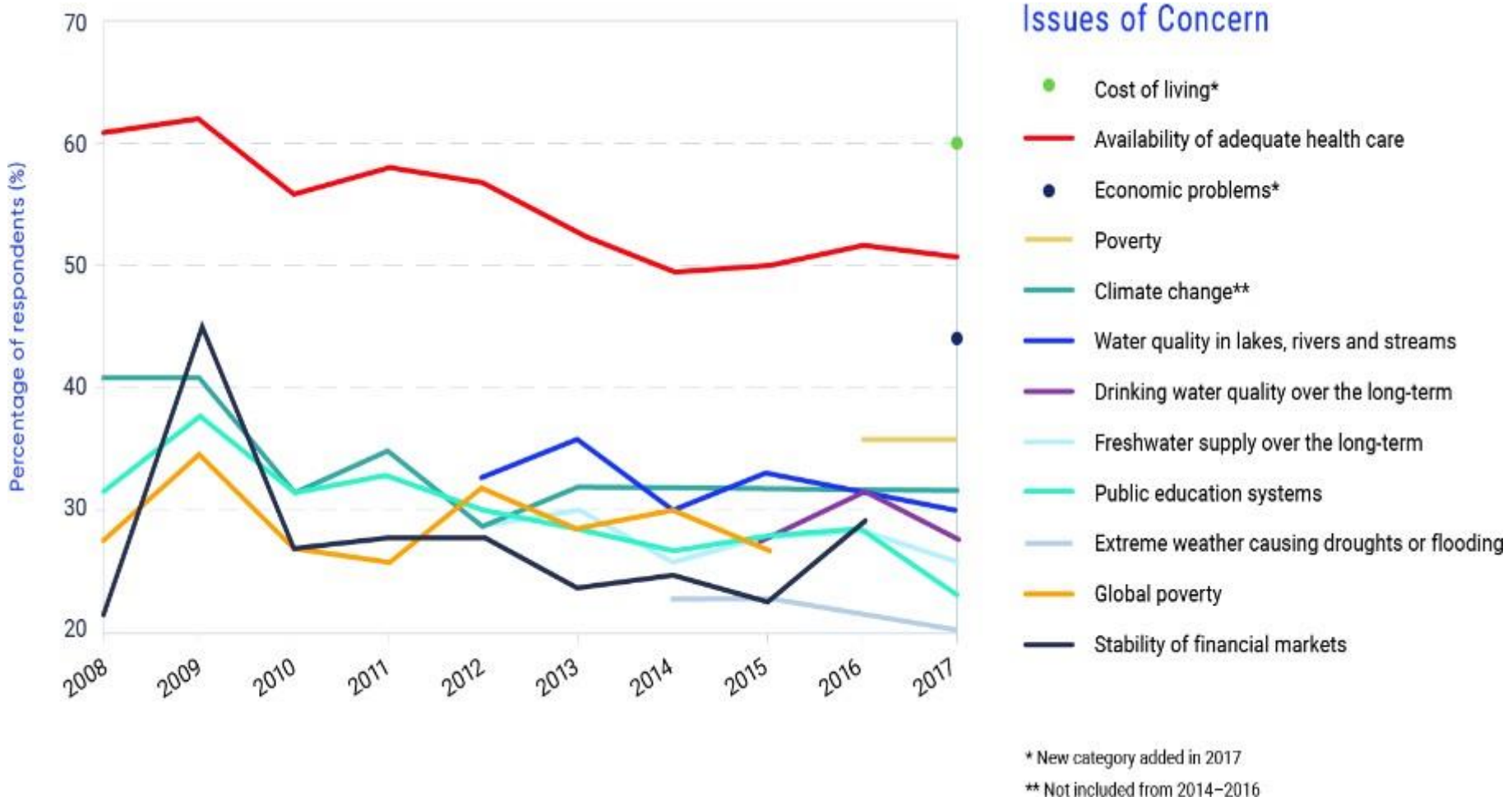
Williams, B. K., and Brown, E. D. (2014): Adaptive Management: From More Talk to Real Action; Environmental Management, v. 53, p. 465–479; Bizikova, L., Tyler, S., Roy, D., and Swanson, D. (2013): Strengthening Adaptive Capacity in Four Canadian Provinces: ADAPTool analysis of selected sectoral policies. A synthesis report; IISD Report submitted to Climate Change Impacts and Adaptation Division, Natural Resources Canada.

Key Message 4

Successful adaptation requires public buy-in to the science of climate change and the need to implement adaptation policies. A majority of Canadians support policies to address water-related problems, but managing water resources ranks low on the list of salient problems after the economy, health care, and cost of living. Extreme events, including floods, droughts, and episodes of poor water quality, often bring the need for changes to water management to the forefront.

Public Attitudes

- Climate change = more extreme storms, flooding and droughts
- Low level of preparedness for extreme events like floods
- Disconnect between practitioner and public perspectives



Percent of respondents across Canada who indicated they were “very concerned” about water issues and climate change from 2008 to 2017, from RBC Canadian Water Attitudes Study.

RBC.(2017): Canadian Water Attitudes Study; Blue Water Project; 92 pp.

WHY CANADA NEEDS TO REINVEST IN WATER

In recent surveys of 2,300 Canadians... [1, 2]

ONLY 6% OF CANADIANS

know that they are located in a designated flood-risk area.

LESS THAN 30% OF CANADIANS

have pursued flood protective measures.

Another survey shows that... [3]

ONLY 1 IN 5 CANADIANS

believe that major investments in water-related infrastructure are required.

Water managers and regulators believe ageing water-related infrastructure is the **most prominent future risk** to the Canadian water sector.

Municipalities are responsible for **60%** of public infrastructure, but lack capacity to raise revenue for maintaining & upgrading necessary water-related infrastructure.

As a result, less than 20% of municipalities have formally introduced strategies to adapt their water-related assets.

IMPROVE PUBLIC PERCEPTION

Building public support by emphasizing the health, economic & environmental benefits of investments in water systems may increase their priority among decision-makers.

ADDRESS CAPACITY ISSUES

Exploring partnerships (local, regional, or national) to address water-related risks of climate change, facilitating information sharing, and increasing technical and human resources will help address the capacity-related issues municipalities are facing.

PROMOTE BETTER DESIGN AND MAINTENANCE

Building redundancies into water systems, ensuring codes/standards reflect reliable & up-to-date information, and integrating more green infrastructure within design and construction will strengthen these systems over the long-term.

PRODUCED FOR: CANADIAN WATER AND WASTEWATER ASSOCIATION
DEVELOPED BY ICLEI CANADA WITH SUPPORT FROM NATURAL RESOURCES CANADA

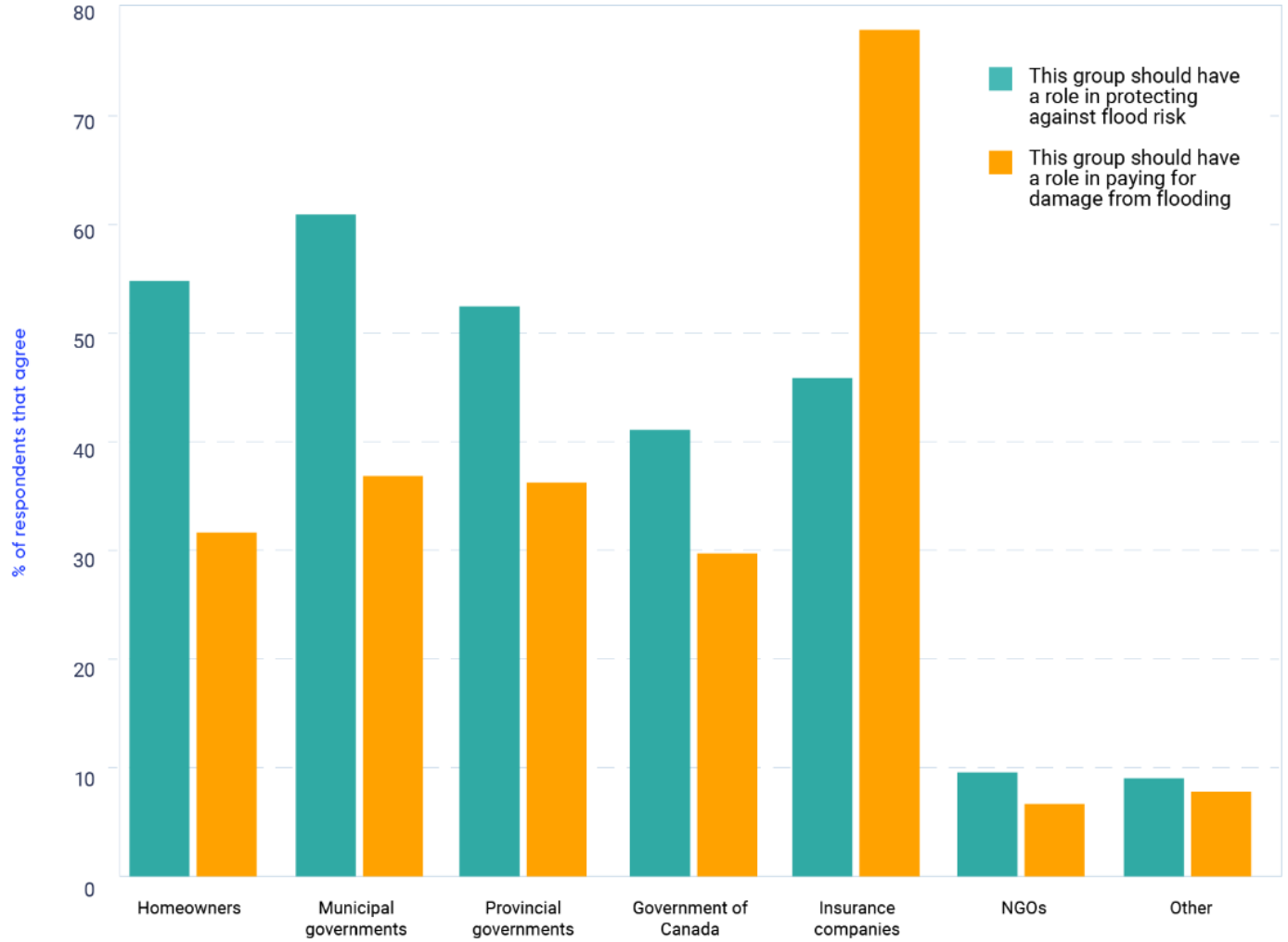
1 Henstra, D., Thistlethwaite, J., Brown, C. and Scott, D. (2019). Flood risk management and shared responsibility: Exploring Canadian public attitudes and expectations. *Journal of Flood Risk Management*, 12, 1–10. Retrieved June 2020, from https://doi.org/10.1111/jfr3.12346

2 Thistlethwaite, J., Henstra, D., Peddle, S. and Scott, D. (2017). Canadian voices on changing flood risk: Findings from a national survey. Faculty of Environment, University of Waterloo, Ontario, 1–8. Retrieved June 2020, from https://uwaterloo.ca/climate-centre/sites/ca.climate-centre/files/uploads/files/canadian_voices_on_changing_flood_risk_fnl.pdf

3 Royal Bank of Canada (2017). Canadian Water Attitudes Study. Blue Water Project, 92 p. Retrieved June 2020, from http://www.rbc.com/community-sustainability/_assets-custom/pdf/CWAS-2017-report.pdf

Overall, Canadians Want Action

- Surveys show strong support overall for action on water-related impacts of climate change.
- Canadians want strong government role, to enforce stricter regulations and require commercial/industrial users to pay the full cost of water supply.
- Support for action can diminish from issue fatigue and politicization of the issues.



The percentage of 2, 300 surveyed Canadians who indicated to what extent they believe each group should play a role in protecting against flood risk (green) and paying for flood damages (orange) from Thistlethwaite et al., (2017)

Thistlethwaite, J., Henstra, D., Peddle, S., and Scott, D. (2017): Canadian voices on changing flood risk: Findings from a national survey; Faculty of Environment, University of Waterloo; Ontario; p. 1–8.

Building Public Support

- Canadians want info to be relevant and able to be applied.
- Emphasizing co-benefits of action - new framing of problems (e.g. “lower incidence of disease”).
- Early engagement of stakeholders.
- Mainstreaming “water/climate” issues within other policy issues such as urban development.
- Reducing barriers such as time or financial constraints.

Thistlethwaite et al. (2017) found that 92% of survey respondents want publicly available flood risk maps with flood mitigation information, and want access to this information when they are considering home ownership.

Sherren and Verstraten (2013) found water quality improvements matter more to farmers restoring wetlands in Manitoba, as opposed to climate change.

After identifying financial constraints as a major barrier to the adoption of water conservation behaviours, the City of Barrie, Ontario introduced a rebate program and an interest-free pay-back scheme for water-efficient appliances and installation, ultimately deferring millions of dollars in water infrastructure spending.

Key Message 5

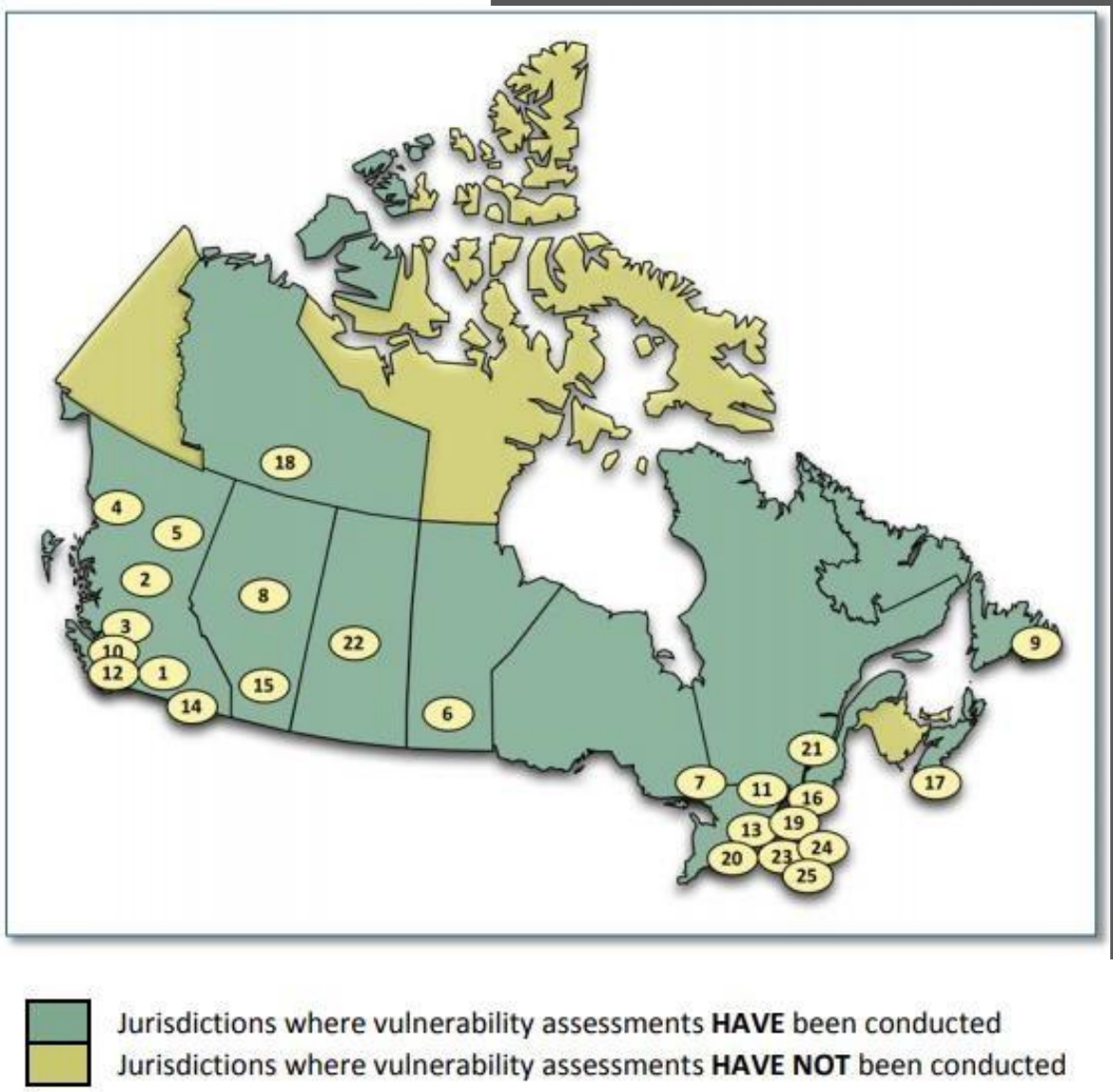
Reducing vulnerabilities in water systems involves identifying weaknesses under current and future climate conditions. Vulnerability reduction requires that practitioners have access to high quality and locally relevant data. While there is considerable variation in the quality and resolution of available data to monitor change in uncertain environmental systems, resilient design is emerging in built and natural infrastructure solutions.

Information Systems

- Vulnerability studies regularly pursued, but very different methodologies used.
- Technical challenges in identifying a range of climate change impacts.
- High quality, systematic, regularized data collection is not the norm in many parts of Canada.
- Range of info available across organizations – but uneven capacity to provide & data varies significantly in its quality, and temporal and spatial resolution.

Nodelcorp Consulting (2014) synthesized 25 vulnerability assessments across Canada. With respect to information systems they note:

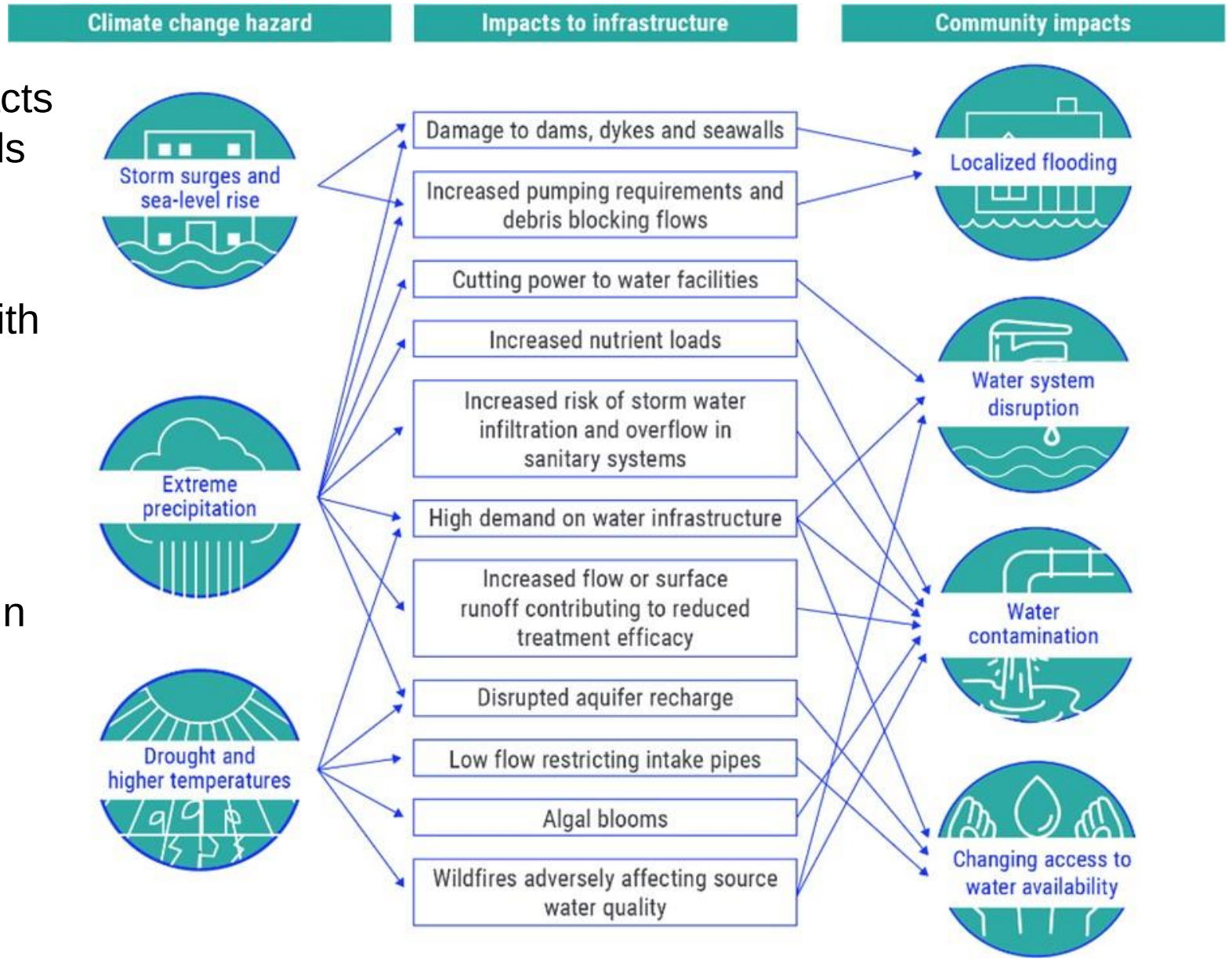
- The computational expense of obtaining robust climate change info
- Local expertise is highly valuable
- Some jurisdictions using very dated info and methods



Nodelcorp Consulting. (2014): Review and Analysis of Climate Change Vulnerability Assessments of Canadian Water Management and Drainage Infrastructure.

Infrastructure

- Water-related climate change impacts constitute some of the main hazards to all Canadian infrastructure.
- Generally, more resilient infrastructure is well-maintained, with reliable and up-to-date codes and standards, and/or may build in redundancies.
- 3 major vulnerabilities:
    1. Assumed stationarity in design and operation;
    2. A tendency to not account for low probability/high impact events;
    3. Costly to maintain, upgrade, and adhere to increasingly stringent regulations.



Natural Infrastructure

"the use of natural resources such as plants, soils and wetlands to reduce or mitigate the impact of climate change or natural hazards."
- Infrastructure Canada (2018)

Gibsons, BC, found they would need to spend $3.5-$4 M on engineered assets to provide the same level of stormwater service as the City's naturally occurring ponds.

Toronto's Green Roof Program contributes to an estimated reduction of just over 12,000 m^3 (435,000 ft^3) of stormwater annually, and the creation of over 100 related jobs.

Pelly's Lake, a restored and engineered wetland in Manitoba, provides flood reduction, water quality and other benefits valued at $3.7 million.

Moudrak, N., Feltmate, B., Venema, H., Osman, H. (2018): Combating Canada's Rising Flood Costs: Natural infrastructure is an underutilized option; Prepared for Insurance Bureau of Canada; By Intact Centre on Climate Adaptation, University of Waterloo.; ICF. (2018): Best practices and resources on climate resilient natural infrastructure; Prepared for Canadian Council of Ministers of the Environment, 60 pp.

Conclusions

- Global climate change has already altered Canada's cold-dominated water cycle.
- We observe promising examples of coordinated action, new techniques to plan under uncertainty, campaigns to build public support, and strategies to build and maintain more resilient infrastructure.
- Adaptation efforts are largely individual efforts or one-off experiments pursued at a variety of scales. Adaptation to water-related risks has not yet reached critical urgency in the minds of Canadians to catalyze widespread institutionalized and systematic adaptation processes.

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Upcoming ECS Lunch and Learns!

Wednesday, December 15
11:30am-12:30pm

TRCA's Ecosystem Compensation Program

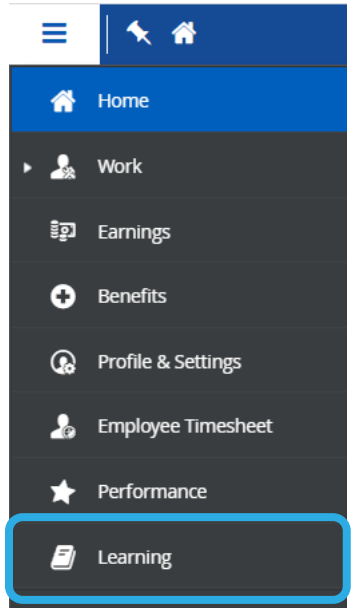
By Kelly Jamieson and Noah Gaetz

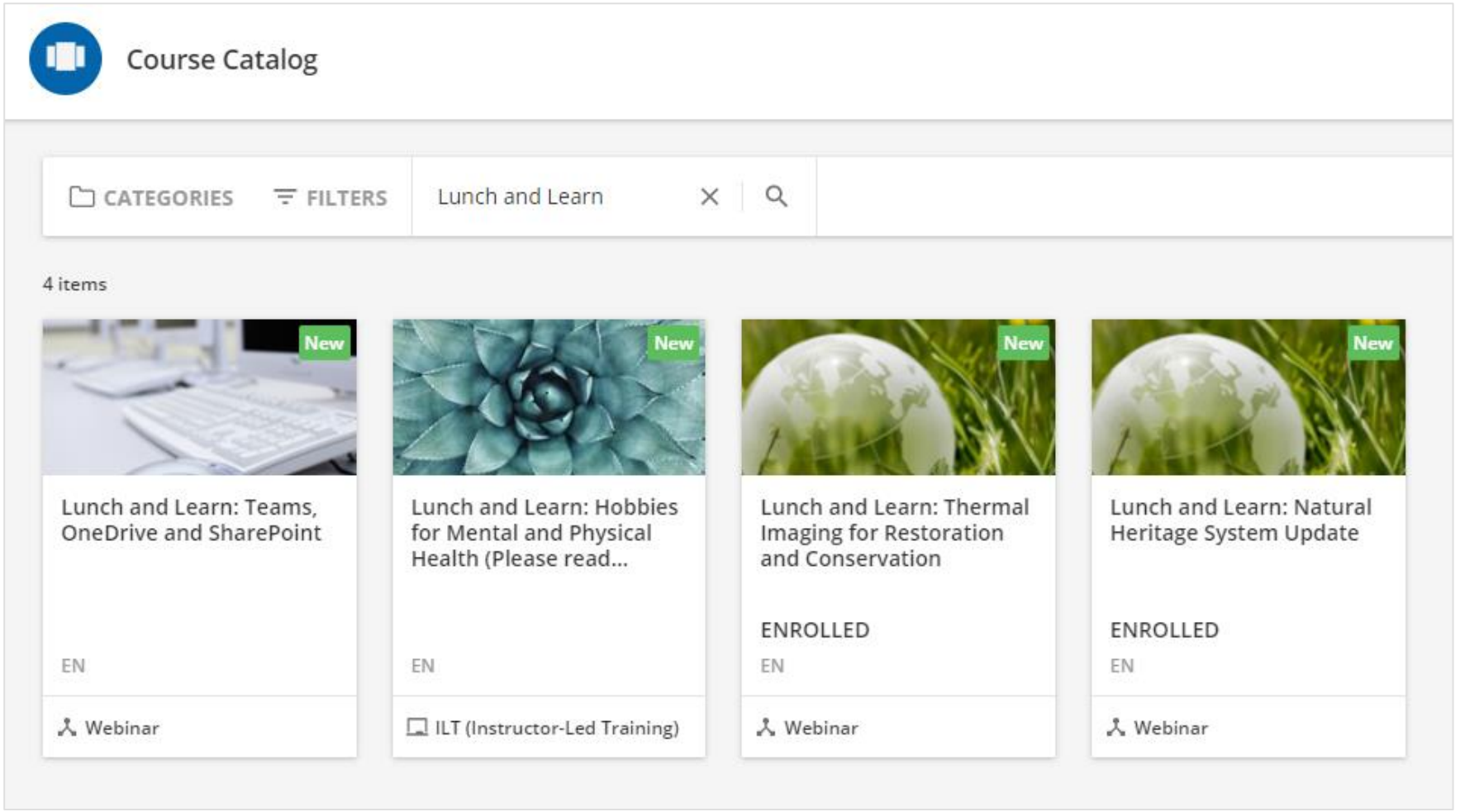
Wednesday, January 26
11:00am-12:00pm

Ontario's New Excess Soil Regulations

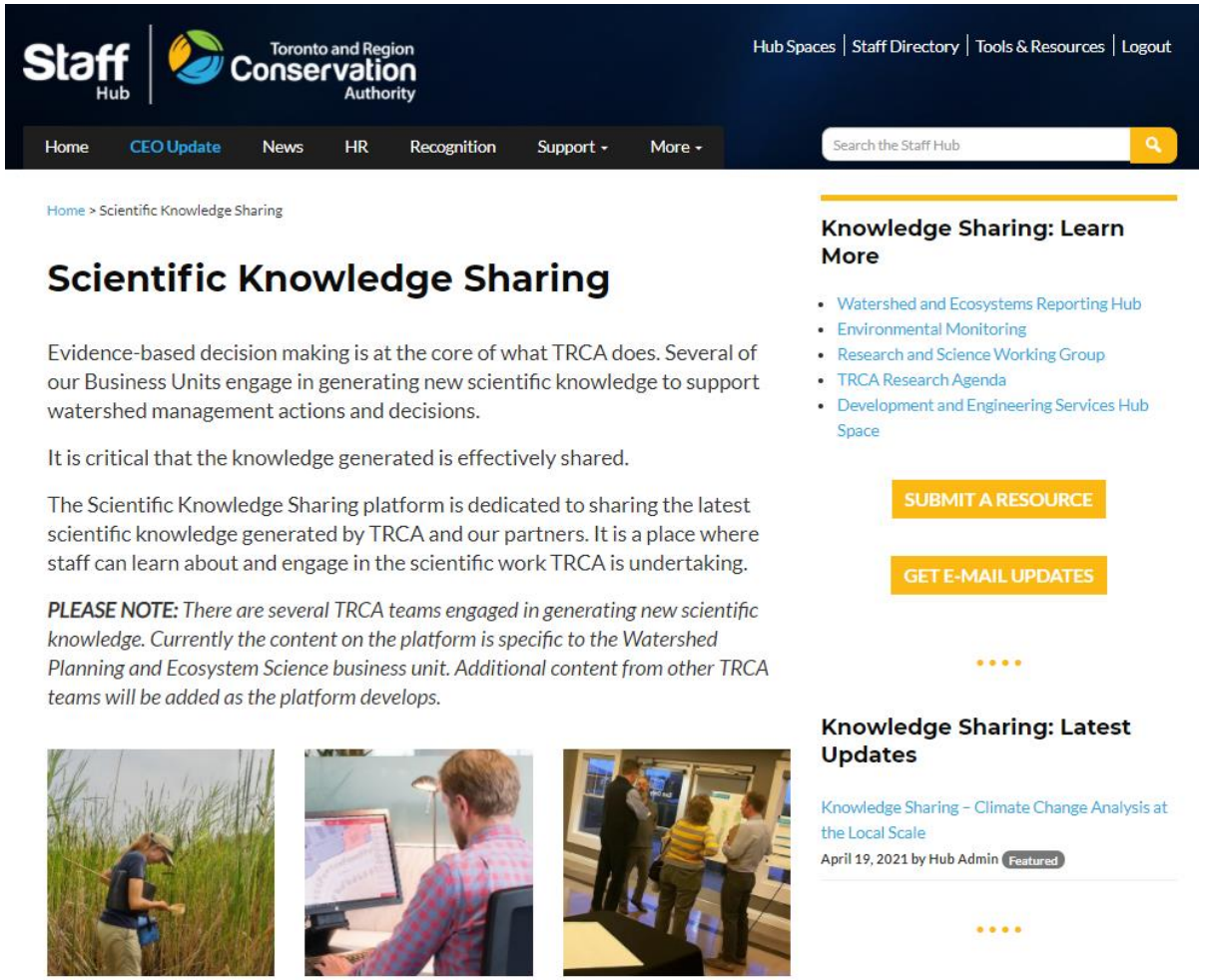
By Don Ford

Learning Management System





Scientific Knowledge Sharing Hub



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- Open Data & Information +
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- Presentations to Partners +
- Reports and Technical Papers +
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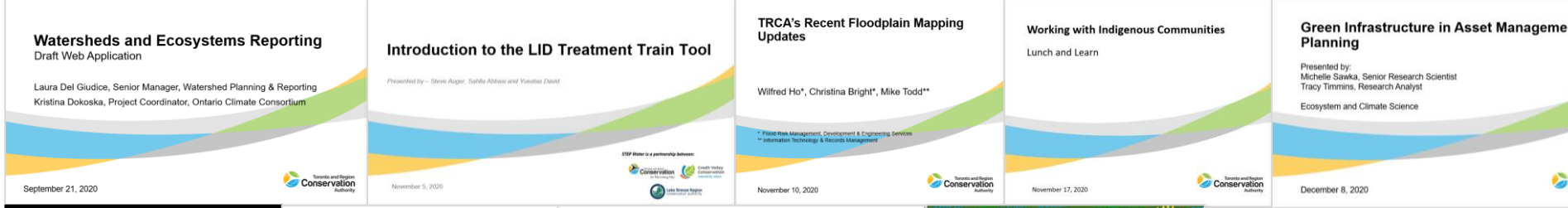
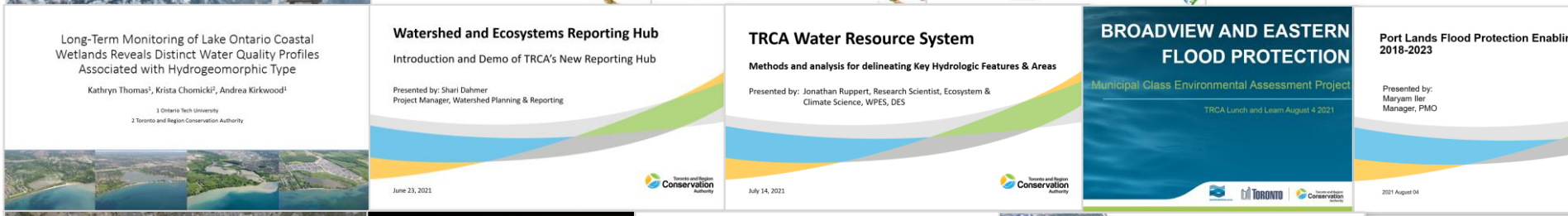
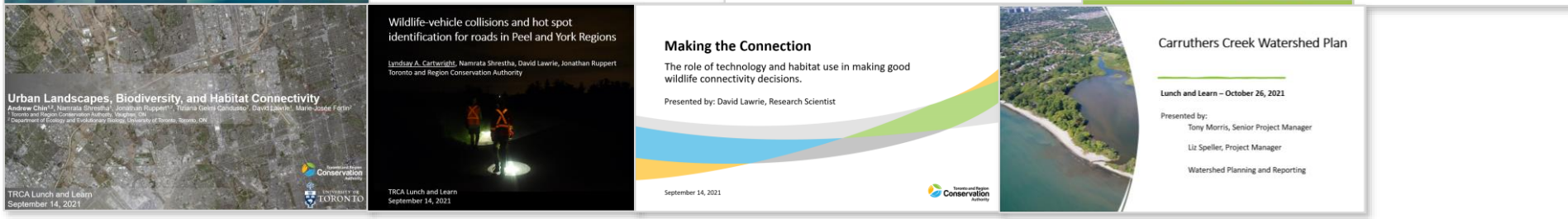
- Videos +
- Webinars and Lunch & Learns +

Past Recordings







Thank you

For questions about the ECS Lunch and Learn Series, please contact:

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Toronto and Region Conservation Authority