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Toronto and Region Conservation Authority - Flood Control Dam Water Resources Infrastructure Assessment

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National Engineering Vulnerability Assessment of Public Infrastructure to Climate Change

TORONTO AND REGION Conservation for The Living City

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Agenda

- Introduction
- Step 1 Project Definition
- Step 2 Data Gathering and Sufficiency
- Step 3 Risk Assessment
- Step 4 Engineering Analysis
- Step 5 Recommendations

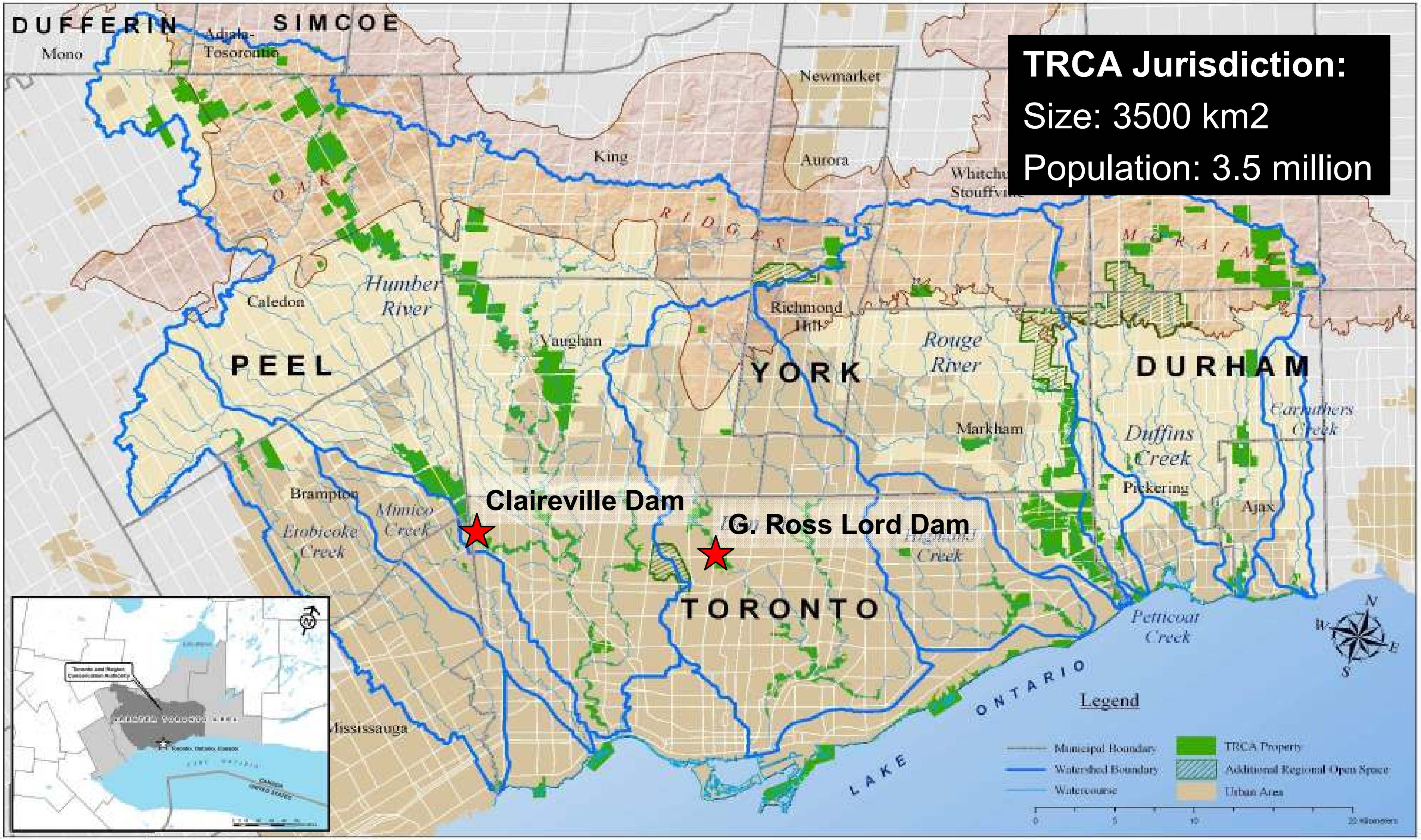
What is a Conservation Authority?

- In the Province of Ontario, Conservation Authorities are community-based environmental agencies dedicated to conserving, restoring, developing and managing natural resources on a watershed basis.
- The mandate of conservation authorities is to: "…**ensure the conservation, restoration and responsible management of Ontario's water, land and natural habitats through programs that balance human and economic needs**." (*Ontario Conservation Authorities Act*)
- Key water resources management activities:
  - flood forecasting and warning
  - floodplain mapping and regulation
  - urban stormwater management
  - flood and erosion control works

TRCA Jurisdiction:

Size: 3500 km2

Population: 3.5 million



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Introduction

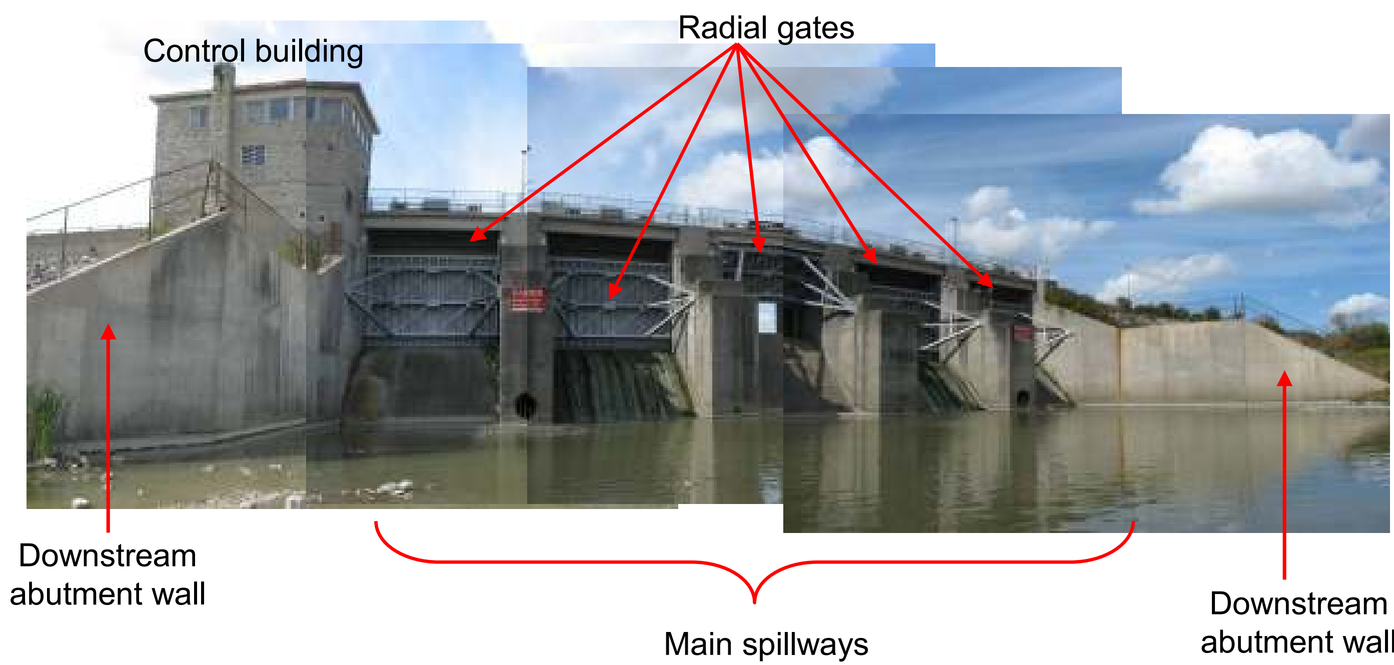
- **Who?**
  - The study was co-funded by the Toronto and Region Conservation Authority (TRCA) and Engineers Canada
- **What, Where, and When**?
  - The 2009 study involved an engineering vulnerability assessment of the Claireville and G. Ross Lord dams and reservoirs to both existing climate and future climate change
- **How?**
  - Applied the Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol Version 9

Introduction

- **Why?**
  - Liability: Failure of either dam would likely result in significant loss of life and/or property damage.
  - TRCA wants to understand both **existing and future** climate-related risks to the dams
  - Looking at both the existing and future context will allow us to understand and manage our current risks, and to understand and plan for how climate change may change these risks.

Step # 1 Project Definition – Claireville Dam

- Constructed in 1963 – 1964
- 460 m long earth embankment with 60 m wide concrete spillway
- Reservoir maximum storage volume of 4,700,000 m^3



Step #1 Project Definition – G. Ross Lord Dam

- Constructed in 1973
- Earthen embankment, crest length 370 m, 10 m wide spillway
- Reservoir maximum storage volume 5,000,000 m^3

Control building
Radial gates
Spillway piers and lateral walls
Concrete spillway tailrace structure
Embankment dam (downstream)

Step 1 Project Definition: Assumptions/Qualifiers

- The study did not include a detailed hydrologic or hydraulic assessment of changed dam inflow regimes since:
  - Previous analysis has shown that the dams are resilient to all but the most extreme inflow events
  - Current climate science cannot provide useful projections of the future frequency and magnitude of the most extreme events
  - Ontario provincial policy on this issue is currently being examined

Step # 2 Data Gathering and Sufficiency

- The dams were broken down into all of their components and grouped into the following general categories:
  - Administration/Staff/Operations
  - Reservoir
  - Spillway Structures
  - Mechanical Systems
  - Embankment Dams
  - Groundwater Drainage/Management Systems
  - Electric Power Supply
  - Control and Monitoring Systems
  - Communications
  - Safety Systems

Step # 2 Data Gathering and Sufficiency

(Climate Analysis and Projections)

- Two types of data were required:

1. Historic data to describe the **existing** condition
   - Environment Canada (EC) Climate Normals
   - EC Archives
   - Ontario Climate Hazards –ontario.hazards.ca (NWT pnr.hazards.ca)

2. Climate projections to describe the potential **future** condition
   - Climate trend analyses by EC and others
   - Global Climate Model (GCM) ensemble output for "2050's" from EC - www.cccsn.ca
   - Scientific literature
   - Regional Climate Model (RCM) output was **not** used

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Step # 2 Data Gathering and Sufficiency

(Climate Analysis and Projections)

- Parameters considered relevant to the geographic area and to risk and vulnerability of the Claireville and G. Ross Lord dams:

- High Temperature
- Low Temperature
- Heat Wave
- Cold Wave
- Extreme Diurnal Temperature Variability
- Freeze-Thaw
- Heavy Rain
- Heavy 5-Day Total Rainfall
- Winter Rain
- Freezing rain
- Ice Storm
- Heavy Snow
- Snow Accumulation
- Blowing Snow/Blizzard
- Lightning
- Hailstorms
- Hurricanes/Tropical Storms
- High Wind
- Tornados
- Drought and Dry Periods
- Heavy Fog

Step # 2 Data Gathering and Sufficiency

- Probability scores from 0-7 were assigned for existing *and* future probability of the occurrence of each parameter

Climate Parameters for which the probability scores **increased** from historical to future
High Temperature
Heat Wave
Heavy Rain
Heavy 5-Day Total Rainfall
Freezing Rain
Ice Storm
Hurricane/Tropical Storm
Drought/Dry Period

Climate Parameters for which the probability scores **decreased** from historical to future
Low Temperature
Cold Wave
Extreme Diurnal Temperature Variability
Freeze Thaw
Snow Accumulation

Step #3 Risk Assessment

- A risk assessment workshop was conducted on November 9th, 2009
- The workshop participants were from the GENIVAR team, TRCA staff, and the Project Advisory Committee
- In order to validate initial findings, the participants provided input on:
  - Interactions between climate events and infrastructure components relevant to the study (Claireville 777 & G.Ross Lord 903)
  - Severity of the impact climate event on the infrastructure component from a scale of 0 (negligible) to 7 (extreme)

STEP # 3 Risk Assessment

- TRCA modified the PIEVC approach in version 9 of the protocol by assessing **both existing and future** risk.
- Developing an understanding of existing risk has a number of benefits:
  - Allows for infrastructure to be assessed in terms of current climate conditions, providing an understanding of existing climate risk
  - The delta change between existing and future climate risk provides context for the assessment of climate change risk and vulnerability (including identifying **reduced** risk)
  - Facilitates planning (capital work, maintenance and operations) for integration of necessary adaptive capacity by having a better understanding of need and the timeframe associated with climate vulnerabilities

Step # 3 Risk Assessment

- Risk = P x S
  - P = Probability of Climate Event
  - S = Severity of the climate event on the component

- For both dams there were 1680 interactions, 688 considered relevant
  - 60% were in the low risk category (under CC)
  - 40% were in the medium risk category (under CC)
  - None were in the high risk category (under either existing or CC)

	EXISTING	FUTURE (2050)
Low Risk (P x S < 12)	361	413
Medium Risk (12 < P x S <36)	327	275

Step # 4 Engineering Analysis

- Vulnerability exists when the infrastructure has insufficient capacity to withstand the loads placed upon it

	Claireville	G. Ross Lord
No. of interactions considered in the engineering analysis	209	204
No. of interactions assessed to be vulnerable	50	51

- Generally, the vulnerabilities exist to the following climate events: Freezing Rain, Ice Storm, Hurricane/Tropical Storm, High Wind, and Tornado.

Step # 5 Recommendations (Conclusions)

- In general, the two dams are resilient to both existing climate conditions and conditions that are likely to be experienced in the future
- The climate events posing the highest vulnerability to the dams are extreme events such as hurricanes, tornados and ice storms; the probability of these events occurring is likely to increase in the future
- It is important that TRCA continue to operate, monitor, and maintain the infrastructure effectively

Step # 5 Recommendations

- Continue to monitor the risks and vulnerabilities identified through the assessment, particularly as components continue to age
- Preserve the high standard of maintenance and management that TRCA has devoted to the dams to this point
- Monitor the progress in climate science and revisit assessment as advances are made
- Consider the consequences of “high-impact” events (low overall risk score but high severity), and develop mitigation or response plans to address them
- Review and/or develop emergency response plans for extreme weather events associated with the assessed existing and future dam vulnerability: tornados, hurricanes, extreme wind, and ice storms.

Step # 5 Recommendations – Protocol Review

- The PIEVC protocol provided a clear step-by-step process and an organized, consistent framework for conducting the vulnerability assessment
- Challenges were experienced in producing climate analysis results in the form required by all of the steps in the Protocol
- Future vulnerability alone does not provide an explicit understanding of climate change risk
- It is important to identify and consider further interactions with low overall risk scores but high severity scores since they could potentially cause a critical loss of function
- Collecting climate information to support the vulnerability assessment is time-consuming and effort-intensive; as part of the final pilot assessments, PIEVC should consider analysing the overall climate variables by infrastructure type and developing standardized data sets and/or techniques