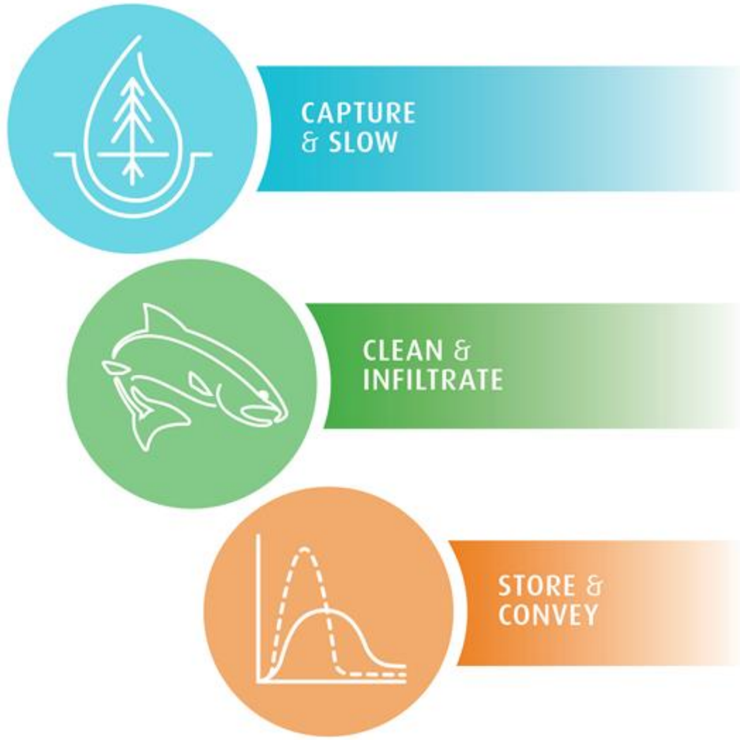

APPENDIX L – INFILTRATION TRENCH & SOAKAWAY MANHOLE

Green Stormwater Infrastructure Design Guidelines for the Capital Region

SPRING 2019

Infiltration Trench & Soakaway Manhole[1]

Description

An infiltration trench system includes an inlet pipe or water source, catch basin sump, perforated distribution pipe, infiltration trench and overflow to the storm drainage system. Although commonly in a linear trench shape, the same principles apply to underground drain rock infiltration devices of any shape. Other common terms used are rock trench or rock pit.

A soakaway manhole system includes an inlet pipe, a sedimentation manhole, and 1 or more soakaway manholes with connecting pipes.

Other common terms used are infiltration sump, dry well, or infiltration shaft.

Figure 1 Infiltration facility at University of Victoria

These GSI facilities allow the runoff to infiltrate into the native soil. They typically service individual lots and receive only roof and walk-way runoff. They are typically designed for a frequent, small storm such as a 1-yr event. These GSI facilities have limited capabilities for controlling the peak discharge from storms greater than the design storm. They are best used in conjunction with other GSI facilities to manage the peak discharges of runoff. Performance of these GSI facilities are based on the available soil infiltration capabilities at the site in question. These GSI facilities are suitable for small sites (area <2 acres).

Selection and Application

- Infiltration trenches are often used to allow roof runoff to soak away into the ground. With water quality pre-treatment, they can be used for infiltration of other surface waters. Although ideally located under surface soils that will allow some evaporation, there are applications where an infiltration trench can be installed under pavement, provided that the structural design of the pavement is appropriate for this use.
- Suitable for clean, unpolluted runoff from many development situations – residential areas, municipal office complexes, rooftop runoff, parks and greenspace, golf courses (Stephens et al., 2002).
- In order to protect the groundwater they are not suited for parking and heavy traffic roadway runoff unless installed in conjunction with water quality pre-treatment designed to remove hydrocarbons and heavy metals.

[1] **Adapted with permission from Metro Vancouver.**
Original document: Metro Vancouver's Stormwater Source Control Design Guidelines 2012, primary author Kerr Wood Leidal Associates Ltd. with Lanarc Consultants Ltd and Goya Ngan, http://www.metrovancouver.org/services/liquid-waste/LiquidWastePublications/StormwaterSourceControlDesignGuidelines2012StormwaterSourceControlDesignGuidelines2012.pdf
Adaptations authored by: Opus International Consultants (Canada) Limited
Design guidelines drawings by: Kerr Wood Leidal Associates Ltd

- An infiltration trench does not itself provide treatment; for any situation where treatment is necessary, such as runoff from vehicle-accessible surfaces, an infiltration rain garden should be considered.
- Provision of underground overflow allows use of the technique in most soils, including clay with infiltration rates as low as 0.6 mm/hr.
- Due to the low infiltration rates and high rainfall common across the CRD, an infiltration trench will generally be more space-efficient for meeting volume capture targets for development. For small impervious areas, a soakaway manhole may be more appropriate.
- Soakaway manholes do not provide a large benefit, so are often used in conjunction with other GSI facilities.
- It is recommended to follow minimum setback requirements per the municipality/provincial guidelines to avoid slope failure issues, damage to the nearest structure and possibility of polluting the existing water wells, etc. If steep slopes or drinking water wells exist within 200 m horizontally from the proposed infiltration trench or soakaway manhole, provide a hydro-geotechnical report to analyze site-specific risks and determine setbacks. Guidelines for setbacks to steep slopes are 60 m from the tops of slopes more than 3 m high and steeper than 2h:1v. Setbacks to drinking water wells should at least equal the BC Ministry of Health minimum setback from well to septic field (30 m at time of writing).

Table 1 Infiltration Trench & Soakaway Manhole Setbacks

Consideration for Setbacks From	***Distance (m)**
Up-gradient of building foundations	Site dependent, 3 m minimum
Property Line	Site dependent, 1.2 m minimum
Drinking Water Well	Site dependent, 30 m minimum
Up-gradient of septic field	Site dependent
Seasonal High Water Table	Site dependent
Up-gradient Active of inactive landfill or contaminated site	Site dependent
Up-gradient of steep (>15%) slope	Site dependent, 200 m minimum

*or as directed by a Qualified Professional

Design Guidelines

Infiltration Trench System:

1. Detailed design requirements should be evaluated for each individual application based on site-specific constraints and objectives.
2. Follow all applicable federal, provincial and municipal regulations.
3. Geo-technical investigations are recommended with soil permeability testing being the minimum requirement for design. Advice from a professional engineer for design is recommended.
4. Partial Infiltration with flow restrictor – designed with a perforated pipe and flow restrictor located at the bottom of the drain rock reservoir. A small orifice in the flow restrictor allows the gradual decanting of water

above the perforated pipe, with infiltration occurring as much as possible. These systems are essentially underground detention systems, and are used in cases where the underlying soil has low permeability or there is high water table. This type of design is generally not needed if only upstream paved area is discharged to pervious paving at a ratio of 2:1 or less, but could be used if roof water is discharged to permeable paving at more than 2:1 I/P ratio.

5. Locate infiltration trench at least 3 m from any building, 1.2 m from property lines, and 6 m from adjacent infiltration facilities (or as recommended by local bylaws or a geotechnical engineer).
6. If any surface water is to enter the system, provide pre-treatment and upstream erosion control to avoid sedimentation in the infiltration trench. Provide non-erodible material and sediment cleanout basins at point-source inlets.
7. To avoid groundwater pollution, do not direct un-treated polluted runoff to infiltration trench or soakaway manhole:
   - Direct clean runoff (roof, non-vehicle paving) to infiltration trench or soakaway manhole.
   - For polluted runoff (roads, parking areas, other pollution sources), provide upstream source control (rain garden or infiltration swale) for pollutant reduction prior to release to infiltration trench or soakaway manhole.
8. Identify pollutant sources other than vehicles, particularly in industrial/commercial hotspots, that require pre-treatment or source control upstream of this GSI facility.
9. Sump: A concrete, plastic, or other non-degradable box with strength suitable to withstand surface loads. Provide a lid for periodic inspection and cleanout. Include a T-inlet pipe to trap oils, sediments and debris. Weep holes may be included to dewater the sump, for mosquito management.
10. Perforated distribution pipe and bottom of drain rock to be installed level. If more than 1 section of infiltration trench is required, design so that underground water is temporarily 'ponded' in each infiltration section, using underground weirs of undisturbed native material or constructed ditch blocks designed to create underground pooling in the reservoir sufficient for infiltration performance.
11. Separation from base of drain rock reservoir to water table should be a minimum of 600 mm.
12. Infiltration trench bottom width is not restricted to but is generally between 600 mm and 2,400 mm.
13. A minimum drainage time of 6 hrs should be provided to ensure satisfactory pollutant removal. The trench should drain prior to the next storm event. The drainage time will depend on the average time between storm events.
14. Install the infiltration trench in native ground, and avoid over-compaction of the trench sides and bottom, which reduces infiltration. Base of trench should be scarified to a minimum of 150 mm prior to installation of the rock reservoir material.
15. Observation well for each infiltration trench (optional, but recommended to allow monitoring of water depth in the reservoir): vertical standpipe, with perforated sides, and locking lid.

16. A bypass or overflow must be included in the facility design to accommodate flows in excess of the design infiltration volume.
17. Avoid utility or other crossings of the infiltration trench. Where utility trenches must be constructed crossing below the infiltration trench, install trench dams to avoid infiltration water following the utility trench.
18. A typical infiltration trench has a simple overflow to the storm system. In areas where native soil infiltration is poor, a partial-infiltration rock trench may be used to achieve increased capture of runoff. This design will separate the perforated inflow pipe and perforated outflow pipe such that a layer of storage is rock is provided between the inflow and outflow elevations. The outflow pipe will connect to a control structure in a catch basin that provides overflow while maintaining a slow decanting of the water in the rock trench between storms.

Soakaway Manhole System:

1. Detailed design requirements should be evaluated for each individual application based on site-specific constraints and objectives.
2. Follow all applicable federal, provincial and municipal regulations.
3. Provide a report from a geotechnical engineer including on-site test data of infiltration rates at the depth of the proposed infiltration. The bottom of the soakaway manhole shall be at least 600 mm above the seasonal high water table or bedrock, or as recommended by the engineer.
4. Provide a sedimentation manhole, and a maximum of 2 soakaway manholes in series, unless otherwise approved. Minimum distance between soakaway manholes shall be 8 m.
5. Provide an overflow from soakaway manhole to the storm drainage system or major storm flow path.
6. Size the soakaway manhole system by continuous flow modelling.

Infiltration Trench Sizing

Sizing methods are presented here for the infiltration trench, but not the soakaway manhole.

In this guide, a simplified sizing approach has been developed that does not require water balance modelling or continuous simulation.

1. For this approach, the infiltration trench is assumed to be a rectilinear underground facility defined by a base area which is the same as the footprint, and a depth of rock in the trench. Depth of cover over the rock trench is not considered or accounted for.
2. In general, the infiltration trench is sized based on the upstream impervious area that it serves. Similar to the rain garden, this relationship can be defined by the ratio of impervious area to pervious area (e.g., I/P ratio). For the simplified sizing approaches here, this represents the ratio of upstream impervious area (also called catchment area) to base area (bottom area) of the infiltration trench. I/P ratio to achieve the target capture criteria will be calculated by the 2 sizing methods below.

3. Sizing presented here is for infiltration of rainwater for "capture" and prevention of site runoff. No sizing and design is provided for any required pre-treatment facility.

Sizing for Depth Capture Criteria: R mm in 24 hrs

See Appendix A, Table 1 to determine R mm of rain in 24 hrs for area-specific GSI facility rainfall capture targets – confirm with respective municipality.

1. Determine the maximum rock depth according to the drain time (4 days max.) and round down to the nearest 50 mm increment for constructability; standard depth range used in this sizing guidance is 300 mm to 2,000 mm:

$$D_R = \frac{Ks \times T \times 24}{n}$$

Where:
D_R = Depth (thickness) of rock in trench (mm)
Ks = Saturated hydraulic conductivity of subsurface soil (mm/hr), as measured during winter saturated soil conditions
T = allowable drain time (days)
n = porosity of drain rock in reservoir (unitless, e.g., 0.35)

2. Use the following equation to determine the base (bottom) area of rock trench required by finding the I/P ratio for the site:

$$I / P = \frac{24 \times Ks + D_R \times n}{R} - 1$$

Where:
I/P = Ratio of impervious tributary area to rock trench base area (unitless)
R = Rainfall capture depth (mm)
Ks = Saturated hydraulic conductivity of subsurface soil (mm/hr), as measured during winter saturated soil conditions
D_R = Depth (thickness) of rock reservoir (mm)
n = porosity of drain rock in reservoir (unitless, e.g., 0.35)

3. To find the rock trench base area:

$$BaseArea = \frac{\text{Impervious Tributary Area}}{I / P}$$

4. If the site cannot accommodate the I/P ratio required to provide the target capture, a partial-infiltration rock trench with flow restrictor design may be used.

5. A 0.25 L/s/ha (or 0.09 mm/hr) unit discharge may be recommended for the flow restrictor at the downstream end of the swale underdrain.

6. Calculate the allowable discharge through the orifice:

$$Q = \frac{0.25 \times A_{SITE}}{1000}$$

Where:
Q = Allowable discharge through orifice (m^3/s)
0.25 = Recommended unit discharge (L/s/ha)
A_{SITE} = Total site area draining to the swale, including the swale area (ha)

7. Solving the orifice equation for area of the orifice (A_0):

$$A_O = \frac{Q_O}{K \times \sqrt{2g\Delta h}}$$

Where:
Q_O = Theoretical discharge through infiltration from the impervious area that will be discharged via orifice (m^3/s)
K = Orifice Coefficient (typical value 0.6)
g = gravitational constant
h = differential head equivalent to depth of the perforated drain pipe in the rock trench (typical value 0.3 m)
A_O = Area of the orifice opening (m^2) – generally assumed to be circular for calculation of orifice diameter.

8. The size of the swale is then determined by the available area on the site.

$$I / P = \frac{\text{Impervious } TributaryArea}{BaseArea}$$

9. The depth of the rock reservoir above the orifice outlet is calculated as:

$$D_R = \frac{R \times (I/P+1) - 0.09 mm/hr \times 24 hrs \times (I/P+1) - 24 \times Ks - 0.2 \times D_S}{n}$$

Where:
D_R = Depth (thickness) of rock reservoir (mm)
R = Rainfall capture depth (mm)
I/P = Ratio of impervious tributary area to swale base area (unitless)
0.09 = Recommended unit discharge through orifice (mm/hr)
Ks = Saturated hydraulic conductivity of subsurface soil (mm/hr), as measured during winter saturated soil conditions
D_S = Soil layer depth (thickness); standard value = 300 (mm)
n = porosity of drain rock in reservoir (unitless, e.g., 0.35)

An orifice of no less than 10 mm is recommended to minimize clogging. A 10-mm orifice is the size required for a 0.46-ha tributary area. If the calculated orifice size is less than 10 mm, a regional capture facility servicing at least a 0.46-ha tributary area should be considered.

Guideline Specifications

Materials shall meet Master Municipal Construction Document 2009 (MMCD) requirements, **and**:

1. Infiltration Drain Rock: clean round stone or crushed rock, with a porosity of 35 to 40 % such as 75 mm max, 38 mm min, or MMCD Section 31 05 17 Part 2.6 – Drain Rock, Coarse.
2. Pipe: PVC, DR 35, 100 mm min. dia. with cleanouts certified to CSA B182.1, as per MMCD.
3. Geosynthetics: as per MMCD Section 31 32 19, select for filter criteria or from approved local government product lists.
4. Sand: Pit run sand, as per MMCD Section 31 05 17.
5. Growing Medium or Bioretention Soil Medium (see Table 2) over trench: As per MMCD Section 32 91 21 Topsoil and Finish Grading.
6. Seeding: conform to MMCD Section 32 92 20 Seeding or 32 92 19 Hydraulic Seeding (Note: sodding will be required for erosion control in most instances).
7. Sodding: to MMCD Section 31 92 23 Sodding.
8. All precast sections shall conform to the requirements of ASTM C 478.
9. Invert shall be level and smooth.
10. Soakaway manhole barrel shall not be perforated within 1,200 mm of the cone (top section).

Construction Practices shall meet Master Municipal Construction Document 2009 (MMCD) requirements, **and**:

1. Isolate the infiltration site from sedimentation during construction, either by use of effective erosion and sediment control measures upstream, or by delaying the excavation of 300 mm of material over the final subgrade until after all sediment-producing construction in the drainage area has been completed.
2. Prevent natural or fill soils from intermixing with the infiltration drain rock. All contaminated stone aggregate must be removed and replaced.
3. Infiltration drain rock shall be installed in 300 mm lifts and compacted to eliminate voids between the geotextile and surrounding soils.
4. Provide a min. of 150 mm of 25 mm or 19 mm clean crushed rock under all pipes.

Table 2 Absorbent Landscape Bioretention Soil Mix (BMS)[2]

<table>
<tr><th></th><th>Absorbent landscape Lawn BMS</th><th>Absorbent Landscape Vegetated BMS</th></tr>
<tr><td>Minimum Total Depth</td><td>300 mm</td><td>450 mm</td></tr>
<tr><td>Minimum required saturated hydraulic conductivity</td><td colspan="2">70 mm/hr.</td></tr>
<tr><td>Component (Partial size classes)</td><td colspan="2">Percentage by Dry Weight</td></tr>
<tr><td>Gravel (greater than 2.5 mm)</td><td>0</td><td>0</td></tr>
<tr><td>Sand (greater than 0.05 mm and less than 2.5 mm)
• Sand to be hard, granular sharp sand well washed and free of impurities, chemicals or organic matter.
• Particle size in sand to be:
a) 90-100% passing a 2.50 mm sieve,
b) 0-65% passing a 0.500 mm sieve,
c) 0-5% passing a 0.0500 mm sieve</td><td>65-80</td><td>50-70</td></tr>
<tr><td>Silt (greater than 0.002 mm and less than 0.05 mm)</td><td>5-10</td><td>5-10</td></tr>
<tr><td>Clay (less than 0.002 mm)</td><td>2-5</td><td>2-5</td></tr>
<tr><td>Organic Content (% dry weight) – ensure weed free
• must be well aged organics weed free, preferably manure free and biosolid free.</td><td>5-20</td><td>15-20</td></tr>
<tr><td colspan="3">Other Soil Considerations</td></tr>
<tr><td colspan="3">• pH of mixed materials between 6-8.5
• Safe Soils: The spread and proliferation of invasive species through many regions of the province comes from the re-distribution of invasive species laden soils. In 2016, a Soils and Invasive Species Sub-Working Group was developed to explore province-wide solutions regarding the movement of soil and related materials that may contain invasive species. This Sub-Working Group involves provincial and local government representation. Learn more: Provincial Response to the Resolutions of the 2016 Union of British Columbia Municipalities Convention FEBRUARY 2017
B113 SAFE SOILS PROGRAM (page 111)
http://www.ubcm.ca/assets/Resolutions~and~Policy/Resolutions/Provincial_Responses-2016_UBCM_Resolutions.pdf</td></tr>
</table>

[2] Source: Absorbent Landscape, Stormwater Best Management Practices, District of Saanich
http://www.saanich.ca/assets/Community/Documents/Absorbent%20Landscape.pdf

Infiltration Trench Design Example for Capture of R mm/24-hr Criteria

Scenario Description

A partial infiltration trench is proposed to capture a portion of the runoff from a building roof (see illustration below).

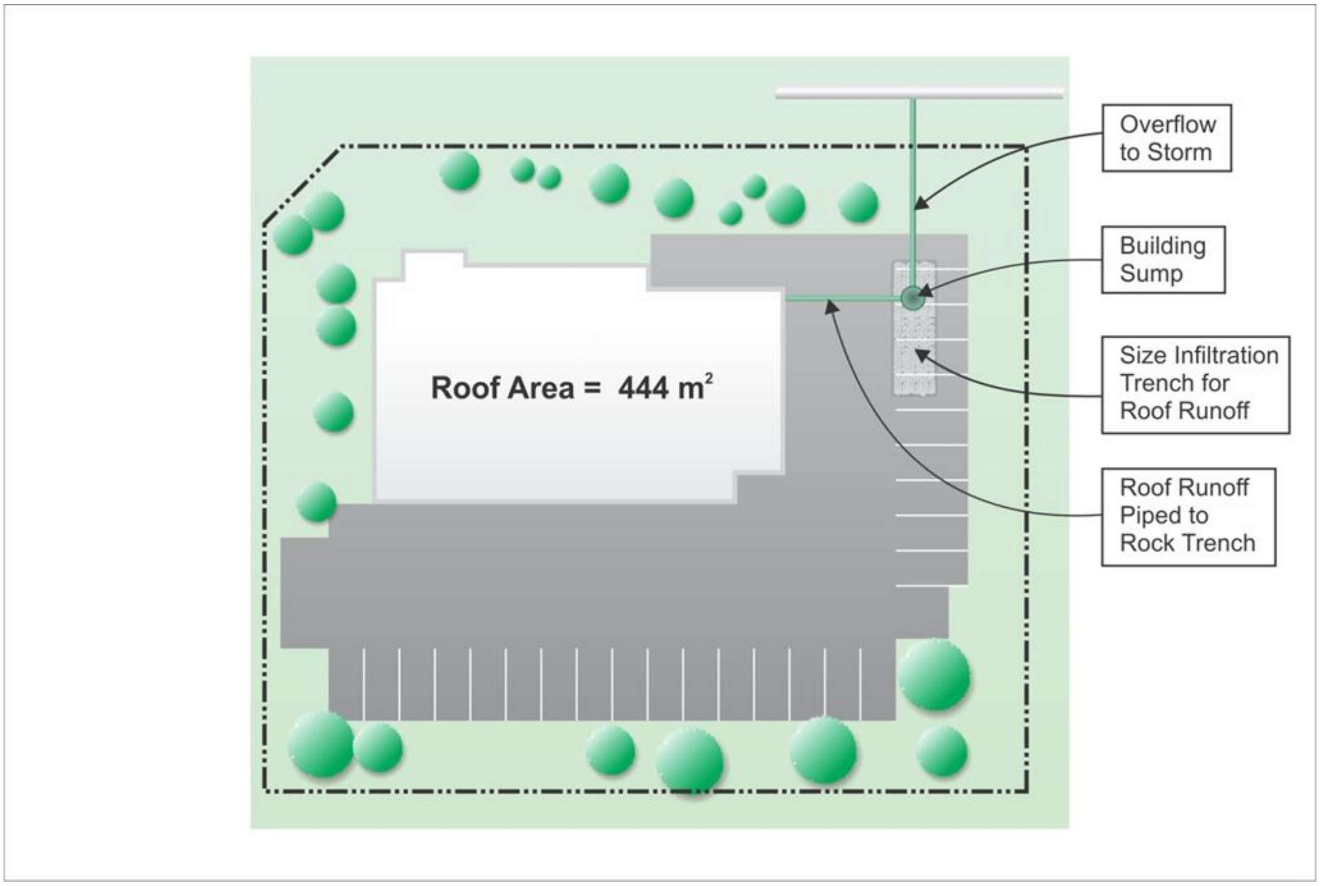

Figure 2 Example – Roof Area Draining to Infiltration Trench

The following parameters are known:

- Roof area = 444 m^2
- 2-year 24-hour rain depth = 53 mm
- Native soil infiltration rate = 5 mm/hr
- Drain time = 4 days
- Capture target is 72% of 2-year 24-hour rain amount = 38 mm

Determine the infiltration trench footprint area, and rock depth and volume below the overflow level.

Sizing

The maximum rock depth for a 4-day drain time is computed using:

$$D_R = \frac{Ks \times T \times 24}{n} = \frac{5mm/hr \times 4days \times 24hr/day}{0.35} = 1{,}400 \text{ mm}$$

Therefore, a 1.4 m deep trench is required to meet the capture target.

The I/P ratio for the site is computed using:

$$I/P = \frac{24 \times Ks + D_R \times n}{R} - 1 =$$

$$\frac{(24hr/day \times 5mm/hr) + (1400\,mm \times 0.35)}{38mm} - 1 = 15$$

To find the rock trench base area:

$$BaseArea = \frac{\text{Impervious Tributary Area}}{I/P} =$$

$$\frac{444 \text{ m2}}{15} = 29.6 \text{ m}^2$$

The rock volume below the overflow elevation is 41 m^3 (29.6 m^2 x 1.4 m).

Hydraulic Components

- **Inlet**: Roof runoff is piped into the building sump. A perforated pipe or series of pipes convey the flow from the sump and distribute it throughout the infiltration trench.
- **Overflow**: The perforated pipes are located along the top of the infiltration trench rock layer. When the trench is full of water, the water level in the building sump reaches the invert of an overflow pipe which conveys excess water to the municipal storm sewer.

Operation and Maintenance Considerations

Infiltration trenches used for vehicle or pedestrian travelled areas require that a pre-treatment system be installed ahead of the infiltration trench to remove sediment and gross pollutants. This will maximize the longevity of the infiltration trench performance.

GSI Driver Effectiveness – Runoff Reduction and Contaminant Removal

International Stormwater BMP Database http://www.bmpdatabase.org/ is a recommended resource for performance summaries of GSI facilities and latest research.

An infiltration trench does not itself provide treatment of stormwater runoff, however, stormwater that is infiltrated and does not enter the storm drain system or receiving aquatic environments is removing all contaminants and provide a runoff volume reduction. Estimates of GSI facility effectiveness are shown in Table 3.

Table 3 Runoff Reduction and Contaminant Removal Summary Table

Infiltration Trench and Soakaway Manholes GSI Facilities	
GSI Driver	***Estimated Effectiveness or Typical % Reduction or Removal**
Capture & Slow – Volume Runoff Reduction	% infiltrated
Store & Convey – Rate Control Delay Peak	% infiltrated
Clean & Infiltrate – Water Quality Treatment	% infiltrated

Note: * Performance of individual GSI facilities will vary depending on site-specific contexts and facility design.

Maintenance

Effective long-term operation of an infiltration trench requires a consistent maintenance inspection schedule. The operation of the infiltration trench is dependent on the effectiveness of the pre-treatment, such as vegetated buffer strips and swales, at removing sediments. Therefore, most of the maintenance should be concentrated on these pre-treatment practices upstream of the trench. The following table lists inspection and maintenance activities for infiltration trenches.

INSPECTION ACTIVITIES	SCHEDULE
Inspect for proper functioning	After every major storm for the first few months to confirm design drain times
Inspect for pollutant contamination, standing water, trash and debris, sediment accumulation	Semi-annual and after extreme events
Inspect pre-treatment devices and diversion structures for damage and sediment accumulation	Semi-annual and after extreme events
MAINTENANCE ACTIVITY	**SCHEDULE**
Mow vegetated filter strips and remove clippings	As needed
Remove sediment, debris, and oil/grease from pre-treatment devices	As needed
Repair undercut and eroded areas and inflow and outflow structures	As needed
Remove trees and large vegetation form vicinity of the infiltration facility	Semi-annual
Replace drainrock/filter fabric	As needed when clogged

1. GRASS OR OTHER PLANTING
2. FINISH GRADE
3. GROWING MEDIUM BACKFILL
4. 100mm DIA PVC DR28 PERFORATED PIPE
5. LIGHT NON-WOVEN GEOTEXTILE C/W MIN. 400mm LAPS
6. 50mm DRAIN ROCK OR ROCK OF EQUAL POROSITY
7. MAXIMUM GROUNDWATER ELEVATION
8. NON-POLLUTED DRAINAGE FROM BUILDING OR TERRACE
9. ALTERNATE SURFACE ROUTE - WITH SPLASH PAD AND VEGETATED SWALE TO CB
10. CB LID / ACCESS HATCH FOR CLEANOUT, INSPECTION AND INFLOW / OVERFLOW FROM SUMP
11. 100mm DIA PVC SOLID PIPE C/W INLET TEE
12. OBSERVATION WELL (OPTIONAL)
13. INVERT TO TOP OF INFILTRATION PIPE (APPROX.)
14. 100mm DIA PVC SOLID PIPE
15. DISCHARGE TO STORM DRAINAGE SYSTEM. ENSURE DRAINAGE DOES NOT IMPACT NEIGHBOURING USES. DIRECT DISCHARGE TO ROAD RIGHT-OF-WAY IF NECESSARY
16. INFILTRATION TRENCH WITH LEVEL BOTTOM
17. CATCH BASIN
18. BUILDING FOOTING DRAIN (NOT CONNECTED TO INFILTRATION FACILITY)
19. BUILDING
20. 50mm DIA MIN. DRAIN HOLE

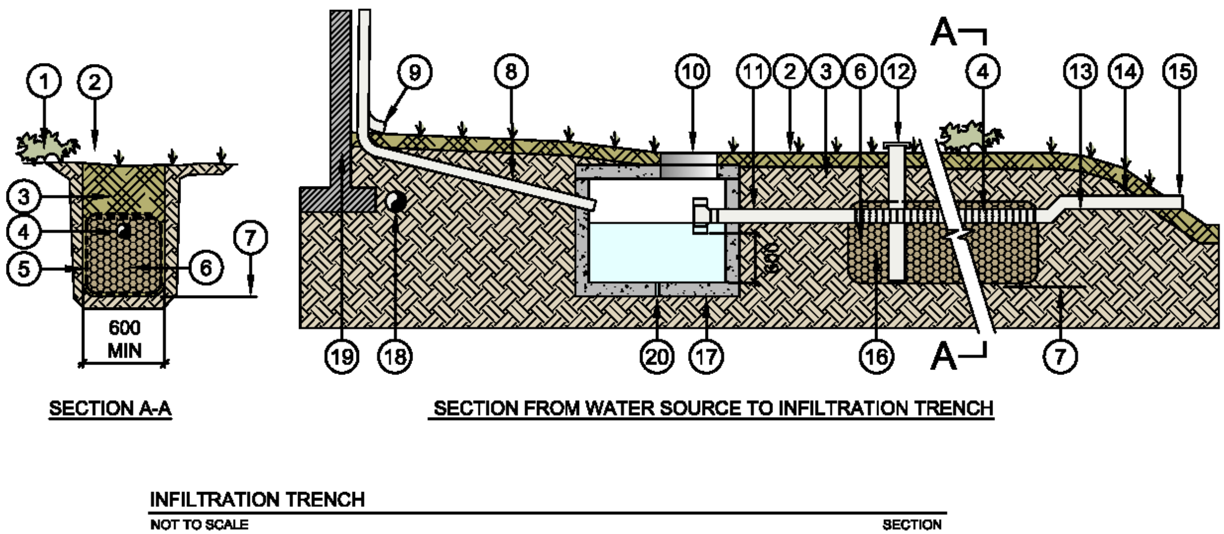

Figure 3 Infiltraiton Trench

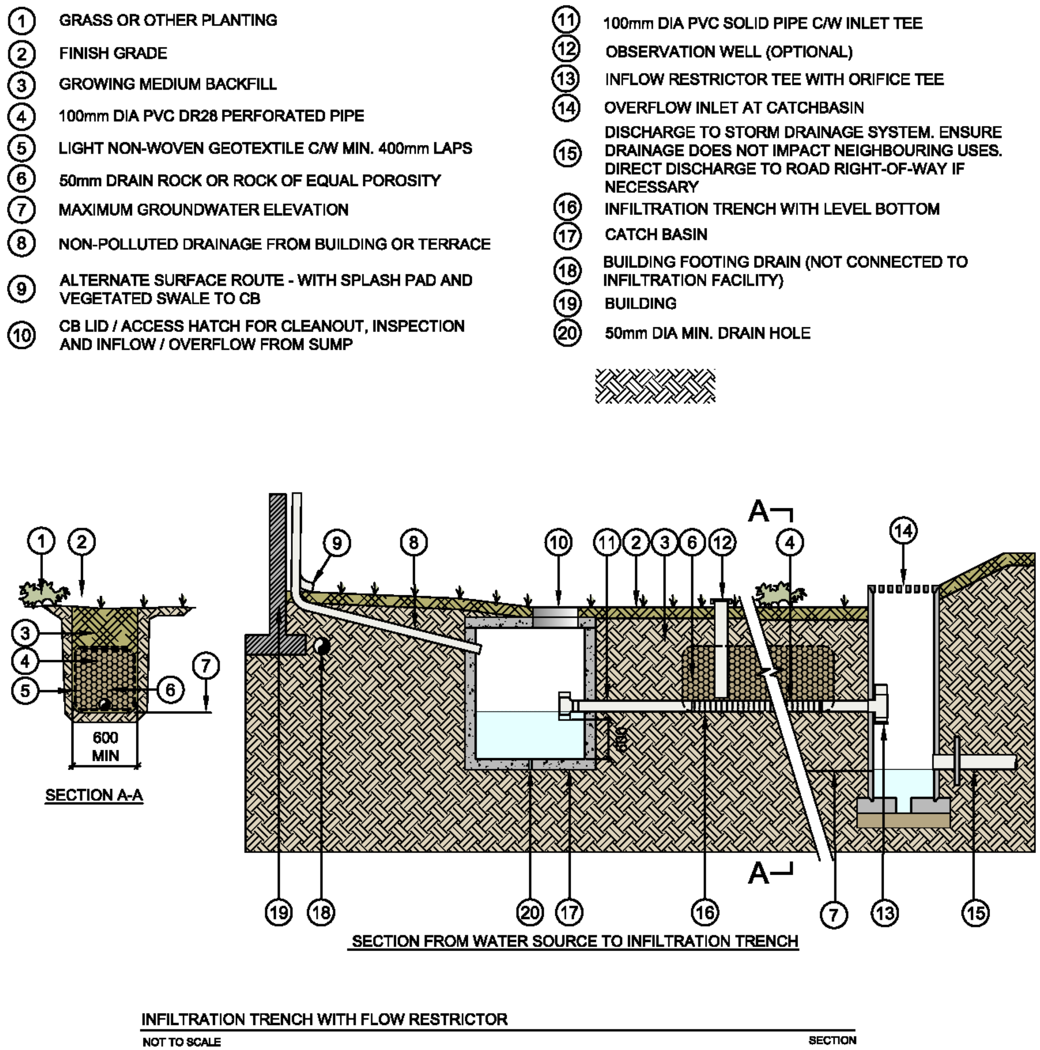

Figure 4 Infiltrtion Trench with Flow Restrictor

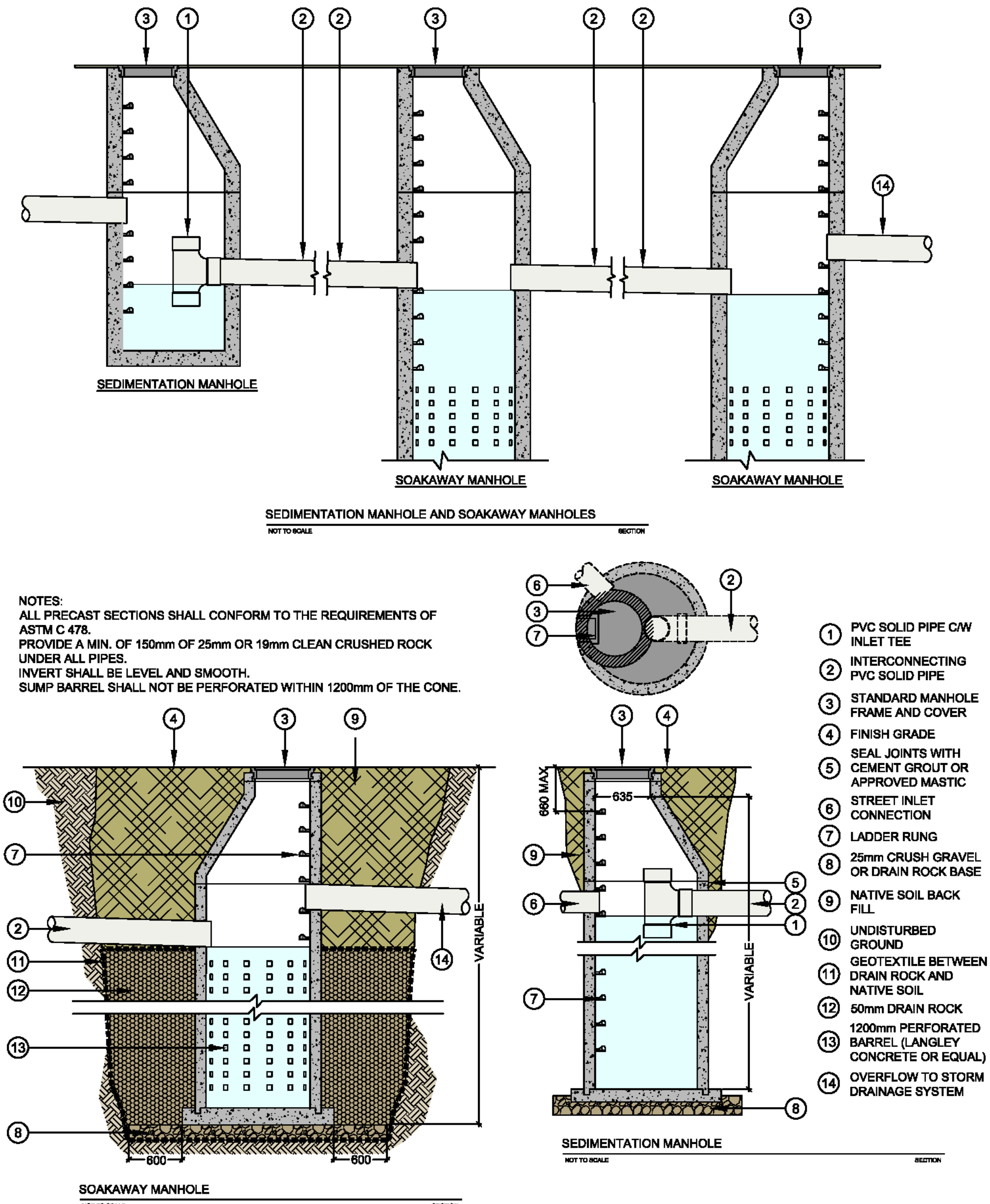

Figure 5 Sedimentation Manhole and Soakaway Manholes (Not to scale, Section)