Toronto's Future Weather & Climate

Presentation to

Parks and Environment Committee

January 29, 2013

TORONTO Environment Office

Livegreen Toronto

Justification for … and Purpose of the Study

Christopher Ll. Morgan, PhD
Program Manager, TEO

Justification for the Study (i)

Questions & Issues

- **City Council Adopted Policy Direction**
  - **- Climate Change, Clean Air & Sustainable Energy Action Plan (2007)**
  - **- Ahead of the Storm (2008) rec. Analysis of Toronto's Changing Climate**

- **Major Questions and Issues**
  - **How HOT will it be?**
  - **How much RAIN & SNOW can we expect?**
  - **How much SMOG will occur?**
  - **How DRY will it be?**
  - **How WINDY will it be?**

Justification for the Study (ii)

Limitations of Global-Regional Climate Models

- **Depict Very Large Areas** - Weather & Climate of Toronto is the same as North Bay & Buffalo
- **Don't Include Local Effects** of Great Lakes, Niagara Escarpment, Oak Ridges Moraine, Tall Buildings etc
- Based on **30-year Weather "Normals"** (exclude more recent & rapid changes – i.e. the "hockey stick" data)
- Weather/Climate **Means Don't Address** the City's **Exposure to Costs of Extreme Events**

Justification for the Study (ii)

Toronto's Recent **Extreme Weather Records**

- **Warmest Summer** in 63 years (2002)
- **Warmest January** in 165 years (2005)
- Record one-day power demand of 27,005 MW due to summer heat (August 1st, 2006)
- **Earliest Heat Wave** (June 19-21, 2012)
- **Highest Summer Rainfall** Ever (2008)
- Three **1 in 100 year storms** in less than 12 years: (July 2000, August 2005, July 2012)

New & Innovative Local Model Approach

- Global Climate Models + Regional Climate Models + **Local Weather** Model (1km^2 Cells)
- **SENES Consultants** ran the computer models
- **ADVISORS & PEER REVIEW GROUP**
  - Environment Canada
  - Ontario Ministry of the Environment
  - Toronto Regional Conservation Authority
- Approach adopted by US National Centre for Atmospheric Research + MOE + UofT (W.R.Pelltier)

New Elements

…. To Include: New Influences

- Included Influence of the **Great Lakes, Niagara Escarpment** and the **Oak Ridges Moraine**.

…. To Model : Two 10 Year Periods

- The "Present" 10 Year Base Period **2000-2009**
- A "Future" 10 Year Period **2040-2049**

…. To Examine: Toronto within the GTA

New Questions

…. To Answer: New Questions

- Focused on obtaining data concerning:

  Future Extremes-of-Weather

  (e.g., Heat Waves & Torrential Storms)

rather than …

Future Averages-of-Climate

(e.g., Average Temperature & Average Rainfall)

But examined such “Averages” to check model validity!

Results of the Study

James Young PhD, PEng, PMet.,
SENES Consultants

What We Did

- Obtained data output relevant to Ontario from combined **Global Climate Models** (Coarse km Resolution) and **Regional Climate Models** (Medium km Resolution) from the Hadley Meteorological Centre UK

- Used that data as the starting point to run **Toronto's Local Weather Model** (Fine km Resolution) regarding 2000-2009 (the "Present") and regarding 2040-2049 (the "Future")

- **Analyzed the Data Created and Analyzed the Results** against rational Meteorological Science and Local Influences (the "Climate Drivers")

Results: Warmer Temperatures (2040's)

- ***Average annual temperatures increase by 4.4°C***

- Projected **average winter** temp. increases by **5.7°C**.
- Projected **average summer** temp. increases by **3.8°C**.

- The **extreme daily minimum** temperature
  - "becomes less cold" by **13°C**.
- The **extreme daily maximum** temperature
  - "becomes warmer" by **7.6°C**.

Confidence in Results: Temperature

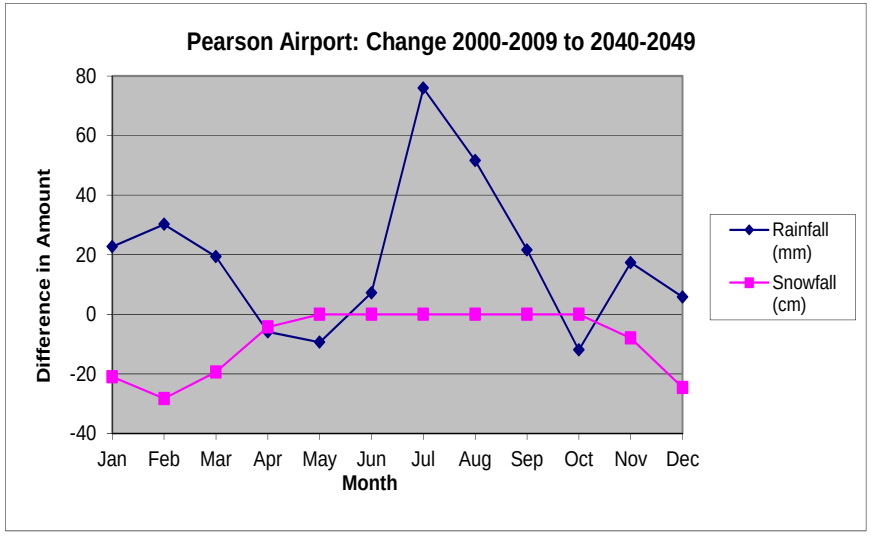
- **Compared with Monitored Means** (2000-2009)
  - Monitored Data from Lester Pearson Airport = ***8.7°C***
  - Toronto's Climate-Weather Model = ***8.7°C***
  - Environment Canada's Model = ***6.7°C***
  - *Our model approach is closer!*

- **Compared with Other Models** (2040-2049) for GTA
  - *Comparing High Resolution (Toronto) versus Low Resolution Models' re: Delta Temperature Values*
  - Our ***4.4°C*** compares favourably with Low Resolution Models showing changes from **-2.7°C** to **6.3°C**

Results: Changes in Precipitation

Snowfall & Rainfall

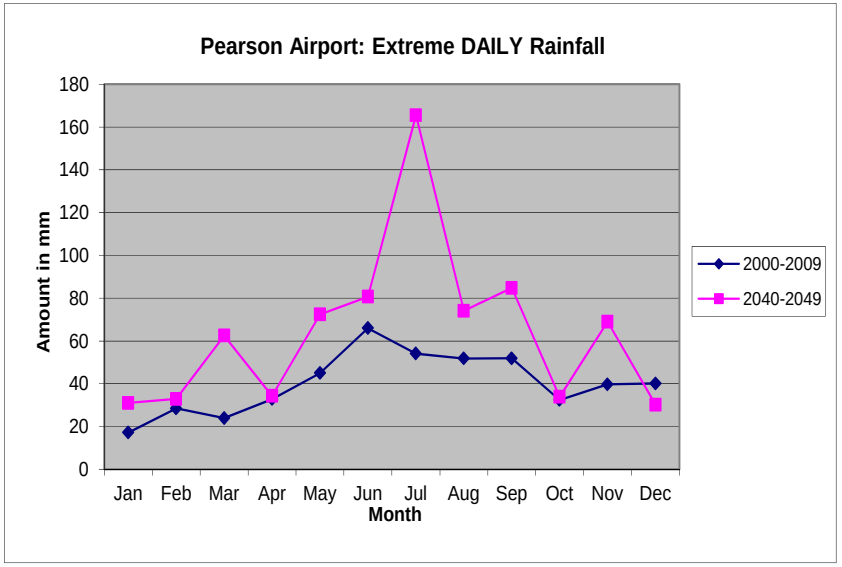
- Less Snow & More Rain -- in Winter
- More Rain in July (80%) & August (50%)



Extreme DAILY Rainfall (>25mm/day)

- Fewer Rain Storms >25 mm in Winter
- Same Number of Storms in Summer

BUT these = Much More Intense Storms !!

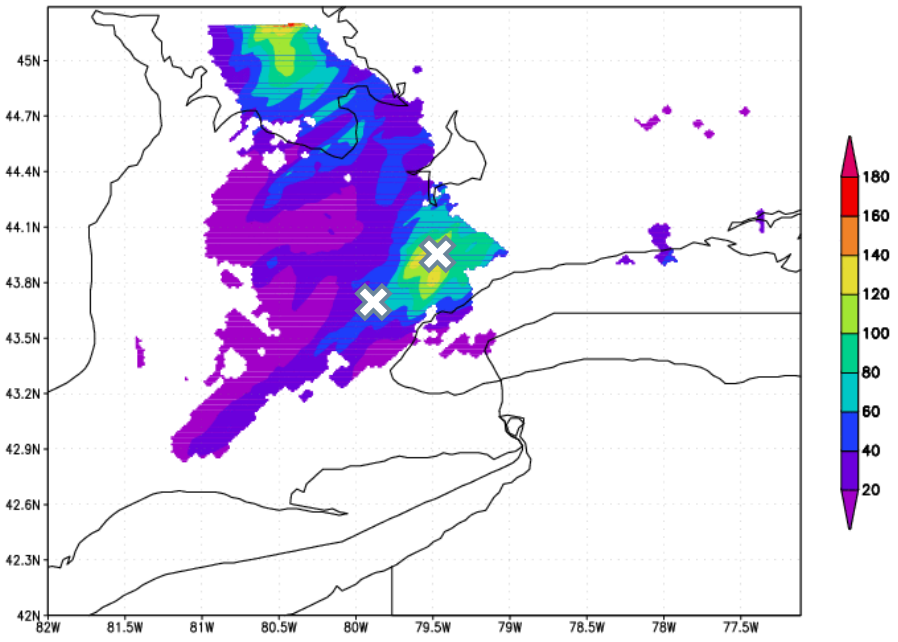


Modelled Daily Extreme Rainfall

Highest Rainfall is shown over Finch Avenue.

- Captured by Modelling, but NOT by Standard Environment Canada Monitoring at Pearson International Airport because the centre of the storm was distant from the airport monitoring station.
- Monitoring stations can only identify what happens at a particular station.
- Modelling this at RCM Scale put it well into New York State with less intensity

Finch Avenue "Washout" 19 August 2005



Expected Changes .... Some Examples

WEATHER EXTREMES	PARAMETER	UNITS	2000-2009	2040-2049
Extreme Rainfall	Maximum Amount in One Day	mm	66	166
	Number of Days with More Than 25mm	days	19	9
	Mean Annual Daily Maximum	mm	48	86
Extreme Heat	Maximum Daily (in °C)	°C	33	44
	Number of Days with Temperature greater than 30 °C	days	20	66
	Number of Heat Waves (3 or more Consecutive Days with Temperatures greater than 32°C)	3-day events	0.57	2.53

Potential Implications of Study Projections … and Next Steps

Lawson J. Oates, MES

Director , Toronto Environment Office

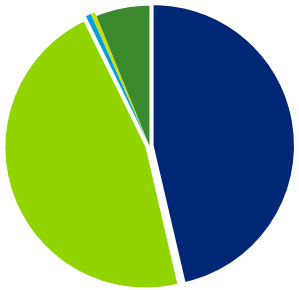
Climate Adaptation & Infrastructure Management Approaches

Objectives

1. **Cost effective pre-emptive adaptation measures**
2. **Minimize cost through adaptive design and construction**
3. **Build resilience and restoration capability into public infrastructure and services**
4. **Risk management analysis**

Avoiding Future Climate Costs

- **August 19, 2005 Storm** impacted Finch Avenue
- at a Cost of **$47 million** to the City
- plus **$600 million** in Private Costs



City's Adaptation Responsibilities

- Air Conditioning Peaks & Blackouts **Toronto Hydro**
- Storms & Urban Flooding **Toronto Water**
- Culverts & City Roads **Toronto Transportation**

- Gardens & Trees **Toronto Parks & Recreation**
- Storms **Toronto Region Conservation Authority**
- People in Need **Shelter, Support & Housing**
- Street Ventilation (re Smog etc) **City Planning**

WeatherWise Partnership Participants

ISSUE: Increased Summer Temperatures - A/C, Electricity Demand, Heat Vulnerability

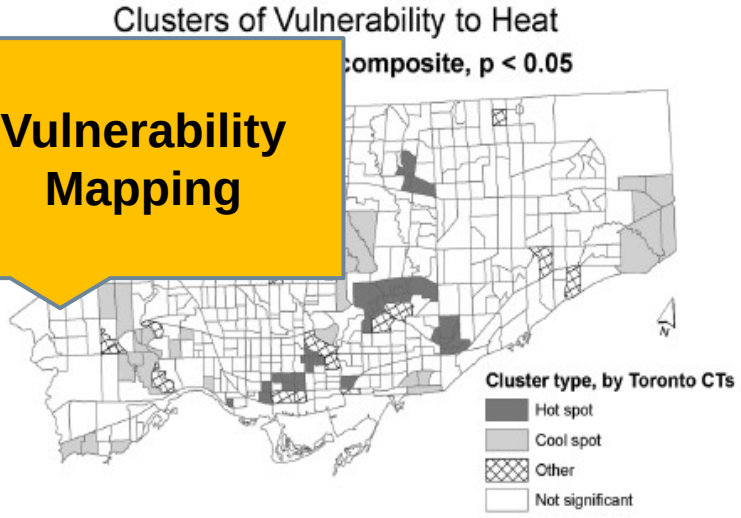
Expected in **2040-2049:** Almost "**6 times**" **increase in A/C use** during days with greater than 24**° C**

ADAPTATION: Options & Actions

Cooling Centres, Shade

Green Roofs

Vulnerability Mapping



Cool Roofs

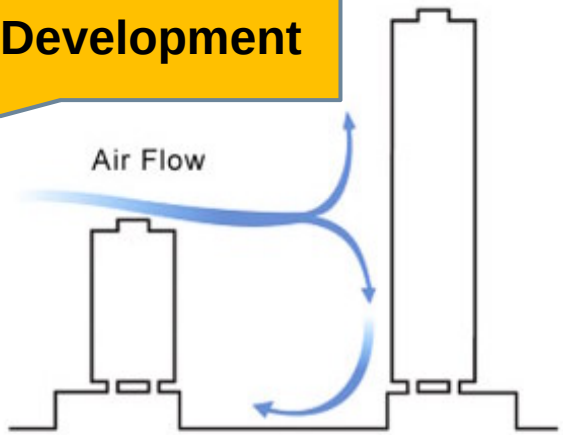
ISSUE: Increased Summer Temperatures – Impact Air Quality (SMOG)

Heat waves & smog events go hand in hand

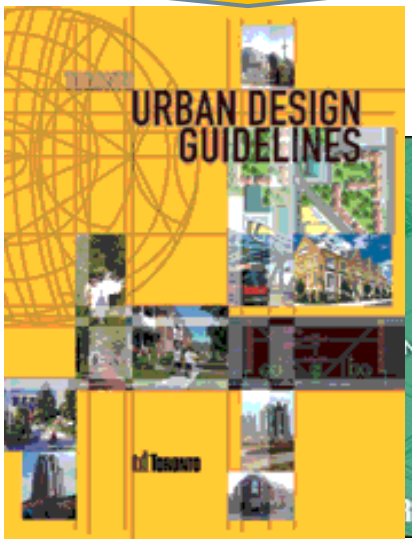
More Heat means More Smog

ADAPTATION: Options & Actions

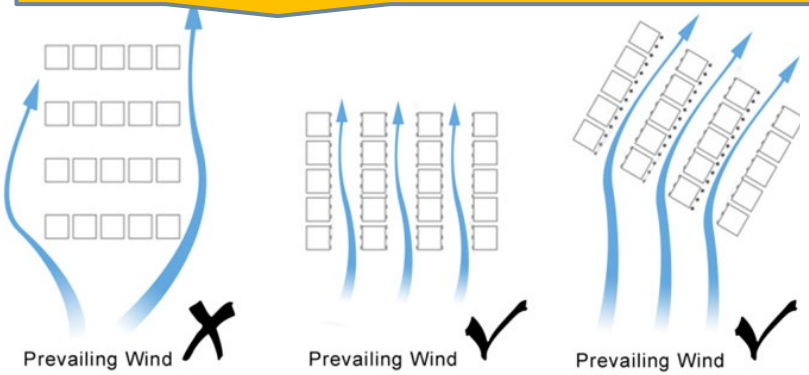
Site Development

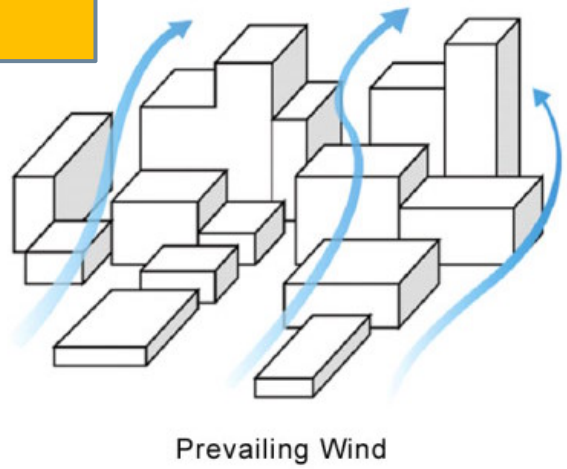


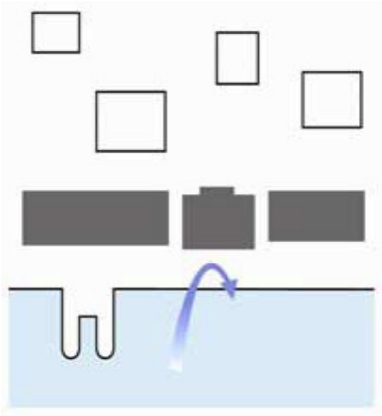
Encourage Air Ventilation in Streets



Neighbourhood Development







Mainstreaming of Adaptation

Toronto to host Chief Planners Roundtable on Resilient Cities

Toronto's Chief Planner told the Toronto Board of Trade:

- ***"Climate change could have significant planning implications in the years ahead"***
- ***"Thinking about resiliency and how we're going to adapt to changing weather patterns… needs to be injected into our conversation of city building"***

http://news.nationalpost.com/2013/01/14/from-a-growth-to-climate-change-five-highlights-of-the-toronto-chief-planners-speech-to-the-board-of-trade/

LIVABLE CITIES FORUM 2012
Creating Adaptive and Resilient Communities | Hamilton

ICLEI Local Governments for Sustainability

ISSUE: Increased Summer Temperatures – Transportation Systems

ADAPTATION: Options & Actions – Low Tech Response

Learning from Others – Portland, Oregon

ADAPTATION: Options & Actions

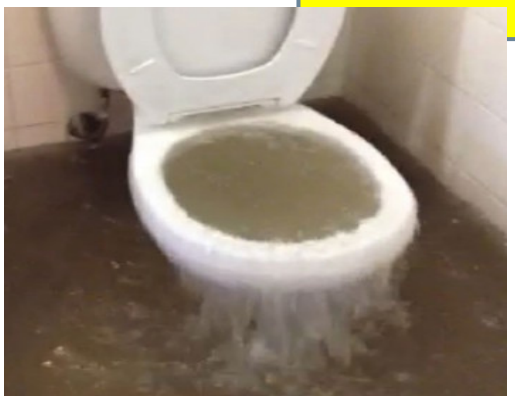
Mechanical components in traffic control systems have temperature thresholds

Simple adaptation option, install fans to ensure continued operation

ISSUE: Increased Rainfall – Culverts, Roads and Drainage

Increase in Rainfall Intensity and Magnitude

Basement Flooding



Road Washouts

Urban Flooding

Increased pressure on storm water systems & water treatment

Property Damage, Housing Habitability

ADAPTATION: Options & Actions

Downspout Disconnection

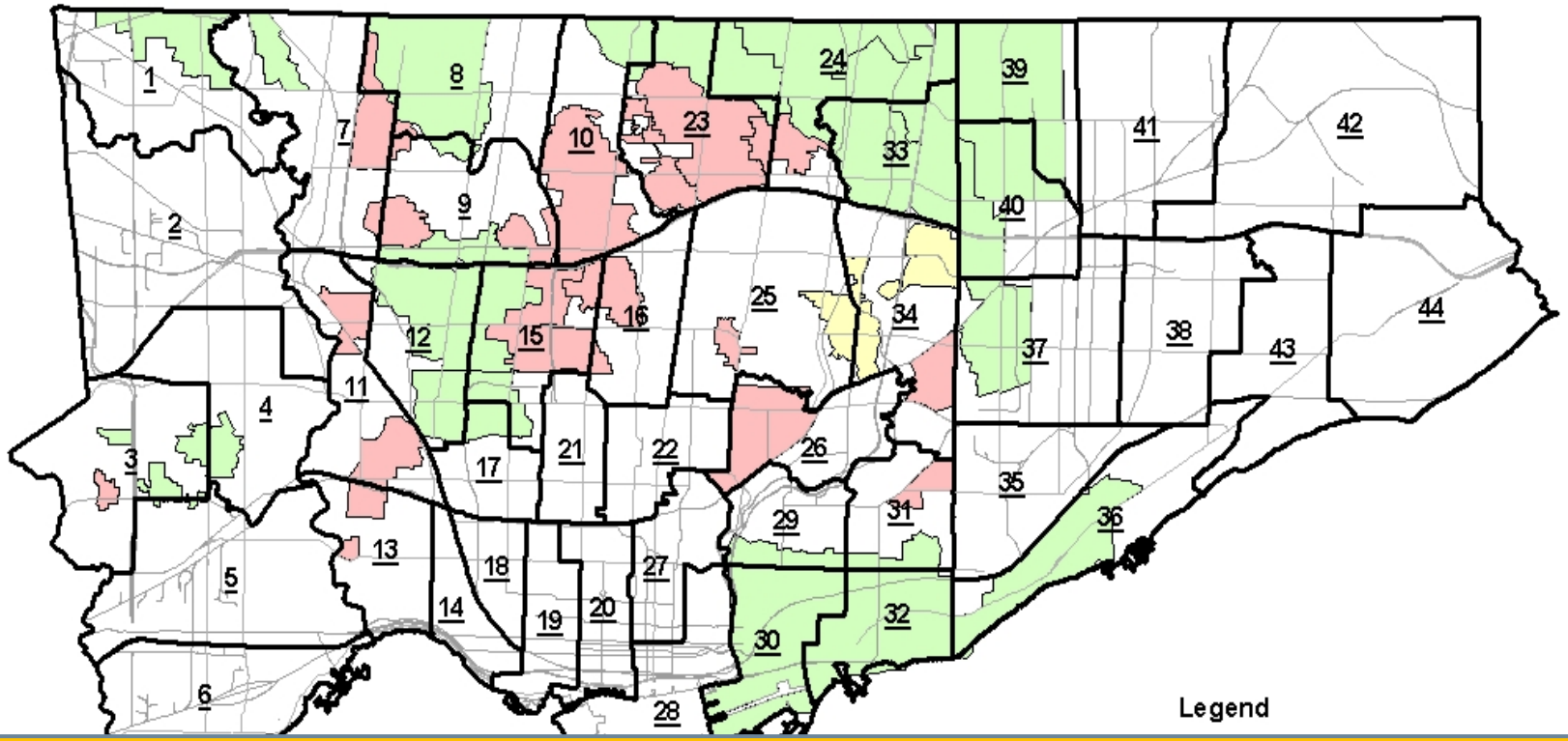
Underground Stormwater Storage Tank

Finch Ave

Stream and aquatic habitat restoration

End of Pipe Facilities

Basement Flooding Protection Program - 34 Priority Study Areas



Enhanced Design Standards:

- May 2000 storm event for Sanitary Sewers.
- 100 Year design storm event for Storm Drainage systems.

Only a few cities undertake a similar risk assessment and mitigation approach.

Conclusions

- Toronto's Future Weather Will Be Different with an increase in extreme weather events

- We Must Continue to Adapt to the Changes
  - City Divisions can now undertake individual Climate Change Risk Assessments (using City Risk Tool)

- Monitor Situation & Update Study as Required

Thank You

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