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PERMEABLE PAVEMENTS

Effective: 05/01/2017

The Permeable Pavement methods described in this document are based on the permeable paving design found in Chapter 5 of the Maryland Stormwater Design Manual and the Environmental Site Design (ESD) Process & Computations Supplement dated July 2010. Where deemed appropriate, the design specifications have been modified by the Montgomery County Department of Permitting Services (DPS). DPS requires that all permeable pavements shall include an over-drain system but no underdrain system. These design standards are meant to establish minimum stormwater management (SWM) treatment requirements and are not intended to provide guidance or requirements for adequate structural design. Appropriate design for the anticipated traffic load and use is the responsibility of the design engineer.

The reduction of imperviousness and use of alternative surfaces should be considered prior to other nonstructural and micro-scale ESD practices. All proprietary components must be designed and installed per manufacturer's recommendations.

A. Facility Description

Permeable pavements are alternative surfaces that may be used to provide ESD treatment for paved surfaces and to reduce RCN values.

The principal components of permeable pavement include: a) a permeable pavement layer b) a 6" to 12" stone sub-base layer of clean, open graded, washed aggregate, c) a 6" of washed concrete sand bridging layer between the stone and the underlying soil subgrade, d) an over-drain system for excess runoff, and e) permeable filter fabric used on the excavated sides.

Permeable Pavements include:

Permeable Interlocking Pavers are different from pervious and porous pavers in that rainwater passes around the pavers opposed to through it. The paver gap aggregate shall be a silica-based aggregate per manufacturer's recommendations or meeting ASTM D448 size criteria of No. 8, 89, or 9 stone.

Pervious/Porous Pavers - Only those products that have been approved in writing by DPS may be used for SWM.

Pervious Concrete - Installation must be performed by a National Ready Mixed

Association Certified Pervious Concrete Installer. All construction must be done per American Concrete Institute (ACI) 522.13.

Pervious Asphalt - Pervious asphalt may be acceptable for use in non-vehicular use areas but only with prior approval from DPS on a case-by-case basis.

B. System Design Considerations

1. Applicability

Permeable pavements are applicable where underlying soils are conducive to infiltration. Permeable pavements should NOT be used in areas where they may cause a risk of foundation or basement damage, interference with subsurface sewage disposal systems, or detrimental impacts to other underground structures or utilities. In Montgomery County, permeable pavement within the public right-of-way is limited to sidewalks only. Permeable pavement should NOT be placed within a public utility easement (P.U.E.) without specific prior approval of all affected utility companies.

2. Safe Conveyance

Permeable pavement designs must incorporate a method to collect runoff in excess of the target treatment volume and convey it away from the measure. The excess runoff, up to the 10-yr storm, must be safely conveyed to a stable outfall. In some instances, this can be achieved with a pipe over-drain system.

3. Groundwater

The bottom of the sub-base reservoir shall be at least four (4) feet above the seasonal high water table.

C. Specifications and Details

1. Sizing

Permeable pavements are an at-source practice for reducing the effects of impervious cover. They should be sized to capture and store 100% of the target treatment volume. The total treatment storage provided in a facility that can be credited towards meeting the ESD requirement, ESD_v, shall be computed as the storage in the stone subbase and sand bridging layer below the overdrain pipes. Computations shall account for the porosity ($n = 0.30$) of the stone and sand. To account for continual vehicular compaction that permeable pavement receive, the porosity of permeable pavements is not 40% like all other ESD practices.

Runoff from adjacent paved and unpaved areas onto permeable pavement should be limited and whenever possible diverted away. However, in some cases, this is either unavoidable due to site layout and grading or an intentional element of the design (such as treating impervious drive aisles adjacent to permeable paving.) When that is the case the amount of drainage area that can be treated by the practice is limited as follows: the maximum ratio of adjacent contributing drainage area to permeable paving surface area

is 1:1, so the contributing drainage area cannot be greater than the permeable pavement surface area.

Runoff from landscaped areas, forests, and other planted areas contains organics that hasten pavement clogging and increase maintenance costs. Runoff from adjacent areas with this type of cover should be minimized as much as possible.

When designed properly the total storage volume provided in this practice, ESDv, can include the volume in stone and sand voids extended under adjacent impervious areas. For instance, the stone and sand voids underneath both a permeable pavement parking bays plus an upland adjacent impervious asphalt drive aisle can count towards the total storage volume provided.

Storage in permeable pavements in excess of that required to treat the runoff for the 1-yr, 24-hour design storm (2.6") shall not be counted towards the ESDv provided. Therefore, as an Alternative Surface with a maximum allowable 1:1 additional contributing drainage area, the maximum treatment volume is often limited to the volume achieved by the 1-yr design storm.

2. Location

Hotspot Runoff: Permeable pavements should not be used to treat hotspots that generate higher concentrations of hydrocarbons, trace metals, or toxicants than are found in typical stormwater runoff and may contaminate groundwater.

Specific approval from the Fire Marshal's office is required for each permeable pavement placement area that is part of the proposed fire access route. The storage volume for any pervious surface shall be located down gradient of building structures and be setback a minimum of 100 feet from unconfined water supply wells, 25 feet from septic systems, 10 feet from buildings, and 10 feet from any other infiltrating practice. Clearance from site utilities should be per the requirements of the respective utility companies.

When proposed adjacent to slopes 15% or greater, a Geotechnical Engineer's recommendation addressing slope stability is required to be incorporated into the design.

3. Soils

Permeable pavements shall not be used in areas of compacted fill or Karst topography. Soil Typing is required to determine that permeable pavement is an applicable SWM practice; See Montgomery County "Soil Testing Guidelines for Stormwater Management Practices". In applications exceeding 10,000 ft.² of treated area (area of permeable paving plus any other areas draining to it), underlying soils shall have a measured infiltration rate (f) of 0.52 in/hr. or greater.

4. Topography

Runoff shall sheetflow across permeable pavements and the surface must slope gradually (<5%).

5. Installation

Final grading for installation shall not take place until the surrounding site is stabilized. If this cannot be accomplished, runoff from disturbed areas shall be diverted around proposed permeable pavement locations.

Soil subgrades shall not be compacted. Construction should be performed with lightweight, wide tracked equipment to minimize compaction.

6. Edge Treatments

A permeable non-woven geotextile filter fabric shall line the excavated sides to prevent soil migration.

Permeable concrete must include a 6" ribbon curb surrounding all edges set at least as deep as the permeable pavement layer. Where surrounded by curbing, full gutter pans must be included. Permeable pavers must include a full gutter pan when surrounded by curbing. Ribbon curbs around other edges are optional but encouraged. Ribbon curbs are not required for permeable sidewalks.

7. Over-drain Systems

All permeable pavements shall be designed with sufficient subsurface depth to ensure that the total treatment volume does not rise into the pavement where the freeze/thaw cycle could damage the pavement. An over-drain system shall be incorporated into the design to safely convey the runoff in excess of the treatment volume to a stable outfall.

Over-drain pipes should have a minimum of 12" of total cover to the paving surface. A 6" layer of stone must be placed between the bottom of pavers and the top of the over-drain pipe. In addition to the guidance in this document, pipe placement should meet manufacturer's minimum recommendations. Over-drain pipe shall be 4" schedule 40 PVC or HDPE N-12 and perforated with 3/8" holes – 4 inch on center. All applications, except sidewalks, require an over-drain system even if the area as small as a few parking spaces. The location and layout of the over-drain system is largely dependent on the permeable pavement configuration but generally one linear foot of over-drain should collect no more than 600 sq. ft. of area.

For sloped applications the over-drain system should be placed at the low end of the slope. The terminal end of all over-drain pipes must be capped. The over-drain pipe must have at least 3" of Stone Sub-base under the over-drain pipe to prevent migration of sand into the over-drain pipe system.

8. Stone Sub-Base

A sub-base layer of clean, open graded, washed silica stone meeting MD SHA Coarse Aggregate 57 grading requirements shall be used below the pavement layer. Filter fabric shall never be used horizontally between the sub-base material and soil subgrade.

9. Sand Bridging Layer

A 6" layer of washed ASTM C33 Fine Aggregate Concrete Sand (See MCDPS Sand Specifications) shall be used as a bridging layer between the treatment storage volume and soil subgrade.

10. Soil Subgrade

The soil subgrade shall be proof rolled per site geotechnical engineer's recommendations and scarified prior to placement of sub-base materials. The bottom of the sand layer shall be level so that runoff will be able to infiltrate evenly through the entire surface. If a level soil subgrade cannot be achieved, then the subgrade may be stepped (see Stepped Soil Subgrade detail) with the use of lateral flow barriers between each cell to contain runoff and prevent erosion of the soil subgrade.

In this case the maximum allowable subgrade slope is 5% and the maximum creditable average depth of treatment storage is still 12" per cell.

11. Lateral Flow Barriers

Lateral flow barriers of compacted suitable soil, framing wrapped in 30-mil plastic, or other engineer design barrier to lateral flow must separate cells that do not share the same soil subgrade elevation. The lateral flow barriers are that portion of the practice that force the ponding of water across sloped installations; see Stepped / Sloped Soil Subgrade details. Water will only pond in that portion of the Stone Sub-base that is below the over-drain pipe. The maximum average creditable depth of storage is 12"; in sloped applications the maximum depth of water ponding against a lateral flow barrier is 24".

12. Planting

To minimize the potential for clogging, planting adjacent to permeable pavements should be designed with debris and maintenance in mind; trees with needles, and other evergreen species should be avoided, as well as planting beds that require frequent mulching. Permeable pavement should not be placed in applications in forests or immediately downstream of highly vegetated areas, e.g. park paths, where they are likely to clog.

13. Maintenance & Signage

Permeable pavements are susceptible to clogging. Owners are to be educated in proper system maintenance, including proper treatment for ice and snow in the winter to allow the system to function properly. Use of salts on permeable pavement will decrease the expected lifespan of materials and may not be used within the first 12 months of placement of a poured-in place permeable concrete. All other restrictions should be per manufacturer's specifications. Application of coarse sand on top of permeable pavement will require vacuum cleaning each spring.

All maintenance and signage shall be done in accordance with Montgomery County Department of Environmental Protection (DEP) guidelines. Signage will be reviewed as a part of the SWM Plan technical review.

14. Post-Construction

Poured in place concrete must remain free from all light vehicular traffic, for a minimum of 7 days. Heavy vehicular traffic must be restricted for at least 10 days after placement.

Post construction infiltration rates required for all surfaces must conform to ASTM C1701 for poured in place permeable concrete, or ASTM C1781 for permeable pavers. Infiltration rate and specific test locations must be submitted along with the Stormwater Management “Asbuilt plan”. Permeable pavement must be vacuum cleaned and paver joints refilled as necessary prior to final inspection.

D. Permeable Pavement Sizing Examples

ESD Values for Permeable Pavements

The practice must be sized to capture and store 100% of the target treatment volume, 1.0” over contributing drainage area. The maximum treatment storage volume that can be credited towards the ESD requirement, ESD_v, is equivalent to the runoff from a 1-year 24-hour rainfall or 2.6”. The treatment volume provided shall be determined as the porosity (void space) in the stone sub-base and the sand below the over-drain pipe and cannot exceed the maximum treatment storage volume. The void ratio used in the calculation storage in permeable pavements is 30%.

Sizing Example for Level & Stepped Subgrade (Parking w/ Impervious Drive Aisle)

A permeable pavement practice is being integrated into the design of parking lot that is part of a larger development. A 24’ wide crowned impervious asphalt paving drive aisle is provided in-between two rows of 25 permeable paving parking stalls. Each stall is 8.5’ wide and 18’ long. The drive aisle and parking stalls are 25 x 8.5’ = 212.5’ long. Thus the contributing impervious drive aisle area is 24’ x 212.5’ = 5,100 sq. ft. and the permeable paving parking areas are each 18’ x 212.5’ = 3,825 sq. ft. For this example it is assumed that the longitudinal slope of the parking lot is either 0.0% or the subgrade is stepped to accommodate the slope.

A 6” stone sub-base and 6” sand bridging layer (12” infiltrating subbase) is continuously provided underneath both the impervious drive aisle and the adjacent permeable paving parking.

Impervious asphalt drive aisle (A _i)	= 5,100 ft. ²
Permeable paving area (A _p)	= 7,650 ft. ²
DA ratio (A _i / A _p)	= 5,100 / 7,650 = 0.67 ≤ 1
Total drainage area to permeable paving (A)	= A _p + A _i = 12,750 > 10,000

→Soil Infiltration Testing Required

$$\begin{aligned} \text{Area of infiltrating sub-base } (A_f) &= 12,750 \text{ ft.}^2 \\ \text{Average Depth of infiltrating subbase } (d_f) & \\ \quad +\text{Depth of stone sub-base below underdrain} &= 6'' \\ \quad +\text{Depth of sand} &= \underline{6''} \\ &= 1.0 \text{ ft} \\ \\ \text{Constructed Treatment Volume (ESDv)} &= A_f * d_f * \Phi \text{ (porosity)} \\ &= 12,750 \text{ ft.}^2 * 1 \text{ ft} * 0.30 \\ &= 3,825 \text{ ft.}^3 \end{aligned}$$

Calculate and compare the maximum treatment volume that can be credited in the facility:

$$\begin{aligned} \text{Volumetric Runoff Coefficient (Rv)} &= 0.05 + (.009 * I) \\ &= 0.05 + (.009 * 100) = 0.95 \\ \\ \text{Maximum Treatment Volume (ESDvmax)} &= [(Pe) (Rv) (A)] / 12 \\ &= [(2.6) (0.95) (12,750)] / 12 \\ &= 2,624 \text{ ft.}^3 \\ \\ 3,825 \text{ ft}^3 \text{ (Constructed volume)} &< 2,624 \text{ ft.}^3 \text{ (ESDvmax)} \\ \\ &\rightarrow 2,624 \text{ ft}^3 \text{ total treatment storage provided, ESDv} \end{aligned}$$

Sizing Example for Level & Stepped Subgrade (Parking without Infiltrating Drive Aisle)

Utilizing the same configuration of impervious drive aisle and pervious paving parking stalls as above, but in this example the infiltrating subbase is NOT extended under the impervious drive aisle. For this example it is assumed that the longitudinal slope of the parking lot is either 0.0% or the subgrade is stepped to accommodate the slope.

$$\begin{aligned} \text{Impervious asphalt drive aisle } (A_i) &= 5,100 \text{ ft.}^2 \\ \text{Permeable paving area } (A_p) &= 7,650 \text{ ft.}^2 \\ \\ \text{DA ratio } (A_i / A_p) &= 5,100 / 7,650 \\ &= 0.67 \leq 1 \\ \\ \text{Total drainage area to permeable paving } (A) &= A_p + A_i \\ &= 12,750 > 10,000 \\ &\rightarrow \text{Soil Infiltration Testing Required} \\ \\ \text{Area of infiltrating sub-base } (A_f) &= 7,650 \text{ ft.}^2 \\ \text{Average Depth of infiltrating subbase } (d_f) & \\ \quad +\text{Depth of stone sub-base below underdrain} &= 6'' \\ \quad +\text{Depth of sand} &= \underline{6''} \end{aligned}$$

$$= 1.0 \text{ ft}$$

Constructed Treatment Volume (ESDv)

$$\begin{aligned} &= A_f * d_f * \Phi \text{ (porosity)} \\ &= 7,650 \text{ ft.}^2 * 1 \text{ ft} * 0.30 \\ &= 2,295 \text{ ft.}^3 \end{aligned}$$

Calculate and compare the maximum treatment volume that can be credited in the facility:

Maximum Treatment Volume (ESDvmax)

$$\begin{aligned} &= [(Pe) (Rv) (A)] / 12 \\ &= [(2.6) (0.95) (12,750)] / 12 \\ &= 2,624 \text{ ft.}^3 \end{aligned}$$

$$2,295 \text{ ft}^3 \text{ (Constructed volume)} < 2,624 \text{ ft.}^3 \text{ (ESDvmax)}$$

→2,295 ft³ total treatment storage provided, ESDv

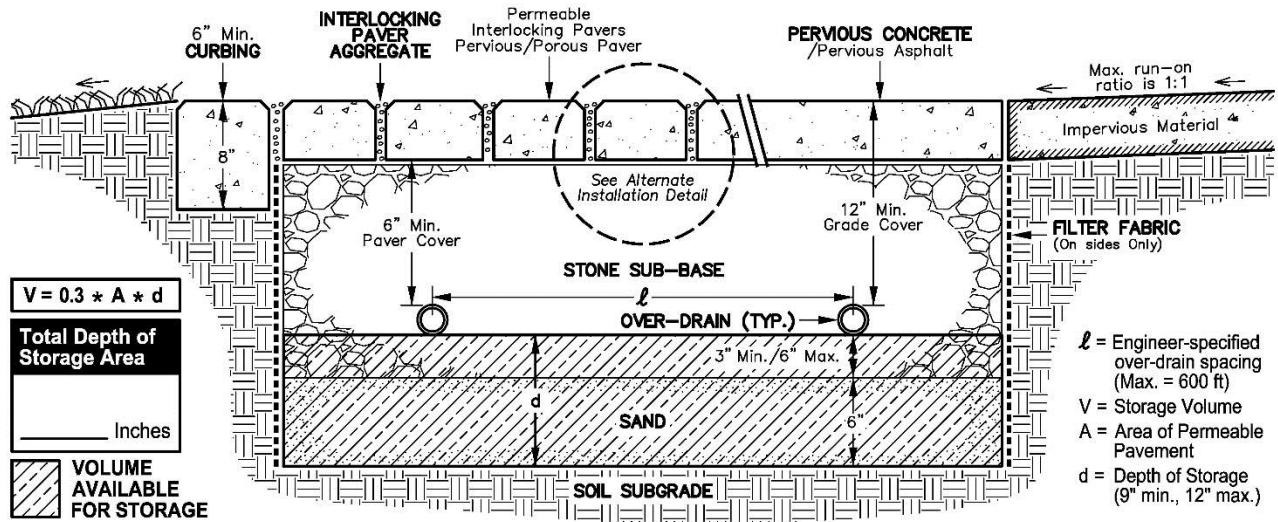
Sizing Example for Level & Sloped Subgrade (Parking without Infiltrating Drive Aisle)

Utilizing the same configuration of impervious drive aisle and pervious paving parking stalls as above, but in this example the infiltrating subbase is NOT extended under the impervious drive aisle. And in this example the drive aisle and parking stalls are longitudinally sloped at a 3% perpendicular to the direction of traffic in addition to being crowned.

In this case since the designer wishes to maintain the 12" maximum average creditable depth of storage with a stepped subgrade application. Each level step must have 6" of sand and 6" of stone sub-base and be 34' wide before a lateral flow barrier and over-drain pipes to separate the next lower cell. At 3% grade the 12" depth would be covered in $12" / 3\% = 33.33'$; this case assume the lateral flow barrier is not more than 0.66' or 8" wide.

If the designer wish to utilize a slope construction practice, 24" of stone sub-base would be place under the over-drain. The distance between lateral flow barriers to 66.67'. At 3% grade the depth of storage will vary between 24" and 0" in $2' / 3\% = 66.67'$. In this case since at the average depth of storage is still 12" all of the calculations remain the same as the last example.

PERMEABLE PAVEMENT:



GENERAL REQUIREMENTS:

Within three (3) days of installation, contractor must perform single ring infiltration tests. Poured-in-place concrete must remain free from all light vehicular traffic for a minimum of seven (7) days. Heavy vehicular traffic must be restricted for at least ten (10) days after placement.

Post construction of infiltration rates required for all surfaces must conform to ASTM C1701 for poured-in-place permeable concrete, or ASTM C1781 for permeable pavers.

SETBACKS:

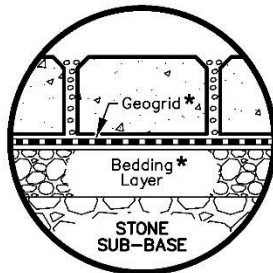
Permeable Pavements require MC DOT prior written approval before being designed within public rights of way.

The storage volume for any pervious surface shall be located down gradient of building structures and be setback a minimum of:

- 100 feet from primary potable water supply or open loop geothermal wells (10' for SF Residential)
- 50 feet from alternate potable water supply or closed loop geothermal wells (No Setback for S.F. Residential)
- 25 feet from septic systems (10' for S.F. Residential)
- 10 feet from any other Infiltrating ESD Practice
- 10 feet from buildings
- Raised mulch/planting beds shall not be placed adjacent to Permeable Pavement

ALTERNATE INSTALLATION DETAIL:

Optional engineer-approved installation as per manufacturers recommendations. *



LEGEND:

- CURBING** 6" minimum width. Curbing is not required for sidewalk applications.
- INTERLOCKING PAVER AGGREGATE** Paver gap aggregate shall be a silica-based stone per manufacturer's recommendations or meeting ASTM D448 size criteria of No. 8, 89, or 9 stone.
- FILTER FABRIC** Engineer-approved, permeable, non-woven geotextile fabric. On sides only.
- OVER-DRAIN** 4" Schedule 40 PVC or HDPE N-12 installed perpendicular to grade. One foot of over-drain is required for every 600 sq. ft. Over-drain may not connect to drywells or any other SWM. Over-drain discharge point must be shown on the plan view.
- OVER-DRAIN PERFORATION**
 - 3/8 Inch Holes
 - 4 Inches on center
 - 90° around pipe
- STONE SUB-BASE** Clean open graded, washed silica stone meeting MD SHA Course Aggregate 57 grading requirements. Filter cloth shall not be used horizontally between the sub-base material and the soil sub-grade.
- SAND** See Montgomery County Sand Specifications.
- SOIL SUBGRADE** Site geotechnical engineer-approved subgrade shall be proof rolled and scarified. Bottom shall be flat or per Stepped/Sloped Permeable Pavement Detail.
- PERVIOUS CONCRETE** Pervious concrete construction must be performed by National Ready Mixed Association Certified Pervious Concrete Installer. All construction must be done per ACI 522.13.



**MONTGOMERY COUNTY
DEPARTMENT OF
PERMITTING SERVICES**

WATER RESOURCES DIVISION

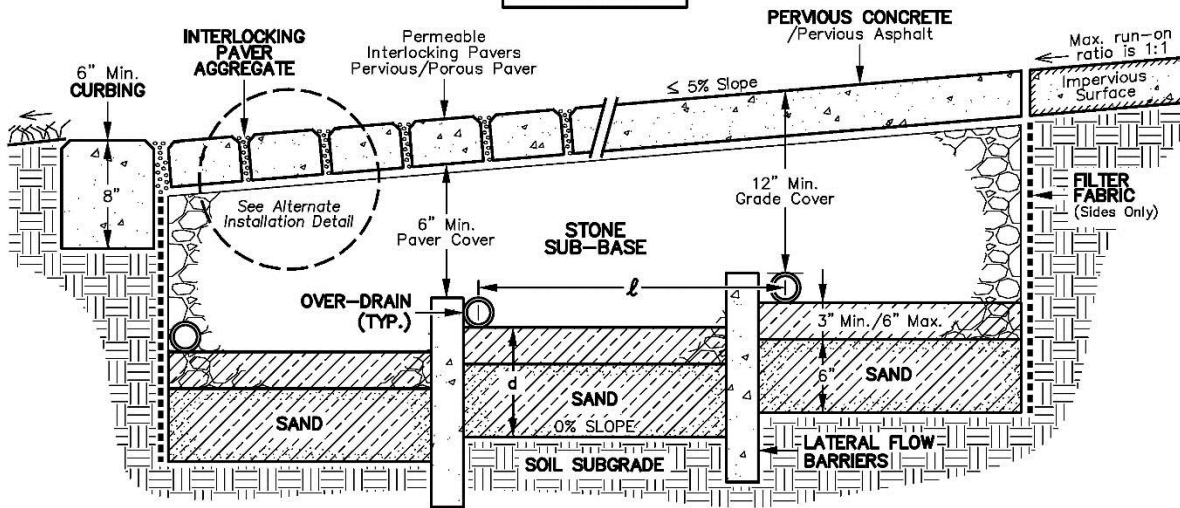
PERMEABLE PAVEMENT DETAIL

DATE:
MAY 1, 2017

SCALE:
NONE

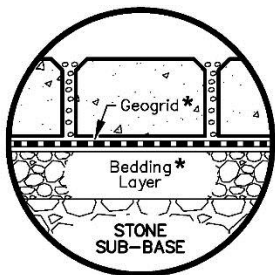
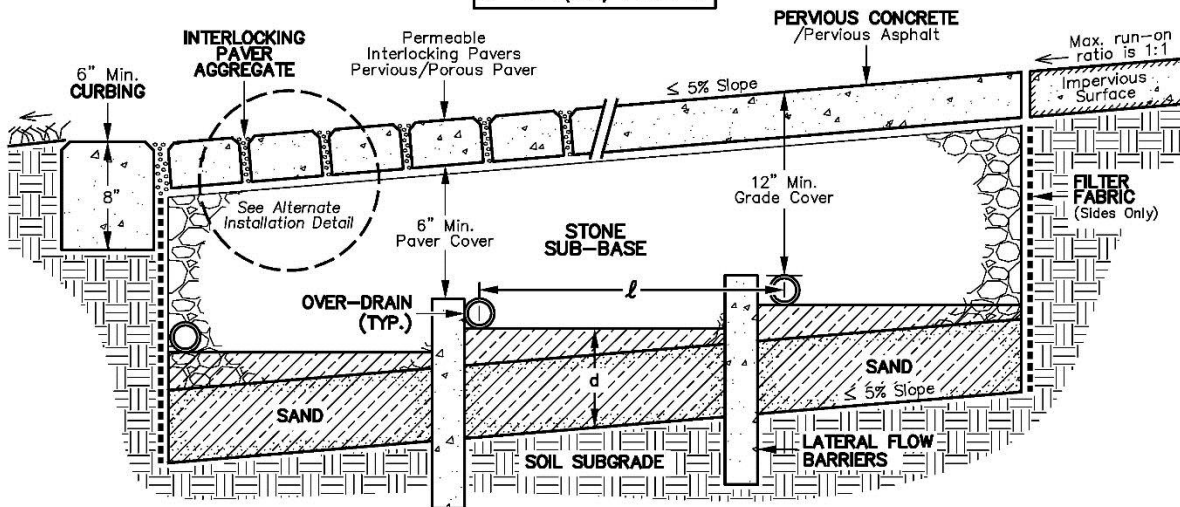
PERMEABLE PAVEMENT WITH STEPPED SOIL SUBGRADE:

$$V = 0.3 * A * d$$



PERMEABLE PAVEMENT WITH SLOPED SOIL SUBGRADE

$$V = 1/2 (0.3) * A * d$$

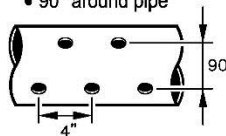


ALTERNATE INSTALLATION DETAIL:

Optional engineer-approved installation as per manufacturers recommendations. *

OVER-DRAIN PERFORATION:

- 3/8 Inch Holes
- 4 Inches on center
- 90° around pipe



 VOLUME AVAILABLE FOR STORAGE

l = Engineer-specified over-drain spacing (Max. = 600 ft)
 V = Storage Volume
 A = Area of Permeable Pavement
 d = Depth of Storage (12" maximum average)



**MONTGOMERY COUNTY
 DEPARTMENT OF
 PERMITTING SERVICES**
 WATER RESOURCES DIVISION

**PERMEABLE
 PAVEMENT DETAIL**

DATE:
 MAY 1, 2017

SCALE:
 NONE