Red Hill Creek - The 100+ year return frequency discharge experiment

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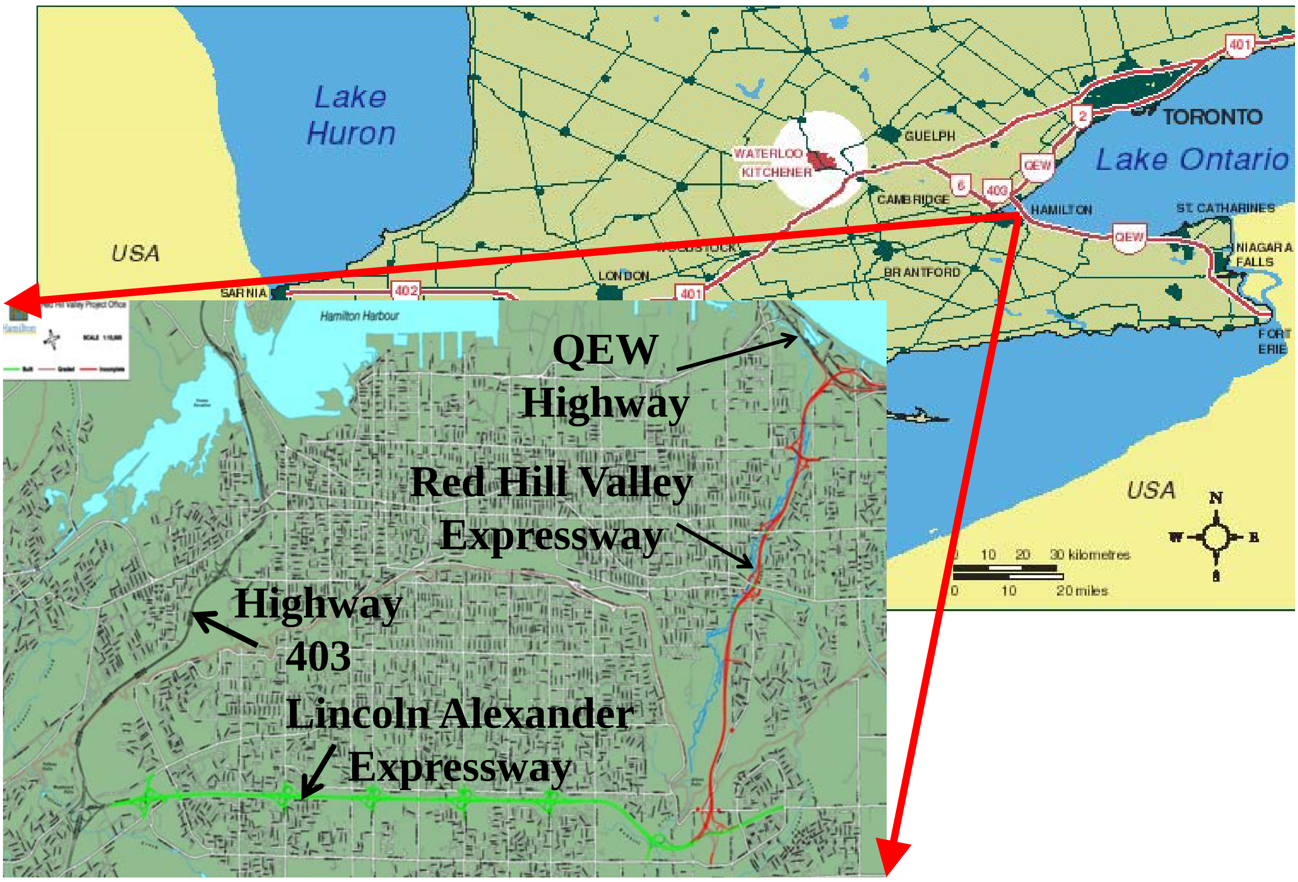
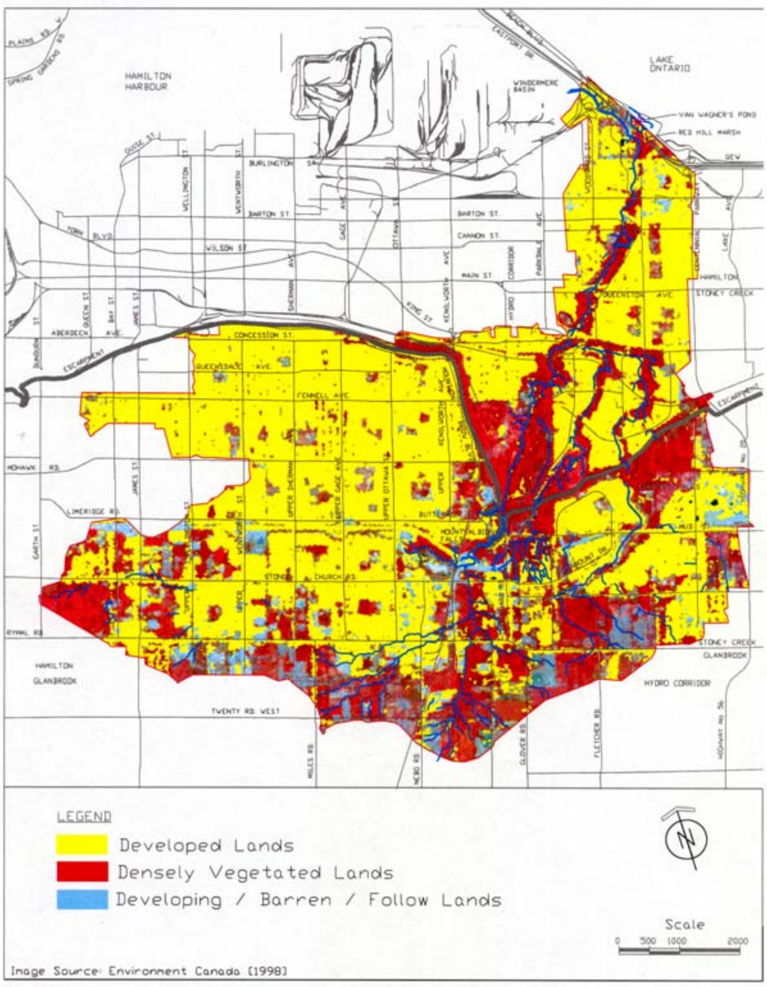
University of Waterloo

SITE LOCATION



Red Hill Creek Watershed Land Use



Natural Channel Design (Annable, 1996)

- Emulates a channel that is in a period of quiescent evolution,

- Maintains a stable dimension, pattern and profile,

- Conveys the sediment load and grains size distribution supplied by the effective watershed,

- Conveys low, bankfull an flood flows within a cross-sectional profile characterized by at least three distinguishable channels

- Supports a thriving benthic and fisheries habitat,

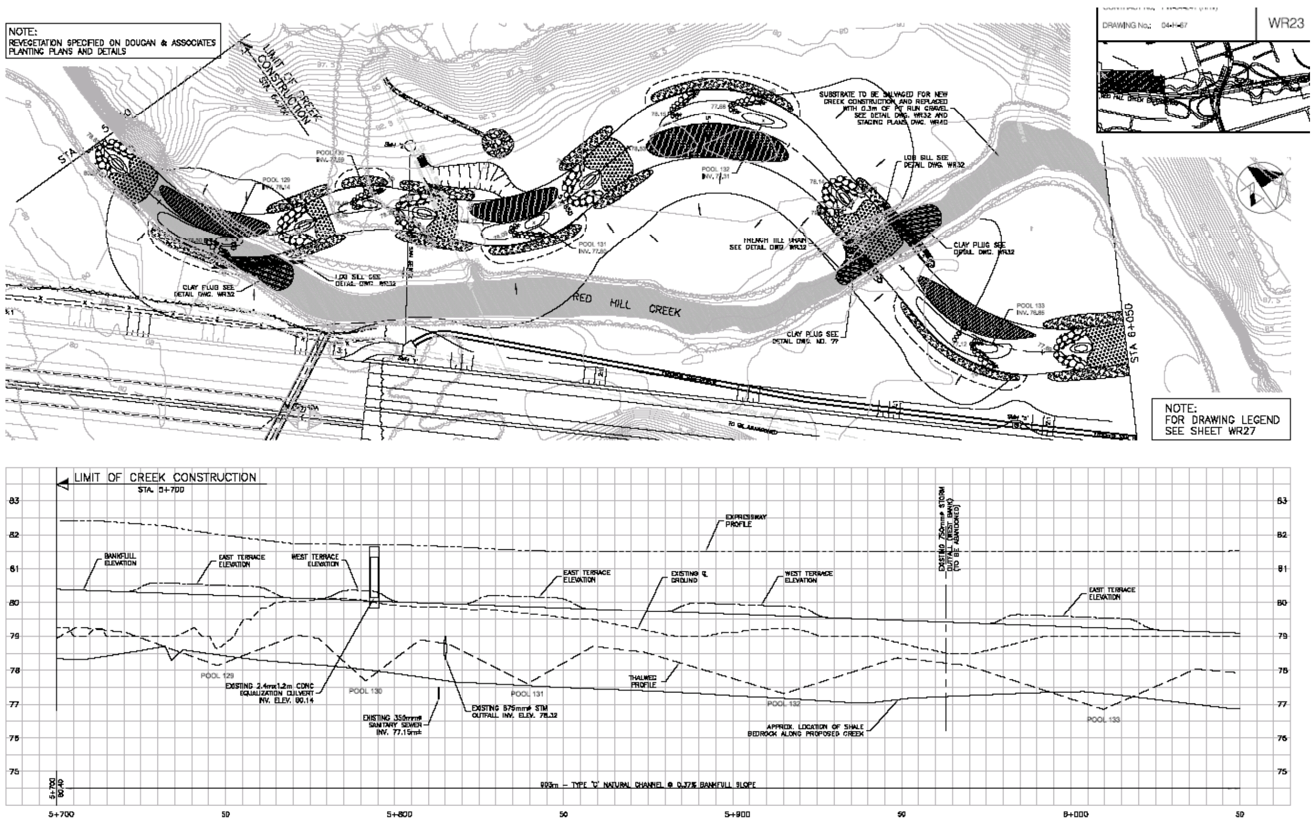
- Minimizes long term maintenance.

- The design can absorb change.

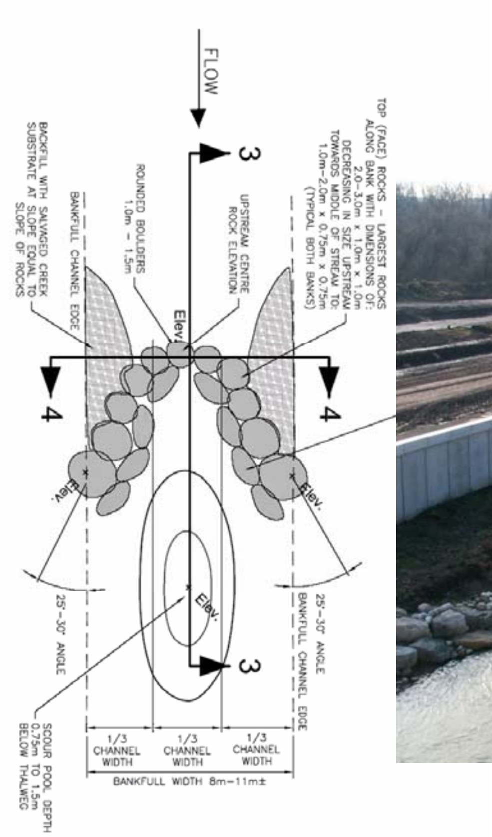
Design

Previously Proposed	Designed / Constructed
5.5km of concrete lined channel	7.2 of creek channel using NCD techniques (0.0km concrete lined channel)
19 Bridge Crossings (14m spans)	9 Bridge Crossings (min. 32m spans)
Destruction of fish habitat	Increased diversity in fish habitat
	Elimination of combined sewer overflows
	Excavation of 230,000 m^3 of material from the valley walls (banks) to accommodate floodplain function
Estimated Construction cost: $13.8 Million (Cdn)	Final Construction cost: $7.2 Million (Cdn)

Design



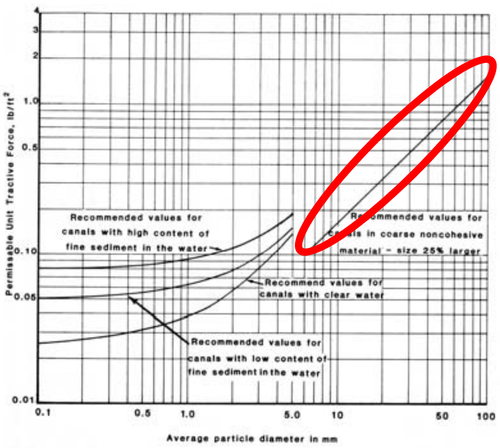
Cross Vanes



Rocky Ramps

Average particle size (d_{50}) > Critical Particle Size

$D_{50} > 9810RS_f$



Substrate placement on Riffle & Point Bars

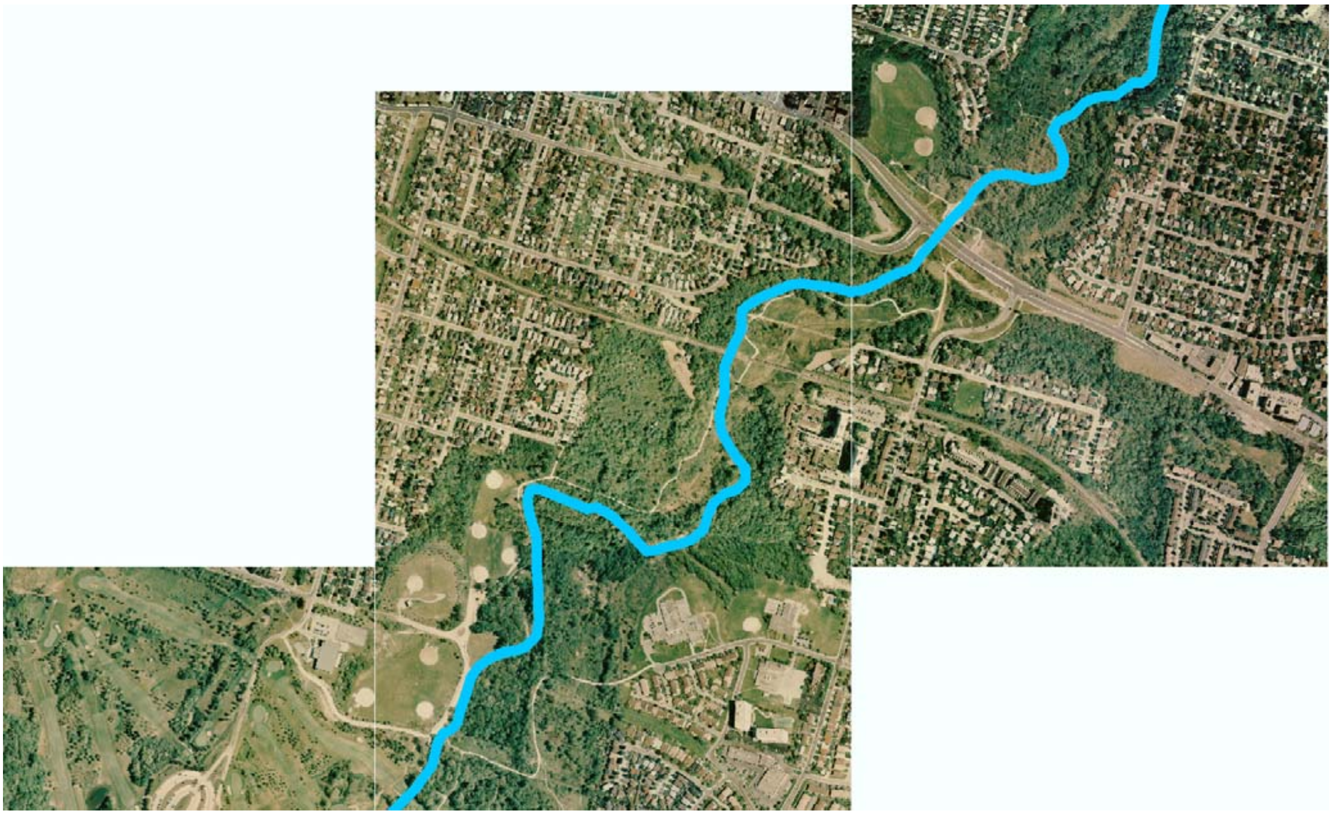
- Riffle sections over-excavated to 1-1/2 times average live scour depth (determined from field measurements),
- Substrate size based upon shear stress, tractive force analysis & permissible particle size analyses, coarsest materials placed on riffles,
- Finer gravels placed on point bars

Sod Mats

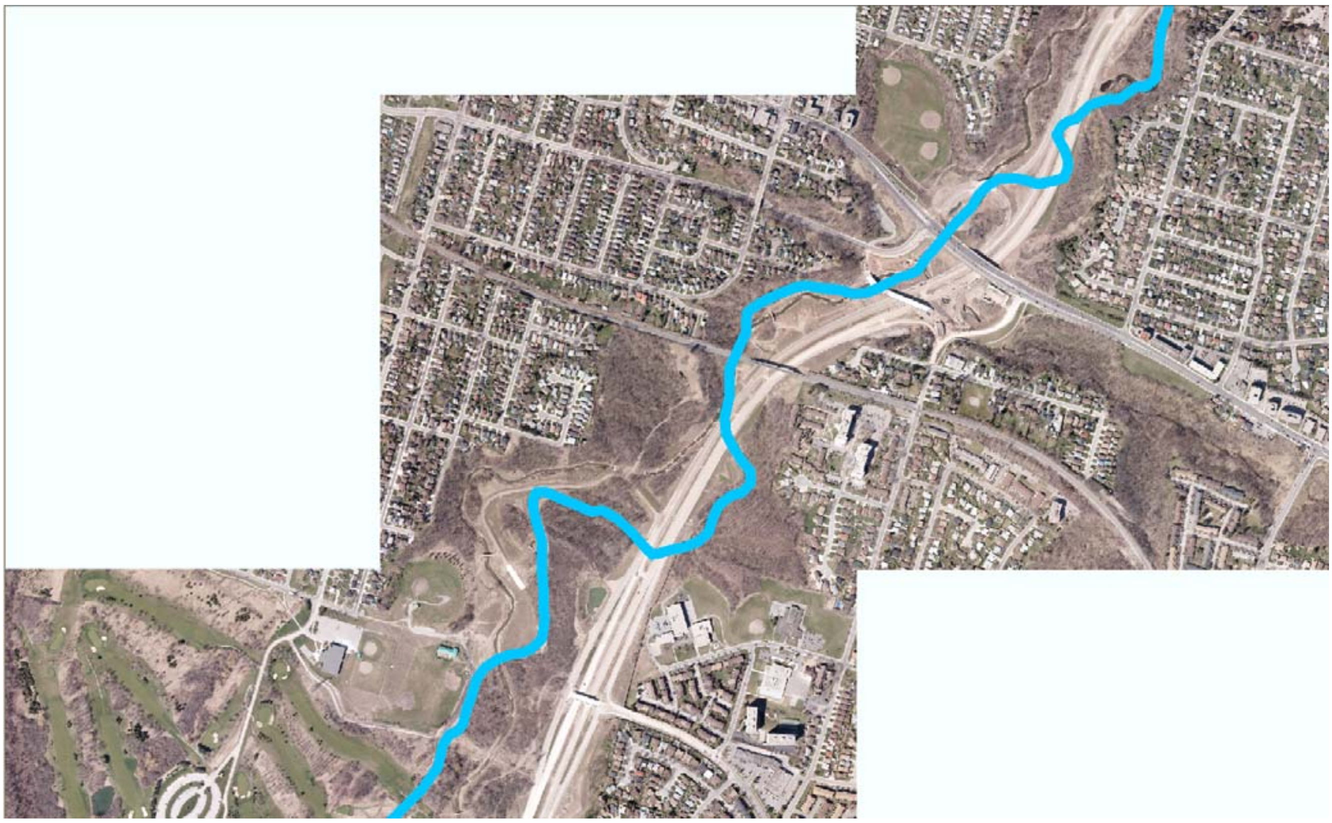
Before

After

Before

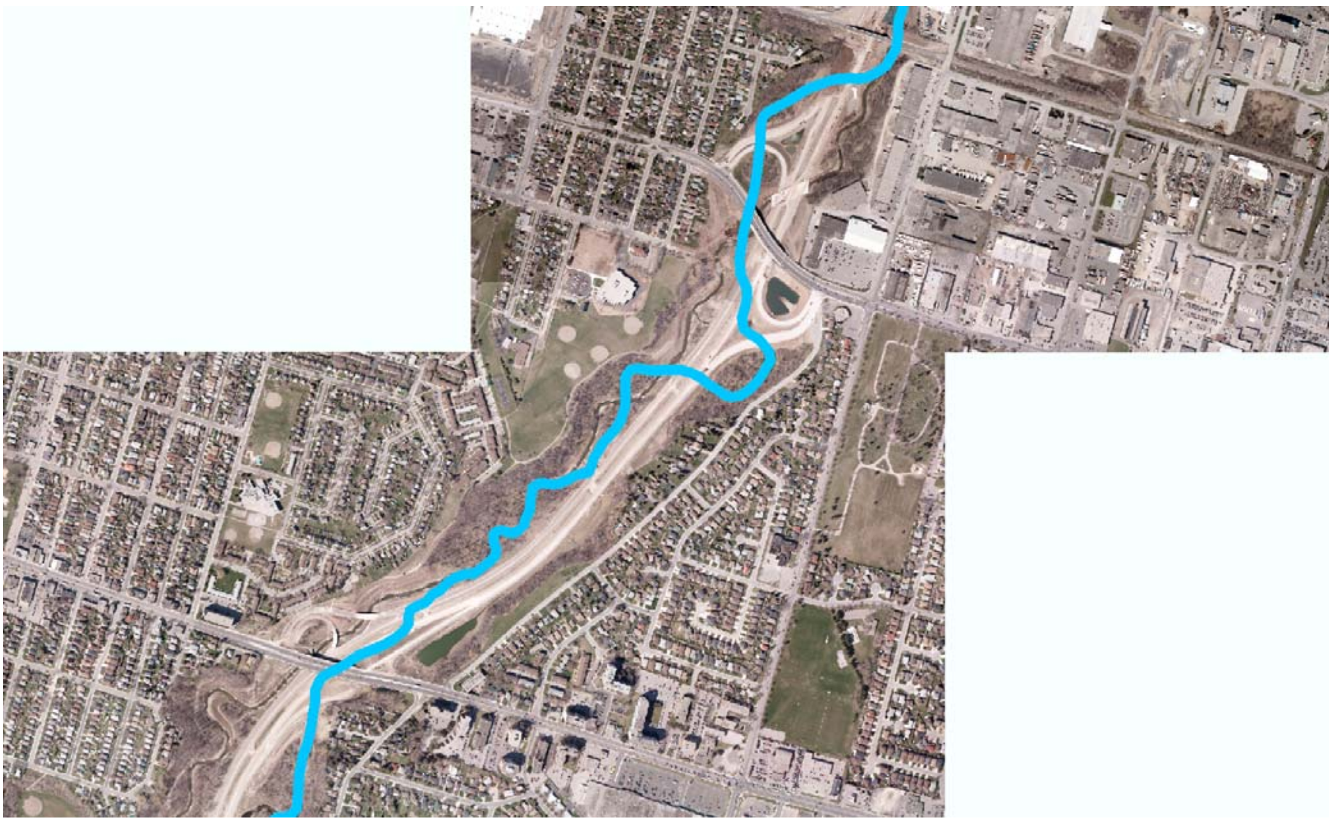


After



Before

After



Before

After

Monitoring

-118 cross sections surveyed on an annual basis to evaluate lateral and vertical erosion/deposition rates,

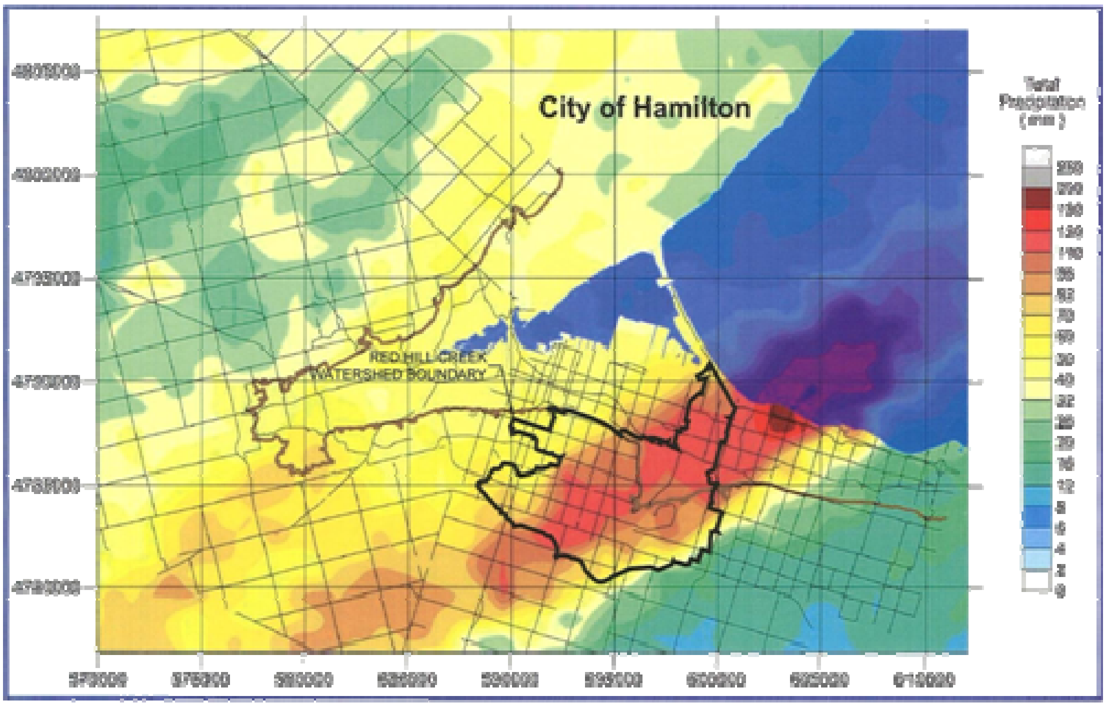
-Annual longitudinal profile examining changes in pool depths, inspecting for nickpoint migration

-118 pebble counts on an annual basis to evaluate trends in sediment

- Continuous upstream and downstream flow monitoring

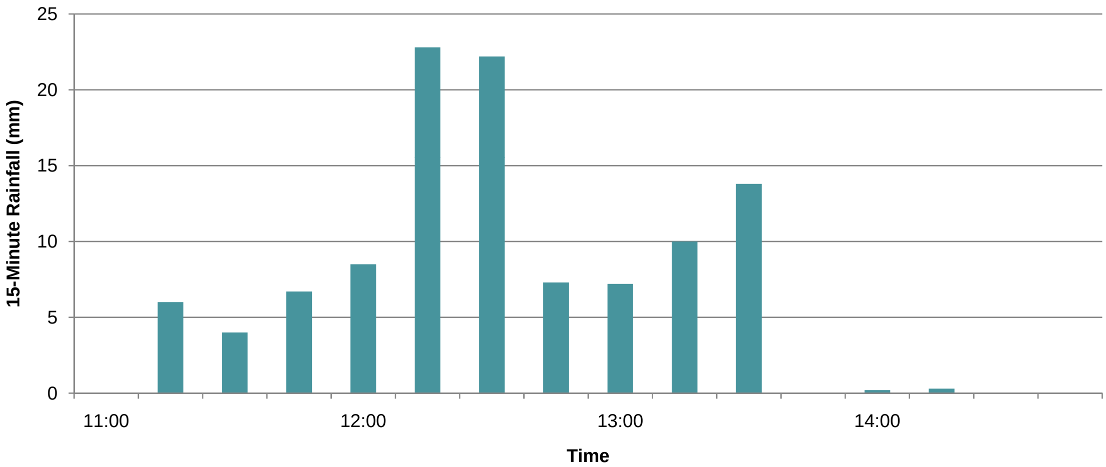
- Photographic inventory to document the re-growth of vegetation and maintain a visual record

- As-build inventory of the stream channel and all structures.



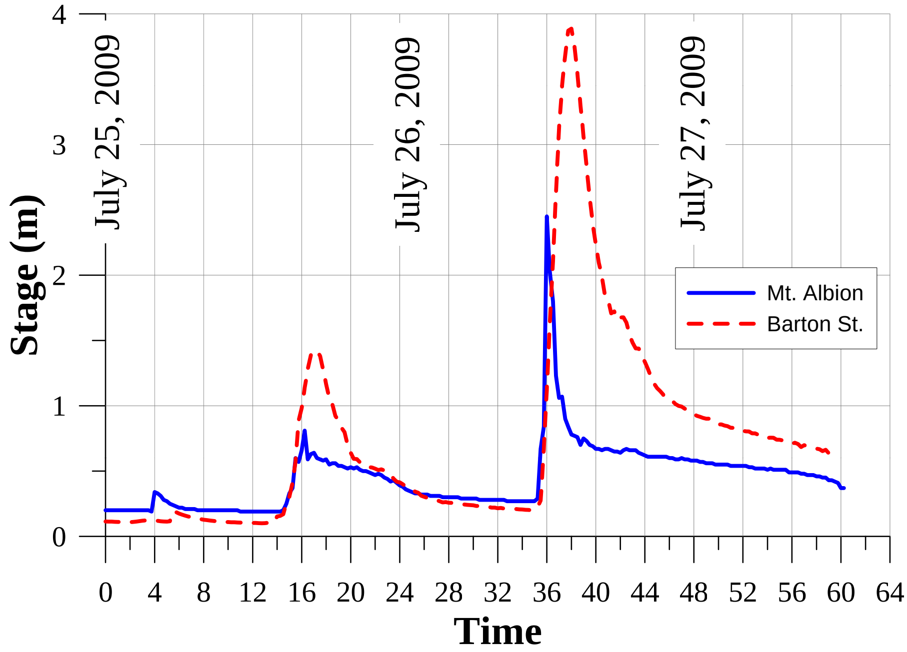
Rainfall

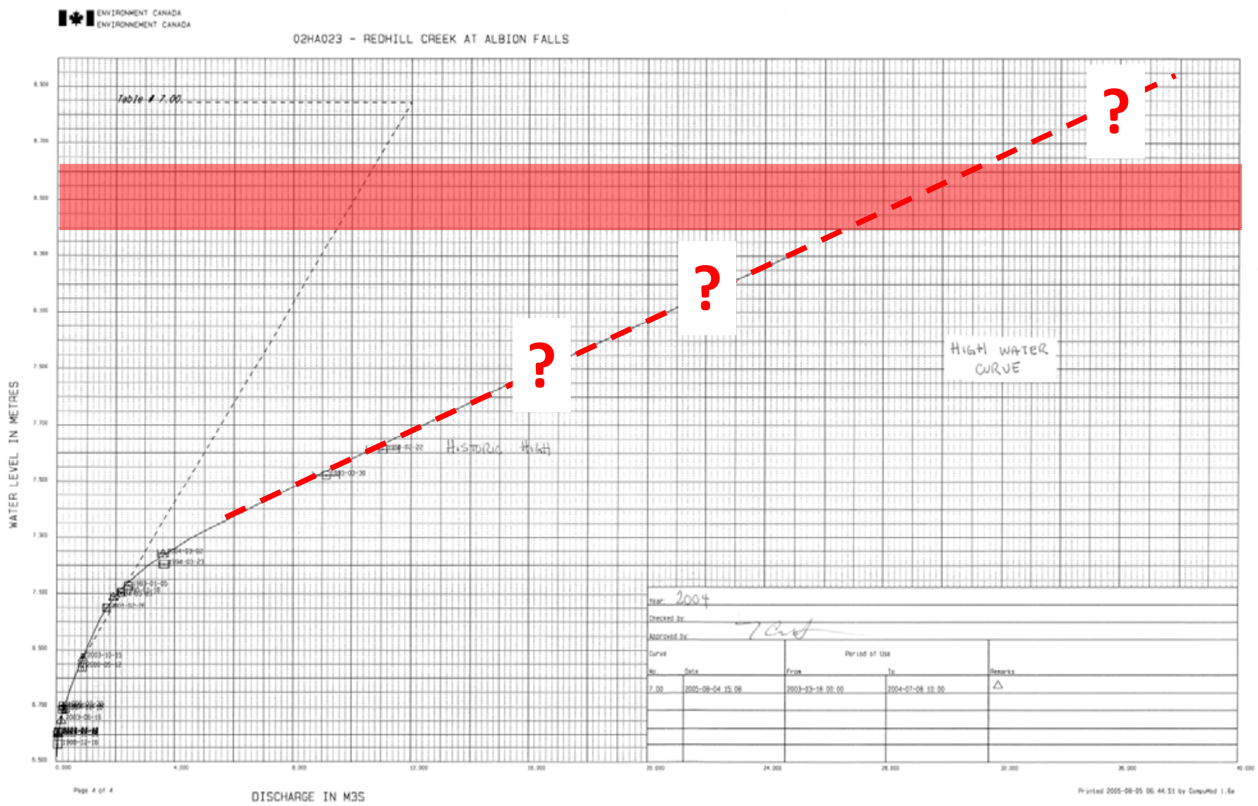
All but one ground based rain gauge in the direct path of the storm were destroyed – one remaining gauge recorded 111.7 mm (4.4 inches) with over 98.5 mm (3.9 inches) falling in a two (2) hour span.



July 26 storm was preceded by an average of 57.9 mm (2.3 inches) of rain in the five days leading up to the storm.

Preliminary Stage Data
Red Hill Creek, Hamilton, Ontario





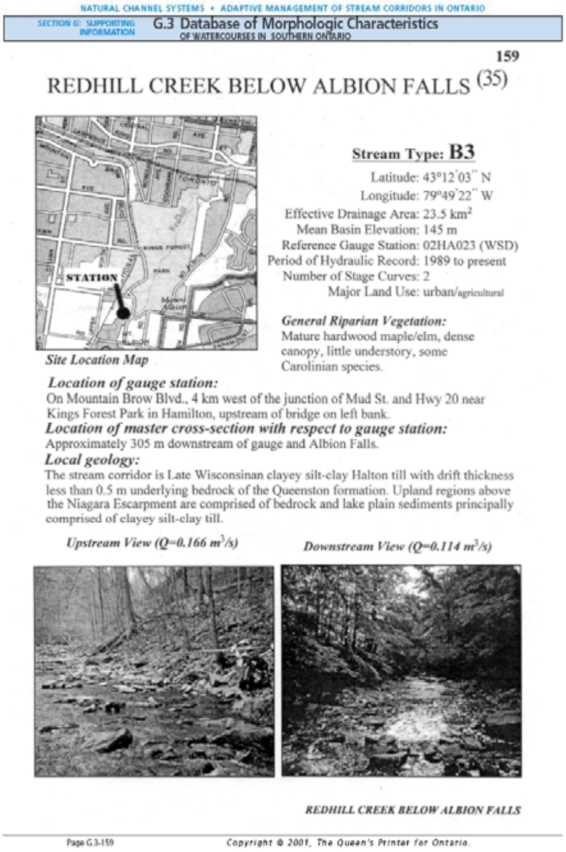
Hydrology

Simulated Peak Flows (m^3/s) Comparison of July 26, 2009 Storm Response to 100 year Event and Hurricane Hazel				
Location	**100-Year Storm Event (Based on Continuous Simulation)**	**Regional Storm (Hurricane Hazel)**	**July 26, 2009 Storm Event (Using Radar Rainfall)**	**Percentage of 100 Year Storm Event**
CNR	99.2	458	153	154%
Davis Creek at Mt. Albion Rd.	31.0	110	58.9	196%
King Street	76.5	338	80.2	105%
Albion Falls	64.6	235	63.1	98%

Upstream

Upstream

Red Hill Creek @ Mt. Albion (Annable, 1996)



NATURAL CHANNEL SYSTEMS • ADAPTIVE MANAGEMENT OF STREAM CORRIDORS IN ONTARIO

SECTION G: SUPPORTING INFORMATION | G.3 Database of Morphologic Characteristics OF WATERCOURSES IN SOUTHERN ONTARIO

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REDHILL CREEK BELOW ALBION FALLS (35)

Stream Type: B3

Latitude: 43°12'03" N
Longitude: 79°49'22" W
Effective Drainage Area: 23.5 km²
Mean Basin Elevation: 145 m
Reference Gauge Station: 02HA023 (WSD)
Period of Hydraulic Record: 1989 to present
Number of Stage Curves: 2
Major Land Use: urban/agricultural

General Riparian Vegetation:
Mature hardwood maple/elm, dense canopy, little understory, some Carolinian species.

Site Location Map

Location of gauge station:
On Mountain Brow Blvd., 4 km west of the junction of Mud St. and Hwy 20 near Kings Forest Park in Hamilton, upstream of bridge on left bank.

Location of master cross-section with respect to gauge station:
Approximately 305 m downstream of gauge and Albion Falls.

Local geology:
The stream corridor is Late Wisconsinan clayey silt-clay Halton till with drift thickness less than 0.5 m underlying bedrock of the Queenston formation. Upland regions above the Niagara Escarpment are comprised of bedrock and lake plain sediments principally comprised of clayey silt-clay till.

Upstream View (Q=0.166 m³/s) *Downstream View (Q=0.114 m³/s)*

REDHILL CREEK BELOW ALBION FALLS

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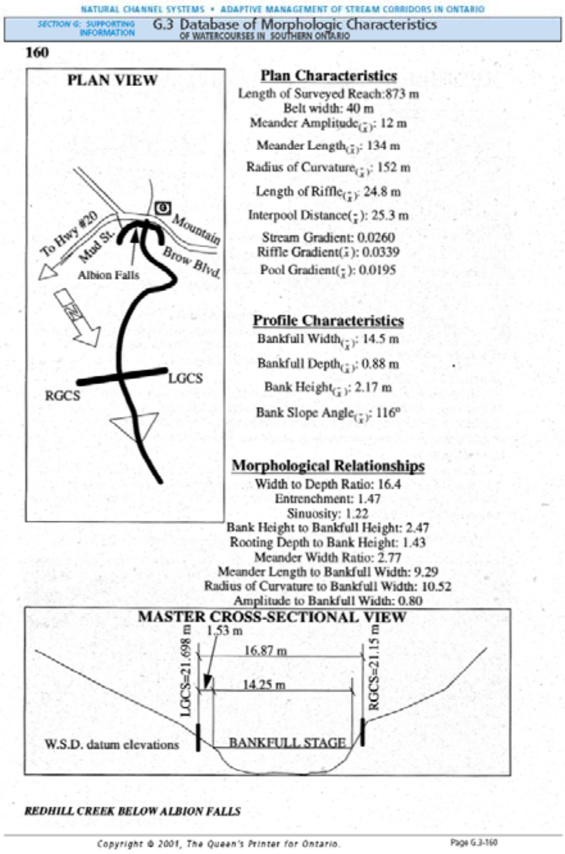

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PLAN VIEW

Plan Characteristics
Length of Surveyed Reach: 873 m
Belt width: 40 m
Meander Amplitude: 12 m
Meander Length: 134 m
Radius of Curvature: 152 m
Length of Riffle: 24.8 m
Interpool Distance: 25.3 m
Stream Gradient: 0.0260
Riffle Gradient: 0.0339
Pool Gradient: 0.0195

Profile Characteristics
Bankfull Width: 14.5 m
Bankfull Depth: 0.88 m
Bank Height: 2.17 m
Bank Slope Angle: 116°

Morphological Relationships
Width to Depth Ratio: 16.4
Entrenchment: 1.47
Sinuosity: 1.22
Bank Height to Bankfull Height: 2.47
Rooting Depth to Bank Height: 1.43
Meander Width Ratio: 2.77
Meander Length to Bankfull Width: 9.29
Radius of Curvature to Bankfull Width: 10.52
Amplitude to Bankfull Width: 0.80

MASTER CROSS-SECTIONAL VIEW

REDHILL CREEK BELOW ALBION FALLS

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Upstream of rehabilitated site

Widened Sections range between: 16m – 21m

Sections still demonstrating quasi-stable characteristics range between:

8m – 10m.

Upstream

Evidence of Downcutting

Upstream

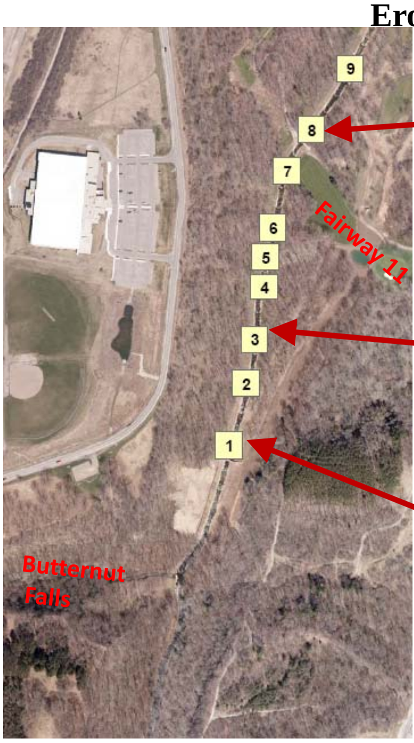
Upstream

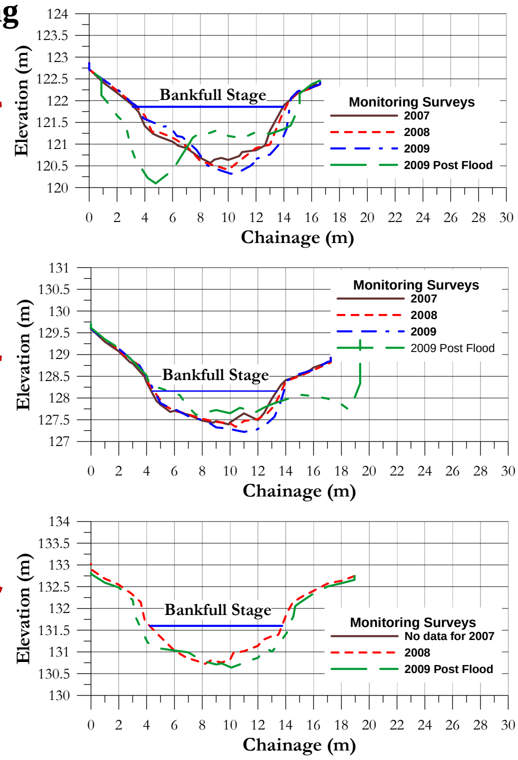
Temporary Overflow and Transport During Flood

A common hydraulic and scour response

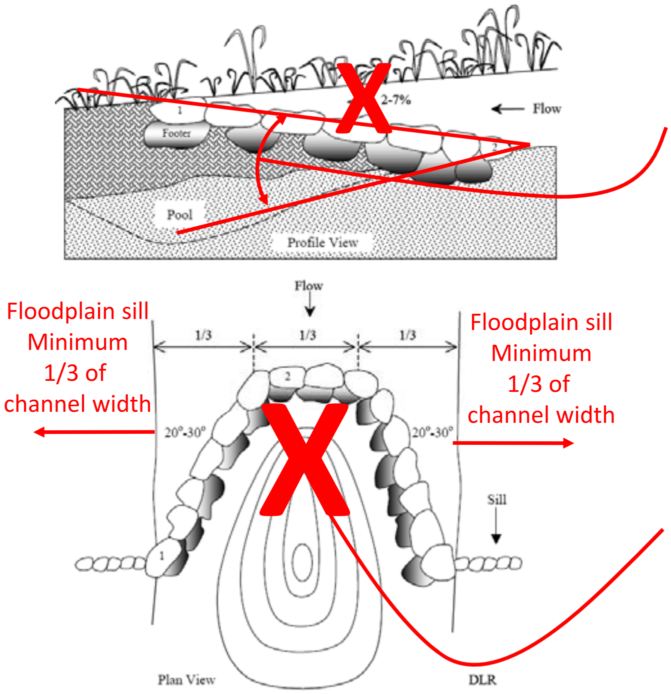
Systematic response in steeper reach sections where flow depths and velocities remained high in region between the floodplain and bankfull depth in the location of sills. Resulting in scour of very unconsolidated colluvial material. When flows undermined the sills, they continued to downcut into, and below, the main in-stream structures leading to structure failure

Erosion Monitoring





In-stream Structure Observations



Maximum arm slope found to be stable was 4% for the combined bed slope and arm slope. Therefore, if you have a 3% bed slope, the arm slope should be a maximum of 1%!

Single tier cross vanes lead to too much convergence of flow undermining footer rocks leading to structure failure in steep channel slopes and fine-grained material

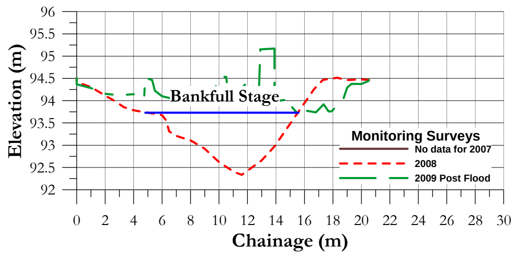
(from Rosgen, 1998)

Cascade Vanes

Cascade Vanes

Channel Responses from Infrastructure

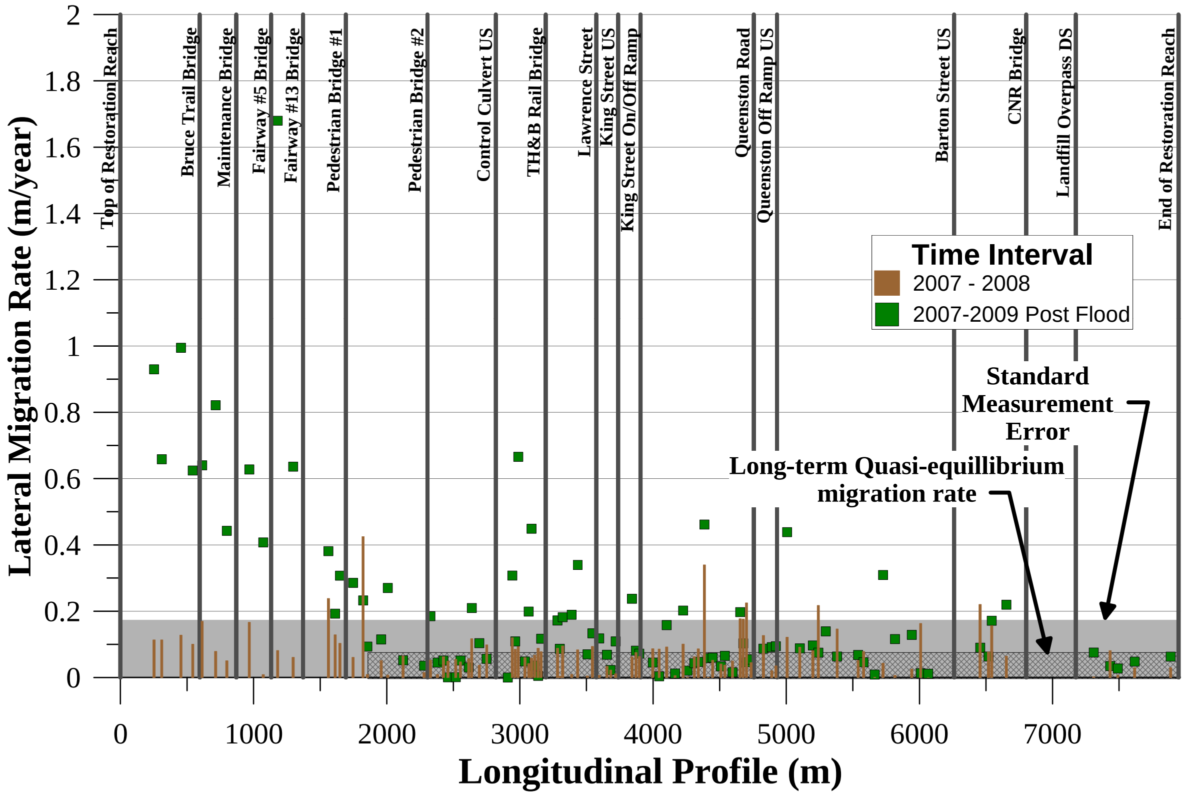
Constriction Culvert



Known long-term maintenance location

Field observations identify sizable quantities of shale in floodplain regions downstream of culvert. Concern exist over how much erosion has occurred in culvert. The culvert must be dewatered for inspection by lowering the downstream invert and reconstruction of the in-stream structures.

Lateral Migration



All-in-all

About 1100m – 1300m were in need of modifications or reconstruction

Relative to the magnitude of the flood, the adverse channel responses are relatively minor, compared to what could have occurred or what might have occurred in the old channel alignment,

The plan profile has remained in the design location with localized minor lateral adjustments of 1m – 5m (particularly through the bend by the maintenance bridge on the golf course),

The longitudinal profile has remained, for the majority of the reach, as designed. There are noted areas of deposition (downstream of the golf course and downstream of the constriction culvert as a result of excess upstream supply).

Subsequent floods have led to observable head cutting and loss of vertical control in some regions that requires mitigation.

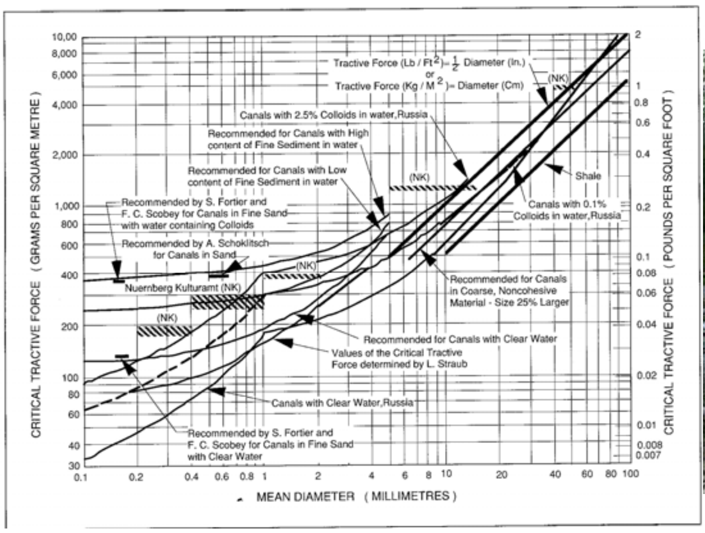
Continued Post-storm Responses

Continued widening on concave arc of bends where structures and sills have been flanked.

Continued Post-storm Responses

Continued channel responses demonstrate the importance of grade control to maintain vertical stability

Design of riffle structures (such as rocky ramps) need to be designed for the hydraulic radius of floods larger than bankfull the intent is for the structures to remain "stable"



Floodplains are your friend!

Reaches where floodplains were greater than 3 times bankfull width suffered nominal or un-measureable disturbance from the extreme flood (regardless if they were well vegetated or not).

Monitoring was Key!

-Much anecdotal evidence (by many parties) of what happened,

- Monitoring documented the post-construction conditions which lead to a strong understanding of the causes of sub-reach failures and also lead the modifications which are expected to increase channel stability,

-Without monitoring, there is NO feed back to future projects and decision makers on how to improve designs,

- Provides a means to distinguish myths and perceptions from fact!


Questions?