Sustainable Technologies
EVALUATION PROGRAM

Performance and Cost Effectiveness of Retrofitted Roadside Biofilter Swales in Brampton, Ontario

Presented by:

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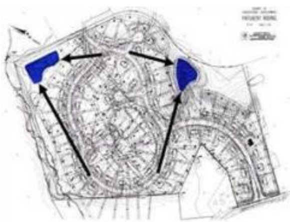
STEP Water is a partnership between:

Toronto and Region Conservation for The Living City

Credit Valley Conservation inspired by nature

Lake Simcoe Region conservation authority

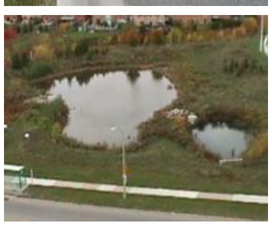
Rethinking stormwater infrastructure



Large, centralized → Small, distributed

Single function → Multifunction

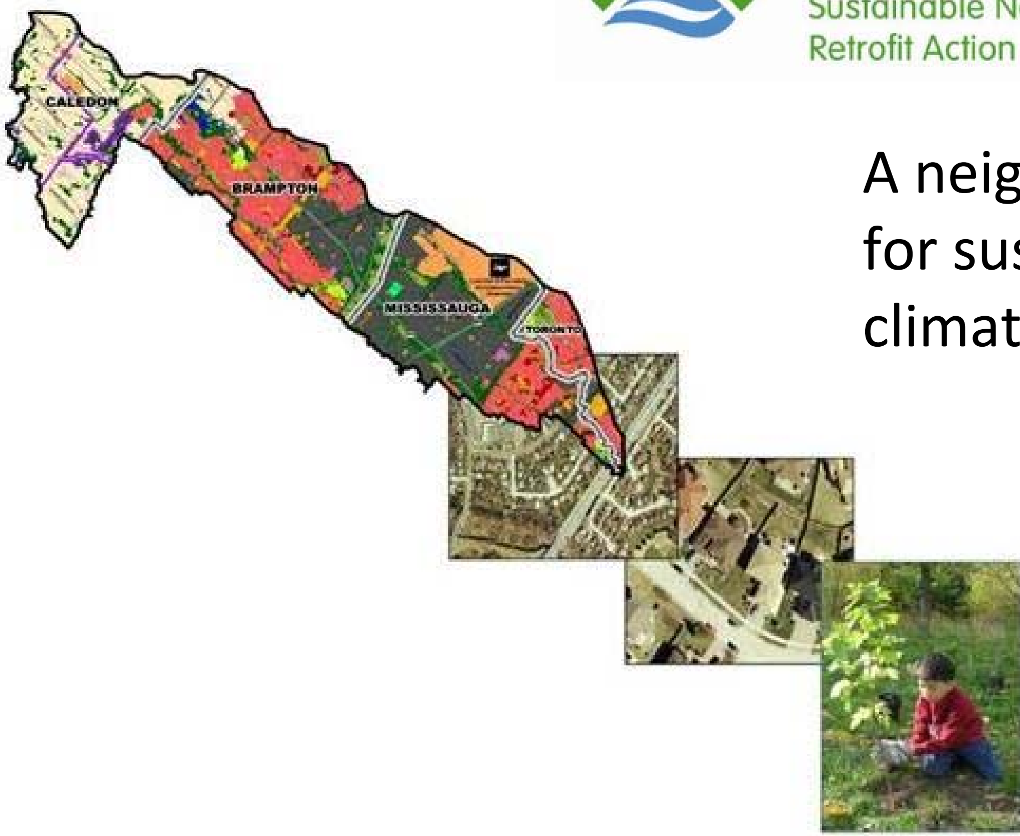
Pipes, sewers, curbs and gutters → Soils, vegetation and hardscapes



Manage flow rates → Manage the water cycle

SNAP

Sustainable Neighbourhood Retrofit Action Plan



A neighbourhood-based solution for sustainable urban renewal and climate action.

- ✓ Brings efficiencies
- ✓ Draws strong community support
- ✓ Builds innovative partnerships for implementation

County Court SNAP - Creating a sense of community

GREEN HOME MAKEOVER

Green renovation & landscapes

County Court Park renewal

Bioretention

Upper Nine SW pond transformation

Habitat Restoration

Rainwater harvesting for irrigation

Green parking lots

Urban forest

County Court Blvd. biofilter swales

Demonstrating a strategic financing model and interdepartmental cooperation.

Basis for engaging community and measuring outcomes

- ✓ Routine road reconstruction scheduled by City
- ✓ Few street trees
- ✓ High visibility
- ✓ Adjacent to County Court Park
- ✓ Low permeability clayey native soil over bedrock
- ✓ Region of Peel watermain below footprint

County Court Boulevard, Brampton, 2014 (pre-construction)

County Court Blvd. biofilter swales – Design

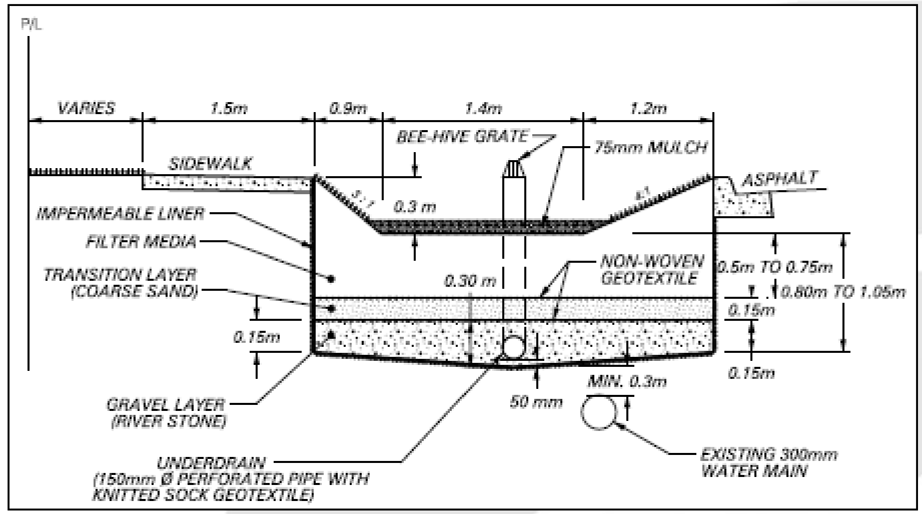
- Two lined bioretention (biofilter) swales, 70 m (West) and 85 m (East) length x 3 m width, constructed in 2014/15 that receives runoff from 1,904 m^2 portion of County Court Blvd.;
- Impervious liner and sub-drain pipe (no infiltration design) to limit risk of damage to watermain located below swale footprints;

Before (2014)

After (2016)

County Court Blvd. biofilter swales – Design

- Impervious to pervious area (I:P) ratio of 4:1;
- ~ 1 m deep, vertical walled excavation lined with EPDM (rubber) geomembrane;
- 150 mm dia. perforated pipe sub-drain with filter sock and standpipes;
- 15 cm coarse sand transition layer sandwiched between geotextile;
- 50 to 75 cm depth of filter media (85% sand-sized, 4% O.M.);
- OPSD 605.040 concrete asphalt spillways (2 per bioswale) and simple curb cuts as inlets (5 to 6).



County Court Blvd. biofilter swales – Construction

- Vertical excavation destabilized the gravel base of the existing curb, necessitating replacement;
- Encountered groundwater in lowest portions of the excavation, complicating liner installation;
- Modified curbs not constructed to OPSD specifications – needed to replace of 4 of 15 with OPSD 605.040 concrete asphalt spillways;
- Missing curb cut inlet u/s of one road catchbasin.

County Court Blvd. biofilter swales – Landscaping

- Original planting plan: mix of flowers, herbs and ornamental grasses with shredded mulch cover;
- Community planting event in fall 2014;
- Vegetation cover <80% after 2 years – too few plants, lack of watering and mulch, dry spring 2015, road reconstruction in summer 2016 were contributing factors;
- Grass/herb seed mix spread on biomedia in fall 2015 - poor results;
- Added river-run stone cover around surviving plants in 2016.

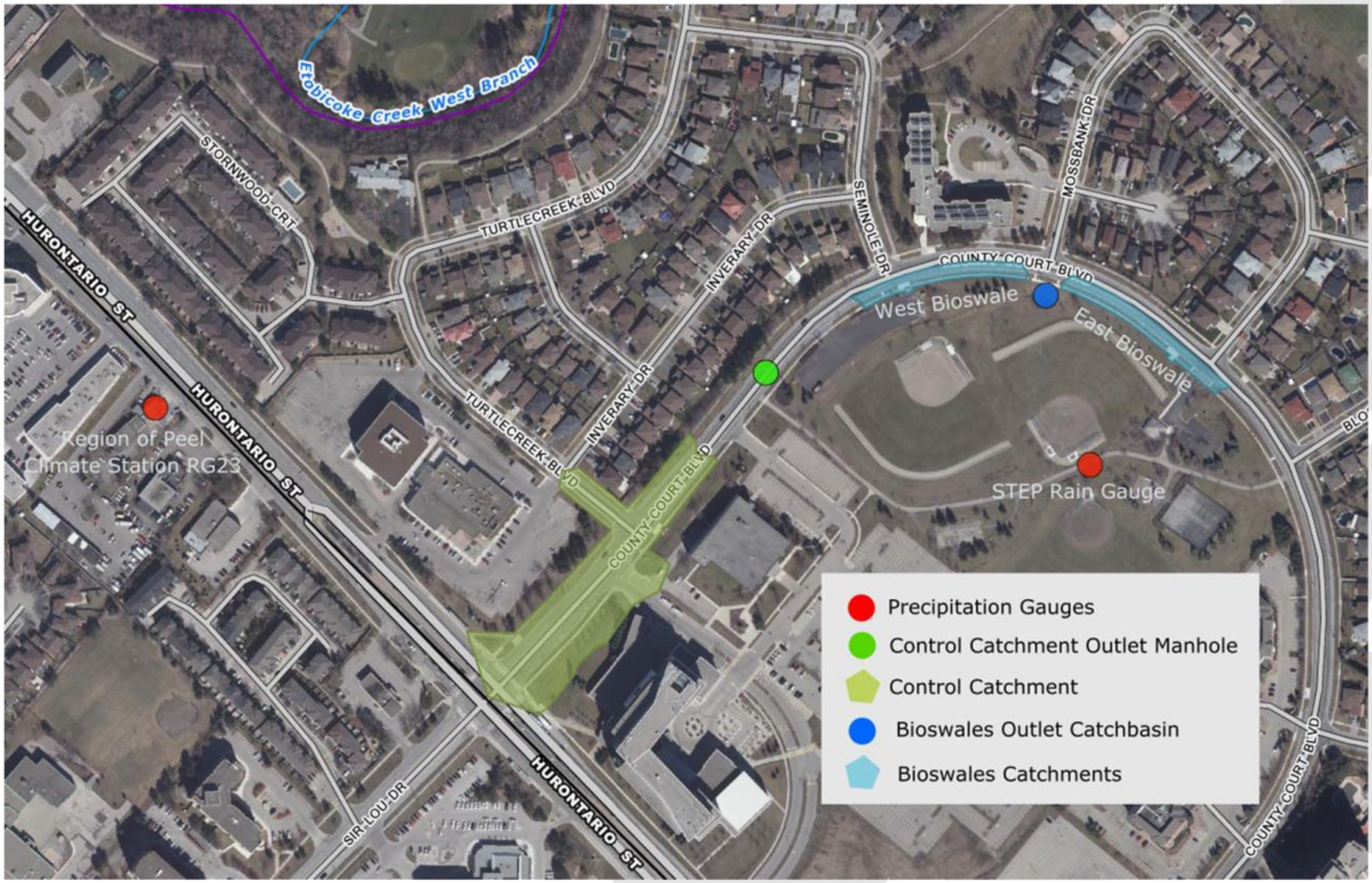
West Swale - June 2016

West Swale – Oct. 2016

County Court Blvd. biofilter swales – Performance evaluation

- Continuous field monitoring to evaluate runoff volume and pollutant load reduction and examine effects on effluent temperature;
- Examine effects of winter operation on treatment performance and maintenance needs;
- Compared bioswale flow volumes, rates & water quality to runoff from an untreated portion of County Court Blvd. (Control catchment);

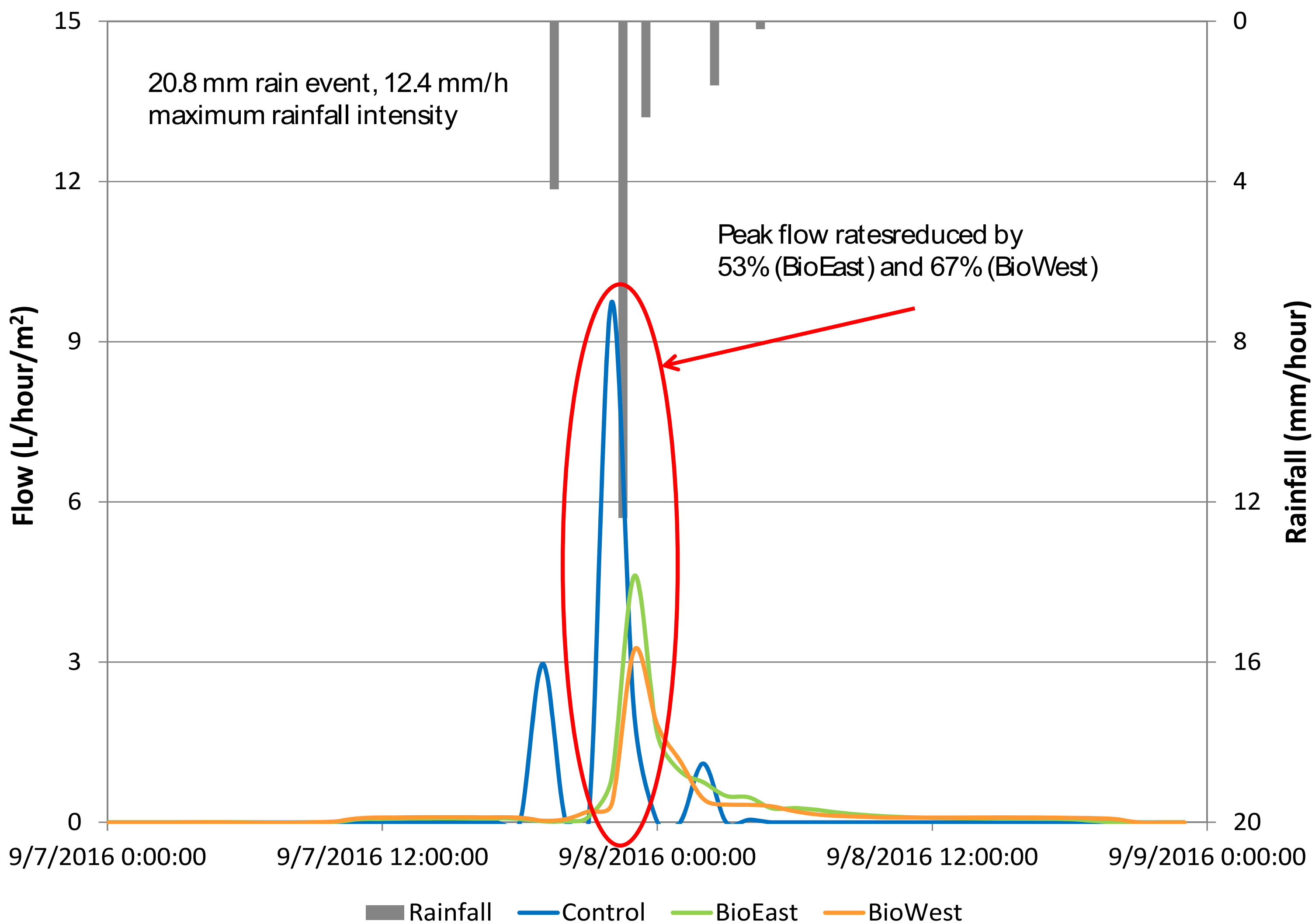
County Court Blvd. biofilter swales – Performance evaluation



County Court Blvd. biofilter swales – Performance evaluation

- Evaluated runoff reduction through continuous flow monitoring during simulated and natural storm events;
- Simulated storm event testing (Nov. 2014) indicated potential to reduce runoff in order of 30% for a 12 mm simulated event on dry soil;
- Biofilter swales with 4:1 I:P ratio can retain all runoff from rainfall events up to 3.0 mm in depth;
- Runoff reduction (2015/16 rain events, n = 80):
  - East Bioswale: 17%
  - West Bioswale: 34%

Peak flow rate reduction

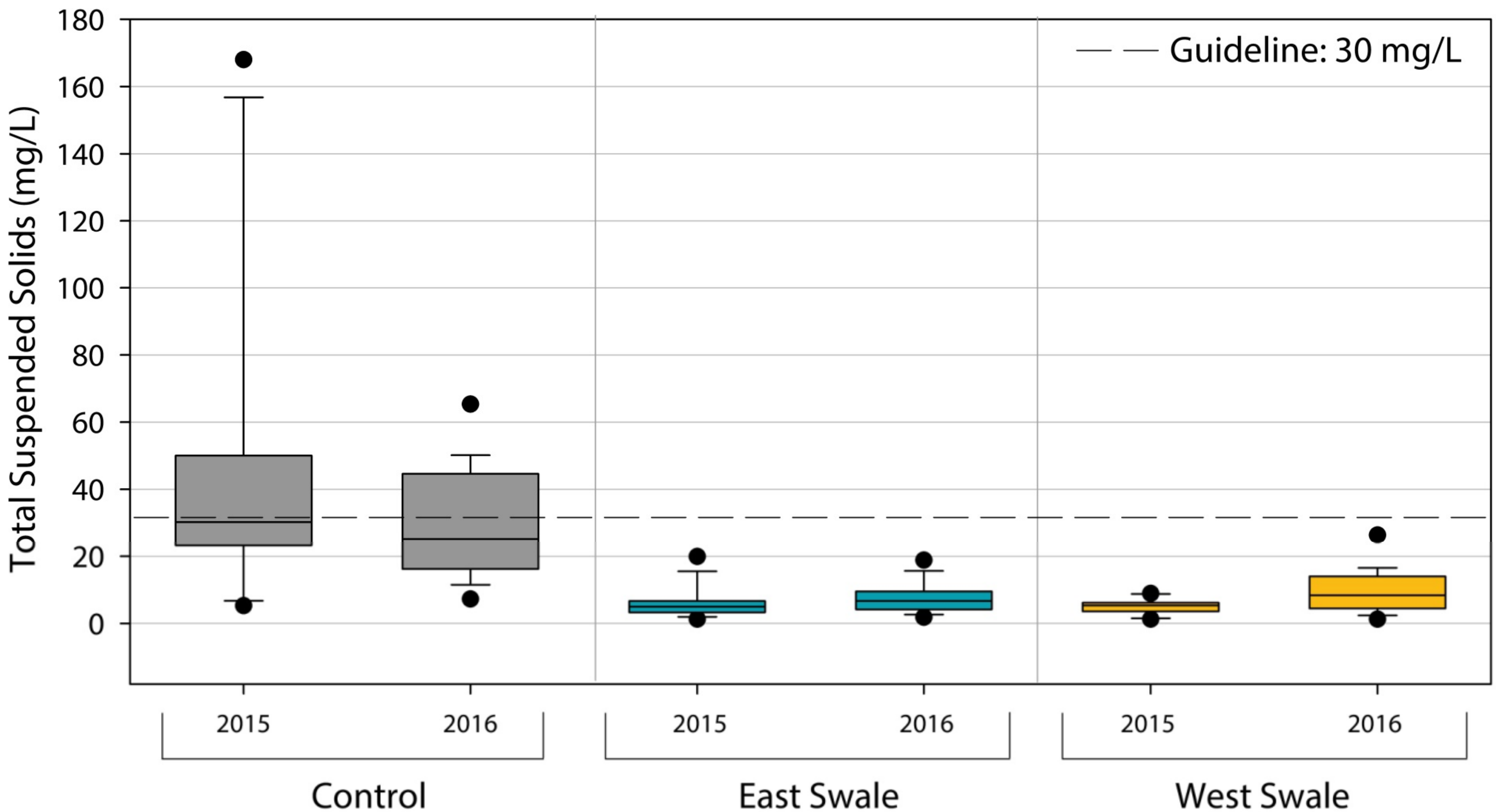


Water quality - statistical significance

Pollutant	Control vs. East (ANOVA 2015-2016)	Control vs. West (ANOVA 2015-2016)	East vs. West (ANOVA 2015-2016)
Chloride	C < E	C < W	Not sig.
Suspended Solids	C > E	C > W	Not sig.
Nitrogen, Total	Not sig.	Not sig.	Not sig.
Phosphorus, Total	Not sig.	Not sig.	Not sig.
Phosphate	C < E	C < W	Not sig.
Oil and Grease	C > E	C > W	Not sig.
Hardness	C < E	C < W	Not sig.
Chromium	C > E	C > W	Not sig.
Copper	C > E	C > W	Not sig.
Lead	Not sig.	Not sig.	Not sig.
Sodium	C < E	C < W	Not sig.
Zinc	C < E	Not sig.	Not sig.

Based on sample event mean concentrations from 35 rain events

County Court Blvd. biofilter swales – Total Suspended Solids



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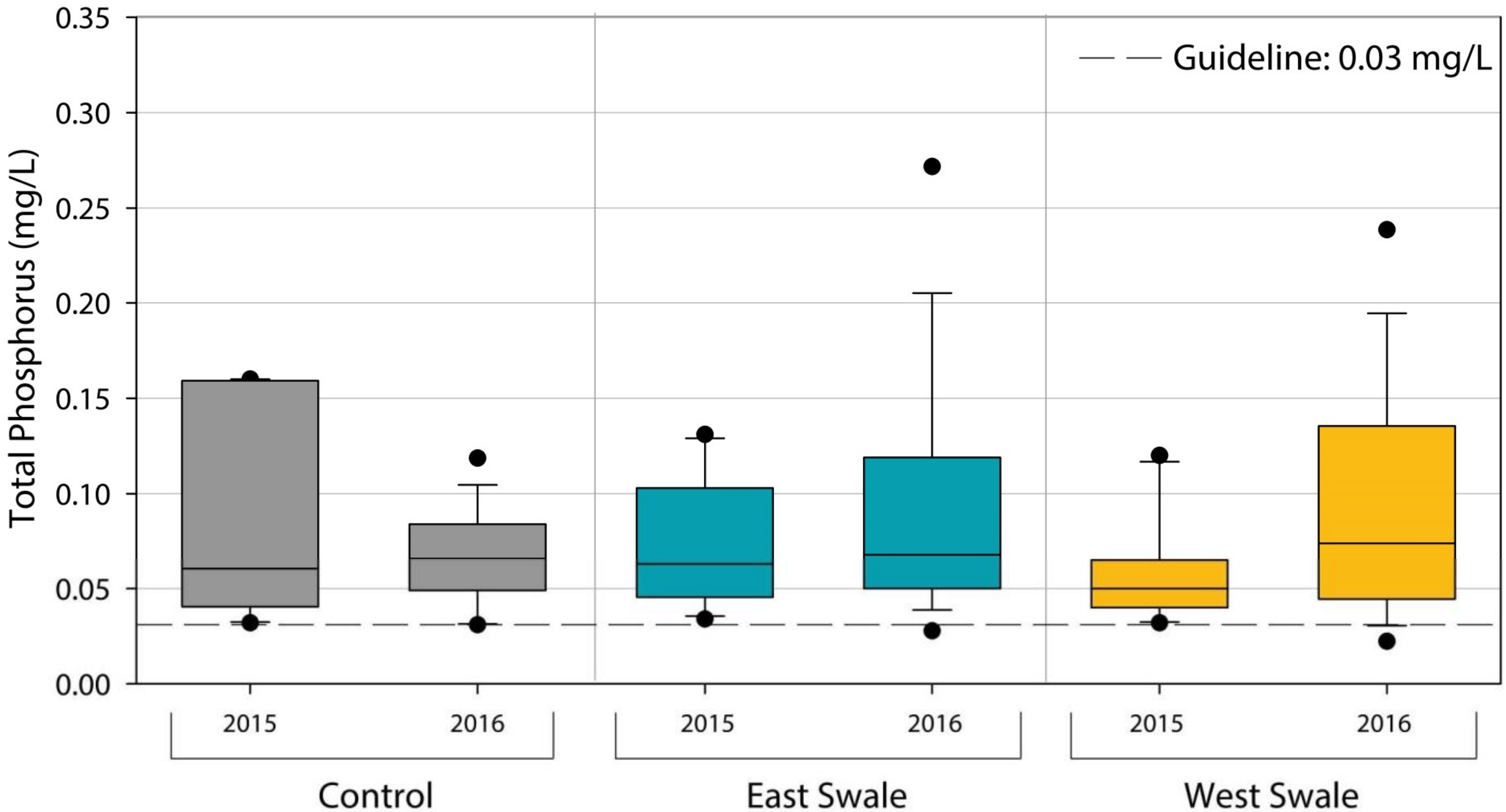
County Court Blvd. biofilter swales – Total Phosphorus



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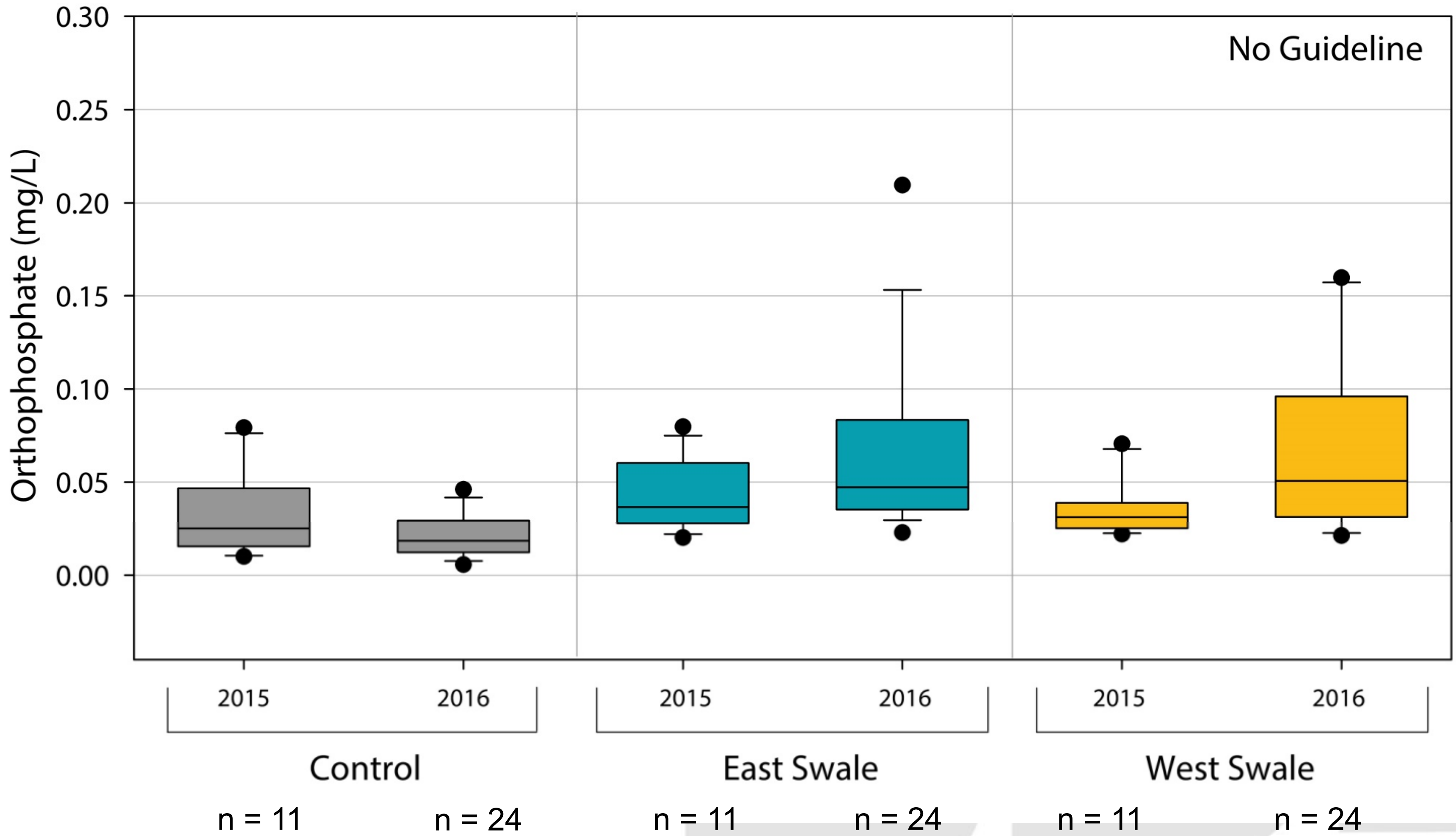
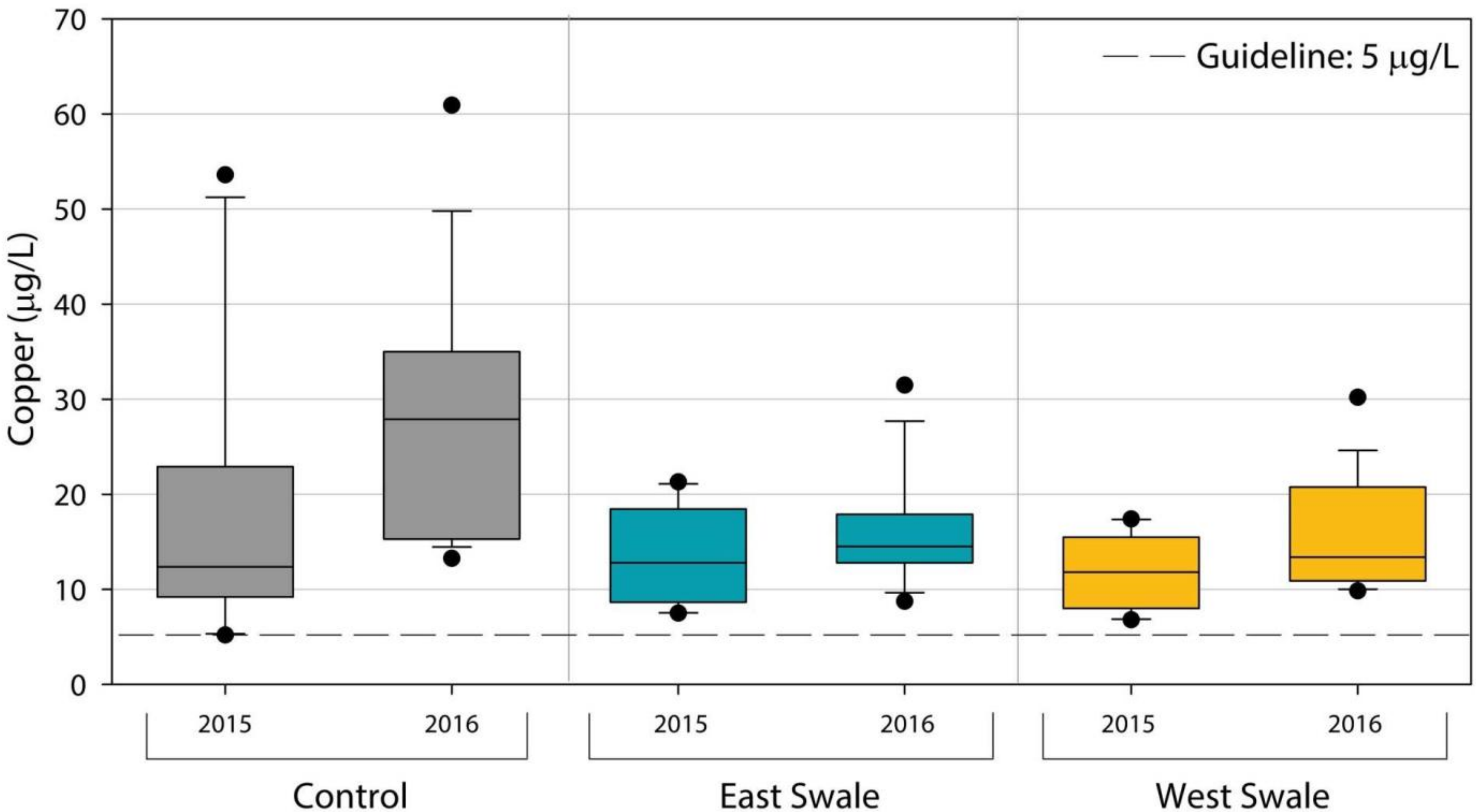
County Court Blvd. biofilter swales – Soluble Phosphorus



County Court Blvd. biofilter swales – Copper



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Effluent pollutant concentrations

Parameter	Unit	Guideline	Control	East Bioswale		West Bioswale	
			Effluent conc. (median)	Effluent conc. (median)	Removal Efficiency (%)	Effluent conc. (median)	Removal Efficiency (%)
Chloride	mg/L	120/640	32.1	149	-364	81.35	-153
Solids, suspended	mg/L	25	27.8	5	82	5.4	81
Nitrogen, Total	mg/L	n/a	1.11	0.81	2[illegible]	[illegible]	23
Nitrogen; NH_3+NH_4	mg/L	0.019	0.246	0.034	8[illegible]	[illegible]	88
Nitrogen, nitrite (NO_2)	mg/L	0.060	0.055	0.008	8[illegible]	[illegible]	82
Nitrogen, NO_2+NO_3	mg/L	n/a	0.373	0.297	20	0.31	17
Phosphorus, Total (TP)	mg/L	0.03	0.066	0.059	11	0.05	24
Phosphorus, Phosphate	mg/L	n/a	0.018	0.041	-1[illegible]	[illegible]	[illegible]67
Oil & Grease	mg/L	n/a	1.85	0.5	7[illegible]	[illegible]	[illegible]73
Aluminum	ug/L	75	180	130	28	95.5	47
Boron	ug/L	1500/2900	13.5	46	-241	47	-248
Chromium	ug/L	9.9	11.8	2.5	79	2.5	79
Copper	ug/L	5	21.3	13.6	36	12.05	43
Iron	ug/L	300	360	190	4[illegible]	[illegible]	50
Sodium	ug/L	n/a	22.6	135	-4[illegible]	[illegible]	[illegible]349
Zinc	ug/L	20	85.7	95.5	-1[illegible]	[illegible]	-2

Int'l SWM BMP Database:

Bioretention 78%
Enhanced Swale 47%

Bioretention -28%
Enhanced Swale -72%

Bioretention 36%
Enhanced Swale 37%

TSS load reduction

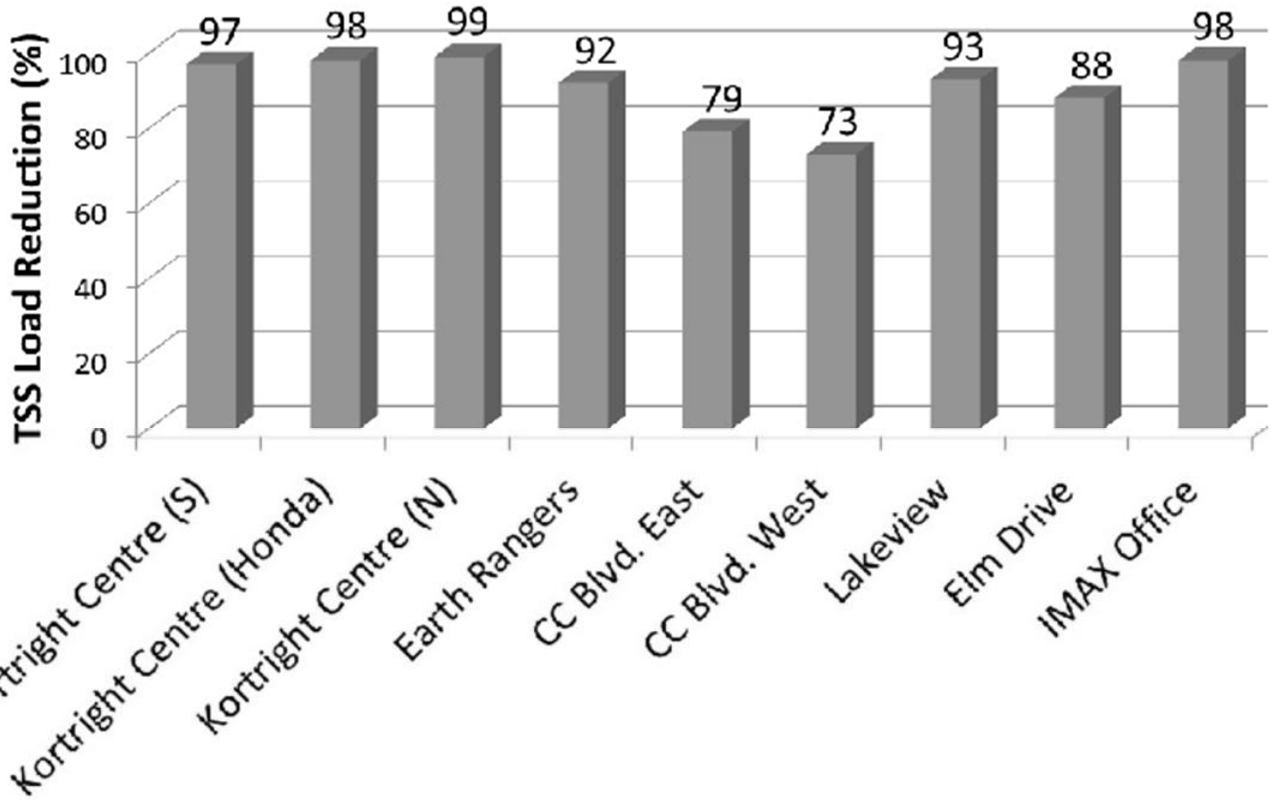
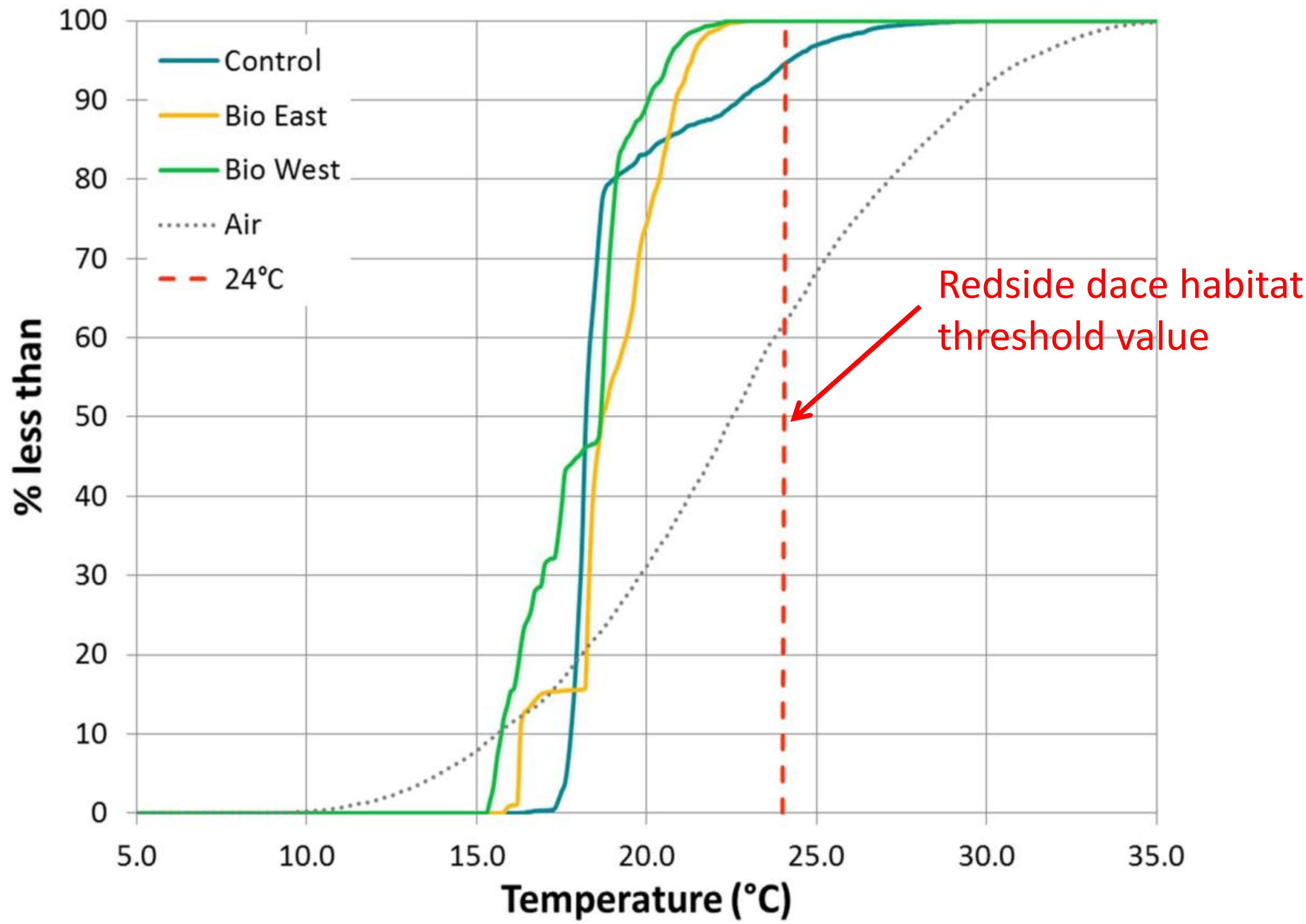


Figure 4. Total Suspended Solids (TSS) load reductions

Source: Comparative Performance Assessment of Bioretention in Ontario Technical Brief (STEP, 2019)

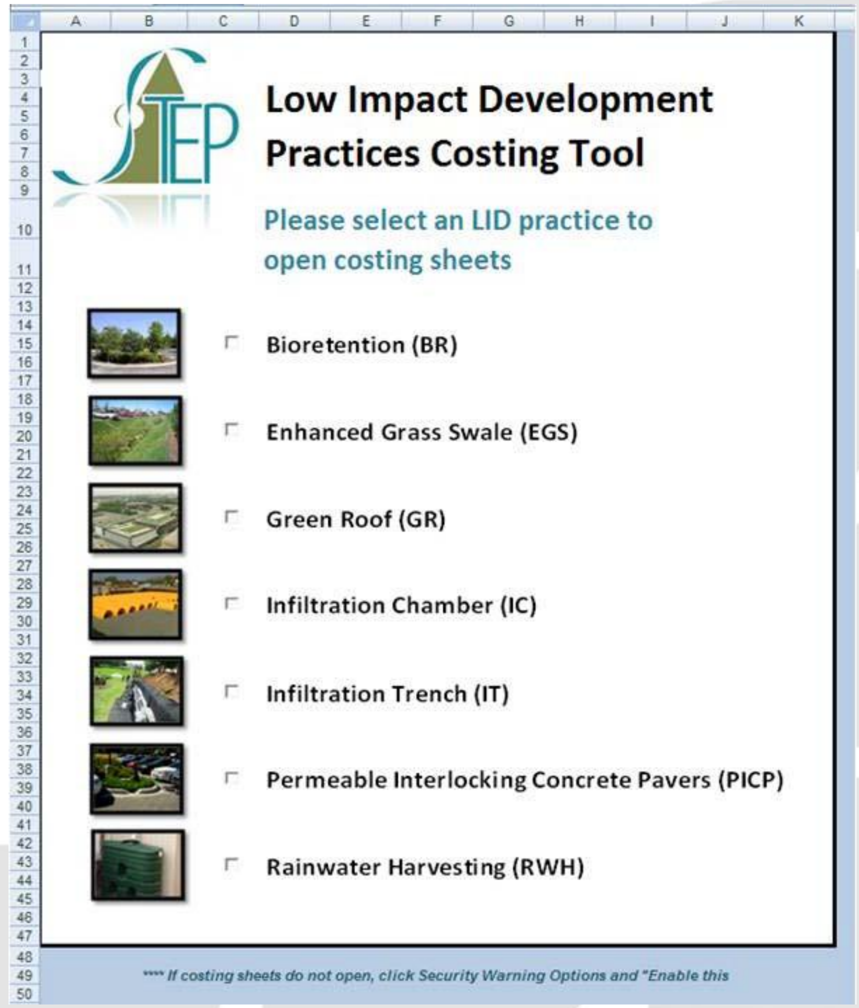
Effect on effluent temperature



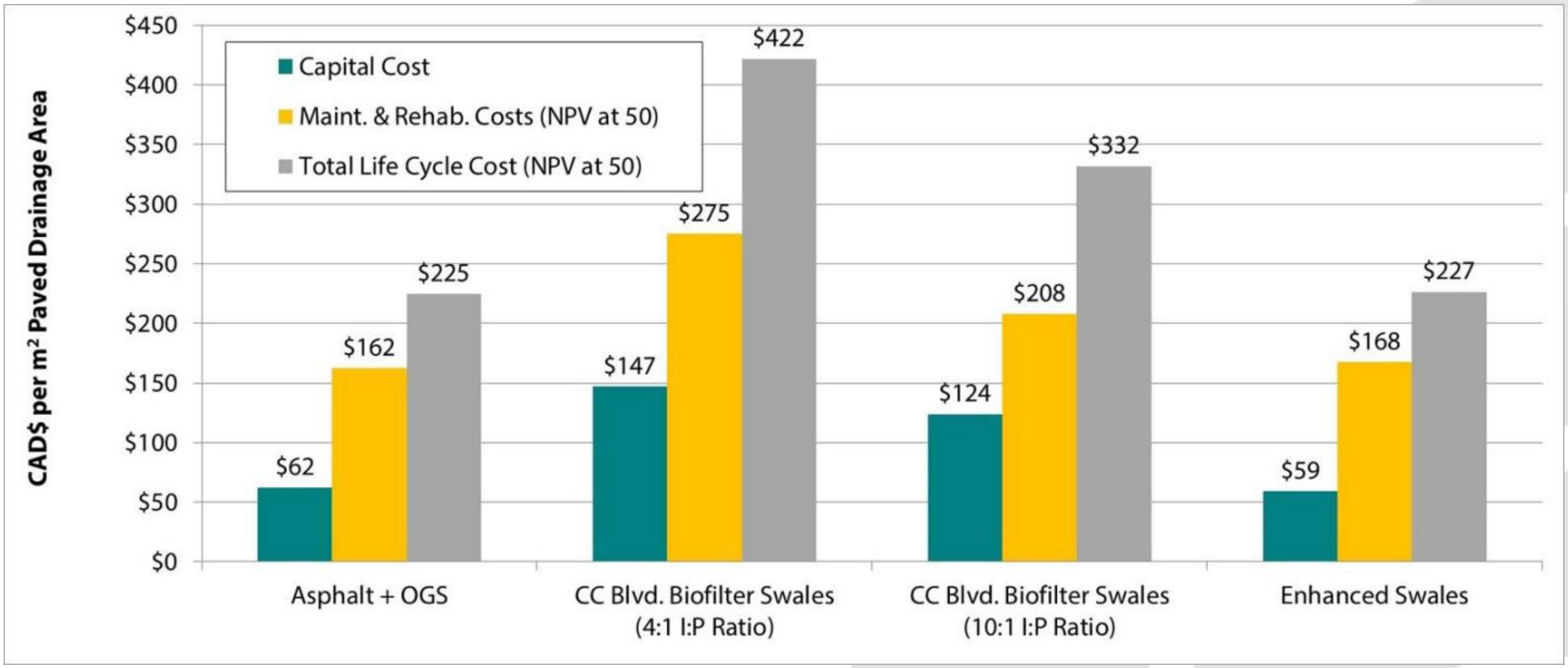
LID Life Cycle Costing Tool

- User enters site characteristics, and can modify default design and maintenance parameters;
- Tool provides capital, maintenance, inspection and rehabilitation cost estimates;
- Inflation factor can be applied to update costs to current year;
- Version 1.1 free to download;
- Version 2.0 coming soon!

https://sustainabletechnologies.ca

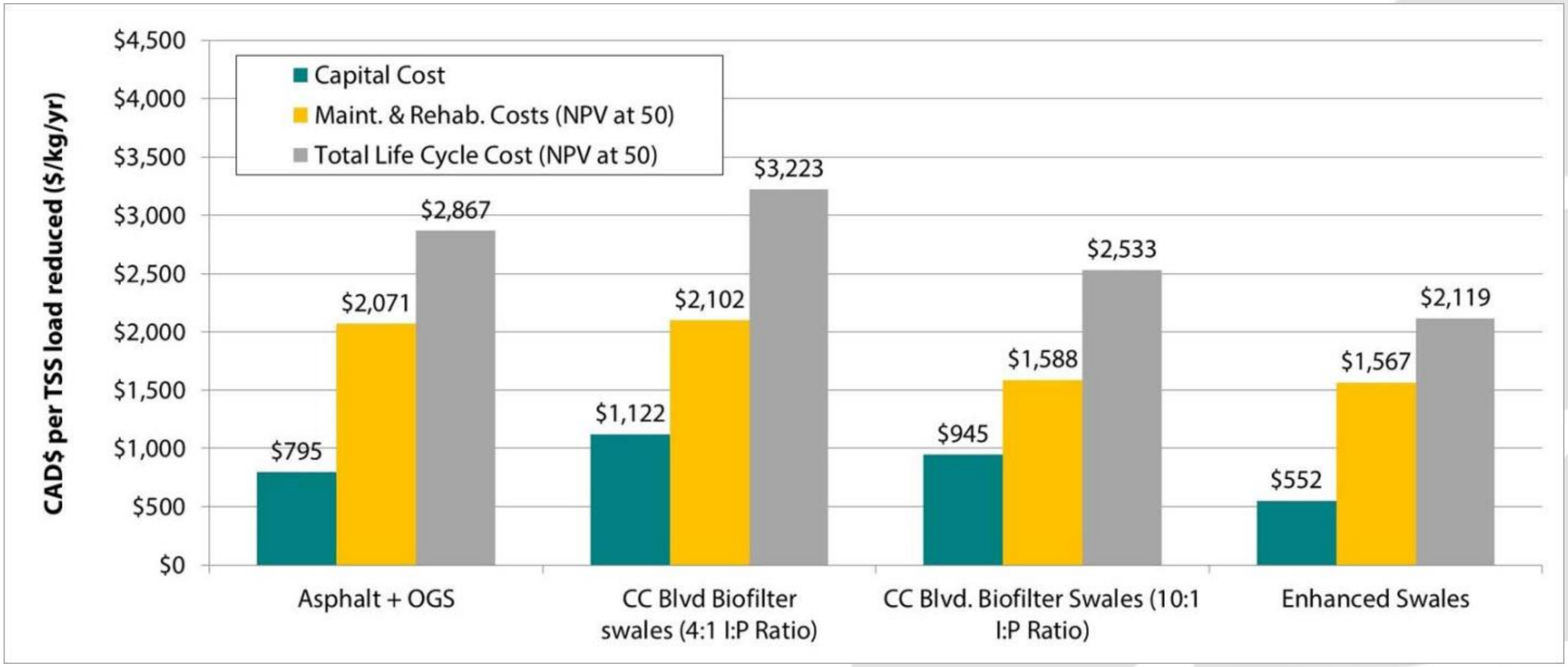


Life cycle cost per paved drainage area



But OGS and enhanced swales provide lower pollutant removal efficiencies…

Life cycle cost per pollutant load removal



Biofilter swales are still more expensive to construct, but life cycle maintenance and rehabilitation costs are similar to, or cheaper than oil and grit separators (OGS) and enhanced swales while providing superior treatment performance.

Lessons Learned - Implementation

- Construction supervision, rigorous inspection and testing prior to assumption and routine maintenance (annual to biannual) is critical;
- Landscaping plan needed further consideration of context and available resources/capacity for maintenance – choose easy to maintain plants tolerant to wet, dry and salt; plants need watering during 1st growing season (biweekly for 1st 2 months in absence of rain) & maintain 5 to10 cm shredded wood mulch cover.

Conclusions

- Planned infrastructure renewal projects can be leveraged to achieve greater impact by taking an integrated, multi-objective approach;
- Biofilter swales are effective at reducing runoff volume (17 to 34%), attenuating peak flow rate, removing some pollutants and reducing thermal loading relative to the control catchment.
- Field assessment of groundwater levels and quality should be undertaken to inform design, in addition to reviewing historical borehole records;
- Negative and weak removal efficiencies for nutrients and some metals – biomedia specifications for lined, filtration-only bioswales and stormwater planters should include additive(s) or be combined with engineered media filters to enhance removal;
- Life cycle cost of suspended solids removal for biofilter swales estimated to be favorable over HDS/OGS units but slightly higher than lower performing enhanced swales;

Project supporters

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Toronto and Region Conservation
for The Living City

Region of Peel
Working for you

SNAP
Sustainable Neighbourhood Retrofit Action Plan

TD

TreeCanada

Thank you

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Visit the STEP exhibit booth #29 in Gallery B

LID Life Cycle Costing Tool estimate:
1,904 m² CDA; 4:1 I:P area ratio; 203.4 m³ storage

COUNTY COURT BLVD. BIOFILTER SWALES

Cost Estimate Summary

Grand total for this project	
$180,016.62	
Total costs by area	
Pre-construction	$1,928.50
Excavation	$7,496.88
Materials & Installation	$146,280.20
Inspections	$7,945.89
Other	$16,365.15

Retrofit Cost	
Percentage of total cost	16%
Total	$28,802.66

Life Cycle Totals	
50 YEAR EVALUATION PERIOD	
PV of maintenance & rehabilitation	$247,411.18
PV of all costs	$456,230.46
25 YEAR EVALUATION PERIOD	
PV of maintenance & rehabilitation	$136,580.27
PV of all costs	$345,399.54