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An Economic Analysis of Green and Grey Infrastructure Benefits and Costs

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March 21, 2019 - Brampton, Ontario





OUTLINE

- 1) Infrastructure Cost Policies
- 2) History of Cost-Benefit Analysis
- 3) Green Infrastructure Policy and Costs
- 4) Research Gaps and National Guidelines
- 5) Markham Case Study Grey and Green Infrastructure Strategy Benefits and Costs





Regulating Infrastructure Cost in Ontario

Provincial Policy Statement (2014):

"Infrastructure ... shall be provided in a coordinated, **efficient and** <u>cost-effective</u> manner"

Infrastructure for Jobs and Prosperity Act (2015) O. Reg. 588/17 (2017) :

Asset management plans must show "For each asset category, the lifecycle activities that would need to be undertaken ... and the <u>costs</u> of providing those activities."

These activities must also consider "the lowest cost to maintain the current levels of service"

Class Environmental Assessments (2015):

For wastewater projects "Economic Environment includes commercial and industrial land uses and activities. It also **includes the financial** <u>costs</u> associated with the alternatives, including **construction**, **operation**, **maintenance**, **and property costs**."



History of Cost-Benefit Analysis (CBA)

• Long-standing requirement to evaluate feasibility of flood reduction projects:

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Eckstein 1958: "Feasibility is interpreted to mean that 'the **benefits**, to whomever they may accrue, **are in excess if the estimated costs**', following a requirement specified in the Flood Control Act of 1936."

<u>Watt 1989</u>: "It is therefore reasonable to require that all projects that provide or **improve flood protection be justified economically** before public funds are allocated"

"benefits should exceed cost by a sufficient margin"





CBA in Ontario Class EAs ... Very Rare

 No formal requirement for Cost-Benefit Analysis in economic evaluation.

Dillon Consulting Limited 2004:

Evaluated flood control on a catchmentby-catchment basis in Stratford storm system Master Plan.

Prioritized works to guide subsequent Class EA study in high benefit / cost ratio locations.



Stratford City-Wide Storm System Master Plan:

https://files.onhttps://nparc.nrc-cnrc.gc.ca/eng/view/accepted/?id=7b18d8c9-6c5f-425f-8338-ac4a24f8170bario.ca/infrastructure_update_2017-_eng_0.pdf

Cost benefit analysis is like jazz flute

and a later of the



CBA for Federal Reg's and Grants ... Mandatory

• Canadian government requires CBA to evaluate new regulations and disaster mitigation grant applications.

<u>Treasury Board 2007</u>: Regulations that impose a cost of \$1M or more on stakeholders require monetized benefit and cost evaluation.

Infrastructure Canada 2018: Return on Investment (ROI) analysis for eligible projects **must show benefit / cost ratio of 2:1** or more, with deferred socio-economic and environmental costs (benefits).



 Treasury Board Report 2017-2018:
 https://files.onhttps://www.tbs-sct.gc.ca/rtrap-parfa/analys/analys-eng.pdf

 Disaster Mitigation Adaptation Fund Guidelines:
 https://files.ontario.ca/infrastructure_update_2017-_eng_0.pdf



Ontario Green Infrastructure Policy

 Ministry of Environment and Climate Change (now Ministry of Environment, Conservation and Parks) draft LID manual proposed Ontario-wide targets. Did not address costs.

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"Excessive costs alone shall not be considered an acceptable constraint"

(first draft)

Draft No. 2 LID Manual: https://drive.google.com/open?id=1NHtrjCglDgox4tYISLU5LLZYS32Ea4MN







 "This plan will ensure we balance a healthy environment with a healthy economy."

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 Highlights frustration of taxpayers who see "hard-earned tax-dollars being put towards policies and programs that don't deliver results".

Preserving and Protecting our Environment for Future Generations

A Made-in-Ontario Environment Plan

Ministry of the Environment, Conservation and Parks

Ontario Environment Plan:





Ontario-Wide Draft Policy Cost Implications

 "Estimates suggest that green infrastructure adaptation costs could be as high as \$400,000 per hectare, inclusive of recently tendered construction projects. This means that the long-term **province-wide costs** to developers and municipalities—and, ultimately, the end consumer and economy—total **hundreds of billions of dollars**." (Bill 139 Review 2017)

Hectares Urban Land x Cost Per ha = Initial Capital Cost

852,000 x \$390,000 = \$332 B

Bill 139 Review: https://drive.google.com/open?id=1az42-2TZrcmRm2uHVcxG6mc3LBtb8vv-

Initial Cost Assessment : https://www.cityfloodmap.com/2016/11/green-infrastructure-solution-to-urban.html





Green Infrastructure Capital Cost Review

• Costs from various sources (1200+ projects) have confirmed magnitude of cost issue and need to assess lifecycle costs and cost effectiveness.

Ontario Tenders

City / Town	LID Type (Project Name)	Capital + Soft Cost (\$)	Service Area (ha)	Cost / Hectare (\$ / ha)
Markham	Rain Garden (Glencrest Park)	\$216,000	1.6	\$135,000
Brampton	Bioswale (County Court SNAP)	\$130, 514	0.2	\$652,570
Whitchurch-Stouffville	Various Measures (Coultic Park & CC P. Lot)	\$106,671	0.11	\$969,741
Ottawa	Bioretention (Sunnyside / Road)	\$282,887	0.464	\$609,670
Ottawa	Bioswale (Stewart / Road)	\$363,452	2.01	\$180,821
Ajax	Rain Garden (Lake Driveway)	\$350,000	0.14	\$2,500,000
Mississauga	Bioswale & Pavers (Elm Drive)	\$226,000	0.633	\$357,030
Mississauga	Bioswale (Lakeview)	\$420,900	1.6	\$363,063
Mississauga	Bioswale/Permeable S.Walk (Alpha Mills Rd)	\$148,521	0.3	\$495,070
Newmarket	Bi			\$371,552
London				\$500,068
London	🖩 5575 000	nor r	າວ 👘	\$290,312
London	· 73/3,000	PCII	iu –	\$554,266
London	LI	•		\$189,692
London	LID 580 sq.m (Commissioners Road)	\$334,656	0.87	\$384,662
London	LID 1440 sq.m (Southwest Community Centre)	\$223,708	2.16	\$103,569
London	LID 150 sq.m (No. 11 Fire Station)	\$63,708	0.23	\$283,147
Newmarket	Enhanced Swale (Woodland Court)	\$37,860	0.02	\$1,892,985
East-Gwillimbury	P.Pavement/Bioswale (Municipal Office)	\$155,433	0.23	\$665,949
Bradford West- Gwillimbury	P.Pavement/Bioswale (LID Parking Lot)	\$471,385	0.29	\$1,625,467
Uxbridge	Bioswale (Recreation Complex)	\$85,087	1.67	\$50,951
Aurora	Permeable Pavement, Rain Garden (Recreation Complex Roof and Parking)	\$339,005	1.98	\$171,215
Innisfil	Permeable Pavement, Rain Garden (Fire Station Parking Lot and Roof)	\$84,003	1.98	\$42,426
			A	6575.060

Philadelphia Clean Waters

New York State







Cost data from 127 green stormwater infrastructure projects in Onondaga County, N.Y., demonstrate th influence of both scale and implementation program. Graph by CH2M

Ontario Tenders : Philadelphia, NY Costs :

https://www.cityfloodmap.com/2018/05/are-lids-financially-sustainable-in.html

Costs : https://www.cityfloodmap.com/2018/07/green-infrastructure-capital-and.html

They've done studies you know.

60% of the time it works all the time.



Some Research Overstates Benefits, Incomplete on Costs

 Cites 'meta-analysis' benefits as real "Performance monitoring results" for flood damage reduction (e.g., Pelly's Lake wetland case study).

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- Omits cost-effectiveness of the recommended measures: "cost rankings are not normalized with consideration of performance effectiveness"
- However Press Release promotes
 "solutions that can be deployed practically and <u>cost-effectively</u> within communities"



ICCA Weathering the Storm Report Review: https://goo.gl/Y3vWzx



National Research Council Guidelines

 NRC is developing Guidelines on Undertaking a Comprehensive Analysis of Benefits, Costs and Uncertainties of Storm Drainage Infrastructure in a Changing Climate

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Cost Efficiency Principles in Markham

Excellence Markham Framework:

Financial Performance is a key outcome of ... "how we run the joint"





MARKHAM

PROGRAM



Markham Case Study

- Analysis of city-wide Flood Control Program costs and benefits initiated to:
 - i) estimate DMAF project Return on Investment for flood control
 - ii) evaluate green infrastructure (LID) costeffectiveness for:
 - Flood control
 - Watercourse erosion repair mitigation
 - Water quality improvements (based on willingness to pay)

Markham Flood Control :

https://www.markham.ca/wps/portal/home/neighbourhood-services/water-sewer/projects-and-programs/06-projects-and-programs





Markham Case Study - Strategies

- Focus on 25% of city (pre-1980s)
 - Strategy A grey infrastructure (current program incl. one central wetland)

St.

Yonge

Strategy B

green infrastructure

Strategy C
 90% grey
 10% green







Markham Case Study - Benefits

- Flood control benefits
 - Deferred damages based on scaled regional reported claims
- Erosion control benefits
 - Lower creek repairs based on lifecycle costs (green only)
- Watershed quality benefits
 - Willingness-to-pay for water quality improvements based on Rouge R. source control study (green only)



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INTRODUCTION

There is much healthy debate in the industry relating to the implementation of

Marbek



Assessing the Economic Value of Protecting the Great Lakes: Rouge River Case Study for Nutrient Reduction and Nearshore Health Protection

Final Report

Submitted to Ontario Ministry of Environment Submitted by

Marbek

November 2010

222 Somerset Street West, Suite 3 Ottawa, Ontario, Canada K2P 263 Tel: +1 613 523-0784 Fax: +1 613 523-0717 info@marbek.ca haging stormwater runoff and which is not traditionally employed methods. A rational the type of storm drainage infrastructure – of this paper – that might be appropriate to rements (or reasonably reliable estimates) of over an appropriate time horizon.

el, the benefits derived from both green and ociated costs to identify the economic return it-cost ratios. The analysis uses actual cost as ongoing maintenance costs) derived from benefits considered include avoided damages s) and, particularly for the case of green of reduced erosion mitigation and estimates ality improvements. Further, the analysis l) scale, using the City of Markham as a case ple of the information that can be useful for s at that level. Although not explicitly y (approach) and methodology remain valid ndary Plans, individual municipal or private ell as higher level policy evaluation.

a methodology for benefit-cost analysis of story of such analysis and a review of current sis applying this methodology across the City flood control benefits derived from reported for various strategies including all-grey, alles. Conclusions, including considerations for irriorities for infrastructure investments are





Markham Case Study - Costs

- Grey infrastructure
 - Capital completed, tendered, & designed projects, Class EA estimates, program costs
 - O&M equivalent to existing lifecycle program costs
- Green infrastructure
 - Capital average of unit cost for all LID types (excl. green roof)
 - **O&M** per Philadelphia clean waters pilot lifecycle costs



C





Markham Flood Control Program Activities and Costs







Strategies - 50 Shades of Grey to Green







Annual Costs and Benefits







Annual Costs and Benefits







Conclusions

- Cost-benefit analysis for infrastructure investments is making a comeback (mandatory for disaster mitigation grant applications (DMAF)).
- NRC's upcoming cost-benefit guidelines can support more consistent & thorough cost-benefit analyses, improving reliability & decision making.
- Markham case study evaluating current grey and alternative green infrastructure strategies shows:
 - City's current Flood Control Program (low cost programs, extensive grey infrastructure projects, isolated green projects) is cost-effective with projected benefits over twice the costs.
 - Benefits for green infrastructure implementation warrant detailed study on cost, and willingness to pay for quality improvements given unfavourable benefit/cost from a system-wide lifecycle perspective.





Thank You

More Rob :

Blog: <u>www.CityFloodMap.com</u> Podcast: <u>Open During Construction</u> on iTunes Twitter: <u>@RobertMuir_PEng</u>



More City of Markham :

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