Institute for Catastrophic Loss Reduction
Building resilient communities

Institut de Prévention des Sinistres Catastrophiques
Bâtir des communautés résilientes

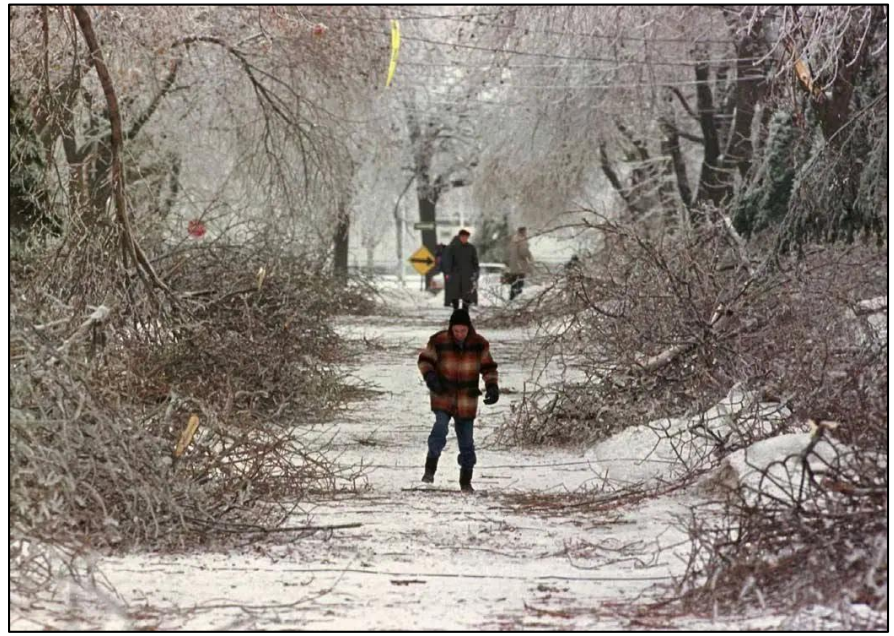
The Role of PEO in the Climate Crisis Issue: Mitigating and Adapting Infrastructure for Climate Resiliency

David Lapp FCAE FEC P. Eng., Senior Adviser on Resilient Infrastructure
PEO Mississauga Chapter Seminar
April 26, 2021

Institute for Catastrophic Loss Reduction

- Formed in 1997: Protect people and property from the impacts of extreme natural events
- Independent, non-profit
- An institute of Western University
- Regular funding from a membership that represents ~90% of Canadian P&C insurance market
- Additionally: Research & projects for/with government agencies, private industry, co-funding with NSERC, SSHRC, etc.
- Manage the PIEVC Program and the PIEVC Protocol for infrastructure climate risk and vulnerability assessment
- www.iclr.org

Western Institute for Catastrophic Loss Reduction (ICLR)



1998 Eastern Canadian Ice Storm
$2 Billion (2018 CAD – IBC, 2019)

Photo: Ryan Remiorz/Canadian Press

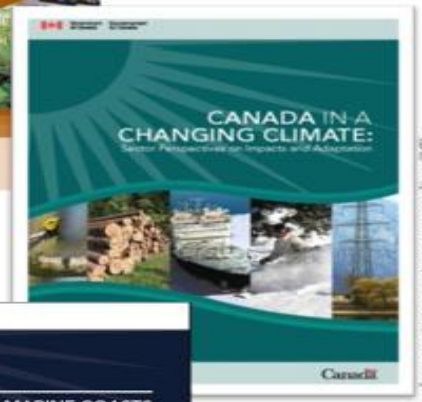

Our world is changing

Changing climates, changing loadings…

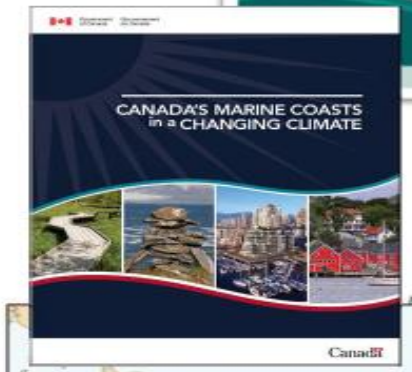
- Changing temperature
- Changes in seasonality and type of precipitation
- Changes in extreme wind loadings
- Frequency and Intensity of precipitation
- Earlier freshet
- Sea level rise and storm surge
- More freeze-thaw cycles
- Melting permafrost
- Climate is non-stationary……

Canada's climate is changing and further changes are inevitable

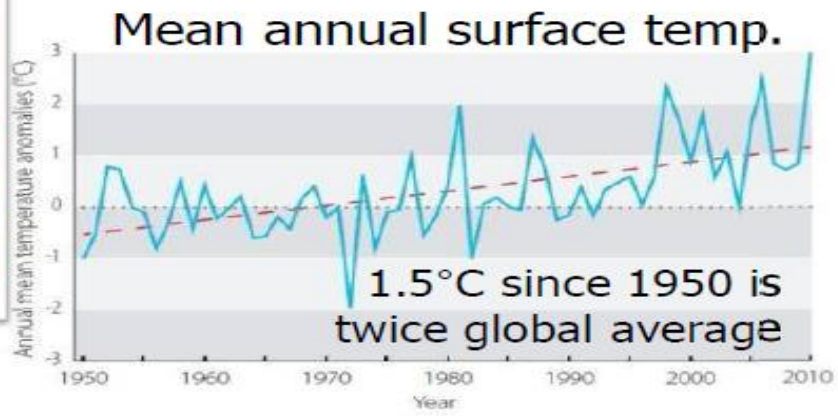
2008

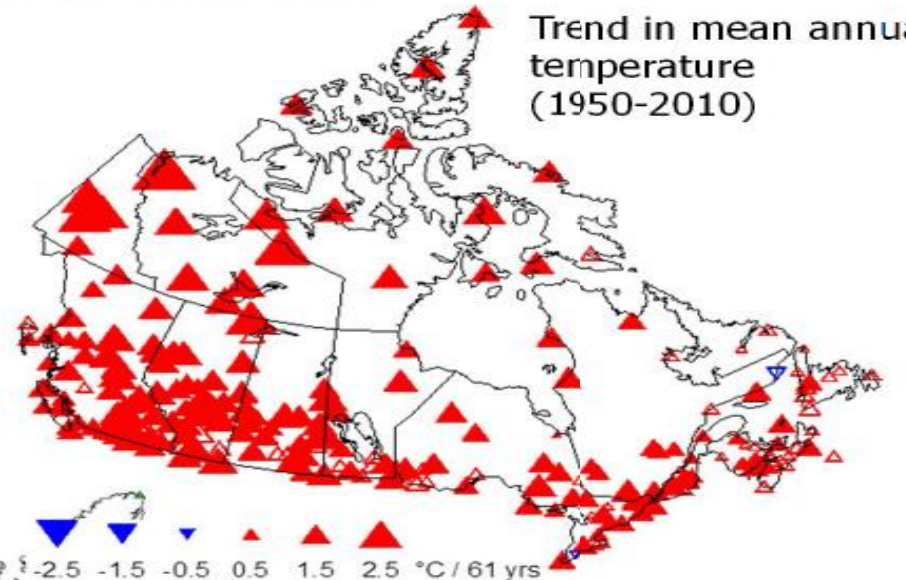


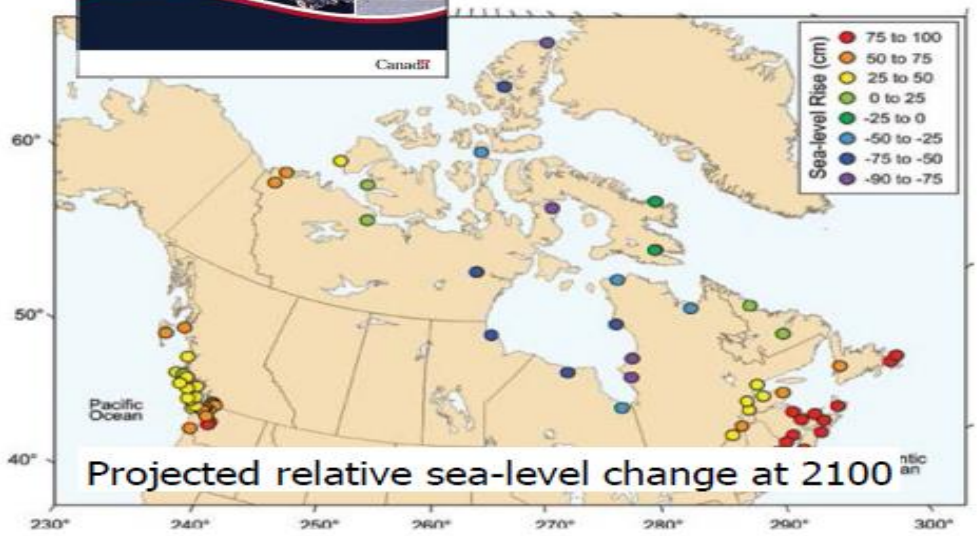
2014

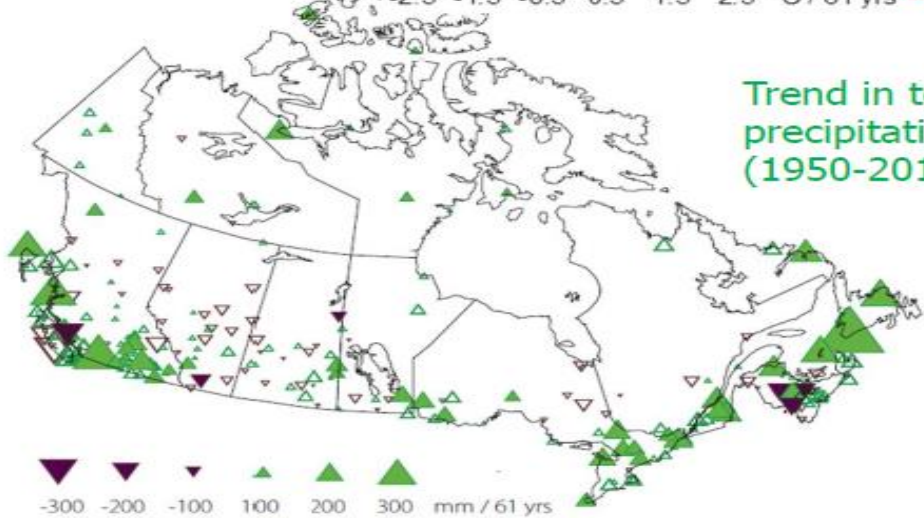


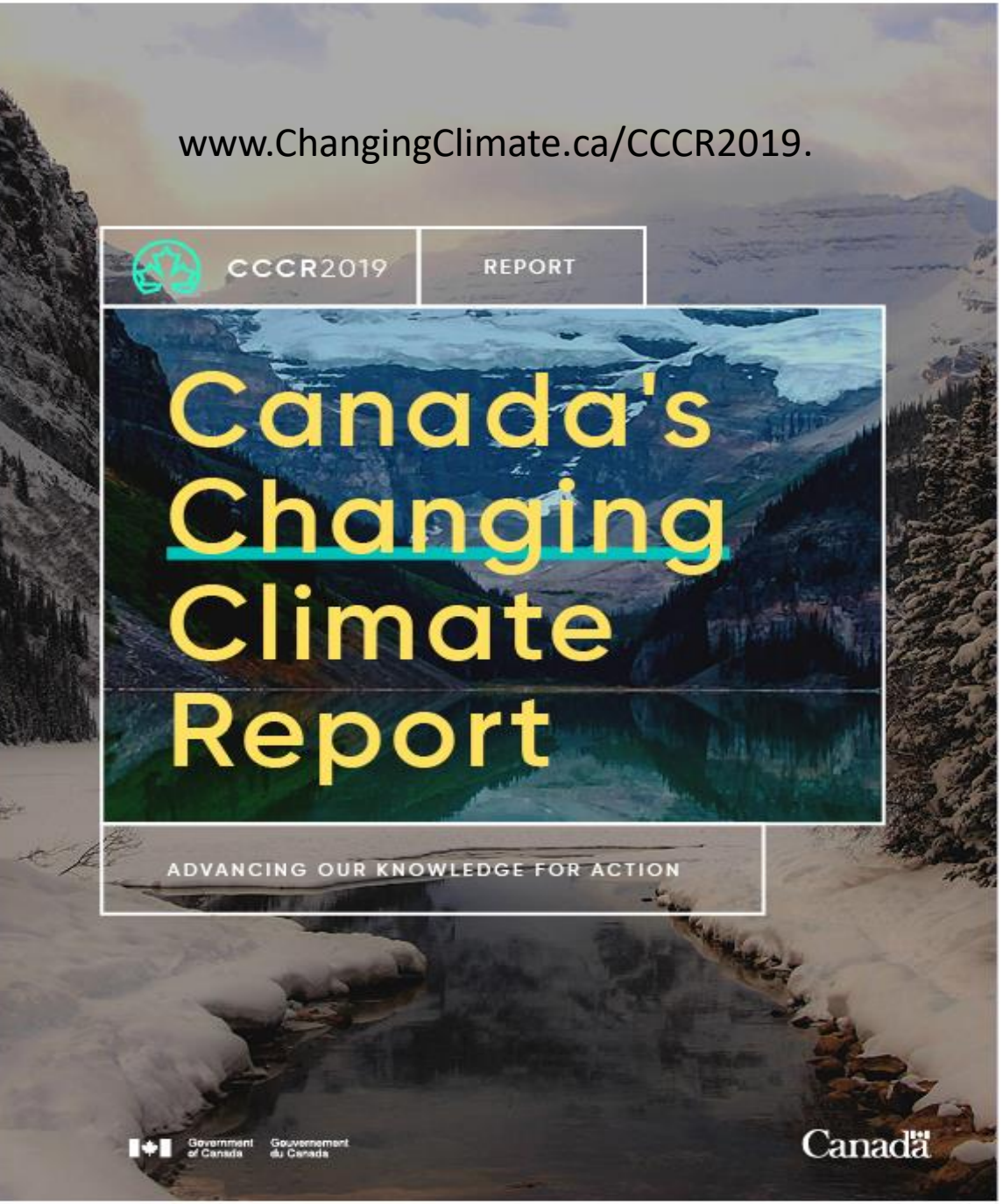
2016







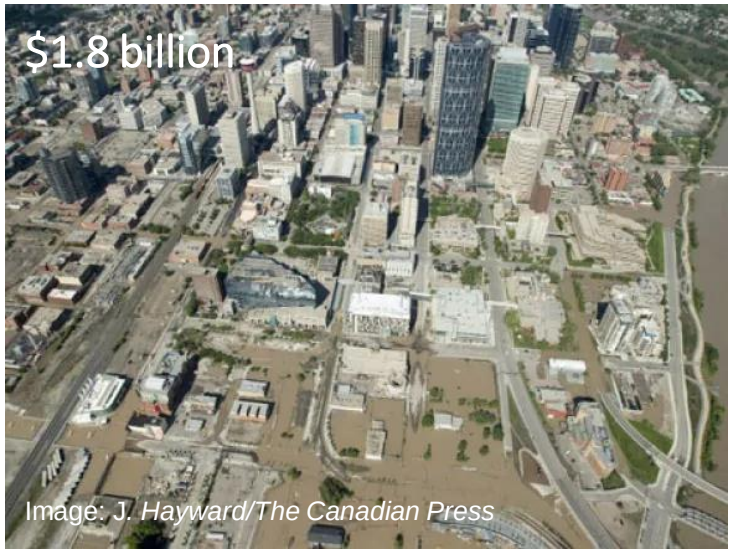




Released in 2019, this report is about how and why Canada's climate has changed and what changes are projected for the future. Led by Environment and Climate Change Canada, it is the first report to be released as part of Canada in a Changing Climate: Advancing our Knowledge for Action.

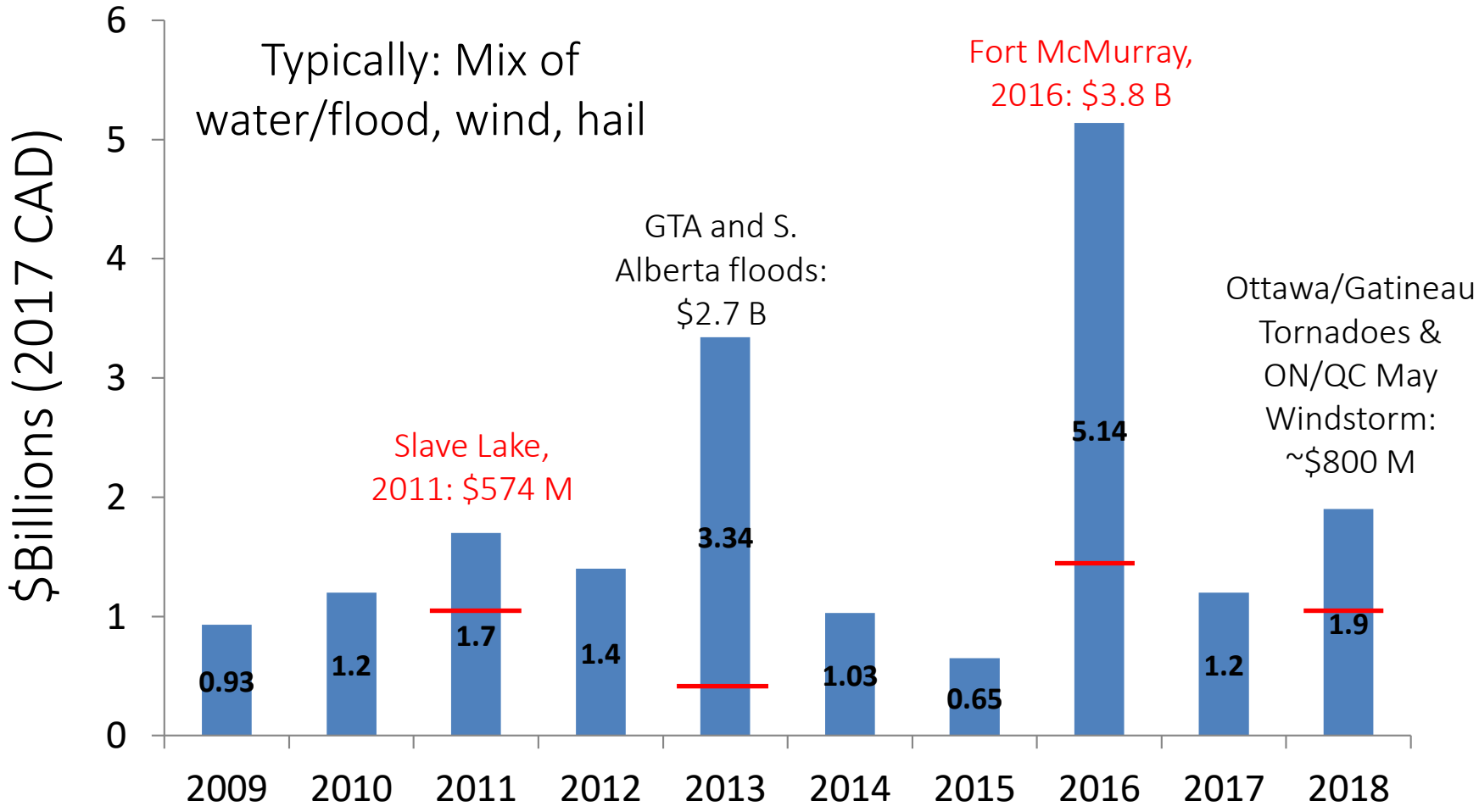
What impact are we seeing?

- From 2009 to present: ~$21 billion in insured loss for “Cats” (events totaling $25 M and over – Source: CatIQ)
- 2020 alone: $2.2 billion
- Extreme rain/flood, high wind, hail – also wildland fire



Loss figures: Insurance Bureau of Canada, 2020 – adjusted to 2019 CAD

What impacts are we seeing?



Source: IBC 2018; 2019

2009-2018: 103 catastrophe events (events >$25 M)

Engineering Vulnerability Outside Floodplain

Source : Credit Valley Conservation Authority

QEW & N. Service Road at Cooksville Ck

Mississauga Valley Blvd at Lolita Gardens

Existing Vulnerability Outside Floodplain

Paisley Blvd East

Dixie Rd north of Lakeshore Rd

Photo by Fred Loek, Mississauga News


August 2005 Storm - Toronto
Photos courtesy
Jane-Finch.com

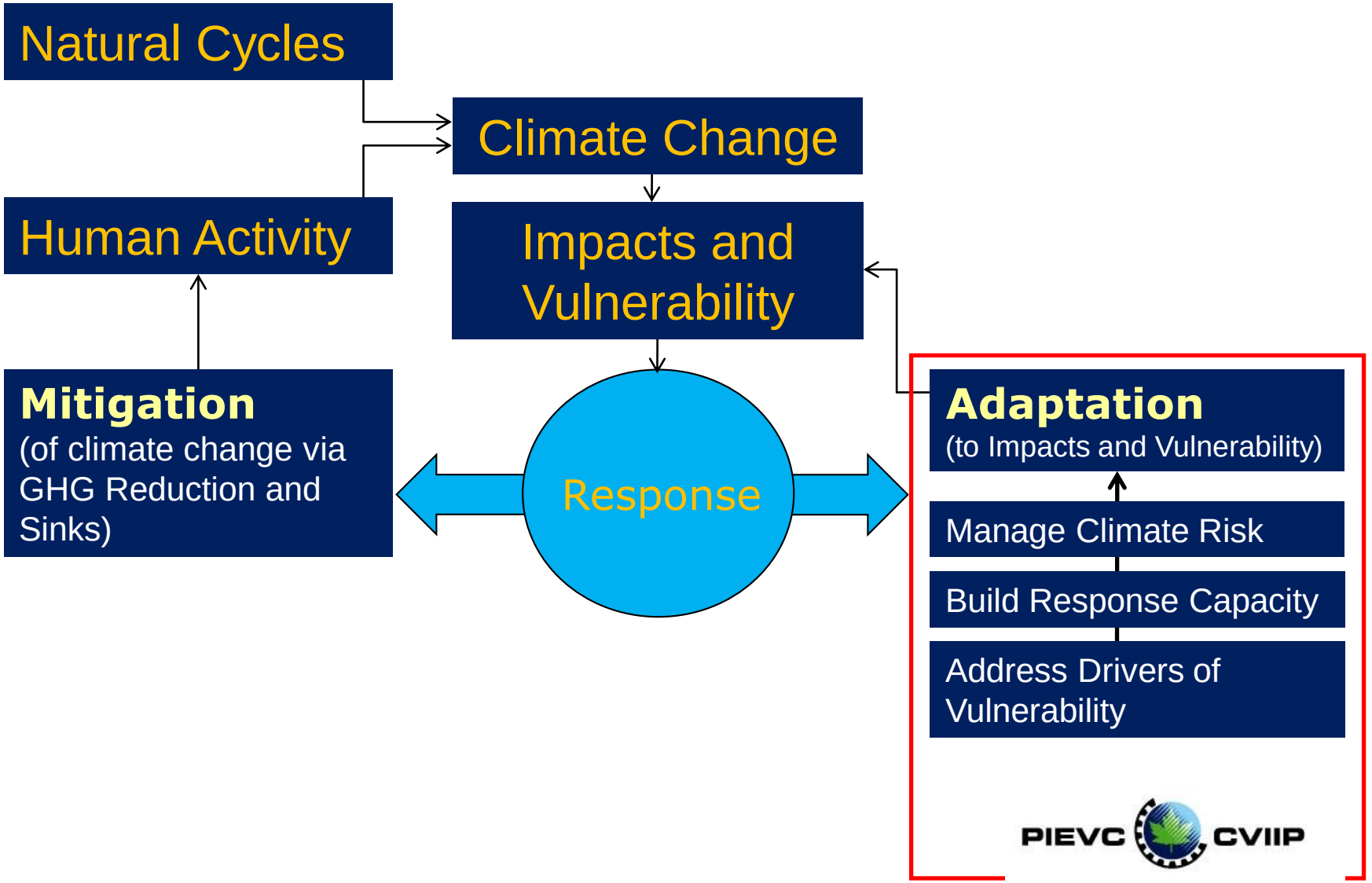
Infrastructure Interdependencies

Factors can combine

Combination of events can exacerbate the vulnerability

- ***Events can occur in rapid succession***
  - Two 100-year return events in 24 hours
- ***Events can add together***
  - Extreme rainfall + hail
  - Cold weather + rainfall
- ***Management or maintenance practices can intensify impacts***
  - Infrequent culvert clearing + severe rain
- ***Change of use can intensify impacts***
  - Urbanization → changes in drainage regime → increased drainage flow

Strategies for Managing Climate Change Impacts



Engineers, infrastructure and climate change

1. Professional engineers hold paramount the health, safety and welfare of the public and have regard for the environment

2. Civil infrastructure and buildings contribute to public health, safety and quality of life through safe and reliable service

3. Engineers must consider economic, social and environmental factors to achieve sustainable infrastructure that serves the public over its lifespan

4. Extreme weather and changing climate threatens the integrity, durability and reliability of our infrastructure – now and in the future

5. The changing climate is another uncertainty in the design, operation and maintenance of sustainable infrastructure that delivers safe and cost-effective service

6. Engineers adopt the notion of **climate resilient infrastructure**

Defining Climate Resilient Infrastructure

Climate resilient infrastructure serves to

Protect – shelters communities (e.g. berms) from climate impacts

Withstand / Accommodate – climate impacts (e.g. reinforced seasonal ice road / more permeable urban landcover)

Three key elements: 1) **location, 2) design/build 3) planned operation and maintenance** -- to minimize adverse effects on delivery of infrastructure services (e.g. water, energy, transportation), levels of service, and the rate of decay, failure, repair and replacement.

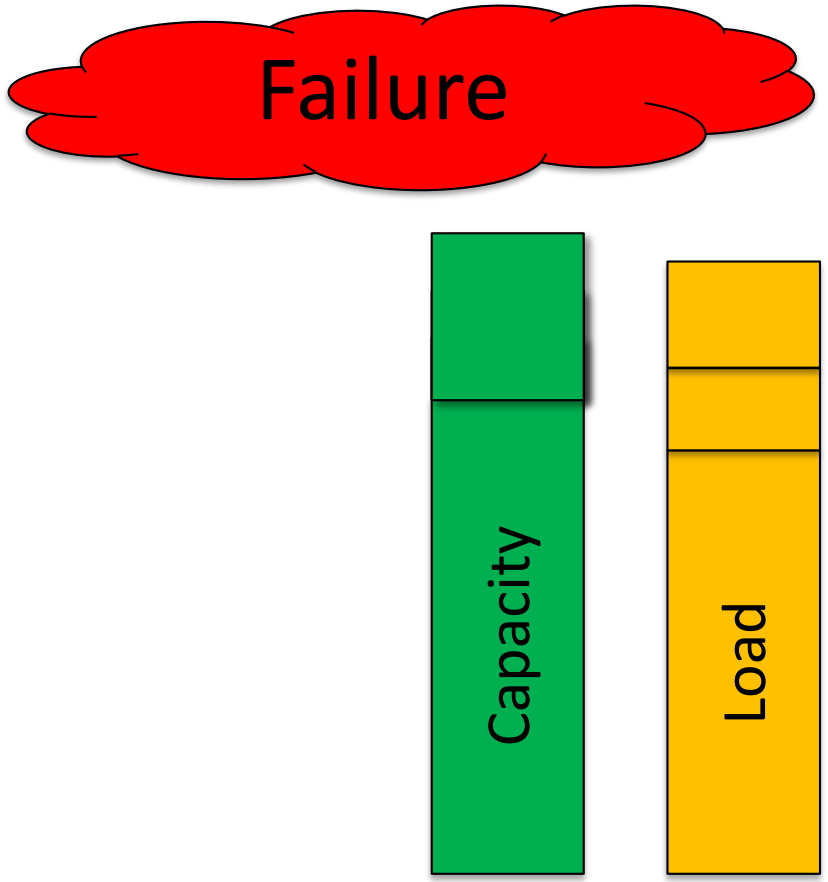
It can be **traditional built or natural infrastructure** and for **new** builds or **rehabilitation/retrofit**.

Source

Climate Resilient infrastructure – Costs and Benefits

- **Mitigate loss of life**, injuries, illness, human suffering and other socio-economic consequences
- **Enhance infrastructure and buildings performance** and reliable levels of service
- **Reduce the total cost of asset ownership** and reduce premature decay / failure
- **Support jobs** and economic growth
- **Lower carbon footprints** by reducing repair/replacement needs
- **Support quality of life** especially through co-benefits (e.g. air quality, green space)

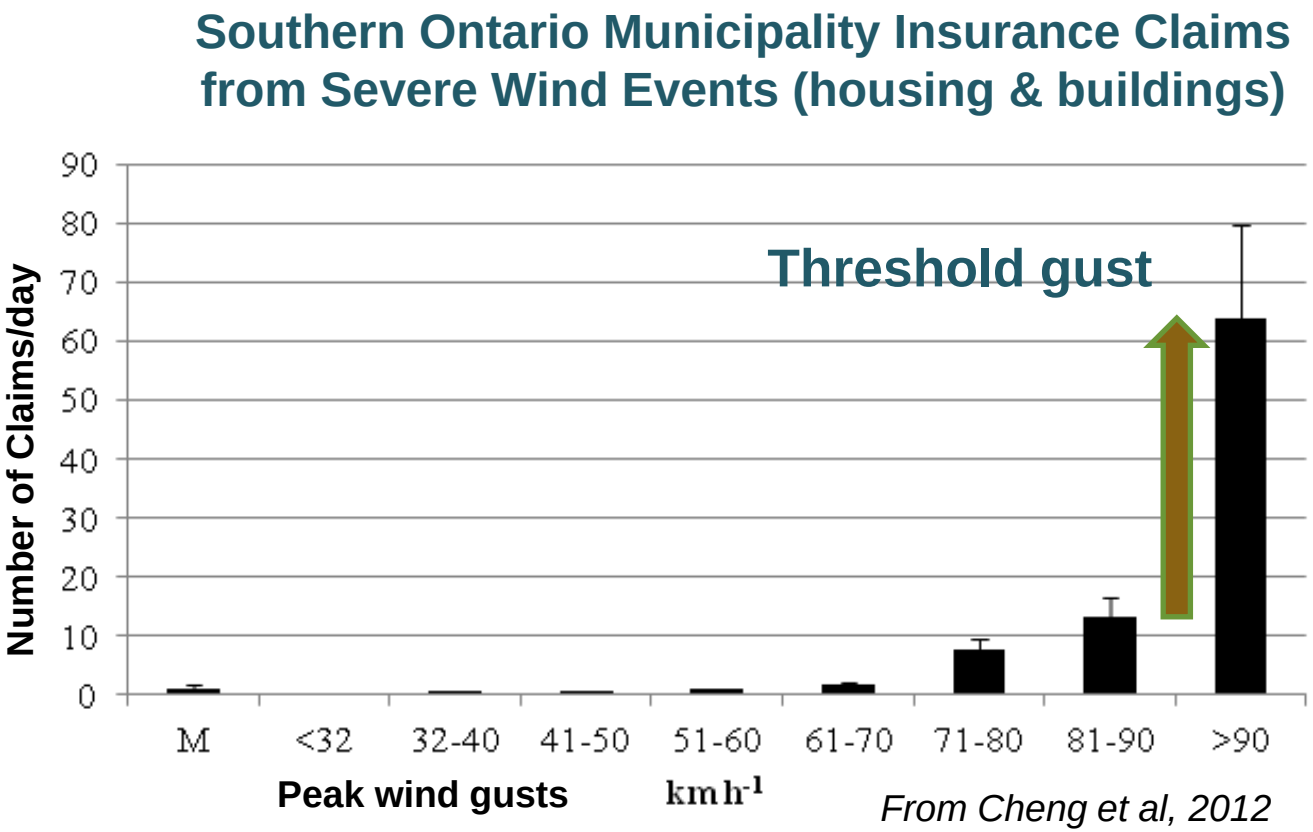
How do Small Changes Lead to Catastrophic Failure?



- Design Capacity
- Safety Factor
- Impact of age on structure
- Impact of unforeseen weathering

- Design Load
- Change of use over time
  - e.g. population growth
- Severe climate event

Small Changes in Climate Matter

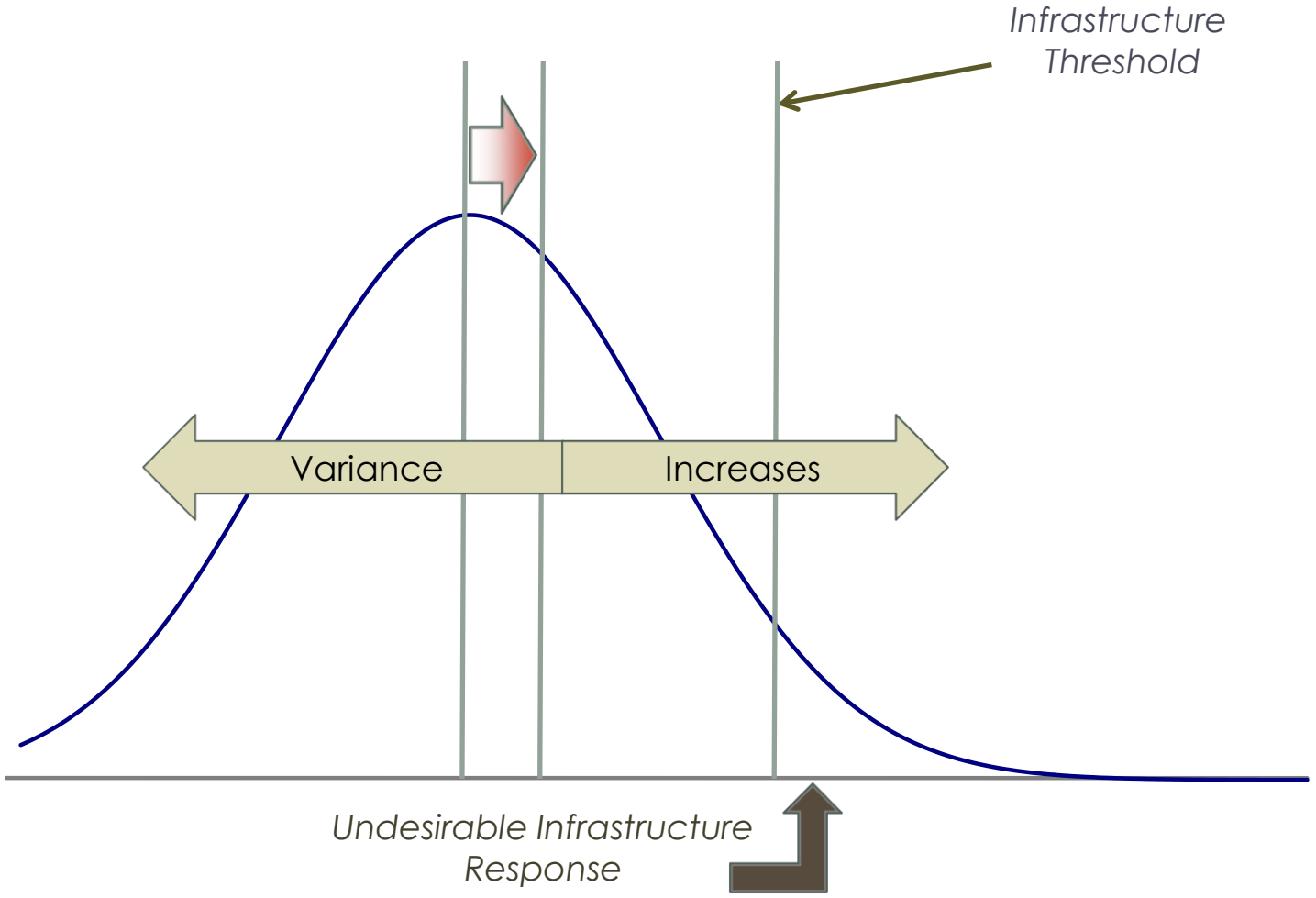


From Cheng et al, 2012

Study currently in publication

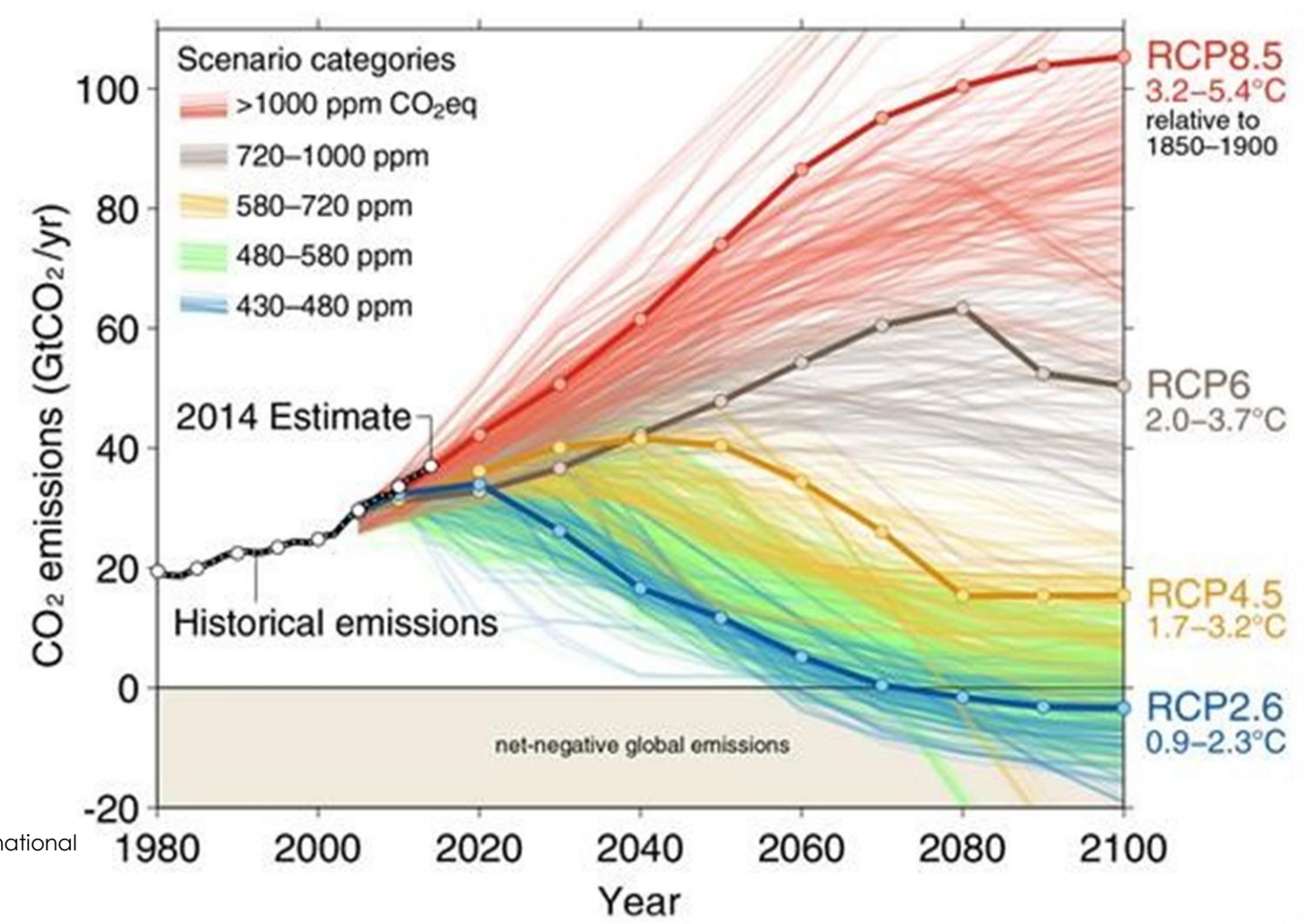
2012 CC study: Hours with wind gusts ≥ 70 km/hr may increase >30% by 2050s…with further increases for higher gusts

Impact on Mean & Variance



Future climate change will be very GHG emission dependent

Representative concentration pathways (GHGs)



Source: Risk Sciences International

Uncertainty in climate change model outputs varies…

Most Confident

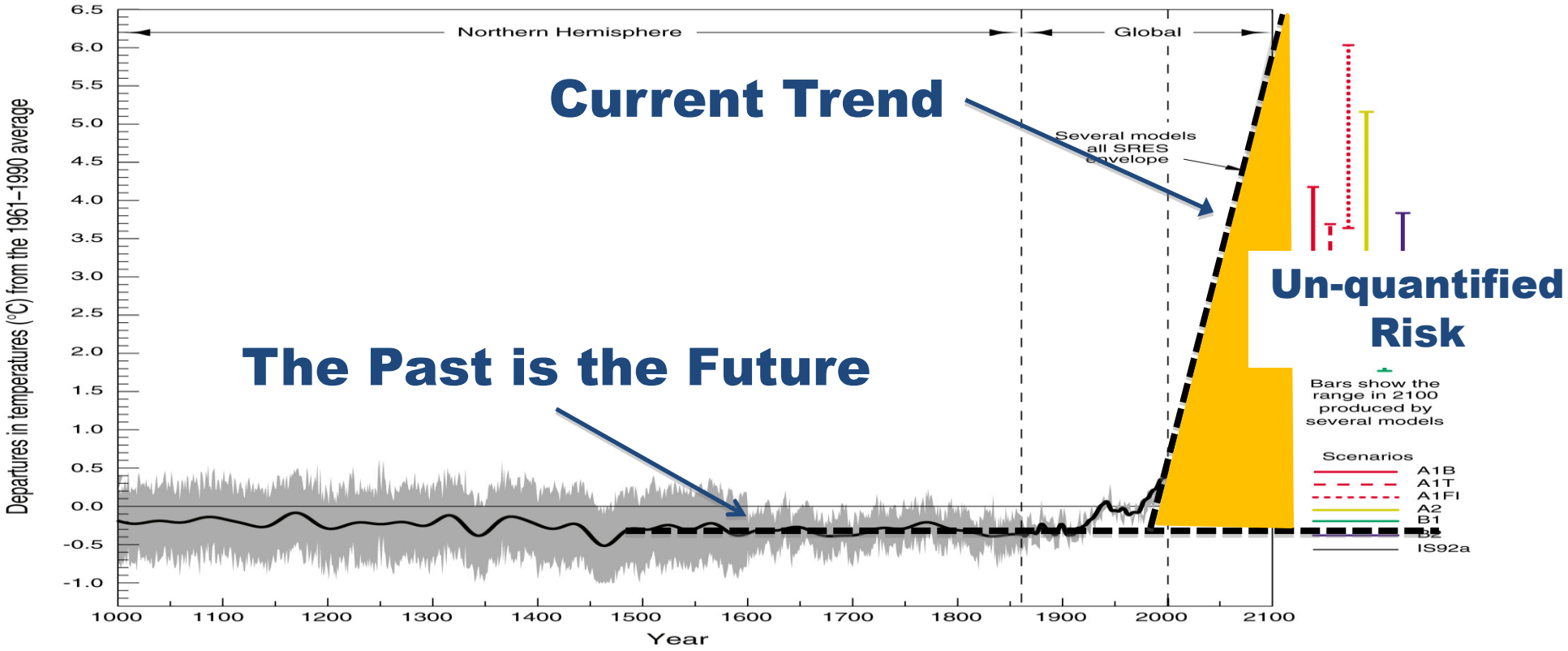
Least / Less Confident

More CERTAINTY → **Less CERTAINTY**

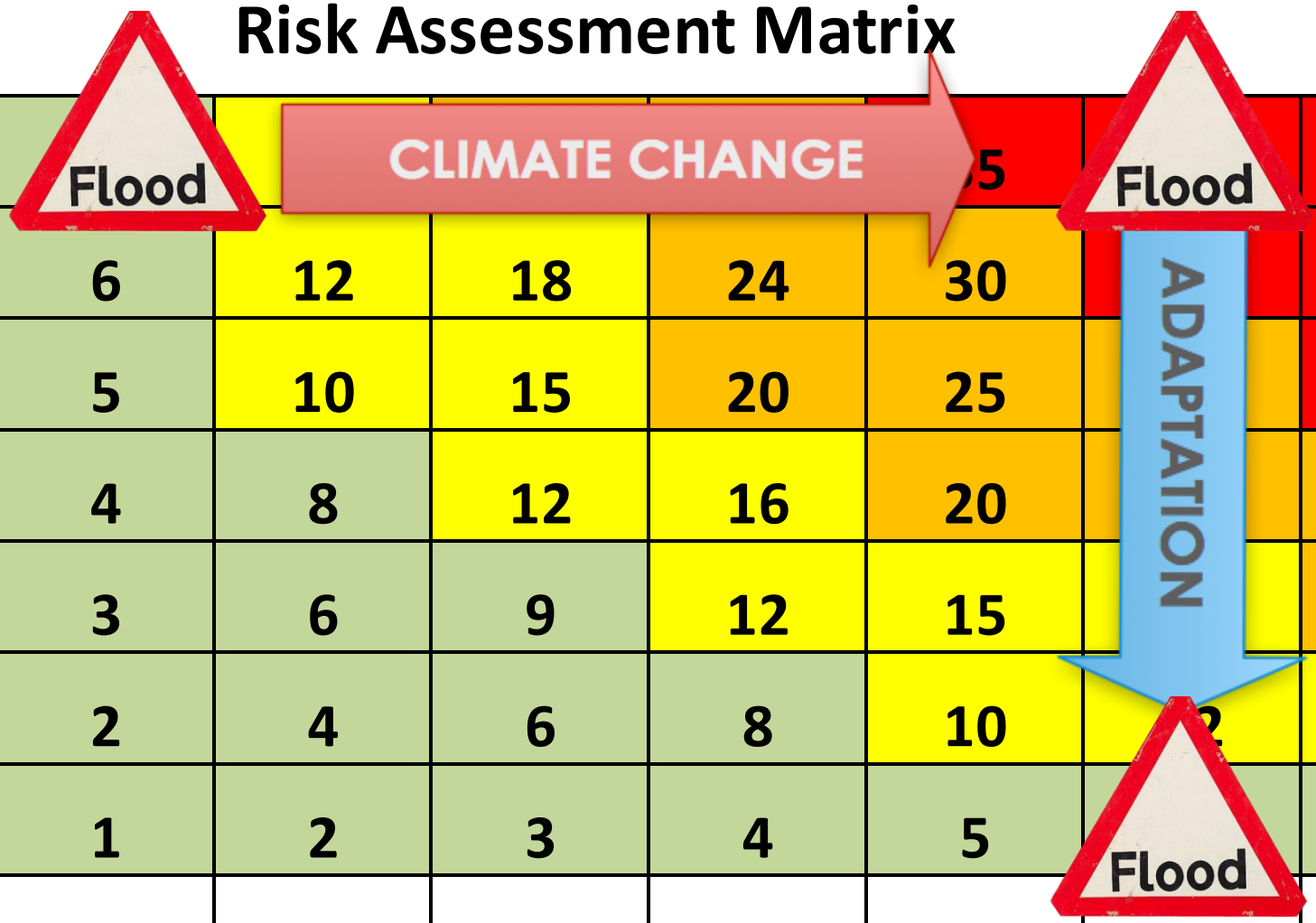
- Longer growing season
- Warmer winters
- More heat waves
- More winter precipitation
- More intense rainfall
- More severe ice storms
- Increase in wind extremes

From an Infrastructure Planning, Design and Operations Perspective

- Past climate is not a good predictor of the future



Risk Assessment Matrix



Consequence								
	7					5		49
	6	6	12	18	24	30		42
	5	5	10	15	20	25		35
	4	4	8	12	16	20		28
	3	3	6	9	12	15		21
	2	2	4	6	8	10	2	14
	1	1	2	3	4	5		7
		1	2	3	4	5	6	7
		Probability of Occurrence						

The Engineering Profession's Response for Climate Adaptation and Resiliency

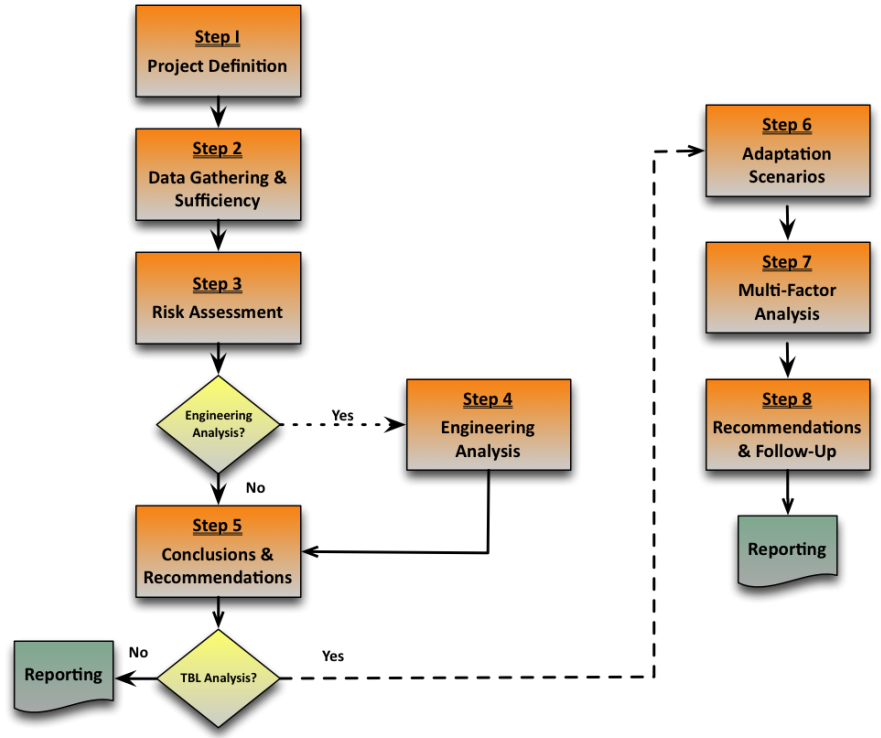
- What has been done?
- What should PEO (and OSPE) do?

What has been done?

- Climate risk and vulnerability assessment (PIEVC Protocol)
- National guidelines – Engineers Canada
- Standards of practice and climate change action plan – EGBC
- Capacity development (education and training – PEGNL, EGNB, EGMB, Climate Risk Institute, Royal Roads University)
- Codes, standards and related instruments e.g. guidelines

PIEVC Program and PIEVC Protocol

- Development beginning in 2005 – Engineers Canada, with support from federal gov't (NRCan)
- Committee: Cross section of infrastructure experts, federal, provincial, municipal gov't, utilities, owners, academics, etc. - see www.pievc.ca for more information
- Developed to assist engineers in factoring climate change impacts into plans for design, operation and maintenance of public infrastructure
- Applied by qualified, professional engineers
- Involvement of designers, operators, management, administration, operations, climate experts, etc.



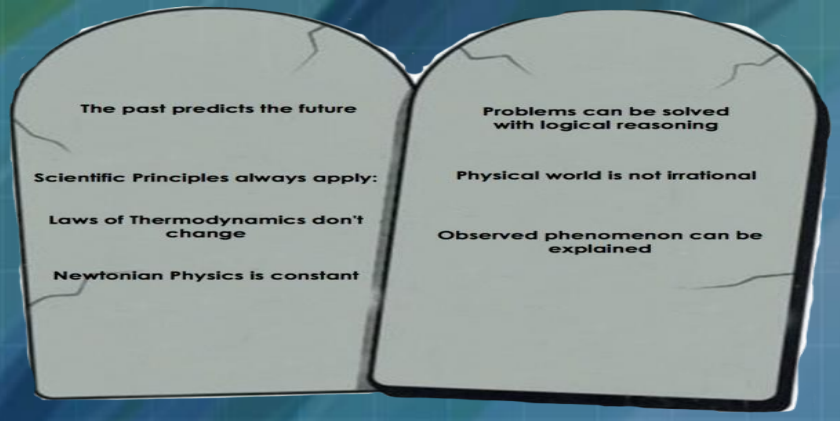
PIEVC Program – A Body of Knowledge

Over 100 completed assessments to date:

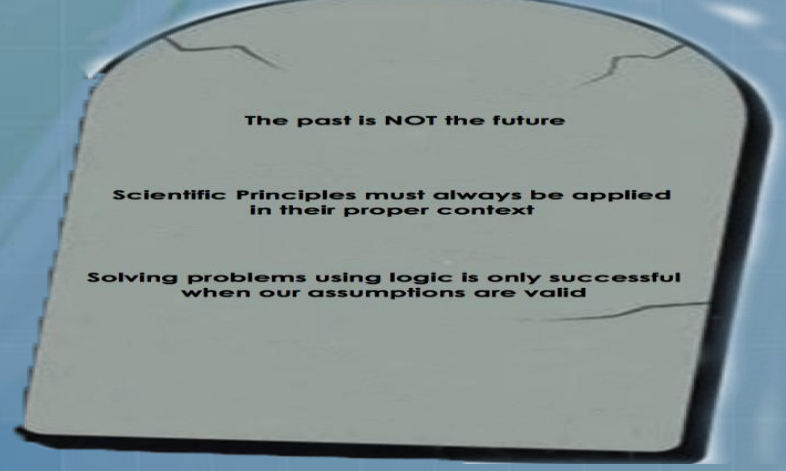
- Water resources systems
- Storm & wastewater systems
- Roads and bridges
- Buildings
- Transportation infrastructure
- Energy infrastructure
- Healthcare infrastructure
- Parks and natural infrastructure
- Coastal infrastructure

Applied across Canada, and internationally (translated to French, Spanish, Portuguese, Vietnamese)

www.pievc.ca



Public Guideline



Principles of Climate Adaptation and Mitigation for Engineers September 2017

engineerscanada
ingénieurscanada

https://engineerscanada.ca/publications/public-guideline-principles-of-climate-change-adaptation-for-professional-engineers

Engineers Canada Public Guidelines and Papers
Scope, Authority and Structure

Scope

Guidance on how engineers can address climate change in their professional work.

Promote consistent practices across the country

Define and explain the professional practice elements of an issue – **what** to do, **not how** to do it

Authority

Not regulations or rules; they define or explain discrete topics related to the practice and regulation of engineering in Canada.

Do not establish a legal standard of care or conduct, and they do not include or constitute legal or professional advice.

Structure of This Guideline

Define the principle

Amplification and commentary

Implementing actions

Goal

Ensure that professional engineers consider the implications of climate change in their professional practice and that they create a clear record of the outcomes of those considerations.

Limitations of Authority on Climate-Related Matters

Engineers have a duty to inform their clients or employers regarding matters related to climate change adaptation, mitigation and resiliency that may impact the professional activities for which they are responsible

Engineers are not expected to assume responsibility for considering the implications of climate change adaptation in engineered systems or mitigation efforts beyond the scope of their authority.

Engineer presents the alternatives and rationale for implementing solutions BUT the decision on the form of such solutions remains with the client or employer

Rationale

The engineer's job is to assess and minimize climate risks within the scope of their work, which includes being a trusted advisor to the client while balancing client needs and the project budget. This understanding imposes a responsibility of due diligence on the engineering profession to address the issue of climate change within engineering works.

Principles of Climate Adaptation and Mitigation for Engineers

- ✓Integrate climate adaptation and resilience into practice
- ✓Integrate climate mitigation into practice
- ✓Review adequacy of current standards
- ✓Exercise professional judgment
- ✓Interpret climate information
- ✓Emphasize innovation in mitigation and adaptation
- ✓Work with specialists and stakeholders
- ✓Use effective language
- ✓Plan for service life and resilience
- ✓Apply risk management principles for uncertainty
- ✓Monitor legal liabilities

https://engineerscanada.ca/public-guideline-principles-of-climate-adaptation-and-mitigation-for-engineers

Principles of Climate Adaptation and Mitigation for Engineers

Principle #1 - Integrate Climate Adaptation and Resiliency into Practice

Integrate an understanding of the impacts of climate change, weather, and resiliency into the normal day-to-day design, operation, maintenance, planning and procurement activities for which engineers are professionally responsible.

Engineers engaged in direct and indirect work associated with all types of civil infrastructure and built environments should be aware of the climate change issue and always consider if and how their work could be affected by current and future climate.

Engineers engaged in and advising on infrastructure specification and procurement should recommend including climate considerations.

Engineers in management positions or advising management should recommend the provision of sufficient financial resources or proposal evaluation incentives to support the integration of climate considerations.

Purpose

To offer a considered interpretation of the responsibilities of engineers to adapt to a changing climate and mitigate the change. The application of the principles will always be a matter of professional judgement

Principles of Climate Adaptation and Mitigation for Engineers

Principle #2 - Integrate Climate Mitigation into Practice

Engineers should investigate and evaluate options for minimizing GHG releases into the atmosphere whenever there is potential for such releases from current operations and installations or new installations.

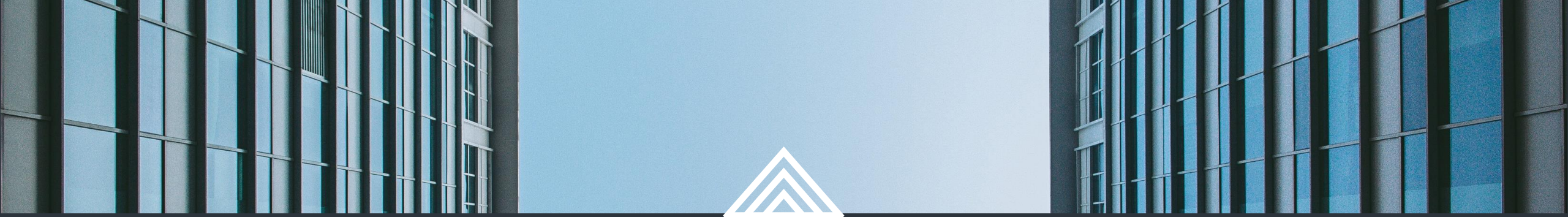
Scope often includes GHG validation and verification for reporting or regulatory purposes or for carbon credits

An engineering input to carbon mitigation would include a comprehensive approach to the identification and advancement of technologies under the following themes:

- Energy saving or efficiency measures;
- Standards to encourage the use of sustainable materials and renewable energies;
- Alternative propulsion technologies and fuels;
- Electric propulsion especially for vehicles;
- Electric transmission, distribution and storage using smart grids;
- Environmentally sound carbon and capture technologies; and
- Nuclear waste management and next-generation nuclear power plants.

Amplification

All engineering disciplines that perform design work need to take the potential for carbon releases into consideration, while civil, chemical, electrical, and mechanical engineers should consider climate mitigation in essentially all of their projects.



ENGINEERS & GEOSCIENTISTS
BRITISH COLUMBIA

Guidelines - Developing Climate Change-Resilient Designs for Highway Infrastructure in BC

Harshan Radhakrishnan, P.Eng., Glen Zachary, P.Eng., Des Goold, P.Eng.,

December 2nd, 2020

Engineers and Geoscientists BC Positions

A Changing Climate in British Columbia, 2014:

- Commits the regulatory body to raising awareness about the potential impacts of the changing climate as they relate to professional practice, and to provide information and assistance
- Expect that registrants keep themselves informed about the changing climate, and consider impacts on their professional activities

ENGINEERS & GEOSCIENTISTS BRITISH COLUMBIA

Mandate and Role

- Expressed legal authority to establish, monitor and enforce standards of practice
- Professional Practice Guidelines:
  - Respond to demand side legislation from Provincial and local governments
  - Develop a standard level of expectation for stakeholders
  - Sets minimum acceptable standard of practice for registrants

Climate Resilience Guidelines: An Overview

- Published in July 2020 as finalized Version 2.0, includes numerous updates to the interim (December 2016) version
- Applicable to: BCMoTI highway infrastructure design projects
  - New and retrofit projects
- Not a technical standard of care
- Standard of practice for engineers and geoscientists to meet their duty of care in professional practice

Guideline Contents

Professional Practice (incl. level of effort)

Documentation:

1. Assurance Statement
2. Design Criteria Sheet
3. Climate Resilience Design Report

Education and training requirements

Case studies

Climate Science as it relates to practice

EGBC Climate Change Action Plan – March 2021

GOALS

Adapting to Climate Change
Support the effective assessment and management of climate risk in the practice of professional engineering and geoscience in BC.

Reducing Greenhouse Gas Emissions
Support registrants to develop and implement solutions to reduce greenhouse gas emissions.

OBJECTIVES AND ACTIONS

Leadership and Collaboration

Lead the engineering and geoscience professions' response to climate change in BC and collaborate with others t o leverage resources and enhance impact.

Action 1: Leadership

Continue to raise awareness and demonstrate the need to act on the impacts of climate change and professional responsibilities.

Action 2: Collaboration

Engineers Canada, Geoscientists Canada and other provincial/territorial regulatory bodies: Collaborate on all climate change issues of inter-provincial/territorial and national relevance.

Regulatory and standard-setting bodies: Provide input on the updating of regulations, codes and standards used by engineering and geoscience professionals to incorporate climate change.

Professional and industry associations: Share relevant guidance and information, and partner on educational and/or professional events.

Organizations that provide climate data, expertise and training: Partner to access the latest information, tools and experts for educational events (e.g. Pacific Climate Impacts Consortium).

Registration and Competency

Update the registration process for professional engineers and geoscientists to incorporate climate change competencies.

Action 3: Applicants

Work with Engineers Canada and Geoscientists Canada to ensure climate change is adequately addressed within competency assessments as part of applications for professional registration.

Incorporate climate change into the Professional Engineering and Geoscience Practice in BC online seminar for applicants.

Action 4: Areas of Practice

Explore adding new areas of practice to recognize new areas of competency.

Education and Knowledge Sharing

Build registrants' knowledge and capacity to consider climate change in their professional practice.

Action 5: Basic Education

Provide free or low-cost continuing education sessions on climate change as part of the ethical and/or regulatory learning offerings established through the Continuing Education Program.

Action 6: Advanced Education

Expand Engineers and Geoscientists BC's course offerings and offerings through other channels to support registrants in developing more advanced skills and knowledge for adapting to a changing climate and reducing greenhouse gas emissions.

Action 7: Knowledge Sharing

Support and actively encourage registrants to network and share knowledge on the challenges and opportunities that climate change brings to professional practice.

Practice Resources

Provide registrants with practical and relevant practice resources to help them deliver appropriate responses to a changing climate and reduce GHG emissions.

Action 8: Practice Guidance

Provide guidance (e.g. practice guidelines, practice advisories) on adapting to climate change and/or reducing greenhouse gas emissions in a manner that is relevant for specific professional practice applications (e.g. guidance on specific hazards or emission sources).

Action 9: CC Information Portal

Promote and continue to develop Engineers and Geoscientists BC's Climate Change Information Portal.

Action 10: Support for Firms

Provide firm registrants and their professional employees with guidance and/or training on adapting to climate change and/or reducing greenhouse gas emissions with respect to the practice of professional engineering and professional geoscience.

Note: "GHG" = greenhouse gas "CC" = climate change

How did EGBC Develop its Climate Change Action Plan?

- Formation of a Climate Change Advisory Group reporting to Council
- 2014 EGBC Climate Change Position Paper on evolving responsibilities for engineers and geoscientists
- 2016 EGBC Position Paper on Human-Induced Climate Change
- 2017 Climate Change Awareness Survey of Members
- 2018 AGM Member Motion “That council considers putting together a comprehensive climate change action plan to support members in addressing this issue”
- 2020 Consultation with registrants, industry professionals and the wider professional community – What Was Said Report https://www.egbc.ca/getmedia/fdcb28dd-39f3-4972-b838-34c09ad3b1c3/Climate-Change-Action-Plan-What-We-Heard-Report.pdf.aspx
- Development and Maintenance of a Climate Change Information Portal https://www.egbc.ca/Practice-Resources/Programs-Resources/Climate-Sustainability/Climate-Change-Information-Portal
- 2021 EGBC Climate Change Action Plan published https://www.egbc.ca/Practice-Resources/Consultations/Climate-Change-Action-Plan

NRC·CNRC

NRC.CANADA.CA

Progress towards a Climate Resilient Built Environment

Webinar: Canada's Climate Change Adaptation Platform

Marianne Armstrong

National Research Council Canada
March 29, 2021

CLIMATE RESILIENT BUILDINGS & CORE PUBLIC INFRASTRUCTURE (CRBCPI)

Developed world-leading research and foundational science to advance the field of climate change adaptation for buildings and infrastructure

Translated this science into decision support tools, including codes, guides and models for the design of resilient new, and rehabilitation of existing, buildings and core public infrastructure in key sectors to ensure that climate change and extreme weather events are addressed

Climate Data • Roads
Buildings • Bridges
Water/Wastewater
Transit • Decision
Support Tools
LCA

Developing Future Climatic Design Data

- **Partnership** with Environment and Climate Change Canada (ECCC) and Pacific Climate Impacts Consortium (PCIC)
- **Forward-looking climatic design data** is published!
- **climate-scenarios.canada.ca**
- General guidance on how to use this data will be available soon.

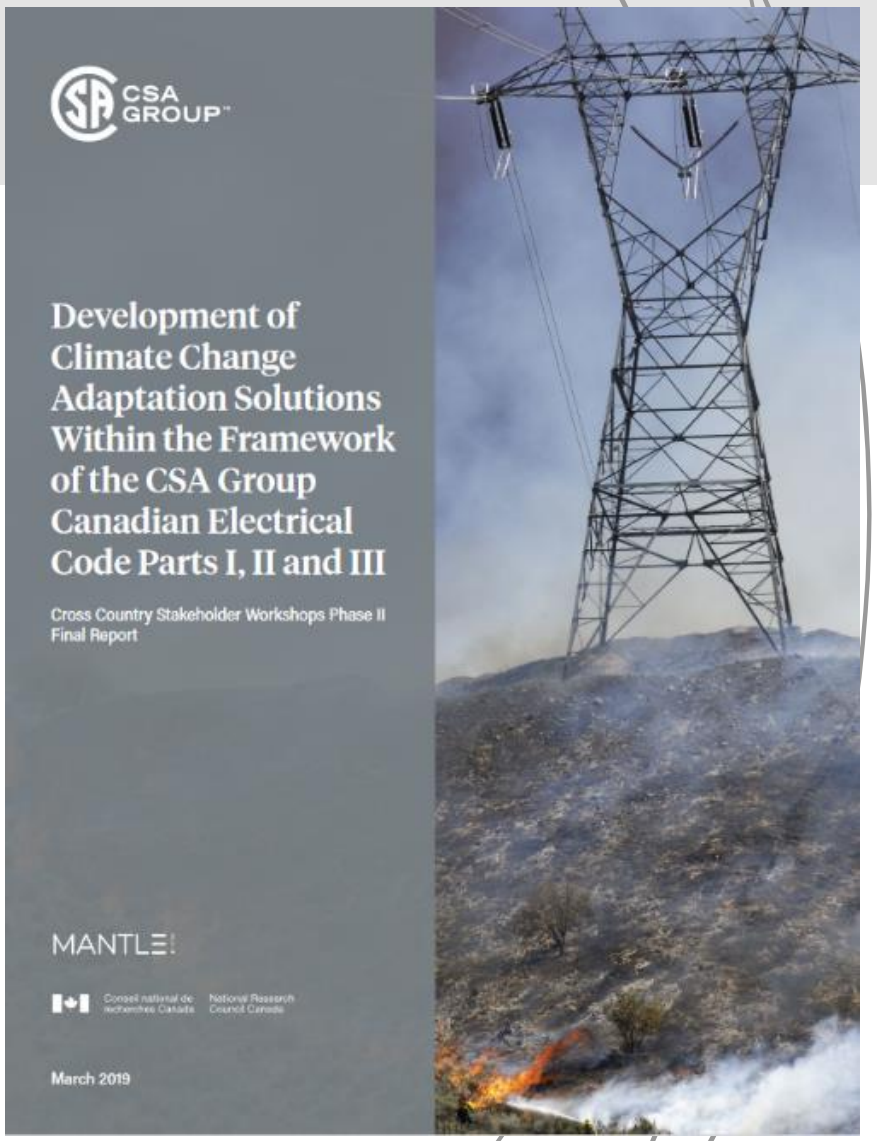
Peace tower weather station

Canadian Electrical Code

Following a series of Cross-Canada workshops, **50 proposals for change** were prepared and submitted to the Committees of the CEC

https://www.csagroup.org/wp-content/uploads/CSA-RR_CEC-ClimateChange.pdf

25th Edition of the Canadian Electrical Codes Part 1 (released in January 2021) incorporates 5 accepted proposals for change including the new terms “Flood hazard zone”, and “Flood elevation” and new requirements for equipment installation



Buildings Highlights

Climatic Design Data, Flooding and Wildfire Guidelines

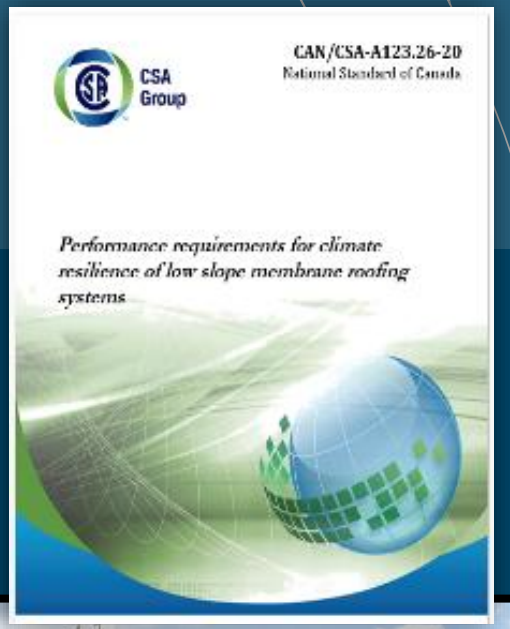
Developed the first standard addressing climate resiliency of roofing in the world: **Performance Requirements for Climate Resilience of Low Slope Membrane Roofing Systems (CSA A123.26-20)** and the associated web-based **Climate Roof Calculator**

Evolved the Guideline on **Durability in Buildings (CSA S478) to a Standard**

Developed **Guidance for prevention of overheating in interior spaces,** linked to human physiological response, and including future impacts of urban heat islanding.

2020 National Building Code (NBC) will include updated climatic design data, new provisions for snow loading on roofs, updates to referenced standards

Proposed climate change provisions for the
2025 National Building Code (NBC)



Bridges Highlights

Updated Climatic Design Data and Sustainability provisions in the 2019 Canadian Highway Bridge Design Code (CHBDC)

Developed full provisions for the **2025 CHBDC to include design for future climate loads**

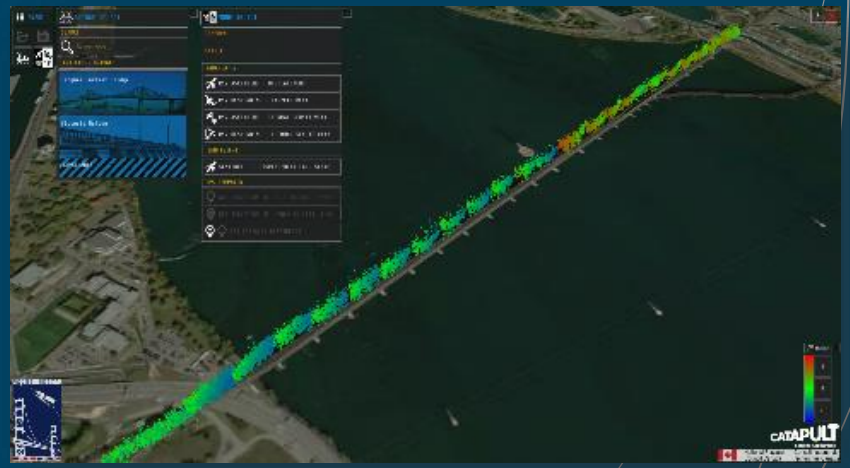
Assessed the Impact of extreme climate loads on **new & existing bridges,** and of ice and debris on **bridge pier stability**

Developed models of accelerated **deterioration of bridges & service loads**

Demonstrated the **Brigital software: Satellite-based** bridge performance assessment – guidelines and tools

Investigated the **vibration of bridge stay cables** in wet, icy and dry conditions, triggering potential updates to the Post Tensioning Institute Stay Cable Design Guidelines

2019 CHBDC Data for Ice Accretion replaced 1974 data in CHBDC 2014



Satellite-measured thermal displacements of Victoria Bridge (Montréal, Canada)

Infrastructure Resilience Professional (IRP)

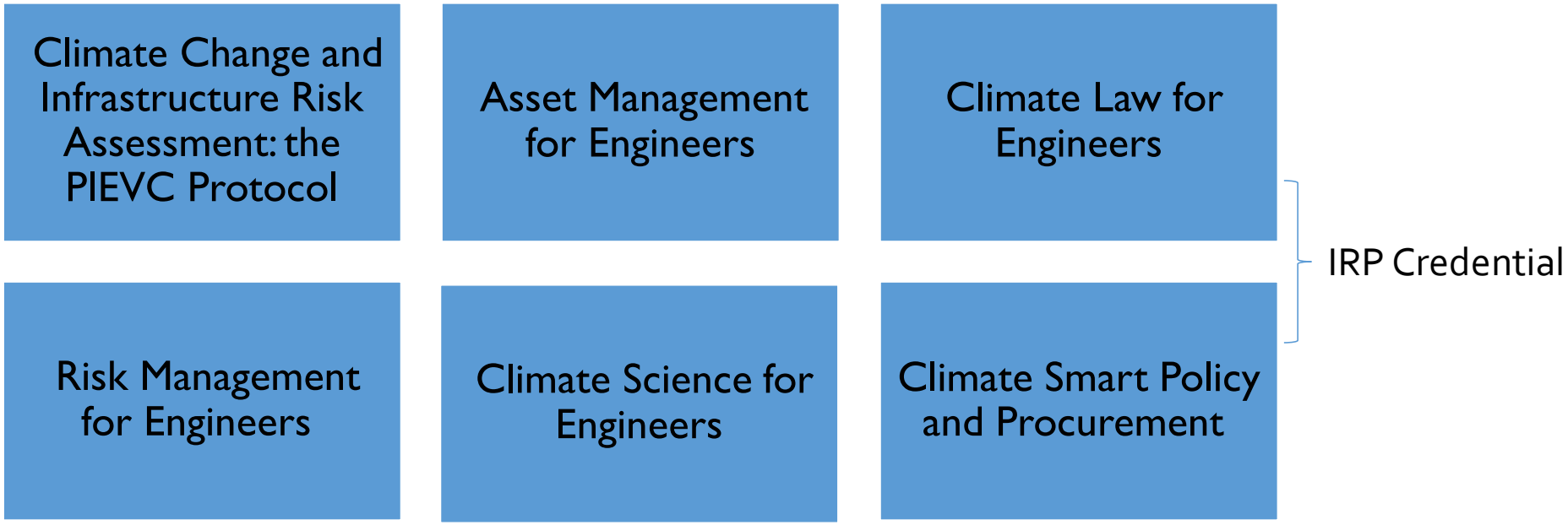
Credentialling Program

What is IRP?

The IRP Program has been designed to help engineers **strengthen the knowledge and competencies** they require to advance more climate-resilient approaches for the planning, design and management of infrastructure.

- Benefits? Enhances confidence the infrastructure engineer has the knowledge to:
  - use requisite tools to assess future climate impacts;
  - apply a systems approach to threats on infrastructure services, to maintain their safe operations; and,
  - reduce risk to the public resulting from a changing climate.

Courses



https://climateriskinstitute.ca/irp-page/

What can PEO/OSPE do?

- Develop and adopt a Climate Change Position/Policy
- Develop practice standards and guidelines on adaptation and mitigation
- Engage with Ontario Government on climate resiliency and mitigation policy, procurement, infrastructure codes and standards and related instruments
- Work with OSPE and Third Party Providers on CPD Offerings
- Support IRP credential for licensed engineers

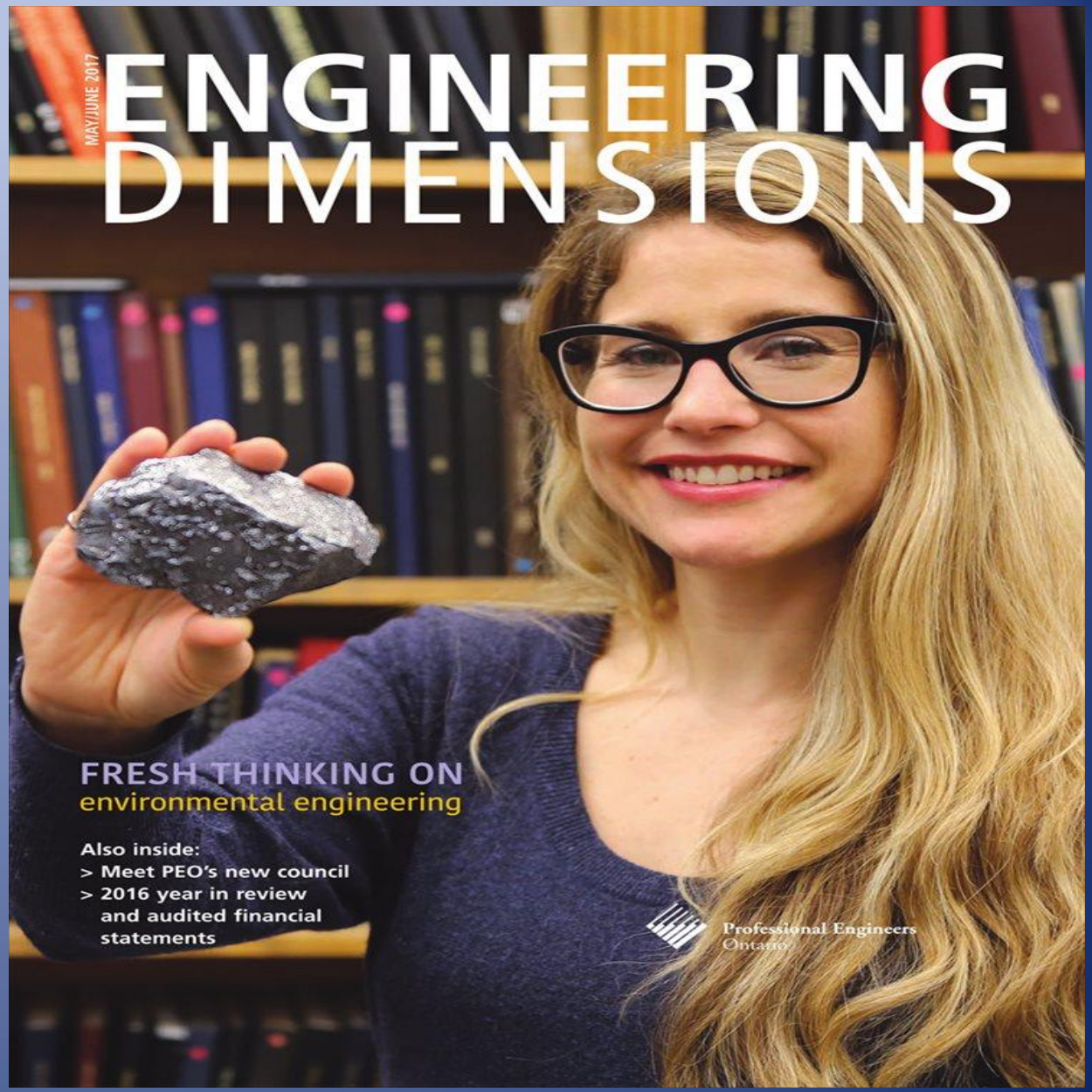
What can PEO/OSPE do?

- Support inclusion of climate change in undergraduate/graduate curriculum (accreditation criteria)
- Support PEO Chapter workshops and seminars on climate related topics that support engineering practice
- Partner with fellow engineering regulators for access to resources, shared CPD and training materials and opportunities, advice
- Develop a PEO/OSPE Climate Change Action Plan for Engineers

“it is critical the profession (engineering) create conditions where climate change adaptation is not only an accepted part of daily practice, but also a guiding principle of professional practice.

Individual engineers should make reasonable efforts to incorporate adaptation into their personal professional practice through continuing professional development and experience

This, in turn, calls on engineers to communicate more effectively with decision makers about climate change adaptation issues and the associated risks.”



Climate Resilient Infrastructure Resources

1. CCCS: canada.ca/en/environment-climate-change/services/climate-change/canadian-centre-climate-services.html
2. INFC's Climate Lens: infrastructure.gc.ca/pub/other-autre/cl-occ-eng.html
3. Climate Resilient Buildings and Core Public Infrastructure:infrastructure.gc.ca/pub/other-autre/cl-occ-eng.html
4. DMAF: infrastructure.gc.ca/dmaf-faac/index-eng.html
5. ICIP Covid-19 Resilience Stream: https://www.infrastructure.gc.ca/plan/covid-19-resilience-eng.html
6. PIEVC: https://pievc.ca/
7. NRCan's BRACE projects: nrcan.gc.ca/climate-change/impacts-adaptations/building-regional-adaptation-capacity-and-expertise-brace-program/21324
8. Infrastructure and Buildings Working Group: http://www.ibwgsop.org/
9. FCM Municipalities for Climate Innovation Program: fcm.ca/en/programs/municipalities-climate-innovation-program
10. FCM Municipal Asset Mgmt. Program: https://fcm.ca/en/programs/municipal-asset-management-program
11. FCM Natural Assets Hub: https://fcm.ca/en/resources/mcip/natural-assets-bolster-climate-resilience
12. Natural Infrastructure- GIOC Resource Hub: https://greeninfrastructureontario.org/municipal-hub/
13. Climate risk institute Training and Credentialing in Climate Resiliency: climateriskinstitute.ca/training-and-credentialing/
14. Memorial University Centre for Risk, Integrity and Safety Engineering Trainings: mun.ca/engineering/crise/about_us/C-RiseTutorialSeries.php
15. US EPA-ARC-X: https://www.epa.gov/arc-x
16. US Climate Resilience Toolkit: https://toolkit.climate.gov/


EVENTS DEFINE OUR PROFESSION
THEY CHALLENGE CONVENTION AND DEFINE
WHAT IT MEANS TO BE AN ENGINEER

Institute for Catastrophic Loss Reduction
Building resilient communities

Institut de Prévention des Sinistres Catastrophiques
Bâtir des communautés résilientes

THANK YOU!

David Lapp FCAE FEC P. Eng.,
Senior Adviser on Resilient Infrastructure
david.lapp.peng@gmail.com
dlapp@iclr.org
613-793-2203