4. STORMWATER MANAGEMENT APPROACH

4.1. Planning Objectives

A SWMMP is required to increase resiliency of the stormwater system to extreme climate conditions, support continued use and development of the Park, and leverage opportunities for environmental and cultural sustainability. The plan will introduce stormwater management improvements to protect key park features from frequent/nuisance flooding while also providing room for flood water and coastal inundation under extreme conditions. These improvements will demonstrate new local climate change adaptation approaches to stormwater management in a coastal environment. The City and First Nations will collaborate to preserve and improve the spiritual and archaeological significance of the Park while also stewarding park ecosystems for future generations.

Overall, the SWMMP outlines the strategies, capital improvements, and maintenance programs needed to improve the capacity of the current stormwater management system, support future development and protect the natural features unique to the Park. The SWMMP will address the following goals to establish a sustainable and integrated stormwater management program:

Flood Mitigation & Resiliency:
The Park's stormwater system effectively manages the quantity and delivery of runoff in a manner that protects the environment, infrastructure, and the health and safety of park users under existing and future climate conditions. The City sets clear expectations for park users for climate conditions that will exceed system capacity and require temporary closures.

Collaborate with First Nations:
The City and First Nations are working collaboratively to maintain and improve the spiritual and archeological significance of the Park.

Ecosystem Health & Water Quality:
The City and First Nations are working collaboratively as stewards of park ecosystems for future generations. The surface water, groundwater and natural resources in and downstream of the Park maintain their ecological integrity and provide their original level of function and value.

Operations & Maintenance:
The Park's stormwater systems are maintained, managed and operated in a sustainable and cost-effective manner.

Monitoring & Data Management:
The City monitors precipitation at the Park and aligns irrigation activities with actual precipitation events. The City expands monitoring programs to inform climate change adaptation measures.

Education & Outreach:
The City's residents and businesses have a good understanding of stormwater management, climate change adaptation and First Nations' heritage in the Park, and are committed stewards of Parksville Bay and the Englishman River Estuary.

Developing objectives and action items that support attainment of each goal in the SWMMP Implementation Plan will chart a course of action for the City's stormwater management efforts in the Park over the next 20 years, aligned with the Parksville Community Park Master Plan 2017-2037 (Vancouver Island University and City of Parksville 2017), and help the City secure funding support, such as climate change adaptation grants. Longer term implementation will be refined through updates to the SWMMP that align with other planning exercises, such as a sea level rise adaptation plan for Parksville Bay and the Englishman River Estuary.

4.2. Performance Objectives

The key objectives for performance of the Park's stormwater management system include the following:

1. Mitigate flood risk during extreme rainfall and coastal inundation events to acceptable levels of risk with measures such as allowing up to 0.15 m of flooding on roads and parking lots or temporarily closing areas where flood mitigation is cost prohibitive.
2. Mitigate non-point source pollution impacts to receiving waters and their ecosystems by capturing and treating the first flush event (31 mm 24-hour event).
3. Offset potable water demand to the extent feasible.
4. Be resilient to coastal inundation within the Park, such as excessive erosion from wave action, debris, and saltwater.
5. Prevent nuisance flooding (>6 cm)during the late-century 10-year 24-hour rainfall event, considering the late-century astronomical tide as a potential constraint to sea outfall capacity.
6. Support future use and development of the Park and associated increases in imperviousness.
7. Support PCPSWMMP goals with public awareness and education initiatives, cost effective operation and maintenance plans, strengthened environmental stewardship and awareness by park users of the cultural importance of the First Nation archaeological site.

4.3. Sizing Criteria

- Water quality treatment provided for the first flush event (31 mm, 24-hour event) through infiltration facilities, raingardens, the dry basin or a water quality unit. Vegetated facilities must drain within 48 hours of the event to support vegetation and provide capacity for future events.
- Storage, infiltration and conveyance capacity in the system provided to prevent surface flooding greater than 6cm deep during the 10-year 24-hour late century rainfall event. Existing infiltration facilities must be rehabilitated to meet this design criteria. Discharge to the sea outfall must consider limited outlet capacity due to late-century astronomical tides and potential clogging from sediment.
- Assess vulnerability of the system and provide temporary ponding / emergency procedures for extreme rainfall and coastal inundation conditions, including:
  - *Drainage of late century 100-year 24-hour rainfall event*
  - *Drainage of late century 10-year and 100-year coastal inundation across the Park*

4.4. Treatment Train Approach

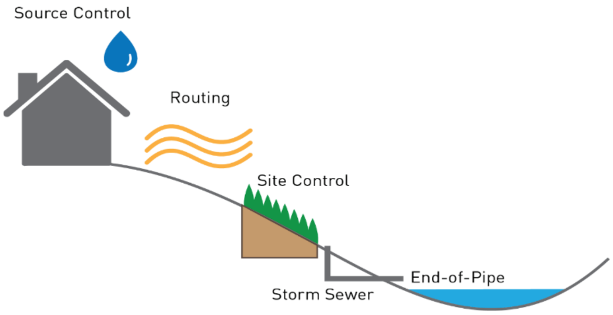


Figure 23. Treatment Train Components

The treatment train approach to stormwater management is recommended for future upgrades. The approach uses multiple practices to manage the quantity and quality of stormwater runoff as it travels across the landscape from its point of origin to the downstream waterbody. A simple schematic of a treatment train is provided in Figure 23.

Treatment trains are often selected to minimize the amount of stormwater runoff generated on site and maximize control of pollutants while complying with constraints such as limited space, physical conditions and regulatory requirements. Source, conveyance, and site controls include Better Site Design (BSD) techniques, Low Impact Development (LID) and Green Infrastructure (GI) strategies that work with nature to manage stormwater as close to its source as possible (see Figure 24). In general, these practices are favoured over end-of-pipe facilities because they reduce stormwater volumes and pollutant loading, which often results in lower stormwater management costs (less hard infrastructure, smaller end of pipe practices, less expensive operation and maintenance). They mimic natural processes to infiltrate, filter, evaporate, and transpire stormwater. Where source, conveyance, and site controls are insufficient or infeasible, traditional conveyance (e.g. storm sewers, ditches, culverts) and end-of-pipe facilities (e.g. ponds) can be used as part of the treatment train approach. End-of pipe facilities focus on centralized detention of stormwater, which involves storing and then slowly releasing stormwater while settling suspended sediment and associated pollutants to the bottom of facilities. Detention is one approach to mitigating flood risk and improving resiliency to large rain events. Examples of conventional stormwater management facilities include wet ponds, dry ponds, constructed wetlands, detention chambers, and hydrodynamic separators (e.g. oil-grit separators). Additional processes can be included in end-of-pipe facilities to enhance their benefits, such as percolation trenches or rock pits to cool discharge from the ponds.

The treatment train approach is consistent with current best practices in stormwater management to deliver cost-effective improvements that offer multiple benefits to the community. The increased use of Green Infrastructure to address issues related to water quality and flooding can also serve to increase community resilience to climate change and improve quality of life by providing other benefits such as increased tree canopy, reducing urban heat island effect, improving air quality and increasing wildlife habitat. These best management practices (BMPs) should be used to retrofit the system and cost-effectively manage runoff volumes, as illustrated in Figure 24. The benefits, suitability and constraints of these practices are outlined in Table 8 to Table 10. Table 11 summarizes runoff volume control practices suitable in the Park based on feasibility-level screening and the constraints identified in Table 10.

Within Parksville Community Park, the main constraint to consider in terms of runoff volume control is the potential risk of shallow groundwater limiting infiltration capacity at several locations. In addition, there is one location east of the lacrosse court where infiltration will be limited by organic silt soils.

Figure 24. Runoff Volume Control Practices

Table 8. Benefits of Runoff Volume Control Practices

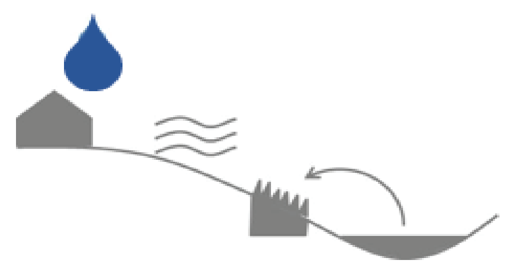
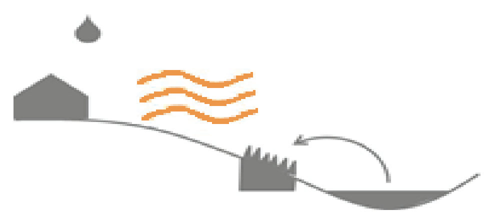
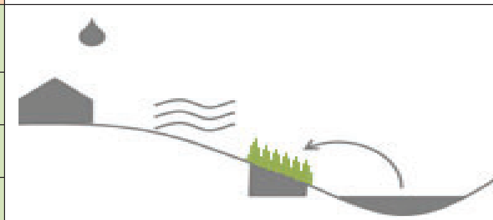
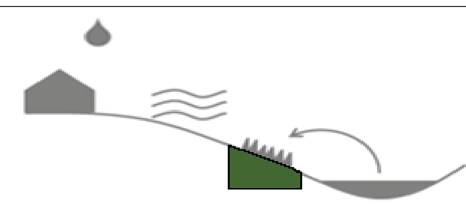
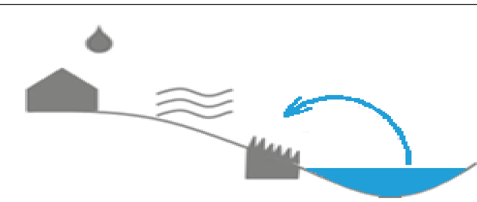
	Runoff Volume Reduction BMP	Location in the Landscape	Hydrologic Benefits: Infiltration	Hydrologic Benefits: Evapo-transpiration	Hydrologic Benefits: Runoff Volume Reduction	Surface Water Pollutant Removal: Total Phosphorus (TP)*	Surface Water Pollutant Removal: Total Nitrogen (TN)*	Surface Water Pollutant Removal: Total Suspended Sediment (TSS)	Surface Water Pollutant Removal: Metals*	Surface Water Pollutant Removal: Thermal**	Ancillary Benefits: Improve Air Quality	Ancillary Benefits: Reduce Urban Heat Island	Ancillary Benefits: Reduce Energy	Ancillary Benefits: Reduce CO2	Ancillary Benefits: Create Habitat
SOURCE CONTROL	Impervious Cover Reduction		High	High	40%	30-55%	64%			Low	✓	✓			
	Soil Amendments/ Decompaction		High	High	75-90%	50-75%	50-75%		25-90%	High					
	Native Ground Cover		High	High	40%				25-90%	Low	✓	✓		✓	✓
	Impervious Disconnection		High	High	25-50%	25-50%	25-50%			Low					
	Urban Tree Canopy		High	High						High	✓	✓	✓	✓	✓
	Permeable Pavement		High		45-85%	40-55%	50-55%	60-80%	<0-90%	Med					
	Green Roof			High	45-90%	highly variable	20-90%	70-90%	80%	Med	✓	✓	✓	✓	✓
	Blue Roof			High	45-90%	highly variable	20-90%	70-90%	80%	Med			✓		
ROUTING	Level Spreaders			Med	50-75%	50-75%	50-75%			Med					
	Filter Strips		Low	Med	25-75%	<0-45%	<0-15%	80-85%	<0-80%	Med				✓	✓
	Dry Swales & Enhanced Grass Swales		Low	Med	10-60%	<0-10%	<0-10%	0-30%	<0-70%	Low	✓	✓		✓	✓
SURFACE TREATMENT	Bioretention (without underdrain)		High	High	65-85%	<0-30%	<0-30%	70-90%	<0-90%	High	✓	✓		✓	✓
	Biofiltration (with underdrain)			High	40-45%	<0-30%	<0-30%	70-85%	<0-90%	Low	✓	✓		✓	✓
	Tree Trenches / Soil Cells		High	High	50-90%	44%	50%	85%	35%	High	✓	✓	✓	✓	✓
	Infiltration Basins		High	High	50-90%	15-90%	60-90%			High				✓	✓
SUBSURFACE TREATMENT	Infiltration Trenches		High	High	50-90%	15-90%	60-90%			High					
	Below-ground Recharge Systems		High		85%	50-80%	40-70%	70-90%	70-90%	High					
REUSE	Rainwater Harvesting			Low	40%	40%	40%			Low			✓		
	Stormwater Harvesting		Low	High	20-75%	45-95%		65-80%		Med			✓		

TABLE NOTES

Legend: High (full bar), Med (half bar), Low (empty bar)

Reduction ranges represent variations in design and site conditions across multiple studies. As a result, comparisons between BMPs across different studies may not reflect true performance. Please refer to the individual references reported for more information on how the volume and pollutant reductions were calculated. Utilizing good design practices will generally achieve removals toward the top end of the range.

* Effluent concentrations can be greater than influent, depending on facility soils and design.

** Relative effectiveness estimated based on average runoff volume reduction as a surrogate for thermal load reduction. Reductions are also dependent on thermal load from catchment.

Extent of benefits depend on a variety of factors including size of BMP, pre-development condition, construction, and maintenance methods, etc.

SOURCE: WERF 2016; WERF 2014; Dane County; USEPA 2017; EOR; UNH 2012

Table 9. Development Suitability and Simplicity of Runoff Volume Control Practices

	Runoff Volume Reduction BMP	New/Re-Development			Land Use Setting												Simplicity of Implementation				
		New Development	Retrofit	Re-development	Ultra Urban	Wide Urban Road ROW	Narrow Urban Road ROW	Rural Road ROW	Urban Park/Plaza	Open Space/Park	Commercial	Institutional	Industrial	Residential - Single Family	Residential - Multi-Family	Rural	Design	Construction	Inspection	City Process	Maintenance
SOURCE CONTROL	Impervious Cover Reduction	High	High	High	High	Low	Low	Med	Med	Low	High	High	Med	High	Med	High	High	High	High	High	High
	Soil Amendments/ Decompaction	High	High	High	Low	Low	Low	Low	Med	High	High	High	Med	High	High	High	High	Med	Low	High	High
	Native Ground Cover	High	High	High	Med	Low	Low	Low	Med	High	High	High	High	High	High	High	High	High	High	High	Med
	Impervious Disconnection	High	High	High	Low	Low	Low	High	High	Low	Low	Low	Low	High	High	High	High	High	High	High	High
	Urban Tree Canopy	High	High	High	High	High	High	High	High	High	High	High	High	High	High	High	High	High	Med	Med	Med
	Permeable Pavement	High	High	High	High	Low	High	Low	High	Low	High	High	High	High	High	High	Low	Low	Med	Low	Low
	Green Roof	High	Med	High	High	N/A	N/A	N/A	Med	Low	High	High	High	High	High	High	Low	Low	Low	Low	Med
	Blue Roof	High	Med	High	High	N/A	N/A	N/A	Med	Low	High	High	High	High	High	High	Low	Low	Low	Low	Med
ROUTING	Level Spreaders	High	High	High	Low	Low	Low	Low	Med	High	High	High	High	High	High	Low	Med	Low	Med	Med	Med
	Filter Strips	High	High	High	High	Low	Low	High	Med	High	High	High	Med	High	High	High	Low	High	Med	Med	High
	Dry Swales & Enhanced Grass Swales	High	Med	High	Med	Low	Low	High	Med	High	High	High	High	High	High	High	Med	Low	Low	Low	Med
SURFACE TREATMENT	Bioretention (without underdrain)	High	High	High	High	Med	Med	High	Med	High	High	High	High	High	High	High	Low	Low	Low	Med	Med
	Biofiltration (with underdrain)	High	High	High	High	High	High	High	Med	High	High	High	High	High	High	High	Low	Low	Low	Med	Med
	Tree Trenches / Soil Cells	High	High	High	High	High	High	Med	High	Low	High	High	High	Low	High	Low	Low	Med	Med	Low	Med
	Infiltration Basins	High	Med	High	Med	Low	Low	High	Med	High	High	High	High	High	High	High	Low	Med	Low	Med	Med
SUBSURFACE TREATMENT	Infiltration Trenches	High	Med	High	Med	High	High	High	High	Med	High	High	High	Low	High	High	Low	Low	Low	Low	Med
	Below-ground Recharge Systems	High	High	High	Med	High	High	High	High	Med	High	High	High	Low	High	Low	Low	Low	Med	Low	Med
REUSE	Rainwater Harvesting	High	High	High	High	Low	Low	Low	Med	Low	High	High	High	High	High	High	Low	Med	Med	Med	Med
	Stormwater Harvesting	High	High	High	High	High	High	High	Med	High	High	High	High	High	High	High	Low	Med	Med	Med	Med
NOTES	Legend: High / Med / Low																				

SOURCE: DEQ 2016, DEQ 2016, COE 2016, TRCA 2016

Table 10. Design Criteria and Considerations for Runoff Volume Control Practices

	Runoff Volume Reduction BMP	Design Criteria					Design Considerations			Maintenance		Cost	
		Suitability by Soil Type	Slope	Suitability for Contaminated Site	Drainage Area to Footprint Ratio	Seasonal High Groundwater Separation	Pre-Treatment	Setback	Potential for Urban Aesthetic	Lifespan (years)	Level of Effort	Capital Cost ($/ha catchment)	Lifecycle Cost ($/ha catchment)
SOURCE CONTROL	Impervious Cover Reduction	High	<15%	Med					N/A	30+	Low	$$	$
SOURCE CONTROL	Soil Amendments/ Decompaction	High	<15%	Med					N/A	30+	Low	$	$
SOURCE CONTROL	Native Ground Cover	High	1-5%	Med					N/A	30+	Low	$	$
SOURCE CONTROL	Impervious Disconnection	High	1-5%	Med		0.6 m			↓	30+	Low	$$	$
SOURCE CONTROL	Urban Tree Canopy	High		High				Foundation		30+		$$	$$
SOURCE CONTROL	Permeable Pavement	High	1-5%	Med	Area 1:2:1	1 m		Foundation		15-25	High	$$$	$$
SOURCE CONTROL	Green Roof	High	0-10% (>5% req. design mod.)	High	Area 1:1 (Direct Rainfall Only)					Asphalt Life + 20	Med	$$$	$$
SOURCE CONTROL	Blue Roof	High	0-10% (>5% req. design mod.)	High	Area 1:1 (Direct Rainfall Only)					Asphalt Life + 20	Med	$$$	$$
ROUTING	Level Spreaders	High	<15%	Med					N/A	10-20	Low	$$	$$$
ROUTING	Filter Strips	High	1-5%	High	<25 m Length <3% slope	0.6 m			N/A	30+	Low	$$	$$$
ROUTING	Dry Swales & Enhanced Grass Swales	Med	0.5-3%*	Med	Length 5-15:1 (<0.8 ha)	1 m	✓	Foundation	N/A	30+	High	$$	$$$
SURFACE TREATMENT	Bioretention (without underdrain)	Med	1-5%	Low	Area 5-15:1 (0.2-0.8 ha)	0.5 m**	✓	Foundation	↓	25	Med	$	$$
SURFACE TREATMENT	Biofiltration (with underdrain)	High	0.5-2%	High	Area 5-15:1 (0.2-0.8 ha)	1 m*	✓	Foundation	↓	25	High	$	$$
SURFACE TREATMENT	Tree Trenches / Soil Cells	High	0.5-2%	High	Area 5-15:1 (0.2-0.8 ha)	0.5 m**	✓	Utilities, Foundation	↑	30+	High	$$	$$$
SURFACE TREATMENT	Infiltration Basins	Med	<15%	Low	Area 5-30:1 (10 for Roads)	0.5 m**	✓	Foundation	N/A	20-30	Med	$	$$
SUBSURFACE TREATMENT	Infiltration Trenches	Med	<15%	Low	Area 5-30:1 (10 for Roads)	0.5 m**	✓	Foundation	↑	20-30	High	$	$$
SUBSURFACE TREATMENT	Below-ground Recharge Systems	Med	<15%	Low	Area 5-30:1 (10 for Roads) Width >Depth	0.5 m**	✓	Foundation	↑	20-30	High	$$	$$$
REUSE	Rainwater Harvesting	High	<15%	High					↑	30+	High	$	$$
REUSE	Stormwater Harvesting	High	<15%	High					↑	30+	High	$	$$
NOTES	Legend: High, Med, Low	All (High); A & B (Med)	*slopes greater than 1% require check dams or grade control			**Stormwater Planning - A Guidebook for British Columbia	Required ✓		High potential: ↑ Low potential: ↓			$$$ $$ $	High Med Low

SOURCE: DEQ 2016, CVC/TRCA 2010, DEQ 2016, CVC/TRCA 2010; CRWA, EOR, STEP 2013, COE 2016; EOR, CHI & Autocase, 2017

Sources for Table 8, Table 9 and Table 10

Clary, J., Jones, J., Leisenring, M., Hobson, P., Strecker, E. (2016). International Stormwater BMP Database - 2016 Summary Statistics, Final Report. Prepared for Water Environment & Reuse Foundation (WERF). Virginia, USA.

Geosyntec Consultants, Inc., Wright Water Engineers, Inc. (2014). Summary of BMP Performance for Stormwater Report Data - International Stormwater BMP Database. Prepared for Water Environment Research Foundation (WERF).

Balousek, J. (2003). Quanifying decreases in Stormwater Runoff from Deep Tilling, Chisel Plowing and Compost Amendment. Dane County Land Conservation Department.

US EPA (2017). International Stormwater BMP Database, www.bmpdatabase.org, accessed November 7, 2017.

Professional Judgement, EOR Inc., 2017

Minnesota Stormwater Manual, 2017. Accessed November 8, 2017, https://stormwater.pca.state.mn.us/index.php?title=Calculating_credits_for_tree_trenches_and_tree_boxes

Houle, J., Roseen, R., Ballestero, T., Puls, T., Sherrard , J. 2013. Comparison of Maintenance Cost, Labour Demands, and System Performance for LID and Conventional Stormwater Management. Journal of Environmental Engineering 2013:139:932-938.

Oregon Department of Environmental Quality (DEQ). 2016. Low Impact Development in Western Oregon: A Practical Guide for Watershed Health. Prepared by Green Girl Land Development Solutions, LLC.

Van Seters, T., Graham, C., Rocha, L., Uda, M., Kennedy, C. 2013. Assessment of Life Cycle Costs for Low Impact Development Stormwater Management Practices. Prepared for the Sustainable Technologies Evaluation Program (STEP) of Toronto and Region Conservation Association (TRCA)

City of Edmonton (COE). 2016. Low Impact Development Construction Inspection and Maintenance Guide. Prepared by Urban Systems Inc.

Toronto and Region Conservation Authority (TRCA). 2016. Low Impact Development Stormwater Management Practice Inspection and Maintenance Guide. Prepared by the Sustainable Technologies Evaluation Program. Vaughan, Ontario.

EOR, CHI & Impact Infrastructure (2017). Low Impact Development Location Study Part 1. City of Edmonton

Table 11. Runoff Volume Control Practice Feasibility at Parksville Community Park

Shallow Groundwater

	Runoff Volume Reduction BMP	Land Use Campatibility	Design Criteria: Soils	Slope	Contaminated Sites	Drainage Area to Footprint Ratio	Groundwater Table Separation	Constraints from Design Considerations	Preferred Feasible BMPs
	Site Conditions	Open Space/Park	A/B	2%	None	Varies	<0.5m	Setback Minimal from Adjacent Buildings	
SOURCE CONTROL	Impervious Cover Reduction	Low							Low
	Soil Amendments/ Decompaction	High							High
	Native Ground Cover	High							High
	Impervious Disconnection	Low							High
	Urban Tree Canopy	High							High
	Permeable Pavement	Low					*		*
	Green Roof	Low							Low
	Blue Roof	Low							Low
ROUTING	Level Spreaders	High							High
	Filter Strips	High					*		*
	Dry Swales & Enhanced Grass Swales	High					*		*
SURFACE TREATMENT	Bioretention (without underdrain)	High					*		*
	Biofiltration (with underdrain)	High					N/A		N/A
	Tree Trenches / Soil Cells	Low					*		*
	Infiltration Basins	High					*		*
SUBSURFACE TREATMENT	Infiltration Trenches	Medium					*		*
	Below-ground Recharge Systems	Medium					*		*
REUSE	Rainwater Harvesting	Low							Low
	Stormwater Harvesting	High							High

Deep Groundwater

	Runoff Volume Reduction BMP	Land Use Campatibility	Design Criteria: Soils	Slope	Contaminated Sites	Drainage Area to Footprint Ratio	Groundwater Table Separation	Constraints from Design Considerations	Preferred Feasible BMPs
	Site Conditions	Open Space/Park	A/B	2%	None	Varies	>=0.5m	Setback Minimal from Adjacent Buildings	
SOURCE CONTROL	Impervious Cover Reduction	Low							Low
	Soil Amendments/ Decompaction	High							High
	Native Ground Cover	High							High
	Impervious Disconnection	Low							Low
	Urban Tree Canopy	High							High
	Permeable Pavement	Low							Low
	Green Roof	Low							Low
	Blue Roof	Low							Low
ROUTING	Level Spreaders	High							High
	Filter Strips	High							High
	Dry Swales & Enhanced Grass Swales	High							High
SURFACE TREATMENT	Bioretention (without underdrain)	High							High
	Biofiltration (with underdrain)	High							High
	Tree Trenches / Soil Cells	Medium							Low
	Infiltration Basins	High							High
SUBSURFACE TREATMENT	Infiltration Trenches	Medium							Medium
	Below-ground Recharge Systems	Medium							Medium
REUSE	Rainwater Harvesting	Low							Low
	Stormwater Harvesting	High							High

Organic Silt Soils

	Runoff Volume Reduction BMP	Land Use Campatibility	Design Criteria: Soils	Slope	Contaminated Sites	Drainage Area to Footprint Ratio	Groundwater Table Separation	Constraints from Design Considerations	Preferred Feasible BMPs
	Site Conditions	Open Space/Park	D	2%	None	Varies	>=1.0m	Setback Minimal from Adjacent Buildings	
SOURCE CONTROL	Impervious Cover Reduction	Low							Low
	Soil Amendments/ Decompaction	High							High
	Native Ground Cover	High							High
	Impervious Disconnection	Low							Low
	Urban Tree Canopy	High							High
	Permeable Pavement	Low							Low
	Green Roof	Low							Low
	Blue Roof	Low							Low
ROUTING	Level Spreaders	High							High
	Filter Strips	High							High
	Dry Swales & Enhanced Grass Swales	High	N/A						
SURFACE TREATMENT	Bioretention (without underdrain)	High	N/A						
	Biofiltration (with underdrain)	High							High
	Tree Trenches / Soil Cells	Medium							Low
	Infiltration Basins	High	N/A						
SUBSURFACE TREATMENT	Infiltration Trenches	Medium	N/A						
	Below-ground Recharge Systems	Medium	N/A						
REUSE	Rainwater Harvesting	Low							Low
	Stormwater Harvesting	High							High

NOTES

Legend: High / Medium / Low

N/A = BMP not compatible with site

* = BMP requires design modification

This page intentionally left blank.