



Management of Toronto's Watercourses over nearly three Decades

(Reactive, Proactive & Adaptive Management)

Natural Channels Conference *June 8-10, 2026*

Session G Management of Natural Channel Assets and Urban Infrastructure

Bill Snodgrass^{1,2}, Adam Zietara¹, Kumar Sivakumaran^{3,2}, Daniel McCreery³, Rod Anderton^{1,2,4}

¹Toronto Water(TW), City of Toronto, Canada

²Retired from Toronto; ⁴Consultant

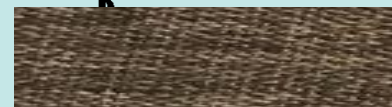
³Engineering & Construction Services, City of Toronto, Canada

WWFMP Philosophy - Proactive

- Wet weather flow issues to be managed on a watershed basis



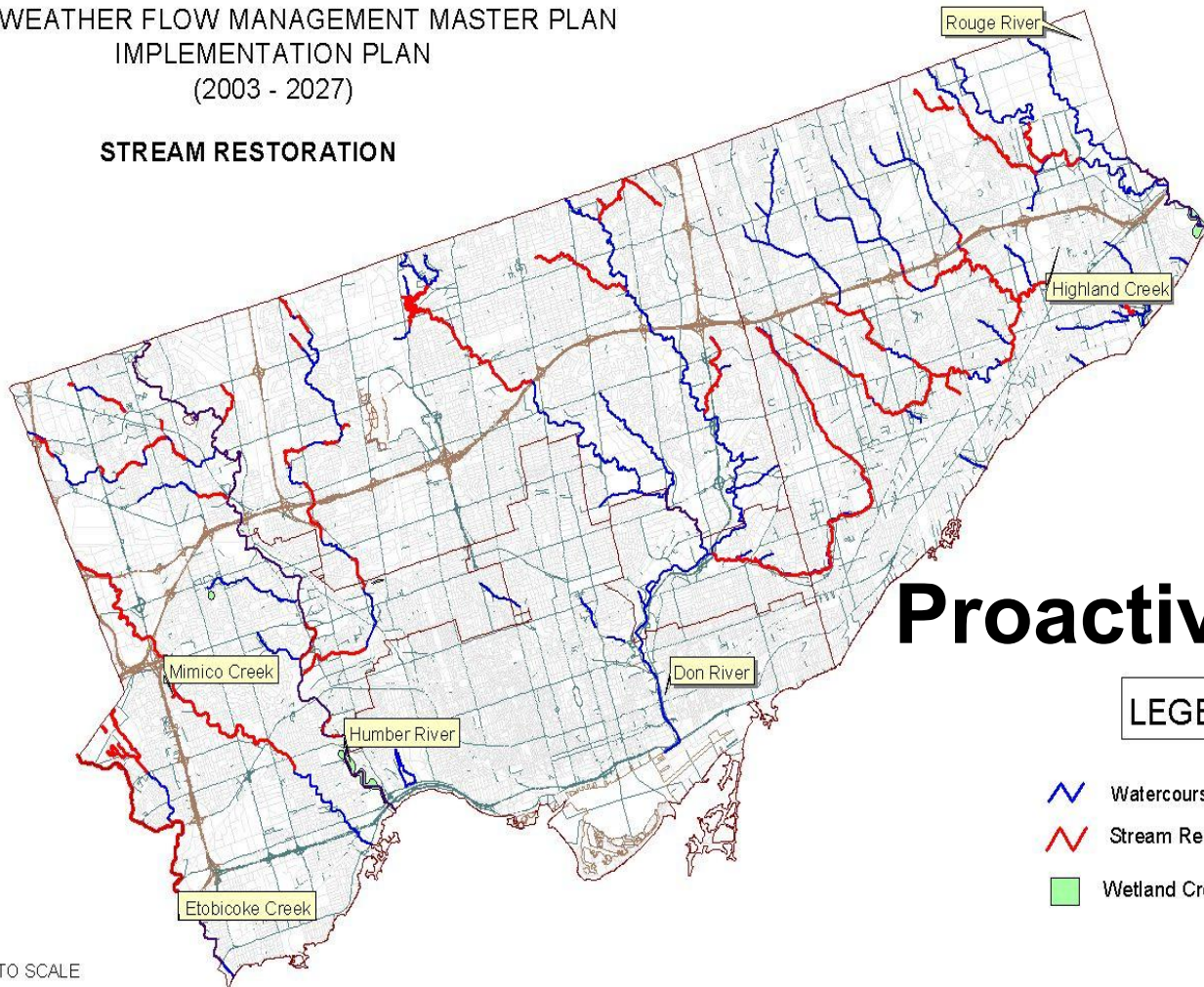
- Stormwater Management using a hierarchical approach:
 - Source Controls – lot level
 - Conveyance System – road right of way
 - End-of-pipe – before stormwater is discharged
- Consider Source control measures first and balance them with the other measures in regards to effects on Environmental // Social // Economic Factors



WWFMP (2003) Stream Restoration 122 km of Creek in 25 Year, 122 M

CITY OF TORONTO
WET WEATHER FLOW MANAGEMENT MASTER PLAN
IMPLEMENTATION PLAN
(2003 - 2027)

STREAM RESTORATION

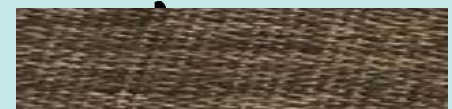
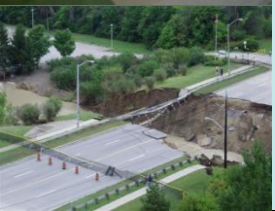


Proactive

LEGEND

-  Watercourse
-  Stream Restoration
-  Wetland Creation/Restoration

Aug 19 2025 Storm - Finch @ Black Creek

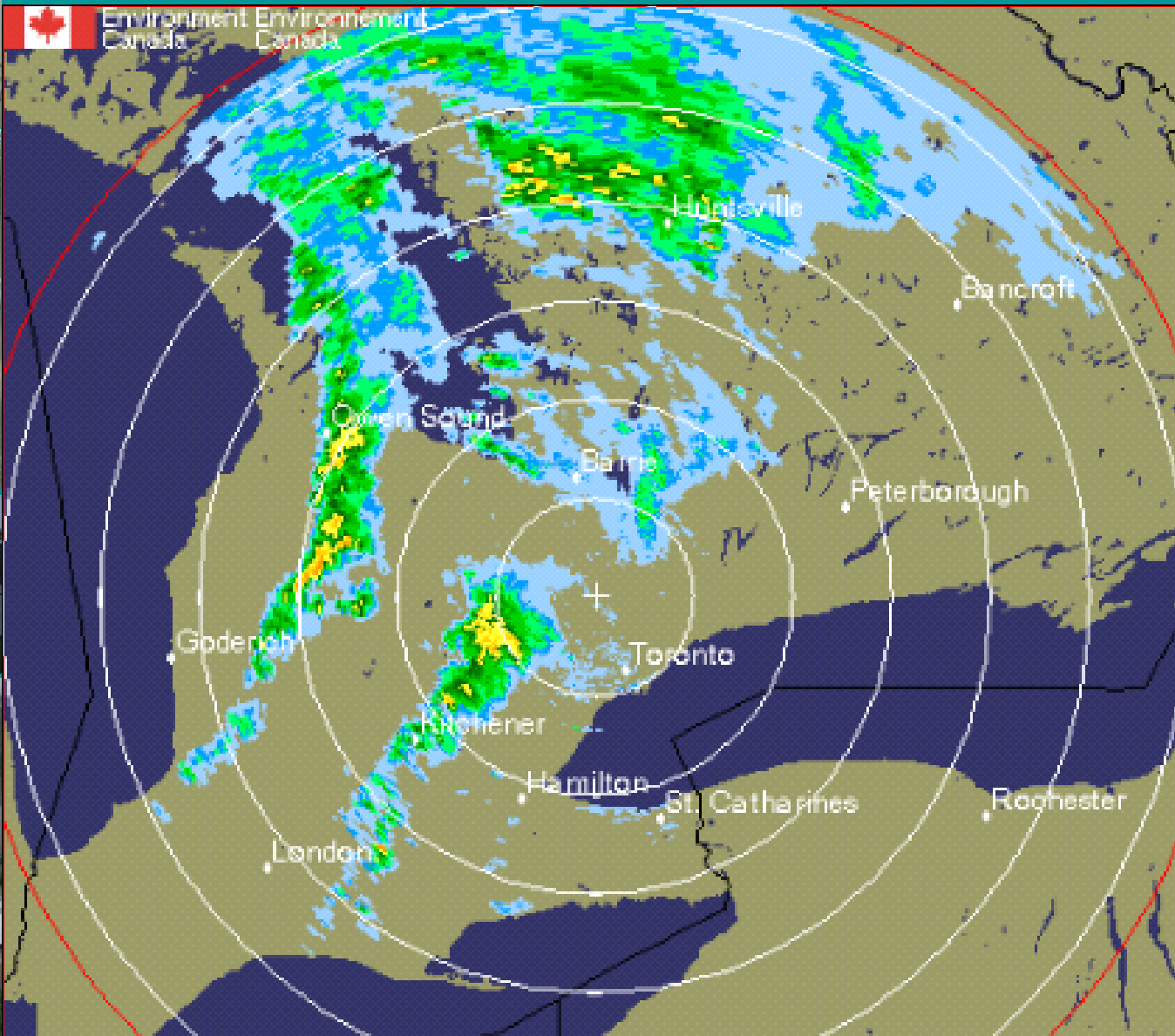
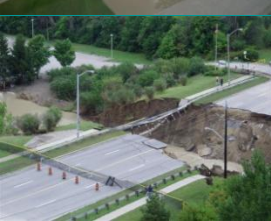


Characteristics of August 19, 2005 Storm

- 2-3 hour storm
- exceeded 1 in 100 year storm in north part of the City
 - Highway 401 to Steeles Avenue corridor
- City of Toronto rain gauge station recorded 153 millimetres



August 19 – 3:00 pm



Environment Canada
Environnement Canada

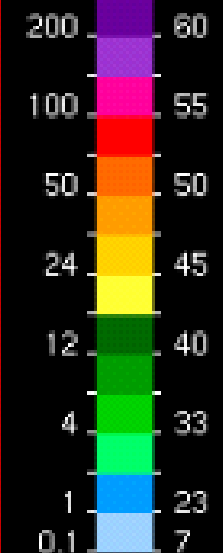
King City
WKR

1800 UTC
2005-08-19

Scale/Échelle:
1km/Pixel

40 KM

Rain/Pluie
mm/hr dBZ

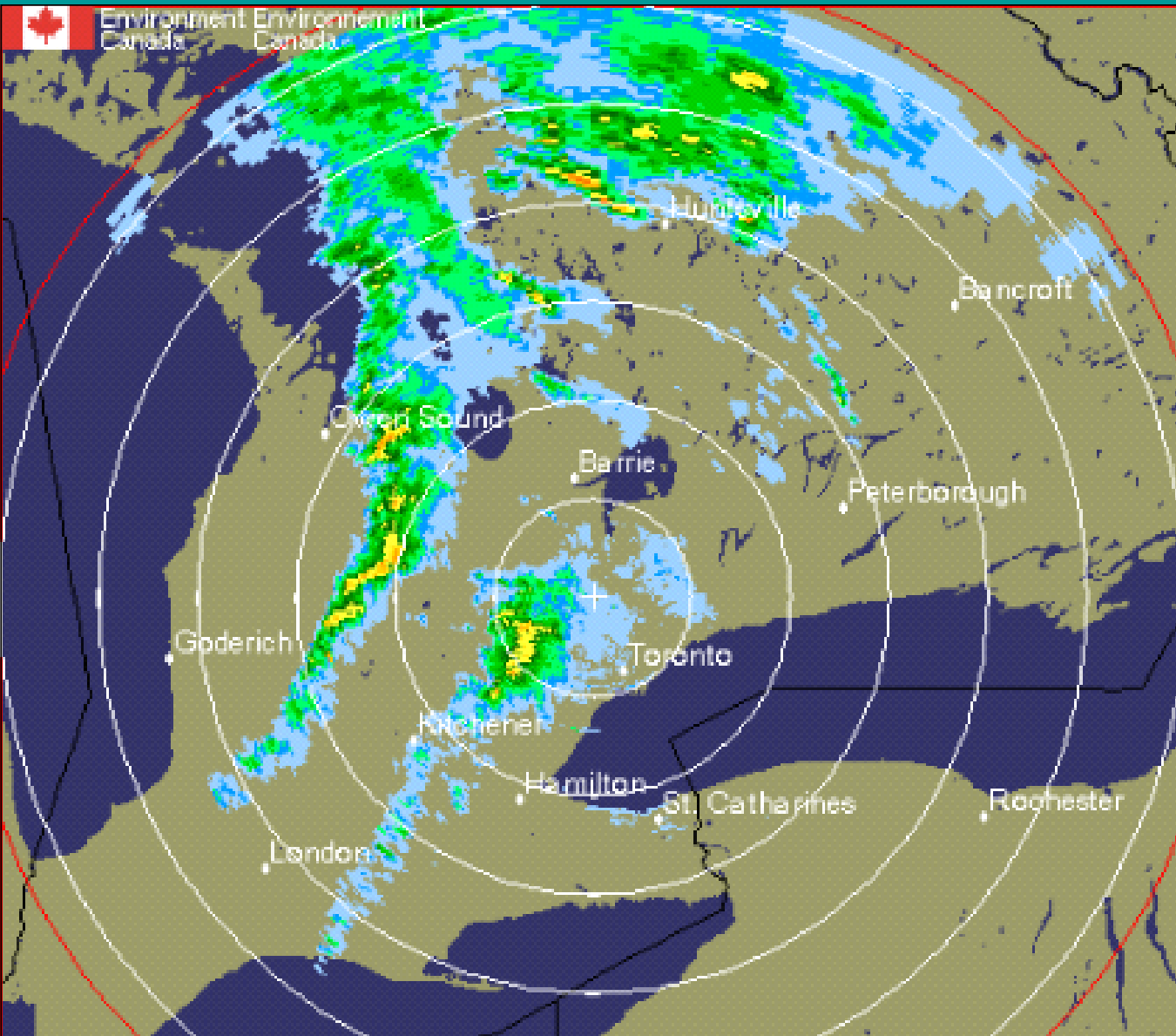
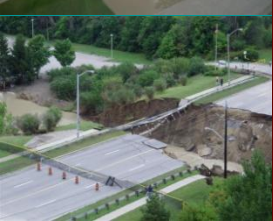


CAPPI 1.5 km

Noise/Bruit: 51.2

Elev/Alt: 0.24

August 19 – 3:30 pm

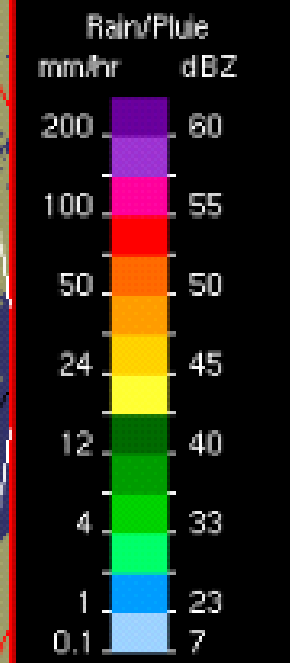


Environment Canada / Environnement Canada

King City WKR

1830 UTC
2005-08-19

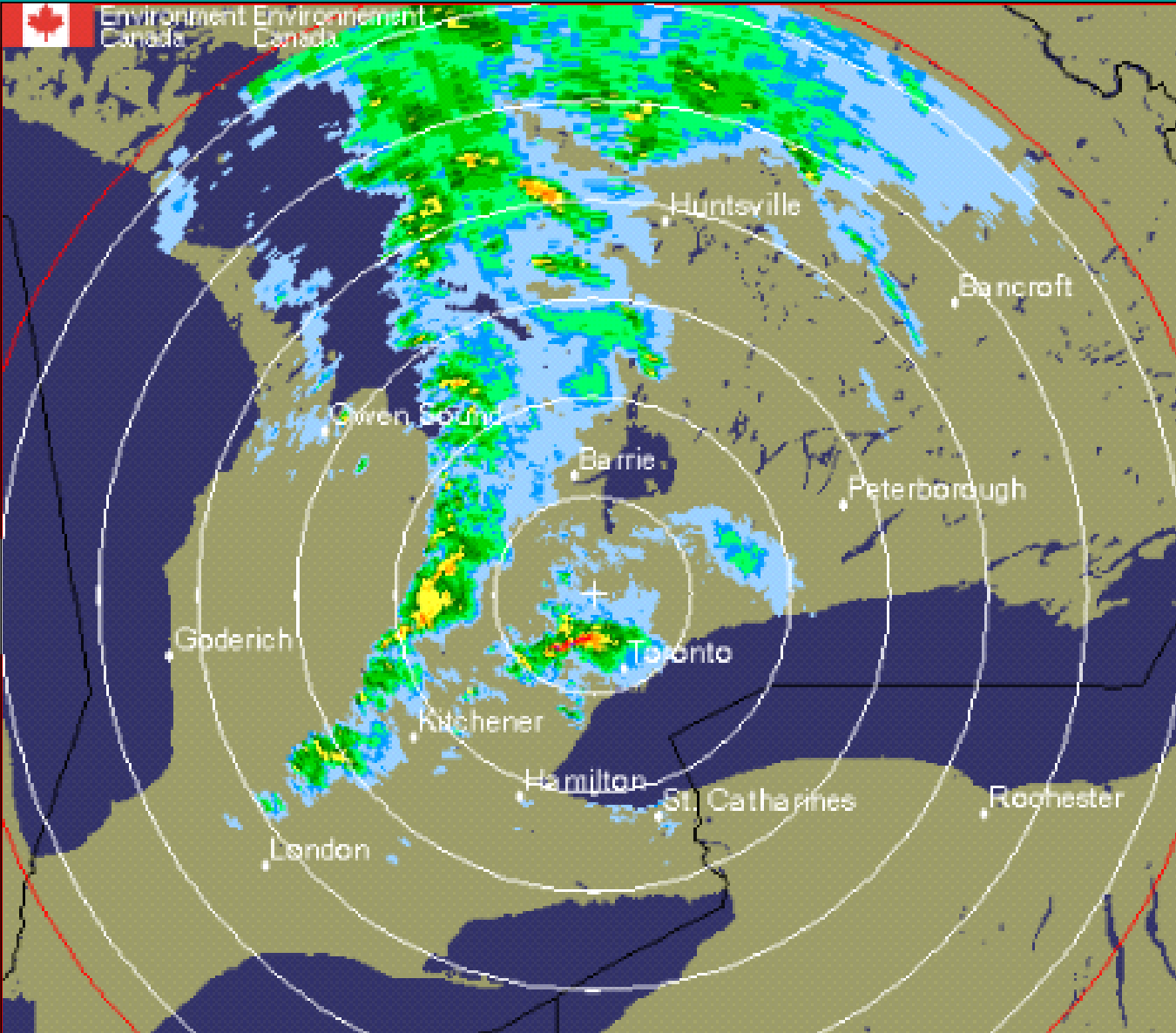
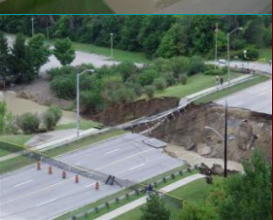
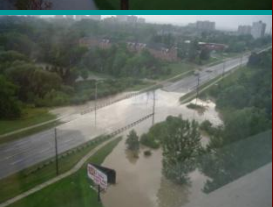
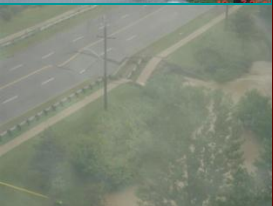
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40 KM |



CAPPI 1.5 km

Noise/Bruit: 51.2
Elev/Alt: 0.24

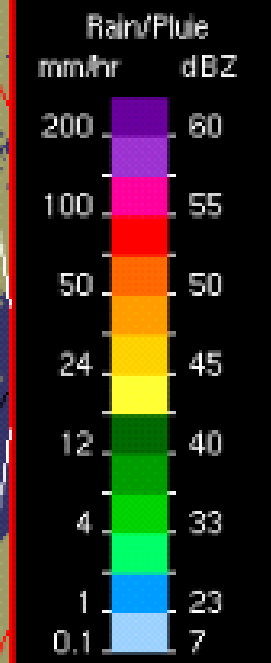
August 19 – 4:10 pm



Environment Canada / Environnement Canada

King City
WKR
1910 UTC
2005-08-19

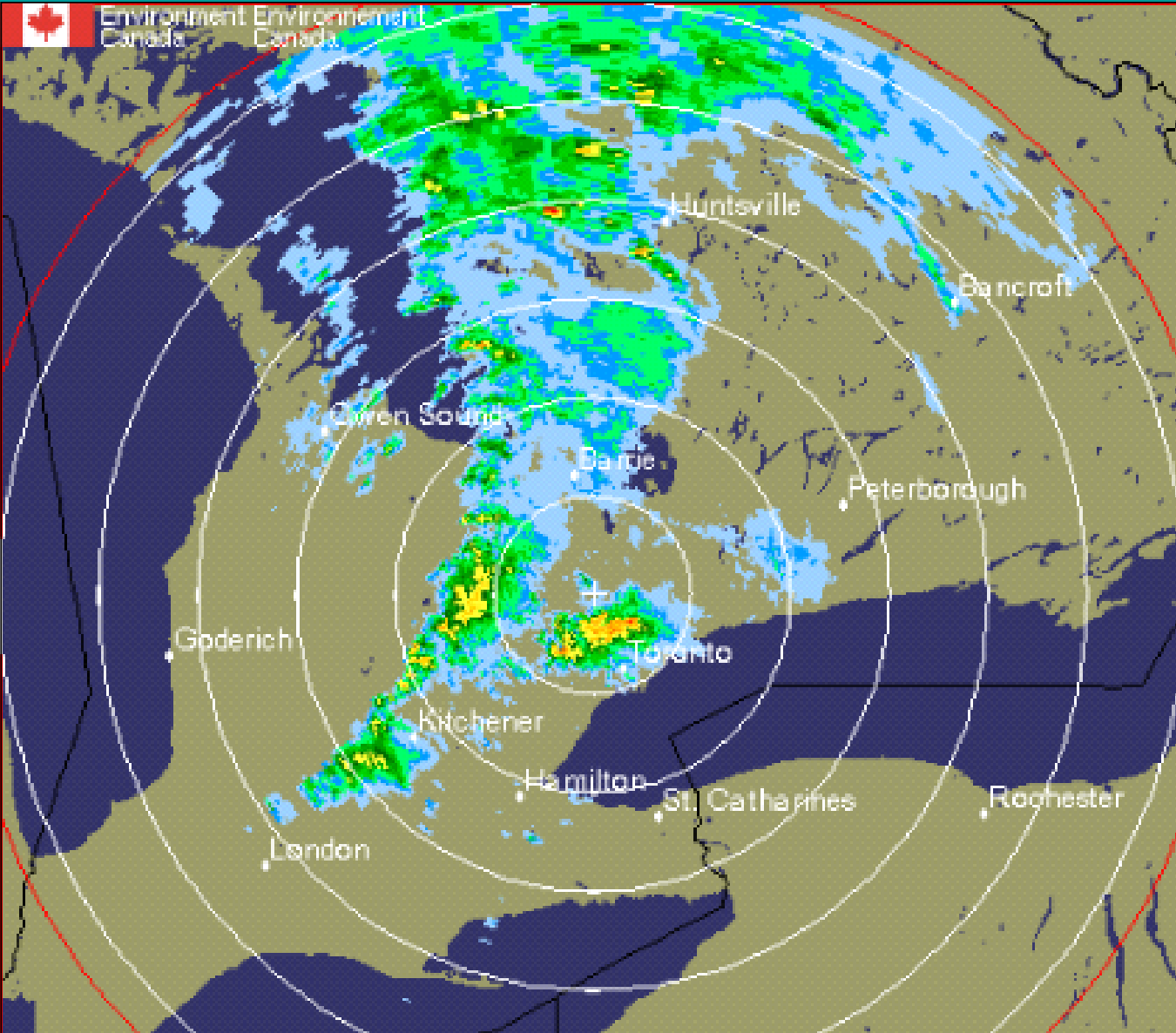
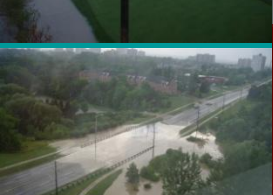
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CAPPI 1.5 km

Noise/Bruit: 51.2
Elev/Alt: 0.29

August 19 – 4:30 pm

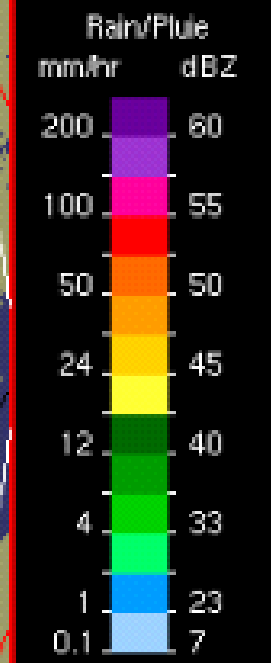


Environment Canada / Environnement Canada

King City WKR

1930 UTC
2005-08-19

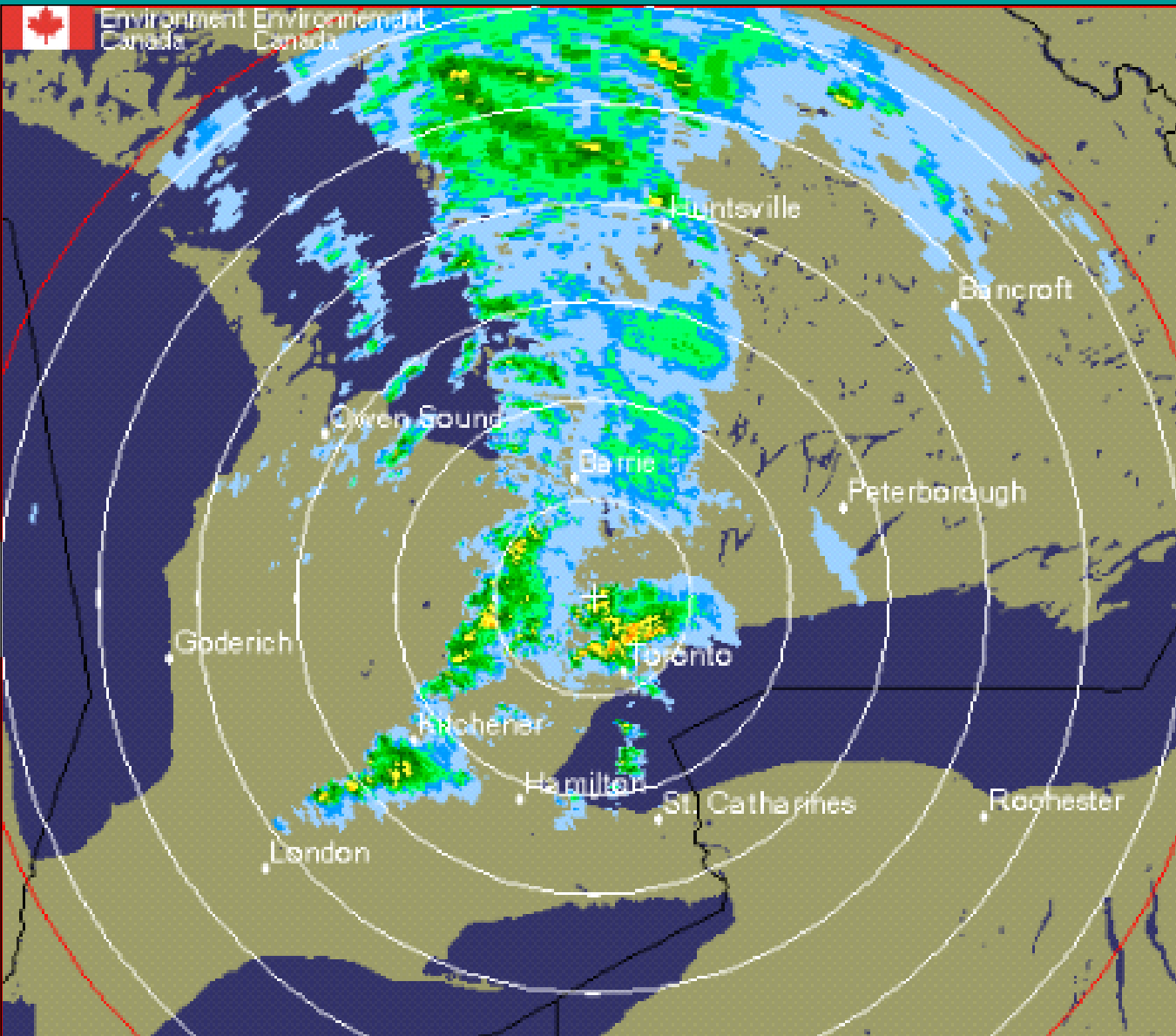
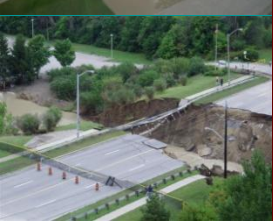
Scale/Échelle:
1km/Pixel
40 KM |



CAPPI 1.5 km

Noise/Bruit: 51.2
Elev/Alt: 0.29

August 19 – 4:50 pm

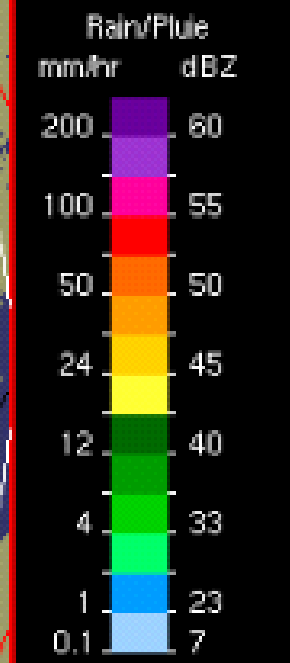


 Environment Canada / Environnement Canada

King City
WKR

1950 UTC
2005-08-19

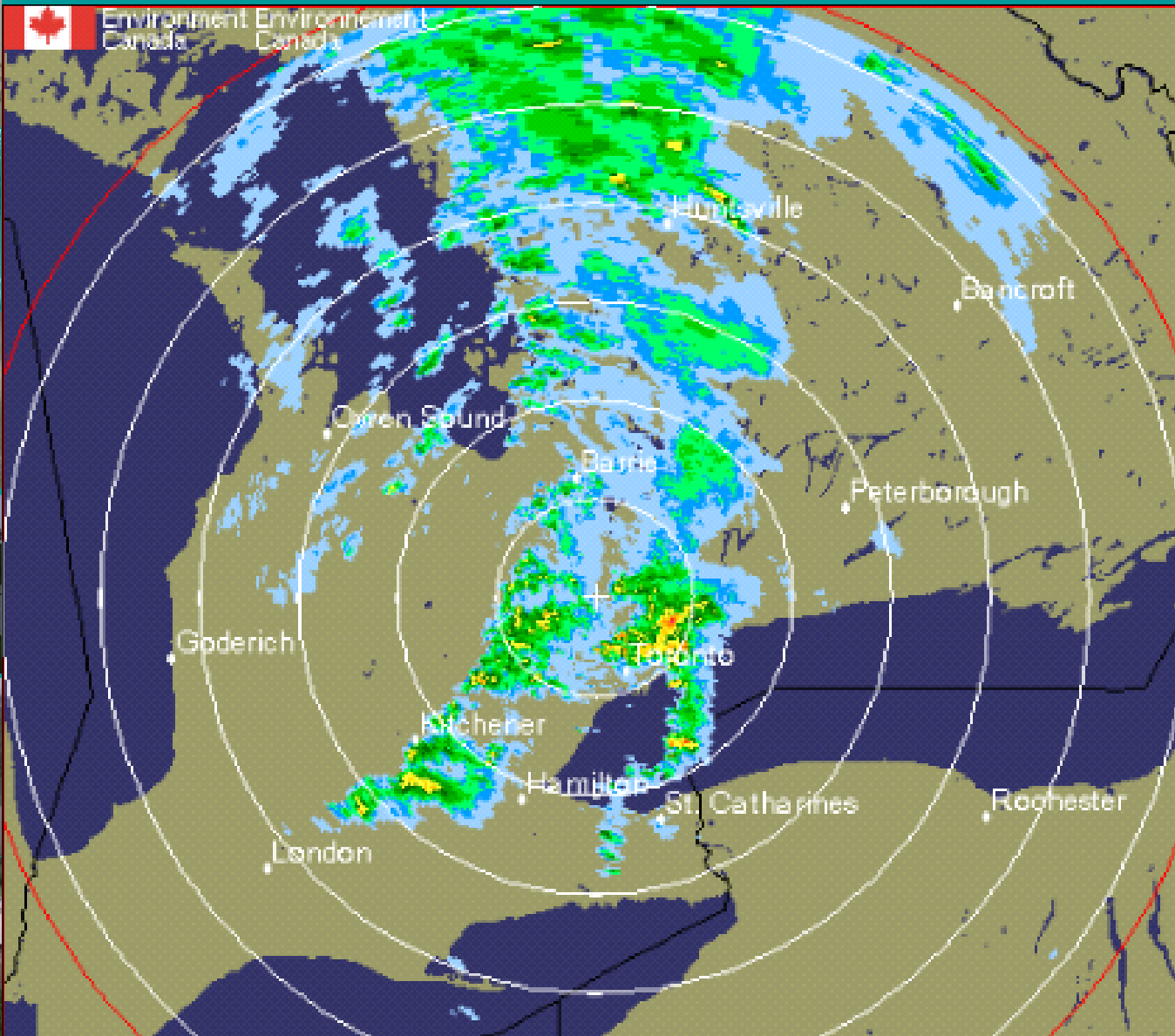
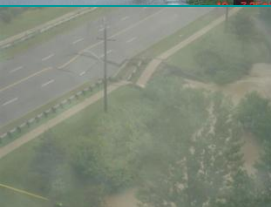
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40 KM |



CAPPI 1.5 km

Noise/Bruit: 51.2
Elev/Alt: 0.21

August 19 – 5:10 pm

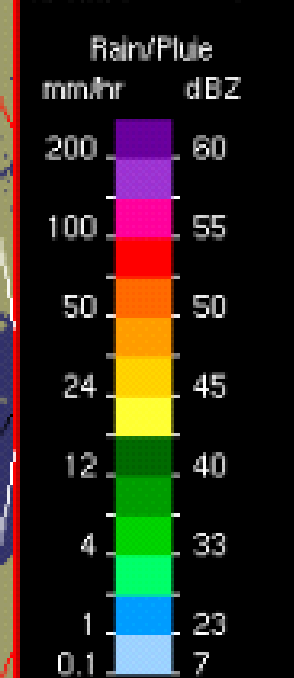


Environment Canada / Environnement Canada

King City WKR

2010 UTC
2005-08-19

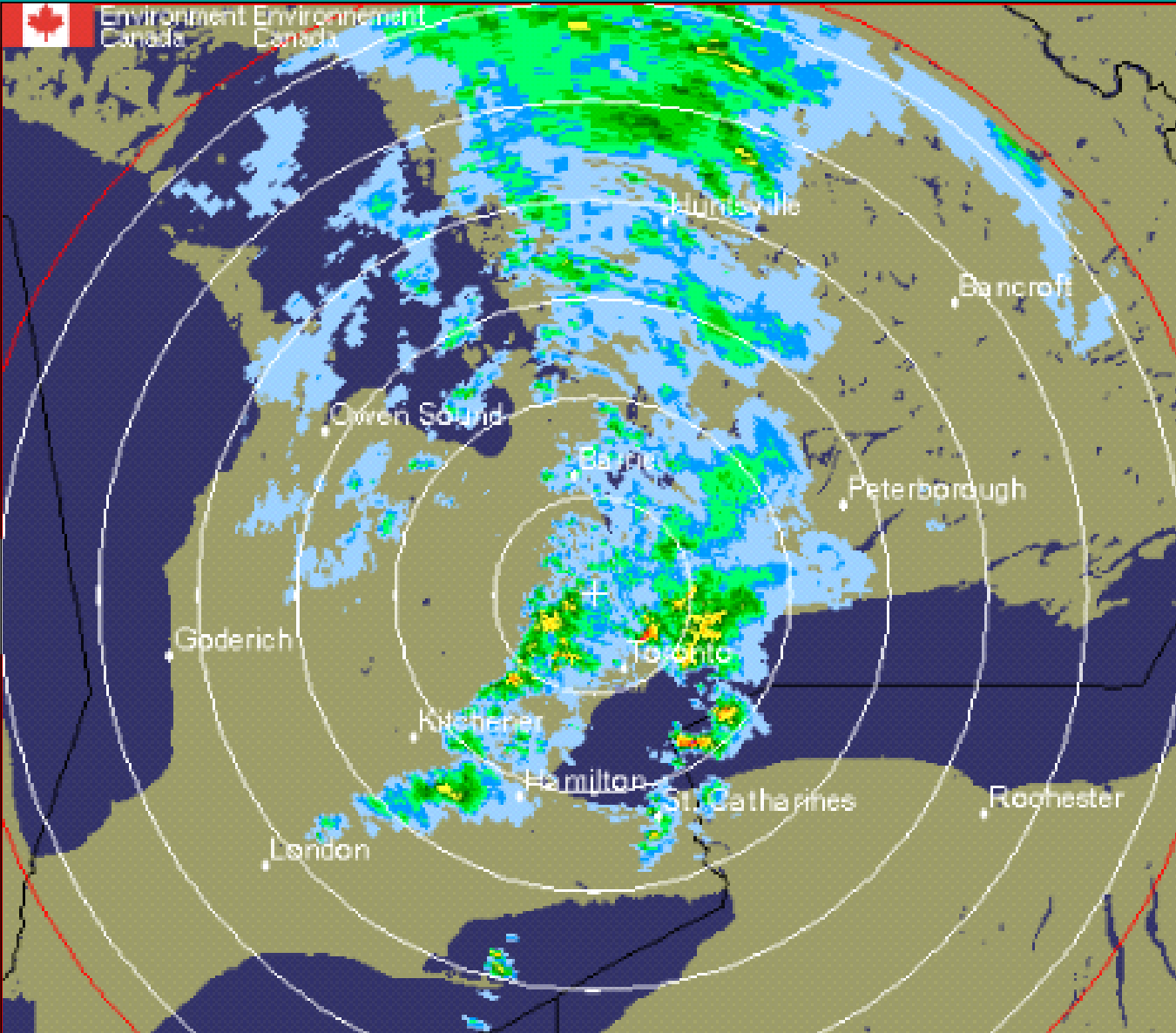
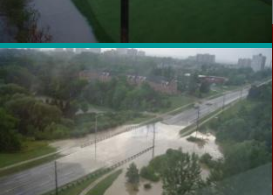
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CAPPI 1.5 km

Noise/Bruit: 51.2
Elev/Alt: 0.24

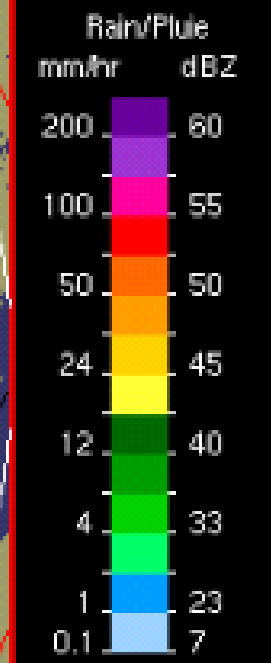
August 19 – 5:30 pm



Environment Canada / Environnement Canada

King City WKR
2030 UTC
2005-08-19

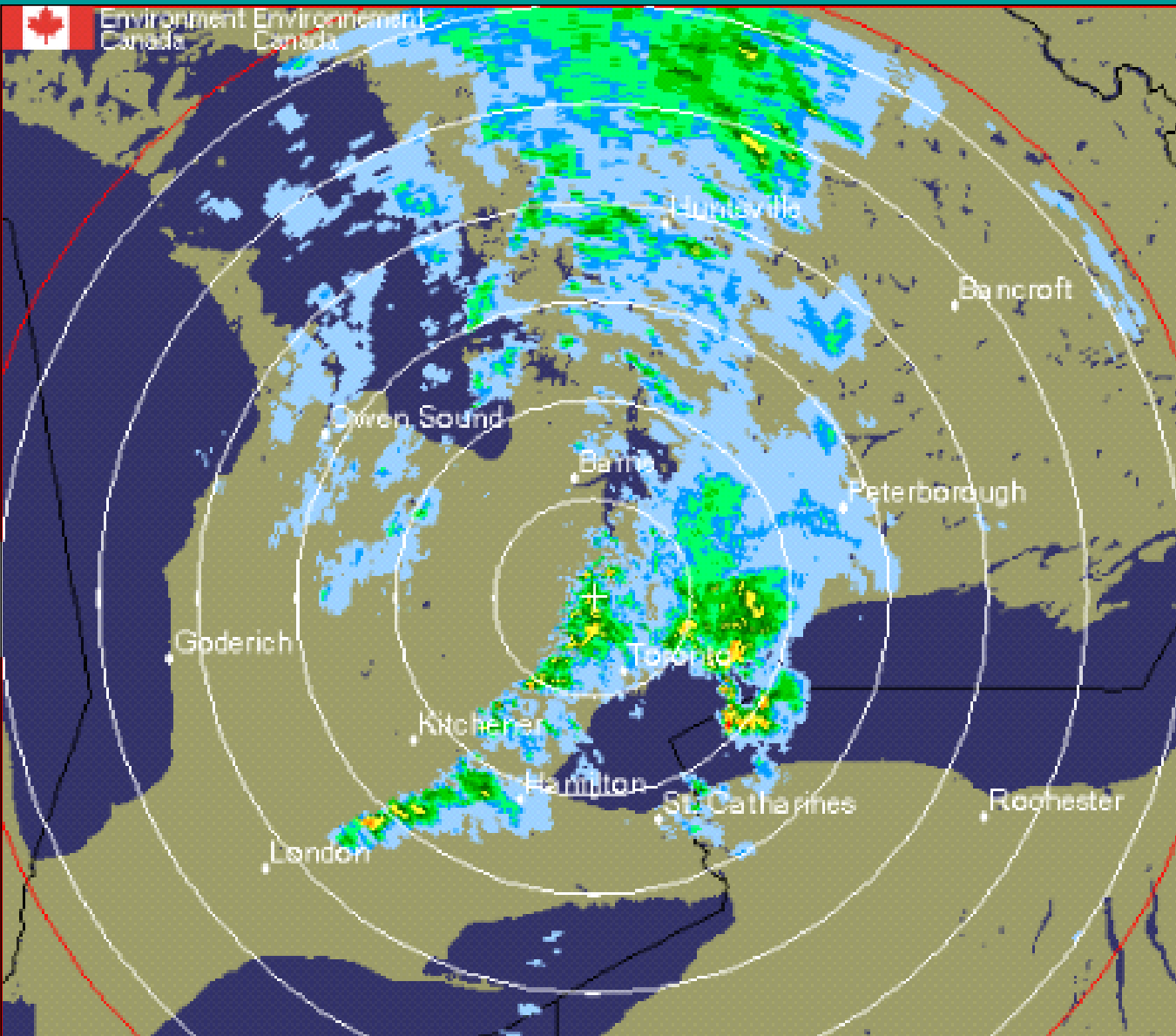
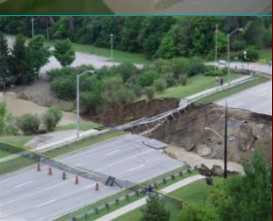
Scale/Échelle:
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40 KM |



CAPPI 1.5 km

Noise/Bruit: 51.2
Elev/Alt: 0.29

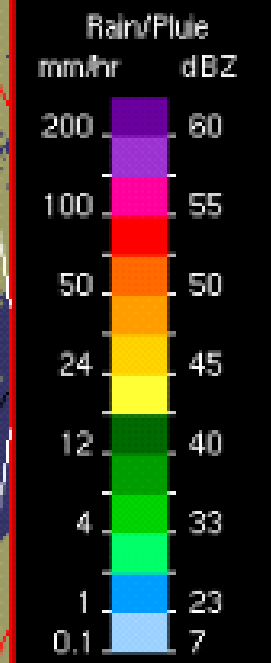
August 19 – 5:50 pm



Environment Canada / Environnement Canada

King City WKR
2050 UTC
2005-08-19

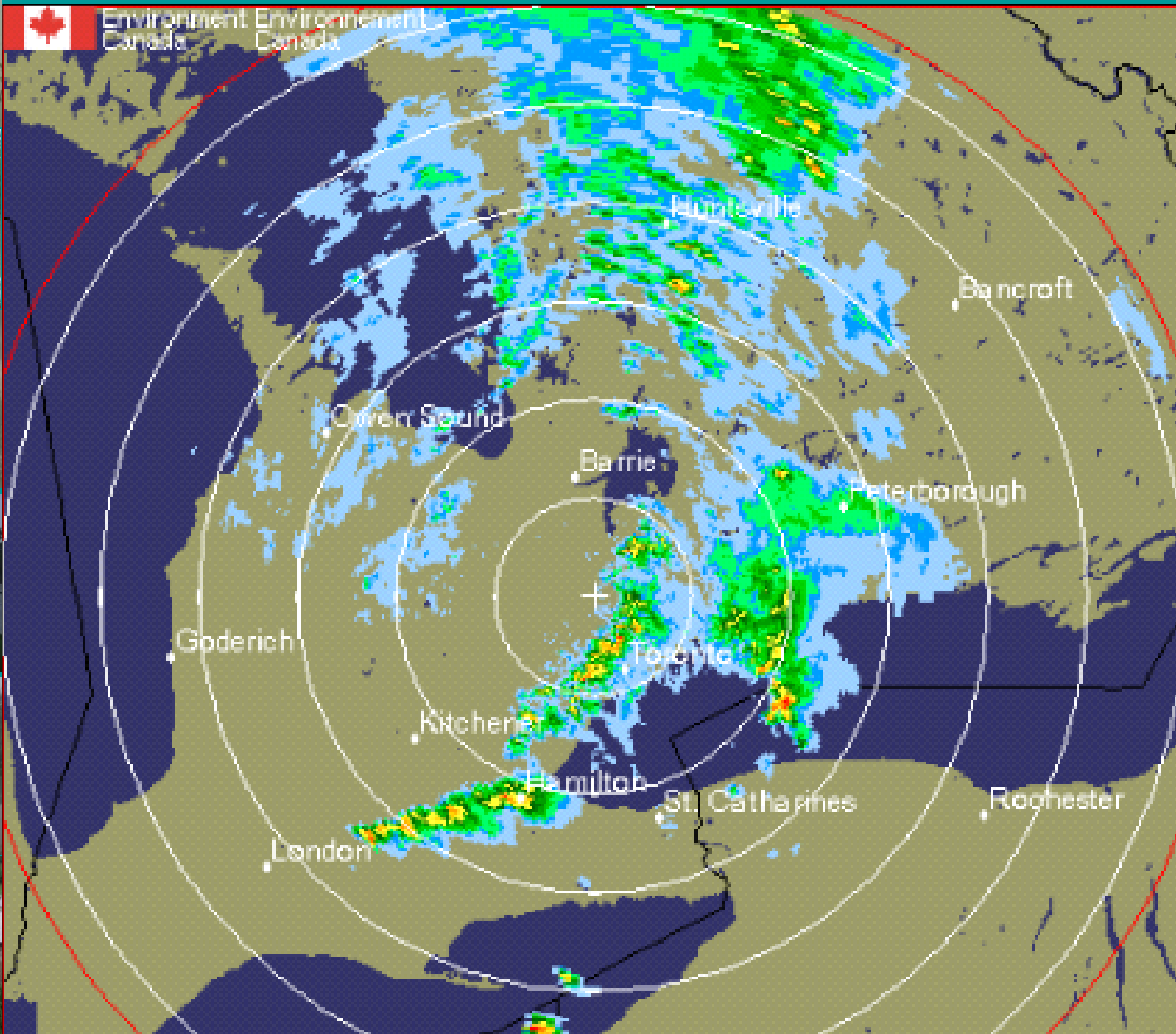
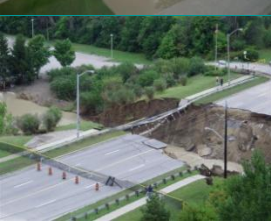
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40 KM |



CAPPI 1.5 km

Noise/Bruit: 51.2
Elev/Alt: 0.31

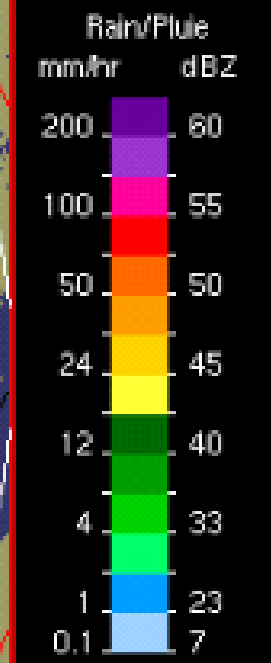
August 19 – 6:10 pm



Environment Canada / Environnement Canada

King City
WKR
2110 UTC
2005-08-19

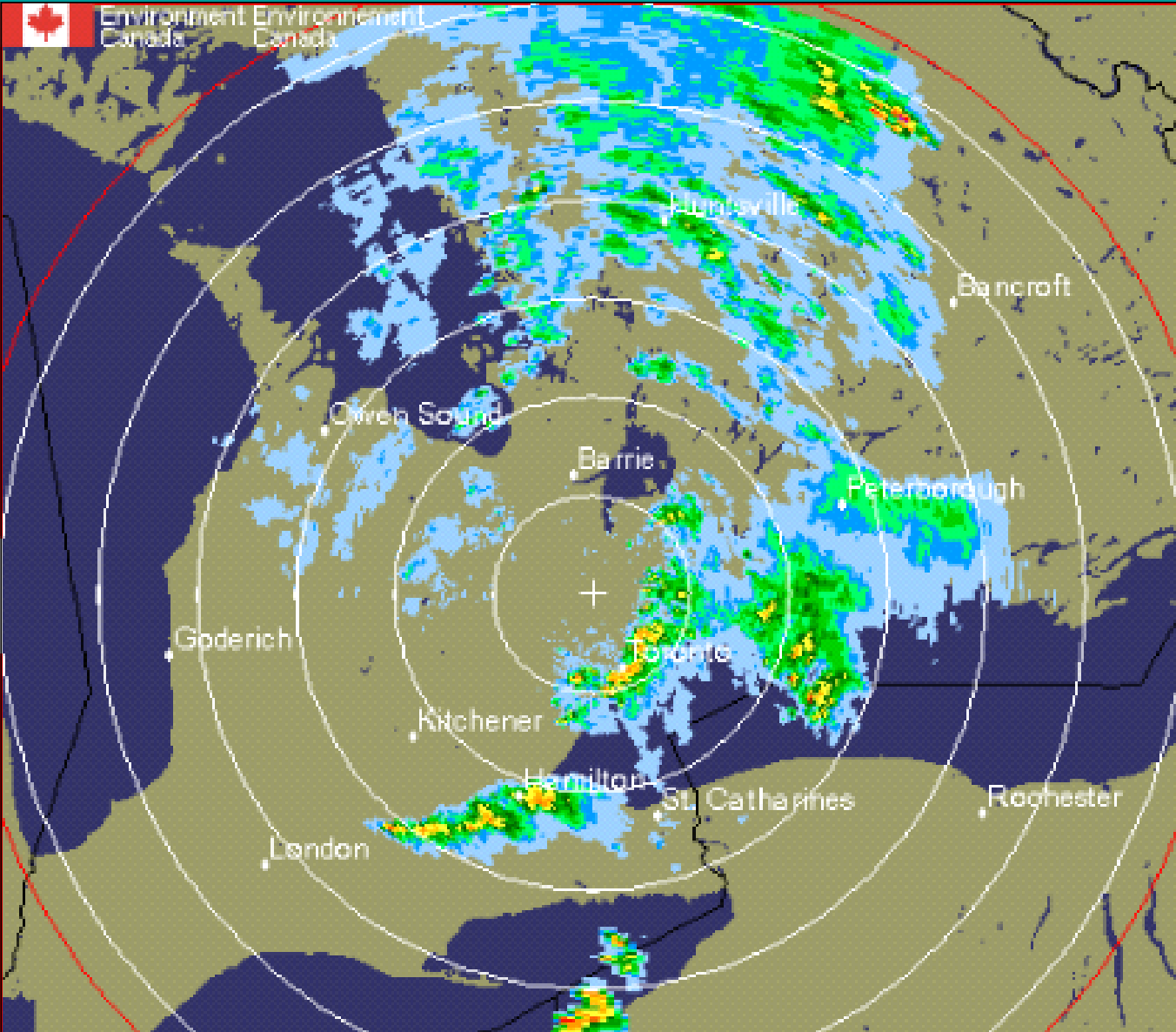
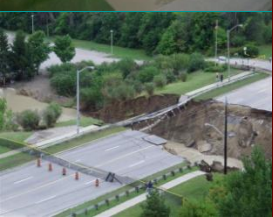
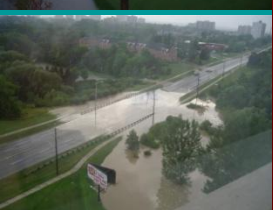
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40 KM |



CAPPI 1.5 km

Noise/Bruit: 51.2
Elev/Alt: 0.29

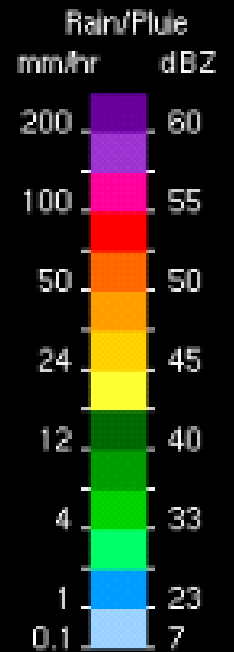
August 19 – 6:30 pm



Environment Canada / Environnement Canada

King City
WKR
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2005-08-19

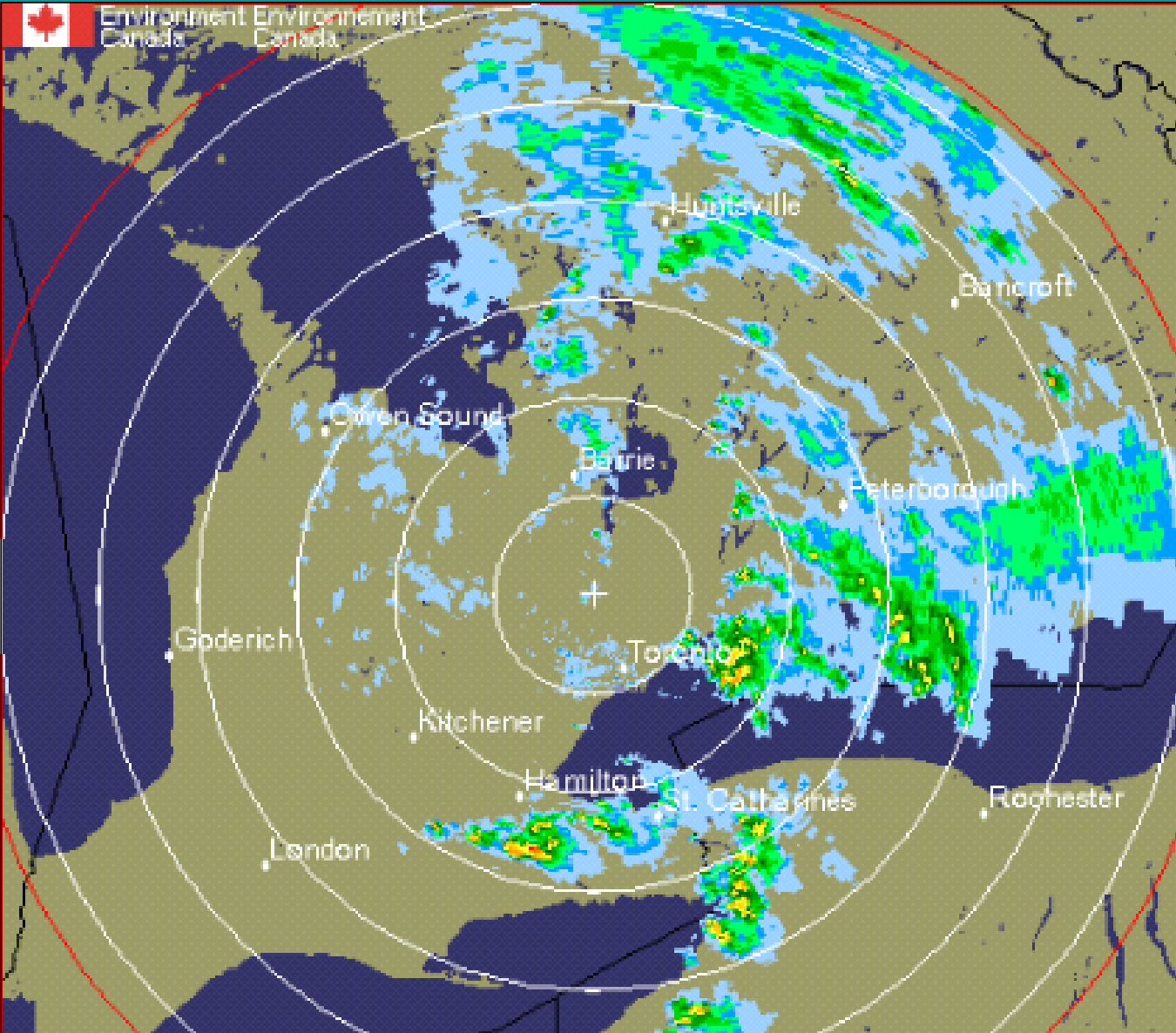
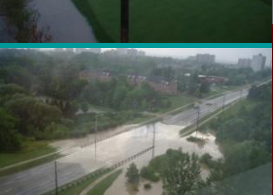
Scale/Échelle:
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40 KM |



CAPPI 1.5 km

Noise/Bruit: 51.2
Elev/Alt: 0.31

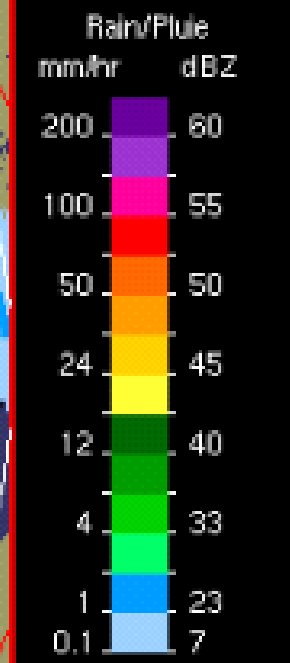
August 19 – 7:30 pm



King City
WKR

2230 UTC
2005-08-19

Scale/Échelle:
1km/Pixel
40 KM |



CAPPI 1.5 km

Noise/Bruit: 51.2
Elev/Alt: 0.31

Rain Gauge Data

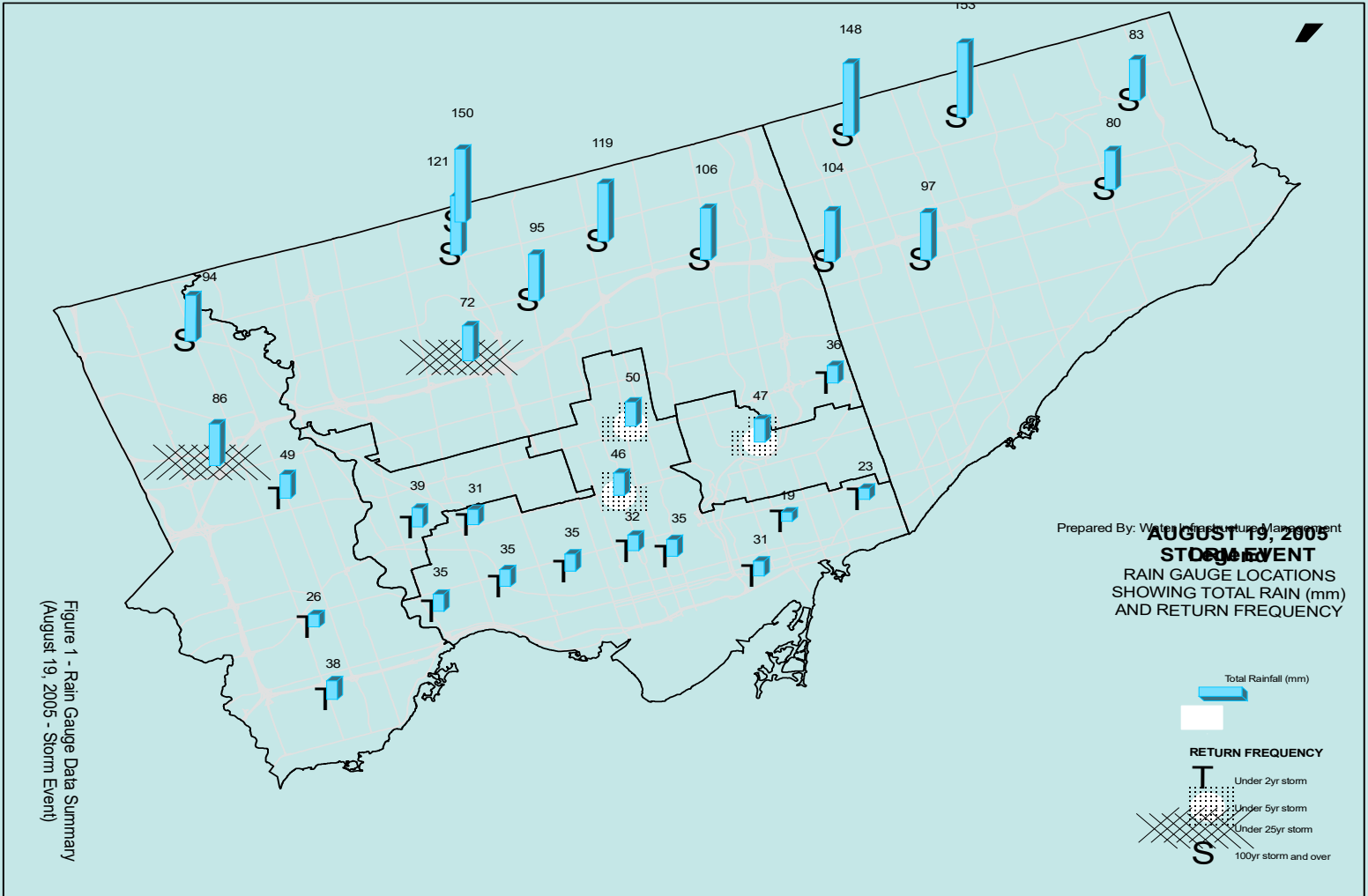
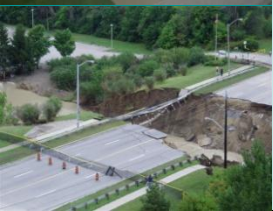
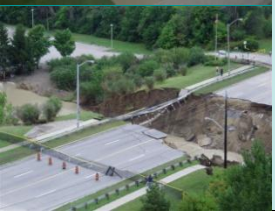
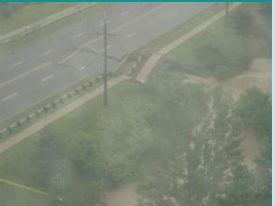


Figure 1 - Rain Gauge Data Summary
 (August 19, 2005 - Storm Event)



Damage Summary

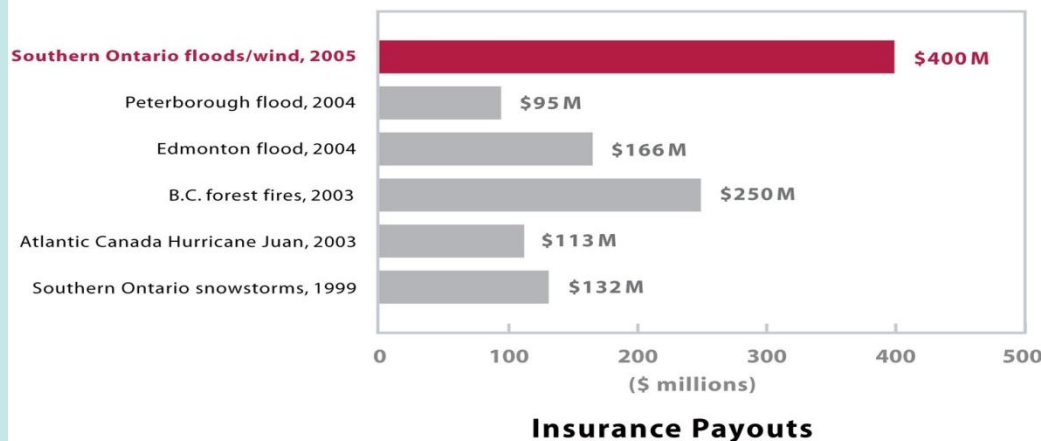
- Flash floods of creeks, rivers and ravines
- Overflowed stream banks
- Watercourse bank erosion
- Damage to public and private infrastructure and property
- Sewer Backups



Insurance Bureau of Canada (2005)

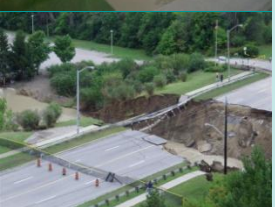
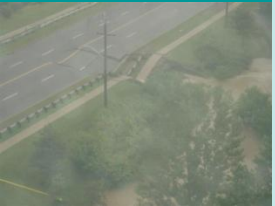
- most expensive natural disaster in Ontario history
- expect to pay out more than \$400 million
- impact from Kitchener-Waterloo to Toronto to Durham & beyond
- vast majority of claims for sewer back-ups

Recent Canadian Natural Disasters



Stream Erosion

- Over 140 sites (Toronto Water, Parks & TRCA) were investigated to prioritize repairs
- Several TW sites – STS pipe was visible or undercut
- One site – lost the STS
- Lessons from May 2000 storm – took 4 - 5 years to repair $\frac{3}{4}$ of sites



An aerial photograph of a river valley. A pink line is drawn across the image, following a path that appears to be a sewer line. The line starts from the left edge, moves diagonally down and right, then turns more sharply down and right, and finally turns slightly up and right. A white arrow points from the text 'Trunk Sanitary Sewer' to the pink line. The river is visible in the center and right, with a meander cutoff. The surrounding terrain is hilly and covered with sparse vegetation.

Trunk Sanitary Sewer

“An Act of God” - Meander cutoff occurred, MH and STS sections were lost

Break At Meander Cutoff
AUGUST 2005 (POST-STORM) Ortho Images

Trunk Sanitary Sewer



Technical Services
Survey and Mapping Services
Mapping Services
18 Dyas Rd, 4th Floor
Toronto, Ontario M3B 1V5
Tel: 416-392-7665 Fax: 416-392-0081

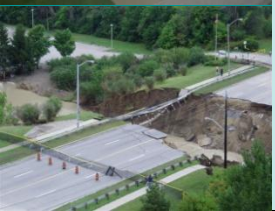
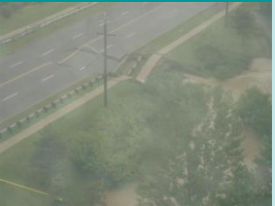


0 5 10 20 Meters

“Time of photo – about one week later – Aug 26-27

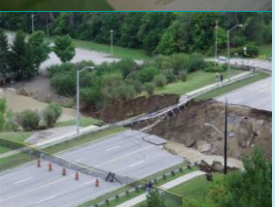
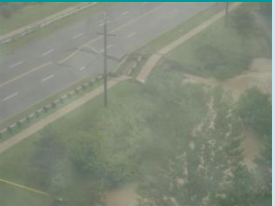
Highland Creek Trunk Sanitary Sewer Repair

- Creek redirected and trench excavated to intercept the sanitary flows
- Spill contained by Monday evening (Aug 12)
- Permanent repair of the trunk sewer completed fall 2005 (Emergency Tender)
- Design (and EA in parallel) for most appropriate method of protection from further damage for this valley segment initiated in Sept 2005



What have I observed: (i) Management Issues & (ii) changes over < ~ 3 decades

- 1 Knowledgeable Team
- 2 Regulatory Management
- 3 Design
- 4 Construction & Water Management
- 5 Mother Nature at 10 years
- 6 – 13 Etc





1. Knowledgeable Team- A Team of 36 people

- John Mackay, Kazmir Kaczor, Alonso Walters, Greg Snooks and Sam Grossi - **Construction**
- Don Sorel, Dennis Snow, Paul Viggiani, **Const Management**
- Lee Anne Jones, Annette Kopec **Finance**
- Mario Crognale, Frank Quarisa **City Manag.**
- Martin Bugden, Tracey Keeso, Frank Trinchini, Paul Clements, M D'Andrea, Tony Pagnanelli, J P'Ng,
- Kumar Sivakumar, Cliff Chu, Beth McEwen, Chris Hope, **P M**
- Craig Macrae, Brian Hindley, Dave Maunder, et al Aquafor-Beech, **Geomorphic and Fish Consultants**
- Paul Ainslie, City Councillor, Ward 43 – Local Councillor
-
- Diane Chester **Communications**

- **Agency Review Staff** (W May, M Preston, Helal Sayeed, L Matos, S Woolfenden, L Cook, S Dhalla, S Heuchert, . . .)

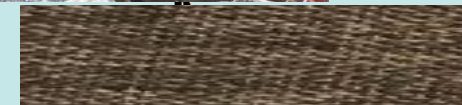


1. Knowledgeable Field work Leaders (In-Field adjustments)



2. Regulatory : Emergency Works & State of Good Repair

- Phone Calls to DFO, MNR, & TRCA to set up procedures
- Response to May 12, 2000 and August 19, 2005 Storms,
- Response to many other storms
- Work Locations Dictated by Immediate Need
- Design based on geomorphic principles
- Guided by GSMP where completed

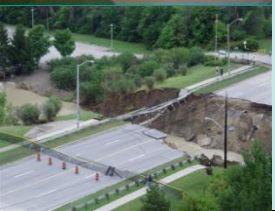


2. Regulatory Changes (2+ decades; urban erosive stream channels)

- MNR – LRIA decreasing in 2005
- DFO – 2005 – key regulator
 - Riffle Pool design – self compensating
 - Late 2000s – decreased role
 - Mid 2015 onward – increased, more strategic role
- CA's – flood and erosion – key role since 2022; fish habitat – decreased role
- MECP – rare and endangered species (recent role)

3. Design, Emergency Works 2005 & EA

Exposed Trunk Sanitary Sewer



3 Design - Place Creek where Mother Nature left it after Aug 19 2005

Reactive Management with Planning = Adaptive



NOI PLAN SHEET

GENERAL NOTES

1. SEE SET OF DRAWINGS TO BE USED IN CONJUNCTION WITH THIS DRAWING.
2. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY PERMITS AND APPROVALS FROM THE APPROPRIATE AGENCIES.
3. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY PERMITS AND APPROVALS FROM THE APPROPRIATE AGENCIES.
4. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY PERMITS AND APPROVALS FROM THE APPROPRIATE AGENCIES.

LEGEND

- THALWEG
- CREEK
- FLOODPLAIN
- ARBITRARY
- POB
- ROFFLE

Aqua

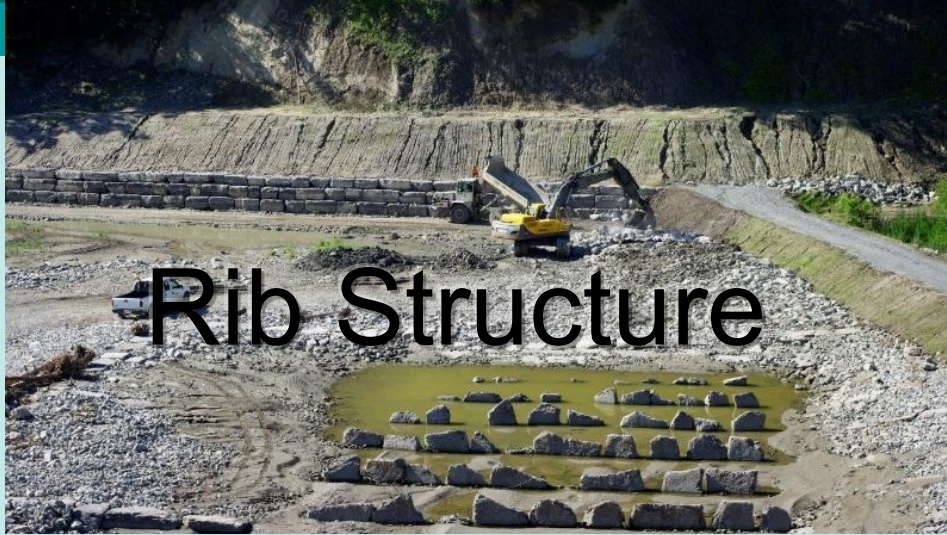
High Emer



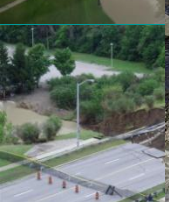
4. Construction & Water Management. - V S 8 Nov 2007



4. Nearing Completion Summer 2008

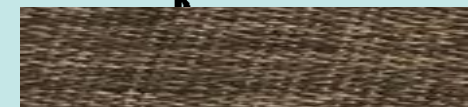


5. Depend on Mother Nature Oct 2015



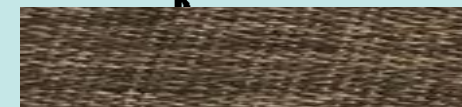
6 Evolution of Cost Estimates (STS protection since 1999)

- 1999 (Highland VS 4; tender) – 1M/km (10 ½ % to 2022)
- 2007 (City work, 44 m) – 6 M/km
- 2011-15 (VS4, 26 m, tendered) – 6M/km (5 ½ % to 2022)
- 2021-2023 (conceptual design for 3 Highland projects; 3 consultants) – ~10 -11 M/km



6. Costing (2nd International Conference, (Mar 1999))

- Costing – Range 200k/m - 800k/m
- Highland VS 4 Cost 1M/km – used for TW 2003 WWFMP Study
- (Removal of a concrete liner in trapezoidal channel and replacement with Natural Channel liner)
- Snodgrass W.J., & 11 Coauthors [D. MacMunford, R Levesque, B Trushinski, L Arishenkoff, C Macrae, T Patterson, M D'Andrea, D. Maunder, L Farrell, J Parish and M Ali} (1999) “Cost Estimation of Stream Restoration Projects and Engineered / Natural Channel Systems in Ontario”. Proceedings Second International Conference on Natural Channel Systems, Niagara Falls, Ontario, Canada, March 1-5, 1999 (Published by Credit Vallet Conservation).



7. GSMPs (Geomorphic Systems Master Plan) EA.

(Focus : Geomorphic System and Aquatic Habitat)

Watershed Scale

- WWFMP
- Highland Creek GSMP

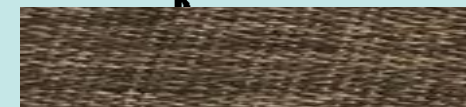
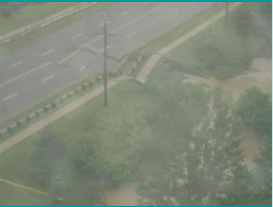
(Valley Segment (VS) to site scale)

Tributary Scale

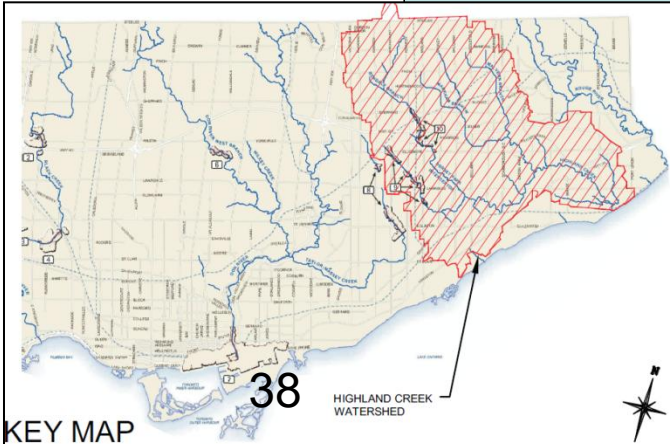
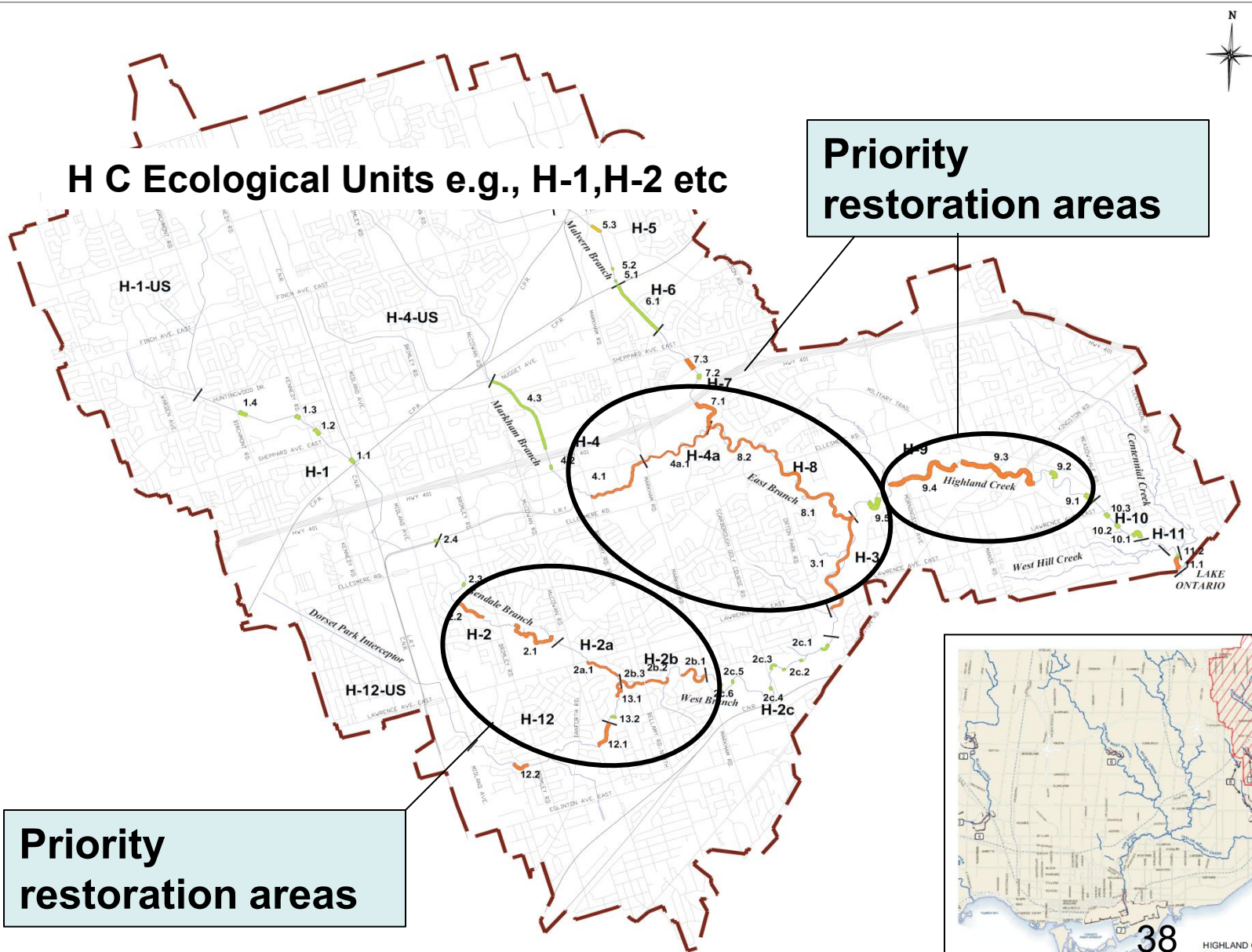
- Burke Brook
- Newtonbrooke
- Taylor Massey Creek
- Mud
- Duncan
- Wilket + 5 others

VS – Aquatic Ecological Unit

from Seelback in Michigan

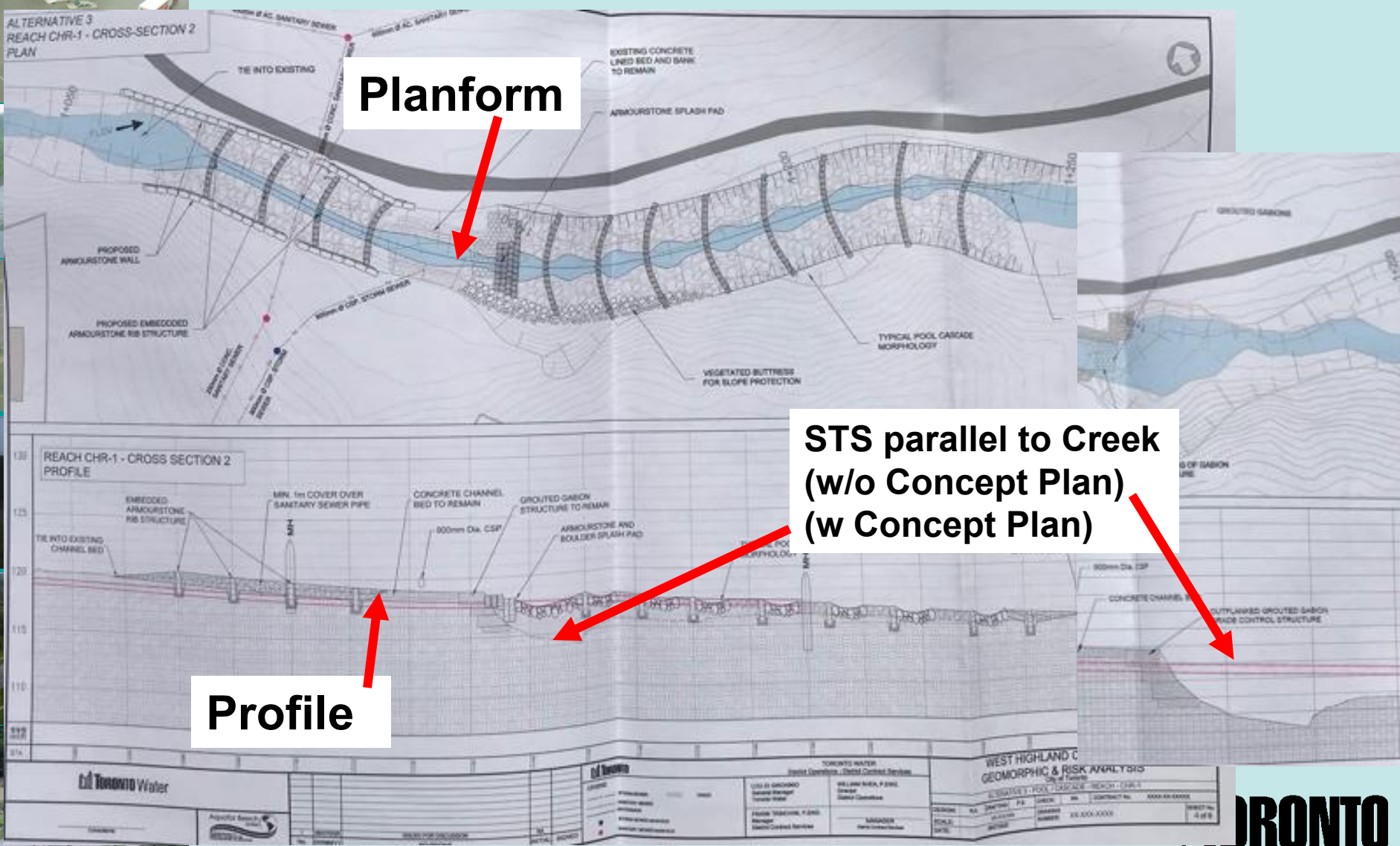


7. Highland Creek Watershed GSMP



8. Concept Design Report (post EA)

Note the level of detail



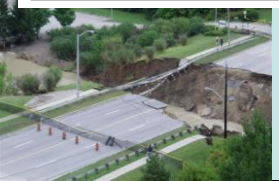
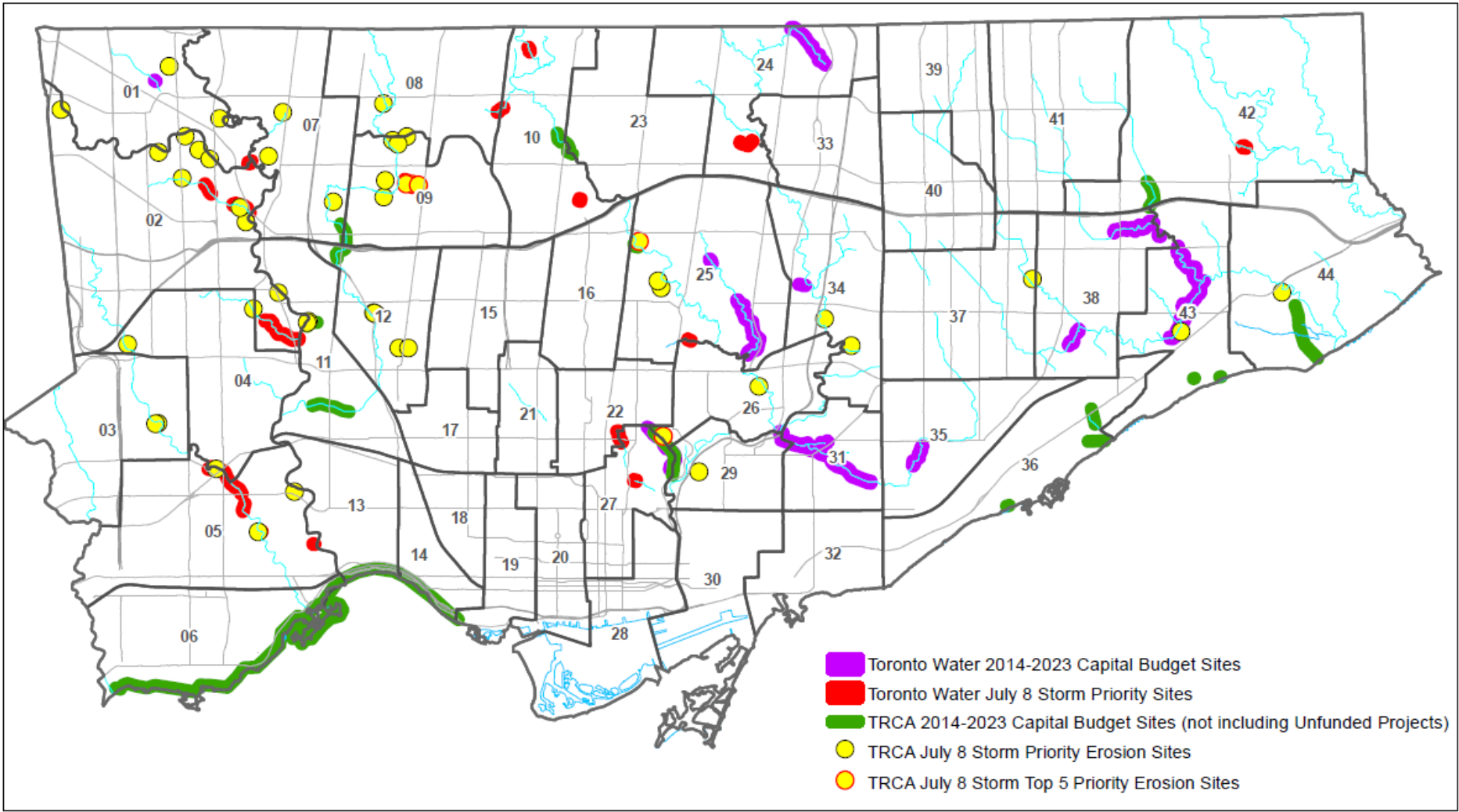
9. Toronto Stream's Organization

(Four groups for 25+ years),

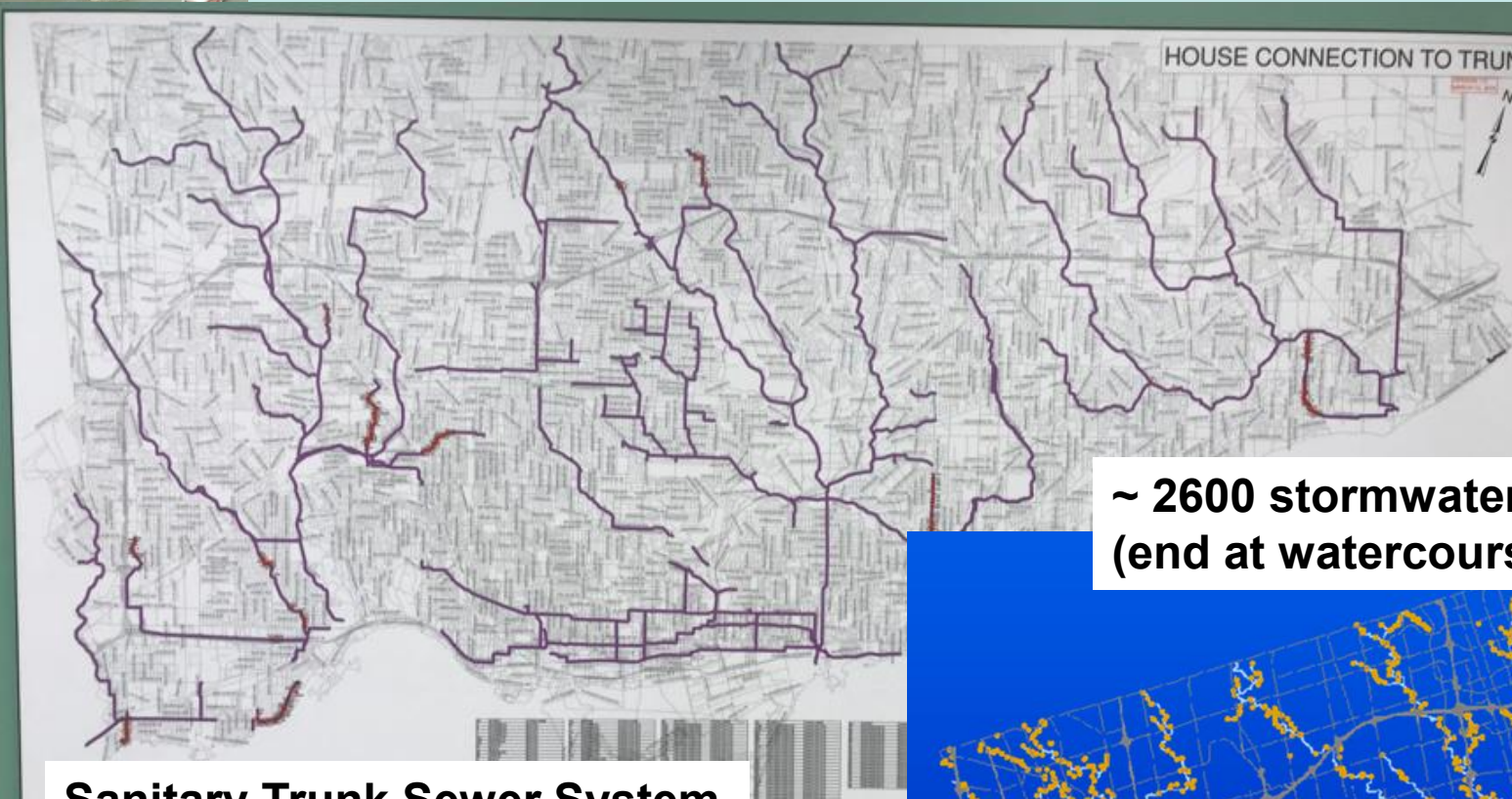
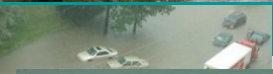
- **Planning (TW)** –inspections, define EAs, prioritize and schedule D & C, 20 Year Capital Plan, SOGR backlog (Rob Chan)
- **Delivery** (Consultant, tenders) **Engineering Construction Services** (Daniel McCreery & Devin Coone)
- **Public Consultation Unit**
- **Others** (TRCA, Forestry, Transportation)



10 Example Capital Plan Coordination Map (TW 10 -20 Year Capital Plan)



11. To protect these assets in urban channels



Sanitary Trunk Sewer System

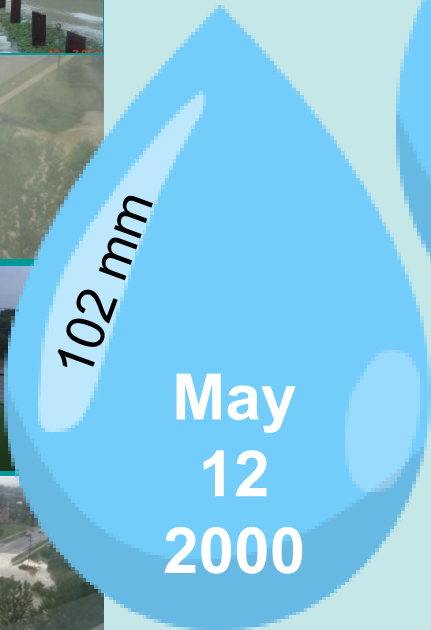
(follows creeks & rivers)

**~ 2600 stormwater outfalls
(end at watercourses)**





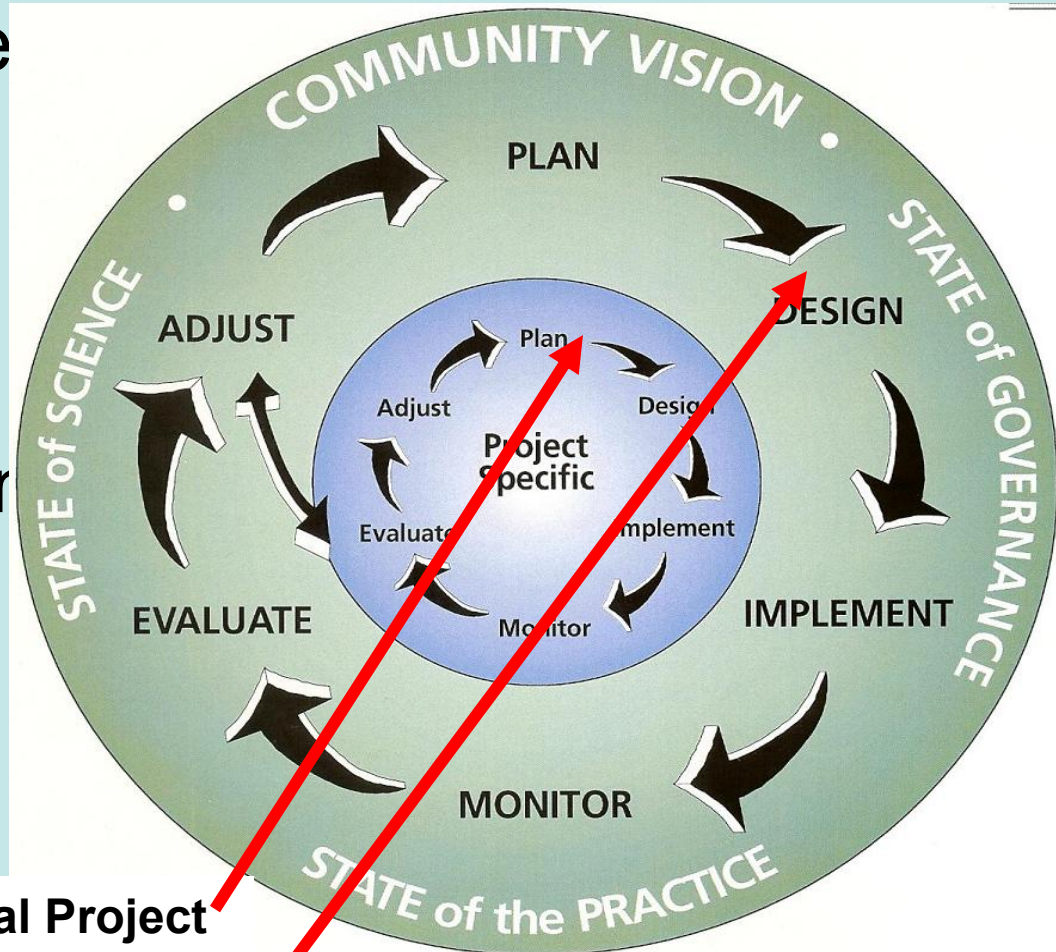
12. Key Storm Events



Climate change effects are likely within the spectrum of storms that we have adapted to and hence we have demonstrated our resilience

13 Practice Adaptive Management ('The Guideline')

- Institutionalize AEM process
- Documented in "A M of Stream Corridors in Ontario" (2002)



Individual Project

10 year Capital Plan of projects

14. Our biggest Challenge- maintain stable riffle (focus for Monitoring 'Design Life')

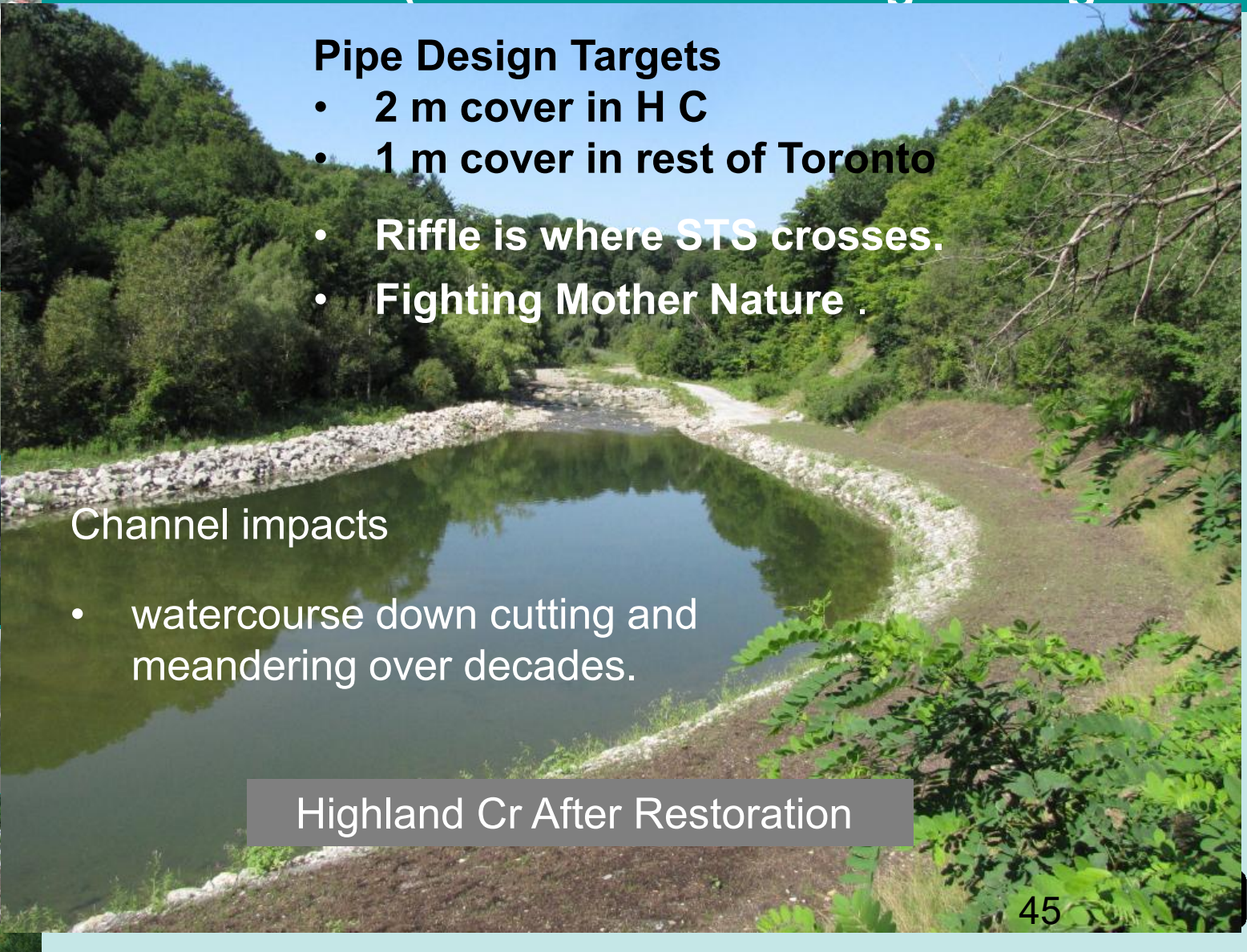
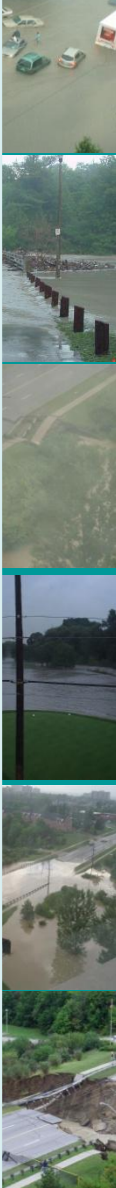
Pipe Design Targets

- 2 m cover in H C
- 1 m cover in rest of Toronto
- Riffle is where STS crosses.
- Fighting Mother Nature .

Channel impacts

- watercourse down cutting and meandering over decades.

Highland Cr After Restoration



14 Another Challenge – bedrock stream (Georgian bay shales)

- Redox controlled weathering – longer drought conditions=dryer bed)

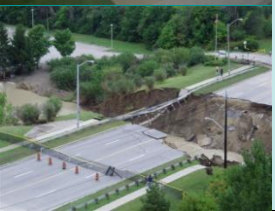


15 Summary – My estimates of part of your future

- Change will be a constant in one's **career** (e.g. Federal Govt's regulatory reduction; eg AI)
- Assimilating the effects of climate change into your practice. (NCS Initiative has a guideline but not a code of practice)
- Practicing Adaptive Management (working with Mother Nature)
- Urban channels – monitoring the physical stability of riffles



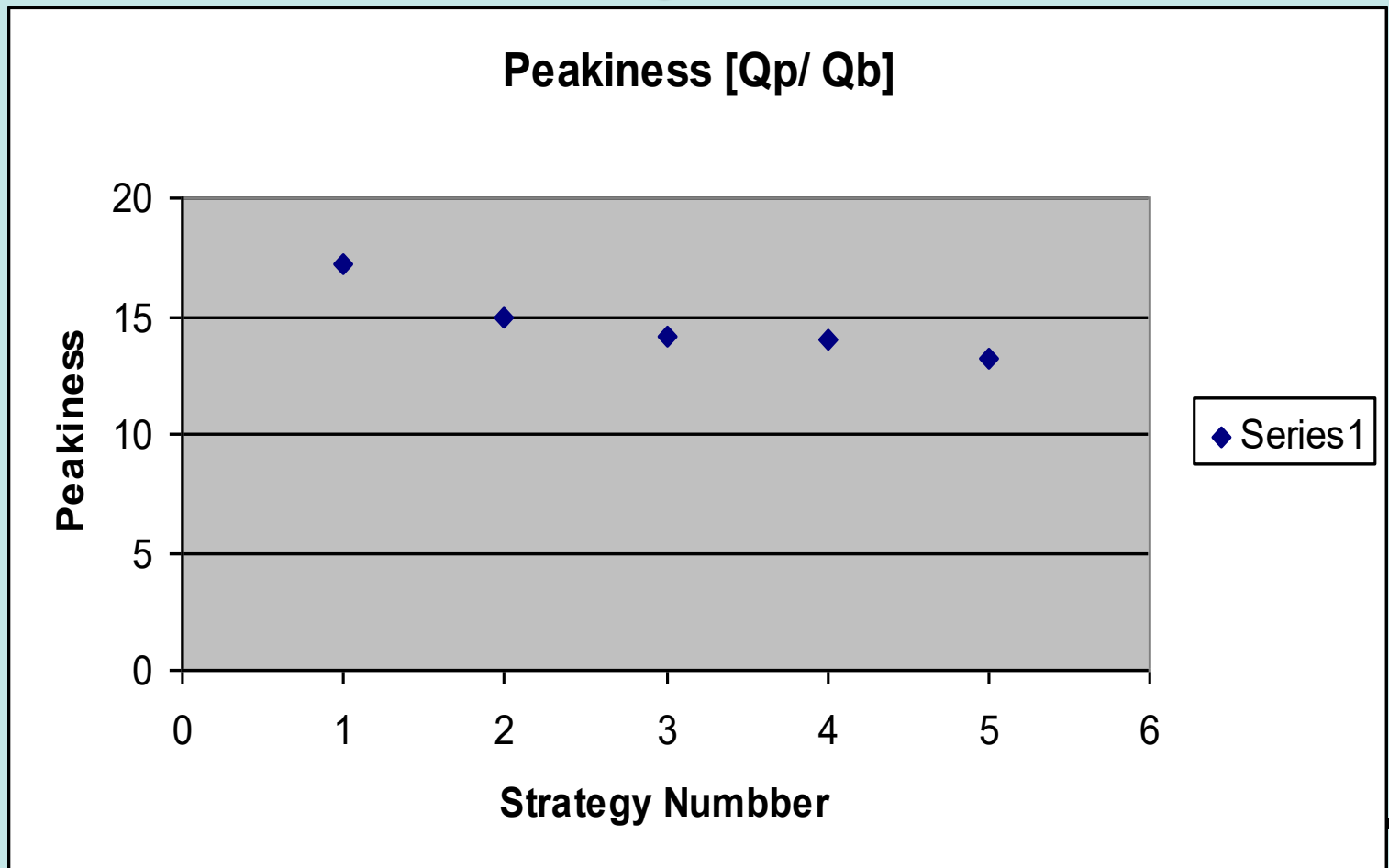
Thank you



Geomorphic & Aquatic habitat Response (Don R trib.)

Target Moderate – 8.5

Significant - 6





Ellesmere Rd

1939 Highland Creek Centre Line

1978 Highland Creek Centre Line

2005 Highland Creek Centre Line

Trunk Sanitary Sewer

BOTANY HILL RD

PLOVER RD

POYSETT PL

NELSON RD

2067 ELLESMERE RD

2077 ELLESMERE RD

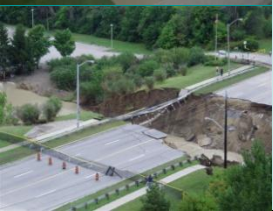
LAN AVE

Reactive Management



Finch @ Black Creek





2 High Pressure Gas Mains

Broken Watermain

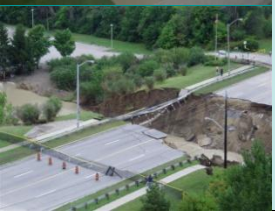
Broken Maintenance Hole

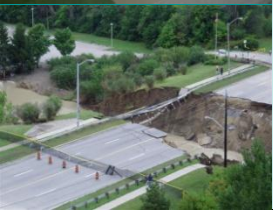
Bell Canada Plant

Bell Canada Plant

Parks Path

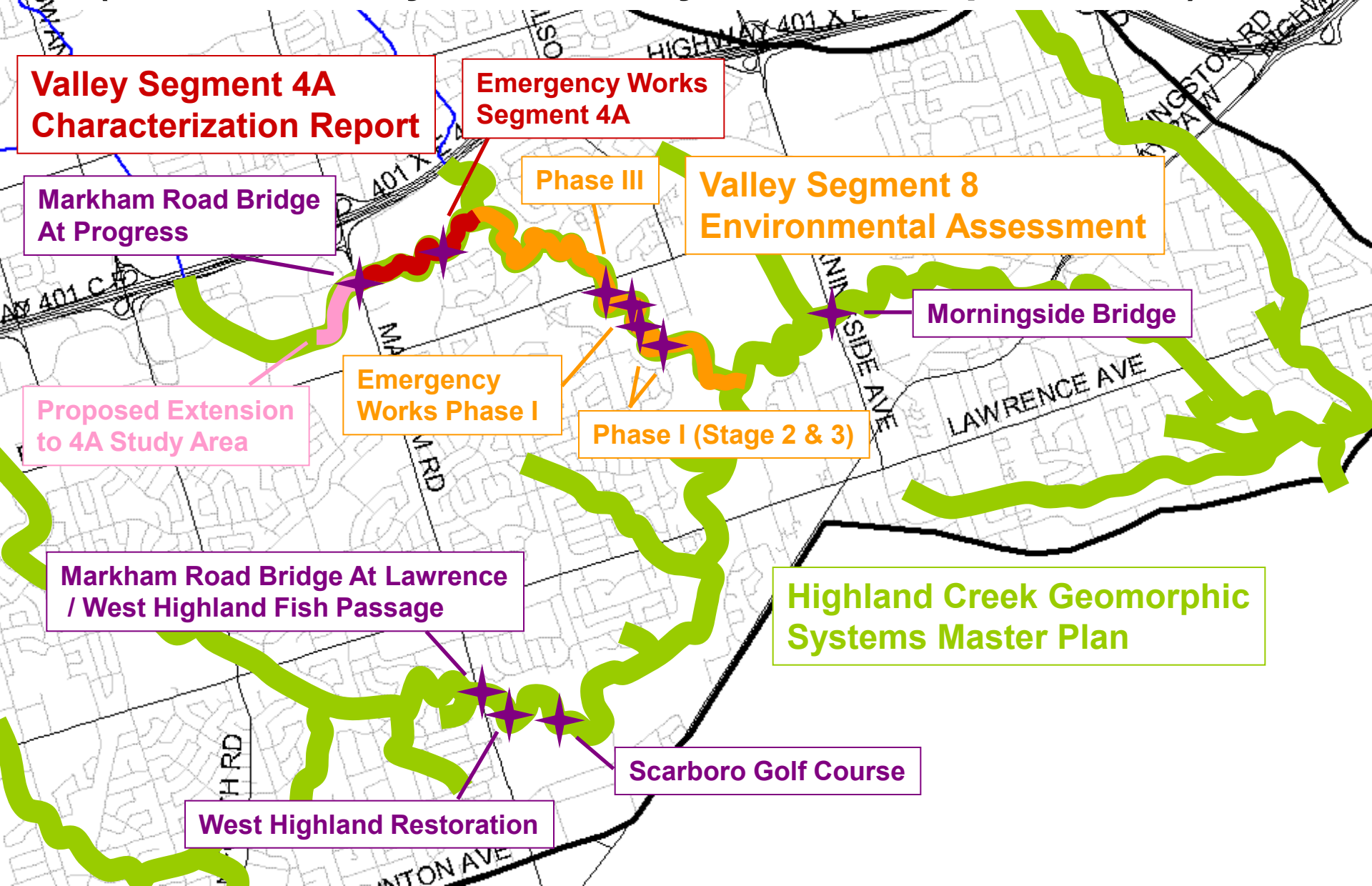
Toronto Hydro and Rogers Cable





(i) DFO / MNR / TRCA Permits

(The bain of my existence, yet essential part of life)



**Valley Segment 4A
Characterization Report**

**Emergency Works
Segment 4A**

Phase III

**Valley Segment 8
Environmental Assessment**

**Markham Road Bridge
At Progress**

Morningside Bridge

**Proposed Extension
to 4A Study Area**

**Emergency
Works Phase I**

Phase I (Stage 2 & 3)

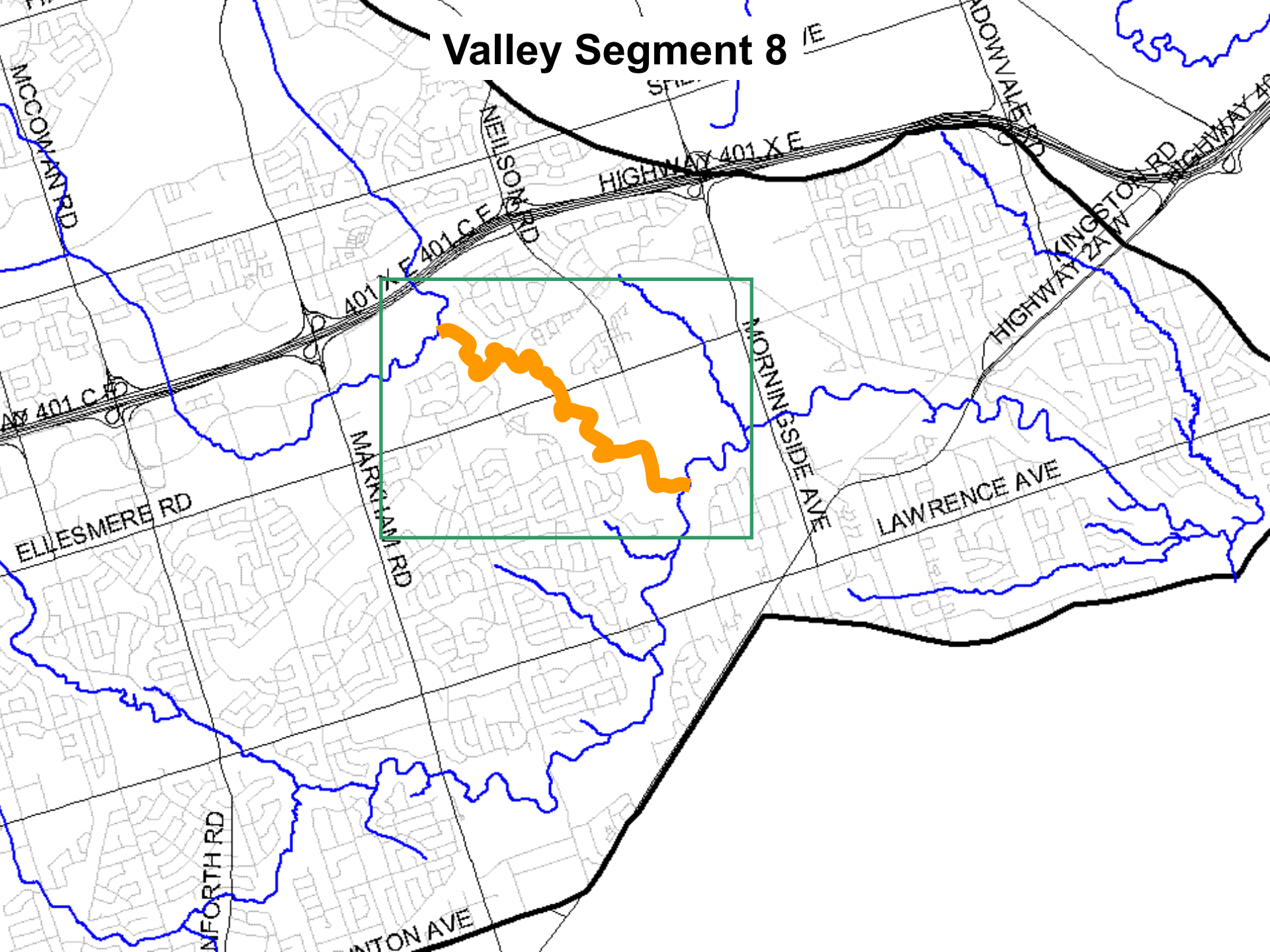
**Markham Road Bridge At Lawrence
/ West Highland Fish Passage**

**Highland Creek Geomorphic
Systems Master Plan**

Scarboro Golf Course

West Highland Restoration

Valley Segment 8



Valley Segment 8 – Current Conditions

