

# An Ensemble Approach to Holistic Flood Risk Management

**Multi-Hazards Risk and Resilience Workshop**  
**University of Western Ontario**  
**4-5 November 2019**

LCol (Ret) Nick Martyn CD, BMASc, GMICE  
Founder, CEO RiskLogik

**crci**



UNIVERSITY OF TORONTO  
FACULTY OF APPLIED SCIENCE & ENGINEERING



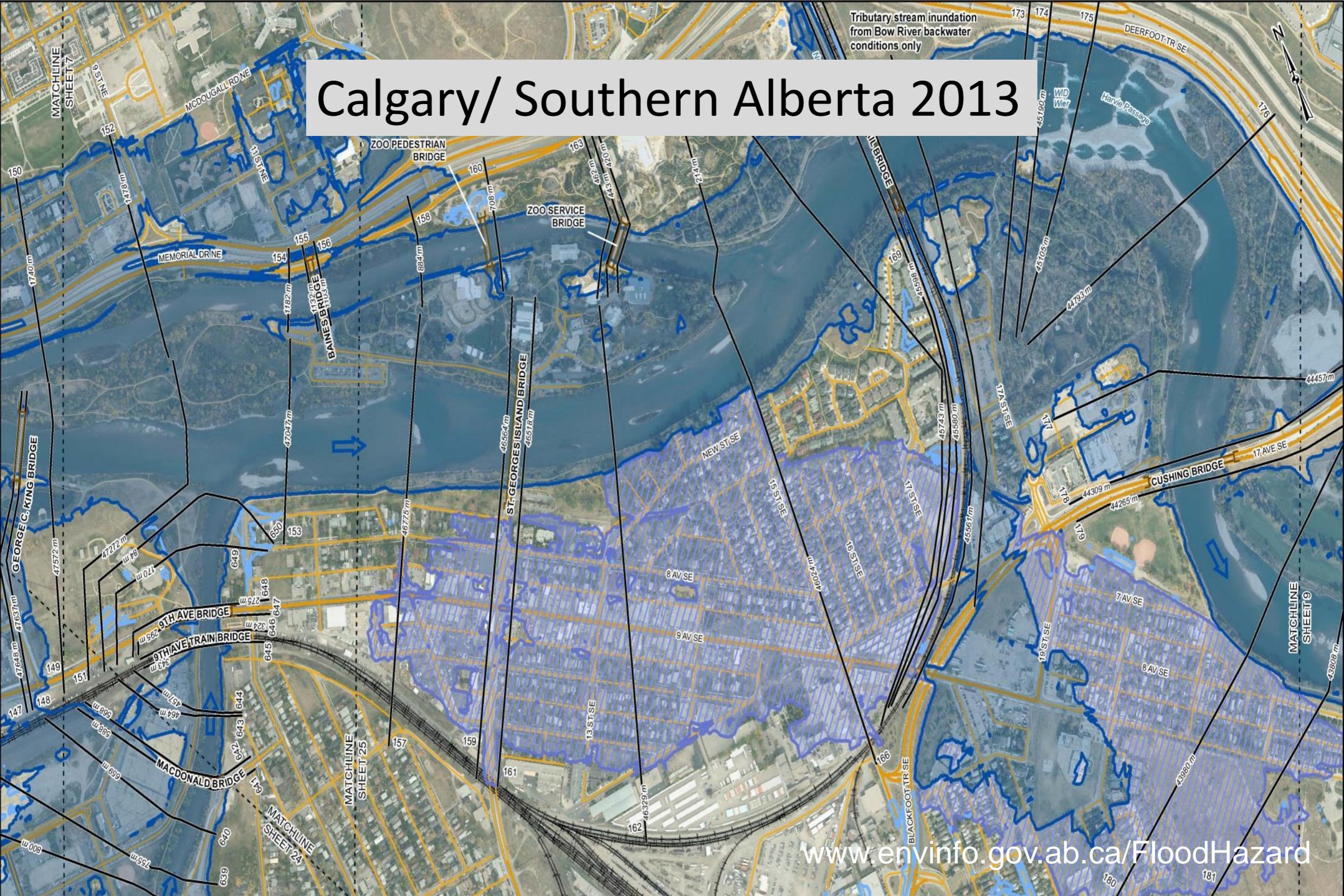
# Ottawa River 2019



# Ottawa River 2017

# Calgary/ Southern Alberta 2013

Tributary stream inundation from Bow River backwater conditions only



[www.envinfo.gov.ab.ca/FloodHazard](http://www.envinfo.gov.ab.ca/FloodHazard)

## 100 Year Flood



**OVER  
14,500**

**HOMES DAMAGED**



**80  
SCHOOLS  
DAMAGED**



**10  
HEALTH  
FACILITIES  
DAMAGED**



**30  
COMMUNITIES  
IMPACTED**



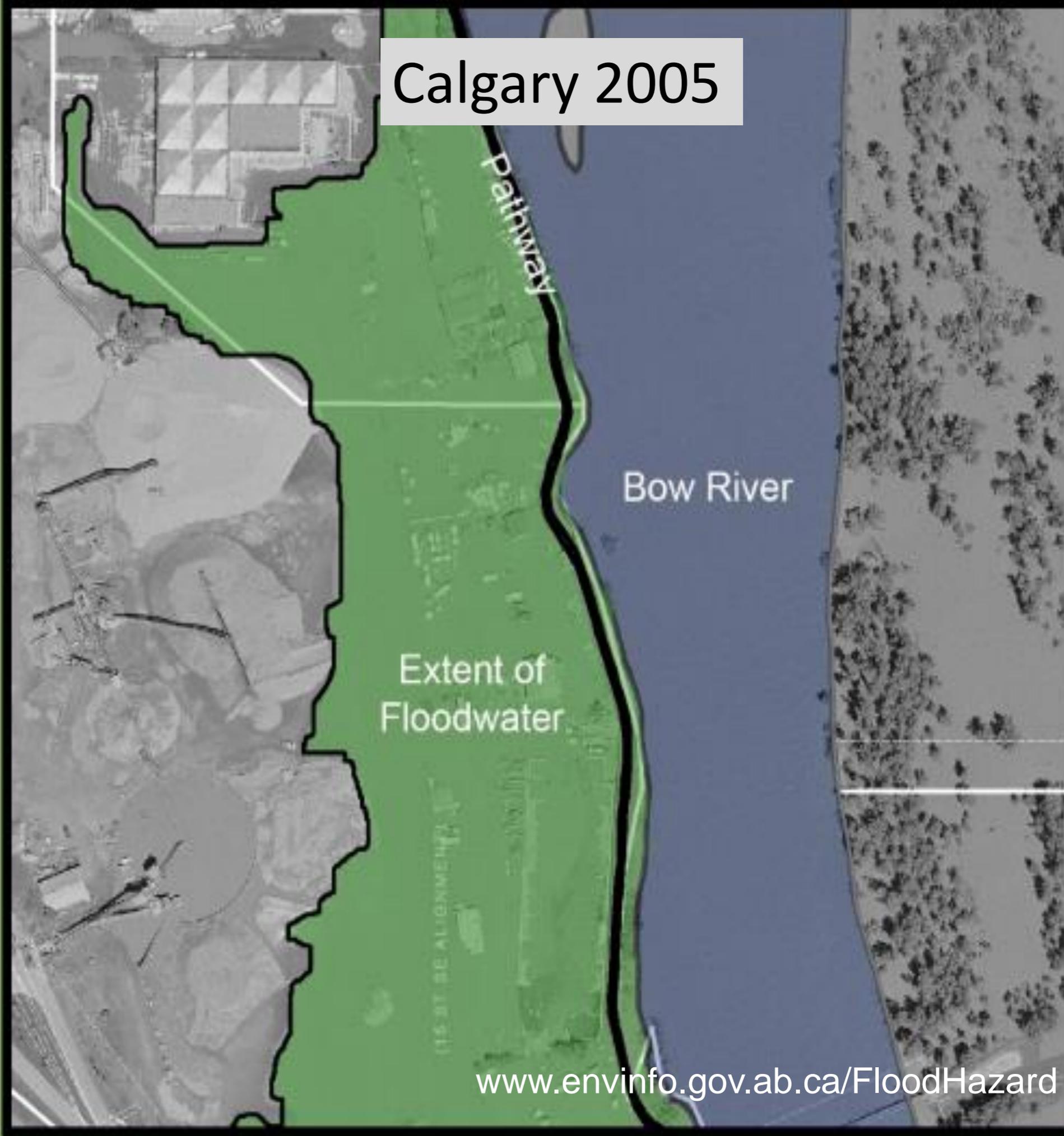
**985  
KM  
ROADS CLOSED**

**3,000  
BUSINESSES  
AFFECTED**

**100,000  
PEOPLE  
EVACUATED**

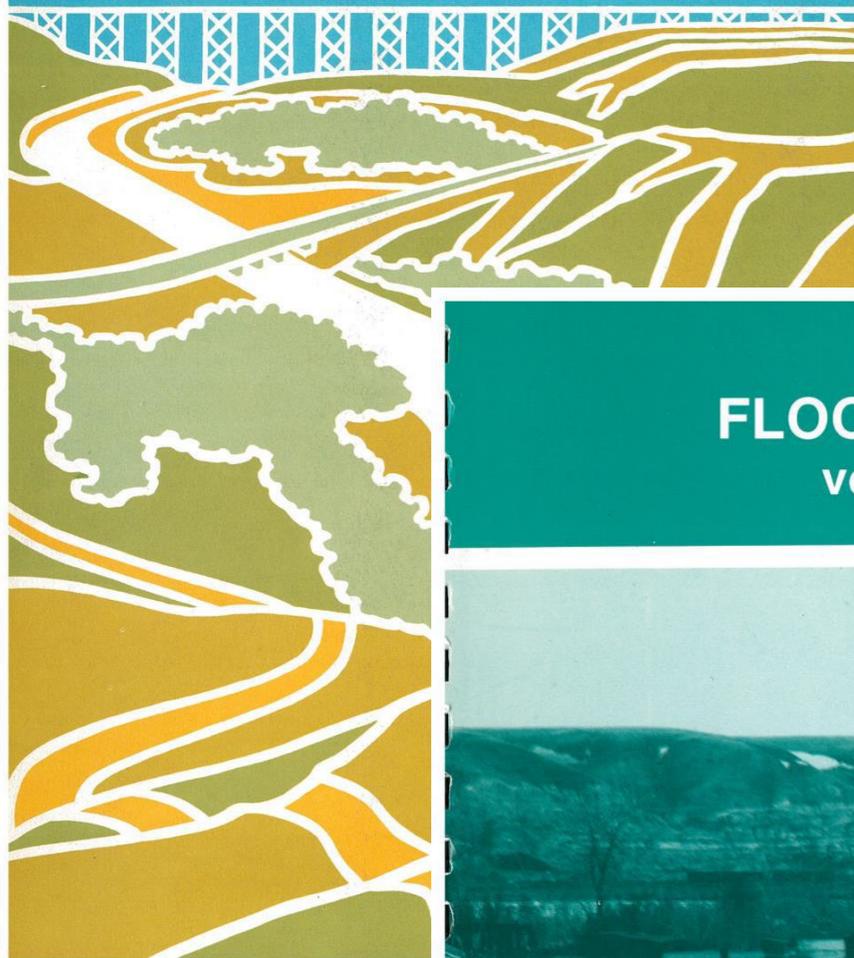


# Calgary 2005

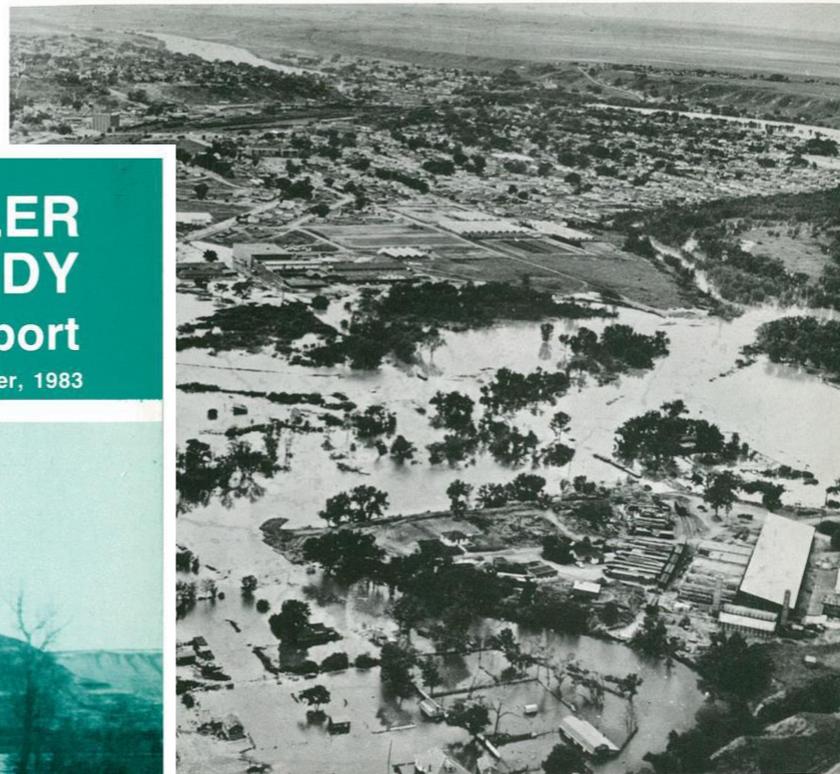


# The Science is Known

FLOODPLAIN STUDY  
OLDMAN RIVER THROUGH LETHBRIDGE

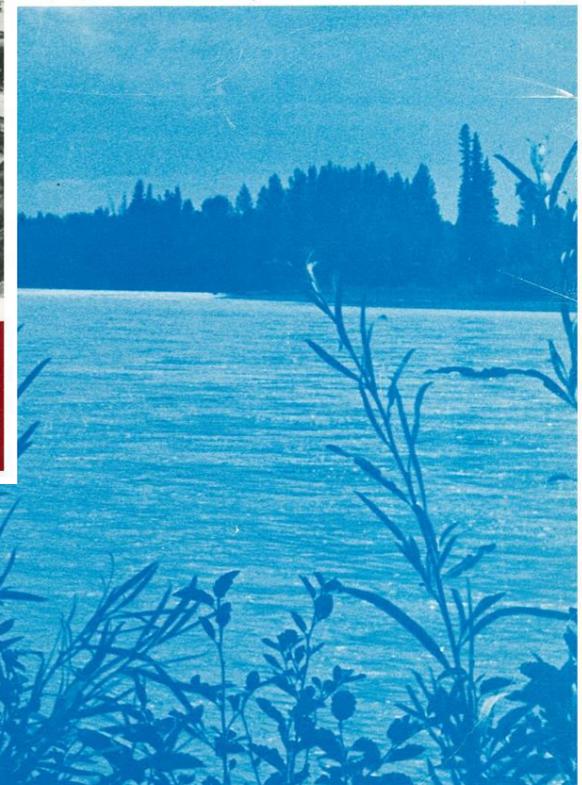


MEDICINE HAT  
FLOODPLAIN STUDY  
SUMMARY REPORT



Flooding at Medicine Hat - June, 1953

whitecourt  
floodplain  
study



DRUMHELLER  
FLOODPLAIN STUDY  
volume I main report

November, 1983



Newcastle Flood - April 21, 1948

Resources

Alberta  
ENVIRONMENT  
Water Resources Management

Alberta  
ENVIRONMENT  
Water Resources Management  
Services  
Technical Services Division

Alberta

# Where we are Failing



# Risk Communication

Risk  
Assessment

---

Science Based

Likelihood  
Consequence  
Mitigations

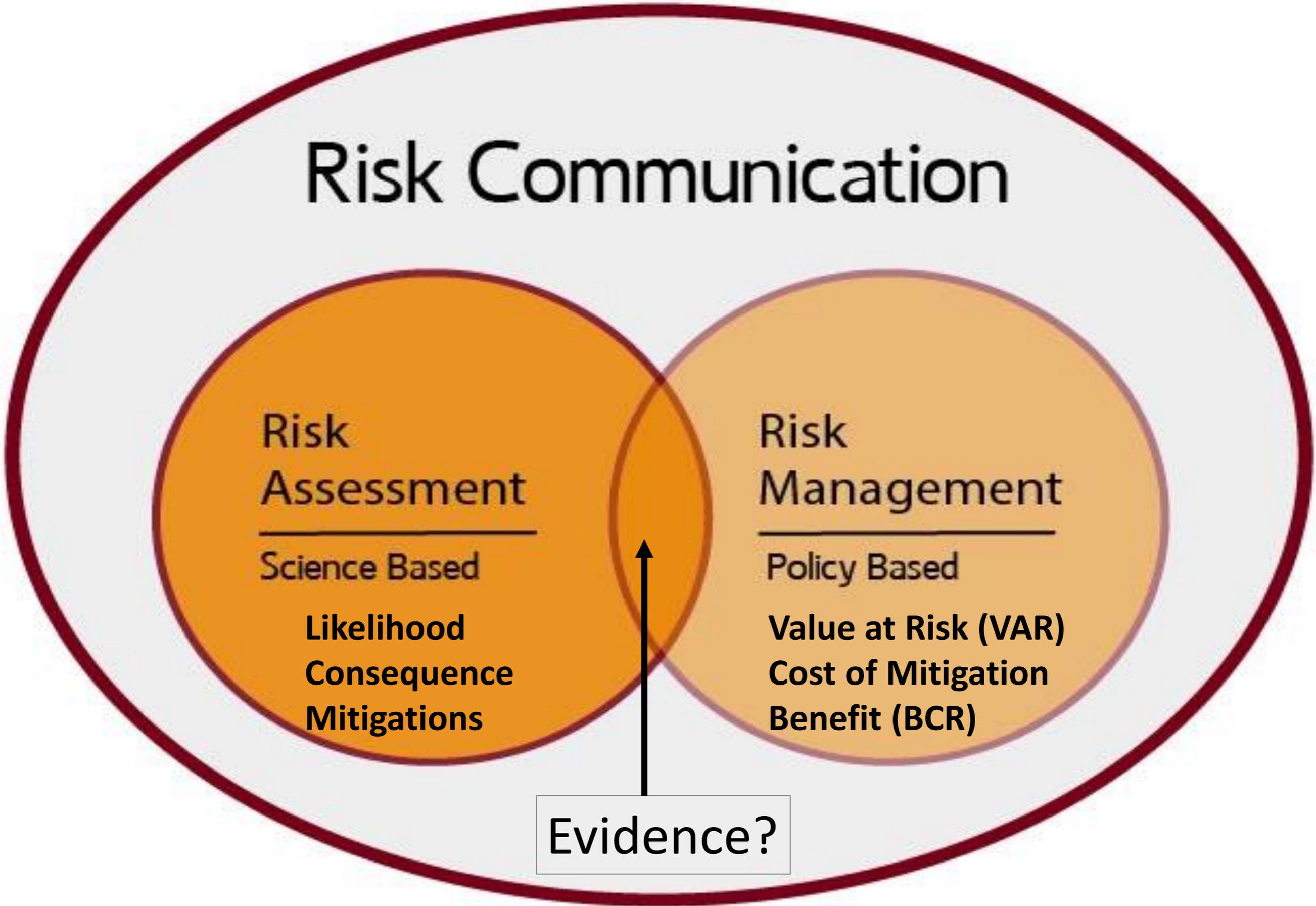
Risk  
Management

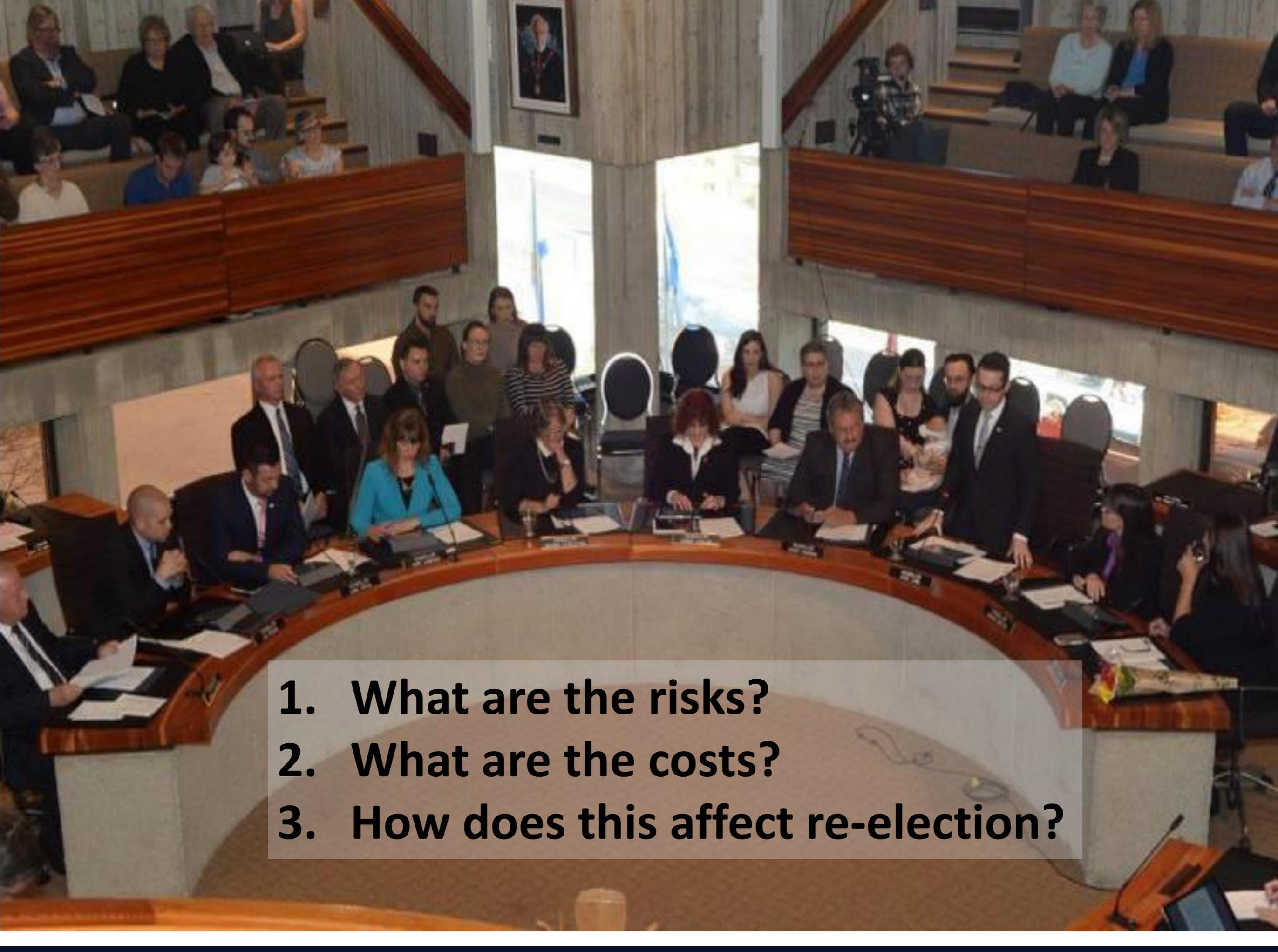
---

Policy Based

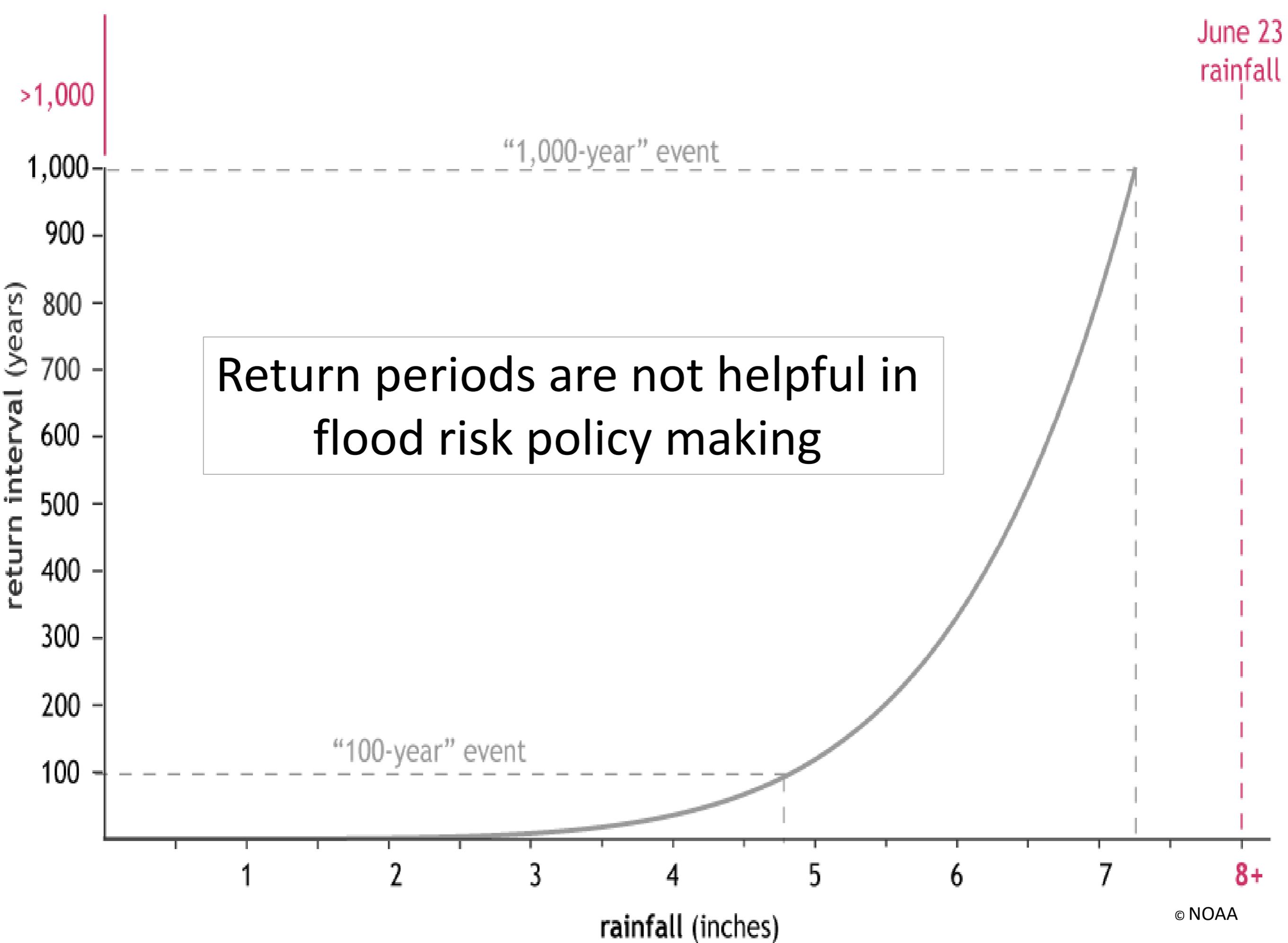
Value at Risk (VAR)  
Cost of Mitigation  
Benefit (BCR)

Evidence?





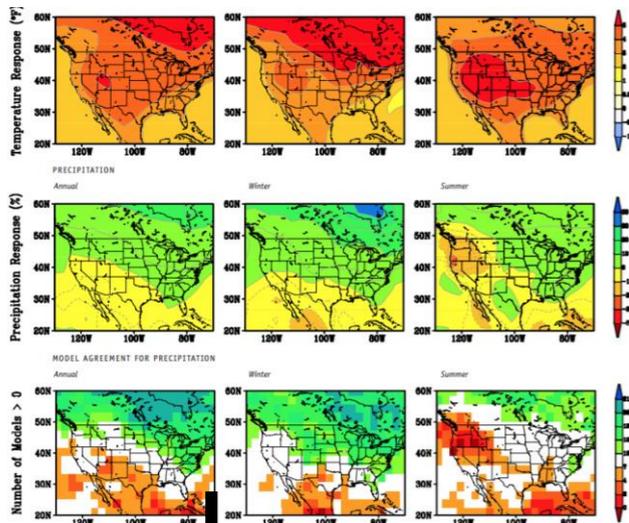
- 1. What are the risks?**
- 2. What are the costs?**
- 3. How does this affect re-election?**



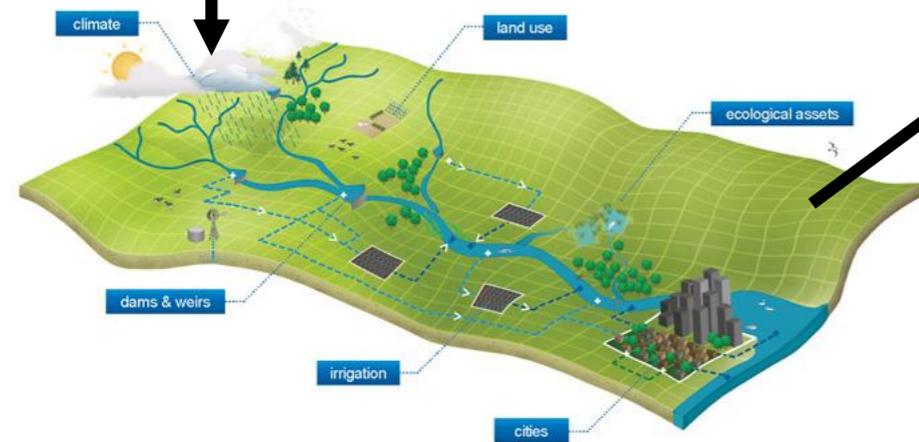
# Characteristics of an Holistic Approach

- Evidence Based
- Auditable
- Repeatable
- Verifiable
- Dynamic
- Scenario based
- Understandable to policy makers

# Holistic Ensemble Approach

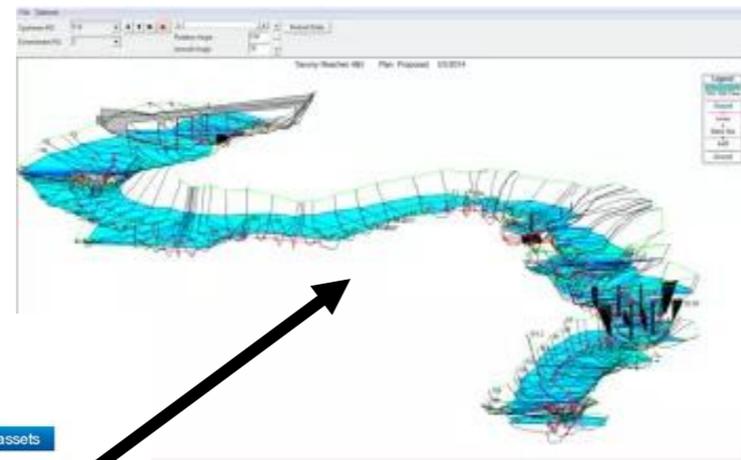
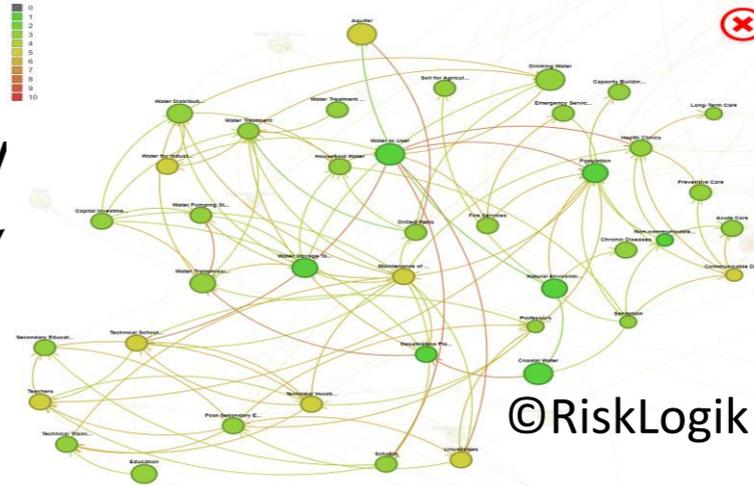


© NOAA  
Downscaled Climate Models



Digital Watershed Model

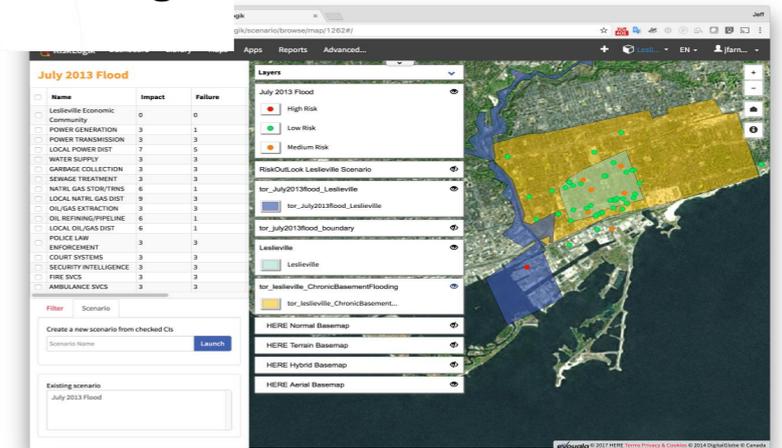
Infrastructure inter-dependency model



©FEMA/DHS  
Hydrological Model

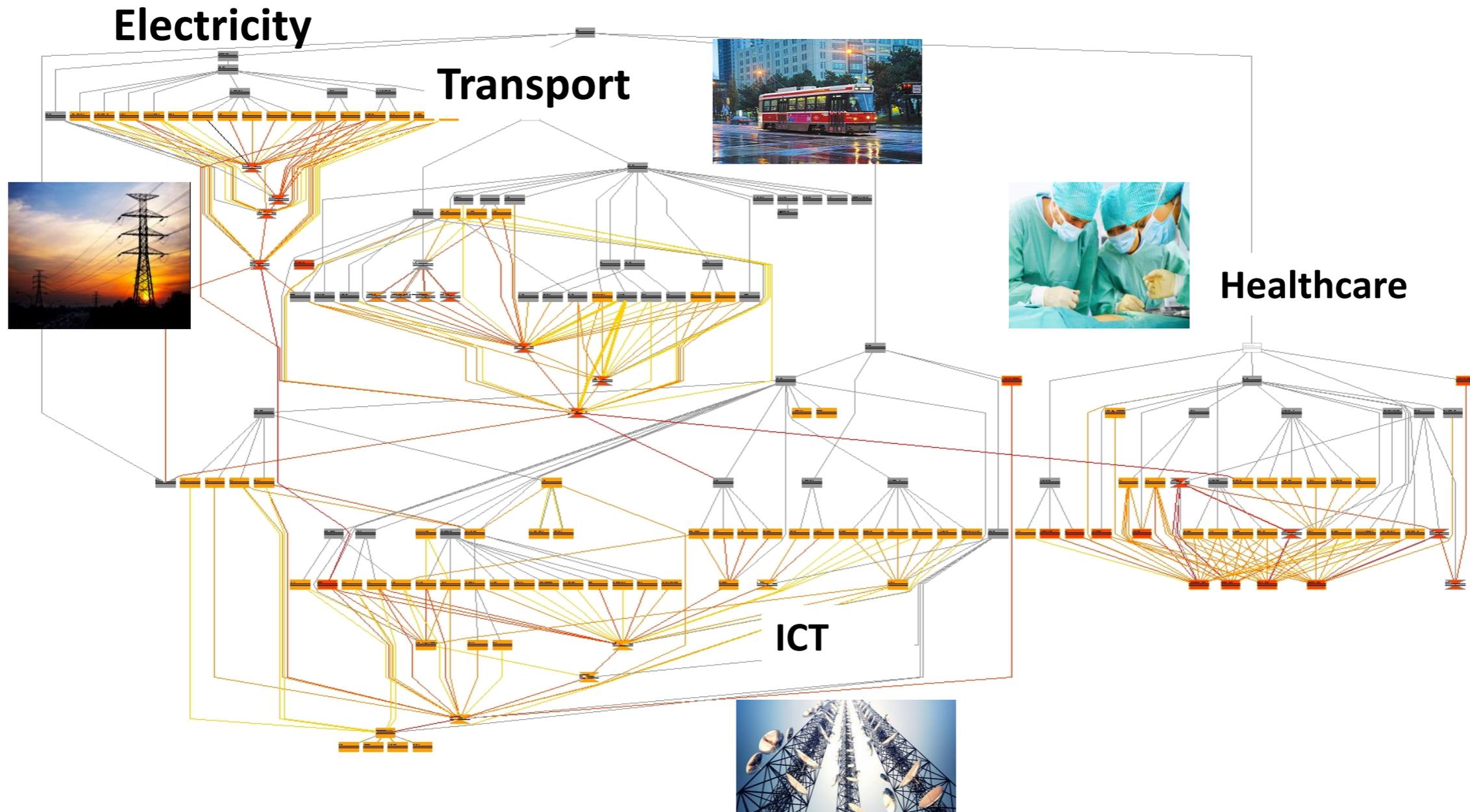
©RiskLogik

Integrated Flood Effects Modelling

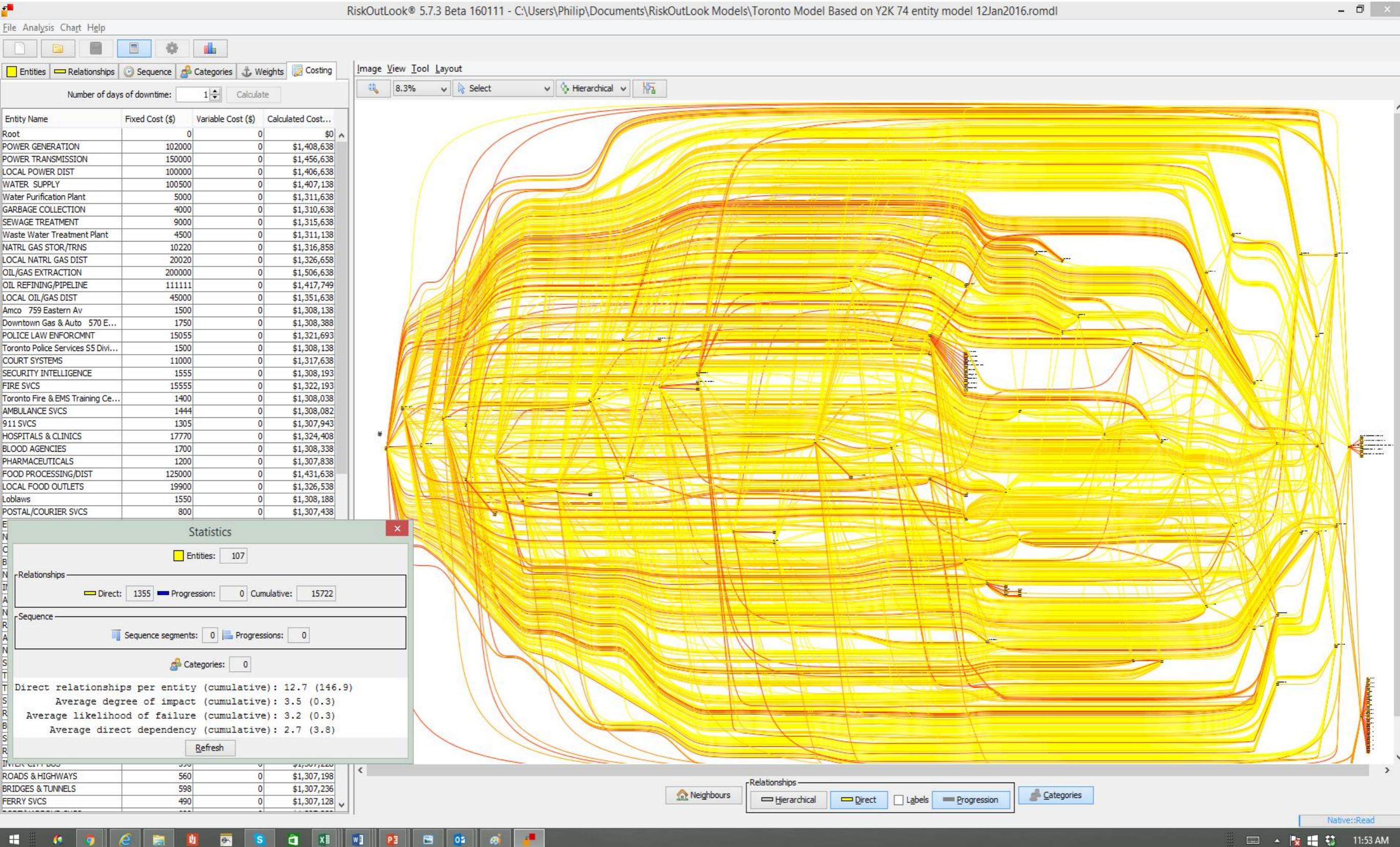


- Value At Risk
- Mitigation Scenarios
- Benefit:Cost Ratios

# Infrastructure Interdependency Mapping



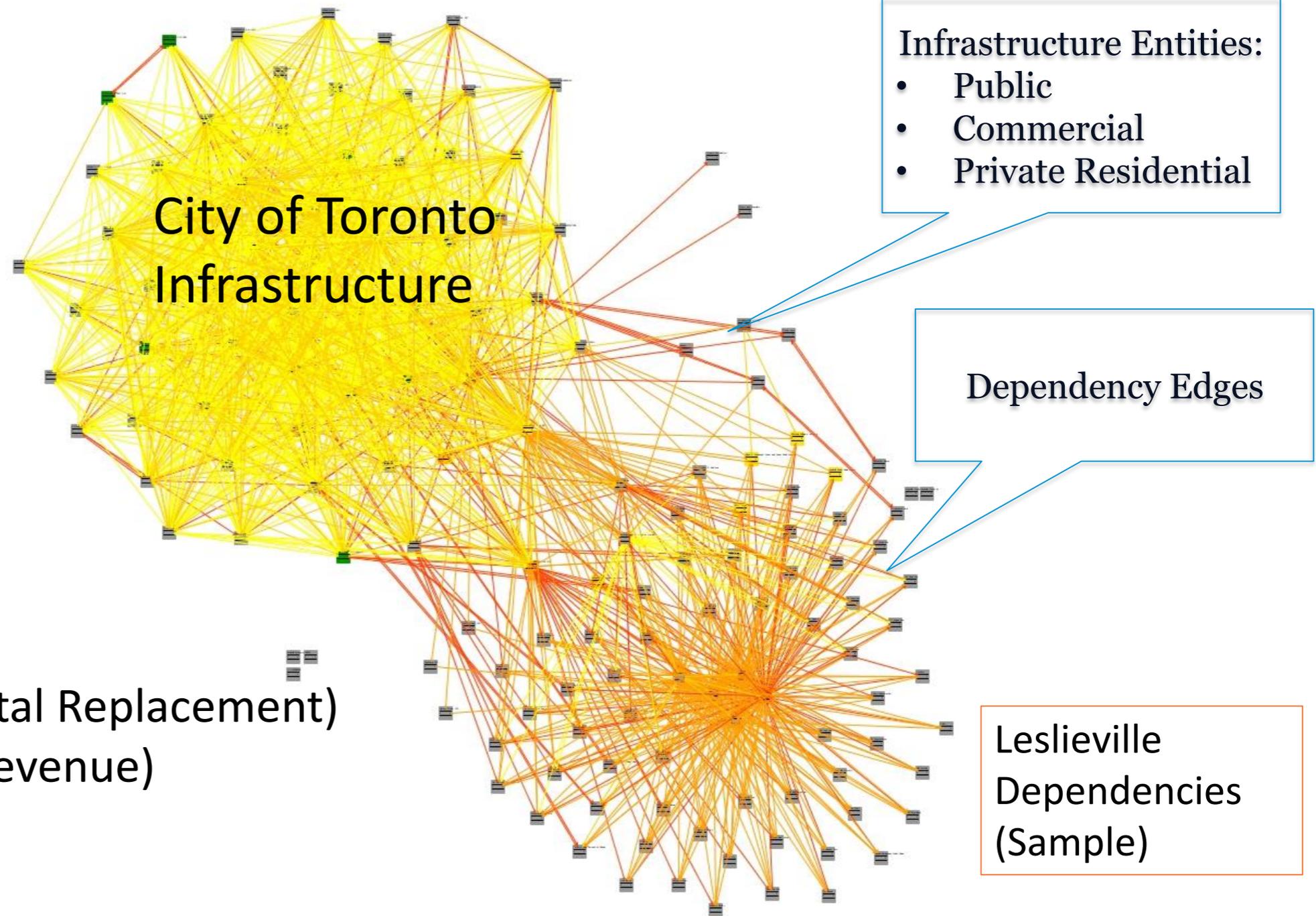
# City Scale Infrastructure Interdependency Maps



# Leslieville Infrastructure Sub-Model

## Entity Metadata

- Entity ID
- Location
- Impact
- LoF
- Dependents
- Fixed Cost (Capital Replacement)
- Variable Cost (Revenue)



# Leslieville Experiment: Spatial Control Framework

**RiskOutLook Leslieville Scenario**

<input type="checkbox"/>	Name	Impact	Failure
<input type="checkbox"/>	Leslieville Economic Community	0	0
<input type="checkbox"/>	POWER GENERATION	3	1
<input type="checkbox"/>	POWER TRANSMISSION	3	3
<input type="checkbox"/>	LOCAL POWER DIST	7	5
<input type="checkbox"/>	WATER SUPPLY	3	3
<input type="checkbox"/>	GARBAGE COLLECTION	3	3
<input type="checkbox"/>	SEWAGE TREATMENT	3	3
<input type="checkbox"/>	NATRL GAS STOR/TRNS	6	1
<input type="checkbox"/>	LOCAL NATRL GAS DIST	9	3
<input type="checkbox"/>	OIL/GAS EXTRACTION	3	3
<input type="checkbox"/>	OIL REFINING/PIPELINE	6	1
<input type="checkbox"/>	LOCAL OIL/GAS DIST	6	1
<input type="checkbox"/>	POLICE LAW ENFORCEMENT	3	3
<input type="checkbox"/>	COURT SYSTEMS	3	3
<input type="checkbox"/>	SECURITY INTELLIGENCE	3	3
<input type="checkbox"/>	FIRE SVCS	3	3
<input type="checkbox"/>	AMBULANCE SVCS	3	3

Filter: Scenario

Search:

Draw filter polygon:

Filter CI from data

- Almonte\_104m\_AGL\_flood
- tor\_July2013flood\_Leslieville
- tor\_july2013flood\_boundary
- tor\_leslieville\_ChronicBasementFlooding

**Layers**

- RiskOutLook Leslieville Scenario
  - High Risk
  - Low Risk
  - Medium Risk
- tor\_July2013flood\_Leslieville
- tor\_july2013flood\_boundary
- Leslieville
  - Leslieville
- tor\_leslieville\_ChronicBasementFlooding
- HERE Normal Basemap
- HERE Terrain Basemap
- HERE Hybrid Basemap
- HERE Aerial Basemap

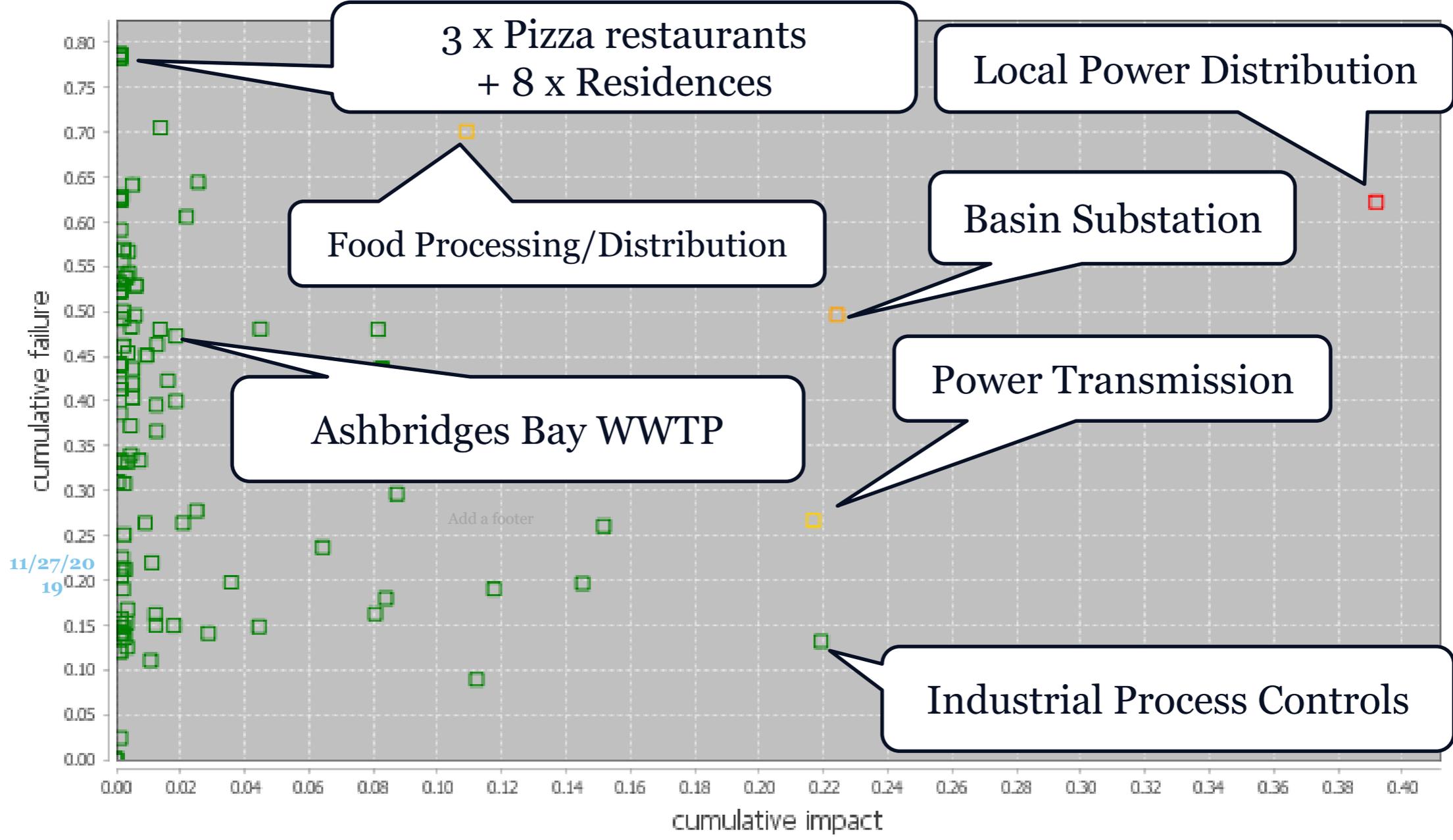
**Map Callouts:**

- Don River Valley
- Sample Entities
- Basin Substation
- Ashbridges Bay WWTP

evouala © 2017 HERE Terms Privacy & Cookies © 2014 DigitalGlobe © Canada

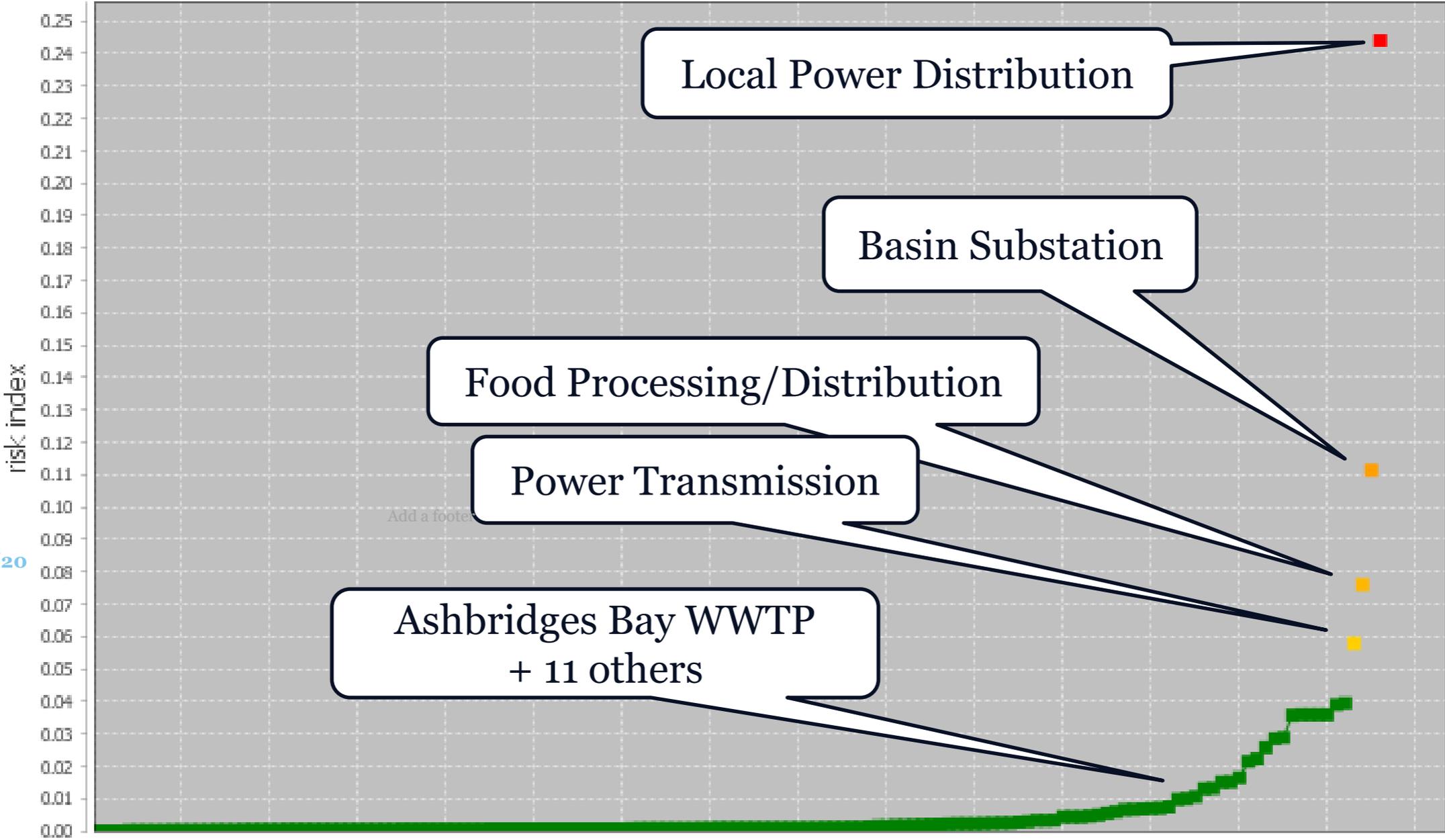
# Leslieville Inherent Risk Plot (Heat Map)

Cumulative Impact versus Cumulative Failure



# Leslieville Inherent Risk Hierarchy

Group versus Risk Index





© CTV News.ca

July 8 2013

### July 2013 Flood

<input type="checkbox"/>	Name	Impact	Failure
<input type="checkbox"/>	Leslieville Economic Community	0	0
<input type="checkbox"/>	POWER GENERATION	3	1
<input type="checkbox"/>	POWER TRANSMISSION	3	3
<input type="checkbox"/>	LOCAL POWER DIST	7	5
<input type="checkbox"/>	WATER SUPPLY	3	3
<input type="checkbox"/>	GARBAGE COLLECTION	3	3
<input type="checkbox"/>	SEWAGE TREATMENT	3	3
<input type="checkbox"/>	NATRL GAS STOR/TRNS	6	1
<input type="checkbox"/>	LOCAL NATRL GAS DIST	9	3
<input type="checkbox"/>	OIL/GAS EXTRACTION	3	3
<input type="checkbox"/>	OIL REFINING/PIPELINE	6	1
<input type="checkbox"/>	LOCAL OIL/GAS DIST	6	1
<input type="checkbox"/>	POLICE LAW ENFORCEMENT	3	3
<input type="checkbox"/>	COURT SYSTEMS	3	3
<input type="checkbox"/>	SECURITY INTELLIGENCE	3	3
<input type="checkbox"/>	FIRE SVCS	3	3
<input type="checkbox"/>	AMBULANCE SVCS	3	3

**Filter** Scenario

Create a new scenario from checked CIs

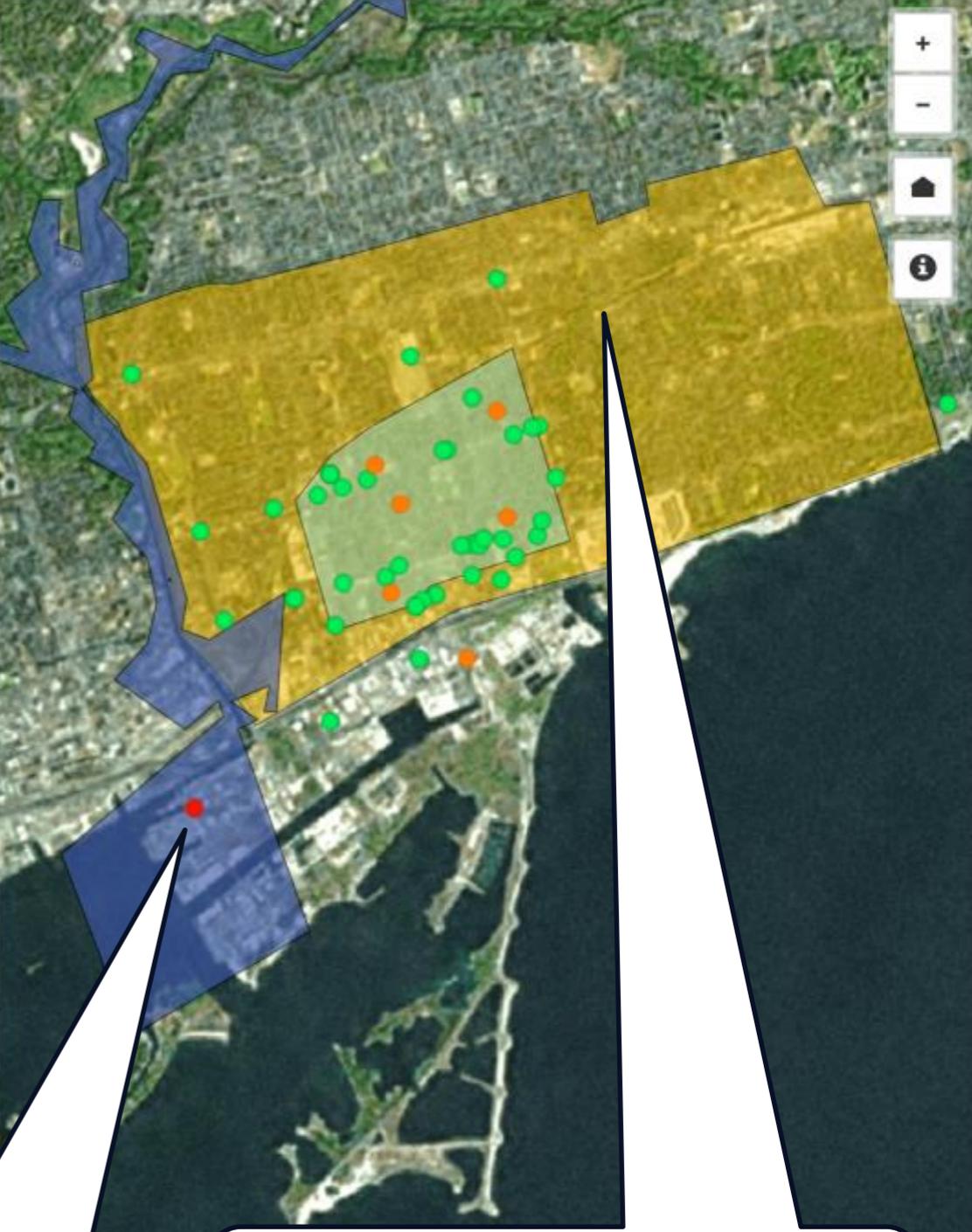
Scenario Name  **Launch**

Existing scenario

July 2013 Flood

**Layers**

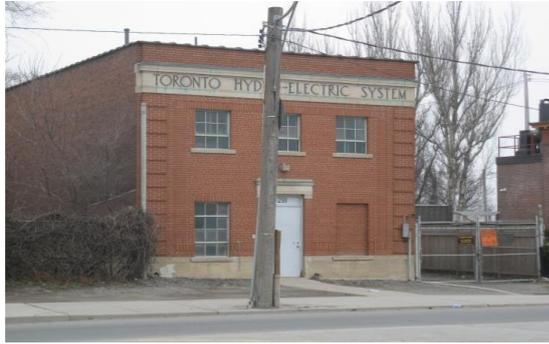
- July 2013 Flood
  - High Risk
  - Low Risk
  - Medium Risk
- RiskOutLook Leslieville Scenario
- tor\_July2013flood\_Leslieville
  - tor\_July2013flood\_Leslieville
- tor\_july2013flood\_boundary
- Leslieville
  - Leslieville
- tor\_leslieville\_ChronicBasementFlooding
  - tor\_leslieville\_ChronicBasement...
- HERE Normal Basemap
- HERE Terrain Basemap
- HERE Hybrid Basemap
- HERE Aerial Basemap



Basin Substation **FAILS**

Area affected by Ashbridges Bay WWTP **FAILURE**

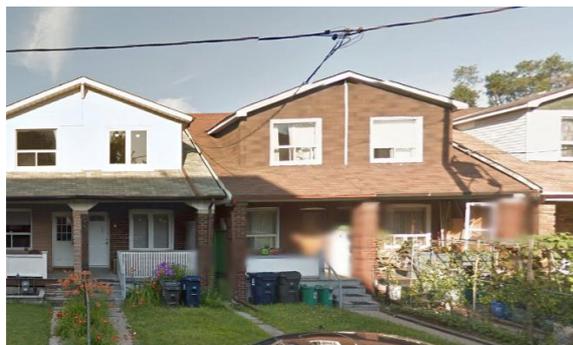
# Scenario One: Value at Risk



**Public Costs: \$5,163,762**



**Commercial Costs: \$2,234,370**



**Residential Costs: \$291,250**

Entity Type	Entity Name	Fixed Costs	Variable Costs	Calculated Cost
Public	Basin Substation	\$100,000	\$10,000	\$363,614
	Ashbridges Bay WWTP	\$14,500	\$35,000	\$362,276
	Riverdale Collegiate Institute	\$4,500	\$12,500	\$338,042
Commercial	Loblaws	\$50,000	\$25,000	\$396,766
	7 Eleven	\$3,500	\$2,250	\$5,750
	Tim Hortons	\$55,000	\$15,000	\$70,000
	McDonalds	\$67,500	\$25,000	\$92,500
Residential	151 Pape Avenue	\$15,000	\$500	\$15,500
	145 Carlaw Avenue	\$25,000	\$1,000	\$26,000
	37 Winnifred Avenue	\$35,000	\$750	\$35,750

**Capital Value at Risk for 69 Example Entities:  
\$7,689,382**

# University of Toronto Engineering

LCol (Ret) Nick Martyn CD, BMASc, GMICE  
Founder, CEO RiskLogik

[Nicholas.martyn@mail.utoronto.ca](mailto:Nicholas.martyn@mail.utoronto.ca)

[Nick.martyn@risklogik.com](mailto:Nick.martyn@risklogik.com)



UNIVERSITY OF TORONTO  
FACULTY OF APPLIED SCIENCE & ENGINEERING