Climate Change (Water Resource Impacts) and Adaptation

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Outline of talk…

- "Big Picture" perspective from the Intergovernmental Panel on Climate Change (IPCC)
- Assessments at the regional/local level to inform adaptation decision-making
  - 3 case studies to illustrate approaches




Intergovernmental Panel on Climate Change (IPCC)

- Authoritative international <u>scientific</u> body on climate change
  - Governments decide on need and scope of IPCC reports
  - Content must be policy relevant not policy prescriptive
  - Multiple rounds of review
  - Approval of documents by 150+ countries
  - http://www.ipcc.ch/

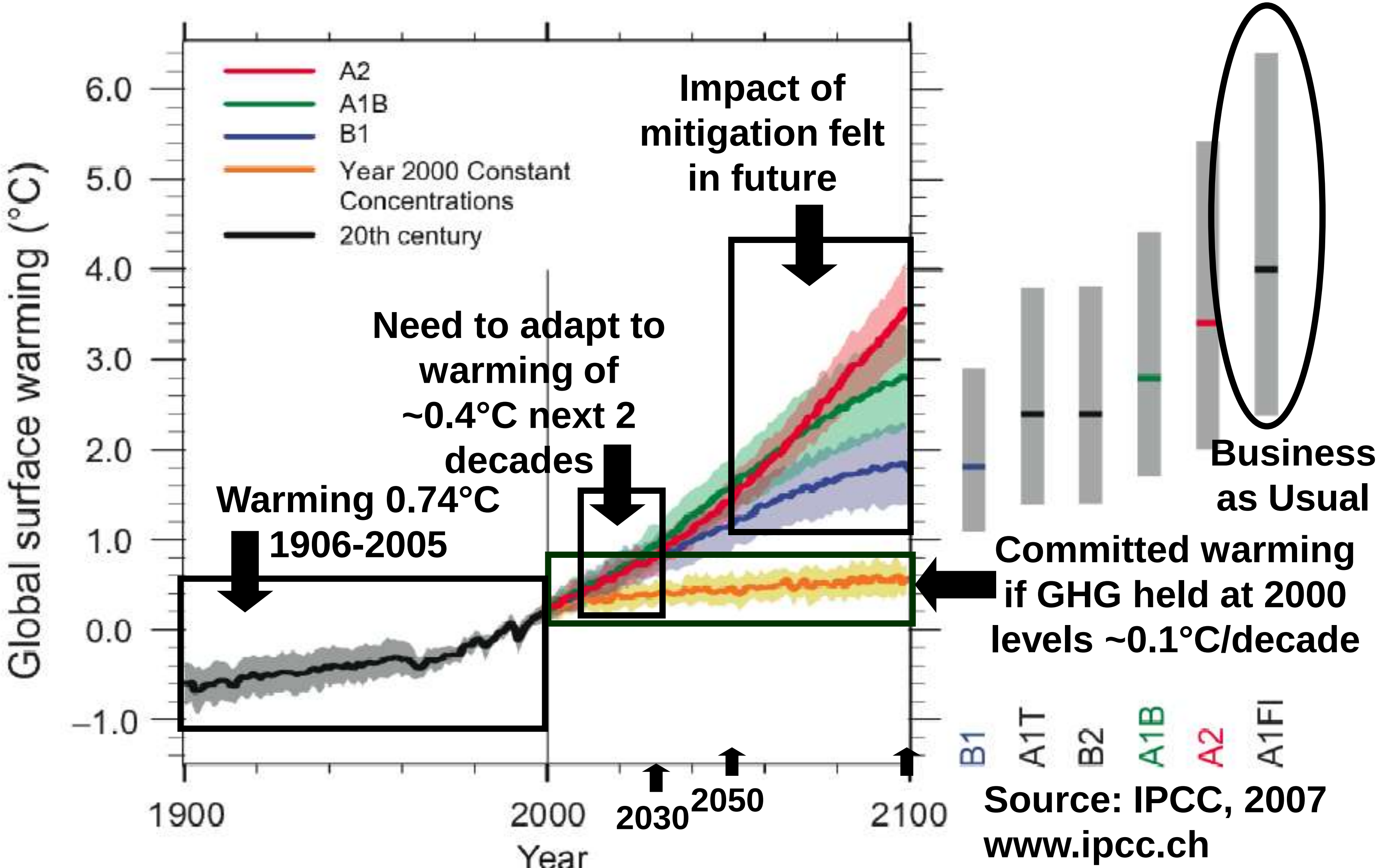
Working Group I: The Physical Science Basis

- **"Warming of the climate system is unequivocal"**
- **Most of increase in global temperatures since the 1950s very likely due to increase in anthropogenic GHG concentrations**
- **Global warming by 2100: 1.8° C to 4.0° C**

Working Group II: Impacts, Adaptation and Vulnerability

- **Observed changes in physical & biological systems**
- **"Adaptation will be necessary to address impacts resulting from warming which is already unavoidable"**

Future conditions…



Source: IPCC, 2007
www.ipcc.ch

We need to adapt (and mitigate)…

- Balanced response to climate change:
  - **Mitigation** – reduce emissions and increase sinks of greenhouse gases to halt/prevent climate change
    - change light bulbs to cap and trade program
  - **Adaptation** – respond to impacts of changing climate - moderate harm or exploit beneficial opportunities
    - water conservation to integrated water strategy

Managers will have to deal with new realities …

- <u>Change:</u>
  - distribution, amount, timing & quality of water supply
  - more extreme conditions
- <u>Uncertainty</u>:
  - past climate is not a reliable guide for future planning



New flooding risks and potential increase in damages …

- More intense precipitation & winter rain
  - – flooding in winter and summer?
- Infrastructure must accommodate higher flows
  - – safety & performance issues; green infrastructure
- Re-evaluate floodplain management & emergency preparedness
  - – more structures & people exposed

Increased risk of low flow (drought)…

- Summer and fall low flows may be lower & last longer
  - pollutant concentration could increase
  - challenges in assimilating pollutants from point sources
- Mismatch between supply & demand
  - potential conflict between in-stream ecological needs & economic uses of water




More difficult to meet water quality goals…

- Extreme precipitation events
  - combined sewer overflows
  - non-point source pollution - sediment and nutrient input from erosion
- Low flow in streams
  - assimilating pollutants from sewage treatment plants and industry
- Warmer water temperatures
  - dissolved oxygen issues
  - algae blooms - taste and odour problems

"Mainstream" climate change into decision-making …some approaches to inform process …

- Impact Assessment *
  - What are the expected impacts of climate change on natural and human systems?
- Risk Assessment
  - What is the risk (probability X consequences) associated with a specific climate change impact?
  - What are the greatest risks related to climate change?
- Vulnerability *
  - To what degree is the system susceptible to or unable to cope with the effects of climate change?
- Policy Assessment
  - How effective are our policies, programs, and projects given a changing climate?
  - Do our current policies increase or decrease vulnerability?
- Adaptive Management*
  - How does one address the uncertainty of climate change and use monitoring, modelling and stakeholder input to inform "learn by doing" decision-making

Climate Change Case Study
Credit River – Subwatershed 19

R. Walker, EBNFLO Environmental

D. Van Vliet & S. Bellamy, AquaResource Inc.

AquaResource Inc.
Integrity • Technology • Solutions

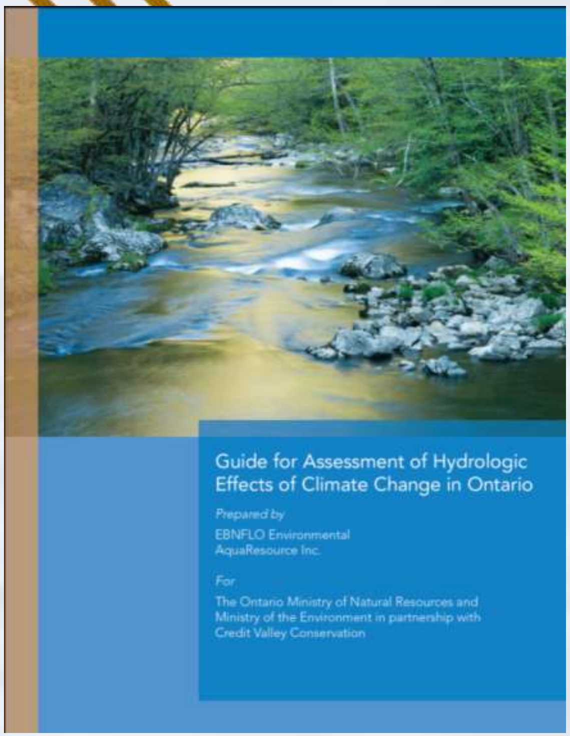
EBNFLO Environmental

Case Study

AquaResource Inc.
Integrity • Technology • Solutions

EBNFLO Environmental

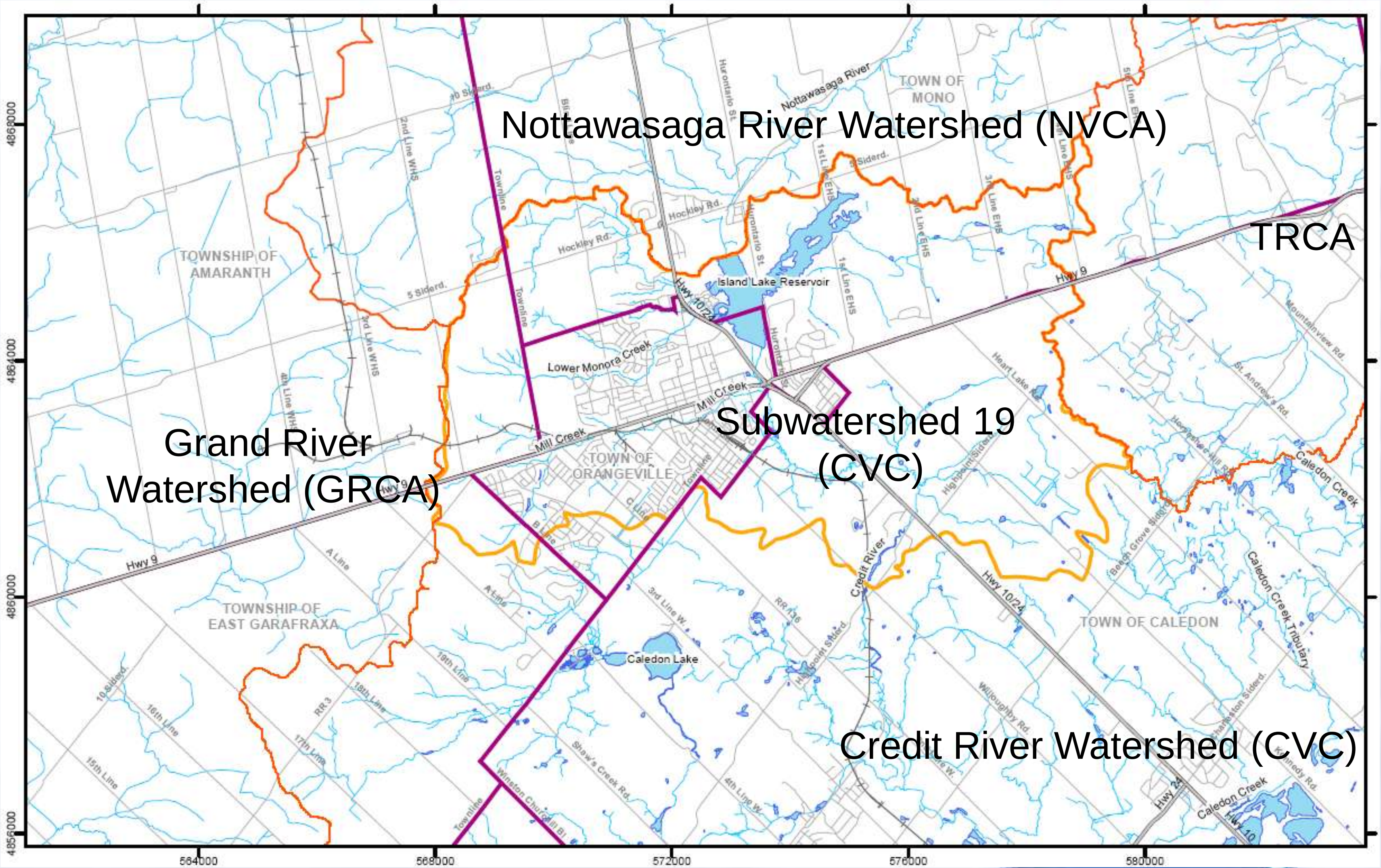
1. Purpose
2. Background
   - Study Area
   - Ongoing Studies
3. Case Study – Scenarios
   - Climate Scenario Selection
   - Statistical Downscaling
4. Case Study – Assessment
   - Surface Water (HSP-F) Model
   - Groundwater (MODFLOW) Model
5. Overall Summary of Results
6. Implications to Clean Water Act – Water Budgets
   - Tier Two Subwatershed Stress Assessment
   - Tier Three Water Budget and Local Area Risk Assessment



Ontario

2. Study Area and Background

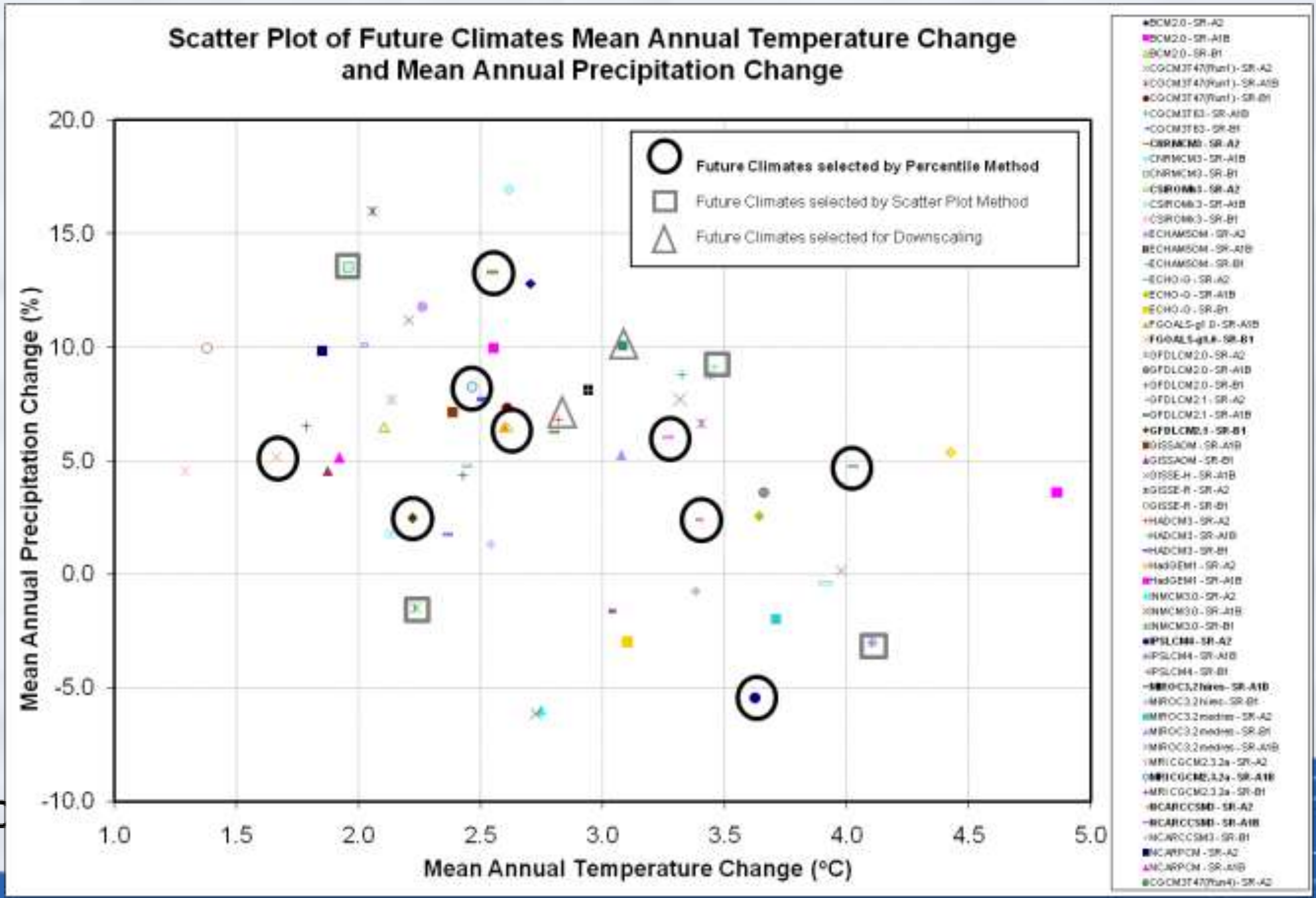
Subwatershed 19 – The Headwaters Subwatershed



Ontario

3. Case Study – Climate Scenarios

- Scenario Development
  - Selection of 9 GCMs using Percentile Method + Current
  - Statistical Downscaling of two GCM Scenarios (SDSM)
    - Canadian Global Climate Model 3T47 A1B and A2



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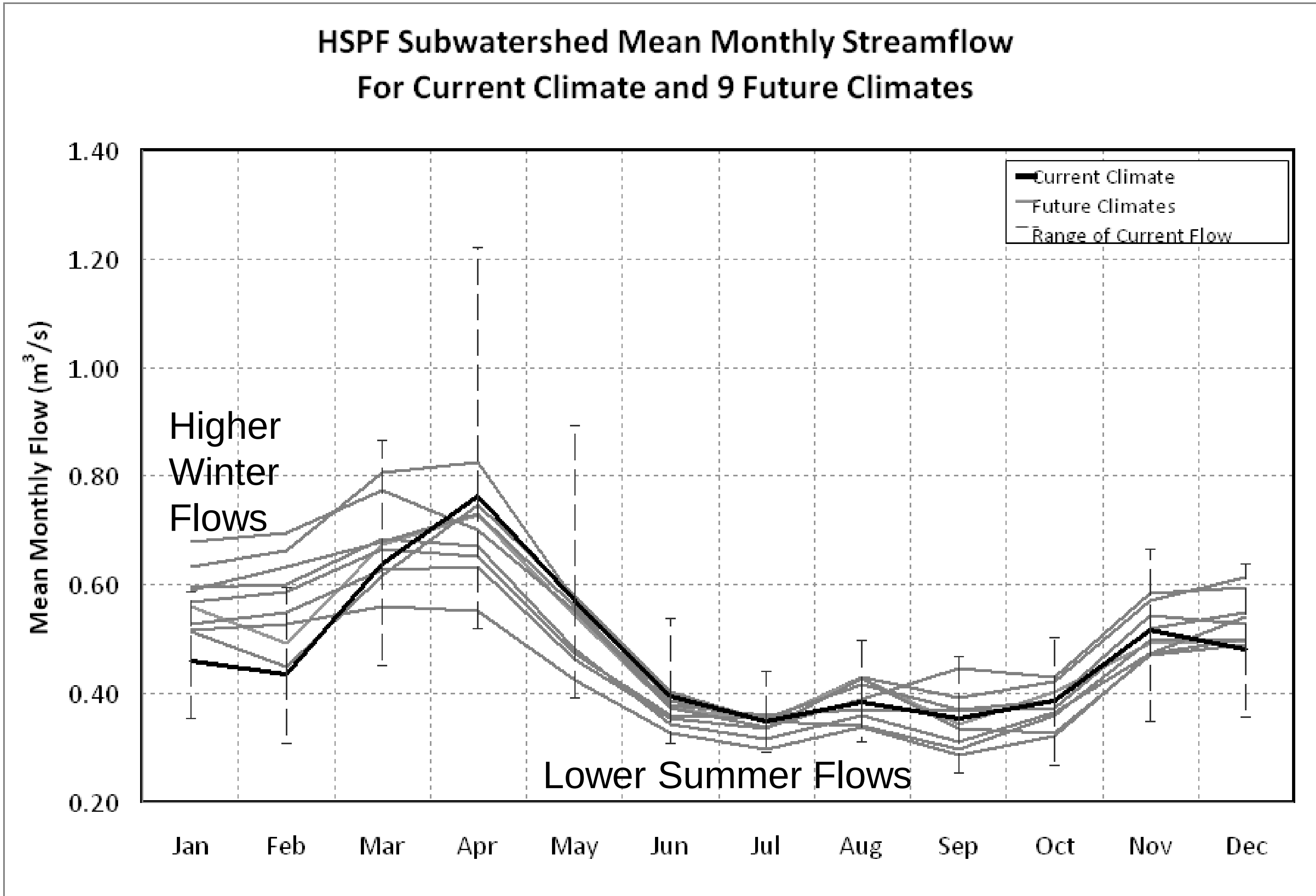
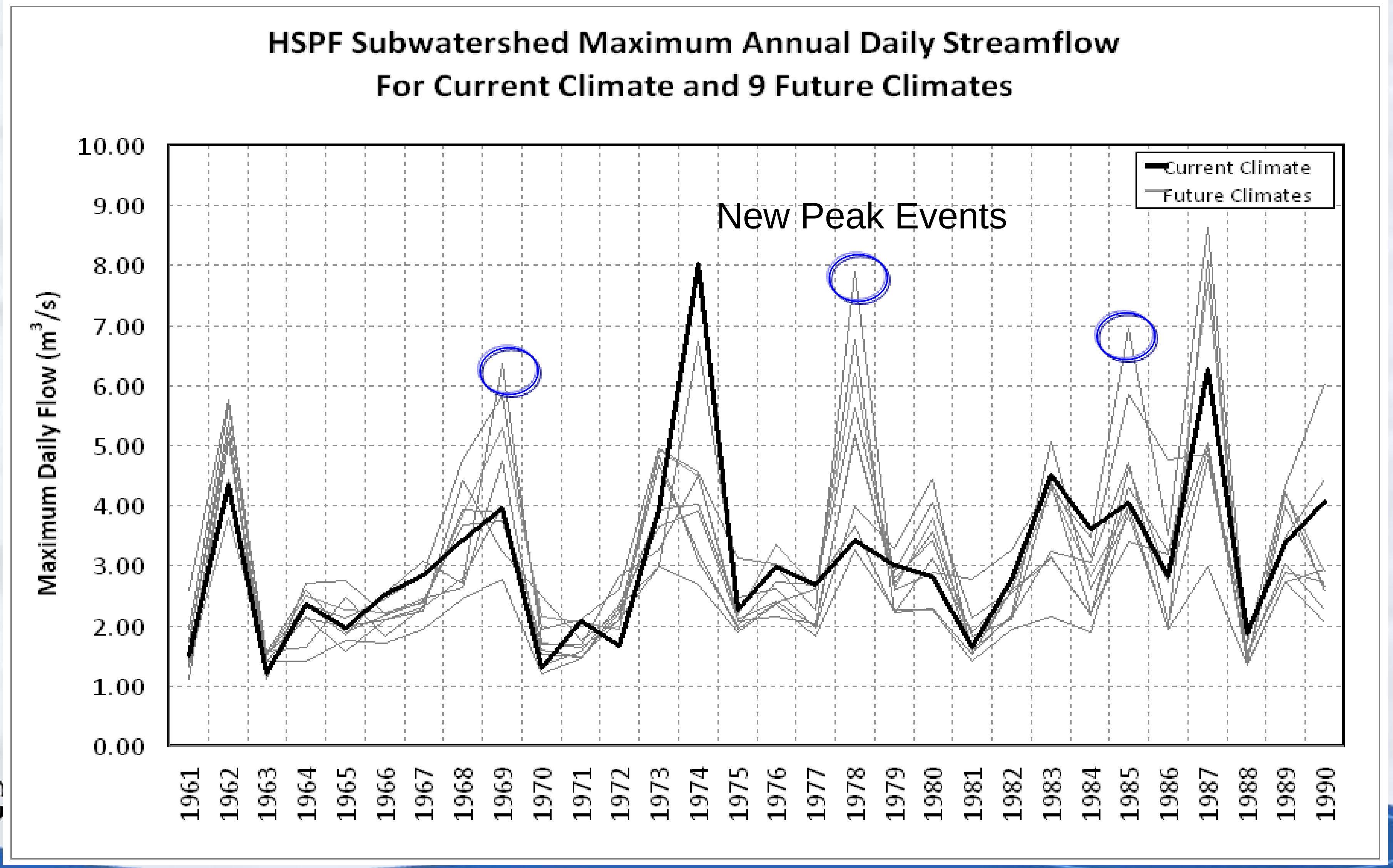
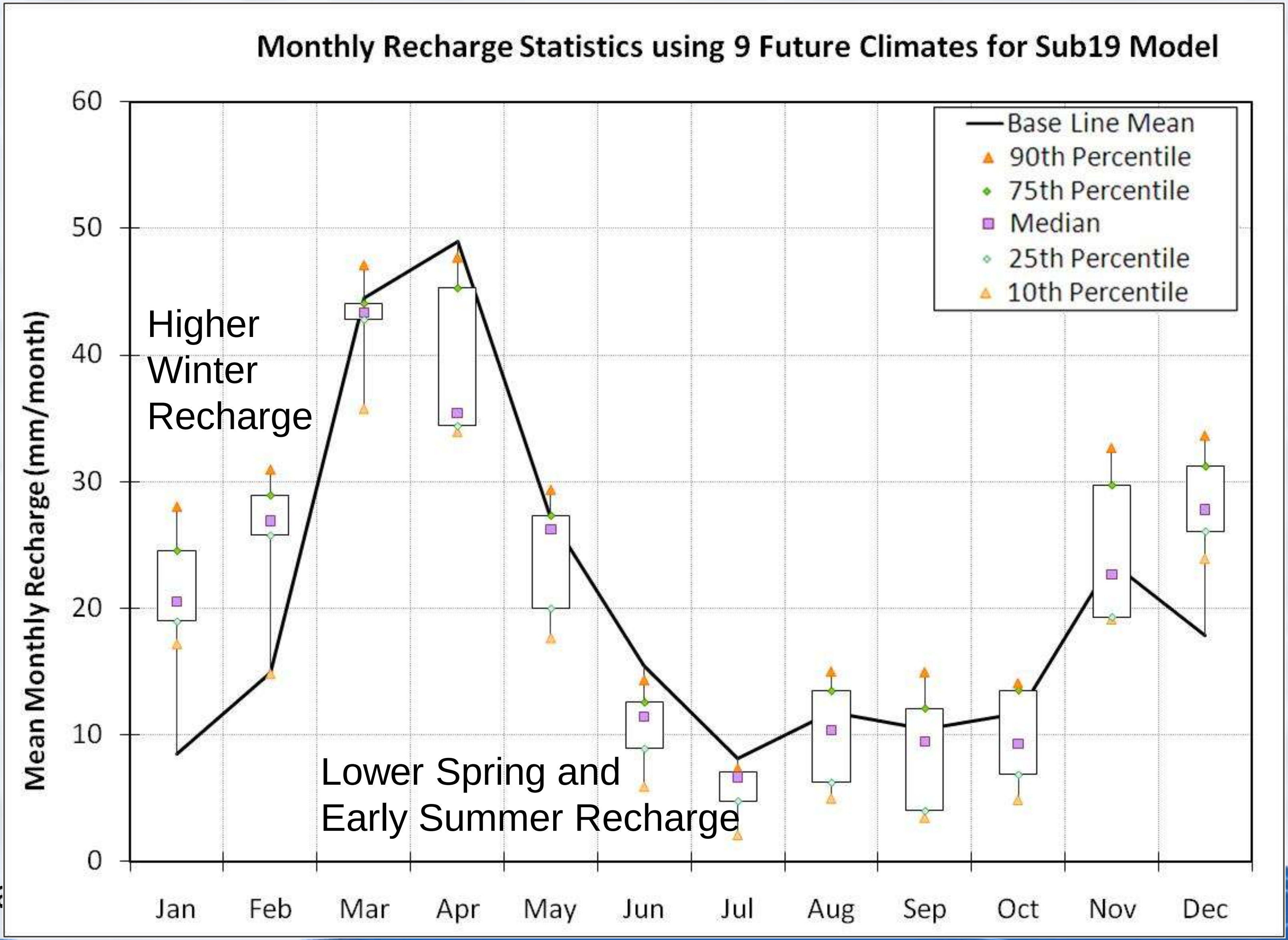
5. Overall Summary of Results
HSPF – Mean Monthly Streamflow



5. Overall Summary of Results
HSPF – Maximum Daily Flow



5. Overall Summary of Results
HSPF – Groundwater Recharge



5. Overall Summary of Results
General Observations from Case Study

- Streamflow
  - Seasonal shift – increased winter flows, lower spring flows due to change in snow accumulation and snowmelt
  - Increased incidences of extreme high flows
  - Impacts to low flows not definitive
- Groundwater
  - Seasonal distribution of groundwater recharge (higher winter recharge, lower summer recharge)
  - Projected changes to average annual recharge not definitive
  - Seasonal groundwater discharge trends do not change; however the magnitude increases or decreases depending on the scenario.
- SDSM Downscaling versus GCM's
  - SDSM projections fall within range of projections for GCM climate scenarios

Ontario





Expanding the Assessment of Vulnerability: A Case Study of the Forks of the Thames in London, Ontario

Linda Mortsch

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Research collaborators on CFCAS project: D.H. Burn, A. Emerson, A.J. Hebb, P. Kay, and K. Wey (U of Waterloo), G. McBean, P. Prodanovic, S.P. Simonovic - PI (UWO), M. Davidge, Rick Goldt, M. Helsten, T. Hollingsworth (UTRCA)

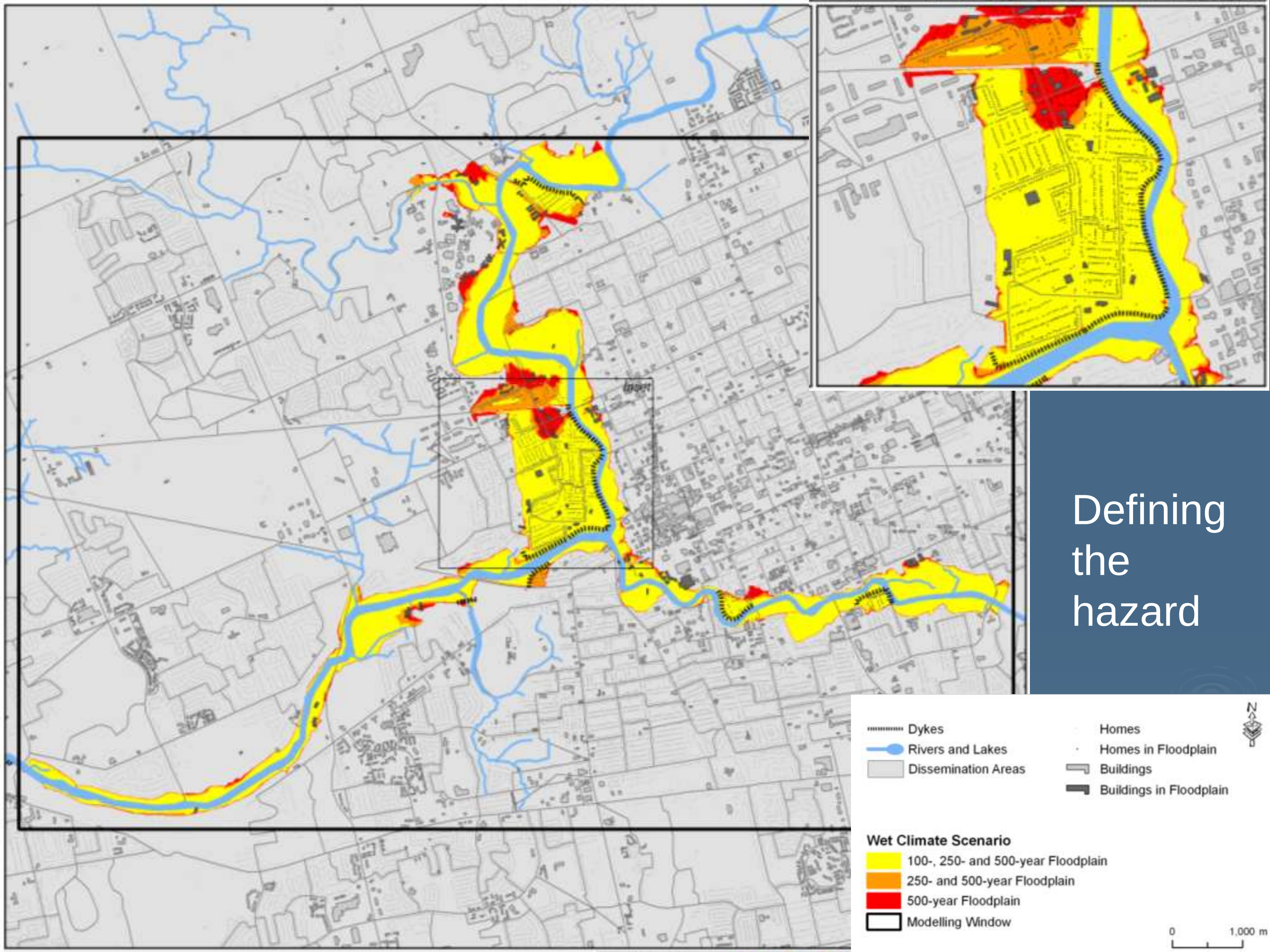
Scope of assessment

- Increase in intense rainfall events - more urban flooding
- Explore different perspectives of vulnerability
  - Hazard
  - Emergency preparedness
  - Adaptive capacity
- Adaptive capacity includes:
  - Proactive flood-proofing actions prior to an event
  - Responding during the flooding emergency
  - Recovering after a flooding event
- Identify high risk areas and vulnerable populations

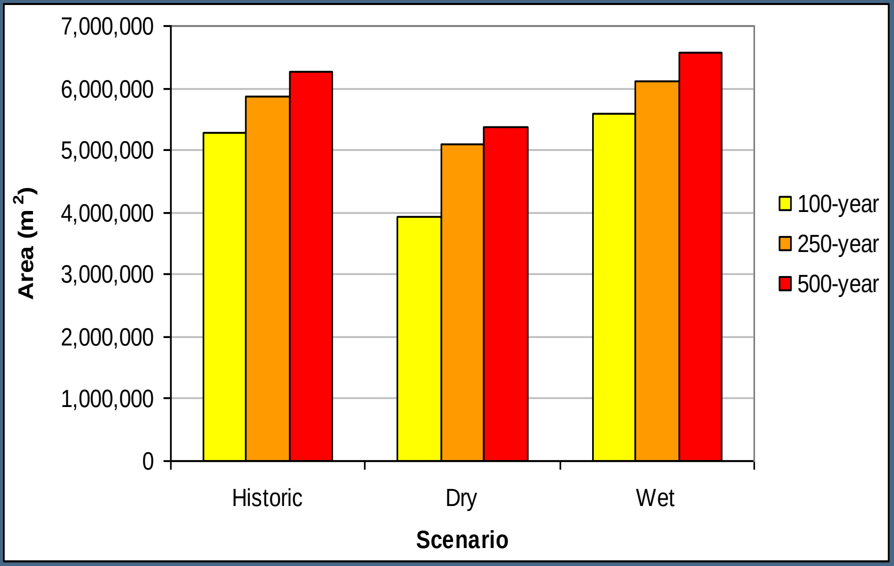
Hazard analysis

- Changes in the physical characteristics of the hazard
  - change in extent of 1 in 100-, 250- and 500-year flood (area in hectares and percent change from base case)
- Estimated/counted number of people and structures affected

Defining the hazard



Area, People and Structures Affected



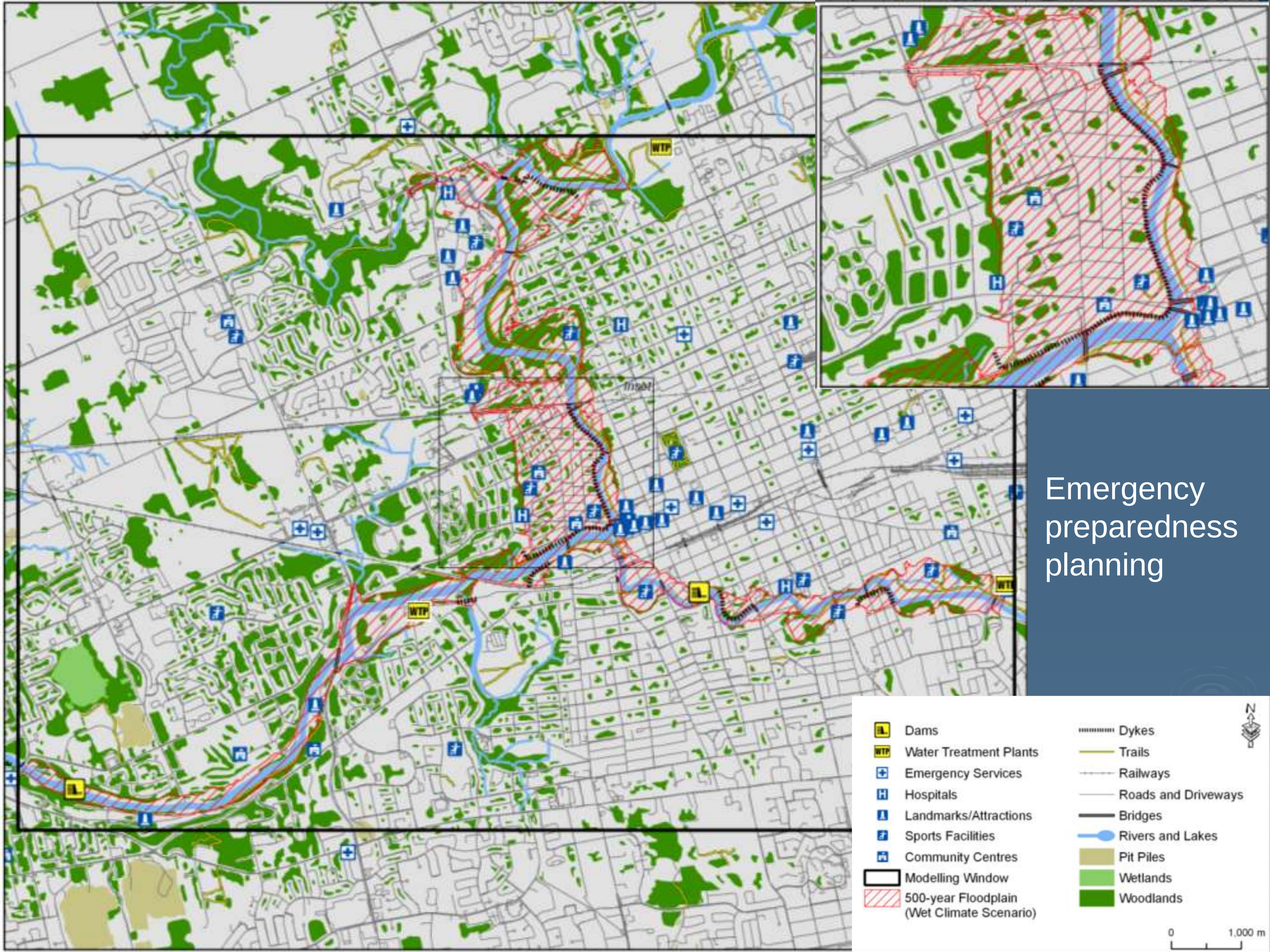
* Population and dwelling counts estimated based on the proportion of the Dissemination Area (DA) flooded

Flood line	Climate Scenario	Area (m²)	Change in		No. Homes Flooded	No. Buildings Flooded	Proportion Affected (Census Data)*	
			Area (m²)	%			Pop.	Dwellings
100-year	Historic	5,291,440			1,141	34	7,701	3,969
	Dry	3,930,436	-1,361,004	-25.7	68	18	4,881	2,521
	Wet	5,595,988	+304,548	+5.8	1,249	42	7,949	4,109
250-year	Historic	5,858,976			1,376	58	8,474	4,381
	Dry	5,101,848	-757,128	-12.9	1,059	33	7,351	3,802
	Wet	6,116,988	+258,012	+4.4	1,486	59	8,745	4,543
500-year	Historic	6,268,729			1,560	71	9,119	4,740
	Dry	5,362,852	-905,877	-14.5	1,155	36	7,717	3,988
	Wet	6,567,292	+298,563	+4.8	1,690	83	9,388	4,886

Emergency preparedness analysis

- What infrastructure is vulnerable/exposed to flooding?
  - Roads and bridges
  - Community centres, hospitals
  - Water treatment plants

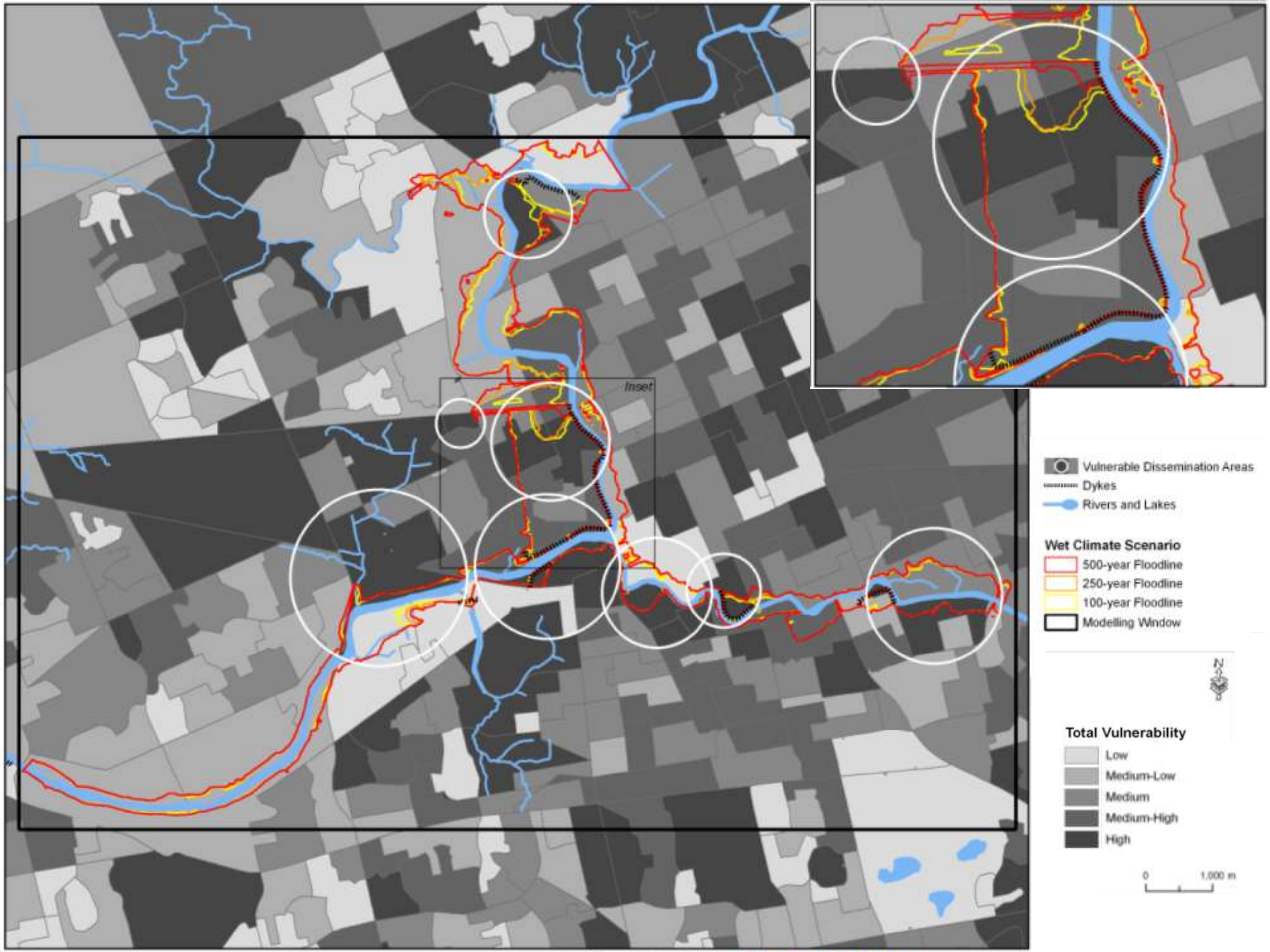
Emergency preparedness planning



Social vulnerability analysis

Indicators of Vulnerability:

- Theme 1 – Ability to Cope and Respond
  - Over 65 years of age
  - Under 19 years of age
  - No Knowledge of Official Languages
  - Female
- Theme 2 – Differential Access to Resources
  - Low Income Households
  - Single Parent Families
  - Rely on Public Transit
  - Renters
- Theme 3 – Level of Situational Exposure
  - Housing Type (single, semi-detached, mobile, apartment etc.)
  - Period of Construction (built before 1970)


Inset
Vulnerable Dissemination Areas
Dykes
Rivers and Lakes
Wet Climate Scenario
500-year Floodline
250-year Floodline
100-year Floodline
Modelling Window
N
Total Vulnerability
Low
Medium-Low
Medium
Medium-High
High
0
1,000 m

Adaptive Management

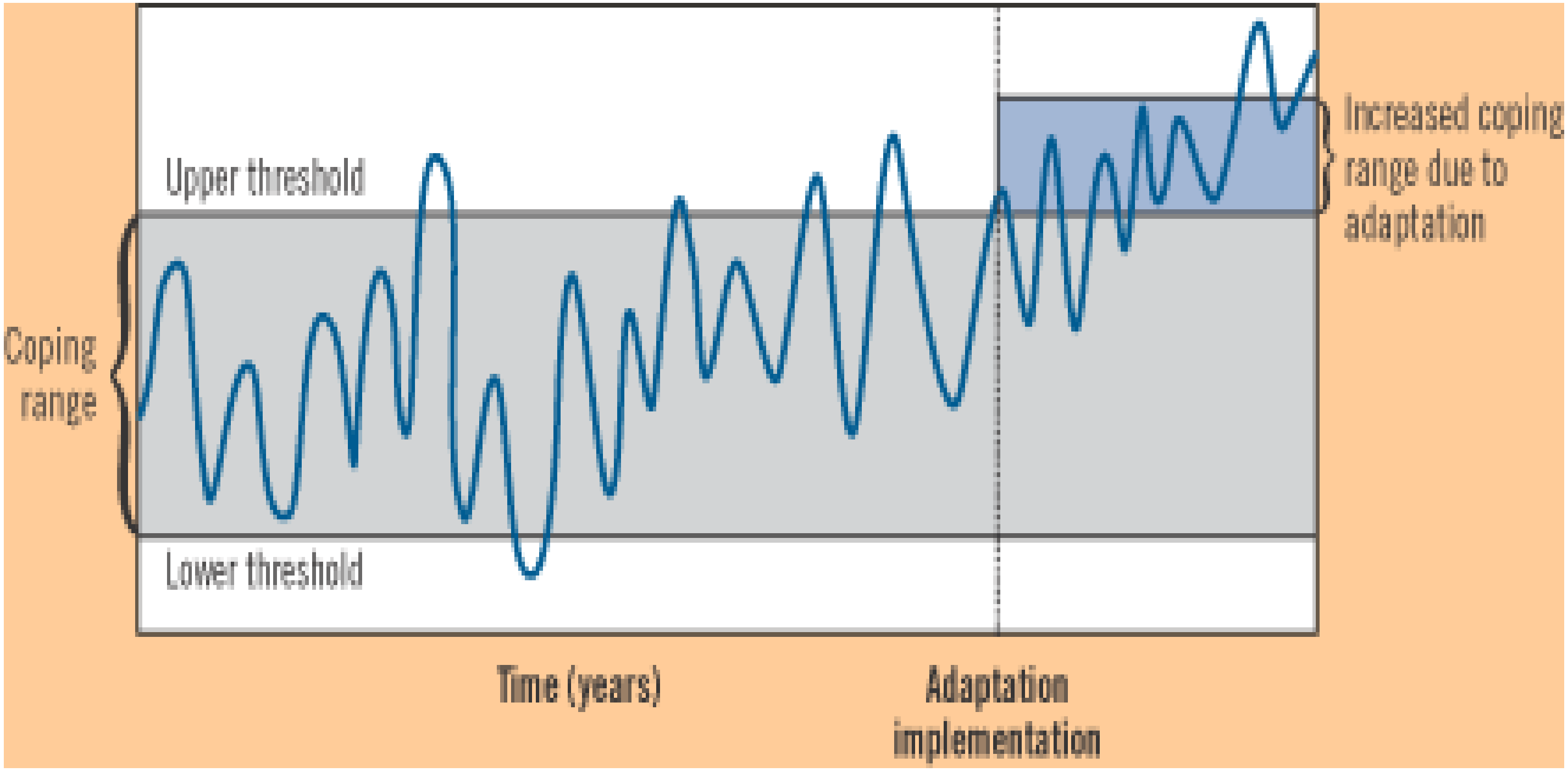
Co-chairs

Wendy Leger (EC) & Jen Read (GLOS)

International Upper GL Study

- A.M. for Lake Superior Regulation
- Coordinated, Bi-national Hydroclimate, Modelling and Forecasting Distribution

Coping zones key to assessing vulnerability and defining when and what type of action required…



Source: Lemmen and Warren, 2004

Task 1: Define System Vulnerabilities

- Stakeholders define critical thresholds and coping zones A, B, and C for their interest and by location.
  - "A" is the preferred or acceptable zone,
  - "B" the zone that is difficult but can be coped with under current management regimes, and
  - "C" the zone where management would have to be adapted to avoid serious negative consequences.
- Help determine when to alter water regulation rules
- Focus will be to identify/prioritize greatest vulnerabilities of interests and locations

Descriptive Framework of Biological Condition

Pristine

Zone A — Natural Variability

Zone B

Critical Threshold →

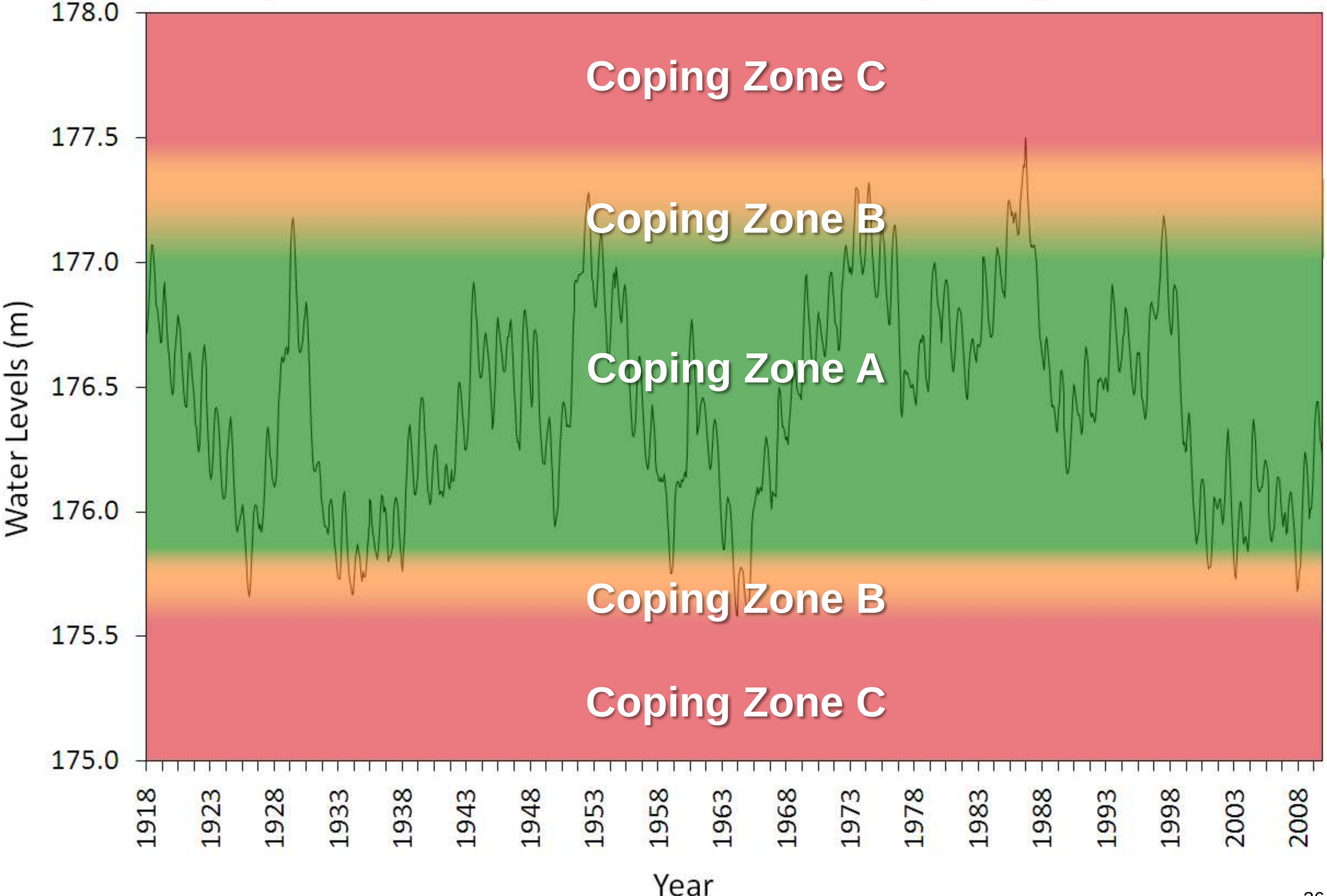
Zone C

Degraded

Impact Score	Biological Condition
1	**Natural or native condition** Native structural, functional, and taxonomic integrity is preserved; ecosystem function is preserved within range of natural variability
2	**Minimal changes in structure of biotic community; minimal changes in ecosystem function** Virtually all native taxa are maintained with some changes in biomass and/or abundance; ecosystem functions are fully maintained within range of natural variability
3	**Evident changes in structure of biotic community; minimal changes in ecosystem function** Some changes in structure due to loss of some rare native taxa; shifts in relative abundance of taxa but sensitive–ubiquitous taxa are common and abundant; ecosystem functions are fully maintained through redundant attributes of the system
4	**Moderate changes in structure of biotic community; minimal changes ecosystem function** Moderate changes in structure due to replacement of some sensitive–ubiquitous taxa by more tolerant taxa, but reproducing populations of some sensitive taxa are maintained; overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes
5	**Major changes in structure of biotic community; moderate changes in ecosystem function** Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity and redundancy; increased buildup or export of unused materials
6	**Severe changes in structure of biotic community; major loss of ecosystem function** Extreme changes in structure; wholesale changes in taxonomic composition; extreme alterations from normal densities and distributions; organism conditioning is often poor; ecosystem functions are severely altered

Jackson and Davies (2006), Bain (2007)

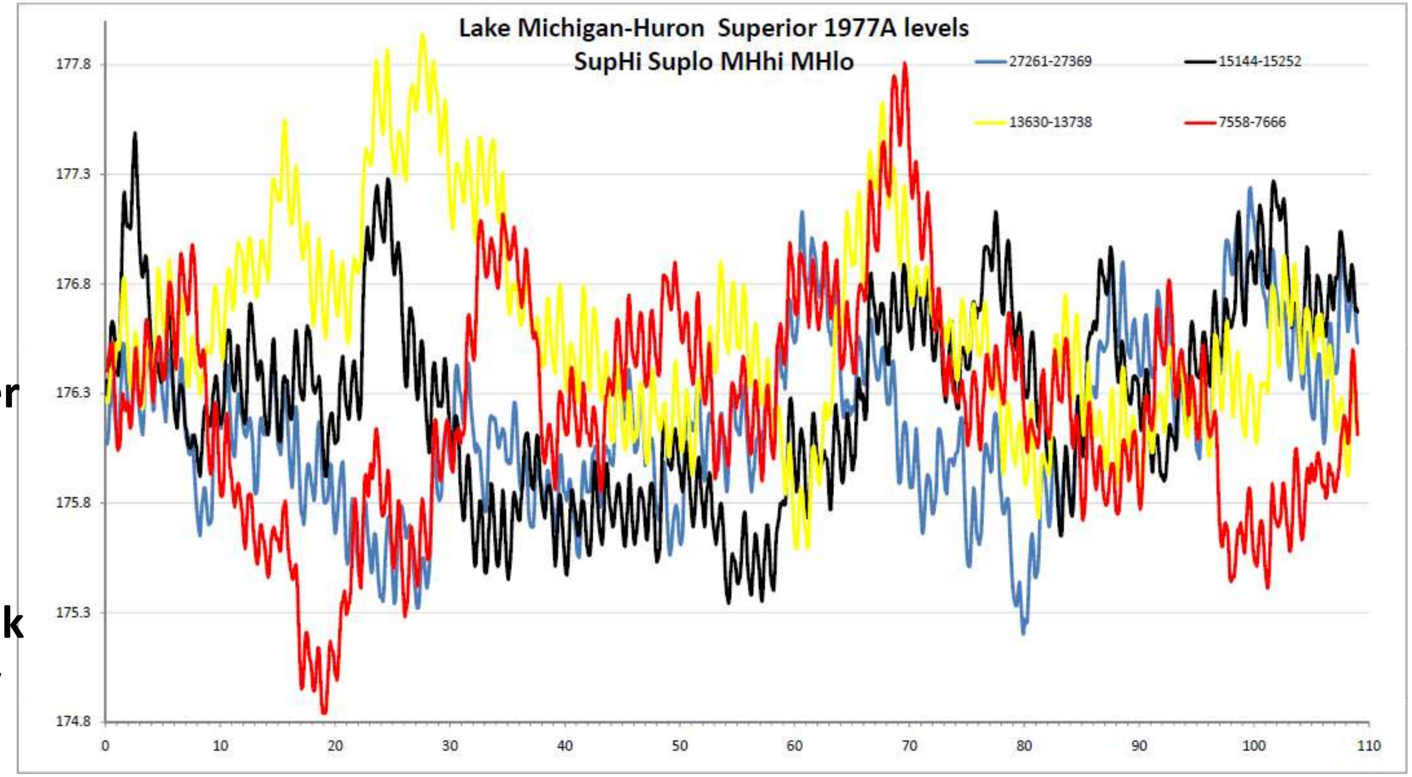
Example of MI-Huron Coping Zone



100s of Supply Sequences

- Historical (1900–2008)
- Stochastic
- GCMs
- RCMs
- Paleo

Characterize the water level coping zones in terms of magnitude, frequency, duration and variability and link these to water supply sequences



Task 3: Risk Evaluation

Define the frequency/plausibility of the risk

- Determine occurrence of thresholds or "A", "B", "C" zones in supply sequences
- Plausibility means that climatologists have evidence that these supplies could happen within the next 20 to 50 years.
  - supported quantitatively using existing, stochastic and climate change water supply sequences.

INTERNATIONAL Upper Great Lakes STUDY

Coping Zones / Plausibility

Focus of adaptive management will be on the things we are most concerned about and least prepared for.

Impacts					
Zone C ***Irreversible Damages***	**Low**	**Moderate**	**Moderate**	**High**	**Extreme**
Zone B *Seeing Significant Damages*	**Neg.**	**Moderate**	**Moderate**	**Moderate**	**High**
Zone A *Anticipated Costs*	**Neg.**	**Neg.**	**Slight**	**Slight**	**Slight**
	No indication scenario will occur	Unlikely but cannot be ruled out	Expected, but extreme or rare or distant	Unusual but expected	Common, imminent

Not very plausible → *Very plausible*

Plausibility

Final comments:

- Uncertainty not a reason for no action on climate change:
  - Detecting changes in climate – what is occurring in region?
  - Understand sensitivities to climate (coping zones, thresholds)
  - Use scenario-generating techniques to explore potential futures and assess robustness/resilience (where are the vulnerabilities?)
  - Encourage adaptation activities based on best available science, flexible design, larger margins of error
  - Monitoring of conditions and adaptive management