

Durham Region's Natural Environment Climate Change Summit

Extreme Weather Resiliency and Climate Adaptation Through Strategic Asset Management & Infrastructure Investments

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OUTLINE

- 1) Regulations on Resiliency
- 2) Upgrading Historical Service vs. Future Adaptation
- 3) Rainfall Risk Factors
- 4) Strategic Flood Resiliency – Where to Act in Durham
- 5) Policies, Programs and Projects for Cost-Effective Resiliency
- 6) Markham Flood Control Program Review – Grey and Green Infrastructure Strategies

Ontario Drivers for Assessing Climate Change Risks

Provincial Policy Statement (2014):

“Infrastructure ... shall be provided in a coordinated, **efficient and cost-effective manner that considers impacts from climate change**”

Infrastructure for Jobs and Prosperity Act (2015):

“Infrastructure planning and investment should minimize the impact of infrastructure on the environment ... **should be designed to be resilient to effects of climate change.**”

Environmental Assessments (2017):

“ ... proponents to consider measures to adapt to climate change: **How vulnerable might a project be to a changing climate?**

Bill 139 (2017) :

“OP shall contain policies that identify goals, objectives and actions to ... **provide for adaptation to a changing climate, including through increasing resiliency.**”

Ontario Drivers for Assessing Climate Change Risks

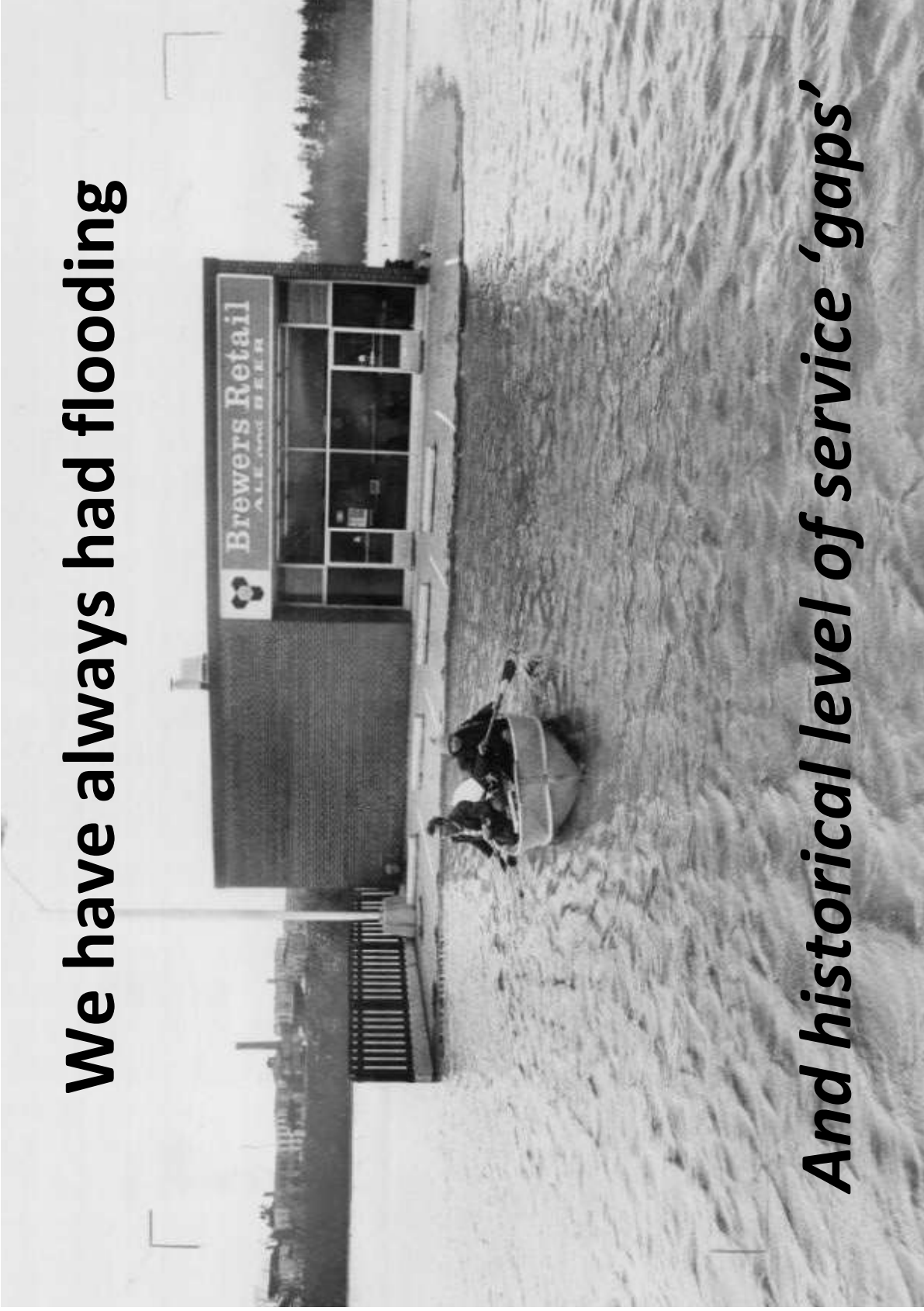
O. Reg. 588/17: ASSET MANAGEMENT PLANNING FOR MUNICIPAL INFRASTRUCTURE

(July 1, 2019) “first strategic asset management policy” shall include “the municipality’s commitment to consider, as part of its asset management planning” including “the actions that may be required to address the vulnerabilities that may be caused by climate change” .

(July 1, 2024) “Every asset management plan must include the proposed levels of service for core stormwater management assets:

1. Percentage of properties resilient to a 100-year storm.
2. Percentage of stormwater management system resilient to a 5-year storm.

We have always had flooding

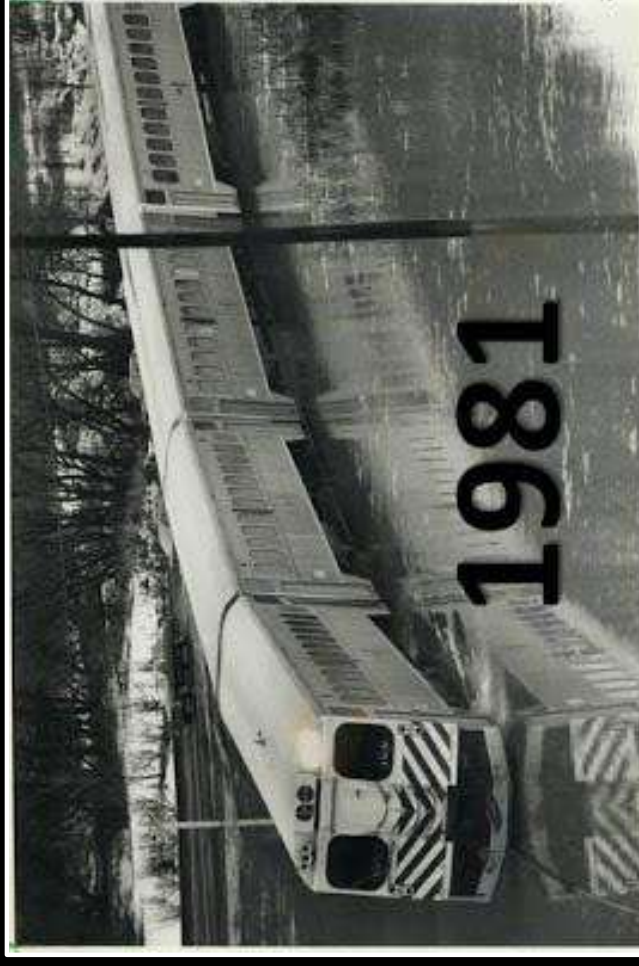
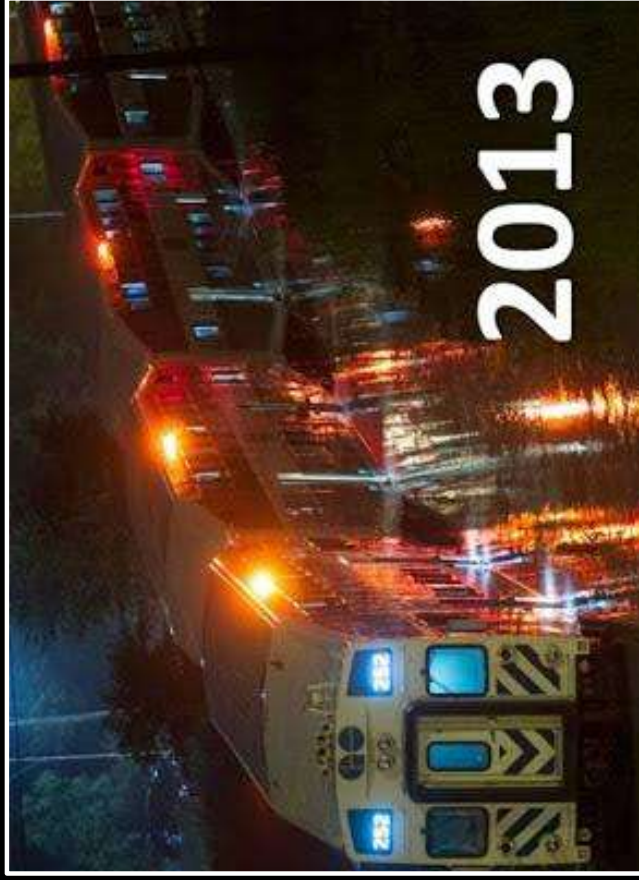


And historical level of service 'gaps'

... longstanding 'gaps' are challenging.

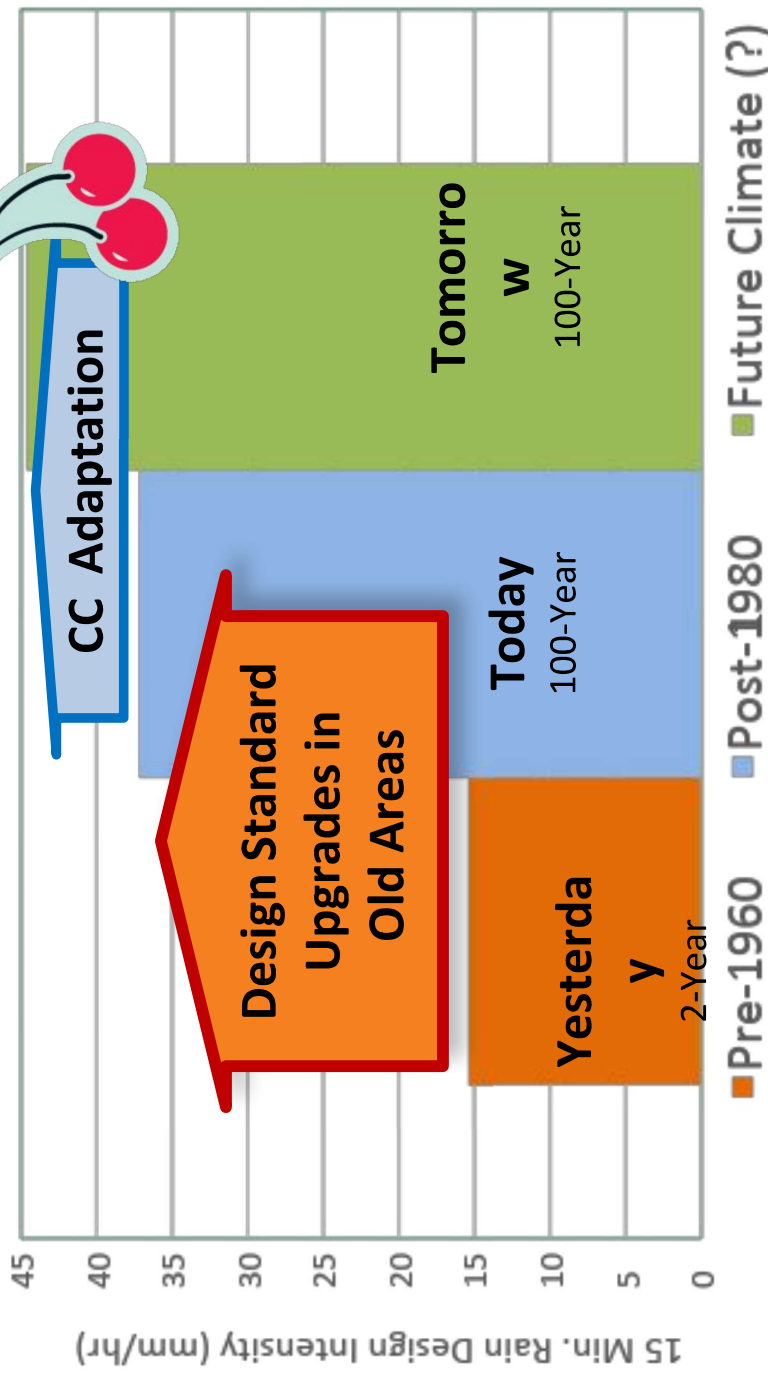


Repeated operational problems?



*Should not be confused with climate
change risks*

Difference Between Increasing Historical Levels of Service & Future Climate Change Adaptation ?

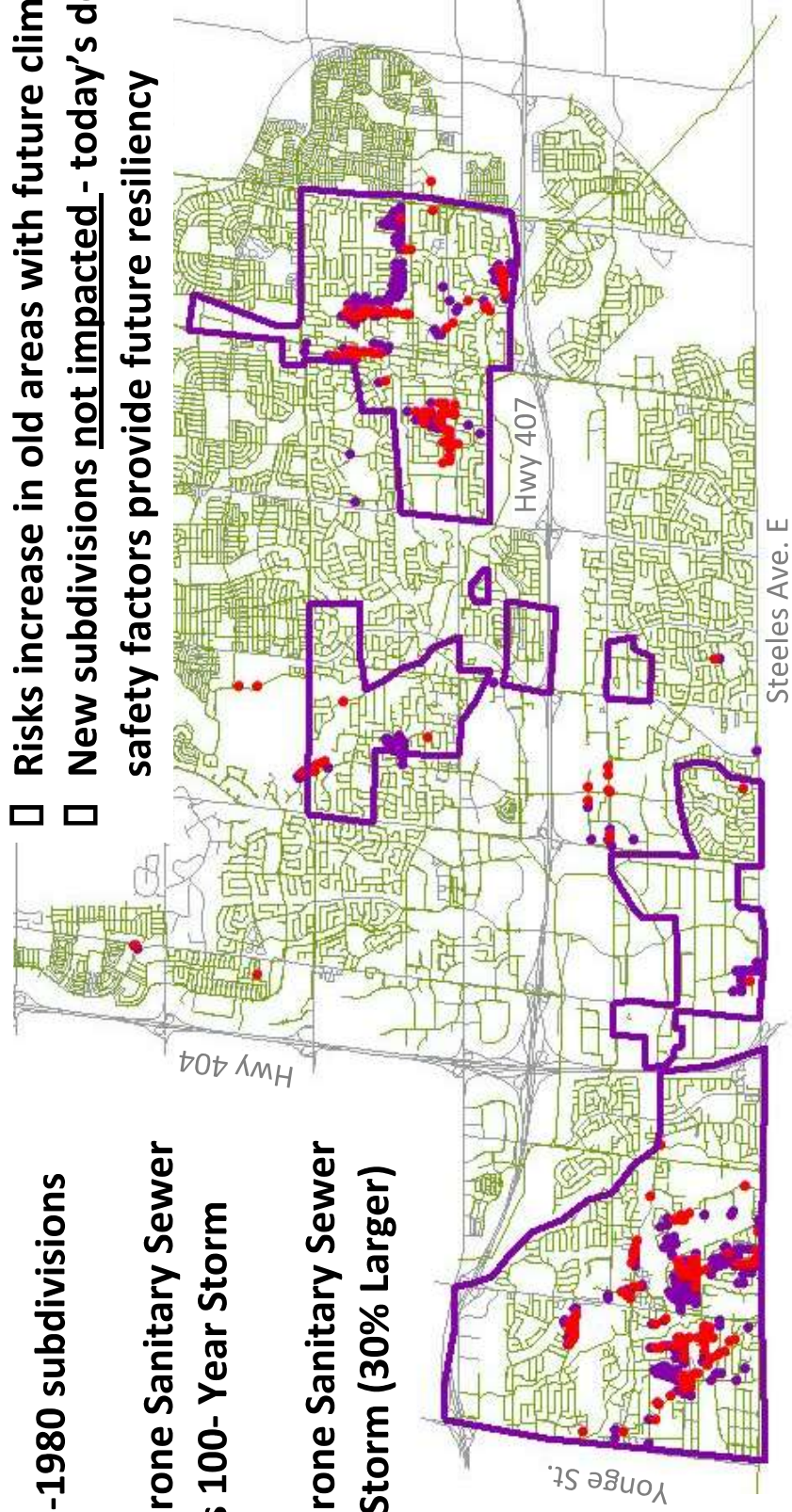


- **Historical upgrades first = very extensive capacity upgrades to meet today's standards.**
- **Next climate adaptation requires +20% more capacity.**

Strategically Increase Flood Resiliency for Today's Extremes in "Old Areas"

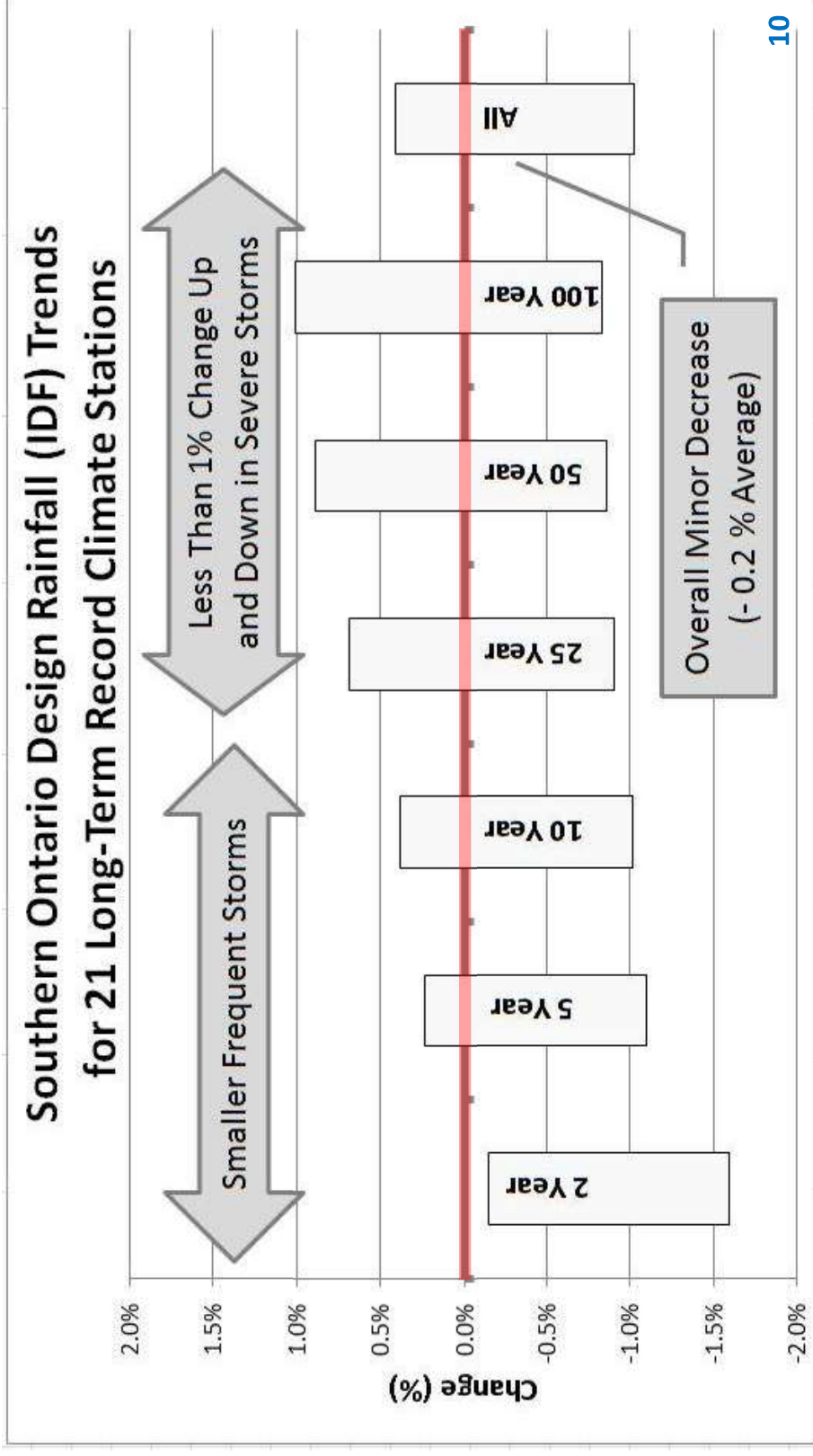
- Old pre-1980 subdivisions
- Risks increase in old areas with future climate
- Flood Prone Sanitary Sewer Today's 100- Year Storm
- New subdivisions not impacted - today's design safety factors provide future resiliency

- Flood Prone Sanitary Sewer Future Storm (30% Larger)



Rainfall Risk Factors – No Change in Design Intensities

- Since 1990, 0.2% drop in rain design intensities for long term stations ([link](#)).
- Some RCM's suggest lower extreme rain in 2050 ([link](#)).
- Still need future safety factors.



Where Should Durham Consider Added Flood Resiliency ?

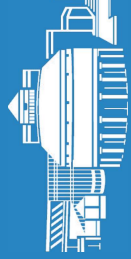
- Areas with high historical growth and intensification before modern storm drainage and sanitary sewer standards have been implemented.

Where?

- Construction Era, Infrastructure Standards and Extreme Rainfall Flood Resiliency and Risk <https://bit.ly/2TTE627>

How?

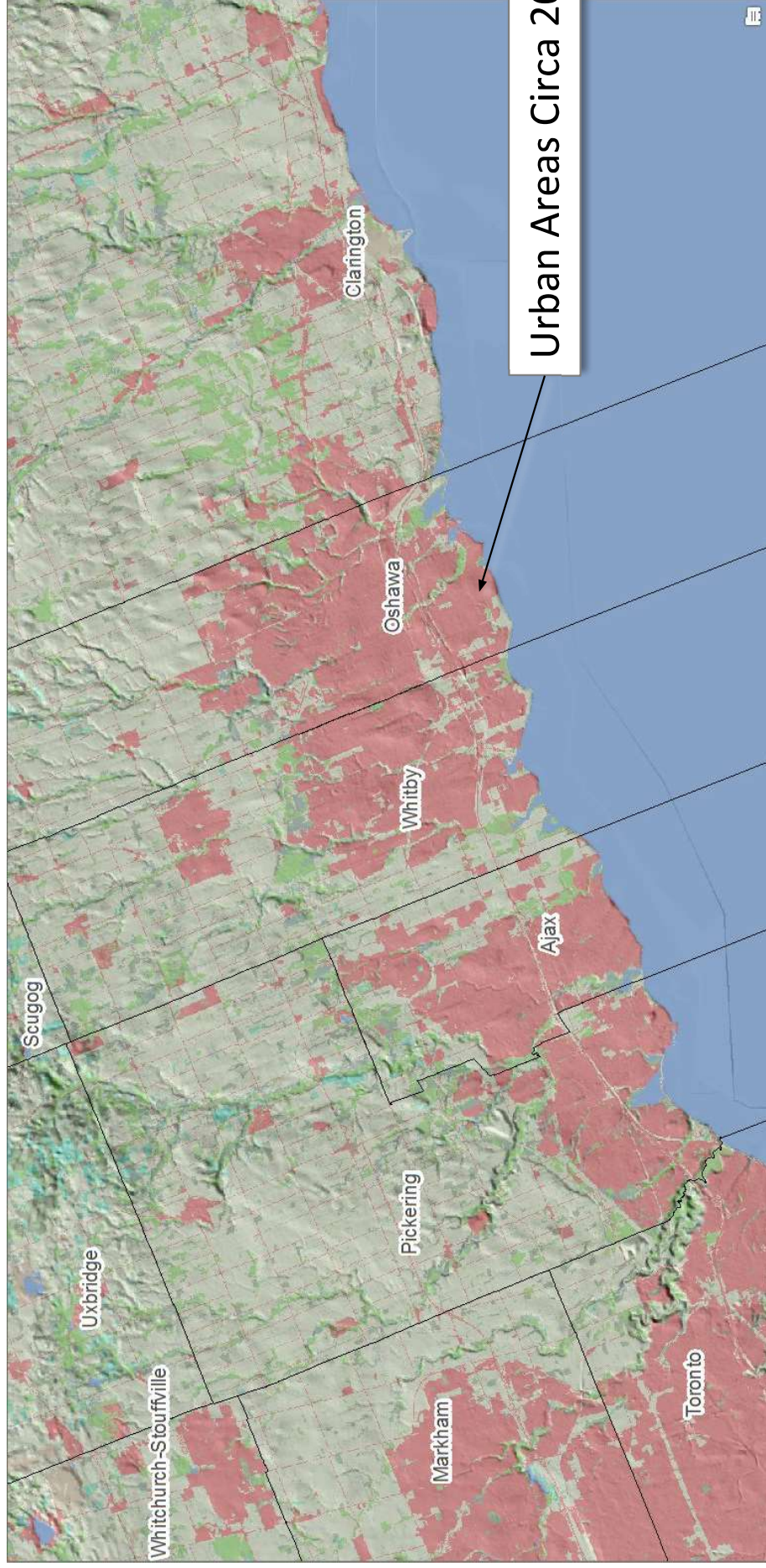
- Reducing Flood Risk from Flood Plain to Floor Drain. Developing a Canadian Standard for Design Standard Adaptation in Existing Communities <https://bit.ly/2GMINqR>

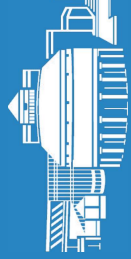


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Where Should Durham Consider Added Flood Resiliency ?

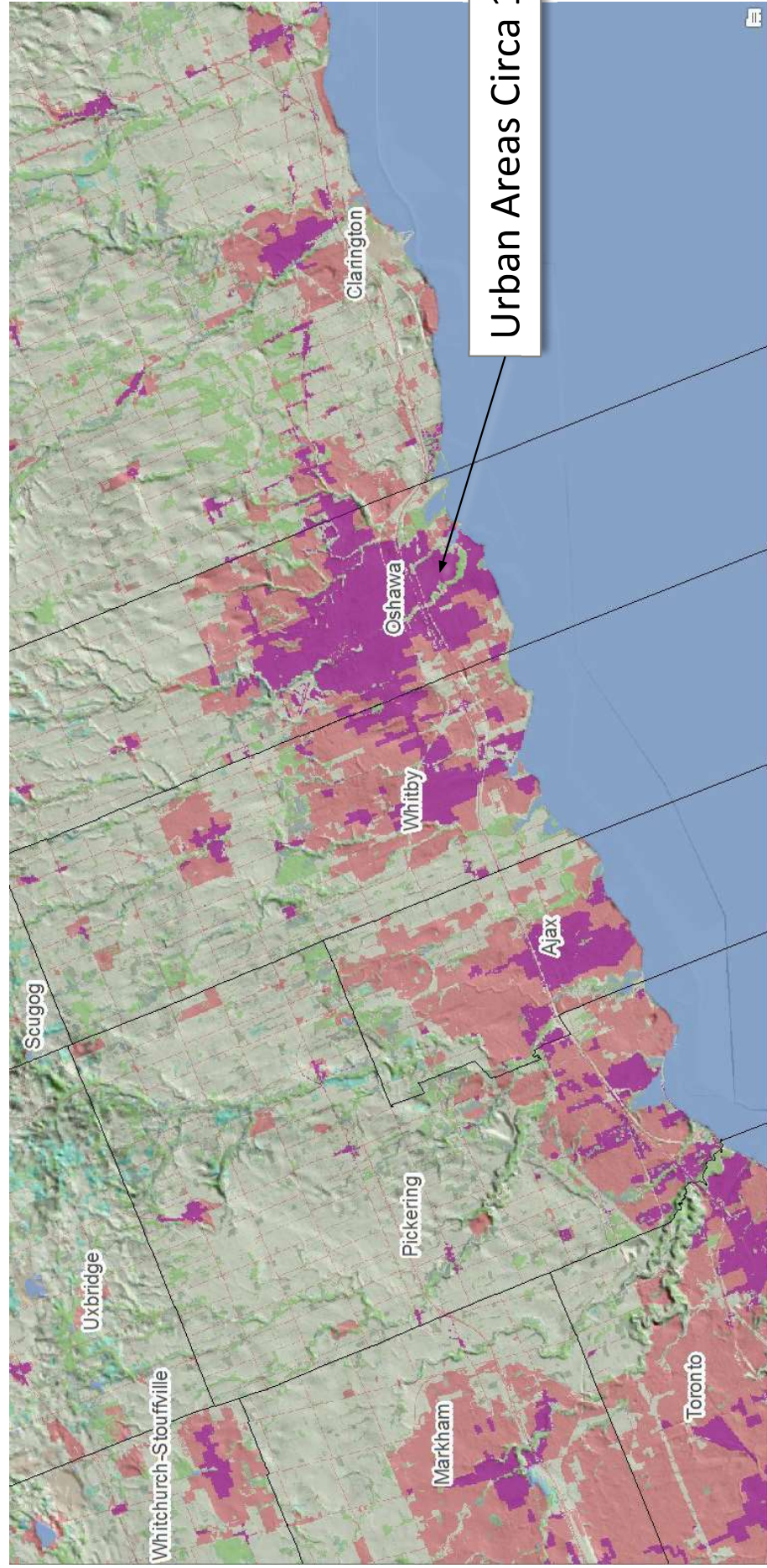


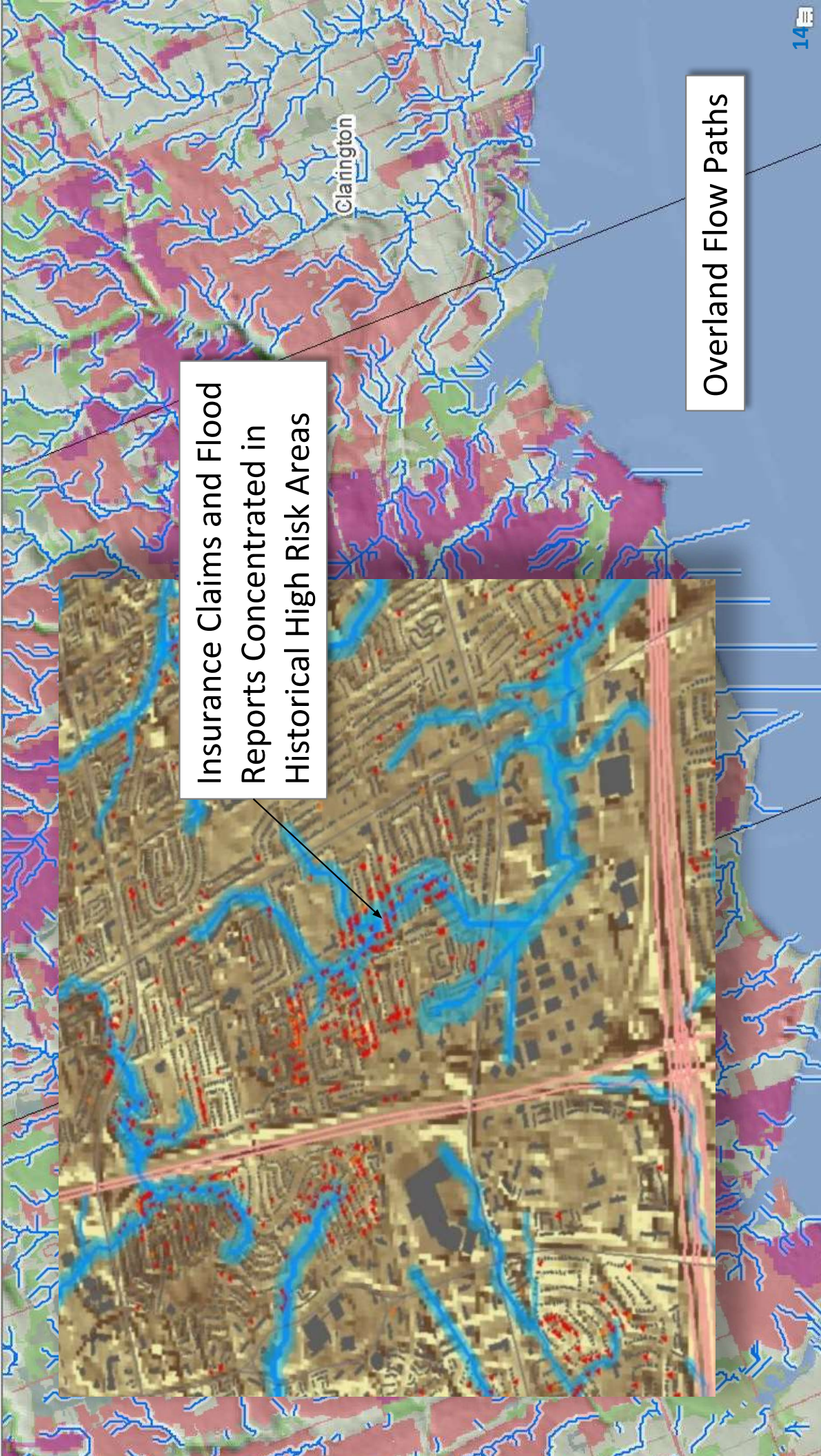


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Where Should Durham Consider Added Flood Resiliency ?





Insurance Claims and Flood Reports Concentrated in Historical High Risk Areas

Overland Flow Paths

Cost- Effective Policies, Programs & Capital Works Projects

- **Policies / Design Standards (prevention):**

- Land use planning / floodplain mgmt.
- Engineering standards

60 Times
Reduction in
Flood Density

- **Programs (low cost remediation)**

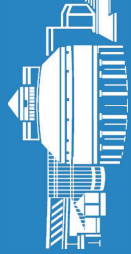
- Sanitary downspout disconnection
- Plumbing protection / backwater valves

Double Sanitary
Capacity with
Lower Storm Flows

- **Capital Works Projects (high cost remediation)**

- Sewer capacity upgrades (grey)
- Storage facilities (grey)
- Low impact development (green ?)

Is it cost effective ?
Do Benefits exceed
Costs (ROI) ?



Green Infrastructure – Recent Local Tender Costs

City / Town	LID Type (Project Name)	Capital + Soft Cost (\$)	Service Area (ha)	Cost / Hectare (\$ / ha)
Markham	Bioswale & Infiltration Trenches (Crescent Blvd)	\$783,602	1.9	\$412,422
Markham	Rain Garden (Glen)			\$5,000
Brampton	Bioswale (County)			\$2,570
Whitchurch-Stouffville	Various Measure			\$9,741
Ottawa	Bioretention (Sun)			\$9,670
Ottawa	Bioswale (Stewart)			\$0,821
Ajax	Rain Garden (Lake Driveway)	\$350,000	0.14	\$2,500,000
Mississauga	Bioswale & Pavers (Elm Drive)	\$226,000	0.633	\$357,030
Mississ				\$363,063
Mississ				\$495,070
Newm				\$371,552
Londr				\$500,068
Londr				\$290,312
Londr				\$554,266
Londr				\$189,692
Londr				\$384,662
Londr				\$103,569
Londr				\$283,147
Newm				\$1,892,985
East-G				\$665,949
Bradfo				\$1,625,467
Gwillim				\$50,951
Uxbrid				\$171,215
Aurora	Complex Roof and Parking			\$42,426
Innisfil	Permeable Pavement, Rain Garden (Fire Station Parking Lot and Roof)	\$84,003	1.98	\$42,426

Ajax Rain Gardens \$350,000 to service 0.14 hectares

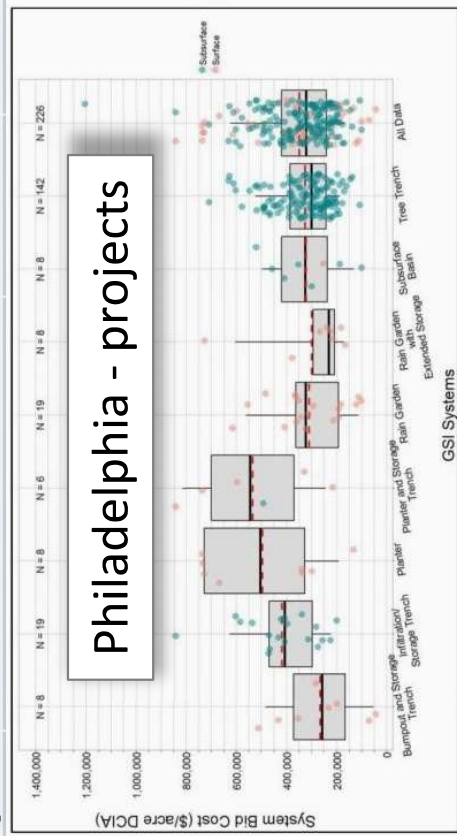


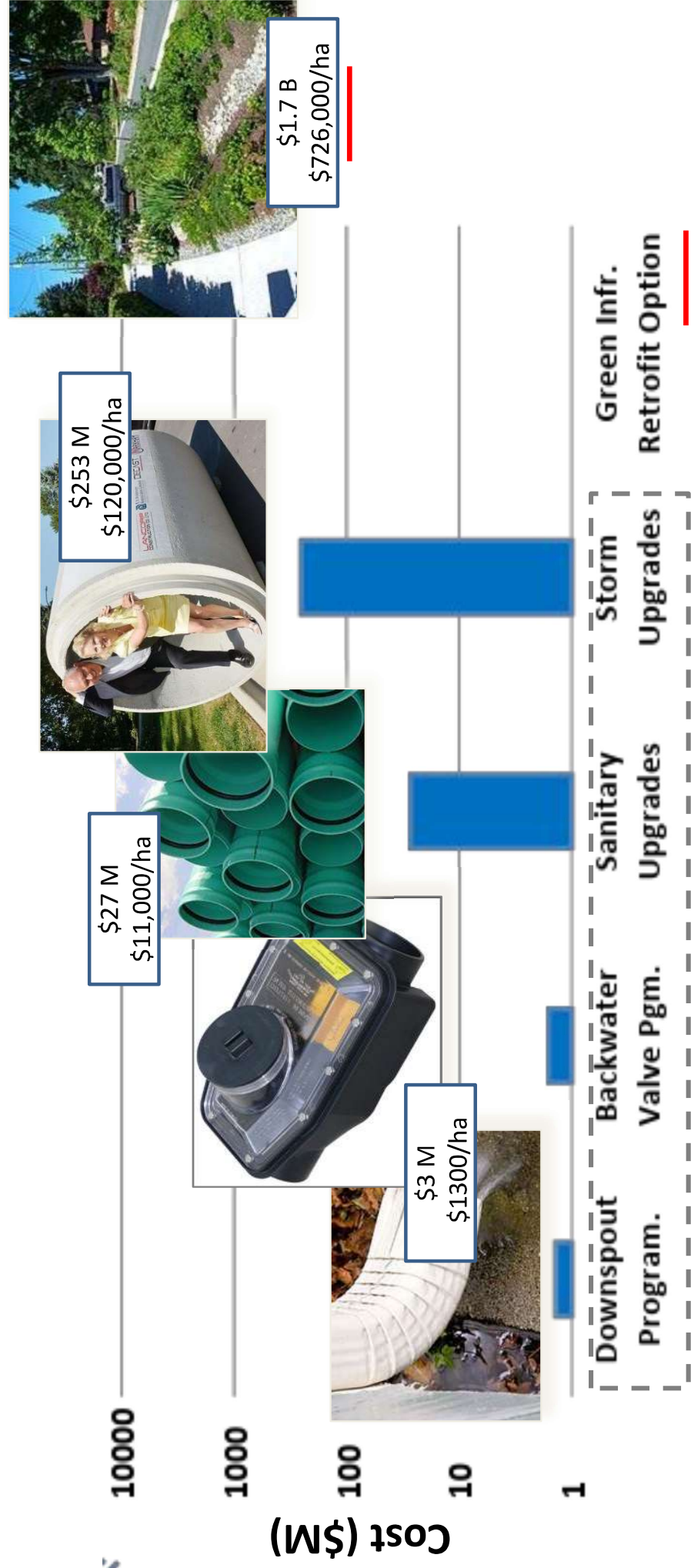
Figure 4-9: Bid Price per Managed Impervious Area (2015 USD) by GSI System

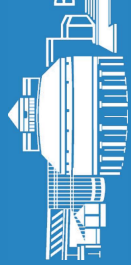
Approximately \$600,000 per hectare in capital cost.

Retrofitting Ontario's 852,000 urban hectares would cost about **half a trillion dollars**.

US costs of \$860,000 per **impervious** hectare give cost of **\$360 billion**.

Markham Flood Control Program Activities and Costs





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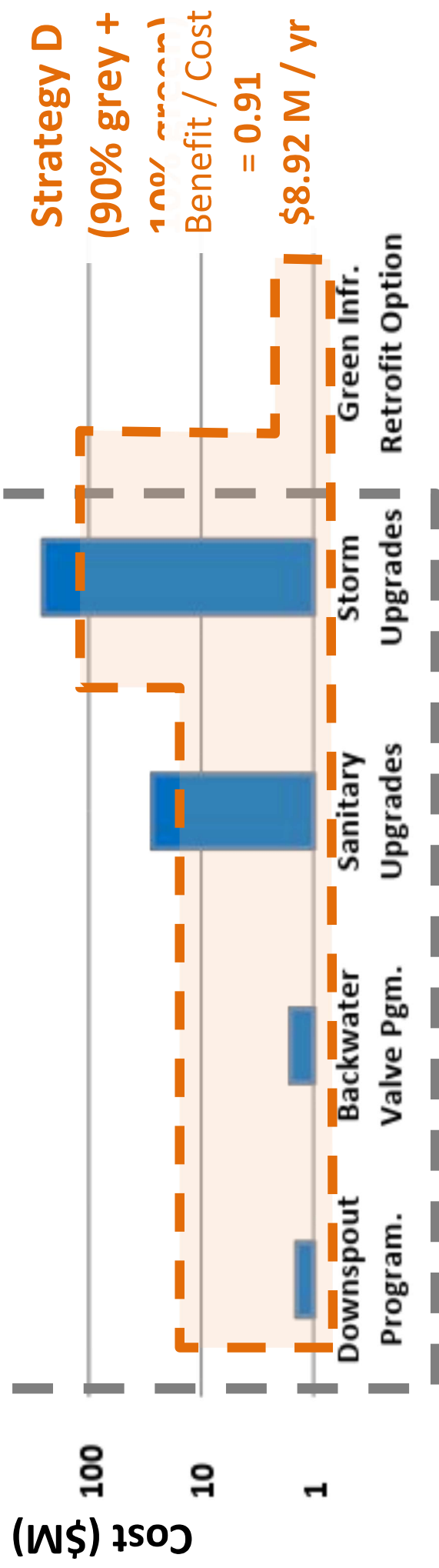


50 Shades of Grey to Green Strategies



WEAO paper :
<https://bit.ly/2VEIMtb>

Strategy A (grey)
Benefit / Cost = 2.52
\$ 2.83 M / yr



Conclusions

- **New regulations, guidelines require design & actions to adapt to future climate:**
 - Resiliency gaps are in historical service areas under existing weather stresses.
 - Improving existing infrastructure levels of service (first step) has a climate adaptation co-benefit.
- **Standards, programs and capital works increase resiliency with varying degrees of cost-effectiveness:**
 - Today's standards & low cost programs offer effective & timely flood risk reduction.
 - Grey & green infrastructure require assessment of cost effectiveness for flood remediation. Recent studies have gaps: see [Storm Warts](#).
- **Markham's Flood Control Program has a favourable benefit/cost ratio considering flood control benefits and full lifecycle cost accounting:**
 - Alternative strategies show lower cost effectiveness. See [WEAO 2019 Paper](#).
 - Upcoming National Research Council guidelines will help guide robust analysis.

Thank You

Questions ?

More Rob :

Blog: www.CityFloodMap.com

Podcast: [Open During Construction on iTunes](#)

Twitter: [@RobertMuir_PEng](#)



More City of Markham :

Web: www.markham.ca

Twitter: [@CityofMarkham](#)

Resources On Flood Risk Factors & Resiliency

- **Observed rain intensities decreasing in S. Ontario (Environment Canada data):**
 - <https://www.chijournal.org/C449>
 - <http://www.cityfloodmap.com/2018/07/decrease-in-southern-ontario-design.html>
- **Design rain intensities not increasing (engineering studies):**
 - <https://www.cityfloodmap.com/2018/03/extreme-rainfall-and-climate-change-in.html>
- **Predicted lower rainfall intensities in Ontario:**
 - <http://www.cityfloodmap.com/2018/04/climate-models-predict-decreasing.html>
- **Urbanization affects flood risk:**
 - <https://www.cityfloodmap.com/2016/08/urbanization-and-runoff-explain.html>
- **Historical design standards affect flood risk:**
 - <https://www.cityfloodmap.com/2018/03/construction-era-infrastructure.html>
- **Operational risk factors vs climate change risks (GO Train):**
 - <https://www.cityfloodmap.com/2015/12/toronto-go-train-flood-avoidable-july-8.html>
- **Lake Ontario levels in 2017 barely above historical extremes:**
 - <https://www.cityfloodmap.com/2017/09/toronto-island-flooding-2017-were-lake.html>
- **Green infrastructure lifecycle costs:**
 - <https://www.cityfloodmap.com/2018/07/green-infrastructure-capital-and.html>
- **Grey and green infrastructure strategies for flood control, erosion mitigation and water quality improvement:**
 - <https://www.cityfloodmap.com/2019/02/an-economic-analysis-of-green-v-grey.html>