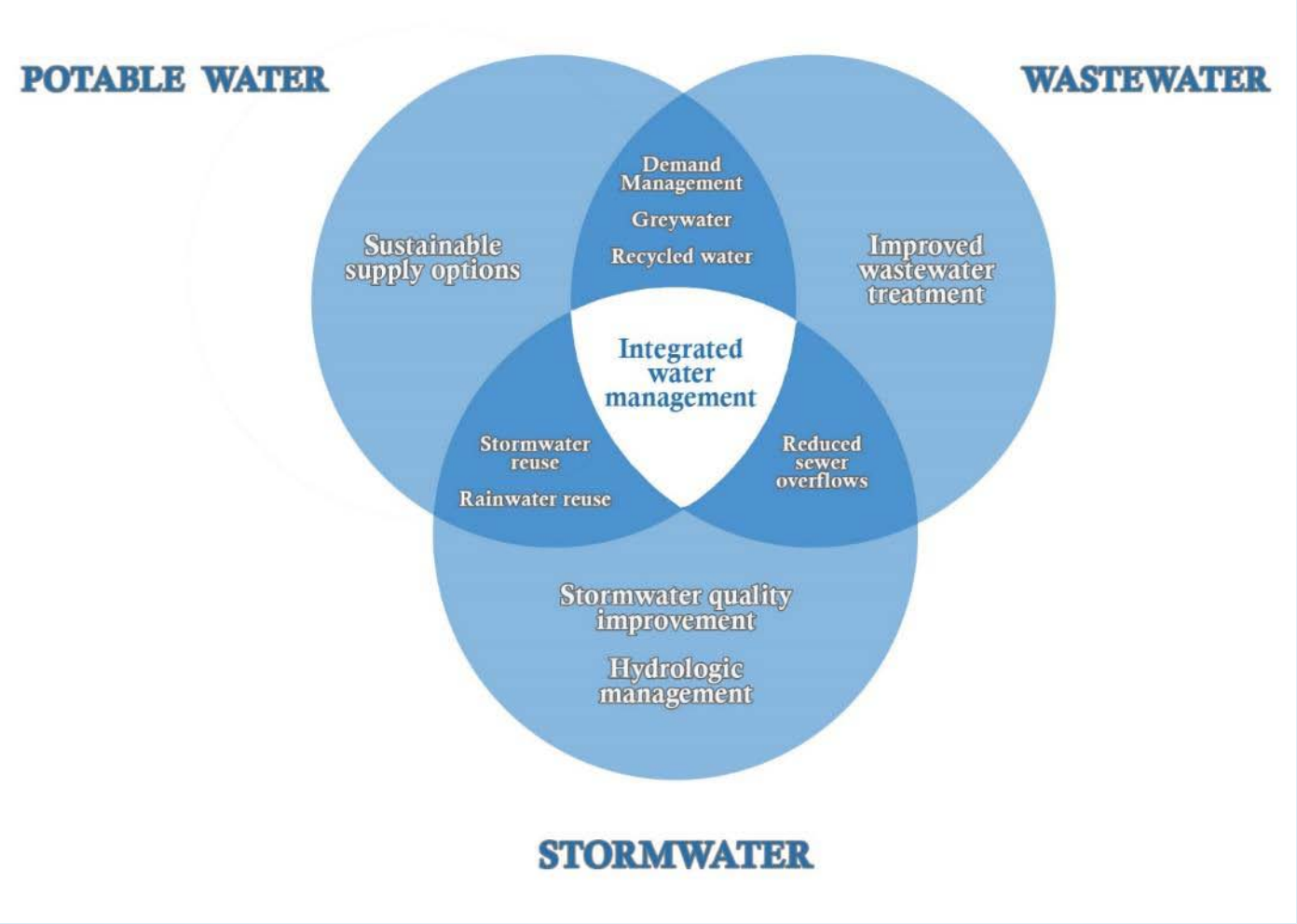
Reconnecting the Great Lakes Water Cycle

Selecting Least Cost Green Infrastructure

James W. Ridgway, PE

September 29, 2015

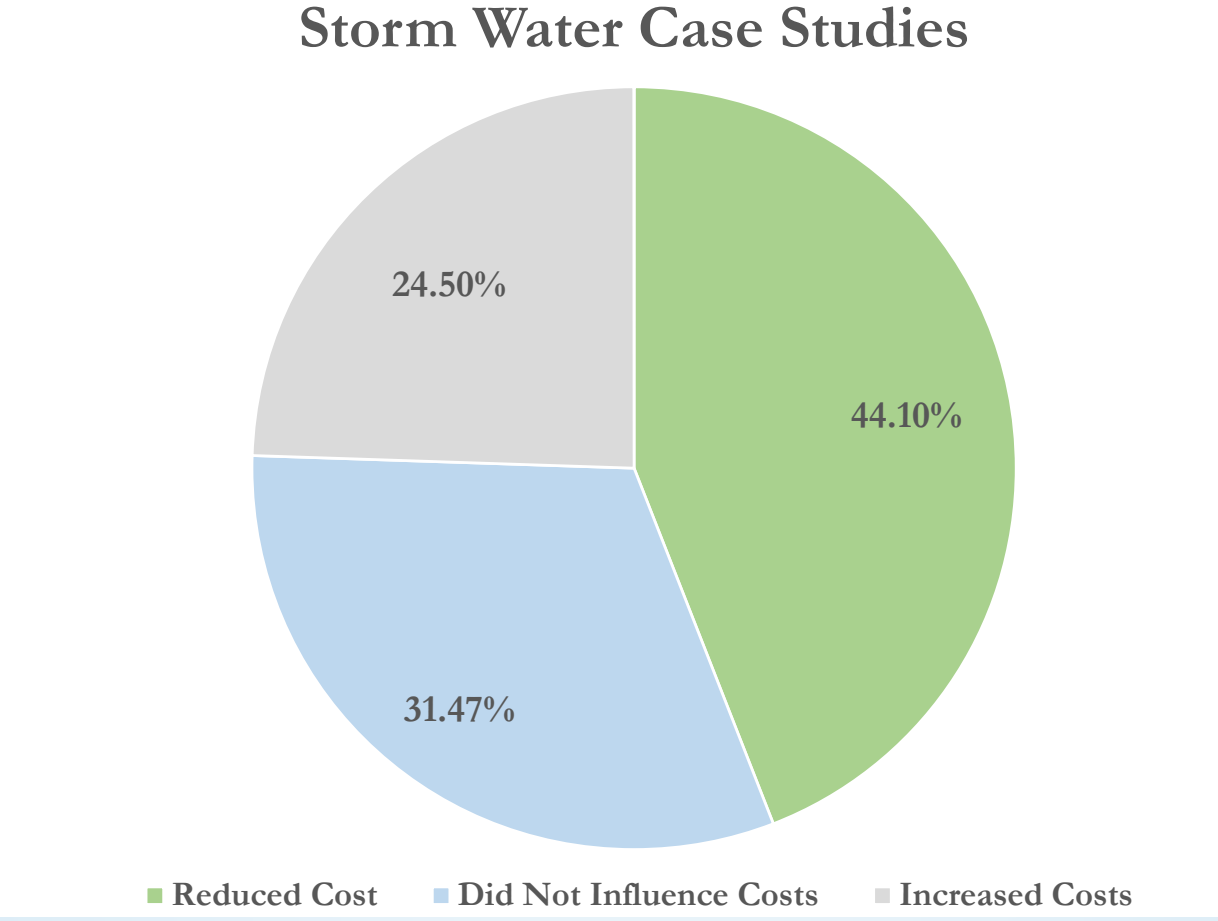
Integrated Water Management??





IS GREEN INFRASTRUCTURE LESS COSTLY THEN GRAY INFRASTRUCTURE?

Cost of Green Infrastructure vs. Gray Infrastructure



479 case studies collect by American Society of Landscape Architects at the request of USEPA - www.asla.org/stormwateroverview.aspx

Evaluating Green Infrastructure?

Not All green Infrastructure is Created Equally

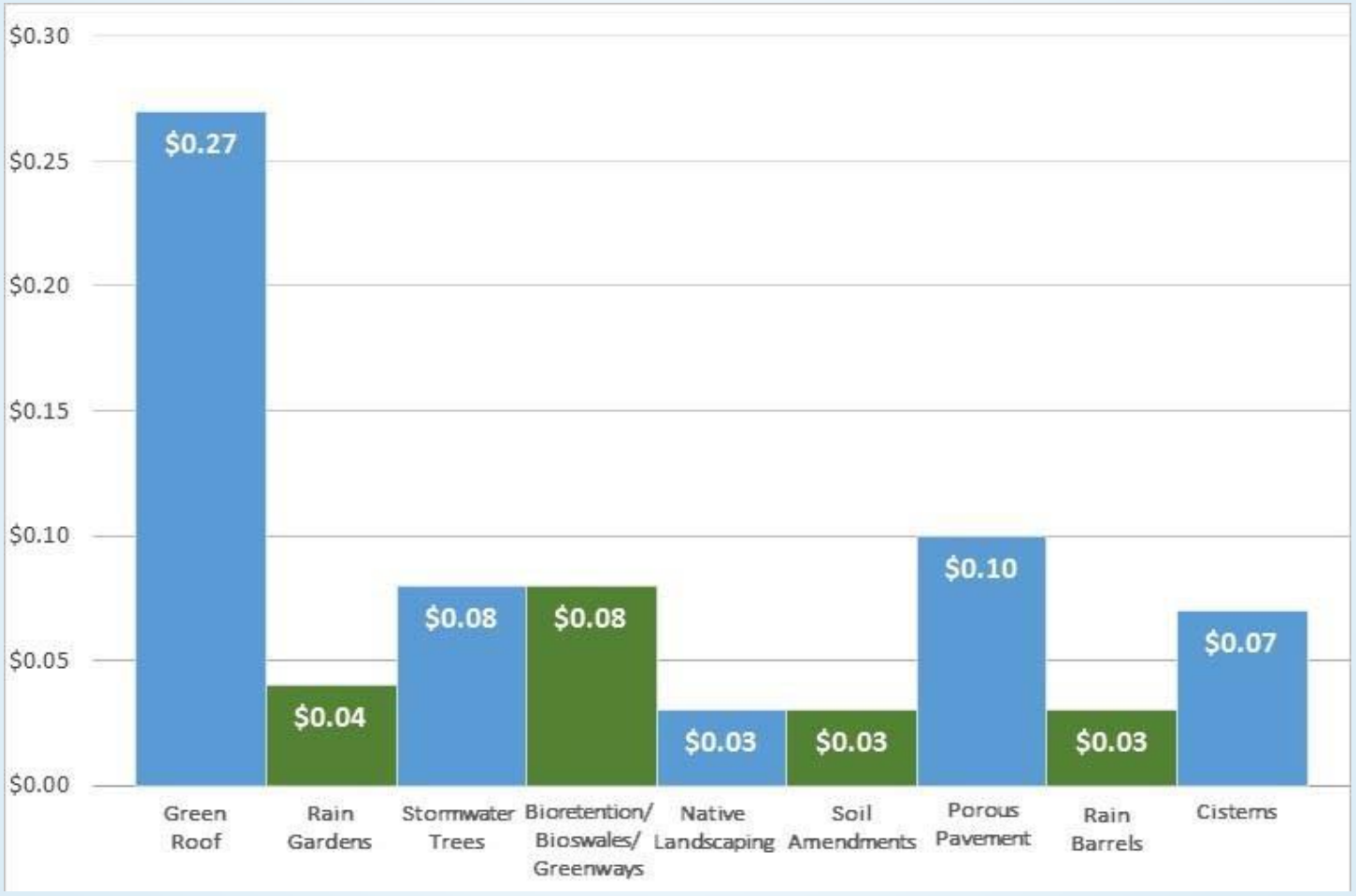
- Volume Control
  - Infiltration – Is it possible?
  - Reduce peak offsite runoff rates – Is it necessary?
  - Divert flows from sewers – of course!
- Define Capture Requirement
- Define Release Rate
- Identify Available Area



IS VOLUME THE DRIVING FORCE?

Incremental Cost per Annual Gallon Captured

(Milwaukee Metropolitan Sewerage District, 2013)

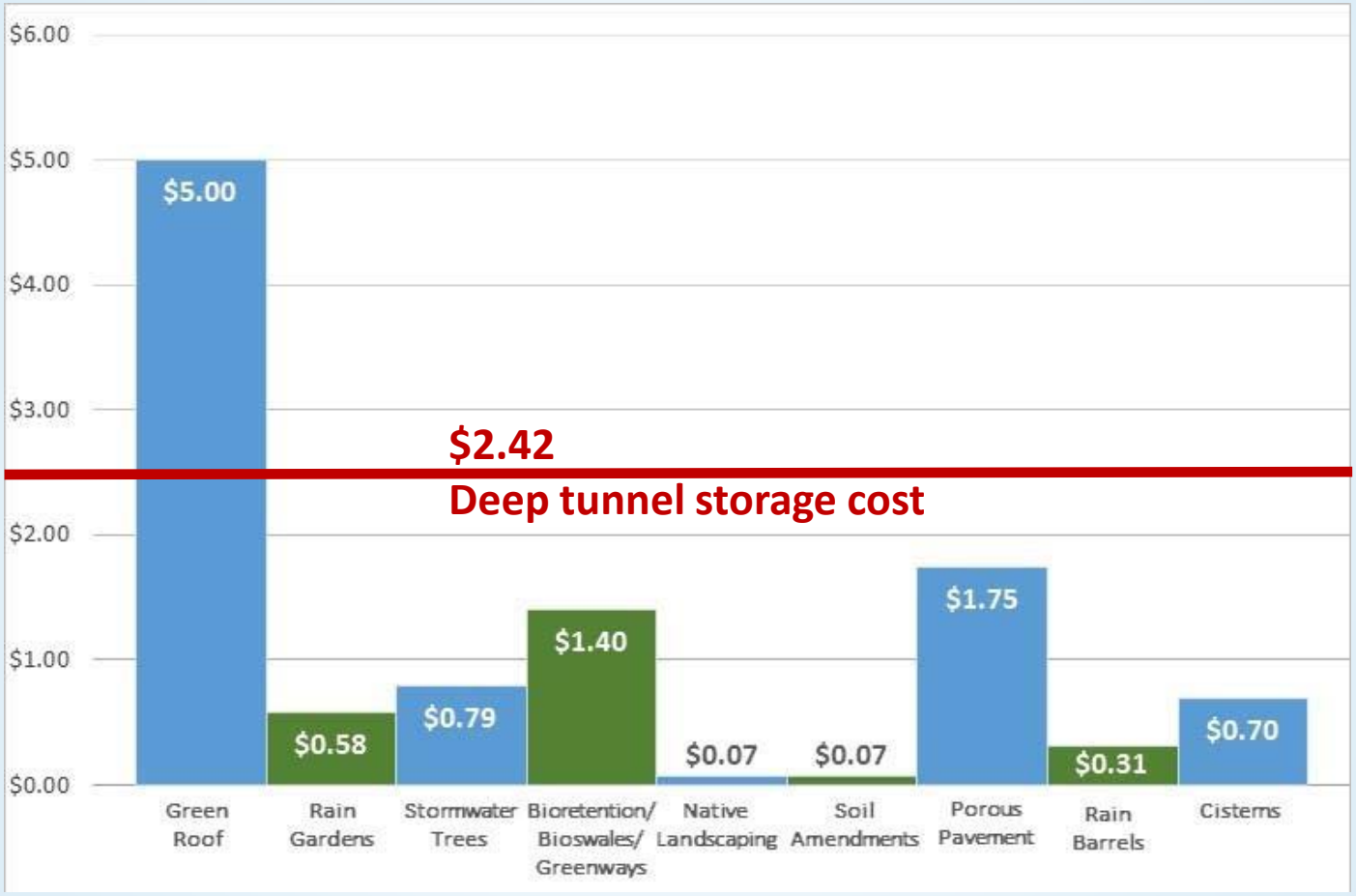




IS AREA THE DRIVING FORCE?

Incremental Cost per Square Foot Managed

(Milwaukee Metropolitan Sewerage District, 2013)



Note: The green infrastructure strategies supporting green alleys, streets, and parking lots are included in other strategies. The wetlands Green Infrastructure Strategy is encouraged but not quantified in the plan.

Stand-alone Costs (per green infrastructure SF and per SF managed) and the Relationship to Incremental Costs

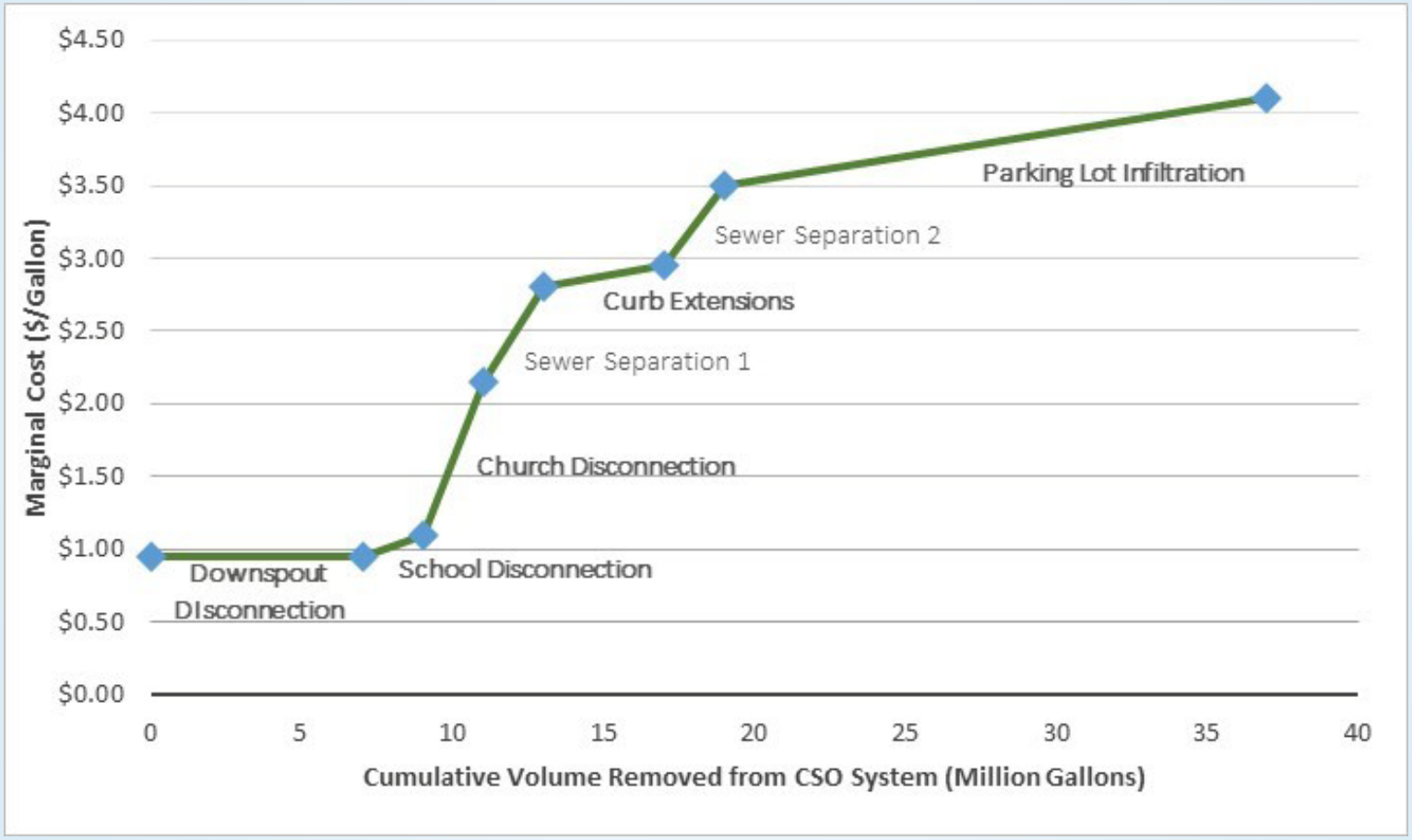
(Milwaukee Metropolitan Sewerage District, 2013)

Green Infrastructure Strategy	Stand-alone Cost ($/SF)	Loading Ratio (Ratio of Area Managed to Area of GI)	Stand-alone Cost ($/SF Managed)	Incremental GI Cost Compared to Stand-alone Cost	Description of Cost Assumption
Green Roofs[1]	$11.50	1.0	$11.50	43%	Median PWD cost ($11.50/SF)
Rain Gardens	$10.00	12.0	$0.83	70%	Middle of FCGS range rounded up to $10/SF
Stormwater Trees[2]	$0.80	0.5	$1.58	50%	FCGS cost
Bioretention/ Bioswale	$24.00	12.0	$2.00	70%	Average between PWD[3] and SUSTAIN[4] demonstration project
Native Landscaping/Soil Amendments	$0.11	1.0	$0.11	60%	Middle of FCGS[5] range, rounded up to nearest $1,000
Porous Pavement	$10.00	4.0	$2.50	70%	$10/SF, approximately 90 percent of median PWD costs
44-gallon Rain Barrels[6]	$120 (each)	N/A	$0.34	90%	Middle of FCGS range rounded up to nearest $10
1,000-gallon Cisterns[7]	$5,000 (each)	N/A	$0.78	90%	$5/gal., middle of FCGS range for 1,000-gal cistern

[1]Incremental cost of green roofs set to 43 percent to match MMSD's $5/SF ($217,800/acre) green roof incentive program.
[2]Trees are assumed to have an average 10-ft canopy radius (314 SF), with 50 percent assumed to be overhanging impervious area.
[3]PWD is Philadelphia Water Department.
[4]SUSTAIN is from (MMSD 2011) Determining the Potential of Green Infrastructure to Reduce Overflows in Milwaukee.
[5]FCGS is "Fresh Coast Green Solutions" (MMSD 2009).
[6]Each rain barrel is assumed to manage 350 SF of rooftop; therefore, 124.5 barrels are required for 1 acre of roof.
[7]Each 1,000-gallon cistern is assumed to manage 6,500 SF of impervious area; therefore, 6.7 cisterns are required for 1 acre.

Costs and Cumulative Volume of Stormwater Removed from the CSO System through Various Gray and Green Strategies (Green in Bold)

(Odefey, 2012)





WHAT ARE THE POLITICAL DRIVERS?

Elected Officials Priorities

(a.k.a. The Political Drivers)

- Clean Drinking Water
  - Don't run out of water
  - No Nitrates in Drinking Water (Blue Baby Syndrome)
  - No Polluting Surface Source Water (Toledo Crisis)
- No Flooding
- Keep Sewage out of Recreational Waters
- General Water Quality Improvement
- Quality of Life/Economic Development

- Beyond that – details may confuse the subject



WHAT ARE THE TECHNICAL DRIVERS?

Public Works Priorities

(a.k.a. The Technical Drivers)

- Volume Management
  - No Flooding
  - Reduce Flashy Flows
  - Limit Erosion
- Pollutant Removal
  - Bacteria
  - Oxygen Demanding Materials
  - Phosphorous/Nitrogen
  - Other Pollutants
- Green Space
- Quality of Life



WHAT DO ELECTED OFFICIALS AND PUBLIC SERVANTS BOTH WANT?

Green Infrastructure is Infrastructure

To Protect the Great Lakes
We Must Restore the Hydrology

- We must continues to control/minimize flooding
- We must remove sources of sewage
- We need to lower peak flows / raise low flows
- We want to increase infiltration/ raise groundwater
- To minimize cost we must combine grey with green infrastructure for optimal performance



WATER RESOURCES IMPACT ASSESSMENT TOOL

Water Resources Impact Assessment Tool

- Prioritize the challenges
- Select Design Drivers
- Identify Funding Requirements/Opportunities
- Minimize Cost
- Maximize Benefit
- Aggregate Solutions
- Finance Large Scale Implementation

Step 1: Calculating Runoff

Establish the Rainfall Event

Click here for directions

Tip

Rain Event: 1.5 inches

0.5
1
1.5
2
2.5
3
3.5
4

Enter Data Here

Enter Land Cover Areas

Click here for directions

Land Cover Key

Tip

Project Totals

Site Area (ac)	5.60	acres
Impervious Area (ac)	3.37	acres
Runoff Volume (ft^3)	18,404	cubic feet

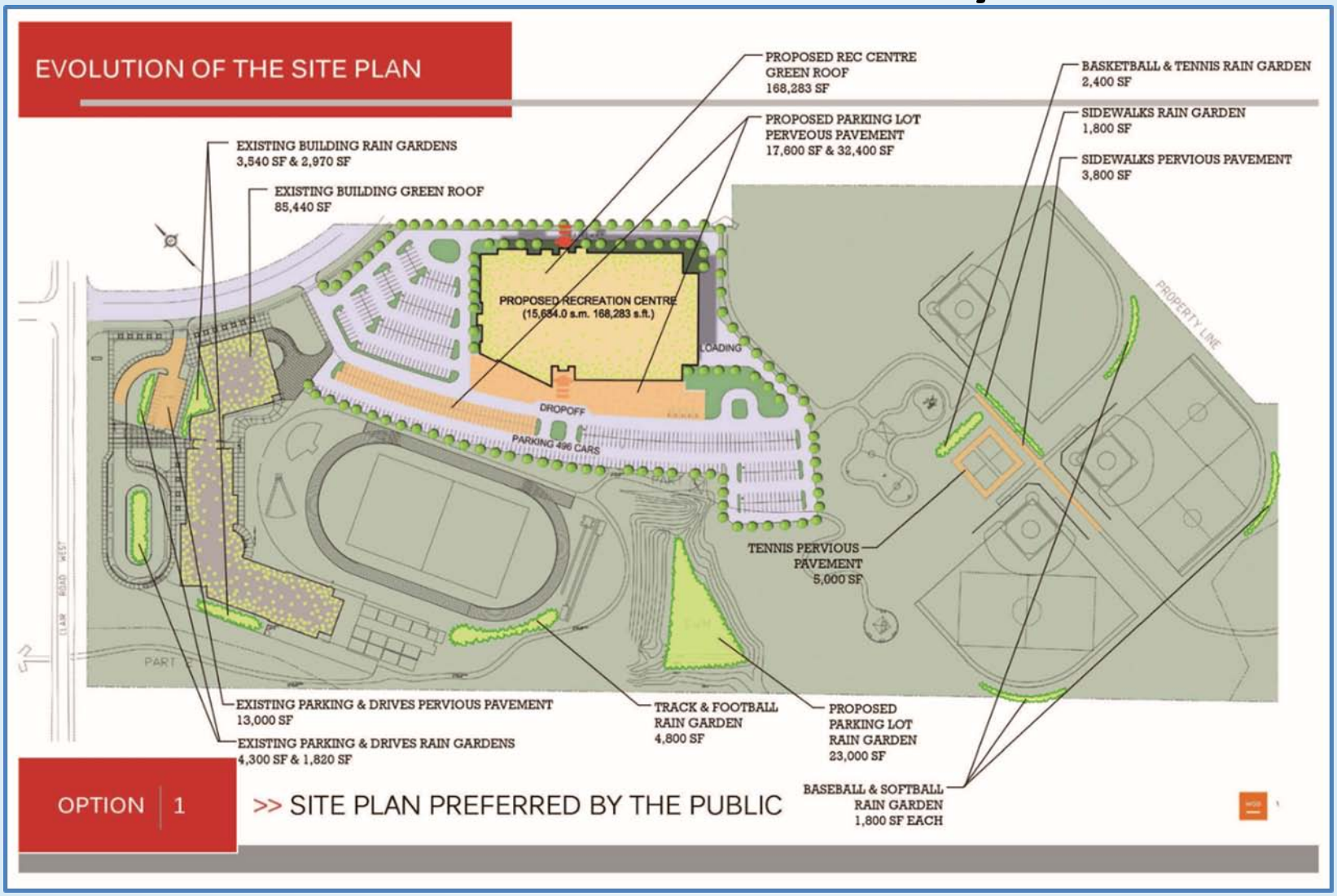
	Land Cover	Condition	Hydrologic Soil Type	Area (sf)	Area (ac)	CN (TR-55)	S	Runoff, Q (in)	Runoff Volume (ft^3)
1	Existing Building	N/A	N/A	60,000	1.377	98	0.2	1.28	**6,400.71**
2	Proposed Building	N/A	N/A	30,000	0.689	98	0.2	1.28	**3,200.36**
3	Existing Paved Parking Area	N/A	N/A	10,000	0.230	98	0.2	1.28	**1,066.79**
4	Proposed Paved Parking Area	N/A	N/A	10,000	0.230	98	0.2	1.28	**1,066.79**
5	Existing Paved Walkway	N/A	N/A	1,500	0.034	98	0.2	1.28	**160.02**
6	Proposed Paved Walkway	N/A	N/A	500	0.011	98	0.2	1.28	**53.34**
7	Existing Roadway	N/A	N/A	25,000	0.574	98	0.2	1.28	**2,666.96**
8	Proposed Roadway	N/A	N/A	10,000	0.230	98	0.2	1.28	**1,066.79**
9	Open Space	Poor	C	5,000	0.115	86	1.6	0.49	**205.08**
10	Pasture	Fair	B	2,500	0.057	69	4.5	0.07	**14.79**
11	Meadow	N/A	C	1,500	0.034	71	4.1	0.10	**12.23**
12	Brush	Poor	D	3,000	0.069	83	2.0	0.38	**94.70**
13	Woodland/Grassland	Good	C	10,000	0.230	72	3.9	0.11	**94.27**
14	Woods	Good	C	50,000	1.148	70	4.3	0.08	**349.38**
15	Bare Soil	N/A	D	25,000	0.574	94	0.6	0.94	**1,951.41**



GUELPH, ONTARIO
(AN EXAMPLE)


GREEN INFRASTRUCTURE CONCEPTUAL DESIGN
STEVENSON STREET CORRIDOR
SOUTH END COMMUNITY PARK
GUELPH, ONTARIO
CANADA
ECT
Environmental Consulting & Technology, Inc.

South End Community Park



Comparing Volume Captured to Area Required

Volume (CF) Stored per 100 SF of BMP
88
33
30
7

BMP	Ponding Depth (inches)	Planting Material Depth (inches)	Stone Base Depth (inches)	Volume (CF) Stored per 100 SF of BMP
Rain Garden	6	12	6	**88**
Blue Roof	4	0	0	**33**
Intensive Green Roof	0	18	0	**30**
Extensive Green Roof	0	4	0	**7**

South End Community Park

Calculating Site-wide Runoff

Rainfall = 1 inch

Rainfall = 1 inches

	Cover Type	Soil Type	Area (sf)	Area (ac)	CN (TR-55)	S	Runoff, Q (in)	Runoff Volume, V (ft3)	Total Runoff Volume (ft3)
Ex. Building	Impervious	D	85,437	1.961	98	0.2	0.8	5,631.06	5,631.06
	Urban Compact	D	-	0.000	84	1.9	0.0	-	
Ex. Parking & Drives	Impervious	D	76,037	1.746	98	0.2	0.8	5,011.48	5,326.83
	Urban Compact	D	24,922	0.572	84	1.9	0.2	315.35	
Track & Football	Impervious	D	40,643	0.933	98	0.2	0.79	2,678.73	4,180.37
	Urban Compact	D	118,674	2.724	84	1.9	0.15	1,501.64	
Basketball, Tennis & Splash Pad	Impervious	D	31,041	0.713	98	0.2	0.79	2,045.88	2,045.88
	Urban Compact	D	-	0.000	84	1.9	0.00	-	
	pervious	D	23,482	0.539	98	0.2	0.79	1,547.67	1,547.67
	ban Compact	D	-	0.000	84	1.9	0.00	-	
	pervious	D	-	0.000	98	0.2	0.00	-	1,516.37
	ban Compact	D	119,838	2.751	84	1.9	0.15	1,516.37	
	pervious	D	-	0.000	98	0.2	0.00	-	1,508.04
	rban Compact	D	119,180	2.736	84	1.9	0.15	1,508.04	
Softball #2	Impervious	D	-	0.000	98	0.2	0.00	-	1,506.70
	Urban Compact	D	119,074	2.734	84	1.9	0.15	1,506.70	
Proposed Rec Centre	Impervious	D	168,283	3.863	98	0.2	0.79	11,091.33	11,091.33
	Urban Compact	D	-	0.000	84	1.9	0.00	-	
Proposed Parking	Impervious	D	292,391	6.712	98	0.2	0.79	19,271.15	19,474.92
	Urban Compact	D	16,104	0.370	84	1.9	0.15	203.77	

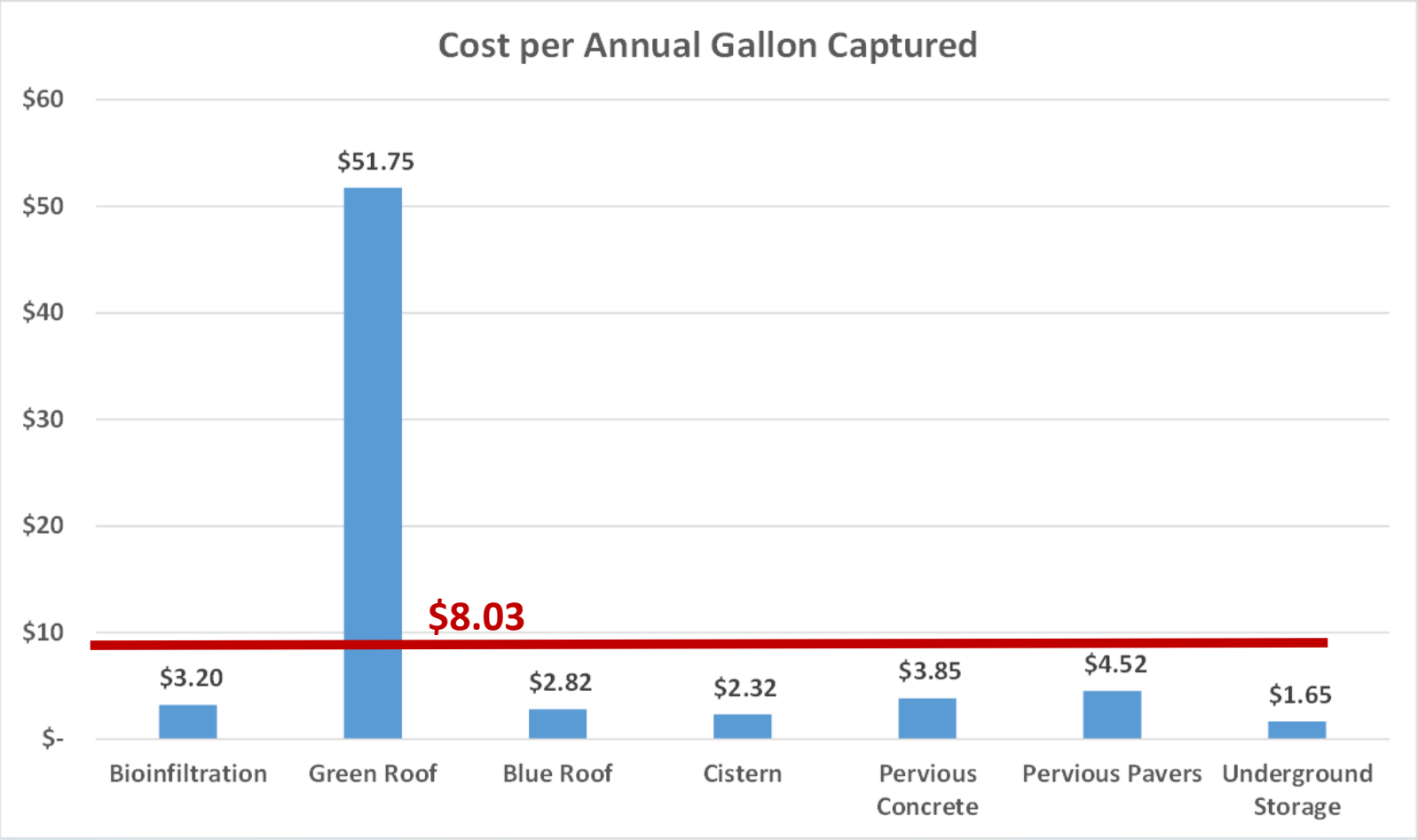
Proposed Rec Centre

Impervious

Urban Compact

11,091.33

South End Community Park



South End Community Park

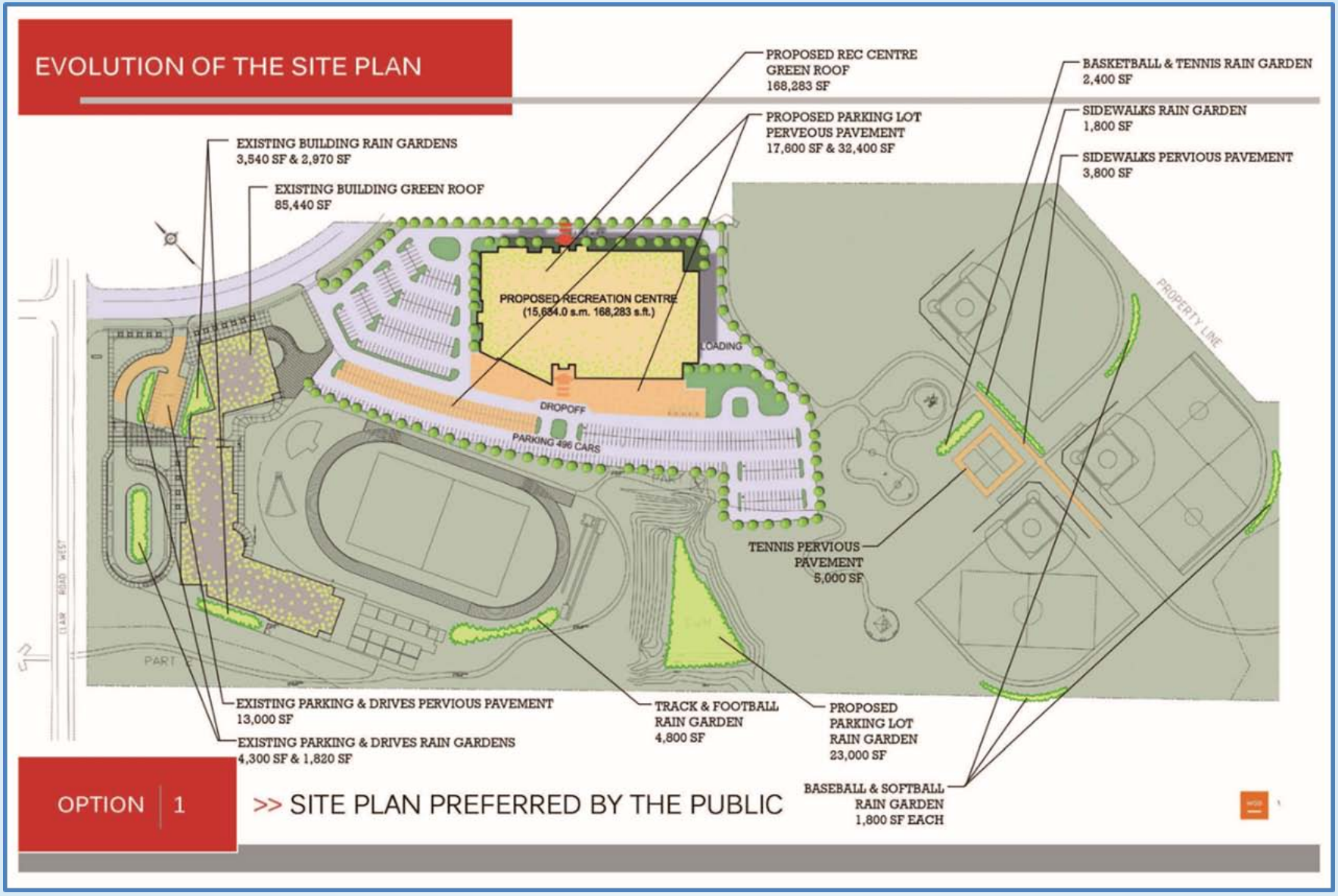
Identifying Least Cost BMPs

IMPLEMENTATION COSTS - South End Community Park

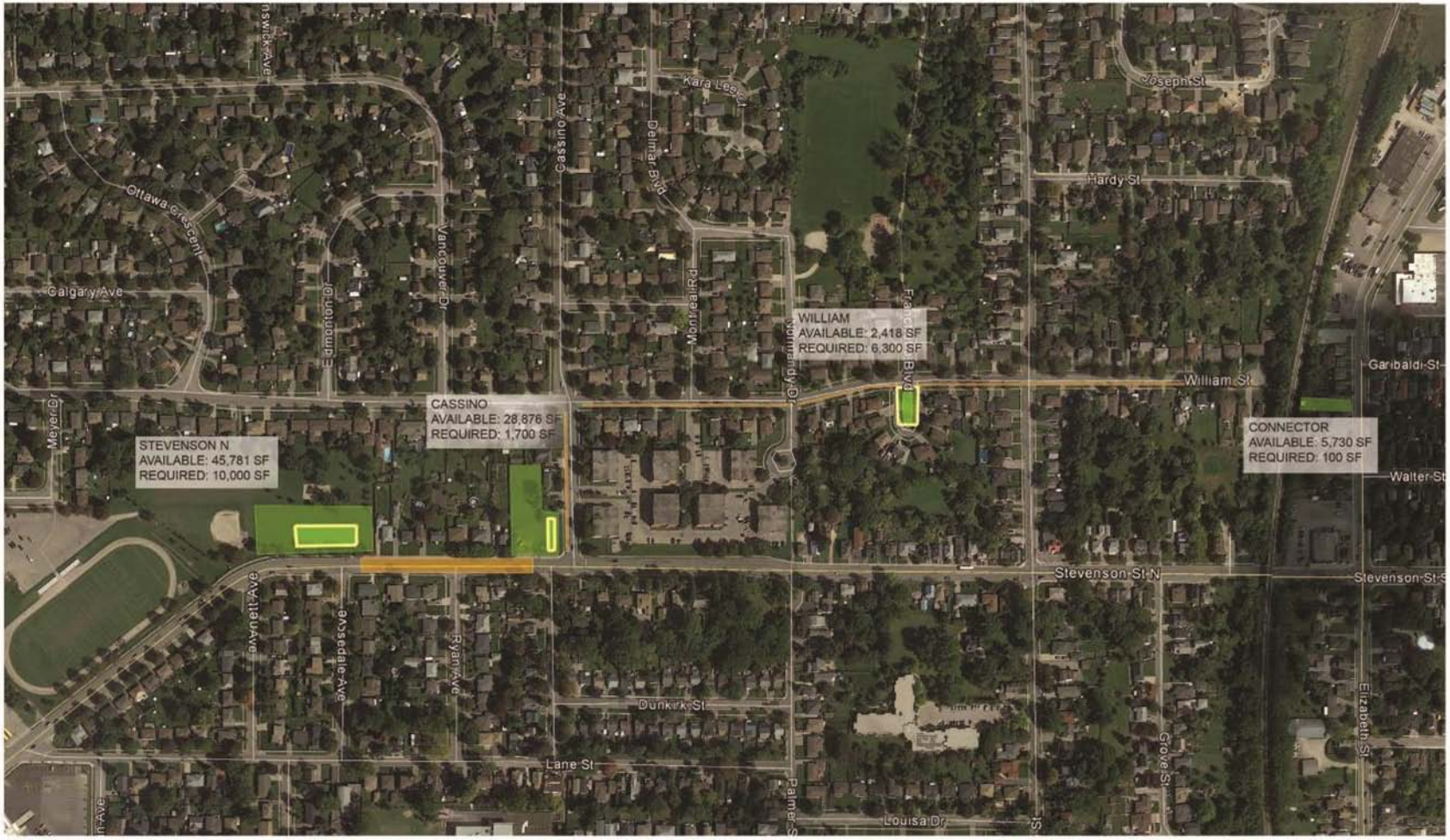
	Location	BMP	Size	Unit	Unit Price	Construction Cost	Annual Maintenance Cost	Lowest Year 1 Cost
1	Existing Building	Bioinfiltration	6,500	SF	$ 12.00	$ 78,000.00	$ 3,250.00	$ 58,416.75
		Green Roof	85,437	SF	$ 15.00	$ 1,281,556.50	$ 35,200.09	
		Blue Roof	85,437	SF	$ 4.00	$ 341,748.40	$ 17,087.42	
		Cistern	5631.0584	CF	$ 10.00	$ 56,310.58	$ 2,106.16	
2	Existing Drives & Parking	Bioinfiltration	6100	SF	$ 12.00	$ 73,200.00	$ 3,050.00	$ 39,280.16
		Pervious Concrete	13000	SF	$ 7.00	$ 91,000.00	$ 2,080.00	
		Pervious Pavers	13000	SF	$ 9.00	$ 117,000.00	$ 468.00	
		Underground Storage	5326.8262	CF	$ 7.00	$ 37,287.78	$ 1,992.37	
3	Track & Football	Bioinfiltration	4800	SF	$ 12.00	$ 57,600.00	$ 2,400.00	$ 60,000.00
4	Basketball, Splash Pad, Tennis	Bioinfiltration				$ 28,[illegible]		.00
		Pervious Concrete				$ 35,[illegible]		
						$ 21,[illegible]		
						$ 26,[illegible]		.00
						$ 34,[illegible]		
						$ 21,[illegible]		.00
						$ 21,[illegible]		.00
						$ 21,[illegible]		.00
						$ 156,[illegible]		
						$ 2,524,[illegible]		.78
						$ 336,[illegible]		
						$ 110,[illegible]		
10	Rec Parking	Bioinfiltration	23000	SF	$ 12.00	$ 276,000.00	$ 11,500.00	$ 143,608.55
		Pervious Concrete	50000	SF	$ 7.00	$ 350,000.00	$ 8,000.00	
		Pervious Pavers	50000	SF	$ 9.00	$ 450,000.00	$ 1,800.00	
		Underground Storage	19474.917	CF	$ 7.00	$ 136,324.42	$ 7,284.13	

Lowest Cost Total	**$ 536,367.23**

Existing Drives & Parking	Size	Construction Cost
Bioinfiltration	6,100	$73,200
Pervious Concrete	13,000	$91,000
Pervious Pavers	13,000	$117,000
Underground Storage	5,326	$37,287


EVOLUTION OF THE SITE PLAN
PROPOSED REC CENTRE
GREEN ROOF
168,283 SF
PROPOSED PARKING LOT
PERVEOUS PAVEMENT
17,600 SF & 32,400 SF
BASKETBALL & TENNIS RAIN GARDEN
2,400 SF
SIDEWALKS RAIN GARDEN
1,800 SF
SIDEWALKS PERVIOUS PAVEMENT
3,800 SF
EXISTING BUILDING RAIN GARDENS
3,540 SF & 2,970 SF
EXISTING BUILDING GREEN ROOF
85,440 SF
PROPOSED RECREATION CENTRE
(15,634.0 s.m. 168,283 s.ft.)
LOADING
DROPOFF
PARKING 496 CARS
PROPERTY LINE
TENNIS PERVIOUS
PAVEMENT
5,000 SF
EXISTING PARKING & DRIVES PERVIOUS PAVEMENT
13,000 SF
EXISTING PARKING & DRIVES RAIN GARDENS
4,300 SF & 1,820 SF
TRACK & FOOTBALL
RAIN GARDEN
4,800 SF
PROPOSED
PARKING LOT
RAIN GARDEN
23,000 SF
BASEBALL & SOFTBALL
RAIN GARDEN
1,800 SF EACH
OPTION | 1
>> SITE PLAN PREFERRED BY THE PUBLIC

Stevenson Street



ECT Environmental Consulting & Technology, Inc.

STEVENSON STREET GREEN INFRASTRUCTURE PLAN

Bioinfiltration Areas Pervious Pavement Areas

June 4, 2015

Identifying Least Cost BMPs

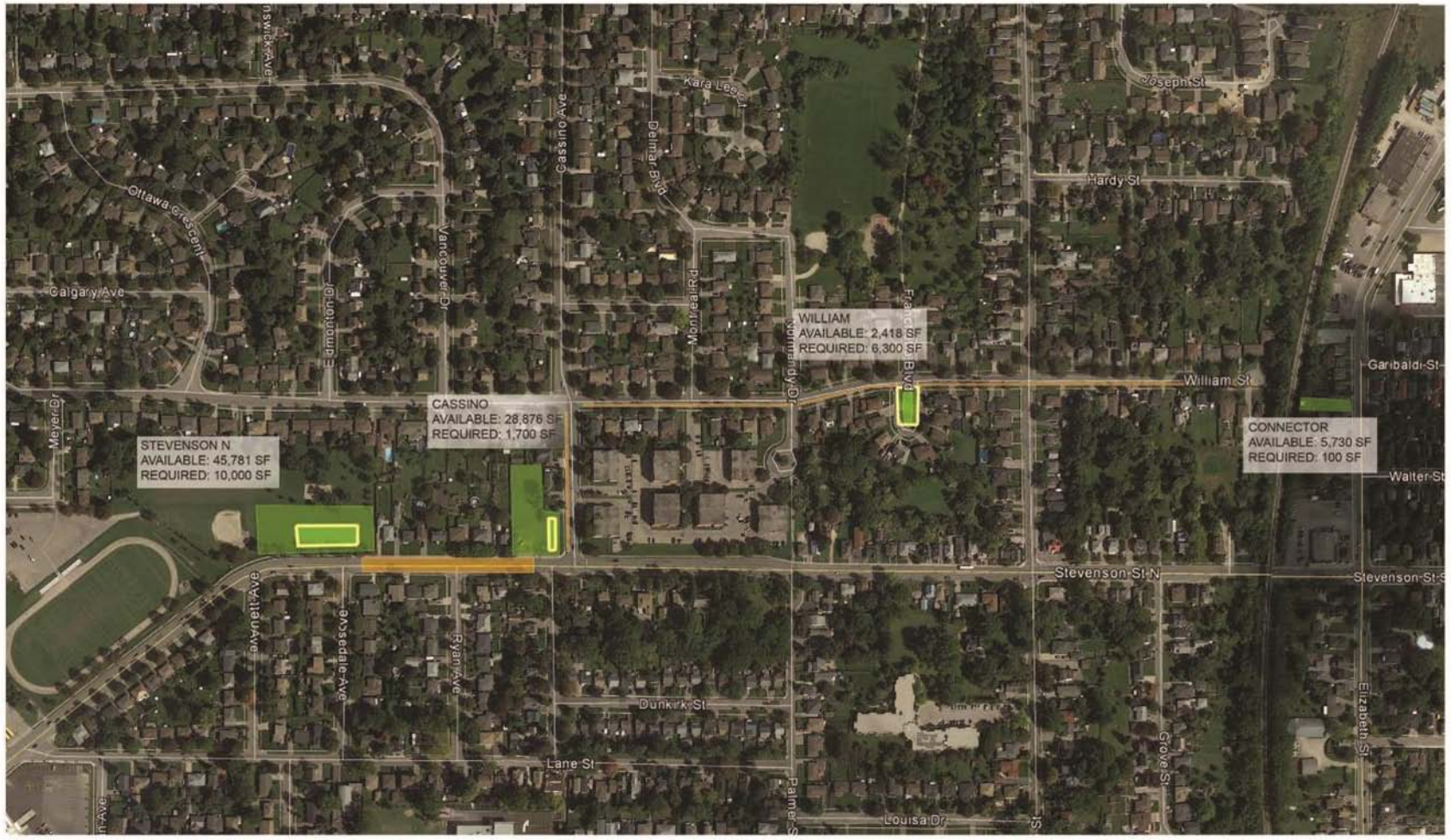
IMPLEMENTATION COSTS - Stevenson Street GI Plan

Location	BMP	Size	Unit	Feasibility	Unit Price	Construction Cost	Annual Maintenance Cost	Lowest Year 1 Cost
Stevenson N	Bioinfiltration	10,000	SF	1	$ 12.00	$ 120,000.00	$ 3,400.00	$ 89,915.08
	Pervious Concrete	21,000	SF	1	$ 7.00	$ 147,000.00	$ 3,360.00	
	Pervious Pavers	21,000	SF	1	$ 9.00	$ 189,000.00	$ 756.00	
	Underground Storage	8,667	CF	1	$ 10.00	$ 86,673.39	$ 3,241.68	
	Bioinfiltration	1,700	S		.00			$ 10,410.49
	Pervious Concrete	3,400	S		.00			
			S		.00			
			C		.00			
			S		.00			$ 40,351.23
			S		.00			
			S		.00			
			C		.00			
			S		.00			$ 593.26
			S		.00			

Lowest Cost Total	$ 141,270.05

Stevenson N	Size	Construction Cost
Bioinfiltration	10,000	$120,000
Pervious Concrete	21,000	$147,000
Pervious Pavers	21,000	$189,000
Underground Storage	8,667	$86,673

Sized to Capture 1” of Rain



ECT Environmental Consulting & Technology, Inc.

STEVENSON STREET GREEN INFRASTRUCTURE PLAN

Bioinfiltration Areas Pervious Pavement Areas

June 4, 2015


QUESTIONS?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