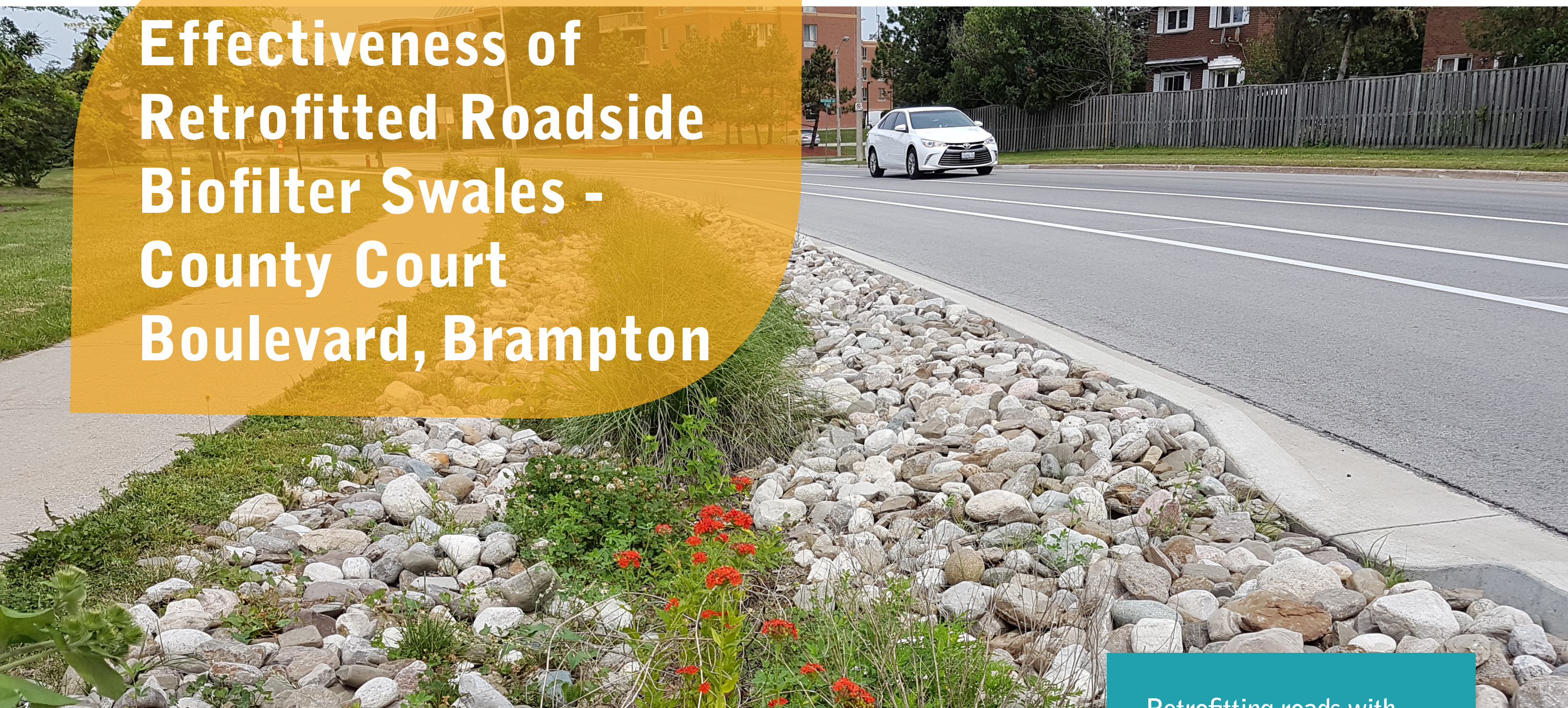
TECHNICAL BRIEF

Sustainable Technologies
EVALUATION PROGRAM

Low Impact Development

Effectiveness of Retrofitted Roadside Biofilter Swales - County Court Boulevard, Brampton



This study evaluates the effectiveness of two lined, filtration-only bioretention swales (i.e., biofilter swales) retrofitted into a portion of the right-of-way of County Court Boulevard, a medium-traffic collector road in the City of Brampton. Scheduling of road maintenance work by the Public Works and Transportation department in 2014 provided the opportunity to retrofit biofilter swales for stormwater treatment within the road right-of-way adjacent to County Court Park. Effectiveness of the biofilter swales retrofit project was examined with respect to the following:

- Runoff volume and pollutant load reduction;
- Effects on effluent temperature;
- Effects of winter operation on treatment performance and maintenance needs, and;
- Life cycle cost of total suspended solids removal over a 50 year life cycle.

Stormwater treatment performance of each biofilter swale and effluent temperature was continually monitored for 16 months in parallel with an untreated portion of County Court Blvd. (i.e., control catchment). Observed suspended solids treatment performance was combined with a 50 year life cycle cost estimate, generated using the LID Life Cycle Costing Tool. Results were compared with estimates for other stormwater retrofit practices suited to roadways and infiltration constrained contexts: (i) hydrodynamic separator; and (ii) grass swale). The understanding gained about the performance and cost-effectiveness of biofilter swales helps inform decisions regarding practices to consider as part of future road reconstruction or other linear infrastructure renewal projects. Based on these findings, recommendations for future planning processes, designs, specifications, operation and maintenance practices and research are provided.

> *"The City of Brampton has been able to take a standard road-reconstruction project, and incorporate specially designed biofilter swales to improve stormwater treatment and help transform local public space. This is a great success story." - Michael Hoy, Senior Environmental Policy Planner, City of Brampton*

Retrofitting roads with stormwater source controls requires practices that are suited to constrained spaces. Bioretention is a highly adaptable practice that uses the natural properties and functions of soils, plants and microbes to filter and retain stormwater and associated pollutants. They are gently sloping, shallow excavations, often featuring a sub-drain pipe, backfilled with layers of drainage stone, engineered media, and covered with mulch, stone and vegetation. They can fit in a wide variety of spaces, providing aesthetic appeal to roadsides, parks and plazas.

INTRODUCTION

In the County Court neighbourhood of Brampton, and many Ontario communities developed prior to 1990, there are few or no stormwater treatment facilities or "best management practices (BMPs)" in place to improve the quality of urban runoff prior to it being discharged to receiving waters. Delivering untreated runoff to urban waterways results in poor water quality during wet weather, which leads to aquatic habitats and communities of low diversity and other water resource beneficial use impairments.

Etobicoke Creek, which drains the neighbourhood, is a heavily urbanized watershed with limited and outdated stormwater management infrastructure. Owing to an unbalanced watershed water budget, stream flows are flashy during wet weather, channels are eroding at accelerated rates, risk of flooding is high, and water quality is poor (TRCA, 2018).

Improving stormwater management and aquatic habitat in communities like County Court that lack adequate controls involves retrofitting new treatment practices where they can be integrated with existing infrastructure, often in constrained spaces. Due to their linear orientation, bioretention swales are well-suited for integration into linear infrastructure corridors such as road rights-of-way.

The genesis of this "green street" retrofit project began when the area became the focus of a Sustainable Neighbourhood Retrofit Action Plan (SNAP), a partnership initiative of the City of Brampton, Toronto and Region Conservation Authority and Region of Peel. SNAP goals are to accelerate environmental improvements and urban renewal at the neighbourhood scale and promote widespread adoption of sustainable technologies, practices and lifestyles in the community. An integrated, community-based planning approach is taken to overcome urban retrofit challenges and address a broad range of objectives with locally tailored solutions.

In 2014, as part of scheduled road reconstruction work, the City of Brampton retrofitted two "filtration only" bioretention swales (i.e., biofilter swales) featuring impermeable liners within the right-of-way of a portion of County Court Boulevard. Impermeable liners were included in the design at the request of Region of Peel to protect their watermain pipe located below the footprint of the swales from potential impacts on the steel reinforced concrete structures supporting the pipes that may be caused by enhanced infiltration of de-icing salt laden runoff.

As the first project of its kind in the City of Brampton, there was interest in evaluating the treatment performance and life cycle cost-effectiveness of the retrofit bioswales to help inform decisions regarding stormwater practices to consider as part of future road reconstruction and linear infrastructure renewal work. Better understanding the effects of winter operation on both treatment performance and maintenance needs was also of interest to inform infrastructure asset management programs and procedures.

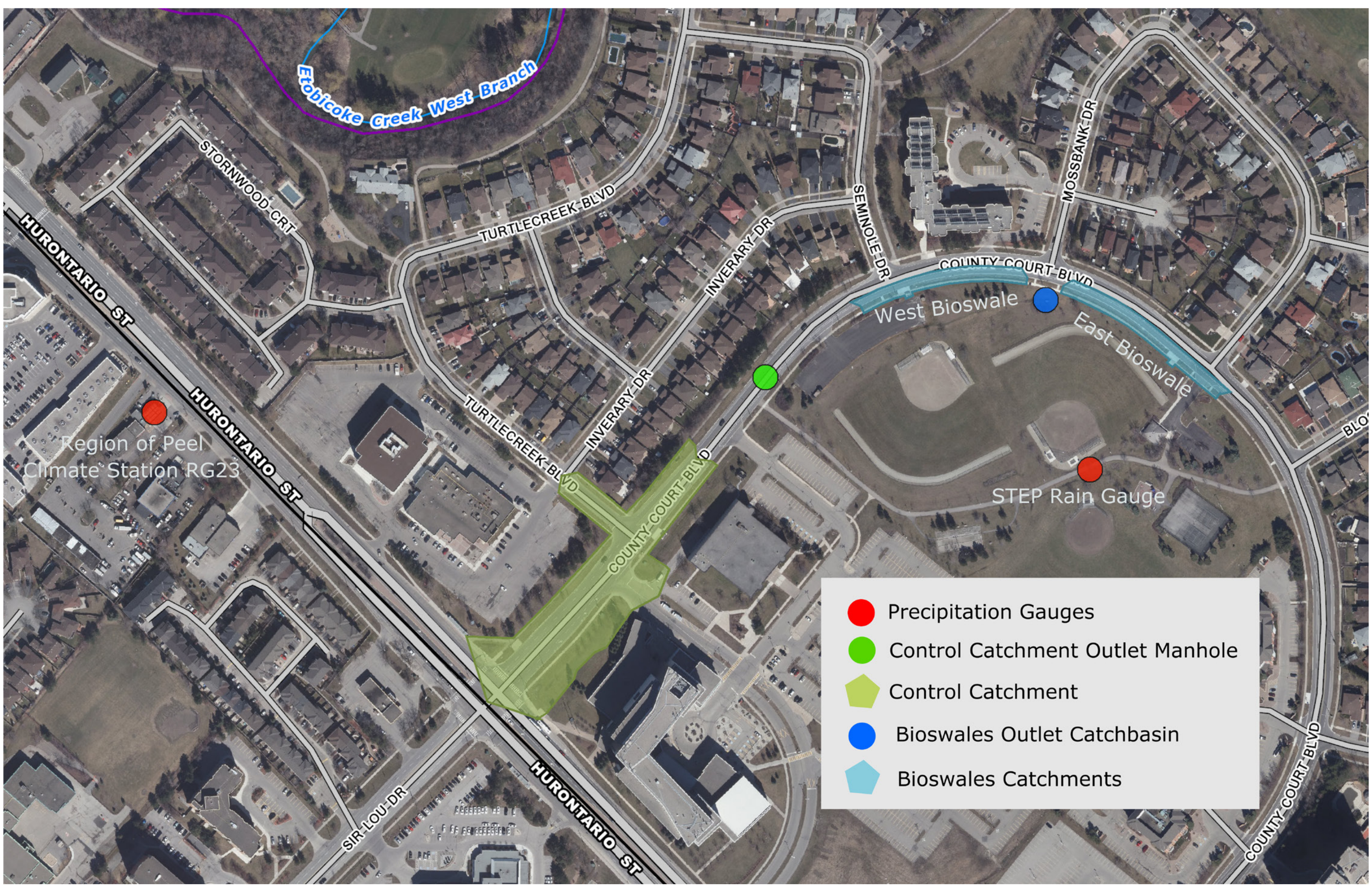


Figure 1: County Court Blvd. Biofilter Swales Retrofit Project Site

STUDY SITE

County Court Blvd. is a medium traffic collector road that services residential, commercial, institutional and parkland areas in the neighbourhood. It receives in the order of 1,900 to 2,900 vehicle trips per day. As part of scheduled road renewal work, two lined bioretention swales (biofilter swales or bioswales hereafter) were constructed that receive and treat runoff from a total drainage area of 3,094 square metres (m^2), including 1,904 m^2 of impervious area that includes portions of the roadway and sidewalk adjacent to County Court Park (Figure 1). Characteristics of the study catchments are described in Table 1.

The length of the biofilter swales are 85 metres (hereafter referred to as East Bioswale) and 70 metres (hereafter referred to as West Bioswale), and each are 3 metres (m) in width (Figure 2). Road runoff enters the biofilter swales via a series of two concrete OPSD 605.040 asphalt spillways and 5 to 6 simple curb openings along their length (8 and 7 inlets each for East and West Bioswales respectively). The swale surface was planted with a mixture of salt tolerant plants (grasses and flowers; pots and plugs) in fall 2014, and bare areas that remained in fall 2015 were seeded with a mixture of native grasses. Cobble-sized river stone was added in 2016 as cover over portions of the swales that remained unvegetated to improve aesthetics and prevent erosion at inlets.

Table 1: County Court Blvd. Biofilter Swales Evaluation Study Catchment Characteristics

Catchment	Control		E. Bioswale		W. Bioswale	
Area (m^2)	7,358		1,716		1,378	
Imperviousness (%)	74.9		61.5		61.5	
Practice Footprint Area (m^2)	n/a		255		210	
Impervious to Practice Footprint Area (I:P) Ratio	n/a		4.1:1		4.0:1	
Outlet location	Manhole MH18, east of northern intersection of County Court Blvd. and Hurontario St.		County Court Park ditch inlet catchbasin		County Court Park ditch inlet catchbasin	
Land cover (m^2)	Imperv.	Perv.	Imperv.	Perv.	Imperv.	Perv.
	5,509	1,849	1,056	660	848	530
Watershed	Etobicoke Creek (West Branch)					
Annual precipitation (mm) [1]	785.9					
Annual runoff (mm) [2]	597.3		519.9		519.9	

Notes:

1. Average annual precipitation is based on Environment and Climate Change Canada Climate Normals, Toronto Lester B. Pearson International Airport station, 1981 – 2010 (ECCC, 2010).
2. Annual runoff volume estimates are based on catchment area, area-weighted runoff coefficient based on land cover (impervious = 0.95; pervious = 0.20), and mean annual precipitation depth.

Inflowing runoff is filtered via percolation through a 0.5 m to 0.75 m bioretention media bed that supports the plantings, followed by a layer of geotextile filter fabric, a 0.15 m coarse sand transition layer, and the geotextile-wrapped drainage stone base and 0.15 m diameter perforated sub-drain pipe (Figure 2). To prevent infiltration an impermeable geomembrane liner was installed on the bottom and sides of each swale and the sub-drain pipe was installed on top of the liner.

The biofilter swale sub-drains convey filtered runoff to a ditch inlet catchbasin in County Court Park which outlets to the municipal storm sewer and ultimately to Etobicoke Creek. During an extreme storm event that produces runoff at a rate that exceeds the treatment capacity of the biofilter swales, flows are conveyed to the storm sewer system by downstream roadway catchbasins.

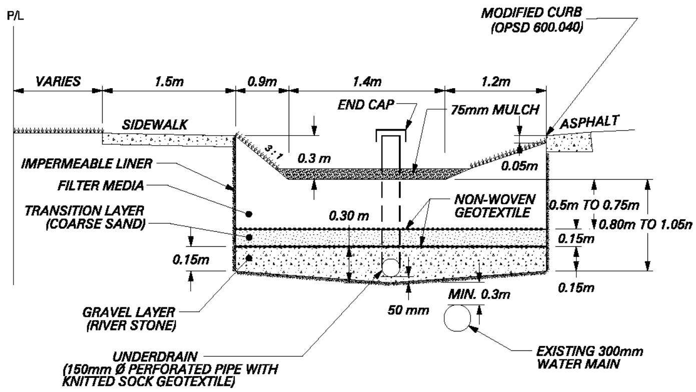


Figure 2: Typical cross-section of County Court Blvd. East Biofilter Swale
Soursce: City of Brampton Works and Transportation, 2014

EVALUATION APPROACH

Stormwater treatment performance of the two biofilter swales was evaluated in terms of their ability to reduce runoff volume and pollutant loads from their respective drainage areas, and their effect on effluent temperature through continuous field monitoring and modelling. Each biofilter swale was evaluated relative to parallel measurements from an untreated portion of County Court Blvd. (i.e., control catchment) over the monitoring period. Precipitation depth was continuously measured using a tipping bucket rain gauge installed in County Court Park and a four season Region of Peel gauge, both within one kilometre of the site (Figure 1). Event mean pollutant concentrations were estimated through automated sampling of effluent from the biofilter swale sub-drain pipes and from the untreated control catchment outlet storm sewer pipe during rain storms.

Flow from the East and West Bioswale sub-drains was continuously monitored using two orificed standpipe and stilling well apparatuses that were custom built and calibrated prior to their deployment. Flow from the control catchment was monitored using an area-velocity flow probe installed on the invert of the 450 mm dia. concrete storm sewer pipe. However the data produced was unreliable due to poor consistency in rating curves. In the absence of reliable measured data, flow from the control catchment was estimated through modelling. A SWMM5 hydrologic model of the control catchment was developed and used to simulate outflow on a continuous basis using the LID Treatment Train Tool (TRCA, LSRCA & CVC, 2017) measured 2015 to 2016 precipitation depth and air temperature data as model inputs. Storm event based estimates of control catchment flow were also calculated based on precipitation depth, catchment area, and runoff coefficients (Table 1).

Pollutant event mean concentrations were combined with measured (bioswales) and modelled (control) catchment flow data to calculate pollutant loads, normalized by their respective drainage areas. Pollutant load removal efficiencies of the biofilter swales were calculated for total suspended solids (TSS), nutrients, metals, oil and grease, sodium and chloride.

By combining measured TSS load removal with project design details, actual costs (where available) and life cycle maintenance and rehabilitation cost estimates, predictions were made of the annual cost per kilogram (kg) of TSS removed based on a 50 year operating period. Estimates were compared to those predicted for other stormwater retrofit options suited to infiltration constrained roadway contexts: hydrodynamic (i.e., oil and grit) separators; and grass swales.

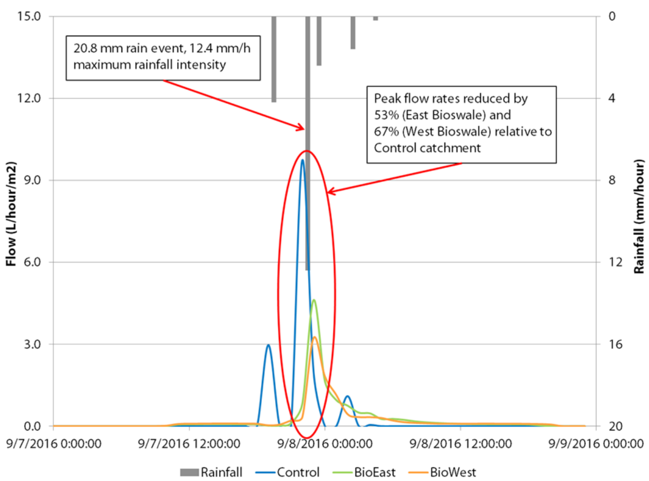


Figure 3: Hydrograph comparing flow rates for Control, East and West Bioswales catchments normalized by drainage area during an intense rain event on September 8, 2016.

Effects of winter operation on treatment performance and maintenance needs were also examined by damming the inlets to the West Bioswale over the winter 2015/16 period while the East Bioswale remained fully on-line (i.e., in service). Flow and electrical conductivity in each bioswale sub-drain were continuously monitored. Bioretention media was periodically sampled and laboratory tested over the winter 2015 to fall 2016 period to examine the effects of exposure to deicing salt laden runoff on sodium adsorption ratio (SAR) and cation exchange capacity (CEC) and seasonal changes.

Additionally, interviews were conducted with municipal and TRCA staff involved in the project and a workshop was convened to summarize key barriers to, and enablers of integrated infrastructure projects and make recommendations to improve future plans.

STUDY FINDINGS

Continuous monitoring of biofilter swale sub-drain flows during simulated and natural storm events and surface infiltration rate tests confirmed that the East and West Bioswale are draining acceptably and capable of reducing runoff volume from their drainage areas by 15 and 34% respectively, through soil moisture retention and evapotranspiration alone. In comparison, other stormwater retrofit options suited to infiltration constrained roadways like grass swales typically achieve in the order of 40% runoff reduction (Jones et al., 2012) while hydrodynamic separators provide no runoff volume reduction benefit. Both bioswales were affected by ingress of shallow groundwater (i.e., interflow) during most of the year, indicating that the liners are leaking and not protecting the underlying watermain from infiltrating road runoff as intended. Differences in runoff reduction performance between the bioswales may be due to variation in the extent to which they are affected by interflow from surrounding landscapes or in the leakiness of the liner.

Table 2: Statistically significant differences at the 95% confidence level between the Control runoff and the Biofilter Swale effluent concentrations

Pollutant	Control vs. East (ANOVA 2015-2016)	Control vs. West (ANOVA 2015-2016)	East vs. West (ANOVA 2015-2016)
Aluminum	Not sig.	Not sig.	Not sig.
Chloride	C < ES	C < WS	Not sig.
Chromium	C > ES	C > WS	Not sig.
Copper	C > ES	C > WS	Not sig.
Hardness	C < ES	C < WS	Not sig.
Iron	C > ES	C > WS	Not sig.
Nitrogen, NH3+NH4	C > ES	C > WS	Not sig.
Nitrogen, Nitrite	C > ES	C > WS	Not sig.
Oil and Grease	C > ES	C > WS	Not sig.
Phosphate	C < ES	C < WS	Not sig.
Sodium	C < ES	C < WS	Not sig.
Total Phosphorus	Not sig.	Not sig.	Not sig.
Total Suspended Solids	*C > ES*	*C > WS*	Not sig.
Zinc	*C < ES*	Not sig.	Not sig.

As expected, peak flow rates normalized to catchment area were substantially lower from the bioswales than the control. During some of the largest and most intense rain storms that occurred over the evaluation period, peak flow rates from the bioswale sub-drains were in the order of 50 to 70% less than from the control catchment. Figure 3 compares storm hydrographs for East and West Bioswale sub-drain and Control catchment flows during one of the most intense rain storms observed over the evaluation period.

Concentrations and loads of some, but not all pollutants in effluent from the biofilter swales were significantly lower than in flow from the control catchment. Storm event flows from the control catchment often exceeded water quality guidelines for Aluminum, Chloride, Chromium, Copper, Iron, Ammonia+Ammonium, Nitrite, Total Phosphorus, Total Suspended Sediment and Zinc (CCME, 2011; OMOEE, 1999). Based on ANOVA analyses of paired storm event data sets, statistically significant differences were observed between control and bioswale effluent concentrations for several of these common stormwater pollutants over the 2015 and 2016 spring to fall monitoring periods (Table 2). Bioswale effluent concentrations and loads were significantly lower than the control catchment for Chromium, Copper, Iron, Ammonia + Ammonium, Nitrite, Oil and Grease and Total Suspended Solids. Loads were reduced by between 5 and 77%, clearly indicating that water quality benefits are being achieved. However, they were higher or not significantly different from the control catchment for Aluminum, Chloride, Phosphate, Sodium, Total Phosphorus and Zinc. Furthermore, it was observed that treated bioswale effluent still exceeded Provincial Water Quality Objectives for Aluminum, Chloride, Copper, Iron, Total Phosphorus and Zinc.

Laboratory testing of bioswale sub-drain and control catchment effluent grab samples during dry weather revealed that shallow groundwater in the area routinely exceeds the Canadian Environmental Quality Guideline acute impact threshold for Chloride (640 mg/L) and Provincial Water Quality Objectives for Aluminum (75 µg/L), Copper (5 µg/L), Total Phosphorus (0.03 mg/L) and Zinc (2 µg/L). Flow monitoring confirmed that bioswale sub-drains were intercepting this contaminated interflow water over the majority of the monitoring period. Therefore bioswale pollutant removal efficiency estimates for metals and nutrients are likely conservative (i.e., under-estimated).

Interception of shallow groundwater containing elevated levels of these pollutants by the bioswale sub-drains and leaching from the bioretention media contributed to observed guidelines exceedances for nutrients in sub-drain flows. The magnitude of exceedances for Phosphate and Total Phosphorus in bioswale effluent suggests that even though the media met specifications for low organic matter (3 to 5%) and available Phosphorus (12 to 40 ppm), it still leached a considerable amount over their first two years of operation. It is important to note that the media used to construct the bioswales was confirmed to meet design specifications through laboratory testing prior to delivery and after installation.

Observed pollutant removal efficiencies of the biofilter swales were generally greater than or similar to International Stormwater BMP Database records for full or partial infiltration bioretention designs, grass swales and oil and grit separators (Table 3).

Comparison of pollutant concentrations and loads in effluents from the East and West Bioswales after the West Bioswale was taken out of service for winter 2015/16 indicate that winter operation had no statistically significant effects on treatment performance. Effluent pollutant concentrations from East and West Bioswales were not significantly different from each other based on examination of results by year and for 2015 and 2016 combined data sets. Based on bioswale sub-drain flow data it is clear that the method used to take the West Bioswale out of service (plywood dams staked to the back of the curb cut inlets with sandbags in front) reduced sediment accumulation on the media bed surface, but did not entirely prevent de-icing salt laden runoff from entering the practice. Substantial amounts of snow and snowmelt was observed to be transported over the curb and into the bioswales through plowing and splashing from passing vehicles.

Table 3: Observed pollutant removal efficiencies and runoff volume reductions and comparison with literature values for bioretention and grass swales

Pollutant	East Bioswales[1]	West Bioswales[1]	Bioretention[2]	Grass Swale[2]	Oil and Grit Separators[3]
Chromium	79	79	22	32	n/a
Copper	36	43	38	5	27
Iron	47	50	-98	-60	n/a
Nitrogen, NH3+NH4	86	88	n/a	n/a	n/a
Nitrogen, Nitrite	85	82	n/a	n/a	n/a
Phosphorus, Total	11	24	-85	-67	40
Suspended Solids, Total	82	81	75	16	45
Zinc	-11	-2	76	18	12
Runoff Volume[4]	15	34	57[4]	42[4]	0

Notes:

1. Pollutant removal efficiency values are percentages based on the difference in median concentrations between effluent from the control catchment and the bioswale over the monitoring period.
2. Literature values for pollutant removal efficiencies are based on the difference in median concentrations for all International Stormwater Best Practice Performance Database records for grass swales and full- or partial-infiltration bioretention designs as of 2016 (Clary et al. 2017).
3. Literature values for pollutant removal efficiencies are based on the difference in median concentrations for all International Stormwater BMP Database records for oil/grit separators and baffle boxes as of 2011 (Geosyntec Consultants and Wright Water Engineers, 2012).
4. Literature values for runoff volume reduction are based on the median of all International Stormwater Best Management Practices Database records for grass swales and full- or partial-infiltration bioretention designs as of 2010 (Geosyntec Consultants and Wright Water Engineers, 2011).
5. n/a = information not available.

While life cycle cost estimates suggest that biofilter swales are slightly more expensive than oil and grit separators and grass swales per unit drainage area treated, their superior pollutant removal performance and ease of maintenance make them economically preferable from a pollutant removal cost effectiveness perspective. The total life cycle cost per unit total suspended solids (TSS) load reduced over a 50 year operating period for the County Court Blvd. biofilter swales is estimated to be $3,223 (CDN dollars) per kg TSS removed per year, based on measured treatment performance, actual construction costs provided by City of Brampton, and maintenance and rehabilitation cost estimates generated by the LID Life Cycle Costing Tool (TRCA & U of T, 2013; TRCA, 2018). In comparison, the tool predicts costs of $2,867 and $2,119 per kg TSS removed per year for separators and grass swales, respectively (Figure 4). It is important to note that the County Court Blvd. biofilter swales were designed with lower impervious to practice footprint area (I:P) ratios than what is recommended in design guidance (4:1 as opposed to 10:1) which inflated the costs.

Maximum temperature of biofilter swale effluent was on average 7.4 °C cooler than control catchment runoff, and never exceeded the coolwater aquatic habitat guideline value of 24 °C, thereby providing a more suitable thermal regime for downstream aquatic life. This represents an

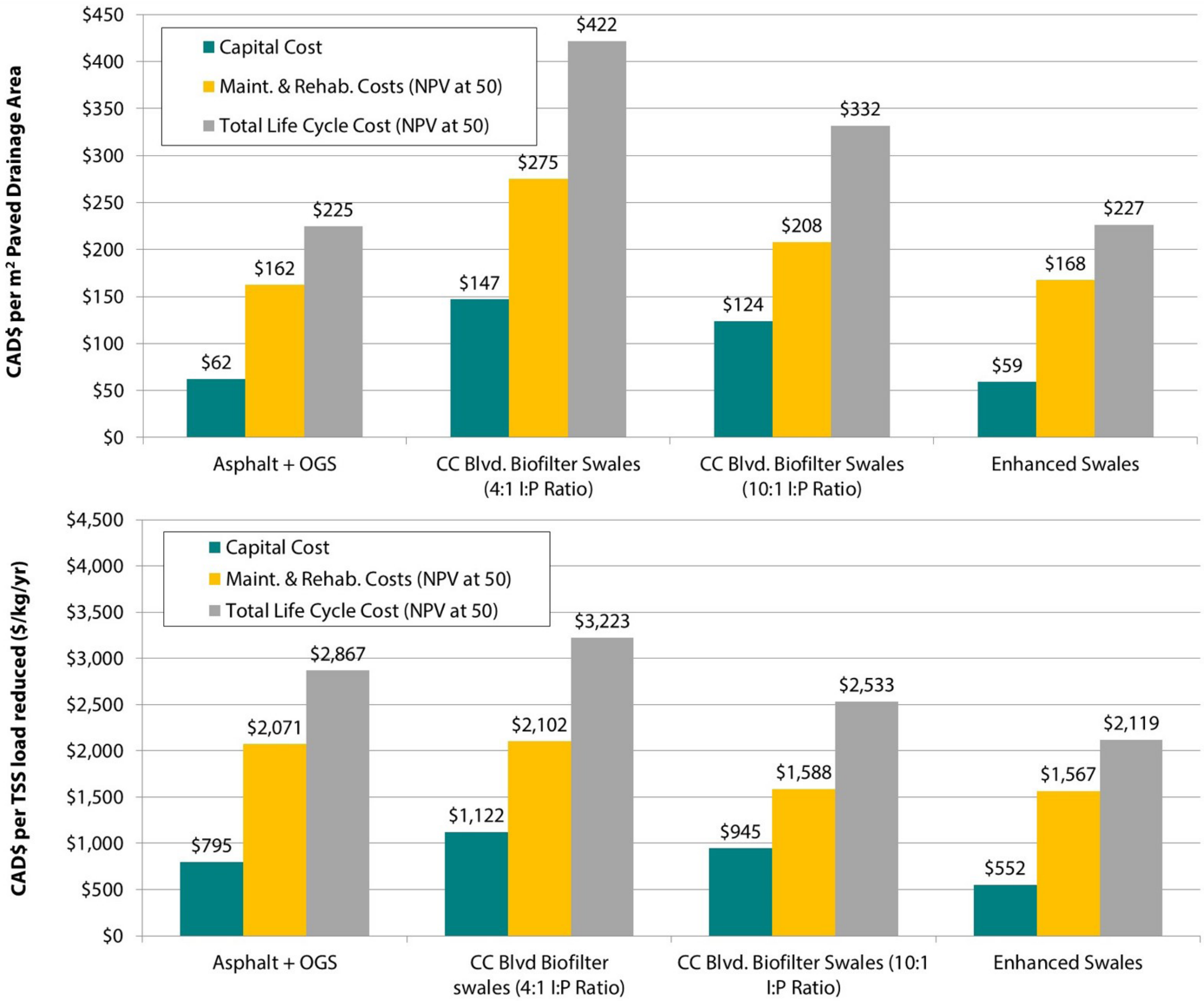


Figure 4: Comparisons of life cycle cost estimates for oil and grit separators, biofilter swales and enhanced grass swales

important benefit of bioretention over other treatment systems, such as ponds, which have been shown to increase runoff temperatures by 5 to 9 °C. Figure 5 illustrates the differences in effluent temperatures between the Control, East and West Bioswales during summer 2016, expressed in terms of cumulative frequency plots.

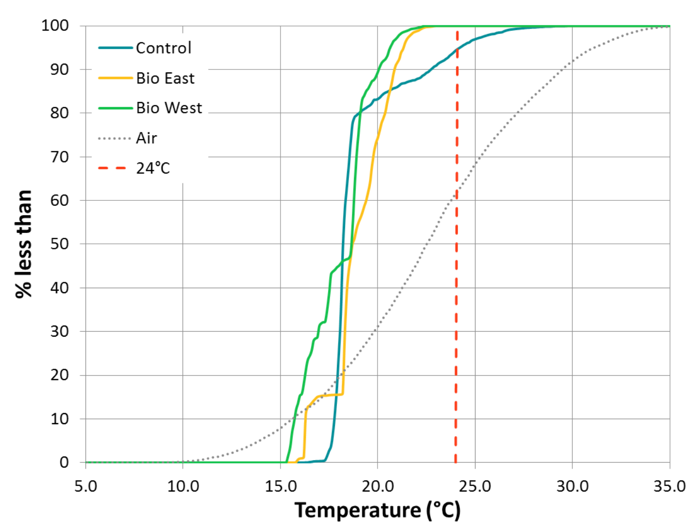


Figure 5: Cumulative frequency plots for air temperature, the control runoff, and effluent from East and West Bioswales (June 1 to September 30, 2016)

Bioretention media samples exceeded Ontario Record of Site Condition Standards (OMOE, 2011) for Sodium Adsorption Ratio (SAR) during winter months, due to exposure to de-icing salt laden runoff but returned to levels below guidelines by the end of April. Spring rain events were effective at flushing excess sodium ions from the bioretention media early in the growing season. Cation Exchange Capacity remained above Ontario Soil Fertility Handbook guidelines (OMAFRA, 2006) year round, indicating that one season of winter operation did not substantially affect this parameter that can influence metal and nutrient retention capacity of the bioretention media.

Experiences gained through the County Court SNAP project highlight the critical importance of having a champion within the implementing organization to facilitate inter-departmental coordination, stakeholder engagement and their integration into project plans. The project stakeholder workshop identified several enabling factors to consider when planning future projects. Integrated infrastructure renewal project teams should be open to piloting innovative (i.e., non-standard) designs and practices as means of achieving multiple objectives and desired outcomes/cobenefits. Integrated approaches to project planning require high levels of coordination and pooling of information for decision-making. Project objectives and team member roles and responsibilities must be clear early in the planning process.

CONCLUSIONS

This study demonstrated the viability of filtration-only, lined bioretention swales as a retrofit stormwater source control practices to treat runoff from a medium-traffic road within the climatic context of the Greater Toronto Area. The following conclusions, recommendations and further research needs are offered based on the findings from this study.

Stormwater treatment performance and bioswale design

Results show that the biofilter swales have been effective in meeting their design objectives by reducing runoff volumes, attenuating peak flows, removing pollutants and reducing thermal loading relative to the control catchment. Since the swale was lined, soil moisture retention and evapotranspiration were the primary drivers for runoff volume reductions. These reduction rates were relatively modest at 15 and 34% for the East and West Bioswales, respectively. Higher rates are expected in the future as the vegetation becomes more established and larger root and leaf mass enhances interception and facilitates removal of moisture from the soil root zone.

In addition to reducing the volume of runoff, rates of release were also much more controlled, with initiation of runoff occurring later than asphalt, and peaks dampened by the soil filtering process. Further peak flow reductions can be achieved by fitting an orifice on the outlet pipe to enhance active storage and detention of runoff.

Filtration has been shown in other studies to be an effective means of reducing suspended solids and other contaminants transported in stormwater runoff, and this study shows similar results. The concentration of TSS was significantly lower than asphalt runoff concentrations, and median bioswale effluent concentrations were below 10 mg/L.

Asphalt is not a primary source of nutrients such as Phosphorus, therefore it was not surprising that filtered runoff had higher concentrations of these constituents as even sandy soils naturally contain nutrients. Even on a load basis, which accounts for reduced runoff volumes, dissolved Phosphorus was still higher from the bioswales than the untreated control. These findings suggest that for lined, filtration-only practices, where pollutant removal is primarily through retention in the BMP and not runoff reduction, bioretention media specifications for the organic component should be for material with low nutrient availability (e.g., shredded bark/wood/yard waste compost). Media specifications should also allow for a finer soil texture (e.g., up to 12% clay) which boosts retention of nutrients and metals, or include a treatment enhancing additive, particularly if draining to a highly sensitive receiving water.

The bioswales provided substantial thermal load attenuation benefits. A 7^{0}C difference in maximum temperatures was observed between control and biofilter swale effluents, and maximum temperatures never exceeded 22^{0}C even during hot summer days. This is below the 24^{0}C threshold for the protection of redside dace, and only slightly above the coldwater fishery threshold of 21^{0}C.

In situations where it is necessary or desirable to take stormwater treatment practices out of service for the winter months, inlets should be designed with water-tight sluice gates that can be shut off more effectively than the damming approach used in this study.

Project Implementation

Design of the biofilter swales called for a vertical excavation along the back of the existing concrete curb, which was installed over granular A backfill, which began to collapse once exposed, putting the curb at risk of damage and necessitating its replacement with a wider style. In future retrofit designs where existing curbs are to be retained and altered, bioswale excavations should be offset from the backs of the curbs and the excavation sidewalls should be sloped, to help avoid destabilization.

The importance of diligent attention to details during construction was highlighted when visual inspections revealed that the contractor had missed installing a curb opening and that 4 of 15 inlets were not built to the OPSD specification and had to be reconstructed. A strategy for avoiding such complications is regular meetings between the contractor and project manager, and inspections during critical points in the construction process.

Simulated storm event testing results were consistent with continuous natural storm event monitoring. As simulated storm event tests are much quicker and cheaper to perform than most continuous monitoring programs, project managers should consider performing them as part of substantial completion/deficiency inspections.

Further Research Needs

One objective of this study was to examine the effects of winter operation on bioswale vegetation maintenance needs. Unfortunately, vegetation only became well established late in the study and blocking of inlets was not entirely effective at keeping de-icing laden runoff out. Soils showed some build-up of salts, but these leached out quickly with the spring rains, suggesting that any impacts to vegetation during the growing season are likely to be relatively minor. Further study of this issue is needed to better characterize the conditions (e.g. media drainage rates and plant selection) under which salt may present challenges regarding vegetation maintenance and replacement costs.

Further research on the long-term function of lined bioretention practices is needed to provide better data on changes in performance over time, the required frequency of maintenance, and the interval at which full scale rehabilitation may be needed. The role of mulch and stone cover, vegetation and associated microbial processes in maintaining stormwater treatment performance is not well understood. Further research is needed to identify the types of bioretention media, operation practices and vegetation best suited to meeting their pollutant load reduction functions, and how their characteristics influence maintenance needs.

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Figure 6: Curb inlet at the bioretention

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About STEP

The water component of the Sustainable Technologies Evaluation Program (STEP) is a partnership between Toronto and Region Conservation Authority (TRCA), Credit Valley Conservation (CVC), and Lake Simcoe Region Conservation Authority (LSRCA).

Toronto and Region Conservation Authority