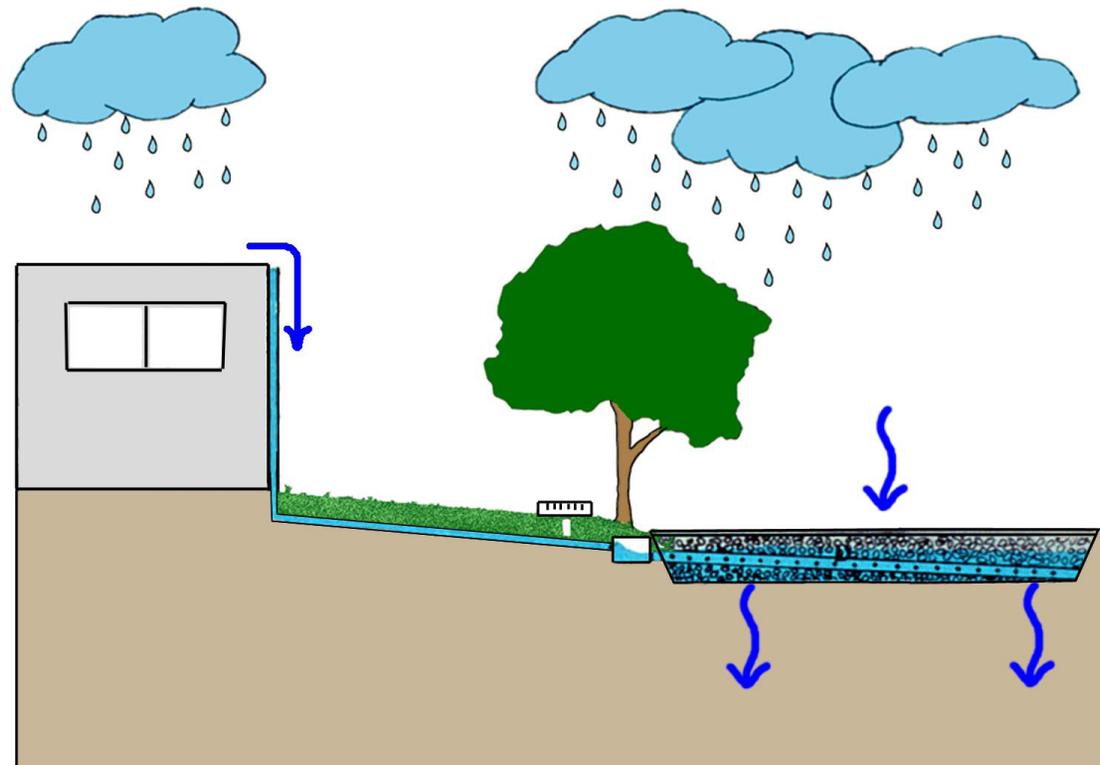


Subsurface Infiltration Bed



The Subsurface Infiltration Bed BMP consists of a storage bed underlying either a vegetated or hardscaped surface for the purpose of temporary storage and infiltration of stormwater runoff. Subsurface Infiltration beds are ideally suited for large, generally flat spaces, such as lawns, meadows, patios, walkways, or driveways, located downhill from nearby residential structures (homes, sheds, garages, etc). The storage media for subsurface infiltration beds typically consists of clean-washed, uniformly graded stone aggregate, though pre-fabricated, manufactured storage options are also available. These options are generally variations on interlocking plastic blocks that can more than double the storage capacity of aggregate, though at an increased cost.

The most important component in this BMP is the bed beneath the surface. The bed actually holds stormwater while it slowly percolates through the stone and into the soil below.

If designed, constructed, and maintained as per the following guidelines, Subsurface Infiltration systems can provide significant stormwater runoff improvements, including reduced peak rates, volumes, and velocities, improved water quality, and reduced downstream erosion and flooding. These systems can also maintain aquifer recharge, while at the same time preserving or creating valuable landscaped or parking areas. When constructed beneath attractive hardscaped surfaces, whether pervious or not, they can even enhance site aesthetics, to the level desired by the homeowner. Subsurface Infiltration systems have the added benefit of functioning year-round, given that the infiltration surface is typically below the frost line.

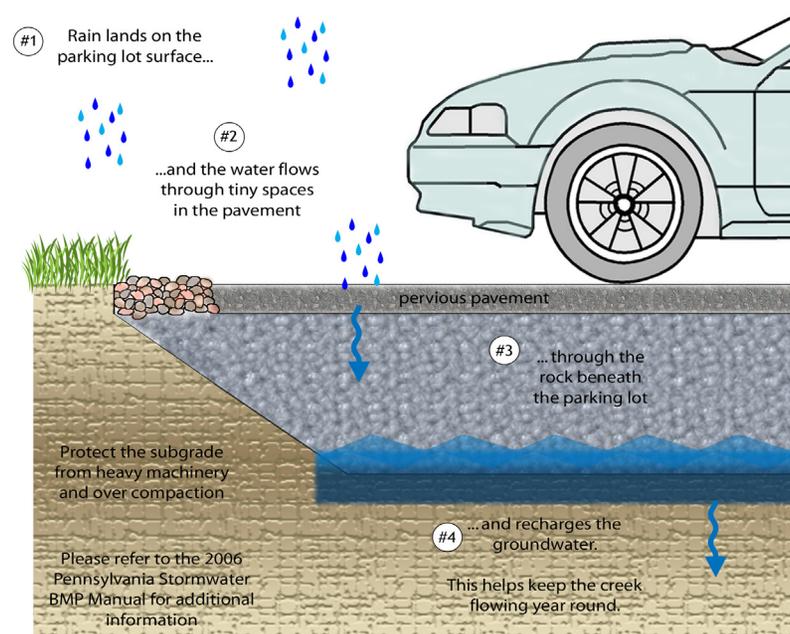


Image: Cahill Associates, Inc.

Benefits



Benefits

- improved water quality
- reduced runoff volume and rate
- increased groundwater recharge
- can be integrated with site hardscaping (patios, walkways, driveways, etc) or fit aesthetically into the landscaping
- reduced downstream erosion

Costs



Cost Considerations

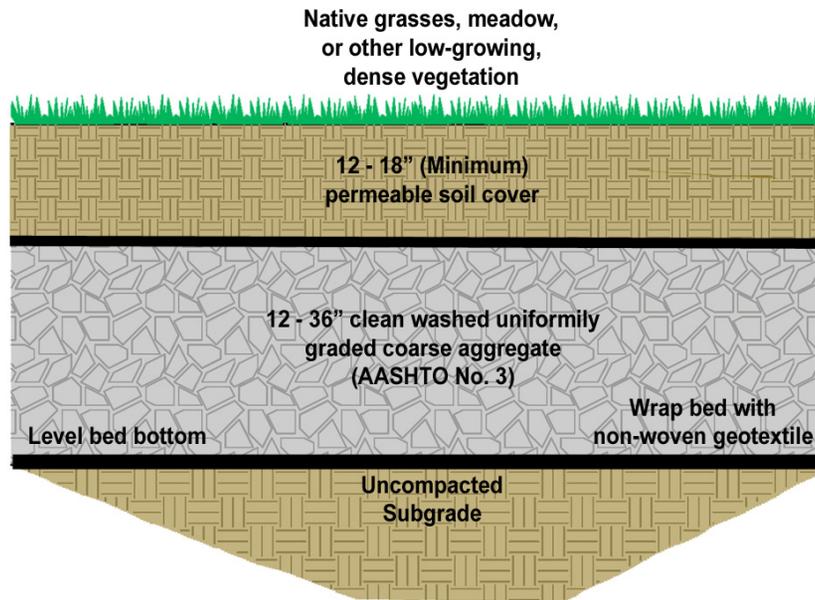
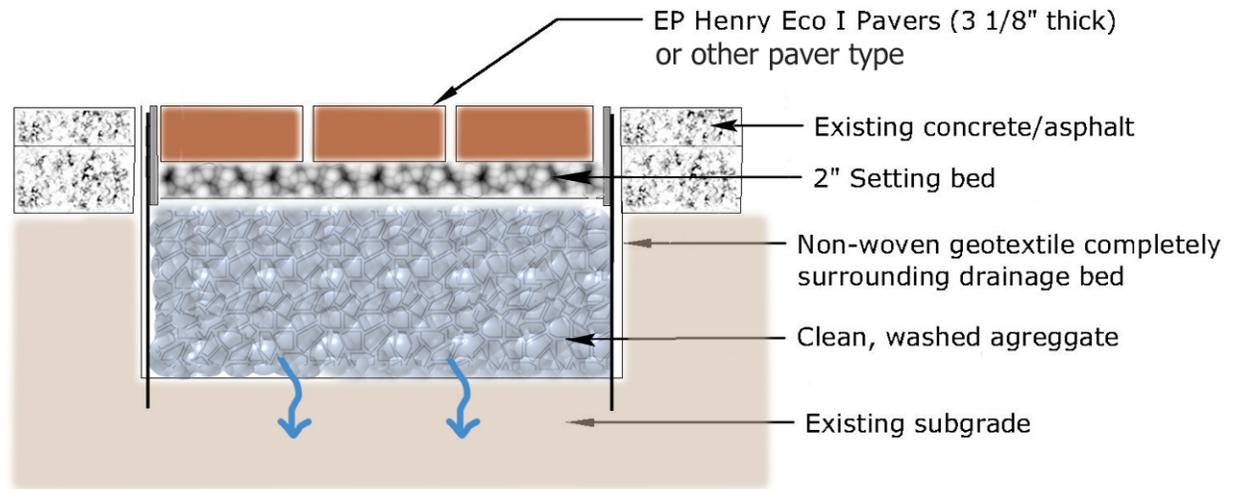
The construction cost of Subsurface Infiltration can vary greatly depending on design variations, configuration, size, desired storage volume, and site-specific conditions, among other factors. Typical construction costs for an aggregate infiltration bed are around \$6 per square foot, which includes excavation, aggregate (2 feet assumed, though this varies), nonwoven geotextile, pipes, and plantings. Paver blocks, if desired, will vary in cost depending on type (concrete vs. plastic) and manufacturer. Concrete pavers usually cost between \$3-4 per square foot, while plastic pavers cost between \$2-3 per square foot. In the case of the former however, prices as high as \$10 per square foot have been reported.

Compared with a standard hardscaped patio, a patio with a Subsurface Infiltration bed will usually prove more expensive to install. The added cost lies in the underlying aggregate bed, which is generally deeper than a conventional hardscaped subbase and lined with a geotextile fabric.



Prefabricated porous pavers are an affordable option if you are planning to install a new patio or driveway and would like to reduce your stormwater footprint.

A subsurface infiltration bed is constructed underneath the ground, and is "topped" with either native vegetation or a hardscaping material



Images: Cahill Associates, Inc.

Ease of Development/Construction

A Subsurface Infiltration Bed typically contains the following components:

1. **Stone** shall be 2- to 1-inch, clean washed, uniformly graded coarse aggregate (AASHTO size No. 3).
2. Nonwoven **Geotextile** fabric
3. **Topsoil** (if needed)
4. Continuously perforated **Pipe** with a minimum inside diameter of 4 inches.
5. Alternative **storage media** (plastic, concrete, or other): Follow manufacturers' specifications.
6. **Hardscaping** (pavers, brick, plastic, or other): Follow manufacturers' specifications.
or
7. Native **planting** mix.

A Subsurface Infiltration bed typically consists of 12 to 36 inches of aggregate ranging from 1 to 2 inches in gradation (e.g. AASHTO No.3). Both larger and smaller sized aggregates are also acceptable, provided the following important criteria are met: the aggregate must be uniformly-graded, clean-washed, and contain around 40% void space for stormwater storage. The installed depth of a Subsurface Infiltration bed is a function of various factors, including stormwater storage requirements, frost depth considerations, bed-rock/groundwater table depth, and site grading. Another factor influencing bed depth is the size and depth of the roof drains, which should be connected directly into the aggregate.

Underneath this native perennial bed is a stone-filled infiltration bed



Image: Cahill Associates, Inc.

The bottom slope of a Subsurface Infiltration bed should be level, or with a slope less than or equal to 1%. A level bottom encourages uniform water distribution and infiltration. 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 and/or storage media in the event of malfunction. All Subsurface Infiltration beds should be designed with an overflow for extreme storm events. Known as an *outlet control structure*, this is normally provided in the form of an inlet box or cleanout with an internal weir plate and/or low-flow outlet orifice. The specific design of these structures may vary, depending on factors such as runoff rate and storage requirements, but it must always include positive overflow from the system while providing maximum storage opportunities. The homeowner should allow overflow volumes to discharge from the system at some downhill point on their property in a stabilized fashion. This is usually accomplished with the use of a level-spreader pipe (a perforated pipe perpendicular to the direction of flow, sometimes wrapped in fabric and covered with rock) or with a flared-end section and erosion control matting.

While most Subsurface Infiltration areas consist of an aggregate storage bed, alternative subsurface storage products may also be employed. These usually include a variety of proprietary, interlocking plastic or concrete units that afford much greater storage capacity than aggregate, but at an increased cost. Homeowners are encouraged to research all of the subsurface storage options before selecting the most appropriate one for their application.

Subsurface Infiltration Beds are generally constructed in the following sequence:

1. Protect Subsurface Infiltration area from excessive compaction prior to installation.
2. If Subsurface Infiltration beds are part of a larger construction project, install Subsurface Infiltration beds during the later phases in order to prevent sedimentation and/or damage from construction activity. As necessary, install and maintain proper erosion and sediment control measures during construction.
3. Excavate Subsurface Infiltration bed bottom to a uniform, level, and uncompacted subgrade free from rocks and debris. Do NOT compact subgrade. To the greatest extent possible, excavation should be performed with the lightest practical equipment. Excavation equipment should be placed outside the limits of the Subsurface Infiltration bed.
4. Completely wrap the Subsurface Infiltration bed with nonwoven geotextile. (If sediment and/or debris have accumulated in the Subsurface Infiltration bed bottom, remove it prior to geotextile placement.) Geotextile rolls should overlap by a minimum of 24 inches within the excavated area. Fold back and secure excess geotextile during stone placement.

5. Install continuously perforated pipe, observation wells, and all other Subsurface Infiltration structures. Connect roof leaders to structures and/or bed as required.
6. Place uniformly graded, clean-washed aggregate in 6-inch lifts, lightly compacting between lifts. Fold and secure nonwoven geotextile over aggregate, with minimum overlap of 12 inches.
7. Place 12-inch lift of approved Topsoil over bed, as indicated on plans. Seed and stabilize topsoil.
OR
Install hardscaped surface material, as per manufacturer's specifications. Protect pervious pavers, if applicable, during the remainder of construction.
8. Follow maintenance guidelines, as discussed below.

Aesthetics



Aesthetics

Since Subsurface Infiltration systems are typically installed underground and near residential structures, they do not greatly impact site aesthetics. Therefore, if a visually unobtrusive stormwater control device is desired, Subsurface Infiltration makes for an excellent choice. Of course, Subsurface Infiltration can also be constructed in such a way as to enhance site aesthetics. Vegetated Subsurface Infiltration systems can be just as attractive as Rain Gardens, while those systems constructed under hardscaped surfaces such as patios, walkways, or driveways, can be nicely integrated into the built environment. Depending on the location, use, and selected material, hardscaped Subsurface Infiltration systems can be quite attractive, adding value to any residence.



Image modified by Cahill Associates

Excavate the subsurface infiltration bed, keeping the bottom level and uncompacted



Construction of a subsurface infiltration bed under a driveway made of standard asphalt.

Completely wrap the bed with nonwoven geotextile



Place clean aggregate into the bed, folding geotextile around aggregate.



Images: Cahill Associates, Inc.

This driveway uses a trench drain at the base of the driveway to divert surface runoff into the bed.



All of the houses in this photo have infiltration beds beneath standard asphalt driveways.



Many homes incorporate rain gardens for additional stormwater management



Township Review

In most cases, there should be no need for special Township review, permitting actions, and so forth when Subsurface Infiltration systems are developed - unless the area being disturbed is quite large, thereby qualifying as an action which triggers related permits, reviews, approvals. The homeowner should consult with both the Township Engineer and an Engineering or Landscape Design Professional to aid in the design and construction of the Subsurface Infiltration system. The Township will answer homeowner's questions for these systems, though the homeowner may require assistance from a Professional Engineer or Landscape Designer to develop more detailed plans.

Site Constraints

Like Dry Wells, Subsurface Infiltration beds are sized to temporarily retain and infiltrate stormwater runoff from roofs of structures. A Subsurface Infiltration bed usually provides stormwater management for a limited roof area. Care should be taken not to hydraulically overload a bed based on bottom infiltration area and contributing roof drainage area.

Subsurface Infiltration beds are not recommended when their installation would create a significant risk for basement seepage or flooding. In general, 10 feet of separation, preferably down-slope, is recommended between beds and building foundations. However, this distance may be shortened at the discretion of the designer or homeowner. Shorter separation distances may warrant an impermeable liner to be installed on the building side of the bed. The bottom of a Subsurface Infiltration bed should be at least two feet above seasonal high-water table and bedrock or shown to be otherwise capable of handling expected drainage volumes. Consult the county Soils map to determine if your property contains seasonally high water table soil series.

As with other infiltration measures, Subsurface Infiltration areas should not be placed on areas of recent or compacted fill. Any necessary grade adjustments requiring fill should be done using the aggregate sub-base material, or alternative storage media if applicable. Areas of historical fill (>5 years) may be considered if other criteria are met. Surface grading should be relatively flat, although a relatively mild slope between 1% and 3% is usually recommended to facilitate drainage, especially if pervious hardscaping is not employed. In areas with poorly-draining soils, Subsurface Infiltration areas may be designed to slowly discharge to nearby rain gardens, wetlands, or other vegetated areas.

Variations

As its name suggests, Subsurface Infiltration is generally employed for temporary storage and infiltration of stormwater runoff in subsurface storage media, whether aggregate, concrete, plastic, or other. However, in the case of vegetated Subsurface Infiltration beds, runoff may be temporarily stored on the surface (to depths less than 6 inches) to enhance the storage capacity of the system. (In this way, a vegetated Subsurface Infiltration bed acts very much like a Rain Garden.) A Subsurface Infiltration bed should always be constructed such that it completely drains out within 72 hours.

As previously noted, the surface of a Subsurface Infiltration bed can either be **vegetated** (native or drought-tolerant vegetation is recommended) or finished with a **hardscaped** surface, such as concrete, brick, or plastic pavers, which may or may not be pervious. In the case of the latter, Subsurface Infiltration can be effectively integrated into new residential exterior spaces, including patios, walkways, or driveways. Below is a brief discussion on the two most common types of pervious hardscaping surfaces for residential applications: Block Pavers and Plastic Grid Pavers.

Pervious Pavers allow stormwater to soak into a subsurface infiltration bed



Block Pavers are usually concrete units that interlock with one another but leave open void space between them in order to infiltrate stormwater into the underlying aggregate base. The thickness of the aggregate subbase, as well as the type of material used to fill in the void spaces, determines the amount of infiltration permitted. A typical concrete block pavement installation consists of an uncompacted soil subgrade, an aggregate base, a layer of bedding sand, and the grid pavers themselves. The void space within the pavers can be filled with either gravel or soil and grass. Block Pavers are often very attractive and therefore especially well suited to patios, walkways, and other areas where aesthetics are important. Proper site preparation, installation, and maintenance are very important to the Block Pavers' long-term success.

Plastic Grid Pavers are pavers constructed primarily from recycled plastic materials that can be filled with either gravel or soil and grass, with the former being the better choice for more frequently and intensely used areas, such as driveways. Due to their inherent flexibility, Plastic Grid Pavers can be used on sites with uneven terrain, though they do not have as much intrinsic strength as concrete pavers. As with Block Pavers, proper site placement, installation, and maintenance are key to their overall success. For example, it is important to avoid allowing large volumes of runoff from adjacent impervious areas onto the grid pavers, since that could clog them with sediment and deposit salt on the vegetation in the winter.

As new products are always arriving on the market, the designer or homeowner is encouraged to evaluate the benefits of various products with respect to the specific application. Many paver manufacturers recommend compaction of the soil and do not include a subsurface drainage/storage area. Therefore, they do not provide optimal stormwater management benefits. A system with a compacted subgrade will not provide significant infiltration.

Maintenance



Maintenance

Subsurface Infiltration is generally less maintenance intensive than other practices of its type. Generally speaking, vegetation associated with Subsurface Infiltration practices is less substantial than practices like Rain Gardens and Vegetated Swales and therefore requires less maintenance. Maintenance activities required for the storage 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 at least 2 times per year.
- The overlying vegetation of Subsurface Infiltration features should be maintained in good condition, and any bare spots revegetated as soon as possible.
- Vehicular access on vegetated Subsurface Infiltration areas should be prohibited, and care should be taken to avoid excessive compaction by lawn mowers.

If pervious pavers are utilized, the primary goal of maintenance is to prevent the pavers and/or underlying infiltration bed from being clogged with fine sediments. To keep the system clean throughout the year and prolong its life-span, the pervious pavers should be washed with a high pressure hose and then swept in order to loosen and remove any clogged particles. If the gravel in-fill becomes too clogged, or gets displaced (and then lost) due to foot/vehicular traffic, it should be refilled as necessary. Planted areas adjacent to pervious pavers should be kept well maintained to prevent soil washout onto the pavers. If any washout does occur it should be cleaned off the pavers immediately to prevent further clogging of the pores. Furthermore, if any bare spots or eroded areas are observed within the planted areas, they should be replanted and/or stabilized at once. Planted areas should be inspected on a semiannual basis. Salts and sands should be used sparingly, if at all, for deicing in the winter.

Maintenance for pavers filled with soil and grass includes mowing, irrigation, fertilization, and seeding. From time to time, individual grids, especially if plastic, may need to be replaced. Snow shoveling should be done carefully, so as not to scrape and dislodge paver in-fill.