5.3.1 Pervious Pavement

Description

Pervious pavement consists of a pervious (permeable) surface typically composed of asphalt, concrete, pavers, reinforced turf, or rubber play surface overlain on a subsurface typically composed of open-graded stone storage or infiltration bed. Stormwater drains through the surface (see Figure 5.3.1-1), is temporarily held in the voids of the infiltration bed, and then slowly infiltrates into the underlying, uncompacted soils.

Figure 5.3.1-1. Rainfall drains directly through pervious asphalt pavement (left side of photo) but can be seen as runoff on standard impervious asphalt pavement (right side of photo).

Pervious pavement areas are well suited for parking lots, playgrounds, plazas, pathways, and other hardscape pavement areas. Stormwater runoff from other portions of the site can be conveyed into the stormwater bed for management. Pervious pavement can be used on low volume streets if conditions are suitable to control sediment and maintain the pervious pavement. If infiltration is not feasible or is limited, the subsurface bed can include an underdrain system for slow release. Pervious pavement systems can be designed to provide SOV, rate control, and water quality.

Pervious pavement should not be used in "hot spot" areas or areas where material may be stored on the pavement. It should be used with caution in high-traffic parking areas, such as convenience stores, due to traffic levels and high pollutant loads. It can be used in areas of heavy vehicle use, such as industrial areas, provided that the pervious pavement is properly designed for the loads it will carry. Pervious pavement often has limited shear strength and is not suitable for vehicles with heavy point loads (such as airplanes) or for use on steep slopes (greater than 6 percent).

BMP Functions Table

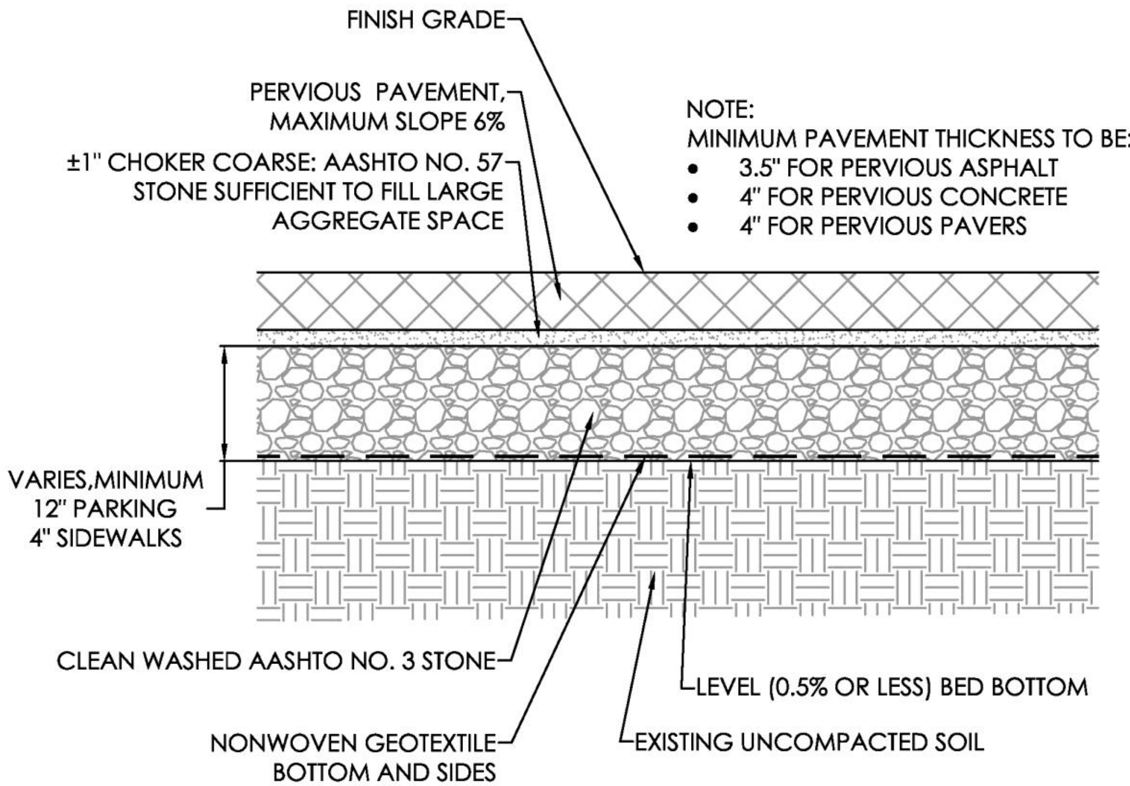
BMP	Applicability*	Volume Reduction	Water Quality	Peak Rate Reduction	Recharge	Runoff Temperature Mitigation	Heat Island	Habitat Creation	Maintenance Burden	Cost
Pervious Pavement	U/S/R	H	H	H	H	H	M	L	L	M

KEY: U = Urban; S = Suburban; R = Rural; H = High; M = Medium; L = Low

*Rating varies based on design considerations.

Key Design Features

- Pervious surface pavement material.
- Clean-washed, open-graded stone storage bed with minimum of 40 percent void space.
- Additional storage may be achieved through the use of perforated pipes set in the stone bed or proprietary stormwater storage products.
- Can be designed to capture entire volume of small storms and to provide peak rate control for larger storms.
- Often manages runoff from other portions of the site that can be conveyed into the stormwater bed.
- Large impervious areas should **not** be designed to discharge onto the pervious pavement because clogging may occur. These areas should be treated by vegetated BMPs (i.e., swales or filter strips) or sediment removal systems before discharge into the stormwater bed.
- Surface and stone bed must be designed for anticipated traffic loads.
- Level, uncompacted subgrade (see Figure 5.3.1-2).
- Nonwoven geotextile at soil/stone interface.
- Generally not recommended for traffic surfaces with slopes greater than 6 percent.
- Designed with alternate method to convey water into stormwater bed if pavement clogs.
- May include pipe distribution network.
- Always includes positive overflow.
- Should not be placed on compacted fill (fill with stone, as needed).
- When possible, infiltration beds should be placed on upland soils.



PERVIOUS PAVEMENT CROSS-SECTION
FIGURE 5.3.1-2 NTS

Figure 5.3.1-2. Pervious pavement cross-section. Pervious pavement beds should always be placed on level (0.5 percent slope or less) bed bottoms to prevent ponding in one area of the bed.

Applications

- Roadways, walkways, parking stalls
- Parking lots
- Playgrounds, plazas, terraces, and basketball and tennis courts
- Low volume streets
- Not suitable for hot spot areas unless designed for spill containment
- Not suitable for areas subject to high levels of sediment and debris

Advantages

- When used to provide volume reduction (SOV), may provide a Curve Number reduction and may reduce the peak rate requirements for the site.
- Reduces the space required for stormwater management by incorporating stormwater into the building program (parking, hardscape).
- Can manage a significant quantity of runoff and function as a regional system.
- Well suited to directly receive "clean" roof runoff.
- Can be designed to include peak rate control.
- Effective in contaminant reduction such as total suspended soils, metals, and oil and grease.
- Can be benched or terraced to accommodate slopes.
- Withstands freeze-thaw cycles and generally requires less winter maintenance than standard pavement.
- Lifespan comparable to traditional pavements and cost-effective when used to meet SOV requirements.

Disadvantages

- High clogging potential if runoff from high-sediment areas is not pretreated.
- Not suitable for pavements with high shear stress requirements or steep slopes.
- Requires alternate maintenance requirements from traditional asphalt (i.e., vacuuming, removal of vegetation between pavers, etc.).
- Must be offset from foundations/basements.
- Not applicable with high bedrock, high groundwater, or contaminated soils.
- Infiltration requires suitable site conditions.

Applications

Pervious pavement can be used in myriad ways in the urban and suburban environments, on residential, institutional, and commercial properties and within the public right-of-way. Potential applications include parking lots, parking stalls on roadways, alleys, sidewalks and paths, plazas, playgrounds, and athletic fields and courts. If pervious pavement is applied on residential lots, the property owner must be made aware that pavement is pervious.

Sidewalk: Pervious Concrete Pavement

Figure 5.3.1-3. Pervious concrete sidewalk. Constructing sidewalks with pervious concrete reduces impervious area. The sidewalk can also be designed to include a stormwater bed with capacity to receive runoff from adjacent impervious areas (i.e., driveways, roads). This is most applicable where sidewalks are level or mildly sloped (less than 3 percent).

Plaza: Pervious Pavers

Figure 5.3.1-4. Pervious concrete pavers for terrace area. Pervious pavers are ideal for plaza and terrace areas.

Parking Lot: Pervious Asphalt and Pervious Concrete Parking Lot

Figure 5.3.1-5. Pervious asphalt and pervious concrete parking lot. The University of North Carolina Chapel Hill park and ride lots include both pervious concrete and pervious asphalt.

Basketball Court: Pervious Asphalt

Figure 5.3.1-6. Pervious asphalt basketball court. Pervious asphalt on play surfaces does not form puddles and is quieter when balls bounce.

Types of Pervious Pavement

Figure 5.3.1-7a. Pervious Asphalt

Figure 5.3.1-7-b. Pervious Concrete

Figure 5.3.1-7-c. Concrete Pavers

Figure 5.3.1-7-d. Brick Pavers

Figure 5.3.1-7-e. Reinforced Turf or Gravel

There are several types of pervious pavement available, including proprietary products. The type of pervious pavement selected by the designer is a function of:

- Use and durability: This includes whether the pervious pavement will be subject to traffic loads, and the nature and extent of anticipated traffic loads.
- Appearance: Pervious pavers can be quite attractive while pervious concrete often has a coarse texture and cannot be “finished” like standard concrete.
- Cost: Pervious asphalt pavement is often the least expensive material, while pavers are often the most expensive.
- Maintenance: The amount of trash and debris may affect pervious pavement selection. Asphalt and concrete can be maintained by vacuum sweeping. Pervious pavers may require more maintenance for

debris removal (i.e., cigarette butts and small debris) and for the removal of vegetation between pavers.

Pervious Bituminous Asphalt

Pervious asphalt is similar to standard asphalt except that the aggregate fines (particles less than 0.60 micrometers [µm], or the No. 30 sieve) are kept to a maximum of 5 percent within the asphalt. Because of reduced fines, pervious asphalt has less shear strength than standard asphalt and is not suitable for heavy point loads. Improvements in open-graded highway overlays have led to improvements in pervious asphalt, including additives that increase the durability of the asphalt (i.e., PG 76-22 as specified by the American Association of State Highway and Transportation Officials [AASHTO], which includes a styrene-butadiene-styrene elastomer polymer binder). The use of fiber additives may also increase the shear strength of pervious asphalt.

Figure 5.3.1-8. It is important that pervious pavement be placed at the correct temperature as determined by the drain-down test for the asphalt mix.

One of the most critical components of a successful pervious asphalt installation is the application of a drain-down test (ASTM D6390) to determine the optimum asphalt temperature for placement. Asphalt binds differently to different types of aggregate (i.e., it binds better to limestone than granite). It is important to determine the optimum placement temperature for the aggregate in use to prevent drain-down (see Figure 5.3.1-8). Drain-down reduces the durability of the pavement at the surface and may create a clogging layer below the pervious asphalt.

Figure 5.3.1-9. Pervious asphalt at this commercial parking lot includes recycled rubber in the bituminous mix.

Pervious pavement may also include recycled asphalt or recycled rubber (see Figure 5.3.1-9). Detailed specifications and installation guidance on pervious asphalt can be obtained from the National Asphalt Pavement Association (NAPA) (http://www.asphaltpavement.org/).

Pervious Concrete

Pervious concrete has a reduced amount of fines and may have a different aggregate gradation than standard concrete. It has a coarser texture than standard concrete and has different requirements for mixing and placing. As with standard concrete, formwork is required for placement. Pervious concrete must be carefully rolled to prevent the concrete from forming an impermeable layer at the surface. Detailed specification and placement guidance is available from the National Ready Mix Concrete Association (http://www.nrmca.org/) and the Florida Concrete Association (http://www.fcpa.org/).

Pervious Concrete Pavers and Brick Pavers

Pervious concrete and brick pavers include openings or gaps filled with clean gravel for water to move into the gravel bed below the paver. The pavers may be interlocking or offset. There are a number of products available from different manufacturers, each with different guidance for installation. However, as with any paver, the pavers must include an edge restraint for installation. If the subgrade below the paver is compacted during construction, the pavers cannot infiltrate.

Figure 5.3.1-10. This standard asphalt path is 8 feet wide and includes a stone stormwater bed that is 14 feet wide to support an emergency vehicle. The grassed edges are constructed of reinforced turf grids over the stormwater bed. The bed receives runoff from the roof leaders of the adjacent building.

Reinforced Turf and Gravel

A number of products are available that consist of plastic grids that can be filled with either a sand/turf mix or a clean gravel mix. These products are especially useful in low-traffic areas, such as overflow parking lots or fire lanes (see Figure 5.3.1-10). Soil mixes must be carefully designed to allow drainage while also supporting vegetation. The designer may use the bioretention soils specifications for this purpose.

Pervious Rubber and Manufactured Pervious Mixes

In addition to manufactured grids and structural products to create pervious pavements, various manufactured materials are available for pervious pavements, including polymer bound pervious mixes composed of recycled rubber, glass, stone, and other materials. These products tend to be more costly but also provide an aesthetic that is often desired or needed. The products may or may not be suitable for traffic loads as indicated by the manufacturer. The use of pervious rubber surfaces (which are traditionally used in splash pools and similar installations) can provide an ideal stormwater management system and safe play surface in playground areas (see Figure 5.3.1-11).

Figure 5.3.1-11. Pervious rubber is an ideal material for a stormwater BMP constructed as part of a playground.

ITEM	RECOMMENDATION	REFERENCE SECTION
Drainage Area and Location Recommendations	Locate the pervious pavement so sediment laden runoff will not drain onto pavement surface. Locate so that bed bottoms are flat or have a maximum of 0.5% slope. Do not locate on fill material.	5.3.1.1
Concept Phase Loading Ratio (LR) (Recommended)	1:8 for South Chickamauga Watershed	5.3.1.5
	1:10 for all other Watersheds	
Concept Phase Surface Area Size (ft^2) (Recommended)	Impervious Drainage Area Managed (ft^2) / Loading Ratio	5.3.1.5
Entrance/Flow conditions	Surface Dispersed: Direct rainfall, sheetflow from standard pavement, or combined with pre-treatment (i.e., filter strip).	5.3.1.2
	Direct Connection (into stone bed): Recommended only for "clean" runoff such as roofs	
Pretreatment/Management of Sediment Trash and Debris	Required for high sediment drainage areas. See Filter Strip (BMP 5.3.6)	5.3.1.3
SOV Volume or Water Quality Volume Credit	Static Storage provided by Stone Storage (if applicable), Other structures (pipes, rain storage units, etc.)	5.3.1.4
Stone Storage Coefficient and Volume	0.4 Storage Volume = Stone Depth (ft) x Stone Area (ft2) x 0.4	5.3.1.4
Manufactured Storage Units Coefficient and Volume	0.85 - 0.95 Storage Volume = Manufactured Unit Depth (ft) x Manufactured Unit Area (ft2) x 0.85	5.3.1.4
Perforated Pipes Storage Coefficient and Volume	1.0 Storage Volume = Perforated Pipe Length (ft) x Perforated Pipe Area (ft2) x1.0	5.3.1.4
Stone Depths	Sidewalks and pedestrian paths: 4 inches minimum	5.3.1.5
	Vehicular paths: 12 inches minimum	
Pipe sizes for Overflow and Peak Rate	Minimum size 12 inch diameter. See Stormwater System Specifications	5.3.1.6
Freeboard in Stormwater Bed	2 inch minimum on smaller systems	5.3.1.7
	4 inch minimum on larger systems	
Conveyance Capacity	Peak rate 10-year, 24-hour rainfall event	5.3.1.6
Underdrain	Required if Infiltration Rate < 0.1 inches per hour	5.3.1.8
Setback from Structures	Required. See Stormwater Specification for Impervious Liner	Protocol 1
Coordination with Other Utilities	Required	Protocol 2
Infiltration Testing	Required	Protocol 3
Infiltration System Setbacks	Required	Protocol 4
Vegetation and Mulch	Required	Protocol 5
Inspection and Longterm Maintenance	Required	Chapter 8

Table 5.3.1-1. Pervious Pavement Design Criteria

Applicable Protocols and Specifications

The following Protocols and Specifications (see Appendices A through F) are applicable to pervious pavement and must be addressed:

- Protocol 1 Setbacks from Structures
- Protocol 2 Coordination with Other Utilities
- Protocol 3 Site Evaluation and Infiltration Testing
- Protocol 4 Infiltration System Design and Construction Guidelines
- Stormwater System Specifications
  - Aggregates and Drainage Layers
  - Pipes
  - Control Structures
  - Geotextiles
  - Impervious Liners and Waterproofing

Design Considerations for Pervious Pavement

Pervious pavement can be a cost-effective and durable water management BMP that serves traditional functions. It is imperative that pervious pavement be designed and constructed properly. It is not applicable to all project types and locations.

1. Location and Capture Area

Pervious pavement can be located:

- Close to the source of runoff to minimize the need for additional stormwater structures.
- As part of a "regional" or site stormwater management system, designed to capture runoff from a larger drainage area. This is especially applicable for large parking lot areas.

Pervious pavements are **not** recommended within floodplain areas where the deposition of fine sediment from flood events may damage the pervious nature of the material.

Drainage Area

Figure 5.3.1-12. The stormwater bed beneath this pervious concrete plaza was used as a temporary sediment basin (with basin bottom at least 2 feet above final stormwater bed bottom elevation) during construction of the site. After the surrounding site work was completed, the sediment was removed and the bed excavated to its final depth. The stormwater bed and overlying pervious pavement were then installed.

- It is critical that all pervious pavements be located so that sediment-laden runoff does **not** drain onto the pavement surface (see Figure 5.3.1-12). During construction, erosion and sediment control measures must be maintained until the site is fully stabilized. Sediment-laden runoff can clog both the pervious pavement surface and the underlying infiltration bed.
- Pervious pavement captures direct rainfall, however, runoff from adjacent areas can be directed into the subsurface bed for storage and management. The subsurface bed often has a greater stone subbase thickness for structural stability than is required for direct rainfall capture. Clean roof runoff can be discharged directly into a subsurface bed beneath a pervious parking lot (catch basins with sumps are recommended to capture sediment). Surface runoff from other impervious areas should be addressed with measures (i.e., filter strips, vegetated swales) to reduce excessive sediment before the runoff is discharged (usually via pipe) into the bed.
- It is **not** recommended that large impervious pavement areas drain directly onto a smaller pervious pavement area, because the sediment will tend to clog the smaller pervious pavement area.
- Pervious pavement with infiltration should not be used in hot spot areas where there is the potential for runoff with higher than average pollutant levels to enter the groundwater. Only the hot area is precluded from pervious pavement use; other portions of the site may be well-suited for pervious pavement use.

Slope

- Pervious pavement with infiltration should not be constructed on fill material, because compacted fill prevents infiltration.
- The bed bottom must be level or with a slope less than 0.5 percent. If needed, the subsurface infiltration bed may be benched or terraced on slopes (see Figures 5.3.1-13 and 5.3.1-14).

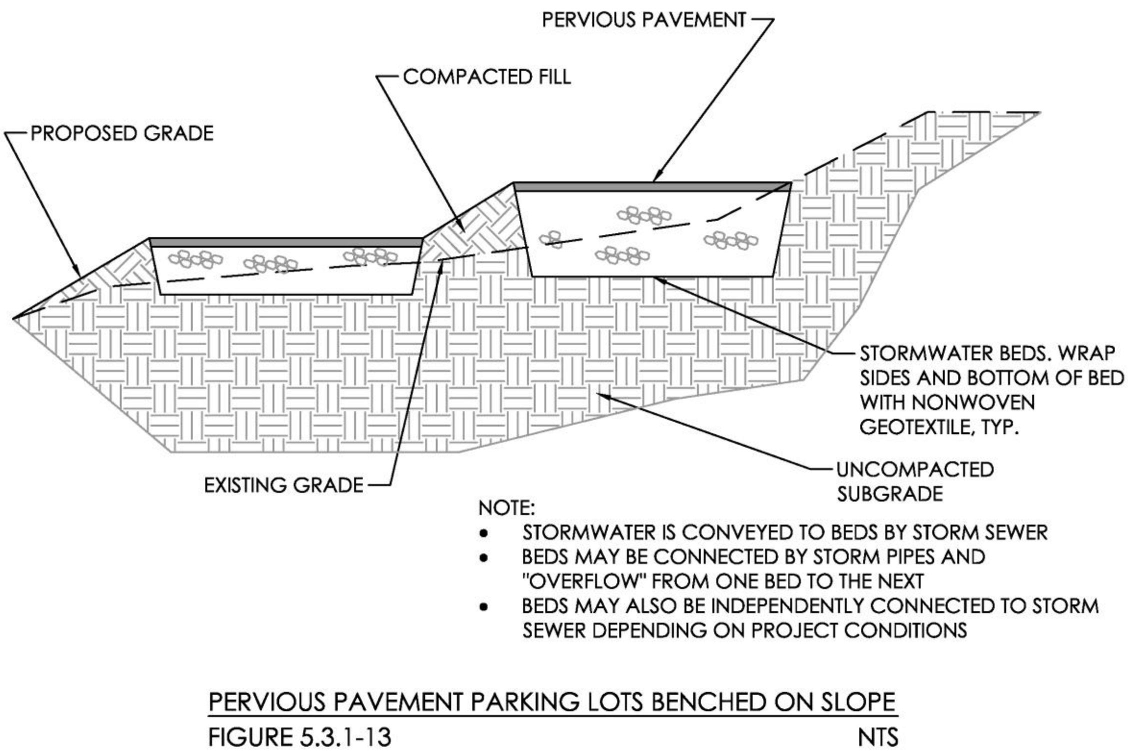


Figure 5.3.1-13. Pervious pavement beds can be terraced on a slope to provide level infiltration bed bottoms and to reduce the pavement slope.

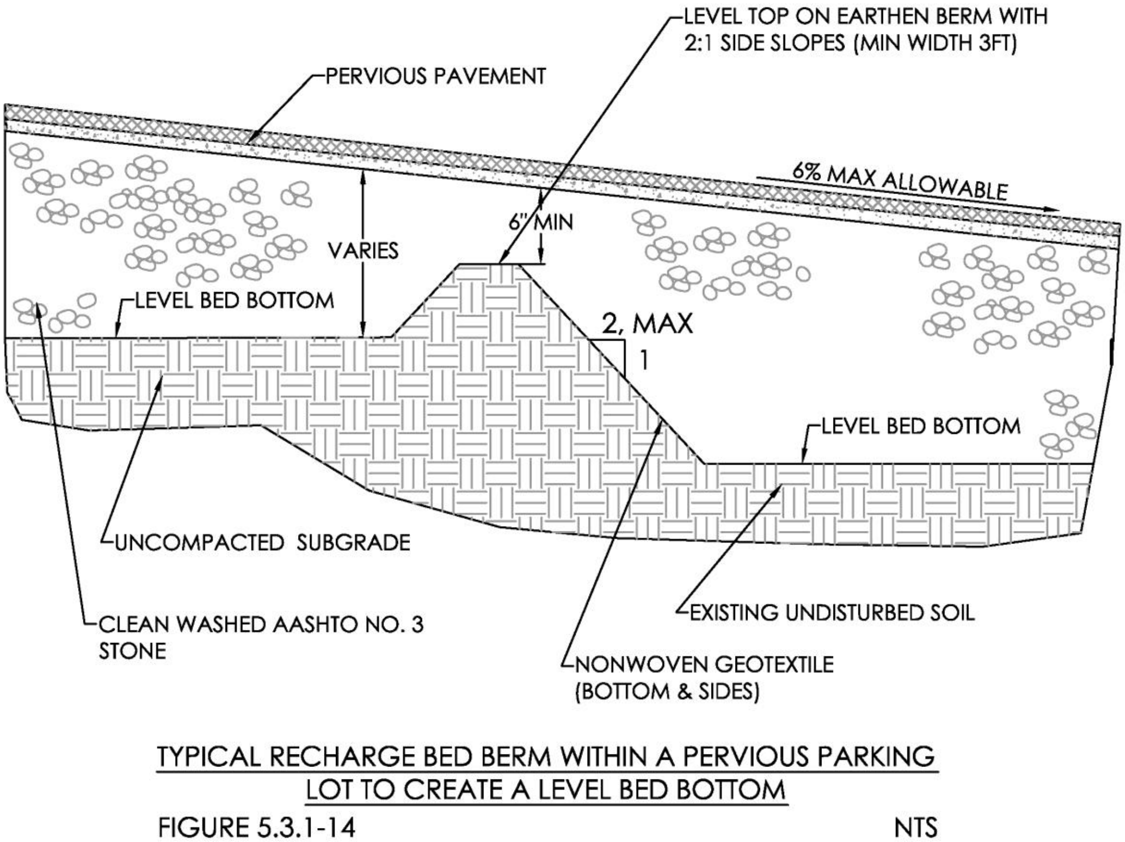


Figure 5.3.1-14. Berms can be used within a pervious pavement bed to create level infiltration areas within a single infiltration bed.

2. **Entrance/Flow Conditions**

- It is recommended that pervious pavement systems be designed with an alternate method for water to enter the stormwater bed, especially for larger systems such as parking lots. Options include open-graded stone edge treatments or inlets and trench drains. In the event that the bed surface is accidentally seal coated or becomes clogged, water can still enter the stormwater bed (see Figure 5.3.1-15).
- If runoff is collected from other surface drainage areas and discharged into the stormwater bed, it should be treated via a sumped inlet, water quality inlet, or other measure.
- It is **not** recommended that large impervious areas be discharged directly onto pervious pavement. The sediment loads may result in pavement clogging. Large impervious areas may be managed within the stormwater bed, but should be pre-treated.
- If large impervious areas will drain toward a pervious pavement, a vegetated filter strip should be used to reduce sediment flowing onto the bed. Alternately, water can be directed around the pavement via a berm or other grading design measure.

Figure 5.3.1-15. Pervious pavement can be constructed with an unpaved pervious edge treatment. In the event that the pavement is seal coated, clogged, or not functioning, runoff from the pavement can still enter the stormwater bed.

3. **Management of Sediment, Trash, and Debris/Potential Clogging Issues**

- Construction is the most critical period for pervious pavement, and it is essential that sediment-laden runoff be prevented from entering the bed or washing onto the pavement. Unstabilized areas cannot be allowed to discharge onto the pervious pavement.
- Pavement can be vacuumed to remove any sediment deposition from pervious asphalt or concrete. This should be done as soon as sediment deposition is observed.
- It is recommended that pervious asphalt and concrete be vacuumed twice per year.
- Roof runoff is generally lower in sediment and can be conveyed directly into a bed; however, a cleanout for roof leaders is required in the event that pipe clogging occurs.
- Runoff from roof areas that receive high amounts of leaf debris or other materials (such as deposition from equipment) should include sediment traps, or should be reconsidered. It may be preferable to discharge these roof areas to a vegetated swale or filter strip prior to discharge into the bed.

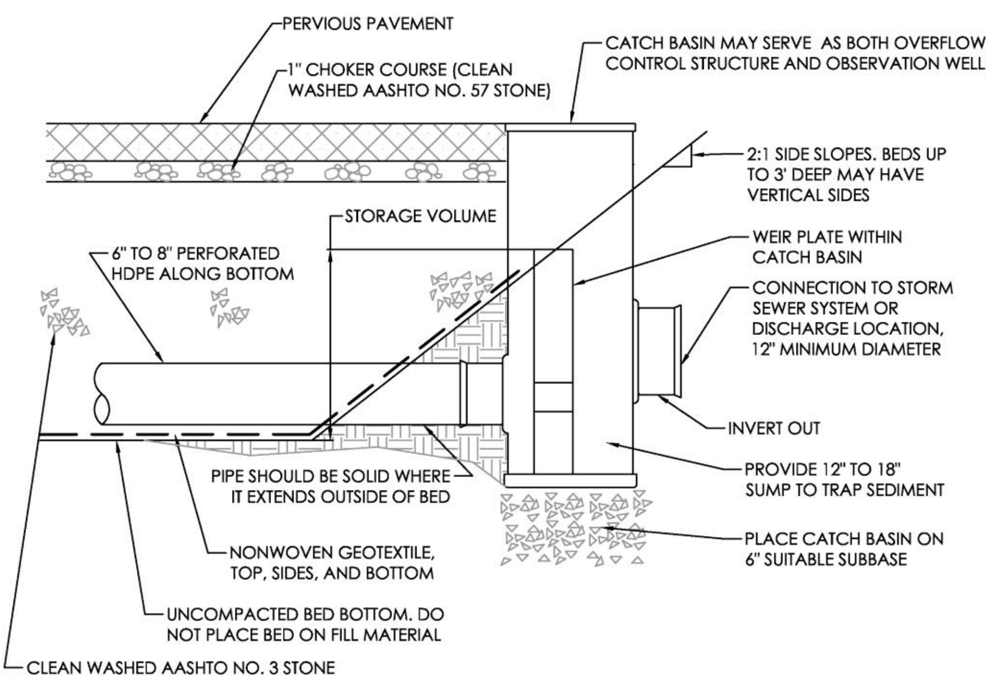
Figure 5.3.1-16. Extending the geotextile over the stone bed during construction of this pervious concrete sidewalk prevents sediment from entering the bed. In this example, the stone bed is wider than the sidewalk. It is designed to manage street runoff (from left) after treatment through a vegetated swale. Runoff sheet flows into the swale over the curb after construction of the final pavement course.

- Pervious pavement should **not** be pressure washed; pressure washing will only force sediment farther into the pavement or into the stormwater bed.

4. Storage and Stay-on-Volume

Pervious pavement that **only manages the rainfall that lands on the pavement can be excluded from the impervious area for purposes of calculating SOV**. This is especially applicable for pervious pavements such as pervious paver walkways.

For pervious pavement that includes a stormwater bed and that receives runoff from other areas, the **storage** capacity of the pervious pavement bed is measured as the volume **below** the lowest discharge invert (overflow) (see Figure 5.3.1-17).



PERVIOUS PAVEMENT INFILTRATION BED AND OVERFLOW CONTROL STRUCTURE WITH WEIR

FIGURE 5.3.1-17 NTS

Figure 5.3.1-17. A catch basin with a weir can serve as an overflow control structure for the stormwater bed beneath a pervious pavement. The SOV depth is controlled by the weir. Larger storms overtop the weir and are conveyed to the storm sewer or appropriate discharge point. The designer should always confirm that the water level will never be high enough to saturate or move upward through the pervious pavement.

Storage Volume (ft^3) =

Bed Length (ft) x Bed Width (ft) x Bed Depth (ft) Below Overflow Elevation x Void Ratio

Void ratios are generally:

- 0.40 for clean-washed aggregate such as AASHTO No. 3
- 0.85 to 0.95 for manufactured storage units depending on manufacturer
- 1.0 for the interior volume in perforated pipes within the bed

The **SOV** is a function of the storage volume available for the 1-inch or 1.6-inch storm. See Chapter 3 for more information on SOV.

5. Area, Stone Bed Depth, and Dimensions

The size and surface area of the pervious pavement area and infiltration bed are usually a function of the pavement requirements rather than the stormwater needs. The amount of parking, paths, and other pavements required for site program needs usually determine the extent of pervious pavement area.

The minimum depth of the stone bed beneath the pavement is a function of the structural stability needs of the pavement, and should be determined by the design engineer based on anticipated use. The stone bed depth may be increased as needed to accommodate additional stormwater storage volume. As a general rule, the aggregate bed for a light vehicle area constructed on uncompacted subgrade should not be less than 12 inches in depth, provided that the aggregate (such as a clean-washed AASHTO No. 3 [angular 1½- to 2½-inch aggregate]) can provide stability. Higher traffic loads may require additional bed depth. Sidewalks and paths should not be constructed with less than 4 inches of aggregate. In each application, the appropriate bed depth for stability and traffic load must be determined by the designer.

Alternate storage media designed for stormwater systems (i.e., modular units) may be used; however, the designer must verify that all such products are suitable for use when traffic loads apply. The designer is responsible for the proper structural design of each installation according to material selected and project traffic loads.

Because the aggregate subbase will often provide more volume storage than is necessary to manage the direct rainfall onto pervious pavement, the stormwater bed can be designed to serve as a site BMP that captures runoff from other impervious areas and portions of the site. This is often very cost-effective. For infiltration systems, it is important **not** to concentrate too much stormwater in one location for management. This can lead to accelerated clogging from sediment, high water depths that may compress soils, and soils that do not dry out between storms (and change structure). It also provides soil/water contact for water quality improvement. A basic design rule is to design pervious pavement with a surface area that is a ratio of the impervious and compacted pervious areas draining to the stormwater bed. The amount of rainfall volume must also be considered. The following ratios based on design rainfall depth can be used to estimate pervious pavement area:

1-inch Rainfall
1:10 ratio of surface area to impervious drainage area

1.6-inch Rainfall
1:8 ratio of surface area to impervious drainage area

Stormwater beds can be designed for deeper water depths during the larger, and less frequent, peak rate storm events (if necessary) to provide peak rate mitigation. The detention capacity of the bed can be analyzed and a hydrograph routed through the bed in the same manner as for a detention basin (taking into account the volume as a function of stone or media porosity).

The bed depth of water storage is primarily determined by the rainfall depth managed and the loading ratio, and influenced to a lesser extent by the infiltration rate. **There is no specific limit on the maximum width or length of an infiltration bed beneath pervious pavement. However, designers are discouraged from designing excessively deep infiltration beds (more than 5 feet for the SOV capacity), even in areas with high infiltration rates, due to concerns that the pressure at greater water depths may compact or alter the underlying soil.** There is no depth limit on non-infiltrating, slow-release beds.

Beds can be designed for short-term, deeper water depths during the larger, and less frequent, peak rate storm events if necessary to provide peak rate mitigation.

Proprietary products may be used as storage media, and as a substitute for stone subbase; however, all products must be approved by the City. There are a number of modular subsurface, plastic, interlocking storage units that provide higher void space and comparable structural stability as AASHTO No. 3, but they may be more costly.

6. Overflow and Peak Rate

All stormwater beds beneath pervious pavements must provide a safe means for water to exit the system when large storms generate more stormwater runoff than the bed can hold. The inclusion of a positive overflow route ensures that flooding risks and related property damage are minimized. The positive overflow route is often in the form of a modified inlet box with an internal concrete weir (or weir plate, see Figure 5.3.1-18), or simply an overflow pipe at an invert higher than the inlet pipe invert. This maximizes the volume managed by the bed, while providing sufficient cover for overflow pipes. When water overtops the weir, it discharges via a pipe to the storm sewer or to another approved discharge point.

Figure 5.3.1-18. Structures can be purchased with weirs at the desired elevations that allow the small storm volume to be retained while larger flows can safely be conveyed (also see Figure 5.3.1-17).

The overflow structure can be designed to function as a detention rate control structure for peak rate control, and can be modeled or evaluated as a detention system. Temporarily higher effective water depths are acceptable during large storm events managed for peak rate control. The catch basins can be used as overflow structures in large storms, and as rate control structures in larger storm events if the bed is constructed with sufficient capacity.

The minimum allowable diameter of an overflow pipe is 12 inches unless otherwise approved by the City.

<u>Peak Rate Control and Infiltration Credit</u>

For the purposes of site peak rate control, the designer may adjust the Curve Number value based on the volume managed by both the SOV and the infiltration volume that occurs during a portion of a 24-hour storm event. This allows the designer to account for runoff that was captured by applying low-impact development and to develop a representative lower Curve Number. This procedure is described in Chapter 7.

When adjusting the Curve Number, the infiltration volume can be estimated as the infiltration that occurs during 12 hours of a 24-hour design storm. This will ensure that estimated infiltration volumes are not greater than the actual volume captured within the BMP.

Infiltration Volume (ft^3) = Pervious Pavement Bottom Area (ft^2) x Infiltration Rate (in/hr) x 1/12 x 12 hours

7. Freeboard

It is essential that pervious pavement systems be designed so that there is **never an opportunity for the water level to saturate the pervious surface material**. This is essential to the long-term stability and durability of the pervious surface. For this reason, it is recommended that all pervious pavement be designed with a freeboard within the stormwater bed such that the water level never reaches the top of the bed or surcharges the bed. A minimum freeboard of 2 inches is recommended on smaller systems such as sidewalks and 4 inches on larger systems such as parking lots.

8. Underdrain

An underdrain system is used to ensure that water moves through the system when the native soil infiltration rate is not high enough to empty the bed of water, or if the bed is underlain by an impervious liner and designed only for slow release. Underdrain systems should discharge to the existing stormwater system or a location approved by the City. Underdrain systems must be included in the design if the native soil infiltration is less than 0.1 inch per hour, or if the bed is designed for slow release. See Protocol 3 for the infiltration testing procedure and Protocol 4 for infiltration system guidelines.

9. Waterproofing

In some instances where pervious pavement systems are designed to infiltrate, there may be concerns about impacts on adjacent structures such as basements or on the subbase of adjacent paved surfaces. The system may also be designed with an underdrain for slow-release of flows rather than infiltration if there are concerns regarding lateral movement of water from the sides or bottom of the subsurface infiltration beds. For all pervious pavement systems, the designer must evaluate the impact of the system on adjacent structures and utilities as defined in Protocol, 1 Setbacks from Structures and Protocol 2, Coordination with Other Utilities. The liner if applied must meet the guidelines provided in the Stormwater Specification.

Where pervious pavement immediately adjoins standard pavement, a liner or waterstop should be employed to prevent water from entering the standard pavement subbase (see Figure 5.3.1-19).

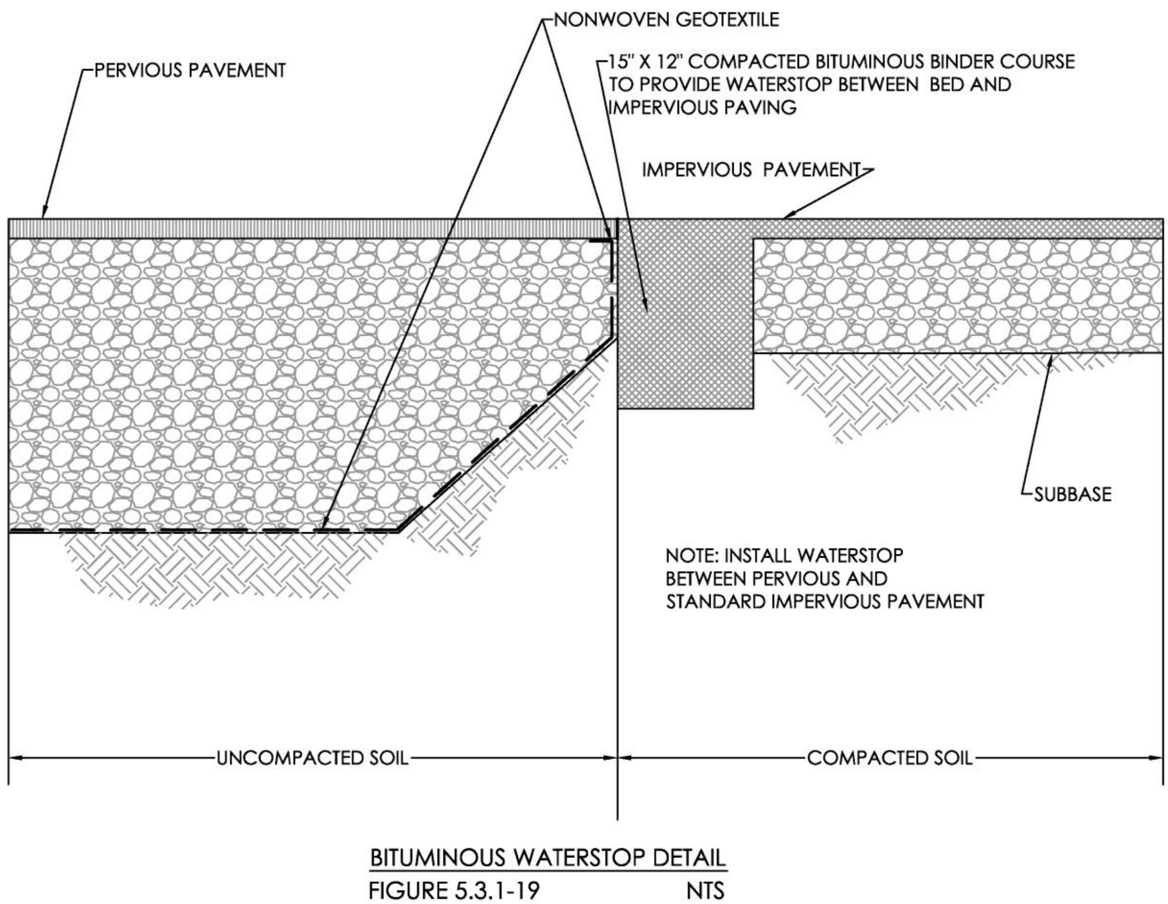


Figure 5.3.1-19. A bituminous waterstop can be used to prevent lateral movement of water between standard and pervious asphalt.

10. Water Quality/Total Suspended Solids

Pervious pavement systems that can capture and manage the required SOV through infiltration are considered to meet all water quality requirements. Pervious pavement beds that are underdrained, but can capture the required water quality volume as defined in Chapter 7, are also considered to provide water quality treatment. See Chapter 7 for additional discussion, and the Subsurface Infiltration Bed Worksheet for calculations.

Sizing Calculations Worksheet for Pervious Paving

(Link to Worksheet)

Construction Considerations

For the best success, pervious pavement systems should not be installed until site construction is complete and site stabilization has occurred. Pervious pavement systems completed before site stabilization **must** be protected from receiving sediment-laden runoff. Runoff should be directed around the completed pervious pavement system until site stabilization has occurred. **Sediment-laden water must not be allowed to enter pervious pavement systems or to drain onto pervious pavement surfaces.**

The excavated capacity of the stormwater bed may be used as a temporary sediment trap area during construction. The bed should not be excavated to final grade until the system is converted from a sediment trap to a stormwater bed. It is recommended that the sediment trap bottom elevation be 2 feet above the final stormwater bed elevation. Underdrained infiltration beds may be used as sediment traps during construction to the final bed bottom elevation.

Construction Sequence Example

Step 1 Excavate and Prepare Subgrade

a. Do **not** compact or subject pervious pavement locations to excessive construction equipment traffic during construction. Protect areas from vehicle traffic during construction with construction fence, silt fence, or compost sock.
b. Initial excavation of infiltration beds can be performed during rough site grading. When performing initial excavation, do not grade bottom beyond 2 feet above the final bed bottom elevation. Complete final excavation only after all disturbed areas in the drainage area have been stabilized, or after the bed is adequately protected from receiving sediment-laden water (i.e., with erosion and sediment control measures around the BMP).
c. Remove fine materials and/or surface ponding in the grading bottom, caused by erosion, with light equipment and scarify the underlying soils to a minimum depth of 6 inches with a York rake or equivalent by light tractor.
d. Leave earthen berms between infiltration beds (if used) in place during excavation. These berms do not require compaction if proven stable during construction. Constructing berms with fill is discouraged. If necessary, key constructed berms into the subbase and compact to 95 percent density. All constructed berms shall be designed by a qualified engineer.
e. Bring subgrade of infiltration bed to line, grade, and elevations indicated. Fill and lightly regrade any areas damaged by erosion, ponding, or traffic compaction. All infiltration beds should be level grade on the bottom.
f. Halt excavation and notify engineer immediately if evidence of sinkhole activity or unanticipated bedrock or groundwater conditions are encountered, or other site conditions that may affect infiltration bed design or performance become evident.

Step 2 Install Overflow Structure and Other Stormwater Structures

a. Place the stormwater overflow structure on suitable subgrade to prevent settling. Install overflow structure, inlet pipes, curbs, and other stormwater structures as appropriate before placement of stone storage bed.
b. Close and secure all inlets, pipes, trench drains, and other structures to prevent runoff from entering the infiltration bed before completion and site stabilization.
c. Maintain drainage overflow pathways during construction, while infiltration bed is closed, to provide for drainage during storm events.
d. Infiltration bed conditions should be observed by the design engineer, following excavation and grading and prior to placement of geotextile and aggregate materials, to confirm that construction requirements have been met. Documentation must be provided to the City (see Appendix I).

Figures 5.3.1-20a and b. Geotextile and perforated distribution pipes are placed on an uncompacted subgrade, and stone is placed without compacting the bed bottom. Distribution pipes can be designed to extend through berms within the bed.

Step 3 Install Infiltration Bed

a. Place geotextile and bed aggregate immediately after approval of subgrade preparation and installation of structures. Install geotextile in accordance with manufacturer's standards and recommendations. Overlap adjacent strips of geotextile a minimum of 16 inches and secure at least 4 feet outside of the bed to prevent any runoff or sediment from entering the storage bed. This edge strip should remain in place until all bare soils contiguous to beds are stabilized and vegetated. Once the site is fully stabilized, cut excess geotextile along bed edges back to gravel edge.

Figure 5.3.1-21: Although the subgrade is uncompacted to allow for infiltration, the stone bed is placed in layers and rolled to provide a suitable subbase for construction vehicles and future traffic loads.

b. Place clean-washed, uniformly graded aggregate in the bed in maximum 8-inch lifts. Compact each layer lightly while keeping construction equipment off the bed bottom as much as possible.
c. Once bed aggregate is installed to the desired grade, install a 1-inch layer of choker base course (AASHTO No. 57) aggregate uniformly over the surface. This ensures an even surface for paving.

Step 4 Install Pervious Pavement

a. Install pervious pavement in accordance with specifications and/or manufacturer's requirements.
b. Test the pavement surface for permeability by applying clean water at the rate of at least 5 gallons per minute per square foot (gpm/ft^2) over the surface, using a hose or other distribution device. All applied water should directly infiltrate without ponding or creating surface runoff.
c. As required for pervious asphalt and concrete, protect pervious pavement from vehicle access for the duration indicated in the specifications.

Operations and Maintenance

It is recommended that signage be installed at all pervious pavement installations to ensure institutional memory that the pavement is pervious and should not be repaved, seal-coated, etc.

Special Maintenance Considerations:

- Prevent Clogging of Pavement Surface with Sediment
  - Vacuum pavement twice per year.
  - Maintain planted areas adjacent to pavement.
  - Immediately clean any soil deposited on pavement.
  - Do not allow construction staging, soil/mulch storage, etc. on unprotected pavement surface.
  - Clean inlets draining to the subsurface bed twice per year.
- Snow/Ice Removal
  - Pervious pavement systems generally perform better and require less treatment than standard pavements.
  - Abrasives such as sand or cinders should not be applied on or adjacent to pervious pavement.
  - Snow plowing is acceptable but should be done carefully (i.e., the blade should be set slightly higher than usual).
  - Salt application is acceptable, although more environmentally benign deicers are preferable.
- Repairs
  - The surface should never be seal coated.
  - Damaged areas less than 50 square feet can be patched with pervious or standard asphalt.
  - Larger areas should be patched with an approved pervious asphalt.

Winter Maintenance

Winter maintenance for a pervious parking lot may be necessary, but is usually less intensive than that required for a standard asphalt lot. By its very nature, a pervious pavement system with a subsurface aggregate bed has superior snow melting characteristics than standard pavement. The underlying stone bed tends to absorb and retain heat so that freezing rain and snow melt faster on pervious pavement. Therefore, ice and light snow accumulation are generally not as problematic. However, snow will accumulate during heavier storms. Abrasives such as sand or cinders should not be applied on or adjacent to the pervious pavement. Snow plowing is acceptable, provided it is done carefully (i.e., by setting the blade slightly higher than usual, about an inch). Salt is acceptable for use as a deicer on the pervious pavement, although nontoxic, organic deicers, applied either as blended, magnesium chloride-based liquid products or as pretreated salt, are preferable.

Repairs

Potholes in the pervious pavement are extremely unlikely, although settling might occur if a soft spot in the subgrade is not removed during construction. For damaged areas of less than 50 square feet, a declivity could be patched by any means suitable with standard pavement, with the loss of porosity of that area being insignificant. The declivity can also be filled with pervious mix. If an area greater than 50 square feet is in need of repair, approval of patch type must be sought from either the engineer or the owner. Under no circumstance is the pavement surface to ever be seal coated. Any required repair of drainage structures should be done promptly to ensure continued proper functioning of the system.