# City of London
# Climate Change Adaptation Strategy
# Dealing with Extreme Rainfall Events

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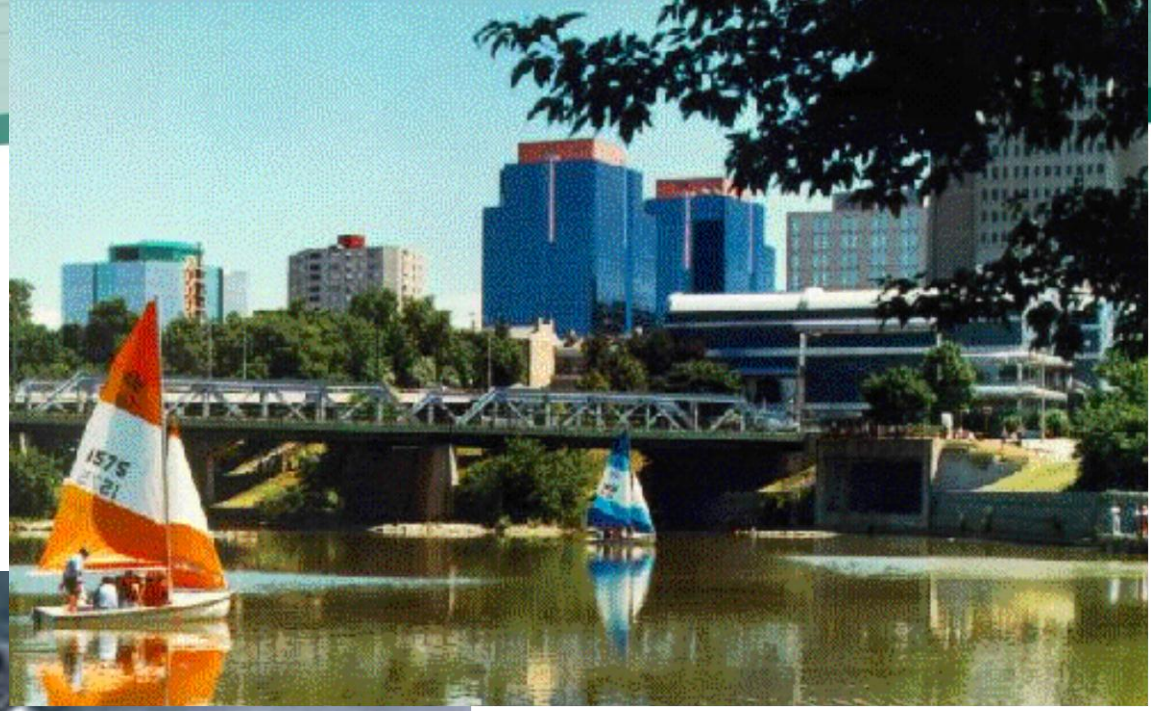
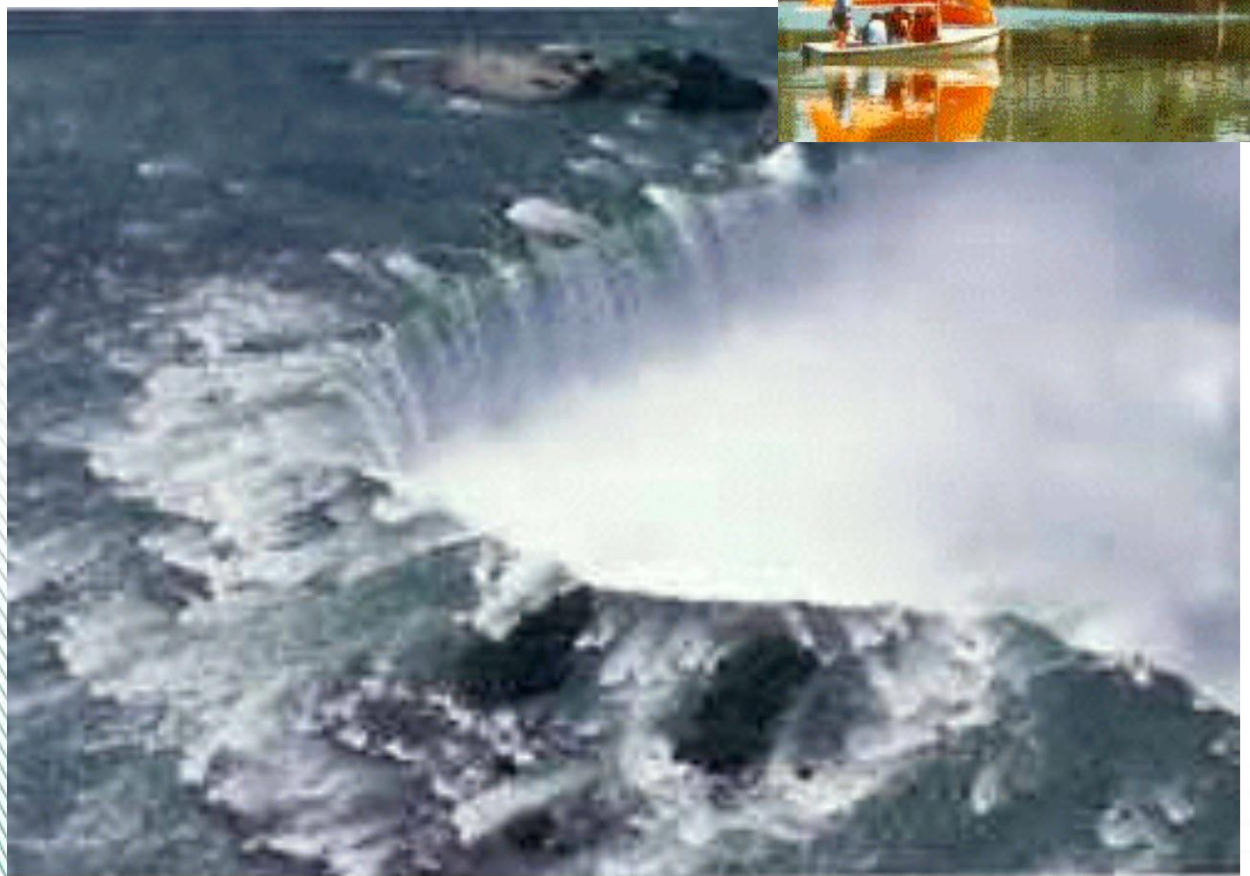
# Climate Change Adaptation Strategy Dealing with Extreme Rainfall Events

- London's Two-Phased Climate Change Adaptation Strategy
- Updated Rainfall IDF Curves under Changing Climate
- The City of London: Vulnerability of Infrastructure to Climate Change
- Phase 1- Completion and Phase 2 Update
- Next Steps

London
CANADA

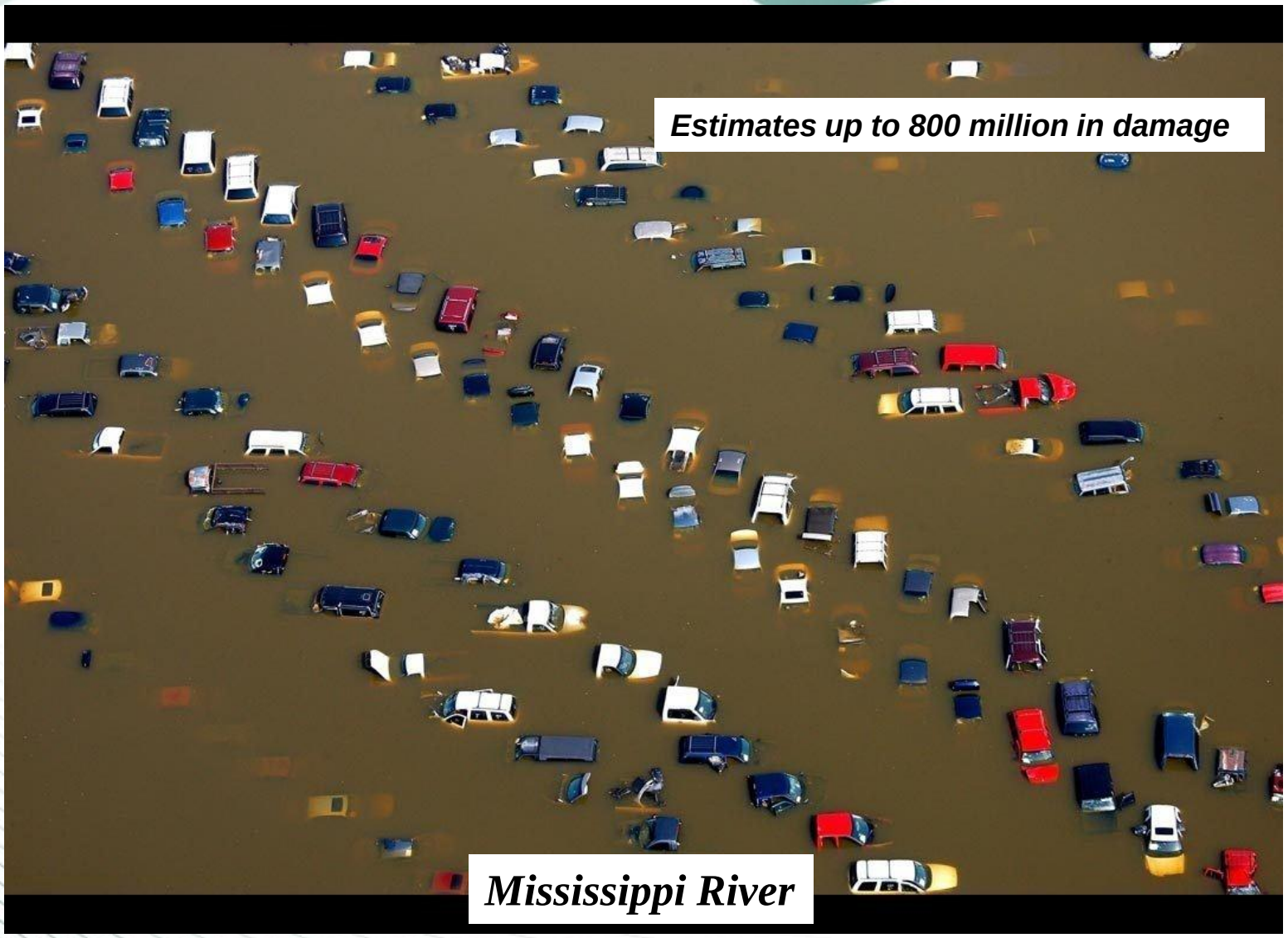
# Our water resources are Canada's most important treasures.






To protect your rivers,
Protect your mountains
Emperor yu of china, 1600 B.C.

# 2011 Flooding



# 2011 Flooding

# Ontario's Vulnerability to Extreme Rainfall/Flooding

*London 2000*

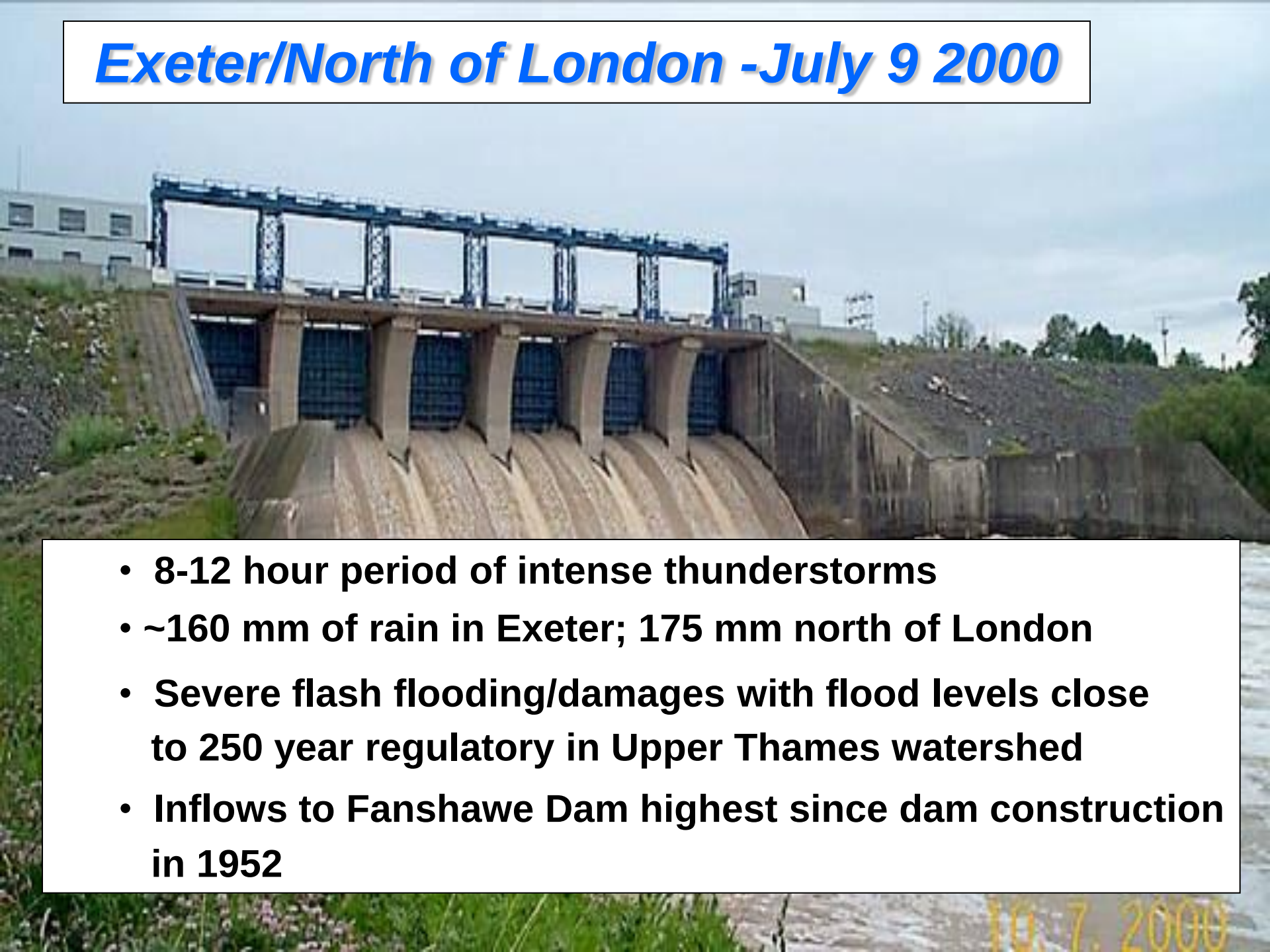
*2002 NW Ontario*

*Peterborough 2004*

*Toronto 2005*

Source: Environment Canada. Eastern Ontario Flood Forecasting and Warning Group Meeting, 2007.

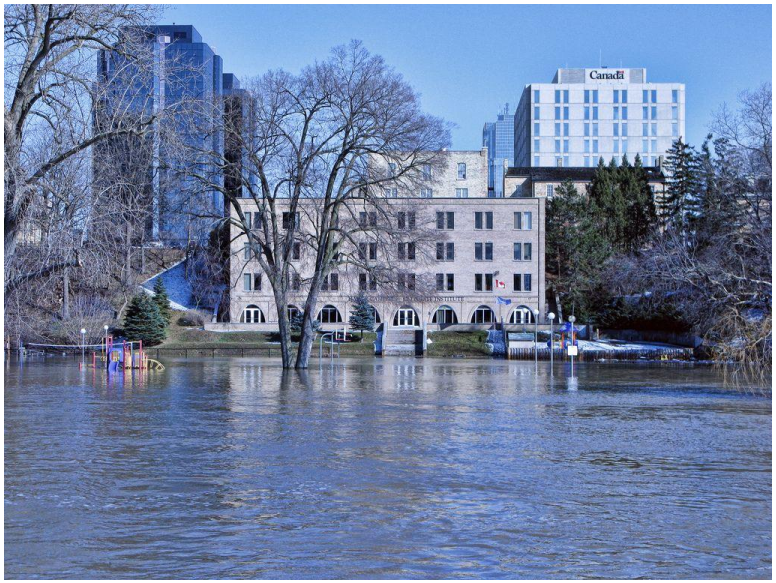
# Exeter/North of London -July 9 2000



- 8-12 hour period of intense thunderstorms
- ~160 mm of rain in Exeter; 175 mm north of London
- Severe flash flooding/damages with flood levels close to 250 year regulatory in Upper Thames watershed
- Inflows to Fanshawe Dam highest since dam construction in 1952

# Severe Flooding on the Thames is nothing new

- In the last 30 years:
  - March 1977;
  - September 1986
  - July 2000
  - April 2008
  - December 2008



in 2000

# Extreme Events -Climate Change

The Environment Canada Study "*Climate Change and Extreme Rainfall-related Flooding Risk in Ontario*" states:

*"The implementation of the [climate] change should be taken in consideration in adjusting engineering infrastructures design standards and developing adaptation strategies and policies."*

## 2007Council's Approved *Two-phase Climate Change Adaptation Strategy*

## *Phase 1 - Short-term Strategy:*

- Conduct general risk and consequence analyses to determine level of service of 'the City of London: Vulnerability of Infrastructure to Climate Change
- Review Ontario municipalities practices and standards
- Update the City's current IDF curves, using data from London Airport (1965-2003) Updated Rainfall IDF Curves under Changing Climate

## *Climate Change studies funding was approved $1.3M*

# 2007Council's Approved *Two-phase Climate Change Adaptation Strategy*

## *Phase 2 – Long-term Strategy:*

- Update London's Subwatershed studies (water resources components functions and features and slope stability)
- Develop Green Infrastructure Plan for water resources/SWM system including environmental/ ecological approach
- Finalize a Climate Change Long Term Adaptation Strategy

## 2007Council's Approved
## *Two-phase Climate Change Adaptation Strategy*

In the end of 2008 the City commissioned two studies:

- Rainfall Intensity Duration Frequency (IDF) Curve for the City of London under the Changing Climate

- Vulnerability of Infrastructure to Climate Change

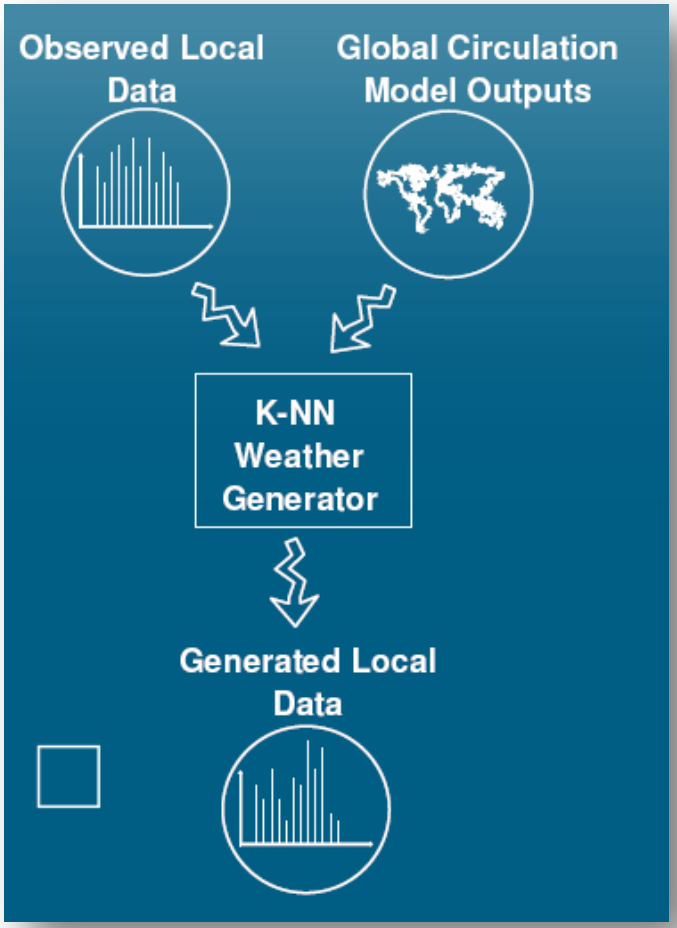
# 2007Council's Approved *Two-phase Climate Change Adaptation Strategy*

**The Studies Team for these studies was assembled and incorporated:**

- UWO Research Team that provides scientific evaluations lead by Professor S. Simonovic
- Engineering Consulting Team – Delcan lead by L. Alperin to oversee consistency and the implementation of engineering practices and standards
- SWM Unit to mange these studies and coordinate the input from various City's division and departments on the critical infrastructures

# Rainfall IDF Curve for the City of London under the Changing Climate - IDF Update

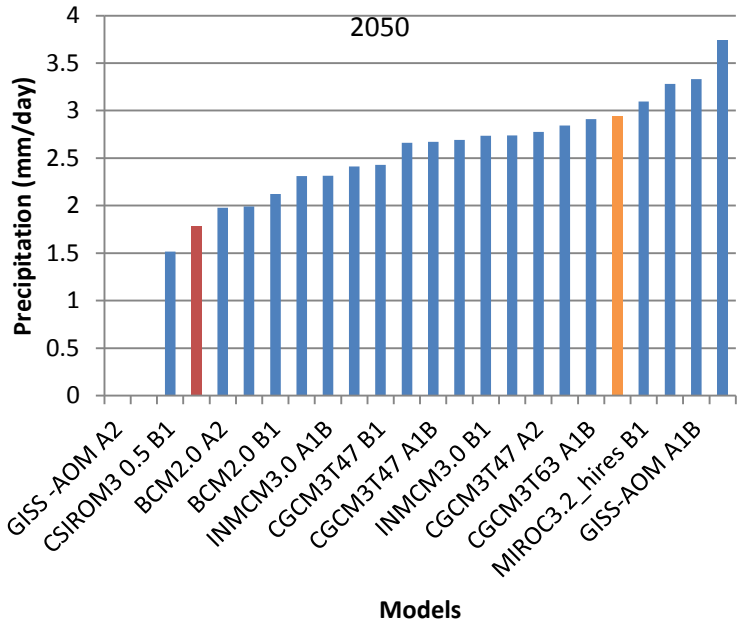
- Methodology
  - Two climate scenarios
  - Input
    - Global Circulation Models outputs
    - London Airport data 1961-2003
  - K-Nearest Neighbour (K-NN) weather generator
  - Synthetic series of rainfall data for each scenario
  - Development of IDF Curves



# IDF Update - Scenarios

Global Circulation Model (GCM) simulations simply offer possibilities of what might happen if the future development follows a certain course of action (i.e. continual growth of population, increased carbon dioxide emissions, increased urbanization, etc.).

- Climate Change Lower Bound Scenario (CC_LB)
  - The lowest extent of change
- Climate Change Upper Bound Scenario (CC_UB)
  - The highest extent of change
- Any scenario between these two is equally likely and there is no scientific criteria that can help in isolating a particular scenario



# IDF Update - Input

- Global Circulation Models outputs
  - climate change scenario data was obtained from the Canadian Climate Impacts Scenarios group at the University of Victoria, Canada (http://www.cics.uvic.ca).
  - Time series data was obtained for the grid point containing the City of London for the time slice of 2040-2069, representing average climatic conditions for the year 2050.
  - Historic global circulation data, also obtained from the University of Victoria, consists of data for period 1961-1990 and represents the baseline global data
- London Airport data 1961-2003
  - For-the-day-maximum rainfall time series for 5, 10, 15, 30 minutes, and 1, 2, 6, 12 and 24 hour intervals.

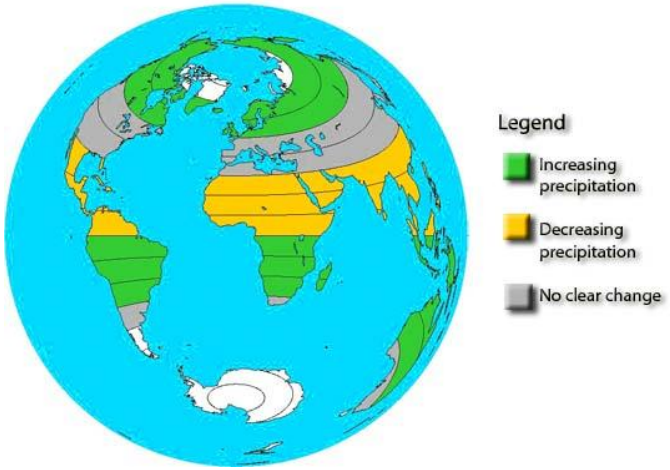
# IDF Update - K-NN weather generator

- Stochastic simulation tool able to produce large sequences of weather data.
- Algorithm has a perturbation mechanism that allows newly generated values to be outside of the observed range

# IDF Update - Results

The study recommend that:

- Difference between climate change and Environment Canada IDF curves11% – 35%
- the City of London proceeded with a change upwards of the current IDF curves by 21% upon completing the Subwatershed Studies updates
- an economic analysis be performed to make certain that this revised standard is justified economically based on the overall best benefit to the City and all who are impacted.



# Our Historical standards are not able to provide adequate flooding protection

- Standards based on historical design storms:
  - No longer representative
  - Existing properties in areas with risk of flooding
- Some infrastructure may no have the capacity to handle the new extreme events

Labatt Park

# The City of London: Vulnerability of Infrastructure to Climate Change Study

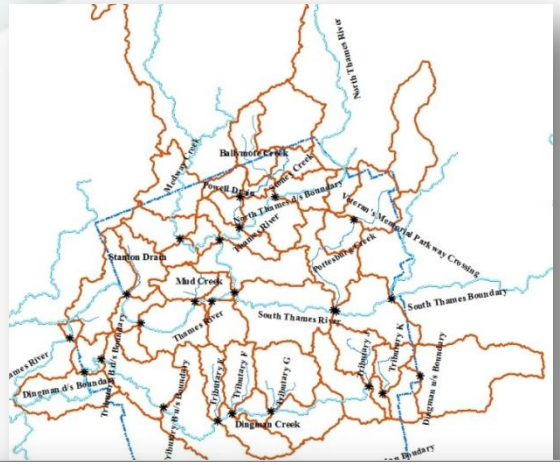
**Vulnerability of Infrastructure to Climate Change commenced the end of 2009 and the infrastructure data considered for this study included:**

- 216 bridges & culverts,
- 520 km of  arterial roads,
- more than 3,000 buildings within the flooding area under consideration,
- more that 1,300 km of sanitary/storm pipe network,
- 6 pollution control plants, and
- approximately 100 stormwater management facilities.

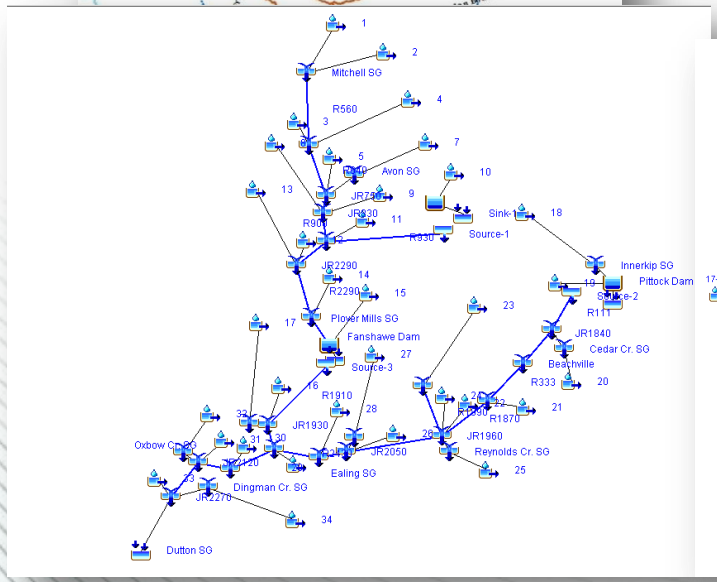
# Hydrologic Modelling

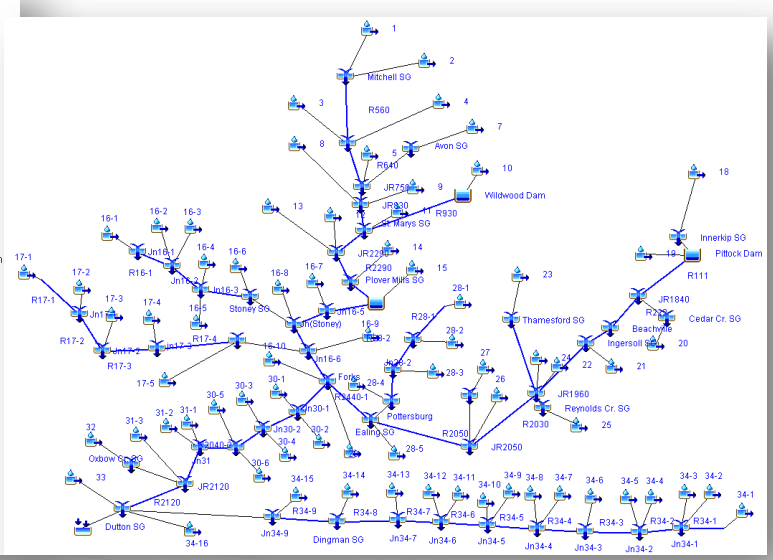
- Two hydrologic scenarios
  - 100 year return period
  - 250 year return period

# Hydrologic Modelling



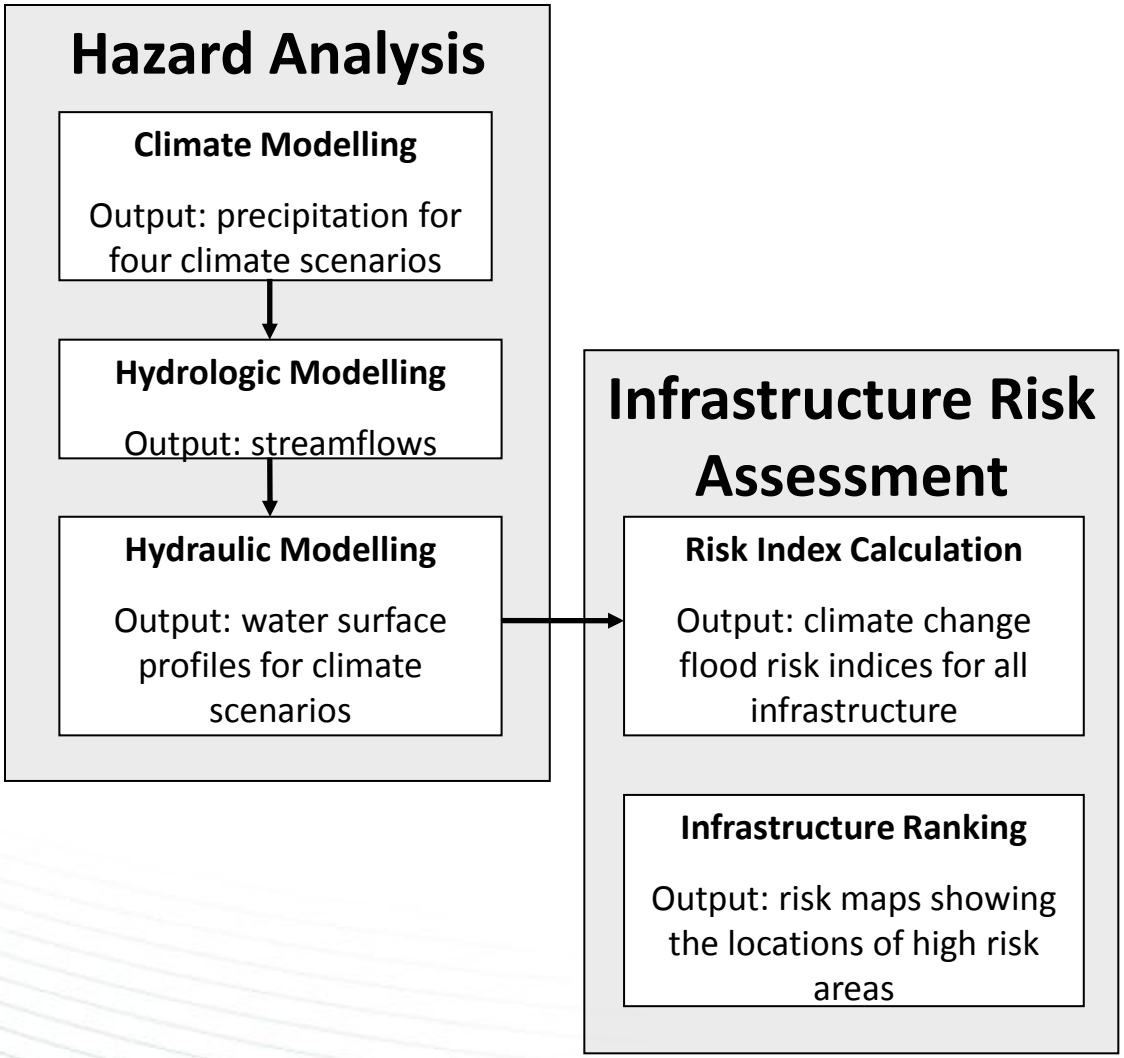

- Modification of HEC-HMS
- Nesting of sub-basins
  - Medway (5 sub-basins)
  - Stoney (6 sub-basins)
  - Pottersburg (4 sub-basins)
  - Dingman (16 sub-basins)



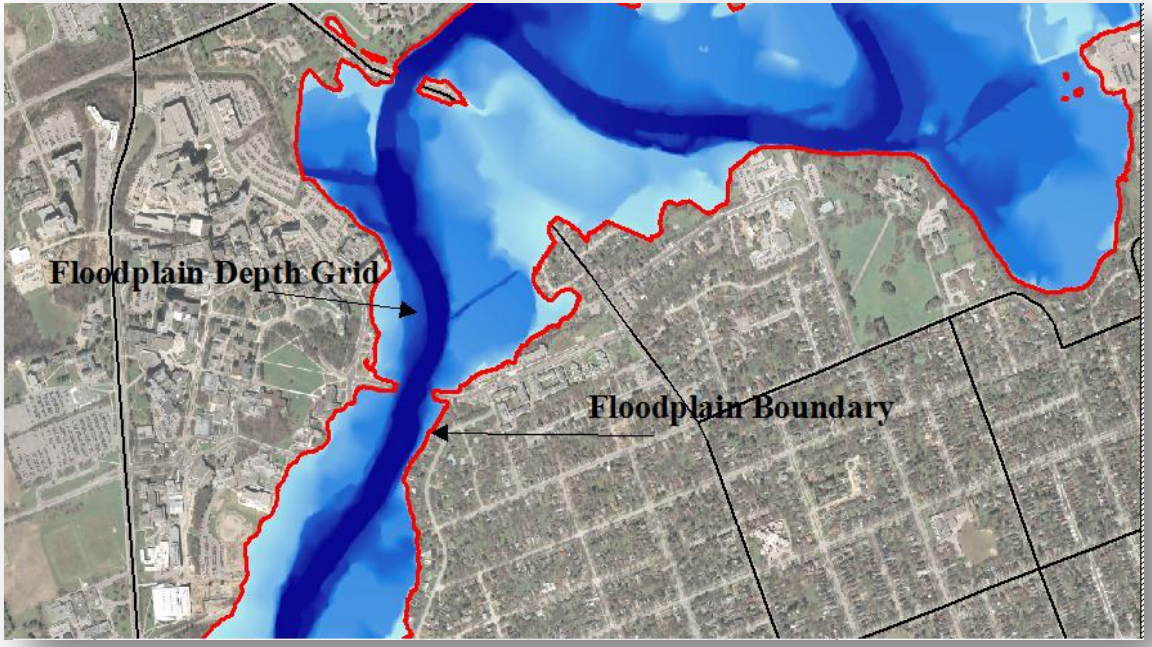
# Vulnerability of Infrastructure

- Methodology

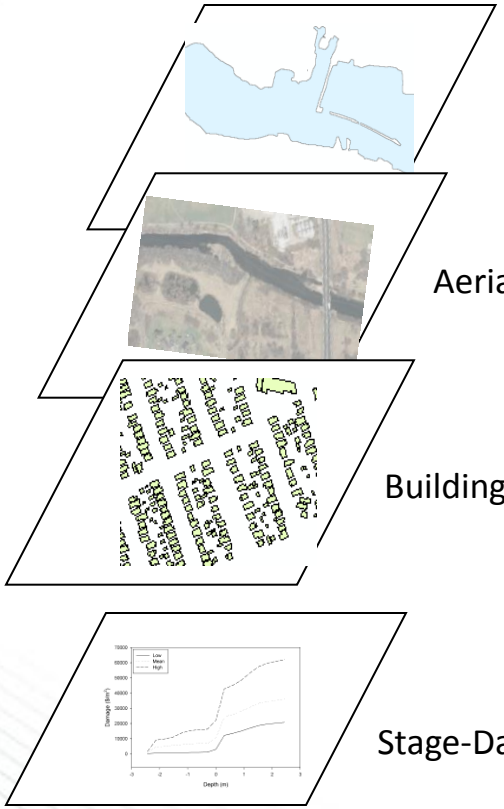


# Vulnerability of Infrastructure

- HEC-RAS and HEC-GeoRAS
- Input: Streamflows from hydrologic model
- Output: floodplains to represent flood extent and depth for use in risk analysis



# Vulnerability of Infrastructure – Index Calculation

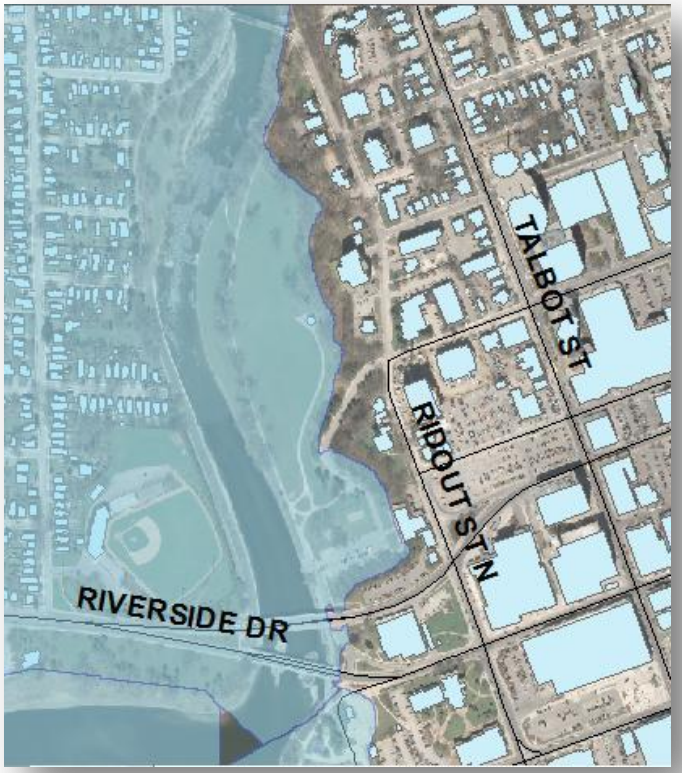


Floodplain

Aerial photo

Buildings

Stage-Damage Curves




Identify inundated infrastructure

# Vulnerability of Infrastructure - Results

The study provided flood risk analyses and identified areas of high risk within the City of London:

- Pollution control plants are high risk infrastructure, specifically the Area containing the Greenway PCP
- Area behind Broughdale dyke along the North
- Area behind West London Dyke near the downtown Forks
- Pottersburg Creek southwest of Trafalgar Street and Clarke Road

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# Vulnerability of Infrastructure - Results

- Existing conditions: 250 year flood – the cost in damages was estimated approximately $600 M
- Climate change conditions: 250 year flood – the cost in damages was estimated approximately $1B
- Climate change evaluation generated an increase in risk of approximately 70%

# Vulnerability of Infrastructure Recommendations to Council

- That the City of London proceeds with a change upwards of the current IDF curves by 21%;
- to continue with Phase 2 of the Climate Change Adaptation Strategy:
  - Assess the impact of Climate Change on the existing stormwater management plans developed for the Dingman Creek, Stoney Creek, Mud Creek, Medway Creek and Pottersburg Creek subwatershed studies;
  - develop a stormwater management plan for the Central Thames area under climate change including Slope Stability issues;
  - Develop a Green Infrastructure Plan to incorporate an environmental/ ecological approach to water resources management; and
  - Develop a long term Stormwater Adaptation Strategy to Climate Change.

# Vulnerability of Infrastructure Recommendations to Council

Subwatershed studies intended to assess impacts and develop mitigation strategies

- Optimize and minimize requirements for storages (on-line and off-line)
- Preliminary estimate of direct increase on SWM footprint is 10-15% assuming IDF increases 21%

21% increase in IDF curves from EC IDF is intended not substantial impact on pipe sizes as the City does not use EC IDF for pipe design

# The City of London: Vulnerability of Infrastructure to Climate Change

- This study was limited to the assessment of flooding as it is related to climate change and the risk to infrastructure.
- It is important to consider **social implications** of flooding related to climate change, as these can also have an impact on public infrastructure risks and prioritization.

# Decision (City Council , July 25, 2011)

Planning, Environmental and Engineering Services **BE DIRECTED** to proceed with the next set of Climate Change Adaptation Strategy studies as follows:

(i) update the Water Resources Components of the existing Subwatershed Studies such as the Dingman Creek, Stoney Creek, Mud Creek, Medway Creek and Pottersburg Creek using the Climate Change Upper Bound (CC_UB) scenarios in order to develop climate change Adaptation Policies; assess the impacts of these scenarios on the City's infrastructure and develop mitigation strategies;

(ii) develop the Water Resources Components and slope stability evaluation for a Central Thames Subwatershed Study using the Climate Change Upper Bound (CC_UB) scenarios in order to develop climate change Adaptation Policies, assess the impacts of these scenarios on the City's infrastructure and develop mitigation strategies;

(iii) develop a Green Infrastructure Plan to incorporate an environmental/ecological approach to water resources management;

(iv) develop a Long-Term Climate Change Adaptation Strategy on the basis of the outputs from studies (i) to (iii); and,

(v) use of 21% Intensity Duration Frequency (IDF) for modeling purposes; and

# *Phase 2 – Long-term Strategy:*

Subwatershed studies will assess impacts and develop mitigation strategies

- Optimize and minimize requirements for storages (on-line and off-line)
- Preliminary estimate of direct increase on SWM footprint is  10-15% assuming IDF increases 21%
- 21% increase in IDF curves from EC IDF will have minimal impact on pipe sizes as the City does not use EC IDF for pipe design

# *Phase 2 – Long-term Strategy:*

The future City's works will include:

- Updates to the Emergency Response plans;
- Developing new protocols for essential services (hospitals, fire stations, schools, etc.) in the flood zones
- Inspection of dams, dykes in particular the Broughdale and West London dykes
- Increasing bridges, dykes and dams elevations as new or reconstruction work is proceeding
- Upgrading existing infrastructure as appropriate

# *Two-phase Climate Change Adaptation Strategy*
# *Phase 2 – Long-term Strategy:*

The City commenced Phase 2 ***Climate Change Adaptation Strategy Implementation in 2012***

- the Water Recourses and Slope Stability components of Dingman Creek, Mud Creek, Medway Creek and Pottersburg Creek Subwatershed Studies Updates are ongoing and intended to be completed by the City in spring of 2013
- the Water Recourses and Slope Stability components of the Central Thames Subwatershed Studies are ongoing and intended to be completed by the City in spring of 2014
- The first Green Infrastructure SWM Stoney Creek Erosion Control Wetland that service app. 3000 ha was constructed in 2012 and we are intend to work on the Green Infrastructure standards in 2013
- a Climate Change Long Term Adaptation Strategy will be starting in the end of 2014

# Stoney Creek SWM Erosion Control Wetland – Green Infrastructure

# Stoney Creek SWM Erosion Control Wetland – Green Infrastructure