BMP #: Subsurface Infiltration

Subsurface Infiltration is the temporary storage and infiltration of stormwater runoff accomplished by placing an infiltration bed of varying types beneath an engineered layer of soil and vegetation.

Key Design Elements

- Beds filled with stone (or alternative) as needed
- Uncompacted sub-base
- Wrapped in non-woven geotextile
- Level bed bottoms
- Provide positive stormwater overflow from beds
- Protect from sedimentation during construction
- Provide perforated pipe network along bed bottom for distribution
- Open-graded sub-base with minimum 40% void space
- Do not place bed bottom on compacted fill

Potential Applications

Residential Subdivision:	**YES**
Commercial:	**YES**
Ultra Urban:	**YES**
Industrial:	**YES**
Retrofit:	**YES**
Highway/Road:	**LIMITED**

Stormwater Functions

Volume Reduction:	**High**
Recharge:	**High**
Peak Rate Control:	**High**
Water Quality:	**High**

Pollutant Removal

Total Suspended Solids:	**x**
Nutrients:	**x**
Metals:	**x**
Pathogens:	**x**

Description

Subsurface Infiltration consists of a vegetated, highly pervious soil media underlain by an aggregate (or alternative) bed for temporary storage and infiltration of stormwater runoff. Subsurface Infiltration is ideally suited for expansive, generally flat open spaces, such as lawns, meadows, and playfields, which are located downhill from nearby impervious areas. Subsurface Infiltration beds can be stepped or terraced down sloping terrain provided that the base of the bed remains level. Stormwater runoff from these nearby impervious areas (including rooftops, parking lots, roads, walkways, etc.) is directly conveyed to the subsurface storage media, where it is then distributed via a network of perforated piping.

The storage media for subsurface infiltration beds typically consists of clean washed, uniformly graded aggregate. However, other storage media alternatives are available in the marketplace. These alternatives are generally variations on plastic cells that more than double the storage capacity of aggregate beds, at a substantially increased cost. Storage media alternatives are ideally suited for sites where potential infiltration area is limited. They may encourage concentrated loading (as opposed to distributed) in some sites.

If designed, constructed, and maintained as per the following guidelines, Subsurface Infiltration features can stand-alone as significant stormwater runoff volume, rate, and quality control practices. These systems can also maintain aquifer recharge, while preserving valuable open space. They have the added benefit of functioning year-round, given that the infiltration surface is typically below the frost line.

Variations

As its name suggests, Subsurface Infiltration is generally employed for temporary storage and infiltration of runoff in subsurface storage media. However, in some cases, runoff may be temporarily stored on the surface (to depths less than 6 inches) to enhance volume capacity of the system. The overall system design shall ensure that runoff detained on the surface will seep through the permeable soil layer (or drain through area drains) and into the infiltration bed in less than 48 hours. Subsurface Infiltration areas are often used for recreational purposes and therefore extended periods of standing water are not acceptable.

Conversely, Subsurface Infiltration may not require significant engineering of replaced soil or vegetation on top of the infiltration bed, provided that the bulk of the stormwater flows are being piped into the appropriate bed.

Applications

- **Direct Connection of Roof Leaders**

  Runoff from nearby roofs shall be directly conveyed to subsurface beds via roof leader connections to perforated piping. Roof runoff generally has relatively low sediment levels, making it ideally suited for direct discharge to an infiltration bed. However, cleanout(s) with a sediment sump are still recommended between the building and infiltration bed.

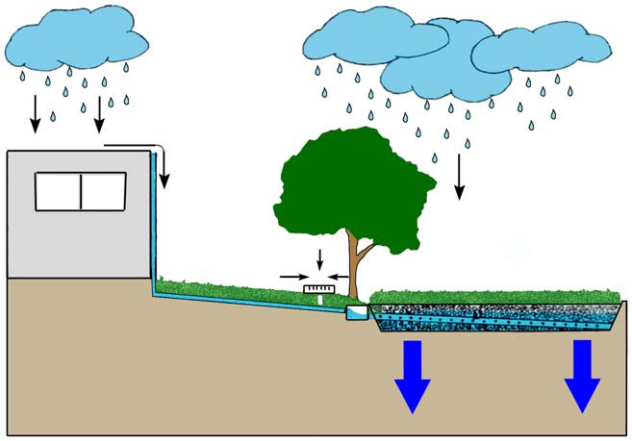

Figure 1. Roof leader connection to subsurface infiltration bed

- **Direct Connection of Inlets**

  Catch Basins, inlets, and area drains may be directly connected to Subsurface Infiltration beds. However, sediment and debris removal must be provided. Storm structures should therefore include sediment trap areas below the inverts of discharge pipes to trap solids and debris. In areas of high traffic or excessive generation of sediment, litter, and other similar materials, a water quality insert may be required.

- **Under Recreational Fields**

  Subsurface Infiltration is very well suited below playfields and other recreational areas. Special consideration should be given to the engineered soil mix in those cases.

Figure 2. Subsurface infiltration under athletic field

- **Under Open Space**

  Subsurface Infiltration is also appropriate in either existing or proposed open space areas. Ideally, these areas are vegetated with native grasses and/or vegetation to enhance site aesthetics and landscaping plans. Aside from occasional clean-outs or outlet structures, Subsurface Infiltration systems are essentially hidden stormwater management features, making them ideal for open space locations (deed restricted open space locations are especially desirable because such locations minimize the chance that Subsurface Infiltration systems will be disturbed or disrupted accidentally in the future.

- **Other Applications**

  Other applications of Subsurface Infiltration beds may be determined by the Design Professional as appropriate.

Design Considerations

1. Soil Investigation and Percolation Testing is required (see Section x/x).

2. Guidelines for Infiltration Systems must be met (i.e., depth to water table, setbacks, Loading Rates, etc. See Section x/x).

3. The overall site shall be evaluated for potential Subsurface Infiltration areas early in the design process, as effective design requires consideration of existing site characteristics (topography, natural features/drainage ways, soils, geology, etc.).

4. Control of Sediment is critical. Rigorous installation and maintenance of erosion and sediment control measures is required to prevent sediment deposition within the stone bed. Non-woven geotextile may be folded over the edge of the bed until the site is stabilized.

5. The Infiltration bed must be wrapped in non-woven geotextile filter fabric.

6. Subsurface Infiltration areas shall not be placed on areas of fill or compacted fill. Any grade adjustments requiring fill shall be done using the stone sub-base material, or alternative.

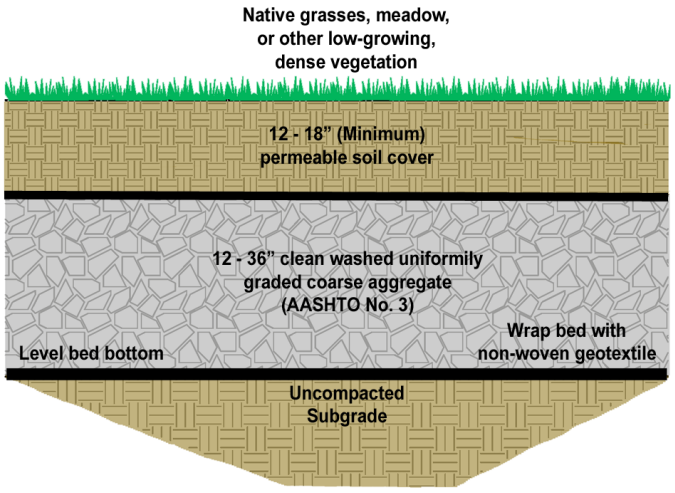

Figure 3. Cross Section detail of subsurface infiltration bed

7. The subsurface infiltration bed is typically comprised of 12-36 inches of aggregate, such as AASHTO No.3, which ranges 1.5-2.5 inches in gradation. Depending on local aggregate availability, both larger and smaller size aggregate has been used. The critical requirements are that the aggregate be uniformly graded, clean washed, and contain at least 40% void space. The depth of the bed is a function of stormwater storage requirements, frost depth considerations, and site grading. Infiltration beds are typically sized to mitigate the increased runoff volume from a 2-year design storm.

8. Water Quality Inlet or Catch Basin with Sump (see Sections x/x) required for all surface inlets, designed to avoid standing water for periods greater than 48 hours.

9. Infiltration beds may be placed on a slope by benching or terracing infiltration levels.

10. Perforated pipes along the bottom of the bed are necessary to evenly distribute runoff over the entire bed bottom. Continuously perforated pipes shall connect structures (such as cleanouts and inlet boxes). Pipes shall lay flat along the bed bottom and provide for uniform distribution of water. Depending on size, these pipes may provide additional storage volume. Perforated pipes shall have a positive flow connection designed to allow high flows to be conveyed through the bed.

11. The slope of the infiltration bed bottom should be level or with a slope no greater than 1%. The bed may be constructed as a series of “steps” if necessary. A level bottom assures even water distribution and infiltration.

12. Cleanouts or inlets should be installed at a few locations within the bed and at appropriate intervals to allow access to the perforated piping network.

13. While infiltration beds are typically sized to handle the increased volume from a 2-yr design storm, they must also be able to convey and mitigate the peak of the less-frequent, more intense storms (such as the 100-yr). Control in the beds is usually provided in the form of an outlet control structure. A modified inlet box with an internal concrete weir (or weir plate) and low-flow orifice is a common type of control structure. The specific design of these

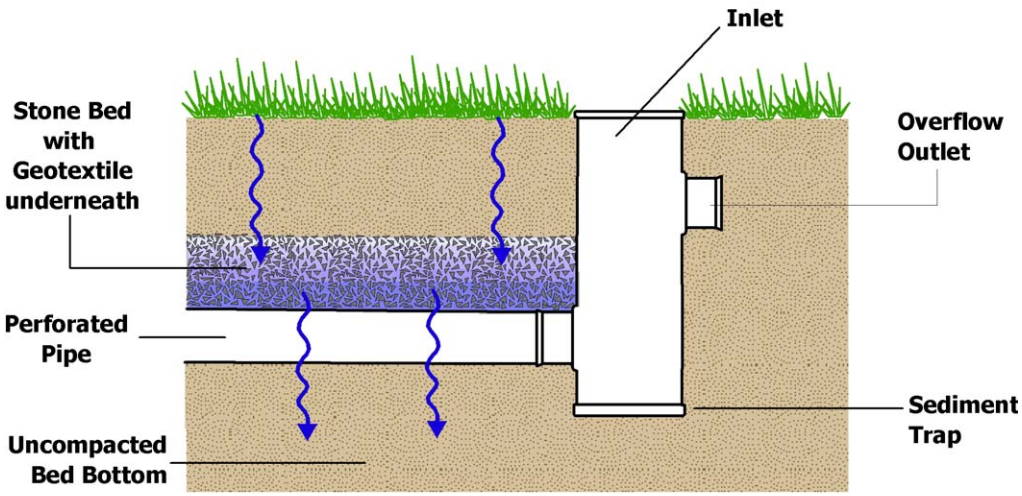

Figure 4. Subsurface Infiltration Bed cross-section (WILL BE UPDATED ASAP)

structures may vary, depending on factors such as rate and storage requirements, but it must always include positive overflow from the system. The overflow structure is used to maximize the water level in the stone bed, while providing sufficient cover for overflow pipes. Generally, the top of the outlet pipe shall be 4 inches below the top of the aggregate to prevent saturated soil conditions in remote areas of the bed. As with all infiltration practices, multiple discharge points are recommended.

14. Adequate soil cover (12 - 18" minimum) must be maintained above the infiltration bed to ensure structural stability and functional integrity. Soil cover shall be of an engineered and highly permeable nature, except when precluded by other design considerations.

15. Open space overlying infiltration beds can be vegetated with native grasses, meadow mix, or other low-growing, dense vegetation. These plants have longer roots than traditional grass and will likely benefit from the moisture in the infiltration bed, improving the growth of these plantings and increasing evapotranspiration.

16. Fertilizer shall never be required by a maintenance plan and should be minimized.

17. The surface (above the stone bed) should be compacted as minimally as possible to allow for surface percolation through the engineered soil layer and into the stone bed.

18. Subsurface Infiltration areas shall be designed to drain the maximum acceptable impervious drainage area. To the extent possible, runoff from nearby roofs, parking lots, and other impervious surfaces shall be directly conveyed into the subsurface beds.

19. Surface grading should be relatively flat, although a relatively mild slope between 1% and 3% is recommended to facilitate drainage.

20. In those areas where the threat of spills and groundwater contamination is quite likely, pretreatment systems, such as filters and wetlands, may be required before any infiltration occurs. In Hot Spot areas, such as truck stops and fueling stations, the suitability of Subsurface Infiltration must be carefully considered.

21. In areas with poorly-draining soils, Subsurface Infiltration areas may be designed to overflow to adjacent wetlands or bioretention areas.

22. While most Subsurface Infiltration areas consist of an aggregate storage bed, alternative subsurface storage products may also be employed. These include a variety of proprietary, interlocking plastic units that contain much greater storage capacity than aggregate, at an increased cost.

23. The sub-surface bed and overflow may be designed and evaluated in the same manner as a detention basin to demonstrate the mitigation of peak flow rates. In this manner, detention basins may be eliminated or significantly reduced in size.

24. During Construction, the excavated bed may serve as a Temporary Sediment Basin or Trap. This will reduce overall site disturbance. The bed shall be excavated to within 6 inches of the final bed bottom elevation for use as a sediment trap or basin. Following construction and site stabilization, sediment shall be removed and final grades established.

Detailed Stormwater Functions

1. Infiltration Area:

The Infiltration Area is the bottom area of the bed, defined as:

Length of bed x Width of bed = Infiltration Area (Bottom Area) (if rectangular)

This is the area to be considered when evaluating the Loading Rate to the Infiltration bed.

2. Volume:

The storage volume of the Infiltration Bed is defined as the area beneath the discharge invert. This is equal to:

Length x Width x Depth below invert x Void Ratio in medium

The void ratio in stone is 40% for AASTO No 3, and 94% for Rainstore. If the conveyance pipe is within the Storage Volume area, the volume of the pipe may also be included. All Infiltration Beds should be designed to infiltrate or empty within 48 hours.

3. Peak Rate Mitigation Calculations: See Section z/z in Section 8 for Peak Rate Mitigation methodology which addresses link between volume reduction and peak rate control.

4. Water Quality Improvement: See Section a/a in Section 8 for Water Quality Improvement methodology, which addresses pollutant removal effectiveness of this BMP.

Construction Sequence

1. Due to the nature of construction sites, Subsurface Infiltration should be installed toward the end of the construction period, if possible. (Infiltration beds may be used as temporary sediment basins or traps provided they are excavated to within 6 to12 inches of the designated final bed bottom elevation. Once the site is stabilized and sediment storage is no longer required, the bed is excavated to its final grade and the infiltration bed is installed.)

2. Install and maintain adequate Erosion and Sediment Control Measures (as per the Pennsylvania Erosion and Sedimentation Control Program Manual) during construction.

3. The existing subgrade under the bed areas shall NOT be compacted or subject to excessive construction equipment traffic prior to geotextile and stone bed placement.

4. Where erosion of subgrade has caused accumulation of fine materials and/or surface ponding, this material shall be removed with light equipment and the underlying soils scarified to a minimum depth of 6 inches with a York rake (or equivalent) and light tractor. All fine grading shall be done by hand. All bed bottoms are level grade.

5. Earthen berms (if used) between infiltration beds shall be left in place during excavation. These berms do not require compaction if proven stable during construction.

6. Install upstream and downstream control structures, cleanouts, perforated piping, and all other necessary stormwater structures.

7. Geotextile and bed aggregate shall be placed immediately after approval of subgrade preparation and installation of structures. Geotextile is to be placed in accordance with manufacturer's standards and recommendations. Adjacent strips of geotextile shall overlap a minimum of 16 inches. It shall also be secured at least 4 feet outside of bed in order to prevent any runoff or sediment from entering the storage bed. This edge strip shall remain in place until all bare soils contiguous to beds are stabilized and vegetated. As the site is fully stabilized, excess geotextile along bed edges can be cut back to gravel edge.
8. Clean (washed), uniformly-graded aggregate is placed in the bed in maximum 8-inch lifts. Each layer shall be lightly compacted, with construction equipment kept off the bed bottom as much as possible.

9. Place approved soil media over infiltration bed in maximum 6-inch lifts.

10. Seed and stabilize topsoil.

11. Do not remove inlet protection or other Erosion and Sediment Control measures until site is fully stabilized.

Maintenance and Inspection Issues

As with other BMP's combining vegetated and infiltration elements, Subsurface Infiltration systems require sustained maintenance efforts for continued functionality. Subsurface Infiltration is actually less maintenance intensive than other practices of its type. Generally speaking, vegetation associated with Subsurface Infiltration practices is less substantial than practices such as Recharge Gardens and Vegetated Swales and therefore requires less maintenance. Subsurface Infiltration areas surfaced with turf grass may actually require more frequent mowing. Maintenance activities required for the subsurface bed are similar to those of any infiltration system and focus on regular sediment and debris removal. The following represents the recommended maintenance efforts:

- All Catch Basins and Inlets should be inspected and cleaned on an annual basis.

- The overlying vegetation of Subsurface Infiltration features should be maintained in good condition, and any bare spots immediately revegetated.

- Vehicular access on Subsurface Infiltration areas should be prohibited, and care should be taken to avoid excessive compaction by mowers. If access is needed, use of permeable, turf reinforcement should be considered.

Cost Issues

The construction cost of Subsurface Infiltration can vary greatly depending on design variations, configuration, location, desired storage volume, and site-specific conditions, among other factors. Typical construction costs are about $5.70 per square-foot, which includes excavation, aggregate (2.0 feet assumed), non-woven geotextile, pipes and plantings.

Specifications:

The following specifications are provided for information purposes only. These specifications include information on acceptable materials for typical applications, but are by no means exclusive or limiting. The designer is responsible for developing detailed specifications for individual design projects in accordance with the project conditions.

1. Stone for infiltration beds shall be 2-inch to 1-inch uniformly graded coarse aggregate, with a wash loss of no more than 0.5%, AASHTO size number 3 per AASHTO Specifications, Part I, 19th Ed., 1998, or later and shall have voids ³ 35% as measured by ASTM-C29.

2. Non-Woven Geotextile shall consist of needled non-woven polypropylene fibers and meet the following properties:

a. Grab Tensile Strength (ASTM-D4632) ≥ 120 lbs
b. Mullen Burst Strength (ASTM-D3786) ≥ 225 psi
c. Flow Rate (ASTM-D4491) ≥ 95 gal/min/ft^2
d. UV Resistance after 500 hrs (ASTM-D4355) ≥ 70%
e. Heat-set or heat-calendared fabrics are not permitted
Acceptable types include Mirafi 140N, Amoco 4547, and Geotex 451.

3. Topsoil amended with compost (See soil restoration BMP)

4. Pipe shall be continuously perforated, smooth interior, with a minimum inside diameter of 8-inches. High-density polyethylene (HDPE) pipe shall meet AASHTO M252, Type S or AASHTO M294, Type S.

5. Catch Basins/Inlet Boxes

a. Concrete Construction: Concrete construction shall be in accordance with Section 1001, PennDOT Specifications, 1990 or latest edition.
b. Precast Concrete Inlets and Manholes: Precast concrete inlets may be substituted for cast-in-place structures and shall be constructed as specified for cast-in-place. Precast structures may be used in only those areas where there is no conflict with existing underground structures which may necessitate revision of inverts. Precast structures shall be placed on a 6 inch bed of compacted coarse aggregate Size No. 2A. Reinforcement steel, if required for handling, shall have a minimum of 2-inch cover. Handling devices, if used, shall be removable and the holes filled with concrete. Type M standard PennDOT inlet boxes will be modified to provide minimum 12 inch sump storage and bottom leaching basins, open to gravel sumps in subgrade, when situated in the recharge bed.

c. All PVC Catch Basins/Cleanouts/Inline Drains shall have H-10 or H-20 rated grates, depending on their placement (H-20 if vehicular loading).
d. Steel reinforcing bars over the top of the outlet structure shall conform to ASTM A615, grades 60 and 40.
e. HDPE Flared End Section shall be installed according to manufacturers' specifications.
f. Permanent turf reinforcement matting shall be installed according to manufacturers' specifications.

6. Alternative storage media see Manufacturer's specifications.

7. Vegetation see Native Plant List in appendix.

References and Sources