4.4 Soakaways, Infiltration Trenches and Chambers

4.4.1 Overview

Description

On sites suitable for underground stormwater infiltration practices, there are a variety of facility design options to consider, such as soakaways, infiltration trenches and infiltration chambers.

Soakaways are rectangular or circular excavations lined with geotextile fabric and filled with clean granular stone or other void forming material, that receive runoff from a perforated pipe inlet and allow it to infiltrate into the native soil (Figures 4.4.1 and 4.4.3). They typically service individual lots and receive only roof and walkway runoff (City of Toronto, 2002; OMOE, 2003) but can also be designed to receive overflows from rainwater harvesting systems. Soakaways can also be referred to as infiltration galleries, dry wells or soakaway pits.

Infiltration trenches are rectangular trenches lined with geotextile fabric and filled with clean granular stone or other void forming material. Like soakaways, they typically service an individual lot and receive only roof and walkway runoff. This design variation on soakaways is well suited to sites where available space for infiltration is limited to narrow strips of land between buildings or properties, or along road rights-of-way (Figure 4.4.1). They can also be referred to as infiltration galleries or linear soakaways.

Figure 4.4.1 Construction of a soakaway in a residential subdivision and infiltration trenches in parkland settings

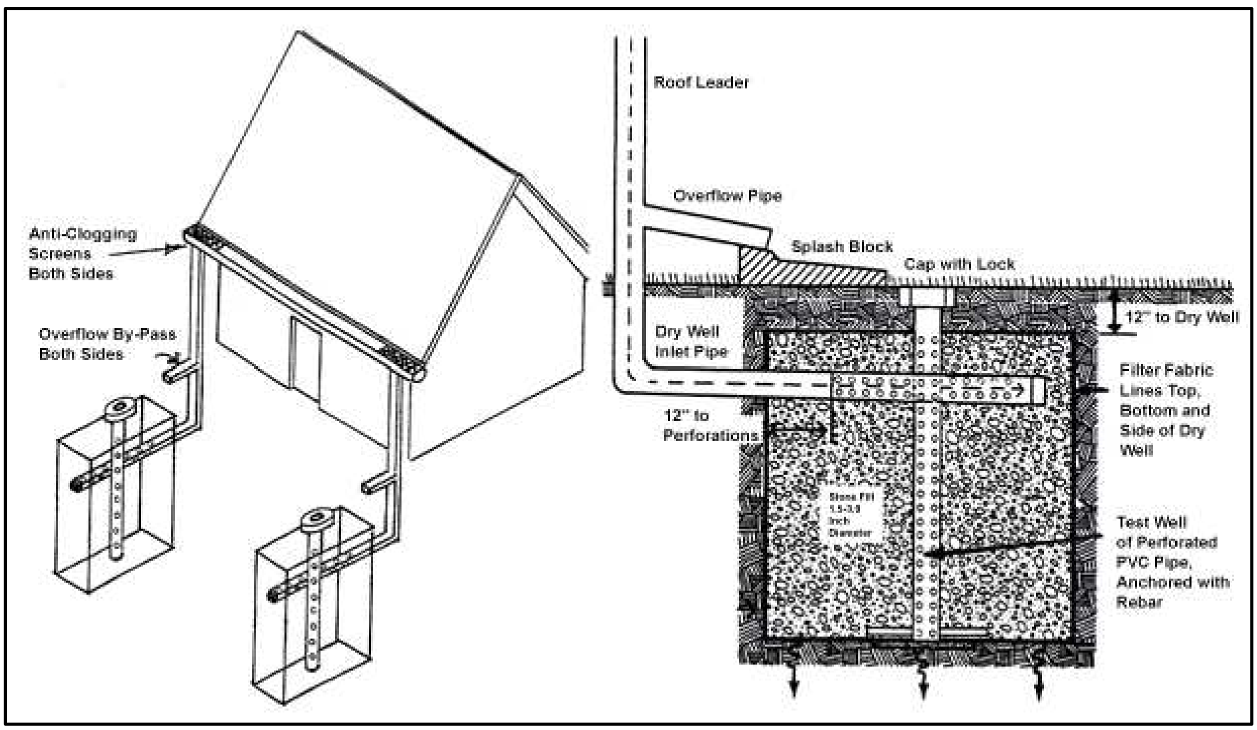
Source: Lanark Consultants (left); Cahill Associates (centre); North Dakota State University (right)

Infiltration chambers are another design variation on soakaways. They include a range of proprietary manufactured modular structures installed underground, typically under parking or landscaped areas that create large void spaces for temporary storage of stormwater runoff and allow it to infiltrate into the underlying native soil (Figure 4.4.2). Structures typically have open bottoms, perforated side walls and optional underlying granular stone reservoirs. They can be installed individually or in series in trench or bed configurations. They can infiltrate roof, walkway, parking lot and road runoff with adequate pretreatment. Due to the large volume of underground void space they create in comparison to a soakaway of the same dimensions, and the modular nature of their design, they are well suited to sites where available space for other types of BMPs is limited, or where it is desirable for the facility to have little or no surface footprint (*e.g.*, high density development contexts). They can also be referred to as infiltration tanks.

Figure 4.4.2 Infiltration chambers under construction in commercial developments

Source: StormTech (left); Cultech (right)

Figure 4.4.3 Schematic of a dry well soakaway



Common Concerns

There are several common concerns associated with the use of soakaways, infiltration trenches and infiltration chambers:

- *Risk of Groundwater Contamination*: Most pollutants in urban runoff are well retained by infiltration practices and soils and therefore, have a low to moderate potential for groundwater contamination (Pitt *et al.*, 1999). Chloride and sodium from de-icing salts applied to roads and parking areas during winter are not well attenuated in soil and can easily travel to shallow groundwater. Infiltration of de-icing salt constituents is also known to increase the mobility of certain heavy metals in soil (*e.g.*, lead, copper and cadmium), thereby raising the potential for elevated concentrations in underlying groundwater (Amrhein *et al.*, 1992; Bauske and Goetz, 1993). However, very few studies that have sampled groundwater below infiltration facilities or roadside ditches receiving de-icing salt laden runoff have found concentrations of heavy metals that exceed drinking water standards (*e.g.*, Howard and Beck, 1993; Granato *et al.*, 1995). To minimize risk of groundwater contamination the following management approaches are recommended (Pitt *et al*., 1999; TRCA, 2009b):

- stormwater infiltration practices should not receive runoff from high traffic areas where large amounts of de-icing salts are applied (*e.g.*, busy highways), nor from pollution hot spots (*e.g.*, source areas where land uses or activities have the potential to generate highly contaminated runoff such as vehicle fuelling, servicing or demolition areas, outdoor storage or handling areas for hazardous materials and some heavy industry sites);
- prioritize infiltration of runoff from source areas that are comparatively less contaminated such as roofs, low traffic roads and parking areas; and,
- apply sedimentation pretreatment practices (*e.g.*, oil and grit separators) before infiltration of road or parking area runoff;

- *Risk of Soil Contamination:* Available evidence from monitoring studies indicates that small distributed stormwater infiltration practices do not contaminate underlying soils, even after 10 years of operation (TRCA, 2008).

- *On Private Property:* If soakaways, infiltration trenches or infiltration chambers are installed on private lots, property owners or managers will need to be educated on their routine maintenance needs, understand the long-term maintenance plan, and be subject to a legally binding maintenance agreement. An incentive program such as a storm sewer user fee based on the area of impervious cover on a property that is directly connected to a storm sewer (*i.e.*, does not first drain to a pervious area or LID practice) could be used to encourage property owners or managers to maintain existing practices. Alternatively, infiltration practices could be located in an expanded road right-of-way or “stormwater easement” so that municipal staff can access the facility in the event it fails to function properly.

- *Standing Water and Mosquitoes:* The detention of water in a soakaway, infiltration trench or chamber should be solely underground.

- *Foundations and Seepage:* Soakaways, infiltration trenches and chambers should be set back at least four (4) metres from building foundations. Overflow pipes should discharge to pervious areas that are located at least 2 metres from building foundations and slope away from the building.

- *Winter Operation:* Soakaways, infiltration trenches and chambers will continue to function during winter months if the inlet pipe and top of the facility is located below the local maximum frost penetration depth (MTO, 2005).

Physical Suitability and Constraints
Key constraints for soakaways, infiltration trenches and chambers include:

- *Wellhead Protection:* Facilities receiving road or parking lot runoff should not be located within two (2) year time-of-travel wellhead protection areas.

- *Site Topography:* Facilities cannot be located on natural slopes greater than 15%.

- *Water Table:* The bottom of the facility should be vertically separated by one (1) metre from the seasonally high water table or top of bedrock elevation.

- *Soils:* Soakaways, infiltration trenches and chambers can be constructed over any soil type, but hydrologic soil group A or B soils are best for achieving water balance and channel erosion control objectives. If possible, facilities should be located in portions of the site with the highest native soil infiltration rates. Designers should verify the soil infiltration rate at the proposed location and depth through field measurement of hydraulic conductivity under field saturated conditions using the methods described in Appendix C.

- *Drainage Area:* Soakaways and infiltration trenches typically service individual lots and receive roof and walkway runoff only. Infiltration chambers can treat roof, walkway and low to medium traffic road or parking lot runoff with adequate sedimentation pretreatment. They can be designed with an impervious drainage area to treatment facility area ratio of between 5:1 and 20:1. A maximum ratio of 10:1 is recommended for facilities receiving road or parking lot runoff.

- *Pollution Hot Spot Runoff:* To protect groundwater from possible contamination, source areas where land uses or human activities have the potential to generate highly contaminated runoff (*e.g.*, vehicle fueling, servicing and demolition areas, outdoor storage and handling areas for hazardous materials and some heavy industry sites) should not be treated by soakaways, infiltration trenches or chambers.

- *Setbacks from Buildings*: Facilities should be setback a minimum of four (4) metres from building foundations.

- *Proximity to Underground Utilities:* Local utility design guidance should be consulted to define the horizontal and vertical offsets. Generally, requirements for underground utilities passing near the practice will be no different than for utilities in other pervious areas. However, the designer should consider the need for long term maintenance when locating infiltration facilities near other underground utilities.

Typical Performance

The ability of soakaways, infiltration trenches and infiltration chambers to help meet SWM objectives is summarized in Table 4.4.1.

Table 4.4.1 Ability of soakaways, infiltration trenches and chambers to meet SWM objectives

BMP	Water Balance Benefit	Water Quality Improvement	Stream Channel Erosion Control Benefit
Soakaways, Infiltration Trenches and Chambers	Yes	Yes	Partial - depends on soil infiltration rate

Water Balance

The degree to which the water balance objective is met will depend on the amount of runoff stored and infiltrated by the facility. Limited data are available on the runoff reduction capabilities of soakaways, infiltration trenches and chambers, although they are likely similar to perforated pipe systems (Table 4.4.2).

Table 4.4.2 Volumetric runoff reduction[1] achieved by infiltration trenches and perforated pipe systems

LID Practice	Location	Runoff Reduction[1]	Reference
Infiltration trench with underdrain	Virginia	60%	Schueler (1983)
Grass swale/ Perforated pipe system	Ontario	73%	J.F. Sabourin and Associates (2008a)
Grass swale/ Perforated pipe system	Ontario	86%	J.F. Sabourin and Associates (2008a)
Perforated pipe system	Ontario	95%	SWAMP (2005)
Perforated pipe system	Ontario	89%	SWAMP (2005)
Runoff Reduction Estimate[2]		**85%**	

Notes:

1. Runoff reduction estimates are based on differences in runoff volume between the practice and a conventional impervious surface over the period of monitoring.
2. This estimate is provided only for the purpose of initial screening of LID practices suitable for achieving stormwater management objectives and targets. Performance of individual facilities will vary depending on site specific contexts and facility design parameters and should be estimated as part of the design process and submitted with other documentation for review by the approval authority.

Water Quality – Pollutant Removal Capacity

Performance results from a limited number of field studies indicate that subsurface stormwater infiltration practices are effective BMPs for pollutant removal (TRCA, 2009b). These types of practices provide effective removal for many pollutants as a result of sedimentation, filtering, and soil adsorption. It is also important to note that there is a relationship between the water balance and water quality functions. If an infiltration practice infiltrates and evaporates 100% of the runoff from a site, then there is essentially no pollution leaving the site in surface runoff. Furthermore, treatment of infiltrated runoff continues to occur as it leaves the facility and moves through the native soil. The performance of soakaways, infiltration trenches and chambers would be expected to reduce pollutants in runoff in a manner similar to perforated pipe systems. Table 4.4.3 summarizes pollutant removal results from performance studies of soakaways, infiltration trenches and perforated pipe systems.

Table 4.4.3 Pollutant removal efficiencies[1] for soakaways, infiltration trenches and perforated pipe systems (in percent)

BMP	Reference	Location	Lead	Copper	Zinc	TSS[2]	TP[3]	TKN[4]
Soakaway	Barraud *et al*. (1999)	Valence, France	98	NT	54 to 88	NT	NT	NT
Infiltration trench	ASCE (2000)[5]	Various	70 to 90	70 to 90	70 to 90	70 to 90	50 to 70	40 to 70
Grass swale/ perforated pipe system	SWAMP (2002)	North York, Ontario	75	96	93	24	84	84
Grass swale/ perforated pipe system	J.F. Sabourin & Associates (2008a)	Nepean, Ontario	>99[6]	66	0	81	81	72
Grass swale/ perforated pipe system	J.F. Sabourin & Associates (2008a)	Nepean, Ontario	>99[6]	>99[6]	90	96	93	93

Notes:

NT = not tested

1. Pollutant removal efficiency refers to the pollutant load reduction from the inflow to the outflow (from an underdrain) of the practice, over the period of monitoring and are reported as percentages).
2. Total suspended solids (TSS)
3. Total phosphorus (TP)
4. Total Kjeldahl nitrogen (TKN)
5. Pollutant removal efficiencies are reported as ranges because they are based on a synthesis of several performance monitoring studies that were available as of 2000.
6. Concentrations at the outlet were below the detection limit.

Stream Channel Erosion Control

While soakaways and infiltration trenches are not specifically designed to store the channel erosion control volume, their ability to reduce runoff volume should help protect downstream channels from erosion. Recent research on the performance of an infiltration chamber system installed at the University of New Hampshire has shown a mean annual peak flow reduction of 87% over a two year monitoring period (Roseen *et al.,* 2009), indicating that such facilities can provide significant downstream erosion control benefits.

4.4.2 Design Template

Applications

Soakaways and infiltration trenches are typically applied to capture and treat roof and walkway runoff from residential lots, but can also be designed for other types of development sites. Infiltration chambers can treat roof, walkway, parking lot and low to medium traffic road runoff with adequate pretreatment. Each practice serves a relatively small drainage area, such as a single roof, parking lot or road. Infiltration chambers have greater storage volumes than soakaways or trenches of the same dimensions and may receive runoff from larger or multiple source areas. Because the majority of components associated with these facilities are located underground, they have a very small surface footprint, which makes them highly suited to high density development contexts (*i.e.*, ultra urban areas). Other components of a development site, such as parking lots, parks, or sports fields can be located on top of the facilities, thereby helping to conserve highly valued developable land.

Typical Details
Typical details of soakaways, infiltration trenches and chambers are provided in Figures 4.4.4 to 4.4.6. Planners should also refer to Figures 4.5 and 4.6 in the OMOE *Stormwater Management Planning and Design Manual* (OMOE, 2003).

Design Guidance

Geometry and Site Layout
Soakaways and infiltration chambers can be designed in a variety of shapes, while infiltration trenches are typically rectangular excavations with a bottom width generally between 600 and 2400 mm (GVRD, 2005). Facilities should have level or nearly level bed bottoms.

Pretreatment
It is important to prevent sediment and debris from entering infiltration facilities because they could contribute to clogging and failure of the system. The following pretreatment devices are options:

- *Leaf Screens:* Leaf screens are mesh screens installed either on the building eavestroughs or roof downspouts and are used to remove leaves and other large debris from roof runoff. Leaf screens must be regularly cleaned to be effective; if not maintained, they can become clogged and prevent rainwater from flowing into the facility.

- *In-ground filters*: Filters placed between a conveyance pipe and the facility (*e.g.*, oil and grit separators, sedimentation chamber or sump), that can be designed to remove both large and fine particulate from runoff. A number of proprietary stormwater filter designs are available. Like leaf screens, they require regular cleaning to ensure they do not become clogged.

- *Vegetated filter strips or grass swales:* Road and parking lot runoff can be pretreated with vegetated filter strips or grass swales prior to entering the infiltration practice. The swale could be designed as a simple grass channel, an enhanced grass swale (section 4.8) or dry swale (section 4.9).

Figure 4.4.4 Roundabout island soakaway

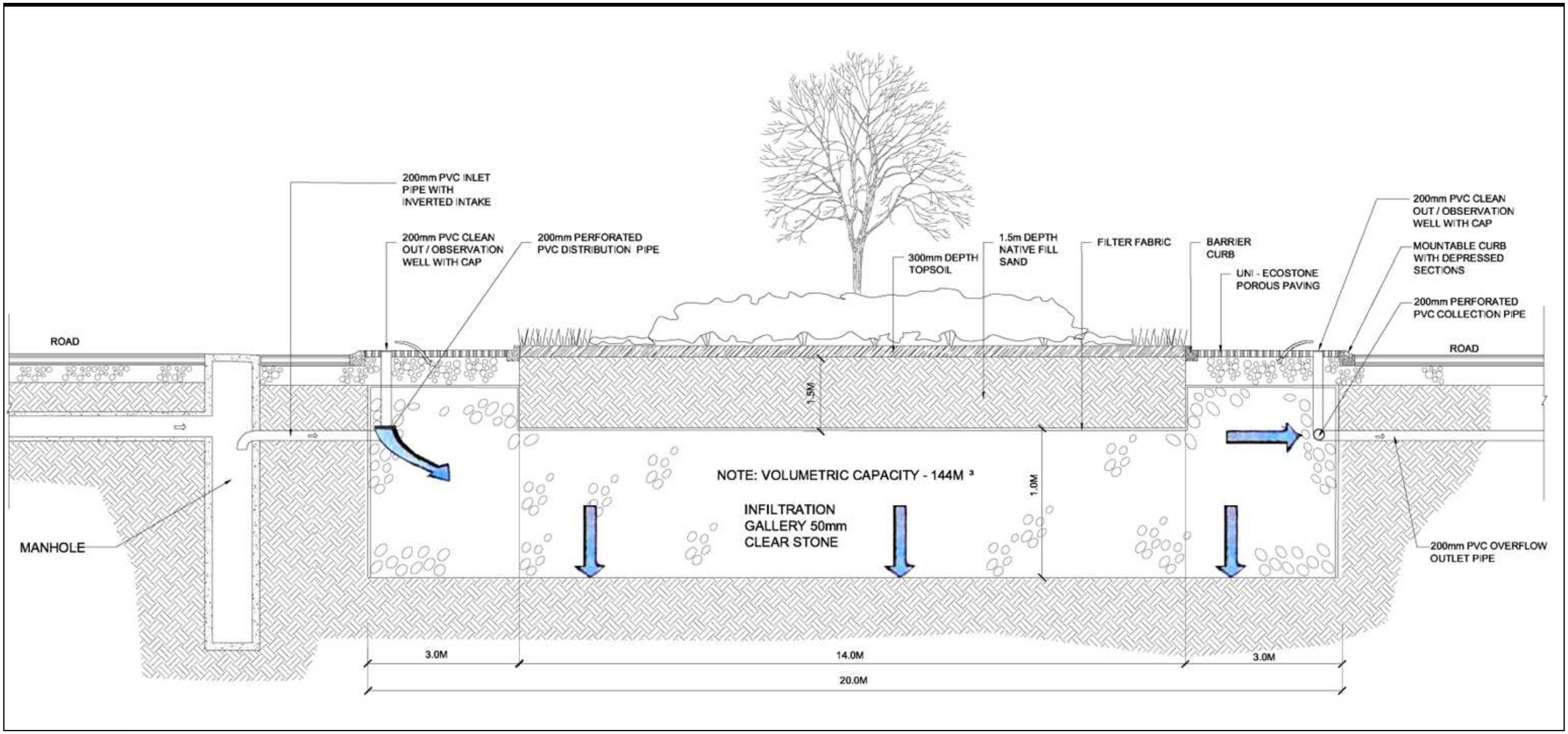


Figure 4.4.5 Plan view of an infiltration trench below a laneway

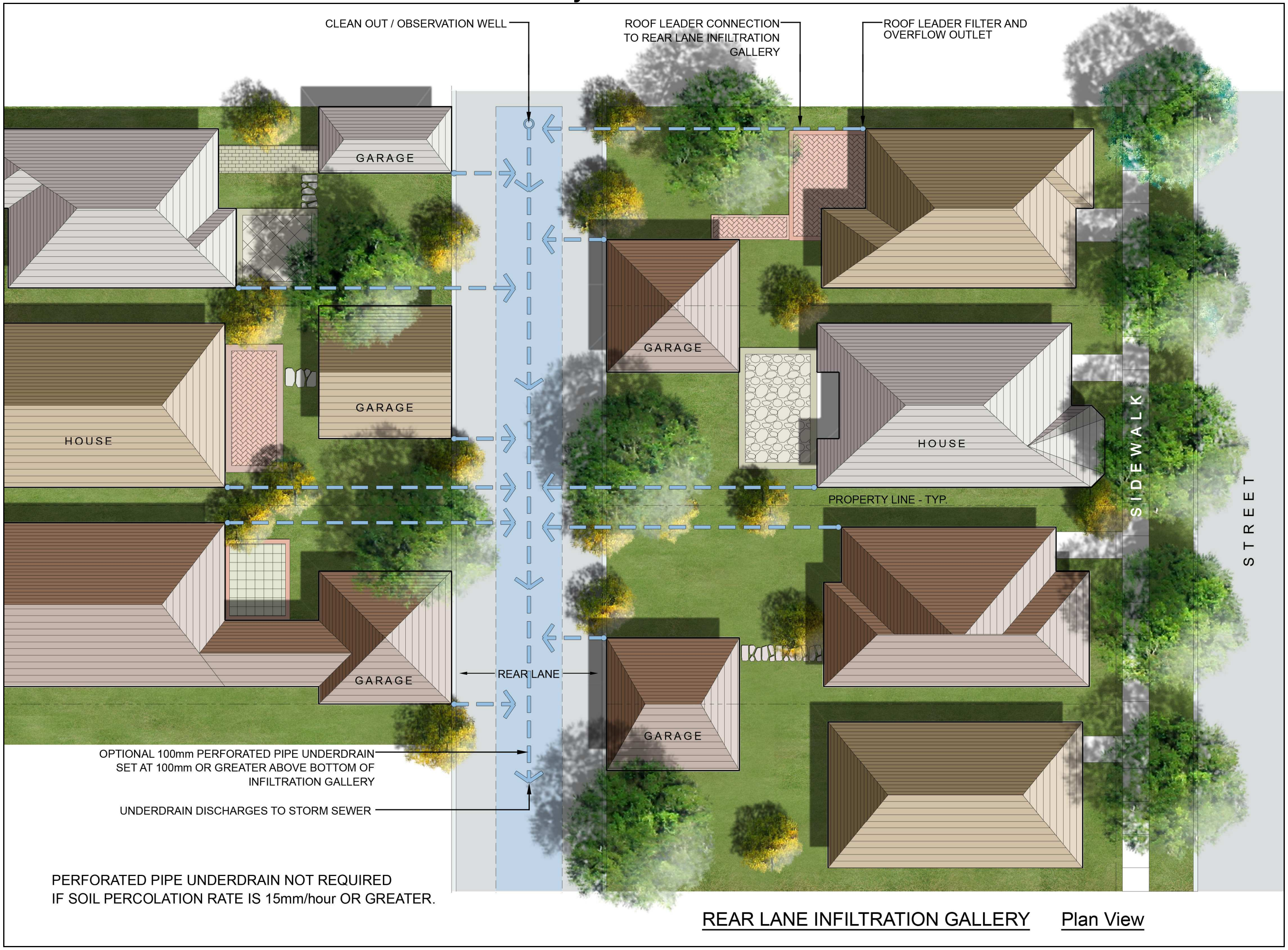


Figure 4.4.6 Cross section of an infiltration trench system below a laneway

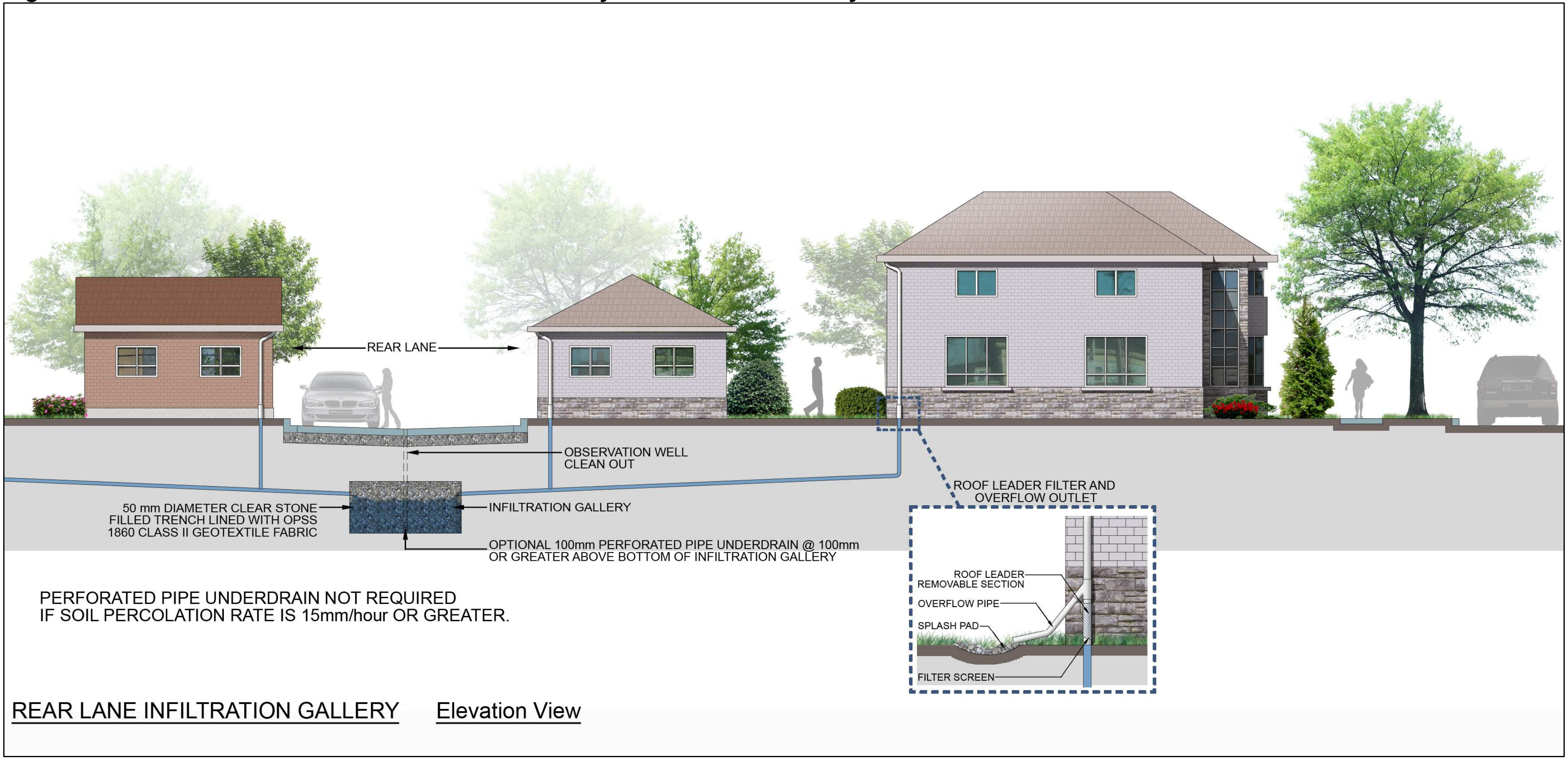


Figure 4.4.7 Schematic of an infiltration chamber system below a parking lot

INFILTRATION CHAMBER SYSTEM BELOW A PARKING LOT

Conveyance and Overflow
Inlet pipes to soakaways and infiltration trenches are typically perforated pipe connected to a standard non-perforated pipe or eavestrough that conveys runoff from the source area to the facility. The inlet and overflow outlet to the facility should be installed below the maximum frost penetration depth to prevent freezing (MTO, 2005). The overflow outlet can simply be the perforated pipe inlet that backs up when the facility is at capacity and discharges to a splash pad and pervious area at grade (OMOE, 2003) or can be a pipe that is at or near the top of the gravel layer and is connected to a storm sewer. Outlet pipes must have capacity equal to or greater than the inlet.

Monitoring Wells
Capped vertical non-perforated pipes connected to the inlet and outlet pipes are recommended to provide a means of inspecting and flushing them out as part of routine maintenance. A capped vertical standpipe consisting of an anchored 100 to 150 millimetre diameter perforated pipe with a lockable cap installed to the bottom of the facility is also recommended for monitoring the length of time required to fully drain the facility between storms. Manholes and inspection ports should be installed in infiltration chambers to provide access for monitoring and maintenance activities.

Filter Media

- *Stone reservoir*: Soakaways and infiltration trenches should be filled with uniformly-graded, washed stone that provides 30 to 40% void space. Granular material should be 50 mm clear stone.

- *Geotextile:* A non-woven needle punched, or woven monofilament geotextile fabric should be installed around the stone reservoir of soakaways and infiltration trenches with a minimum overlap at the top of 300 mm. Woven slit film and non-woven heat bonded fabrics should not be used as they are prone to clogging. The primary function of the geotextile is separation between two dissimilar soils. When a finer grained soil overlies a coarser grained soil or aggregate layer (*e.g.*, stone reservoir), the geotextile prevents clogging of the void spaces from downward migration of soil particles. When a coarser grained aggregate layer (*e.g.*, stone reservoir) overlies a finer grained native soil, the geotextile prevents slumping from downward migration of the aggregate into the underlying soil. Geotextile may also enhance the capacity of the facility to reduce petroleum hydrocarbons in runoff, as microbial communities responsible for their decomposition tend to concentrate in geotextile fabrics (Newman *et al.*, 2006a). Specification of geotextile fabrics in soakaways and infiltration trenches should consider the apparent opening size (AOS) for non-woven fabrics, or percent open area (POA) for woven fabrics, which affect the long term ability to maintain water flow. Other factors that need consideration include maximum forces to be exerted on the fabric, and the load bearing ratio, texture (*i.e.*, grain size distribution) and permeability of the native soil in which they will be installed. Table 4.4.4 provides further detail regarding geotextile specifications.

Other Design Resources

Several other manuals that provide useful design guidance for soakaways, infiltration trenches and infiltration chambers are:

Ontario Ministry of the Environment (OMOE). 2003. Stormwater Management Planning and Design Manual. Toronto, Ontario.

Center for Watershed Protection (CWP). 2007b. Urban Stormwater Retrofit Manual. Ellicott City, MD.

Greater Vancouver Regional District (GVRD). 2005. Stormwater Source Control Guidelines 2005.

New York State Stormwater Management Design Manual. http://www.dec.ny.gov/chemical/29072.html

Pennsylvania Department of Environmental Protection (PDEP). 2006. Stormwater Best Management Practices Manual.

BMP Sizing

The depth of the soakaway or infiltration trench is dependent on the native soil infiltration rate, porosity (void space ratio) of the gravel storage layer media (i.e, aggregate material used in the stone reservoir) and the targeted time period to achieve complete drainage between storm events. The maximum allowable depth of the stone reservoir for designs without an underdrain can be calculated using the following equation:

$$d_{r\ max} = i * t_s / V_r$$

Where:

$d_{r\ max}$ = Maximum stone reservoir depth (mm)
i = Infiltration rate for native soils (mm/hr)
V_r = Void space ratio for aggregate used (typically 0.4 for 50 mm clear stone)
t_s = Time to drain (design for 48 hour time to drain is recommended)

The value for native soil infiltration rate (i) used in the above equation should be the design infiltration rate that incorporates a safety correction factor based on the ratio of the mean value at the proposed bottom elevation of the practice to the mean value in the least permeable soil horizon within 1.5 metres of the proposed bottom elevation (see Appendix C, Table C2). On highly permeable soils (e.g., infiltration rate of 45 mm/hr or greater), a maximum stone reservoir depth of 2 metres is recommended to prevent soil compaction and loss of permeability from the mass of overlying stone and stored water.

For designs that include an underdrain, the above equation can be used to determine the maximum depth of the stone reservoir below the invert of the underdrain pipe.

Once the depth of the stone reservoir is determined the water quality volume, computed using the methods in the relevant CVC and TRCA stormwater management criteria documents (CVC, 2010; TRCA, 2010), can be used to determine the footprint needed using the following equation:

$A_f = WQV / (d_r * V_r)$

Where:

A_f = Footprint surface area (m^2)
WQV = Water quality volume (m^3)
d_r = Stone reservoir depth (m)
V_r = Void space ratio for aggregate used (typically 0.4 for 50 mm clear stone)

The ratio of impervious drainage area to footprint surface area of the practice should be between 5:1 and 20:1 to limit the rate of accumulation of fine sediments and thereby prevent clogging.

Design Specifications

Recommended design specifications for soakaways and infiltration trenches are provided in Table 4.4.4 below. Infiltration chambers are typically proprietary designs with material specifications provided by the manufacturers.

Table 4.4.4 Design specifications for soakaways and infiltration trenches

Component	Specification	Quantity
Inlet/Overflow Pipe	Pipe should be continuously perforated, smooth interior, HDPE or equivalent material, with a minimum inside diameter of 100 millimetres.	Perforated pipe inlet/outlet should run lengthwise through the facility. Non-perforated pipe should be used for conveyance to the facility.
Stone	The facility should be filled with 50 mm clear stone with a 40% void ratio.	Volume of the facility is calculated by method in the previous section of this guide.
Geotextile	Material specifications should conform to Ontario Provincial Standard Specification (OPSS) 1860 for Class II geotextile fabrics. Should be woven monofilament or non-woven needle punched fabrics. Woven slit film and non-woven heat bonded fabrics should not be used as they are prone to clogging. Primary considerations are: - Suitable apparent opening size (AOS) for non-woven fabrics, or percent open area (POA) for woven fabrics, to maintain water flow even with sediment and microbial film build-up; - Maximum forces that will be exerted on the fabric (*i.e.*, what tensile, tear and	Based on the volume of the facility.

Component	Specification	Quantity
	puncture strength ratings are required?); - Load bearing ratio of the underlying native soil (*i.e.*, is geotextile needed to prevent downward migration of aggregate into the native soil?); - Texture (*i.e.*, grain size distribution) of the overlying native soil, filter media soil or aggregate material; and - Permeability of the native soil. The following geotextile fabric selection criteria are suggested (adapted from AASHTO, 2002; Smith, 2006; and U.S. Dept. of Defense, 2004): <u>Apparent Opening Size (AOS; max. average roll value) or Percent Open Area (POA)</u> For fine grained soils with more than 85% of particles smaller than 0.075 mm (passing a No. 200 sieve): AOS ≤ 0.3 mm (non-woven fabrics) For fine grained soils with 50 to 85% of particles smaller than 0.075 mm (passing a No. 200 sieve): AOS ≤ 0.3 mm (non-woven fabrics) POA ≥ 4% (woven fabrics) For coarser grained soils with 5 to 50% of particles smaller than 0.075 mm (passing a No. 200 sieve): AOS ≤ 0.6 mm (non-woven fabrics) POA ≥ 4% (woven fabrics) For coarse grained soils with less than 5% of particles smaller than 0.075 mm (passing a No. 200 sieve): AOS ≤ 0.6 mm (non-woven fabrics) POA ≥ 10% (woven fabrics) <u>Hydraulic Conductivity (k, in cm/sec)</u> k (fabric) > k (soil) <u>Permittivity (in sec^{-1})</u> Where, Permittivity = k (fabric)/thickness (fabric): For fine grained soils with more than 50% of particles smaller than 0.075 mm (passing a No. 200 sieve), Permittivity should be 0.1 sec^{-1}	

Component	Specification	Quantity
	For coarser grained soils with 15 to 50% of particles smaller than 0.075 mm (passing a No. 200 sieve), Permittivity should be 0.2 sec^{-1}. For coarse grained soil with less than 15% of particles smaller than 0.075 mm (passing a No. 200 sieve), Permittivity should be 0.5 sec^{-1}.	

Construction Considerations

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

- *Soil Disturbance and Compaction:* Before site work begins, locations of facilities should be clearly marked. Only vehicular traffic used for construction of the infiltration facility should be allowed close to the facility location.

- *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 facility location. After the site is vegetated, erosion and sediment control structures can be removed (PWD, 2007).

Infiltration facilities are particularly vulnerable to failure during the construction phase for two reasons. First, if the construction sequence is not followed correctly, construction sediment can clog the pit. In addition, heavy construction can result in compaction of the soil, which can then reduce the soil's infiltration rate. For this reason, a careful construction sequence needs to be followed. This includes:

1. Heavy equipment and traffic should avoid traveling over the proposed location of the facility to minimize compaction of the soil.

2. Facilities should be kept "off-line" until construction is complete. They should never serve as a sediment control device during site construction. Sediment should be prevented from entering the infiltration facility using super silt fence, diversion berms or other means

3. Upland drainage areas need to be properly stabilized with a thick layer of vegetation, particularly immediately following construction, to reduce sediment loads.

4. The facility should be excavated to design dimensions from the side using a backhoe or excavator. The base of the facility should be level or nearly level.

5. The bottom of the facility should be scarified to improve infiltration. An optional 150 mm of sand could be spread for the bottom filter layer. The monitoring well should be anchored and stone should be added to the facility in 0.3 metre lifts.

6. Geotextile fabric should be correctly installed in the soakaway or infiltration trench excavation. Large tree roots should be trimmed flush with the sides of the facility to prevent puncturing or tearing of the fabric during subsequent installation procedures. When laying out the geotextile, the width should include sufficient material to compensate for perimeter irregularities in the facility and for a 150 mm minimum top overlap. Voids may occur between the fabric and the excavated sides of the facility. Natural soils should be placed in any voids to ensure fabric conformity to the excavation sides.

4.4.3 Maintenance and Construction Costs

Inspection and Maintenance

As with all infiltration practices, these facilities require regular inspection to ensure they continue to function. Maintenance typically consists of cleaning out leaves, debris and accumulated sediment caught in pretreatment devices, inlets and outlets annually or as needed. Inspection via an monitoring well should be performed to ensure the facility drains within the maximum acceptable length of time (typically 72 hours) at least annually and following every major storm event (>25 mm). If the time required to fully drain exceeds 72 hours, drain via pumping and clean out the perforated pipe underdrain, if present. If slow drainage persists, the system may need removal and replacement of granular material and/or geotextile fabric (PDEP, 2006). The expected lifespan of infiltration practices is not well understood, however, it can be expected that it will vary depending on pretreatment practice maintenance frequency, and the sediment texture and load coming from the catchment. Soakaways have been observed to continue to function well after more than 30 years of operation (Barraud *et al*., 1999; Norrström, 2005).

Installation and Operation Costs

Very limited information is available regarding construction costs for soakaways, infiltration trenches and infiltration chambers. Due to similarities in design, soakaways and infiltration trench construction costs are likely comparable to those for bioretention systems. In a study by the Center for Watershed Protection to estimate and compare construction costs for various stormwater BMPs, the median base construction cost for bioretention was estimated to be $62,765 (2006 USD) per impervious hectare treated with estimates ranging from $49,175 to $103,165 (CWP, 2007b). These estimates do not include design and engineering costs, which could range from 5 to 40% of the base construction cost (CWP, 2007b).

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