Permeable Pavement

Description: Permeable pavements allow stormwater runoff to filter through voids in the pavement surface into an underlying stone reservoir, where it is temporarily stored and/or infiltrated. Porous paving systems have several design variants that include: Permeable Interlocking Concrete Pavers (PICP), pervious concrete, and reinforced turf or gravel systems. All have a similar structure, consisting of a surface pavement layer, an underlying stone aggregate reservoir layer, and a filter layer or fabric installed on the bottom.

Advantages/Benefits:

- Runoff volume reduction
- Can increase aesthetic value
- Provides water quality treatment
- Can provide groundwater recharge

Disadvantages/Limitations:

- Cost
- Maintenance
- Limited to low traffic areas with limited structural loading
- Potential issues with handicap access
- Infiltration can be limited by underlying soil property
- Not effective on steep slopes

Selection Criteria:

40% – 80% Runoff Reduction Credit

Land Use Considerations:

- X **Residential**
- X **Commercial**
- X **Industrial**

Maintenance:

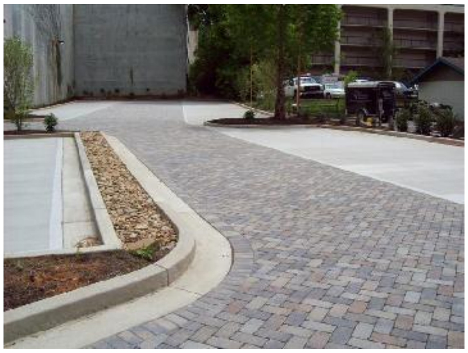
- Turf pavers can require mowing, fertilization, and irrigation. Plowing is possible, but requires use of skids
- Sand and salt should not be applied
- Adjacent areas should be fully stabilized with vegetation to prevent sediment-laden runoff from clogging the surface
- A vacuum-type sweeper or high-pressure hosing (for porous concrete) should be used for cleaning

Maintenance Burden

L = Low M = Moderate H = High

H

SECTION 1: DESCRIPTION



Permeable pavements are alternative paving surfaces that allow stormwater runoff to filter through voids in the pavement surface into an underlying stone reservoir, where it is temporarily stored and infiltrated. Permeable pavements consist of a surface pavement layer, an underlying stone aggregate reservoir layer and a filter layer or fabric installed on the bottom.

The thickness of the reservoir layer is determined by both a structural and hydrologic design analysis. The reservoir layer serves to retain stormwater and also supports the design traffic loads for the pavement. If infiltration rates in the native soils permit, permeable pavement shall be designed without an underdrain, to enable full infiltration of runoff. In low-infiltration soils, some of the filtered runoff is collected in an underdrain and returned to the storm drain system. A combination of these methods can be used to infiltrate a portion of the filtered runoff.

Permeable pavement is typically designed to treat stormwater that falls on the actual pavement surface area, but it may also be used to accept run-on from small adjacent impervious areas, such as impermeable driving lanes or rooftops. However, careful sediment control is needed for any run-on areas to avoid clogging of the down-gradient permeable pavement. Permeable pavement has been used at commercial, institutional, and residential sites in spaces that are traditionally impervious. Permeable pavement promotes a high degree of runoff volume reduction and nutrient removal, and it can also reduce the effective impervious cover of a development site.

SECTION 2: PERFORMANCE

The overall runoff reduction of permeable pavement is shown in **Table 3.1**.

Table 3.1. Runoff Volume Reduction Provided by Permeable Pavement

Stormwater Function	Level 1 Design	Level 2 Design
Runoff Volume Reduction (RR)	40%	80%
Treatment Volume (Tv) Multiplier*	1.0	1.25

*Incorporated into LID Site Design Tool spreadsheet calculations
Sources: CSN (2008) and CWP (2007)

SECTION 3: TYPICAL DETAILS

See **Appendix 3-B** and **3-C** for required standard notes and typical details for use in construction plans.

SECTION 4: PHYSICAL FEASIBILITY & DESIGN APPLICATIONS

Since permeable pavement has a very high runoff reduction capability, it should always be considered as an alternative to conventional pavement. Permeable pavement is not intended to treat sites with high sediment or trash/debris loads, since such loads will cause the practice to clog and fail. Permeable pavement is subject to the same considerations as most infiltration practices, as described below.

Types of Surface Pavement. Permeable Interlocking Concrete Pavers (PICP), pervious concrete, and reinforced turf or gravel systems are permitted.

Infiltration/Soils. Infiltration is a key component of Low Impact Development design. Infiltration testing may be required for permeable pavement areas (see Section 5.1). Soil conditions do not constrain the use of permeable pavement but can affect the design requirements. Hydrologic Soil Groups (HSG) should be determined from NRCS soil data. For more information on soil types go to: http://websoilsurvey.nrcs.usda.gov/app/. Alternative HSG classifications will be considered when supporting reports from a licensed soil scientist or geotechnical engineer are provided.

Available Space. A prime advantage of permeable pavement is that it does not normally require additional space at a new development or redevelopment site, which can be important for tight sites or areas where land prices are high.

Accessibility. Permeable pavement facilities must be accessible to various types of equipment for periodic maintenance.

Contributing Drainage Area. Field experience has shown that an upgradient drainage area (even if it is impervious) can contribute particulates to the permeable pavement and lead to clogging (Hirschman, et al., 2009). Therefore, careful sediment source control and/or a pre-treatment strip or sump (e.g., stone or gravel) should be used to control sediment run-on to the permeable pavement section. For Level 1 permeable pavement, the external drainage area contributing runoff to permeable pavement should be less than or equal to the area of the permeable pavement itself (i.e. 1:1 ratio) and it should be as close to 100% impervious as possible. No external drainage area will be allowed to run-on to Level 2 permeable pavement. Nominal areas of run-on (e.g. landscapes islands and sidewalks) can be permitted with MWS staff approval. See Section 5.2.3 for an Alternative Design Method to increase contributing drainage.

Pavement Slope. Steep slopes can reduce the stormwater storage capability of permeable pavement and may cause shifting of the pavement surface and base materials. The surface slope should be less than 10% to encourage infiltration but is not recommended to be more than 1%. The subgrade slope of a permeable pavement installation should be as flat as possible (i.e., 0-1% longitudinal slope) in order to establish level reservoir storage areas. This promotes even distribution and infiltration of the required treatment volume storage. Designers shall use a terraced subgrade design for permeable pavement in sloped areas, especially when the surface slope is greater than 1%. Lateral slopes should be 0%.

Subsurface Constraints. Permeable pavement subgrade shall always be separated from the water table and bedrock. A separation distance of 2 feet is required between the bottom of the excavated permeable pavement area and the seasonally high ground water table and/or bedrock.

Utilities. Public underground utilities and associated easements shall not be located within the permeable pavement footprint. Local utility design guidance shall be consulted in order to determine clearances required between stormwater infrastructure and other dry and wet utility lines. Private utilities should not be located within the permeable pavement area when possible.

Hotspot Land Uses. Runoff from hotspot land uses should not be treated with infiltrating permeable pavement without appropriate pretreatment and MWS staff approval. For additional information on stormwater hotspots, please consult **Section 6.3**.

Floodplains. Permeable pavement shall be constructed outside the limits of the 100-year floodplain. Flood waters from the 100-year event or smaller shall be prohibited from entering the overflow system.

Setbacks. It is not recommended to place permeable pavement areas immediately adjacent to structures. To avoid the risk of seepage, a licensed professional engineer should be consulted to determine the appropriate setbacks necessary to prevent permeable pavement infiltration from compromising structural foundations or pavement. At a minimum, permeable pavement areas should be located a horizontal distance of 100 feet from any water supply well and 50 feet from septic systems.

Applications. Permeable pavement can be used as an alternative to most types of conventional pavement at residential, commercial and institutional developments; however, it is not currently approved for use in the Right of Way (ROW).

Structural Design. If permeable pavement will be used in a parking lot or other setting that involves vehicles, the pavement surface must be able to support the maximum anticipated traffic load. Designers should determine structural design requirements by consulting transportation design guidance sources and the manufacturer's specific recommendations.

The resulting structural requirements may include, but are not limited to, the thickness of the pavement, filter, and reservoir layer. Designers should note that if the underlying soils have a low California Bearing Ratio (CBR) (less than 4%), they may need to be compacted to at least 95% of the Standard Proctor Density, which generally rules out their use for infiltration.

SECTION 5: DESIGN CRITERIA

5.1 Soil Infiltration Rate Testing

Infiltration testing is optional for permeable pavement due to the possibility of having to compact the subgrade to support vehicle loading. If during the design phase it is determined that subgrade compaction will be required, the designer should consider using underdrains. Otherwise, test pit(s), compacted to the necessary density, must be utilized on the site to determine infiltration.

To perform infiltration testing one must measure the infiltration rate of subsoils at the subgrade elevation of the permeable pavement area. If the infiltration rate exceeds 0.5 inch per hour, an underdrain should not be utilized. If the infiltration rate of subsoils is greater than 0.1 inch per hour and less than or equal to 0.5 inch per hour, underdrains will be required. On-site soil infiltration rate testing procedures are outlined in **Appendix 3-A**. The number of soil tests varies based on the size of the permeable pavement area:

- < 1,000 ft^2 = 2 tests
- 1,000 – 10,000 ft^2 = 4 tests
- >10,000 ft^2 = 4 tests + 1 test for every additional 5,000 ft^2

If an underdrain with a gravel sump is used for Level 2, the bottom of the sump must be at least two feet above bedrock and the seasonally high groundwater table.

For sites with large amounts of cut or fill it may not be practical to perform infiltration testing prior to grading the site. In these cases, a mass grading permit will be required.

5.2 Sizing of Permeable Pavement Practices

5.2.1 Stormwater Quality

Sizing of the surface area (SA) for permeable pavement practices is based on the computed Treatment Volume (T_v) of the contributing drainage area and the storage provided in the facility. The required surface area (in square feet) is computed as the Treatment Volume (in cubic feet) divided by the equivalent storage depth (in feet). The equivalent storage depth is computed as the depth of gravel (in feet) multiplied by the accepted porosity (see **Table 3.2**). See Section 5.5 for material specifications. Based on volume calculations, the minimum 8" reservoir layer is sufficient to contain the required Treatment Volume for the typical permeable pavement contributing drainage area (see Section 4).

Table 3.2 Permeable Pavement Typical Section for Water Quality Calculations

Infiltration (i)	N/A	i > 0.5"/hr	i ≤0.5"hr	Porosity Value (n)
	Level 1 (inches)	Level 2 (inches)	Level 2 (inches)	
Permeable pavement*	Varies based on type and manufacturer's specification			N/A
Bedding	Varies based on type and manufacturer's specification			N/A
Reservoir (minimum)	8	8	8	0.40
Sump*	0	0	12	0.40
Sand Choker**	2-4	2-4	2-4	N/A

* Cannot be used in De and surface area calculations.

**Filter fabric can be used as an alternative (see Section 5.5)

5.2.2 Stormwater Quantity

If designed with sufficient volume and appropriate outlet structures including a high flow bypass, peak attenuation control may be provided by the permeable pavement. Hydrologic calculations utilizing the SCS method may be necessary to demonstrate pre versus post peak flow rates.

Subsurface Storage. Designers may be able to create additional subsurface storage for flow attenuation by increasing the subsurface volume without necessarily increasing the permeable pavement footprint. Additional volume can be provided by increasing the depth of the reservoir layer with additional stone or approved proprietary storage products. Subsurface storage within the sump layer will not be allowed without sufficient infiltration (see Section 5.1).

Adjusted CN. With infiltration rates greater than 0.5 inch per hour (see Section 5.1), the removal of volume by permeable pavement changes the runoff depth entering downstream flood control facilities. An approximate approach to accounting for the removal of volume is to calculate an "effective SCS curve number" (CN_{adj}), which is less than the actual curve number (CN). CN_{adj} can then be used in hydrologic calculations and in routing. This method is detailed in Volume 5 Section 3.2.5.

5.2.3 Alternative Design Method

Studies show that maintained permeable pavements produce very little surface runoff. Consequently, practices in well drained soils with adequate storage and no underdrain yield very high runoff reduction results. Therefore, increasing the contributing drainage area to a maximum 3:1 ratio to the permeable pavement surface area can be considered. For example, a permeable pavement area of 100 SF could receive up to 300 SF of additional contributing drainage area outside of the permeable pavement footprint.

This alternative design method can be used for level 1 and level 2 facilities that are utilizing reinforced turf systems, reinforced gravel systems, or concrete pavers. To determine if the alternative design method can be utilized, infiltration rates must meet or exceed 0.5 inch per hour (Section 5.1).

Use the following equation to calculate the required reservoir depth :

Equation 3.1. Required Depth of Reservoir Layer

$$D_{r-r} = \frac{T_{v-r}}{S \quad * n}$$

Where:

$D_{r\text{-}req}$	=	The required depth of the reservoir layer (ft.); 8-inch minimum
$T_{v\text{-}req}$	=	The required treatment volume (cu. ft.)
SA	=	The surface area of the permeable pavement (sq. ft.)
n	=	The porosity for the reservoir layer (0.4)

The maximum allowable depth of the reservoir layer is constrained by the maximum allowable drain time, which is calculated using **Equation 3.2**.

Equation 3.2. Maximum Depth of Reservoir Layer

$$D_{r-m} = \frac{\left({}^{i}/_{2} \times t_d\right)}{n}$$

Where:

$D_{r\text{-}max}$	=	The maximum depth of the reservoir layer (ft.)
i	=	The field-verified infiltration rate for native soils (ft./day)
t_d	=	The maximum allowable time to drain the reservoir layer, typically 48 hours
n	=	The porosity for the reservoir layer (0.4)

The required depth of the reservoir layer ($D_{r\text{-}req}$) must not exceed the maximum depth of reservoir layer ($D_{r\text{-}max}$). If $D_{r\text{-}req}$ exceeds $D_{r\text{-}max}$, then the run-on ratio must be reduced.

5.3 Pretreatment

Pretreatment for most permeable pavement applications is not necessary, since the surface acts as pretreatment to the reservoir layer below. Additional pretreatment is required if the pavement receives run-on from an adjacent pervious or impervious area. For example, a gravel filter strip can be placed along the edge of the permeable pavement section to trap coarse sediment particles before reaching the permeable pavement surface.

5.4 Conveyance and Overflow

Permeable pavement designs should include methods to convey larger storms (e.g., 2-yr, 10-yr) to the storm drain system. This can be accomplished by placing storm drain inlets at the lowest elevation of the permeable pavement surface.

5.5 Permeable Pavement Material Specifications

Table 3.3 outlines the standard material specifications used to construct permeable pavement areas. Designers should consult manufacturer's technical specifications for specific criteria and guidance.

Table 3.3. Material Specifications for Underneath the Pavement Surface

Material	Specification	Notes
Permeable Pavement System	Permeable Interlocking Concrete Pavers Pervious Concrete Reinforced Turf Systems Reinforced Gravel Systems	ASTM C936 ASTM C1688/C1688M & ACI 522 ASTM D638 ASTM D638
Bedding Layer	#8 or #89 clean washed stone	Meet TDOT Construction Specifications.
Reservoir Layer	#57 or #2 clean washed stone	Meet TDOT Construction Specifications.
Underdrain	4- or 6-inch dual wall HDPE or SDR 35 PVC pipe with 3/8-inch perforations at 6 inches on center	AASHTO M 252 Place perforated pipe at base of reservoir layer at the lower end of the paver cell.
Cleanout	6-inch SDR 35 PVC pipe with vented cap	Use traffic rated casting where required. Provide cleanouts at the upper end of the underdrain.
Observation Well	6-inch SDR 35 PVC pipe with vented cap and anchor plate	Use traffic rated casting where required. Number of wells equals the number of test pits required for infiltration testing (see Appendix 3-A)
Sand Choker/Geotextile	2- to 4-inch layer of coarse sand Filter fabric (125 gpm/sq.ft.)	Meet TDOT Construction Specifications AASHTO M288-06, ASTM D4491 & D4751
Impermeable Liner (if needed)	Use a thirty mil (minimum) PVC Geomembrane liner covered by 8 to 12 oz./sq. yd.^{2} non-woven geotextile.	

SECTION 6: SPECIAL CASE DESIGN ADAPTATIONS

6.1 Shallow Bedrock and Groundwater Connectivity

Many parts of Nashville have shallow bedrock, which can constrain the application of infiltrative permeable pavement areas. In such settings, other GIPs may be more applicable.

For more information on bedrock depths download the GIS data set from: http://water.usgs.gov/GIS/metadata/usgswrd/XML/regolith.xml.

6.2 Karst

Karst regions are found in much of Middle Tennessee, which complicates both land development and stormwater design. Infiltrative permeable pavement designs shall not be used in any area with a high risk of sinkhole formation. On the other hand, non-infiltrative designs that meet separation distance requirements (2 feet) and possess an impermeable bottom liner and an underdrain can be considered.

6.3 Hotspots

Stormwater hotspots are operations or activities that are known to produce higher concentrations of stormwater pollutants and/or have a greater risk for spills, leaks or illicit discharges. Infiltrative permeable pavement designs shall not be used in any area with a hotspot designation without appropriate pretreatment, impermeable barriers, and MWS staff approval.

SECTION 7: CONSTRUCTION

7.1 Construction

Construction Stage Erosion and Sediment Controls. Permeable pavement areas should be fully protected from sediment laden runoff and vehicular tracking during construction. Ideally, permeable pavement areas should remain outside the limit of disturbance during construction to prevent soil compaction by heavy equipment.

Sediment traps or basins may be located within permeable pavement excavation limits during construction. However, these must be accompanied by notes and graphic details on the erosion prevention and sediment control (EPSC) plan specifying that the maximum excavation depth at the construction stage must be at least 1 foot above the post-construction subgrade elevation. The plan must also show the proper procedures for converting the temporary sediment control practice to a permeable pavement facility, including dewatering, cleanout and stabilization.

Excavation. The proposed site should be checked for existing utilities prior to any excavation. It is very important to minimize compaction of both the base of the permeable pavement area and the required backfill. When possible, excavators should work from the sides of the permeable pavement area to remove original soil. If the permeable pavement area is excavated using a loader, the contractor must use wide track or marsh track equipment, or light equipment with turf type tires. Use of equipment with narrow tracks or narrow tires, rubber tires with large lugs, or high-pressure tires will cause excessive compaction resulting in reduced infiltration rates and is not acceptable. Compaction will significantly contribute to design failure of infiltrative permeable pavement areas.

7.2 Permeable Pavement Installation

Construction should take place during appropriate weather conditions. The following is a typical construction sequence to properly install permeable pavement. These steps may be modified to reflect different permeable pavement applications or expected site conditions:

Step 1. The designer and the installer should have a preconstruction meeting, checking the boundaries of the contributing drainage area and the actual inlet elevations to ensure they conform to original design. Since other contractors may be responsible for constructing portions of the site, it is quite common to find subtle differences in site grading, drainage and paving elevations that can produce hydraulically important differences for the proposed permeable pavement area. The designer should clearly communicate, in writing, any project changes determined during the preconstruction meeting to the installer and the plan review/inspection authority.

Step 2. Ensure that the entire contributing drainage area has been stabilized prior to permeable pavement construction. Otherwise, use EPSC measures as outlined in Section 7.1.

Step 3. Excavation to the base of the permeable pavement should follow the guidelines found in Section 7.1. Contractors should use a cell construction approach in larger permeable pavement areas.

Step 4. The native soils along the bottom and sides of the permeable pavement system should be scarified or tilled to a depth of 3 to 4 inches prior to the placement of the filter layer or filter fabric. In large scale paving applications with weak soils, the soil subgrade may need to be compacted to 95% of the Standard Proctor Density to achieve the desired load-bearing capacity. (NOTE: This effectively eliminates the infiltration function of the installation, and it must be addressed during hydrologic design.)

Step 5. Install all layers and components of the permeable pavement per plans.

Step 6. Conduct the final construction inspection (see **Section 8**). Then log the GPS coordinates for each permeable pavement facility and submit them to MWS.

SECTION 8: AS-BUILT REQUIREMENTS

After the permeable pavement area has been constructed, the owner/developer must have an as-built certification of the permeable pavement area conducted by a registered Professional Engineer. The as-built certification verifies that the GIP was installed per the approved plan. The following items shall be provided in addition to the as-built requirements found in SWMM Volume 1.

1. The Engineer shall include a copy of the GIP summary table found in **Appendix 3-D**.
2. Topographic survey of the subgrade when benching or subsurface terracing is used.
3. Supporting documents such as invoices and photographs should be included in the submittal package.

SECTION 9: MAINTENANCE

9.1 Maintenance Document

The requirements for the Maintenance Document are in Appendix C of Volume 1 of the Manual. They include the execution and recording of an Inspection and Maintenance Agreement or a Declaration of Restrictions and Covenants, and the development of a Long Term Maintenance Plan (LTMP) by the design engineer. The LTMP contains a description of the stormwater system components and information on the required inspection and maintenance activities. The LTMP for permeable pavement should also note which conventional parking lot maintenance tasks must be *avoided* (e.g., sanding, re-sealing, re-surfacing, power-washing). Signs should be posted on larger parking lots to indicate their stormwater function and special maintenance requirements.

9.2 Maintenance Tasks

It is difficult to prescribe the specific types or frequency of maintenance tasks that are needed to maintain the hydrologic function of permeable pavement systems over time. Most installations work reasonably well year after year with little or no maintenance, whereas some have problems right from the start.

One preventative maintenance task for large-scale applications involves vacuum sweeping on a frequency consistent with the use and loadings encountered in the parking lot. Many consider an annual, dry-weather sweeping in the spring months to be important. The contract for sweeping should specify that a vacuum sweeper be used that does not use water spray, since spraying may lead to subsurface clogging. Vacuum settings for large-scale interlocking paver applications should be calibrated so they *do not* pick up the stones between pavement blocks.

9.3 Maintenance Inspections

It is highly recommended that a spring maintenance inspection and cleanup be conducted at each permeable pavement site, particularly at large-scale applications.

Maintenance of permeable pavement is driven by annual inspections that evaluate the condition and performance of the practice. The following are suggested annual maintenance inspection points for permeable pavements:

- The drawdown rate should be measured at the observation well for three (3) days following a storm event in excess of 0.5 inch in depth. If standing water is still observed in the well after three days, this is a clear sign that clogging is a problem.
- Inspect the surface of the permeable pavement for evidence of sediment deposition, organic debris, staining or ponding that may indicate surface clogging. If any signs of clogging are noted, schedule a vacuum sweeper (no brooms or water spray) to remove deposited material. Then, test sections by pouring water from a five-gallon bucket to ensure they work.
- Inspect the structural integrity of the pavement surface, looking for signs of surface deterioration, such as slumping, cracking, spalling or broken pavers. Replace or repair affected areas, as necessary.
- Check inlets, pretreatment cells and any flow diversion structures for sediment buildup and structural damage. Note if any sediment needs to be removed.
- Inspect the condition of the observation well and make sure it is still capped.
- Generally, inspect any contributing drainage area for any controllable sources of sediment or erosion.

SECTION 10: COMMUNITY & ENVIRONMENTAL CONCERNS

The following is a list of some community and environmental concerns that may arise when infiltration practices are proposed:

Compliance with the Americans with Disabilities Act (ADA). Porous concrete is generally considered to be ADA compliant. Interlocking concrete pavers are considered to be ADA compliant, if designers ensure that surface openings between pavers do not exceed 0.5 inch. However, some forms of interlocking pavers may not be suitable for handicapped parking spaces. Interlocking concrete pavers interspersed with other hardscape features (e.g., concrete walkways) *can* be used in creative designs to address ADA issues.

Vehicle Safety. Permeable pavement is generally considered to be a safer surface than conventional pavement, according to research reported by Smith (2006) and Jackson (2007). Permeable pavement has less risk of hydroplaning, more rapid ice melt and better traction than conventional pavement.

Air and Runoff Temperature. Permeable pavement appears to have some value in reducing summer runoff temperatures, which can be important in watersheds with sensitive cold-water fish populations. The temperature reduction effect is greatest when runoff is infiltrated into the sub-base, but some cooling may also occur in the reservoir layer, when underdrains are used. ICPI (2008) notes that the use of certain reflective colors for interlocking concrete pavers can also help moderate surface parking lot temperatures.

Groundwater Injection Permits. Groundwater injection permits are required if the infiltration practice is deeper than the longest surface area dimension of the practice. Designers should investigate whether or not a proposed infiltration practice is subject to Tennessee groundwater injection well permit requirements.

SECTION 11: REFERENCES

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APPENDIX 3-A

INFILTRATION SOIL TESTING PROCEDURES

I. Test Pit/Boring Procedures

1. The number of required test pits or standard soil borings is based on proposed infiltration area:
   - < 1,000 ft² = 2 tests
   - 1,000 – 10,000 ft² = 4 tests
   - >10,000 ft² = 4 tests + 1 test for every additional 5,000 ft²
2. The location of each test pit or standard soil boring should correspond to the location of the proposed infiltration area.
3. Excavate each test pit or penetrate each standard soil boring to a depth at least 2 feet below the bottom of the proposed infiltration area.
4. If the groundwater table is located within 2 feet of the bottom of the proposed facility, determine the depth to the groundwater table immediately upon excavation and again 24 hours after excavation is completed.
5. Determine the USDA or Unified Soil Classification system textures at the bottom of the proposed infiltration area and at a depth that is 2 feet below the bottom. All soil horizons should be classified and described.
6. If bedrock is located within 2 feet of the bottom of the proposed infiltration area, determine the depth to the bedrock layer.
7. Test pit/soil boring stakes should be left in the field to identify where soil investigations were performed.

II. Infiltration Testing Procedures

1. The number of required infiltration tests is based on proposed infiltration area:
   - < 1,000 ft² = 2 tests
   - 1,000 – 10,000 ft² = 4 tests
   - >10,000 ft² = 4 tests + 1 test for every additional 5,000 ft²
2. The location of each infiltration test should correspond to the location of the proposed infiltration area.
3. Install a test casing (e.g., a rigid, 4 to 6 inch diameter pipe) to a depth 2 feet below the bottom of the proposed infiltration area.
4. Remove all loose material from the sides of the test casing and any smeared soil material from the bottom of the test casing to provide a natural soil interface into which water may percolate. If desired, a 2-inch layer of coarse sand or fine gravel may be placed at the bottom of the test casing to prevent clogging and scouring of the underlying soils. Fill the test casing with clean water to a depth of 2 feet, and allow the underlying soils to presoak for 24 hours.
5. After 24 hours, refill the test casing with another 2 feet of clean water and measure the drop in water level within the test casing after one hour. Repeat the procedure three (3) additional times by filling the test casing with clean water and measuring the drop in water level after one hour. A total of four (4) observations must be completed. The infiltration rate of the underlying soils may be reported either as the average of all four observations or the value of the last observation. The infiltration rate should be

reported in terms of inches per hour.

6. Infiltration testing may be performed within an open test pit or a standard soil boring.
7. After infiltration testing is completed, the test casing should be removed and the test pit or soil boring should be backfilled and restored.

APPENDIX 3-B

STANDARD NOTES

Required Permeable Pavement Notes:

- Vehicular traffic shall be prohibited on the pervious pavement until the site is stable to prevent sediment from being deposited by vehicles.
- Contractor, Engineer, or Owners Representative shall notify MWS NPDES at least 48 hours prior to the installation of the pervious layer to observe the sub-base material.

APPENDIX 3-C

STANDARD DETAILS

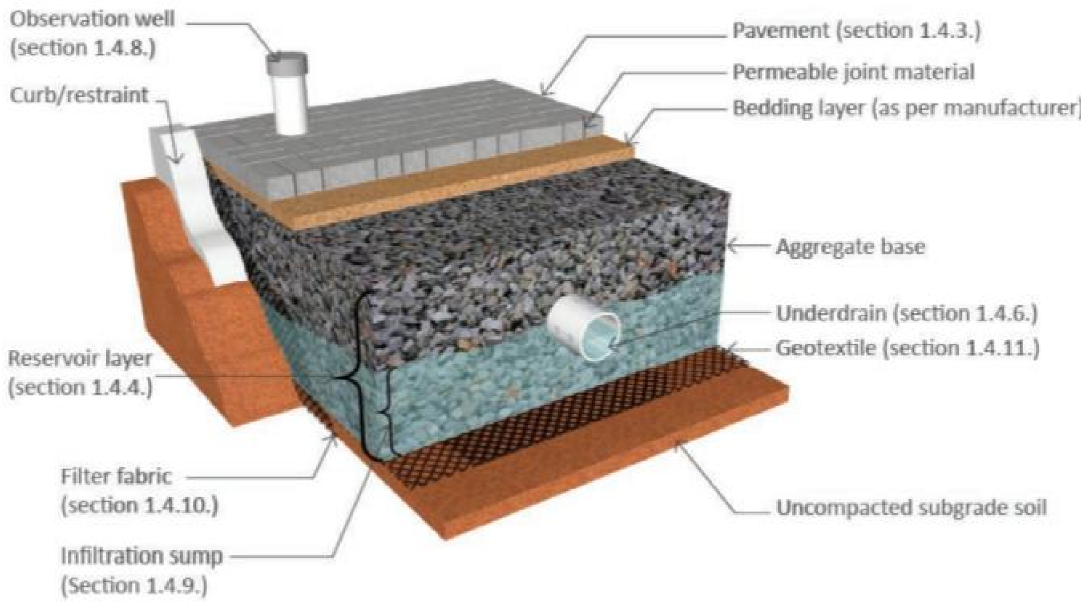

Figure 3.1. Schematic Profile of Permeable Pavement
(Source: TDEC, 2014, MWS edited 2020)

APPENDIX 3-D

AS-BUILT REQUIREMENTS

A printer friendly version of this table can be found on the MWS Development Services website or by request.

Permeable Pavement Number:

	Design	As-built
Treatment Volume (Tv), CF		
Surface Area, SF		
Overflow (TOC) Elevation*		
Reservoir Depth		
Underdrain Invert Depth*		
Outlet Elevation*		
Sump Depth		
* N/A if not required		
ALL Elevation shall be NAVD88		