Don River Watershed Site Evaluation—Predicting Effectiveness of Stormwater Source Controls in Urban Watershed Revitalization

INTRODUCTION

The Don River flows through the heart of the Greater Toronto Area. From its headwaters on the Oak Ridges Moraine to its mouth in the heart of Toronto's industrial waterfront, the watershed is over 80 per cent urbanized. Fifteen years ago Toronto and Region Conservation and the Don Watershed Task Force released *Forty Steps to a New Don,* a call to action to restore this troubled river system. Since then, countless volunteers and agency staff have worked to implement that vision of a revitalized Don River.

In 2006, Toronto and Region Conservation began the process of updating the science on this watershed and developing a new *Don River Watershed Plan* for the next phase in its restoration. The need for innovative stormwater management practices emerged as a key component of the recommendations from the new Don plan. Much of the watershed is already built up so the emphasis is on retrofitting existing communities with enhanced stormwater management. Stormwater source controls (also called low impact development measures) such as permeable pavement, bioswales, rain gardens, rainwater harvesting and downspout disconnection are recommended for private and public lands. As space and capital dollars for stormwater work are limited, creative solutions that achieve multiple objectives and integrate well with existing communities are needed.

To illustrate possible scenarios for implementing the watershed plan's recommendations at a local scale, five concept site plans were developed. The sites were chosen to be representative of common challenges faced in many locations throughout the watershed. The plans illustrated a suite of actions that could be implemented to achieve gains in water quality, water balance, erosion control, natural heritage protection and community engagement within the context of other sustainability elements. Three of the five site plans proposed significant stormwater source control activities.

As a part of a broader research initiative to support the development of a hydrologic modelling tool, CMHC provided research funding to apply the hydrologic model to the three sites to assess the outcomes of different residential developments and other measures on stormwater and how innovative practices can mitigate adverse environmental impacts of stormwater. The hydrologic modelling was used to estimate the potential reductions in peak flows (and associated flood risk and erosion potential) and overall flow volume that might result from implementing these measures.

HYDROLOGIC MODELLING METHODOLOGY

Three scenarios were modelled at each site:

- pre-development agricultural conditions;
- existing urban conditions;
- proposed conditions with the stormwater source control measures outlined in the concept site plans.

The analysis for each site was completed using the hydrologic modelling software Visual OTTHYMO version 2.0. Modifications were made to the model input values for each scenario based on the different land use and stormwater source control assumptions. Each of the three scenarios was run at a variety of storm intensities. The smallest storm event was five millimetres, a rainfall event that is very common in southern Ontario.

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The modelling was also completed for 25 mm, two-year, five-year, 10-year, 25-year, 50-year and 100-year return period storm events. The following sections describe the features of each concept site plan and the hydrologic model findings.

CONCEPT SITE 1

Building Sustainable Neighbourhoods – Warden Woods Residential Area, Toronto

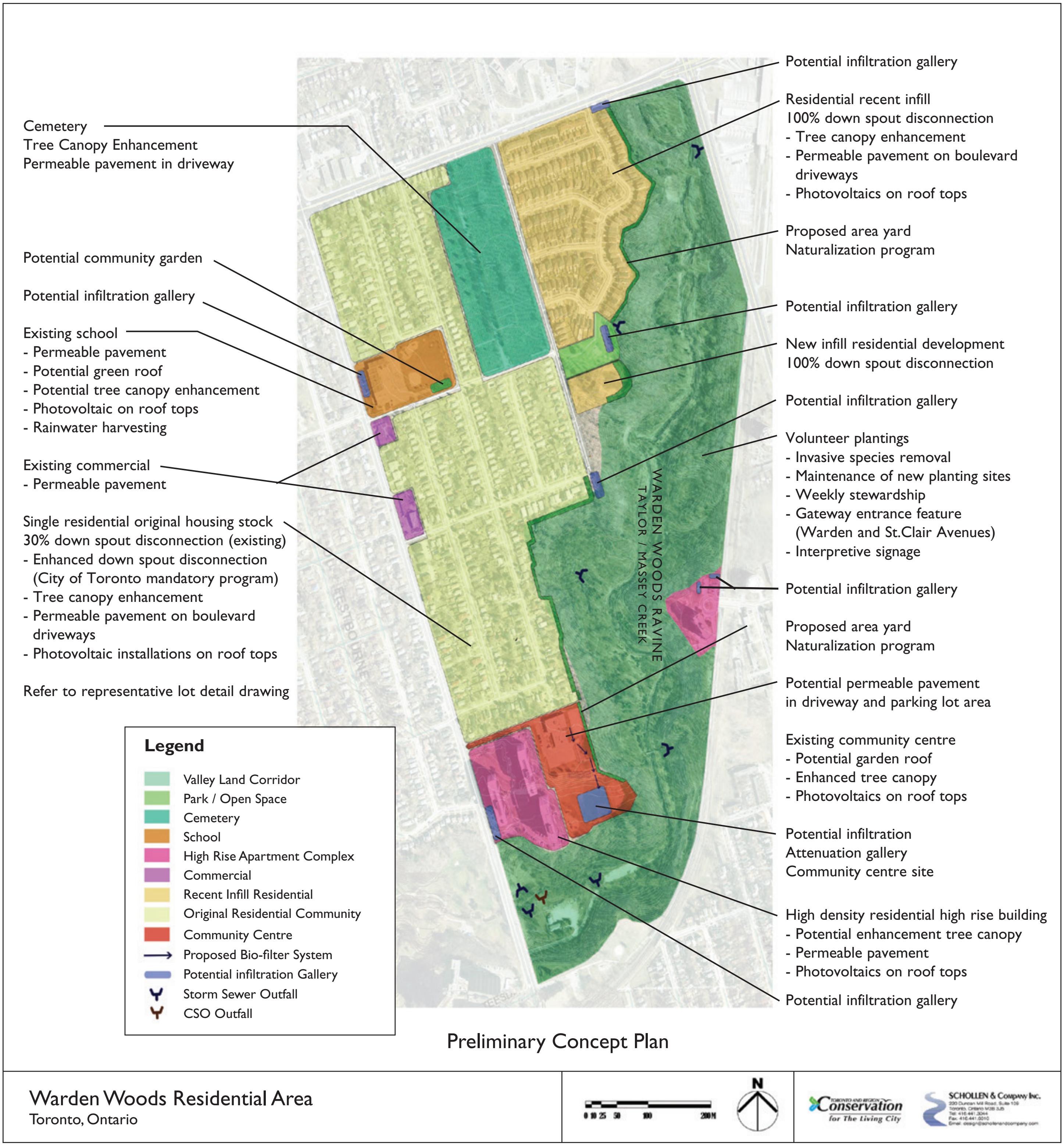

Figure 1 Warden Woods Concept Plan

Concept Site Features

The 1950s suburban single family housing that covers much of the Warden Woods area is typical of many older residential areas throughout the watershed. The concept site plan showcases how such older housing stock can be made more sustainable by improving energy efficiency and water conservation, and implementing other green retrofits.

Diverting stormwater from the combined sewer system will also reduce overflows into Taylor/Massey Creek, mitigate erosion and improve downstream water quality. Under the site plan, improved stormwater management and water infiltration/attenuation techniques would be implemented. The valley parks and other natural areas would be protected and regenerated to restore ecosystem functionality and improve community enjoyment. In addition to promoting a more sustainable community, the site plan would: restore vegetation and enhance the tree canopy; mitigate the urban heat island effect; enhance public awareness of environmental/conservation practices; and improve the streetscape and pedestrian realms.

Modelling Results

The stormwater management components in the 'proposed conditions' scenario for Warden Woods reduced peak flows and flow volume for both the smaller storm events and the larger, less common storms in the modelling.

For the most frequent category of storms (resulting in 5-25 mm of precipitation), peak flows were reduced 40-45% and runoff volume is decreased by about 20-45%. This decrease in runoff would help to reduce many of the erosion and water quality concerns in this section of Taylor/Massey Creek.

Peak flows from larger storm events (i.e., those that would occur in the 5-100 year timeframe) would also be reduced by 20-35%. The concept site plan would improve the resiliency of the system and help mitigate the impacts of these events.

Existing: The right-of-way bordering the Dawes Road Cemetery. Note, the roadside swale which enhances the potential for stormwater infiltration.

Prospective: A more attractive, pedestrian friendly streetscape. Additional native trees have been planted. Low-maintenance "rain gardens" are designed to encourage water infiltration. A new, more efficient biofilter system has replaced the swale.

Figure 2 Transforming a 1950s Suburban Community

CONCEPT SITE 2

Ravine Challenges – Mud Creek, Toronto

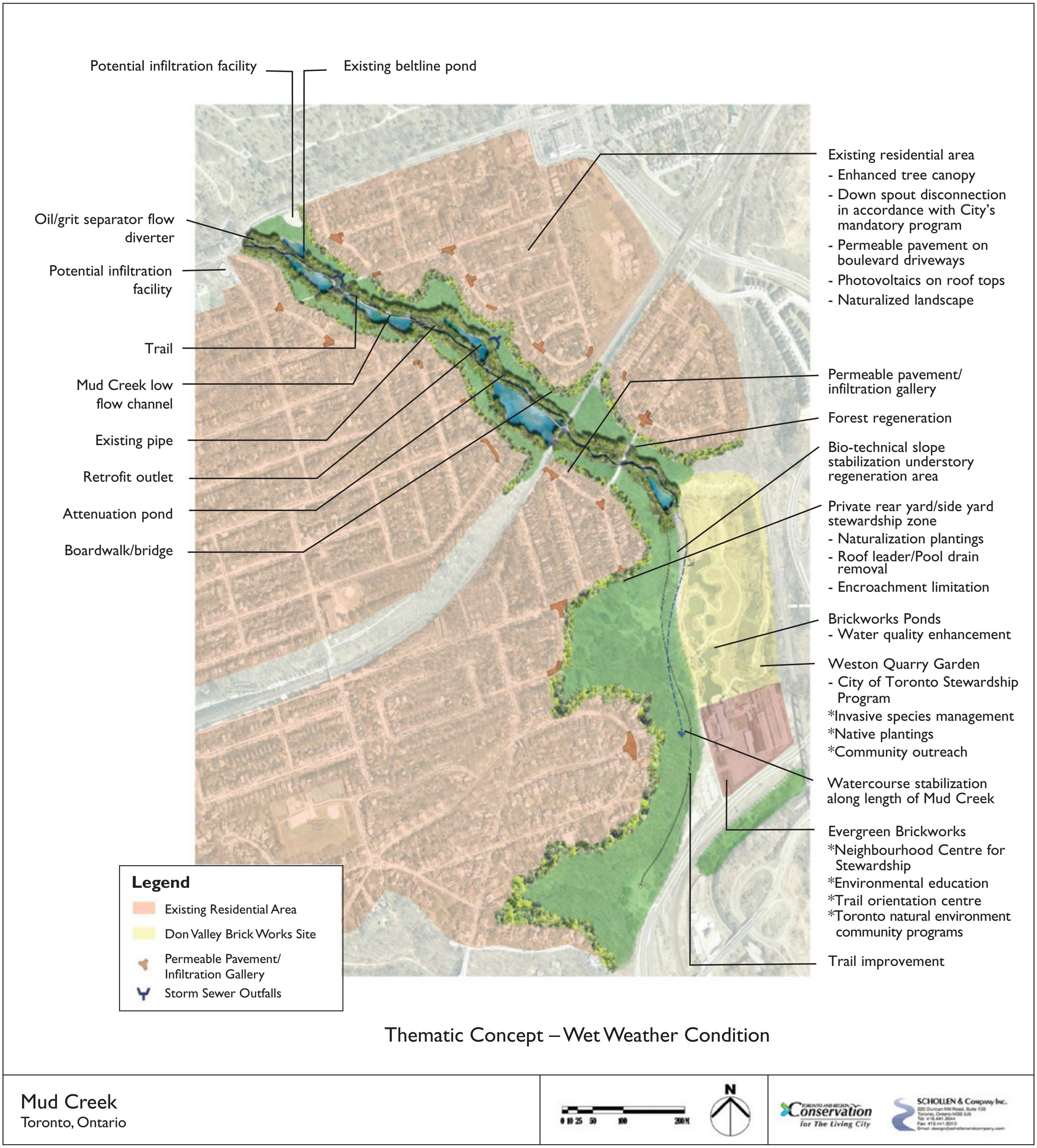

Figure 3 Concept Plan for Mud Creek

Concept Site Features

The erosion problems evident in Mud Creek are typical of those seen in many other ravines throughout the lower part of the watershed. The contributing causes are ineffective stormwater control, heavy pedestrian traffic on formal and informal trails and the actions of neighbouring homeowners. This concept site highlights community stewardship initiatives to manage stormwater at the lot level on neighbouring properties and eliminate encroachment. Suggested actions include: infiltration galleries, bioswales, permeable pavement on driveways, downspout disconnection and green roof technology.

The concept site plan also addresses wet weather flow control by creating a series of flow regulating structures and water holding ponds (attenuation areas) upstream of each piped segment of the creek. In addition, a new surface baseflow channel would be created along the entire length of the ravine. The currently deteriorating gabions along the exposed stream banks would be replaced with biotechnical stabilization works such as stone in-laid with vegetation, and the failed grade control structures near the Don Valley Brick Works site would be replaced and upgraded. A number of additional initiatives would be undertaken to increase the ravine's biodiversity, improve the trail system, protect at-risk environmental components, and expand public outreach through interpretive signage.

Modelling Results

The 'proposed conditions' scenario for the Mud Creek site plan modelled the potential effects of the source control measures on the tablelands on peak flow and flow volume. Results showed reductions in peak flows (22-52%) and flow volume (6-53%) from the existing conditions. The greatest reductions in both peak flows and flow volume are seen in the smallest storm events. This supports the case for implementing these measures as the smaller (<20mm) storms are the most common type of event in this area and have a significant cumulative impact on erosion in the creek.

Existing: the trail traveling north towards the Governors Road bridge. The hard-packed trail has encroached into the surrounding forest and a number of dead limbs and fallen trunks pose a threat to trail users.

Prospective: The trail has been narrowed, surfaced and repositioned alongside the new surface channel which carries the baseflow of Mud Creek. The channel banks are protected by stone interspersed with native vegetative plantings.

Figure 4 Transforming a Buried Creek

CONCEPT SITE 3 –

A Sustainability Makeover: Generic Commercial/Industrial Example

Figure 5 Generic Commercial/Industrial Concept Plan

Concept Site Features

The generic commercial / industrial site is representative of many sites throughout the watershed built prior to the establishment of current standards for sustainability. Many of these aging sites are due for redevelopment, presenting an excellent opportunity to work with private sector and municipal partners to give these sites a sustainability makeover. TRCA will continue to search for a suitable demonstration site to implement the concept site plan in partnership with local business groups and the municipality.

The concept plan is focused on rebuilding/retrofitting the study area to restore water balance, mitigate flooding, improve water quality and enhance overall environmental sustainability. The plan addresses the needs of a generic industrial park, typical of many across the watershed, that were built in the 1960s without consideration of modern stormwater management or energy efficiency standards. Many of these areas are currently in transition, with facilities being upgraded and retrofitted to meet modern business requirements. The remaking of an aged, inefficient industrial area will demonstrate the feasibility and benefits of both modest retrofits and bold planning moves in achieving water balance and environmental sustainability objectives.

Modelling Results

This site showed the greatest potential reduction in peak flow rates (ranges from 30% for a 100 year storm event to 80% for a 5 mm storm) and total runoff volumes (20-85% reductions) of all the concept sites under the 'proposed conditions'. Much of the site is currently blanketed by hard and impervious surfaces—roadways, roofs, parking lots and storage areas. The modelling results suggest significant benefits that can result from retrofitting existing industrial developments with source control projects.

A water budget analysis evaluated the impact of the conceptual source control measures on stormwater runoff volumes and potable water usage. City of Toronto design criteria were used to estimate average annual potable water use and calculate an estimated reduction based on the rainwater harvesting proposals in the concept plan. The modelling predicted a 30% reduction in potable water use if the rainwater harvesting assumptions are implemented. This reduction in water use also saves energy costs associated with pumping and treating water.

Existing: Typical of many low rise industrial areas across the watershed, hard and impermeable surfaces predominate which encourages rapid runoff and potential flooding. The tree canopy is largely absent, the streetscape bleak, and there are few alternatives to truck and car transport.

Prospective: Trees and low maintenance native vegetation have been planted along the right-of-way, while a public transit route and bike lanes are added. Solar panels have been installed on the large flat roof of the closest facility. Where feasible, parking lots and driveways are retrofitted with semi-permeable surfaces.

Figure 6 Transforming an Industrial Enclave

CONCLUSIONS

The implementation of low impact development measures in existing areas has a significant impact on the reduction of both peak stormwater release rates and runoff volumes. However, it should be noted that the types of low impact development measures that can be implemented for a subject location depend highly on the existing site conditions and constraints and the type of land use. As a result, it is difficult to generalize the effects of the measures as they will be different on a site by site basis.

IMPLICATIONS FOR THE HOUSING INDUSTRY

The results of the modelling indicate that implementation of innovative stormwater control practices and low impact development strategies can result in more resilient stormwater management systems and, by extension, better protection of watersheds and surface water quality. The stormwater modelling of the watershed revitalization scenarios provided a quantitative estimate of potential impacts associated with the stormwater control measures. This information can help to support the development of business cases for implementing such practices at the sites studied and similar locations throughout the watershed. The research project provides useful examples of innovative stormwater measures for those considering similar measures elsewhere.

CMHC Project Manager: Cate Soroczan

Housing Research at CMHC

Under Part IX of the ***National Housing Act***, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

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GENERAL DESCRIPTION

Rainwater harvesting is the process of intercepting, diverting and storing rainfall for future use. The rain that falls upon a catchment surface, such as a rooftop, is collected and conveyed into an above- or below-ground storage tank. Storage tanks range in size from relatively small rain tanks for residential land uses, to large cisterns for industrial, commercial and institutional land uses. A typical pre-fabricated cistern for residential use can range from 750 to 40,000 liters in size.

Captured rainwater is pumped into the building where it can be used for non-potable water uses such as toilet flushing, for use in washing machines or for irrigation purposes. It is estimated that this application alone can reduce the household municipal water consumption by up to 55%. The capture and re-use of rainwater can, in turn, significantly reduce stormwater runoff volumes and pollutant loads. By providing a reliable and renewable source of water to end users, rainwater harvesting systems can also help reduce the demand on municipal treated water supplies.

DESIGN PRINCIPLES

CATCHMENT SURFACE

The catchment surface is simply the surface from which rainfall is collected. Generally, rooftops are used as the preferred catchment surface for rainwater harvesting systems, although rainwater can also be harvested from other impervious surfaces, such as parking lots and driveways. The quality of the harvested water will vary according to the material from which the catchment is constructed. Water harvested from certain types of rooftops, such as asphalt shingle, tar and gravel, and wood shingle roofs, should only be used for landscape irrigation or toilet flushing.

COLLECTION AND CONVEYANCE SYSTEM

The collection and conveyance system consists of gutters, downspouts and pipes that channel stormwater runoff into storage tanks. Gutters and downspouts should be designed as they would for a building without a rainwater harvesting system. When sizing gutters and downspouts, designers should configure the conveyance system in a way that minimizes the frequency of overflow events. Conveyance pipes leading to the cistern do not need to be buried but all sections must have a minimum 2% slope.

PRE-TREATMENT

Pre-treatment is needed to remove debris, dust, leaves, and other material that accumulates on rooftops to prevent clogging within the rainwater harvesting system. Pretreatment devices include leaf screens, roof washers and first-flush diverters. Self cleaning rainwater filters, smoothing or calming inlets to prevent sediment entrainment , cleaning mechanism for floating debris such as pollen, and a floating suction pipe to avoid resuspension of solid when water is suctioned from the tank to the distribution system are typical measures to ensure the water entering toilets is visibly indistinguishable from tap water.

STORAGE TANKS

The storage tank is the most important, and typically the most expensive component of a rainwater harvesting system. The required size of storage tank is dictated by several variables: rainfall and snowfall frequencies and totals, the intended use of the harvested water, the catchment surface area, aesthetics, and budget. In the Greater Toronto Area, a suggested target for sizing the storage tank would be based on the predicted demand for water over a 10 to 12 day period.

DISTRIBUTION

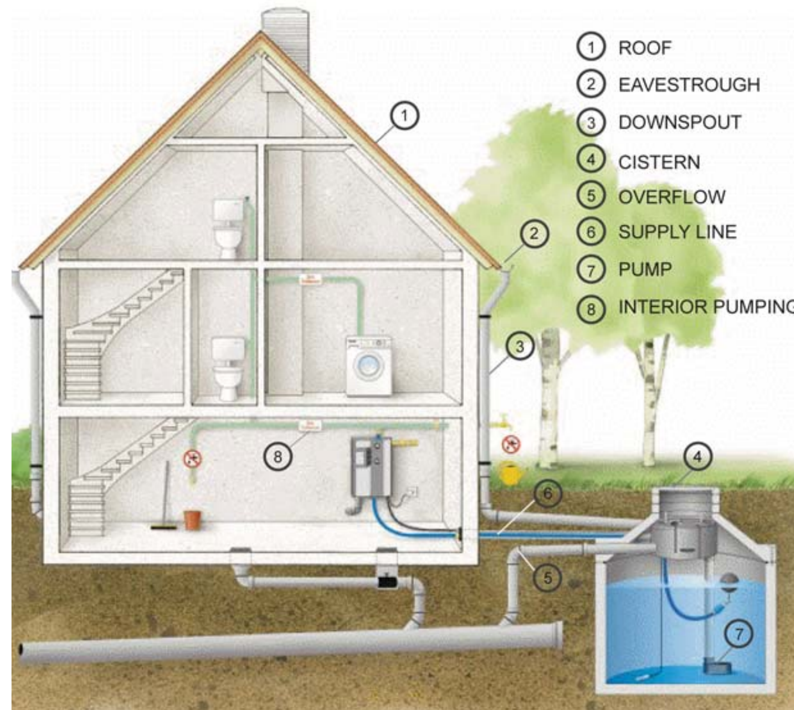
Most distribution systems are gravity fed or operate using pumps to convey harvested rainwater from the storage tank to its final destination. Typical outdoor applications use gravity to feed hoses via a tap and spigot. For underground cisterns or large sites, a water pump may be needed. Indoor rainwater harvesting systems usually consist of piping as well as a pump, pressure tank, and backflow preventer. The typical pump and pressure tank arrangement consists of a multistage centrifugal pump, which draws water out of the storage tank into the pressure tank, where it is stored for distribution.

OVERFLOW AND DIVERSION

An overflow system should be included as part of the design in the event that multiple storms occur in succession and fill rainwater storage. (Overflow pipes should have a capacity equal to or greater than the inflow pipes). The overflow usually consists of corrugated plastic hoses from the top of the cistern to the pervious area down gradient of the storage tank. The pervious area should be designed as simple downspout disconnection (refer to LID 3), a filter strip (refer to LID 8), or a grass channel (refer to LID 11). Overflow pipe can be connected to storm sewer system underground if storage tank is used.

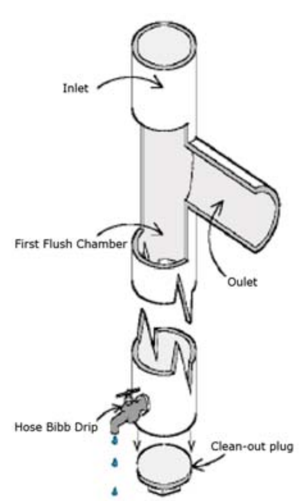
ACCESS AND MAINTENANCE

For underground cisterns, a standard size manhole opening should be provided for maintenance purposes. This access point should be secured with a lock to prevent unwanted access. A drain plug or clean-out sump, also draining to a pervious area, should be installed to allow the system to be completely emptied if needed.

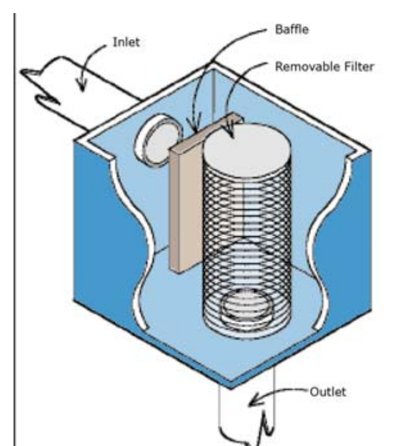


Source www.fbr.de/English/rainwater01.htm

OVERVIEW



FIRST FLUSH DIVERTER



ROOF WASHER

STORMWATER FUNCTIONAL PERFORMANCE

	Water Balance	Water Quality	Geomorphic
Rainwater Harvesting	Possible Depends on water usage	Yes Size for the water quality volume	Partial Can be used with other practices

GENERAL SPECIFICATIONS

Component	Specification	Quantity
Gutters and Downspouts	Materials: PVC pipe, vinyl, aluminum & galvanized steel	Length of gutters and downspouts is determined by the size and layout of catchment and location of tanks
Pre-treatment	At least one of the following: • First flush diverter • Roof washer • Leaf and mosquito screen	1 per inlet to the collection system
Storage Tanks	• Materials used to construct storage tanks should be structurally sound • Tanks should be constructed on native soil • Tanks should be sealed to be water tight with non-toxic substances • Tanks should be opaque to prevent the growth of algae • Reused tanks should be fit for potable water or food grade products • Underground cisterns should have a min of 1m soil coverage	The size of the cistern is determined during design calculations

Note: This table does not address indoor systems or pumps

CONSTRUCTION CONSIDERATIONS

It is advisable to have an experienced contractor install cisterns who is familiar with cistern sizing, installation materials, and proper site placement. A minimum one-year warranty is recommended.

OPERATIONS & MAINTENANCE REQUIREMENTS

Maintenance requirements vary according to usage. Systems used to provide supplemental irrigation water have relatively low maintenance requirements, while systems designed for indoor uses have much higher maintenance requirements. All systems should undergo semi-annual inspections to keep leaf screens gutters and downspouts free from leaves and other debris; to check mosquito screens and patch holes or gaps immediately; to clean and maintain first flush diverters and roof washers, especially those on drip irrigation systems; to inspect and clean storage tank lids, paying special attention to vents and screens on inflow and outflow spigots; and to replace damaged system components as needed.

MOSQUITO CONTROL

If screening is not sufficient to deter mosquitoes, vegetable oil can be used to smother larvae. Alternatively mosquito dunks or pellets containing larvicide can be used.

WINTER OPERATION

Rainwater harvesting systems have a number of components that can be affected by freezing winter temperatures. For above-ground systems, winter-time operation may not be possible. At the start of the winter season, above-ground systems should be disconnected and drained. It may be possible to reconnect roof leader systems for the winter. For below-ground and indoor systems, downspouts and overflow components should be checked for ice blockage during snowmelt events.

SITE CONSIDERATIONS

Available Space
Storage tanks can be located in a variety of locations, therefore, creative solutions can mitigate space limitations

Site Topography
Influences the placement of the storage tanks and the design of the rainwater distribution system

Drainage Area & Runoff Volume
Is limited by the daily water demand and available storage area.

Soil
Cistern should be placed on or in native soil rather than fill soil

Head
Is required and depends on the use of the water

Hotspot Land Uses
Effective solution for rooftops of sites with ground level stormwater hotspot operations

Winter Operation
Can be used throughout the winter if tanks are located inside or under ground

Underground Utilities
Have a locate done first. Findings may constrain the location and depth of underground rainwater storage tanks

Plumbing Code
Code allows harvested rain water for toilet and urinal flushing, but systems require installation backflow prevention devices

Mosquitoes
Tanks can create suitable habitat & breeding ground for mosquitoes, however screens and larvicide can be used as deterrents

Child Safety
Must not have unsecured openings large enough for children to get into

Setback from Buildings
Tanks to be water tight and avoid ponding or saturation within 3m of the building foundation

Vehicle Loading
Locations with vehicle traffic should be avoided for subsurface tank placement

Drawdown Between Storms
Proper sizing of the system will match the storage container sizing with water requirements of the residential, institutional or commercial user.

ESTIMATED INSTALLATION COST

0 | $500 | $1000

$250-1000 / m3 of runoff treated

FUNCTIONAL PERFORMANCE

WATER BALANCE

WATER QUALITY

GEOMORPHIC

TARGETED POLLUTANTS

BACTERIA

TSS

HYDROCARBONS

METALS

NUTRIENTS

CVC/TRCA SWM DESIGN GUIDELINE MANUAL

RAINWATER HARVESTING

CVC Credit Valley Conservation
Toronto and Region Conservation for The Living City

FACT SHEET

LID 1

CROSS REFERENCE: TRCA MANUAL, SECTION 3.6.1

GENERAL DESCRIPTION

Green rooftop, also known as "living roofs" or "eco-roofs," consist of a layer of vegetation and soil installed on top of a conventional flat or sloped roof. Green roofs are touted for their benefits to cities, as they can improve energy efficiency, reduce heat island effects, and create urban green space for passive recreation or aesthetics. To a water resources manager, they are attractive for their water quality, water balance, and geomorphic benefits. Hydrologically speaking, the green roof assembly acts like a lawn or meadow by storing rainwater in the soil and pond areas. Excess rainfall enters underdrains and overflow points and is conveyed in a typical building drainage system. After a storm, stored water either evaporates or is evapotranspired by the plants.

There are two types of green roofs: intensive and extensive. Intensive green roofs can be planted with deeply rooted plants and generally have a deeper soil layer. Extensive green roofs are systems consisting of a thin layer of soil with a herbaceous vegetative cover. There are two installation options: conventional and modular construction.

DESIGN PRINCIPLES

ROOF STRUCTURE
The load bearing capacity of the roof structure must be sufficient to support soil and plants of the green roof assembly, as well as the live load associated with maintenance staff accessing the roof. Generally, green roof assembly weighing more than 80 kilograms per square metre when saturated require consultation with a structural engineer. Green roof assembly may be installed on roofs with slopes up to 10%. On sloped roofs additional erosion control measures, such as cross-battens, may be necessary to

WATERPROOFING SYSTEM
In a green roof system, the first layer above the roof surface is a waterproofing membrane. Two common waterproofing techniques used for the construction of green roofs are monolithic and thermoplastic sheet membranes. Another option is a liquid-applied Inverted Roofing Membrane Assembly System in which the insulation is placed over the waterproofing, which adheres to the roof structure. An additional protective layer is generally placed on top of the membrane followed by a physical or chemical root barrier. Once the waterproofing system has been installed it should be fully tested prior to construction of the drainage system. Electronic leak detection systems should also be installed at this time.

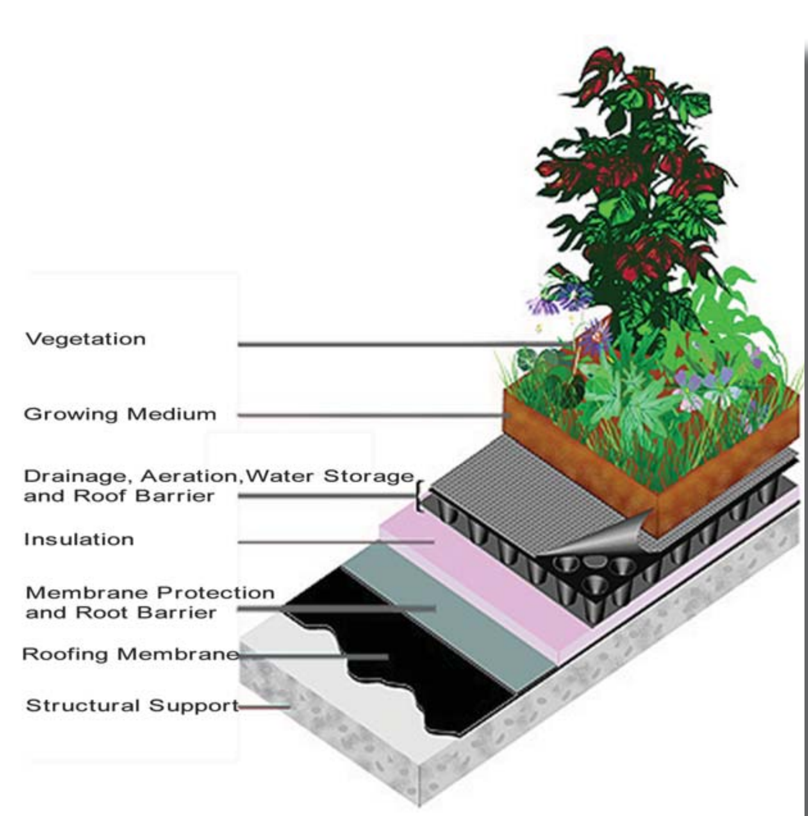
DRAINAGE LAYER
The drainage system includes a porous drainage layer and a geosynthetic filter mat to prevent fine soil particles from clogging the porous media. The drainage layer can be made up of gravels or recycled-polyethylene materials that are capable of water retention and efficient drainage. The depth of the drainage layer depends on the load bearing capacity of the roof structure and the stormwater retention requirements. The porosity of the drainage layer should be greater than or equal to 25%.

CONVEYANCE AND OVERFLOW
Once the porous media is saturated, all runoff (infiltrate or overland flow), should be directed to a traditional rooftop storm drain system. Alternately, roof drain flow restrictors can be used. Excess runoff can be directed through roof leaders to divert rain water to another stormwater best management practice (BMP) such as a Rainwater Harvesting cistern (refer to LID 1), a disconnection downspout (refer to LID 3), a Soakaway Pits (refer to LID 4) or a Special Bioretention area (refer to LID 5).

GROWING MEDIUM
The medium is usually a mixture of sand, gravel, crushed brick, compost or organic matter combined with soil. The soil medium ranges between 80 and 150 millimeters in depth and increases the roof load by 80 to 170 kilograms per square metre when fully saturated. Growing media that contain phosphorus rich fertilizers or excessive nutrient levels should be avoided.

ALTERNATE DESIGN MODULAR SYSTEMS
Modular systems are essentially trays of vegetation in a growing medium that are grown off-site and simply placed on the roof for complete coverage. There are also pre-cultivated vegetation blankets that are grown in a flexible rather than rigid structure and thus can be rolled out onto the roof. The advantage of them is that they can be removed for maintenance.

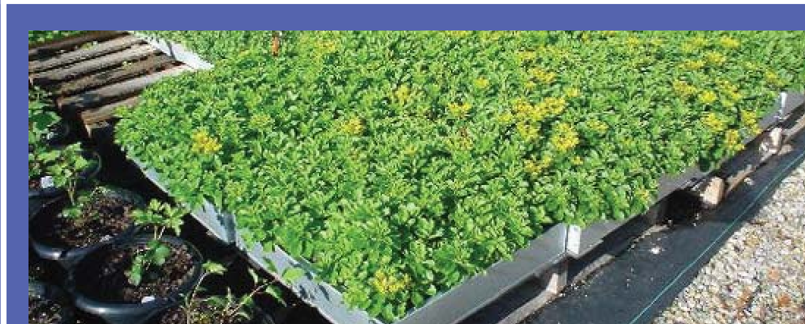
LANDSCAPING
The use of native plants on green roofs is encouraged. A qualified botanist or landscape architect should be consulted when choosing plant material. For extensive systems, plant material should be confined to hardier or indigenous varieties of grass and sedum. Root size and depth should also be considered to ensure that the plant will stabilize the shallow depth of soil media.



DETAIL

Green Rooftops are composed of:

- A roof structure capable of supporting the weight of a green roof system;
- A waterproofing system designed to protect the building and roof structure;
- A drainage layer that consists of a porous medium capable of water storage for plant uptake;
- A geosynthetic layer to prevent fine soil media from clogging the porous media;
- Soil with appropriate characteristics to support selected green roof plants;
- Plants with appropriate tolerance for harsh rooftop conditions and shallow rooting depths.



STORMWATER FUNCTIONAL PERFORMANCE

	Water Balance	Water Quality	Geomorphic
Green Rooftops	High	High	High

GENERAL SPECIFICATIONS

ASTM International released the following Green Roof standards in 2005:

- E2396-05 Standard Test Method for Saturated Water Permeability of Granular Drainage Media;
- E2397-05 Standard Determination of Dead Loads and Live Loads associated with Green Roof Systems;
- E2398-05 Standard test method for water capture and media retention of geocomposite drain layers for green roof systems;
- E2399-05 Standard Test Method for Maximum Media Density for Dead Load Analysis of Green Roof Systems; and
- E2400-06 Standard Guide for Selection, Installation, and Maintenance of Plants for Green Roof Systems.

Although the Ontario Building Code (2006) does not specifically address the construction of green roofs, requirements from the Building Code Act and Division B may apply to components of the construction. Further requirements from sections 2.4 and 2.11 of the 1997 Ontario Fire Code also require consideration.

OPERATIONS & MAINTENANCE REQUIREMENTS

- Green roof maintenance is typically greatest in the first two years as plants become established. Vegetation should be monitored to ensure establishment and viability.
- Regular operation of a green roof includes irrigation and leak detection. Watering should be based on actual soil moisture conditions as plants are designed to be drought tolerant. Electronic leak detection is recommended. This system, also used with traditional roofs, must be installed prior to the green roof.
- Ongoing maintenance should occur at least twice per year and should include weeding to remove volunteer seedlings and debris removal. In particular, the overflow conveyance system should be kept clear.

CONSTRUCTION CONSIDERATIONS

An experienced professional green roof installer should install the green roof designed by an architect (or landscape architect) who must work with contractor to ensure that the waterproofing membrane installed is appropriate for use under a green roof assembly. Conventional green roof assemblies should be constructed in sections for easier inspection and maintenance access to the membrane and roof drains. Green roofs can be purchased as a complete system from specialized suppliers who distribute all the assembly components, including the waterproofing membrane. Alternatively a professional landscape architect can design a customized green roof and specify different suppliers for each component of the system.

SITE CONSIDERATIONS

Roof Slope
Green rooftops may be installed on roofs with slopes up to 10%

Drainage Area & Runoff Volume
Green rooftops are designed to capture rainfall directly onto the surface. They are not designed to receive runoff diverted from other areas

COMMON CONCERNS

STRUCTURAL REQUIREMENTS
Load bearing capacity of the building structure and selected roof deck need to be sufficient to support the weight of the soil, vegetation and ponded water, and may need to support pedestrians, landscaping, pavers, etc. Standards for dead and live design loads are available from ASTM International.

WATER DAMAGE TO ROOF
Failure of waterproofing elements may present a risk of water damage. However, similar to traditional roof installations, a warranty can ensure that any damage to the waterproofing system will be repaired. Leak detection systems can also be installed to minimize or prevent water damage.

VEGETATION MAINTENANCE
Appropriate plant selection will help to ensure plant survival during weather extremes. Vegetation maintenance costs decreases substantially after the first 2 years ,once plants are established.

COST
An alternatives analysis to determine cost effectiveness for a given site should include the roofing lifespan, energy savings, stormwater management requirement, aesthetics, market value, tax and other municipal incentives. It is estimated that green roofs can extend the life of a roof by as long as 20 years and reduce energy demands by as much as 75% .

COLD CLIMATE
Green rooftops are a feasible BMP for cold climates. Snow can protect the vegetation layer and once thawed, will infiltrate into the growing media or drain away like stormwater during a rain event. No seasonal adjustments in operation are needed.

ESTIMATED INSTALLATION COST

0 $500 $1000

$120-300 / m2

FUNCTIONAL PERFORMANCE

WATER BALANCE

WATER QUALITY

GEOMORPHIC

TARGETED POLLUTANTS

BACTERIA

TSS

HYDROCARBONS

METALS

NUTRIENTS

CVC/TRCA SWM DESIGN GUIDELINE MANUAL

GREEN ROOFS

CVC

Toronto and Region Conservation for The Living City

FACT SHEET

LID 2

CROSS REFERENCE: TRCA MANUAL, SECTION 3.6.2

DOWNSPOUT DISCONNECTION

CVC/TRCA SWM DESIGN GUIDELINE MANUAL

GENERAL DESCRIPTION

Simple downspout disconnection involves directing flow from downspouts to a pervious area. This prevents stormwater from directly entering the storm drain system or flowing across a "connected" impervious surface such as a driveway that drains to a storm sewer system. Functional downspout disconnection requires a minimum length of pervious flow path and certain soil conditions. When soils do not allow 25 mm/hr of infiltration, compost amendments and/or soil loosening must be used in conjunction with downspout disconnection.

DESIGN PRINCIPLES

Downspout disconnections should meet the following criteria:

- The contributing flow path from impervious areas should not exceed 25 metres (maximum length of flow path over impervious surface);
- The disconnection length should exceed the contributing flow path (flow path from outlet at impervious area to discharge point at property line);
- A compensatory mechanism (compost amendment, rain tank or rain garden) is needed if the disconnection length is less than 15 metres and/or the post construction Hydrologic Soil Group is C or D;
- Pervious areas used for disconnection should be graded to a slope of the 1 to 2% range, and never exceed 5%;
- The total impervious area contributing to any single discharge point should not exceed 100 square metres and should drain continuously through a pervious filter until reaching a property line or drainage swale;
- The disconnection should not cause basement seepage (this involves extending downspouts at least 3 metres from the building if the ground does not slope away from the building);
- The splash block should distribute runoff evenly over turf or landscaping areas.

Other Design Guidance

City of Toronto Downspout Disconnect Program

Region of Peel - Conservation Peel

APPLICATIONS

There are many options for keeping residential and non-residential rooftop runoff out of the storm drain system. Some options other than simple disconnection to lawns are as follows:

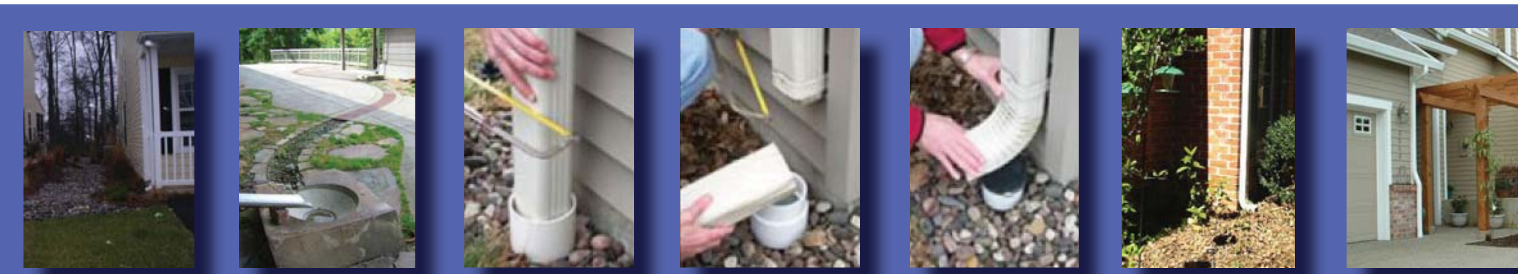
RESIDENTIAL ROOFTOP APPLICATION

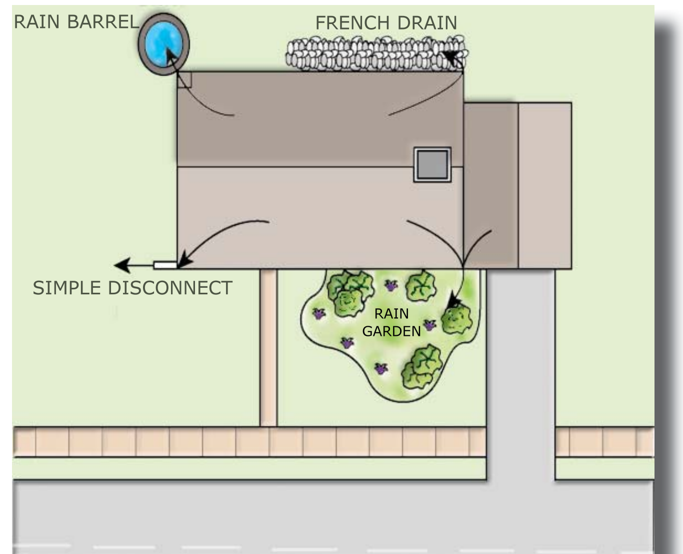
- Simple disconnection to Grass Channel (refer to LID 11) or Filter Strip (refer to LID 9)
- Compost Amendments (refer to LID 7)
- Soakaway Pits (refer to LID 4)
- Rain Gardens (refer to LID 5)
- Rain Barrels and Rainwater Harvesting (refer to LID 1)
- Simple disconnection to Permeable Driveways (refer to LID 10)
- Simple disconnection to rear/front yards

NON-RESIDENTIAL ROOFTOP APPLICATION

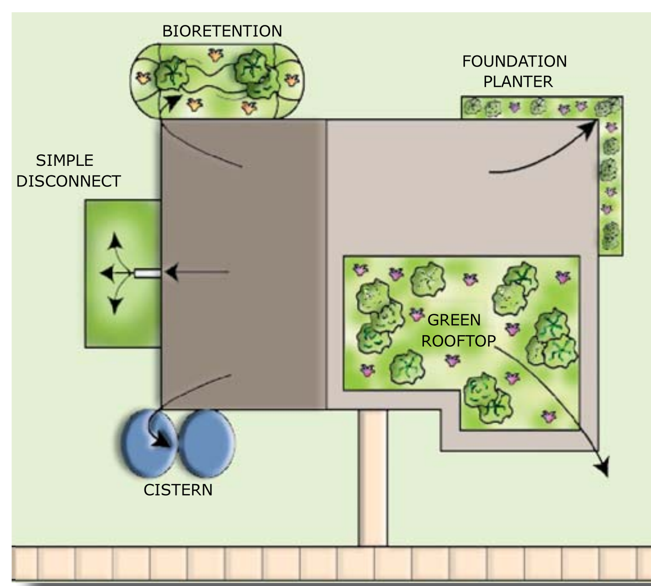
- Simple disconnection to Grass Channel (refer to LID 11) or Filter Strip (refer to LID 9)
- Bioretention (refer to LID 5)
- Stormwater Planters (refer to LID 6)
- Cisterns and Rainwater Harvesting (refer to LID 1)
- Compost Amendments (refer to LID 7)
- Soakaway Pits (refer to LID 4)

Treatments listed above in refer to the LID fact sheets. Cistern and soakaway pits usually replace simple disconnection; They are not 'compensatory' devices in the same way that compost amendments are. In the diagram, treatments such as bioretention are shown to be separate from simple downspout disconnection and/or compost amendment, as they add storage volume, infiltration capacity or other treatment mechanisms.





RESIDENTIAL



COMMERCIAL

STORMWATER FUNCTIONAL PERFORMANCE

	Water Balance	Water Quality	Geomorphic
Downspout Disconnection	Partial Depends on infiltration rates and evapo-transpiration	Partial Depends on infiltration rates and length of disconnection and compensatory devices	Partial Depends on combination with other practices

Downspout disconnection is primarily a practice used to achieve water balance, although it can contribute to water quality improvement.

Very limited research has been conducted on the runoff reduction rates for rooftop disconnection, so initial estimates are drawn from research on filter strips, which operate in a similar manner. The research indicates that runoff reduction is a function of soil type, slope, vegetative cover and filtering distance.

A conservative runoff reduction rate for rooftop disconnection is 25% for *HSG C and D soils and 50% for *HSG A and B soils. These values apply to disconnection that meet the feasibility criteria outlined in this section, and do not include any further runoff reduction due to the use of compost amendments along the filter path.

*Hydrologic soil group (HSG) classification is based on the ability of the soil to transmit and runoff. Soil groups rank from A-D .Group A is sand, loamy sand or sandy loam types of soils. Group B is silt loam or loam. Group C soils are sandy clay loam. Group D soils are clay loam, silty clay loam, sandy clay, silty clay or clay

OVERVIEW

CONSTRUCTION CONSIDERATIONS

- Soil Disturbance and Compaction: Only vehicular traffic necessary for construction should be allowed on the disconnection area.
- Erosion and Sediment Control: If possible, construction runoff should be directed away from the proposed disconnection site. After the contributing drainage area and the disconnection area are stabilized and vegetated, erosion and sediment control structures can be removed.
- Soil Tilling: All sites should receive several passes with the rototiller to adjust for compaction that occurred during construction.

OPERATIONS & MAINTENANCE REQUIREMENTS

Maintenance of disconnected downspouts for stormwater management will generally be no different than maintenance of other lawns or landscaped areas. In general, a maintenance agreement with owners will be required to ensure that downspouts remain disconnected and the pervious area remains pervious. For long-term efficacy, the pervious area should be protected from compaction. One method is to plant shrubs or trees along the perimeter of the pervious area to prevent vehicle traffic. On commercial sites, the pervious area should not include an area with high foot traffic.

SITE CONSIDERATIONS

Available Space
Minimum disconnection flow length is 20m.

Site Topography
Must discharge to a gradual slope away from the building at 1% to 5%

Drainage Area & Runoff Volume
Max recommended drainage area is 100 Sq.m for simple disconnection without compensatory devices.

Soil
If native soils do not infiltrate at 15mm/hr or greater, they must be amended.

Hotspot Runoff
Disconnection may be used to treat the rooftop runoff at a stormwater hot spot if the rooftop runoff is kept separate from other impervious surfaces.

Water Table
Min separation from water table 0.5m

Setback from Buildings
3m distance is required if the grade away from the building is flat.

Distance to Impervious Cover
At least 3m for impervious surface.

COMMON CONCERNS

FOUNDATION & SEEPAGE
Flow from disconnected downspouts can be conveyed through surface pipes to a distance 3 metres away from the foundation. This is not necessary if the ground slopes away from the building.

COMPACTION
Compaction of amended soils will significantly decrease the efficiency of downspout disconnection. Vehicle traffic and high foot traffic should be barred from the area. Planting trees around the perimeter of the amended area is one technique for preventing vehicle access otherwise use permeable paving (refer to LID10).

STANDING WATER AND PONDING
Amendments should store water within the soil structure. Downspout disconnection is not intended to pond water, so any standing water at the end of the rainstorm should be gone within 24 hours.

ESTIMATED DISCONNECTION COST

0 — $500 — $1000

Approx. $100/Downspout

FUNCTIONAL PERFORMANCE

- WATER BALANCE
- WATER QUALITY
- GEOMORPHIC

TARGETED POLLUTANTS

- BACTERIA
- TSS
- HYDROCARBONS
- METALS
- NUTRIENTS

FACT SHEET

LID 3

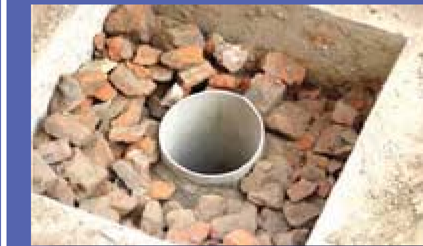
CROSS REFERENCE: TRCA MANUAL, SECTION 3.6.3

SOAKAWAYS PITS

CVC/TRCA SWM DESIGN GUIDELINE MANUAL

GENERAL DESCRIPTION

Soakaway pits are stone-filled trenches that temporarily store water to be infiltrated. Runoff from rooftop leaders is directed to the trench via a downspout or swale.
French drains and dry wells are variations on the soakaway pit, with slightly different geometries. A French drain is a shallow underground trench with a perforated pipe running along the bottom. A dry well is deeper and shorter. The sizing calculations and materials for these practices are the same.



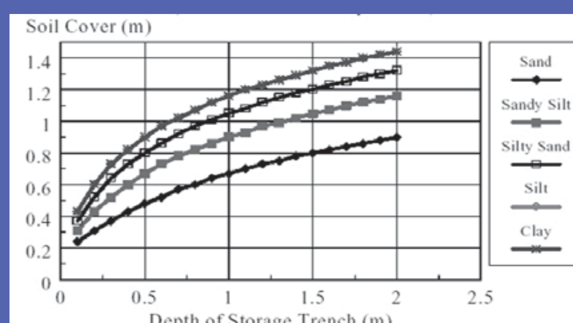
DESIGN PRINCIPLES

SOIL CHARACTERISTICS

Designers should verify site-specific soil permeability at the proposed location using the standard methods for on-site soil investigation.

GEOMETRY AND SITE LAYOUT

Soakaway pits should be sized according to the amount of rooftop runoff received. Typically, they are 1.2 to 1.5 metres wide, and 0.5 to 1.5 metres deep, with the length dependent on the contributing drainage area. They should have a minimum depth of 300 millimeters soil cover over the top. The soil cover depends on soil type and depth of the trench.



SOIL COVER FOR TRENCHES (MOEE SWM MANUAL)

PRE-TREATMENT

It is important to prevent sediment and debris from entering soakaway pits because they could contribute to clogging and failure of the system. Use the following pre-treatment devices:

LEAF SCREENS are mesh screens installed either in the gutter or downspout and are used to remove leaves and other large debris from rooftop runoff.

ROOF WASHERS are used to filter small debris from rainwater. Roof washers consist of a tank, usually between 100 and 200 liters in size, with leaf strainers and a filter with openings as small as 30-microns.

CONVEYANCE AND OVERFLOW

An overflow pipe should be installed from the roof leader that discharges to a splash pad (MOE, 2003). The overflow should be designed as with any other downspout.

FILTER MEDIA AND UNDERDRAINS

The depth of the stone in the soakaway pit should be determined using the sizing criteria, with the maximum depth being 1.5 metres. The soakaway pit should be filled with uniformly-graded, washed 50 mm diameter stone with a 40% void capacity. Non-woven filter cloth should be used to line the trench to prevent the pore space between the clear stones from being blocked by surrounding native material.

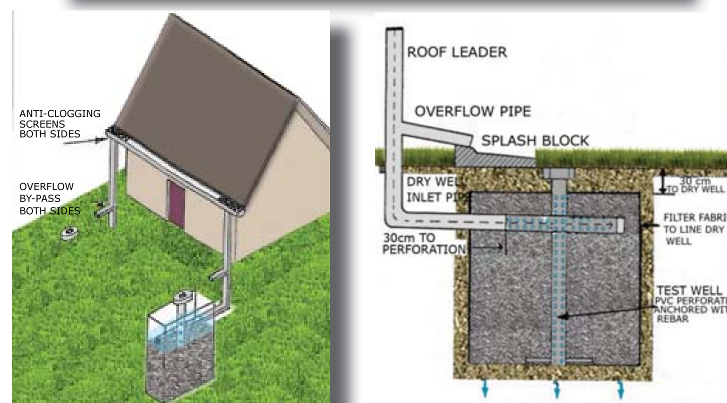
OTHER DETAILS

A test well should be installed in every soakaway pit, consisting of an anchored 100 to 150 millimeter diameter perforated PVC pipe with a lockable cap installed flush with the ground surface.

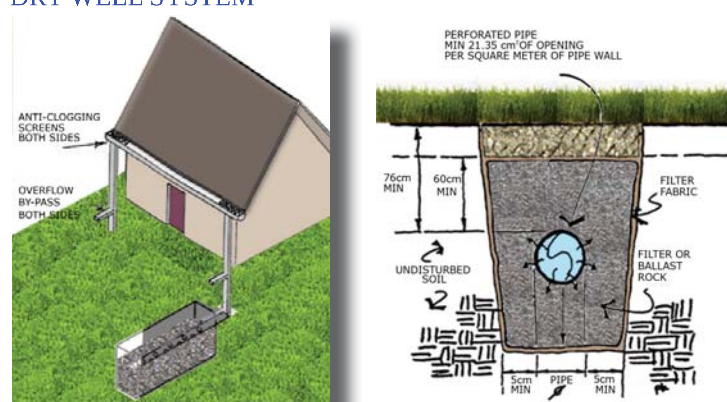
LANDSCAPING

The soakaway pit may be covered with grass or other herbaceous vegetation. Root intrusion should be considered in planting trees near the trench.

OVERVIEW



DRY WELL SYSTEM



FRENCH DRAIN SYSTEM

STORMWATER FUNCTIONAL PERFORMANCE

	Water Balance	Water Quality	Geomorphic
Soakaway Pits	Yes	Yes	Potentially

GENERAL SPECIFICATIONS

Material	Specification
Underdrain	Pipe should be continuously perforated, smooth interior, with a minimum inside diameter of 100 millimeters. HDPE pipe is recommended. Perforated pipe should run lengthwise through the soakaway pit. Non-perforated pipe should run for the 4 metres between the building and the soakaway pit.
Stone	The soakaway pit should be filled with 50 mm diameter clear stone with a 40% void capacity.
Geotextile	Non-woven Geotextile should consist of needled non-woven polypropylene fibers, according to OPSS1860

CONSTRUCTION CONSIDERATIONS

Erosion and sediment control and compaction are the main construction concerns.

SOIL DISTURBANCE AND COMPACTION: Before site work begins, areas for soakaway pits should be clearly marked. Only vehicular traffic used for construction should be allowed close to the strip.

EROSION AND SEDIMENT CONTROL: Infiltration practices should never serve as a sediment control device during construction. Construction runoff should be directed away from the proposed filter strip site. After the site is vegetated, erosion and sediment control structures can be removed.

OTHER DESIGN RESOURCES

Several other manuals that provide useful design guidance for soakaway pits are:

- Ontario Ministry of the Environment (MOE). 2003. Stormwater Management Planning and Design Manual. Ontario, Canada.
- Center for Watershed Protection (CWP). 2007. Urban Stormwater Retrofit Manual (Draft Release). Ellicott City, MD.
- New York State Stormwater Management Design Manual.

OPERATIONS & MAINTENANCE REQUIREMENTS

Because these practices are out of sight, maintenance tends to be neglected. Regular maintenance consists of clearing out leaves and debris caught in the gutter screen. Inspection via an observation well should be performed annually. This inspection is required to ensure that the stone fill is level to the ground surface and that the filter fabric has not become clogged with material. If the stone becomes clogged, it must be replaced.

SITE CONSIDERATIONS

Available Space
Ensure adequate surface area outside of 4m setback

Site Topography
Cannot be located on natural slopes greater than 15%

Drainage Area & Runoff Volume
Should include rooftop runoff and can be as large as 4000 m²

Soil
Infiltration potential of underlying soil should be considered.

Water Table
Bottom of soakaway pit should be vertically separated by 1 metre from seasonally high water table or bedrock layers. In areas of drinking water source vertical separation should be

Setback from Buildings
Min 4m from structure.

Utilities
Min 1.5m from public utility line.

COMMON CONCERNS

ON INDIVIDUAL RESIDENTIAL PROPERTIES

If soakaway pits are installed on private lots, homeowners will need to be educated about their routine maintenance needs, understand the long-term maintenance plan, and be subject to a legally binding maintenance agreement.

PONDED WATER AND MOSQUITOES

The detention of water in a soakaway pit should be solely underground. Surface pounding can be prevented with proper soil testing and design.

FOUNDATION AND SEEPAGE

A setback of 4 metres is recommended. Any overflow should be conveyed off the site.

WINTER OPERATION

Soakaway pits will function during winter months unless the discharge point or perforated pipe is not below the frost line.

ESTIMATED INSTALLATION COST

0 — $500 — $1000

$500 / m3 of treated water

FUNCTIONAL PERFORMANCE

- WATER BALANCE
- WATER QUALITY
- GEOMORPHIC

TARGETED POLLUTANTS

- BACTERIA
- TSS
- HYDROCARBONS
- METALS
- NUTRIENTS

CVC Credit Valley Conservation — Toronto and Region Conservation for The Living City

FACT SHEET

LID 4

CROSS REFERENCE: TRCA MANUAL, SECTION 3.6.4

BIORETENTION

CVC/TRCA SWM DESIGN GUIDELINE MANUAL

GENERAL DESCRIPTION

Bioretention areas are planted depressions that store and filter rainwater to enhance water quality. They may be used to pre-treatment of runoff prior to discharge into infiltration systems. Bioretention areas can be used to store excess stormwater when the downstream infiltration system has been surcharged. This allows infiltration to occur over an extended duration of time allowing more runoff to be infiltrated by the system. Bioretention areas also treat stormwater runoff by passing it through an engineered filter medium, collecting it in an underdrain and then returning it back to the storm drain system.

The primary component of a bioretention practice is the filter bed. A mixture of sand, soil, and organic material provides a filtering medium. Pre-treatment, such as a settling forebay or grass filter strip, precedes the filter bed to remove particles that would otherwise clog the filter bed. Bioretention areas should be installed in commercial, institutional, and residential sites in spaces that are traditionally pervious and landscaped. Bioretention are installed close to the impervious area that generates the runoff. Typical locations are in and around parking lots, in traffic islands and near building roof leaders with the minimum 4 meters distance .

DESIGN PRINCIPLES

SOIL CHARACTERISTICS

Soil permeability test is required to verify the need of underdrain perforated pipe, as soil media will be engineered fill.

GEOMETRY & SITE LAYOUT

Key geometry and site layout factors include:

Minimum footprint of the filter bed area is based on the drainage area. Footprints far in excess of the calculated area are not desirable, as the bioretention plants may not receive adequate water.

The inflow points and outlet point should be placed to force the longest flow path possible within the bioretention cell.

The filter bed surface should drain towards the outlet point at approximately 1% slope.

PRE-TREATMENT

Enhanced pre-treatment seeks to capture and remove coarse sediment particles before they reach the filter bed to prevent premature clogging and prolong effective function of bioretention. A two-cell design that incorporates a forebay is recommended as it provides the most-effective pre-treatment. Channel pre-treatment measures include: two-cell design (recommended) or rip rap and/or dense vegetation and sheet flow measures include: grass filter strip, gravel diaphragm and a 50-150 millimeters drop.

CONVEYANCE AND OVERFLOW

Designers should always incorporate an overflow structure to safely convey larger storms through the bioretention cell. The invert of the overflow should be placed at the maximum water surface elevation of the bioretention area. In conjunction, a bypass channel should be created so that higher flows do not pass over the surface of the filter bed.
Perforated drain pipe should be provided below frost heave depth of 1.2 m

FILTER MEDIA COMPOSITION

The recommended bioretention soil mixture is 85 to 88% sand, 8 to 12% soil fines, and 3 to 5% organic matter.

LANDSCAPING

Landscaping is critical to the function and appearance of bioretention. Where possible, a combination of native trees, shrubs, and perennial herbaceous materials is preferred. Alternatively, designers may wish to consider covers such as turf, river stone, or gravel. The decision on what type of surface cover to use should be based on both function and cost. Plant covers need to be tolerant of salt and periodic inundation.

MULCH

Mulch is critical to capture pollutants, prevent clogging from rain splash, and retain moisture during dry periods.

OPERATIONS & MAINTENANCE REQUIREMENTS

Bioretention requires routine maintenance of the landscaping as well as periodic inspection for less frequent maintenance needs. For the first six months following construction, the site should be inspected a minimum of two times or after each storm event greater than 10mm. Subsequent inspections should be conducted in the spring of each year and after rainfall of 60mm or more. Routine maintenance of bioretention can be integrated into other landscape maintenance regime.

Legally binding maintenance agreements are a necessity for all bioretention. Agreements should specify property owner's responsibilities and the municipality's right to enter the property for inspection and corrective action.

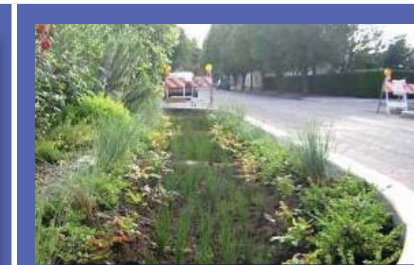
Routine maintenance activities such as trash removal, pruning, weeding and mowing should be done on an as required basis. Watering should be scheduled weekly during the first year and bi-weekly or as needed in the second year based on rainfall

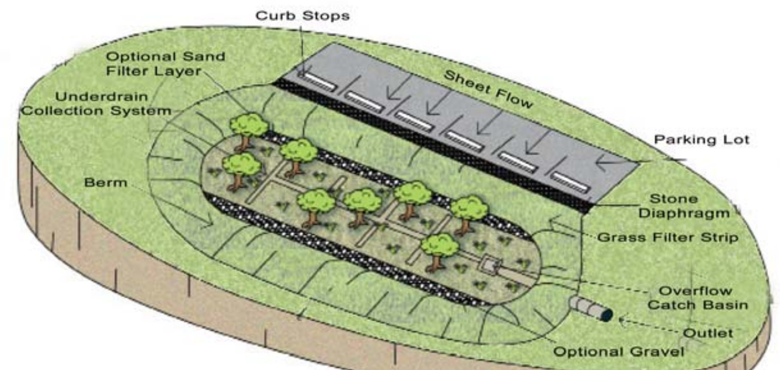
Annual maintenance activities include adding reinforcement planting, removal of accumulated sand from filter bed after snow melt, inspection of inflow points and grass filter strips, removal of invasive plants, supplementing mulch, and stabilization of bare soil drainage areas.

The following repairs may be required based on the annual inspection:

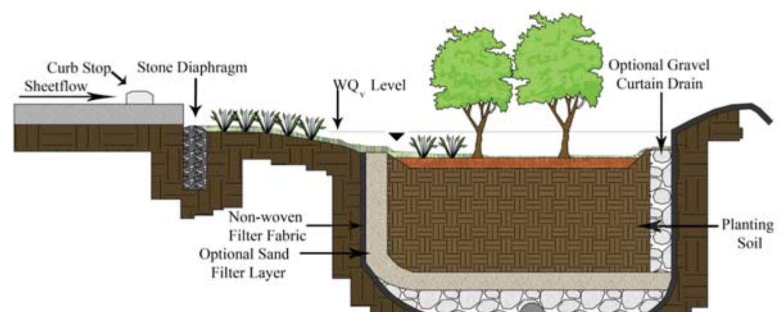
- SURFACE COVER/FILTER BED: The surface of the filter bed becomes clogged with fine sediment over time. Core aeration or deep tilling of non-vegetated areas may relieve the problem. The surface cover layer will need to be removed and replaced every three years. The inlets and pretreatment measures for the bioretention retrofit also need frequent inspections.
- PONDED WATER: If water remains for more than 48 hours after a storm, adjustments to the grading or underdrain repairs may be needed. The surface of the filter bed should also be checked for accumulated sediment.



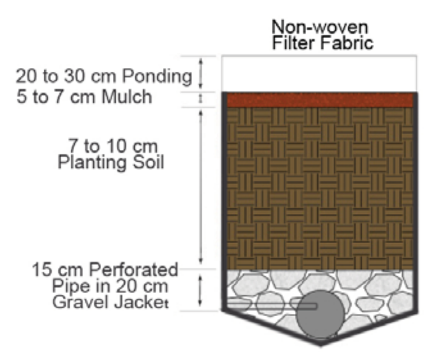





OVERVIEW



SECTION



DETAILED SECTION

STORMWATER FUNCTIONAL PERFORMANCE

	Water Balance	Water Quality	Geomorphic
Bioretention with infiltration (No underdrain)	Yes	Yes Size for full water quality volume	Possible Based on available storage volume & infiltration rates
Bioretention with underdrain	Moderate Based on native soil infiltration rates and storage in gravel layer	Yes- Size for full water quality volume	Possible Based on available storage volume and infiltration rates

GENERAL SPECIFICATIONS

Material	Specification	Quantity
Filter Media Composition	Filter Soil Mixture: 85-88% Sand 8-12% Soil fines 3-5% organic matter	Volumetric computation based on surface area and depth used in design computation
Filter Media Testing	P-Index range 10-30 CECs greater than 10 Infiltration rate 25-50mm/hr	N/A
Mulch Layer	Shredded hardwood bark mulch	75mm layer on surface of filter bed
Gravel	Granular A;50mm clear stone - double washed	Volumetric computation based on depth
Underdrain	Perforated PVC or corrugated HDPE - 100mm dia. min	• Perforated pipe - length of cell • Non-perforated - to connect with storm drainage • T's as needed for underdrain configuration
Native Soil Infiltration Testing	For designs without an underdrain infiltration should exceed 25mm/hr	One test per 10 m² of bioretention area

SITE CONSIDERATIONS

Available Space
Open areas at least five to 10 percent of the size of the contributing drainage area.

Site Topography
Contributing Slopes - 1% to 5% slope
Ideally located in a natural depression

Drainage Area & Runoff Volume
Drainage area should not exceed 2 hectares to one bioretention facility.
- Typical DA =0.1 to .5 hectares

Soil
Confirm adequate soil infiltration through onsite testing
- If infiltration rate is less than 15mm/hr, underdrain required.

Head
Vertical dist. between inflow to LID pratice and drainage system

Hotspot Land Uses
Should not be used to treat stormwater hotspot areas. Impermeable liner should be used for filtration of hotspot runoff

Setbacks from:

Water Table
Min separation from the seasonal high water table is 1m from the bottom of bioretention.

Utilities
Consult local utility design guidance for horizontal and vertical clearance between storm drains, ditches, and surface water bodies.

Overhead Wires & Trees
Check whether max. future tree canopy height in bioretention area, will interfere with existing overhead phone and power lines.

CONSTRUCTION CONSIDERATIONS

Bioretention sites should remain outside the limit of disturbance until construction of the bioretention begins.This will prevent soil compaction by heavy equipment. Bioretention locations should never be used as the site of sediment basins during construction, as the concentration of fines will prevent post-construction infiltration.

To prevent sediment from clogging the surface of a bioretention cell, stormwater should be diverted away from the bioretention until the drainage area is fully stabilized.

Construction Inspection should focus on erosion & sediment control, materials elevations and landscape stabilization

ESTIMATED INSTALLATION COST

Highly Variable

FUNCTIONAL PERFORMANCE

WATER BALANCE
WATER QUALITY
GEOMORPHIC

TARGETED POLLUTANTS

Bacteria
TSS
HYDROCARBONS
METALS
NUTRIENTS

CVC
Toronto and Region Conservation for The Living City

FACT SHEET

LID 5

CROSS REFERENCE: TRCA MANUAL, SECTION 3.6.5

GENERAL DESCRIPTION

"Special bioretention" designs treat stormwater in the same way as regular bioretention, however, they are adapted to fit into the "containers" of urban landscapes. Typically, these practices are placed into the roadway right-of-way (or boulevard), landscaping beds in urban settings, tree-pits, and plazas.

- Extended tree pits and stormwater curb extensions (also known as parallel bioretention) are used in the roadway right-of way, either in the sidewalk area, a chicane or a lay-by.
- Stormwater planters (or foundation planters) are used adjacent to buildings and in plazas, differing from traditional landscaping beds by receiving runoff from other surfaces.
- Front yard bioretention is used to capture roof overflow or lawn and driveway runoff from low to medium density residential lots in a slight depressed area between the home and the street. The bottom of the bioretention area is connected by an underdrain to the main storm drain pipe located underneath the street. The concept is to take advantage of the 1.5 to 2-metre drop from the roof leader to the street storm drain pipe by creating a 2 to 3-metre wide bioretention corridor from roof to the street. The minimum effective length of the bioretention corridor is 5 metres.
- Curb extensions are, like extended tree pits, installed in the road right-of-way and can also act to control parking. In place of an otherwise raised concrete surface, the area is constructed as a depression with vegetation and used for stormwater treatment.

DESIGN PRINCIPLES

GEOMETRY AND SITE LAYOUT

- The geometry of bioretention area is often influenced by other elements of landscape design.
- The designer should divert runoff from various impervious surfaces into small bioretention cells.
- Inlets and outlets should be located as far apart as possible.
- Within the bioretention cell the ground surface should slope at 1%

PRE-TREATMENT

Materials used may be chosen based on their aesthetic qualities in addition to their functional properties.

- Gravel diaphragm (sheet flow): Should run perpendicular to the flow path at the end of pavement to promote settling.
- 50-150 millimeters drop (sheet flow): From a hard-edged surface into a gravel diaphragm, dissipates energy and promotes settling.
- Rip rap and/or dense vegetation (channel flow): These energy dissipation techniques are acceptable pre-treatment alternatives on small scale bioretention cells with max 100 sq.m of drainage area.
- Gutter screens: Screens are appropriate for pre-treatment of runoff from roof leaders.

CONVEYANCE AND OVERFLOW

The inflow conveyance may take one of the following forms:

- Downspout to a fore bay or stone energy dissipater;
- Sheet flow off of a depressed curb;
- Curb cut into the bioretention area;
- Covered drain that conveys flow across sidewalk from the curb or downspout;
- Grates or trench drain that capture runoff from the sidewalk or plaza;

Overflow can either be diverted from entering the bioretention cell or via an overflow inlet. Some methods include:

- Sizing curb openings to capture only the water quality volume while higher flows remain in the gutter.
- Utility landscaping type inlets or standpipes with trash guards as overflow devices.
- Using a pre-treatment chamber with a weir design that limits flow to the filter bed area.

FILTER MEDIA

The recommended soil mixture is 85 to 88% sand, 8 to 12% soil fines, and 3 to 5% organic matter.

OTHER DETAILS

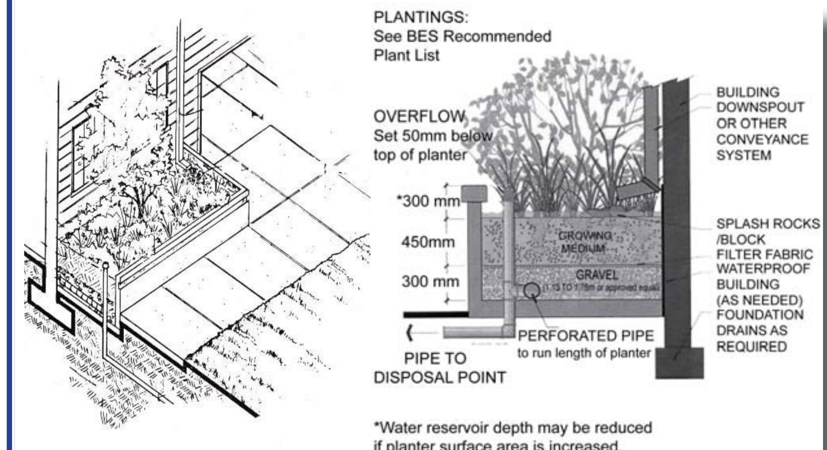
In urban settings, the trash load and pedestrian traffic call for special considerations. Consider using the following adaptations in the design of bioretention devices:

- "A trash rack" device installed between the pre-treatment cell and the main filter bed allowing trash to be collected from one location.
- A 'trash rack' can be placed across curb cuts. It is a device used to keep trash in the gutter until it can be picked up by street sweeping equipment.
- A pre-treatment area can be placed above ground. Alternatively a manhole or grate directly over the pre-treatment area can also be utilized.
- Placing tree pit grates over filter bed media is a possible solution to address pedestrian traffic and trash accumulation.
- Tree pit fencing can restrict foot traffic across the bioretention filter bed and serve as a protective barrier from abrupt level changes in pavement where depressed bioretention cells are utilized.
- Educational signage can be incorporated into the designs.
- Landscaping stone, river rock, or boulders can be included.

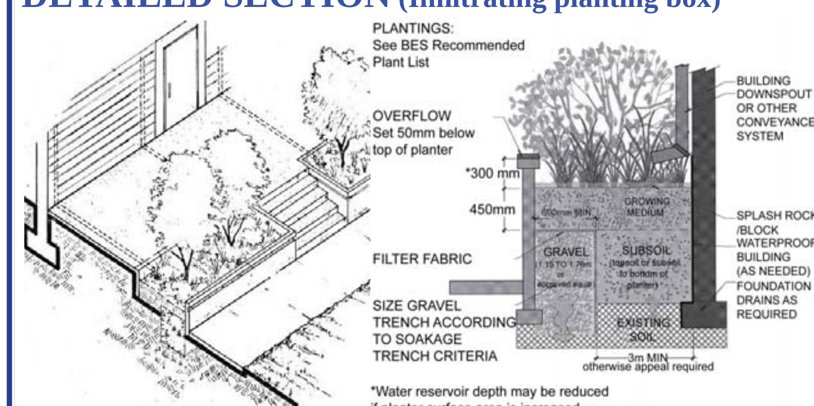




OVERVIEW



DETAILED SECTION (Infiltrating planting box)



DETAILED SECTION (Filtering planting box)

STORMWATER FUNCTIONAL PERFORMANCE

	Water Balance	Water Quality	Geomorphic
Bioretention with infiltration (No underdrain)	Yes	Yes, Size for full water quality volume	Possible, Can be used in treatment train
Bioretention with underdrain	Moderate, Based on native soil infiltration rates and storage in gravel layer	Yes, Size for full water quality volume	No, Can be used in treatment train

GENERAL SPECIFICATIONS

Material	Specification	Quantity
Filter Media Composition	Filter Soil Mixture: 85-88% Sand 8-12% Soil fines 3-5% organic matter	Volumetric computation based on surface area and depth used in design computation
Filter Media Testing	P-Index range 10-30 CECs greater than 10 Infiltration rate 25-50mm/hr	N/A
Mulch Layer	Shredded hardwood bark mulch for weed control.	75mm layer on surface of filter bed
Gravel	Granular A;50mm clear stone - double washed	Volumetric computation based on depth
Underdrain	Perforated PVC or corrugated HDPE - 100mm dia. min	• Perforated pipe - length of cell • Non-perforated - to connect with storm drainage • T's as needed for underdrain configuration
Native Soil Infiltration Testing	For designs without an underdrain infiltration should exceed 25mm/hr	One test per 10 m^2 of bioretention area

OPERATIONS & MAINTENANCE REQUIREMENTS

Maintenance needs are similar to regular bioretention. Routine operation and maintenance tasks are key to public acceptance of these special, highly visible bioretention units. Weeding, pruning, and trash removal should be done as needed to maintain the aesthetics for community acceptance.

LANDSCAPING

The level of landscaping maintenance will drive some of the choices:

- Bioretention cells can be formal gardens or naturalized landscaping.
- In areas with less maintenance and where trash accumulation in shrubbery or herbaceous plants consider a "turf and trees" landscaping model.
- Include spaces for herbaceous flowering plants at entrance location.

As with regular bioretention, the selected perennials, shrubs, and trees must be tolerant of salt, drought, and periodic inundation. Additionally, tree species should be those that are known to survive well in the compacted soils and polluted air and water of an urban landscape. The use of native plants in bioretention areas is encouraged (refer to TRCA manual plant list).

SITE CONSIDERATIONS

Available Space
Open areas at least five to 10 percent of the size of the contributing drainage area.

Site Topography
Longitudinal slope must be considered. For linear bioretention practices -over 4% slope- "Multi-Cell" design is needed (refer to LID 5).

Drainage Area & Runoff Volume
Drainage area should not exceed 2 hectares to one bioretention facility.

- Typical DA =0.1 to .5 hectares

Soil
Confirm adequate soil infiltration through onsite testing. If infiltration rates less than 15mm/hr, underdrain required.

Head
Vertical dist. between downstream storm drain invert to inflow point:1 to 1.5m

Hotspot Land Uses
Should not be used to treat stormwater hotspot areas. Impermeable liner should be used for filtration of hotspot runoff.

Setback from Buildings
Three metre setback should be used if an impermeable liner is not used.

Water Table
Min separation from water table - 1m

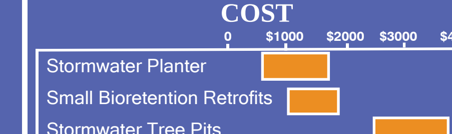
Utilities
Care should be taken to provide utility-specific horizontal and vertical offsets. If water and sewer laterals (house connections) conflict, revisit the off-sets with the utility company and create a sequence of construction that avoids impact to existing service.

Overhead Wires & Trees
Check whether future tree canopy heights in the bioretention area will interfere with existing overhead phone and power lines.

CONSTRUCTION CONSIDERATIONS

Construction considerations are the same as regular bioretention. The construction considerations for sequencing and inspection are generally the same for special bioretention. Due to the locations of many "special bioretention" facilities in the road right-of-way, considerations of traffic control and utility conflicts must be part of the plans and inspections.

ESTIMATED INSTALLATION COST



FUNCTIONAL PERFORMANCE

WATER BALANCE

WATER QUALITY

GEOMORPHIC

TARGETED POLLUTANTS

BACTERIA

TSS

HYDROCARBON

METALS

NUTRIENTS

CVC/TRCA SWM DESIGN GUIDELINE MANUAL

SPECIAL BIORETENTION

CVC

Toronto and Region Conservation for The Living City

FACT SHEET

LID 6

CROSS REFERENCE: TRCA MANUAL, SECTION 3.6.6

GENERAL DESCRIPTION

Soil amendments can help restore soil properties to pre-development conditions by reversing the loss of organic matter and compaction. They also are used to make hydrologic group *'C' and 'D' soils suitable for on-site stormwater best management practices such as downspout disconnection, filter strips, and grass channels. Soil amendments can consist of organic compost and may have the following benefits:

- Increased infilteration
- Increased stormwater storage in the soil matrix
- Increased survival rate of new planting
- Improve plant health
- Increased root growth and stabilization against erosion
- Decreased need for irrigation and fertilization of landscaping.

*C: These soils have a slow infiltration rate when thoroughly wetted.
D: (High runoff potential). These soils have a very slow infiltration rate when thoroughly wetted.

DESIGN PRINCIPLES

GEOMETERY AND SOIL MEDIA

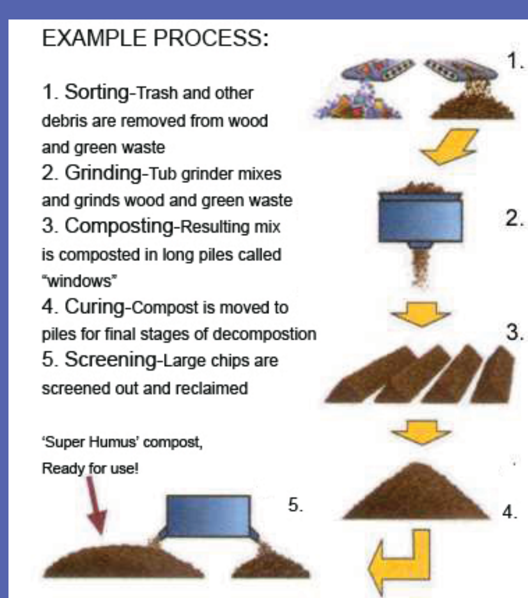
- Flow from the downspout : spread over a 3 metre-wide strip extending down-gradient from the building to the street or conveyance system.
- Existing soils in the strip : scarified or tilled to a depth of 300 to 450 mm and amended with well-aged compost to achieve an organic matter content in the range of 8 to 13%.
- The depth of soil amendment is based on the relationship of the contributing rooftop area to the area of the soil amendment strip, using the following general guidance:
  Roof Area /Soil Area = 1, use 100mm compost,
  Roof Area /Soil Area = 2, use 200mm compost,
  Roof Area /Soil Area = 3, use 300mm of compost, till to 450 to 600mm depth.

Similar sizing criteria when they are used to enhance the performance of a grass channel:

- Flow in the grass channel should be spread over a 3 metre-wide strip extending the length of the bottom of the channel.
- Existing soils in the strip should be scarified or tilled to a depth of 300 mm and soils mixed with 150 to 200 mm of well-aged compost to achieve an organic matter content in the range of 8 to 13%.
- The amended area will need to be rapidly stabilized with perennial, salt tolerant grass species. For grass channels on steep slopes, it may be necessary to install a protective biodegradable geotextile fabric.
- Ensure that the final elevation of the grass channel meets original hydraulic capacity.

LANDSCAPING

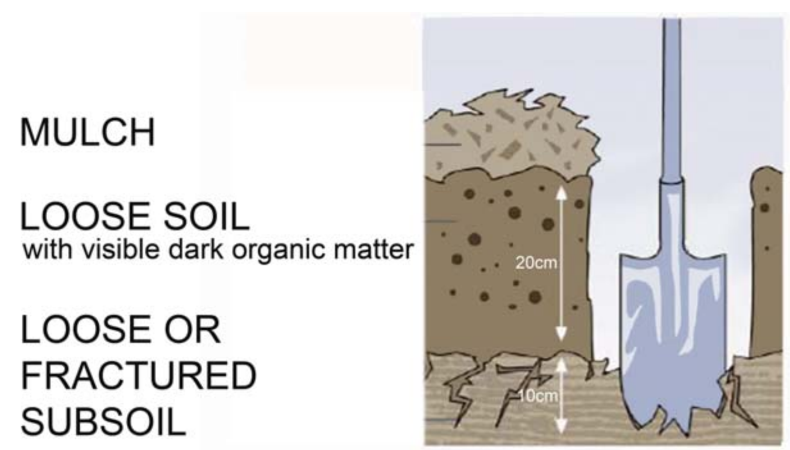
Groundcovers should be planted after soils are amended. Turf is the most frequently used groundcover, but trees or other herbaceous plants will provide greater infiltration and evapotranspiration benefits.







OVERVIEW



Test holes should be about 30cm deep (after first scraping away any mulch) and about 30cm square.

AMENDED SOIL PROFILE.

STORMWATER FUNCTIONAL PERFORMANCE

	Water Balance	Water Quality	Geomorphic
Compost Amendments	Moderate Increases infiltration rates from 2 to 10 times over unamended soil rates.Stores rainfall in the soil structure.	Moderate Nutrient concentration are higher, but TSS metals, bacteria and hydrocarbons are lower because they reduce runoff loads over conventional soils.	Moderate It contributes to a lower peak discharge, and can help reduce the size of total runoff storage needed.

GENERAL SPECIFICATIONS

Leaf compost should be made exclusively of fallen deciduous leaves with less than 5% dry weight of woody or green yard debris materials. The compost should contain less than 0.5% foreign material such as glass or plastic contaminants and should be certified as pesticide free. The use of leaf mulch, composted mixed yard debris, biosolids, mushroom compost or composted animal manure is prohibited.

The compost should be matured and should have been composted for a period of at least one year and exhibit no further composition. Visual appearance of leaf matter in the compost is not acceptable. The compost should have a dry bulk density ranging from 640 to 800 kg/m^3, a pH between 6 to 8 and a *CEC at or in excess 50 meq/100 grams dry weight.

*Cation Exchange Capacity (CEC): measure of the soil capacity to exchange ions.

Organic Content of Amended Soils	8 to 13% of dry weight 30 to 40% by volume
Organic Content of Compost	Minimum 50%
Compaction	In turf areas compact to 85% of maximum dry density

CONSTRUCTION CONSIDERATIONS

The construction sequence for compost amendments differs depending whether the practice will be applied to a large area or a narrow filter strip such as in a rooftop disconnection or grass channel. For larger areas, a typical construction sequence is as follows.

1.Prior to building, the proposed area should be deep tilled to a depth of 0.6 to 0.9 metres using a tractor with two deep shanks (curved metal bars) to create rips perpendicular to the direction of flow. This step is usually omitted when compost is used for narrow filter strips.

2.A second deep tilling is needed after final building lots have been graded to a depth of 300 to 450 mm.

3.An acceptable compost mix is then incorporated into the soil using a rototiller or similar equipment at the volumetric rate of one part compost to two parts soils.

4.The site should be leveled and seeds or sod used to establish a vigorous grass cover. Lime or irrigation may initially be needed during the vegetation establishment phase.

5.Compost amendment areas exceeding 1000 square metres should employ simple erosion control measures, such as silt fences, to reduce the potential for erosion.

6.Construction inspection involves digging a test pit to verify the depth of mulch, amended soil and scarification. A rod penetrometer should be used to establish the depth of uncompacted soil at about four locations per hectare test.

SITE CONSIDERATIONS

Site Topography
Max slope10%

Drainage Area & Runoff Volume
Suitable in areas with low infiltration rates. If the pervious area will be used to filter runoff (downspout disconnections and grass channels), the area or strip of amended soils should be hydraulically connected to the stormwater conveyance system.

Soil - Suitable for all soil types except those that are saturated or seasonally wet.

Setback from Buildings
Not recommended when the downhill slope runs toward an existing or proposed building foundation.

Water Table
Min separation from water table: 0.5m

Overhead Wires & Trees
Excavation to be conducted outside tree drip line only.

OPERATIONS & MAINTENANCE REQUIREMENTS

In order to ensure that pervious areas continue to provide the benefits of compost amendments, a legally binding maintenance agreement with the owners should be in place to ensure that downspouts remain disconnected and the pervious area remains pervious. For long-term efficacy, the area should be protected from compaction. One way of doing this is to plant shrubs or trees along the perimeter of the pervious area to prevent vehicle traffic. On commercial sites, the pervious area should not include an area with high foot traffic.

ESTIMATED INSTALLATION COST

No cost estimates are available specifically for compost amendments.

FUNCTIONAL PERFORMANCE

WATER BALANCE
WATER QUALITY
GEOMORPHIC

TARGETED POLLUTANTS

BACTERIA
TSS
HYDROCARB0NS
METALS
NUTRIENTS

CVC/TRCA SWM DESIGN GUIDELINE MANUAL

SOIL AMENDMENTS

CVC
Toronto and Region Conservation for The Living City

FACT SHEET

LID 7

CROSS REFERENCE: TRCA MANUAL, SECTION 3.6.7

GENERAL DESCRIPTION

Tree conservation at development sites should be given priority as a technique to maintain a natural hydrologic regime. When tree conservation is not an option, new trees should be planted in pervious areas of development sites. Tree clusters planted in turf grass or barren ground, with the explicit goal of establishing mature forest canopy can reduce stormwater runoff volume and peak flow. Additionally, tree clusters can improve water quality, generate organic soils, absorb greenhouse gases, create wildlife habitat, and provide shading to mitigate temperature increases at development sites.

Tree clusters function similarly to forested areas by intercepting rainfall and allowing the processes of evapotranspiration (ET) and infiltration to reduce stormwater runoff. Some planting clusters are designed to receive sheet flow, particularly from pervious areas. Soil at tree cluster sites must remain undisturbed during construction or be amended to achieve the desired benefits. Research on rainfall interception, ET and pollutant removal provided by individual trees shows that tree clusters can significantly reduce runoff volumes and pollutant loads at a development site.

DESIGN PRINCIPLES

GEOMETRY AND SITE LAYOUT

- Shape: Topography will dictate the shape. Any shape can be used.
- Slope: For slopes up to 3:1 (H:V): flat or slightly concave,
- Size: Depends on the number and size of the trees within the cluster. Min.3 trees. Use a 10-year canopy projection.
- Depth: 1m backfill using soils suitable for plant growth and in compatibility to site soils.

SOIL MEDIA

For sites with native soil infiltration rates of 25 mm/hr or less, composition of soils should be used. For sites with infiltration rates greater than 25 mm/hr, soils with topsoil intact can be used as is. If topsoil is not present, the guidlines for soil amendments should be used (refer to LID7)

LANDSCAPING

Selected tree species should be suited to the anticipated degree of inundation and should meet site constraints, such as setbacks to buildings and underground infrastructure services. Designers should specify salt tolerant species in tree clusters that will receive snow melt from roadways, parking lots, or snow storage piles. Mature tree height should also be considered. To receive stormwater credit, newly planted deciduous trees must have a minimum caliper of 50 mm. Evergreen trees must be at least 1.8 m in height.

Source for tree species: CVC/TRCA manual plant list.

OTHER DETAILS

Heavy foot traffic through tree clusters can compact soils and reduce the infiltration capacity. Therefore, barriers consisting of shrubbery, fences, benches, bollards and chains (techniques that do not impede the flow of water for high foot traffic) should be utilized.

OPERATIONS & MAINTENANCE REQUIREMENTS

Maintenance

Begins with a construction contract that includes a care and replacement warranty to ensure vegetation gets properly established and survives during the first two growing seasons following construction.

Routine Maintenance Activities

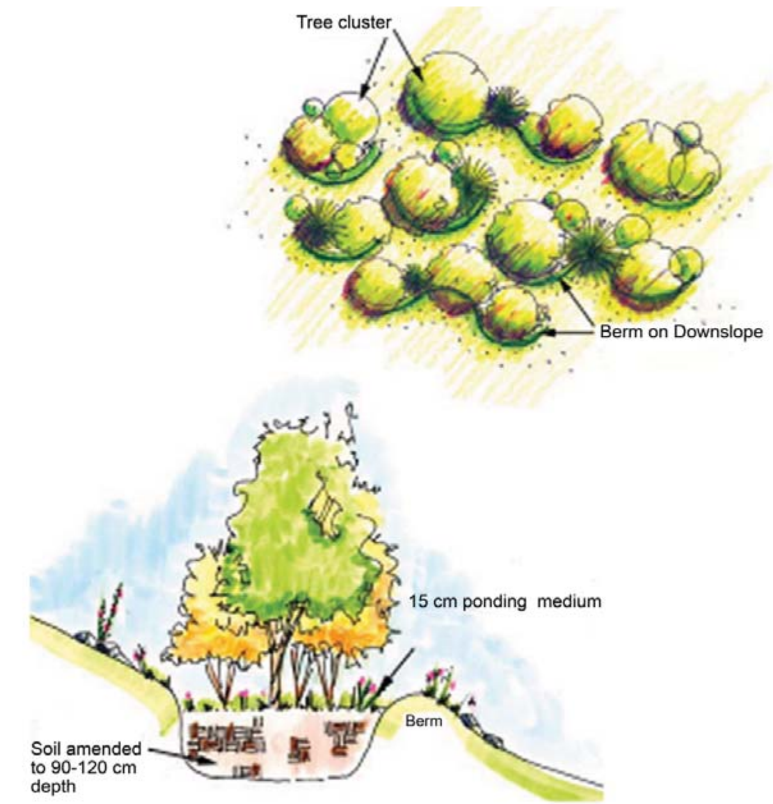
1.Include trash removal
2.Weeding as needed
3.Water as required to maintain healthy growth between APRIL and SEPTEMBER and bi-weekly during second year.

Annual Maintenance

- Plant additional trees if the original trees have not successfully established or have been damaged
- Remove trash and debris accumulated in the tree planting cluster
- Remove invasive plants
- Prune trees as required
- Supplement mulch in tree clusters where leaf litter is removed
- Stabilize areas of bare soil

Special Maintenance Needs

Careful maintenance is needed to prevent damage to trees. Proper pruning is necessary to prevent damage to susceptibility disease. If mowing or weed-whacking occurs around trees, landscape contractors should know how to avoid scarring the tree.



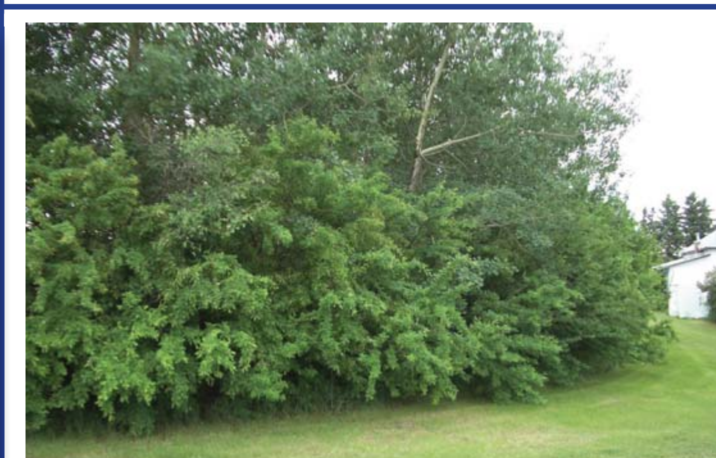
TREE CLUSTERS ON SLOPE TO DRAIN WATER

POTENTIAL LOCATIONS ON A DEVELOPMENT SITE

STORMWATER FUNCTIONAL PERFORMANCE

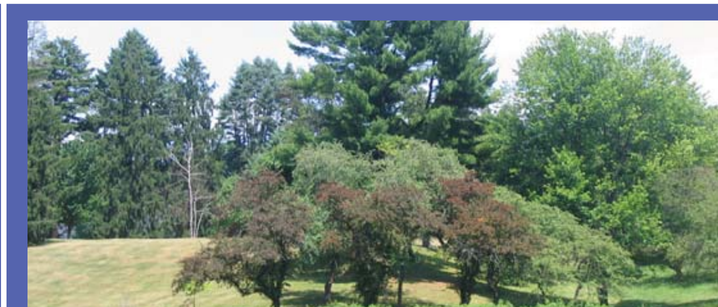
	Water Balance	Water Quality	Geomorphic
Tree Clusters	Partially Good or excellent stream condition is correlated with 45 to 60% tree cover in a watershed	Partially Annual quantification of Benefit per tree: 22 grams nitrogen per tree per year (Based on daily rate of nitrogen uptake by poplar trees)	Partially The water balance benefits will reduce the volume of runoff, resulting in a geomorphic benefit from the lower discharge. Additionally, the higher infiltration rates as compared to turf will reduce peak flows and sustain baseflow.

Component	Specification	Quantity
Planting Bed Soils	For sites with native soil infiltration rates of 25 mm/hr or less, composition of soil should be used. For sites with infiltration rates greater than 25 mm/hr, soils with topsoil intact can be used as is. If topsoil is not present, the guidelines for soil amendments (refer to LID7) should be used.	Total soil area to be excavated is equal to $0.6m^3$ per $1m^2$ of future canopy cover (maturity).



CONSTRUCTION CONSIDERATIONS

New tree cluster planting locations should be clearly marked before site work begins to avoid disturbance during construction. To minimize soil compaction, no vehicular traffic, except that specifically used to construct the facilities, should be allowed within 3 metres of the tree planting sites (For existing trees no vehicle traffic is to be allowed within dripline of trees) The sites should also be protected from stormwater runoff which can cause erosion and sedimentation. Planting should not occur until the adjoining areas draining into the tree clusters are stabilized.



SITE CONSIDERATIONS

Available Space
Depends on the number and the ultimate size of the trees. Mature trees with 1.0 m^2 of canopy need 0.6 m^2 of usable soil.

Site Topography
Max. Slope 3:1 (H:V).

Drainage Area & Runoff Volume
If a tree cluster receives sheet flow from moderate to large areas of impervious cover, it should be designed as a forested filter strip, dry swale, bioretention, or stormwater tree pit (special bioretention).

Soil- Aeration and the addition of compost amendments should be used to improve the soil

Hotspot Land Uses
Pollutant tolerant species can be used, but should not be expected to perform as the sole means of runoff treatment.

Underground Utilities
Trees should be offset from underground utilities to prevent permanent damage to the roots during maintenance.

Water Table
Found within one metre of the surface can lead to the prolonged saturation of tree roots, which can cause mortality in tree species intended for use in drier upland areas. On development sites with a high water table, species with high tolerance of frequent inundation should be used.

Setback from Buildings
Critical root zone of trees are typically measured as 300 mm for every 25 mm of trunk diameter at breast height. Adequate root zone for mature trees should be protected to ensure health of trees.

Distance to Impervious Cover:
Trees should be located no closer than 8 metres of the relevant impervious area.

Overhead Wires:
Check if future tree canopy growth will interfere with overhead utility lines. Appropriate mature height should be selected, or a setback provided of 3 to 5 meters from the expected 10-year canopy to overhead lines.

ESTIMATED INSTALLATION COST

Highly Variable

FUNCTIONAL PERFORMANCE

- WATER BALANCE
- WATER QUALITY
- GEOMORPHIC

TARGETED POLLUTANTS

- BACTERIA
- TSS
- HYDROCARBONS
- METALS
- NUTRIENTS

CVC/TRCA SWM DESIGN GUIDELINE MANUAL

TREE CLUSTERS

CVC
Toronto and Region Conservation for The Living City

FACT SHEET

LID 8

CROSS REFERENCE: TRCA MANUAL, SECTION 3.6.8

GENERAL DESCRIPTION

Filter strips are vegetated areas that treat sheet flow from adjacent impervious areas. Filter strips slow runoff velocities and settle out sediment and pollutants. Small depressions can be used to provide some storage. In permeable soils, storage and infiltration occurs. Originally used as an agricultural treatment practice, filter strips have evolved into an urban stormwater management practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. Filter strips are limited in attenuating flows and can be susceptible to "short circuiting" by concentrated flows, which result in little or no treatment of stormwater runoff. Therefore, it is often beneficial to combine filter strips with other best management practices to maximize water quality/ flow attenuation benefits. Filter strips can also provide a convenient area for snow storage and treatment, and are particularly valuable due to their capacity for meltwater infiltration. Because filter strip designs include few pipes or other structures, physical changes to the practice are not needed for wintertime operation.

DESIGN PRINCIPLES

GEOMETRY AND SITE LAYOUT

In all cases, the filter strip length must exceed the contributing flow path.

- The maximum contributing sheet flow path from adjacent pervious and impervious areas: 25-50m max (flow path slope:3% for 15m segment).
- Max length of the filter strip over which runoff is spread: 60 m
- Min flow length: 5m -Preferred lengths at slopes less than 5%: 10-15m, steeper slopes: 15-20 m

PRETREATMENT

Utilize a pea gravel diaphragm (a small trench running along the top of the filter strip) at the top of the slope. It serves 2 purposes; it acts as a pre-treatment device and it acts as a level spreader. Larger stone should be used for steep drainage areas.

CONVEYANCE AND OVERFLOW

When slopes exceed 5% a series of level spreaders should be used e.g. curb cut combined with a gravel level spreader, slotted or depressed curb on level spreader in form of an earthen berm. The filter strip should drain continuously as sheet flow until reaching a property line or drainage swale. It should be designed with a pervious berm of sand and gravel at the bottom of the filter strip for shallow ponding. Berm height: 150 to 300mm above the bottom of the depression. The volume ponded behind the berm should be equal to the water quality volume. During larger storms, runoff will overtop the berm. A berm is not needed when filter strips are used as pre-treatment to another stormwater best management practice.

FILTER MEDIA

Undisturbed soil should be conserved. For compacted soil or soil lacking organic material, amendments should be used. Soil amendments should be provided on all disturbed soils in the Hydrologic Soil Groups B, C and D categories.

LANDSCAPING

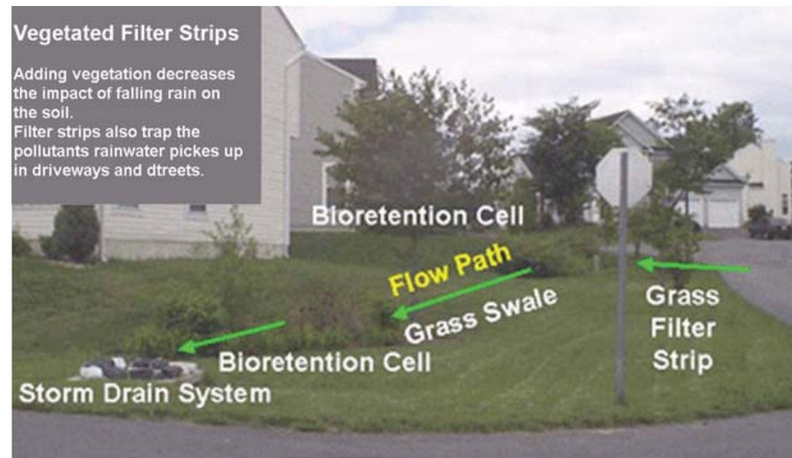
Turf grasses, meadow grasses, shrubs, and trees can be planted. Designers should choose vegetation that stabilizes the soil and is salt tolerant, particularly where the filter strip may be used for snow storage. It should be planted with salt-tolerant grass species. Vegetation at the toe of the slope should withstand both wet and dry periods. "Traditional filter strips" grass areas that are intended to treat sheet flow from adjacent impervious areas. An alternative design could be a forested filter strip. "Multi-zone filter strips" feature several vegetation zones that provide a gradual transition from turf to meadow to shrub and forest.

FUTURE ACCESS

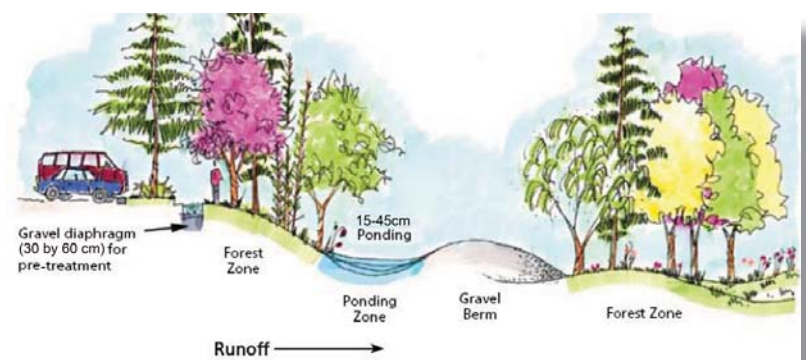
Should be protected by a perpetual easement or deed restriction that assigns the responsible party to ensure no future development, disturbance or clearing can occur within the area.







FILTER STRIPS AS A PART OF TREATMENT TRAIN



FORESTED FILTER STRIP PROFILE

MULTI -ZONE FILTER STRIP PROFILE

STORMWATER FUNCTIONAL PERFORMANCE

	Water Balance	Water Quality	Geomorphic
Filter Strips	Possible, depends on infiltration rates	Yes	Partially

GENERAL SPECIFICATIONS

Component	Specification	Quantity
Gravel Diaphragm	• Use clean bank-run gravel.	Diaphragm should be a minimum of 300 mm wide and 600 mm deep.
Gravel Pervious Berm	• Berm should be composed of sand (35-60%), silt (30-55%), and gravel (10-25%). Gravel should be 15-25 mm in diameter.	N/A

SITE CONSIDERATIONS

Available Space
The ratio between drainage area and footprint of the filter strip: 6:1.Min10m of land must be available in the direction of flow

Site Topography
Recommended filter strip slope: between 2% and 5%
Best used on sites with natural sheet flow. Though steeper slopes increase the likelihood of erosion, periodic level spreaders or terraces can be used to counteract this.

Drainage Area & Runoff Volume
Filter strips are used to treat very small drainage areas. Maximum contributing drainage area is 2 hectares. As a rule, flow tends to concentrate after 20m of flow length for impervious surfaces, and 45m for pervious surfaces. When the existing flow at a site is concentrated, a vegetated swale should be used instead of a filter strip.

Soil
Filter strips are appropriate for all soil types. In soils with high clay content, water balance objections may not be achieved. Use compost amendment (refer to LID7) for very poor soils that cannot sustain a grass cover.

Hotspot Land Uses
Filter strips should not accept hotspot runoff, since the infiltrated runoff could cause groundwater contamination.

Underground Utilities
Underground pipes and conduits that cross the filter strip are acceptable.

Water table
Min 500 mm should separate filter strip from groundwater to prevent contamination and to ensure that the filter strip does not remain wet between storms.

Setback from Buildings
3 metre setback is recommended.

FUNCTIONAL PERFORMANCE

- WATER BALANCE
- WATER QUALITY
- GEOMORPHIC

TARGETED POLLUTANTS

- BACTERIA
- TSS
- HYDROCARBONS
- METALS
- NUTRIENTS

CVC/TRCA SWM DESIGN GUIDELINE MANUAL

FILTER STRIPS

CVC Credit Valley Conservation — Toronto and Region Conservation for The Living City

OPERATIONS & MAINTENANCE REQUIREMENTS

Maintenance
Concentrated flow should not short circuit. No vehicle traffic, limited foot traffic. Use lightest possible mowing equipment.

Typical Maintenance Activities for Filter Strips
At least twice yearly: (More frequently if desired for aesthetic reasons)
- Mow grass to remove woody material. Maintain min grass height of 150 mm. Mow perpendicular to flow path to prevent erosion and scour
- Weed as needed.
- Remove trash and debris.
- Water between April-September of the first 2 years
- Inspect pea gravel diaphragms and check dams for clogging

ANNUALLY
- Inspect filter strip for erosion and formation of rills or gullies
- Mulch in spring (deicing salts can reduce organic content of the soil.)
- Remove surface sands accumulated over the winter.
- Plant alternative species if the original vegetative cover has not been successful
- Remove invasive plants.
- Prune trees as needed (infrequently)
- Remove sediment build-up within the bottom of the grass channel once it has accumulated to 25% of the original design volume

CONSTRUCTION CONSIDERATIONS

The following recommendations should be considered during construction:

- Soil Disturbance and Compaction: Before site work begins, areas for filter strips should be clearly marked and protected by signage and silt fencing. Only vehicular traffic used for construction should be allowed within 3m of the filter strip. Fine grading is critical to ensure sheet flow.
- Erosion and Sediment Control: Construction runoff should be direct away from the proposed filter strip site.
- Vegetation: Water between April and September of the first 2 years to promote vegetation establishment. Ideally, filter strips should be installed when vegetation can be established without irrigation.

ESTIMATED INSTALLATION COST

Actual construction costs can vary:
- Seed cost: $3.50 per m²
- Sod cost: $9 per m²
- Maintenance costs: about $0.10 m² -year.

FACT SHEET

LID 9

CROSS REFERENCE: TRCA MANUAL, SECTION 3.6.9

PERMEABLE PAVEMENT

CVC/TRCA SWM DESIGN GUIDELINE MANUAL

GENERAL DESCRIPTION

Permeable pavements can be used as alternatives to traditional hard surface paving systems that create expanses of impervious surface such as parking lots, driveways, access roads, plazas, and walkways. Examples of permeable pavement types include: open joint permeable pavers, pervious concrete and porous asphalt.

Permeable paving allows for filtration, storage, or infiltration of runoff, which can reduce stormwater flows compared to traditional impervious paving surfaces like concrete and asphalt.

Porous asphalt and pervious concrete are pavement mixes with washed aggregate to eliminate fines. The resulting voids allow stormwater to filter through the pavement into an underlying stone reservoir. Water then infiltrates or enters an underdrain system. Permeable pavements are best applied as part of a "treatment train" approach to managing stormwater.

Permeable pavers include products such as plastic lattice or grid systems, interlocking concrete modules and brick pavers. Permeable pavers provide an aesthetic alternative to traditional paving and are typically applied to smaller drainage areas.

DESIGN PRINCIPLES

GEOMETRY & SITE LAYOUT
Permeable pavement systems are often used for entire parking lot areas or driveways. Alternatively they can be designed in a series of narrow strips. Non-porous surfaces can be designed to drain as sheet flow into the pervious pavement surface. To capture runoff from intense rainfall events, the runoff should be directed to cross pervious areas to account for concentrated flows that may form due to pavement joints.

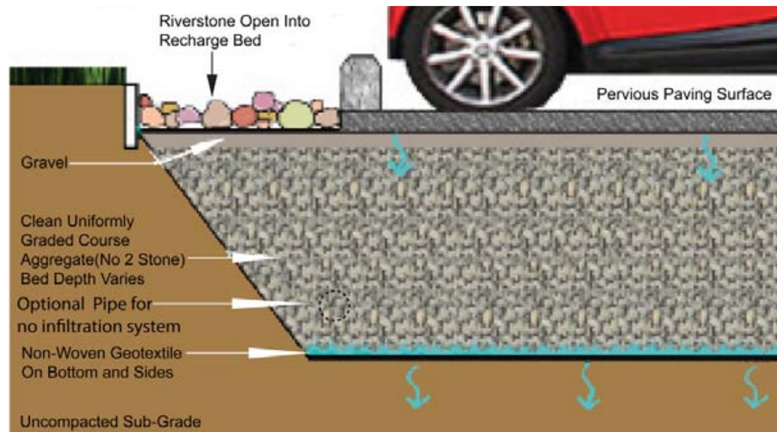
PRE-TREATMENT
In most permeable pavement designs, the surface acts as pre-treatment to the stone reservoir below. Another pre-treatment element is 3-5 mm clear stone layer above the coarse gravel treatment reservoir. The effectiveness of both of these pre-treatment measures can be inconsistent, which is one reason vacuum sweeping is needed to keep the surface clean.

CONVEYANCE AND OVERFLOW
Designs should include methods to convey larger storms to the storm drain system. One option is to set storm drain inlets slightly above the surface elevation of the system. Another design option intended as a backup water removal mechanism is an "overflow edge." An "overflow-edge" is a trench surrounding the edge of the system that connects to the stone reservoir below the surface.

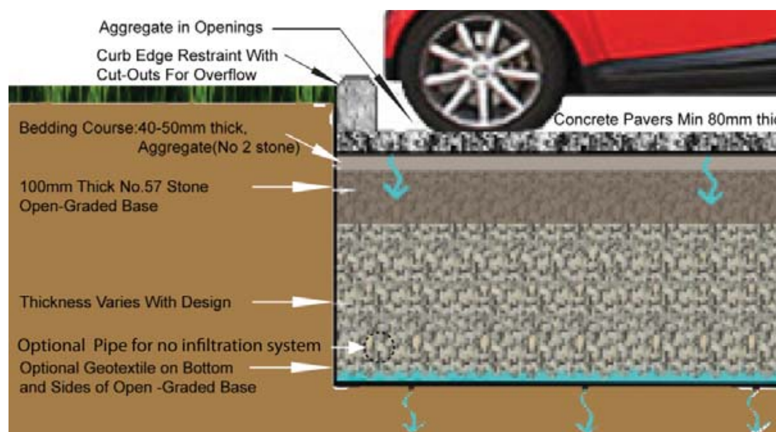
STONE RESERVOIR
The stone reservoir directly below the porous surface should be composed of layers of small diameter stone that the depth of the base is sized for the storm event to be treated. Recommended detention times in base are typically 48 to 72 hours for 25mm storm. Sizing is based on the storage volume provided by the void spaces of the stone reservoir. A typical void space ratio is 0.4. The bottom of the reservoir should be completely flat so that runoff will be able to infiltrate evenly through the entire surface. If the system is not designed for infiltration, the bottom of the reservoir should be sloped at 1 to 5% toward the underdrain.

EDGE RESTRAINTS
The provision of suitable edge restraints is critical to the satisfactory performance of interlocking concrete block pavement. The pavers must abut tightly against the restraints to prevent rotation under load and any consequent spreading of joints. The restraints must be sufficiently stable that, in addition to providing suitable edge support for the paver units, they are able to withstand the impact of temperature changes, vehicular traffic and/or snow removal equipment.



POROUS PAVING



OPEN JOINT PRECAST PERMEABLE PAVERS

STORMWATER TYPICAL PERFORMANCE

	Water Balance	Water Quality	Geomorphic
Permeable Pavers and porous Pavement with stone reservoir	Yes	Yes or Partially - size stone reservoir for full or partial water quality volume	Yes

Volumetric Runoff Reduction from Permeable Pavement
45% - with underdrain collection at base of stone reservoir
90% - without underdrain

GENERAL SPECIFICATIONS

Material	Specification	Quantity
Pervious concrete	• NO4-RG-S7 Proven to have the best freeze-thaw durability after 300 freeze- thaw cycles (Schaefer et al., 2006) • 28 day compressive strength = 5.5-20MPa • Void Ratio = 14%-31% • Permeability= 900-21,500mm/hr	
Permeable Pavers	• Conform to manufacturers specifications • ASTM No. 8 crushed aggregate • Pavers to meet minimum material and physical properties set fourth in the ASTM C 936 • Pigment on concrete pavers conform to ASTM C979 • Max allowable breakage - 5%	Min paver thickness 80mm - vehicular & 60mm pedestrian Joint width max 15mm for pedestrian
Subsurface Storage Bed Aggregates	• Max wash loss - 0.5% • Minimum durability index of 35 • Maximum abrasion of 10% for 100 revolutions and max 50% for 500 revolutions	Min 800mm undisturbed infiltration medium
Geotextile Liner	• Grab tensile strength ≥ 54.4kg (120lbs) • Mullen bust test ≥ 1.5 MPa • Flow rate ≥ 95 gal/min/ft2 • UV Resistance after 500hrs ≥70% • Heat-set or heat-calendared fabrics- not permitted • Choker coarse aggregate should meet AASHTO No.57. Storage stone should meet AASHTO No.2 or3	5-10mm poly alkane geotextile Non-woven preferred Min 200-600mm layer of clean aggregate below porous surfaces when ground stays frozen for extended periods
Underdrain	Should be constructed in accordance with OPS 405 100mm perforated	Pipes should terminate 0.3m short of side of opening for base

SITE CONSIDERATIONS

Drainage Area & Runoff Volume
Impervious area should not exceed 2x the area of permeable paving. Storage layer underneath must be sized to accommodate run off water

Soil -Confirm adequate soil infiltration through onsite testing. Underdrains are required for infiltration rates less than 15mm/hr

Head -
Ideal vertical dist. between inflow to LID practice and drainage system:0.5 to 1m

Topography
Permeable Pavement -1% to 5% slope
Surrounding land not to exceed 20% slope

Winter Operation - Permeable paving systems should not be used when sand or other granular materials are applied, since they clog the system

Water Table
locate at least 1-1.5m above seasonally high ground water table, at least 30m from drinking water wells

Setback from Buildings
Locate on the downslope from building foundations, min setback 3m down grade

Hotspot Land Uses
Should not be used to treat stormwater hotspot areas due to potential ground water contamination

Proximity to Underground Utilities
Local utility design guidance should be consulted to define horizontal and vertical offsets

CONSTRUCTION CONSIDERATIONS

CLOGGING
Treatment area should be fully protected through construction

BASE CONSTRUCTION
Aggregate compacted with a min 10 ton steel drum

WEATHER
Extremely high and low temperatures should be avoided during construction

PAVEMENT MIX
Testing of materials onsite is critical

PAVEMENT PLACEMENT
Industry reps should be consulted for specifications on batching and placement

FUNCTIONAL PERFORMANCE

- WATER BALANCE
- WATER QUALITY
- GEOMORPHIC

TARGETED POLLUTANTS

- BACTERIA
- TSS
- HYDROCARBONS
- METALS
- NUTRIENTS

OPERATION & MAINTENANCE CONSIDERATIONS

Porous concrete/pavement and permeable pavers should only be used with a commitment to long-term maintenance. A carefully worded maintenance agreement that provides specific guidance is essential. The agreement should clearly identify treatment of the following issues:

DEICERS: If sand is used for traction during the winter, it can quickly lead to clogging of pavements.

SNOW PLOWING: The blade of the plow should be set 25mm higher than normal when plowing on these surfaces. When contamination is an issue, snow piles and melt should NOT be directed toward these systems

INLET STRUCTURES: Drainage pipes and structures within or draining to the subsurface bedding beneath porous pavement should be cleaned out at regular intervals

HEAVY VEHICLES: Trucks and heavy vehicles can grind dirt into the porous surface causing clogging and, therefore, should be prevented from tracking or spilling dirt onto the pavement

CONSTRUCTION AND HAZARDOUS MATERIALS: All construction or hazardous materials carriers should be prohibited from entering permeable paver or porous pavement sites

SURFACE SWEEPING: Vacuum sweeping on a quarterly or biannual basis will mitigate sediment accumulation and ensure continued porosity

GRASS PAVERS: Paver or grid systems that have been planted with grass should be routinely mown and bare areas should be routinely seeded

DRAINAGE AREAS: Areas contributing to the permeable paving site need to be routinely mowed and bare areas routinely seeded

ESTIMATED INSTALLATION COST

$180-880 / m³ of runoff treated

FACT SHEET

LID 10

CROSS REFERENCE: TRCA MANUAL, SECTION 3.6.10

GENERAL DESCRIPTION

Grass channels have long been used for conveyance, particularly as roadway drainage. More recently, their benefits as a stormwater best management practice have been recognized. Grass channels are closer in hydrologic properties to natural zero order headwater streams than drainage systems composed of curb and gutter, inlets, and pipes. Grass channels allow infiltration, discharge at a lower rate, and reduce pollutant loads. However they are not capable of providing the same level of water balance and water quality benefits as dry swales, as they lack the engineered soil media and storage volumes of that best management practice.

Where development density, topography and soils permit, grass channels are a preferable alternative to both curb and gutter and storm drains as a stormwater conveyance system. When properly incorporated into an overall site design, grass channels can reduce impervious cover, accent the natural landscape, and provide aesthetic benefits.

DESIGN PRINCIPLES

GEOMETRY AND SITE LAYOUT

- Shape: should be designed with a trapezoidal or parabolic cross section. Trapezoidal channels will generally evolve into parabolic channels over time initial trapezoidal cross-section design should be checked for capacity and conveyance assuming it is a parabolic cross-section.
- Bottom Width: between 1 and 3 metres. It should allow for shallow flows and adequate water quality treatment, while preventing flows from concentrating and creating gullies.
- Longitudinal Slopes: between 1% and 4%. Check dams can be used to create the target slope on soils with good infiltration potential and be underdrained in soils with poor infiltration potential.
- Length: parallels the road when used for roadside drainage, and should be equal to or greater than the roadway length. In Hydrologic Soil Group D soils, a minimum residence time of 5 minutes and maximum velocity of 0.3 m/s translates to a minimum length of 60 metres.
- Flow Depth: max. should correspond to two-thirds the height of the vegetation. Vegetation in some grass channels may reach heights of 150 millimeters or more, therefore, a maximum flow depth of 100 millimeters is recommended during the water quality storm event.
- Side Slopes: should be as flat as possible to aid in providing pretreatment for lateral incoming flows and to maximize the channel filtering surface. Steeper side slopes are likely to have erosion gullying from incoming lateral flows. A maximum slope of 3:1 (H:V) is recommended and a 4:1 slope is preferred where space permits.

PRE-TREATMENT

A pea gravel diaphragm located along the top of each bank can also be used to provide pre-treatment of any stormwater runoff that may be entering the channel laterally along its length. Gentle side slopes (< 3:1) act as a filter strip to provide pre-treatment for any lateral sheet flow entering the channel.

CONVEYANCE AND OVERFLOW

They must be designed for a velocity of 0.3 m/s or less for the water quality design storm. The channel should also convey the locally required design storm (usually the 10 year storm) at non-erosive velocities.

SOIL MEDIA

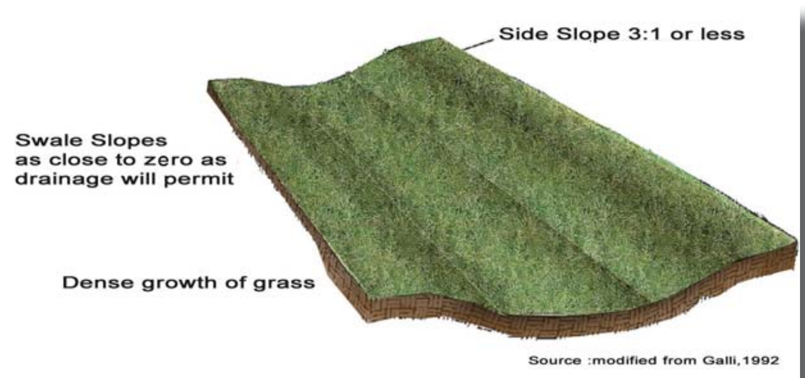
Poor soils, or those with very low organic content, can be amended using compost or other amendments to better support plant growth

LANDSCAPING

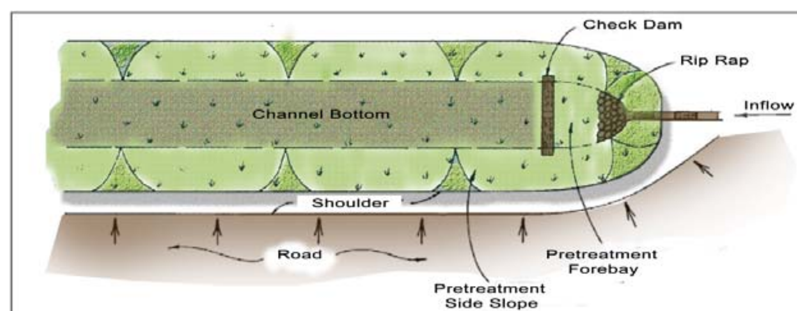
Grasses that can withstand both wet and dry periods as well as relatively high velocity flows within the channel should be chosen. For applications along roads and parking lots, salt tolerant species should be chosen. Taller and denser grasses are preferable, though the species of grass is less important than good stabilization. A list of grass species suitable for use in grass channels in the CVC/TRCA watersheds is found in the Stormwater Management Planning and Design Manual.

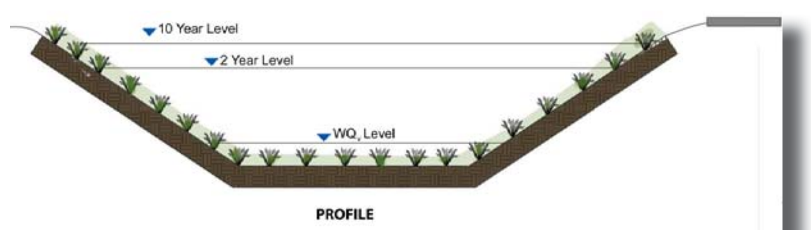






PLAN VIEW OF A GRASS CHANNEL





PLAN AND PROFILE VIEWS

STORMWATER TYPICAL PERFORMANCE

	Water Balance	Water Quality	Geomorphic
Grass Channel	Partially	Yes, if velocity is less than 0.3 m/s	No

GENERAL SPECIFICATIONS

Component	Specification	Quantity
Check Dams	Check dams should be constructed of a non-erosive material such as wood, gabions, riprap, or concrete. All check dams should be underlain with filter fabric conforming to local design standards. Wood used for check dams should consist of pressure treated logs or timbers, or water-resistant tree species such as cedar, hemlock, swamp oak or locust.	Computation of check dam material needed based on surface area and depth used in design computations.
Diaphragm	Pea gravel used to construct pre-treatment diaphragms should consist of washed, open graded course aggregate between 3 and 10mm in diameter and conforming to local design standards.	Volumetric computation of pea gravel needed based on surface area and depth used in design computations.

CONSTRUCTION CONSIDERATIONS

Grass channels should be clearly marked before site work begins to avoid disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within the channel site. Any accumulation of sediment that does occur within the channel must be removed during the final stages of grading to achieve the design cross-section. Final grading and planting should not occur until the adjoining areas draining into the channel are stabilized. Flows should not be diverted into the channel until the banks are stabilized.

Preferably, the channel should be installed at a time of year best for establishment of the vegetation without irrigation. Installation of erosion control matting or blanketing to stabilize soil during establishment of vegetation is highly recommended. If sod is used, it should be placed with staggered ends and secured by rolling the sod. This helps to prevent gullying.

OPERATIONS & MAINTENANCE REQUIREMENTS

Maintenance

Preservation of water quality benefits should be assured. Routine roadside ditch maintenance practices such as scraping and re-grading should be avoided at channel locations.

Owner should be responsible for maintenance of on-site channels. Roadside channels in residential areas also generally receive routine maintenance from homeowners. Residents should be educated on correct grass height and fertilizer rates to keep lawns and grass channels from becoming nutrient sources.

Typical Maintenance Activities for Grass Channels

- Mow grass at least twice yearly (more frequently if desired for aesthetic reasons) to remove woody material. Maintain minimum grass height of 150mm.

Annually:

- Inspect pea gravel diaphragms and check dams for clogging
- Inspect grass along side slopes for erosion and formation of rills or glies
- Remove trash and debris accumulated in the channel
- Based on inspection, plant an alternative grass species if the original grass cover has not been successfully established.

As needed (Infrequently)

- Sediment build-up within the bottom of the grass channel should be removed once it has accumulated to 25% of the original design volume.

SITE CONSIDERATIONS

Available Space
Grass channels usually consume about 5 to 15 percent of their contributing drainage area. A width of at least 2 metres is needed.

Site Topography
Site topography can constrain the application of grass channels. Longitudinal slopes between 1 and 4% are recommended. This prevents ponding while providing residence time and preventing erosion. On steeper slopes, check dams can be used.

Drainage Area & Runoff Volume
The conveyance capacity should match the drainage area. Sheet flow to the grass channel is preferable. If drainage areas are greater than 2 hectares, high discharge through the channel may not allow for filtering and infiltration, and may create erosive conditions.

Soil
Grass channels can be applied on sites with any type of soils. However, grass channels situated on Hydrologic Soil Group D soils should have a maximum velocity of 0.3 m/s during the 25 mm storm.

Hotspot Land Uses
Grass channels are not recommended for hotspots, due to the potential for infiltration of untreated stormwater.

Underground Utilities
Utilities running parallel to the grass channel should be offset from the center line of the channel. Underground (below the channel invert) utility crossings are not a problem.

Water table
Designers should separate the bottom of the channel from groundwater by at least 0.6 metres.

Setback from Buildings
Channels should be located a minimum of 3 metres from building foundations to prevent water damage.

ESTIMATED INSTALLATION COST

$32000 — $105,000

$52000 / PER m^2 TREATED

FUNCTIONAL PERFORMANCE

WATER BALANCE
WATER QUALITY
GEOMORPHIC

TARGETED POLLUTANTS

BACTERIA
TSS
HYDROCARBONS
METALS
NUTRIENTS

CVC/TRCA SWM DESIGN GUIDELINE MANUAL

GRASS CHANNELS

FACT SHEET

LID 11

CROSS REFERENCE: TRCA MANUAL, SECTION 3.6.11

GENERAL DESCRIPTION

Dry swales are essentially bioretention cells that are configured as linear channels. They are soil filter systems that temporarily store and then filter the desired water quality volume. Dry swales are similar to bioretention areas in that they rely on the same soil mix at the bottom of the channel. Stormwater is treated by filtering first through the soil bed then flowing into an underdrain, which conveys treated runoff back to the conveyance system further downstream. The underdrain system consists of a perforated pipe within a gravel layer on the bottom of the swale. Dry swales may appear as simple grassed channels with the same shape and turf cover, while others may have more elaborate landscaping.

DESIGN PRINCIPLES

GEOMETRY AND SITE LAYOUT

- Shape: a parabolic shape is preferable for aesthetic, maintenance and hydraulic reasons.
- Bottom Width: for the trapezoidal cross section: between 0.75 and 2 m. For greater widths, bioretention or special bioretention (refer to LID 5,6) should be used
- Side Slopes: max 2:1.
- Swale Longitudinal Slope: moderately flat with a slope between 1% and 2% is recommended. Slopes of up to 4% can be utilized, if check dams are used. It should be wide enough for maintenance access .

PRE-TREATMENT

Enhanced pre-treatment seeks to capture and remove coarse sediment particles before they reach the filter bed to prevent premature clogging and prolong effective function of dry swales.

- Two-cell design (channel flow): Recommended forebay ponding volume should account for 25% of the water quality volume and be designed with a 2:1 length to width ratio.
- Grass filter strip (sheet flow): Min width:3m For smaller strips more frequent maintenance of the filter bed can be anticipated.
- Gravel diaphragm (sheet flow): At the end of pavement, perpendicular to the flow path.
- 50-150 millimeter drop (sheet flow): From a hard-edged surface into a gravel or stone diaphragm can be used to dissipate energy and promote settling.
- Rip rap and/or dense vegetation (channel flow): On small swales with min. 100 m^2 drainage area are acceptable.

CONVEYANCE AND OVERFLOW

Dry swales should be designed for a max velocity of 0.3 m/s for the water quality design storm. The swale should also convey the locally required design storm (usually the 10 year storm) at non-erosive velocities.

FILTER MEDIA AND UNDERDRAINS

The soil bed below the dry swale should have moderately permeable soil material with a high level of organic material. The soil bed depth should be 500 to 750mm with a gravel/pipe underdrain system. The min interface between the underdrain gravel and the underlying soil should be150mm. The recommended dry swale soil mixture should be 85 to 88% sand, 8 to 12% soil fines, and 3 to 5% organic matter.

LANDSCAPING

Grasses, herbaceous plants, or trees that can withstand both wet and dry periods. Relatively high velocity flows within the channel and along roads and parking lots which exhibit high salt tolerance should be chosen. Taller and denser grasses are preferable, though the species is less important than good stabilization.

OPERATIONS & MAINTENANCE REQUIREMENTS

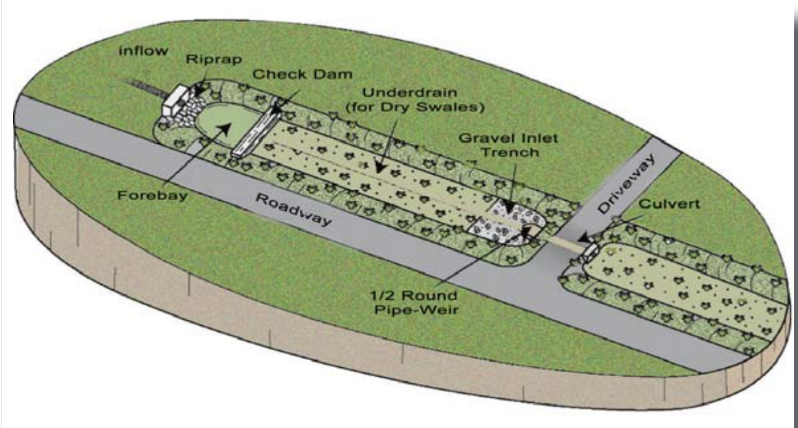
Operations such as sediment removal, spot re-vegetation, and inlet stabilization may be required. For the first 6 months following construction, the site should be inspected after each storm event greater than 10 mm, or a minimum of twice in the spring of each year. In 2-3 growing seasons the erosion and sediment control may be necessary.

ROUTINE MAINTENANCE AND OPERATION

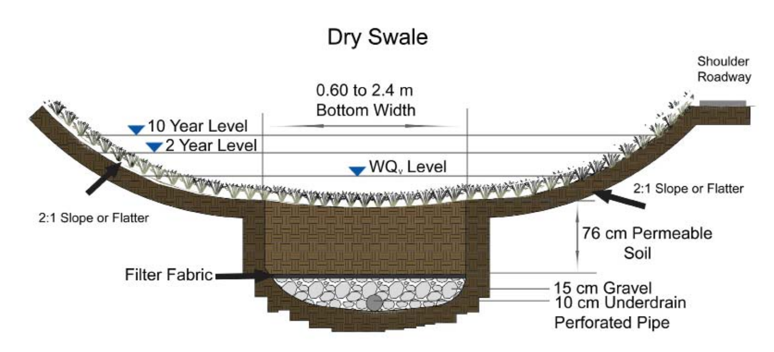
- Trash Removal: As needed.
- Pruning and Weeding : As needed.
- Mow grass to remove woody material: As needed
- Maintain minimum grass height of 150 mm: Weekly during first year
- Watering: Bi-weekly during second year (Apr - Oct). As needed based on rainfall.

ANNUAL INSPECTION AND MAINTENANCE

- A one year care and replacement warranty is required.
- Remove accumulated sand on the filter bed following snow melt.
- Check inflow points for clogging and remove any sediment.
- Inspect grass filter strips for erosion or gullies.
- Examine the drainage area for bare soil.



OVERVIEW



SECTION

STORMWATER FUNCTIONAL PERFORMANCE

	Water Balance	Water Quality	Geomorphic
Dry Swale	Possible Based on infiltration rates.	Yes	Possible Based on available storage volume and infiltration rates

GENERAL SPECIFICATIONS

Material	Specification	Quantity
Filter Media Composition	Filter Soil Mixtures to contain: • 85-88% sand • 8-12% soil fines • 3-5% organic matter in form of leaf compost	Volumetric computation based on surface area and depth used in design computation
Filter Media Testing	P-Index range 10-30 CECs greater than 10 Infiltration rate 25-50mm/hr	N/A
Mulch Layer	• Triple-shredded hardwood -min 75mm deep. • Erosion and sediment control matting - coconut fiber or equivalent where flow velocities dictate	-Mulch - volumetric based on surface area and mulch depth. -Matting - square metres based on surface area of filter bed.
Gravel	• Clean and free of all soil and fines, double-washed aggregate for underdrain. • 1 - 13 mm stone for top choker stone layer min 75mm deep • Granular A; 50 mm clear stone for bottom underdrain layer, min 300mm deep	Volumetric computation based on depth
Underdrain	• Perforated PVC or corrugated HDPE - 100mm dia. min • Set pipe invert above invert of underdrain stone layer-100mm. min	-Perforated pipe for length of bioretention cell. -Non-perforated pipe as needed to connect with storm drain system. -One or more caps. -T's as needed for underdrain configuration.
Check Dams	• Non-erosive material such as wood, gabions, riprap, or concrete. Underlain with filter fabric conforming to local design standards. • Wood: pressure treated logs or timbers, or water-resistant tree species such as cedar, hemlock, swamp oak or locust.	Computation of check dam material needed based on surface area and depth used in design computations.
Native Soil Infiltration Testing	Must exceed 25mm/hr.	One test per 10 m^2 of bioretention area.

CONSTRUCTION CONSIDERATIONS

Sites should remain outside the limit of disturbance until construction of the swale begins to prevent soil compaction by heavy equipment. Dry swale locations should never be used as the site of sediment basins during construction. To prevent sediment from clogging the surface of a dry swale, stormwater should be diverted away from the practice until the drainage area is fully stabilized. Three key steps should be emphasized:

-First: the contributing drainage area has been fully stabilized prior to construction.
-Second: elevations at driveway culverts and check dams should be checked for ponding depth
-Lastly: before bringing the swale “on line” the swale channel and side slopes should be rapidly stabilized with biodegradable geotextile blankets and seeding.

CONSTRUCTION INSPECTION

Common construction pitfalls can be avoided by careful construction supervision that focuses on the following aspects:

EROSION AND SEDIMENT CONTROL

- Dry swale locations should be blocked from construction traffic and should not be used for erosion and sediment control.
- Proper erosion & sediment controls required for the drainage area.

MATERIALS

- Gravel for the underdrain should be clean and washed; no fines should be present in the material.
- Underdrain pipe material should be perforated and of the correct size.

SITE CONSIDERATIONS

Available Space
Footprints about 5 to 15% of the size of the contributing drainage area
-Min segments between driveways in residential areas: 5 metres in length
-Overall swale length must be greater than overall culvert length.

Site Topography
Contributing Slopes- longitudinal slopes of max 4%.

Drainage Area & Runoff Volume
Max drainage area: 2 hectares

Soil
Confirm adequate soil permeability through onsite testing
For permeability rate less than 25mm/hr, underdrain is needed.

Head
An elevation drop is required between the inflow point and the downstream storm drain invert.

Hotspot Land Uses
Should not be used to treat run-off from hotspot areas. Impermeable liner should be used for filtration of hotspot runoff.

Setback from Buildings
If swale is not lined with an impermeable fabric: min. separation from building foundation - 4m

Setback from Utilities
Consult local utility for design guidance for horizontal and vertical clearance between storm drains, ditches, and surface water bodies

UNDERDRAIN AND FILTER MEDIA

•A cap should be placed on the upstream end of the underdrain.
•Filter media should be tested to confirm that it meets specifications.
•Mulch composition should be correct.
•Matting, if used, should be installed correctly, and durable enough to last at least 2 growing seasons.

ELEVATIONS

Check elevations of the following items:
•Depth of gravel & invert of the underdrain
•Inverts for inflow and outflow points
•Filter depth after media is placed
•Ponding depth between the surface of the filter bed and the overflow structure
•Mulch depth

LANDSCAPING AND STABILIZATION

•Correct vegetation should be planted.
•Pre-treatment area should be stabilized.
•Drainage area should be stabilized prior to directing water to the swale.

The following items should be checked after the first rainfall event:
•Sheet flow occurs as designed.
•Outfall protection/energy dissipation at concentrated inflow is stable.
•Flows do not concentrate within the swale
•Swale drains within the designed draw down time (24-48 hours).
•Sediment accumulation is nil.

ESTIMATED INSTALLATION COST

$30,000-105,000 / $50,OOOPer H treated

$300-900 / $500 Per m2

FUNCTIONAL PERFORMANCE

WATER BALANCE

WATER QUALITY

GEOMORPHIC

TARGETED POLLUTANTS

BACTERIA

TSS

HYDROCARBONS

METALS

NUTRIENTS

CVC/TRCA SWM DESIGN GUIDELINE MANUAL

DRY SWALES

CVC
Toronto and Region Conservation for The Living City

FACT SHEET

LID 12

CROSS REFERENCE: TRCA MANUAL, SECTION 3.6.12