



Don Mills Channel

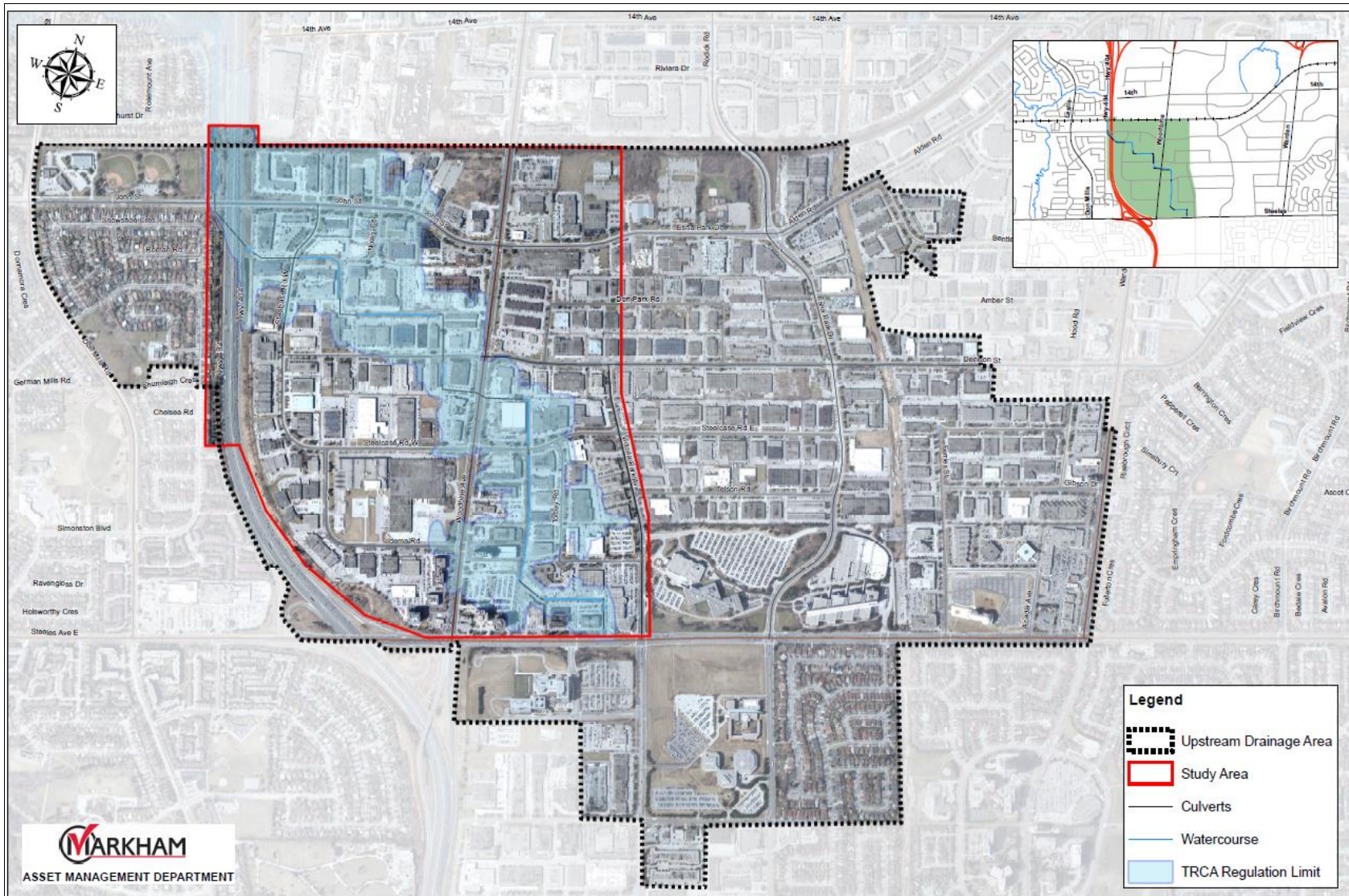
Advanced Modeling and Economic Analysis of Flood Remediation in the City of Markham

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STUDY AREA



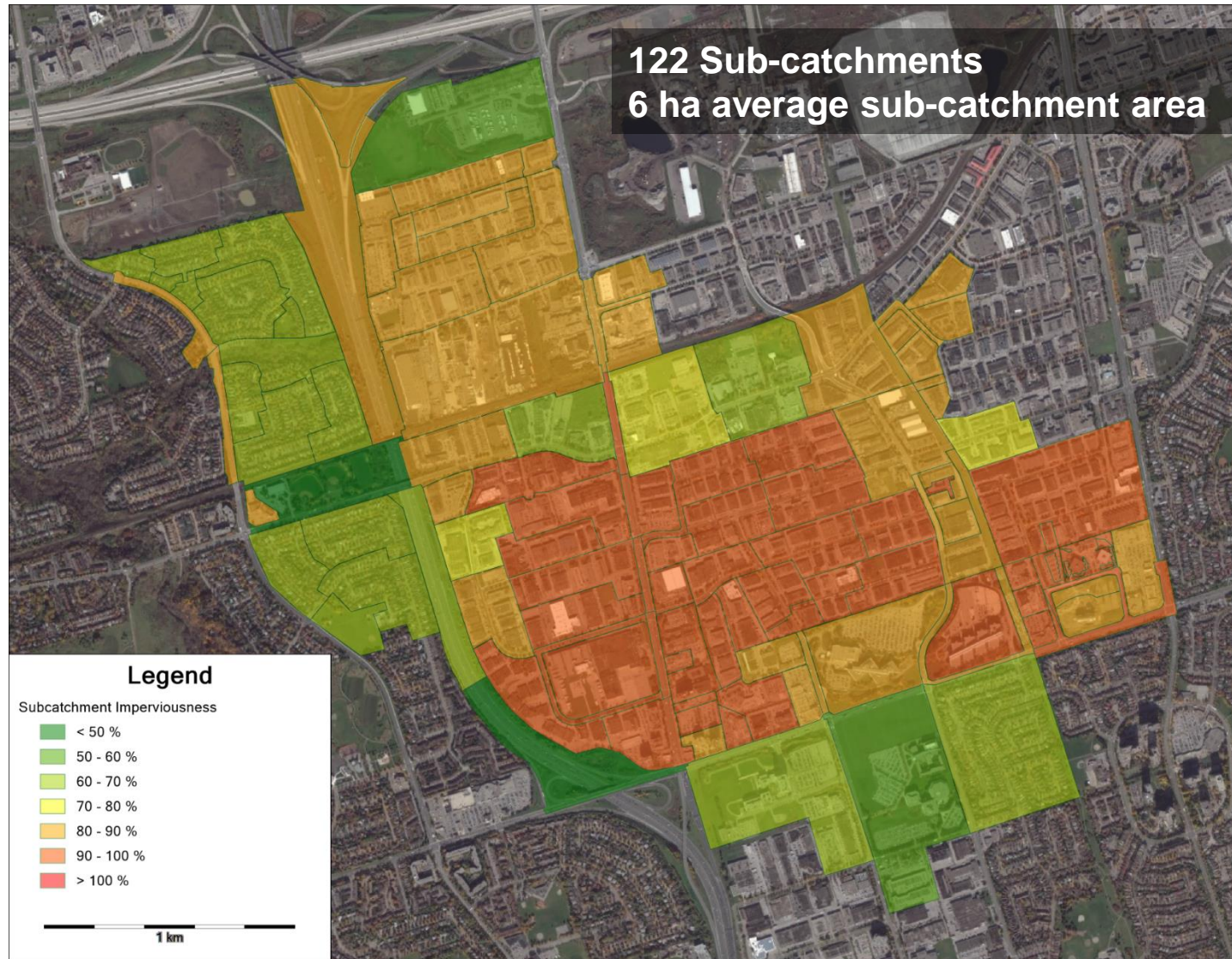
- The total drainage area to Highway 404 is approx. 450 ha, of which approx. 80 ha is within the City of Toronto
- Most of the area was developed in the 1970's and 1980's
- Only the more recent developments incorporate on-site peak flow controls

HISTORY OF FLOODING ALONG THE DON MILLS CHANNEL

1985 (10 – 25 year)	August 2005 (> 100 yr)	July 2014 (10 – 25 year)	August 2014 (50 – 100 year)
			

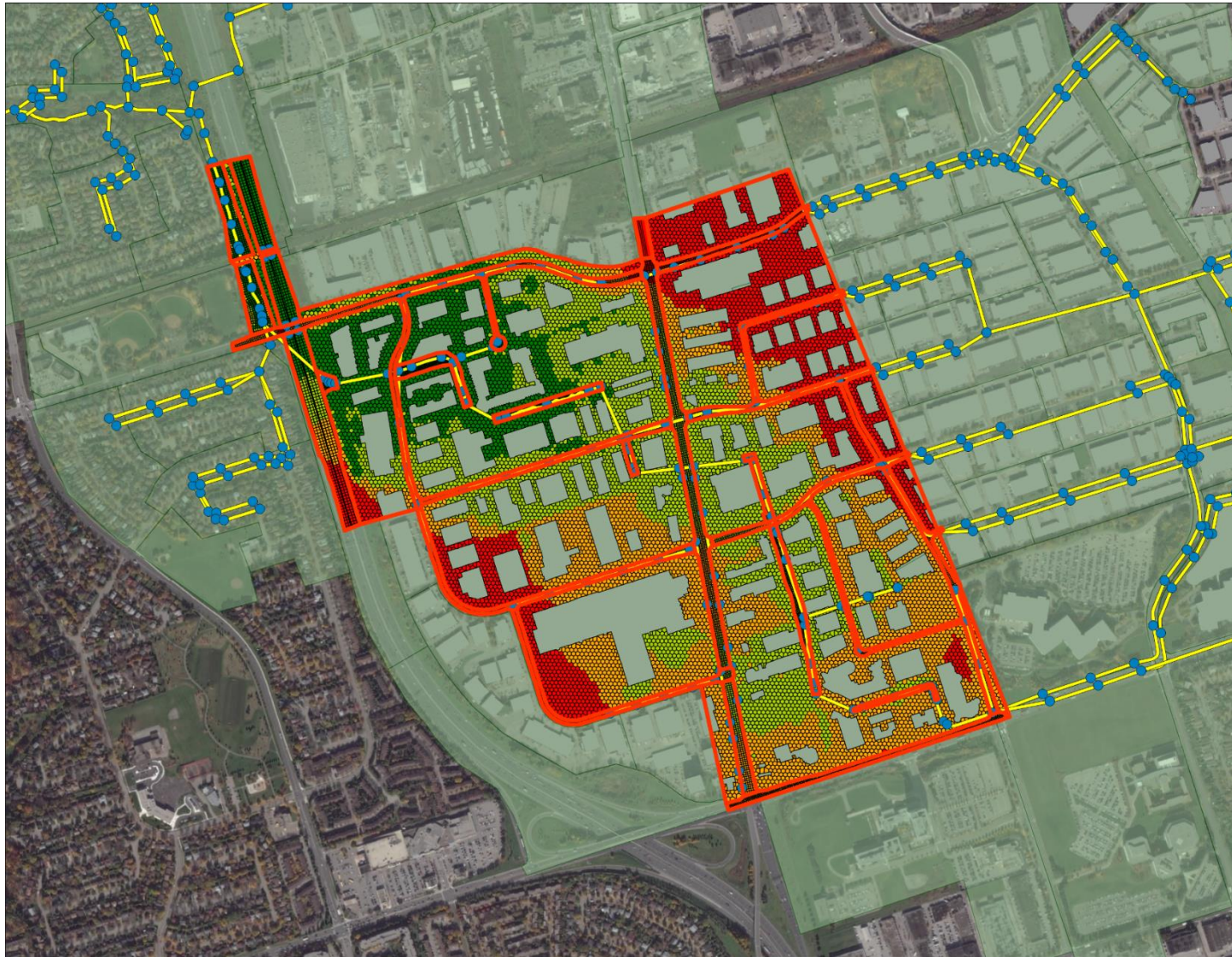
PCSWMM INTEGRATED 1D-2D MODEL SET-UP

122 Sub-catchments
6 ha average sub-catchment area



- Data sources for model set-up
- ❑ Storm sewer network (GIS)
 - ❑ Digital elevation model and breaklines
 - ❑ HEC-RAS model for open channel and culverts
 - ❑ Land use
 - ❑ Soils mapping
 - ❑ Property and building footprints
 - ❑ Site plans with details of on-site controls

PCSWMM INTEGRATED 1D-2D MODEL SET-UP

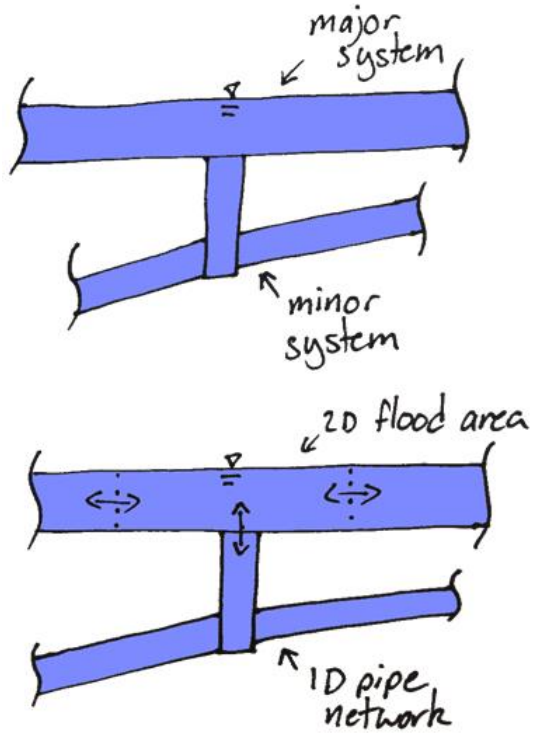


Model Characteristics

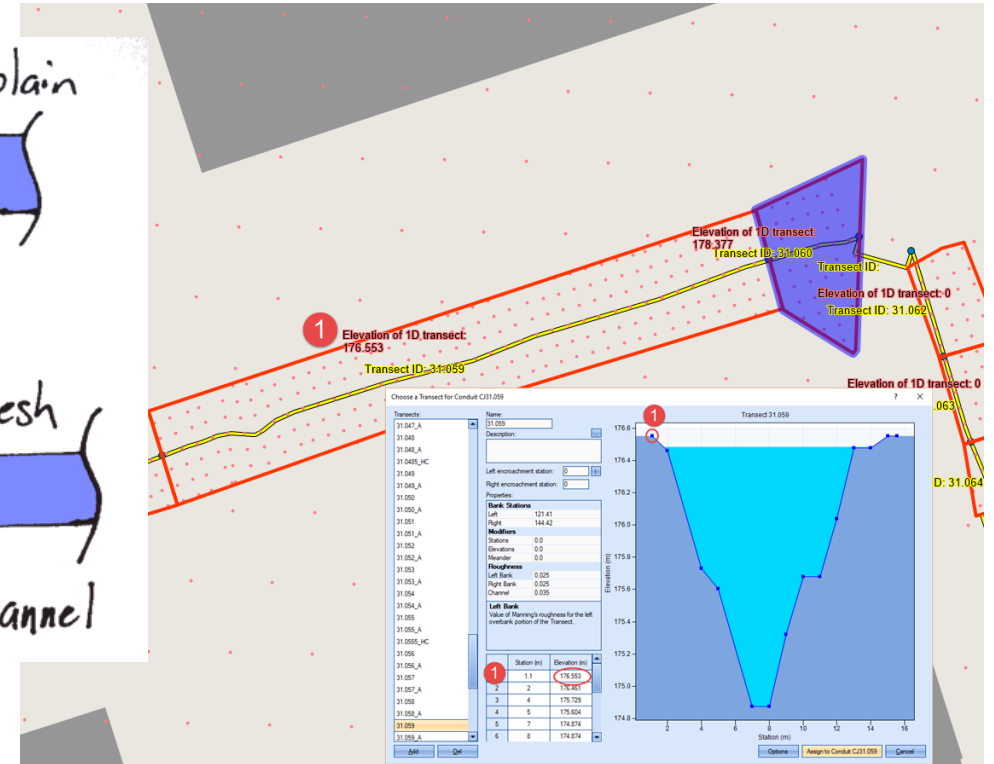
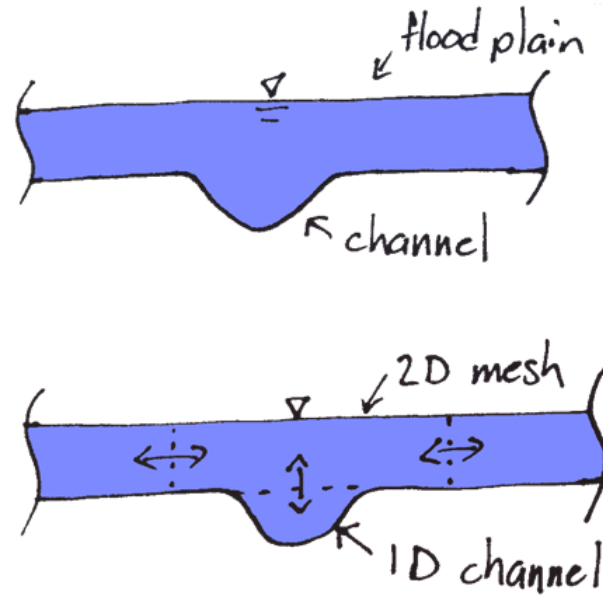
- More than 24,000 2D cells covering approx. 160 ha
- Minor system (pipes > 600 mm)
- Major system outside the 2D grid areas
- Directional mesh for roadways and open channels (3 m to 4 m resolution)
- Hexagonal mesh for all other areas (10 m resolution)
- Building footprints represented as obstructions
- 38 orifices to represent on-site peak flow controls

PCSWMM INTEGRATED 1D-2D MODEL SET-UP

Minor/major drainage split



1D Channel / 2D grid split



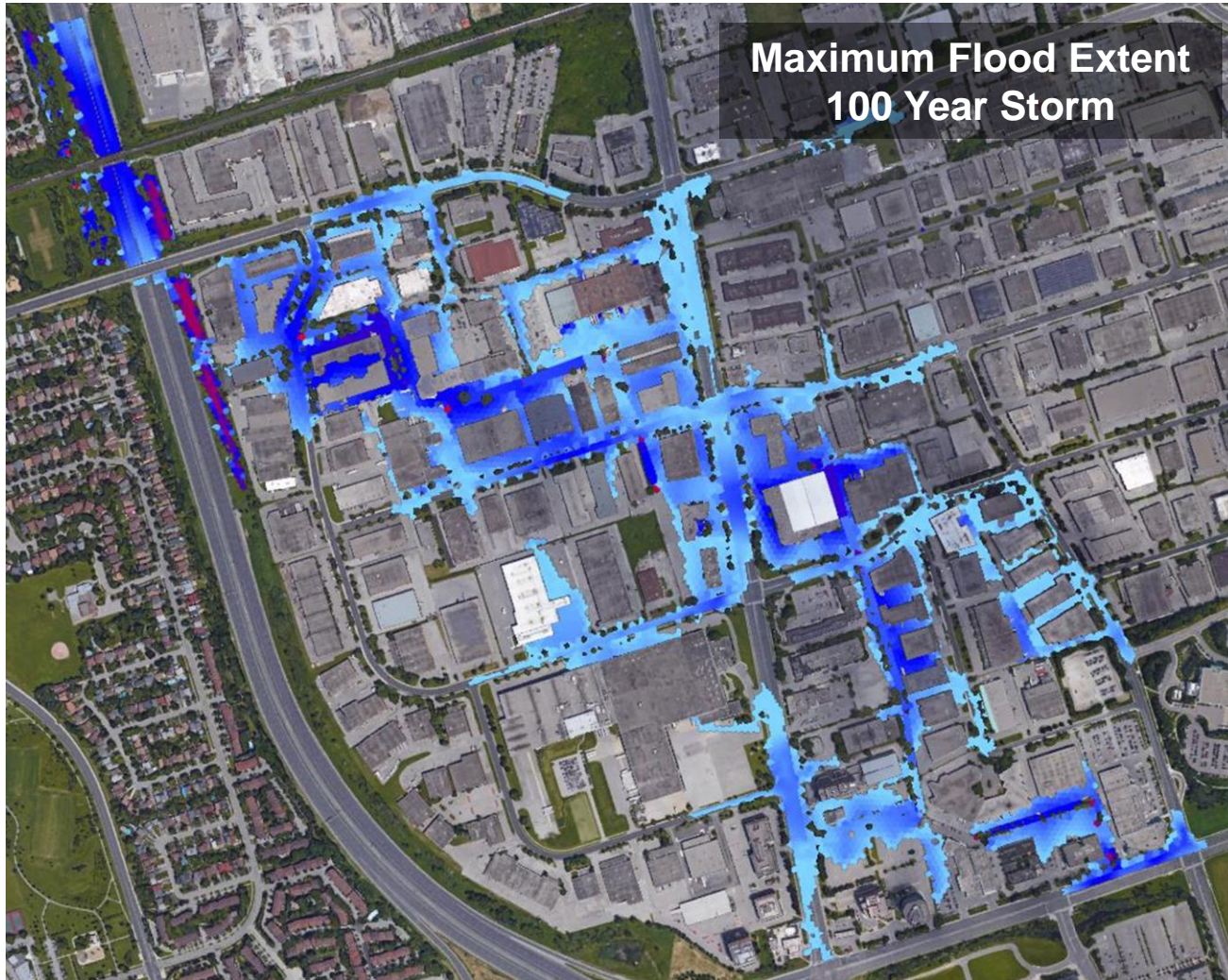
PCSWMM MODEL VALIDATION

August 2005 Storm Event



Depth and extent of flooding predicted by detailed hydrologic model developed for this study

FLOOD DAMAGE ESTIMATES



Flood Damages include

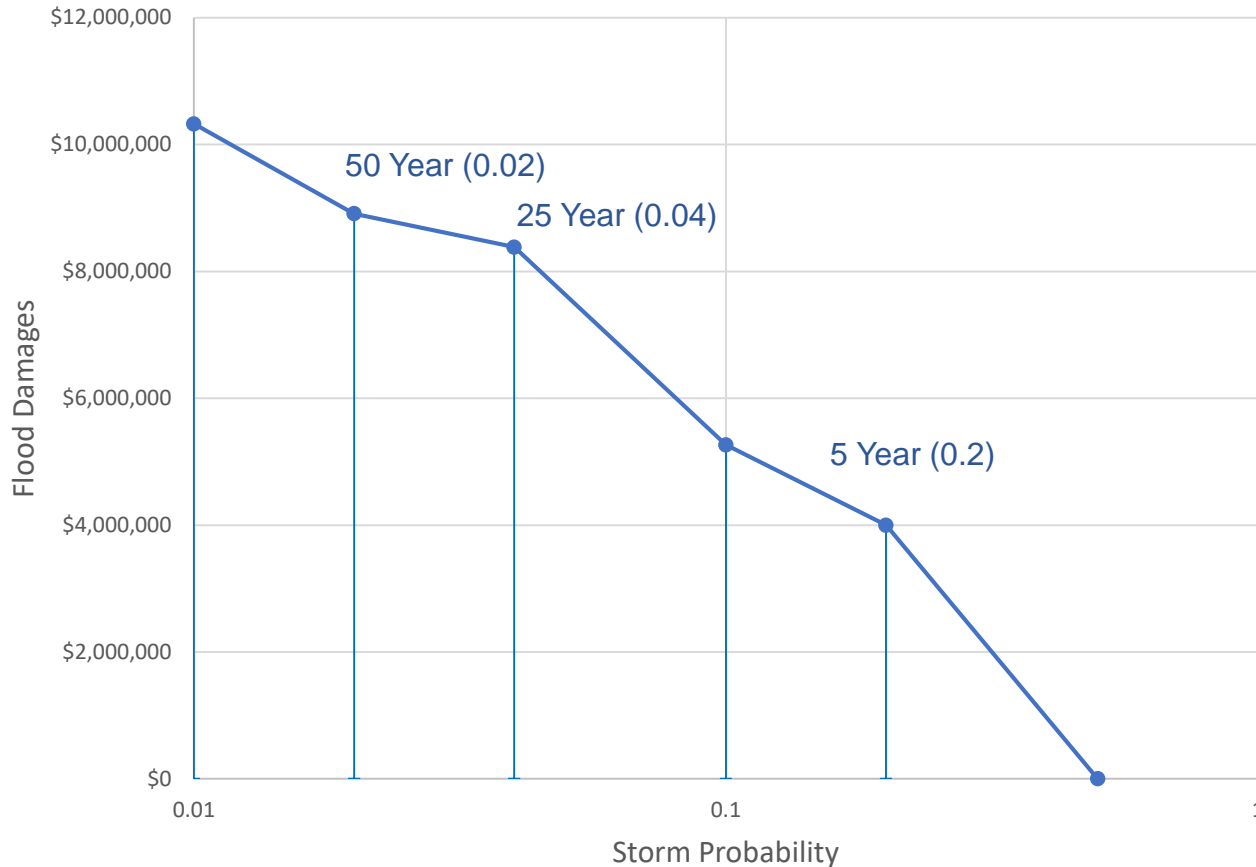
- Direct damages: Damages to structures and contents
- Indirect damages: Loss of business, damages to private vehicles in parking lots

Flood damages are highly variable, depending on building use and timing of flooding

Direct flood damages were estimated as 10% of MPAC assessed value for all properties where flood depths were higher than the ground floor elevation. This estimate was based on both local claims for flood damages and input from the insurance industry

FLOOD DAMAGE ESTIMATES

Average Annualized Flood Damages



Average annualized flood damages was calculated as:

$$\sum \text{Risk of Flooding} \times \text{Corresponding Flood Damages}$$

100 Year Storm: 58 Buildings impacted, \$10.3 Million in direct flood damages

Averaged annualized direct flood damages, existing conditions: \$1.7 Million per year

ALTERNATIVE SOLUTIONS

Enhanced Channel Maintenance



Channel Widening



Acquisition of Flood Prone Properties



Underground Flood Storage / LID

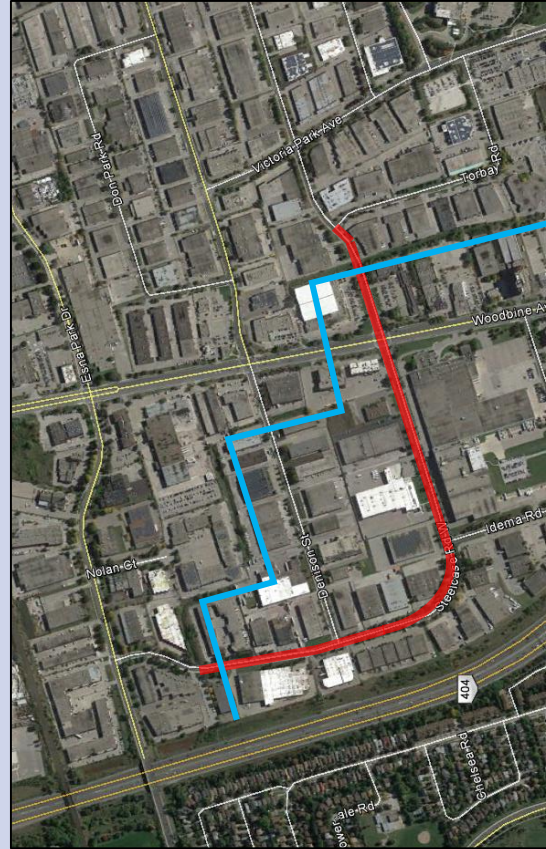


ALTERNATIVE SOLUTIONS

Central Municipal Flood Storage



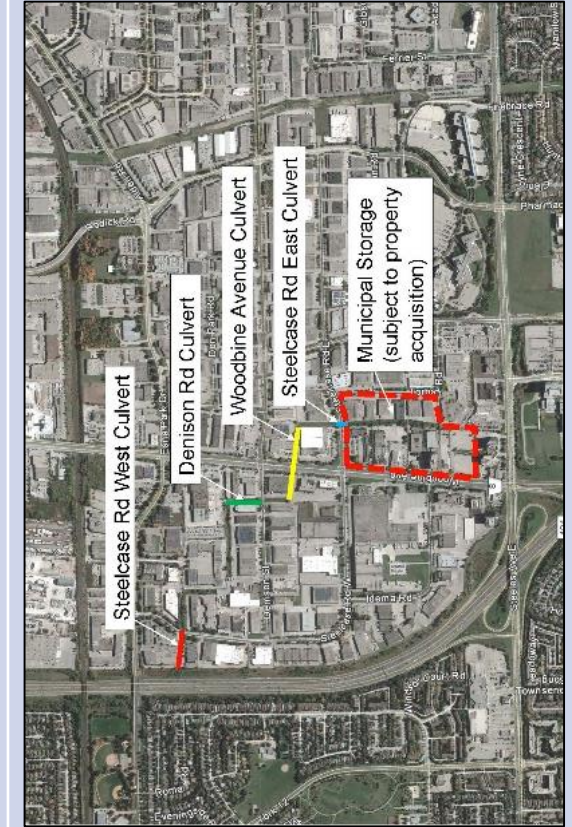
Flow Diversion



Flood Proofing and Education



Combined Option



QUALITATIVE EVALUATION OF ALTERNATIVES

Alternative	Natural Environment		Social/Cultural Environment		Technical Environment		Overall		Financial Environment
	Impacts	Benefits	Impacts	Benefits	Challenges	Performance	Cumulative Impact	Cumulative Benefit	
Status Quo	●	○	●	○	●	○	●	○	No capital costs, as no works are proposed Negligible reduction in flood damages
Enhanced Channel Maintenance	●	○	●	○	●	○	●	○	Very Low cost No reduction in flood damages
Channel Widening	●	●	●	●	○	●	●	●	Very High cost, loss of tax revenue from acquired properties Elimination of flood damages for up to the 100 year storm
Acquisition of Flood Prone Properties	●	○	●	●	○	●	●	●	High cost, loss of tax revenue from acquired properties Elimination of flood damages for up to the 5 year storm
Underground Storage	●	○	●	○	○	●	●	○	Medium / High construction cost, High lifecycle maintenance / replacement cost Elimination of flood damages for up to the 5 year storm
Central Municipal Flood Control Storage	●	●	●	●	●	○	●	○	Low / Medium cost Damages reduced to \$0.9 Million per year
Flow Diversion	●	○	●	○	○	○	●	○	Low / Medium construction and lifecycle maintenance / replacement cost
Flood Proofing and Education	●	○	●	○	○	○	●	○	Low cost Damages reduced to \$0.9 Million per year if 5 year protection is achieved at all flood prone buildings
Combined Alternative – Central Municipal Flood Storage, Culvert Upgrades and Education Program	●	●	●	●	○	●	●	●	Medium cost Damages reduced to \$0.2 Million per year

DETAILED FINANCIAL EVALUATION OF ALTERNATIVES

Financial impact is one of a number of evaluation criteria under the Municipal Class EA process

Given the significant cost of approx. \$70 Million to implement the recommended alternative, a more rigorous financial analysis was warranted

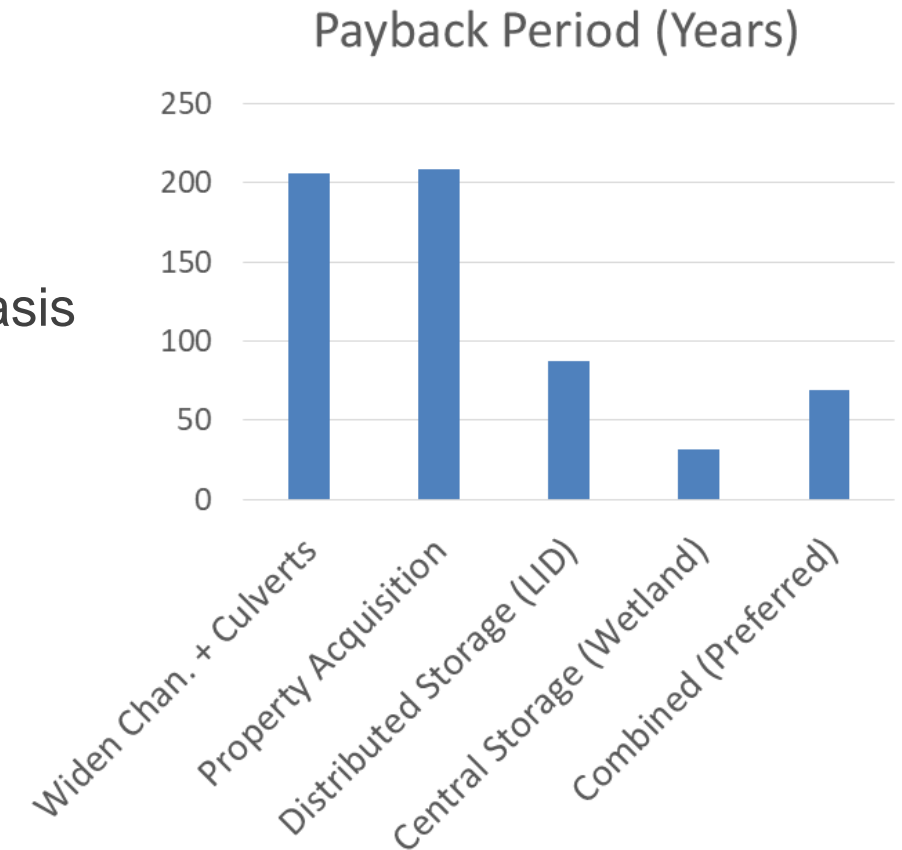
Inputs to the financial analysis included

- Initial capital construction costs
- Long term operation and maintenance costs
- Reduction in direct flood damages on an average annual basis

Payback period was used as a metric to evaluate alternative solutions

$$\text{Payback Period} = \frac{\text{Initial Capital Costs}}{\text{Reduction in avg. annual damages} - \text{annual O\&M Costs}}$$

The Central Storage option has the shortest payback period, but does not achieve the desired minimum 5 year protection



DETAILED FINANCIAL EVALUATION OF ALTERNATIVES

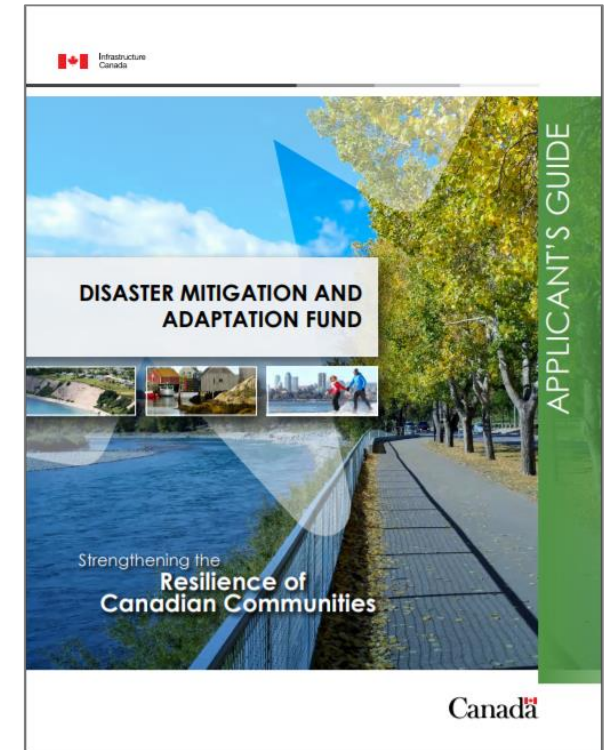
Infrastructure Canada requires a Return on Investment (ROI) analysis for eligible projects under the Disaster Mitigation Adaptation Fund (DMAF) grant program

Projects must show benefit / cost ratio of 2:1 or more, with deferred socio-economic and environmental costs (benefits)

Total (direct + indirect) flood damages were used for the ROI analysis. The insurance industry estimates that total flood damages are 1.8 x direct, insured losses.

Over a 100 year time horizon, total flood damages will be reduced by \$2.7 Million per year x 100 years = \$270 Million on an average annualized basis

Benefit:Cost = \$270 M ÷ \$69 M = 3.9:1, which is significantly better than 2:1

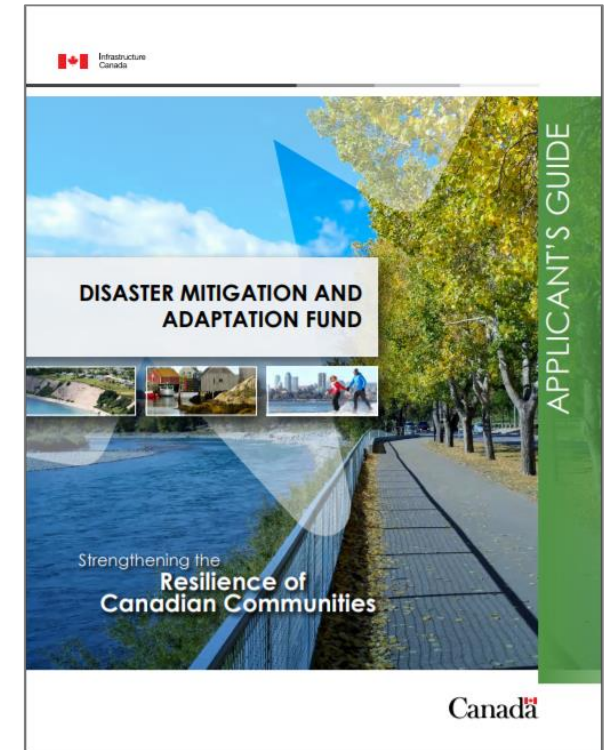


DETAILED FINANCIAL EVALUATION OF ALTERNATIVES

Markham applied 3 different methods to assess deferred damage benefits:

- Don Mills Channel: Estimated reduction in total flood damages on an average annualized basis over a 100 year time frame
- Thornhill Community Centre Area: Estimated based on historical claims
- West Thornhill Sewer Upgrades: Estimated based on annualized regional insured losses scaled to project areas

Combined Overall Benefit:Cost = 4.7:1



CONCLUSIONS

- ❑ Complex hydrologic/hydraulic models are needed to understand complex flooding problems in urban areas
- ❑ Estimating flood damages as a % of MPAC assessed value is an objective tool to calculate overall damage estimates
- ❑ More rigorous financial analyses are needed to justify and secure funding for capital intensive flood reduction projects
- ❑ Predicted reductions in average annualized flood damages is one of a number of methods available to quantify benefits for cost benefit analysis under DMAF and other funding programs
- ❑ Industry standards are needed to ensure that costs and benefits associated with flood reduction infrastructure projects are accounted for in a clear, consistent manner

