FACT SHEET

Sustainable Technologies
EVALUATION PROGRAM

Permeable Pavements

Inspection and Maintenance of Stormwater Best Management Practices

Permeable pavements contain many small openings (i.e., joints or pores) that allow rainfall and snowmelt (i.e., stormwater) to drain through them instead of running off the surface as it does on impervious pavements like conventional asphalt and concrete. Permeable pavements treat the stormwater that falls on them and may be designed to also receive runoff from adjacent impermeable surfaces (e.g., pavements and roofs) as either sheet flow or from a pipe (e.g., roof downspout) connected to the washed gravel base. Captured water is temporarily stored in the base where it either soaks into the underlying native soil and replenishes groundwater, or is conveyed to a municipal storm sewer or other BMP by sub-drains (i.e., underground perforated pipes). An overflow outlet is needed to safely convey flows during flood events. Depending on the permeability of the underlying soil and other constraints, the pavement may be designed with no sub-drain for full infiltration, with a sub-drain for partial infiltration, or with an impermeable liner and sub-drain for a no infiltration practice. The sub-drain pipe may feature a flow restrictor (e.g., orifice cap or valve) for gradually releasing detained water and optimizing the amount drained by infiltration into the underlying soil. Key components of permeable pavements for inspection and maintenance are described in Table 1 and Figure 2.

Susceptibility to clogging of the pavement joints or pores, or underlying geotextile filter fabric from fine sediment accumulation is the main concern for permeable pavement systems. Regular vacuuming with regenerative air or pure vacuum sweepers will help to maintain their drainage performance.

BENEFITS

- Reduce the quantity of pollutants and runoff being discharged to municipal storm sewers and receiving waters (i.e., rivers, lakes and wetlands);
- Replenish groundwater resources and keep the flow of water to our rivers and lakes cool for temperature-sensitive fish like trout and salmon;
- Can be used for low to medium traffic roads, parking spaces, driveways, pedestrian plazas and walkways.

RELATED TERMS

Permeable interlocking pavers (i.e., block pavers): Precast modular units made of concrete, pervious concrete or rubber/plastic composite, designed to create open joints between pavers that are filled with fine, washed gravel and installed on an open-graded, washed gravel base and sub-base.
Permeable interlocking grids (i.e., grid pavers): Precast concrete or manufactured plastic grids with open cells that can be filled with fine gravel or a mixture of gravel, sand and topsoil and planted with grass or low-growing ground covers, installed on an open-graded washed gravel base.
Pervious concrete: a rigid pavement installed as pre-cast blocks or poured in place on an open-graded, washed gravel base that uses a cementitious binder to adhere aggregate together, similar to conventional concrete, except that the fine aggregate component is minimized or eliminated which results in the formation of connected pores throughout.
Porous asphalt: a flexible pavement installed on an open-graded, washed gravel base that uses a bituminous binder to adhere aggregate together, similar to conventional asphalt, except that the fine aggregate component is minimized or eliminated which results in the formation of connected pores throughout.
Permeable articulating concrete block: Precast concrete blocks designed with open joints that require no gravel joint fill material, linked together into mats by cables and installed on an open-graded, washed gravel base.

Figure 1. Pervious concrete parking lot

TIPS TO HELP PRESERVE BMP FUNCTION

- Prohibit access by construction vehicles to prevent tracking of sediment on to the surface;

- Prohibit storage of plowed snow, soil, compost, sand, salt or unwashed gravel on permeable pavements to prevent clogging of joints or pores, or protect the pavement surface with tarps or geotextile during temporary storage of such materials;

- Permeable pavements can be plowed for snow removal like conventional pavements. To reduce the risk of dislodging pavers or grids and minimize displacement of joint or cell fill material, raise the plow blade off the pavement surface (e.g., 0.6 cm or 1/4") with a shoe attachment;

- Do not spread sand on permeable pavements as part of winter maintenance as it will quickly clog the joints or pores and impair drainage function. On permeable interlocking pavers and grid systems filled with gravel, if application of an anti-skid material is desirable, spread the same fine washed gravel material used to fill the paver joints or grid cells;

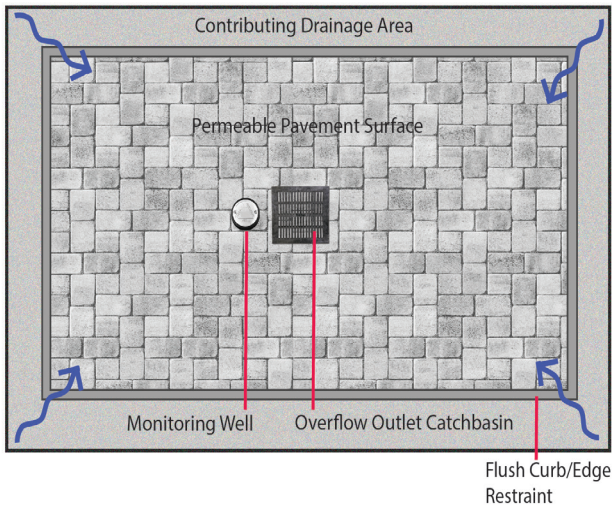
- De-icers should be used sparingly during winter. Due to their freely draining design, ice will not form on permeable pavements as readily as it does on conventional impermeable pavements during thaw-freeze cycles.

- Never use sealants on porous asphalt or pervious concrete;

- Adjacent landscaping should be covered with vegetation and not drain to the pavement to prevent eroding soil from reaching the surface.

KEY COMPONENTS AND INSPECTION AND MAINTENANCE TASKS

Figure 2. Generalized plan and cross-section views showing key components of permeable pavements



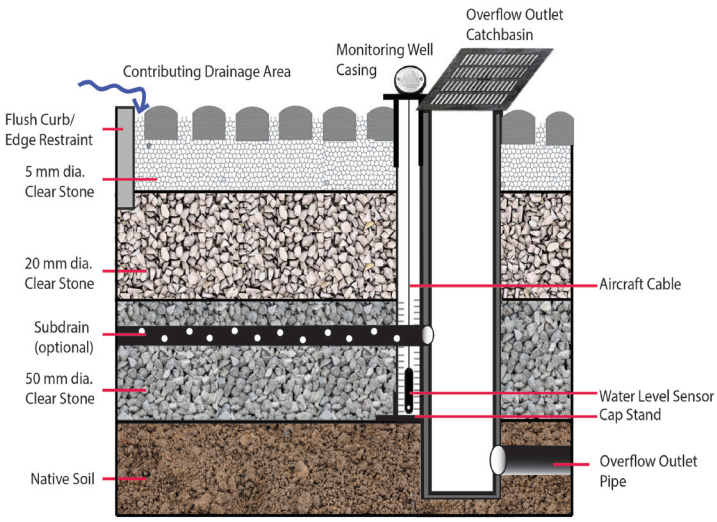
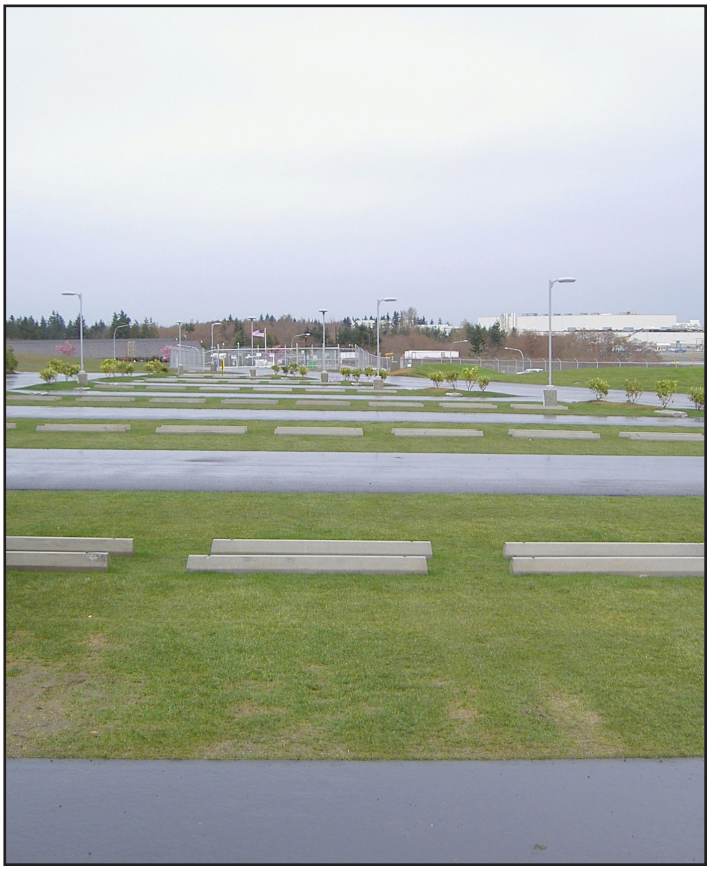


Table 1. Key components, descriptions and routine inspection and maintenance tasks.

Component	Description	Inspection and Maintenance Tasks
Contributing drainage area (CDA)	Area(s) from which runoff directed to the BMP originates; includes the pavement itself and any adjacent impermeable pavement or roofs that drain to it.	• Remove trash, debris and sediment regularly from pavements (biannually to quarterly) and eavestroughs (annually).
Inlets	Structures that deliver water to the BMP (e.g., impermeable pavement edges, pipes from roof downspouts or catchbasins).	• Keep free of obstructions.; • Remove trash, sediment and debris regularly (biannually-quarterly).
Pavement surface	The surface of the pavement, including pavers/pavement, joints and edge restraints (e.g., curbs, edging); should not allow water to pond on the surface so any observation or evidence of surface ponding (e.g., sediment caking on the pavement) indicates a drainage problem.	• Check for sediment, surface ponding, deformation, sink holes, damage and loss of joint fill; • Remove trash regularly (biannually-quarterly); • Grid systems with soil and grass fill are maintained like lawns; • Sweep and vacuum interlocking and rigid pavements regularly (annually-biannually) with regenerative air/pure vacuum sweeper. • Plow snow as needed and spread deicers sparingly during winter; • Repair ruts or local sinking of 15 mm or greater over a 3 metre length, adjacent pavers or cracks in pervious concrete or porous asphalt are vertically offset by 5 mm or greater and paver joint fill is missing or below 15 mm from the paver surface.
Vegetation	Applies to grid paver systems only; a mixture of deep rooting perennial grasses or low growing ground covers, tolerant to both wet and dry conditions and salt (if receiving impermeable pavement runoff); roots uptake water and return it to the atmosphere, provide habitat for soil organisms that break down pollutants trapped in the soil and help maintain soil structure and permeability.	• Grid systems with soil and grass fill are maintained like lawns; • In the first 2 months water frequently (biweekly in the absence or rain) and as needed (e.g., bimonthly) over the remainder of the first growing season; • Remove weeds and undesirable plants biannually to quarterly; • Replace/reseed dead plantings annually to achieve 80% cover by the third growing season; • Do not apply chemical fertilizers.
Overflow Outlet	Structures (e.g., catchbasin, curb-cut, swale) that convey flow that exceeds the storage capacity of the BMP to another drainage system (e.g., municipal storm sewer or other BMP).	• Keep free of obstructions; • Remove trash, sediment, debris, and clippings regularly (biannually-quarterly).
Sub-drain	Optional component comprised of perforated pipe(s) surrounded by gravel and may be wrapped in geotextile filter fabric; installed in the base or sub-base gravel layer to collect and convey treated water to an adjacent drainage system or other BMP; may also include a flow restrictor.	• Keep pipe and flow restrictor free of obstructions by flushing annually; • Inspect flow restrictor regularly (biannually-quarterly).
Monitoring Well	Standpipe that extends from the bottom of the excavation to just below the pavement surface and contains perforations or slots to allow measurement of subsurface water level; used to track drainage performance over the operating life cycle of the BMP.	• Standpipes should be securely capped on both ends and protected from damage by vehicular traffic by a casing.
Control Structure	Manhole or catchbasin to which the sub-drain outlets that provides access to the sub-drain and flow restrictor. Inspect for accessibility, damage and sediment.	• Remove trash, debris and sediment regularly (biannually-quarterly).

Figure 3. Grassed permeable pavements (Images courtesy of: LEFT - Herrera Consulting, RIGHT - UNILOCK)



REHABILITATION

Table 2. Key components, typical problems and rehabilitation tasks.

Component	Problem	Rehabilitation Tasks
Pavement Surface	Major cracks, spalling or raveling of the porous asphalt or pervious concrete surface	Fill small potholes or cracks with patching mixes (consult with product vendor for further guidance). Large potholes or cracks may require cutting and replacing a section of the surface layer. Replace with the same permeable material where possible. Conventional asphalt or concrete could be acceptable if the cumulative area remains below 15% of the total BMP footprint area.
	Paver or grid unit is missing, damaged or displaced	Replace or reset unit by hand and restore joint or grid cell fill material that meets design specification.
	Surface infiltration rate < 150 mm/h (determined by single-ring infiltrometer measurements, one per 250 m2 of BMP area)	Sweep and thoroughly vacuum with a pure vacuum sweeper to remove accumulated sediment. Replace joint fill material removed through vacuuming. Pretreatment of the surface of slow draining pavements (e.g., water-assisted or mechanical techniques) prior to vacuuming may be warranted where surface clogging of joints or pores is visible. If surface drainage performance remains unacceptable, remove all pavers, bedding and joint fill in affected area and top 5 cm (2") of base aggregate and replace with new bedding and joint fill materials that meet design specifications.
Vegetation	Poor grass cover on interlocking permeable grid system	Aerate and dethatch or remove and replace planting soil in affected area with material that meets design specifications and replant.
Sub-drain	Sub-drain perforated pipe is obstructed	Schedule hydro-vac truck or drain-snaking service to remove the obstruction.

TYPES OF INSPECTIONS

Routine Operation: Regular inspections (twice annually, at a minimum) done as part of routine maintenance tasks over the operating phase of the BMP life cycle to determine if frequencies are adequate and when rehabilitation or further investigation into BMP function is warranted.

Maintenance and Performance Verification: Periodic inspections done every 5 years (maintenance verifications) and every 15 years (performance verifications) post-construction over the operating life cycle of the BMP to ensure compliance with the maintenance agreement (e.g., Environmental Compliance Approval permit) conditions, evaluate functional performance and determine when rehabilitation or replacement is necessary.

INSPECTION TIME COMMITMENTS AND COSTS

Estimates are based on a typical partial infiltration permeable pavement design (i.e., includes a sub-drain); estimates for other designs (i.e., full infiltration and no-infiltration) are described in the Low Impact Development (LID) Stormwater Management Practice Inspection and Maintenance Guide available at https://sustainabletechnologies.ca

Table 3. Time commitments and costs for inspection of permeable pavement

Permeable Pavement	Routine Operation	Maintenance Verification	Performance Verification
Tasks to complete	12	10	10
Visits (per year)	1	1 every 5 years	1 every 15 years
Time (hours per m^2 BMP area)	0.001	0.001	0.001
Cost	$0.06	$0.05	$0.05
Performance Verification Options ($ per m^2 BMP area)			
Surface infiltration rate testing: $0.21 5 tests			
Simulated storm event testing: $2.09			
Natural storm event testing: $2.00, 2 months monitoring			

Figure 3. Sediment accumulation on permeable pavement

Figure 4. Permeable pavements in needs of maintenance

Table 4. Task cost estimates for maintenance and rehabilitation of a partial infiltration permeable pavement

Permeable Pavement	Costs per m^2 of BMP area	
Tasks	**Min.**	**High**
Remove litter	$0.33	$0.63
Surface vacuum - Starts year 2	$0.40	$0.80
Restriping	$0.46	$0.46
Replace pavers	$0.50	$1.00
Clean out pipes	$0.04	$0.04
Re-place joint material after vacuuming	$0.18	$0.36
Rehabilitation	$76.55	$76.55

For a detailed description of construction, inspection, maintenance and rehabilitation cost assumptions see section 7.1.7 of the LID Stormwater Management Practice Inspection and Maintenance Guide. To generate BMP-specific cost estimates use the LID Life Cycle Costing Tool available at https://sustainabletechnologies.ca.

Table 5. Construction and life cycle cost estimates

Permeable Pavement	**Costs per m^2 of BMP area + CDA**	
	Minimum	**High**
Construction	$54.85	
LIFE CYCLE COSTS		
25 year evaluation period		
Average annual maintenance	$0.60	$1.05
Maintenance and rehabilitation	$12.40	$21.35
50 year evaluation period		
Average annual maintenance	$0.55	$0.95
Maintenance and rehabilitation	$58.20	$77.60

Figure 5. Permeable interlocking recycled rubber composite pavers in a parking lot

Figure 6. Surface infiltration testing with single-ring infiltrometer

This communication has been prepared by the Sustainable Technologies Evaluation Program (STEP) with funding support from the Toronto and Region Remedial Action Plan (RAP), Region of Peel, York Region and City of Toronto. The contents of this fact sheet do not necessarily represent the policies of the supporting agencies and the funding does not indicate an endorsement of the contents.

For more detailed information on inspection, testing and maintenance of permeable pavements and a field data form (checklist) to use for collecting and recording inspection results, please refer to Appendix D of the Low Impact Development Stormwater Management Practice Inspection and Maintenance Guide, available at **https://sustainabletechologies.ca**.

For more information about STEP and other resources and studies related to stormwater management, visit our website or email us at **STEP@trca.on.ca**.

Toronto and Region Conservation *for* The Living City