Evaluating the Effectiveness of Stream Rehabilitation Projects: Lessons Learned From 10 Years of Monitoring

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Sustainable Technologies Evaluation Program

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The Living City Foundation

Toronto and Region Conservation for The Living City

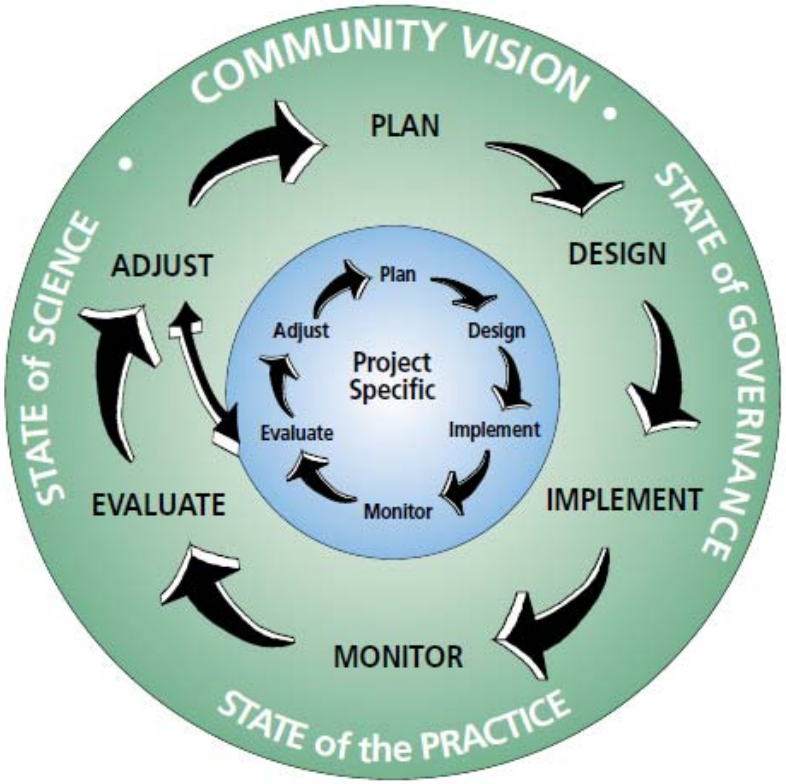
Natural Channel Design (NCD)

- Reconstruction or rehabilitation of a stream channel and floodplain using techniques to restore or replicate natural channel system form and functions;
- Principal objectives are:
  - Mimic the self-sustaining geomorphic forms and processes of an undisturbed watercourse subject to the same catchment-scale influences and local conditions;
  - Support aquatic and riparian ecosystems of composition and quality that are reflective of an undisturbed watercourse subject to the same catchment-scale influences and local conditions.

Evolving the practice requires monitoring and evaluation

- NCD involves complex and inter-related processes;
- In practice for 20+ years in Ontario with few systematic evaluations of performance;
- Limits the ability of practitioners and regulators to apply an AEM process.

Adaptive Environmental Management Process



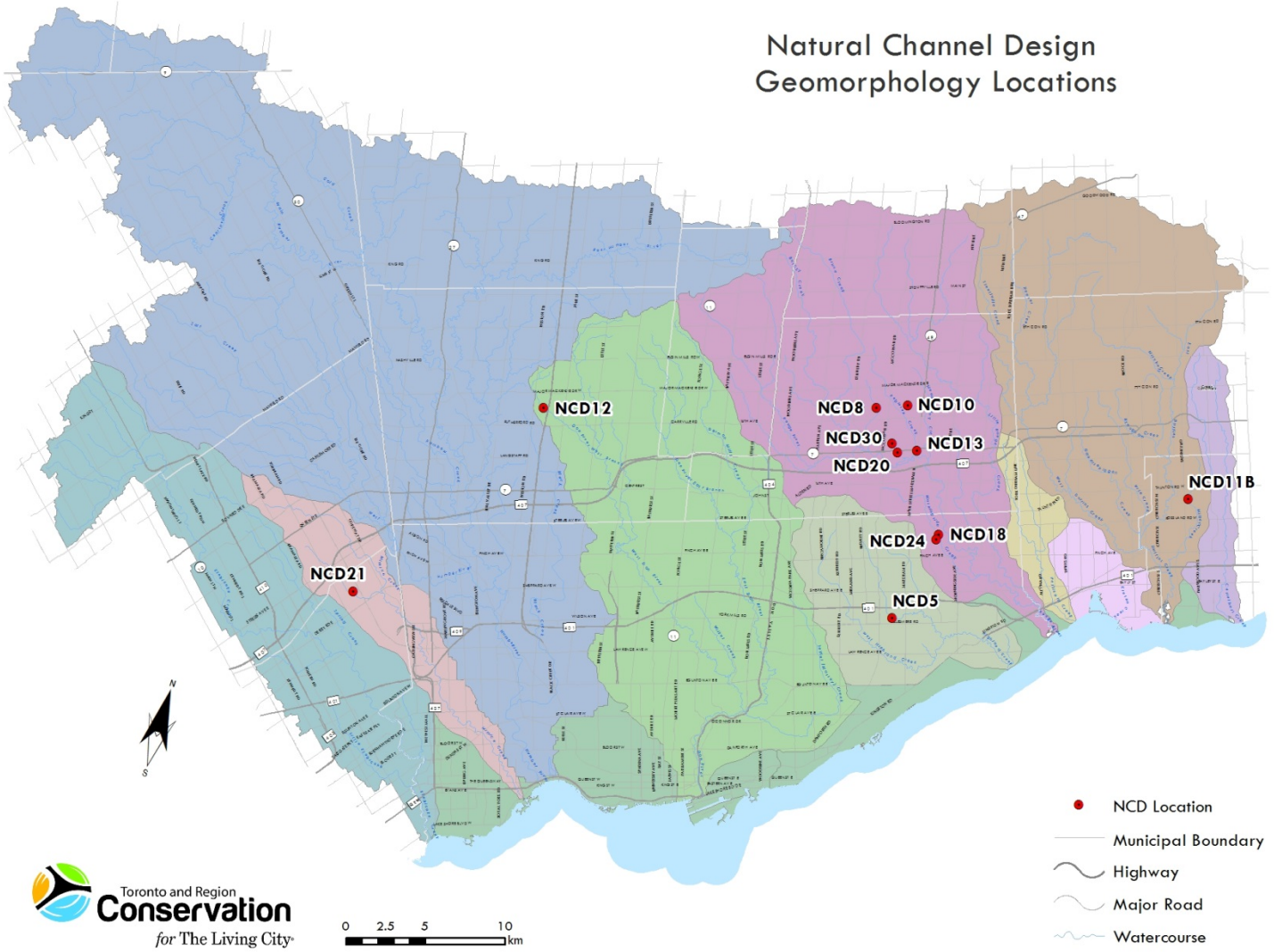
Natural Channel Design Monitoring Program - 2005 to 2014

10 year workplan to:

- Develop guidance on the design of monitoring programs for stream rehabilitation projects;
- Implement programs at 10 NCD sites around the GTA to evaluate if design objectives are being achieved in the 5 to 15 years post-construction time frame;
- Adapt the monitoring program design guidance as warranted based on experiences gained through program implementation.

Available at http://sustainabletechnologies.ca

NCD Monitoring Program 2005 - 2014

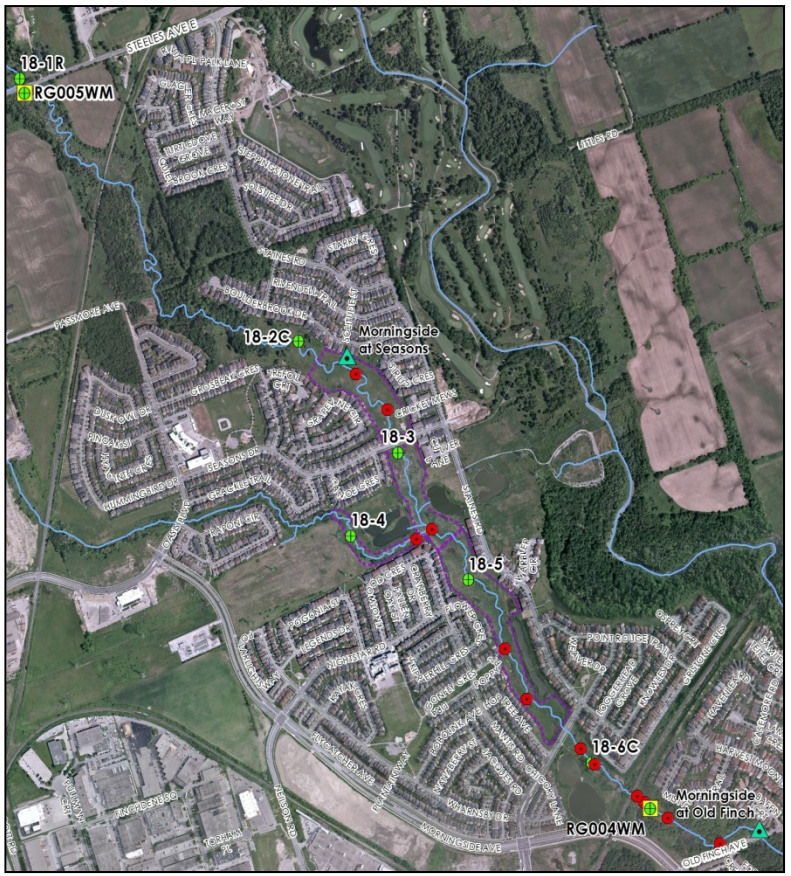


Monitoring Program Components

Catchment Characteristics	Size; Land use & Road density; SWM quantity/quality control.
Geomorphic System	Rapid Geomorphic Assessment; Long-profile; Cross-sections (riffle/pool/run); Bank/substrate characterization; Erosion pins.
Aquatic System	Fish & Benthic Macroinvertebrates (BMI) sampling; Aquatic habitat survey (OSAP).
Terrestrial System	Vegetation Communities (ELC); Flora; Breeding birds; Amphibians.

Monitoring Program Design

- Comparing reconstructed reaches (treated) to preconstruction data or an upstream or downstream untreated control reach;
- Pre-construction biological data often unavailable or inadequate;
- Geomorphic surveys 5 - 9 yrs. apart;
- Aquatic surveys 2 - 5 yrs. apart;
- Terrestrial surveys 5 - 7 yrs. apart;
- Fish barriers survey;
- Catchment characteristics;
- Aerial photo analysis.



NCD Site Evaluation Dashboard

- Used a “key indicators dashboard” approach to developing and integrated understanding of site conditions, temporal trends & evaluate performance;
- Simple three category system for classifying indicator conditions & temporal trends;
- Helped with developing an integrated understanding of site conditions and making comparisons between components and sites.

“Good”	**“Fair”**	**“Poor”**
In regime	In transition	In adjustment
More	Similar	Less
Better	Similar	Worse
Objectives achieved	Inconclusive	Needs work
Stable	Aggrading	Degrading
Similar	Finer	Coarser

NCD Project Evaluation Indicators Dashboard

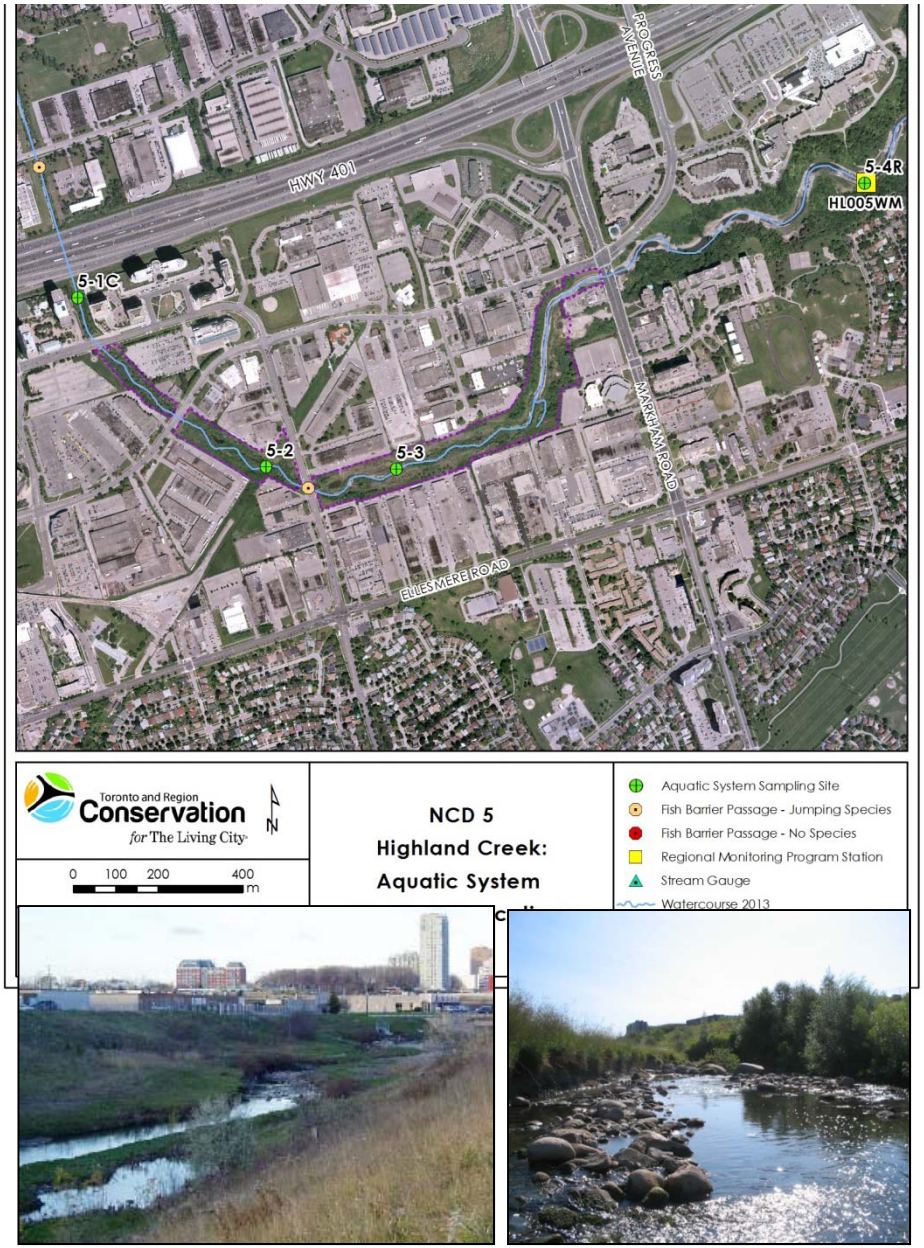
Geomorphology	
Number of Meander Bends	25
RGA	In Adjustment
Longitudinal Profile	Unstable
Cross-Sectional Area Surveys	Aggrading, Widening, Entrenched
Substrate Characterization	Similar
Bank Erosion Pins	>17 cm/year
Riparian Conditions	Fair
Access to Floodplain	Poor
Aquatic Ecosystem	
Age at Sampling Years	-1, 5, 11, 13,17
Fish Community Composition	Tolerant species
Fish - Temporal	Similar
Fish - Treated vs. Reference	Similar
Evidence of Beaver Activity	No
Structural Fish Barrier Presence	Yes
BMI - Temporal	Getting Worse
BMI - Treated vs Control	Getting Worse
Terrestrial Ecosystem	
Surveyed Area (ha)	11.2
Wetland Vegetation Community Area	Increasing
Exotic Disturbance (% disturbed)	85
Percent Non-Planted Native Flora	41
Number of Vegetation Communities (#/ha)	1.7
Total Number of Vegetation Communities L1-L4	4 (2006/2007)
Number of Flora Species (#/ha)	22
Total Number of Flora Species L1-L4	24 (2006/2007)
Number Breeding Birds (#/ha)	2.8
Total Number of Breeding Birds L1-L4	8 (Increase - 2006:6; 2008:7; 2009:7)
Number of Amphibian Species	1
Number of Amphibian Species L1-L4	1 (2007/2008/2009)
Incidental Species	Beaver, eastern chipmunk, eastern cottontail, mink, muskrat, white-tailed deer

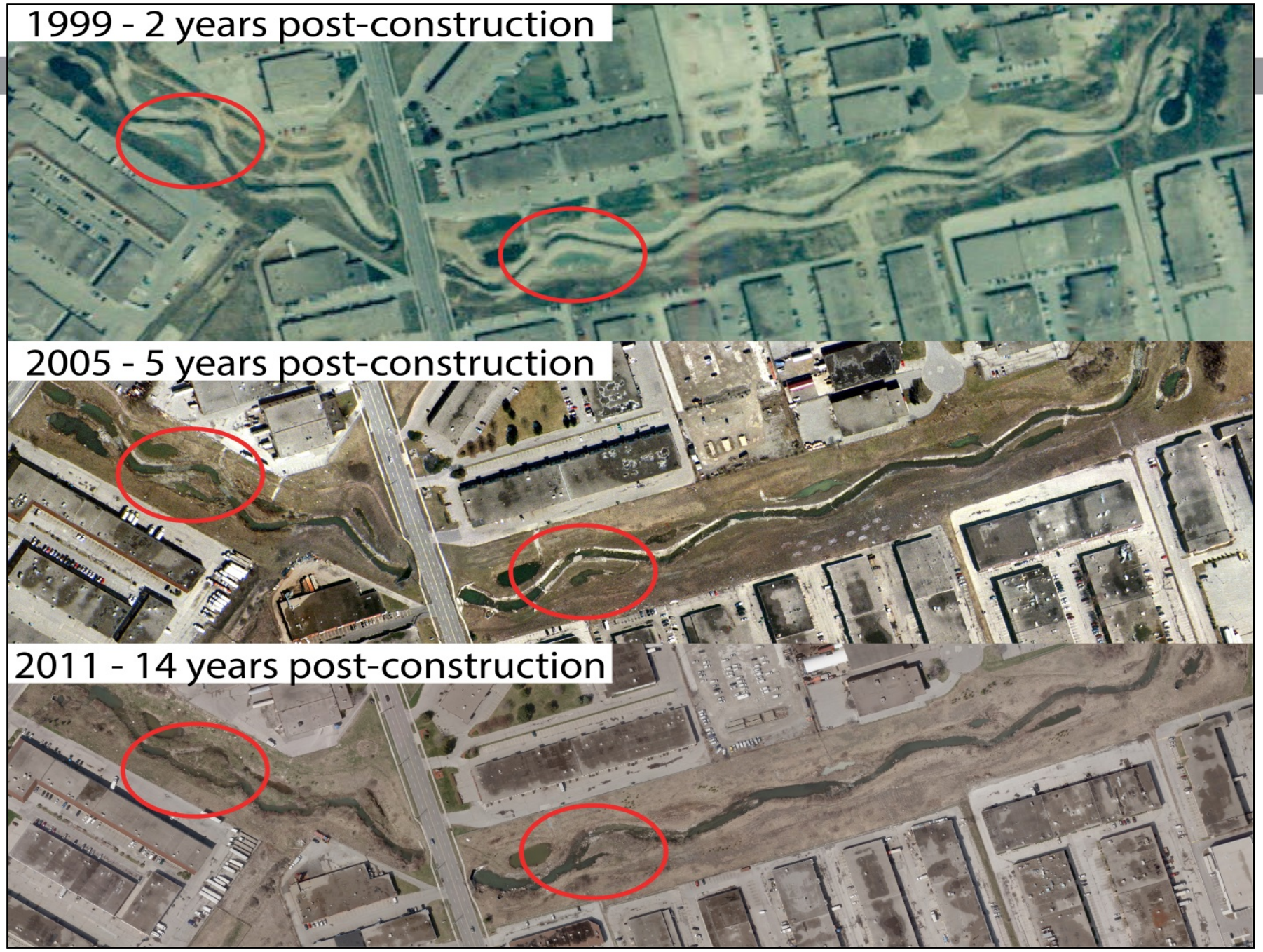
Summary – Geomorphic System

Site	SWM Controls	Age*	Channel State (RGA)	Active Processes	Substrate - Temporal
NCD 5	**No**	14	**In Adjustment; Entrenchment**	Widening; Degradation & Aggradation	Similar
NCD 8	Yes	13	**In Transition**	Widening; Aggradation;	Similar
NCD 10	Yes	12	In Regime	Stable; Aggradation;	Finer
NCD 11	Yes	10	In Regime	Widening; Aggradation	Finer
NCD 12	Yes	13	In Regime	Widening; Aggradation	Similar
NCD 13	**Part**	11	**In Transition; Entrenchment**	Widening; Degradation	Coarser
NCD 18	Yes	11	In Regime	Stable/Narrowing; Aggradation	Similar
NCD 20	**No**	10	**In Transition; Entrenchment**	Widening; Degradation	Coarser
NCD 21	**No**	10	**In Adjustment; Entrenched**	Widening: Degradation	Similar
NCD 30	**No**	8	**In Transition; Entrenchment**	Widening; Degradation & Aggradation	Finer

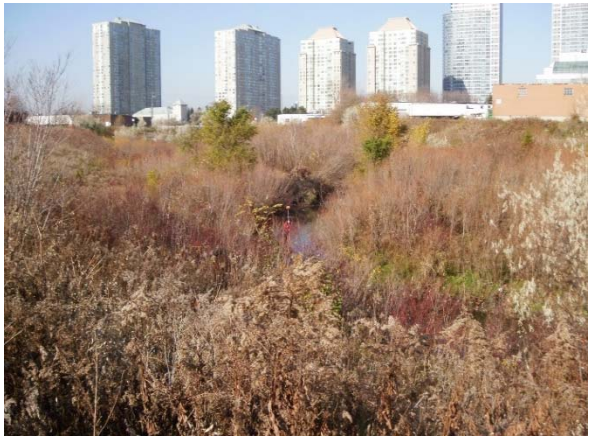
NCD 5 – Highland Creek, Toronto

- Originally re-constructed in late 1960s; rehabilitated in 1997;
- 1,896 ha. drainage area;
- Fully urban drainage area (road density of 10 km/km2; no SWM u/s;
- 1800 m length, 40 to 60 m valley;
- Design objectives:
  - Renaturalize straightened, hardened channel and reconnect with floodplain;
  - Create and improve aquatic habitat for fish & other organisms;
  - Enhance recreational value & aesthetics.
- Design features:
  - Remove gabions, add rock vortex weirs, plunge pools, crib walls, riparian wetlands, plantings.
- Surveyed at 7 and 12 years p/c.




1999 - 2 years post-construction
2005 - 5 years post-construction
2011 - 14 years post-construction

Photographic surveys



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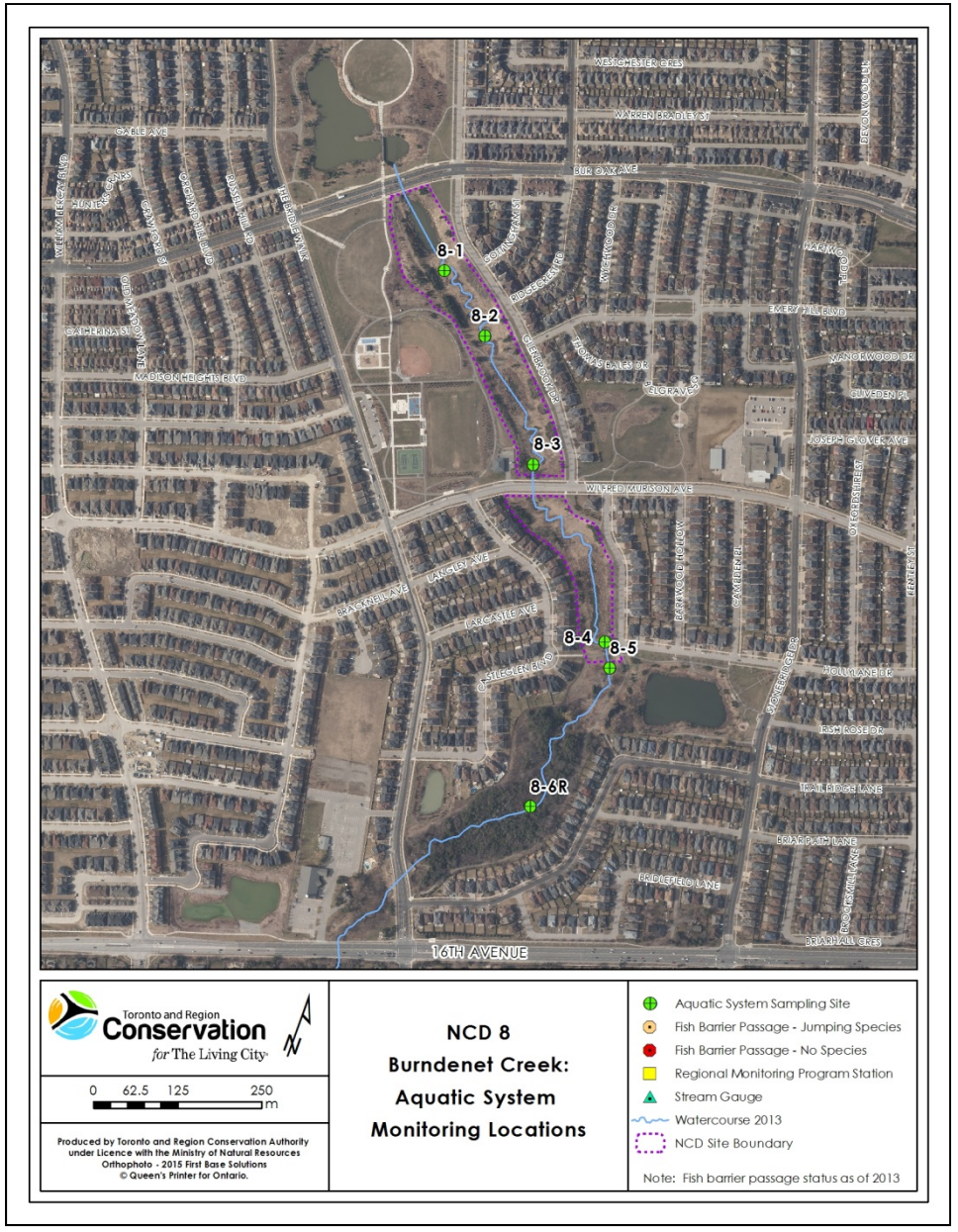
NCD 8 – Burndenet Creek, Markham

- Constructed in 1999;
- 217.4 ha. catchment;
- 63% urban with SWM ponds;
- 900 m length, 60 m valley width
- Design objectives:
  - Lower channel to accommodate SWM pond outlets;
  - Restore natural channel form and function;
  - Rosgen E6 type channel;
  - Appropriate aquatic and terrestrial habitats;
- Design features:
  - Sinuous meandering channel, brush mattresses, fascines, live stakes, on-line wet meadows, riparian plantings (tree/shrub & herb seed mix).
- Surveyed at 7 and 13 years p/c.



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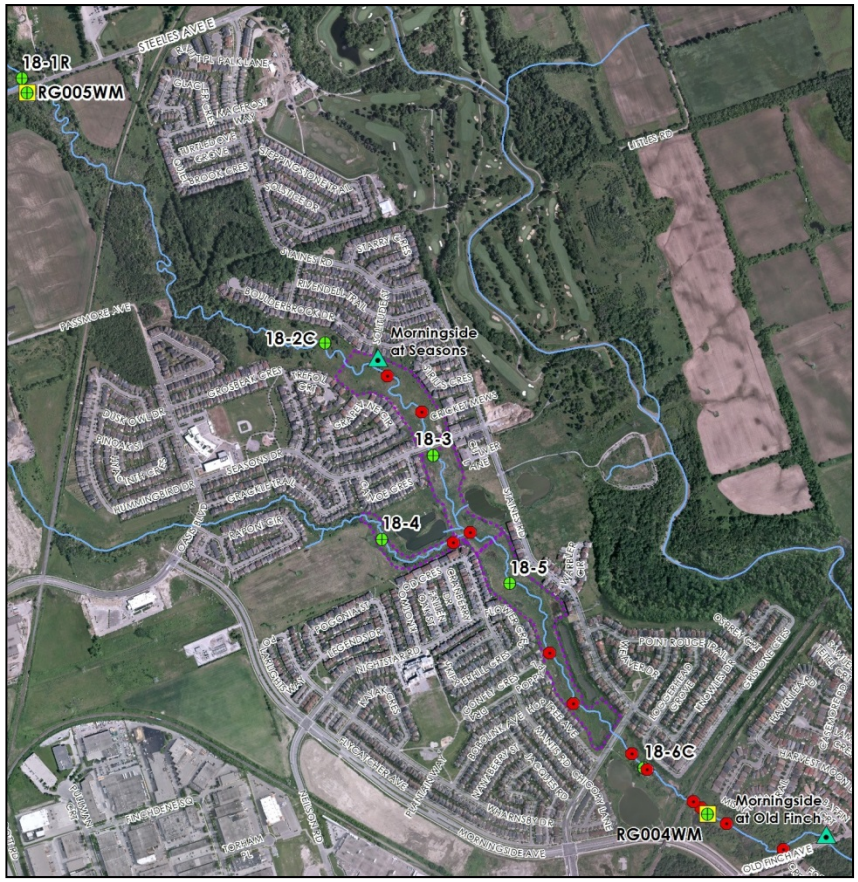
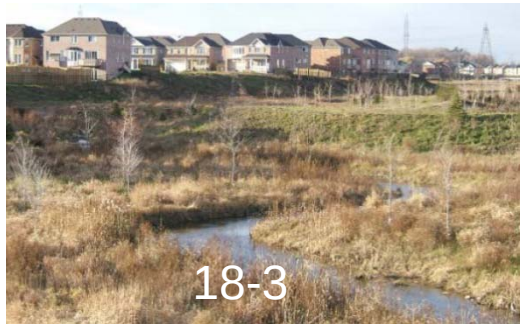
NCD 18 – Morningside Creek, Toronto

- Constructed in 2003;
- 1,433 ha. catchment;
- 84% urban with SWM ponds;
- Road density: 8.8 km/km^2
- 1,750 m length, 8 to 60 m valley;
- Design objectives:
  - Realignment
  - Restore form and function of stream corridor
  - Appropriate and diverse aquatic and terrestrial habitats.
- Design features:
  - Vortex weirs, rocky ramps, riparian plantings with deep rooting native grasses (prairie cord grass), high root density plants on outsides of meanders.
- Surveyed 1,2,3 and 11 years p/c.





Photographic surveys

Geomorphic System conclusions

- All (4) channels with no SWM quantity & quality controls upstream were found to be still in transition & entrenched, or in adjustment 10 to 15 years post-construction;
- Bank failures more common where herbs & grasses are the only vegetation cover types;
  - Supplemental bank treatments/plantings to establish deeply rooting shrubs & trees in problem areas;
- All (5) channels with catchments serviced by SWM quantity & quality controls were found to be in-regime or in-transition but not entrenched 10 to 15 years post-construction;

Lessons learned about monitoring program design…

- Future NCD projects need more clearly stated design objectives, ideally for each system component, to provide a better basis for evaluations of performance;
- Pre-construction biological data, as-built geomorphic surveys and concurrent surveys of control and impacted (i.e. treated) reaches (BACI study design) provides optimal data for performance evaluations;
- Consistent use of standard monitoring methods and protocols, and timing of data collection is essential for comparisons between sampling events and project sites
  - Conduct Geomorphic and Aquatic System surveys at the same time, or in the same month/season each event.

Lessons learned about monitoring program design…

- Use aerial photo analysis to scan for planform changes or evidence of damming, ponding or beaver activity;
- As part of assumption inspections require as-built drawings and repeat Geomorphic and Aquatic System & Terrestrial (fauna) surveys at years 1, 2 & 3 post-construction, ELC & flora surveys at 3 years post-construction;
- For performance monitoring repeat Geomorphic and Aquatic System & Terrestrial (fauna) surveys three (3) times within 5 to 10 years post-construction time period;

Lessons learned about monitoring program design…

- Repeat ELC and flora surveys at 10 yrs. post-construction;
- If still in-adjustment, repeat Geomorphic and Aquatic System and Terrestrial (fauna) surveys another 3 times within 10 to 15 yrs. post-construction time period;
- If an u/s or d/s control (untreated) reach is not available, monitor a reference reach with similar watershed characteristics;
- Conduct in-stream fish barrier assessments each time Aquatic System surveys are conducted.

Next STEPs

- Release of NCD Monitoring Program 2005 to 2014 Summary Report (December 2016);
- Update of Monitoring Protocol document (2017)
- Applying BACI study design to evaluations of TRCA-led stream rehabilitation projects in Region of Peel since 2010.

Project supporters

Thank you

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