7.4 Permeable Pavements

7.4.1 BMP Overview

Permeable pavements contain many small openings (i.e., joints or pores) that allow rainfall and snowmelt to drain through them instead of running off the surface as it does on impervious pavements like conventional asphalt and concrete (Permeable Pavement Task Committee, 2015). Permeable pavements treat the precipitation 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) discharged to the pavement surface or connected to the aggregate base . Water that has infiltrated through the permeable pavement is temporarily stored in the clear stone (i.e., washed gravel) aggregate base. There it either percolates into the underlying native sub-soil and replenishes the groundwater system, or the filtered water is conveyed to a municipal storm sewer or another stormwater BMP by a perforated pipe sub-drain. An overflow outlet is necessary to safely convey flows from major storm events to a storm sewer or another BMP. Key components of permeable pavements for inspection and maintenance are described in Table 7.19 and Figure 7.4.

Properly functioning permeable pavements reduce the quantity of runoff and pollutants being discharged to municipal storm sewers and receiving waters (i.e., rivers, lakes and wetlands) and can help replenish groundwater resources. They can be used for low to medium traffic roads, parking spaces, driveways, pedestrian plazas and walkways.

There are a variety of types of permeable pavements that differ in terms of the surface layer:

- 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 aggregate and installed on an open-graded aggregate (i.e., clear stone) base and sub-base.
- permeable interlocking grid systems (i.e., grid pavers) – Precast concrete or manufactured plastic grids with open cells that can be filled with aggregate or a mixture of sand, gravel and topsoil and planted with grass or low-growing ground covers and are installed on an open-graded aggregate base.
- pervious concrete – a rigid pavement installed on an open-graded aggregate 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 aggregate 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.

Depending on the permeability of the underlying native sub-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 or detention and filtration only practice. The sub-drain pipe may feature a flow restrictor (e.g., orificed cap, ball valve) for BMP designed to control the peak flow rate.

Table 7.19: *Key components of permeable pavements for inspection and maintenance.*

Component	Description
Contributing Drainage Area	The area from which runoff directed to the BMP originates. CDAs include impervious and pervious areas draining to the BMP and the BMP itself. CDAs should be free of point sources of pollutants (e.g., leaking waste containers, spills, failing ESCs). Trash, sediment and debris should be removed regularly from pavements and other stormwater conveyances (e.g., gutters, eavestroughs) draining to the BMP.
Pavement surface	The surface should be inspected to confirm dimensions are acceptable, check for damage, deformation (e.g. ruts), unevenness, open joints and sediment accumulation. Permeable pavements should not allow ponding of water on the surface to occur when functioning acceptably so any observation of surface ponding indicates that a problem exists. Trash and natural debris should be periodically removed. Permeable interlocking pavers, pervious concrete and porous asphalt need to be swept and vacuumed regularly to remove fine sediment from joints and pores, and plowed of snow and spread with deicing salt as needed during winter. Sand should not be spread as an anti-slip agent as it will clog the joints or pores. Grid systems with topsoil and grass fill are maintained like lawns.
Vegetation	Permeable interlocking grid systems may be filled with topsoil and planted with grass. Routine maintenance of grid system grass cover is the same as conventional lawns (i.e., weeding, mowing, watering during droughts). In the first 2 months of establishment, plantings need to be irrigated frequently (e.g., bi-weekly). Where compost amended topsoil is used to fill grid cells, periodic top dressing with compost should be all that is needed to maintain healthy vegetation cover (i.e., application of chemical fertilizers should not be a part of routine maintenance).
Overflow outlets	Flows exceeding the storage capacity of the BMP are conveyed to an adjacent drainage system via an overflow outlet structure (e.g., flush curb, curb-cut, catchbasin). Overflow outlet structures must be kept free of obstructions to ensure stormwater is safely conveyed during major storm events.
Sub-drain	Sub-drains are optional components that may be included where the permeability of the underlying native sub-soil is low or, due to other constraints, an impermeable liner is required. They are installed in the pavement base to collect and convey filtered water to an adjacent drainage system. Sub-drains are comprised of perforated pipes wrapped in a gravel blanket and in some cases geotextile filter fabric. The perforated pipe must be kept free of obstructions to ensure that the subsurface water storage capacity of the BMP drains within a specified time period. A maintenance port standpipe may be connected to the perforated pipe to provide a means of flushing and inspecting it. Perforated pipes should be routinely flushed with water to remove sediment. If the sub-drain is equipped with a flow-restrictor (e.g., orifice plate, ball valve) to attenuate flow rates, the flow restrictor must be inspected and cleaned regularly.

Monitoring well	Standpipes that extend from just below the surface of the pavement to the bottom of the excavation and contain perforations or slots to allow observation and measurement of subsurface water level in the BMP. Monitoring wells are needed to determine if the BMP drains within an acceptable time period and to track drainage performance over its operating lifespan. Standpipes should be securely capped on both ends and remain undamaged and free of sediment which may require periodic flushing.
Control structure	The manhole or catchbasin to which the sub-drain outlets that provides access to the sub-drain and flow restrictor device, if present. Inspect for damage and sediment.

7.4.2 *Inspection and Testing Framework*

Table 7.20 describes what visual and testing indicators should be used during each type of inspection for permeable pavements and provides a basis for planning field work. Numbers in the first column refer to the section of Chapter 8 that provides detailed guidance on standard protocols and test methods for assessing the respective indicator.

7.4.3 *Critical Timing of Construction Inspections*

Construction inspections take place during several points in the construction sequence, specific to the type of LID BMP, but at a minimum should be done weekly and include the following:

1. During site preparation, prior to BMP excavation and grading to ensure the CDA is stabilized and/or flow diversion devices are in place and confirm that construction materials meet design specifications;
2. At completion of excavation and grading, prior to backfilling and installation of pipes to ensure depths, slopes and elevations are acceptable;
3. At completion of installation of pipes, prior to completion of backfilling to ensure slopes and elevations are acceptable;
4. After final grading, prior to surface course installation to ensure depths, slopes and elevations are acceptable;
5. Prior to hand-off points in the construction sequence when the contractor responsible for the work changes (i.e., hand-offs between the storm sewer servicing, paving, building and landscaping contractors);
6. After every large storm event (e.g., 15 mm rainfall depth or greater) to ensure flow diversion devices are functioning and adequately maintained.

Table 7.21 describes critical points during the construction sequence when inspections should be performed prior to proceeding further. Table 7.21 can also be used as a checklist during Construction inspections, in addition to the Inspection Field Data Forms provided in Appendix C.

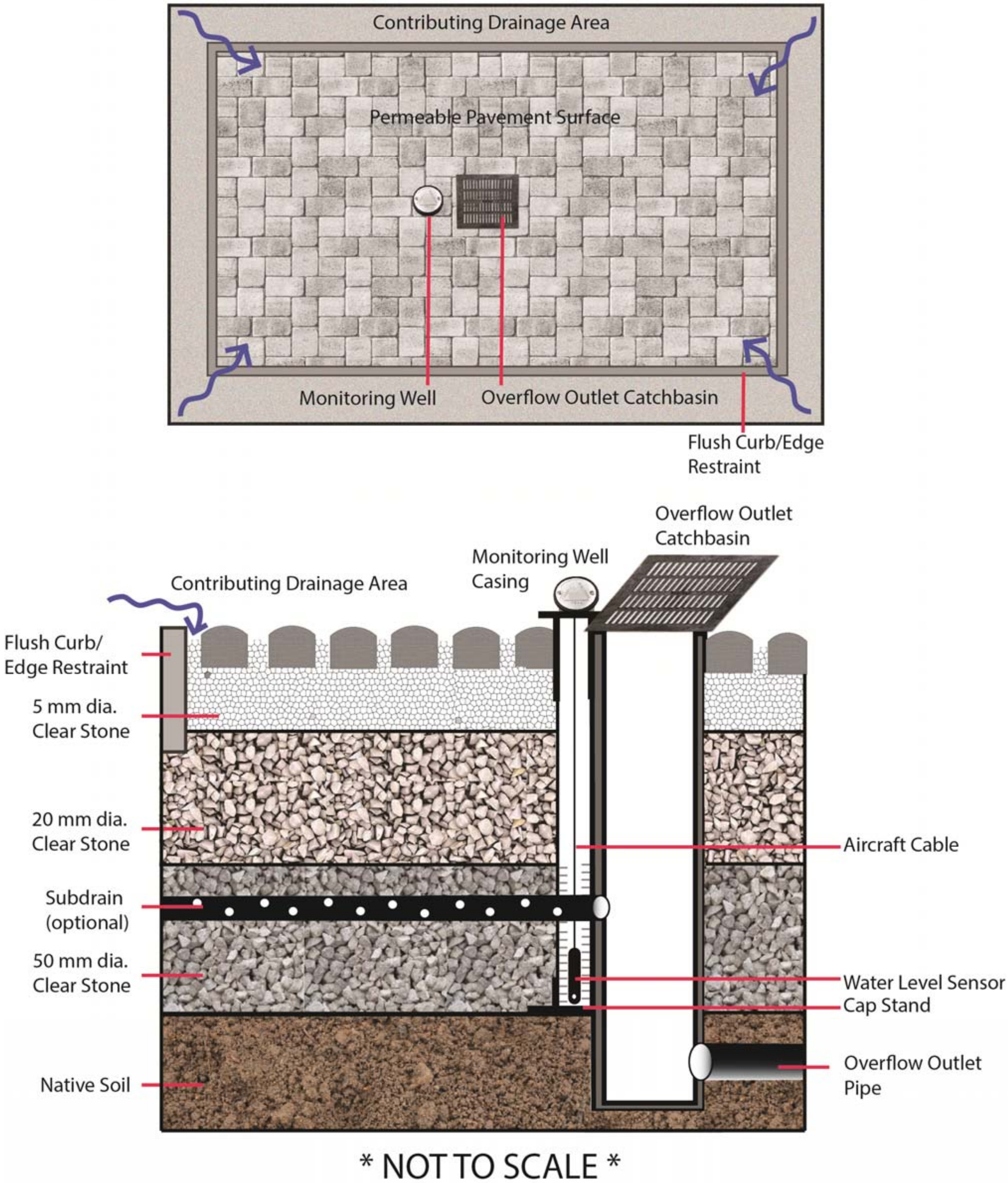

Figure 7.4: *Generalized plan and cross-section views of a permeable pavement showing key components.*

Table 7.20: *Inspection and testing indicators framework for permeable pavements.*

INSPECTION AND TESTING FRAMEWORK					
PERMEABLE PAVEMENTS		Inspection Type			
Section	**Indicator**	**Construction**	**Assumption**	**Routine Operation**	**Verification**
Visual indicators					
C.1	CDA condition	x	x	x	x
C.6	BMP dimensions	x	x		x
C.9	Standing water		x	x	x
C.10	Trash		x	x	
C.17	Vegetation cover	x	x	x	x
C.18	Vegetation condition		x	x	
C.19	Vegetation composition	x	x	x	
C.20	Monitoring well condition	x	x	x	x
C.21	Sub-drain/Perforated pipe obstruction		x		x
C.22	Overflow outlet obstruction	x	x	x	x
C.23	Pavement surface condition		x	x	
C.24	Pavement surface sediment accumulation	x	x	x	x
C.25	Control structure condition	x	x	x	x
C.26	Control structure sediment accumulation	x	x	x	x
Testing indicators					
8.4	Surface infiltration rate testing		x		(x)
8.5	Natural or simulated storm event testing		x		(x)
8.6	Continuous monitoring		x		(x)

(x) denotes indicators to be used for Performance Verification inspections only (i.e., not for Maintenance Verification inspections)

Table 7.21: *Critical timing of construction inspections - permeable pavements.*

Construction Sequence Step and Timing	Inspection Item	Observations [1]
Site Preparation – after site clearing and grading, prior to BMP excavation and grading	Natural heritage system and tree protection areas remain fenced off	
	ESCs protecting BMP layout area are installed properly	
	CDA is stabilized or runoff is diverted around BMP layout area	
	BMP layout area has been cleared and is staked/delineated	
	Benchmark elevation(s) are established nearby	
	Construction materials have been confirmed to meet design specifications	
BMP Excavation and Grading - prior to backfilling and installation of pipes/catchbasins	Excavation location, footprint, depth and slope are acceptable	
	Excavated soil is stockpiled outside the CDA	
BMP Installation – after installation of pipes/catchbasins, prior to completion of backfilling	Impermeable liner installed correctly, if applicable	
	Structural components (e.g., pavement base, curbs) installation is acceptable	
	Installations of sub-drain pipes (e.g., locations, elevations, slopes), standpipes/monitoring wells are acceptable	
	Sub-drain trench dams installed correctly (location, elevation)	
	Surface coarse installation (elevation, slope, monitoring wells) is acceptable	

Notes:

1. S = Satisfactory; U= Unsatisfactory; NA = Not Applicable

7.4.4 Inspection Field Data Forms

Template forms for recording inspection observations, measurements, sampling location details and follow-up actions have been prepared for each LID BMP type and can be found in Appendix C.

7.4.5 Routine Maintenance

Table 7.22 describes routine maintenance tasks for permeable pavements, organized by BMP component, along with recommended minimum frequencies. It also suggests higher frequencies for certain tasks that may be warranted for BMPs located in highly visible locations or those receiving flow from high traffic (vehicle or pedestrian) areas or those designed with higher than recommended impermeable drainage area to permeable BMP footprint area ratios (I:P ratios). Tasks involving removal of trash, debris and sediment and weeding/trimming of vegetation for BMPs in such contexts may need to be done more frequently (i.e., higher standards may be warranted).

Individuals conducting vegetation maintenance and in particular, weeding (i.e., removal of undesirable vegetation), should be familiar with the species of plants specified in the planting plan and experienced in plant identification and methods of removing/controlling noxious weeds. Key resources on these topics are provided below:

- Agriculture and Agri-food Canada's WeedInfo database, http://www.weedinfo.ca/en/
- Ontario Ministry of Agriculture, Food and Rural Affairs' Ontario Weed Gallery, http://www.omafra.gov.on.ca/english/crops/facts/ontweeds/weedgal.htm
- Ontario Ministry of Agriculture, Food and Rural Affairs' Noxious Weeds In Ontario list, http://www.omafra.gov.on.ca/english/crops/facts/noxious_weeds.htm
- Ontario Invasive Plant Council's Quick Reference Guide to Invasive Plant Species, http://www.ontarioinvasiveplants.ca/files/Invasives_booklet_2.pdf
- <u>Plants of Southern Ontario</u> (book), 2014, by Richard Dickinson and France Royer, Lone Pine Publishing, 528 pgs.
- <u>Weeds of North America</u> (book), 2014, by Richard Dickinson and France Royer, University of Chicago Press, 656 pgs.

Table 7.22: *Routine maintenance tasks for permeable pavements.*

Component	Routine Maintenance Task	Frequency[1]	
		Minimum[2]	High[3]
Contributing Drainage Area	Remove trash, natural debris, clippings and sediment	BA	Q
	Re-plant or seed bare soil areas	A	BA
Overflow outlets	Remove trash, natural debris and clippings	BA	Q
	Remove accumulated sediment	A	BA
Pavement surface	Remove trash, natural debris and clippings (rakes and leaf blowers)	BA	Q
	Remove accumulated sediment (sweep and vacuum)[4]	A	BA
	Replace/top up joint or grid fill material (if applicable)	A	BA
	Remove undesirable vegetation (e.g., tree seedlings, invasives/weeds)	A	BA
	Plow snow and apply de-icing salt during winter	AN	AN
	Re-paint lines/parking space divisions (if applicable)	Every 3 years	Every 3 years

Vegetation	◖ Watering during first two months after planting	BW	BW
	◖ Watering for the remainder of the first two (2) growing seasons (i.e., May to September) after planting or until vegetation is established	AN	AN
	◖ Watering for the remainder of the BMP lifespan	D	AN
	◖ Mow grass to maintain height between 5 to 10 cm.	M	BM
	◖ Remove undesirable vegetation (e.g., tree seedlings, invasives/weeds)	A	BA
	◖ Overseed and top dress bare areas with compost to maintain a minimum of 80% grass cover [5]	A	BA
Sub-drain & Monitoring well	◖ Flush out accumulated sediment with hose or pressure washer	A	A

Notes:

1. A = Annually; AN = As needed based on Routine Operation inspections; BA = Bi-annually or twice per year, ideally in the spring and late fall/early winter; BM = Bi-monthly; BW = Bi-weekly or twice per week; M = Monthly; D = During drought conditions classified by Agriculture and Agri-Food Canada's Canadian Drought Monitor as severe (D2) or higher (AAC, 2015); Q = Quarterly or four times per year, ideally in the spring, summer, early fall and late fall/early winter; W = Weekly.
2. These frequencies are recommended as the minimum necessary to ensure the BMP functions adequately over its expected lifespan.
3. High priority BMPs such as or those draining to a sensitive receiving waterbody, those receiving drainage from high traffic areas, or those designed with larger than recommended impervious drainage area to pervious BMP footprint area ratios (i.e., I:P ratios), may warrant a higher frequency of routine maintenance tasks involving removal of trash/debris/sediment and mowing/weeding/trimming of vegetation.
4. For permeable interlocking pavers, pervious concrete and porous asphalt, use regenerative air vacuum sweepers for routine maintenance and pure vacuum sweepers for rehabilitating slow draining/clogged pavements. Sweeping and vacuuming should be done during dry weather.
5. For grid systems where cells are filled with topsoil and grass, aim to achieve 80% grass cover by the end of the establishment/warranty period (e.g., two years after planting).

Tips to help preserve BMP function

- Never use sealants on porous asphalt nor pervious concrete;
- Prohibit access by construction vehicles to prevent tracking of sediment on to the surface;

- Prohibit storage of 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;
- Landscaped areas adjacent to permeable pavements should be covered with vegetation and not drain to the pavement where possible to prevent eroding soil from reaching the surface;
- Use a mulching mower to mow permeable interlocking grid systems with grass cover;
- 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/cell fill material, the plow blade should be slightly raised off the pavement surface (e.g., 0.6 cm or 1/4”) with a shoe attachment;
- Plowed snow piles should not be stored on permeable pavements to reduce the risk of clogging from sediment accumulation upon melting;
- 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; and
- De-icers should be used sparingly, as needed 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 winter thaw-freeze cycles.

7.4.6 Rehabilitation and Repair

Table 7.23 provides guidance on rehabilitation and repair work specific to permeable pavements organized according to BMP component.

Table 7.23: *Rehabilitation and repair guidance for permeable pavements.*

BMP Component	Problem	Task
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 replacement of 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 is < 250 mm/h	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 techniques, additional sweeping) 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 and top 5 cm (2") of base aggregate and replace with new materials that meet design specifications.
Vegetation	Poor grass cover on interlocking permeable grid system	Aerate or remove and replace growing medium in affected area with material that meets design specifications and replant.
Sub-drain	Sub-drain perforated pipe is obstructed by sediment	Schedule hydro-vac truck or drain-snaking service to remove the obstruction.

7.4.7 Life Cycle Costs of Inspection and Maintenance

Estimates of the life cycle costs of inspection and maintenance have been produced using the latest version of the LID Life Cycle Costing Tool (STEP, 2016) to assist stormwater infrastructure planners, designers and asset managers with planning and preparing budgets. For more details of the tool's assumption, see Section 7.1.7 and refer to the project report (TRCA and U of T, 2013a).

For permeable pavements it is assumed that rehabilitation of the pavement surface will be needed once the BMP reaches 30 years of age in order to maintain surface drainage performance at an acceptable level. Included in the rehabilitation costs are (de)mobilization costs, as equipment would not have been present on site. Design costs were not included in the rehabilitation as it was assumed that the original LID practice design would be used to inform this work. The annual average maintenance cost does not include rehabilitation costs and therefore represents an average of routine maintenance tasks, as outlined in Table 7.22. All cost value estimates represent the NPV as the calculation takes into account average annual interest (2%) and discount (3%) rates over the evaluation time periods.

Design variations for permeable pavements can be broken down into three main categories: Full Infiltration design, where the pavement drains through infiltration into the underlying subsoil alone (i.e., no sub-drain); Partial Infiltration design, where drainage is through the combination of a sub-drain and infiltration into the underlying subsoil (i.e., with a sub-drain); or No Infiltration (i.e., filtration-only design) that includes an impermeable liner between the base of the BMP and the underlying native sub-soil, where drainage is through a sub-drain alone (i.e., with a sub-drain and impermeable liner). For each design variation, life cycle cost estimates have been calculated for two level-of-service scenarios: the minimum recommended frequency of inspection and maintenance tasks (i.e., Table 7.20 and Table 7.22 "Minimum Frequency" column), and a high frequency scenario (i.e., Table 7.20 and Table 7.22 "High Frequency" column) to provide an indication of the potential range. A rehabilitation period of 30 years is assumed, at which point rehabilitative maintenance of the pavement surface is undertaken to maintain acceptable drainage performance.

The costing presented in this section is specific to permeable interlocking concrete pavers (PICP), as defined in the Tool. This product has been selected for costing due to its popularity and well-understood maintenance needs (Permeable Pavements Task Committee, 2015).

For all permeable pavement design variations, the CDA has been defined as 2,000 m^2 of which 1,000 m^2 is impermeable pavement draining to the pavers, and 1,000 m^2 is permeable pavement. The impervious area to pervious area ratio (I:P ratio) used to size the BMP footprint is 1:1, which is in accordance with recommendations in the LID SWM Planning and Design Guide (CVC & TRCA, 2010). The Full Infiltration design does not include a sub-drain and assumes a native sub-soil infiltration rate of 20 mm/h. The base granular reservoir is 350 mm deep and is capable of storing runoff from a 61 mm rain event over the CDA. A monitoring well is included for inspection purposes. The Partial Infiltration design includes a sub-drain and assumes a native sub-soil infiltration rate of 10 mm/h. The base granular reservoir is 350 mm deep and is capable of storing runoff from a 9 mm rain event before the stored volume reaches the perforated underdrain pipe located 50 mm above the native sub-soil. Although a flow restrictor is recommended to maximize infiltration, the cost of this feature is not included due to its relatively low cost. The No Infiltration design includes a sub-drain pipe installed on the bottom of the sub-surface water storage reservoir and an impermeable liner. All other features are the same as the Partial Infiltration design variation.

Estimates of the life cycle costs of PICP permeable pavement in Canadian dollars per unit CDA ($/$m^2$) are presented in Table 7.24. The LID Life Cycle Costing Tool allows users to select what BMP type and design variation applies, and to use the default assumptions to generate planning level cost estimates. Users can also input their own values relating to a site or area, design, unit costs, and inspection and maintenance task frequencies to generate customized cost estimates, specific to a certain project, context or stormwater infrastructure program.

For all BMP design variations and maintenance scenarios, it is assumed that rehabilitation of the pavement surface will be necessary when the BMP reaches 30 years of age to maintain acceptable surface drainage performance. Rehabilitation of PICP pavements is assumed to typically involve the following tasks and associated costs:

- Remove pavers, bedding and joint fill and top 5 cm (2″) of base aggregate and replace with new material that meets design specifications;
- Construction and Assumption inspection and testing associated with rehabilitation work to confirm that materials meet design specifications and installation is acceptable, including compaction and surface infiltration rate testing.

Table 7.24: *Life cycle costs for permeable interlocking concrete pavers.*

Permeable Interlocking Concrete Pavers (PICP)	Minimum Frequency			High Frequency		
Design Variation	**Full Infiltr.**	**Partial Infiltr.**	**No Infiltr.**	**Full Infiltr.**	**Partial Infiltr.**	**No Infiltr.**
Construction Costs	$53.60	$54.85	$61.95	$53.60	$54.85	$61.95
Rehabilitation Costs	$29.80	$29.80	$29.80	$29.35	$29.35	$29.35
Rehabilitation Period (years in service)	30	30	30	30	30	30
50 YEAR EVALUATION PERIOD						
Average Annual Maintenance	$0.55	$0.55	$0.55	$0.95	$0.95	$0.95
Maintenance and Rehabilitation	$57.35	$58.20	$58.20	$76.75	$77.60	$77.60
25 YEAR EVALUATION PERIOD						
Average Annual Maintenance	$0.60	$0.60	$0.60	$1.05	$1.05	$1.05
Maintenance and Rehabilitation	$11.95	$12.40	$12.40	$20.90	$21.35	$21.35

Notes:

1. Estimated life cycle costs represent NPV of associated costs in Canadian dollars per square metre of CDA ($\$/m^2$).
2. Average annual maintenance cost estimates represent NPV of all costs incurred over the time period and do not include rehabilitation costs.
3. Rehabilitation cost estimates represent NPV of all costs related to rehabilitative maintenance work assumed to be needed after 30 years in service, including those associated with inspection.
4. Full Infiltration design life cycle costs are lower than Partial and No Infiltration designs due to the absence of a sub-drain to construct, inspect and routinely flush.
5. Rehabilitation costs for Full Infiltration designs are estimated to be 54.8% to 55.6% of the original construction costs for High and Minimum Recommended Frequency maintenance program scenarios, respectively.
6. Rehabilitation costs for Partial Infiltration designs are estimated to be 53.5% to 54.3% of the original construction costs for High and Minimum Recommended Frequency maintenance program scenarios, respectively.
7. Rehabilitation costs for No Infiltration designs are estimated to be 47.4% to 48.1% of the original construction costs for High and Minimum Recommended Frequency maintenance program scenarios, respectively.
8. Maintenance and rehabilitation costs over a 25 year time period for the Minimum Recommended maintenance scenario are estimated to be 22.3%, of the original construction costs for Full Infiltration design, 22.6% for Partial Infiltration design, and 20.0% for No Infiltration design.

9. Maintenance and rehabilitation costs over a 25 year time period for the High Frequency maintenance scenario are estimated to be 39.0% of the original construction costs for Full, 38.9% for Partial Infiltration designs, and 34.5% for No Infiltration designs.
10. Maintenance and rehabilitation costs over a 50 year time period for the Minimum Recommended Frequency maintenance scenario are estimated to be approximately1.07 times the original construction cost for Full, 1.06 times the original construction costs for Partial Infiltration designs, and 93.9.% the original construction cost for No Infiltration designs.
11. Maintenance and rehabilitation costs over a 50 year time period for the High Frequency maintenance scenario are estimated to be approximately 1.43 times the original construction cost for Full, 1.41 times the original construction costs for Partial Infiltration designs, and 1.25 times the original construction cost for No Infiltration designs.